# **TEST REPORT**

### 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: DRTFCC1712-0277

 $\mathbf{\overline{D}}$  Dt&C

2. Customer

• Name (FCC) : HYUNDAI MOBIS CO., LTD.

• Name (IC) : Hyundai MOBIS Co., Ltd

• Address (FCC) : 203, Teheran-ro Gangnam-gu Seoul South Korea 135-977

• Address (IC) : 203, Teheran-ro Gangnam-gu Seoul 135-977 Korea (Republic Of)

3. Use of Report : FCC & IC Original Grant

4. Product Name / Model Name : DIGITAL CAR AUDIO SYSTEM / Model(FCC) : ADB10DLAN, Model(IC) : ADB10DLKN

FCC ID: TQ8-ADB10DLAN, IC: 5074A-ADB10DLKN

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 : 2017.11.24 ~ 2017.11.30

7. Testing Environment : See appended test report.

8. Test Result : Refer to the attached test result.

Affirmatio	Tested by	Technical Manager	
n	Name : JaeHyeok Bang	Name : GeunKi Son	(Signature)
The test	t results presented in this test report are limited	only to the sample supplied	by applicant and
the use	of this test report is inhibited other than its purp	oose. This test report shall no	t be reproduced
	except in full, without the written ap	proval of DT&C Co., Ltd.	
	2017.12.	20.	, <i>i</i> s
	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
DRTFCC1712-0277	Dec. 20, 2017	Initial issue



## **Table of Contents**

1. General Information	
1.1 Testing Laboratory	
1.2 Testing Environment	
1.3 Measurement Uncertainty	4
1.4 Details of Applicant	5
1.5 Description of EUT	5
1.6 Declaration by the applicant / manufacturer	5
1.7 Information about the FHSS characteristics	6
1.8 Test Equipment List	7
1.9 Summary of Test Results	
1.10 Conclusion of worst-case and operation mode	
2. Maximum Peak Output Power Measurement	
2.1 Test Setup	
2.2 Limit	
2.3 Test Procedure	
2.4 Test Results	
3. 20 dB BW	
3.1 Test Setup	
3.2 Limit	
3.3 Test Procedure	
3.3 Test Procedure	
4. Carrier Frequency Separation	
4.1 Test Setup	
4.2 Limit 4.3 Procedure	
	-
4.4 Test Results	
5. Number of Hopping Frequencies	
5.1 Test Setup	
5.2 Limit	
5.3 Procedure	
5.4 Test Results	
6. Time of Occupancy (Dwell Time)	
6.1 Test Setup	
6.2 Limit	
6.3 Test Procedure	
6.4 Test Results	
7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission	
7.1 Test Setup	
7.2 Limit	
7.3. Test Procedures	
7.3.1. Test Procedures for Radiated Spurious Emissions	
7.3.2. Test Procedures for Conducted Spurious Emissions	
7.4. Test Results	
7.4.1. Radiated Emissions	
7.4.2. Conducted Spurious Emissions	44
8. Transmitter AC Power Line Conducted Emission	
8.1 Test Setup	
8.2 Limit	
8.3 Test Procedures	
8.4 Test Results	
9. Antenna Requirement	
10. Occupied Bandwidth (99 %)	
10.1 Test Setup	
10.2 Limit	
10.3 Test Procedure	
10.4 Test Results	
	. 79



### **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	
Temperature	+22 °C ~ +25 °C
Relative Humidity	40 % ~ 43 %

#### **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 %, $k = 2$ )	
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 (FCC)	: HYUNDAI MOBIS CO., LTD.	
Applicant (IC)	: Hyundai MOBIS Co., Ltd	
Address (FCC)	: 203, Teheran-ro, Gangnam-gu Seoul South Korea 135-977	
Address (IC)	: 203, Teheran-ro, Gangnam-gu Seoul 135-977 Korea (Republic	c Of)
Contact person (FCC)	: Seung Hoon Choe	
Contact person (IC)	: Seung Hoon Choe	

### 1.5 Description of EUT

EUT	DIGITAL CAR AUDIO SYSTEM	
Model Name(FCC)	ADB10DLAN	
Model Name(IC)	ADB10DLKN	
Add Model Name(FCC)	ADB10DJGG, ADB10DJMG, ADB10DJGN, ADB10DJGE, ADB11DJGG, ADB12DJGG, ADBC0DJUG, ADB10DJGL, ADB11DLGN, ADB10DLGL, ADB10DLBB, ADB10DJAN	
Add Model Name(IC)	ADB10DJKN	
Serial Number	Identical prototype	
Hardware version	1.0	
Software version	1.0	
Power Supply	DC :14.4 V	
Frequency Range	2402 MHz ~ 2480 MHz	
Modulation Technique	GFSK, π/4-DQPSK, 8DPSK	
Number of Channels	79	
Antenna Type /Antenna Gain	Dielectric Chip Antenna / PK : -0.10 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	MY43000211
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
Power Splitter	Anritsu	K241B	17/01/11	18/01/11	1301183
Bluetooth Tester	TESCOM	TC-3000C	17/01/11	18/01/11	3000C000396
Loop Antenna	Schwarzbeck	FMZB1513	16/04/22	18/04/22	1513-128
BILOG ANTENNA	Schwarzbeck	VULB 9160	16/08/05	18/08/05	9160-3362
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
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2496A MA2411B	17/04/11	18/04/11	1338004 1306053

Note: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2016.

#### 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
	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	C Note2	
15.207 RSS-Gen(8.8)	AC Conducted Emissions	FCC 15.207 Limits	AC Line Conducted	NA <sup>Note3</sup>
15.203	Antenna Requirements	FCC 15.203	-	С

Note 2 : For radiated emission tests below 30 MHz were performed on semi-anechoic chamber which is correlated with OATS.

Note 3 : This device is installed in a car. Therefore the power source is a battery of car.

#### 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).

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 Channer	dBm	mW	dBm	mW	
	Lowest	1.27	1.34	2.17	1.65	
<u>GFSK</u>	Middle	1.51	1.42	2.74	1.88	
	Highest	0.97	1.25	2.70	1.86	
	Lowest	-0.26	0.94	3.39	2.18	
<u>π/4DQPSK</u>	Middle	-0.04	0.99	3.94	2.48	
	Highest	-0.61	0.87	3.39	2.18	
	Lowest	-0.28	0.94	3.71	2.35	
<u>8DPSK</u>	Middle	-0.06	0.99	4.39	2.75	
	Highest	-0.62	0.87	3.71	2.35	

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

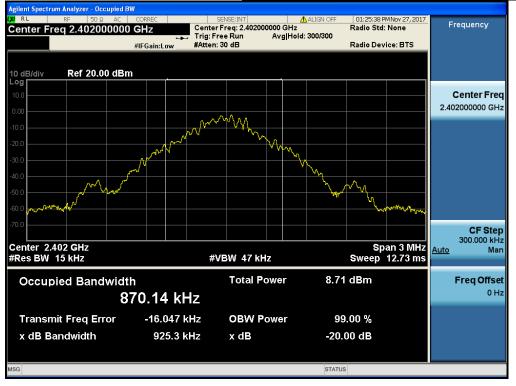
- 1. The 20 dB bandwidth were measured with a spectrum analyzer connected to RF antenna Connector (conducted measurement) while EUT was operating in transmit mode. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer.
- 2. The bandwidth of the fundamental frequency was 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	0.925		
<u>GFSK</u>	Middle	0.888		
	Highest	0.955		
	Lowest	1.206		
<u>π/4DQPSK</u>	Middle	1.279		
	Highest	1.309		
	Lowest	1.248		
<u>8DPSK</u>	Middle	1.266		
	Highest	1.259		

#### 3.4 Test Results

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

#### Lowest Channel & Modulation : GFSK

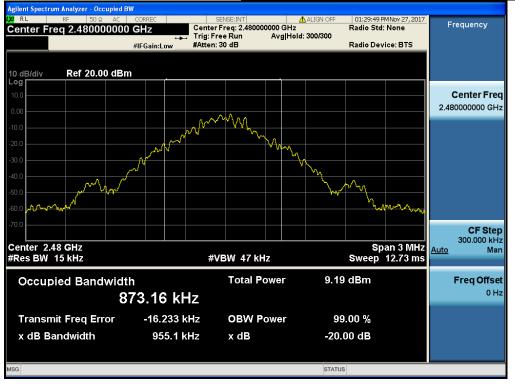


#### 20 dB Bandwidth

#### Middle Channel & Modulation : GFSK

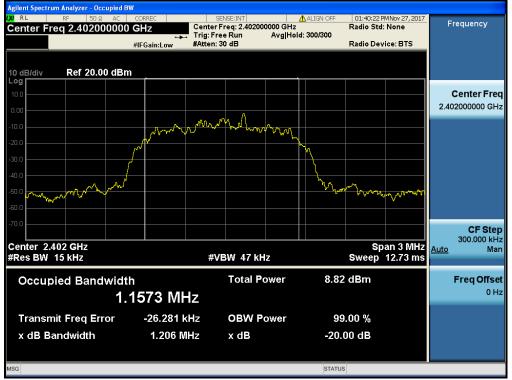


#### Highest Channel & Modulation : GFSK

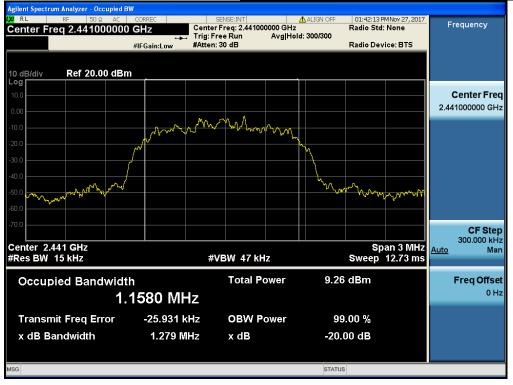


#### 20 dB Bandwidth

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

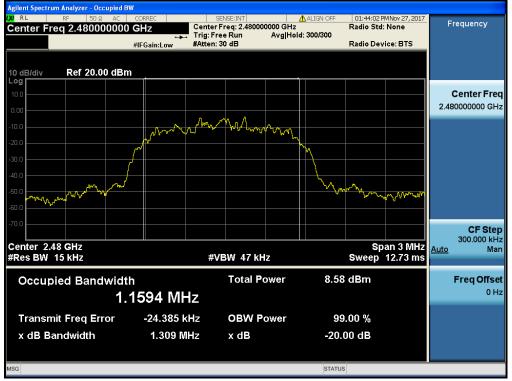


#### Middle Channel & Modulation : π/4DQPSK



#### 20 dB Bandwidth

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

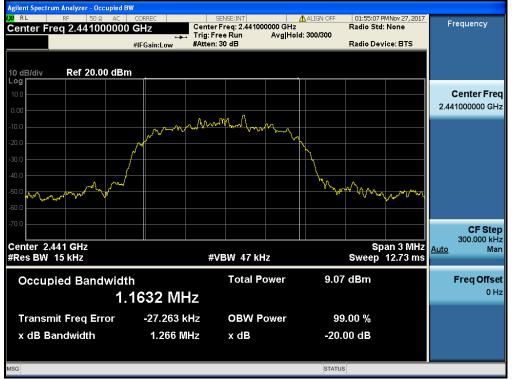


#### Lowest Channel & Modulation : 8DPSK



#### 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
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)
Enable	GFSK	2440.982	2441.984	1.002
	π/4-DQPSK	2440.982	2441.981	0.999
	8DPSK	2441.132	2442.134	1.002

#### AFH mode

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.030	2442.029	0.999
Enable	π/4-DQPSK	2440.982	2441.981	0.999
	8DPSK	2441.132	2442.134	1.002

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



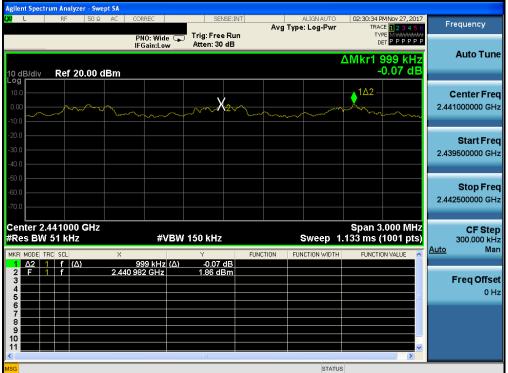
#### Carrier Frequency Separation (FH)

Hopping mode : Enable & GFSK

Agilent Spect											
LXI L	RF	50 Ω	AC	CORREC	S	ENSE:INT	Aug T	ALIGNAUTO e: Log-Pwr		MNov 27, 2017	Frequency
				PNO: Wide	Trig: Fr	ee Run	Avgiyp	e: Log-Pwr	TY	E 123456 E M <del>WWWWW</del>	
				IFGain:Low	Atten: 3				DI	ΤΡΡΡΡΡ	
									/kr1 1.0	02 MH7	Auto Tune
10 dB/div	Dof	20.00 c	Bm							0.01 dB	
Log	Kei	20.00 0							ĺ.		
10.0									1∆2		Center Freq
0.00	~					X					2.441000000 GHz
-10.0					, ~ · · · ·						
							~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~				
-20.0											Start Freq
-30.0											2.439500000 GHz
-40.0											
-50.0											
-60.0											Stop Freq
											2.442500000 GHz
-70.0											
Center 2.	44100								Snan 3	.000 MHz	05.04
#Res BW				#VI	3W 150 kH	7		Sween 1	.133 ms (	1001 nts)	CF Step 300.000 kHz
-											Auto Man
MKR MODE T	RC SCL	(4)	×	.002 MHz (	A) 0.0/	FUN 1 dB	ICTION FU	NCTION WIDTH	FUNCTIO	N VALUE	
2 F 1		<u>[]</u>		982 GHz	1.87 (	dBm					
3											Freq Offset
4 5										=	0 Hz
6											
7 8											
9											
10											
11					ш					>	
MSG								STATU	5		
								UNIT			

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

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





### Carrier Frequency Separation (FH)

Hopping mode : Enable & 8DPSK

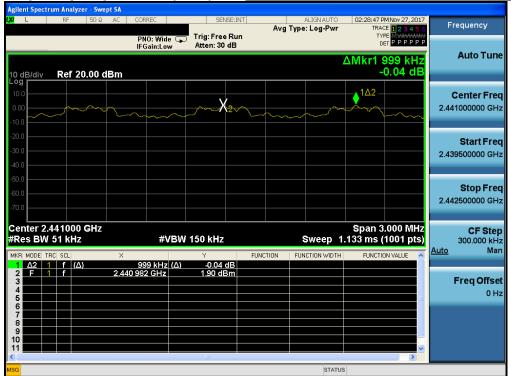




### Carrier Frequency Separation (AFH) <u>Hopping mode : Enable & GFSK</u>

Agilent Spectrum Analyzer - Swept SA					
L RF 50Ω AC I	CORREC		ALIGNAUTO Avg Type: Log-Pwr	02:20:20 PMNov 27, 2017 TRACE 1 2 3 4 5 6	Frequency
		Free Run n: 30 dB			Auto Tune
10 dB/div Ref 20.00 dBm 10.0 0.00 -10.0				0.04 dB	Center Freq 2.441000000 GHz
-20.0					Start Freq 2.439500000 GHz
-50.0 -60.0 -70.0					<b>Stop Freq</b> 2.442500000 GHz
Center 2.441000 GHz #Res BW 51 kHz	#VBW 150			Span 3.000 MHz 133 ms (1001 pts)	CF Step 300.000 kHz <u>Auto</u> Man
MKR MODE TRC SCL X	999 kHz (Δ)	FUNCTIO	N FUNCTION WIDTH	FUNCTION VALUE	<u>rato</u> mari
		79 dBm			<b>Freq Offset</b> 0 Hz
7 8 9 10 11					
K MSG			STATUS	>	

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





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

Agilent Spectrum Analyzer - Swept SA				
L RF 50 Ω AC CORREC	SENSE:INT	ALIGNAUTO Avg Type: Log-Pwr	02:32:21 PM Nov 27, 2017 TRACE 1 2 3 4 5 6	Frequency
PNO: Wid IFGain:Lo			TYPE MWWWWW DET PPPPP	<b>A</b>
10 dB/div Ref 20.00 dBm		ΔN	1kr1 1.002 MHz 0.06 dB	Auto Tune
Log 10.0 0.00 -10.0	~~~~~~X~~~~		1Δ2 ~~~~	Center Freq 2.441000000 GHz
-20.0				<b>Start Freq</b> 2.439500000 GHz
-50.0 -60.0 -70.0				<b>Stop Freq</b> 2.442500000 GHz
	VBW 150 kHz	-	Span 3.000 MHz .133 ms (1001 pts)	CF Step 300.000 kHz <u>Auto</u> Man
MKR MODE TRC SCL Χ 1 Δ2 1 f (Δ) 1.002 MHz	Y FUNCTIO	IN FUNCTION WIDTH	FUNCTION VALUE	
2 F 1 f 2.441 132 GHz 3 4 5 5				<b>Freq Offset</b> 0 Hz
6 7 8 9 9				
11			~	
MSG	HU	STATUS		



### 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 individual channels, set the RBW to less than 30% of the channel spacing								
or the 20 dB bandwidth, whichever 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



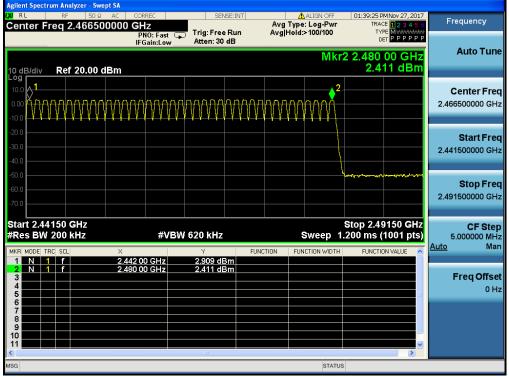
### Number of Hopping Frequencies 1(FH)



Agilent Spectr LXI RL	rum Ana RF	lyzer - Sv 50 9		CORREC		SEN	ISE:INT		ALIGN OFF	01:38:23	MNov 27, 2017	
Center F	req 2	.4165	00000	GHz PNO: Fa	_	Trig: Free	Run		e: Log-Pwr I:>100/100	Tγ	CE 123456 PE MWWWWW	Frequency
				PNU: Fa	ow	Atten: 30				C	PPPPP	A
									Mkr		00 GHz	Auto Tune
10 dB/div Log	Ref	20.00	dBm			1		1		2.8	79 dBm	
10.0			1								<u>2</u>	Center Freq
0.00			Ann	กกุกก	חתר	กกกกก	ANAAF	ANAAA	งกุกกุก	งกกกก	INAAAA	2.416500000 GHz
-10.0			_ { ¥ ¥ }	I ¥ ¥ ¥ ¥	Υ¥	L Ų Ų Ų Ų .	YYYY	¥¥¥¥¥	<u> </u>	V V V V V	¥ ¥ ¥ ¥ ¥ I	
-20.0			-									Start Freq
-30.0												2.391500000 GHz
-40.0			<u> </u>									
-50.0	~~~~	ليح <u>رديها مم</u> تي										
-60.0												<b>Stop Freq</b> 2.441500000 GHz
-70.0												2.441500000 GH2
Start 2.39	150	2H7								Ston 2.4	4150 GHz	OF Oton
#Res BW				#	VBW	620 kHz			Sweep 1		(1001 pts)	CF Step 5.000000 MHz
MKR MODE T	RC SCL		Х		1	Y	FUN	CTION FU	NCTION WIDTH	FUNCTI	ON VALUE 🔥	<u>Auto</u> Man
1 N 1 2 N 1	l f		2.4	02 00 GH; 41 00 GH;	z	2.397 dl 2.879 dl	3m					
3			2.4	4100 687	4	2.013 u						Freq Offset
4 5											=	0 Hz
6												
8												
10												
11 <						Ш					>	
MSG									STATU	S		
	_				_							

#### Hopping mode : Enable & GFSK

Number of Hopping Frequencies 2(FH)





### Number of Hopping Frequencies 1(FH)



Agilent Spectrum Analyzer - Swept SA					
LXURL RF 50Ω AC	CORREC	SENSE:INT	ALIGN OFF	01:48:47 PM Nov 27, 2017	Frequency
Center Freq 2.416500000	GHz		Avg Type: Log-Pwr Avg Hold:>100/100	TRACE 1 2 3 4 5 6 TYPE M WWWWW	riequency
		en: 30 dB	Avginola:>100/100	DETPPPPP	
	II Gam.cow			Auto Tune	
			MKr2	2 2.441 00 GHz	, and , and
10 dB/div Ref 20.00 dBm				2.506 dBm	
Log					
10.0					Center Freq
0.00	ᠬ᠕᠕᠕᠕᠕᠕	$\gamma \sim \sim$	$\sqrt{1}$	ᠰᡊ᠕ᡔᡳᡗᠯ᠕᠕᠕	2.416500000 GHz
-10.0					
-20.0					Start Freq
-30.0					2.391500000 GHz
-40.0					2.391500000 GH2
-50.0 manner maker of					04 <b>-</b>
-60.0					Stop Freq
-70.0					2.441500000 GHz
-70.0					
Start 2.39150 GHz				Stop 2.44150 GHz	05.04
#Res BW 200 kHz	#VBW 620			200 ms (1001 pts)	CF Step 5.000000 MHz
#Res Dw 200 RHz	#8D98 020	NI12	aweep I.	200 ms (1001 pts)	Auto Man
MKR MODE TRC SCL X		Y FUNCTI	ON FUNCTION WIDTH	FUNCTION VALUE	Auto Mari
		020 dBm			
2 N 1 f 2.44	41 00 GHz 2.9	506 dBm			Freq Offset
4					0 Hz
5					0 112
6					
8					
9					
10					
11				~	
Nee			071710		
MSG			STATUS		

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

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

ent So ctrum Analyzer ≜ Frequency Center Freq 2.466500000 GHz Avg Type: Log-Pwr Avg|Hold:>100/100 TRACE Trig: Free Run Atten: 30 dB PNO: Fast 😱 IFGain:Low Auto Tune Mkr2 2.480 00 GHz 1.087 dBm 0 dB/div Ref 20.00 dBm 1 **Center Freq** 2.466500000 GHz MAA Start Freq 2.441500000 GHz 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 <u>Auto</u> 2.442 00 GHz 2.480 00 GHz 2.895 dBm 1.087 dBm N Freq Offset 0 Hz



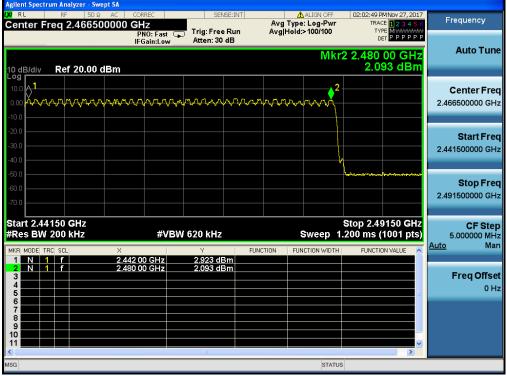
#### Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA KM RL RF 50Ω AC Center Freq 2.416500000	CORREC GHZ PNO: Fast C Tri	SENSE:INT	ALIGN OFF Avg Type: Log-Pwr Avg Hold:>100/100	02:01:47 PM Nov 27, 2017 TRACE 1 2 3 4 5 6 TYPE MWWWWW	Frequency
10 dB/div Ref 20.00 dBm	IFGain:Low Att	en: 30 dB	Mkr	2 2.441 00 GHz 2.528 dBm	Auto Tune
10.0 0.00 -10.0		ᡊᢧᡗᢏᡗ᠋ᡎᡘᢩᠵᢪᠧᡗᡀᡐᢧᢉᡶ	$\gamma$	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Center Freq 2.416500000 GHz
-20.0					Start Freq 2.391500000 GHz
-50.0					<b>Stop Freq</b> 2.441500000 GHz
Start 2.39150 GHz #Res BW 200 kHz MKR MODE TRC SCL X		Y FUNCI	Sweep 1	Stop 2.44150 GHz .200 ms (1001 pts) FUNCTION VALUE	CF Step 5.000000 MHz <u>Auto</u> Man
1 N 1 F 2.44 2 N 1 F 2.44 3		324 dBm 528 dBm			Freq Offset 0 Hz
7 8 9 10 11				~	
MSG			STATUS	· · · · · · · · · · · · · · · · · · ·	

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

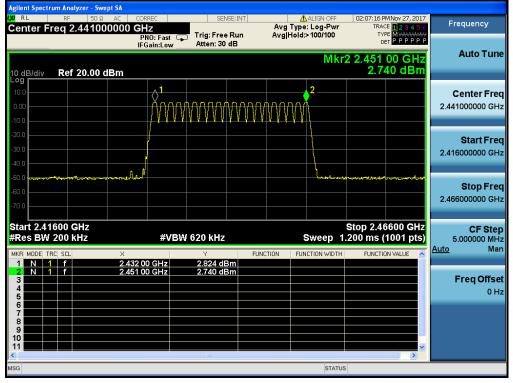
#### Hopping mode : Enable & 8DPSK





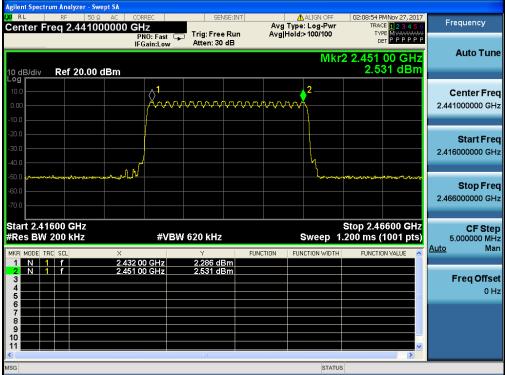
#### Number of Hopping Frequencies 1(AFH)





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

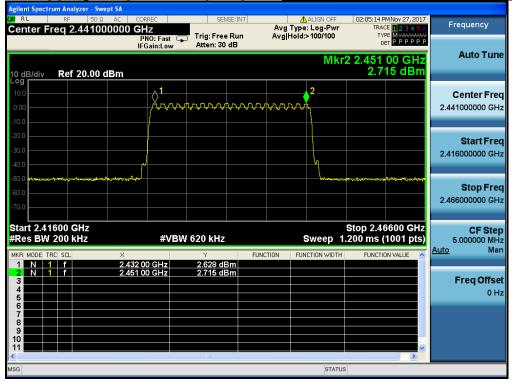
#### <u>Hopping mode : Enable & π/4-DQPSK</u>





#### 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)
Enable	DH 5	79	2.880	3.750	0.307
	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)
Enable	DH 5	20	2.880	3.750	0.154
	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 ×

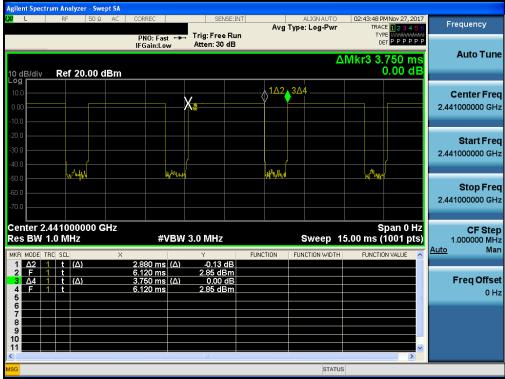
((Hopping rate ÷ Time slots) ÷ Hopping channel)

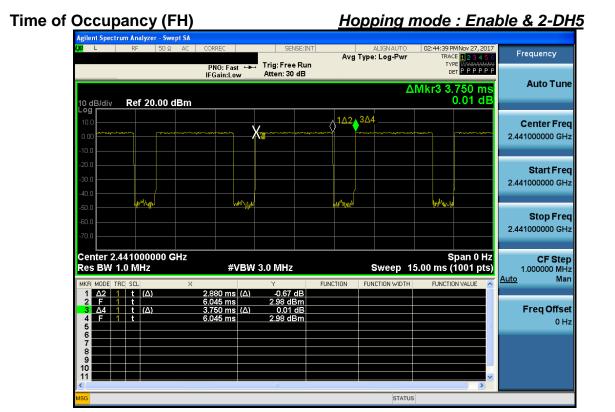
- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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



#### Time of Occupancy (FH)



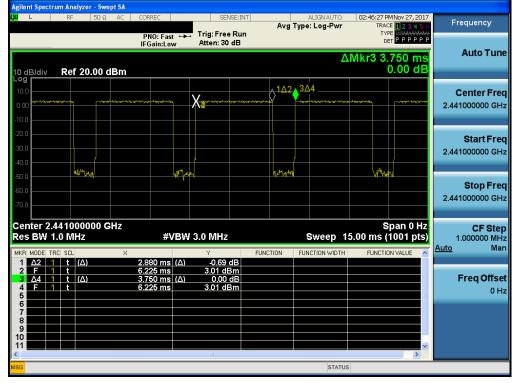


### Hopping mode : Enable & DH5



#### Hopping mode : Enable & 3-DH5

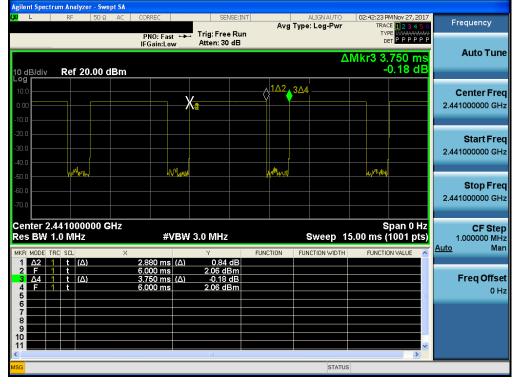
### Time of Occupancy (FH)





### Time of Occupancy (AFH)

#### Hopping mode : Enable & DH5



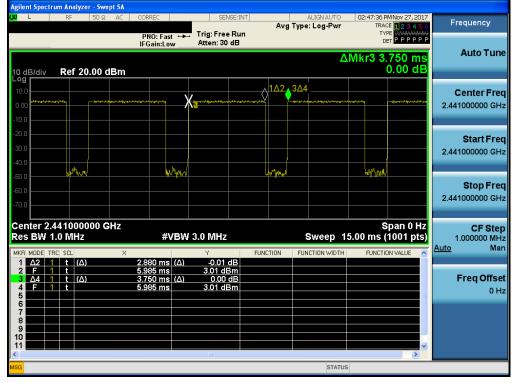
#### Time of Occupancy (AFH) SENSE:INT 02:45:17 PM Nov 27, 2017 Frequency Aug Type: Log-Pwr TRACE 7 2 3 Trig: Free Run Atten: 30 dB TYP DET P P P P P PNO: Fast IFGain:Low Auto Tune ΔMkr3 3.750 m -0.01 dE Ref 20.00 dBm I0 dB/div \_og r <u>1∆2</u>\_3∆4 **Center Freq** Xa 2.441000000 GHz Start Freq 2.441000000 GHz ulum where WW 1 Timb Stop Freq 2.441000000 GHz Span 0 Hz Sweep 15.00 ms (1001 pts) Center 2.441000000 GHz CF Step 1.000000 MHz Res BW 1.0 MHz #VBW 3.0 MHz Auto Man FUNCTION FUNCTION WIDTH FUNCTION 1 1 t (Δ) 1 t 1 t (Δ) 1 t (Δ) -0.52 dB 3.01 dBm -0.01 dB 3.01 dBm 0 ms (∆) Δ2 F ∆4 F 3.750 ms (Δ) 6.120 ms <u>120 ms</u> Freq Offset 4 0 Hz

### Hopping mode : Enable & 2-DH5



#### 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

- 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

#### 9 kHz ~ 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)
2388.79	V	Х	PK	45.94	0.70	N/A	N/A	46.64	74.00	27.36
2388.79	V	Х	AV	45.94	0.70	-24.79	N/A	21.85	54.00	32.15
4804.63	V	Х	PK	44.87	4.77	N/A	N/A	49.64	74.00	24.36
4804.63	V	Х	AV	44.87	4.77	-24.79	N/A	24.85	54.00	29.15

#### 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)
4882.10	V	Х	PK	45.04	5.11	N/A	N/A	50.15	74.00	23.85
4882.10	V	Х	AV	45.04	5.11	-24.79	N/A	25.36	54.00	28.64

#### 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)
2492.87	V	Х	PK	47.37	1.01	N/A	N/A	48.38	74.00	25.62
2492.87	V	Х	AV	47.37	1.01	-24.79	N/A	23.59	54.00	30.41
4959.94	V	Х	PK	44.94	5.34	N/A	N/A	50.28	74.00	23.72
4959.94	V	Х	AV	44.94	5.34	-24.79	N/A	25.49	54.00	28.51

#### Note.

1. The radiated emissions were investigated 9 kHz 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.



#### 9 kHz ~ 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)
2388.90	V	Х	PK	45.58	0.70	N/A	N/A	46.28	74.00	27.72
2388.90	V	Х	AV	45.58	0.70	-24.79	N/A	21.49	54.00	32.51
4804.23	V	Х	PK	44.38	4.77	N/A	N/A	49.15	74.00	24.85
4804.23	V	Х	AV	44.38	4.77	-24.79	N/A	24.36	54.00	29.64

#### 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)
4881.91	V	Х	PK	44.95	5.11	N/A	N/A	50.06	74.00	23.94
4881.91	V	Х	AV	44.95	5.11	-24.79	N/A	25.27	54.00	28.73

#### 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)
2493.09	V	Х	PK	46.01	1.01	N/A	N/A	47.02	74.00	26.98
2493.09	V	Х	AV	46.01	1.01	-24.79	N/A	22.23	54.00	31.77
4960.40	V	Х	PK	44.19	5.34	N/A	N/A	49.53	74.00	24.47
4960.40	V	Х	AV	44.19	5.34	-24.79	N/A	24.74	54.00	29.26

#### Note.

1. The radiated emissions were investigated 9 kHz 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.



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)
2389.24	V	Х	PK	45.16	0.70	N/A	N/A	45.86	74.00	28.14
2389.24	V	Х	AV	45.16	0.70	-24.79	N/A	21.07	54.00	32.93
4804.16	V	Х	PK	45.38	4.77	N/A	N/A	50.15	74.00	23.85
4804.16	V	Х	AV	45.38	4.77	-24.79	N/A	25.36	54.00	28.64

#### 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)
4881.69	V	Х	PK	44.28	5.10	N/A	N/A	49.38	74.00	24.62
4881.69	V	Х	AV	44.28	5.10	-24.79	N/A	24.59	54.00	29.41

#### 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)
2492.24	V	Х	PK	46.92	1.01	N/A	N/A	47.93	74.00	26.07
2492.24	V	Х	AV	46.92	1.01	-24.79	N/A	23.14	54.00	30.86
4959.69	V	Х	PK	44.67	5.34	N/A	N/A	50.01	74.00	23.99
4959.69	V	Х	AV	44.67	5.34	-24.79	N/A	25.22	54.00	28.78

#### Note.

1. The radiated emissions were investigated 9 kHz 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

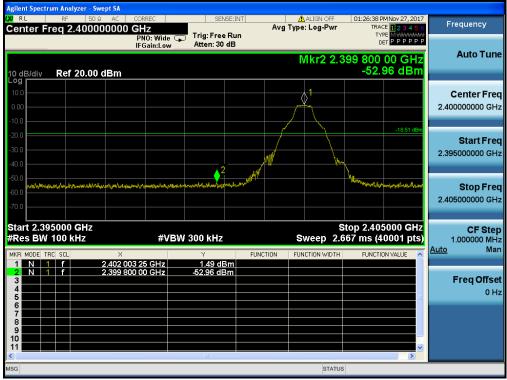
Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.

#### 7.4.2. Conducted Spurious Emissions



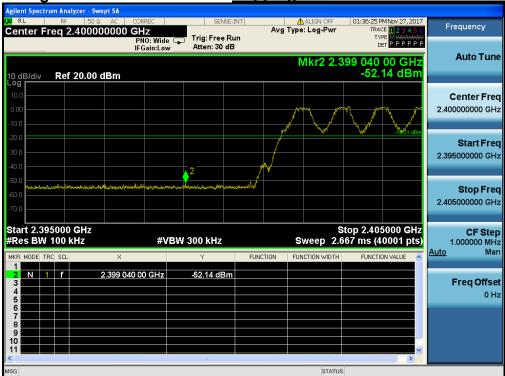
#### Low Band-edge

#### Lowest Channel & Modulation : GFSK



#### Low Band-edge

#### Hopping mode & Modulation : GFSK





### Conducted Spurious Emissions <u>Lowest Channel & Modulation : GFSK</u>

	pectrum /																					
ixi RL Cente			50 Q /					Tuinu	SENS	E:INT		Avg		ALIGN OF		T	RACE	lov 27, 20 2 3 4 5 1 00000	56	F	requency	
10 dB/c	div R	ef 20.	00 d	Bm		10: Fa Gain:Lo	ist 🖵 ow		n: 30 d						N	1kr2 2	DET F	PPPF	e P IZ		Auto Tur	ne
Log 10.0 -																					<b>Center Fr</b> 5.004500 Mi	
-20.0 -30.0 -40.0	2																	-18.51 dl	Bm		Start Fre 9.000 ki	1.1
-50.0 -60.0 -70.0	hope , i hope hits		handalar	det Party	haile dh	ning said	h daiye atta inka	ander for the start	19.16°).00.191	gäljasent dat	, وا <del>ن</del> ايور,	tanı-la	Ha. Hangar	Ndulhandar M <sup>a</sup> d		ing a the state of t	1.1900 p. 1.11	ing fright were	<b>/</b> **	3(	<b>Stop Fre</b> 0.000000 Mi	
MKR MOI	BW 10	CL		×	002			300 H			FUNC	TION		weep ction wid	_	33 ms				Auto	CF Ste 2.999100 Mi Mi	
1 N 3 4 5 6 7 8 9 10 11					283.	4 kHz 4 kHz		-48.9	1 dBr 1 dBr	n n 											Freq Offs 01	
MSG														STA		LDC C	Coupl	ed				





#### Lowest Channel & Modulation : GFSK





#### **Reference for limit**

#### Middle Channel & Modulation : GFSK



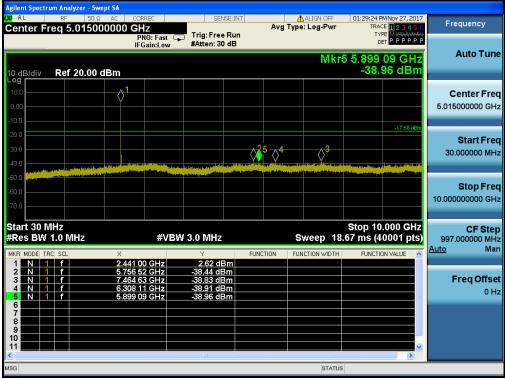
#### **Conducted Spurious Emissions**

#### Middle Channel & Modulation : GFSK

ilent Spectrum Analyzer Su B I ٨ 01:29:11 PM Nov 27, 2017 Frequency Center Freg 15.004500 MHz Avg Type: Log-Pwr Trig: Free Run #Atten: 30 dB TYPE MWWWWWW DET P P P P P PNO: Fast 😱 IFGain:Low Auto Tune Mkr2 310.4 kHz -48.57 dBm Ref 20.00 dBm 10 dB/div **Center Freq** 15.004500 MHz Start Freq 9 000 kHz Stop Freq 30.000000 MHz Stop 30.00 MHz Sweep 5.333 ms (40001 pts) Start 9 kHz #Res BW 100 kHz CF Step 2.999100 MHz #VBW 300 kHz Man Auto FUNCTION EUNCTION WIDTH FUNCTION VALUE 310.4 kHz 310.4 kHz -48.57 dBm -48.57 dBm N <u>1</u> 1 Freq Offset 0 Hz 11 DC Coupled



#### Middle Channel & Modulation : GFSK

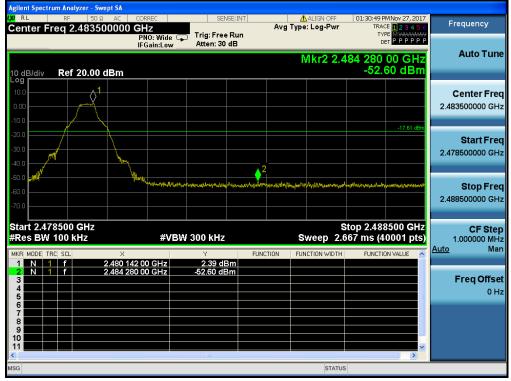






#### **High Band-edge**

### Highest Channel & Modulation : GFSK



#### **High Band-edge** m Analyzer - Swept SA 01:37:21 PM TRACE Avg Type: Log-Pwr Frequency Center Freq 2.483500000 GHz Trig: Free Run PNO: Wide 😱 IFGain:Low Atten: 30 dB Auto Tune Mkr2 2.485 460 00 GHz -51.97 dBm Ref 20.00 dBm 10 dB/div Log r **Center Freq** 2.483500000 GHz -17.61 di Start Freq 2.478500000 GHz Stop Freq 2.488500000 GHz Start 2.478500 GHz #Res BW 100 kHz Stop 2.488500 GHz Sweep 2.667 ms (40001 pts) CF Step 1.000000 MHz Man #VBW 300 kHz <u>Auto</u> FUNCTION FUNCTION WIDTH FUNCTION VALU 2.485 460 00 GHz -51.97 dBm N 1 f Freq Offset 0 Hz STATUS

### Hopping mode & Modulation : GFSK



### Highest Channel & Modulation : GFSK

	it Spectr																	
<b>lxi</b> R		RF		50 Ω 🧘 Ε		REC		SE	NSE:IN	IT			ALIGN OFF		01 PM Nov 27, 2		E	requency
Cen	ter F	req	15.00	)450(	) MHz			Trig: Fre	~ D		Avg	ype	: Log-Pwr	1	RACE 1 2 3 4	56		requeries
						NO: Fas Gain:Lo		Atten: 30		•					DET PPP	ΡP		
	_					Jamico				_		_						Auto Tune
														WKr2	286.4 kl	Z		
<u>1</u> 0 d	B/div	Re	f 20.0	)0 dB	m									-4	8.72 dB	m		
Log																		
10.0																		Center Freq
0.00																	16	5.004500 MHz
-10.0																		
															-17.61	dBm		
-20.0																		Start Fred
-30.0																		9.000 kHz
-40.0	2_																	5.000 KH2
-50.0	1																	Stop Freq
-60.0			e and where	in the second	المراقع الانباط	Margaret and a fill	internetingente	nya kangdana bina		estrady.	a share the	la series	depublic history and	ing detain the		hirite		
-70.0																	30	0.000000 MHz
10.0																		
Sta	t9k⊦	7				1								Stor	30.00 M	H7		CF Step
	sBW		kH7			#\	VRW 3	00 kHz				S	ween 5		(40001 p			cr Step 2.999100 MHz
						"										~/	Auto	Man
	MODE   TF				Х			Y		FUNG	CTION	FUN	CTION WIDTH	FUN	CTION VALUE	^	Auto	
1	N 1 N 1	f				.4 kHz .4 kHz		-48.72 d -48.72 d	Bm									_
3					200	<u>.4 KITZ</u>		-40.72 u										Freq Offset
4																		0 Hz
5		_														=		0112
6							<u> </u>											
8																		
9																		
10		_																
<		_																
MSG	_	_	_	_		_		_	_	_		-	STATE	S 🚺 DC (	Coupled	-		
DOW													STATU		Joupleu			





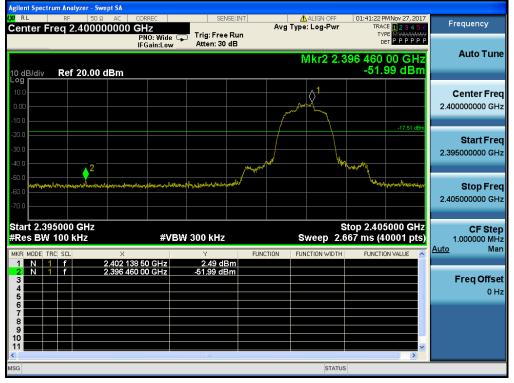
### Highest Channel & Modulation : GFSK





#### Low Band-edge

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



#### Low Band-edge

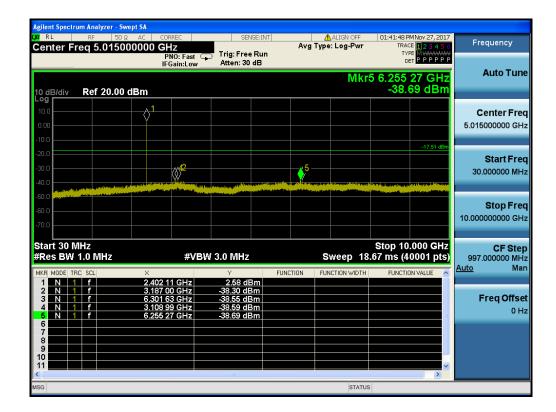
#### Hopping mode & Modulation : π/4DQPSK





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

Agilent Spectrum Analyzer - Swept SA					
📈 RL   RF   50 Ω 🧥 DC	CORREC	SENSE:INT	🛕 ALIGN OFF	01:41:34 PM Nov 27, 2017	Frequency
Center Freq 15.004500 M	Hz _		Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE M WWWWWW	riequency
		rig: Free Run .tten: 30 dB		DET PPPPP	
	IFGain:LUW F				Auto Tune
			1	vlkr2 285.7 kHz	Auto Tune
10 dB/div Ref 20.00 dBm				-48.84 dBm	
Log					
10.0					Center Freq
0.00					15.004500 MHz
-10.0					
				-17.51 dBm	
-20.0					Start Freq
-30.0					•
					9.000 kHz
-50.0					
-60.0	resident have a second a state of the second states	<u>مار المحافظ الم</u>	nutur, product a state of the product of the second states of the second	en provinsi and a state of the	Stop Freq
-70.0					30.000000 MHz
-70.0					
Start 9 kHz				Stop 30.00 MHz	
#Res BW 100 kHz	#VBW 30		Owner 52	33 ms (40001 pts)	CF Step
#Res BW TOO KHZ	#VEVV JU	V KHZ	Sweep 5.3		2.999100 MHz Auto Man
MKR MODE TRC SCL X		Y FUNCT	ION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
1 N 1 f	285.7 kHz -4	8.84 dBm			
2 N 1 f	<u>285.7 kHz</u> -∠	8.84 dBm			Freq Offset
4					•
5				=	0 Hz
6					
8					
9					
10					
11				~	
<		ш			
MSG			STATUS	L Coupled	





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



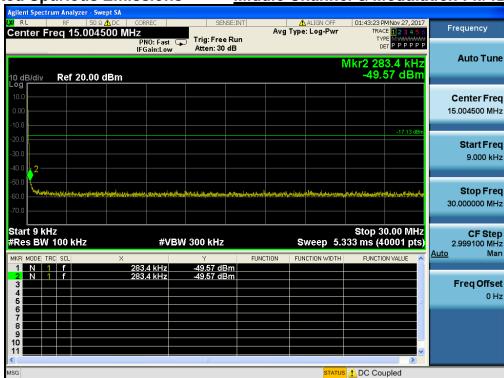


#### Reference for limit

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

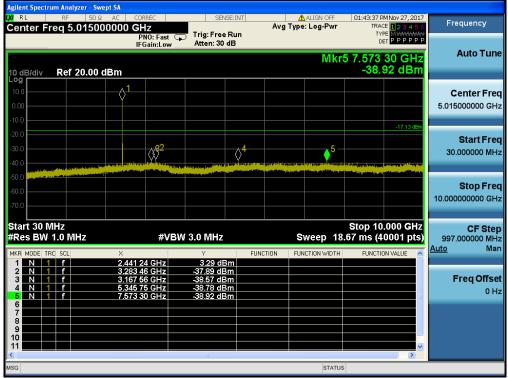


#### Conducted Spurious Emissions <u>Middle Channel & Modulation : π/4DQPSK</u>













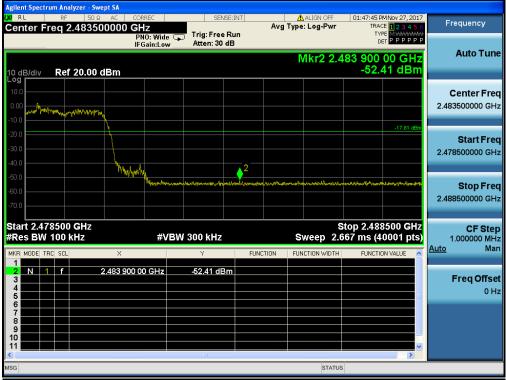
#### High Band-edge

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

Agilent Spectrum Analyzer - Swept SA					
LXU RL RF 50Ω AC	CORREC	SENSE:INT	ALIGN OFF	01:45:02 PM Nov 27, 2017	Frequency
Center Freq 2.483500000			g Type: Log-Pwr	TRACE 123456 TYPE MWWWWW	пециенсу
		Free Run n:30 dB		DETPPPPP	
	IFGain:Low Atter	n. 50 db			Auto Tune
			Mkr2 2.4	87 640 00 GHz	Auto Tune
10 dB/div Ref 20.00 dBm				-52.41 dBm	
Log					
10.0					Center Freq
0.00					2.483500000 GHz
and the second					2.483500000 GHZ
-10.0					
-20.0				-17.81 dBm	
					Start Freq
-30.0					2.478500000 GHz
-40.0					
-50.0	- And			▲2	
	Mary Martin Branning	A segular Amalian representation	moundance	untermetrallichter	Stop Freq
-60.0					
-70.0					2.488500000 GHz
Start 2.478500 GHz			G	top 2.488500 GHz	05.04+**
#Res BW 100 kHz	#VBW 300			67 ms (40001 pts)	CF Step 1.000000 MHz
WRES BW 100 KHZ	#8D88 300 P	4112	Sweep 2.0	707 ms (40001 pts)	Auto Man
MKR MODE TRC SCL X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	Auto Wan
1 N 1 f 2.480 1;	29 25 GHz 2.1	9 dBm			
2 N 1 f 2.487 64	40 00 GHz -52.4	1 dBm			Freq Offset
4					
5				i i i i i i i i i i i i i i i i i i i	0 Hz
6					
7					
8					
10					
11				~	
<				>	
MSG			STATUS	5	
				1	

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

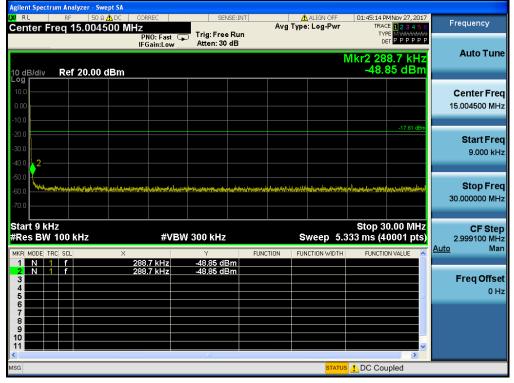
#### <u>High Band-edge</u>





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

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







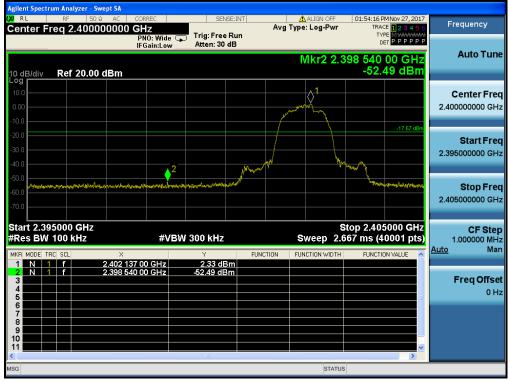
#### Highest Channel & Modulation : π/4DQPSK





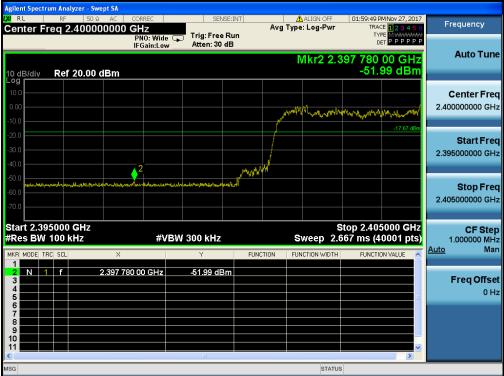
#### Low Band-edge

#### Lowest Channel & Modulation : 8DPSK



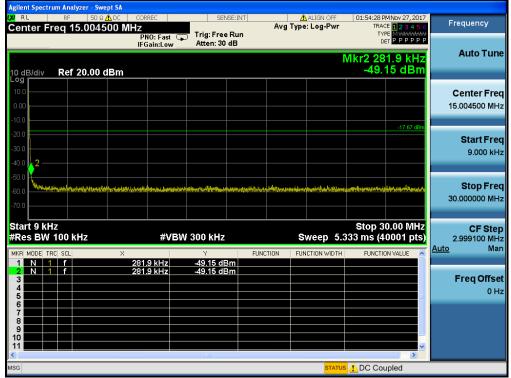
#### Low Band-edge

#### Hopping mode & Modulation : 8DPSK





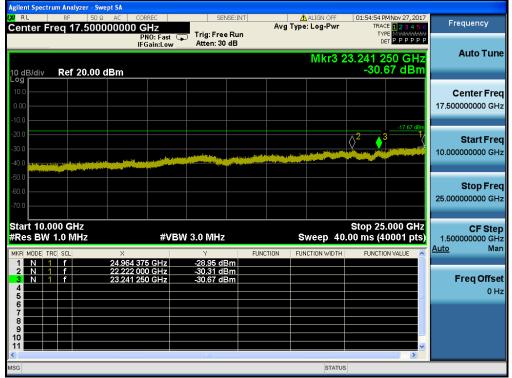
#### Lowest Channel & Modulation : 8DPSK







#### Lowest Channel & Modulation : 8DPSK





#### **Reference for limit**

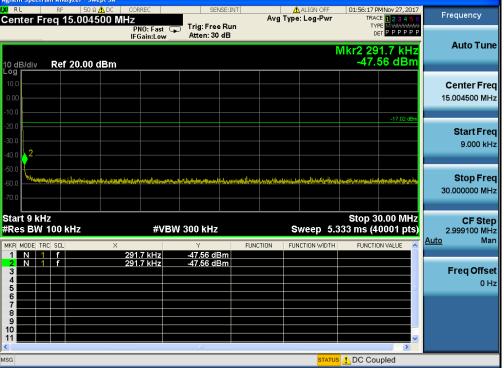
#### Middle Channel & Modulation : 8DPSK



#### **Conducted Spurious Emissions**

#### Middle Channel & Modulation : 8DPSK

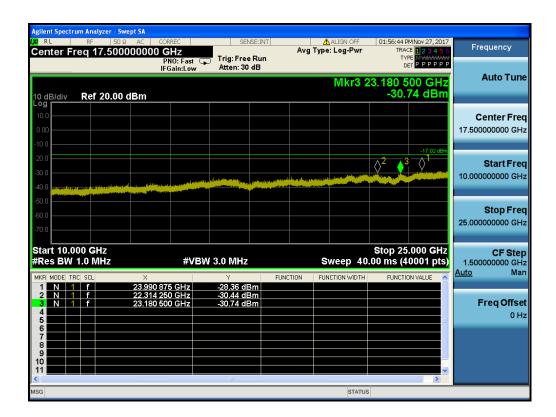
#### ent Spectrum Analyzer Swent Si





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

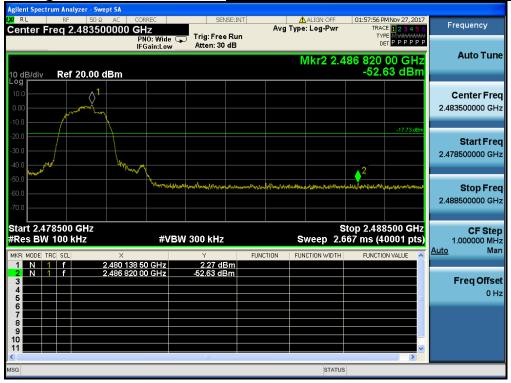






#### High Band-edge

### Highest Channel & Modulation : 8DPSK



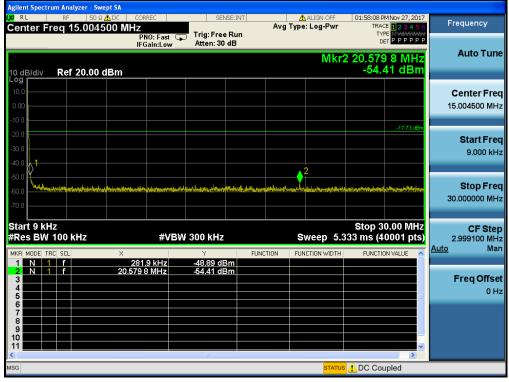
#### High Band-edge

#### Hopping mode & Modulation : 8DPSK













#### Highest Channel & Modulation : 8DPSK



### 8. Transmitter AC Power Line Conducted Emission

#### 8.1 Test Setup

NA

#### 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.

Frequency Range (MHz)	Conducted Limit (dBuV)				
Frequency Range (Minz)	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

NA



## 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.)

#### - 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	0.880
<u>GFSK</u>	Middle	0.877
	Highest	0.881
	Lowest	1.159
<u>π/4DQPSK</u>	Middle	1.158
	Highest	1.160
	Lowest	1.155
<u>8DPSK</u>	Middle	1.163
	Highest	1.161



#### Occupied Bandwidth (99 %)

#### Middle Channel & GFSK

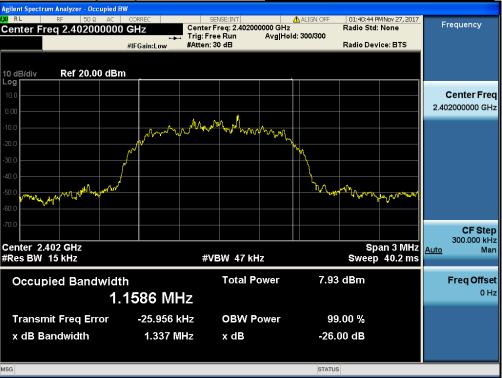
Lowest Channel & GFSK



Highest Channel & GFSK

#### Occupied Bandwidth (99 %)

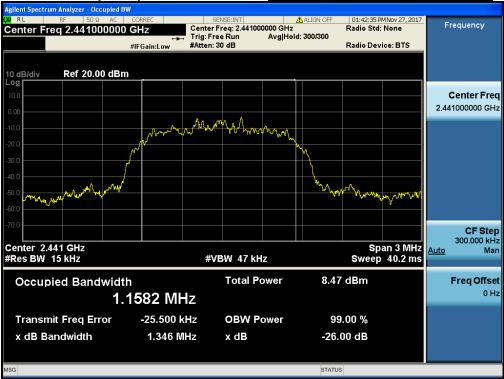




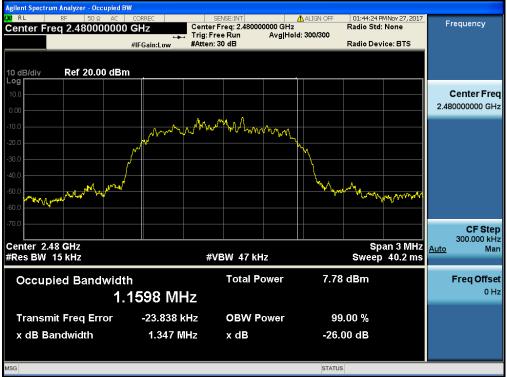
#### Occupied Bandwidth (99 %)

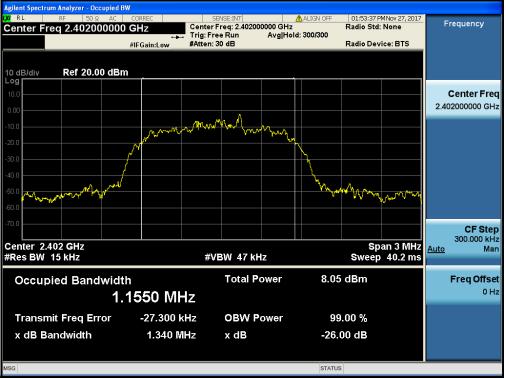
#### Middle Channel & π/4 DQPSK

Lowest Channel & π/4 DQPSK







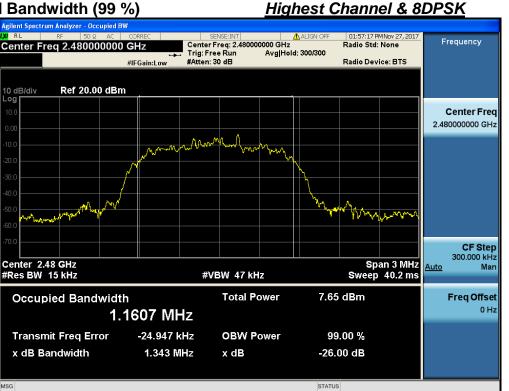


#### Occupied Bandwidth (99 %)

#### Middle Channel & 8DPSK

Lowest Channel & 8DPSK

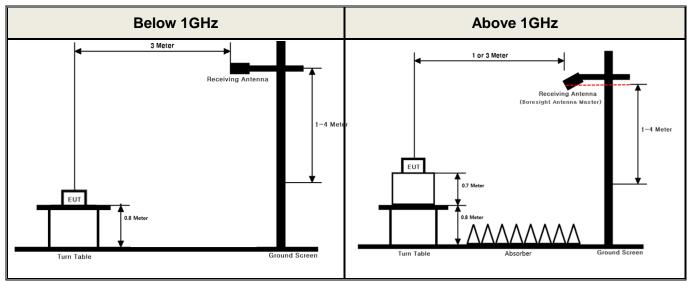




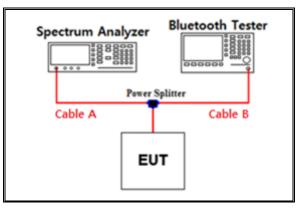
### **APPENDIX I**

#### Test set up diagrams

#### Radiated Measurement



Conducted Measurement



#### Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	6.23	15	9.80
1	7.03	20	11.05
2.402 & 2.441 & 2480	7.57	25	12.69
5	8.10	-	-
10	9.52	-	-

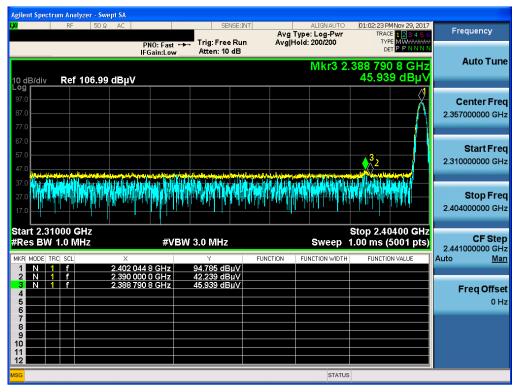
Note 1 : The path loss from EUT to Spectrum analyzer were measured and used for test.

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

### **APPENDIX II**

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

#### GFSK & Lowest & X & Ver



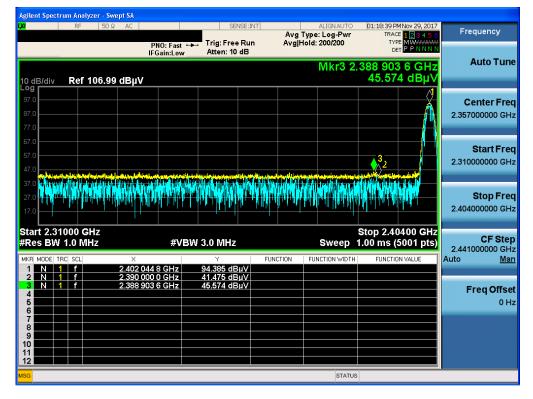
#### **Detector Mode : PK**

#### GFSK & Highest & X & Ver

Agilent Spectrum Analyzer - Swept SA				
LX/ RF 50Ω AC	SENSE	INT ALIGN AUTO Avg Type: Log-Pwr	12:58:59 PM Nov 29, 2017	Frequency
	PNO: Fast ↔ Trig: Free Ru IFGain:Low Atten: 10 dB		TRACE 123456 TYPE MWWWWWW DET PPNNNN	
10 dB/div Ref 106.99 dBµV		Mkr3 2	492 867 6 GHz 47.363 dBµV	Auto Tune
97.0 87.0 77.0				Center Fred 2.489000000 GH2
67.0 57.0 47.0			William and a start of the star	<b>Start Fred</b> 2.478000000 GH2
27.0 17.0				<b>Stop Free</b> 2.500000000 GH:
Start 2.47800 GHz #Res BW 1.0 MHz	#VBW 3.0 MHz	Sweep	Stop 2.50000 GHz 1.00 ms (5001 pts)	CF Step 2.441000000 GH
MKR MODE TRC SCL X	Y	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	Auto <u>Mar</u>
2 N 1 f 2.483 50	28 4 GHz 96.962 dBµV 00 0 GHz 42.453 dBµV 67 6 GHz 47.363 dBµV			Freq Offset 0 Hz
7 8 9 10				
MSG		STATUS		

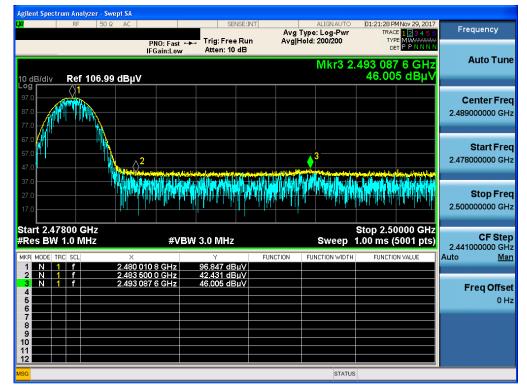


#### $\pi$ /4DQPSK & Lowest & X & Ver



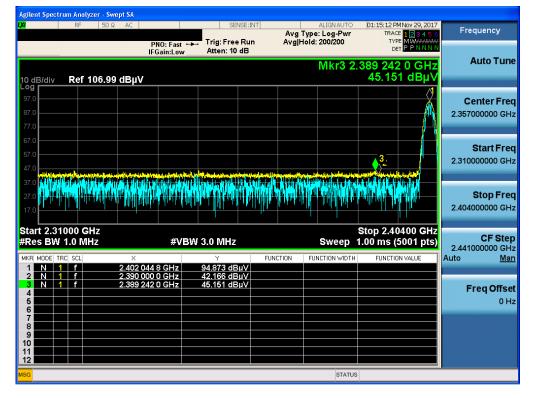
#### Detector Mode : PK

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



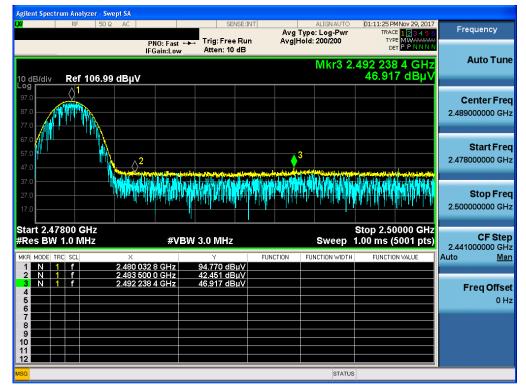


#### 8DPSK & Lowest & X & Ver



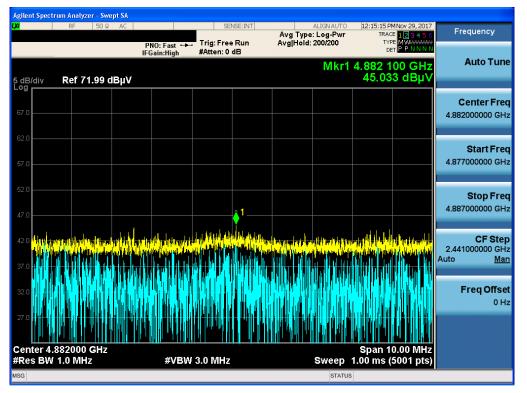
#### **Detector Mode : PK**

#### 8DPSK & Highest & X & Ver



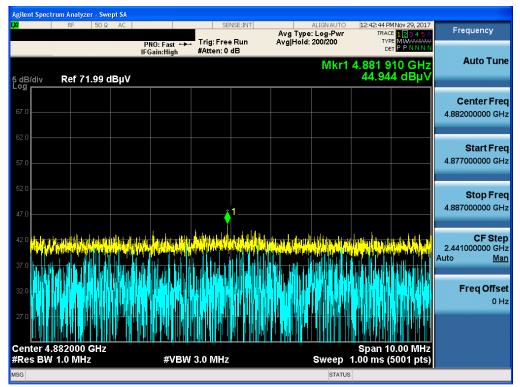


#### GFSK & Middle & X & Ver



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

#### **Detector Mode : PK**





#### 8DPSK & Lowest & X & Ver

