

FCC TEST REPORT

Product Name: TWS earbuds with charging case
Trade Mark: Gems
Model No.: TWS07
Report Number: 201010047RFC-1
Test Standards: FCC 47 CFR Part 15 Subpart C
FCC ID: 2AO23-TWS07
Test Result: PASS
Date of Issue: October 21, 2020

Prepared for:

Chug, Inc.

7157 Shady Oak Road Eden Prairie, Washington Minnesota United States

Prepared by:

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October 21, 2020

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UTTR-RF-FCCPART15.247-V1.0

Version

Version No.	Date	Description
V1.0	October 21, 2020	Original

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1. GENERAL INFORMATION

1.1 CLIENT INFORMATION

Applicant:	Chug, Inc.
Address of Applicant:	7157 Shady Oak Road Eden Prairie, Washington Minnesota United States
Manufacturer:	DONGGUAN LINPA ACOUSTIC TECHNOLOGY CO., LTD
Address of Manufacturer:	2A,No 60, Lizhong Road,Dali Qingxi Town, Dongguan City, China

1.2 EUT INFORMATION

1.2.1 General Description of EUT

Product Name:	TWS earbuds with charging case	
Model No.:	TWS07	
Trade Mark:	Gems	
DUT Stage:	Production Unit	
EUT Supports Function:	2.4 GHz ISM Band:	Bluetooth 5.0 (only support BR+EDR)
Software Version:	V1.0	
Hardware Version:	V1.0	
Sample Received Date:	October 10, 2020	
Sample Tested Date:	October 15, 2020 to October 15, 2020	

1.2.2 Description of Accessories

Battery(Charging Case)	
Model No.:	603030
Battery Type:	Lithium-ion Polymer Rechargeable Battery
Rated Voltage:	3.7 Vdc
Limited Charge Voltage:	4.2 Vdc
Rated Capacity:	450mAh

Cable	
Description:	USB Micro-B Plug Cable
Cable Type:	Unshielded without ferrite
Length:	0.3 Meter

Battery(Earbuds)	
Model No.:	401020
Battery Type:	Lithium-ion Polymer Rechargeable Battery
Rated Voltage:	3.7 Vdc
Limited Charge Voltage:	4.2 Vdc
Rated Capacity:	50mAh

1.3 PRODUCT SPECIFICATION SUBJECTIVE TO THIS STANDARD

Frequency Band:	2400 MHz to 2483.5 MHz
Frequency Range:	2402 MHz to 2480 MHz
Bluetooth Version:	Bluetooth BR + EDR
Modulation Technique:	Frequency Hopping Spread Spectrum(FHSS)
Type of Modulation:	GFSK, $\pi/4$ DQPSK
Number of Channels:	79
Channel Separation:	1 MHz
Hopping Channel Type:	Adaptive Frequency Hopping Systems
Antenna Type:	FPC Antenna
Antenna Gain:	1.9 dBi
Maximum Peak Power:	-0.051 dBm
Normal Test Voltage:	3.7 Vdc

1.4 OTHER INFORMATION

Operation Frequency Each of Channel	
$f = 2402 + k \text{ MHz}, k = 0, \dots, 78$	
Note:	
f	is the operating frequency (MHz);
k	is the operating channel.

Modulation Configure			
Modulation	Packet	Packet Type	Packet Size
GFSK	1-DH1	4	27
	1-DH3	11	183
	1-DH5	15	339
$\pi/4$ DQPSK	2-DH1	20	54
	2-DH3	26	367
	2-DH5	30	679

1.5 DESCRIPTION OF SUPPORT UNITS

The EUT has been tested with associated equipment below.

1) Support Equipment

Description	Manufacturer	Model No.	Serial Number	Supplied by
Notebook	Lenovo	E450	SL10G10780	UnionTrust
Mouse	DELL	MS111	CN-011D3V-738	UnionTrust

2) Support Cable

Cable No.	Description	Connector	Length	Supplied by
1	Antenna Cable	SMA	0.20 Meter	UnionTrust
2	serial port	USB	0.50 Meter	UnionTrust

1.6 TEST LOCATION

Shenzhen UnionTrust Quality and Technology Co., Ltd.

Address: 16/F, Block A, Building 6, Baoneng Science and Technology Park, Qingxiang Road No.1, Longhua New District, Shenzhen, China 518109
Telephone: +86 (0) 755 2823 0888
Fax: +86 (0) 755 2823 0886

1.7 TEST FACILITY

The test facility is recognized, certified, or accredited by the following organizations:

CNAS-Lab Code: L9069

The measuring equipment utilized to perform the tests documented in this report has been calibrated once a year or in accordance with the manufacturer's recommendations, and is traceable under the ISO/IEC/EN 17025 to international or national standards. Equipment has been calibrated by accredited calibration laboratories.

A2LA-Lab Certificate No.: 4312.01

Shenzhen UnionTrust Quality and Technology Co., Ltd. has been accredited by A2LA for technical competence in the field of electrical testing, and proved to be in compliance with ISO/IEC 17025: 2005 General Requirements for the Competence of Testing and Calibration Laboratories and any additional program requirements in the identified field of testing.

ISED Wireless Device Testing Laboratories

CAB identifier: CN0032

FCC Accredited Lab.

Designation Number: CN1194
Test Firm Registration Number: 259480

1.8 DEVIATION FROM STANDARDS

None.

1.9 ABNORMALITIES FROM STANDARD CONDITIONS

None.

1.10 OTHER INFORMATION REQUESTED BY THE CUSTOMER

None.

1.11 MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

No.	Item	Measurement Uncertainty
1	Conducted emission 9KHz-150KHz	±3.2 dB
2	Conducted emission 150KHz-30MHz	±2.7 dB
3	Radiated emission 9KHz-30MHz	± 4.7 dB
4	Radiated emission 30MHz-1GHz	± 4.6 dB
5	Radiated emission 1GHz-18GHz	± 4.4 dB
6	Radiated emission 18GHz-26GHz	± 4.6 dB
7	Radiated emission 26GHz-40GHz	± 4.6 dB

2. TEST SUMMARY

FCC 47 CFR Part 15 Subpart C Test Cases			
Test Item	Test Requirement	Test Method	Result
Antenna Requirement	FCC 47 CFR Part 15 Subpart C Section 15.203/15.247 (c)	N/A	PASS
AC Power Line Conducted Emission	FCC 47 CFR Part 15 Subpart C Section 15.207	ANSI C63.10-2013 Section 6.2	N/A(Note2)
Conducted Peak Output Power	FCC 47 CFR Part 15 Subpart C Section 15.247 (b)(1)	ANSI C63.10-2013 Section 7.8.5	PASS
20 dB Bandwidth	FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)	ANSI C63.10-2013 Section 6.9.2	PASS
Carrier Frequencies Separation	FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)	ANSI C63.10-2013 Section 7.8.2	PASS
Number of Hopping Channel	FCC 47 CFR Part 15 Subpart C Section 15.247 (b)(1)	ANSI C63.10-2013 Section 7.8.3	PASS
Dwell Time	FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)	ANSI C63.10-2013 Section 7.8.4	PASS
Conducted Out of Band Emission	FCC 47 CFR Part 15 Subpart C Section 15.247(d)	ANSI C63.10-2013 Section 6.10.4 & Section 7.8.8	PASS
Radiated Emissions	FCC 47 CFR Part 15 Subpart C Section 15.205/15.209	ANSI C63.10-2013 Section 6.3 & 6.5 & 6.6	PASS
Band Edge Measurement	FCC 47 CFR Part 15 Subpart C Section 15.205/15.209	ANSI C63.10-2013 Section 6.10.5	PASS
Note:			
1) N/A: In this whole report not applicable.			
2) This EUT is worked by the battery.			

3. EQUIPMENT LIST

Radiated Emission Test Equipment List						
Used	Equipment	Manufacturer	Model No.	Serial Number	Cal. date (mm dd, yyyy)	Cal. Due date (mm dd, yyyy)
<input checked="" type="checkbox"/>	3M Chamber & Accessory Equipment	ETS-LINDGREN	3M	N/A	Dec. 03, 2018	Dec. 03, 2021
<input checked="" type="checkbox"/>	Receiver	R&S	ESIB26	100114	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	Loop Antenna	ETS-LINDGREN	6502	00202525	Nov. 16, 2019	Nov. 15, 2020
<input checked="" type="checkbox"/>	Broadband Antenna	ETS-LINDGREN	3142E	00201566	Nov. 16, 2019	Nov. 15, 2020
<input checked="" type="checkbox"/>	6dB Attenuator	Talent	RA6A5-N-18	18103001	Nov. 16, 2019	Nov. 15, 2020
<input checked="" type="checkbox"/>	Preamplifier	HP	8447F	2805A02960	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	Horn Antenna (Pre-amplifier)	ETS-LINDGREN	3117-PA	00201874	May. 30, 2020	May. 29, 2021
<input checked="" type="checkbox"/>	Multi device Controller	ETS-LINDGREN	7006-001	00160105	N/A	N/A
<input checked="" type="checkbox"/>	Test Software	Audix	e3	Software Version: 9.160323		

Conducted RF test Equipment List						
Used	Equipment	Manufacturer	Model No.	Serial Number	Cal. date (mm dd, yyyy)	Cal. Due date (mm dd, yyyy)
<input checked="" type="checkbox"/>	EXG-B RF Analog Signal Generator	KEYSIGHT	N5171B	MY53051777	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	MXG X-Series RF Vector Signal Generator	KEYSIGHT	N5182B	MY51350267	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	EXA Signal Analyzer	KEYSIGHT	N9010A	MY51440197	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	USB Wideband Power Sensor	KEYSIGHT	U2021XA	MY55430035	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	USB Wideband Power Sensor	KEYSIGHT	U2021XA	MY55430023	Nov. 24, 2019	Nov. 23, 2020
<input checked="" type="checkbox"/>	4ch. Simultaneous Sampling 14 Bits 2MS/s	KEYSIGHT	U2531A	TW55193502	N/A	N/A
<input checked="" type="checkbox"/>	Temp Humidity chamber	Votisch	VT4002	58566133290020	May. 11, 2020	May. 10, 2021
<input checked="" type="checkbox"/>	Wideband Radio Communication Tester	R&S	CMW500	120932	Jul. 20, 2020	Jul. 19, 2021
<input checked="" type="checkbox"/>	Shielding room	ETS-Lindgren	333	Euroshiedpn-T J2343-S1608	Jun. 5, 2020	Jun. 4, 2021
<input checked="" type="checkbox"/>	Temperature & Humidity Datalogger	CEM	DT-172	200408605	Jul. 24, 2020	Jul. 23, 2021
<input checked="" type="checkbox"/>	Test Software	Automation TestSystem	ECIT	Software Version: 1.0.7515.16529		

4. TEST CONFIGURATION

4.1 ENVIRONMENTAL CONDITIONS FOR TESTING

4.1.1 Normal or Extreme Test Conditions

Environment Parameter	Selected Values During Tests		
Test Condition	Ambient		
	Temperature (°C)	Voltage (V)	Relative Humidity (%)
NT/NV	+15 to +35	3.7	20 to 75
Remark:			
1) NV: Normal Voltage; NT: Normal Temperature			

4.1.2 Record of Normal Environment

Test Item	Temperature (°C)	Relative Humidity (%)	Pressure (kPa)	Tested by
Conducted Peak Output Power	24.1	45.72	100.33	Gavin Xu
20 dB Bandwidth	24.1	45.72	100.33	Gavin Xu
Carrier Frequencies Separation	24.1	45.72	100.33	Gavin Xu
Number of Hopping Channel	24.1	45.72	100.33	Gavin Xu
Dwell Time	24.1	45.72	100.33	Gavin Xu
Conducted Out of Band Emission	24.1	45.72	100.33	Gavin Xu
Radiated Emissions	25.2	52.0	100.02	Asia Yan
Band Edge Measurement	25.2	52.0	100.02	Asia Yan

4.2 TEST CHANNELS

Mode	Tx/Rx Frequency	Test RF Channel Lists		
		Lowest(L)	Middle(M)	Highest(H)
GFSK (DH1, DH3, DH5)	2402 MHz to 2480 MHz	Channel 0	Channel 39	Channel 78
		2402 MHz	2441 MHz	2480 MHz
π /4DQPSK (DH1, DH3, DH5)	2402 MHz to 2480 MHz	Channel 0	Channel 39	Channel 78
		2402 MHz	2441 MHz	2480 MHz

4.3 EUT TEST STATUS

Type of Modulation	Tx Function	Description
GFSK/ π /4DQPSK	1Tx	<ol style="list-style-type: none"> Keep the EUT in continuously transmitting with Modulation test single Keep the EUT in continuously transmitting with Modulation test Hopping Frequency.

Power Setting
Power Setting: 10

Test Software
Test software name: FCC_assist_1.0.1.2;

4.4 PRE-SCAN

4.4.1 Pre-scan under all packets at middle channel

Conducted Average Power (dBm) for packets						
Type of Modulation	GFSK			π/4DQPSK		
Packets	1-DH1	1-DH3	1-DH5	2-DH1	2-DH3	2-DH5
Power (dBm)	-2.55	-2.62	-3.18	-3.84	-3.91	-4.48

4.4.2 Worst-case data packets

Type of Modulation	Worst-case data rates
GFSK	1-DH5
π/4DQPSK	2-DH5

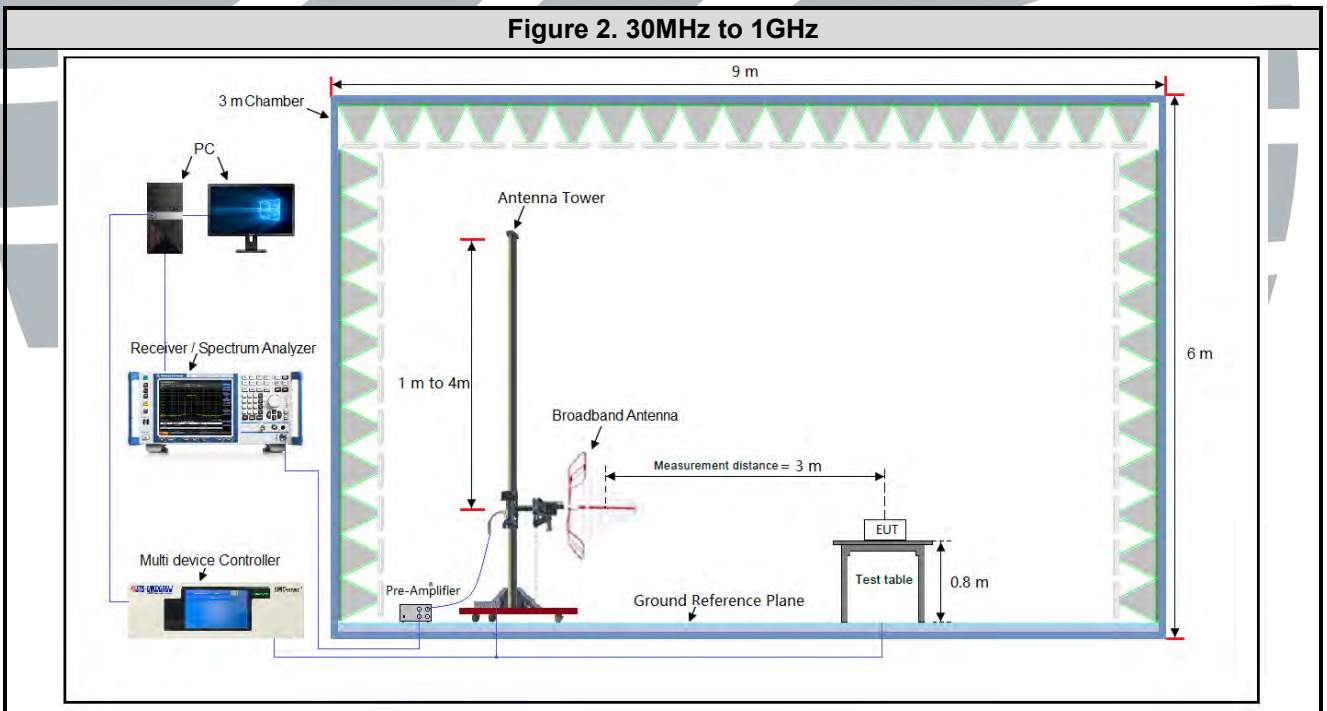
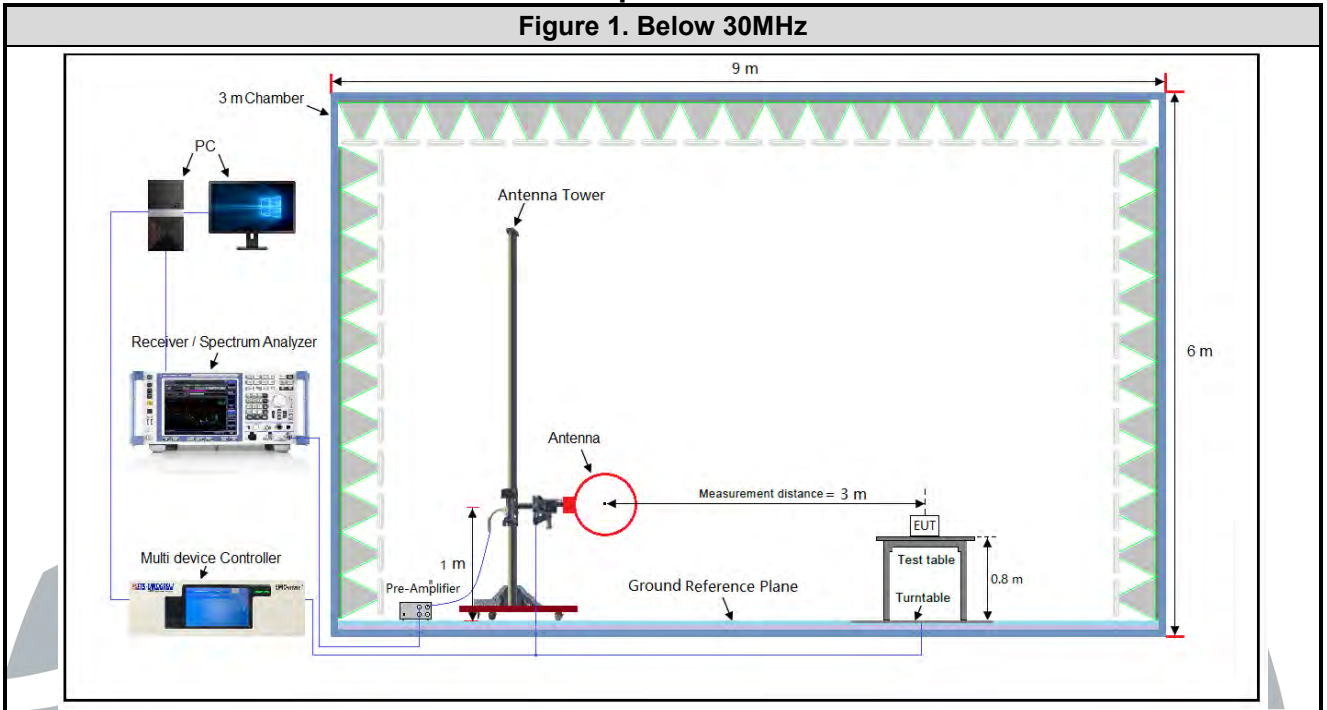
4.4.3 Tested channel detail

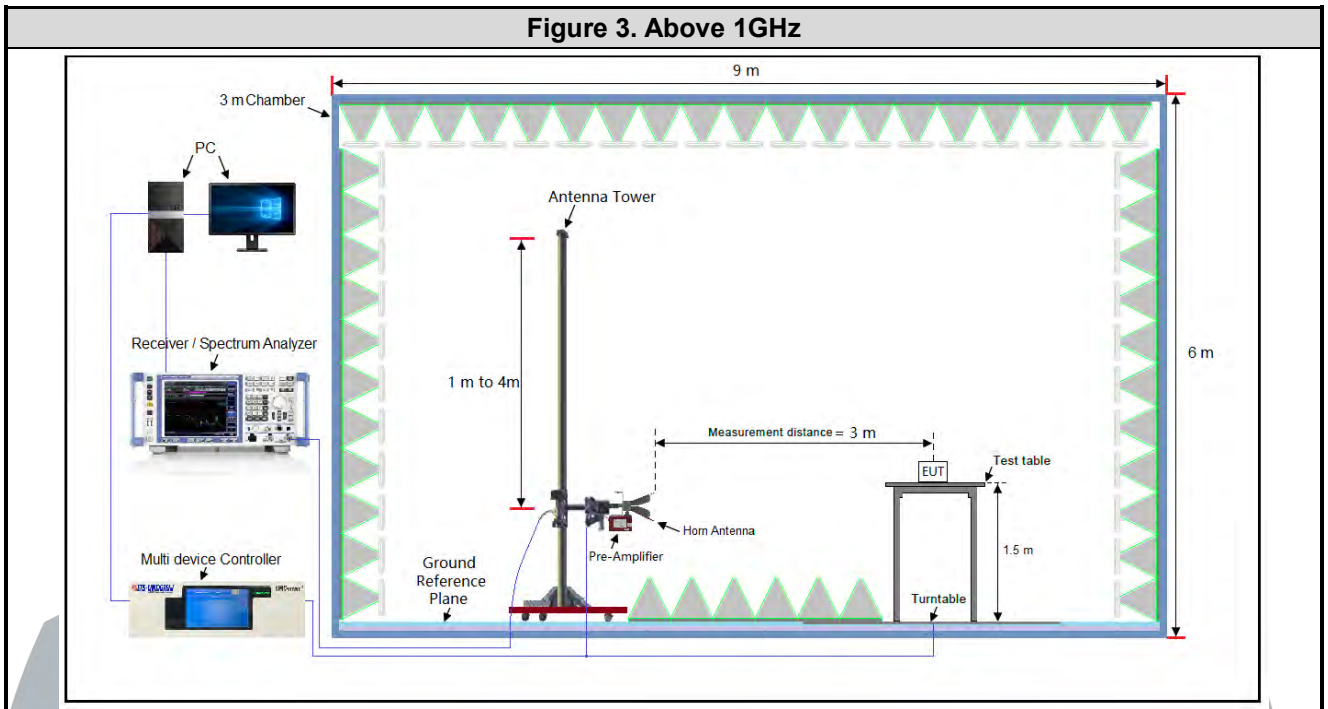
Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data packets and antenna ports (if EUT with antenna diversity architecture). Following channel(s) was (were) selected for the final test as listed below.

Type of Modulation	GFSK			π/4DQPSK			8DPSK		
Data Packets	1-DH 1	1-DH 3	1-DH 5	2-DH 1	2-DH 3	2-DH 5	3-DH 1	3-DH 3	3-DH 5
Available Channel	0 to 78								
Test Item	Test channel and choose of data packets								
AC Power Line Conducted Emission	Frequency Hopping Channel 0 to 78 <input type="checkbox"/> Link								
Conducted Peak Output Power	Channel 0 & 39 & 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20 dB Bandwidth	Channel 0 & 39 & 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Carrier Frequencies Separation	Frequency Hopping Channel 0 to 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Number of Hopping Channel	Frequency Hopping Channel 0 to 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dwell Time	Channel 39								
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Conducted Out of Band Emission	Channel 0 & 39 & 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Radiated Emissions	Channel 0 & 39 & 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Band Edge Measurements (Radiated)	Channel 0 & 78								
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Remark:									
1. The mark "☒" means is chosen for testing;									
2. The mark "☐" means is not chosen for testing.									

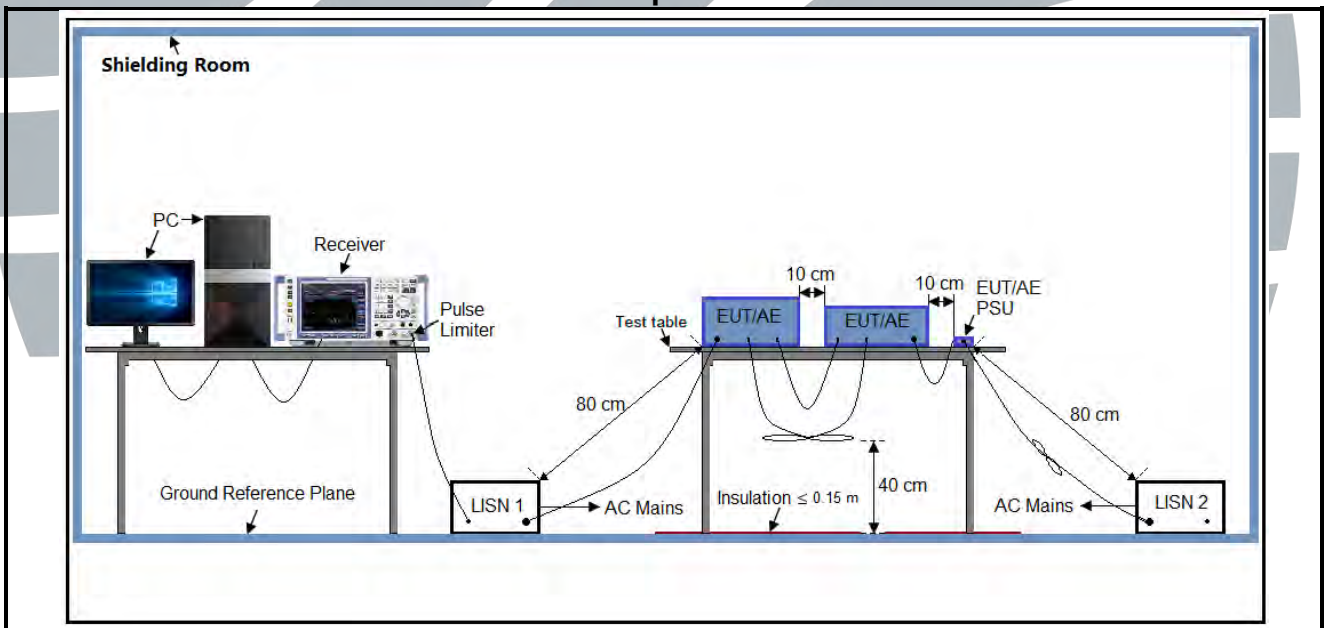
4.5 TEST SETUP

4.5.1 For Radiated Emissions test setup

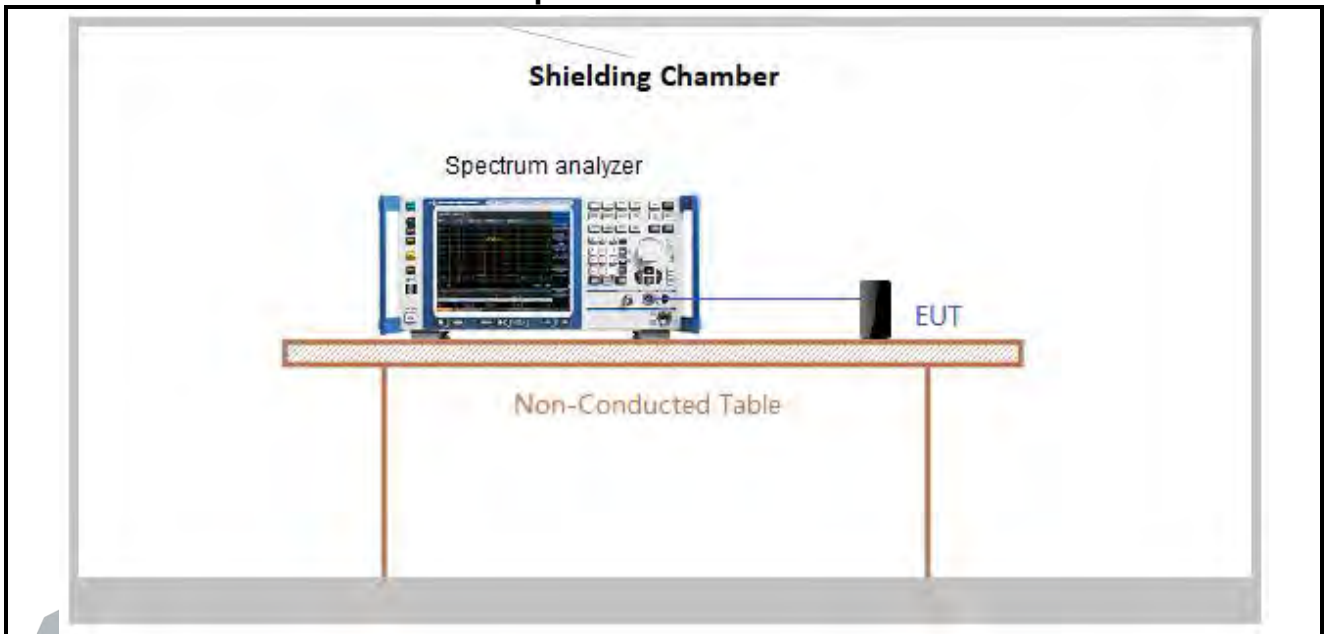




4.5.2 For Conducted Emissions test setup



4.5.3 For Conducted RF test setup



4.6 SYSTEM TEST CONFIGURATION

For emissions testing, the equipment under test (EUT) setup to transmit continuously to simplify the measurement methodology. Care was taken to ensure proper power supply voltages during testing. During testing, radiated emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario. It was powered by a 3.7V battery. Only the worst case data were recorded in this test report.

The signal is maximized through rotation and placement in the three orthogonal axes. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters. Radiated emissions are taken at three meters unless the signal level is too low for measurement at that distance. If necessary, a pre-amplifier is used and/or the test is conducted at a closer distance. Therefore, all final radiated testing was performed with the EUT in (see table below) orientation.

Frequency	Mode	Antenna Port	Worst-case axis positioning
Above 1GHz	1TX	Chain 0	Y axis

All readings are extrapolated back to the equivalent three meter reading using inverse scaling with distance. Analyzer resolution is 100 kHz or greater for frequencies below 1000 MHz. The resolution is 1 MHz or greater for frequencies above 1000 MHz. The spurious emissions more than 20 dB below the permissible value are not reported.

Radiated emission measurement were performed from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

4.7 DUTY CYCLE

Test Procedure: ANSI C63.10-2013 Clause 11.6.

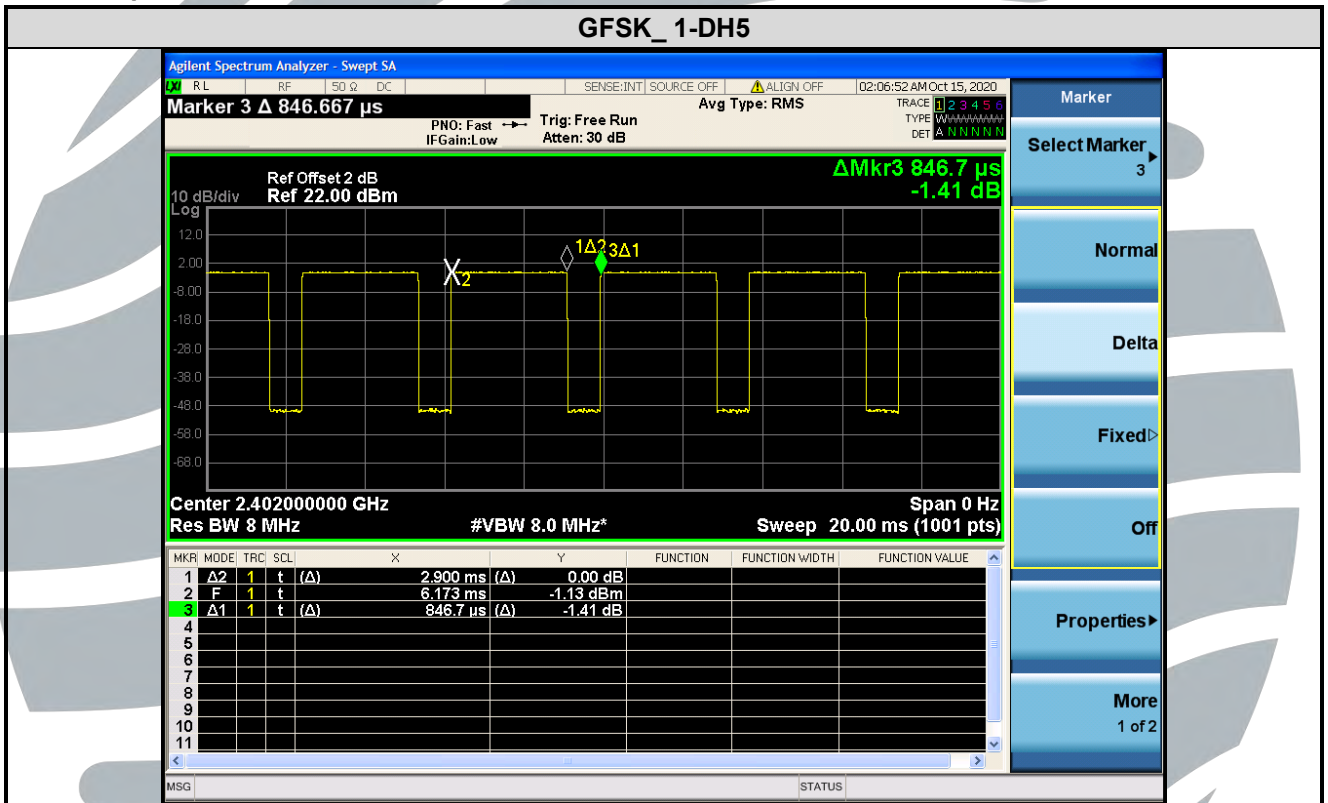
Test Results

Type of Modulation	Packets	On Time (msec)	Period (msec)	Duty Cycle (linear)	Duty Cycle (%)	Duty Cycle Factor (dB)	1/ T Minimum VBW (kHz)	Average Factor (dB)
GFSK	1-DH5	2.9000	3.7467	0.77	77.40	1.11	0.34	-2.23

Remark:

- 1) Duty cycle= On Time/ Period;
- 2) Duty Cycle factor = 10 * log(1/ Duty cycle);
- 3) Average factor = 20 log₁₀ Duty Cycle.

The test plots as follows



5. RADIO TECHNICAL REQUIREMENTS SPECIFICATION

5.1 REFERENCE DOCUMENTS FOR TESTING

No.	Identity	Document Title
1	FCC 47 CFR Part 2	Frequency allocations and radio treaty matters; general rules and regulations
2	FCC 47 CFR Part 15	Radio Frequency Devices
3	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
4	KDB 558074 D01 15.247 Meas Guidance v05r02	Guidance for compliance measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum system, and Hybrid system devices operating under Section 15.247 of the FCC rules

5.2 ANTENNA REQUIREMENT

Standard Requirement
<p>15.203 requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.</p>
<p>15.247(b) (4) requirement: The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.</p>
<p>EUT Antenna: Antenna in the interior of the equipment and no consideration of replacement. The gain of the antenna is 1.9 dBi.</p>

5.3 CONDUCTED PEAK OUTPUT POWER

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247 (b)(1)
Test Method: ANSI C63.10-2013 Section 7.8.5
Limit: 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 band: 1 watt.
 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.
Test Procedure: Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

- a) Use the following spectrum analyzer settings:
 - 1) Span: Approximately 5 x 20 dB bandwidth, centered on a hopping channel.
 - 2) RBW > 20 dB bandwidth of the emission being measured.
 - 3) VBW ≥ RBW.
 - 4) Sweep: Auto.
 - 5) Detector function: Peak.
 - 6) Trace: Max hold.
- b) Allow trace to stabilize.
- c) Use the marker-to-peak function to set the marker to the peak of the emission.
- d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
- e) A plot of the test results and setup description shall be included in the test report.

Test Setup: Refer to section 4.5.3 for details.

Instruments Used: Refer to section 3 for details

Test Results: Pass

Type of Modulation	Peak Output Power (dBm)			Peak Output Power (mW)		
	Channel 0	Channel 39	Channel 78	Channel 0	Channel 39	Channel 78
GFSK	-1.295	-1.29	-1.881	0.74	0.74	0.65
$\pi/4$ DQPSK	-0.414	-0.051	-0.677	0.91	0.99	0.86

Note: The antenna gain of 1.9 dBi less than 6dBi maximum permission antenna gain value based on 125 mW peak output power limit.

The test plots as follows:



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<http://www.uttlab.com>

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5.420 DB BANDWIDTH

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)
Test Method: ANSI C63.10-2013 Section 6.9.2
Limit: None; for reporting purposes only.
Test Procedure: Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
 Use the following spectrum analyzer settings:

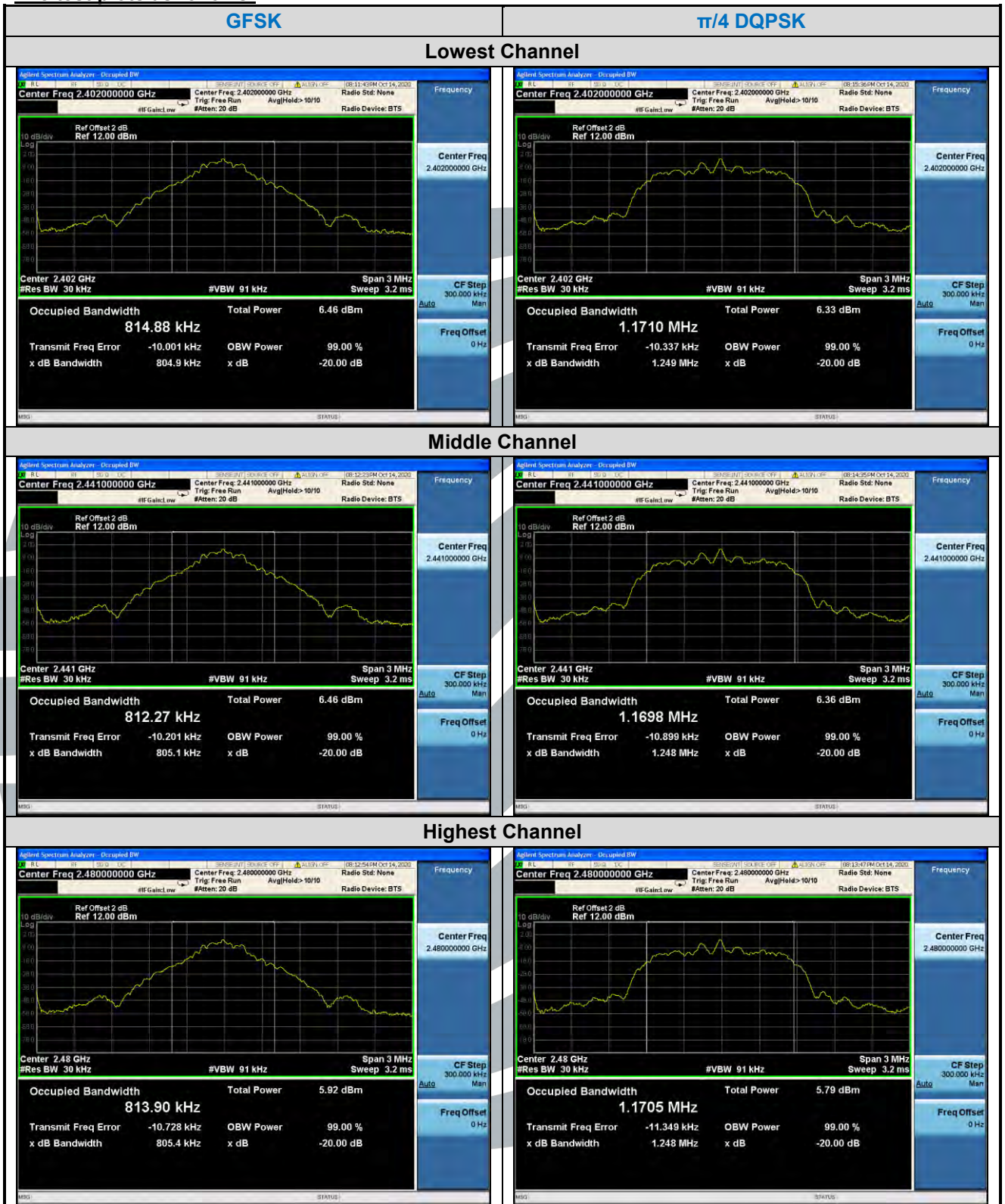
- a) Span = approximately 2 to 5 times the OBW, centered on a hopping channel.
- b) RBW = 1% to 5% of the OBW.
- c) VBW ≥ 3 x RBW
- d) Sweep = auto;
- e) Detector function = peak
- f) Trace = max hold
- g) All the trace to stabilize, use the marker-to-peak function to set the marker to the peak of the emission, use the marker-delta function to measure and record the 20dB down bandwidth of the emission.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

Test Setup: Refer to section 4.5.3 for details.
Instruments Used: Refer to section 3 for details
Test Results: Pass

Type of Modulation	20 dB Bandwidth (MHz)			Occupied Bandwidth (MHz)		
	Channel 0	Channel 39	Channel 78	Channel 0	Channel 39	Channel 78
GFSK	0.8049	0.8051	0.8054	0.81488	0.81227	0.81390
π/4 DQPSK	1.2490	1.2480	1.2480	1.17100	1.16980	1.17050

The test plots as follows:



5.5 CARRIER FREQUENCIES SEPARATION

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)

Test Method: ANSI C63.10-2013 Section 7.8.2

Limit: 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. 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.

Test Procedure: Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

Use the following spectrum analyzer settings:

- a) Span: Wide enough to capture the peaks of two adjacent channels.
- b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- c) Video (or average) bandwidth (VBW) ≥ RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.
- h) Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

Test Setup: Refer to section 4.5.3 for details.

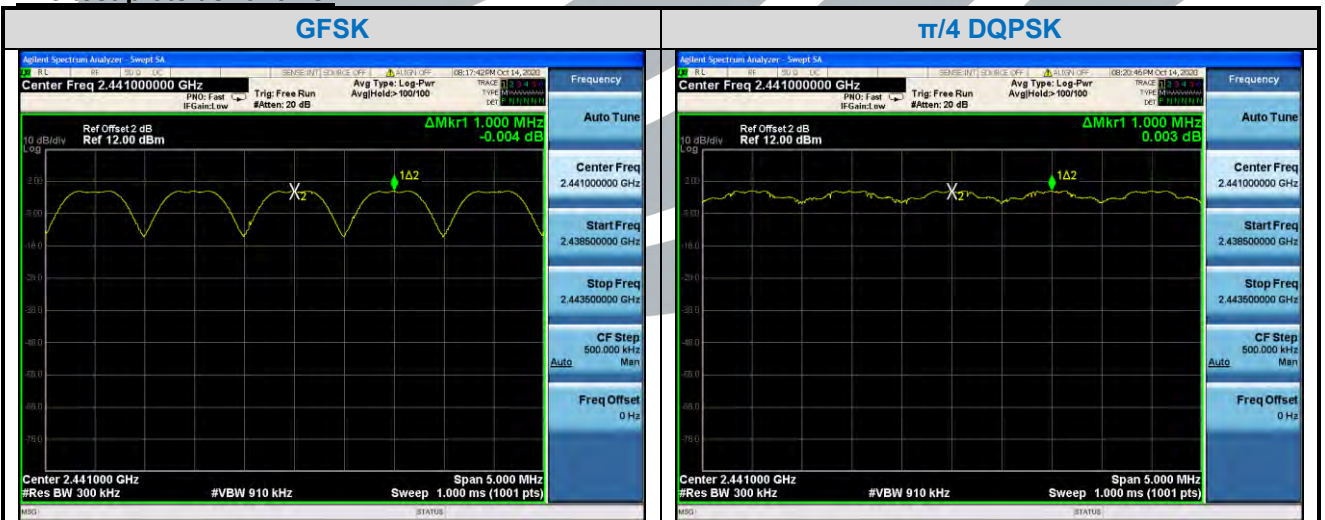
Instruments Used: Refer to section 3 for details

Test Results: Pass

Type of Modulation	Adjacent Channel Separation (MHz)	
	Channel 39	Channel 39
GFSK	1.000	0.537
$\pi/4$ DQPSK	1.000	0.833

Note: The minimum limit is two-third 20 dB bandwidth.

The test plots as follows:



5.6 NUMBER OF HOPPING CHANNEL

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247(b)(1)
Test Method: ANSI C63.10-2013 Section 7.8.3
Limit: Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.
Test Procedure: Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
 Use the following spectrum analyzer settings:

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW < 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW ≥ RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

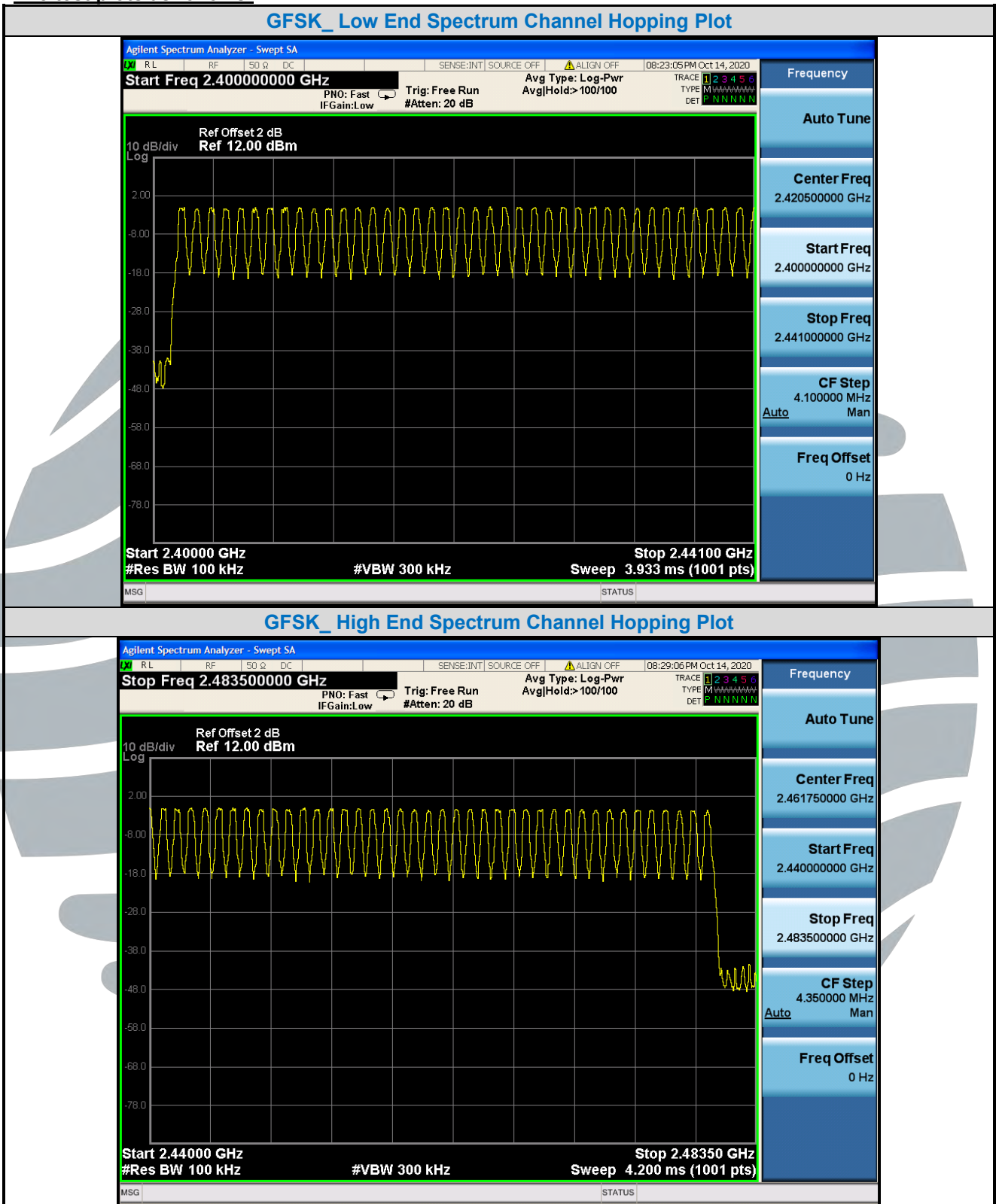
Test Setup: Refer to section 4.5.3 for details.

Instruments Used: Refer to section 3 for details

Test Results: Pass

Type of Modulation	Number of Hopping Channel
GFSK	79
$\pi/4$ DQPSK	79

The test plots as follows:



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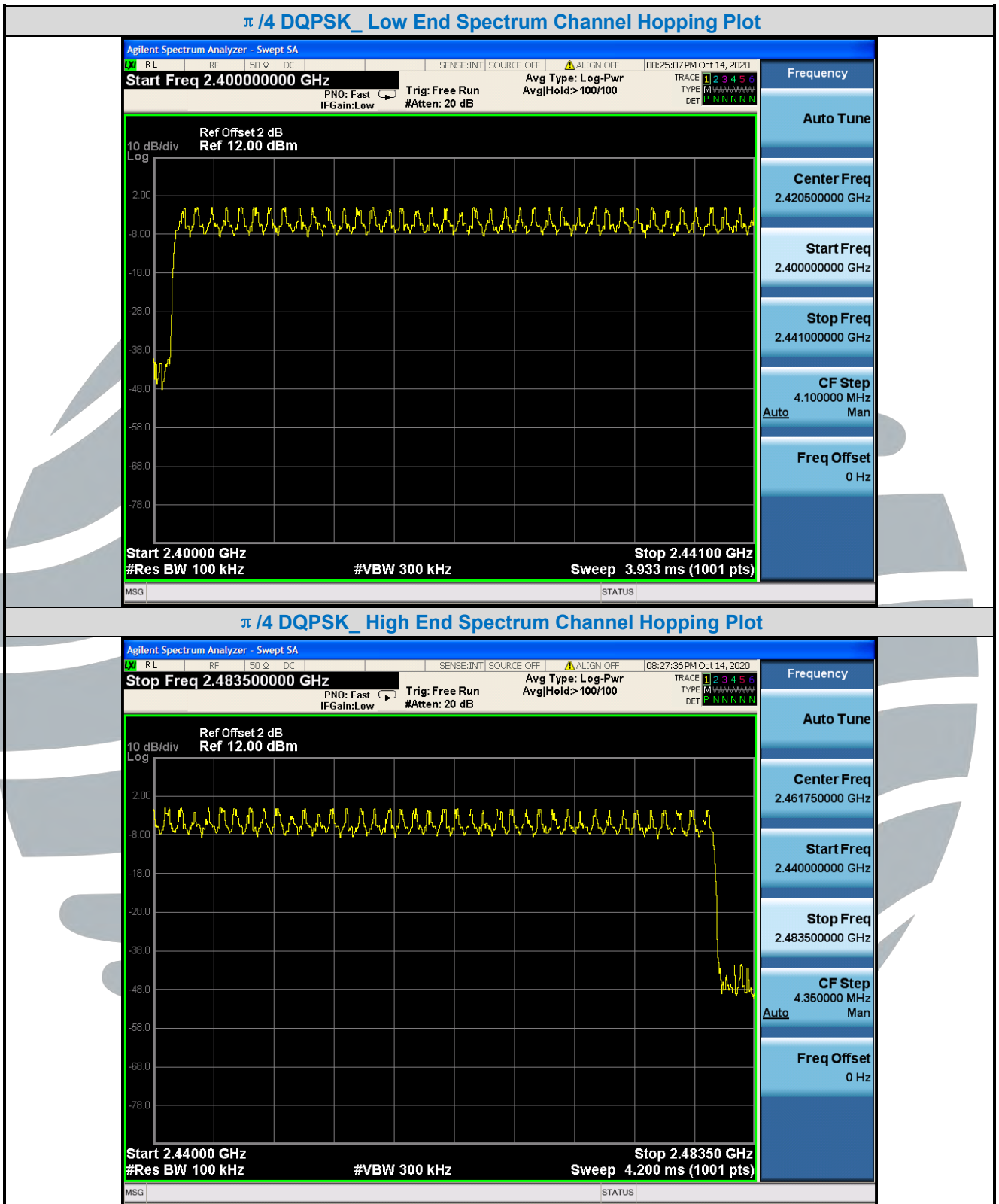
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5.7 DWELL TIME

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247(a)(1)
Test Method: ANSI C63.10-2013 Section 7.8.4
Limit: 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.
Test Procedure: Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
 Use the following spectrum analyzer settings:

- a) Span = zero span, centered on a hopping channel
- b) RBW shall be \leq channel spacing and where possible RBW should be set $\gg 1 / T$, where T is the expected dwell time per channel.
- c) Sweep = As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- d) Detector function = peak
- e) Trace = max hold
- f) Use the marker-delta function to determine the dwell time

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

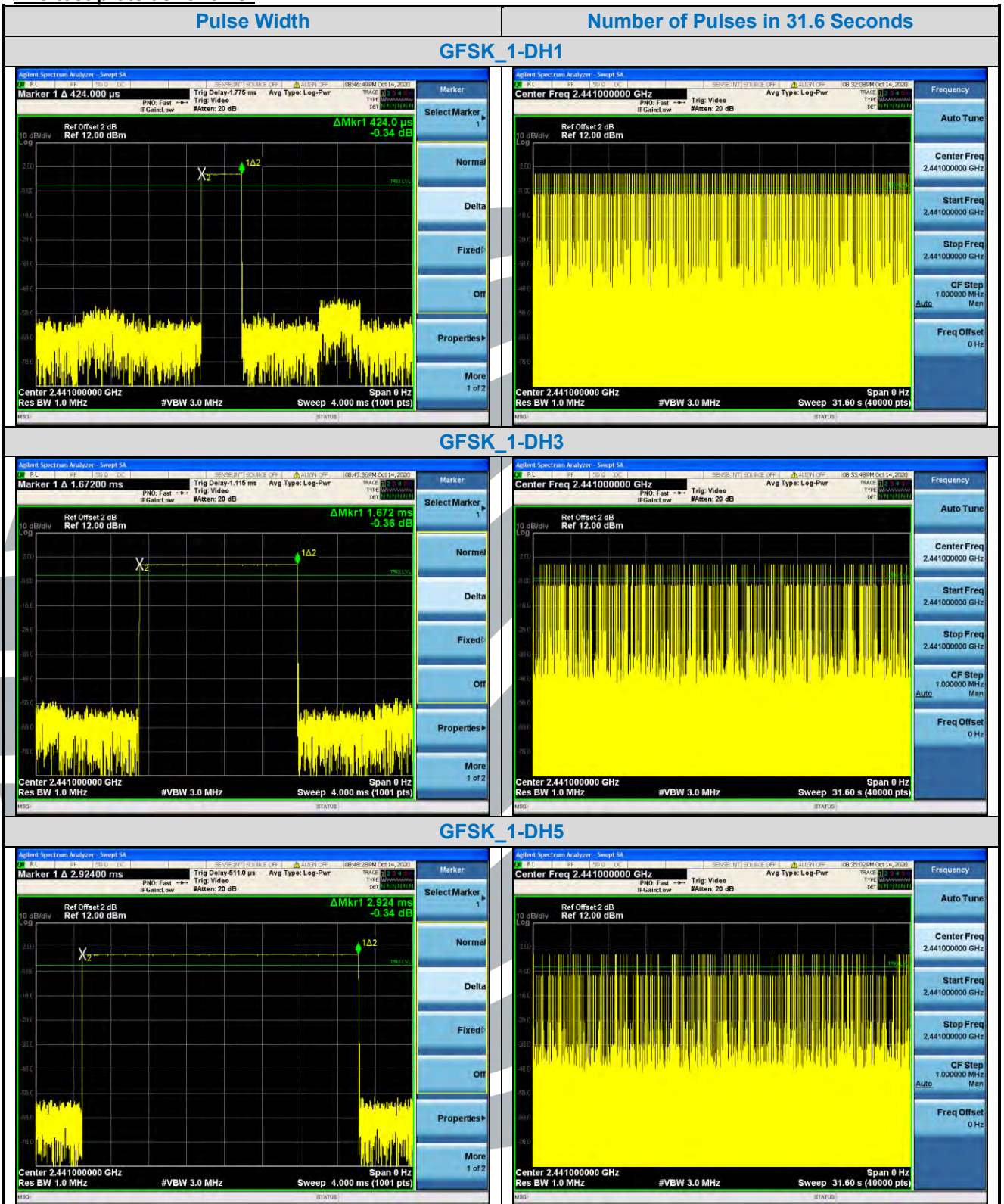
Test Setup: Refer to section 4.5.3 for details.

Instruments Used: Refer to section 3 for details

Test Results: Pass

Type of Modulation	Test Frequency	Packet	Pulse Width	Number of Pulses in 31.6 seconds	Dwell Time	Limit
			ms		ms	ms
GFSK	2441MHz	1-DH1	0.424	245.000	103.88	< 400
		1-DH3	1.672	111.000	185.59	< 400
		1-DH5	2.924	95.000	277.78	< 400
$\pi/4$ DQPSK	2441MHz	2-DH1	0.424	252.000	106.85	< 400
		2-DH3	1.680	120.000	201.60	< 400
		2-DH5	2.928	85.000	248.88	< 400

The test plots as follows:



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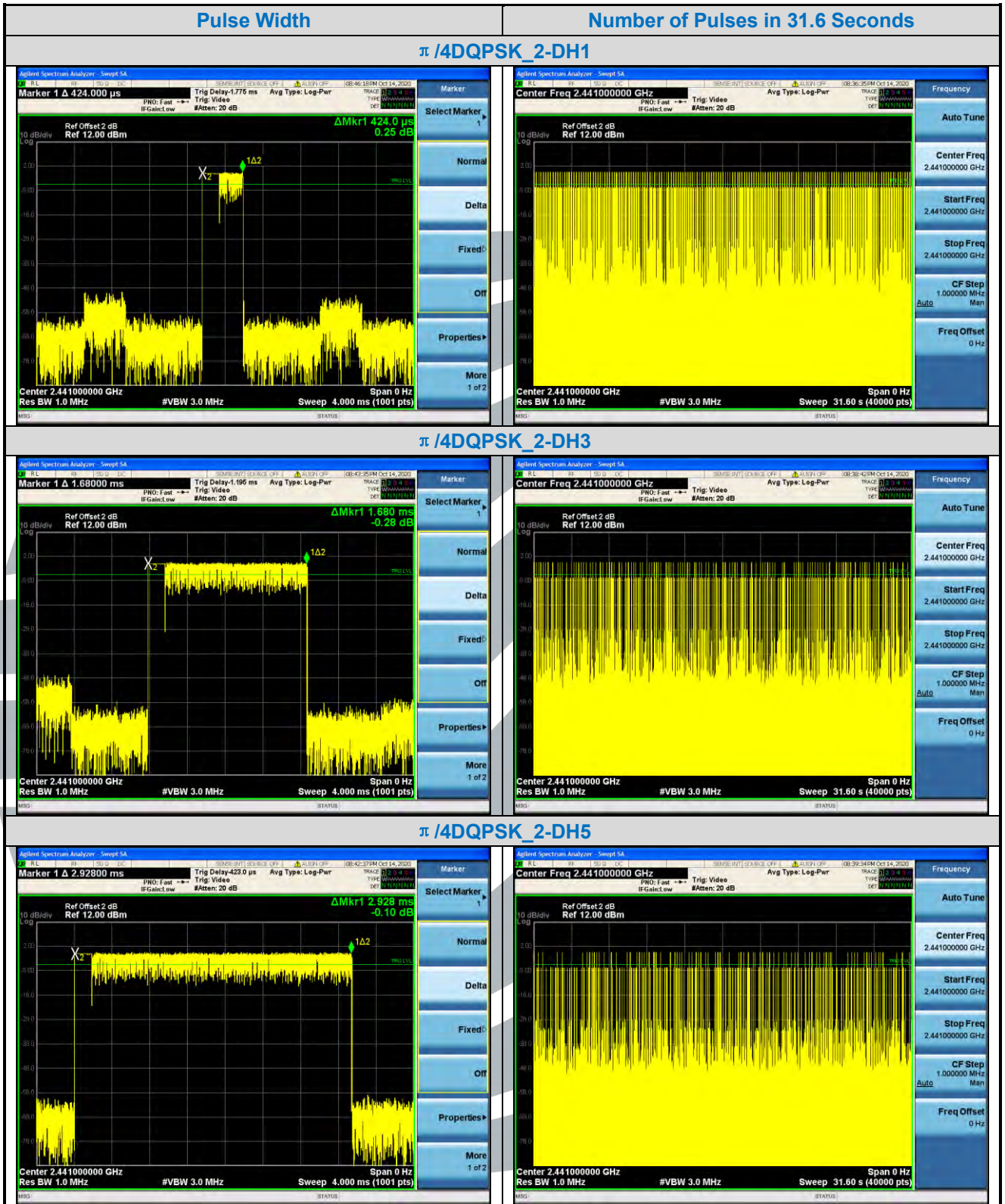
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5.8 CONDUCTED OUT OF BAND EMISSION

- Test Requirement:** FCC 47 CFR Part 15 Subpart C Section 15.247(d)
- Test Method:** ANSI C63.10-2013 Section 6.10.4 & Section 7.8.8
- Limit:** In any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power.
- Test Procedure:** Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
Use the following spectrum analyzer settings:

Step 1: Measurement Procedure REF

- a) Set instrument center frequency to 2400 MHz or 2483.5 MHz.
- b) 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 that fall outside of the authorized band of operation.
- c) Set the RBW = 100 kHz.
- d) Set the VBW $\geq 3 \times$ RBW.
- e) Detector = peak.
- f) Sweep time = auto couple.
- g) Sweep points $\geq 2 \times$ Span/RBW
- h) Trace mode = max hold.
- i) Allow the trace to stabilize.
- j) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

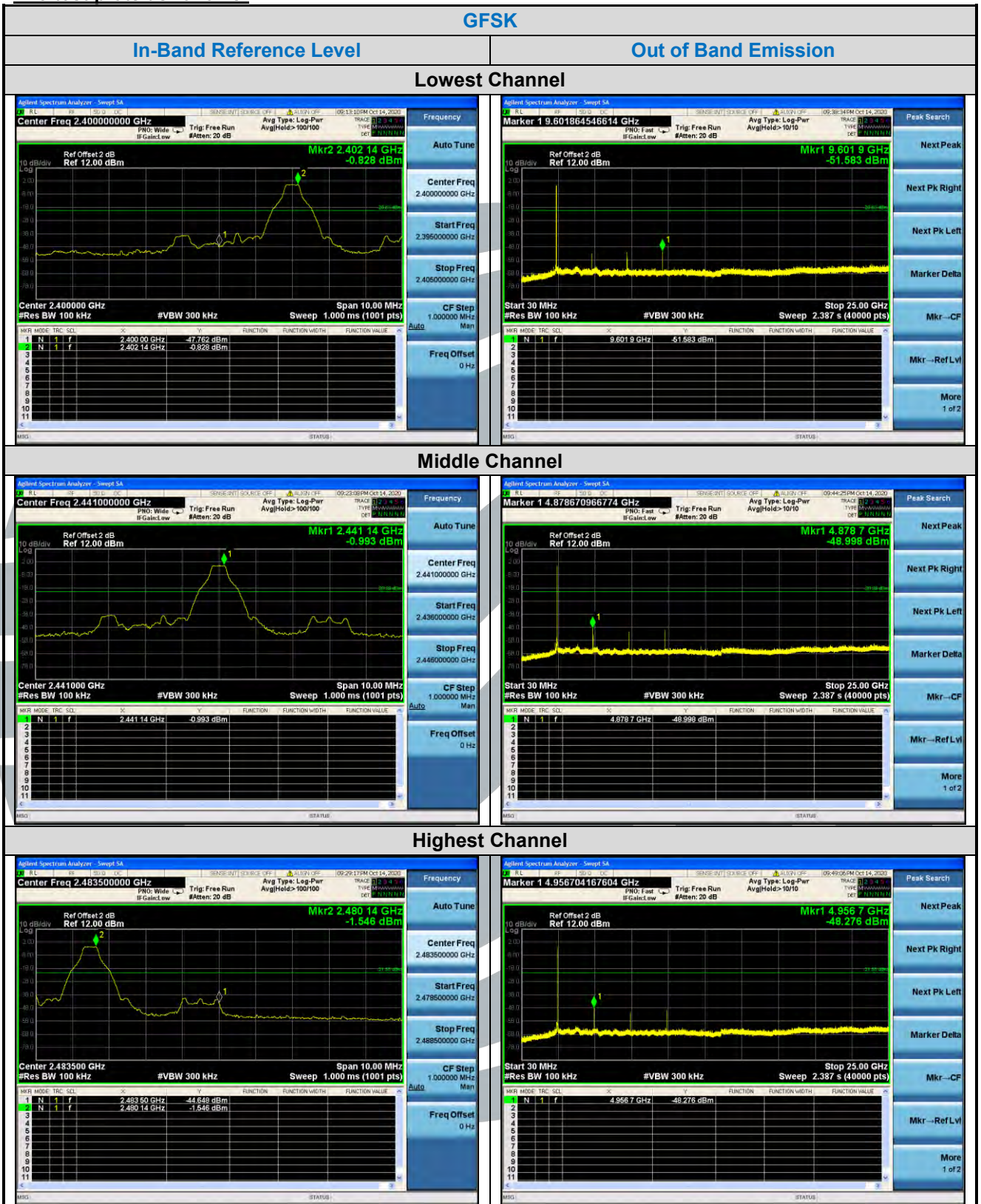
Step 2: Measurement Procedure OOBE

- a) Set RBW = 100 kHz.
- b) Set VBW ≥ 300 kHz.
- c) Detector = peak.
- d) Sweep = auto couple.
- e) Trace Mode = max hold.
- f) Allow trace to fully stabilize.
- g) Use the peak marker function to determine the maximum amplitude level.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

- Test Setup:** Refer to section 4.5.3 for details.
- Instruments Used:** Refer to section 3 for details
- Test Mode:** Hopping Frequencies Transmitter mode
- Test Results:** Pass

The test plots as follows:



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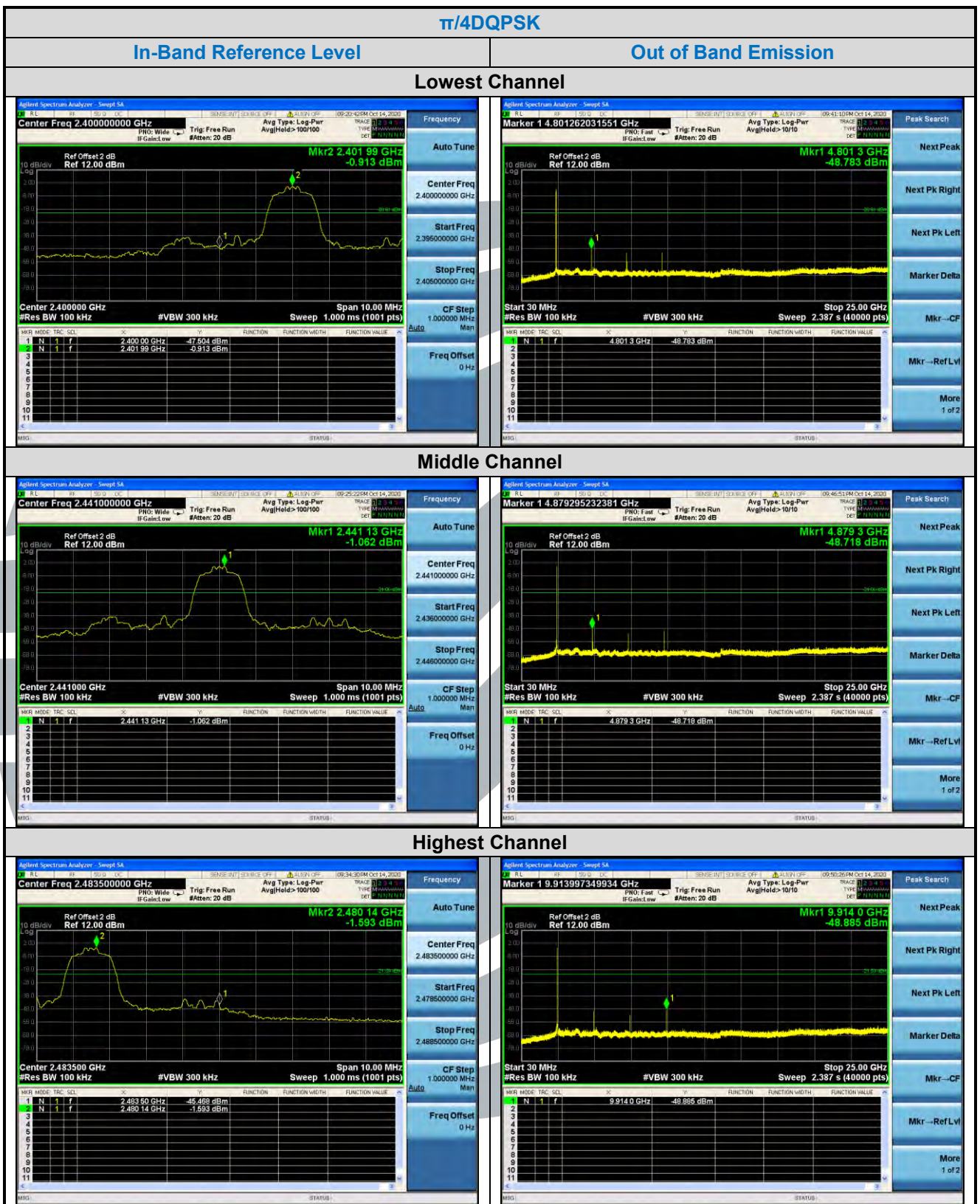
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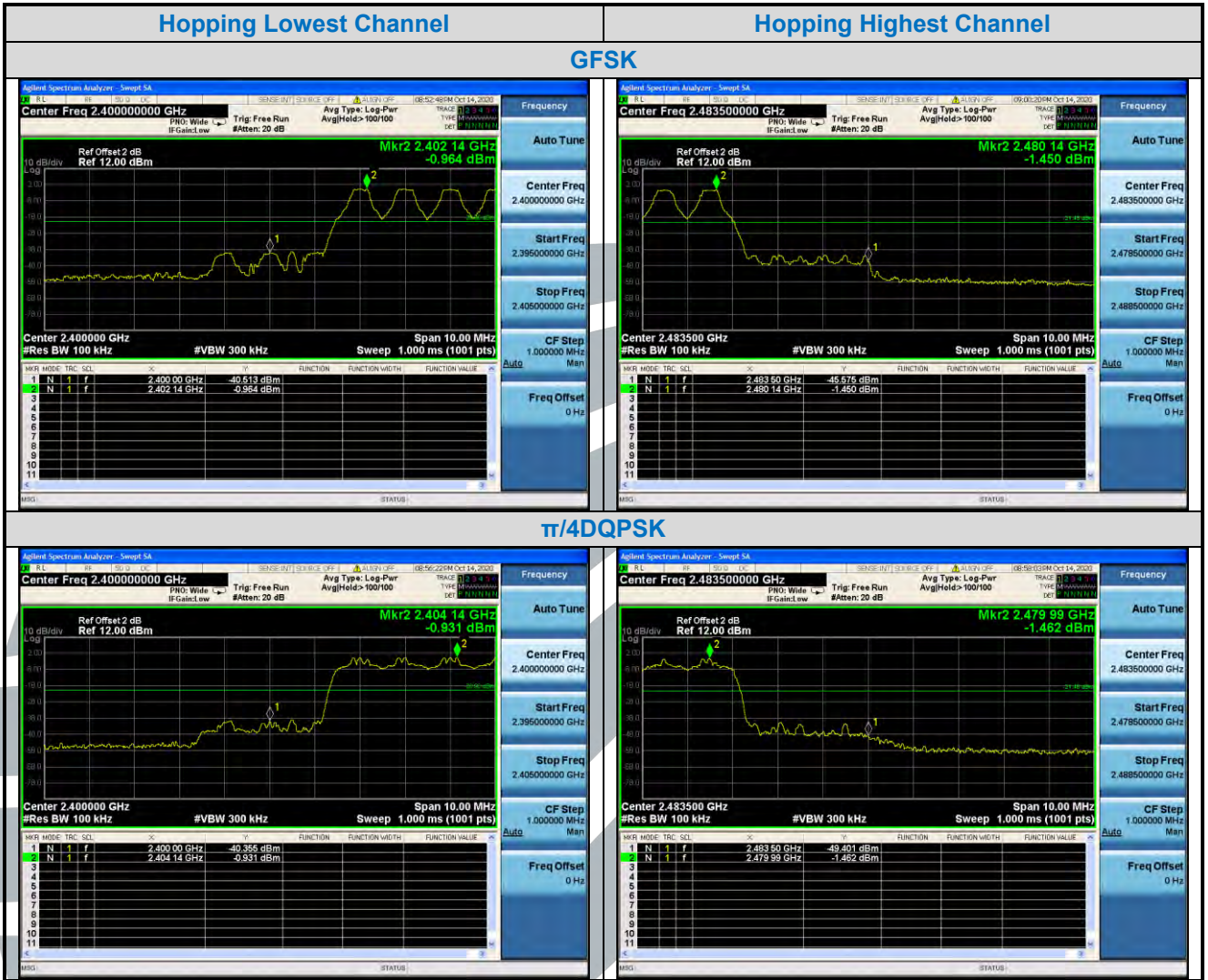
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5.9 RADIATED SPURIOUS EMISSIONS

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.205/15.209

Test Method: ANSI C63.10-2013 Section 6.3 & 6.5 & 6.6

Receiver Setup:

Frequency	RBW
0.009 MHz-0.150 MHz	200/300 kHz
0.150 MHz -30 MHz	9/10 kHz
30 MHz-1 GHz	100/120 kHz
Above 1 GHz	1 MHz

Limits:

Spurious Emissions

Frequency	Field strength (microvolt/meter)	Limit (dBµV/m)	Remark	Measurement distance (m)
0.009 MHz-0.490 MHz	2400/F(kHz)	--	--	300
0.490 MHz-1.705 MHz	24000/F(kHz)	--	--	30
1.705 MHz-30 MHz	30	--	--	30
30 MHz-88 MHz	100	40.0	Quasi-peak	3
88 MHz-216 MHz	150	43.5	Quasi-peak	3
216 MHz-960 MHz	200	46.0	Quasi-peak	3
960MHz-1GHz	500	54.0	Quasi-peak	3
Above 1 GHz	500	54.0	Average	3

Remark:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000 MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20 dB under any condition of modulation.

Test Setup: Refer to section 4.5.1 for details.

Test Procedures:

1. From 30 MHz to 1GHz test procedure as below:
 - 1) The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
 - 2) The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
 - 3) The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
 - 4) For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rota table table was turned from 0 degrees to 360 degrees to find the maximum reading.
 - 5) The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
 - 6) If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
2. Above 1GHz test procedure as below:
 - 1) Different between above is the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber and change form table 0.8 meter to 1.5 meter(Above 18GHz the distance is 1 meter and table is 1.5 meter).

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- 2) Test the EUT in the lowest channel ,middle channel, the Highest channel
- 3) The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the Y axis positioning which it is worse case.
- 4) Repeat above procedures until all frequencies measured was complete.

Equipment Used: Refer to section 3 for details.

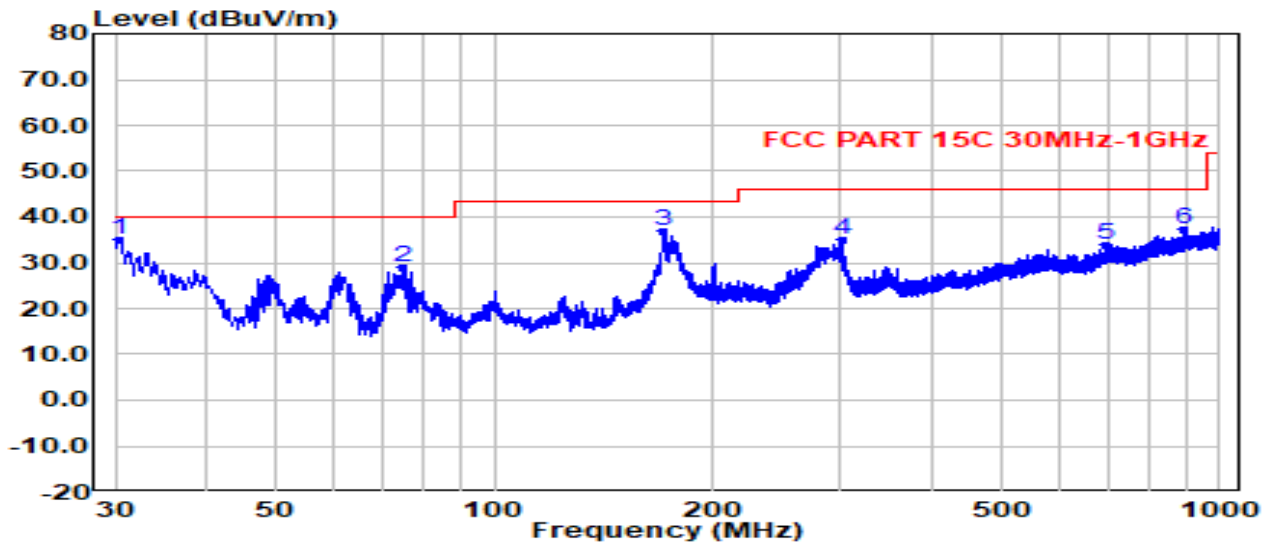
Test Result: Pass

The measurement data as follows:

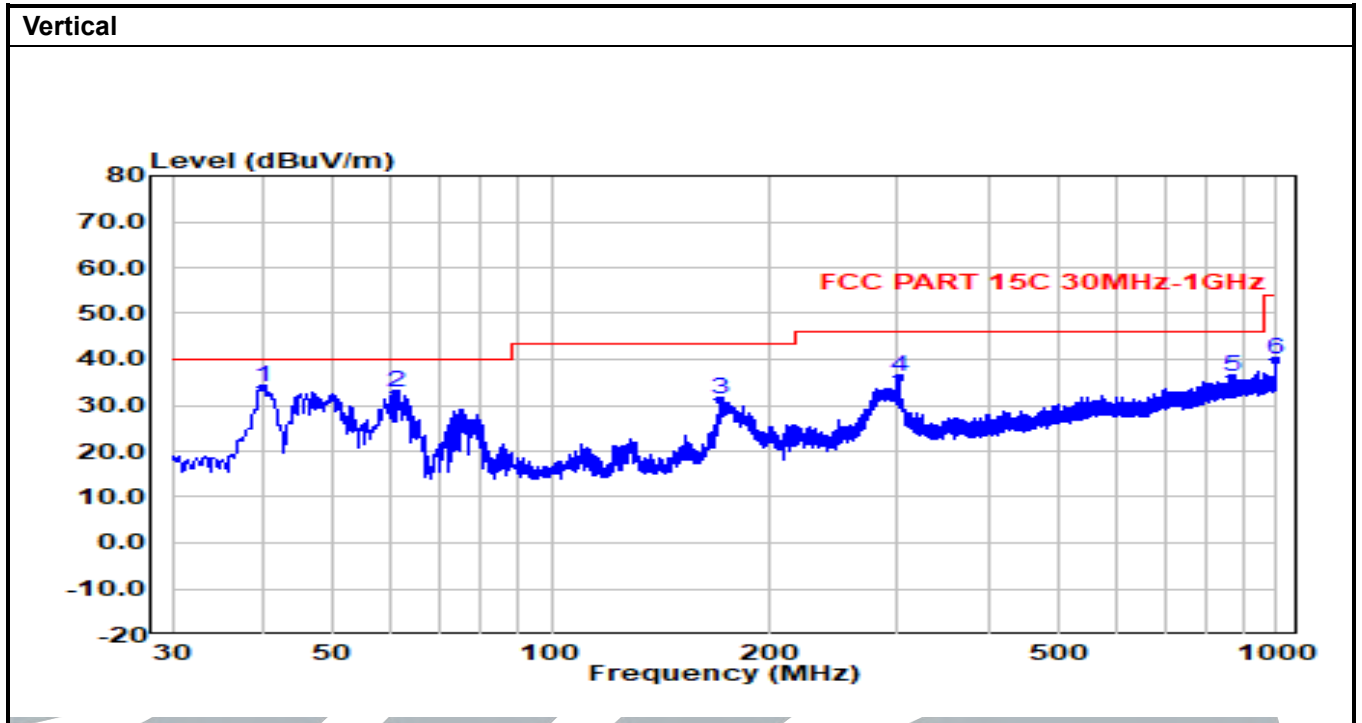
Radiated Emission Test Data (9 KHz ~ 30 MHz):
The amplitude of spurious emissions attenuated more than 20 dB below the permissible value is not required to be report.

Radiated Emission Test Data (30 MHz ~ 1 GHz):
Left Earbud_Worst-Case Configuration

Horizontal



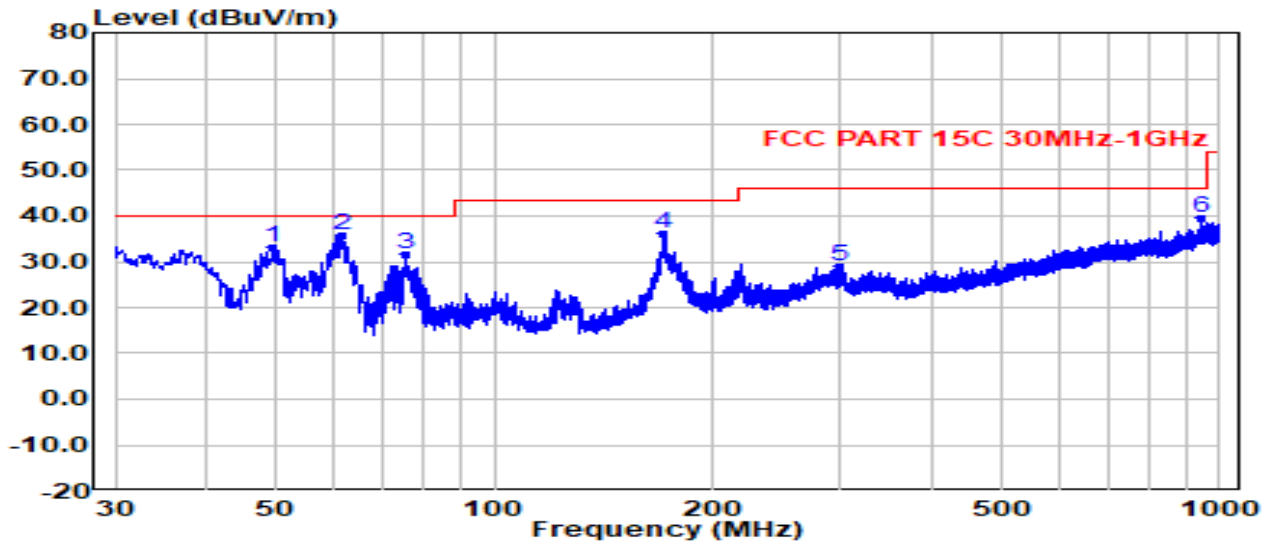
No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	39.895	22.64	11.44	34.08	40.00	-5.92	QP
2	60.849	24.40	8.40	32.79	40.00	-7.21	QP
3	171.440	19.56	11.79	31.35	43.50	-12.15	QP
4	301.336	19.38	16.77	36.15	46.00	-9.85	QP
5	867.485	7.10	29.01	36.11	46.00	-9.89	QP
6	997.575	9.42	30.70	40.12	54.00	-13.88	QP



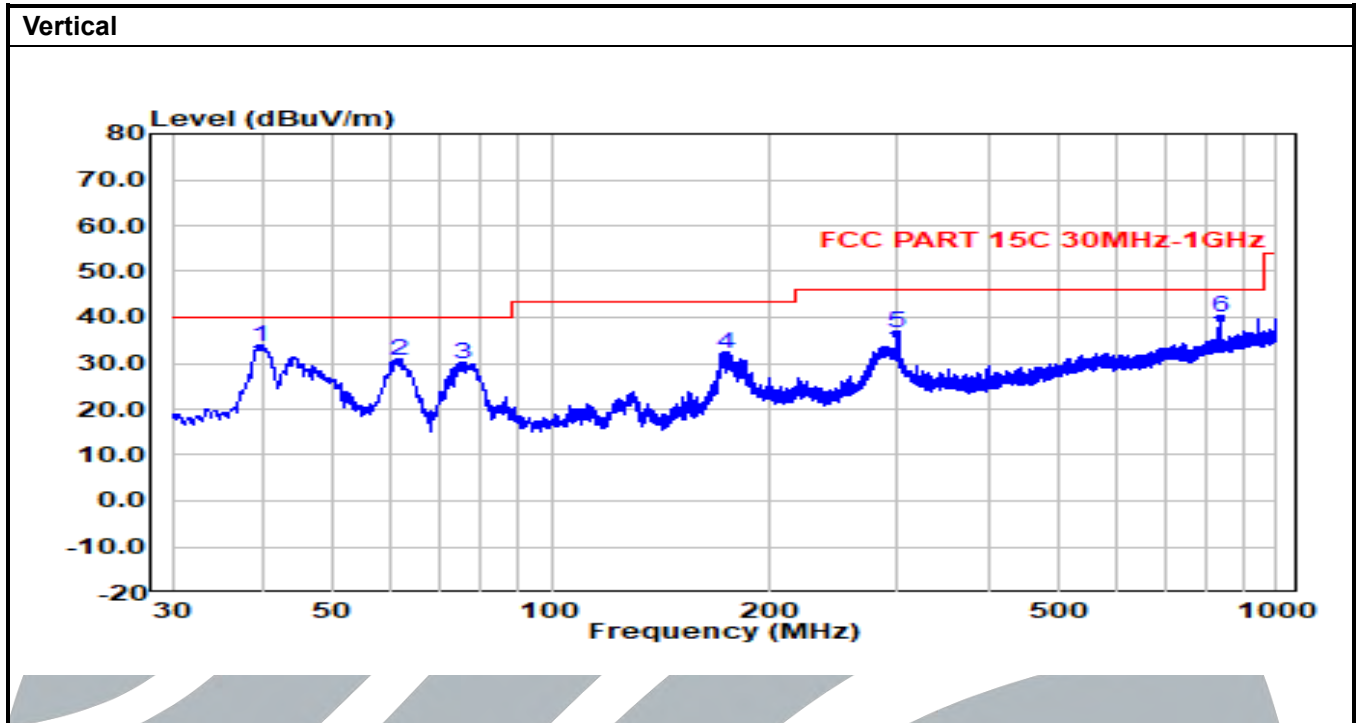
No.	Frequency (MHz)	Reading (dBUV)	Correction factor (dB)	Result (dBUV/m)	Limit (dBUV/m)	Margin (dB)	Detector
1	39.701	21.90	11.56	33.46	40.00	-6.54	QP
2	61.819	22.14	8.44	30.59	40.00	-9.41	QP
3	75.401	20.80	9.18	29.98	40.00	-10.02	QP
4	174.739	19.89	12.06	31.96	43.50	-11.54	QP
5	299.590	19.76	16.73	36.48	46.00	-9.52	QP
6	833.628	11.41	28.74	40.14	46.00	-5.86	QP

Radiated Emission Test Data (30 MHz ~ 1 GHz):
Right Earbud_Worst-Case Configuration

Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	49.402	24.46	8.78	33.24	40.00	-6.76	QP
2	61.722	27.69	8.03	35.71	40.00	-4.29	QP
3	75.304	22.34	9.18	31.52	40.00	-8.48	QP
4	171.440	24.57	11.79	36.37	43.50	-7.13	QP
5	299.687	12.49	16.73	29.22	46.00	-16.78	QP
6	946.257	8.40	31.39	39.79	46.00	-6.21	QP



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	39.701	21.90	11.56	33.46	40.00	-6.54	QP
2	61.819	22.14	8.44	30.59	40.00	-9.41	QP
3	75.401	20.80	9.18	29.98	40.00	-10.02	QP
4	174.739	19.89	12.06	31.96	43.50	-11.54	QP
5	299.590	19.76	16.73	36.48	46.00	-9.52	QP
6	833.628	11.41	28.74	40.14	46.00	-5.86	QP

Radiated Emission Test Data (Above 1GHz):
Left Earbud _Lowest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4804.00	44.11	4.75	48.86	74.00	-25.14	Peak	Horizontal
2	4804.00	38.61	4.76	43.37	54.00	-10.63	Average	Horizontal
3	7206.00	41.25	6.78	48.03	74.00	-25.97	Peak	Horizontal
4	7206.00	32.80	6.78	39.58	54.00	-14.42	Average	Horizontal
5	4804.00	50.04	4.39	54.43	74.00	-19.57	Peak	Vertical
6	4804.00	38.99	4.39	43.38	54.00	-10.62	Average	Vertical
7	7206.00	42.25	6.48	48.73	74.00	-25.27	Peak	Vertical
8	7206.00	35.42	6.48	41.89	54.00	-12.11	Average	Vertical

Left Earbud _Middle Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4882.00	45.89	3.92	50.66	74.00	-23.34	Peak	Horizontal
2	4882.00	38.57	3.92	43.34	54.00	-10.66	Average	Horizontal
3	7323.00	38.62	4.84	45.61	74.00	-28.39	Peak	Horizontal
4	7323.00	31.75	4.84	38.74	54.00	-15.26	Average	Horizontal
5	4882.00	48.21	3.92	52.60	74.00	-21.40	Peak	Vertical
6	4882.00	41.28	3.92	45.67	54.00	-8.33	Average	Vertical
7	7323.00	39.02	4.84	45.71	74.00	-28.29	Peak	Vertical
8	7323.00	33.70	4.84	40.39	54.00	-13.61	Average	Vertical

Left Earbud _Highest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4960.00	45.75	3.96	50.54	74.00	-23.46	Peak	Horizontal
2	4960.00	37.91	3.96	42.70	54.00	-11.30	Average	Horizontal
3	7440.00	40.03	4.95	47.23	74.00	-26.77	Peak	Horizontal
4	7440.00	32.76	4.95	39.96	54.00	-14.04	Average	Horizontal
5	4960.00	34.31	3.96	48.29	74.00	-25.71	Peak	Vertical
6	4960.00	41.12	3.96	45.52	54.00	-8.48	Average	Vertical
7	7440.00	36.13	4.95	48.06	74.00	-25.94	Peak	Vertical
8	7440.00	36.13	4.95	40.68	54.00	-13.32	Average	Vertical

Radiated Emission Test Data (Above 1GHz):
Right Earbud _Lowest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4804.00	47.06	4.76	51.82	74.00	-22.18	Peak	Horizontal
2	4804.00	40.59	4.76	45.35	54.00	-8.65	Average	Horizontal
3	7206.00	37.91	6.78	44.69	74.00	-29.31	Peak	Horizontal
4	7206.00	34.40	6.78	41.18	54.00	-12.82	Average	Horizontal
5	4804.00	48.89	4.40	53.29	74.00	-20.71	Peak	Vertical
6	4804.00	40.11	4.40	44.51	54.00	-9.49	Average	Vertical
7	7206.00	40.61	6.48	47.09	74.00	-26.91	Peak	Vertical
8	7206.00	34.78	6.48	41.26	54.00	-12.74	Average	Vertical

Right Earbud _Middle Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4882.00	47.22	4.77	51.99	74.00	-22.01	Peak	Horizontal
2	4882.00	39.62	4.77	44.39	54.00	-9.61	Average	Horizontal
3	7323.00	39.89	6.99	46.88	74.00	-27.12	Peak	Horizontal
4	7323.00	33.05	6.99	40.04	54.00	-13.96	Average	Horizontal
5	4882.00	47.03	4.39	51.42	74.00	-22.58	Peak	Vertical
6	4882.00	40.76	4.39	45.15	54.00	-8.85	Average	Vertical
7	7323.00	39.34	6.69	46.03	74.00	-27.97	Peak	Vertical
8	7323.00	35.33	6.52	41.85	54.00	-12.15	Average	Vertical

Right Earbud _Highest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4960.00	46.79	4.79	51.58	74.00	-22.42	Peak	Horizontal
2	4960.00	38.40	4.79	43.19	54.00	-10.81	Average	Horizontal
3	7440.00	39.97	7.20	47.17	74.00	-26.83	Peak	Horizontal
4	7440.00	34.67	7.20	41.87	54.00	-12.13	Average	Horizontal
5	4960.00	45.50	4.40	49.90	74.00	-24.10	Peak	Vertical
6	4960.00	39.18	4.40	43.58	54.00	-10.42	Average	Vertical
7	7440.00	38.96	6.90	45.86	74.00	-28.14	Peak	Vertical
8	7440.00	34.48	6.90	41.38	54.00	-12.62	Average	Vertical

Remark:

1. Correct Factor = Antenna Factor + Cable Loss - Amplifier Gain, the value was added to Original Receiver Reading by the software automatically.
2. Result = Reading + Correct Factor.
3. Margin = Result - Limit

5.10 BAND EDGE MEASUREMENTS (RADIATED)

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.205/15.209

Test Method: ANSI C63.10-2013 Section 6.10.5

Limits:

Radiated emissions which fall in the restricted bands, as defined in section 15.205(a), must also comply with the radiated emission limits specified in section 15.209(a).

Frequency	Limit (dBµV/m @3m)	Remark
30 MHz-88 MHz	40.0	Quasi-peak Value
88 MHz-216 MHz	43.5	Quasi-peak Value
216 MHz-960 MHz	46.0	Quasi-peak Value
960 MHz-1 GHz	54.0	Quasi-peak Value
Above 1 GHz	54.0	Average Value
	74.0	Peak Value

Test Setup: Refer to section 4.5.1 for details.

Test Procedures:

Radiated band edge measurements at 2390 MHz and 2483.5 MHz were made with the unit transmitting in the low end of the channel range and the high end closest to the restricted bands respectively. The emissions were made on the 966 Semi-Chamber. Use (resolution bandwidth (RBW) = 1 MHz, video bandwidth (VBW) = 3 MHz for peak levels and RBW = 1 MHz and VBW = 10 Hz or 1/T for average levels).

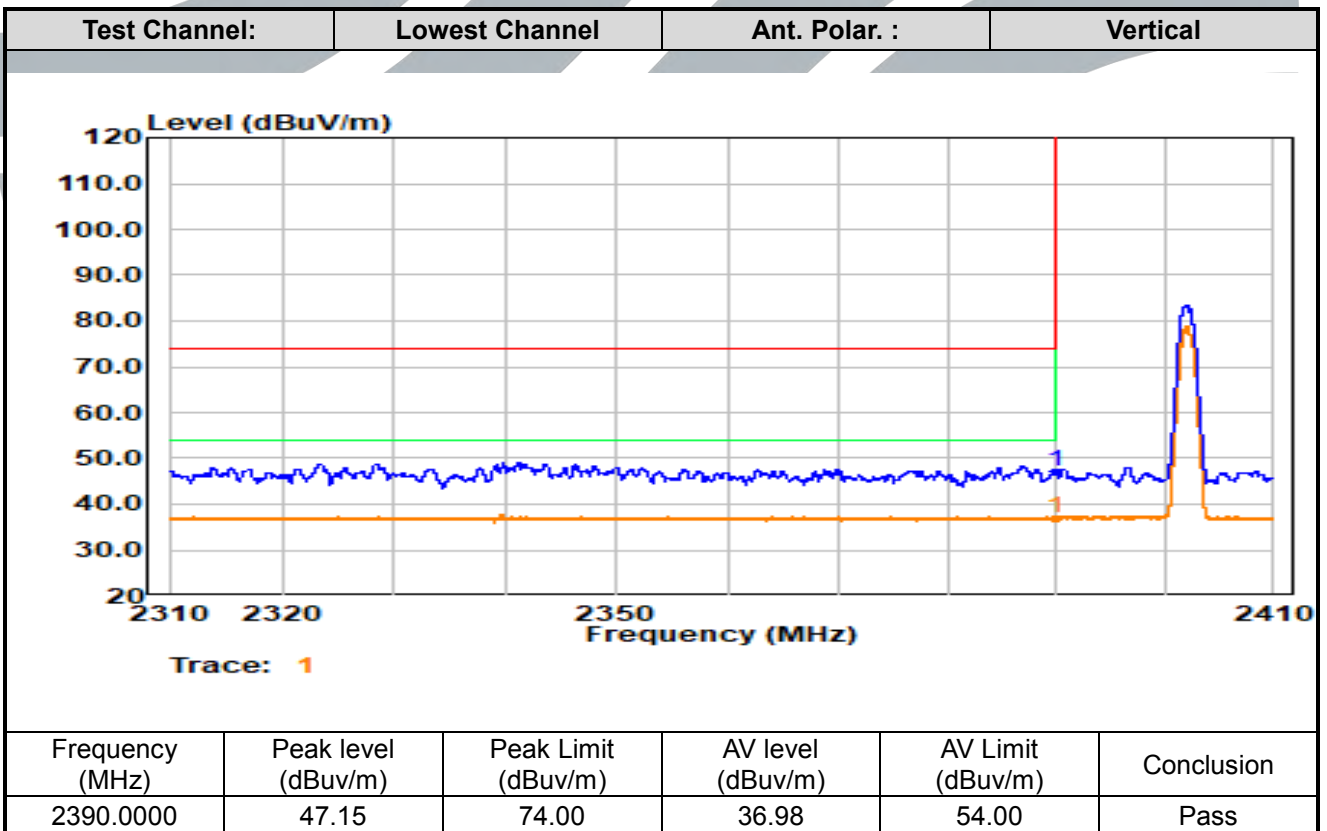
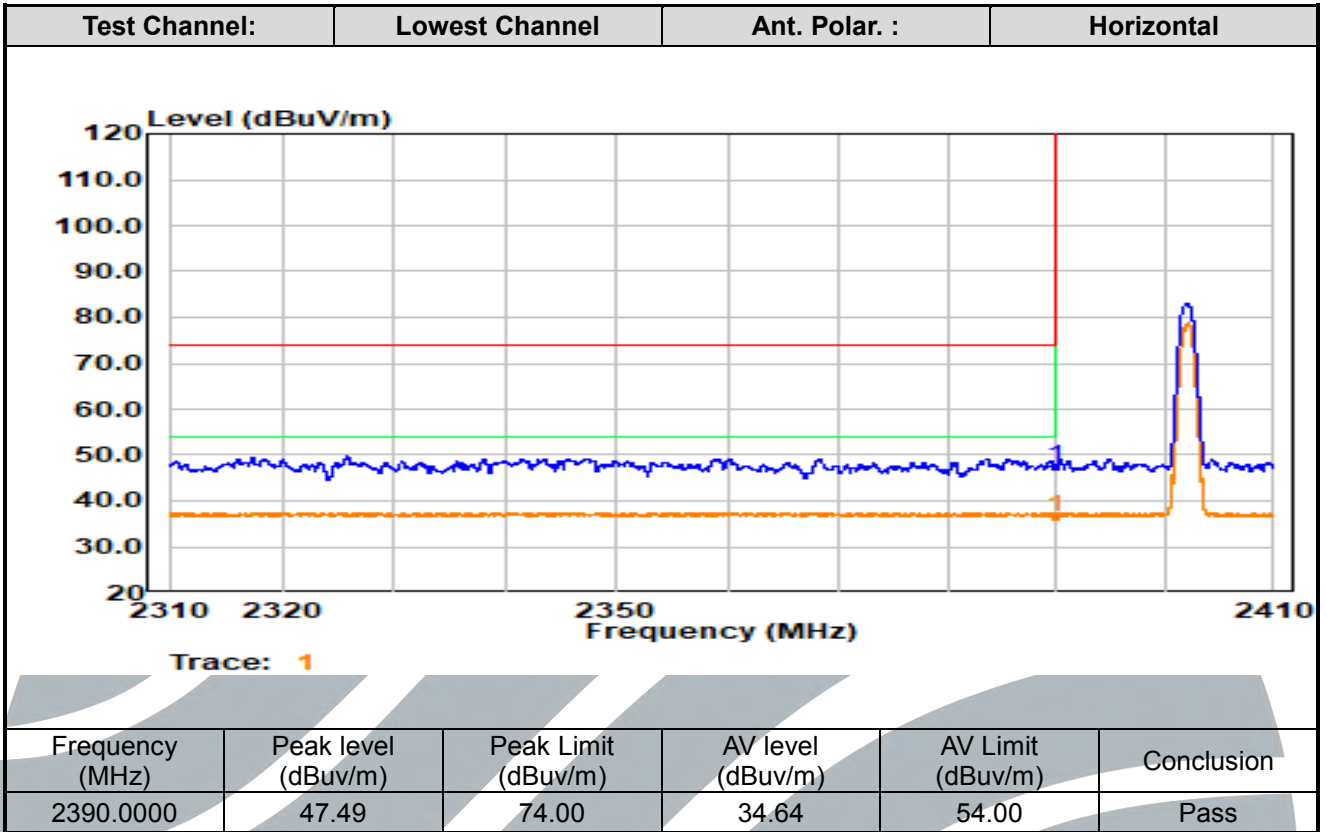
1. Use radiated spurious emission test procedure described in clause 5.10. The transmitter output (antenna port) was connected to the test receiver.
2. Set the PK and AV limit line.
3. Record the fundamental emission and emissions out of the band-edge.
4. Determine band-edge compliance as required.

Equipment Used: Refer to section 3 for details.

Test Result: Pass

The measurement data as follows:

Left Earbud



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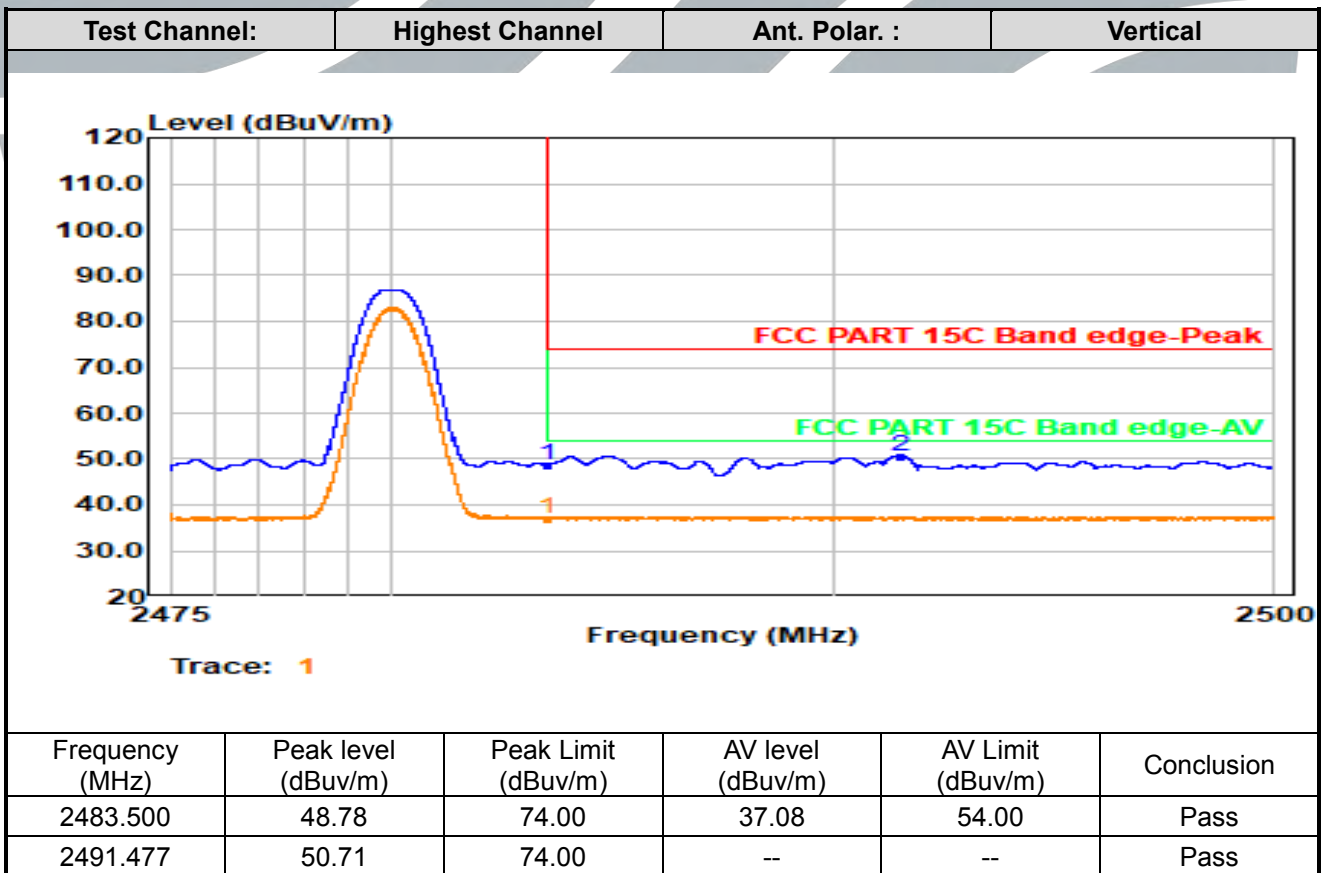
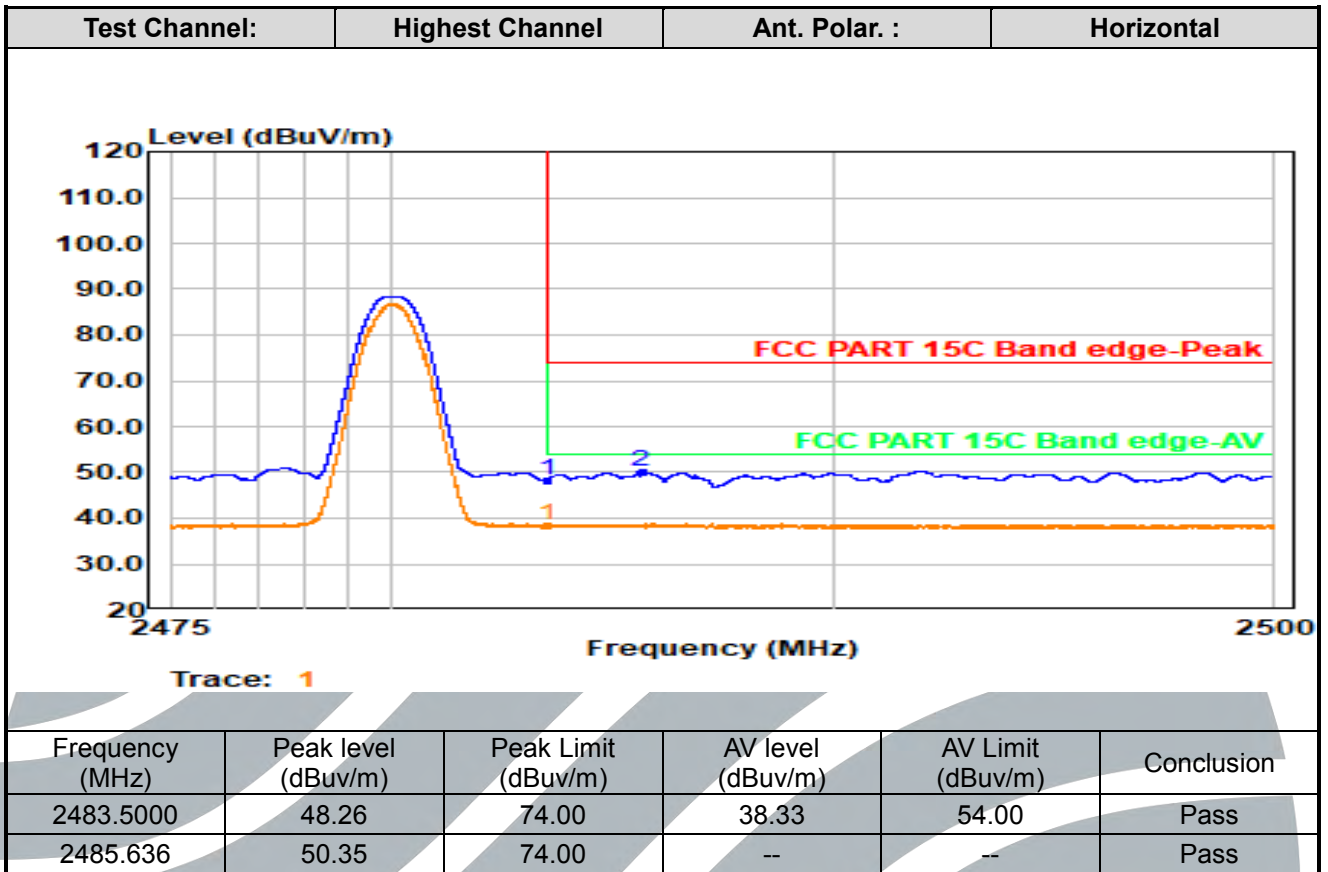
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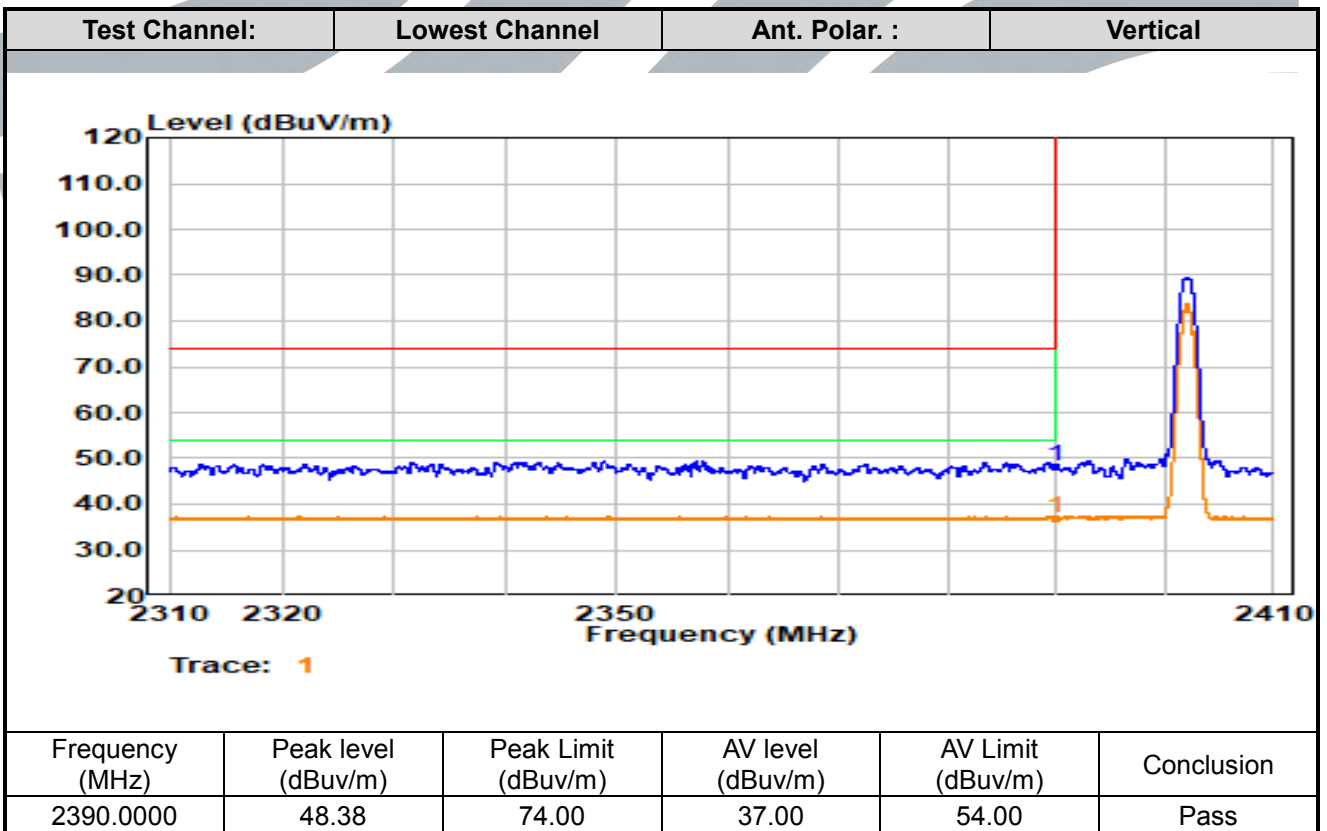
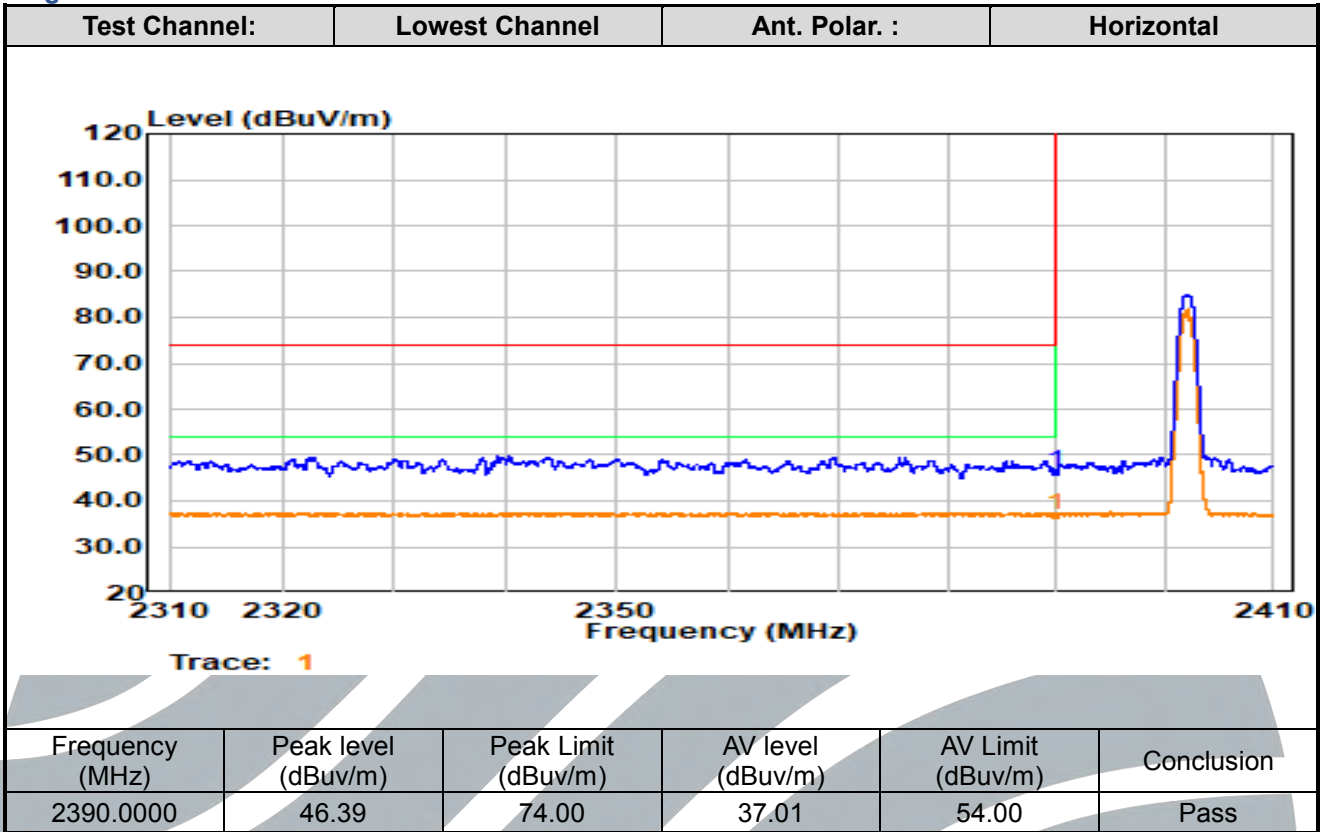
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Right Earbud



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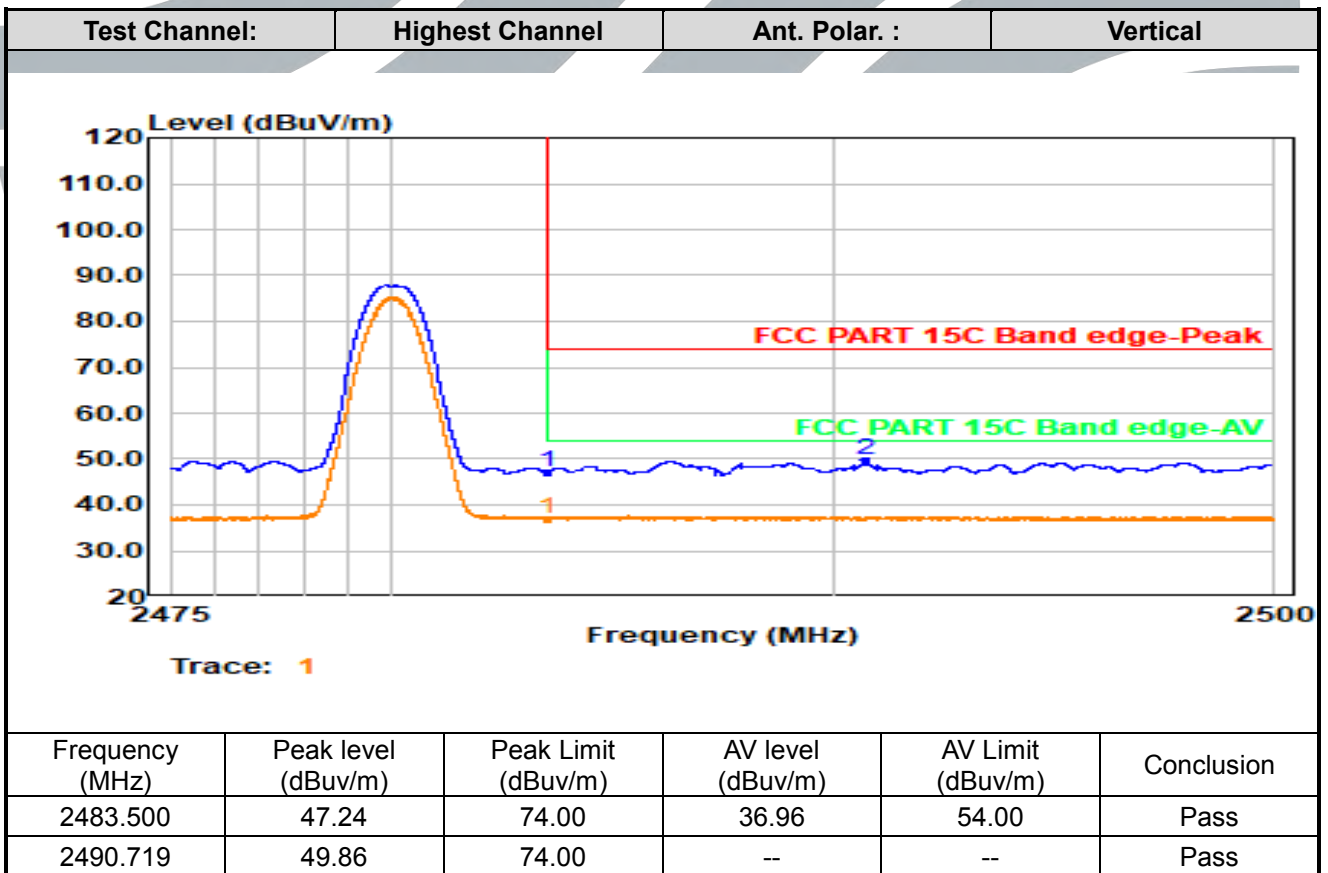
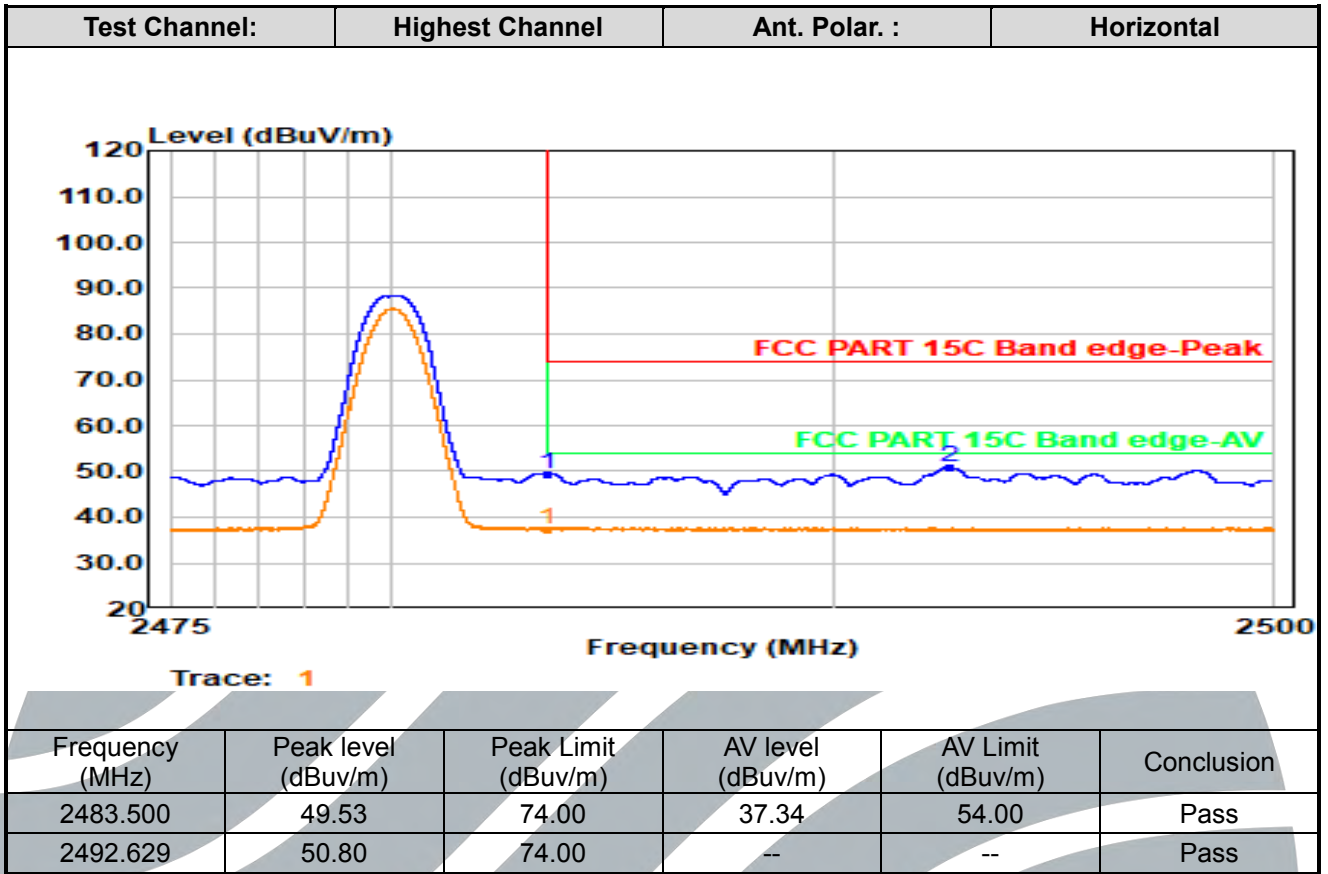
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APPENDIX 1 PHOTOS OF TEST SETUP

See test photos attached in Appendix 1 for the actual connections between Product and support equipment.

APPENDIX 2 PHOTOS OF EUT CONSTRUCTIONAL DETAILS

Refer to Appendix 2 for EUT external and internal photos.

*** End of Report ***

The test report is effective only with both signature and specialized stamp. The result(s) shown in this report refer only to the sample(s) tested. Without written approval of UnionTrust, this report can't be reproduced except in full.
