



LP0002-2020

TEST REPORT

For

Halio Inc.

3955 Trust Way
Hayward, CA 94545, USA

Model: DR250

Report Type: Original Report	Product Type: Electrochromic Windows Driver
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Report Number: R2103314-NCC	
Report Date: 2021-10-12	
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* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk “*”

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2103314-NCC	Original Report	2021-10-12

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test report was prepared on behalf of *Halio Inc* and their product model: DR250, or the “EUT” as referred to in this report. It is an Electrochromic Windows Driver with radio that operates within the 2400-2483.5 MHz frequency range.

EUT receive date: 2021-05-03

EUT SW version: 1.3.121+4616fd8.master.20200914.160920

Brand: HALIO

1.2 Mechanical Description of EUT

DR250 measures approximately 17.3cm(L) 3cm(W) 7.9 cm(H) and weighs approximately 0.34 kg.

The data gathered are from two production samples provided by Halio Inc:

Conducted sample SN:0101A210720092

Radiated sample SN: 0101A210720034

1.3 Objective

This report was prepared on behalf of *Halio Inc* in accordance with LP0002-2020.

The objective was to determine compliance with LP0002-2020 for Antenna Requirement, RF Exposure, AC Line Conducted Emissions, Emission Bandwidth, Radiated & Conducted Spurious Emissions, 100 kHz Band Edges, Maximum Output Power, and Peak Power Spectrum Density

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 LP0002-2020.

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 3297.02), in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report.

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

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

- For the USA (Federal Communications Commission):

- 1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
- 2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
- 3- All Telephone Terminal Equipment within FCC Scope C.

- For the Canada (Industry Canada):

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

- For Singapore (Info-Communications Development Authority (IDA)):

- 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2

- For the Hong Kong Special Administrative Region:

- 1 All Radio Equipment, per KHCA 10XX-series Specifications;
- 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
- 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.

- For Japan:

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

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

- 1 Electronics and Office Equipment:
 - for Telephony (ver. 3.0)
 - for Audio/Video (ver. 3.0)
 - for Battery Charging Systems (ver. 1.1)

- for Set-top Boxes & Cable Boxes (ver. 4.1)
- for Televisions (ver. 6.1)
- for Computers (ver. 6.0)
- for Displays (ver. 6.0)
- for Imaging Equipment (ver. 2.0)
- for Computer Servers (ver. 2.0)
- 2 Commercial Food Service Equipment
 - for Commercial Dishwashers (ver. 2.0)
 - for Commercial Ice Machines (ver. 2.0)
 - for Commercial Ovens (ver. 2.1)
 - for Commercial Refrigerators and Freezers
- 3 Lighting Products
 - For Decorative Light Strings (ver. 1.5)
 - For Luminaires (including sub-components) and Lamps (ver. 1.2)
 - For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
 - For Integral LED Lamps (ver. 1.4)
- 4 Heating, Ventilation, and AC Products
 - for Residential Ceiling Fans (ver. 3.0)
 - for Residential Ventilating Fans (ver. 3.2)
- 5 Other
 - For Water Coolers (ver. 3.0)

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

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Innovation, Science and Economic development Canada - 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 in accordance to ANSI C63.10.

2.2 EUT Exercise Software

The software “Tera Term” was used to transmit signal for all the modules. The following channels and power settings were selected for testing.

Modulation	Channel Frequency (MHz)	Power Setting
O-QPSK	2405	19
	2440	19
	2475	19

2.3 Duty Cycle Correction Factor

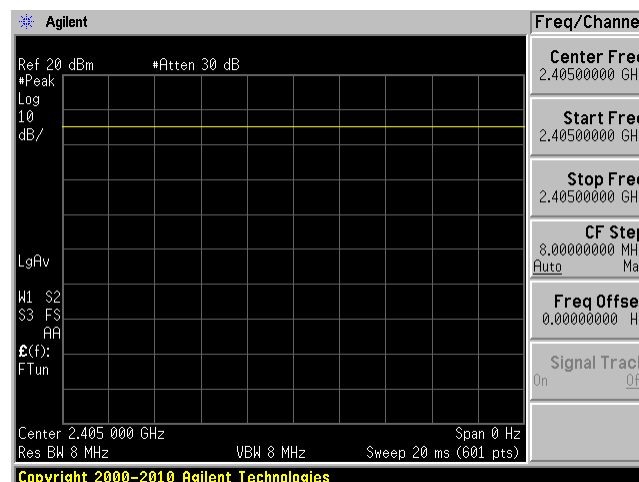
According to KDB 558074 D01 DTS Meas Guidance v05r02 section 6.0:

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

Radio frequency (MHz)	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
2405	-	-	100	0

Duty Cycle = On Time (ms)/ Period (ms)

Duty Cycle Correction Factor (dB) = $10 \cdot \log(1/\text{Duty Cycle})$



2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

Manufacturer/Brand	Description	Model No.	Serial No.
Dell	Laptop	Latitude E4610	GB1ZVM1

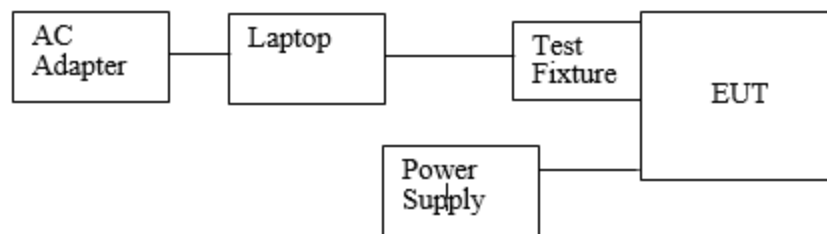
*Note: Not for sale, only for support testing

2.6 Remote Support Equipment

Manufacturer/Brand	Description	Model No.	Serial No.
Meanwell	DC Power Supply	HEP-600C-48	RB80003231
Halio Inc.	Edge Connector Board	-	-

2.7 Interface Ports and Cabling

Manufacturer/Brand	Cable Description	Model No.	Length (m)	From	To
-	USB Type A to Micro USB Type B	-	< 1 m	Edge Connector Board	Laptop
Monoprice	Power cables	16/2 16 awg 2 conductor hi-strand ofc cmp/cl3p 4003289 c(ETL)us	< 1 m	EUT	Power Supply



3 Summary of Test Results

Results reported relate only to the product tested.

Standard Rules	Description of Test	Results
LP0002-2020 §3.2	Antenna Requirements	Compliant
LP0002-2020 §6.20.2	RF Exposure	Compliant
LP0002-2020 §3.3	AC Line Conducted Emissions	N/A ¹
LP0002-2020 §3.5, §3.6, §3.7, §3.9	Radiated Spurious Emissions	Compliant
LP0002-2020 §4.10.1.6(2)(A)	6 dB & 99% Emission Bandwidth	Compliant
LP0002-2020 §4.10.1.2	Maximum Output Power	Compliant
LP0002-2020 §4.10.1.6(2)(B)	Peak Power Spectral Density	Compliant
LP0002-2020 §4.10.1.6	100 kHz Bandwidth of Frequency Band Edge	Compliant
LP0002-2020 §4.10.1.5	Spurious Emissions at Antenna Port	Compliant

Note¹: Device is DC powered, thus AC Line Conducted Emissions is not required.

4 LP0002-2020 §3.2 - Antenna Requirements

4.1 Applicable Standards

According to LP-0002-2020 §3.2,

Antenna requirement: Low-power radio frequency transmitter or transceiver (receiver) shall utilize a permanently, semi-permanently attached antenna or uses a unique coupling of the antenna and at any cable connector between the transmitter and the antenna. The antenna shall be an omni-directional type. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector or other than authorized is prohibited. Such standard connectors are for example: BNC, F type, N type, M type, UG type, RCA, SMA, SMB, and other standard type antenna connectors.

4.2 Antenna Description

External/Internal/ Integral	Frequency Range (MHz)	Antenna Type	Maximum Antenna Gain (dBi)
Internal	2400-2483.5 MHz	Chip	1.3

Antenna gain is information provided by customer.

Antenna manufacturer/brand name: Johanson Technology

Antenna model: 2450AT43B100

5 LP0002-2020 §6.20.2 - RF Exposure

5.1 Applicable Standards

According to LP0002-2020 §6.20.2, for purposes of RF exposure assessment requirements, Maximum Permissible Exposure (MPE) shall be measured, if separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. Limits are as follows:

6.20.2.1 Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
0.3-3.0	614	1.63	*100	6
3-30	1842/f	4.89/f	*900/f ²	6
30-300	61.4	0.163	1.0	6
300-1,500	-----	-----	f/300	6
1,500-100,000	-----	-----	5.0	6

Note 1: asterisk (*) is plane-wave equivalent power density.

Note 2: f is the testing frequency in MHz.

6.20.2.2 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)
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
300-1,500	-----	-----	f/1500	30
1,500-100,000	-----	-----	1.0	30

Note 1: asterisk (*) is plane-wave equivalent power density.

Note 2: f is the testing frequency in MHz.

5.2 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

5.3 MPE Results

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>14.84</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>30.4789499</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>2405</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>1.3</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1.348962883</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u>	<u>0.0081796</u>
<u>NCC MPE limit for uncontrolled exposure at prediction frequency</u> <u>(mW/cm²):</u>	<u>1.0</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.0081796 mW/cm². Limit is 1.0 mW/cm².

6 LP0002-2020 §3.5, §3.6 & §3.7, §3.9 - Spurious Radiated Emissions

6.1 Applicable Standards

As per LP0002-2020 §3.5, Additional regulations shall apply except for this standard. The fundamental frequency of any low-power radio-frequency devices shall be restricted in any of the operation bands listed below; spurious emissions shall be permitted in any of frequency band listed below and shall meet the field strength requirement of 3.6:

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
0.090 ~ 0.110	322.00 ~ 335.40	3500.0 ~ 4400.0
0.490 ~ 0.510	399.90 ~ 410.00	4500.0 ~ 5250.0
2.172 ~ 2.198	485.00 ~ 510.00	5350.0 ~ 5460.0
3.013 ~ 3.033	608.00 ~ 614.00	7250.0 ~ 7750.0
4.115 ~ 4.198	703.00 ~ 748.00	8025.0 ~ 8500.0
5.670 ~ 5.690	758.00 ~ 803.00	9000.0 ~ 9200.0
6.200 ~ 6.300	825.00 ~ 915.00	9300.0 ~ 9500.0
8.230 ~ 8.400	930.00 ~ 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 ~ 1785.0	15350 ~ 16200

16.700 ~ 16.755	1805.0 ~ 1880.0	17700 ~ 21400
19.965 ~ 20.020	1885.0 ~ 1900.0	22010 ~ 23120
25.500 ~ 25.700	1905.0 ~ 1985.0	23600 ~ 24000
37.475 ~ 38.275	2010.0 ~ 2025.0	31200 ~ 31800
73.500 ~ 75.400	2110.0 ~ 2170.0	36430 ~ 36500
108.00 ~ 138.00	2200.0 ~ 2300.0	38600 +
149.90 ~ 150.05	2310.0 ~ 2390.0	
156.70 ~ 156.90	2483.5 ~ 2900.0	
162.01 ~ 167.17	3260.0 ~ 3267.0	
167.72 ~ 173.20	3332.0 ~ 3339.0	
240.00 ~ 285.00	3345.8 ~ 3358.0	)

As per LP0002-2020 §3.6, additional regulations shall apply except for this standard, the emissions from the low-power radio-frequency devices shall be less than or equal 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.

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
$0.009 \leq f \leq 0.490$	2400/Freq.(kHz)	300
$0.490 < f \leq 1.705$	24000/Freq.(kHz)	30
$1.705 < f \leq 30.0$	30	30
$30 \leq f \leq 88$	100	3
$88 < f \leq 216$	150	3
$216 < f \leq 960$	200	3
$960 < f$	500	3

As per LP0002-2020 §3.7, the field strength radio frequency 9-90 kHz, 110-490 kHz and 1000 MHz above stipulated in the above table shall be measured according to an average detector and comply with Section 6.15.2, while others shall be measured using a CISPR quasi-peak detector. Those not specified above shall comply with Section 6.5 and the frequency bands measurement of radiated emission shall accord with Section 6.14.

As Per LP0002-2018 §3.9: If the transmitter and receiver of the low-power radio-frequency device are sold in one set, the corresponding type approval review documents shall be submitted; otherwise the transmitter and receiver should be applied for approval together. The receiver radiated field strength must not exceed the emission specified in Section 3.6 and the receiver shall not receive, demodulate frequency listed in Section 3.5.

6.2 Test Setup

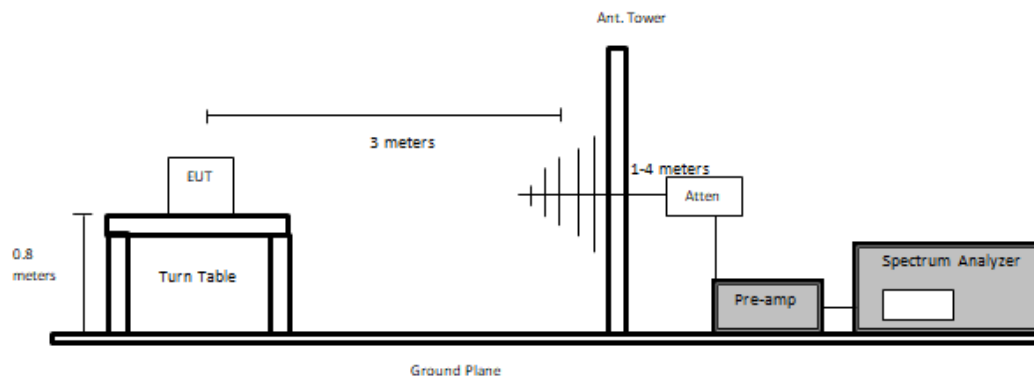
The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013.

The spacing between the peripherals was 10 centimeters.

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

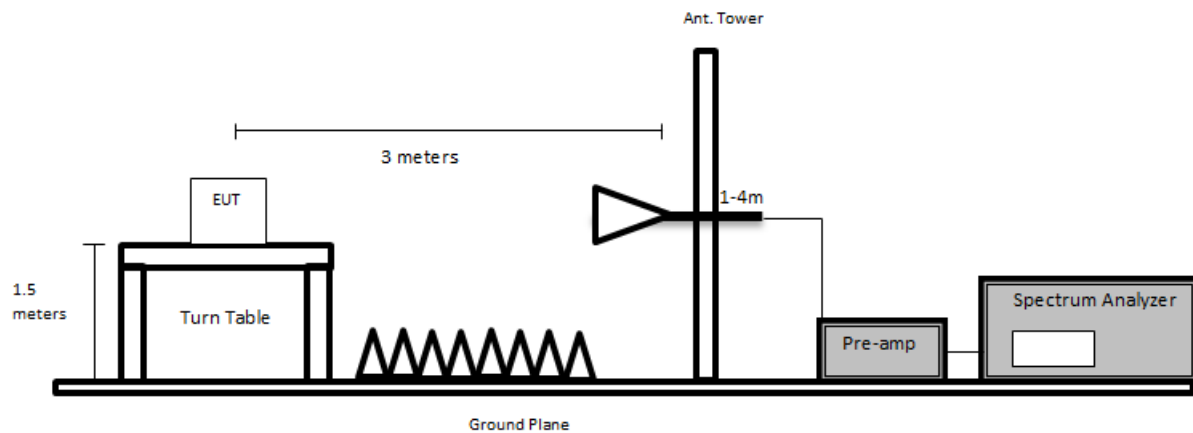
6.3 Test Setup Block Diagrams

Below 1GHz:



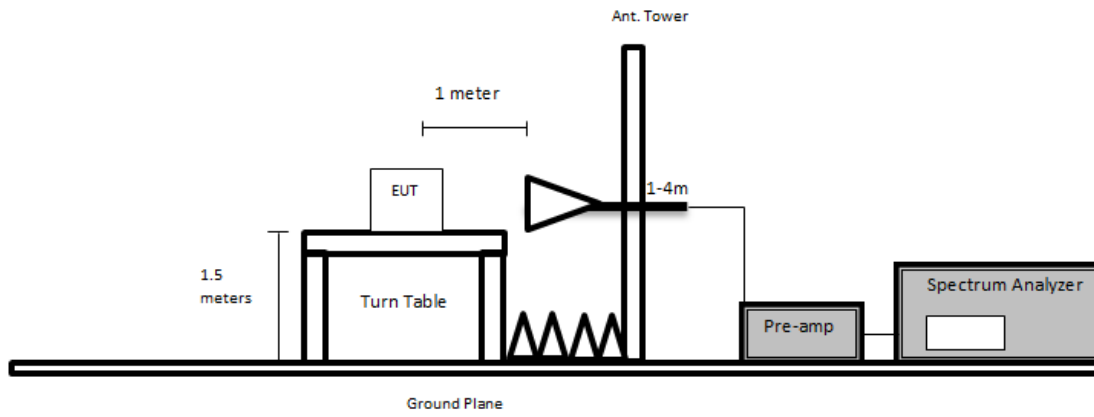
1-18 GHz:

At 3 meters:



18-26.5 GHz

At 1 meter:



6.4 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 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 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

6.5 Corrected Amplitude & Margin Calculation

For emissions below 1 GHz,

The Corrected Amplitude (CA) is calculated by adding the Correction Factor to the S.A. Reading. The basic equation is as follows:

$$CA = S.A. \text{ Reading} + \text{Correction Factor}$$

For example, a corrected amplitude of 40.3 dBuV/m = S.A. Reading (32.5 dBuV) + Correction Factor (7.8 dB/m)

The Correction Factor is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) together. This calculation is done in the measurement software, and reported in the test result section. The basic equation is as follows:

$$\text{Correction Factor} = AF + CL + \text{Atten} - Ga$$

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:

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

For emission above 1 GHz,

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:

$$CA = Ai + AF + CL + \text{Atten} - Ga$$

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:

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

6.6 Test Equipment List and Details

BACL No.	Manufacturer /Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
310	Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950.03	100338	2020-03-17	19 months
811	Keysight Technologies	RF Limiter	11867A	MY42243052	2020-10-27	1 year
624	Agilent	Spectrum Analyzer	E4446A	US44300386	2021-04-27	1 year
	Sunol Science Corp	System Controller	SC110V	122303-1	N/R	N/A
105	HP	Pre-Amplifier	8449B	3147A00400	2021-03-02	1 year
827	AH Systems	Preamplifier	PAM 1840 VH	170	2021-08-03	1 year
90	Wisewave	Horn Antenna	ARH-4223-02	10555-01	2021-04-12	1 year
187	A.R.A	Antenna, Horn	DRG-118/A	1132	2020-02-25	2 years
321	Sunol Sciences	Biconilog Antenna	JB3	A020106-2	2019-11-20	2 years
459	HP	Pre Amplifier	8447D	2443A04374	2020-08-17	14 months
	-	RF cable	-	-	Each time ¹	N/A
	-	Notch Filter	-	-	Each time ¹	N/A
1077	Insulated Wire Corp.	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2021-03-03	1 year
1081	MDP Digital	Times Microwave LMR 400 UltraFex Coaxial Cable 35'	LMR400UF	BACL1904161	2021-06-18	1 year
1101	IW Microwave	157 Series Cable Armored with 2.92mm Male Plugs	KPS-1571AN-2400	DC 1922	2021-07-06	1 year
1151	BACL	5m3 Sensitivity Box	1	2	2020-10-27	1 year

Note¹: cable and notch filter included in the test set-up will be checked each time before testing.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".

6.7 Test Environmental Conditions

Temperature:	22.8 °C
Relative Humidity:	41 %
ATM Pressure:	101.7 kPa

The testing was performed by Deepak Mishra on 2021-09-30 at 5 meter chamber 3.

6.8 Summary of Test Results

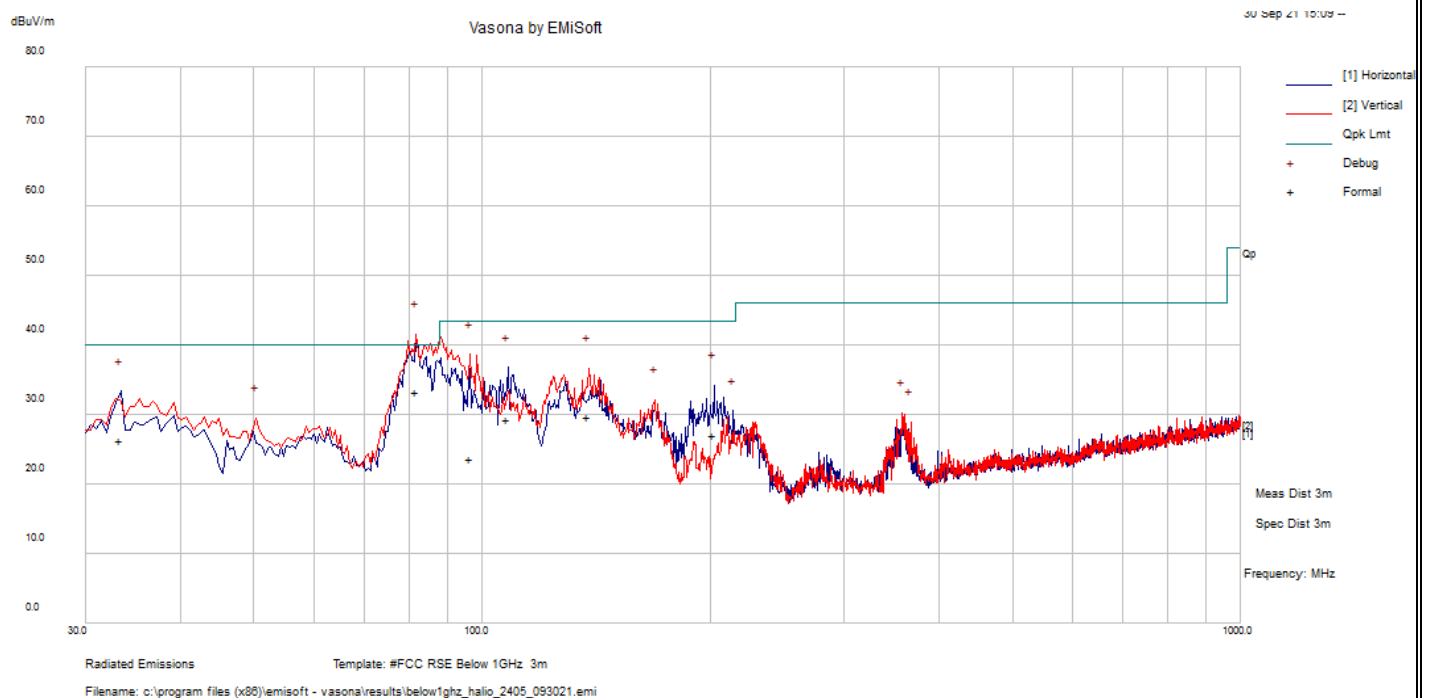
According to the data hereinafter, the EUT complied with LP0002-2020 standard's radiated emissions limits, and had the worst margin of:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Transmitting Channel (MHz)
-6.75	81.77925	V	2405

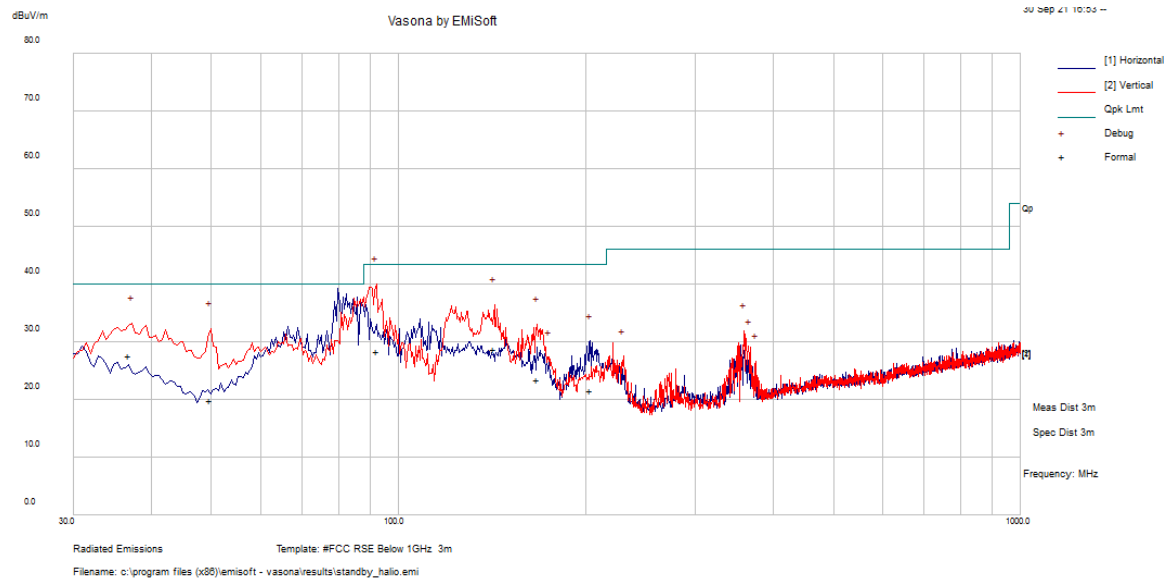
6.9 Radiated Emissions Test Results

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

Tx:



Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBuV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBuV/m)	Margin (dB)	Comment
81.77925	44.28	-11.03	33.25	136	V	89	40	-6.75	Pass
96.32425	32.5	-8.89	23.6	213	H	291	43.5	-19.9	Pass
33.30175	26.4	-0.1	26.29	287	V	235	40	-13.71	Pass
107.7808	35.3	-5.89	29.4	171	H	293	43.5	-14.1	Pass
137.8363	34.67	-5.05	29.61	157	V	49	43.5	-13.89	Pass
202.1098	32.99	-6.03	26.97	172	H	284	43.5	-16.53	Pass

RX:

Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBuV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBuV/m)	Margin (dB)	Comment
92.3925	38.29	-9.99	28.3	245	V	334	43.5	-15.2	Pass
36.912	30.48	-2.84	27.64	102	V	331	40	-12.36	Pass
142.1523	34.22	-5.46	28.76	106	V	214	43.5	-14.74	Pass
49.8385	30.49	-10.68	19.81	186	V	204	40	-20.19	Pass
166.9803	29.8	-6.26	23.54	134	V	141	43.5	-19.96	Pass
203.2748	28.09	-6.51	21.58	124	H	71	43.5	-21.92	Pass

2) 1-26.5GHz Worst Case Spurious Emissions

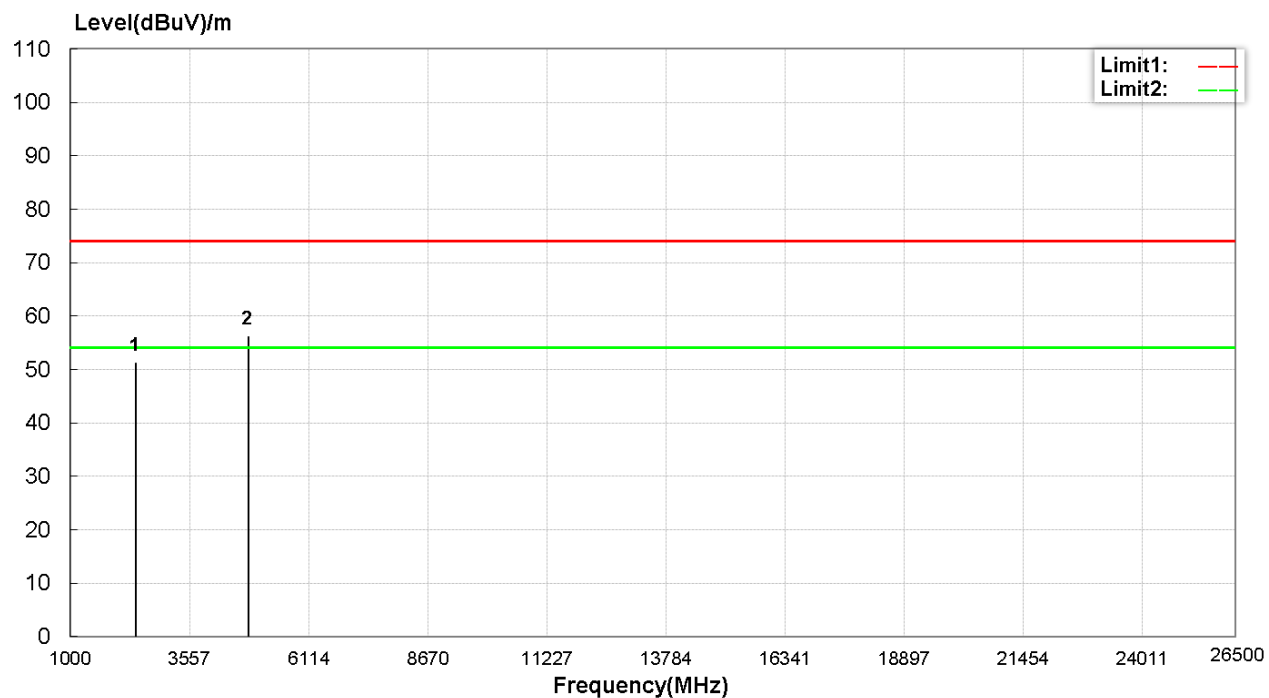
Note: 1-18GHz measured at 3 meters and 18-26.5GHz measured at 1 meter

Tx:

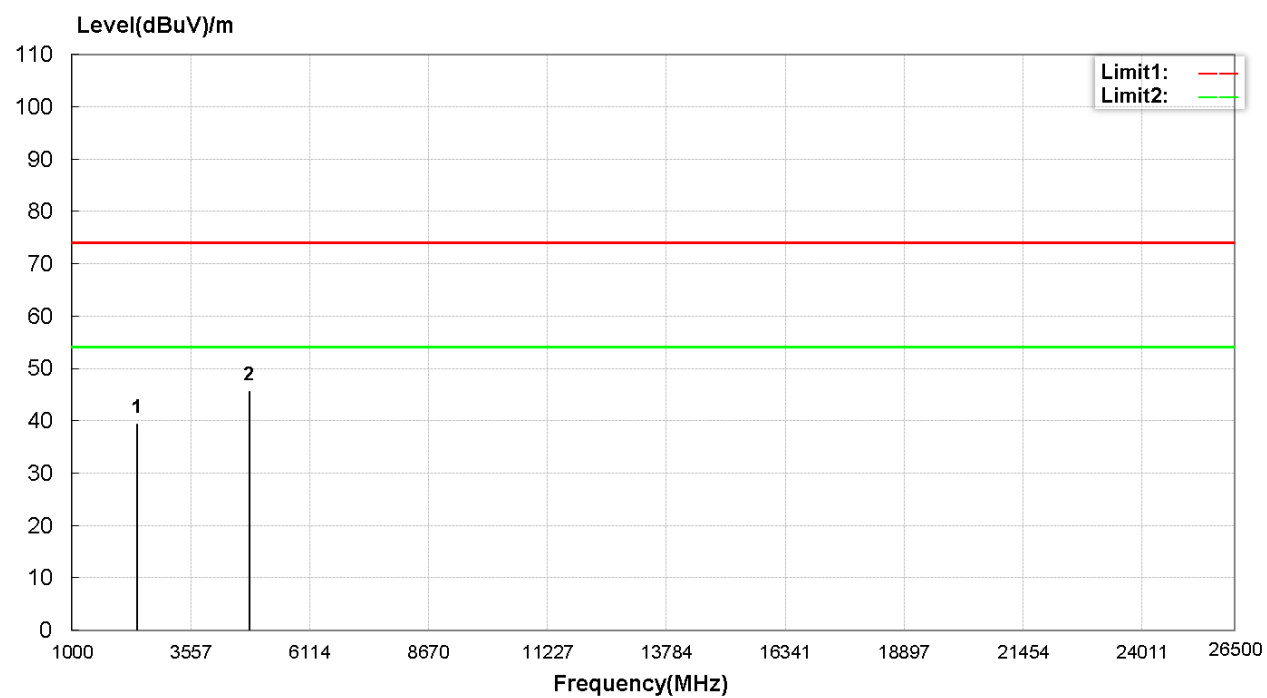
Frequency (MHz)	S.A. Reading (dBμV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre- Amp. (dB)	Cord. Reading (dBμV/m)	LP0002-2020		Note
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBμV/m)	Margin (dB)	
Low Channel Frequency: 2405 MHz											
2390	50.86	134	240	H	32.228	4.913	36.863	51.14	74	-22.86	Peak
2390	48.93	238	150	V	32.228	4.913	36.863	49.21	74	-24.79	Peak
2390	39.01	134	240	H	32.228	4.913	36.863	39.29	54	-14.71	Ave
2390	36.64	238	150	V	32.228	4.913	36.863	36.92	54	-17.08	Ave
4810	47.35	172	193	V	34.70	9.826	35.707	56.17	74	-17.83	Peak
4810	35.63	172	193	V	34.70	9.826	35.707	44.45	54	-9.55	Ave
4810	47.26	35	305	H	34.70	9.826	35.707	56.08	74	-17.92	Peak
4810	36.69	35	305	H	34.70	9.826	35.707	45.51	54	-8.49	Ave
Middle Channel Frequency: 2440 MHz											
4880	44.46	360	150	V	34.68	9.826	35.707	53.26	74	-20.74	Peak
4880	33.07	360	150	V	34.68	9.826	35.707	41.87	54	-12.13	Ave
4880	43.92	165	293	H	34.68	9.826	35.707	52.72	74	-21.28	Peak
4880	32.94	165	293	H	34.68	9.826	35.707	41.74	54	-12.26	Ave
High Channel Frequency: 2475 MHz											
2483.5	48	138	112	H	32.665	4.913	36.863	48.72	74	-25.29	Peak
2483.5	45.01	124	190	V	32.665	4.913	36.863	45.73	74	-28.28	Peak
2483.5	36.39	138	112	H	32.665	4.913	36.863	37.11	54	-16.90	Ave
2483.5	33.12	124	190	V	32.665	4.913	36.863	33.83	54	-20.17	Ave
4950	45.60	72	120	V	34.68	9.826	35.707	54.40	74	-19.60	Peak
4950	35.38	72	120	V	34.68	9.826	35.707	44.18	54	-9.82	Ave
4950	44.99	230	150	H	34.68	9.826	35.707	53.79	74	-20.21	Peak
4950	33.44	230	150	H	34.68	9.826	35.707	42.24	54	-11.76	Ave

2405 MHz Horizontal

Peak

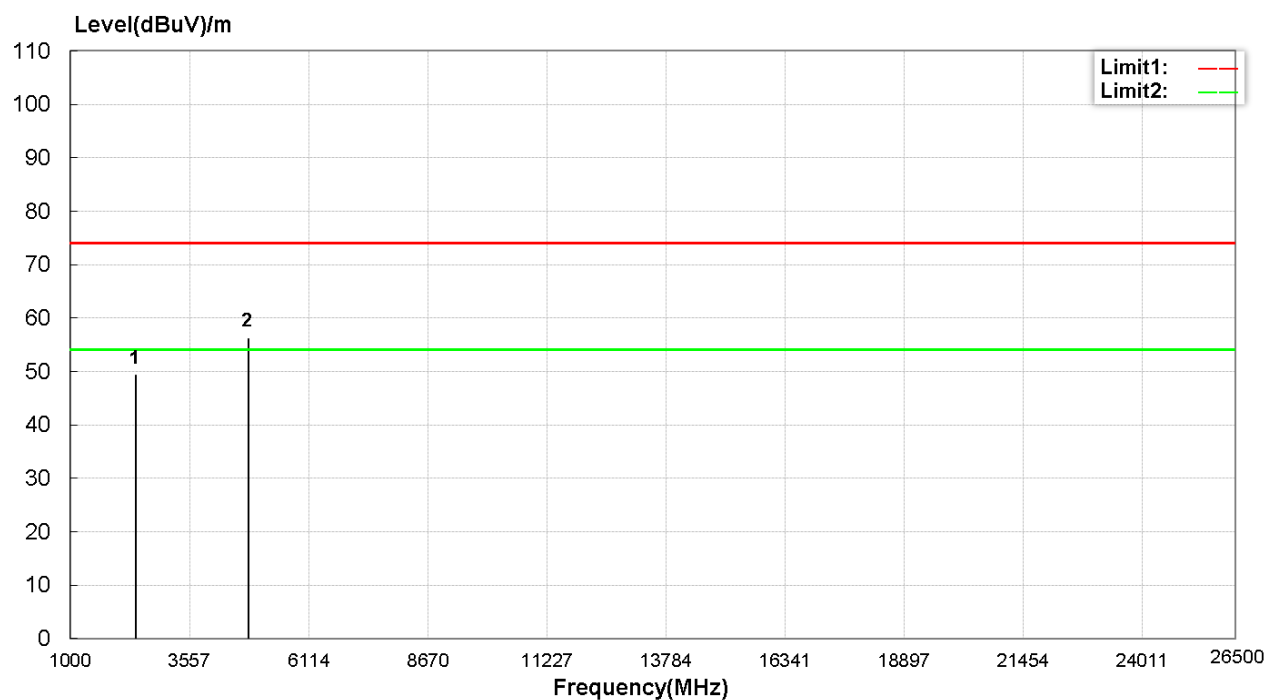


Avg

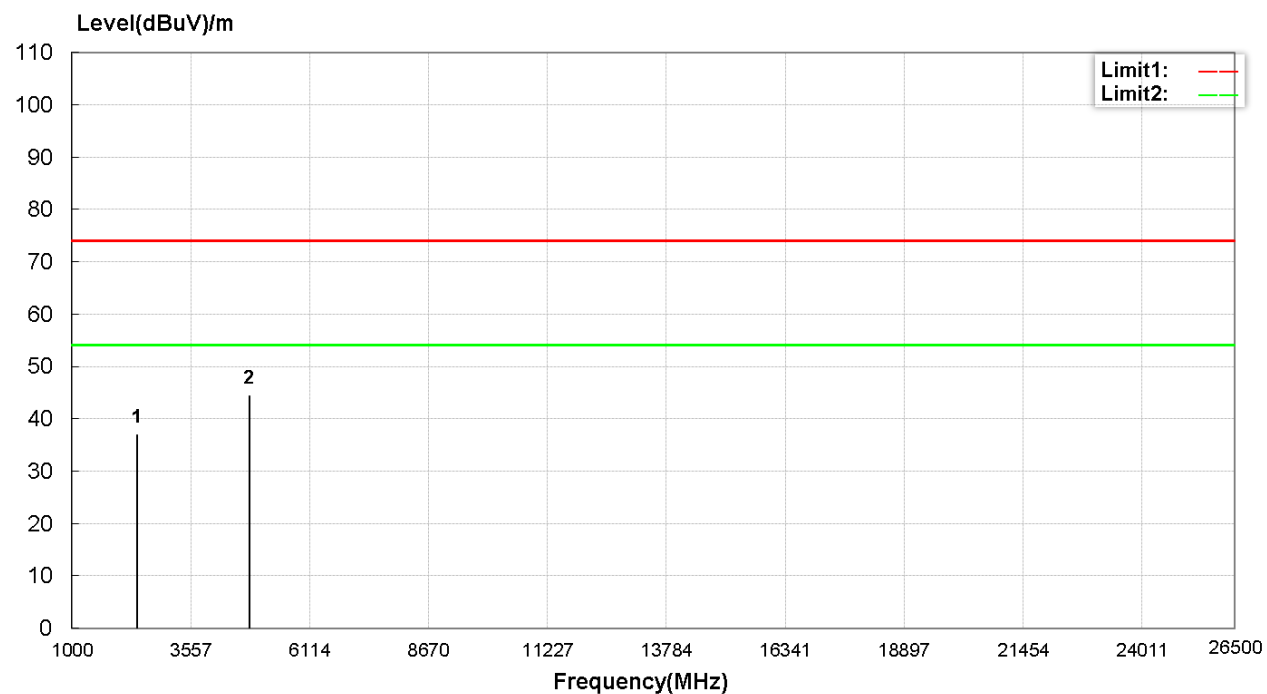


2405 MHz Vertical

Peak

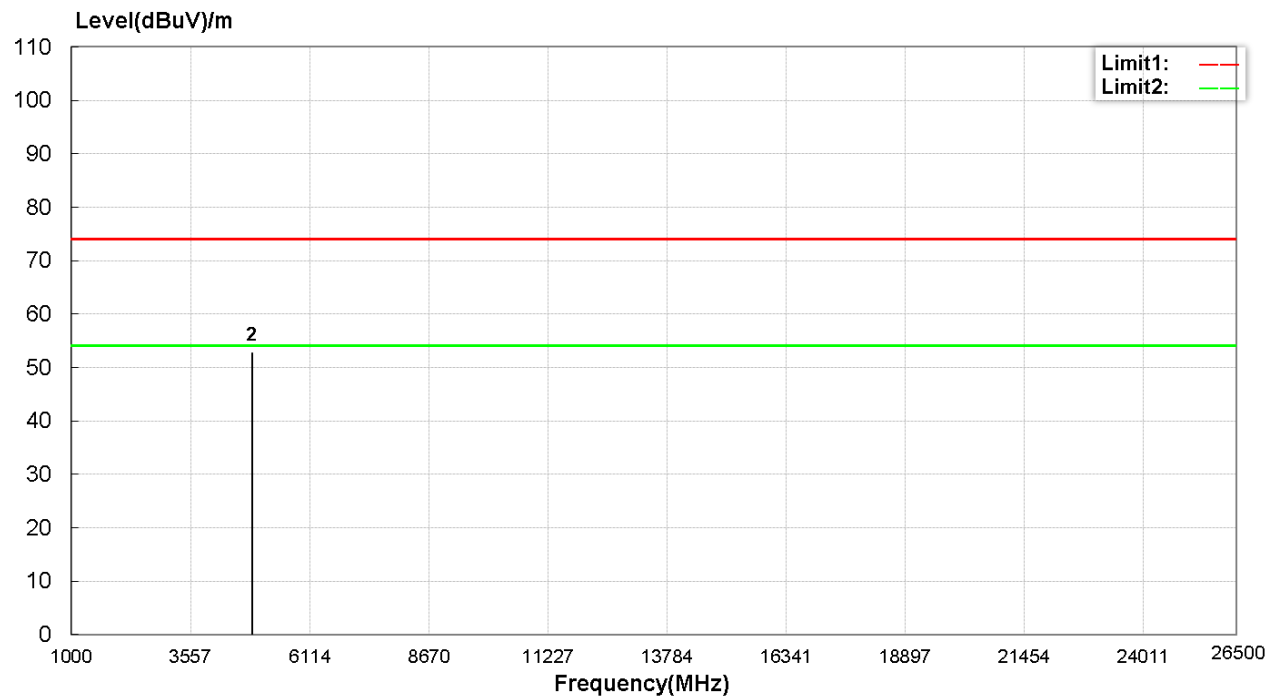


Avg

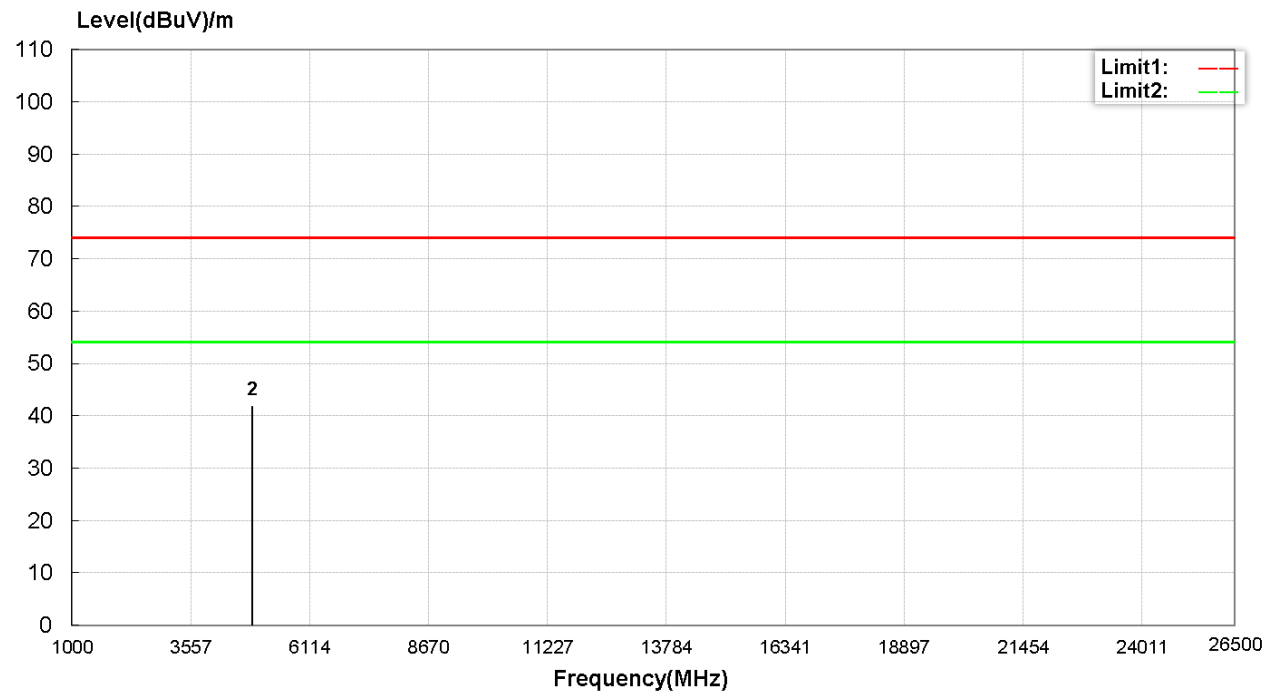


2440 MHz Horizontal

Peak

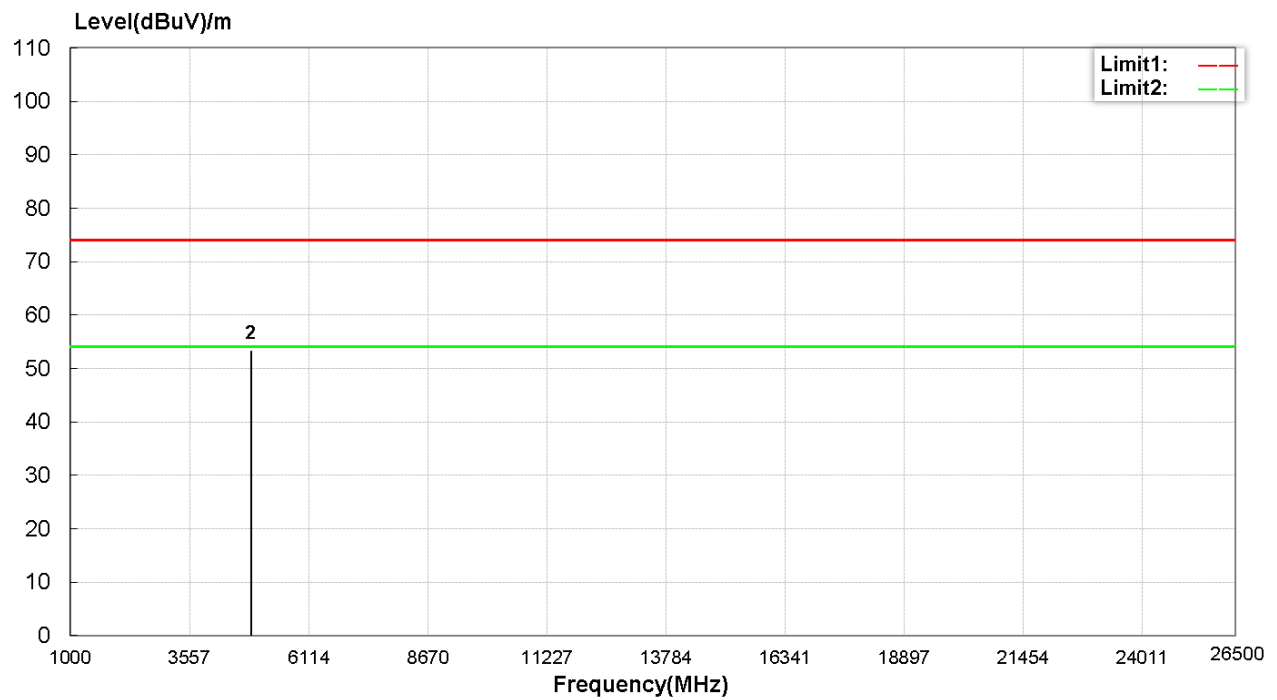


Avg

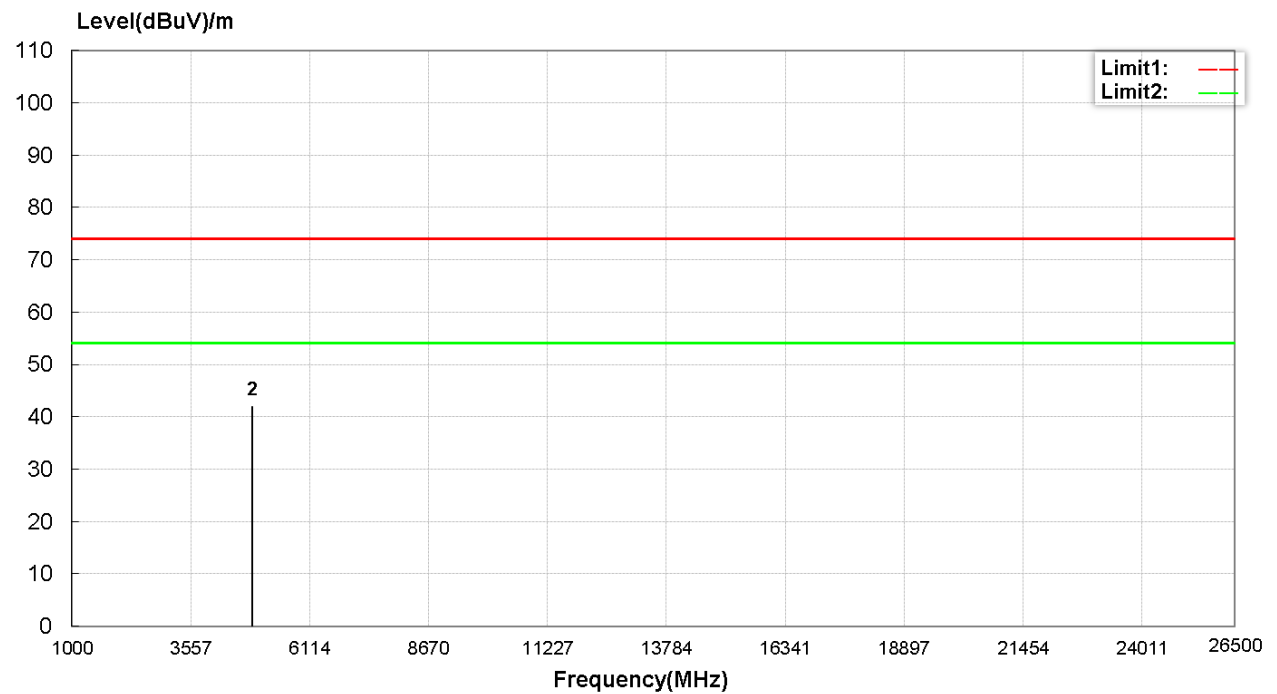


2440 MHz Vertical

Peak

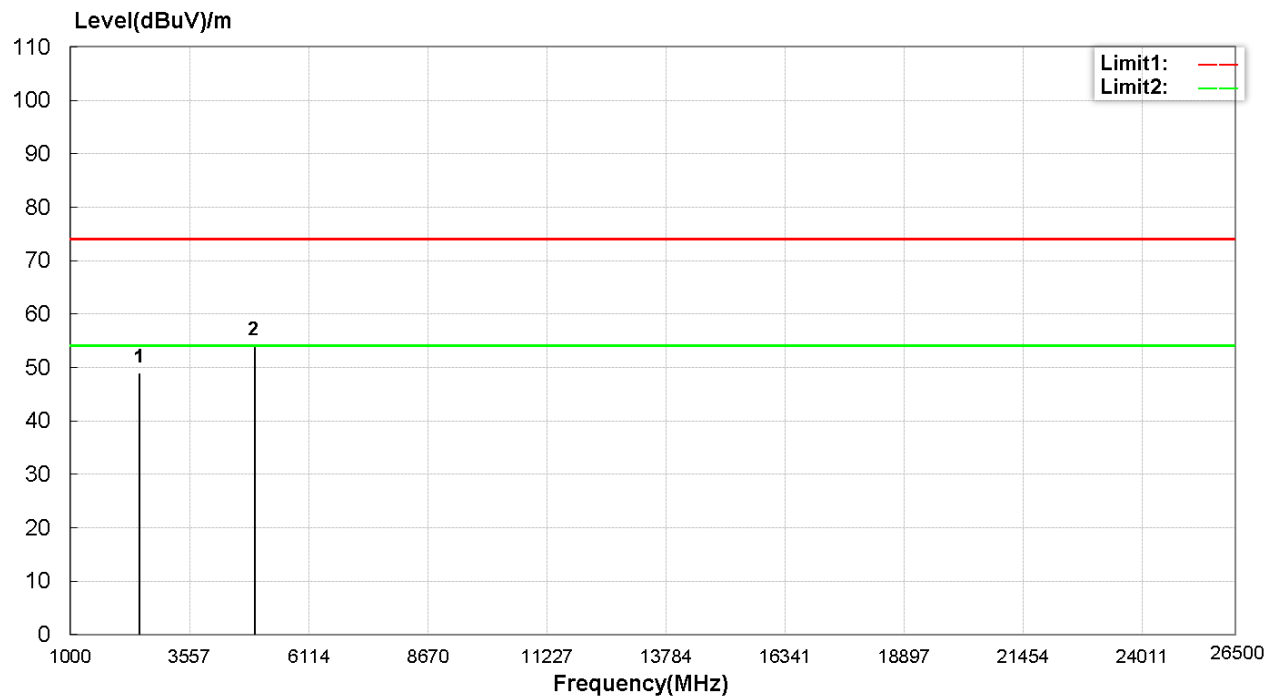


Avg

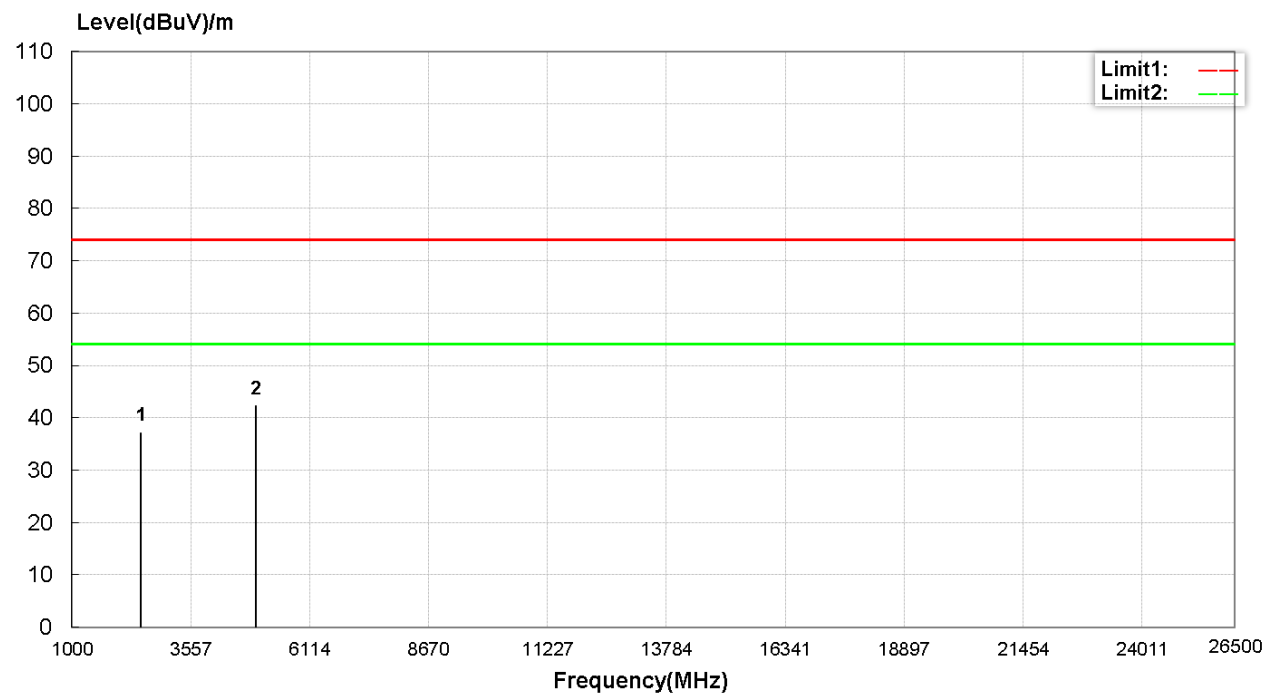


2475 MHz Horizontal

Peak

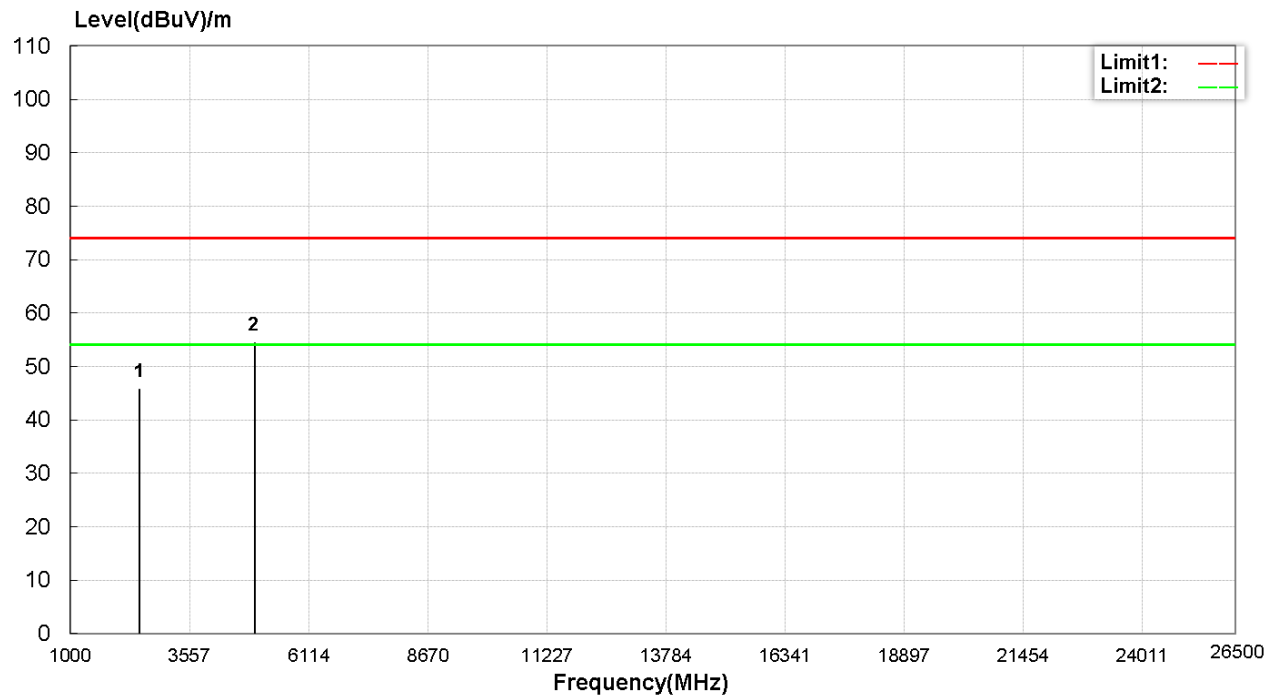


Avg

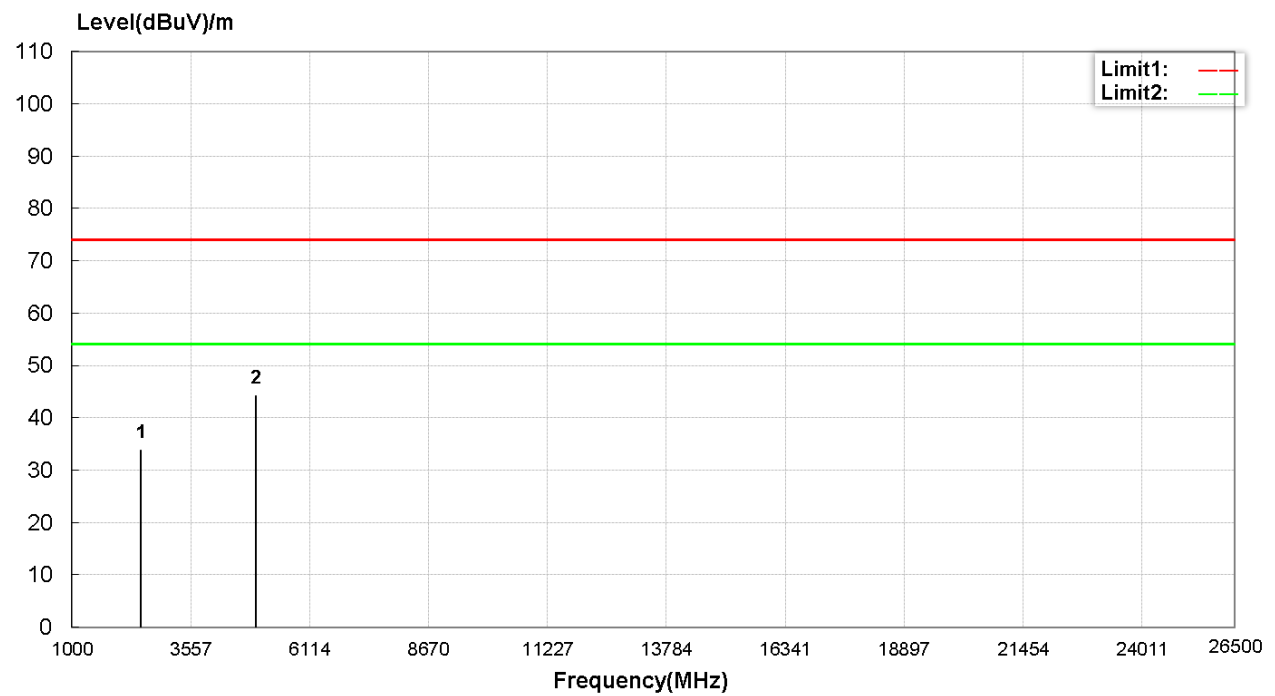


2475 MHz Vertical

Peak



Avg

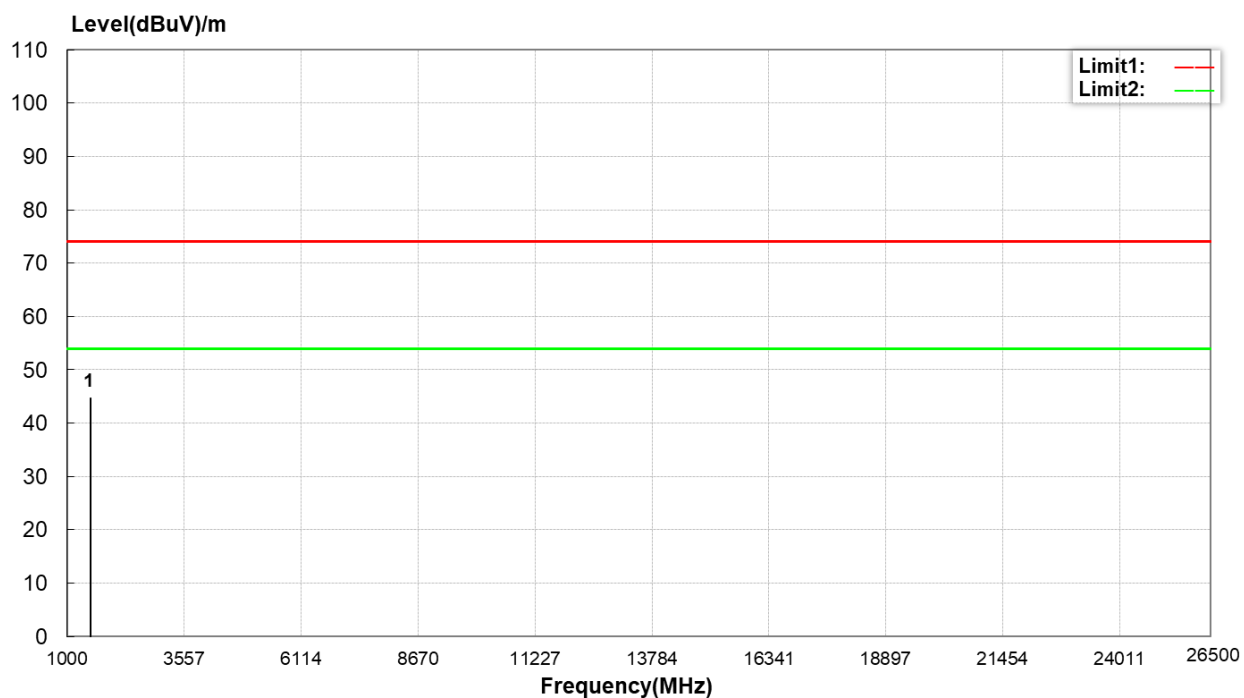


Rx:

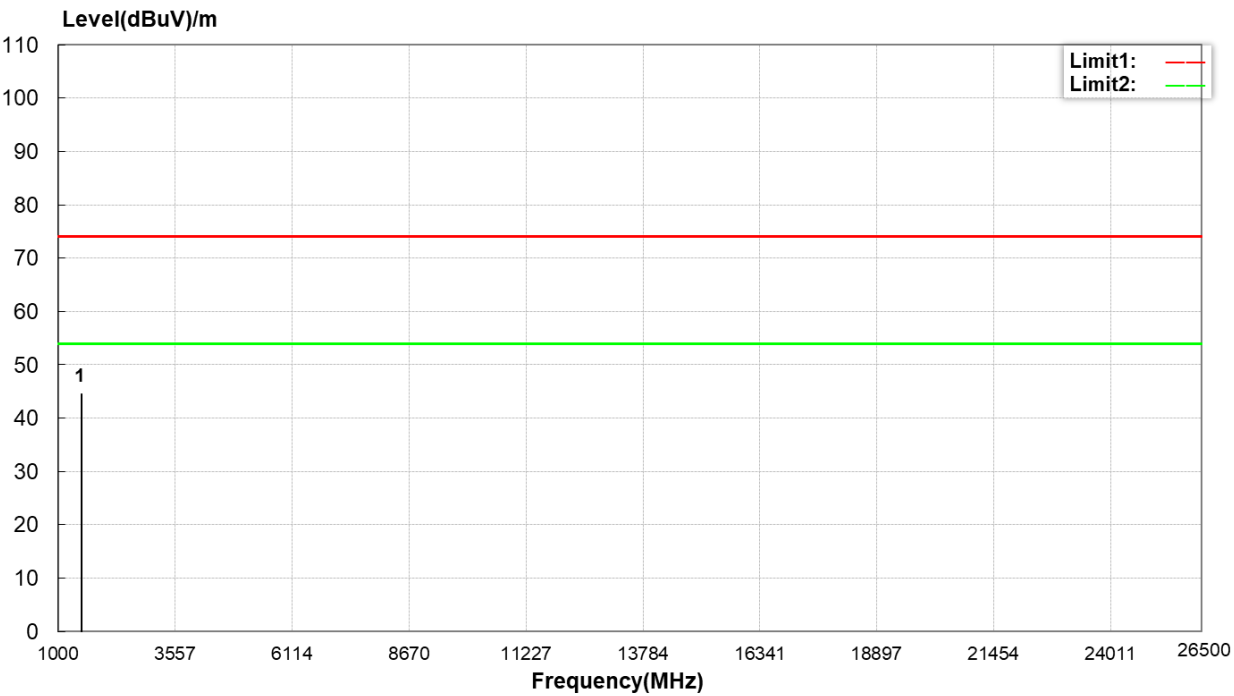
Frequency (MHz)	S.A. Reading (dBμV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre- Amp. (dB)	Cord. Reading (dBμV/m)	LP0002-2020		Note
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBμV/m)	Margin (dB)	
Receiver											
1500	50.14	0	100	H	28	4.136	37.589	44.69	54	-9.31	Peak
1500	50.07	0	100	V	28	4.136	37.589	44.62	54	-9.38	Peak

Note: the peak measurements were recorded and compared with Average limit.

Horizontal



Vertical



7 LP0002-2020 §4.10.1.6(2)(A) - Emission Bandwidth

7.1 Applicable Standards

According to LP0002-2020 §4.10.1.6(2)(A): the minimum 6 dB bandwidth shall be 500 kHz.

7.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: 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

BACL No.	Manufacturer /Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	17 months
-	-	RF cable	-	-	Each time ¹	N/A
-	-	10 dB attenuator	-	-	Each time ¹	N/A

Note¹: equipment included in the test set-up will be checked each time before testing.

Statement of Traceability: **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".

7.4 Test Environmental Conditions

Temperature:	23.5° C
Relative Humidity:	49 %
ATM Pressure:	100.57 KPa

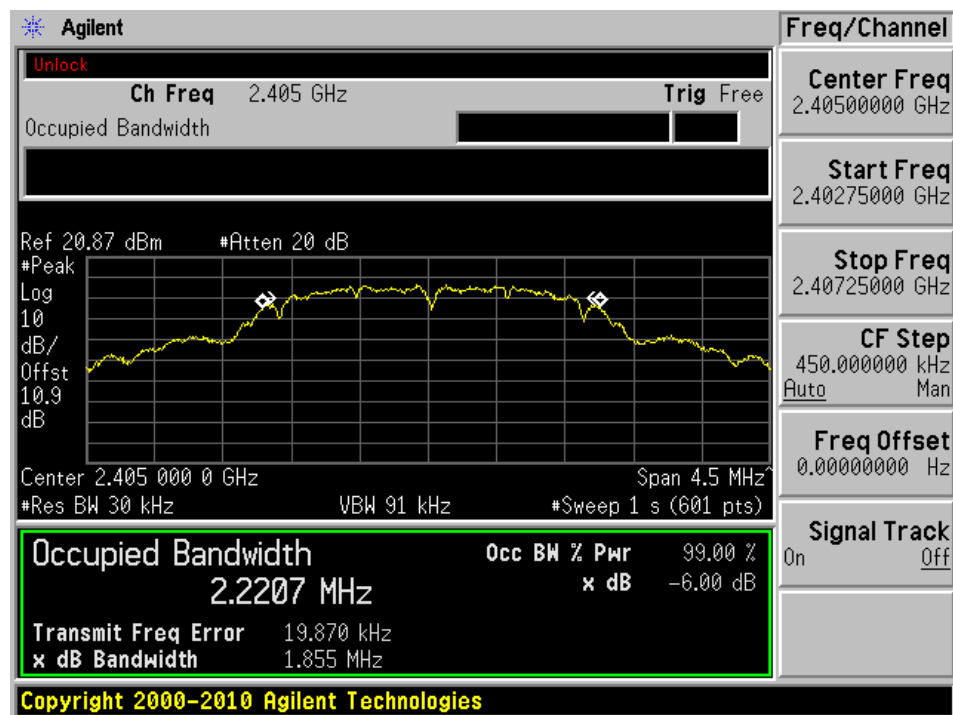
The testing was performed by Deepak Mishra on 2021-08-27 at RF test site.

7.5 Test Results

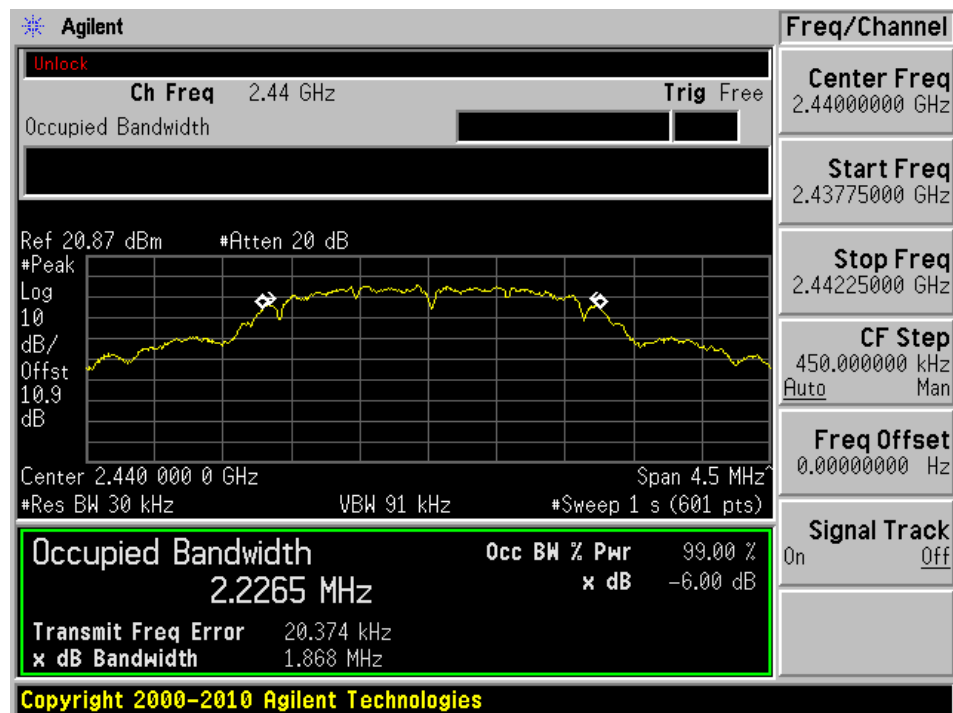
Channel	Frequency (MHz)	99% OBW (MHz)	-6 dB OBW (kHz)
Low	2405	2.2207	1.685
Middle	2440	2.2265	1.695
High	2475	2.2293	1.694

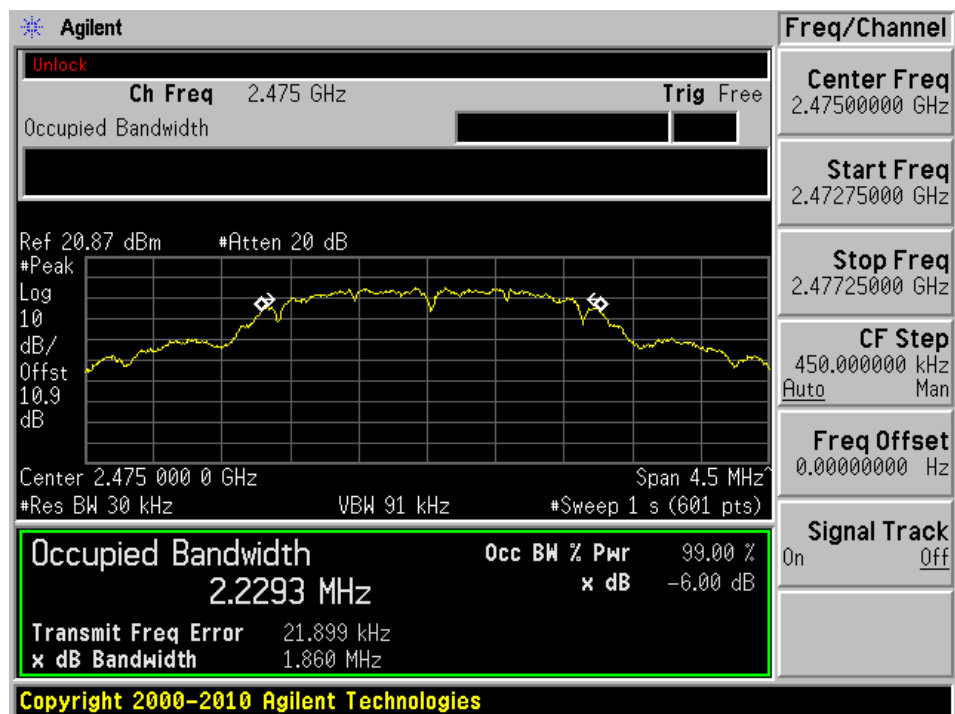
Please refer to the following plots for detailed test results.

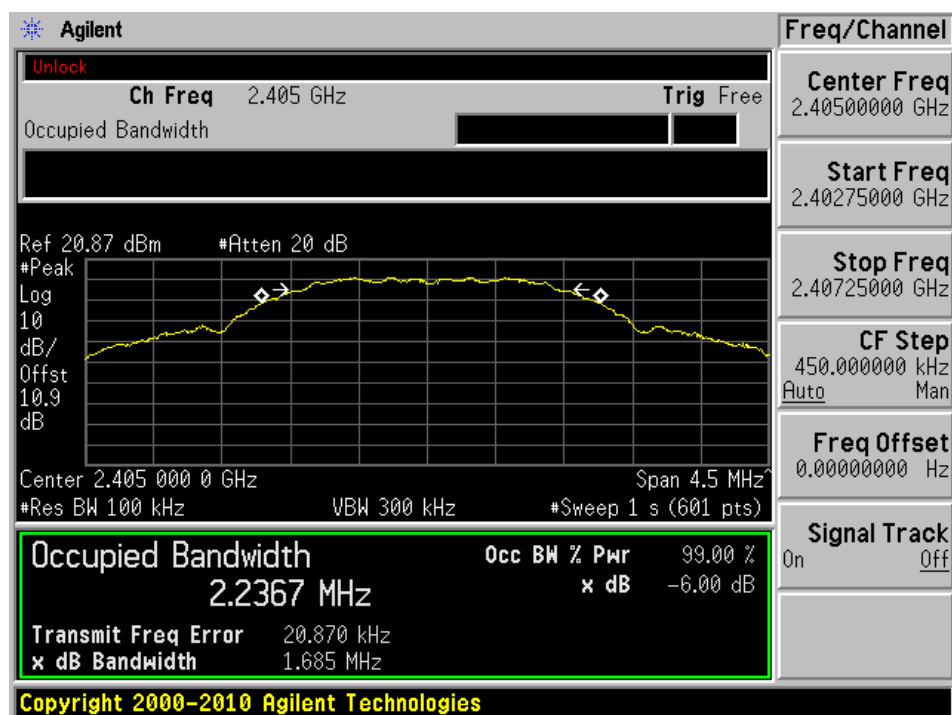
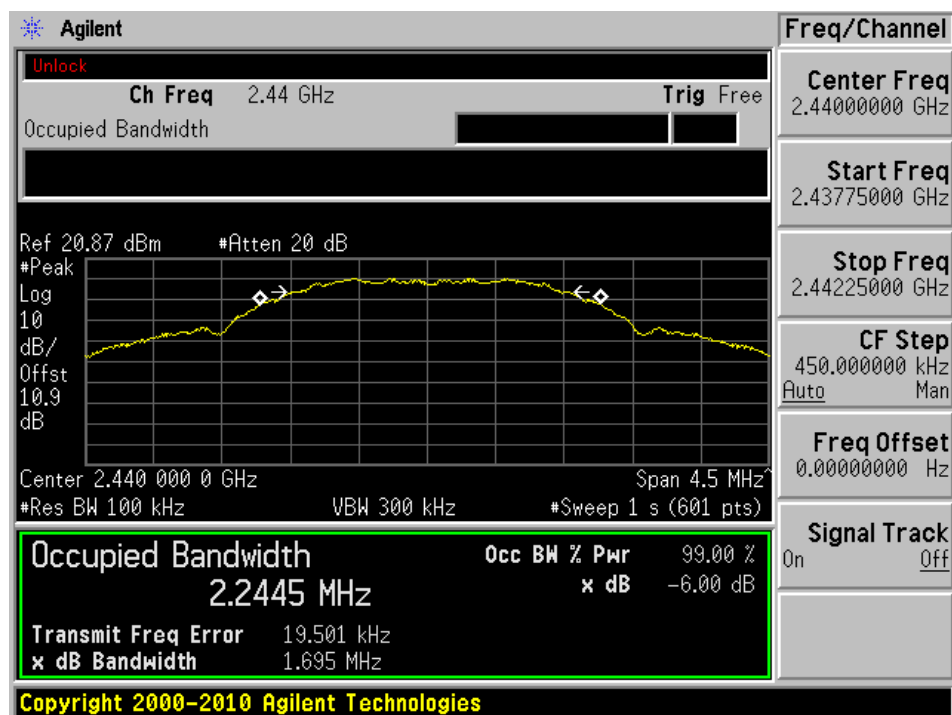
99% OBW, Low Channel: 2405 MHz

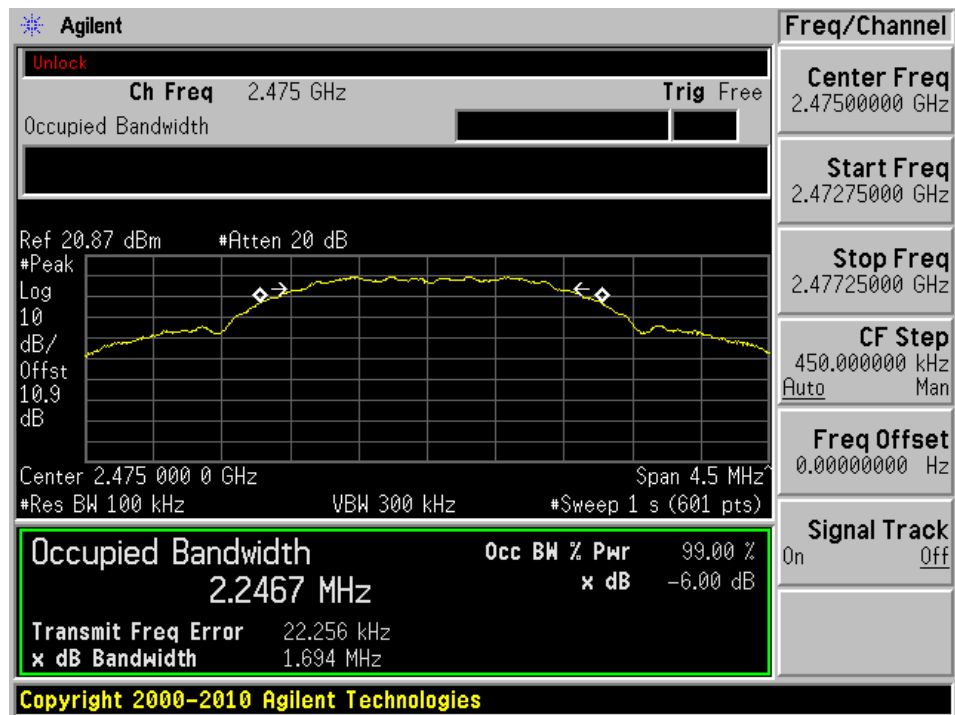


99% OBW, Middle Channel: 2440 MHz



99% OBW, High Channel: 2475 MHz

-6 dB OBW, Low Channel: 2405 MHz**-6 dB OBW, Middle Channel: 2440 MHz**

-6 dB OBW, High Channel: 2475 MHz

8 LP0002-2020 §4.10.1.2 - Maximum Output Power

8.1 Applicable Standards

According to LP0002-2020 §4.10.1.2: For systems employing digital modulation: below 1 Watt (inclusive).

8.2 Measurement Procedure

The measurements are based on ANSI C63.10-2013, Section 11.9.2.2.2.

8.3 Test Equipment List and Details

BACL No.	Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
697	ETS- Lindgren	Power Sensor	7002-006	160097	2021-02-12	2 years
-	-	RF cable	-	-	Each time ¹	N/A
-	-	10dB attenuator	-	-	Each time ¹	N/A

Note¹: equipment in the test set-up will be checked each time before testing.

Statement of Traceability: *BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

8.4 Test Environmental Conditions

Temperature:	23.5 °C
Relative Humidity:	48 %
ATM Pressure:	101.4 kPa

The testing was performed by Deepak Mishra on 2021-08-24 at RF Site.

8.5 Test Results

Channel	Frequency (MHz)	Conducted Output Power (dBm)	LP0002 Limit (dBm)
Low	2405	14.84	30
Middle	2440	14.75	30
High	2475	13.88	30

9 LP0002-2020 §4.10.1.6(2)(B) - Peak Power Spectral Density

9.1 Applicable Standards

According to LP0002-2020 §4.10.1.6(2)(B), for digitally modulated systems, the minimum 6dB bandwidth shall be at least 500 kHz.

9.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: 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.

9.3 Test Equipment List and Details

BACL No.	Manufacturer /Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	17 months
	-	RF cable	-	-	Each time ¹	N/A
	-	10 dB attenuator	-	-	Each time ¹	N/A

Note¹: equipment included in the test set-up will be checked each time before testing.

Statement of Traceability: *BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

9.4 Test Environmental Conditions

Temperature:	23.5° C
Relative Humidity:	49 %
ATM Pressure:	100.5 KPa

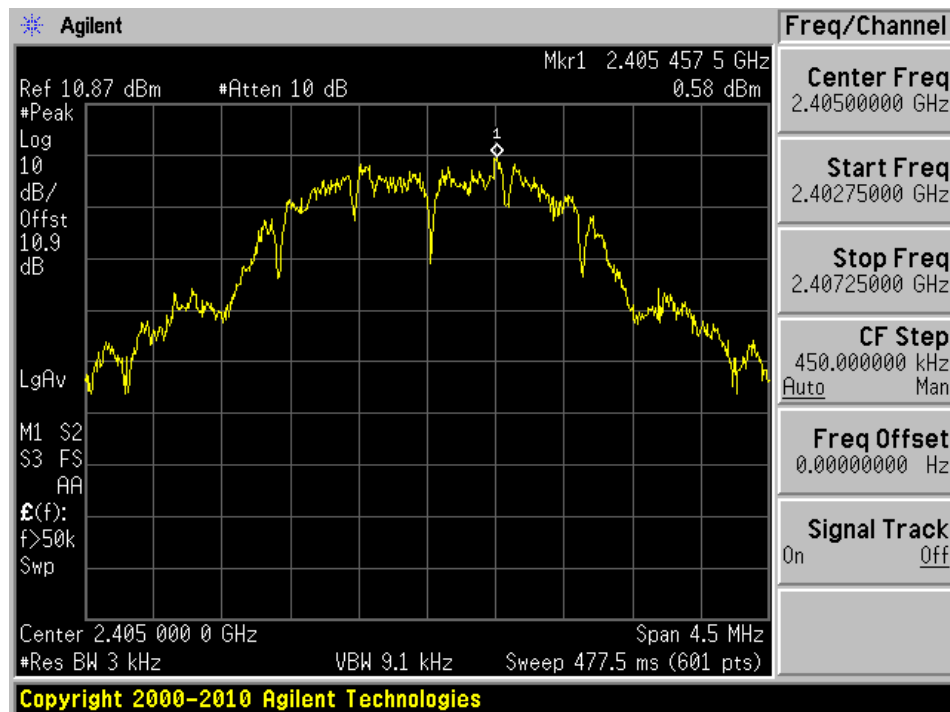
The testing was performed by Deepak Mishra on 2021-08-27 at RF test site.

9.5 Test Results

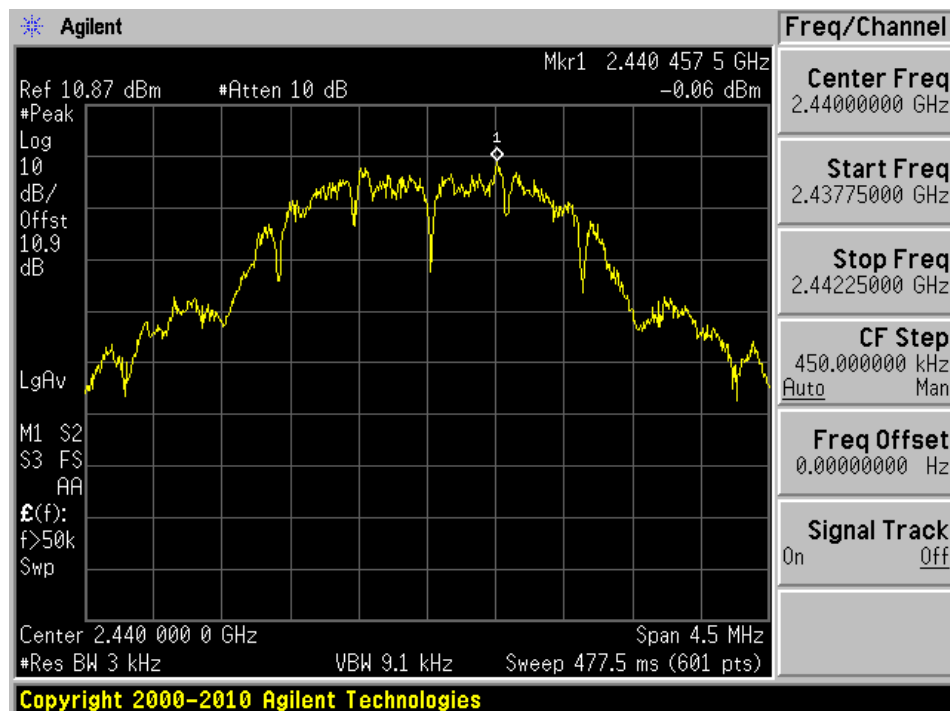
Channel	Frequency (MHz)	Conducted PSD (dBm/3 kHz)	LP0002 Limit (dBm/3 kHz)
Low	2405	0.58	8
Middle	2440	-0.06	8
High	2475	-1.48	8

Please refer to the following measurement plots.

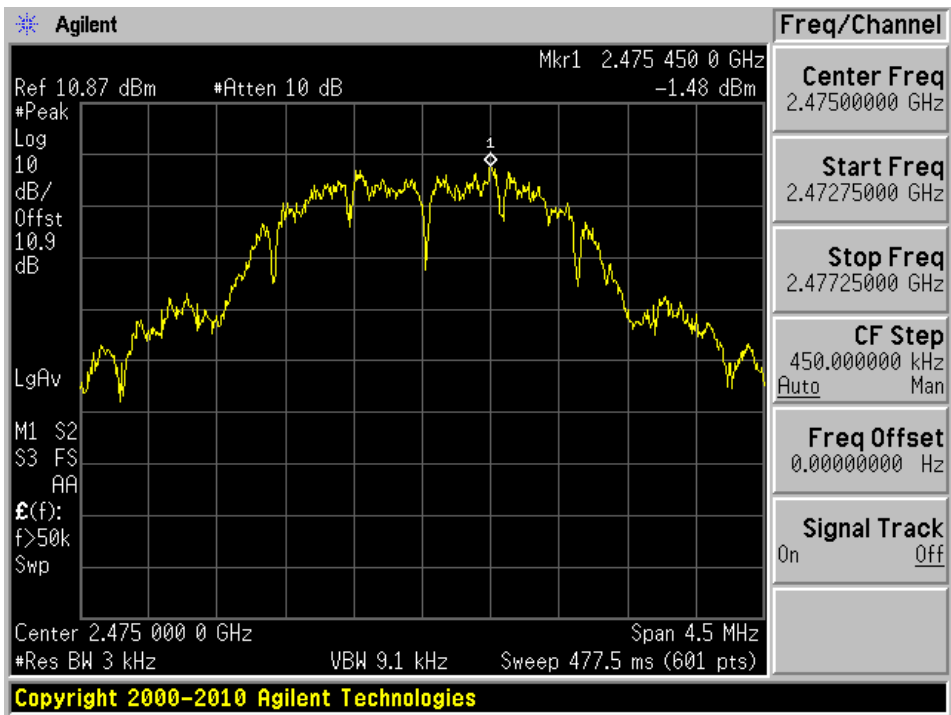
Low Channel: 2405 MHz



Middle Channel: 2440 MHz



High Channel: 2475 MHz



10 LP0002-2020 §4.10.1.5 - 100 kHz Bandwidth of Band Edges

10.1 Applicable Standards

According to LP0002-2020 §4.10.1.5, 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to 12 Appendix II of this section, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the paragraph (1) (C) of this section 4.10.1.2.

In addition, radiated emissions that fall under Section 3.5 the restricted bands must also comply with the radiated emission limit specified in Section 3.6.

10.2 Measurement Procedure

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

RBW = 100 kHz

VBW = 300 kHz

Sweep = coupled

Detector function = peak

Trace = max hold

10.3 Test Equipment List and Details

BACL No.	Manufacturer /Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	17 months
	-	RF cable	-	-	Each time ¹	N/A
	-	10 dB attenuator	-	-	Each time ¹	N/A

Note¹: cable included in the test set-up will be checked each time before testing.

Statement of Traceability: *BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

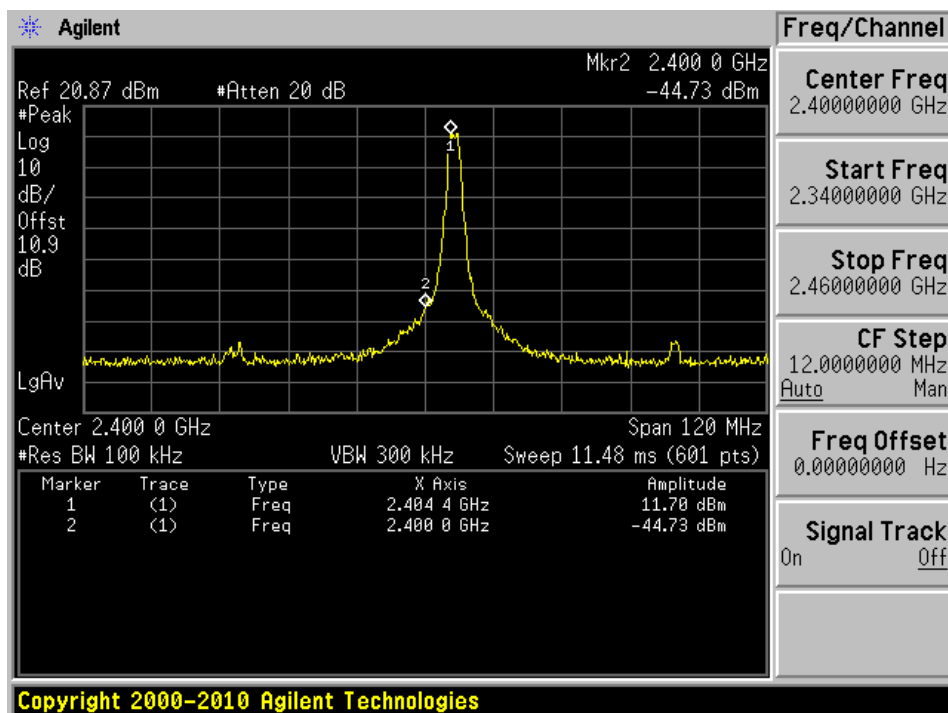
10.4 Test Environmental Conditions

Temperature:	23.5° C
Relative Humidity:	49 %
ATM Pressure:	100.5 KPa

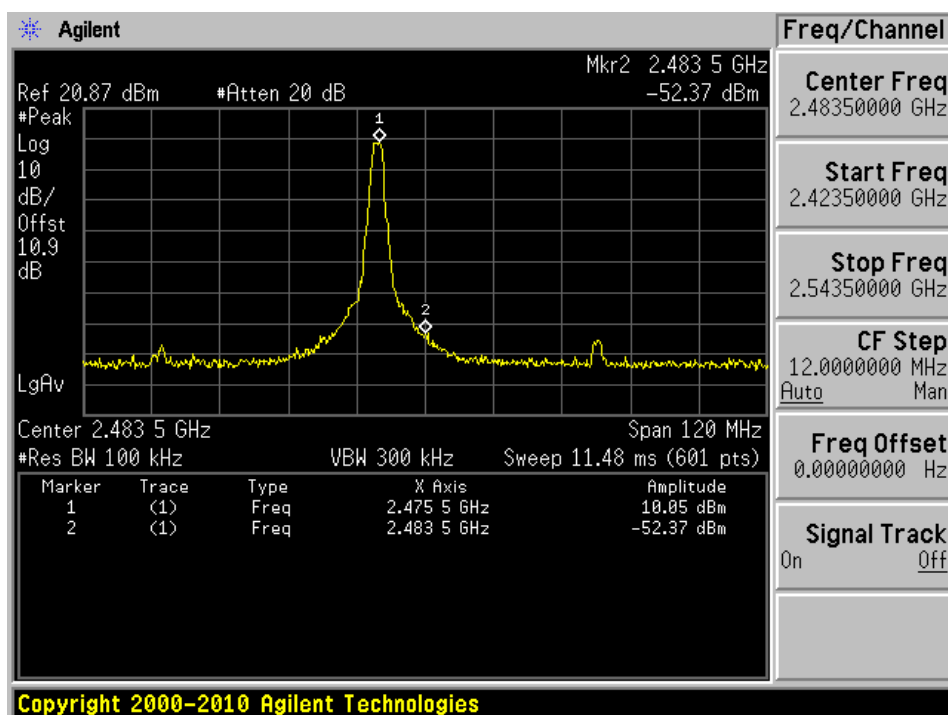
The testing was performed by Deepak Mishra on 2021-08-27 at RF test site.

10.5 Test Results

Low Channel: 2405 MHz



High Channel: 2475 MHz



11 LP0002-2020 §4.10.1.5 - Spurious Emissions at Antenna Terminals

11.1 Applicable Standards

For LP0002-2020 §4.10.1.5, 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to Appendix II of this section, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the paragraph (1) (C) of this section 4.10.1.2.

In addition, radiated emissions that fall under Section 3.5 the restricted bands must also comply with the radiated emission limit specified in Section 3.6.

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

BACL No.	Manufacturer /Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	17 months
	-	RF cable	-	-	Each time ¹	N/A
	-	10 dB attenuator	-	-	Each time ¹	N/A

Note¹: cable included in the test set-up will be checked each time before testing.

Statement of Traceability: **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".

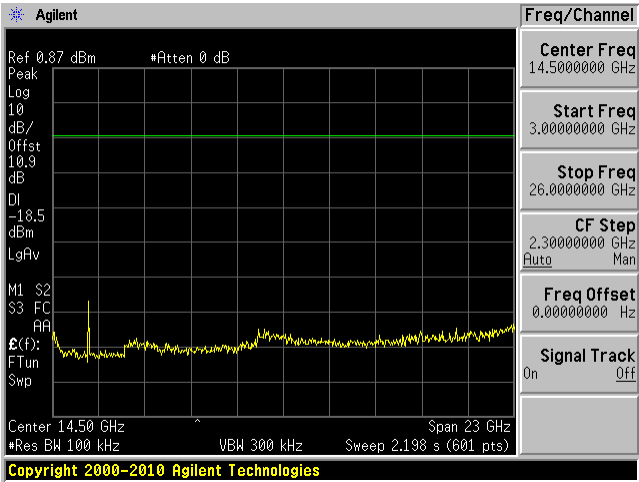
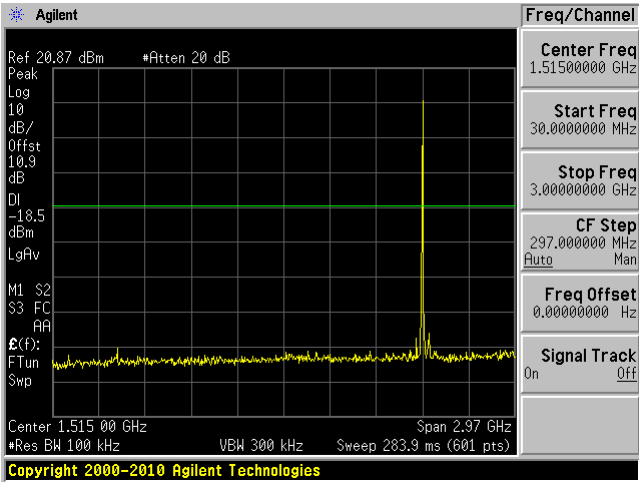
11.4 Test Environmental Conditions

Temperature:	23.5° C
Relative Humidity:	49 %
ATM Pressure:	100.5 KPa

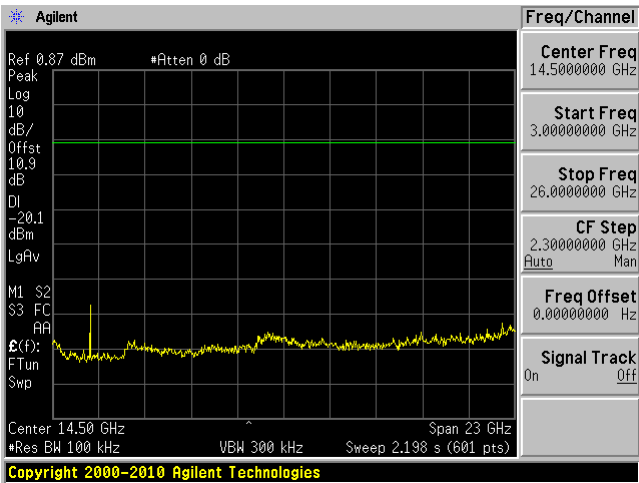
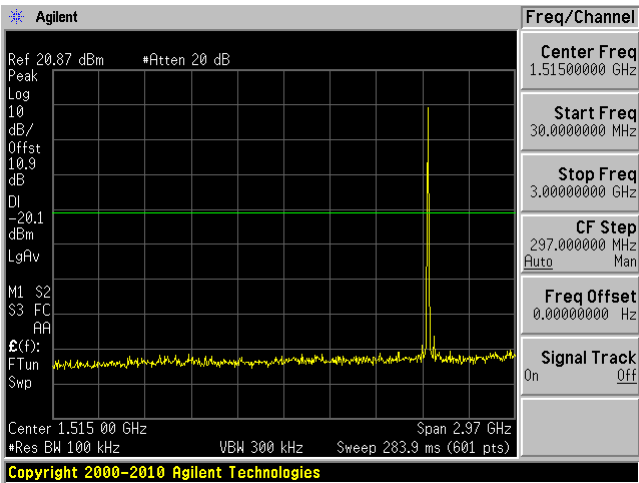
The testing was performed by Deepak Mishra on 2021-08-27 at RF test site.

11.5 Test Results

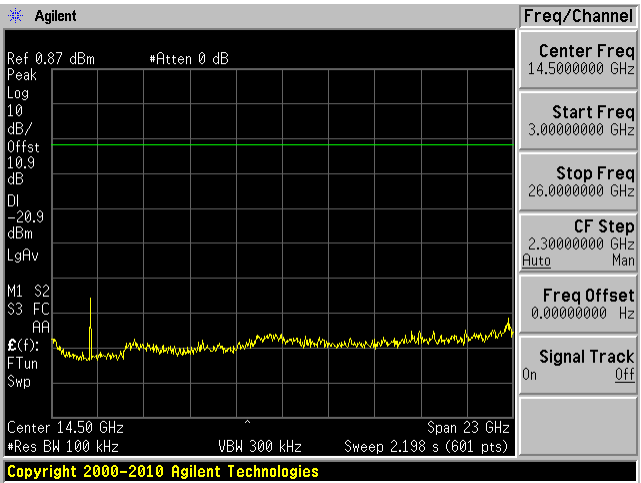
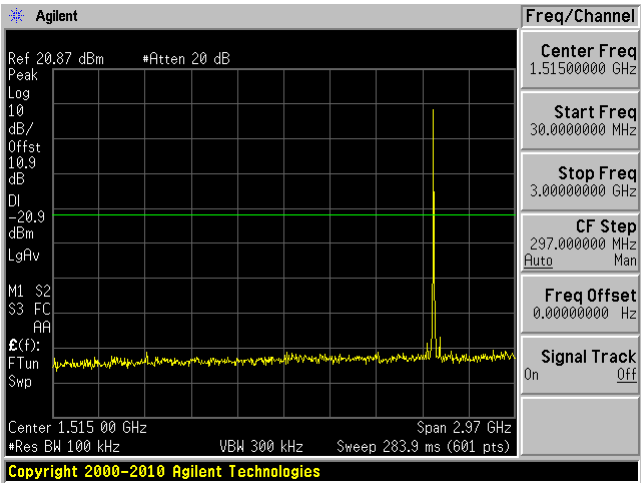
Low Channel: 2405 MHz



Middle Channel: 2440 MHz



High Channel: 2475 MHz



12 Annex A (Normative) - Test Setup Photographs

Please refer to the attachment

13 Annex B (Normative) - EUT External Photographs

Please refer to the attachment

14 Annex C (Normative) - EUT Internal Photographs

Please refer to the attachment

15 Annex D (Normative) - A2LA Electrical Testing Certificate**Accredited Laboratory**

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories. This laboratory also meets A2LA R222 - Specific Requirements EPA ENERGY STAR Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

Presented this 10th day of March 2021.

A blue ink signature of Trace McInturff.

Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2022

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

Please follow the web link below for a full ISO 17025 scope

<https://www.a2la.org/scopepdf/3297-02.pdf>

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