# **TEST REPORT**

	DT&C Co., Ltd.			
Dt&C	42, Yurim-ro, 154Beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 17042 Tel : 031-321-2664, Fax : 031-321-1664			
1. Report No: DRTFCC2006-016	6			
2. Customer				
• Name : HYUNDAI MOBIS CO.,	LTD.			
• Address : 203, Teheran-ro Gang	nam-gu, Seoul, South Korea 135-977			
3. Use of Report : FCC Original Gra	ant			
	ISPLAY CAR SYSTEM / DA330G2AN			
FCC ID : TQ8-DA330G2AN 5. Test Method Used : ANSI C63.1				
Test Specification : FCC Part 15.				
6. Date of Test : 2020.03.27 ~ 2020	0.04.13			
7 Location of Test : X Permanent Testing Lab On Site Testing				
8. Testing Environment : See appe	nded test report.			
9. Test Result : Refer to the attache	ed test result.			
The regulte about in this test report ret	er only to the sample(s) tested unless otherwise stated.			
Tested by	C Poviewed by			
Affirmation Name : InHee Bae	Name : JaeJin Lee (Signature)			
2020. 06. 12.				
DT&C Co., Ltd.				
Not abided by KS Q ISO / IEC 17025 and KOLAS accreditation.				
If this report is required to confirmation of authenticity, please contact to report@dtnc.net				



# **Test Report Version**

Test Report No.	Date	Description	Revised By	Reviewed by
DRTFCC2006-0166	Jun. 12, 2020	Initial issue	InHee Bae	JaeJin Lee



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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 test site complies with the requirements of § 2.948 according to ANSI C63.4-2014.

#### - FCC MRA Designation No. : KR0034

www.dtnc.net		
Telephone	:	+ 82-31-321-2664
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#### **1.2 Testing Environment**

Ambient Condition	
<ul> <li>Temperature</li> </ul>	+23 °C ~ +25 °C
Relative Humidity	43 % ~ 46 %

#### 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 Power0.7 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)	4.9 dB (The confidence level is about 95 %, k = 2)	
Radiated spurious emission (1 GHz ~ 18 GHz)	5.1 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, South Korea 135-977
Contact person	:	Seung Hoon Choe

### 1.5 Description of EUT

EUT	DISPLAY CAR SYSTEM		
Model Name	DA330G2AN		
Add Model Name DA330G2GG, DA330G2FG, DA331G2GG, DA33 DA330G2GL, DA330G2MG, DA330G2FN, DA33 DA330G2EP, DA331G2EP, DA332G2EP, DA333 DA330G2UA, DT330G2AN, DA330G2GU, DA33 DA331G2EG, DA334G2EP, DA335G2EP, DA336 DA331G7GG, DA330G7GN, DA330G7GL, DA330 DA330G7EP, DA331G7EP, DA332G7EP, DA3333 DA330G7EP, DA331G7EP, DA332G7EP, DA3333 DA330G7UA, DT330G7AN			
Hardware Version	V 1.0		
Software Version	V 1.0		
Serial Number	Identical prototype		
Power Supply	DC 14.4 V		
Frequency Range	2402 MHz ~ 2480 MHz		
Modulation Technique (data rate)	GFSK(1Mbps), π/4DQPSK(2Mbps), 8DPSK(3Mbps)		
Number of Channels	79		
Antenna Type	PCB Pattern Antenna		
Antenna Gain	PK : -0.18 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 bandwidths 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	19/12/16	20/12/16	MY49060056
Spectrum Analyzer	Agilent Technologies	N9020A	19/12/16	20/12/16	MY48011700
Spectrum Analyzer	Agilent Technologies	N9020A	19/12/16	20/12/16	MY48010133
DC Power Supply	Agilent Technologies	66332A	19/06/25	20/06/25	MY43001173
DC Power Supply	SM techno	SDP30-5D	19/06/24	20/06/24	305DMG305
Multimeter	FLUKE	17B	19/12/16	20/12/16	26030065WS
Signal Generator	Rohde Schwarz	SMBV100A	19/12/16	20/12/16	255571
Signal Generator	ANRITSU	MG3695C	19/12/16	20/12/16	173501
Thermohygrometer	BODYCOM	BJ5478	19/12/18	20/12/18	120612-1
Thermohygrometer	BODYCOM	BJ5478	19/12/18	20/12/18	120612-2
Thermohygrometer	BODYCOM	BJ5478	19/06/25	20/06/25	N/A
Power Divider	Weinschel	WA1574	19/06/25	20/06/25	WA1574-4
BlueTooth Tester	Tescom	TC-3000C	19/06/24	20/06/24	3000C000563
Loop Antenna	Schwarzbeck	FMZB1513	20/02/19	22/02/19	1513-128
BILOG ANTENNA	Schwarzbeck	VULB 9160	19/04/23	21/04/23	9160-3362
Horn Antenna	ETS-Lindgren	3115	20/01/30	22/01/30	6419
Horn Antenna	A.H.Systems Inc.	SAS-574	19/07/03	21/07/03	155
PreAmplifier	tsj	MLA-0118-B01-40	19/12/16	20/12/16	1852267
PreAmplifier	tsj	MLA-1840-J02-45	19/06/27	20/06/27	16966-10728
PreAmplifier	H.P	8447D	19/12/16	20/12/16	2944A07774
High Pass Filter	Wainwright Instruments	WHKX12-935-1000- 15000-40SS	19/06/26	20/06/26	8
High Pass Filter	Wainwright Instruments	WHKX10-2838-3300- 18000-60SS	19/06/26	20/06/26	1
High Pass Filter	Wainwright Instruments	WHNX8.0/26.5-6SS	19/06/27	20/06/27	3
Attenuator	Hefei Shunze	SS5T2.92-10-40	19/06/27	20/06/27	16012202
Attenuator	SRTechnology	F01-B0606-01	19/06/27	20/06/27	13092403
Attenuator	Aeroflex/Weinschel	20515	19/06/27	20/06/27	Y2370
Attenuator	SMAJK	SMAJK-2-3	19/06/27	20/06/27	2
Attenuator	Aeroflex/Weinschel	56-3	19/06/25	20/06/25	Y2342
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2495A MA2490A	19/06/24	20/06/24	1306007 1249001
EMI Receiver	ROHDE&SCHWARZ	ESW44	19/07/30	20/07/30	101645
Cable	Junkosha	MWX241	20/01/13	21/01/13	G-04
Cable	Junkosha	MWX241	20/01/13	21/01/13	G-07
Cable	DT&C	Cable	20/01/13	21/01/13	G-13
Cable	DT&C	Cable	20/01/13	21/01/13	G-14
Cable	HUBER+SUHNER	SUCOFLEX 104	20/01/13	21/01/13	G-15
Cable	Radiall	TESTPRO3	20/01/16	21/01/16	M-01
Cable	Junkosha	MWX315	20/01/16	21/01/16	M-05
Cable	Junkosha	MWX221	20/01/16	21/01/16	M-06
Cable	Radiall	TESTPRO3	20/01/15	21/01/15	RF-64
Test Software	tsj	Radiated Emission Measurement	N/A	N/A	Version 2.00.0177

Note 1: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017. Note 2: The cable is not a regular calibration item, so it has been calibrated by DT & C itself.



#### 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. =< 0.5 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(6.7)	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	с
15.207 RSS-Gen(8.8)	AC Conducted Emissions	FCC 15.207 Limits	AC Line Conducted	NA Note3
15.203	Antenna Requirements	FCC 15.203	-	С

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 types 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. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

#### IC Requirements

 RSS-247(5.4) (b), 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, except as provided in section 5.4(e)

#### 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 peak output power 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 t Power	Peak Output Power			
Wouldton	rested Ghanner	dBm	mW	dBm	mW		
	Lowest	0.25	1.06	1.38	1.37		
<u>GFSK</u>	Middle	0.53	1.13	1.79	1.51		
	Highest	0.38	1.09	1.45	1.40		
	Lowest	-3.96	0.40	-1.69	0.68		
<u>π/4DQPSK</u>	Middle	-3.27	0.47	-1.17	0.76		
	Highest	-3.56	0.44	-1.57	0.70		
	Lowest	-3.95	0.40	-1.20	0.76		
<u>8DPSK</u>	Middle	-3.27	0.47	-0.70	0.85		
	Highest	-3.56	0.44	-1.06	0.78		

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**





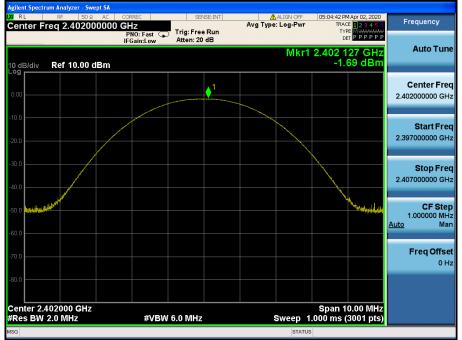


Highest Channel & Modulation : GFSK



#### **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 & Occupied 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 = 1% to 5% of the 20 dB BW & Occupied BW
  - $VBW \ge 3 \times RBW$

Span = between two times and five times the 20 dB bandwidth & Occupied BW

Sweep = auto

Detector function = peak

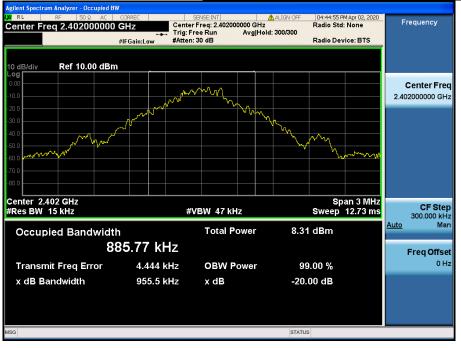
Trace = max hold

#### 3.4 Test Results

Modulation	Tested Channel	20 dB BW (MHz)
	Lowest	0.956
<u>GFSK</u>	Middle	0.956
	Highest	0.951
	Lowest	1.343
<u>π/4DQPSK</u>	Middle	1.344
	Highest	1.345
	Lowest	1.344
<u>8DPSK</u>	Middle	1.352
	Highest	1.345

TDt&C

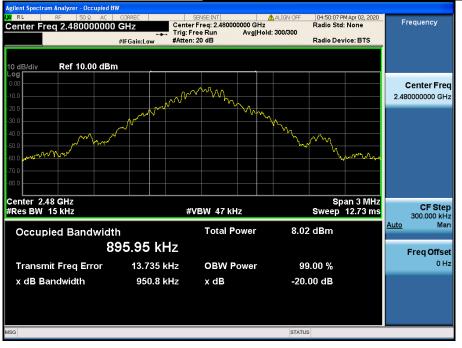
#### Lowest Channel & Modulation : GFSK



#### 20 dB BW

#### Middle Channel & Modulation : GFSK Analyzer - Occupied BW Center Freq: 2.441000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 20 dB 04:47:29 PM Apr 02, 2020 Radio Std: None Center Freq 2.441000000 GHz Frequency #IFGain:Low Radio Device: BTS Ref 10.00 dBm **Center Freq** ላሌለ 2.441000000 GHz Center 2.441 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 8.35 dBm 895.63 kHz Freq Offset 0 Hz 9.093 kHz 99.00 % Transmit Freq Error **OBW Power** x dB Bandwidth 955.8 kHz x dB -20.00 dB STATUS

#### Highest Channel & Modulation : GFSK



#### 20 dB BW

#### Lowest Channel & Modulation : π/4DQPSK Analyzer - Occupied BW r servsk:INT| ▲ALIGN OFF Center Freq: 2.402000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 20 dB 05:04:19 PM Apr 02, 2020 Radio Std: None Center Freq 2.402000000 GHz Frequency #IFGain:Low Radio Device: BTS Ref 10.00 dBm **Center Freq** 2.402000000 GHz ሰብ $\wedge \mathcal{M}$ Center 2.402 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 2.79 dBm 1.2141 MHz Freq Offset 0 Hz 2.018 kHz 99.00 % Transmit Freq Error **OBW Power** x dB Bandwidth 1.343 MHz x dB -20.00 dB STATUS



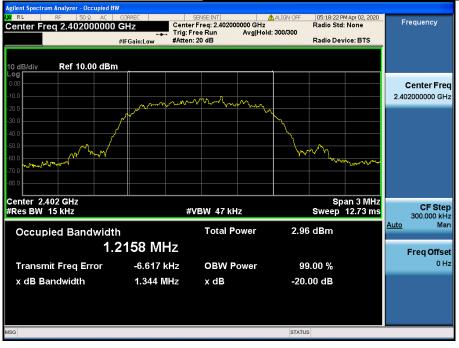
#### Middle Channel & Modulation : π/4DQPSK



#### 20 dB BW

#### Highest Channel & Modulation : π/4DQPSK Occupied BW r servsk:INT| ▲ALIGN OFF Center Freq: 2.48000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 20 dB 05:09:28 PM Apr 02, 2020 Radio Std: None Center Freq 2.480000000 GHz Frequency #IFGain:Low Radio Device: BTS Ref 10.00 dBm **Center Freq** 2.48000000 GHz Avr. $\sim \sim$ Center 2.48 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 3.17 dBm 1.2121 MHz Freq Offset 0 Hz 10.134 kHz 99.00 % Transmit Freq Error **OBW Power** x dB Bandwidth 1.345 MHz x dB -20.00 dB STATUS

#### Lowest Channel & Modulation : 8DPSK



#### 20 dB BW

#### Middle Channel & Modulation : 8DPSK Analyzer - Occupied BW Center Freq: 2.441000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 20 dB 05:20:58 PM Apr 02, 2020 Radio Std: None Center Freq 2.441000000 GHz Frequency #IFGain:Low Radio Device: BTS Ref 10.00 dBm **Center Freq** 2.441000000 GHz 5 $\sim \sim$ Center 2.441 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 3.42 dBm 1.2174 MHz Freq Offset **OBW Power** 0 Hz 99.00 % Transmit Freq Error -1.866 kHz x dB Bandwidth 1.352 MHz x dB -20.00 dB STATUS



### 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 reference channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.014	2442.012	0.998
Enable	π/4DQPSK	2440.012	2441.015	1.003
	8DPSK	2441.000	2442.009	1.009

#### AFH mode

Hopping Mode	Modulation	Peak of reference channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.016	2442.018	1.002
Enable	π/4DQPSK	2441.016	2442.016	1.000
	8DPSK	2440.011	2441.011	1.000

Note 1 : See next pages for actual measured spectrum

#### - 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) <u>Hopping mode : Enable & 8DPSK</u>

RL epter Er		0 000000 GI	RREC	SENSE:		ALIGN OFF	TRAC	1 Apr 02, 2020 E <b>1 2 3 4 5 6</b>	Freque	ency
	6y 2.441	Р	NO: Wide G Gain:Low	Trig: Free Ri Atten: 20 dE	un Š		TYP		Aut	to Tune
0 dB/div .og	Ref 10.0	0 dBm						0.05 dB	Cent	er Fred
20.0			~~~~	X2	~~~~~	~~~~~	~~~	~~~~	2.441000	
80.0 40.0									Sta 2.439500	art Fred
50.0 60.0										
10.0 10.0									2.442500	o <b>p Fre</b> 000 GH
enter 2.4 Res BW	41000 GH 51 kHz	lz	#VBI	№ 150 kHz		Sweep 1	Span 3 .200 ms (	.000 MHz 3001 pts)	300	CF Stej .000 kH
2 F 1	f (Δ)	× 1.00 2.441 00	09 MHz (Δ) 00 GHz	∀ -0.05 dB -4.61 dBm	FUNCTION	FUNCTION WIDTH	FUNCTIO	IN VALUE	Auto	Ma
3 4 5 6								=	Fred	q <b>Offse</b> 0 H
7 <b>1 1 1 1 1 1 1 1 1 1</b>										
				ш				~		
3G						STATUS	6			



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



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







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

XI RL Center Fr	RF 50 Ω req 2.44100	00000 GH			Bun	Avg Ty	ALIGN OFF	TRAC	1 Apr 02, 2020 E <b>1 2 3 4 5 6</b> E M <del>V W W W W</del>	Fre	quency
10 dB/div	Ref 10.00	IFO	IO: Wide 🖵 Gain:Low	Atten: 20			ΔN	DE 1kr1 1.0	TPPPPP	4	Auto Tune
-10.0 -20.0	X	·	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		1Δ2	~~~~					enter Fred 000000 GH:
-30.0 -40.0 -50.0											Start Free
-60.0 -70.0 -80.0											<b>Stop Fre</b> 600000 GH
Res BW	RC SCL	×		/ 150 kHz		CTION F	Sweep 1	Span 3. 200 ms (3.		3 <u>Auto</u>	<b>CF Ste</b> 00.000 kH Ma
1 Δ2 1 2 F 1 3 4 5		1.00 2.440 01	0 MHz (Δ) 1 GHz	0.12 d -4.62 dB					=	F	r <b>eq Offse</b> 0 H
6 7 8 9 10											
sg				110			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 = 30 MHz	Start Frequency = 2426.0 MHz,	Stop Frequency = 2456.0 MHz
RBW = To identify clearly the in or the 20 dB bandwidth		o 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)
	GFSK	79
Enable	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

Agne LXI F		cti ui	RF	uyzer - Sv	wept Ω /		COR	PEC			0	INSE:I	NT				Â	ALIGN	OFF		14.55	41.06	4 Apr 02	2020	-		_	_
		Fre		2.4165										_	A١	g Ty			-Pwr		m.30.	TRAC	ε 123	4 5		Fre	quency	
							P	10: Fa	ist G		ig: Fre ten: 2		In									TYP	TPPP	PPI	ž			
							IFC	iain:L	ow	A	.ten. z	u ab									_		_	_	ΞL		Auto T	une
																		N	IKr2	2.	44		00 0					
10 c Log	B/div	/	Ref	10.00				_				_		_			_			_		1.3	53 d	Bm				
0.0					Q	1 നന	лл	۸A	ററ	100	n n r	۱nr	ากก	۱n	nn	лп	i n	nn	n n r	٦nı	٦A	۸n	nnr	in r	11	<b>C</b>	enter F	roa
-10.0						/ \/ \	{		ΥŸ	¥Ψ	1 V V	YY	VV	γı	14	IV.	YY	I V V	ΥŸ	ΥV	γų	V	ΥŸ	γ¥			500000	
						, ,								·												2.410	00000	GHZ
-20.0																												
-30.0					1																					1	Start F	req
-40.0					$\left\{ - \right\}$																					2.391	500000	GHz
-50.0				ا ر																								
-60.0		en se en	wmr	monton																								
-70.0																											Stop F	
-80.0																										2.441	500000	GHz
	rt 2.																						150				CFS	Step
#Re	s B	W 2	270	кНz				#	VBV	V 82	0 kH2	Z					Ş	we	ep 1	1.00	0 n	is (	3001	pts			000000	
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1	N	1	f f			2.402	2 000	) GH	z		1.21 d 1.53 d	Bm				_												
3						2.44	1 000		<u> </u>		1.00 0	6111														F	req Of	fset
4									—							_								_				0 Hz
6																												
7																												
9																												
10												_				_												
<		_																						>				
MSG														_			_		STATU	IS								
	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-				

### Number of <u>Hopping Frequencies 2(FH)</u>

#### Hopping mode : Enable & GFSK

RL RF 50 Ω AC enter Freq 2.466500000	GHz PNO: Fast C Trig: Fre	ee Run	ALIGN OFF	04:56:53 PM Apr 02, 2020 TRACE 1 2 3 4 5 6 TYPE MWWWWW DET P P P P P P	Frequency
dB/div Ref 10.00 dBm	IFGain:Low Atten: 2	20 88	Mkr2	2.480 000 GHz 1.29 dBm	Auto Tun
	MAMAAAAA				Center Fre 2.466500000 G⊦
0 0 0					<b>Start Fre</b> 2.441500000 GF
1.0 1.0 1.0				Portiliarine growth and water for the	<b>Stop Fre</b> 2.491500000 GH
art 2.44150 GHz Res BW 270 kHz	#VBW 820 kH	z		Stop 2.49150 GHz .000 ms (3001 pts)	CF Ste 5.000000 Mi Auto Mi
INDE         INDE         St.L         X           1         N         1         f         2.44;           2         N         1         f         2.44;           3         4         1         f         2.49;           5         5         5         5         5	2 000 GHz 1.68 c 0 000 GHz 1.29 c	dBm	UNCTION WIDTH	FUNCTION VALUE	Freq Offs
				~	



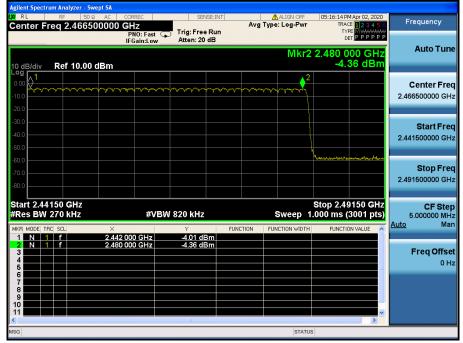
#### Number of <u>Hopping Frequencies 1(FH)</u>

#### Hopping mode : Enable & π/4DQPSK

RL enter	RF 5	500000 G	ORREC HZ PNO: Fast	SENSE			ALIGN OFF	TRA	M Apr 02, 2020 CE <b>1 2 3 4 5 6</b> PE M <del>WWWWWW</del>	Frequency
0 dB/div	Ref 10.0		FGain:Low	Atten: 20 d			Mkr2	D 2.441 C	00 GHz	Auto Tuno
0.00			ᠰ᠇ᡧᢇ᠕ᢇᡇ	مىلىكى بەر سەر سەر سەر سەر سەر سەر سەر سەر سەر س	ᠵᢇ᠆ᢇᠬ	ᠬ᠊᠆ᡟ᠆ᠰ᠆	****	******		<b>Center Fred</b> 2.416500000 GHz
20.0 30.0 \$0.0 50.0										<b>Start Fre</b> 2.391500000 GH
50.0 <b></b> 70.0 30.0	eorosenekeesteetka Milliando/									<b>Stop Fred</b> 2.441500000 GH:
Res B		×		<b>∛ 820 kHz</b> Y	FUNCT		Sweep 1	.000 ms (	4150 GHz 3001 pts)	CF Step 5.000000 MHz <u>Auto</u> Mar
1 N 2 N 3 4 5 6	1 f 1 f		000 GHz 000 GHz	-4.45 dBr -3.76 dBr	n n					Freq Offse 0 H:
7 8 9 10 11										
ISG							STATUS	5		

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

#### Hopping mode : Enable & π/4DQPSK





### Number of Hopping Frequencies 1(FH)

#### Hopping mode : Enable & 8DPSK

		ctrun		ilyzer - S															
Con		Ere	RF	50 2.416	Ω 5011			REC		S	ENSE:	INT	Ava		ALIGN OFF		PM Apr 02, 2020 ACE <b>1 2 3 4 5</b> (		Frequency
Cer	uer	нц	-q 2	.4100	500	000	PI	VO: Fas	at 🕞	Trig: Fr		ın				T	VPE MWWWWW	÷.	
		_					IFC	Gain:Lo	w	Atten: 2	20 dB							Ξl	Auto Tune
			_												WKr2		000 GHz .88 dBm		
10 dl Log	B/div	1	Ret	10.00	Jai	3m					_		1				.00 0.011		
0.00						<b>}</b> —													Center Freq
-10.0					_(	v~v	$\sqrt{1}$	وسروسرار	~~~~	$\gamma$	~~~~	-Andrew Rower	y vrye	w w	A Martin	hor ward			2.416500000 GHz
-20.0																			
-30.0																			
																			Start Freq
-40.0					1														2.391500000 GHz
-50.0					٦														
-60.0	an/ha/"	"Albertof		الالمانية المحالية	-														Stop Freq
-70.0																			2.441500000 GHz
-80.0																			2.441000000 0112
Star		204	50													<b>O</b> tem 2 /			
siai #Re								#	/BiA	/ 820 kH	7				Sween 1		4150 GHz (3001 pts)		CF Step 5.000000 MHz
				<b>NI 12</b>	_						-								Auto Man
MKH	MODE	TRU 1	f			× 2.40	2 00	) GHz		-4.35 d	iBm		CTION	FUN	ICTION WIDTH	FUNC	TON VALUE		
2	N	1	f					) GHz		-3.88									Freq Offset
3																			0 Hz
5																	=		0 112
7																			
8									-										
10																			
11				_				_									~		
MSG	_				-	-	_	_	_		_		_	_	STATU	5	<u>.</u>		
	-	-	-			-	-		-		-		_	-					

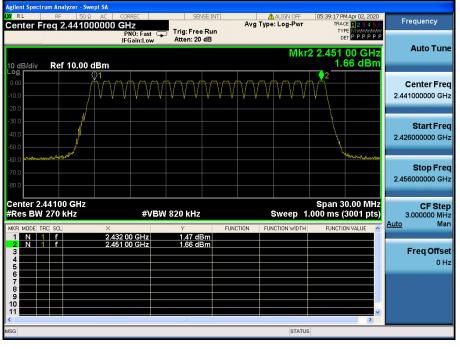
### Number of <u>Hopping Frequencies 2(FH)</u>

#### Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA				
RL RF 50 Ω AC Center Freq 2.466500000		ALIGN OFF Avg Type: Log-Pwr	05:30:18 PM Apr 02, 2020 TRACE 123456	Frequency
10 dB/div Ref 10.00 dBm	PNO: Fast IFGain:Low Atten: 20 dB	Mkr2	түре рет Р Р Р Р Р Р Р 2.480 000 GHz -4.28 dBm	Auto Tune
Log 1 0.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00		2		Center Fred 2.466500000 GH
-30.0 -40.0 -50.0				<b>Start Fre</b> 2.441500000 GH
-60.0			hand a family and a family and a family	<b>Stop Fre</b> 2.491500000 GH
Start 2.44150 GHz #Res BW 270 kHz	#VBW 820 kHz		Stop 2.49150 GHz 000 ms (3001 pts)	CF Ste 5.000000 MH Auto Ma
1         N         1         f         2.442           2         N         1         f         2.448           3         -         -         -           4         -         -         -           5         -         -         -           6         -         -         -           7         -         -         -           8         -         -         -	2 000 GHz -3.74 dBm 0 000 GHz -4.28 dBm	INCTION FUNCTION WIDTH	FUNCTION VALUE	Freq Offso 0 H
9 10 11 11 11 11 11 11 11 11 11 11 11 11	ui -	STATUS	×	

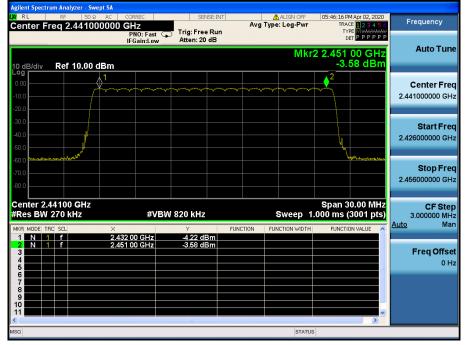


#### Number of Hopping Frequencies 1(AFH) Hopping mode : Enable & GFSK



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

#### Hopping mode : Enable & $\pi/4DQPSK$





# Number of Hopping Frequencies 1(AFH) Hopping mode : Enable & 8DPSK

RL RF 50 Center Freq 2.441		SENSE:INT	ALIGN OFF Avg Type: Log-Pwr	05:51:27 PM Apr 02, 2020 TRACE 123456 TYPE MWWWWW	Frequency
0 dB/div Ref 10.00	PNO: Fast IFGain:Lov 0 dBm		Mkr	2 2.451 00 GHz -3.46 dBm	Auto Tun
•g 0.00 10.0 20.0					<b>Center Fre</b> 2.441000000 GH
30.0 40.0 50.0					<b>Start Fre</b> 2.426000000 GH
60.0 <b>1/1-100 /1100 //1000 //10000 //1000 //1000 //</b>					<b>Stop Fre</b> 2.456000000 G⊦
enter 2.44100 GHz Res BW 270 kHz		'BW 820 kHz	Sweep 1	Span 30.00 MHz .000 ms (3001 pts)	CF Ste 3.000000 MH <u>Auto</u> Ma
1 N 1 F 2 N 1 F 3 4 5	2.432 00 GHz 2.451 00 GHz	-3.54 dBm -3.46 dBm			Freq Offso 0 ⊦
6 7 8 9 9 10					
G		illi -	STATU	5	



### 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 Trace = max hold

Detector function = peak

6.4 Test Results

FH mode

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

#### AFH mode

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

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

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

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

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



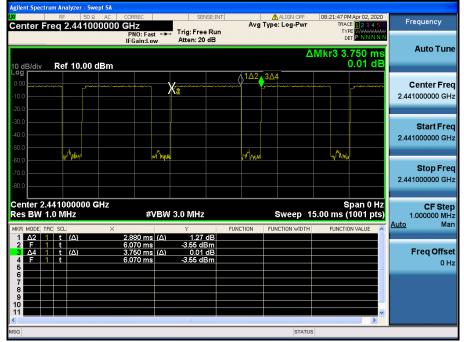
Time of Occupancy (FH)

#### Avg Type: Log-Pwr Frequency PNO: Fast Trig: Free Run Atten: 20 dB TYPE DET Auto Tune ΔMkr3 3.750 ms -0.01 dB Ref 10.00 dBm **∆1∆23**∆4 X **Center Freq** 2.441000000 GHz Start Freq 2.441000000 GHz when Merry atu m lan Stop Freq 2.441000000 GHz CF Step 1.000000 MHz Man Center 2.441000000 GHz Res BW 1.0 MHz Span 0 Hz Sweep 15.00 ms (1001 pts) #VBW 3.0 MHz Auto t (Δ) Δ2 1 2 1. Freq Offset Δ4 F t (Δ) ns (Δ) .01 dE 6.310 1.76 dBr 0 Hz

#### Hopping mode : Enable & DH5

#### Time of Occupancy (FH)

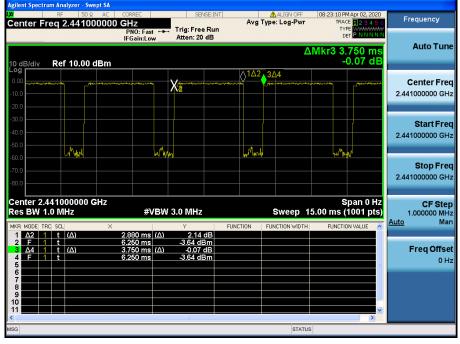
#### Hopping mode : Enable & 2-DH5





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

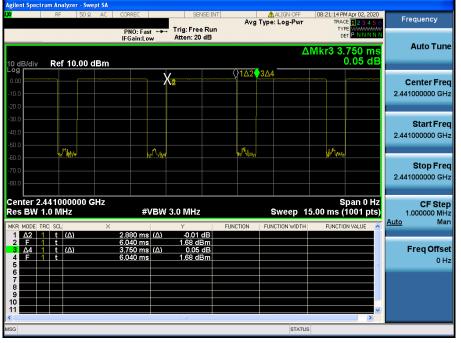
#### Time of Occupancy (FH)





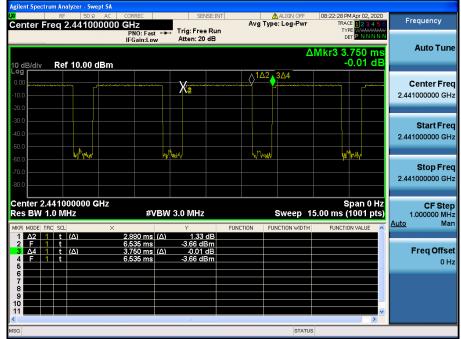
# Hopping mode : Enable & DH5

# Time of Occupancy (AFH)



# Time of Oc<u>cupancy (AFH)</u>

# Hopping mode : Enable & 2-DH5





Time of Occupancy (AFH)

# Hopping mode : Enable & 3-DH5

enter	Freq	2.4410	Ω AC	CORREC O GHZ PNO: F IFGain:		•	Trig: Free Atten: 20				ALIGN OFF e: Log-Pwr		TRACE	Apr 02, 2020 1 2 3 4 5 6 F N N N N N F N N N N N	Fi	equency
) dB/div	Re	f 10.00	dBm								1	\Mkr3	3 3.1 (	750 ms ).07 dB		Auto Tur
og 0.00 0.0		-J <sup>arrier</sup> terret	t aver the second		Х	2	÷~~~	\1	∆2	3∆4 ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	n fersen an	**		<u> ۱۹۹۲ میں دور دور دور دور دور دور دور دور دور دور</u>		Center Fre
io.o io.o io.o	. h . i				rkan				Mraul			N <sup>49</sup> maler			2.44	<b>Start Fr</b> 1000000 Gi
i0.0 10.0 10.0	MY W				NM V			vy	· <b>` Y I</b> A	,		M M/M			2.44	<b>Stop Fr</b> 1000000 GI
enter 2 es BW	1.0 N		GHz		#VE	W :	3.0 MHz Y	F	UNCT		Sweep		ıs (1	oan 0 Hz 1001 pts) NVALUE	<u>Auto</u>	CF Ste .000000 M M
1 Δ2 2 F 3 Δ4 4 F 5	1 t	(Δ) (Δ)		2.880 n 5.455 n 3.750 n 5.455 n	ns ns (/		2.17 c -3.76 dB 0.07 c -3.76 dB	m IB								Freq Offs
6 7 8																
9														~		



# 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 §15.205(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	GHz
0.009 ~ 0.110	16.42 ~ 16.423	399.90 ~ 410	4.5 ~ 5.15
0.495 ~ 0.505	16.69475 ~ 16.69525	608 ~ 614	5.35 ~ 5.46
2.1735 ~ 2.1905	16.80425 ~ 16.80475	960 ~ 1240	7.25 ~ 7.75
4.125 ~ 4.128	25.5 ~ 25.67	1300 ~ 1427	8.025 ~ 8.5
4.17725 ~ 4.17775	37.5 ~ 38.25	1435 ~ 1626.5	9.0 ~ 9.2
4.20725 ~ 4.20775	73 ~ 74.6	1645.5 ~ 1646.5	9.3 ~ 9.5
6.215 ~ 6.218	74.8 ~ 75.2	1660 ~ 1710	10.6 ~ 12.7
6.26775 ~ 6.26825	108 ~ 121.94	1718.8 ~ 1722.2	13.25 ~ 13.4
6.31175 ~ 6.31225	123 ~ 138	2200 ~ 2300	14.47 ~ 14.5
8.291 ~ 8.294	149.9 ~ 150.05	2310 ~ 2390	15.35 ~ 16.2
8.362 ~ 8.366	156.52475 ~ 156.52525	2483.5 ~ 2500	17.7 ~ 21.4
8.37625 ~ 8.38675	156.7 ~ 156.9	2690 ~ 2900	22.01 ~ 23.12
8.41425 ~ 8.41475	162.0125 ~ 167.17	3260 ~ 3267	23.6 ~ 24.0
12.29 ~ 12.293	167.72 ~ 173.2	3332 ~ 3339	31.2 ~ 31.8
12.51975 ~ 12.52025	240 ~ 285	3345.8 ~ 3358	36.43 ~ 36.5
12.57675 ~ 12.57725	322 ~ 335.4	3600 ~ 4400	Above 38.6
13.36 ~ 13.41			

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.

#### **Measurement Instrument Setting**

- 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.



Dt&C

#### 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)
2385.73	Н	Х	PK	49.82	4.79	N/A	N/A	54.61	74.00	19.39
2385.73	Н	Х	AV	49.82	4.79	-24.79	N/A	29.82	54.00	24.18
4803.52	Н	Х	PK	50.56	0.78	N/A	N/A	51.34	74.00	22.66
4803.52	Н	Х	AV	50.56	0.78	-24.79	N/A	26.55	54.00	27.45

#### 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)
4880.30	Н	Х	PK	49.58	1.32	N/A	N/A	50.90	74.00	23.10
4880.30	Н	Х	AV	49.58	1.32	-24.79	N/A	26.11	54.00	27.89

#### 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)
2483.65	Н	Х	PK	49.43	5.25	N/A	N/A	54.68	74.00	19.32
2483.65	Н	Х	AV	49.43	5.25	-24.79	N/A	29.89	54.00	24.11
4960.43	Н	Х	PK	49.20	1.61	N/A	N/A	50.81	74.00	23.19
4960.43	Н	Х	AV	49.20	1.61	-24.79	N/A	26.02	54.00	27.98

#### <u>Note.</u>

1. The radiated emissions were investigated up to 25 GHz. 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 )** = <u>-24.79 dB</u> 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)
2389.06	Н	Х	PK	49.46	4.80	N/A	N/A	54.26	74.00	19.74
2389.06	Н	Х	AV	49.46	4.80	-24.79	N/A	29.47	54.00	24.53
4802.19	Н	Х	PK	49.17	0.77	N/A	N/A	49.94	74.00	24.06
4802.19	Н	Х	AV	49.17	0.77	-24.79	N/A	25.15	54.00	28.85

#### 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)
4881.37	Н	Х	PK	49.55	1.35	N/A	N/A	50.90	74.00	23.10
4881.37	Н	Х	AV	49.55	1.35	-24.79	N/A	26.11	54.00	27.89

#### 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)
2488.93	Н	Х	PK	50.73	5.33	N/A	N/A	56.06	74.00	17.94
2488.93	Н	Х	AV	50.73	5.33	-24.79	N/A	31.27	54.00	22.73
4959.63	Н	Х	PK	49.62	1.61	N/A	N/A	51.23	74.00	22.77
4959.63	Н	Х	AV	49.62	1.61	-24.79	N/A	26.44	54.00	27.56

Note.

1. The radiated emissions were investigated up to 25 GHz. 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 )** = <u>-24.79 dB</u> 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.



<ul> <li>Lowest Cł</li> </ul>	nannel									
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)
2386.96	Н	Х	PK	48.89	4.79	N/A	N/A	53.68	74.00	20.32
2386.96	Н	Х	AV	48.89	4.79	-24.79	N/A	28.89	54.00	25.11
4804.73	Н	Х	PK	50.15	0.78	N/A	N/A	50.93	74.00	23.07
4804.73	Н	Х	AV	50.15	0.78	-24.79	N/A	26.14	54.00	27.86

#### 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)
4881.62	Н	Х	PK	49.53	1.35	N/A	N/A	50.88	74.00	23.12
4881.62	Н	Х	AV	49.53	1.35	-24.79	N/A	26.09	54.00	27.91

#### 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)
2483.57	Н	Х	PK	48.69	5.25	N/A	N/A	53.94	74.00	20.06
2483.57	Н	Х	AV	48.69	5.25	-24.79	N/A	29.15	54.00	24.85
4960.54	Н	Х	PK	49.29	1.61	N/A	N/A	50.90	74.00	23.10
4960.54	Н	Х	AV	49.29	1.61	-24.79	N/A	26.11	54.00	27.89

Note.

1. The radiated emissions were investigated up to 25 GHz. 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 )** = <u>-24.79 dB</u> 4. Sample Calculation.

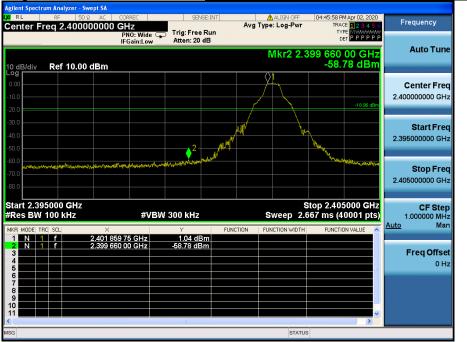
Margin = Limit – Result / Result = Reading + T.F + D.C.F / T.F = AF + CL – AG

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





#### Low Band-edge



#### Lowest Channel & Modulation : GFSK

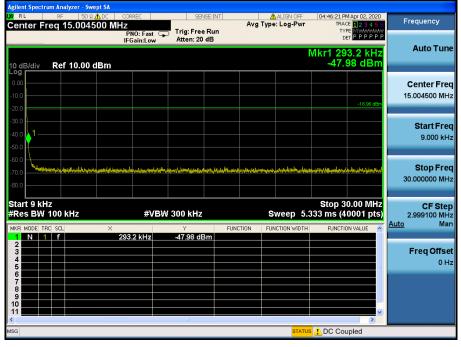
#### Low Band-edge

# Hopping mode & Modulation : GFSK





# Lowest Channel & Modulation : GFSK



Agilent Spectrum Analyzer					
Center Freq 5.01	50 Ω AC CORREC 5000000 GHz	SENSE:INT	ALIGN OFF Avg Type: Log-Pwr	04:46:44 PM Apr 02, 2020 TRACE 123456	Frequency
	PNO: Fast IFGain:Low	Trig: Free Run Atten: 20 dB			
10 dB/div Ref 10.0	00 dBm		Mkı	5 6.879 64 GHz -47.95 dBm	Auto Tune
Log 0.00 -10.0 -20.0				-18.96 dBm	Center Freq 5.015000000 GHz
-30.0			55	2 <sup>2</sup>	Start Freq 30.000000 MHz
-60.0 -70.0 -80.0					<b>Stop Freq</b> 10.00000000 GHz
Start 30 MHz #Res BW 1.0 MHz	#VE	W 3.0 MHz	Sweep 18	Stop 10.000 GHz 3.67 ms (40001 pts)	CF Step 997.000000 MHz Auto Man
MKR MODE TRC SCL	× 2.402 36 GHz	Y 1.38 dBm	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	Auto Wan
2 N 1 f 3 N 1 f 4 N 1 f 5 N 1 f	9.516 95 GHz 3.154 85 GHz 7.498 53 GHz 6.879 64 GHz	-47.34 dBm -47.55 dBm -47.90 dBm -47.95 dBm			<b>Freq Offset</b> 0 Hz
7 8 9 10					
<pre>11</pre>				>	
MSG			STATU	S	



# Lowest Channel & Modulation : GFSK





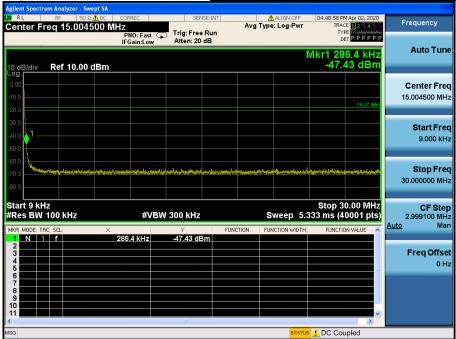
**Reference for limit** 

# Middle Channel & Modulation : GFSK



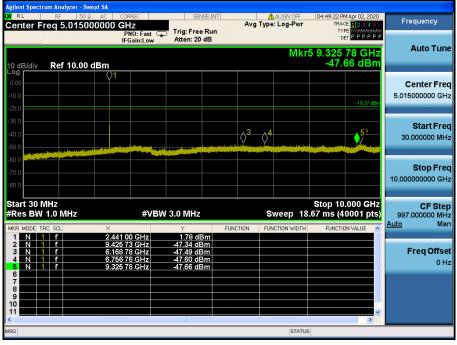
#### Conducted Spurious Emissions









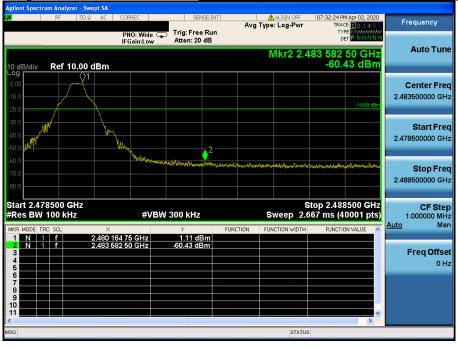






# High Band-edge

# Highest Channel & Modulation : GFSK



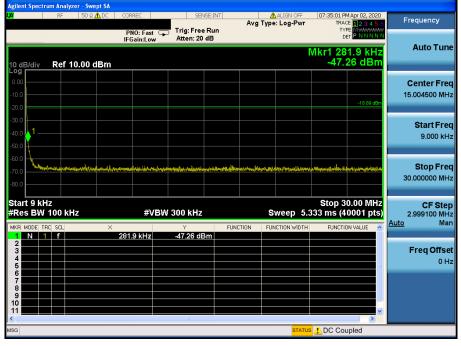
# **High Band-edge**

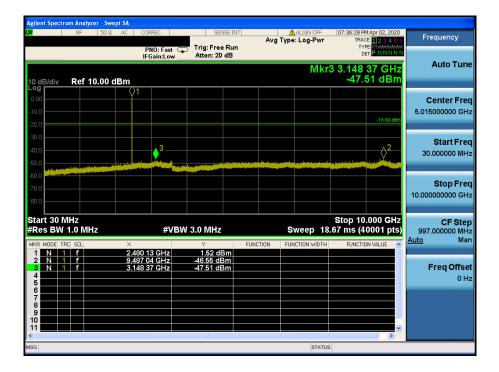
# Hopping mode & Modulation : GFSK





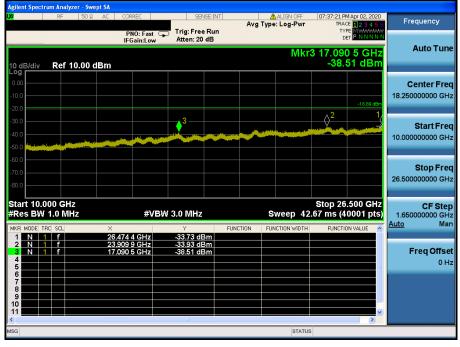
#### Highest Channel & Modulation : GFSK







# Highest Channel & Modulation : GFSK





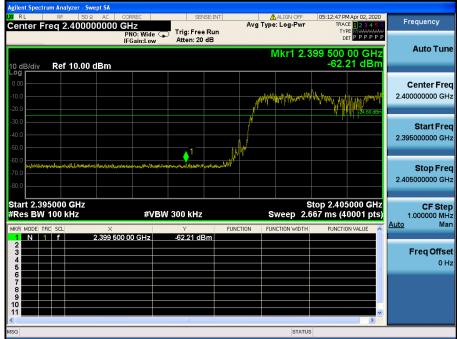
#### Low Band-edge

# Lowest Channel & Modulation : π/4DQPSK



#### Low Band-edge

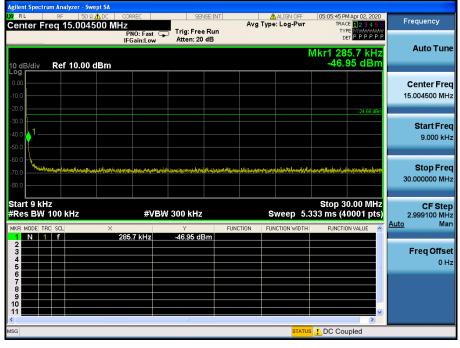
# Hopping mode & Modulation : π/4DQPSK







# Lowest Channel & Modulation : π/4DQPSK



Agilent Spectrum Analyzer - S							
Center Freq 5.015		SENSE:INT		ALIGN OFF	05:06:09 PM	Apr 02, 2020	Frequency
	PNO: Fast C IFGain:Low	<ul> <li>Trig: Free Run Atten: 20 dB</li> </ul>			TYPE DET	PPPPP	
10 dB/div Ref 10.0	0 dBm			Mkr	5 9.535 e -47.8	65 GHz 8 dBm	Auto Tune
10.00 -10.0	\$ <sup>1</sup>					-24.66 dBm	Center Freq 5.015000000 GHz
-30.0 -40.0 -50.0			2		¢ <sup>4</sup>	5	Start Freq 30.000000 MHz
-60.0 -70.0 -80.0							<b>Stop Freq</b> 10.000000000 GHz
Start 30 MHz #Res BW 1.0 MHz		W 3.0 MHz		Sweep 18		001 pts)	CF Step 997.000000 MHz Auto Man
MKR MODE TRC SCL	× 2.402 36 GHz	-2.03 dBm	FUNCTION F	UNCTION WIDTH	FUNCTION	VALUE	
2 N 1 F 3 N 1 F 4 N 1 F 5 N 1 F	6.067 33 GHz 7.649 07 GHz 8.291 64 GHz 9.535 65 GHz	-47.17 dBm -47.70 dBm -47.76 dBm -47.88 dBm					Freq Offset 0 Hz
6 7 7 8 9 9 10 10							
MSG		III		STATUS	1		



# Lowest Channel & Modulation : π/4DQPSK







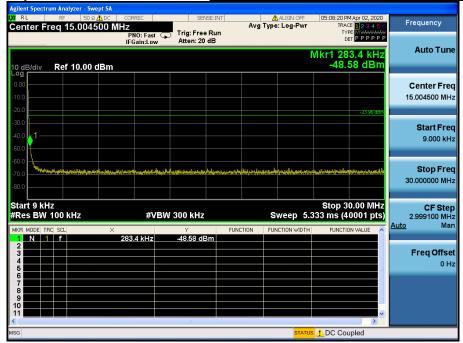
#### Reference for limit

Middle Channel & Modulation : π/4DQPSK



#### Conducted Spurious Emissions

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







# Middle Channel & Modulation : π/4DQPSK









# High Band-edge

# Highest Channel & Modulation : π/4DQPSK



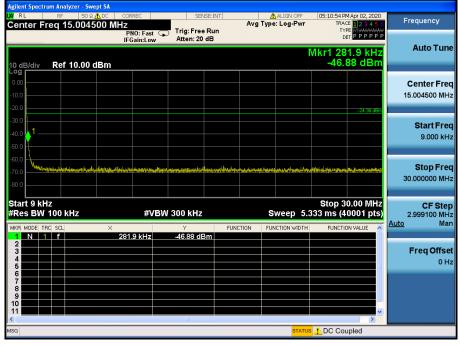
# High Band-edge

# Hopping mode & Modulation : π/4DQPSK





# Highest Channel & Modulation : π/4DQPSK



Agilent Spectrum Analyzer - Swept SA		SENSE: INT	ALIGN OFF	05:11:18 PM Apr 02, 2020	
Center Freq 5.0150000	0 GHz PNO: Fast	Trig: Free Run Atten: 20 dB	Avg Type: Log-Pwr		Frequency
10 dB/div Ref 10.00 dBm	il odineou	Atten: 20 dB	Mkr	5 3.148 62 GHz -47.84 dBm	Auto Tune
-10.0					Center Freq 5.015000000 GHz
-30.0 -40.0 -50.0	5	and the second second second second	¢ <sup>3</sup> ↓ <sup>4</sup>	-24.36 dBm	Start Freq 30.000000 MHz
-60.0 -70.0 -80.0					Stop Freq 10.00000000 GHz
Start 30 MHz #Res BW 1.0 MHz	#VBW 3		Sweep 18	Stop 10.000 GHz .67 ms (40001 pts)	<b>CF Step</b> 997.000000 MHz <u>Auto</u> Man
2 N 1 f 99 3 N 1 f 66 4 N 1 f 66	5.128 65 GHz 5.814 83 GHz	-2.07 dBm -47.66 dBm -47.78 dBm -47.78 dBm -47.84 dBm			Freq Offset 0 Hz
7 8 9 10 11				×	
MSG			STATUS		



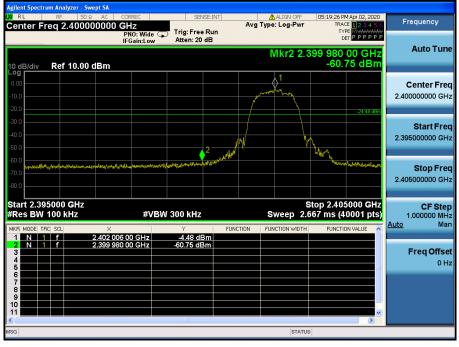
# Highest Channel & Modulation : π/4DQPSK





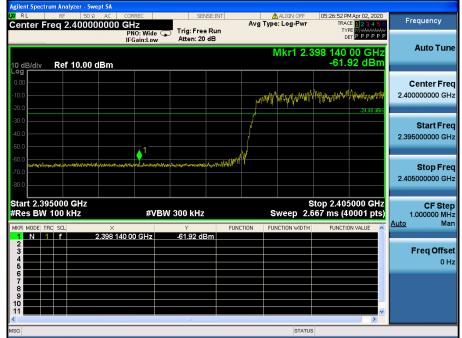
#### Low Band-edge

# Lowest Channel & Modulation : 8DPSK



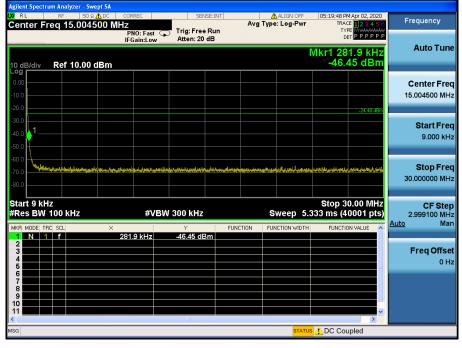
#### Low Band-edge

# Hopping mode & Modulation : 8DPSK





### Lowest Channel & Modulation : 8DPSK







# Lowest Channel & Modulation : 8DPSK



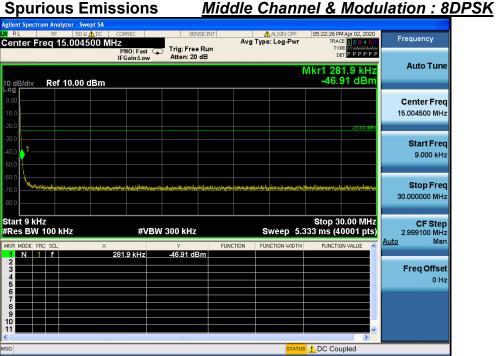


#### **Reference for limit**





#### **Conducted Spurious Emissions**







#### Middle Channel & Modulation : 8DPSK

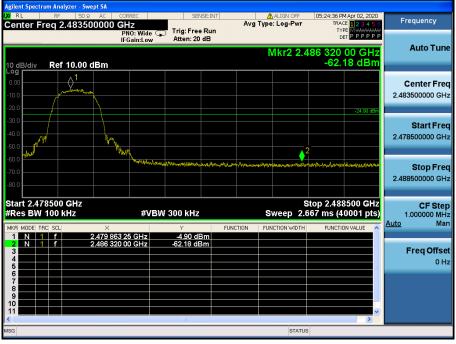






#### High Band-edge

# Highest Channel & Modulation : 8DPSK



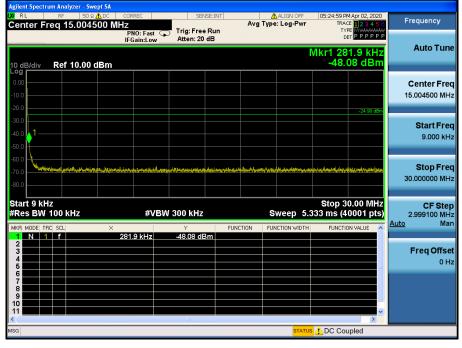
# High Band-edge

# Hopping mode & Modulation : 8DPSK





#### Highest Channel & Modulation : 8DPSK

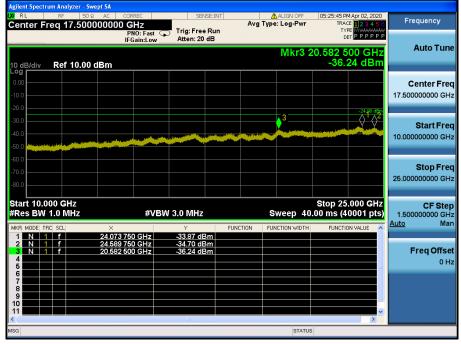


(IRL	RF	50 Ω		RREC	SENSE		ALIGN		5:25:22 PM Ap		Englisher
Center	Freq 5	.015000		Z NO: Fast (	Trig: Free R		vg Type: Log-	-Pwr	TRACE	23456 MMMMM PPPPP	Frequency
				Gain:Low	Atten: 20 dE				DET	PPPPP	
								Mkr5 7	.701 67		Auto Tune
10 dB/div	Ref	10.00 dE	m						-48.05	dBm	
											Center Free
-10.0											5.015000000 GH
-20.0											0.0100000000011
-30.0										-24.90 dBm	
-40.0							. 1	. 5	. 2	×2	Start Free
							$\Diamond$		0	$\Sigma$	30.000000 MH;
-50.0	a la bann b										
-60.0											Stop Free
-70.0											10.000000000 GH
-80.0											
Start 30	MHz	I						S	top 10.00	0 GHz	CF Ster
#Res B	W 1.0 №	IHz		#VB	W 3.0 MHz		Sweep	o 18.67	ms (400	01 pts)	997.000000 MH
MKR MODE	TRC SCL		×		Y	FUNCTION	FUNCTION V	WIDTH	FUNCTION V	ALUE 🔼	<u>Auto</u> Mar
1 N 2 N	1 f		2.480 3		-2.11 dBm -47.12 dBm		_				
3 N	1 f		8.921 0	0 GHz	-47.72 dBm						Freq Offse
4 N 5 N	1 f 1 f		6.878 8 7.701 6		-47.72 dBm -48.05 dBm					-	0 H
6											
8											
9											
44										~	
										>	





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.

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

\* Decreases with the logarithm of the frequency

#### 8.3 Test Procedures

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

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

#### 8.4 Test Results

NA



# 9. Antenna Requirement

🛈 Dt&C

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 printed on the PCB. (Refer to Internal Photo file.) Therefore this E.U.T Complies with the requirement of §15.203

#### - Minimum Standard :

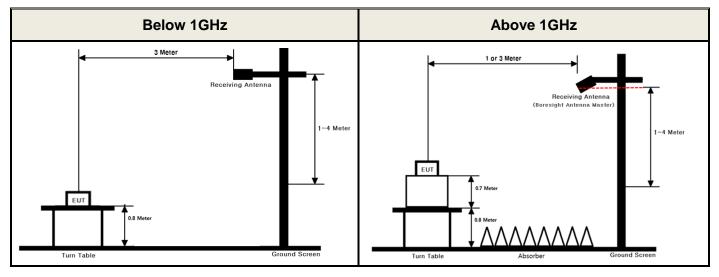
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions.



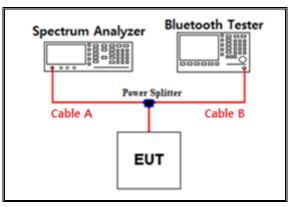
# **APPENDIX I**

# Test set up diagrams

#### Radiated Measurement



#### Conducted Measurement



#### Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	6.35	15	11.20
1	7.17	20	13.20
2.402 & 2.441 & 2.480	7.72	25	13.65
5	8.77	-	-
10	10.24	-	-

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

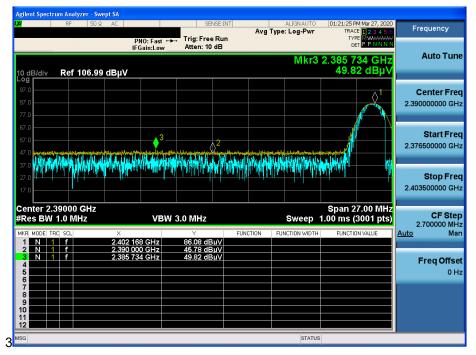
Path loss (S/A's Correction factor) = Cable A+ Power splitter



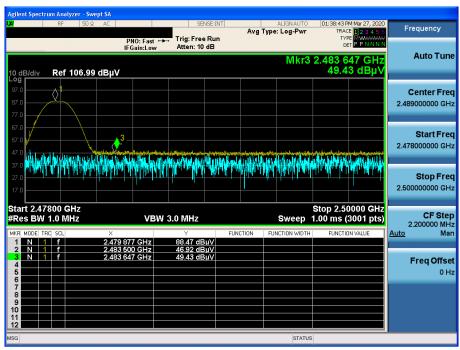
# **APPENDIX II**

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

#### GFSK & Lowest & X & Hor



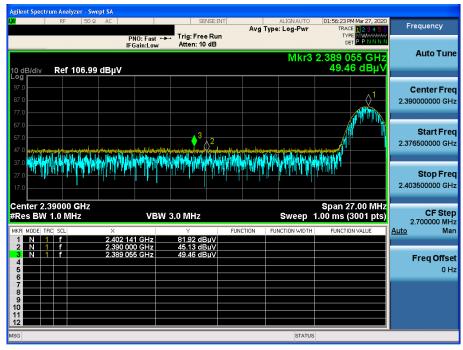
#### GFSK & Highest & X & Hor



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

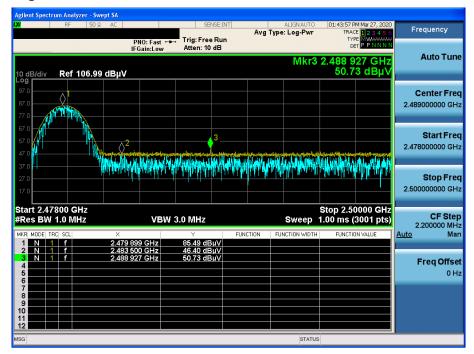


#### $\pi/4DQPSK$ & Lowest & X & Hor



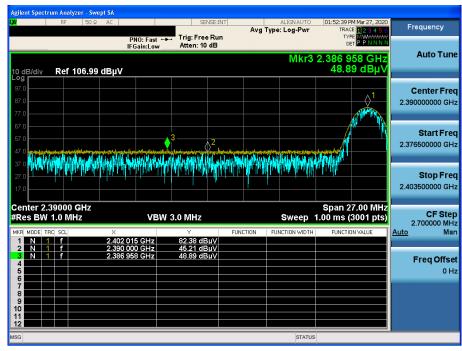
#### **Detector Mode : PK**

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



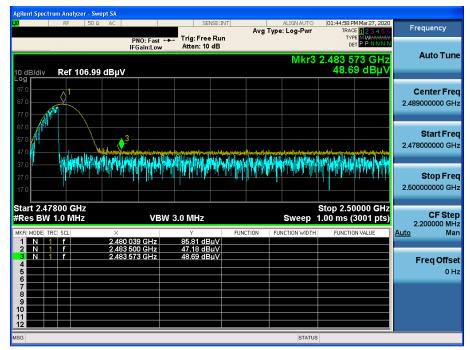


#### 8DPSK & Lowest & X & Hor



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

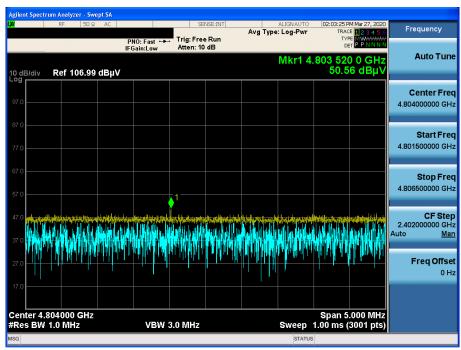
#### 8DPSK & Highest & X & Hor





#### GFSK & Lowest & X & Hor

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



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

#### Frequency Avg Type: Log-Pwr TYF DE Mkr1 4.959 626 7 GH: 49.62 dBµ Auto Tune Ref 106.99 dBµV 10 dB/div **Center Freq** 4.960000000 GHz Start Freq 4.957500000 GHz Stop Freq 4.962500000 GHz ٥ CF Step 2.48000000 GHz and all a Adult field bet a Auto Mar Freq Offset 0 Hz Center 4.960000 GHz #Res BW 1.0 MHz Span 5.000 MHz Sweep 1.00 ms (3001 pts) VBW 3.0 MHz

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



#### 8DPSK & Lowest & X & Hor

