TEST REPORT

Dt&C

Dt&C Co., Ltd.

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

1. Report No : DRTFCC2303-0042(1)						
2. Customer						
• Name (FCC) : MOTREX CO., LTD.						
 Address (FCC) : Seoyoung Bldg. 25, Hwangsaeul-ro 258beon-gil,Bundang-gu, Seongnam-si, Gyeonggi-do,South Korea 						
3. Use of Report : FCC Original Grant						
4. Product Name / Model Name : SMART DISPLAY / MS400ASP2PE FCC ID : BP9-MS400ASP2PE						
5. FCC Regulation(s): Part 15.247 Test Method used: KDB558074 D01v05r02, ANSI C63.10-2013						
6. Date of Test : 2023.02.06 ~ 2023.03.13						
7. Location of Test : X Permanent Testing Lab On Site Testing						
8. Testing Environment : See appended test report.						
9. Test Result : Refer to the attached test result.						
The results shown in this test report refer only to the sample(s) tested unless otherwise stated. This test report is not related to KOLAS accreditation.						
Affirmation Tested by Technical Manager						
Affirmation Name : SeungMin Gil (Sewigure) Name : JaeJin Lee (Signature)						
2023.04.06.						
Dt&C Co., Ltd.						

Test Report Version

Test Report No.	Date	Description	Revised by	Reviewed by
DRTFCC2303-0042	Mar. 29, 2023	Initial issue	SeungMin Gil	JaeJin Lee
DRTFCC2303-0042(1)	Apr. 06, 2023	Update for add model name	SeungMin Gil	JaeJin Lee



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1. General Information

1.1. Description of EUT

Equipment Class	DSS-Part 15 Spread Spectrum Transmitter		
Product Name	SMART DISPLAY		
Model Name	MS400ASP2PE		
Add Model Name	MS400ASP2cPE		
Firmware Version Identification Number	Rev 0.1		
EUT Serial Number	No Specified		
Power Supply	DC 12 V		
Frequency Range	2 402 MHz ~ 2 480 MHz		
Max. RF Output Power	6.35 dBm (0.004 W)		
Modulation Technique (Data rate)	GFSK(1 Mbps), π/4DQPSK(2 Mbps), 8DPSK(3 Mbps)		
Number of Channels	79		
Antenna Specification	Antenna Type: Dielectric Chip Antenna Gain: 4.84 dBi (PK)		

1.2. Declaration by the applicant / manufacturer

- NA



1.3. 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 Part 2.948 according to ANSI C63.4-2014.

- FCC & IC MRA Designation No. : KR0034

- ISED#: 5740A

www.dtnc.net		
Telephone	:	+ 82-31-321-2664
FAX	:	+ 82-31-321-1664

1.4. Testing Environment

Ambient Condition	
Temperature	+20 °C ~ +25 °C
 Relative Humidity 	35 % ~ 45 %

1.5. 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.

Parameter	Measurement uncertainty
Antenna-port conducted emission	1.1 dB (The confidence level is about 95 %, $k = 2$)
Radiated emission (1 GHz Below)	4.8 dB (The confidence level is about 95 %, $k = 2$)
Radiated emission (1 GHz ~ 18 GHz)	5.0 dB (The confidence level is about 95 %, $k = 2$)
Radiated emission (18 GHz Above)	5.2 dB (The confidence level is about 95 %, k = 2)

1.6. 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 sequenc e 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.

1.7. Conclusion of worst-case and operation mode

The EUT has three types of modulation (GFSK, π /4DQPSK and 8DPSK). Therefore all applicable requirements were tested with all the modulations. And packet type was tested at the worst case(DH5).

EUT Operation test setup

Bluetooth tester was used to control the transmit parameters during test.

Tested frequency information,

- Hopping Function : Enable

	Tested Frequency (MHz)
Hopping Band	2 402 ~ 2 480

- Hopping Function : Disable

	Tested Frequency (MHz)		
Lowest Channel	2 402		
Middle Channel	2 441		
Highest Channel	2 480		





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	22/12/16	23/12/16	MY48010133
Spectrum Analyzer	Agilent Technologies	N9020A	22/12/16	23/12/16	MY48011700
Spectrum Analyzer	Agilent Technologies	N9020A	22/06/24	23/06/24	US47360812
DC Power Supply	Agilent Technologies	66332A	22/06/24	23/06/24	US37473627
DC Power Supply	SM techno	SDP30-5D	22/06/24	23/06/24	305DMG288
BlueTooth Tester	TESCOM	TC-3000C	22/06/24	23/06/24	3000C000563
Power Splitter	Anritsu	K241B	22/06/24	23/06/24	020611
Multimeter	FLUKE	17B+	22/12/16	23/12/16	36390701WS
Signal Generator	Rohde Schwarz	SMBV100A	22/12/16	23/12/16	255571
Signal Generator	ANRITSU	MG3695C	22/12/16	23/12/16	173501
Thermohygrometer	BODYCOM	BJ5478	22/12/16	23/12/16	120612-1
Thermohygrometer	BODYCOM	BJ5478	22/12/16	23/12/16	120612-2
Thermohygrometer	BODYCOM	BJ5478	22/06/24	23/06/24	N/A
Loop Antenna	ETS-Lindgren	6502	22/12/16	24/12/16	00226186
Hybrid Antenna	Schwarzbeck	VULB 9160	22/12/16	23/12/16	3362
Horn Antenna	ETS-Lindgren	3117	22/06/24	23/06/24	00143278
Horn Antenna	A.H.Systems Inc.	SAS-574	22/06/24	23/06/24	155
PreAmplifier	tsj	MLA-0118-B01-40	22/12/16	23/12/16	1852267
PreAmplifier	tsj	MLA-1840-J02-45	22/06/24	23/06/24	16966-10728
PreAmplifier	H.P	8447D	22/12/16	23/12/16	2944A07774
High Pass Filter	Wainwright Instruments	WHKX12-935-1000- 15000-40SS	22/06/24	23/06/24	8
High Pass Filter	Wainwright Instruments	WHKX10-2838-3300- 18000-60SS	22/06/24	23/06/24	1
High Pass Filter	Wainwright Instruments	WHNX8.0/26.5-6SS	22/06/24	23/06/24	3
Attenuator	Hefei Shunze	SS5T2.92-10-40	22/06/24	23/06/24	16012202
Attenuator	Aeroflex/Weinschel	56-3	22/06/24	23/06/24	Y2370
Attenuator	SMAJK	SMAJK-2-3	22/06/24	23/06/24	3
Attenuator	SMAJK	SMAJK-2-3	22/06/24	23/06/24	2
Attenuator	Aeroflex/Weinschel	86-10-11	22/06/24	23/06/24	408
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2496A MA2490A	22/12/16	23/12/16	1338004 1249303
Receiver	Rohde Schwarz	ESCI3	22/09/19	23/09/19	100798
Cable	Dt&C	Cable	23/01/04	24/01/04	G-2
Cable	HUBER+SUHNER	SUCOFLEX 100	23/01/04	24/01/04	G-3
Cable	Dt&C	Cable	20/01/04	24/01/04	G-4
Cable	OMT	YSS21S	23/01/04	24/01/04	G-5
Cable	HUBER+SUHNER	SUCOFLEX100	23/01/04	24/01/04	M-01
Cable	HUBER+SUHNER	SUCOFLEX100	23/01/04	24/01/04	M-02
Cable	Junkosha	MWX241/B	23/01/04	24/01/04	M-03
Cable	JUNFLON	J12J101757-00	23/01/04	24/01/04	M-07
Cable	HUBER+SUHNER	SUCOFLEX106	23/01/04	24/01/04	M-09
Cable	RADIALL	TESTPRO 3	23/01/04	24/01/04	RFC-70
Test Software	tsj	Radiated Emission Measurement	NA	NA	Version 2.00.0147

Note1: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017 Note2: The cable is not a regular calibration item, so it has been calibrated by Dt&C itself.



2. Antenna Requirement

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.

Conclusion: Comply

The antenna is attached on the PCB by means of unique connector. Therefore this E.U.T complies with the requirement of Part 15.203

3. Summary of Test Results

FCC part section(s)	Test Description	Limit (Using in 2 400~ 2 483.5 MHz)	Test Condition	Status Note 1
15.247(a) 15.247(b)	Maximum Peak Conducted Output Power	=< 0.125 W(conducted)		с
	20 dB Bandwidth	NA		С
15 247(2)	Carrier Frequency Separation	>= 25 kHz or >= Two thirds of the 20 dB BW, whichever is greater.	Conducted	с
15.247(a)	Number of Hopping Channels	>= 15 hops		с
	Time of Occupancy	=< 0.4 seconds		С
15.247(d)	Unwanted Emissions (Conducted)	The radiated emission to any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density.		с
15.247(d) 15.205 15.209	Unwanted Emissions (Radiated)	Part 15.209 Limits (Refer to section 9)	Radiated	С
15.207	AC Power-Line Conducted Emissions	Part 15.207 Limits (Refer to section 10)	AC Line Conducted	NA Note3
15.203	Antenna Requirement	Part 15.203 (Refer to section 2)	-	С

Note 2: For radiated emission tests below 30 MHz were performed on semi-anechoic chamber which is correlated with OATS. Note 3: This device is installed in a car. Therefore the power source is a battery of car.



4. Maximum Peak Conducted Output Power

4.1. Test Setup

Refer to the APPENDIX I.

4.2. 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 2 400 MHz 2 483.5 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.
- 2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 2 483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 MHz 5 805 MHz band : 1 Watt. For all other frequency hopping systems in the 2 400 MHz 2 483.5 MHz band: 0.125 watts.

4.3. 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

4.4. Test Results

Modulation	Tested Channel	Burst Average Output Power		Peak Output Power	
		dBm	mW	dBm	mW
	Lowest	3.35	2.16	3.42	2.20
<u>GFSK</u>	Middle	2.87	1.94	3.16	2.07
	Highest	2.76	1.89	3.03	2.01
	Lowest	3.83	2.42	5.79	3.79
<u>π/4DQPSK</u>	Middle	3.62	2.30	5.88	3.87
	Highest	3.45	2.21	5.69	3.71
<u>8DPSK</u>	Lowest	3.83	2.42	6.33	4.30
	Middle	3.59	2.29	6.35	4.32
	Highest	3.41	2.19	5.95	3.94

Note 1: The 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

Middle Channel & Modulation : GFSK









Peak Output Power

Lowest Channel & Modulation : π/4DQPSK





Middle Channel & Modulation : π/4DQPSK



Peak Output Power

Highest Channel & Modulation : π/4DQPSK







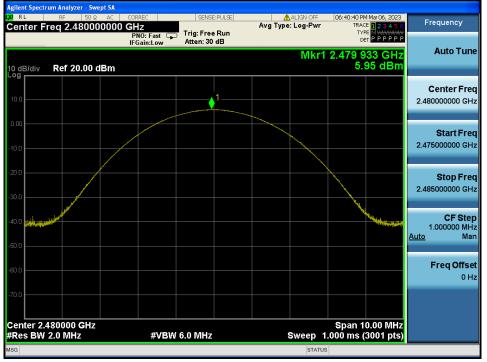








Highest Channel & Modulation : 8DPSK





5. 20 dB BW

5.1. Test Setup

Refer to the APPENDIX I.

5.2. Limit

Limit : Not Applicable

5.3. Test Procedure

- 1. The 20 dB bandwidth was 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

 $VBW \ge 3 \times RBW$

Span = between two times and five times the 20 dB bandwidth

Sweep = auto

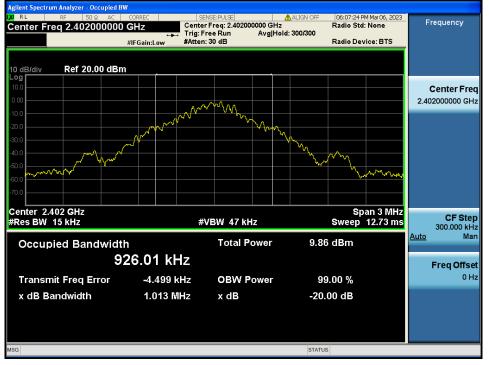
Detector function = peak

Trace = max hold

5.4. Test Results

Modulation	Tested Channel	20 dB BW (MHz)
	Lowest	1.013
<u>GFSK</u>	Middle	1.011
	Highest	1.014
	Lowest	1.347
<u>π/4DQPSK</u>	Middle	1.345
	Highest	1.352
	Lowest	1.348
<u>8DPSK</u>	Middle	1.352
	Highest	1.345

Lowest Channel & Modulation : GFSK

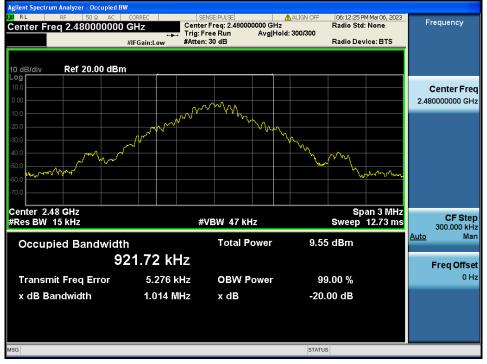


20 dB BW

Middle Channel & Modulation : GFSK



Highest Channel & Modulation : GFSK



20 dB BW

Lowest Channel & Modulation : π/4DQPSK



Middle Channel & Modulation : π/4DQPSK



20 dB BW

Highest Channel & Modulation : π/4DQPSK





Lowest Channel & Modulation : 8DPSK

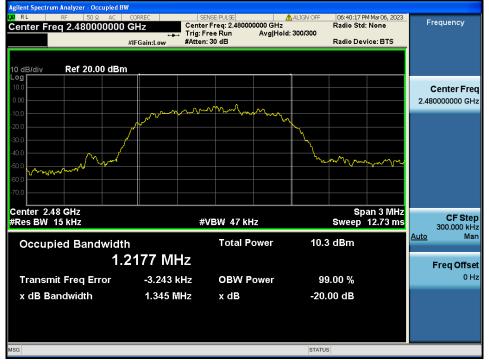


20 dB BW

Middle Channel & Modulation : 8DPSK



Highest Channel & Modulation : 8DPSK





6. Carrier Frequency Separation

6.1. Test Setup

Refer to the APPENDIX I.

6.2. Limit

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

6.3. Test 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

6.4. Test Results

FH mode

Hopping Mode	Modulation	Peak of reference channel(MHz)	Peak of adjacent Channel(MHz)	Test Result (MHz)
	GFSK	2 441.004	2 442.000	0.996
Enable	π/4DQPSK	2 441.000	2 442.005	1.005
-	8DPSK	2 441.000	2 442.000	1.000

AFH mode

Hopping Mode	Modulation	Peak of reference channel(MHz)	Peak of adjacent Channel(MHz)	Test Result (MHz)
	GFSK	2 441.002	2 442.001	0.999
Enable	π/4DQPSK	2 440.999	2 442.003	1.004
	8DPSK	2 441.000	2 441.998	0.998

Note 1 : See next pages for actual measured spectrum



Carrier Frequency Separation (FH)

Hopping mode : Enable&GFSK

M RL RF 50.2. AC CORREC [SENSE:PULSE] ▲ALIGN OFF [06:20:40 PM Mar 06; 2023 Frequency Center Freq 2.441000000 GHz Trig: Free Run PN0: Wide IFGain:Low Trig: Free Run Atten: 30 dB Avg Type: Log-Pwr TRACE Trig: P P P P P Trig: Free Run Atten: 30 dB Avg Type: Log-Pwr TRACE P P P P P P Auto Tur 10 dB/div Ref 20.00 dBm 0.05 dB 0.05 dB Center Fre 2.441000000 G Center Fre
PN0: Wide Trig: Free Run IF Gain:Low Atten: 30 dB 0 dB/div Ref 20.00 dBm 0.05 dB 10.0 0.00 Atten: 20
ΔMRFT 996 KH2 10 dB/div Ref 20.00 dBm 0.05 dB 10 0 100 100 100 0.00 2.44100000 G 2.44100000 G
10.0 0.00 Υ2
200 300
50.0 Stop Fr -60.0 2.442500000 G .70.0 2.442500000 G
Center 2.441000 GHz Span 3.000 MHz CF Ste #Res BW 51 kHz #VBW 150 kHz Sweep 1.200 ms (3001 pts) 300.000 kHz
MKR MODE TRC SLI X Y FUNCTION FUNCTION VALUE Auto M 1 Δ2 1 f (Δ) 996 kHz (Δ) 0.05 dB Image: Comparison of the second secon
2 F 1 f 2.441 004 GHz 2.51 dBm 3 4 5 5 6 7
MSG STATUS

Carrier Frequency Separation (FH)

Hopping mode : Enable&π/4DQPSK





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

Agilent Spectr											
Center Fi	RF rea 2.44	50 Q AC	CORREC		PULSE	Avg Ty	ALIGN OFF pe: Log-Pwr	TRAC	4 Mar 06, 2023 E <mark>1 2 3 4 5</mark> 6		Frequency
			PNO: Wide IFGain:Lov								
10 dB/div	Ref 20	.00 dBm					ΔN	1kr1 1.0	00 MHz 0.00 dB		Auto Tune
Log 10.0 0.00 -10.0		~~~	~~~~	~~~~>	<u>k</u>		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	<u>1Δ2</u>		2.4	Center Freq 41000000 GHz
-20.0										2.4	Start Freq 39500000 GHz
-50.0 -60.0 -70.0										2.4	Stop Freq 42500000 GHz
Center 2.4 #Res BW	51 kHz	GHz	#V	'BW 150 kHz Y	E III	ICTION F	Sweep 1	.200 ms (.000 MHz 3001 pts)	Auto	CF Step 300.000 kHz Man
1 △2 1 2 F 1 3 4 6 6 7 8 9 9 10 11	f (Δ)		1.000 MHz 41 000 GHz		dB			FORCIU	NVALUE V		Freq Offset 0 Hz
MSG							STATUS	6			



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

Agilent Spectrum Analyzer - Swept SA				
IM RL RF 50 Ω AC Center Freq 2.441000000	CORREC SENSE:PU	.SE Avg Type: Log-Pwi	06:57:31 PM Mar 06, 2023 TRACE 1 2 3 4 5 6	Frequency
Center 11eq 2.44 100000	PNO: Wide Trig: Free Ru IFGain:Low Atten: 30 dB		TYPE MWWWWW DET P P P P P P	
10 dB/div Ref 20.00 dBm			ΔMkr1 999 kHz -0.04 dB	Auto Tune
10.0 0.00 -10.0	×2		1Δ2	Center Freq 2.441000000 GHz
-20.0				Start Freq 2.439500000 GHz
-50.0 -60.0 -70.0				Stop Freq 2.442500000 GHz
Center 2.441000 GHz #Res BW 51 kHz	#VBW 150 kHz	Sweep	Span 3.000 MHz 1.200 ms (3001 pts)	CF Step 300.000 kHz Auto Man
MKR MODE TRC SCL X	999 kHz (Δ) -0.04 dB	FUNCTION FUNCTION WIDT	H FUNCTION VALUE	Auto Wan
	1002 GHz 2.40 dBm			Freq Offset 0 Hz
7 8 9 9 9 10 11				
<	ш			
MSG		STAT	US	

Carrier Frequency Separation (AFH) <u>Hopping mode : Enable&π/4DQPSK</u>

Agilent Spectrum	Analyzer - Swep	it SA					
Center Fre		AC CORREC 0000 GHz PNO: Wid	SENSE:PU	Avg Typ	ALIGN OFF	07:00:55 PM Mar 06, 2023 TRACE 12345 (TYPE MWWWWW	
10 dB/div	Ref 20.00 di	IFGain:Lo			ΔN	ост Р Р Р Р Р Р Ikr1 1.004 MHz -0.02 dB	Auto Tune
10.0 0.00 -10.0		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	X2	~~~~~~	~~~~~	<u>1Δ2</u>	Center Freq 2.441000000 GHz
-20.0 -30.0 -40.0							Start Freq 2.439500000 GHz
-50.0 -60.0 -70.0							Stop Freq 2.442500000 GHz
Center 2.44 #Res BW 51		#\	/BW 150 kHz		Sweep 1	Span 3.000 MHz 200 ms (3001 pts)	CF Step 300.000 kHz Auto Man
MKR MODE TRC	scL f (Δ)	× 1.004 MHz	γ (Δ) -0.02 dB		JNCTION WIDTH	FUNCTION VALUE	Adto
2 F 1 3 4 5 5	f	2.440 999 GHz	2.79 dBm				Freq Offset 0 Hz
6 7 8 9 10							
11						×	
MSG					STATUS		



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

Agilent Spectrum Analyzer - Swept SA				
RL RF 50 Ω AC Center Freq 2.441000000	CORREC SENSE:PULSE	ALIGN OFF	07:04:19 PM Mar 06, 2023 TRACE 1 2 3 4 5 6	Frequency
	PNO: Wide Trig: Free Run IFGain:Low Atten: 30 dB		TYPE MWWWWW DET PPPPP	
10 dB/div Ref 20.00 dBm		,	∆Mkr1 998 kHz -0.09 dB	Auto Tune
Log 10.0 0.00 -10.0	X2	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1Δ2	Center Freq 2.441000000 GHz
-20.0				Start Freq 2.439500000 GHz
-50.0 -60.0 -70.0				Stop Freq 2.442500000 GHz
Center 2.441000 GHz #Res BW 51 kHz	#VBW 150 kHz		Span 3.000 MHz .200 ms (3001 pts)	CF Step 300.000 kHz Auto Man
MKR MODE TRC SCL \times	998 kHz (Δ) -0.09 dB	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	<u>inter</u>
2 F 1 f 2.44 3 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	11 000 GHz 2.80 dBm		=	Freq Offset 0 Hz
6 7 8 9 10 11				
<	ш.			
MSG		STATUS	5	



7. Number of Hopping Channels

7.1. Test Setup

Refer to the APPENDIX I.

7.2. Limit

Limit : >= 15 hops

7.3. Test 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 2 400 MHz ~ 2 483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz	Start Frequency = 2 391.5 MHz,	Stop Frequency = 2 441.5 MHz
	Start Frequency = 2 441.5 MHz,	Stop Frequency = 2 491.5 MHz
Span for AFH mode = 30 MHz	Start Frequency = 2 426.0 MHz,	Stop Frequency = 2 456.0 MHz
RBW = To identify clearly the indiv	vidual channels, set the RBW to lea	ss than 30 % of the channel spacing
or the 20 dB bandwidth, v	vhichever is smaller.	
VBW ≥ RBW	Sweep = auto	
Detector function = peak	Trace = max hold	

7.4. 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.



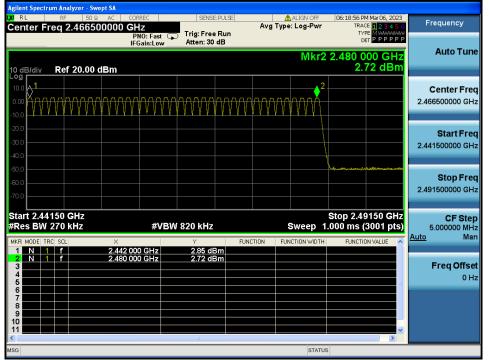
Number of Hopping Channels 1(FH)

Hopping mode : Enable & GFSK

Agilent Spectrum Analyzer - Swept SA					
LXIRL RF 50Ω AC	CORREC	SENSE:PULSE	ALIGN OFF	06:17:44 PM Mar 06, 2023	Frequency
Center Freq 2.41650000		Trig: Free Run	Avg Type: Log-Pwr	TRACE 123456	
	PNO: Fast 🖵 IFGain:Low	Atten: 30 dB		DETPPPP	
	II OUIIILOU		Mino	0.444.000 OH-	Auto Tune
			MKr2	2.441 000 GHz	
10 dB/div Ref 20.00 dBm				2.90 dBm	
Log					
10.0					Center Freq
0.00 Ån	יתהחתחחו	ากกุกกุกกุกกุก	<u> </u>	AAAAAAAAAAA	2.416500000 GHz
1 I I I I I I I I I I I I I I I I I I I	*****	*****		/ \ \ \ \ \ \ \ \ \ \ \ \ \ \	
-10.0		* * 1 • • • • • • •			
-20.0					Otherst English
-30.0					Start Freq
-30.0					2.391500000 GHz
-40.0					
-50 0 man and man and man mark					
					Stop Freq
-60.0					2.441500000 GHz
-70.0					2.441500000 GHZ
Start 2.39150 GHz				Stop 2.44150 GHz	CF Step
#Res BW 270 kHz	#VBW	820 kHz	Sween 1	.000 ms (3001 pts)	5.000000 MHz
			-		Auto Man
MKR MODE TRC SCL X		Y FUNC	TION FUNCTION WIDTH	FUNCTION VALUE	Auto
	02 000 GHz	3.12 dBm			
2 N 1 f 2.4	41 000 GHz	2.90 dBm			Freq Offset
4					
5					0 Hz
6					
7					
8 9					
10					
11				*	
<		ш		>	
MSG			STATUS		

Number of Hopping Channels 2(FH)

Hopping mode : Enable & GFSK





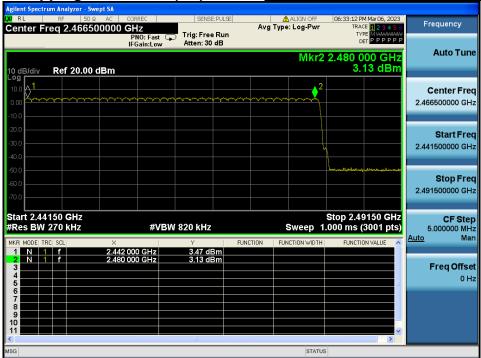
Number of Hopping Channels 1(FH)

Hopping mode : Enable&π/4DQPSK

				Swept SA								
l XI R		RF)Ω AC	CORREC	SE	NSE:PULSE		ALIGN OFF		M Mar 06, 2023	Frequency
Cen	iter Fr	req 2	2.416	500000		TrimE	ree Run	Avg	Type: Log-Pwr	TRA	CE 123456 PE MWWWWW	riequeriey
					PNO: Fast IFGain:Lov						ETPPPPP	
					IFGall.LUV	, nacen.	00 45					Auto Tune
									Mkr2		00 GHz	Autorune
10 d	B/div	Ref	f 20.0	0 dBm						3.	24 dBm	
Log												
10.0	L			- <mark>8</mark> 1-								Center Freq
0.00				_X~~	$\sim \sim $	\sim	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~	γ		·~~~~~	2.416500000 GHz
												2.41000000000112
-10.0												
-20.0												Start Freq
-30.0												
												2.391500000 GHz
-40.0				(⁴								
-50.0	and a start of the	ases, and	ومعدرة روداوهم	<u>k</u>								
-60.0												Stop Freq
												2.441500000 GHz
-70.0												
	t 2.39						-		-		4150 GHz	CF Step
#Re	s BW	270	kHz		#V	'BW 820 ki	IZ		Sweep 7	1.000 ms ((3001 pts)	5.000000 MHz
MKR	MODE TH	IC SCL		×		Y		FUNCTION	FUNCTION WIDTH	FUNCTI	ON VALUE	<u>Auto</u> Man
1	N 1	f		2.4(02 000 GHz	3.14	dBm					
2	N 1	f		2.44	11 000 GHz	3.24	dBm					Ener Offerst
3												Freq Offset
5											=	0 Hz
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7		_										
8												
10												
11											~	
<						ш					>	
MSG									STATU	IS		
	_	-	_	_								

Number of Hopping Channels 2(FH)

Hopping mode : Enable &π/4DQPSK





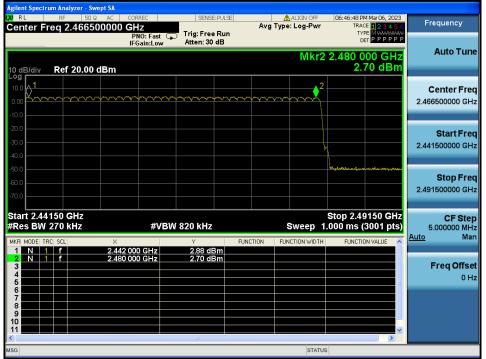
Number of Hopping Channels 1(FH)

Hopping mode : Enable&8DPSK

Agilent Spectrum Analyzer - Swept SA				
LX/RL RF 50 Q AC	CORREC SENSE:		06:45:36 PM Mar 06, 2023	Frequency
Center Freq 2.416500000	GHz	Avg Type: Log-Pwr	TRACE 123456 TYPE MWWWWW	Frequency
	PNO: Fast 😱 Ing. Free		DET P P P P P	
	IFGain:Low Atten: 30	30		
		Mkr	2 2.441 000 GHz	Auto Tune
10 dB/div Ref 20.00 dBm			3.25 dBm	
Log				
10.0			2	Center Freq
0.00		110010101110		2.416500000 GHz
-10.0				
-20.0				Start Freq
-30.0				2.391500000 GHz
-40.0				2.531500000 GHZ
-40.0				
-50.0 menon for any desilver of				
-60.0				Stop Freq
				2.441500000 GHz
-70.0				
Start 2.39150 GHz			Stop 2.44150 GHz	CF Step
#Res BW 270 kHz	#VBW 820 kHz	Sweep	1.000 ms (3001 pts)	5.000000 MHz
MKR MODE TRC SCL X	Y	FUNCTION FUNCTION WIDTH	H FUNCTION VALUE	<u>Auto</u> Man
	2 000 GHz 3.18 dB			
	1 000 GHz 3.25 dB			
3				Freq Offset
4				0 Hz
5				
6				
8				
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10				
11			×	
			>	
MSG		STAT	US	

Number of Hopping Channels 2(FH)







Number of Hopping Channels 1(AFH)

Hopping mode : Enable & GFSK

Agilent Spectrum Analyzer - Swept SA				
LX/RL RF 500 AC			.IGN OFF 06:53:42 PM	
Center Freq 2.441000000	GHz RNO: Fact Trig: Fre	Avg Type: L	.og-Pwr TRACE	123456 Frequency
	PNO: Fast Trig: Fre IFGain:Low Atten: 30		DET	PPPPP
	IFGalli.LUW Ficteri. of	/ 40		Auto Tune
			Mkr2 2.451 0	JUGHZ
10 dB/div Ref 20.00 dBm			2.8	1 dBm
Log				
10.0			2	Center Freq
	haaaaaa.	haaaaa	mmm	2.441000000 GHz
J V V	V V V V V V	$\mathbf{W} \mathbf{W} \mathbf{W} \mathbf{W} \mathbf{W} \mathbf{W} \mathbf{W}$	$\{ V V V \}$	2.44 1000000 GHZ
-10.0	<u> </u>	<u> </u>	<u> </u>	
-20.0				
				Start Freq
-30.0				2.426000000 GHz
-40.0			\	
-50.0 -turner and			Nu.,	- A kulle state
				Stop Freq
-60.0				
-70.0				2.456000000 GHz
Center 2.44100 GHz			Span 30	
#Res BW 270 kHz	#VBW 820 kHz	e.,	veep 1.000 ms (3	
#Res DW 270 RHz	#VDVV 820 KH2		veep 1.000 ms (5	
MKR MODE TRC SCL X	Y		ION WIDTH FUNCTION	IVALUE A Man
1 N 1 f 2.43	32 00 GHz 2.70 d			
	51 00 GHz 2.81 d	Bm		Freq Offset
3				
5				0 Hz
6				
7				
8				
9				
11				~
<				>
MSG			STATUS	
			5.74100	

Number of Hopping Channels 1(AFH)

Hopping mode : Enable &π/4DQPSK





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

Agilent Spe										
LXI RL	RF		Ω AC	CORREC	SENSE:PU		ALIGN OFF		M Mar 06, 2023	Frequency
Center	Freq 2	2.441	000000	GHz			Type: Log-Pwr	TRA	^{CE} 123456	riequency
				PNO: Fast	Trig: Free Ri Atten: 30 dE			IY D	PE MWWWWW ET P P P P P P	
				IFGain:Low	Atten: 30 dE				en j.	Auto Tuno
							Mkr	2 2.451	00 GHz	Auto Tune
	Def		a d D ma						78 dBm	
10 dB/div Log r	/ Re	20.0	0 dBm						o abiii	
10.0			1					▲2		
10.0								_ - -		Center Freq
0.00			~~~~v	******	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~					2.441000000 GHz
-10.0			/							
- 10.0										
-20.0								+		Start Freq
-30.0										-
								5		2.426000000 GHz
-40.0		كعبر						+		
-50.0		كلابيت							anna anna	
										Stop Freq
-60.0										2.456000000 GHz
-70.0										2.456000000 GH2
Center	2 44 10	0 CH2	,					Snan 3	0.00 MHz	0.5.04
#Res B				#\/B	W 820 kHz		Sweep 1	oon me /	2001 ntc)	CF Step
#Res D	WW 270	NПZ		#VD	W 020 KHZ		Sweep	.000 ms (Juo r pisj	3.000000 MHz
MKR MODE	TRC SCL		X		Y	FUNCTION	FUNCTION WIDTH	FUNCTI	ON VALUE	<u>Auto</u> Man
1 N	1 f		2.4	32 00 GHz	3.28 dBm					
2 N	1 f		2.4	51 00 GHz	3.78 dBm					
3										Freq Offset
4										0 Hz
6										
7										
8										
9										
10										
11									~	
<u> </u>					Ш				>	
MSG							STATU	S		
		_								



8. Time of Occupancy

8.1. Test Setup

Refer to the APPENDIX I.

8.2. Limit

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

8.3. 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 = 2 441 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

8.4. 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 slots / RX = 1 slot)
- Hopping Rate = 1 600 for FH mode & 800 for AFH mode

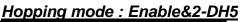
Note 2 : See next pages for actual measured spectrum plots.



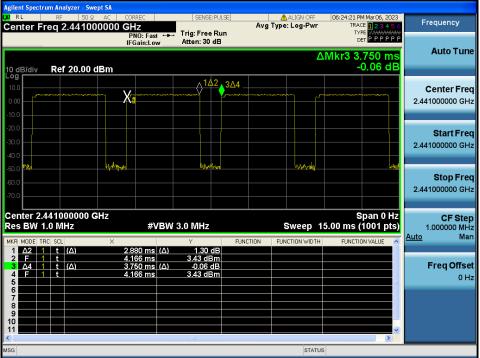
Time of Occupancy (FH)

		trun		alyzer -																
<mark>IXI</mark> RI Cen		Ere	RF	5 2.441	Δ Δ				SENSE	E:PULSE		Avg '		ALIGN OFF Log-Pwr			4 Mar 06, E 123		ſ	Frequency
					0000		PNO: Fas IFGain:Lo		Trig: Free Atten: 30			-		-			E WWW			
			-				IF Galil.LU	w	Pitterii. 00				_		ΔMk	r3 3	750	ms		Auto Tune
10 di	3/div		Rei	20.0	0 dBi	m										-	0.06	dB		
Log				2.010								۸ 1۸2	24	٨						
10.0									X		k			+						Center Freq
0.00																				2.441000000 GHz
-10.0																				
-20.0				ſ																Start Freq
-30.0 -40.0																				2.441000000 GHz
-40.0				whereas				win	(ha)			wind				n.ml	ж			
-50.0									r											Stop Freq
-70.0																				2.441000000 GHz
-70.0																				
				0000) GHz	Z							_			S	pan 0	Hz		CF Step
Res	_	_	_	HZ			#	V B W	3.0 MHz					weep		```		_		1.000000 MHz Auto Man
MKR I	MODE	TRC 1		<i>(</i> Δ)		×	2.880 ms	(A)	Y -0.26	dB	FUNCT	ION	FUNC	CTION WIDTH	1	FUNCTIO	IN VALUE	^	Ê	
2	F A4	1	t	(Δ)		6	5.249 ms 3.750 ms		3.04 df -0.06	3m										Freq Offset
4	F F	1	t	(<u></u>		é	5.249 ms		-0.06 3.04 di	ањ Зт										0 Hz
5 6																		=		
7																			L	
9																			L	
10 11																		~	L	
<	_	_	_	_				_	ш									>	L	
MSG														STAT	US					

Time of Occupancy (FH)



Hopping mode : Enable&DH5





Time of Occupancy (FH)

Hopping mode : Enable&3-DH5

	50 Q AC CORRE	c	SENSE:PULSE		ALIGN OFF		Mar 06, 2023 E <mark>1 2 3 4 5 6</mark>	Frequency
Center Freq 2.44	PNO:		g:FreeRun :en:30 dB	Avg	pe. Log-Pwr	TYP		
	Iroal	II.LOW PRO				∆Mkr3 3.	750 ms	Auto Tune
10 dB/div Ref 20.	.00 dBm					(0.00 dB	
10.0				4		andre dan er han er her er her her her her her her her h		Center Freq
0.00	X_2							2.441000000 GHz
-10.0								
-30.0								Start Freq 2.441000000 GHz
-40.0	L.J.divly/							
-50.0 ¥ -60.0			n _A awiny		(PTMAQA)		Ֆ /ավհ	Stop Freq
-50.0								2.441000000 GHz
Center 2.4410000								
Res BW 1.0 MHz		#VBW 3.0	MHz		Sweep	ۍ / 15.00 ms	pan 0 Hz 1001 pts)	CF Step 1.000000 MHz
MKR MODE TRC SCL	×	ms (Δ)	۲ 1.23 dB	FUNCTION	FUNCTION WIDTH	H FUNCTIO	N VALUE	<u>Auto</u> Man
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	3.986	ms (Δ) ms (Δ)	1.25 dB 1.30 dBm 0.00 dB					Freq Offset
4 F 1 t	3.986	ms 3	1.30 dBm					0 Hz
6								
8								
10								
MSG			Ш		STATI	US	>	



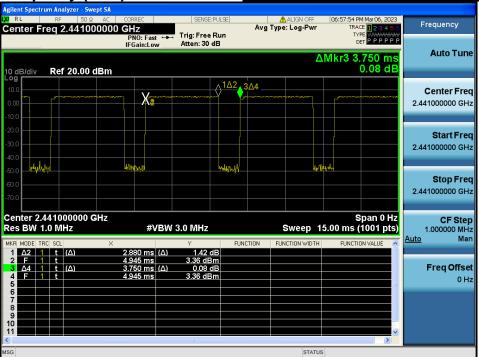
Time of Occupancy (AFH)

Hopping mode : Enable&DH5

	um Analyzer - Swept					
LXIRL	RF 50 Ω / reg 2.4410000		SENSE:PULSE	ALIGN OFF Avg Type: Log-Pwr	06:52:24 PM Mar 06, 2023 TRACE 1 2 3 4 5 6	Frequency
Center F	req 2.4410000	PNO: Fast 🔸	Trig: Free Run	Arg Type. Logi wi		
		IFGain:Low	Atten: 30 dB			Auto Tune
				Δ	Mkr3 3.750 ms	Auto Tune
10 dB/div Log	Ref 20.00 dB	m			0.07 dB	
10.0				<u>_1</u> 22_304		Center Freq
0.00	<u> </u>					2.441000000 GHz
-10.0						
-20.0						
-30.0						Start Freq
-40.0						2.441000000 GHz
-50.0	who	4,01	mound	Marthursd	maker	
-60.0						Stop Freq
-70.0						2.441000000 GHz
-70.0						
	441000000 GH		·		Span 0 Hz	CF Step
Res BW 1	1.0 MHz	#VBW	3.0 MHz	Sweep 1	5.00 ms (1001 pts)	1.000000 MHz
MKR MODE TH		×		FUNCTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
1 <u>Δ2</u> 1 2 F 1	t (Δ)	2.880 ms (∆) 7.358 ms	0.08 dB 2.89 dBm			
3 🛆 4 1	t (Δ)	3.750 ms (∆)	0.07 dB			Freq Offset
4 5		7.358 ms	2.89 dBm		=	0 Hz
6						
8						
9						
11					~	
MSG				STATUS	>	
Woo				STATUS		

Time of Occupancy (AFH)







Time of Occupancy (AFH)

Hopping mode : Enable&3-DH5

Agilent Spectrum Analyzer - Swept SA	CORREC SEN	ISE:PULSE	ALIGN OFF 07:01:	18 PM Mar 06, 2023	_
Center Freq 2.441000000	GHz PNO: Fast +++ Trig: Fr		e: Log-Pwr	TRACE 123456 TYPE WWWWWW	Frequency
	IFGain:Low Atten:			DET PPPPP	
			ΔMkr3	3.750 ms	Auto Tune
10 dB/div Ref 20.00 dBm				-0.12 dB	
10.0					Center Freq
	Xa	and encode and a growth			2.441000000 GHz
-10.0					
-20.0					Start Freq
-30.0					2.441000000 GHz
-40.0					
-50.0	Pulpanjjel	hipter	herus	und	Stop Freq
-60.0					2.441000000 GHz
-70.0					
Center 2.441000000 GHz				Span 0 Hz	CF Step
Res BW 1.0 MHz	#VBW 3.0 MH	Z	Sweep 15.00 n		1.000000 MHz
MKR MODE TRC SCL X	Y		NCTION WIDTH FU	NCTION VALUE	<u>Auto</u> Man
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	2.880 ms (Δ) 3.5 5.874 ms 2.01	5 dB dBm			
3 Δ4 1 t (Δ) 4 F 1 t	3.750 ms (∆) -0.13 5.874 ms 2.01	2 dB			Freq Offset
5	2.01				0 Hz
6 7 7					
8					
10				~	
<	ш			>	
MSG			STATUS		



9. Unwanted Emissions

9.1. Test Setup

Refer to the APPENDIX I.

9.2. Limit

Part 15.247(d), Part 15.205, Part 15.209

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 Part 15.247 the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.205(c)).

- Part 15.209: General requirement

Frequency (MHz)	FCC Limit (uV/m)	Measurement Distance (m)
0.009 - 0.490	2 400 / F (kHz)	300
0.490 - 1.705	24 000 / F (kHz)	30
1.705 – 30.0	30	30

Frequency (MHz)	FCC Limit (uV/m)	Measurement Distance (m)
30 ~ 88	100 **	3
88 ~ 216	150 **	3
216 ~ 960	200 **	3
Above 960	500	3

**Except as provided in paragraph (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.



MHz	MHz	MHz	MHz	GHz	GHz
0.009 ~ 0.110	8.414 25 ~ 8.414 75	108 ~ 121.94	1 300 ~ 1 427	4.5 ~ 5.15	14.47 ~ 14.5
0.495 ~ 0.505	12.29 ~ 12.293	123 ~ 138	1 435 ~ 1 626.5	5.35 ~ 5.46	15.35 ~ 16.2
2.173 5 ~ 2.190 5	12.519 75 ~ 12.520 25	149.9 ~ 150.05	1 645.5 ~ 1 646.5	7.25 ~ 7.75	17.7 ~ 21.4
4.125 ~ 4.128	12.576 75 ~ 12.577 25	156.524 75 ~ 156.525 25	1 660 ~ 1 710	8.025 ~ 8.5	22.01 ~ 23.12
4.177 25 ~ 4.177 75	13.36 ~ 13.41	156.7 ~ 156.9	1 718.8 ~ 1 722.2	9.0 ~ 9.2	23.6 ~ 24.0
4.207 25 ~ 4.207 75	16.42 ~ 16.423	162.012 5 ~ 167.17	2 200 ~ 2 300	9.3 ~ 9.5	31.2 ~ 31.8
6.215 ~ 6.218	16.694 75 ~ 16.695 25	167.72 ~ 173.2	2 310 ~ 2 390	10.6 ~ 12.7	36.43 ~ 36.5
6.267 75 ~ 6.268 25	16.804 25 ~ 16.804 75	240 ~ 285	2 483.5 ~ 2 500	13.25 ~ 13.4	Above 38.6
6.311 75 ~ 6.312 25	25.5 ~ 25.67	322 ~ 335.4	2 655 ~ 2 900		
8.291 ~ 8.294	37.5 ~ 38.25	399.90 ~ 410	3 260 ~ 3 267		
8.362 ~ 8.366	73 ~ 74.6	608 ~ 614	3 332 ~ 3 339		
8.376 25 ~ 8.386 75	74.8 ~ 75.2	960 ~ 1 240	3 345.8 ~ 3 358		
			3 600 ~ 4 400		

9.3. Test Procedures

9.3.1. Test Procedures for Unwanted Emissions(Radiated)

- 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.
- For measurements above 1 GHz 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 1 000 MHz
 The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasipeak detection (QP) at frequency below 1 GHz.
- Frequencies above 1 000 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.

For unwanted emission with 100% duty cycle, test method was used section 4.1.4.2.5 of ANSI 63.10-2013.

- 1. RBW = 1 MHz
- 2. VBW \geq 3 x RBW
- 3. Detector = RMS
- 4. Averaging type = power (i.e., RMS)
- 5. Sweep time = auto
- 6. Measuerment BW(RBW) ≥ Bin size



9.3.2. Test Procedures for Unwanted Emissions(Conducted)

- 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 : 40 001

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 : 40 001

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 = 2 001 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.

9.4. Test Results

9.4.1. Unwanted Emissions(Radiated)

Test Notes.

- 1. The radiated emissions below 1 GHz were investigated 9 kHz to 1 GHz and the worst case data was reported.
- Information of Distance Correction Factor For finding emissions, measurements may be performed at a distance closer than that specified in the regulations.

In this case, the distance correction factor is applied to the result.

- Calculation of distance factor

At frequencies below 30 MHz = 40 log(tested distance / specified distance)

At frequencies at or above 30 MHz = 20 log(tested distance / specified distance)

When distance factor is "N/A", the measurements were performed at the specified distance and distance factor is not applied. 3. DCCF Calculation. (DCCF = Duty Cycle Correction Factor)

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

- 100 ms / Δt [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

- DCCF = 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 + TF + DCCF + DCF / TF = AF + CL + HL + AL - AG

Where, TF = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain, HL = High pass filter Loss,

AL = Attenuator Loss, DCCF = Duty Cycle Correction Factor, DCF = Distance Correction Factor

9 kHz ~ 1 GHz Data (Modulation : GFSK)

Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
317.78	Н	Х	PK	40.36	-4.20	N/A	N/A	36.16	46.02	9.86
332.64	Н	Х	PK	39.50	-3.71	N/A	N/A	35.79	46.02	10.23
928.21	V	Х	PK	26.00	7.91	N/A	N/A	33.91	46.02	12.11
-	-	-	-	-	-	-	-	-	-	-

TM1 & Highest & X & Hor

Detector Mode : PK





Test Notes.

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

2. Information of Distance Correction Factor

For finding emissions, measurements may be performed at a distance closer than that specified in the regulations.

In this case, the distance correction factor is applied to the result.

- Calculation of distance factor

At frequencies below 30 MHz = 40 log(tested distance / specified distance)

At frequencies at or above 30 MHz = 20 log(tested distance / specified distance)

When distance factor is "N/A", the measurements were performed at the specified distance and distance factor is not applied. 3. DCCF Calculation. (DCCF = Duty Cycle Correction Factor)

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

- 100 ms / Δt [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

- DCCF = 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 + TF+ DCCF + DCF / TF = AF + CL + HL + AL - AG

Where, TF = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain, HL = High pass filter Loss,

AL = Attenuator Loss, DCCF = Duty Cycle Correction Factor, DCF = Distance Correction Factor

1 GHz ~ 25 GHz Data (Modulation : <u>GFSK</u>)

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 389.68	V	Х	PK	49.99	4.60	N/A	N/A	54.59	74.00	19.41
2 389.68	V	Х	AV	49.99	4.60	-24.79	N/A	29.80	54.00	24.20
4 804.09	V	Х	PK	50.04	2.43	N/A	N/A	52.47	74.00	21.53
4 804.09	V	Х	AV	50.04	2.43	-24.79	N/A	27.68	54.00	26.32
4 999.79	V	Х	PK	52.99	2.69	N/A	N/A	55.68	74.00	18.32
4 999.89	V	Х	AV	45.96	2.69	N/A	N/A	48.65	54.00	5.35

Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4 880.40	V	Х	PK	49.16	2.35	N/A	N/A	51.51	74.00	22.49
4 880.40	V	Х	AV	49.16	2.35	-24.79	N/A	26.72	54.00	27.28
5 000.15	V	Х	PK	53.04	2.69	N/A	N/A	55.73	74.00	18.27
5 000.06	V	Х	AV	45.73	2.69	N/A	N/A	48.42	54.00	5.58

Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 484.14	V	Х	PK	50.41	5.62	N/A	N/A	56.03	74.00	17.97
2 484.14	V	Х	AV	50.41	5.62	-24.79	N/A	31.24	54.00	22.76
4 959.58	V	Х	PK	49.19	2.69	N/A	N/A	51.88	74.00	22.12
4 959.58	V	Х	AV	49.19	2.69	-24.79	N/A	27.09	54.00	26.91
4 999.74	V	Х	PK	52.99	2.69	N/A	N/A	55.68	74.00	18.32
4 999.89	V	Х	AV	45.84	2.69	N/A	N/A	48.53	54.00	5.47



1 GHz ~ 25 GHz Data (Modulation : π /4DQPSK)

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 388.61	V	Х	PK	49.99	4.60	N/A	N/A	54.59	74.00	19.41
2 388.61	V	Х	AV	49.99	4.60	-24.79	N/A	29.80	54.00	24.20
4 804.32	V	Х	PK	49.70	2.43	N/A	N/A	52.13	74.00	21.87
4 804.32	V	Х	AV	49.70	2.43	-24.79	N/A	27.34	54.00	26.66
4 999.96	V	Х	PK	52.91	2.69	N/A	N/A	55.60	74.00	18.40
4 999.98	V	Х	AV	45.84	2.69	N/A	N/A	48.53	54.00	5.47

Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4 881.72	V	Х	PK	50.11	2.39	N/A	N/A	52.50	74.00	21.50
4 881.72	V	Х	AV	50.11	2.39	-24.79	N/A	27.71	54.00	26.29
5 000.08	V	Х	PK	52.19	2.69	N/A	N/A	54.88	74.00	19.12
5 000.10	V	Х	AV	45.62	2.69	N/A	N/A	48.31	54.00	5.69

Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 484.58	V	Х	PK	49.46	5.63	N/A	N/A	55.09	74.00	18.91
2 484.58	V	Х	AV	49.46	5.63	-24.79	N/A	30.30	54.00	23.70
4 960.68	V	Х	PK	49.46	2.69	N/A	N/A	52.15	74.00	21.85
4 960.68	V	Х	AV	49.46	2.69	-24.79	N/A	27.36	54.00	26.64
5 000.15	V	Х	PK	52.89	2.69	N/A	N/A	55.58	74.00	18.42
5 000.08	V	Х	AV	45.83	2.69	N/A	N/A	48.52	54.00	5.48



1 GHz ~ 25 GHz Data (Modulation : <u>8DPSK</u>)

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 389.45	V	Х	PK	49.58	4.60	N/A	N/A	54.18	74.00	19.82
2 389.45	V	Х	AV	49.58	4.60	-24.79	N/A	29.39	54.00	24.61
4 804.20	V	Х	PK	50.09	2.43	N/A	N/A	52.52	74.00	21.48
4 804.20	V	Х	AV	50.09	2.43	-24.79	N/A	27.73	54.00	26.27
4 999.71	V	Х	PK	52.96	2.69	N/A	N/A	55.65	74.00	18.35
4 999.92	V	Х	AV	46.01	2.69	N/A	N/A	48.70	54.00	5.30

Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4 880.26	V	Х	PK	49.88	2.35	N/A	N/A	52.23	74.00	21.77
4 880.26	V	Х	AV	49.88	2.35	-24.79	N/A	27.44	54.00	26.56
5 000.09	V	Х	PK	52.86	2.69	N/A	N/A	55.55	74.00	18.45
5 000.04	V	Х	AV	45.90	2.69	N/A	N/A	48.59	54.00	5.41

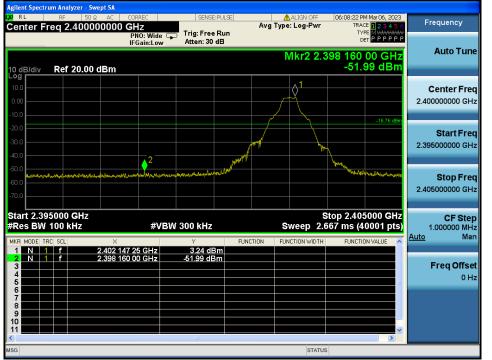
Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	TF (dB/m)	DCCF (dB)	DCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2 484.89	V	Х	PK	50.24	5.64	N/A	N/A	55.88	74.00	18.12
2 484.89	V	Х	AV	50.24	5.64	-24.79	N/A	31.09	54.00	22.91
4 960.11	V	Х	PK	50.57	2.69	N/A	N/A	53.26	74.00	20.74
4 960.11	V	Х	AV	50.57	2.69	-24.79	N/A	28.47	54.00	25.53
5 000.10	V	Х	PK	53.06	2.69	N/A	N/A	55.75	74.00	18.25
5 000.03	V	Х	AV	45.90	2.69	N/A	N/A	48.59	54.00	5.41



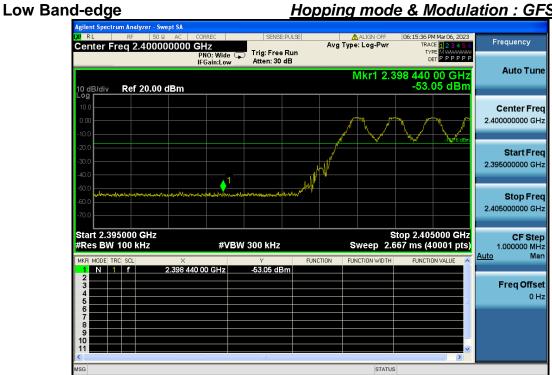
9.4.2. Unwanted Emissions(Conducted)

Low Band-edge



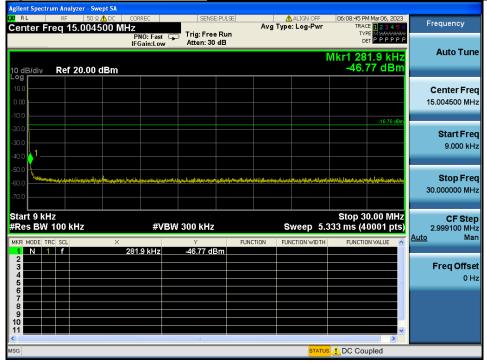
Lowest Channel & Modulation : GFSK

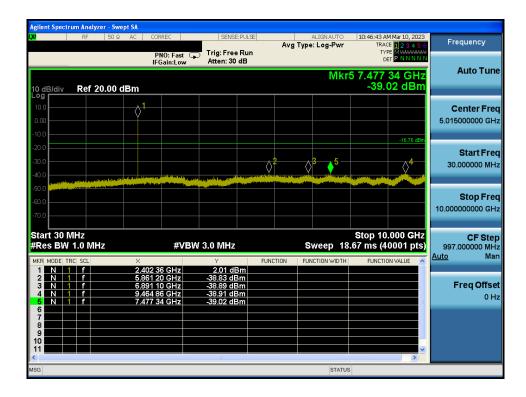
Hopping mode & Modulation : GFSK





Lowest Channel & Modulation : GFSK







Conducted Spurious Emissions <u>Low</u>

Lowest Channel & Modulation : GFSK



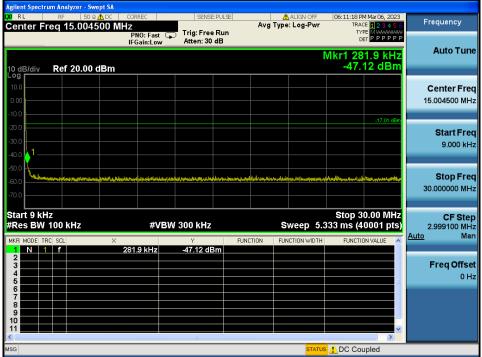


Reference for limit

Middle Channel & Modulation : GFSK

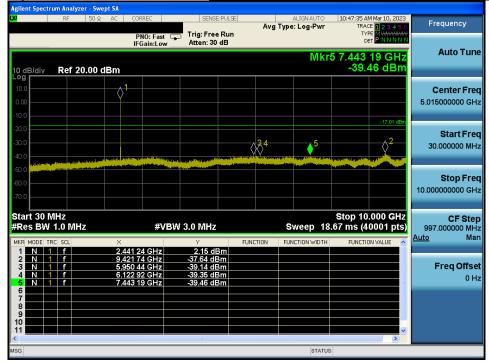








Middle Channel & Modulation : GFSK

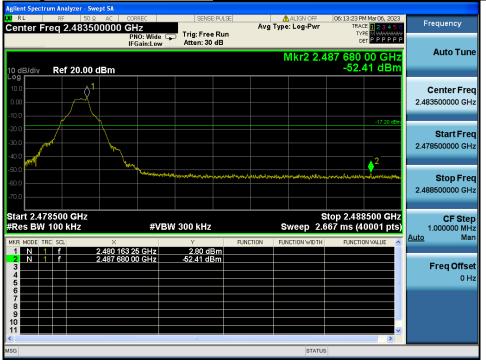






High Band-edge

Highest Channel & Modulation : GFSK



High Band-edge

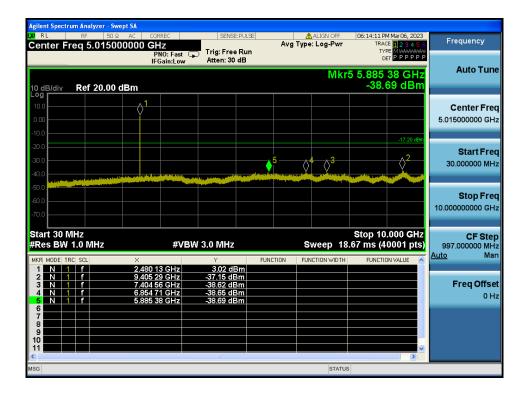
Hopping mode & Modulation : GFSK





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

nt Spectrum Analyzer - Swept SA 46 PM Mar 06, 2023 TRACE 1 2 3 4 5 6 TYPE M WWWWWW DET P P P P P RL Avg Type: Log-Pwr Frequency Center Freq 15.004500 MHz Trig: Free Run Atten: 30 dB PNO: Fast 😱 IFGain:Low Auto Tune Mkr1 281.9 kHz -47.00 dBm Ref 20.00 dBm l0 dB/div _og r **Center Freq** 15.004500 MHz Start Freq 9.000 kHz Stop Freq 30.000000 MHz Start 9 kHz #Res BW 100 kHz Stop 30.00 MHz Sweep 5.333 ms (40001 pts) CF Step 2.999100 MHz #VBW 300 kHz Man <u>Auto</u> MKR MODE TRO FUNCTION FUNCTION WIDTH VALU -47.00 dBm N 1 f 281.9 kHz Freq Offset 0 Hz 6 10 11 L DC Coupled ISG





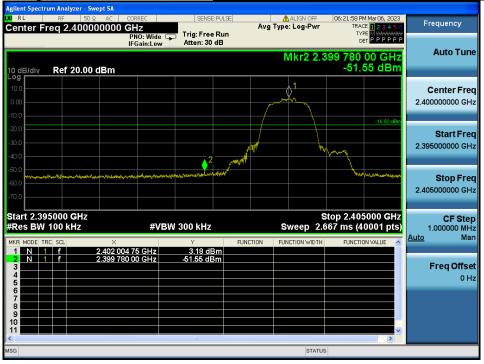
Conducted Spurious Emissions <u>Highest Channel & Modulation : GFSK</u>

Agilent Spectrum Analyzer - Swept SA				
κ 50 Ω AC CORREC Center Freq 17.500000000 GHz	SENSE:PULSE	ALIGN OFF	06:14:34 PM Mar 06, 2023 TRACE 1 2 3 4 5 6	Frequency
PNO: Fast IFGain:Lov				Auto Tune
10 dB/div Ref 20.00 dBm		Mkr3 2	1.170 500 GHz -30.99 dBm	Auto Tunc
10.0 0.00 -10.0				Center Freq 17.50000000 GHz
-20.0 -30.0 -40.0			-17.20 dBm	Start Freq 10.00000000 GHz
-500 -600 -700				Stop Freq 25.00000000 GHz
	'BW 3.0 MHz		Stop 25.000 GHz .00 ms (40001 pts)	CF Step 1.50000000 GHz <u>Auto</u> Man
MKR MODE TRC SCL X 1 N 1 f 24.735 625 GHz	Y FUNC -28.80 dBm	TION FUNCTION WIDTH	FUNCTION VALUE	
2 N 1 f 23.741125 GHz 3 N 1 f 21.170 500 GHz 4 5	-30.86 dBm -30.99 dBm			Freq Offset 0 Hz
6 7 8 9 9				
11			<u> </u>	
MSG		STATUS		



Low Band-edge

Lowest Channel & Modulation : π/4DQPSK



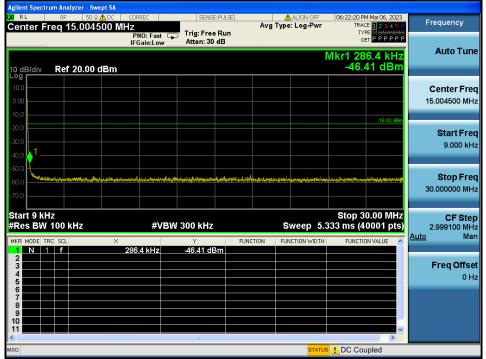
Low Band-edge

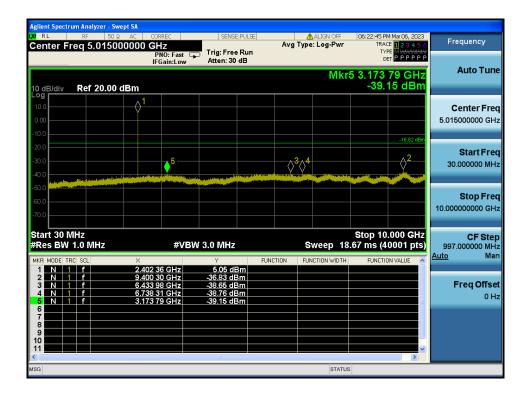
Hopping mode & Modulation : π/4DQPSK





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







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



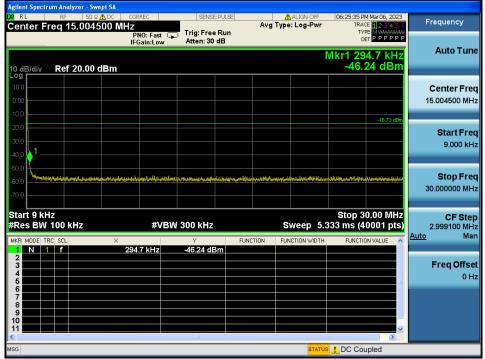


Reference for limit

Middle Channel & Modulation : π/4DQPSK

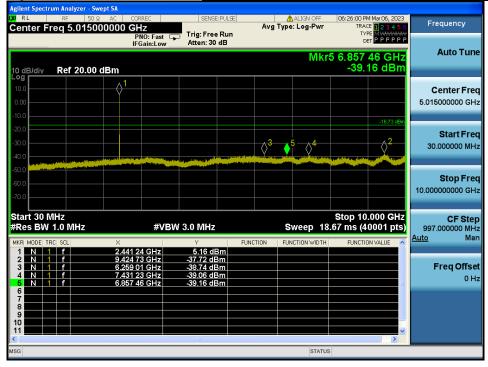


Conducted Spurious Emissions <u>Middle Channel & Modulation : π/4DQPSK</u>





Middle Channel & Modulation : π/4DQPSK







High Band-edge

Highest Channel & Modulation : π/4DQPSK



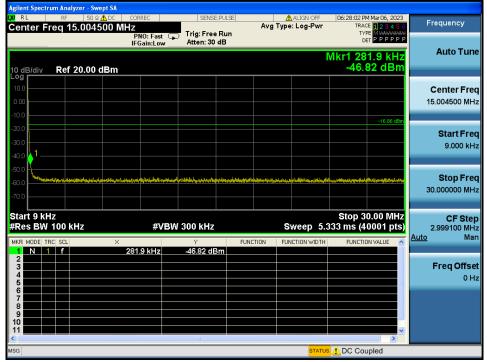
High Band-edge

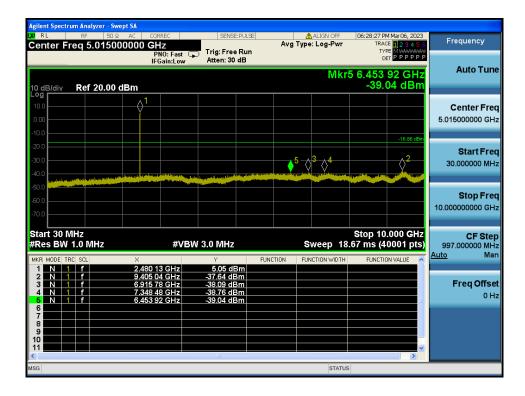
Hopping mode & Modulation : π/4DQPSK





Highest Channel & Modulation : π/4DQPSK







Highest Channel & Modulation : π/4DQPSK





Low Band-edge

Lowest Channel & Modulation : 8DPSK



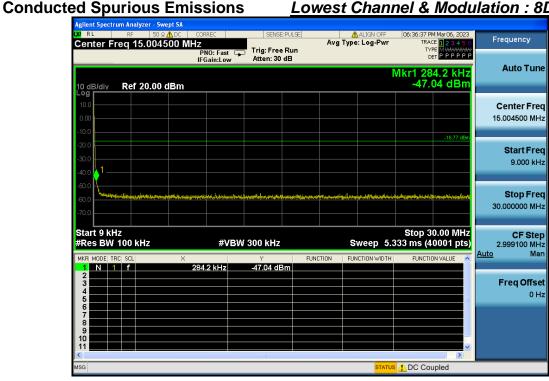
Low Band-edge

Hopping mode & Modulation : 8DPSK





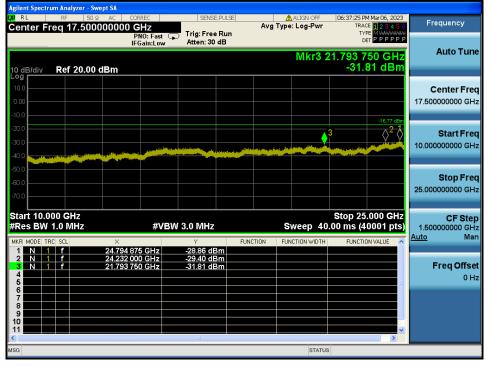
Lowest Channel & Modulation : 8DPSK







Lowest Channel & Modulation : 8DPSK



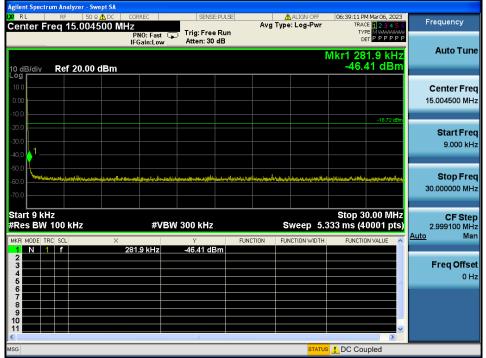


Reference for limit



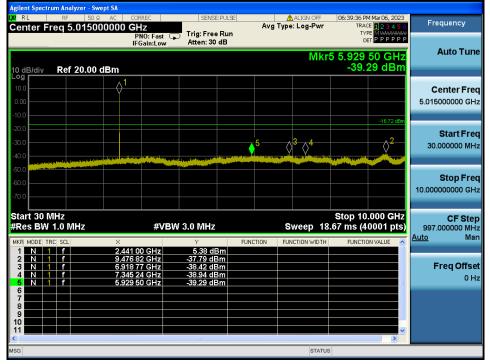


Conducted Spurious Emissions <u>Middle Channel & Modulation : 8DPSK</u>





Middle Channel & Modulation : 8DPSK







High Band-edge

Highest Channel & Modulation : 8DPSK



High Band-edge

Hopping mode & Modulation : 8DPSK





Highest Channel & Modulation : 8DPSK

Agilent Spect												
LXIRL	RF	50 Ω <u>Λ</u> DC	CORREC		SENSE:P	ULSE		🚹 ALIGN OFF		M Mar 06, 2023	Frequ	0001
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			PNO: Fas IFGain:Lo		ig: Free R ten: 30 di				™ ₪ Mkr1 28			ito Tune
10 dB/div Log	Ref 20	.00 dBm							-47.	13 dBm		
10.0											Cen	ter Freq
0.00											15.004	4500 MHz
-10.0										-17.11 dBm		
-30.0												a rt Freq 9.000 kHz
-40.0												9.000 KHZ
-50.0	4 A 105 -										5	op Freq
-60.0	***************	A Statistical Statistical Statistics	e Microsof Michael Michael			h jindad Alilinda	r (- in fision fision	haithial eal failte an thair an tha	ainain. Migel <u>ar a</u> h varihin fi j	Ale de service de la co sta		0000 MHz
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8												
10										~		
<												
MSG								STATU:	S 🔔 DC Coi	upled		





Highest Channel & Modulation : 8DPSK



10. AC Power-Line Conducted Emissions

10.1. Test Setup

NA

10.2. 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)						
	Quasi-Peak	Average					
0.15 ~ 0.50	66 to 56 *	56 to 46 *					
0.5 ~ 5.0	56	46					
5 ~ 30	60	50					

* Decreases with the logarithm of the frequency

10.3. Test Procedure

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

- 1. 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.

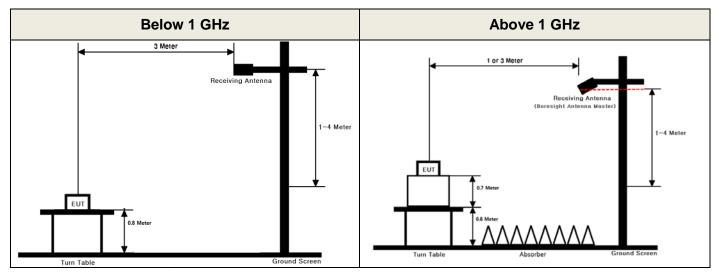
10.4. Test Results

NA

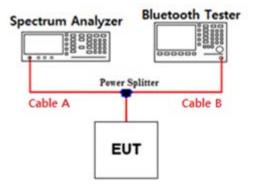
APPENDIX I

Test set up diagrams

Radiated Measurement



Conducted Measurement



Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	6.53	15	7.83
1	6.83	20	8.09
2.402 & 2.441 & 2.480	6.96	25	8.69
5	7.04	-	-
10	7.38	-	-

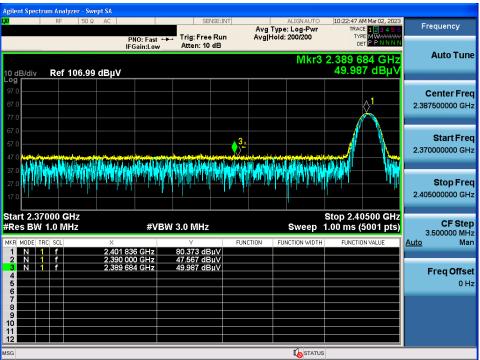
Note 1: The path loss from EUT to Spectrum analyzer was measured and used for test. Path loss (S/A's correction factor) = Cable A + Power Splitter



APPENDIX II

Unwanted Emissions (Radiated) Test Plot

GFSK & Lowest & X & Ver



GFSK & Highest & X & Ver

Frequency Avg Type: Log-Pwr Avg|Hold: 200/200 Trig: Free Run Atten: 10 dB PNO: Fast ↔↔ IFGain:Low Auto Tune 84 142 4 GH2 50.405 dBµ\ Mkr3 2.484 Ref 106.99 dBµV **Center Freq** 2.489000000 GHz Start Freq $\sqrt{2}$ 2.478000000 GHz HIN T Stop Freq 2.50000000 GHz Start 2.47800 GHz #Res BW 1.0 MHz Stop 2.50000 GHz 1.00 ms (5001 pts) CF Step 2.200000 MHz Man #VBW 3.0 MHz Sweep Auto FUNCTION FUNCTION 47.221 dBμ 50.405 dBμ Freq Offset 0 Hz 5 6 7 8 9 10 11 12 MSG **I**STATUS

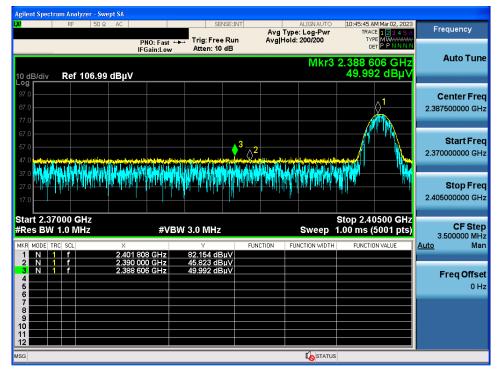
Detector Mode : PK

Detector Mode : PK



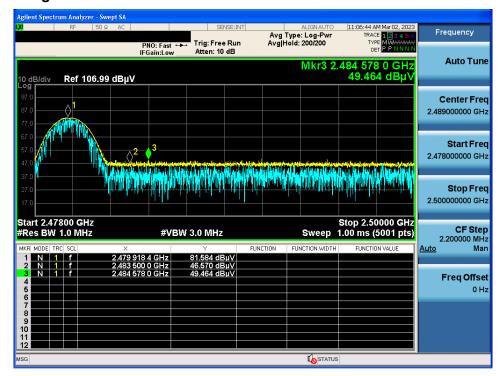
Detector Mode : PK

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



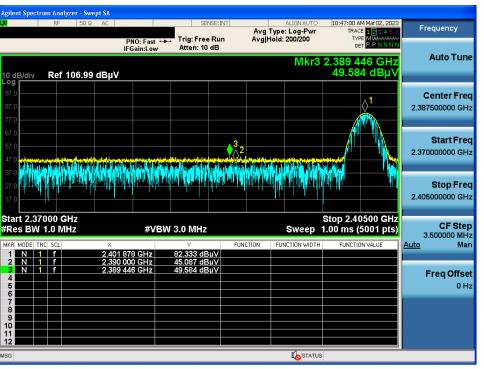
Detector Mode : PK

π /4DQPSK & Highest & X & Ver



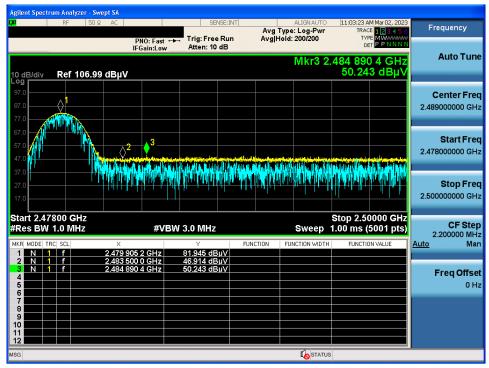


8DPSK & Lowest & X & Ver



Detector Mode : PK

8DPSK & Highest & X & Ver

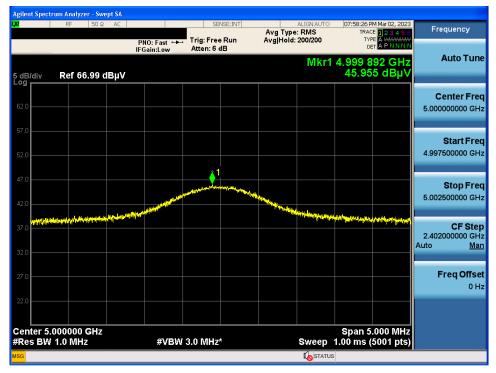


Detector Mode : PK



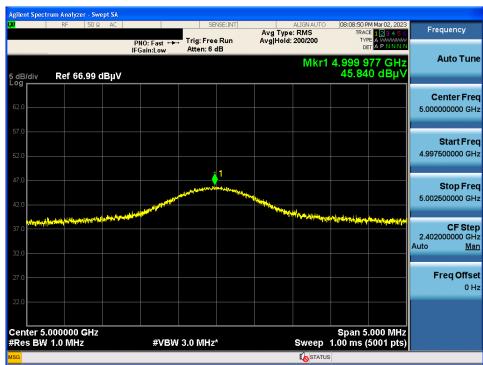
Detector Mode : AV

GFSK & Lowest & X & Ver



π /4DQPSK & Lowest & X & Ver

Detector Mode : AV





Detector Mode : AV

8DPSK & Lowest & X & Ver

