



LP0002-2018

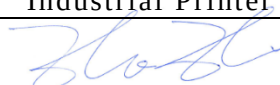
TEST REPORT

For

Zebra Technologies Corporation

3 Overlook Point,
Lincolnshire, IL 60069, USA

**Model: ZT421,
ZT411**

Report Type: Original Report	Product Type: Industrial Printer
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Report Number: R1907243-247 (DSS)	
Report Date: 2019-08-23	
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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	R1907243-247 (DSS)	Original Report	2019-08-23

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *Zebra Technologies Corporation*, and their product model: *ZQ3BT*, or the “EUT” as referred to in this report. The model was installed in the host models: ZT411 and ZT421. Brand: ZEBRA.

1.2 Objective

This report is prepared on behalf of *Zebra Technologies Corporation*, in accordance with LP0002-2018.

The objective is to determine compliance with LP0002-2018 for Output Power, Antenna Requirements, 20 dB Bandwidth, 100 kHz Bandwidth of Band Edges Measurement, Conducted and Radiated Spurious Emissions, Number of Hopping Channels, Dwell Time, and Hopping Channel Separation.

Model Number	ZQ3BT
FCC ID	I28-ZBRZQ3BT
IC	3798B-ZBRZQ3BT
Radio Type	Bluetooth Ver4.0+EDR
Operating Frequency	2402MHz - 2480MHz
Modulation	FHSS (BDR/EDR); GFSK (LE)
Channel Spacing	1MHz (BDR, EDR); 2MHz (LE)
Chip Type Antenna Gain	1.69 dBi
RF Output power	0.0052W (BDR/EDR); 0.0029 (LE)

Model Number	M6e-MicroTT (EUT)
FCC ID	I28-RFIDM6EMTT
IC	3798B-RFIDM6EMTT
Radio Type	UHF RFID
Operating Frequency	902MHz – 928MHz
Modulation	ASK
Channel Spacing	500KHz
PCB Array Antenna Gain	-36 dBi
RF Output power	0.647W

Model Number	WYSBHVXGXG
FCC ID	I28MD-FXLAN11AC
IC	3798B-FXLAN11AC
Radio Type	WLAN-ac/bt
Operating Frequency	2402MHz – 2480MHz, 2412MHz – 2462MHz 5180MHz – 5240MHz, 5260MHz – 5320MHz 5500MHz – 5700MHz, 5745MHz – 5825MHz
Modulation	FHSS (BDR/EDR); GFSK (LE); DSSS, OFDM (WLAN)
Channel Spacing	1MHz (BDR, EDR); 2MHz (LE) 5MHz (2.4G); 20MHz (5G); 40MHz (5G) ; 80MHz (5G)
Omnidirectional Antenna Gain	3 dBi (2.4G)5 dBi (5G);
RF Output power	0.007W (BDR/EDR); 0.0106W (LE) 0.0475W (2.4G WLAN); 0.0157W (UNII-1); 0.0162W (UNII-2); 0.0248W (UNII-2E); 0.0149W (UNII-3)

1.3 Related Submittal(s)/Grant(s)

R1907243-247 DTS

1.4 Test Methodology

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

1.5 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 %

1.6 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.

1.7 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 in accordance to ANSI C63.10-2013.

The worst-case data rates are determined by measuring the peak power across all data rates.

ZT411 (Power 200W, 4-inch wide) and ZT421 (Power 250W, 6-inch wide) have been pretest, also test by EMC, and the radiated test worst case is ZT421. Due to above, ZT421 is main test in test report. Conduction had test two model.

Bluetooth Receiver Mode is working with NFC Receiver mode. (Please refer to R1907243-247 Report)

2.2 EUT Exercise Software

The test software used was QRCT provided by *Zebra Technologies Corporation*, the software is compliant with the standard requirements being tested against.

Modulation	Frequency (MHz)	Power Setting
GFSK	2402	default
	2441	default
	2480	default
$\pi/4$ -DQPSK	2402	default
	2441	default
	2480	default
8PSK	2402	default
	2441	default
	2480	default

2.3 Duty Cycle Correction Factor

According to ANSI C63.10-2013 section 7.5:

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval. The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in following equation:

$$\delta(\text{dB}) = 20\log(\Delta)$$

where

δ is the duty cycle correction factor (dB)

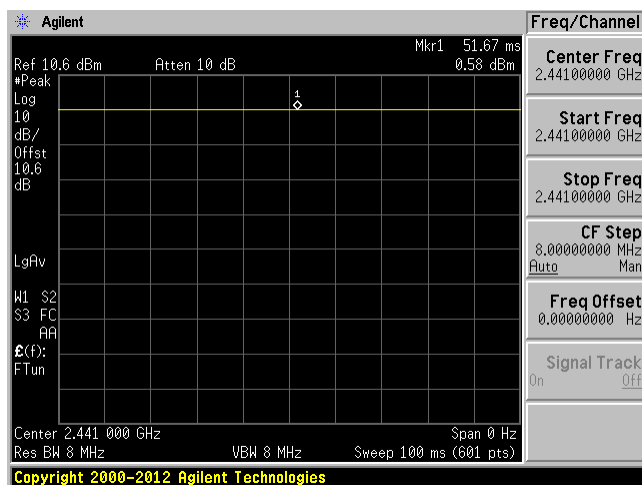
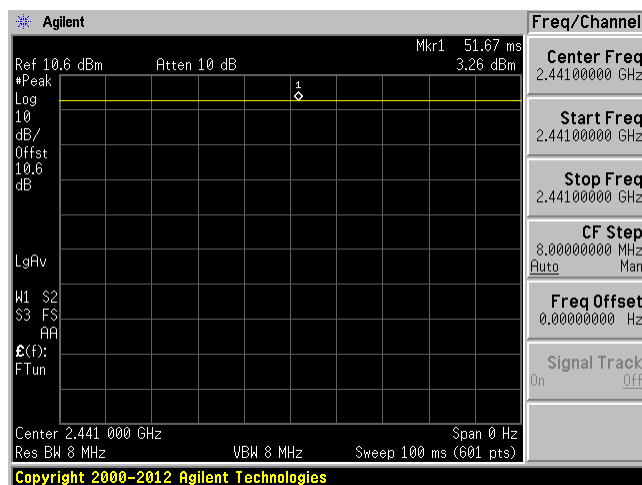
Δ is the duty cycle (dimensionless)

Radio Mode	On Time (μs)	Period (μs)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
GFSK	N/A	N/A	100	0
$\pi/4$ -DQPSK	N/A	N/A	100	0
8DPSK	N/A	N/A	100	0

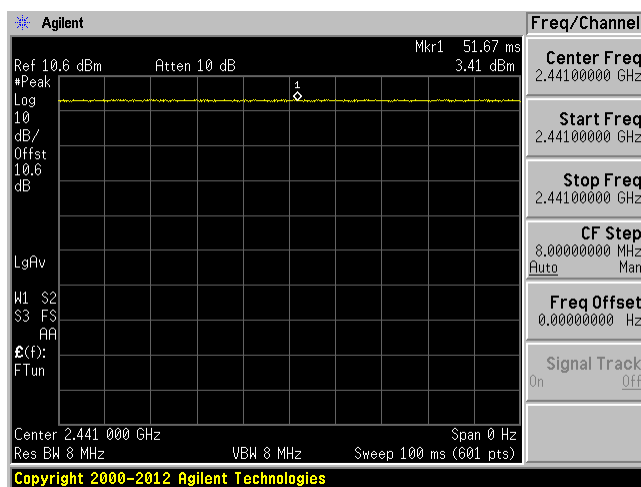
Duty Cycle = On Time (ms)/ Period (ms)

Please refer to the following plots.

GFSK Mode

 $\pi/4$ -DQPSK Mode

8DPSK Mode



2.4 Equipment Modifications

A hole was cut on the side of the EUT to allow for RF cable connection to the power spectrum analyzer

2.5 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E6410
HP	Test Laptop	ZBook
Zebra	Simulated Load	Zebra
Zebra	Main Board	N/A
Chang Yang	USB Cable	N/A
Zebra	Serial Cable	Zebra-S
Zebra	Communications Cable	Zebra-C
Chang Yang	RJ45	N/A

3 Summary of Test Results

Results reported relate only to the product tested.

Rules	Description of Test	Results
LP0002-2018 §2.2	Antenna Requirement	Compliant
LP0002-2018 §2.3	AC Line Conducted Emissions	Compliant
LP0002-2018 §5.20.2.2	RF Exposure	Compliant
LP0002-2018 §3.10	Spurious Emissions at Antenna Port	Compliant
LP0002-2018 §3.10	Radiated Spurious Emissions	Compliant
LP0002-2018 §3.10	20 dB and 99% Emission Bandwidth	Compliant
LP0002-2018 §3.10	Maximum Peak Output Power	Compliant
LP0002-2018 §3.10	100 kHz Bandwidth of Frequency Band Edge	Compliant
LP0002-2018 §3.10	Number of Hopping Channels	Compliant
LP0002-2018 §3.10	Hopping Channel Separation	Compliant
LP0002-2018 §3.10	Dwell Time	Compliant

4 LP0002-2018 §2.2 - Antenna Requirements

4.1 Applicable Standards

According to LP0002-2018 §2.2,

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

The antennas used by the EUT are permanent attached antennas.

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
Bluetooth	2402-2480	1.69

5 LP0002-2018 §5.20.2.2– RF Exposure

5.1 Applicable Standards

According to LP0002-2018 §5.20.2.2

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)
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

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

Maximum output power at antenna input terminal (dBm): 3.62

Maximum output power at antenna input terminal (mW): 2.30

Prediction distance (cm): 20

Prediction frequency (MHz): 2402

Maximum Antenna Gain, typical (dBi): 1.69

Maximum Antenna Gain (numeric): 1.48

Power density of prediction frequency at 20.0 cm (mW/cm²): 0.000676

MPE limit for uncontrolled exposure at prediction frequency (mW/cm²): 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 0.000676mW/cm². Limit is 1.0 mW/cm².

6 LP0002-2018 §2.3- AC Line Conducted Emissions

6.1 Applicable Standards

As per LP0002-2018§2.3 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 μ H/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

6.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used were LP0002-2018 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 110 V / 60 Hz AC power.

6.3 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”.

6.4 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:

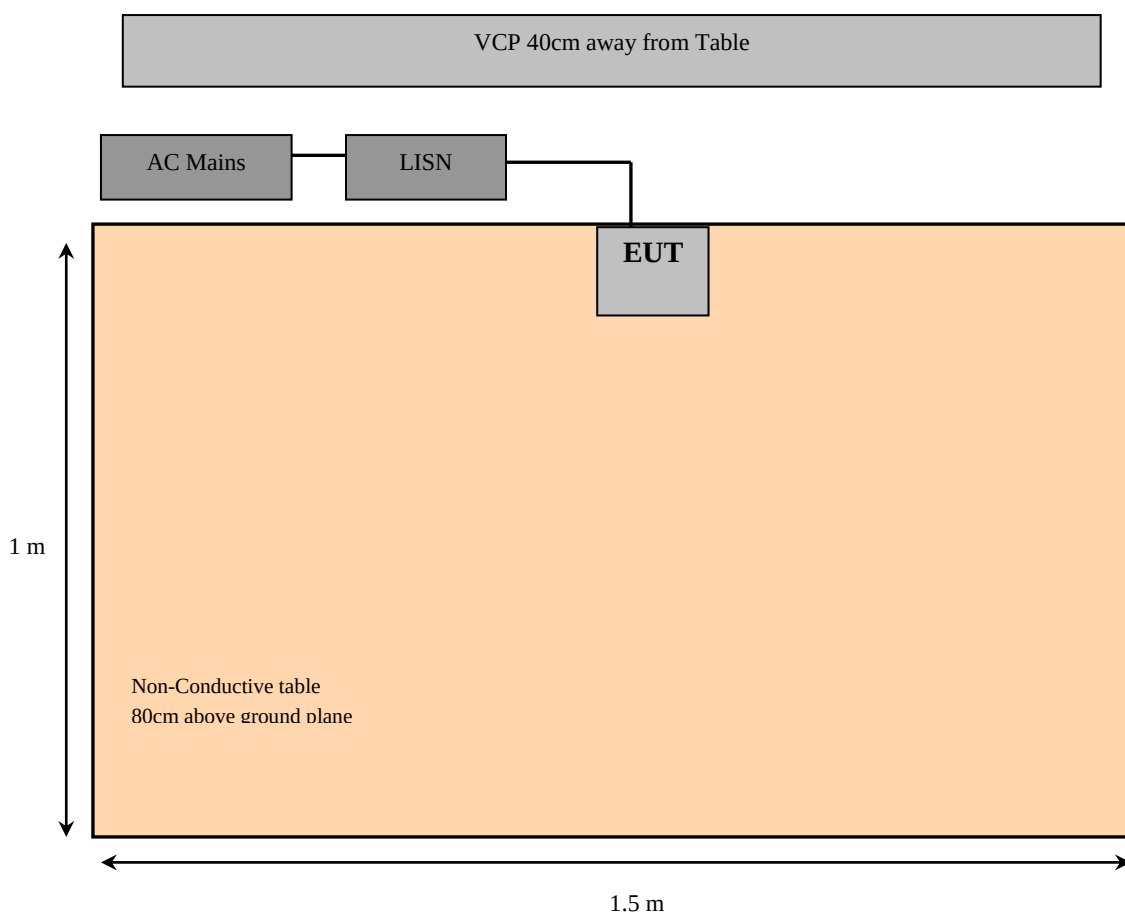
$$CA = Ai + CL + Atten$$

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:

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

6.5 Test Setup Block Diagram



6.6 Test Equipment List and Details

Manufacturer	5.3.1.1.1 Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101963	2018-07-27	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150202	2019-02-25	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	N/R	N/A
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160132	2018-05-16	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 years

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

6.7 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	37 %
ATM Pressure:	101.6 kPa

The testing was performed by Zhao Zhao on 2019-05-02 in 5 meter chamber 3.

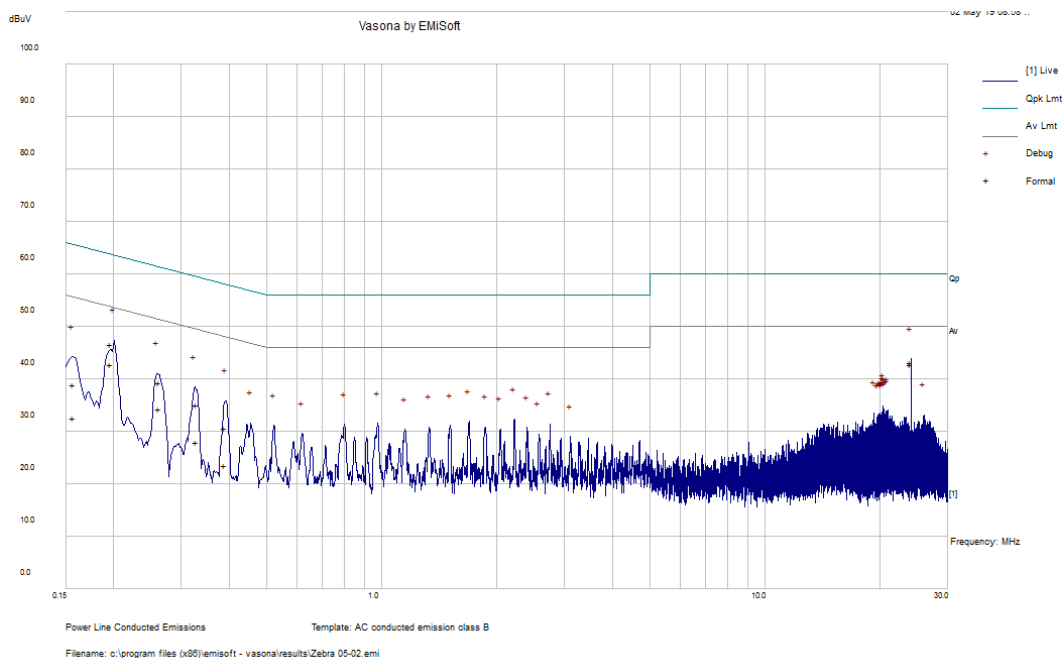
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the LP0002-2018 standard's conducted emissions limits, with the margin reading of:

Connection: AC/DC Adapter Connected to 110 V/60 Hz, AC			
Margin (dB)	Frequency (MHz)	Conductor Mode (Line/Neutral)	Range (MHz)
-6.82	24.002166	Line	0.15-30

Worst Case Classic Bluetooth/BLE for Host ZT411

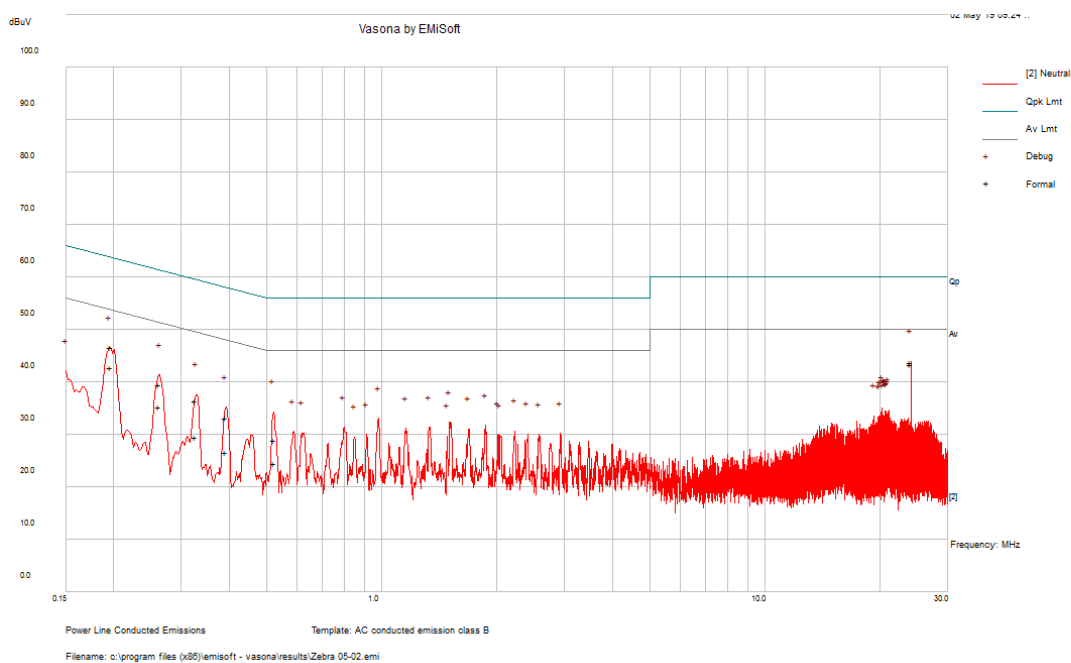
110 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
24.002166	42.87	Line	60	-17.13	QP
0.195887	46.69	Line	63.78	-17.09	QP
0.263251	39.43	Line	61.33	-21.9	QP
0.328867	35.19	Line	59.48	-24.29	QP
0.156875	38.88	Line	65.63	-26.75	QP
0.388303	30.67	Line	58.1	-27.43	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
24.002166	43.18	Line	50	-6.82	Ave.
0.195887	42.84	Line	53.78	-10.94	Ave.
0.263251	34.41	Line	51.33	-16.92	Ave.
0.328867	27.96	Line	49.48	-21.52	Ave.
0.156875	32.53	Line	55.63	-23.09	Ave.
0.388303	23.52	Line	48.1	-24.58	Ave.

110 V, 60 Hz – Neutral

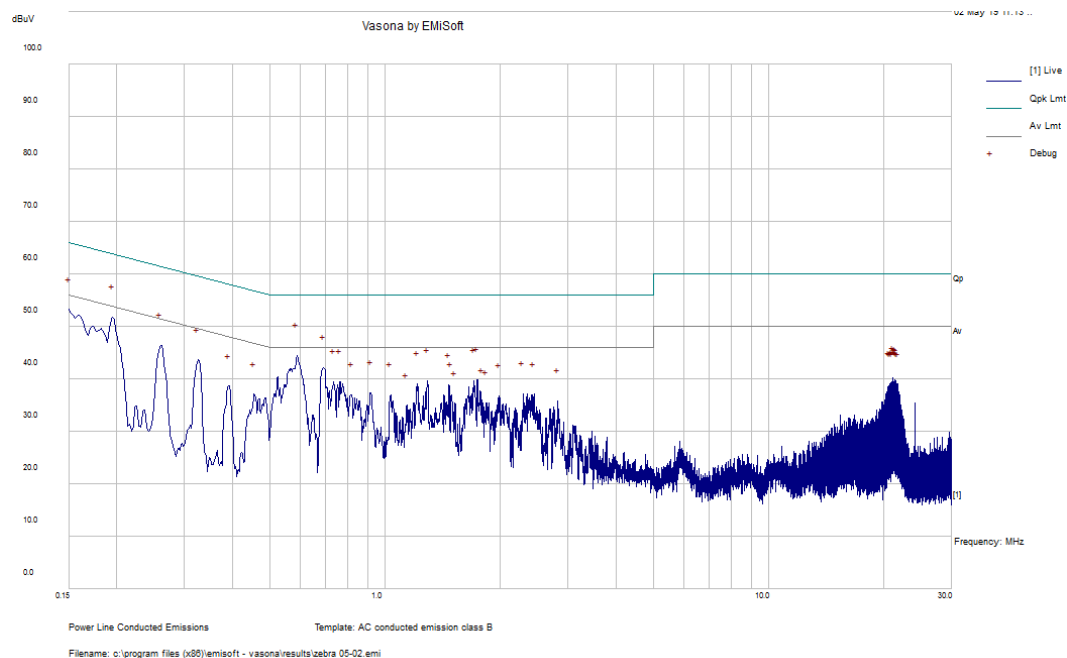


Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
24.001068	43.47	Neutral	60	-16.53	QP
0.196176	46.66	Neutral	63.77	-17.11	QP
0.261762	39.47	Neutral	61.38	-21.91	QP
0.524853	28.96	Neutral	56	-27.04	QP
0.326082	36.41	Neutral	59.55	-23.14	QP
0.390787	33.26	Neutral	58.05	-24.79	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
24.001068	43.79	Neutral	50	-6.21	Ave.
0.196176	42.9	Neutral	53.77	-10.87	Ave.
0.261762	35.27	Neutral	51.38	-16.11	Ave.
0.524853	24.63	Neutral	46	-21.37	Ave.
0.326082	29.46	Neutral	49.55	-20.09	Ave.
0.390787	26.66	Neutral	48.05	-21.39	Ave.

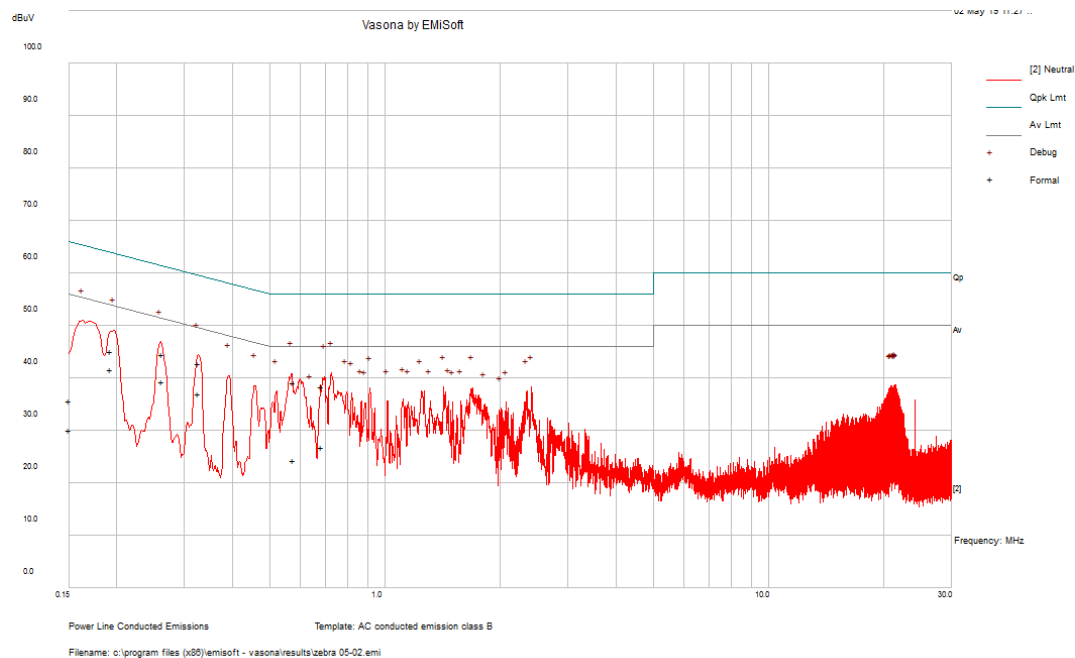
Worst Case Classic Bluetooth/BLE for Host ZT421

110 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.576837	39.21	Line	56	-16.79	QP
0.192306	45.1	Line	63.94	-18.84	QP
0.150322	35.79	Line	65.98	-30.19	QP
0.682931	38.47	Line	56	-17.53	QP
0.262063	44.51	Line	61.37	-16.85	QP
0.326113	42.86	Line	59.55	-16.69	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.576837	24.33	Line	46	-21.67	Ave.
0.192306	41.71	Line	53.94	-12.22	Ave.
0.150322	30.2	Line	55.98	-25.78	Ave.
0.682931	26.78	Line	46	-19.22	Ave.
0.262063	39.27	Line	51.37	-12.1	Ave.
0.326113	37.08	Line	49.55	-12.47	Ave.

110 V, 60 Hz – Neutral

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.158199	50.2	Neutral	65.56	-15.35	QP
0.261739	44.72	Neutral	61.38	-16.65	QP
0.195828	47.38	Neutral	63.79	-16.4	QP
0.720956	38.88	Neutral	56	-17.12	QP
0.326617	42.62	Neutral	59.54	-16.92	QP
0.566732	40.87	Neutral	56	-15.13	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.158199	36.72	Neutral	55.56	-18.84	Ave.
0.261739	39.45	Neutral	51.38	-11.93	Ave.
0.195828	44.18	Neutral	53.79	-9.6	Ave.
0.720956	27.12	Neutral	46	-18.88	Ave.
0.326617	36.81	Neutral	49.54	-12.73	Ave.
0.566732	27.67	Neutral	46	-18.33	Ave.

7 LP0002-2018 §3.10 - Spurious Radiated Emissions

7.1 Applicable Standards

As Per LP0002-2018 §2.7 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 2.8:

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 LP0002-2018 §2.8, 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

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 5.15.2, while others shall be measured using a CISPR quasi-peak detector. Those not specified above shall comply with Section 5.5 and the frequency bands measurement of radiated emission shall accord with Section 5.14

7.2 Test Setup

The radiated emissions tests were performed in the Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the LP0002-2018 limits.

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

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:

$$RBW = 100 \text{ kHz} / VBW = 300 \text{ kHz} / \text{Sweep} = \text{Auto}$$

Above 1000 MHz:

- (1) Peak: $RBW = 1\text{MHz} / VBW = 1\text{MHz} / \text{Sweep} = \text{Auto}$
- (2) Average: $RBW = 1\text{MHz} / VBW = 10\text{Hz or } 1/T / \text{Sweep} = \text{Auto}$

7.4 Corrected Amplitude and 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:

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

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:

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

7.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 year
Agilent	Analyzer, Spectrum	E4446A	US44300386	2018-06-01	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2018-02-26	2 year
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2019-04-02	2 years
Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2017-12-15	2 years
Agilent	Amplifier, Pre	8447D	2944A10187	2019-04-11	1 year
HP	Pre-Amplifier	8449B	3008A01978	2018-08-10	1year
A.H. Systems	Pre-Amplifier	PAM 1840V	170	2018-09-10	1 year
Insulted Wire Corp.	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2019-05-08	1 Year
-	SMA cable	-	C0002	Each time ¹	N/A
-	N-Type Cable	-	C00013	Each time ¹	N/A
-	N-Type Cable	-	C00014	Each time ¹	N/A
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note¹: 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.*

7.6 Test Environmental Conditions

Temperature:	23 °C
Relative Humidity:	42 %
ATM Pressure:	102.7 kPa

The testing was performed by Zhao Zhao from 2019-05-13 and 2019-05-14 in 5m3 chamber.

7.7 Summary of Test Results

According to the data hereinafter, the EUT complied with LP0002-2018§3.10 standard's radiated emissions limits, and had the worst margin of:

30-1000 MHz:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Detector Mode
-18.41	31.86975	Vertical	Quasi Peak

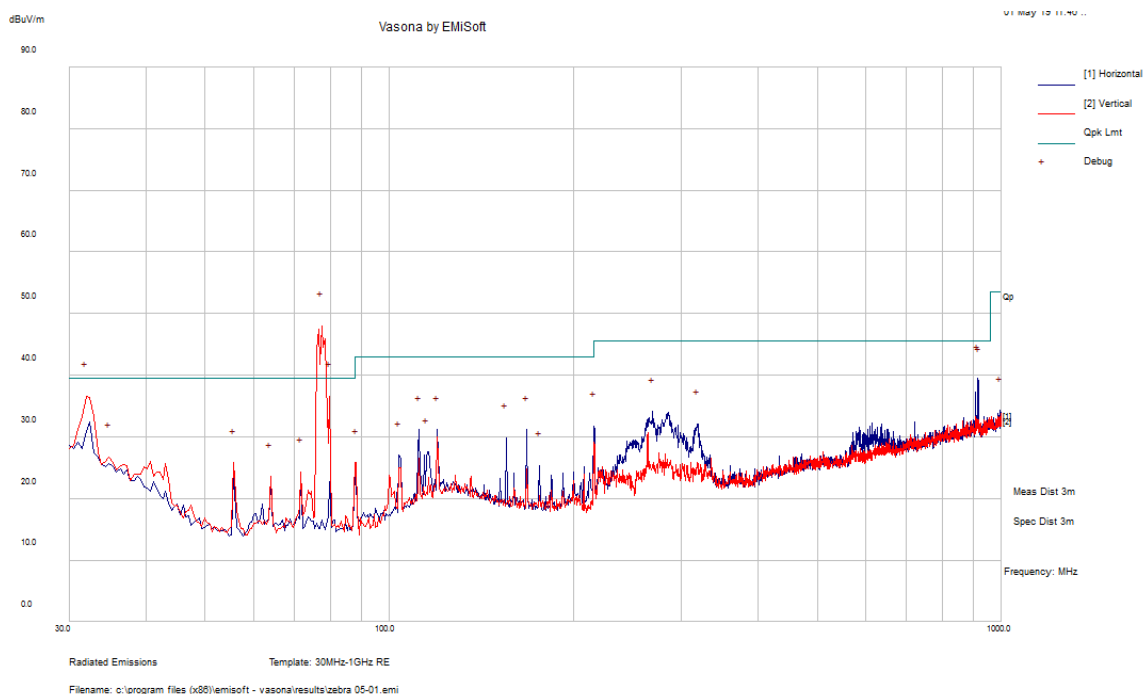
1-26.5 GHz:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Detector Mode
-3.57	2390	Horizontal	Average

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

7.8 Radiated Emissions Test Results

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



Frequency (MHz)	Corrected Amplitude (dBuV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (Degrees)	Limit (dBuV/m)	Margin (dB)	Comment
77.531	9.64	229	V	306	39.5	-29.86	QP
77.39225	10.28	272	V	23	39.5	-29.22	QP
32.1335	20.89	204	V	323	39.5	-18.61	QP
31.86975	21.09	299	V	198	39.5	-18.41	QP
80.019	19.49	127	V	183	39.5	-20.01	QP
79.98025	18.36	210	V	30	39.5	-21.14	QP

2) 1–25 GHz Measured at 3 meters

BDR Mode

Freq. (MHz)	S.A. Reading (dBμV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre- Amp. (dB)	Cord. Reading (dBμV/m)			Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBμV/m)	Margin (dB)	
Low channel 2402MHz											
2390	28.61	33	143	H	28.87	5.05	0.00	62.53	74	-11.48	PK
2390	16.52	33	143	H	28.87	5.05	0.00	50.44	54	-3.57	AV
2390	28.30	49	123	V	28.89	5.05	0.00	62.24	74	-11.76	PK
2390	15.23	49	123	V	28.89	5.05	0.00	49.17	54	-4.83	AV
4804	46.30	0	100	H	32.46	8.40	35.75	51.41	74	-22.60	PK
4804	32.55	0	100	H	32.46	8.40	35.75	37.66	54	-16.35	AV
4804	46.47	0	100	V	32.86	8.40	35.75	51.98	74	-22.02	PK
4804	32.21	0	100	V	32.86	8.40	35.75	37.72	54	-16.28	AV
Middle channel 2441MHz											
4882	45.73	0	100	H	32.56	8.62	38.09	48.82	74	-25.18	PK
4882	31.85	0	100	H	32.56	8.62	38.09	34.94	54	-19.06	AV
4882	44.74	0	100	V	32.56	8.62	38.09	47.83	74	-26.17	PK
4882	32.02	0	100	V	32.56	8.62	38.09	35.11	54	-18.89	AV
High channel 2480MHz											
2483.5	28.14	30	136	H	29.17	5.17	0.00	62.48	74	-11.52	PK
2483.5	15.48	30	136	H	29.17	5.17	0.00	49.82	54	-4.18	AV
2483.5	27.65	53	140	V	29.10	5.17	0.00	61.92	74	-12.09	PK
2483.5	14.84	53	140	V	29.10	5.17	0.00	49.11	54	-4.90	AV
4960	45.77	0	100	H	32.56	8.81	35.66	51.48	74	-22.52	PK
4960	31.32	0	100	H	32.56	8.81	35.66	37.03	54	-16.97	AV
4960	46.04	0	100	V	32.56	8.81	35.66	51.75	74	-22.25	PK
4960	32.11	0	100	V	32.56	8.81	35.66	37.82	54	-16.18	AV

EDR Mode

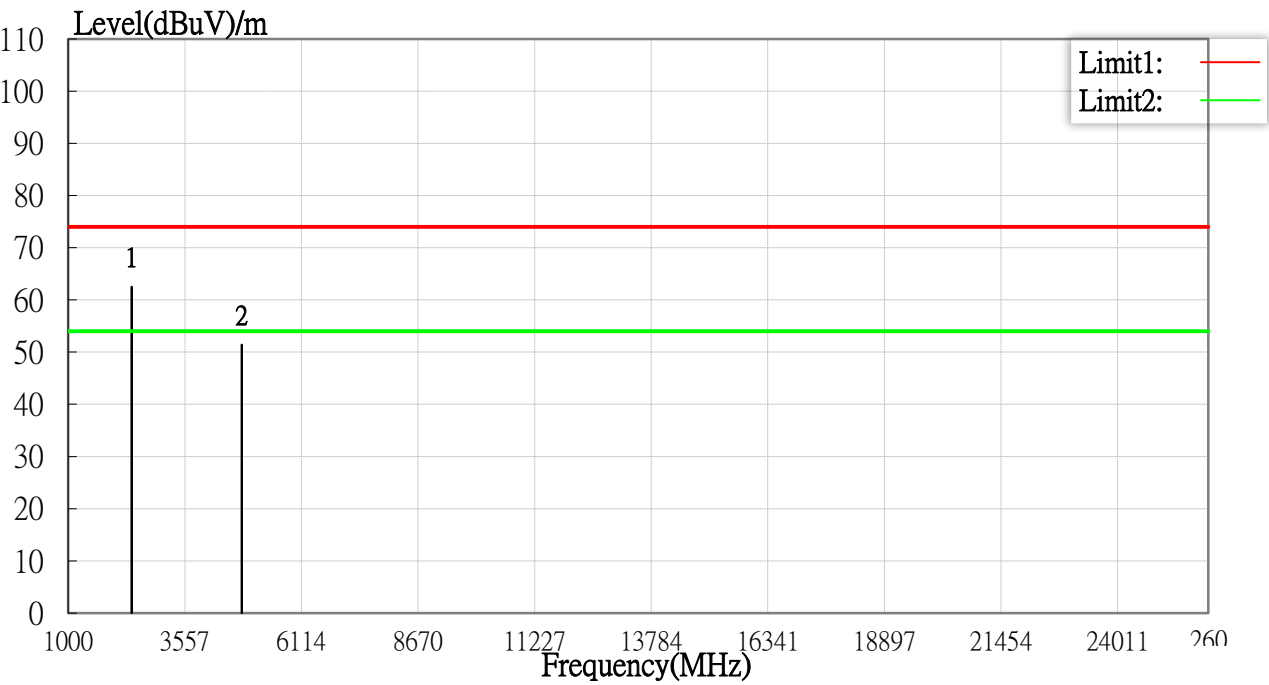
Freq. (MHz)	S.A. Reading (dBμV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre- Amp. (dB)	Cord. Reading (dBμV/m)			Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBμV/m)	Margin (dB)	
Low channel 2402MHz											
2390	27.87	19	137	H	28.87	5.05	0.00	61.79	74	-12.22	PK
2390	14.69	19	137	H	28.87	5.05	0.00	48.61	54	-5.40	AV
2390	27.59	47	141	V	28.89	5.05	0.00	61.53	74	-12.47	PK
2390	14.52	47	141	V	28.89	5.05	0.00	48.46	54	-5.54	AV
4804	46.73	36	132	H	32.46	8.40	35.75	51.84	74	-22.17	PK
4804	32.63	36	132	H	32.46	8.40	35.75	37.74	54	-16.27	AV
4804	46.44	29	132	V	32.86	8.40	35.75	51.95	74	-22.05	PK
4804	35.04	29	132	V	32.86	8.40	35.75	40.55	54	-13.45	AV
Middle channel 2441MHz											
4882	47.27	32	130	H	32.56	8.62	38.09	50.36	74	-23.64	PK
4882	37.05	32	130	H	32.56	8.62	38.09	40.14	54	-13.86	AV
4882	47.05	33	132	V	32.56	8.62	38.09	50.14	74	-23.86	PK
4882	34.72	33	132	V	32.56	8.62	38.09	37.81	54	-16.19	AV
High channel 2480MHz											
2483.5	29.19	29	138	H	29.17	5.17	0.00	63.53	74	-10.47	PK
2483.5	15.27	29	138	H	29.17	5.17	0.00	49.61	54	-4.39	AV
2483.5	28.68	55	138	V	29.10	5.17	0.00	62.95	74	-11.06	PK
2483.5	15.19	55	138	V	29.10	5.17	0.00	49.46	54	-4.55	AV
4960	47.85	33	137	H	32.56	8.81	35.66	53.56	74	-20.44	PK
4960	36.61	33	137	H	32.56	8.81	35.66	42.32	54	-11.68	AV
4960	46.47	34	140	V	32.56	8.81	35.66	52.18	74	-21.82	PK
4960	33.72	34	140	V	32.56	8.81	35.66	39.43	54	-14.57	AV

BDR

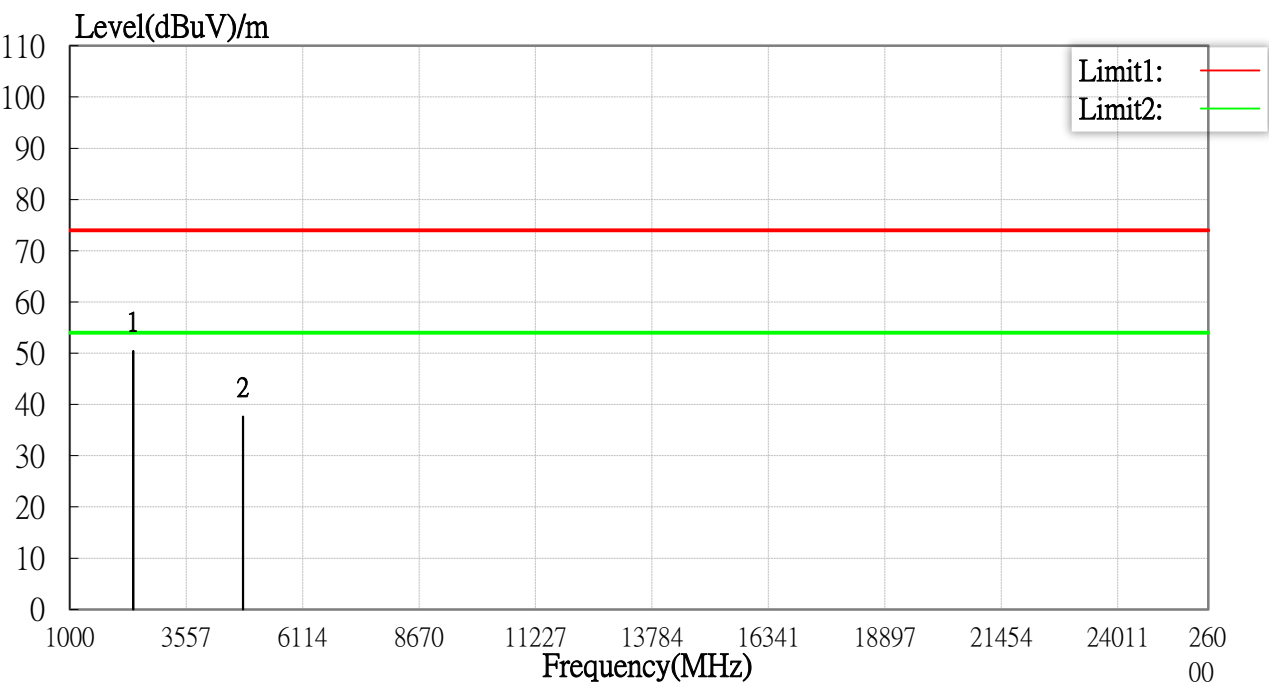
Low Channel

Horizontal

Peak

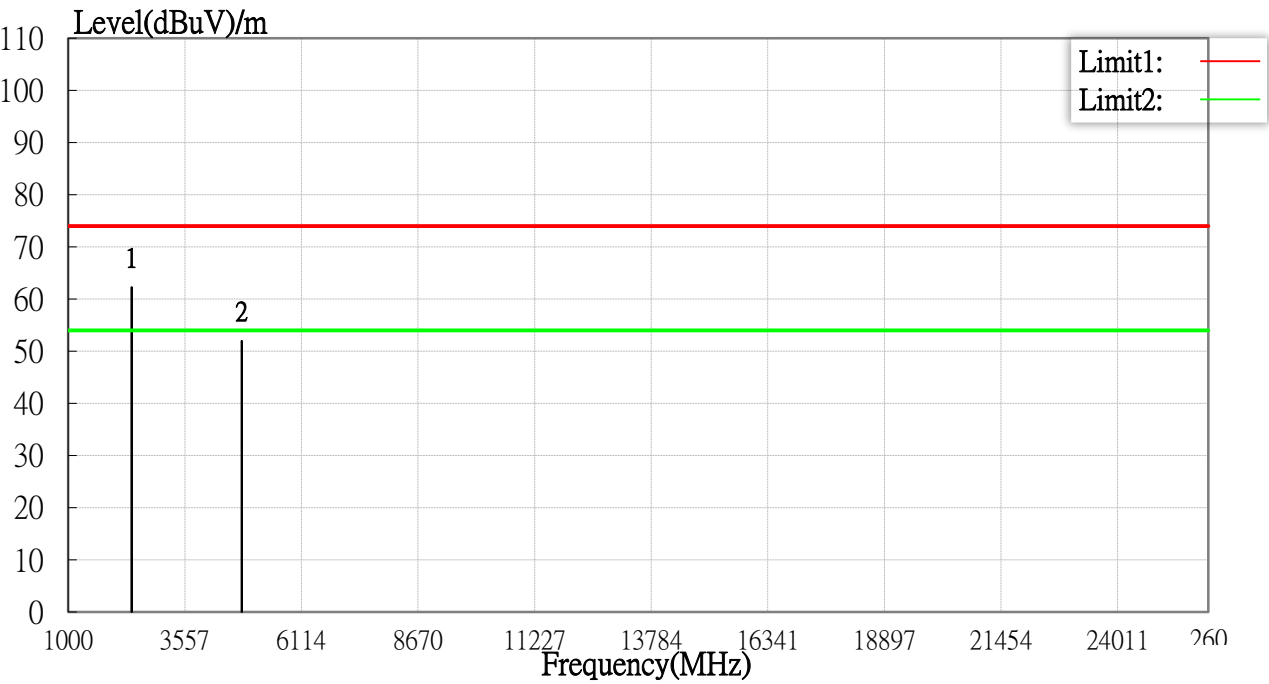


Ave

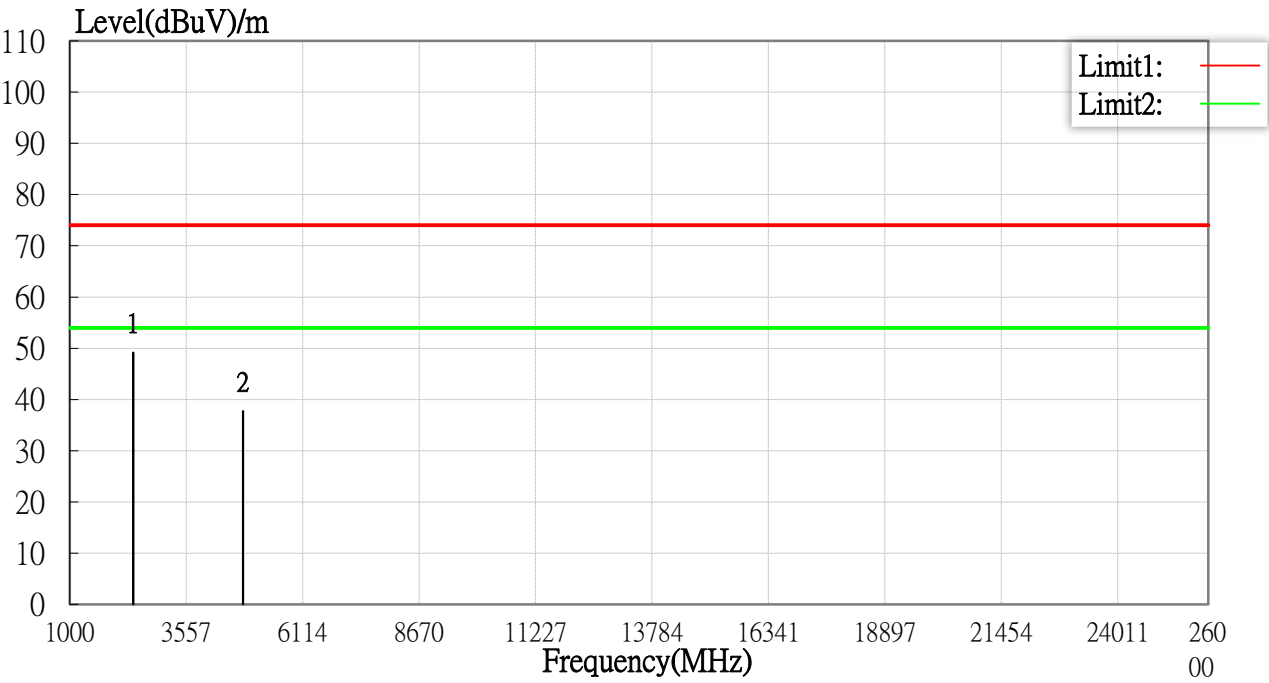


Vertical

Peak



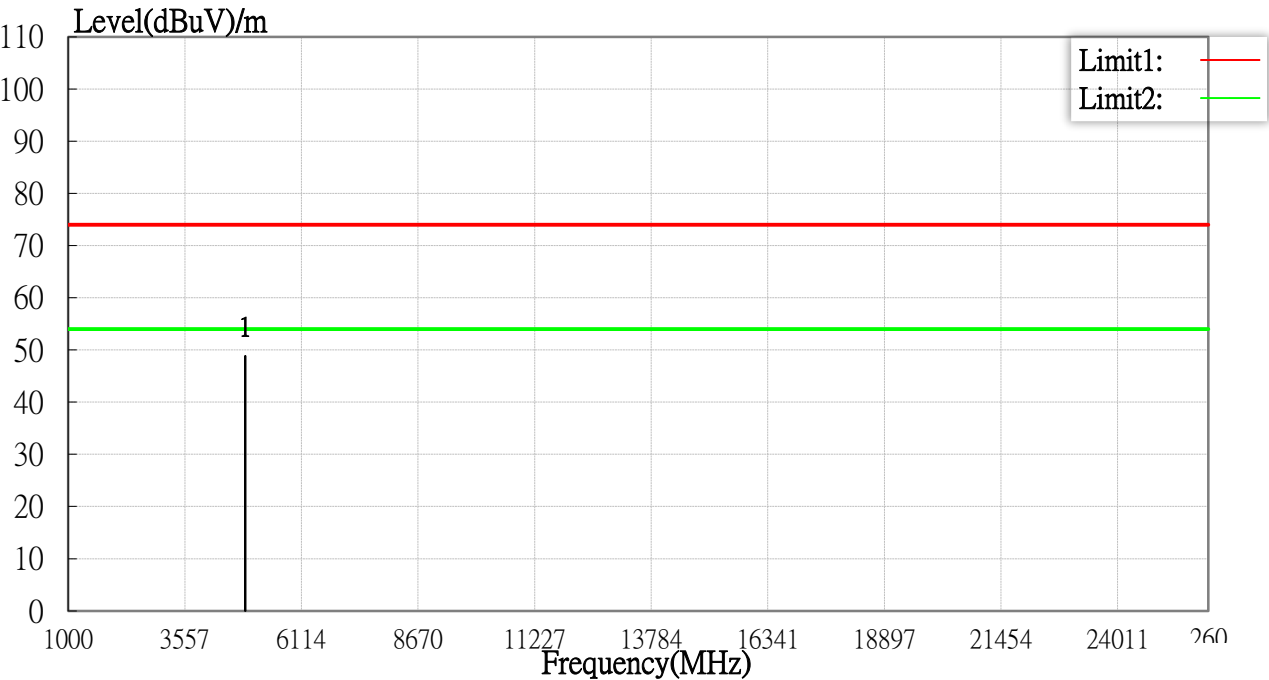
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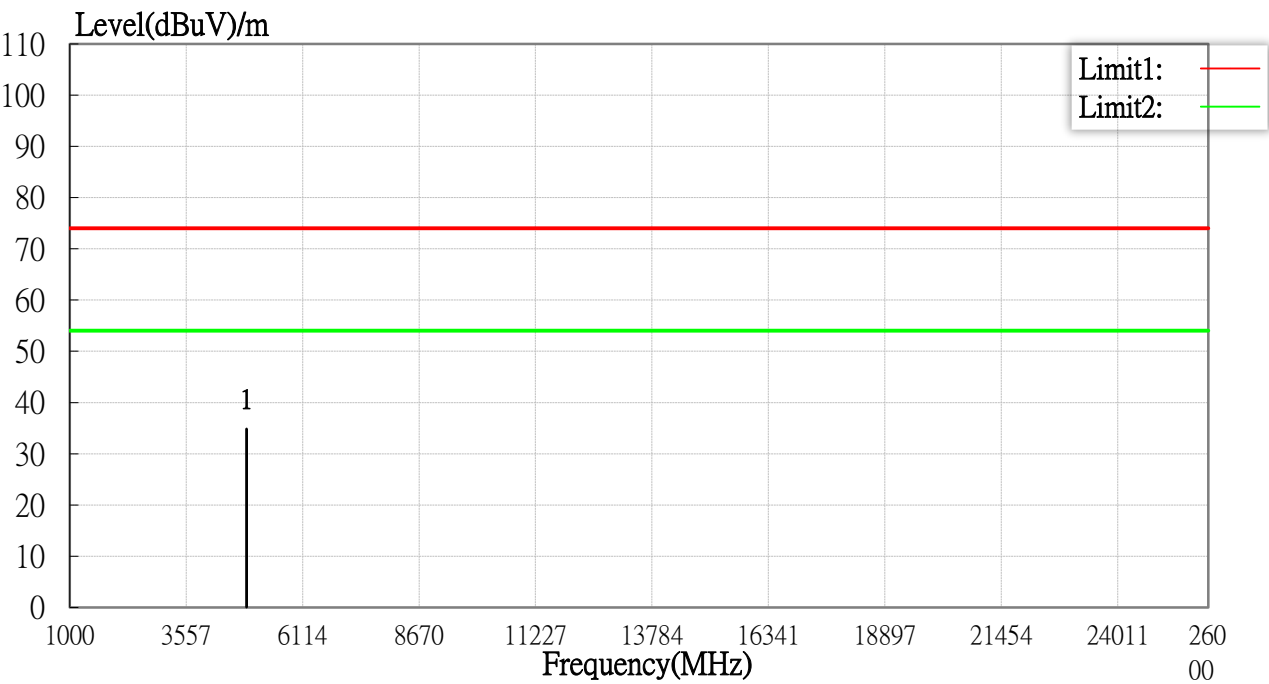
Middle Channel

Horizontal

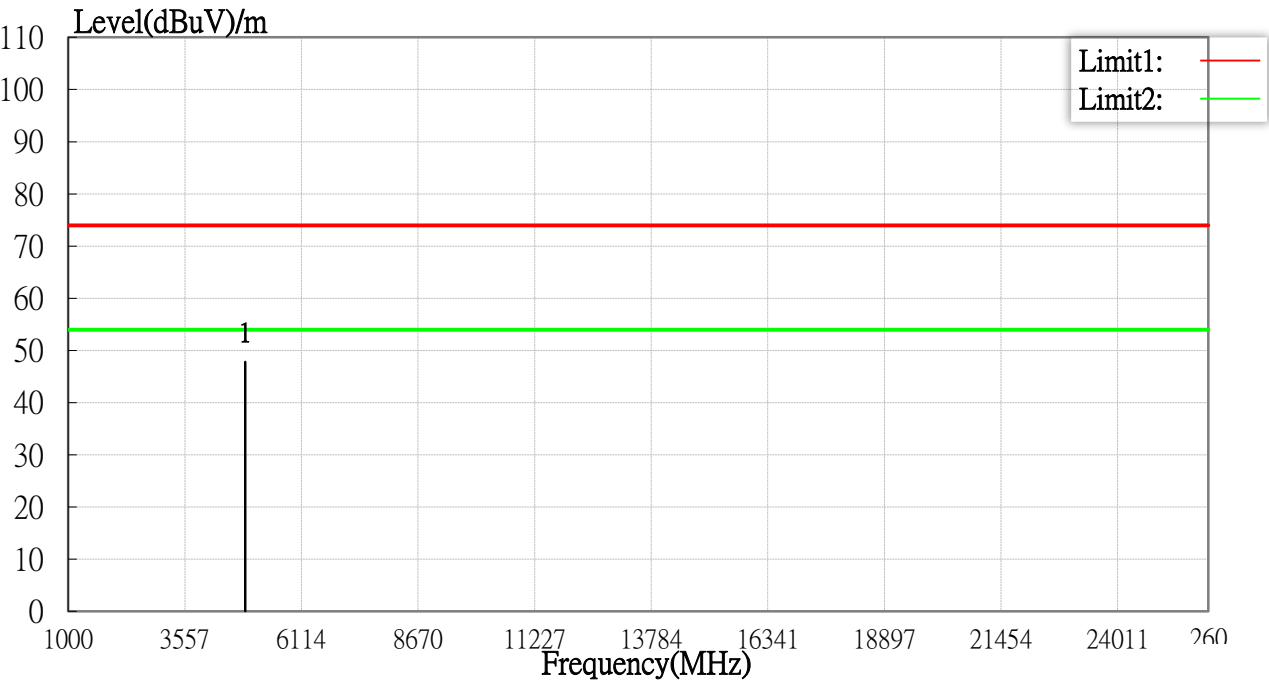
Peak



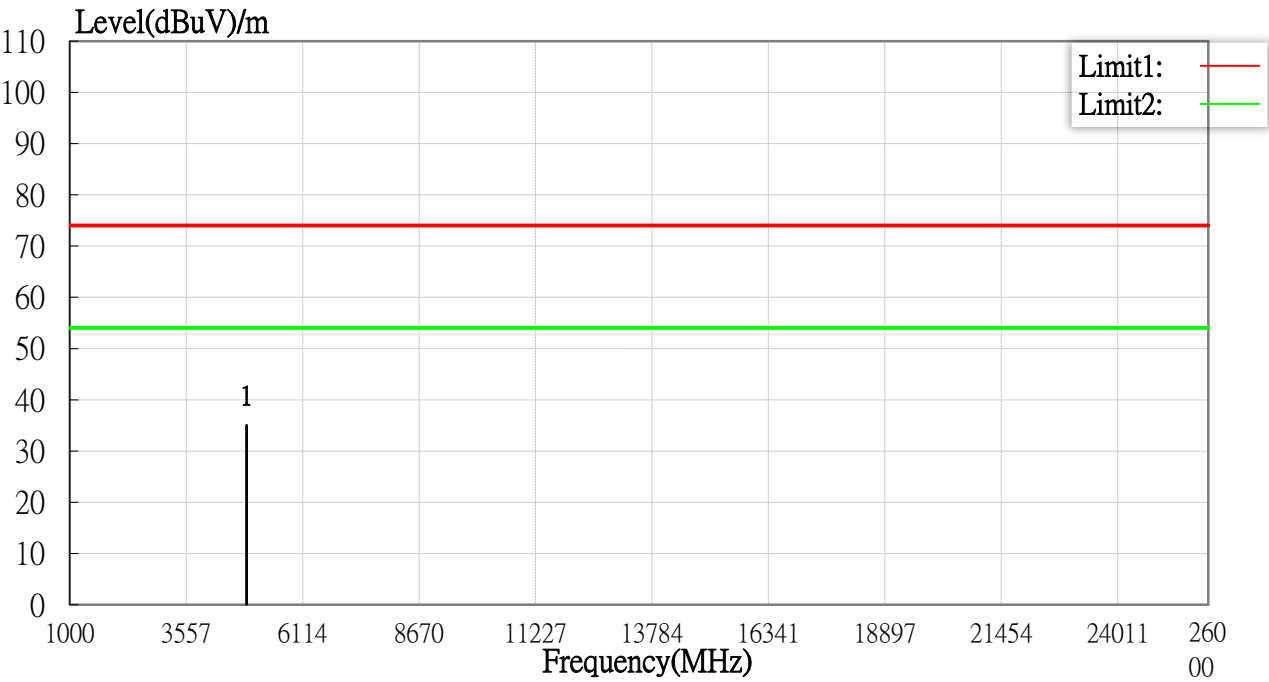
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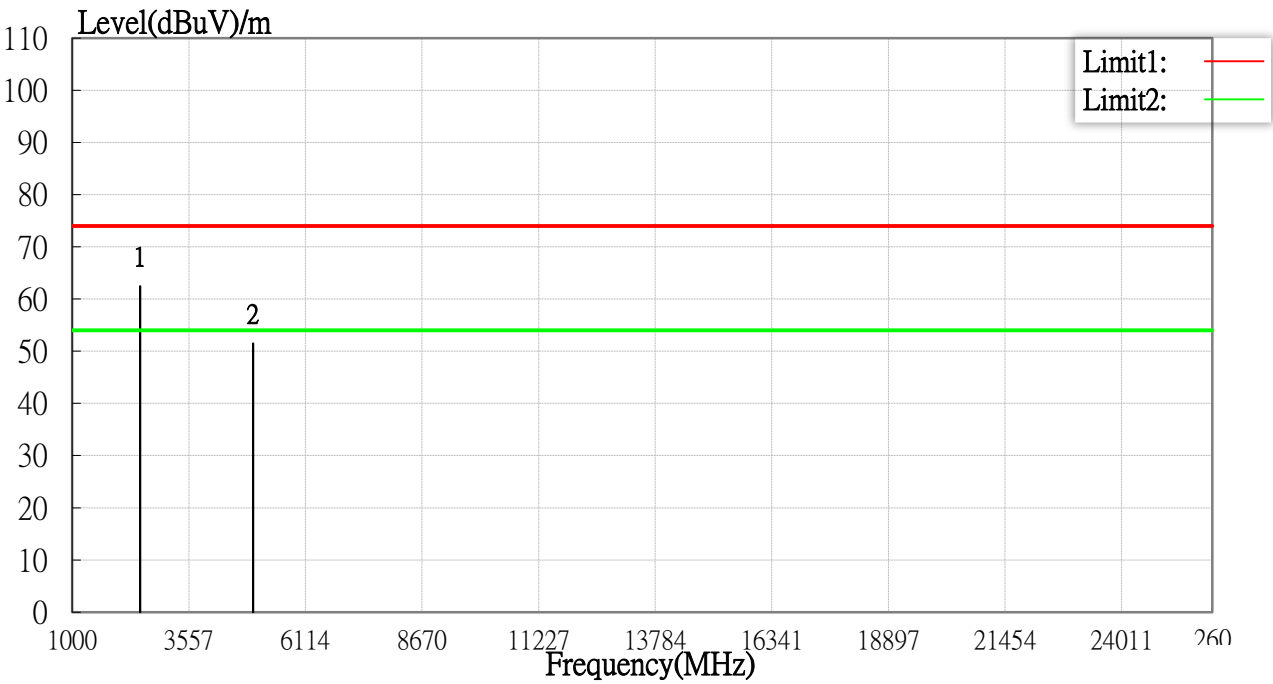
Vertical
Peak



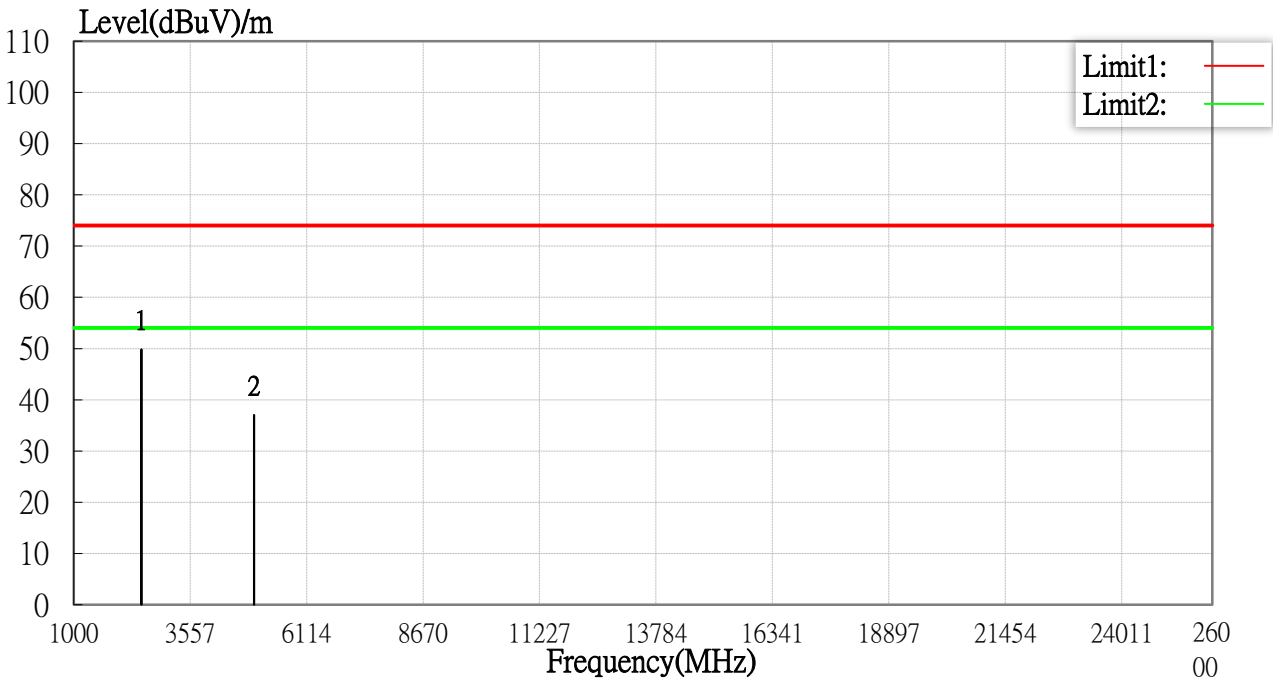
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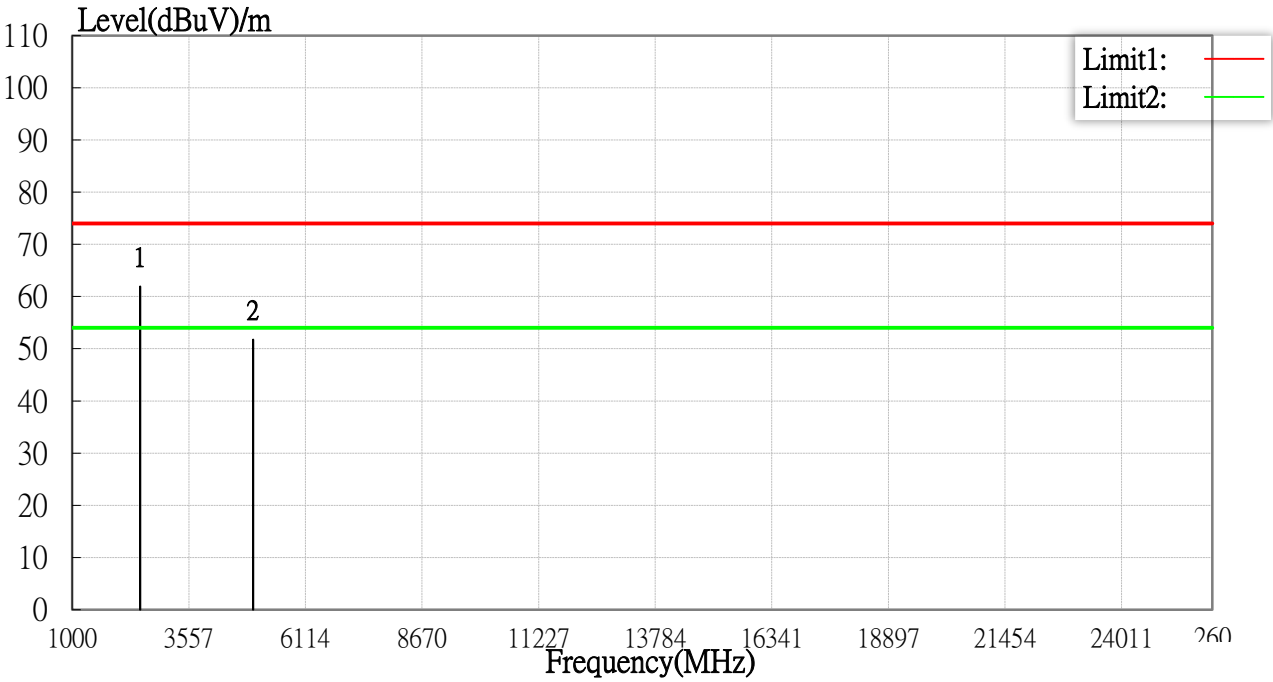
High Channel
Horizontal
Peak



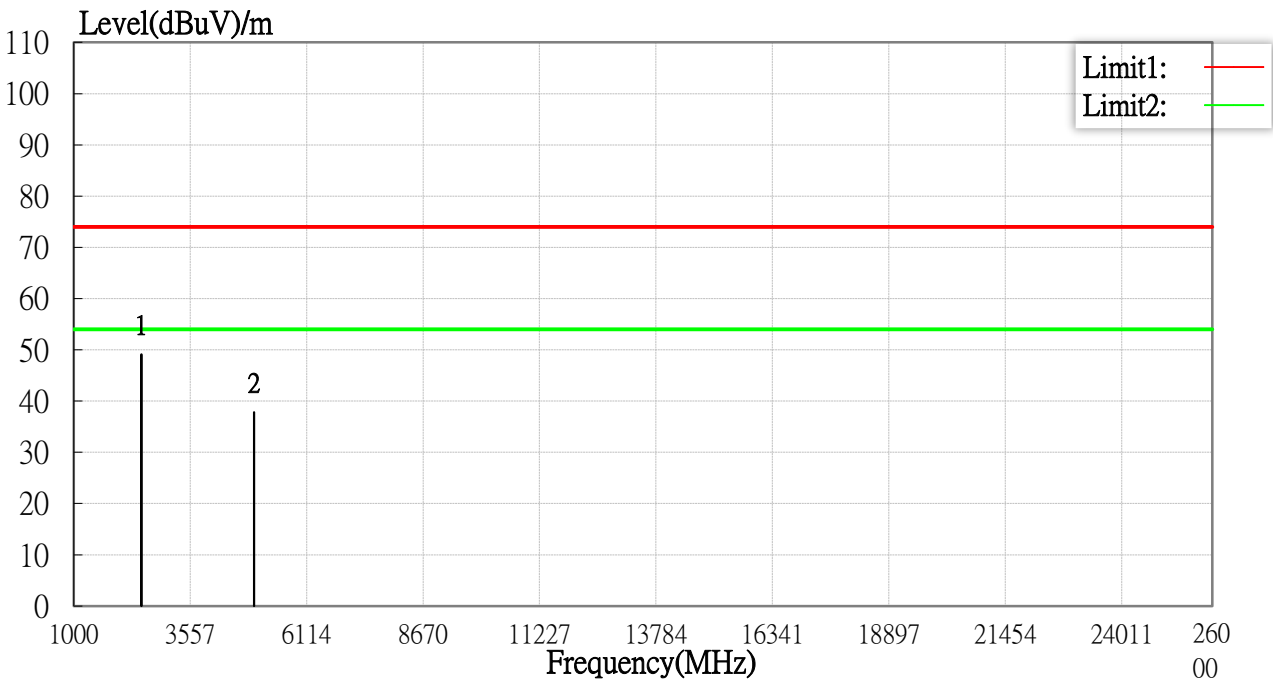
Ave



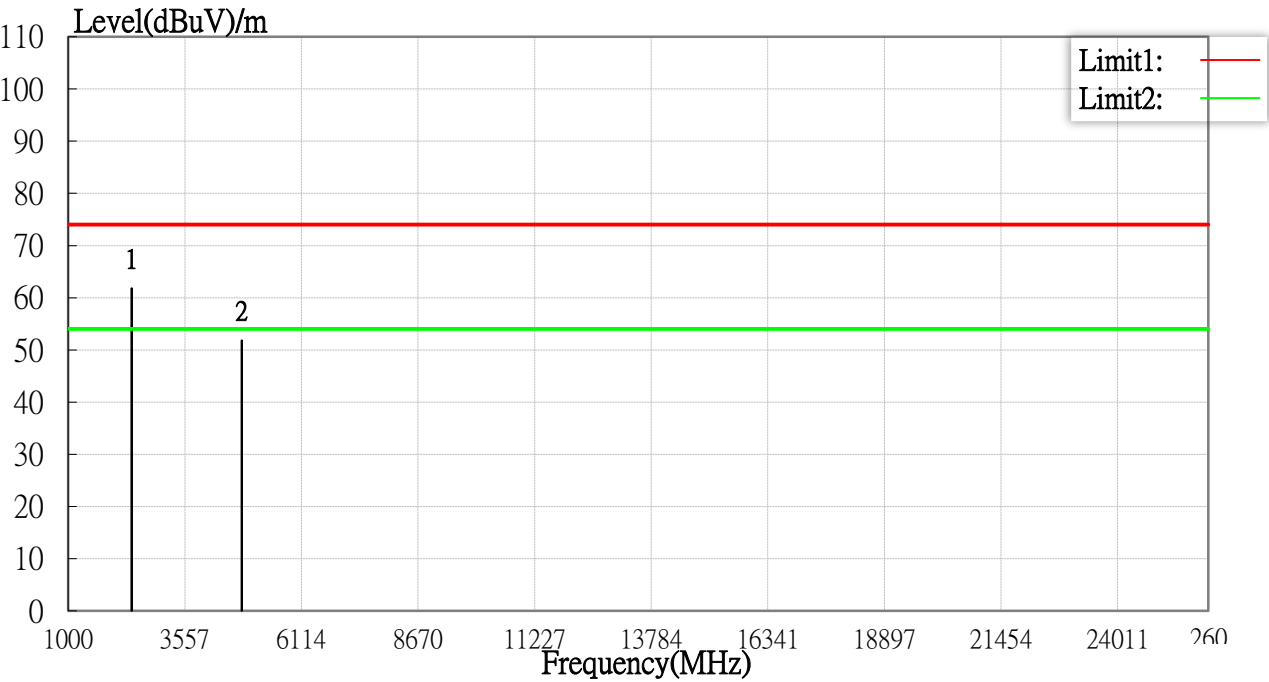
Vertical
Peak



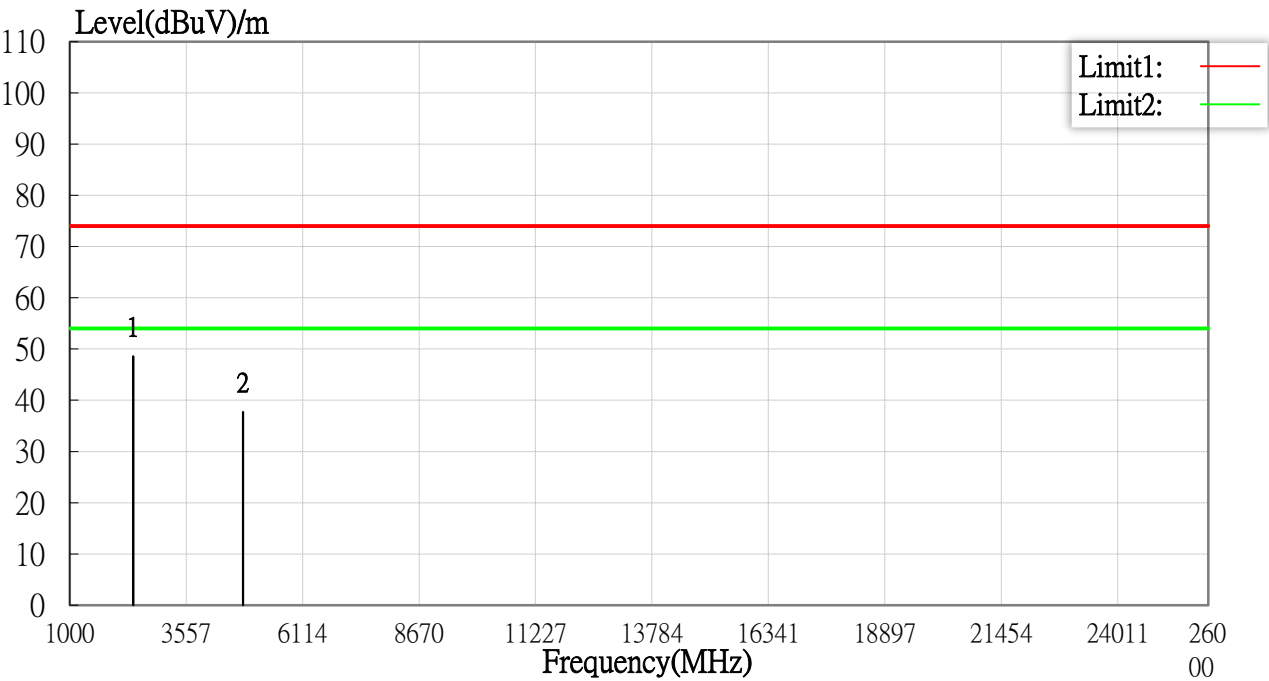
Ave



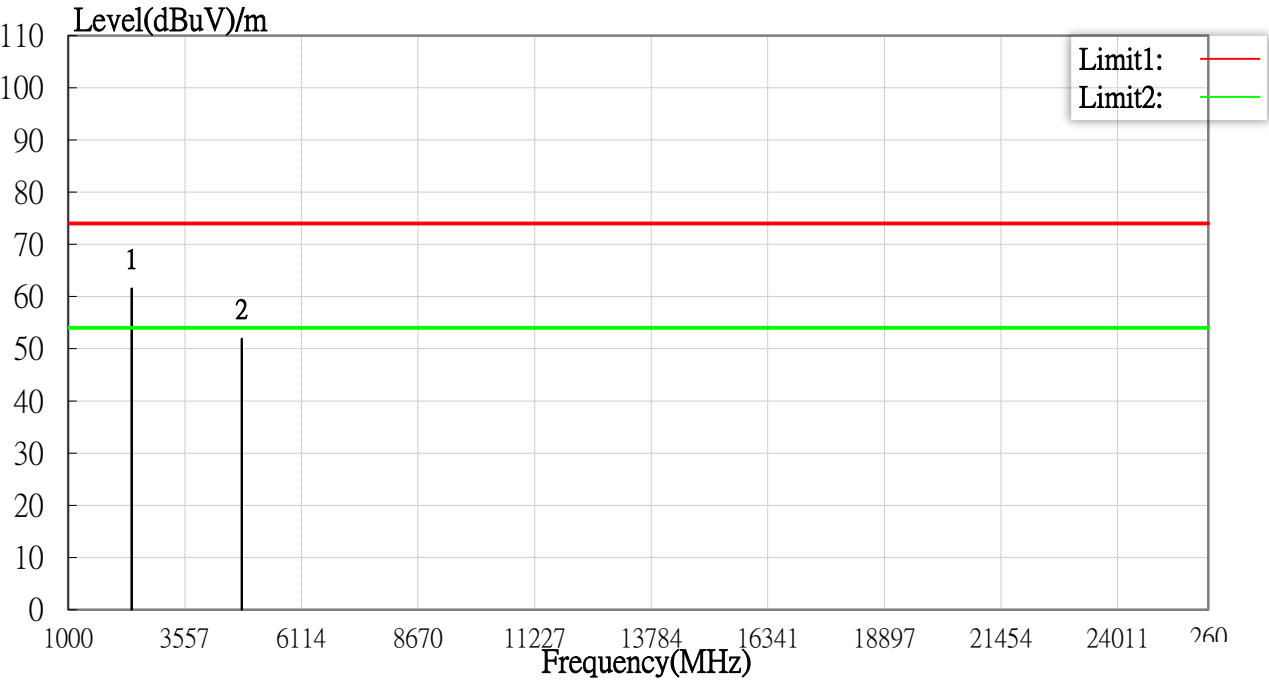
EDR
Low Channel
Horizontal
Peak



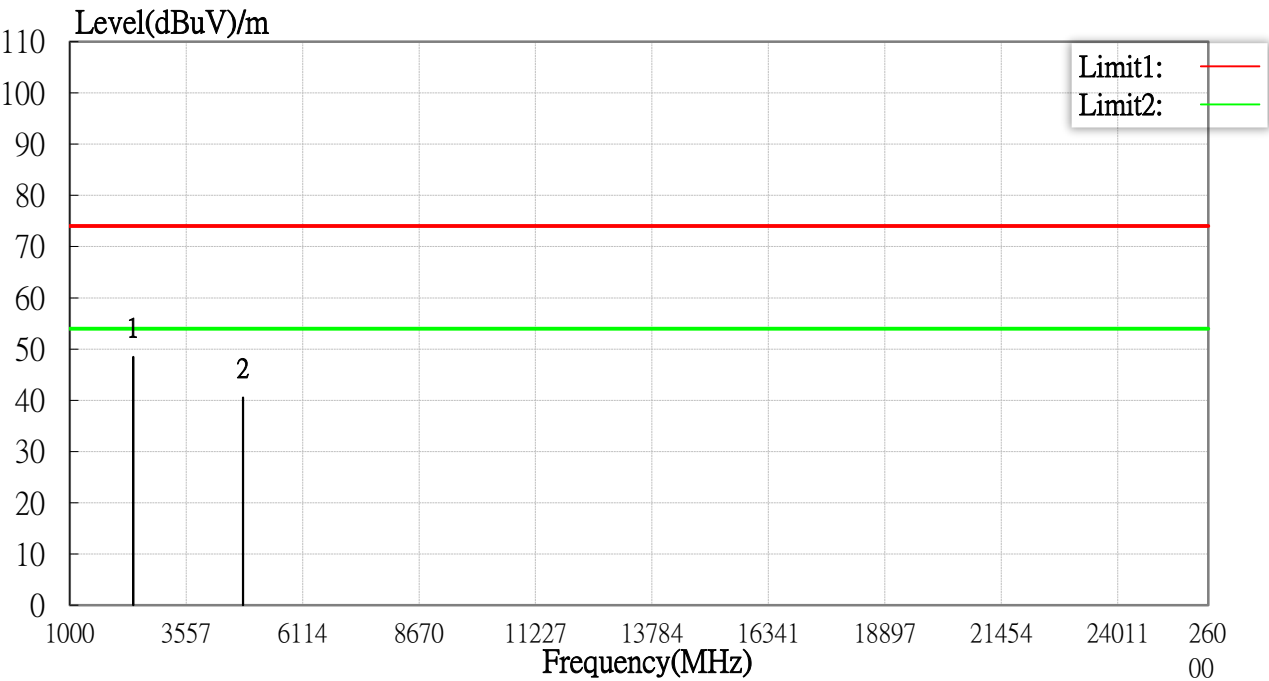
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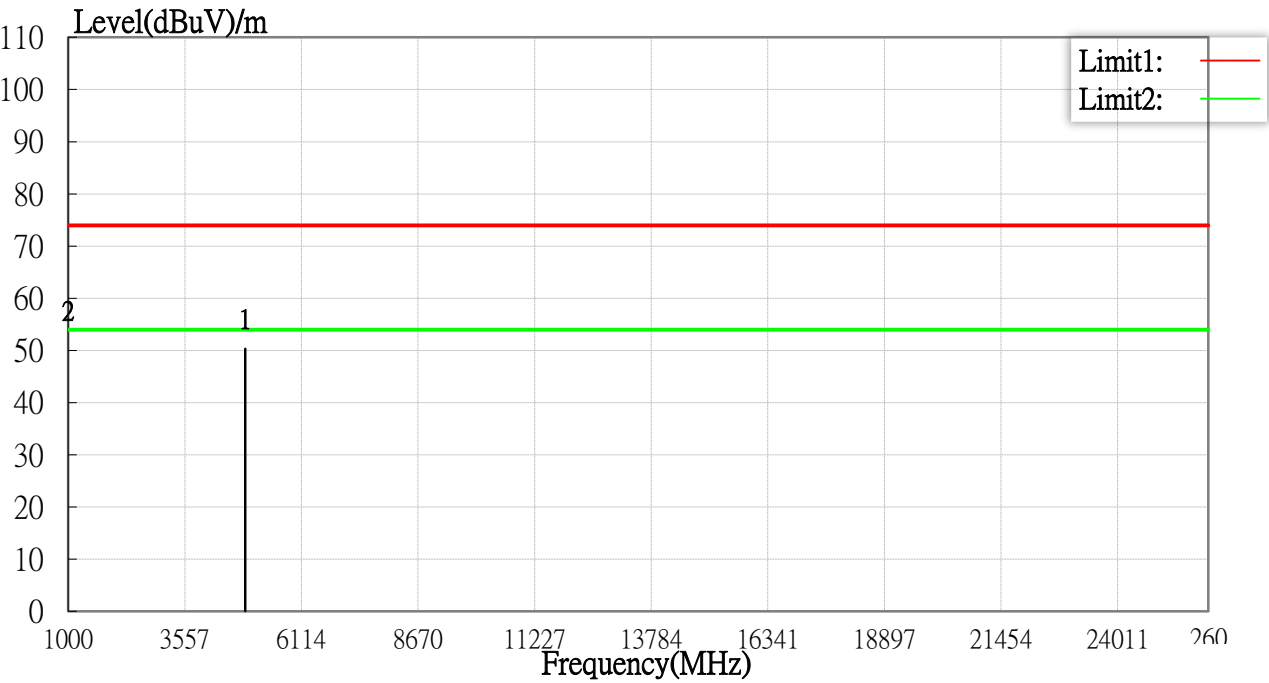
Vertical
Peak



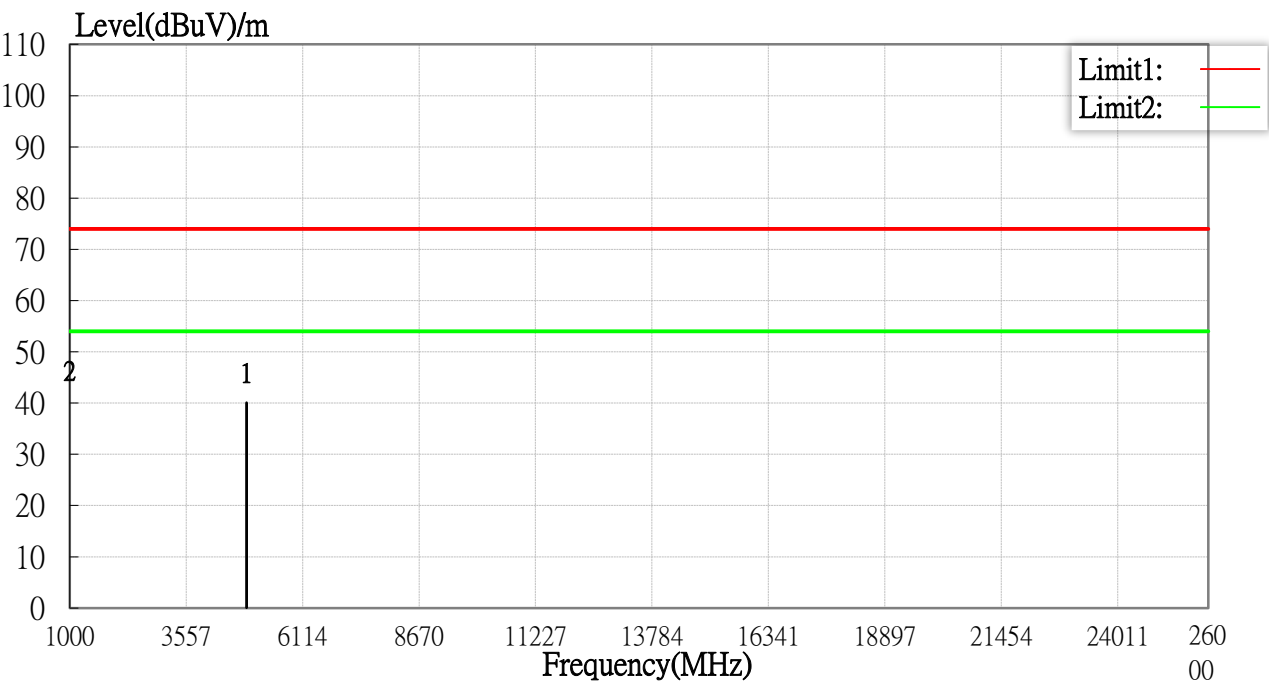
Ave



Middle Channel
Peak

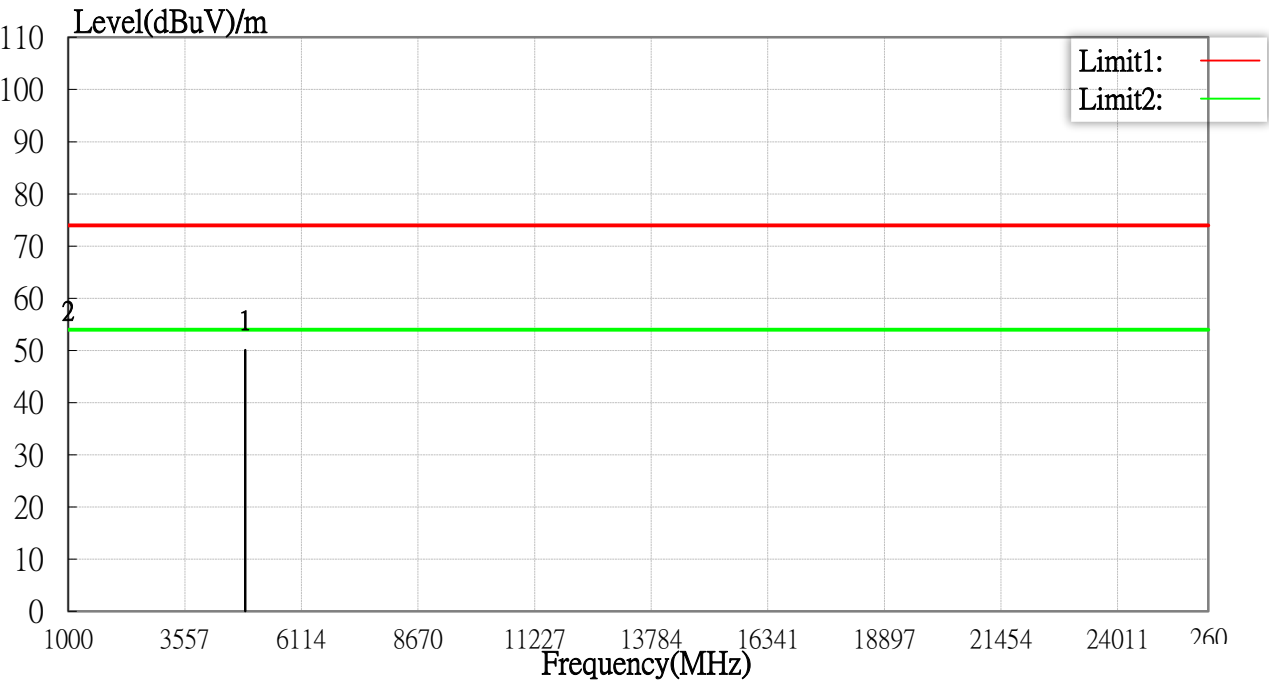


Ave

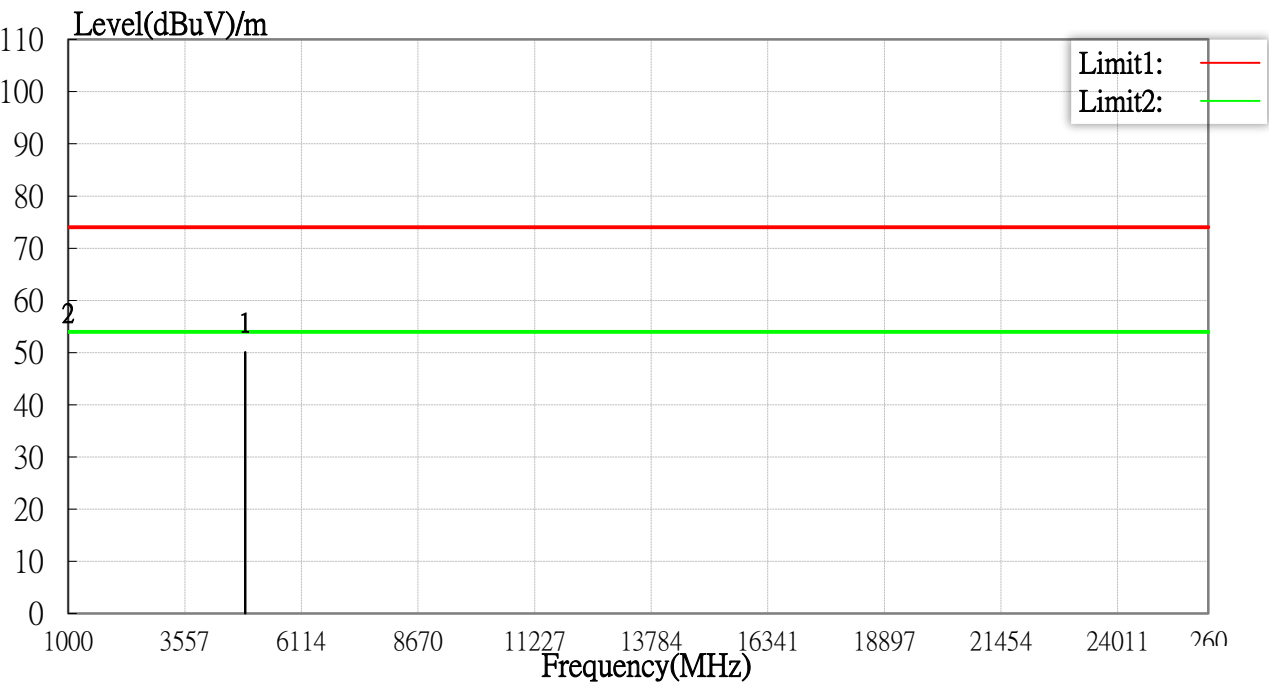


Vertical

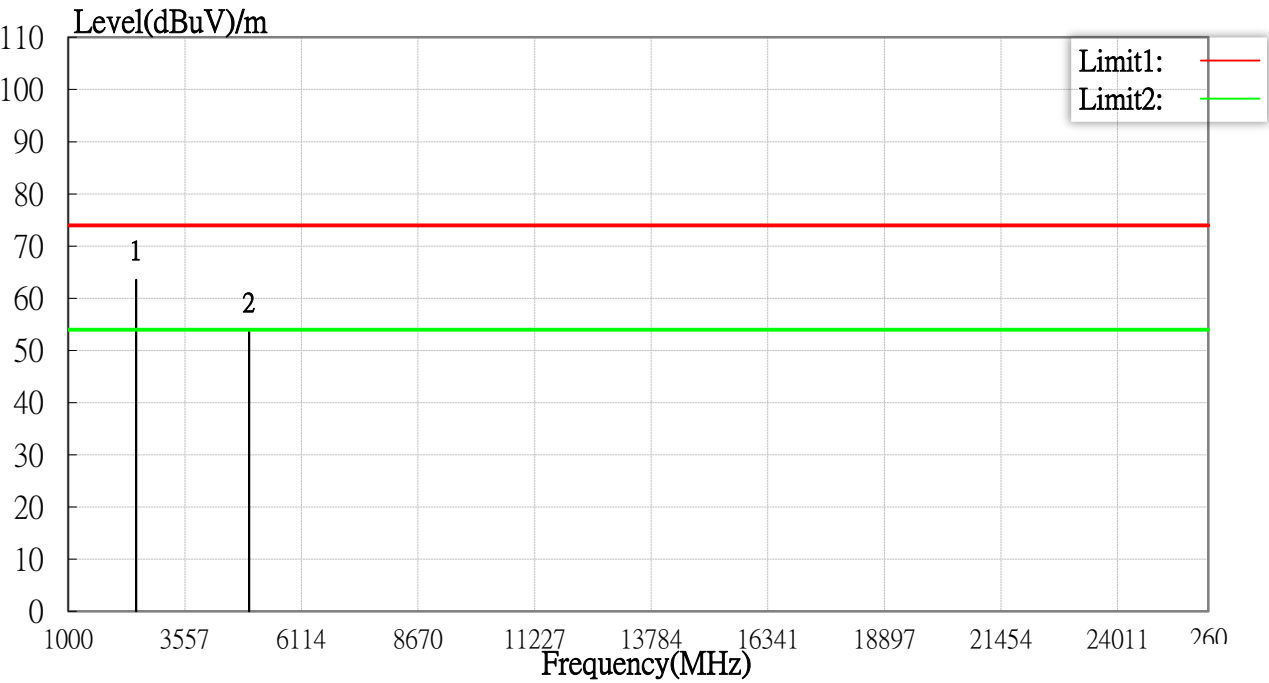
Peak



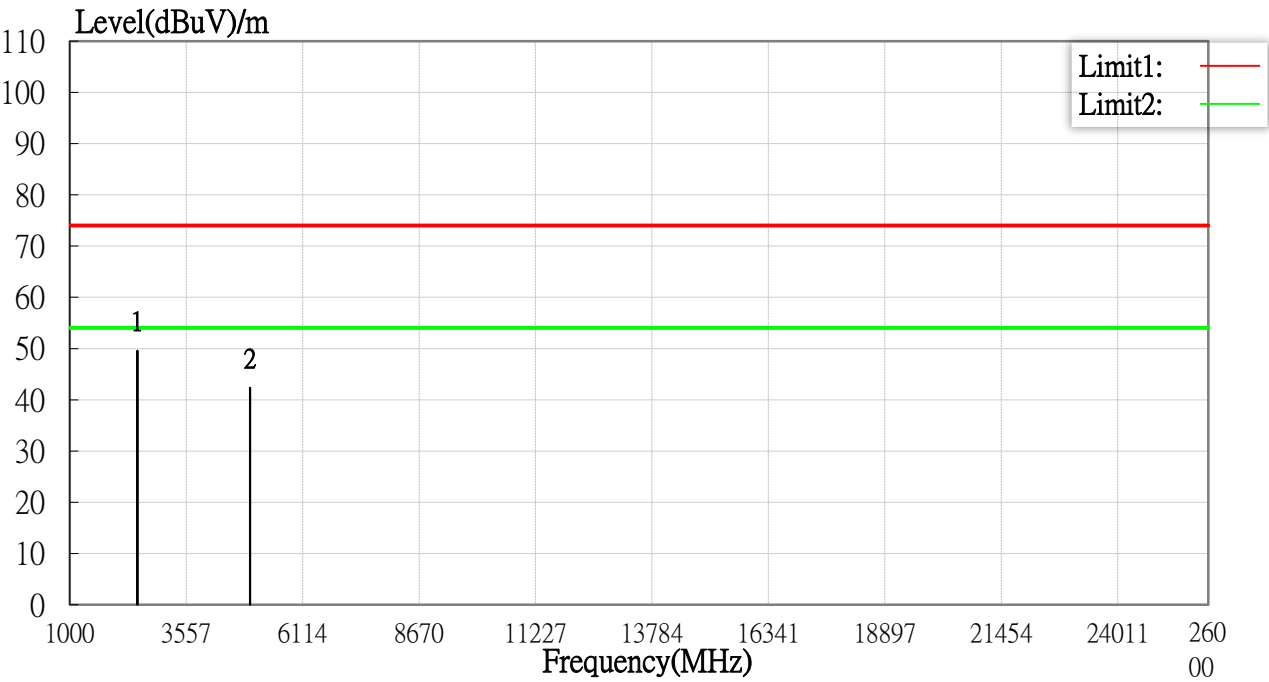
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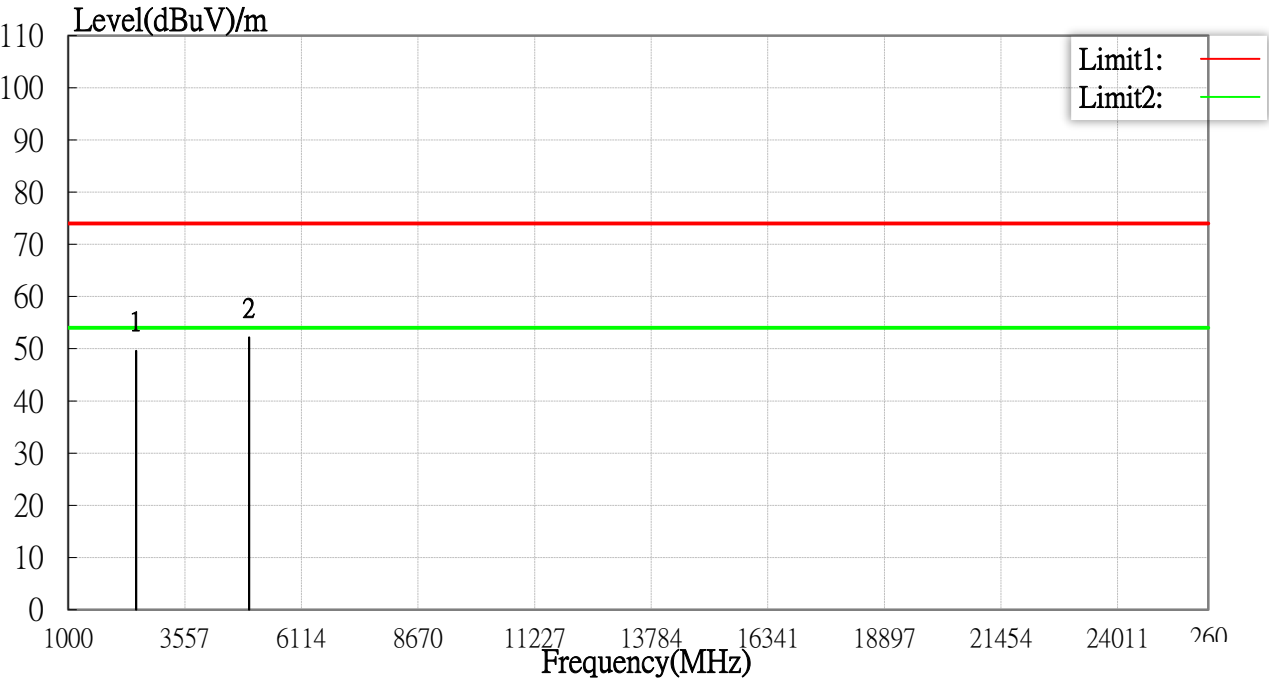
Middle Channel
Horizontal
Peak



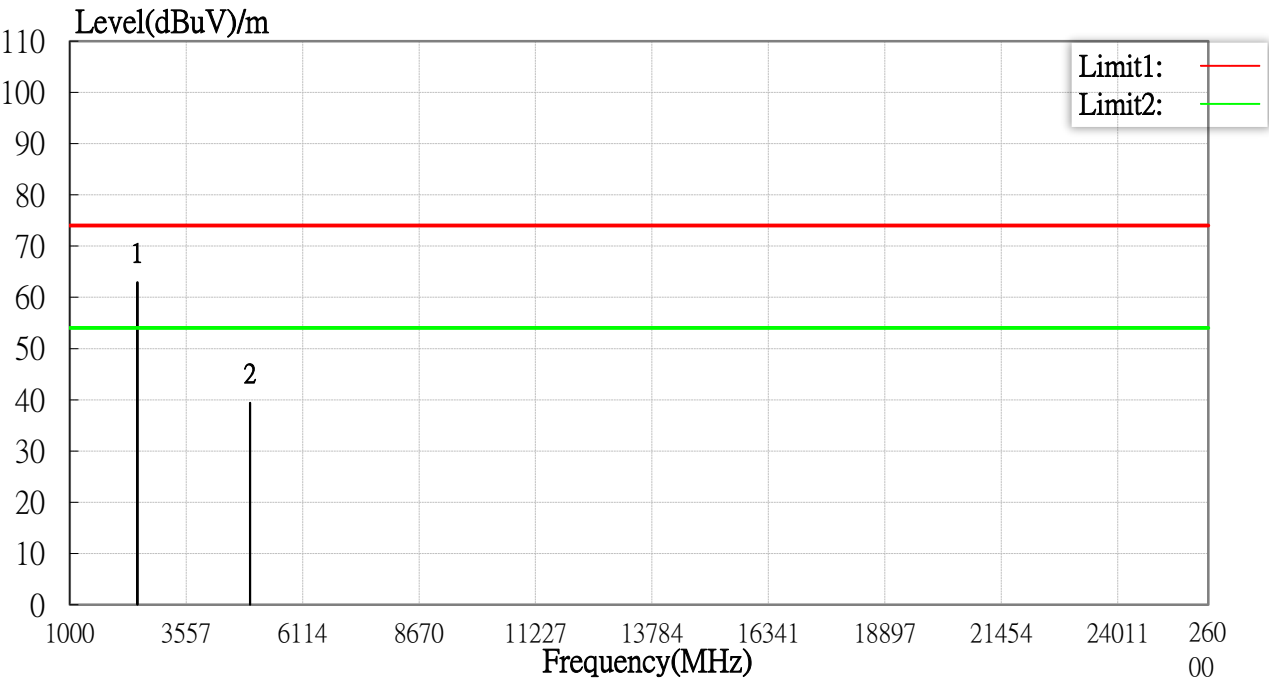
Ave



Vertical
Peak



Ave



8 LP0002-2018 §3.10 - Emission Bandwidth

8.1 Applicable Standards

According to LP0002-2018§3.10: the maximum 20 dB bandwidth of the hopping channel shall be presented.

8.2 Measurement Procedure

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

RBW = 1% to 5 % of the 99% occupied bandwidth or 100k Hz

VBW = 3RBW

Sweep = auto

Detector function = peak

Trace = max hold

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20 dB 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:	22°C
Relative Humidity:	42 %
ATM Pressure:	102.6 KPa

The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

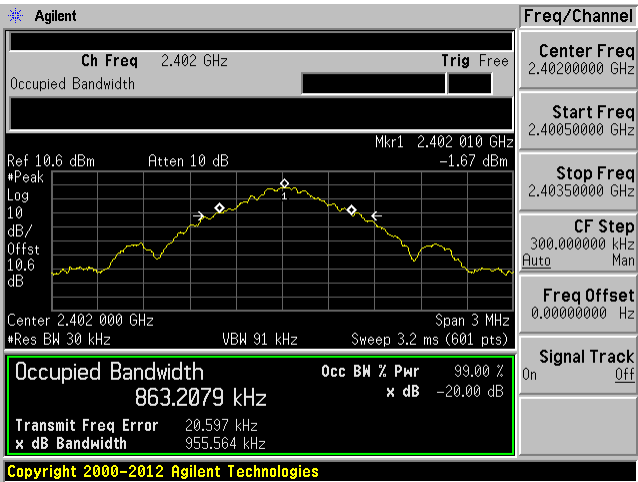
8.5 Test Results

Channel	Frequency (MHz)	99% OBW (kHz)	20 dB OBW (kHz)
GFSK			
Low	2402	863.2	955.6
Middle	2441	866.8	957.7
High	2480	865.5	959.0
$\pi/4$ -DQPSK			
Low	2402	1222.6	1385
Middle	2441	1220.9	1384
High	2480	1219.9	1384
8DPSK			
Low	2402	1223.6	1365
Middle	2441	1224.4	1438
High	2480	1221.8	1364

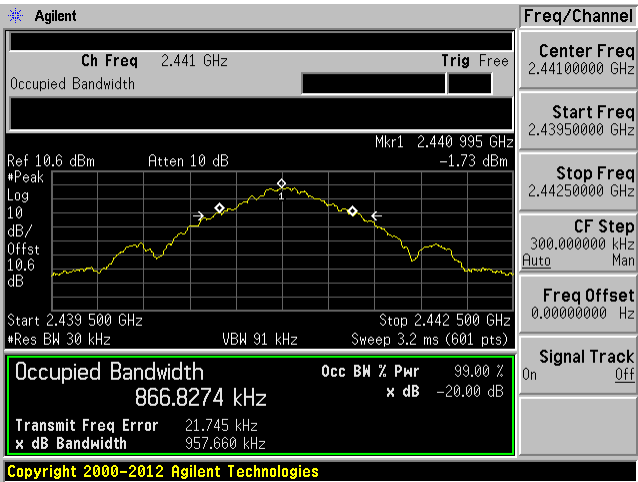
Please refer to the following plots for detailed test results.

GFSK

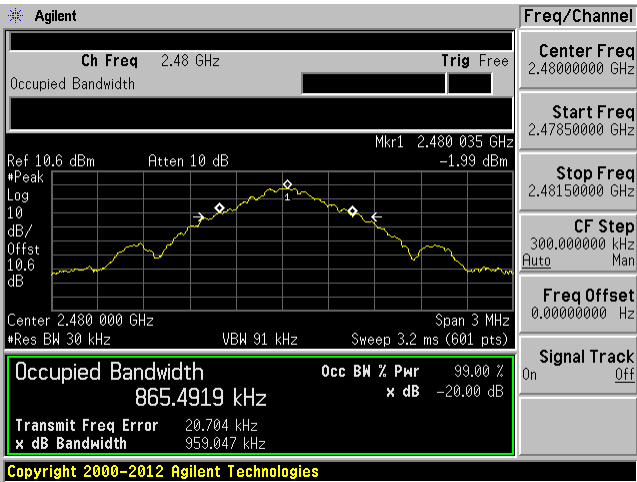
Low Channel 2402 MHz



Middle Channel 2441 MHz

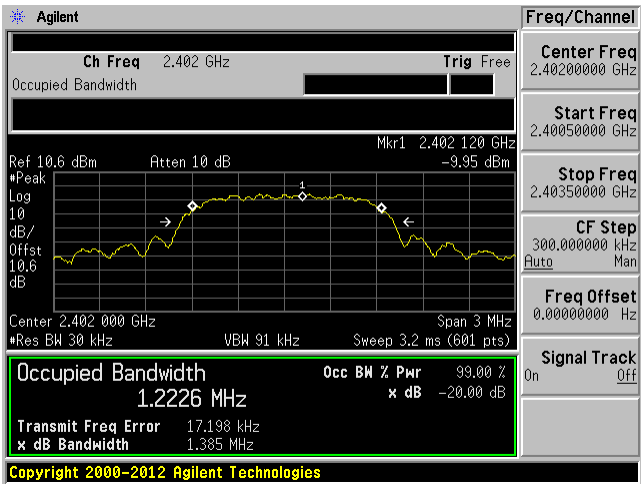


High Channel 2480 MHz

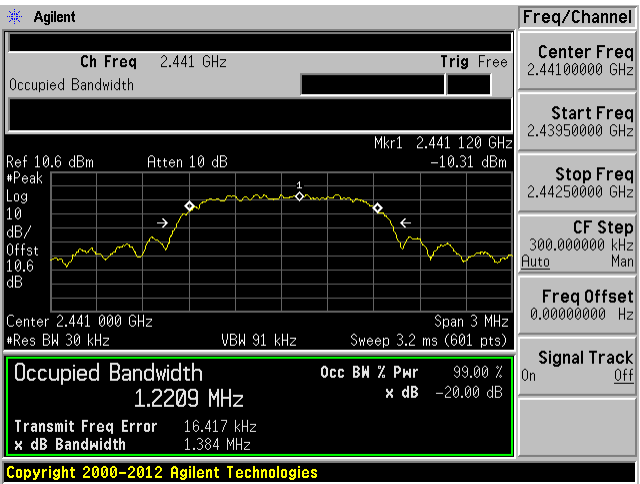


$\pi/4$ -DQPSK

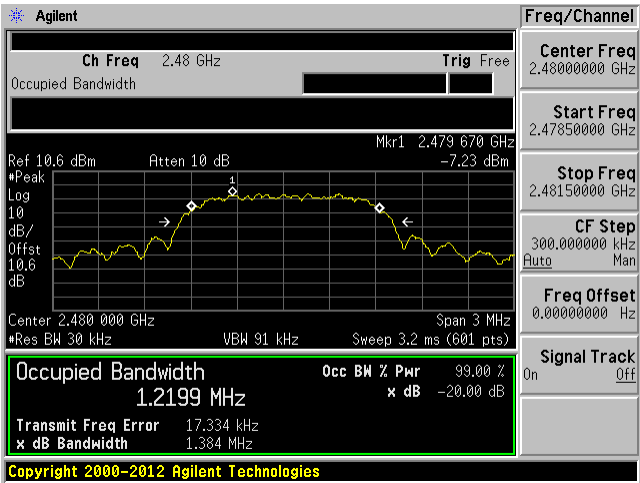
Low Channel 2402 MHz



Middle Channel 2441 MHz

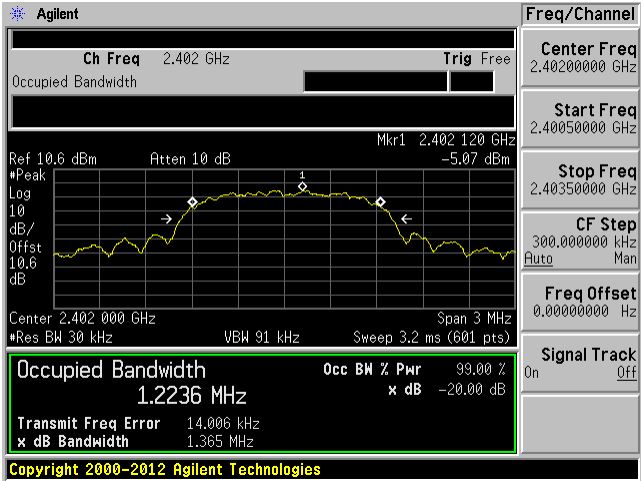


High Channel 2480 MHz

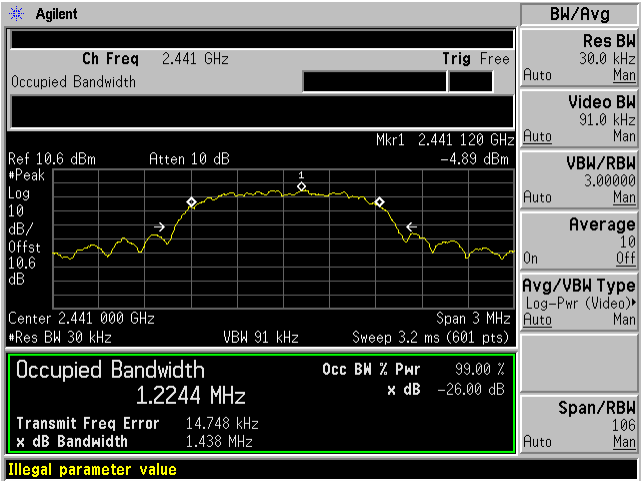


8DPSK

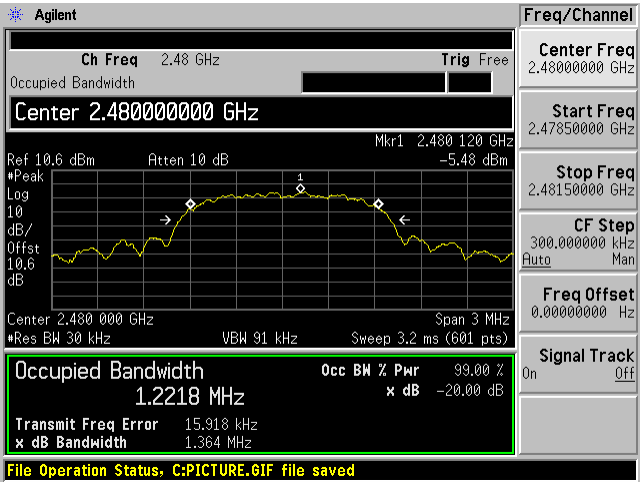
Low Channel 2402 MHz



Middle Channel 2441 MHz



High Channel 2480 MHz



9 LP0002-2018 §3.10 - Output Power

9.1 Applicable Standards

According LP0002-2018§3.10: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz

9.2 Measurement Procedure

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

RBW > the 20 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB 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:	23 °C
Relative Humidity:	42 %
ATM Pressure:	102.9 KPa

The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

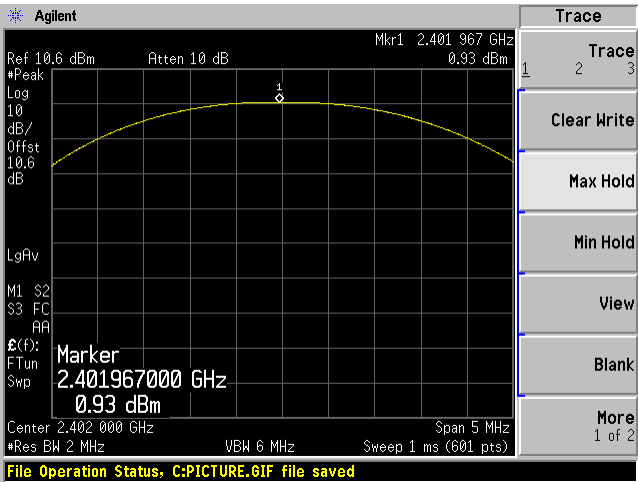
9.5 Test Results

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)
GFSK			
Low	2402	0.93	30
Middle	2441	0.79	30
High	2480	0.36	30
Π/4-DQPSK			
Low	2402	3.39	30
Middle	2441	3.08	30
High	2480	2.79	30
8DPSK			
Low	2402	3.62	30
Middle	2441	3.55	30
High	2480	3.31	30

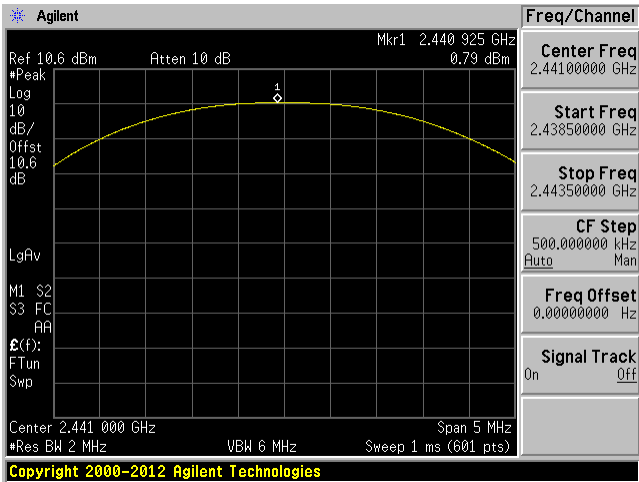
Please refer to the following plots for detailed test results.

GFSK

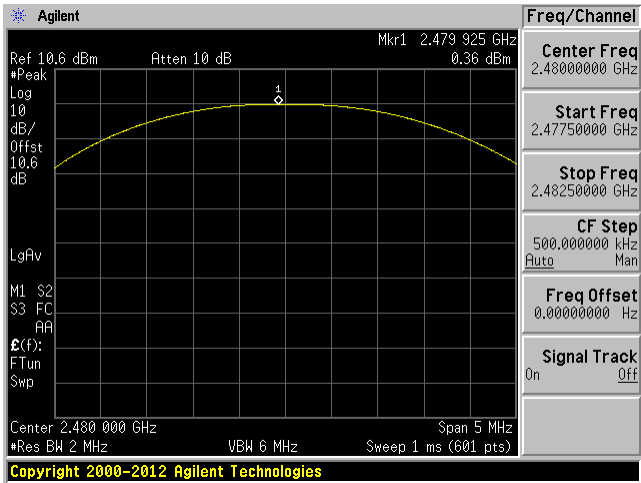
Low Channel 2402 MHz



Middle Channel 2441 MHz

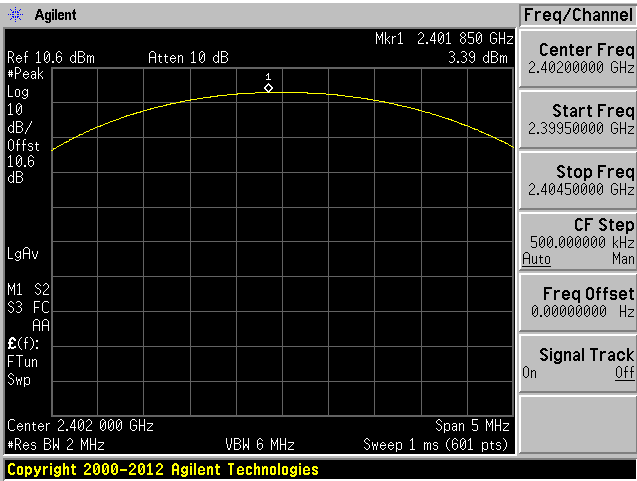


High Channel 2480 MHz

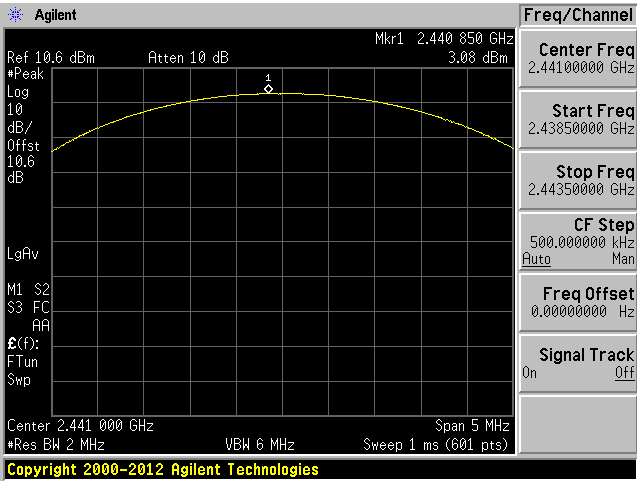


$\pi/4$ -DQPSK

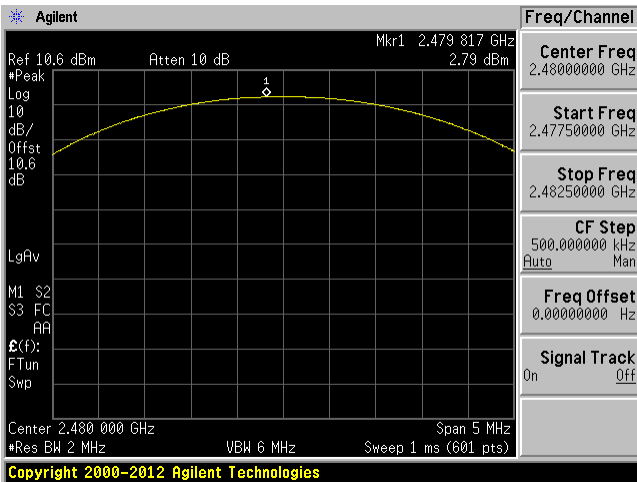
Low Channel 2402 MHz



Middle Channel 2441 MHz

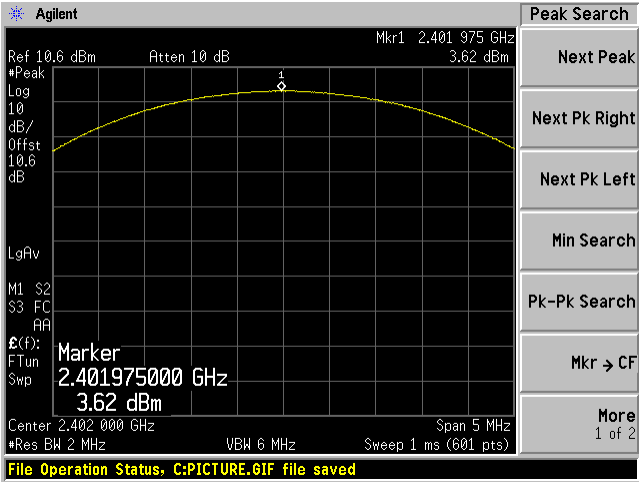


High Channel 2480 MHz

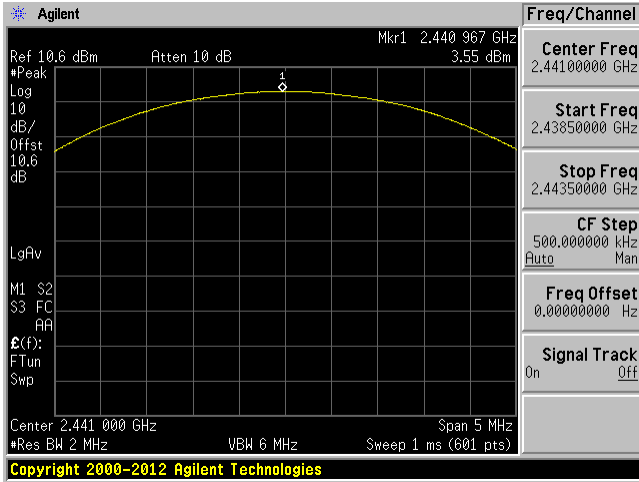


8DPSK

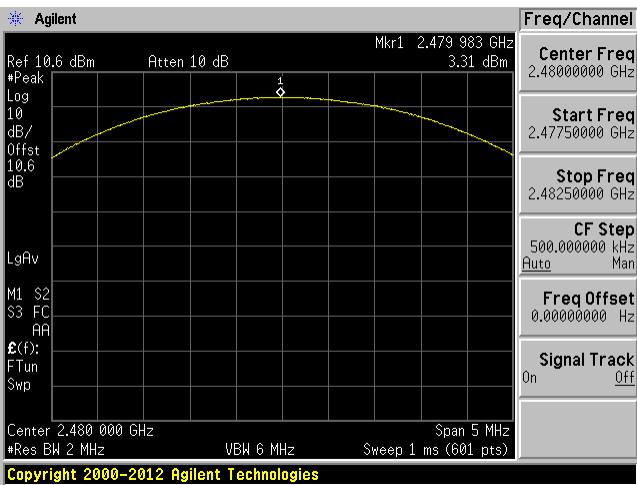
Low Channel 2402 MHz



Middle Channel 2441 MHz



High Channel 2480 MHz



10 LP0002-2018 §3.10 - 100 kHz Bandwidth of Band Edges

10.1 Applicable Standards

According to LP0002-2018§3.10, 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.

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

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	10 dB 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

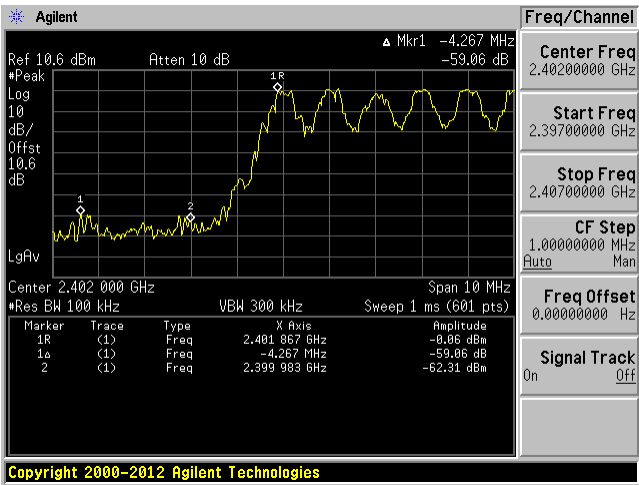
Temperature:	22 °C
Relative Humidity:	42 %
ATM Pressure:	102.6 KPa

The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

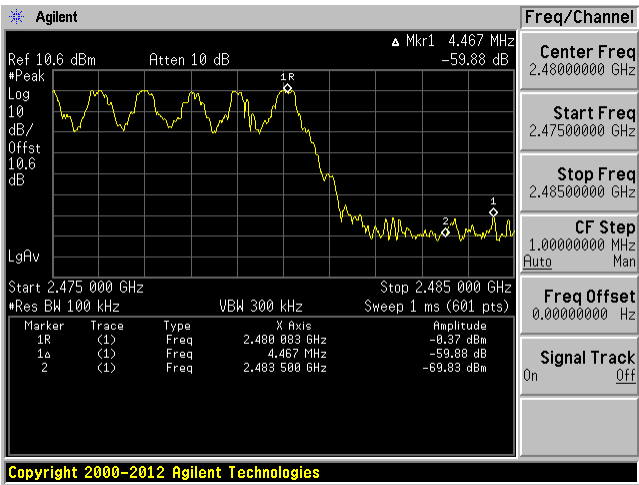
10.5 Test Results

Hopping Mode
GFSK

Low Channel 2402 MHz

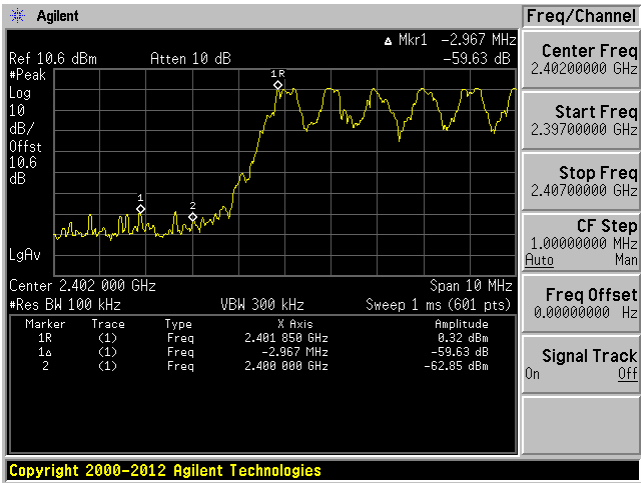


High Channel 2480 MHz

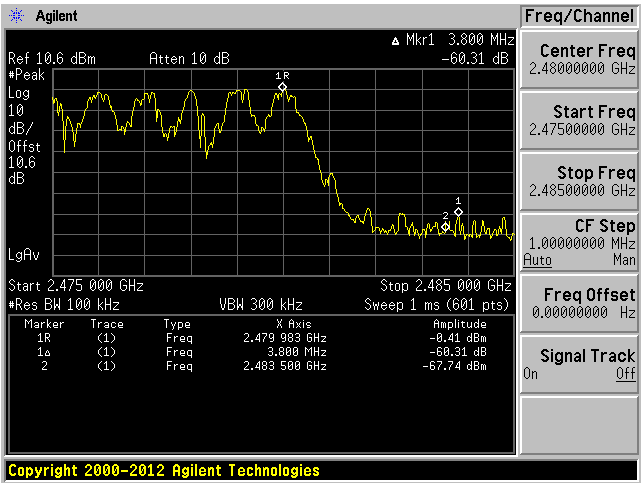


$\pi/4$ -DQPSK

Low Channel 2402 MHz

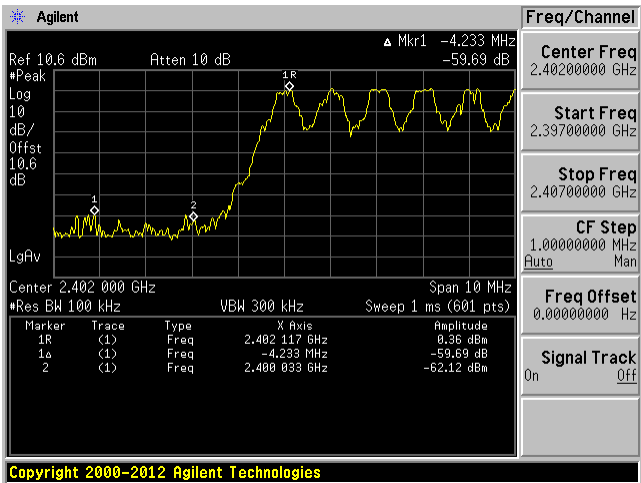


High Channel 2480 MHz

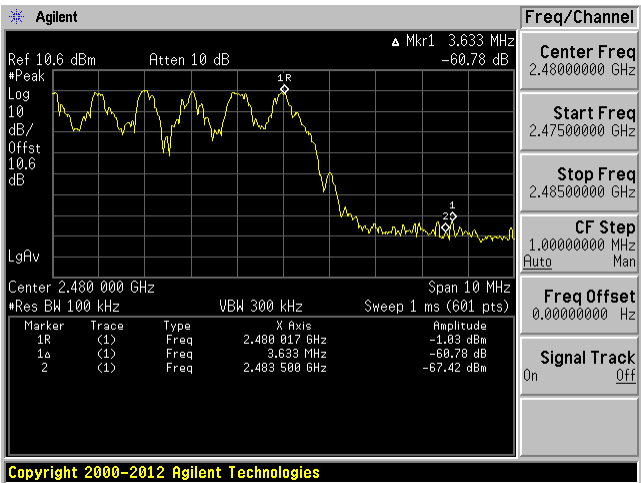


8DPSK

Low Channel 2402 MHz

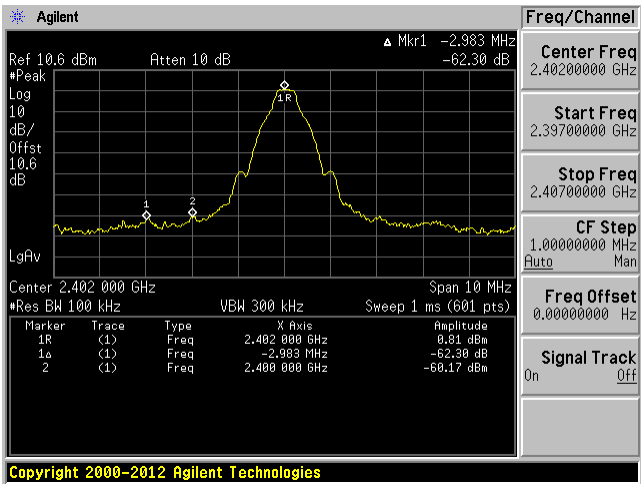


High Channel 2480 MHz

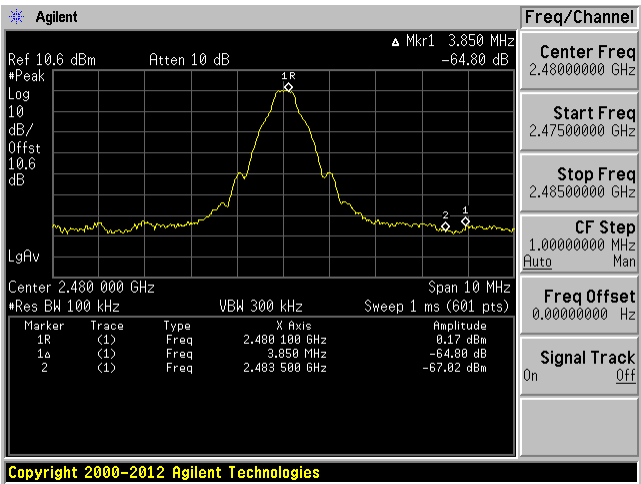


Hopping Mode OFF
GFSK

Low Channel 2402 MHz

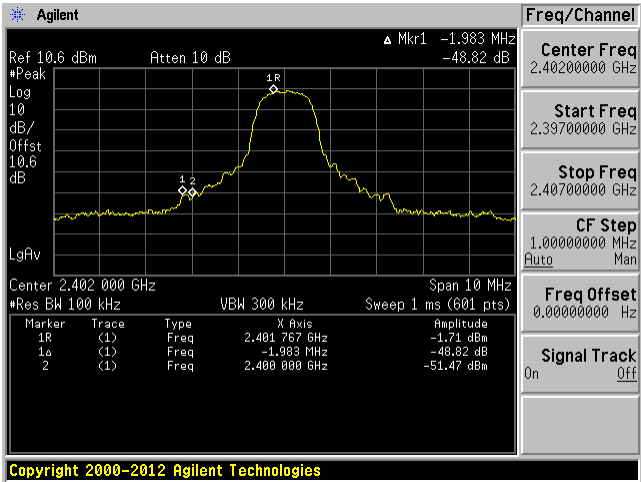


High Channel 2480 MHz

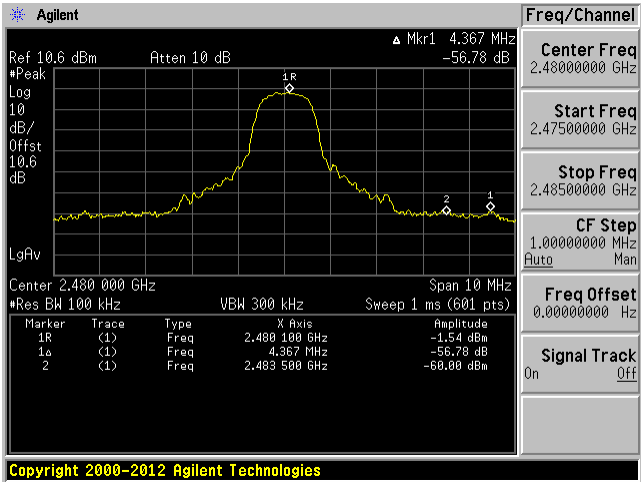


$\pi/4$ -DQPSK

Low Channel 2402 MHz

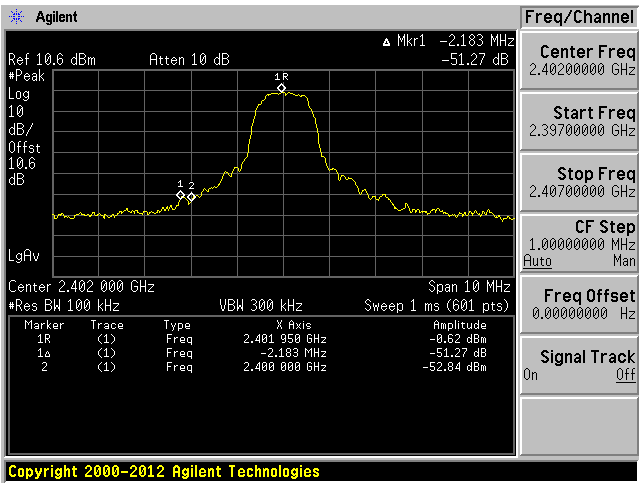


High Channel 2480 MHz

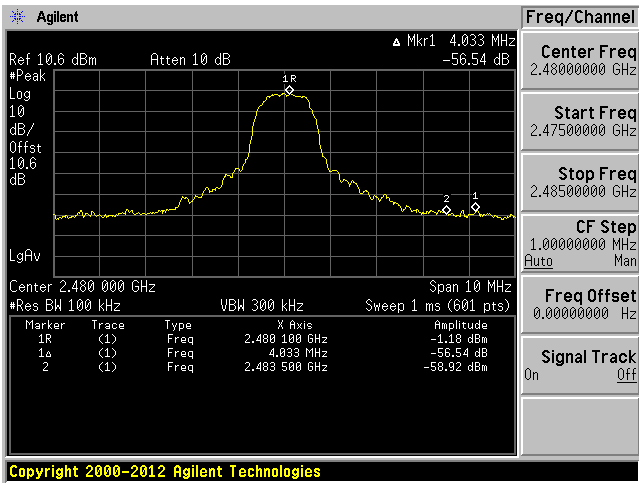


8DPSK

Low Channel 2402 MHz



High Channel 2480 MHz



11 LP0002-2018 §3.10 - Dwell Time

11.1 Applicable Standards

According to LP0002-2018§3.10, Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

11.2 Measurement Procedure

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

Span = zero span, centered on a hopping channel

RBW $\leq$ channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel

Sweep = as necessary to capture the entire dwell time per hopping channel

Detector function = peak

Trace = max hold

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

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements.

Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

$$\begin{aligned} &(\text{Number of hops in the period specified in the requirements}) = \\ &(\text{number of hops on spectrum analyzer}) \times (\text{period specified in the requirements} / \text{analyzer sweep time}) \end{aligned}$$

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

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	10 dB 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:	22 °C
Relative Humidity:	42 %
ATM Pressure:	102.5 KPa

The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

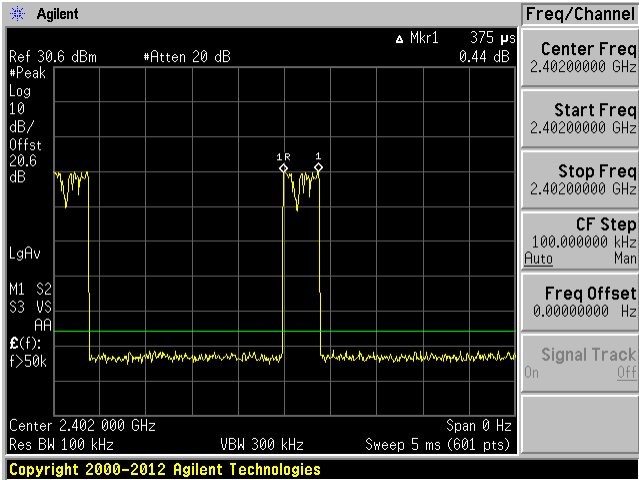
11.5 Test Results

Mode		Channel	Pulse Width (ms)	Dwell Time(s)	Limit(s)	Result
BDR (GFSK)	DH1	Low	0.375	0.120	0.4	Pass
		Middle	0.375	0.120	0.4	Pass
		High	0.375	0.120	0.4	Pass
		Note: DH1: Dwell time = Pulse time*(1600/2/79)*31.6				
	DH3	Low	1.633	0.261	0.4	Pass
		Middle	1.617	0.259	0.4	Pass
		High	1.633	0.261	0.4	Pass
		Note: DH3: Dwell time = Pulse time*(1600/4/79) *31.6				
	DH5	Low	2.867	0.306	0.4	Pass
		Middle	2.9	0.309	0.4	Pass
		High	2.867	0.306	0.4	Pass
		Note: DH5: Dwell time = Pulse time*(1600/6/79) *31.6				
EDR ($\pi/4$ -DQPSK)	2DH1	Low	0.383	0.123	0.4	Pass
		Middle	0.383	0.123	0.4	Pass
		High	0.392	0.125	0.4	Pass
		Note: DH1: Dwell time = Pulse time*(1600/2/79) *31.6				
	2DH3	Low	1.65	0.264	0.4	Pass
		Middle	1.65	0.264	0.4	Pass
		High	1.633	0.261	0.4	Pass
		Note: DH3: Dwell time = Pulse time*(1600/4/79) *31.6				
	2DH5	Low	2.867	0.306	0.4	Pass
		Middle	2.867	0.306	0.4	Pass
		High	2.9	0.309	0.4	Pass
		Note: DH5: Dwell time = Pulse time*(1600/6/79) *31.6				
EDR (8DPSK)	3DH1	Low	0.4	0.128	0.4	Pass
		Middle	0.392	0.125	0.4	Pass
		High	0.392	0.125	0.4	Pass
		Note: DH1: Dwell time = Pulse time*(1600/2/79) *31.6				
	3DH3	Low	1.65	0.264	0.4	Pass
		Middle	1.65	0.264	0.4	Pass
		High	1.633	0.261	0.4	Pass
		Note: DH3: Dwell time = Pulse time*(1600/4/79) *31.6				
	3DH5	Low	2.9	0.309	0.4	Pass
		Middle	2.9	0.309	0.4	Pass
		High	2.9	0.309	0.4	Pass
		Note: DH5: Dwell time = Pulse time*(1600/6/79) *31.6				

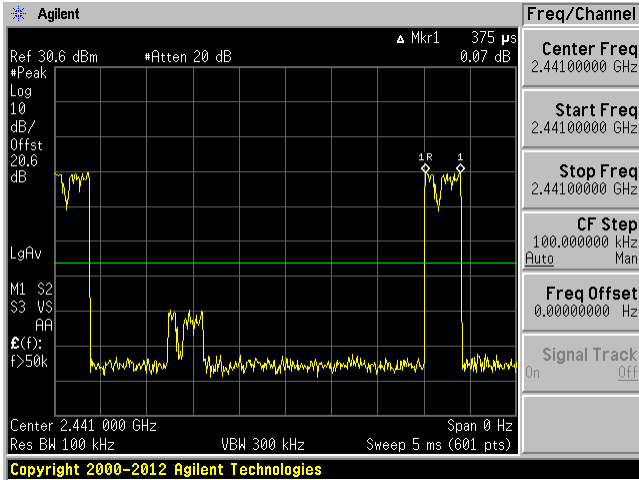
Please refer to the following plots for detailed test results.

GFSK, DH1 Pulse Width

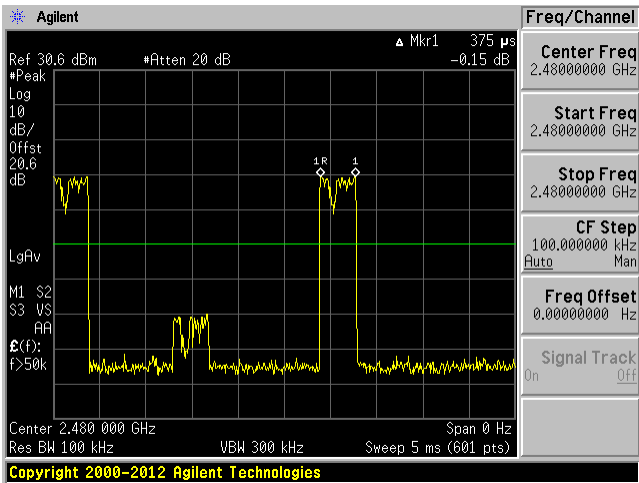
Low Channel 2402 MHz



Middle Channel 2441 MHz

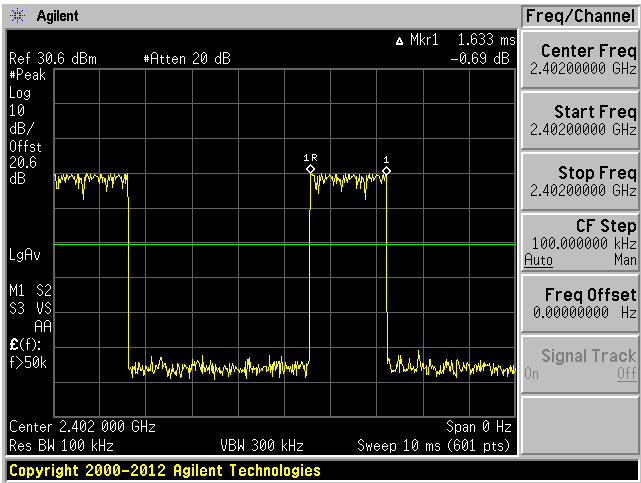


High Channel 2480 MHz

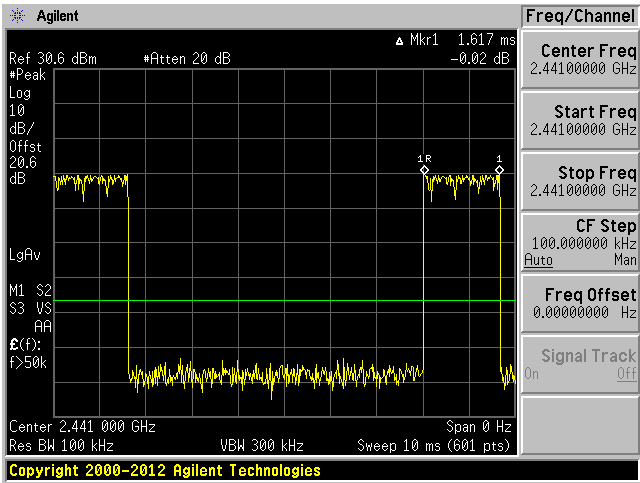


GFSK, DH3 Pulse Width

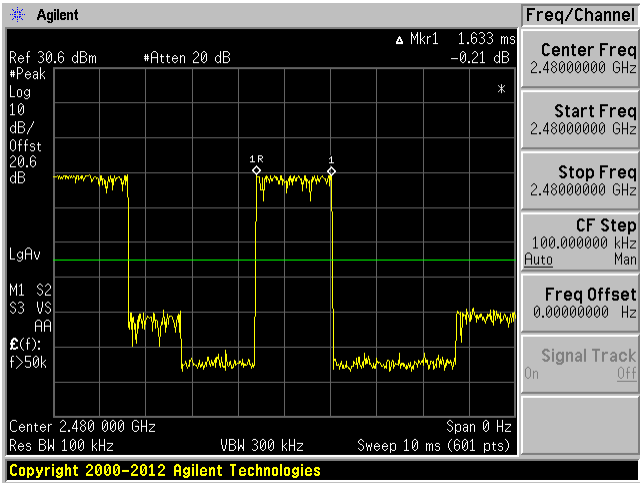
Low Channel 2402 MHz



Middle Channel 2441 MHz

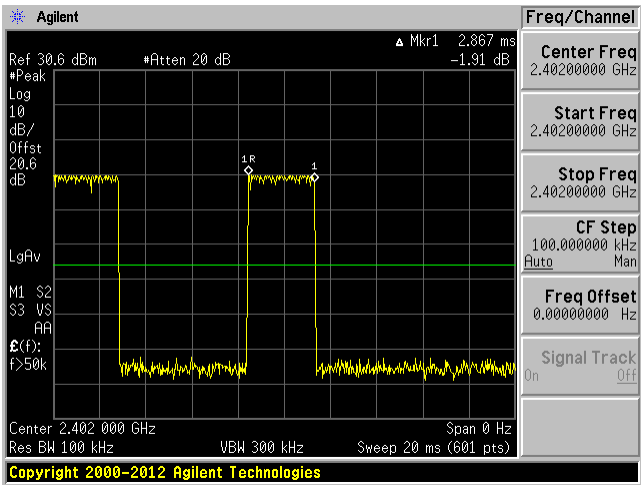


High Channel 2480 MHz

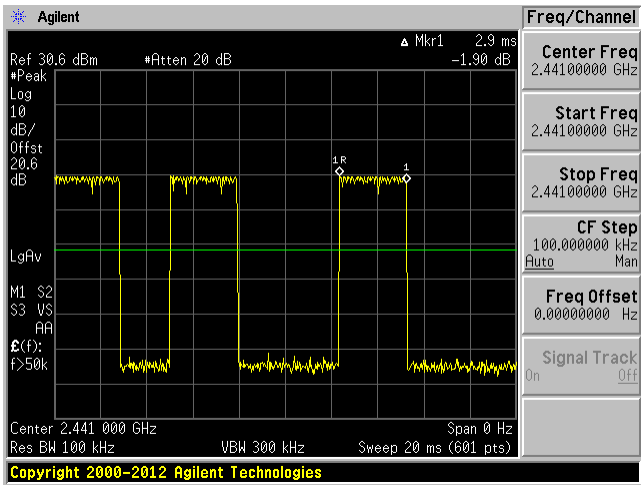


GFSK, DH5 Pulse Width

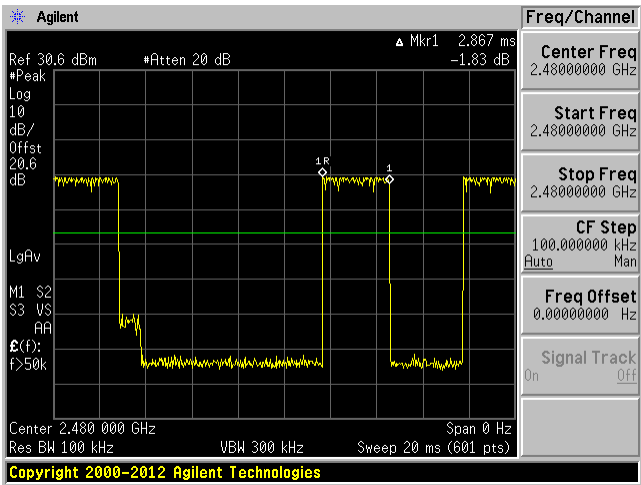
Low Channel 2402 MHz



Middle Channel 2441 MHz

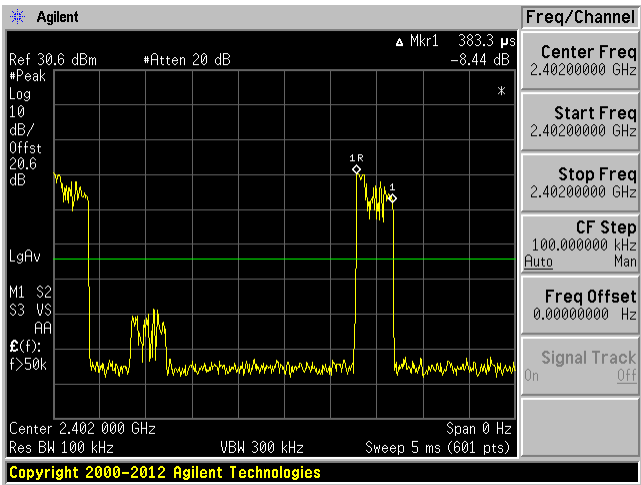


High Channel 2480 MHz

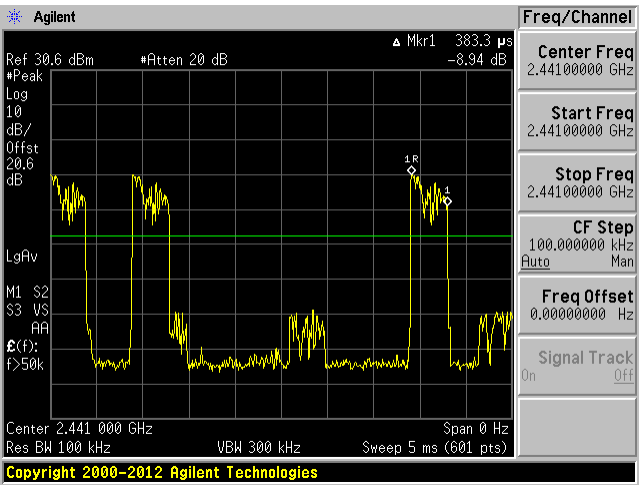


Π/4-DQPSK, DH1 Pulse Width

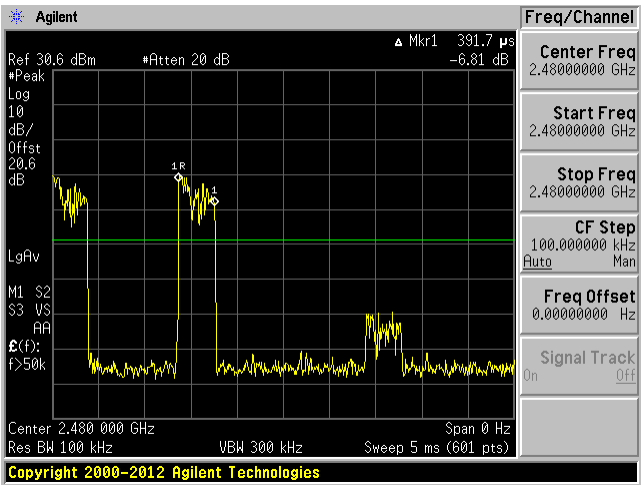
Low Channel 2402 MHz



Middle Channel 2441 MHz

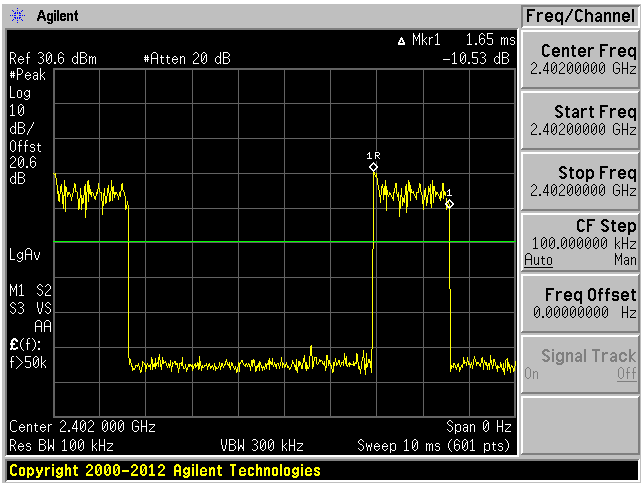


High Channel 2480 MHz

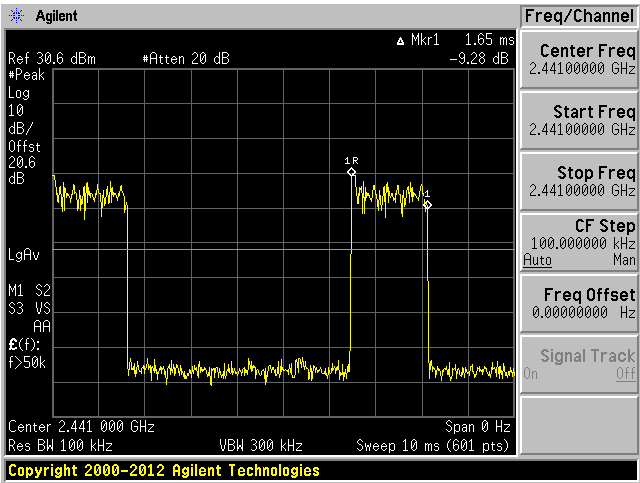


II/4-DQPSK, DH3 Pulse Width

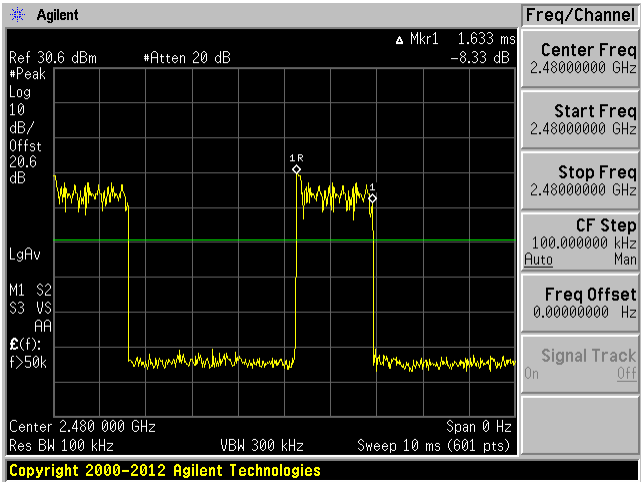
Low Channel 2402 MHz



Middle Channel 2441 MHz

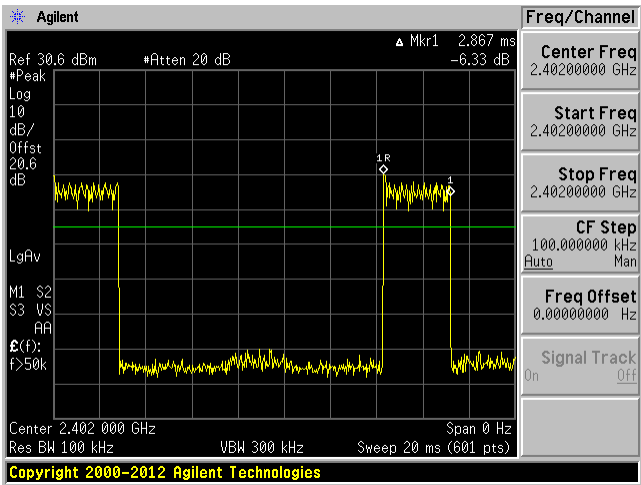


High Channel 2480 MHz

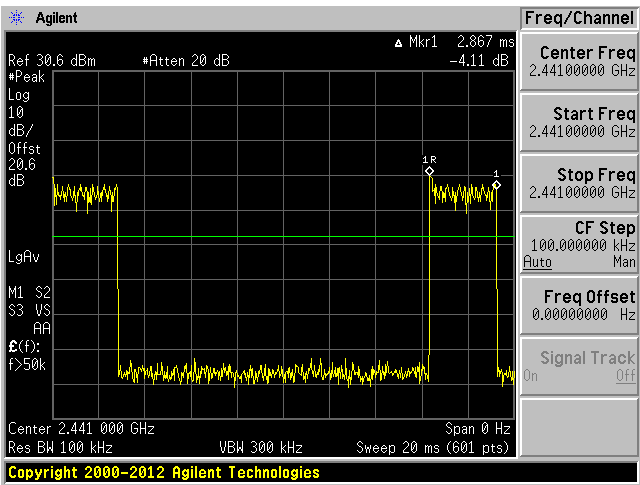


Π/4-DQPSK, DH5 Pulse Width

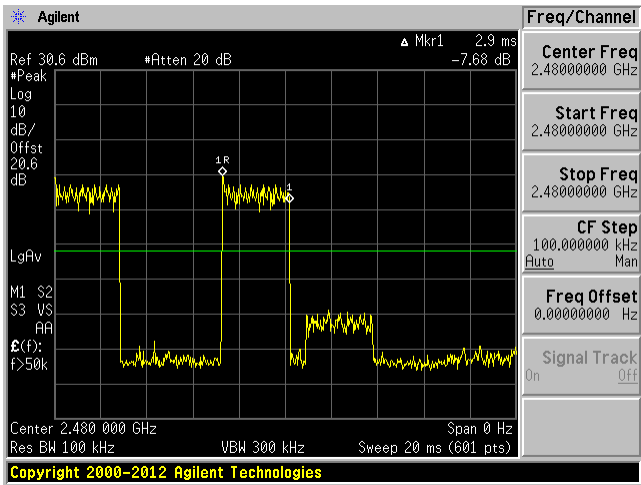
Low Channel 2402 MHz



Middle Channel 2441 MHz

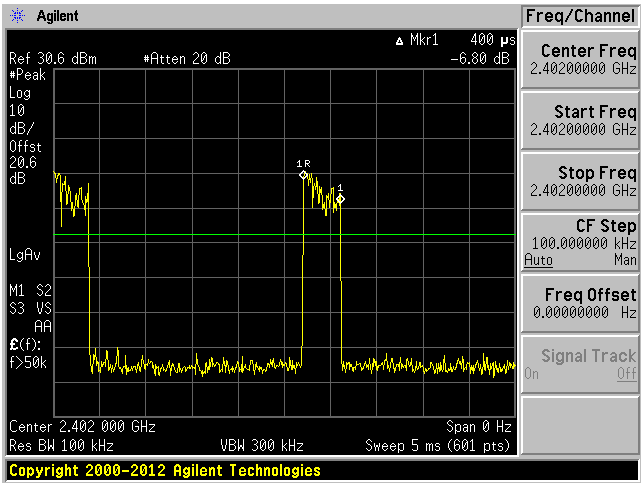


High Channel 2480 MHz

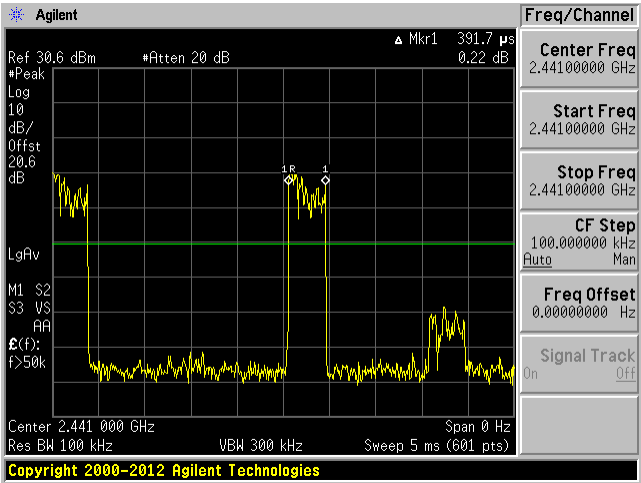


8DPSK, DH1 Pulse Width

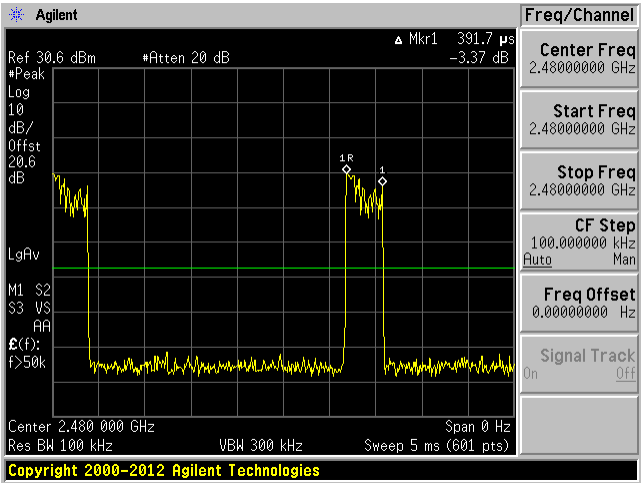
Low Channel 2402 MHz



Middle Channel 2441 MHz

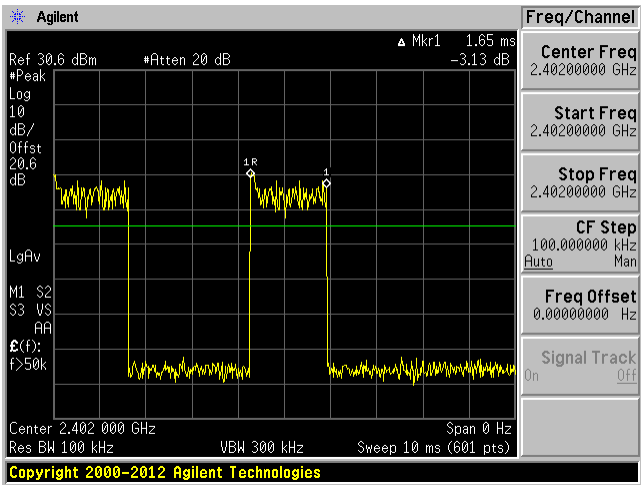


High Channel 2480 MHz

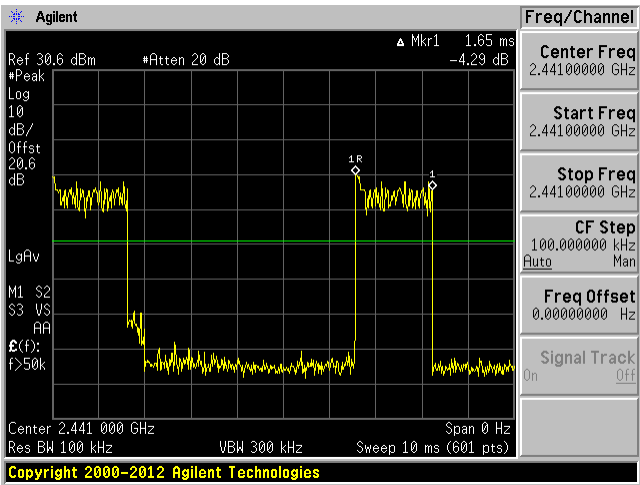


8DPSK, DH3 Pulse Width

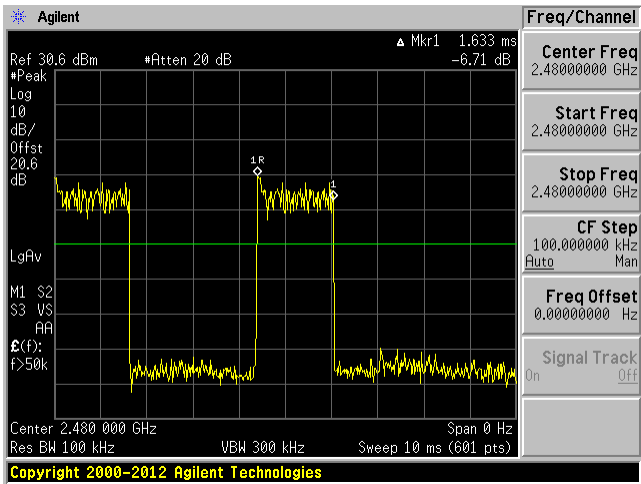
Low Channel 2402 MHz



Middle Channel 2441 MHz

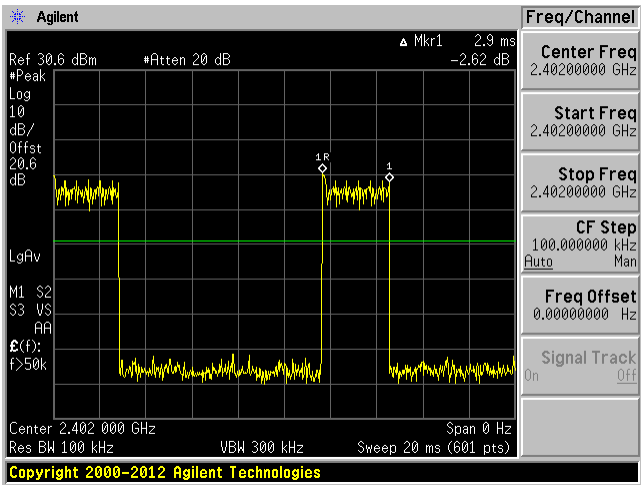


High Channel 2480 MHz

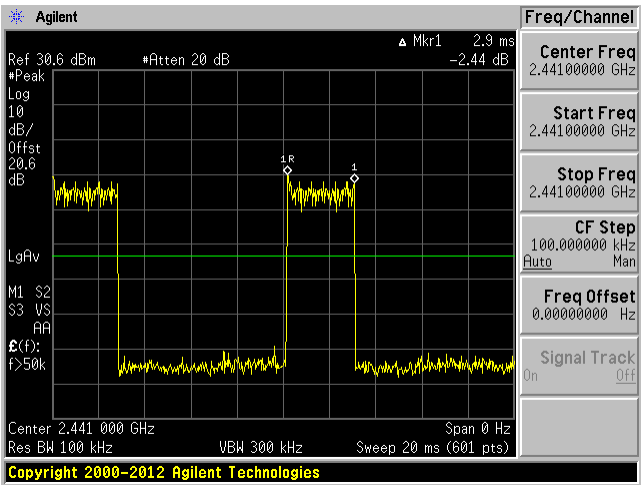


8DPSK, DH5 Pulse Width

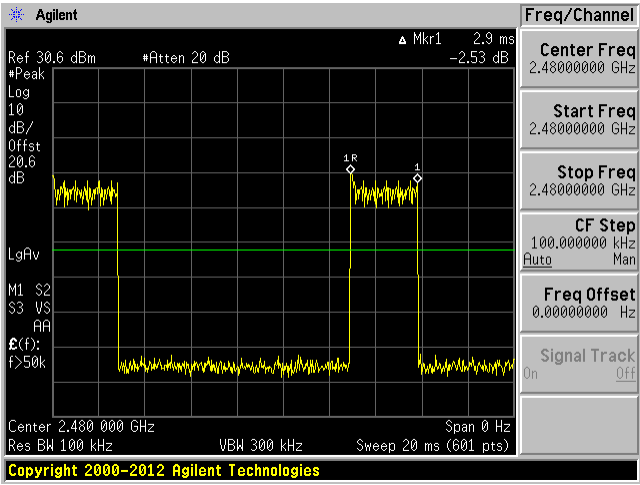
Low Channel 2402 MHz



Middle Channel 2441 MHz



High Channel 2480 MHz



12 LP0002-2018 §3.10 - Number of Hopping Channels

12.1 Applicable Standards

According to LP0002-2018 §3.10: Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

12.2 Test Procedure

Span = the frequency band of operation

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

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

12.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	10 dB 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.*

12.4 Test Environmental Conditions

Temperature:	23 °C
Relative Humidity:	42 %
ATM Pressure:	102.5 KPa

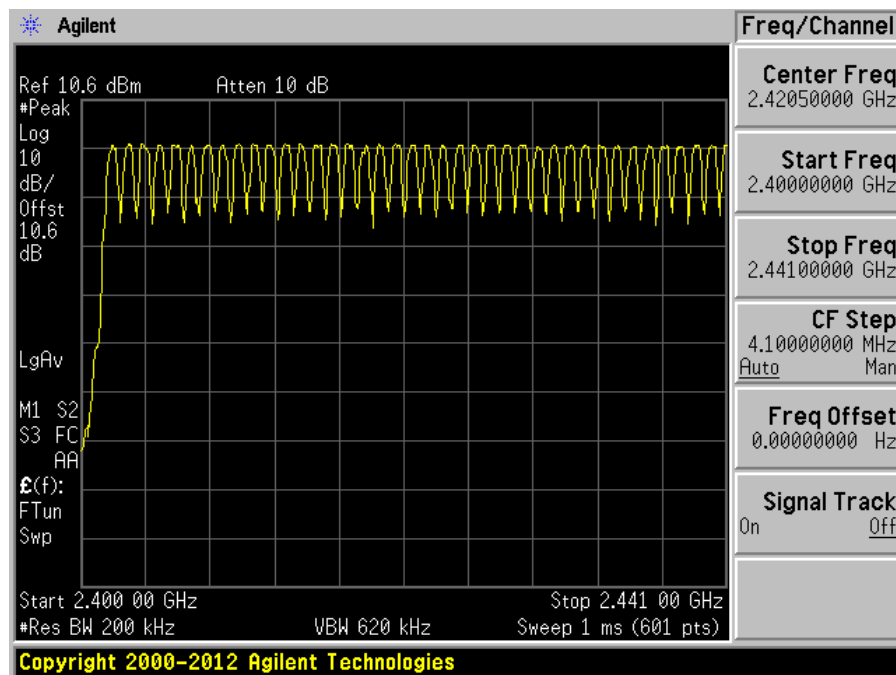
The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

12.5 Test Results

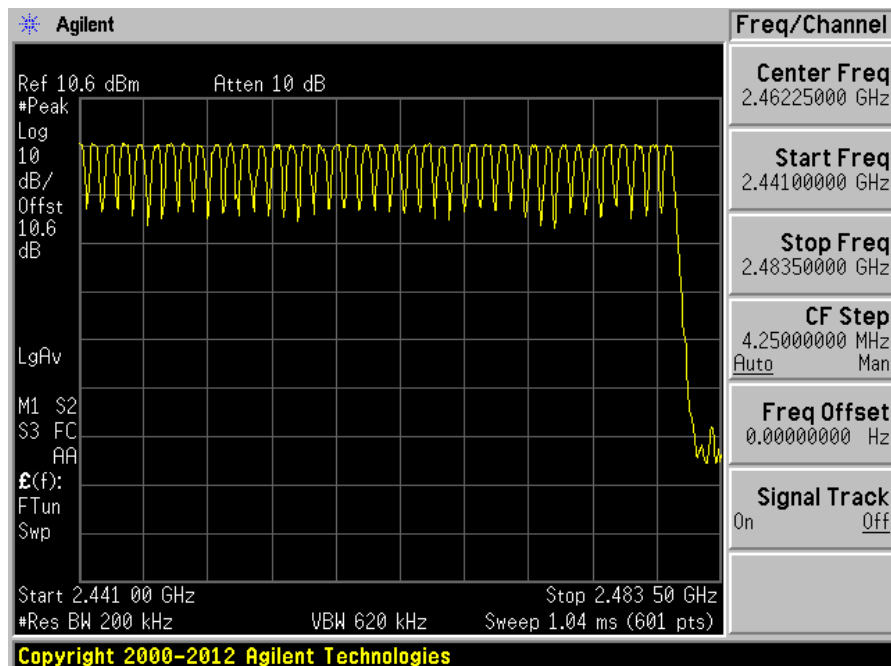
Total 79 channels; please refer to the plots hereinafter.

GFSK

39 Channels between 2400 to 2441 MHz

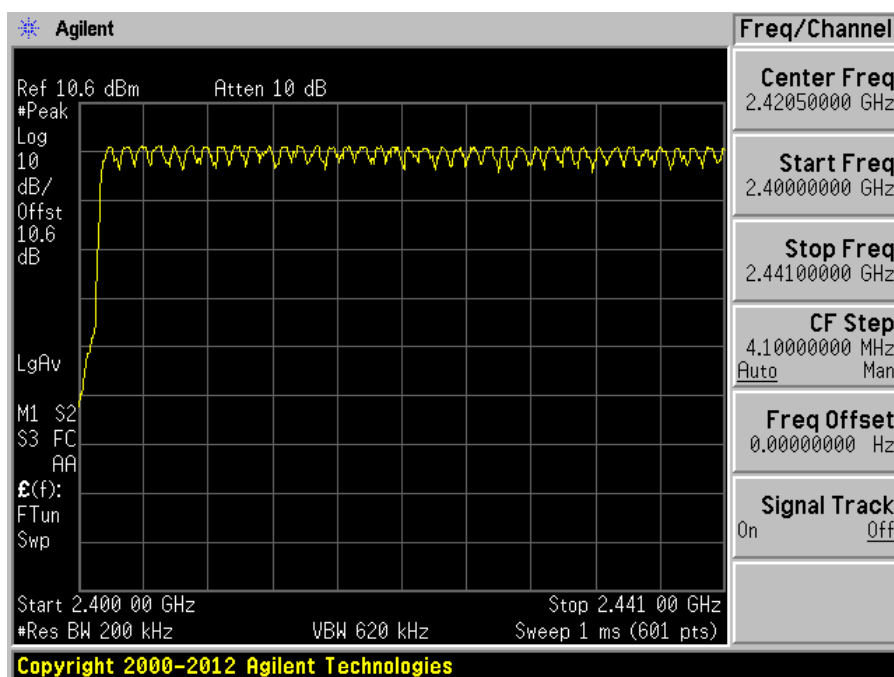


40 Channels between 2441 to 2483.5 MHz

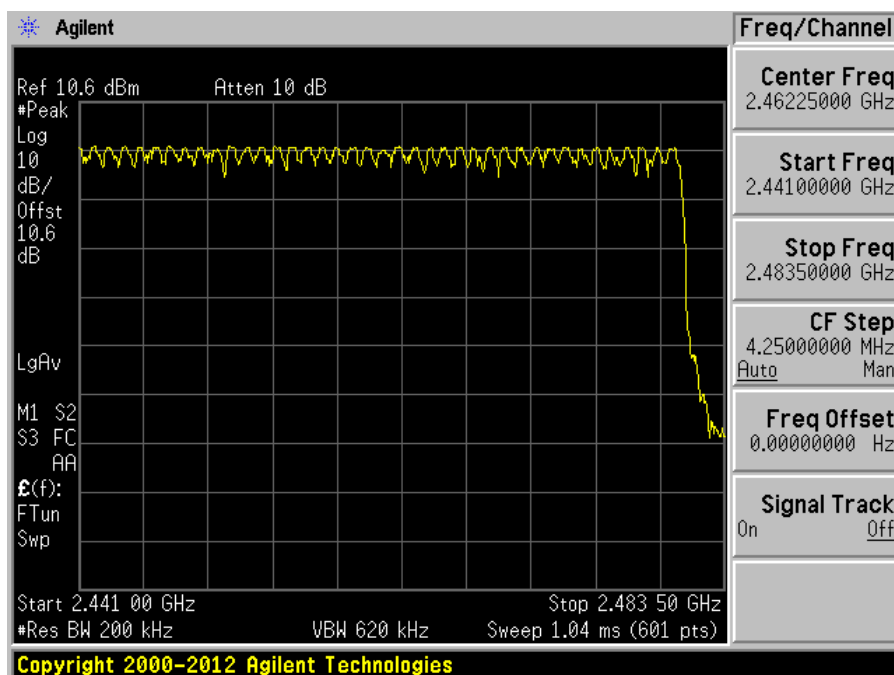


$\pi/4$ -DQPSK

39 Channels between 2400 to 2441 MHz

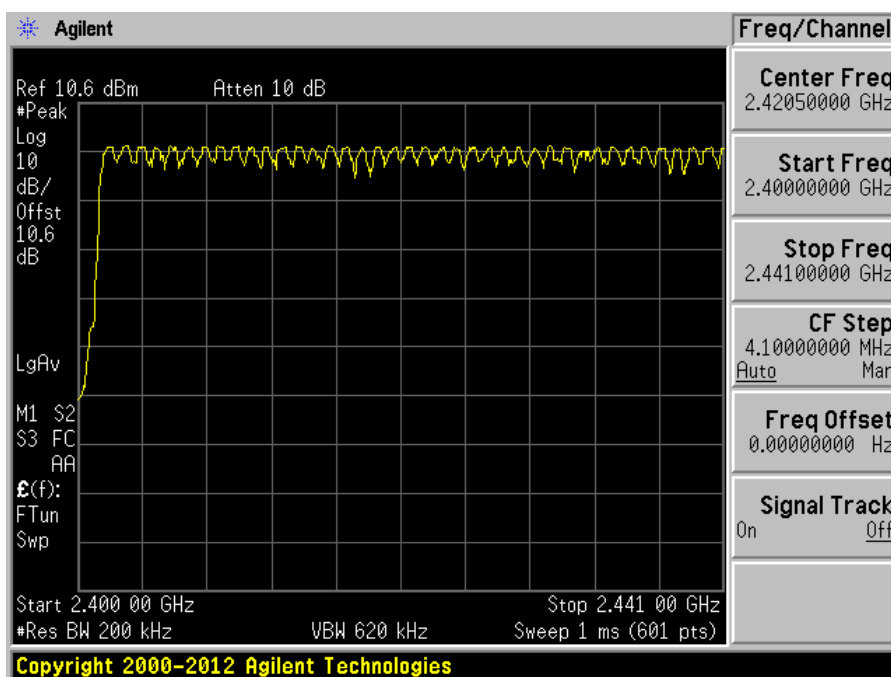


40 Channels between 2441 to 2483.5 MHz

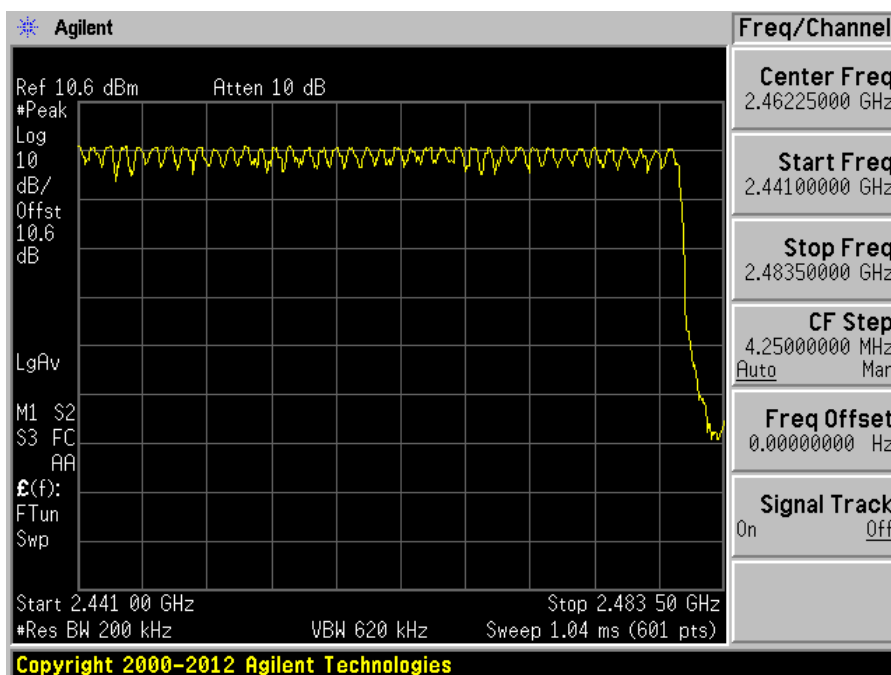


8DPSK

39 Channels between 2400 to 2441 MHz



40 Channels between 2441 to 2483.5 MHz



13 LP0002-2018 §3.10 - Hopping Channel Separation

13.1 Applicable Standards

According to LP0002-2018 §3.10: Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

13.2 Test Procedure

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

Resolution (or IF) Bandwidth (RBW) $\approx$ 30% of the channel spacing, adjust as necessary to best identify the center of each individual channel

Video (or Average) Bandwidth (VBW) $\geq$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

13.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB 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.

13.4 Test Environmental Conditions

Temperature:	23 °C
Relative Humidity:	42 %
ATM Pressure:	102.5 KPa

The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

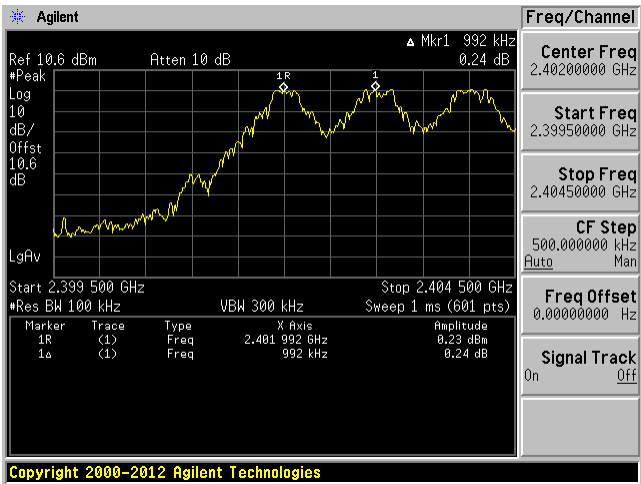
13.5 Test Results

Channel	Frequency (MHz)	Channel Separation (kHz)	Limit > 2/3 20 dB OBW (kHz)
GFSK			
Low	2402	992	637.07
Middle	2441	1000	638.47
High	2480	1008	639.33
$\pi/4$ -DQPSK			
Low	2402	983	923.33
Middle	2441	1008	922.67
High	2480	942	922.67
8DPSK			
Low	2402	1025	910.00
Middle	2441	1042	958.67
High	2480	1058	909.33

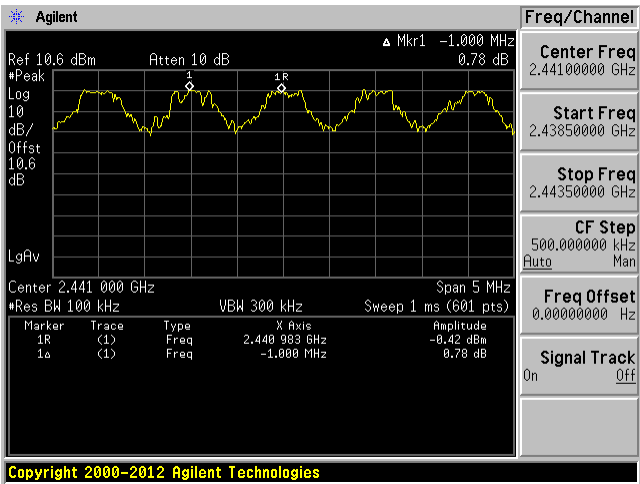
Please refer to following plots.

GFSK

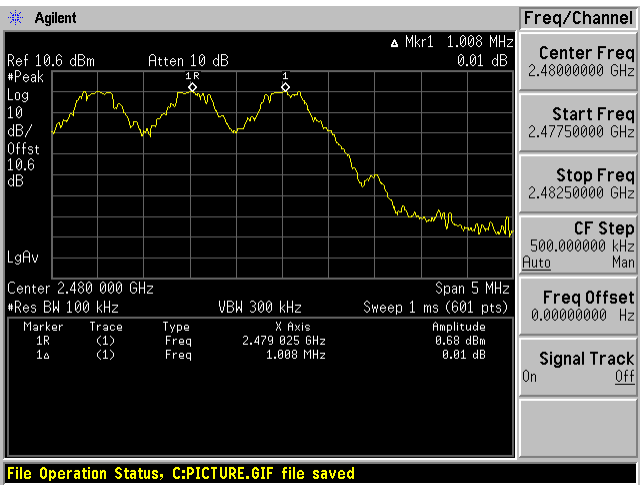
Low Channel 2402 MHz



Middle Channel 2441 MHz

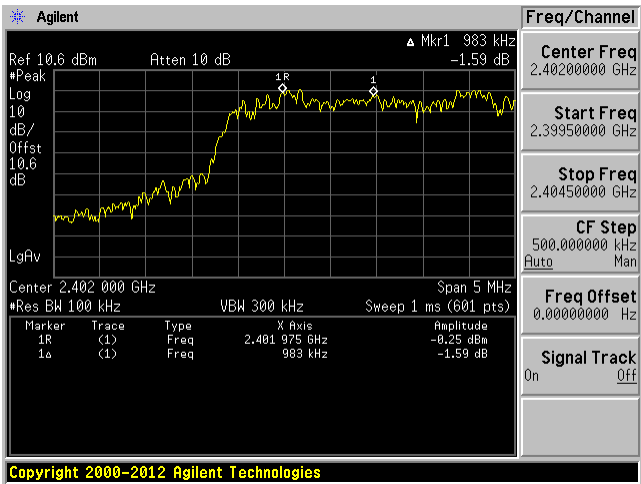


High Channel 2480 MHz

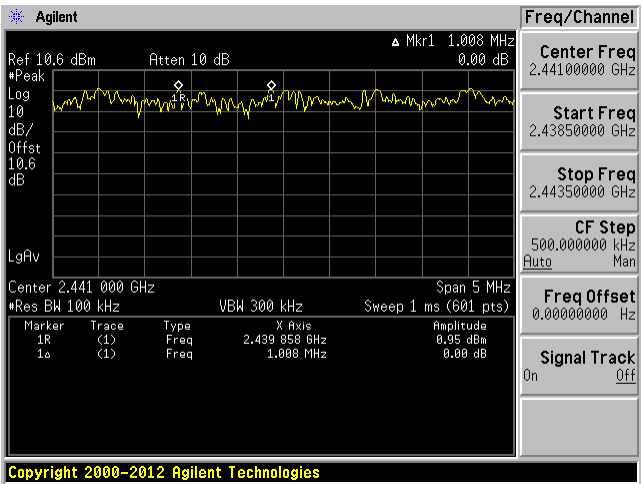


$\pi/4$ -DQPSK

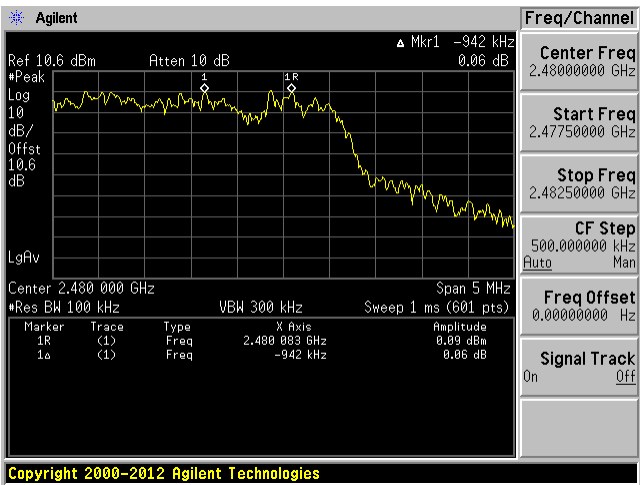
Low Channel 2402 MHz



Middle Channel 2441 MHz

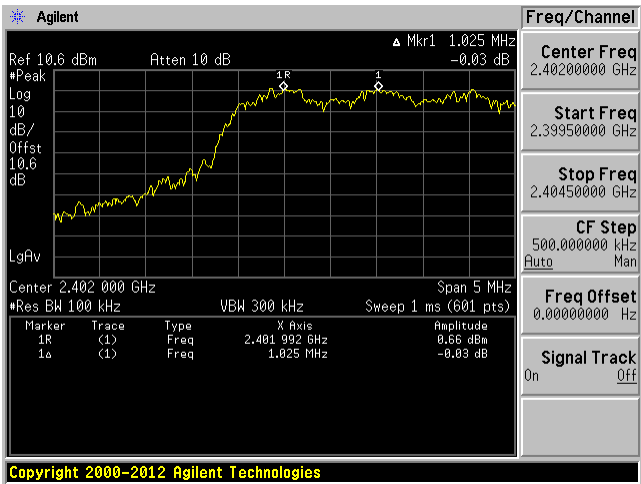


High Channel 2480 MHz

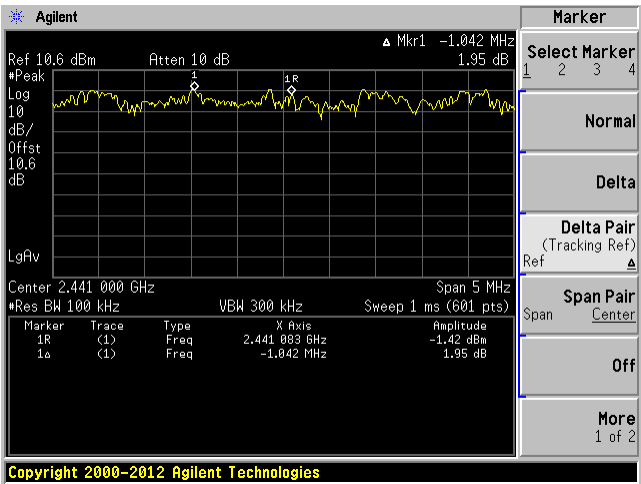


8DPSK

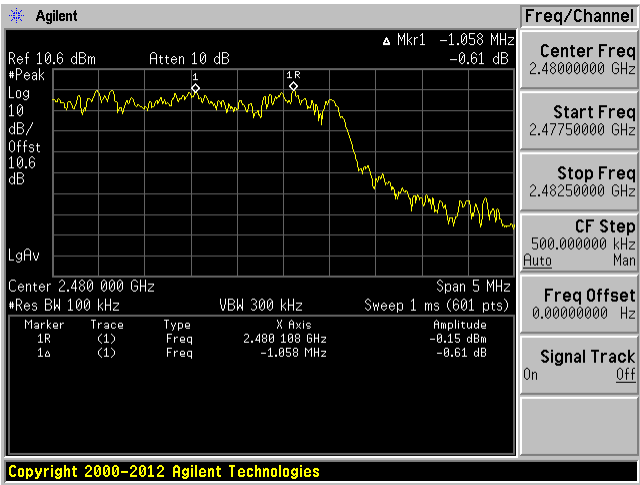
Low Channel 2402 MHz



Middle Channel 2441 MHz



High Channel 2480 MHz



14 LP0002-2018 §3.10- Spurious Emissions at Antenna Terminals

14.1 Applicable Standards

As per LP0002-2018 §3.10, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB.

14.2 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.

14.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	US44300386	2019-06-26	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB 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.*

14.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	42 %
ATM Pressure:	102.5 KPa

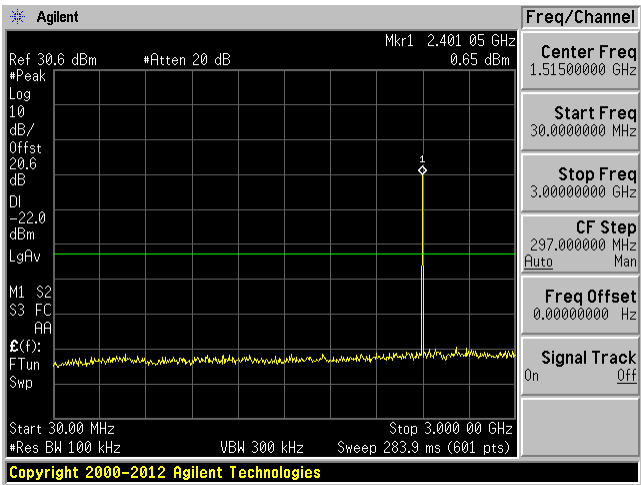
The testing was performed by Zhao Zhao on 2019-08-09 at RF site.

14.5 Test Results

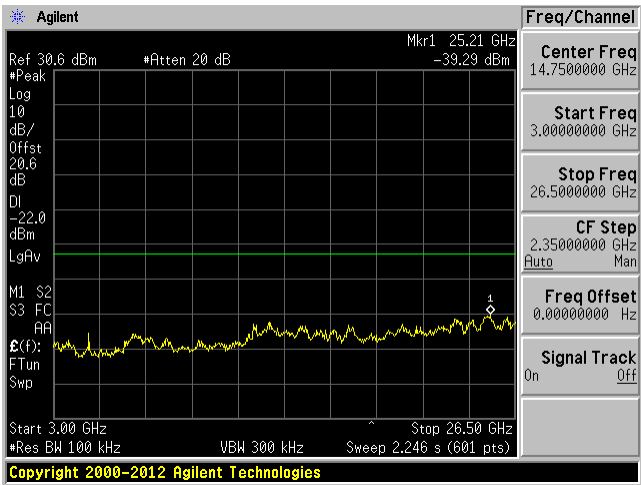
Please refer to following plots.

GFSK

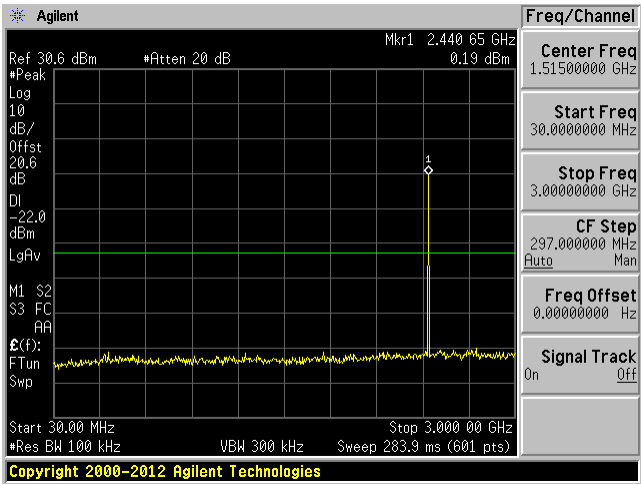
Low Channel 30 MHz – 3 GHz



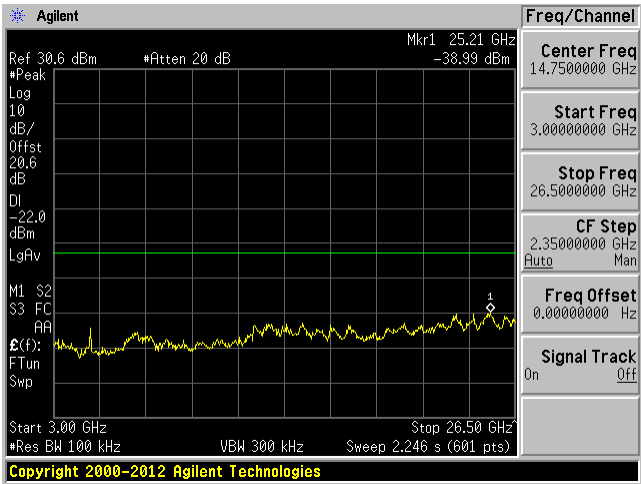
Low Channel 3 GHz – 26 GHz



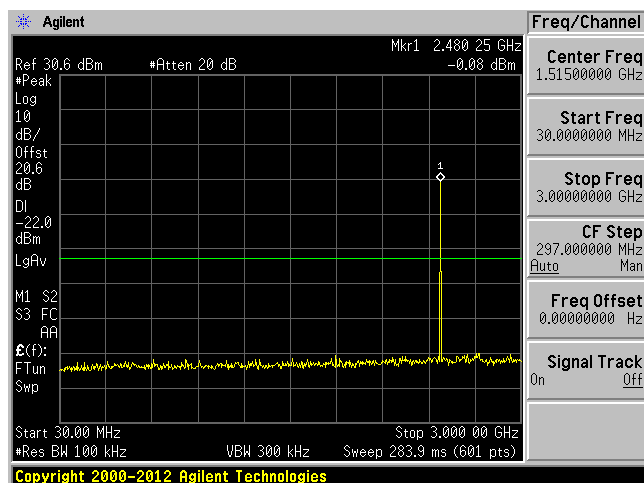
Middle Channel 30 MHz – 3 GHz



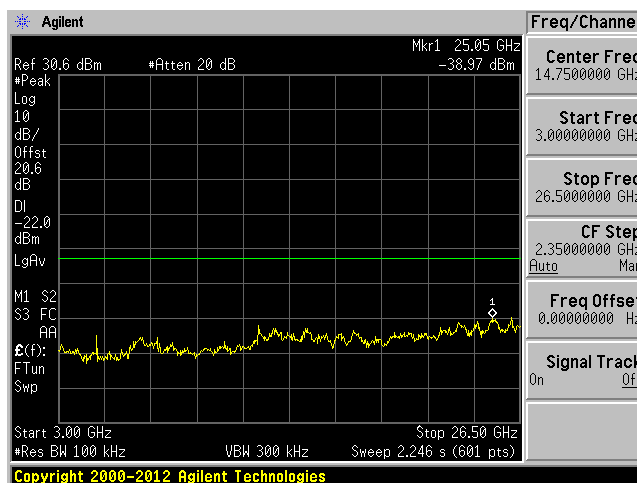
Middle Channel 3 GHz – 26 GHz



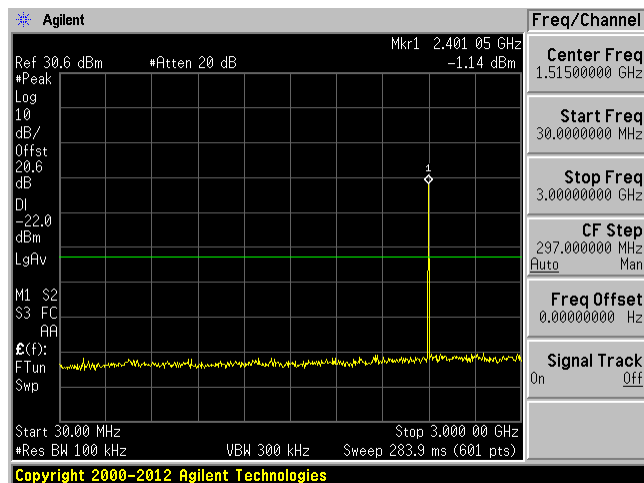
High Channel 30 MHz – 3 GHz



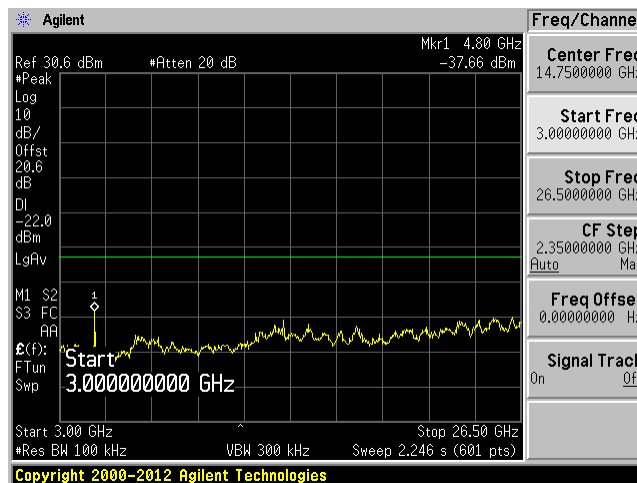
High Channel 3 GHz – 26 GHz

 $\pi/4$ -DQPSK

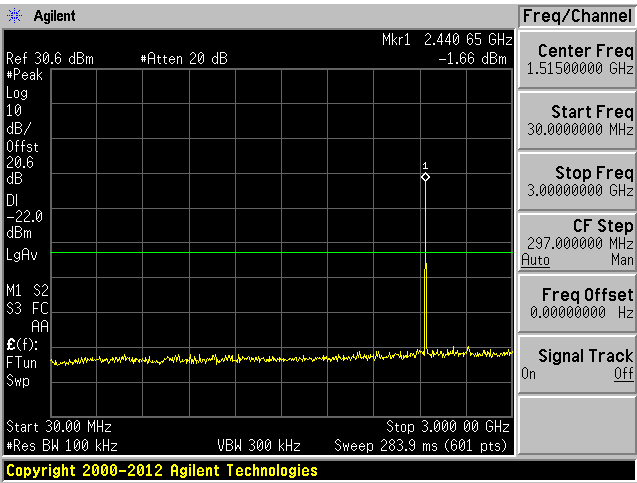
Low Channel 30 MHz – 3 GHz



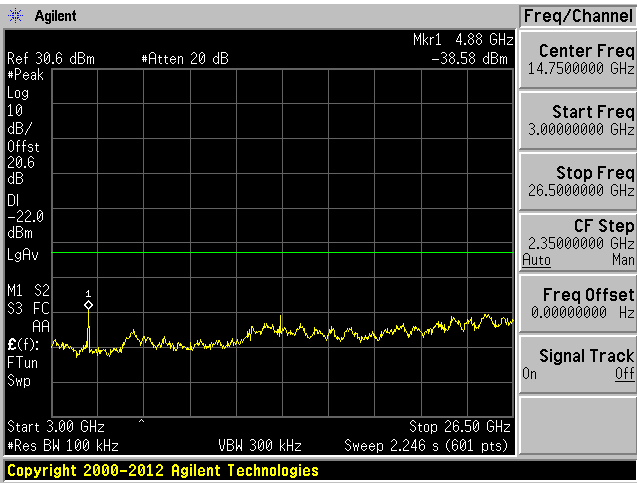
Low Channel 3 GHz – 26 GHz



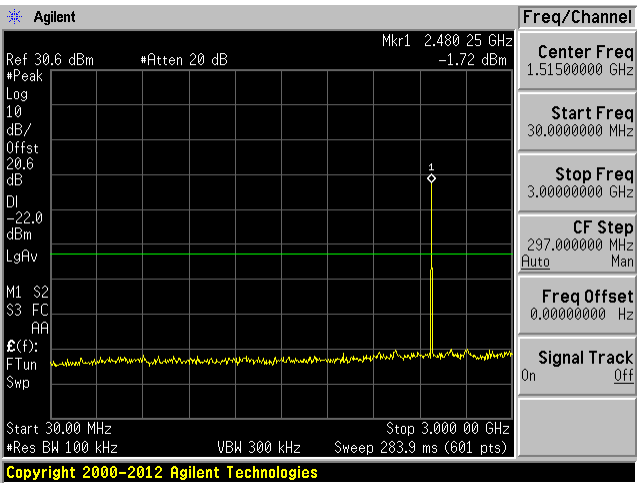
Middle Channel 30 MHz – 3 GHz



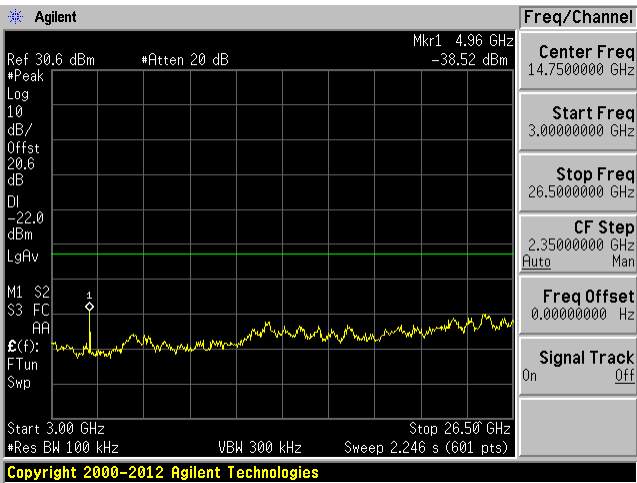
Middle Channel 3 GHz – 26 GHz



High Channel 30 MHz – 3 GHz

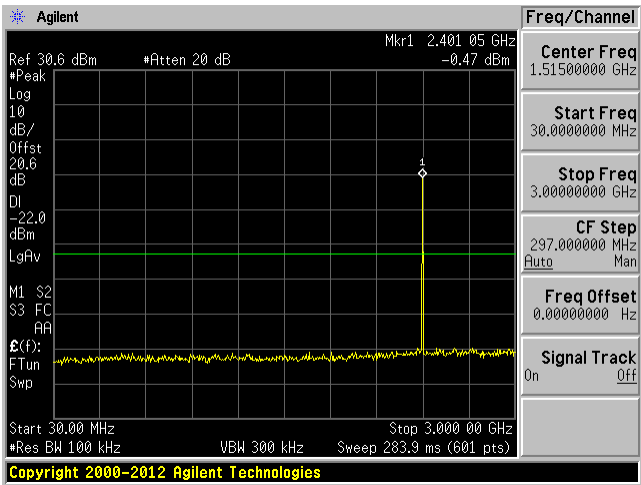


High Channel 3 GHz – 26 GHz

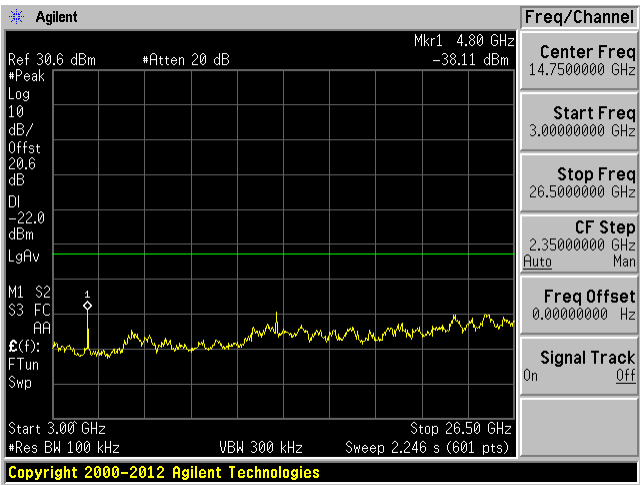


8DPSK

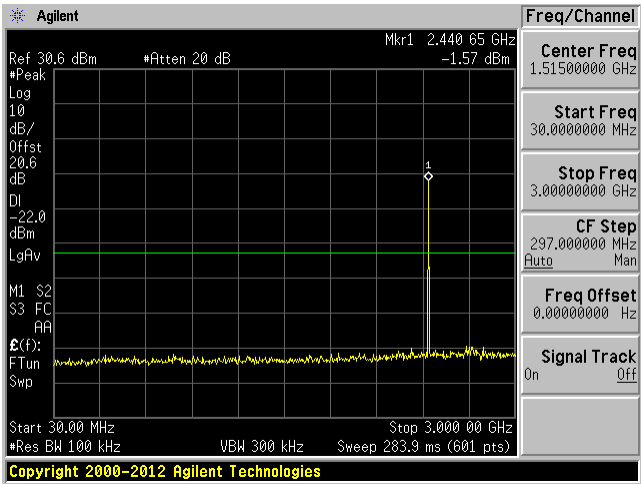
Low Channel 30 MHz – 3 GHz



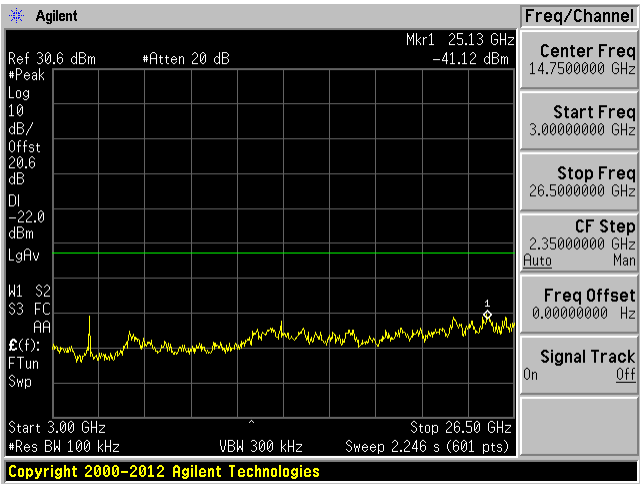
Low Channel 3 GHz – 26 GHz



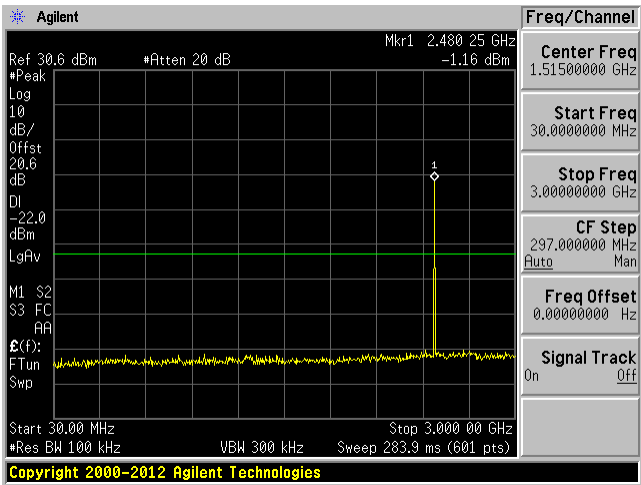
Middle Channel 30 MHz – 3 GHz



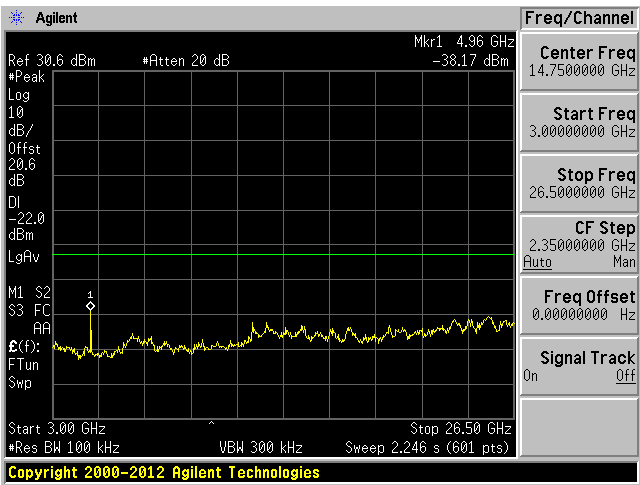
Middle Channel 3 GHz – 26 GHz



High Channel 30 MHz – 3 GHz



High Channel 3 GHz – 26 GHz



15 Annex A (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

16 Annex B (Normative) – EUT Photographs

Please refer to the attachment.

17 Annex C (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 17025:2005 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 2nd day of October 2018.

A blue ink signature of the Vice President, Accreditation Services.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2020
Revised June 5, 2019

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>

--- END OF REPORT ---