

10. Occupied Bandwidth(-20dB)

10.1 Standard and Limit

According to 15.215 (c), intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

10.2 Test Procedure

According to the ANSI 63.10-2013, section 6.9, the emission bandwidth test method as follows.

- 1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
- 2) Set the spectrum analyzer to any one measured frequency within its operating range.
- 3) Set RBW = 30kHz, VBW = 100kHz, Sweep = Auto.
- 4) Set a reference level on the measuring instrument equal to the highest peak value.
- 5) Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
- 6) Repeat the above procedures until all frequencies measured were complete.



Test Setup Block Diagram

10.3 Test Data and Results

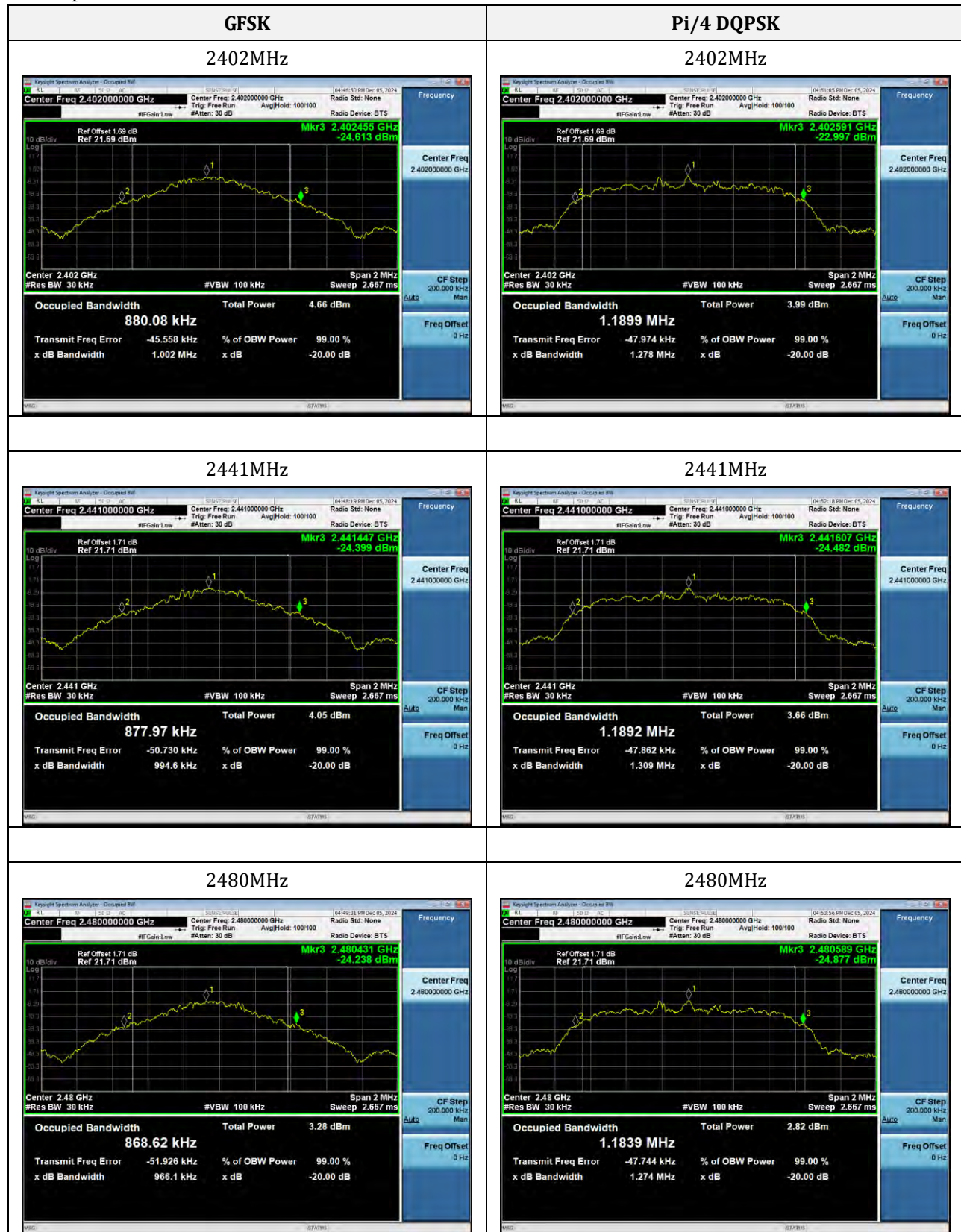
Left earphone:

Test Mode	Test Channel (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (kHz)
GFSK	2402	1.002	880.08
	2441	0.995	877.97
	2480	0.966	868.62
Pi/4 DQPSK	2402	1.278	1189.9
	2441	1.309	1189.2
	2480	1.274	1183.9
8DPSK	2402	1.337	1208.6
	2441	1.295	1192.1
	2480	1.33	1209.2

Right earphone:

Test Mode	Test Channel (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (kHz)
GFSK	2402	1.036	905.81
	2441	1.003	898.11
	2480	0.988	892.5
Pi/4 DQPSK	2402	1.323	1209.8
	2441	1.317	1202.6
	2480	1.302	1196.4
8DPSK	2402	1.305	1211.4
	2441	1.3	1199.8
	2480	1.305	1202.7

Left earphone:



8DPSK

2402MHz



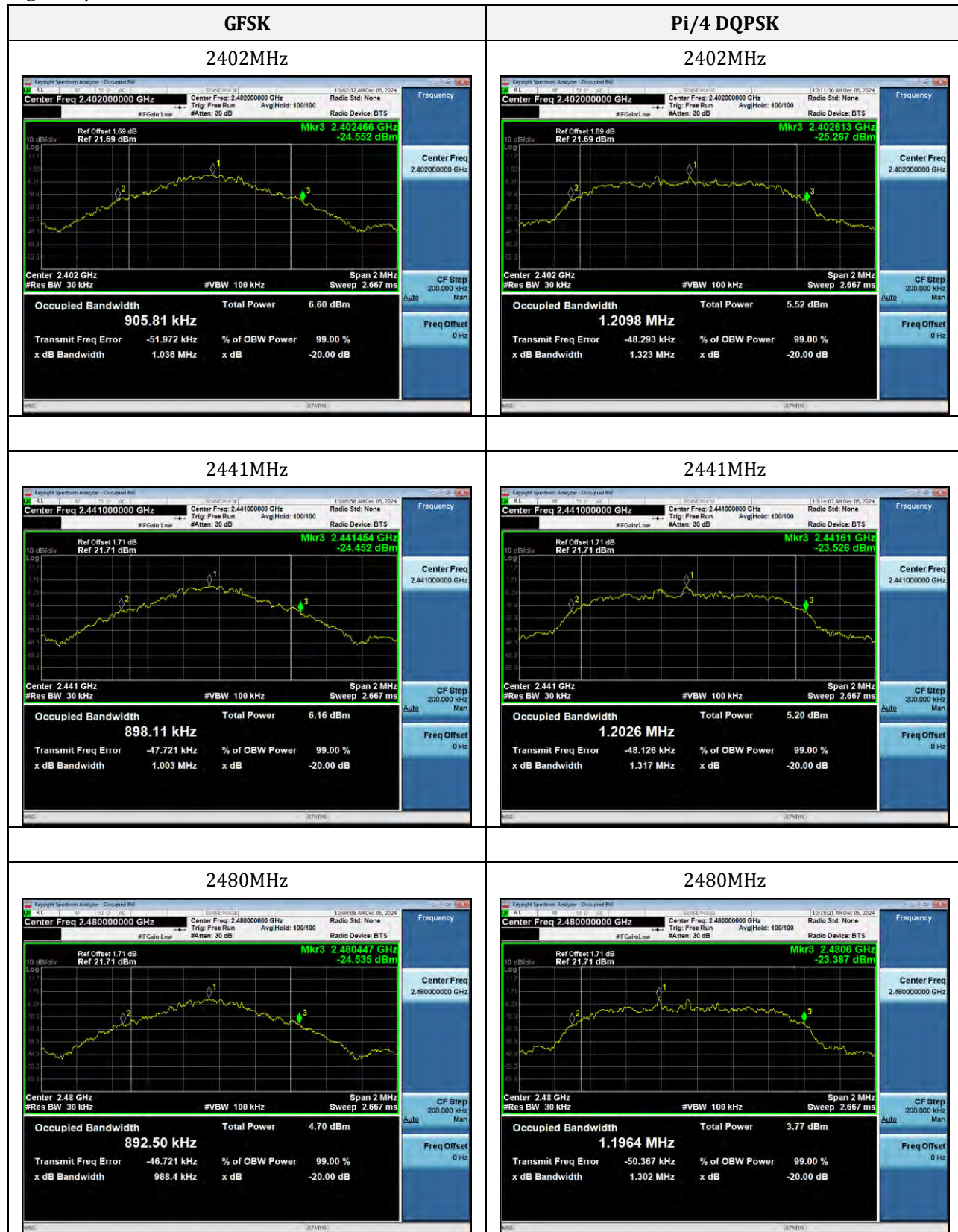
2441MHz



2480MHz



Right earphone:



8DPSK

2402MHz



2441MHz



2480MHz



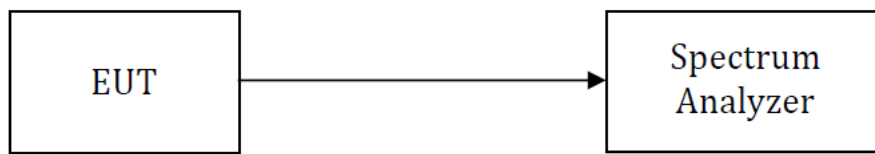
11. Carrier Frequencies Separation

11.1 Standard and Limit

According to FCC 15.247(a)(1), 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, and frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

11.2 Test Procedure

- 1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
- 2) Set the spectrum analyzer to any one measured frequency within its operating range.
- 3) Set RBW = 30kHz, VBW = 100kHz, Sweep = Auto, Detector = Peak.
- 4) By using the Max Hold function, record the separation of two adjacent channels.
- 5) Measure the frequency difference of these two adjacent channels by spectrum analyzer mark function. and then plot the result on the screen of the spectrum analyzer.
- 6) Repeat above procedures until all frequencies measured were complete.



Test Setup Block Diagram

11.3 Test Data and Results

Left earphone:

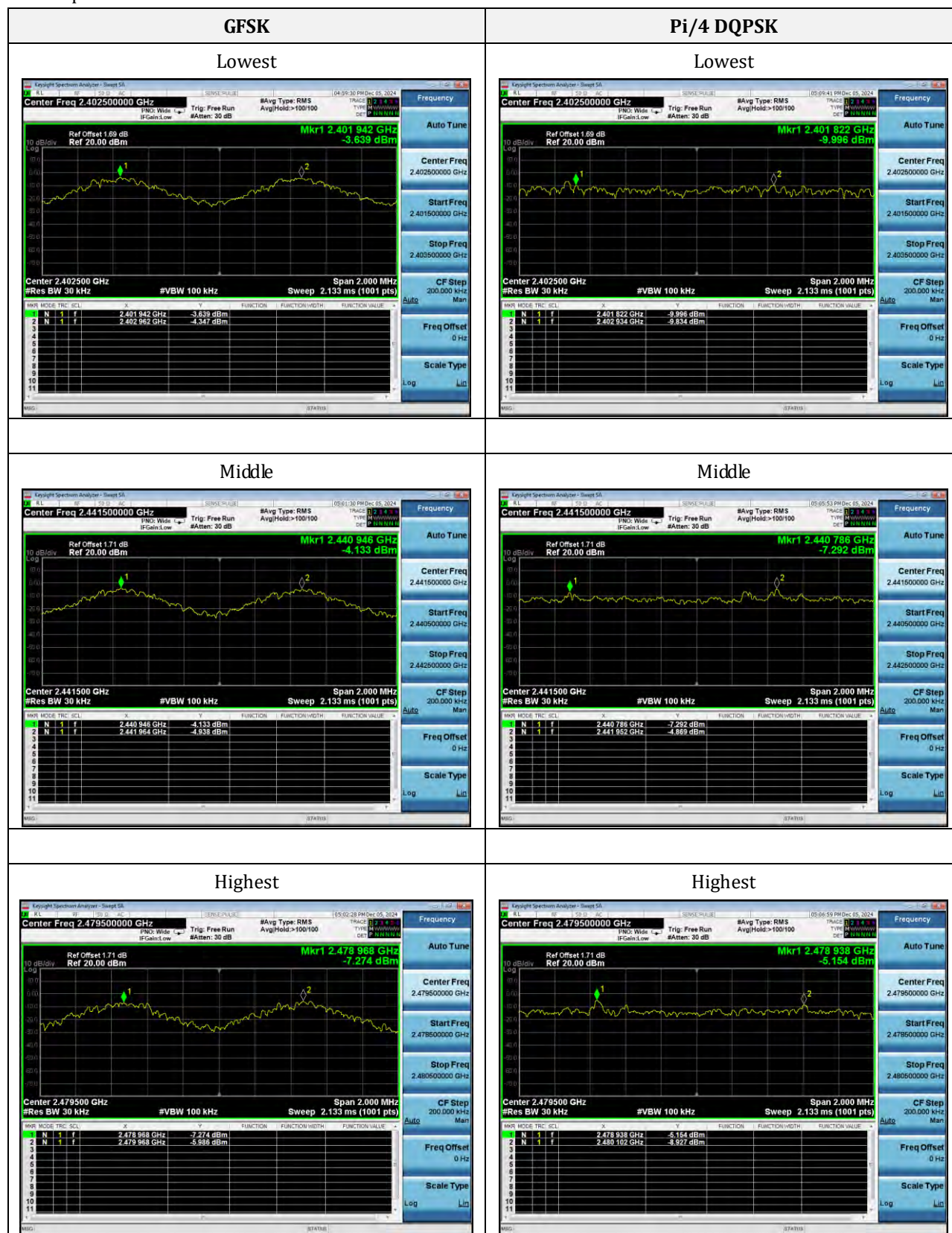
Test Mode	Test Channel	Test Freq. 1 (MHz)	Test Freq. 2 (MHz)	CFS (MHz)	Limit (MHz)
GFSK	Lowest	2401.942	2402.962	1.02	0.668
	Middle	2440.946	2441.964	1.018	0.663
	Highest	2478.968	2479.968	1	0.644
Pi/4 DQPSK	Lowest	2401.822	2402.934	1.112	0.852
	Middle	2440.786	2441.952	1.166	0.873
	Highest	2478.938	2480.102	1.164	0.849
8DPSK	Lowest	2401.788	2402.768	0.98	0.891
	Middle	2440.924	2441.92	0.996	0.863
	Highest	2478.788	2479.952	1.164	0.887

Right earphone:

Test Mode	Test Channel	Test Freq. 1 (MHz)	Test Freq. 2 (MHz)	CFS (MHz)	Limit (MHz)
GFSK	Lowest	2401.958	2402.95	0.992	0.691
	Middle	2440.946	2441.942	0.996	0.669
	Highest	2478.958	2479.96	1.002	0.659
Pi/4 DQPSK	Lowest	2401.776	2402.912	1.136	0.882
	Middle	2440.792	2441.782	0.99	0.878
	Highest	2478.79	2479.928	1.138	0.868
8DPSK	Lowest	2401.854	2402.792	0.938	0.87
	Middle	2440.94	2441.944	1.004	0.867
	Highest	2478.94	2479.928	0.988	0.87

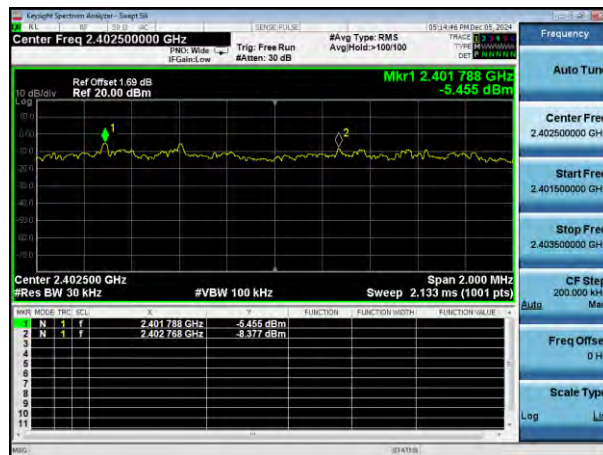
Note: $CFS(\text{Channel Frequency Separation}) = \text{Test Freq. 2} - \text{Test Freq. 1}$

Left earphone:

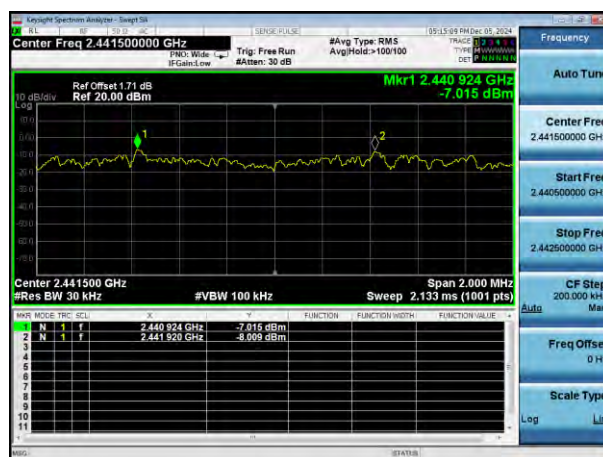


8DPSK

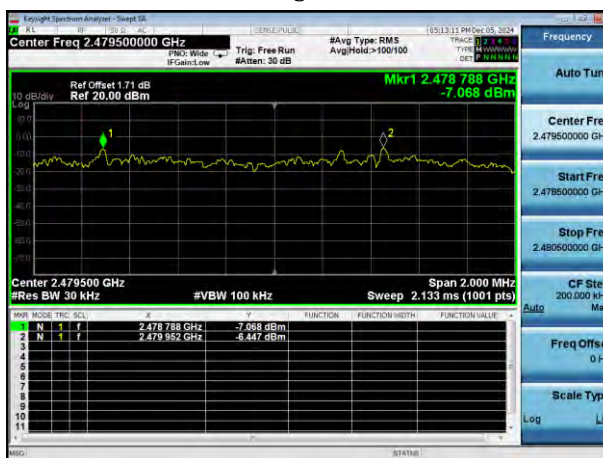
Lowest



Middle



Highest

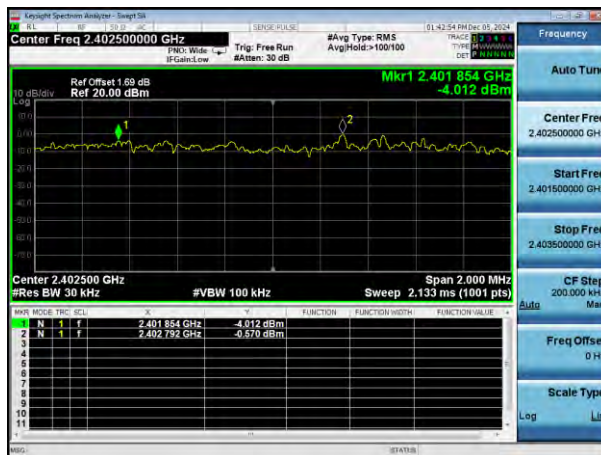


Right earphone:

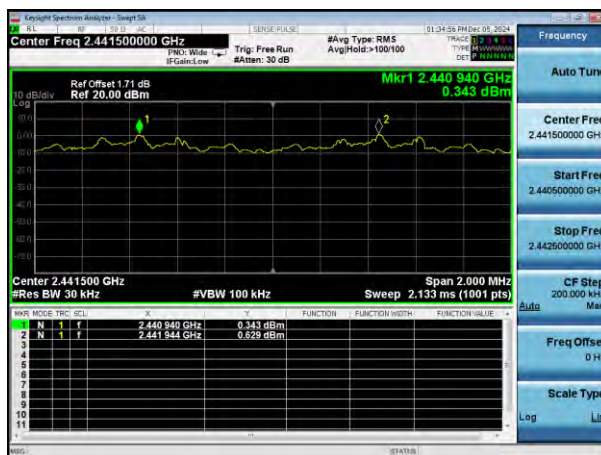


8DPSK

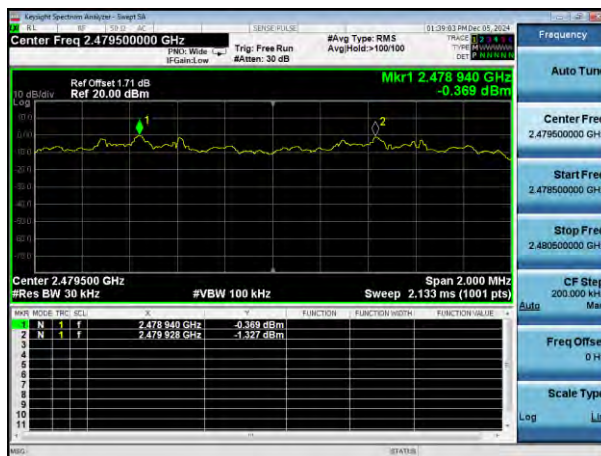
Lowest



Middle



Highest



12. Number of Hopping Channel

12.1 Standard and Limit

According to FCC 15.247(a)(1), 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, and frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

12.2 Test Procedure

- 1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
- 2) Set the spectrum analyzer to any one measured frequency within its operating range.
- 3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
- 4) Set the spectrum analyzer on Max hold mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.
- 5) Set the spectrum analyzer on View mode and then plot the result on the screen of the spectrum analyzer.
- 6) Repeat the above procedures until all frequencies measured were complete.



12.3 Test Data and Results

Left earphone:

Test Mode	Number of Hopping Channel	Limit	Test Result
GFSK	79	15	Pass
Pi/4 DQPSK	79	15	Pass
8DPSK	79	15	Pass

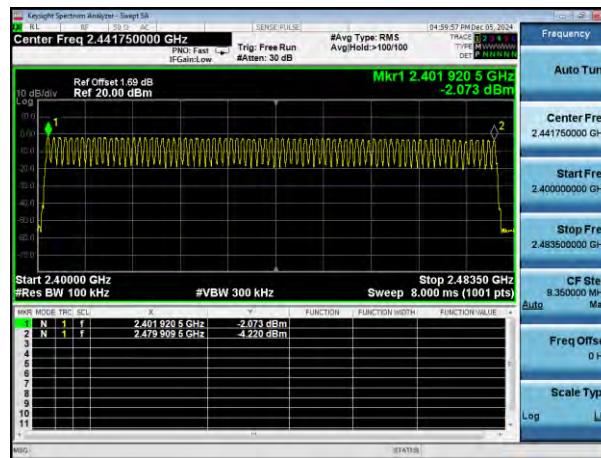
Right earphone:

Test Mode	Number of Hopping Channel	Limit	Test Result
GFSK	79	15	Pass
Pi/4 DQPSK	79	15	Pass
8DPSK	79	15	Pass

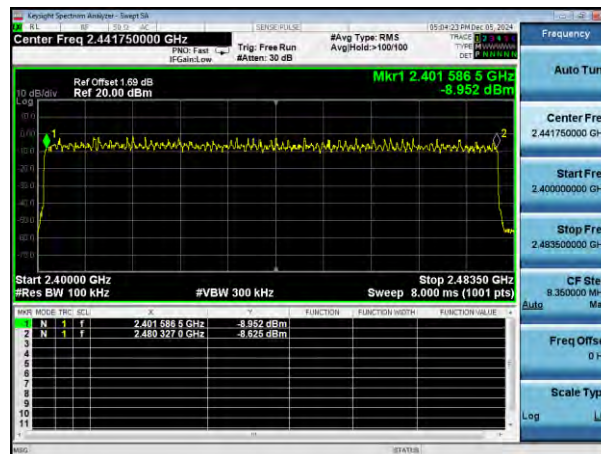
Left earphone:

Number of Hopping Channel

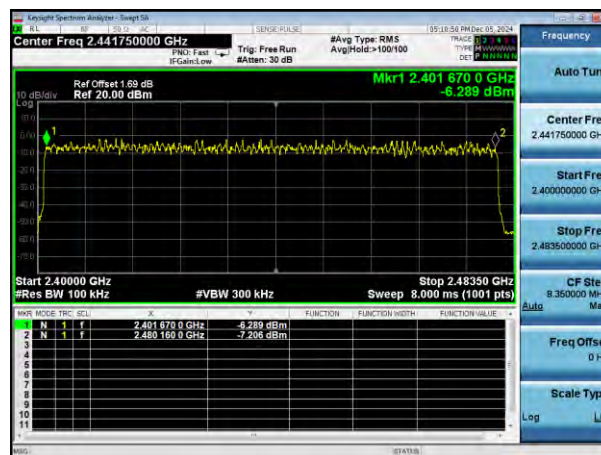
GFSK



Pi/4 DQPSK



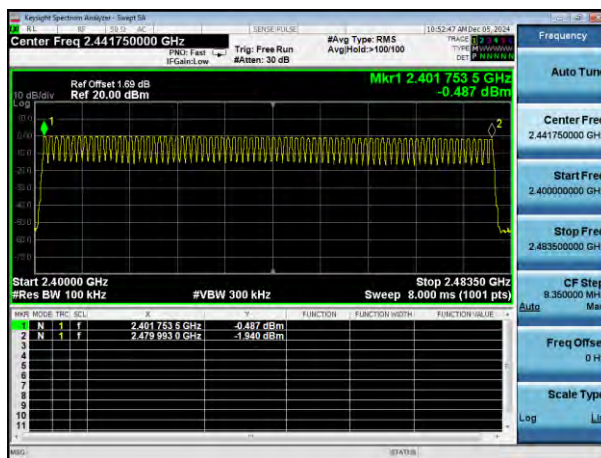
8DPSK



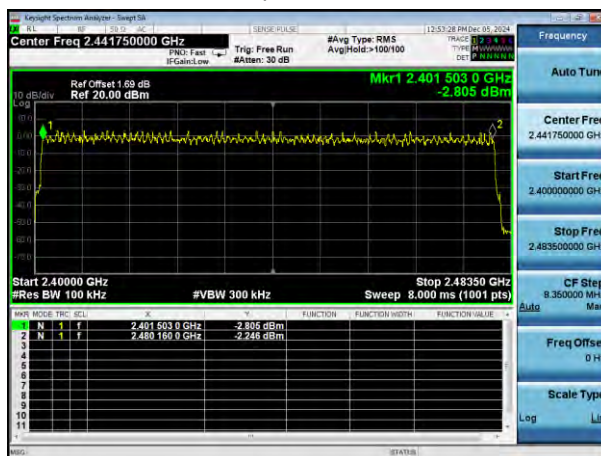
Right earphone:

Number of Hopping Channel

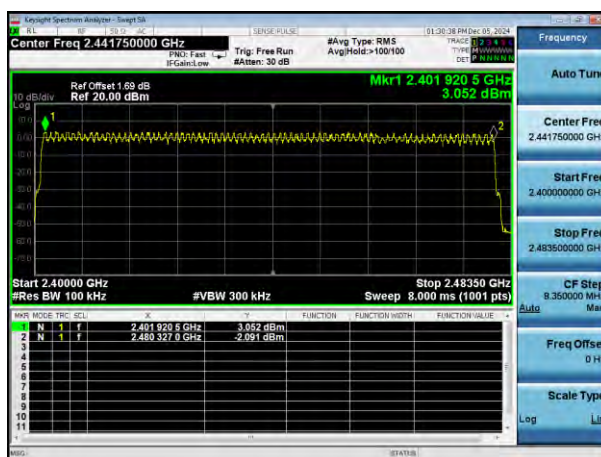
GFSK



Pi/4 DQPSK



8DPSK



13. Band-edge Emission(Conducted)

13.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. 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) (see § 15.205(c)).

13.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.10.

- 1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
- 2) Set the spectrum analyzer to any one measured frequency within its operating range.
- 3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
- 4) Measure the highest amplitude appearing on spectral display and set it as a reference level.
- 5) Set a convenient frequency span including 100 kHz bandwidth from band edge.
- 6) Measure the emission and marking the edge frequency.
- 7) Repeat above procedures until all frequencies measured were complete.



Test Setup Block Diagram

13.3 Test Data and Results

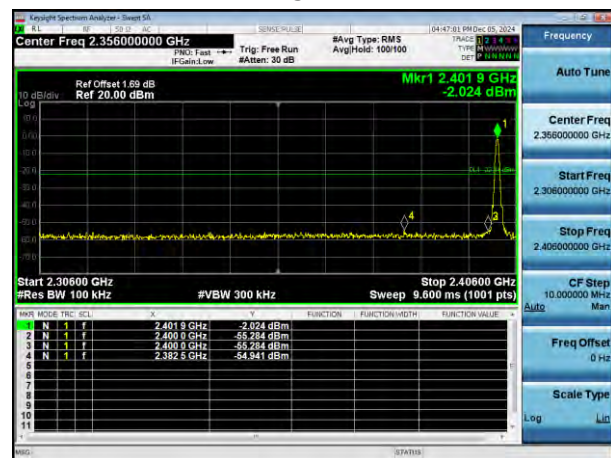
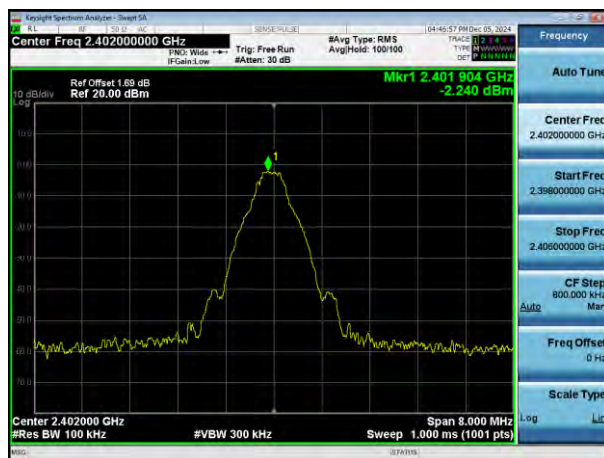
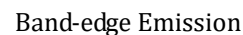
Left earphone:

Test Mode	Band-edge	Test Channel (MHz)	Max. Value (dBc)	Limit (dBc)	Test Result
No-Hopping					
GFSK	Lowest	2402	-52.7	-20	Pass
	Highest	2480	-52.47	-20	Pass
Pi/4 DQPSK	Lowest	2402	-48.41	-20	Pass
	Highest	2480	-51.73	-20	Pass
8DPSK	Lowest	2402	-51	-20	Pass
	Highest	2480	-51.32	-20	Pass
Hopping					
GFSK	Lowest	2402	-51.29	-20	Pass
	Highest	2480	-51.01	-20	Pass
Pi/4 DQPSK	Lowest	2402	-52.55	-20	Pass
	Highest	2480	-50.65	-20	Pass
8DPSK	Lowest	2402	-51.88	-20	Pass
	Highest	2480	-50.3	-20	Pass

Right earphone:

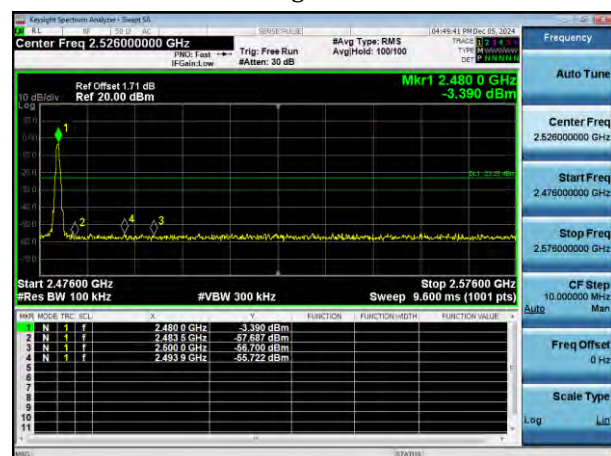
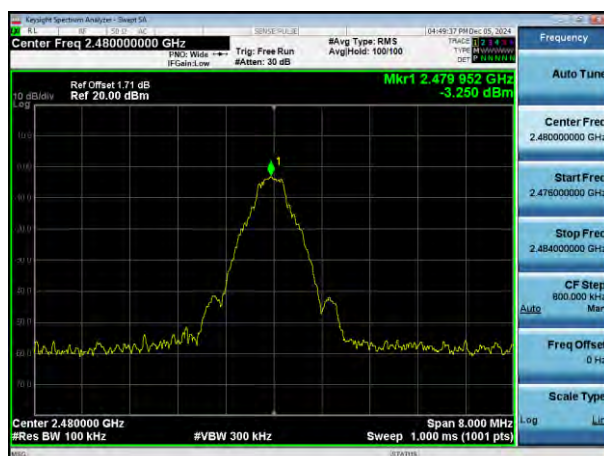
Test Mode	Band-edge	Test Channel (MHz)	Max. Value (dBc)	Limit (dBc)	Test Result
No-Hopping					
GFSK	Lowest	2402	-54.54	-20	Pass
	Highest	2480	-53.4	-20	Pass
Pi/4 DQPSK	Lowest	2402	-53.09	-20	Pass
	Highest	2480	-52.54	-20	Pass
8DPSK	Lowest	2402	-51.74	-20	Pass
	Highest	2480	-51.65	-20	Pass
Hopping					
GFSK	Lowest	2402	-53	-20	Pass
	Highest	2480	-54.67	-20	Pass
Pi/4 DQPSK	Lowest	2402	-53.71	-20	Pass
	Highest	2480	-54.59	-20	Pass
8DPSK	Lowest	2402	-53.57	-20	Pass
	Highest	2480	-54.3	-20	Pass

No-Hopping GFSK Lowest



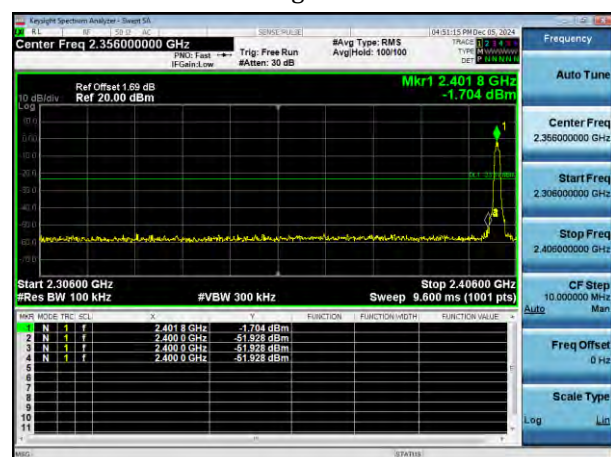
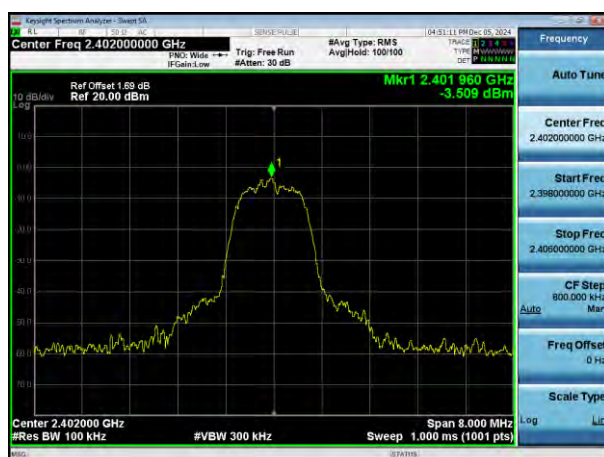
Reference Power

Band-edge Emission



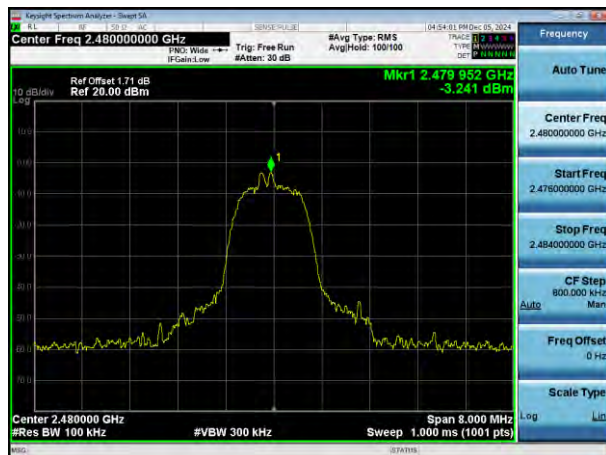
Reference Power

Band-edge Emission

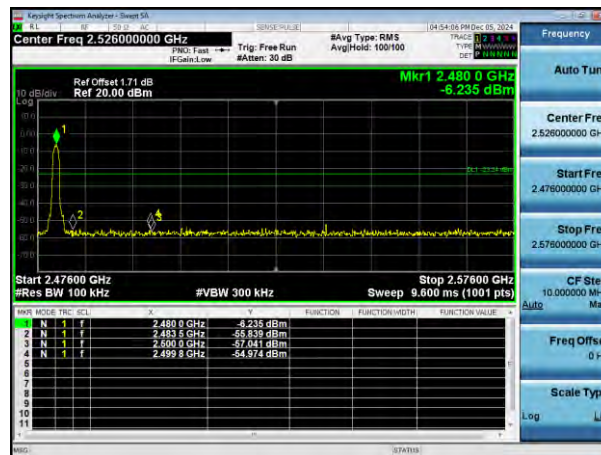


No-Hopping Pi/4 DQPSK Highest

Reference Power

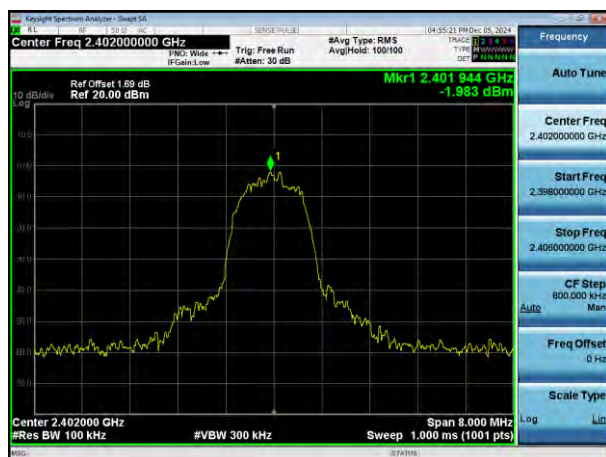


Band-edge Emission

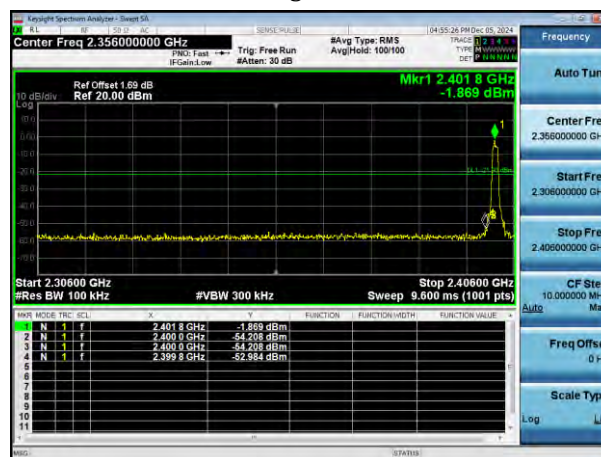


No-Hopping 8DPSK Lowest

Reference Power

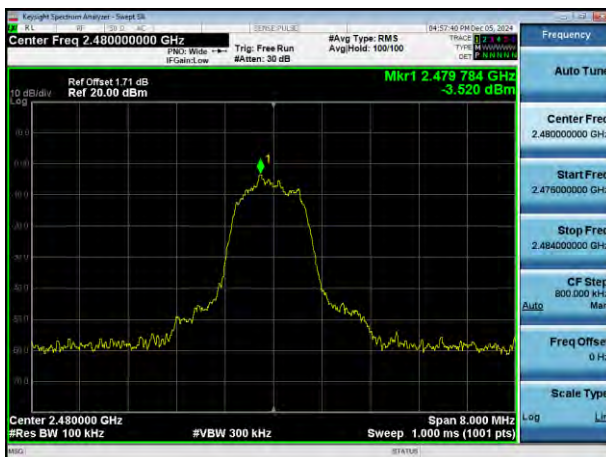


Band-edge Emission

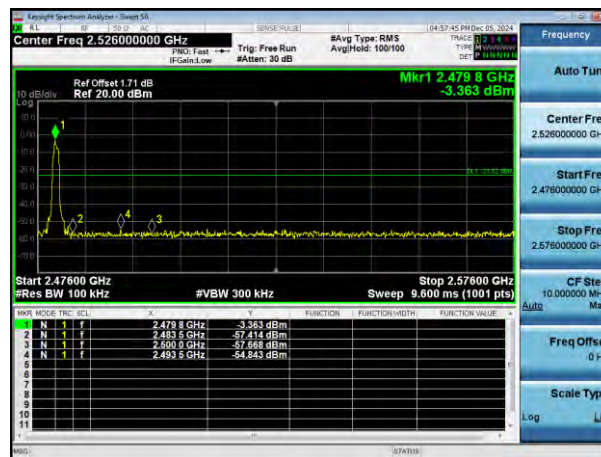


No-Hopping 8DPSK Highest

Reference Power



Band-edge Emission

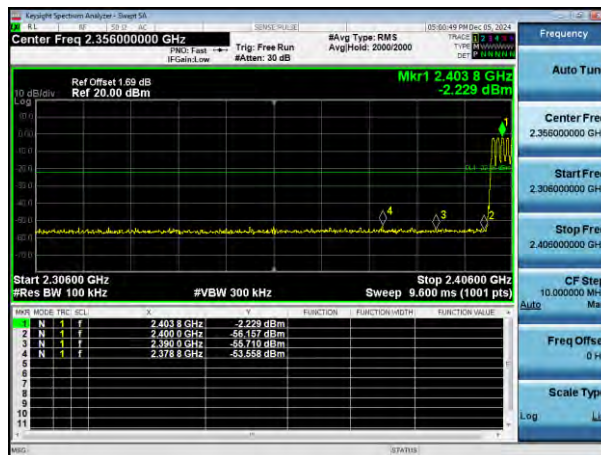


Hopping GFSK Lowest

Reference Power

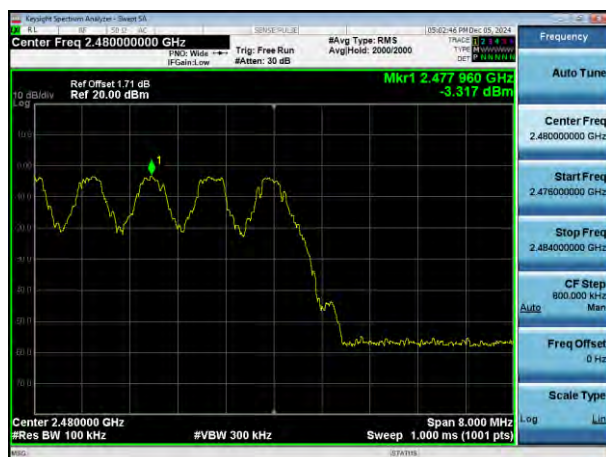


Band-edge Emission

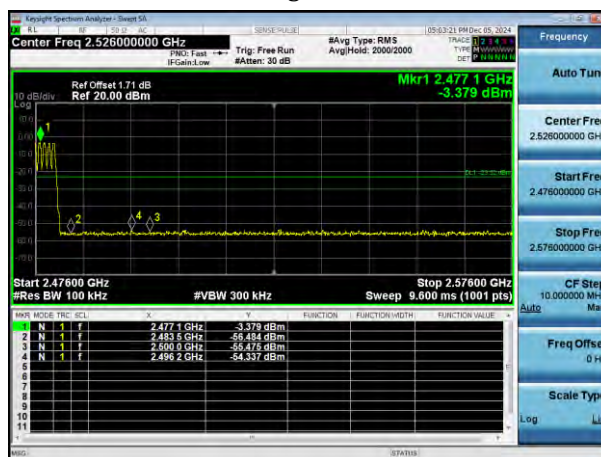


Hopping GFSK Highest

Reference Power



Band-edge Emission

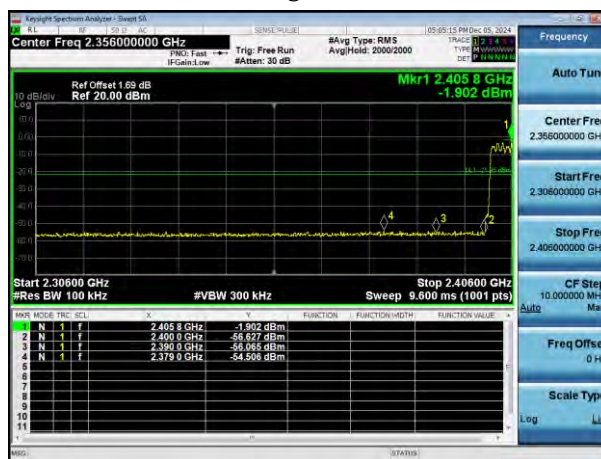


Hopping Pi/4 DQPSK Lowest

Reference Power

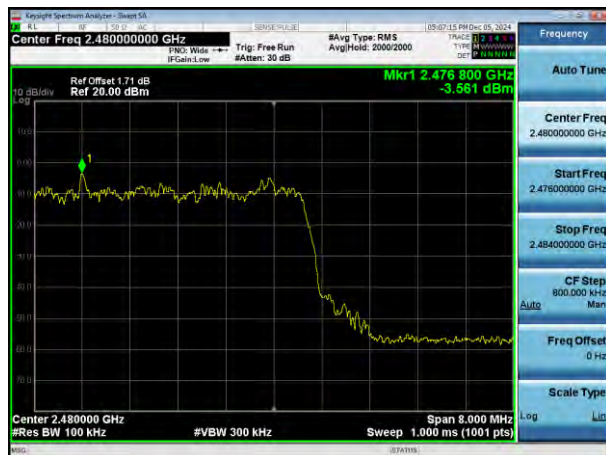


Band-edge Emission

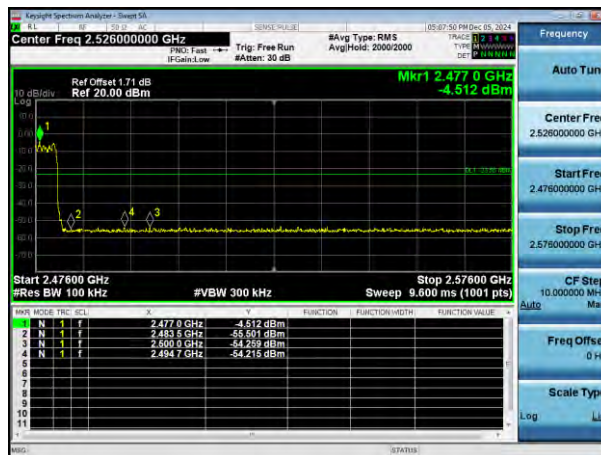


Hopping Pi/4 DQPSK Highest

Reference Power

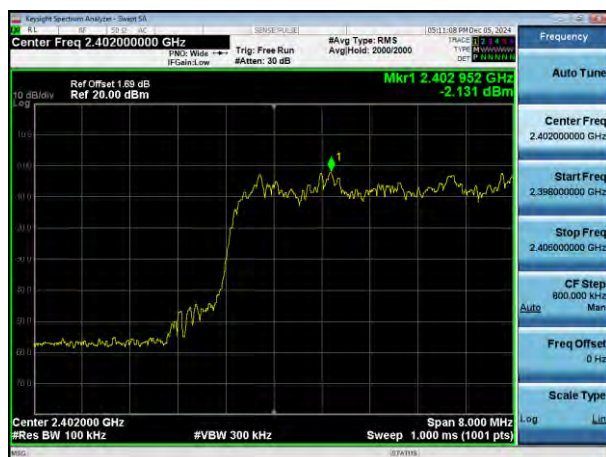


Band-edge Emission

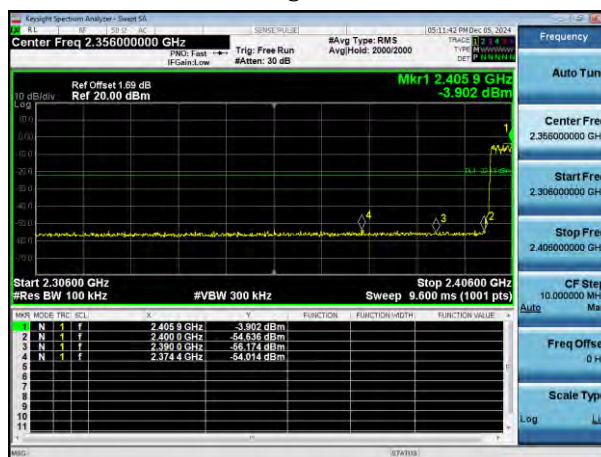


Hopping 8DPSK Lowest

Reference Power

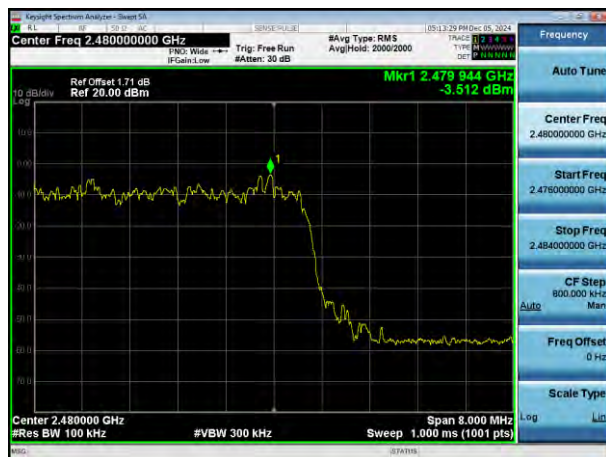


Band-edge Emission

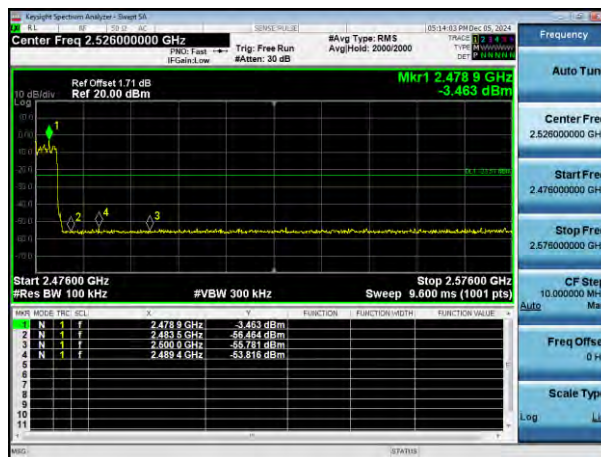


Hopping 8DPSK Highest

Reference Power



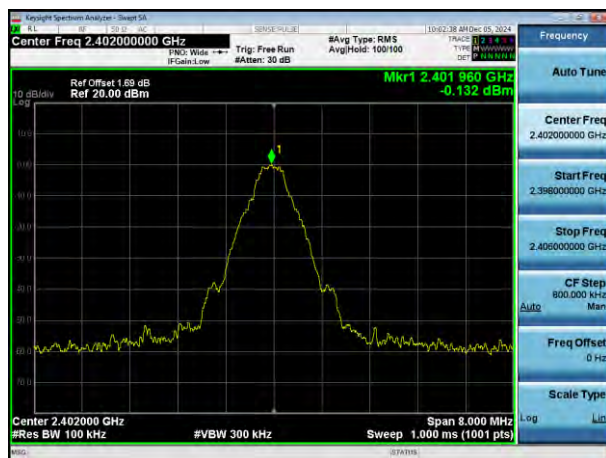
Band-edge Emission



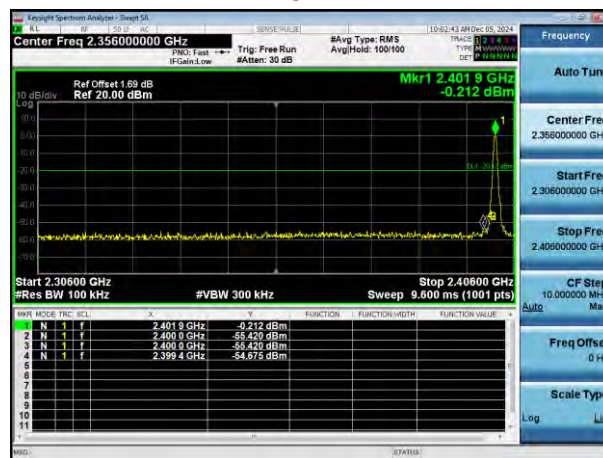
Right earphone:

No-Hopping GFSK Lowest

Reference Power

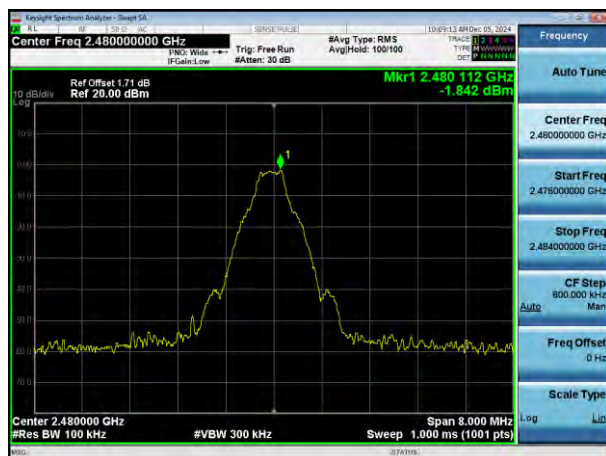


Band-edge Emission

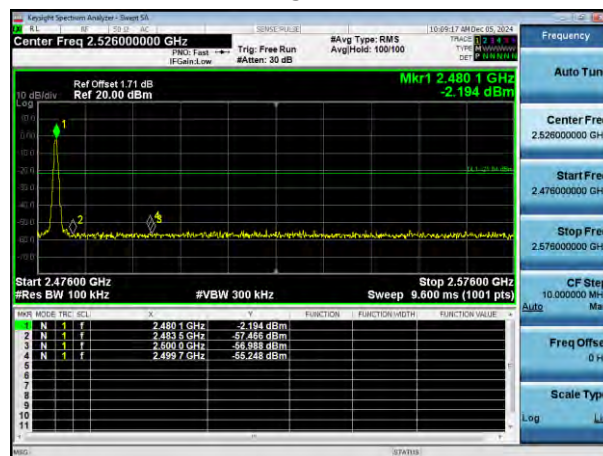


No-Hopping GFSK Highest

Reference Power

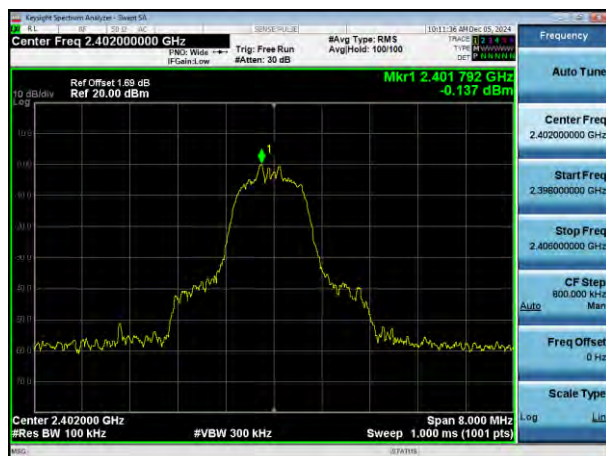


Band-edge Emission

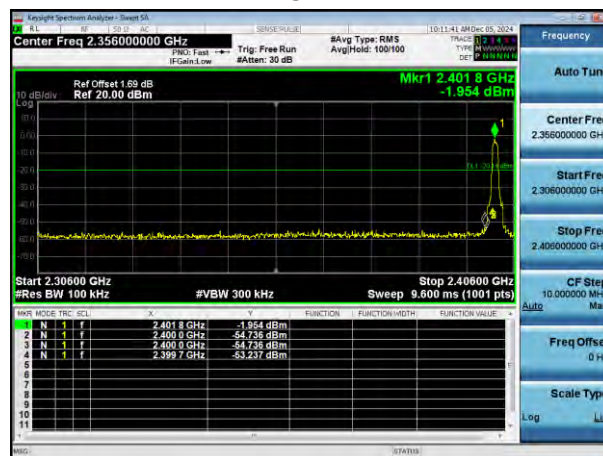


No-Hopping Pi/4 DQPSK Lowest

Reference Power

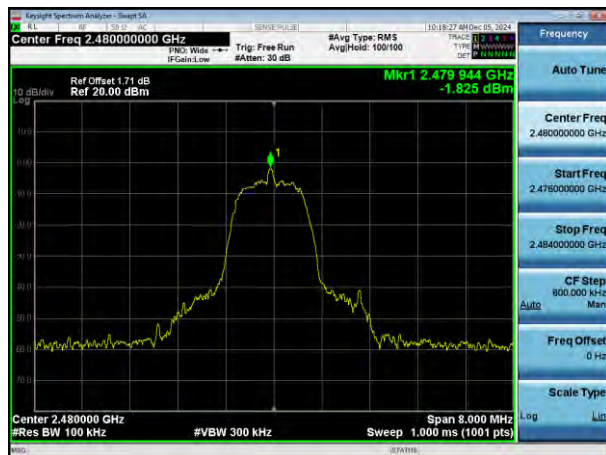


Band-edge Emission

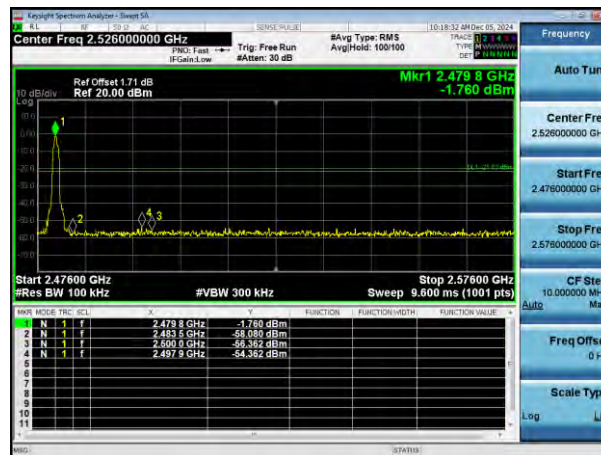


No-Hopping Pi/4 DQPSK Highest

Reference Power

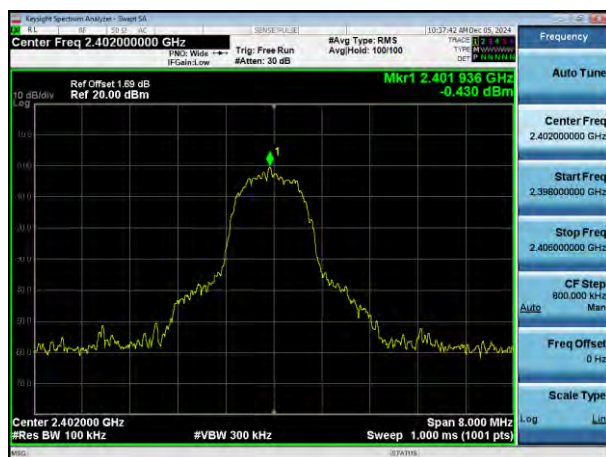


Band-edge Emission

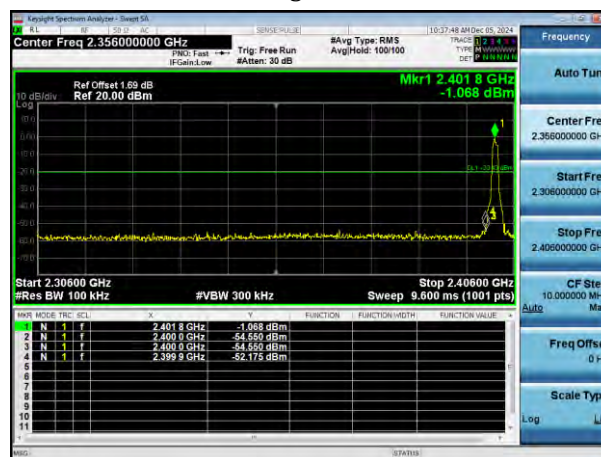


No-Hopping 8DPSK Lowest

Reference Power

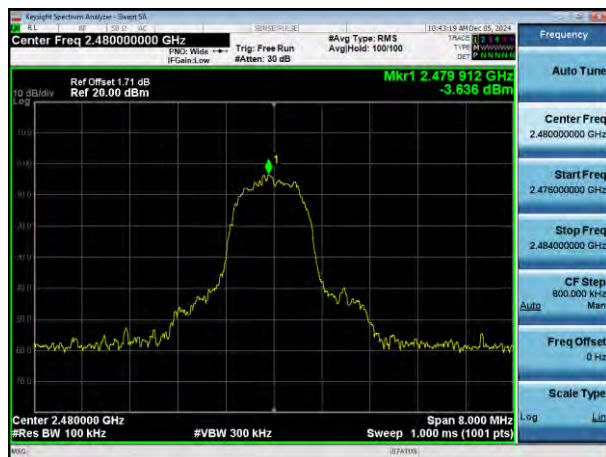


Band-edge Emission

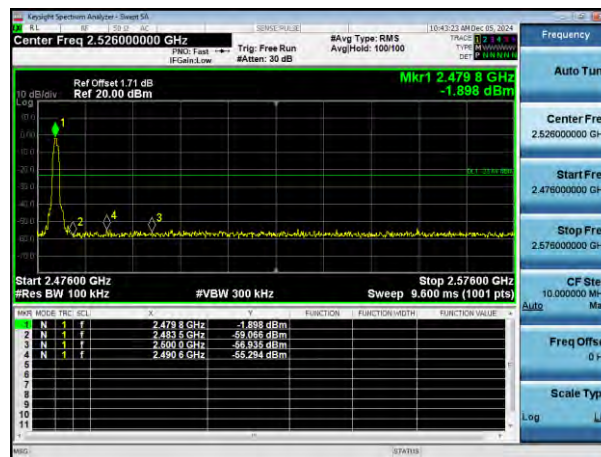


No-Hopping 8DPSK Highest

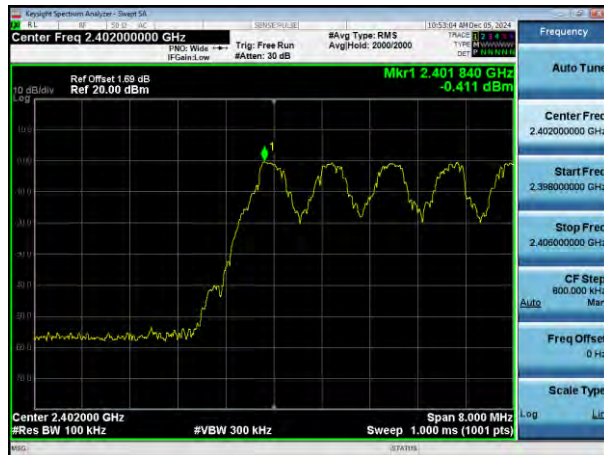
Reference Power



Band-edge Emission



Reference Power



Copyright Spectrum Analyzer - Sweet 32

KL 1 1 50.0 dBm

10:53:40 48 Dec 05, 2024

Center Freq 2.356000000 GHz

#Avg Type: RMS Avg/Mod: 2000/2000

Time 2.149 s

Frequency

Auto Tune

Center Freq 2.356000000 GHz

Start Freq 2.306000000 GHz

Stop Freq 2.406000000 GHz

CF Step 10.000000 MHz

Auto Man

Freq Offset 1.69 dB Ref 20.00 dBm

IF Gain: Low Trg: Free Run #Att: 30 dB

Mkr1 2.404 8 GHz -0.214 dBm

10 dB/div

Log

Start 2.306000 GHz #Res BW 100 kHz

#VBW 300 kHz

Stop 2.406000 GHz

Sweep 9.600 ms (1001 pts)

1 2 3 4

LINE	TYPE	FREQ	AMPL	FUNCTION	FUNCTION WIDTH	FUNCTION RANGE
1	N	2.404 8 GHz	-0.214 dBm			
2	N	2.400 0 GHz	-54.736 dBm			
3	N	2.399 0 GHz	-55.692 dBm			
4	N	2.348 0 GHz	-53.418 dBm			

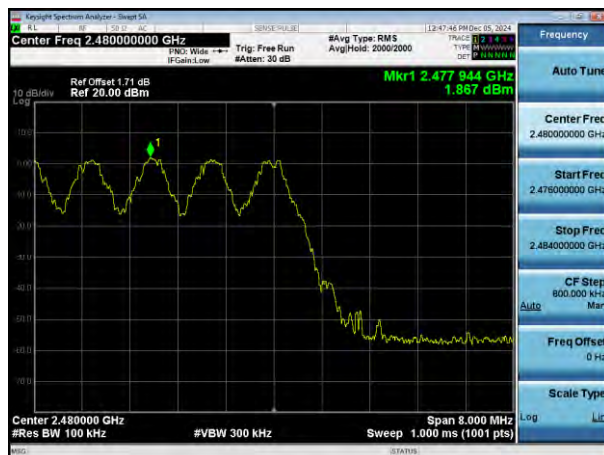
5 6 7 8 9 10 11

Log Lin

Scale Type

MSG: (STATUS)

Reference Power



Copyright Spectrum Analyzer - Sweet 16

Center Freq 2.526000000 GHz

Avg Type: RMS
Avg Hold: 2000/2000

FNO: Fast
Trig: Free Run
Scales: Low
Ref Offset 1.71 dB
Ref 20.00 dBm

Mkr1 2.477 1 GHz
1.838 dBm

Start 2.47600 GHz
Res BW 100 kHz
#VBW 300 kHz
Stop 2.57600 GHz
Sweep 9.000 ms (1001 pts)

INVT	MODB	TRIG	ACL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
2	N	1	f	2.477 1 GHz	1.838 dBm			
3	N	1	f	2.482 5 GHz	-55.888 dBm			
4	N	1	f	2.500 0 GHz	-53.076 dBm			
4	N	1	f	2.499 9 GHz	-52.855 dBm			

Frequency

Auto Tune

Center Freq
2.526000000 GHz

Start Freq
2.476000000 GHz

Stop Freq
2.576000000 GHz

CF Step
10.000000 MHz

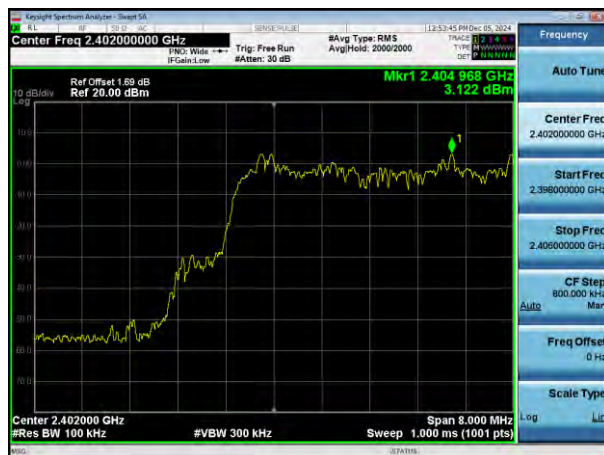
Auto Man

Freq Offset
0 Hz

Scale Type

Log Lin

Reference Power



Copyright Spectrum Analyzer - Sweet 5A

KL RF 50.0 AC

Center Freq 2.356000000 GHz

Avg Type: RMS

Trig: Free Run

Auto Tune

Frequency

Center Freq 2.356000000 GHz

Start Freq 2.306000000 GHz

Stop Freq 2.406000000 GHz

CF Step 10.000000 MHz

Auto Man

Freq Offset 0 Hz

Scale Type Lin

Log Lin

12.54-21.94 Dec 05, 2024

TRACED 1 2 3 4

TIME 0.000000

Marker 1 2.4058 GHz

3.097 dBm

Ref Offset 1.69 dB

Ref 20.00 dBm

10 dBm

0 dBm

-10 dBm

-20 dBm

-30 dBm

-40 dBm

-50 dBm

-60 dBm

-70 dBm

Start 2.306000 GHz

#Res BW 100 kHz

#VBW 300 kHz

Sweep 9.000 ms (1001 pts)

Stop 2.406000 GHz

POINT	FREQ	POWER
1	2.4058 GHz	-50.097 dBm
2	2.4000 GHz	-50.190 dBm
3	2.3960 GHz	-54.963 dBm
4	2.3558 GHz	-50.558 dBm

INVT MODE THZ GHz

1 2.4058 GHz

2 2.4000 GHz

3 2.3960 GHz

4 2.3558 GHz

FUNCTION

FUNCTION WIDTH

FUNCTION VALUE

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2

3

4

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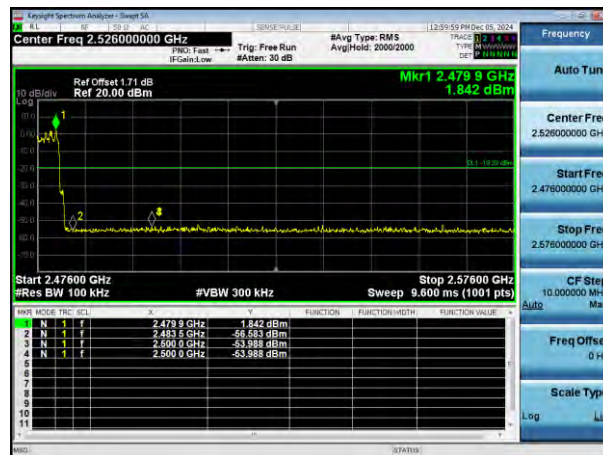
353

Hopping Pi/4 DQPSK Highest

Reference Power

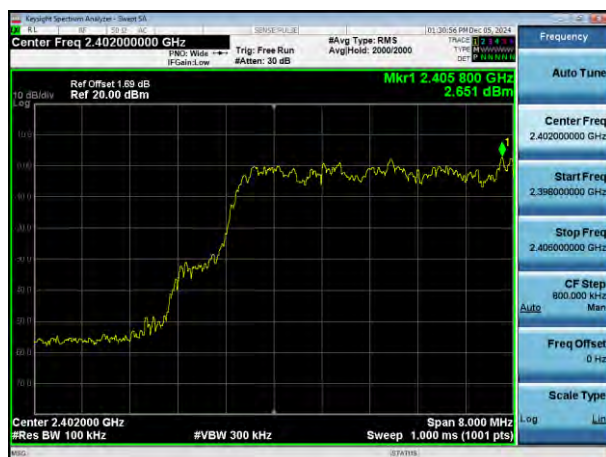


Band-edge Emission

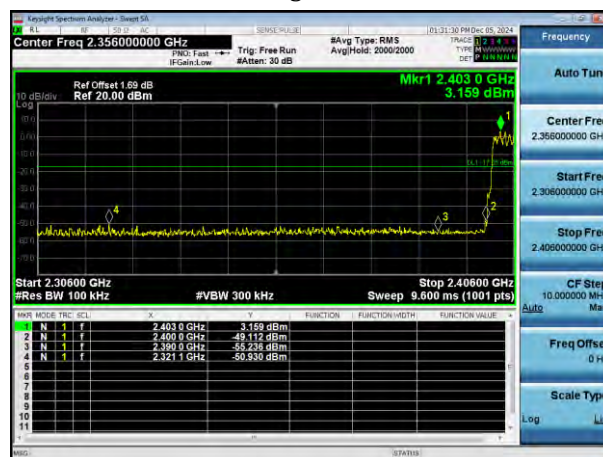


Hopping 8DPSK Lowest

Reference Power

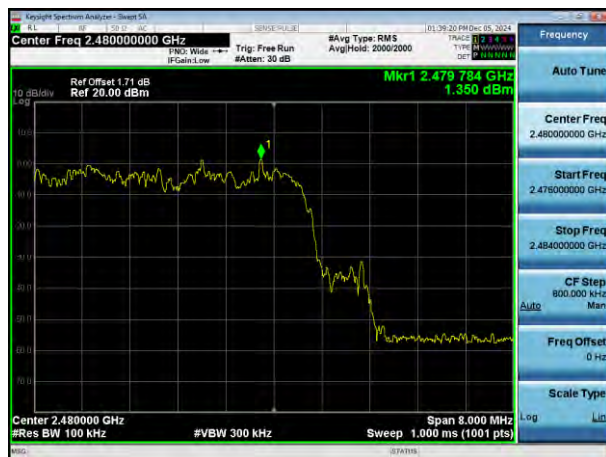


Band-edge Emission

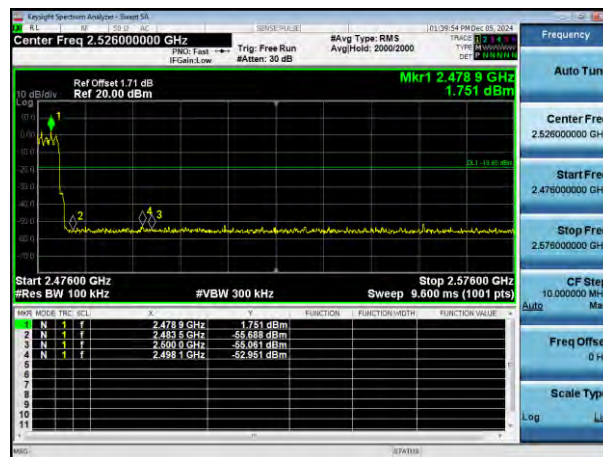


Hopping 8DPSK Highest

Reference Power



Band-edge Emission



14. Conducted RF Spurious Emissions

14.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. 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) (see § 15.205(c)).

14.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.7.

- 1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
- 2) Set the spectrum analyzer to any one measured frequency within its operating range.
- 3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
- 4) Measure the highest amplitude appearing on spectral display and set it as a reference level.
- 5) Measure the spurious emissions with frequency range from 9kHz to 26.5GHz.
- 6) Repeat above procedures until all measured frequencies were complete.



Test Setup Block Diagram

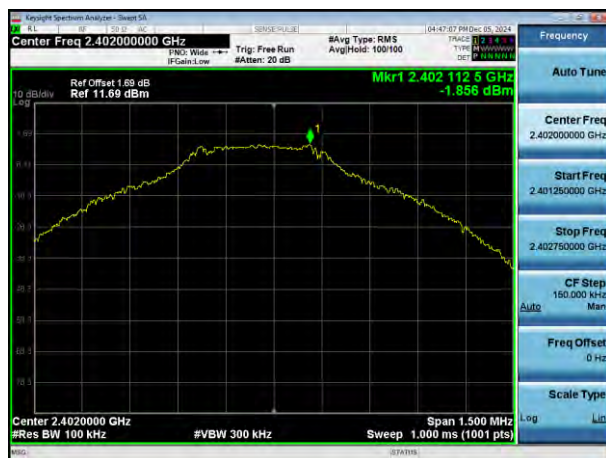
14.3 Test Data and Results

Note: The measurement frequency range is from 9kHz to the 10th harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions measurement data.

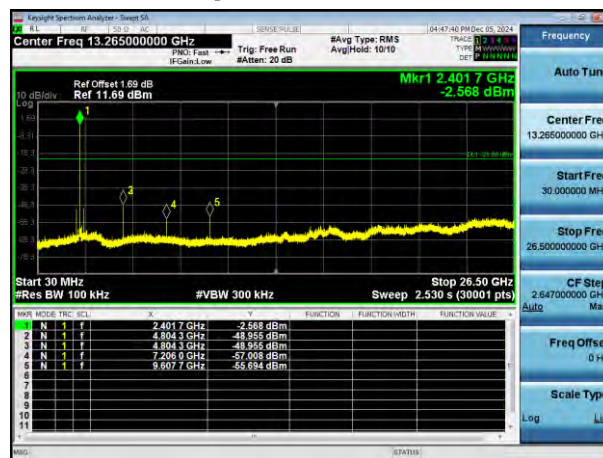
Left earphone:

GFSK Lowest

Reference Power



Spurious Emissions

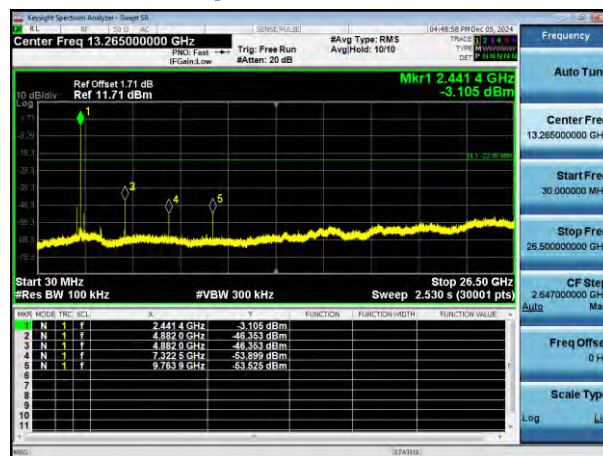


GFSK Middle

Reference Power



Spurious Emissions

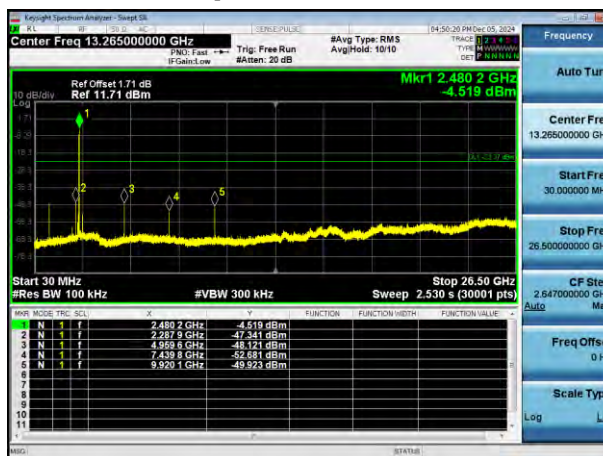


GFSK Highest

Reference Power



Spurious Emissions

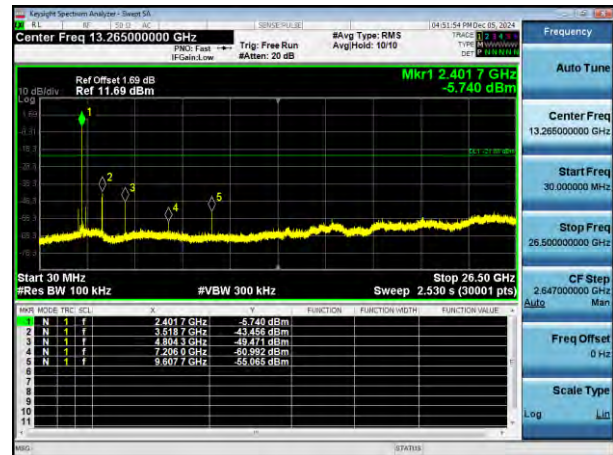


Pi/4 DQPSK Lowest

Reference Power



Spurious Emissions

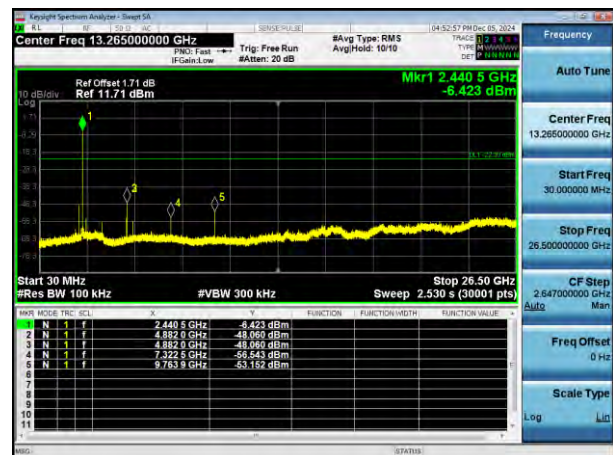


Pi/4 DQPSK Middle

Reference Power



Spurious Emissions

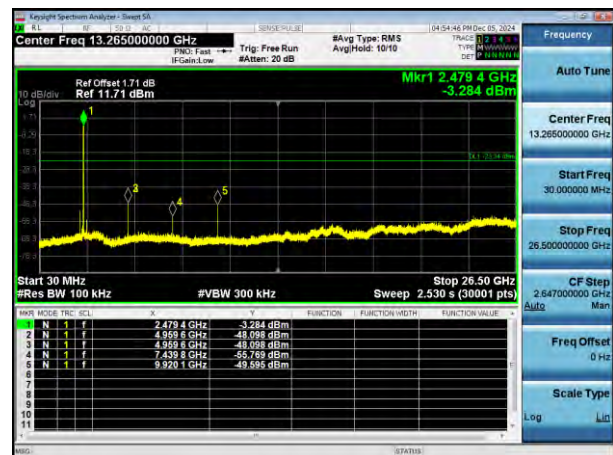


Pi/4 DQPSK Highest

Reference Power



Spurious Emissions

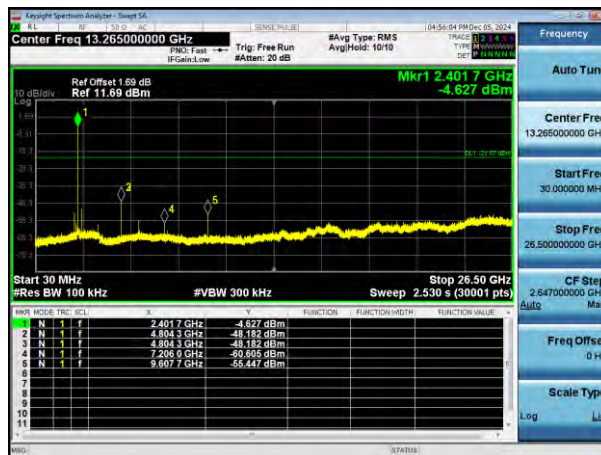


8DPSK Lowest

Reference Power



Spurious Emissions

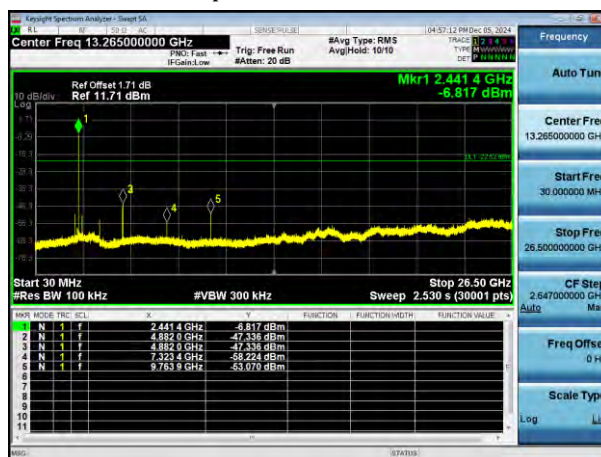


8DPSK Middle

Reference Power



Spurious Emissions

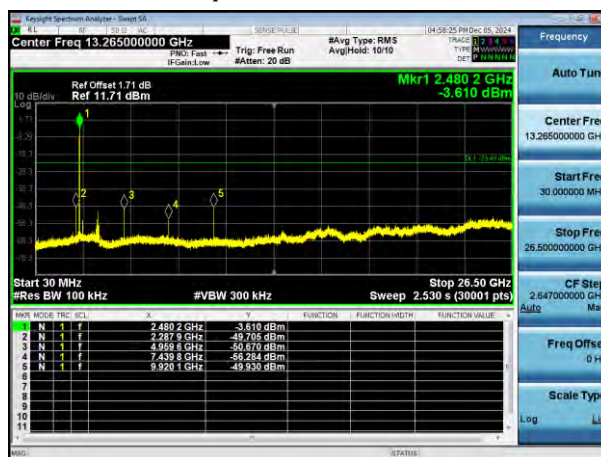


8DPSK Highest

Reference Power



Spurious Emissions



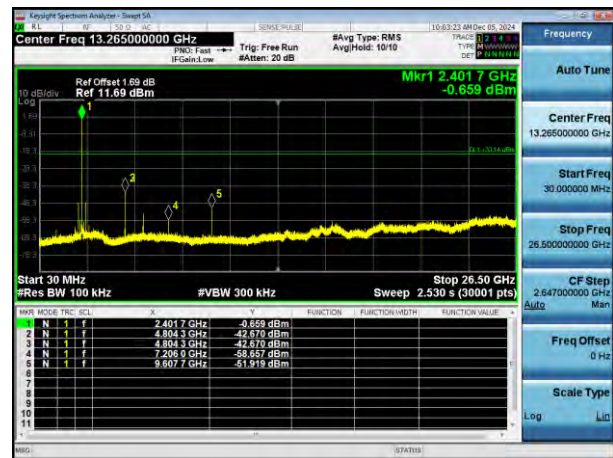
Right earphone:

GFSK Lowest

Reference Power



Spurious Emissions

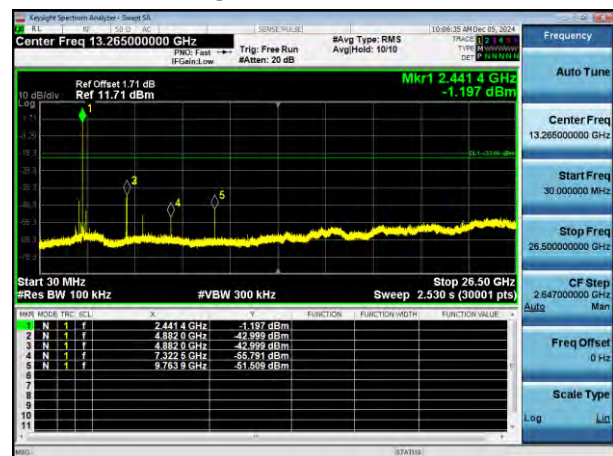


GFSK Middle

Reference Power



Spurious Emissions

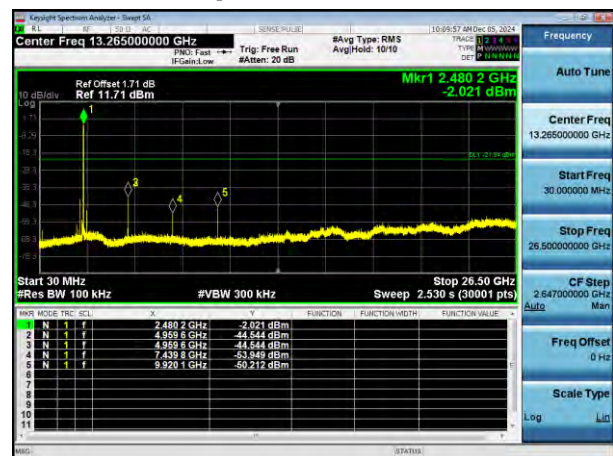


GFSK Highest

Reference Power



Spurious Emissions

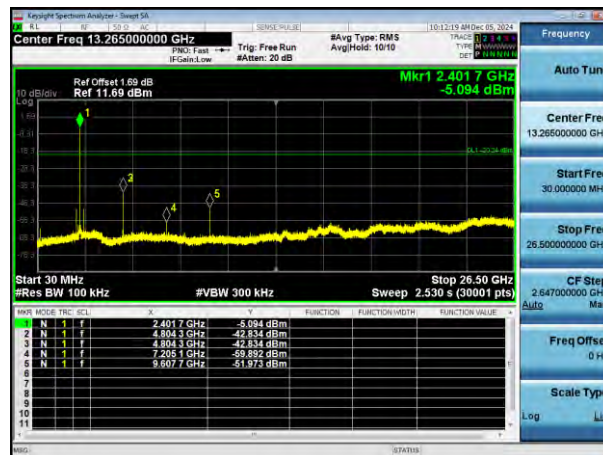


Pi/4 DQPSK Lowest

Reference Power



Spurious Emissions

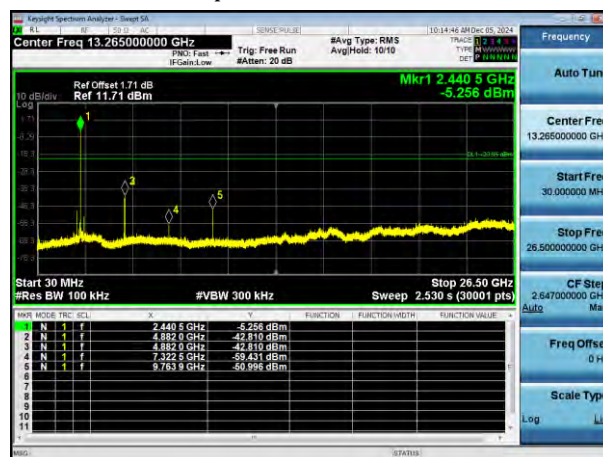


Pi/4 DQPSK Middle

Reference Power



Spurious Emissions

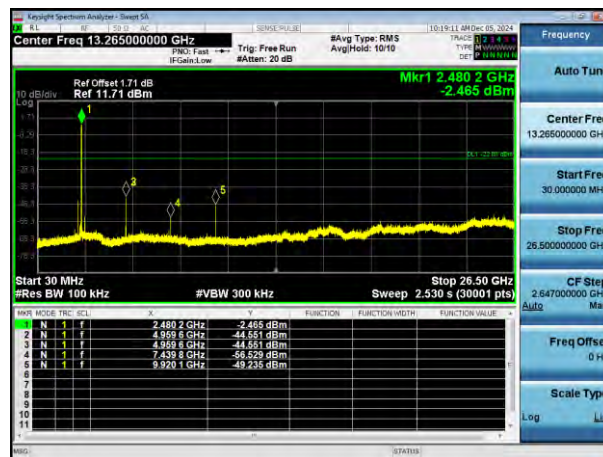


Pi/4 DQPSK Highest

Reference Power

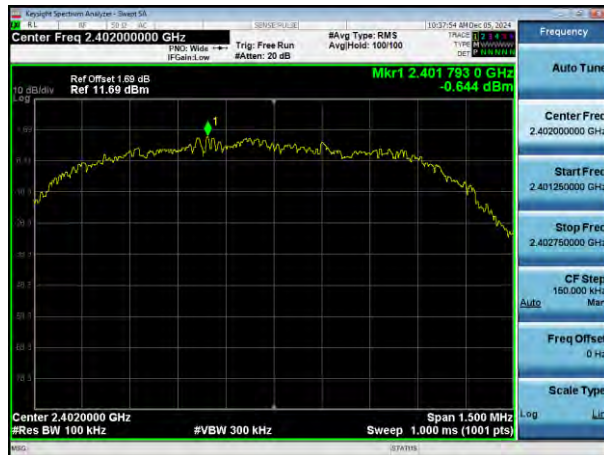


Spurious Emissions

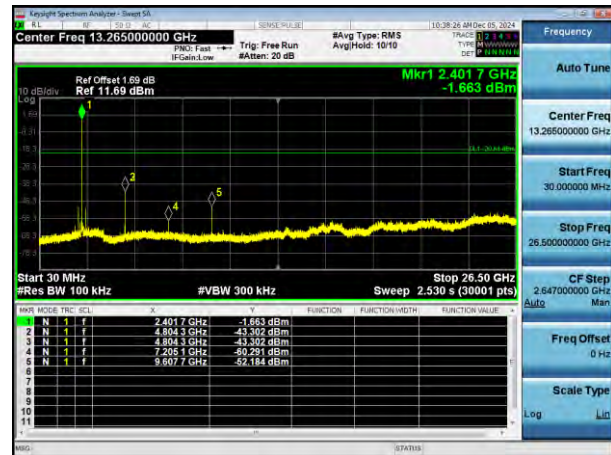


8DPSK Lowest

Reference Power



Spurious Emissions

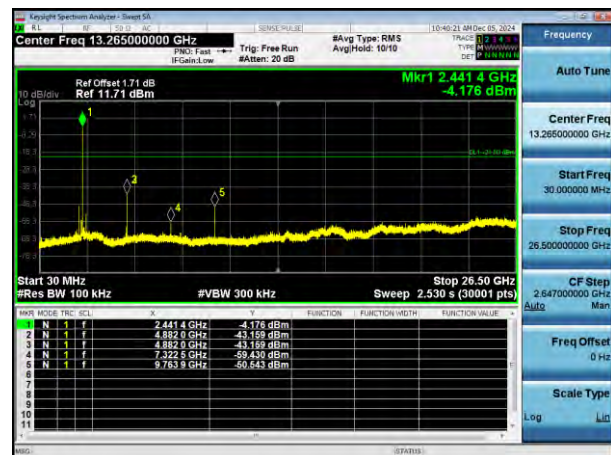


8DPSK Middle

Reference Power



Spurious Emissions

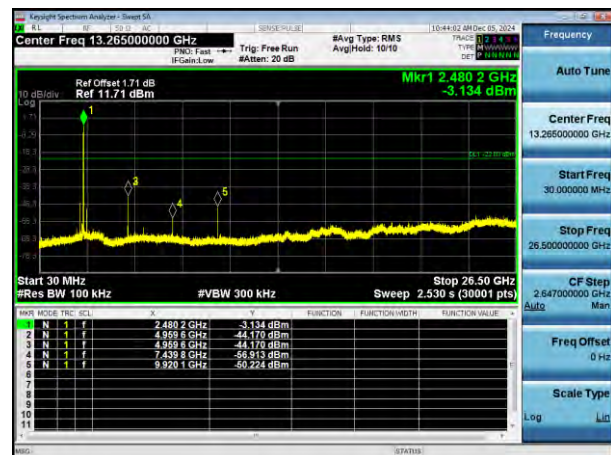


8DPSK Highest

Reference Power



Spurious Emissions



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