# **TEST REPORT**

# **Dt&C**

## DT&C Co., Ltd.

42, Yurim-ro, 154Beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 17042 Tel : 031-321-2664, Fax : 031-321-1664

- 1. Report No: DRTFCC1712-0261
- 2. Customer
  - Name : Sena Technologies, Inc.
  - Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, South Korea
- 3. Use of Report : FCC & IC Original Grant
- 4. Product Name / Model Name : SFx / SP52-C FCC ID : S7A-SP52 / IC : 8154A-SP52
- 5. Test Method Used : ANSI C63.10-2013

Test Specification : FCC Part 15 Subpart C.247

RSS-247 Issue 2 (2017-02), RSS-GEN Issue 4 (2014-11)

- 6. Date of Test : 2017.11.20 ~ 2017.11.29
- 7. Testing Environment : See appended test report.
- 8. Test Result : Refer to the attached test result.

Affirmation	Tested by	Technical Manager					
Ammalion	Name : JungWoo Kim	Name : GeunKi Son (Signature)					
The tes	t results presented in this test report are limite	d only to the sample supplied by applicant and					
the use of	this test report is inhibited other than its purpos	se. This test report shall not be reproduced except					
	in full, without the written appr	oval of DT&C Co., Ltd.					
	2017.12.05.						
	DT&C Co., Ltd.						
		·					

If this report is required to confirmation of authenticity, please contact to report@dtnc.net



## **Test Report Version**

Test Report No.	Date	Description
DRTFCC1712-0261	Dec. 05, 2017	Initial issue



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## **1. General Information**

## 1.1 Testing Laboratory

#### DT&C Co., Ltd.

The 3 m test site and conducted measurement facility used to collect the radiated data are located at the 42, Yurim-ro, 154beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea 17042. The site is constructed in conformance with the requirements.

#### - FCC MRA Accredited Test Firm No. : KR0034

- IC Test site No. : 5740A-4			
www.dtnc.net			
Telephone	÷	+ 82-31-321-2664	
FAX	:	+ 82-31-321-1664	

#### **1.2 Testing Environment**

Ambient Condition	
<ul> <li>Temperature</li> </ul>	+22 °C ~ +24 °C
Relative Humidity	41 % ~ 44 % R.H.

#### **1.3 Measurement Uncertainty**

The measurement uncertainties shown below were calculated in accordance with requirements of ANSI C63.4-2014 and ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence.

Test items	Measurement uncertainty		
Transmitter Output Power	0.9 dB (The confidence level is about 95 %, $k = 2$ )		
Conducted spurious emission	0.9 dB (The confidence level is about 95 %, $k = 2$ )		
AC conducted emission	2.4 dB (The confidence level is about 95 %, $k = 2$ )		
Radiated spurious emission (1 GHz Below)	5.1 dB (The confidence level is about 95 %, k = 2)		
Radiated spurious emission (1 GHz ~ 18 GHz)	5.4 dB (The confidence level is about 95 %, k = 2)		
Radiated spurious emission (18 GHz Above)	5.3 dB (The confidence level is about 95 %, $k = 2$ )		

## **1.4 Details of Applicant**

Applicant	:	Sena Technologies,Inc.
Address	:	19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, South Korea
Contact person	:	Seunghyun Kim

## 1.5 Description of EUT

EUT	SFx
Model Name	SP52-C
Add Model Name	SP52-A, SP52-B
Serial Number	Identical prototype
Hardware version	1.0
Software version	1.0
Power Supply	DC 3.7 V
Frequency Range	2402 MHz ~ 2480 MHz
Modulation Technique	GFSK, π/4-DQPSK, 8DPSK
Number of Channels	79
Antenna Type /Antenna Gain	Internal Antenna / PK : 0.52 dBi

## 1.6 Declaration by the applicant / manufacturer

- NA

#### 1.7 Information about the FHSS characteristics

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following :
  - A) The hopping sequence is pseudorandom
    - Note 1 : Pseudorandom Frequency Hopping Sequence Table as below:
      - Channel: 08, 24, 40, 56, 42, 54, 72, 09, 01, 11, 33, 41, 34, 42, 65, 73, 53, 69, 06, 22, 04, 20, 36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 41, 58, 44, 60, 76, 13, 03, 11, 35, 43, 37, 45, 69, 77, 52, 71, 08, 24, 06, 24, 48, 56, 45, 46, 70, 01, 72, 06, 25, 33, 12, 28, 49, 60, 45, 58, 74, 13, 05, 18, 37, 49 etc
      - The System receiver have input bandwidths that match the hopping channel badwidths of Their corresponding transmitters and shift frequencies in synchroniztation with the transmit Ted signals.
  - B) All channels are used equally on average
  - C) The receiver input bandwidth equals the transmit bandwidth
  - D) The receiver hops in sequence with the transmit signal
- 15.247(g) : In accordance with the Bluetooth Industry Standard, the system is designed to comply with all
  of the regulations in Section 15.247 when the transmitter is presented with a continuous data
  (or information) system.
- 15.247(h) : In accordance with the Bluetooth Industry Standard, the system does not coordinate its channels selection / hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.
- 15.247(h) : The EUT employs Adaptive Frequency Hopping (AFH) which identifies sources of interference namely devices operating in 802.11 WLAN and excludes them from the list of available channels. The process of re-mapping reduces the number of test channels from 79 channels to a minimum number of 20 channels.

## **1.8 Test Equipment List**

Туре	Manufacturer	Model	Cal.Date (yy/mm/dd)	Next.Cal.Date (yy/mm/dd)	S/N
Spectrum Analyzer	Agilent Technologies	N9020A	17/09/06	18/09/06	MY50200834
Spectrum Analyzer	Agilent Technologies	N9020A	17/09/05	18/09/05	MY46471251
Multimeter	FLUKE	17B	17/04/12	18/04/12	26030065WS
DC Power Supply	Agilent	66332A	17/09/05	18/09/05	US37473422
Signal Generator	Rohde Schwarz	SMBV100A	17/01/04	18/01/04	255571
Signal Generator	Rohde Schwarz	SMF100A	17/04/21	18/04/21	102341
Thermohygrometer	BODYCOM	BJ5478	17/04/11	18/04/11	120612-2
Loop Antenna	Schwarzbeck	FMZB1513	16/04/22	18/04/22	1513-128
BILOG ANTENNA	Schwarzbeck	VULB 9160	16/11/11	18/11/11	3151
Horn Antenna	ETS-LINDGREN	3117	16/05/03	18/05/03	00140394
Horn Antenna	A.H.Systems Inc.	SAS-574	17/07/31	19/07/31	155
PreAmplifier	Agilent	8449B	17/09/05	18/09/05	3008A002108
PreAmplifier	TSJ	MLA-010K01- B01-27	17/03/06	18/03/06	1844539
EMI Test Receiver	Rohde Schwarz	ESR7	17/02/16	18/02/16	101061
High-pass filter	Wainwright	WHKX12- 2580-3000- 18000-80SS	17/09/05	18/09/05	3
High-pass filter	Wainwright	WHNX6-6320- 8000-26500- 40CC	17/09/05	18/09/05	1
EMI Test Receiver	R&S	ESCI	17/02/26	18/02/16	100364
SINGLE-PHASE MASTER	NF	4420	17/09/01	18/09/01	3049354420023
LISN	SCHWARZBECK	NNLK 8121	17/04/03	18/04/03	6182
PULSE LIMITER	ROHDE&SCHWARZ	ESH3-Z2	17/01/03	18/01/03	101334

Note: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017.

## 1.9 Summary of Test Results

FCC Part RSS Std.	Parameter	<b>Limit</b> (Using in 2400~ 2483.5 MHz)	Test Condition	Status Note 1
	Carrier Frequency Separation	>= 25 kHz or >= Two thirds of the 20 dB BW, whichever is greater.		с
15.247(a) RSS-247(5.1)	Number of Hopping Frequencies	>= 15 hops		С
100-247(0.1)	20 dB Bandwidth N/A			С
	Dwell Time	=< 0.4 seconds		С
15.247(b) RSS-247(5.4)	Transmitter Output Power	For FCC =< 1 Watt , if CHs >= 75 Others =< 0.125 W For IC if CHs >= 75 =< 1 Watt For Conducted Power =< 4 Watt For e.i.r.p, Others =< 0.125 W For Conducted Power. =< 4 Watt For e.i.r.p	Conducted	С
15.247(d) RSS-247(5.5)	Conducted Spurious Emissions	The radiated emission to any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density.		с
RSS Gen(6.6)	Occupied Bandwidth (99 %)	N/A		С
15.247(d) 15.205 & 209 RSS-247(5.5) RSS-Gen (8.9 & 8.10)	Radiated Spurious Emissions	FCC 15.209 Limits	Radiated	C Note2,3
15.207 RSS-Gen(8.8)	AC Conducted Emissions	FCC 15.207 Limits	AC Line Conducted	С
15.203 RSS-Gen(8.3)	Antenna Requirements	FCC 15.203	-	С
Note 1 : C = Comply Note 2 : This test ite	<ul> <li>NC = Not Comply NT = Not Tested</li> <li>m was performed in each axis and the wo</li> </ul>	NA = Not Applicable rst case data was reported.		

Note 4 : The sample was tested according to the following specifications :

- ANSI C63.10-2013

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## 1.10 Conclusion of worst-case and operation mode

The EUT has three type of modulation (GFSK,  $\pi$ /4DQPSK and 8DPSK).

Therefore all applicable requirements were tested with all the modulations.

And packet type was tested at the worst case(DH5).

The field strength of spurious emission was measured in three orthogonal EUT positions (X-axis, Y-axis and Z-axis).

Tested frequency information,

- Hopping Function : Enable

	TX Frequency (MHz)	RX Frequency (MHz)
Hopping Band	2402 ~ 2480	2402 ~ 2480

- Hopping Function : Disable

	TX Frequency (MHz)	RX Frequency (MHz)
Lowest Channel	2402	2402
Middle Channel	2441	2441
Highest Channel	2480	2480



## 2. Maximum Peak Output Power Measurement

## 2.1 Test Setup

Refer to the APPENDIX I.

## 2.2 Limit

#### FCC Requirements

The maximum peak output power of the intentional radiator shall not exceed the following :

- 1. §15.247(a)(1), 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.
- §15.247(b)(1), For frequency hopping systems operating in the 2400 2483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725 5805 MHz band : 1 Watt.

#### IC Requirements

1. RSS-247(5.4), For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W.

#### 2.3 Test Procedure

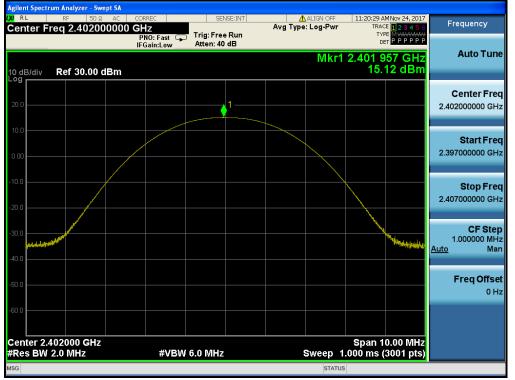
- 1. The RF output power was measured with a spectrum analyzer connected to the RF Antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, A spectrum analyzer was used to record the shape of the transmit signal.
- 2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using ;
  Span = approximately 5 times of the 20 dB bandwidth, centered on a hopping channel
  RBW ≥ 20 dB BW
  VBW ≥ RBW
  Sweep = auto
  Detector function = peak
  Trace = max hold

## 2.4 Test Results

Modulation	Tested Channel		Average Power	Peak Output Power		
Modulation	resteu Ghanner	dBm	mW	dBm	mW	
	Lowest	13.97	24.95	15.12	32.51	
<u>GFSK</u>	Middle	16.45	44.16	17.68	58.61	
	Highest	16.74	47.21	17.91	61.80	
	Lowest	4.54	2.84	7.79	6.01	
<u>π/4DQPSK</u>	Middle	5.94	3.93	9.54	9.00	
	Highest	6.19	4.16	9.76	9.46	
	Lowest	4.55	2.85	8.42	6.95	
<u>8DPSK</u>	Middle	5.95	3.94	10.23	10.54	
	Highest	6.21	4.18	10.55	11.35	

Note 1 : The frame average output power was tested using an average power meter for reference only. Note 2 : See next pages for actual measured spectrum plots.





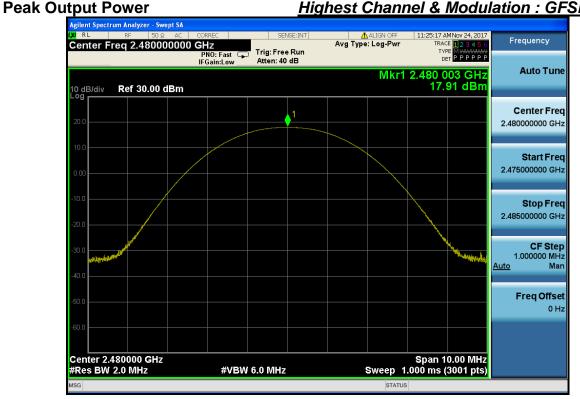
## Lowest Channel & Modulation : GFSK

#### Peak Output Power

#### Middle Channel & Modulation : GFSK







## Highest Channel & Modulation : GFSK

#### **Peak Output Power**

#### Lowest Channel & Modulation : π/4DQPSK





## Middle Channel & Modulation : π/4DQPSK



#### Peak Output Power

#### Highest Channel & Modulation : π/4DQPSK





#### Lowest Channel & Modulation : 8DPSK



#### Peak Output Power

#### Middle Channel & Modulation : 8DPSK





## Highest Channel & Modulation : 8DPSK



## 3. 20 dB BW

## 3.1 Test Setup

Refer to the APPENDIX I.

## 3.2 Limit

Limit : Not Applicable

### 3.3 Test Procedure

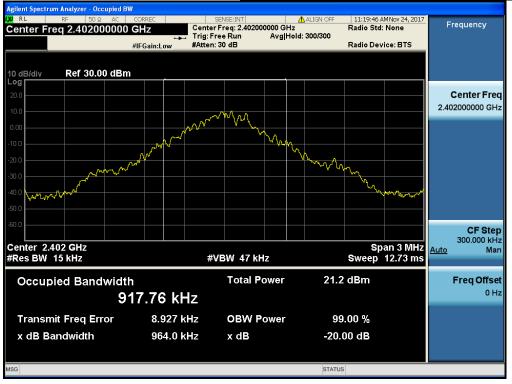
- 1. The 20 dB bandwidth were measured with a spectrum analyzer connected to RF antenna Connector (conducted measurement) while EUT was operating in transmit mode. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer.
- 2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using below setting: RBW shall be in the range of 1% to 5% of the 20 dB bandwidth and VBW ≥ 3 × RBW, Span = between two times and five times the 20 dB bandwidth.

Modulation	Tested Channel	20 dB BW (MHz)		
	Lowest	0.964		
<u>GFSK</u>	Middle	1.011		
	Highest	1.018		
	Lowest	1.273		
<u>π/4DQPSK</u>	Middle	1.273		
	Highest	1.253		
	Lowest	1.254		
<u>8DPSK</u>	Middle	1.256		
	Highest	1.249		

## 3.4 Test Results

Note 1 : See next pages for actual measured spectrum plots.



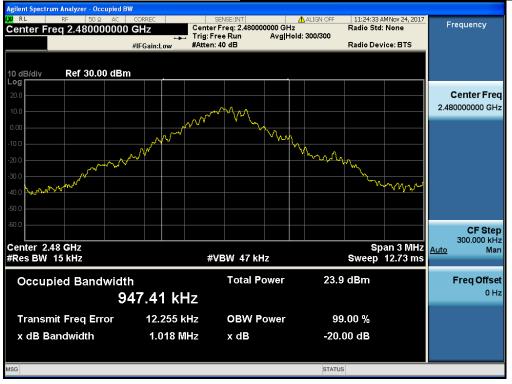


#### 20 dB Bandwidth

#### Middle Channel & Modulation : GFSK

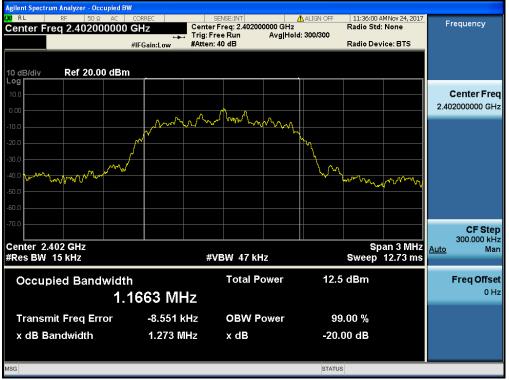




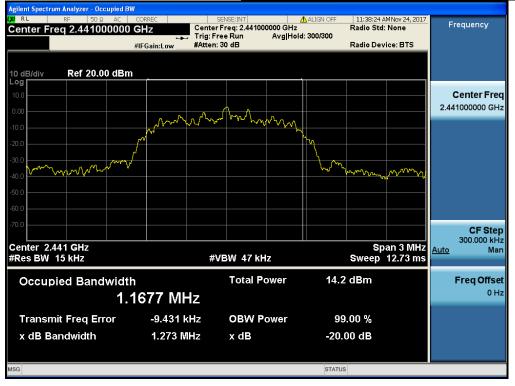


#### 20 dB Bandwidth

#### Lowest Channel & Modulation : π/4DQPSK



## Middle Channel & Modulation : π/4DQPSK

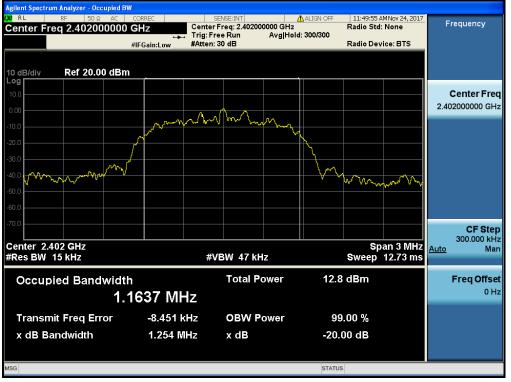


#### 20 dB Bandwidth

#### Highest Channel & Modulation : π/4DQPSK







#### 20 dB Bandwidth

#### Middle Channel & Modulation : 8DPSK



## Highest Channel & Modulation : 8DPSK





## 4. Carrier Frequency Separation

## 4.1 Test Setup

Refer to the APPENDIX I.

## 4.2 Limit

Limit :  $\geq$  25 kHz or  $\geq$  Two-Thirds of the 20 dB BW whichever is greater.

## 4.3 Procedure

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

After the trace being stable, the reading value between the peaks of the adjacent channels using the markerdelta function was recorded as the measurement results.

The spectrum analyzer is set to :

Span = wide enough to capture the peaks of two adjacent channels

RBW = Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.

VBW ≥ RBW		Sweep	= auto
Data star function	maal	Traca	

#### Detector function = peak Trace = max hold

## 4.4 Test Results

#### FH mode

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.000	2441.999	0.999
Enable	π/4-DQPSK	2441.003	2442.002	0.999
	8DPSK	2441.003	2442.002	0.999

#### AFH mode

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.000	2441.999	0.999
Enable	π/4-DQPSK	2441.000	2441.999	0.999
	8DPSK	2441.003	2442.002	0.999

Note 1 : See next pages for actual measured spectrum plots.

#### - Minimum Standard :

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



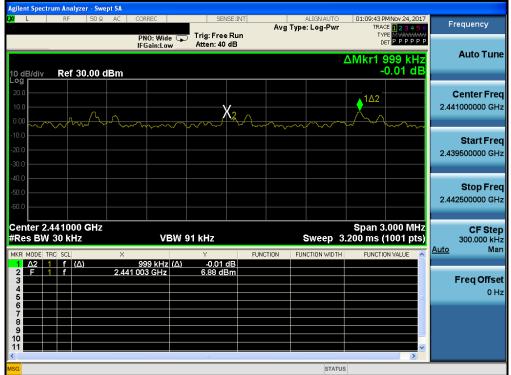
## Carrier Frequency Separation (FH)





#### **Carrier Frequency Separation (FH)**

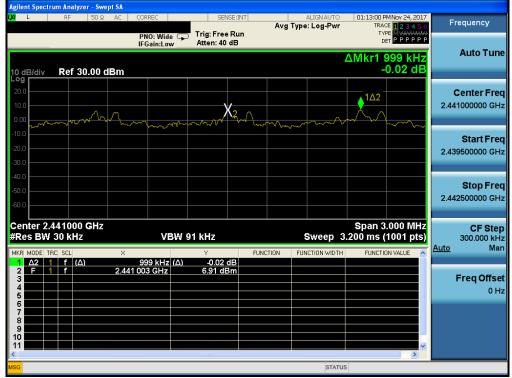
#### Hopping mode : Enable & π/4-DQPSK





## Carrier Frequency Separation (FH)

Hopping mode : Enable & 8DPSK

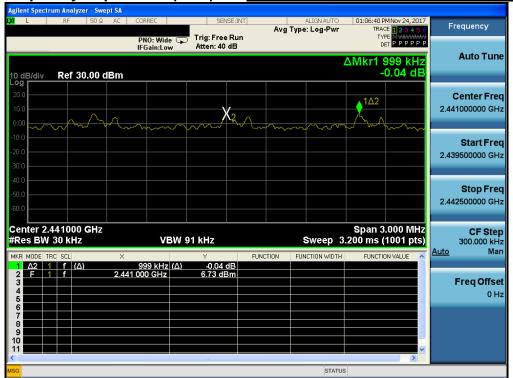




## Carrier Frequency Separation (AFH) <u>Hopping mode : Enable & GFSK</u>

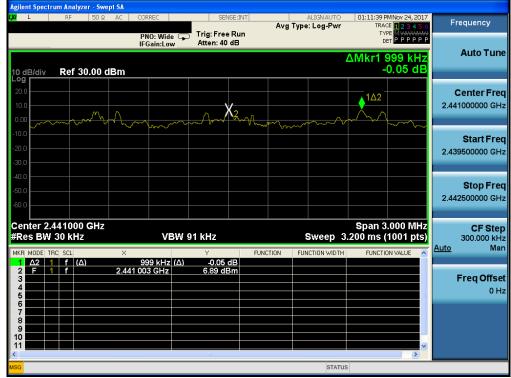
Agilent Spectrum Analyzer - Swept SA				
💢 L 🛛 RF 🛛 50 Ω AC CO	RREC SENSE:IN	ALIGNAUTO Avg Type: Log-Pwr	01:00:56 PM Nov 24, 2017 TRACE 1 2 3 4 5 6	Frequency
D	NO: Wide 🧊 Trig: Free Run			
	Gain:Low Atten: 40 dB		DET PPPPP	
			∆Mkr1 999 kHz	Auto Tune
10 dB/div Ref 30.00 dBm			-0.01 dB	
Log			▲1∆2	
20.0	~X2			Center Freq
10.0		A A A		2.441000000 GHz
0.00		- Hourse		
-10.0				Start Freq
-20.0				2.439500000 GHz
-30.0				2.439500000 GH2
-40.0				
				Stop Freq
-50.0				2.442500000 GHz
-60.0				
Center 2.441000 GHz			Span 3.000 MHz	CF Step
#Res BW 30 kHz	VBW 91 kHz	Sweep 3	3.200 ms (1001 pts)	300.000 kHz
MKR MODEL TRC SCL X	Y	FUNCTION FUNCTION WIDTH		<u>Auto</u> Man
1 Δ2 1 f (Δ) 9	99 kHz (Δ) -0.01 dB			
2 F 1 f 2.441 00	00 GHz 15.53 dBm			Freq Offset
4				0 Hz
5			=	
7				
8				
10				
11			~	
MSG		STATU	IS	
		oixid		

## Carrier Frequency Separation (AFH) <u>Hopping mode : Enable & $\pi/4$ -DQPSK</u>





## Carrier Frequency Separation (AFH) <u>Hopping mode : Enable & 8DPSK</u>





## 5. Number of Hopping Frequencies

## 5.1 Test Setup

Refer to the APPENDIX I.

## 5.2 Limit

Limit : >= 15 hops

## 5.3 Procedure

The number of hopping frequencies was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

To get higher resolution, two frequency ranges for FH mode within the 2400 ~ 2483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz	Start Frequency = 2391.5 MHz,	Stop Frequency = 2441.5 MHz
	Start Frequency = 2441.5 MHz,	Stop Frequency = 2491.5 MHz
Span for AFH mode = 50 MHz	Start Frequency = 2416.0 MHz,	Stop Frequency = 2466.0 MHz
RBW = To identify clearly the ind	ividual channels, set the RBW to	less than 30% of the channel spacing
or the 20 dB bandwidth, w	/hichever is smaller.	
VBW ≥ RBW	Sweep = auto	
Detector function = peak	Trace = max hold	

#### 5.4 Test Results

#### FH mode

Hopping mode	Modulation	Test Result (Total Hops)
	GFSK	79
Enable	π/4-DQPSK	79
	8DPSK	79

#### AFH mode

Hopping mode	Modulation	Test Result (Total Hops)
	GFSK	20
Enable	π/4-DQPSK	20
	8DPSK	20

Note 1 : See next pages for actual measured spectrum plots.

#### - Minimum Standard :

At least 15 hopes

## Number of Hopping Frequencies 1(FH)



Agilent Spectrum Analyzer - Sv									
	Ω AC COR		SEN	SE:INT		ALIGN OFF		MNov 24, 2017	Frequency
Center Freq 2.4165	00000 GH	Z	Trig: Free	Dun	Avg lype Avg Hold:	: Log-Pwr	TVI	CE 123456 PE MWWWWW	Trequency
		10: Fast 😱 Gain:Low	Atten: 40		Avginoia.	/ 100/100	DI	ТРРРРР	
	IFG	Sain:LOW	Auen. 40	40					Auto Tune
						Mkr	2 2.441	00 GHz	Autorune
10 dB/div Ref 30.00	dBm						17.2	92 dBm	
Log								2	
20.0	1								Center Freq
	Χαραρ	ΛΛΛΛΛ	nnnnn	ለስለለበ	ոռոռո	00000	ոռորո	NNNNÅ	•
10.0		1 I V V I V	V V V V V		יעעעטי	MM	* * * * * *	/	2.416500000 GHz
0.00	11.4.4.4		8 9 8 9 9	1141					
40.0									
-10.0	1								Start Freq
-20.0	{								2.391500000 GHz
-30.0									2.391300000 GHz
-30.0									
-40.0									
-50.0									Stop Freq
									2.441500000 GHz
-60.0									
Start 2.39150 GHz								150 GHz	CF Step
#Res BW 200 kHz		#VBW	620 kHz			Sweep 1	.200 ms (	1001 pts)	5.000000 MHz
									Auto Man
MKR MODE TRC SCL	×		Y	FUNC	TION FUN	ICTION WIDTH	FUNCTIO	ON VALUE	
1 N 1 f	2.402 00		14.498 dE 17.292 dE						
3	2.441.00	5 GH2	17.232 UE						Freq Offset
4									0 Hz
5								=	0 112
6				_					
7 8				_					
9									
10									
11								~	
<								>	
MSG						STATUS	;		

#### Number of Hopping Frequencies 2(FH)

### Hopping mode : Enable & GFSK

gilent Spectrum Analyzer Swont Si RL 11:32:06 AM Nov 24, 2017 Frequency Avg Type: Log-Pwr Avg|Hold:>100/100 Center Freq 2.466500000 GHz TRACE Trig: Free Run Atten: 40 dB DET P P P P P PNO: Fast 🖵 IFGain:Low Auto Tune Mkr2 2.480 00 GHz 17.495 dBm Ref 30.00 dBm 0 dB/div **Center Freq** 2.466500000 GHz Start Freq 2.441500000 GHz A . Stop Freq 2.491500000 GHz Start 2.44150 GHz #Res BW 200 kHz Stop 2.49150 GHz Sweep 1.200 ms (1001 pts) CF Step 5.000000 MHz Man #VBW 620 kHz Auto FUNCTION FUNCTION WIDTH 2.442 00 GHz 2.480 00 GHz 17.315 dBm 17.495 dBm Ň Freq Offset 0 Hz

## Number of Hopping Frequencies 1(FH)



Agilent Spect											
LXIRL	RF	50 Ω				SENSE:INT	Au	ALIGN OFF		AMNov 24, 2017 CE 1 2 3 4 5 6	Frequency
Center F	req 2.4	4165L	00000	GHz PNO: Fast	👝 Tria: F	ree Run		old:>100/100	Tγ	PE M WWWWWW	
				IFGain:Low	Atten:				C	PPPPP	
								Mk	2 2 111	00 GHz	Auto Tune
								IVIN		89 dBm	
10 dB/div Log	Ref 2	20.00	aBM						7.0	05 0.511	
10.0			1							<b>\</b>	Center Freq
			Nrv~	ᢉᡃᠰᡎᢦᢦᡏᡳᠰᡳ	$\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{$	an source	www	᠕᠕᠕᠕ᠺᠺ	wwwww	$\psi \gamma \gamma$	
0.00											2.416500000 GHz
-10.0											
-20.0			<u> </u>								
-30.0											Start Freq
		~									2.391500000 GHz
-40.0		_N									
-50.0											
-60.0		<b>.</b>									Stop Freq
											2.441500000 GHz
-70.0											
Start 2.39	1450 0								Oton 2.4	4450 CH-	
#Res BW				-#\/E	3W 620 ki	1-		Sucon		4150 GHz (1001 pts)	CF Step
#Res Dw	200 Kr	12		#VE	5VV 020 KI	12		sweep	1.200 1115 1	(1001 pts)	5.000000 MHz Auto Man
MKR MODE T			×		Y		JNCTION	FUNCTION WIDTH	I FUNCTI	ON VALUE	<u>Auto</u> Man
1 N *	<u> </u>		2.40	2 00 GHz 1 00 GHz	5.832 7.389						
2 N ·			2.44	1 UU GHZ	7.389	dBm					Freq Offset
4											0 Hz
5										=	0112
7											
8											
9											
11										~	
<					Ш					>	
MSG								STATU	JS		

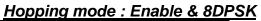
## <u>Hopping mode : Enable & π/4-DQPSK</u>

## Number of Hopping Frequencies 2(FH)





## Number of Hopping Frequencies 1(FH)



Agilent Spectrum Analyzer - Swept SA					
LXIRL RF 50Ω AC	CORREC	SENSE:INT	🛕 ALIGN OFF	11:59:31 AMNov 24, 2017	<b>F</b>
Center Freq 2.416500000	GHz		vg Type: Log-Pwr	TRACE 1 2 3 4 5 6	Frequency
	PNO: East		g Hold:>100/100	TYPE MWWWWWW DET P P P P P P	
	IFGain:Low Atte	n:30 dB		DETPPPPP	
			B A Loop		Auto Tune
			IVIKE	2 2.441 00 GHz	
10 dB/div Ref 20.00 dBm				7.541 dBm	
Log					
					O
10.0	mmmmm	2022222222	ATAAAAAA	araanaana	Center Freq
0.00					2.416500000 GHz
-10.0					
-20.0					
					Start Freq
-30.0					2.391500000 GHz
					2.031000000 0112
-40.0					
-50.0					
and the second s					Stop Freq
-60.0					
-70.0					2.441500000 GHz
-70.0					
Start 2.39150 GHz				Stop 2.44150 GHz	CF Step
#Res BW 200 kHz	#VBW 620	kHz	Sweep 1.	200 ms (1001 pts)	5.000000 MHz
			-		Auto Man
MKR MODE TRC SCL X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	<u>riaro</u> mari
		6 dBm			
	41 00 GHz 7.54	11 dBm			
3					Freq Offset
4					0 Hz
5					
6					
7					
8					
10					
11					
<				>	
MSG			STATUS		

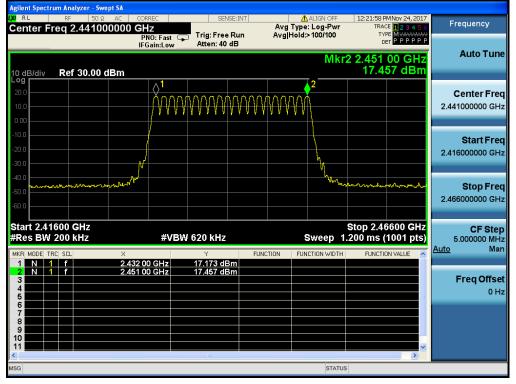
#### Hopping mode : Enable & 8DPSK

## Number of Hopping Frequencies 2(FH)



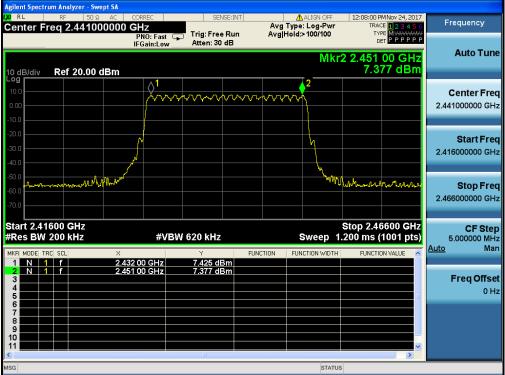
## Number of Hopping Frequencies 1(AFH)





#### Number of Hopping Frequencies 1(AFH)

## <u>Hopping mode : Enable & π/4-DQPSK</u>





## Number of Hopping Frequencies 1(AFH)





## 6. Time of Occupancy (Dwell Time)

## 6.1 Test Setup

Refer to the APPENDIX I.

## 6.2 Limit

The maximum permissible time of occupancy is 400 ms within a period of 400 ms multiplied by the number of hopping channels employed.

## 6.3 Test Procedure

The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

The spectrum analyzer is set to :

 Center frequency = 2441 MHz
 Span = zero

 RBW = 1 MHz (RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel)

 VBW ≥ RBW
 Detector function = peak

 Trace = max hold

## 6.4 Test Results

FH mode

Hopping mode	Packet Type	Number of hopping Channels	Burst On Time (ms)	Period (ms)	Test Result (sec)		
	DH 5	79	2.880	3.750	0.307		
Enable	2 DH 5	79	2.880	3.750	0.307		
	3 DH 5	79	2.880	3.750	0.307		

AFH mode

Hopping mode	Packet Type	Number of hopping Channels	Burst On Time (ms)	Period (ms)	Test Result (sec)		
	DH 5	20	2.880	3.750	0.154		
Enable	2 DH 5	20	2.880	3.750	0.154		
	3 DH 5	20	2.880	3.750	0.154		

Note 1 : Dwell Time = 0.4 × Hopping channel × Burst ON time ×

((Hopping rate ÷ Time slots) ÷ Hopping channel)

- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

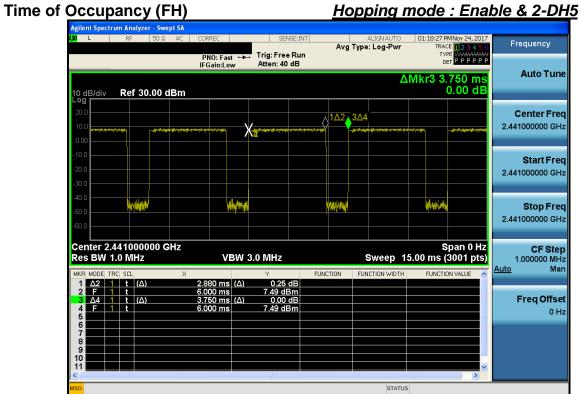
Note 2 : See next pages for actual measured spectrum plots.



Time of Occupancy (FH)

			alyzer - S															
LXI I	-	RF	50	Ω AC	COF	RREC		SEN	SE:INT		Ava		ALIGN AU" : Log-P1			M Nov 24, 2 CE <mark>1 2 3 4</mark>		Frequency
						NO: Fas		Trig: Free Atten: 40			Ū		Ū		TY		ANA	
		_			IFU	Gain:Lo	w	Atten: 40	40	_		_						Auto Tune
10 di	3/div	Re	f 30.00	dBm										Δ	Vikr3 3. -	0.02 d	B	
Log									∧1∆2	<u> </u>	4							
20.0						X			Ŷ <u></u>	2								Center Freq
10.0																		2.441000000 GHz
0.00																		
-10.0										$\vdash$								Start Freq
-20.0										$\vdash$								2.441000000 GHz
-30.0										$\vdash$								
-40.0	and interview				P. M. THE									http://				Stop Freq
-50.0					add <sub>0</sub> M	, <b>U</b>			الريوا الدر					a pil pi	PP			2.441000000 GHz
-60.0																		2.441000000 0112
Cen	ter 2 4	410	00000	GH7												pan 0 l	17	CE Otom
	BW 1			UIIZ		#\	/BW	3.0 MHz				5	Sweep	) 15	.00 ms (	3001 pt	S)	CF Step 1.000000 MHz
MKB	MODE TR	ci sci		×	(		<u> </u>	Y		FUNC	TION	FUN	CTION WI	DTH	FUNCTI	ON VALUE	~	<u>Auto</u> Man
	Δ2 1	t	(Δ)			80 ms		0.97										
2 3	<u>F</u> 1 Δ4 1	t	(Δ)		3.7	40 ms 50 ms	(Δ)	<u>13.95 d⊟</u> -0.02 o	зB									Freq Offset
4	F 1	t			4.7	40 ms		13.95 dE	3m								_	0 Hz
6																	-	
7																		
9 10																		
11																	~	
≤ MSG		_			_		_		_	_	_	_	OT	ATUO		>		
MSG	MSG STATUS																	

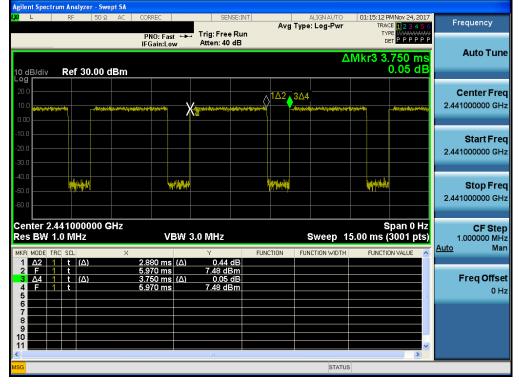
#### Hopping mode : Enable & DH5





## Hopping mode : Enable & 3-DH5

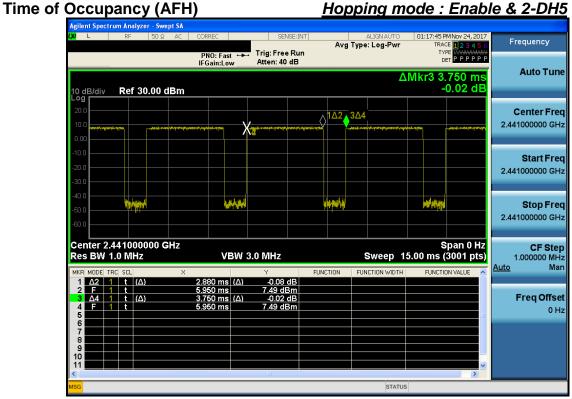
## Time of Occupancy (FH)





### Hopping mode : Enable & DH5

#### nt Spectrum Analyz 22 PMI TRACE Frequency Avg Type: Log-Pwr Trig: Free Run TYPE PNO: Fast IFGain:Low Atten: 40 dB Auto Tune ΔMkr3 3.750 ms -0.01 dB Ref 30.00 dBm 10 dB/div Log **Center Freq** XT 2.441000000 GHz Start Freq 2.441000000 GHz łł# 槲 Stop Freq in a 2.441000000 GHz Center 2.441000000 GHz Res BW 1.0 MHz Span 0 Hz Sweep 15.00 ms (3001 pts) **CF Step** 1.000000 MHz Man #VBW 3.0 MHz <u>Auto</u> MKR MODE TRC SCL FUNCTION FUNCTION WIDTH FUNCTION VALUE Δ2 1 E 1 (Δ) (Δ) 0.97 dB 14.27 dBm -0.01 dB 14.27 dBm 5.970 ms 3.750 ms (Δ) 5.970 ms F ∆4 F 1 t (Δ) 1 t **Freq Offset** 45 0 Hz 6 STATUS



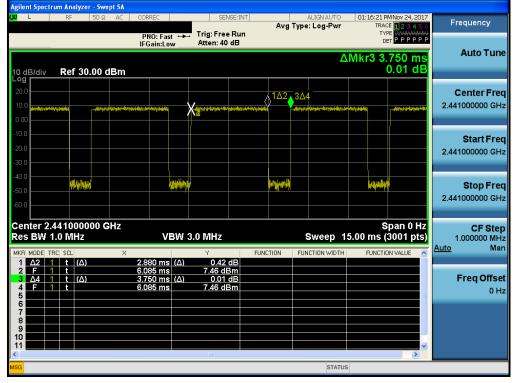
### Hopping mode : Enable & 2-DH5

Time of Occupancy (AFH)



### Hopping mode : Enable & 3-DH5

## Time of Occupancy (AFH)





# 7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

### 7.1 Test Setup

Refer to the APPENDIX I.

### 7.2 Limit

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

According to § 15.209(a), except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Limit (uV/m)	Measurement Distance (meter)
0.009 ~ 0.490	2400/F (kHz)	300
0.490 ~ 1705	24000/F (kHz)	30
1705 ~ 30.0	30	30
30 ~ 88	100 **	3
88 ~ 216	150 **	3
216 ~ 960	200 **	3
Above 960	500	3

\*\* Except as provided in 15.209(g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 - 72 MHz, 76 - 88 MHz, 174 - 216 MHz or 470 - 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

According to § 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below :

MHz	MHz	MHz	MHz	GHz	GHz
0.009 ~ 0.110	8.41425 ~ 8.41475	108 ~ 121.94	1300 ~ 1427	4.5 ~ 5.15	14.47 ~ 14.5
0.495 ~ 0.505	12.29 ~ 12.293	123 ~ 138	1435 ~ 1626.5	5.35 ~ 5.46	15.35 ~ 16.2
2.1735 ~ 2.1905	12.51975 ~ 12.52025	149.9 ~ 150.05	1645.5 ~ 1646.5	7.25 ~ 7.75	17.7 ~ 21.4
4.125 ~ 4.128	12.57675 ~ 12.57725	156.52475 ~ 156.52525	1660 ~ 1710	8.025 ~ 8.5	22.01 ~ 23.12
4.17725 ~ 4.17775	13.36 ~ 13.41	156.7 ~ 156.9	1718.8 ~ 1722.2	9.0 ~ 9.2	23.6 ~ 24.0
4.20725 ~ 4.20775	16.42 ~ 16.423	162.0125 ~ 167.17	2200 ~ 2300	9.3 ~ 9.5	31.2 ~ 31.8
6.215 ~ 6.218	16.69475 ~ 16.69525	167.72 ~ 173.2	2310 ~ 2390	10.6 ~ 12.7	36.43 ~ 36.5
6.26775 ~ 6.26825	16.80425 ~ 16.80475	240 ~ 285	2483.5 ~ 2500	13.25 ~ 13.4	Above 38.6
6.31175 ~ 6.31225	25.5 ~ 25.67	322 ~ 335.4	2655 ~ 2900		
8.291 ~ 8.294	37.5 ~ 38.25	399.90 ~ 410	3260 ~ 3267		
8.362 ~ 8.366	73 ~ 74.6	608 ~ 614	3332 ~ 3339		
8.37625 ~ 8.38675	74.8 ~ 75.2	960 ~ 1240	3345.8 ~ 3358		
			3600 ~ 4400		

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.



### 7.3. Test Procedures

#### 7.3.1. Test Procedures for Radiated Spurious Emissions

- 1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m. The table was rotated 360 degrees to determine the position of the highest radiation.
- 2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
- 3. For measurements above 1GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 GHz, the absorbers are removed.
- 4. The antenna is a broadband antenna, and its 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.
- 5. 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 table was turned from 0 degrees to 360 degrees to find the maximum reading.
- 6. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- 7. If the emission level of the EUT in peak mode was 10 dB 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 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

Note: The radiated spurious emission was tested with below settings.

- Frequencies less than or equal to 1000 MHz The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) at frequency below 1 GHz.
- Frequencies above 1000 MHz
   The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
   The result of Average measurement is calculated using PK result and duty correction factor.



#### 7.3.2. Test Procedures for Conducted Spurious Emissions

- 1. The transmitter output was connected to the spectrum analyzer.
- 2. The **reference level** of the fundamental frequency was measured with the spectrum analyzer using RBW = 100 kHz, VBW = 300 kHz.
- 3. The conducted spurious emission was tested each ranges were set as below.

Frequency range : 9 kHz ~ 30 MHz RBW = 100 kHz, VBW = 300 kHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40001

Frequency range : 30 MHz ~ 10 GHz, 10 GHz ~ 25 GHz RBW = 1 MHz, VBW = 3 MHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40001

LIMIT LINE = 20 dB below of the reference level of above measurement procedure Step 2. (RBW = 100 kHz, VBW = 300 kHz)

If the emission level with above setting was close to the limit (ie, less than 3 dB margin) then zoom scan is required using RBW = 100 kHz, VBW = 300 kHz, SPAN = 100 MHz and BINS = 2001 to get accurate emission level within 100 kHz BW.

Also the path loss for conducted measurement setup was used as described on the Appendix I of this test report.



### 7.4. Test Results

#### 7.4.1. Radiated Emissions

#### 9kHz ~ 25 GHz Data (Modulation : GFSK)

#### Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2381.58	Н	Х	PK	57.75	0.67	N/A	N/A	58.42	74.00	15.58
2381.58	Н	Х	AV	57.75	0.67	-24.79	N/A	33.63	54.00	20.37
4803.94	Н	Y	PK	53.75	4.77	N/A	N/A	58.52	74.00	15.48
4803.94	Н	Y	AV	53.75	4.77	-24.79	N/A	33.73	54.00	20.27
12009.01	V	Х	PK	53.68	13.33	N/A	N/A	67.01	74.00	6.99
12009.01	V	Х	AV	53.68	13.33	-24.79	N/A	42.22	54.00	11.78

#### Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4882.04	Н	Y	PK	60.09	5.11	N/A	N/A	65.20	74.00	8.80
4882.04	Н	Y	AV	60.09	5.11	-24.79	N/A	40.41	54.00	13.59
12205.26	V	Х	PK	50.30	13.55	N/A	N/A	63.85	74.00	10.15
12205.26	V	Х	AV	50.30	13.55	-24.79	N/A	39.06	54.00	14.94

#### Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.84	Н	Х	PK	60.82	0.94	N/A	N/A	61.76	74.00	12.24
2483.84	н	Х	AV	60.82	0.94	-24.79	N/A	36.97	54.00	17.03
4960.21	н	Y	PK	60.59	5.34	N/A	N/A	65.93	74.00	8.07
4960.21	н	Y	AV	60.59	5.34	-24.79	N/A	41.14	54.00	12.86
12399.05	V	Х	PK	54.01	13.77	N/A	N/A	67.78	74.00	6.22
12399.05	V	Х	AV	54.01	13.77	-24.79	N/A	42.99	54.00	11.01

#### Note.

1. The radiated emissions were investigated 9kHz to 25GHz. And no other spurious and harmonic emissions were found above listed frequencies.

2. Information of Distance Factor

For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.

- Calculation of distance factor = 20 log( applied distance / required distance ) = 20 log( 1 m / 3 m ) = -9.54 dB

When distance factor is "N/A", the distance is 3 m and distance factor is not applied.

3. D.C.F Calculation. (D.C.F = Duty Cycle Correction Factor)

- Time to cycle through all channels =  $\Delta t$  = T [ms] X 20 minimum hopping channels , where T = pulse width = 2.88 ms

- 100 ms /  $\Delta t$  [ms] = H -> Round up to next highest integer, to account for worst case, H' = 100 / (2.88 X 20) = 1.74  $\approx$  2

- The Worst Case Dwell Time = T [ms] x H' = 2.88 ms X 2 = 5.76 ms

- D.C.F = 20 Log(The Worst Case Dwell Time / 100 ms) dB = 20 log( 5.76 / 100 ) = -24.79 dB

4. Sample Calculation.

Margin = Limit - Result / Result = Reading + T.F + D.C.F / T.F = AF + CL - AG

Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.

IC: 8154A-SP52



#### 9kHz ~ 25 GHz Data (Modulation : $\pi$ /4DQPSK)

#### Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2375.84	Н	Х	PK	49.70	0.64	N/A	N/A	50.34	74.00	23.66
2375.84	Н	Х	AV	49.70	0.64	-24.79	N/A	25.55	54.00	28.45
4804.42	Н	Y	PK	49.35	4.77	N/A	N/A	54.12	74.00	19.88
4804.42	Н	Y	AV	49.35	4.77	-24.79	N/A	29.33	54.00	24.67
12009.08	V	Х	PK	47.42	13.33	N/A	N/A	60.75	74.00	13.25
12009.08	V	Х	AV	47.42	13.33	-24.79	N/A	35.96	54.00	18.04

#### Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4882.09	Н	Y	PK	54.51	5.11	N/A	N/A	59.62	74.00	14.38
4882.09	Н	Y	AV	54.51	5.11	-24.79	N/A	34.83	54.00	19.17
12203.80	V	Х	PK	47.28	13.55	N/A	N/A	60.83	74.00	13.17
12203.80	V	Х	AV	47.28	13.55	-24.79	N/A	36.04	54.00	17.96

#### Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.53	Н	Х	PK	53.04	0.94	N/A	N/A	53.98	74.00	20.02
2483.53	Н	Х	AV	53.04	0.94	-24.79	N/A	29.19	54.00	24.81
4959.98	Н	Y	PK	53.22	5.34	N/A	N/A	58.56	74.00	15.44
4959.98	Н	Y	AV	53.22	5.34	-24.79	N/A	33.77	54.00	20.23
12399.15	V	Х	PK	46.84	13.77	N/A	N/A	60.61	74.00	13.39
12399.15	V	Х	AV	46.84	13.77	-24.79	N/A	35.82	54.00	18.18

#### Note.

1. The radiated emissions were investigated 9kHz to 25GHz. And no other spurious and harmonic emissions were found above listed frequencies.

2. Information of Distance Factor

For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.

- Calculation of distance factor = 20 log( applied distance / required distance ) = 20 log( 1 m / 3 m ) = -9.54 dB

When distance factor is "N/A", the distance is 3 m and distance factor is not applied.

3. D.C.F Calculation. (D.C.F = Duty Cycle Correction Factor)

- Time to cycle through all channels =  $\Delta t$  = T [ms] X 20 minimum hopping channels , where T = pulse width = 2.88 ms

- 100 ms /  $\Delta$ t [ms] = H -> Round up to next highest integer, to account for worst case, H' = 100 / ( 2.88 X 20 ) = 1.74 = 2

- The Worst Case Dwell Time = T [ms] x H' = 2.88 ms X 2 = 5.76 ms

- D.C.F = 20 Log(The Worst Case Dwell Time / 100 ms) dB = 20 log( 5.76 / 100 ) = -24.79 dB

4. Sample Calculation.

Margin = Limit - Result / Result = Reading + T.F + D.C.F / T.F = AF + CL - AG

Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.



#### 9kHz ~ 25 GHz Data (Modulation : 8DPSK)

#### Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2375.90	Н	Х	PK	49.25	0.64	N/A	N/A	49.89	74.00	24.11
2375.90	Н	Х	AV	49.25	0.64	-24.79	N/A	25.10	54.00	28.90
4803.87	Н	Y	PK	49.11	4.77	N/A	N/A	53.88	74.00	20.12
4803.87	Н	Y	AV	49.11	4.77	-24.79	N/A	29.09	54.00	24.91
12010.65	V	Х	PK	47.38	13.33	N/A	N/A	60.71	74.00	13.29
12010.65	V	Х	AV	47.38	13.33	-24.79	N/A	35.92	54.00	18.08

#### Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4881.82	Н	Y	PK	54.18	5.11	N/A	N/A	59.29	74.00	14.71
4881.82	Н	Y	AV	54.18	5.11	-24.79	N/A	34.50	54.00	19.50
12204.90	V	Х	PK	47.38	13.55	N/A	N/A	60.93	74.00	13.07
12204.90	V	Х	AV	47.38	13.55	-24.79	N/A	36.14	54.00	17.86

#### Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.51	Н	Х	PK	53.92	0.94	N/A	N/A	54.86	74.00	19.14
2483.51	Н	Х	AV	53.92	0.94	-24.79	N/A	30.07	54.00	23.93
4960.01	Н	Y	PK	53.74	5.34	N/A	N/A	59.08	74.00	14.92
4960.01	Н	Y	AV	53.74	5.34	-24.79	N/A	34.29	54.00	19.71
12399.54	V	Х	PK	46.93	13.77	N/A	N/A	60.70	74.00	13.30
12399.54	V	Х	AV	46.93	13.77	-24.79	N/A	35.91	54.00	18.09

#### Note.

1. The radiated emissions were investigated 9kHz to 25GHz. And no other spurious and harmonic emissions were found above listed frequencies.

2. Information of Distance Factor

For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.

- Calculation of distance factor = 20 log( applied distance / required distance ) = 20 log( 1 m / 3 m ) = -9.54 dB

When distance factor is "N/A", the distance is 3 m and distance factor is not applied.

3. D.C.F Calculation. (D.C.F = Duty Cycle Correction Factor)

- Time to cycle through all channels =  $\Delta t$  = T [ms] X 20 minimum hopping channels , where T = pulse width = 2.88 ms

- 100 ms /  $\Delta t$  [ms] = H -> Round up to next highest integer, to account for worst case, H' = 100 / (2.88 X 20) = 1.74  $\approx$  2

- The Worst Case Dwell Time = T [ms] x H' = 2.88 ms X 2 = 5.76 ms

- D.C.F = 20 Log(The Worst Case Dwell Time / 100 ms) dB = 20 log( 5.76 / 100 ) = -24.79 dB

4. Sample Calculation.

Margin = Limit - Result / Result = Reading + T.F + D.C.F / T.F = AF + CL - AG

Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.



#### Low Band-edge



#### Lowest Channel & Modulation : GFSK

### Low Band-edge

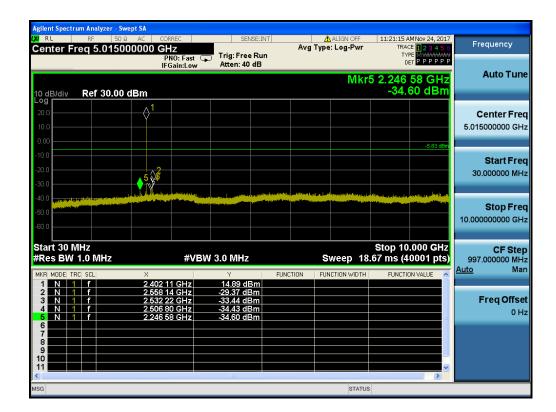
#### Hopping mode & Modulation : GFSK





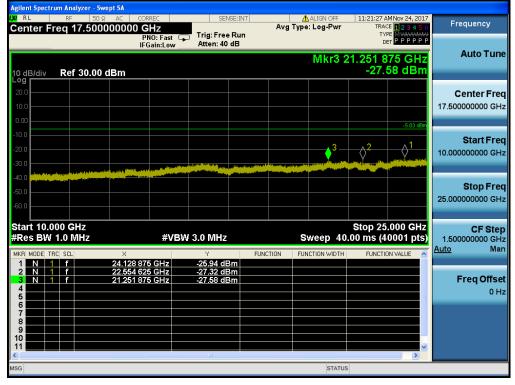
### Lowest Channel & Modulation : GFSK

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### Lowest Channel & Modulation : GFSK





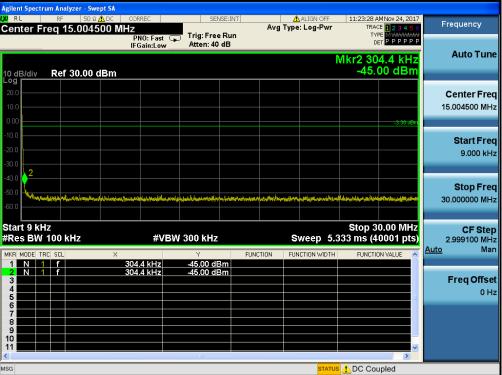
**Reference for limit** 



#### Middle Channel & Modulation : GFSK

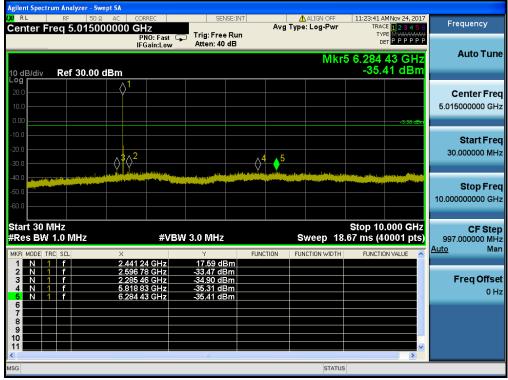


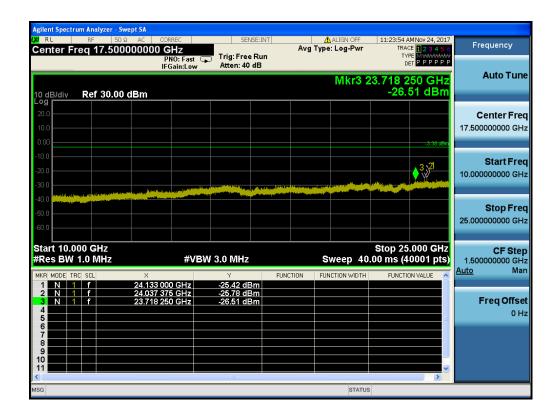








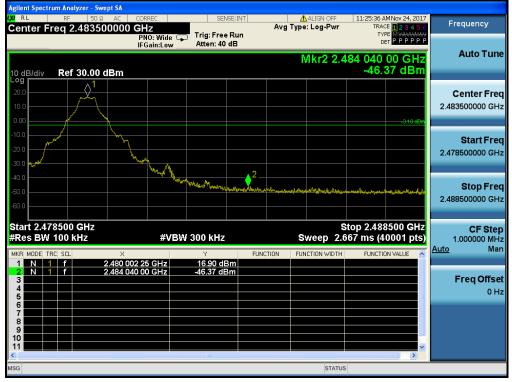






#### High Band-edge

### Highest Channel & Modulation : GFSK



#### High Band-edge Agilent Spectrum Analyzer - Swept SA

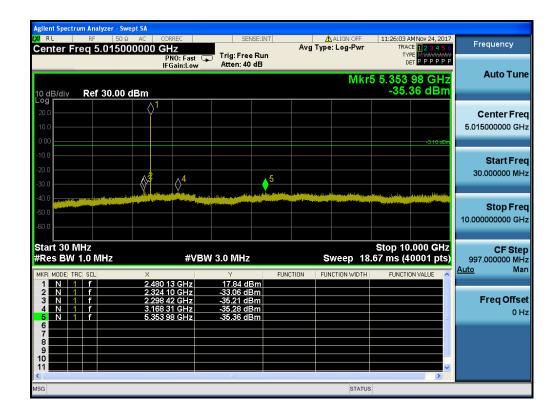
#### Hopping mode & Modulation : GFSK





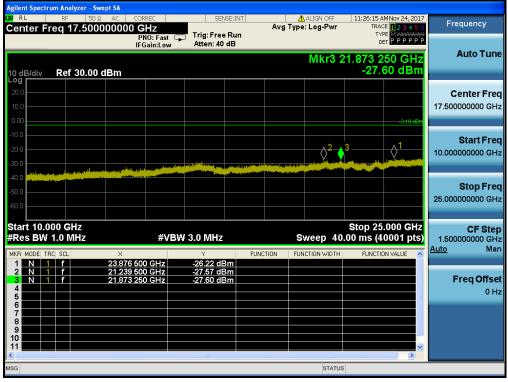
### Highest Channel & Modulation : GFSK

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### Highest Channel & Modulation : GFSK





#### Low Band-edge

### Lowest Channel & Modulation : π/4DQPSK



#### Low Band-edge

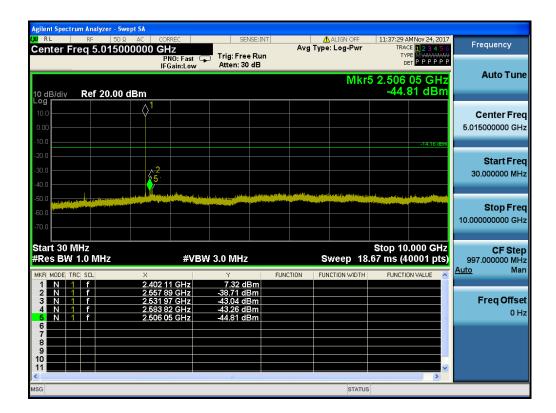
#### Hopping mode & Modulation : π/4DQPSK





### Lowest Channel & Modulation : π/4DQPSK

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### Lowest Channel & Modulation : π/4DQPSK

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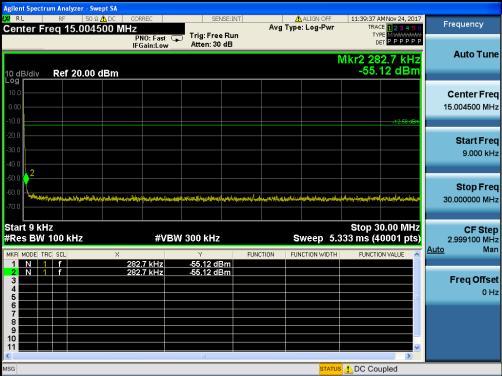
#### Reference for limit

### Middle Channel & Modulation : π/4DQPSK



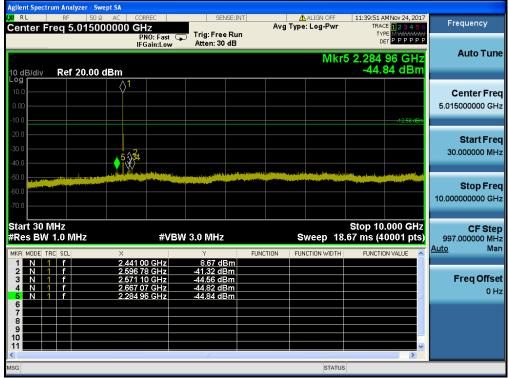
#### Conducted Spurious Emissions <u>Mid</u>

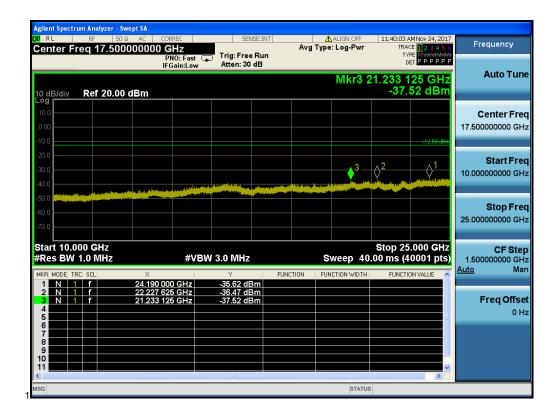
#### Middle Channel & Modulation : π/4DQPSK













### High Band-edge

### Highest Channel & Modulation : π/4DQPSK



#### High Band-edge

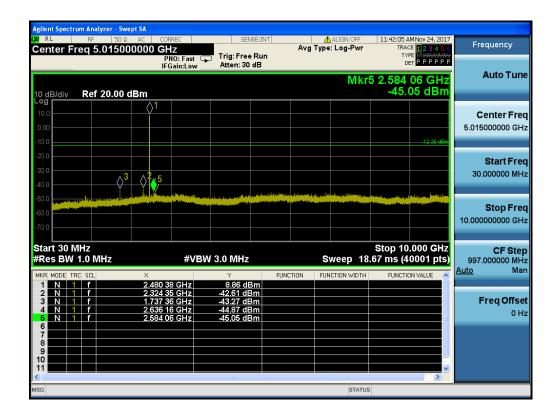
### Hopping mode & Modulation : π/4DQPSK





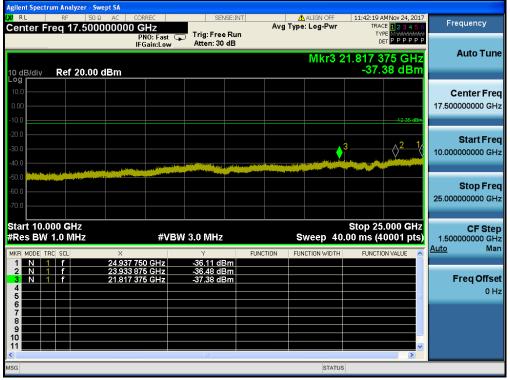
### Highest Channel & Modulation : π/4DQPSK

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													Auto Mar
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### Highest Channel & Modulation : π/4DQPSK





#### Low Band-edge

#### Lowest Channel & Modulation : 8DPSK



#### Low Band-edge

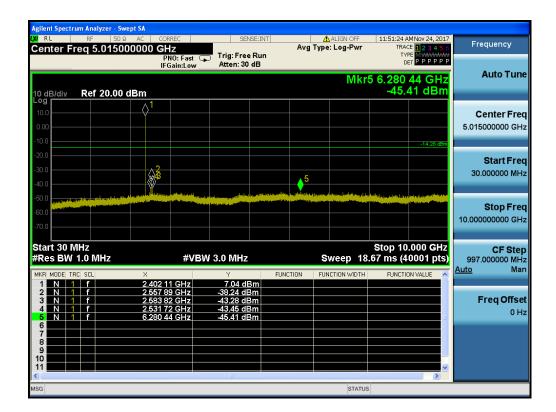
#### Hopping mode & Modulation : 8DPSK





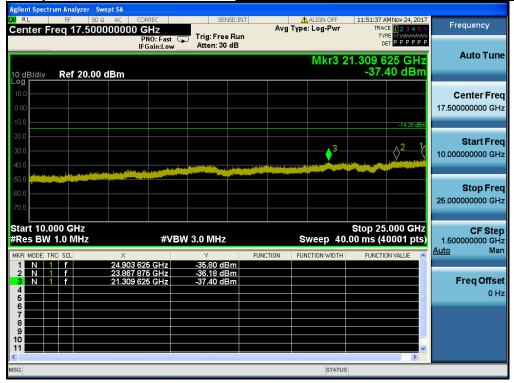
### Lowest Channel & Modulation : 8DPSK

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### Lowest Channel & Modulation : 8DPSK





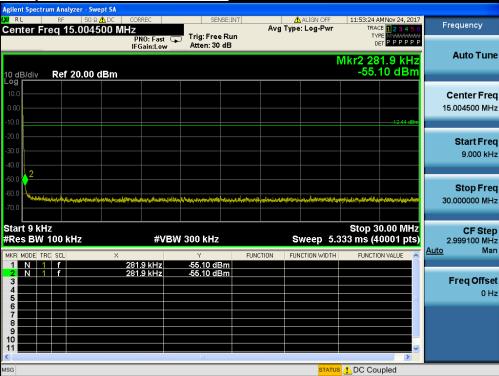
#### **Reference for limit**

### Middle Channel & Modulation : 8DPSK



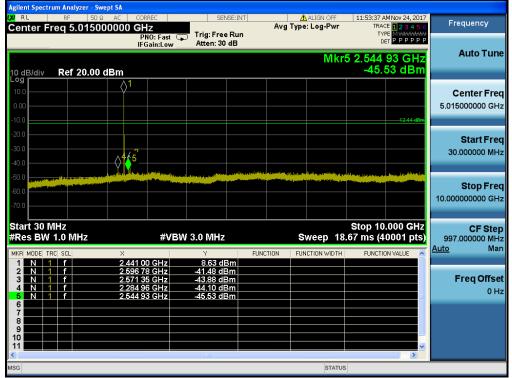
#### Conducted Spurious Emissions

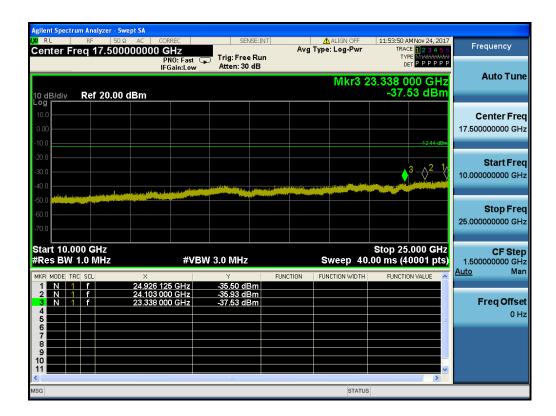
#### Middle Channel & Modulation : 8DPSK





#### Conducted Spurious Emissions <u>Middle Channel & Modulation : 8DPSK</u>







#### High Band-edge

### Highest Channel & Modulation : 8DPSK



#### High Band-edge

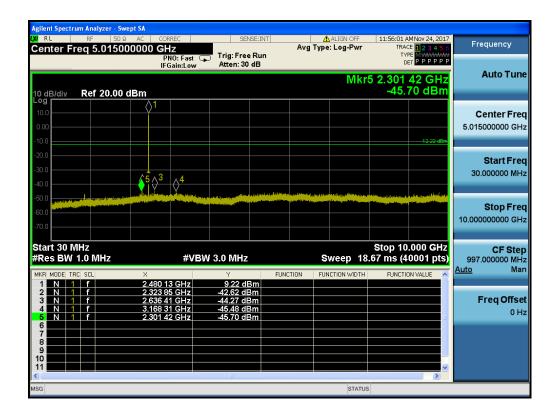
#### Hopping mode & Modulation : 8DPSK





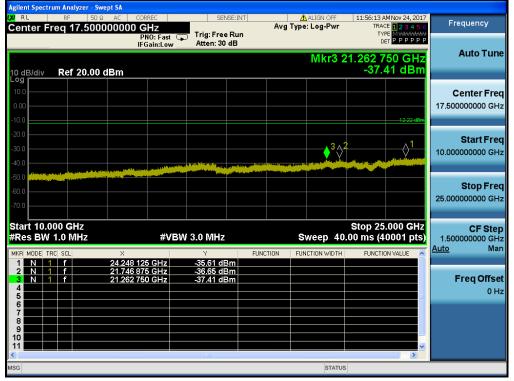
### Highest Channel & Modulation : 8DPSK

			alyzer - Sw												
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					IFGain:Lov	v Atte	n: 30 d	a 🗅							Auto Tuno
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-20.0															Stort From
-30.0	l														Start Freq
															9.000 kHz
-40.0															
-50.0	<u>\2</u>														
	V														Stop Freq
-60.0	Martin alle		stated frontiers of	ي المحمد الم	أستاله منبط ومقتر			, kontrola	dia a su da a		. La danal	معاليه ومراجع المراجع	والمتعادية والمتعادية		
-70.0	- Alterny	A HILL					and so the			ality in 192	and the lines				30.000000 MHz
10.0															
Ctor	t9kH	_		ļ								Oton 2			
					-443	BW AAA				•		Stop 3	0.00 MH	1	CF Step
#Re	s BW	100	KHZ		#V	'BW 300	KHZ			Swee	эр э.:	333 ms (4	uuun pts		2.999100 MHz
MKB 1	MODE TR	d sa	1	×		Y		FLIN	CTION	FUNCTION	N WIDTH	EUNCTI	ON VALUE		<u>ito</u> Man
1	N 1	f			281.9 kHz	-54.7	4 dB	m							
2	N 1	f			281.9 kHz		'4 dB								
3															Freq Offset
4								_							0 Hz
5		-													
7		+													
8															
9															
10															
11													`		
<												_	>		
MSG											STATUS	DC Co	upled		





### Highest Channel & Modulation : 8DPSK





## 8. Transmitter AC Power Line Conducted Emission

### 8.1 Test Setup

See test photographs for the actual connections between EUT and support equipment.

### 8.2 Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network (LISN).

Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

	Conducted I	Limit (dBuV)
Frequency Range (MHz)	Quasi-Peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

\* Decreases with the logarithm of the frequency

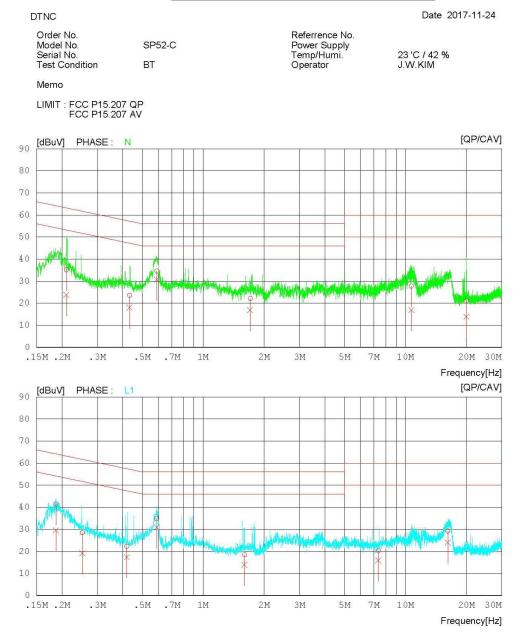
### 8.3 Test Procedures

Conducted emissions from the EUT were measured according to the ANSI C63.10.

- The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
- 2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
- 3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
- 4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

### 8.4 Test Results AC Line Conducted Emissions (Graph) = Modulation : <u>GFSK</u>

### **Results of Conducted Emission**



### AC Line Conducted Emissions (List) = Modulation : <u>GFSK</u>

### **Results of Conducted Emission**

DTNC			Date	2017-11-24
Order No. Model No. Serial No. Test Condition	SP52-C BT	Referrence Power Supj Temp/Hum Operator	ply	%
Memo				
LIMIT : FCC P15 FCC P15				
NO FREQ	READING C.FACTOR OP CAV	RESULT LIM OP CAV OP	IT MARGIN CAV OP CAV	PHASE
[MHz]	[dBuV][dBuV] [dB]	~ ~ ~	[dBuV] [dBuV] [dBuV]	7]
1 0.21060	25.2813.87 9.90	35.18 23.77 63.18	53.18 28.00 29.41	N
2 0.43265	13.60 8.08 9.90	23.50 17.98 57.20	47.20 33.7029.22	Ν
	24.6020.82 9.91	34.51 30.73 56.00	46.00 21.49 15.27	Ν
4 1.70860	12.06 6.92 9.94	22.00 16.86 56.00	46.00 34.00 29.14	Ν
5 10.70520			50.00 32.2133.06	Ν
6 20.03000			50.00 38.8136.14	Ν
7 0.18706			54.17 22.7824.76	L1
8 0.25238			51.68 33.34 32.53	L1
9 0.41950			47.46 35.1930.13	L1
	24.9421.00 9.91		46.00 21.1515.09	L1
11 1.60040			46.00 37.68 32.27	L1
12 7.35360			50.00 39.8634.15	L1
13 16.21780	18.8713.72 10.25	29.12 23.97 60.00 !	50.00 30.8826.03	L1



### 9. Antenna Requirement

Describe how the EUT complies with the requirement that either its antenna is permanently attached, or that

it employs a unique antenna connector, for every antenna proposed for use with the EUT.

#### Conclusion: Comply

The antenna is permanently attached.(Refer to Internal Photo file.) Therefore this E.U.T Complies with the requirement of §15.203

#### - Minimum Standard :

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 shall be considered sufficient to comply with the provisions.

# 10.1 Test Setup

Refer to the APPENDIX I.

# 10.2 Limit

Limit : Not Applicable

# **10.3 Test Procedure**

The 99 % power bandwidth was measured with a calibrated spectrum analyzer.

The resolution bandwidth (RBW) shall be in the range of 1 % to 5 % of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately  $3 \times RBW$ .

Spectrum analyzer plots are included on the following pages.

# **10.4 Test Results**

Modulation	Tested Channel	Test Results (MHz)					
	Lowest	0.916					
<u>GFSK</u>	Middle	0.947					
	Highest	0.950					
	Lowest	1.165					
<u>π/4DQPSK</u>	Middle	1.167					
	Highest	1.169					
	Lowest	1.163					
<u>8DPSK</u>	Middle	1.168					
	Highest	1.170					





### Occupied Bandwidth (99 %)

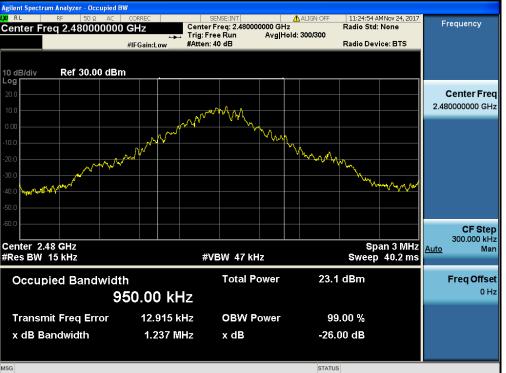
# Middle Channel & GFSK

Lowest Channel & GFSK



Highest Channel & GFSK

# Occupied Bandwidth (99 %)



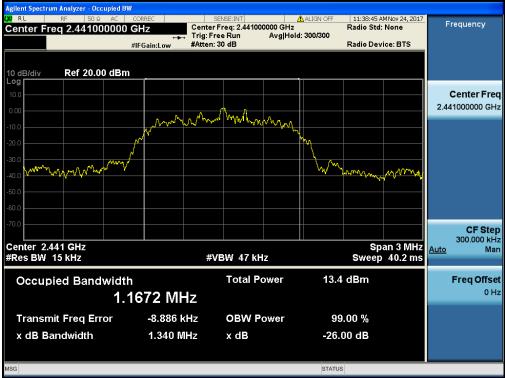
#### TRF-RF-237(04)170516



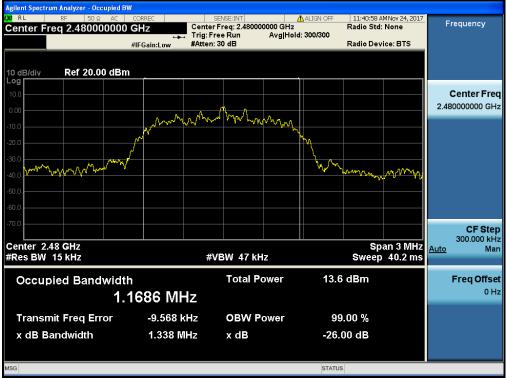
# Occupied Bandwidth (99 %)

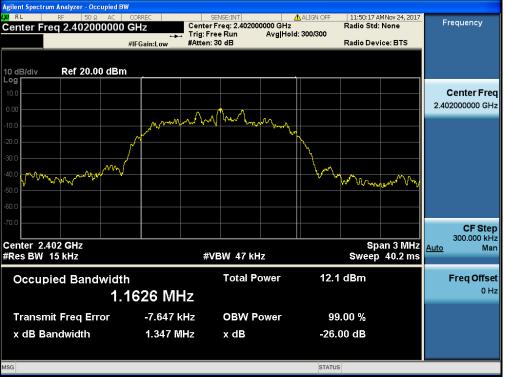
# Middle Channel & π/4 DQPSK

Lowest Channel & π/4 DQPSK





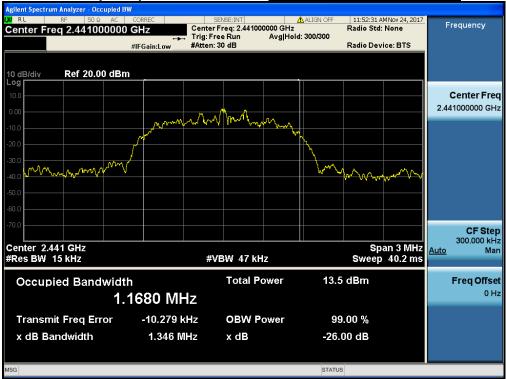




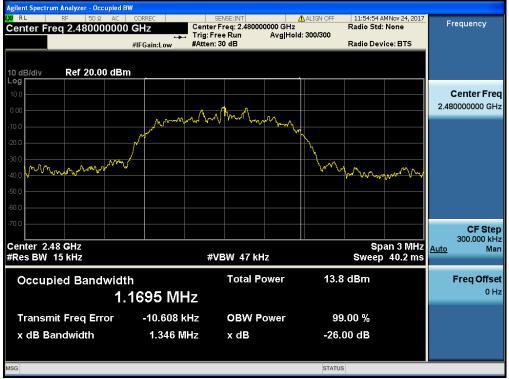
# Occupied Bandwidth (99 %)

# Middle Channel & 8DPSK

Lowest Channel & 8DPSK



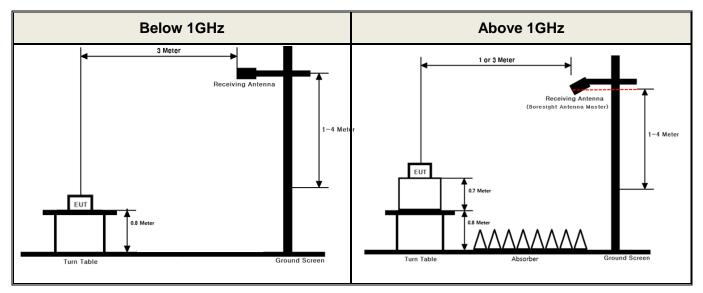


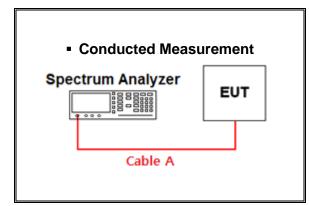


# **APPENDIX I**

## Test set up diagrams

### Radiated Measurement





#### Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	0.16	15	4.02
1	0.79	20	4.41
2.402 & 2.441 & 2.480	1.24	25	5.40
5	1.72	-	-
10	3.00	-	-

Note 1 : The path loss from EUT to Spectrum analyzer were measured and used for test.

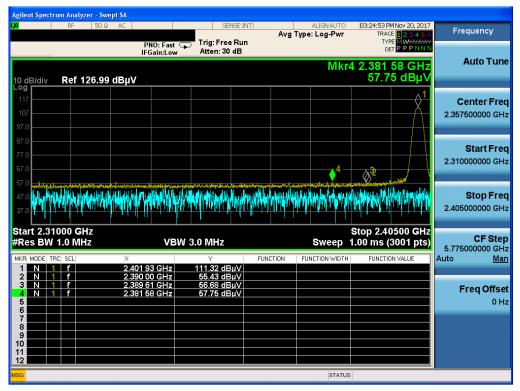
Path loss ( S/A's Correction factor) = Cable A



# **APPENDIX II**

# **Unwanted Emissions (Radiated) Test Plot**

### GFSK & Lowest & X & Hor



### **Detector Mode : PK**

## GFSK & Highest & X & Hor

Agilent Spectrum Analyzer - Swept SA					
<b>LXI</b> RF 50 Ω AC		SENSE:INT	ALIGN AUTO Avg Type: Log-Pwr	03:21:57 PM Nov 20, 2017 TRACE 1 2 3 4 5 6	Frequency
		rig: Free Run	Avg Type: Log-Pwr	TYPE MW <del>ANANA</del>	
	IFGain:Low A	tten: 30 dB		2.483 842 GHz	Auto Tuno
	Auto Tune				
10 dB/div Ref 126.99 dB	V			60.82 dBµV	
					Conton From
107					Center Freq 2.487500000 GHz
97.0					2.487500000 GH2
87.0					
77.0					Start Freq
	×23				2.475000000 GHz
57.0 47.0 411006. stand withit the state	the loca to be an in the best of the best of	WALL WALL & BARRIE	its addressed a shall be build to south	tel Annihilita de Lik Annihilit	Stop Freq
		TANAN TALAN ANA MANANA	ana dina mahina di kang		2.500000000 GHz
37.0				• 1 11 14 II • • • • •	2.300000000 GHZ
Start 2.47500 GHz				Stop 2.50000 GHz	
#Res BW 1.0 MHz	VBW 3.0	MHz	Sweep	1.00 ms (3001 pts)	CF Step 5.77500000 GHz
MKR MODE TRC SCL >>	<	Y FUN	TION FUNCTION WIDTH	FUNCTION VALUE	Auto Man
		2.16 dBµV 0.01 dBµV			
		0.01 dBµV 0.82 dBµV			Freq Offset
4 5					0 Hz
6					0112
8					
9					
10					
12					
MSG			STATUS		

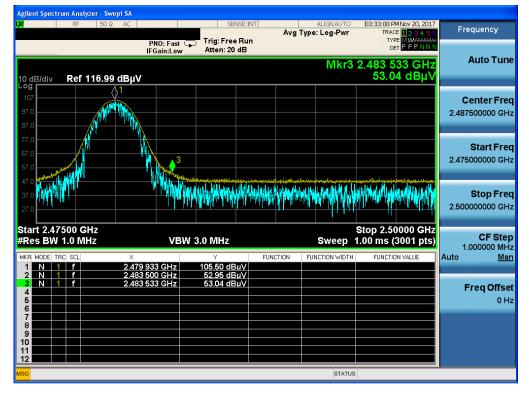


## $\pi/4DQPSK$ & Lowest & X & Hor

Agilent	Spectri	um An	alyzer - S	wept SA													
LXI		RF	: 50	Ω AC			SEI	VSE:IN	Г			ALIGN AUTO	03:27:54 F			<b>-</b>	
										Avg 1	Type:	Log-Pwr	TRA	CE 1234	5.6	Frequency	
					PNO: Fast	Ω	Trig: Free						TY	PE MWWW	<del>, (1111)</del>		
					IFGain:Low	<u>ر ان </u>	Atten: 20	dB					D	et p p p t	IN N		
												Mler	4 2.375	04 C		Auto Tun	e
												INIM	4 2.375	04 G	-6		
10 dB/div Ref 116.99 dBµV 49.70 dBµV																	
Log L															1		
107															$\vdash$	Center Fre	
07.0														1 (	$\mathbf{i}$		- 1
97.0																2.357500000 GH	IZ
87.0															4		
77.0																Start Fre	
67.0															_1		
												4	_		1	2.310000000 GH	Iz
57.0												+	<u>~^~</u> 2	+			
47.0					فليستلم والمستحد		مىلارلىمى مىلىك		بر		والمنبنجة	الماديلة توجد والداد	- A CARLER AND A CARLER	and the			
	Land de	hi Maa	ALC: N	4. 44.4	In said with	h ku	i dista da filo	iter h	1.0 44	enals tells	atiala.	A the Manuakan	differentiation	ALL OF BUILD	r da	04 E	
37.0	80 A.U		i di salij	tir di di s		机纤带	an a	March 1	10.1	hinn in	Mi L			1409.00		Stop Fre	q
27.0	the fatter		n i frai	101	מיון בקרוע מאון און	1.1	<u>1.1616.06</u>	1.01	1.14		. Idla	. <b></b>			u yu	2.405000000 GH	łz
21.0										1 1				1	÷ 1		
Oto the	0.04	~~~	<u> </u>										Oton 0.4	0500 0			
Start												_	Stop 2.4	0000 G	HZ	CF Ste	n
#Res	ВW	1.0	VIHZ		VB	W 3.	0 MHz				#	Sweep	1.00 ms (	3001 p	ts)	5.775000000 GH	
MKR MC			1	×			Y	_	FLINK	CTION	L CUN	CTION MODILI	FUNCTI	ON VALUE	_	Auto Ma	
		it Sti					105.41 dB		FUN	JIIUN	FUN	CTION WIDTH	FUNCT	UN VALUE	_	Auto <u>Ivia</u>	ш
1	<u> </u>	÷		2.	401 96 GHz 390 00 GHz		47.18 dB										
3		F			389 43 GHz		49.11 dB										
4		F			375 84 GHz		49.70 dB									Freq Offse	et
5				<u> </u>	010040112		40.10 UL	мх								0 H	17
6																	-
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MSG												STATUS	3				
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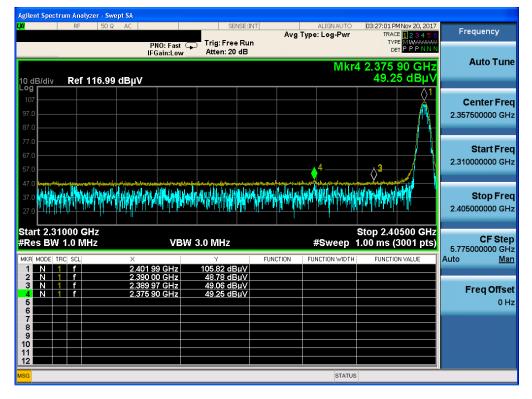
# **Detector Mode : PK**

### $\pi$ /4DQPSK & Highest & X & Hor



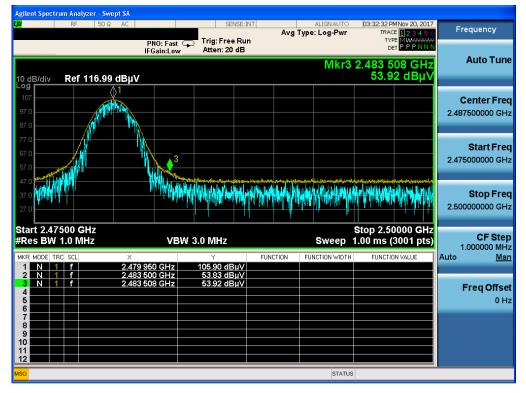


### 8DPSK & Lowest & X & Hor



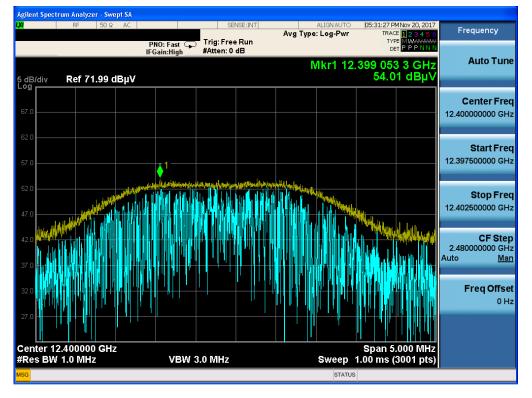
## Detector Mode : PK

# 8DPSK & Highest & X & Hor



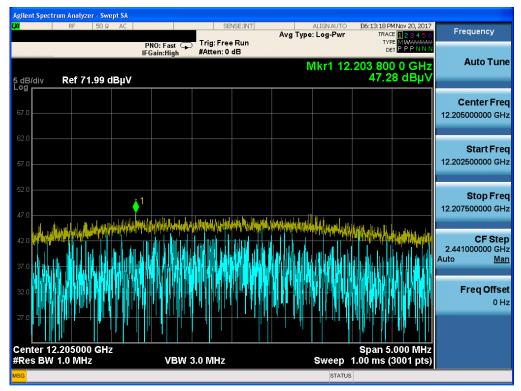


## GFSK & Highest & X & Ver



### $\pi$ /4DQPSK & Middle & X & Ver

### **Detector Mode : PK**





### 8DPSK & Middle & X & Ver

