

5. -20 dB Bandwidth Measurement

5.1. Limit

Test Requirement: FCC CFR47 Part 15 Section 15.247

Test Method: KDB 558074 D01 15.247 Meas Guidance v05r02 April 2, 2019; ANSI C63.10-2020 + Cor. 1-2023+C63.10a-2024 + Errata to C63.10a-2024

5.2. Test Setup



5.3. Test Procedure

For 20dB Bandwidth Measurement

Using the following spectrum analyzer settings:

1. Span= approximately 2 to 3 times the 20dB bandwidth, centered on a hopping channel.
2. Set the RBW = 30 kHz.
3. Set the VBW = 100 kHz.
4. Sweep time = auto couple.
5. Detector function = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.

For 99% Bandwidth Measurement

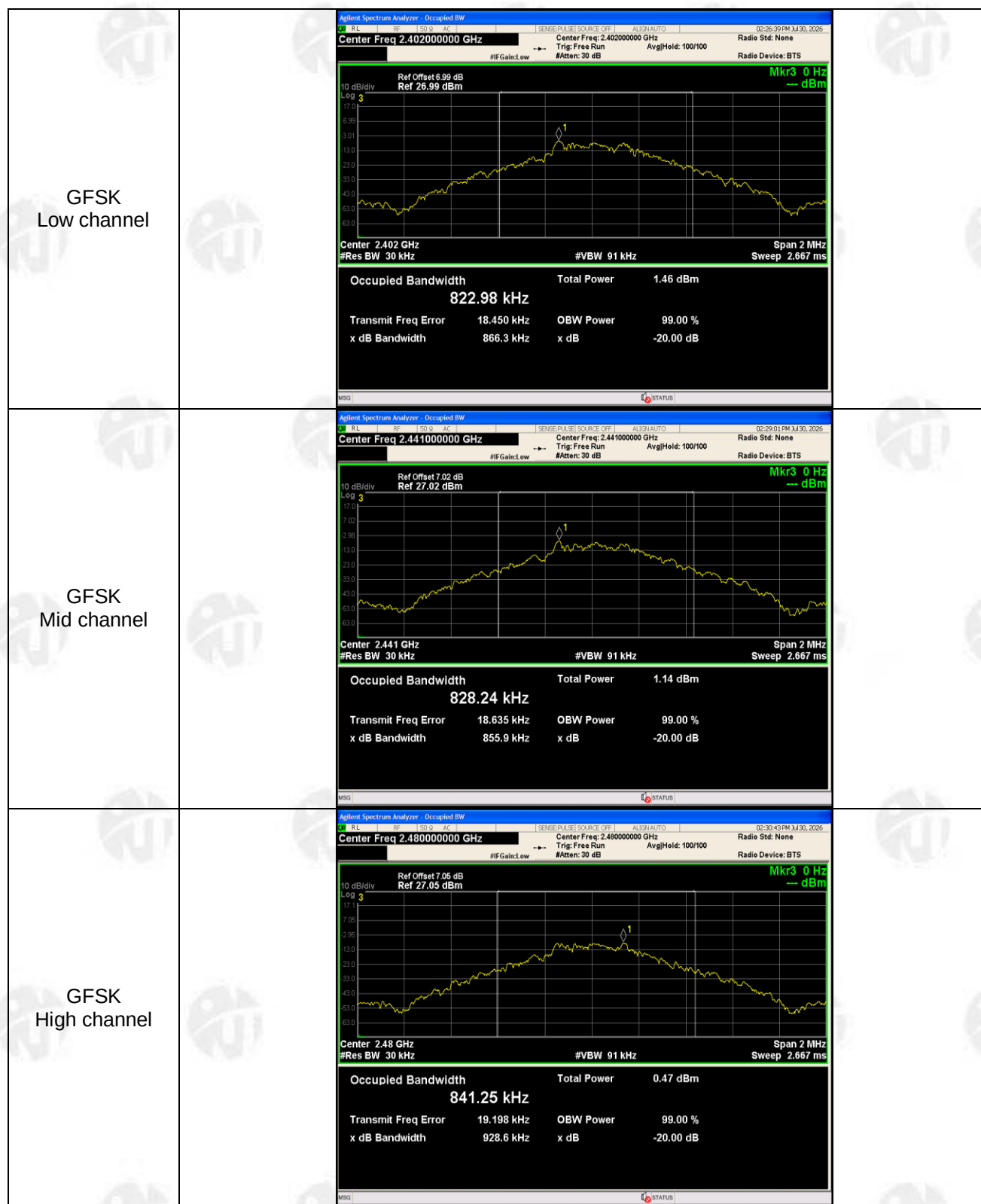
1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;
2. Set the spectrum analyzer: RBW = 1%-5% OBW, VBW ≥ 3RBW

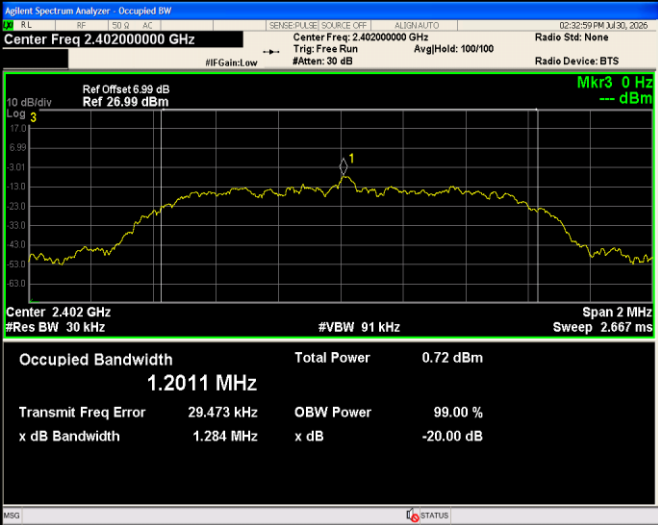
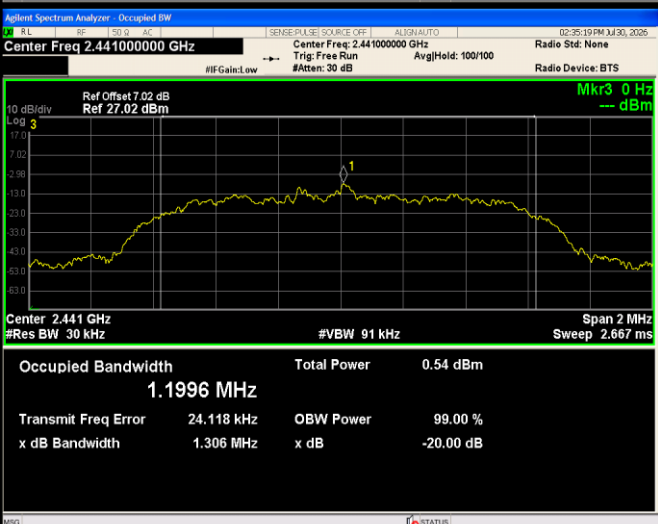
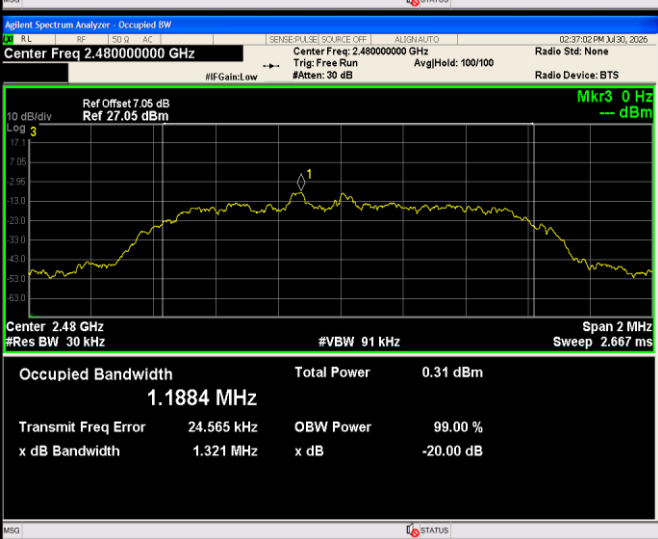
5.4. Test Result

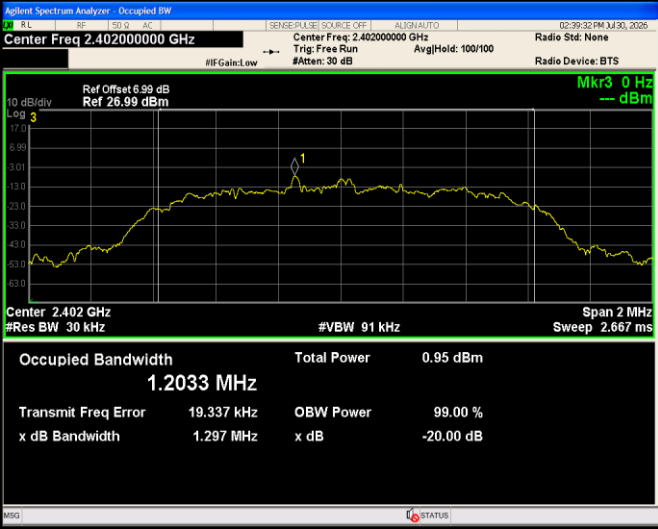
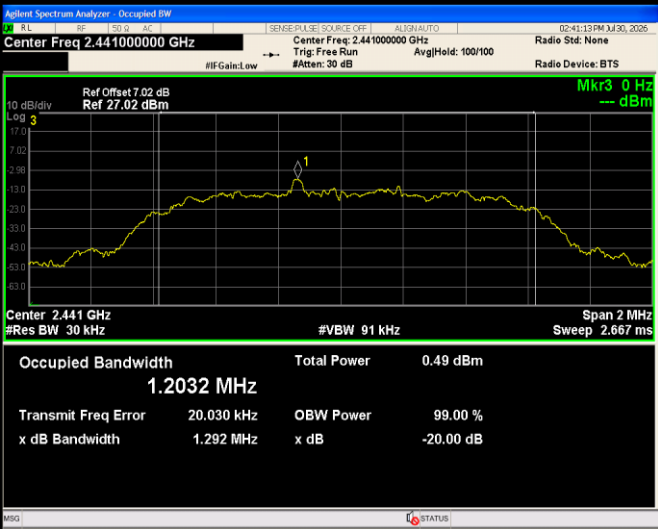
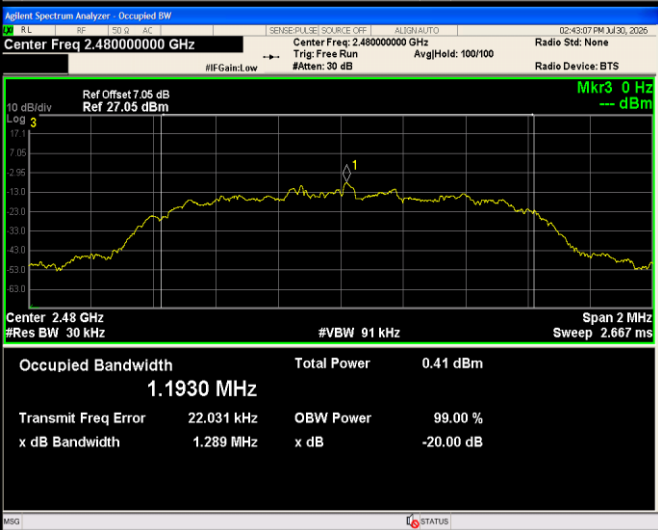
Test Mode	Frequency	20dB Bandwidth (MHz)	Result
GFSK	Low channel	0.866	PASS
	Mid channel	0.856	PASS
	High channel	0.929	PASS
$\pi/4$ DQPSK	Low channel	1.284	PASS
	Mid channel	1.306	PASS
	High channel	1.321	PASS
8DPSK	Low channel	1.297	PASS
	Mid channel	1.292	PASS
	High channel	1.289	PASS

Note: All modes of operation were Pre-scan and the worst-case emissions are reported.

Test Graph:



$\pi/4$-DQPSK Low channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.40200000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.2011 MHz Total Power: 0.72 dBm Transmit Freq Error: 29.473 kHz OBW Power: 99.00 % x dB Bandwidth: 1.284 MHz x dB: -20.00 dB
$\pi/4$-DQPSK Mid channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.44100000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.1996 MHz Total Power: 0.54 dBm Transmit Freq Error: 24.118 kHz OBW Power: 99.00 % x dB Bandwidth: 1.306 MHz x dB: -20.00 dB
$\pi/4$-DQPSK High channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.48000000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.1884 MHz Total Power: 0.31 dBm Transmit Freq Error: 24.565 kHz OBW Power: 99.00 % x dB Bandwidth: 1.321 MHz x dB: -20.00 dB

8DPSK Low channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.40200000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.2033 MHz Total Power: 0.95 dBm Transmit Freq Error: 19.337 kHz OBW Power: 99.00 % x dB Bandwidth: 1.297 MHz x dB: -20.00 dB
8DPSK Mid channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.44100000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.2032 MHz Total Power: 0.49 dBm Transmit Freq Error: 20.030 kHz OBW Power: 99.00 % x dB Bandwidth: 1.292 MHz x dB: -20.00 dB
8DPSK High channel	 Agilent Spectrum Analyzer - Occupied BW Center Freq: 2.48000000 GHz Span: 2 MHz Res BW: 30 kHz Occupied Bandwidth: 1.1930 MHz Total Power: 0.41 dBm Transmit Freq Error: 22.031 kHz OBW Power: 99.00 % x dB Bandwidth: 1.289 MHz x dB: -20.00 dB

6. Carrier Frequency Separation Test

6.1. Limit

Test Standard	FCC Part15 C Section 15.247 (a)(1)
Test Limit	>25KHz or >two-thirds of the 20 dB bandwidth

6.2. Test Setup



6.3. Test Procedure

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

1. Span= Wide enough to capture the peaks of two adjacent channels
2. Set the RBW = 300 kHz.
3. Set the VBW = 1 MHz.
4. Sweep time = auto couple.
5. Detector function = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.

6.4. Test Result

Mode	Channel.	Carrier Frequency Separation [MHz]	Limit(2/3 of the 20dB bandwidth MHz)	Verdict
GFSK	LCH	1.002	0.578	PASS
GFSK	MCH	0.996	0.571	PASS
GFSK	HCH	0.998	0.619	PASS
$\pi/4$ DQPSK	LCH	0.996	0.856	PASS
$\pi/4$ DQPSK	MCH	1.000	0.870	PASS
$\pi/4$ DQPSK	HCH	1.004	0.880	PASS
8DPSK	LCH	1.002	0.865	PASS
8DPSK	MCH	1.004	0.862	PASS
8DPSK	HCH	1.004	0.859	PASS

Test Graph

Graphs

GFSK/LCH

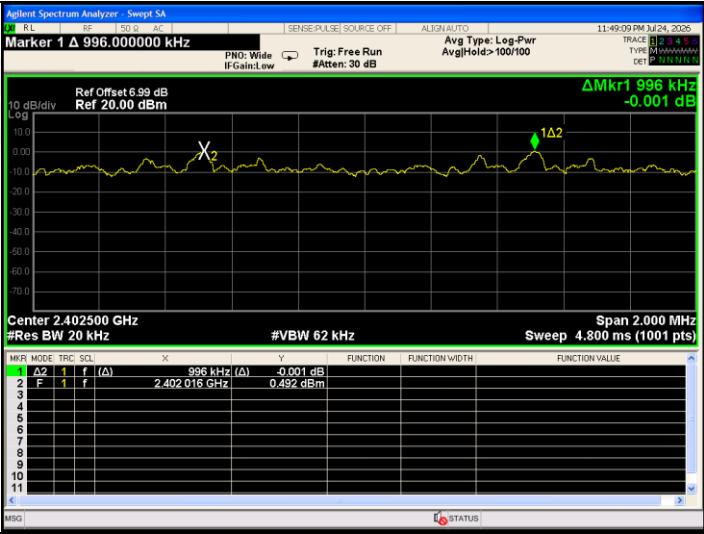
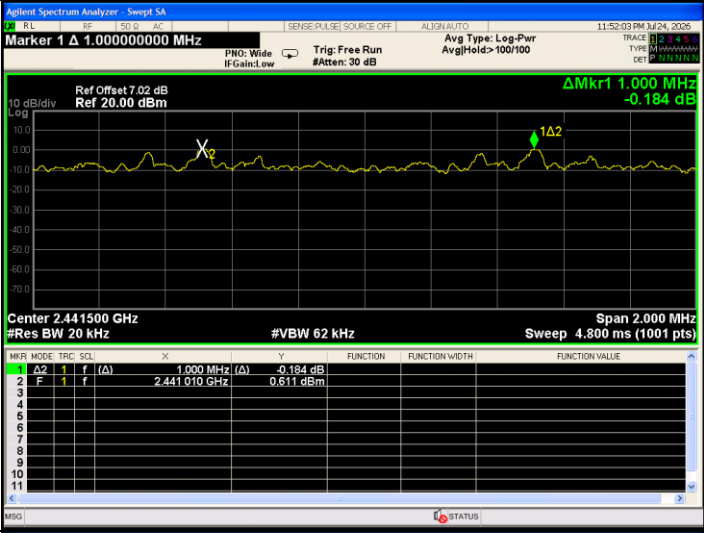
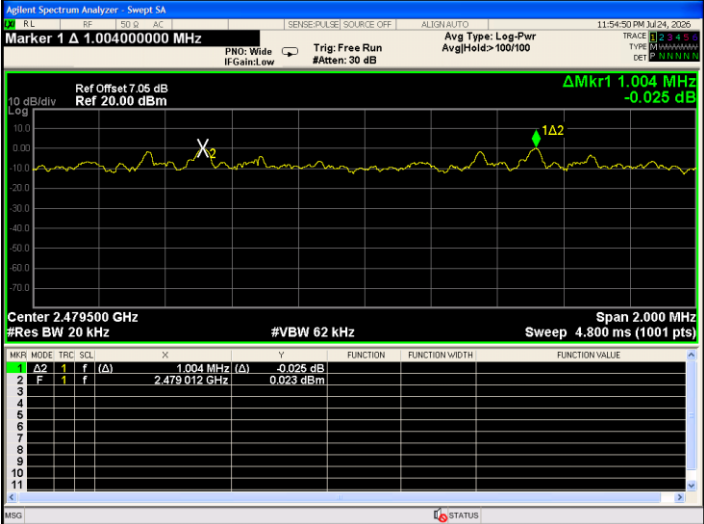


GFSK/MCH

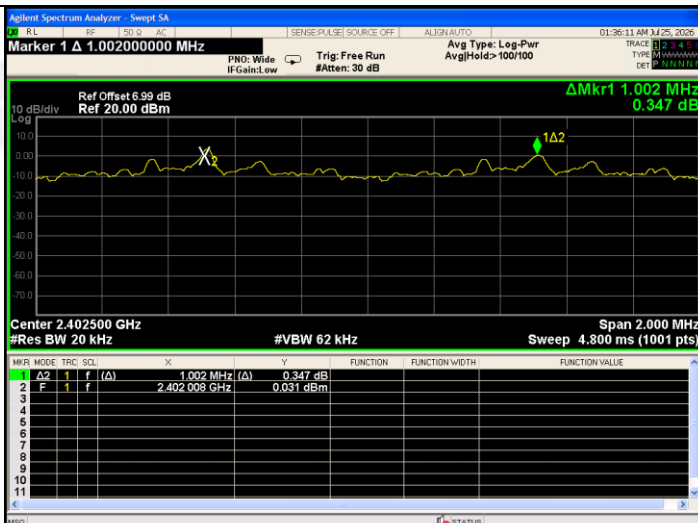


GFSK/HCH

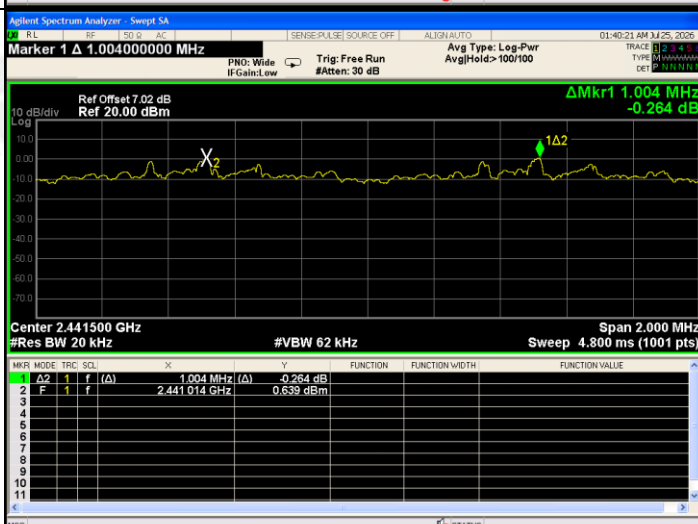


$\pi/4$DQPSK/LCH	
$\pi/4$DQPSK/MCH	
$\pi/4$DQPSK/HCH	

8DPSK/LCH



8DPSK /MCH



8DPSK /HCH



7. Number of Hopping Channel Test

7.1. Limit

Test Standard	FCC Part15 C Section 15.247 (a)(1)(iii)
Test Limit	>15 channels

7.2. Test Setup



7.3. Test Procedure

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

1. Span= Wide enough to capture the peaks of two adjacent channels
2. Set the RBW = 100 kHz.
3. Set the VBW = 300 kHz.
4. Sweep time = auto couple.
5. Detector function = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.

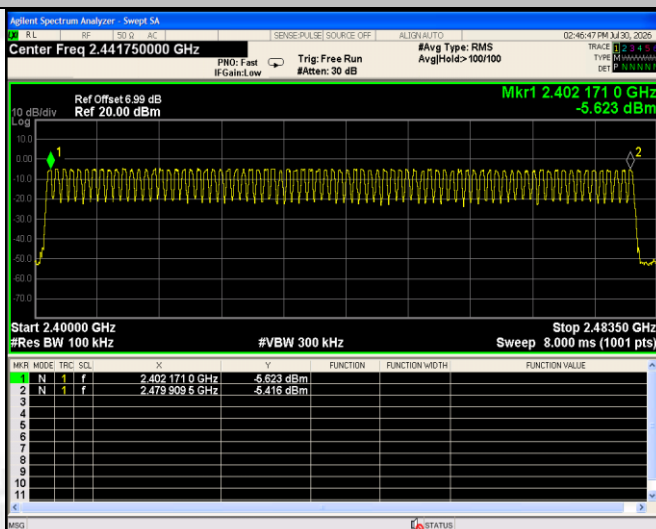
7.4. Test Result

Mode	Channel.	Number of Hopping Channel	Limit	Verdict
GFSK	Hop	79	≥ 15	PASS
$\pi/4$ DQPSK	Hop	79	≥ 15	PASS
8DPSK	Hop	79	≥ 15	PASS

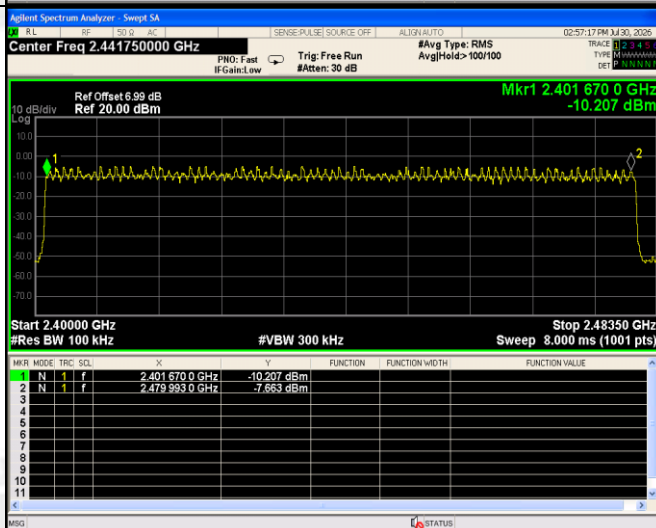
Test Graph

Graphs

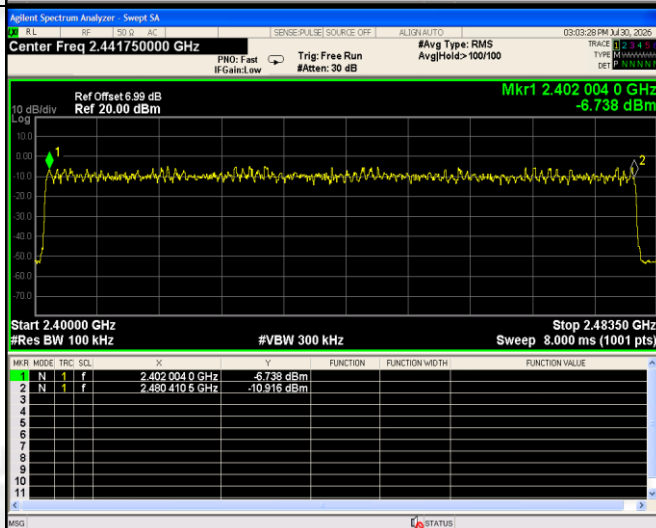
GFSK/Hop



π /4DQPSK/Hop



8DPSK/Hop



8. Dwell Time Test

8.1. Limit

Test Standard	FCC Part15 C Section 15.247 (a)(1)(iii)
Test Limit	0.4 sec

8.2. Test setup



8.3. Test Procedure

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

1. Span= zero span, centered on a hopping channel
2. Set the RBW = 1 MHz.
3. Set the VBW = 3 MHz.
4. Sweep time = as necessary to capture the entire dwell time per hopping channel.
5. Detector function = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. The burst width [ms/hop/ch], which is directly measured, refers to the duration on one channel hop.
The hops per second for all channels: The selected EUT Conf uses a slot type of 5-Tx&1-Rx and a Hopping rate of 1600 [ch*hop/s] for all channels. So the final hopping rate for all channels is $1600/6=266.67$ [ch*hop/s]
- The hops per second on one channel: 266.67 [ch*hops/s]/ 79 [ch]= 3.38 [hop/s].
- The total hops for all channels within the dwell time calculation duration: 3.38 [hop/s]* 31.6 [s*ch]= 106.67 [hop*ch].
- The dwell time for all channels hopping: 106.67 [hop*ch]*Burst Width [ms/hop/ch].
9. The duration for dwell time calculation: 0.4 [s]*hopping number= 0.4 [s]* 79 [ch]= 31.6 [s*ch].
10. Pulse Time(ms)*Total Hops=Dwell Time

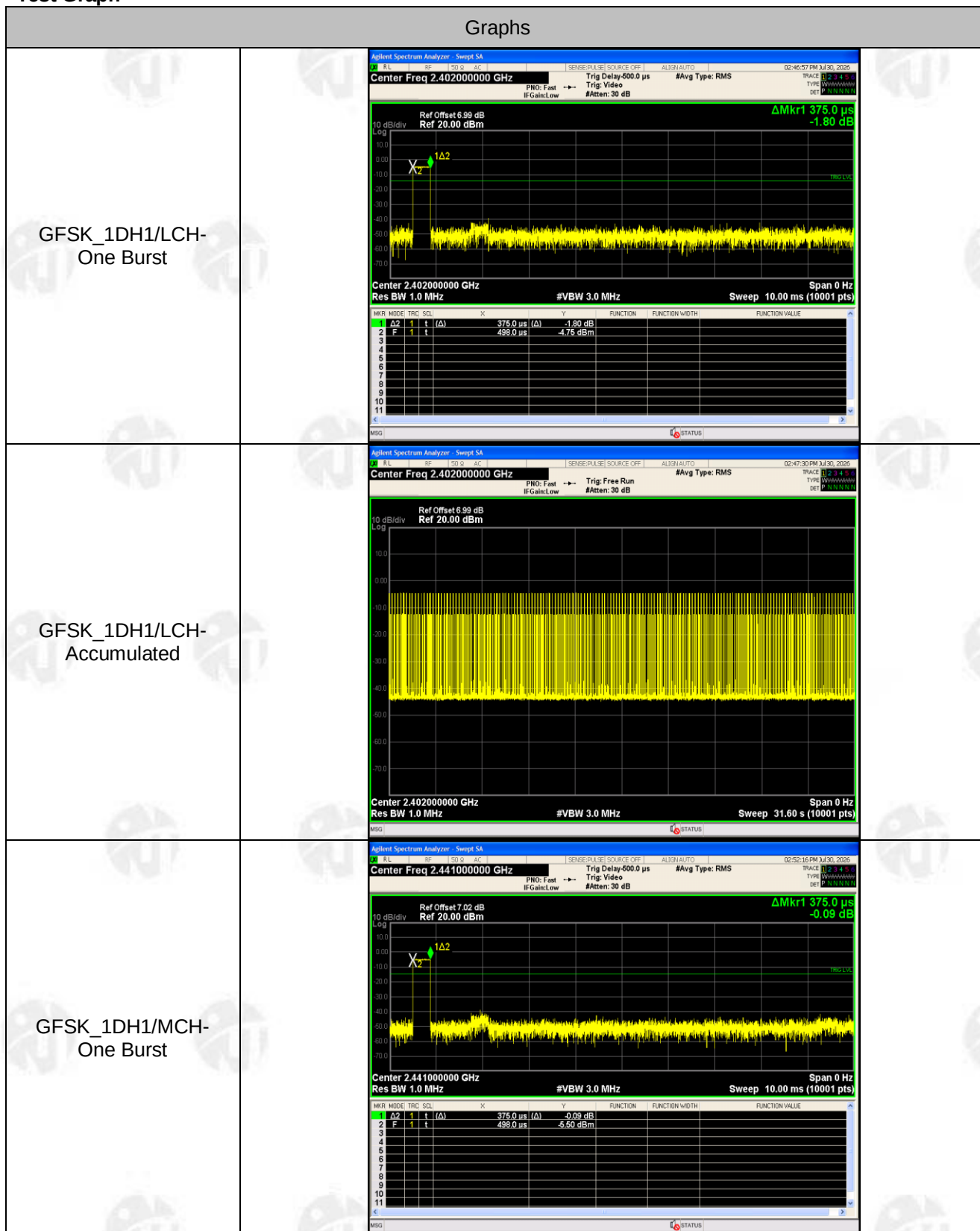
8.4. Test Result

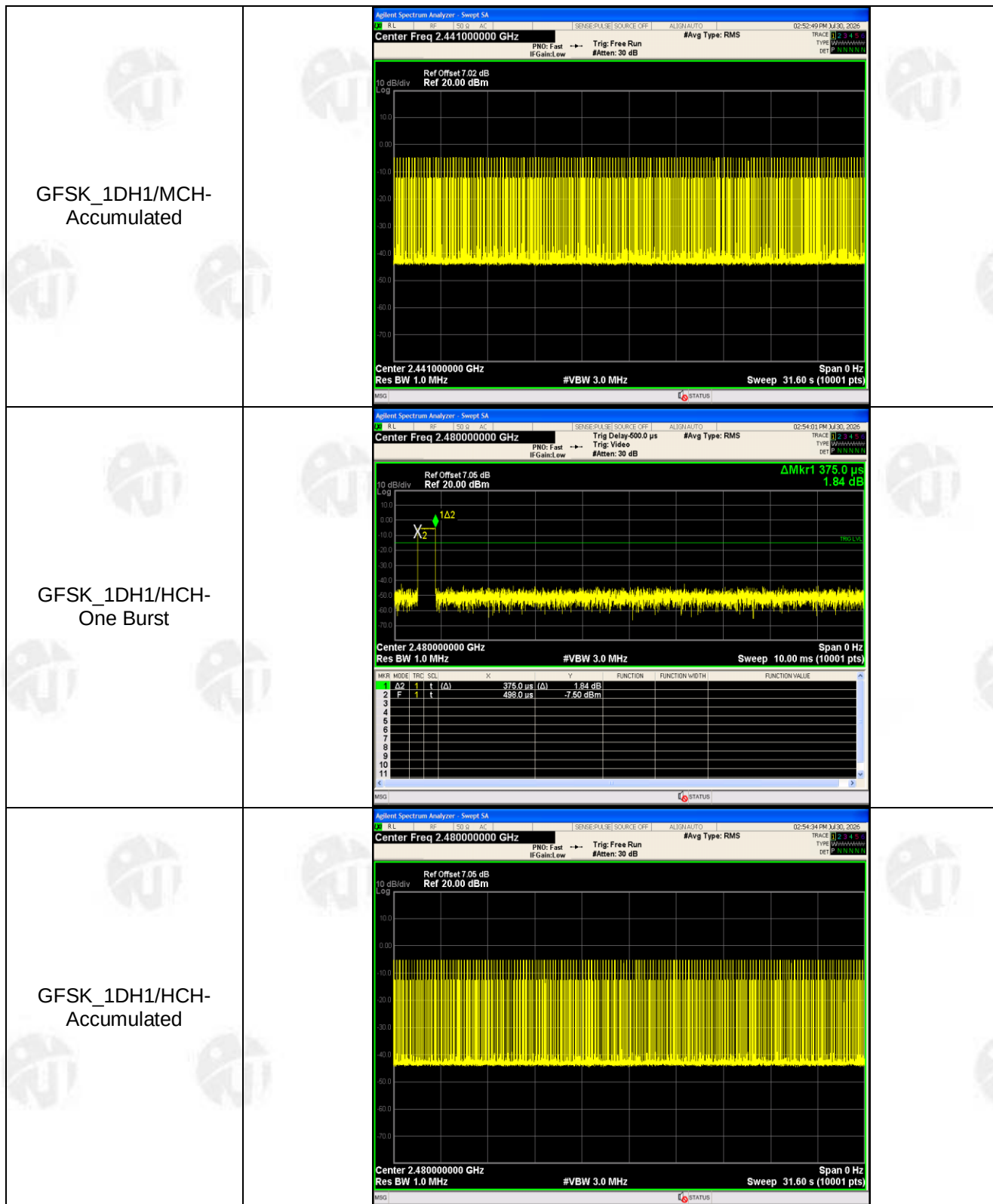
Packet	Channel	Pulse Time (ms)	Burst Count (Num)	Total Dwell Time (ms)	Limit (ms)	Verdict
DH1	LCH	0.375	317	118.875	400	PASS
DH1	MCH	0.375	315	118.125	400	PASS
DH1	HCH	0.375	315	118.125	400	PASS
2DH3	LCH	1.637	166	271.742	400	PASS
2DH3	MCH	1.636	169	276.484	400	PASS
2DH3	HCH	1.637	156	255.372	400	PASS
3DH5	LCH	2.887	108	311.796	400	PASS
3DH5	MCH	2.887	107	308.909	400	PASS
3DH5	HCH	2.887	98	282.926	400	PASS

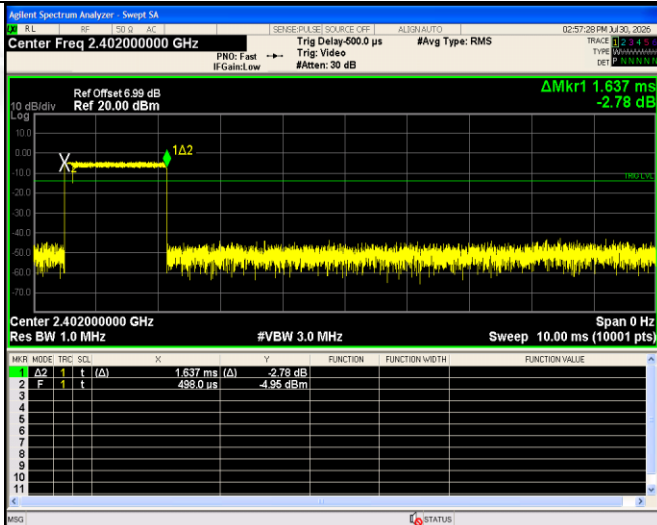
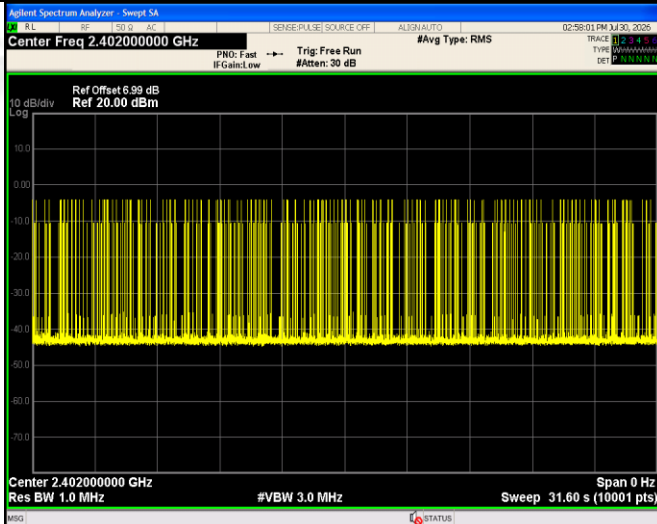
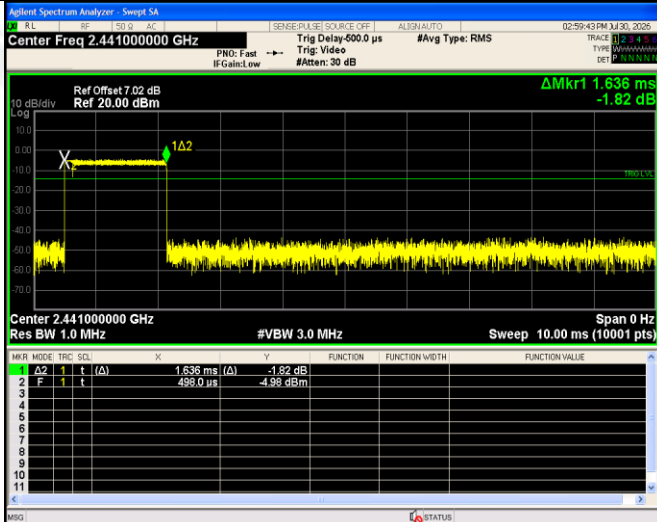
Remark: Dwell time = Pulse time * Total Hops

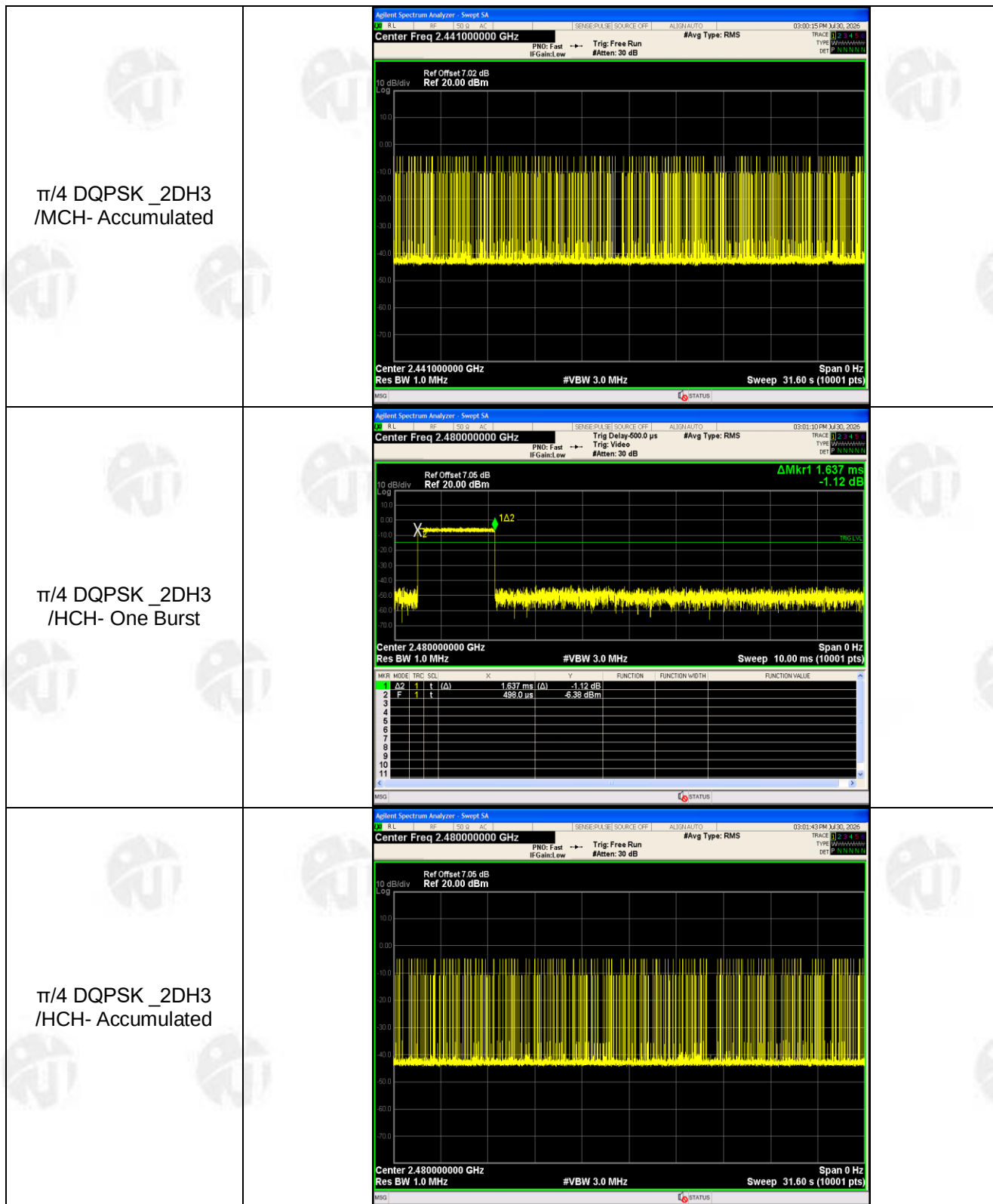
Remark: Mkr Delta is once pulse time.

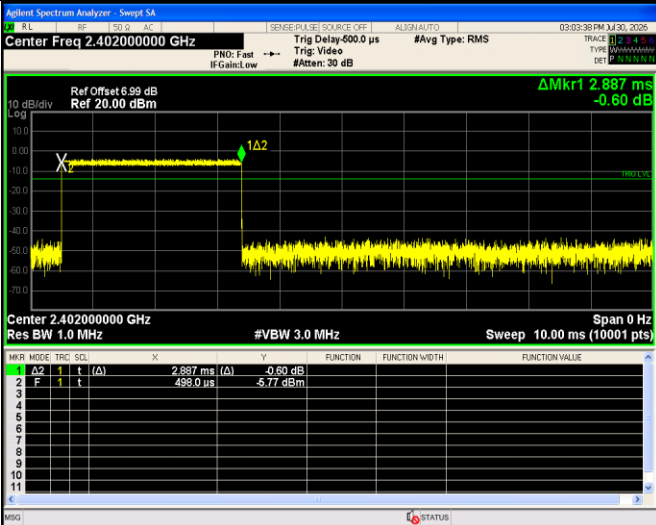
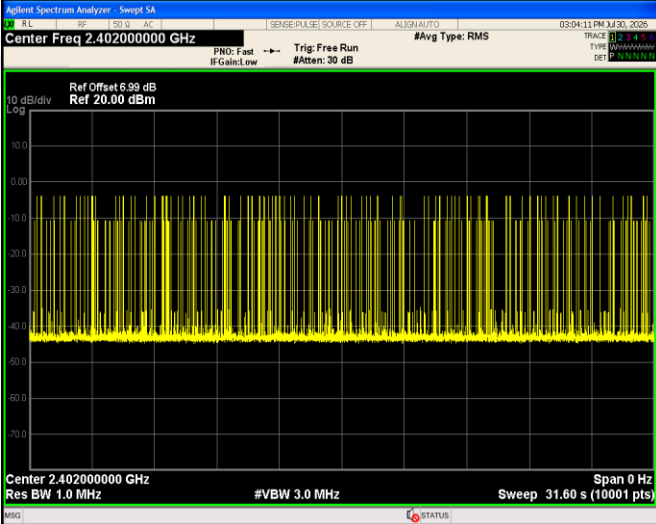
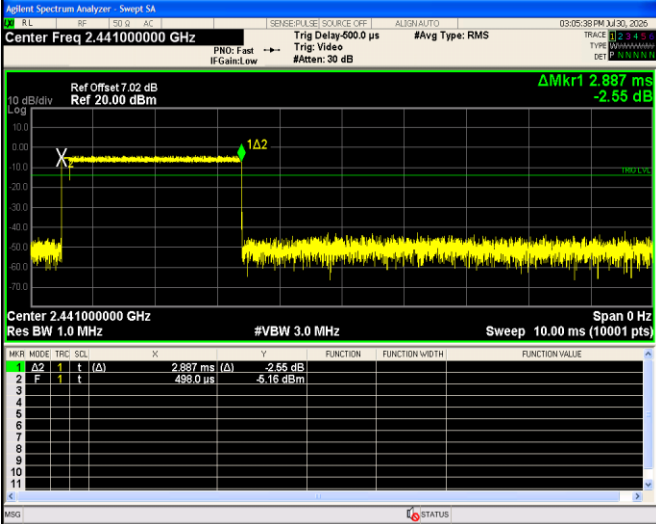
Test Graph

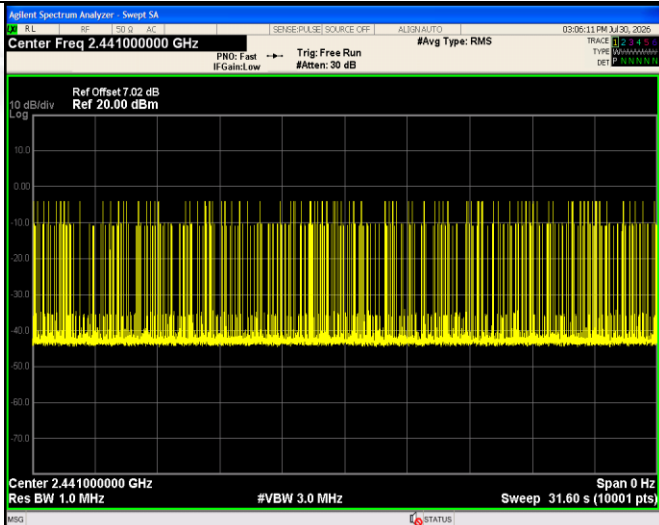
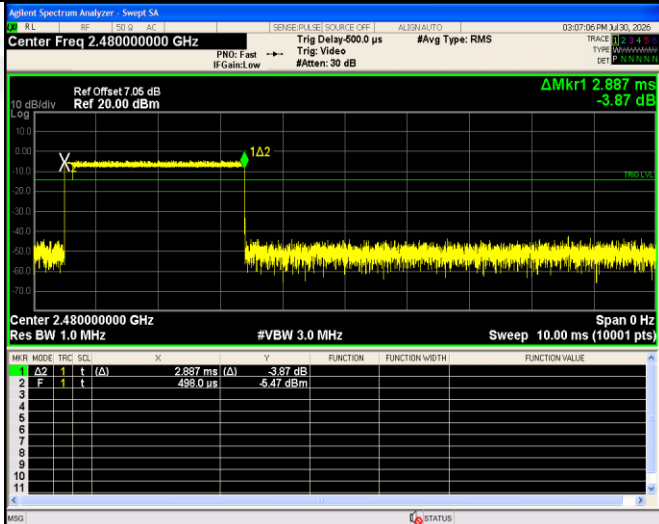
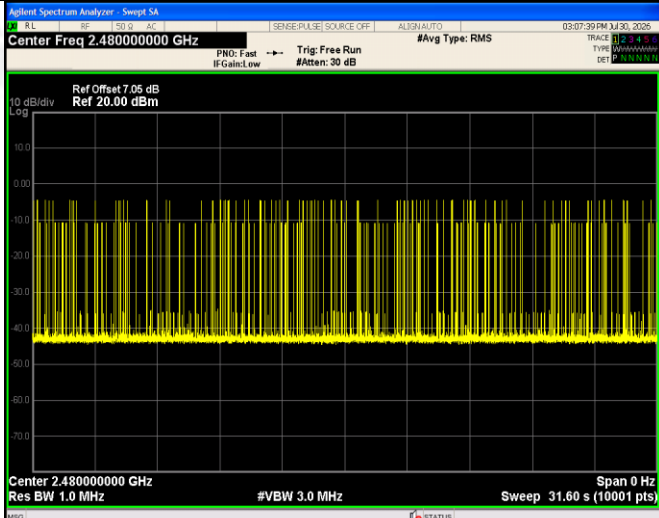




$\pi/4$ DQPSK_2DH3 /LCH- One Burst	 <table><tr><th>MNR</th><th>MODE</th><th>TRC</th><th>SCL</th><th>X</th><th>Y</th><th>FUNCTION</th><th>FUNCTION WIDTH</th><th>FUNCTION VALUE</th></tr><tr><td>1</td><td>A2</td><td>1</td><td>t</td><td>(A)</td><td>1.637 ms</td><td>(A)</td><td>-2.78 dB</td><td></td></tr><tr><td>2</td><td>F</td><td>1</td><td>t</td><td>(A)</td><td>498.0 μs</td><td>(A)</td><td>-4.95 dBm</td><td></td></tr></table>	MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	1	A2	1	t	(A)	1.637 ms	(A)	-2.78 dB		2	F	1	t	(A)	498.0 μ s	(A)	-4.95 dBm	
MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE																				
1	A2	1	t	(A)	1.637 ms	(A)	-2.78 dB																					
2	F	1	t	(A)	498.0 μ s	(A)	-4.95 dBm																					
$\pi/4$ DQPSK_2DH3 /LCH- Accumulated	 <table><tr><th>MNR</th><th>MODE</th><th>TRC</th><th>SCL</th><th>X</th><th>Y</th><th>FUNCTION</th><th>FUNCTION WIDTH</th><th>FUNCTION VALUE</th></tr><tr><td>1</td><td>A2</td><td>1</td><td>t</td><td>(A)</td><td>1.637 ms</td><td>(A)</td><td>-2.78 dB</td><td></td></tr><tr><td>2</td><td>F</td><td>1</td><td>t</td><td>(A)</td><td>498.0 μs</td><td>(A)</td><td>-4.95 dBm</td><td></td></tr></table>	MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	1	A2	1	t	(A)	1.637 ms	(A)	-2.78 dB		2	F	1	t	(A)	498.0 μ s	(A)	-4.95 dBm	
MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE																				
1	A2	1	t	(A)	1.637 ms	(A)	-2.78 dB																					
2	F	1	t	(A)	498.0 μ s	(A)	-4.95 dBm																					
$\pi/4$ DQPSK_2DH3 /MCH- One Burst	 <table><tr><th>MNR</th><th>MODE</th><th>TRC</th><th>SCL</th><th>X</th><th>Y</th><th>FUNCTION</th><th>FUNCTION WIDTH</th><th>FUNCTION VALUE</th></tr><tr><td>1</td><td>A2</td><td>1</td><td>t</td><td>(A)</td><td>1.636 ms</td><td>(A)</td><td>-1.82 dB</td><td></td></tr><tr><td>2</td><td>F</td><td>1</td><td>t</td><td>(A)</td><td>498.0 μs</td><td>(A)</td><td>-4.98 dBm</td><td></td></tr></table>	MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	1	A2	1	t	(A)	1.636 ms	(A)	-1.82 dB		2	F	1	t	(A)	498.0 μ s	(A)	-4.98 dBm	
MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE																				
1	A2	1	t	(A)	1.636 ms	(A)	-1.82 dB																					
2	F	1	t	(A)	498.0 μ s	(A)	-4.98 dBm																					



8DPSK_3DH5/LCH- One Burst	
8DPSK_3DH5/LCH- Accumulated	
8DPSK_3DH5/MCH- One Burst	

8DPSK_3DH5/MCH-Accumulated																																																																																																													
8DPSK_3DH5/HCH-One Burst	 <table><thead><tr><th>MNR</th><th>MODE</th><th>TRC</th><th>SOL</th><th>X</th><th>Y</th><th>FUNCTION</th><th>FUNCTION WIDTH</th><th>FUNCTION VALUE</th></tr></thead><tbody><tr><td>1</td><td>Δ2</td><td>1</td><td>t</td><td>(Δ)</td><td>2.887 ms (Δ)</td><td>-3.87 dB</td><td></td><td></td></tr><tr><td>2</td><td>F</td><td>1</td><td>t</td><td></td><td>498.0 μs</td><td>-5.47 dBm</td><td></td><td></td></tr><tr><td>3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>7</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>11</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></tbody></table>	MNR	MODE	TRC	SOL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	1	Δ2	1	t	(Δ)	2.887 ms (Δ)	-3.87 dB			2	F	1	t		498.0 μs	-5.47 dBm			3									4									5									6									7									8									9									10									11								
MNR	MODE	TRC	SOL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE																																																																																																					
1	Δ2	1	t	(Δ)	2.887 ms (Δ)	-3.87 dB																																																																																																							
2	F	1	t		498.0 μs	-5.47 dBm																																																																																																							
3																																																																																																													
4																																																																																																													
5																																																																																																													
6																																																																																																													
7																																																																																																													
8																																																																																																													
9																																																																																																													
10																																																																																																													
11																																																																																																													
8DPSK_3DH5/HCH-Accumulated																																																																																																													

9. Conducted Spurious Emissions and Band Edge Requirement

9.1. Limit

Test Standard	FCC Part15 C Section 15.247 (d)
Test Limit	in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in 15.209(a).

9.2. Test Setup

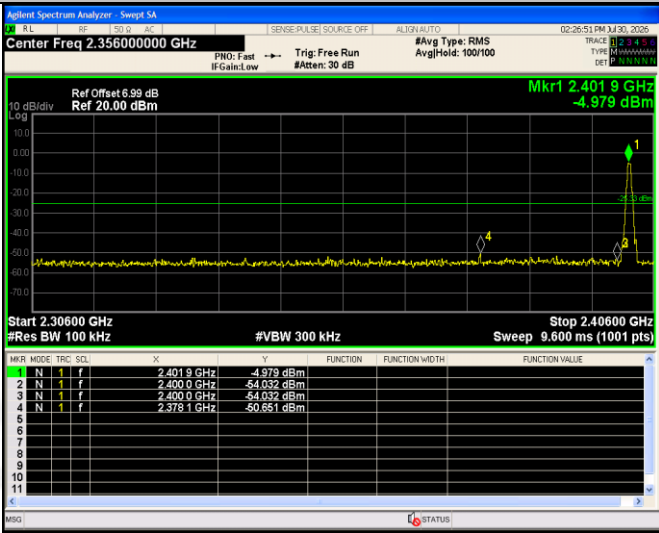
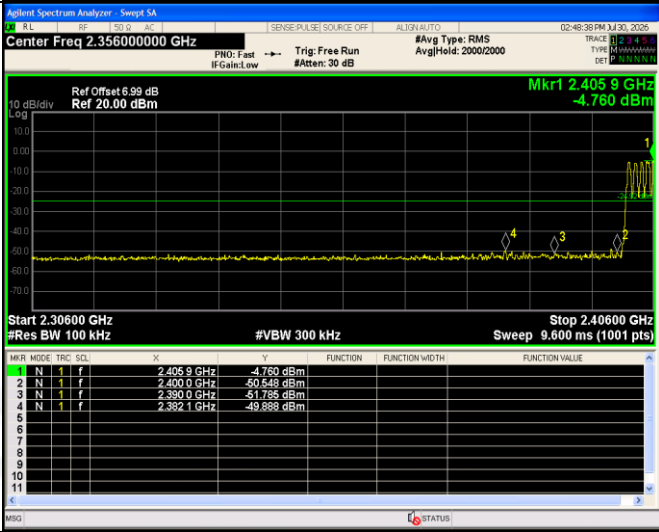
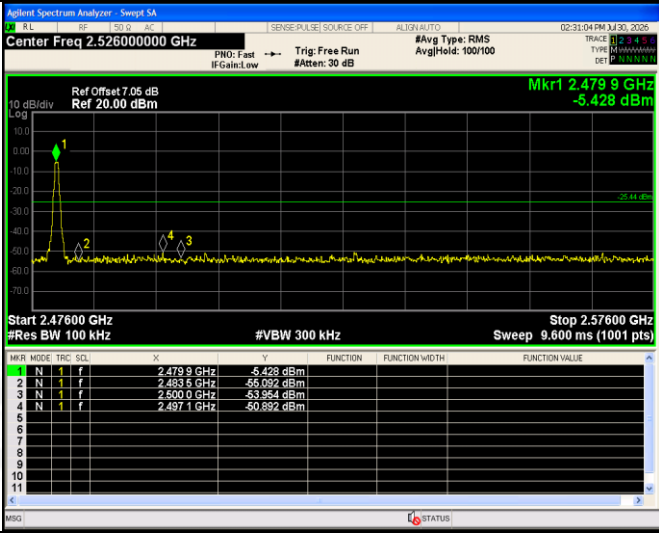


9.3. Test Procedure

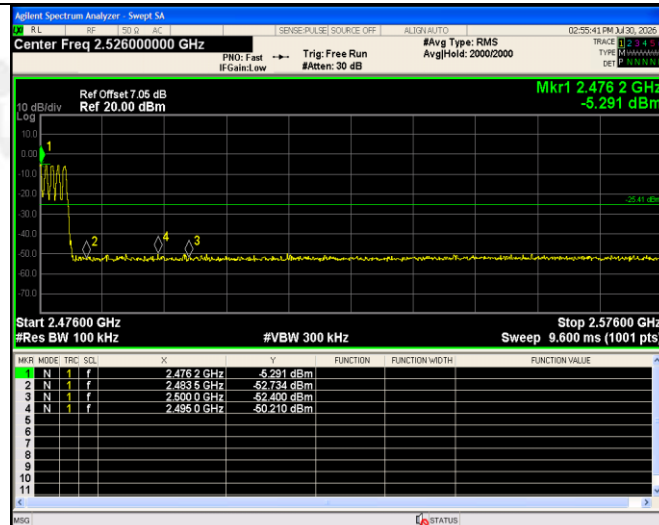
The EUT must have its hopping/Non-hopping function enabled. Using the following spectrum analyzer setting:

1. Set the RBW = 100kHz.
2. Set the VBW = 300kHz.
3. Sweep time = auto couple.
4. Detector function = peak.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.

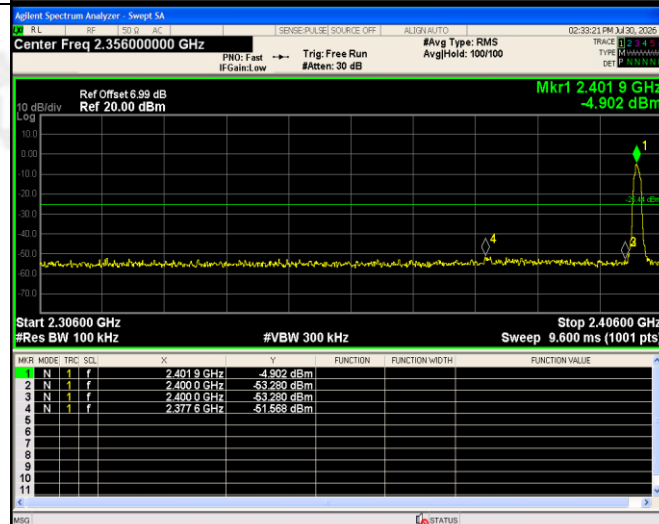
9.4. Test Result

BAND EDGE Graphs		
GFSK/LCH/ No Hop		
GFSK/LCH/ Hop		
GFSK/HCH/ No Hop		

GFSK/HCH/
Hop



$\pi/4$ DQPSK/LCH/
No Hop



$\pi/4$ DQPSK/LCH/
Hop

