TEST REPORT

KOSTEC Co., Ltd. 28(175-20, Annyeong-dong) 406-gil sejaro, Hwaseong-si, Gyeonggi-do, Korea Tel:031-222-4251, Fax:031-222-4252	Report No.: KST-FCR-170009	KOSTEC Co., Ltd. http://www.kostec.org

1. Applicant

- Name : HUMAN-LINE
- Address : 5F, sung-eun B/D,396-4, Gyeongsu-daero, Gwonseon-gu, Suwon-si, Gyeonggi-do, Korea(16571)

2. Test Item

- Product Name: MentalDoctor Smart S2
- Model Name: MB-200
- Brand: MentalDoctor
- FCC ID: 2AOBD-MB-200

3. Manufacturer

- Name : HUMAN-LINE
- Address : 5F, sung-eun B/D,396-4, Gyeongsu-daero, Gwonseon-gu, Suwon-si, Gyeonggi-do, Korea(16571)

4. Date of Test : 2017. 10. 23. ~ 2017. 10. 25.

5. Test Method Used : FCC CFR 47, Part 15. Subpart C-15.247
DA 00-705

6. Test Result : Compliance

7. Note: None

Supplementary Information

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI C 63.10-2013.

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

Affirmation	Tested by Name : Lee, Mi-Young (Signature)	Technical Manager Name : Park, Gyeong-Hyeon (Signature)

2017. 11. 13.

KOSTEC Co., Ltd.

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1. GENERAL INFORMATION

1.1 Test Facility

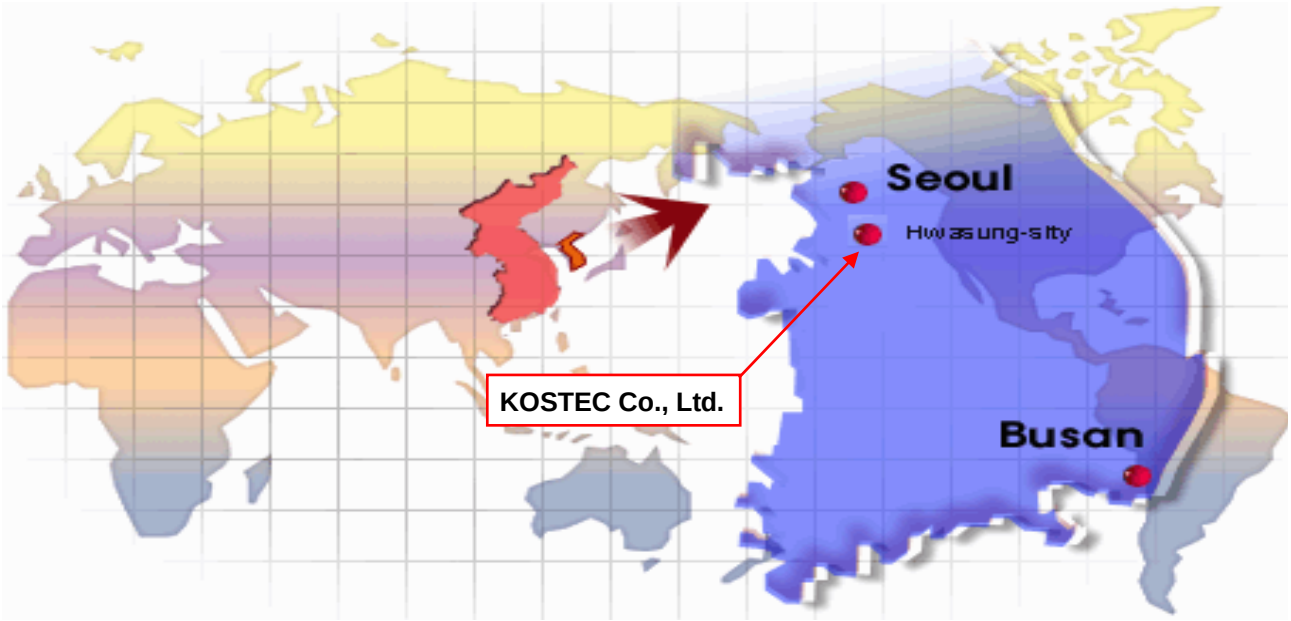
Test laboratory and address

KOSTEC Co., Ltd.
128(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea

Registration information

KOLAS No. : 232
FCC Designation No. : KR0041
IC Registration Site No. : 8305A-1

1.2 Location



1.3 Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
-	Initial issue	All	Gyeong Hyeon, Park	2017. 11. 13.

2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

Equipment Name	MentalDoctor Smart S2
Model No	MB-200
Usage	Eye movements with Bluetooth.
Serial Number	Proto type
Modulation type	FHSS (GFSK, π/4 DQPSK, 8DPSK)
Emission Type	F1D/G1D
Maximum output power	5.98 dBm
Operated Frequency	2 402 MHz ~ 2 480 MHz
Channel Number	79
Operation temperature	0 °C ~ 40 °C
Power Source	DC 3.7 V battery
Antenna Description	PCB antenna embed in PCB of EUT, max gain :1.139 dBi
Remark	1. The device was operating at its maximum output power for all measurements. 2. The radiation measurements are performed in X, Y, Z axis positioning. Only the worst case (X) is shown in the report. 3. The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.
FCC ID	2AOBD-MB-200

3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

Eye movements with Bluetooth.

3.2 Used peripherals list

Description	Model No.	Serial No.	Manufacture	Remark
Notebook	BCM-1063	2Z7S1Z1	Dell Inc	
Adapter	DA65NM111-00	None	Dell Inc	For notebook

3.3 Product Modification

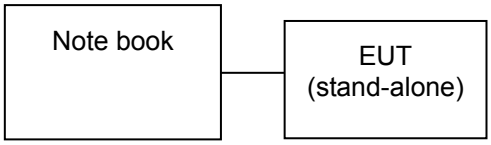
N/A

3.4 Operating Mode

Constantly transmitting with a modulated carrier at maximum power on the low, middle and high channels.

3.5 Test Setup of EUT

The measurements were taken in continuous transmit mode using the test mode which controlled by BlueSuite. The test program and the test Jig and cables were provided by the applicant.



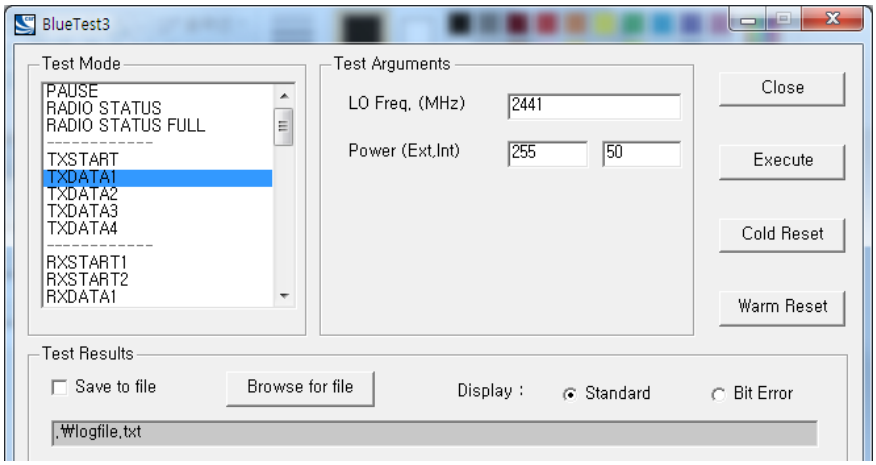
3.6 Parameters of Test Software Setting

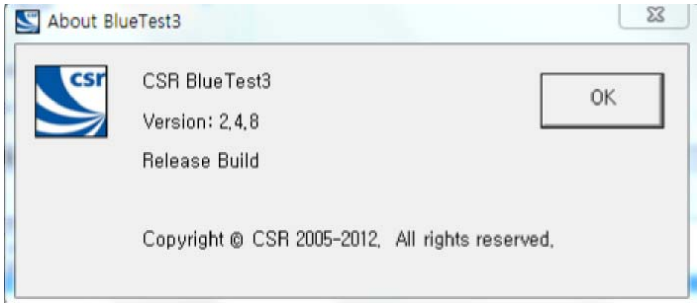
During testing, Channel & Power Controlling Software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product.

▣ TX Power setting value during test

Band	TX Power setting value		
	Low CH	Middle CH	High CH
2.4 GHz band	255/50	255/50	255/50

▣ Test Program





3.7 Table for Test condition

Test Items	Channel No	Frequency (㎒)	Operated Condition
Channel Separation	39, 40	2 441, 2 442	Hopping on and continuous modulation setting mode
Number of Hopping Channels	0 ~ 78	2 402 ~ 2 480	Hopping on mode
Time of occupancy	39	2 441	Hopping on mode
Peak Output Power	0	2 402	Hopping off and continuous modulation setting mode
	39	2 441	
	78	2 480	
Band-edge Compliance	0	2 402	Hopping off and continuous modulation setting mode
	78	2 480	
Spurious RF conducted emissions	-	-	Frequency band setting by required standard (FCC Rules)*
Spurious radiated emissions	-	-	

*Note: Channel number is selected lowest, middle, highest channel and also hopping on/off mode operation

3.8 Used Test Equipment List

No.	Instrument	Model	S/N	Manufacturer	Due to cal date	Cal interval	used
1	T & H Chamber	EY-101	90E14260	TABAI ESPEC	2018.09.06	1 year	☐
2	T & H Chamber	RCT-V-THC-403-1(H)	20030210	R.C.T	2018.09.06	1 year	☐
3	Spectrum Analyzer	8563E	3846A10662	Agilent Technology	2018.02.02	1 year	☐
4	Spectrum Analyzer	8593E	3710A02859	Agilent Technology	2018.02.02	1 year	☐
5	Spectrum Analyzer	FSV30	20-353063	Rohde& Schwarz	2018.02.01	1 year	☒
6	Signal Analyzer	N9010A	MY56070441	Agilent Technologies	2018.05.15	1 year	☐
7	EMI Test Receiver	ESCI7	100823	Rohde& Schwarz	2018.01.31	1 year	☒
8	EMI Test Receiver	ESI	837514/004	Rohde& Schwarz	2018.09.05	1 year	☒
9	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2018.02.03	1 year	☐
10	Network Analyzer	8753ES	US39172348	AGILENT	2018.09.04	1 year	☐
11	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2018.02.01	1 year	☐
12	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2018.02.01	1 year	☐
13	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2018.02.01	1 year	☐
14	Modulation Analyzer	8901A	3538A07071	Agilent Technology	2018.02.02	1 year	☐
15	Audio Analyzer	8903B	3514A16919	Agilent Technology	2018.01.31	1 year	☐
16	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2018.02.02	1 year	☐
17	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2018.09.04	1 year	☐
18	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2018.02.02	1 year	☐
19	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2018.02.02	1 year	☐
20	Signal Generator	SMB100A	179628	Rohde & Schwarz	2018.05.18	1 year	☒
21	Tracking Source	85645A	070521-A1	Agilent Technology	2018.02.03	1 year	☐
22	SLIDAC	None	0207-4	Myoung sung Ele.	2018.01.31	1 year	☐
23	DC Power supply	DRP-5030	9028029	Digital Electronic Co.,Ltd	2018.02.01	1 year	☐
24	DC Power supply	6038A	3440A12674	Agilent Technology	2018.01.31	1 year	☐
25	DC Power supply	E3610A	KR24104505	Agilent Technology	2018.01.31	1 year	☐
26	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2018.01.31	1 year	☐
27	DC Power Supply	SM 3004-D	114701000117	DELTA ELEKTRONIKA	2018.01.31	1 year	☐
28	Dummy Load	8173	3780	Bird Electronic Co., Corp	2018.02.03	1 year	☐
29	Attenuator	50FH-030-500	140410 9433	JEW Idustries Inc.	2018.02.02	1 year	☐
30	Attenuator	24-30-34	BX5630	Aeroflex / Weinschel	2017.12.27	1 year	☐
31	Attenuator	8498A	3318A09485	HP	2018.02.01	1 year	☐
32	Step Attenuator	8494B	3308A32809	HP	2018.02.02	1 year	☐
33	Attenuator	18B50W-20F	64671	INMET	2018.02.02	1 year	☒
34	Attenuator	10 dB	1	Rohde & Schwarz	2018.05.18	1 year	☐
35	Attenuator	10 dB	2	Rohde & Schwarz	2018.05.18	1 year	☐
36	Attenuator	10 dB	3	Rohde & Schwarz	2018.05.18	1 year	☐
37	Attenuator	10 dB	4	Rohde & Schwarz	2018.05.18	1 year	☐
38	Attenuator	54A-10	74564	WEINSCHEL	2018.05.18	1 year	☐
39	Attenuator	56-10	66920	WEINSCHEL	2018.05.18	1 year	☐
40	Power divider	11636B	51212	HP	2018.02.01	1 year	☐
41	3Way Power divider	KPDSU3W	00070365	KMW	2018.09.04	1 year	☐
42	4Way Power divider	70052651	173834	KRYTAR	2018.02.01	1 year	☐
43	3Way Power divider	1580	SQ361	WEINSCHEL	2018.05.18	1 year	☐
44	OSP	OSP120	101577	Rohde & Schwarz	2018.05.19	1 year	☐
45	White noise audio filter	ST31EQ	101902	SoundTech	2018.09.04	1 year	☐
46	Dual directional coupler	778D	17693	HEWLETT PACKARD	2018.02.02	1 year	☐
47	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2018.02.02	1 year	☐
48	Band rejection filter	3TNF-0006	26	DOVER Tech	2018.02.03	1 year	☐
49	Band rejection filter	3TNF-0008	317	DOVER Tech	2018.02.03	1 year	☐
50	Band rejection filter	3TNF-0007	311	DOVER Tech	2018.02.03	1 year	☐

No.	Instrument	Model	S/N	Manufacturer	Due to cal date	Cal interval	used
51	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2018.02.02	1 year	☒
52	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2018.05.18	1 year	☐
53	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2018.05.18	1 year	☐
54	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2018.05.18	1 year	☐
55	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2018.02.02	1 year	☐
56	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2018.02.02	1 year	☐
57	Highpass Filter	WHNX6-5530-3000-26500-40CC	2	Wainwright Instruments GmbH	2018.05.19	1 year	☐
58	Highpass Filter	WHNX6-2370-7000-26500-40CC	4	Wainwright Instruments GmbH	2018.05.19	1 year	☐
59	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2018.02.03	1 year	☐
60	Radio Communication Tester	CMU 200	112026	Rohde & Schwarz	2018.02.03	1 year	☐
61	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2018.02.03	1 year	☐
62	Loop Antenna	6502	9203-0493	EMCO	2019.05.29	2 year	☒
63	BiconiLog Antenna	3142B	9910-1432	EMCO	2018.04.25	2 year	☒
64	Trilog-Broadband Antenna	VULB 9168	9168-606	SCHWARZBECK	2018.09.09	2 year	☐
65	Horn Antenna	3115	2996	EMCO	2018.02.11	2 year	☒
66	Horn Antenna	BBHA9170	BBHA9170152	SCHWARZBECK	2019.04.25	2 year	☒
67	Antenna Master(3)	AT13	None	AUDIX	N/A	N/A	☒
68	Turn Table(3)	None	None	AUDIX	N/A	N/A	☒
69	PREAMPLIFIER(3)	8449B	3008A02577	Agilent	2018.02.01	1 year	☒
70	Antenna Master(10)	MA4000-EP	None	inno systems GmbH	N/A	N/A	☒
71	Turn Table(10)	None	None	inno systems GmbH	N/A	N/A	☒
72	AMPLIFIER(10)	TK-PA6S	120009	TESTEK	2018.01.31	1 year	☒
73	AMPLIFIER	8447D	2944A07881	H.P	2018.01.31	1 year	☐
74	Antenna Mast	MA2000-EP	None	inno systems GmbH	N/A	N/A	☐
75	Turn Device	DE3700-RH	None	inno systems GmbH	N/A	N/A	☐

4. SUMMARY TEST RESULTS

Description of Test	FCC Rule	Reference Clause	Used	Test Result
Peak Output Power	§ 15.247(b)(1)	Clause 5.1	☒	Compliance
20 dB Bandwidth	§ 15.247(a)(1)	Clause 5.2	☒	Compliance
Channel Separation	§ 15.247(a)(1)	Clause 5.3	☒	Compliance
Number of Hopping Channels	§ 15.247(a)(1)	Clause 5.4	☒	Compliance
Time of Occupancy	§ 15.247(a)(1)	Clause 5.5	☒	Compliance
Conducted Spurious Emissions	§ 15.247(d)	Clause 5.6	☒	Compliance
Radiated Spurious Emissions	§ 15.247(d), § 15.209, and § 15.205	Clause 5.7	☒	Compliance
Antenna Requirement	§ 15.203	Clause 5.8	☒	Compliance
AC Power Conducted emissions	§ 15.207	Clause 5.9	☐	N/A
Compliance: The EUT complies with the essential requirements in the standard. Not Compliance : The EUT does not comply with the essential requirements in the standard. N/A : The test was not applicable in the standard. ; This test item is not applicable as the product solely employs battery power for operation. The product does not transmit during charging mode.				

Procedure Reference

FCC CFR 47, Part 15. Subpart C-15.247

DA 00-705

ANSI C 63.10-2013

5. MEASUREMENT RESULTS

5.1 Peak Output Power

5.1.1 Standard Applicable [FCC §15.247(b)(1)]

For frequency hopping systems operating in the 2 400 ~ 2 483.5 ㎒ band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 ~ 5 850 MHz band : 1 Watt. For all other frequency hopping systems in the 2400 ~ 2483.5 MHz band: 0.125 watts.

5.1.2 Test Environment conditions

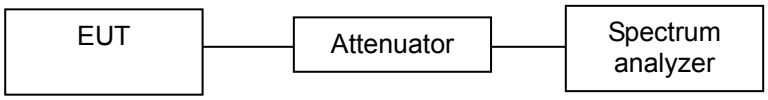
• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.1.3 Measurement Procedure

ANSI C63.10: 2013 and FCC Public Notice DA 00-705 Released March 30, 2000: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems. The peak output power was measured using the marker to peak function of the spectrum analyzer.

The spectrum analyzer is set to the as follows :
• Span : approximately 5 times the 20 dB bandwidth
• RBW : > 20 dB bandwidth of the emission being measured
• VBW ≥ RBW.
• Sweep time = auto
• Detector = peak.
• Trace mode = max hold.
• Allow trace to fully stabilize.
• Use the peak marker function to determine the maximum amplitude level.

5.1.4 Test setup



5.1.5 Measurement Result

▣ BDR(GFSK)

Channel	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Test Results
0	2 402	5.11	30	Compliance
39	2 441	5.42	30	Compliance
78	2 480	5.98	30	Compliance

▣ EDR(π/4DQPSK)

Channel	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Test Results
0	2 402	3.52	30	Compliance
39	2 441	4.17	30	Compliance
78	2 480	5.00	30	Compliance

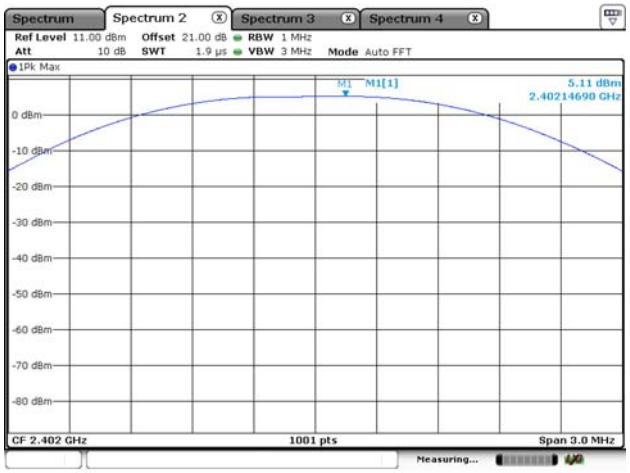
▣ EDR(8DPSK)

Channel	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Test Results
0	2 402	3.82	30	Compliance
39	2 441	4.36	30	Compliance
78	2 480	5.14	30	Compliance

5.1.6 Test Plot

▣ BDR(GFSK)

CH Low



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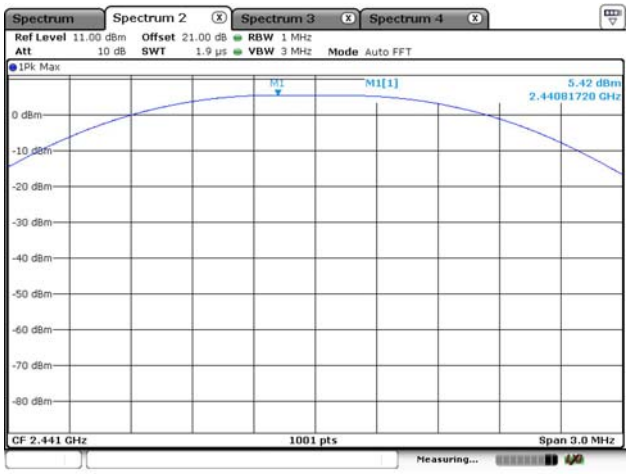

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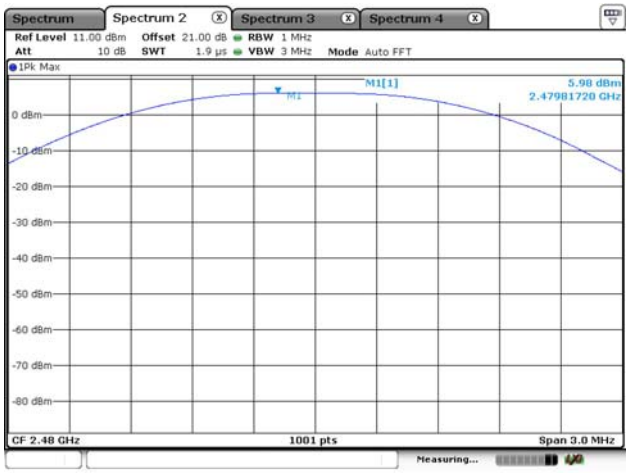
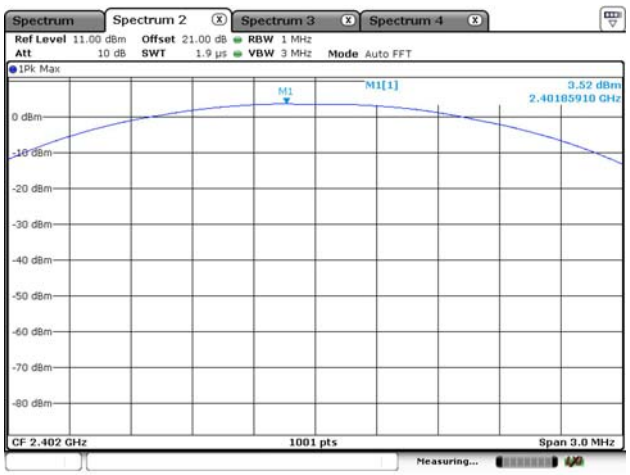


▣ EDR(π/4DQPSK)

CH Low



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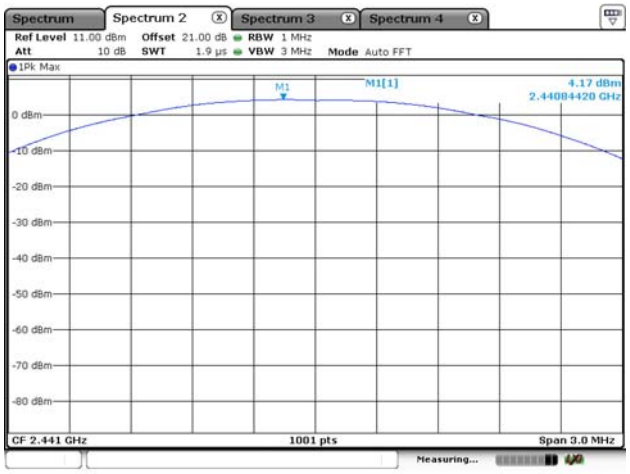

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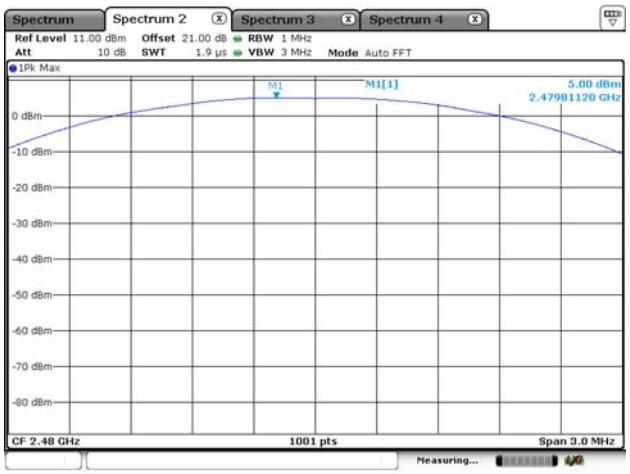
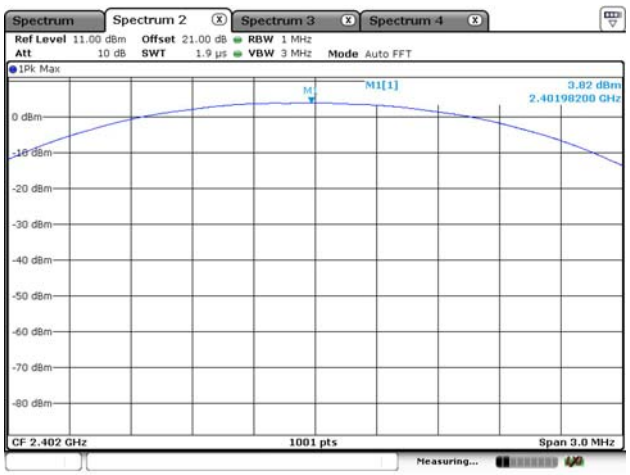


▣ EDR(8DPSK)

CH Low



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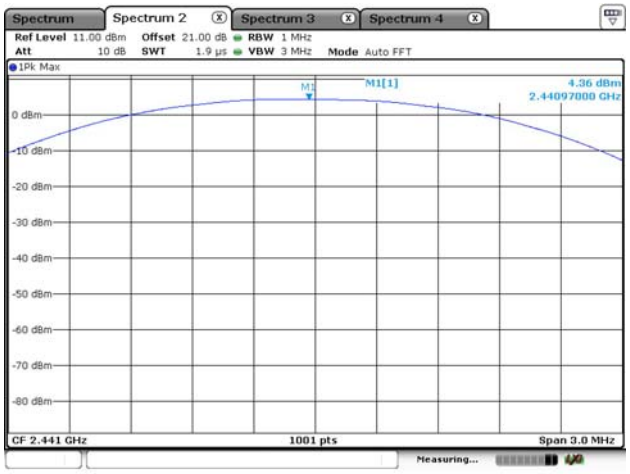

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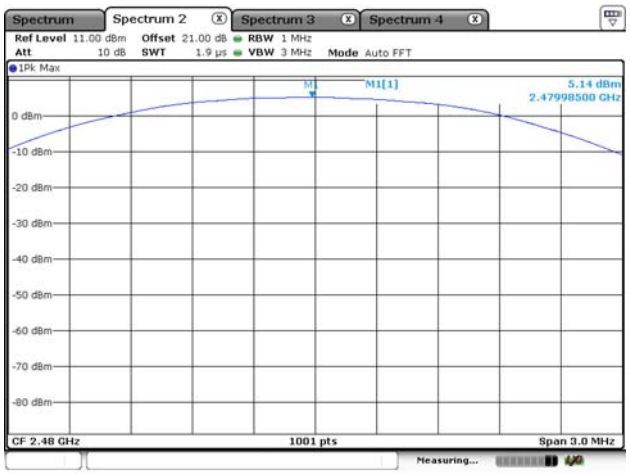


5.2 20 dB Bandwidth

5.2.1 Standard Applicable [FCC §15.247(a)(1)]

Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

5.2.2 Test Environment conditions

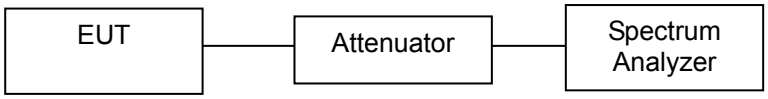
• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.2.3 Measurement Procedure

ANSI C63.10: 2013 and FCC Public Notice DA 00-705 Released March 30, 2000: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW ≥ 1 % of the 20 dB bandwidth and VBW ≥ RBW.
3. Measured the spectrum width with power higher than 20 dB below carrier.

5.2.4 Test setup



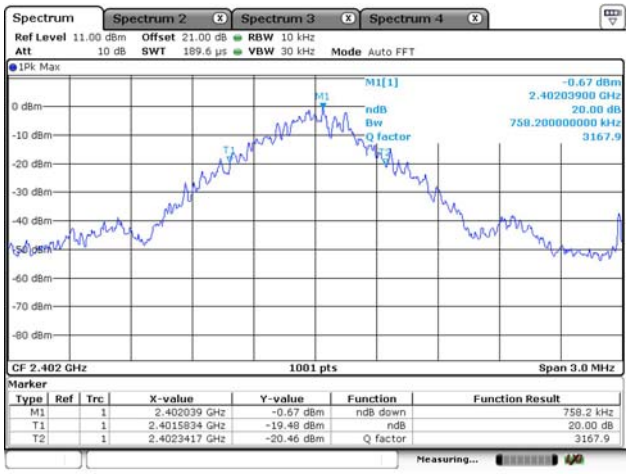
5.2.5 Measurement Result

Modulation Type	Channel	Frequency [MHz]	20 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Limit [MHz]	Test Results
BDR(GFSK)	0	2 402	0.758	0.869	-	Compliance
	39	2 441	0.758	0.866	-	Compliance
	78	2 480	0.761	0.863	-	Compliance
EDR(π/4DQPSK)	0	2 402	1.193	1.166	-	Compliance
	39	2 441	1.208	1.169	-	Compliance
	78	2 480	1.211	1.181	-	Compliance
EDR(8DPSK)	0	2 402	1.265	1.178	-	Compliance
	39	2 441	1.247	1.181	-	Compliance
	78	2 480	1.268	1.193	-	Compliance

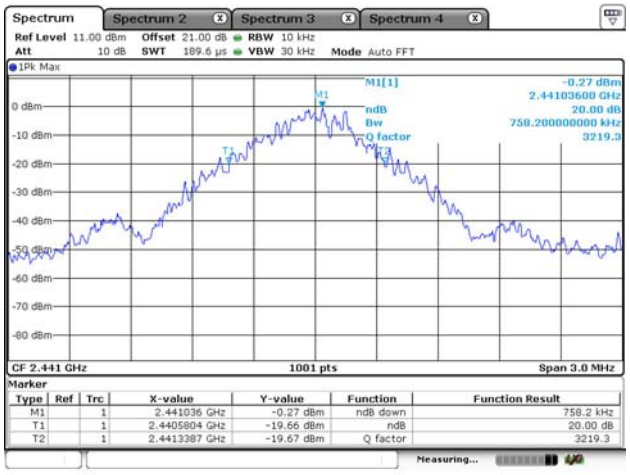
5.2.6 Test Plot (20 dB bandwidth)

▣ BDR(GFSK)

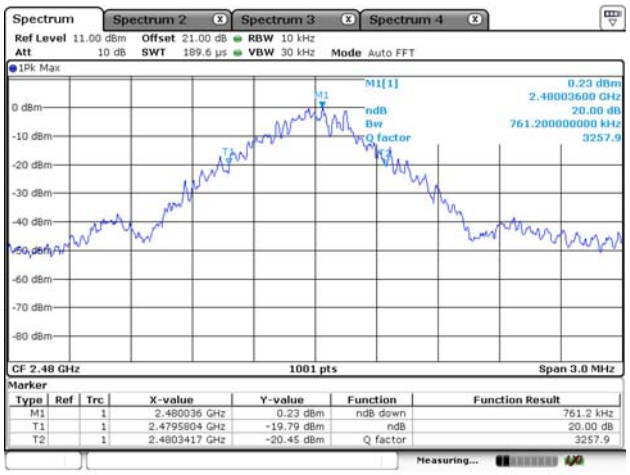
CH Low



CH Middle

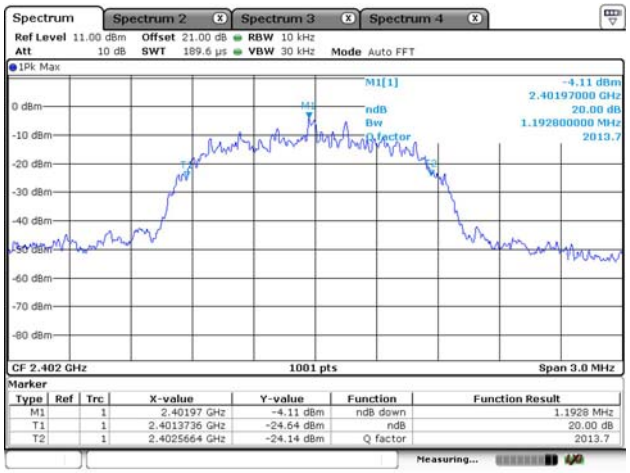


CH High

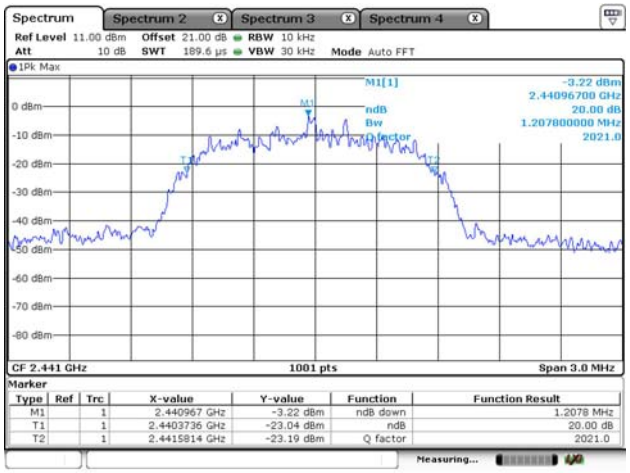


▣ EDR(π/4DQPSK)

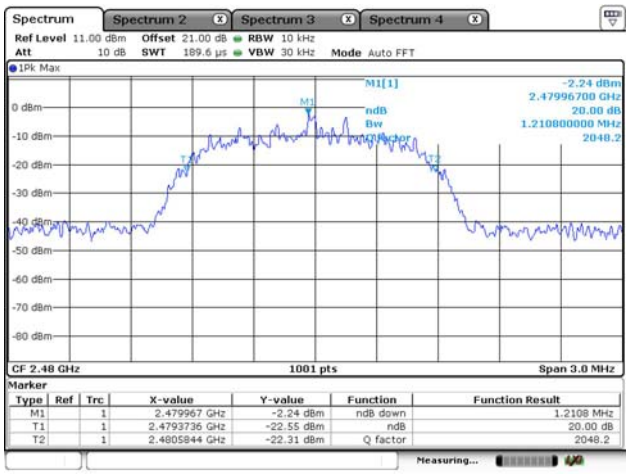
CH Low



CH Middle

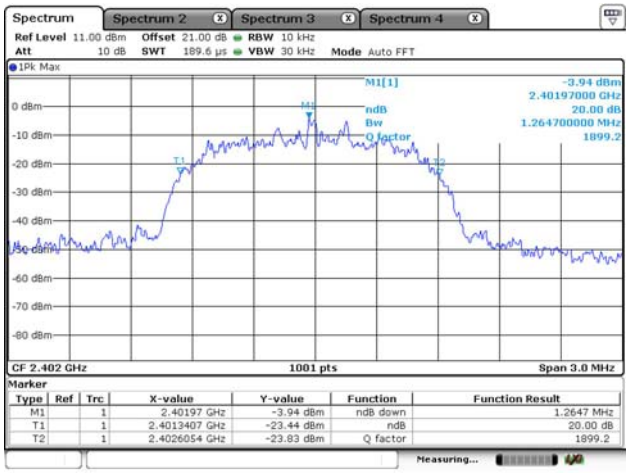


CH High

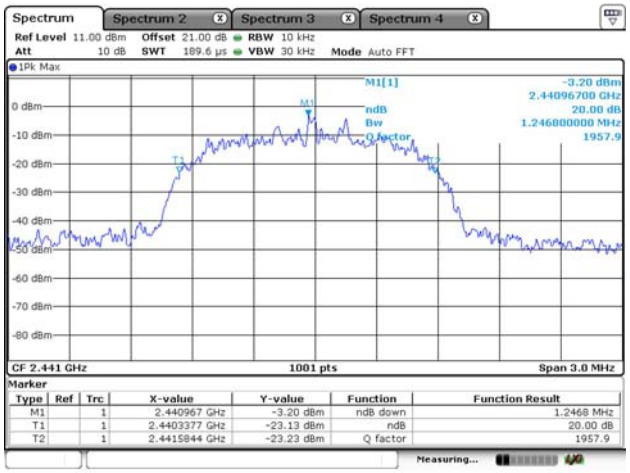


▣ EDR(8DPSK)

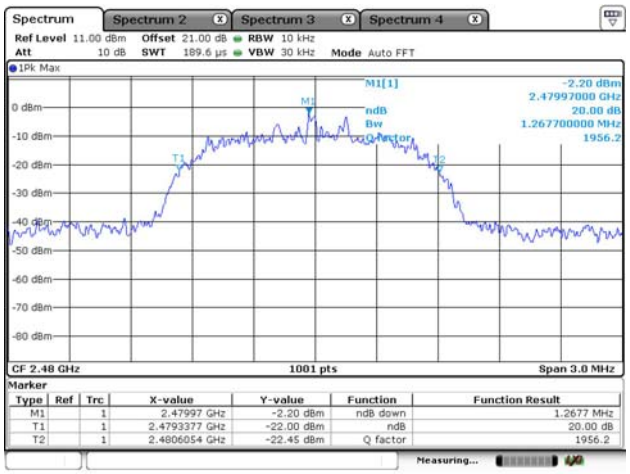
CH Low



CH Middle



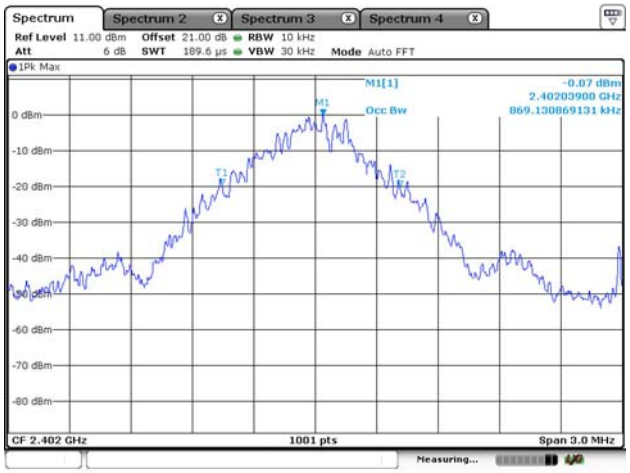
CH High



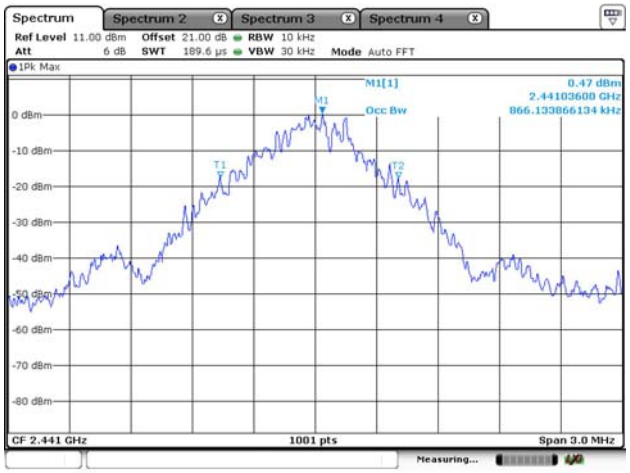
Test Plot (99 % bandwidth)

▣ BDR(GFSK)

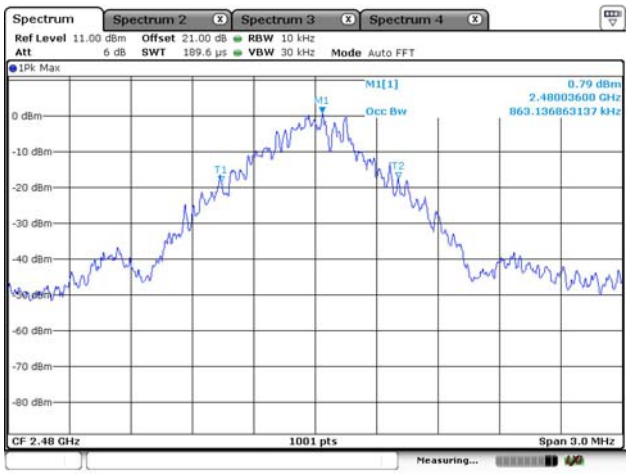
CH Low



CH Middle

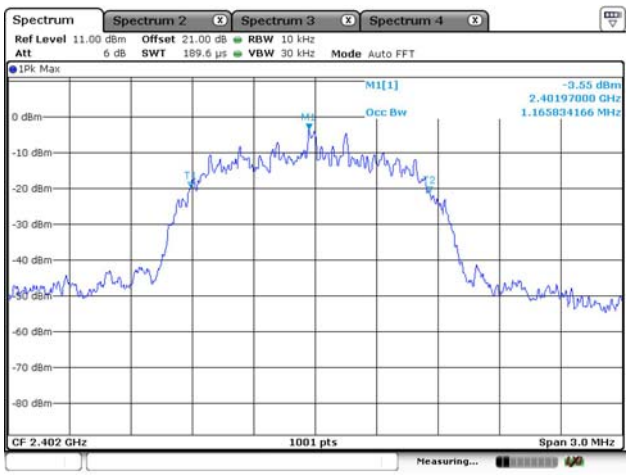


CH High

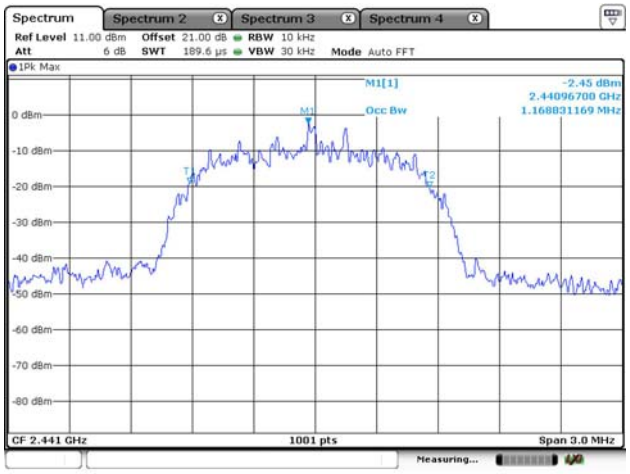


▣ EDR(π/4DQPSK)

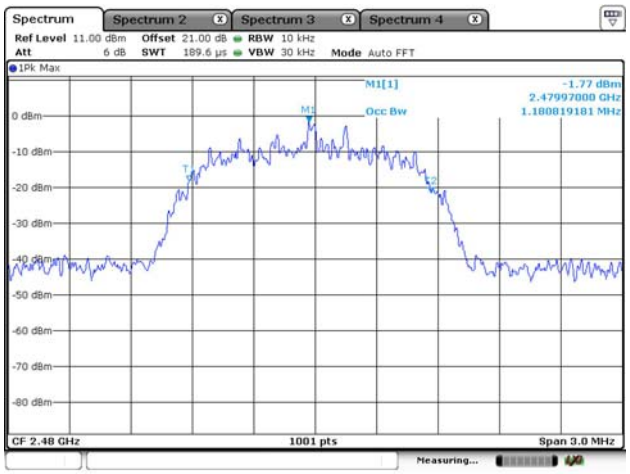
CH Low



CH Middle

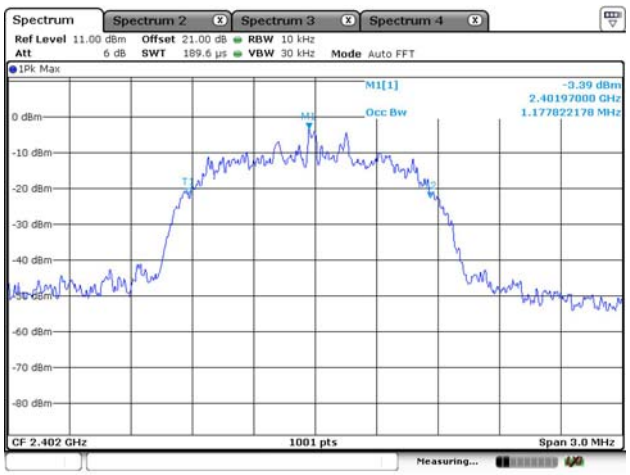


CH High

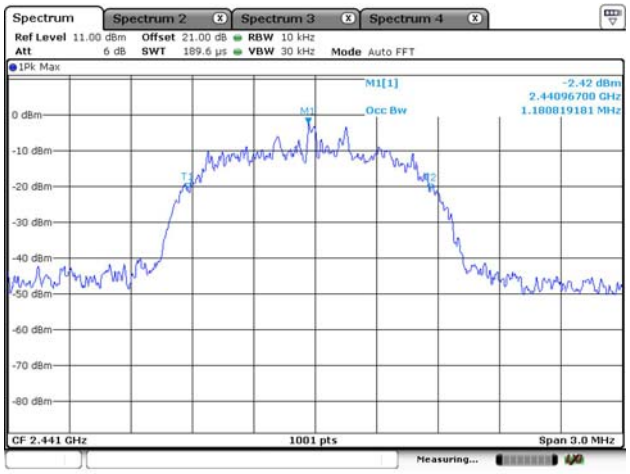


▣ EDR(8DPSK)

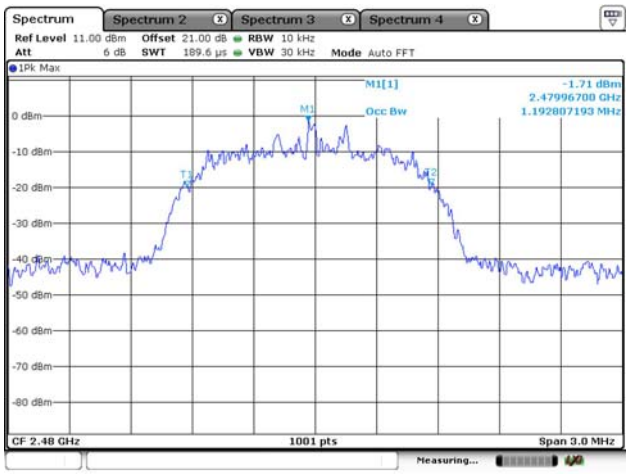
CH Low



CH Middle



CH High



5.3 Channel Separation

5.3.1 Standard Applicable [FCC §15.247(a)(1)]

Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

5.3.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.3.3 Measurement Procedure

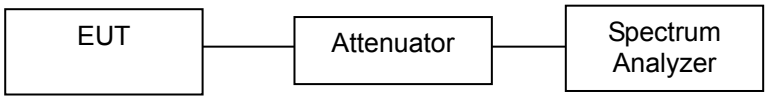
ANSI C63.10: 2013 and FCC Public Notice DA 00-705 Released March 30, 2000: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The resolution bandwidth of 30 kHz and the video bandwidth of 100 kHz were used.
3. After the trace being stable, the reading value between the peak of the adjacent channels using the marker- Delta function was recorded as the measurement results.

The spectrum analyzer is set to the as follows :

• Span : wide enough to capture the peak of two adjacent channels
• RBW : ≥ 1% of the span
• VBW : ≥ RBW
• Sweep : auto
• Detector function : peak
• Trace : max hold

5.3.4 Test setup



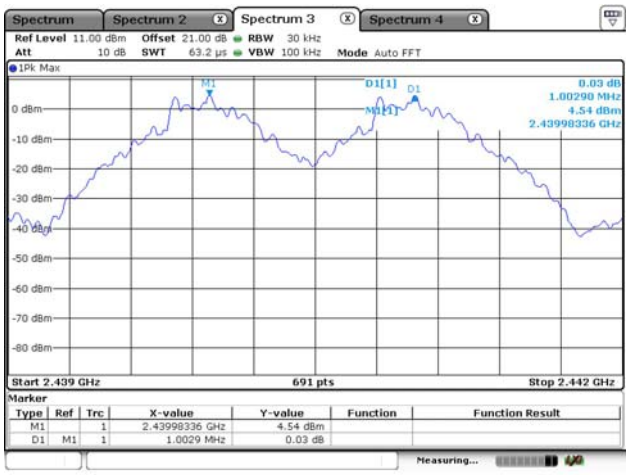
5.3.5 Measurement Result

Modulation Type	Channel	Frequency[MHz]	Channel Separation(MHz)	Limit(MHz)	Test Results
BDR(GFSK)	39	2441	1.00	≥0.51	Compliance
EDR(π/4DQPSK)	39	2441	1.00	≥0.81	Compliance
EDR(8DPSK)	39	2441	1.00	≥0.83	Compliance

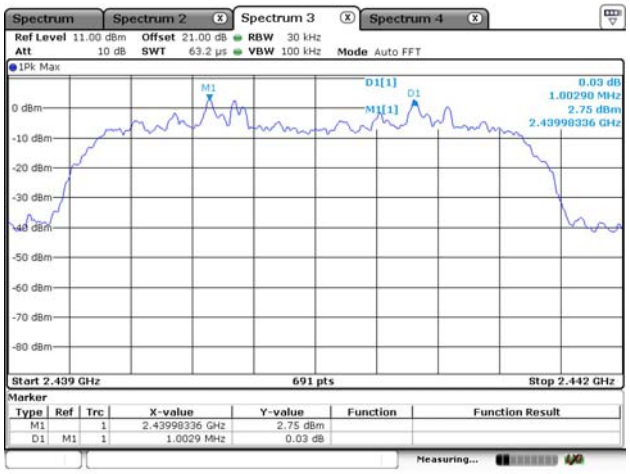
* Limit : ≥ 25 kHz or two-thirds of the 20 dB bandwidth

5.3.6 Test plot

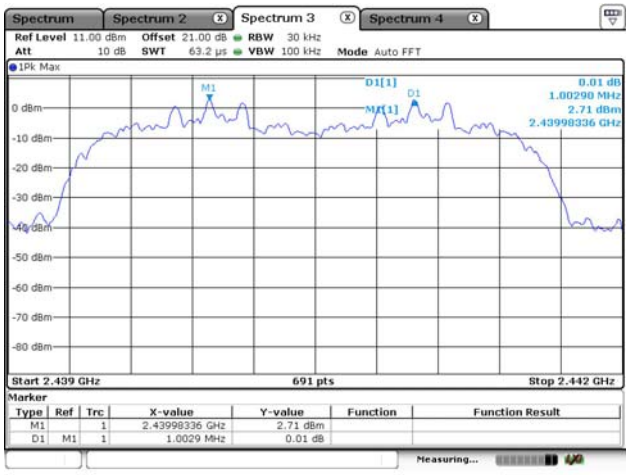
▣ BDR(GFSK)



EDR(π/4DQPSK)



EDR(8DPSK)



5.4 Number of Hopping Channels

5.4.1 Standard Applicable [FCC §15.247(a)(1) / RSS-247, 5.1.4]

Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1)(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

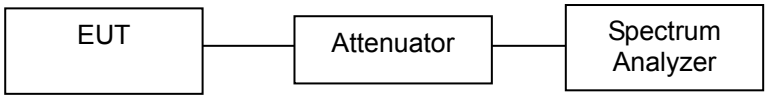
5.4.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.4.3 Measurement Procedure

ANSI C63.10: 2013 and FCC Public Notice DA 00-705 Released March 30, 2000: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

5.4.4 Test setup

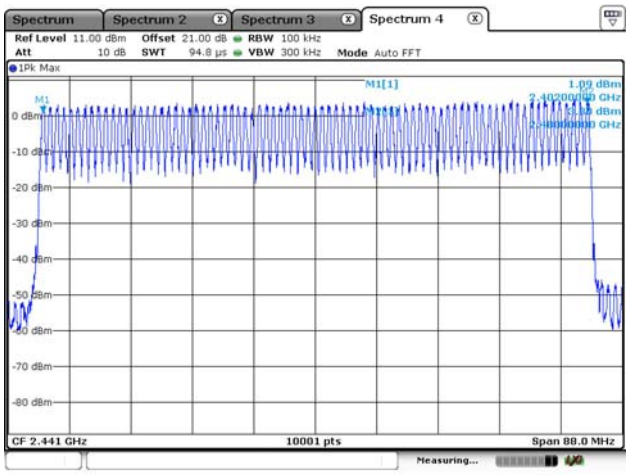


5.4.5 Measurement Result

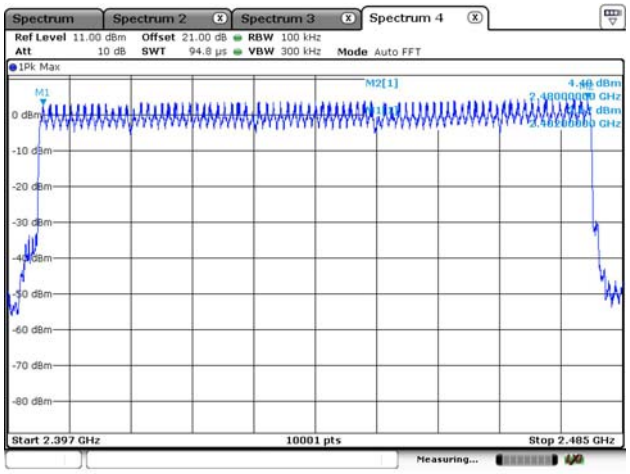
Modulation Type	Hopping channels number	Limit	Test Results
BDR(GFSK)	79	≥15	Compliance
EDR(π/4DQPSK)	79	≥15	Compliance
EDR(8DPSK)	79	≥15	Compliance

5.4.6 Test plot

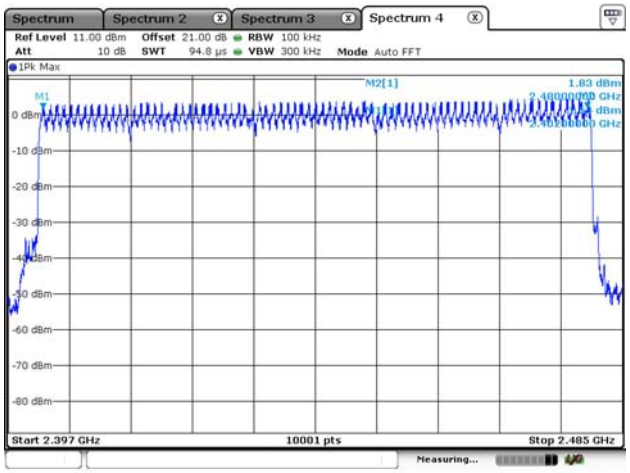
▣ BDR(GFSK)



EDR(π/4DQPSK)



EDR(8DPSK)



5.5 Time of Occupancy

5.5.1 Standard Applicable [FCC §15.247(a)(1) / RSS-247, 5.1.2]

(1)(iii) The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

5.5.2 Test Environment conditions

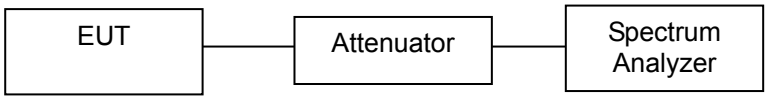
• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.5.3 Measurement Procedure

ANSI C63.10: 2013 and FCC Public Notice DA 00-705 Released March 30, 2000: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled. After used the marker-delta function to determine the dwell time.

5.5.4 Test setup



5.5.5 Measurement Result

Burst width per one hop (ms) (Time slot)			Test Results		
			Dwell time (ms)	Limit	Result
BDR(GFSK)	DH1	0.391	0.125	≤ 0.4	Compliance
	DH3	1.648	0.264	≤ 0.4	Compliance
	DH5	2.900	0.309	≤ 0.4	Compliance
EDR(π/4DQPSK)	2DH1	0.401	0.128	≤ 0.4	Compliance
	2DH3	1.648	0.264	≤ 0.4	Compliance
	2DH5	2.912	0.311	≤ 0.4	Compliance
EDR(8DPSK)	3DH1	0.401	0.128	≤ 0.4	Compliance
	3DH3	1.648	0.264	≤ 0.4	Compliance
	3DH5	2.912	0.311	≤ 0.4	Compliance

Note:
DH1 Packet permit maximum 1600 / 79 / 2 hops per second in each channel (1 time slot RX, 1 time slot TX).
DH3 Packet permit maximum 1600 / 79 / 4 hops per second in each channel (3 time slots RX, 1 time slot TX).
DH5 Packet permit maximum 1600 / 79 / 6 hops per second in each channel (5 time slots RX, 1 time slot TX).

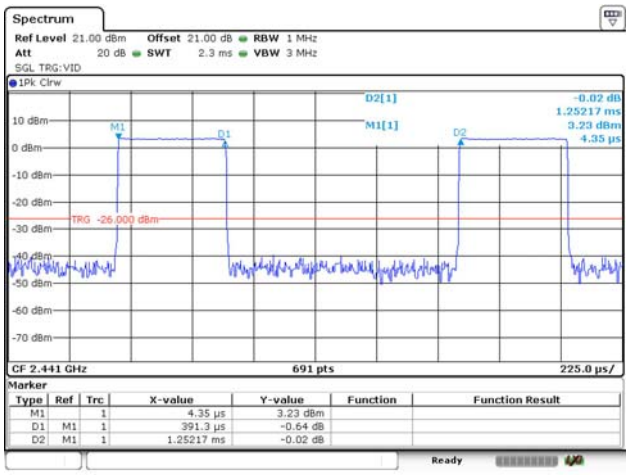
Therefore, dwell Time can be calculated as follows:

Data Packet	Dwell Time(s)
DH1/2DH1/3DH1	1600/79/2*0.4*79*(MkrDelta)/1000
DH3/2DH3/3DH3	1600/79/4*0.4*79*(MkrDelta)/1000
DH5/2DH5/3DH5	1600/79/6*0.4*79*(MkrDelta)/1000

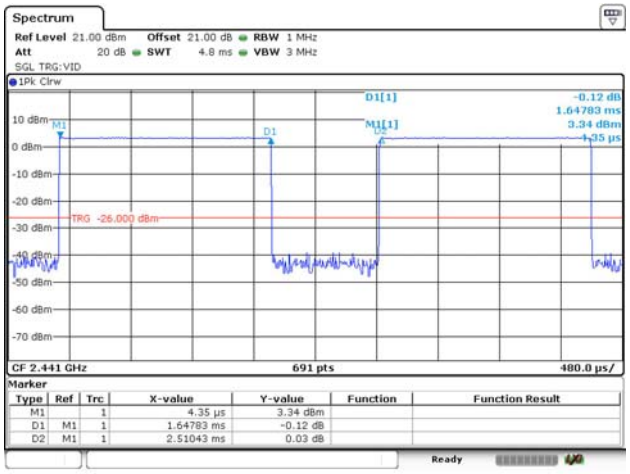
5.5.6 Test plot

▣ BDR(GFSK)

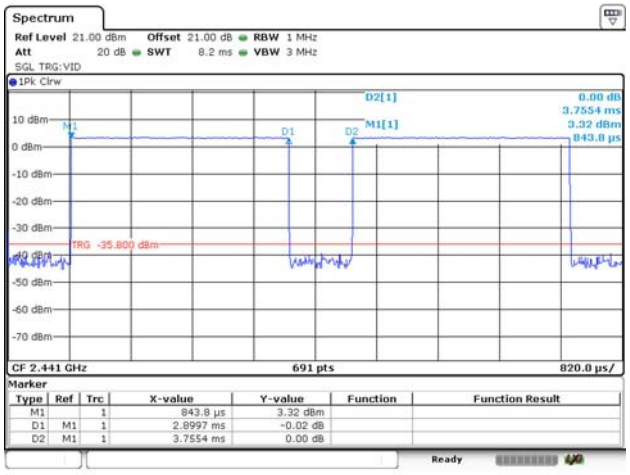
DH1



DH3

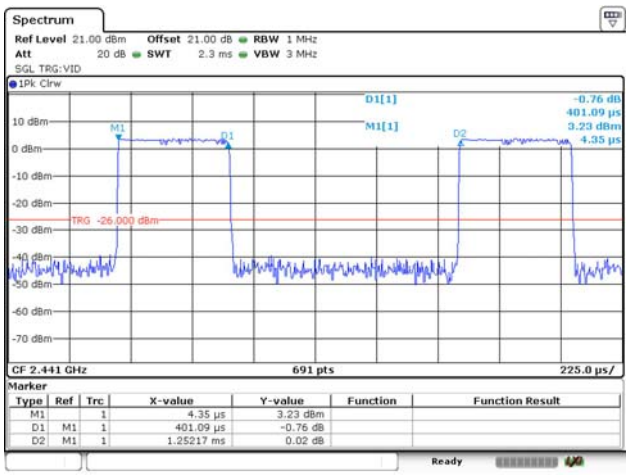


DH5

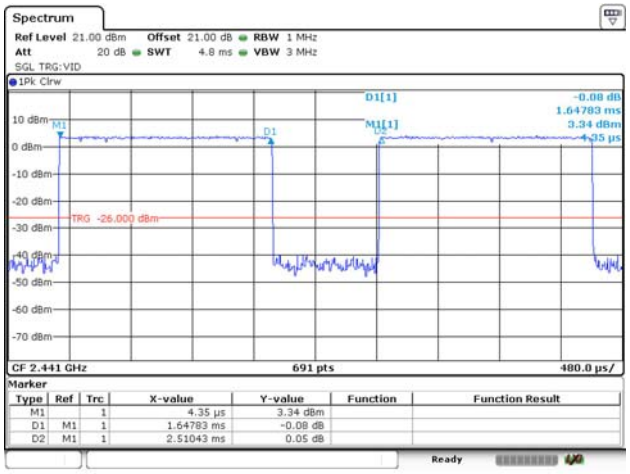


▣ EDR(π/4DQPSK)

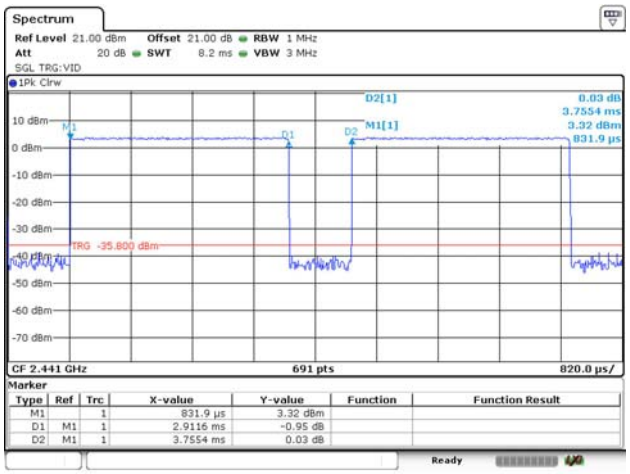
2DH1



2DH3

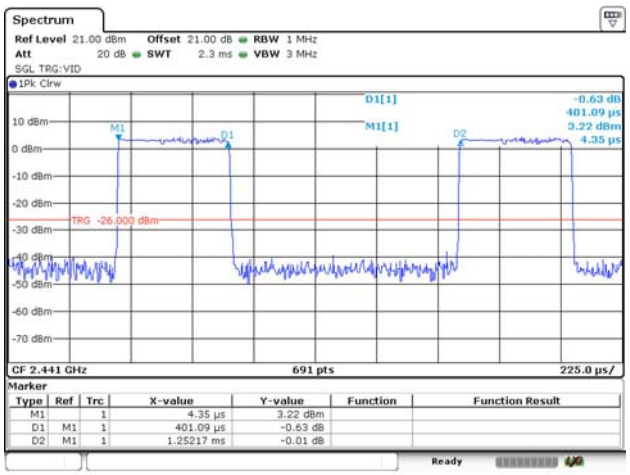


2DH5

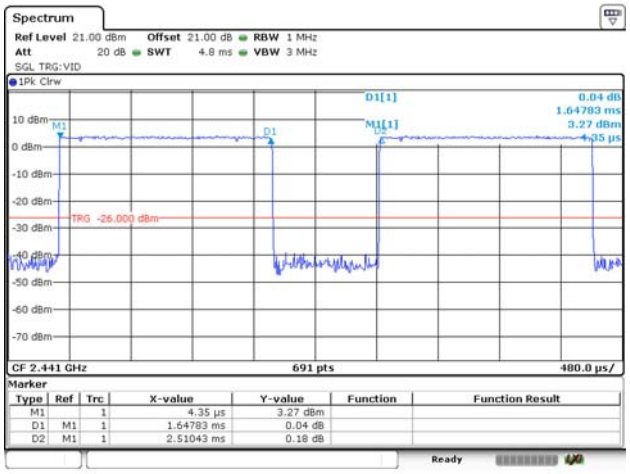


▣ EDR(8DPSK)

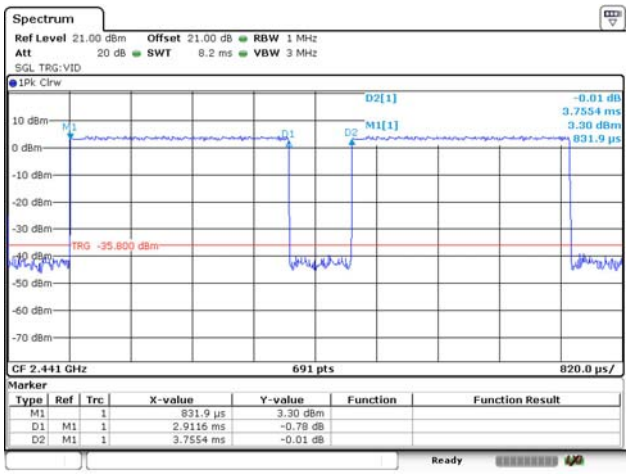
3DH1



3DH3



3DH5



5.6 Conducted Spurious Emissions (Band-edge)

5.6.1 Standard Applicable [FCC §15.247(d) / RSS-247, 5.5]

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 RF conducted.

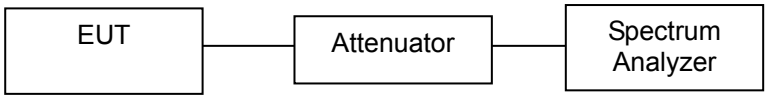
5.6.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.6.3 Measurement Procedure

(1) The transmitter output was connected to the spectrum analyzer through an attenuator.
(2) Conducted spurious emission the bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=100 KHz and VBW=300KHz.
(3) Below -20dB of the highest emission level in operating band.

5.6.4 Test setup



5.6.5 Measurement Result

Setting Channel		Test Results			
		Measured value [dB]		Limit [dB]	Result
		Hop on	Hop off		
BDR(GFSK)	CH 0	-46.95	-43.82	≤ 20 than PSD level	Compliance
	CH 78	-51.49	-58.97		Compliance
EDR(π/4DQPSK)	CH 0	-38.31	-37.14		Compliance
	CH 78	-50.93	-57.64		Compliance
EDR(8DPSK)	CH 0	-37.65	-36.78		Compliance
	CH 78	-50.90	-56.38		Compliance

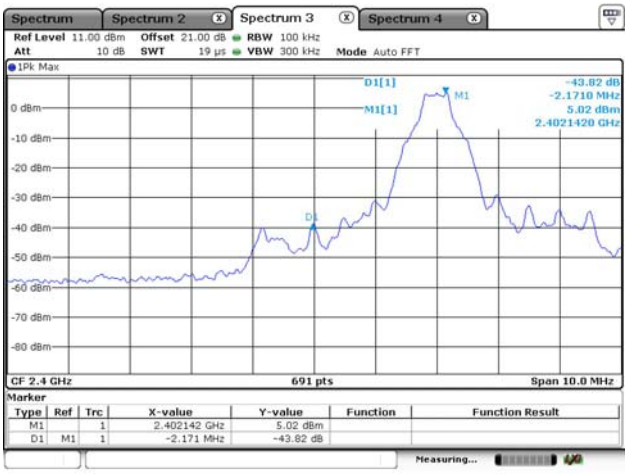
Note: The following plots show that there are no conducted spurious emissions exceeding the 20dB down criteria. Plots are also presented showing the band edge compliance.

5.6.6 Test Plot (Band-edge)

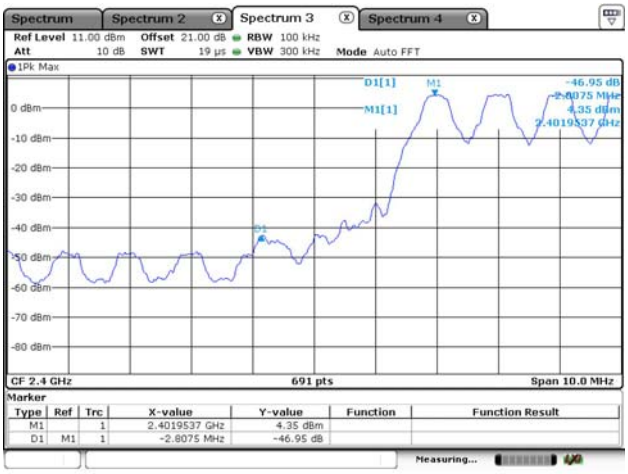
▣ BDR(GFSK)

CH Low

Hop off

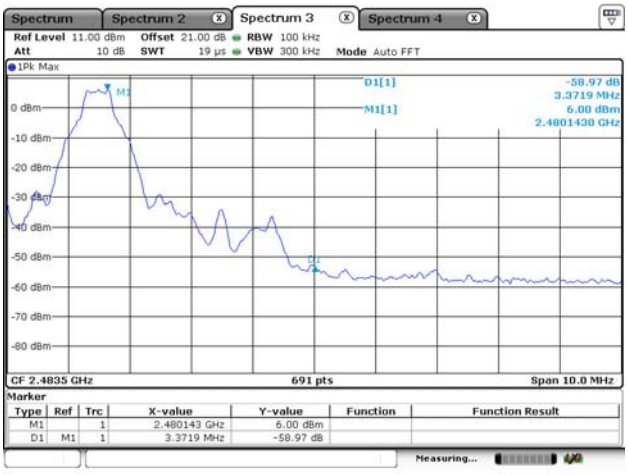


Hop on

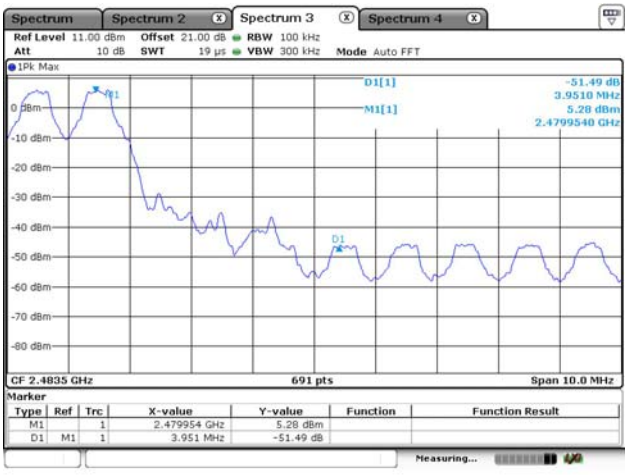


CH High

Hop off



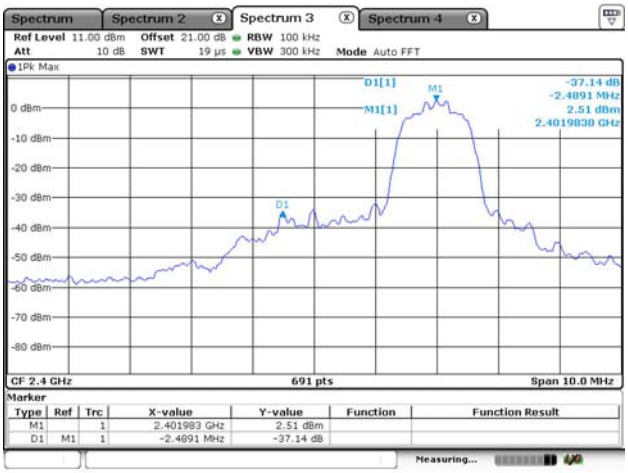
Hop on



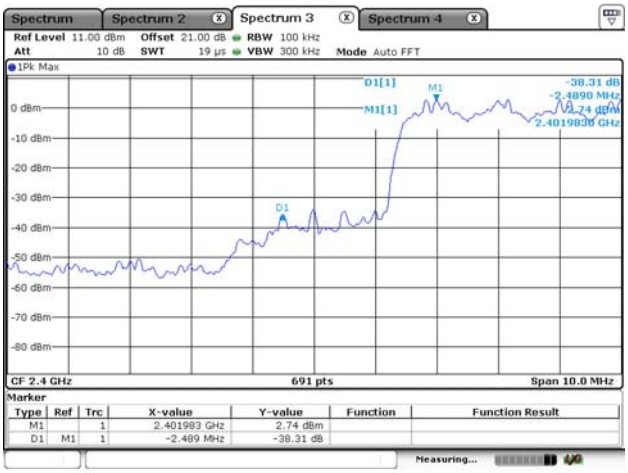
▣ EDR(π/4DQPSK)

CH Low

Hop off

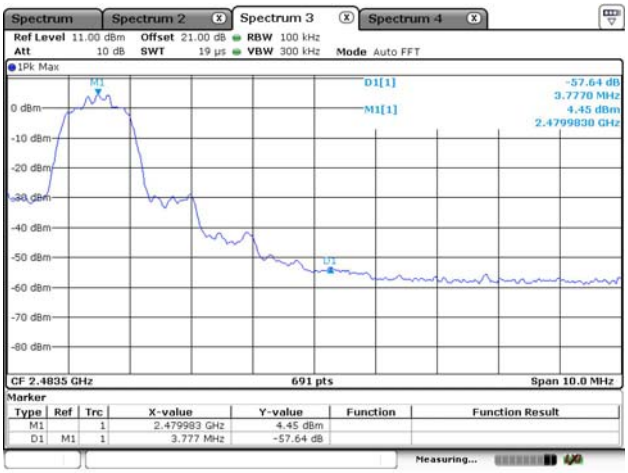


Hop on

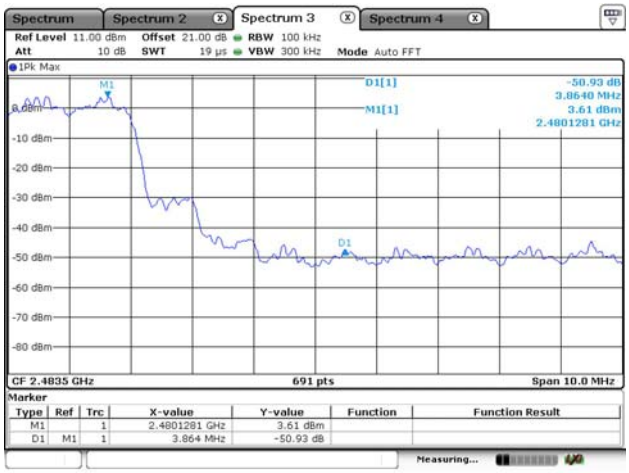


CH High

Hop off



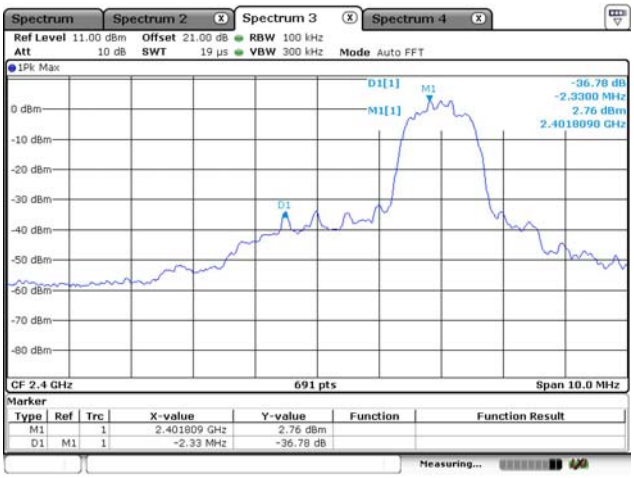
Hop on



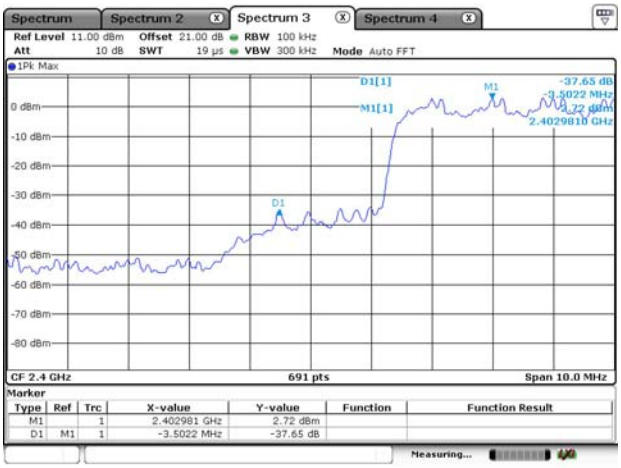
▣ EDR(8DPSK)

CH Low

Hop off

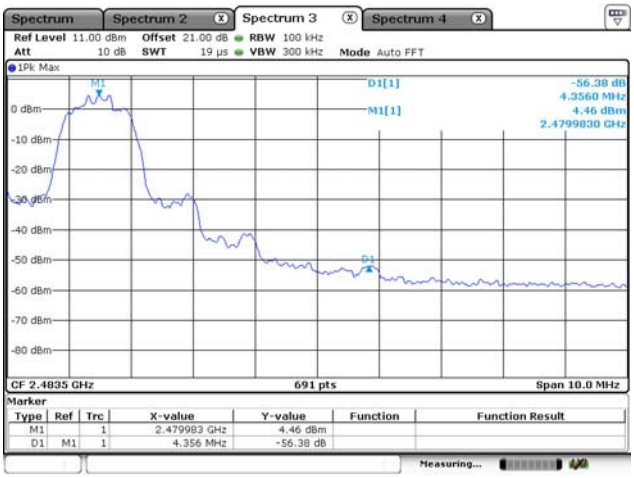


Hop on

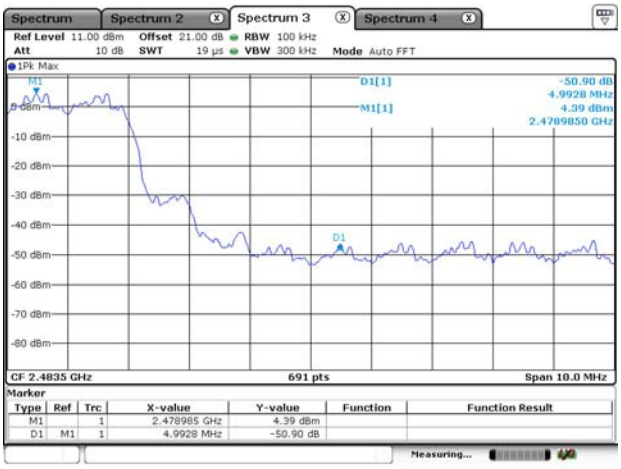


CH High

Hop off



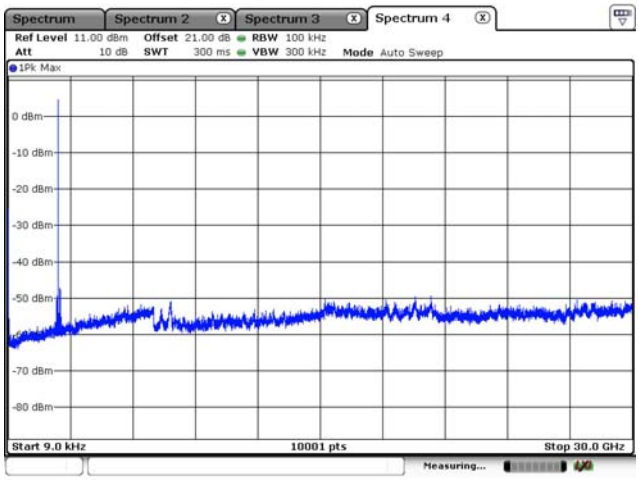
Hop on



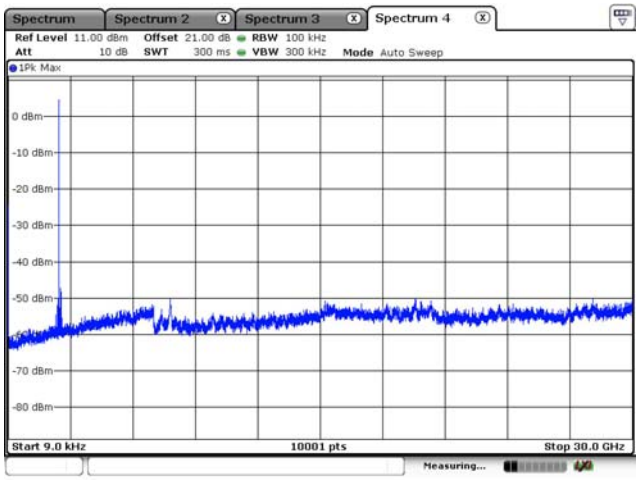
Test Plot (Conducted spurious emissions)

▣ BDR(GFSK)

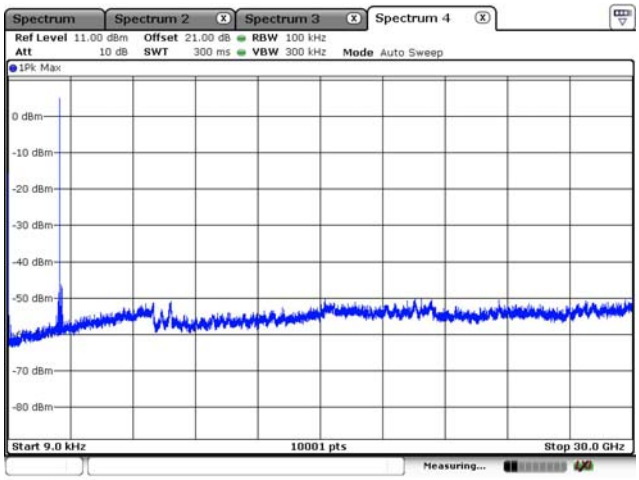
CH Low



CH Middle



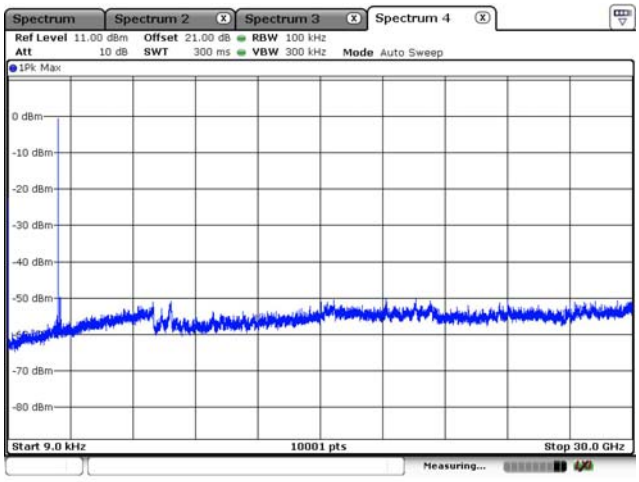
CH High



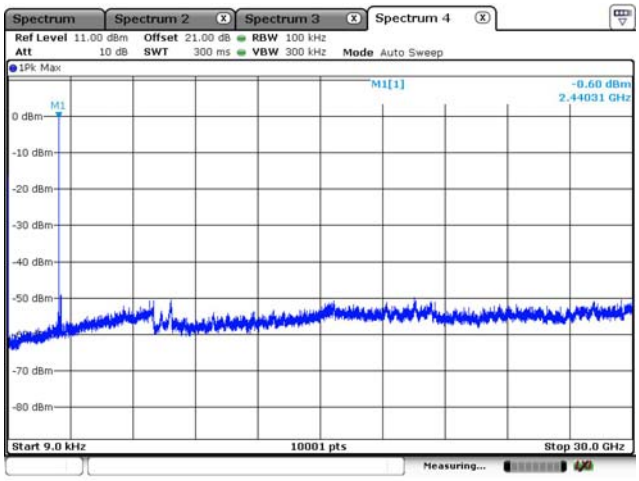
Note: It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits

▣ EDR(π/4DQPSK)

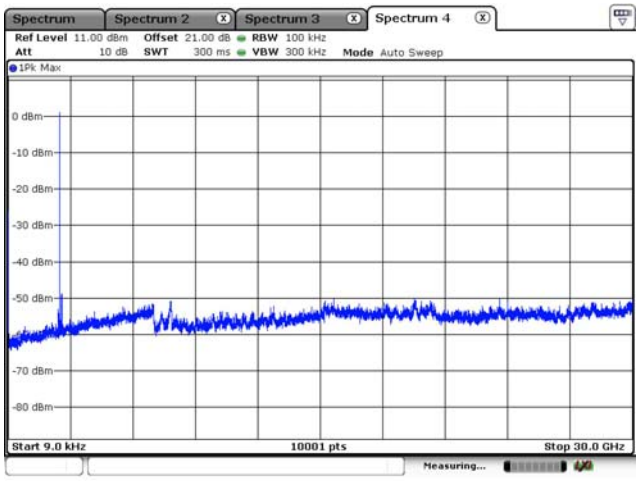
CH Low



CH Middle



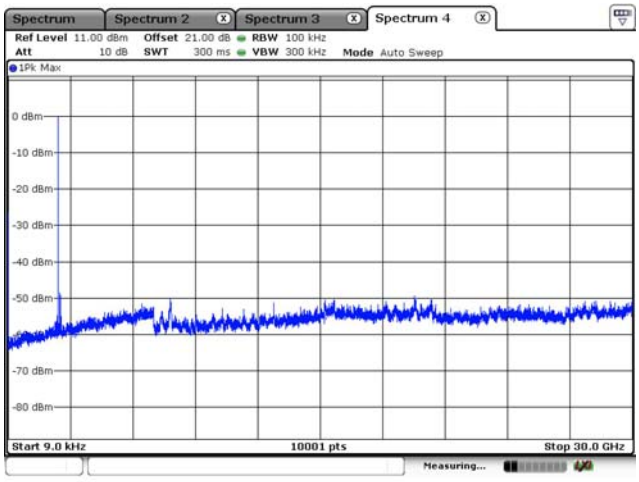
CH High



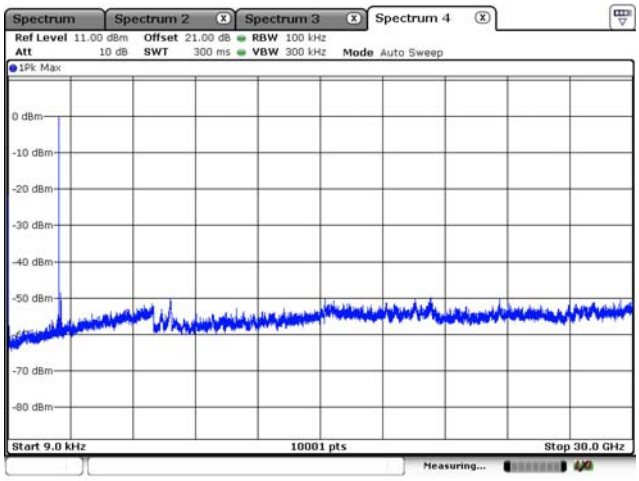
Note: It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits

▣ EDR(8DPSK)

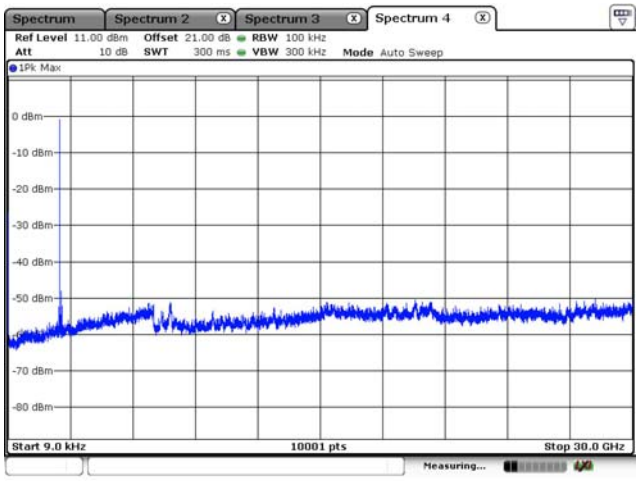
CH Low



CH Middle



CH High



Note: It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits

5.7 Spurious RF Radiated emissions

5.7.1 Standard Applicable [FCC §15.247(d)]

All other emissions outside these bands shall not exceed the general radiated emission limits specified in §15.209(a). And according to §15.33(a)(1), for an intentional radiator operates below 10 GHz, the frequency Range of measurements: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, Whichever is lower. In addition, radiated emissions which fall in the restricted bands, as defined in Sec.15.205(a), must also comply with the radiated emission limits specified in Sec. 15.209(a)

§15.209 limits for radiated emissions measurements (distance at 3 m)

Frequency Band [MHz]	DISTANCE [Meters]	Limit [㎶/m]	Limit [dB㎶/m]	Detector
0.009 ~ 0.490	300	2400/F(kHz)	67.6-20log(F)	Peak
0.490 ~ 1.705	30	24000/F(kHz)	87.6-20log(F)	Peak
1.705 ~ 30.0	30	30	29.54	Peak
30 - 88	3	100 **	40.00	Quasi peak
88 - 216	3	150 **	43.52	Quasi peak
216 - 960	3	200 **	46.02	Quasi peak
Above 960	3	500	54.00	Average
Above 1000	3	74.0 dB㎶/m (Peak), 54.0 dB㎶/m (Average)		
** fundamental emissions from intentional radiators operation 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 Section 15.231 and 15.241				

§15.205. Restrict Band of Operation for FCC

[MHz]	[MHz]	[MHz]	[GHz]
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505**	16.694 75 - 16.695 25	608 - 614	5.35 - 5.46
2.173 5 - 2.190 5	16.804 25 - 16.804 75	960 – 1 240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1 300 – 1 427	8.025 - 8.
4.177 25 - 4.177 75	37.5 -38.25	1 435 – 1 626.5	9.0 - 9.2
4.207 25 - 4.207 75	73 - 74.6	1 645.5 – 1 646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1 660 – 1 710	10.6 - 12.7
6.267 75 - 6.268 25	108 - 121.94	1 718.8 -1 722.2	13.25 - 13.4
6.311 75 - 6.312 25	123 - 138	2 200 – 2 300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2 310 – 2 390	15.35 - 16.2
8.362 - 8.366	156.524 75 - 156.525 25	2 483.5 – 2 500	17.7 - 21.4
8.376 25 - 8.38 6 75	156.7 - 156.9	2 690 – 2 900	22.01 - 23.12
8.414 25 - 8.414 75	162.012 5 - 167.17	3 260 – 3 267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3 332 – 3 339	31.2 - 31.8
12.519 75 - 12.520 25	240 - 285	3 345.8 – 3 358	36.43 - 36.5
12.576 75 - 12.577 25	322 - 335.4	3 600 – 4 400	Above 38.6
13.36 - 13.41			

** Until February 1, 1999, this restricted band shall be 0.490-0.510

5.7.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (50 ~ 53) % R.H.

5.7.3 Measurement Procedure

The measurements procedure of the Spurious RF Radiated emissions is as following describe method.

1. The EUT was placed on the top of a rotating table (0.8 meters for below 1 ㎓ and 1.5 meters for above 1 ㎓) above the ground at a 3 meter camber. The table was rotated 360 degree to determine the position of the highest radiation.
2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna master.
3. The antenna 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.
4. 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 rotating table was turned from 0 - 360 degrees to find the maximum reading.
5. The measuring receiver was set to peak detector and specified bandwidth with max hold function.
6. Low, Middle and high channels were measured, and radiation measurements are performed in X, Y, Z axis positioning. And found the worst axis position and only the test worst case mode is recorded in the report.

• The measurement results are obtained as described below:
Result(㏈㎶/m) = Reading(㏈㎶) + Antenna factor(㏈/m)+ CL(㏈) + other applicable factor (㏈)

• The resolution bandwidth of test receiver/spectrum analyzer is 1 ㎒ and the video bandwidth is 3 ㎒ for RMS Average (Duty cycle < 98 %) for Average detection (AV) at frequency above 1 ㎓, then the measurement results was added to a correction factor (10 log(1/duty cycle)).

• The resolution bandwidth of test receiver/spectrum analyzer is 1 ㎒ and the video bandwidth is 10 ㎐ (Duty cycle ≥ 98 %) for Average detection (AV) at frequency above 1 ㎓.

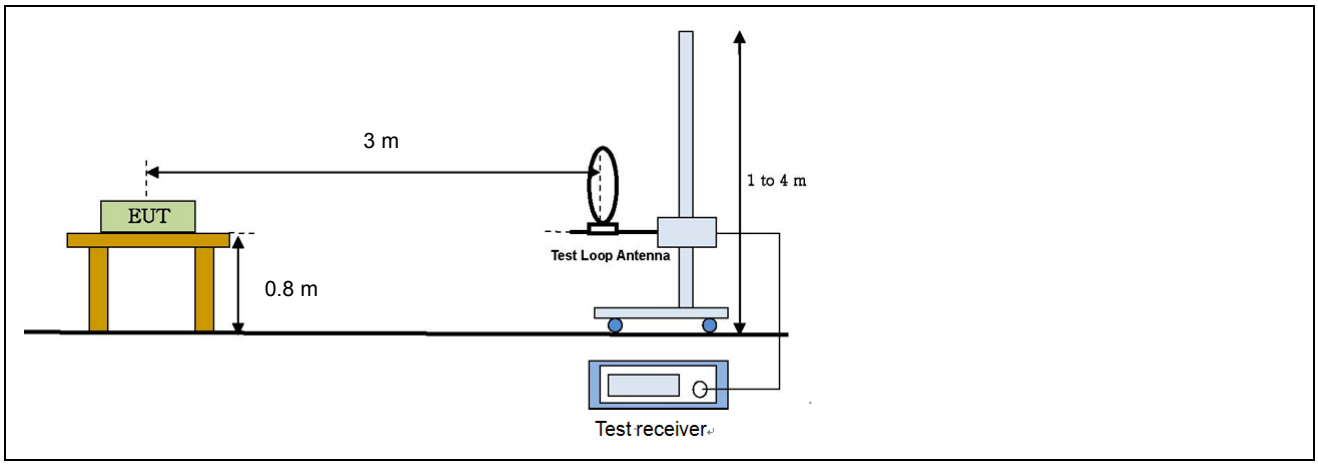
• According to §15.33 (a)(1), Frequency range of radiated measurement is performed the tenth harmonic.

5.7.4 Measurement Uncertainty

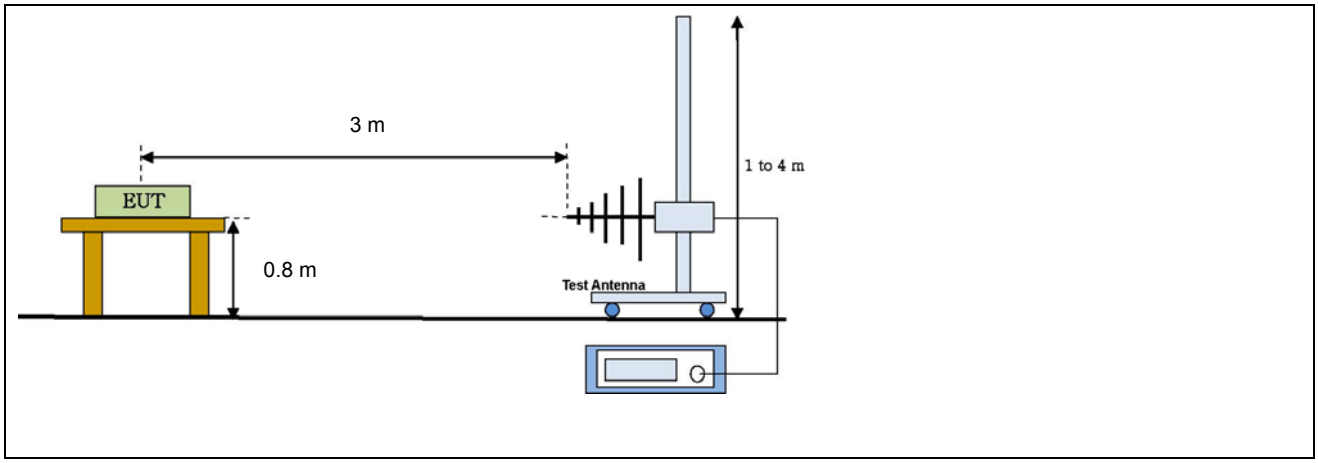
Radiated Emission measurement: Below 1 GHz : 4.32 dB (CL: Approx 95 %, *k*=2)
Above 1 GHz : 4.14 dB (CL: Approx 95 %, *k=2*)

5.7.5 Test Configuration

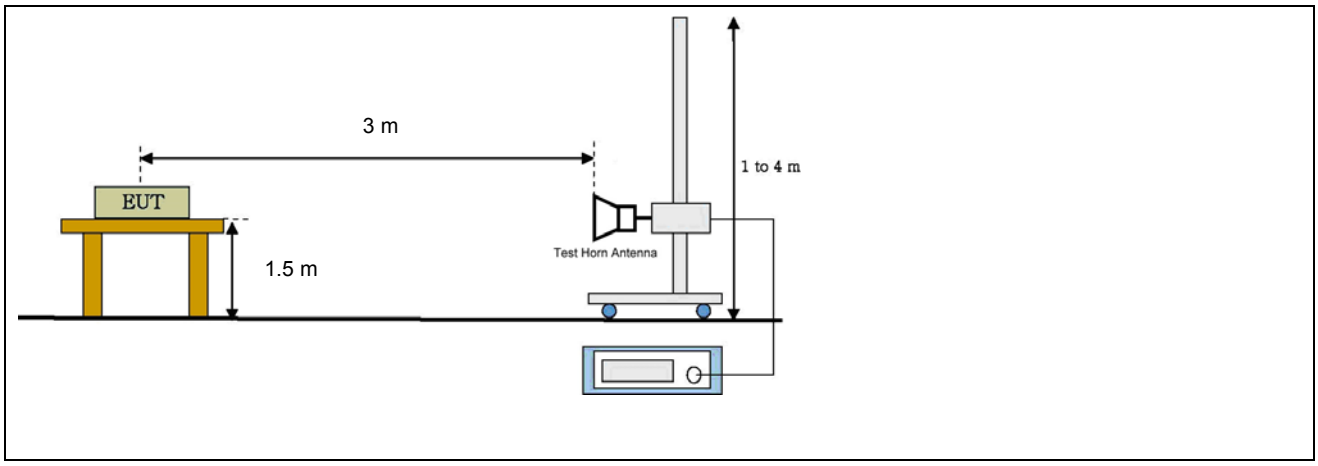
Radiated emission setup, Below 30 MHz



Radiated emission setup, Below 1 000 MHz



Radiated emission setup, Above 1 GHz



5.7.6 Measurement Result

After having pre-scan all modulation mode, found the GFSK modulation which it was worst case, so only the worst case's data on the test report.

Above 1 GHz

CH Low (2 402 MHz)

Freq. (GHz)	Reading (dBμV/m)		Table (Deg)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)		Limit (dBμV/m)		Mgn. (dB)		Result
	PK	AV		Height (m)	Pol. (H/V)	Fctr. (dB/m)			PK	AV	PK	AV	PK	AV	
2.391	44.59	32.30	210	1.0	V	28.88	2.91	-30.68	45.70	33.41	74	54	28.3	20.6	Compliance
2.391	45.09	32.41	210	1.0	H	28.88	2.91	-30.68	46.20	33.52	74	54	27.8	20.5	Compliance

* Restrict band emissions.

CH Middle (2 441 MHz)

Freq. (GHz)	Reading (dBμV/m)		Table (Deg)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)		Limit (dBμV/m)		Mgn. (dB)		Result
	PK	AV		Height (m)	Pol. (H/V)	Fctr. (dB/m)			PK	AV	PK	AV	PK	AV	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Compliance
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Compliance

* There were no spurious emissions

CH High (2 480 MHz)

Freq. (GHz)	Reading (dBμV/m)		Table (Deg)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)		Limit (dBμV/m)		Mgn. (dB)		Result
	PK	AV		Height (m)	Pol. (H/V)	Fctr. (dB/m)			PK	AV	PK	AV	PK	AV	
2.492	45.02	33.17	160	1.0	H	29.30	2.96	-30.53	46.74	34.89	74	54	27.3	19.1	Compliance
2.492	46.51	33.48	160	1.0	V	29.30	2.96	-30.53	48.23	35.20	74	54	25.8	18.8	Compliance

* Restrict band emissions.

※Note

- Above 1 GHz is measured average and peak detector mode on Spectrum analyzer in accordance with FCC Rule15.35
- Limit: 54 dBμV/m(Average), 74 dBμV/m(Peak), Attenuated more than 20 dB below the permissible value.
- It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to measured.
- For the below 30 MHz and above 2.492 GHz, measured any other signal is not detected on test receiver
- The transmitter radiated spectrum was investigated from 9 kHz to 26.5 GHz.

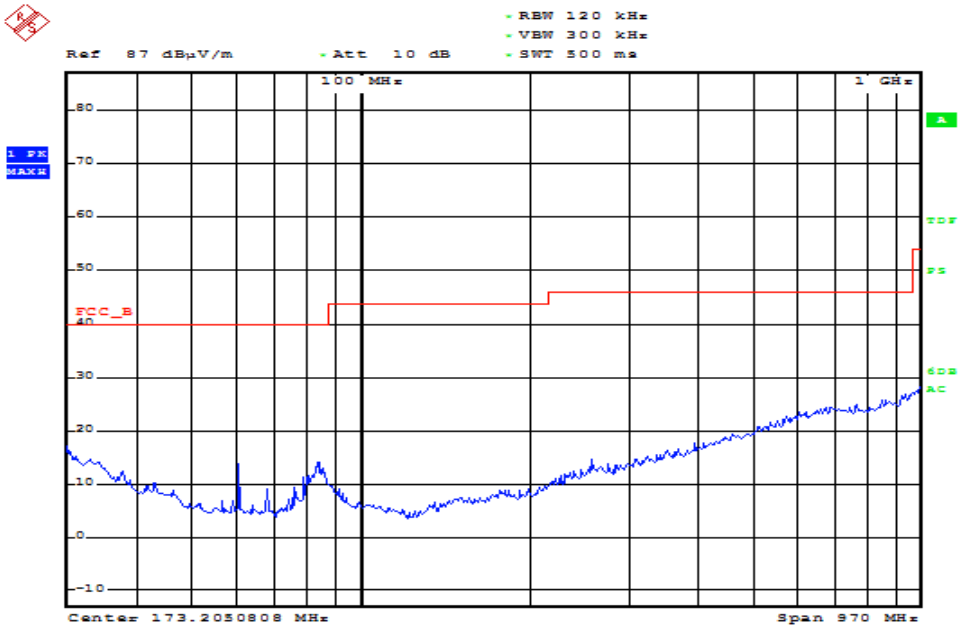
Below 1 GHz

Freq.	Reading	POL	H	Factor			Limit	Result
[㎒]	[dB㎶]		[m]	ANT. [dB/m]	CABLE [dB]	AMP. [dB]	[dB㎶/m]	[dB㎶/m]
51.86	46.94	V	1.5	7.55	2.22	-41.61	40	15.10
80.57	50.18	H	3.2	5.81	2.60	-41.60	40	17.00
128.50	51.03	H	3.0	7.06	3.16	-41.44	43.5	19.80
161.40	46.92	H	2.8	9.24	3.54	-41.29	43.5	18.40
238.20	41.82	H	2.8	11.32	4.08	-41.03	46	16.20

*Result = Reading + antenna factor + cable loss + AMP.
*Reading: test receiver reading value
*POL = antenna Polarization / H = antenna Height *Receiving Antenna Mode : Horizontal, Vertical
*ANT. = antenna factor / CABLE = used cable loss/AMP.: Gain of the Amplifier
*Test site : 10 m Semi-Anechoic chamber

*Worst case only

Horizontal



5.8 Antenna requirement

5.8.1 Standard applicable [FCC §15.203]

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by responsible party shall be used with the device.

The use of a permanently attached antenna or of an antenna that user a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

5.8.2 Antenna details

Frequency Band	Antenna Type	Gain [dBi]	Results
2.4 GHz	PCB antenna	1.139	Compliance

5.9 AC Power Conducted emissions

5.9.1 Standard Applicable [FCC §15.207(a) / RSS-Gen 8.8]

For 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 frequencies hopping mode within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line Impedance stabilization network(LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

§15.207 limits for AC line conducted emissions;

Frequency of Emission(㎒)	Conducted Limit (dBμV)	
	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

5.9.2 Test Environment conditions

• Ambient temperature : (22 ~ 23) ℃ • Relative Humidity : (48 ~ 50) % R.H.

5.9.3 Measurement Procedure

EUT was placed on a non- metallic table height of 0.8 m above the reference ground plane. Cables connected to EUT were fixed to cause maximum emission. Test was made with the antenna positioned in both the horizontal and vertical planes of polarization. The measurement antenna was varied in height above the conducting ground plane to obtain the Maximum signal strength.

5.9.4 Used equipment

Equipment	Model No.	Serial No.	Manufacturer	Next cal date	Cal interval	Used
Test receiver	ESCS30	100111	Rohde & Schwarz	2018. 01. 31	1 year	☒
LISN	ESH2-Z5	100044	R&S	2018. 01. 31	1 year	☐
	ESH3-Z5	100147	R&S	2018. 01. 31	1 year	☒

*Test Program: “ ESXS-K1 V2.2”
Measurement uncertainty
Conducted Emission measurement: 4.48 dB (CL: Approx 95 %, *k*=2)

5.9.5 Measurement Result

N/A

Freq.	Factor [dB]		POL	QP			CISPR AV		
				Limit	Reading	Result	Limit	Reading	Result
[㎒]	LISN	CABLE +P/L		[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]

* LISN: LISN insertion Loss, Cable: Cable Loss, P/L:pulse limiter factor
* L: Line. Live, N: Line. Neutral
* Reading: test receiver reading value (with cable loss & pulse limiter factor)
* Result = LISN + Reading