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: DRTFCC1902-0040
- 2. Customer
 - Name : BLUEBIRD INC.
 - Address : (Dogok-dong, SEI Tower 13,14) 39, Eonjuro30-gil, Gangnam-gu, Seoul South Korea
- 3. Use of Report : FCC Original Grant
- 4. Product Name / Model Name : Enterprise Full Touch Handheld Computer / EF501 FCC ID : SS4EF501X
- 5. Test Method Used : ANSI C63.10-2013 Test Specification : FCC Part 15 Subpart C.247
- 6. Date of Test : 2019.01.22 ~ 2019.01.30
- 7. Testing Environment : See appended test report.
- 8. Test Result : Refer to the attached test result.

Affirmation	Tested by		Reviewed by	AAD
	Name : JaeHyeok Bang	(Signiture)	Name : Geunki Son	(Signature)

The test results presented in this test report are limited only to the sample supplied by applicant and the use of this test report is inhibited other than its purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

2019.02.20.

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
DRTFCC1902-0040	Feb. 20, 2019	Initial issue



Table of Contents

1. General Information	4
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	
1.8 Test Equipment List	
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 & Occupied Bandwidth	
3.1 Test Setup	
3.1 Test Setup	
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	34
6.2 Limit	34
6.3 Test Procedure	34
6.4 Test Results	34
7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission	39
7.1 Test Setup	39
7.2 Limit	39
7.3. Test Procedures	40
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	
	69
8. Transmitter AC Power Line Conducted Emission	
8. Transmitter AC Power Line Conducted Emission	
8. Transmitter AC Power Line Conducted Emission 8.1 Test Setup	69
8. Transmitter AC Power Line Conducted Emission 8.1 Test Setup	69 69
 8. Transmitter AC Power Line Conducted Emission	69 69 69
 8. Transmitter AC Power Line Conducted Emission	69 69 69 70
 8. Transmitter AC Power Line Conducted Emission	69 69 70 72
 8. Transmitter AC Power Line Conducted Emission	69 69 70 72 73

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

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

1.2 Testing Environment

Ambient Condition		
 Temperature 	+18 ℃ ~ +23 ℃	
Relative Humidity	33 % ~ 45 %	

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	0.7 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	:	BLUEBIRD INC.
Address	:	(Dogok-dong, SEI Tower 13,14) 39, Eonjuro30-gil, Gangnam-gu, Seoul South Korea
Contact person	:	Yongsik Jang

1.5 Description of EUT

EUT	Enterprise Full Touch Handheld Computer
Model Name	EF501
Add Model Name	EF501R
Hardware Version	R1.0
Software Version	R1.12
Serial Number	Identical prototype
Power Supply	DC 3.80 V
Frequency Range	2402 MHz ~ 2480 MHz
Modulation Technique	GFSK, π/4DQPSK, 8DPSK
Number of Channels	79
Antenna Type	PIFA Antenna
Antenna Gain	PK : 1.11 dBi

1.6 Declaration by the applicant / manufacturer

- NA

1.7 Information about the FHSS characteristics

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following :
 - A) The hopping sequence is pseudorandom
 - Note 1 : Pseudorandom Frequency Hopping Sequence Table as below:
 - Channel: 08, 24, 40, 56, 42, 54, 72, 09, 01, 11, 33, 41, 34, 42, 65, 73, 53, 69, 06, 22, 04, 20, 36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 41, 58, 44, 60, 76, 13, 03, 11, 35, 43, 37, 45, 69, 77, 52, 71, 08, 24, 06, 24, 48, 56, 45, 46, 70, 01, 72, 06, 25, 33, 12, 28, 49, 60, 45, 58, 74, 13, 05, 18, 37, 49 etc

The System receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchroniztation with the transmit ted signals.

- B) All channels are used equally on average
- C) The receiver input bandwidth equals the transmit bandwidth
- D) The receiver hops in sequence with the transmit signal
- 15.247(g) : In accordance with the Bluetooth Industry Standard, the system is designed to comply with all
 of the regulations in Section 15.247 when the transmitter is presented with a continuous data
 (or information) system.
- 15.247(h) : In accordance with the Bluetooth Industry Standard, the system does not coordinate its channels selection / hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.
- 15.247(h) : The EUT employs Adaptive Frequency Hopping (AFH) which identifies sources of interference namely devices operating in 802.11 WLAN and excludes them from the list of available channels. The process of re-mapping reduces the number of test channels from 79 channels to a minimum number of 20 channels.

1.8 Test Equipment List

Туре	Manufacturer	Model	Cal.Date (yy/mm/dd)	Next.Cal.Date (yy/mm/dd)	S/N
Spectrum Analyzer	Agilent Technologies	N9020A	18/12/19	19/12/19	MY48010133
Spectrum Analyzer	Agilent Technologies	N9020A	18/07/09	19/07/09	MY46471251
DC Power Supply	Agilent Technologies	66332A	18/07/02	19/07/02	US37473422
Multimeter	FLUKE	17B	18/12/18	19/12/18	26030065WS
Signal Generator	Rohde Schwarz	SMBV100A	18/12/19	19/12/19	255571
Signal Generator	ANRITSU	MG3695C	18/12/10	19/12/10	173501
Thermohygrometer	BODYCOM	BJ5478	18/12/27	19/12/27	120612-1
Thermohygrometer	BODYCOM	BJ5478	18/12/27	19/12/27	120612-2
HYGROMETER	TESTO	608-H1	18/02/10	19/02/10	34862883
Loop Antenna	Schwarzbeck	FMZB1513	18/01/30	20/01/30	1513-128
BILOG ANTENNA	Schwarzbeck	VULB 9160	18/07/13	20/07/13	3359
Horn Antenna	ETS-Lindgren	3117	18/05/10	20/05/10	00140394
Horn Antenna	A.H.Systems Inc.	SAS-574	17/07/31	19/07/31	155
PreAmplifier	Agilent Technologies	8449B	18/07/05	19/07/05	3008A02108
PreAmplifier	H.P	8447D	18/12/18	19/12/18	2944A07774
High Pass Filter	Wainwright Instruments	WHKX12-2580- 3000-18000-80SS	18/07/05	19/07/05	3
Power Splitter	Anritsu	K241B	18/12/18	19/12/18	1301182
BlueTooth Tester	TESCOM	TC-3000B	18/12/18	19/12/18	3000B770243
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2495A MA2490A	18/04/17	19/04/17	1306007 1249001
EMI Test Receiver	Rohde Schwarz	ESR7	18/02/13	19/02/13	101061
EMI Test Receiver	Rohde Schwarz	ESCI7	18/02/12	19/02/12	100910
PULSE LIMITER	Rohde Schwarz	ESH3-Z2	18/09/27	19/09/27	101333
LISN	SCHWARZBECK	NNLK 8121	18/03/20	19/03/20	06183
Cable	Radiall	TESTPRO3	18/07/06	19/07/06	M-01
Cable	Junkosha	MWX315	18/11/19	19/11/19	M-05
Cable	Junkosha	MWX221	18/11/19	19/11/19	M-06
Cable	HUBER+SUHNER	SUCOFLEX103	18/07/06	19/07/06	M-03
Cable	DT&C	Cable	18/07/05	19/07/05	RF-82
Cable	DT&C	Cable	18/06/25	19/06/25	RF-07

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.Number of Hopping Frequencies>= 15 hops			С
15.247(a) RSS-247(5.1)				С
	20 dB Bandwidth	N/A		С
	Dwell Time	=< 0.4 seconds		С
15.247(b) RSS-247(5.4)	Transmitter Output Power	For FCC =< 1 Watt, if CHs >= 75 Others =< 0.125 W For IC if CHs >= 75 =< 1 Watt For Conducted Power =< 4 Watt For e.i.r.p, Others =< 0.125 W For Conducted Power. =< 0.5 Watt For e.i.r.p	Conducted	С
15.247(d) RSS-247(5.5)	Conducted Spurious Emissions	The radiated emission to any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density.		С
RSS Gen(6.7)	Occupied Bandwidth (99 %)	N/A	_	NA
15.247(d) 15.205 & 209 RSS-247(5.5) RSS-Gen (8.9 & 8.10)	Radiated Spurious Emissions	FCC 15.209 Limits	Radiated	C Note3
15.207 RSS-Gen(8.8)	AC Conducted Emissions	FCC 15.207 Limits	AC Line Conducted	С
15.203	Antenna Requirements	FCC 15.203	-	С

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

Note 3 : This 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).

The field strength of spurious emission was measured in three orthogonal EUT positions (X-axis, Y-axis and Z-axis).

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 ≥ 20 dB BW VBW ≥ RBW Sweep = auto Detector function = peak Trace = max hold

2.4 Test Results

Modulation	Tested Channel		Average t Power	Peak Output Power		
Modulation	Tested Ghammer	dBm	mW	dBm	mW	
	Lowest	9.79	9.53	10.94	12.42	
<u>GFSK</u>	Middle	11.46	14.00	12.92	19.59	
	Highest	8.80	7.59	10.32	10.76	
	Lowest	7.67	5.85	10.95	12.45	
<u>π/4DQPSK</u>	Middle	9.29	8.49	12.94	19.68	
	Highest	6.68	4.66	10.31	10.74	
	Lowest	7.68	5.86	11.13	12.97	
<u>8DPSK</u>	Middle	9.30	8.51	13.19	20.84	
	Highest	6.69	4.67	10.54	11.32	

Note 1: The Frame average output power was tested using an average power meter for reference only. Note 2: See next pages for actual measured spectrum plots.

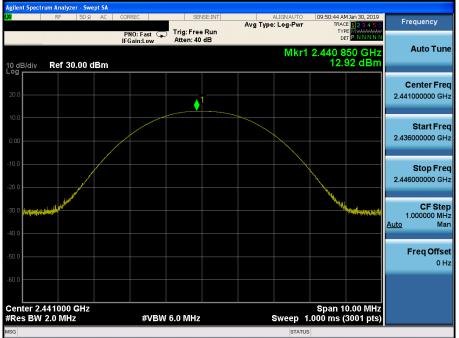


Lowest Channel & Modulation : GFSK



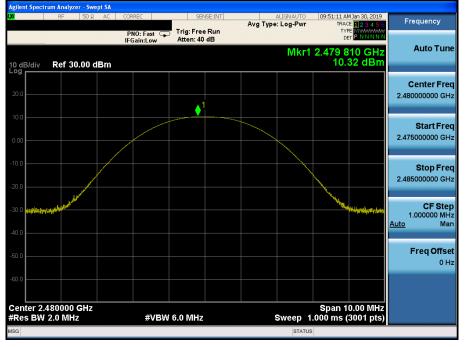
Peak Output Power

Middle Channel & Modulation : GFSK



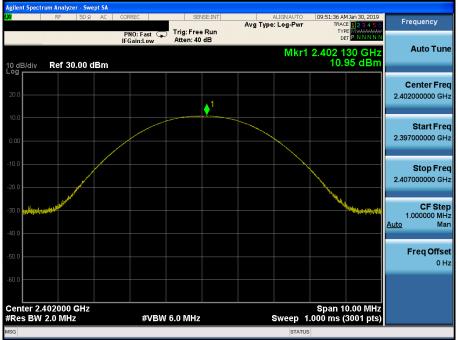


Highest Channel & Modulation : GFSK



Peak Output Power

Lowest Channel & Modulation : π/4DQPSK



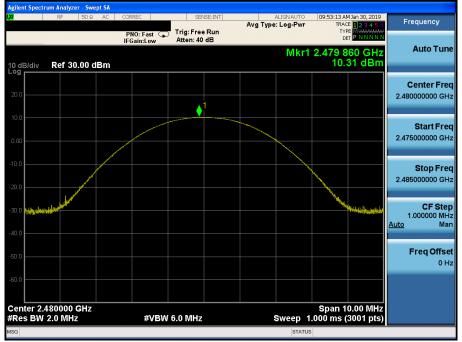


Middle Channel & Modulation : π/4DQPSK



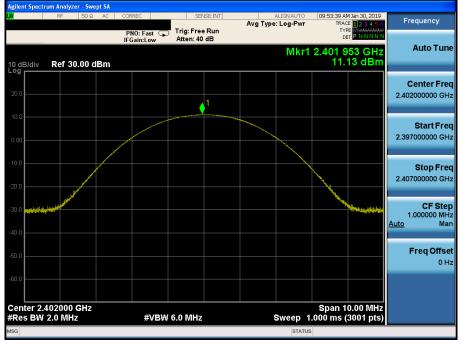
Peak Output Power

Highest Channel & Modulation : π/4DQPSK





Lowest Channel & Modulation : 8DPSK



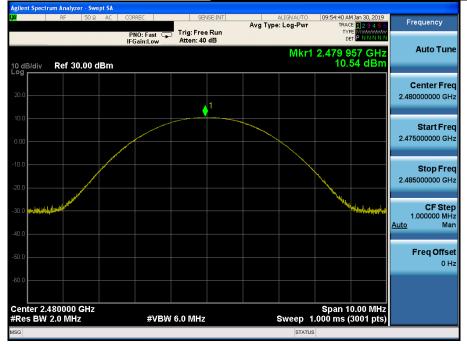
Peak Output Power

Middle Channel & Modulation : 8DPSK





Highest Channel & Modulation : 8DPSK





3. 20 dB BW & Occupied Bandwidth

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

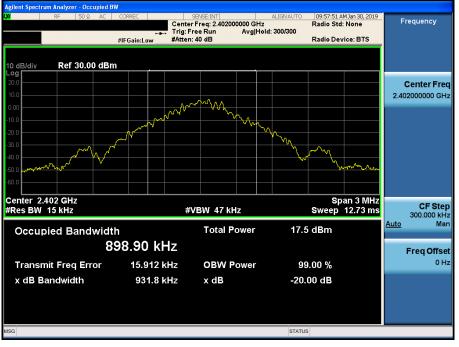
Trace = max hold

3.4 Test Results

Modulation	Tested Channel	20 dB BW (MHz)	Occupied BW (MHz)
	Lowest	0.932	-
<u>GFSK</u>	Middle	0.933	-
	Highest	0.934	-
	Lowest	1.317	-
<u>π/4DQPSK</u>	Middle	1.318	-
	Highest	1.320	-
	Lowest	1.277	-
<u>8DPSK</u>	Middle	1.280	-
	Highest	1.281	-



Lowest Channel & Modulation : GFSK

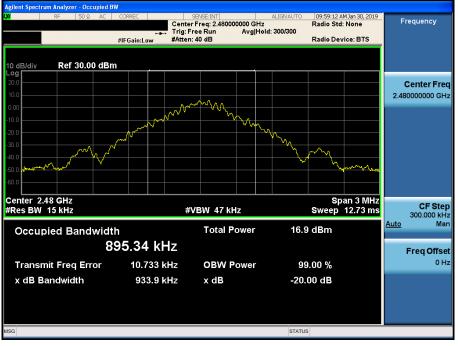


20 dB BW



Middle Channel & Modulation : GFSK

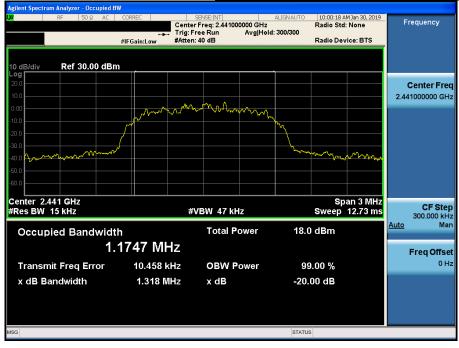
Highest Channel & Modulation : GFSK



20 dB BW

Lowest Channel & Modulation : π/4DQPSK Occupied BW nt Sp 09:59:51 AM Jan 30, 2019 Radio Std: None Center Freq: 2.402000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 40 dB Frequency Radio Device: BTS #IFGain:Low Ref 30.00 dBm dB/div **Center Freq** 2.402000000 GHz $\sqrt{\nu}$ NJAA Am \sim Center 2.402 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 16.1 dBm 1.1797 MHz Freq Offset OBW Power 0 Hz 13.536 kHz 99.00 % Transmit Freq Error x dB Bandwidth 1.317 MHz x dB -20.00 dB STATUS

Middle Channel & Modulation : π/4DQPSK

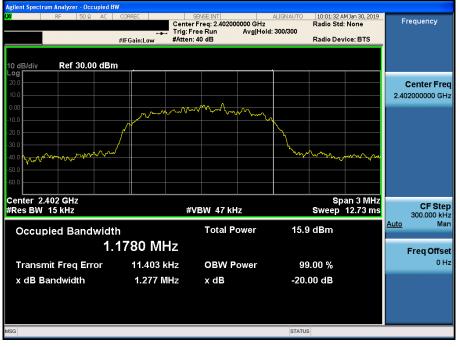


20 dB BW

Highest Channel & Modulation : π/4DQPSK Occupied BW nt Sp Center Freq: 2.48000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 40 dB 10:00:39 AM Jan 30, 2019 Radio Std: None Frequency Radio Device: BTS #IFGain:Low Ref 30.00 dBm dB/div **Center Freq** 2.48000000 GHz 1 mm wh \sim Center 2.48 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 15.4 dBm 1.1771 MHz Freq Offset **OBW Power** 0 Hz 11.067 kHz 99.00 % Transmit Freq Error x dB Bandwidth 1.320 MHz x dB -20.00 dB STATUS



Lowest Channel & Modulation : 8DPSK



20 dB BW

Middle Channel & Modulation : 8DPSK Occupied BW nt Sp 10:01:57 AM Jan 30, 2019 Radio Std: None SERSE:INT ALIGNAUTO Center Freq: 2.441000000 GHz Trig: Free Run Avg|Hold: 300/300 #Atten: 40 dB Frequency Radio Device: BTS #IFGain:Low Ref 30.00 dBm dB/div **Center Freq** 2.441000000 GHz mm Center 2.441 GHz #Res BW 15 kHz Span 3 MHz Sweep 12.73 ms CF Step 300.000 kHz #VBW 47 kHz Auto Mar Occupied Bandwidth Total Power 17.8 dBm 1.1760 MHz Freq Offset **OBW Power** 0 Hz 8.653 kHz 99.00 % Transmit Freq Error x dB Bandwidth 1.280 MHz x dB -20.00 dB STATUS

Highest Channel & Modulation : 8DPSK





4. Carrier Frequency Separation

4.1 Test Setup

Refer to the APPENDIX I.

4.2 Limit

Limit : ≥ 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 center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.010	2442.010	1.000
Enable	π/4DQPSK	2441.009	2442.009	1.000
	8DPSK	2441.005	2442.005	1.000

AFH mode

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2441.168	2442.167	0.999
Enable	π/4DQPSK	2441.162	2442.162	1.000
	8DPSK	2441.166	2442.166	1.000

Note 1 : See next pages for actual measured spectrum

- Minimum Standard :

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Alternatively, frequency hopping systems operating in the 2400 - 2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW



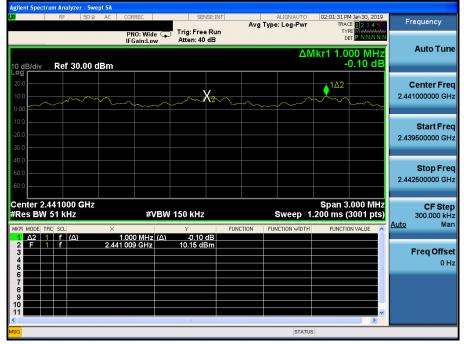
Carrier Frequency Separation (FH)

Hopping mode : Enable & GFSK



Carrier Frequency Separation (FH)

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





Carrier Frequency Separation (FH)

Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - Swept SA					
LX / RF 50Ω AC	CORREC	SENSE:INT	ALIGNAUTO Avg Type: Log-Pwr	02:28:31 PM Jan 30, 2019 TRACE 1 2 3 4 5 6 TYPE MWWWWW	Frequency
10 dB/div Ref 30.00 dBm	PNO: Wide 🖵 IFGain:Low	Atten: 40 dB	ΔΝ	/kr1 1.000 MHz -0.10 dB	Auto Tune
20.0 10.0 0.00	~~~~~	X2~			Center Freq 2.441000000 GHz
-10.0 -20.0 -30.0					Start Freq 2.439500000 GHz
-40.0 -50.0 -60.0					Stop Freq 2.442500000 GHz
Center 2.441000 GHz #Res BW 51 kHz			Sweep 1	Span 3.000 MHz .200 ms (3001 pts) FUNCTION VALUE	CF Step 300.000 kHz <u>Auto</u> Man
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.000 MHz (Δ) 41 005 GHz	-0.10 dB 10.14 dBm			Freq Offset 0 Hz
7 9 10 11				~	
MSG			STATU	5	



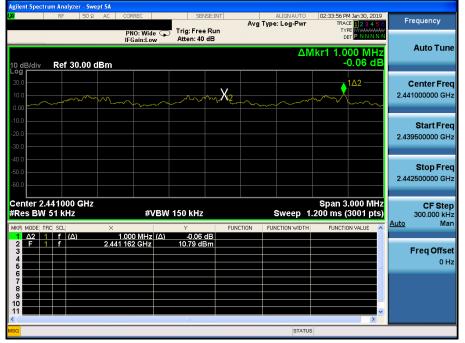


Carrier Frequency Separation (AFH) <u>Hopping mode : Enable & GFSK</u>



Carrier Frequency Separation (AFH)

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







Carrier Frequency Separation (AFH) Hopping mode : Enable & 8DPSK



Agilent Spectrum Analyzer - Swept SA				
LXI RF 50Ω AC	CORREC SENSE:INT	ALIGNAUTO Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6	Frequency
10 dB/div Ref 30.00 dBm	PNO: Wide 🖵 Trig: Free Run IFGain:Low Atten: 40 dB	Δ	TYPE NNNNN DET NNNNN Mkr1 1.000 MHz -0.12 dB	Auto Tune
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	(2		Center Freq 2.441000000 GHz
-10.0				<b>Start Freq</b> 2.439500000 GHz
-40.0 -50.0 -60.0				<b>Stop Freq</b> 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 <u>Auto</u> Man
1 Δ2 1 f (Δ)	1.000 MHz (Δ) -0.12 dB 41 166 GHz 11.05 dBm			Freq Offset 0 Hz
7 8 9 10 11			×	
MSG		STATU		



## 5. Number of Hopping Frequencies

## 5.1 Test Setup

Refer to the APPENDIX I.

## 5.2 Limit

Limit : >= 15 hops

## 5.3 Procedure

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

To get higher resolution, two frequency ranges for FH mode within the 2400 ~ 2483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz	Start Frequency = 2391.5 MHz,	Stop Frequency = 2441.5 MHz
	Start Frequency = 2441.5 MHz,	Stop Frequency = 2491.5 MHz
Span for AFH mode = 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



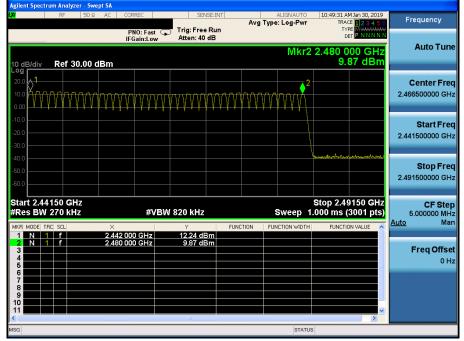
## Number of Hopping Frequencies 1(FH)



<mark>ilent Spectrum Analyzer - Swe</mark> RF 50 Ω	AC CORREC	SENSE:INT	ALIGNAUTO Avg Type: Log-Pwr	10:48:20 AM Jan 30, 2019 TRACE 12 3 4 5 6	Frequency
	PNO: Fast G IFGain:Low	Trig: Free Run Atten: 40 dB		TYPE MWWWWWW DET P N N N N N	
0 dB/div Ref 30.00 c	lBm		Mkr2	2.441 000 GHz 12.39 dBm	Auto Tun
•g 20.0 10.0 .00		MAAAAAAAAA			Center Fre 2.416500000 GF
10.0 20.0 30.0					<b>Start Fre</b> 2.391500000 GH
40.0 <b>***********************************</b>					<b>Stop Fre</b> 2.441500000 G⊦
tart 2.39150 GHz Res BW 270 kHz	X		Sweep 1	Stop 2.44150 GHz .000 ms (3001 pts) FUNCTION VALUE	<b>CF Ste</b> 5.000000 MH <u>Auto</u> Ma
1 N 1 f 2 N 1 f 3 4 5 6	2.402 000 GHz 2.441 000 GHz	10.52 dBm 12.39 dBm			Freq Offse 0 H
6 7 7 8 9 9 10 11					
5G			STATUS	3	

## Number of Hopping Frequencies 2(FH)







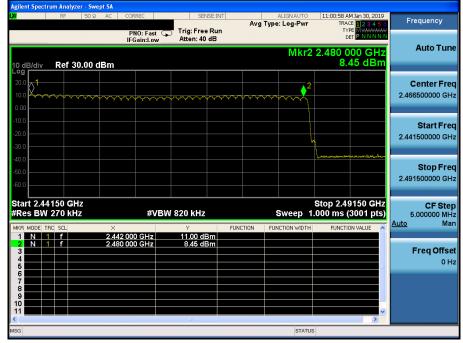
## Number of Hopping Frequencies 1(FH)

## Hopping mode : Enable & π/4DQPSK

	RF	50 Ω	AC COR	RREC		SENSE:	INT	Avg Tv	ALIGNAUTO		AM Jan 30, 2019 CE <b>1 2 3 4 5</b> 6	Frequency
				NO: Fast Gain:Lov		ig: Free R ten: 40 dE				T) [		Auto Tuno
IB/div	Ref 3	0.00 dB	3m						Mkr2		000 GHz 59 dBm	Auto Tulle
		Ŷ	,1 ,	~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	᠂᠂᠂	~~~~	~~~~~~	*****	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Center Fred 2.416500000 GH:
												Start Fred 2.391500000 GHz
	guarre de de											<b>Stop Freq</b> 2.441500000 GHz
s BW	270 GH		×	#V	BW 82	0 kHz	DIN	CTION FI	Sweep 1	.000 ms	4150 GHz (3001 pts)	CF Step 5.000000 MHz <u>Auto</u> Man
N N			2.402 000 2.441 000	0 GHz 0 GHz		9.01 dBm 0.59 dBm			SACHON WOTT			Freq Offset
						Ш			STATUS	5	>	

## Number of Hopping Frequencies 2(FH)

## Hopping mode : Enable & π/4DQPSK





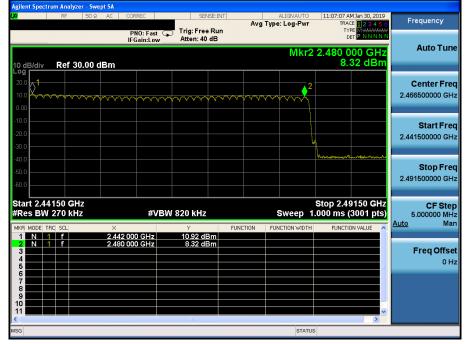
## Number of Hopping Frequencies 1(FH)

## Hopping mode : Enable & 8DPSK

Agilent Spectrum Analyzer - S							
<b>LXI</b> RF 50	IΩ AC CORREC	SENS	E:INT Ava Tu	ALIGNAUTO	11:04:28 AM J	an 30, 2019	Frequency
	PNO:	Fast 😱 Trig: Free	Run		TYPE	MINANANA	
	IFGair	:Low Atten: 40 o	3B		DET	PNNNNN	A
				Mkr2	2.441 00		Auto Tune
10 dB/div Ref 30.00	) dBm				11.08	3 dBm	
Log							
20.0	_∆ ¹						Center Freq
10.0	Xmm	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	$\sim\sim\sim\sim\sim\sim\sim$	and a start when	Aurra	2.416500000 GHz
0.00							
-10.0							Start Freq
-20.0							2.391500000 GHz
-30.0	<u>۸</u>						2.591500000 GHZ
-40.0 Mentermalineer							
							Stop Freq
-50.0							2.441500000 GHz
-60.0							
Start 2.39150 GHz					Stop 2.441	50 CH2	
#Res BW 270 kHz		#VBW 820 kHz		Sween 1	3(0p 2.44 i .000 ms (3(	101 nts)	CF Step 5.000000 MHz
							Auto Man
MKR MODE TRC SCL	× 2.402 000 G	Hz 9.24 dB		UNCTION WIDTH	FUNCTION '	VALUE 🔼	
2 N 1 f	2.442 000 G	Hz 11.08 dB	m				
3							Freq Offset
5						=	0 Hz
6							
8							
9							
11						~	
<							
MSG				STATUS	6		

## Number of Hopping Frequencies 2(FH)

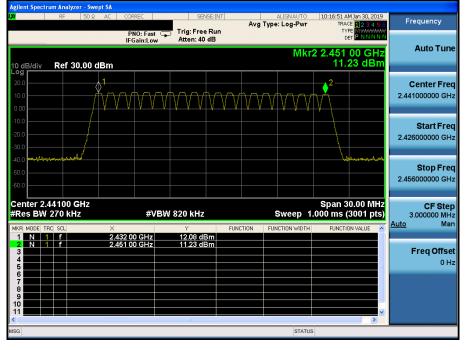
## Hopping mode : Enable & 8DPSK





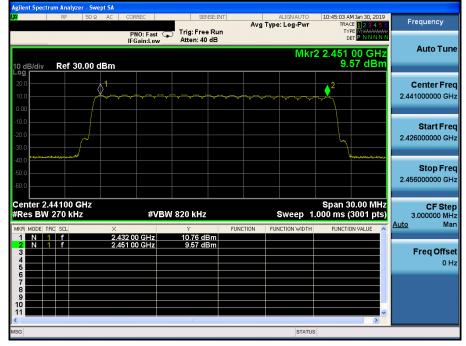
## Number of Hopping Frequencies 1(AFH)

## Hopping mode : Enable & GFSK



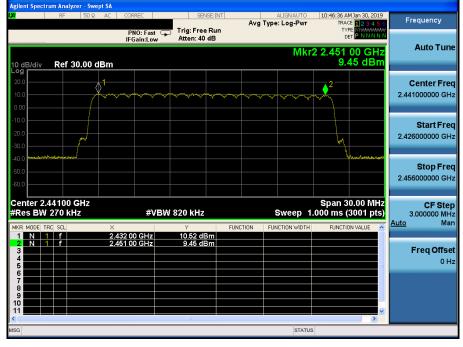
#### Number of Hopping Frequencies 1(AFH)

## Hopping mode : Enable & π/4DQPSK



## Number of Hopping Frequencies 1(AFH)

## Hopping mode : Enable & 8DPSK





## 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)

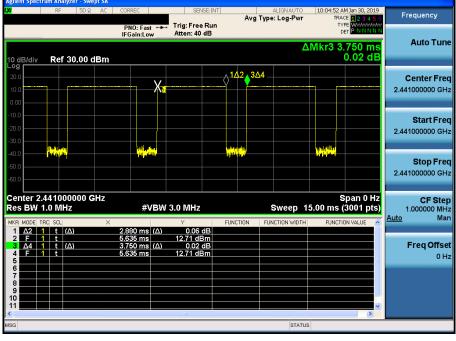
- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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



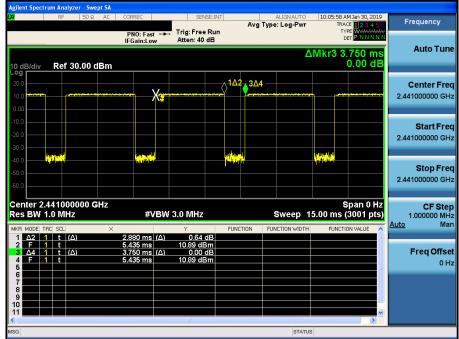
# Hopping mode : Enable & DH5

## Time of Occupancy (FH)



#### Time of Occupancy (FH)

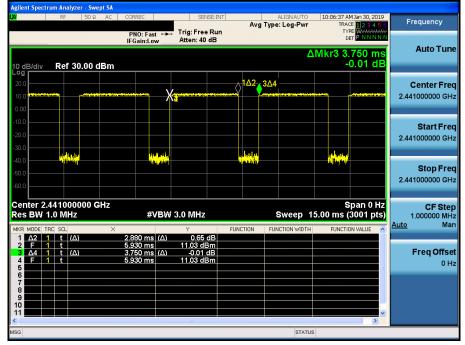
## Hopping mode : Enable & 2-DH5





## Hopping mode : Enable & 3-DH5

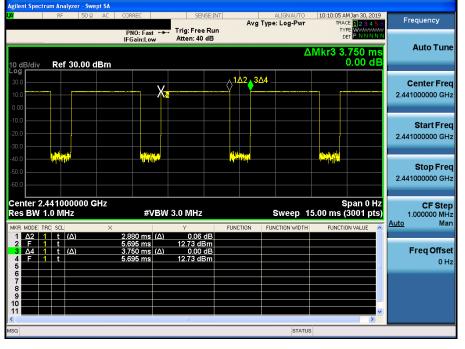
Time of Occupancy (FH)





## Hopping mode : Enable & DH5

## Time of Occupancy (AFH)



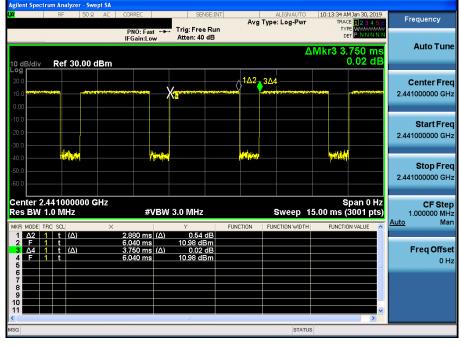
## Time of Occupancy (AFH)

#### Hopping mode : Enable & 2-DH5 Frequency Avg Type: Log-Pwr Trig: Free Run Atten: 40 dB TYPE DE1 PNO: Fast ++-Auto Tune ΔMkr3 3.750 ms -0.51 dE Ref 30.00 dBm /div <u>1Δ2</u> 3∆4 **Center Freq** 2.441000000 GHz Start Freq 2.441000000 GHz with the ha b Stop Freq 2.441000000 GHz Center 2.441000000 GHz Res BW 1.0 MHz Span 0 Hz Sweep 15.00 ms (3001 pts) CF Step 1.000000 MHz Man #VBW 3.0 MHz Auto FUNCTION $\Delta 2$ 1 t ( $\Delta$ ) 1 2 : (A) 0.55 dB 10.99 dBm -0.51 dB 10.99 dBm is (Δ) Freq Offset 0 Hz



## Hopping mode : Enable & 3-DH5

## Time of Occupancy (AFH)





# 7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

## 7.1 Test Setup

Refer to the APPENDIX I.

## 7.2 Limit

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

- 1. Frequency Range Below 1GHz RBW = 100 or 120 kHz, VBW = 3 x RBW, Detector = Peak or Quasi Peak
- 2. Frequency Range Range > 1 GHz
- Peak Measurement

RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Sweep time = Auto, Trace mode = Max Hold until the trace stabilizes

Average Measurement> 1GHz

RBW = 1MHz, VBW  $\geq$  1/T, Detector = Peak, Sweep Time = Auto, Trace Mode = Max Hold until the trace stabilizes