



FCC & ISED CANADA CERTIFICATION TEST REPORT

for the

NA230951

FCC ID: YJ7-NA230951

IC ID: 9082A-NA230951

WLL REPORT# 18776-0951 REV 0

Prepared for:

Stanley Black & Decker, Inc.

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Testing Certificate AT-1448



FCC & ISED Canada Certification Test Report

for the

Stanley Black & Decker, Inc.

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FCC ID: YJ7-NA230951

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July 31, 2024

WLL Report# 18776-0951 Rev 0

Prepared by:

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Steven D. Koster
President



Abstract

This report has been prepared on behalf of Stanley Black & Decker, Inc. to support the attached Application for Equipment Authorization. The test report and application are submitted for a Digital Transmission System (DTS) transmitter under Part 15.247 of the FCC Rules and under Innovation Science and Economic Development (ISED) Canada RSS-247, Issue 3 (8/2023). This certification test report documents the test configuration and test results for the Stanley Black & Decker, Inc., NA230951 Bluetooth LE, limited single-modular transmitter. The information provided in this report is only applicable to device herein documented as the EUT.

Radiated testing was performed in the Free-space Anechoic Chamber Test-site (FACT) 3m chamber of Washington Laboratories, Ltd., located at: 4840 Winchester Boulevard, Suite #5., Frederick, MD 21703. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory. The ISED Canada number for Washington Laboratories is 3035A.

The Stanley Black & Decker, Inc., NA230951, BLE Module [FCC ID: YJ7-NA230951] complies with the requirements for a Digital Transmission System (DTS) transmitter device under FCC Part 15.247 and ISED Canada RSS-247 Issue 3 (8/2023). The device is a limited single-modular transmitter.

Revision History	Description of Change	Date
Rev 0	Initial Release	July 31, 2024
Rev 1	Removed Receiver spurious testing information	August 6, 2024



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1 Introduction

1.1 Compliance Statement

The Stanley Black & Decker, Inc., NA230951, BLE Module [FCC ID: YJ7-NA230951] complies with the requirements for a Digital Transmission System (DTS) transmitter device under FCC Part 15.247 and ISED Canada RSS-247 Issue 3 (8/2023). The device is a limited single-modular transmitter.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with ANSI C63.10-2020 “ANSI Procedures for Compliance Testing of Unlicensed Wireless Devices”. The measurement equipment conforms to ANSI C63.2 “Specifications for Electromagnetic Noise and Field Strength Instrumentation”. The modules were tested “stand alone” as required for modular testing and approval.

1.3 Contract Information

Customer:	Stanley Black & Decker, Inc.
Purchase Order Number:	M865624
Quotation Number:	74701

1.4 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Kirwan Magdamo

1.5 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The ISED Canada OATS number for Washington Laboratories, Ltd. is 3035A. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.



2 Equipment Under Test

2.1 EUT Identification

Table 1: Device Summary

Manufacturer:	Stanley Black & Decker, Inc.	
FCC ID:	YJ7-NA230951	
IC ID:	9082A-NA230951	
Part Number:	NA230951	
HVIN:	NA230951	
Frequency Range:	2402 to 2480 MHz	
Peak Output Power:	0.89 dBm (1.23 mW)	
Antenna Type:	PCB meander trace, peak gain: -6.48 dBi	
FCC Emission Designator:	714KG1D	
IC Emission Designator:	2M1G1D	
6dB Occupied Bandwidth:	714.1 kHz	
99% Occupied Bandwidth:	2.08 MHz	
Protocol:	Bluetooth Low Energy (BLE)	
Modulation and Data Rate:	GFSK (1Mbps)	
	$\pi/4$ DQPSK (2Mbps)	
Keying:	Automatic	
Type of Information:	Digital	
Number of Data Channels:	37	
Interface Cables:	N/A	
Power Source & Voltage:	3VDC, via coin-cell battery	
Worst-Case TX Spurious Emission:	Antenna Port Conducted	2.351 GHz @ -42.8 dBm (Figure 38)
	Radiated Emissions	83.1 MHz @ 31.65 dBuV/m (Table 13)
Software/Firmware Version:	Not Declared by Applicant	
Testing Dates:	6/17/2024 to 7/9/2024	



2.2 EUT Description

The NA230951 is DeWalt's Gen2 Bluetooth Low Energy Module (BLEM). The BLE transmitter module is designed for tracking, locating, enabling/disabling, and customizing DeWalt professional power tools via the DeWalt Site Manger App., and via DeWalt Asset Gateway. The device can operate off the internal CR2450 coin cell battery or alternately the DeWalt battery pack, when present. Please note the device being certified is a limited single-modular transmitter. The module samples were tested stand-alone as required for modular testing and approval.

2.3 Test Configuration and Algorithm

The NA230951, 3.3V Gen2 BLEM was provided in a variety of engineering samples that were configured for testing. The EUT samples were loaded with test-mode software/firmware to allow individual samples to dwell, hop, sweep, and/or receive only as needed for required testing. The EUT was tested in a powered on, steady state. The 2.4GHz BLE radio was exercised as necessary to meet the requirements of the testing. For conducted measurements, the BLE radio was observed through the uFl antenna port. For radiated emissions below 1GHz, the EUT was set to transmit in a hopping enabled mode, sweeping through the ISM band. For radiated emissions above 1GHz, the EUT was set to transmit at the each of the Low, Center, and High Channels. Only the worst-case emissions are provided throughout this report. Additionally, for transmit power setting, or transmit gain setting, the test-mode software was set to a value of "0". This setting was maintained for all testing.

2.4 Deviations to the Test Standard

There were no deviations to the requirements of the standard(s).



2.5 EUT Configuration Details

The EUT was comprised of the following equipment, provided on the following page. All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.

Table 2: EUT System Configuration List

Name / Description	Model Number	Part Number	Serial Number	Rev. #
NA230951 Conducted	--	NA230951	Conducted	rF1
NA230951 Radiated Lo	--	NA230951	2402	rF1
NA230951 Radiated Mid	--	NA230951	2440	rF1
NA230951 Radiated High	--	NA230951	2480	rF1
NA230951 Radiated Hopping	--	NA230951	Hop	rF1
NA230951 Production	--	NA230951	Prod	rF1

Table 3: Support Equipment

Name / Description	Manufacturer	Model Number	Calibration Data
USB to UART Cable	FTDI	TTL-232R-3V3	N/A
UMCC to SMA Cable Assembly	TE Connectivity	2032439-1	N/A
T3 Driver	--	--	N/A

Table 4: Cable Configuration

Ref. ID	EUT Port Name	Cable Description	Qty.	Length (m)	Shielded	Termination Port ID
1	DTM	V+, UART TX, UART RX, GND	1	0.2	No	PC
2	RF Out	Coax with SMA connector	1	1.8	Yes	EMC Receiver



Figure 1: EUT Testing Arrangement (Example Only)

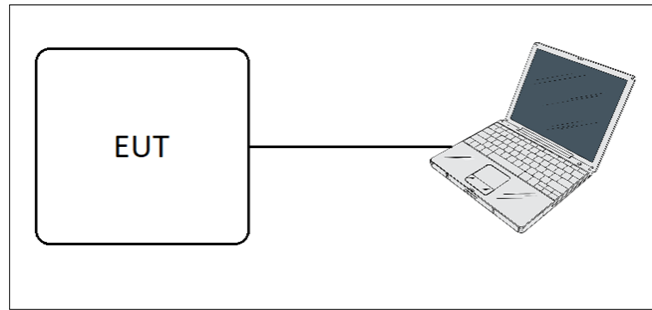
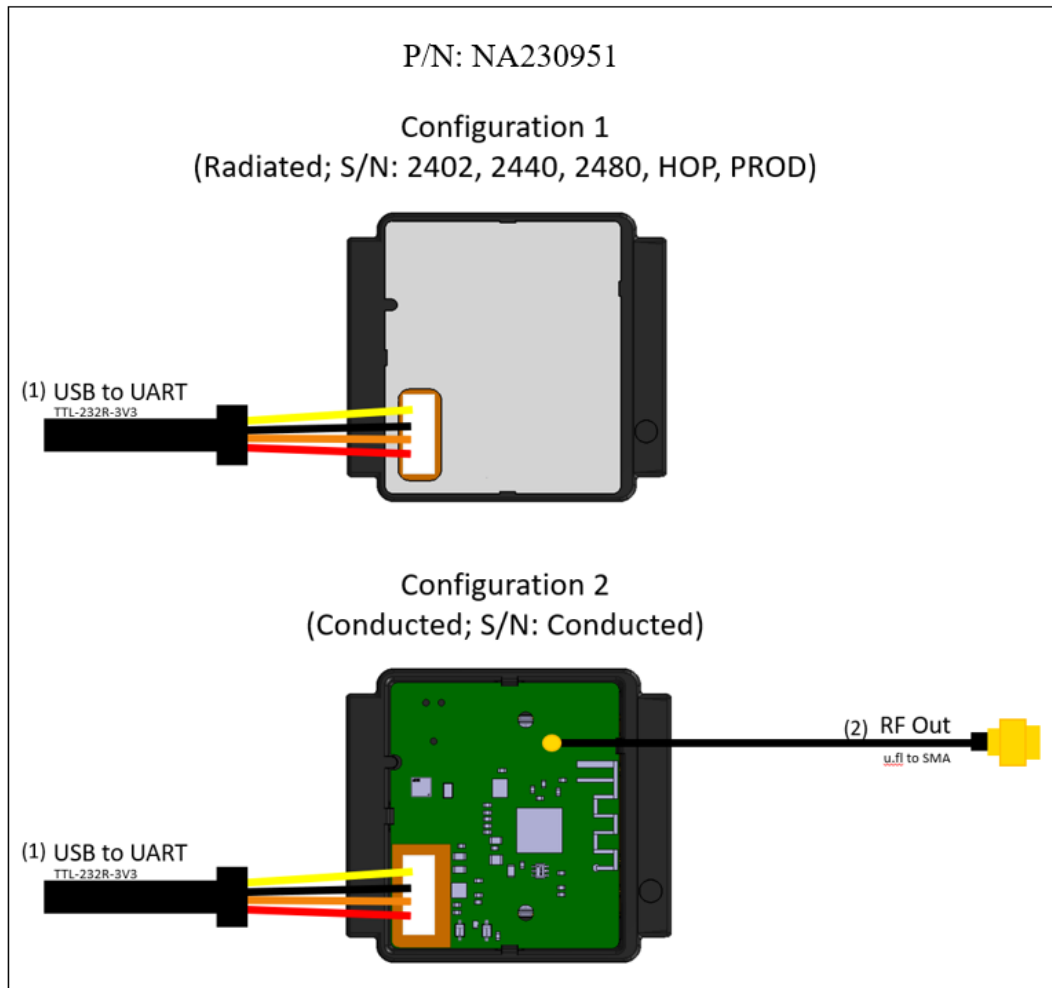


Figure 2: EUT Sample Configuration (Example Only)





3 Test Results

The table below shows the results of testing for compliance with a Digital Transmission System in accordance with FCC Part 15.247 and RSS-247 Issue 3. Full test results are shown in subsequent sub-sections.

Table 5: Testing and Results Summary

FCC Rule Part	IC Rule Part	Description	Result
15.247(a)(2)	RSS-247 [5.2 (a)]	Occupied Channel Bandwidth	Pass
15.247 (b)(3)	RSS-247 [5.4 (d)]	Transmit Output Power	Pass
15.247 (e)	RSS-247 [5.2 (b)]	Power Spectral Density	Pass
15.247 (d)	RSS-247 [5.5]	Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-Gen [8.9/8.10]	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [8.8]	AC Conducted Emissions	N/A *

* the EUT is not subject to the provisions of 15.207 for powerline emissions. This device is powered by coin-cell battery, or the DC voltage will be supplied via the final host integration. The grantee will address this requirement on a case-by-case basis, through subsequent Supplier’s Declaration of Conformity (SDoC) assessments, as the module is integrated into future host products.



3.1 Occupied (DTS) Bandwidth

For a DTS operating in the 2.4GHz band, FCC Rule Part 15.247(a)(2) and RSS-247, 5.2(a) require the minimum 6dB bandwidth be at least 500 kHz. The 99% BW shall also be recorded.

The transmitter occupied bandwidth was measured conducted at the antenna port, by coupling the output of the EUT transmitter to the input of a spectrum analyzer. The measurement level was corrected for any cable and attenuator losses.

3.1.1 Measurement Method

This test was performed in accordance with Clause 11.8.2, Option 2, of ANSI C63.10-2020.

3.1.2 Test Data

The EUT test data is provided below.

The EUT was configured to transmit a modulated signal, with channel hopping disabled.

Table 6: Occupied Bandwidth Results

Modulation	Mode (Data Rate)	Frequency (MHz)	6dB Bandwidth	99% Bandwidth
GFSK	DH5 (1Mbps)	2402	714.1 kHz	1.07 MHz
		2440	721.6 kHz	1.08 MHz
		2480	705.0 kHz	1.08 MHz
$\pi/4$ DQPSK	2DH5 (2Mbps)	2402	1.14 MHz	2.08 MHz
		2440	1.14 MHz	2.08 MHz
		2480	1.13 MHz	2.08 MHz



Figure 3: Occupied Bandwidth, Low Channel, 1Mbps (DH5)

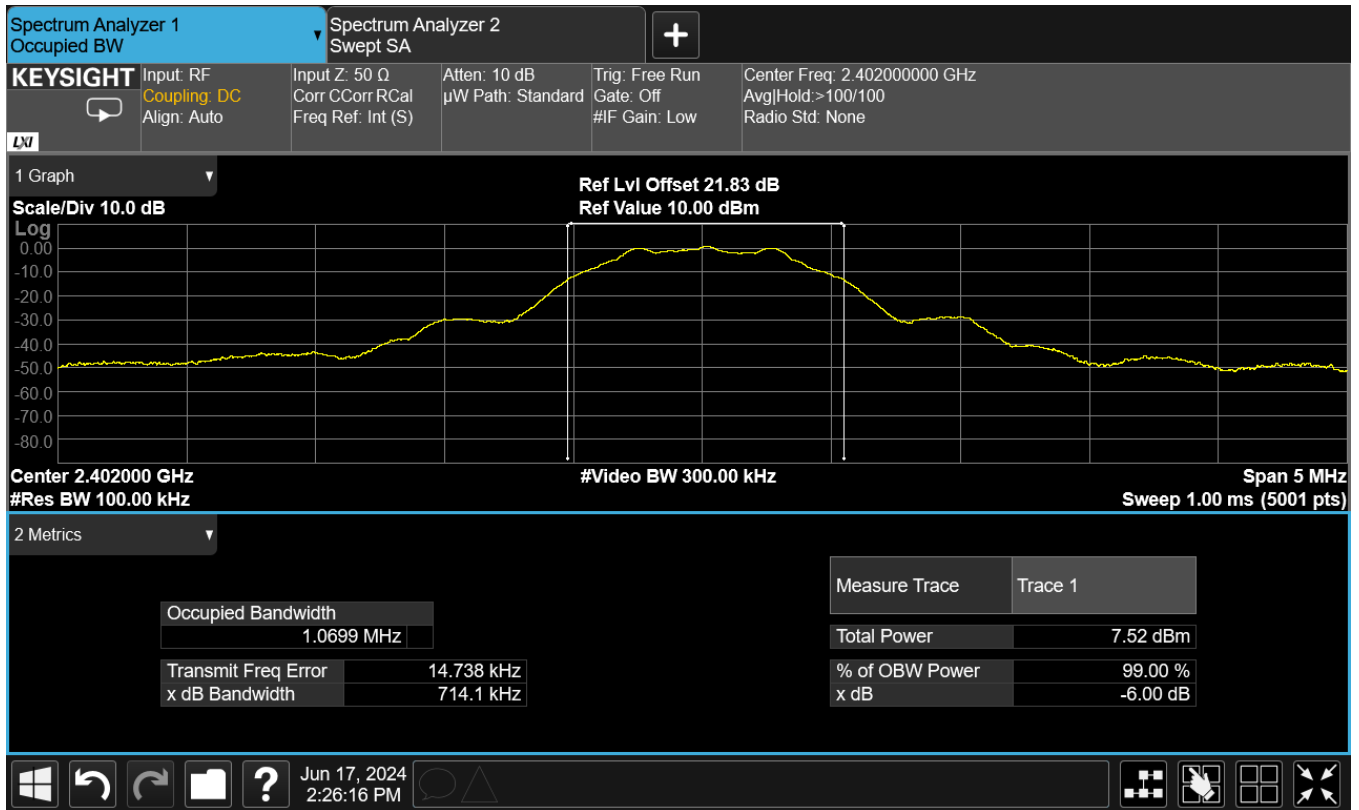




Figure 4: Occupied Bandwidth, Center Channel, 1Mbps (DH5)





Figure 5: Occupied Bandwidth, High Channel, 1Mbps (DH5)

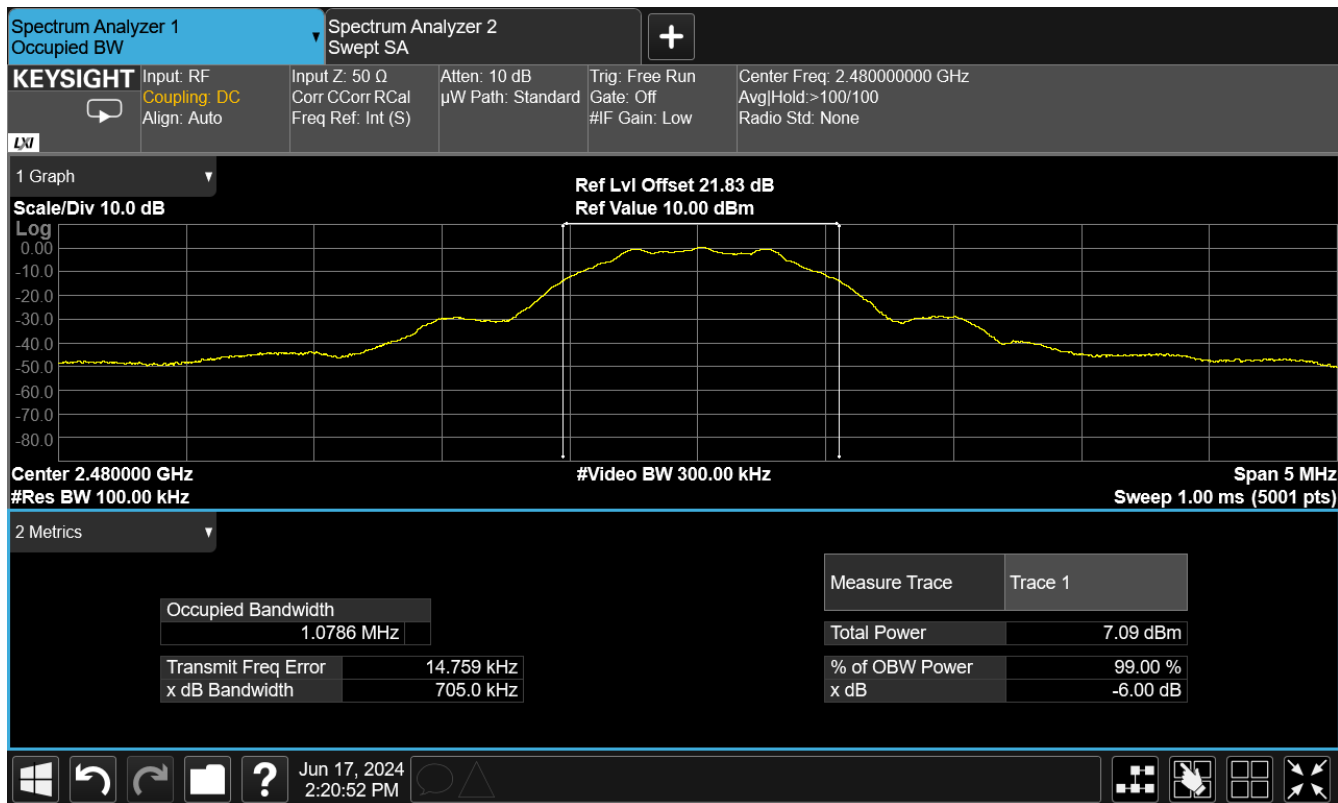




Figure 6: Occupied Bandwidth, Low Channel, 2Mbps (2DH5)

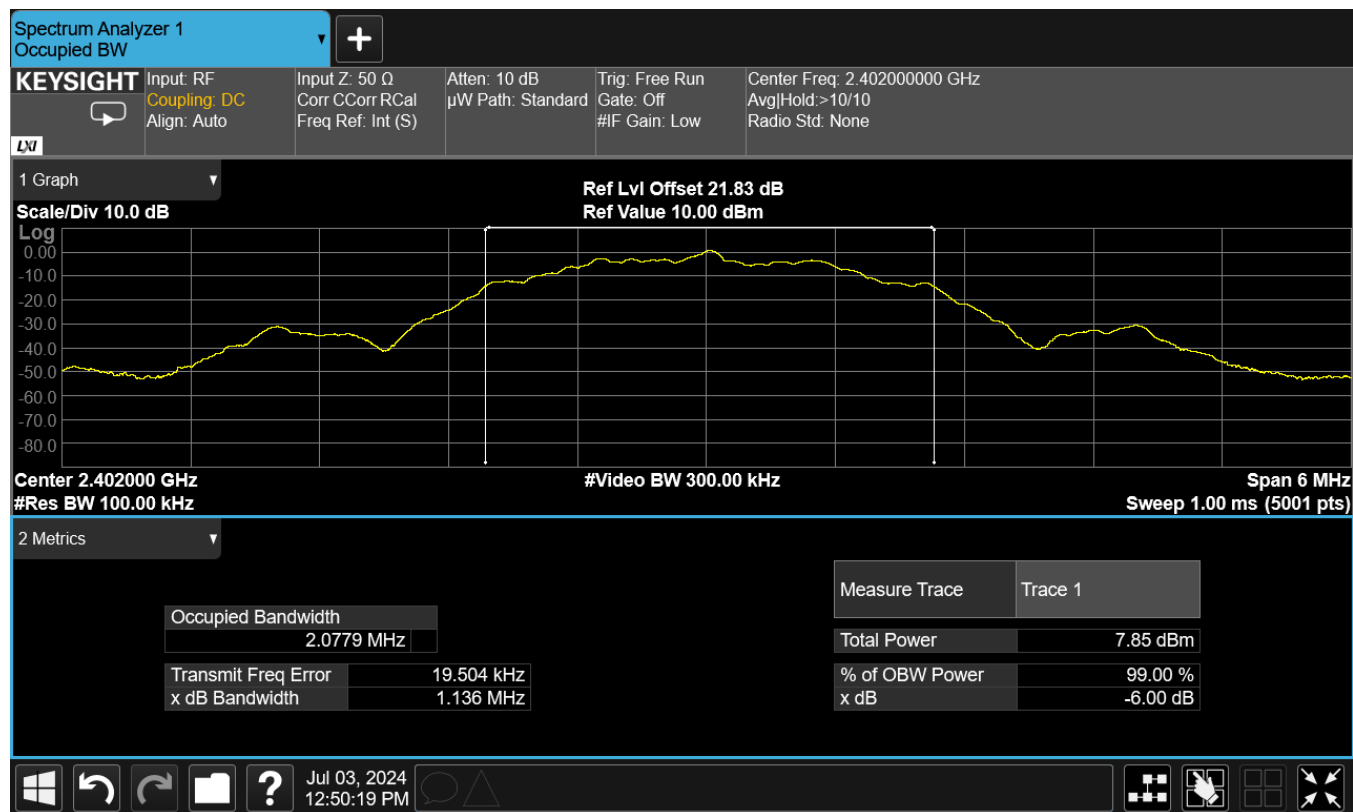




Figure 7: Occupied Bandwidth, Center Channel, 2Mbps (2DH5)

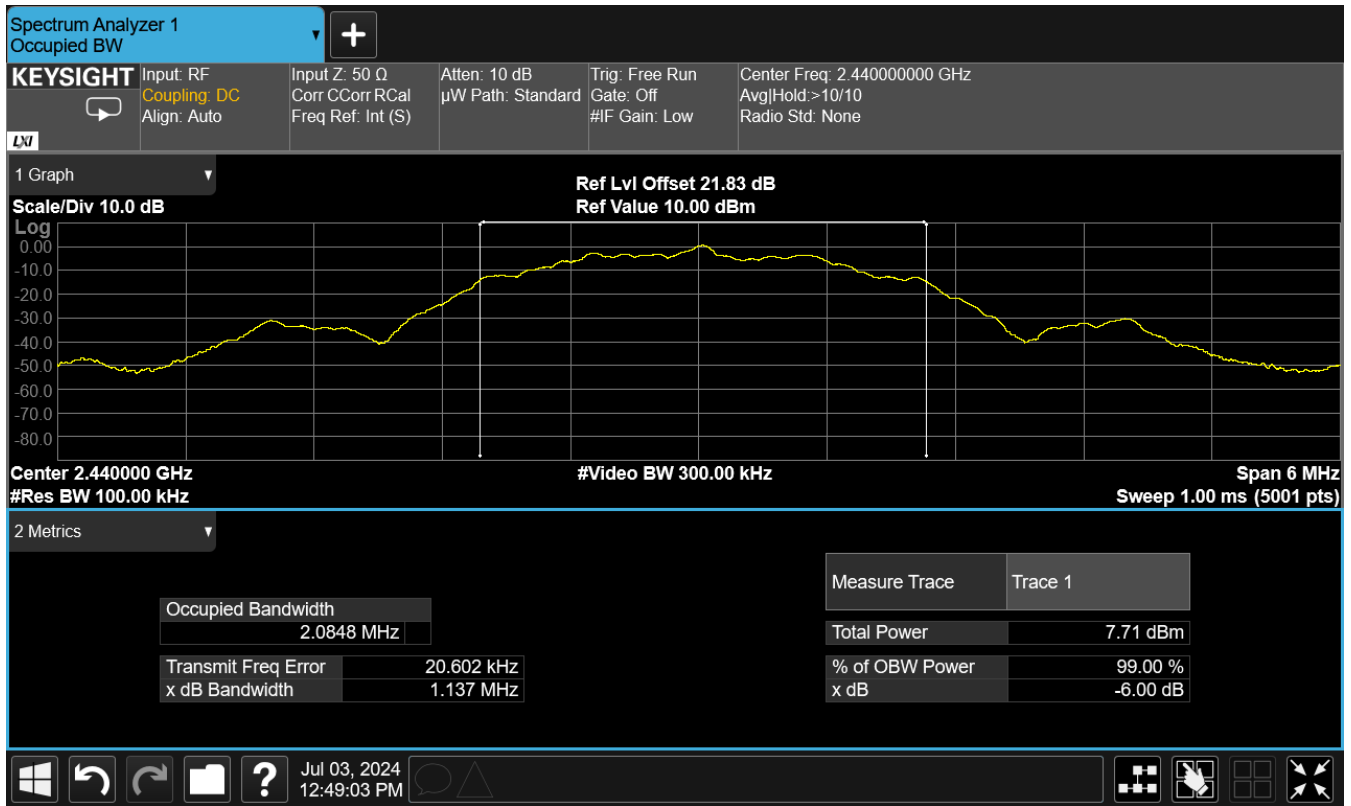
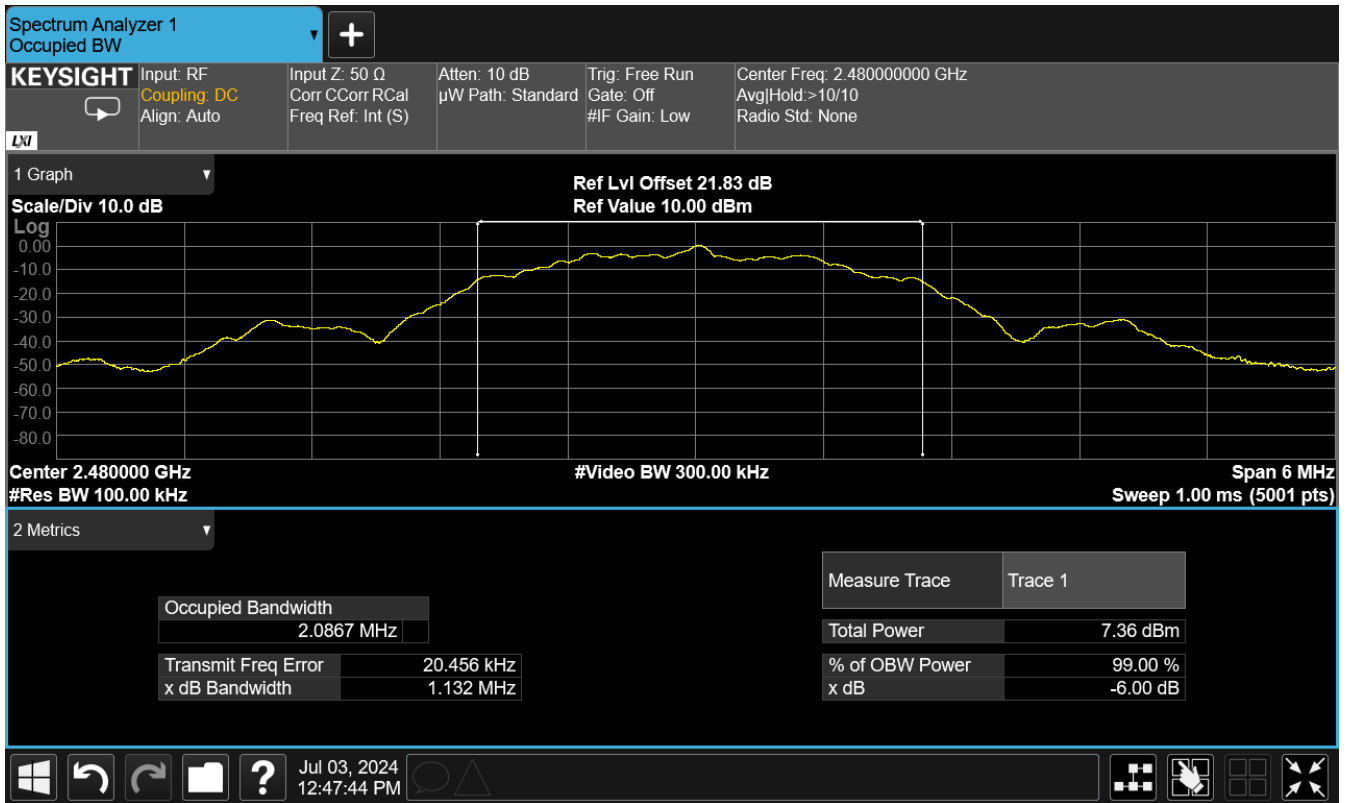




Figure 8: Occupied Bandwidth, High Channel, 2Mbps (2DH5)





3.2 Conducted Peak Output Power

For a DTS operating in the 2.4GHz band, FCC Rule Part 15.247(b)(3) and RSS-247, 5.4(d) require that the maximum peak conducted output power shall not exceed 30 dBm, or 1W. Additionally, the EIRP shall not exceed 36 dBm, or 4W.

The transmitter power was measured conducted at the antenna port, by coupling the output of the EUT transmitter to the input of a spectrum analyzer. The measurement level was corrected for any cable and attenuator losses.

3.2.1 Measurement Method

This test was performed in accordance with Clause 11.9.1.1 of ANSI C63.10-2020.

3.2.2 Test Data

The EUT test data is provided below.

The EUT was configured to transmit a modulated signal, with channel hopping disabled.

The EUT employs a PCB trace antenna with a peak gain of -6.48 dBi.

Table 7: Conducted Output Power Results

Modulation	Mode (Data Rate)	Frequency (MHz)	Peak Power (dBm)	EIRP (dBm)
GFSK	DH5 (1Mbps)	2402	0.89	-5.59
		2440	0.76	-5.72
		2480	0.41	-6.07
$\pi/4$ DQPSK	2DH5 (2Mbps)	2402	0.80	-5.68
		2440	0.66	-5.82
		2480	0.34	-6.14



Figure 9: Peak Output Power, Low Channel, 1Mbps (DH5)

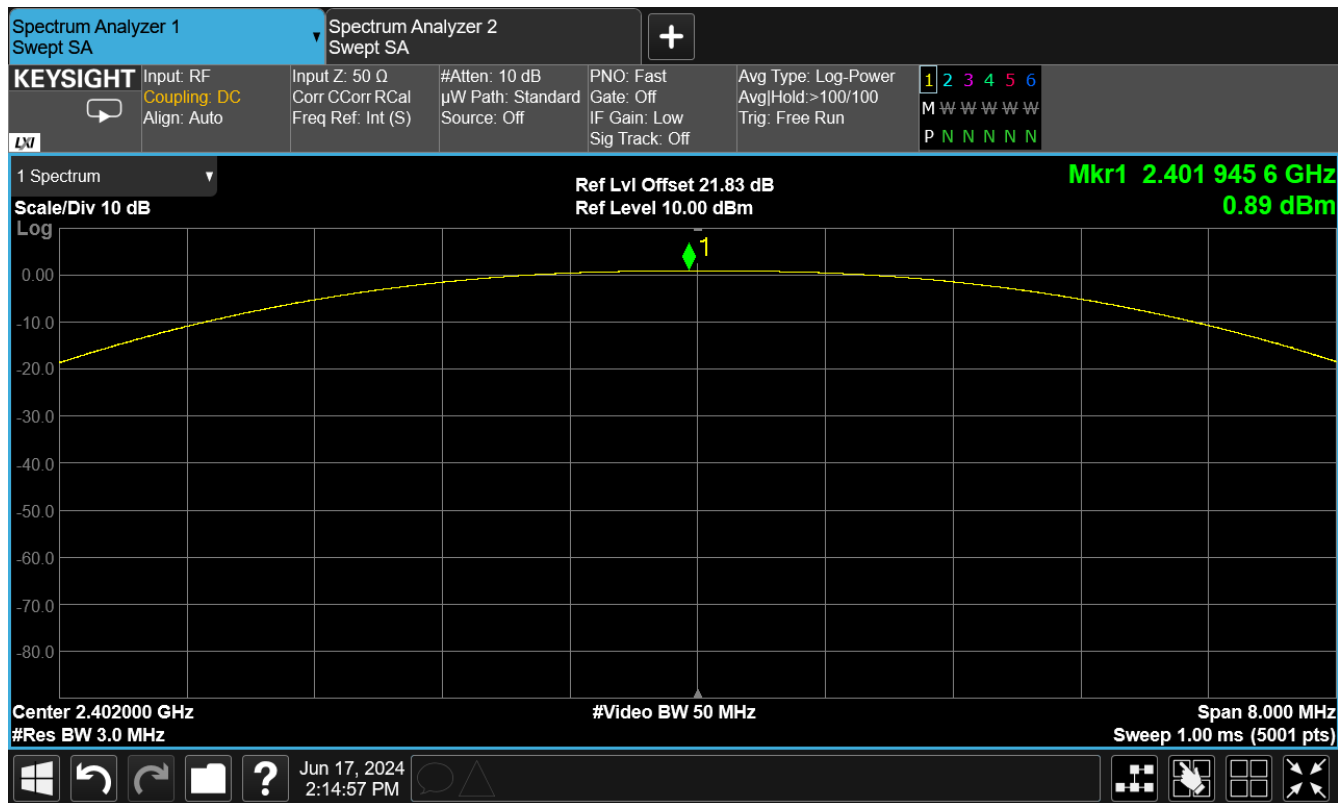




Figure 10: Peak Output Power, Center Channel, 1Mbps (DH5)

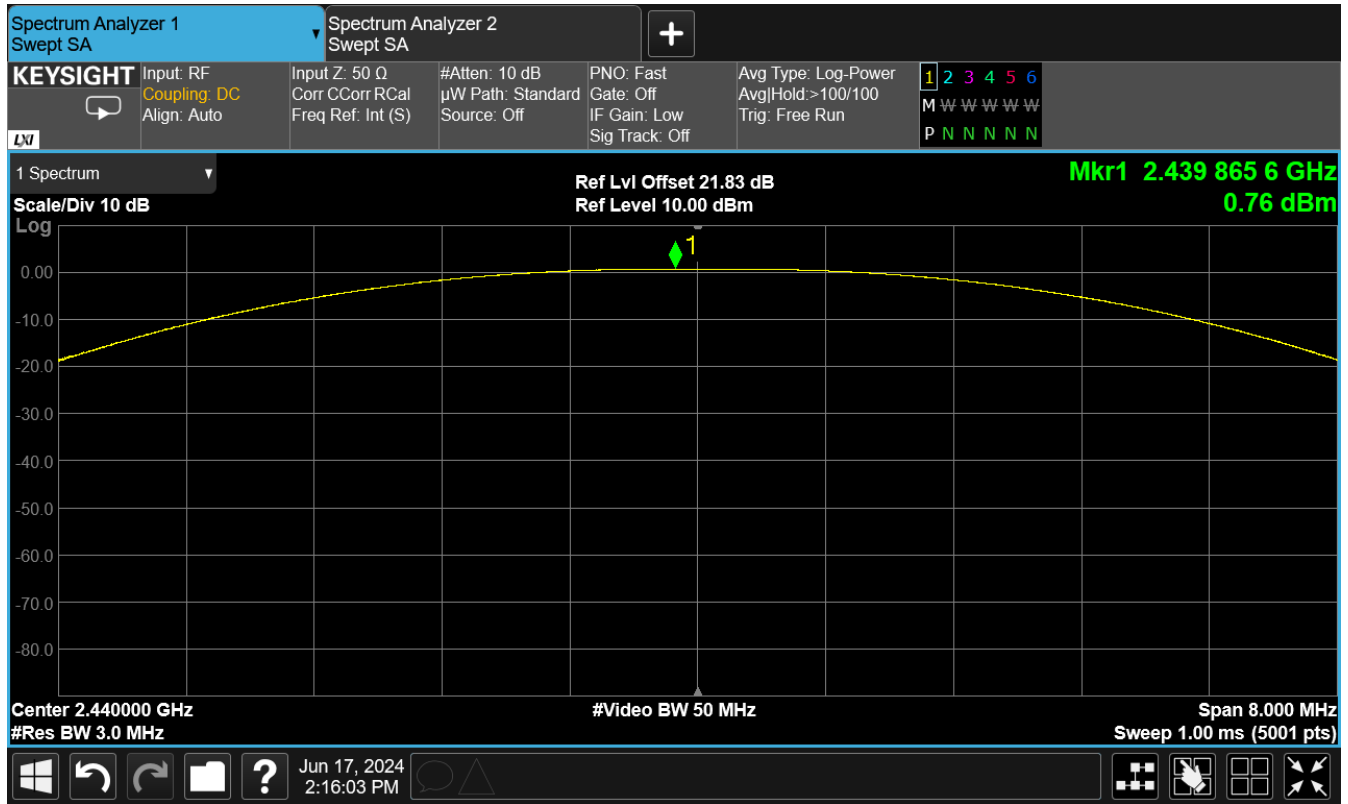




Figure 11: Peak Output Power, High Channel, 1Mbps (DH5)

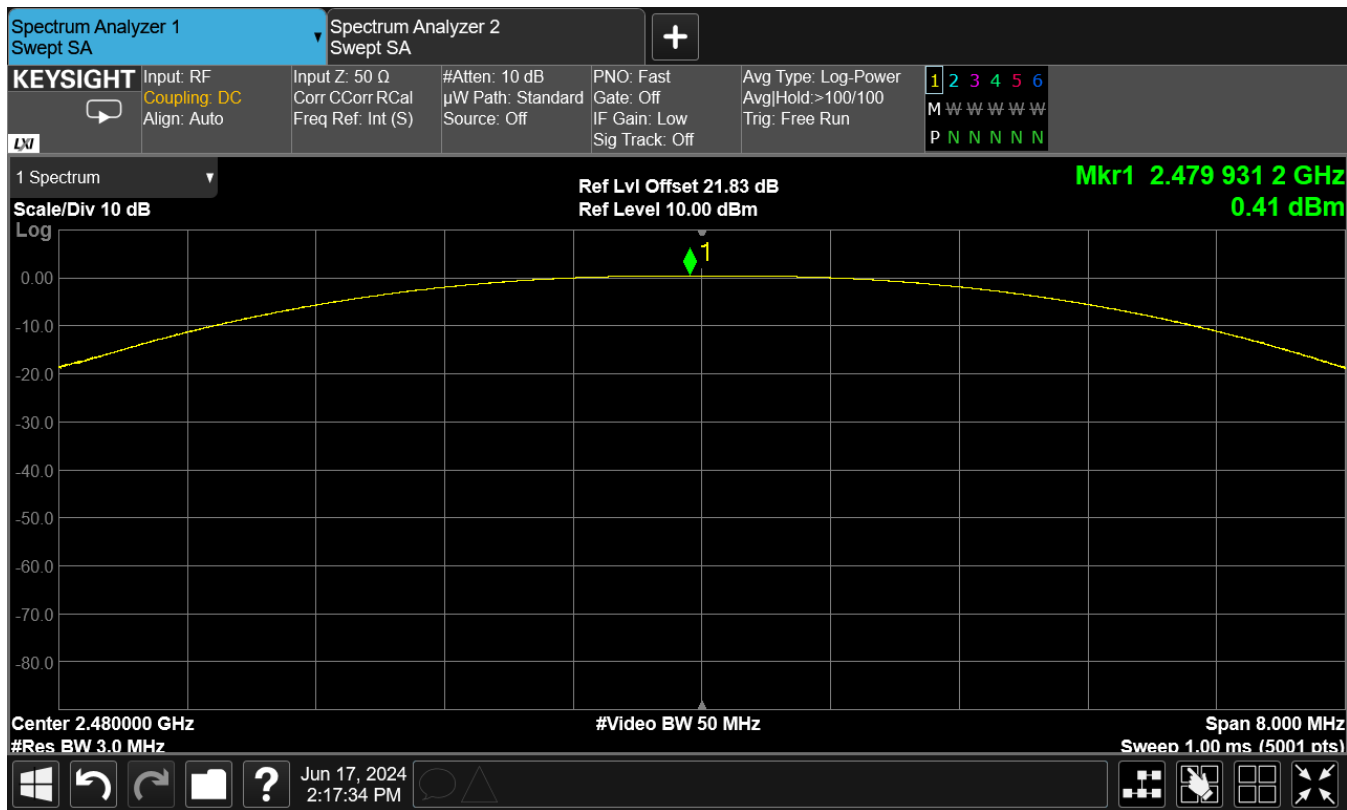




Figure 12: Peak Output Power, Low Channel, 2Mbps (2DH5)

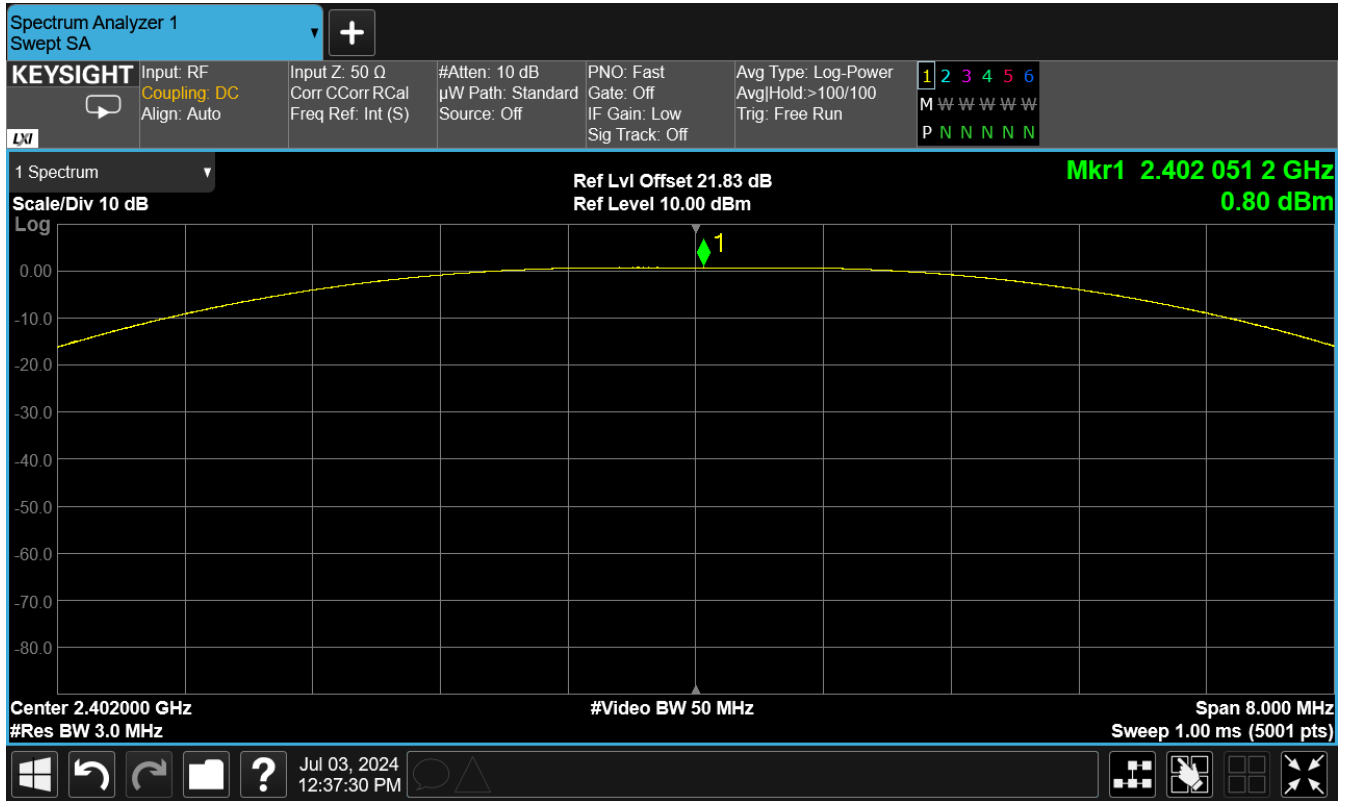




Figure 13: Peak Output Power, Center Channel, 2Mbps (2DH5)

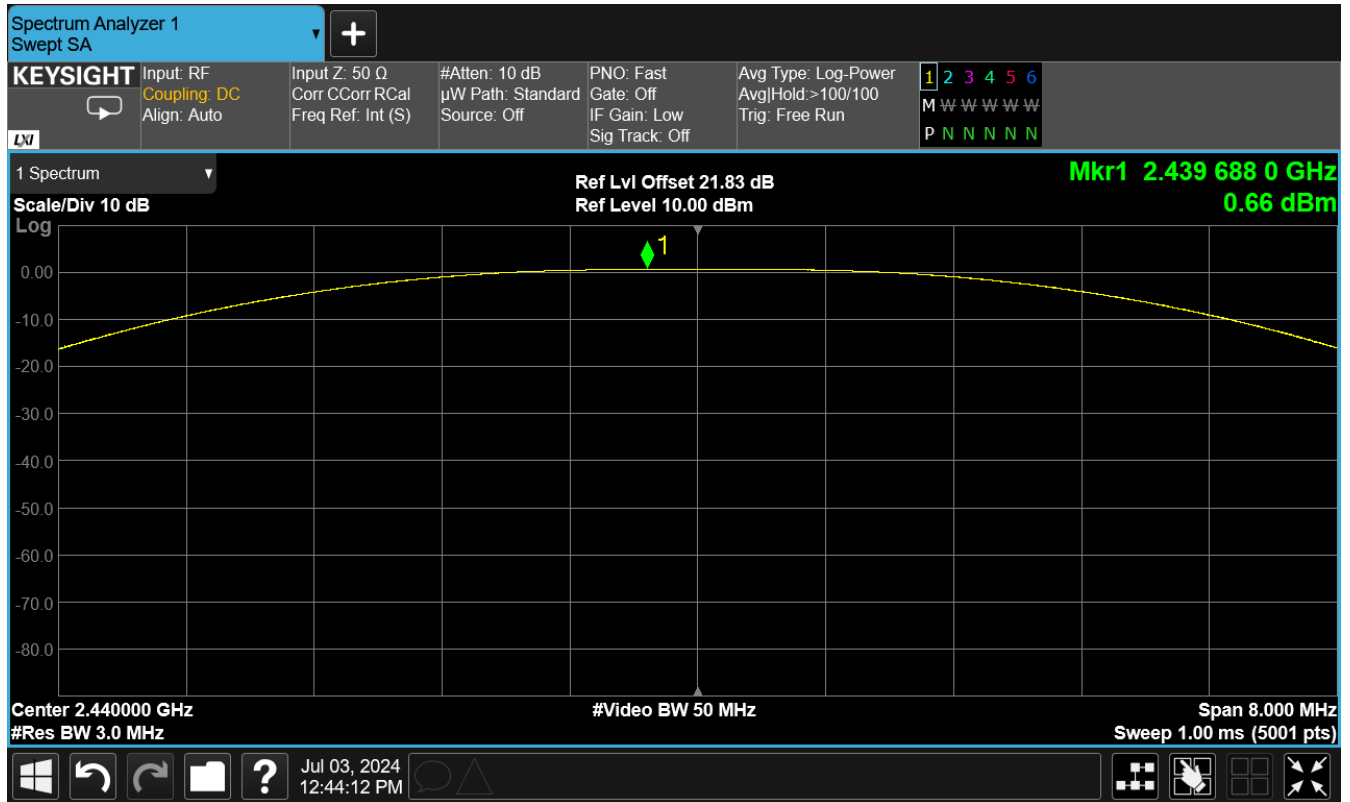
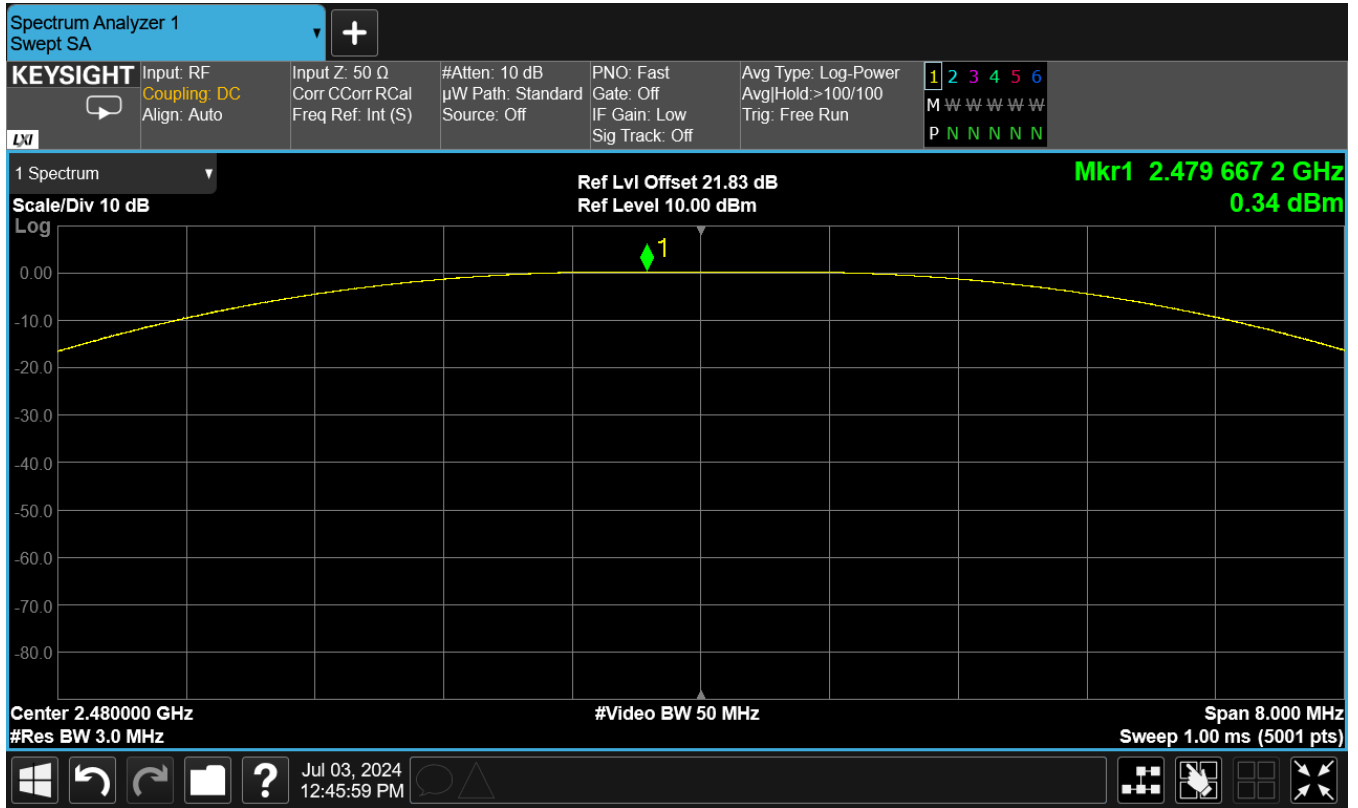




Figure 14: Peak Output Power, High Channel, 2Mbps (2DH5)





3.3 Power Spectral Density

For a DTS operating in the 2.4GHz band, FCC Rule Part 15.247(e) and RSS-247, 5.2(b) require that the maximum peak power spectral density shall not exceed 8 dBm in any 3 kHz band.

The transmitter peak power spectral density was measured conducted at the antenna port, by coupling the output of the EUT transmitter to the input of a spectrum analyzer. The measurement level was corrected for any cable and attenuator losses.

3.3.1 Measurement Method

This test was performed in accordance with Clause 11.10.2 of ANSI C63.10-2020.

3.3.2 Test Data

The EUT test data is provided below.

The EUT was configured to transmit a modulated signal, with channel hopping disabled.

Table 8: Power Spectral Density

Modulation	Mode (Data Rate)	Frequency (MHz)	Measured PSD (dBm)	Result
GFSK	DH5 (1Mbps)	2402	0.70	Pass
		2440	0.58	Pass
		2480	0.24	Pass
$\pi/4$ DQPSK	2DH5 (2Mbps)	2402	0.68	Pass
		2440	0.55	Pass
		2480	0.21	Pass



Figure 15: Power Spectral Density, Low Channel, 1Mbps (DH5)

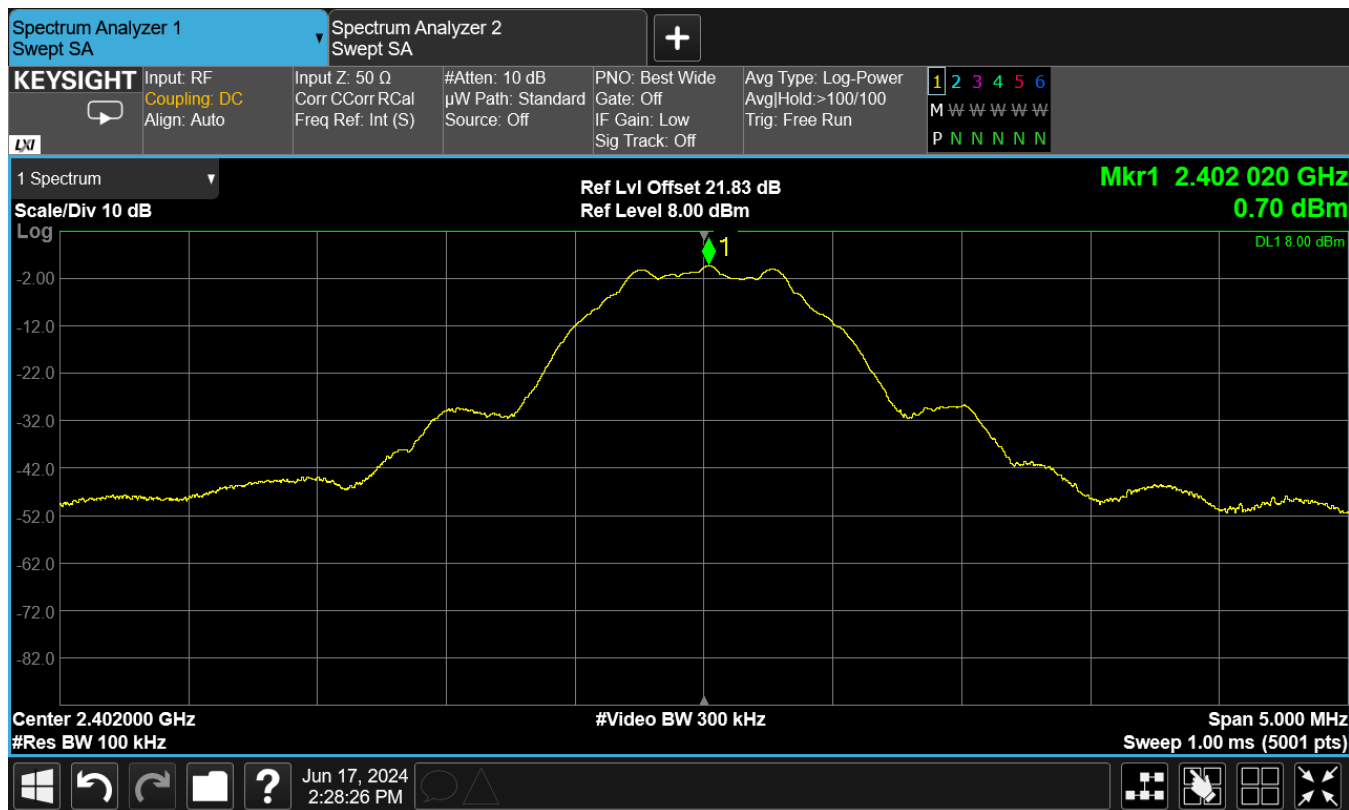




Figure 16: Power Spectral Density, Center Channel, 1Mbps (DH5)

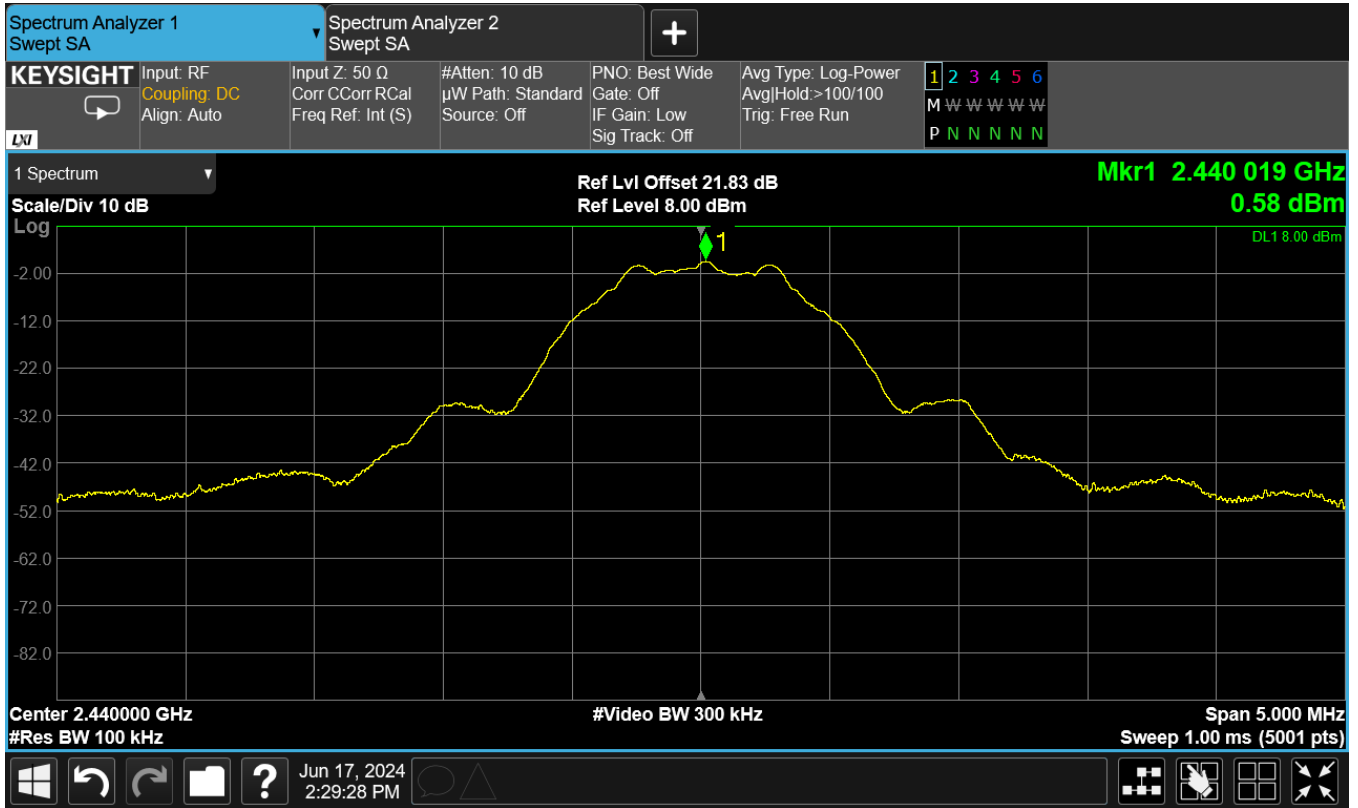




Figure 17: Power Spectral Density, High Channel, 1Mbps (DH5)

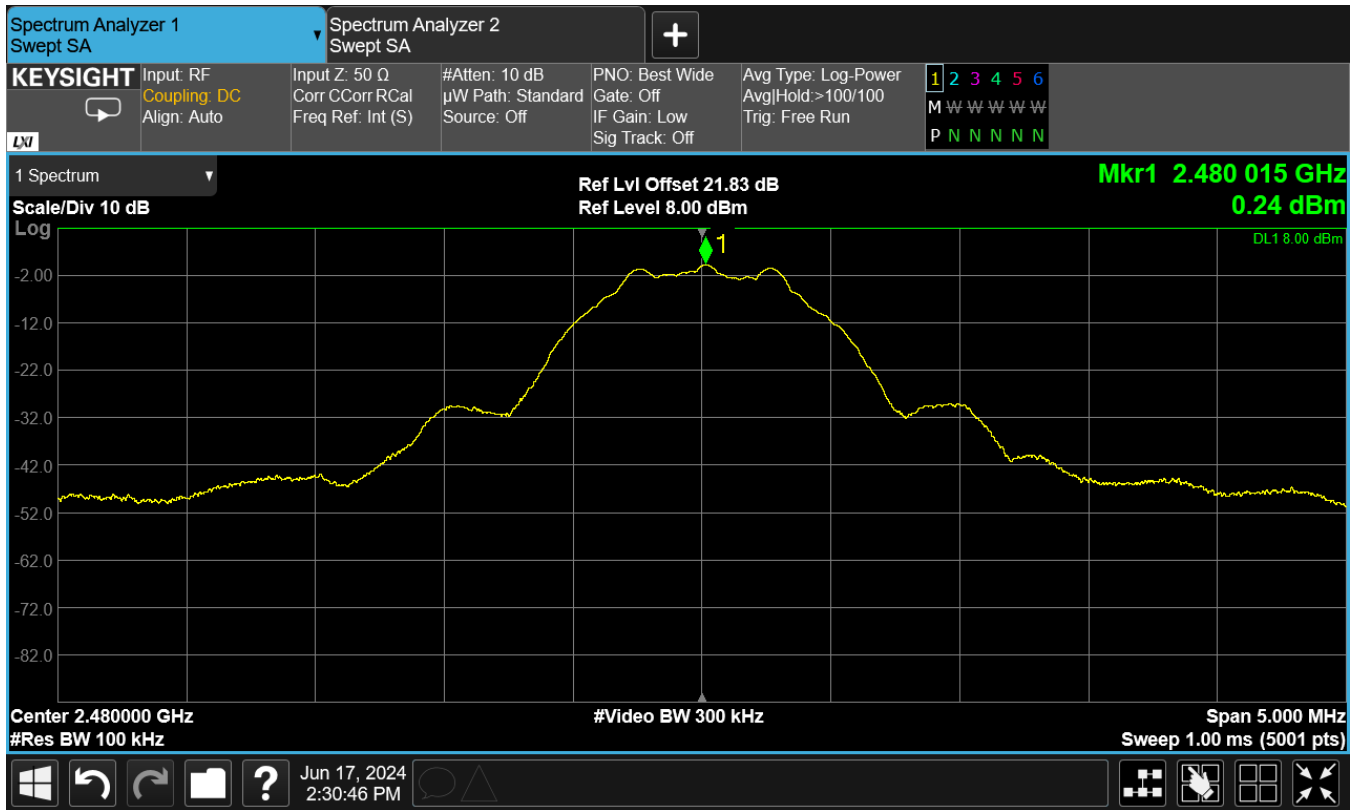




Figure 18: Power Spectral Density, Low Channel, 2Mbps (2DH5)

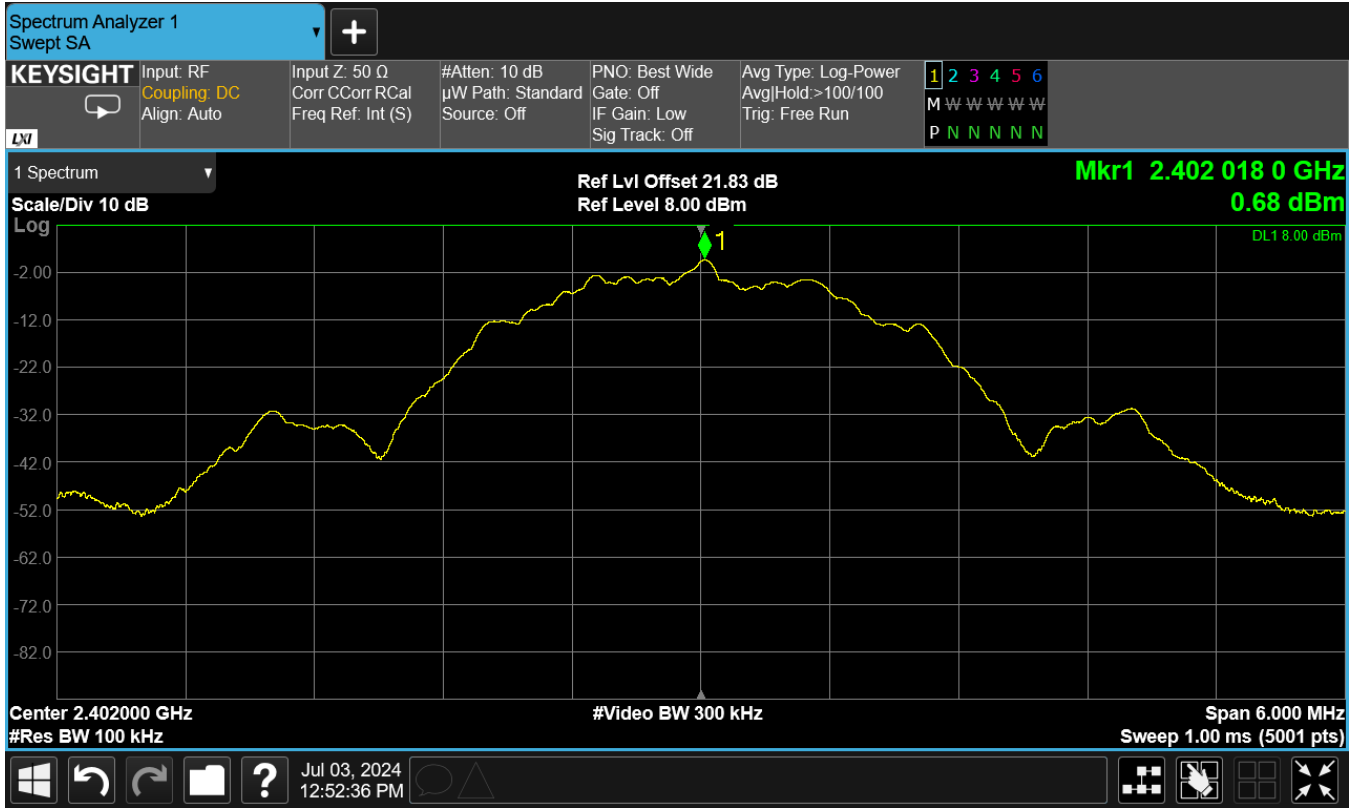




Figure 19: Power Spectral Density, Center Channel, 2Mbps (2DH5)

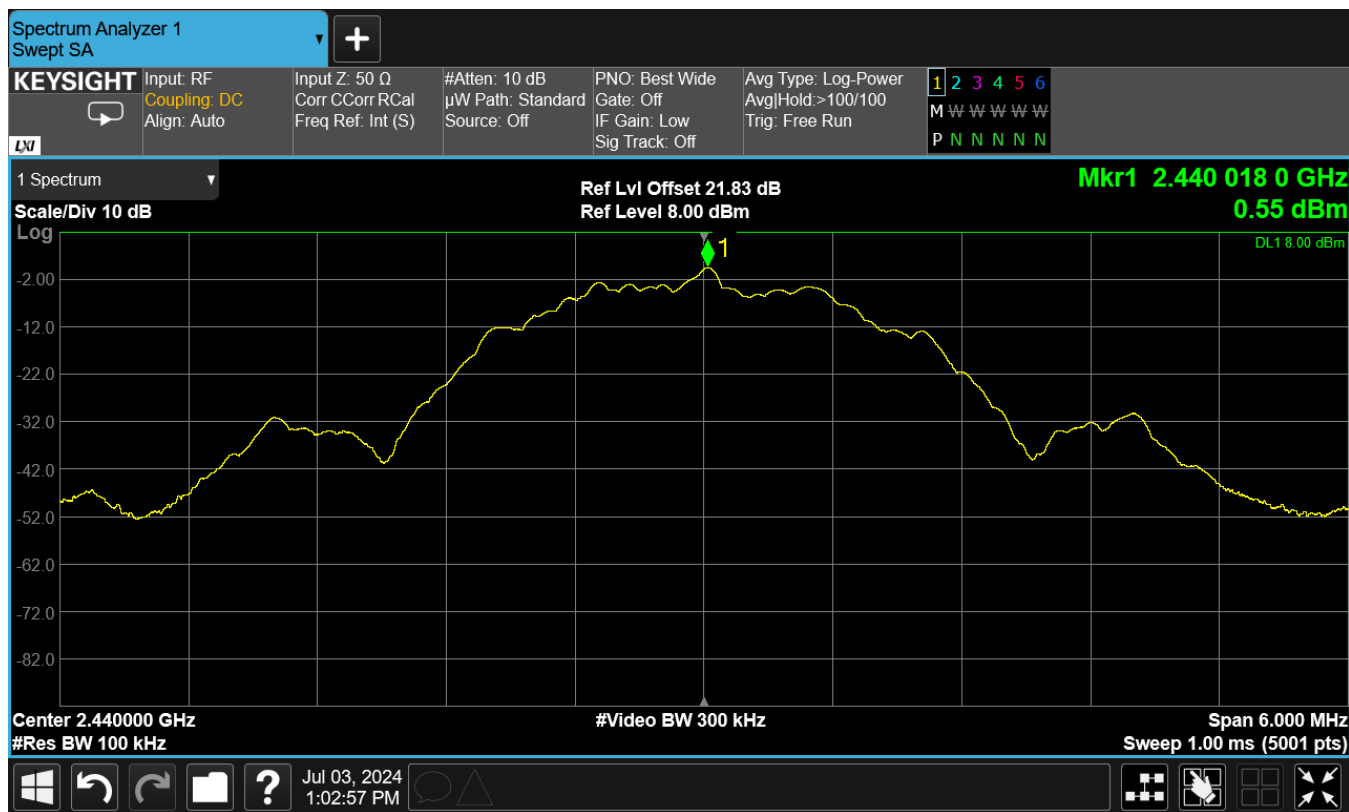
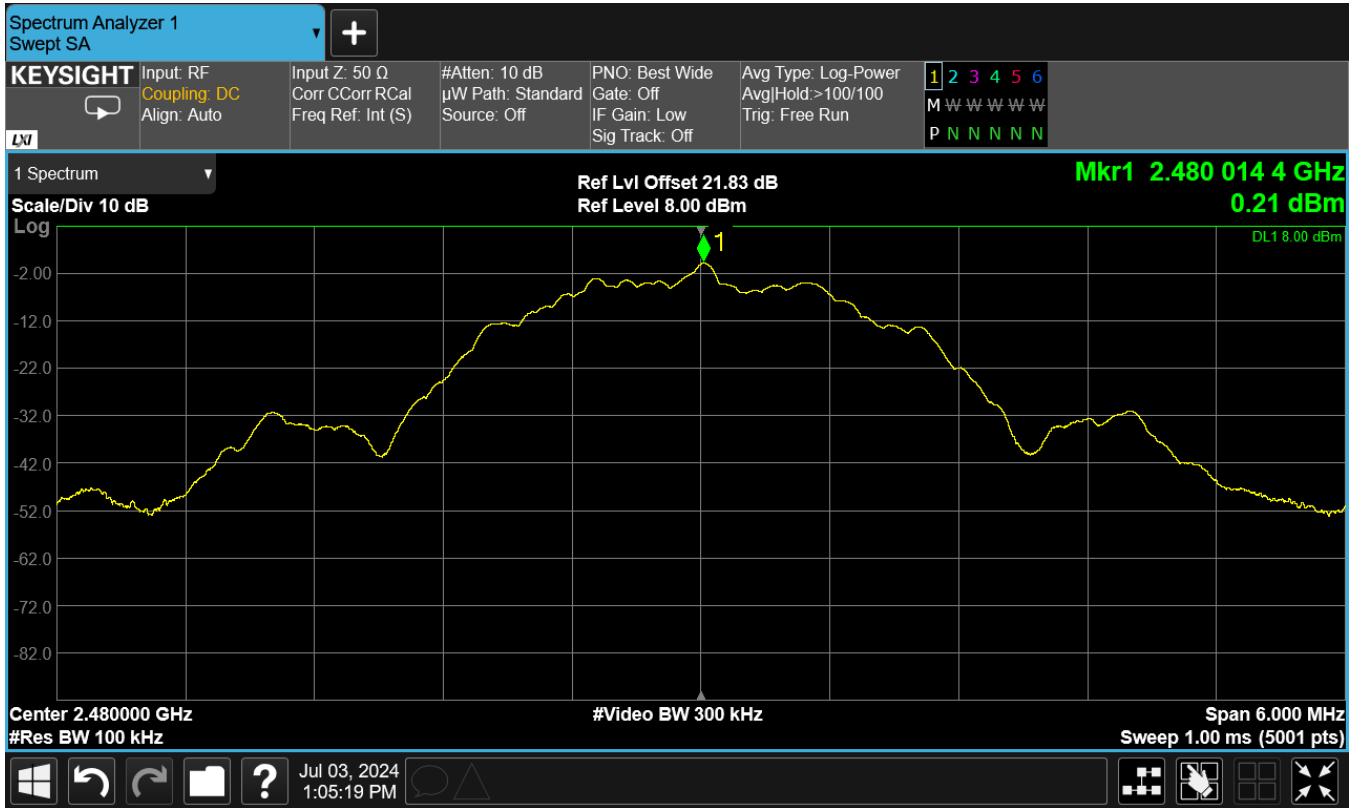




Figure 20: Power Spectral Density, High Channel, 2Mbps (2DH5)





3.4 Conducted Band-edge

This section provides close-up band-edge plots of the low and high channel, with respect to the nearest authorized band-edge.

For a DTS operating in the 2.4GHz band, FCC Rule Part 15.247(d) and RSS-247, 5.5 require that in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the unwanted radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

Band-edge measurements were made conducted at the antenna port, by coupling the output of the EUT transmitter to the input of a spectrum analyzer. The measurement level was corrected for any cable and attenuator losses.

3.4.1 Measurement Method

This test was performed in accordance with Clause 6.10 through Clause 6.10.4 of ANSI C63.10-2020.

3.4.2 Test Data

The EUT test data is provided below.

The EUT was configured to transmit a modulated signal. The EUT was evaluated in two modes, channel hopping enabled and channel hopping disabled. The hopping/sweeping function had no impact on the results of this test. The worst-case bandedge is reported below.



Figure 21: Low Channel Band-Edge, 1Mbps (DH5)

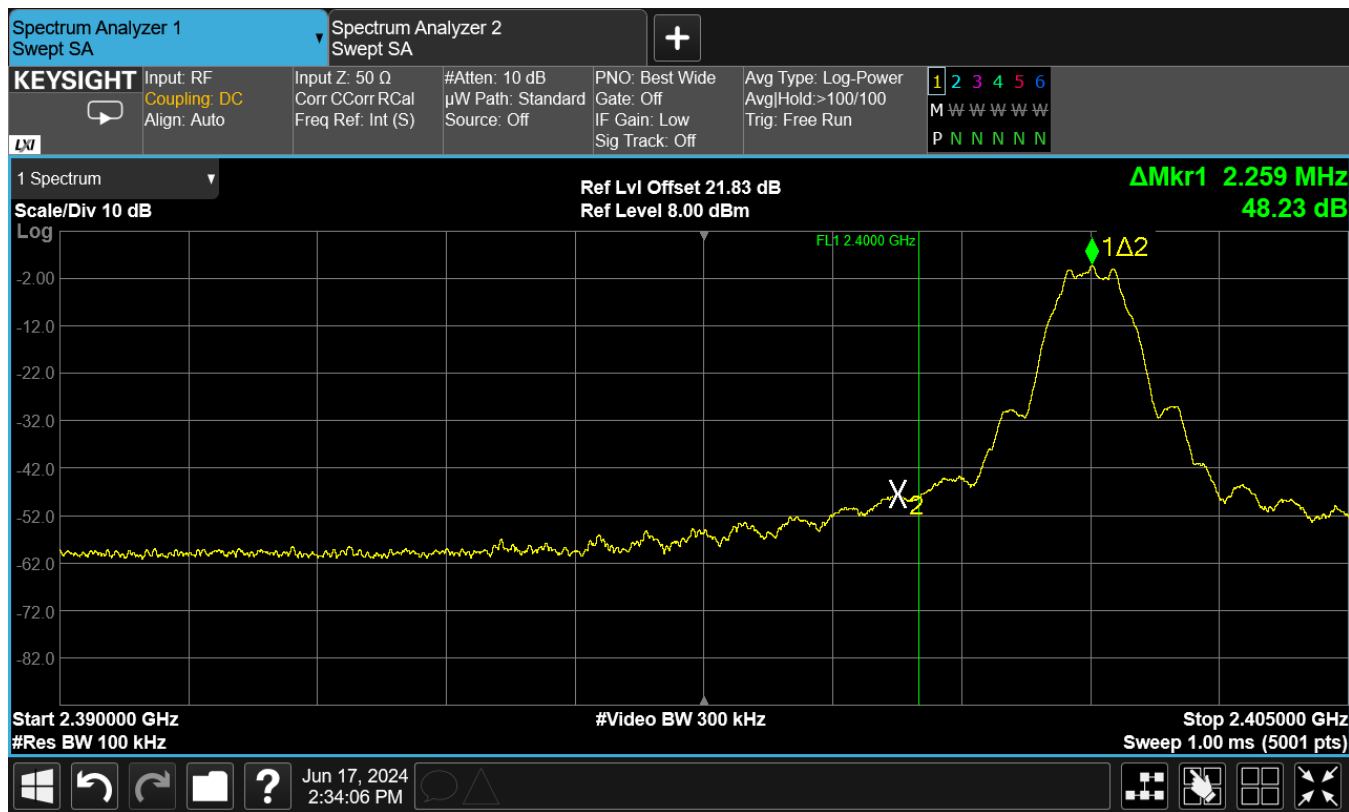




Figure 22: High Channel Band-Edge, 1Mbps (DH5)

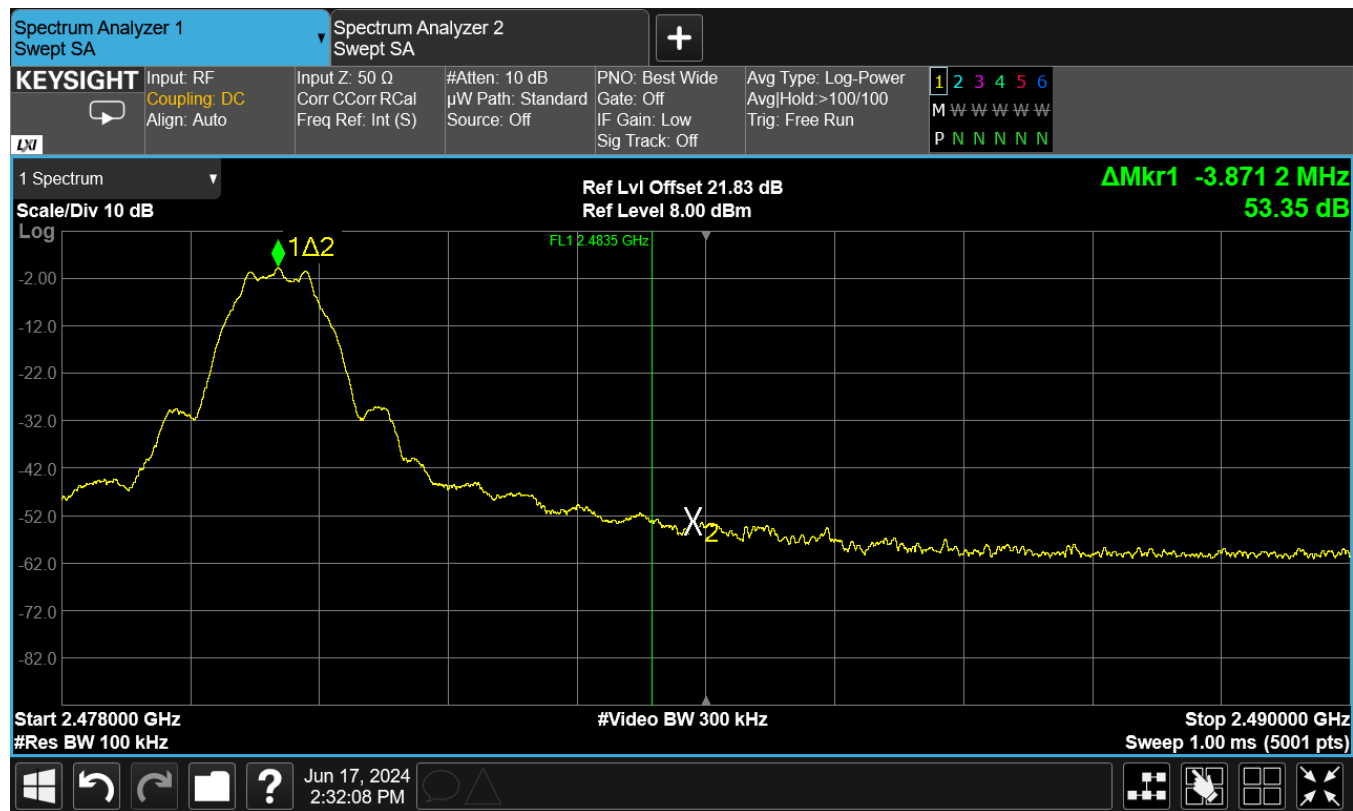




Figure 23: Low Channel Band-Edge, 2Mbps (2DH5)

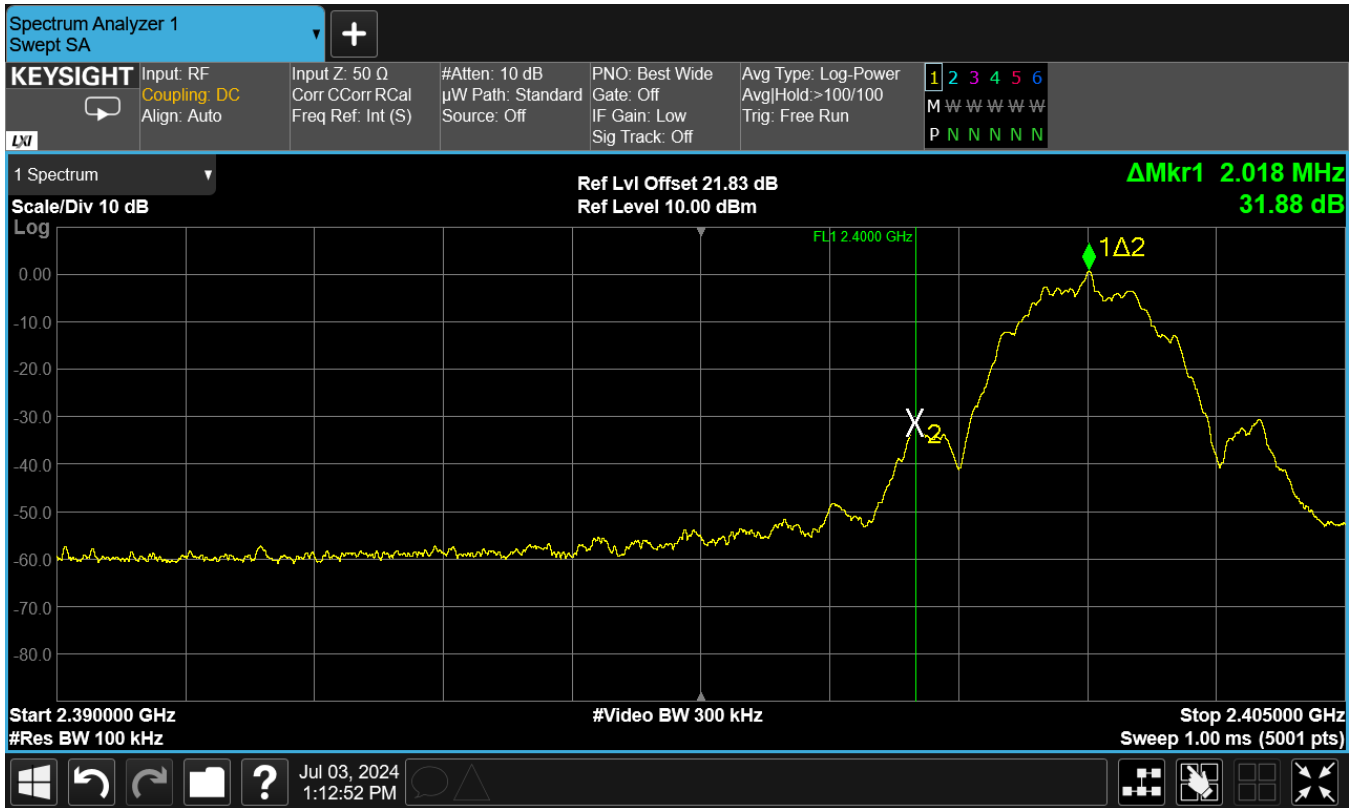
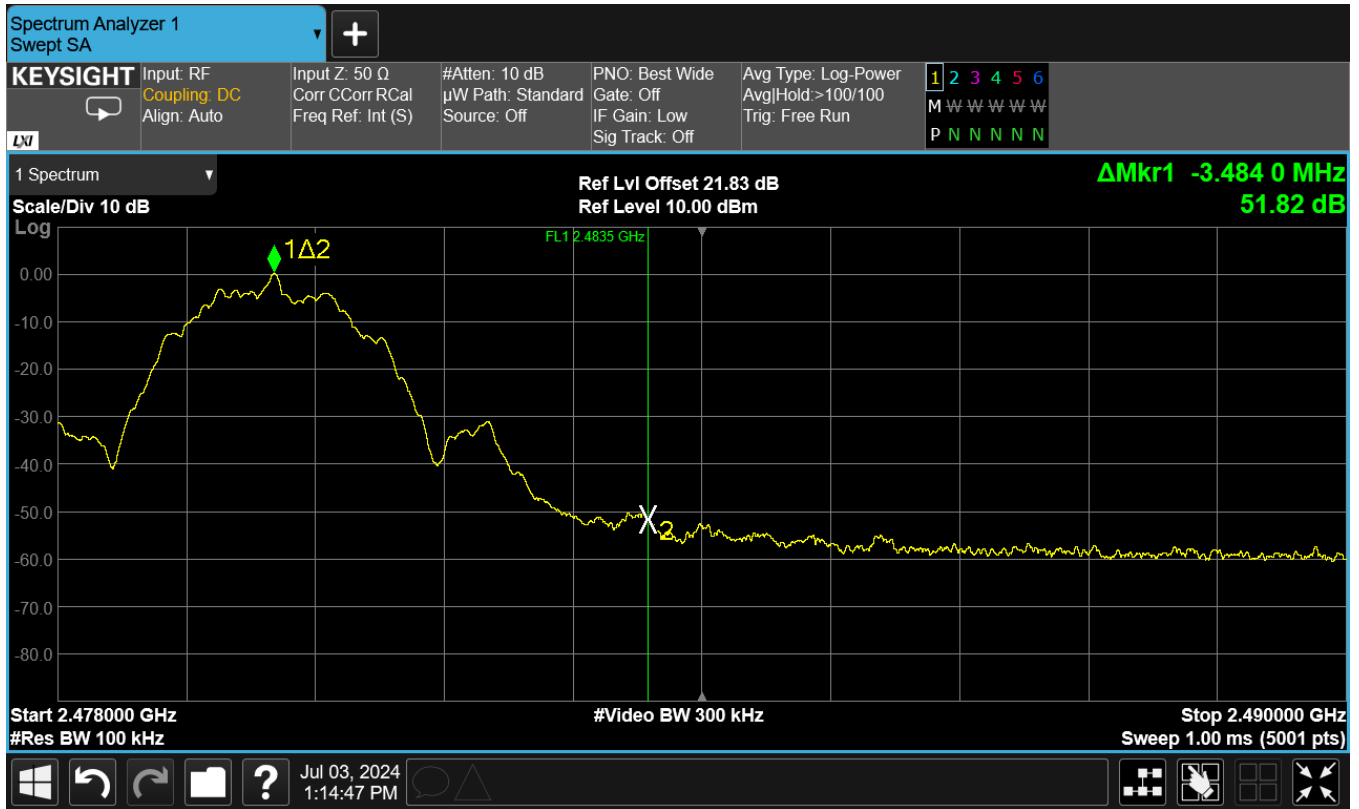




Figure 24: High Channel Band-Edge, 2Mbps (2DH5)





3.5 Conducted Unwanted Spurious Emissions

For a DTS operating in the 2.4GHz band, FCC Rule Part 15.247(d) and RSS-247, 5.5 require that in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the unwanted radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

The transmitter unwanted spurious emissions were evaluated and measured conducted at the antenna port, by coupling the output of the EUT transmitter to the input of a spectrum analyzer. The measurement level was corrected for any cable and attenuator losses.

3.5.1 Measurement Method

This test was performed in accordance with Clause 11.11 of ANSI C63.10-2020.

3.5.2 Test Data

The EUT test data for the low, center, and high channels are provided below.

The EUT was configured to transmit a modulated signal, at both 1Mbps (GFSK) and 2Mbps ($\pi/4$ DQPSK).

The worst-case conducted spurious emission is -42.80 dBm; the limit here is -19.67 dBm (see Figure 38).



Figure 25: Low Channel 1Mbps (DH5) Conducted Spurious Plot 1

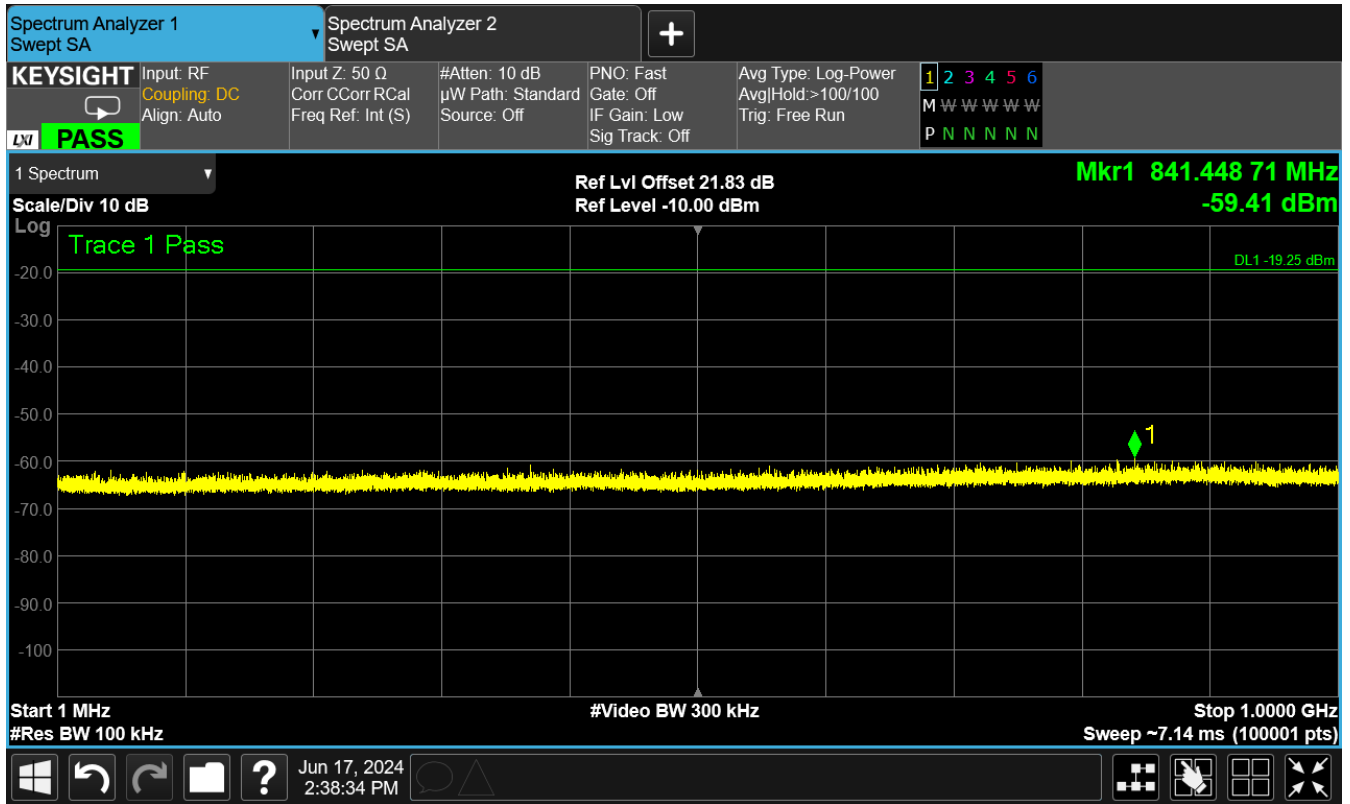




Figure 26: Low Channel 1Mbps (DH5) Conducted Spurious Plot 2

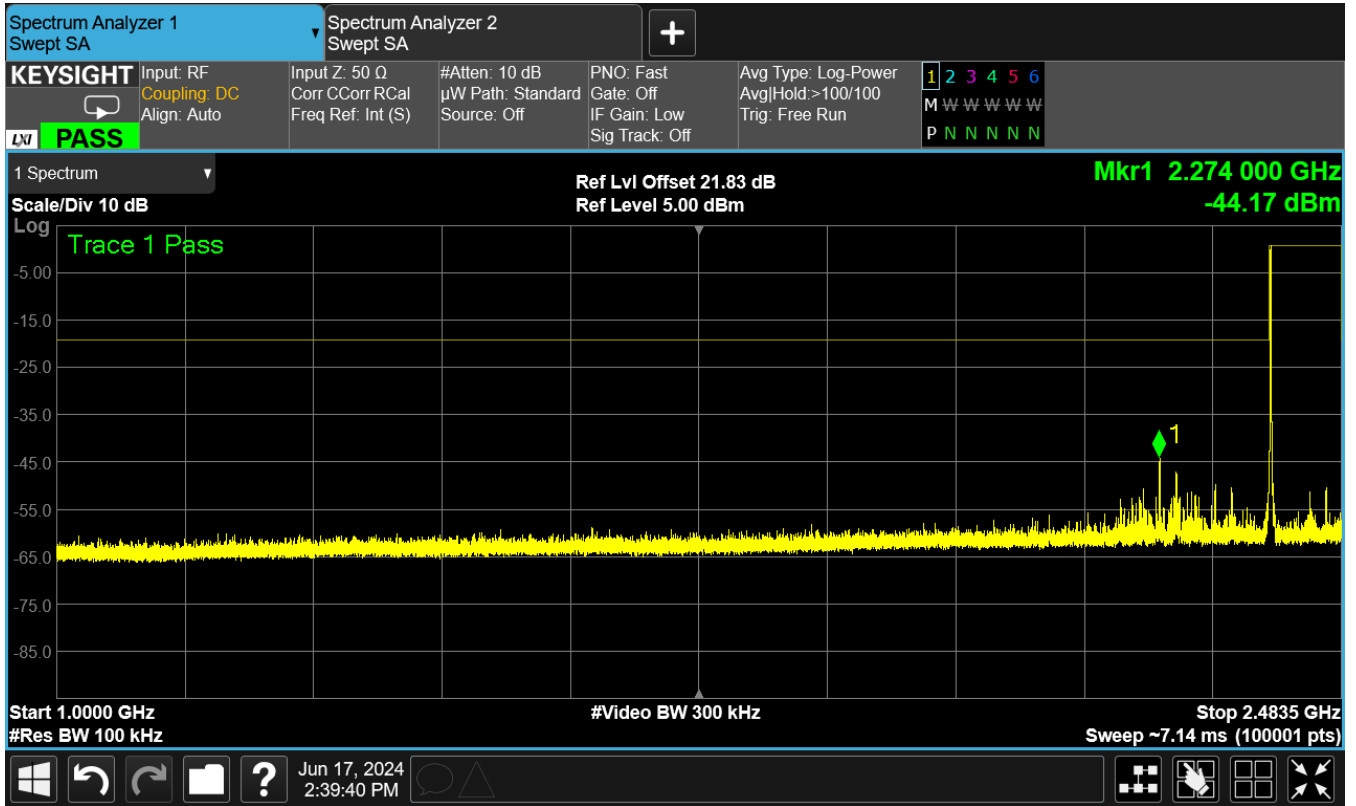




Figure 27: Low Channel 1Mbps (DH5) Conducted Spurious Plot 3

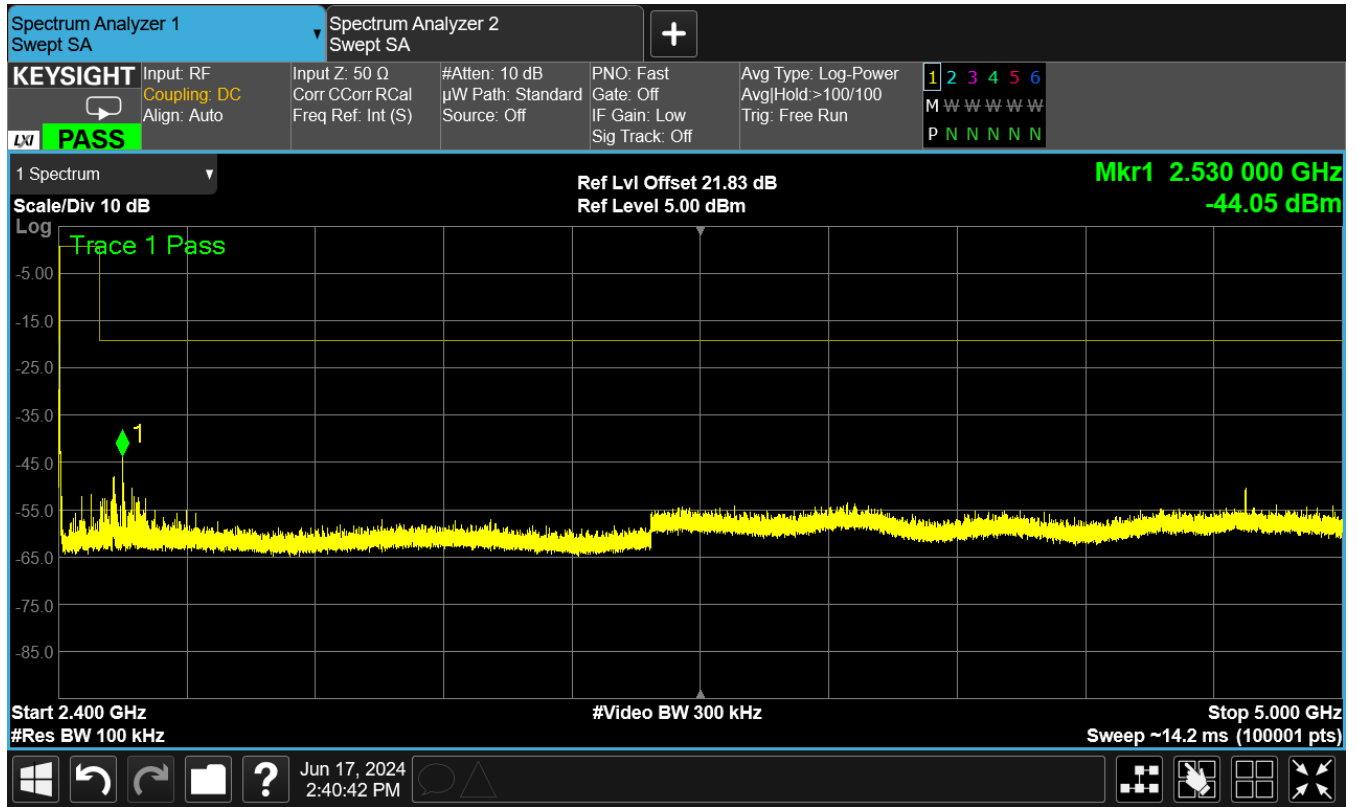




Figure 28: Low Channel 1Mbps (DH5) Conducted Spurious Plot 4

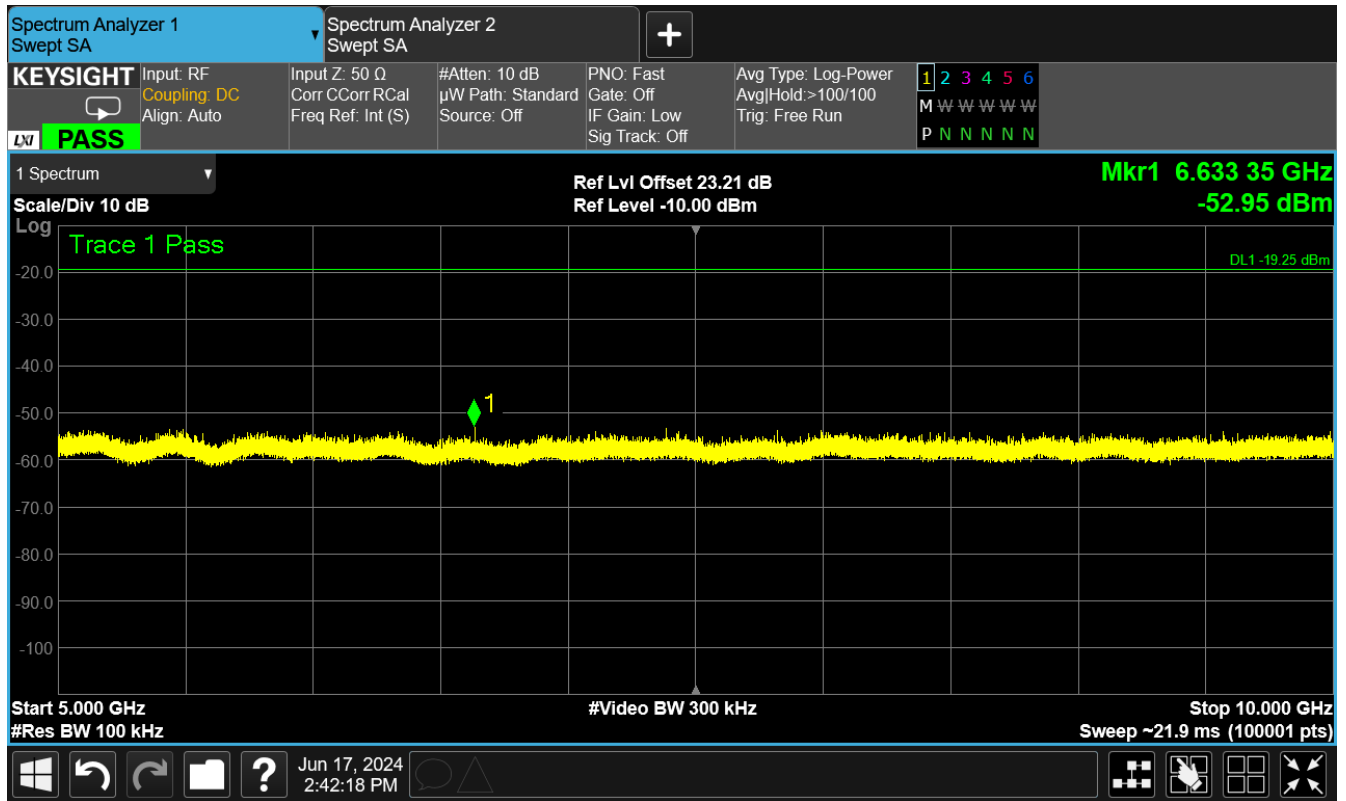




Figure 29: Low Channel 1Mbps (DH5) Conducted Spurious Plot 5

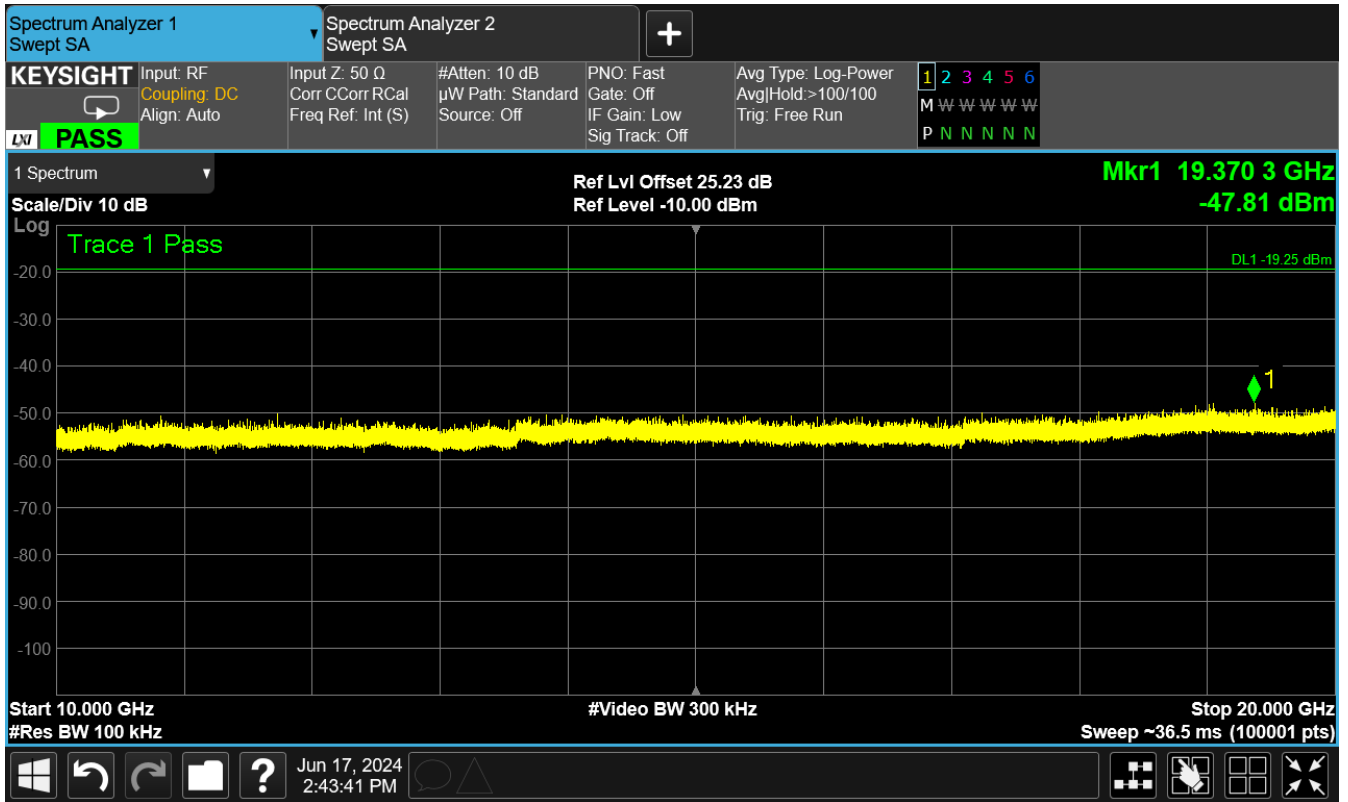




Figure 31: Center Channel 1Mbps (DH5) Conducted Spurious Plot 1

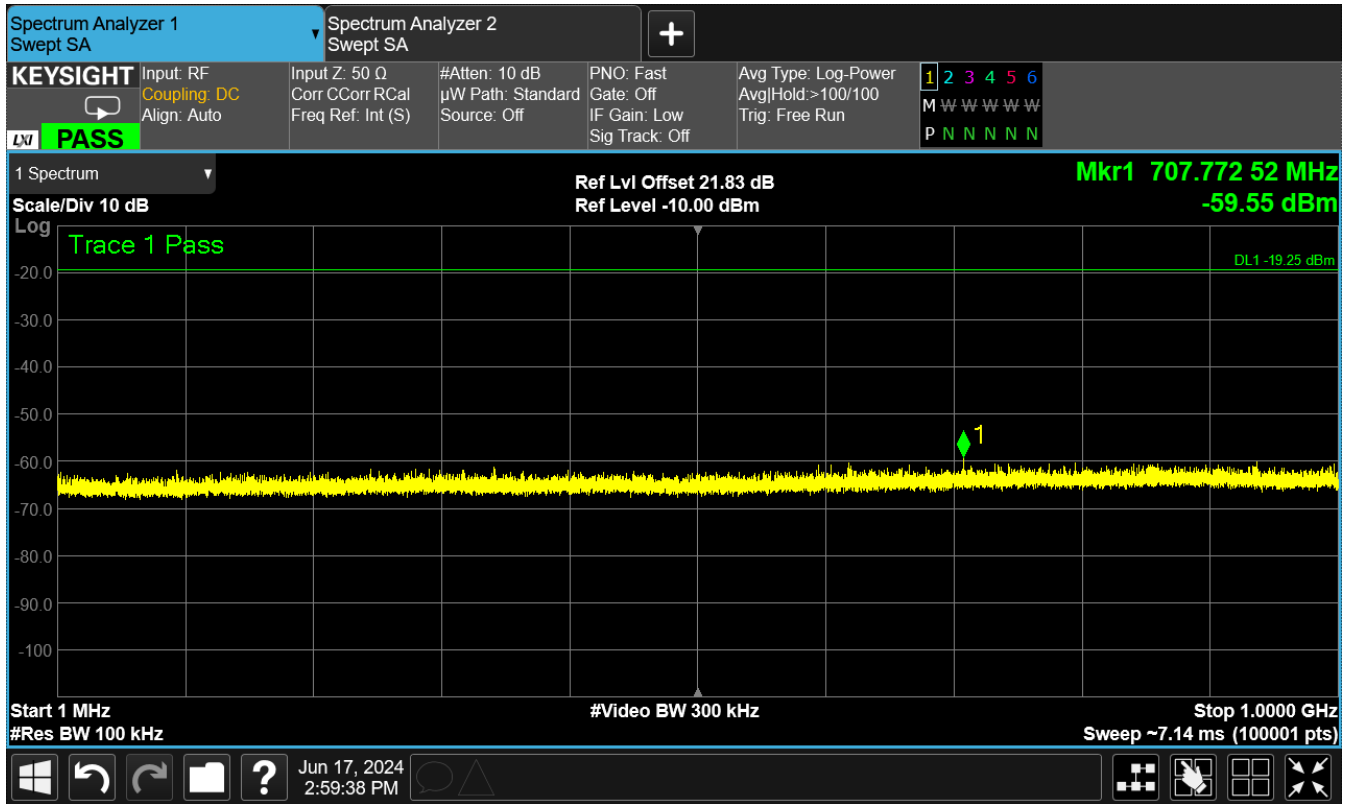




Figure 32: Center Channel 1Mbps (DH5) Conducted Spurious Plot 2

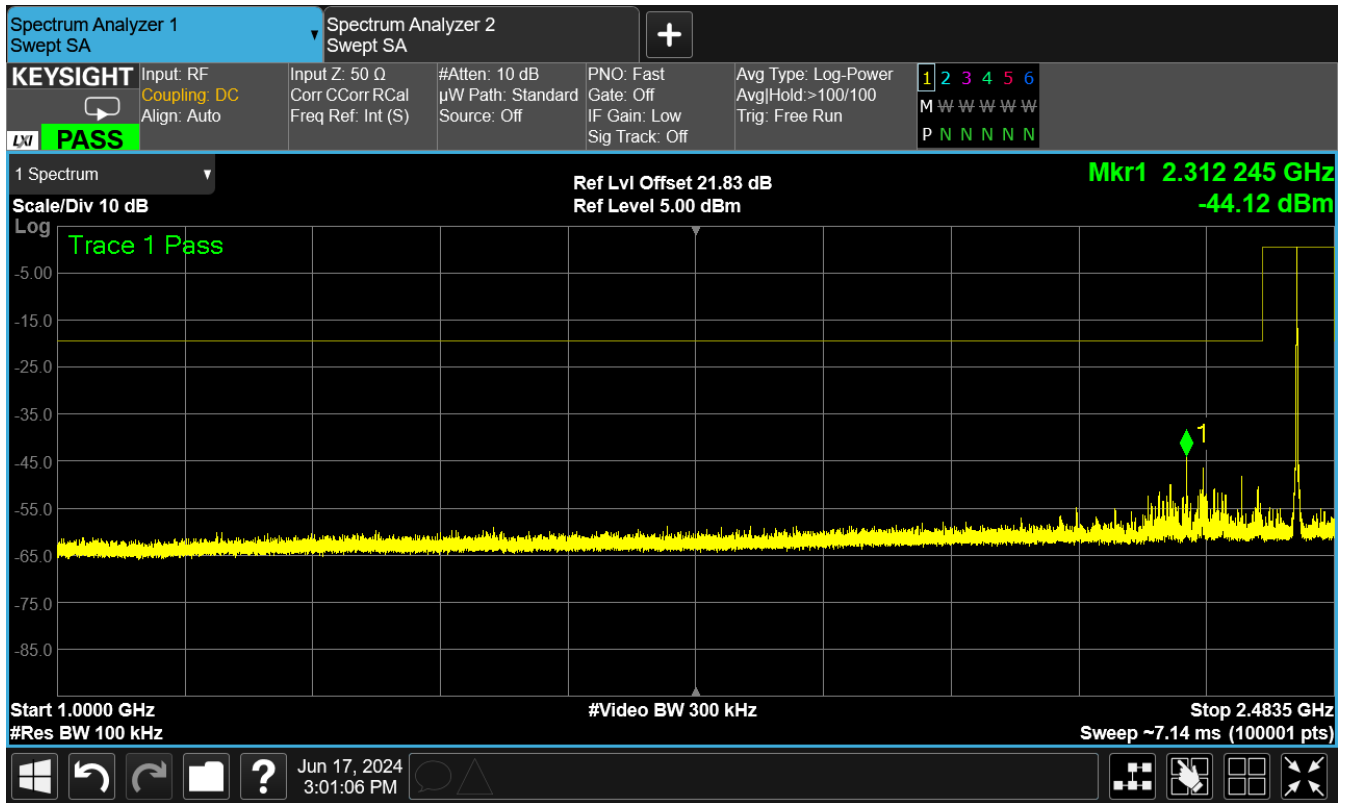




Figure 33: Center Channel 1Mbps (DH5) Conducted Spurious Plot 3

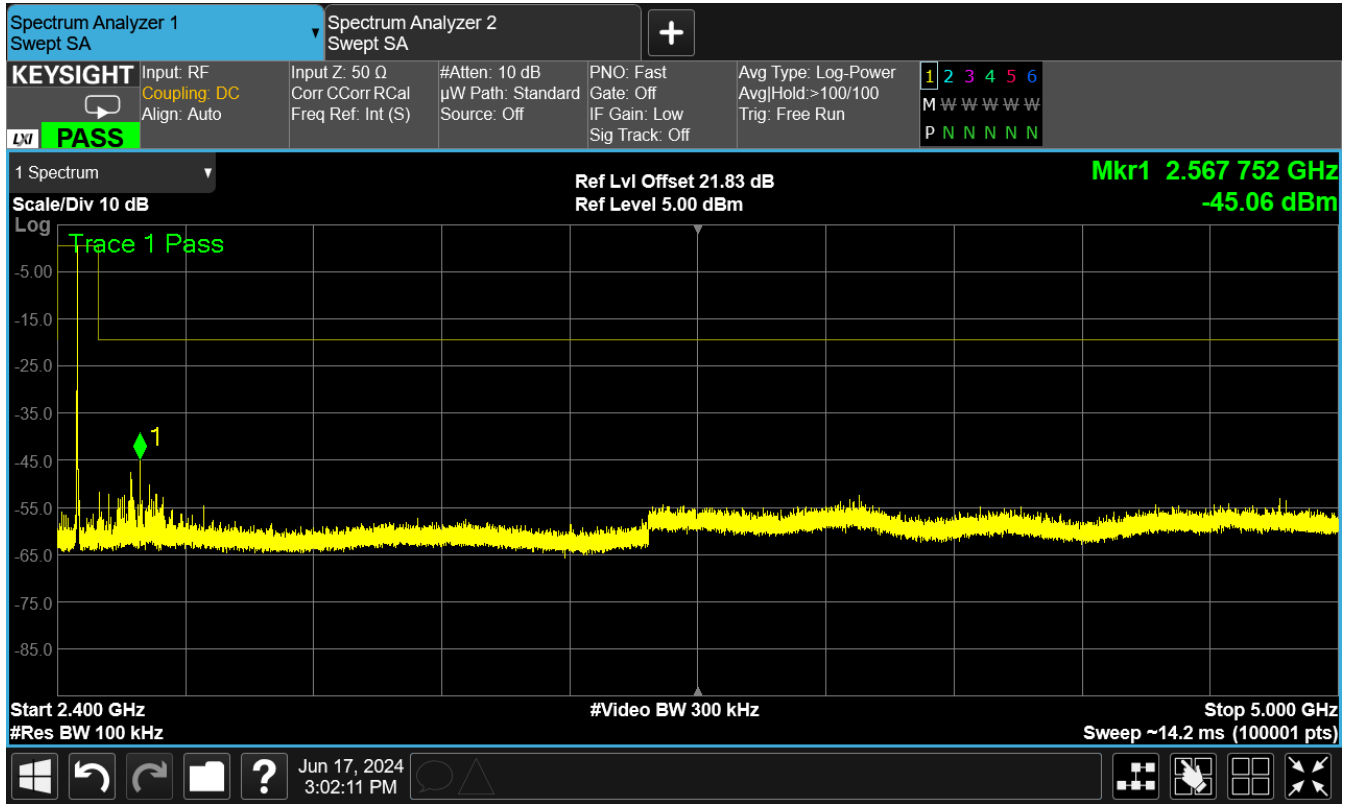




Figure 34: Center Channel 1Mbps (DH5) Conducted Spurious Plot 4

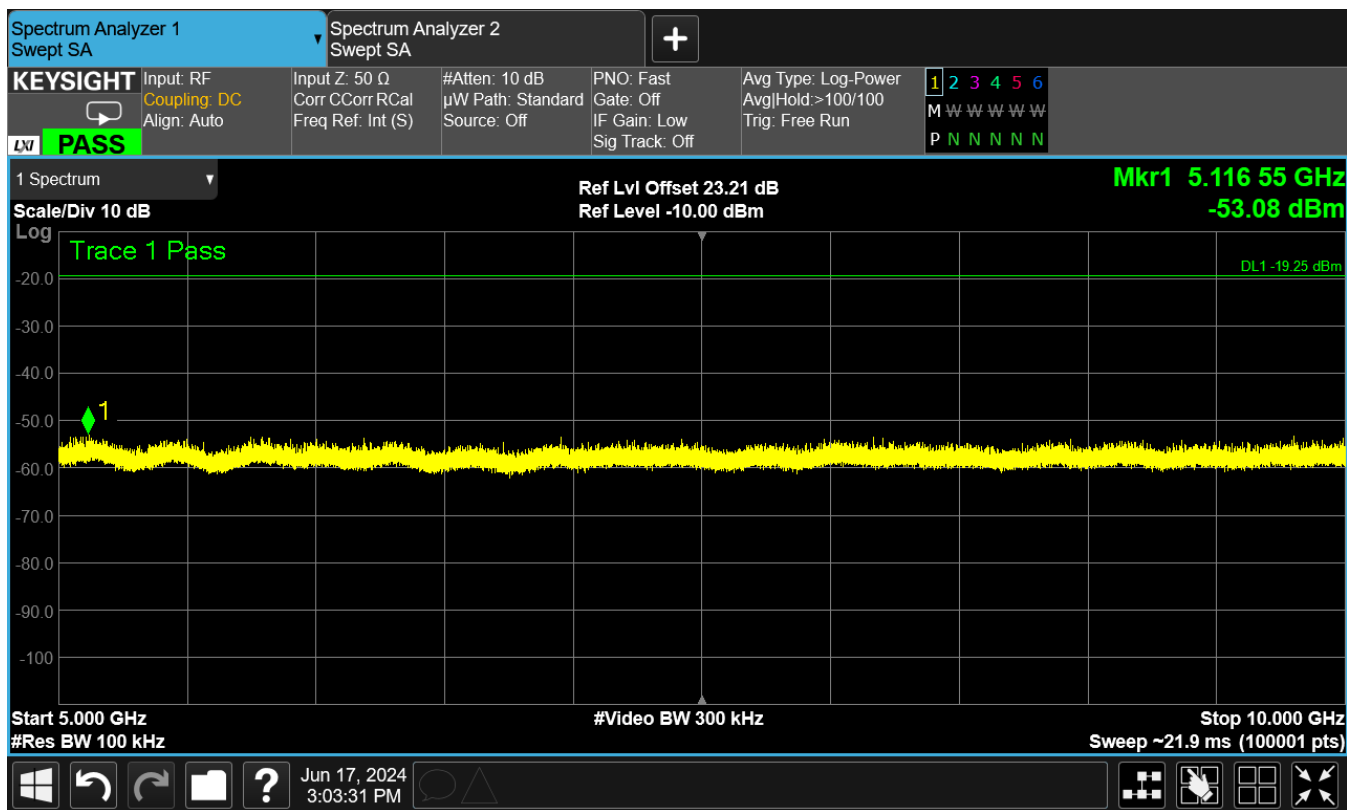




Figure 35: Center Channel 1Mbps (DH5) Conducted Spurious Plot 5

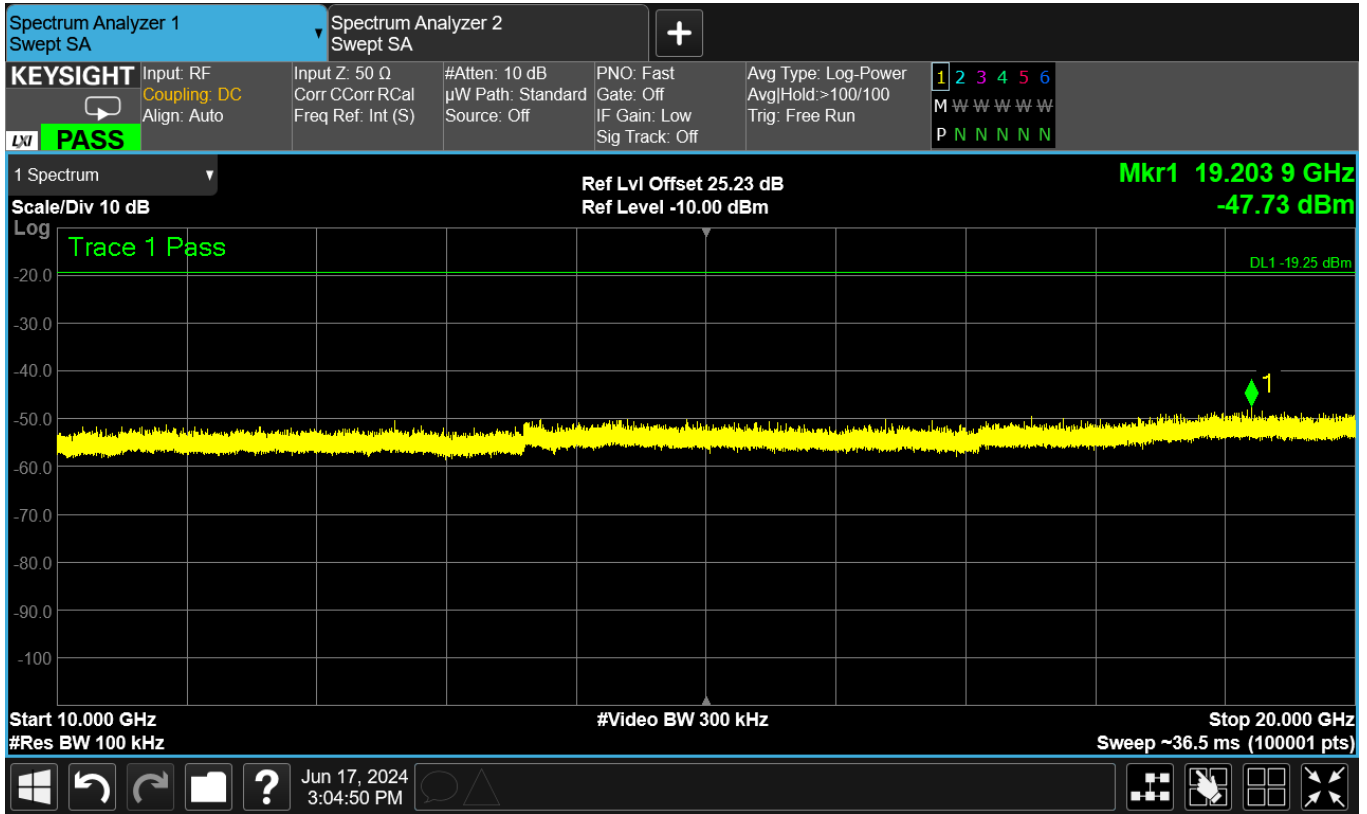




Figure 36: Center Channel 1Mbps (DH5) Conducted Spurious Plot 6

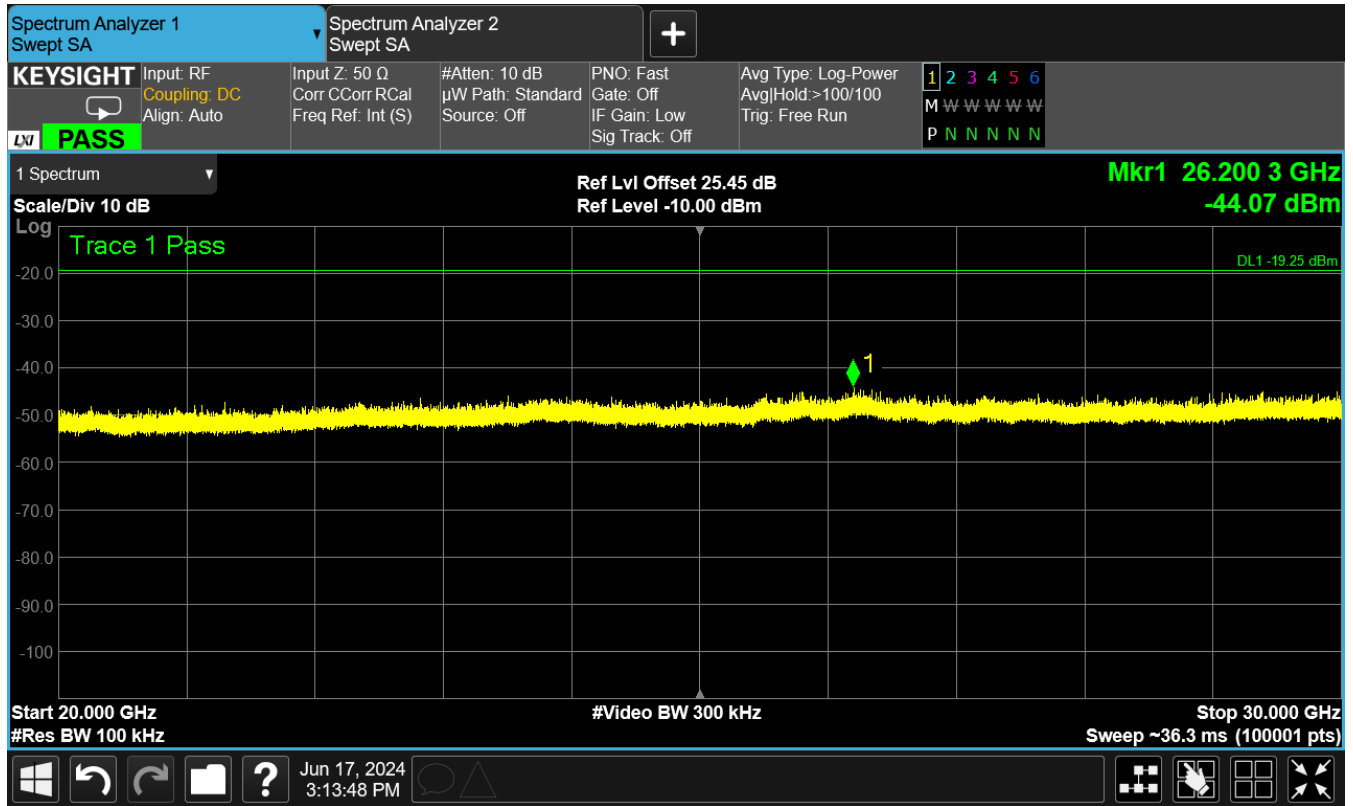




Figure 37: High Channel 1Mbps (DH5) Conducted Spurious Plot 1

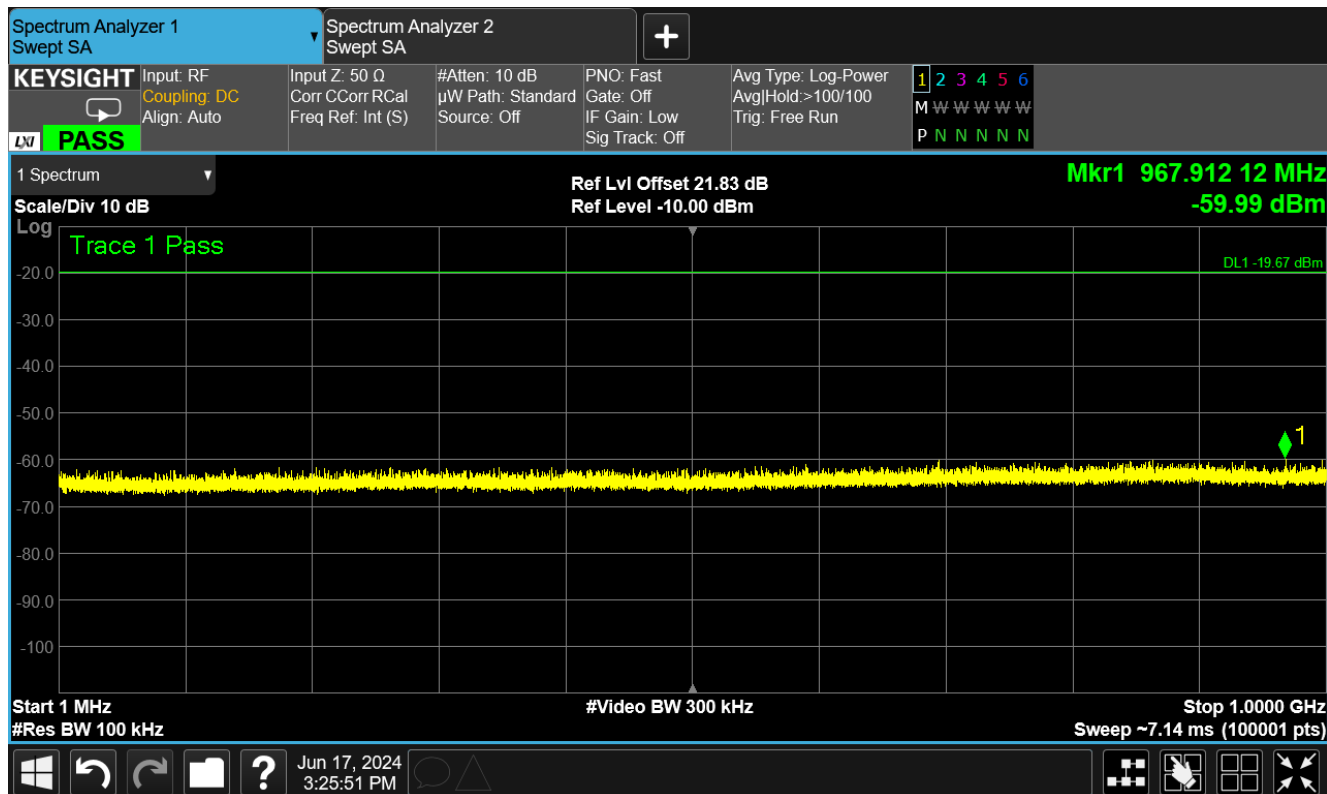




Figure 38: High Channel 1Mbps (DH5) Conducted Spurious Plot 2

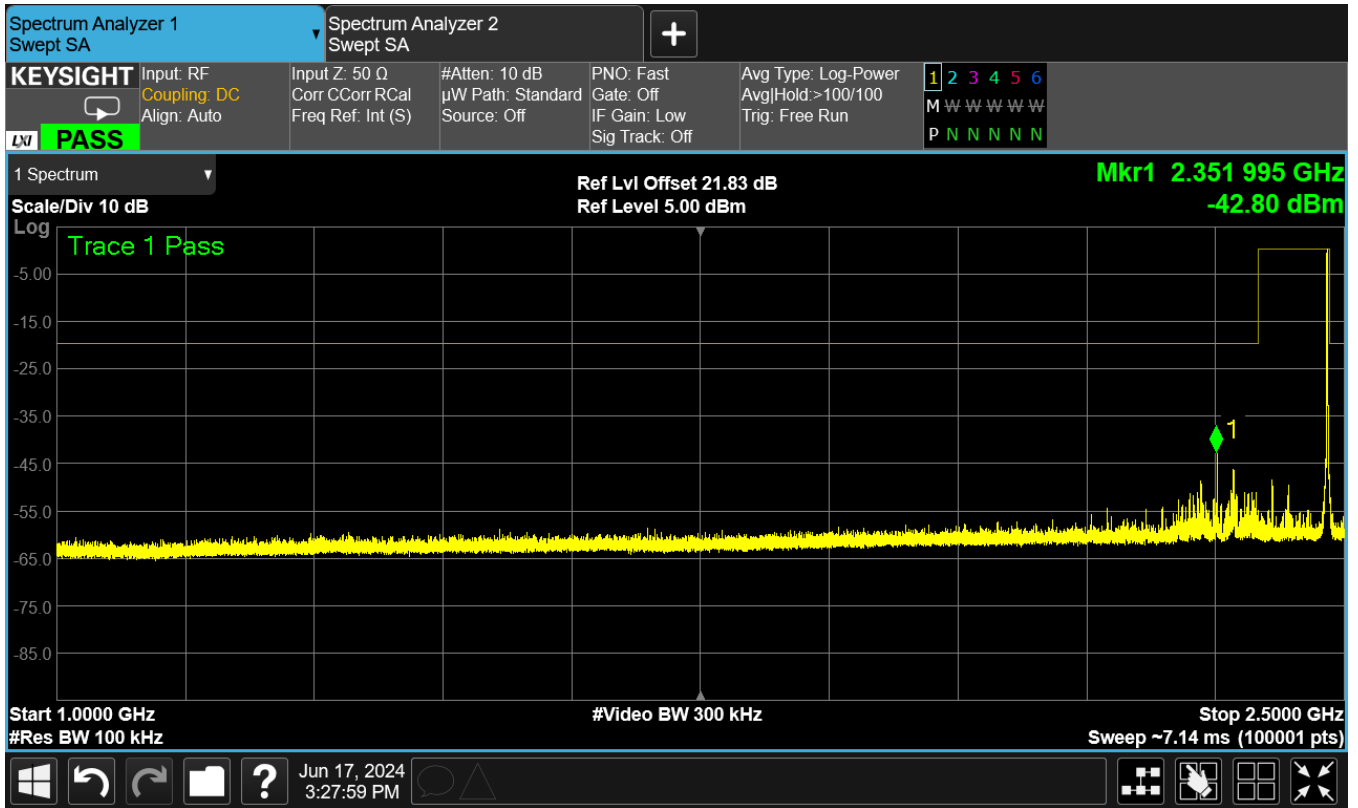




Figure 39: High Channel 1Mbps (DH5) Conducted Spurious Plot 3

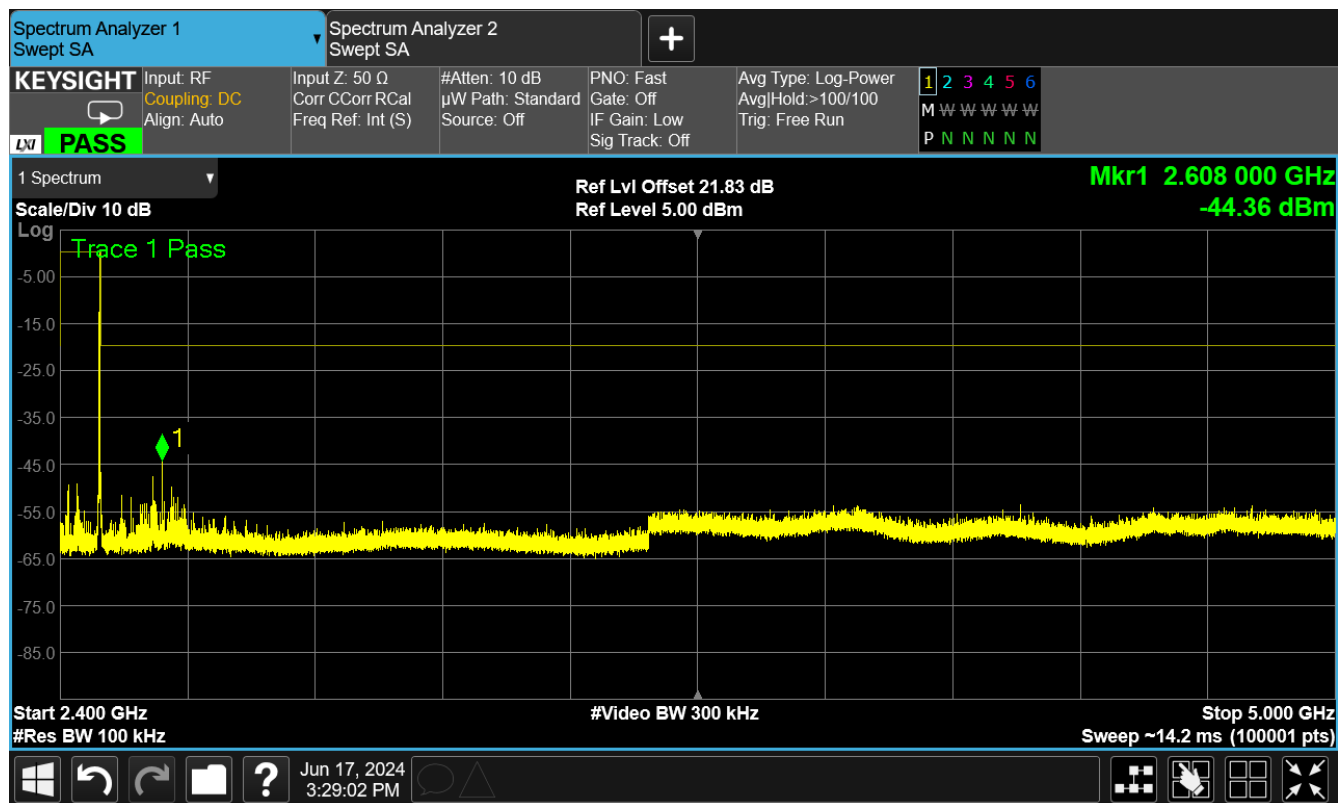




Figure 40: High Channel 1Mbps (DH5) Conducted Spurious Plot 4

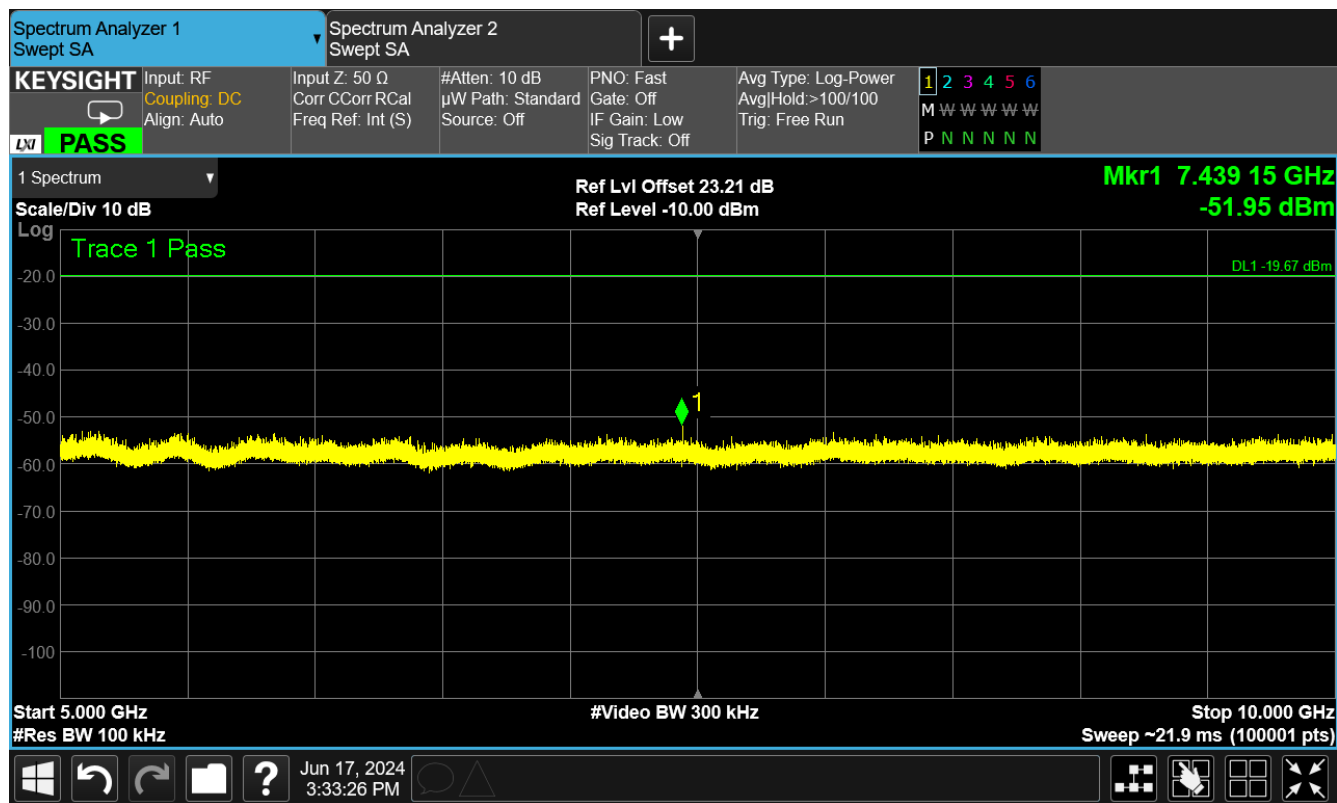




Figure 41: High Channel 1Mbps (DH5) Conducted Spurious Plot 5

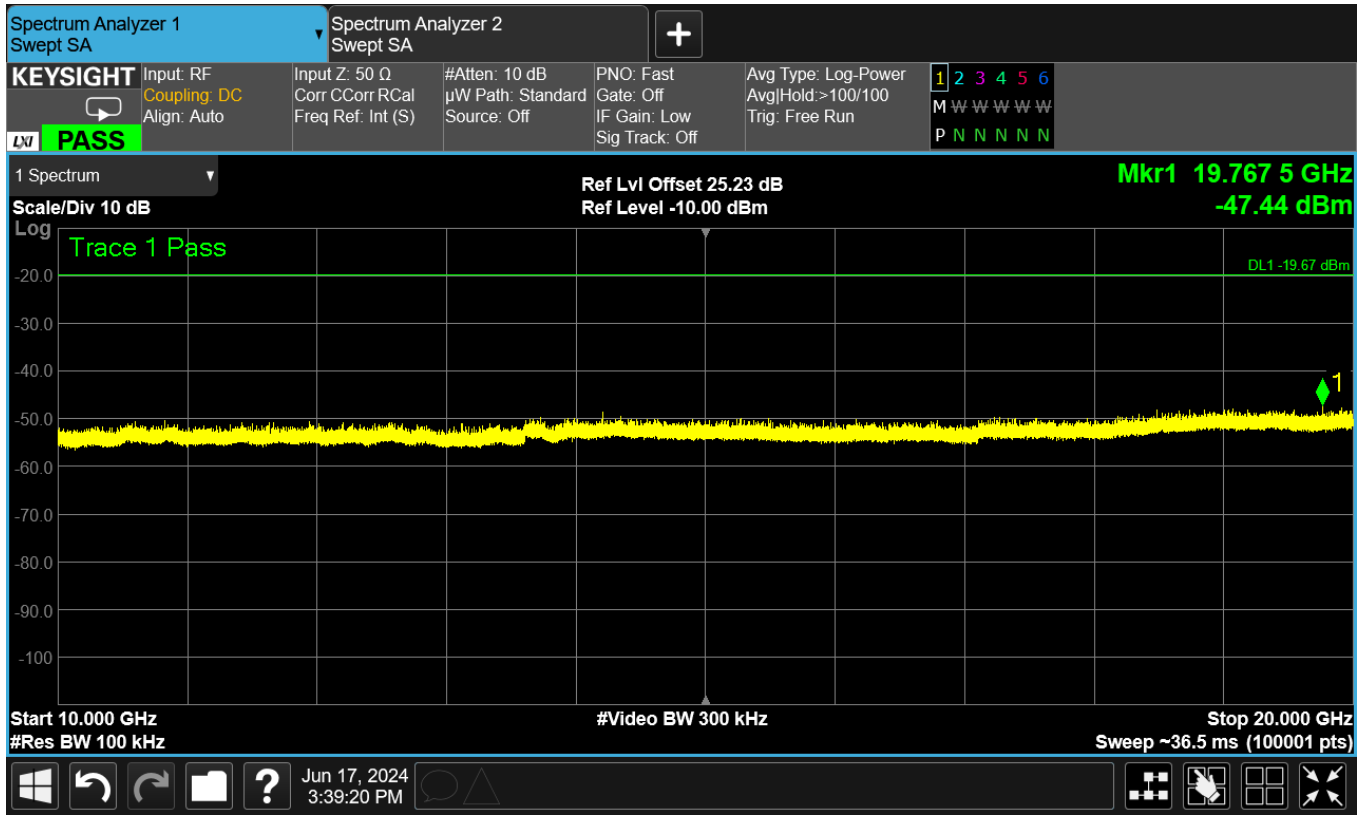
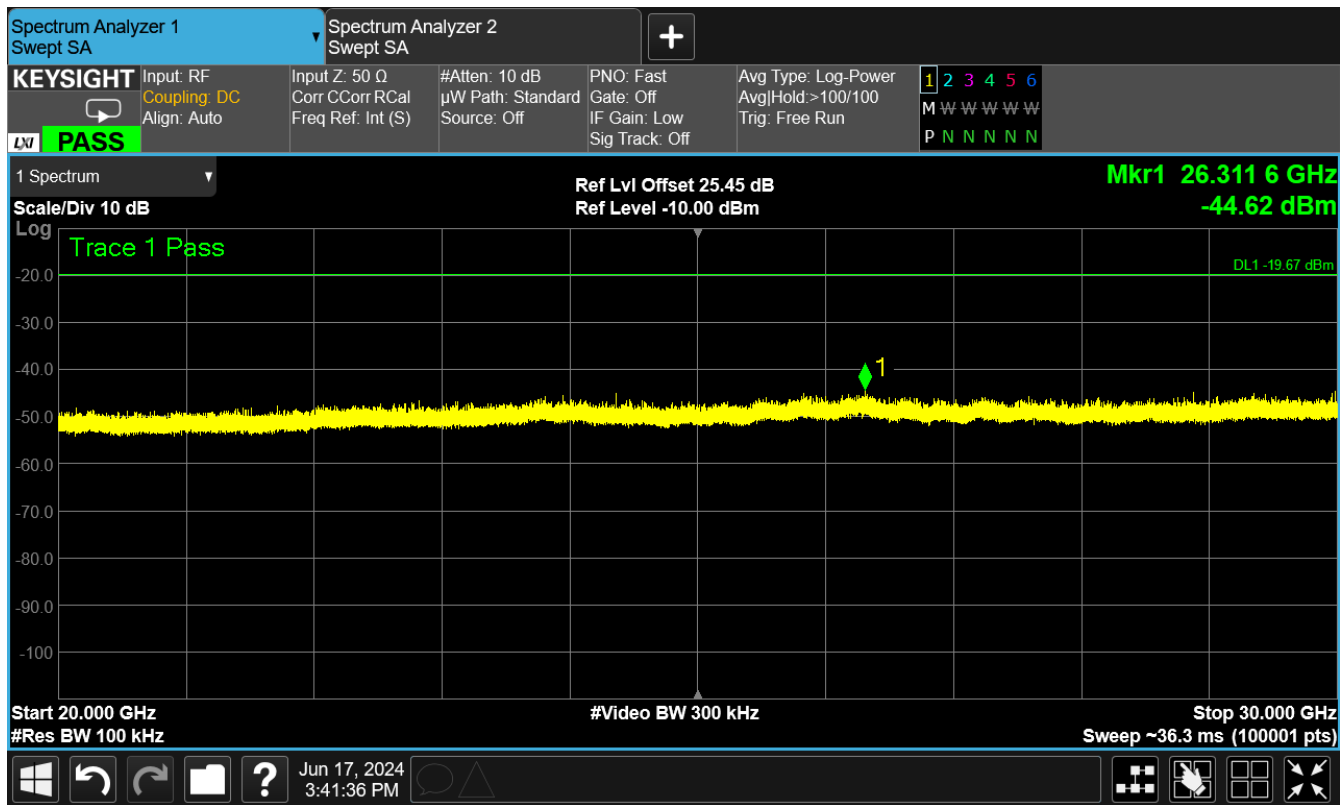




Figure 42: High Channel 1Mbps (DH5) Conducted Spurious Plot 6





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Figure 43: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 1

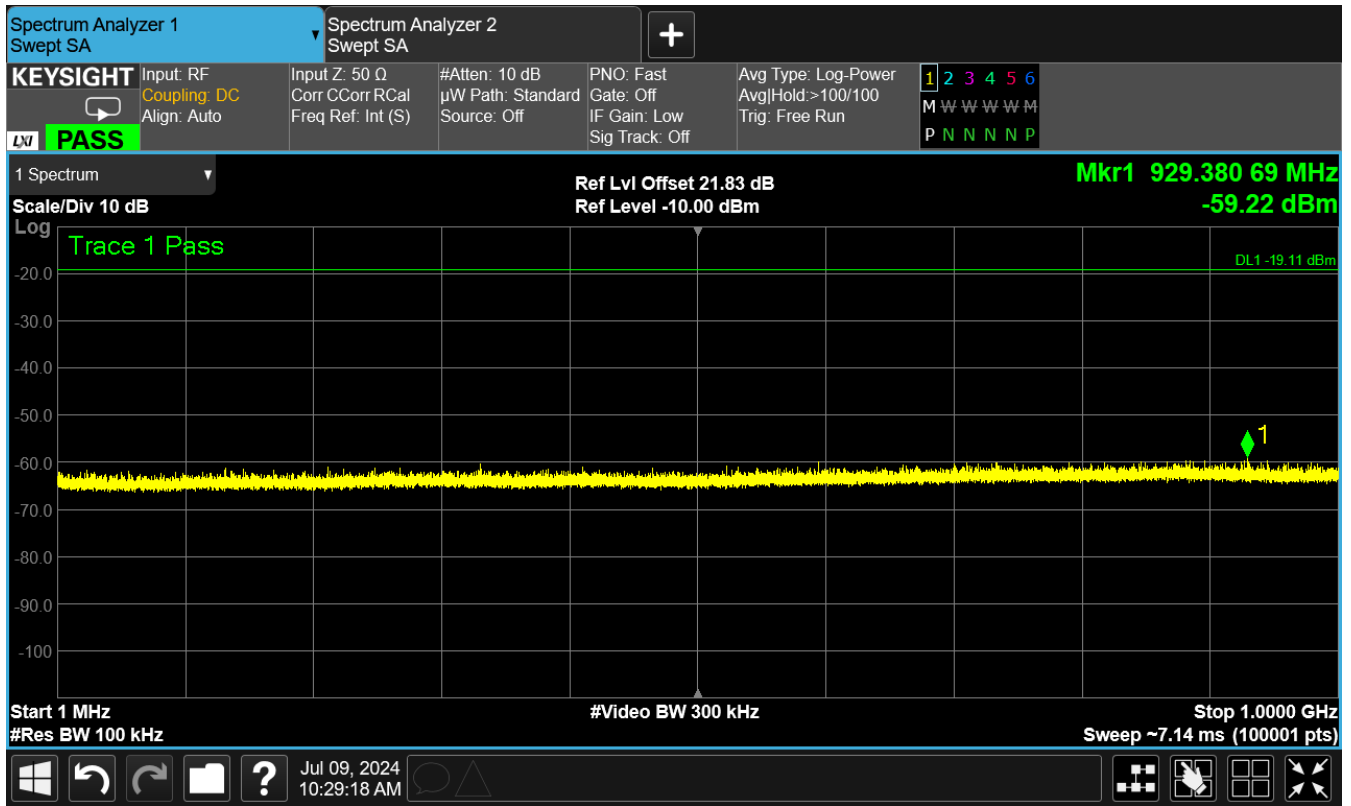




Figure 44: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 2

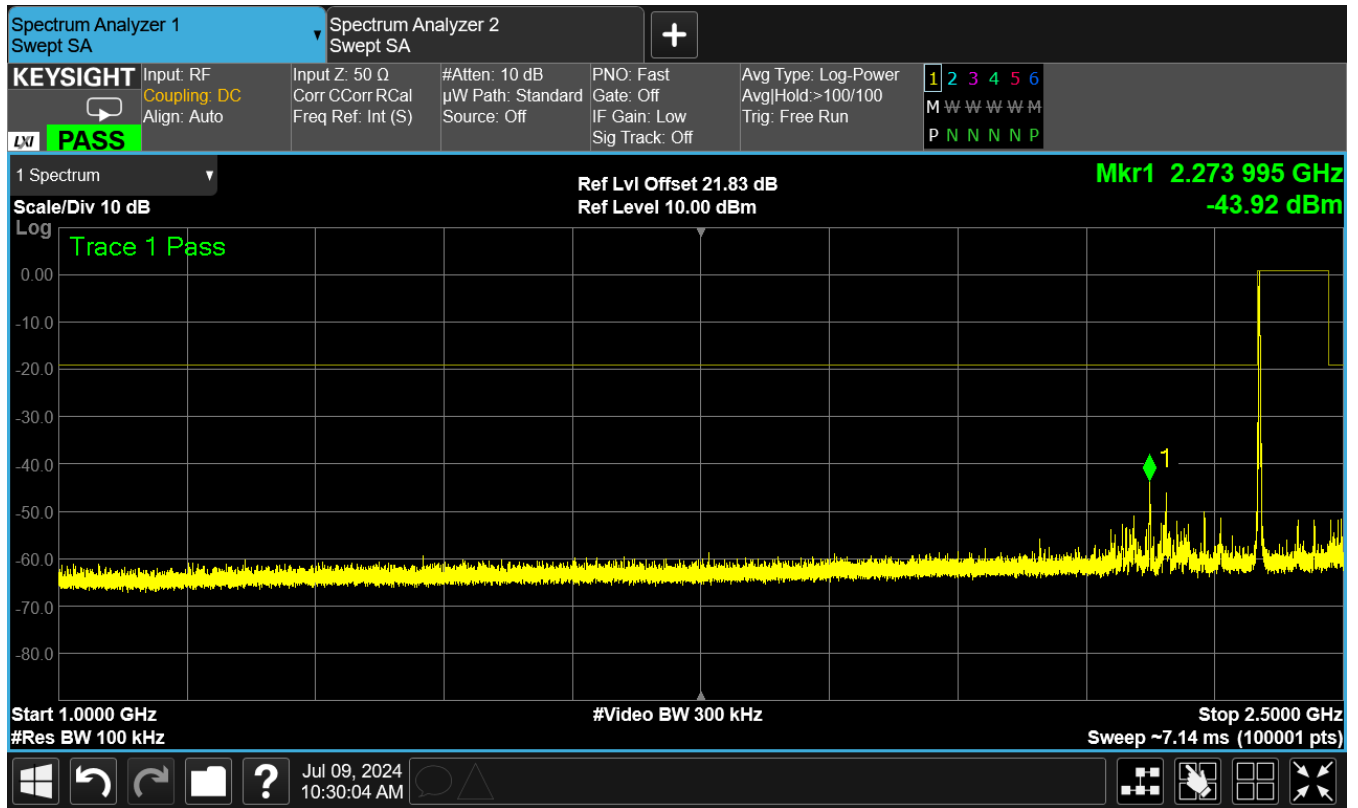




Figure 45: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 3

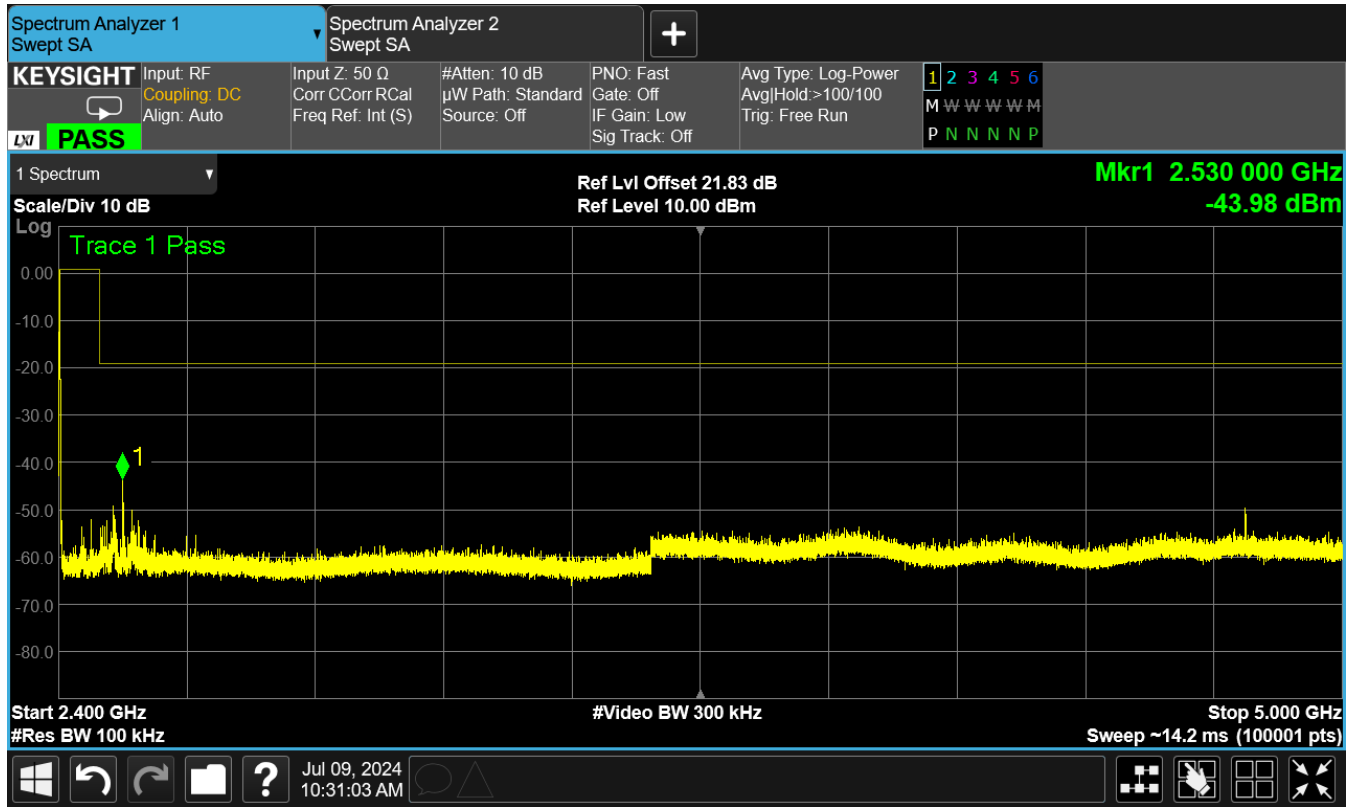




Figure 46: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 4

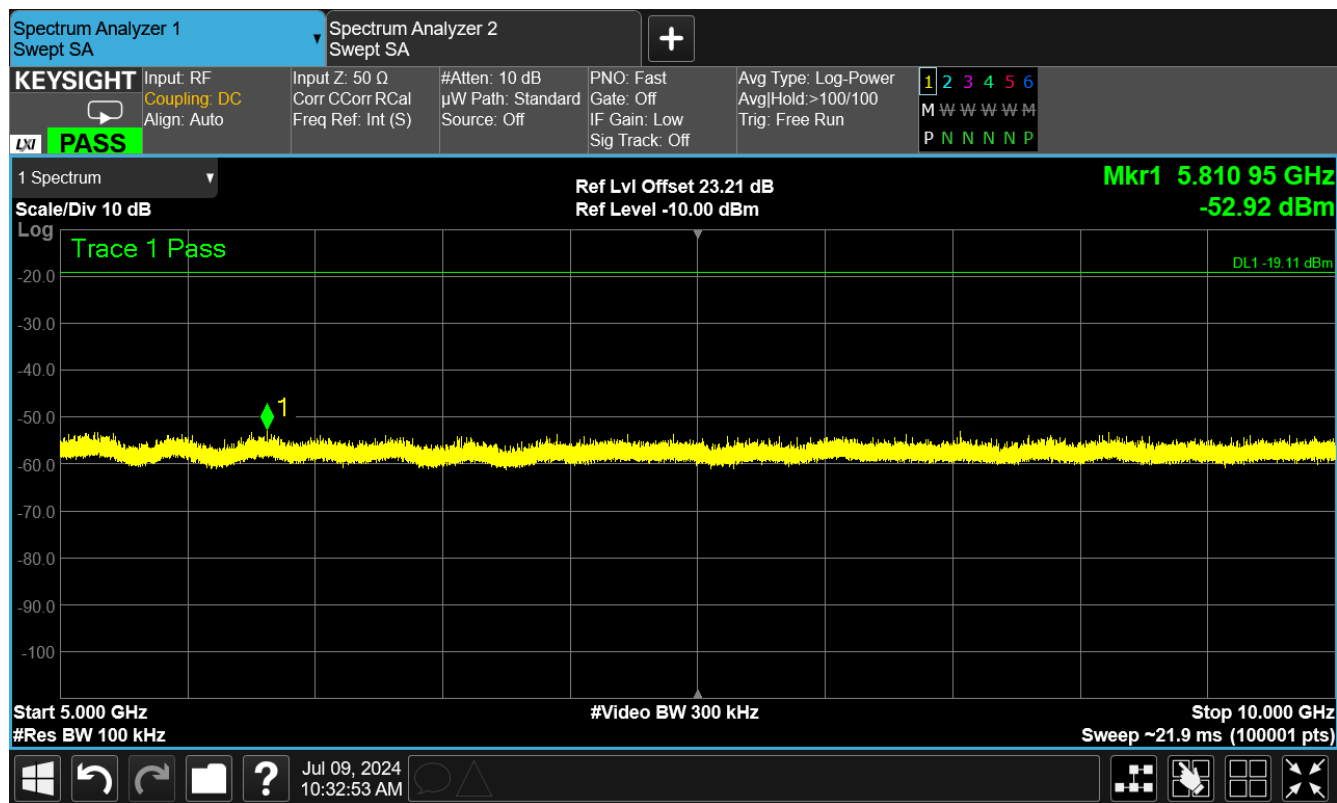




Figure 47: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 5

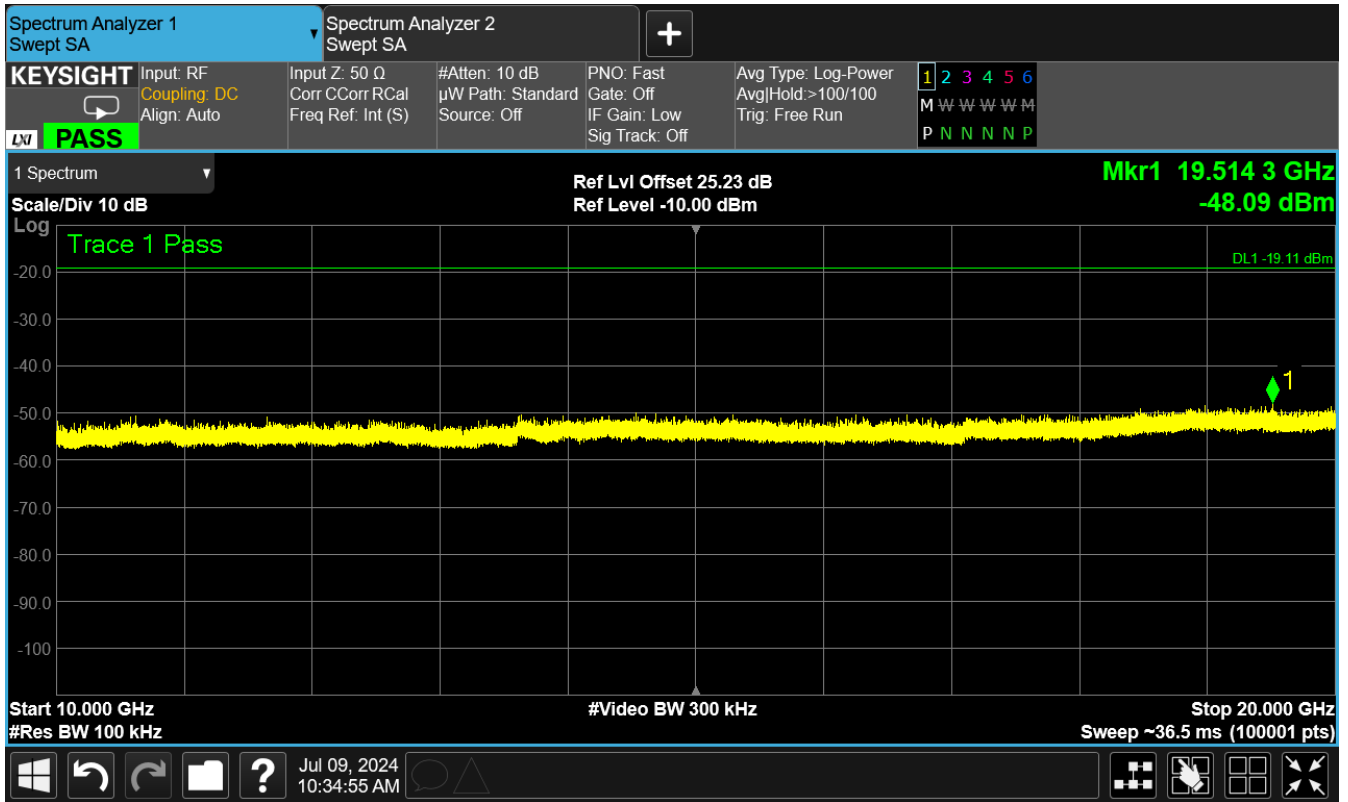




Figure 48: Low Channel 2Mbps (2DH5) Conducted Spurious Plot 6

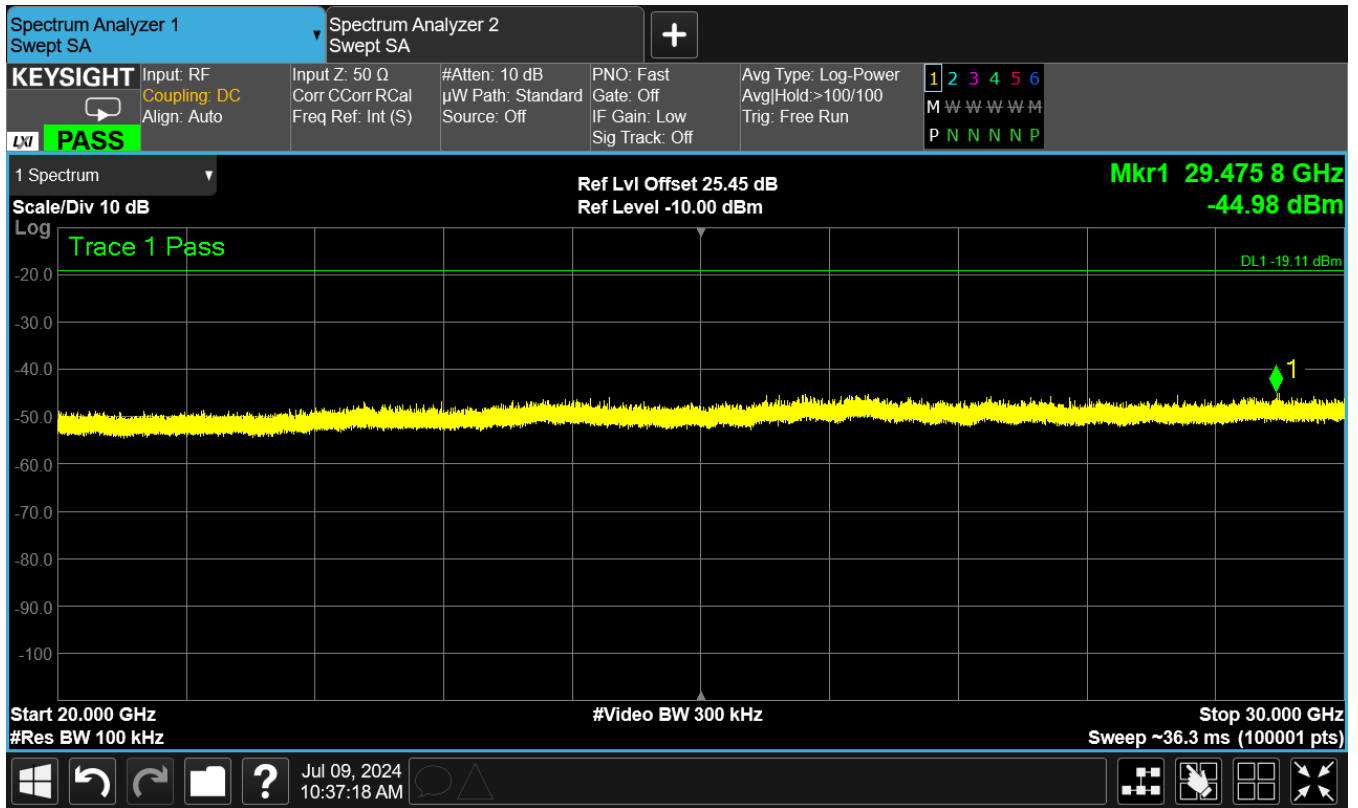




Figure 49: Center Channel 2Mbps (2DH5) Conducted Spurious Plot 1 of 2

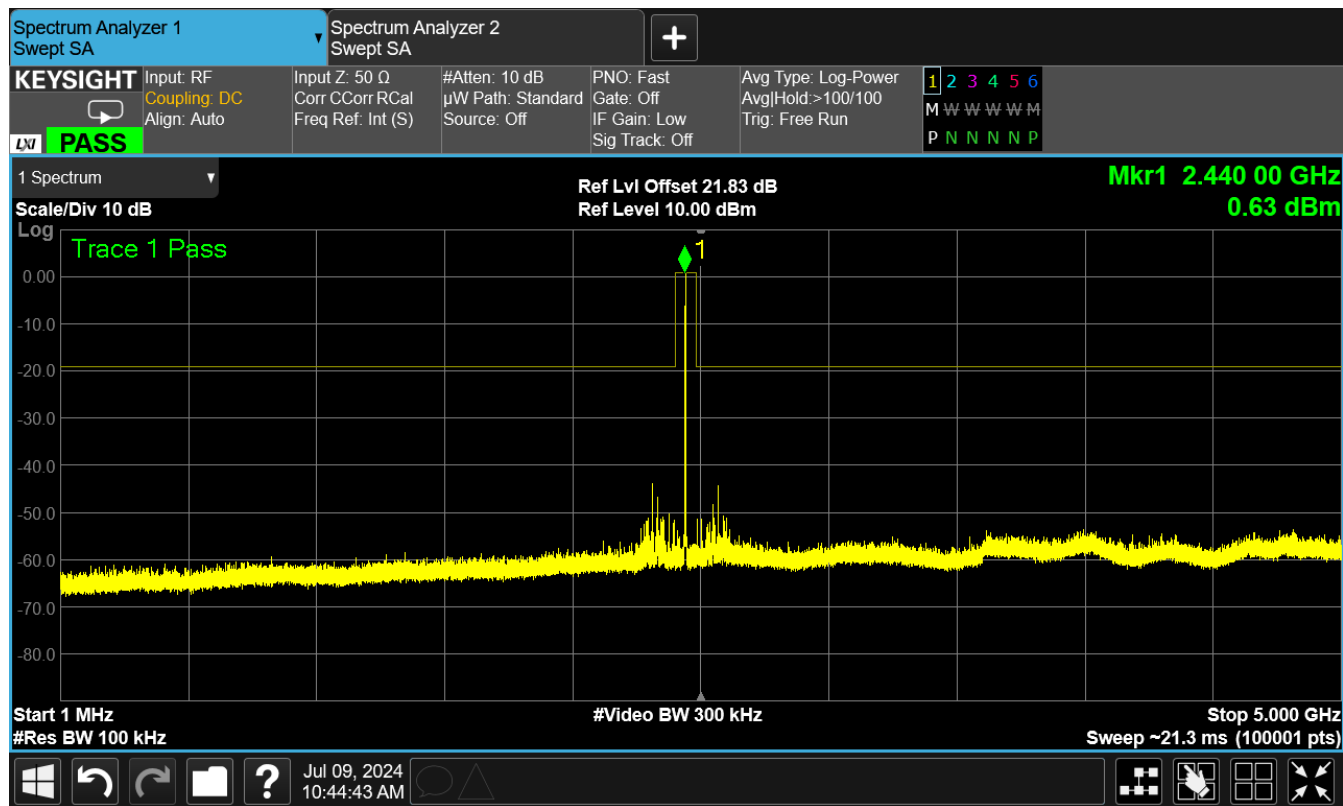




Figure 50: Center Channel 2Mbps (2DH5) Conducted Spurious Plot 2 of 2

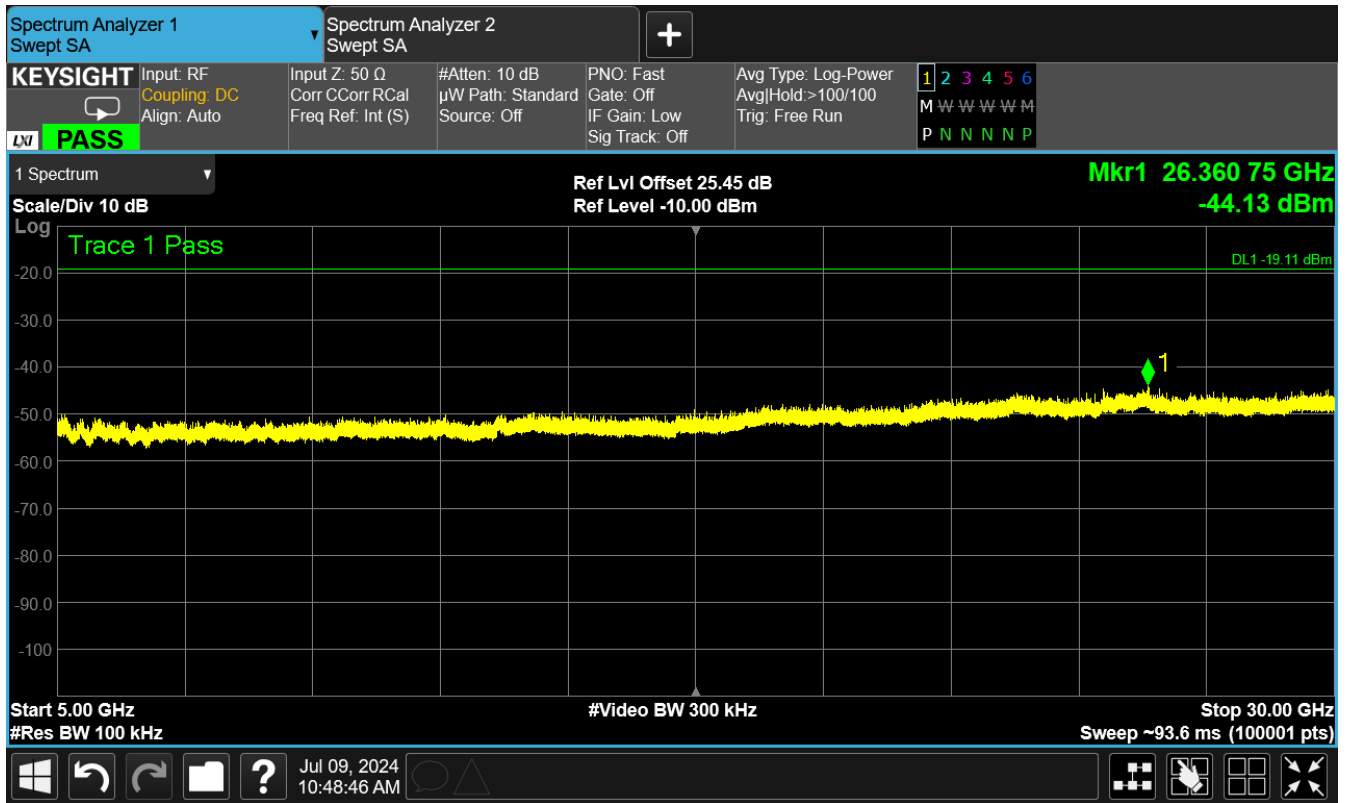




Figure 51: High Channel 2Mbps (2DH5) Conducted Spurious Plot 1

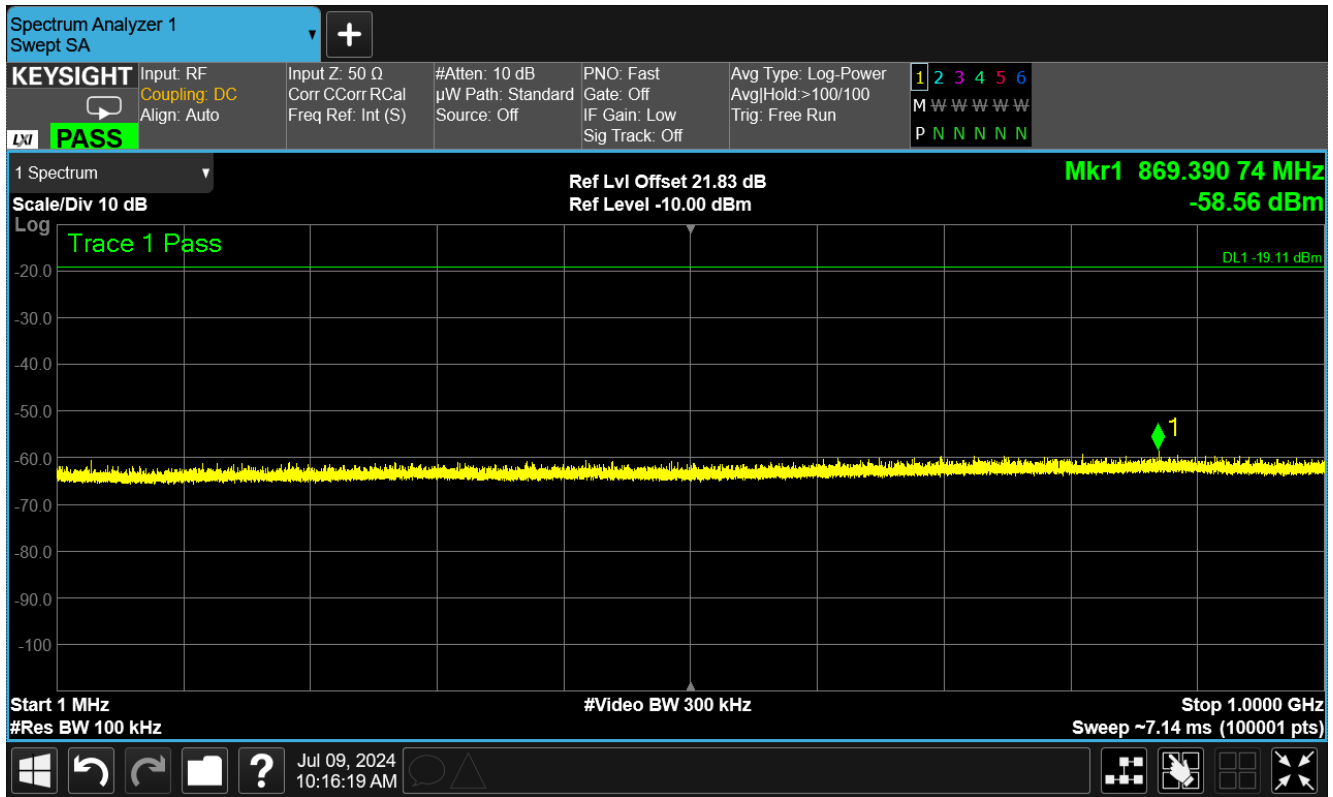




Figure 52: High Channel 2Mbps (2DH5) Conducted Spurious Plot 2

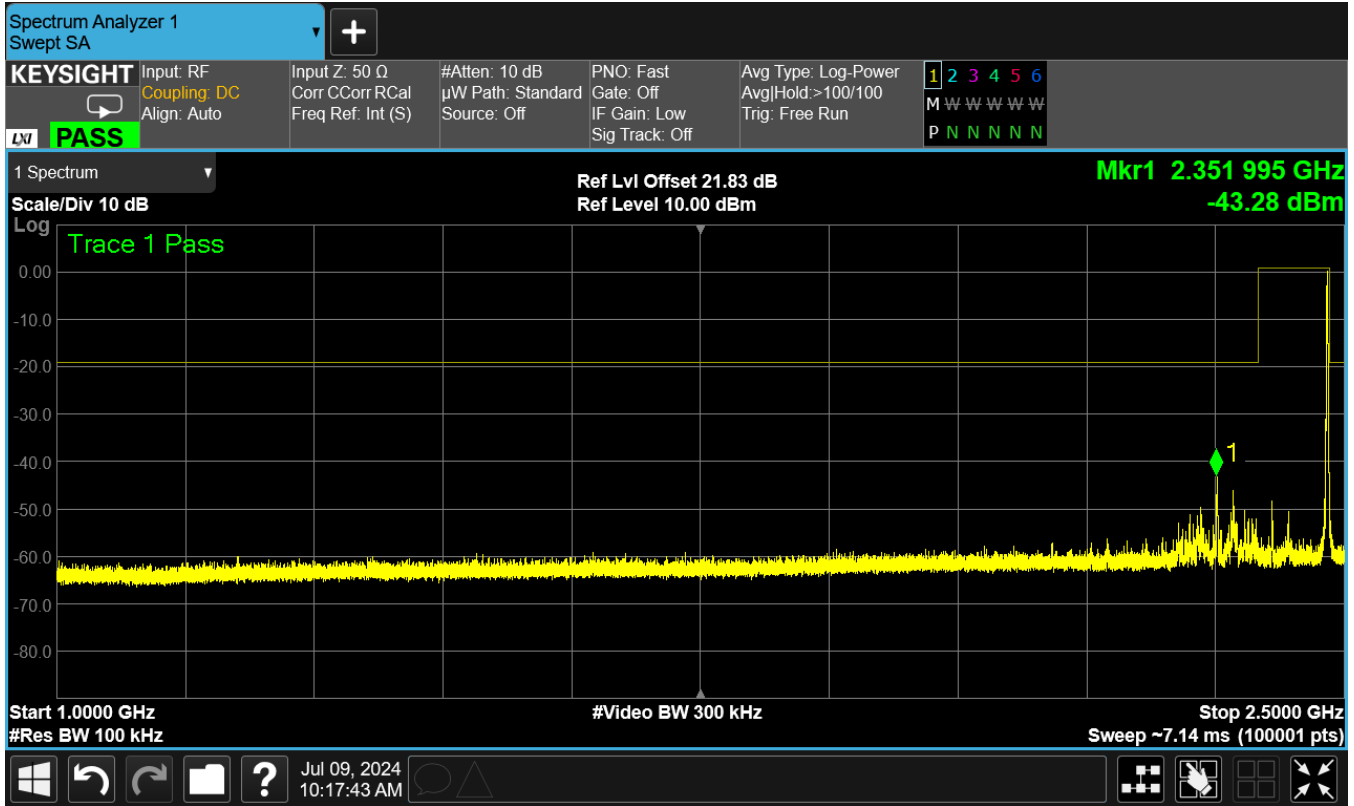




Figure 53: High Channel 2Mbps (2DH5) Conducted Spurious Plot 3

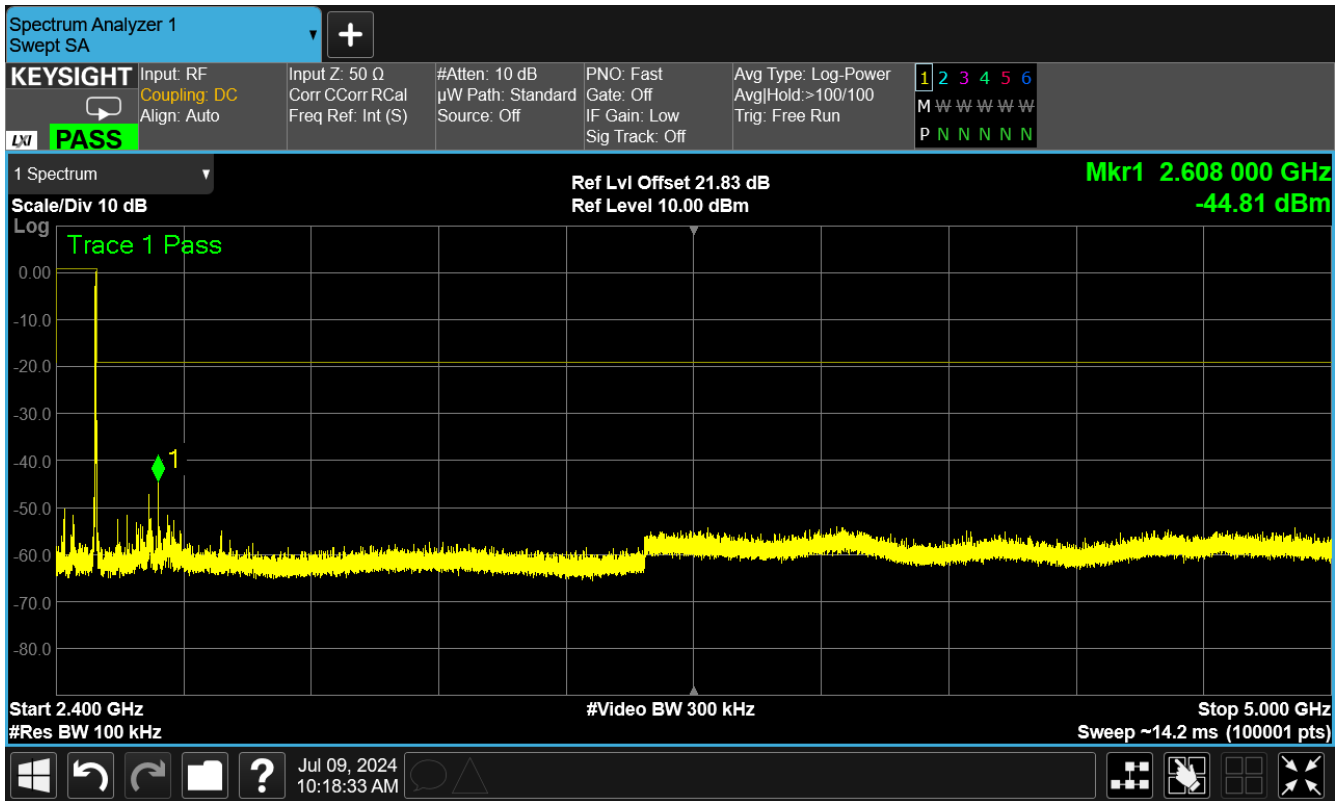




Figure 54: High Channel 2Mbps (2DH5) Conducted Spurious Plot 4

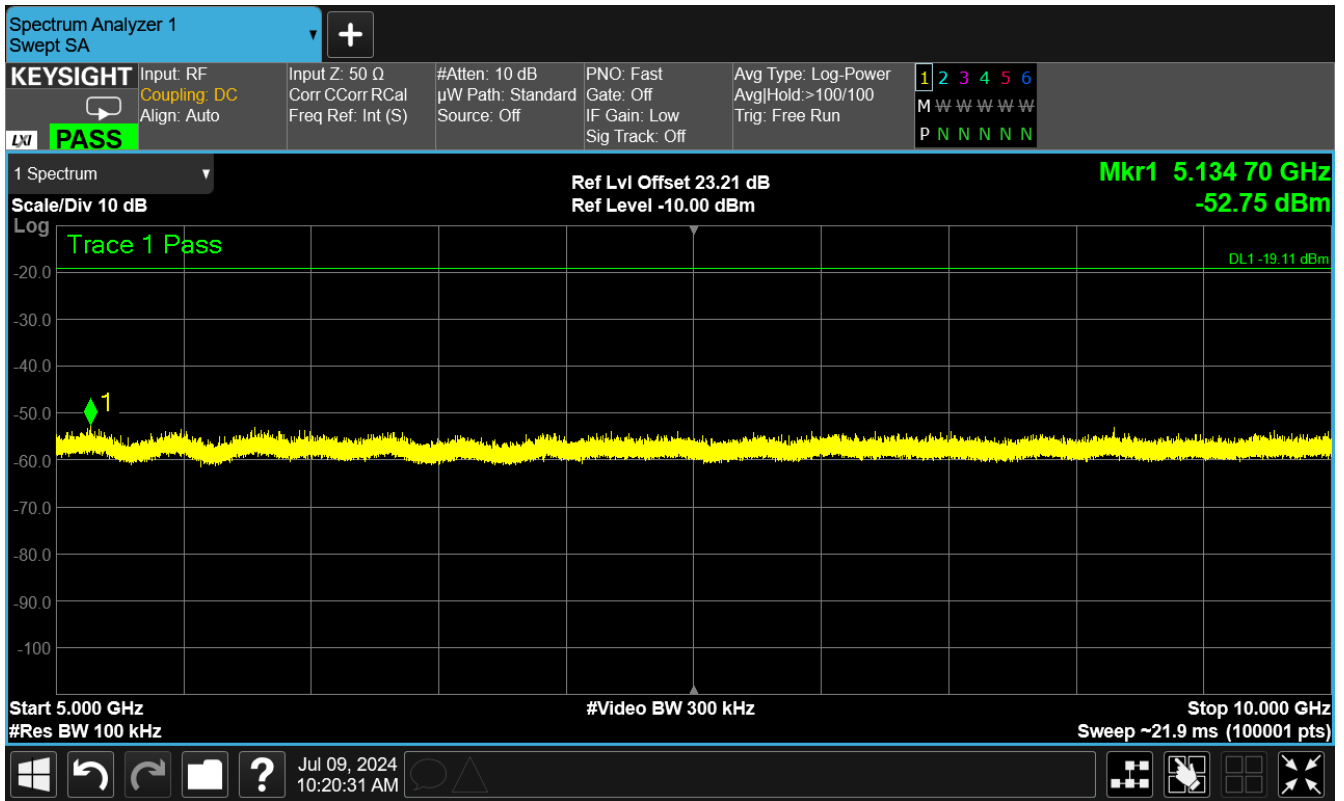




Figure 55: High Channel 2Mbps (2DH5) Conducted Spurious Plot 5

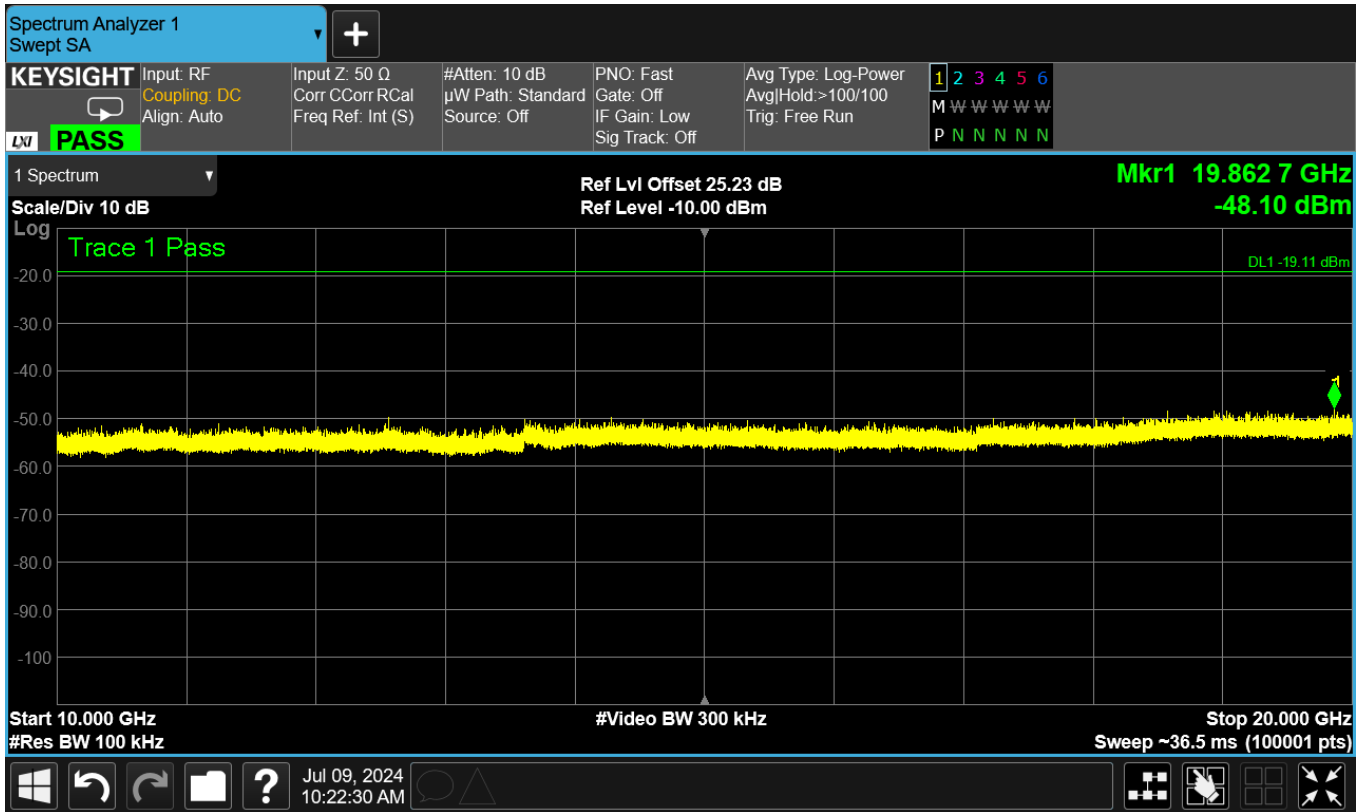
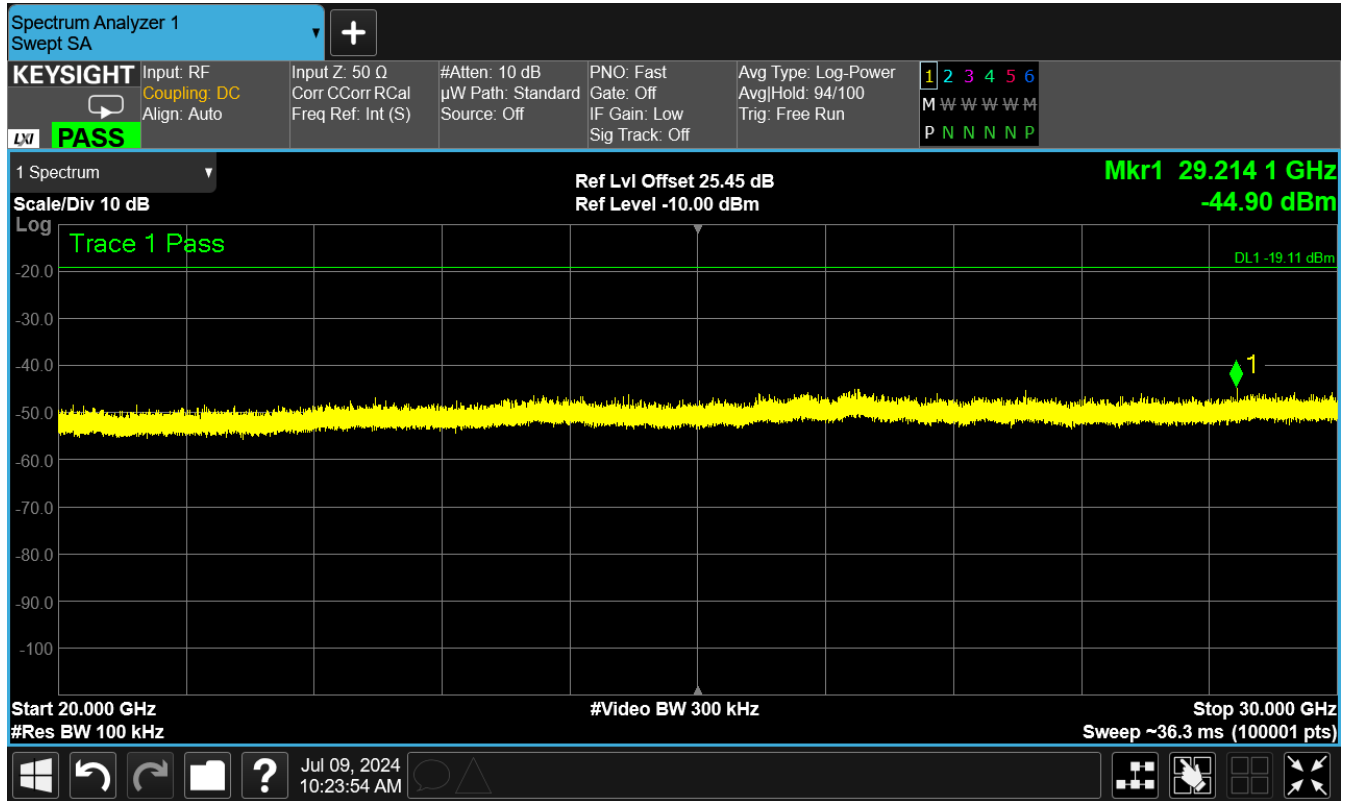




Figure 56: High Channel 2Mbps (2DH5) Conducted Spurious Plot 6





3.6 Radiated Emissions

3.6.1 Requirements

Compliance Standard: FCC Part 15.247, 15.209, 15.205

Radiated Emissions, Compliance Limits	
Frequency Range	Class B Equivalent (3-meters)
30 – 88 MHz	100 μ V/m
88 – 216 MHz	150 μ V/m
216 – 960 MHz	200 μ V/m
> 960 MHz	500 μ V/m

3.6.2 Test Procedure

The requirements of FCC Part 15 and ICES-003 call for the EUT to be placed on a 1 X 1.5 meters non-conductive motorized turntable for radiated testing on a 3-meter open air test site. The height of the table is 80cm for testing below 1GHz. The height of the table is 150cm for testing above 1GHz.

The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Bi-conical and log periodic broadband antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 30 MHz to 26.5 GHz were measured. Both the horizontal and vertical field components were measured.

The output from the antenna was connected, via a preamplifier, to the input of the spectrum analyzer. The detector function was set to quasi-peak or peak, as appropriate. Above 1GHz average measurement are recorded. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth. Frequencies above 1GHz were performed using a measurement bandwidth of 1 MHz with a video bandwidth setting of 10 Hz for the average measurement.

3.6.3 Test Results Summary

The EUT complies with the Class B Radiated Emissions requirements.



3.6.4 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dB μ V to obtain the Radiated Electric Field in dB μ V/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage: VdB μ V

Antenna Correction Factor: AFdB/m

Cable Correction Factor: CFdB

Pre-Amplifier Gain (if applicable): GdB

Electric Field: EdB μ V/m = V dB μ V + AFdB/m + CFdB - GdB

To convert to linear units of measure:: EdB μ V/m/20 Inv log

3.6.5 Test Data

The EUT is fully compliant, and the final test data, for both modes, is provided on the pages below.

There were no EUT emissions detected in the frequency range of 8 GHz to 26.5 GHz.

A complete investigation of the radiated fundamental field strength was performed. The EUT was evaluated in three orthogonal axes (x, y, z). The EUT position the produced the highest radiated power was maintained during all testing.

The EUT was configured to transmit a modulated signal as follows:

- a) for testing of 30 MHz to 1 GHz, the EUT was set to a transmitter enabled mode, the BLE transceiver was set to sweep the 2.4GHz ISM band, in an active advertising mode.
- b) for testing of 1 GHz to 26.5 GHz, the EUT was set to a transmitter enabled mode, the BLE transceiver was set to dwell on the low, center, and high channels.

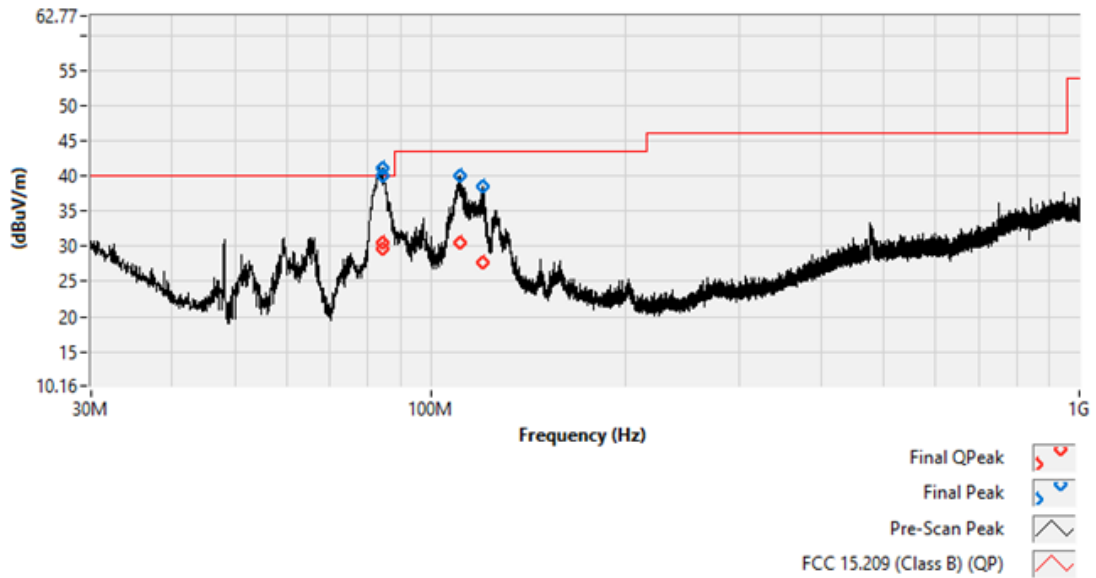
Please accept the 30MHz to 1GHz data to cover the digital portion under the provisions of 15.109(a).



Table 9: Radiated Emissions Test Data, 1Mbps (DH5) 30MHz to 1GHz

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Table (deg)	Antenna (cm)
83.220	Peak	38.502	--	--	270	Horiz, 225
	QP	31.637	40	-8.363	270	Horiz, 225
84.605	Peak	39.978	--	--	180	Vert, 100
	QP	30.581	40	-9.419	180	Vert, 100

1Mbps (GFSK) Pre-scan and Final Data (Vertical)



1Mbps (GFSK) Pre-scan and Final Data (Horizontal)

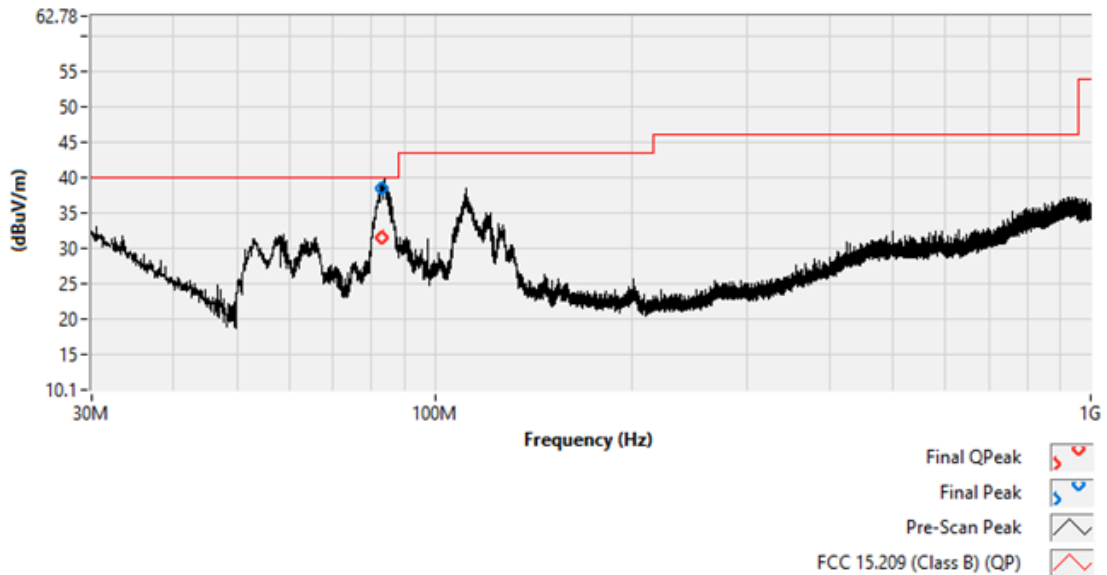




Table 10: Radiated Emissions Test Data, Low Channel, 1Mbps (DH5)

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2390.0 ¹	Peak	46.136	74	-27.864	315	Horiz, 160
	Avg	32.583	54	-21.417	315	Horiz, 160
2402.0 ²	Peak	90.927	--	--	315	Horiz, 160
	Avg	79.974	--	--	315	Horiz, 160
5217.0	Peak	52.901	74	-21.099	315	Horiz, 160
	Avg	39.953	54	-14.047	315	Horiz, 160
7222.0	Peak	57.05	74	-16.95	315	Horiz, 160
	Avg	42.296	54	-11.704	315	Horiz, 160
8343.0 ³	Peak	57.68	74	-16.32	145	Vert, 155
	Avg	43.299	54	-10.701	145	Vert, 155
10315.0 ³	Peak	64.602	74	-9.398	315	Horiz, 160
	Avg	48.558	54	-5.442	315	Horiz, 160
11682.0 ³	Peak	63.381	74	-10.619	315	Horiz, 160
	Avg	48.71	54	-5.290	315	Horiz, 160

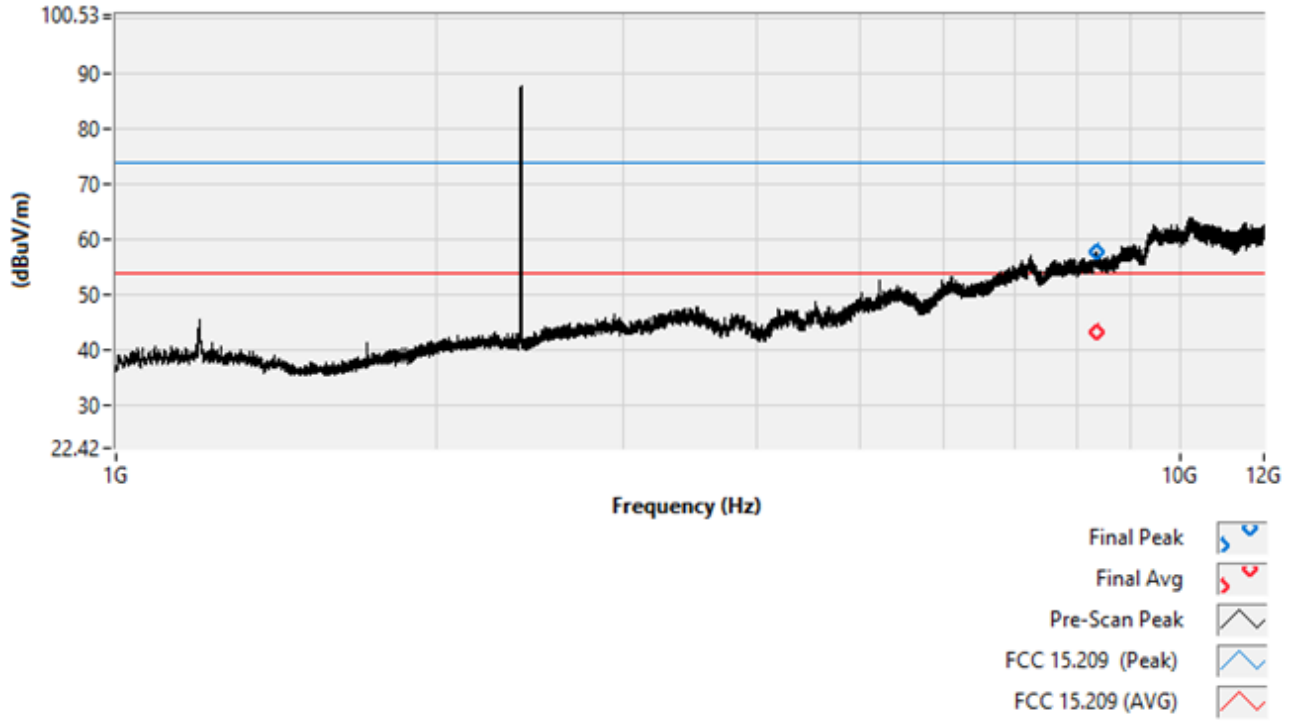
¹ Restricted BE

² Low Chan TX

³ Ambient



Low Chan., 1Mbps (GFSK) Pre-scan and Final Data (Vertical)



Low Chan., 1Mbps (GFSK) Pre-scan and Final Data (Horizontal)

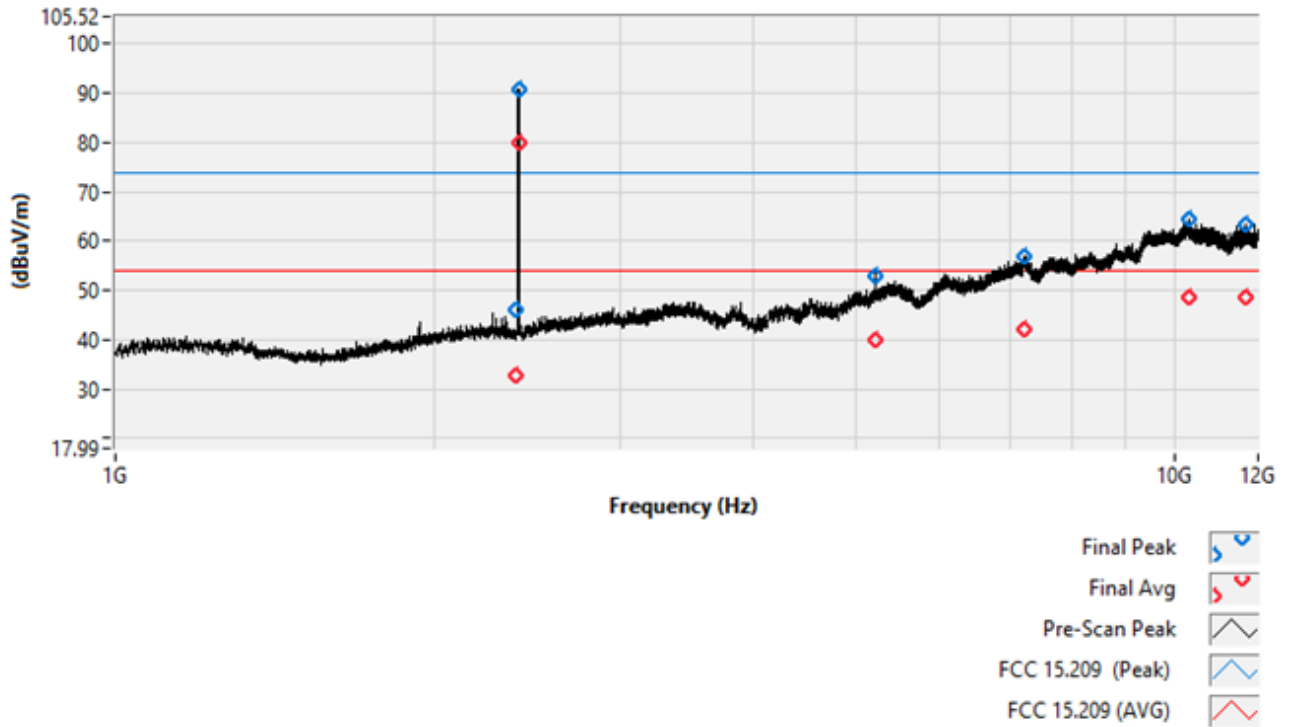
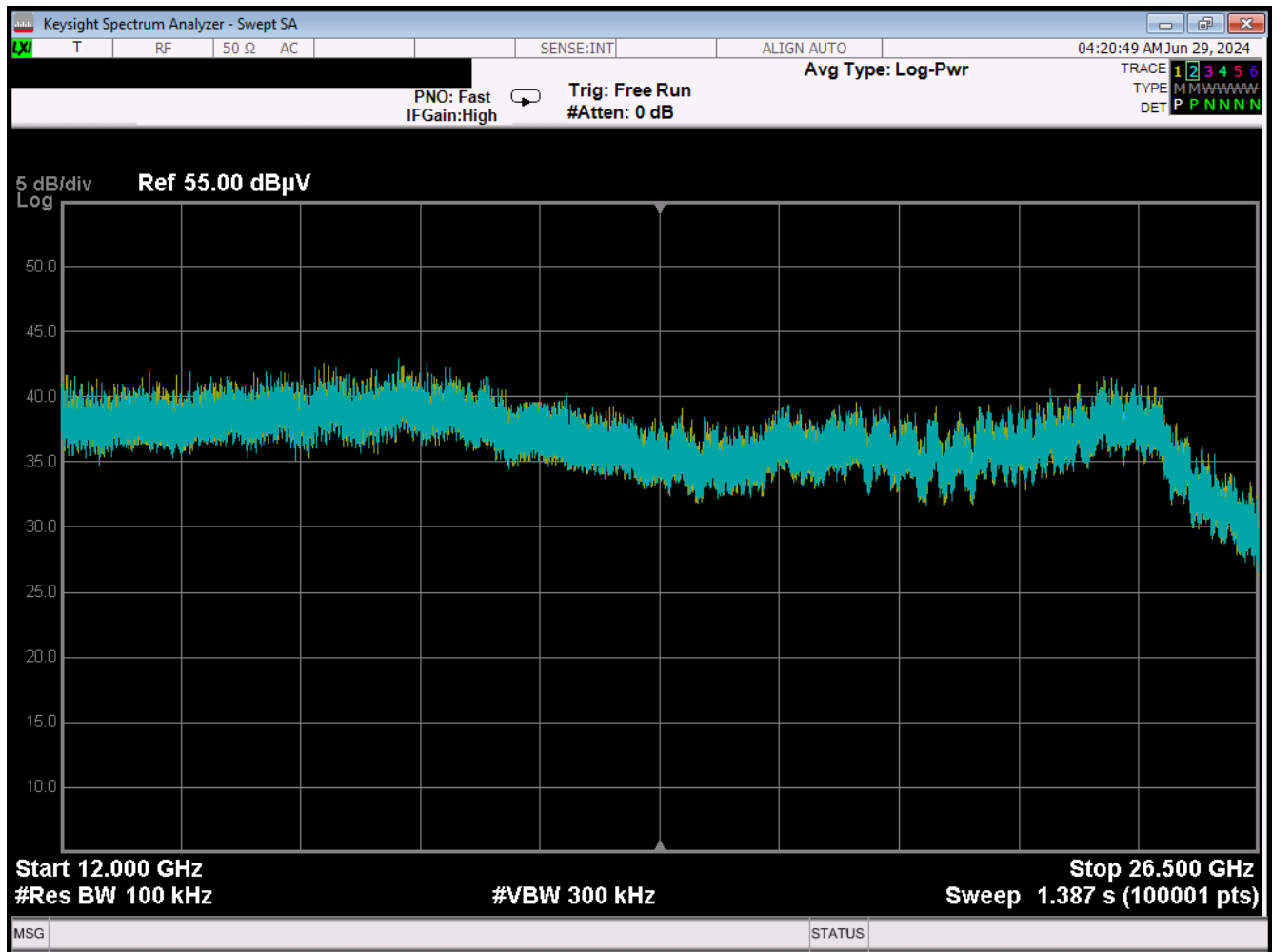




Figure 57: Radiated Emissions, Low Channel, 1Mbps, DH5, (12GHz to 26.5GHz)



- EUT emissions are not detected in this frequency range.
- **Trace 1** = EUT Low Chan. TX On
- **Trace 2** = Ambient



Table 11: Radiated Emissions Test Data, Center Channel, 1Mbps (DH5)

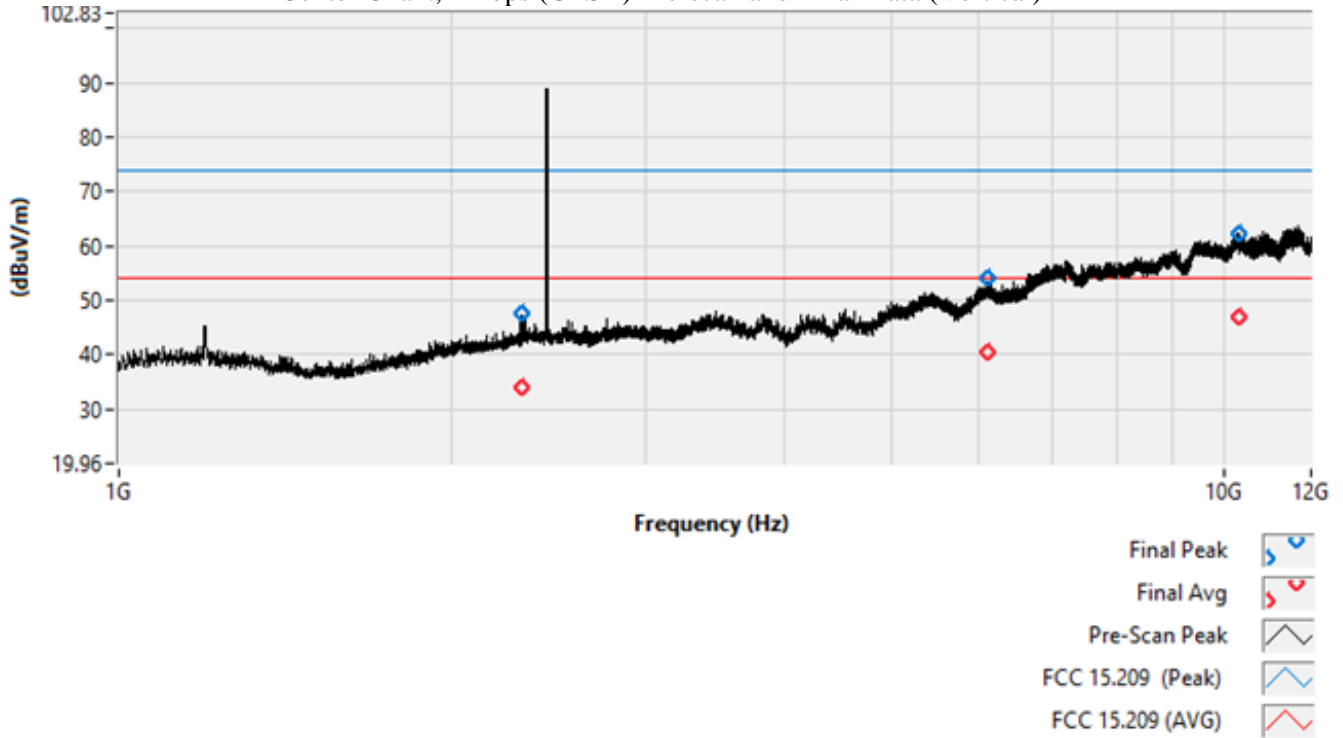
Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2312.0 ¹	Peak	47.512	74	-26.488	145	Vert, 165
	Avg	33.775	54	-20.225	145	Vert, 165
6117.0	Peak	54.033	74	-19.967	145	Vert, 165
	Avg	40.536	54	-13.464	145	Vert, 165
7210.0	Peak	57.576	74	-16.424	245	Horiz, 155
	Avg	42.465	54	-11.535	145	Horiz, 165
10312.0 ²	Peak	62.287	74	-11.713	245	Vert, 155
	Avg	46.991	54	-7.009	145	Vert, 165
11600.0 ²	Peak	60.028	74	-13.972	315	Horiz, 165
	Avg	47.251	54	-6.749	315	Horiz, 165

¹ Emission in a Restricted Band

² Ambient



Center Chan., 1Mbps (GFSK) Pre-scan and Final Data (Vertical)



Center Chan., 1Mbps (GFSK) Pre-scan and Final Data (Horizontal)

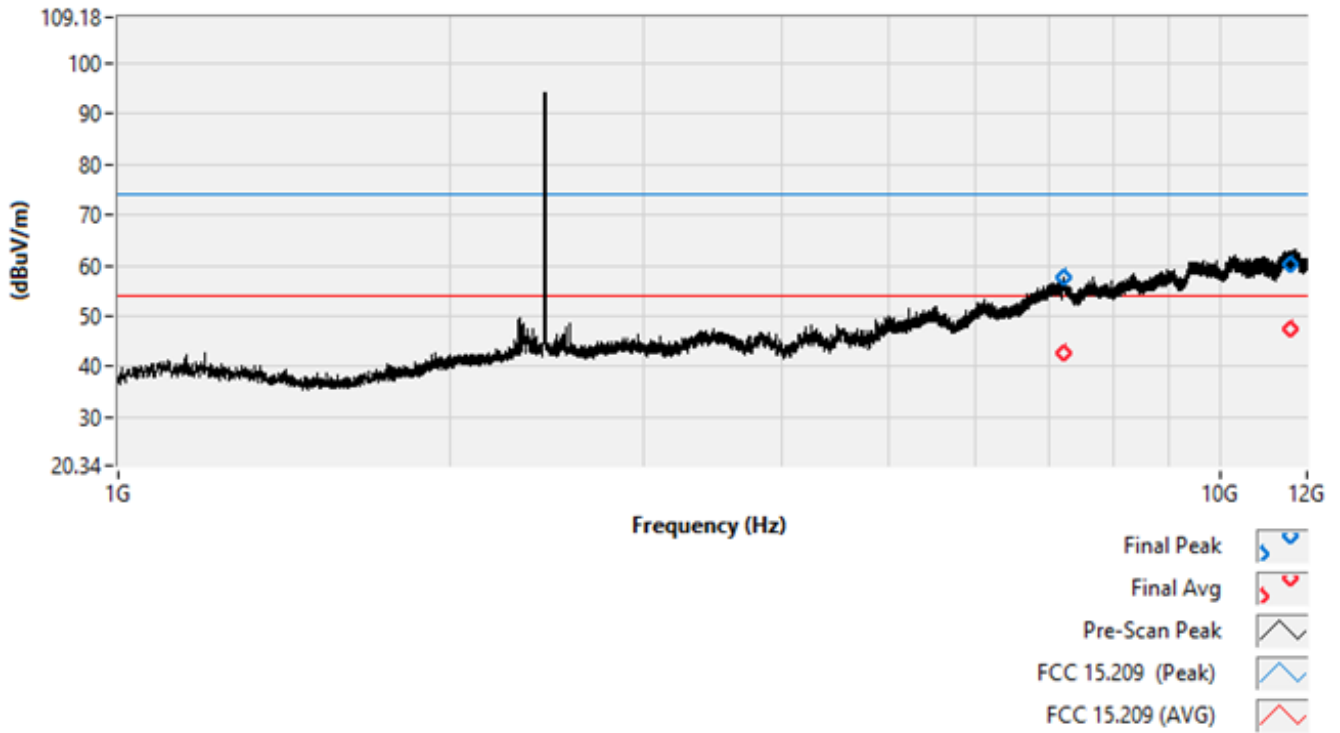
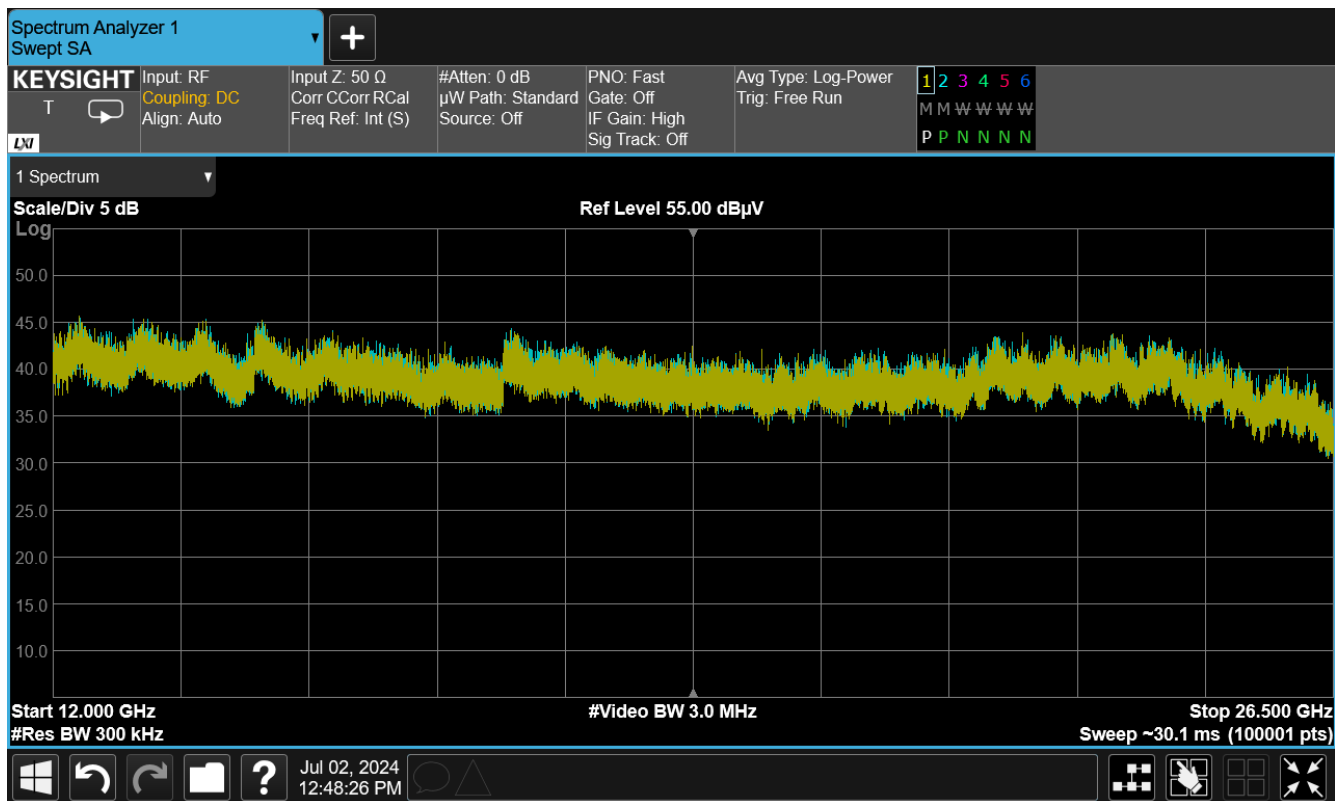




Figure 58: Radiated Emissions, Center Channel, 1Mbps, DH5, (12GHz to 26.5GHz)



- EUT emissions are not detected in this frequency range.
- Trace 1 = EUT Center Chan. TX On
- Trace 2 = Ambient



Table 12: Radiated Emissions Test Data, High Channel, 1Mbps (DH5)

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2480.0 ¹	Peak	90.43	--	--	245	Horiz, 155
	Avg	77.097	--	--	145	Horiz, 165
2483.5 ²	Peak	51.271	74	-22.729	145	Horiz, 165
	Avg	29.611	54	-24.389	145	Horiz, 165
7217.0	Peak	56.891	74	-17.109	245	Vert, 155
	Avg	42.023	54	-11.977	145	Vert, 165
9440.0 ³	Peak	61.363	74	-12.637	245	Vert, 155
	Avg	46.474	54	-7.526	145	Vert, 165
10201.0 ³	Peak	64.011	74	-9.989	245	Horiz, 155
	Avg	47.875	54	-6.125	315	Horiz, 155
10902.0 ³	Peak	63.664	74	-10.336	245	Vert, 155
	Avg	47.784	54	-6.216	145	Vert, 165

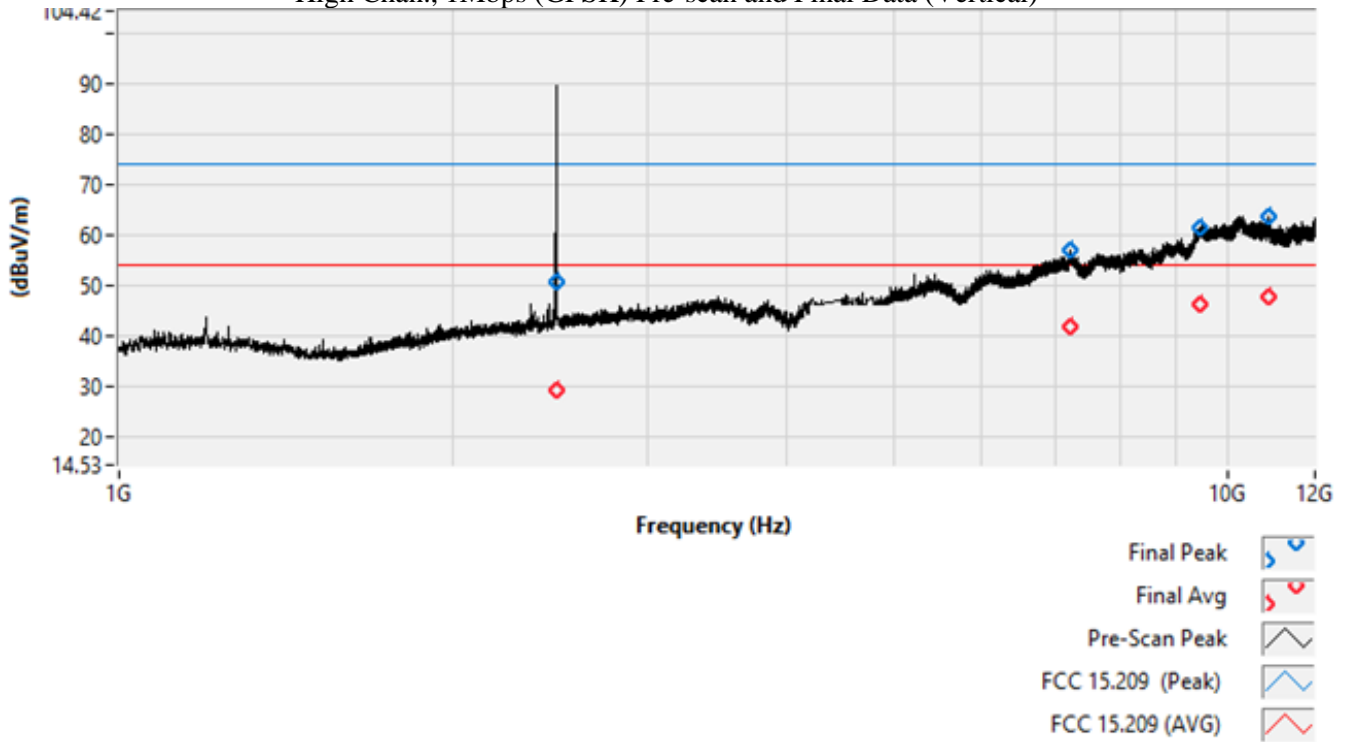
¹ High Chan TX

² Restricted BE

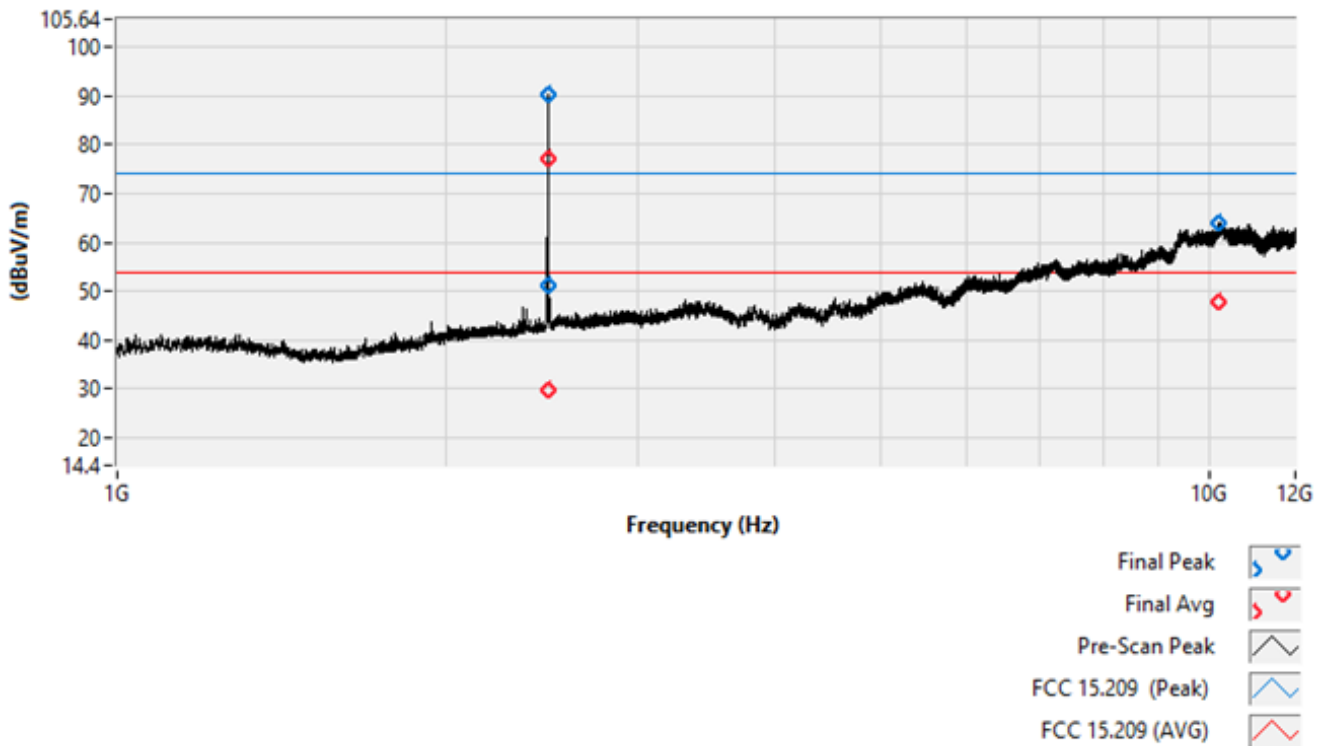
³ Ambient



High Chan., 1Mbps (GFSK) Pre-scan and Final Data (Vertical)



High Chan., 1Mbps (GFSK) Pre-scan and Final Data (Horizontal)





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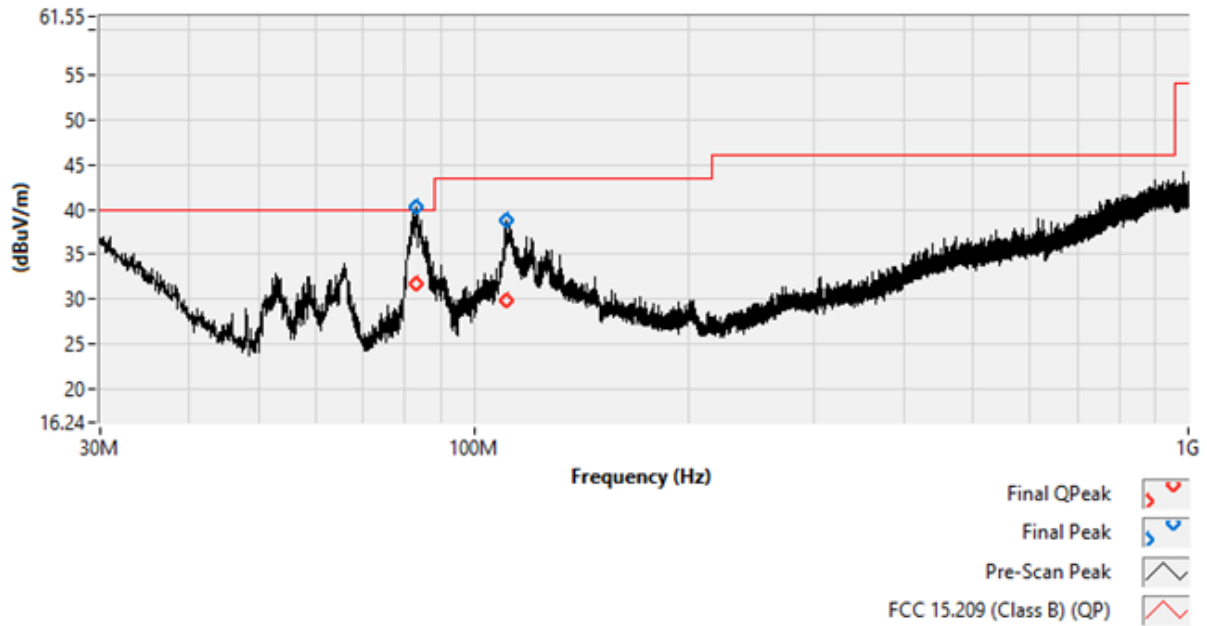
Table 13: Radiated Emissions Test Data, 2Mbps (2DH5) 30MHz to 1GHz

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Table (deg)	Antenna (cm)
30.60	Peak	39.058	--	--	220	Horiz, 190
	QP	32.029	40	-7.971	220	Horiz, 190
82.925	Peak	39.801	--	--	180	Horiz, 155
	QP	31.395	40	-8.605	180	Horiz, 155
83.10	Peak	40.209	--	--	180	Vert, 100
	QP	31.649	40	-8.351	180	Vert, 100
110.82	Peak	38.713	--	--	180	Vert, 100
	QP	29.899	43.5	-13.601	180	Vert, 100
858.228	Peak	43.52	--	--	180	Horiz, 155
	QP	36.157	46	-9.843	180	Horiz, 155
911.085	Peak	44.87	--	--	180	Horiz, 155
	QP	37.128	46	-8.872	180	Horiz, 155
922.004	Peak	45.493	--	--	180	Horiz, 155
	QP	37.709	46	-8.291	180	Horiz, 155

* please note that during this portion of the testing, the mechanical attenuation setting in the spectrum analyzer was unintentionally set to 20dB. This artificially inflated the noise floor. Nevertheless, the measurement system and the EUT unwanted emissions still passed. This note only applies to the frequency range of 30MHz to 1GHz and the 2Mbps EUT mode and explains the “visually close margins” of the plots provided on the following page.



2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Vertical)



2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Horizontal)

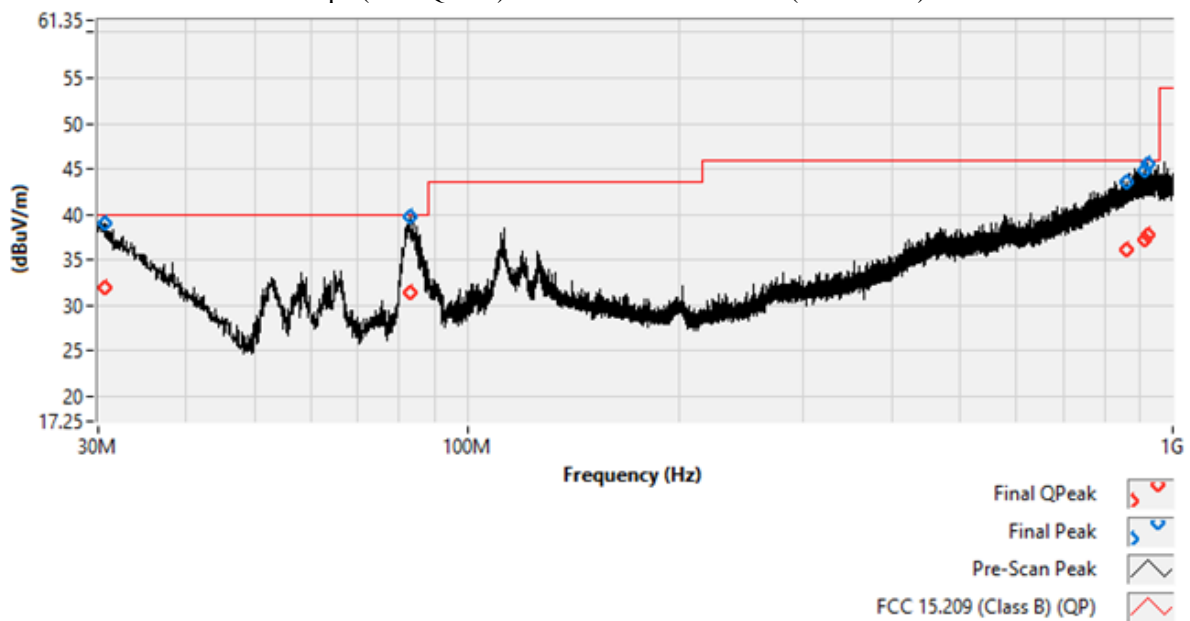




Table 14: Radiated Emissions Test Data, Low Channel, 2Mbps (2DH5)

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2390.0 ¹	Peak	47.009	74	-26.991	315	Vert, 165
	AVG	29.184	54	-24.816	315	Vert, 165
2402.0 ²	Peak	95.583	--	--	245	Horiz, 155
	AVG	74.456	--	--	315	Horiz, 165
7122.0	Peak	56.388	74	-17.612	245	Vert, 155
	AVG	42.194	54	-11.806	315	Vert, 165
9898.0 ³	Peak	60.62	74	-13.38	245	Vert, 155
	AVG	46.908	54	-7.092	315	Vert, 165
10294.0 ³	Peak	62.605	74	-11.395	245	Vert, 155
	AVG	47.256	54	-6.744	315	Vert, 165
11513.0 ³	Peak	63.179	74	-10.821	315	Horiz, 165
	AVG	49.012	54	-4.988	315	Horiz, 165

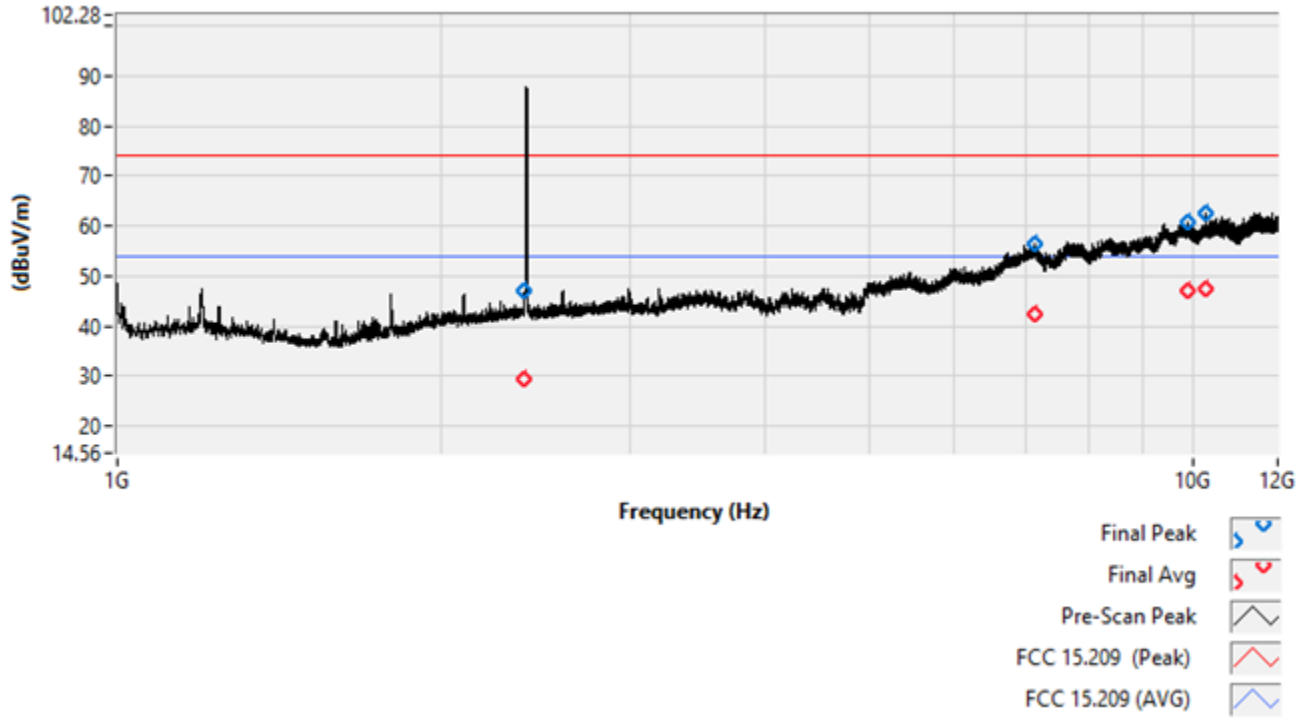
¹ Restricted BE

² Low Chan TX

³ Ambient



Low Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Vertical)



Low Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Horizontal)

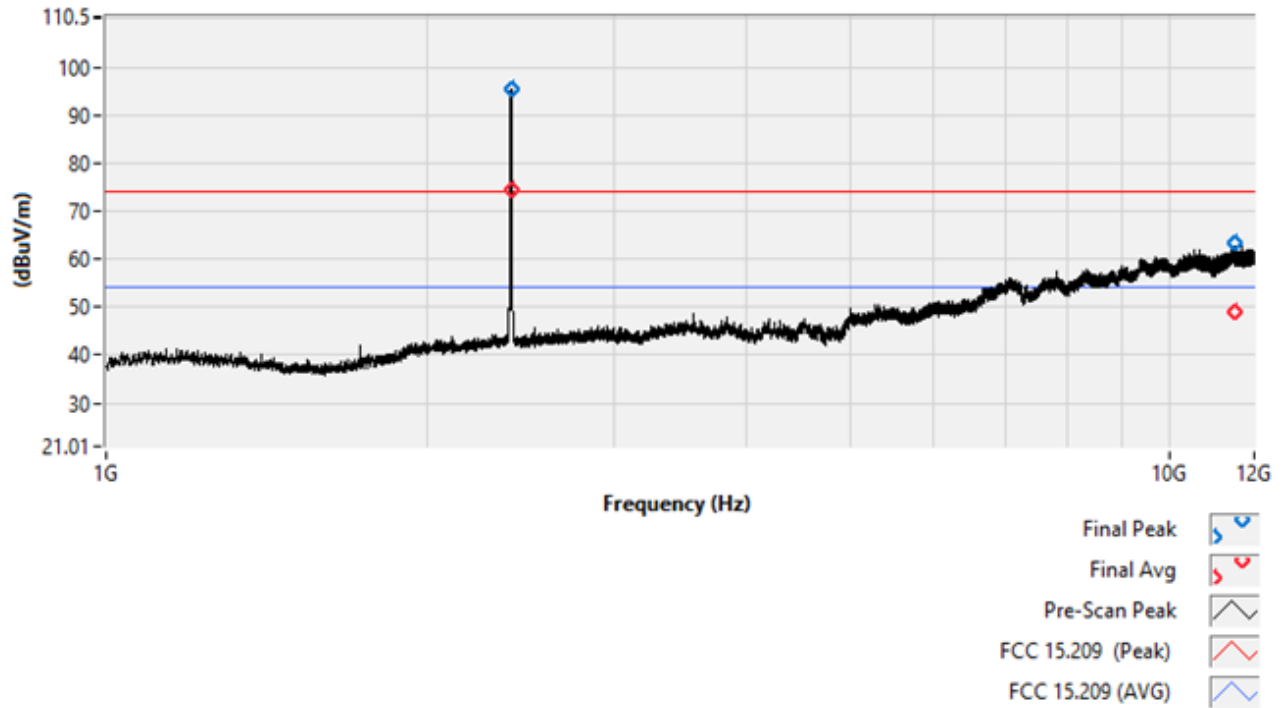
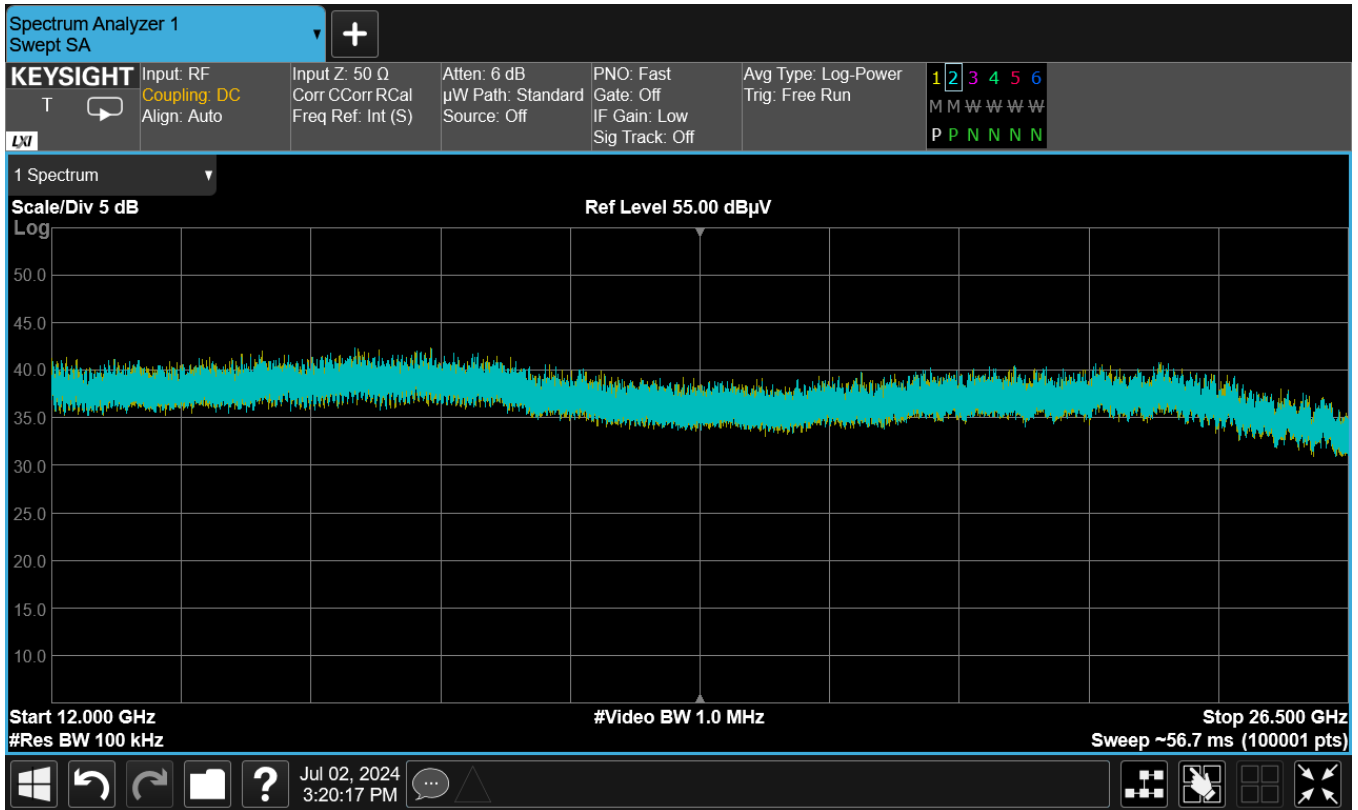




Figure 60: Radiated Emissions, Low Channel, 2Mbps, 2DH5, (12GHz to 26.5GHz)



- EUT emissions are not detected in this frequency range.
- Trace 1 = EUT Low Chan. TX On
- Trace 2 = Ambient



Table 15: Radiated Emissions Test Data, Center Channel, 2Mbps (2DH5)

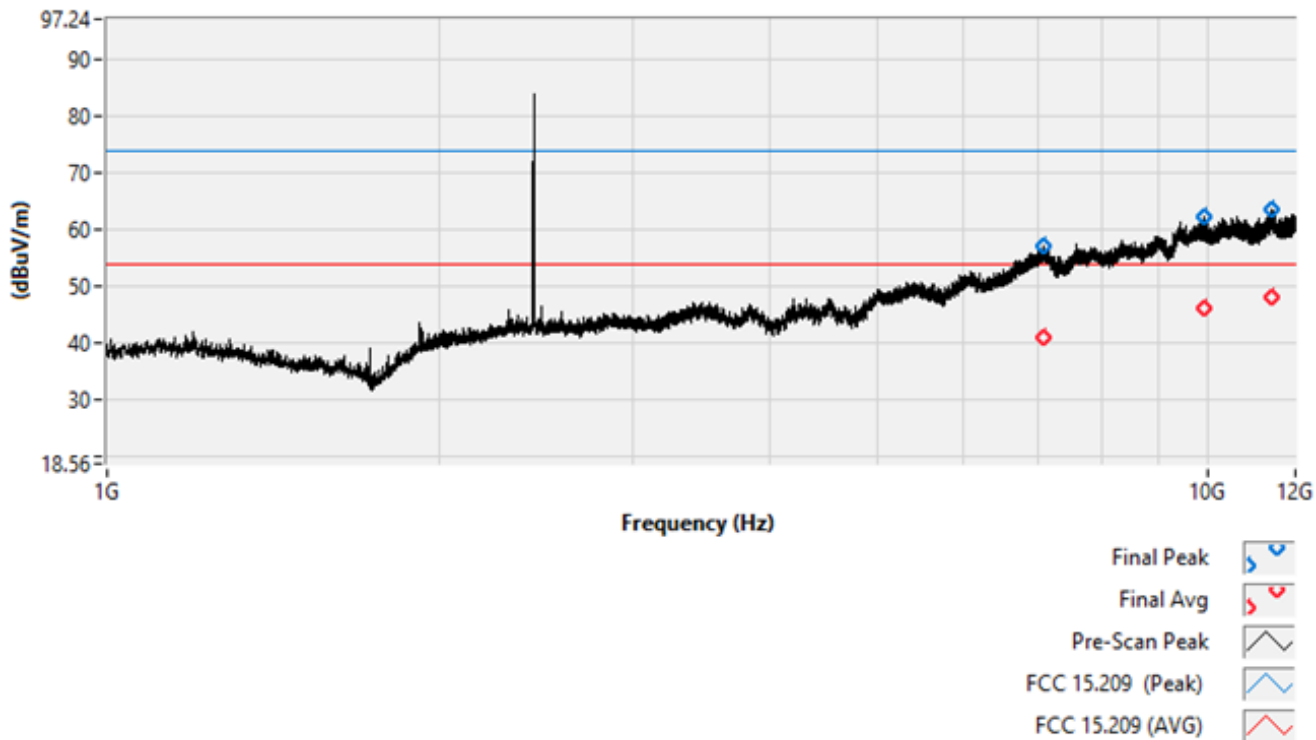
Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2440.0 ¹	Peak	90.191	--	--	180	Horiz, 175
	AVG	74.17	--	--	180	Horiz, 175
7086.0	Peak	57.082	74	-16.918	165	Vert, 160
	AVG	40.911	54	-13.089	165	Vert, 160
9899.0 ²	Peak	62.30	74	-11.70	165	Vert, 160
	AVG	46.244	54	-7.756	165	Vert, 160
11419.0 ²	Peak	63.69	74	-10.31	165	Vert, 160
	AVG	48.093	54	-5.907	165	Vert, 160

¹ Center Chan TX

² Ambient



Center Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Vertical)



Center Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Horizontal)

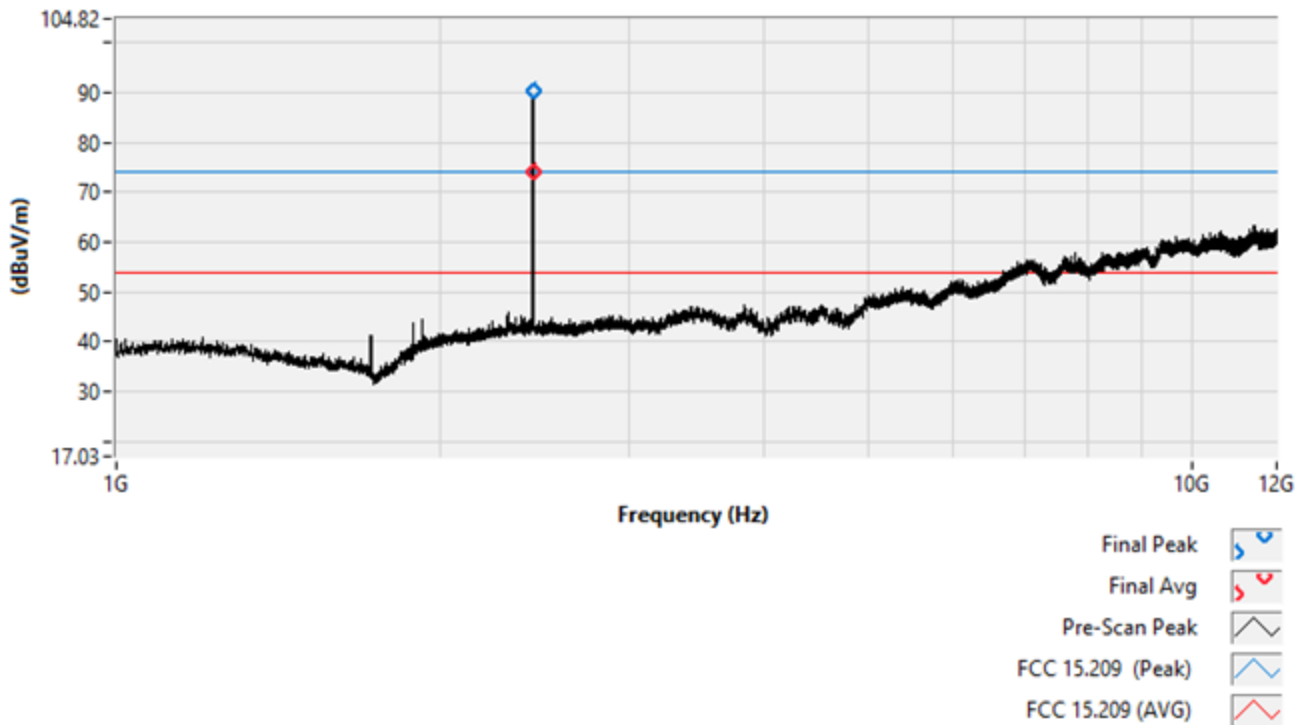
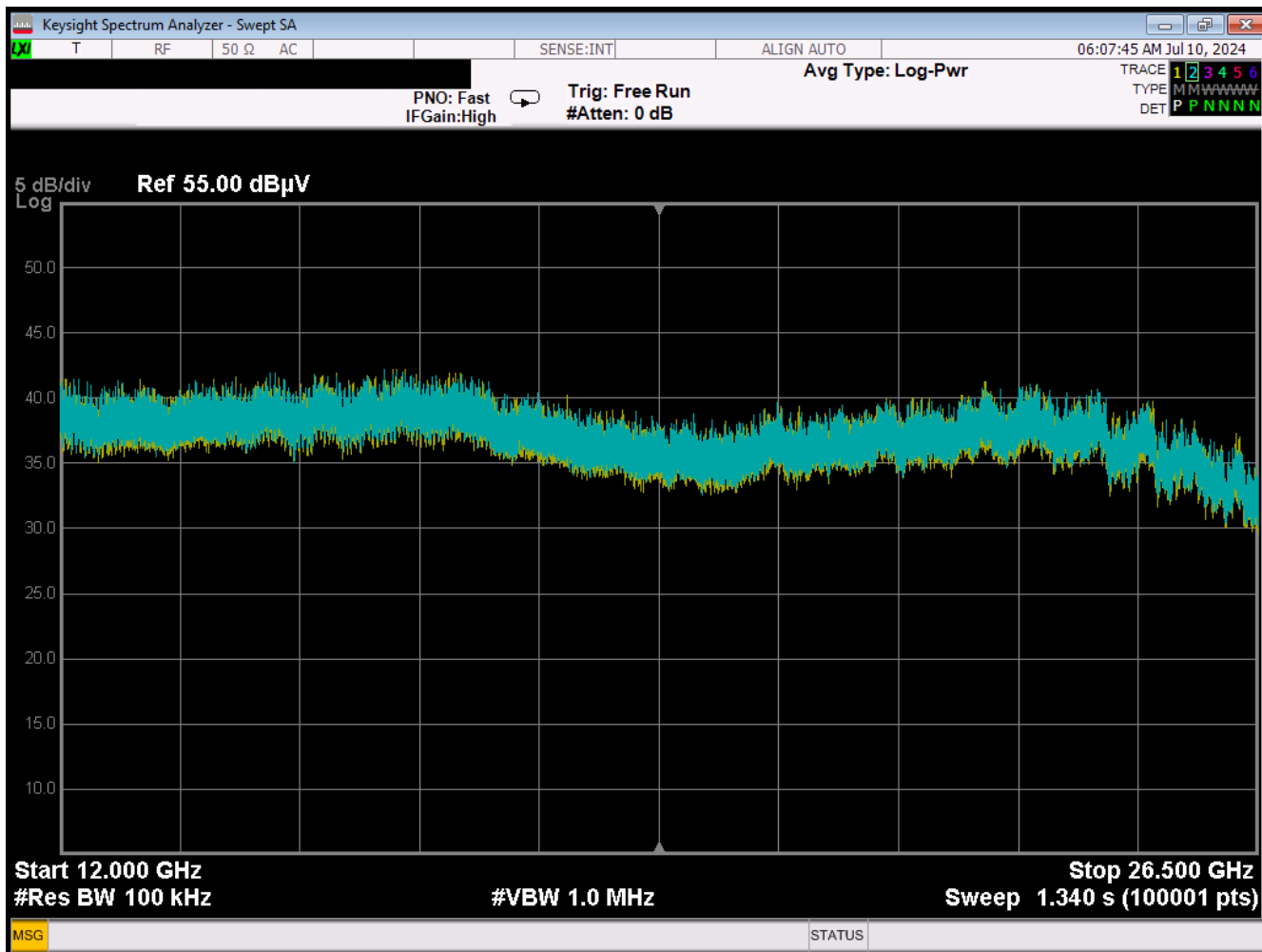




Figure 61: Radiated Emissions, Center Channel, 2Mbps, 2DH5, (12GHz to 26.5GHz)



- EUT emissions are not detected in this frequency range.
- Trace 1 = EUT Center Chan. TX On
- Trace 2 = Ambient



Table 16: Radiated Emissions Test Data, High Channel, 2Mbps (2DH5)

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
2480.0 ¹	Peak	91.935	--	--	165	Vert, 170
	AVG	74.411	--	--	165	Vert, 170
2483.5 ²	Peak	51.504	74	-22.496	165	Vert, 170
	AVG	31.17	54	-22.83	165	Vert, 170
6844.0	Peak	56.866	74	-17.134	165	Vert, 170
	AVG	39.199	54	-14.801	165	Vert, 170
11509.0 ³	Peak	63.78	74	-10.22	165	Vert, 170
	AVG	48.013	54	-5.987	165	Vert, 170

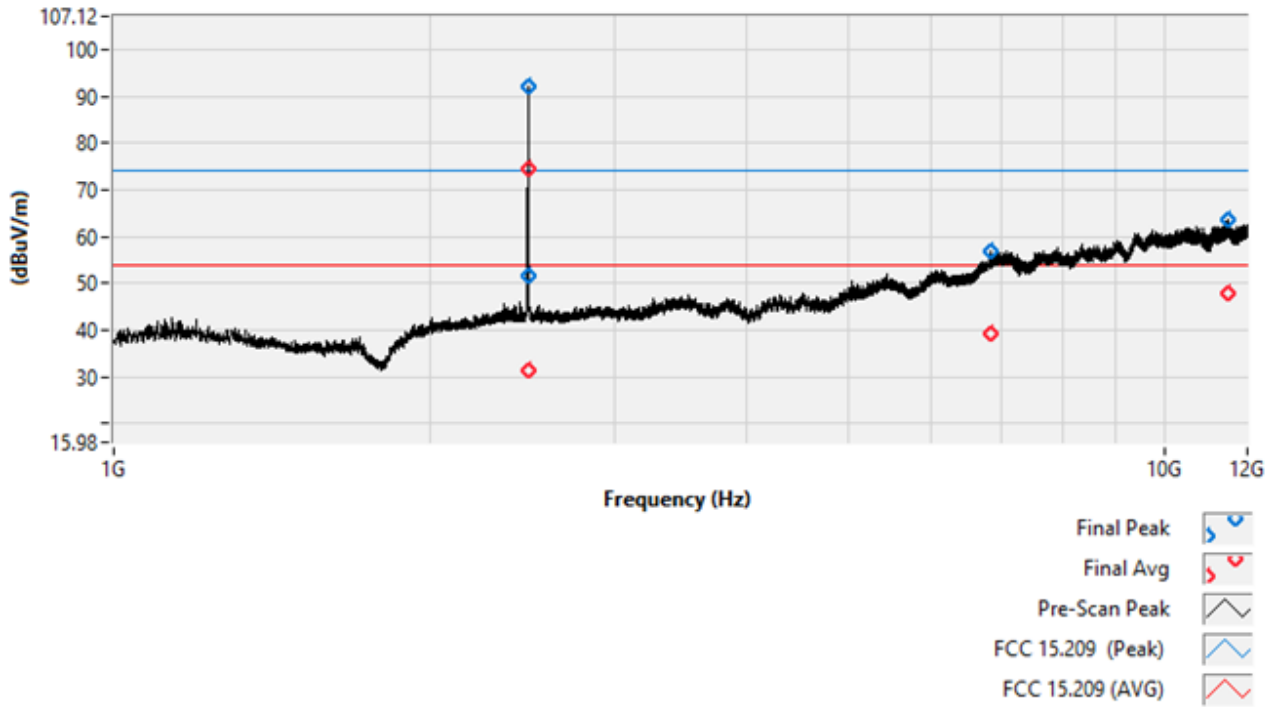
¹ High Chan TX

² Restricted BE

³ Ambient



High Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Vertical)



High Chan., 2Mbps ($\pi/4$ DQPSK) Pre-scan and Final Data (Horizontal)

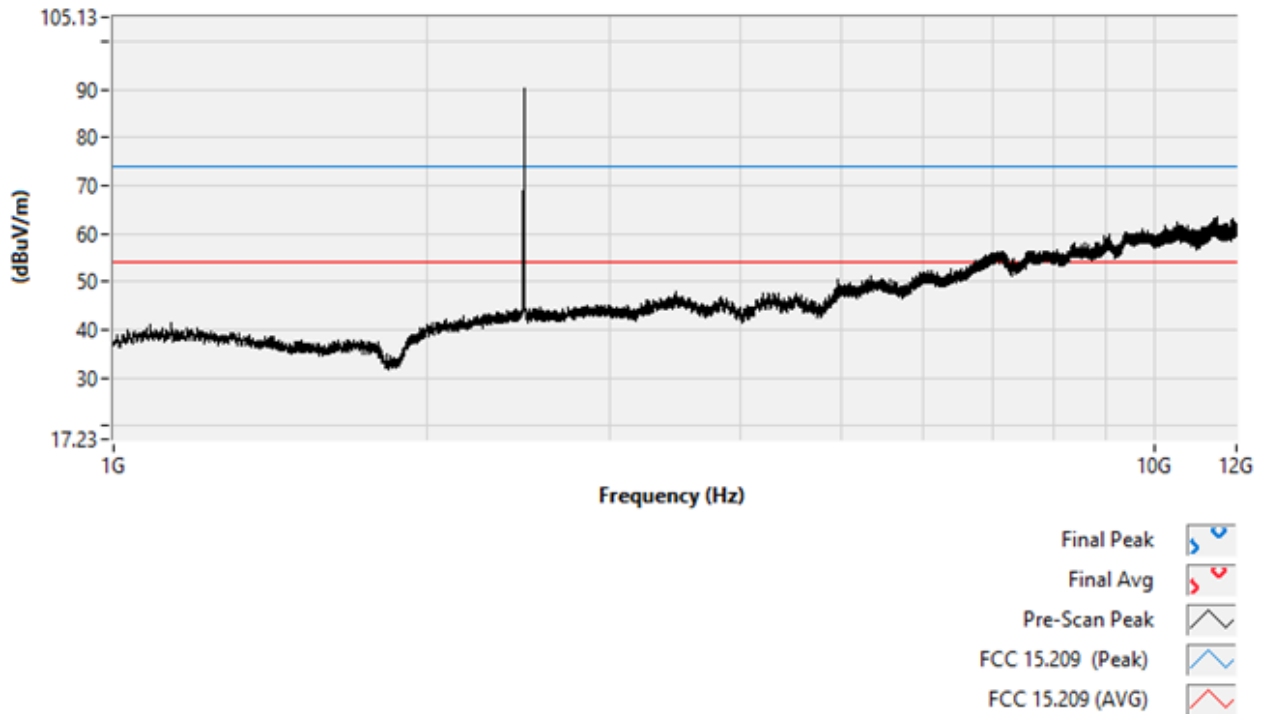
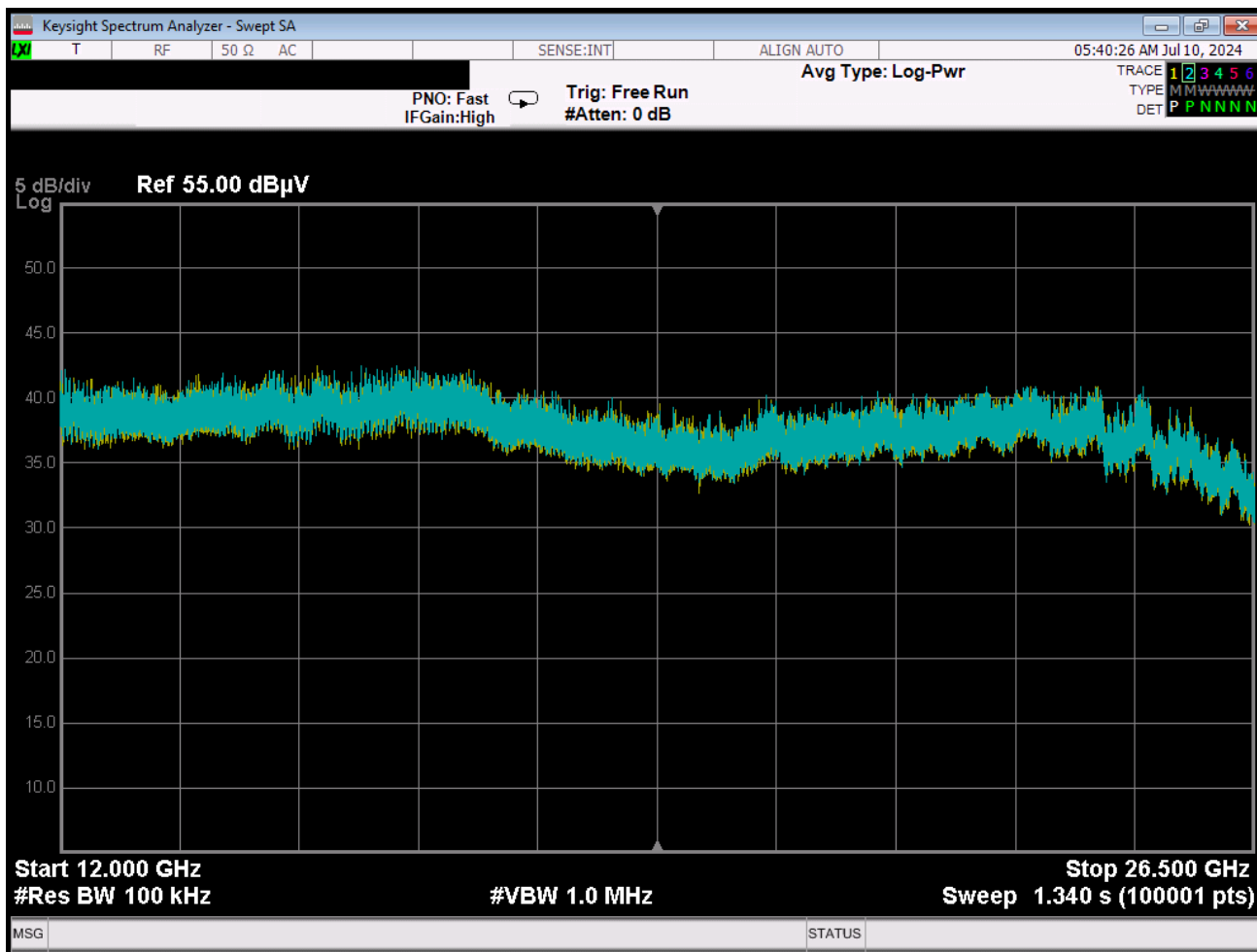




Figure 62: Radiated Emissions, High Channel, 2Mbps, 2DH5, (18GHz to 26.5GHz)



- EUT emissions are not detected in this frequency range.
- Trace 1 = EUT High Chan. TX On
- Trace 2 = Ambient



4 Test Equipment

The table below provides a list of the test equipment used for measurements along with the calibration information.

Table 17: Test Equipment List

Test Name: Radiated Emissions		Testing Dates: 6/17/2024 – 7/9/2024	
Asset #	Manufacturer/Model	Description	Cal. Due
00942	AGILENT, MXA	SPECTRUM ANALYZER	12/19/2024
00993 ¹	KEYSIGHT, MXA	SPECTRUM ANALYZER	11/6/2025
00382	SUNOL SCIENCES CORP.	ANTENNA, LOGPERIOD	6/12/2027
00004	ARA, DRG-118/A	ANTENNA, HORN	6/7/2027
00066	AGILENT	RF PRE-AMPLIFIER	3/29/2025
00065	ELECTRO-METRICS	RF PRE-AMPLIFIER	3/29/2025
00806	MINI-CIRCUITS, 3061	HF COAX CABLE, SMA	12/26/2024
00825	CABLE ASSOCIATES, MTC10	6-METER COAX CABLE, SMA	6/14/2025
00847	ASTROLABS, K-48TG	HF COAX CABLE, SMA	6/14/2025
00731	NARDA, 4779-3	2W, 3DB ATTENUATOR	6/20/2025

¹ the N9020B, MXA has the following instrument software version installed: A.33.03 (2023)



Test Equipment List, Continued

Test Name: Conducted RF Emissions		Testing Dates: 6/17/2024 – 7/9/2024	
Asset #	Manufacturer/Model	Description	Cal. Due
00993 ¹	KEYSIGHT, MXA	SPECTRUM ANALYZER	11/6/2025
00992	KEYSIGHT N5173B	EXG SIGNAL GENERATOR	11/24/2024
00885	ULTIFLEX, UFA2108-0-360	1-METER SMA CABLE	6/25/2025
N/A	WEINSCHTEL, 3.5MM	20DB ATTENUATOR	Cal. Before Use

¹ the N9020B, MXA has the following instrument software version installed: A.33.03 (2023)



5 Measurements

5.1.1 References

ANSI C63.2 (1/2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (1/2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.10 (9/2020) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

5.2 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSS Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1. to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm \sqrt{\frac{a^2}{div_a^2} + \frac{b^2}{div_b^2} + \frac{c^2}{div_c^2} + \dots}$$

where,

- uc = standard uncertainty
- a, b, c,.. = individual uncertainty elements
- Div_a, Div_b, Div_c = the individual uncertainty element divisor based on the probability distribution
- Divisor = 1.732 for rectangular distribution
- Divisor = 2 for normal distribution
- Divisor = 1.414 for trapezoid distribution



Equation 2: Expanded Uncertainty

$$U = ku_c$$

where,

- U = expanded uncertainty
- k = coverage factor
- k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)
- uc = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in the table below.

Table 18: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR32, CISPR14, FCC Part 15	± 2.63 dB
Radiated Emissions	CISPR11, CISPR32, CISPR14, FCC Part 15	± 4.55 dB

5.3 Environmental Conditions

Environmental Conditions During All Measurements

Ambient Temperature:	Between 19.9 and 23.9 °C
Relative Humidity:	Between 45 and 60 %