

Agilent Spectrum Analyzer - Occupied BW

[L] [RL] [RF] [50 Ohm] [SENSE:INT] [ALIGN:AUTO] [11:21:05 PM 3/12/2017]

Center Freq 2.402000000 GHz
 Center Freq: 2.402000000 GHz
 Radio Std: None

Trig: Free Run
 Avg/Hold: 10/10

#IFGain: Low
 #Atten: 30 dB
 Radio Device: B7S

Ref Offset 0.9 dB
 Ref 20.00 dBm

Center 2.402 GHz
 Span 3 MHz

#Res BW 30 kHz
 #VBW 100 kHz
 Sweep 3.2 ms

Occupied Bandwidth	Total Power
898.54 kHz	10.9 dBm

Transmit Freq Error	OBW Power
-39.782 kHz	99.00 %

x dB Bandwidth	x dB
948.1 kHz	-20.00 dB

MSG

STATUS

Agilent Spectrum Analyzer - Occupied BW

RL F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16 F17 F18 F19 F20 F21 F22 F23 F24 F25 F26 F27 F28 F29 F30 F31 F32 F33 F34 F35 F36 F37 F38 F39 F40 F41 F42 F43 F44 F45 F46 F47 F48 F49 F50 F51 F52 F53 F54 F55 F56 F57 F58 F59 F60 F61 F62 F63 F64 F65 F66 F67 F68 F69 F70 F71 F72 F73 F74 F75 F76 F77 F78 F79 F80 F81 F82 F83 F84 F85 F86 F87 F88 F89 F90 F91 F92 F93 F94 F95 F96 F97 F98 F99 F100

Center Freq 2.441000000 GHz

Ref Offset 0.9 dB
Ref 20.00 dBm

SEI [INT] ALIGN [AUTO] 11/23/42 PM 3/12, 2017

Center Freq: 2.441000000 GHz
Trig: Free Run
#Atten: 30 dB

Radio Std: None
Radio Device: BTS

#IFGain: Low
Avg/Hold: > 10/10

Frequency

Center Freq
2.441000000 GHz

CF Step
300.00 kHz
Ma

Auto

Span 3 MHz
Sweep 3.2 ms

Occupied Bandwidth

895.33 kHz

Total Power

11.5 dBm

Transmit Freq Error

-41.985 kHz

OBW Power

99.00 %

x dB Bandwidth

948.7 kHz

x dB

-20.00 dB

Freq Offset

0 Hz

Agilent Spectrum Analyzer - Occupied BW

RL RF ESD A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

SENSE INT ALIGN AUTO 11:32:24 PM Jul 12, 2017

Center Freq 2.480000000 GHz Center Freq: 2.480000000 GHz Radio Std: None

Trig: Free Run Avg/Hold: 10/10

#IF Gain: Low #Atten: 30 dB Radio Device: BTS

Ref Offset 0.9 dB
Ref 20.00 dBm

10 dB/div
Log

Center 2.48 GHz Span 3 MHz

#Res BW 30 kHz #VBW 100 kHz Sweep 3.2 ms

Occupied Bandwidth		Total Power	4.54 dBm
907.46 kHz			
Transmit Freq Error	-47.632 kHz	OBW Power	99.00 %
x dB Bandwidth	968.9 kHz	x dB	-20.00 dB

MSG STATUS

Frequency

Center Freq
2.480000000 GHz

CF Step
300.000 kHz
Ma

Freq Offset
0 Hz

Auto

CH78

Agilent Spectrum Analyzer - Occupied BW

Center Freq 2.402000000 GHz

Ref Offset 0.9 dB
Ref 20.00 dBm

SEIZE INT

ALIGN/AUTO

11:35:24 PM 3/12, 2017

Radio Std: None

Radio Device: BTS

#IFGain: Low

Trig: Free Run

Avg/Hold: 10/10

#Att: 30 dB

Center 2.402 GHz

#Res BW 30 kHz

#VBW 100 kHz

Span 3 MHz

Sweep 3.2 ms

Auto

Occupied Bandwidth

2.1731 MHz

Total Power

9.13 dBm

Transmit Freq Error

-47.319 kHz

OBW Power

99.00 %

x dB Bandwidth

1.278 MHz

x dB

-20.00 dB

Agilent Spectrum Analyzer - Occupied BW

RL	F2	F0 Offset	SENSE INT	ALIGN/AUTO	11/30/53 PM 3/12, 2017
Center Freq 2.441000000 GHz			Center Freq: 2.441000000 GHz	Radio Std: None	Frequency
			Trig: Free Run	Avg/Hold: 10/10	
#IF Gain: Low →			#Atten: 30 dB	Radio Device: BTS	

Ref Offset 0.9 dB
Ref 20.00 dBm

Log
10 dBm/div
-70.0

Center 2.441 GHz	Span 3 MHz
#Res BW 30 kHz	Sweep 3.2 ms
#VBW 100 kHz	

Occupied Bandwidth	Total Power	9.66 dBm
1.1689 MHz		
Transmit Freq Error	-49.473 kHz	OBW Power
x dB Bandwidth	1.278 MHz	99.00 %
	x dB	-20.00 dB

MSG STATUS

Agilent Spectrum Analyzer - Occupied BW

RL RF ISO A FREQ SENSE INT ALIGN AUTO 11:44:55 PM Jul 12, 2017

Center Freq 2.480000000 GHz Center Freq: 2.480000000 GHz Radio Std: None

#IF Gain: Low → Trig: Free Run Avg/Hold: 10/10

Radio Device: BTS

Ref Offset 0.9 dB
Ref 20.00 dBm

10 dB/div
Log

Center 2.48 GHz Span 3 MHz
#Res BW 30 kHz #VBW 100 kHz Sweep 3.2 ms

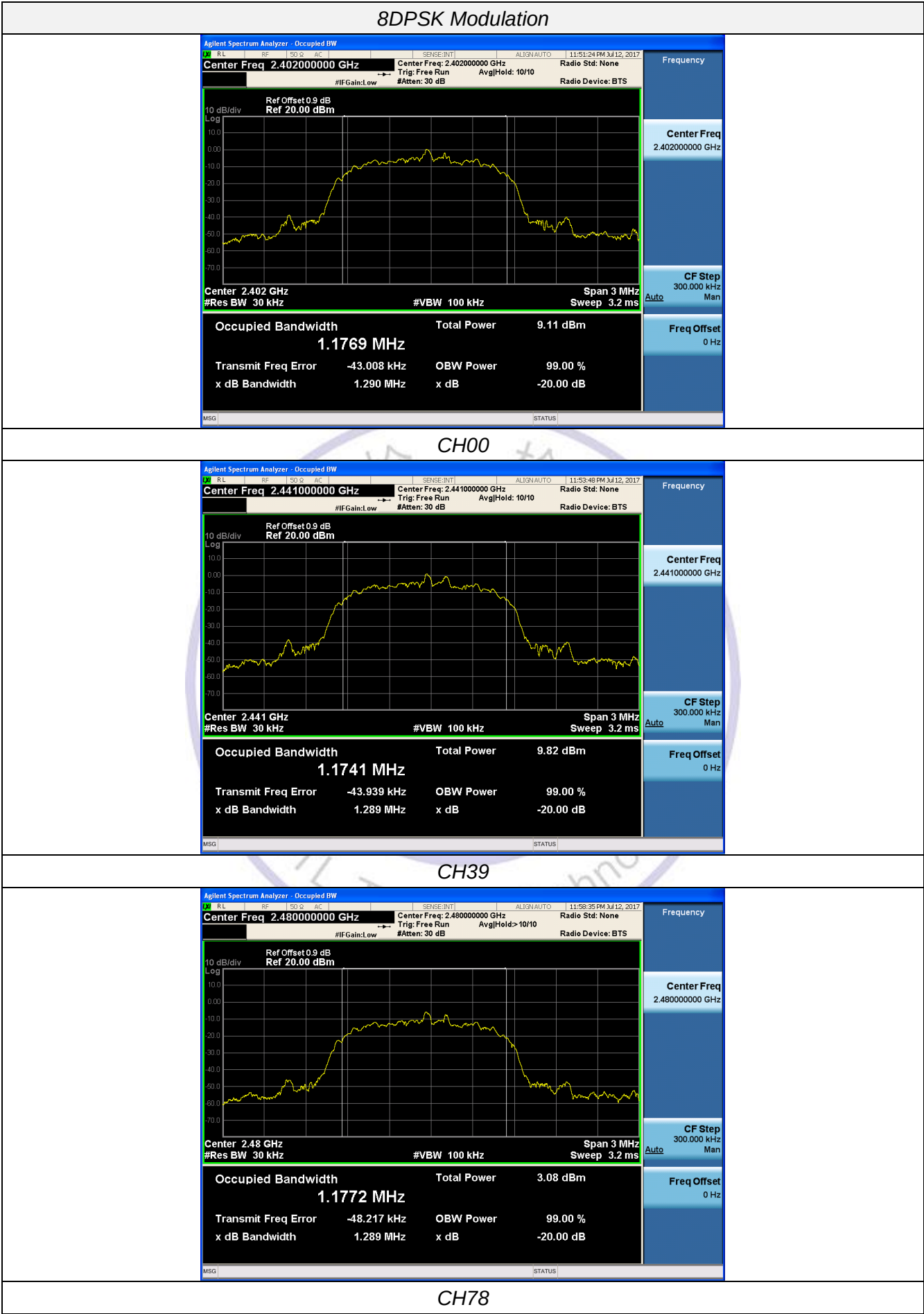
Occupied Bandwidth	Total Power
1.1741 MHz	2.92 dBm

Transmit Freq Error	OBW Power
-51.889 kHz	99.00 %

x dB Bandwidth	x dB
1.279 MHz	-20.00 dB

MSG STATUS

CH78



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	1.136	25KHz or $2/3 \times 20\text{dB}$ bandwidth	Pass
	CH40			
$\pi/4$ DQPSK	CH39	1.252	25KHz or $2/3 \times 20\text{dB}$ bandwidth	Pass
	CH40			
8DPSK	CH39	0.985	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:

Agilent Spectrum Analyzer - Swept SA

RL RF SSB Freq AC → SENSE:INT ALIGN:AUTO 12:25:44 AM 3/13/17

Center Freq 2.440500000 GHz #Avg Type: Pwr(RMS) TRAC 1 2 3 4 5
#RL TYPE M W X Y Z
DET P P P P P

PNO: Far Trig: Free Run #Atten: 40 dB IFGain:Low

Ref Offset 0.9 dB ΔMkr1 1.135 75 MHz
Ref 30.00 dBm 0.437 dB

10 dB/div Log

MFR MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	A2	f	(Δ)	1.135 75 MHz (Δ)	0.437 dB		
2	F	f		2.439 970.00 GHz	3.913 dBm		
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Start 2.439500 GHz #Res BW 100 kHz **Stop 2.441500 GHz**
#VBW 300 kHz Sweep 1.07 ms (8001 pts)

Agilent Spectrum Analyzer - Swept SA

RL RF LO CO AG SENSE:INT ALGSEL:AUTO 12:30:36 AM Jul 13, 2017
Start Freq 2.439500000 GHz PNO: Far → Trg: Free Run #Avg Type: Pow(RMS) TRAC 1 2 3 4 R
IFGain:Low #Atten: 40 dB AvgHld: 100/100 TYPE D W W W W W W W W W
DEF P P P P P P P

Ref Offset 0.9 dB **ΔMkr1 1.251 75 MHz**
Ref 30.00 dBm **-1.133 dB**

Log
20.0
0.00
-10.0
-20.0
-40.0
-60.0

X₂ Δ2

Start 2.439500 GHz Stop 2.441500 GHz
#Res BW 100 kHz #VBW 300 kHz Sweep 1.07 ms (8001 pts)

MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	A2	1	f	(Δ)	1.251 75 MHz (Δ)	-1.133 dB		
2	F	1	f		2.439 813 50 GHz	2.029 dBm		
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

MSG STATUS

Frequency
Auto Tun
Center Fre
2.440500000 GH
Start Fre
2.439500000 GH
Stop Fre
2.441500000 GH
CF Step
200.000 kH
Ma
Freq Offse
0 Hz

[illegible]

3.6. Number of hopping frequency

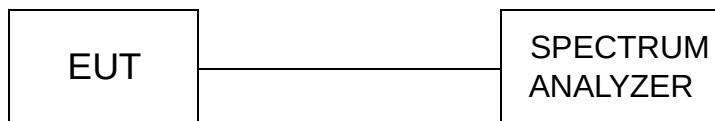
Limit

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:

Agilent Spectrum Analyzer - Swept SA

RL: [] RF: [] FSO: [] AC: [] SENSE: [INT] ALIGN: [AUTO] 12:25:02 AM 3/13/2017

Center Freq 2.441750000 GHz #Avg Type: Pwr(RMS) TRAC: [1] 0 3 4 5 TYPE: [M] M M M M M M M M DET: [P] P P P P P P

PNG: Fast IF Gain: Low Trig: Free Run #Atten: 30 dB Avg/Hold: 100/100

Ref Offset 0.9 dB
Ref 20.00 dBm

ΔMkr1 77.989 MHz
-5.635 dB

Start 2.40000 GHz Stop 2.48350 GHz
#Res BW 100 kHz #VBW 300 kHz Sweep 8.00 ms (8001 pts)

MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	A2	f	(Δ)	77.989 MHz (Δ)	-5.635 dB			
2	F	f		2.401983 GHz	2.824 dBrn			
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

MSG: [] STATUS: []

Agilent Spectrum Analyzer - Swept SA

FREQ: Hz	PZ	EPO: ON AC	SENSE: INT	AUTO/AUTO	12:29:41 AM Jul 13, 2017
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Center Freq 2.441750000 GHz PNO: Fast → Trig: Free Run #Avg Type: Pwr(RMS) TRACE 1 [2] 3 4 5 6
IFGain: Low #Atten: 30 dB AvgHld: 100/100 TYPE MAAAAAA
DET PPPPP

ΔMkr1 77.770 MHz
-6.490 dB

Ref Offset 0.9 dB
Ref 20.00 dBm

Start 2.40000 GHz Stop 2.48350 GHz
#Res BW 100 kHz #VBW 300 kHz Sweep 8.00 ms (8001 pts)

MNR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	A2	f	(Δ)	77.770 MHz (Δ)	-6.490 dB			
2	F	f		2.402 014 GHz	-0.384 dBm			
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

MSG STATUS

[illegible]

3.7. Time of Occupancy (Dwell Time)

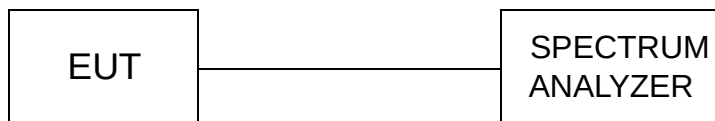
Limit

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

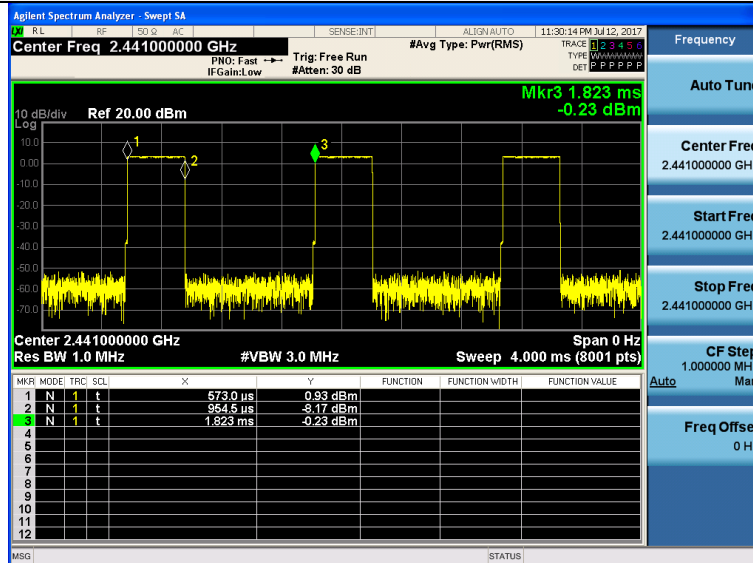
Modulation	Packet	Pulse time (ms)	Dwell time (s)	Limit (s)	Result
GFSK	DH1	0.382	0.122	0.40	Pass
	DH3	1.636	0.262		
	DH5	2.884	0.308		
π/4DQPSK	2-DH1	0.387	0.124	0.40	Pass
	2-DH3	1.639	0.262		
	2-DH5	2.886	0.308		
8DPSK	3-DH1	0.387	0.124	0.40	Pass
	3-DH3	1.637	0.262		
	3-DH5	2.888	0.308		

Note:

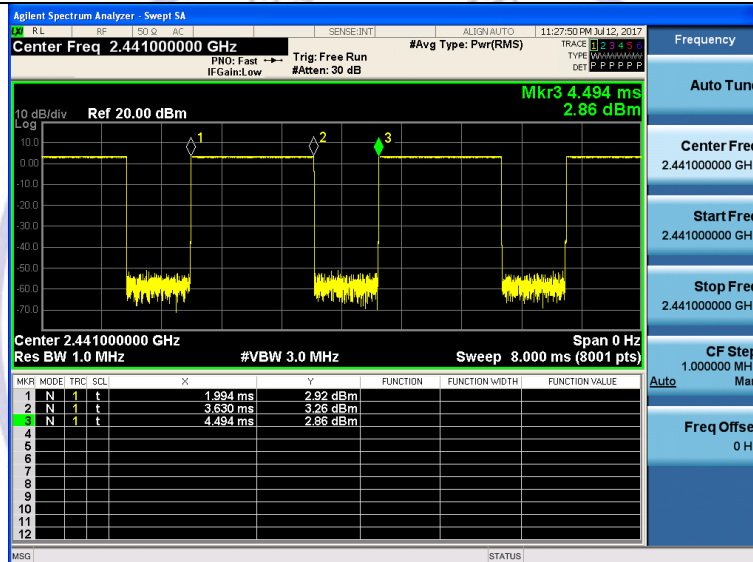
- We have tested all mode at high,middle and low channel,and recoreded worst case at middle channel.
- $\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 2 \div 79) \times 31.6$ Second for DH1, 2-DH1, 3-DH1
 $\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 4 \div 79) \times 31.6$ Second for DH3, 2-DH3, 3-DH3
 $\text{Dwell time} = \text{Pulse time (ms)} \times (1600 \div 6 \div 79) \times 31.6$ Second for DH5, 2-DH5, 3-DH5

Test plot as follows:

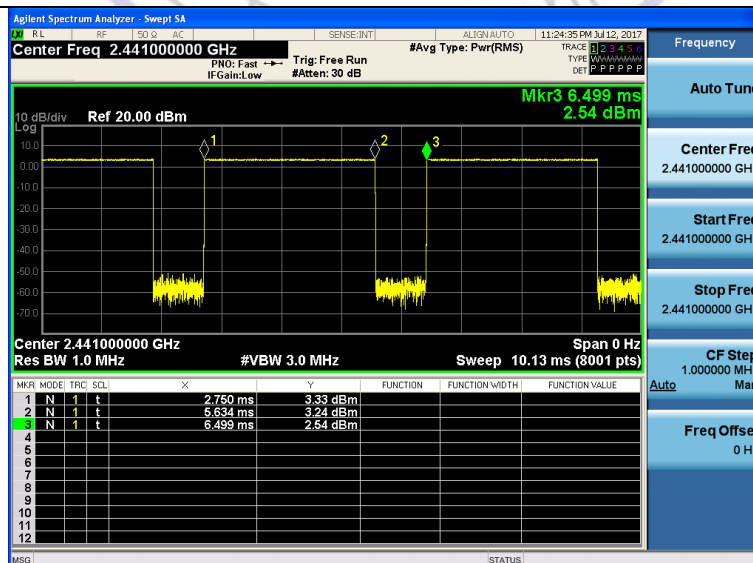
GFSK Modulation



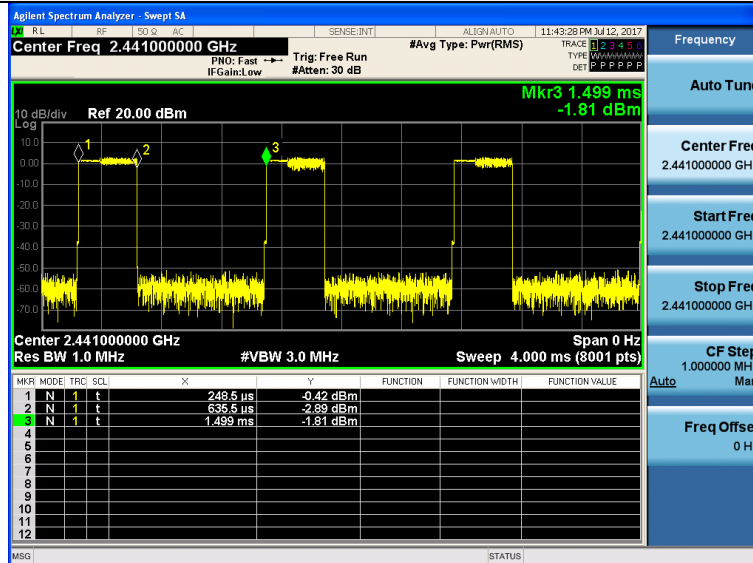
DH1



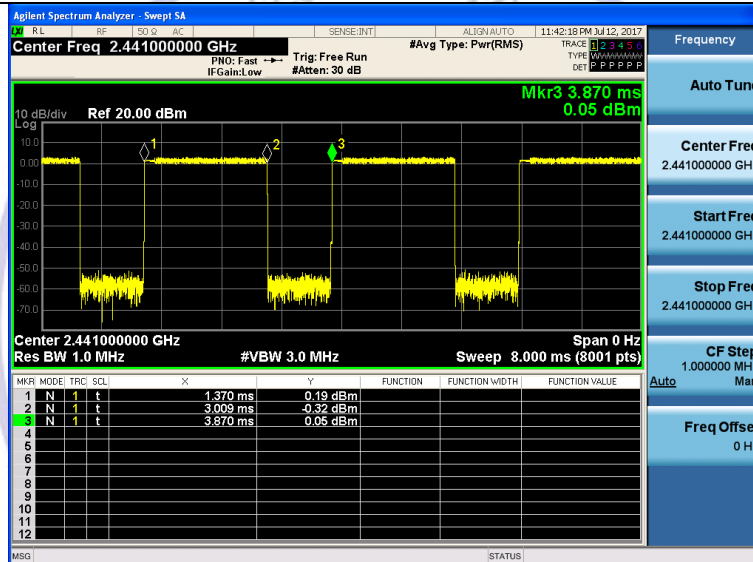
DH3



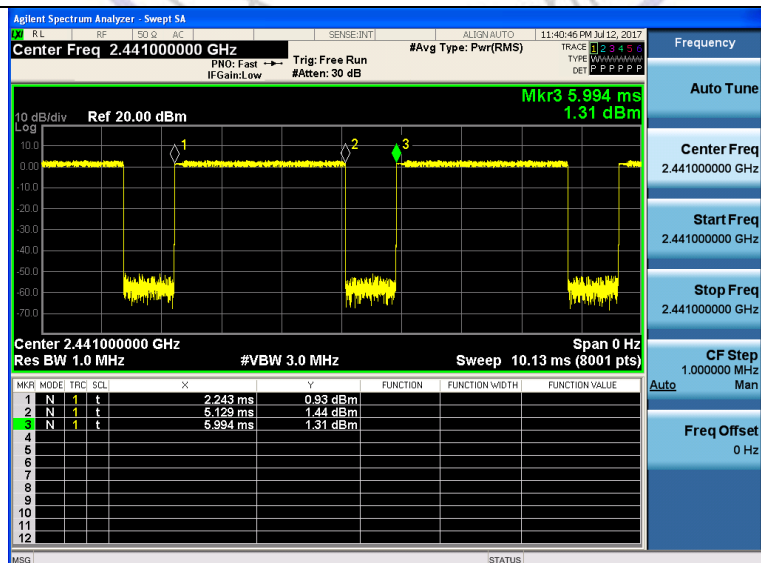
DH5

$\pi/4$ DQPSK Modulation

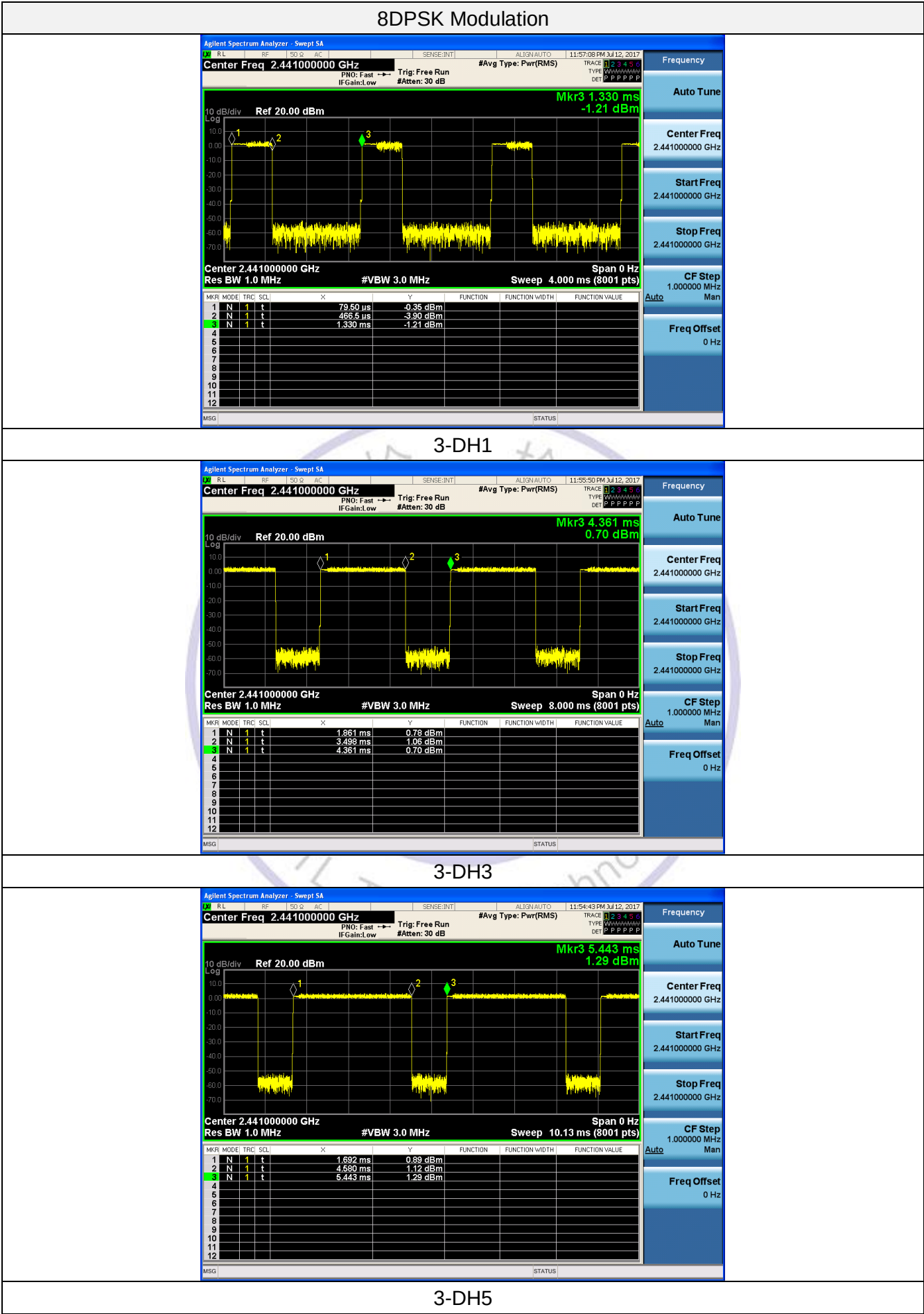
2-DH1



2-DH3



2-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.

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen 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 setting are made of the in-band reference level, bandedge and out-of-band emissions.

Test Configuration



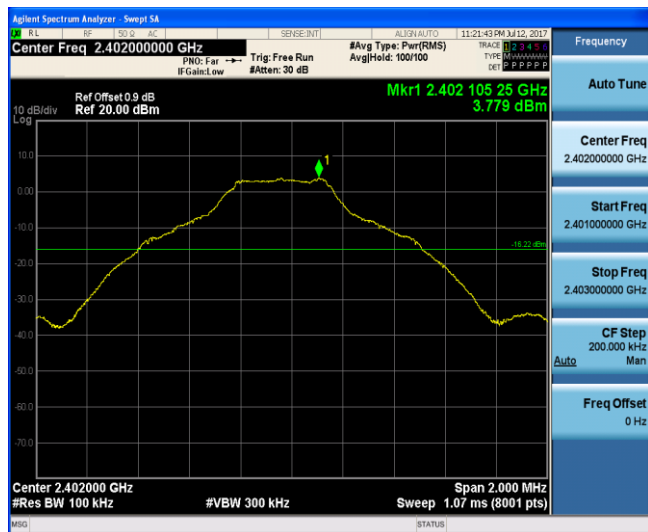
Test Results

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 bandage measurement data.

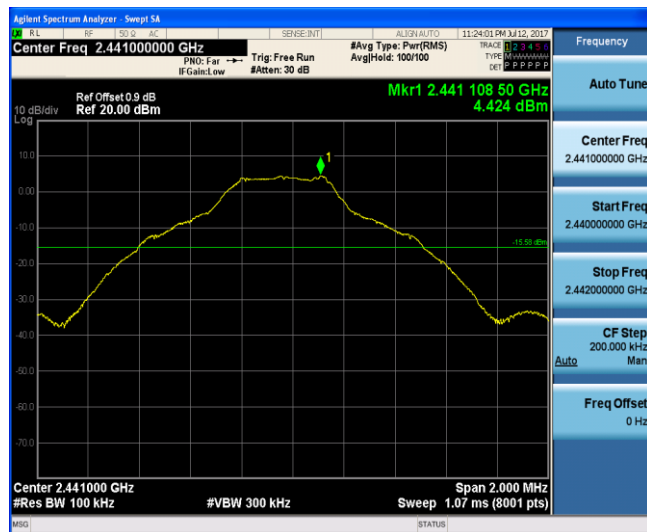
We measured all conditions (DH1, DH3, DH5) and recorded worst case at DH5

Test plot as follows:

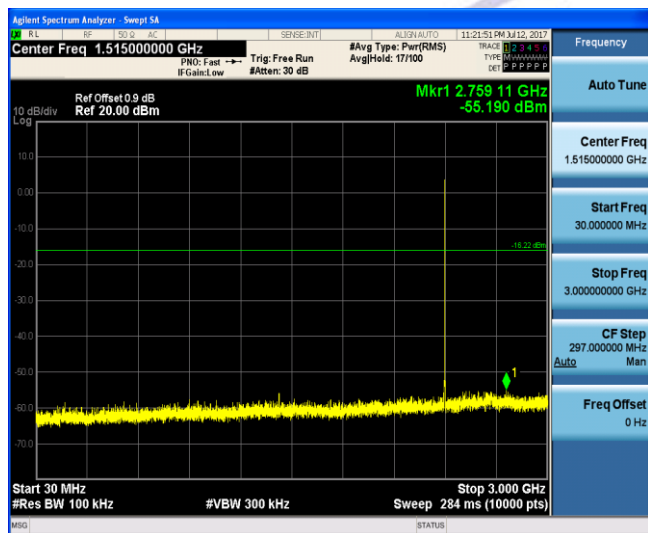
GFSK CH00



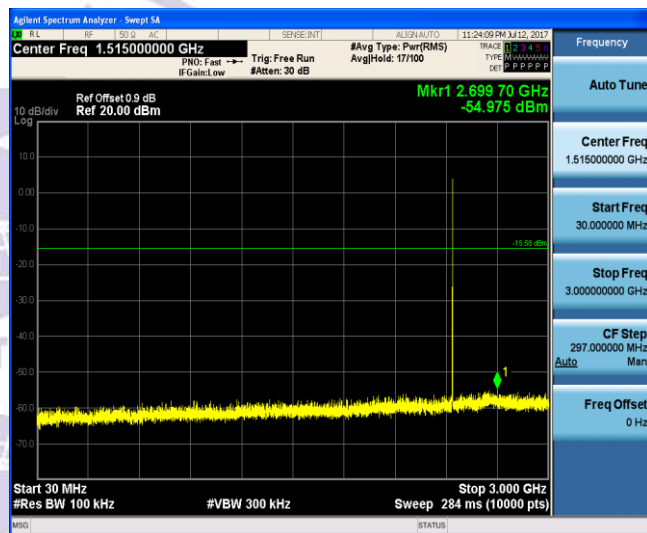
GFSK CH39



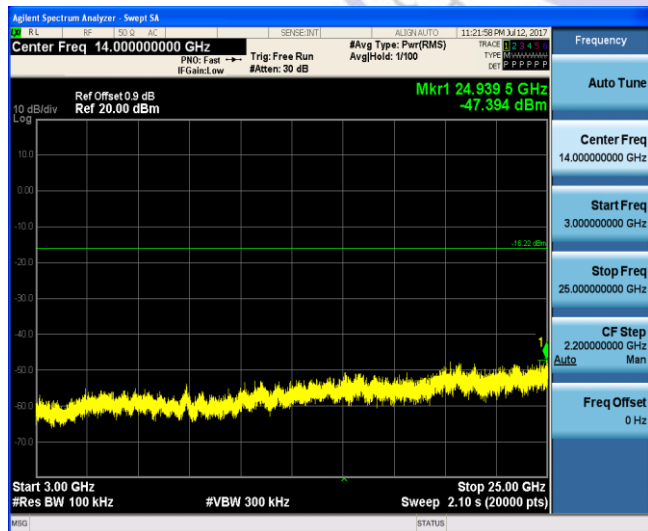
Reference



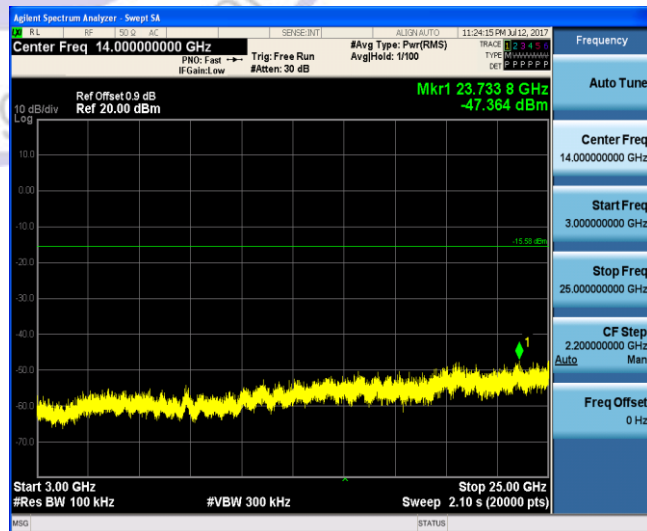
Reference



30MHz-3GHz



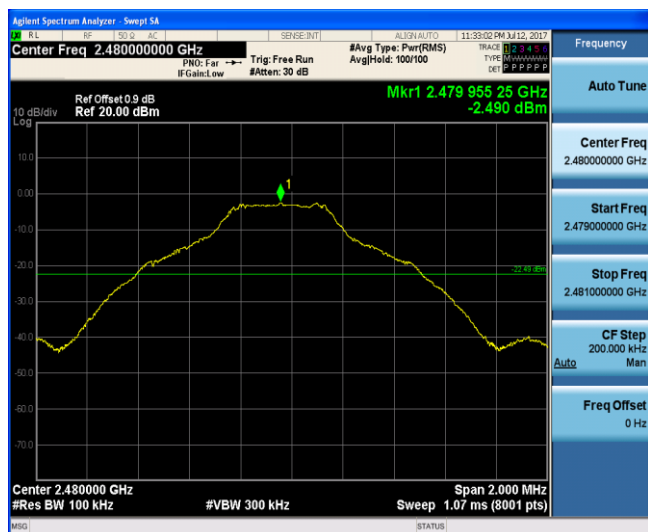
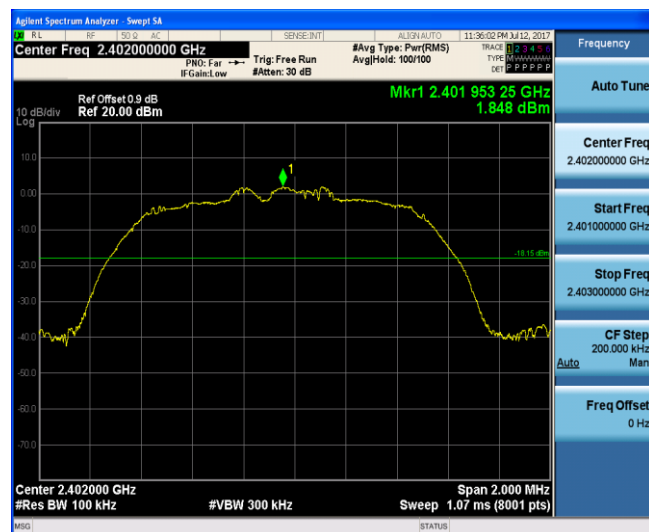
30MHz-3GHz



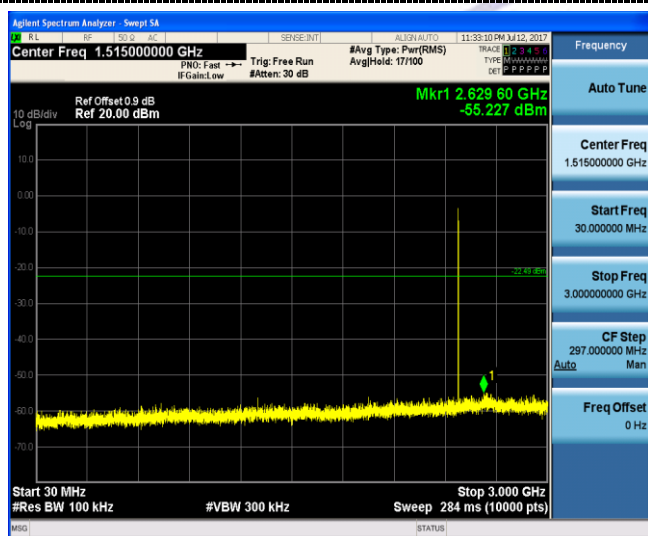
3GHz-25GHz

3GHz-25GHz

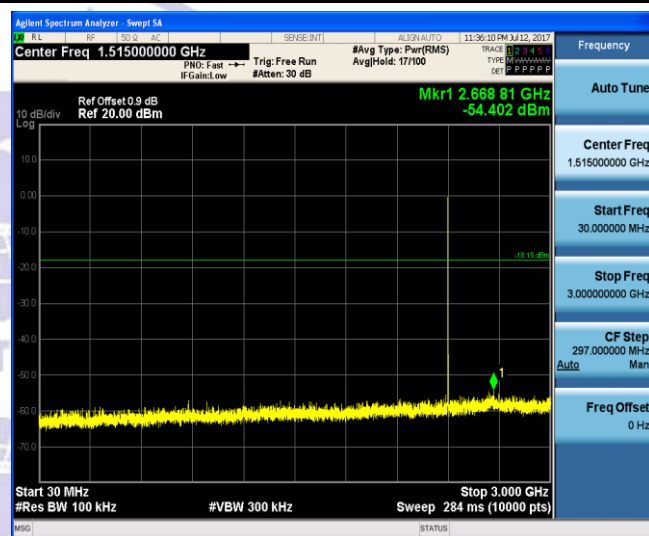
GFSK CH78

 $\pi/4$ DQPSK CH00

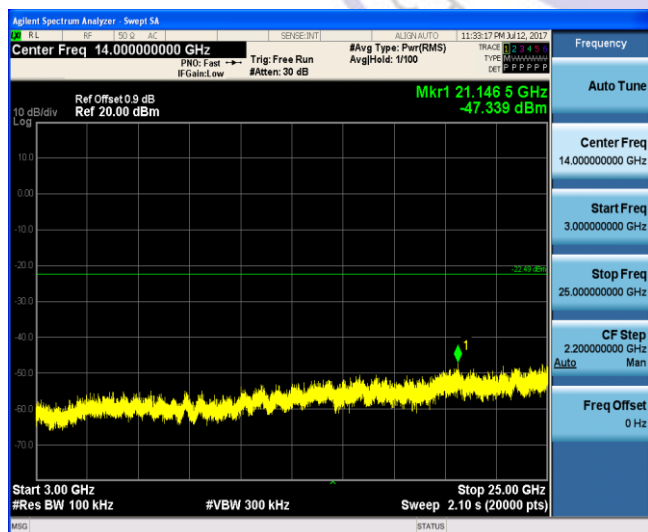
Reference



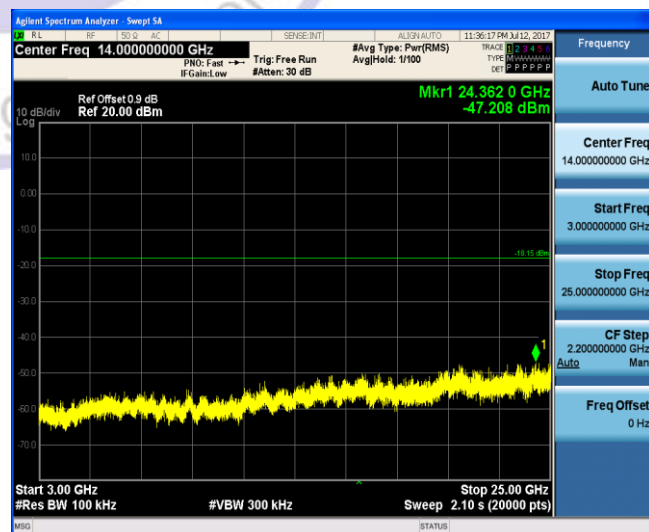
Reference



30MHz-3GHz

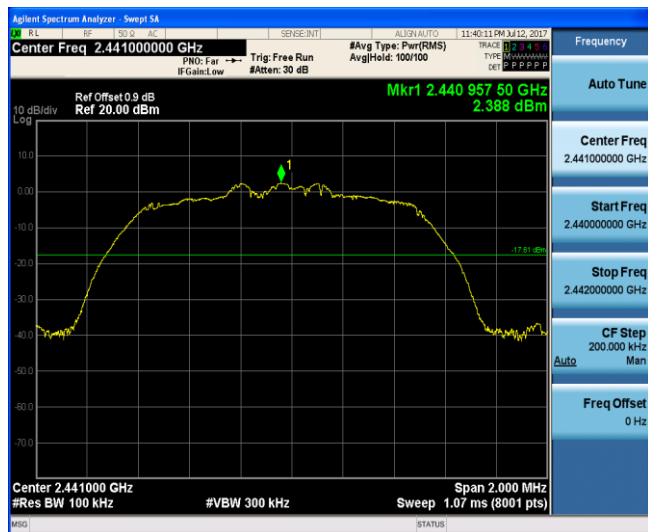
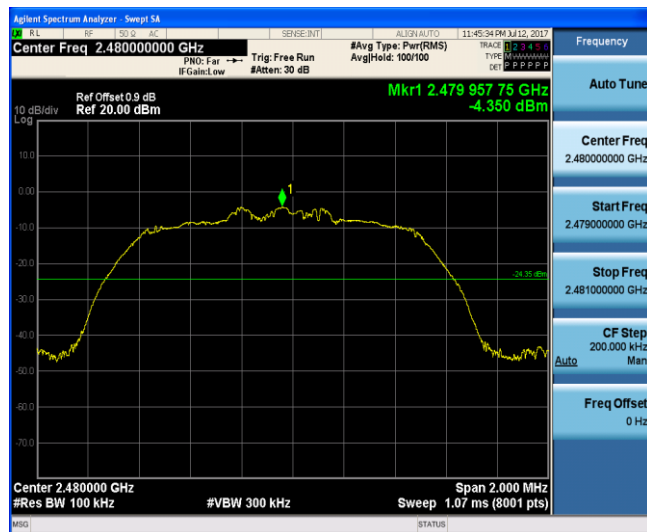


30MHz-3GHz

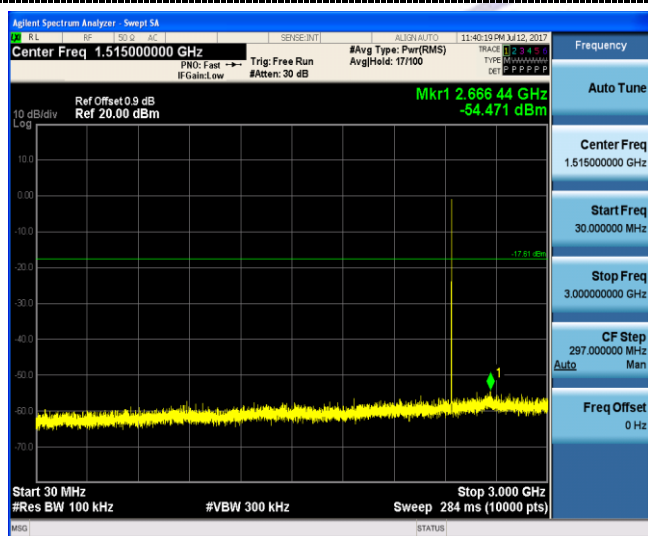


3GHz-25GHz

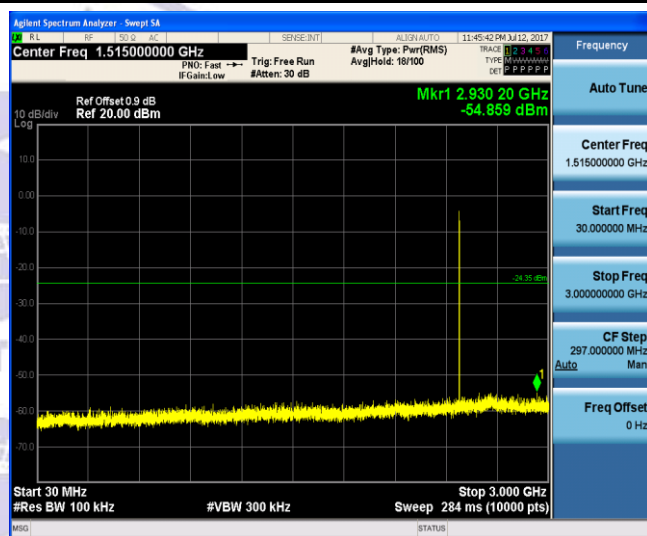
3GHz-25GHz

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

Reference

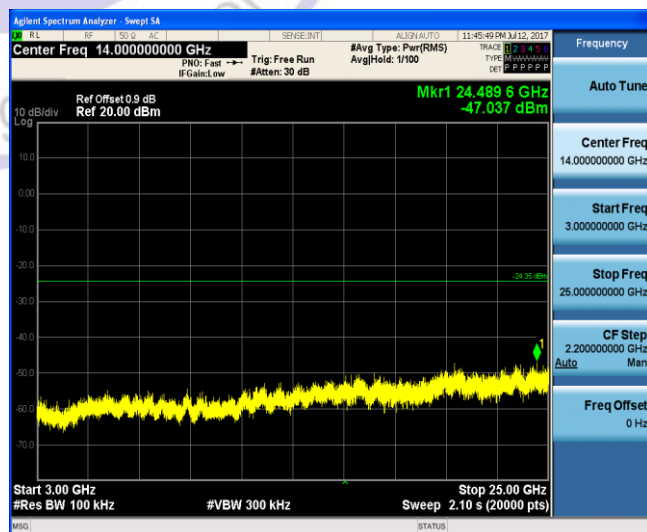
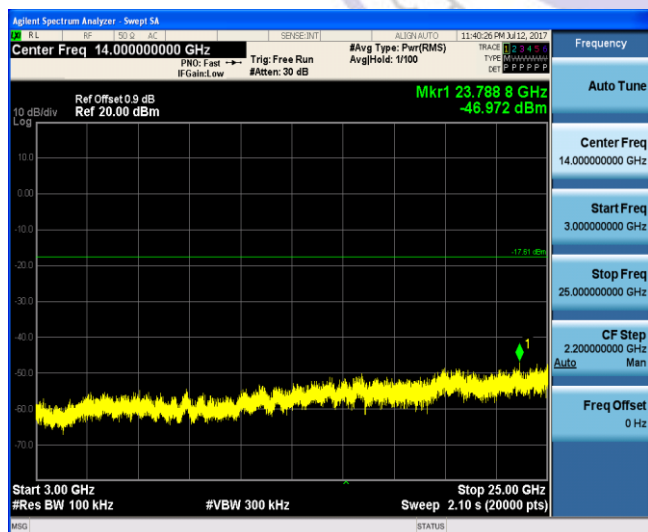


Reference



30MHz-3GHz

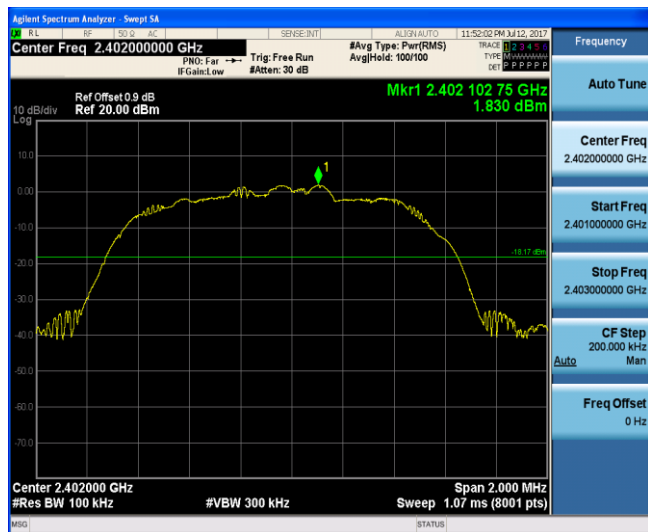
30MHz-3GHz



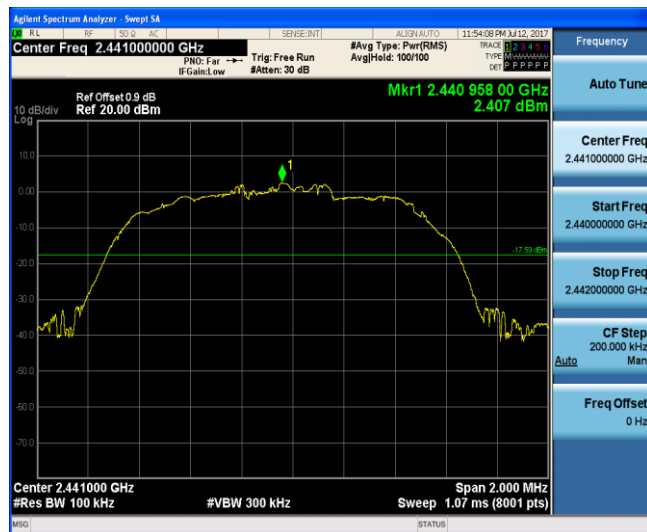
3GHz-25GHz

3GHz-25GHz

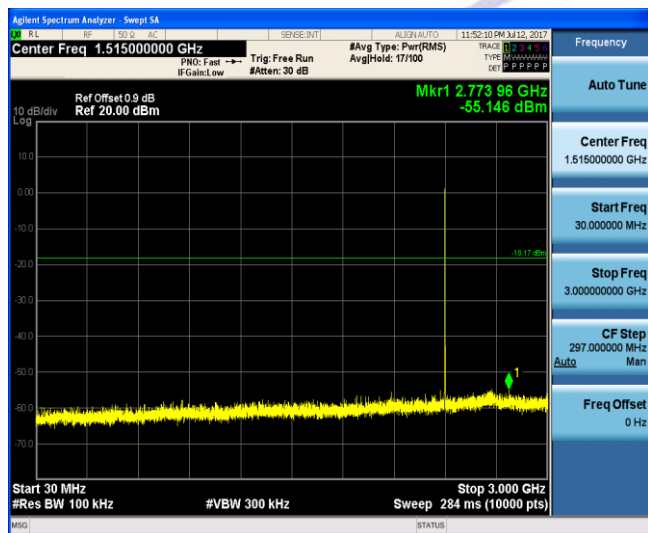
8DPSK CH00



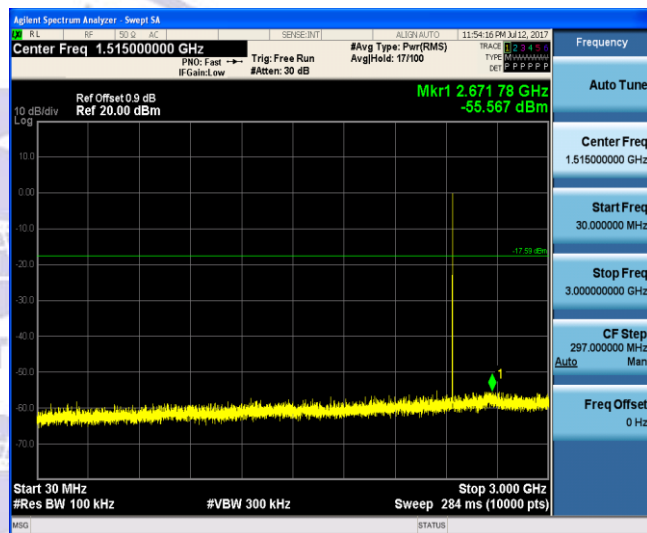
8DPSK CH39



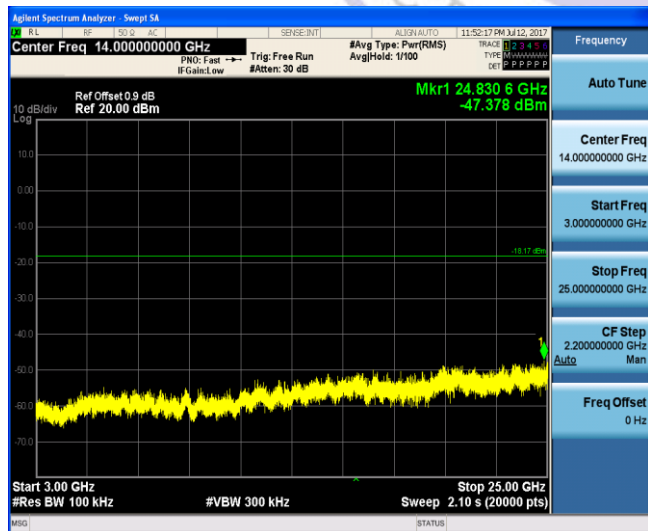
Reference



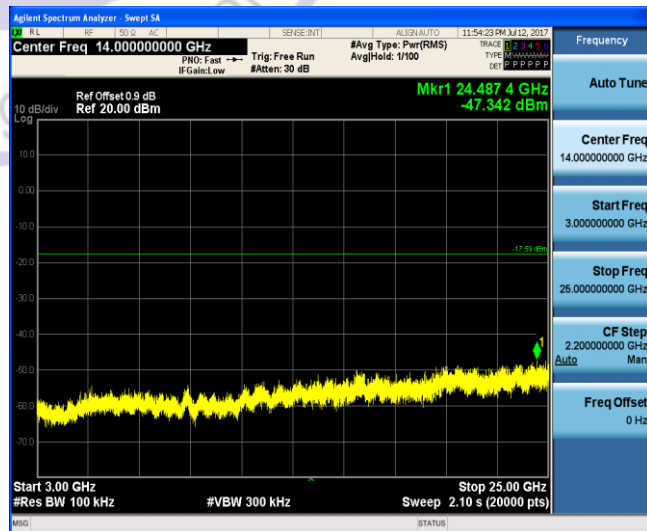
Reference



30MHz-3GHz



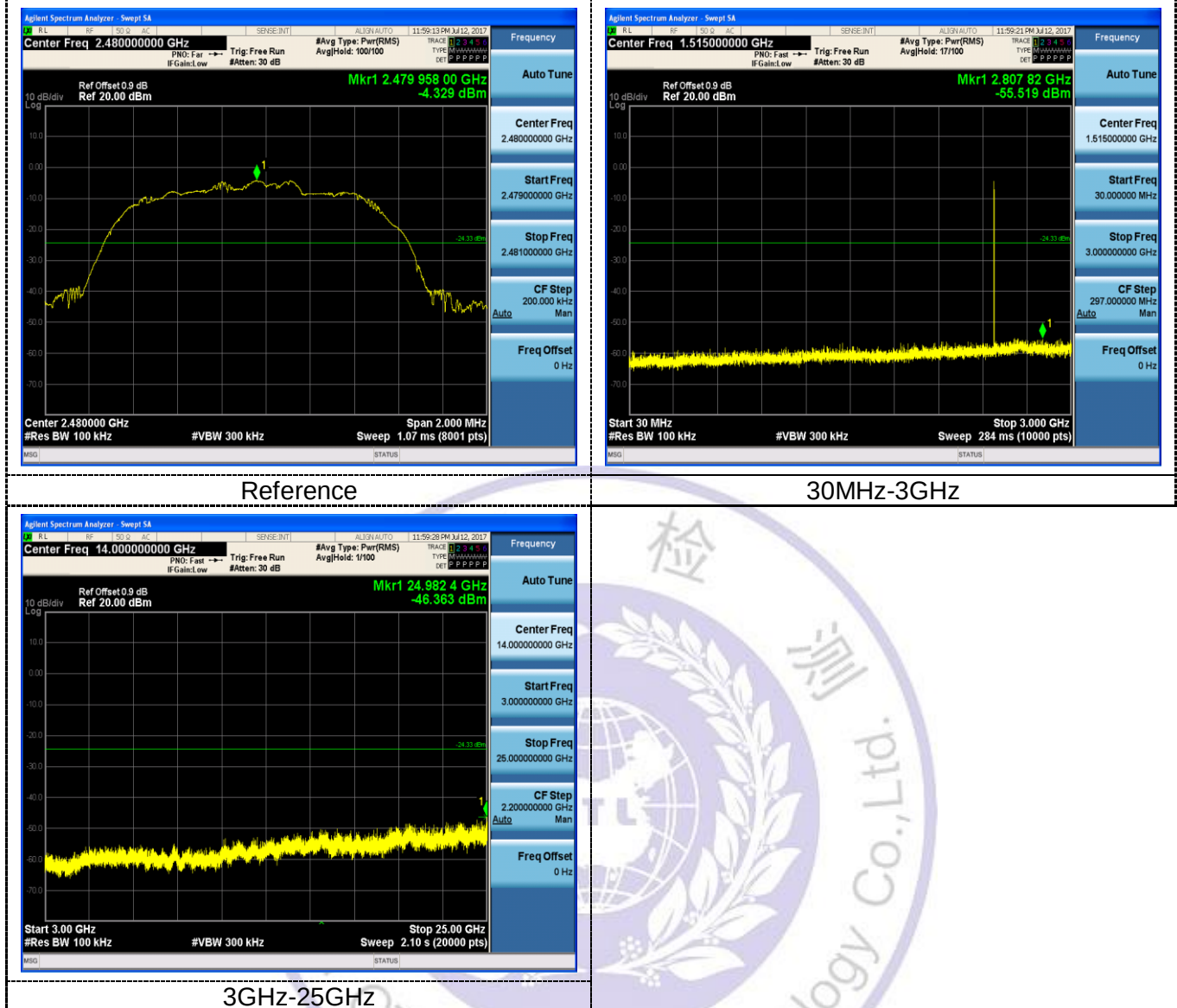
30MHz-3GHz

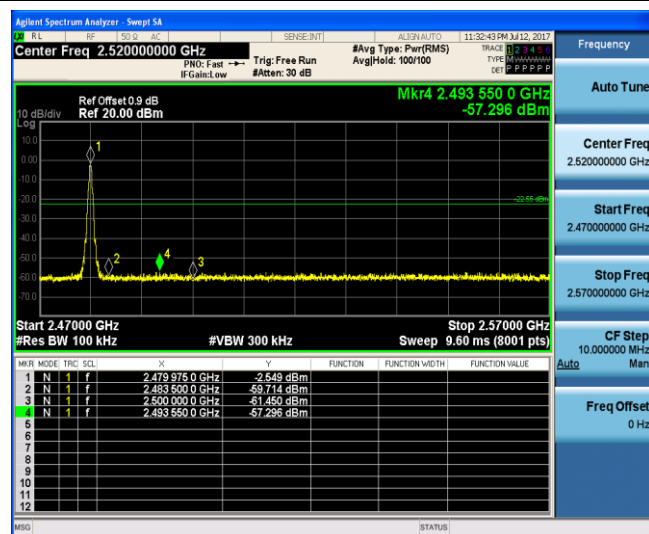
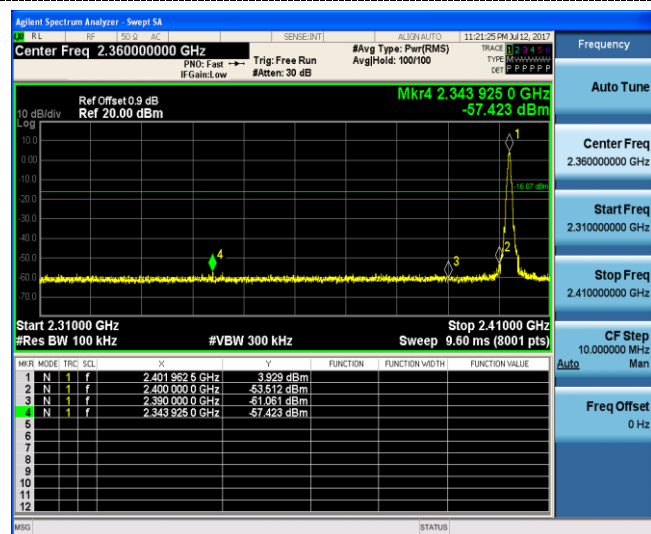


3GHz-25GHz

3GHz-25GHz

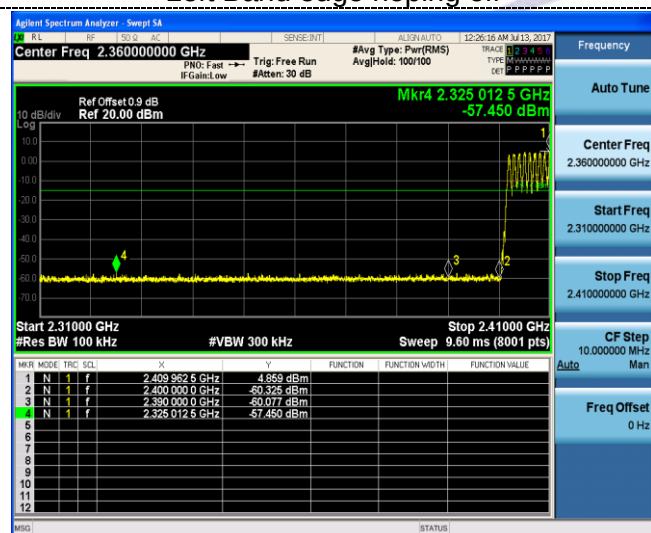
8DPSK CH78



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

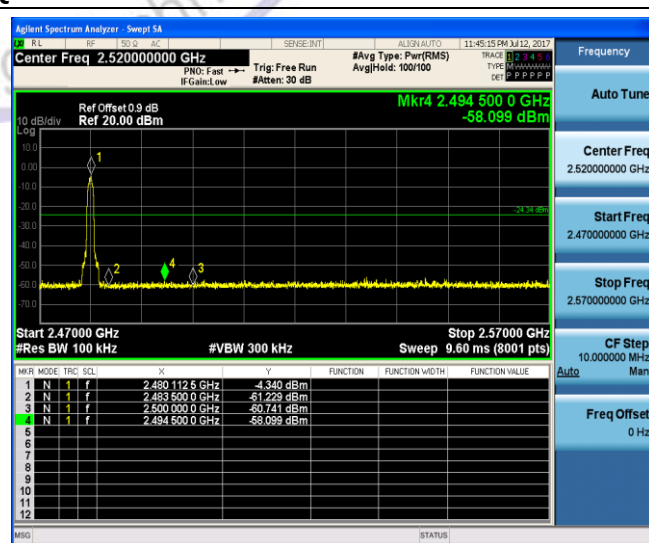
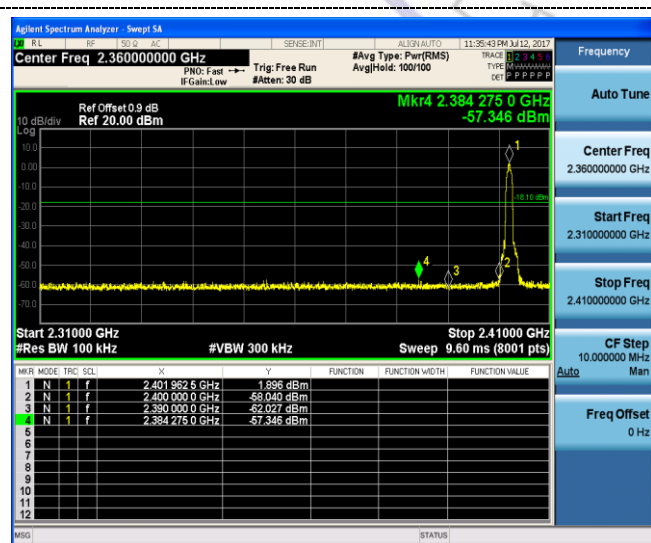
Left Band edge hopping off

Right Band edge hopping off



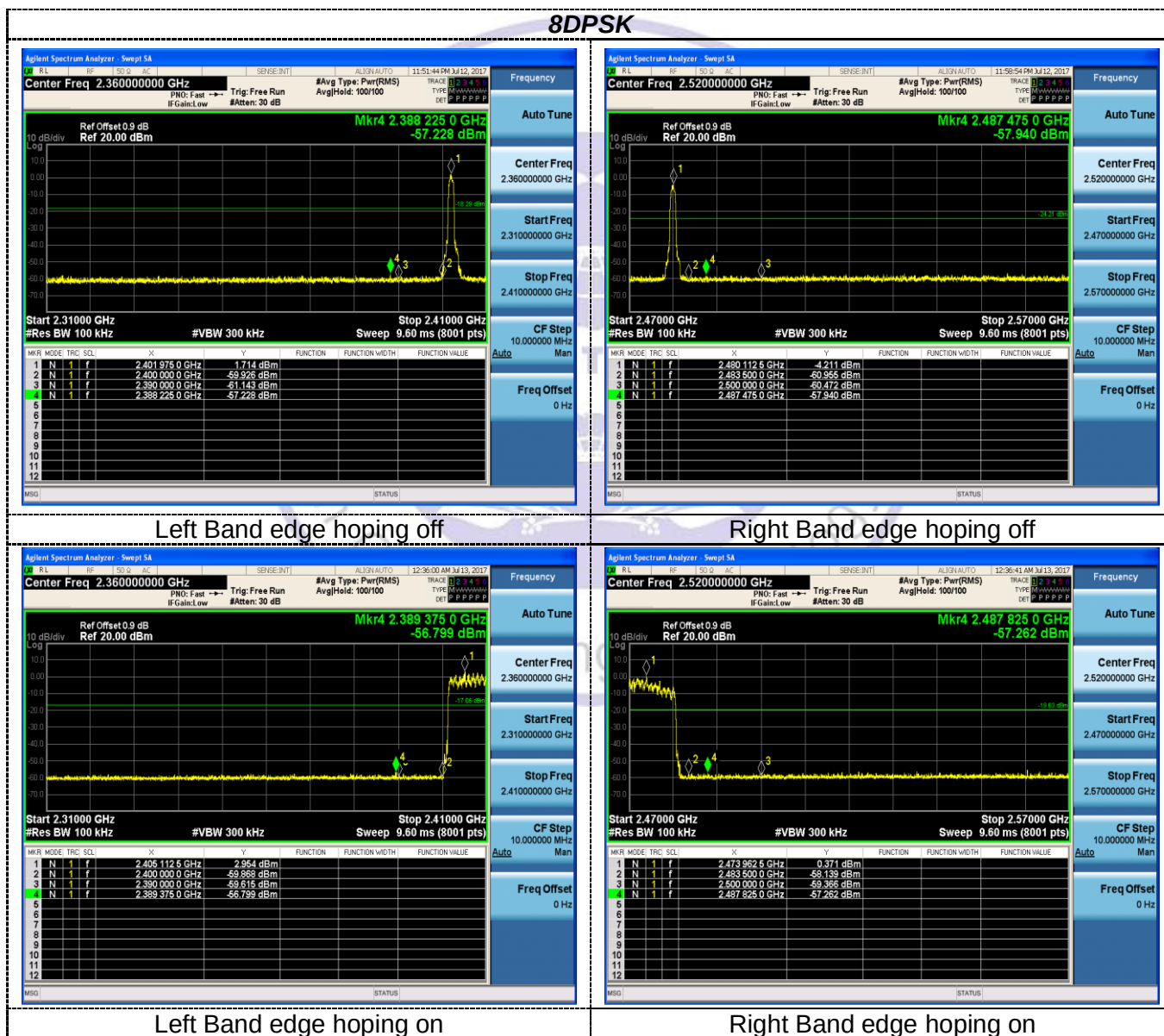
Left Band edge hopping on

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

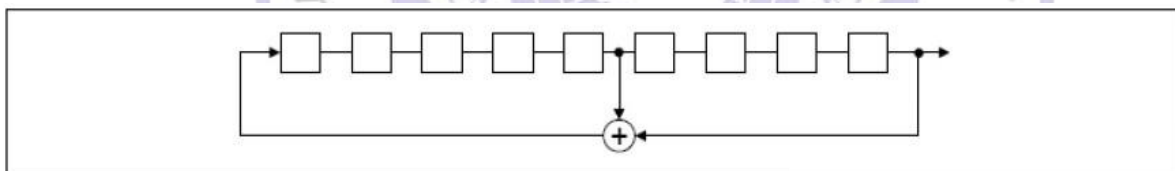
For 47 CFR Part 15C section 15.247 (a) (1) & RSS 247 requirement:

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

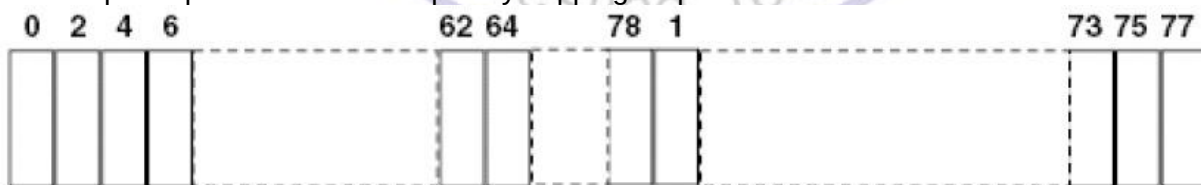
The pseudorandom frequency hopping sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones, for example: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

4. Test Setup Photos of the EUT



CTL Testing Technology

5. External and Internal Photos of the EUT

Please reference to the photo documents.

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

