

3.5. Frequency Separation

LIMIT

According to 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the $2/3 \times 20\text{dB}$ bandwidth of the hopping channel, whichever is greater.

TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 KHz RBW and 300 KHz VBW.

TEST CONFIGURATION



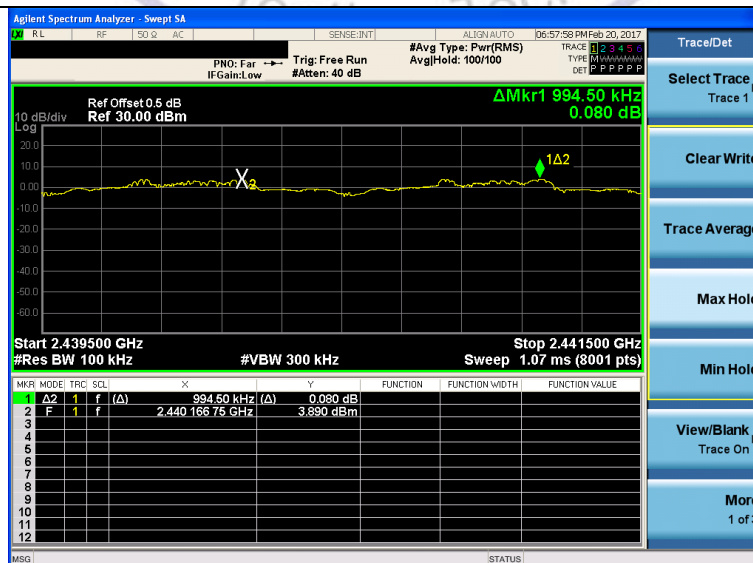
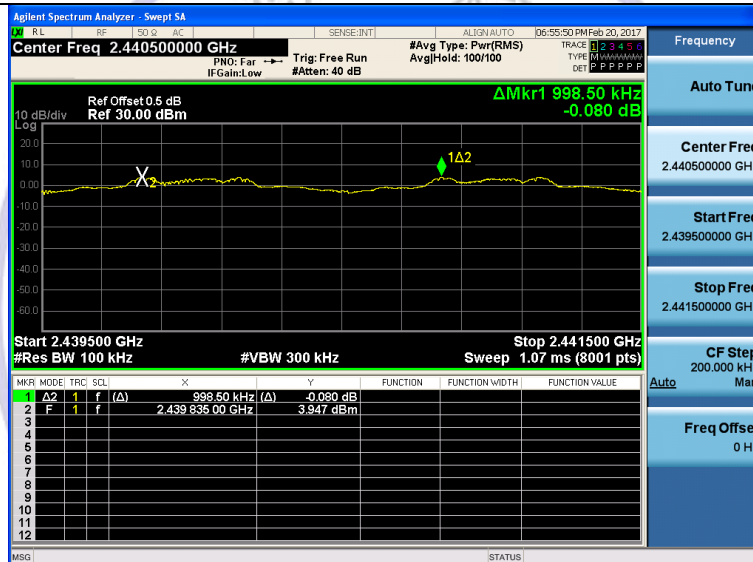
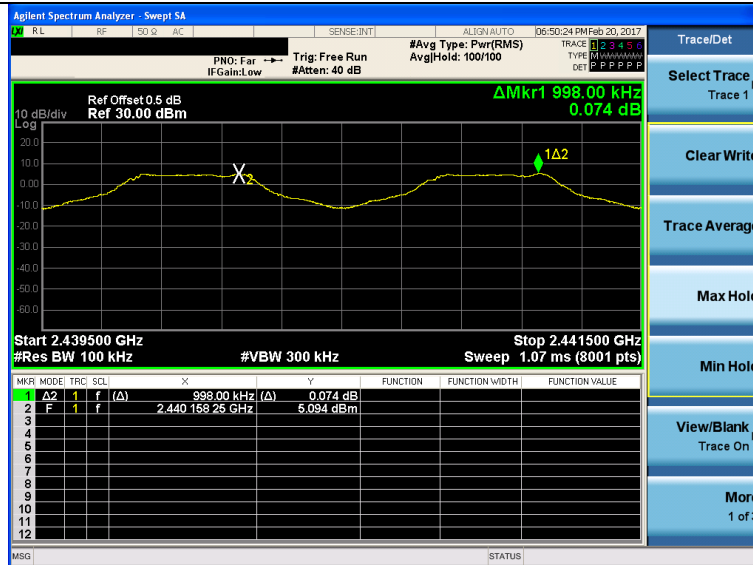
TEST RESULTS

Modulation	Channel	Channel Separation (MHz)	Limit(MHz)	Result
GFSK	CH39	0.998	25KHz or $2/3 \times 20\text{dB}$ bandwidth	Pass
	CH40			
$\pi/4$ DQPSK	CH39	0.999	25KHz or $2/3 \times 20\text{dB}$ bandwidth	Pass
	CH40			
8DPSK	CH39	0.995	25KHz or $2/3 \times 20\text{dB}$ bandwidth	Pass
	CH40			

Note:

We have tested all mode at high, middle and low channel, and recorded worst case at middle

Test plot as follows:



3.6. Number of hopping frequency

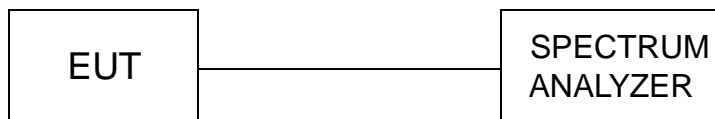
Limit

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

Test Procedure

The transmitter output was connected to the spectrum analyzer through an attenuator. Set spectrum analyzer start 2400MHz to 2483.5MHz with 100 KHz RBW and 300 KHz VBW.

Test Configuration

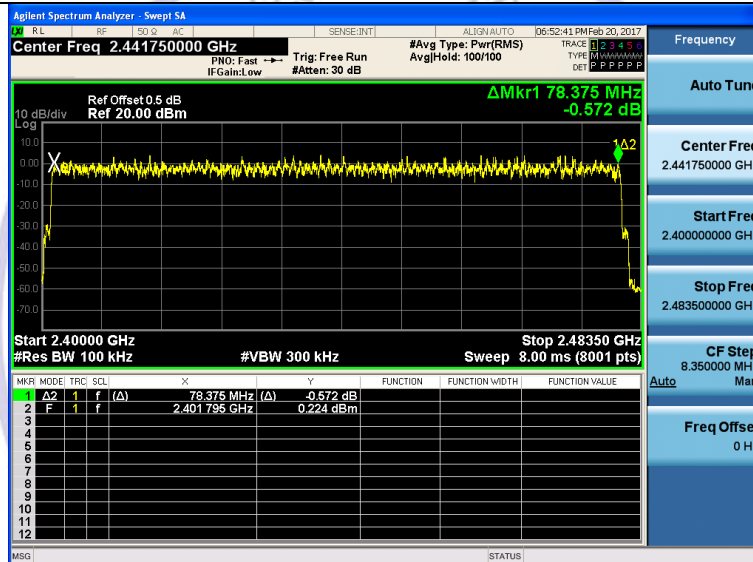
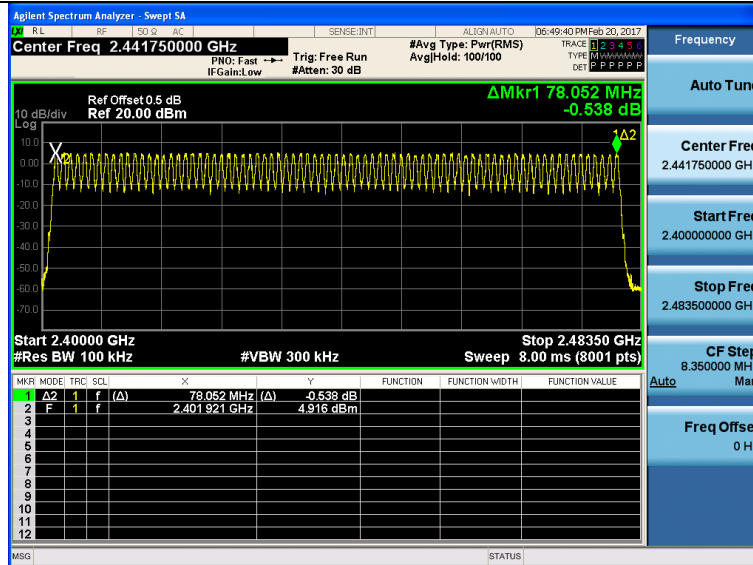
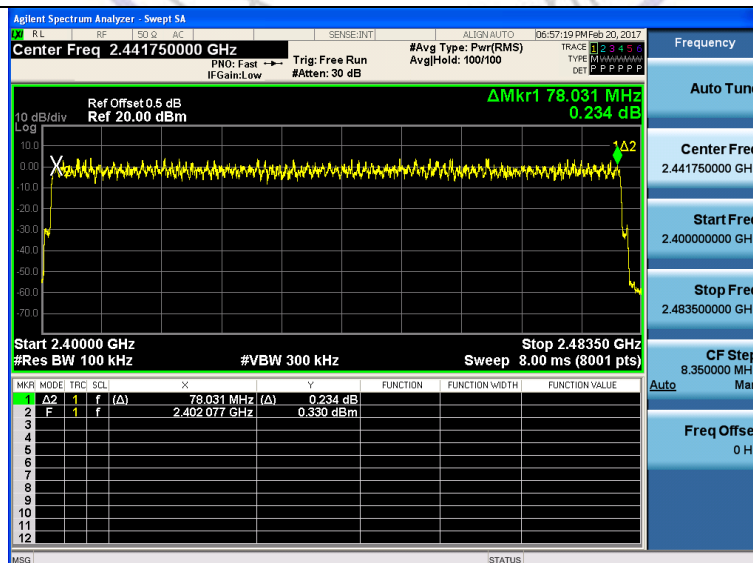


Test Results

Modulation	Number of Hopping Channel	Limit	Result
GFSK	79	≥15	Pass
π/4DQPSK	79		
8DPSK	79		

Test plot as follows:

16QAM Modulation

 ΔM 

3.7. Time of Occupancy (Dwell Time)

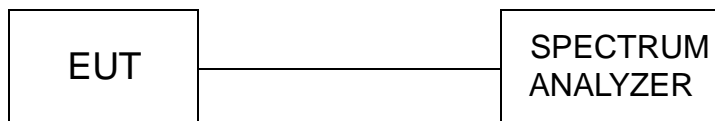
Limit

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

Test Procedure

The transmitter output was connected to the spectrum analyzer through an attenuator. Set center frequency of spectrum analyzer=operating frequency with 1MHz RBW and 1MHz VBW, Span 0Hz.

Test Configuration



Test Results

Modulation	Packet	Pulse time (ms)	Dwell time (s)	Limit (s)	Result
GFSK	DH1	0.367	0.119	0.40	Pass
	DH3	1.627	0.26		
	DH5	2.870	0.307		
π/4DQPSK	2-DH1	0.375	0.121	0.40	Pass
	2-DH3	1.627	0.261		
	2-DH5	2.880	0.307		
8DPSK	3-DH1	0.378	0.121	0.40	Pass
	3-DH3	1.627	0.26		
	3-DH5	2.870	0.307		

Note:

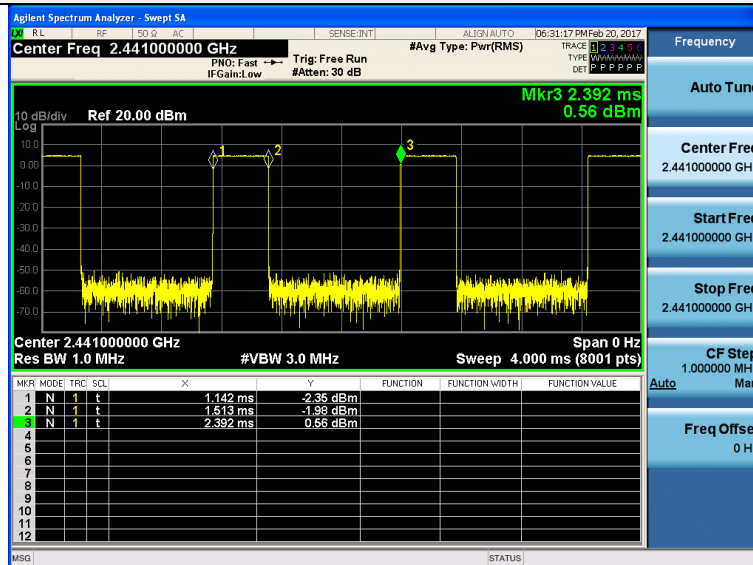
- We have tested all mode at high,middle and low channel,and recoreded worst case at middle channel.
- $$\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 2 \div 79) \times 31.6 \text{ Second for DH1, 2-DH1, 3-DH1}$$

$$\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 4 \div 79) \times 31.6 \text{ Second for DH3, 2-DH3, 3-DH3}$$

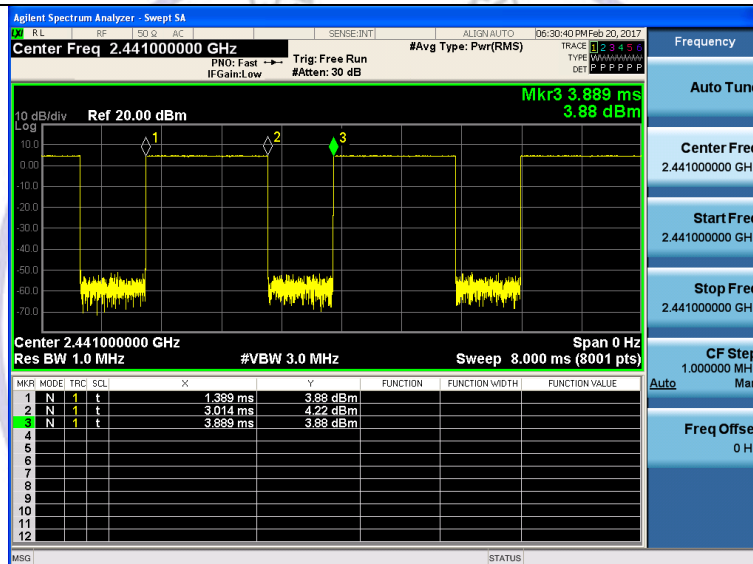
$$\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 6 \div 79) \times 31.6 \text{ Second for DH5, 2-DH5, 3-DH5}$$

Test plot as follows:

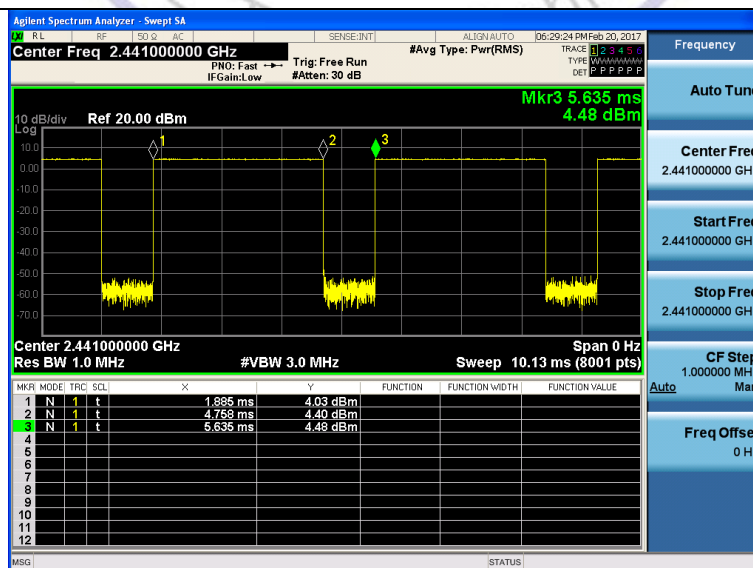
GFSK Modulation



DH1



DH3



DH5

[illegible][illegible]

Agilent Spectrum Analyzer - Swept SA

M R L RF SD G AC SENSE:INT D6:37:10 PM Feb 20, 2017
 Center Freq 2.441000000 GHz #Avg Type: Pwr(RMS) TRACE 1 2 3 5 6
 PNO: Fast → Trg: Free Run TYPE BW=100 kHz
 IF Gain: Low #Atten: 30 dB DET P P P P P

10 dB/div Ref 20.00 dBm Mkr3 5.031 ms 3.04 dBm

Center 2.441000000 GHz Span 0 Hz
 Res BW 1.0 MHz #VBW 3.0 MHz Sweep 10.13 ms (8001 pts)

MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	t	1.281 ms	1.13 dBm			
2	N	1	t	4.157 ms	3.05 dBm			
3	N	1	t	5.031 ms	3.04 dBm			
4								
5								
6								
7								
8								
9								
10								
11								
12								

MSG STATUS

Frequency Auto Tun

Center Freq 2.441000000 GHz

Start Freq 2.441000000 GHz

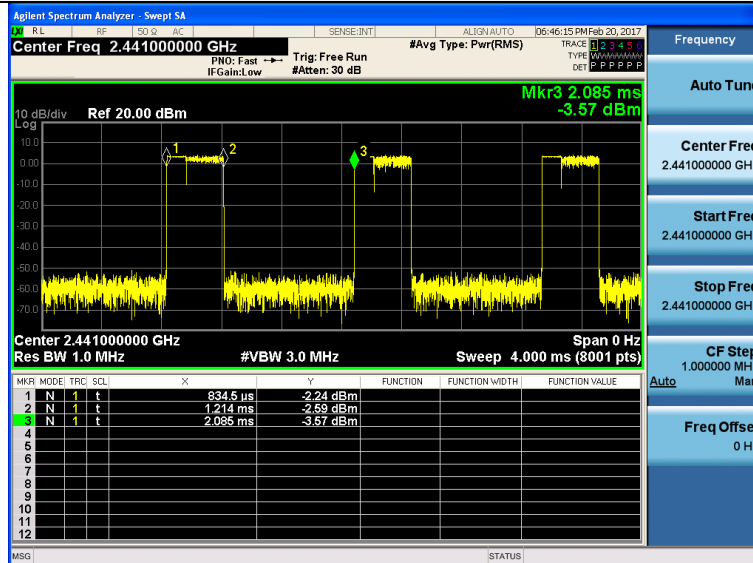
Stop Freq 2.441000000 GHz

CF Step 1.000000 MHz

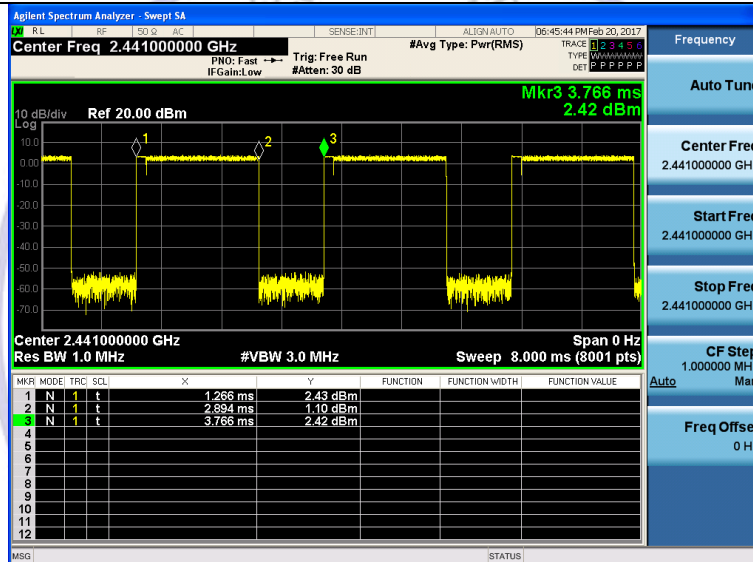
Freq Offset 0 Hz

2-DH5

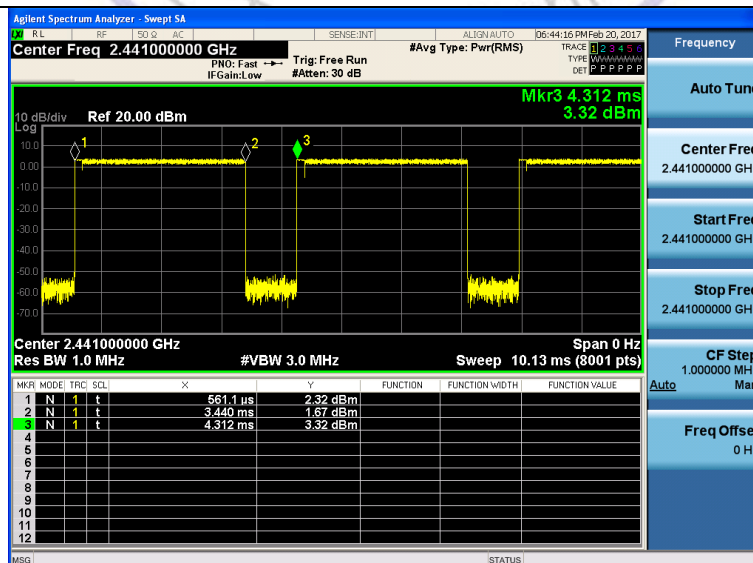
8DPSK Modulation



3-DH1



3-DH3



3-DH5

3.8. Out-of-band Emissions

Limit

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.

Test Procedure

Connect the transmitter output to spectrum analyzer using a low loss RF cable, and set the spectrum analyzer to RBW=100 kHz, VBW= 300 kHz, peak detector, and max hold. Measurements utilizing these settings are made of the in-band reference level, band edge and out-of-band emissions.

Test Configuration



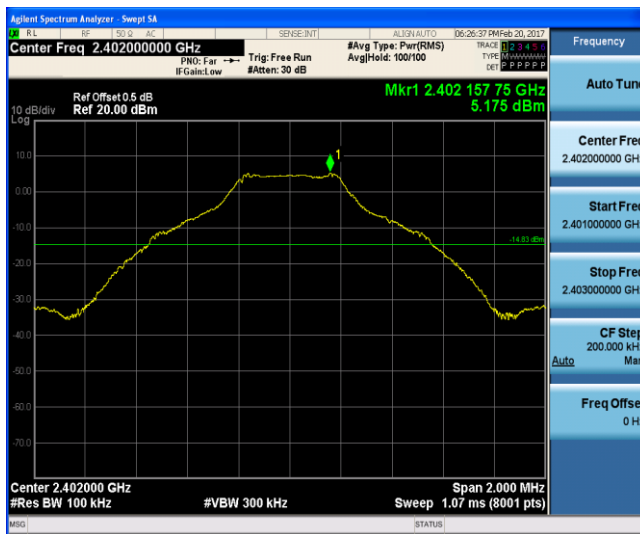
Test Results

Remark: The measurement frequency range is from 30MHz to the 10th harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions and band edge measurement data.

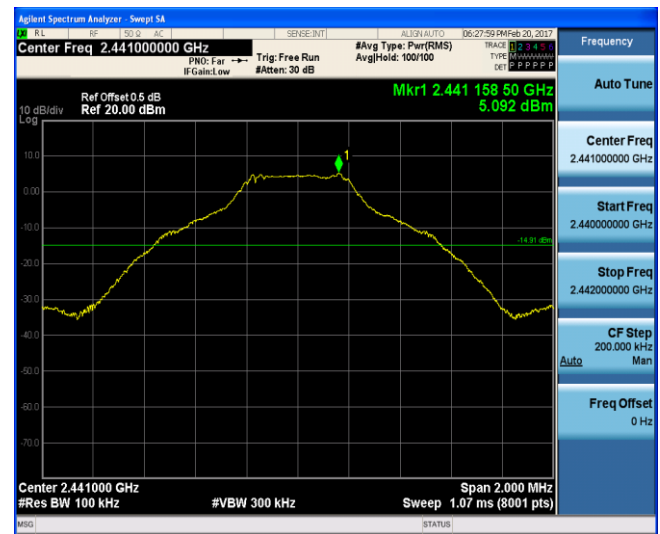
We measured all conditions (DH1, DH3, DH5) and recorded worst case at DH5

Test plot as follows:

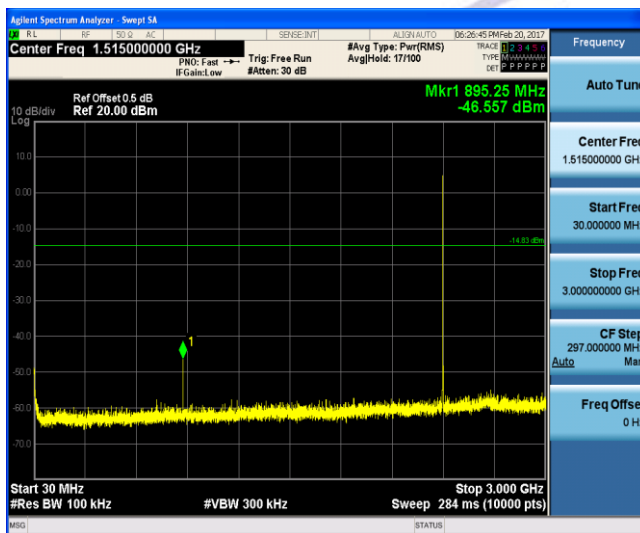
GFSK CH00



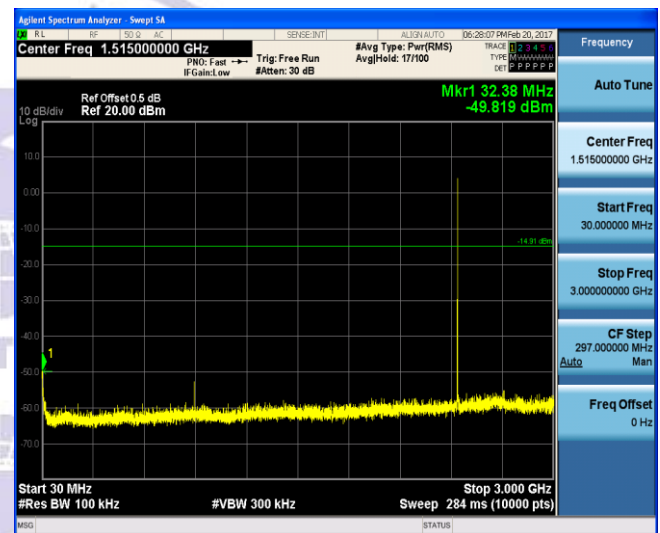
GFSK CH39



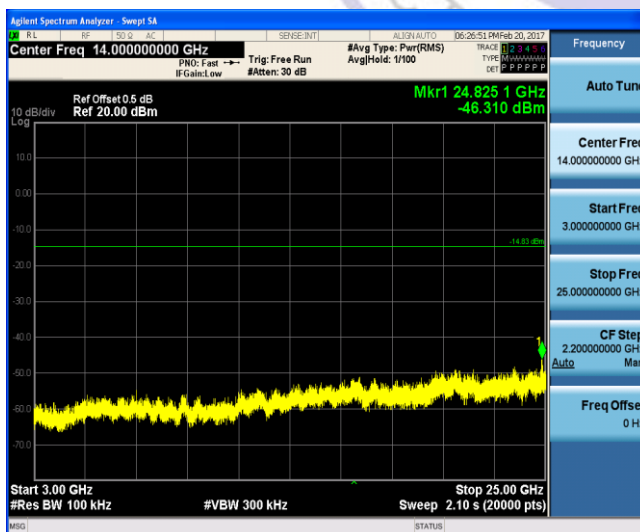
Reference



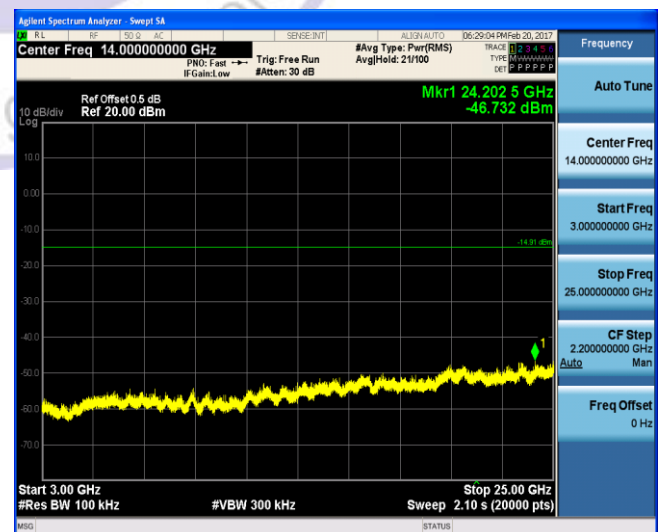
Reference



30MHz-3GHz



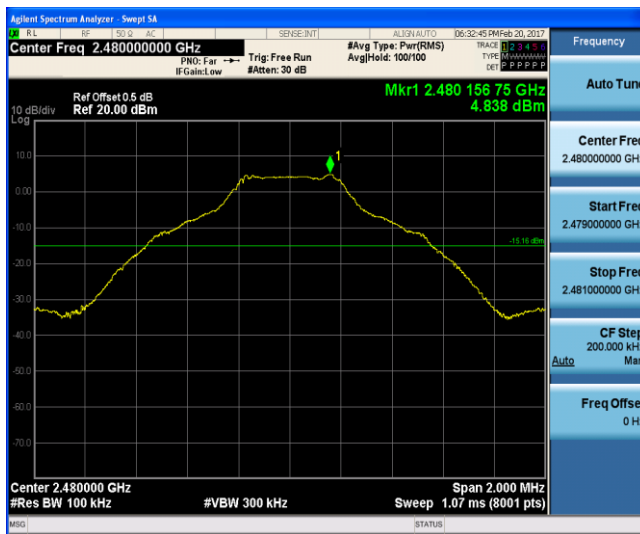
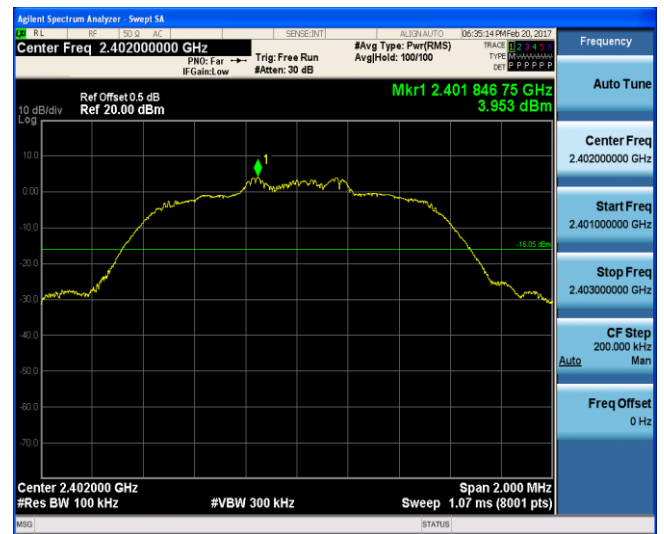
30MHz-3GHz



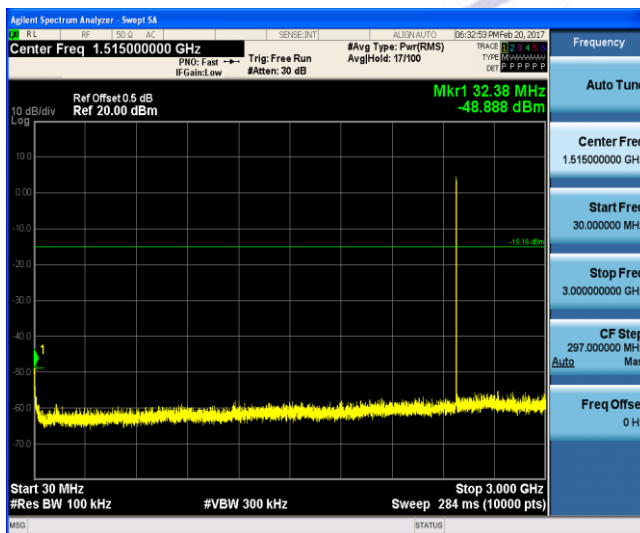
3GHz-25GHz

3GHz-25GHz

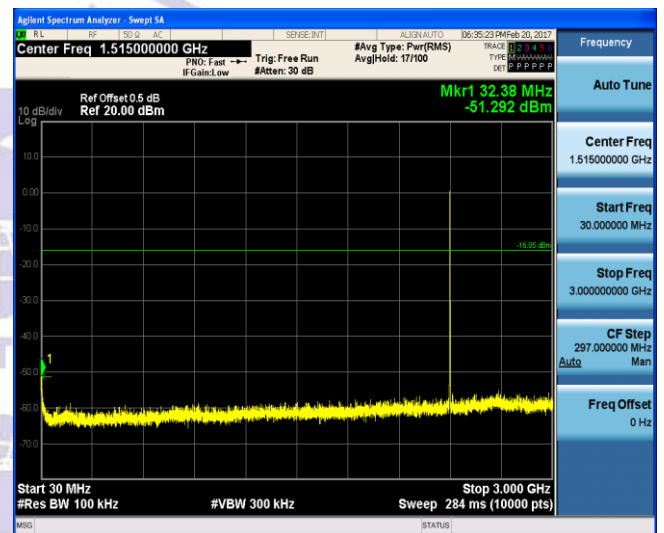
GFSK CH78

 $\pi/4$ DQPSK CH01

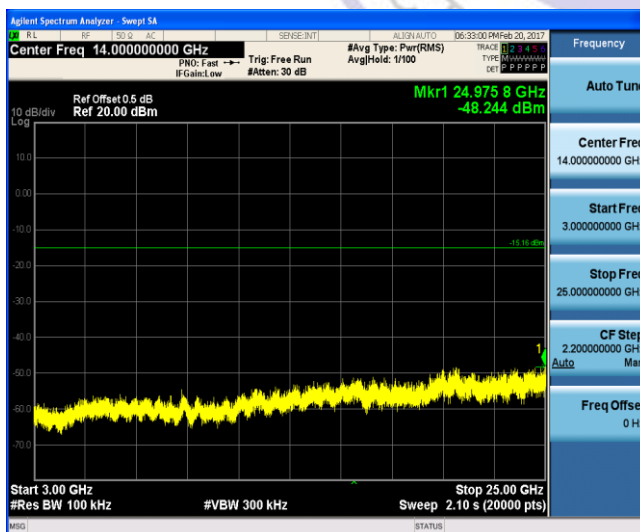
Reference



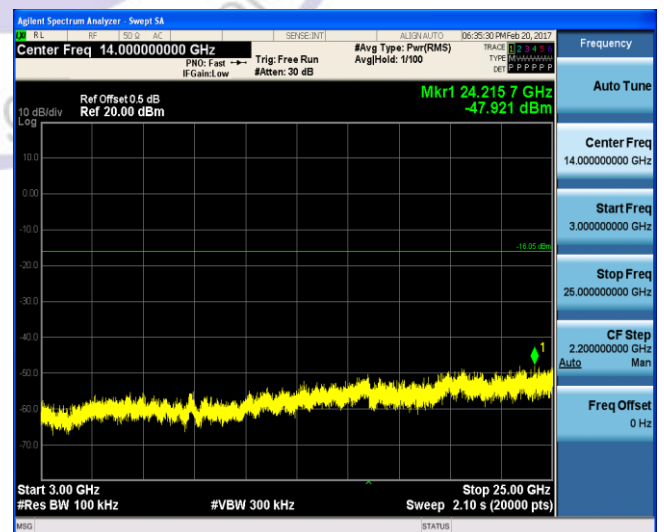
Reference



30MHz-3GHz

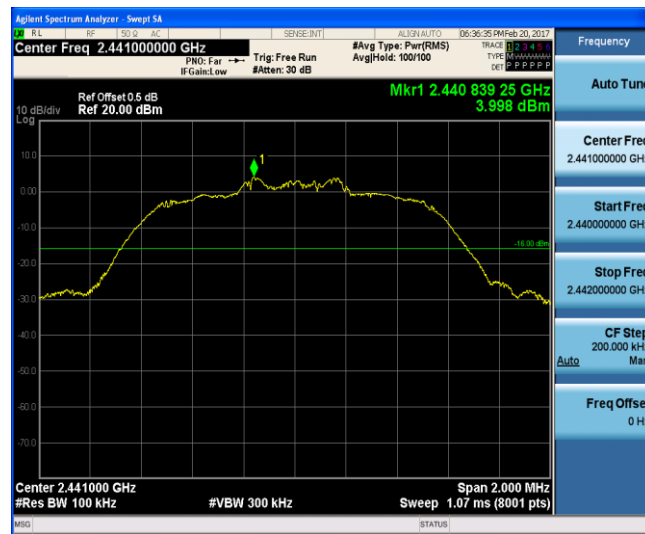
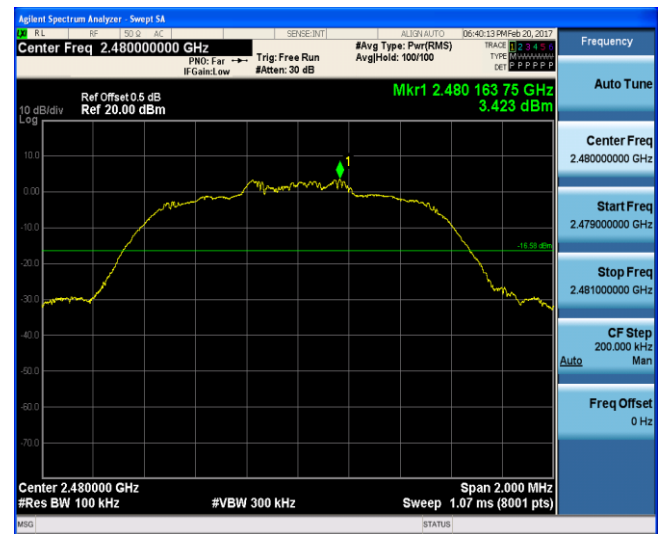


30MHz-3GHz

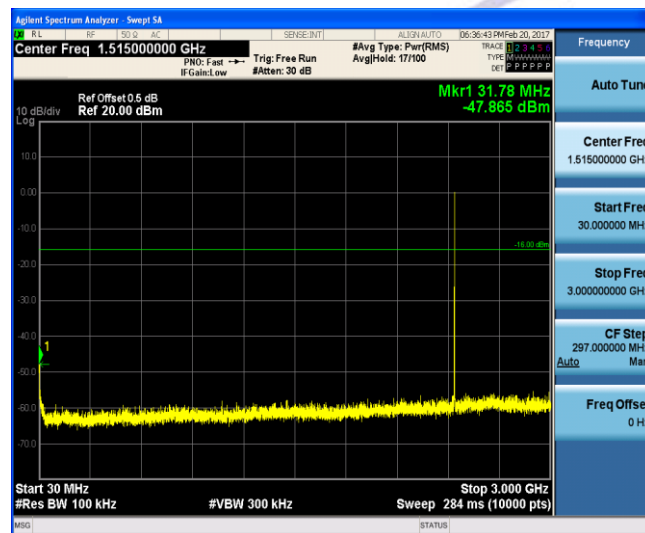


3GHz-25GHz

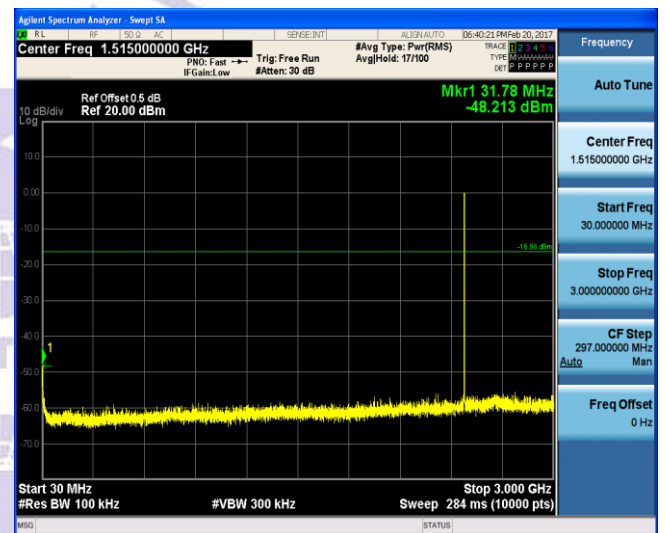
3GHz-25GHz

$\pi/4$ DQPSK CH39 $\pi/4$ DQPSK CH78

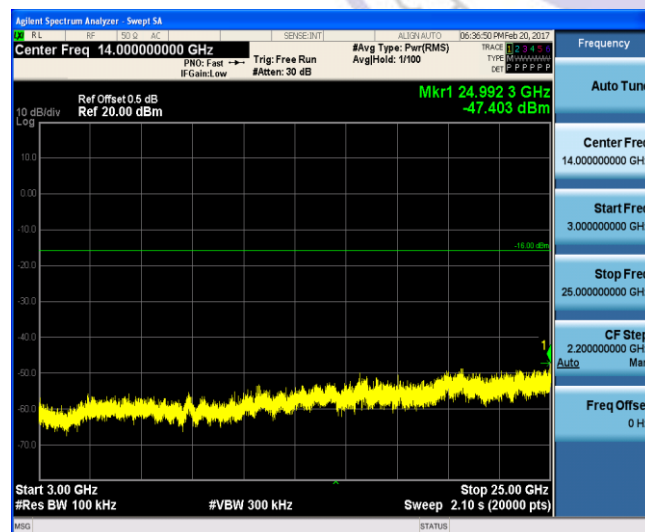
Reference



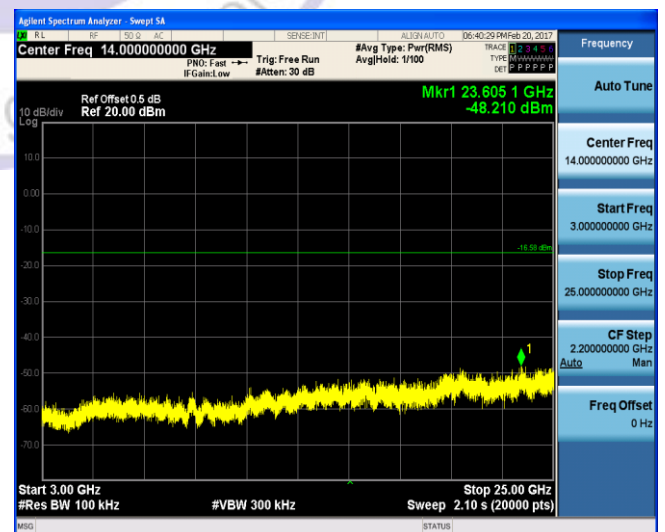
Reference



30MHz-3GHz



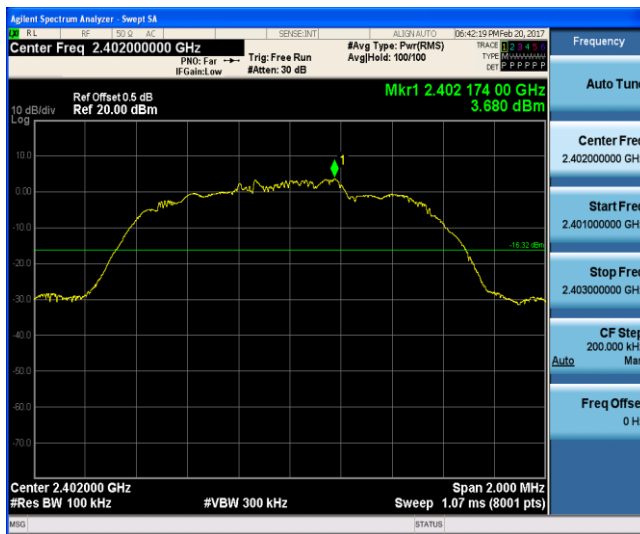
30MHz-3GHz



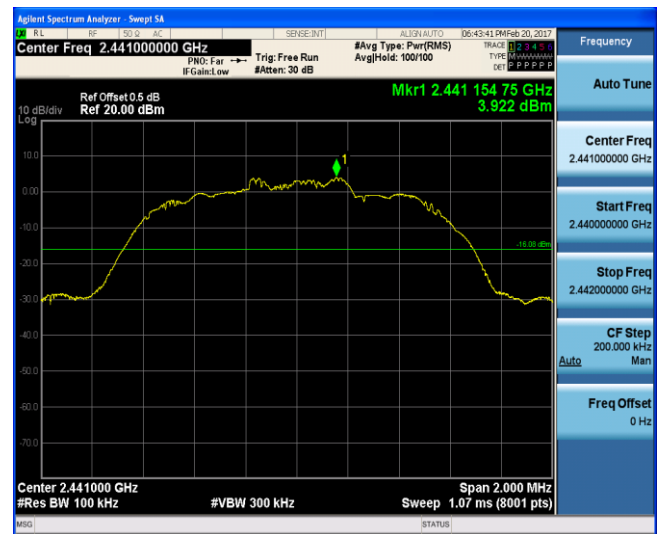
3GHz-25GHz

3GHz-25GHz

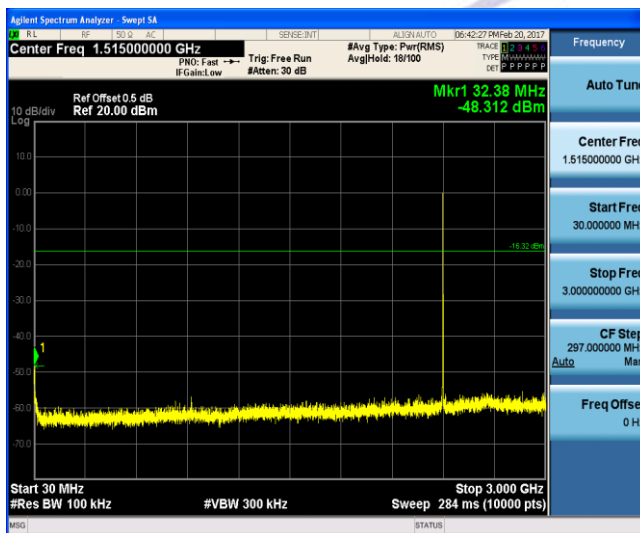
8DPSK CH00



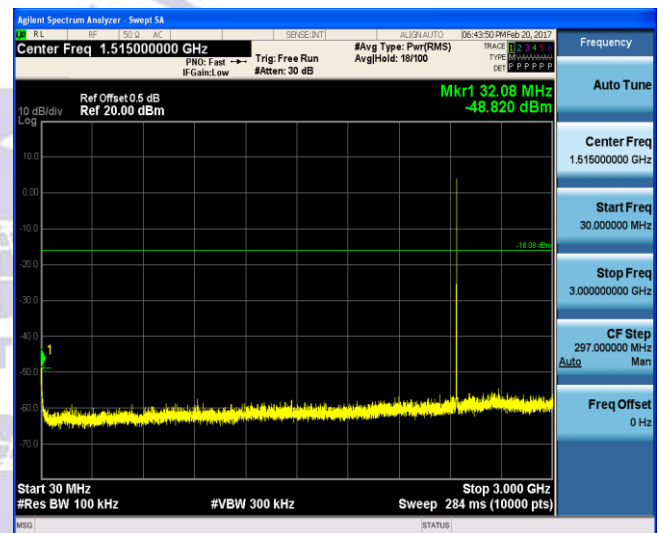
8DPSK CH39



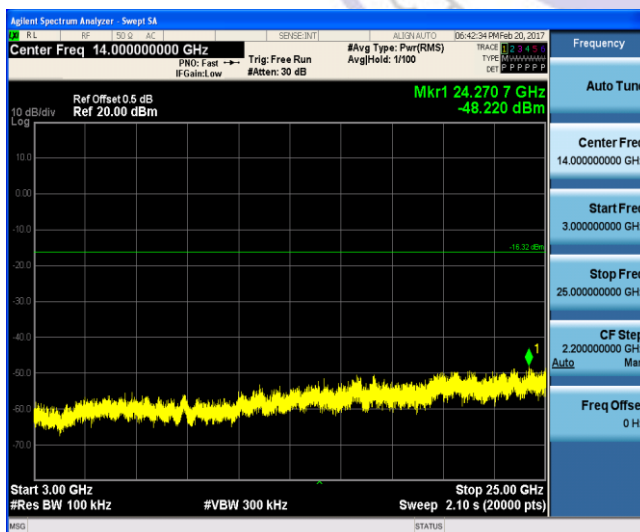
Reference



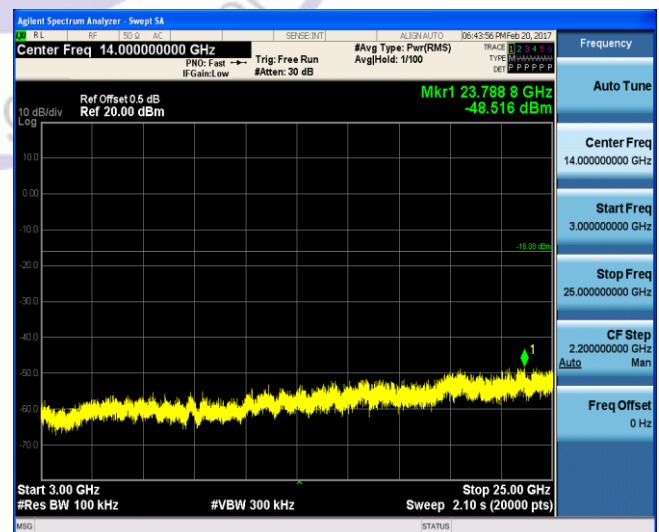
Reference



30MHz-3GHz



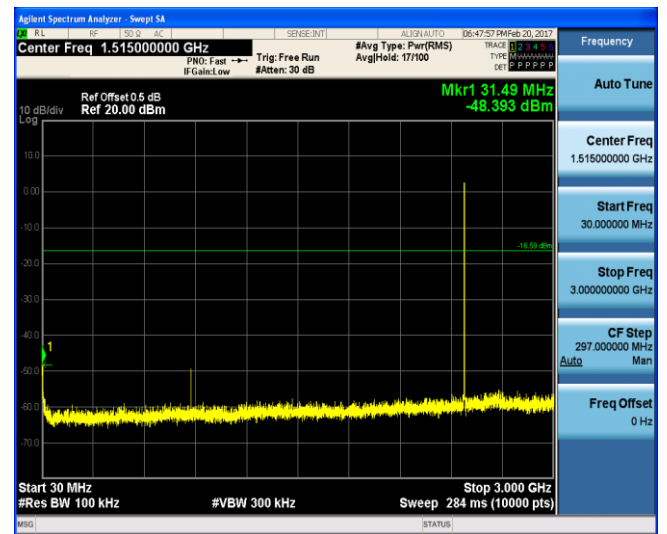
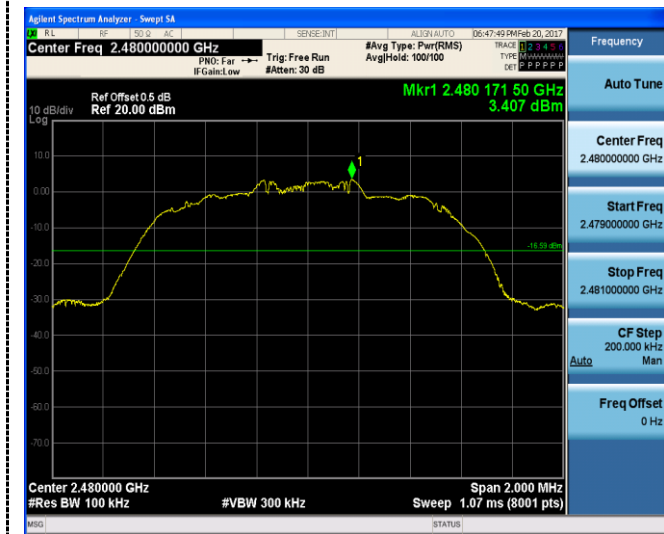
30MHz-3GHz



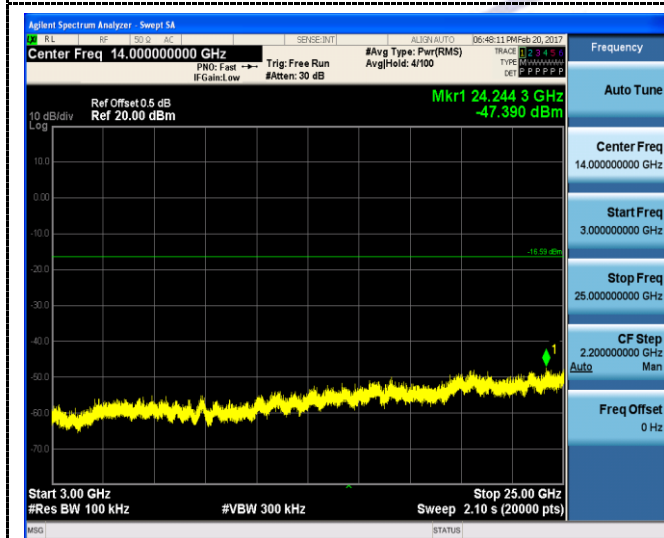
3GHz-25GHz

3GHz-25GHz

8DPSK CH78



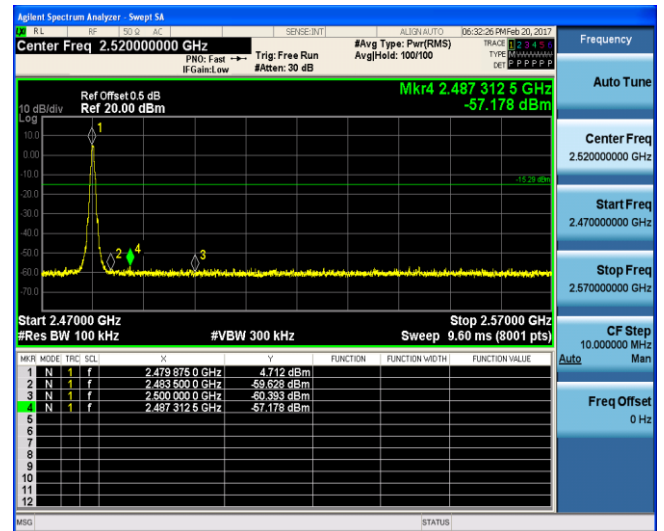
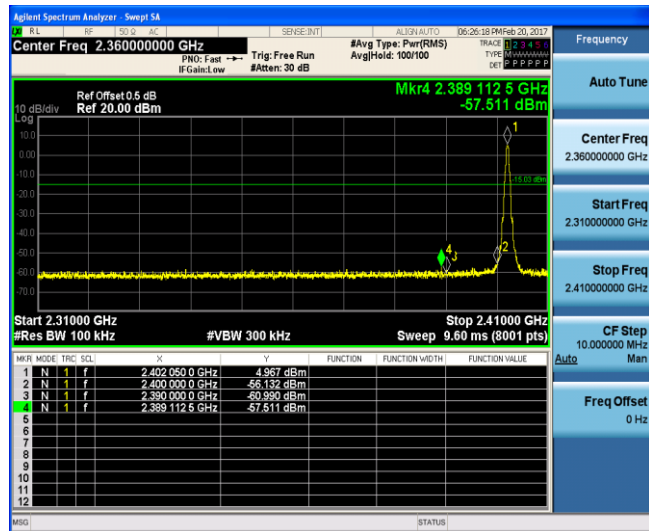
Reference



3GHz-25GHz

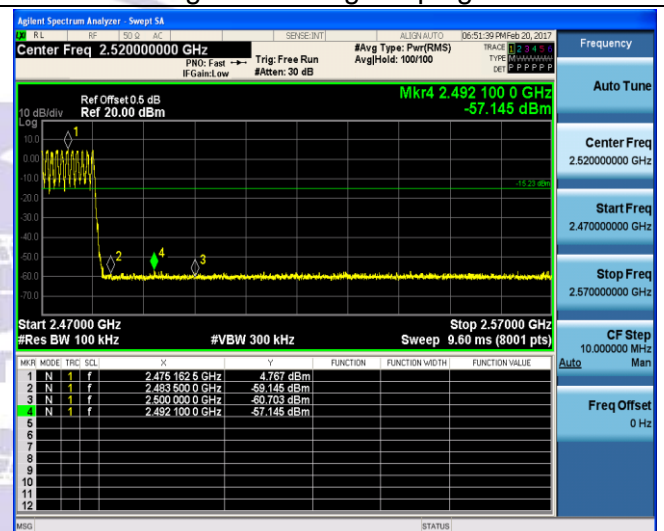
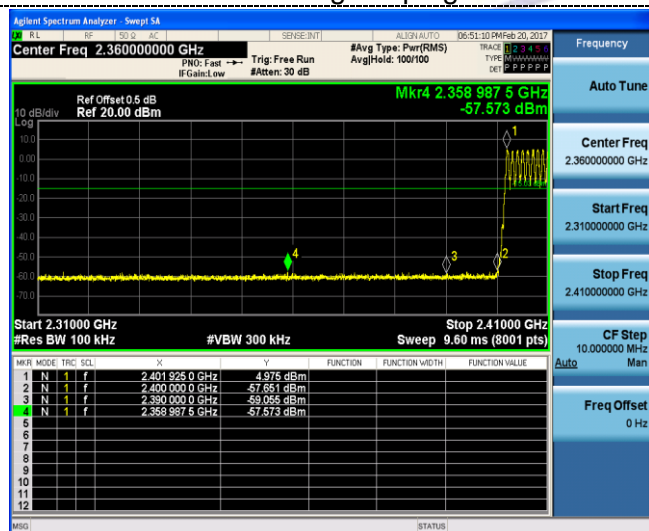
30MHz-3GHz



Band-edge Measurements for RF Conducted Emissions:**GFSK**

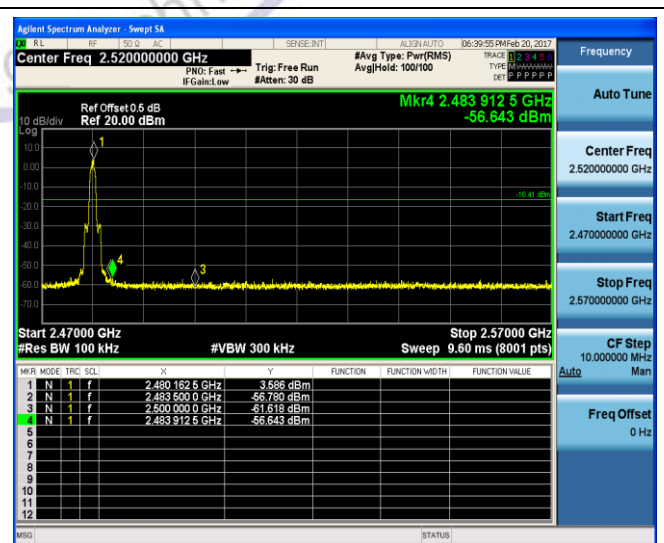
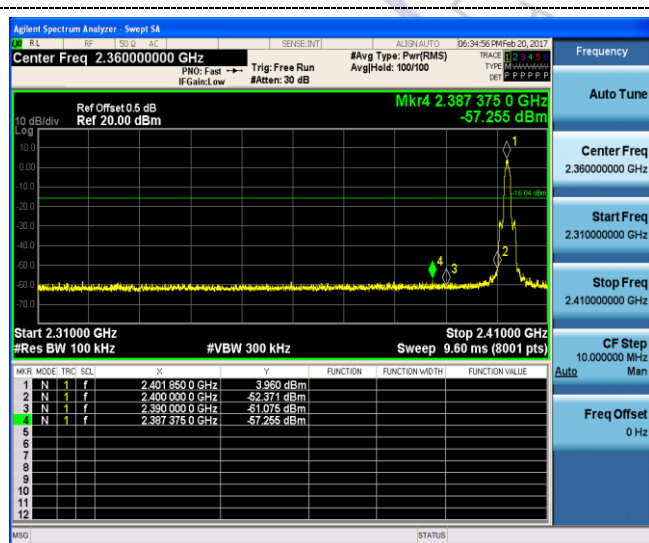
Left Band edge hopping off

Right Band edge hopping off



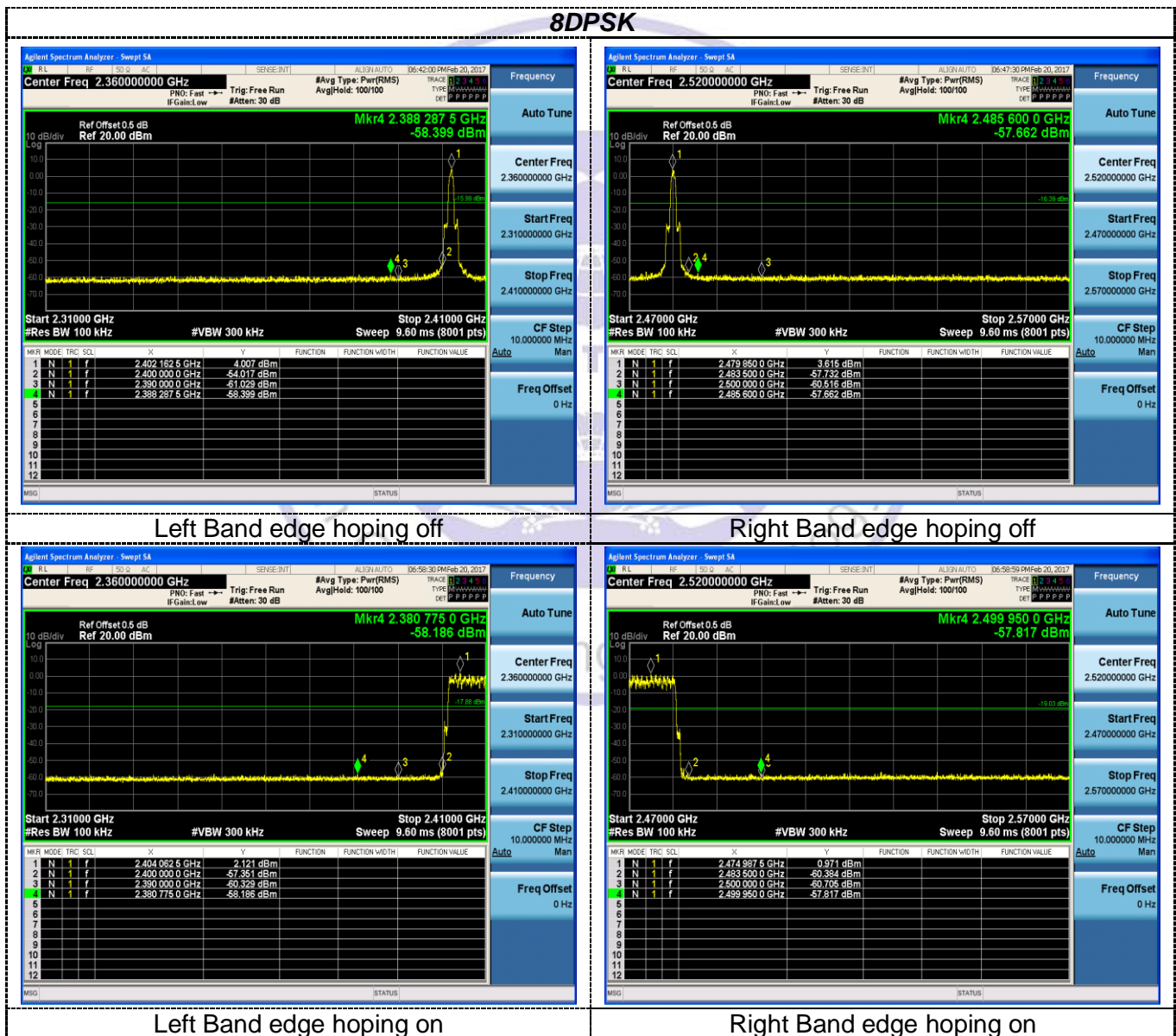
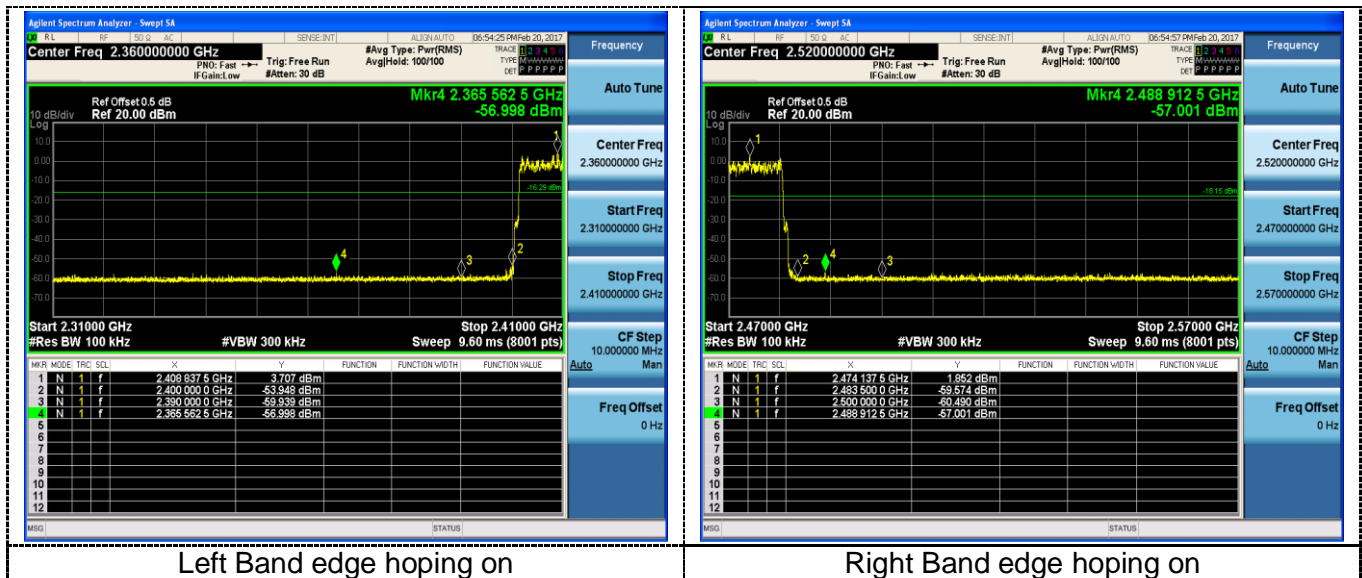
Left Band edge hopping on

Right Band edge hopping on

 $\pi/4$ DQPSK

Left Band edge hopping off

Right Band edge hopping off



3.9. Pseudorandom Frequency Hopping Sequence

TEST APPLICABLE

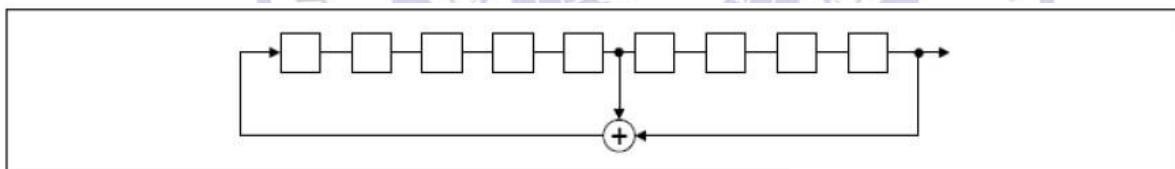
For 47 CFR Part 15C section 15.247 (a) (1) requirement:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hop-ping 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 pseudo randomly 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 hop-ping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

EUT Pseudorandom Frequency Hopping Sequence Requirement

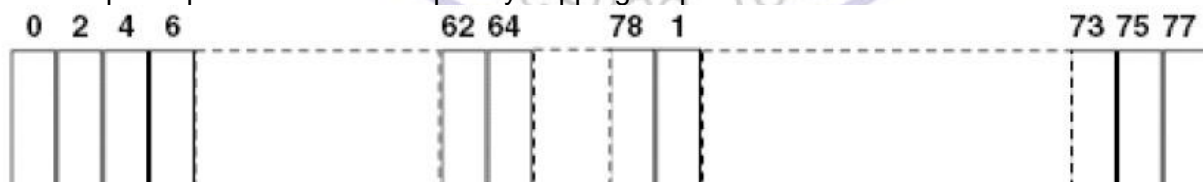
The pseudorandom frequency hopping sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence:29-1=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 follows:



Each frequency used equally one the average by each transmitter.

The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.

3.10. Antenna Requirement

Standard Applicable

For intentional device, according to FCC 47 CFR Section 15.203, 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.

And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

Refer to statement below for compliance

The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed.

Antenna Connected Construction

The maximum gain of antenna was 0dBi.



4. Test Setup Photos of the EUT

Please refer to test setup photo documents.



5. Photos of the EUT

Please refer to EUT photo documents.

***** End of Report *****

