TEST REPORT

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	6		DT&C Co.,	Ltd.
D t&	C		eon-gil, Cheoin-gu, Yong Гel : 031-321-2664, Fax :	in-si, Gyeonggi-do, Korea, 17042 031-321-1664
1. Report No : DRTFCC	2007-020	3		
2. Customer				
• Name : Cresyn Co., L	td.			
• Address : 5 Gangnam	-dearo 107	-gil, Seocho-gu,	Seoul, 06524 South	Korea
3. Use of Report : FCC C)riginal Gra	ant		
4. Product Name / Mode		luetooth Headph	one / PPU-BN0600B	K01
FCC ID : V2R-900LEC	SACY			
5. Test Method Used : Al			074D01v05r02	
Test Specification : FC	C Part 15.	247		
6. Date of Test : 2020.06	.05 ~ 2020	0.06.25		
7. Location of Test : 🖂 I	Permanent	Testing Lab	On Site Test	ing
8. Testing Environment :	See apper	nded test report.		
9. Test Result : Refer to t	he attache	ed test result.		
The results shown in this te	st report ref	er only to the sam	ble(s) tested unless oth	erwise stated.
Tested by		iant	Reviewed by	AC
Affirmation Name : InHee I	Зае	(Sighiure)	Name : JaeJin Lee	KH- (Signature)
2020.07.08.				
		DT&C Co	., Ltd.	
Not a	abided by K	S Q ISO / IEC 170	25 and KOLAS accred	itation.

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
DRTFCC2007-0203	Jul. 08, 2020	Initial issue	InHee Bae	JaeJin Lee



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1. General Information

1.1 Testing Laboratory

DT&C Co., Ltd.

The 3 m test site and conducted measurement facility used to collect the radiated data are located at the 42, Yurim-ro, 154beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea 17042. The test site complies with the requirements of § 2.948 according to ANSI C63.4-2014.

- FCC & IC MRA Designation No. : KR0034

- ISED #: 5740A

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

1.2 Testing Environment

Ambient Condition		
 Temperature 	+21 ℃ ~ +24 ℃	
 Relative Humidity 	35 % ~ 43 %	

1.3 Measurement Uncertainty

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

Test items	Measurement uncertainty
Transmitter Output Power	0.9 dB (The confidence level is about 95 %, k = 2)
Conducted spurious emission	1.0 dB (The confidence level is about 95 %, k = 2)
AC conducted emission	3.6 dB (The confidence level is about 95 %, k = 2)
Radiated spurious emission (1 GHz Below)	4.9 dB (The confidence level is about 95 %, k = 2)
Radiated spurious emission (1 GHz ~ 18 GHz)	5.1 dB (The confidence level is about 95 %, k = 2)
Radiated spurious emission (18 GHz Above)	5.3 dB (The confidence level is about 95 %, k = 2)

1.4 Details of Applicant

Applicant	:	Cresyn Co.,Itd
Address	:	5 Gangnam-dearo 107-gil, Seocho-gu, Seoul, 06524 South Korea
Contact person	:	Young Kwang Kim

1.5 Description of EUT

EUT	Bluetooth Headphone	
Model Name	PPU-BN0600BK01	
Add Model Name	PPU-BN0600WH01	
Serial Number	Identical prototype	
Power Supply	DC 3.7 V	
Frequency Range	2 402 MHz ~ 2 480 MHz	
Modulation Technique	GFSK, π/4DQPSK, 8DPSK	
Number of Channels	79	
Antenna Type	Chip antenna	
Antenna Gain	PK : 2.36 dBi	

1.6 Declaration by the applicant / manufacturer

- NA

1.7 Information about the FHSS characteristics

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

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

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

1.8 Test Equipment List

Туре	Manufacturer	Model	Cal.Date (yy/mm/dd)	Next.Cal.Date (yy/mm/dd)	S/N
Spectrum Analyzer	Agilent Technologies	N9020A	19/06/26	20/06/26	MY50410163
Spectrum Analyzer	Agilent Technologies	N9020A	19/12/16	20/12/16	MY48011700
DC Power Supply	Agilent Technologies	66332A	19/12/16	20/12/16	US37476998
Multimeter	FLUKE	17B	19/12/16	20/12/16	26030065WS
Signal Generator	Rohde Schwarz	SMBV100A	19/12/16	20/12/16	255571
Signal Generator	ANRITSU	MG3695C	19/12/16	20/12/16	173501
Thermohygrometer	BODYCOM	BJ5478	19/12/18	20/12/18	120612-1
Thermohygrometer	BODYCOM	BJ5478	19/12/18	20/12/18	120612-2
Thermohygrometer	BODYCOM	BJ5478	19/06/25	20/06/25	N/A
HYGROMETER	TESTO	608-H1	20/01/21	21/01/21	34862883
Power Divider	Weinschel	WA1575	19/06/27	20/06/27	WA1575-2
BlueTooth Tester	Tescom	TC-3000B	19/12/16	20/12/16	3000B640046
Loop Antenna	ETS-Lindgren	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	20/01/30	22/01/30	6419
Horn Antenna	A.H.Systems Inc.	SAS-574	19/07/03	21/07/03	155
PreAmplifier	tsj	MLA-0118-B01-40	19/12/16	20/12/16	1852267
PreAmplifier	tsj	MLA-1840-J02-45	19/06/27	20/06/27	16966-10728
PreAmplifier	H.P	8447D	19/12/16	20/12/16	2944A07774
High Pass Filter	Wainwright Instruments	WHKX12-935-1000- 15000-40SS	19/06/26	20/06/26	8
High Pass Filter	Wainwright Instruments	WHKX10-2838- 3300-18000-60SS	19/06/26	20/06/26	1
High Pass Filter	Wainwright Instruments	WHNX8.0/26.5-6SS	19/06/27	20/06/27	3
Attenuator	Hefei Shunze	SS5T2.92-10-40	19/06/27	20/06/27	16012202
Attenuator	SRTechnology	F01-B0606-01	19/06/27	20/06/27	13092403
Attenuator	Aeroflex/Weinschel	20515	19/06/27	20/06/27	Y2370
Attenuator	SMAJK	SMAJK-2-3	19/06/27	20/06/27	2
Attenuator	SMAJK	SMAJK-50-10	19/06/25	20/06/25	15081903
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2495A MA2490A	19/06/27	20/06/27	1338003 1249304
EMI Receiver	ROHDE&SCHWARZ	ESW44	19/07/30	20/07/30	101645
EMI Test Receiver	Rohde Schwarz	ESU	20/01/20	21/01/20	100538
PULSE LIMITER	Rohde Schwarz	ESH3-Z2	19/09/17	20/09/17	101333
LISN	SCHWARZBECK	NSLK 8128 RC	19/11/04	20/11/04	8128 RC-387
Cable	Junkosha	MWX241	20/01/13	21/01/13	G-04
Cable	Junkosha	MWX241	20/01/13	21/01/13	G-07
Cable	DT&C	Cable	20/01/13	21/01/13	G-13
Cable	DT&C	Cable	20/01/13	21/01/13	G-14
Cable	HUBER+SUHNER	SUCOFLEX 104	20/01/13	21/01/13	G-15
Cable	Radiall	TESTPRO3	20/01/16	21/01/16	M-01
Cable	Junkosha	MWX315	20/01/16	21/01/16	M-05
Cable	Junkosha	MWX221	20/01/16	21/01/16	M-06
Cable	Radiall	TESTPRO3	20/01/16	21/01/16	RF-55
Cable	DT&C	CABLE	20/01/16	21/01/16	RF-82

Note 1: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017.

Note 2: The cable is not a regular calibration item, so it has been calibrated by DT & C itself.



1.9 Summary of Test Results

FCC Part RSS Std.	Parameter	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
	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 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.				

Dt&C

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	2 402 ~ 2 480	2 402 ~ 2 480

- Hopping Function : Disable

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



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 2 400 MHz 2 483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.
- §15.247(b)(1), For frequency hopping systems operating in the 2 400 MHz 2 483.5 MHz employing at least
 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 MHz 5 805 MHz
 band : 1 Watt. For all other frequency hopping systems in the 2 400 MHz 2 483.5 MHz band: 0.125 watts.

IC Requirements

 RSS-247(5.4) (b), For FHSS operating in the band 2 400 MHz – 2 483.5 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		Average t Power	Peak Output Power	
	rested Ghanner	dBm	mW	dBm	mW
	Lowest	1.91	1.55	3.11	2.05
<u>GFSK</u>	Middle	2.56	1.80	3.75	2.37
	Highest	1.19	1.32	2.36	1.72
	Lowest	1.78	1.51	5.21	3.32
<u>π/4DQPSK</u>	Middle	2.46	1.76	5.93	3.92
	Highest	1.07	1.28	4.49	2.81
<u>8DPSK</u>	Lowest	1.79	1.51	5.70	3.72
	Middle	2.47	1.77	6.46	4.43
	Highest	1.08	1.28	5.00	3.16

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

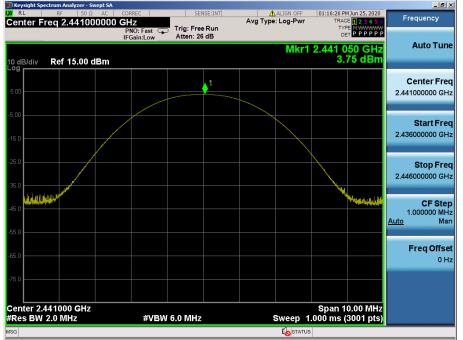






Peak Output Power

Middle Channel & Modulation : GFSK



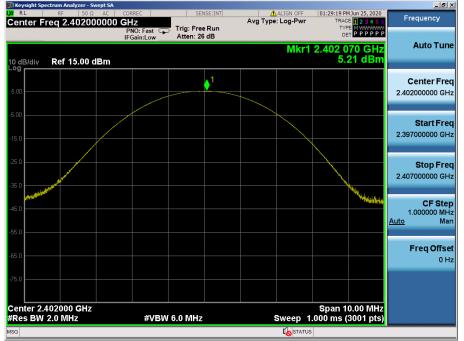


Highest Channel & Modulation : GFSK



Peak Output Power

Lowest Channel & Modulation : π/4DQPSK





Middle Channel & Modulation : π/4DQPSK



Peak Output Power

Highest Channel & Modulation : π/4DQPSK









Peak Output Power

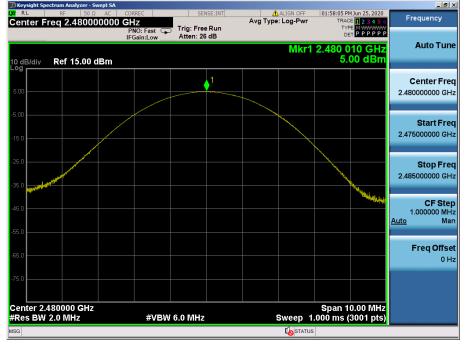
Middle Channel & Modulation : 8DPSK







Highest Channel & Modulation : 8DPSK





3. 20 dB BW & Occupied 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	0.930
<u>GFSK</u>	Middle	0.920
	Highest	0.920
	Lowest	1.340
<u>π/4DQPSK</u>	Middle	1.330
	Highest	1.330
	Lowest	1.340
<u>8DPSK</u>	Middle	1.330
	Highest	1.330



Lowest Channel & Modulation : GFSK



20 dB BW

Middle Channel & Modulation : GFSK





Highest Channel & Modulation : GFSK



20 dB BW

Lowest Channel & Modulation : π/4DQPSK





Middle Channel & Modulation : π/4DQPSK



20 dB BW

Highest Channel & Modulation : π/4DQPSK





Lowest Channel & Modulation : 8DPSK



20 dB BW

Middle Channel & Modulation : 8DPSK





Highest Channel & Modulation : 8DPSK





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

ľ	-н	mo	σαε)	

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2 441.003	2 442.005	1.002
Enable	π/4DQPSK	2 441.005	2 442.007	1.002
	8DPSK	2 441.006	2 442.004	0.998

AFH mode

Hopping Mode	Modulation	Peak of center channel (MHz)	Peak of adjacent Channel (MHz)	Test Result (MHz)
	GFSK	2 441.005	2 442.005	1.000
	π/4DQPSK	2 441.007	2 442.005	0.998
	8DPSK	2 441.004	2 442.006	1.002

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 2 400 MHz – 2 483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW





Carrier Frequency Separation (FH)

Hopping mode : Enable & GFSK



Carrier Frequency Separation (FH) Hop

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





Carrier Frequency Separation (FH)

Hopping mode : Enable & 8DPSK

Keysight Spectrum Analyzer - Swept SA					_ 8 ×
LXI RL RF 50 Ω AC	CORREC	SENSE:INT	ALIGN OFF	02:05:22 PM Jun 25, 2020	Frequency
Center Freq 2.44100000	0 GHz	Trig: Free Run	Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE M	rrequeriey
	PNO: Wide 😱	Atten: 26 dB		DET PPPPP	
	II Gain.cow				Auto Tune
				∆Mkr1 998 kHz	
10 dB/div Ref 15.00 dBm				-0.04 dB	
Log				▲1∆2	
5.00		X			Center Freq
-5.00	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~				2.441000000 GHz
-15.0					
-25.0					Start Freq
-35.0					2.439500000 GHz
-45.0					2.435300000 GHZ
-55.0					Stop Freq
-65.0					
-75.0					2.442500000 GHz
-/5.0					
Center 2.441000 GHz				Span 3.000 MHz	CF Step
#Res BW 51 kHz	#\/D\//	150 kHz	Swoon 1	.200 ms (3001 pts)	300.000 kHz
#Res BW JT KHZ	# 4 0 44	IJU KHZ	Sweep 1	.200 ms (300 r pts)	Auto Man
MKR MODE TRC SCL X			CTION FUNCTION WIDTH	FUNCTION VALUE	
1 Δ2 1 f (Δ)	998 kHz (Δ)	-0.04 dB			
2 F 1 f 2.4	41 006 GHz	2.83 dBm			Freq Offset
4					0 Hz
5					
6					
8					
9					
10					
11 1					
MSG				5	





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

🗊 Keysight Spectrum Analyzer - Swept SA					_ 8 ×
	ORREC SE			PM Jun 25, 2020	ak Search
Marker 1 1.000000000 MHz			e: Log-Pwr TF		ak Search
	NO: Wide 💭 Trig: Fre				
IF	Gain:Low Atten: 2	6 dB			
			ΔMkr1 1.	000 MH-	Next Peak
10 dB/div Ref 15.00 dBm				0.01 dB	
Log			1Δ2		
5.00		V	· · · · · · · · · · · · · · · · · · ·		
		<u>∧</u> 2~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		ext Pk Right
-5.00					
-15.0					
- 15.0					
-25.0					
					Next Pk Left
-35.0					TOALL N LON
-45.0					
-55.0					
					a
-65.0				N	/larker Delta
-75.0					
-75.0					
Center 2.441000 GHz				3.000 MHz	
#Res BW 51 kHz	#VBW 150 kHz		Sweep 1.200 ms	(3001 pts)	Mkr→CF
)					
MKR MODE TRC SCL X	Y		NCTION WIDTH FUNC	TION VALUE	
1 Δ2 1 f (Δ) 1.00	0.01 OMHz (Δ)	dB			
2 F 1 f 2.441 00)5 GHz 2.78 d	Bm			
3				I N	/kr→RefLvl
4					
5					
6					
7					
9					More
10					1 of 2
11					
MSG			I STATUS		
			-		

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

Keysight Spectrum Analyzer - Swept SA				_ <u>-</u>
XI RL RF 50 Ω AC	CORREC SENSE	ALIGN OFF	02:14:22 PM Jun 25, 2020 TRACE 1 2 3 4 5 6	Peak Search
Marker 1 998.000000 kHz	PNO: Wide Trig: Free R	un	TYPE MWWWW DET PPPPP	
10 dB/div Ref 15.00 dBm	IFGain.Low Autom 20 an		ΔMkr1 998 kHz 0.00 dB	Next Peak
Log 5.00 -5.00	~~~~X:	······································		Next Pk Right
-25.0				Next Pk Lef
-65.0 -65.0 -75.0				Marker Delta
Center 2.441000 GHz #Res BW 51 kHz	#VBW 150 kHz		Span 3.000 MHz 1.200 ms (3001 pts)	Mkr→Cf
1 Δ2 1 f (Δ) 2 F 1 f 2.44' 3 4 5 6 6	998 kHz (Δ) 0.00 dE 1 007 GHz 2.76 dBm	FUNCTION FUNCTION WIDTH		Mkr→RefLv
7 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9				More 1 of 2
ISG		In STATU		



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

02:20:41 PMJun 25, 2020 TRACE 1 2 3 4 5 6 TYPE MWWWW DET P P P P P P ALIGN OFF Peak Search Marker 1 1.002000000 MHz PNO: Wide Trig: Free Run IFGain:Low Atten: 26 dB Next Peak ΔMkr1 1.002 MHz -0.02 dB Ref 15.00 dBm X2~ Next Pk Right Next Pk Left Marker Delta Center 2.441000 GHz #Res BW 51 kHz Span 3.000 MHz Sweep 1.200 ms (3001 pts) #VBW 150 kHz Mkr→CF 1.002 MHz (Δ) 2.441 004 GHz Δ2 1 f (Δ) F 1 f -0.02 dB 2.78 dBm Mkr→RefLv More 1 of 2 • Þ **I**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 2 400 MHz ~ 2 483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz	Start Frequency = 2 391.5 MHz,	Stop Frequency = 2 441.5 MHz		
	Start Frequency = 2 441.5 MHz,	Stop Frequency = 2 491.5 MHz		
Span for AFH mode = 30 MHz	Start Frequency = 2 426.0 MHz,	Stop Frequency = 2 456.0 MHz		
RBW = To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.				
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



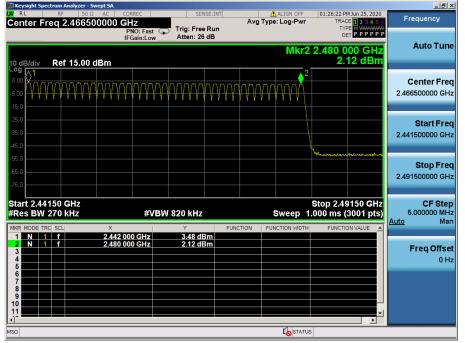
Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & GFSK

LX RL RF 50 9	R AC CORREC	SENSE:INT	ALIGN OFF	01:25:10 PM Jun 25, 2020	
Center Freq 2.4165		SENSE:INT	Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6	Frequency
Center Freq 2.4 105	PNO: Fast	Trig: Free Run	///g //pe. 20g / ///	TYPE M WAAWAAAAA	
	IFGain:Low	Atten: 26 dB		DET PPPPP	
				0 444 000 011-	Auto Tune
			INIKEZ	2.441 000 GHz	
10 dB/div Ref 15.00	dBm			3.48 dBm	
Log	۸1			2	
5.00	Annnaan				Center Freq
-5.00		****	~~~~	♥∀∀∀₩₩₩₩₩₩	2.416500000 GHz
	1 4 4 4 4 4 4 4 4 4	******	* * * * * * * * * * * * *		2.410300000 GHz
-15.0					
-25.0					
					Start Freq
-35.0					2.391500000 GHz
-45.0					
-55.0					Stop Freq
-65.0					
					2.441500000 GHz
-75.0					
Start 2.39150 GHz				Stop 2.44150 GHz	CF Step
#Res BW 270 kHz	#VE	SW 820 kHz	Sweep 1	.000 ms (3001 pts)	5.000000 MHz
MKR MODE TRC SCL	Х	Y EI	JNCTION FUNCTION WIDTH	FUNCTION VALUE	<u>Auto</u> Man
	2.402 000 GHz	2.82 dBm	I ONCTION TONCTION WIDTH		
	2.441 000 GHz	3.48 dBm			
3					Freq Offset
4					0 Hz
6					
7					
8					
9					
10					
				▼	
MSG				5	

Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & GFSK







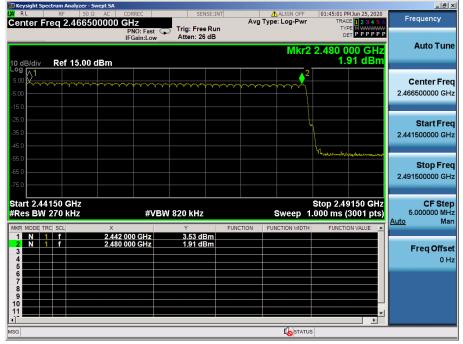
Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & π/4DQPSK

Keysight Spectrum Analyz					
RL RF	50 Ω AC CORREC 6500000 GHz	SENSE:INT	ALIGN OFF	01:43:49 PM Jun 25, 2020 TRACE 1 2 3 4 5 6	Frequency
onton noq 2111	PNO: Fast	Trig: Free Run Atten: 26 dB		DET P P P P P	
	IFGain:Low	Atten. 26 dB			Auto Tune
			MKr2	2.441 000 GHz 3.12 dBm	
0 dB/div Ref 15.	00 dBm			5.12 UBIII	
5.00	1		~~~~~~		Center Fred
5.00				+++++++++++++++++++++++++++++++++++++++	2.416500000 GHz
15.0					
25.0					
	1				Start Freq
35.0					2.391500000 GH;
45.0	/ ⁴				
55.0					Stop Fred
65.0					2.441500000 GHz
75.0					2.441000000 011
Start 2.39150 GHz Res BW 270 kHz		3W 820 kHz	Sweep 1	Stop 2.44150 GHz .000 ms (3001 pts)	CF Step 5.000000 MHz
					Auto Man
MKR MODE TRC SCL	× 2.402 000 GHz	Y FU 2.60 dBm	INCTION FUNCTION WIDTH	FUNCTION VALUE	
2 N 1 f	2.402 000 GHz 2.441 000 GHz	3.12 dBm			Erog Offoot
3					Freq Offset
5					0112
6					
8					
9					
11					
SG				S	

Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & π/4DQPSK







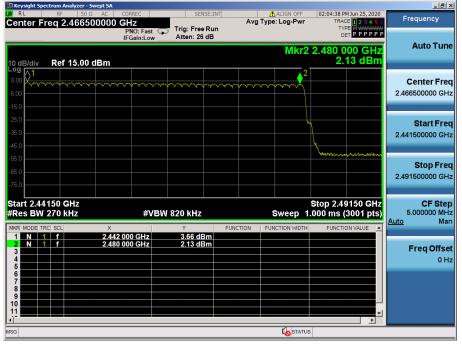
Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & 8DPSK

	sight Spect	ruill A	alyzer - 3	wept SA									_ <u> </u>
Cen		RF	50 Ω 4165	2 AC	CORREC			NSE:INT	Avg	ALIGN OFF	TRA	MJun 25, 2020 CE 1 2 3 4 5 6	Frequency
10 dE			15.00		PNO: Fa IFGain:L		Trig: Free Atten: 26			Mkr2	2.441 (000 GHz	Auto Tune
5.00 -5.00 -15.0		Kei	15.00		~~~~	ᡊ᠆ᠰ᠆	YYYYYY	~~~~	~~~~	*~~		*****	Center Freq 2.416500000 GHz
-15.0 -25.0 -35.0 -45.0			Å										Start Freq 2.391500000 GHz
-55.0 -65.0 -75.0	e, ingentration	No.4814.9~**	ye.A ^{yerre}										Stop Freq 2.441500000 GHz
#Re	t 2.391 s BW 2	70 k		X	#	VBW	/ 820 kHz		JNCTION	Sweep '	1.000 ms (4150 GHz (3001 pts)	CF Step 5.000000 MHz <u>Auto</u> Man
1 2 3 4 5 6 7 8	N 1 N 1	f			000 GH		2.76 d 3.43 d	Bm Bm					Freq Offset 0 Hz
9 10 11 •										Lo statu	IS		

Number of Hopping Frequencies 2(FH)

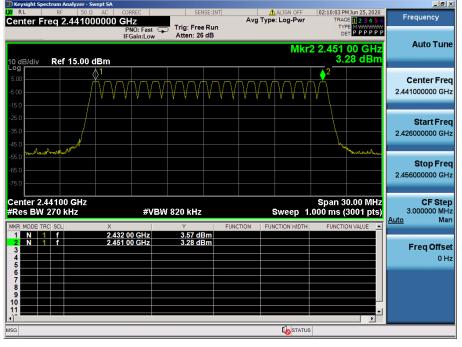
Hopping mode : Enable & 8DPSK





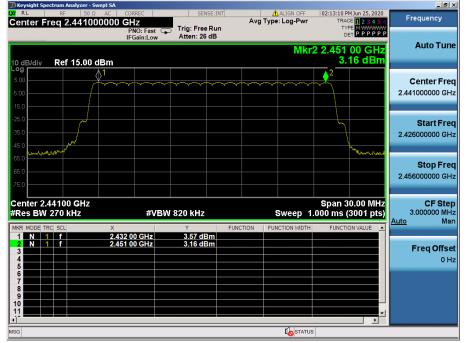
Number of Hopping Frequencies 1(AFH)

Hopping mode : Enable & GFSK



Number of Hopping Frequencies 1(AFH) Hopping

Hopping mode : Enable & π/4DQPSK





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

	m Analyzer - Swept S								_ 6 >
	RF 50 Ω AC		SI	INSE:INT		ALIGN OFF		MJun 25, 2020	Frequency
Center Fred	2.4410000	00 GHZ PNO: Fast	Trig: Fr	e Run	Avg Type	: Log-Pwr		CE 123456 PE MWWWW	
		IFGain:Lov	· · · · ·				D	ETPPPPP	
						Mkr	2 2 451	00 GHz	Auto Tun
						WINI		27 dBm	
10 dB/div R Log	ef 15.00 dBn	n							
5.00	↓						<u> </u>		Center Fre
-5.00		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		h		2.441000000 GH
-5.00									2.441000000 GH
15.0								<u> </u>	
-25.0	~~~~						-		Start Fre
-35.0							\\		
	N								2.426000000 GH
-45.0	n st							Marson	
-55.0									Stop Ero
-65.0									Stop Fre
-75.0									2.456000000 GH
13.0									
Center 2.441	00 GHz						Span 3	0.00 MHz	CF Ster
#Res BW 27		#V	BW 820 kH	z	ş	Sweep 1	.000 ms (3001 pts)	3.000000 MH
MKR MODE TRC S		x	Y	FUNCT		CTION WIDTH		ON VALUE	Auto Ma
1 N 1		^ 2.432 00 GHz	3.57 c			ICTION WIDTH	FUNCTI	ON VALUE	
2 N 1		2.451 00 GHz	3.27 c	IBm					Freq Offse
3 4	_								
5									ОН
6									
7 8									
9									
10									
								<u> </u>	
11 11 15g						I STATUS	Ú.		



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 = 2 441 MHz

Span = zero

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

VBW ≥ RBW

Trace = max hold

6.4 Test Results

FH mode

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

AFH mode

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

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

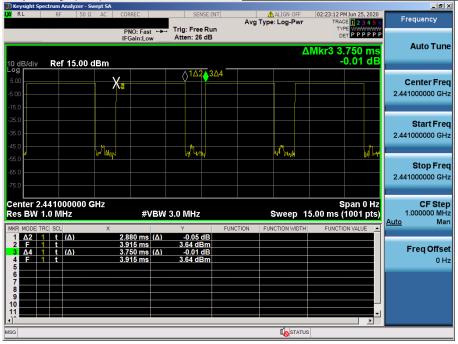
((Hopping rate ÷ Time slots) ÷ Hopping channel)

- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1 600 for FH mode & 800 for AFH mode

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

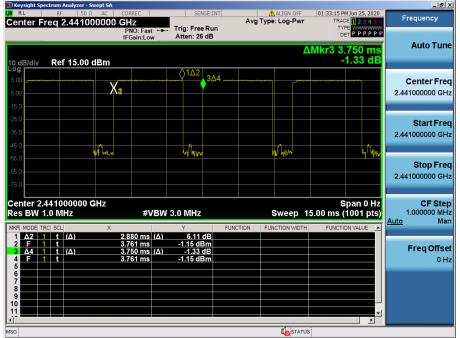


Time of Occupancy (FH)



Time of Occupancy (FH)

Hopping mode : Enable & 2-DH5



Hopping mode : Enable & DH5



Time of Occupancy (FH)

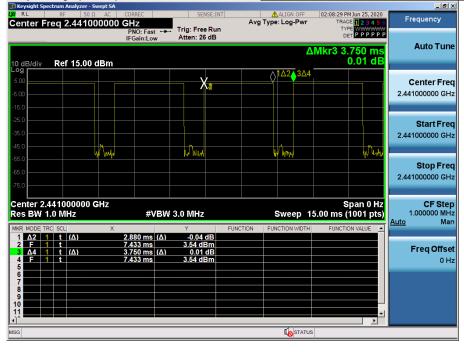
Hopping mode : Enable & 3-DH5

RL RL	ctrum Analyzer - Swept SA RF 50 Ω AC	CORREC	SENSE:IN	T ALIGN OFF	01:54:17 PM Jun 25, 2020	
enter Fr	eq 2.44100000	PNO: Fast 🕶	Trig: Free Run Atten: 26 dB	Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6 TYPE WWWWWW DET P P P P P P	Frequency
0 dB/div	Ref 15.00 dBm	IFGain:Low	Atten: 26 dB		∆Mkr3 3.750 ms -1.32 dB	Auto Tu
og 5.00	angryn fragryn drae y gernyn	dalig ya nafalisi ya min siyonan daliyona d	X2	 3Δ4	70 ye e di hanya di hanya di da	Center Fr 2.441000000 G
25.0						Start Fr
15.0 15.0			with the second		UK Alam	2.441000000 G
5.0 5.0	the Mitch			da Alifain	UR NAV	Stop Fr 2.441000000 G
	41000000 GHz				Span 0 Hz	CF St
es BW 1.			V 3.0 MHz Y 6.73 dB	Sweep 1 FUNCTION FUNCTION WIDTH	15.00 ms (1001 pts)	1.000000 M <u>Auto</u> M
2 F 1 3 Δ4 1 4 F 1	t	6.878 ms 3.750 ms (Δ) 6.878 ms	-1.17 dBm -1.32 dB -1.17 dBm			Freq Offs 0
6 7 8 9						
G				STATU	IS	



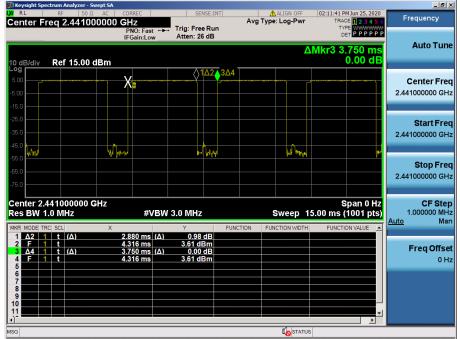
Time of Occupancy (AFH)

Hopping mode : Enable & DH5



Time of Occupancy (AFH)

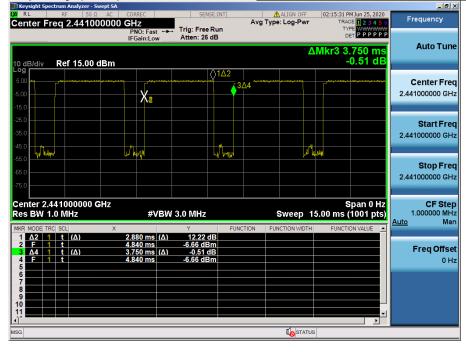
Hopping mode : Enable & 2-DH5





Time of Occupancy (AFH)

Hopping mode : Enable & 3-DH5





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	2 400/F (kHz)	300
0.490 ~ 1705	24 000/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 MHz - 72 MHz, 76 MHz - 88 MHz, 174 MHz - 216 MHz or 470 MHz - 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

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

MHz	MHz	MHz	GHz
0.009 ~ 0.110	16.42 ~ 16.423	399.90 ~ 410	4.5 ~ 5.15
0.495 ~ 0.505	16.69475 ~ 16.69525	608 ~ 614	5.35 ~ 5.46
2.1735 ~ 2.1905	16.80425 ~ 16.80475	960 ~ 1240	7.25 ~ 7.75
4.125 ~ 4.128	25.5 ~ 25.67	130 0 ~ 1427	8.025 ~ 8.5
4.17725 ~ 4.17775	37.5 ~ 38.25	1435 ~ 1626.5	9.0 ~ 9.2
4.20725 ~ 4.20775	73 ~ 74.6	1645.5 ~ 1646.5	9.3 ~ 9.5
6.215 ~ 6.218	74.8 ~ 75.2	166 0 ~ 171 0	10.6 ~ 12.7
6.26775 ~ 6.26825	108 ~ 121.94	1718.8 ~ 172 2.2	13.25 ~ 13.4
6.31175 ~ 6.31225	123 ~ 138	220 0 ~ 2300	14.47 ~ 14.5
8.291 ~ 8.294	149.9 ~ 150.05	231 0 ~ 2390	15.35 ~ 16.2
8.362 ~ 8.366	156.52475 ~ 156.52525	2483.5 ~ 2500	17.7 ~ 21.4
8.37625 ~ 8.38675	156.7 ~ 156.9	2690 ~ 2900	22.01 ~ 23.12
8.41425 ~ 8.41475	162.0125 ~ 167.17	3260 ~ 3267	23.6 ~ 24.0
12.29 ~ 12.293	167.72 ~ 173.2	3332 ~ 3339	31.2 ~ 31.8
12.51975 ~ 12.52025	240 ~ 285	3345.8 ~ 3358	36.43 ~ 36.5
12.57675 ~ 12.57725	322 ~ 335.4	3600 ~ 4400	Above 38.6
13.36 ~ 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.



7.3. Test Procedures

7.3.1. Test Procedures for Radiated Spurious Emissions

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

Measurement Instrument Setting

- Frequencies less than or equal to 1 000 MHz The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) at frequency below 1 GHz.
- Frequencies above 1 000 MHz
 The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
 The result of Average measurement is calculated using PK result and duty correction factor.