# **TEST REPORT**

# **T**Dt&C 4

## 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: DRTFCC1712-0272
- 2. Customer
  - Name : HYUNDAI MOBIS CO., LTD.
  - Address : 203 Teheran-ro, Gangnam-gu, Seoul, South Korea, 135-977
- 3. Use of Report : FCC Original Grant
- 4. Product Name / Model Name : DIGITAL CAR AUDIO SYSTEM / ADC40DLAN FCC ID : TQ8-ADC40DLAN
- 5. Test Method Used : ANSI C63.10-2013

Test Specification : FCC Part 15 Subpart C.247

- 6. Date of Test : 2017.12.04 ~ 2017.12.11
- 7. Testing Environment : See appended test report.
- 8. Test Result : Refer to the attached test result.

Affirmation	Tested by		Technical Manager	light
	Name : JungWoo Kim	SAHATURE)	Name : GeunKi Son	(Signature)

The test 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 purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

2017.12.15.

## 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
DRTFCC1712-0272	Dec. 15, 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

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Telephone	:	+ 82-31-321-2664	
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## **1.2 Testing Environment**

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

## **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	1.0 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	:	HYUNDAI MOBIS CO., LTD.
Address	:	203 Teheran-ro, Gangnam-gu, Seoul, Korea, 135-977
Contact person	:	Seung Hoon Choe

## 1.5 Description of EUT

EUT	DIGITAL CAR AUDIO SYSTEM
Model Name	ADC40DLAN
Add Model Name	-
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/4DQPSK, 8DPSK
Number of Channels	79
Antenna Type /Antenna Gain	Chip Antenna / PK : -0.10 dBi

## **1.6 Support Equipment**

Equipment	Manufacturer	Model No.	Note
-	-	-	-
-	-	-	-

## **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
Power Splitter	Anritsu	K241B	17/01/11	18/01/11	1701101
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	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 C63.5-2017.

## 1.9 Summary of Test Results

FCC Part RSS Std.	Parameter	Limit (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	er 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		NA		
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		
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 1 : C = Comply       NC = Not Comply       NT = Not Tested       NA = Not Applicable         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

 $RBW \ge 20 \text{ dB BW}$  $VBW \ge RBW$ Sweep = autoDetector function = peak Trace = max hold

## 2.4 Test Results

Modulation	Tested Channel		Average t Power	Peak Output Power	
	resteu Ghanner	dBm	mW	dBm	mW
	Lowest	0.59	1.15	1.45	1.40
<u>GFSK</u>	Middle	0.90	1.23	2.11	1.63
	Highest	0.65	1.16	1.61	1.45
	Lowest	-1.05	0.79	2.09	1.62
<u>π/4DQPSK</u>	Middle	-0.55	0.88	2.77	1.89
	Highest	-0.94	0.81	2.33	1.71
<u>8DPSK</u>	Lowest	-1.06	0.78	2.73	1.88
	Middle	-0.55	0.88	3.44	2.21
	Highest	-0.95	0.80	3.00	2.00

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.



**Peak Output Power** 

## Lowest Channel & Modulation : GFSK

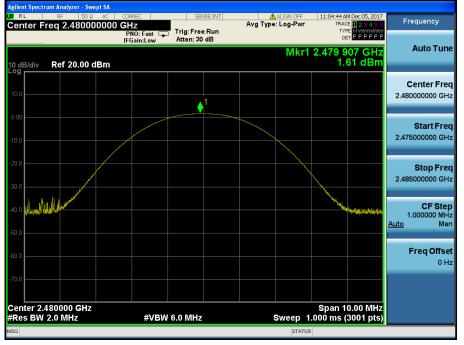


#### **Peak Output Power** Middle Channel & Modulation : GFSK Agilent Spectrum Analyzer - Swept SA :56 AM Dec 05, 201 ALIGN OFF 11:0 Frequency Center Freq 2.441000000 GHz PN0: Fast C IFGain:Low Atten: 30 dB TYPE PPPPP Mkr1 2.440 983 GHz 2.11 dBm Auto Tune 10 dB/div Ref 20.00 dBm **Center Freq** 2.441000000 GHz Start Freq 2.436000000 GHz Stop Freq 2.446000000 GHz ANNA DADANA **CF Step** 1.000000 MHz Man Auto Freq Offset 0 Hz Span 10.00 MHz Sweep 1.000 ms (3001 pts) Center 2.441000 GHz #Res BW 2.0 MHz #VBW 6.0 MHz



**Peak Output Power** 

## Highest Channel & Modulation : GFSK



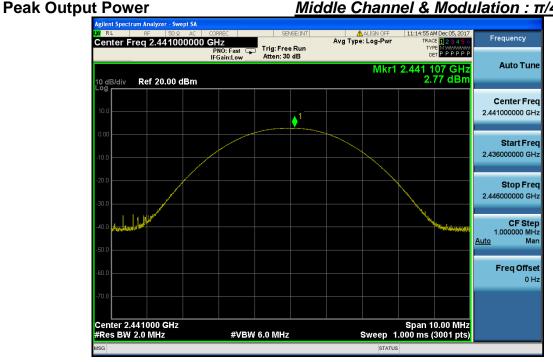
## **Peak Output Power**

## Lowest Channel & Modulation : π/4DQPSK





## Middle Channel & Modulation : π/4DQPSK



## **Peak Output Power**

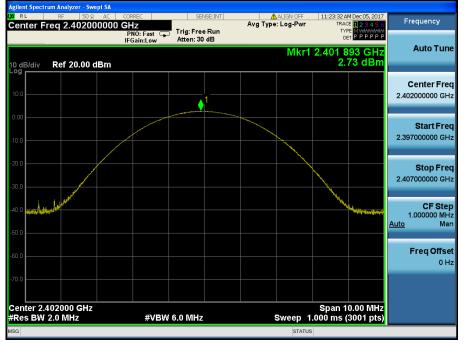
## Highest Channel & Modulation : π/4DQPSK





**Peak Output Power** 

## Lowest Channel & Modulation : 8DPSK



## **Peak Output Power**

## Middle Channel & Modulation : 8DPSK





**Peak Output Power** 

## 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	0.888		
<u>GFSK</u>	Middle	0.926		
	Highest	0.888		
	Lowest	1.305		
<u>π/4DQPSK</u>	Middle	1.305		
	Highest	1.308		
	Lowest	1.266		
<u>8DPSK</u>	Middle	1.258		
	Highest	1.262		

## 3.4 Test Results



## Lowest Channel & Modulation : GFSK



## 20 dB Bandwidth

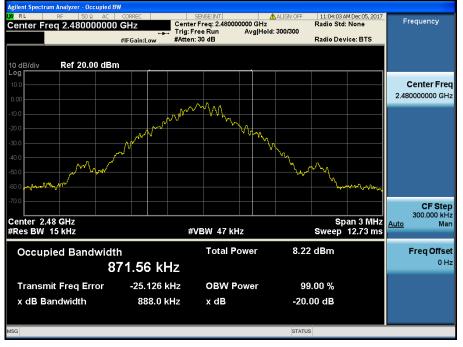
#### Middle Channel & Modulation : GFSK I SENSE:INT ▲ ALIGN OFF Center Freq: 2.441000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 30 dB 11:02:14 AM Dec 05, 201 Radio Std: None Frequency Center Freq 2.441000000 GHz #IFGain:Low Radio Device: BTS Ref 20.00 dBm 0 dB/div **Center Freq** 2.441000000 GHz m W CF Step 300.000 kHz Center 2.441 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms Man <u>Auto</u> #VBW 47 kHz Freq Offset Total Power 8.78 dBm Occupied Bandwidth 0 Hz 870.86 kHz -27.008 kHz Transmit Freq Error **OBW Power** 99.00 % x dB Bandwidth 925.8 kHz x dB -20.00 dB STATUS



# **Dt&C**

## 20 dB Bandwidth

## Highest Channel & Modulation : GFSK



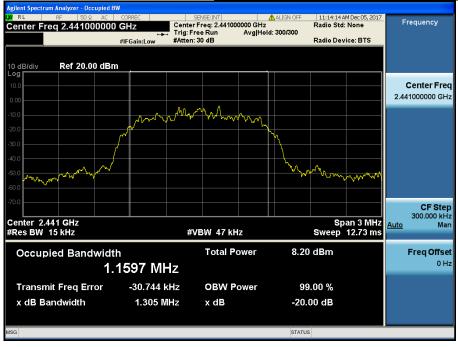
## 20 dB Bandwidth

## Lowest Channel & Modulation : π/4DQPSK



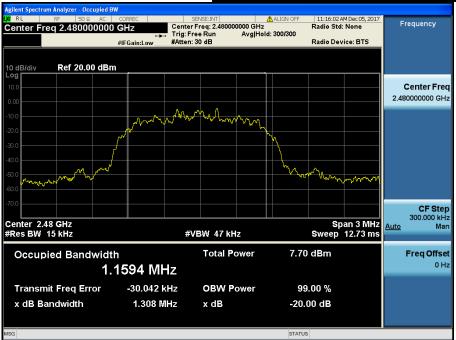


## Middle Channel & Modulation : π/4DQPSK



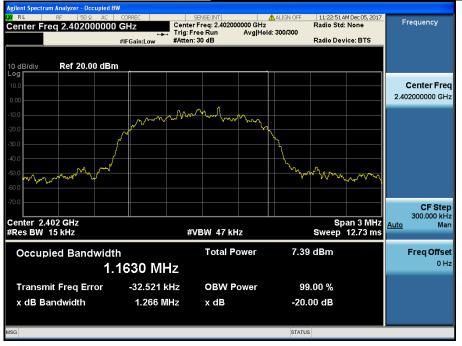
## 20 dB Bandwidth

## Highest Channel & Modulation : π/4DQPSK





## Lowest Channel & Modulation : 8DPSK

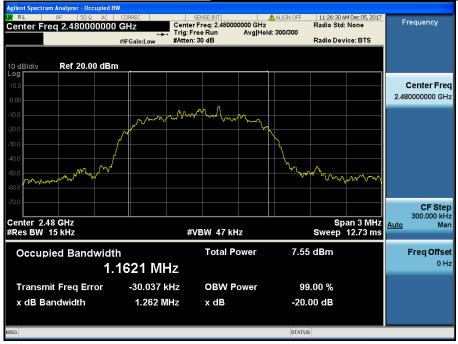


## 20 dB Bandwidth

#### Middle Channel & Modulation : 8DPSK I SENSE:INT ▲ ALIGN OFF Center Freq: 2.441000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 30 dB 11:24:41 AM Dec 05, 201 Radio Std: None Frequency Center Freq 2.441000000 GHz #IFGain:Low Radio Device: BTS Ref 20.00 dBm 10 dB/div **Center Freq** 2.441000000 GHz An WW w CF Step 300.000 kHz Center 2.441 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms Man <u>Auto</u> #VBW 47 kHz Freq Offset Total Power 8.09 dBm Occupied Bandwidth 0 Hz 1.1606 MHz -30.362 kHz **OBW Power** 99.00 % Transmit Freq Error x dB Bandwidth 1.258 MHz x dB -20.00 dB STATUS









## 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)
	GFSK	2440.979	2441.981	1.002
Enable	π/4DQPSK	2440.979	2441.978	0.999
	8DPSK	2440.979	2441.981	1.002

## AFH mode

Hopping Mode	Modulation Peak of center channel (MHz)		Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2440.976	2441.978	1.002
Enable	π/4DQPSK	2440.982	2441.981	0.999
	8DPSK	2440.976	2441.978	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



## Carrier Frequency Separation (FH)

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





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

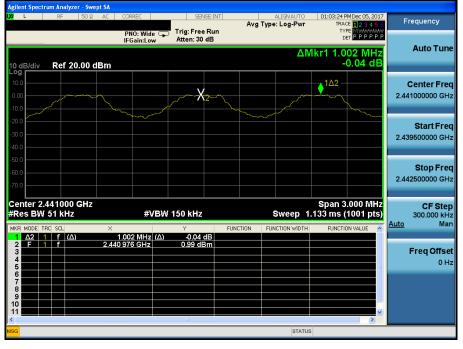
## Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA					
<b>LX</b> I L RF 50Ω AC	CORREC	SENSE:INT	ALIGNAUTO Avg Type: Log-Pwr	01:32:02 PMDec 05, 2017 TRACE 1 2 3 4 5 6	Frequency
10 dB/div Ref 20.00 dBm	PNO: Wide 🖵 IFGain:Low	Atten: 30 dB	ΔΝ	түре Мумини Det Р Р Р Р Р Р Р 1kr1 1.002 MHz -0.05 dB	Auto Tune
Log 10.0 0.00 -10.0	~~~~~	X_2~		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
Center 2.441000 GHz #Res BW 51 kHz	#VBW	150 kHz	-	Span 3.000 MHz .133 ms (1001 pts)	CF Step 300.000 kHz Auto Man
MKR MODE TRC SCI         X           1         Δ2         1         f         (Δ)           2         F         1         f         2.4/3           4         -         -         -         -           5         -         -         -         -           7         -         -         -         -           9         -         -         -         -           9         -         -         -         -           11         -         -         -         -	1.002 MHz (Δ) 10 979 GHz	Y FL -0.05 dB 1.03 dBm	INCTION FUNCTION WIDTH	FUNCTION VALUE	Freq Offset 0 Hz
MSG			STATUS	3	



## Carrier Frequency Separation (AFH)

## Hopping mode : Enable & GFSK



## **Carrier Frequency Separation (AFH)**

## Hopping mode : Enable & π/4DQPSK





## Carrier Frequency Separation (AFH)

## Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA X/ L RF 50 Ω AC	CORREC SENSE:INT	ALIGNAUTO	02:15:38 PMDec 05, 2017	
L Kr JUM AC		Avg Type: Log-Pwr	TRACE 123456	Frequency
10 dB/div Ref 20.00 dBm	PNO: Wide 🖵 Trig: Free Run IFGain:Low Atten: 30 dB	ΔΛ	Ikr1 1.002 MHz 0.03 dB	Auto Tune
Log 10.0 0.00 -10.0	~~~~X2~~			Center Freq 2.441000000 GHz
-20.0				Start Fred 2.439500000 GHz
-50.0				<b>Stop Fred</b> 2.442500000 GH:
Center 2.441000 GHz #Res BW 51 kHz MKR MODE TRC SCL ×		Sweep 1	Span 3.000 MHz .133 ms (1001 pts) FUNCTION VALUE	CF Step 300.000 kH <u>Auto</u> Mar
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.002 MHz (Δ) 0.03 dB 40 976 GHz 1.02 dBm			Freq Offset 0 Hz
7 8 9 10 11			×	
ISG		STATU		



## **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 or the 20 dB bandwidth, w		less than 30% of the channel spacing
VBW ≥ RBW	Sweep = auto	
Detector function = peak	Trace = max hold	

## 5.4 Test Results

## FH mode

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

## AFH mode

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

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

## - Minimum Standard :

At least 15 hopes



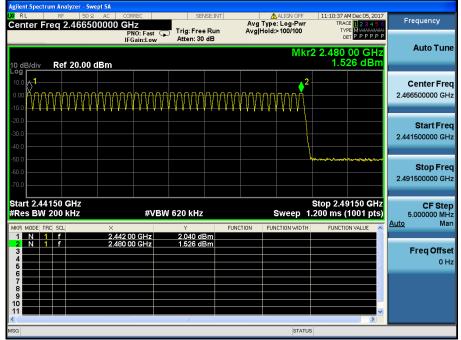
## Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & GFSK

Agient Spectrum (X) RL Center Fre	RF 50 Ω	AC   COR 00000 GH		Trig: Free		ALIGN OFF :: Log-Pwr >100/100	TRA	M Dec 05, 2017 26 <b>1 2 3 4 5 6</b> PE M WWWWWW ET P P P P P P	Frequency
10 dB/div	Ref 20.00 (	IFG	ain:Low	Atten: 30	dB	Mkr	2 2.441	00 GHz 41 dBm	Auto Tune
Log 10.0 0.00 -10.0			NVVV	MM					Center Freq 2.416500000 GHz
-20.0 -30.0 -40.0									<b>Start Freq</b> 2.391500000 GHz
-50.0									<b>Stop Freq</b> 2.441500000 GHz
Start 2.391: #Res BW 20	00 kHz	×	#VBV	∕ 620 kHz	FUN		.200 ms (	150 GHz 1001 pts)	CF Step 5.000000 MHz <u>Auto</u> Man
	f f	2.402 00 2.441 00		1.400 dE 1.941 dE	3m				Freq Offset 0 Hz
7 8 9 10 11								v	
MSG						STATUS	1		

## Number of Hopping Frequencies 2(FH)







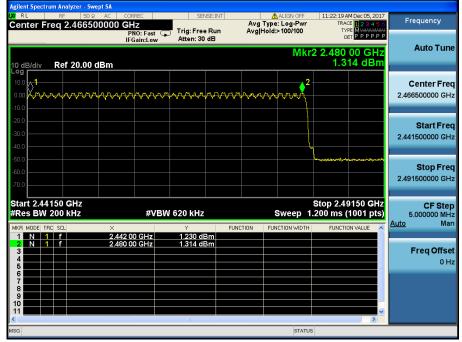
## Number of Hopping Frequencies 1(FH)

## Hopping mode : Enable & π/4DQPSK

xi RL Cento	er Fro	<sub>RF</sub> eq 2		Ω AC	CORRI	z	Tria	SENS : Free l	E:INT		ALIGN OFF ype: Log-Pw old:>100/100	/r 1	17 AM Dec 05, 2017 IRACE 1 2 3 4 5 ( TYPE M		Frequency
10 dB/	/div	Ref	20.00	dBm		D: Fast ⊂ nin:Low		in: 30 d		orgin		kr2 2.44	1 00 GHz	ī	Auto Tune
Log - 10.0 - 0.00 -					᠋ᡎᢧᠬᢧ	᠋᠈ᡩᢦᢌᡗᢦ	mp-yn-yn	ᠵ᠋᠊ᡞ᠊ᠰᡗ	᠋᠂ᠰᡗ᠊ᠰᠰ		$\sim$	ᢣᡧᡘᢇᡘ	un and		<b>Center Freq</b> 2.416500000 GHz
-20.0 - -30.0 - -40.0 -															<b>Start Freq</b> 2.391500000 GHz
-50.0 • -60.0 - -70.0 -	1997 (1984 1994) 1997 (1997 (1997 1994)	1999 - 19	n den of												<b>Stop Freq</b> 2.441500000 GHz
Start #Res		200   SCL		×			W 620		FUNC	CTION	Sweep FUNCTION WID	1.200 m	.44150 GHz s (1001 pts) CTION VALUE		CF Step 5.000000 MHz uto Man
2 3 4 5	N 1 N 1	f		2.4	402 00 441 00	GHz GHz		59 dB 07 dB							<b>Freq Offset</b> 0 Hz
6 7 8 9 10 11													~		
MSG							11	i			STA	TUS			

## Number of Hopping Frequencies 2(FH)

## Hopping mode : Enable & π/4DQPSK





## Number of Hopping Frequencies 1(FH)

## Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA	CORREC SEN	VSE:INT	ALIGN OFF 11:31:15	AM Dec 05, 2017	
Center Freq 2.416500000	GHz PNO: Fast Trig: Free	Avg Type Run Avg Hold:	:Log-Pwr TR		Frequency
10 dB/div Ref 20.00 dBm	IFGain:Low Atten: 30	dB	Mkr2 2.441		Auto Tune
10.0 0.00 -10.0		man man	ᡔᢧ᠊ᠬᠵᠼᠰ	vvvvv	Center Freq 2.416500000 GHz
-20.0					<b>Start Freq</b> 2.391500000 GHz
-50.0					<b>Stop Freq</b> 2.441500000 GHz
Start 2.39150 GHz #Res BW 200 kHz	#VBW 620 kHz		Sweep 1.200 ms		CF Step 5.000000 MHz Auto Man
2 N 1 f 2.44 3 4 5 6 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	02 00 GHz 0.989 dE 41 00 GHz 2.014 dE	3m	ECTION WIDTH FUNCT	ION VALUE	Freq Offset 0 Hz
7 8 9 9 10 11					
MSG			STATUS		

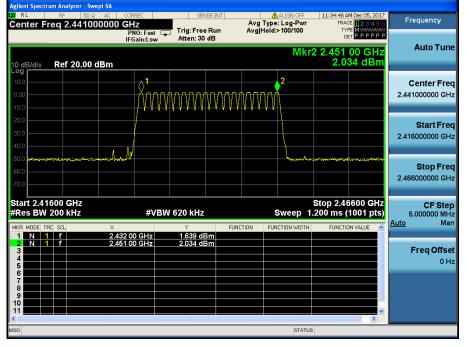
## Number of Hopping Frequencies 2(FH)

## Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA				
Center Freq 2.466500000	CORREC SENSE:INT	ALIGN OFF Avg Type: Log-Pwr	11:32:17 AM Dec 05, 2017 TRACE 2 3 4 5 6	Frequency
10 dB/div Ref 20.00 dBm	PNO: Fast Trig: Free Run IFGain:Low Atten: 30 dB	Avg Hold>100/100 Mkr:	түре рет Р Р Р Р Р Р Р 2 2.480 00 GHz 0.445 dBm	Auto Tune
Log 10.0 1 0.00 A, 4 -10.0	maa			Center Freq 2.466500000 GHz
-20.0		 		Start Freq 2.441500000 GHz
-60.0 -60.0 -70.0				Stop Freq 2.491500000 GHz
Start 2.44150 GHz #Res BW 200 kHz	#VBW 620 kHz	Sweep 1.	Stop 2.49150 GHz 200 ms (1001 pts)	CF Step 5.000000 MHz Auto Mar
	42 00 GHz 1.622 dBm	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	
2 N 1 f 2.4 3 4 5 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	80 00 GHz 0.445 dBm		=	Freq Offset 0 Hz
0         0           7         0           8         0           9         0           10         0				
11 <	III		×	
MSG		STATUS		

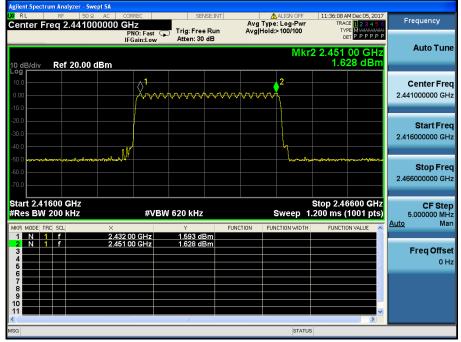
## Number of Hopping Frequencies 1(AFH)

Hopping mode : Enable & GFSK



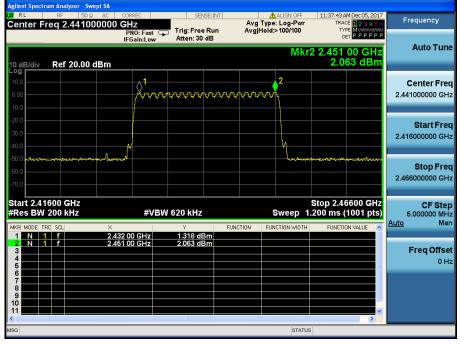
## Number of Hopping Frequencies 1(AFH)





## Number of Hopping Frequencies 1(AFH)

## Hopping mode : Enable & 8DPSK



## 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 ×

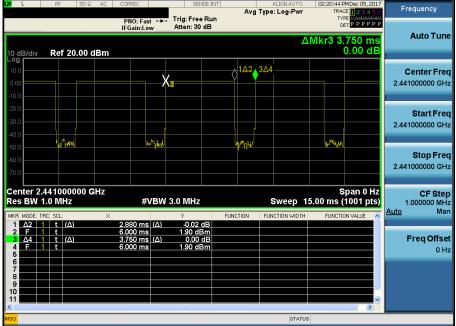
((Hopping rate ÷ Time slots) ÷ Hopping channel)

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

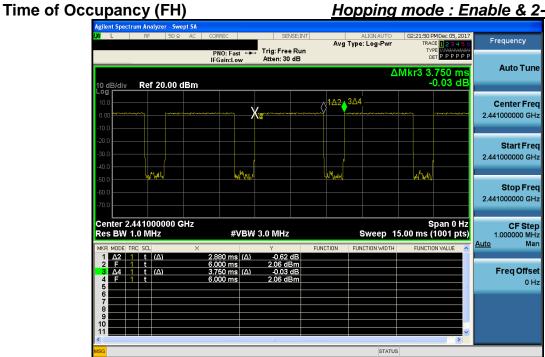
Note 2 : See next pages for actual measured spectrum plots.







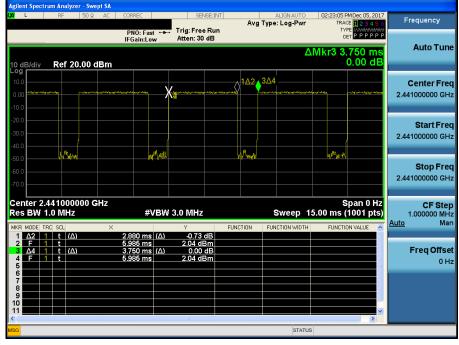
## Hopping mode : Enable & 2-DH5





## Hopping mode : Enable & 3-DH5

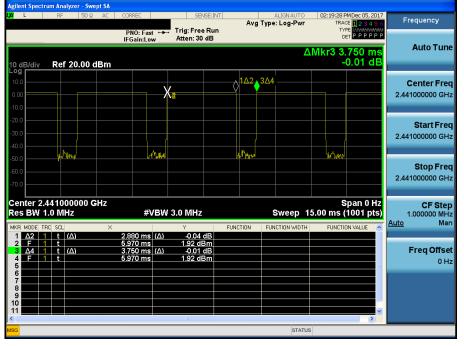
## Time of Occupancy (FH)





### Hopping mode : Enable & DH5

### Time of Occupancy (AFH)



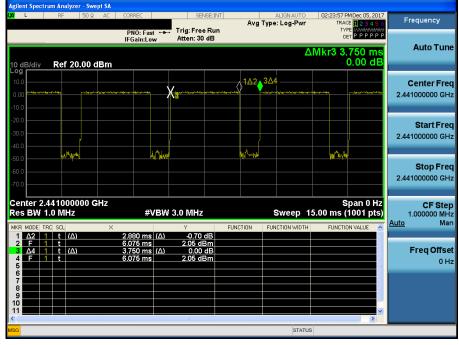
#### Time of Occupancy (AFH)

#### Hopping mode : Enable & 2-DH5 Frequency Avg Type: Log-Pwr Trig: Free Run Atten: 30 dB TYPE DET PPPPP PNO: Fast +++ Auto Tune ΔMkr3 3.750 ms 0.01 dB Ref 20.00 dBm B/div $|\Delta 2$ **Center Freq** X 2.441000000 GHz Start Freq 2.441000000 GHz Johngh w/Mydyla Mus Stop Freq 2.441000000 GHz Center 2.441000000 GHz Res BW 1.0 MHz CF Step 1.000000 MHz Man Span 0 Hz Sweep 15.00 ms (1001 pts) #VBW 3.0 MHz <u>Auto</u> FUNCTION FUNCTION V (A) 2.04 dBm 0.01 dB 2.04 dBm is is (∆) Freq Offset 3.750 n 5.970 n 0 Hz



### 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

#### 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)
2389.09	V	Х	PK	46.07	0.70	N/A	N/A	46.77	74.00	27.23
2389.09	V	Х	AV	46.07	0.70	-24.79	N/A	21.98	54.00	32.02
4803.98	V	Х	PK	45.11	4.77	N/A	N/A	49.88	74.00	24.12
4803.98	V	Х	AV	45.11	4.77	-24.79	N/A	25.09	54.00	28.91

#### 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)
4882.03	V	Х	PK	45.68	5.11	N/A	N/A	50.79	74.00	23.21
4882.03	V	Х	AV	45.68	5.11	-24.79	N/A	26.00	54.00	28.00

#### 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)
2483.67	V	Х	PK	51.60	0.94	N/A	N/A	52.54	74.00	21.46
2483.67	V	Х	AV	51.60	0.94	-24.79	N/A	27.75	54.00	26.25
4959.80	V	Х	PK	46.09	5.34	N/A	N/A	51.43	74.00	22.57
4959.80	V	Х	AV	46.09	5.34	-24.79	N/A	26.64	54.00	27.36

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)
2380.58	V	Х	PK	45.38	0.66	N/A	N/A	46.04	74.00	27.96
2380.58	V	Х	AV	45.38	0.66	-24.79	N/A	21.25	54.00	32.75
4804.09	V	Х	PK	44.82	4.77	N/A	N/A	49.59	74.00	24.41
4804.09	V	Х	AV	44.82	4.77	-24.79	N/A	24.80	54.00	29.20

#### 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)
4881.70	V	Х	PK	44.96	5.10	N/A	N/A	50.06	74.00	23.94
4881.70	V	Х	AV	44.96	5.10	-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)
2483.91	V	Х	PK	49.27	0.94	N/A	N/A	50.21	74.00	23.79
2483.91	V	Х	AV	49.27	0.94	-24.79	N/A	25.42	54.00	28.58
4959.58	V	Х	PK	44.84	5.34	N/A	N/A	50.18	74.00	23.82
4959.58	V	Х	AV	44.84	5.34	-24.79	N/A	25.39	54.00	28.61

#### 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.



#### 9 kHz ~ 25 GHz Data (Modulation : <u>8DPSK</u>)

#### 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)
2388.89	V	Х	PK	46.22	0.70	N/A	N/A	46.92	74.00	27.08
2388.89	V	Х	AV	46.22	0.70	-24.79	N/A	22.13	54.00	31.87
4804.18	V	Х	PK	44.73	4.77	N/A	N/A	49.50	74.00	24.50
4804.18	V	Х	AV	44.73	4.77	-24.79	N/A	24.71	54.00	29.29

#### 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	45.40	5.11	N/A	N/A	50.51	74.00	23.49
4882.10	V	Х	AV	45.40	5.11	-24.79	N/A	25.72	54.00	28.28

#### 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)
2484.46	V	Х	PK	48.05	0.94	N/A	N/A	48.99	74.00	25.01
2484.46	V	Х	AV	48.05	0.94	-24.79	N/A	24.20	54.00	29.80
4960.31	V	Х	PK	45.17	5.34	N/A	N/A	50.51	74.00	23.49
4960.31	V	Х	AV	45.17	5.34	-24.79	N/A	25.72	54.00	28.28

#### 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

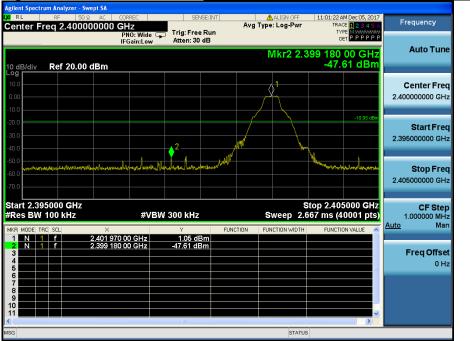
4. Sample Calculation.

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.



#### Low Band-edge



#### Lowest Channel & Modulation : GFSK

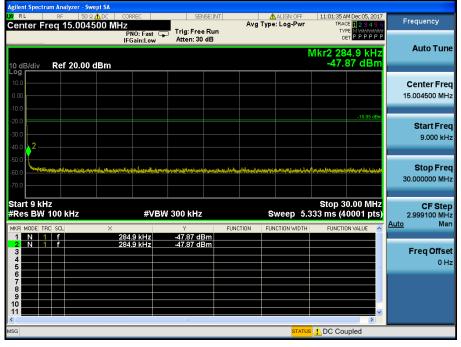
#### Low Band-edge

### Hopping mode & Modulation : GFSK





# Lowest Channel & Modulation : GFSK



Agilent Spectrum Analyzer - Swe		SENSE:INT	ALIGN OFF	11:01:49 AM Dec 05, 2017	
Center Freq 5.01500	0000 GHz		Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE M MARAAAAA	Frequency
	PNO: Fast G IFGain:Low	Atten: 30 dB		DETPPPPP	Auto Tune
10 dB/div Ref 20.00 d	IBm		Mkr	5 5.839 27 GHz -39.59 dBm	Auto Tune
10.0	1				Center Freq
0.00	- ¥				5.015000000 GHz
-10.0				-18.95 dBm	
-20.0					Start Freq
-30.0	$\diamond^4 \diamond^3$	$\Diamond^2$			30.000000 MHz
-50.0					
-60.0					Stop Freq
-70.0					10.00000000 GHz
Start 30 MHz				Stop 10.000 GHz	CF Step
#Res BW 1.0 MHz	#VBV	V 3.0 MHz	Sweep 18	.67 ms (40001 pts)	997.000000 MHz
MKR MODE TRC SCL	× 2.402 11 GHz	Y FU 1.37 dBm	INCTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
2 N 1 f	5.392 86 GHz 3.336 80 GHz	-38.64 dBm -39.19 dBm			Freq Offset
4 N 1 f	2.561 88 GHz 5.839 27 GHz	-39.28 dBm -39.59 dBm			0 Hz
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MSG			STATUS	5	



### Lowest Channel & Modulation : GFSK



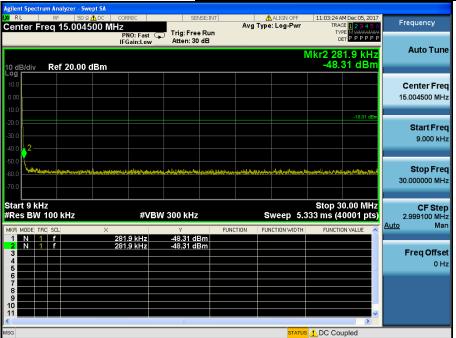


#### Reference for limit

### Middle Channel & Modulation : GFSK



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







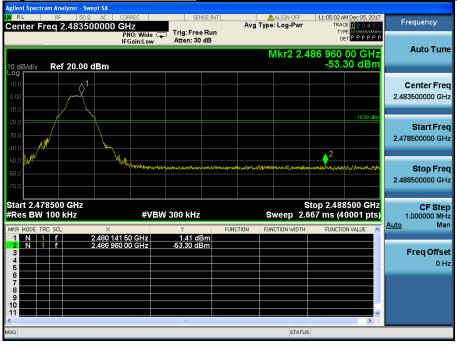






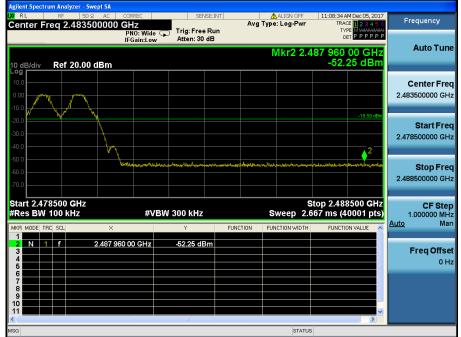
#### **High Band-edge**

### Highest Channel & Modulation : GFSK



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

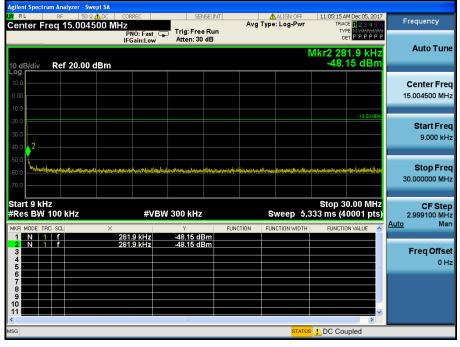
### Hopping mode & Modulation : GFSK







# Highest Channel & Modulation : GFSK



Agilent Spectrum Analyzer - S					
Center Freq 5.0150		SENSE:INT	ALIGN OFF Avg Type: Log-Pwr	11:05:28 AM Dec 05, 2017 TRACE 1 2 3 4 5 6	Frequency
	PNO: Fast G IFGain:Low	Trig: Free Run Atten: 30 dB		TYPE M WANNAAN DET PPPPP	
	IFGalli.cow	- Intelli of the	Mkr	5 3.258 54 GHz	Auto Tune
10 dB/div Ref 20.00	) dBm		IVIKI	-39.33 dBm	
Log					
10.0	\ <b>`</b>				Center Freq
0.00					5.015000000 GHz
-10.0				-18.59 dBm	
-20.0					Start Freq
-30.0	<mark>6</mark> 5,∖2		4		30.000000 MHz
-40.0	THE REPORT OF A DESCRIPTION OF A DESCRIP				
-50.0		المتناقلين فأنتلغ بمحمر إغدها			Stop Freq
-60.0					10.000000000 GHz
-70.0					
Start 30 MHz				Stop 10.000 GHz	CF Step
#Res BW 1.0 MHz	#VBW	/ 3.0 MHz	Sweep 18	.67 ms (40001 pts)	997.000000 MHz
MKR MODE TRC SCL	X	Y FUN	CTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
1 N 1 f	2.480 13 GHz 3.576 58 GHz	1.56 dBm -38.97 dBm			
3 N 1 f	5.513 50 GHz	-39.03 dBm			Freq Offset
4 N 1 f 5 N 1 f	5.869 43 GHz 3.258 54 GHz	-39.22 dBm -39.33 dBm		=	0 Hz
6 7					
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9					
11				✓	
MSG		111	STATUS		
			STATUS		



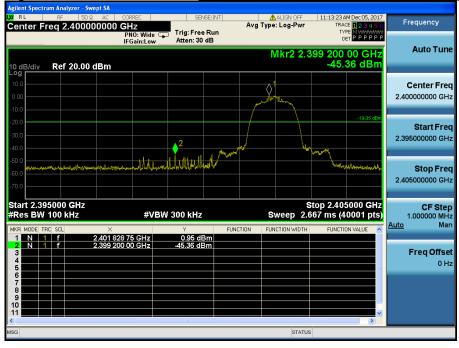
### Highest Channel & Modulation : GFSK





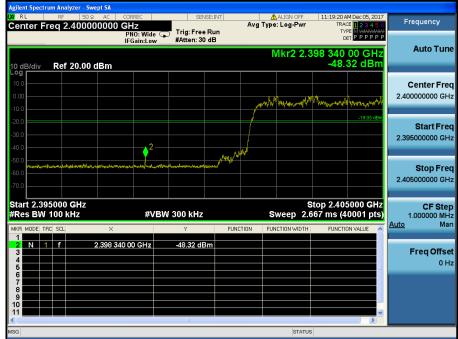
#### Low Band-edge

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



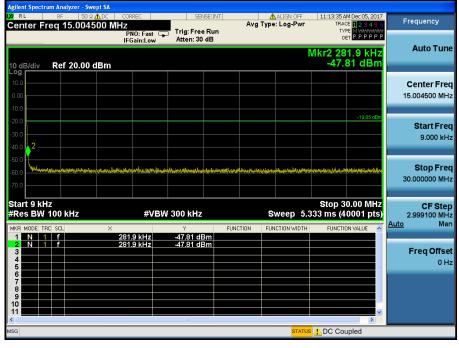
### Low Band-edge

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





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



Agilent Spectrum Analyzer - Swe						
RL RF 50 Ω     Center Freq 5.01500		SENSE:INT		ALIGN OFF	11:13:49 AM Dec 05, 2017 TRACE 1 2 3 4 5 6	Frequency
Center Freq 5.01500	PNO: Fast C IFGain:Low	Trig: Free Run Atten: 30 dB		,		
10 dB/div Ref 20.00 d	Bm			Mkr	5 5.926 01 GHz -39.51 dBm	Auto Tune
10.0 0.00 -10.0	1					Center Freq 5.015000000 GHz
-20.0 -30.0 -40.0	<sup>22</sup>		5		-19.05 dBm	Start Freq 30.000000 MHz
-50.0 -60.0 -70.0						<b>Stop Freq</b> 10.000000000 GHz
Start 30 MHz #Res BW 1.0 MHz	#VB	N 3.0 MHz		Sweep 18	Stop 10.000 GHz 67 ms (40001 pts)	CF Step 997.000000 MHz
MKR MODE TRC SCL	× 2.402 36 GHz	⊻ 1.59 dBm	FUNCTION F	UNCTION WIDTH	FUNCTION VALUE	Auto Man
2 N 1 f 3 N 1 f 4 N 1 f 5 N 1 f	3.154 35 GHz 3.025 99 GHz 7.591 25 GHz 5.926 01 GHz	-39.06 dBm -39.10 dBm -39.49 dBm -39.51 dBm			111	<b>Freq Offset</b> 0 Hz
6 7 8 9 10						
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MSG				STATUS		



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

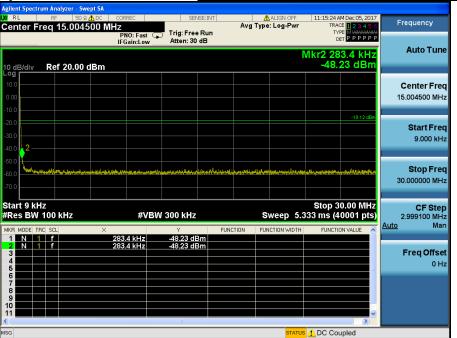


#### Reference for limit

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



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





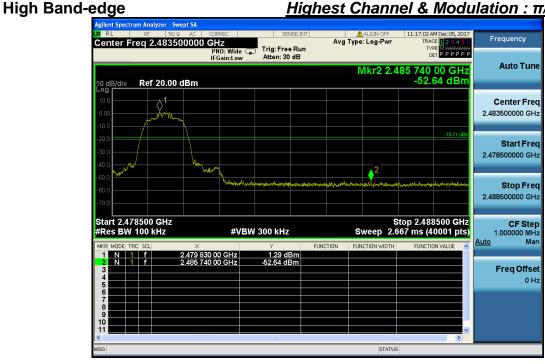
#### Middle Channel & Modulation : π/4DQPSK



Agilent Spectr											
LXIRL	RF			DRREC	Si	NSE:INT	Âva	ALIGN OFF		M Dec 05, 2017 CE <b>1 2 3 4 5 6</b>	
Center F	req	7.5000		PNO: Fast				Type. Log-I wi	TYI		
				Gain:Lov	Atten: 3	0 dB					
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10.0											Center Freq
0.00											17.50000000 GHz
-10.0											
-20.0										-18.12 dBm	
-30.0									• • • • • • • • • • • • • • • • • • •	IVY	Start Freq
-40.0			The second s	a market	And a state of the second	a and a linear second	and the second states				10.00000000 GHz
-50.0		nationalistication	A CONTRACTOR OF STREET								
-60.0											Stop Freq
-70.0											25.00000000 GHz
-70.0											
Start 10.0									Stop 25	.000 GHz	CF Step
#Res BW	1.0 M	Hz		#V	'BW 3.0 MH	2		Sweep 40	.00 ms (4	0001 pts)	
MKR MODE T			×		Y		FUNCTION	FUNCTION WIDTH	FUNCTIO	ON VALUE	<u>Auto</u> Man
1 N 1 2 N 1	f		24.177 6		-28.19 c -29.07 c	Bm					
3 N 1	f		23.260 3	75 GHz	-29.62 c	Bm					Freq Offset
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MSG								STATUS			



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



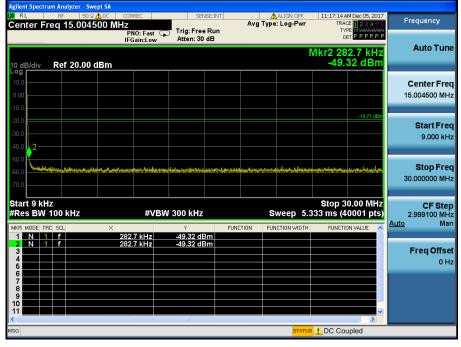
#### High Band-edge

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





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



Agilent Spectrum Analyzer - Swept S	54					
RL RF 50 Ω A     Center Freq 5.0150000		SENSE:IN		ALIGN OFF	11:17:28 AM Dec 05, 2017 TRACE 1 2 3 4 5 6	Frequency
Center Freq 5.0150000	PNO: Fast C IFGain:Low	Trig: Free Run Atten: 30 dB		Type. Log T M		
10 dB/div Ref 20.00 dBr	m			Mkr	5 6.324 31 GHz -39.29 dBm	Auto Tune
10.0 0.00 -10.0	↓ <sup>1</sup>					Center Freq 5.015000000 GHz
-20.0	23		<b>↓</b> <sup>4</sup> <b>↓</b> <sup>5</sup>	- The state of the	-18.71 dBm	Start Freq 30.000000 MHz
-50.0 -70.0						<b>Stop Freq</b> 10.000000000 GHz
Start 30 MHz #Res BW 1.0 MHz	#VB	W 3.0 MHz		Sweep 18	Stop 10.000 GHz .67 ms (40001 pts)	CF Step 997.000000 MHz Auto Man
MKR MODE TRC SCL	× 2.480 38 GHz	ץ 1.50 dBm	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	Auto Man
2 N 1 f 3 N 1 f 4 N 1 f 5 N 1 f	3.145 63 GHz 3.276 73 GHz 5.842 51 GHz 6.324 31 GHz	-38.37 dBm -38.55 dBm -38.96 dBm -39.29 dBm			111	Freq Offset 0 Hz
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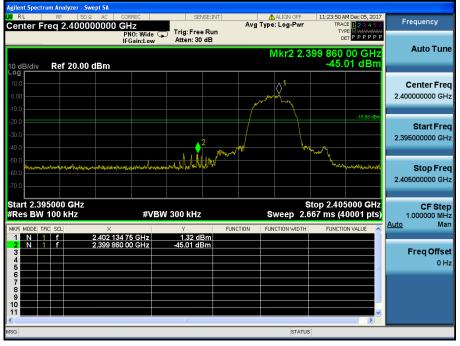
### Highest Channel & Modulation : π/4DQPSK





#### Low Band-edge

### Lowest Channel & Modulation : 8DPSK



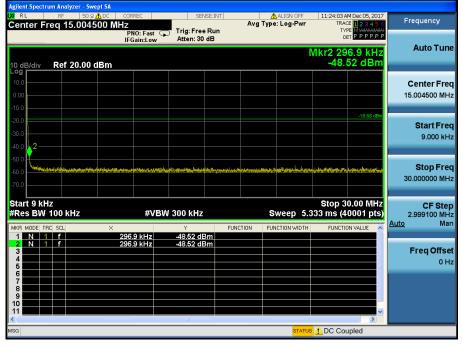
### Low Band-edge

#### Hopping mode & Modulation : 8DPSK





### Lowest Channel & Modulation : 8DPSK



RL RF 50	Ω AC CORREC	SENSE:INT	🛕 ALIGN OFF	11:24:17 AM Dec 05, 2017	<b>F</b>
enter Freq 5.0150	000000 GHz PNO: Fast	Trig: Free Run	Avg Type: Log-Pwr	TRACE 123456 TYPE MWWWWW	Frequency
	IFGain:Low			DETPPPP	
			Mkr	5 9.544 87 GHz	Auto Tun
0 dB/div Ref 20.00	dBm			-39.39 dBm	
0.0	1				Center Fre
	_ \				5.015000000 GH
0.0					3.013000000 GP
				-18.68 dBm	
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0.0	$ \rangle^2$		♦	<b>∆</b> ³5	30.000000 MH
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60.0					10.00000000 GH
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tart 30 MHz				Stop 10.000 GHz	CF Ste
Res BW 1.0 MHz	#V	BW 3.0 MHz	Sweep 18	.67 ms (40001 pts)	997.000000 MH
IKR MODE TRC SCL	×	Y	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Ma
1 N 1 f	2.402 11 GHz 3.138 90 GHz	2.09 dBm -39.08 dBm			
2 N 1 f 3 N 1 f	8.052 11 GHz	-39.18 dBm			Freq Offs
4 N 1 f	5.788 42 GHz 9.544 87 GHz	-39.22 dBm -39.39 dBm			0 H
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G			STATUS	5	



### Lowest Channel & Modulation : 8DPSK



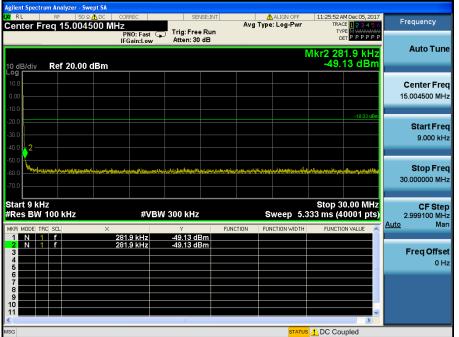


#### **Reference for limit**

Middle Channel & Modulation : 8DPSK

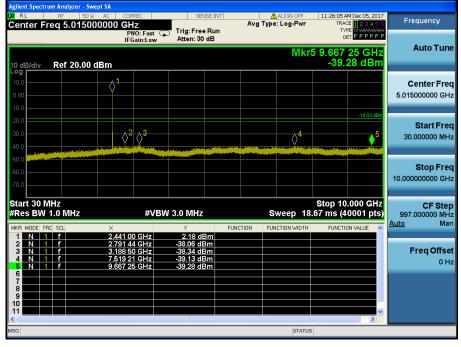


### Conducted Spurious Emissions <u>Middle Channel & Modulation : 8DPSK</u>





### Middle Channel & Modulation : 8DPSK



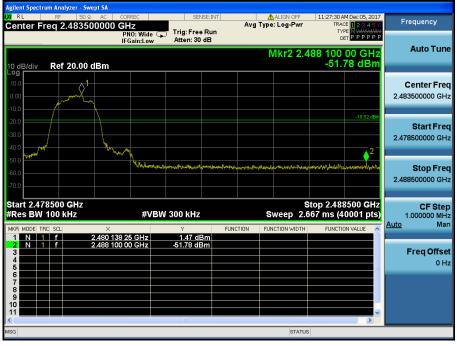
Agilent Spectr	um Analyzer - 1 RF 50		RREC	CENIC	E:INT	ALIGN OFF	11/26/19 4	M Dec 05, 2017	
		0000000			Run	pe: Log-Pwr	TRAC	E 1 2 3 4 5 6 M M M M M M M M P P P P P P P	Frequency
10 dB/div	Ref 20.0		Gain:Low	Atten: 30 t		Mkr3 2	2.310 8		Auto Tune
10.0 0.00									Center Fred 17.500000000 GH;
-20.0							<b>→</b> <sup>3</sup>	-18 03 dBm	Start Free 10.000000000 GH:
-50.0 -60.0 -70.0									Stop Free 25.000000000 GH:
Start 10.0 #Res BW	1.0 MHz	×	#VB\	N 3.0 MHz	50	Sweep 40	.00 ms (4	.000 GHz 0001 pts)	CF Step 1.50000000 GH Auto Mar
1 N 1 2 N 1 3 N 1 4 5 6	f f f	24.033 25 23.226 62 22.310 87	25 GHz	-28.07 dB -30.15 dB -30.41 dB	n n		TONETIC		Freq Offse 0 H:
7 8 9 9 10 11 ×									
WSG						STATUS	5		





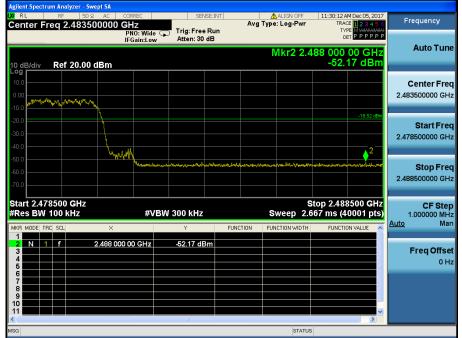
#### **High Band-edge**

### Highest Channel & Modulation : 8DPSK



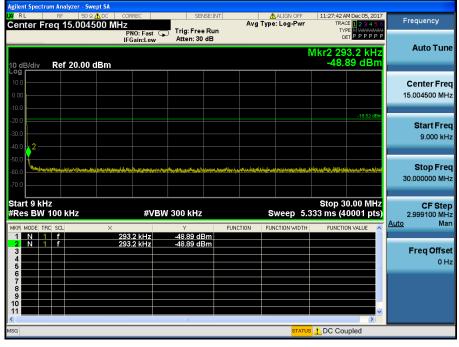
### High Band-edge

### Hopping mode & Modulation : 8DPSK





### Highest Channel & Modulation : 8DPSK



Agilent Spectrum Analyzer - Sw						
Center Freq 5.0150		SENSE:INT		ALIGN OFF	11:27:56 AM Dec 05, 2017 TRACE 2 3 4 5 6	Frequency
	PNO: Fast 🖵 IFGain:Low	Trig: Free Run Atten: 30 dB			TYPE M WAARAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	
10 dB/div Ref 20.00	dBm			Mkr	5 5.913 80 GHz -39.48 dBm	Auto Tune
Log 10.0 0.00 -10.0	1					Center Freq 5.015000000 GHz
-20.0		2	5	<b>4</b>	-18.52 dBm	Start Freq 30.000000 MHz
-50.0						Stop Freq 10.00000000 GHz
Start 30 MHz #Res BW 1.0 MHz	#VBW	/ 3.0 MHz	ę	Sweep 18	Stop 10.000 GHz 67 ms (40001 pts)	CF Step 997.000000 MHz
MKR MODE TRC SCL	× 2.480 13 GHz	⊻ 1.43 dBm	FUNCTION FL	INCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
2 N 1 f 3 N 1 f 4 N 1 f 5 N 1 f	4.989 83 GHz 2.895 13 GHz 7.498 53 GHz 5.913 80 GHz	-38.56 dBm -38.82 dBm -39.47 dBm -39.48 dBm			=	Freq Offset 0 Hz
6 7 8 9 10						
<		III			>	
MSG				STATUS		



### 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.) 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. Occupied Bandwidth (99 %)

### 10.1 Test Setup

NA

## 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.

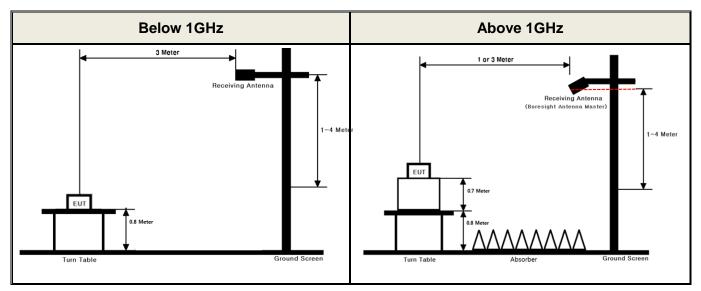
### 10.4 Test Results

NA

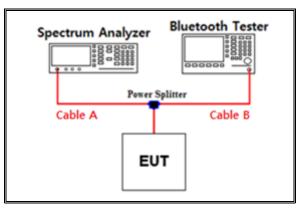
# **APPENDIX I**

#### 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	10.31
1	7.03	20	11.05
2.402 & 2.441 & 2.480	7.57	25	12.69
5	8.10	-	-
10	9.52	-	-

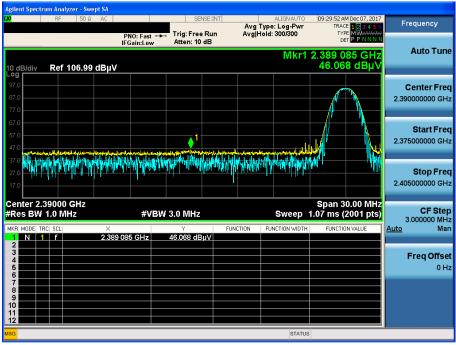
Note 1 : The path loss from EUT to Spectrum analyzer were measured and used for test.

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

# **APPENDIX II**

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

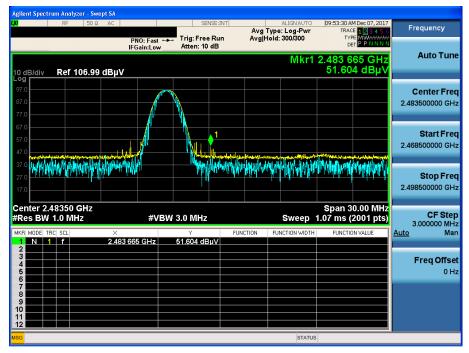
#### GFSK & Lowest & X & Ver



# Detector Mode : PK

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

### GFSK & Highest & X & Ver

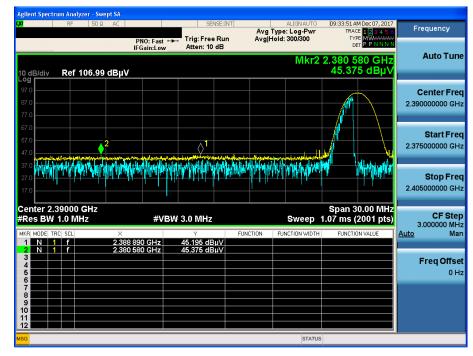






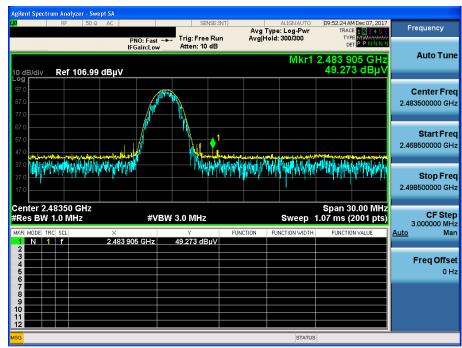
#### $\pi$ /4DQPSK & Lowest & X & Ver

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



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

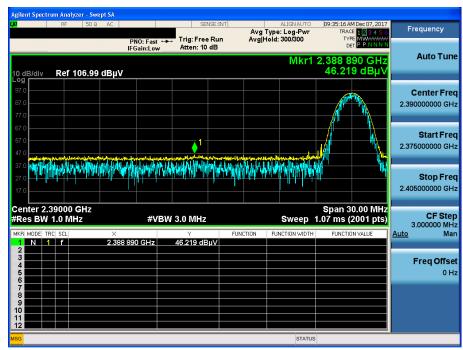
#### **Detector Mode : PK**





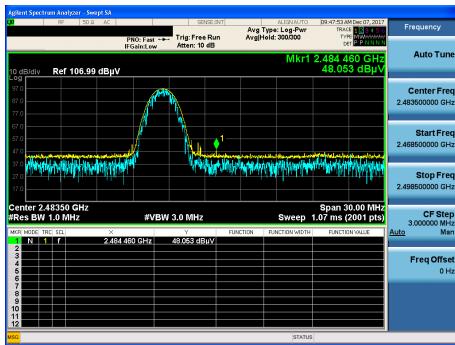
#### 8DPSK & Lowest & X & Ver

### **Detector Mode : PK**



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

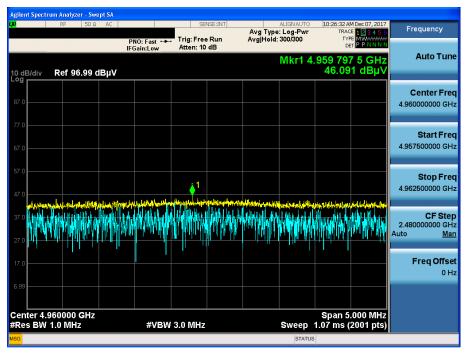
#### 8DPSK & Highest & X & Ver



**Detector Mode : PK** 

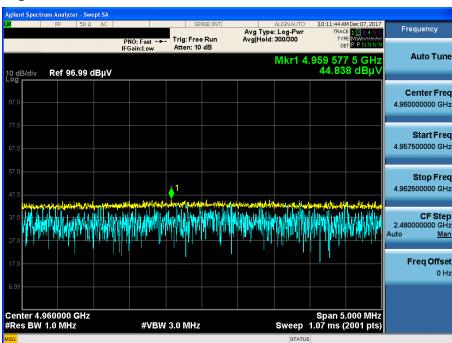


#### GFSK & Highest & X & Ver



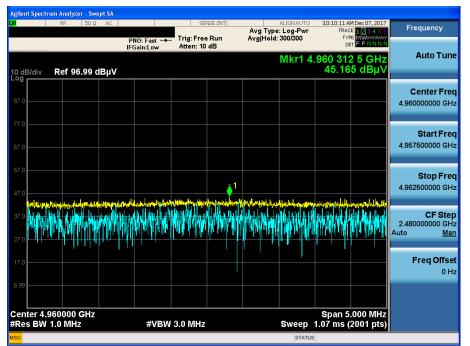
#### π/4DQPSK & Highest & X & Ver

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





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



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