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-190015(1)	KOSTEC Co., Ltd. http://www.kostec.org

1. Applicant
   - Name : Novatron Co., Ltd.
   - Address : Room 1607, 13, Heungdeok1-ro, Giheunggu, Yonginsi, Gyeonggido, 16954, Korea
2. Test Item
   - Product Name: Hybrid Headphone AMP & DAC
   - Model Name: HA500H
   - Brand: -
   - FCC ID: 2ARUY-HA500H
3. Manufacturer
   - Name : Novatron Co., Ltd.
   - Address : Room 1607, 13, Heungdeok1-ro, Giheunggu, Yonginsi, Gyeonggido, 16954, Korea
4. Date of Test : 2019. 08. 12. ~ 2019. 08. 13.
5. Test Method Used : FCC CFR 47, Part 15. Subpart C-15.247
558074 D01 15.247 Meas Guidance v05
ANSI C 63.10-2013
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.
This test report is not related to KOLAS accreditation.

Affirmation	Tested by Name : Jung, Ho-Cheol (Signature)	Technical Manager Name : Park, Gyeong-Hyeon (Signature)

2019. 09. 26.

KOSTEC Co., Ltd.

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1. GENERAL INFORMATION

1.1 Test Facility

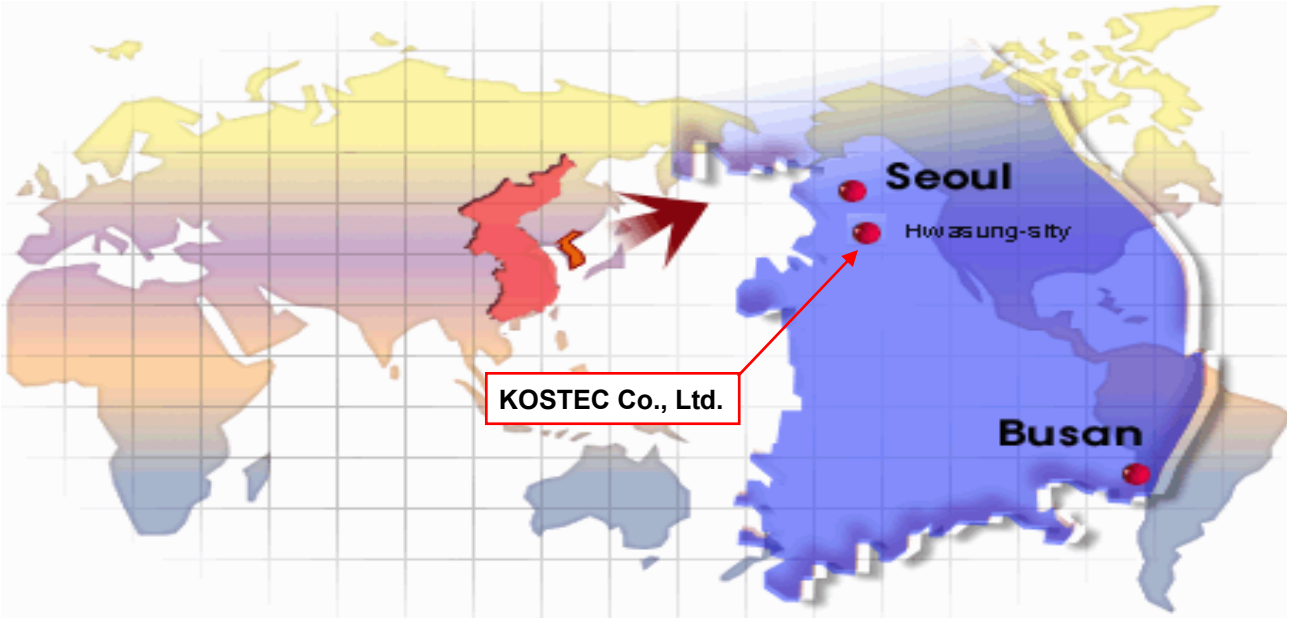
Test laboratory and address

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

Registration information

KOLAS No. : 232
FCC/IC Designation No. : KR0041

1.2 Location



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1.3 Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
-	Initial issue	All	Gyeong Hyeon, Park	2019. 08. 16.
1	Revised 5.8 Antenna details	49	Gyeong Hyeon, Park	2019. 09. 26.

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2. EQUIPMENT DESCRIPTION

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

Equipment Name	Hybrid Headphone AMP & DAC
Model No	HA500H
Usage	Hybrid Headphone AMP & DAC
Serial Number	Proto type
Modulation type	GFSK(BDR 1 Mbps), π/4-DQPSK(EDR 2 Mbps), 8DPSK(EDR 3 Mbps)
Emission Type	F1D, G1D
Maximum output power	2.16 dBm
Operated Frequency	2 402 MHz ~ 2 480 MHz
Channel Number	79
Operation temperature	10 ℃ ~ 40 ℃
Power Source	AC 110 V
Antenna Description	External Dipole Antenna, gain : 3.05 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	2ARUY-HA500H

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3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

TWS Hearing Device

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

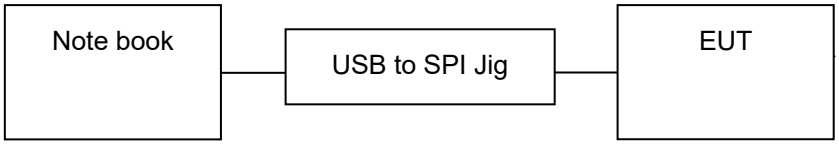
N/A

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 CSR Bluetest3. The test command and the test Jig and cables were provided by the applicant.



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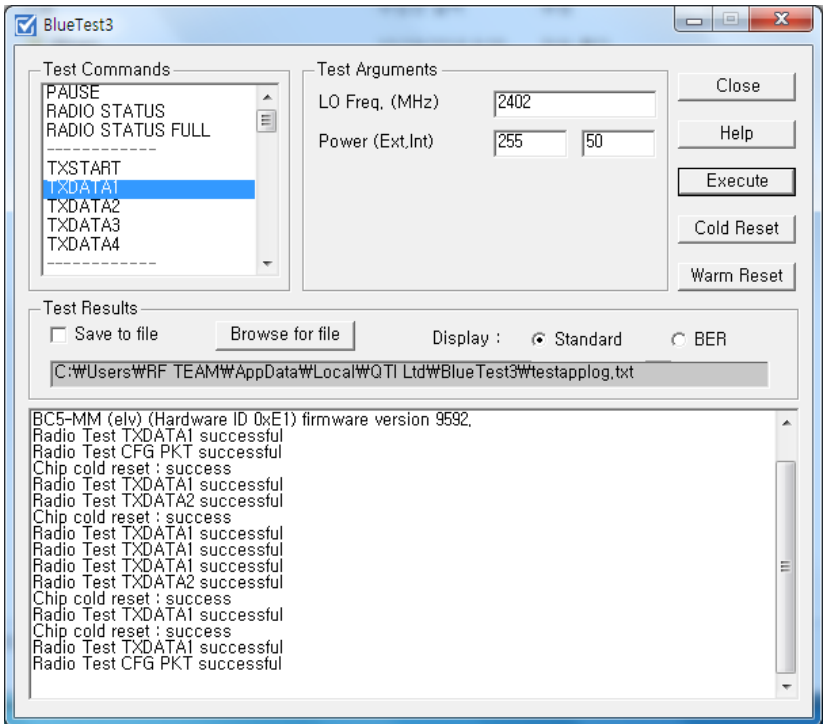
3.6 Parameters of Test Software Setting

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 : CSR Bluetest3 – v2.6.9



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3.7 Table for Test condition

Test Items	Channel No	Frequency (㎒)	Operated Condition
Channel Separation	38	2 440	Hopping on and continuous modulation setting mode
Number of Hopping Channels	0 ~ 78	2 402 ~ 2 480	Hopping on mode
Time of occupancy	38	2 440	Hopping on mode
Peak Output Power	0	2 402	Hopping off and continuous modulation setting mode
	38	2 440	
	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

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3.8 Used Test Equipment List

No.	Instrument	Model	S/N	Manufacturer	Due to cal date	Cal interval	used
1	T & H Chamber	PL-3J	15003623	ESPEC	2019.11.12	1 year	☐
2	T & H Chamber	SH-662	93000067	ESPEC CORP	2019.09.28	1 year	☐
3	Spectrum Analyzer	8563EC	3046A00527	Agilent Technology	2020.01.25	1 year	☐
4	Signal Analyzer	FSV13	101247	Rohde & Schwarz	2020.01.24	1 year	☐
5	Spectrum Analyzer	FSV30	20-353063	Rohde& Schwarz	2020.01.25	1 year	☒
6	Signal Analyzer	N9010A	MY56070441	Agilent Technologies	2019.05.25	1 year	☐
7	EMI Test Receiver	ESCI7	100823	Rohde& Schwarz	2020.01.22	1 year	☒
8	EMI Test Receiver	ESI	837514/004	Rohde& Schwarz	2019.09.03	1 year	☒
9	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2020.01.25	1 year	☐
10	Network Analyzer	8753ES	US39172348	AGILENT	2019.09.03	1 year	☐
11	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2020.01.23	1 year	☐
12	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2020.01.23	1 year	☐
13	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2020.01.24	1 year	☐
14	Audio Analyzer	8903B	3514A16919	Agilent Technology	2020.01.23	1 year	☐
15	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2020.01.23	1 year	☐
16	Modulation Analyzer	8901A	3041A0576	H.P	2020.01.24	1 year	☐
17	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2019.09.04	1 year	☐
18	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2020.01.25	1 year	☐
19	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2020.01.25	1 year	☐
20	GNSS Signal Generator	TC-2800A	2800A000494	TESCOM CO., LTD.	2020.01.24	1 year	☐
21	Signal Generator	SMB100A	179628	Rohde & Schwarz	2019.05.09	1 year	☒
22	SLIDAC	None	0207-4	Myoung sung Ele.	2020.01.23	1 year	☒
23	DC Power supply	DRP-5030	9028029	Digital Electronic Co.,Ltd	2020.01.23	1 year	☐
24	DC Power supply	E3610A	KR24104505	Agilent Technology	2020.01.23	1 year	☐
25	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2020.01.23	1 year	☐
26	DC Power Supply	SM 3400-D	114701000117	DELTA ELEKTRONIKA	2020.01.22	1 year	☐
27	DC Power supply	6632B	MY43004005	Agilent Technology	2020.01.23	1 year	☐
28	DC Power Supply	6632B	MY43004137	Agilent Technology	2020.01.23	1 year	☐
29	Termination	1433-3	LM718	WEINSCHEL	2019.07.09	1 year	☐
30	Termination	1432-3	QR946	AEROFLEX/WEINSCHEL	2019.07.09	1 year	☐
31	Attenuator	24-30-34	BX5630	Aeroflex / Weinschel	2019.12.19	1 year	☐
32	Attenuator	8498A	3318A09485	HP	2020.01.24	1 year	☐
33	Step Attenuator	8494B	3308A32809	HP	2020.01.24	1 year	☐
34	RF Step Attenuator	RSP	100091	Rohde & Schwarz	2020.01.24	1 year	☐
35	Attenuator	18B50W-20F	64671	INMET	2020.01.24	1 year	☒
36	Attenuator	10 dB	1	Rohde & Schwarz	2019.05.04	1 year	☐
37	Attenuator	10 dB	2	Rohde & Schwarz	2019.05.04	1 year	☐
38	Attenuator	10 dB	3	Rohde & Schwarz	2019.05.04	1 year	☐
39	Attenuator	10 dB	4	Rohde & Schwarz	2019.05.04	1 year	☐
40	Attenuator	54A-10	74564	WEINSCHEL	2019.09.04	1 year	☐
41	Attenuator	56-10	66920	WEINSCHEL	2019.05.09	1 year	☐
42	Attenuator	48-20-11	BV2658	Aeroflex/Weinschel	2019.08.06	1 year	☐
43	Attenuator	48-30-33-LIM	BL5350	Weinschel Corp.	2019.07.09	1 year	☐
44	Power divider	11636B	51212	HP	2020.01.28	1 year	☐
45	3Way Power divider	KPDSU3W	00070365	KMW	2019.09.03	1 year	☐
46	4Way Power divider	70052651	173834	KRYTAR	2020.01.28	1 year	☐
47	3Way Power divider	1580	SQ361	WEINSCHEL	2019.05.09	1 year	☐
48	OSP	OSP120	101577	Rohde & Schwarz	2019.05.04	1 year	☐
49	White noise audio filter	ST31EQ	101902	SoundTech	2019.09.04	1 year	☐

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No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
50	Dual directional coupler	778D	17693	HEWLETT PACKARD	2020.01.24	1 year	☐
51	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2020.01.24	1 year	☐
52	Band rejection filter	3TNF-0006	26	DOVER Tech	2020.01.24	1 year	☐
53	Band rejection filter	3TNF-0007	311	DOVER Tech	2020.01.24	1 year	☐
54	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2020.01.24	1 year	☒
55	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2019.05.04	1 year	☐
56	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2019.05.04	1 year	☐
57	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2019.05.04	1 year	☐
58	Band rejection filter	CTF-155M-S1	001	RF One Electronics	2019.09.06	1 year	☐
59	Band rejection filter	CTF-435M-S1	001	RF One Electronics	2019.09.06	1 year	☐
60	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2020.01.24	1 year	☐
61	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2020.01.24	1 year	☐
62	Highpass Filter	WHNX6-5530-7000-26500-40CC	2	Wainwright Instruments GmbH	2019.05.09	1 year	☐
63	Highpass Filter	WHNX6-2370-3000-26500-40CC	4	Wainwright Instruments GmbH	2019.05.09	1 year	☐
64	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2020.01.24	1 year	☐
65	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2020.01.24	1 year	☐
66	Loop Antenna	6502	9203-0493	EMCO	2019.05.29	2 year	☒
67	BiconiLog Antenna	3142B	1745	EMCO	2020.05.10	2 year	☒
68	Biconical Antenna	VUBA9117	9117-342	Schwarz beck	2020.03.12	2 year	☐
69	Trilog-Broadband Antenna	VULB 9168	9168-606	SCHWARZBECK	2020.09.14	2 year	☐
70	Horn Antenna	3115	2996	EMCO	2020.02.14	2 year	☒
71	Horn Antenna	3115	9605-4834	EMCO	2020.03.12	2 year	☐
72	Horn Antenna	BBHA9170	743	SCHWARZBECK	2021.01.22	2 year	☒
73	PREAMPLIFIER(3)	8449B	3008A00149	Agilent	2019.09.05	1 year	☐
74	AMPLIFIER(10)	TK-PA6S	120009	TESTEK	2020.01.22	1 year	☒
75	AMPLIFIER	TK-PA18	150003	TESTEK	2020.01.24	1 year	☒
76	AMPLIFIER	TK-PA1840H	160010-L	TESTEK	2020.01.22	1 year	☒
77	AMPLIFIER	8447D	2944A07881	H.P	2020.01.24	1 year	☐

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3.9 Used Test Cable List

No.	Model	S/N	Manufacturer	Specifications	Cal interval	used
1	SMS112-GL200sD-SMS112-1M	None	GigaLane	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
2	SMS112-GL200sD-SMS112-1M	None	GigaLane	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
3	SMS112-GL200sD-SMS112-1M	None	GigaLane	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
4	L-502W	None	CANARE	9 kHz ~ 3 GHz(1 M)	6 months	☐
5	L-502W	None	CANARE	9 kHz ~ 3 GHz(1 M)	6 months	☐
6	L-502W	None	CANARE	9 kHz ~ 3 GHz(1 M)	6 months	☐
7	SUCOFLEX 126E	MY2202/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
8	SUCOFLEX 126E	MY2203/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☒
9	SUCOFLEX 126E	MY2204/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☒
10	SUCOFLEX 126E	MY2205/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
11	SUCOFLEX 126E	MY2206/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
12	SUCOFLEX 126E	MY2207/26E	SUHNER	9 kHz ~ 26.5 GHz(1 M)	6 months	☐
13	SUCOFLEX 102	MY5433/2	SUHNER	9 kHz ~ 40 GHz(1 M)	6 months	☐
14	SUCOFLEX 102	MY5434/2	SUHNER	9 kHz ~ 40 GHz(1 M)	6 months	☐
15	SUCOFLEX 102	MY5435/2	SUHNER	9 kHz ~ 40 GHz(1 M)	6 months	☐
16	SUCOFLEX 102	MY5436/2	SUHNER	9 kHz ~ 40 GHz(1 M)	6 months	☐
17	SUCOFLEX100	None	SUHNER	9 kHz ~ 26.5 GHz(8 M)	1 year	☒
18	SUCOFLEX102	MY2709/2	SUHNER	9 kHz ~ 40 GHz(5 M)	1 year	☒
19	SUCOFLEX 102	801434/2	SUHNER	9 kHz ~ 40 GHz(2 M)	6 months	☐
20	SUCOFLEX 102	801435/2	SUHNER	9 kHz ~ 40 GHz(2 M)	6 months	☐
21	SUCOFLEX 102	801436/2	SUHNER	9 kHz ~ 40 GHz(2 M)	6 months	☐
22	SUCOFLEX 102	801437/2	SUHNER	9 kHz ~ 40 GHz(2 M)	6 months	☐

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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	☒	Compliance
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.				

Procedure Reference

FCC CFR 47, Part 15. Subpart C-15.247
558074 D01 15.247 Meas Guidance v05
ANSI C 63.10-2013

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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 MHz 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

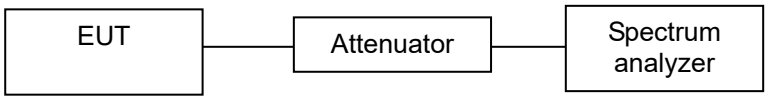
• Ambient temperature : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % R.H.

5.1.3 Measurement Procedure

ANSI C63.10 (2013) : 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	1.17	30	Compliance
38	2 440	1.89	30	Compliance
78	2 480	2.16	30	Compliance

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▣ EDR(π/4DQPSK)

Channel	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Test Results
0	2 402	0.23	30	Compliance
38	2 440	1.02	30	Compliance
78	2 480	0.98	30	Compliance

▣ EDR(8DPSK)

Channel	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Test Results
0	2 402	0.34	30	Compliance
38	2 440	1.08	30	Compliance
78	2 480	1.07	30	Compliance

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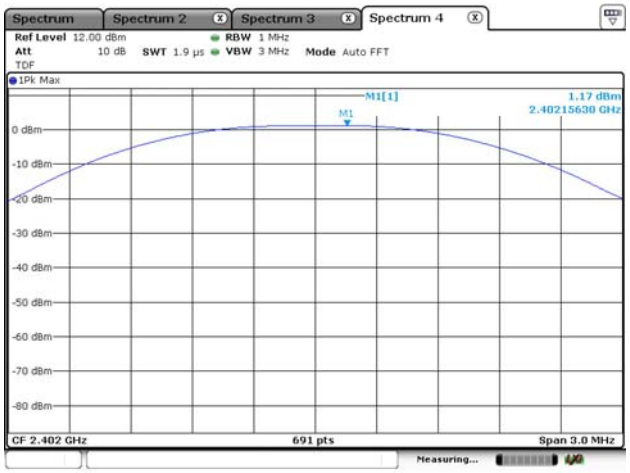
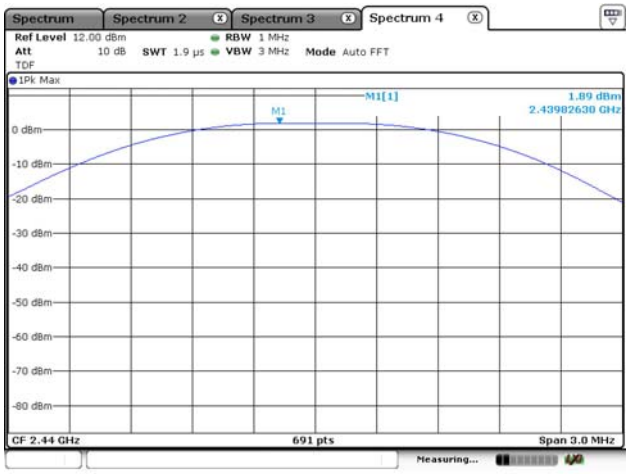
5.1.6 Test Plot

▣ BDR(GFSK)

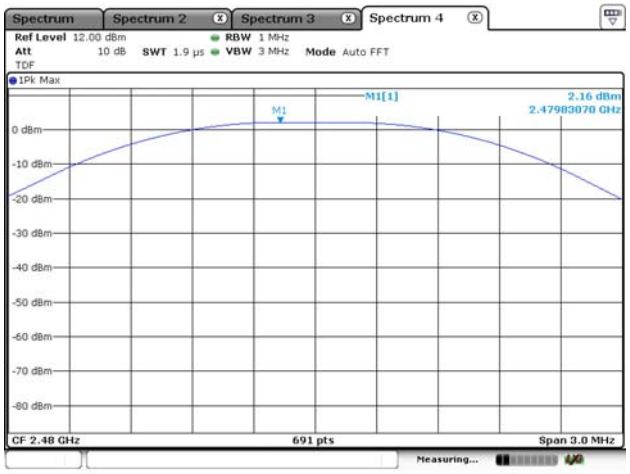
CH Low



CH Middle



CH High



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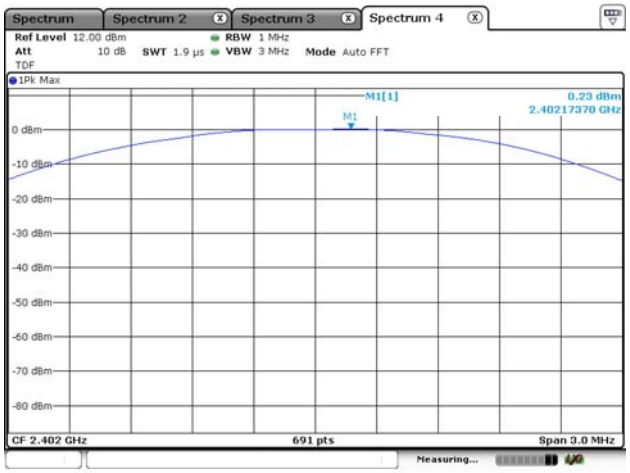
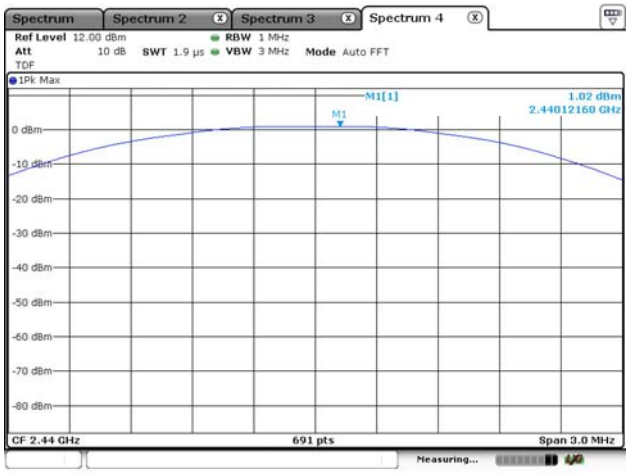
■ EDR(π/4DQPSK)

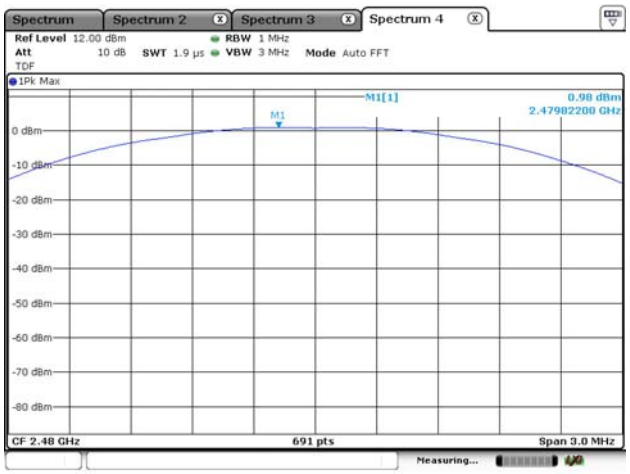
CH Low



CH Middle



CH High



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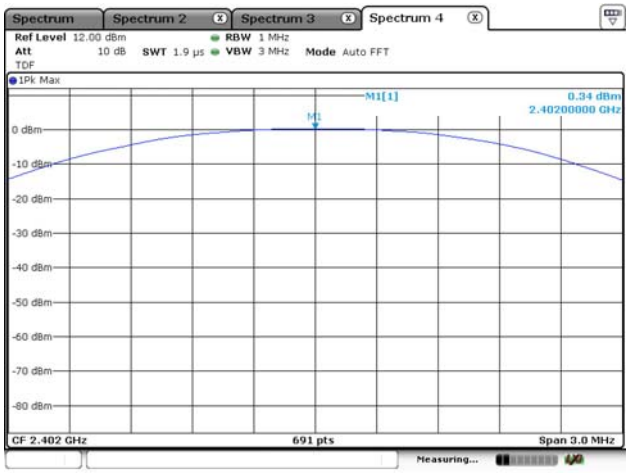
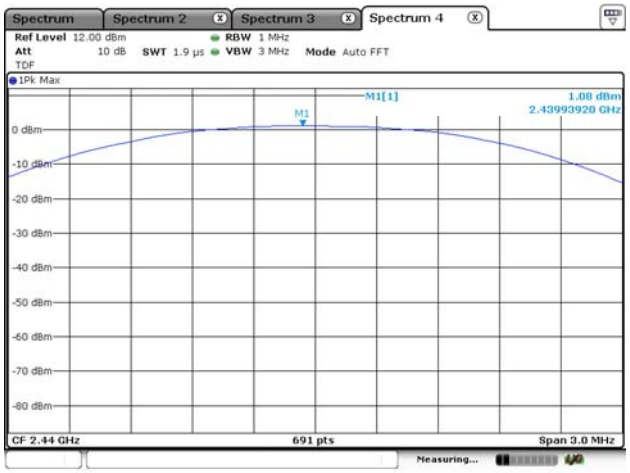
▣ EDR(8DPSK)

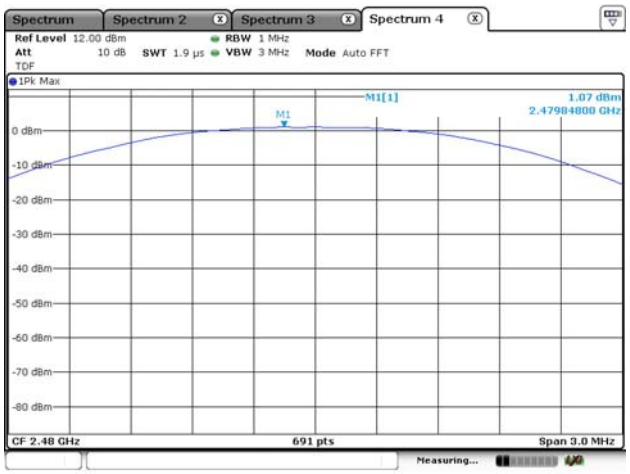
CH Low



CH Middle



CH High



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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

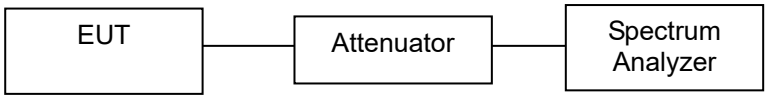
• Ambient temperature : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % R.H.

5.2.3 Measurement Procedure

ANSI C63.10 (2013): 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



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5.2.5 Measurement Result

-Left ear

Modulation Type	Channel	Frequency [MHz]	20 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Limit [MHz]	Test Results
BDR(GFSK)	0	2 402	0.912	0.860	-	Compliance
	38	2 440	0.907	0.855	-	Compliance
	78	2 480	0.907	0.855	-	Compliance
EDR(π/4DQPSK)	0	2 402	1.181	1.168	-	Compliance
	38	2 440	1.237	1.168	-	Compliance
	78	2 480	1.233	1.164	-	Compliance
EDR(8DPSK)	0	2 402	1.203	1.159	-	Compliance
	38	2 440	1.198	1.151	-	Compliance
	78	2 480	1.198	1.146	-	Compliance

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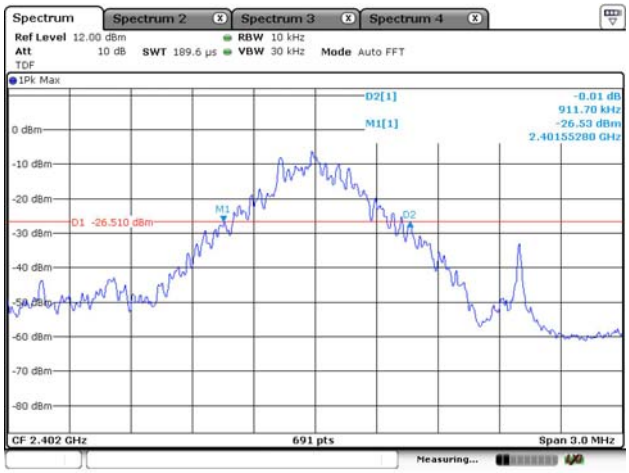
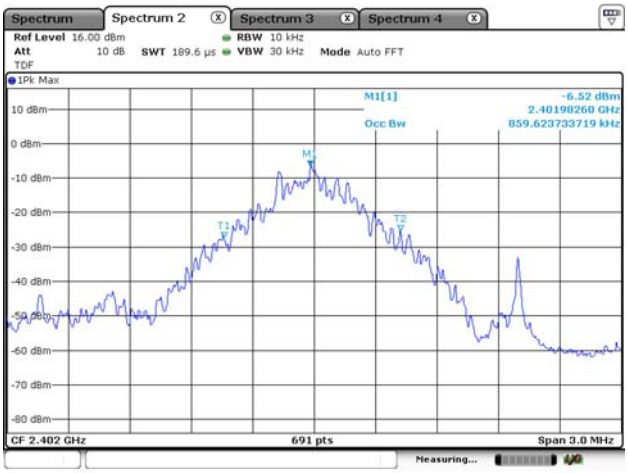
5.2.6 Test Plot

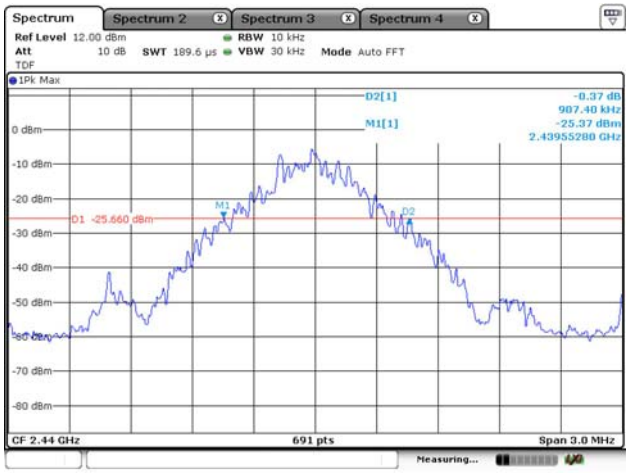
▣ BDR(GFSK)

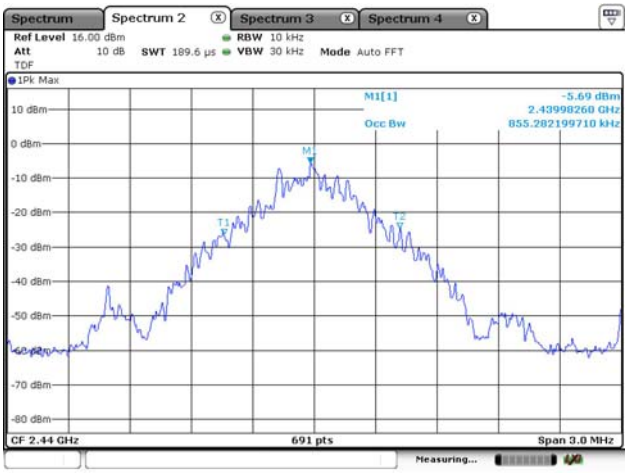
CH Low



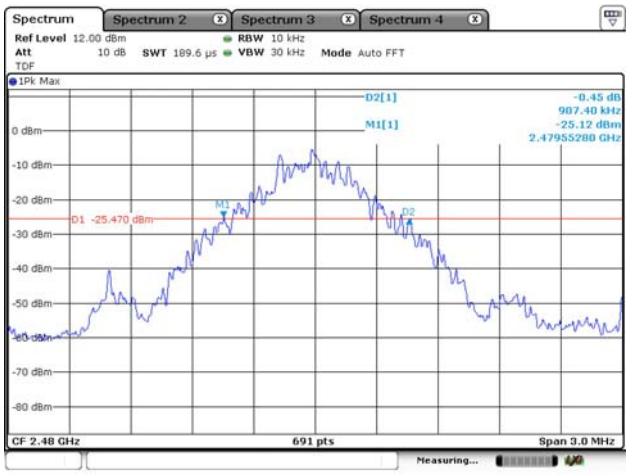


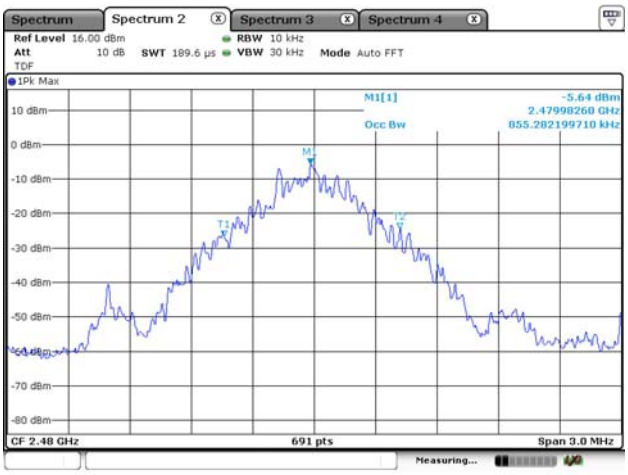
CH Middle





CH High





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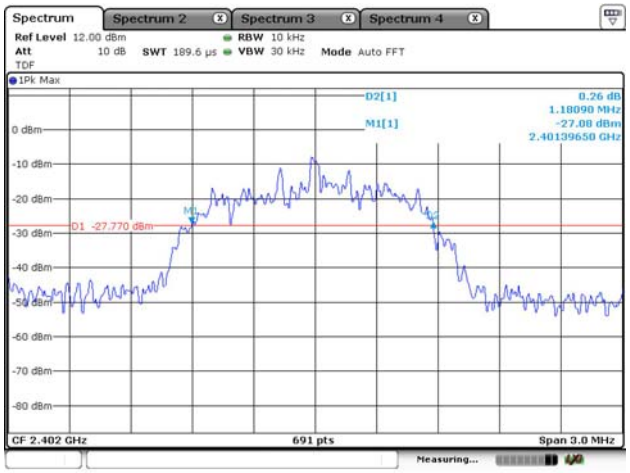
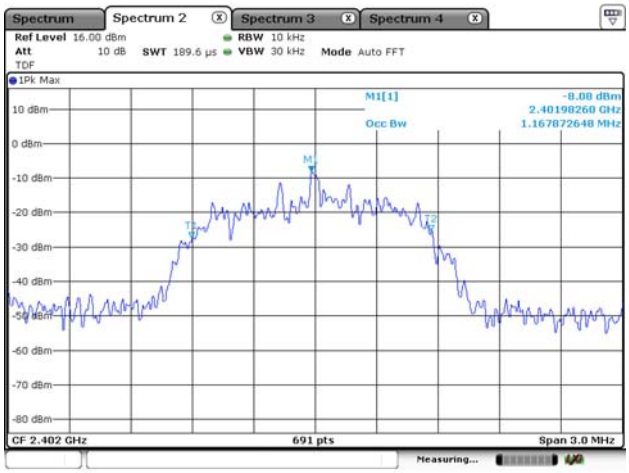
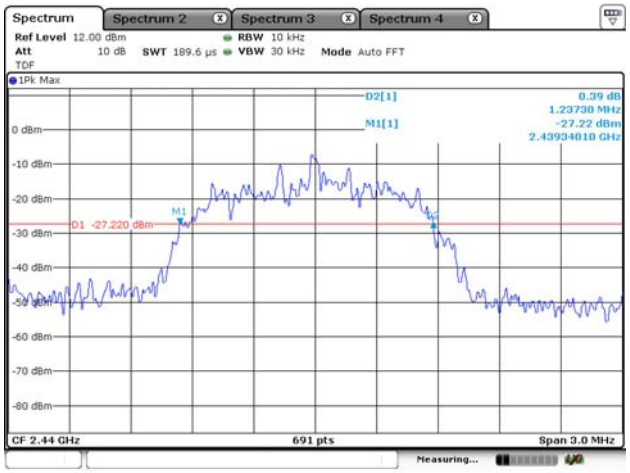
▣ EDR(π/4DQPSK)

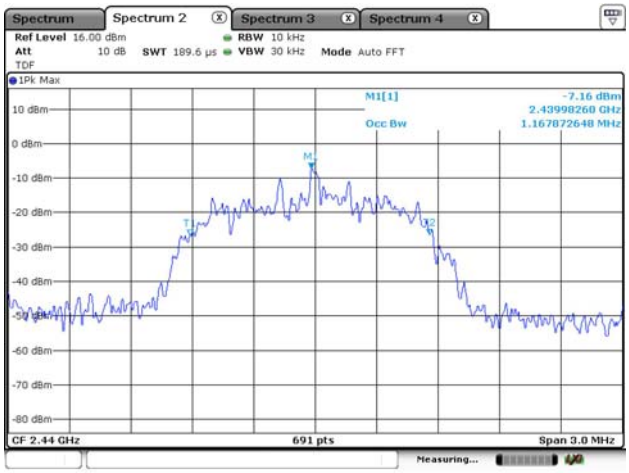
CH Low





CH Middle





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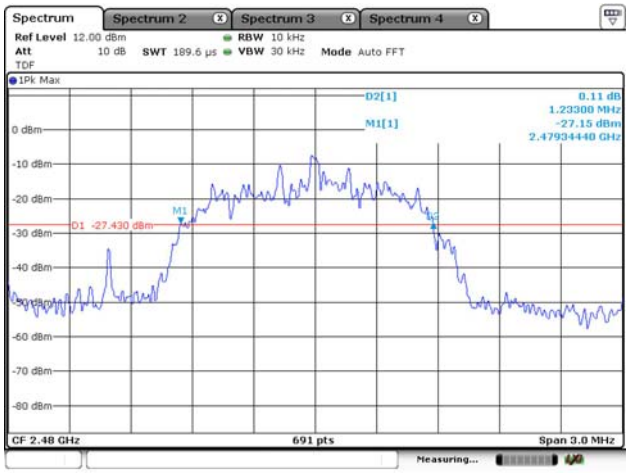

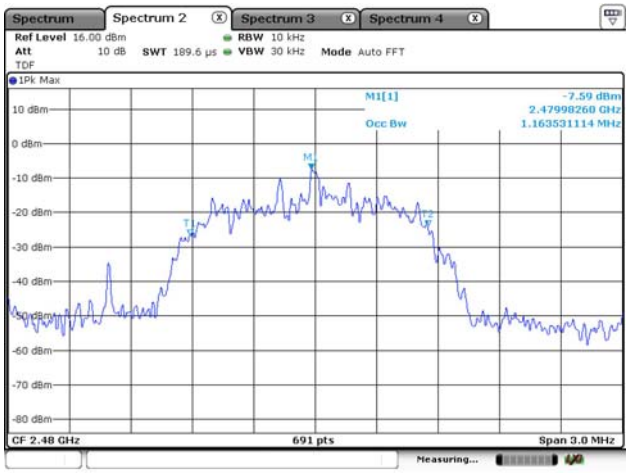

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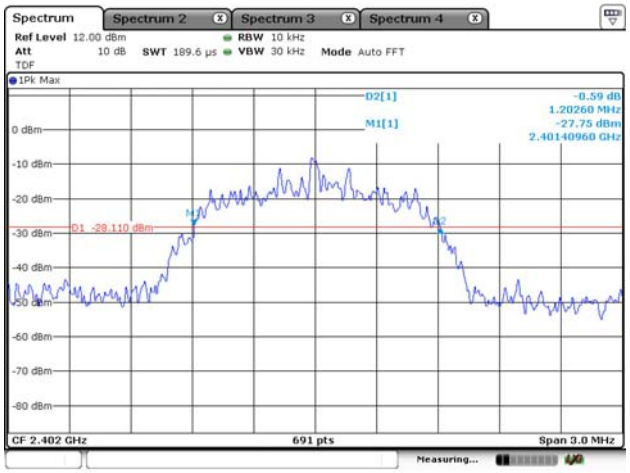
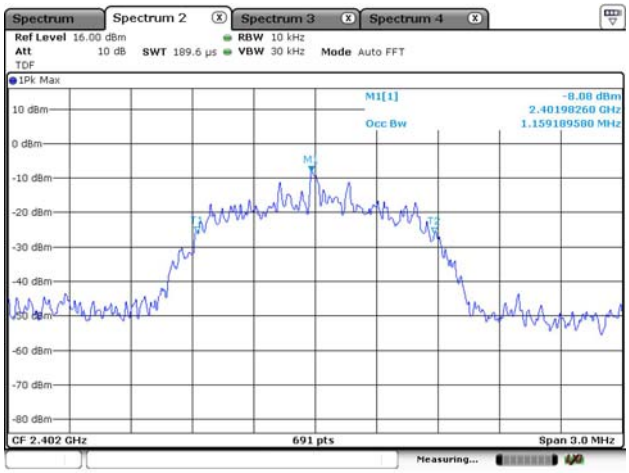
▣ EDR(8DPSK)

CH Low





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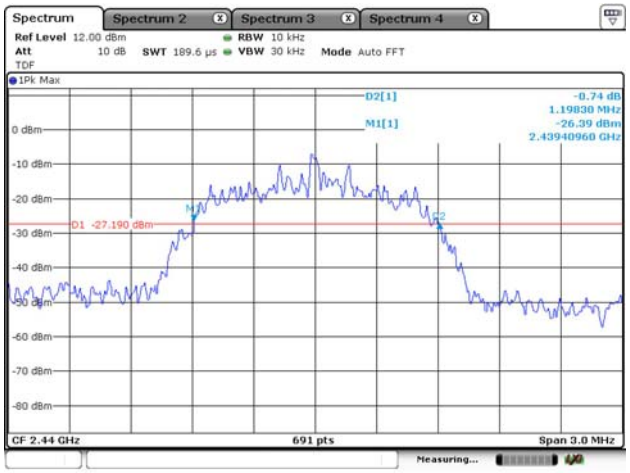
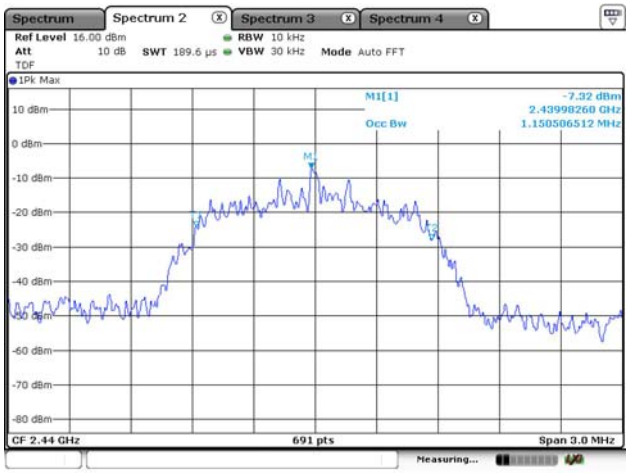
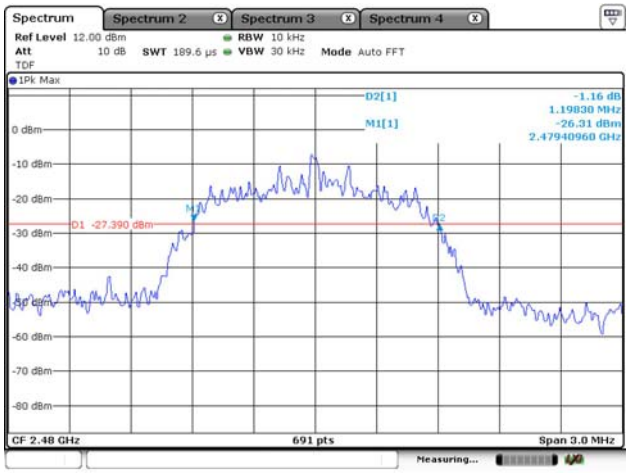
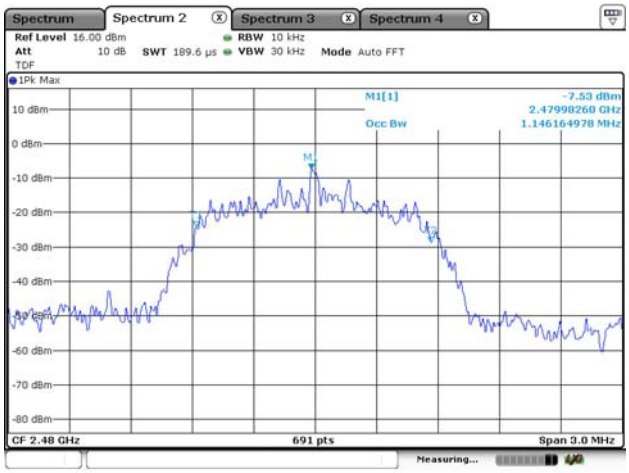




CH High





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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 : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % R.H.

5.3.3 Measurement Procedure

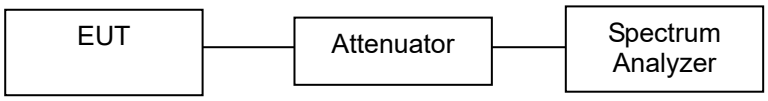
ANSI C63.10 (2013) : Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

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



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5.3.5 Measurement Result

Modulation Type	Channel	Frequency[MHz]	Channel Separation(MHz)	Limit(MHz)	Test Results
BDR(GFSK)	00	2 402	0.999	≥0.608	Compliance
	38	2 440	1.003	≥0.605	Compliance
	78	2 480	0.999	≥0.605	Compliance
EDR(π/4DQPSK)	00	2 402	0.999	≥0.787	Compliance
	38	2 440	0.999	≥0.825	Compliance
	78	2 480	1.004	≥0.822	Compliance
EDR(8DPSK)	00	2 402	1.003	≥0.802	Compliance
	38	2 440	0.999	≥0.799	Compliance
	78	2 480	0.999	≥0.799	Compliance

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

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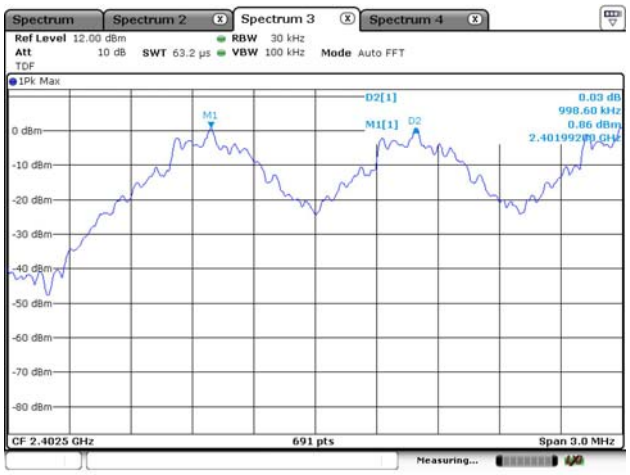
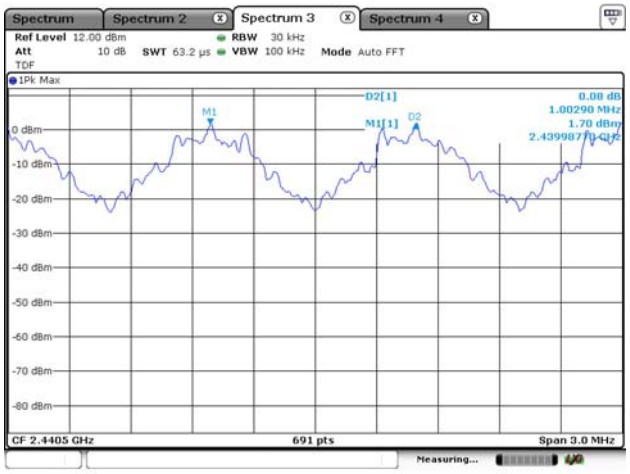
5.3.6 Test plot

▣ BDR(GFSK)

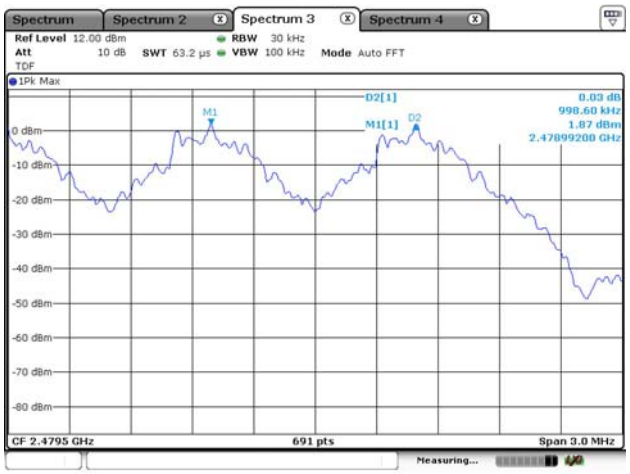
Channel 00



Channel 38



Channel 78



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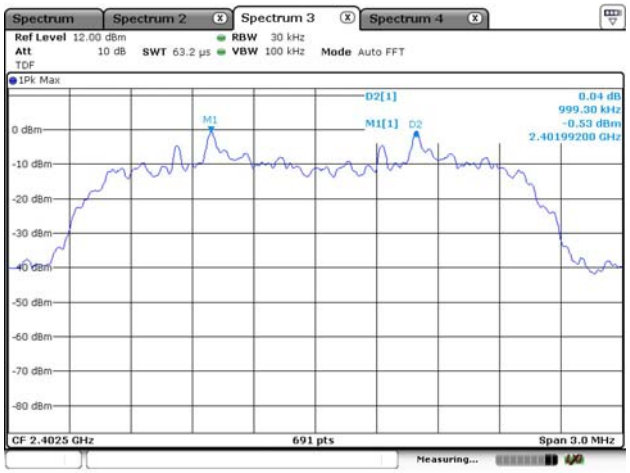
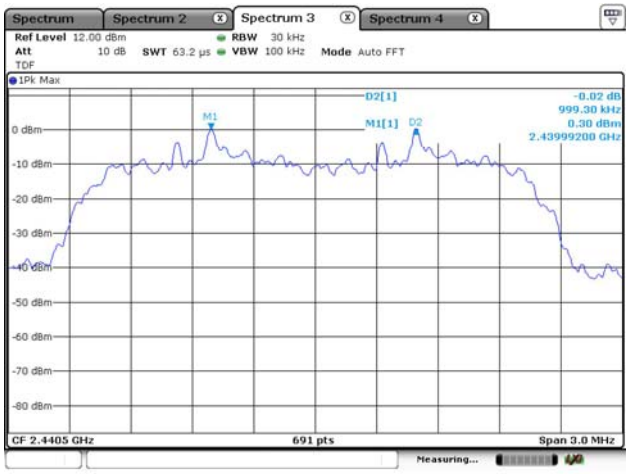
■ EDR(π/4DQPSK)

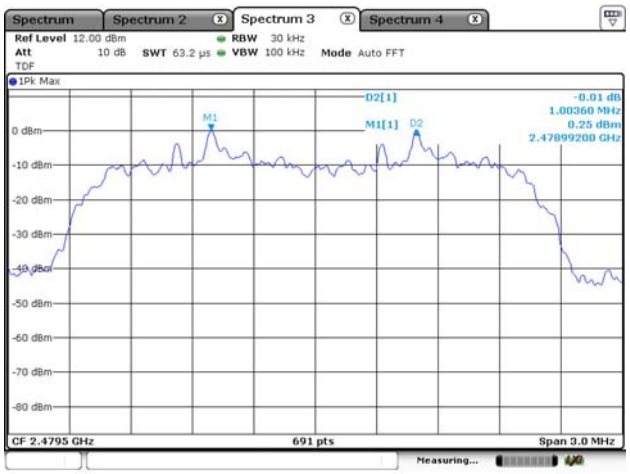
Channel 00



Channel 38



Channel 78



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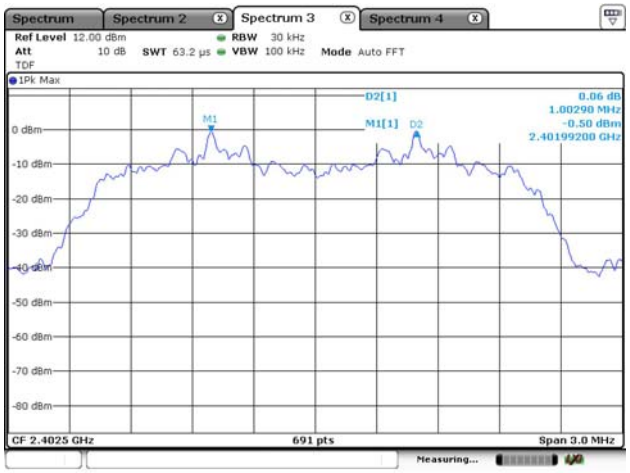
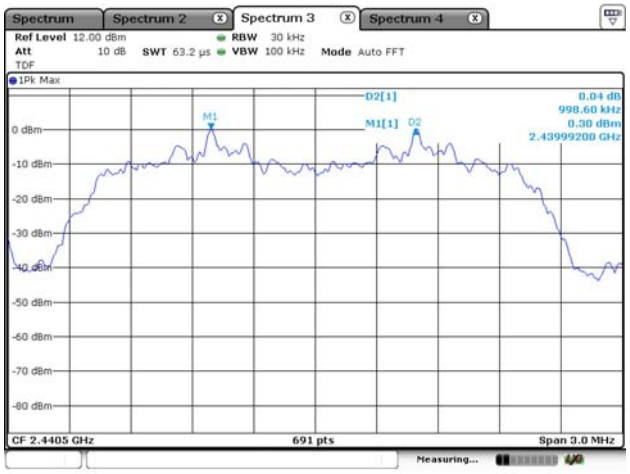
▣ EDR(8DPSK)

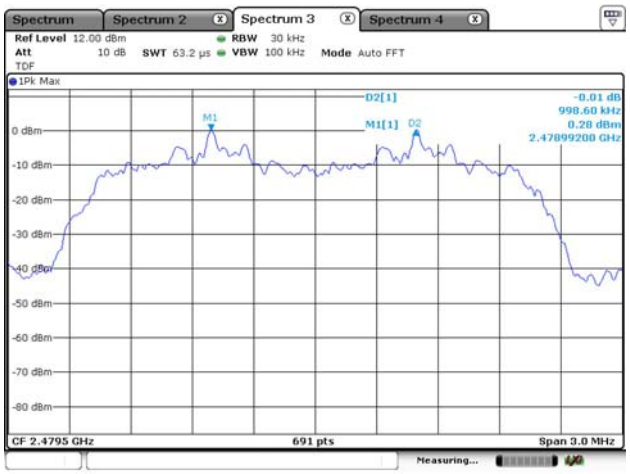
Channel 00



Channel 38



Channel 78



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5.4 Number of Hopping Channels

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

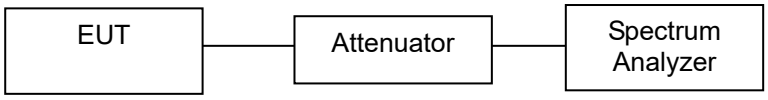
5.4.2 Test Environment conditions

• Ambient temperature : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % 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

-Left ear

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

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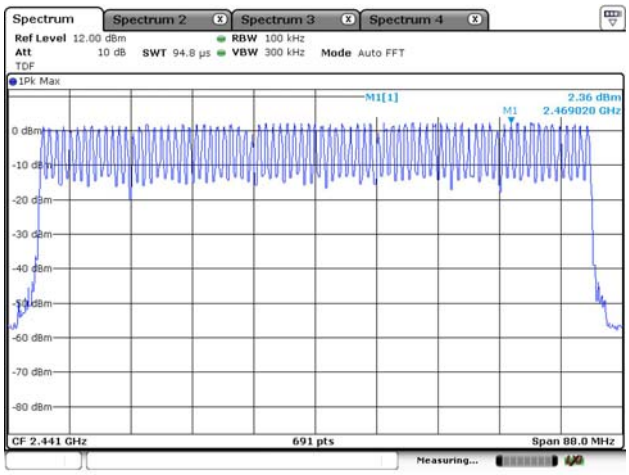
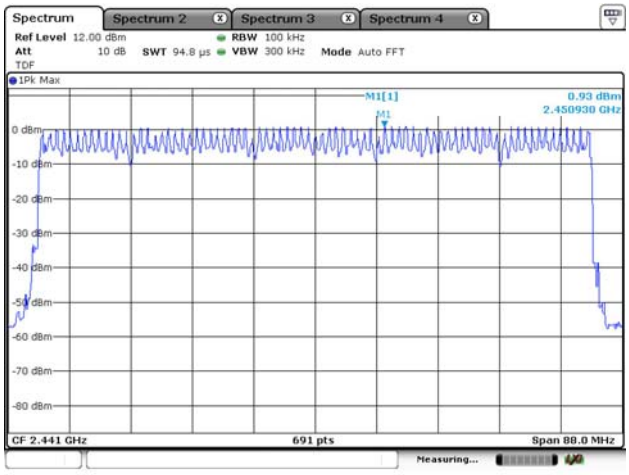
5.4.6 Test plot

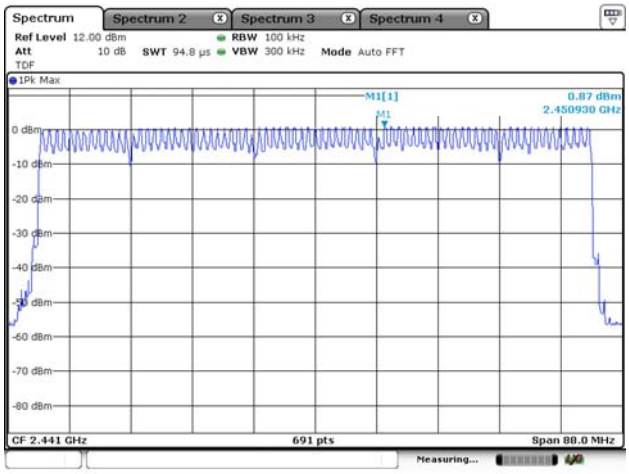
▣ BDR(GFSK)



▣ EDR(π/4DQPSK)



▣ EDR(8DPSK)



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5.5 Time of Occupancy

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

(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

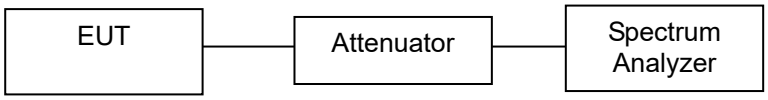
- Ambient temperature : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % R.H.

5.5.3 Measurement Procedure

ANSI C63.10 (2013) : 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



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5.5.5 Measurement Result

Burst width per one hop (ms) (Time slot)			Test Results		
			Dwell time (ms)	Limit	Result
BDR(GFSK)	DH1	0.399	0.128	≤ 0.4	Compliance
	DH3	1.645	0.263	≤ 0.4	Compliance
	DH5	2.906	0.310	≤ 0.4	Compliance
EDR(π/4DQPSK)	2DH1	0.406	0.130	≤ 0.4	Compliance
	2DH3	1.652	0.264	≤ 0.4	Compliance
	2DH5	2.891	0.308	≤ 0.4	Compliance
EDR(8DPSK)	3DH1	0.406	0.130	≤ 0.4	Compliance
	3DH3	1.667	0.267	≤ 0.4	Compliance
	3DH5	2.906	0.310	≤ 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

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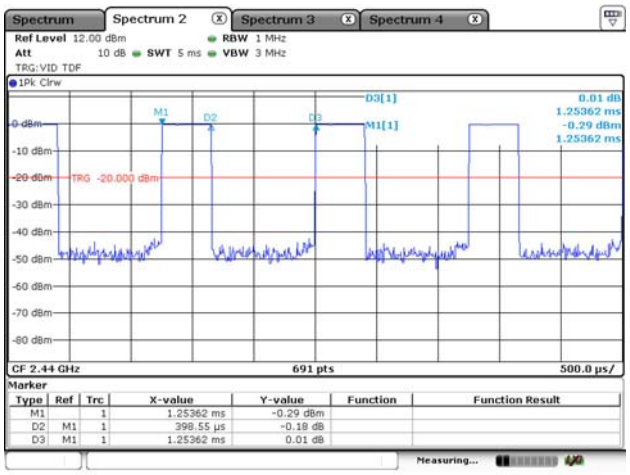
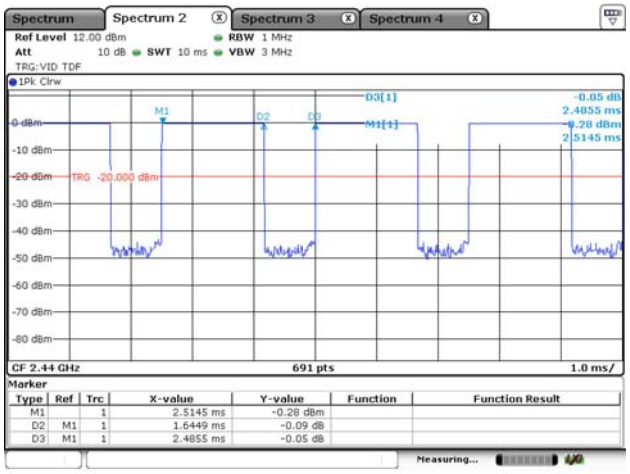
5.5.6 Test plot

▣ BDR(GFSK)

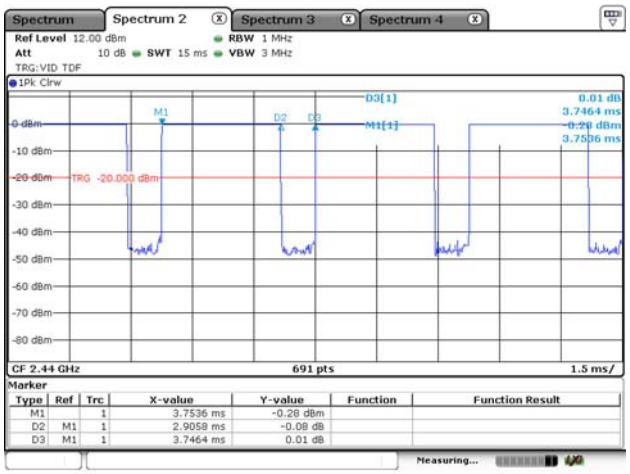
DH1



DH3



DH5



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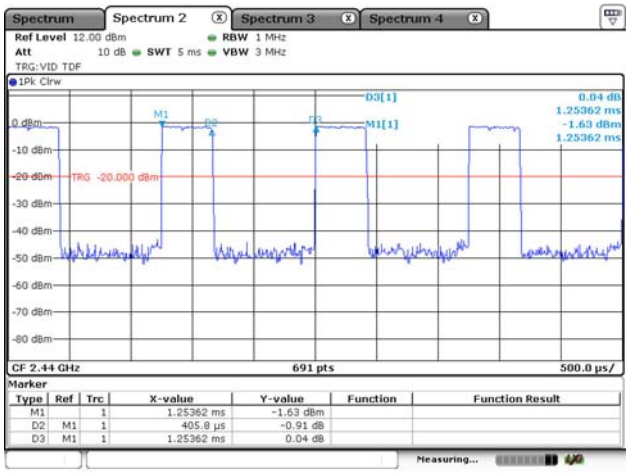
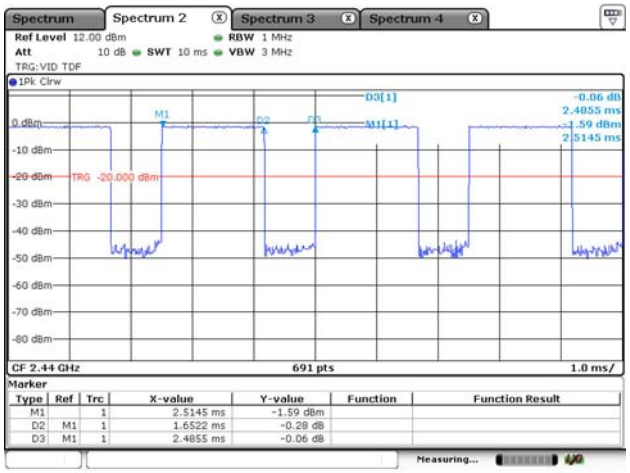
■ EDR(π/4DQPSK)

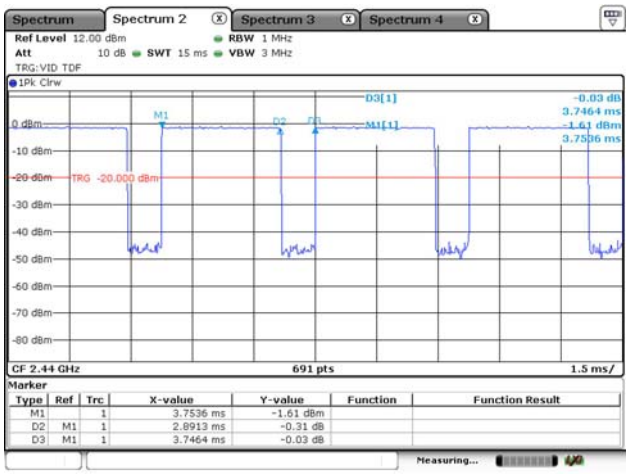
2DH1



2DH3



2DH5



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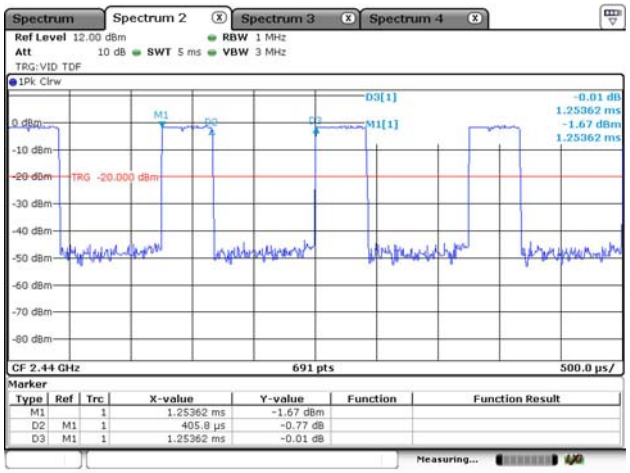
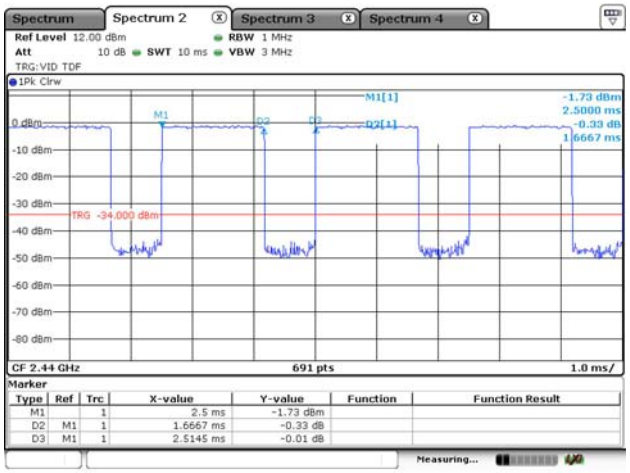
▣ EDR(8DPSK)

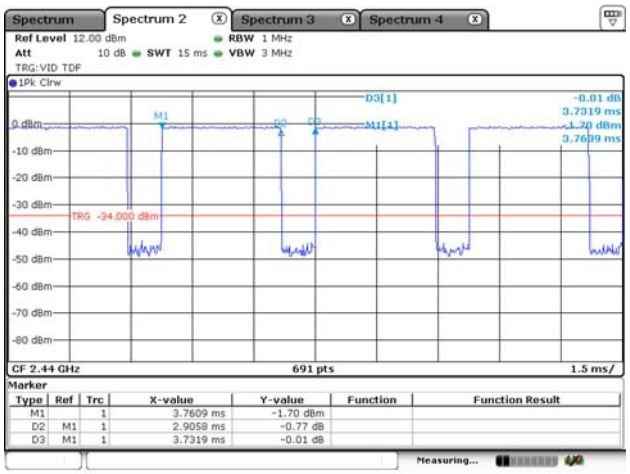
3DH1



3DH3



3DH5



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5.6 Conducted Spurious Emissions (Band-edge)

5.6.1 Standard Applicable [FCC §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 RF conducted.

5.6.2 Test Environment conditions

• Ambient temperature : (23 ~ 24) ℃ • Relative Humidity : (55 ~ 58) % R.H.

5.6.3 Measurement Procedure

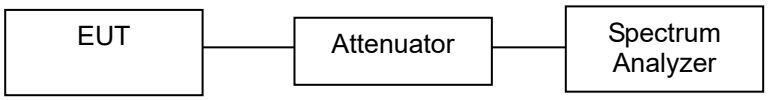
ANSI C63.10 (2013) : Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

(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	-46.16	-47.91	≤ 20 than PSD level	Compliance
	CH 78	-55.96	-56.62		Compliance
EDR(π/4DQPSK)	CH 0	-45.89	-45.79		Compliance
	CH 78	-53.97	-55.48		Compliance
EDR(8DPSK)	CH 0	-46.32	-46.17		Compliance
	CH 78	-54.68	-56.05		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.

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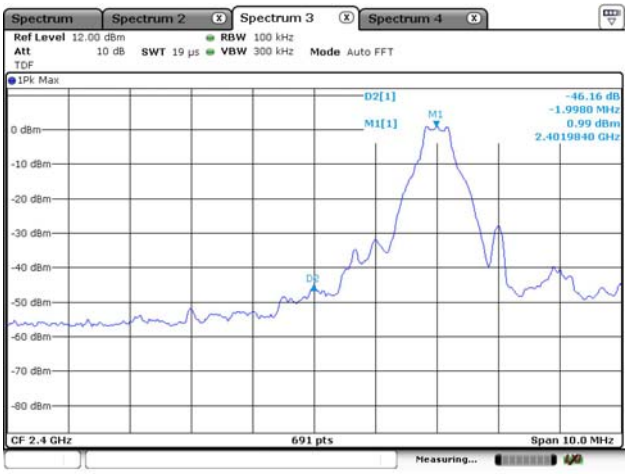
5.6.6 Test Plot (Band-edge)

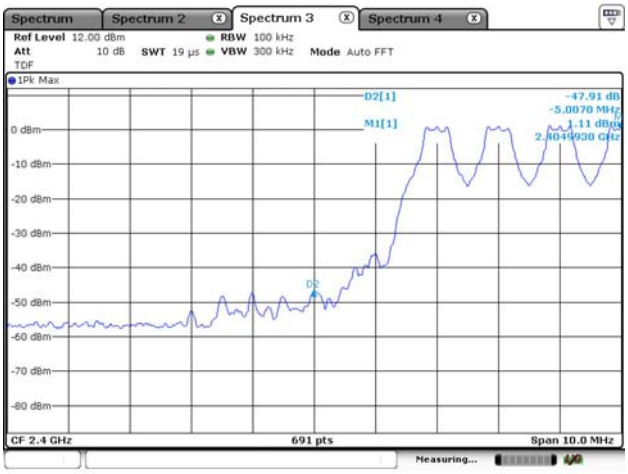
▣ BDR(GFSK)

CH Low

Hop off

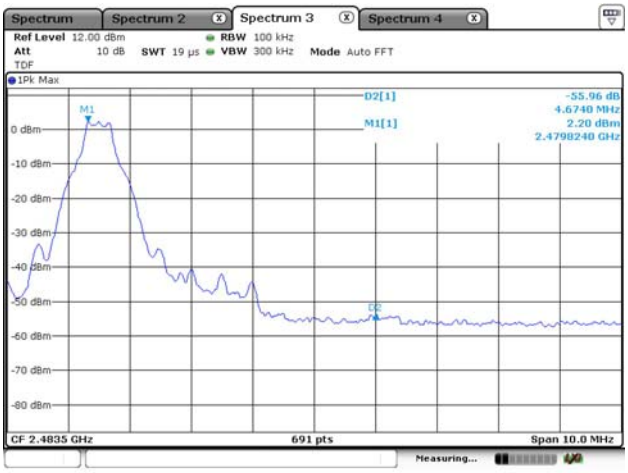


Hop on

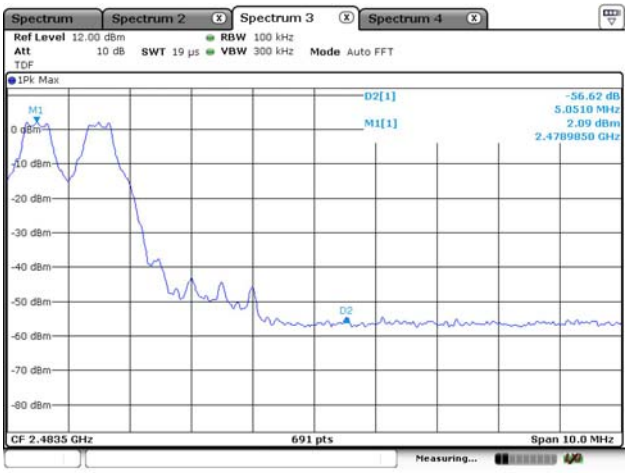


CH High

Hop off



Hop on



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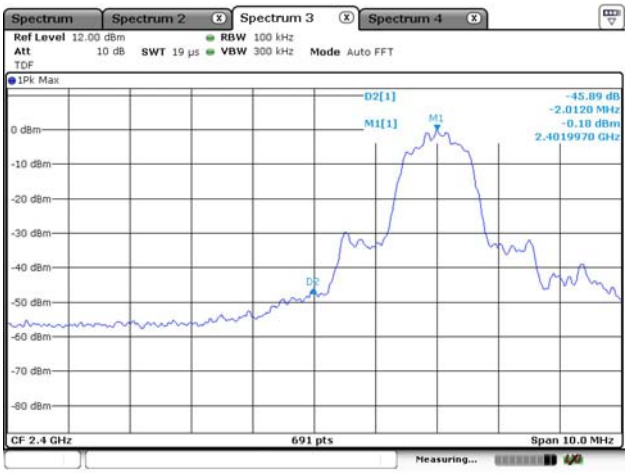
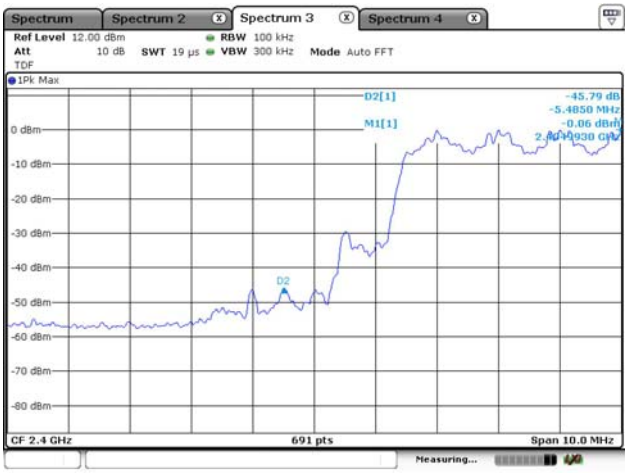
■ EDR(π/4DQPSK)

CH Low

Hop off

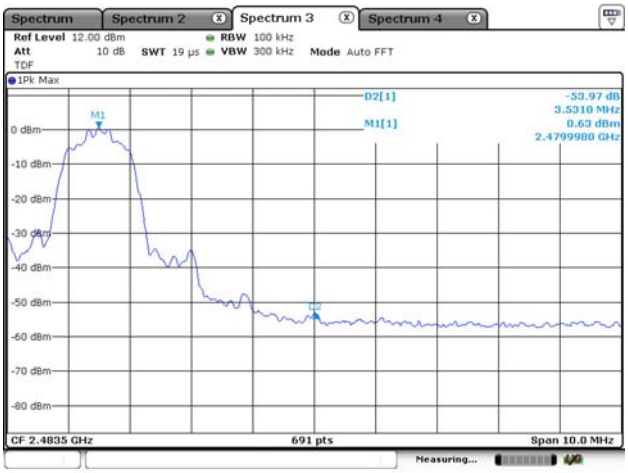


Hop on

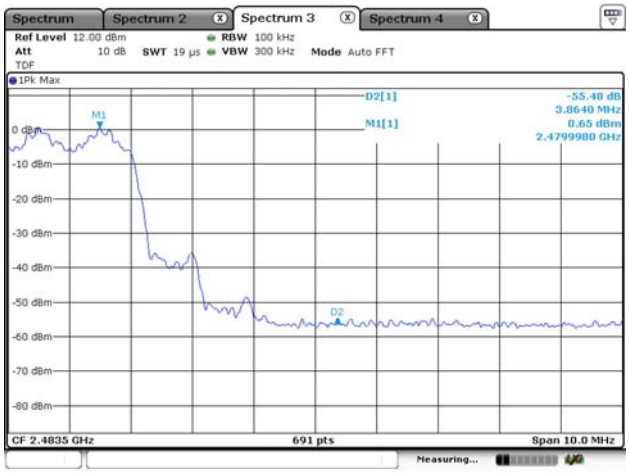


CH High

Hop off



Hop on



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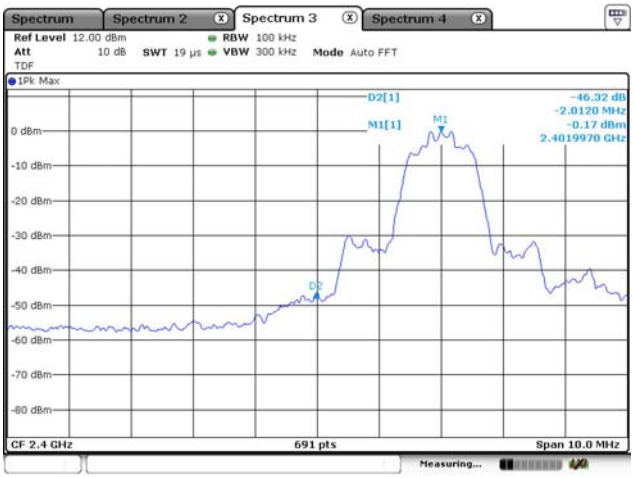
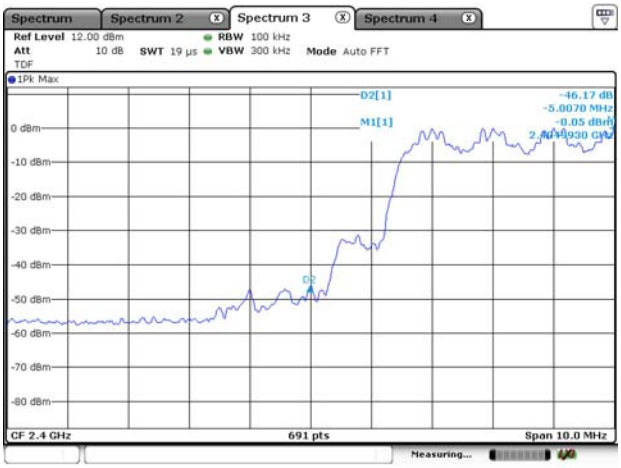
▣ EDR(8DPSK)

CH Low

Hop off

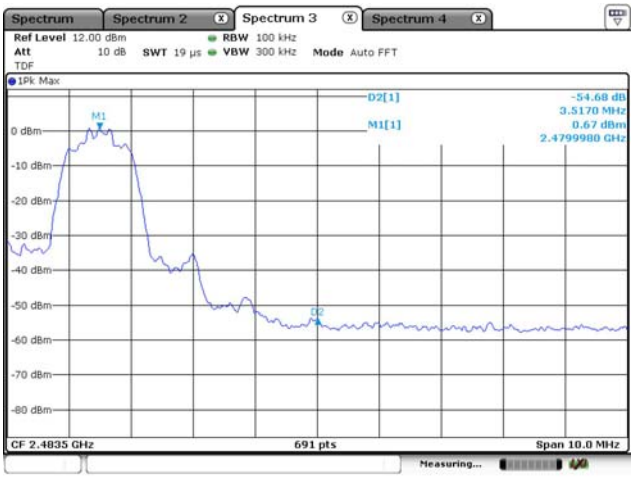


Hop on

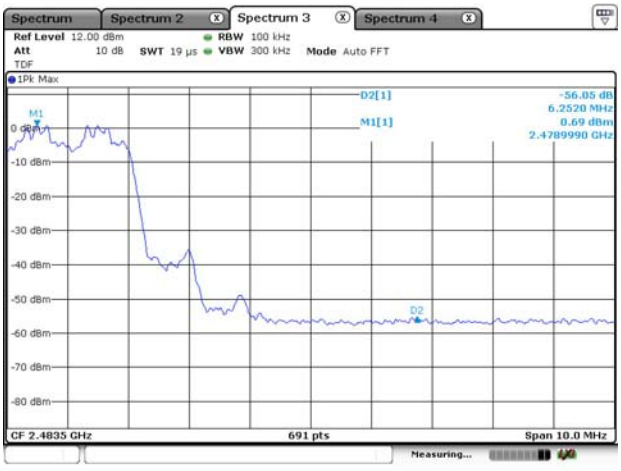


CH High

Hop off



Hop on



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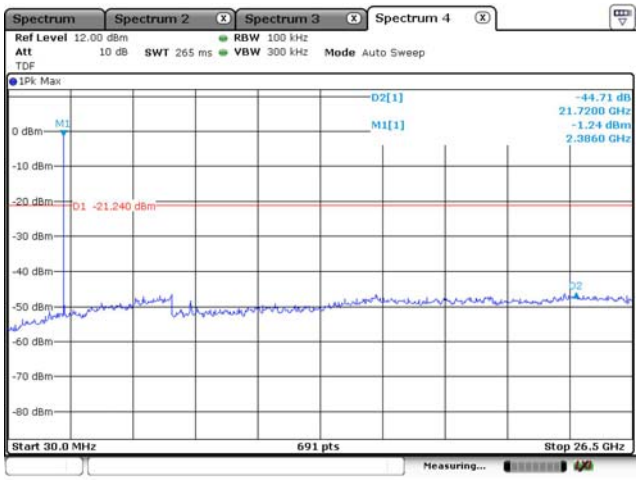
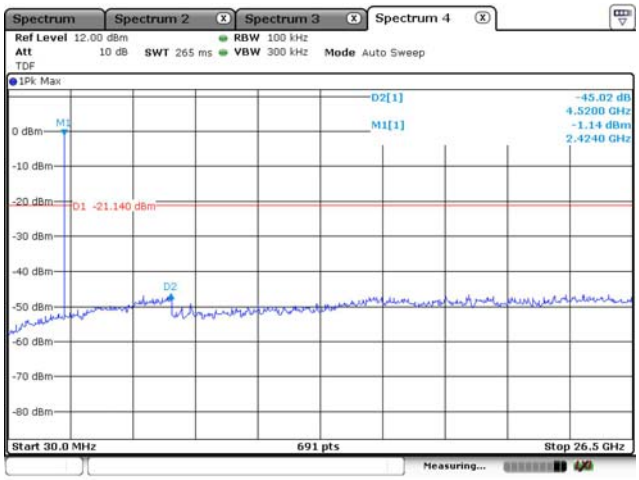
Test Plot (Conducted spurious emissions)

▣ BDR(GFSK)

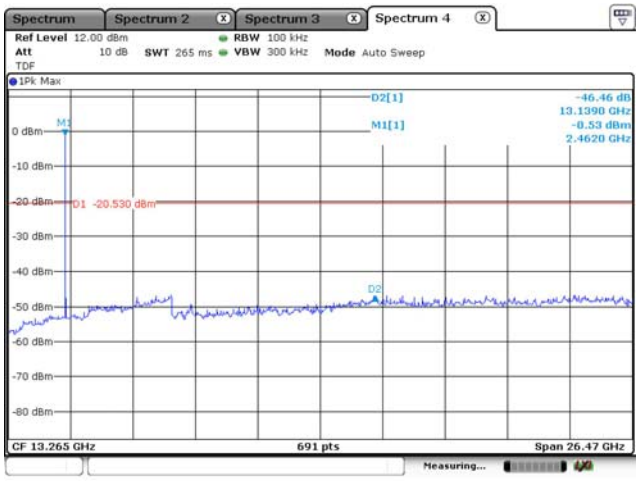
CH Low



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

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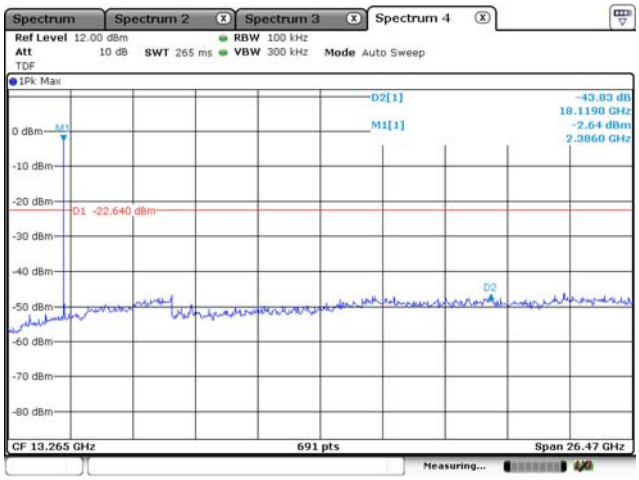
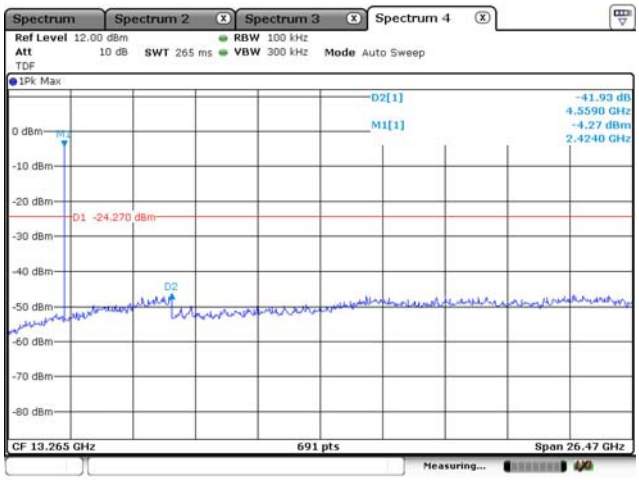
▣ EDR(π/4DQPSK)

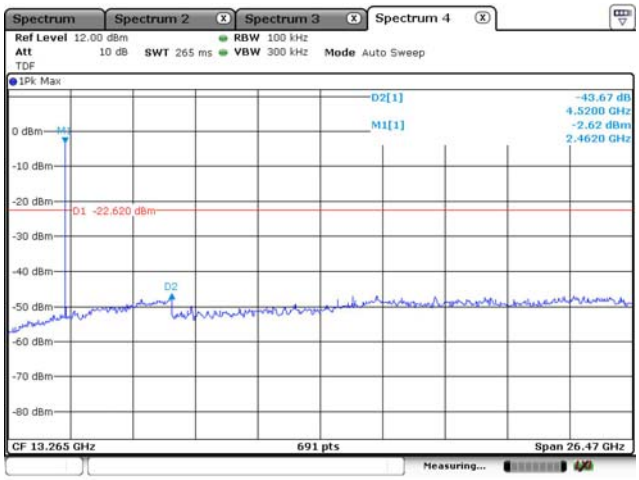
CH Low



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

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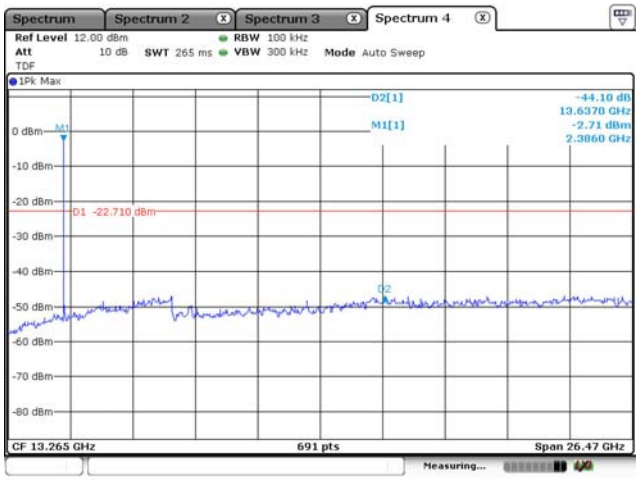
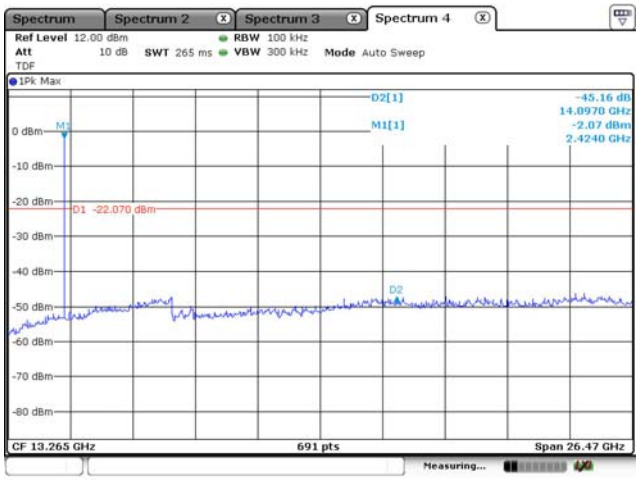
▣ EDR(8DPSK)

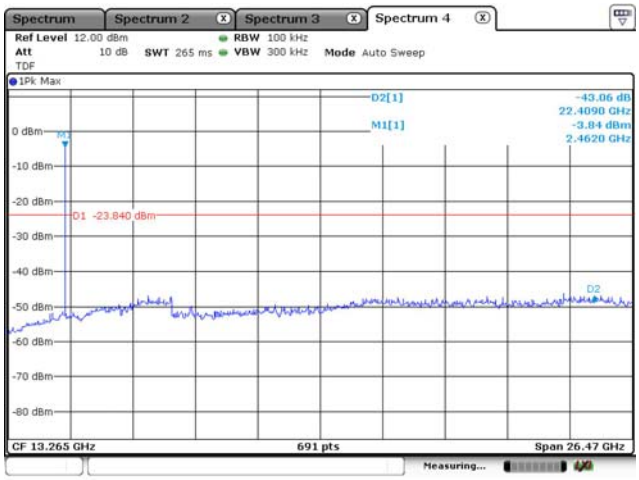
CH Low



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

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5.7 Spurious RF Radiated emissions

5.7.1 Standard Applicable [FCC §15.247(d)]

FCC

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 and RSS-Gen 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

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5.7.2 Test Environment conditions

- Ambient temperature : (22 ~ 24) ℃ • Relative Humidity : (56 ~ 59) % 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 GHz and 1.5 meters for above 1 GHz) 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(dBμV/m) = Reading(dBμV) + Antenna factor(dB/m)+ CL(dB) + other applicable factor (dB)
- The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for RMS Average (Duty cycle < 98 %) for Average detection (AV) at frequency above 1 GHz, 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 MHz and the video bandwidth is 10 Hz (Duty cycle ≥ 98 %) for Average detection (AV) at frequency above 1 GHz.
- According to §15.33 (a)(1), Frequency range of radiated measurement is performed the tenth harmonic.

Above test was performed in accordance with ANSI C63.10-2013 Section 6.10.5 & 6.4, 6.5, 6.6

5.7.4 Measurement Uncertainty

Radiated Emission measurement: Below 1 GHz: 3.66 dB (CL: Approx 95 %, k=2)
Above 1 GHz: 4.04 dB (CL: Approx 95 %, k=2)

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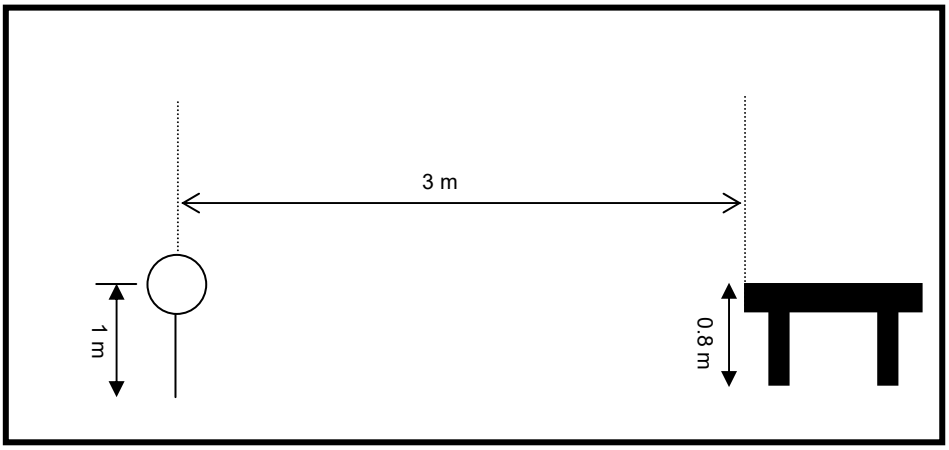
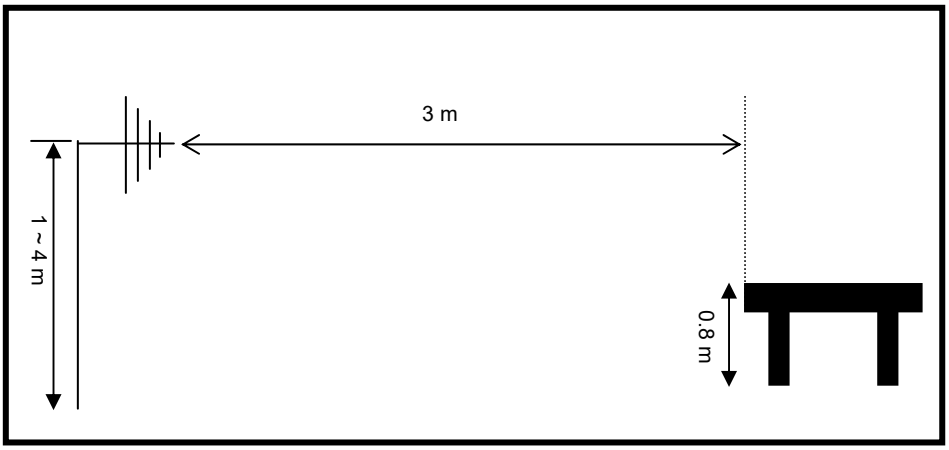
5.7.5 Test Configuration

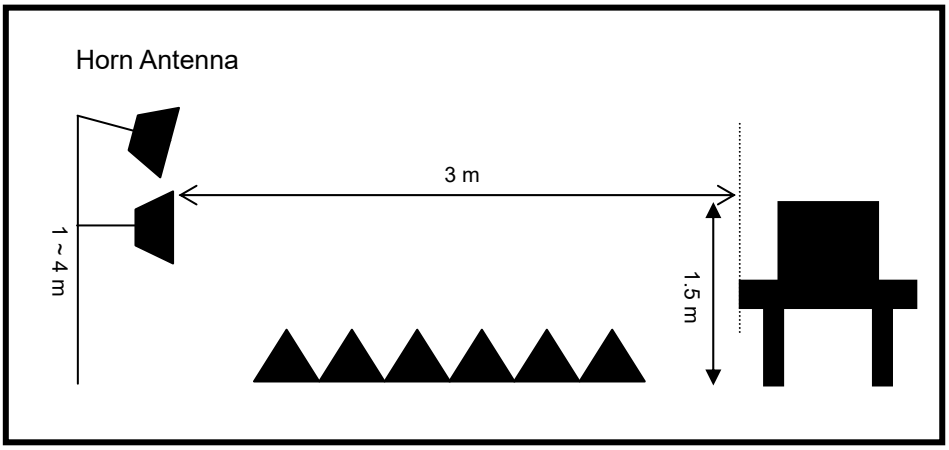
Radiated emission setup, below 30 MHz



Radiated emission setup, below 1 000 MHz



Radiated emission setup, above 1 GHz



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5.7.6 Measurement Result

After having pre-scan all modulation mode, found the BDR(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	
2.376*	47.11	36.06	180	1.0	H	28.28	7.59	-41.93	41.05	30.00	74	54	32.95	24.00	Compliance
2.381*	47.12	34.39	180	1.0	V	28.31	7.59	-41.94	41.07	28.34	74	54	32.93	25.66	Compliance

* Band-edge emissions.

CH Middle (2 440 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*	50.88	38.73	180	1.0	H	28.58	8.07	-42.26	45.27	33.12	74	54	28.73	20.88	Compliance
2.492*	51.50	39.18	180	1.0	V	28.58	8.07	-42.26	45.89	33.57	74	54	28.11	20.43	Compliance

* Restrict band & Band-edge 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.

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▣ Below 1 GHz

Freq. (MHz)	Reading (dBμV/m)	Table (Deg)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn (dB)	Result
			Height (m)	Pol. (H/V)	Fctr. (dB/m)						
46.08	66.83	180	1.5	V	9.95	0.81	-42.14	35.45	40.0	4.55	Compliance
122.89	66.26	270	1.0	V	7.38	1.43	-41.96	33.11	43.5	10.39	Compliance
260.03	56.90	150	1.5	H	12.96	2.17	-41.38	30.65	46.0	15.35	Compliance
368.76	52.53	127	2.3	H	16.15	2.72	-41.02	30.38	46.0	15.62	Compliance
417.82	52.62	128	3.1	H	16.97	2.91	-40.83	31.68	46.0	14.32	Compliance
700.22	43.85	160	1.0	V	22.00	3.80	-39.18	30.47	46.0	15.53	Compliance

Freq.(㎒) : Measurement frequency, Reading(dBμV/m) : Indicated value for test receiver, Table (Deg) : Directional degree of Turn table
Antenna (Height, Pol, Fctr) : Antenna Height, Polarization and Factor, Cbl(㏈) : Cable loss, Pre AMP(㏈) : Preamplifier gain(㏈)
Meas Result (dBμV/m) :Reading(dBμV/m)+ Antenna factor.(dB/m)+ CL(㏈) - Pre AMP(㏈)
Limit(dBμV/m): Limit value specified with FCC Rule, Mgn(㏈) : FCC Limit (dBμV/m) − Meas Result(dBμV/m)

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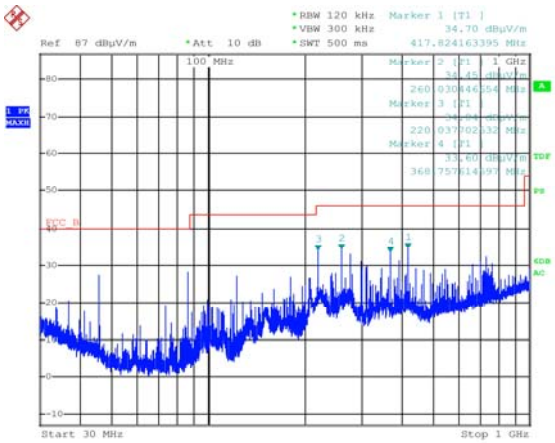
5.7.7 Plots

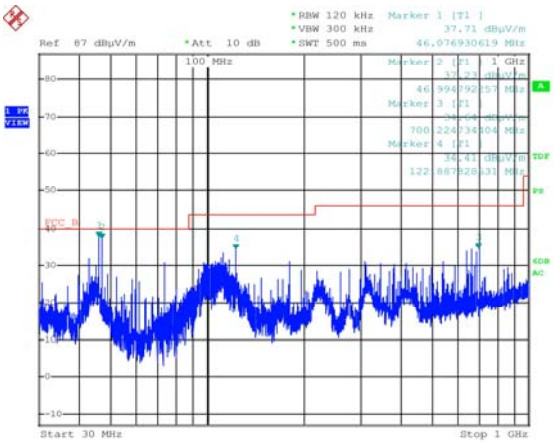
*The worst case only.

▪ Below 1 GHz

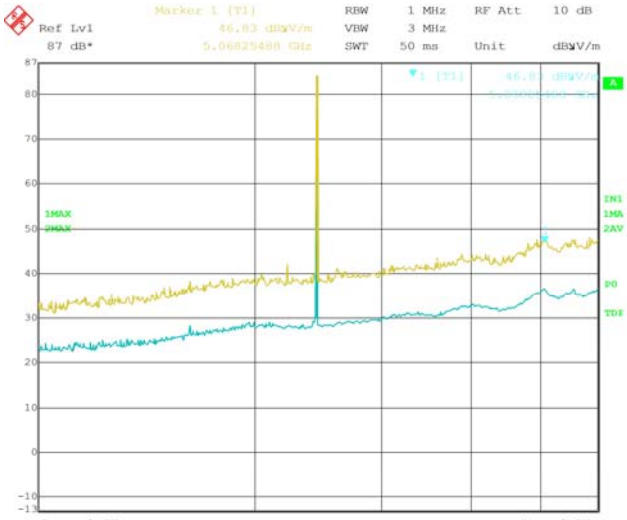
Horizontal

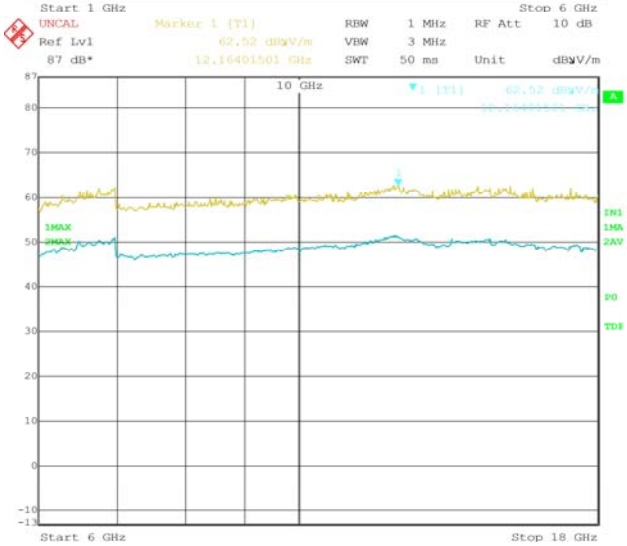


Vertical



▪ Above 1 GHz





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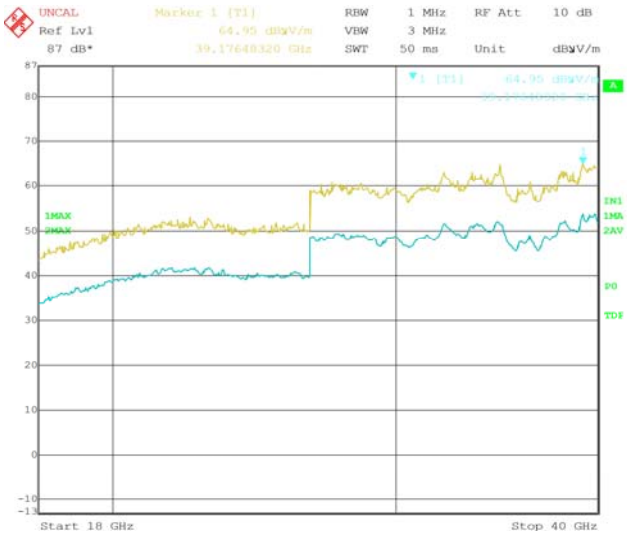

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5.8 Antenna requirement

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.

The manufacturer may design the unit so that broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

5.8.2 Antenna details

Frequency Band	Antenna Type	Gain [dBi]	Results
2.4 GHz	External Dipole antenna(R-SMA)	3.05 dBi	Compliance

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5.9 AC Power Conducted emissions

5.9.1 Standard Applicable [FCC §15.207(a)]

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 ~ 24) ℃ • Relative Humidity : (56 ~ 59) % 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	2020. 01. 22	1 year	☒
Pulse Limiter	ESH3-Z2	100097	Rohde & Schwarz	2020. 01. 22	1 year	☒
LISN	ESH2-Z5	100044	R&S	2020. 01. 22	1 year	☐
	ESH3-Z5	100147	R&S	2020. 01. 22	1 year	☒

*Test Program: " ESXS-K1 V2.2"

Measurement uncertainty
0.15 ~ 30 MHz : ±3.34 (CL: Approx 95 %, *k*=2)

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5.9.5 Measurement Result

Freq.	Factor [dB]		POL	QP			CISPR AV		
				Limit	Reading	Result	Limit	Reading	Result
[MHz]	LISN	CABLE +P/L		[dBμV]	[dBμV]	[dBμV]	[dBμV]	[dBμV]	[dBμV]
0.713	0.09	10.04	L	56.00	47.39	47.48	46.00	32.58	32.67
1.150	0.10	10.07	L	56.00	38.40	38.50	46.00	28.58	28.68
2.775	0.14	10.10	L	56.00	35.91	36.05	46.00	29.87	30.01
4.338	0.19	10.16	L	56.00	33.44	33.63	46.00	28.65	28.84
7.338	0.32	10.32	L	60.00	30.58	30.90	50.00	25.49	25.81
27.650	0.81	10.70	L	60.00	37.08	37.89	50.00	37.89	38.70
0.713	0.10	10.04	N	56.00	48.53	48.63	46.00	33.86	33.96
1.150	0.11	10.07	N	56.00	39.31	39.42	46.00	29.38	29.49
2.025	0.13	10.07	N	56.00	34.46	34.59	46.00	26.65	26.78
5.588	0.23	10.23	N	60.00	35.46	35.69	50.00	28.35	28.58
8.713	0.32	10.35	N	60.00	37.45	37.77	50.00	29.55	29.87
27.650	0.73	10.70	N	60.00	37.36	38.09	50.00	38.20	38.93

* 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

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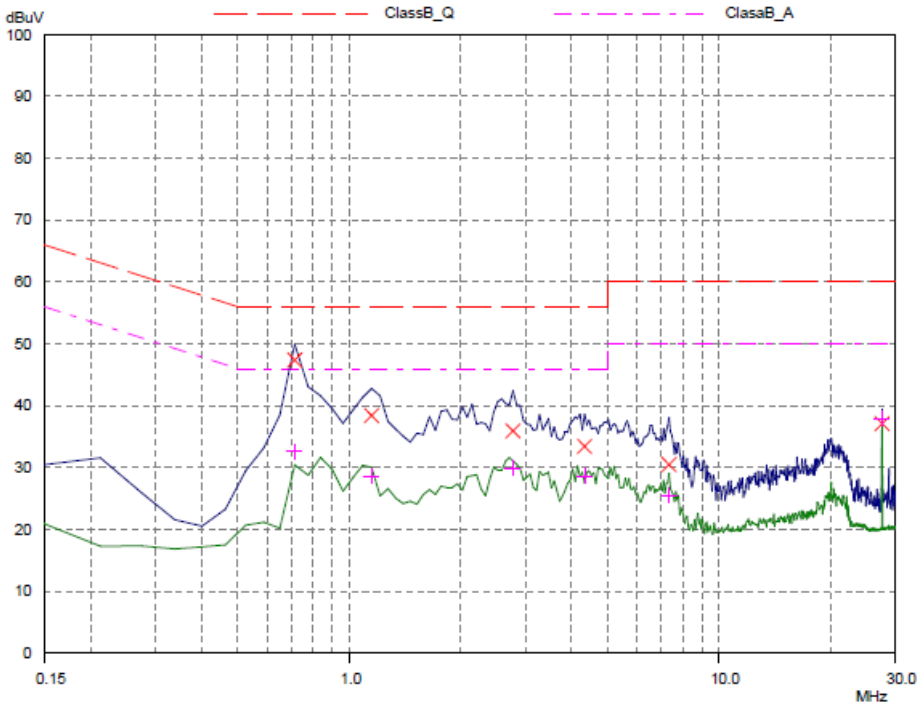
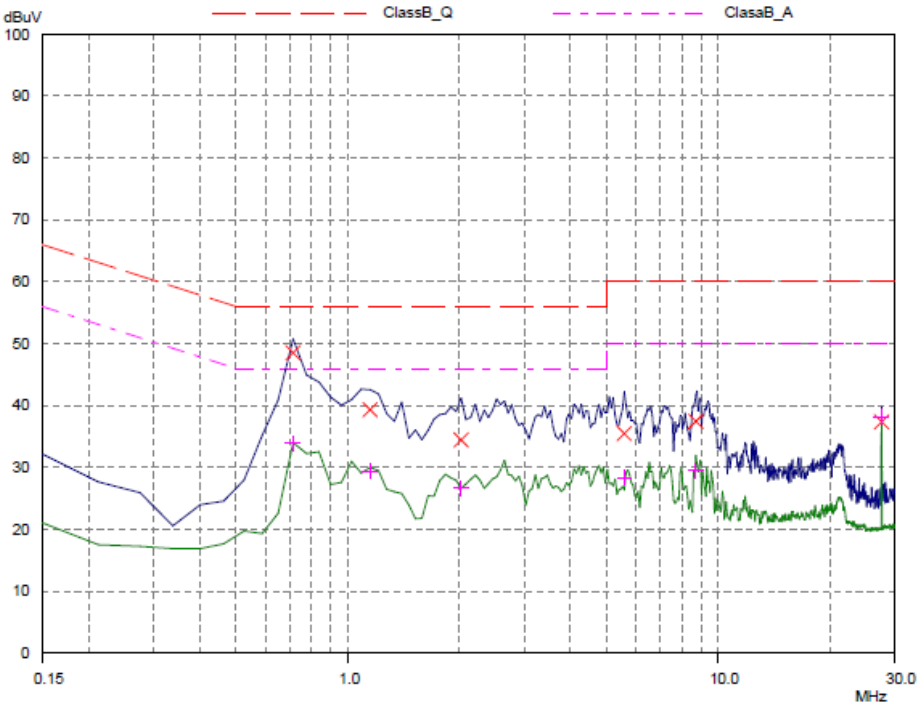
Line. Live



Line. Neutral



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