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: DRTFCC2003-0063 2. Customer Name : LINKFLOW Co., Ltd. · Address : 3,4F, 54, Nonhyeon-ro 2-gil, Gangnam-gu, Seoul, South Korea 3. Use of Report : FCC Original Grant 4. Product Name / Model Name : FITT360 / LF-F200U FCC ID : 2AVCKLFF200U 5. Test Method Used : KDB 558074 D01v05r02, ANSI C63.10-2013 Test Specification : FCC Part 15.247 6. Date of Test : 2019.12.02 ~ 2019.12.20 7. Testing Environment : See appended test report. 8. Test Result : Refer to the attached test result. Tested by Reviewed by M Affirmation Name : InHee Bae Name : Geunki Son The test results presented in this test report are limited only to the sample supplied by applicant and the use of this test report is inhibited other than its purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

2020.03.06.

DT&C Co., Ltd.

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



Test Report Version

Test Report No.	Date	Description	Revised By	Reviewed By
DRTFCC2003-0063	Mar. 06, 2020	Initial issue	InHee Bae	Geunki Son



Table of Contents

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

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 Accredited Test Firm No. : KR0034

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1.2 Testing Environment

Ambient Condition	
 Temperature 	+39 ℃ ~ +45 ℃
 Relative Humidity 	20 % ~ 25 %

1.3 Measurement Uncertainty

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

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

1.4 Details of Applicant

Applicant	:	LINKFLOW Co., Ltd.
Address	:	#3,4F, 54, Nonhyeon-ro 2-gil, Gangnam-gu, Seoul, South Korea
Contact person	:	Minhwan Kim

1.5 Description of EUT

EUT	FITT360
Model Name	LF-F200U
Add Model Name	NA
Hardware Version	Rev.05
Software Version	MR5 1.5.1
Serial Number	Identical prototype
Power Supply	DC 3.8 V
Frequency Range	2402 MHz ~ 2480 MHz
Modulation Technique (Data rate)	GFSK (1Mbps), π/4DQPSK (2Mbps), 8DPSK (3Mbps)
Number of Channels	79
Antenna Type	PIFA Antenna
Antenna Gain	PK : 0.05 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 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.

1.8 Test Equipment List

Туре	Manufacturer	Model	Cal.Date (yy/mm/dd)	Next.Cal.Date (yy/mm/dd)	S/N	
On a star was A a shuman	A sile of Teshasle size	NOODA	18/12/19	19/12/19	MV50440057	
Spectrum Analyzer	Agilent Technologies	N9020A	19/12/18	20/12/18	MY50410357	
On a starting An all man		NOODA	18/12/19	19/12/19	NN/40044700	
Spectrum Analyzer	Agilent Technologies	N9020A	19/12/16	20/12/16	MY48011700	
DC Power Supply	Agilent Technologies	66332A	19/06/25	20/06/25	MY43000211	
Multimeter	FLUKE	17B	18/12/18	19/12/18	26030065WS	
Matameter			19/12/17	20/12/17	20000000000	
Signal Generator	Rohde Schwarz	SMBV100A	18/12/19	19/12/19	255571	
olghar contrator			1912/16	20/12/16	200011	
Signal Generator	ANRITSU	MG3695C	18/12/20	19/12/20	173501	
Thermohygrometer	BODYCOM	BJ5478	18/12/27	19/12/27	120612-1	
Thermohygrometer	BODYCOM	BJ5478	18/12/27	19/12/27	120612-2	
Thermohygrometer	BODYCOM	BJ5478	19/07/03	20/07/03	N/A	
HYGROMETER	TESTO	608-H1	19/01/31	20/01/31	34862883	
Loop Antenna	Schwarzbeck	6502	19/09/18	21/09/18	00226186	
BILOG ANTENNA	Schwarzbeck	VULB 9160	19/04/23	21/04/23	9160-3362	
Horn Antenna	ETS-Lindgren	3115	18/01/30	20/01/30	6419	
Horn Antenna	A.H.Systems Inc.	SAS-574	19/07/03	21/07/03	155	
			18/12/18	19/12/18	4050007	
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	
			18/12/18	19/12/18		
PreAmplifier	H.P	8447D	19/12/16	20/12/16	2944A07774	
			18/12/18	19/12/18	+	
Power Splitter	Anritsu	K241B	19/12/16	20/12/16	1301181	
			18/12/18	19/12/18		
BlueTooth Tester	TESCOM	TC-3000B	19/12/16	20/12/16	3000B770243	
Attenuator	Aeroflex/Weinschel	20515	19/0627	20/06/27	Y2370	
Attenuator	SMAJK	SMAJK-2-3	19/06/27	20/06/27	2	
Attenuator	SRTechnology	F01-B0606-01	19/0627	20/06/27	13092403	
Attenuator	Hefei Shunze	SS5T2.92-10-40	19/06/27	20/06/27	16012202	
High Pass Filter	Wainwright Instruments	WHNX8.0/26.5-6SS	19/06/27	20/06/27	3	
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	
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2496A MA2411B	18/12/19 19/12/16	19/12/19 20/12/16	1338004 1306053	
EMI Test Receiver	Rohde Schwarz	ESCI7	19/01/30	20/01/30	100910	
PULSE LIMITER	Rohde Schwarz	ESH3-Z2	19/09/17	20/09/17	101333	
LISN	SCHWARZBECK	NNLK 8121	19/03/19	20/03/19	06183	
Cable	Radiall	TESTPRO3	19/01/16	20/01/16	M-01	
Cable	Junkosha	MWX315	19/01/16	20/01/16	M-05	
Cable	Junkosha	MWX315	19/01/16	20/01/16	M-06	
Cable	Junkosha	MWX241	19/01/14	20/01/14	G-4	
Cable	Junkosha	MWX241	19/01/14	20/01/14	G-7	
Cable	DT&C	Cable	19/01/14	20/01/14	G-13	
Cable	DT&C	Cable	19/01/14	20/01/14	G-14	
Cable	HUBER+SUHNER	SUCOFLEX 104	19/01/14	20/01/14	G-15	
Cable	DT&C	Cable	19/01/16	20/01/16	RF-82	
Test Software	tsj	Radiated EmissionMeasurement	NA	NA	Version Rev.05	
Test Software	tsj	Noise Terminal VoltageMeasurement	NA	NA	Version MR5 1.5.1	

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.



1.9 Summary of Test Results

FCC Part RSS Std.	Parameter	Limit (Using in 2400~ 2483.5 MHz)	Test Condition	Status Note 1		
	Carrier Frequency Separation	>= 25 kHz or >= Two thirds of the 20 dB BW, whichever is greater.		С		
15.247(a) RSS-247(5.1)	Number of Hopping Frequencies	>= 15 hops		С		
100 247(0.1)	20 dB Bandwidth	N/A		С		
	Dwell Time	=< 0.4 seconds		С		
15.247(b) RSS-247(5.4)	Transmitter Output Power	For FCC =< 1 Watt , if CHs >= 75 Others =< 0.125 W For IC if CHs >= 75 =< 1 Watt For Conducted Power =< 4 Watt For e.i.r.p, Others =< 0.125 W For Conducted Power. =< 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		
Note 1 : C = Comply NC = Not Comply NT = Not Tested NA = Not Applicable Note 2 : For radiated emission tests below 30 MHz were performed on semi-anechoic chamber which is correlated With OATS. With OATS. Note 3 : This test item was performed in each axis and the worst case data was reported.						



1.10 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).

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.
- 2. §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

1. 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

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

2.4 Test Results

Modulation	Tested Channel	Burst Average Output Power		Peak Output Power	
		dBm	mW	dBm	mW
	Lowest	11.07	12.79	11.13	12.97
<u>GFSK</u>	Middle	11.29	13.46	11.34	13.61
	Highest	11.22	13.24	11.30	13.49
	Lowest	9.69	9.31	10.81	12.05
<u>π/4DQPSK</u>	Middle	9.02	7.98	10.78	11.97
	Highest	9.76	9.46	10.93	12.39
<u>8DPSK</u>	Lowest	9.68	9.29	10.98	12.53
	Middle	9.01	7.96	11.04	12.71
	Highest	9.75	9.44	11.12	12.94

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.



Lowest Channel & Modulation : GFSK



Peak Output Power











Peak Output Power

Lowest Channel & Modulation : π/4DQPSK



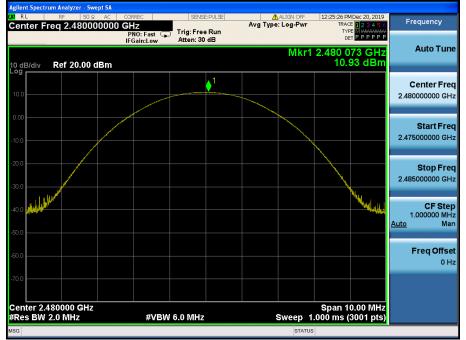


Middle Channel & Modulation : π/4DQPSK



Peak Output Power

Highest Channel & Modulation : π/4DQPSK









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

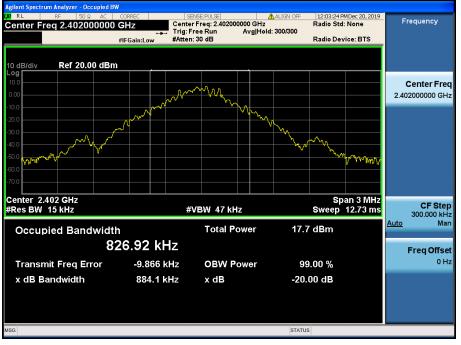
Modulation	Tested Channel	20 dB BW (MHz)
	Lowest	0.884
<u>GFSK</u>	Middle	0.884
	Highest	0.884
	Lowest	1.323
<u>π/4DQPSK</u>	Middle	1.319
	Highest	1.322
	Lowest	1.310
<u>8DPSK</u>	Middle	1.332
	Highest	1.317



TDt&C

20 dB BW

Lowest Channel & Modulation : GFSK



20 dB BW

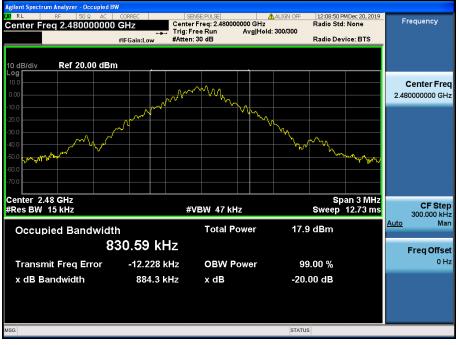


Middle Channel & Modulation : GFSK



20 dB BW

Highest Channel & Modulation : GFSK



20 dB BW

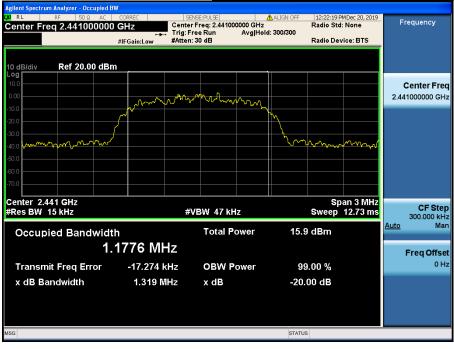
Lowest Channel & Modulation : π/4DQPSK ent Spectrum Analyzer - Occupied BW SENGE:PULGE ALIGN OF Center Freq: 2.402000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 30 dB 12:19:38 PMDec 20, 2019 Radio Std: None Frequency Center Freq 2.402000000 GHz #IFGain:Low Radio Device: BTS Ref 20.00 dBm og **Center Freq** J کر آن 2.402000000 GHz \mathcal{N} <u>ግ.አ</u>/ነ Span 3 MHz Sweep 12.73 ms Center 2.402 GHz #Res BW 15 kHz CF Step 300.000 kHz #VBW 47 kHz Man Auto 16.3 dBm **Total Power Occupied Bandwidth** 1.1932 MHz Freq Offset Transmit Freq Error -13.200 kHz **OBW Power** 99.00 % 0 Hz x dB Bandwidth 1.323 MHz -20.00 dB x dB STATUS



🛈 Dt&C

20 dB BW

Middle Channel & Modulation : π/4DQPSK



20 dB BW

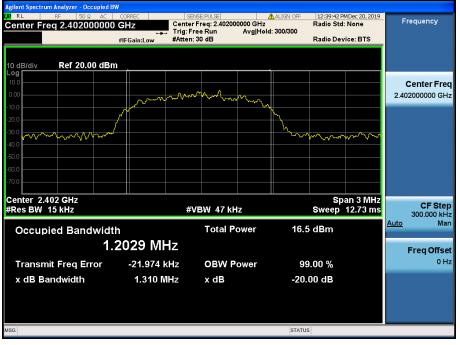
Highest Channel & Modulation : π/4DQPSK m Analyzer - Occupied BW SENSE:PULSE ALIGN OFF Center Freq: 2.480000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 30 dB RI 12:25:02 PMDec 20, 2019 Radio Std: None Frequency Center Freq 2.480000000 GHz #IFGain:Low Radio Device: BTS Ref 20.00 dBm 10 dB/div **Center Freq** 2.48000000 GHz -0- \sim \sim hr Center 2.48 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Ma Total Power 16.4 dBm **Occupied Bandwidth** 1.1927 MHz Freq Offset 0 Hz -13.332 kHz **OBW Power** 99.00 % **Transmit Freq Error** x dB Bandwidth 1.322 MHz x dB -20.00 dB



Dt&C

20 dB BW

Lowest Channel & Modulation : 8DPSK



20 dB BW

Middle Channel & Modulation : 8DPSK ent Spectrum Analyzer - Occupied BW L SERVELFULCE ALIGN OFF Center Freq: 2.441000000 GHz → Trig: Free Run Avg|Hold: 300/300 #Atten: 30 dB 12:42:24 PMDec 20, 2019 Radio Std: None Frequency Center Freq 2.441000000 GHz #IFGain:Low Radio Device: BTS Ref 20.00 dBm og **Center Freq** 2.441000000 GHz $\lambda \Lambda$ Span 3 MHz Sweep 12.73 ms Center 2.441 GHz #Res BW 15 kHz CF Step 300.000 kHz #VBW 47 kHz Man Auto 15.9 dBm **Total Power Occupied Bandwidth** 1.1906 MHz Freq Offset Transmit Freq Error -21.828 kHz **OBW Power** 99.00 % 0 Hz x dB Bandwidth 1.332 MHz -20.00 dB x dB STATUS



20 dB BW

Highest Channel & Modulation : 8DPSK





4. Carrier Frequency Separation

4.1 Test Setup

Refer to the APPENDIX I.

4.2 Limit

Limit : ≥ 25 kHz or ≥ 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.

 $VBW \ge RBW$ 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	2440.978	2441.979	1.001
Enable	π/4DQPSK	2440.984	2441.977	0.993
	8DPSK	2440.980	2441.979	0.999

AFH mode

Hopping Mode	Modulation	Peak of reference channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2440.977	2441.986	1.009
Enable	π/4DQPSK	2440.977	2441.981	1.004
	8DPSK	2440.983	2441.982	0.999

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)





Carrier Frequency Separation (FH)

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







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

Agilent Spectrum Analyzer - Swept SA				
Center Freq 2.441000000		Avg Type: Log-Pwr	12:55:30 PMDec 20, 2019 TRACE 1 2 3 4 5 6 TYPE WINAMANAN	Frequency
10 dB/div Ref 20.00 dBm	PNO: Wide 🆵 Trig: Free F IFGain:Low Atten: 30 d		ΔMkr1 999 kHz 0.42 dB	Auto Tune
Log 10.0 0.00 -10.0	~~~~X2	~~~~~~		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 I.200 ms (3001 pts)	CF Step 300.000 kHz <u>Auto</u> Man
1 Δ2 1 f (Δ)	999 kHz (Δ) 0.42 dl 40 980 GHz 8.48 dBr	3		Freq Offset
6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7				
<			>	
MSG		STATU	S	



Carrier Frequency Separation (AFH)

Hopping mode : Enable & GFSK



Carrier Frequency Separation (AFH)

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



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

RL RF 50 Q AC					
RL RF 50 Ω AC enter Freq 2.441000000	CORREC O GHZ PNO: Wide	SENSE:PULSE	ALIGN OFF	01:11:45 PMDec 20, 2019 TRACE 1 2 3 4 5 6 TYPE M WWWWW DET P P P P P P	Frequency
dB/div Ref 20.00 dBm	IFGain:Low	Atten: 30 dB	,	∆Mkr1 999 kHz 0.46 dB	Auto Tun
Pg 0.0 0.0 0.0	~~~~	X2^_			Center Fre 2.441000000 G⊦
0.0 0.0 0.0					Start Fre 2.439500000 GF
0.0					Stop Fre 2.442500000 GH
enter 2.441000 GHz Res BW 51 kHz		150 kHz		Span 3.000 MHz .200 ms (3001 pts)	CF Ste 300.000 kł Auto Ma
R MODE TRC SCL × 1 Δ2 1 f (Δ) 2 2 F 1 f 2.4/ 3 3 - - - - - 4 - - - - - 5 - - - - - 6 - - - - -	999 kHz (Δ) 40 983 GHz	V FUN 0.46 dB 8.42 dBm	CTION FUNCTION WIDTH	FUNCTION VALUE	Freq Offs
				~	
3			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 ind or the 20 dB bandwidth, w		less than 30% of the channel spacing
VBW ≥ RBW	Sweep = auto	
Detector function = peak	Trace = max hold	

5.4 Test Results

FH mode

Hopping mode	Modulation	Test Result (Total Hops)
	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



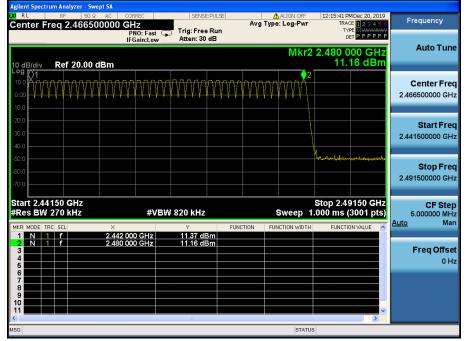
Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & GFSK

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Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & GFSK





Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & π/4DQPSK

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l <mark>XI</mark> RL Cent				Ω AC				E:PULSE	Av		ALIGN OFF	TRA	MDec 20, 2019 CE 1 2 3 4 5 6 PE MUMANA		су
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MSG											STATUS	6			

Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & π/4DQPSK

Agilent Spectrum Analyzer - Swept SA														
Center Freq 2.466500000	GH7	Avg Type	Log-Pwr TRA	MDec 20, 2019 CE 1 2 3 4 5 6 PE M 44444444	Frequency									
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-50.0 -60.0 -70.0			y sarghnan,		Stop Fred 2.491500000 GH;									
Start 2.44150 GHz #Res BW 270 kHz	#VBW 820 kHz		Sweep 1.000 ms		CF Step 5.000000 MH Auto Mar									
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6 7 8 9 9 10 11														
MSG	III		STATUS	>										



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

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l,XI F			RF			AC		RREC		SEN:	6E:PULS	E			ALIGN OFF		PMDec 20, 20:		Frequenc	v
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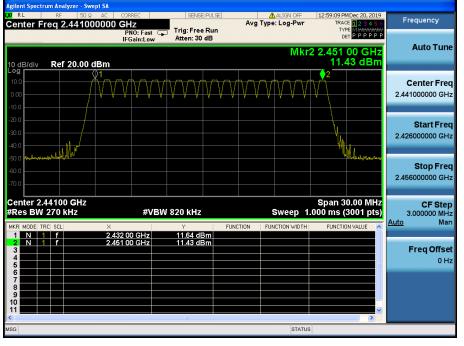
Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & 8DPSK

gilent Spectrum Analyzer - Swept SA					
RL RF 50 Ω AC Center Freg 2.466500000	CORREC GH7	SENSE:PULSE	ALIGN OFF Avg Type: Log-Pwr	12:51:59 PMDec 20, 2019 TRACE 1 2 3 4 5 6	Frequency
	PNO: Fast 😱 IFGain:Low	Trig: Free Run Atten: 30 dB	Mkr2	2.480 000 GHz 8.64 dBm	Auto Tune
10 dB/div Ref 20.00 dBm - og 1 10.0	M. M	᠂ᡐᠧ᠋᠊ᡘ᠊ᡐᠺᡊᡐ	Arrow Arrow 2		Center Freq 2.466500000 GHz
-20.0					Start Fred 2.441500000 GHz
-50.0				Norman and an a state of the state of the	Stop Frec 2.491500000 GHz
Start 2.44150 GHz #Res BW 270 kHz	#VBW	820 kHz	Sweep 1	Stop 2.49150 GHz .000 ms (3001 pts)	CF Step 5.000000 MH: <u>Auto</u> Mar
1 N 1 f 2.44	2 000 GHz 0 000 GHz	9.32 dBm 8.64 dBm			Freq Offset 0 H:
SG			STATUS	3	

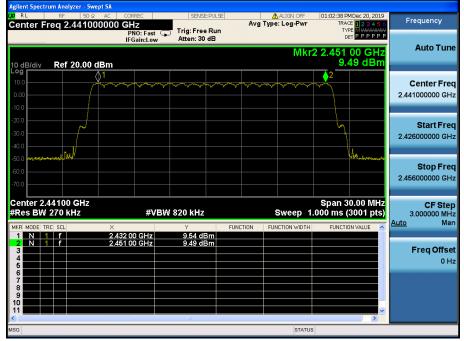
Number of Hopping Frequencies 1(AFH)

Hopping mode : Enable & GFSK



Number of Hopping Frequencies 1(AFH)

Hopping mode : Enable & π/4DQPSK





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

ilent Spectrum Analyzer - Swept SA RL RF 50 Ω AC	CORREC	SENSE:PULSE	ALIGN OFF	01:10:00 PMDec 20, 2019	
enter Freq 2.44100000	0 GHz	Trig: Free Run	Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE M WARMAN	Frequency
0 dB/div Ref 20.00 dBm	PNO: Fast 😱 IFGain:Low	Atten: 30 dB	Mkr	2 2.451 00 GHz 9.37 dBm	Auto Tur
				2	Center Fre 2.441000000 GH
					Start Fre 2.426000000 GH
0.0 .0 .0					Stop Fr 2.456000000 Gi
enter 2.44100 GHz Res BW 270 kHz			Sweep 1	Span 30.00 MHz .000 ms (3001 pts) FUNCTION VALUE	CF Ste 3.000000 M <u>Auto</u> M
2 N 1 f 2 3 4 5 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	432 00 GHz 451 00 GHz	9.52 dBm 9.37 dBm			Freq Offs 01
6 7 8 9 9 0					
G			STATUS	>	



6. Time of Occupancy (Dwell Time)

6.1 Test Setup

Refer to the APPENDIX I.

6.2 Limit

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

6.3 Test Procedure

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

The spectrum analyzer is set to :

Center frequency = 2441 MHz

Span = zero

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

VBW ≥ RBW

Detector function = peak

Trace = max hold

6.4 Test Results

FH mode

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

AFH mode

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

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

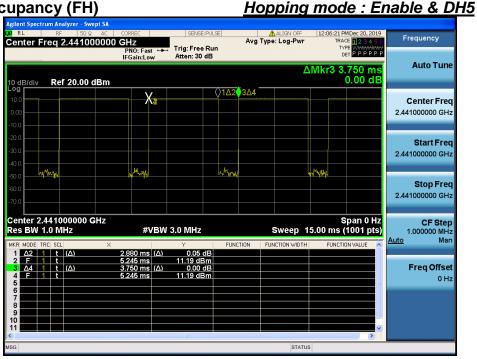
((Hopping rate ÷ Time slots) ÷ Hopping channel)

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

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

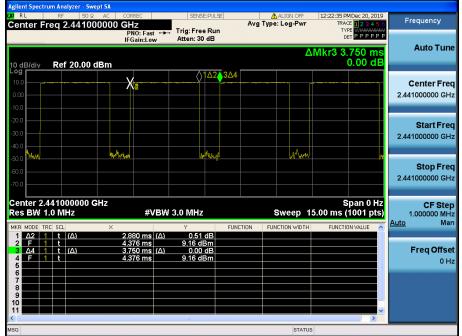


Time of Occupancy (FH)



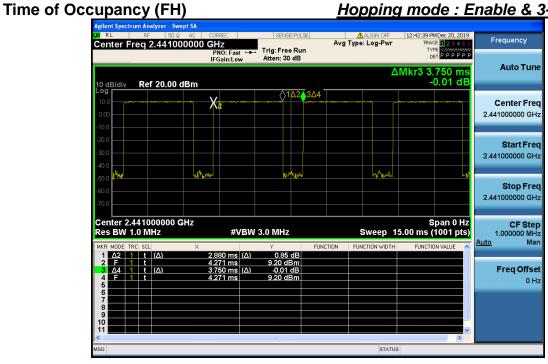
Time of Occupancy (FH)

Hopping mode : Enable & 2-DH5





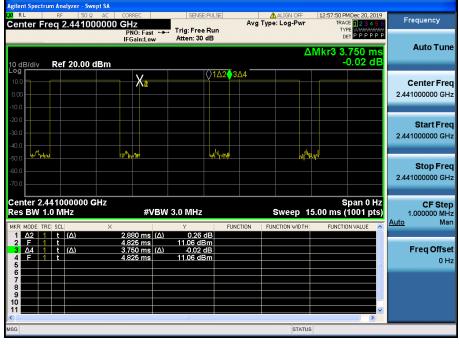
Hopping mode : Enable & 3-DH5





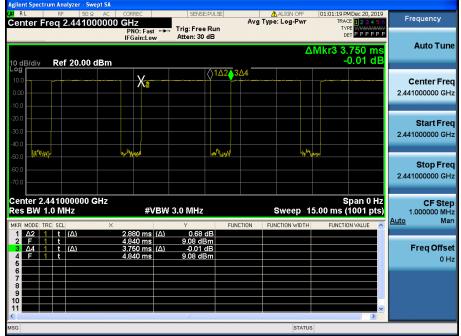
Hopping mode : Enable & DH5

Time of Occupancy (AFH)



Time of Occupancy (AFH)

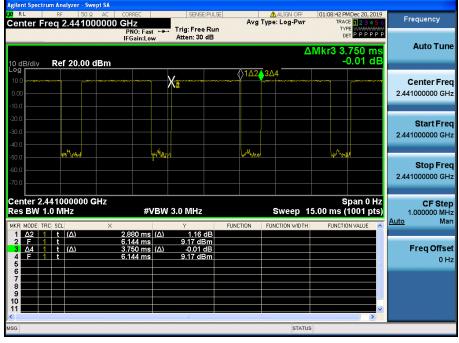
Hopping mode : Enable & 2-DH5





Hopping mode : Enable & 3-DH5

Time of Occupancy (AFH)





7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

7.1 Test Setup

Refer to the APPENDIX I.

7.2 Limit

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

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

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

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

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

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

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



7.3. Test Procedures

7.3.1. Test Procedures for Radiated Spurious Emissions

- The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m. The table was rotated 360 degrees to determine the position of the highest radiation.
- 2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
- 3. For measurements above 1GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 GHz, the absorbers are removed.
- 4. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- 5. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
- 6. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- 7. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

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.



7.3.2. Test Procedures for Conducted Spurious Emissions

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

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

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

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

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

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



7.4. Test Results

7.4.1. Radiated Emissions

9 kHz ~ 25 GHz Data (Modulation : GFSK)

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2388.25	V	Y	PK	49.44	2.33	N/A	N/A	51.77	74.00	22.23
2388.25	V	Y	AV	49.44	2.33	-24.79	N/A	26.98	54.00	27.02
4804.22	V	Х	PK	50.34	1.87	N/A	N/A	52.21	74.00	21.79
4804.22	V	Х	AV	50.34	1.87	-24.79	N/A	27.42	54.00	26.58

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)
4881.94	V	Х	PK	51.22	2.12	N/A	N/A	53.34	74.00	20.66
4881.94	V	Х	AV	51.22	2.12	-24.79	N/A	28.55	54.00	25.45

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)
2483.79	V	Y	PK	49.86	2.81	N/A	N/A	52.67	74.00	21.33
2483.79	V	Y	AV	49.86	2.81	-24.79	N/A	27.88	54.00	26.12
4960.07	V	Х	PK	50.99	2.11	N/A	N/A	53.10	74.00	20.90
4960.07	V	Х	AV	50.99	2.11	-24.79	N/A	28.31	54.00	25.69

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 = 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

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

4. Sample Calculation.

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

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



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

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2388.62	Н	Z	PK	50.75	2.33	N/A	N/A	53.08	74.00	20.92
2388.62	Н	Z	AV	50.75	2.33	-24.79	N/A	28.29	54.00	25.71
4804.21	Н	Z	PK	49.89	1.87	N/A	N/A	51.76	74.00	22.24
4804.21	Н	Z	AV	49.89	1.87	-24.79	N/A	26.97	54.00	27.03

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)
4881.76	Н	Z	PK	50.99	2.12	N/A	N/A	53.11	74.00	20.89
4881.76	Н	Z	AV	50.99	2.12	-24.79	N/A	28.32	54.00	25.68

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)
2483.58	Н	Z	PK	50.20	2.81	N/A	N/A	53.01	74.00	20.99
2483.58	Н	Z	AV	50.20	2.81	-24.79	N/A	28.22	54.00	25.78
4959.97	Н	Z	PK	50.73	2.11	N/A	N/A	52.84	74.00	21.16
4959.97	Н	Z	AV	50.73	2.11	-24.79	N/A	28.05	54.00	25.95

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 = 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

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

4. Sample Calculation.

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

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



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

Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2389.05	Н	Z	PK	49.70	2.33	N/A	N/A	52.03	74.00	21.97
2389.05	Н	Z	AV	49.70	2.33	-24.79	N/A	27.24	54.00	26.76
4804.29	Н	Z	PK	49.62	1.87	N/A	N/A	51.49	74.00	22.51
4804.29	Н	Z	AV	49.62	1.87	-24.79	N/A	26.70	54.00	27.30

Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4882.18	Н	Z	PK	51.15	2.12	N/A	N/A	53.27	74.00	20.73
4882.18	Н	Z	AV	51.15	2.12	-24.79	N/A	28.48	54.00	25.52

Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2484.13	Н	Z	PK	49.80	2.81	N/A	N/A	52.61	74.00	21.39
2484.13	Н	Z	AV	49.80	2.81	-24.79	N/A	27.82	54.00	26.18
4959.90	Н	Z	PK	50.48	2.11	N/A	N/A	52.59	74.00	21.41
4959.90	Н	Z	AV	50.48	2.11	-24.79	N/A	27.80	54.00	26.20

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 dBWhen 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 = 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

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

4. Sample Calculation.

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

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



Low Band-edge



Lowest Channel & Modulation : GFSK

Low Band-edge

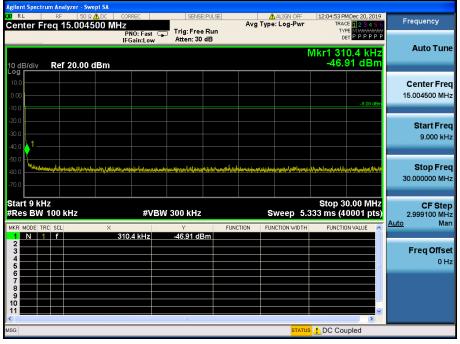
Hopping mode & Modulation : GFSK







Lowest Channel & Modulation : GFSK



	um Analyzer - Swe						
Center F	RF 50 ຊ req 5.01500		SENSE:PULSE	Avg Ty	ALIGN OFF	12:05:16 PMDec 20, 2019 TRACE 1 2 3 4 5 6	Frequency
		PNO: Fast C IFGain:Low	Trig: Free Run Atten: 30 dB		Mice	түре Милинин Det P P P P P P	Auto Tune
10 dB/div Log	Ref 20.00 d	IBm				-38.78 dBm	
10.0							Center Freq
-10.0						-9.08 dBm	5.015000000 GHz
-20.0						^ 2	Start Freq
-30.0				$\wedge^4 \wedge^3$			30.000000 MHz
-40.0							
-60.0							Stop Freq 10.00000000 GHz
-70.0							
Start 30 N #Res BW		#VB	W 3.0 MHz		Sweep 18	Stop 10.000 GHz .67 ms (40001 pts)	CF Step 997.000000 MHz
MKR MODE TR	RC SCL	× 2.402 11 GHz	۲ 11.17 dBm	FUNCTION F	FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
2 N 1	f	9.607 68 GHz	-32.97 dBm				Freq Offset
4 N 1	f	6.278 20 GHz 5.804 87 GHz 3.161 58 GHz	-38.26 dBm -38.52 dBm -38.78 dBm				0 Hz
6		5.101 35 GHZ					
8							
10						×	
MSG			10		STATUS		



Lowest Channel & Modulation : GFSK



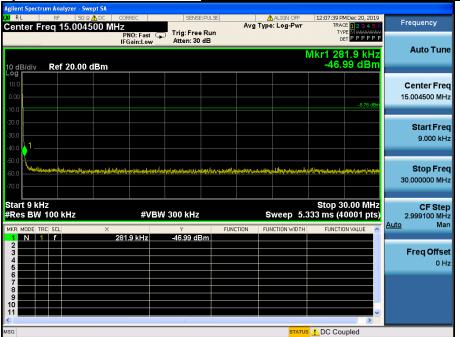


Reference for limit

Middle Channel & Modulation : GFSK



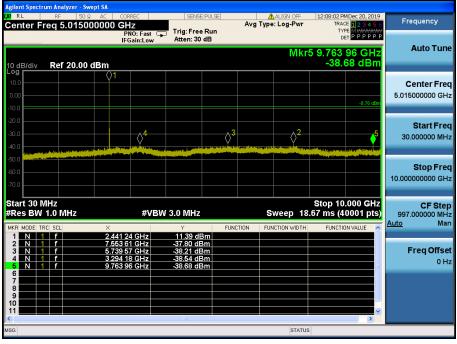
Conducted Spurious Emissions <u>Middle Channel & Modulation : GFSK</u>











Agilent Spectrum Analyzer - Swept SA				
RL RF 50 Ω AC CORRE CORRE Center Freq 17.500000000 GH		ALIGN OFF	12:08:26 PMDec 20, 2019 TRACE 1 2 3 4 5 6	Frequency
PNO	Fast 😱 Trig: Free Run n:Low Atten: 30 dB	• •	TYPE M WARANA	
IFGa	n:Low Atten: 30 dB	ML ₂ 2.	2 046 500 CU	Auto Tune
10 dB/div Ref 20.00 dBm		IVIKIO 2	3.246 500 GHz -32.57 dBm	
Log				
10.0				Center Freq
0.00			-8.76 dBm	17.500000000 GHz
-10.0			. 1	
-30.0			\wedge^3 \wedge^2 \wedge	Start Freq
	والمراجع والمرجع والمتعاد والمحمد والمحم	and the second secon		10.00000000 GHz
-40.0				
				Stop Freq
-60.0				25.00000000 GHz
-70.0				
Start 10.000 GHz			Stop 25.000 GHz	CF Step
#Res BW 1.0 MHz	#VBW 3.0 MHz	Sweep 40	.00 ms (40001 pts)	1.50000000 GHz
MKR MODE TRC SCL X	Y OZ OZ JIDat	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
2 N 1 f 24.169 000 0	Hz -29.81 dBm			
3 N 1 f 23.246 500 0	Hz -32.57 dBm			Freq Offset
5			Ξ	0 Hz
7				
8				
10				
<	101		>	
MSG		STATUS	6	



High Band-edge

Highest Channel & Modulation : GFSK



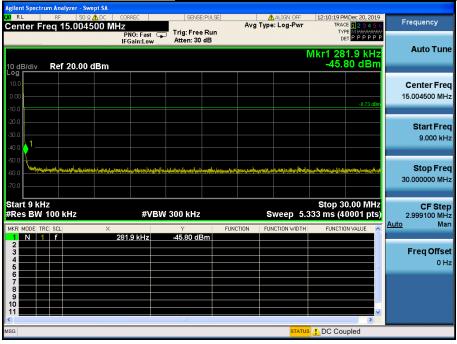
High Band-edge

Hopping mode & Modulation : GFSK





Highest Channel & Modulation : GFSK



	um Analyzer - Swept S						
Center Fr	RF 50 Ω A0 Teq 5.0150000		SENSE:PULSE		ALIGN OFF	12:10:43 PMDec 20, 2019 TRACE 1 2 3 4 5 6 TYPE MWWWWW	Frequency
10 dB/div Log	Ref 20.00 dBr	IFGain:Low	Atten: 30 dB		Mkr	_{сет} ререре 5 7.549 37 GHz -39.12 dBm	Auto Tune
10.0 0.00 -10.0						-8.73 dBm	Center Freq 5.015000000 GHz
-20.0 -30.0 -40.0	The second s		al gen de Tenzanten fan de array a gene de kiner		25-	and an and and and an an an and a	Start Freq 30.000000 MHz
-50.0							Stop Freq 10.000000000 GHz
Start 30 N #Res BW	1.0 MHz		W 3.0 MHz		· · ·	Stop 10.000 GHz .67 ms (40001 pts)	CF Step 997.000000 MHz Auto Man
MKR MODE TR 1 N 1 2 N 1 3 N 1 4 N 1 5 N 1 6 1 1	f f f	X 2.480 13 GHz 6.805 86 GHz 5.843 01 GHz 6.305 87 GHz 7.549 37 GHz	11.34 dBm -38.43 dBm -39.08 dBm -39.11 dBm -39.12 dBm	FUNCTION FI	UNCTION WIDTH	FUNCTION VALUE	Freq Offset
7 8 9 9 10 11 × 10 × 10 × 10 × 10 × 10 × 10						~	
MSG					STATUS		



Highest Channel & Modulation : GFSK





Low Band-edge

Lowest Channel & Modulation : π/4DQPSK



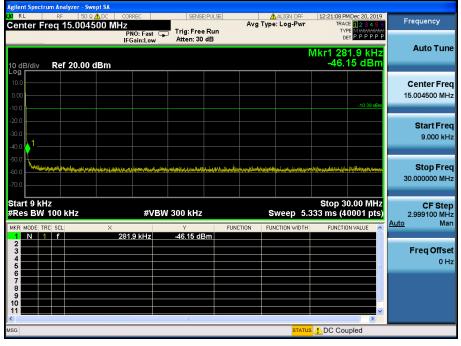
Low Band-edge

Hopping mode & Modulation : π/4DQPSK





Lowest Channel & Modulation : π/4DQPSK







Lowest Channel & Modulation : π/4DQPSK



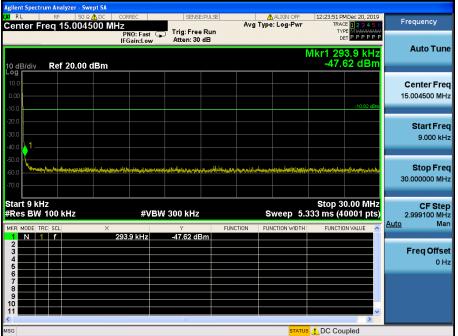


Reference for limit

Middle Channel & Modulation : π/4DQPSK



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





Middle Channel & Modulation : π/4DQPSK

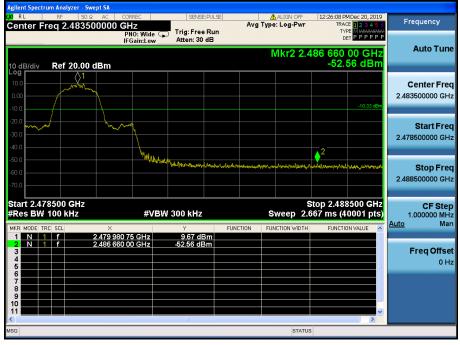


	um Analyzer - Sv									
Center Fr	RF 50: reg 17.500			SENSE:P	ULSE		ALIGN OFF	TRAC	4Dec 20, 2019 E 1 2 3 4 5 6	Frequency
Genter I	loq 17.000	PN	IO: Fast G	Trig: Free R Atten: 30 d		•	-	TY	E MWWWWW	
		IFG	ain:Luw	Fatern: 00 u			Mkr2 2	0 945 7	50 GHz	Auto Tune
10 dB/div Log	Ref 20.00	dBm							74 dBm	
10.0										Center Freq
0.00										17.500000000 GHz
-10.0									-10.82 dBm	
-20.0							3		<mark>_2 </mark> }	Start Freq
-30.0				line .	ملاف د.					10.000000000 GHz
-40.0	a angele an angele an angele a									
-50.0										Stop Freq
-60.0										25.000000000 GHz
-70.0										
Start 10.0							1		.000 GHz	CF Step
#Res BW	1.0 MHz		#VB\	N 3.0 MHz		S	weep 40	.00 ms (4	0001 pts)	1.50000000 GHz
MKR MODE TF	RC SCL	×		Y	FUNCT	ION FUI	NCTION WIDTH	FUNCTIO	IN VALUE	<u>Auto</u> Man
1 N 1 2 N 1	f	24.861 625 24.097 000) GHz	-28.53 dBn -29.98 dBn	î 📃					
3 N 1 4	f	20.845 750	GHz	-32.74 dBn	<u>ו</u>					Freq Offset 0 Hz
5									3	0 H2
7										
9										
10									~	
<				111					>	
MSG							STATUS			



High Band-edge

Highest Channel & Modulation : π/4DQPSK



High Band-edge

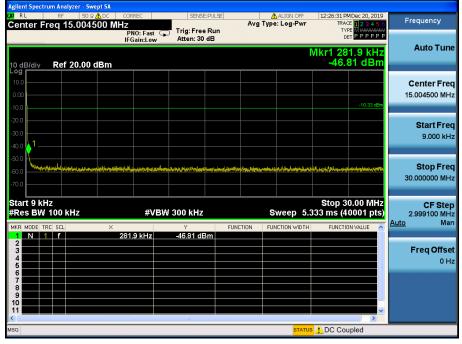
Hopping mode & Modulation : π/4DQPSK







Highest Channel & Modulation : π/4DQPSK



Agilent Spect															
Center F	RF rea		AC DOOO			SE	VSE:PU	.SE	Avg		ALIGN OFF	TRA	MDec 20, 2019 CE 1 2 3 4 5 6	Frequenc	сy
Contor 1	Toq	510100		PN	0: Fast (ain:Low	Trig: Fr Atten:		in	_		-	TY	PE M WAAWAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA		
				160	ain:Luw	Pateri.	00 00				Mke	5 7 472	61 GHz	Auto	Tune
10 dB/div	Re	f 20.00	dBm								IVINI		89 dBm		
Log				⟩1											_
														Center	
													-10.33 dBm	5.01500000	0 GHZ
-10.0															
-20.0											_			Start	Freq
-30.0								$\overline{\mathbb{C}}^3$	$\langle \rangle^2$		→ ⁵ —			30.00000	0 MHz
-40.0 mmalam	a a second se	agaa ahaa haraa d	Contraction of	المرجعة مر			1000 - 100-00 1000 - 100-00			trapie anes Descriptions	A COLUMN AND A COLUMN				
-50.0														Stop	Freq
-60.0														10.00000000	
-70.0															
Start 30 I	MHz											Stop 10	.000 GHz	CE	Step
#Res BW	1.0	MHz			#VB	W 3.0 MH	z			S	weep 18	.67 ms (4	0001 pts)	997.00000	0 MHz
MKR MODE T	RC SCL		×			Y		FUNC	TION	FUN	ICTION WIDTH	FUNCTI	DN VALUE	Auto	Man
1 N *	1 f 1 f			480 13 150 58		10.49 -38.04				-					
3 N	1 f		5.	677 51 536 93	GHz	-38.41 -38.54	dBm							FreqC	
4 N 5 N	1 f			<u>536 93</u> 472 61	GHz	-38.89	dBm dBm						з		0 Hz
6										+					
8															
10															
11													~		
MSG							-			_	STATUS				
	_	_	-	_	_		_	_	-	-					-





Highest Channel & Modulation : π/4DQPSK





Low Band-edge

Lowest Channel & Modulation : 8DPSK



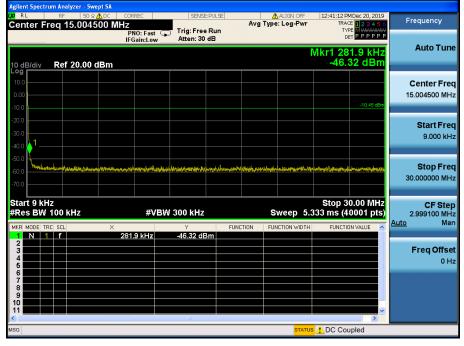
Low Band-edge

Hopping mode & Modulation : 8DPSK





Lowest Channel & Modulation : 8DPSK



Agilent Spectrum Analyzer					
Center Freq 5.01	PNO: Fast	SENSE:PULS	Avg Type: Log-Pwr	12:41:36 PMDec 20, 2019 TRACE 1 2 3 4 5 6 TYPE M WWWWW DET P P P P P P	Frequency
10 dB/div Ref 20.1	IFGain:Low	Atten: 30 dB	Mkr	5 7.015 48 GHz -38.65 dBm	Auto Tune
10.0 -10.0				-10.45 dBm	Center Fre 5.015000000 GH
-20.0	4		3 5		Start Free 30.000000 MH
-50.0					Stop Fre 10.000000000 GH
Start 30 MHz #Res BW 1.0 MHz	#VE	W 3.0 MHz	Sweep 18	Stop 10.000 GHz .67 ms (40001 pts)	CF Ste 997.000000 MH <u>Auto</u> Ma
1 N 1 f 2 N 1 f 3 N 1 f 4 N 1 f 5 N 1 f 6	2.402 11 GHz 9.607 43 GHz 6.434 98 GHz 3.313 62 GHz 7.015 48 GHz	10.27 dBm -34.84 dBm -38.02 dBm -38.55 dBm -38.65 dBm			Freq Offse 0 H
7 9 10 11				~	
ISG			STATUS	6	



Lowest Channel & Modulation : 8DPSK





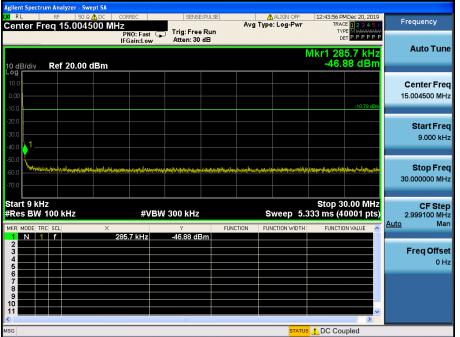
Reference for limit



STATUS

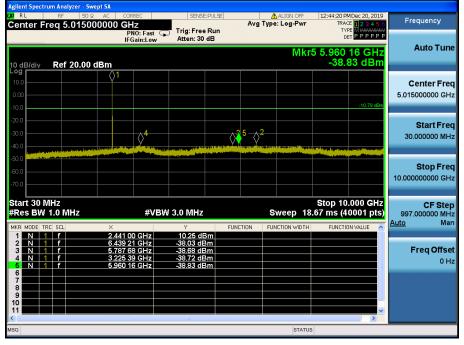
Middle Channel & Modulation : 8DPSK

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





Middle Channel & Modulation : 8DPSK

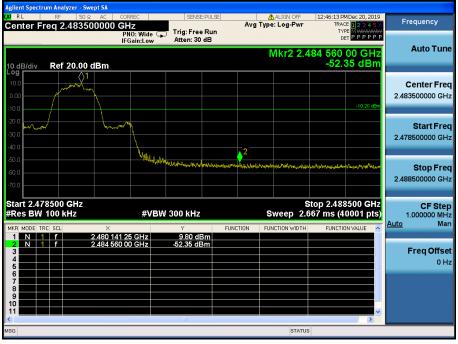


	um Analyzer - S						
LXI RL		Ω AC CORREC	SENSE:PUL		ALIGN OFF	12:44:42 PMDec 20, 2019	Frequency
Center Fi	req 17.50	DOOOOOO GHz PNO: Fast IFGain:Lov			Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE M WHAT AND DET PPPPP	
10 dB/div	Ref 20.00) dBm			Mkr3 2	1.654 250 GHz -32.52 dBm	Auto Tune
Log 10.0 0.00						-10.79 dBm	Center Freq 17.50000000 GHz
-20.0							Start Freq 10.000000000 GHz
-50.0 -60.0 -70.0							Stop Fred 25.000000000 GHz
Start 10.0 #Res BW		#V	/BW 3.0 MHz		Sweep 40	Stop 25.000 GHz .00 ms (40001 pts)	CF Step 1.50000000 GHz
MKR MODE TR	RC SCL	× 24.783 250 GHz	۲ -28.12 dBm	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	Auto Mar
2 N 1 3 N 1 4 5	f	24.191 500 GHz 21.654 250 GHz	-30.18 dBm -32.52 dBm				Freq Offset 0 Hz
6 7 8 9 10							
11			10			×	
MSG					STATUS		



High Band-edge

Highest Channel & Modulation : 8DPSK



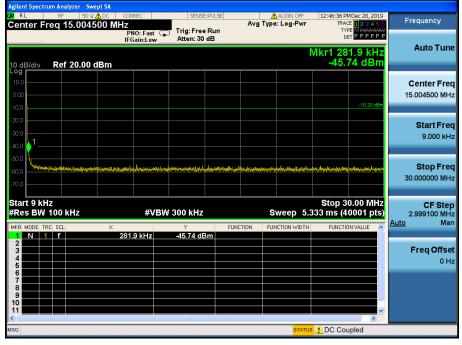
High Band-edge

Hopping mode & Modulation : 8DPSK





Highest Channel & Modulation : 8DPSK





Highest Channel & Modulation : 8DPSK





8. Transmitter AC Power Line Conducted Emission

8.1 Test Setup

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

8.2 Limit

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

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

Frequency Pango (MHz)	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

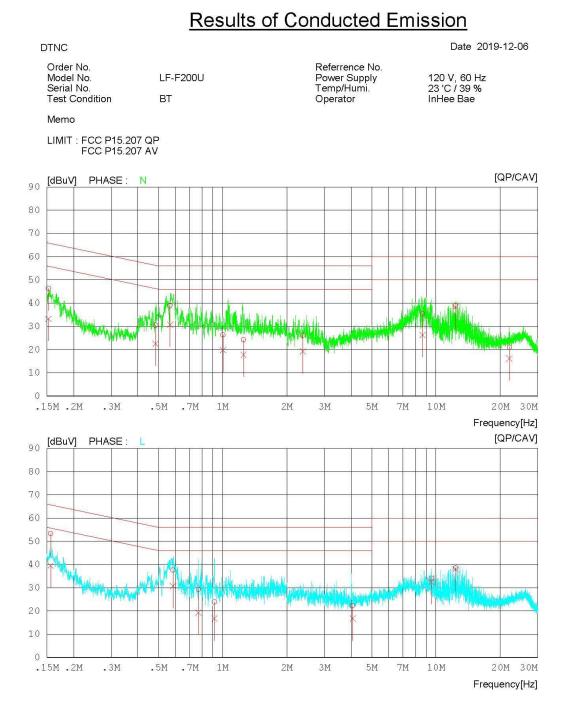
8.3 Test Procedures

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

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



DTNC

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

Results of Conducted Emission

Date 2019-12-06

Order No. Model No. Serial No. Test Condition	LF-F200U BT	Referrence No. Power Supply Temp/Humi. Operator	120 V, 60 Hz 23 'C / 39 % InHee Bae	
Memo				
LIMIT : FCC P15 FCC P15				
NO FREQ [MHz]	READING C.FACTOR QP CAV [dBuV][dBuV] [dB]	QP CAV QP CAV	MARGIN PHASE QP CAV [dBuV][dBuV]	
2 0.48473 3 0.56679 4 1.00260 5 1.25220 6 2.37520 7 8.65680 8 12.35700 9 22.08000 10 0.15614 11 0.58484 12 0.76953 13 0.91448 14 4.06420 15 9.50140	14.13 7.69 10.07 16.06 9.11 10.13 25.05 15.96 10.33 28.31 27.87 10.43 10.42 5.57 10.59 43.21 29.50 10.00 27.54 20.68 10.03 19.23 9.24 10.04 13.84 6.63 10.05	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	19.54 22.65 N 25.77 23.70 N 17.08 15.20 N 29.67 26.16 N 31.80 28.24 N 29.81 26.76 N 24.62 23.71 N 21.26 11.70 N 38.99 33.84 N 12.46 16.17 L 18.43 15.29 L 26.73 26.72 L 32.11 29.32 L 33.78 29.33 L 25.96 17.64 L 21.46 11.93 L	

TRF-RF-237(05)180118



9. Antenna Requirement

Describe how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT.

Conclusion: Comply

The antenna is attached on the device by means of unique connector. Therefore this E.U.T Complies with the requirement of §15.203

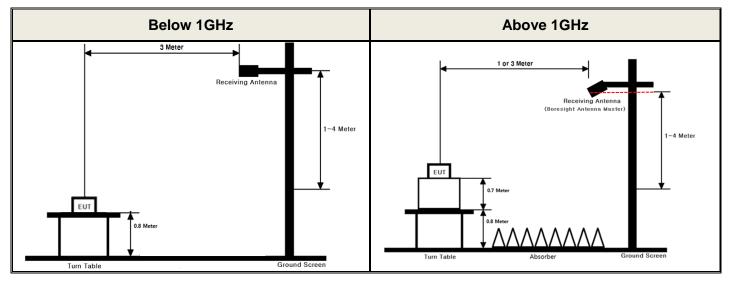
- Minimum Standard :

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.

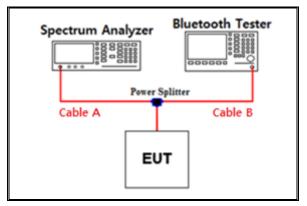
APPENDIX I

Test set up diagrams

Radiated Measurement



Conducted Measurement



Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	6.41	15	8.77
1	6.72	20	9.00
2.402 & 2.440 & 2.480	7.35	25	9.31
5	8.08	-	-
10	8.15	-	-

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

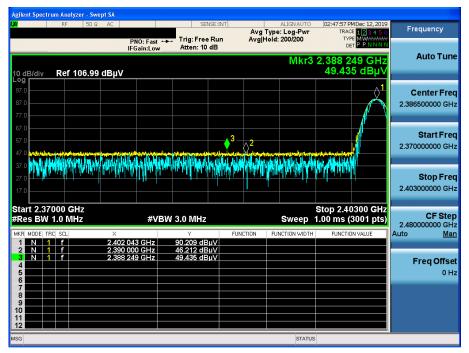


Detector Mode : PK

APPENDIX II

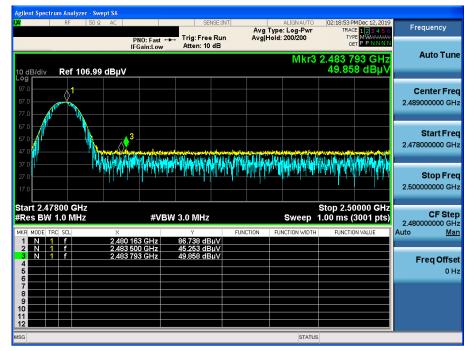
Unwanted Emissions (Radiated) Test Plot

GFSK & Lowest & Y & Ver



Detector Mode : PK

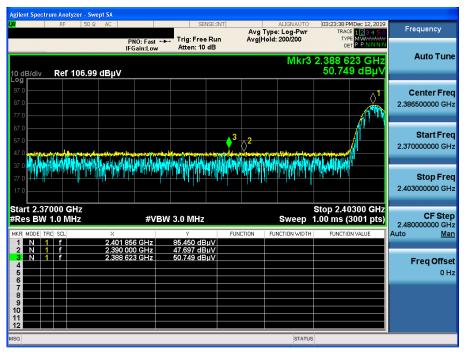
GFSK & Highest & Y & Ver



Detector Mode : PK



π /4DQPSK & Lowest & Z & Hor



Detector Mode : PK

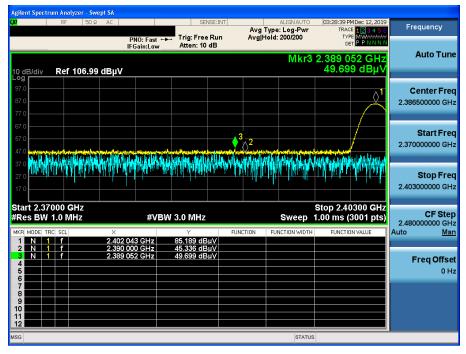
$\pi/4DQPSK$ & Highest & Z & Hor

Agilent Spectrum Analyzer - Swept SA				
ιχί RF 50Ω AC	SENS	E:INT ALIGNAUTO Avg Type: Log-Pwr	03:18:02 PM Dec 12, 2019 TRACE 1 2 3 4 5 6	Frequency
	PNO: Fast ↔ Trig: Free F IFGain:Low Atten: 10 d	B	TYPE MWWWWW DET PPNNNN	Auto Tune
10 dB/div Ref 106.99 dBµV		IVIKIS	2.483 581 GHz 50.200 dBµV	
97.0 87.0 77.0				Center Fred 2.489000000 GH:
67.0 57.0 47.0		uniteration and the second state of the	u den se de la companya de	Start Free 2.478000000 GH:
37.0 17.0 27.0 17.0			M.N.M. HAMMAN	Stop Free 2.500000000 GH
Start 2.47800 GHz #Res BW 1.0 MHz	#VBW 3.0 MHz	Sweep	Stop 2.50000 GHz 1.00 ms (3001 pts)	CF Stej 2.480000000 GH
MKR MODE TRC SCL X 1 N 1 f 2.480	۲ 097 GHz 88.347 dBµ		FUNCTION VALUE	Auto <u>Ma</u>
2 N 1 f 2.483 3 N 1 f 2.483 4 5 6	500 GHz 45.637 dBµ 581 GHz 50.200 dBµ	V V 		Freq Offse 0 H
7 8 9 10				
11 12 MSG		STATU		



Detector Mode : PK

8DPSK & Lowest & Z & Hor



Detector Mode : PK

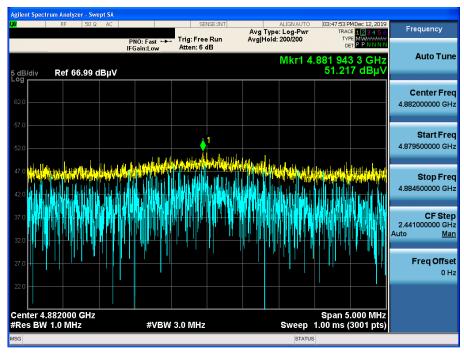
8DPSK & Highest & Z & Hor





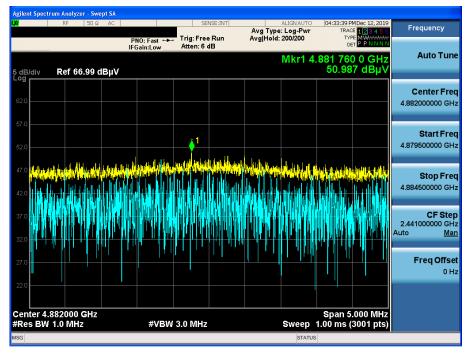
GFSK & Middle & X & Ver





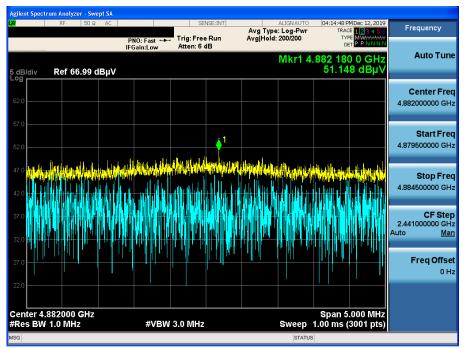
$\pi/4DQPSK$ & Middle & Z & Hor

Detector Mode : PK





8DPSK & Middle & Z & Hor



Detector Mode : PK