TEST REPORT

FCC ID: 2ADYY-TU01AIR-R

Product: TWS Earphone

Model No.: TU01 Air

Trade Mark: TECNO

Report No.: WSCT-ANAB-R&E240800039A-BT

Issued Date: 28 August 2024

Issued for:

TECNO MOBILE LIMITED
FLAT N 16/F BLOCK B UNIVERSAL INDUSTRIAL CENTRE 19-25 SHAN MEI STREET FOTAN NT HONGKONG

Issued By:

World Standardization Certification & Testing Group(Shenzhen) Co.,Ltd.
Building A-B,Baoli'an Industrial Park,No.58 and 60,Tangtou Avenue, Shiyan Street, Bao'an District, Shenzhen City, Guangdong Province, China
TEL: +86-755-26996192
FAX: +86-755-86376605

TABLE OF CONTENTS

1. Test Certification

Product:	TWS Earphone
Model No.:	TU01 Air
Trade Mark:	TECNO
Applicant:	**TECNO MOBILE LIMITED** FLAT N 16/F BLOCK B UNIVERSAL INDUSTRIAL CENTRE 19-25 SHAN MEI STREET FOTAN NT HONGKONG
Manufacturer:	**TECNO MOBILE LIMITED** FLAT N 16/F BLOCK B UNIVERSAL INDUSTRIAL CENTRE 19-25 SHAN MEI STREET FOTAN NT HONGKONG
Date of Test:	15 August 2024 to 28 August 2024
Applicable Standards:	FCC CFR Title 47 Part 15 Subpart C Section 15.247

The above equipment has been tested by World Standardization Certification & Testing Group(Shenzhen)Co., Ltd. and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product/system, which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Tested By: Wang Xiang **(Wang Xiang)**

Checked By: Chen Xu **(Chen Xu)**

Approved By: Li Huaibi **(Li Huaibi)**

Date: 28 August 2024

2. Test Result Summary

Requirement	CFR 47 Section	Result
Antenna Requirement	§15.203/§15.247 (c)	PASS
AC Power Line Conducted Emission	§15.207	NA
Conducted Peak Output Power	§15.247 (b)(1) §2.1046	PASS
20dB Occupied Bandwidth	§15.247 (a)(1) §2.1049	PASS
Carrier Frequencies Separation	§15.247 (a)(1)	PASS
Hopping Channel Number	§15.247 (a)(1)	PASS
Dwell Time	§15.247 (a)(1)	PASS
Radiated Emission	§15.205/§15.209 §2.1053, §2.1057	PASS
Band Edge	§15.247(d) §2.1051, §2.1057	PASS

Note:

1. PASS: Test item meets the requirement.

2. Fail: Test item does not meet the requirement.

3. N/A: Test case does not apply to the test object.

4. The test result judgment is decided by the limit of test standard.

3. EUT Description

Product Name:	TWS Earphone
Model :	TU01 Air
Trade Mark:	TECNO
Operation Frequency:	2402MHz~2480MHz
Channel Separation:	1MHz
Number of Channel:	79
Modulation Type:	GFSK, π/4-DQPSK, 8-DPSK
Modulation Technology:	FHSS
Antenna Type:	PIFA Antenna
Antenna Gain:	-0.78dBi
Operating Voltage	Rechargeable Li-ion Battery: 14340SK Rated Capacity: 840mAh Nominal Voltage: 3.87V Rated Energy:3.26Wh Limited Charge Voltage: 4.45V Rechargeable Li-ion Battery: CP1154AA Nominal Voltage: 3.70V Rated Energy: 0.204Wh Rated Capacity: 55mAh Limited Charge Voltage: 4.20V
Remark:	N/A.

Operation Frequency each of channel for GFSK, π/4-DQPSK, 8DPSK

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	2402MHz	20	2422MHz	40	2442MHz	60	2462MHz
1	2403MHz	21	2423MHz	41	2443MHz	61	2463MHz
…	…	…	…	…	…	…	…
10	2412MHz	30	2432MHz	50	2452MHz	70	2472MHz
11	2413MHz	31	2433MHz	51	2453MHz	71	2473MHz
…	…	…	…	…	…	…	…
18	2420MHz	38	2440MHz	58	2460MHz	78	2480MHz
19	2421MHz	39	2441MHz	59	2461MHz		-
Remark: Channel 0, 39 &78 have been tested for GFSK, π/4-DQPSK, 8DPSK modulation mode.							

4. Genera Information

4.1. Test environment and mode

Operating Environment:	
Temperature:	25.0 °C
Humidity:	56 % RH
Atmospheric Pressure:	1010 mbar
Test Mode:	
Engineering mode:	Keep the EUT in continuous transmitting by select channel and modulations with Fully-charged battery
The sample was placed 0.8m & 1.5m for the measurement below & above 1GHz above the ground plane of 3m chamber. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating the turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages.	

4.2. Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Equipment	Model No.	Serial No.	FCC ID	Trade Name
Adapter	XCU32	/	/	/

Note:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.

2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

3. For conducted measurements (Output Power, 20dB Occupied Bandwidth, Carrier Frequencies Separation, Hopping Channel Number, Dwell Time, Spurious Emissions), the antenna of EUT is connected to the test equipment via temporary antenna connector, the antenna connector is soldered on the antenna port of EUT, and the temporary antenna connector is listed in the Test Instruments.

5. Facilities and Accreditations

5.1. Facilities

All measurement facilities used to collect the measurement data are located at
World Standardization Certification & Testing Group (Shenzhen) Co., Ltd.
Building A-B,Baoli'an Industrial Park,No.58 and 60,Tangtou Avenue, Shiyan Street, Bao'an District, Shenzhen City, Guangdong Province, China

The sites are constructed in conformance with the requirements of ANSI C63.4 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

5.2. ACCREDITATIONS

ANAB - Certificate Number: AT-3951

The EMC Laboratory has been accredited by the American Association for Laboratory Accreditation (ANAB).Certification Number: AT-3951

5.3. Measurement Uncertainty

The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95 %.

No.	Item	MU
1	Conducted Emission Test	±3.2dB
2	RF power, conducted	±0.16dB
3	Spurious emissions, conducted	±0.21dB
4	All emissions, radiated(<1GHz)	±4.7dB
5	All emissions, radiated(>1GHz)	±4.7dB
6	Temperature	±0.5°C
7	Humidity	±2.0%

5.4. MEASUREMENT INSTRUMENTS

NAME OF EQUIPMENT	MANUFACTURER	MODEL	SERIAL NUMBER	Calibration Date	Calibration Due.
Test software	--	EZ-EMC	CON-03A	-	-
Test software	--	MTS8310	-	-	-
EMI Test Receiver	R&S	ESCI	100005	11/05/2023	11/04/2024
LISN	AFJ	LS16	16010222119	11/05/2023	11/04/2024
LISN(EUT)	Mestec	AN3016	04/10040	11/05/2023	11/04/2024
Universal Radio Communication Tester	R&S	CMU 200	1100.0008.02	11/05/2023	11/04/2024
Coaxial cable	Megalon	LMR400	N/A	11/05/2023	11/04/2024
GPIB cable	Megalon	GPIB	N/A	11/05/2023	11/04/2024
Spectrum Analyzer	R&S	FSU	100114	11/05/2023	11/04/2024
Pre Amplifier	H.P.	HP8447E	2945A02715	11/05/2023	11/04/2024
Pre-Amplifier	CDSI	PAP-1G18-38	--	11/05/2023	11/04/2024
Bi-log Antenna	SCHWARZBECK	VULB9168	01488	11/05/2023	11/04/2024
9*6*6 Anechoic	--	--	--	11/05/2023	11/04/2024
Horn Antenna	COMPLIANCE ENGINEERING	CE18000	--	11/05/2023	11/04/2024
Horn Antenna	SCHWARZBECK	BBHA9120D	9120D-631	11/05/2023	11/04/2024
Cable	TIME MICROWAVE	LMR-400	N-TYPE04	11/05/2023	11/04/2024
System-Controller	CCS	N/A	N/A	N.C.R	N.C.R
Turn Table	CCS	N/A	N/A	N.C.R	N.C.R
Antenna Tower	CCS	N/A	N/A	N.C.R	N.C.R
RF cable	Murata	MXHQ87WA3000	-	11/05/2023	11/04/2024
Loop Antenna	EMCO	6502	00042960	11/05/2023	11/04/2024
Horn Antenna	SCHWARZBECK	BBHA 9170	1123	11/05/2023	11/04/2024
Power meter	Anritsu	ML2487A	6K00003613	11/05/2023	11/04/2024
Power sensor	Anritsu	MX248XD	--	11/05/2023	11/04/2024
Spectrum Analyzer	Keysight	N9010B	MY60241089	11/05/2023	11/04/2024

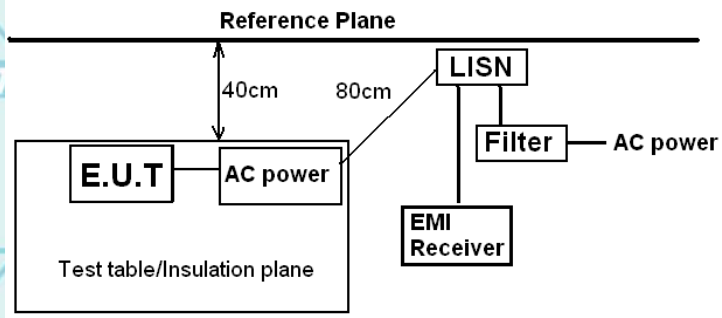
6. Test Results and Measurement Data

6.1. Antenna requirement

Standard requirement:	FCC Part15 C Section 15.203 /247(c)
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. 15.247(c) (1)(i) requirement: (i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.	
E.U.T Antenna:	
The Bluetooth antenna is a PIFA Antenna. it meets the standards, and the best case gain of the antenna is -0.78dBi.	
Please refer to the attachment "TU01 Air(R) Internal Photo" for the antenna location	

6.2. Conducted Emission

6.2.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.207
Test Method:	ANSI C63.10:2014
Frequency Range:	150 kHz to 30 MHz
Receiver setup:	RBW=9 kHz, VBW=30 kHz, Sweep time=auto
Limits:	Frequency range (MHz) / Limit (dBuV): Quasi-peak / Average 0.15-0.5: 66 to 56* / 56 to 46* 0.5-5: 56 / 46 5-30: 60 / 50
Test Setup:	 *Remark:* *E.U.T: Equipment Under Test* *LISN: Line Impedence Stabilization Network* *Test table height=0.8m*
Test Mode:	Refer to item 4.1
Test Procedure:	1. The E.U.T is connected to an adapter through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm/50uH coupling impedance for the measuring equipment. 2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs). 3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10:2014 on conducted measurement.
Test Result:	NA

6.2.2. EUT OPERATING CONDITIONS

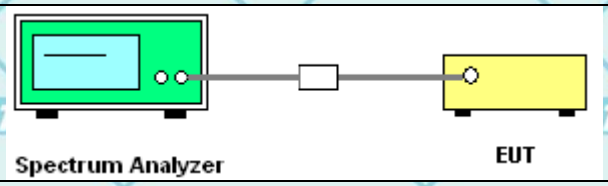
The EUT is working in the Normal link mode. All modes have been tested and normal link mode is worst.
Devices subject to Part 15 must be tested for all available U.S. voltages and frequencies (such as a nominal 120 VAC, 60 Hz and 240 VAC, 50 Hz) for which the device is capable of operation. So, The configuration 120 VAC, 60 Hz and 240 VAC, 50 Hz were tested respectively, but only the worst configuration (120 VAC, 60 Hz) shown here.

Test data:

Note: EUT is powered by batteries and cannot transmit normally while charging. This project does not require testing

6.3. Conducted Output Power

6.3.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (b)(3)
Test Method:	ANSI C63.10:2014
Limit:	Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following: (1) 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. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	Use the following spectrum analyzer settings: Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel RBW > the 20 dB bandwidth of the emission being measured VBW ≥ RBW Sweep = auto Detector function = peak Trace = max hold Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission.
Test Result:	PASS

6.3.2. Test Data

GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	6.50	20.97	PASS
Middle	6.67	20.97	PASS
Highest	6.39	20.97	PASS

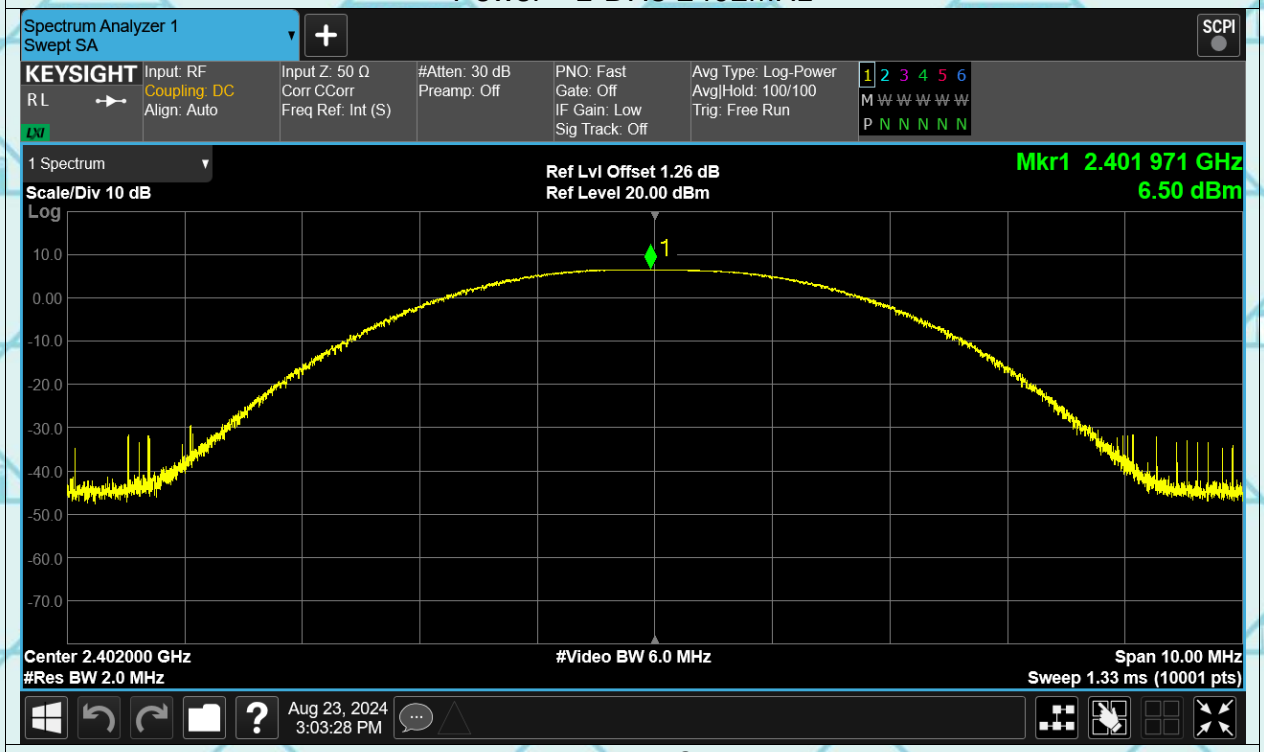
Pi/4DQPSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	6.91	20.97	PASS
Middle	6.95	20.97	PASS
Highest	6.69	20.97	PASS

8DPSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	6.88	20.97	PASS
Middle	6.94	20.97	PASS
Highest	6.65	20.97	PASS

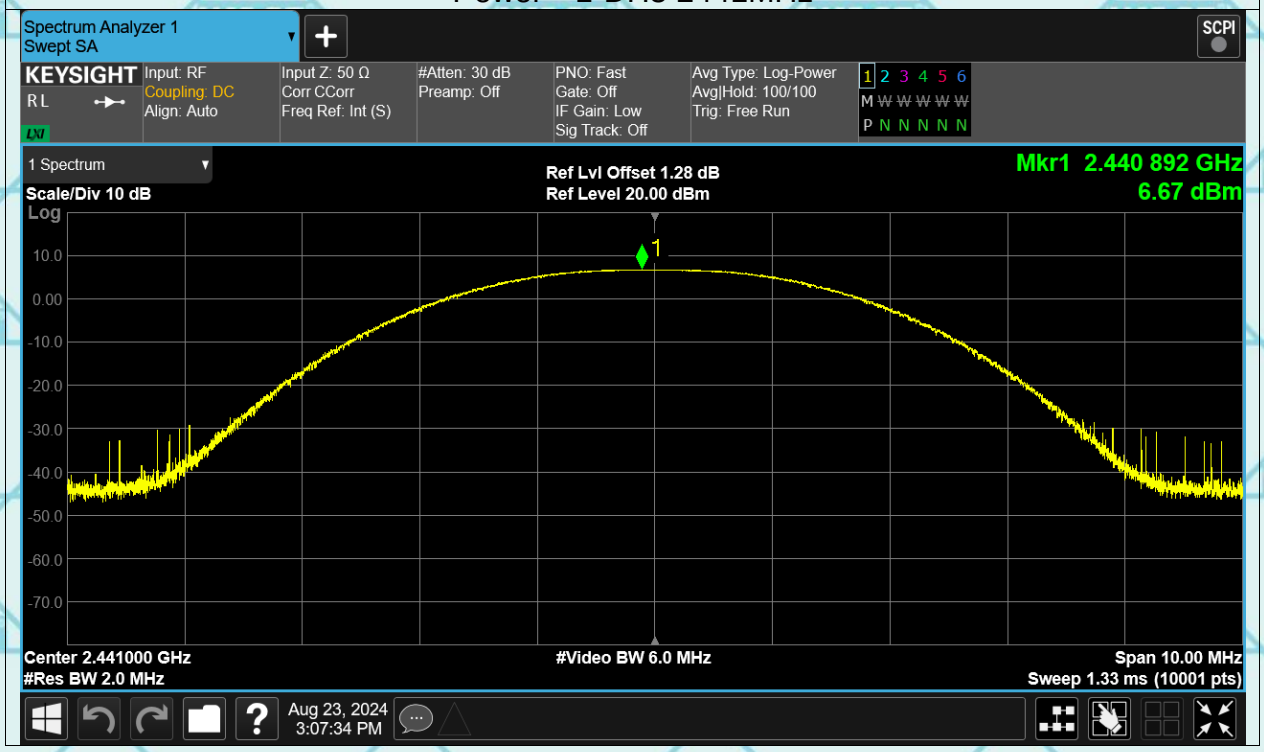
Test plots as follows:

Test Graphs

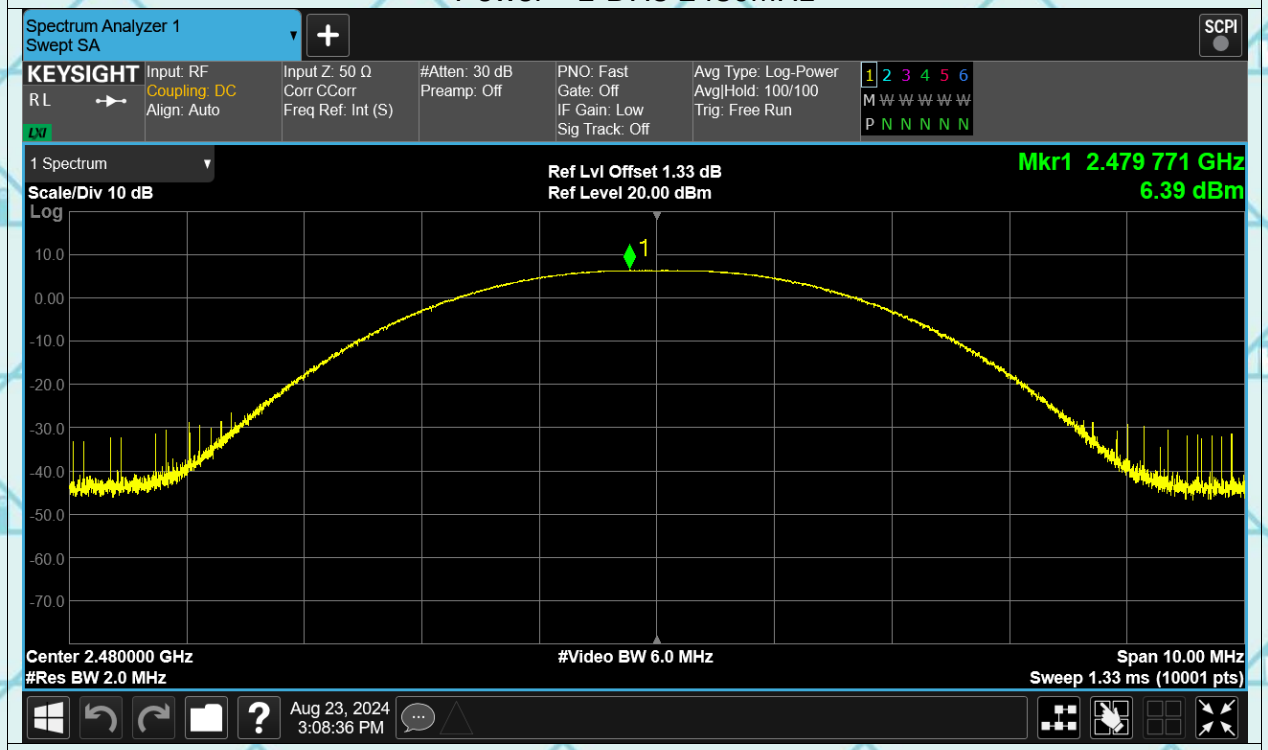
Power 1-DH5 2402MHz



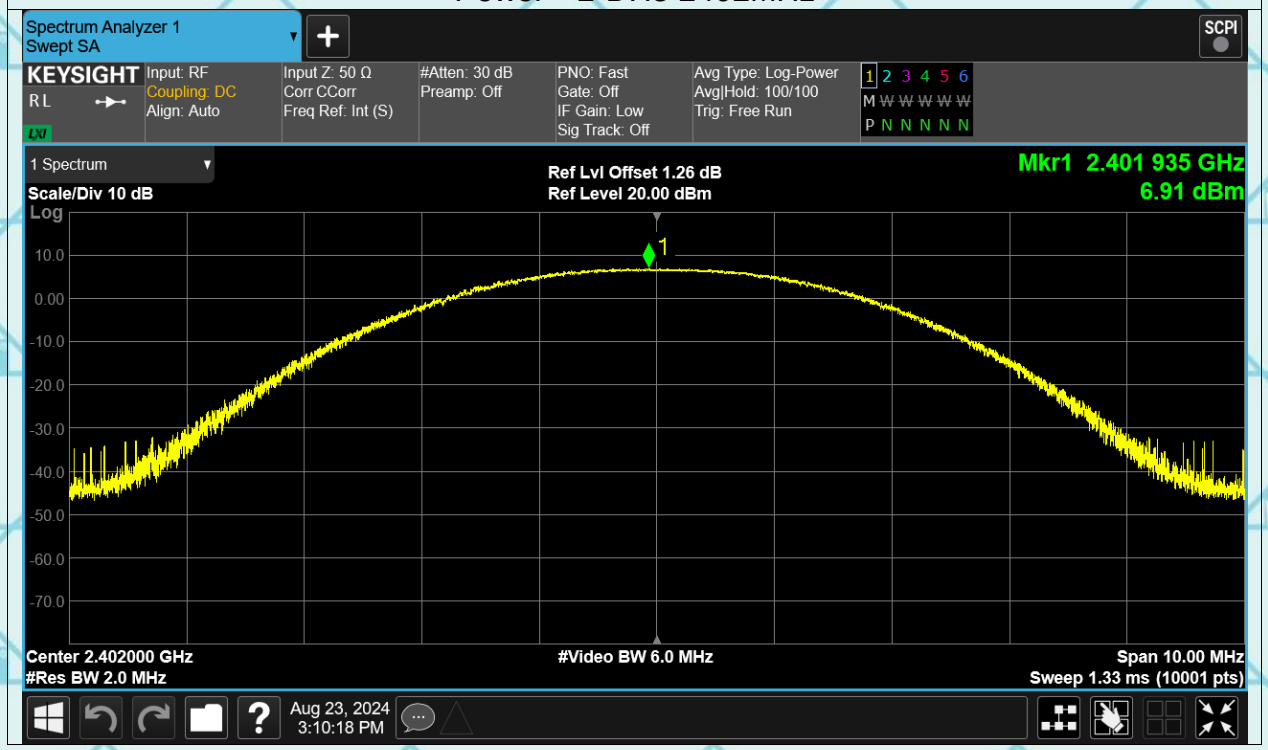
Power 1-DH5 2441MHz



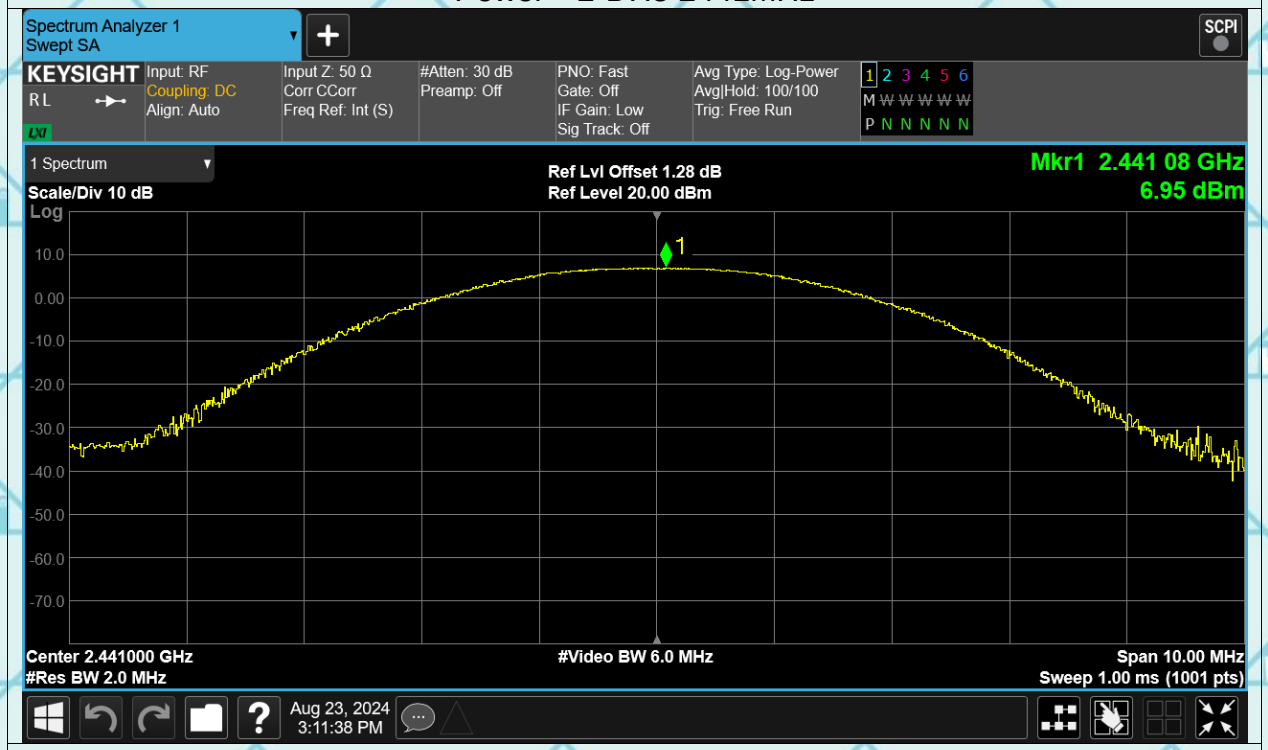
Power 1-DH5 2480MHz



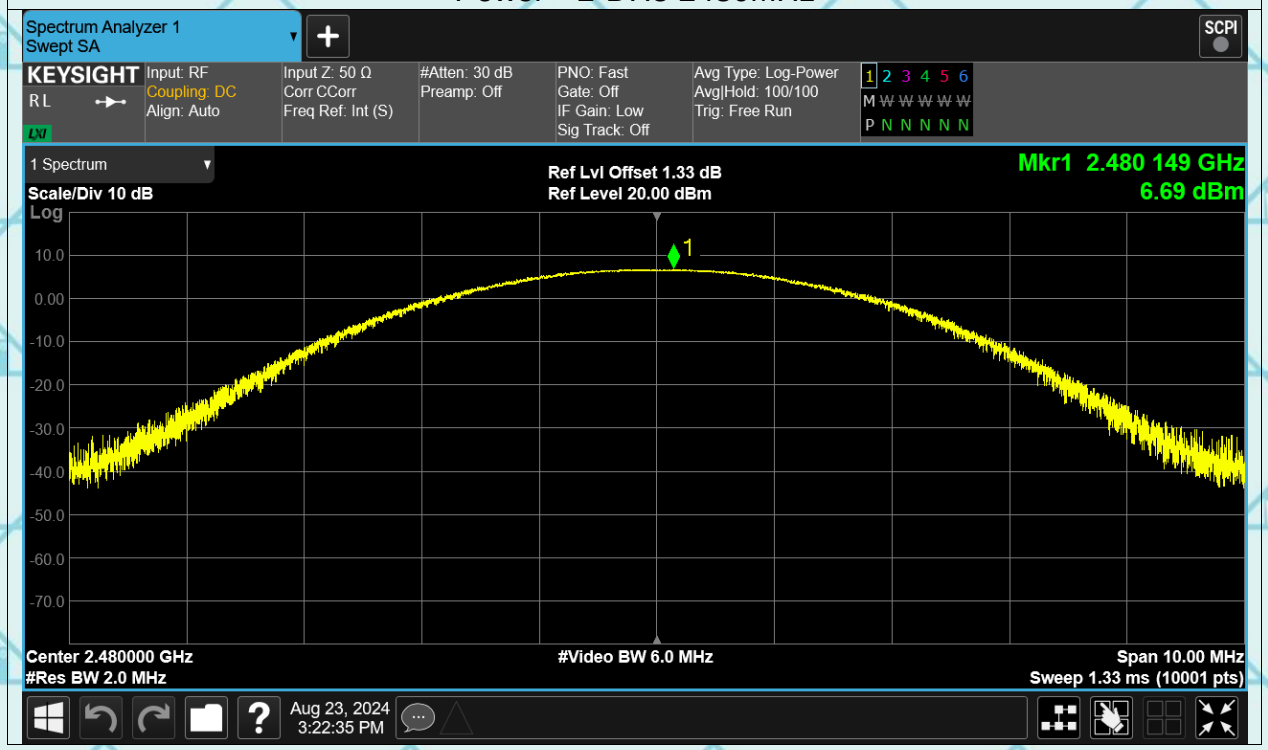
Power 2-DH5 2402MHz



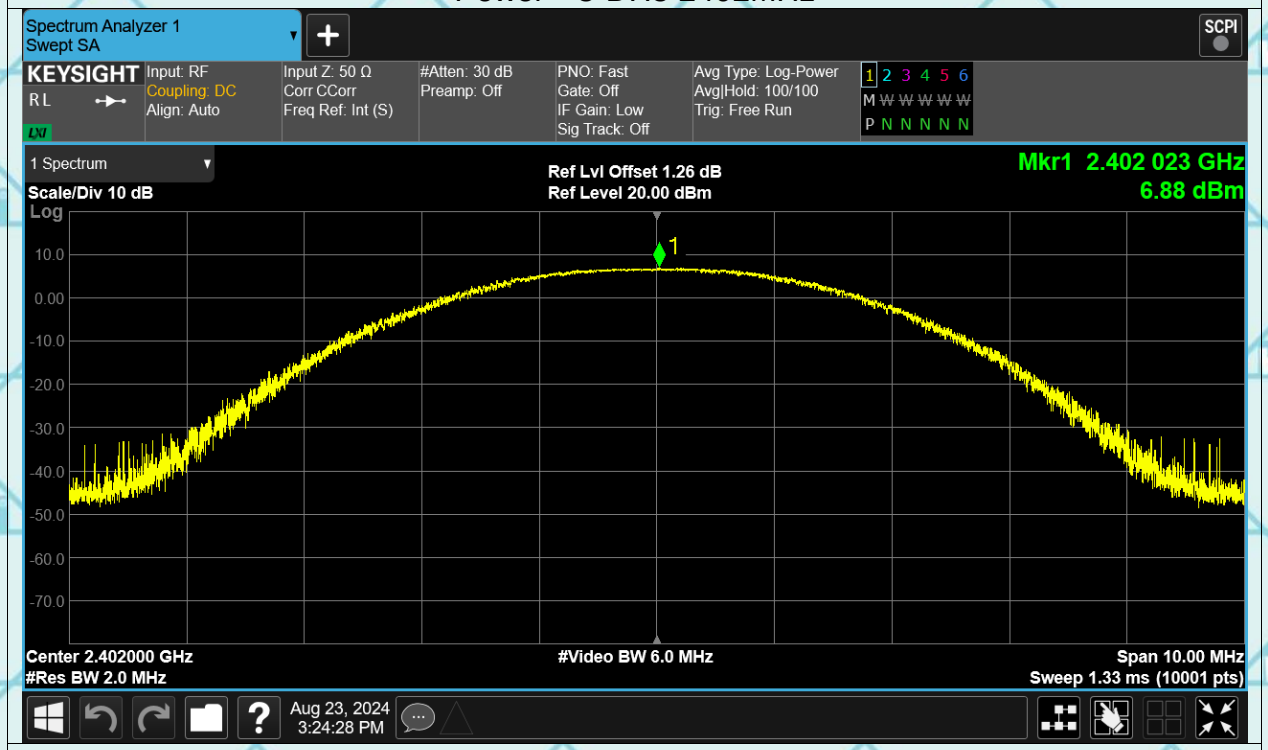
Power 2-DH5 2441MHz



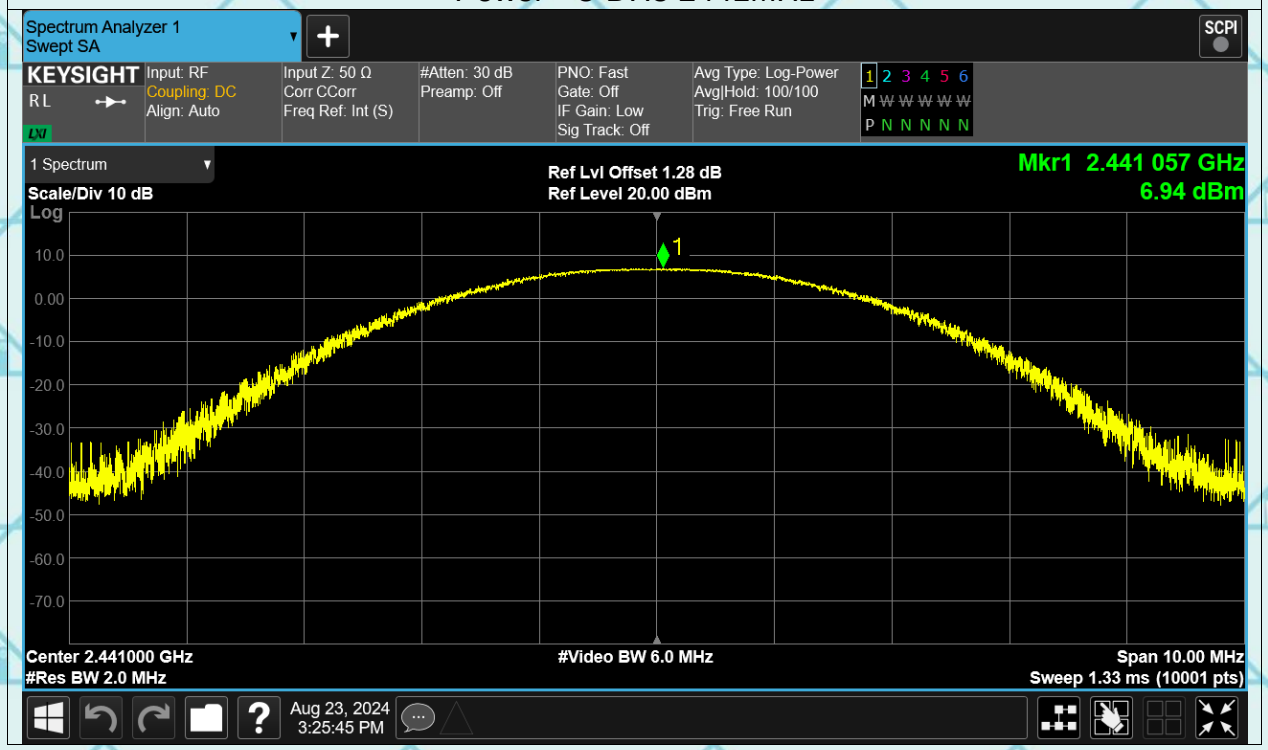
Power 2-DH5 2480MHz



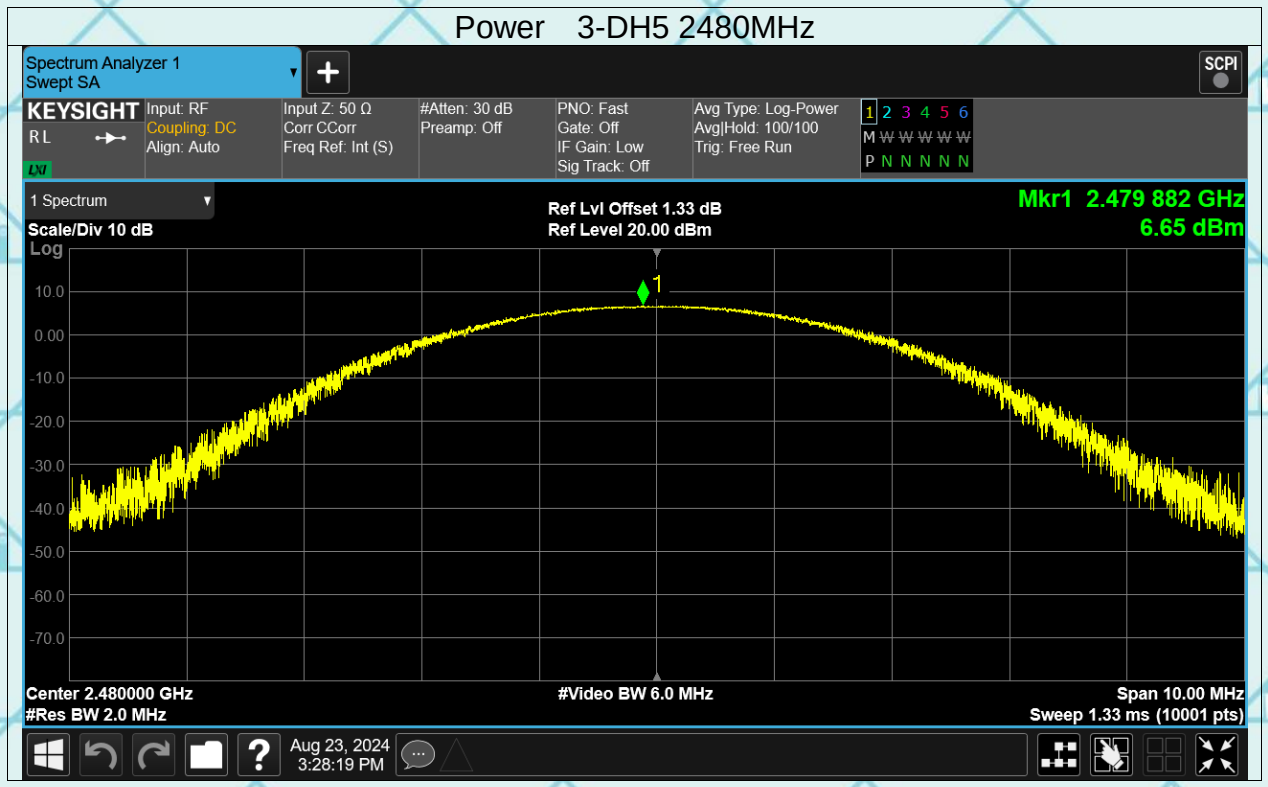
Power 3-DH5 2402MHz



Power 3-DH5 2441MHz

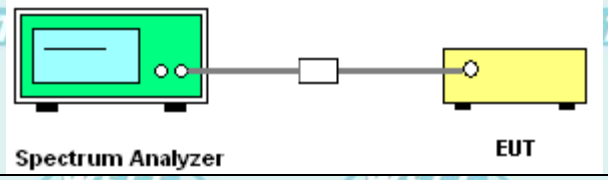


Power 3-DH5 2480MHz



6.4. 20dB Occupy Bandwidth

6.4.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2014
Limit:	N/A
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows ANSI C63.10:2014 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement. Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel; 1%≤ RBW≤5% of the 20 dB bandwidth; VBW≥3RBW; Sweep = auto; Detector function = peak; Trace = max hold. 5. Measure and record the results in the test report.
Test Result:	PASS

6.4.2. Test data

Test channel	-20dB Occupy Bandwidth (MHz)			
	GFSK	π/4-DQPSK	8DPSK	Conclusion
Lowest	1.089	1.386	1.360	PASS
Middle	1.045	1.402	1.340	PASS
Highest	1.027	1.376	1.351	PASS

Test plots as follows:

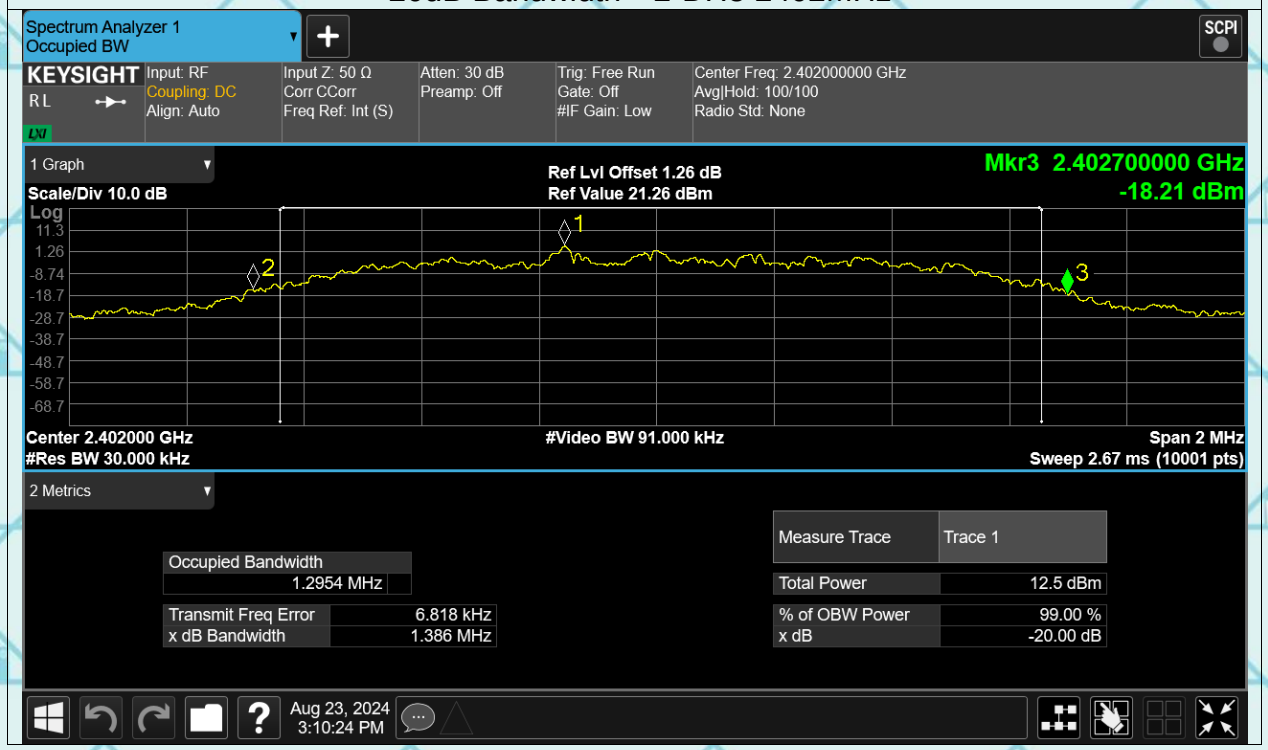
Test Graphs

-20dB Bandwidth 1-DH5 2402MHz

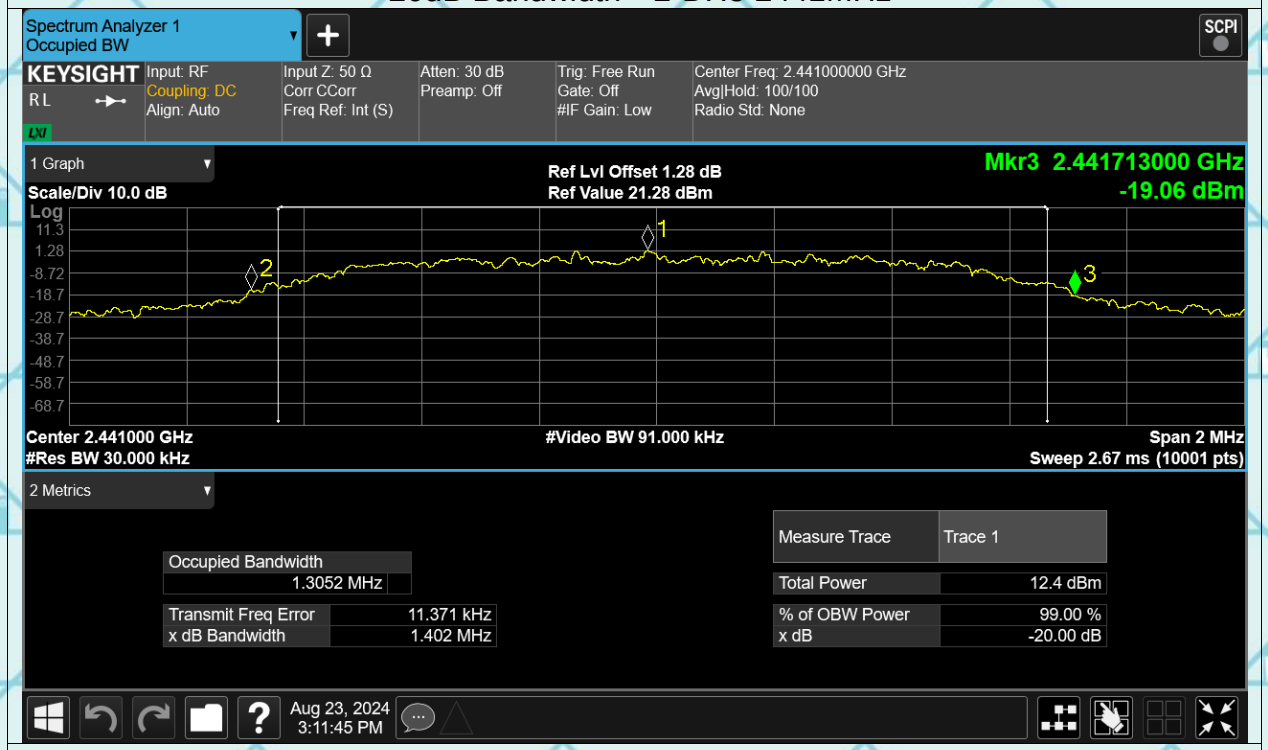
-20dB Bandwidth 1-DH5 2441MHz

-20dB Bandwidth 1-DH5 2480MHz

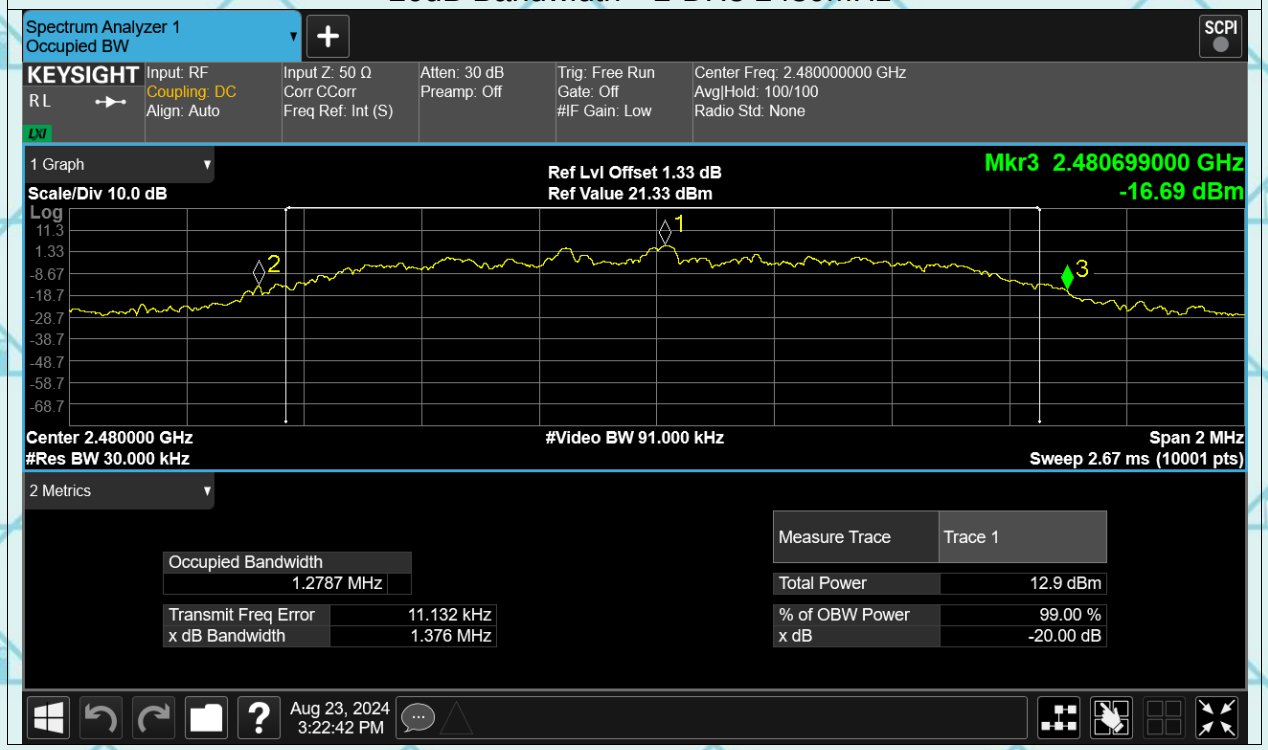
-20dB Bandwidth 2-DH5 2402MHz



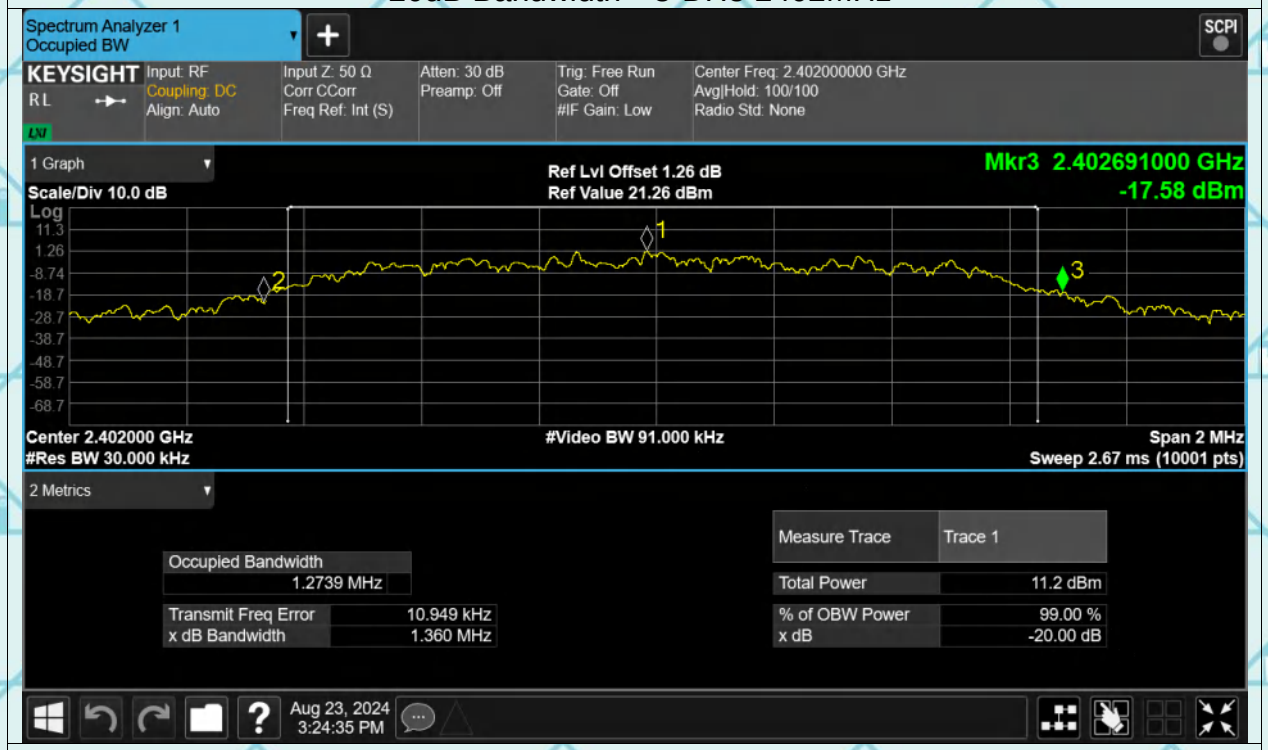
-20dB Bandwidth 2-DH5 2441MHz



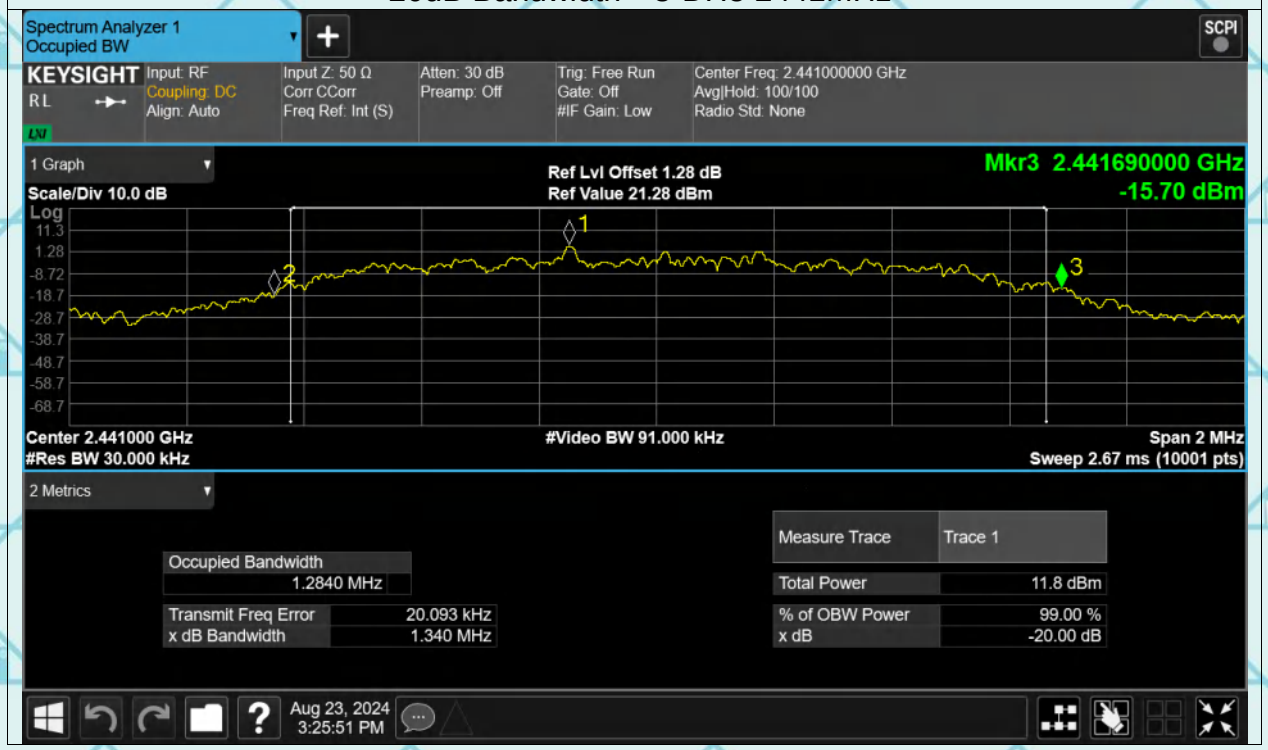
-20dB Bandwidth 2-DH5 2480MHz



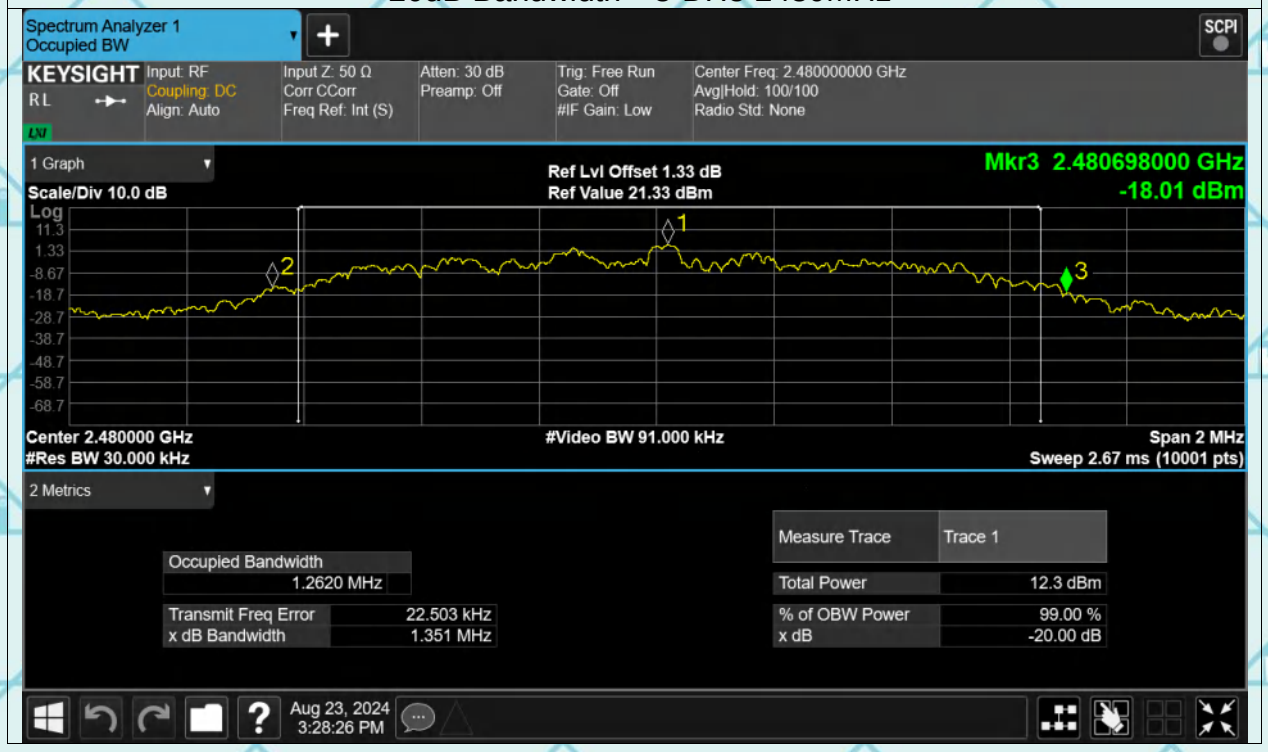
-20dB Bandwidth 3-DH5 2402MHz



-20dB Bandwidth 3-DH5 2441MHz

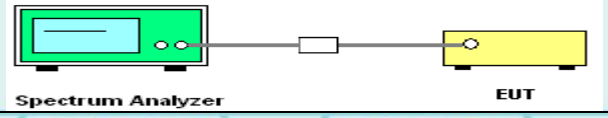


-20dB Bandwidth 3-DH5 2480MHz



6.5. Carrier Frequencies Separation

6.5.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2014
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.
Test Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2014 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = wide enough to capture the peaks of two adjacent channels; RBW is set to approximately 30% of the channel spacing, adjust as necessary to best identify the center of each individual channel; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold. 6. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Record the value in report.
Test Result:	PASS

6.5.2. Test data

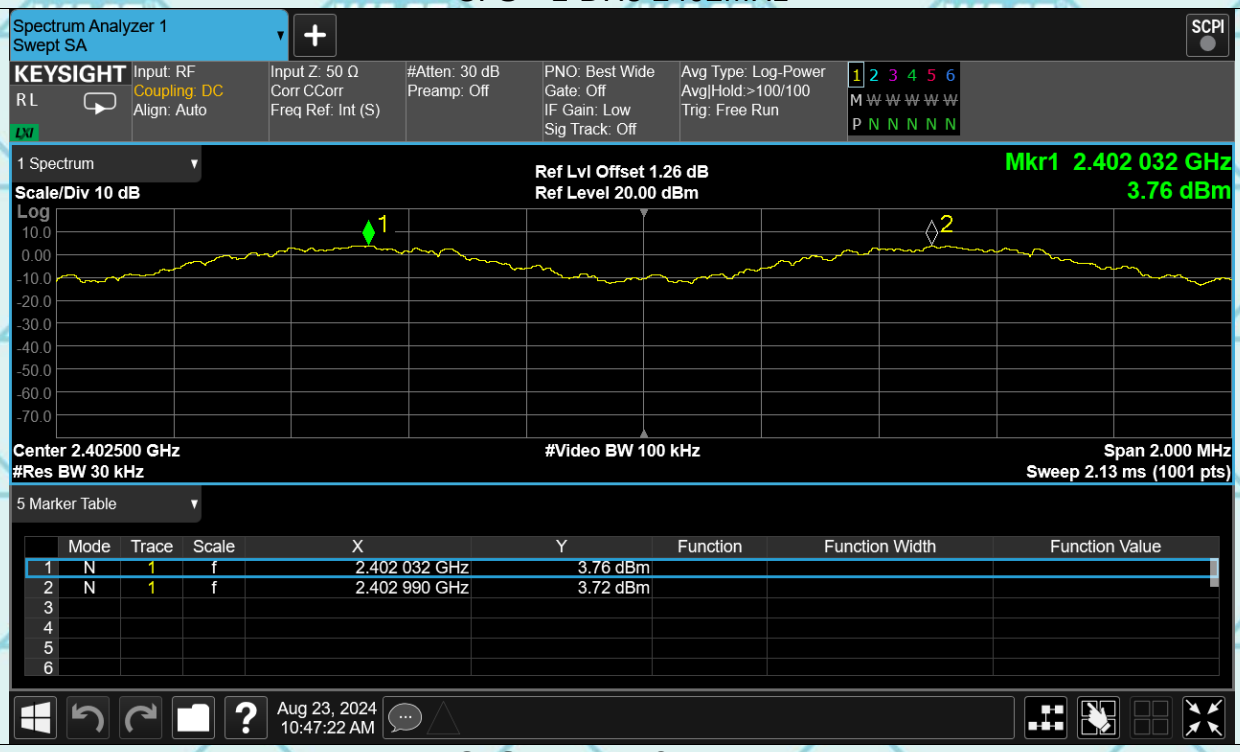
GFSK mode			
Test channel	Carrier Frequencies Separation (MHz)	Limit (MHz)	Result
Lowest	0.958	0.726	PASS
Middle	0.988	0.697	PASS
Highest	1.004	0.685	PASS

Pi/4 DQPSK mode			
Test channel	Carrier Frequencies Separation (MHz)	Limit (MHz)	Result
Lowest	1.162	0.924	PASS
Middle	1.158	0.935	PASS
Highest	1.146	0.917	PASS

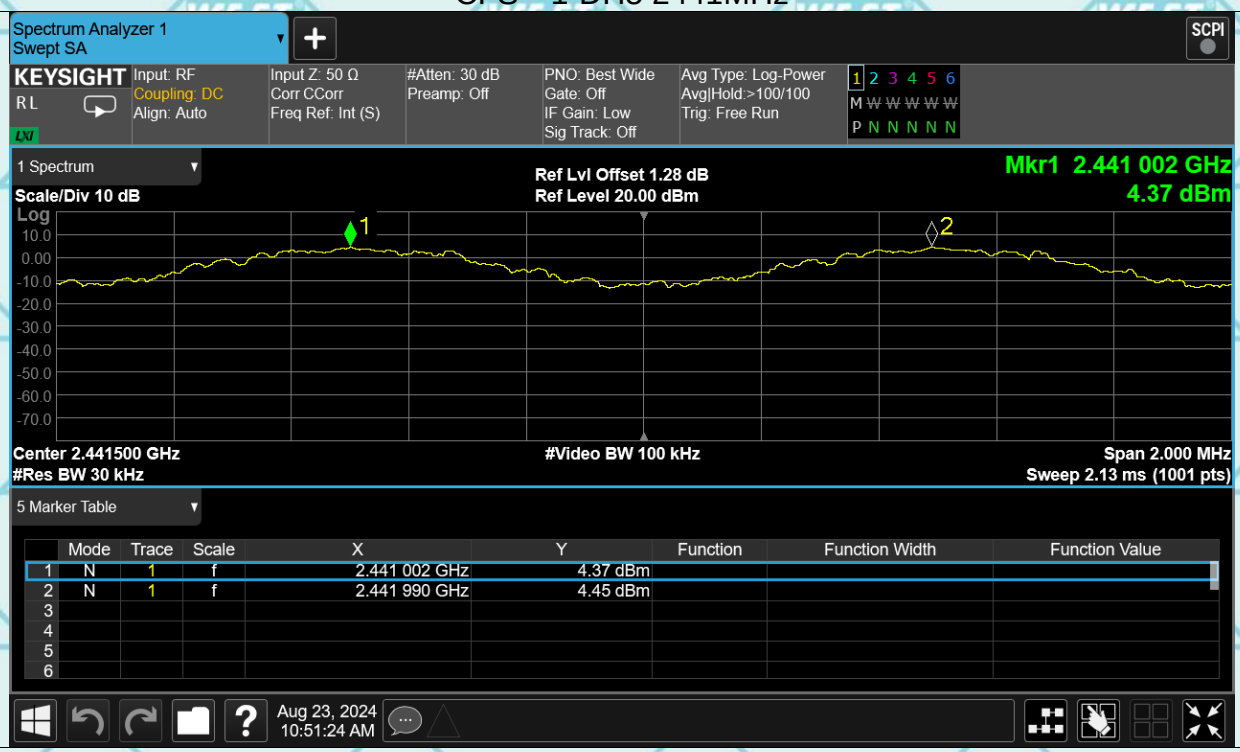
8DPSK mode			
Test channel	Carrier Frequencies Separation (MHz)	Limit (MHz)	Result
Lowest	1.002	0.907	PASS
Middle	1.010	0.893	PASS
Highest	1.010	0.901	PASS

Test Graphs

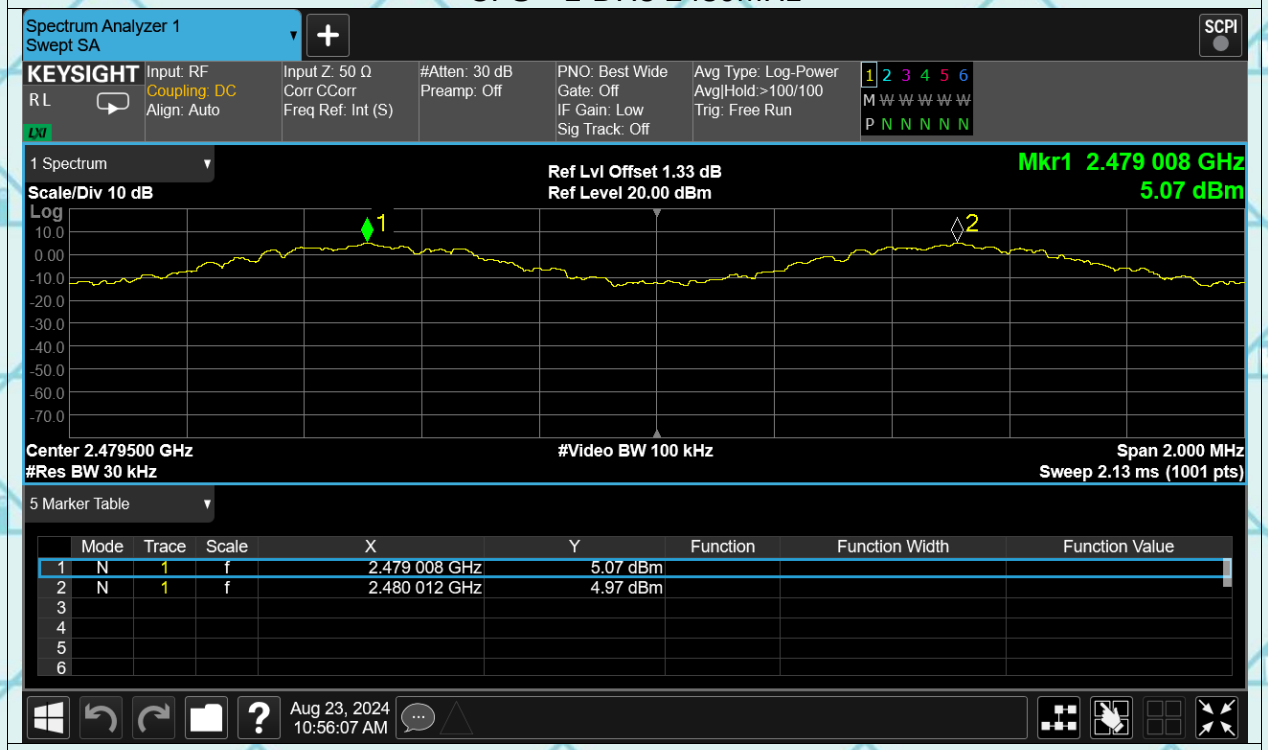
CFS 1-DH5 2402MHz



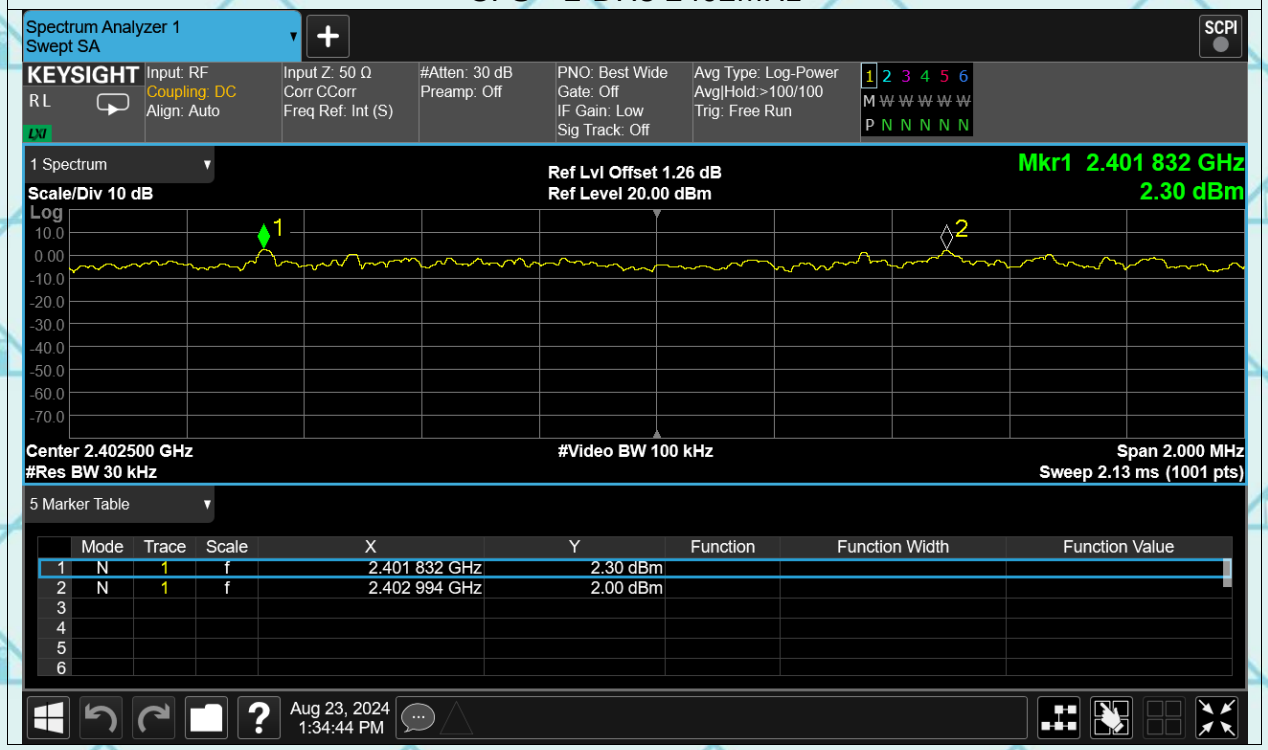
CFS 1-DH5 2441MHz



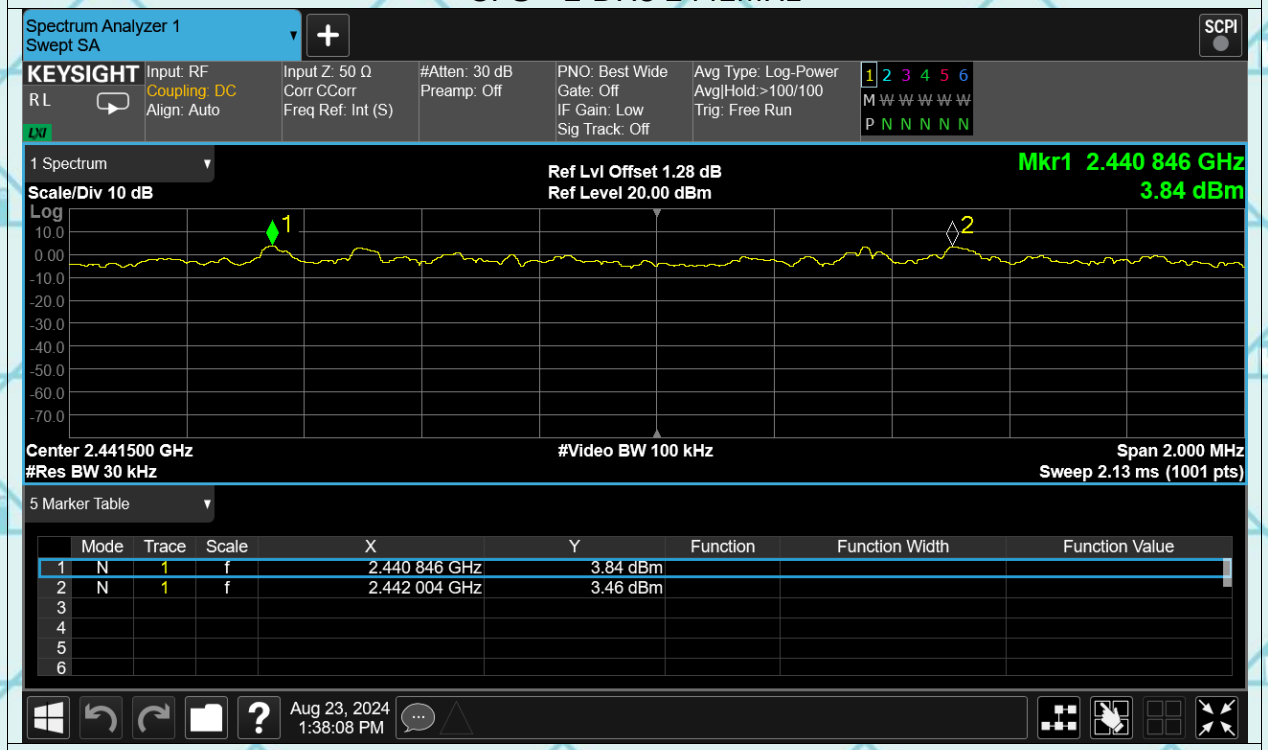
CFS 1-DH5 2480MHz



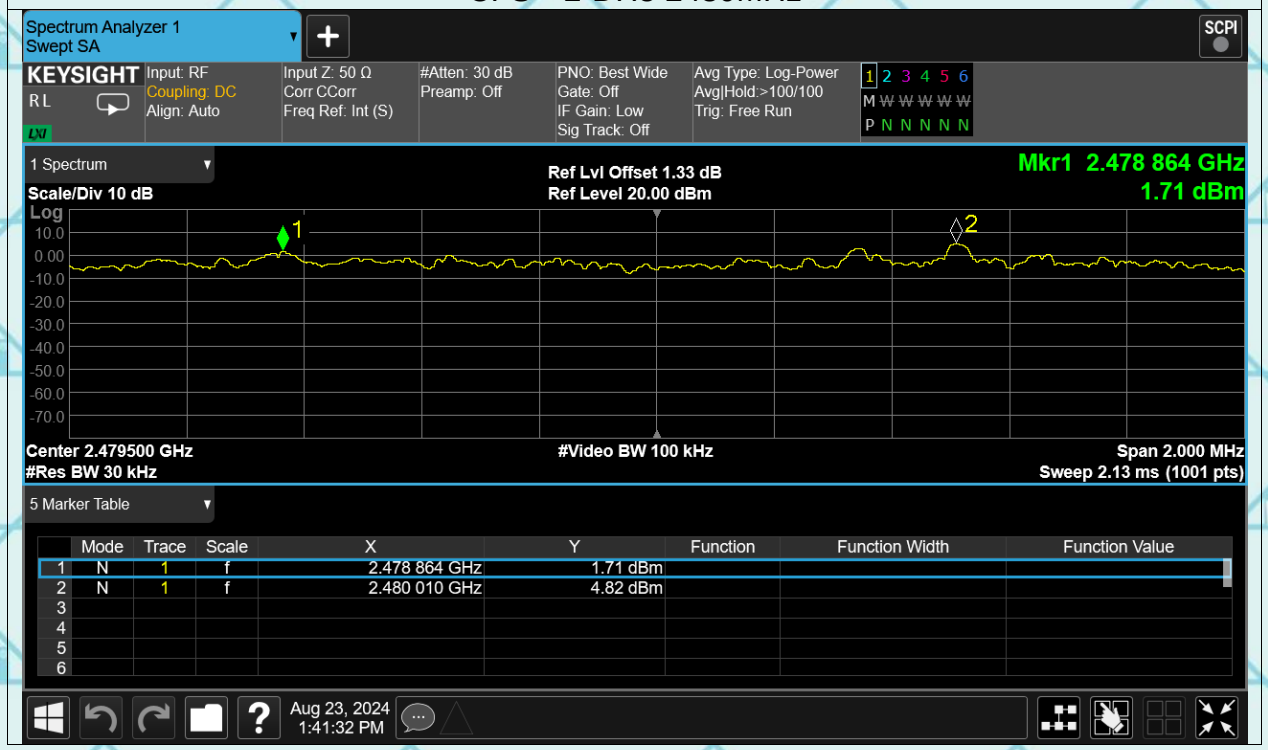
CFS 2-DH5 2402MHz



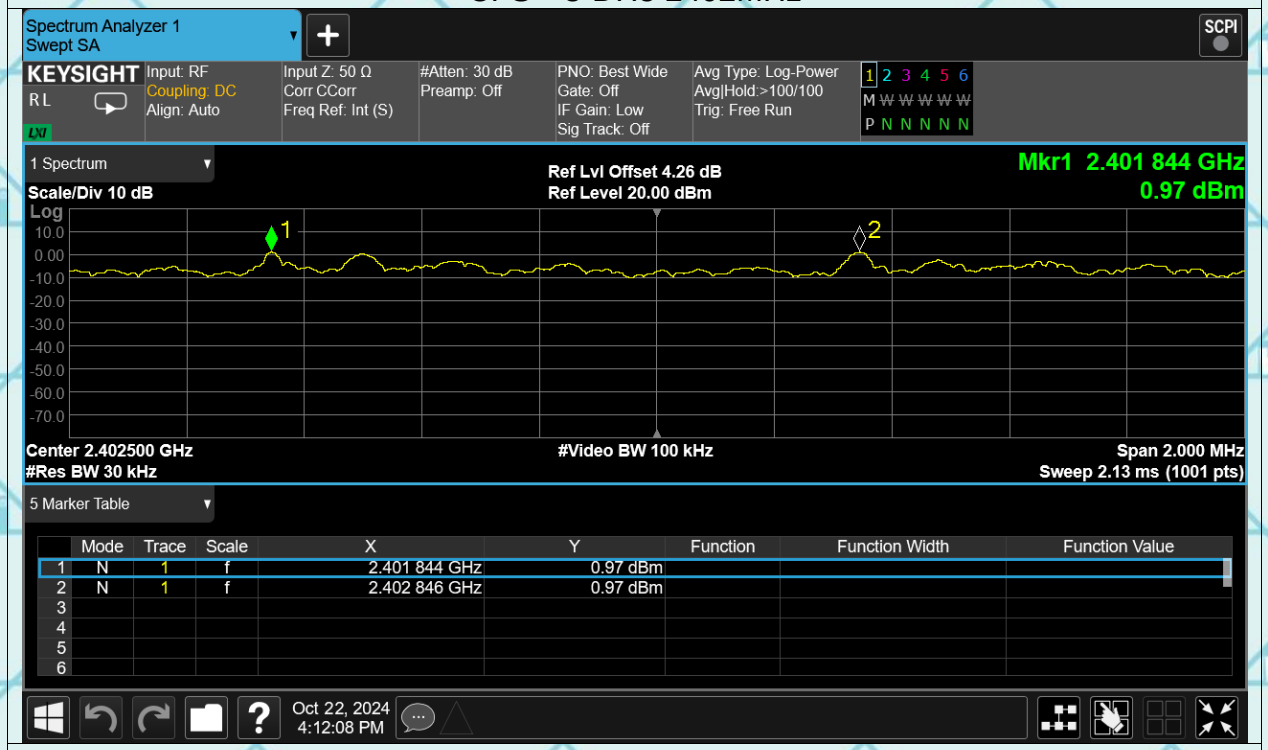
CFS 2-DH5 2441MHz



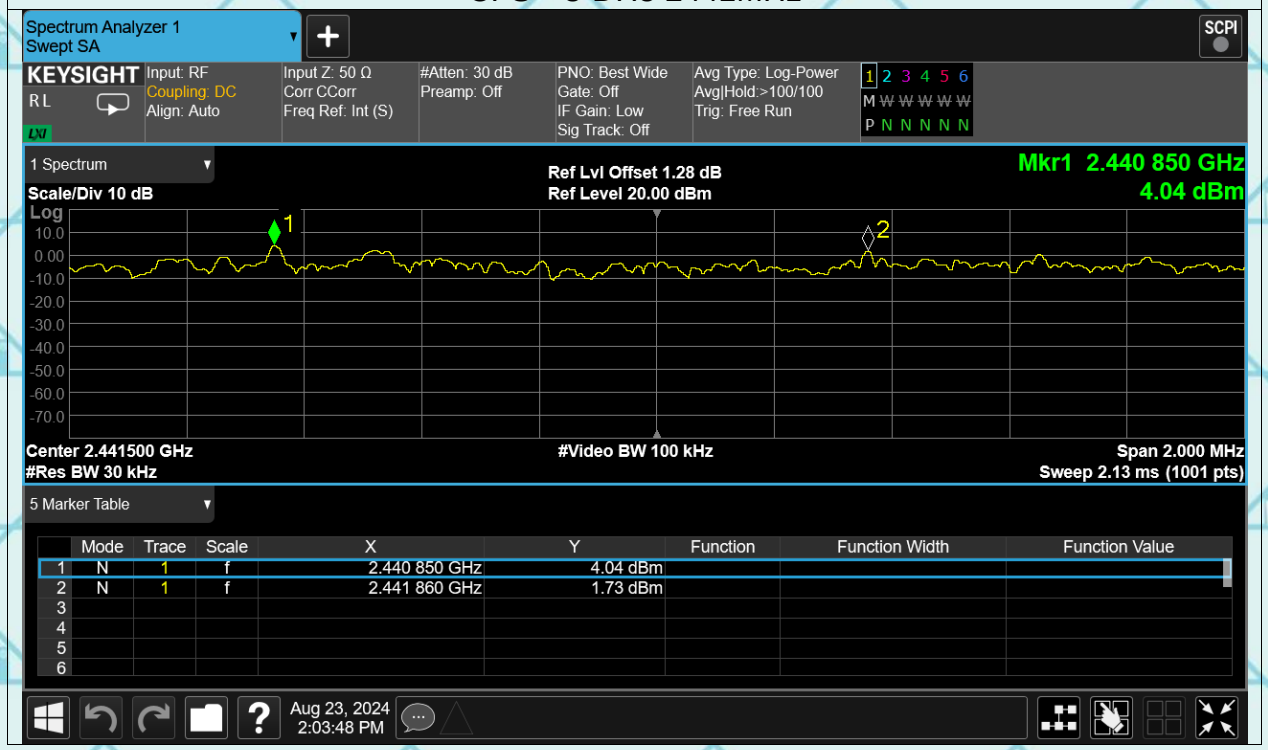
CFS 2-DH5 2480MHz



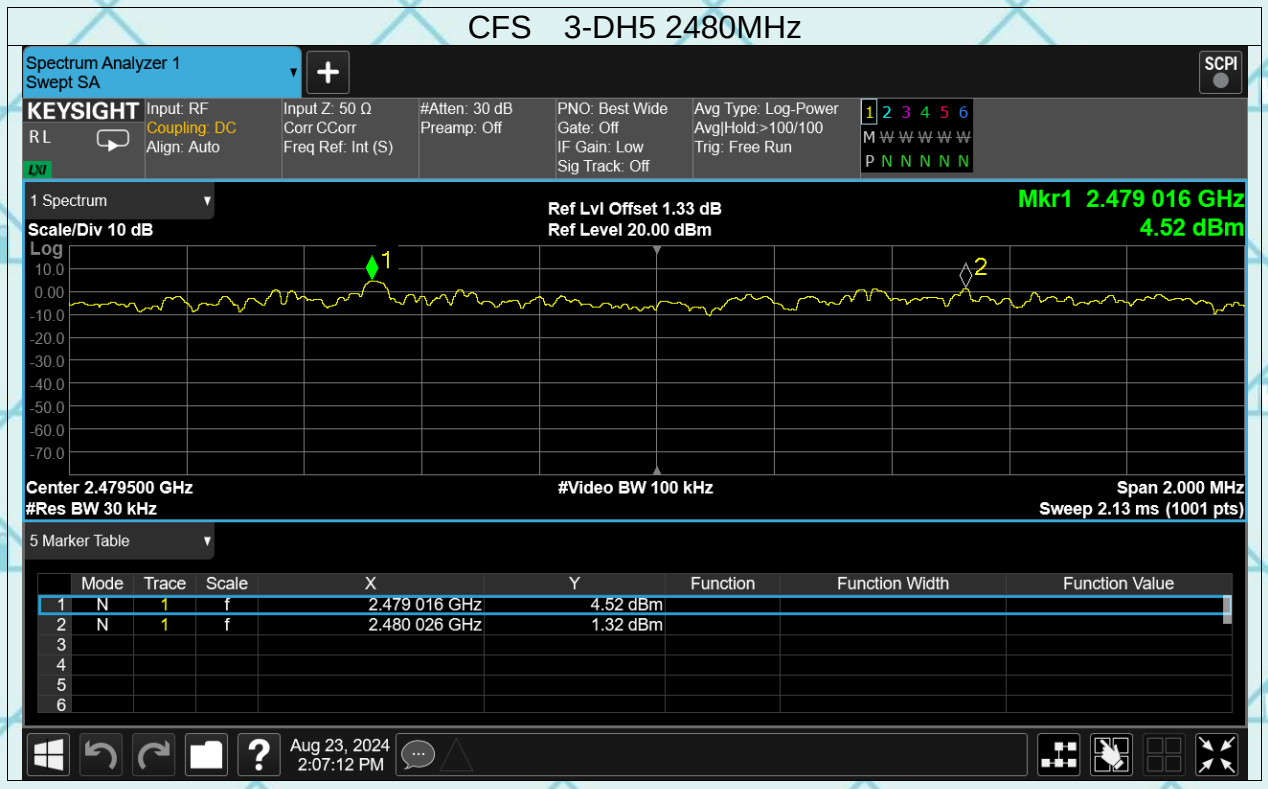
CFS 3-DH5 2402MHz



CFS 3-DH5 2441MHz

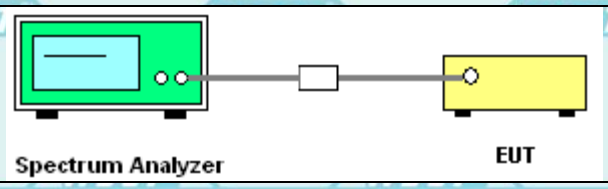


CFS 3-DH5 2480MHz



6.6. Hopping Channel Number

6.6.1. Test Specification

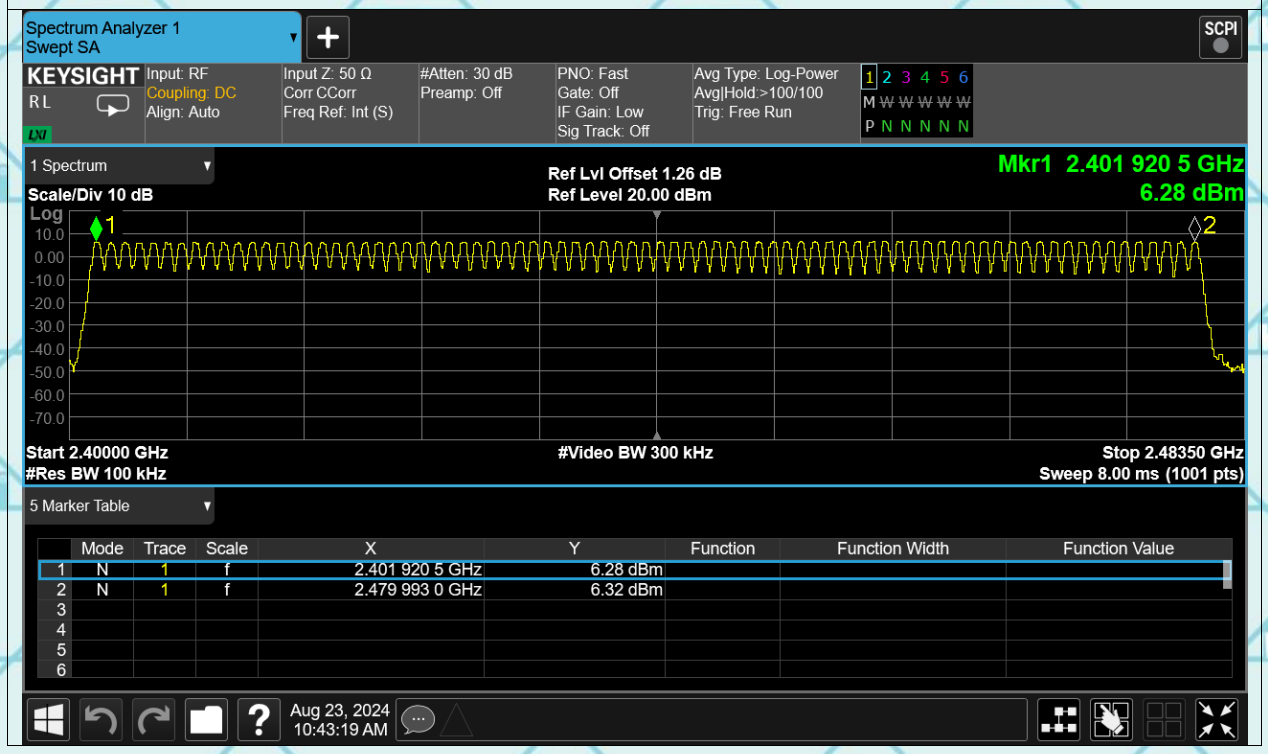
Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2014
Limit:	Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.
Test Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2014 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = the frequency band of operation; set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold. 6. The number of hopping frequency used is defined as the number of total channel. 7. Record the measurement data in report.
Test Result:	PASS

6.6.2. Test data

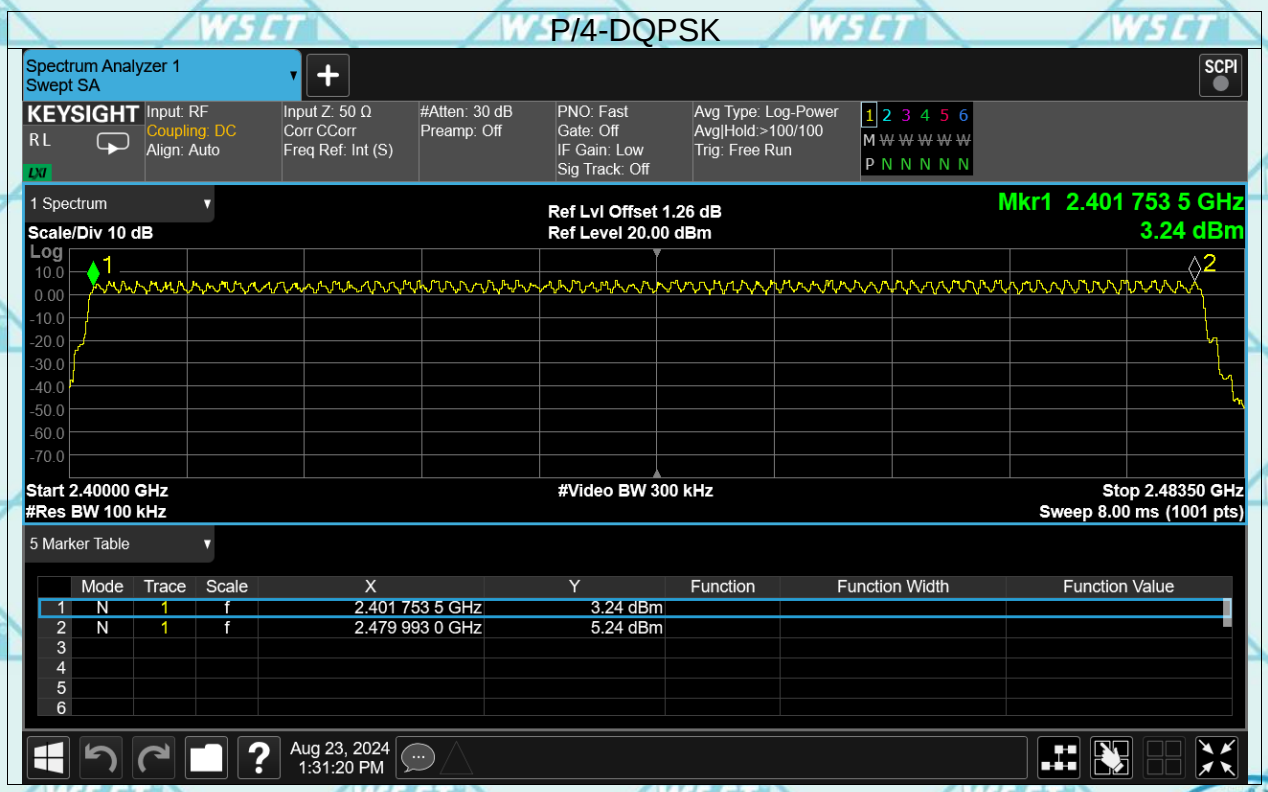
Mode	Hopping channel numbers	Limit	Result
GFSK, P/4-DQPSK, 8DPSK	79	15	PASS

Test plots as follows:

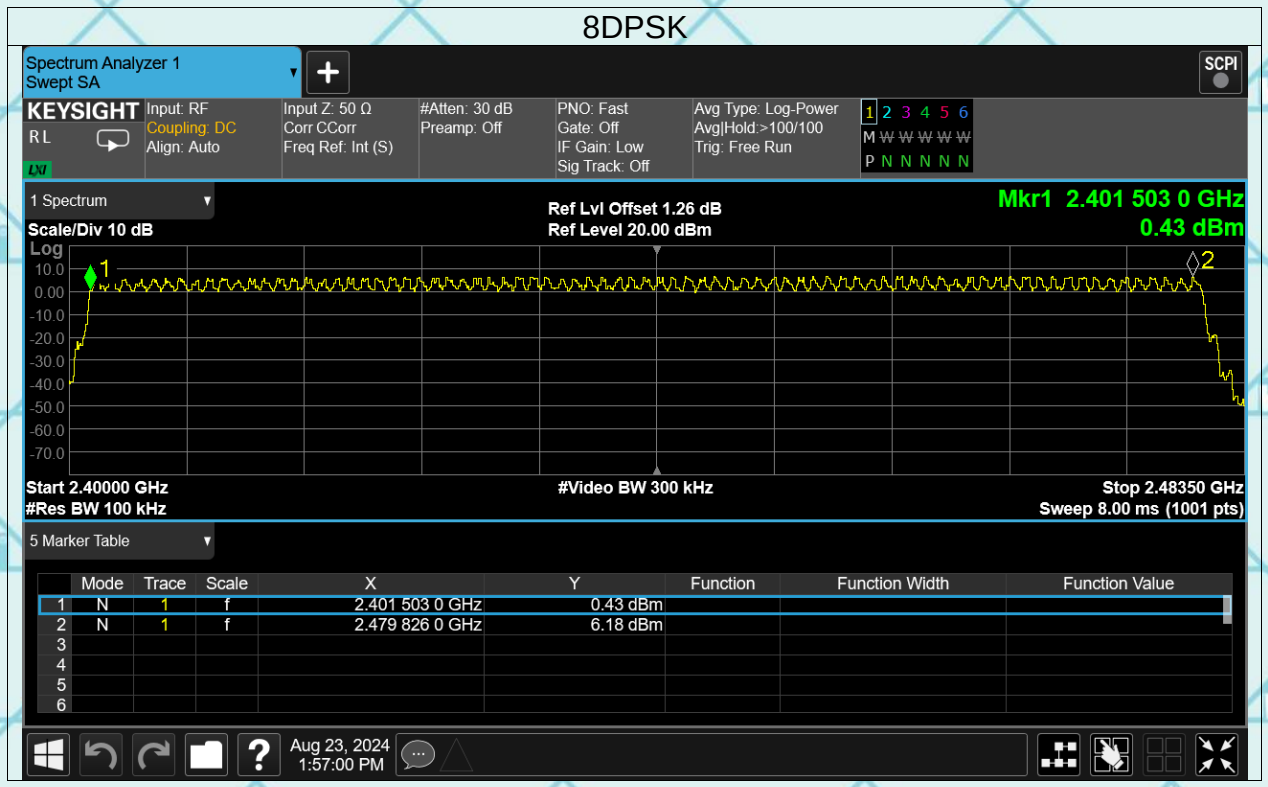
GFSK



P/4-DQPSK

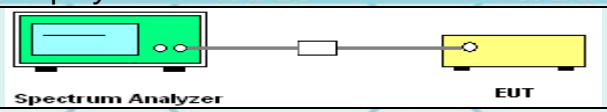


8DPSK


Spectrum Analyzer 1
Swept SA
SCPI
KEYSIGHT
RL
Input: RF
Coupling: DC
Align: Auto
Input Z: 50 Ω
Corr CCorr
Freq Ref: Int (S)
#Atten: 30 dB
Preamp: Off
PNO: Fast
Gate: Off
IF Gain: Low
Sig Track: Off
Avg Type: Log-Power
Avg|Hold:>100/100
Trig: Free Run
1 Spectrum
Scale/Div 10 dB
Ref Lvl Offset 1.26 dB
Ref Level 20.00 dBm
Mkr1 2.401 503 0 GHz
0.43 dBm
Log
10.0
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
Start 2.40000 GHz
#Res BW 100 kHz
#Video BW 300 kHz
Stop 2.48350 GHz
Sweep 8.00 ms (1001 pts)
5 Marker Table
Mode Trace Scale X Y Function Function Width Function Value
1 N 1 f 2.401 503 0 GHz 0.43 dBm
2 N 1 f 2.479 826 0 GHz 6.18 dBm
Aug 23, 2024
1:57:00 PM

6.7. Dwell Time

6.7.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2014
Limit:	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 Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2014 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel; VBW≥RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold. 6. Measure and record the results in the test report.
Test Result:	PASS

6.7.2. Test Data

Mode	Frequency (MHz)	Pulse Time (ms)	Total Dwell Time (ms)	Burst Count	Period Time (ms)	Limit (ms)	Verdict
1-DH1	2402	0.372	186.372	501	31600	400	Pass
1-DH1	2441	0.37	117.29	317	31600	400	Pass
1-DH1	2480	0.372	118.296	318	31600	400	Pass
1-DH3	2402	1.627	314.011	193	31600	400	Pass
1-DH3	2441	1.628	257.224	158	31600	400	Pass
1-DH3	2480	1.627	250.558	154	31600	400	Pass
1-DH5	2402	2.887	326.231	113	31600	400	Pass
1-DH5	2441	2.875	304.75	106	31600	400	Pass
1-DH5	2480	2.877	304.962	106	31600	400	Pass

Note: *1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels.*

For DH1, With channel hopping rate (1600 / 2 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 2 / 79) x (0.4 x 79) = 320 hops

For DH3, With channel hopping rate (1600 / 4 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 4 / 79) x (0.4 x 79) = 160 hops

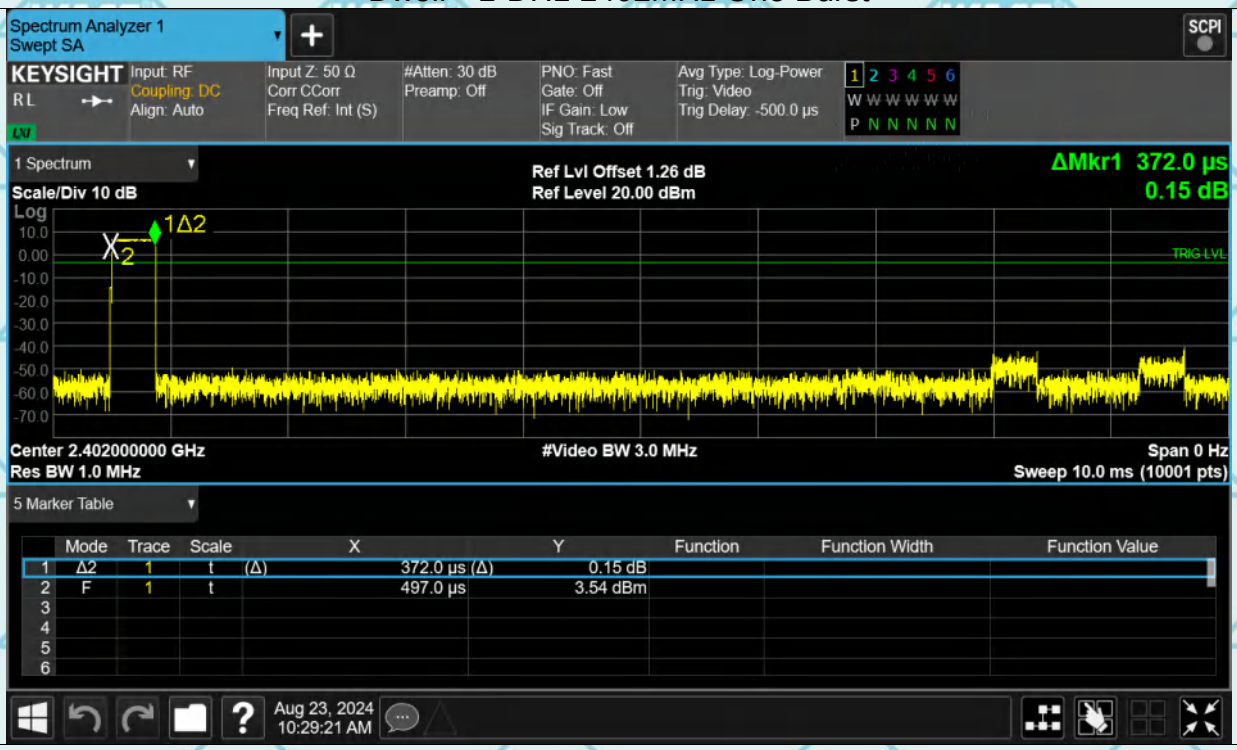
For DH5, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops

2. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

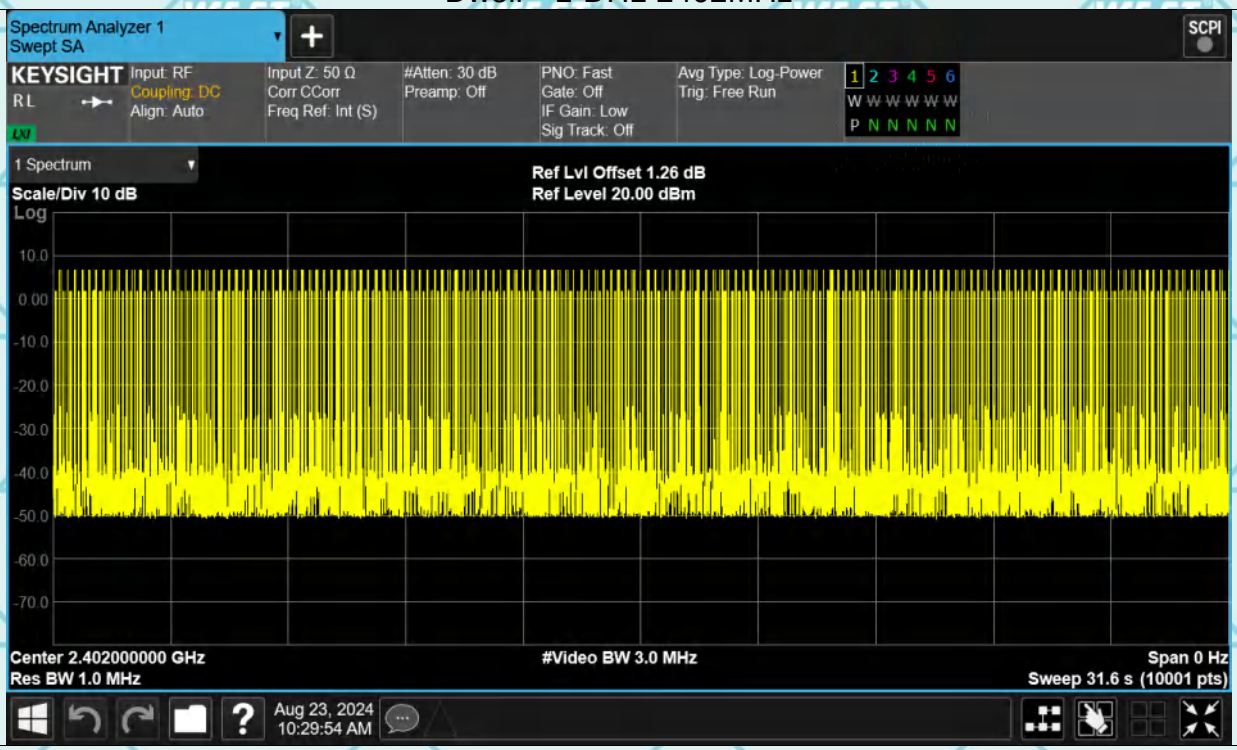
Test plots as follows:

Test Graphs

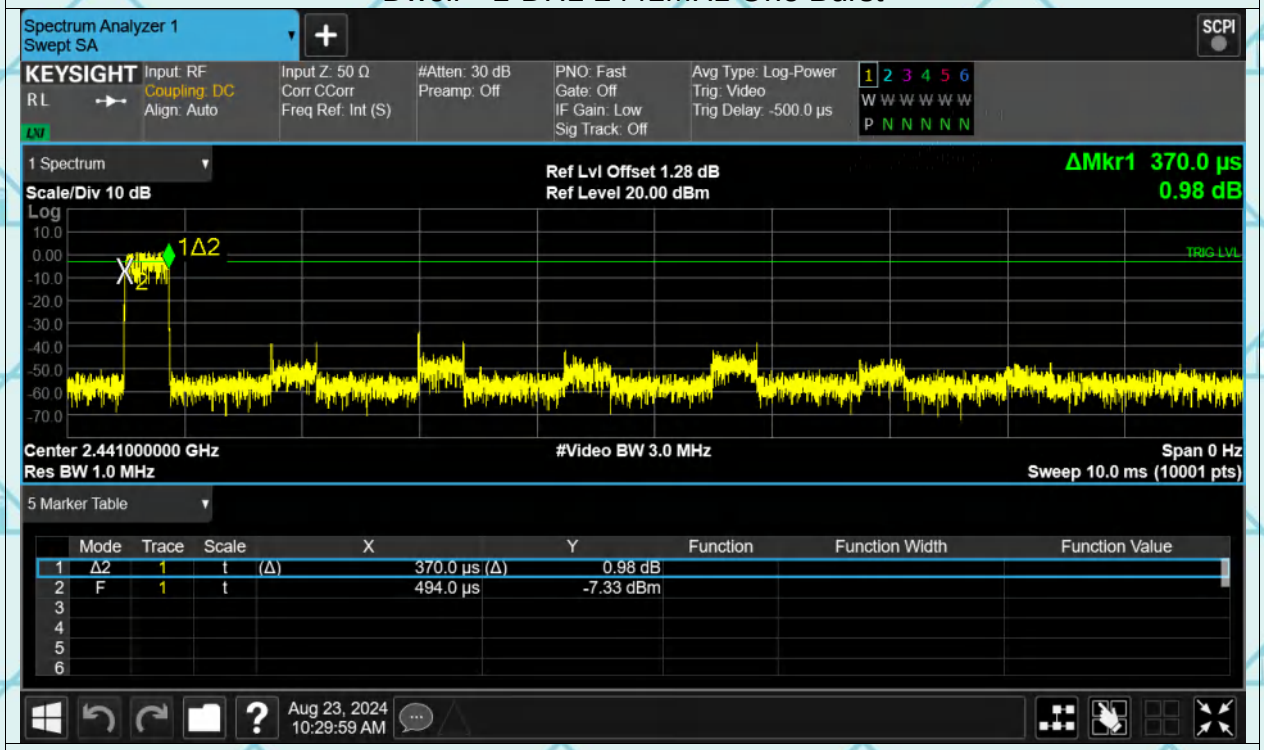
Dwell 1-DH1 2402MHz One Burst



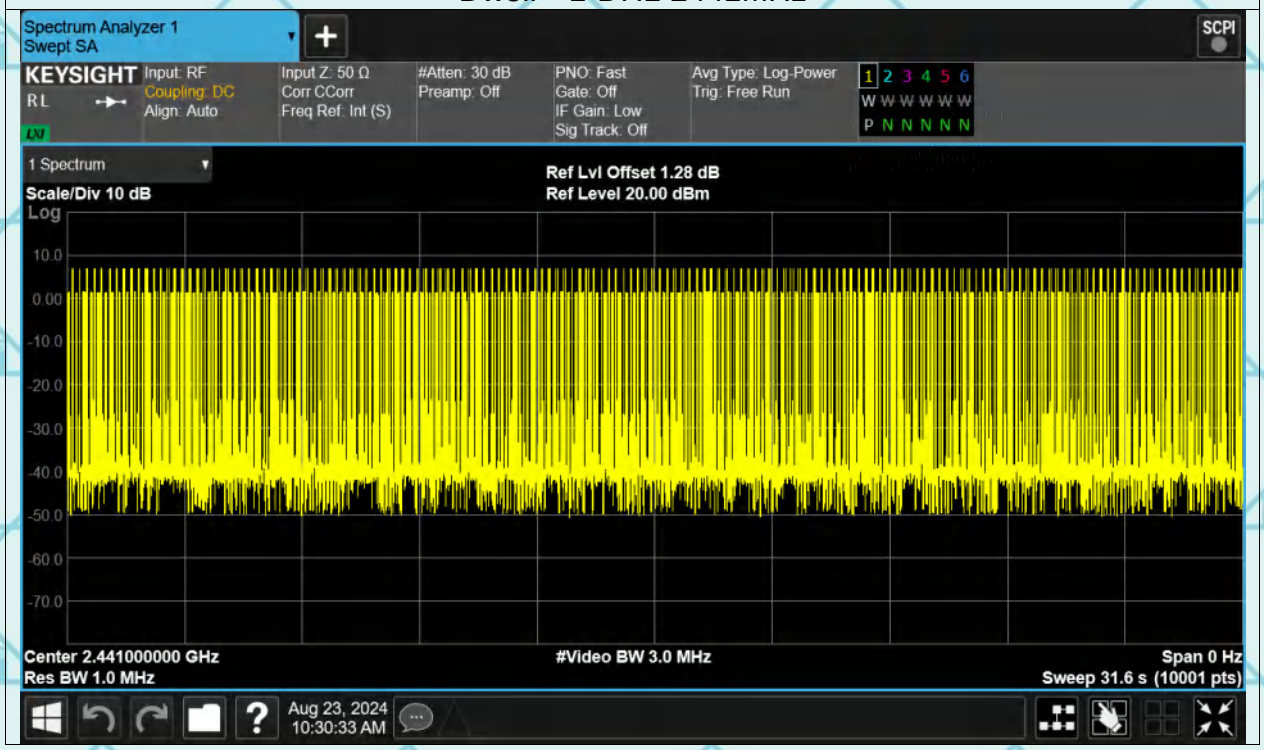
Dwell 1-DH1 2402MHz



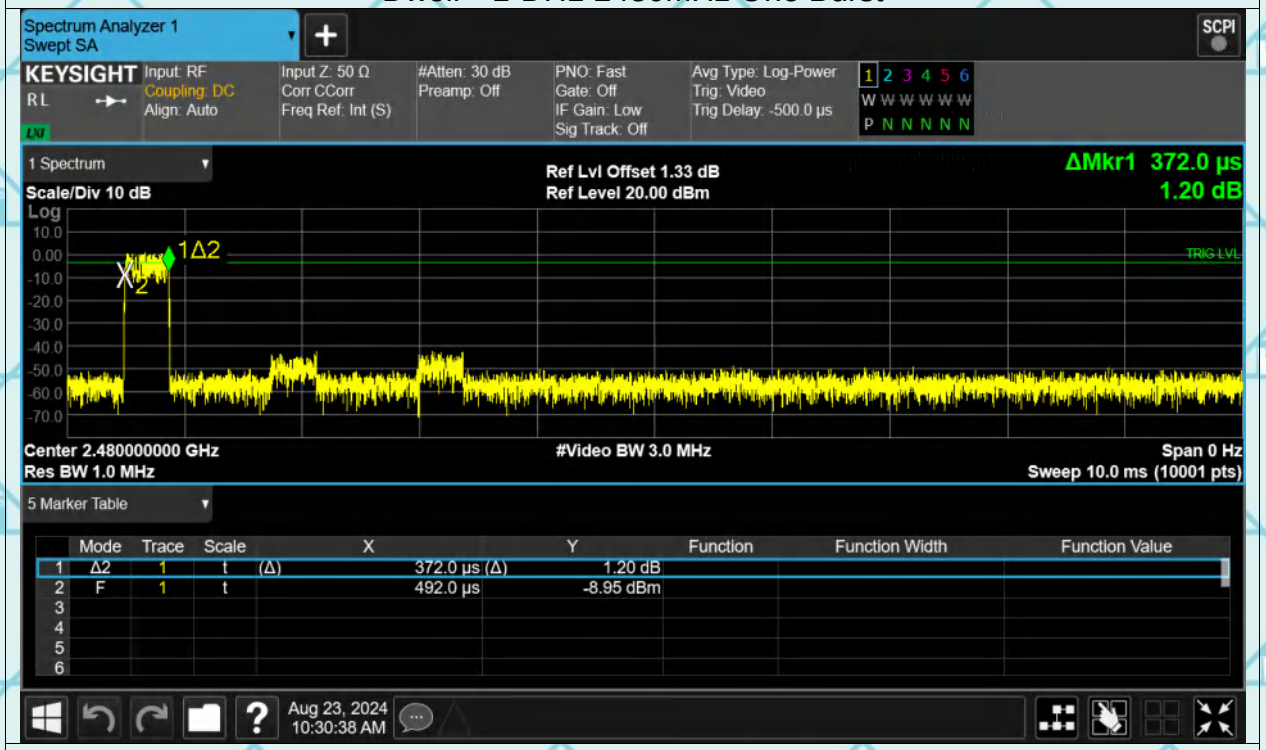
Dwell 1-DH1 2441MHz One Burst



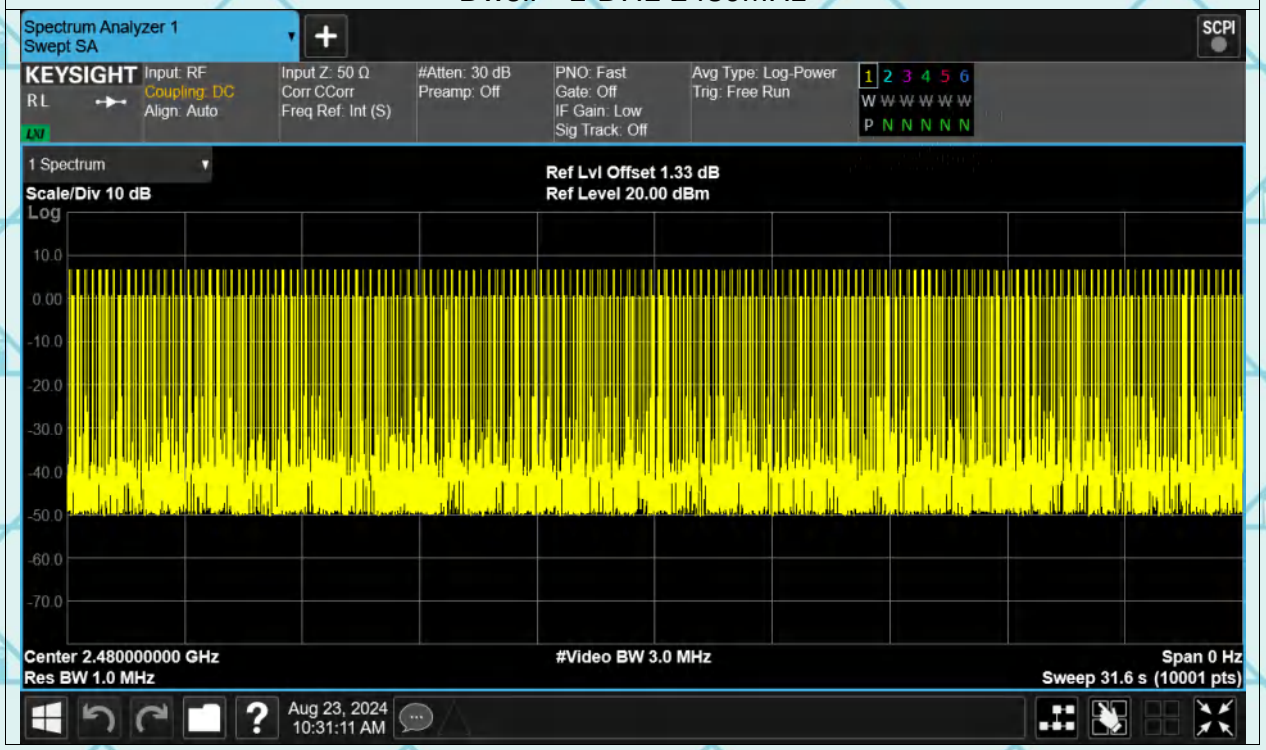
Dwell 1-DH1 2441MHz



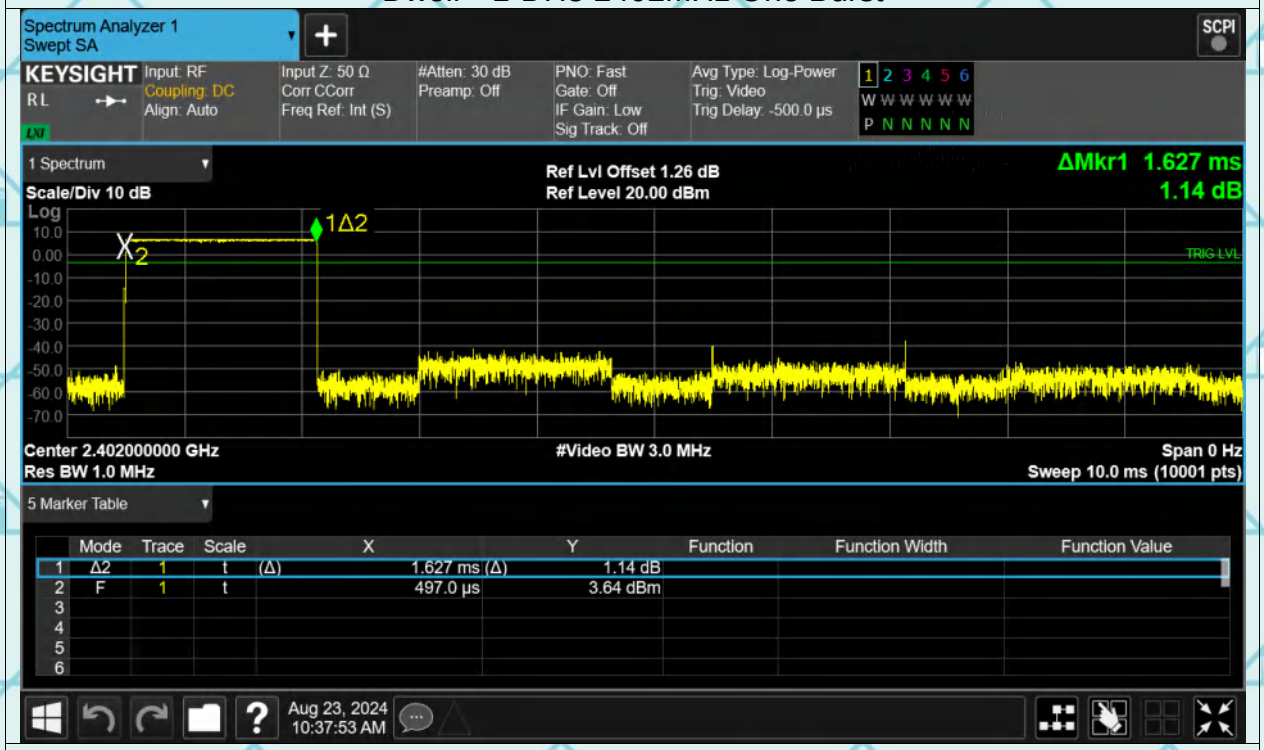
Dwell 1-DH1 2480MHz One Burst



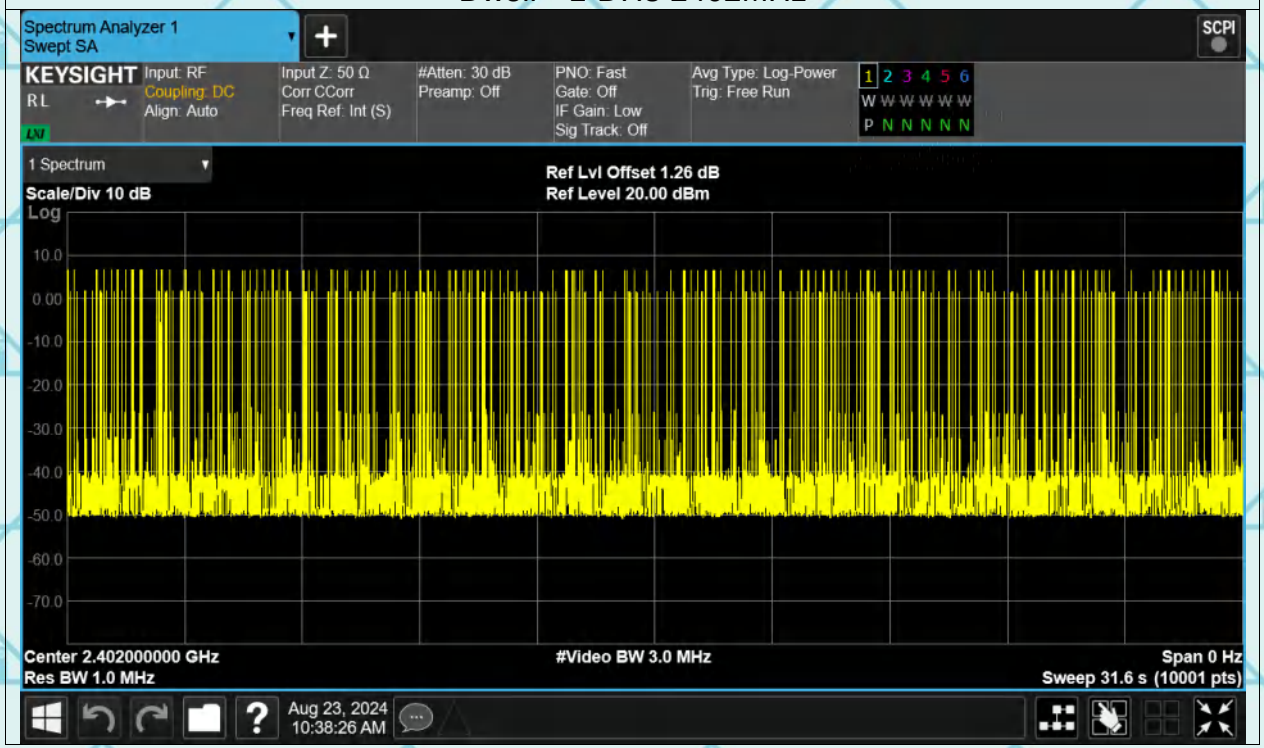
Dwell 1-DH1 2480MHz



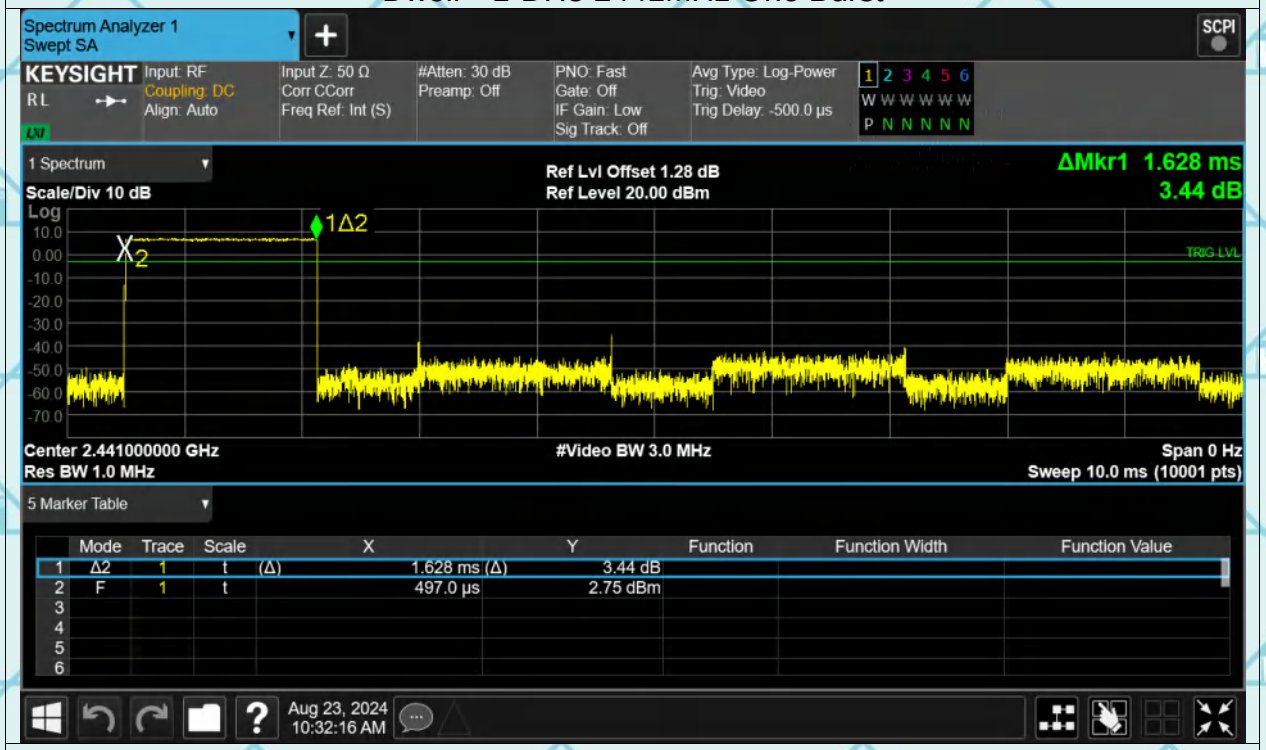
Dwell 1-DH3 2402MHz One Burst



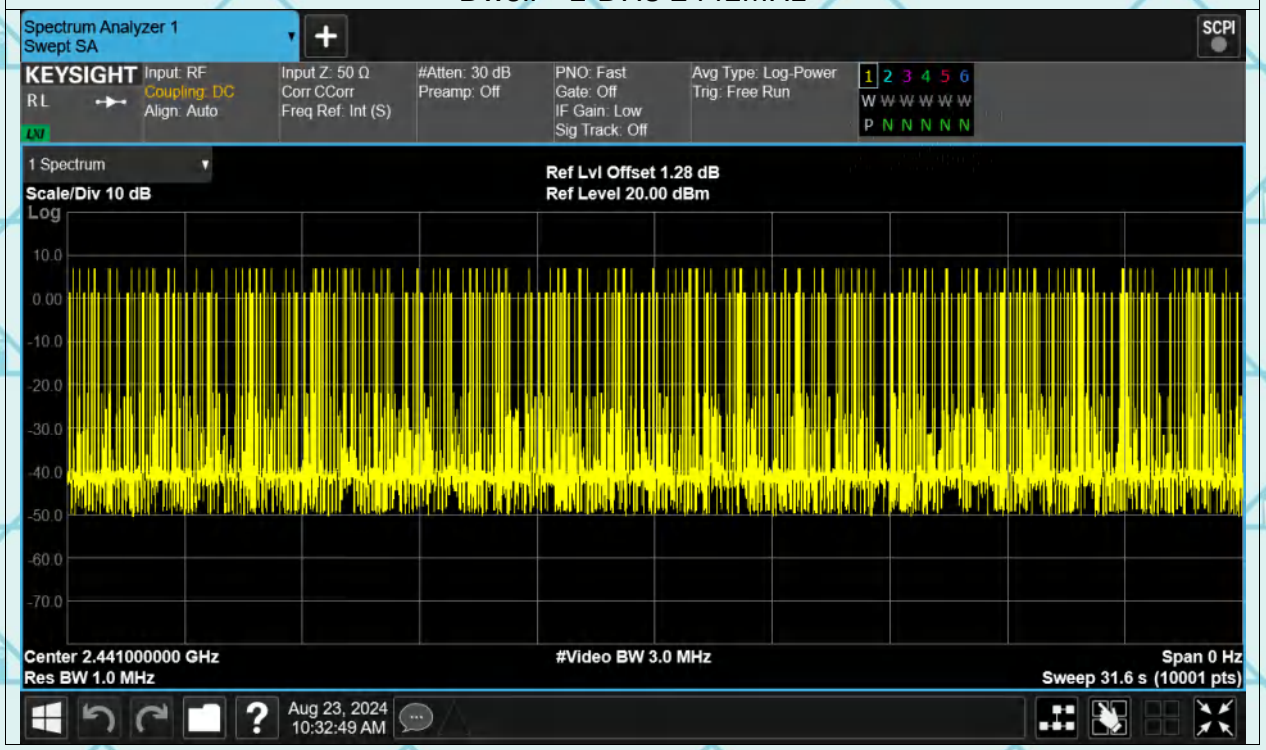
Dwell 1-DH3 2402MHz



Dwell 1-DH3 2441MHz One Burst

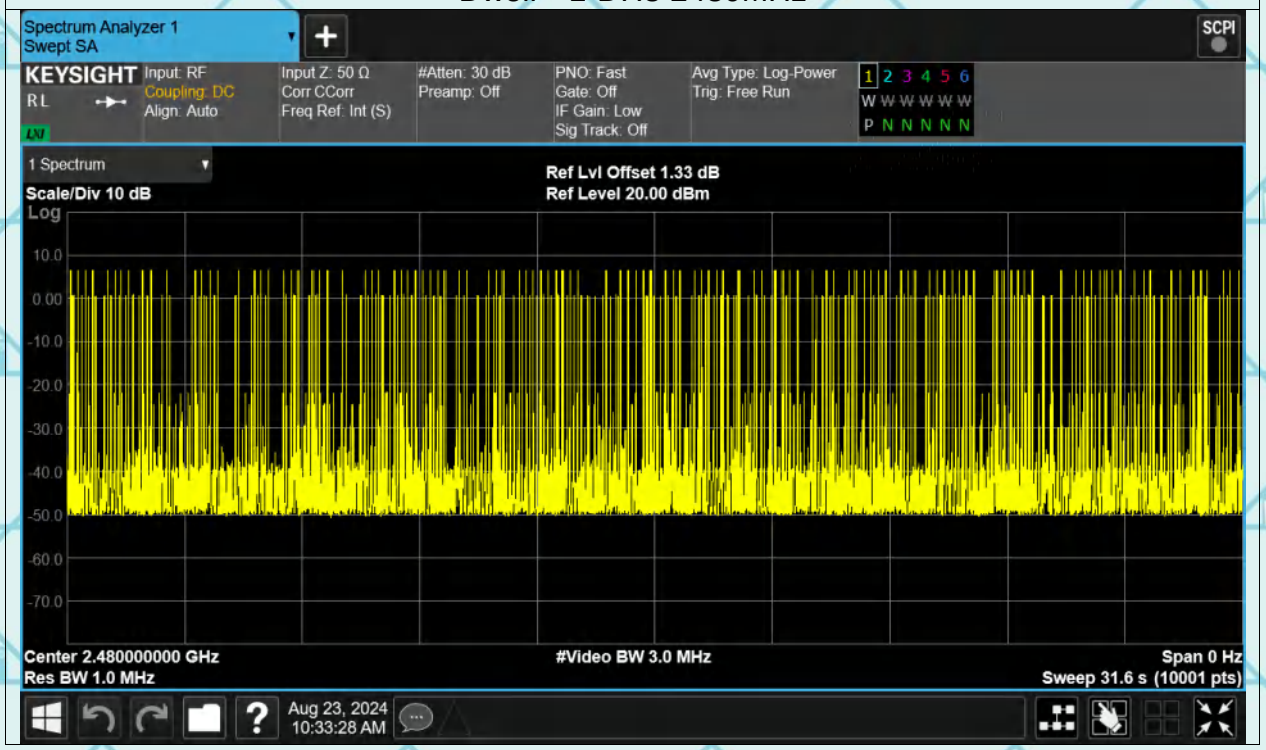


Dwell 1-DH3 2441MHz



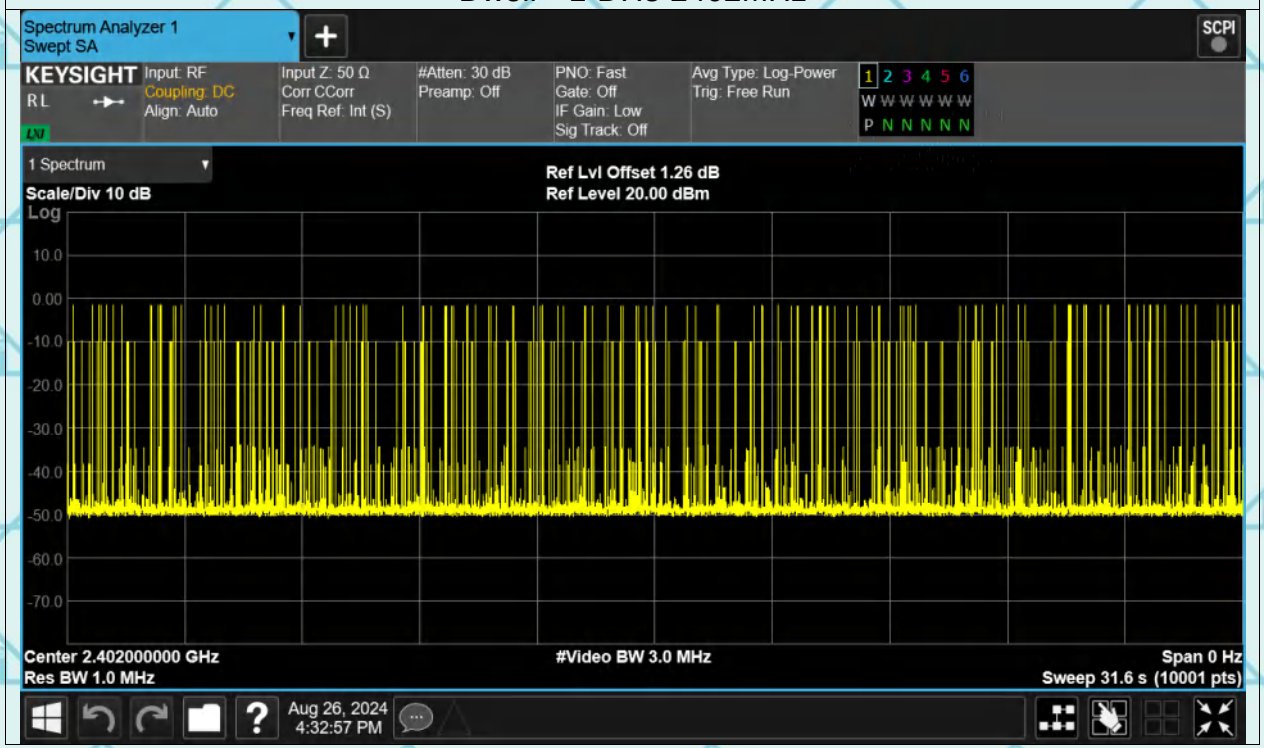
Dwell 1-DH3 2480MHz One Burst

Dwell 1-DH3 2480MHz



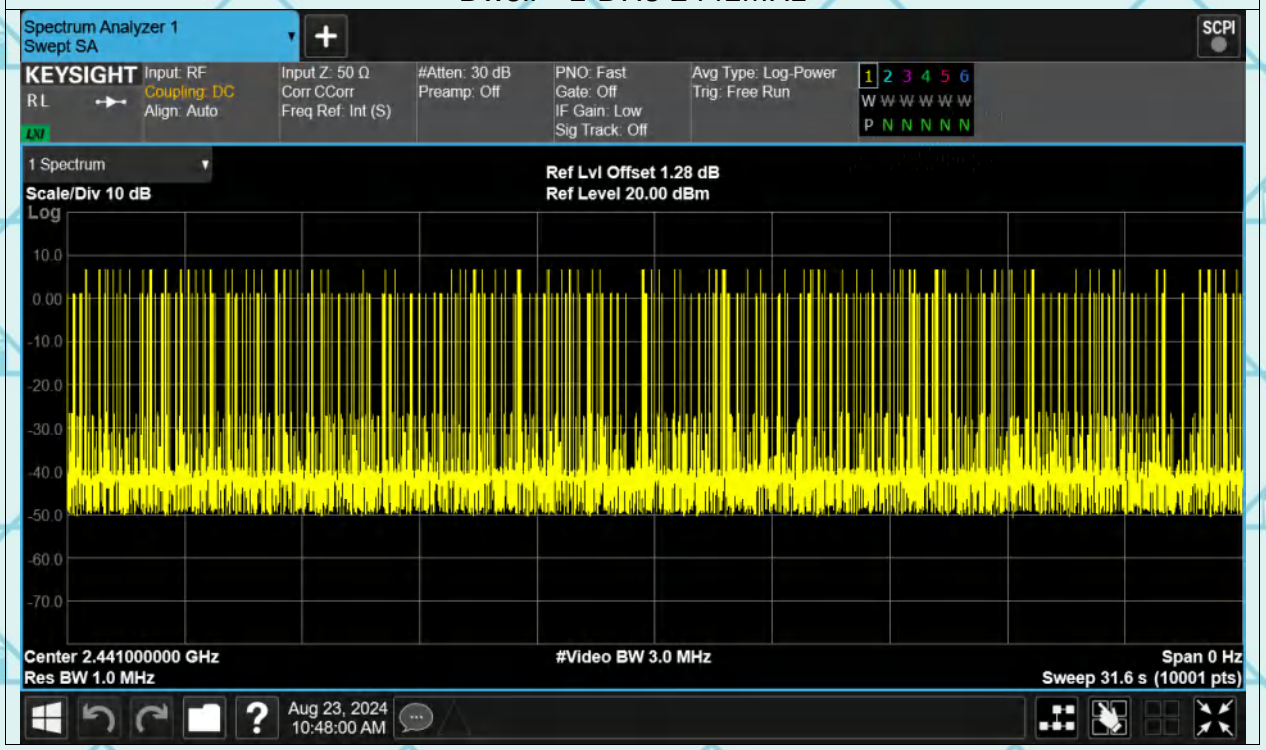
Dwell 1-DH5 2402MHz One Burst

Dwell 1-DH5 2402MHz



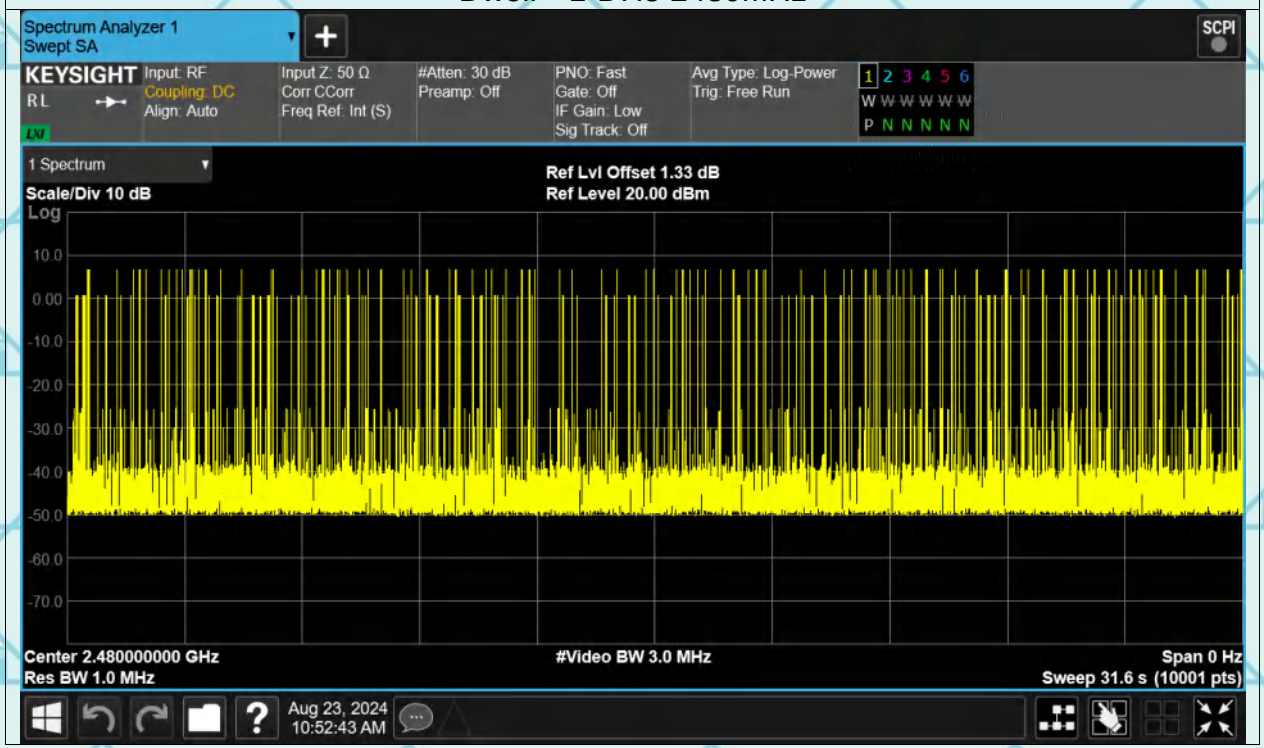
Dwell 1-DH5 2441MHz One Burst

Dwell 1-DH5 2441MHz



Dwell 1-DH5 2480MHz One Burst

Dwell 1-DH5 2480MHz



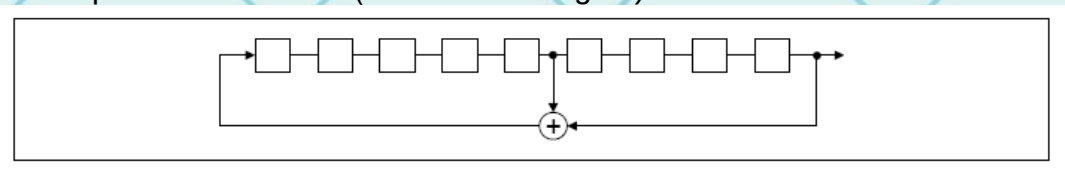
6.8. Pseudorandom Frequency Hopping Sequence

Test Requirement:	FCC Part15 C Section 15.247 (a)(1) requirement:

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

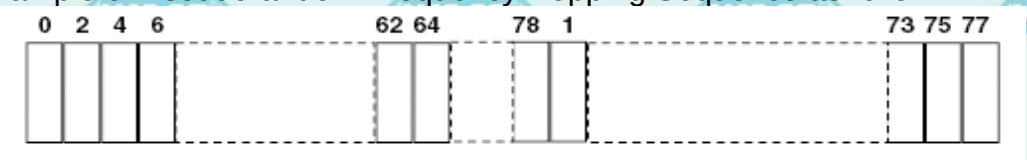
EUT Pseudorandom Frequency Hopping Sequence

The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones; i.e. the shift register is initialized with nine ones.
• Number of shift register stages: 9
• Length of pseudo-random sequence: 2^9 -1 = 511 bits
• Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

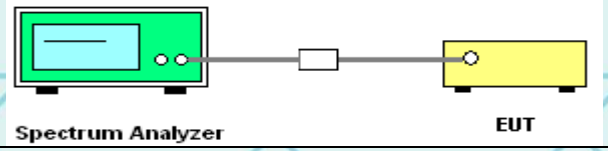
An example of Pseudorandom Frequency Hopping Sequence as follow:



Each frequency used equally on the average by each transmitter.
The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

6.9. Conducted Band Edge Measurement

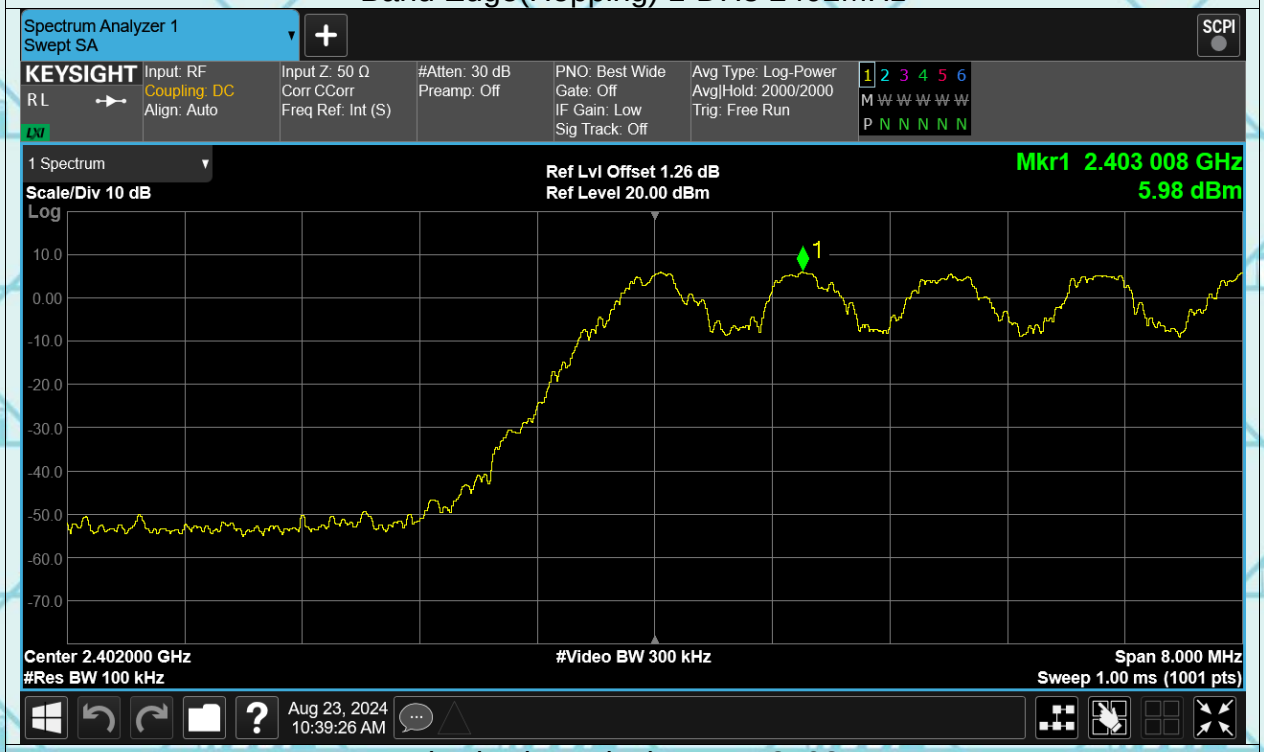
6.9.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2014
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Band-edge Compliance of RF Conducted Emissions of ANSI C63.10:2014 Measurement Guidelines. 2. Set to the maximum power setting and enable the EUT transmit continuously. 3. Set RBW = 100 kHz (≥1% span=10MHz), VBW = 300 kHz (≥RBW). Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used. 4. Enable hopping function of the EUT and then repeat step 2 and 3. 5. Measure and record the results in the test report.
Test Result:	PASS

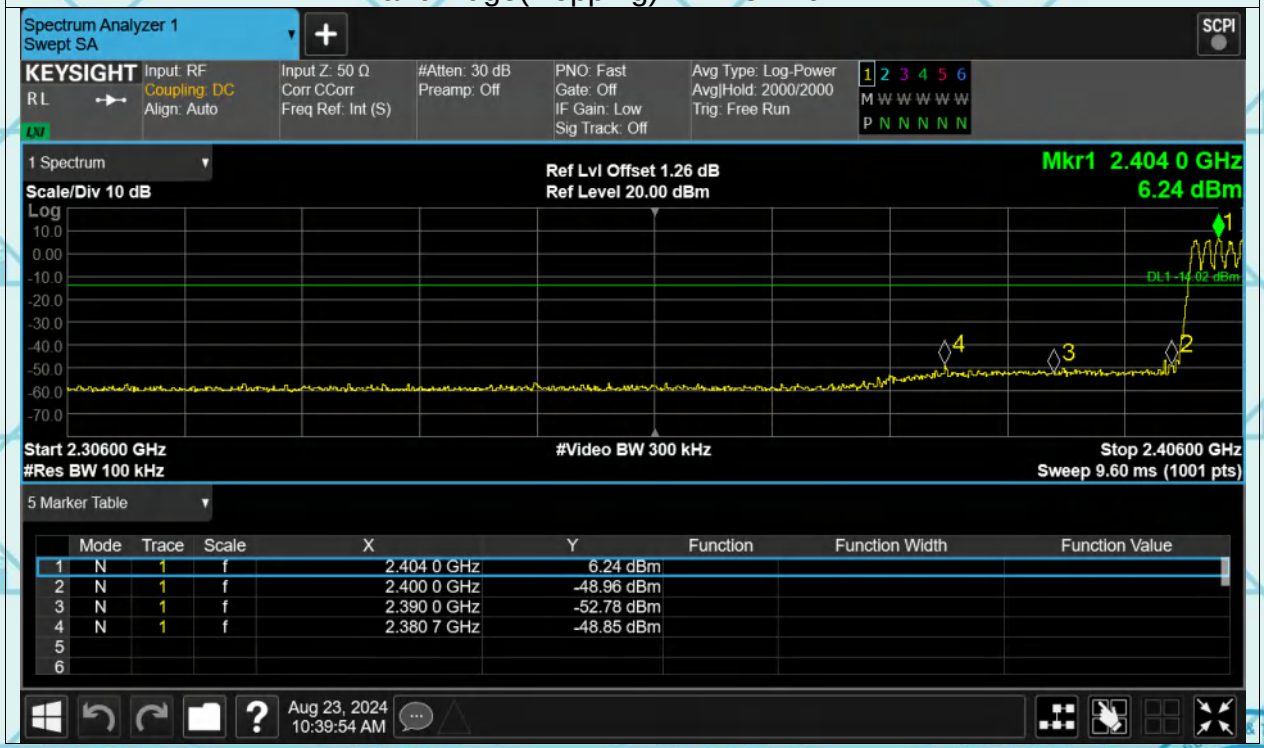
6.9.2. Test Data

GFSK Modulation (the worst case)

Band Edge(Hopping) 1-DH5 2402MHz

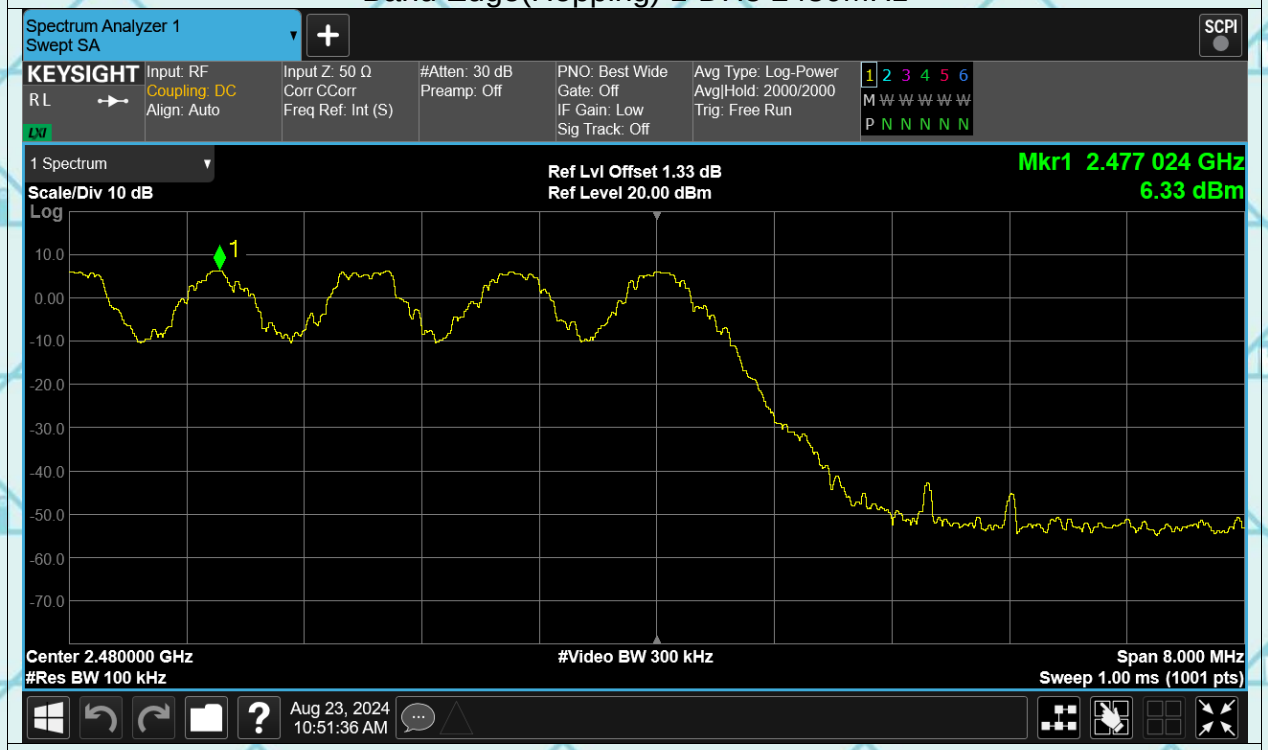


Band Edge(Hopping) 1-DH5 2402MHz

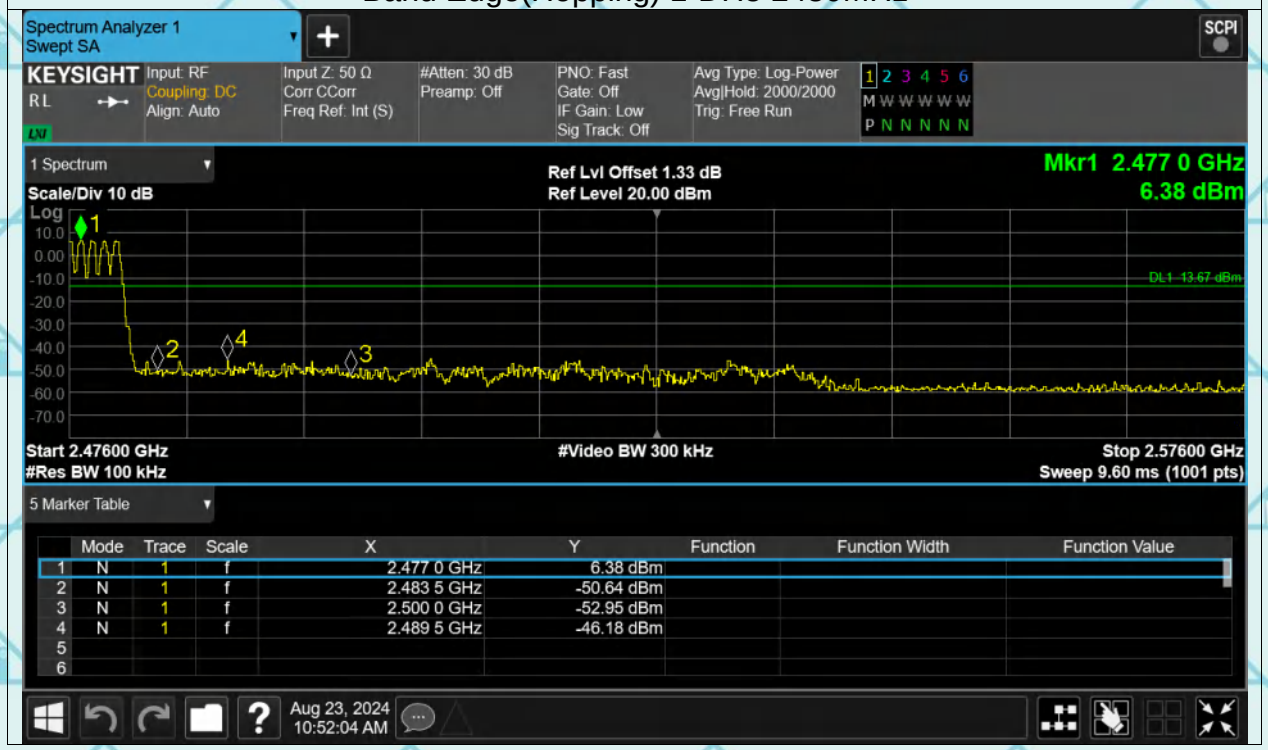


	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.404 0 GHz	6.24 dBm			
2	N	1	f	2.400 0 GHz	-48.96 dBm			
3	N	1	f	2.390 0 GHz	-52.78 dBm			
4	N	1	f	2.380 7 GHz	-48.85 dBm			
5								
6								

Band Edge(Hopping) 1-DH5 2480MHz

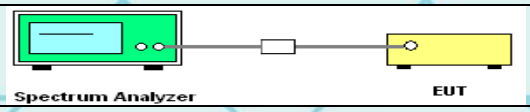


Band Edge(Hopping) 1-DH5 2480MHz



6.10. Conducted Spurious Emission Measurement

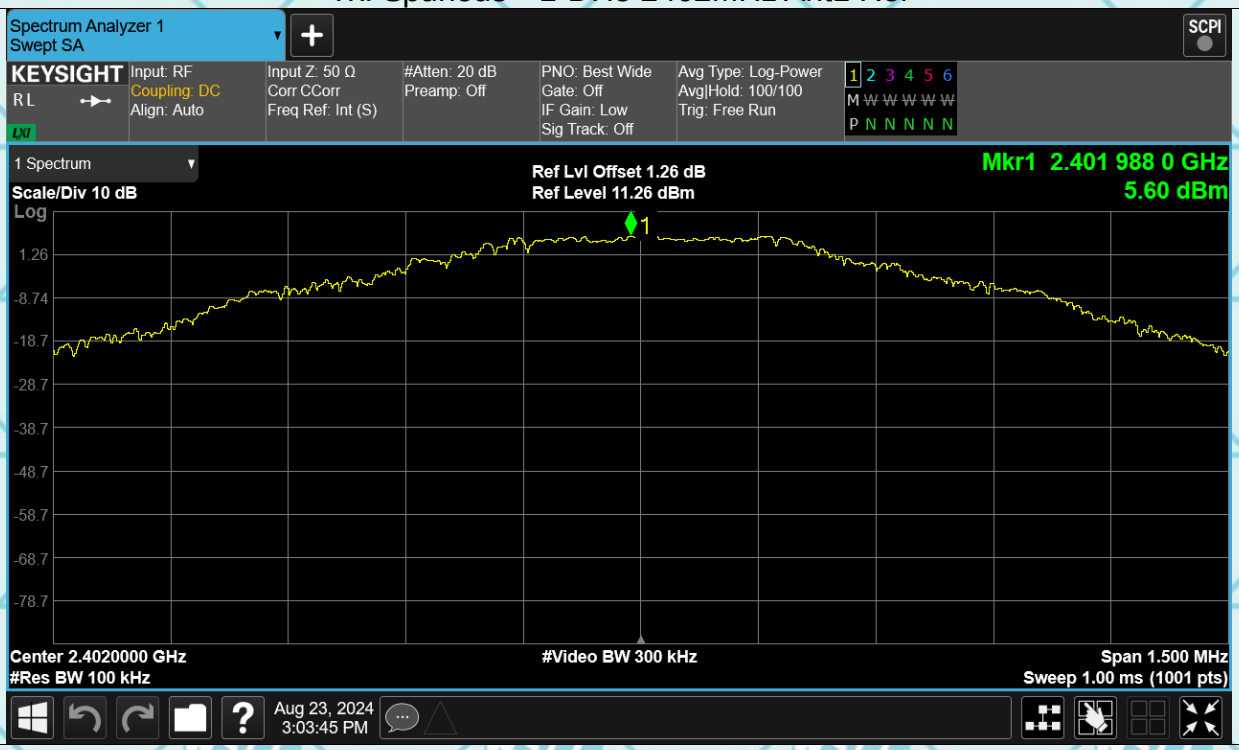
6.10.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2014
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious RF Conducted Emissions of ANSI C63.10:2014 Measurement Guidelines 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW. 5. Measure and record the results in the test report. 6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.
Test Result:	PASS

Test Data

Test Graphs

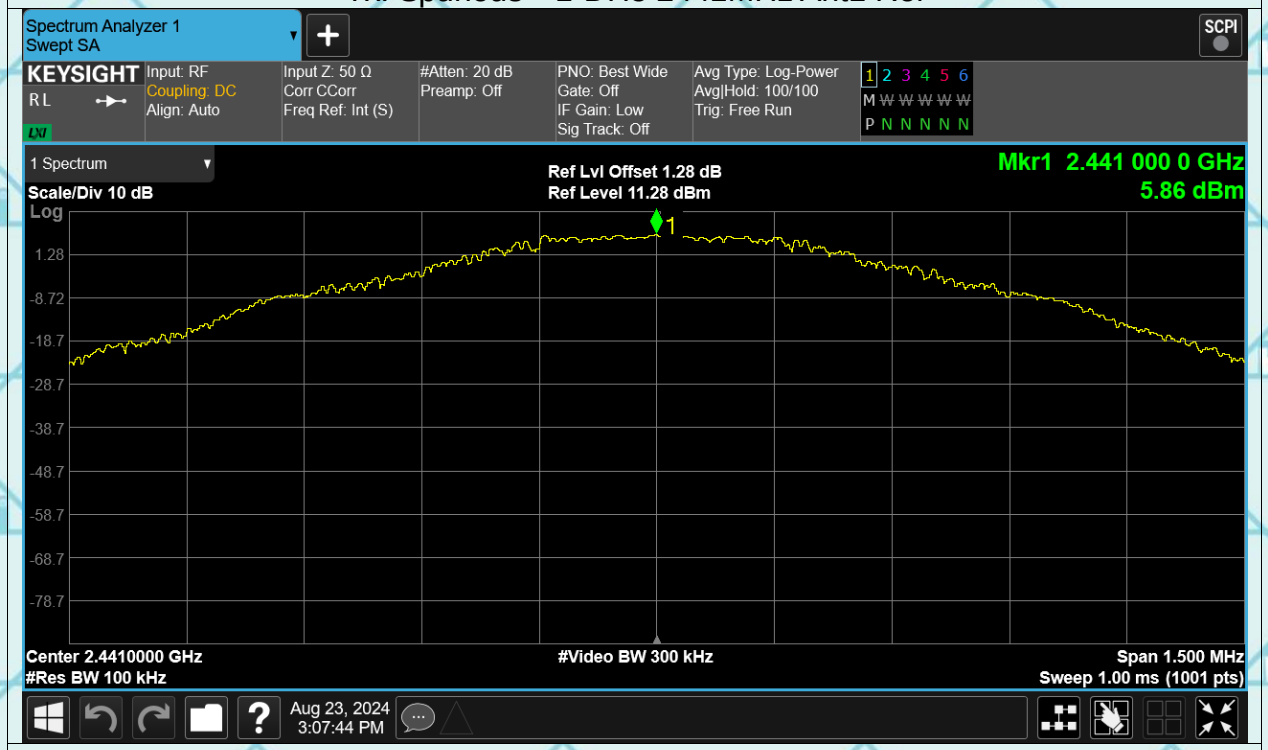
Tx. Spurious 1-DH5 2402MHz Ant1 Ref



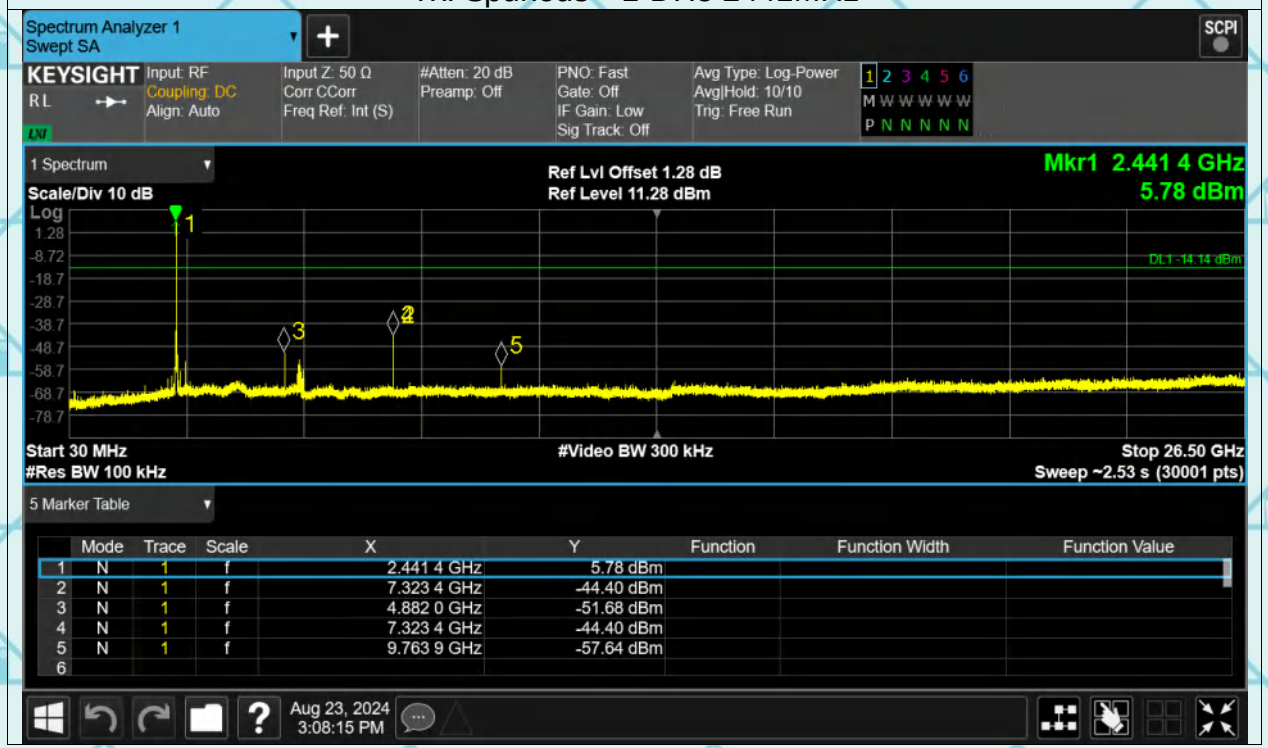
Tx. Spurious 1-DH5 2402MHz

	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.401 7 GHz	5.59 dBm			
2	N	1	f	4.804 3 GHz	-45.27 dBm			
3	N	1	f	4.804 3 GHz	-45.27 dBm			
4	N	1	f	7.206 0 GHz	-45.58 dBm			
5	N	1	f	9.607 7 GHz	-59.16 dBm			
6								

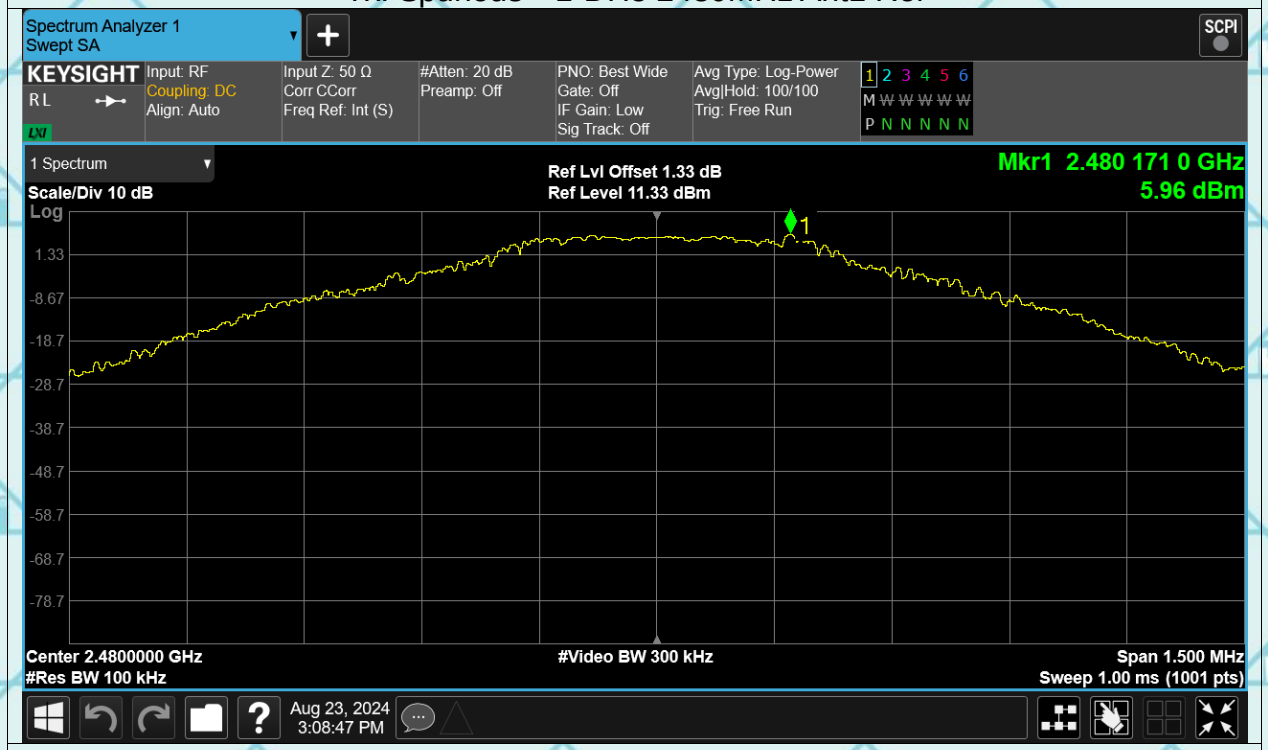
Tx. Spurious 1-DH5 2441MHz Ant1 Ref



Tx. Spurious 1-DH5 2441MHz

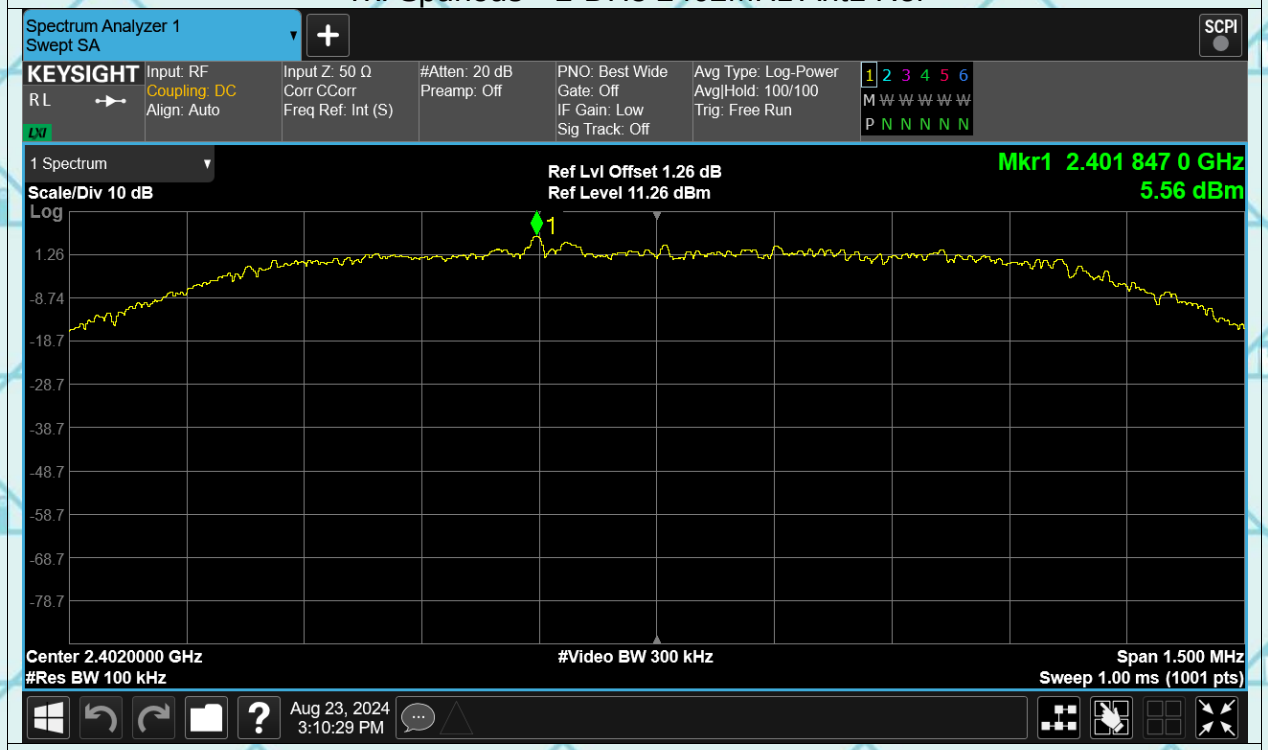


Tx. Spurious 1-DH5 2480MHz Ant1 Ref



Tx. Spurious 1-DH5 2480MHz

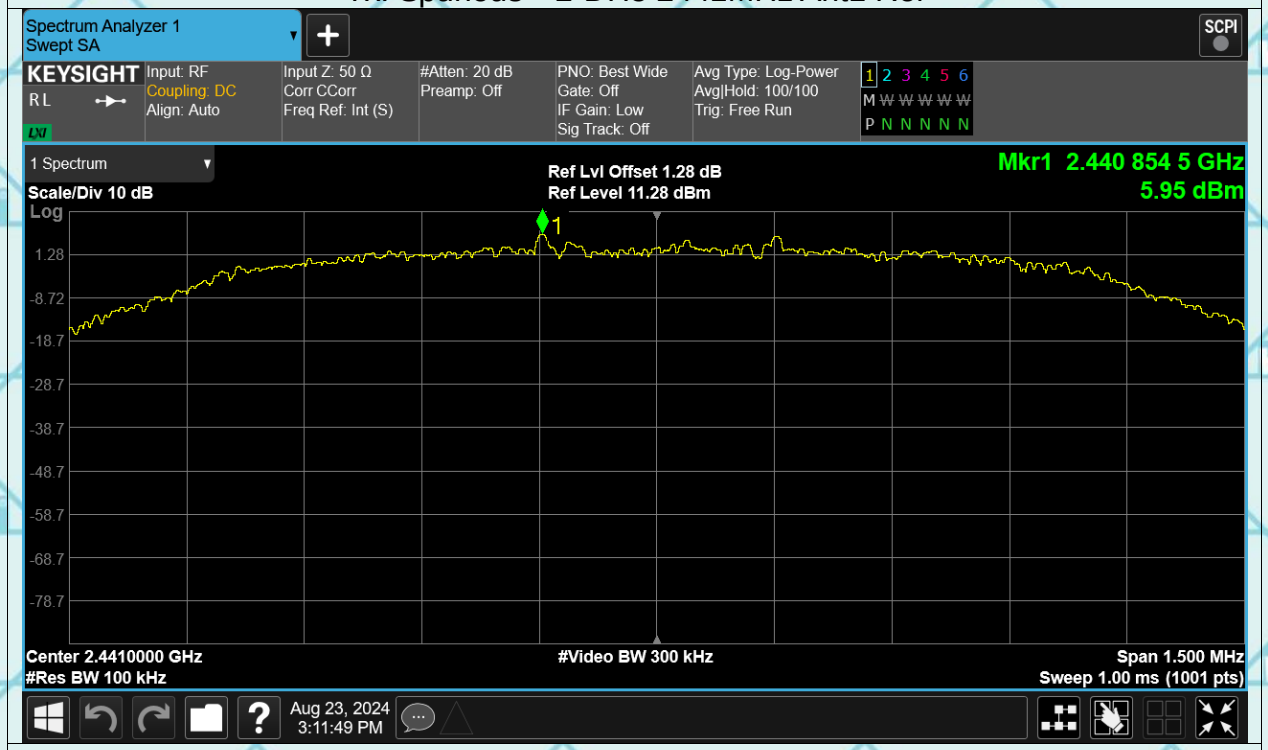
Tx. Spurious 2-DH5 2402MHz Ant1 Ref



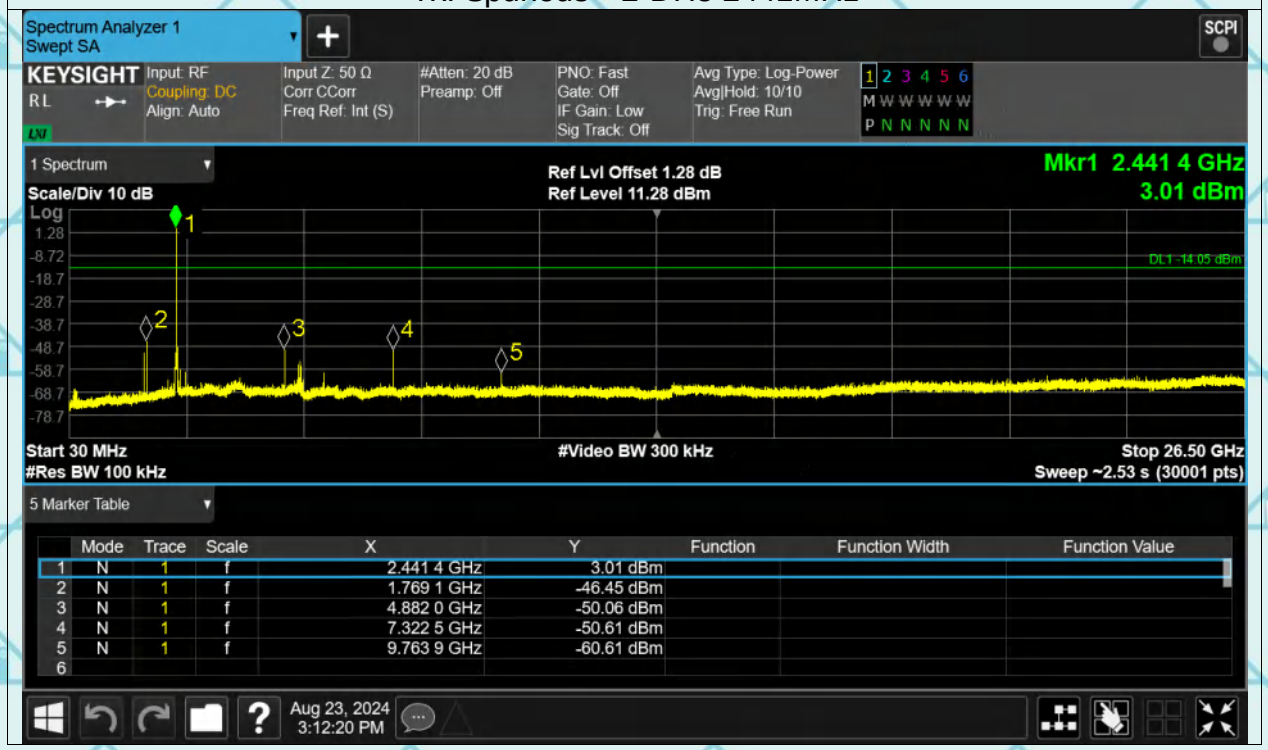
Tx. Spurious 2-DH5 2402MHz

	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.401 7 GHz	2.14 dBm			
2	N	1	f	4.804 3 GHz	-46.81 dBm			
3	N	1	f	4.804 3 GHz	-46.81 dBm			
4	N	1	f	7.206 0 GHz	-48.92 dBm			
5	N	1	f	9.607 7 GHz	-61.67 dBm			
6								

Tx. Spurious 2-DH5 2441MHz Ant1 Ref

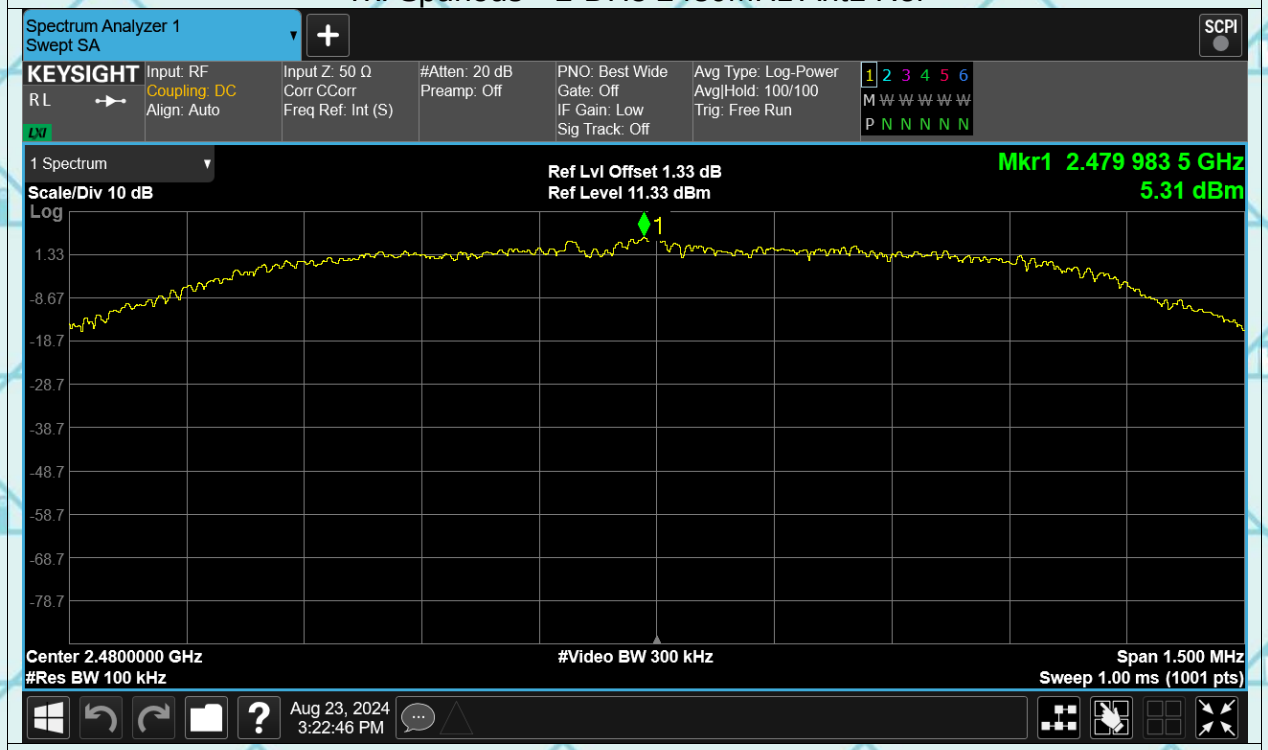


Tx. Spurious 2-DH5 2441MHz

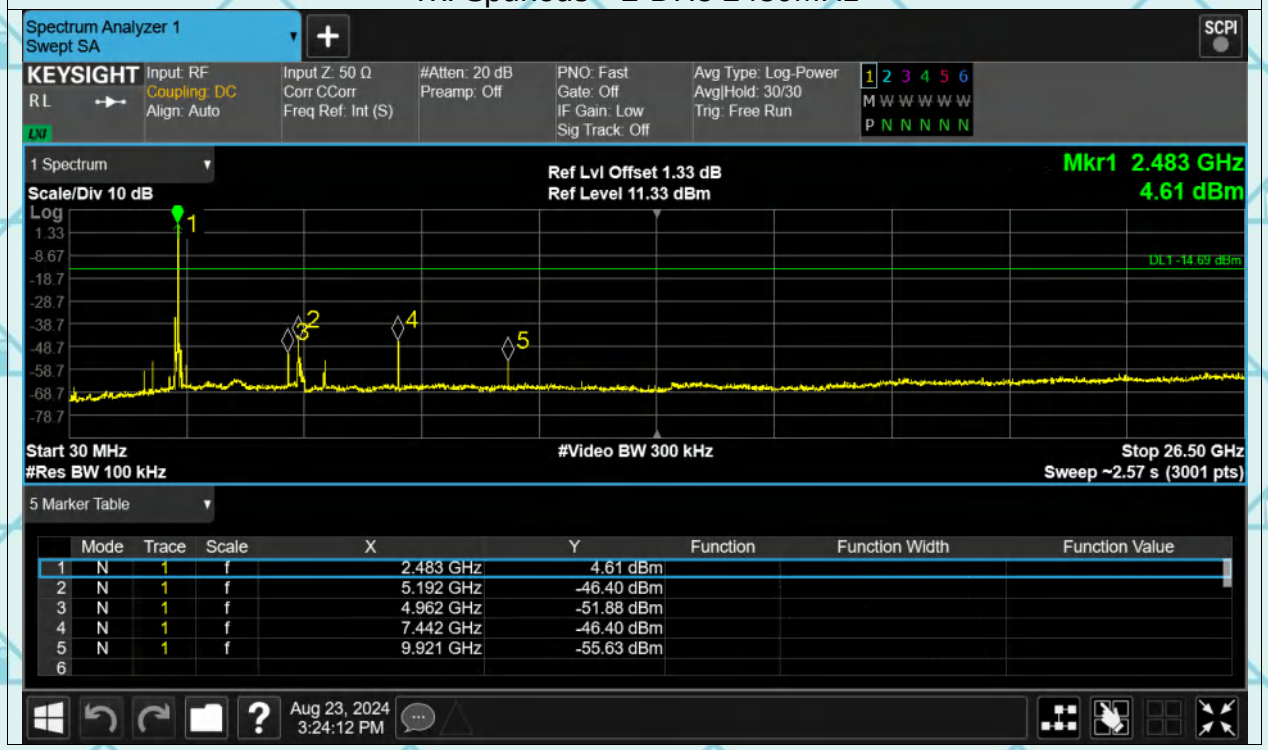


	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.441 4 GHz	3.01 dBm			
2	N	1	f	1.769 1 GHz	-46.45 dBm			
3	N	1	f	4.882 0 GHz	-50.06 dBm			
4	N	1	f	7.322 5 GHz	-50.61 dBm			
5	N	1	f	9.763 9 GHz	-60.61 dBm			
6								

Tx. Spurious 2-DH5 2480MHz Ant1 Ref

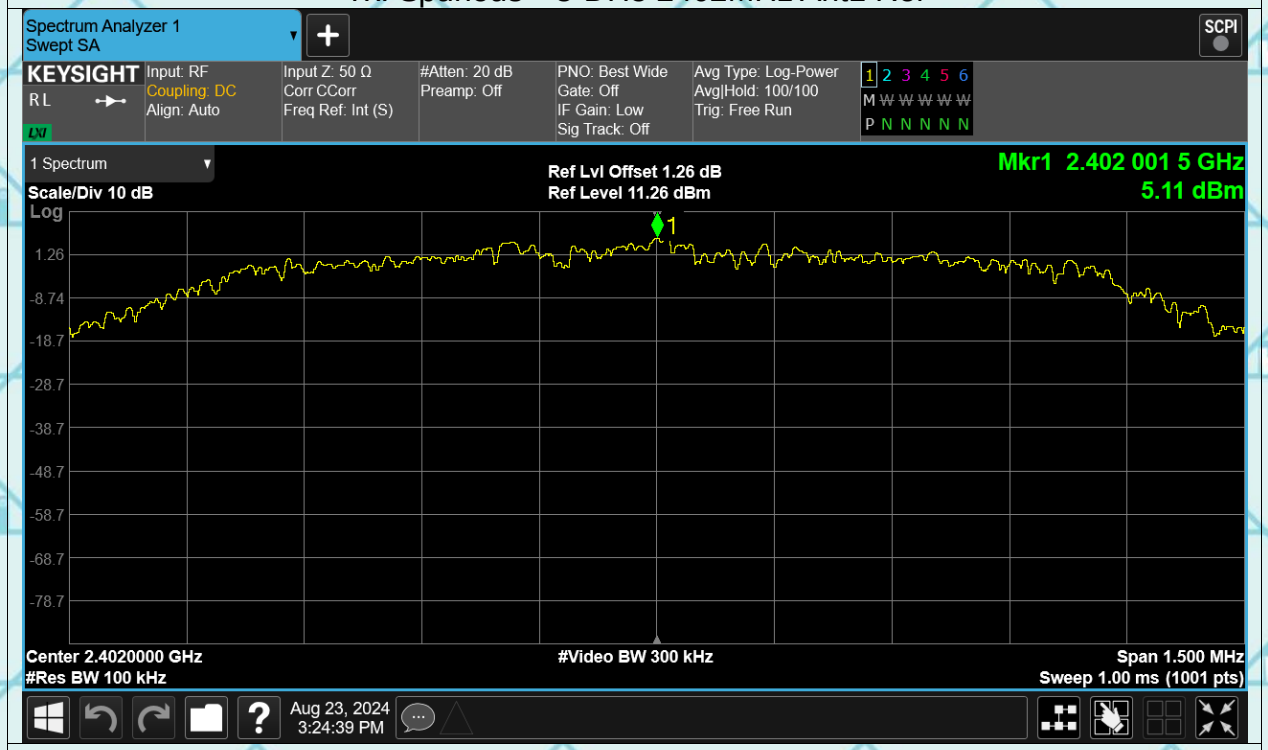


Tx. Spurious 2-DH5 2480MHz

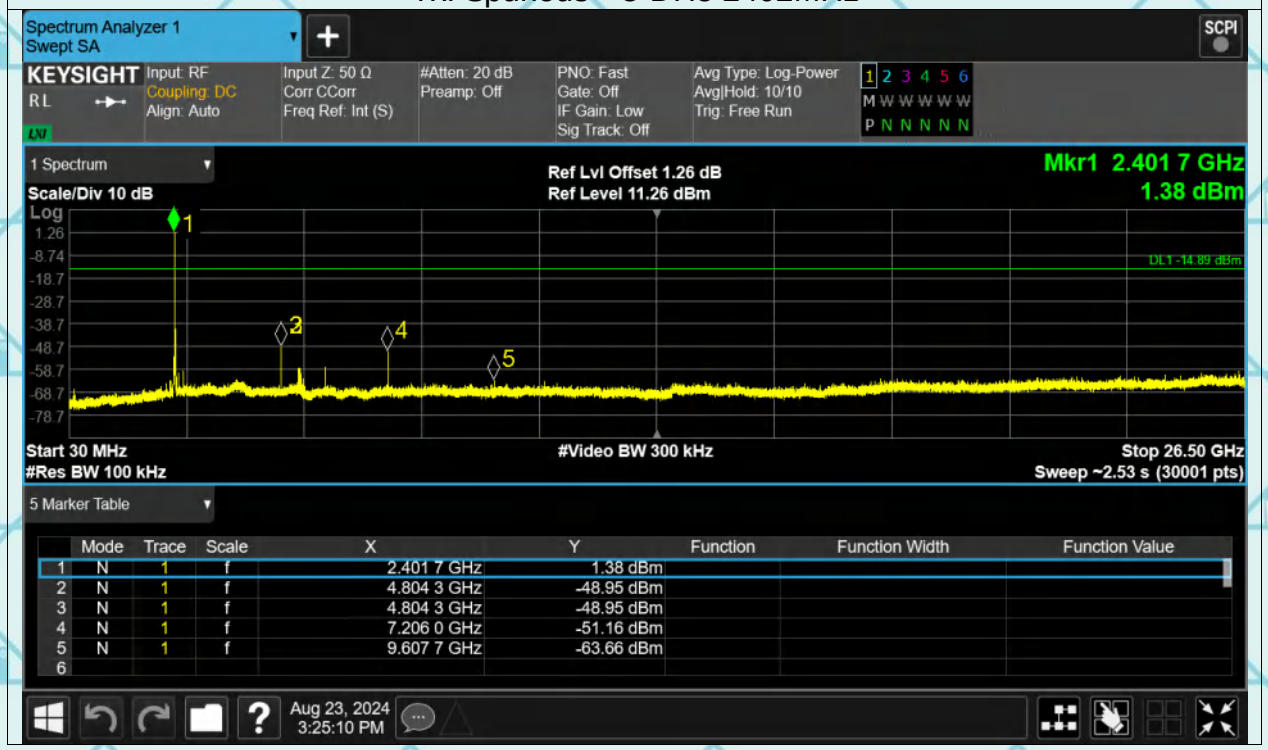


	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.483 GHz	4.61 dBm			
2	N	1	f	5.192 GHz	-46.40 dBm			
3	N	1	f	4.962 GHz	-51.88 dBm			
4	N	1	f	7.442 GHz	-46.40 dBm			
5	N	1	f	9.921 GHz	-55.63 dBm			
6								

Tx. Spurious 3-DH5 2402MHz Ant1 Ref

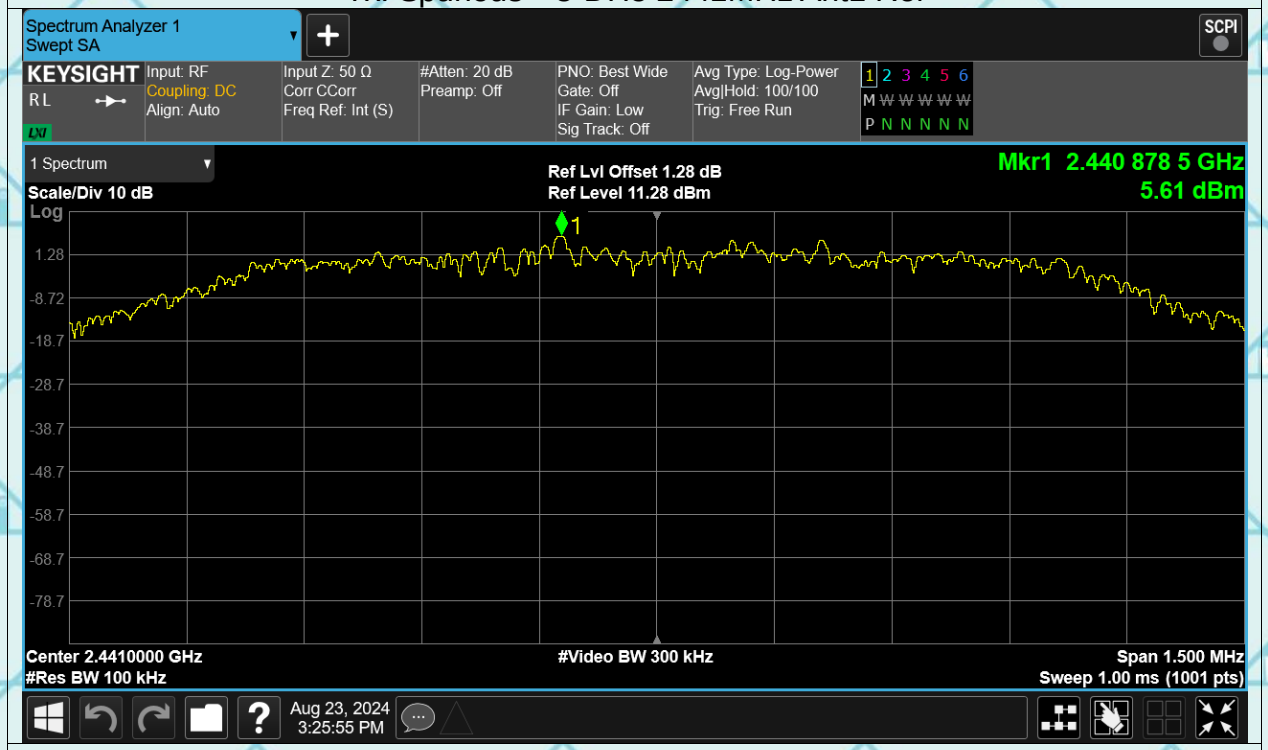


Tx. Spurious 3-DH5 2402MHz



	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.401 7 GHz	1.38 dBm			
2	N	1	f	4.804 3 GHz	-48.95 dBm			
3	N	1	f	4.804 3 GHz	-48.95 dBm			
4	N	1	f	7.206 0 GHz	-51.16 dBm			
5	N	1	f	9.607 7 GHz	-63.66 dBm			
6								

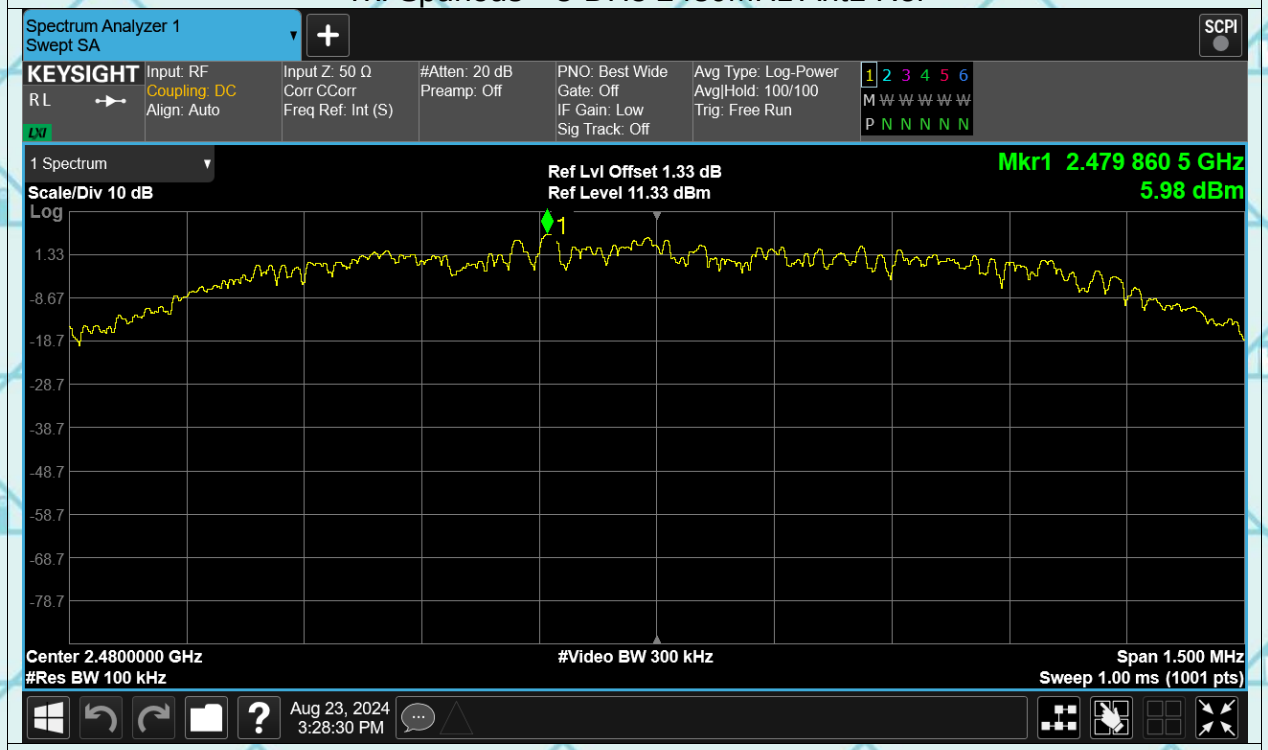
Tx. Spurious 3-DH5 2441MHz Ant1 Ref



Tx. Spurious 3-DH5 2441MHz

	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.440 5 GHz	2.20 dBm			
2	N	1	f	7.322 5 GHz	-45.11 dBm			
3	N	1	f	4.882 0 GHz	-52.33 dBm			
4	N	1	f	7.322 5 GHz	-45.11 dBm			
5	N	1	f	9.763 9 GHz	-59.00 dBm			
6								

Tx. Spurious 3-DH5 2480MHz Ant1 Ref



Tx. Spurious 3-DH5 2480MHz

	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.480 2 GHz	6.24 dBm			
2	N	1	f	7.440 7 GHz	-44.95 dBm			
3	N	1	f	4.959 6 GHz	-50.86 dBm			
4	N	1	f	7.440 7 GHz	-44.95 dBm			
5	N	1	f	9.920 1 GHz	-56.06 dBm			
6								

6.11. Radiated Spurious Emission Measurement

6.11.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.209
Test Method:	ANSI C63.10:2014
Frequency Range:	9 kHz to 25 GHz
Measurement Distance:	3 m
Antenna Polarization:	Horizontal & Vertical

Receiver Setup:

Frequency	Detector	RBW	VBW	Remark
9kHz- 150kHz	Quasi-peak	200Hz	1kHz	Quasi-peak Value
150kHz-30MHz	Quasi-peak	9kHz	30kHz	Quasi-peak Value
30MHz-1GHz	Quasi-peak	100KHz	300KHz	Quasi-peak Value
Above 1GHz	Peak	1MHz	3MHz	Peak Value
	Peak	1MHz	10Hz	Average Value

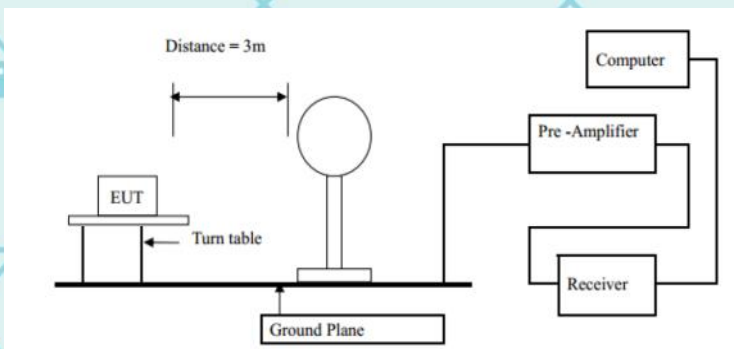
Limit:

Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009-0.490	2400/F(KHz)	300
0.490-1.705	24000/F(KHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

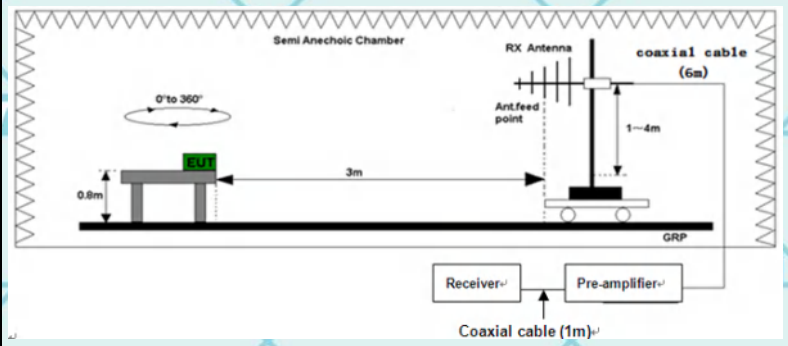
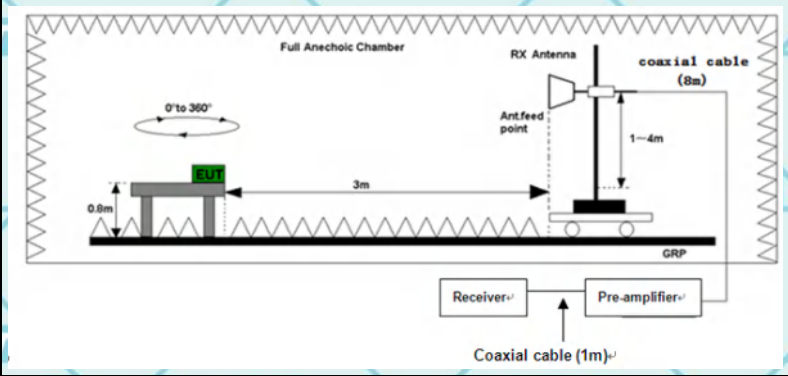
Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Detector
Above 1GHz	500	3	Average
	5000	3	Peak

Test setup:

For radiated emissions below 30MHz



30MHz to 1GHz

	 Above 1GHz 
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious Radiated Emissions of ANSI C63.10:2014 Measurement Guidelines. 2. For the radiated emission test below 1GHz: The EUT was placed on a turntable with 0.8 meter above ground. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high PASS filter are used for the test in order to get better signal level. For the radiated emission test above 1GHz: Place the measurement antenna on a turntable with 1.5 meter above ground, which is away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final

	measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Use the following spectrum analyzer settings: (1) Span shall wide enough to fully capture the emission being measured; (2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak (3) For average measurement: use duty cycle correction factor method per 15.35(c). Duty cycle = On time/100 milliseconds On time =N1*L1+N2*L2+...+Nn-1*LNn-1+Nn*Ln Where N1 is number of type 1 pulses, L1 is length of type 1 pulses, etc. Average Emission Level = Peak Emission Level + 20*log(Duty cycle) Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
Test results:	PASS

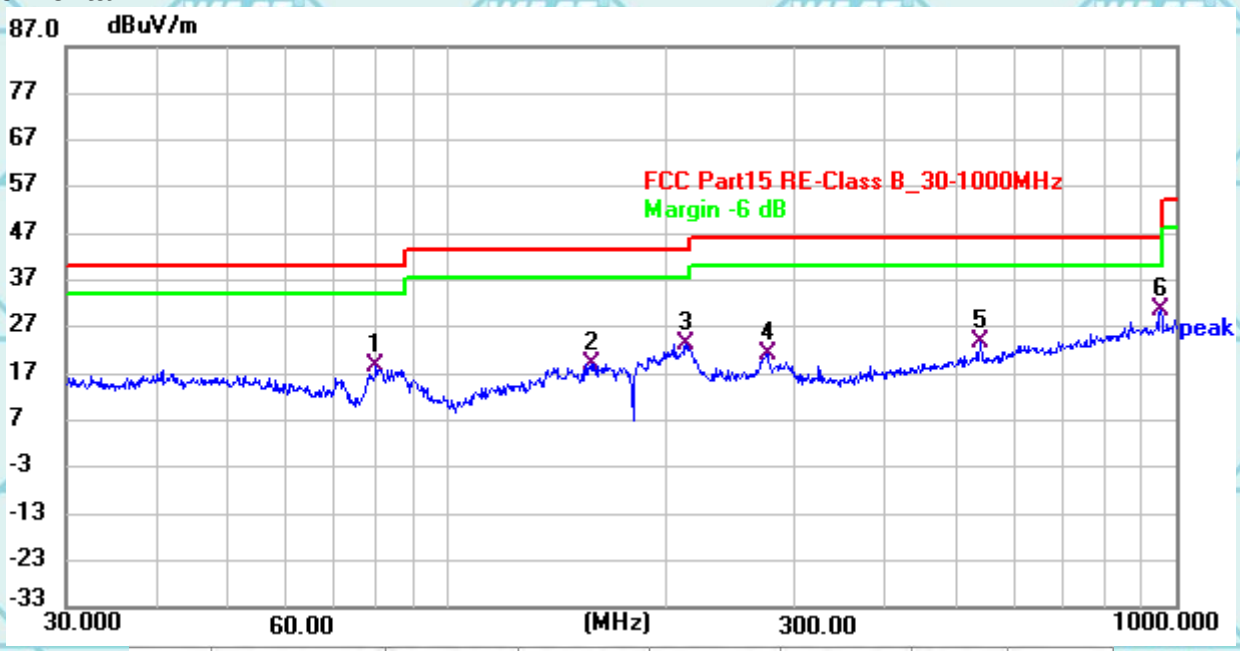
6.11.2. Test Data

Please refer to following diagram for individual

Below 1GHz

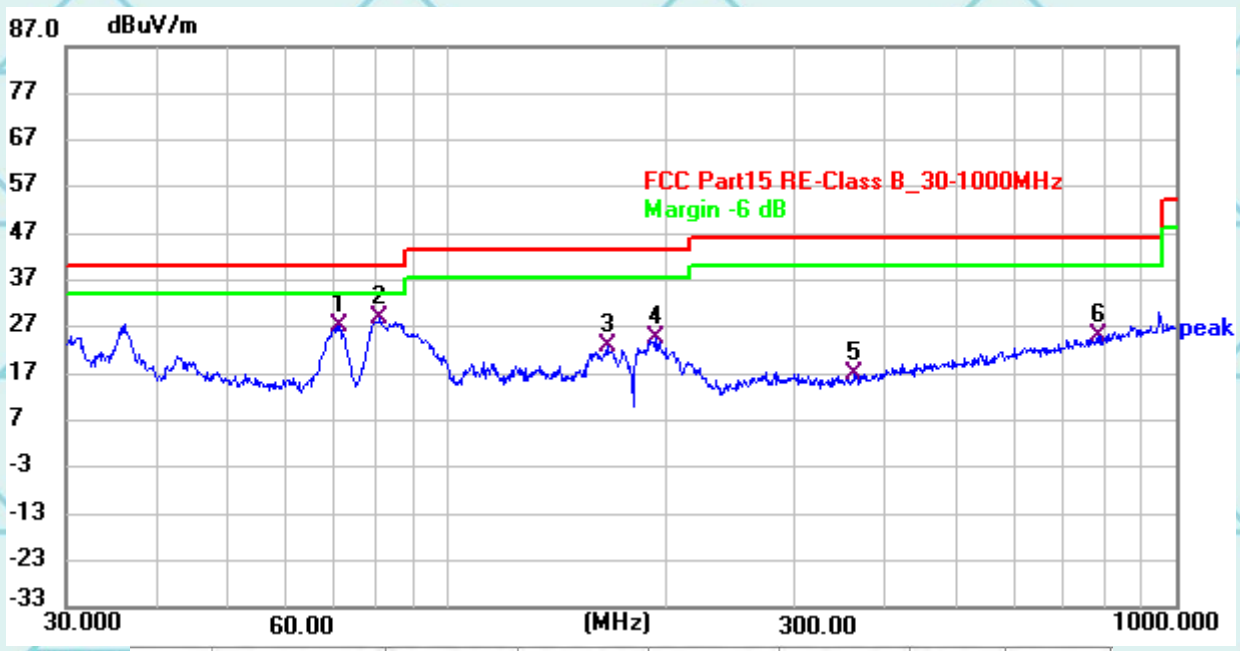
The worst mode is GFSK

Horizontal:



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	79.9053	42.80	-23.96	18.84	40.00	-21.16	QP
2	158.2510	38.82	-19.58	19.24	43.50	-24.26	QP
3	212.8285	47.61	-24.07	23.54	43.50	-19.96	QP
4	276.1235	42.22	-21.15	21.07	46.00	-24.93	QP
5	540.1874	38.81	-15.02	23.79	46.00	-22.21	QP
6 *	952.9287	40.11	-9.32	30.79	46.00	-15.21	QP

Vertical:



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	71.2363	49.81	-22.42	27.39	40.00	-12.61	QP
2 *	81.1406	52.98	-24.07	28.91	40.00	-11.09	QP
3	166.4324	43.21	-20.16	23.05	43.50	-20.45	QP
4	193.8577	47.62	-23.19	24.43	43.50	-19.07	QP
5	363.3028	35.83	-18.95	16.88	46.00	-29.12	QP
6	783.7182	36.36	-11.21	25.15	46.00	-20.85	QP

Note1:
Freq. = Emission frequency in MHz
Reading level (dBμV) = Receiver reading
Corr. Factor (dB) = Antenna factor + Cable loss - Amplifier factor.
Measurement (dBμV) = Reading level (dBμV) + Corr. Factor (dB)
Limit (dBμV) = Limit stated in standard
Margin (dB) = Measurement (dBμV) – Limits (dBμV)

Above 1GHz

Note 1: The marked spikes near 2400 MHz with circle should be ignored because they are Fundamental signal.

Note 2: The spurious above 18G is noise only, do not show on the report.
The worst mode is GFSK

Low channel: 2402MHz

Horizontal:

Susputed Data List

NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	1766.8750	51.12	24.98	26.14	74	-22.88	359	Horizontal	PK	Pass
1	1766.8750	30.98	24.98	6	54	-23.02	359	Horizontal	AV	Pass
2	3515.6250	55.71	28.54	27.17	74	-18.29	175.6	Horizontal	PK	Pass
2	3515.6250	37.55	28.54	9.01	54	-16.45	175.6	Horizontal	AV	Pass
3	5913.7500	57.36	32.66	24.7	74	-16.64	307.1	Horizontal	PK	Pass
3	5913.7500	47.79	32.66	15.13	54	-6.21	307.1	Horizontal	AV	Pass
4	8713.5000	42.58	9.34	33.24	74	-31.42	210.8	Horizontal	PK	Pass
4	8713.5000	34.46	9.34	25.12	54	-19.54	210.8	Horizontal	AV	Pass
5	12100.5000	47.04	16.68	30.36	74	-26.96	351.1	Horizontal	PK	Pass
5	12100.5000	38.85	16.68	22.17	54	-15.15	351.1	Horizontal	AV	Pass
6	17955.0000	53.77	23.61	30.16	74	-20.23	360	Horizontal	PK	Pass
6	17955.0000	46.57	23.61	22.96	54	-7.43	360	Horizontal	AV	Pass

Vertical:

Susputed Data List

NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	2405.0000	46.49	27.28	19.21	74	-27.51	200.6	Vertical	PK	Pass
1	2405.0000	37.45	27.28	10.17	54	-16.55	200.6	Vertical	AV	Pass
2	3596.8750	51.32	28.73	22.59	74	-22.68	323.7	Vertical	PK	Pass
2	3596.8750	38.19	28.73	9.46	54	-15.81	323.7	Vertical	AV	Pass
3	5657.5000	56.86	32.25	24.61	74	-17.14	121.7	Vertical	PK	Pass
3	5657.5000	48.01	32.25	15.76	54	-5.99	121.7	Vertical	AV	Pass
4	9079.5000	43.65	9.91	33.74	74	-30.35	4.6	Vertical	PK	Pass
4	9079.5000	35.39	9.91	25.48	54	-18.61	4.6	Vertical	AV	Pass
5	13606.5000	50.16	17.99	32.17	74	-23.84	289.8	Vertical	PK	Pass
5	13606.5000	42.36	17.99	24.37	54	-11.64	289.8	Vertical	AV	Pass
6	17908.5000	53.16	23.32	29.84	74	-20.84	1.7	Vertical	PK	Pass
6	17908.5000	46.28	23.32	22.96	54	-7.72	1.7	Vertical	AV	Pass

Middle channel: 2440MHz

Horizontal:

Susputed Data List

NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	2446.8750	46.37	27.42	18.95	74	-27.63	165.2	Horizontal	PK	Pass
1	2446.8750	37.69	27.42	10.27	54	-16.31	165.2	Horizontal	AV	Pass
2	3503.7500	52.72	28.51	24.21	74	-21.28	178.3	Horizontal	PK	Pass
2	3503.7500	37.72	28.51	9.21	54	-16.28	178.3	Horizontal	AV	Pass
3	5986.2500	56.73	32.78	23.95	74	-17.27	115	Horizontal	PK	Pass
3	5986.2500	47.32	32.78	14.54	54	-6.68	115	Horizontal	AV	Pass
4	7275.0000	56.68	6.9	49.78	74	-17.32	83	Horizontal	PK	Pass
4	7275.0000	33.83	6.9	26.93	54	-20.17	83	Horizontal	AV	Pass
5	9834.0000	48.93	11.98	36.95	74	-25.07	105.8	Horizontal	PK	Pass
5	9834.0000	36.26	11.98	24.28	54	-17.74	105.8	Horizontal	AV	Pass
6	17992.5000	53.36	23.88	29.48	74	-20.64	139.2	Horizontal	PK	Pass
6	17992.5000	46.92	23.88	23.04	54	-7.08	139.2	Horizontal	AV	Pass

Vertical:

Susputed Data List

NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	2438.1250	50.83	27.39	23.44	74	-23.17	67.8	Vertical	PK	Pass
1	2438.1250	38.17	27.39	10.78	54	-15.83	67.8	Vertical	AV	Pass
2	3522.5000	53.03	28.55	24.48	74	-20.97	27.3	Vertical	PK	Pass
2	3522.5000	37.6	28.55	9.05	54	-16.4	27.3	Vertical	AV	Pass
3	5667.5000	56.94	32.27	24.67	74	-17.06	100.2	Vertical	PK	Pass
3	5667.5000	47.69	32.27	15.42	54	-6.31	100.2	Vertical	AV	Pass
4	8397.0000	42.52	9.09	33.43	74	-31.48	331.6	Vertical	PK	Pass
4	8397.0000	34.96	9.09	25.87	54	-19.04	331.6	Vertical	AV	Pass
5	11968.5000	46.64	16.74	29.9	74	-27.36	2.4	Vertical	PK	Pass
5	11968.5000	39.47	16.74	22.73	54	-14.53	2.4	Vertical	AV	Pass
6	17937.0000	53.75	23.5	30.25	74	-20.25	157	Vertical	PK	Pass
6	17937.0000	46.42	23.5	22.92	54	-7.58	157	Vertical	AV	Pass

High channel: 2480MHz

Horizontal:

Susputed Data List

NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	2438.1250	47.53	27.39	20.14	74	-26.47	114.4	Horizontal	PK	Pass
1	2438.1250	37.69	27.39	10.3	54	-16.31	114.4	Horizontal	AV	Pass
2	4861.2500	52.46	31.32	21.14	74	-21.54	359.5	Horizontal	PK	Pass
2	4861.2500	43.07	31.32	11.75	54	-10.93	359.5	Horizontal	AV	Pass
3	5921.8750	56.6	32.67	23.93	74	-17.4	358.8	Horizontal	PK	Pass
3	5921.8750	47.86	32.67	15.19	54	-6.14	358.8	Horizontal	AV	Pass
4	8175.0000	41.73	8.68	33.05	74	-32.27	171.5	Horizontal	PK	Pass
4	8175.0000	34.66	8.68	25.98	54	-19.34	171.5	Horizontal	AV	Pass
5	10831.5000	46.27	14.82	31.45	74	-27.73	307.8	Horizontal	PK	Pass
5	10831.5000	38.36	14.82	23.54	54	-15.64	307.8	Horizontal	AV	Pass
6	17986.5000	53.31	23.83	29.48	74	-20.69	251.6	Horizontal	PK	Pass
6	17986.5000	46.69	23.83	22.86	54	-7.31	251.6	Horizontal	AV	Pass

Vertical:

Susputed Data List										
NO.	Freq. [MHz]	Reading [dB(uV)]	Factor [dB]	Level [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	2435.6250	47.25	27.38	19.87	74	-26.75	63	Vertical	PK	Pass
1	2435.6250	37.67	27.38	10.29	54	-16.33	63	Vertical	AV	Pass
2	3928.1250	50.61	29.53	21.08	74	-23.39	22.5	Vertical	PK	Pass
2	3928.1250	40.76	29.53	11.23	54	-13.24	22.5	Vertical	AV	Pass
3	5938.1250	56.99	32.7	24.29	74	-17.01	53.5	Vertical	PK	Pass
3	5938.1250	48.08	32.7	15.38	54	-5.92	53.5	Vertical	AV	Pass
4	8499.0000	42.09	9.22	32.87	74	-31.91	55.4	Vertical	PK	Pass
4	8499.0000	34.93	9.22	25.71	54	-19.07	55.4	Vertical	AV	Pass
5	11562.0000	47.1	16.2	30.9	74	-26.9	122.4	Vertical	PK	Pass
5	11562.0000	39.19	16.2	22.99	54	-14.81	122.4	Vertical	AV	Pass
6	17964.0000	53.95	23.67	30.28	74	-20.05	37.5	Vertical	PK	Pass
6	17964.0000	46.8	23.67	23.13	54	-7.2	37.5	Vertical	AV	Pass

Note:

1. *The emission levels of other frequencies are very lower than the limit and not show in test report.*
2. *Measurements were conducted from 1 GHz to the 10th harmonic of highest fundamental frequency.*
3. *Data of measurement shown "---"in the above table mean that the reading of emissions is attenuated more than 20 dB below the limits or the field strength is too small to be measured.*
4. *Measurements were conducted in all three modulation (GFSK, Pi/4 DQPSK, 8DPSK), and the worst case Mode (GFSK) was submitted only.*

*******END OF REPORT*******