RF TEST REPORT

Test Report No.	:	TK-FR11015
Standards	:	Part 15 Subpart B&C 15.247
FCC ID	:	ZGB-WB-859-02T
Description of Product	:	U-BOARD
Applicant	:	PENANDFREE Co.,Ltd
Manufacturer	:	PENANDFREE Co.,Ltd
Model Name	:	WB-859-02T
Date of test(s)	:	2011.04.07 ~ 2011.04.15
Date of issue	:	2011.04.18

The test results relate only to the items tested.

Test and Report Completed by :	Report Approval by :
Kwang-Yeol Choo Test Engineer	Kyu-Chul Shin Technical Manager

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Revision history

Revision	Date of issue	Test report No.	Description
-	2011.04.18	TK-FR11015	Initial

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1.0 General product description

Equipment model name	:	WB-859-02T
Serial number	:	Prototype
EUT condition	:	Pre-production, not damaged
Antenna type & gain	:	Chip antenna(3.1dBi)
Frequency Range	:	2402MHz ~ 2480MHz
Number of channels	:	79
Type of Modulation	:	GFSK
Power Source	:	3.7V DC

1.1 Test frequency

	Low channel	Middle channel	High channel
Frequency (MHz)	2402	2441	2480

1.2 Test mode

- Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

1.3 Model differences

Not applicable

1.4 Device modifications

The following modifications were necessary for compliance: Not applicable manufacturer

1.5 Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook	Samsung	R159	ZKPA93AS900167D

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1.6 Calibration details of equipment used for measurement

Test equipment and test accessories are calibrated on regular basis. The maximum time between calibrations is one year or what is recommended by the manufacturer, whichever is less. All test equipment calibrations are traceable to the Korea Research Institute of Standards and Science (KRISS), therefore, all test data recorded in this report is traceable to KRISS.

1.7 Test facility

The measurement facility is located at 477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea. Tel: +82-31-883-5092/Fax: +82-31-883-5169.
The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.4 and CISPR Publication 22.

1.8 Laboratory accreditations and listings

Country	Agency	Scope of accreditation	Logo
USA	FCC	3 & 10 meter Open Area Test Sites and one conducted site to perform FCC Part 15/18 measurements.	343818
KOREA	KCC	EMI (10 meter Open Area Test Site and two conducted sites) Radio (3 & 10 meter Open Area Test Sites and one conducted site)	KR0100
Canada	IC	3 & 10 meter Open Area Test Sites and one conducted site	4769B-1

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2.0 Summary of tests

Section in FCC Part 15	Parameter	Status
15.247(a)(1)	Frequency separation	C
15.247(a)(1)(iii)	Number of hopping frequency	C
15.247(a)(1)	20 dB bandwidth	C
15.247(a)(1)(iii)	Time of occupancy(Dwell time)	C
15.247(b)(1)	Maximum peak output power	C
15.247(d)	Conducted spurious emission & band edge	C
15.247(d)	Radiated spurious emission & band edge	C
15.207	AC conducted emission	C
Note 1: C=Complies NC=Not complies NT=Not tested NA=Not applicable		
Note 2: The data in this test report are traceable to the national or international standards.		
Note 3: The sample was tested according to the following specification: FCC Part 15.247, ANSI C63.4-2003		

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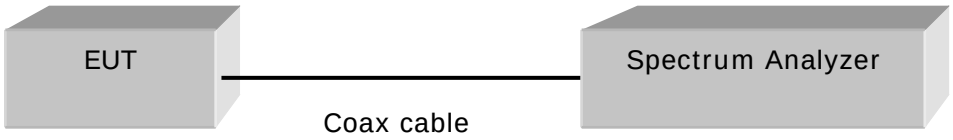
2.1 Technical characteristic test

2.1.1 Frequency separation

Test setup



Test procedure

1. The EUT must have its hopping function enabled.
2. Use the following spectrum analyzer setting
   Span = 3 MHz (wide enough to capture the peaks of two adjacent channels)
   RBW = 30 kHz (≥ 1% of the span)
   VBW = 30 kHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
3. All the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Limit

15.247(a)(1) Frequency hopping system operating in 2400 ~ 2483.5 MHz. Band may have hopping channel carrier frequencies that are separated by 25 kHz or two-third of 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

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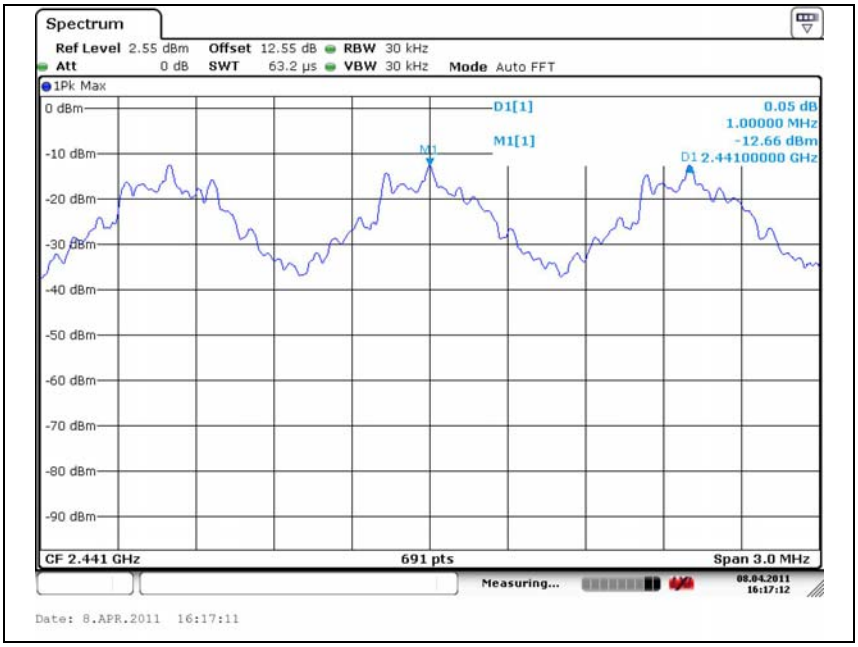
Test results

Operation mode	Frequency (MHz)	Adjacent hopping channel separation (kHz)	Two-third of 20 dB bandwidth (kHz)	Minimum bandwidth (kHz)
GFSK	2441	1000	558	25



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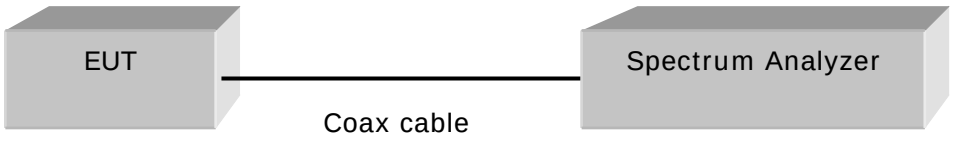
2.1.2 Number of hopping frequency

Test setup



Test procedure

1. The EUT must have its hopping function enabled.
2. Use the following spectrum analyzer setting
   Frequency range: 2400 MHz ~ 2441.5 MHz, 2441.5 MHz ~ 2483.5 MHz
   Span = the frequency band of operation
   RBW = 300 kHz (≥ 1% of the span)
   VBW = 300 kHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
3. All the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Limit

15.247(a)(1)(iii) For frequency hopping system operating in the 2400 - 2483.5 MHz bands shall use at least 15 hopping frequencies.

Test results

Operation mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15

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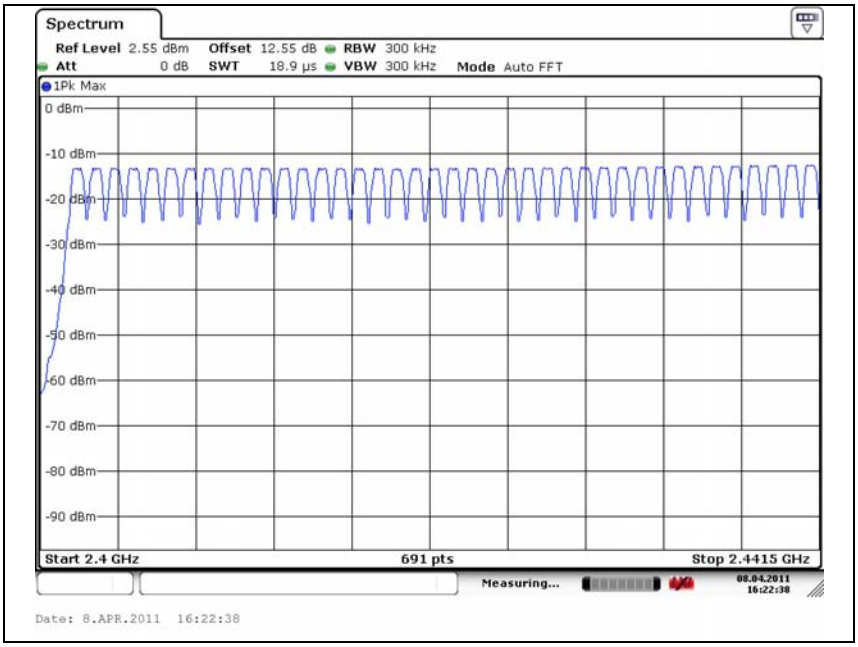
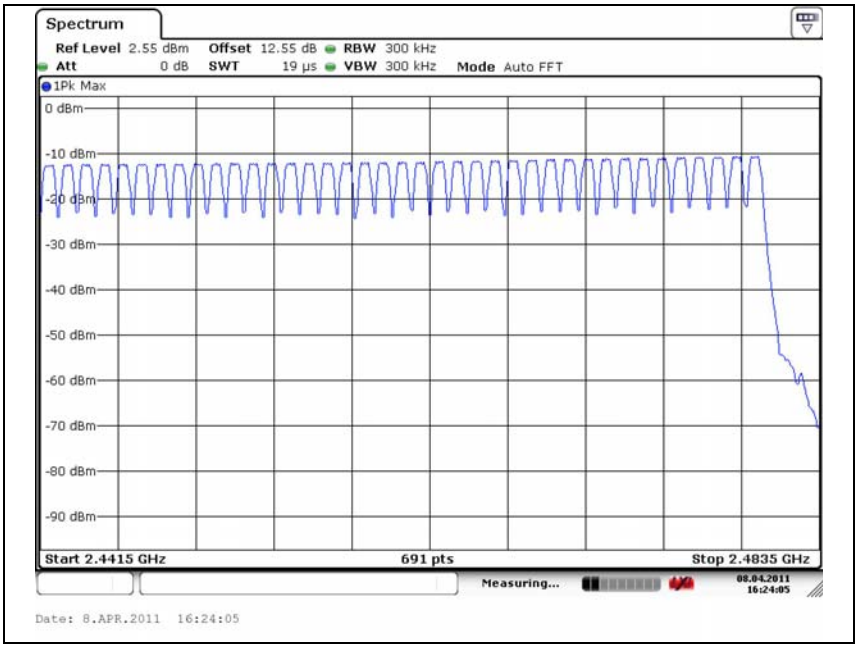
A. 2400 MHz ~ 2441.5 MHz



B. 2441.5 MHz ~ 2483.5 MHz



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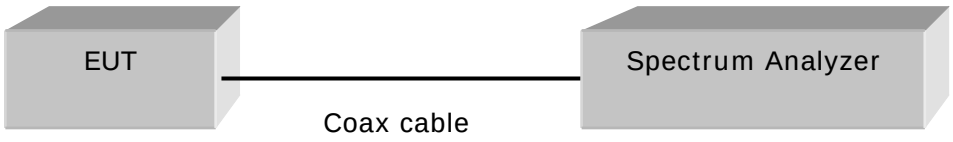
2.1.3 20 dB bandwidth

Test setup



Test procedure

1. Use the following spectrum analyzer setting
   Center frequency: Lowest, middle and highest channels
   Span = 3 MHz (Approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel)
   RBW = 30 kHz (≥ 1% of the span)
   VBW = 30 kHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. The EUT Should be transmitting at its maximum data rate. Allow the trance to stabilize.
   Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker-delta function to measure 20 dB down on side of the emission. Reset the marker-delta function, and move the marker to the other side of the emission, until it is(as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 20 dB bandwidth of the emission. I this value varies with different modes of operation (e.g., date rate, modulation format, etc.), repeat this test for each variation.

Limit

Not applicable

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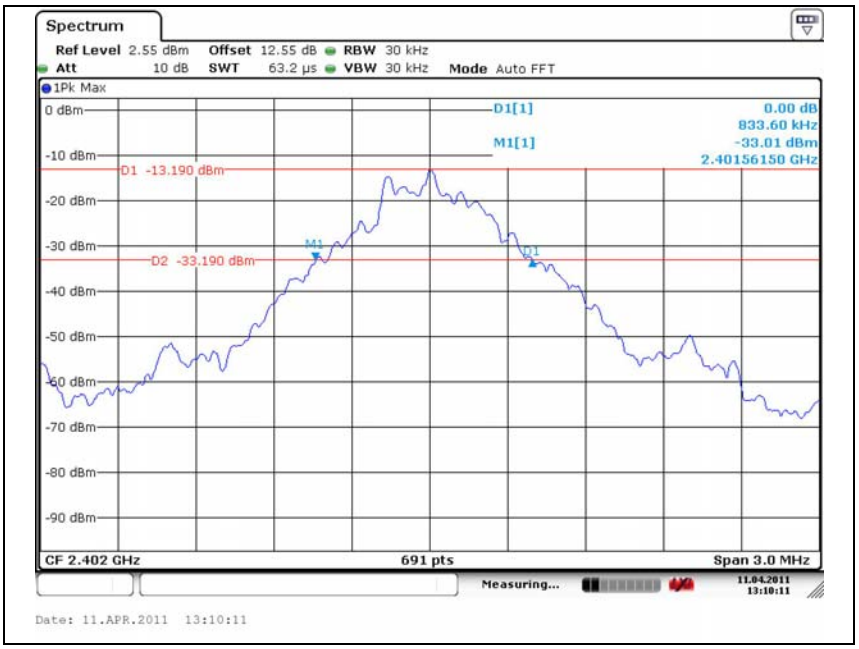
Test results

Operation mode	Frequency(MHz)	20 dB bandwidth(MHz)
GFSK	2402	0.833
	2441	0.837
	2480	0.837

A. Low channel



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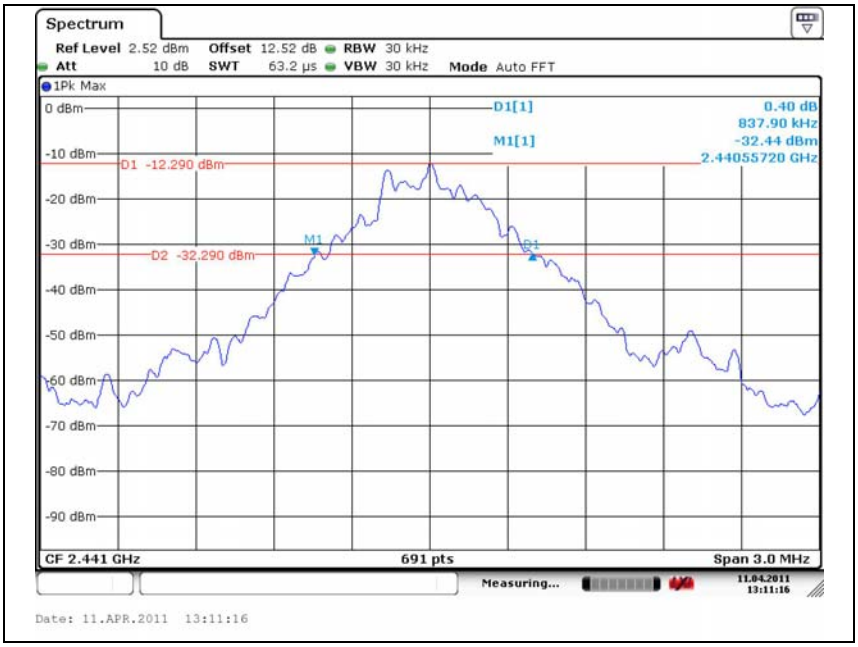
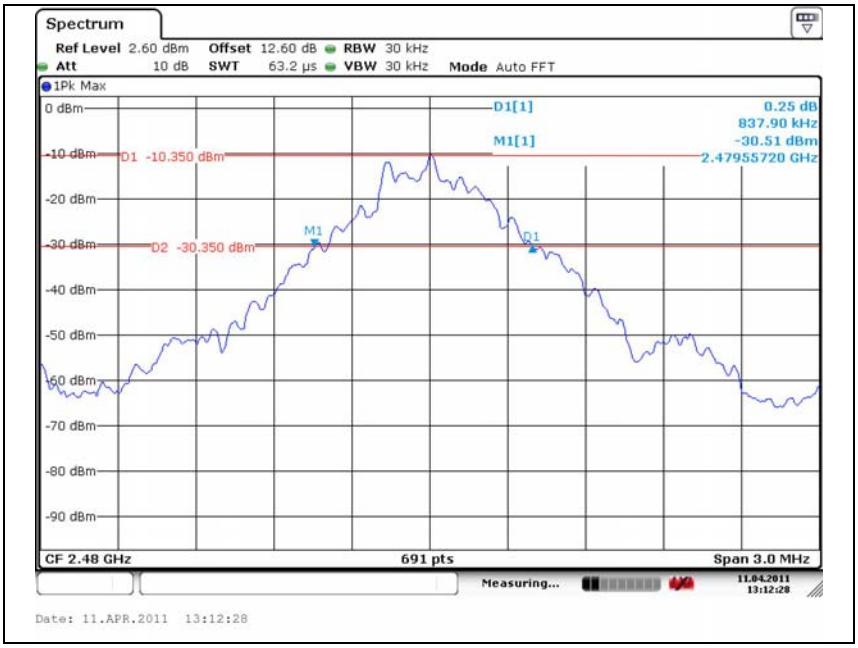
B. Middle channel



C. High channel



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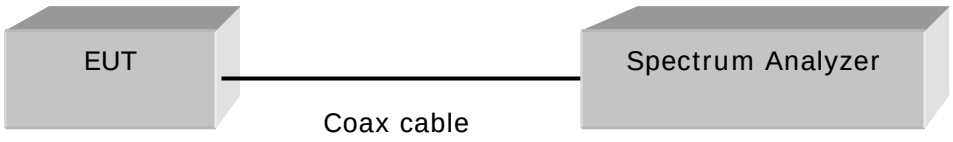
2.1.4 Time of occupancy (Dwell time)

Test setup



Test procedure

1. Use the following spectrum analyzer setting
   Center frequency: 2441 MHz
   Span = Zero span, centered on a hopping channel
   RBW = 1 MHz
   VBW = 1 MHz (≥ RBW)
   Sweep = as necessary to capture the entire dwell time per hopping channel
   Detector function = peak
   Trace = max hold
2. If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g., date rate, modulation format, etc.), repeat this test for each variation.
3. The Bluetooth has 3 type of payload DH1, DH3, DH5. The hopping rate is 1600 per second.

Limit

15.247(a)(1)(iii) For frequency hopping system operating in the 2400 ~ 2483.5 MHz band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

A period time = 0.4(s) × 79 = 31.6(s)

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Test results

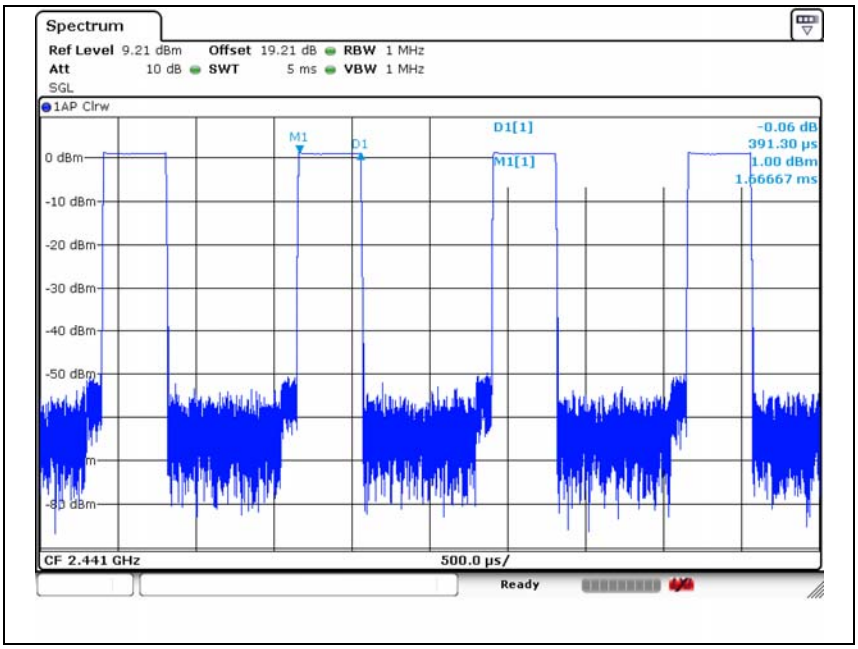
Time of occupancy on the TX channel in 31.6 sec
= time domain slot length × (hop rate ÷ number of hop per channel) × 31.6

Operation mode: GFSK

Packet type	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx channel in 31.6 sec (ms)
DH1	2441	0.391	125.12	400
DH3	2441	1.637	261.92	400
DH5	2441	2.898	309.12	400

※ Remark:
DH1: Dwell time (ms) × [(1600 ÷ 2) ÷ 79] × 31.6(s) = Time of occupancy (ms)
DH3: Dwell time (ms) × [(1600 ÷ 4) ÷ 79] × 31.6(s) = Time of occupancy (ms)
DH5: Dwell time (ms) × [(1600 ÷ 6) ÷ 79] × 31.6(s) = Time of occupancy (ms)

A. Packet type: DH1



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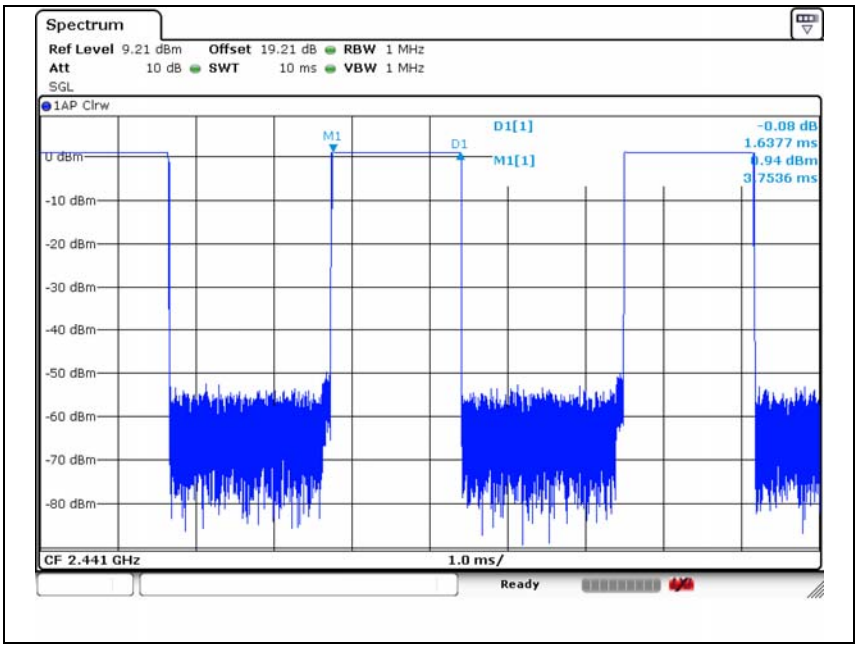
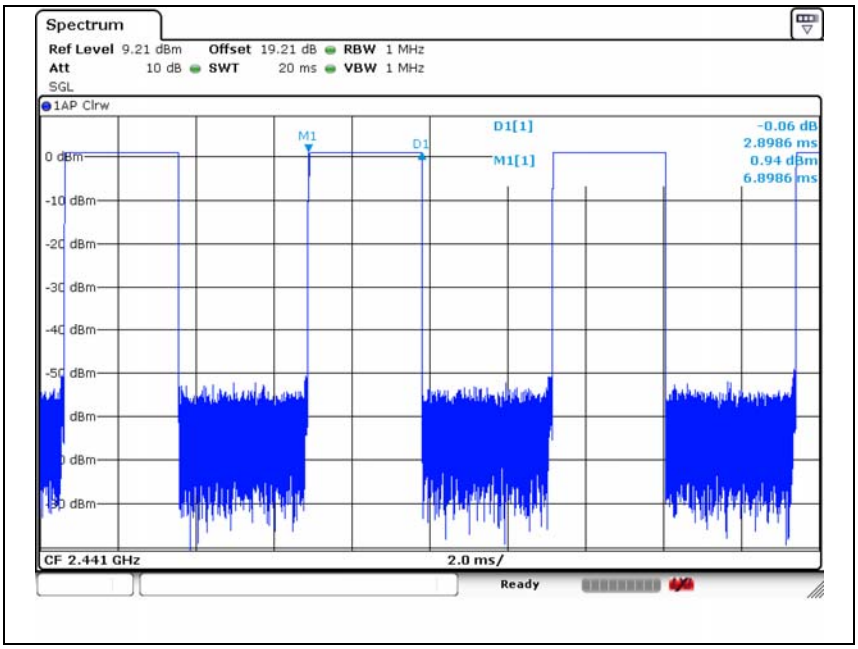
B. Packet type: DH3



C. Packet type: DH5



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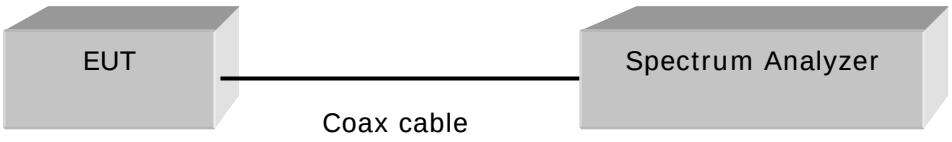
2.1.5 Maximum peak power output power

Test setup



Test procedure

1. Use the following spectrum analyzer setting
   Center frequency: Lowest, middle and highest channels
   Span = 5 MHz (Approximately 5 times the 20 dB bandwidth, centered on a hopping channel)
   RBW = 1 MHz (the 20 dB bandwidth of the emission being measured)
   VBW = 1 MHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power.

Limit

The maximum peak output power of the intentional radiator shall not exceed the following:

1. 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.
2. 15.247(b)(1), For frequency hopping systems operating in the 2400 ~ 2483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725 ~ 5805 MHz band: 1 Watt.

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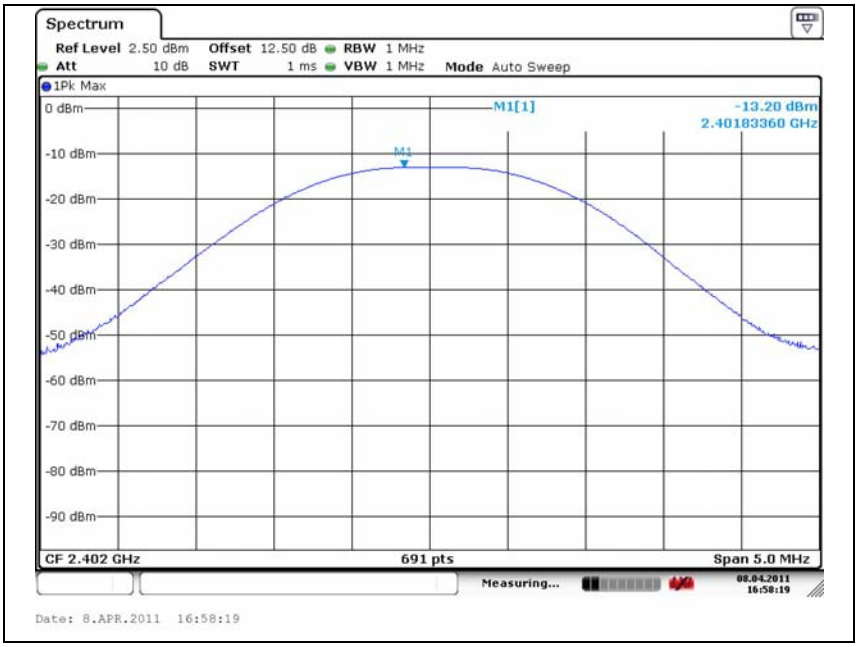
Test results

Operation mode	Frequency(㎒)	Peak output power (dBm)	Limit (dBm)
GFSK	2402	-13.20	30
	2441	-12.60	30
	2480	-10.72	30

A. Low channel



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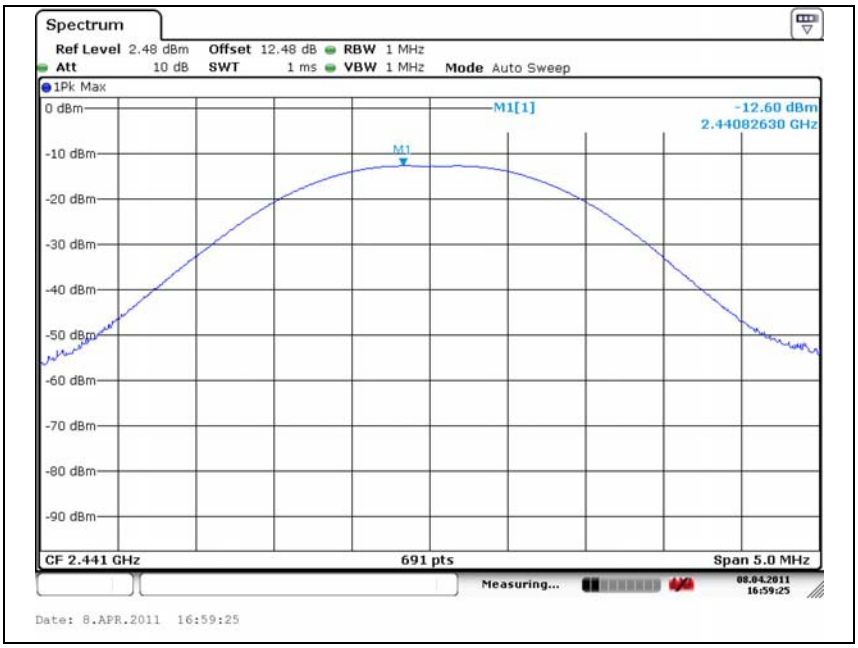
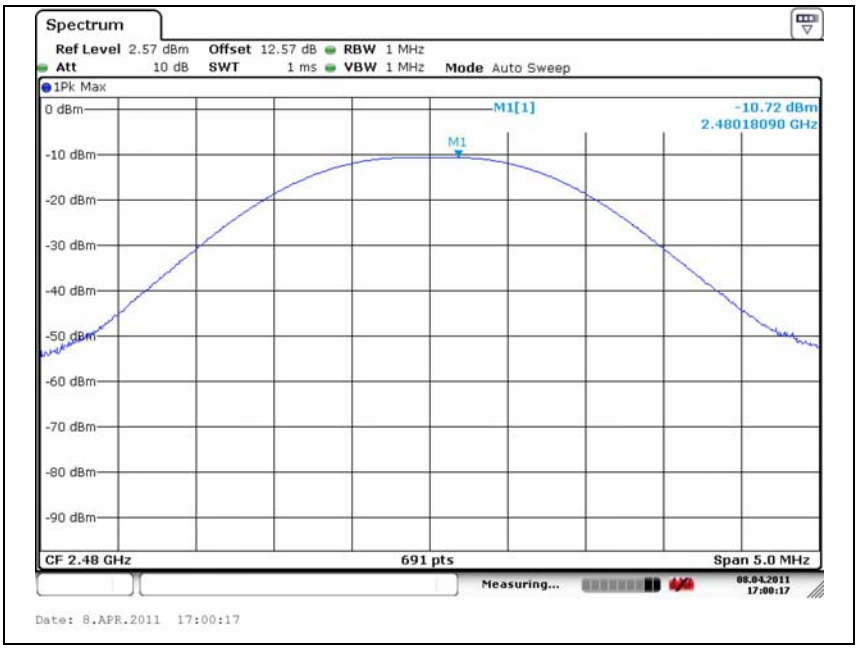
B. Middle channel



C. High channel



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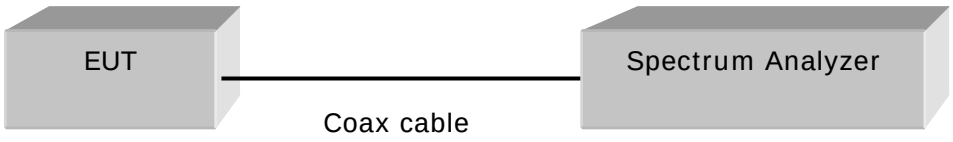
2.1.6 Conducted spurious emission & band edge

Test setup



Test procedure for band edge

1. Use the following spectrum analyzer setting
   Center frequency: Lowest, middle and highest channels
   Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
   RBW = 100 kHz
   VBW = 100 kHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission

Test procedure for spurious emission

1. Use the following spectrum analyzer setting
   Center frequency: Lowest, middle and highest channels
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g,. harmonics) from the lowest frequency generated in the EUT up through the 10th harmonics.
   RBW = 100 kHz
   VBW = 100 kHz (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

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Limit

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

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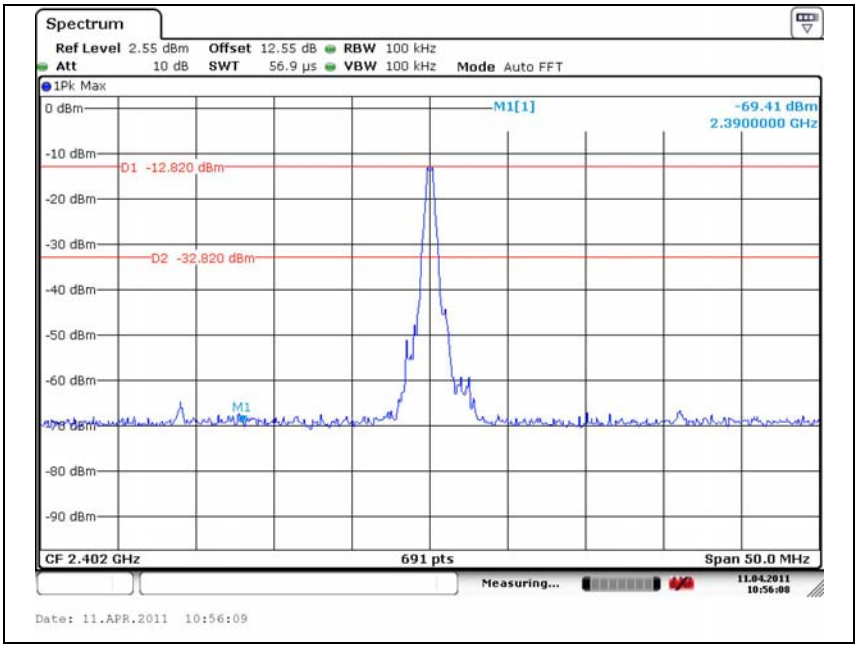
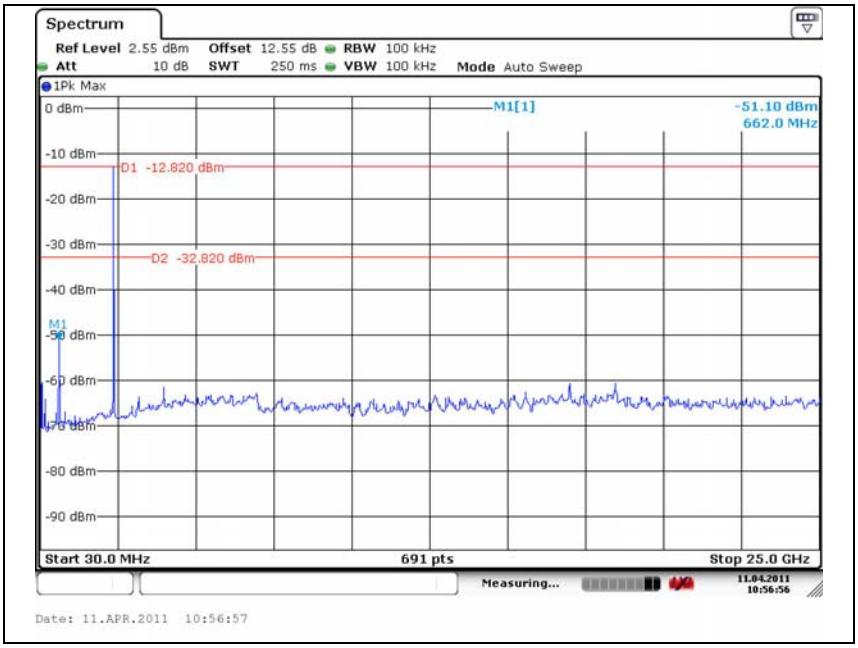
Test results

A. Low channel





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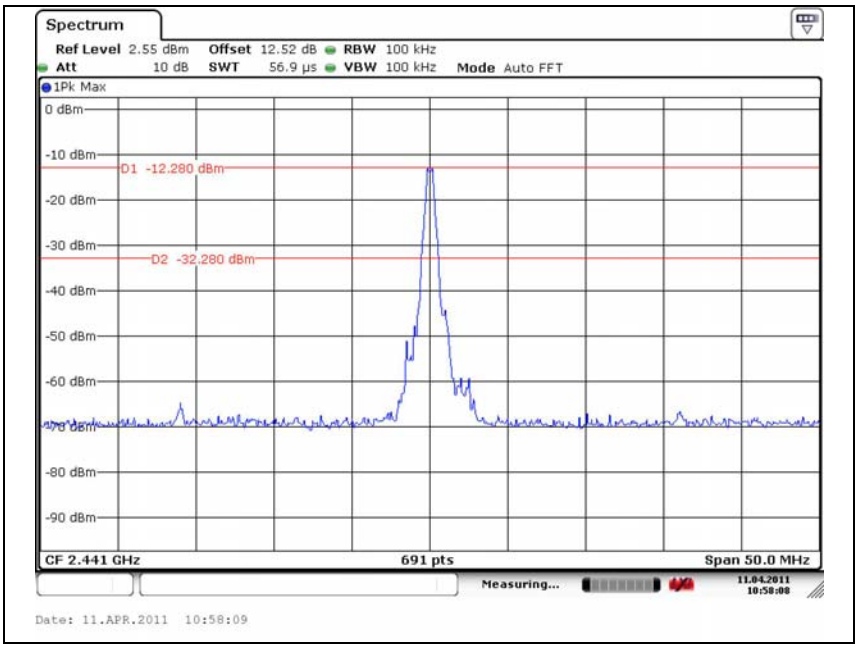
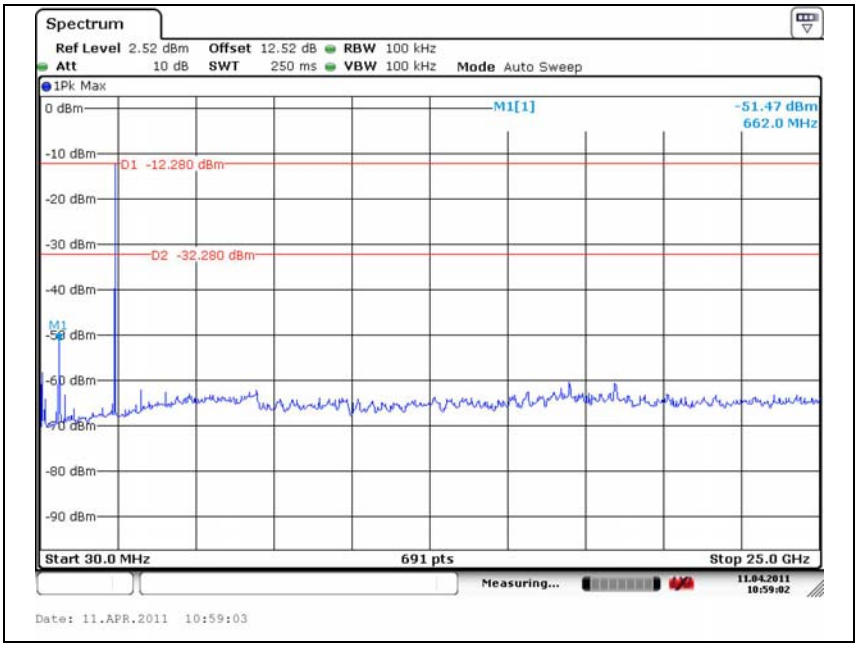
B. Middle channel





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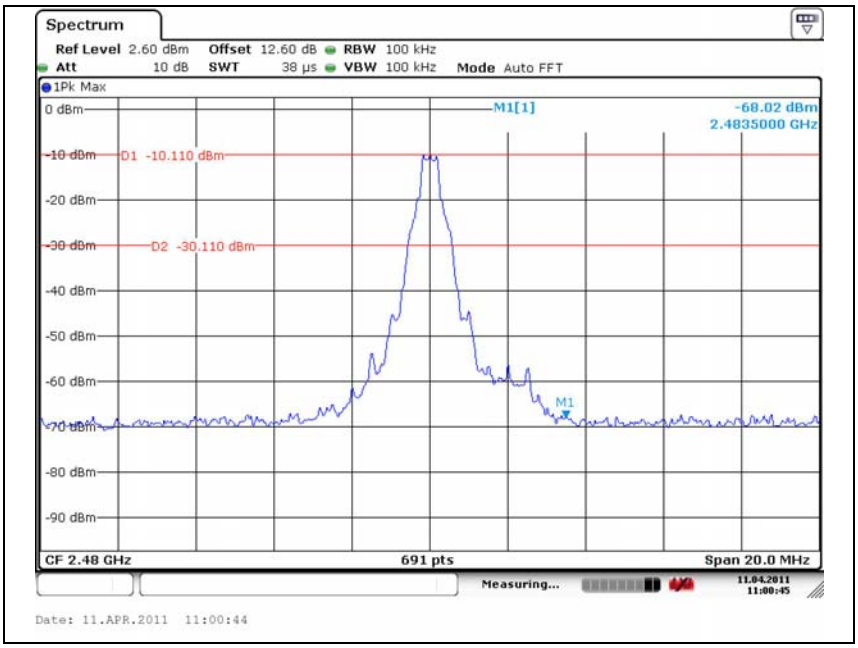
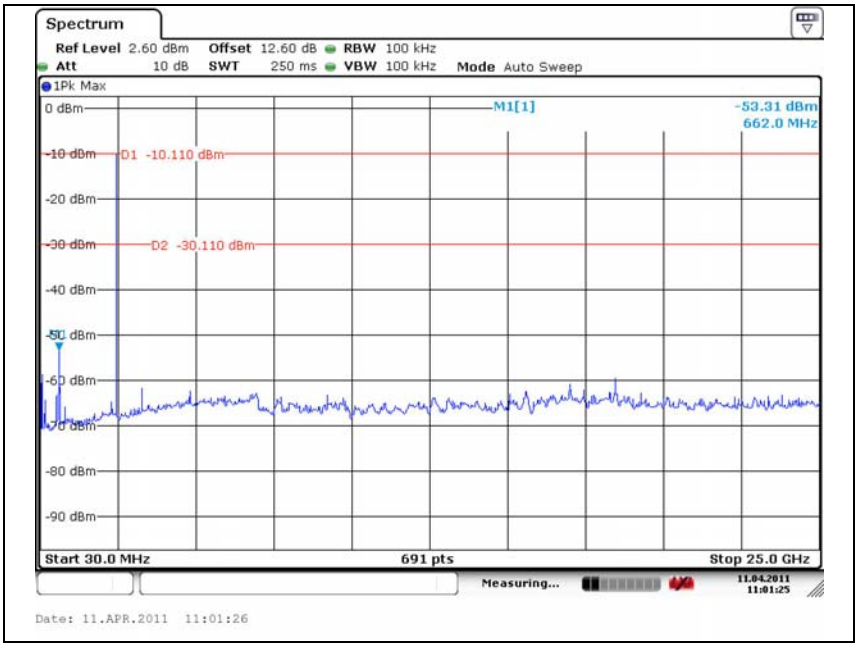
C. High channel





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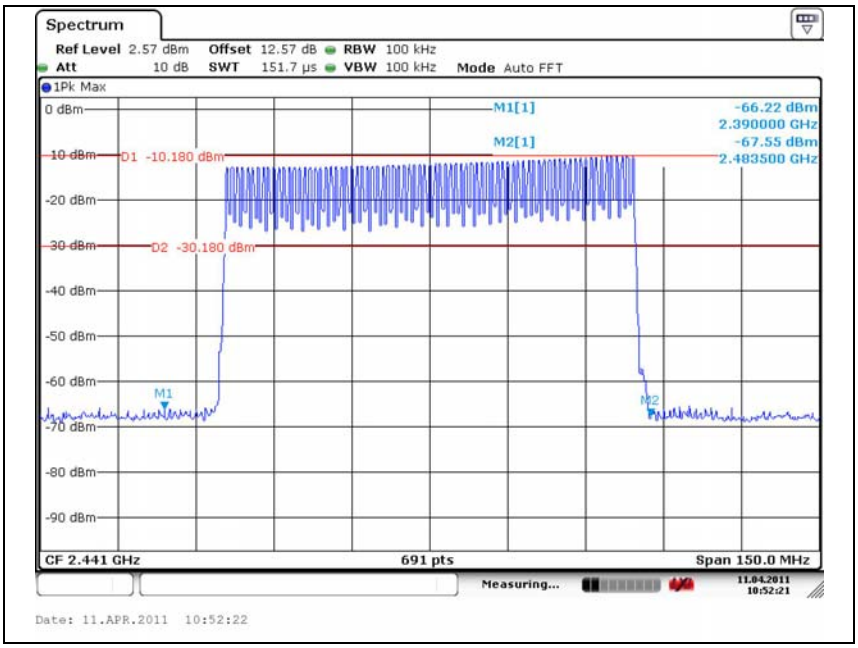
D. Band edge (Hopping mode)



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2.1.7 Radiated spurious emission & band edge

Test location

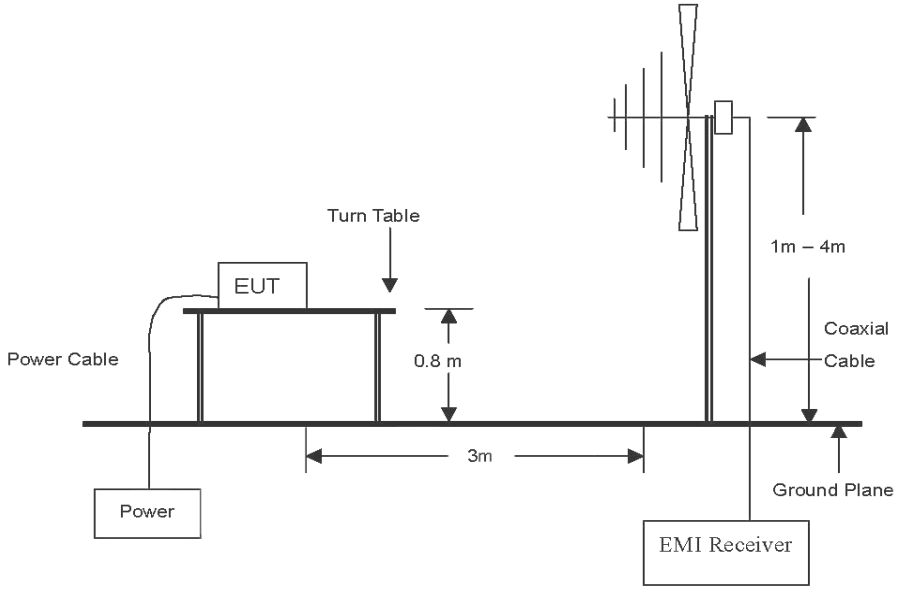
Testing was performed at a test distance of 3 meter Open Area Test Site

Test procedures

The height of the measuring antenna was varied between 1 to 4 m and the table was rotated a full revolution in order to obtain maximum values of the electric field intensity.
The measurement was made in both the vertical and horizontal polarization, and the maximum value is presented in the report.

The spectrum analyzer is set to:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer 120 kHz for Peak detection (PK) or Quasi-peak detection (QP) at frequency below 1 GHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 10 Hz for Average detection (AV) at frequency above 1 GHz.

The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



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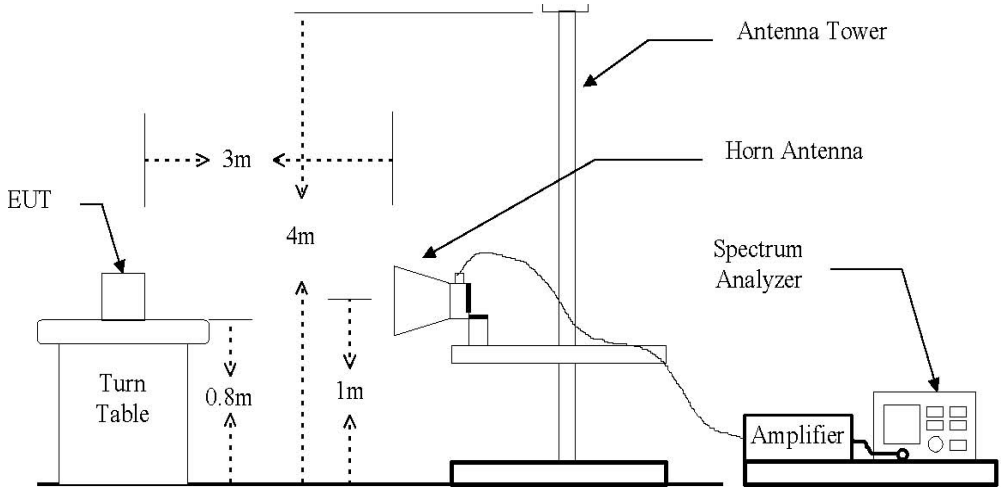
The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to 24 GHz emissions.



Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values：

Frequency (MHz)	Distance (Meters)	Radiated (dBuV/m)	Radiated (uV/m)
30 ~ 88	3	40.0	100
88 ~ 216	3	43.5	150
216 ~ 960	3	46.0	200
Above 960	3	54.0	500

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Test results (Below 1000 MHz)

The frequency spectrum from 30 MHz to 1000 MHz was investigated. Emission levels are not reported much lower than the limits by over 20 dB.

Radiated emissions		Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBuV)	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBuV/m)	Limit (dBuV/ m)	Margin (dB)
307	23.56	H	12.98	1.41	37.94	46	8.06
390	21.46	V	14.57	1.67	37.70	46	8.30
986	18.58	H	22.22	2.71	43.51	54	10.49

※ Remark

1. All spurious emission at channels are almost the same below 1 GHz, so that middle channel was chosen at representative in final test.
2. Actual = Reading + Ant. factor + Amp + CL (Cable loss)
3. Detector mode: Quasi peak
4. To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes.

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Test results (Above 1000 MHz)

A. Low channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBuV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBuV/m)	Limit (dBuV/ m)	Margin (dB)
2390	44.69	Peak	H	28.31	-27.94	45.06	54.00	8.94
2390	43.94	Peak	V	28.31	-27.94	44.31	54.00	9.69
4804	48.04	Peak	V	33.91	-22.29	59.66	74.00	14.34
4804	34.92	Average	V	33.91	-22.29	46.54	54.00	7.46
4804	47.32	Peak	H	33.91	-22.29	58.94	74.00	15.06
4804	34.38	Average	H	33.91	-22.29	46.00	54.00	8.00

B. Middle channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBuV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBuV/m)	Limit (dBuV/ m)	Margin (dB)
4882	48.35	Peak	V	34.16	-22.05	60.46	74.00	13.54
4882	35.24	Average	V	34.16	-22.05	47.35	54.00	6.65
4882	46.53	Peak	H	34.16	-22.05	58.64	74.00	15.36
4882	33.54	Average	H	34.16	-22.05	45.65	54.00	8.35

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C. High channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBuV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL(dB)	Actual (dBuV/m)	Limit (dBuV/ m)	Margin (dB)
2483.5	44.96	Peak	V	28.50	-27.85	45.61	54.00	8.39
2483.5	44.09	Peak	H	28.50	-27.85	44.74	54.00	9.26
4960	46.11	Peak	H	34.42	-21.80	58.73	74.00	15.27
4960	33.03	Average	H	34.42	-21.80	45.65	54.00	8.35
4960	46.79	Peak	V	34.42	-21.80	59.41	74.00	14.59
4960	33.90	Average	V	34.42	-21.80	46.52	54.00	7.48

※ Remark

1. "*" means the restricted band.
2. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
3. Radiated emissions measured in frequency above 1000 MHz were made with an instrument using peak/average detector mode.
4. Average test would be performed if the peak result were greater than the average limit.
5. Actual = Reading + Ant. factor + Amp + CL (Cable loss)
6. To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes.

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2.1.8 AC conducted emissions

Frequency range of measurement
150 kHz to 30 MHz

Instrument settings
IF Band Width: 9 kHz

Test procedures

The EUT was placed on a non-metallic table 0.8m above the metallic, grounded floor and 0.4m from the reference ground plane wall. The distance to other metallic surfaces was at least 0.8m. Amplitude measurements were performed with a quasi-peak detector and an average detector.

Limit

15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50uH/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted limit (dBuV/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

※ **Remark**
Decreases with the logarithm of the frequency.

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Test results

Frequency (MHz)	Correction		Phase Hot/ Neutral	Quasi peak			Average		
	LISN	Cable Loss		Reading	Result	Limit	Reading	Result	Limit
0.159	9.786	0.158	N	32.136	42.080	**66**	22.106	32.050	**56**
0.162	9.793	0.151	H	33.426	43.370	**65**	17.196	27.140	**55**
0.162	9.785	0.151	N	32.134	42.070	**65**	18.534	28.470	**55**
0.168	9.789	0.140	H	38.671	48.600	**65**	26.391	36.320	**55**
0.330	9.757	0.100	N	23.663	33.520	**59**	16.923	26.780	**49**
0.336	9.760	0.100	H	24.100	33.960	**59**	11.270	21.130	**49**
2.286	9.766	0.100	N	27.924	37.790	**56**	21.544	31.410	**46**
2.358	9.774	0.100	H	32.606	42.480	**56**	6.906	16.780	**46**
2.403	9.774	0.100	H	27.856	37.730	**56**	6.906	16.780	**46**
3.045	9.780	0.100	H	31.720	41.600	**56**	17.970	27.850	**46**
3.324	9.780	0.100	N	30.070	39.950	**56**	13.140	23.020	**46**
3.324	9.780	0.100	N	30.070	39.950	**56**	18.060	27.940	**46**
11.865	9.840	0.100	N	23.460	33.400	**60**	12.260	22.200	**50**
11.928	9.850	0.100	H	26.420	36.370	**60**	12.510	22.460	**50**
23.664	9.990	0.100	H	23.600	33.690	**60**	15.100	25.190	**50**
23.664	9.970	0.100	N	22.920	32.990	**60**	14.150	24.220	**50**
23.790	9.970	0.100	N	22.870	32.940	**60**	14.440	24.510	**50**
23.817	9.990	0.100	H	23.310	33.400	**60**	15.350	25.440	**50**

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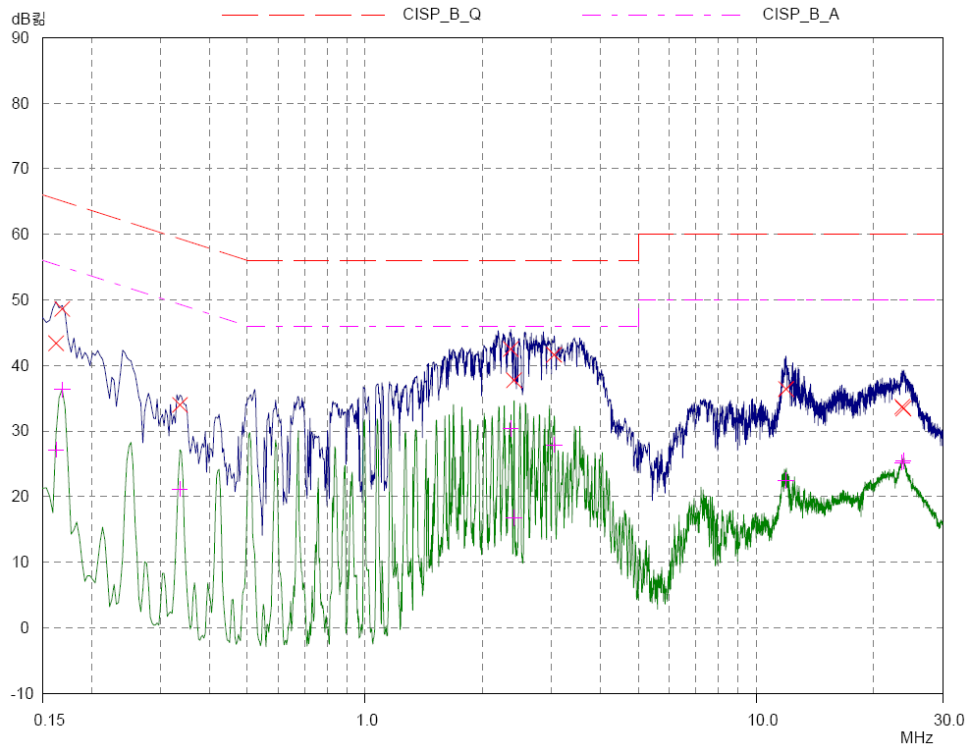
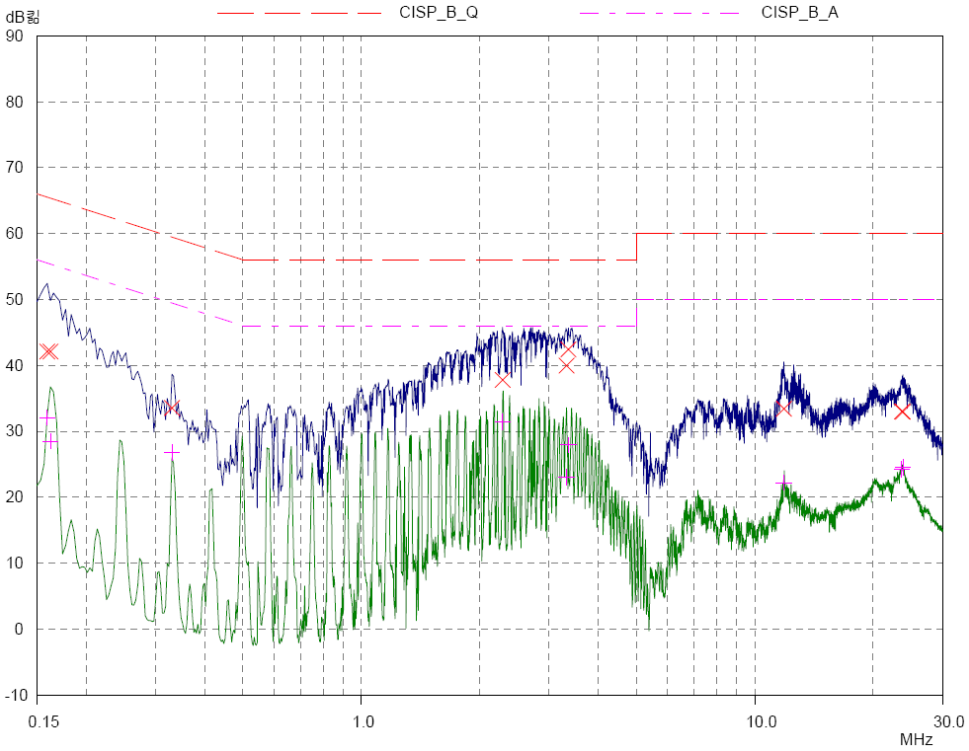
[Hot]



[Neutral]



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Appendix A – Test equipment used for test

Equipment	Manufacturer	Model	Calibration due.
Spectrum Analyzer	R&S	FSV30	2012-01-07
Trilog-Broadband Antenna	SCHWARZBECK	VULB 9168	2013-03-18
Horn Antenna	A.H. System	SAS-571	2013-03-22
High Pass Filter	Wainwright Instrument	WHJS3000-10TT	2012-01-07
Preamplifier	HP	8447F	2011-05-06
Preamplifier	HP	8449B	2011-07-27
EMI Test Receiver	R&S	ESHS10	2011-06-01
EMI Test Receiver	R&S	ESVS10	2011-06-24
LISN	R&S	ENV216	2012-02-16

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Test setup photo and configuration

Radiated field emissions

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AC conducted emission

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