



National Communications Committee
LP0002: 2018

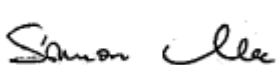
Test and Measurement Report

For

TIGO ENERGY, INC

420 BLOSSOM HILL RD
LOS GATOS, CA 95032

Model: SILICONAIR2

Report Type: Original Report		Product Type: IEEE 802.15.4/ Zigbee Module
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Note: This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp. This report **must not** be used by the customer to claim product certification, approval, or endorsement by A2LA*, NIST, or any agency of the Federal Government.

* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk “*” (Rev.0)

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	S1807273	Original Report	2018-08-07

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of **Tigo Energy, Inc.**, and their product model: SILICONAIR2 or the “EUT” as referred to in this report. It is a IEEE 802.15.4/ Zigbee Module operates in 2.4 GHz. The EUT was received on 09-02-2017.

1.2 Mechanical Description of EUT

Dimensions: approximately 11 cm (L) x 7 cm (W) x 2 cm (H)

Weight: 150 g.

Serial Number: 001-00230-00 assigned by Tigo Energy, Inc..

EUT Photos: See Annex B of this Test Report.

1.3 Objective

The primary Objective of this amendment report for **Tigo Energy, Inc.** is to prepare for submission with the current NCC Standard LP0002 Version January 10, 2018 to obtain NCC radio type approval.

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.

Parameter	Measurement uncertainty
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±0.57 dB
Power Spectral Density, conducted	±1.48dB
Unwanted Emissions, conducted	±1.57dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 dB
Temperature	±2 ° C
Humidity	±5 %
DC and low frequency voltages	±1.0 %
Time	±2 %
Duty Cycle	±3 %

1.7 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.

1.8 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 3279.02), 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 3279.03) 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 3279.01) 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 - ISED) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
 - o BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
 - o NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
 - o EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Low Voltage Directive (LVD) 2014/35/EU
- 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 Media Development Authority - IMDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
 - o ENERGY STAR Recognized Test Laboratory – US EPA
 - o Telecommunications Certification Body (TCB) – US FCC;
 - o Nationally Recognized Test Laboratory (NRTL) – US OSHA
- Vietnam: APEC Tel MRA -Phase I;

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 for each mode based upon investigation by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

2.2 EUT Exercise Software

The test utility used was *Tera Term*, provided by *Tigo Energy, Inc.*, the software is comply with the standard requirements being tested against.

2.3 Equipment Modifications

N/A

2.4 Local Support Equipment

Manufacturer/Product Type	Description	Model No.	Serial No.
Dell	Laptop	E6410	FFXR4Q1

2.5 Support Equipment

There was no support equipment included, or intended for use with EUT during these tests.

Manufacturer	Description	Model Number	Serial Number
Tigo	Device Host Enclosure	TAP	Unknown

2.6 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB	< 1	MM2ES Programming JIG	Laptop

3 Summary of Test Results

Results reported relate only to the product tested.

NCC LP0002 Rules	Description of Test	Result
NCC §2.2, § 3.10.1.3	Antenna Requirement	Compliant
NCC § 2.3	Conducted Emissions	Compliant
NCC § 3.10.1.6	Emission Bandwidth	Compliant
NCC §3.10.1.2	Maximum Peak Output Power	Compliant
NCC § 3.10.1.5	Out of Band Emissions	Compliant
NCC § 3.10.1.6 (2) (B)	Power Spectral Density	Compliant
NCC §2.7, §2.8 & § 3.10.1.5	Radiated Spurious Emissions and Restricted Band	Compliant

4 §2.2, §3.10.1.3– Antenna Description

4.1 Applicable Standards

According to §3.10.1.3, for fixed, point-to-point operations, the following conditions shall be met:

For systems operated in the 2400-2483.5MHz, the peak conducted output power of the intentional radiator is reduced by 1dB for every 3dB when the directional gain of the antenna exceeds 6dBi.

According to §2.2, 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.

4.2 Antenna Description

The antennas used by the EUT are permanent attached antennas.

Manufacturer	Model	Antenna Type	Maximum Antenna Gain (dBi)
Tigo Energy	TIGO Inverted F	Inverted F	-2.5

5 §2.3 - Conducted Emissions

5.1 Applicable Standards

According to §2.3, for Low-power radio-frequency devices 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 [mu] H/50 ohms line impedance stabilization network (LISN). 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 ^{Note}	56 to 46 ^{Note}
0.5-5	56	46
5-30	60	50

Note: Decreases with the logarithm of the frequency.

5.2 Test Setup

The measurement was performed at shield room, using the setup per NCC LP0002 and ANSI C63.4 – 2014 measurement procedure. The specification used was NCC LP0002 §2.3 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.

5.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the I/O port of the Laptop and the power cords of support Laptop were connected to LISN-1.

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”.

5.4 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:

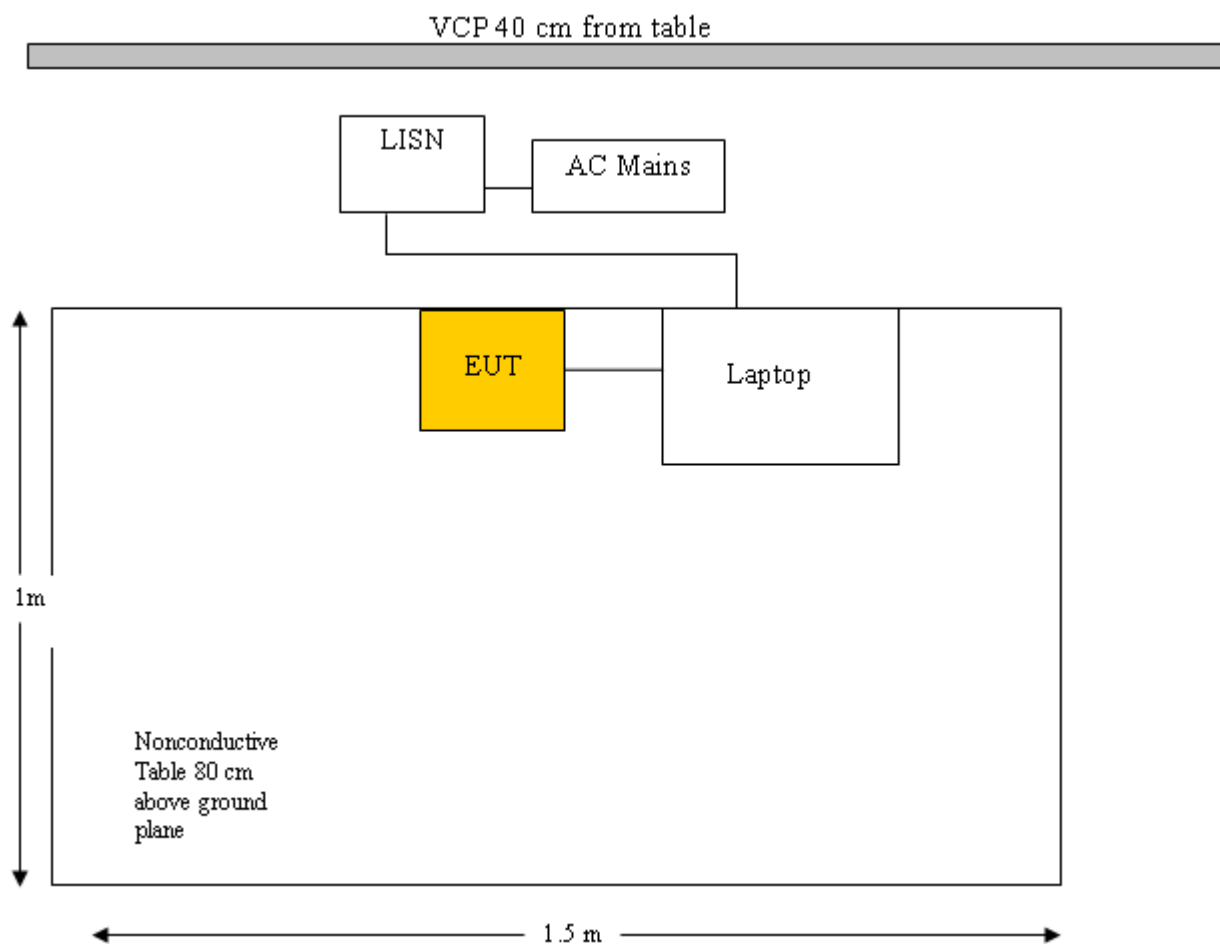
$$CA = Ai + CL + \text{Atten}$$

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:

$$\text{Margin} = \text{Corrected Amplitude} - \text{Limit}$$

5.5 Test Setup Block Diagram



5.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rhode & Shwarz	EMI Test Receiver	100338	N/A	2017-01-20	1 year
Sunol Sciences	LISN	9252-50-R-24-N	511213	2017-06-25	1 year

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

5.7 Test Environmental Conditions

Temperature:	24 °C
Relative Humidity:	45 %
ATM Pressure:	101.64 kPa

The testing was performed by Isaac Aguilar on 2017-09-19 in 5 chamber 3.

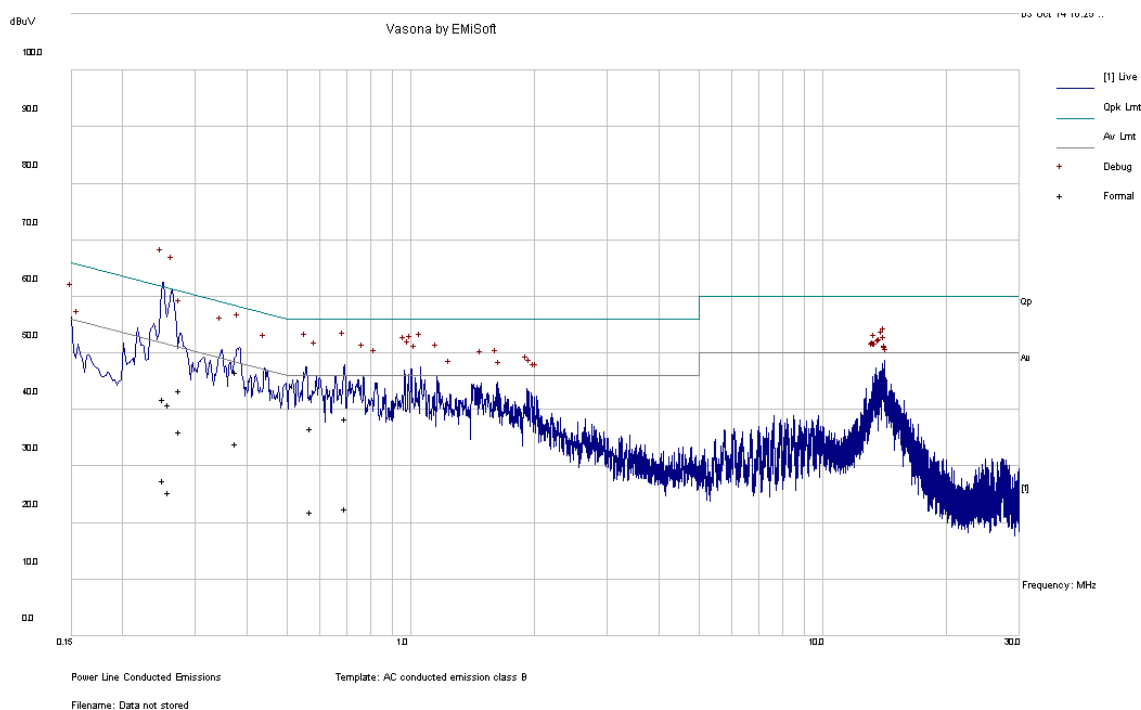
5.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the NCC 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)
-5.95	0.312924	Neutral	0.15-30

5.9 Conducted Emissions Test Plots and Data

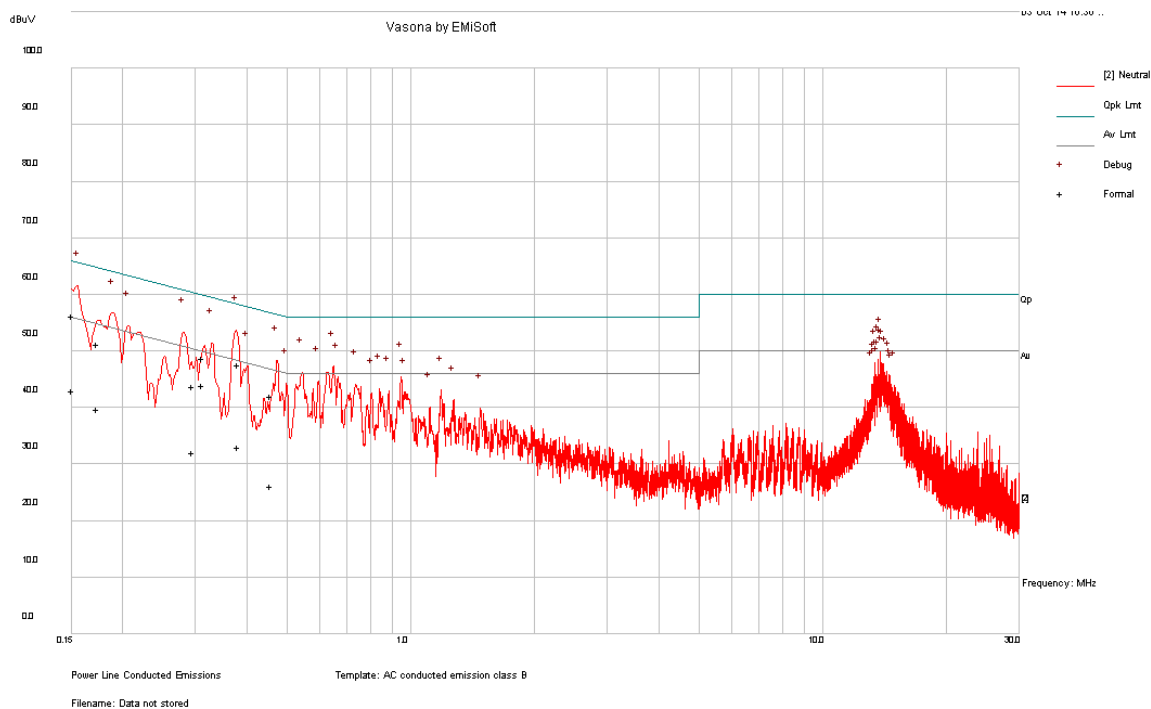
120 V, 60 Hz – Line, AC/DC Adaptor



Frequency (MHz)	Corrected Amplitude (dBμV)	Conductor (Line/Neutral)	Limit (dBμV)	Margin (dB)	Detector (QP/Ave)
0.259546	40.89	Line	61.45	-20.56	QP
0.252204	41.94	Line	61.68	-19.75	QP
0.37849	46.60	Line	58.31	-11.72	QP
0.275475	43.46	Line	60.95	-17.50	QP
0.696744	38.43	Line	56	-17.57	QP
0.572699	36.72	Line	56	-19.28	QP

Frequency (MHz)	Corrected Amplitude (dBμV)	Conductor (Line/Neutral)	Limit (dBμV)	Margin (dB)	Detector (QP/Peak)
0.259546	25.31	Line	51.45	-26.14	Ave
0.252204	27.54	Line	51.68	-24.14	Ave
0.37849	33.92	Line	48.31	-14.39	Ave
0.275475	36.11	Line	50.95	-14.84	Ave
0.696744	22.59	Line	46	-23.41	Ave
0.572699	21.94	Line	46	-24.06	Ave

120 V, 60 Hz – Neutral, AC/DC Adaptor



Frequency (MHz)	Corrected Amplitude (dBμV)	Conductor (Line/Neutral)	Limit (dBμV)	Margin (dB)	Detector (QP/Ave)
0.151025	56.22	Neutral	65.94	-9.72	QP
0.382487	47.62	Neutral	58.23	-10.61	QP
0.173714	51.33	Neutral	64.78	-13.45	QP
0.296839	43.77	Neutral	60.33	-16.56	QP
0.312924	48.85	Neutral	59.89	-11.04	QP
0.457774	42.11	Neutral	56.73	-14.62	QP

Frequency (MHz)	Corrected Amplitude (dBμV)	Conductor (Line/Neutral)	Limit (dBμV)	Margin (dB)	Detector (QP/Peak)
0.151025	42.99	Neutral	55.94	-12.95	Ave
0.382487	33.08	Neutral	48.23	-15.14	Ave
0.173714	39.79	Neutral	54.78	-14.99	Ave
0.296839	32.02	Neutral	50.33	-18.31	Ave
0.312924	43.94	Neutral	49.89	-5.95	Ave
0.457774	26.18	Neutral	46.73	-20.55	Ave

6 §2.7, § 2.8 & §3.10.1.5- Spurious Radiated Emissions and Restricted Band

6.1 Applicable Standards

As per §3.10.1.5, Radiated emission limits which fall in § 2.7 the restricted bands must also comply with the radiated emission limit specified in § 2.8.

As per § 2.7, the fundamental frequency of any low-power radio-frequency devices are restricted in any of the operation bands listed below; the spurious emissions are permitted in any of frequency band listed below and shall meet the field strength requirement of § 2.8:

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
0.090 - 0.110	162.01 - 167.17	3500.0 - 4400.0
0.490 - 0.510	167.72 - 173.20	4500.0 - 5250.0
2.172 - 2.198	240.00 - 285.00	5350.0 - 5460.0
3.013 - 3.033	322.00 - 335.40	7250.0 - 7750.0
4.115 - 4.198	399.90 - 410.00(Note 1)	8025.0 - 8500.0
5.670 - 5.690	608.00 - 614.00	9000.0 - 9200.0
6.200 - 6.300	825.00 - 915.00	9300.0 - 9500.0
8.230 - 8.400	935.00 - 1240.0	10600 - 12700
12.265 - 12.600	1300.0 - 1427.0	13250 - 13400
13.340 - 13.430	1435.0 - 1626.5	14470 - 14500
14.965 - 15.020	1660.0 - 1755.0	15350 - 16200
16.700 - 16.755	1805.0 - 1850.0	17700 - 21400
19.965 - 20.020	2200.0 - 2300.0	22010 - 23120
25.500 - 25.700	2310.0 - 2390.0	23600 - 24000
37.475 - 38.275	2483.5 - 2500.0	31200 - 31800
73.500 - 75.400	2655.0 - 2900.0	36430 - 36500
108.00 - 138.00	3260.0 - 3267.0	38600 + (Note 2)
149.90 - 150.05	3332.0 - 3339.0	
156.70 - 156.90	3345.8 - 3358.0	

Note 1: 402 MHz - 405 MHz MICS systems (Section 4.11) are excluded.

Note 2: 76 GHz - 77 GHz vehicular radar systems (Section 3.13) are excluded.

As per § 2.8, Except higher limit as specified elsewhere in other section, the emissions from the low-power radio-frequency devices shall not exceed the field strength levels specified in the following table and the level of any unwanted emissions shall not exceed the level of the fundamental emission. The tighter limit applies at the band edges.

Frequency (MHz)	Field strength (micro-volts/meter)	Measurement distance (meters)
0.009 - 0.490 (included)	2,400/Freq.(kHz)	300
0.490 (excluded) - 1.705 (included)	24,000/Freq.(kHz)	30
1.705 (excluded) - 30 (excluded)	30	30
30 (included) - 88 (included)	100	3
88 (excluded) -216 (included)	150	3
216 (excluded) -960 (included)	200	3
above 960 (excluded)	500	3

6.2 Test Setup

The radiated emissions tests were performed using the setup accordance with the NCC LP0002 and ANSI C63.10-2013. The specification used was the NCC LP0002 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 were 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 was set 3 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 1000 MHz measurements, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna's polarity should be changed between horizontal and vertical.

The spectrum analyzer or receiver was 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:

$$\text{Margin} = \text{Corrected Amplitude} - \text{Limit}$$

6.5 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Cycle
Rohde & Schwarz	EMI Test Receiver	ESCI	100338	2017-01-20	1 year
Hp	Pre-Amp	8447D	2443A04374	2017-06-09	1 year
Sunol Sciences	Bi-Log Antenna	JB3	A020106-3	2017-07-24	1 year
Agilent	Spectrum Analyzer	E4440A	US422221851	2017-04-09	1 year
Hp	Pre-Amp	8449B	3008A0110320	147-03-10	1 year
Micro-Tonics	Band Pass Filter	BRM50701	160	N/A	N/A
Sunol Sciences	System Controller	SC99V	122303-1	N/R	N/A
Sunol Sciences	Horn Antenna	DRH-118	A052704	2017-03-28	1 year
Wisewave	Horn Antenna	ARH-4223-02	10555-01	2017-05-09	3 years

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

6.6 Test Environmental Conditions

Temperature:	23-25 °C
Relative Humidity:	46-48 %
ATM Pressure:	101.32 – 101.68 kPa

The testing was performed by Isaac Aguilar on 2017-09-19 thru 2017-09-23 in 5 m chamber 3.

6.7 Summary of Test Results

According to the data hereinafter, the EUT complied with the NCC LP0002 standard's radiated emissions limits, and had the worst margin of:

30-1000 MHz:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Channel
-8.85	143.99	H	Low CH

Above 1 GHz:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Channel
-5.66	4879	H	Mid CH

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

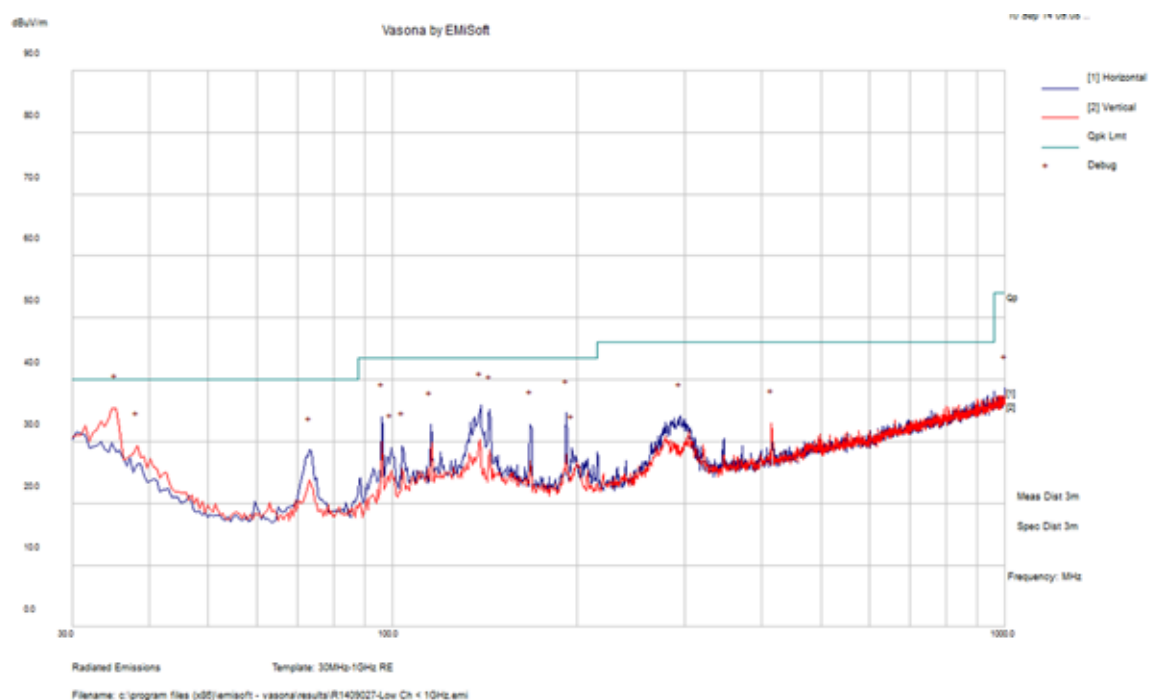
6.8 Radiated Emissions Test Results

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

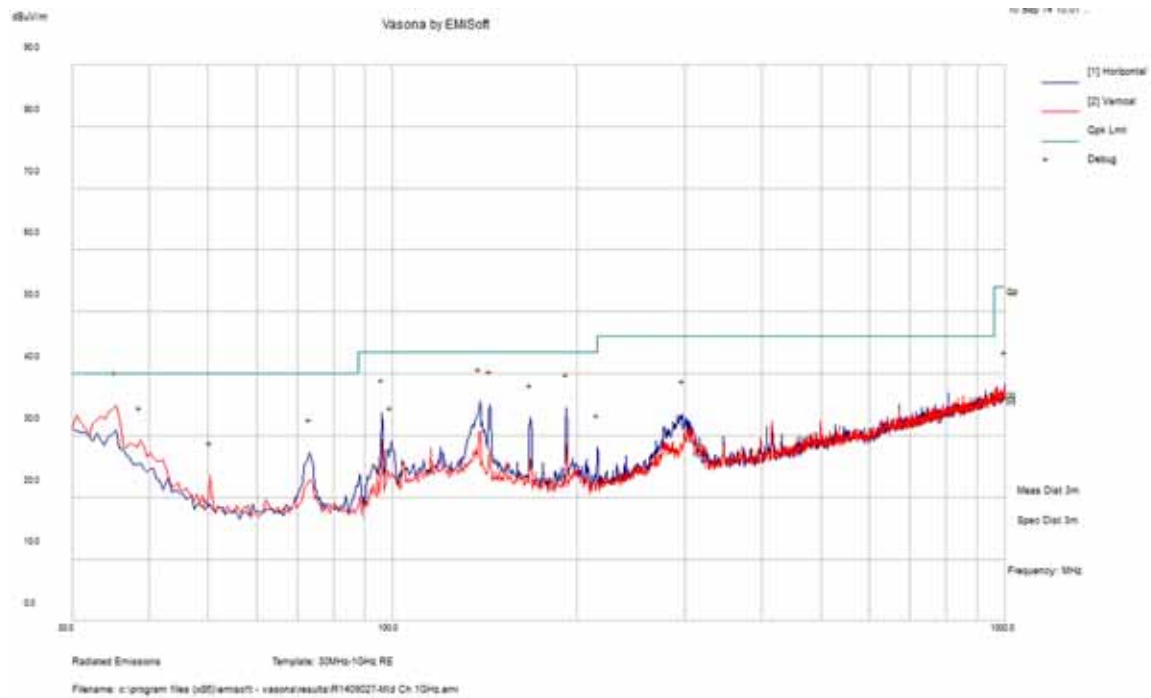
Frequency (MHz)	Corrected Amplitude (dB μ V/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dB μ V/m)	Margin (dB)	Comment
144.00	34.65	165	H	0	43.5	-8.85	QP
143.01	34.63	188	H	350	43.5	-8.87	QP
96.00	32.64	206	H	342	40	-10.86	QP
35.14	28.97	116	V	69	43.5	-11.03	QP
192.03	32.33	179	H	123	43.5	-11.17	QP

Note: Only 5 emissions were present because the other emissions were 20 dB below the limit.

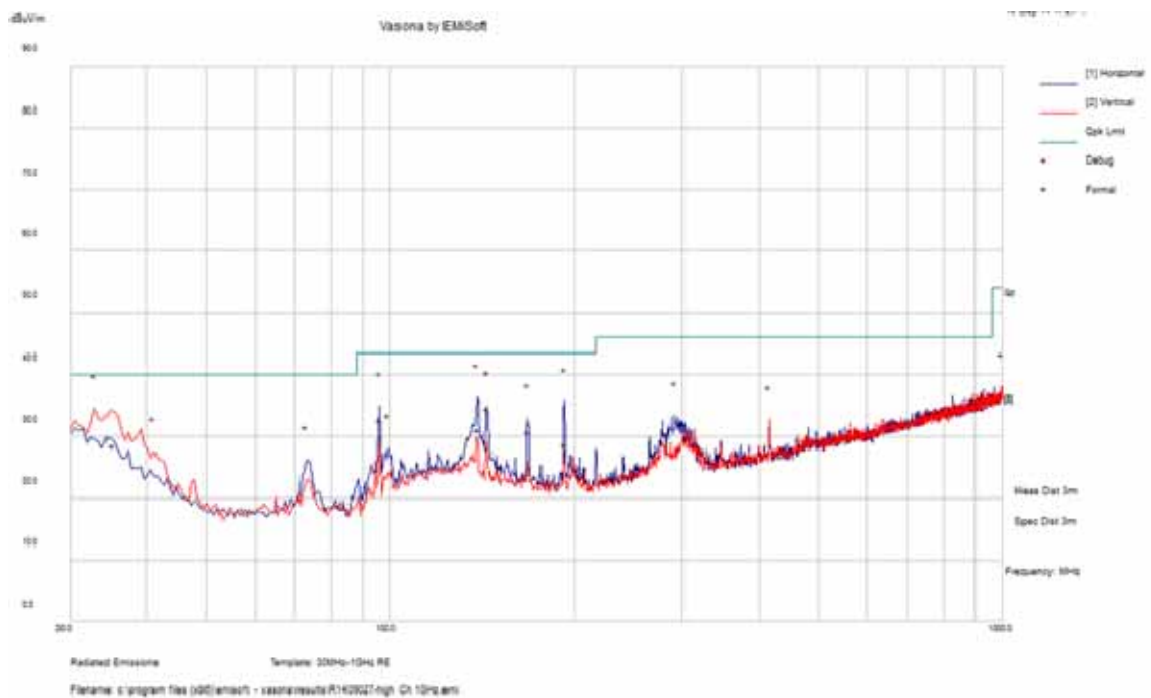
Low Channel, 2405 MHz



Middle Channel, 2440 MHz



High Channel, 2480 MHz



2) 1–25 GHz Measured at 3 meters

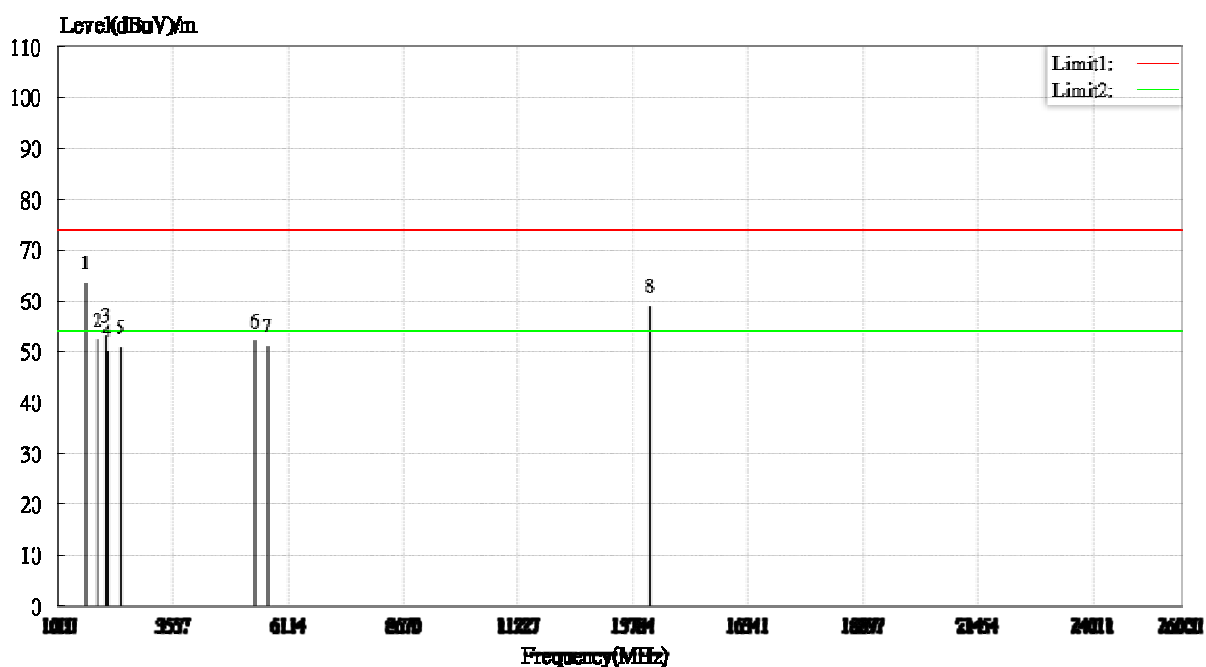
Frequency (MHz)	Corrd. Amp. (dBuV/m)	Test Antenna		Turntable Angle (Degrees)	Limit (dBuV/m)	Margin (dB)	Comment (PK/QP/Ave.)
		Height (cm)	Pol. (V/H)				
Low Channel, 2405 MHz							
14160	59.11	146	V	228	74	-14.89	PK
5665	51.2	100	V	225	74	-22.8	PK
1609	63.64	100	V	71	74	-10.36	PK
2064	53.21	101	V	188	74	-20.79	PK
1886	52.42	112	H	98	74	-21.58	PK
5383	52.21	100	V	172	74	-21.79	PK
2406	50.92	100	H	79	74	-23.08	PK
2104.55	50.29	155	H	7	74	-23.71	PK
14160	48.14	146	V	228	54	-5.86	Ave.
5665	35.5	100	V	225	54	-18.5	Ave.
1609	40.46	100	V	71	54	-13.54	Ave.
2064	36.81	101	V	188	54	-17.19	Ave.
1886	37.07	112	H	98	54	-16.93	Ave.
5383	37.74	100	V	172	54	-16.26	Ave.
2406	39.78	100	H	79	54	-14.22	Ave.
2104.55	37.97	155	H	7	54	-16.03	Ave.
Middle Channel, 2440 MHz							
14179	58.57	189	H	107	74	-15.43	PK
1611	55.34	158	V	151	74	-18.66	PK
4879	56.55	100	H	56	74	-17.45	PK
1883	53	112	V	177	74	-21	PK
1452	50.64	138	V	100	74	-23.36	PK
2104.55	50.29	155	H	7	74	-23.71	PK
5655	49.37	211	V	143	74	-24.63	PK
14179	47.92	189	H	107	54	-6.08	Ave.
1611	33.86	158	V	151	54	-20.14	Ave.
4879	48.34	100	H	56	54	-5.66	Ave.
1883	37.38	112	V	177	54	-16.62	Ave.
1452	31.54	138	V	100	54	-22.46	Ave.
2104.55	37.97	155	H	7	54	-16.03	Ave.
5655	35.2	211	V	143	54	-18.8	Ave.

Frequency (MHz)	Corrd. Amp. (dBuV/m)	Test Antenna		Turntable Angle (Degrees)	Limit (dBuV/m)	Margin (dB)	Comment (PK/QP/Ave.)
		Height (cm)	Pol. (V/H)				
High Channel, 2480 MHz							
14102	58.46	234	V	353	74	-15.54	PK
4961	52.09	138	H	247	74	-21.91	PK
5652	51.46	213	V	179	74	-22.54	PK
1641	51.2	101	V	5	74	-22.8	PK
2061	46.41	100	V	115	74	-27.59	PK
5039	50.48	142	V	138	74	-23.52	PK
2104.55	50.29	155	H	7	74	-23.71	PK
1889	44.46	143	H	100	74	-29.54	PK
14102	48.03	234	V	353	54	-5.97	Ave.
4961	42.16	138	H	247	54	-11.84	Ave.
5652	35.92	213	V	179	54	-18.08	Ave.
1641	30.52	101	V	5	54	-23.48	Ave.
2061	33.52	100	V	115	54	-20.48	Ave.
5039	34.51	142	V	138	54	-19.49	Ave.
2104.55	37.97	155	H	7	54	-16.03	Ave.
1889	31.87	143	H	100	54	-22.13	Ave.

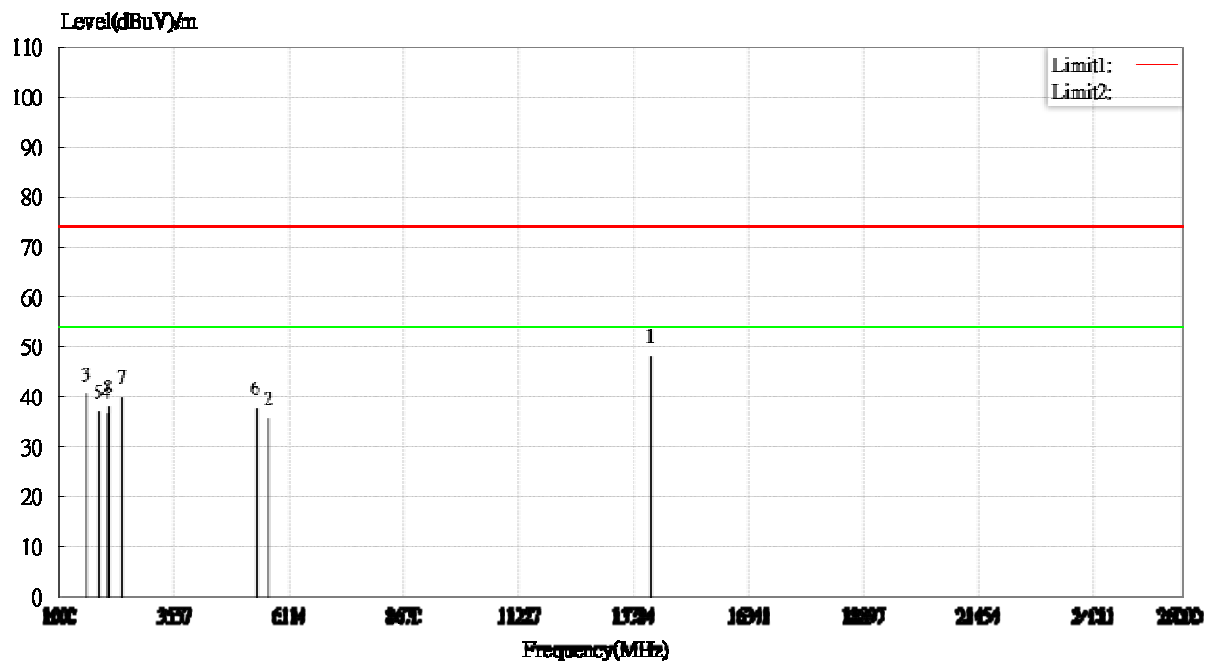
Note¹: Duty Cycle Correction Factor has been added to the measurements.

Note²: The losses and gains are factored into spectrum analyzer before the scans.

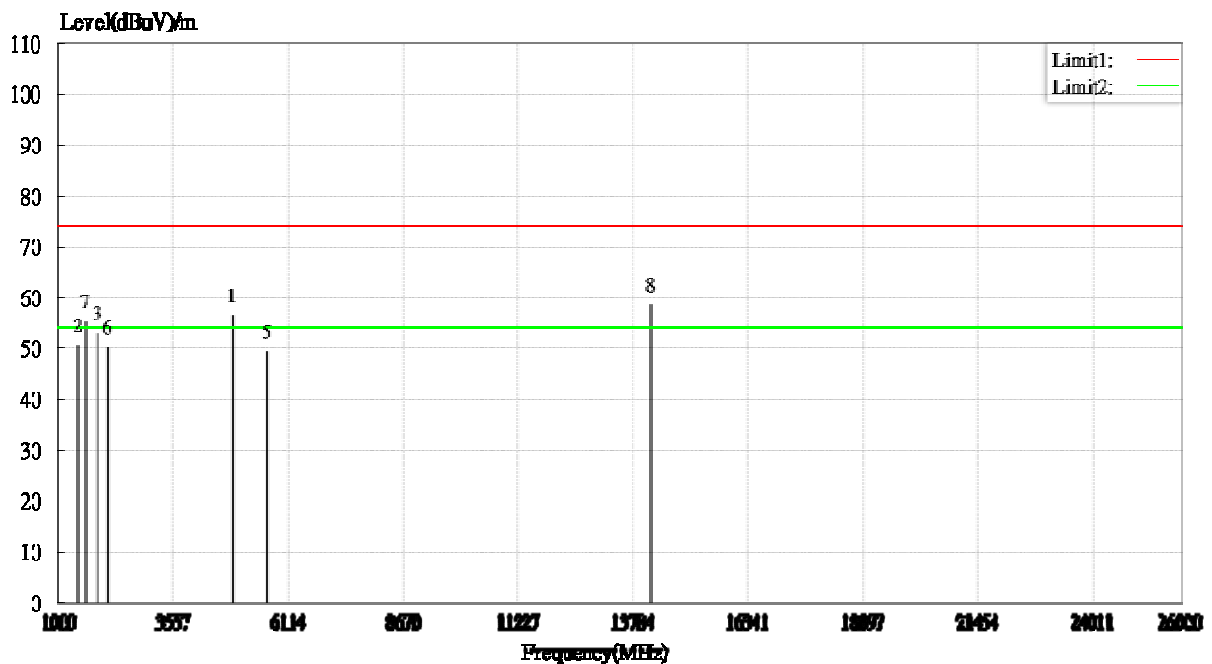
Peak Emissions Low Channel, 2405 MHz



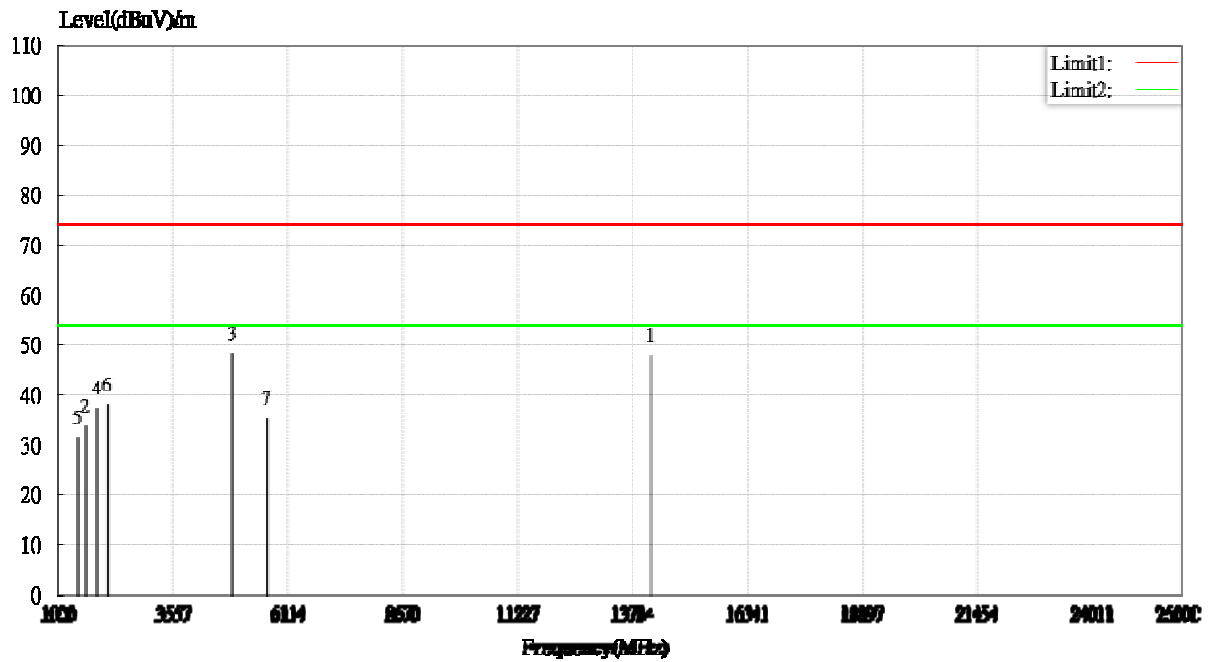
Average Emissions Low Channel, 2405 MHz



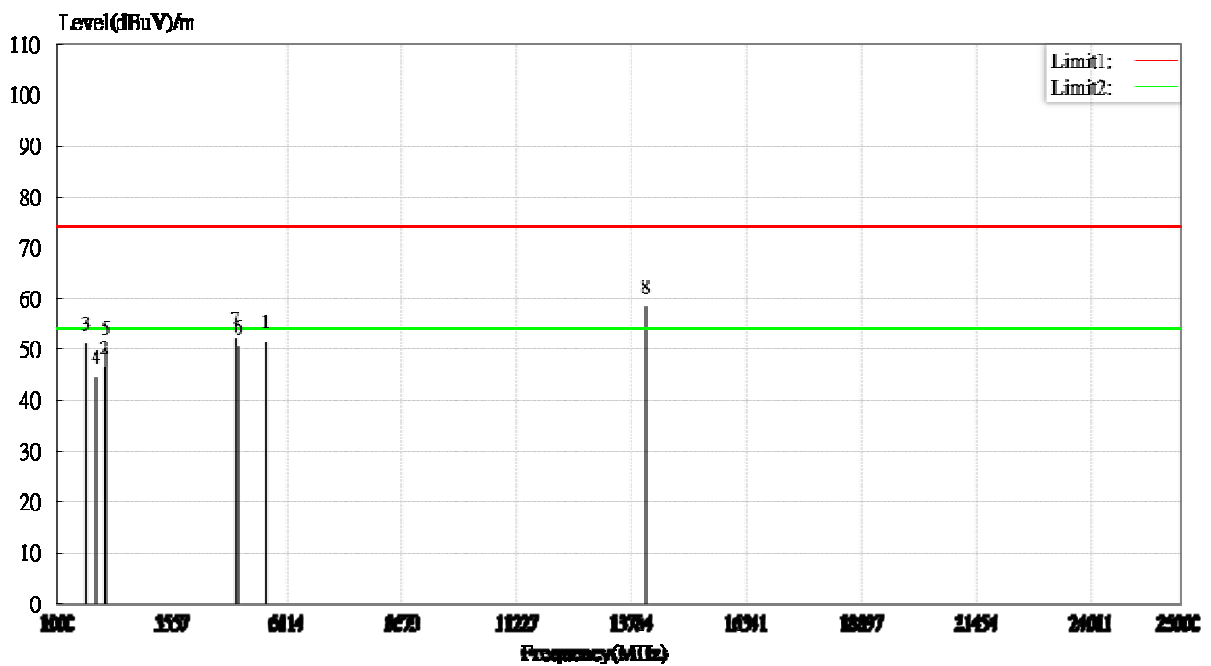
Peak Emissions Middle Channel, 2440 MHz



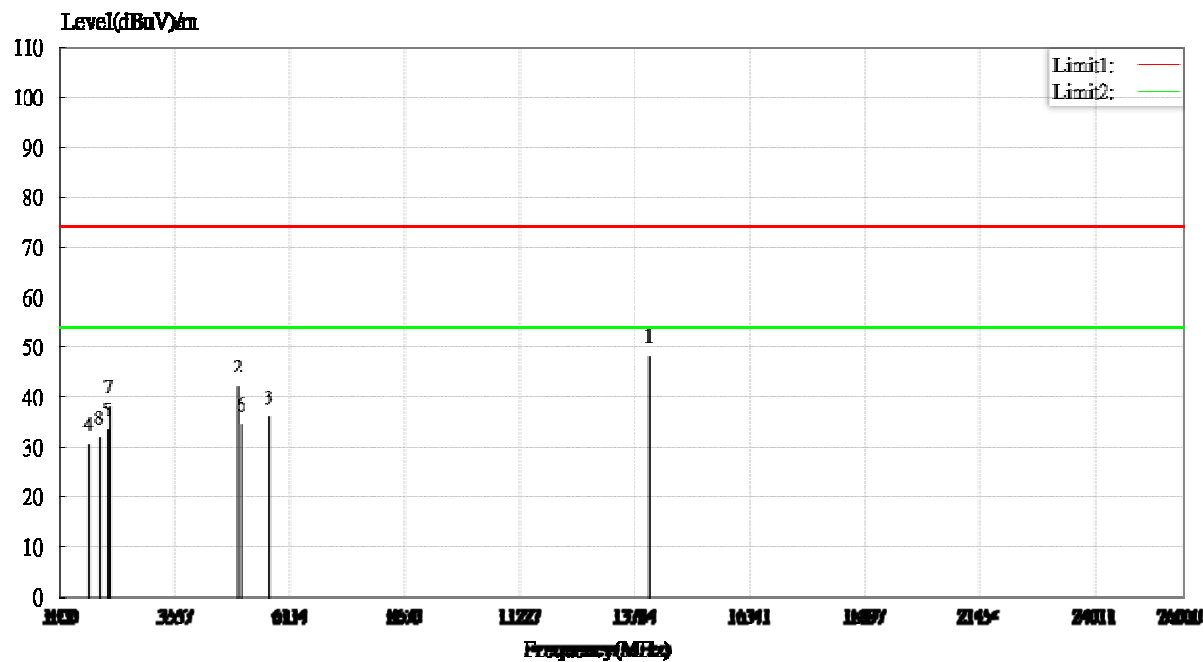
Average Emissions Middle Channel, 2440 MHz



Peak Emissions High Channel, 2480 MHz



Average Emissions High Channel, 2480 MHz



7 §3.10.1.6 – Occupied Bandwidth

7.1 Applicable Standards

According to §3.10.1.6

For digitally modulated systems, the minimum 6dB 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	US42221841	2017-04-09	1 year
-	RF cable	-	-	Each time ¹	N/A
-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: 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

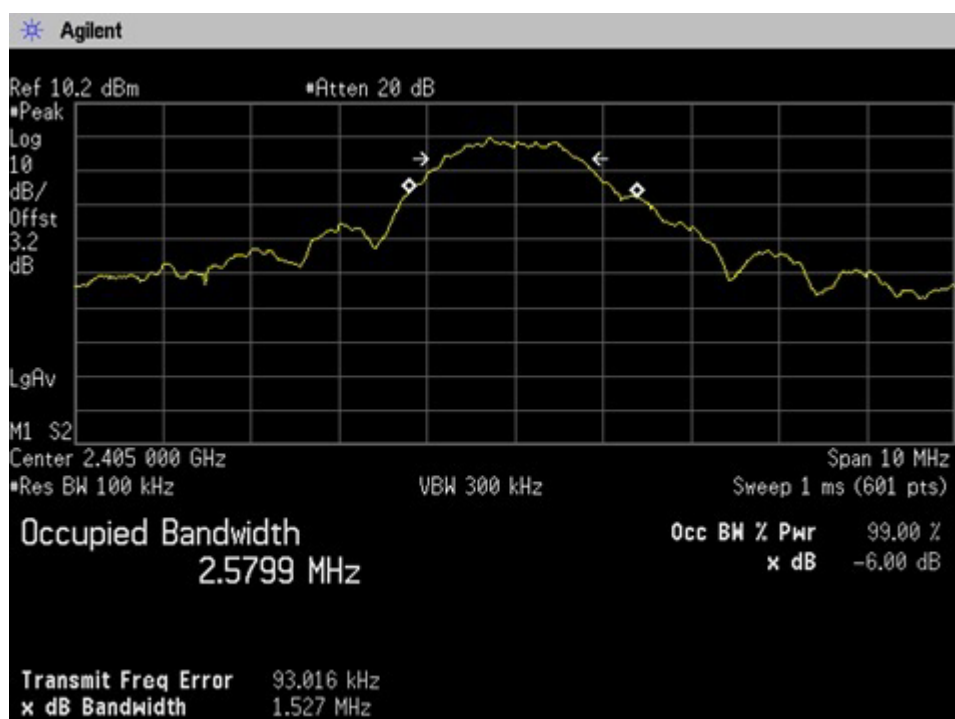
Temperature:	26 °C
Relative Humidity:	39 %
ATM Pressure:	101.28 kPa

The testing was performed by Isaac Aguilar from 2017-08-21 at RF site.

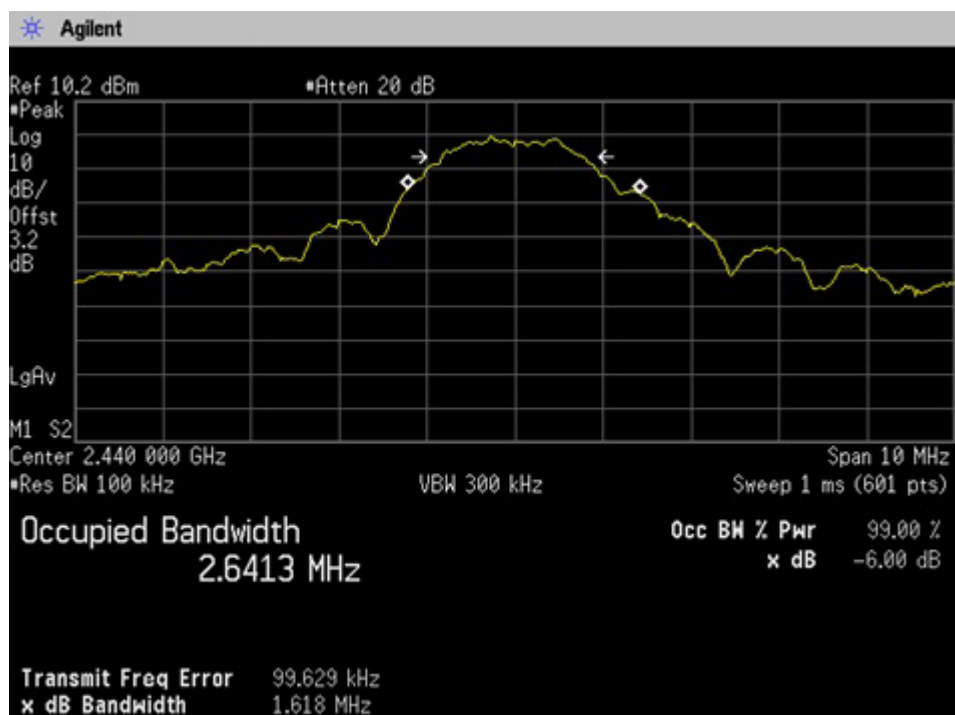
7.5 Test Results

Frequency (MHz)	99% Emission Bandwidth (MHz)	6 dB Emission Bandwidth (MHz)	Limit (MHz)	Result (Pass/Fail)
2405	2.58	1.53	> 0.500	Pass
2440	2.64	1.62	> 0.500	Pass
2480	2.70	1.64	> 0.500	Pass

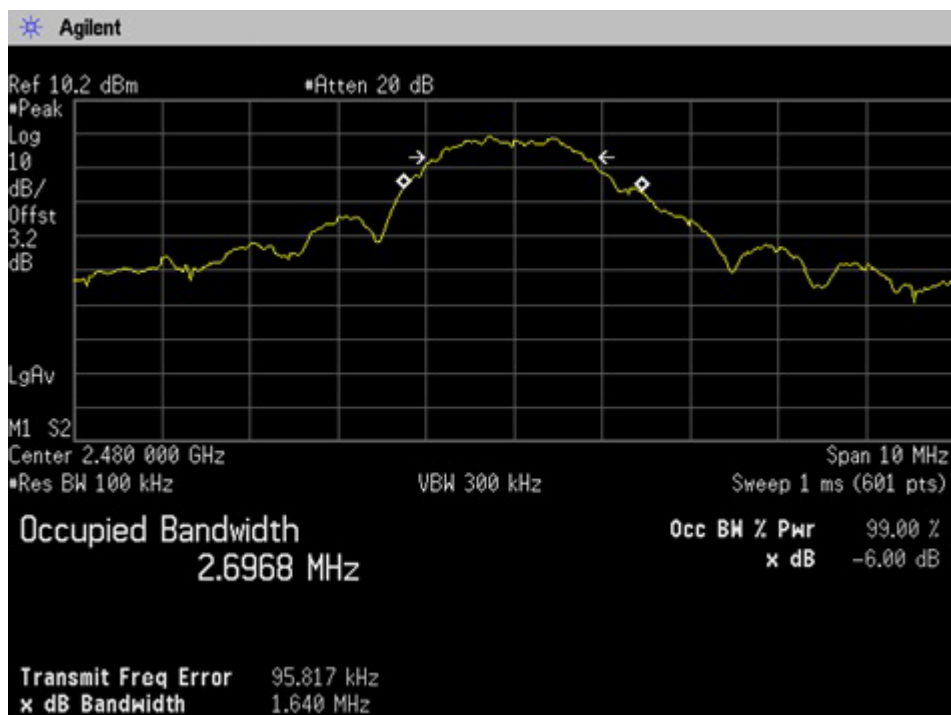
Low Channel, 2405 MHz



Middle Channel, 2440 MHz



High Channel, 2480 MHz



8 §3.10.1.2–Output Power

8.1 Applicable Standards

According to §3.1.10.1(2.3), the limit for systems using digital modulation in the 2412-2462 MHz: Below 1 Watt (30dBm).

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	US42221841	2017-04-09	1 year
-	RF Cable	-	-	Each time ¹	N/A
-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: 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

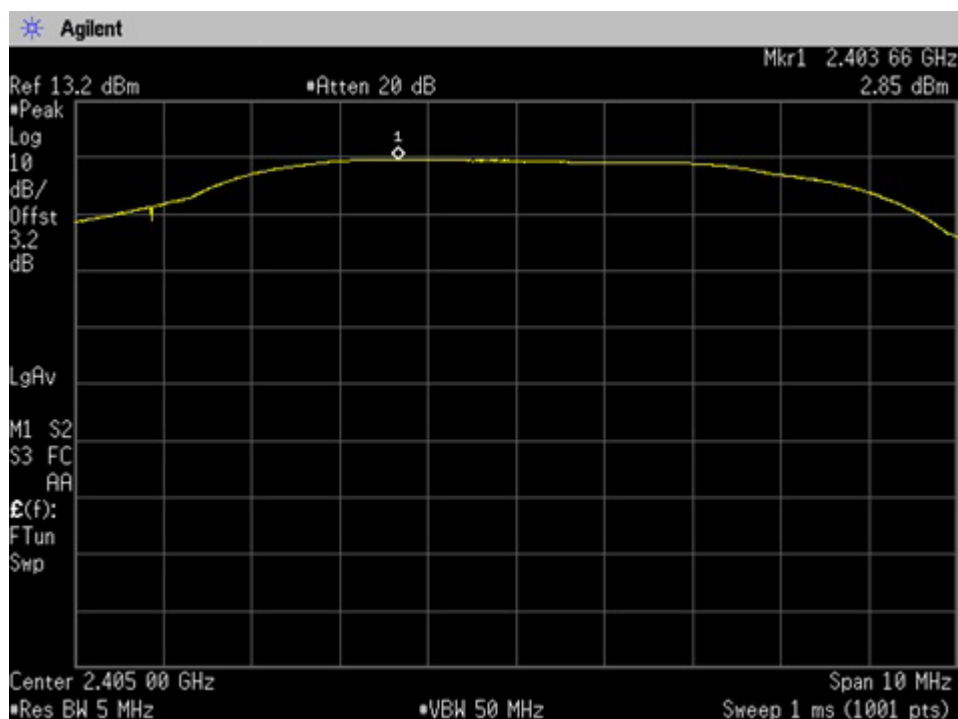
Temperature:	26 °C
Relative Humidity:	39 %
ATM Pressure:	101.28 kPa

The testing was performed by Isaac Aguilar on 2017-08-21 at RF site.

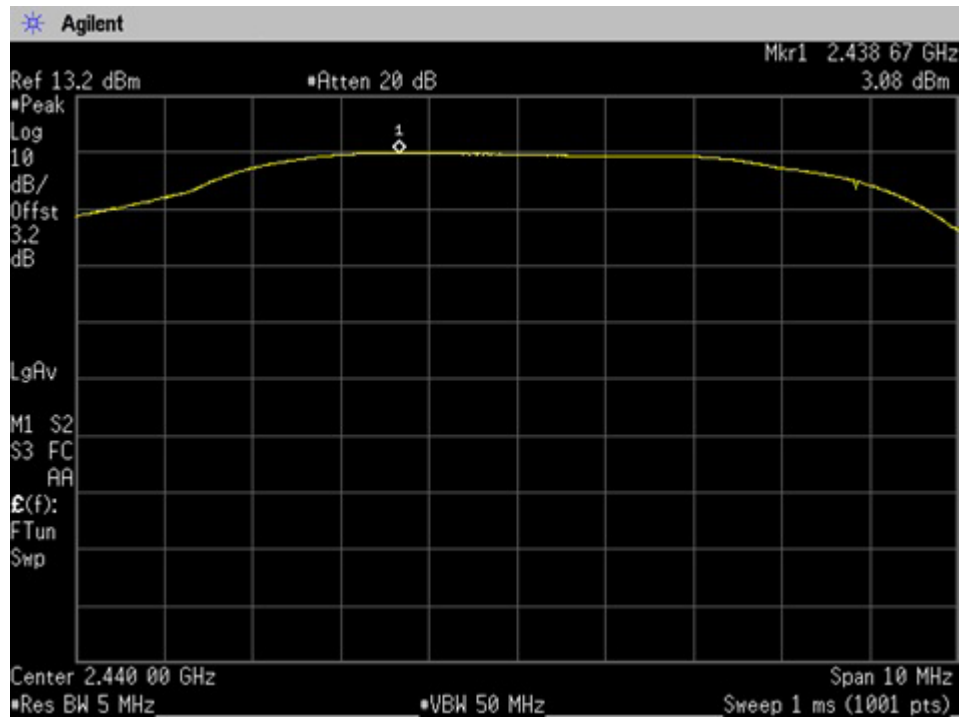
8.5 Test Results

Frequency (MHz)	Conducted Peak Output Power (dBm)	Limit (dBm)	Margin (dB)	Result (Pass/Fail)
2405	2.85	30	-27.15	Pass
2440	3.08	30	-26.92	Pass
2480	3.24	30	-26.76	Pass

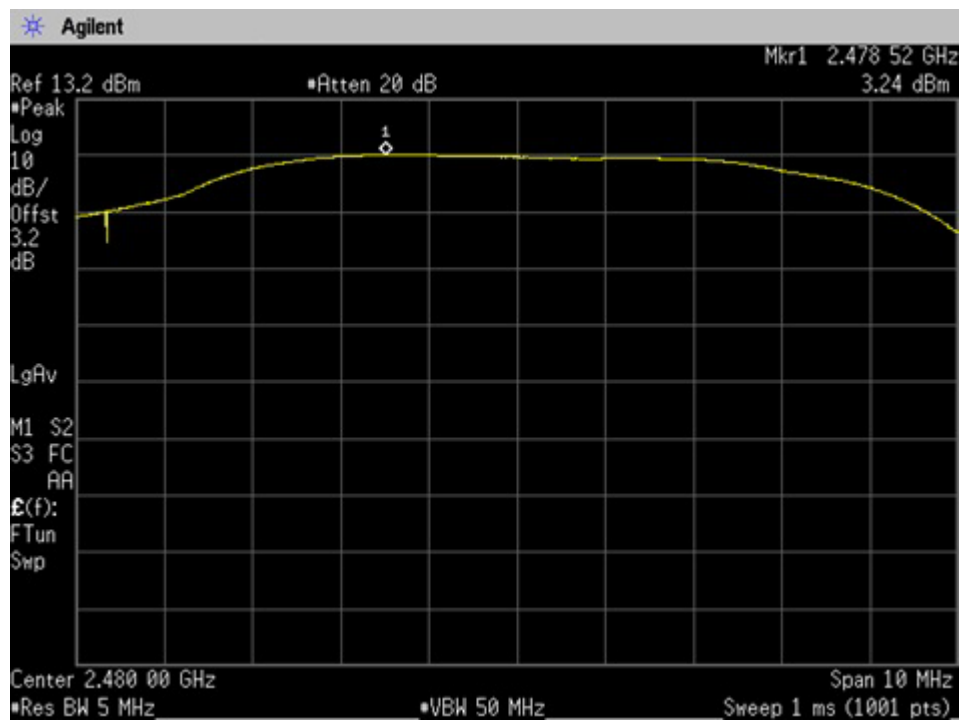
Low Channel, 2405 MHz



Middle Channel, 2440 MHz



High Channel, 2480 MHz



9 §3.10.1.5– Band Edge

9.1 Applicable Standards

According to §3.10.1(5): For transmitter operating within the 2400 – 2483.5 MHz, in any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. If the transmitter measurement is based on the peak conducted output power, as permitted under paragraph 3.10.1 (2) (2.3) of this section, the attenuation required under this paragraph shall be 20dB instead of 30dB. In addition, radiated emissions which fall in § 2.7 the restricted bands must also comply with the radiated emission limit specified in § 2.8.

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	US42221841	2017-04-09	1 year
-	RF Cable	-	-	Each time ¹	N/A
-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: 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.*

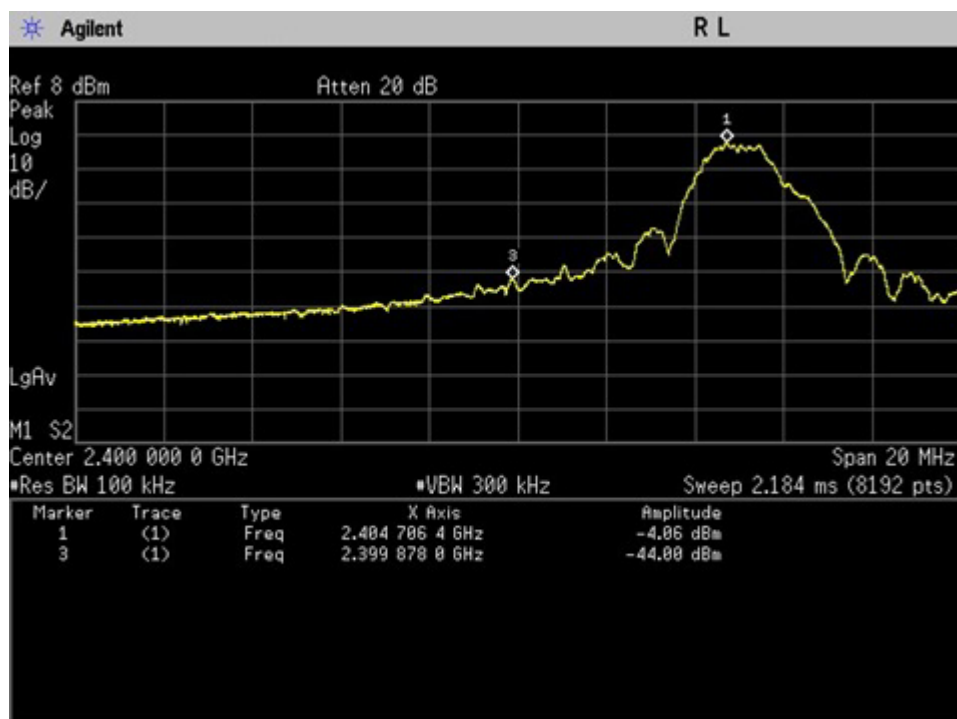
9.4 Test Environmental Conditions

Temperature:	26 °C
Relative Humidity:	39 %
ATM Pressure:	101.28 kPa

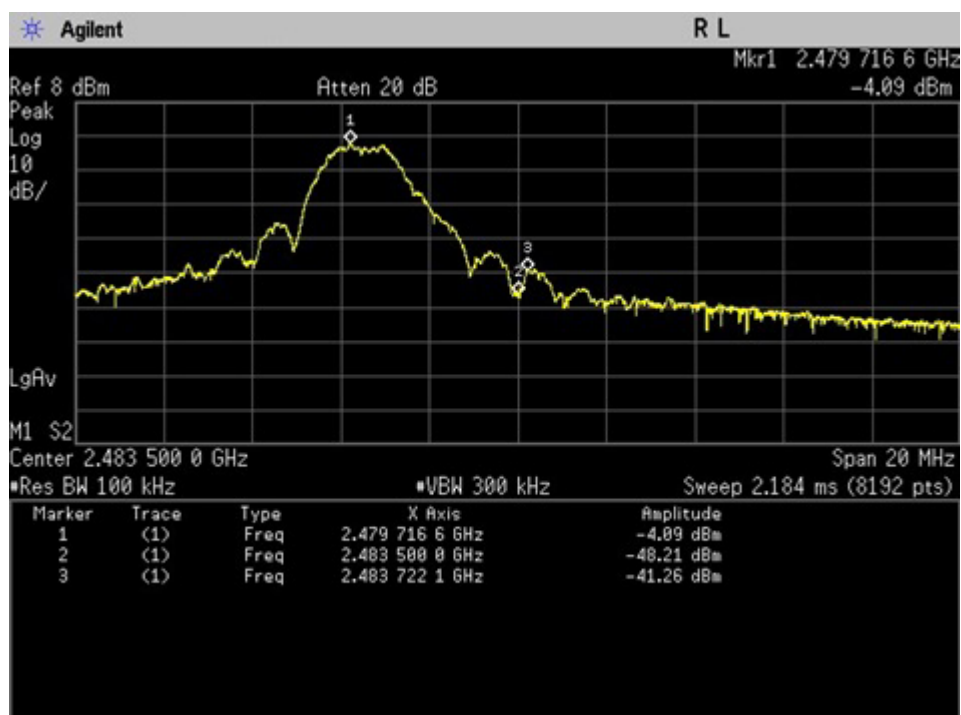
The testing was performed by Isaac Aguilar on 2017-10-01 at RF site.

9.5 Test Results

Low Channel @ Band Edge



High Channel @ Band Edge



10 §3.10.1.6 (2) (B) - Power Spectral Density

10.1 Applicable Standards

According to §3.10.1.6 (2) (B), for digitally modulated systems that operates in 2412MHz – 2462MHz, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3kHz 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	US42221841	2017-04-09	1 year
-	RF Cable	-	-	Each time ¹	N/A
-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: 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:	26 °C
Relative Humidity:	39 %
ATM Pressure:	101.28 kPa

The testing was performed by Isaac Aguilar from 2017-08-21 at RF site.

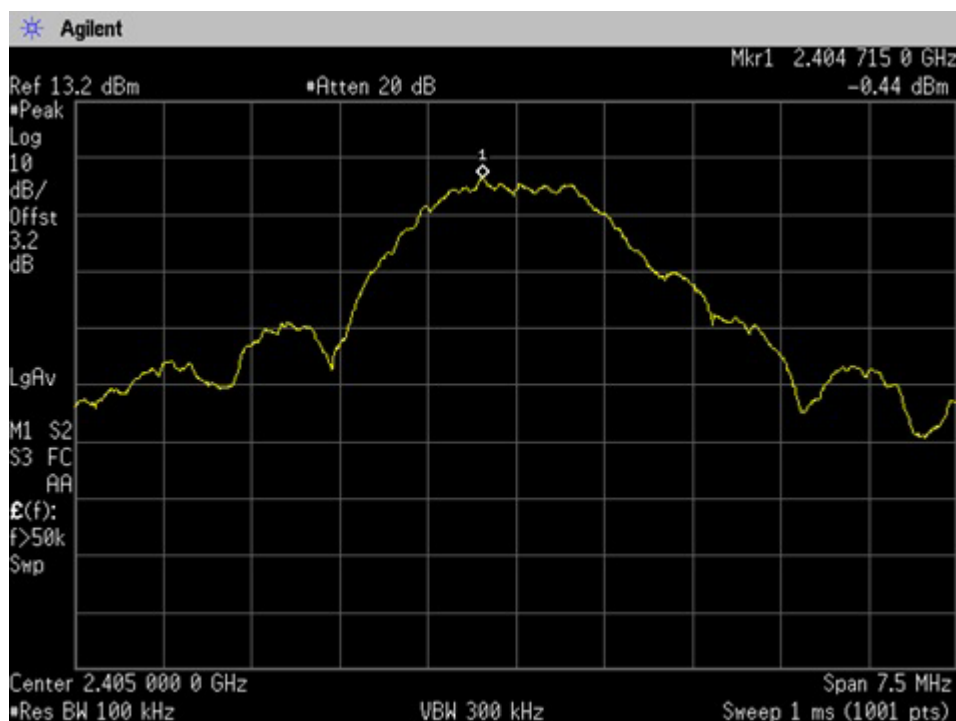
10.5 Test Results

Frequency (MHz)	Measured PSD (dBm/100 kHz)	Corrected PSD (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dBm/3 kHz)	Result (Pass/Fail)
2405	-0.44	-15.66	8	-23.66	Pass
2440	-0.39	-15.61	8	-23.61	Pass
2480	-0.74	-15.96	8	-23.96	Pass

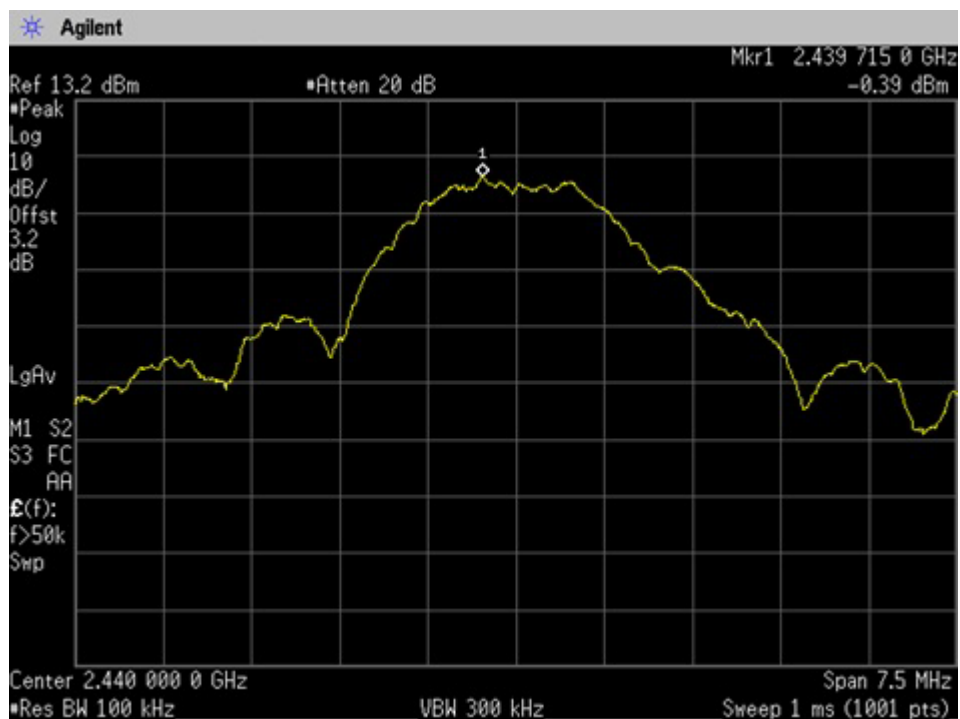
Correction Factor: $10 \cdot \log(100/3) = 15.22$ dB

Please refer to the following plots for detailed test results

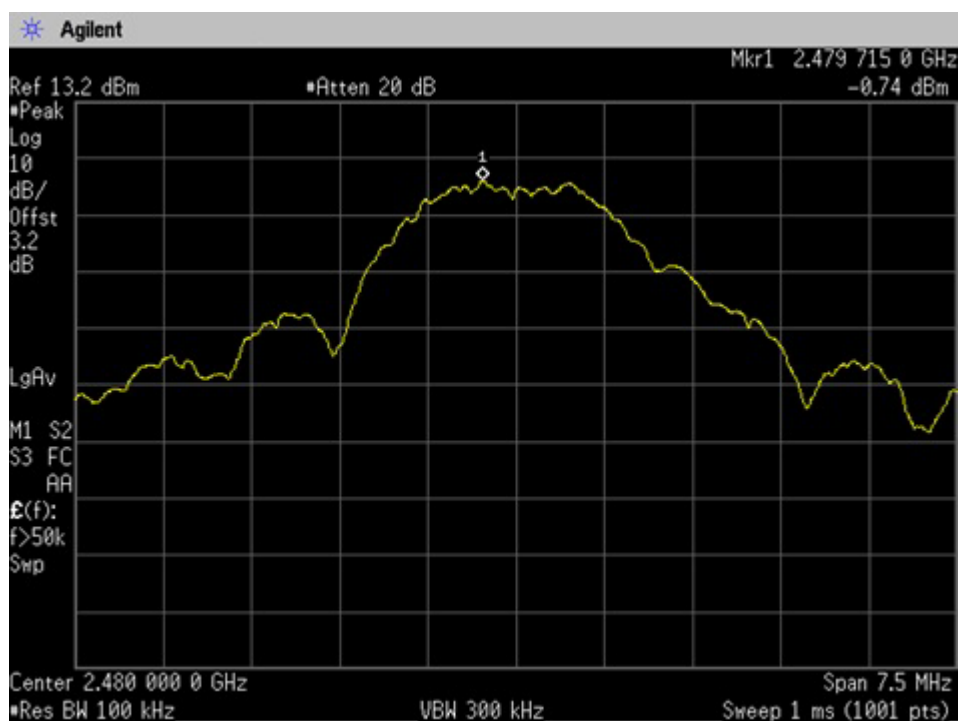
Low Channel, 2405 MHz



Middle Channel, 2440 MHz



High Channel, 2480 MHz



11 §3.10.1.5– Spurious Emissions at Antenna Terminals

11.1 Applicable Standards

According to §3.10.1(5): For transmitter operating within the 2400 – 2483.5 MHz, in any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. If the transmitter measurement is based on the peak conducted output power, as permitted under paragraph 3.10.1 (2) (2.3) of this section, the attenuation required under this paragraph shall be 20dB instead of 30dB. In addition, radiated emissions which fall in § 2.7 the restricted bands must also comply with the radiated emission limit specified in § 2.8.

11.2 Test 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.

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US42221841	2017-04-09	1 year
-	U. FL to SMA pigtail	-	-	Each time ¹	N/A
-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: 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.*

11.4 Test Environmental Conditions

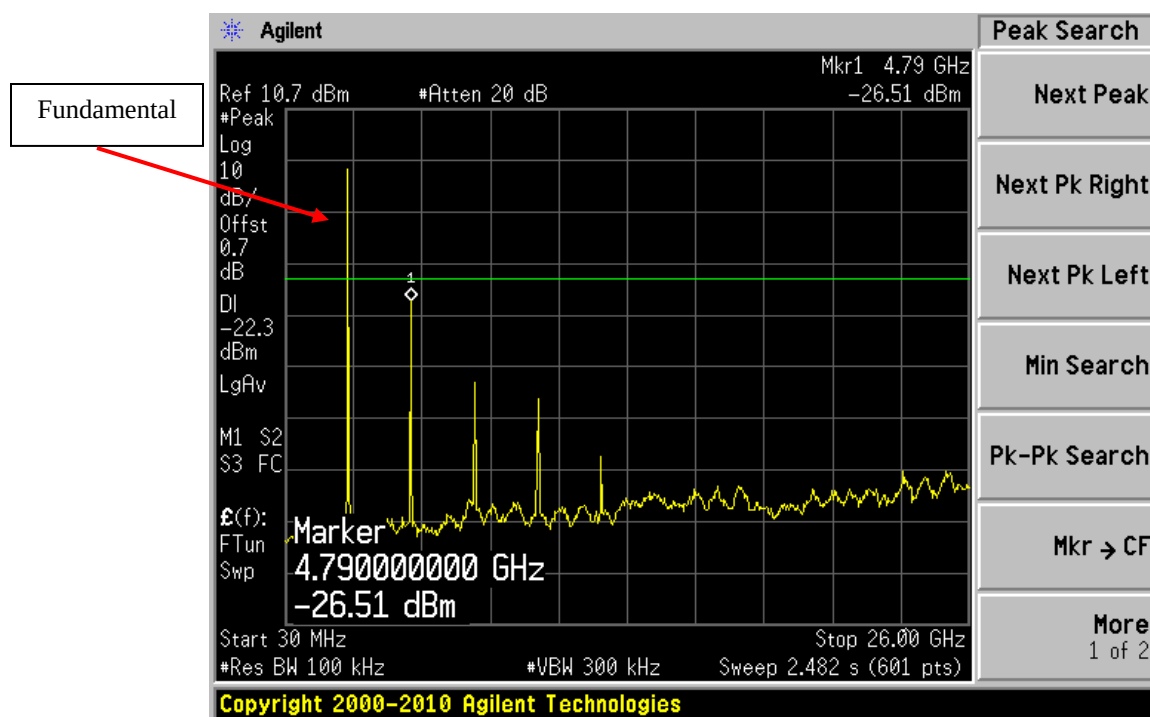
Temperature:	25 °C
Relative Humidity:	46 %
ATM Pressure:	101.68 kPa

The testing was performed by Isaac Aguilar from 2017-09-19 at RF site.

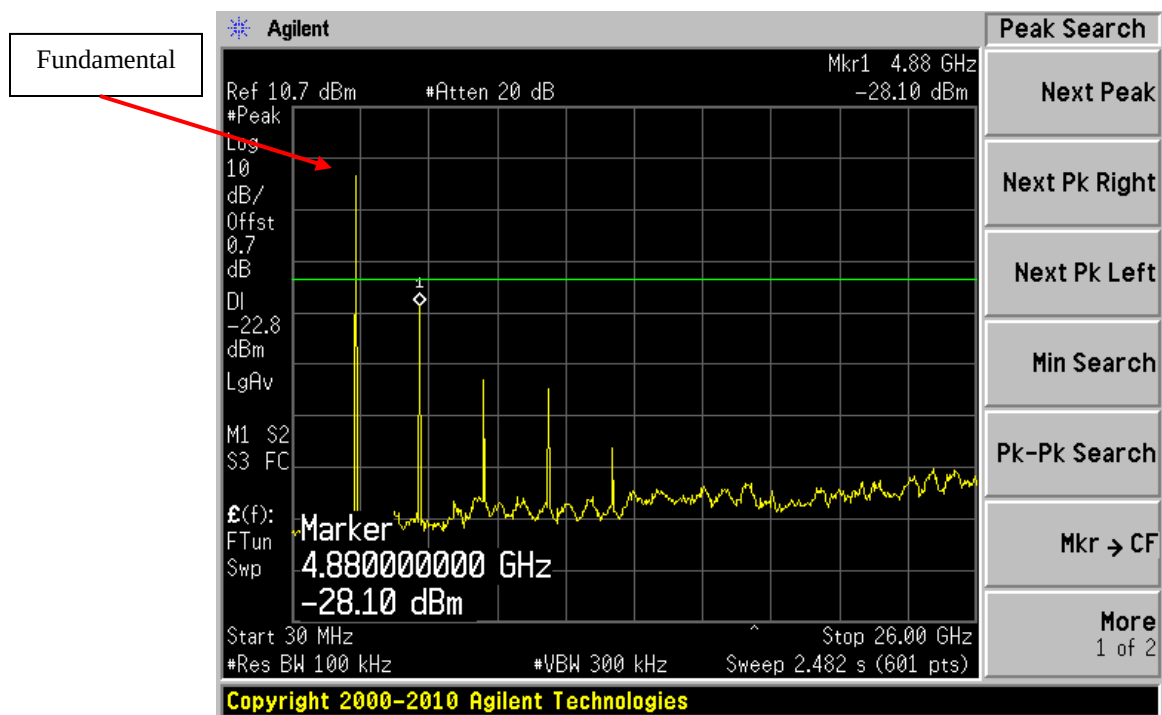
11.5 Test Results

Please refer to following plots.

Low Channel (2405 MHz) Spurious Emissions



Middle Channel (2440 MHz) Spurious Emissions



High Channel (2480 MHz) Spurious Emissions

