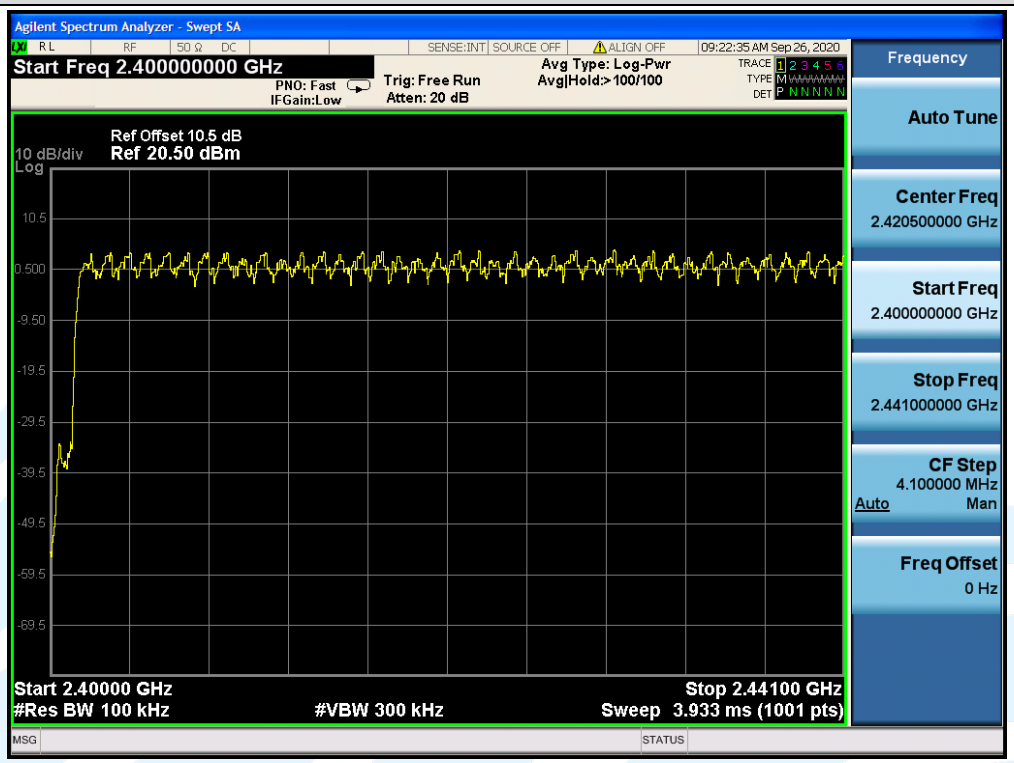
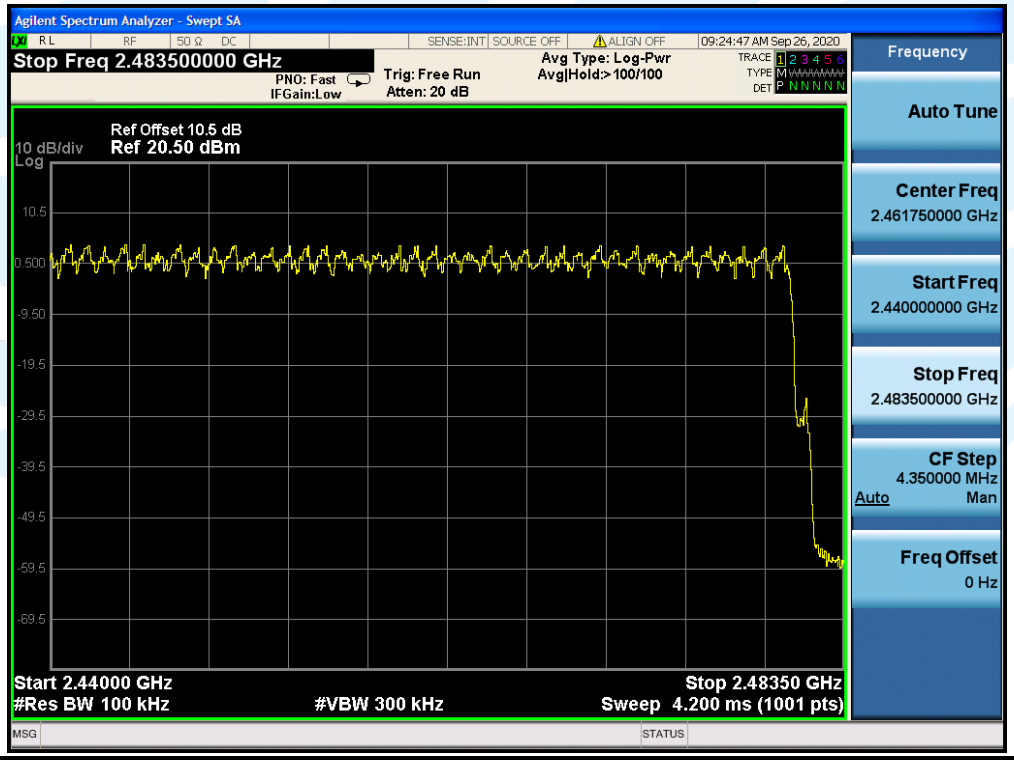
8DPSK_Low End Spectrum Channel Hopping Plot



8DPSK_High End Spectrum Channel Hopping Plot



5.7 DWELL TIME

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247(a)(1)
RSS-247 Issue 2, Section 5.1(d)

Test Method: ANSI C63.10-2013 Section 7.8.4

Limit: Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

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

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

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

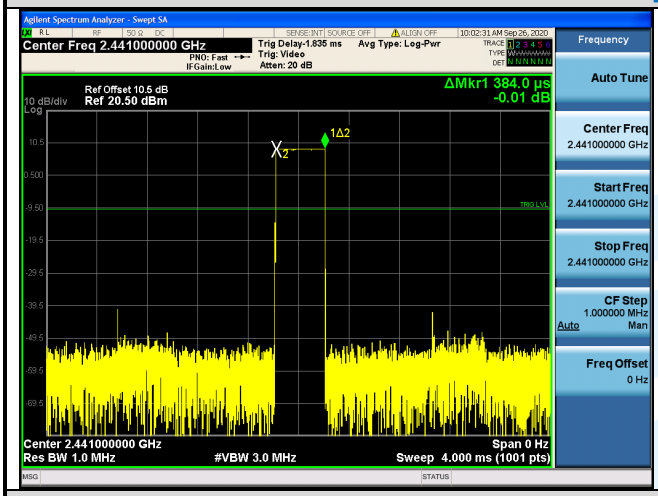
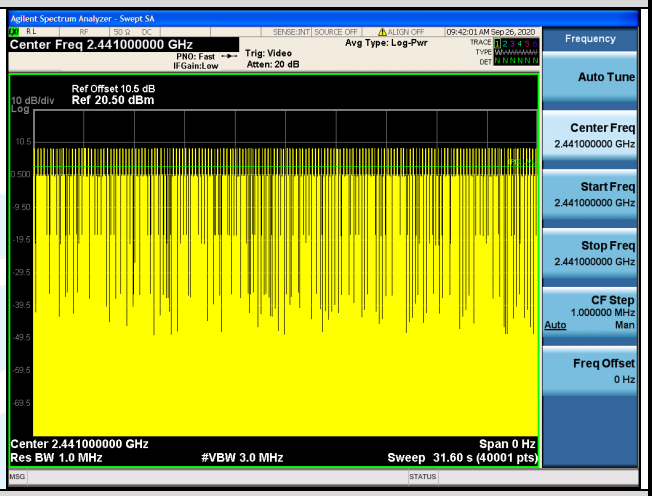
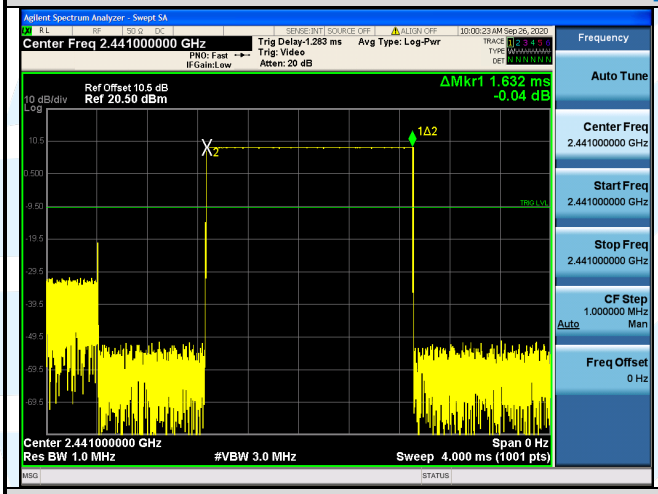
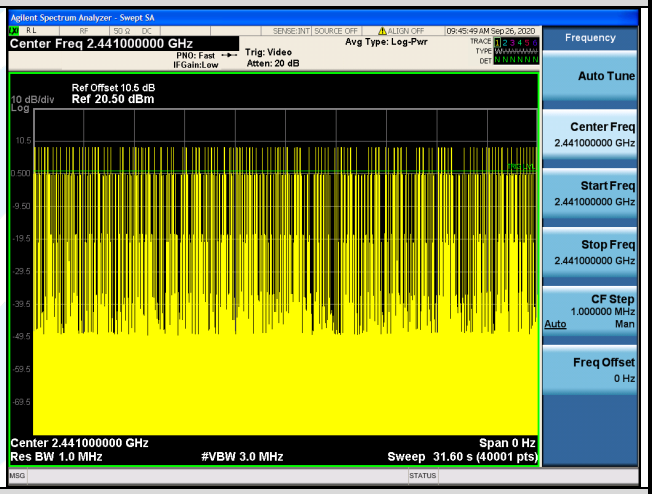
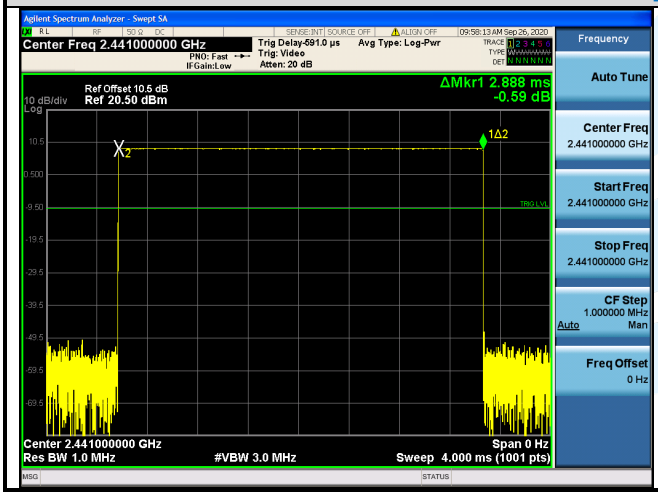
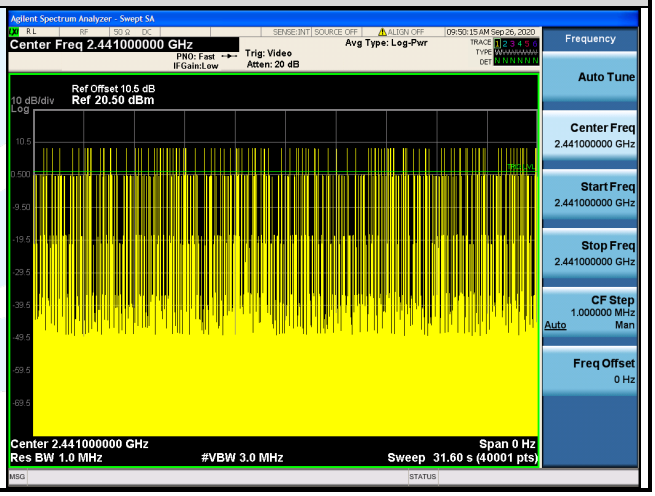
Test Setup: Refer to section 4.5.3 for details.

Instruments Used: Refer to section 3 for details

Test Results: Pass

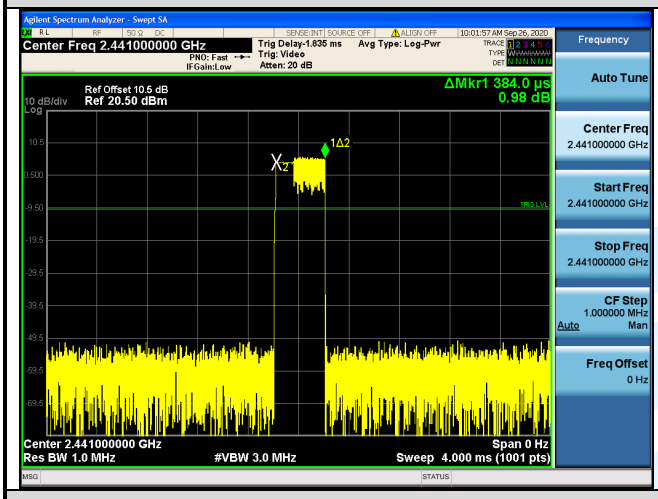
Type of Modulation	Test Frequency	Packet	Pulse Width	Number of Pulses in 31.6 seconds	Dwell Time	Limit
			ms		ms	ms
GFSK	2441MHz	1-DH1	0.384	183.000	70.27	< 400
		1-DH3	1.632	122.000	199.10	< 400
		1-DH5	2.888	95.000	274.36	< 400
π/4 DQPSK	2441MHz	2-DH1	0.384	181.000	69.50	< 400
		2-DH3	1.640	123.000	201.72	< 400
		2-DH5	2.888	88.000	254.14	< 400
8DPSK	2441MHz	3-DH1	0.392	181.000	70.95	< 400
		3-DH3	1.640	120.000	196.80	< 400
		3-DH5	2.888	96.000	**277.25**	< 400

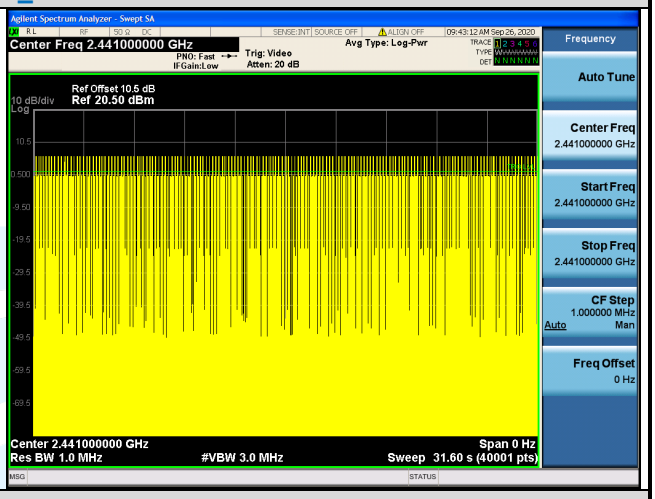
The test plots as follows:

Pulse Width	Number of Pulses in 3.16 Seconds
GFSK_1-DH1	
	
GFSK_1-DH3	
	
GFSK_1-DH5	
	

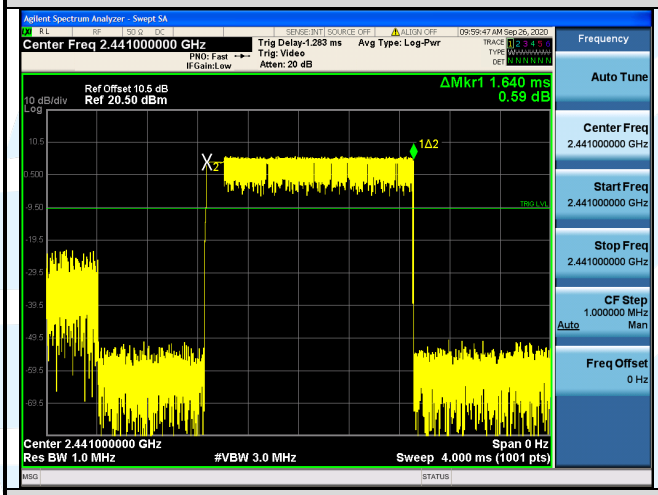
Pulse Width	Number of Pulses in 3.16 Seconds

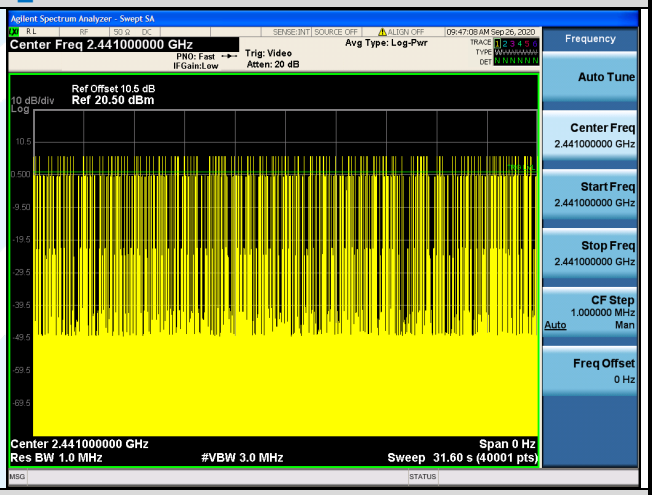
π /4DQPSK_2-DH1



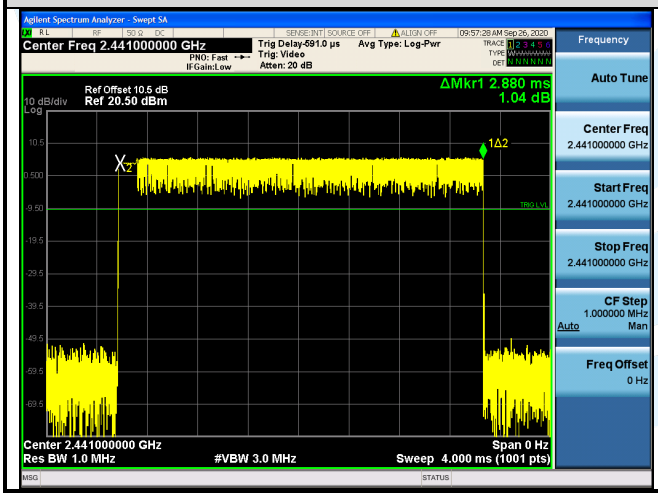


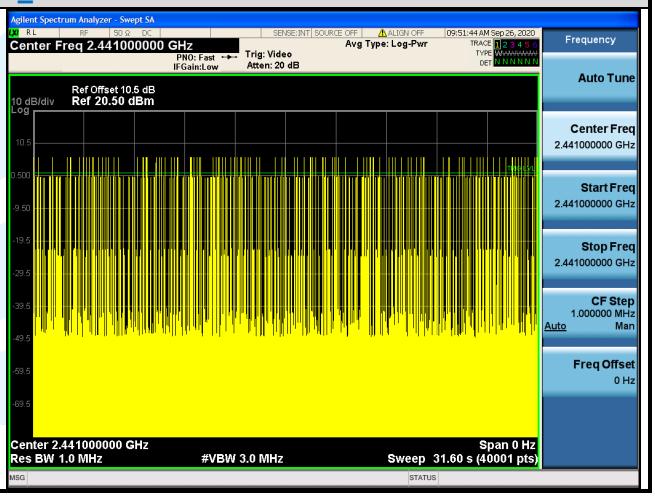
π /4DQPSK_2-DH3





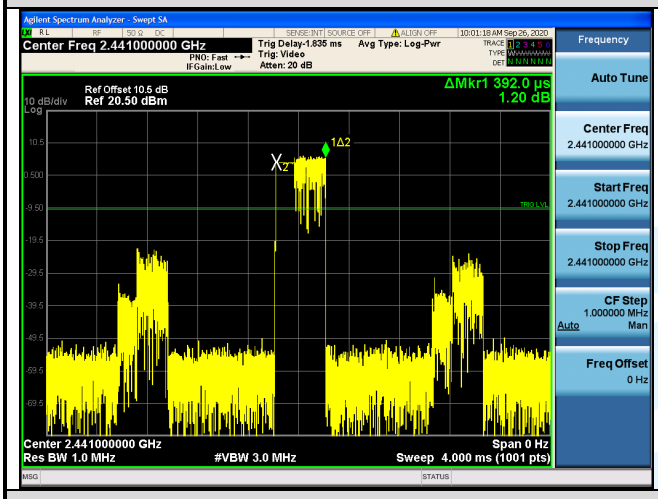
π /4DQPSK_2-DH5

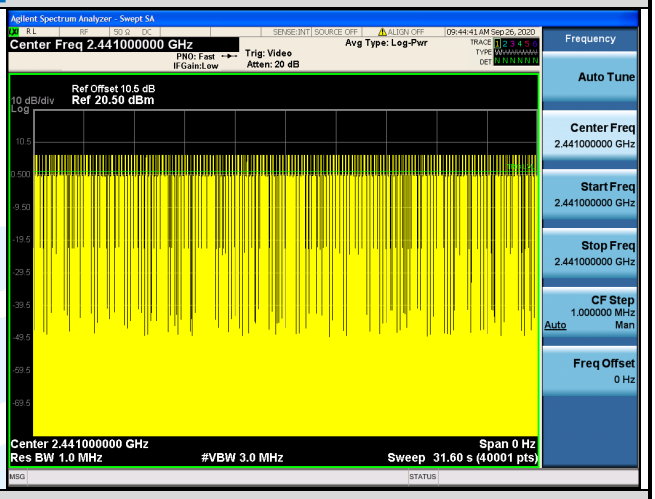




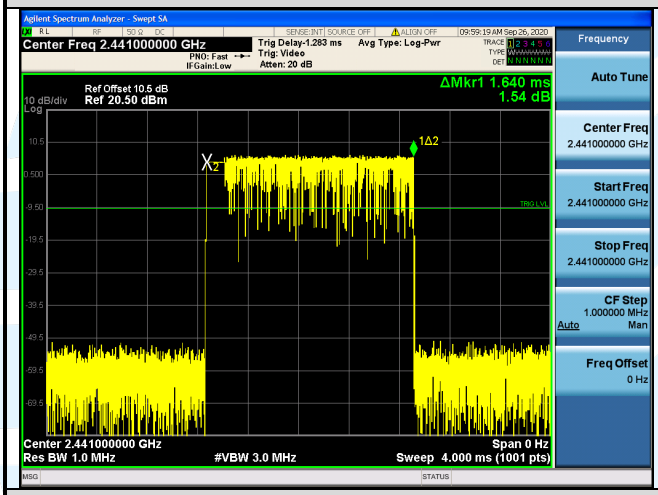
Pulse Width	Number of Pulses in 3.16 Seconds

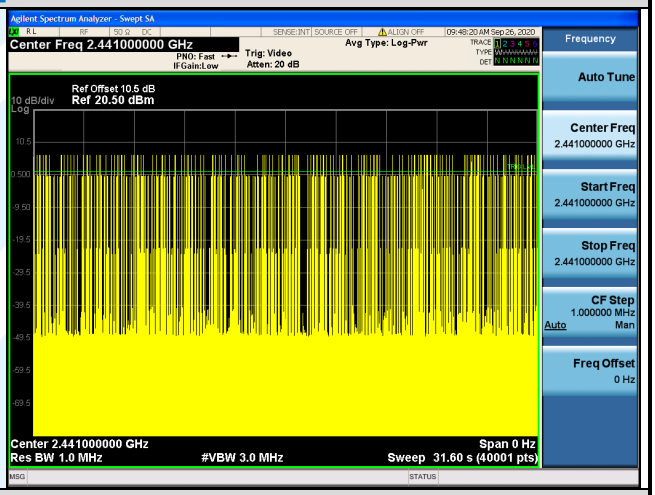
8DPSK_3-DH1



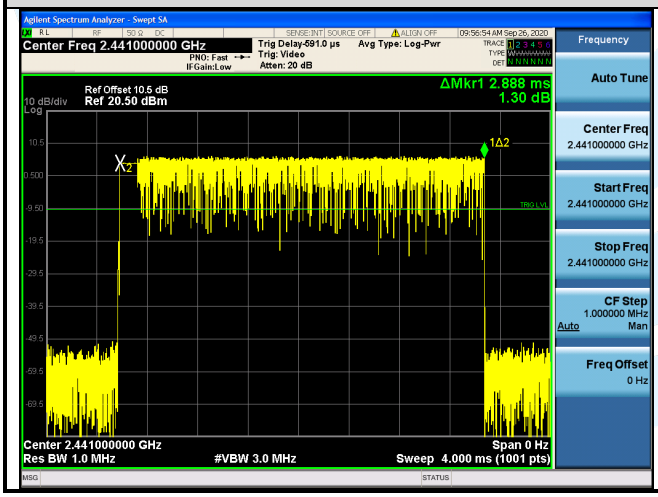


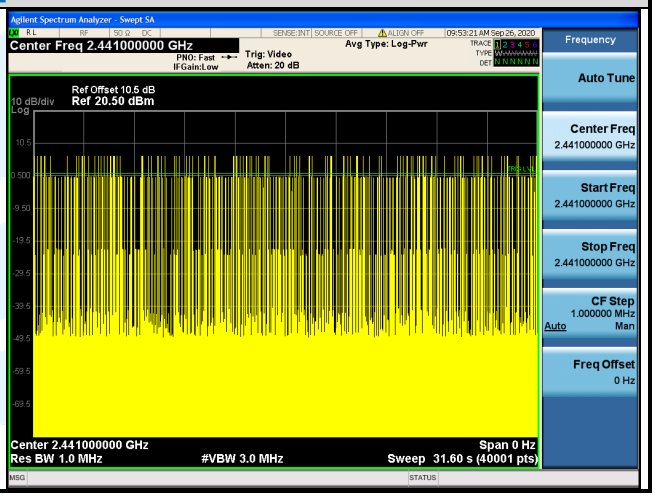
8DPSK_3-DH3





8DPSK_3-DH5





5.8 CONDUCTED OUT OF BAND EMISSION

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.247(d)
RSS-247 Issue 2, Section 5.5

Test Method: ANSI C63.10-2013 Section 6.10.4 & Section 7.8.8

Limit: In any 100kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator in operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power.

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

Step 1:Measurement Procedure REF

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

Step 2:Measurement Procedure OOBE

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

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

Test Setup: Refer to section 4.5.3 for details.

Instruments Used: Refer to section 3 for details

Test Mode: Hopping Frequencies Transmitter mode

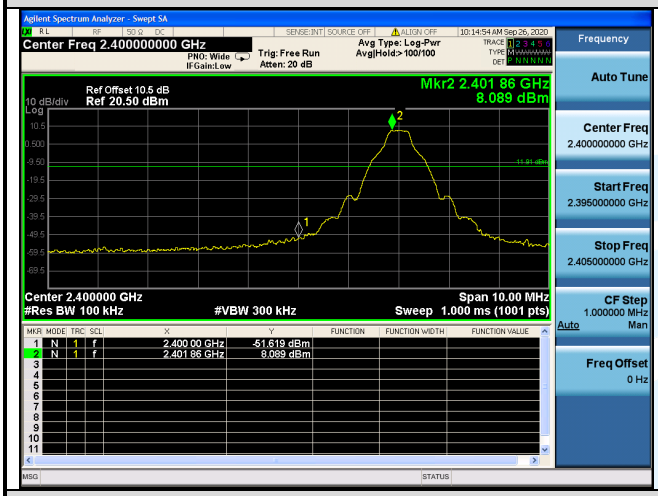
Test Results: Pass

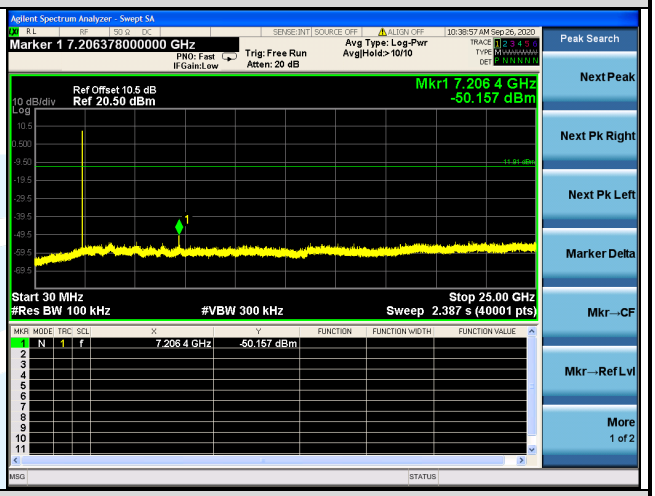
Test Data:

The test plots as follows:

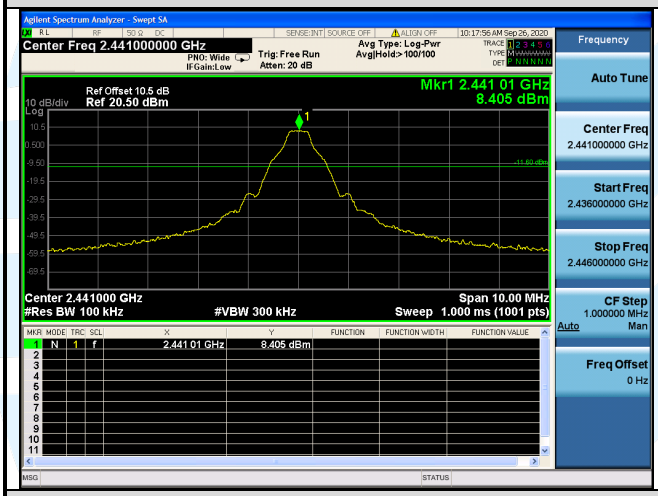
GFSK	
In-Band Reference Level	**Out of Band Emission**

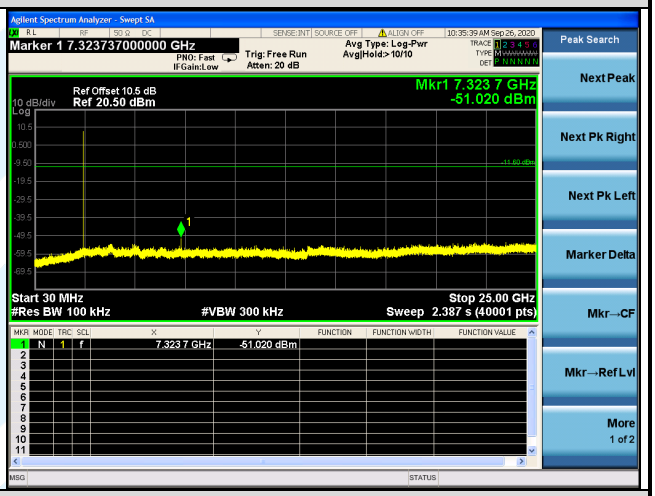
Lowest Channel



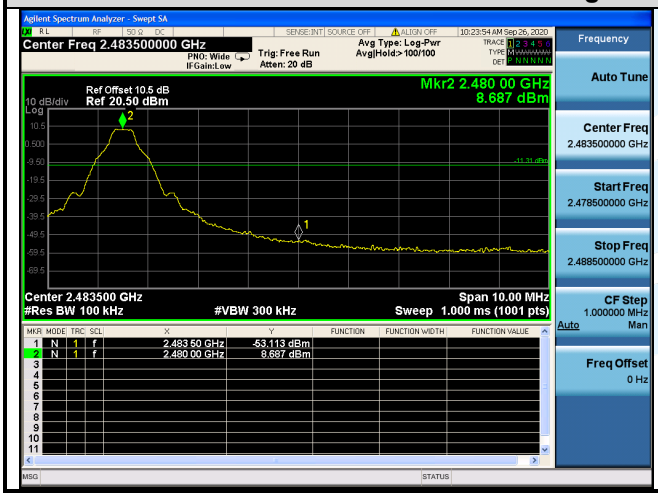


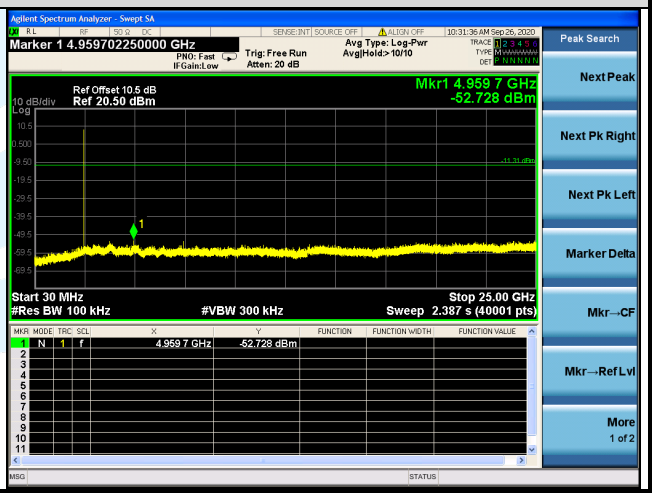
Middle Channel





Highest Channel

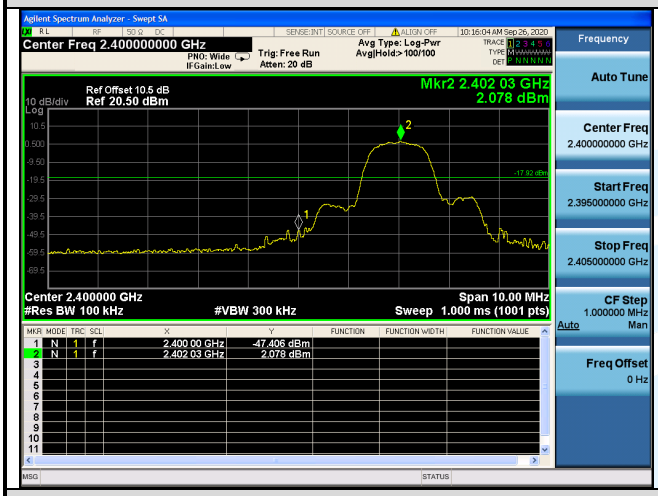


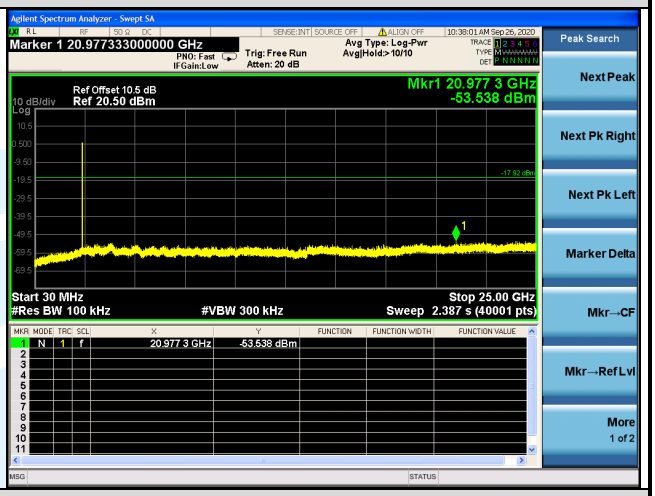


π/4DQPSK

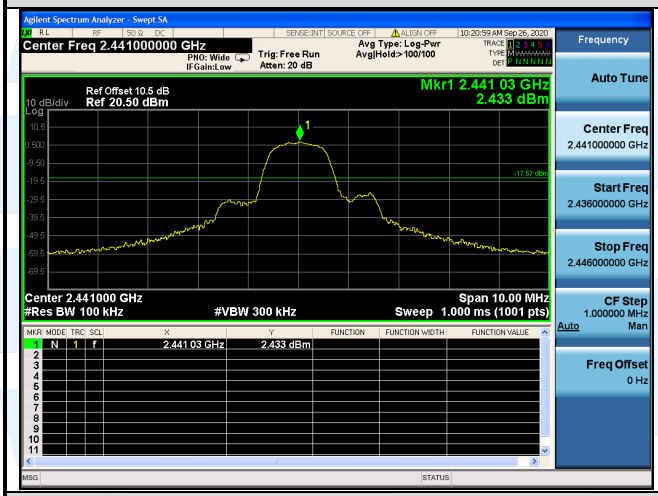
In-Band Reference Level	Out of Band Emission

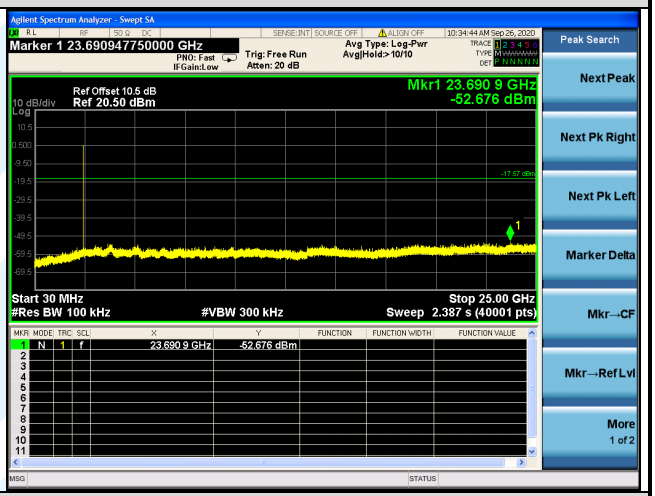
Lowest Channel



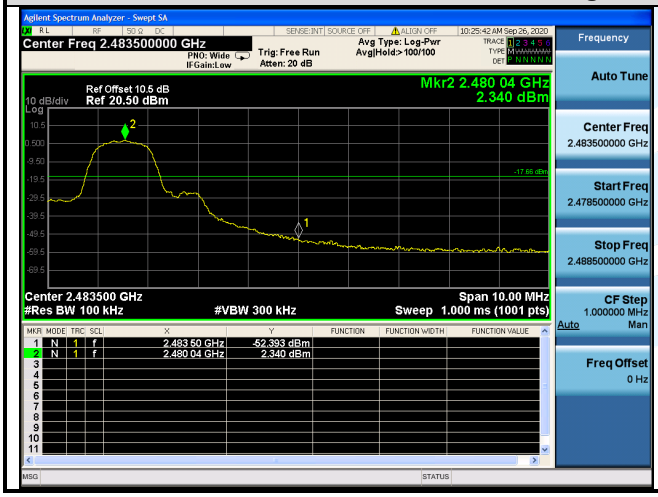


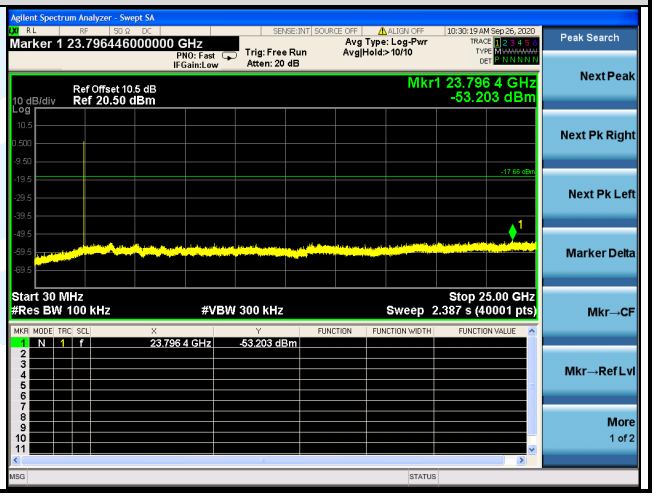
Middle Channel





Highest Channel

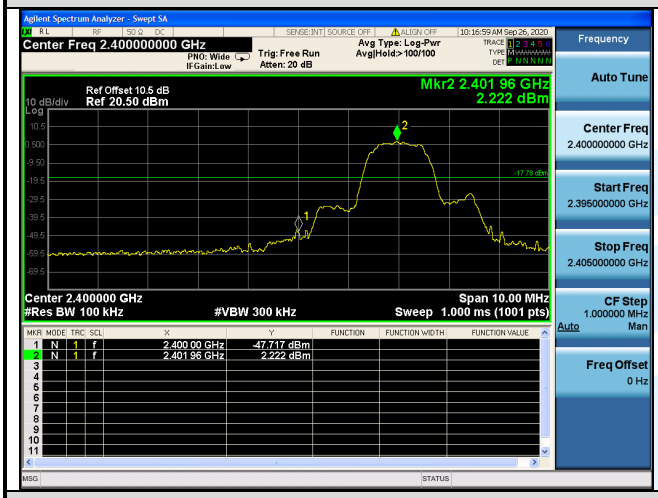


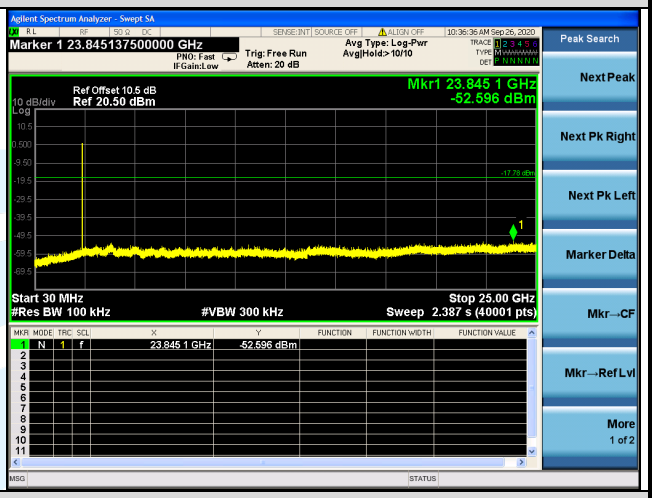


8DPSK

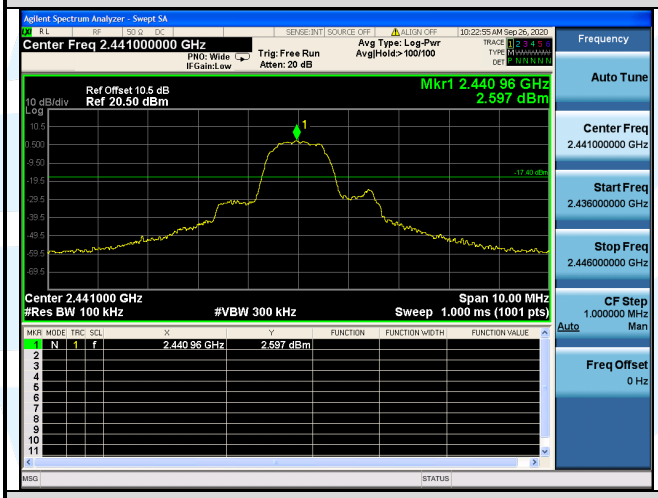
In-Band Reference Level	Out of Band Emission

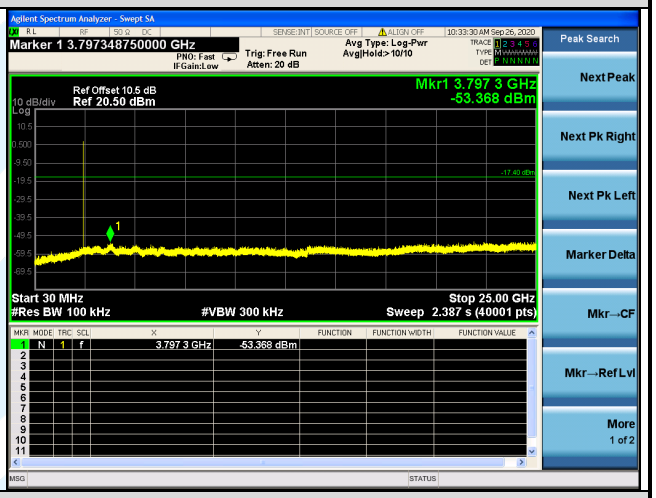
Lowest Channel



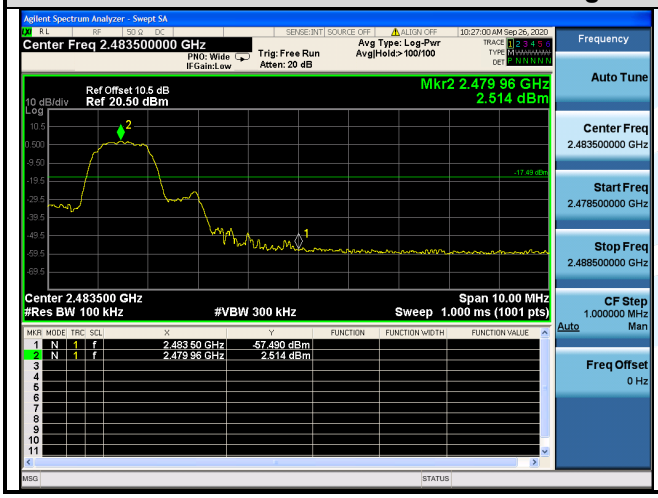


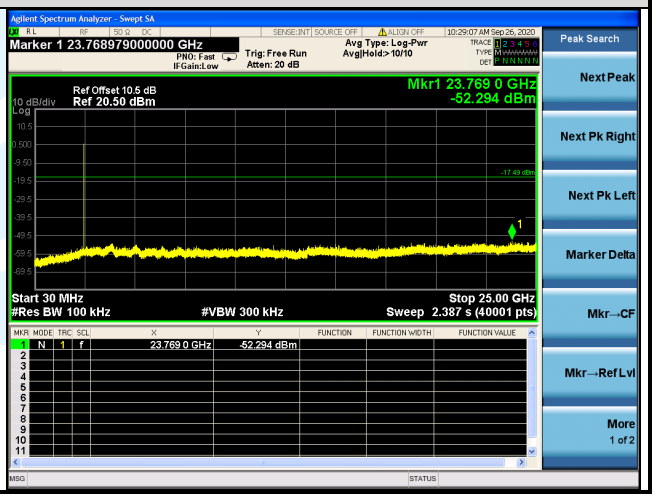
Middle Channel





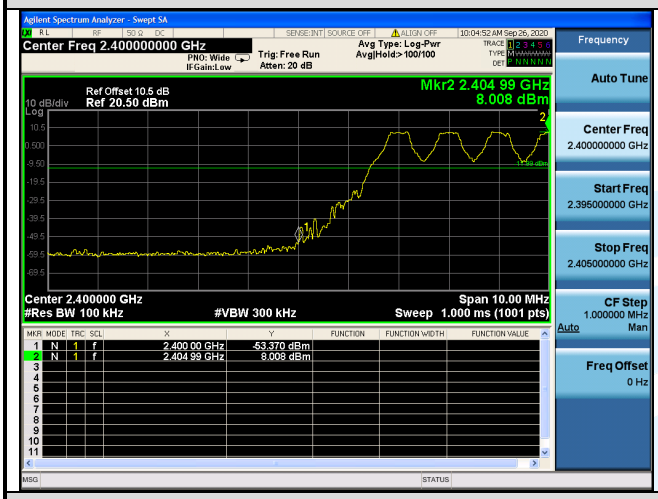
Highest Channel



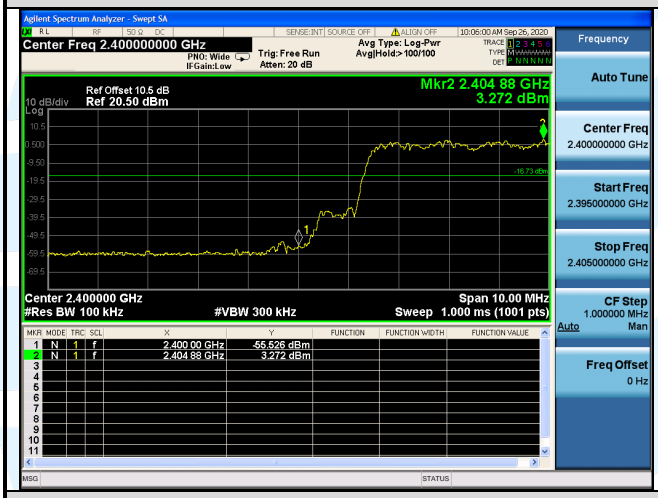


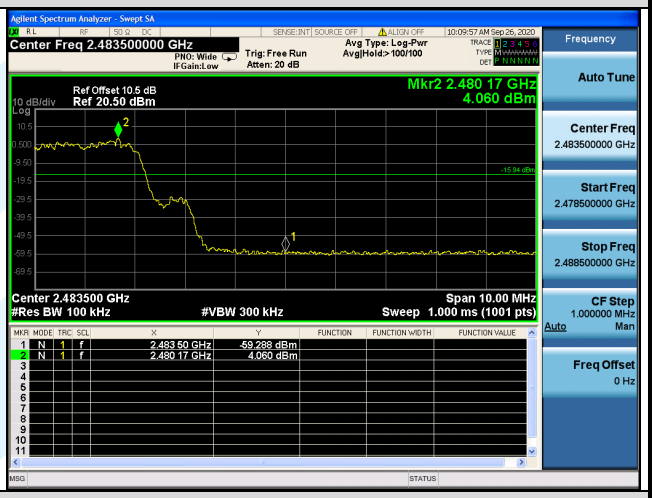
Hopping Lowest Channel	Hopping Highest Channel

GFSK

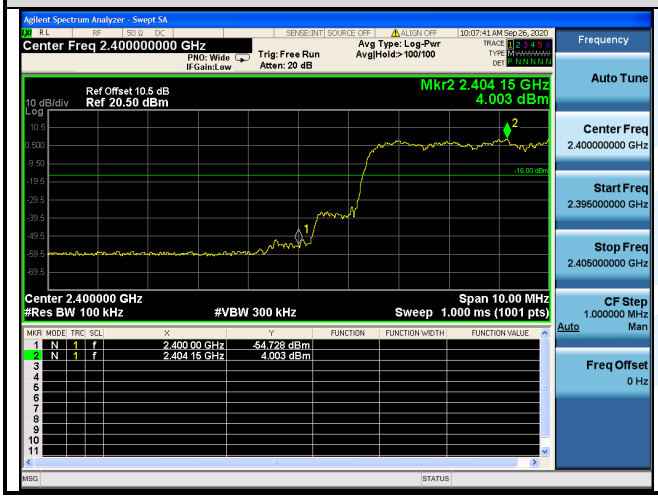


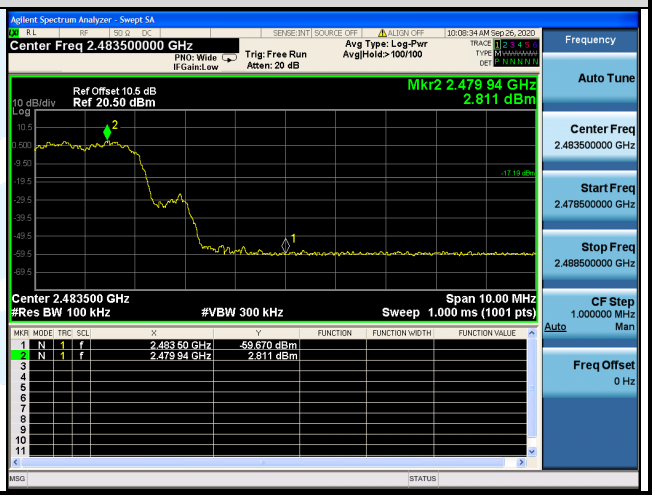
π/4DQPSK





8DPSK





5.9 RADIATED SPURIOUS EMISSIONS

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.205/15.209
RSS-Gen Issue 5, Section 6.13/8.9/8.10

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

Receiver Setup:

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

Limits:

Spurious Emissions

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

Remark:

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

Test Setup: Refer to section 4.5.1 for details.

Test Procedures:

1. From 30 MHz to 1GHz test procedure as below:

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

2. Above 1GHz test procedure as below:

1) Different between above is the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber and change form table 0.8 meter to 1.5 meter(Above 18GHz the distance is 1 meter and table is 1.5 meter).

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

Equipment Used: Refer to section 3 for details.

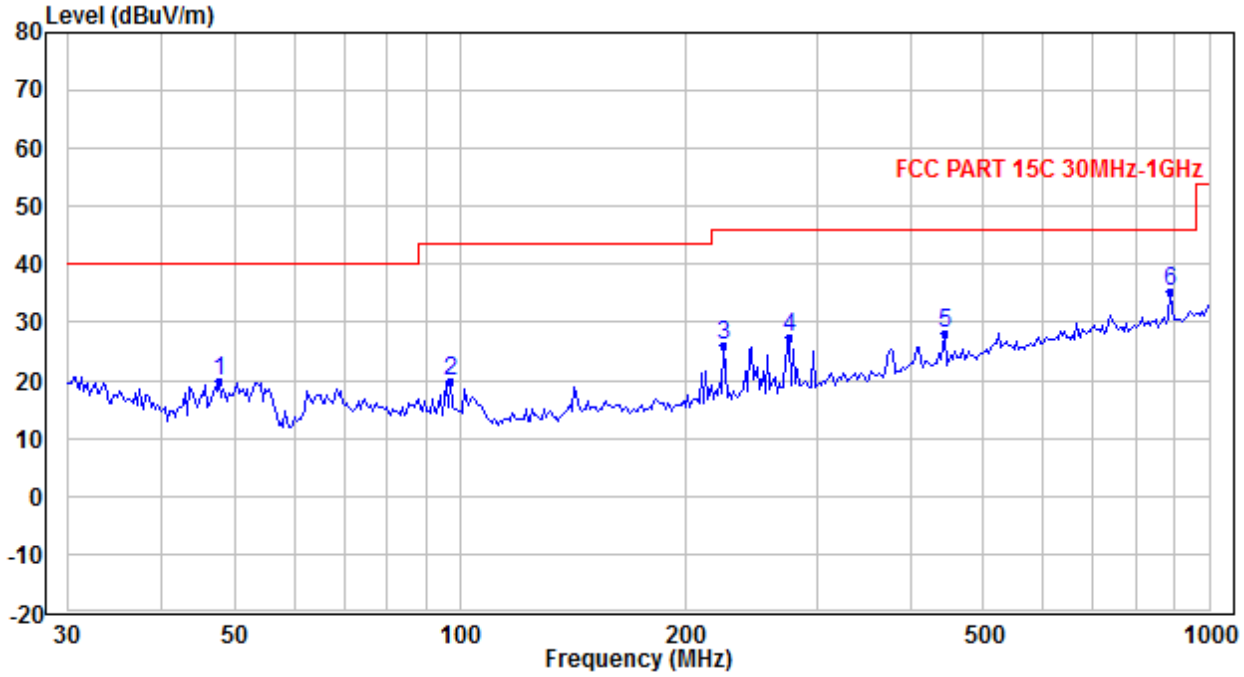
Test Result: Pass

The measurement data as follows:

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

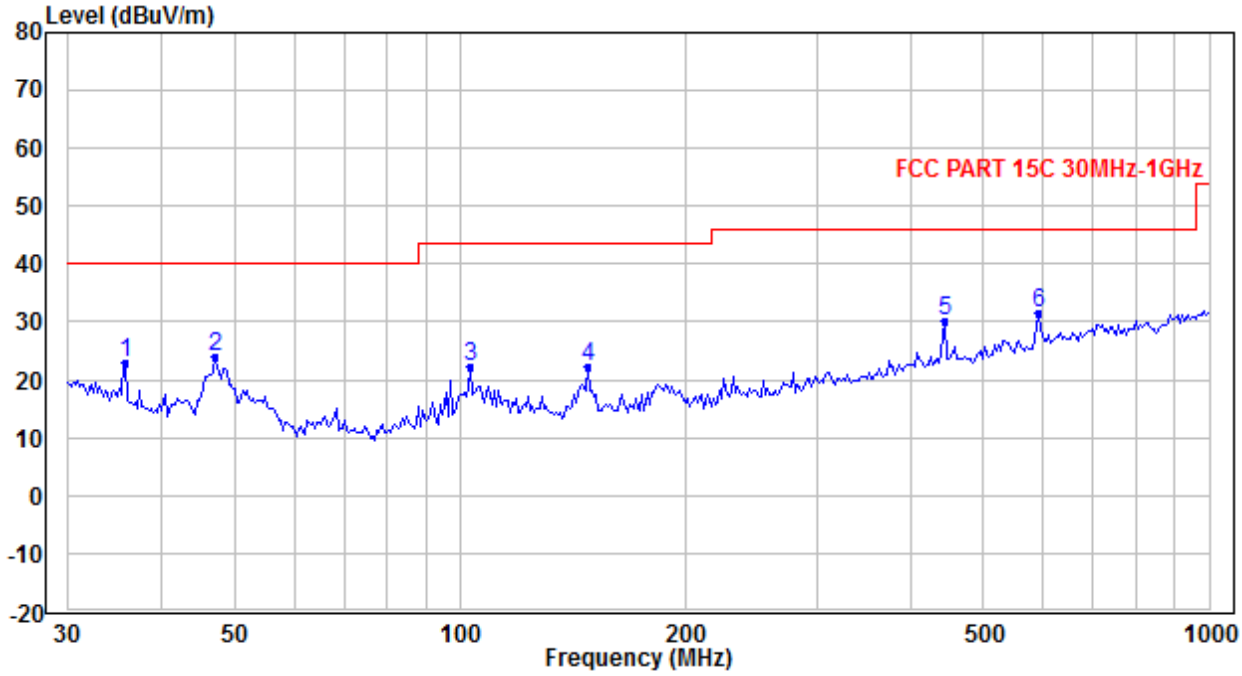
Radiated Emission Test Data (30 MHz ~ 1 GHz):
Worst-Case Configuration

Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	47.703	34.39	-14.44	19.95	40.00	-20.05	QP
2	97.002	33.03	-13.28	19.75	43.50	-23.75	QP
3	225.427	34.07	-7.92	26.15	46.00	-19.85	QP
4	274.446	33.62	-6.07	27.55	46.00	-18.45	QP
5	442.572	30.54	-2.49	28.05	46.00	-17.95	QP
6	887.398	30.76	4.64	35.40	46.00	-10.60	QP

Vertical



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	35.762	32.12	-9.02	23.10	40.00	-16.90	QP
2	47.037	37.51	-13.52	23.99	40.00	-16.01	QP
3	103.335	34.50	-12.39	22.11	43.50	-21.39	QP
4	147.875	33.85	-11.42	22.43	43.50	-21.07	QP
5	442.572	32.81	-2.63	30.18	46.00	-15.82	QP
6	590.351	30.98	0.61	31.59	46.00	-14.41	QP

Radiated Emission Test Data (Above 1GHz):

Lowest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4804.00	43.90	4.44	48.34	74.00	-25.66	Peak	Horizontal
2	4804.00	33.00	4.44	37.44	54.00	-16.56	Average	Horizontal
3	7206.00	48.82	6.66	55.48	74.00	-18.52	Peak	Horizontal
4	7206.00	33.59	6.66	40.25	54.00	-13.75	Average	Horizontal
5	4804.00	44.32	4.00	48.32	74.00	-25.68	Peak	Vertical
6	4804.00	32.84	4.00	36.84	54.00	-17.16	Average	Vertical
7	7206.00	46.42	6.51	52.93	74.00	-21.07	Peak	Vertical
8	7206.00	33.00	6.51	39.51	54.00	-14.49	Average	Vertical

Middle Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4882.00	45.73	4.30	50.03	74.00	-23.97	Peak	Horizontal
2	4882.00	33.30	4.30	37.60	54.00	-16.40	Average	Horizontal
3	7323.00	48.69	6.67	55.36	74.00	-18.64	Peak	Horizontal
4	7323.00	33.32	6.67	39.99	54.00	-14.01	Average	Horizontal
5	4882.00	45.26	3.96	49.22	74.00	-24.78	Peak	Vertical
6	4882.00	33.28	3.96	37.24	54.00	-16.76	Average	Vertical
7	7323.00	46.98	6.47	53.45	74.00	-20.55	Peak	Vertical
8	7323.00	32.80	6.47	39.27	54.00	-14.73	Average	Vertical

Highest Channel:

No.	Frequency (MHz)	Reading (dBuV/m)	Correction factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polaxis
1	4960.00	47.58	3.65	51.23	74.00	-22.77	Peak	Horizontal
2	4960.00	33.59	3.65	37.24	54.00	-16.76	Average	Horizontal
3	7440.00	45.78	6.33	52.11	74.00	-21.89	Peak	Horizontal
4	7440.00	32.47	6.33	38.80	54.00	-15.20	Average	Horizontal
5	4960.00	45.73	3.91	49.64	74.00	-24.36	Peak	Vertical
6	4960.00	33.45	3.91	37.36	54.00	-16.64	Average	Vertical
7	7440.00	45.66	6.43	52.09	74.00	-21.91	Peak	Vertical
8	7440.00	32.19	6.43	38.62	54.00	-15.38	Average	Vertical

Remark:

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

5.10 BAND EDGE MEASUREMENTS (RADIATED)

Test Requirement: FCC 47 CFR Part 15 Subpart C Section 15.205/15.209
RSS-247 Issue 2, Section 5.5

Test Method: ANSI C63.10-2013 Section 6.10.5

Limits:

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

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

Test Setup: Refer to section 4.5.1 for details.

Test Procedures:

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

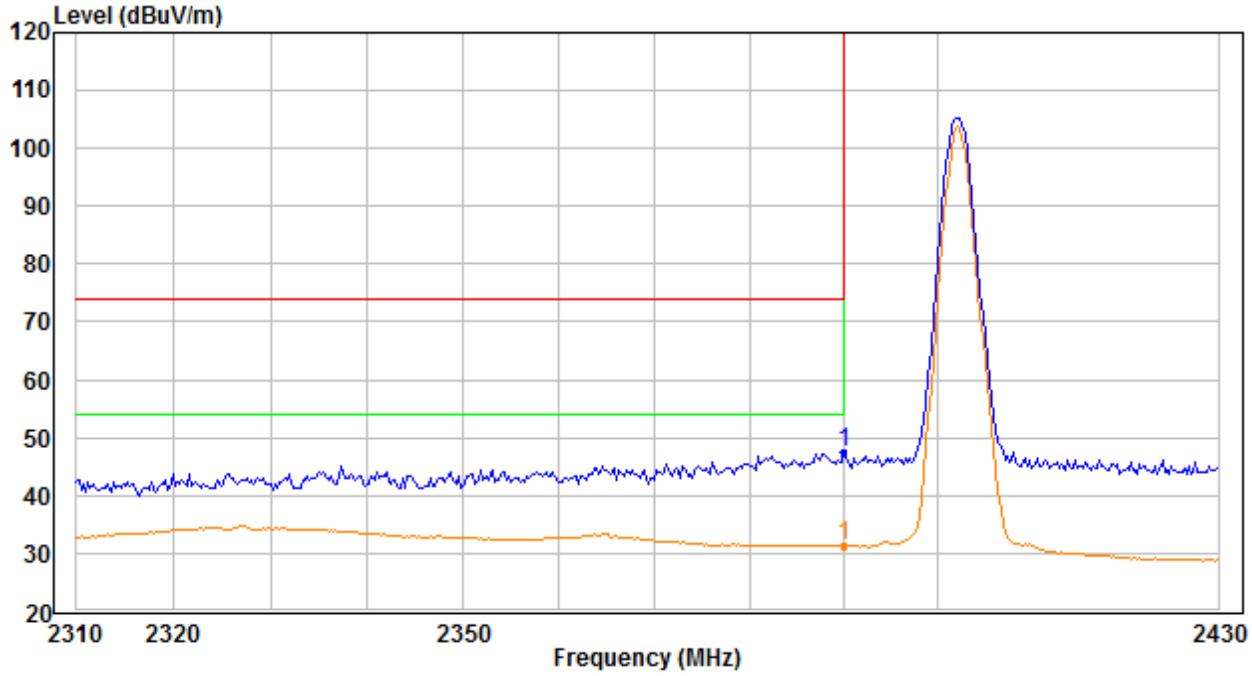
1. Use radiated spurious emission test procedure described in clause 5.10. The transmitter output (antenna port) was connected to the test receiver.
2. Set the PK and AV limit line.
3. Record the fundamental emission and emissions out of the band-edge.
4. Determine band-edge compliance as required.

Equipment Used: Refer to section 3 for details.

Test Result: Pass

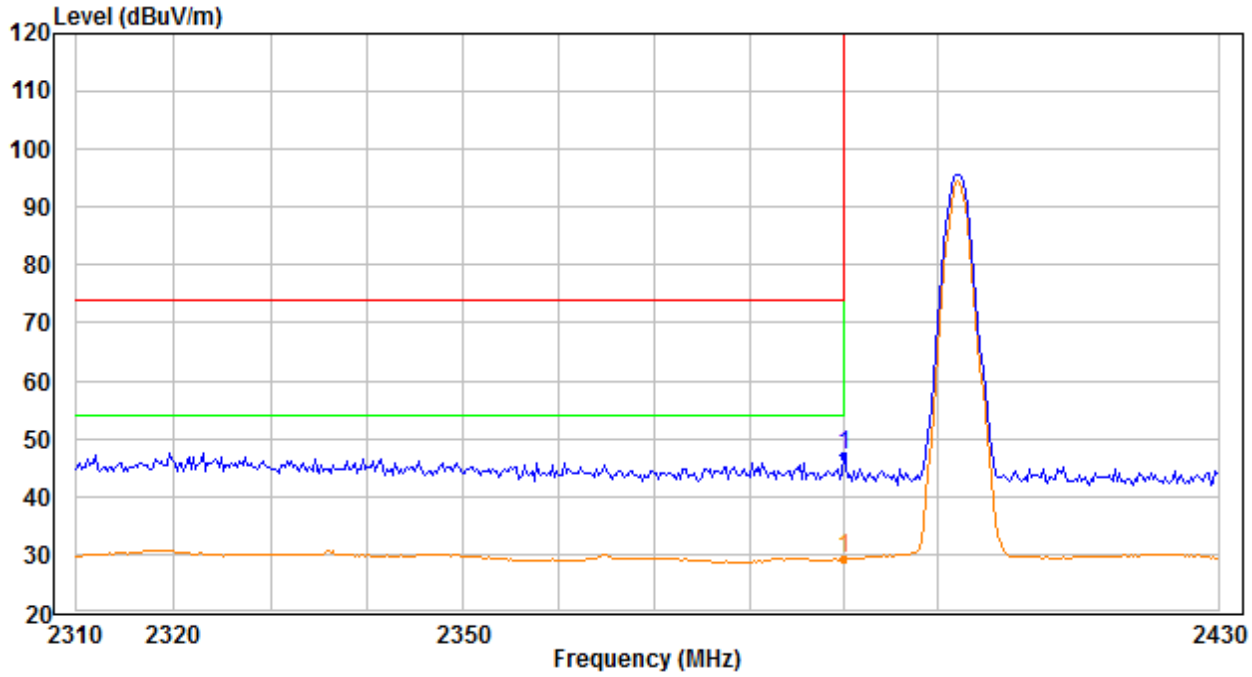
The measurement data as follows:

Test Channel:	Lowest Channel	Ant. Polar. :	Horizontal



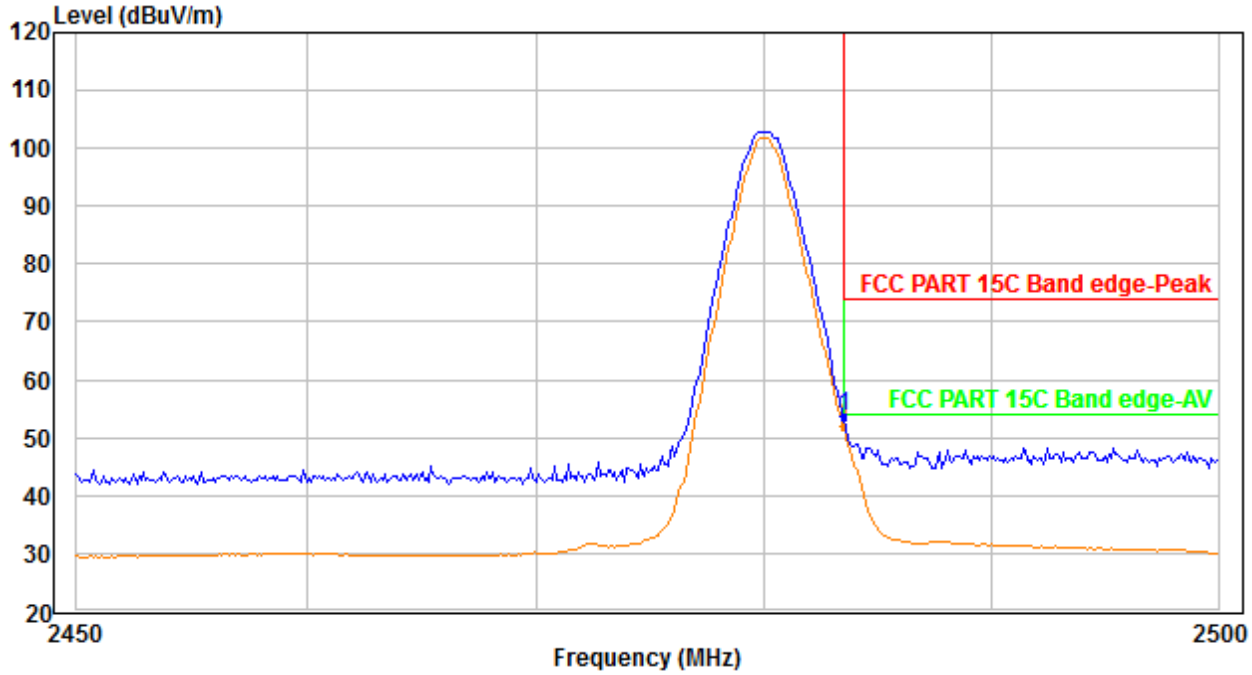
Frequency (MHz)	Peak level (dBuv/m)	Peak Limit (dBuv/m)	AV level (dBuv/m)	AV Limit (dBuv/m)	Conclusion
2390.0000	47.42	74.00	31.17	54.00	Pass

Test Channel:	Lowest Channel	Ant. Polar. :	Vertical



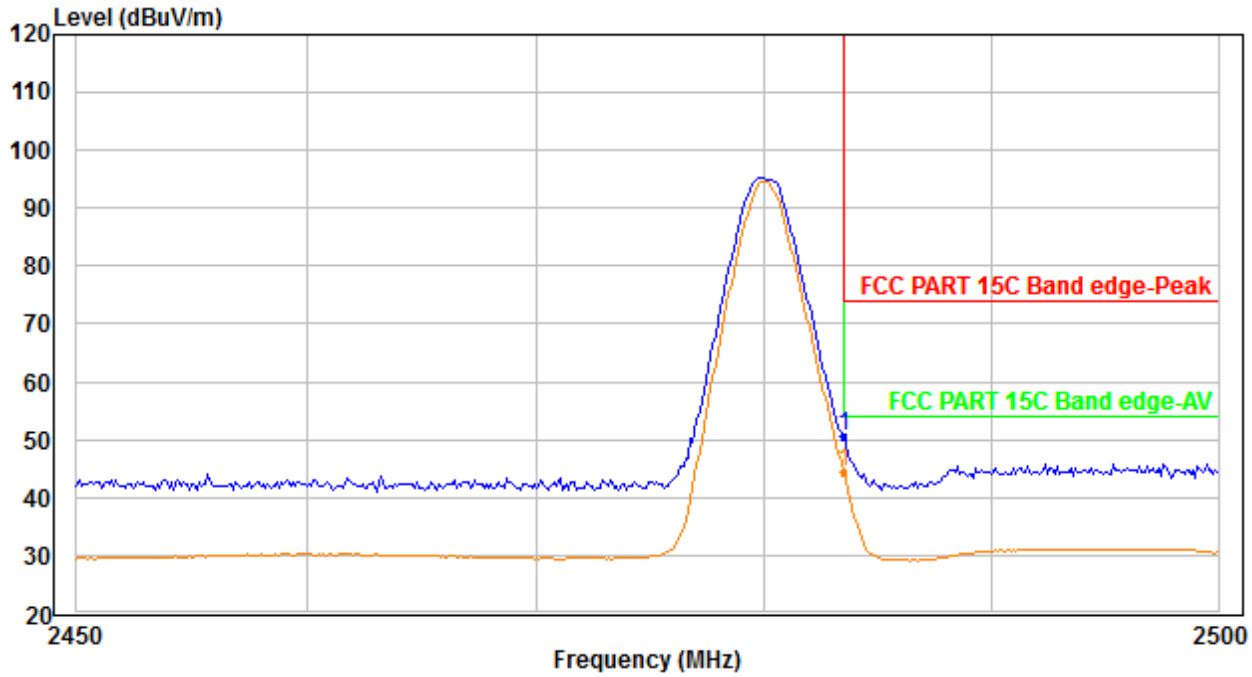
Frequency (MHz)	Peak level (dBuv/m)	Peak Limit (dBuv/m)	AV level (dBuv/m)	AV Limit (dBuv/m)	Conclusion
2390.0000	47.18	74.00	29.12	54.00	Pass

Test Channel:	Highest Channel	Ant. Polar. :	Horizontal



Frequency (MHz)	Peak level (dBuv/m)	Peak Limit (dBuv/m)	AV level (dBuv/m)	AV Limit (dBuv/m)	Conclusion
2483.5000	53.70	74.00	51.96	54.00	Pass

Test Channel:	Highest Channel	Ant. Polar. :	Vertical



Frequency (MHz)	Peak level (dBuv/m)	Peak Limit (dBuv/m)	AV level (dBuv/m)	AV Limit (dBuv/m)	Conclusion
2483.5000	50.67	74.00	44.57	54.00	Pass

5.11 CONDUCTED EMISSION

Test Requirement: 47 CFR Part 15C Section 15.207
RSS-Gen Issue 5, Section 8.8

Test Method: ANSI C63.10-2013 Section 6.2

Limits:

Frequency range (MHz)	Limits (dB(μV)	
	Quasi-peak	Average
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50

Remark:

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15 to 0.50 MHz.

Test Setup: Refer to section 4.5.2 for details.

Test Procedures:

Test frequency range :150KHz-30MHz

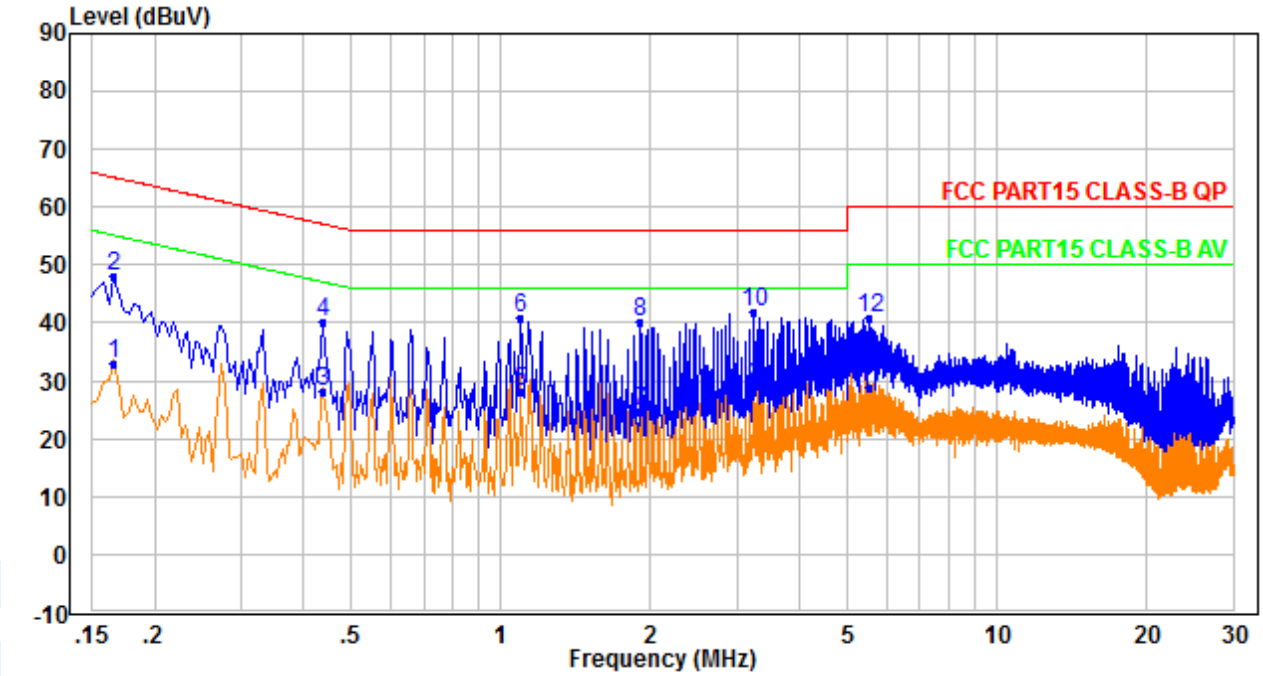
1) The mains terminal disturbance voltage test was conducted in a shielded room.
2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a 50Ω/50μH + 5Ω linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.
3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane,
4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0.4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0.8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane. This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0.8 m from the LISN 2.
5) 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 on conducted measurement.

Equipment Used: Refer to section 3 for details.

Test Result: Pass

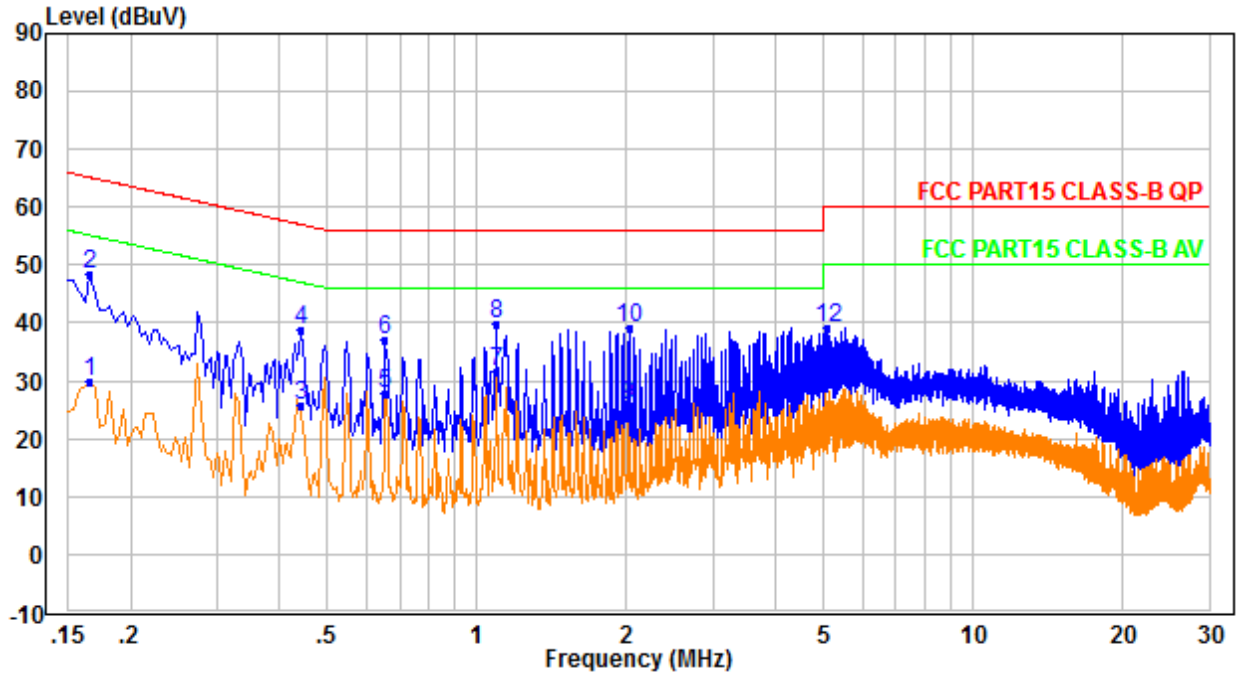
The measurement data as follows:
Quasi Peak and Average:
Mode: BT Link

Live Line



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Detector
1	0.166	24.03	9.05	33.08	55.16	-22.08	Average
2	0.166	38.94	9.05	47.99	65.16	-17.17	QP
3	0.438	19.03	9.23	28.26	47.10	-18.84	Average
4	0.438	30.81	9.23	40.04	57.10	-17.06	QP
5	1.098	18.75	9.42	28.17	46.00	-17.83	Average
6	1.098	31.40	9.42	40.82	56.00	-15.18	QP
7	1.914	15.04	9.58	24.62	46.00	-21.38	Average
8	1.914	30.76	9.58	40.34	56.00	-15.66	QP
9	3.226	19.21	9.61	28.82	46.00	-17.18	Average
10	3.226	32.21	9.61	41.82	56.00	-14.18	QP
11	5.526	19.21	9.65	28.86	50.00	-21.14	Average
12	5.526	31.11	9.65	40.76	60.00	-19.24	QP

Neutral Line



No.	Frequency (MHz)	Reading (dBuV)	Correction factor (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Detector
1	0.166	20.95	9.05	30.00	55.16	-25.16	Average
2	0.166	39.20	9.05	48.25	65.16	-16.91	QP
3	0.442	16.57	9.24	25.81	47.02	-21.21	Average
4	0.442	29.69	9.24	38.93	57.02	-18.09	QP
5	0.654	18.41	9.36	27.77	46.00	-18.23	Average
6	0.654	27.73	9.36	37.09	56.00	-18.91	QP
7	1.094	22.11	9.42	31.53	46.00	-14.47	Average
8	1.094	30.36	9.42	39.78	56.00	-16.22	QP
9	2.026	16.16	9.59	25.75	46.00	-20.25	Average
10	2.026	29.40	9.59	38.99	56.00	-17.01	QP
11	5.086	19.99	9.63	29.62	50.00	-20.38	Average
12	5.086	29.64	9.63	39.27	60.00	-20.73	QP

Remark:

1. Correct Factor = LISN Factor + Cable Loss + Pulse Limiter Factor, the value was added to Original Receiver Reading by the software automatically.
2. Result = Reading + Correct Factor.
3. Margin = Result - Limit
4. An initial pre-scan was performed on the Phase and neutral lines with peak detector. Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission were detected.
5. All possible modes of operation were investigated, and testing at two nominal voltages of 240V/50Hz and 120V/60Hz, only the worst case emissions reported.

APPENDIX 1 PHOTOS OF TEST SETUP

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

APPENDIX 2 PHOTOS OF EUT CONSTRUCTIONAL DETAILS

Refer to Appendix 2 for EUT external and internal photos.

*** End of Report ***

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