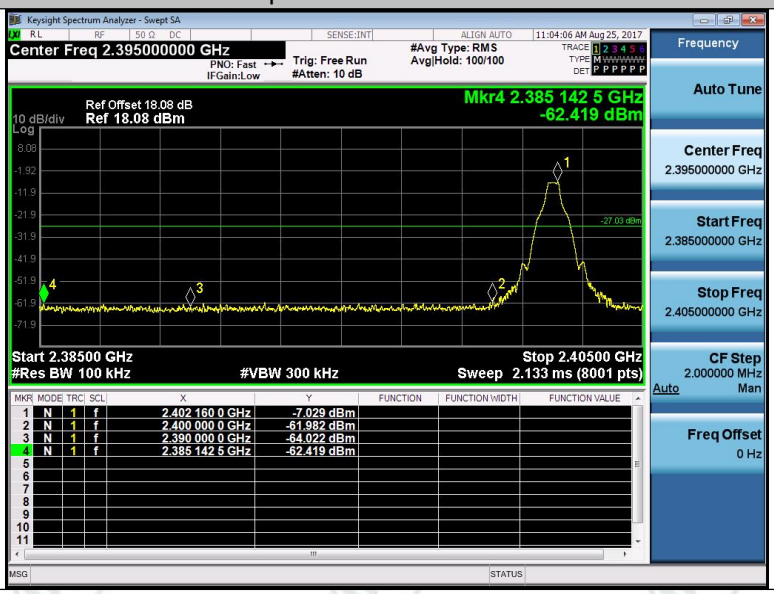
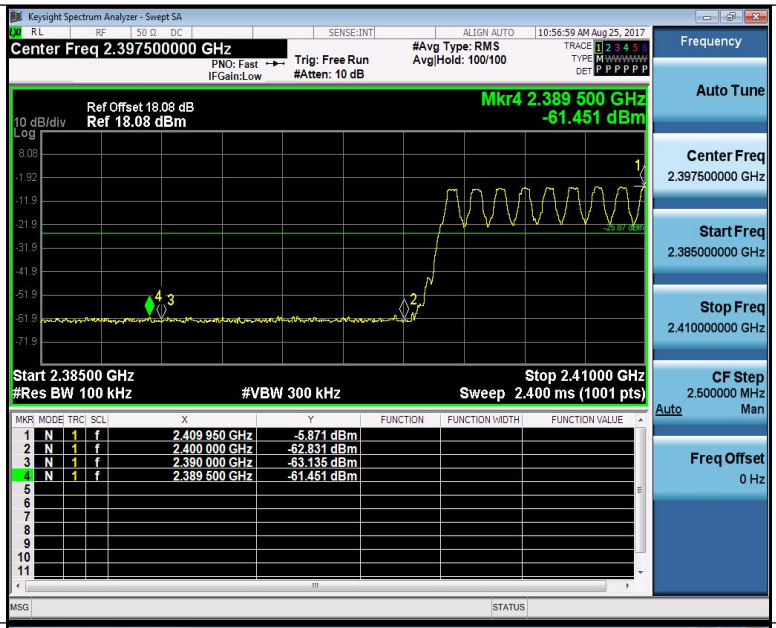
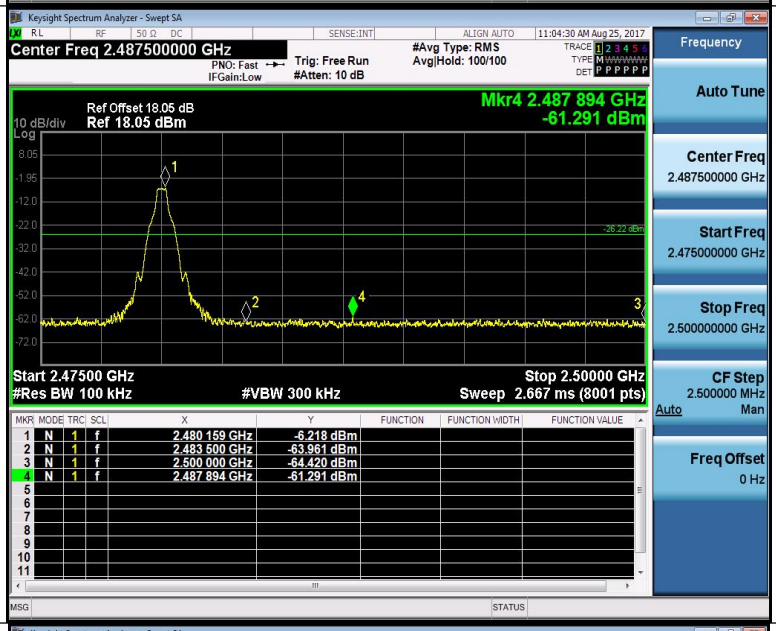
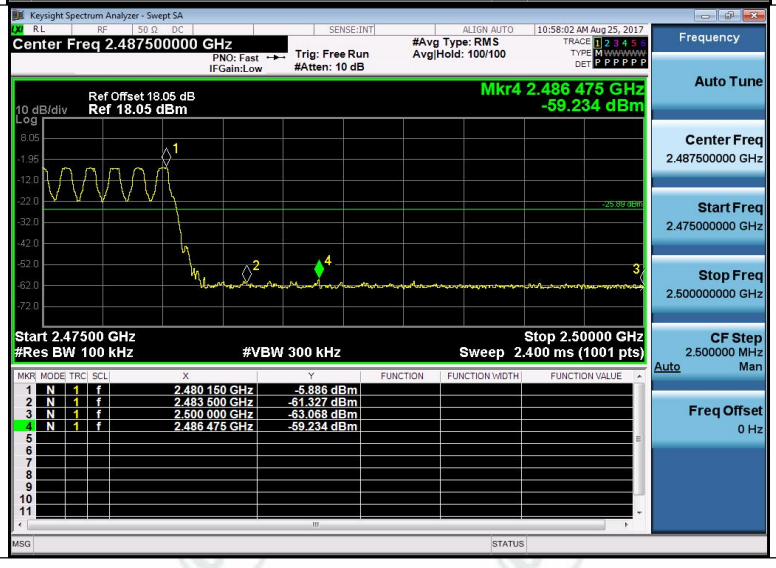
Appendix F): Band-edge for RF Conducted Emissions

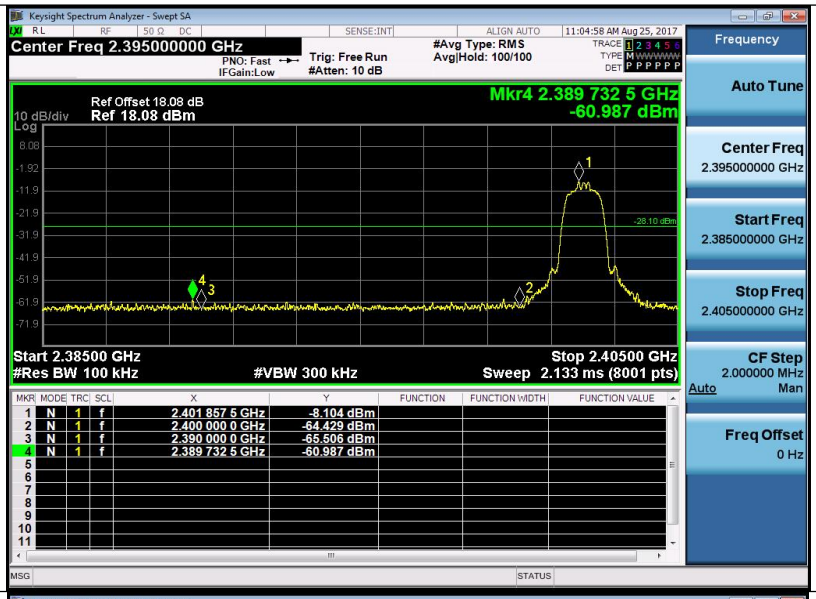
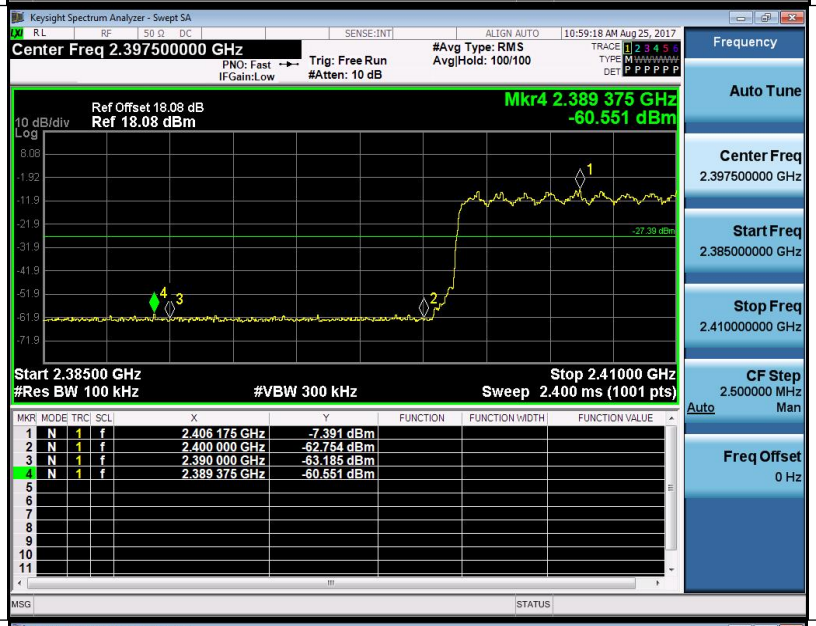
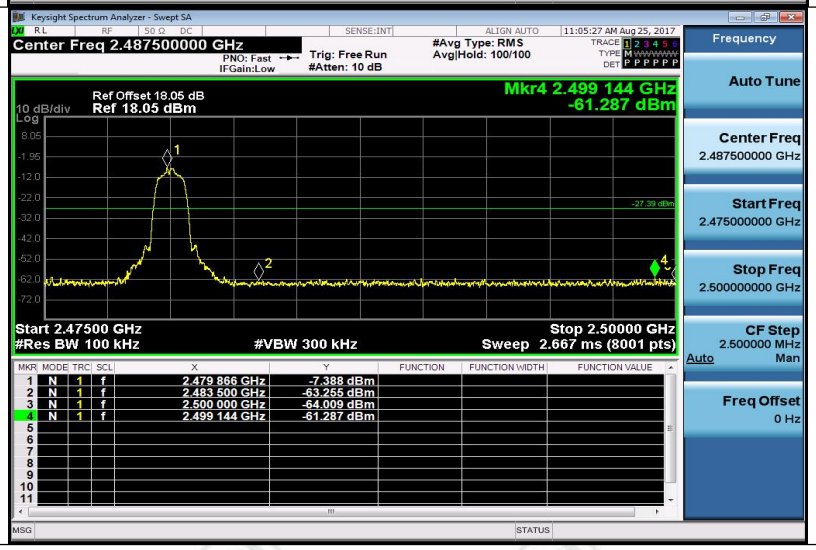
Result Table

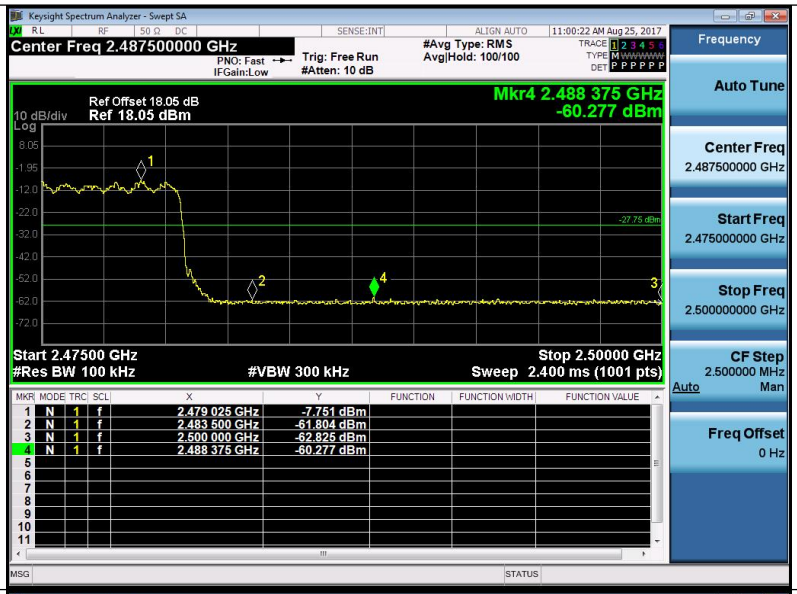
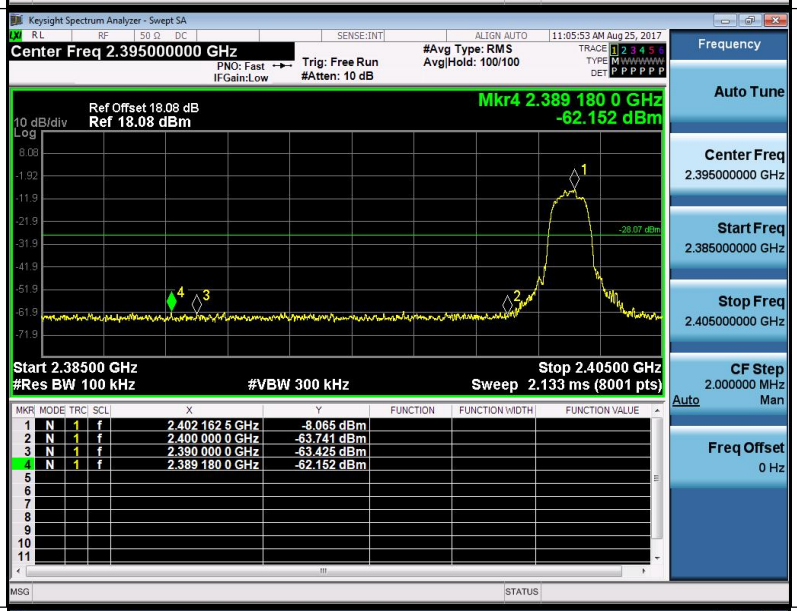
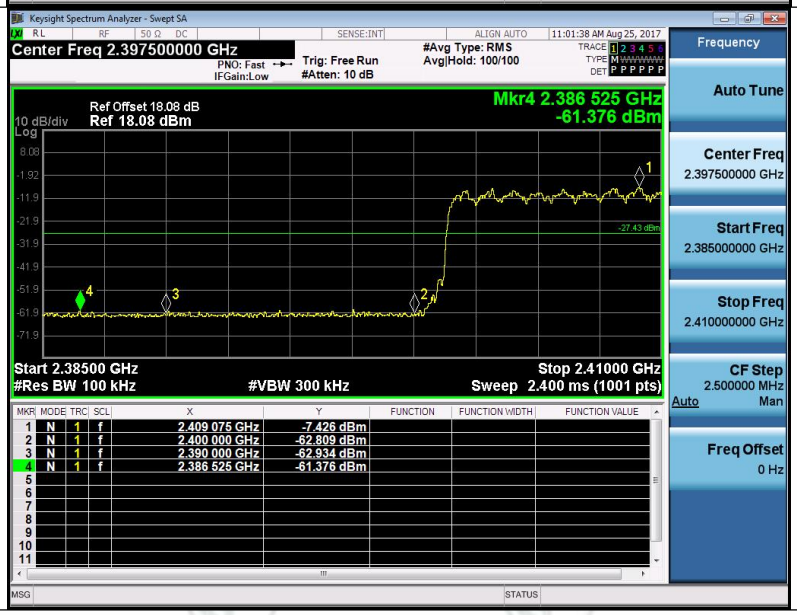
Mode	Channel	Carrier Frequency [MHz]	Carrier Power [dBm]	Frequency Hopping	Max Spurious Level [dBm]	Limit [dBm]	Verdict
GFSK	LCH	2402	-7.029	Off	-61.982	-27.03	PASS
			-5.871	On	-61.451	-25.87	PASS
GFSK	HCH	2480	-6.218	Off	-62.291	-26.22	PASS
			-5.886	On	-59.234	-25.89	PASS
π/4DQPSK	LCH	2402	-8.104	Off	-60.987	-28.10	PASS
			-7.391	On	-60.551	-27.39	PASS
π/4DQPSK	HCH	2480	-7.388	Off	-61.287	-27.39	PASS
			-7.751	On	-60.277	-27.75	PASS
8DPSK	LCH	2402	-8.065	Off	-62.152	-28.07	PASS
			-7.426	On	-61.376	-27.43	PASS
8DPSK	HCH	2480	-7.226	Off	-60.523	-27.23	PASS
			-7.294	On	-59.511	-27.29	PASS

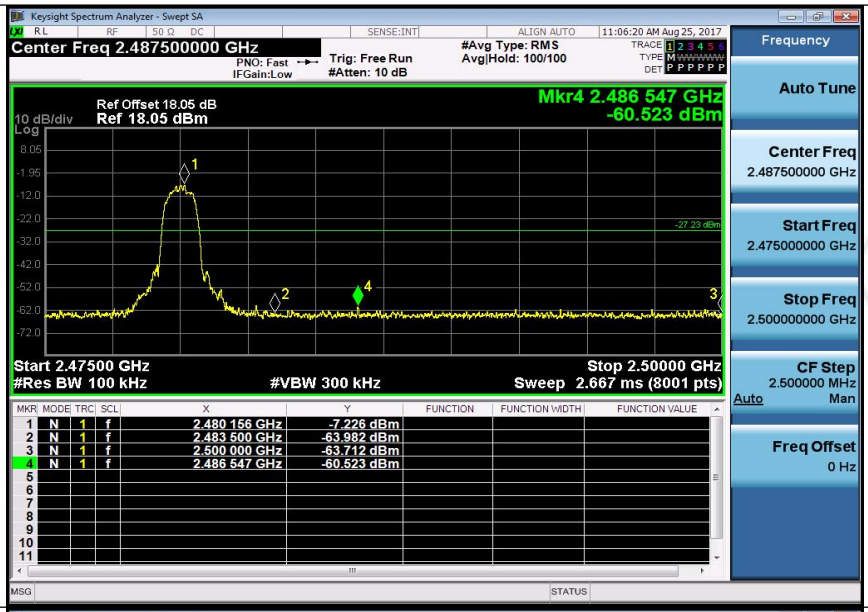
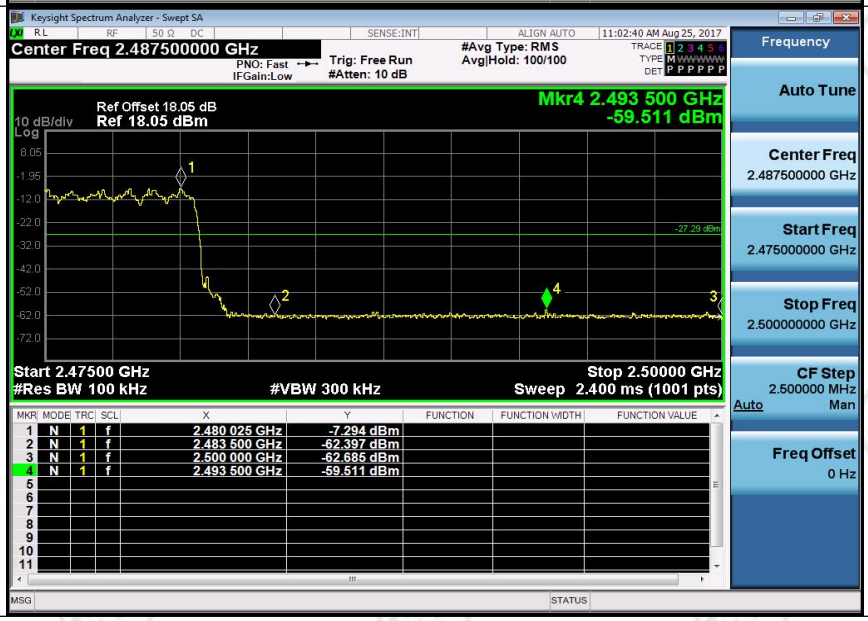
Test Graph

Graphs	
GFSK/LCH/ No Hop	

GFSK/LCH/ Hop		
GFSK/HCH/ No Hop		
GFSK/HCH/ Hop		

π/4DQPSK/LCH/ No Hop		
π/4DQPSK/LCH/ Hop		
π/4DQPSK/HCH/ No Hop		

π/4DQPSK/HCH/ Hop		
8DPSK/LCH/ No Hop		
8DPSK/LCH/ Hop		

8DPSK/HCH/ No Hop		
8DPSK/HCH/ Hop		

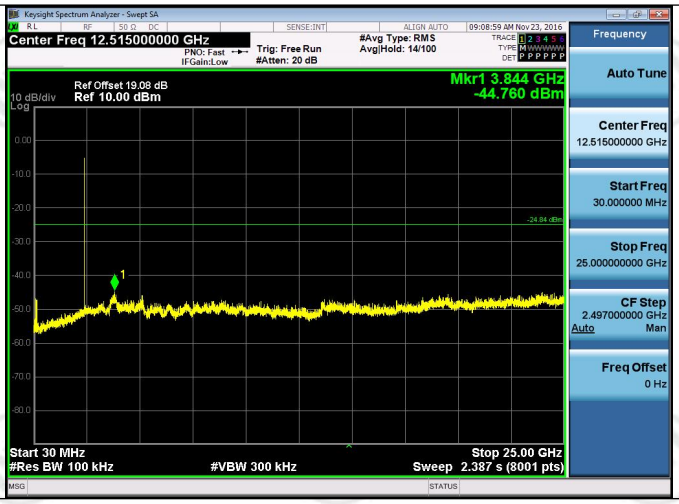
Appendix G): RF Conducted Spurious Emissions

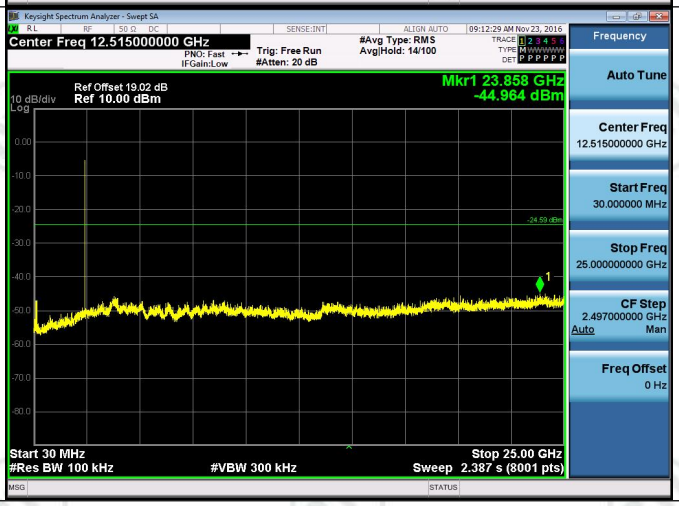
Result Table

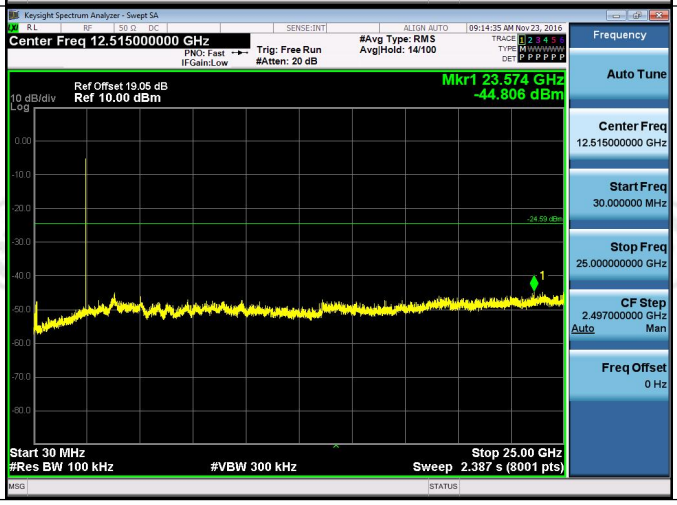
Mode	Channel	Pref [dBm]	Puw[dBm]	Verdict
GFSK	LCH	-4.840	<Limit	PASS
GFSK	MCH	-4.592	<Limit	PASS
GFSK	HCH	-4.590	<Limit	PASS
π/4DQPSK	LCH	-5.852	<Limit	PASS
π/4DQPSK	MCH	-5.653	<Limit	PASS
π/4DQPSK	HCH	-5.650	<Limit	PASS
8DPSK	LCH	-5.891	<Limit	PASS
8DPSK	MCH	-5.656	<Limit	PASS
8DPSK	HCH	-5.629	<Limit	PASS

Test Graph

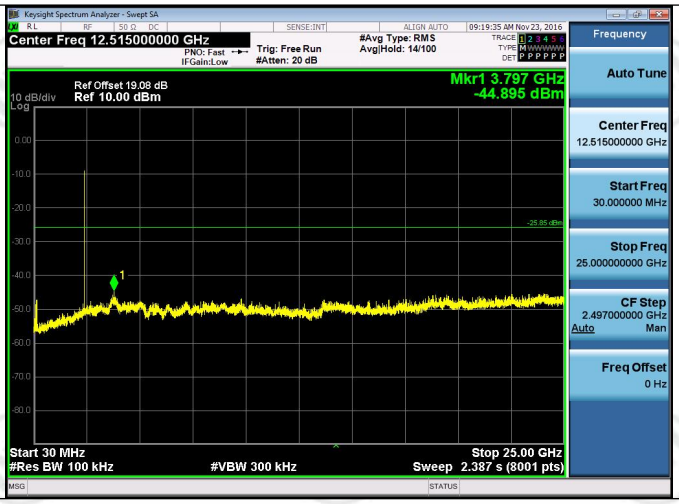
GFSK_LCH_Graphs		
Pref		

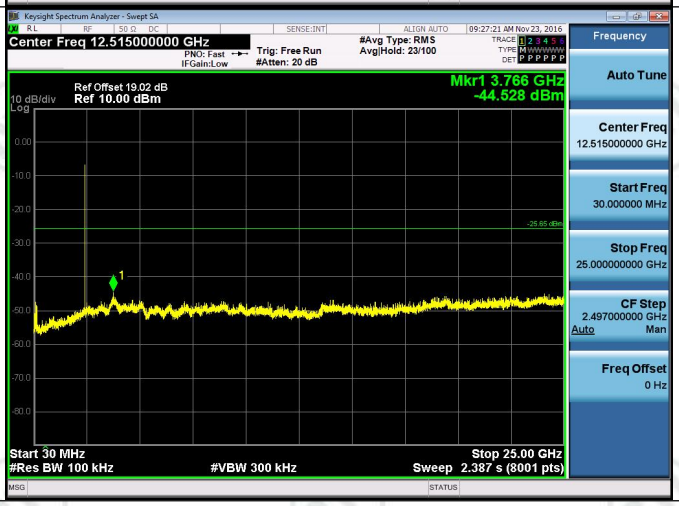
Puw	

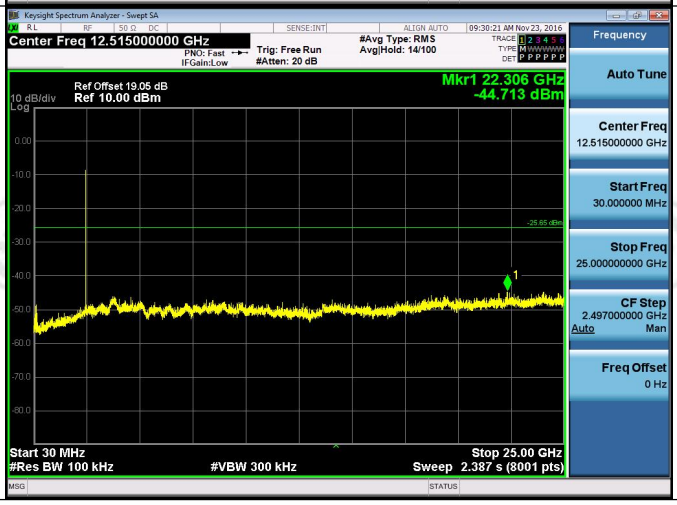
GFSK_MCH_Graphs	
Pref	
Puw	

GFSK_HCH_Graphs		
Pref		
Puw		

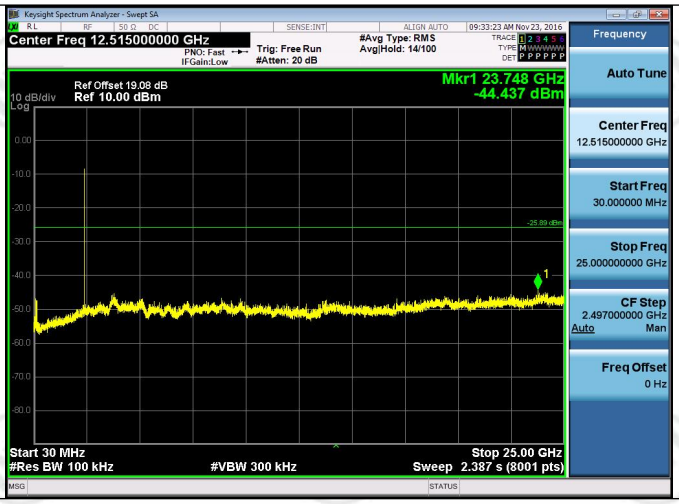
π/4DQPSK_LCH_Graphs		
Pref		

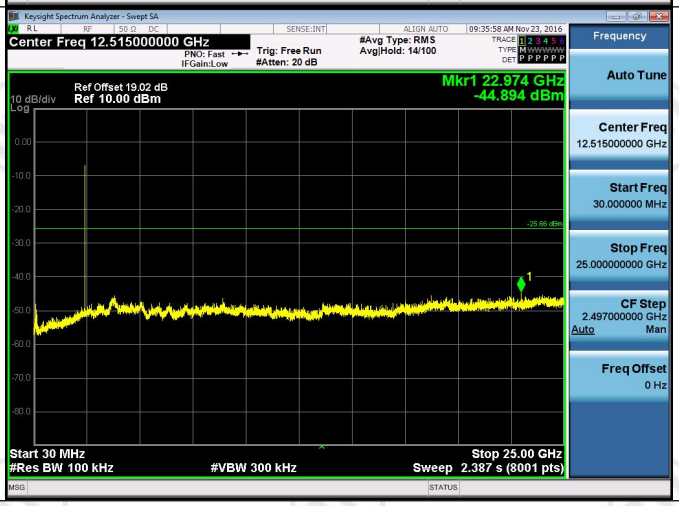
Puw	

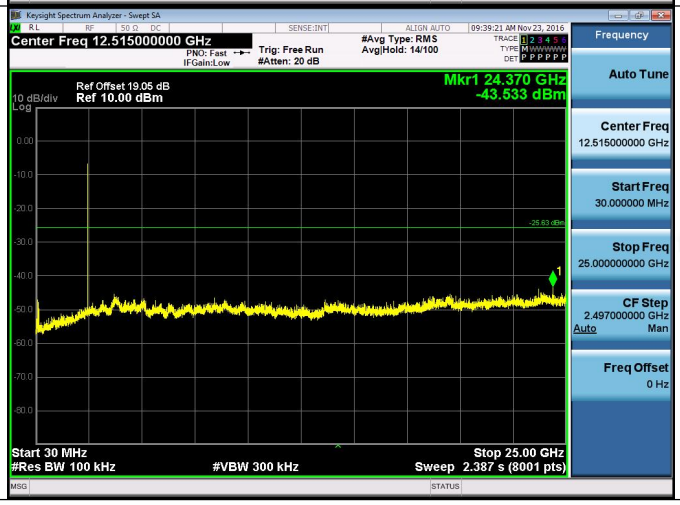
π/4DQPSK_MCH_Graphs	
Pref	
Puw	

π/4DQPSK_HCH_Graphs		
Pref		
Puw		

8DPSK_LCH_Graphs		
Pref		

Puw	

8DPSK_MCH_Graphs	
Pref	
Puw	

8DPSK_HCH_Graphs			
Pref			
Pu w			

Appendix H): Pseudorandom Frequency Hopping Sequence

Test Requirement:	47 CFR Part 15**C Section 15.247 (a)(1) requirement:**

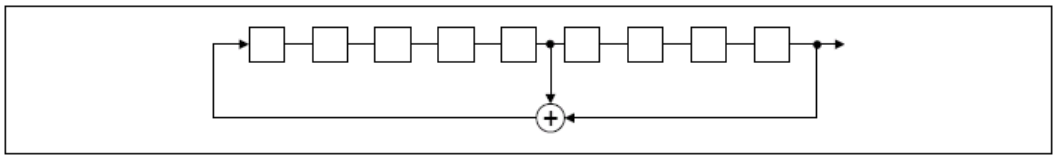
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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

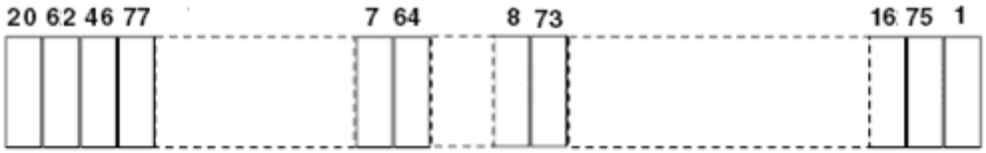
The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized 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.

The device does not have the ability to be coordinated with other FHSS systems in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

Appendix I): Antenna Requirement

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(b) (4) requirement:

The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

EUT Antenna:	

The antenna is PIFA Antenna and no consideration of replacement. The best case gain of the antenna is 2dBi.

Appendix J): AC Power Line Conducted Emission

Test Procedure:	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.
Limit:	

Frequency range (MHz)	Limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

* The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.

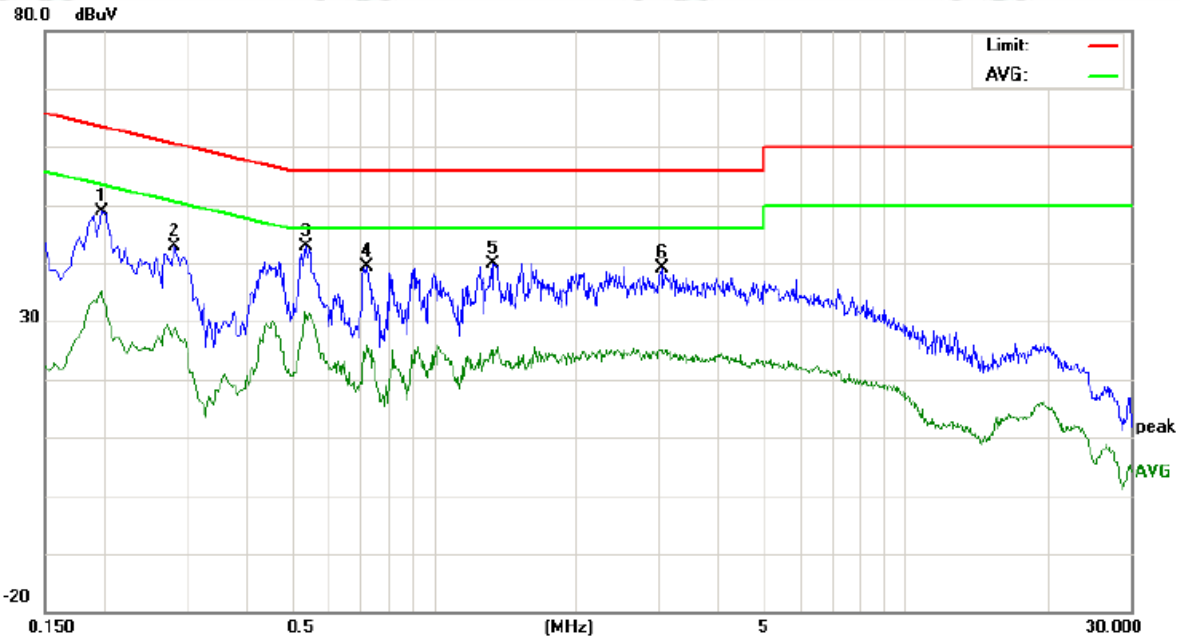
NOTE : The lower limit is applicable at the transition frequency

Measurement Data

An initial pre-scan was performed on the live and neutral lines with peak detector.

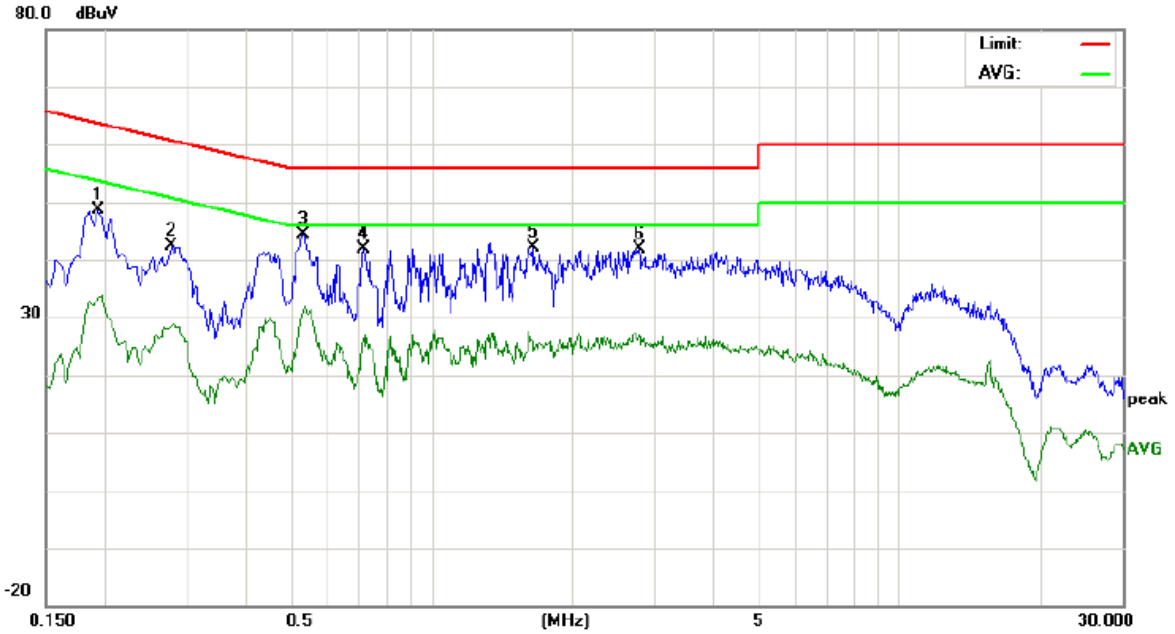
Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission were detected.

Live line:



No.	Freq.	Reading_Level (dBuV)			Correct Factor	Measurement (dBuV)			Limit (dBuV)		Margin (dB)			
	MHz	Peak	QP	AVG	dB	peak	QP	AVG	QP	AVG	QP	AVG	P/F	Comment
1	0.1980	39.09		25.27	9.80	48.89		35.07	63.69	53.69	-14.80	-18.62	P	
2	0.2819	33.03		18.81	9.80	42.83		28.61	60.76	50.76	-17.93	-22.15	P	
3	0.5380	33.04		20.72	9.90	42.94		30.62	56.00	46.00	-13.06	-15.38	P	
4	0.7220	29.55		15.61	9.90	39.45		25.51	56.00	46.00	-16.55	-20.49	P	
5	1.3380	30.12		15.33	9.80	39.92		25.13	56.00	46.00	-16.08	-20.87	P	
6	3.0420	29.18		15.08	10.00	39.18		25.08	56.00	46.00	-16.82	-20.92	P	

Neutral line:



No.	Freq.	Reading_Level (dBuV)			Correct Factor	Measurement (dBuV)			Limit (dBuV)		Margin (dB)			
	MHz	Peak	QP	AVG	dB	peak	QP	AVG	QP	AVG	QP	AVG	P/F	Comment
1	0.1940	38.71		23.28	9.80	48.51		33.08	63.86	53.86	-15.35	-20.78	P	
2	0.2779	32.51		18.70	9.80	42.31		28.50	60.88	50.88	-18.57	-22.38	P	
3	0.5340	34.51		21.50	9.90	44.41		31.40	56.00	46.00	-11.59	-14.60	P	
4	0.7180	32.08		16.38	9.90	41.98		26.28	56.00	46.00	-14.02	-19.72	P	
5	1.6460	32.23		15.92	9.89	42.12		25.81	56.00	46.00	-13.88	-20.19	P	
6	2.7900	31.97		16.92	10.00	41.97		26.92	56.00	46.00	-14.03	-19.08	P	

Notes:

1. The following Quasi-Peak and Average measurements were performed on the EUT:

2. Final Test Level =Receiver Reading + LISN Factor + Cable Loss.

Appendix K): Restricted bands around fundamental frequency (Radiated)

Receiver Setup:

Frequency	Detector	RBW	VBW	Remark
30MHz-1GHz	Quasi-peak	120kHz	300kHz	Quasi-peak
Above 1GHz	Peak	1MHz	3MHz	Peak
	Peak	1MHz	10Hz	Average

Test Procedure:

Below 1GHz test procedure as below:

a. 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.
b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
c. 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.
d. 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 and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
e. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
f. Place a marker at the end of the restricted band closest to the transmit frequency to show compliance. Also measure any emissions in the restricted bands. Save the spectrum analyzer plot. Repeat for each power and modulation for lowest and highest channel

Above 1GHz test procedure as below:

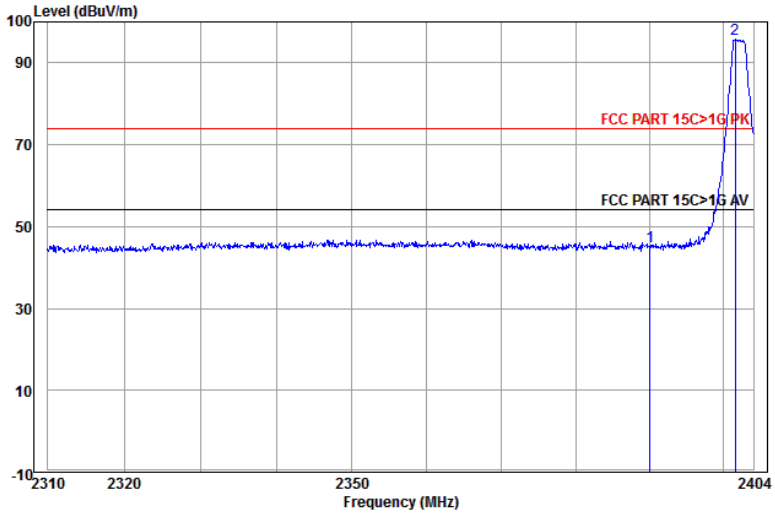
g. Different between above is the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber and change form table 0.8 meter to 1.5 meter(Above 18GHz the distance is 1 meter and table is 1.5 meter).
h. b. Test the EUT in the lowest channel , the Highest channel
i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is worse case.
j. Repeat above procedures until all frequencies measured was complete.

Limit:

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

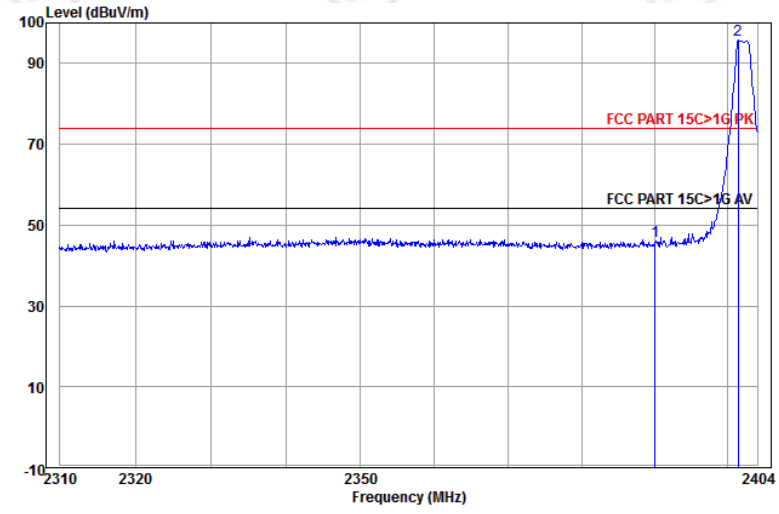
Test plot as follows:

Worse case mode:	GFSK(1-DH5)		
Frequency: 2390.0MHz	Test channel: Lowest	Polarization: Horizontal	Remark: Peak



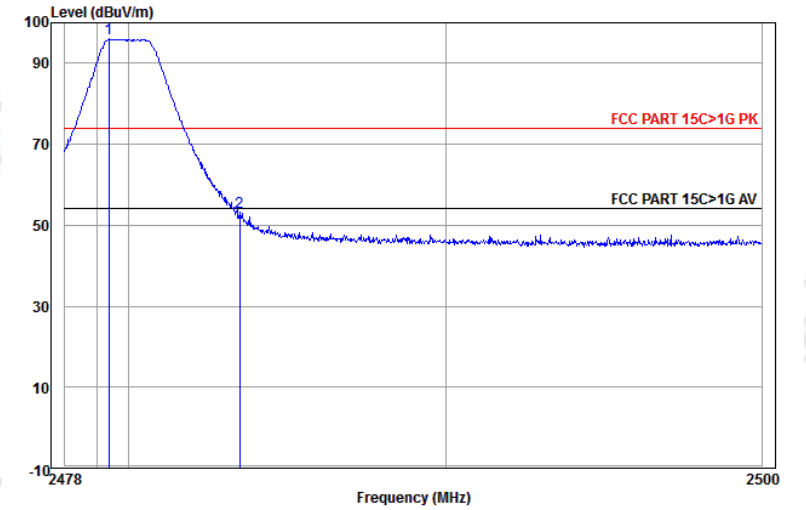
	Freq	Ant Factor	Cable Loss	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Pol/Phase	Remark
	MHz	dB/m	dB	dB	dBuV	dBuV/m	dBuV/m	dB		
1	2390.000	32.53	4.28	34.39	42.77	45.19	74.00	-28.81	Horizontal	
2 pp	2401.508	32.56	4.31	34.39	93.21	95.69	74.00	21.69	Horizontal	

Worse case mode:	GFSK(1-DH5)		
Frequency: 2390.0MHz	Test channel: Lowest	Polarization: Vertical	Remark: Peak



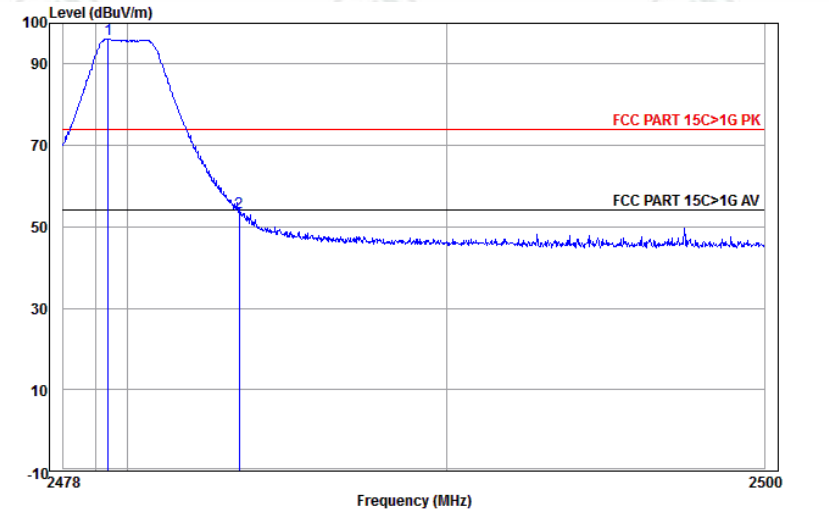
	Freq	Ant Factor	Cable Loss	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Pol/Phase	Remark
	MHz	dB/m	dB	dB	dBuV	dBuV/m	dBuV/m	dB		
1	2390.000	32.53	4.28	34.39	43.55	45.97	74.00	-28.03	Vertical	
2 pp	2401.412	32.56	4.31	34.39	93.26	95.74	74.00	21.74	Vertical	

Worse case mode:	GFSK(1-DH5)		
Frequency: 2483.5MHz	Test channel: Highest	Polarization: Horizontal	Remark: Peak



	Freq	Ant Factor	Cable Loss	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Pol/Phase	Remark
	MHz	dB/m	dB	dB	dBuV	dBuV/m	dBuV/m	dB		
1 pp	2479.380	32.71	4.50	34.41	93.29	96.09	74.00	22.09	Horizontal	
2	2483.500	32.71	4.51	34.41	50.51	53.32	74.00	-20.68	Horizontal	

Worse case mode:	GFSK(1-DH5)		
Frequency: 2483.5MHz	Test channel: Highest	Polarization: Vertical	Remark: Peak



	Freq	Ant Factor	Cable Loss	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Pol/Phase	Remark
	MHz	dB/m	dB	dB	dBuV	dBuV/m	dBuV/m	dB		
1 pp	2479.402	32.71	4.50	34.41	93.37	96.17	74.00	22.17	Vertical	
2	2483.500	32.71	4.51	34.41	50.85	53.66	74.00	-20.34	Vertical	