TEST REPORT

Part 15 Subpart B&C 15.247

Equipment Under Test Galaxy Pen(Bluetooth)

Model Name IPBT-100-01, IPBT-100-02(Family model)

FCC ID ZGBIPBT-100-01

Applicant PENANDFREE Co., Ltd

Manufacturer PENANDFREE Co., Ltd

Date of test(s) 2011.08.05 ~ 2011.08.18

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Issued to

PENANDFREE Co., Ltd
#801, Keumkang Hitech valley 2nd, 138-1, Sangdaewon-dong, Jungwon-gu,
Seongnam-si, Gyeonggi-do, Korea

Issued by

KES Co., Ltd.
C3701 Dongil Techno Town, 889-1, Gwanyang 2-dong, Dongan-gu, Anyang-si,
Gyeonggi-do, 431-716, Korea
477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	**Report approval by :**
Kwang-Yeol Choo Test engineer	Gyu-cheol Shin Technical manager

Revision history

Revision	Date of issue	Test report No.	Description
-	2011.08.18	TK-FR11049	Initial

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1.0 General product description

Equipment under test	Galaxy Pen(Bluetooth)
Model name	IPBT-100-01, IPBT-100-02(Family model)
Serial number	Prototype
Frequency Range	2 402 ㎒ ~ 2 480 ㎒
Modulation technique	GFSK
Number of channels	79
Antenna type & gain	Chip Antenna(3.1dBi)
Power source	3V DC

1.1 Test frequency

	Low channel	**Middle channel**	**High channel**
Frequency (㎒)	2 402	2 441	2 480

1.2 Information about family model

Original model(IPBT-100-01) has family model(IPBT-100-02) according to the purpose and the technology of the product is fundamentally(Hardware & Software) the same.

1.3 Device modifications

N/A

1.4 Test facility

C3701 Dongil Techno Town, 889-1, Gwanyang 2-dong, Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea
477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea

The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.4 and CISPR Publication 22.

1.5 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

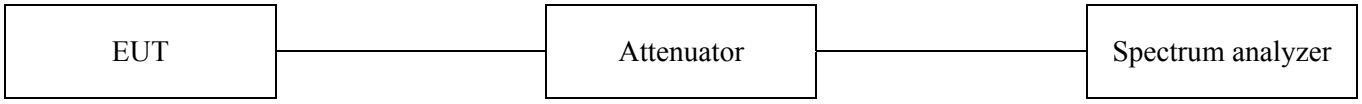
2.0 Summary of tests

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		

2.1 Technical characteristic test

2.1.1 Frequency separation

Test setup



Test procedure

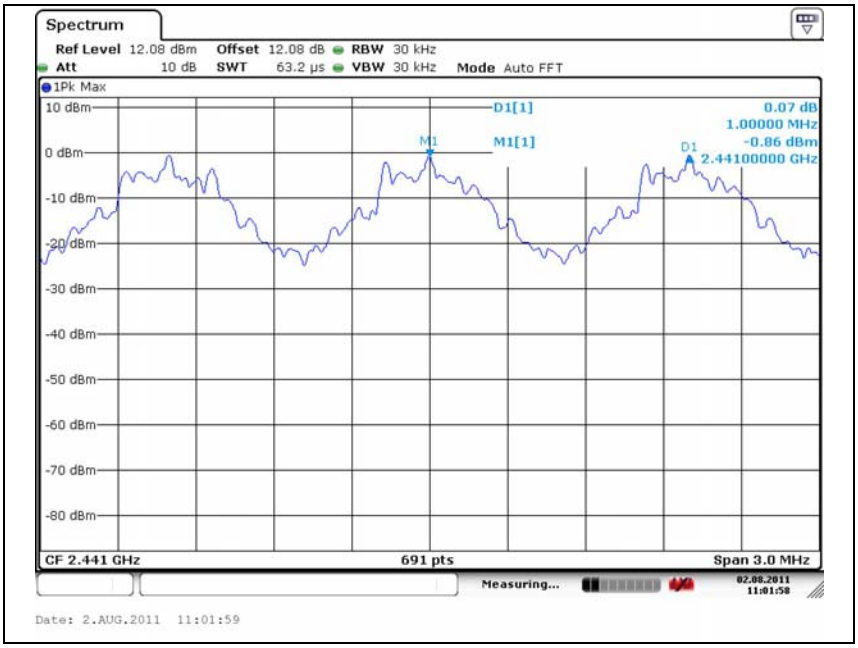
1. The EUT must have its hopping function enabled.
2. Use the following spectrum analyzer setting
   Span = 3 ㎒ (wide enough to capture the peaks of two adjacent channels)
   RBW = 30 ㎑ (≥ 1% of the span)
   VBW = 30 ㎑ (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
3. All the 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 2 400 ~ 2 483.5 ㎒. Band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-third of 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

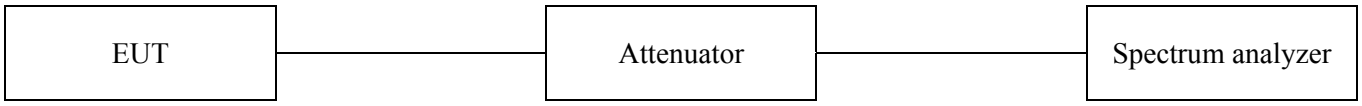
Test results

Operation mode	Frequency (㎒)	Adjacent hopping channel separation (㎑)	Two-third of 20 dB bandwidth (㎑)	Minimum bandwidth (㎑)
GFSK	2 441	1 000	555	25



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: 2 400 ㎒ ~ 2 441.5 ㎒, 2 441.5 ㎒ ~ 2 483.5 ㎒
   Span = the frequency band of operation
   RBW = 300 ㎑ (≥ 1% of the span)
   VBW = 300 ㎑ (≥ 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.

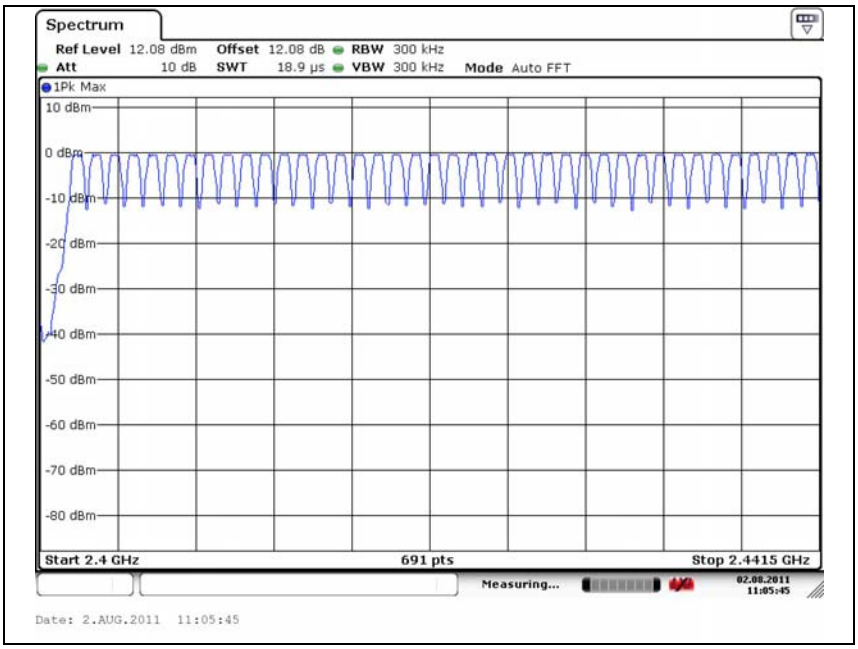
Limit

15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 – 2 483.5 ㎒ bands shall use at least 15 hopping frequencies.

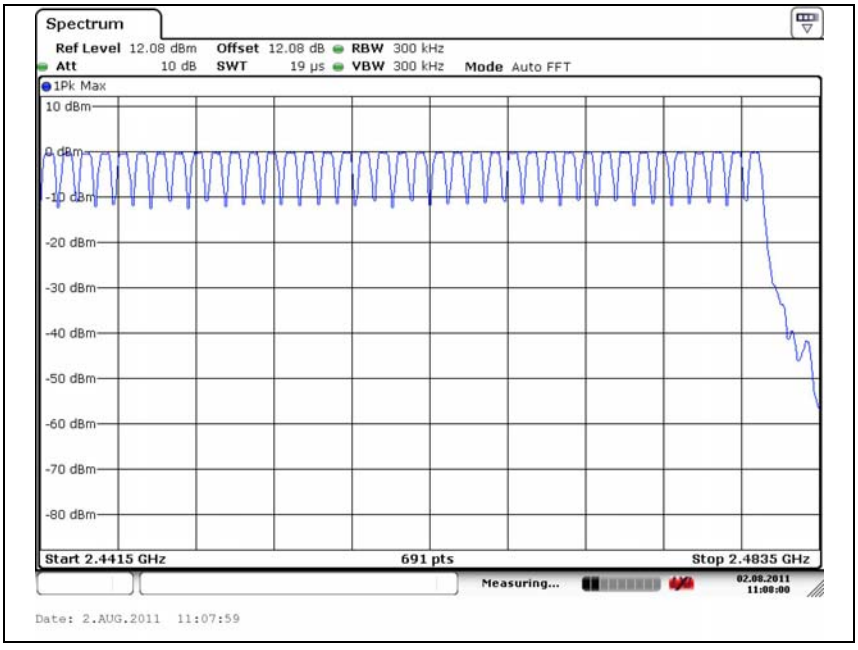
Test results

Operation mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15

A. 2 400 ㎒ ~ 2 441.5 ㎒

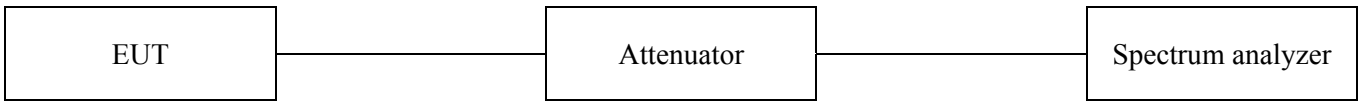


B. 2 441.5 ㎒ ~ 2 483.5 ㎒



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 ㎒ (Approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel)
   RBW = 30 ㎑ (≥ 1% of the span)
   VBW = 30 ㎑ (≥ 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.

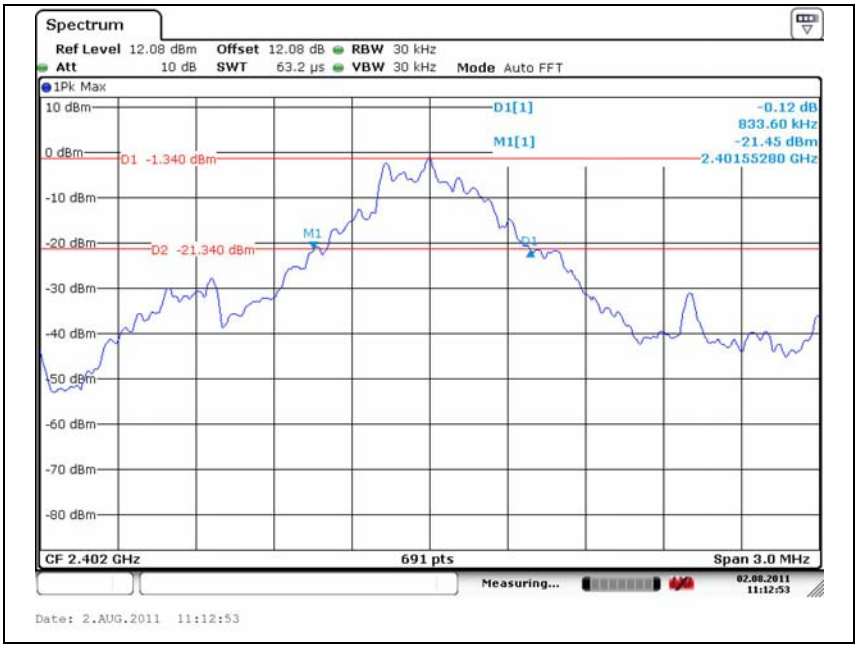
Limit

Not applicable

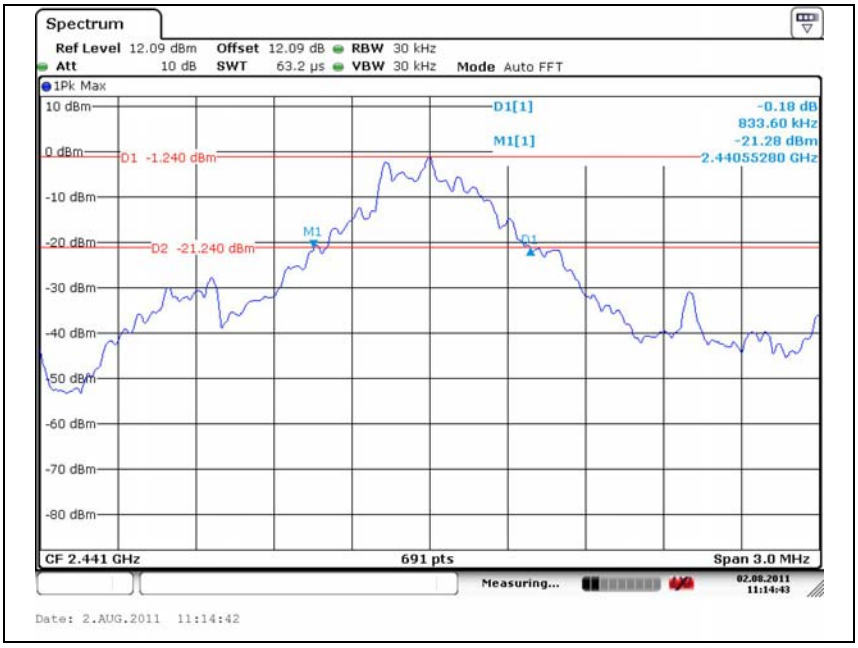
Test results

Operation mode	Frequency(㎒)	20 ㏈ bandwidth(㎒)
GFSK	2 402	0.833
	2 441	0.833
	2 480	0.833

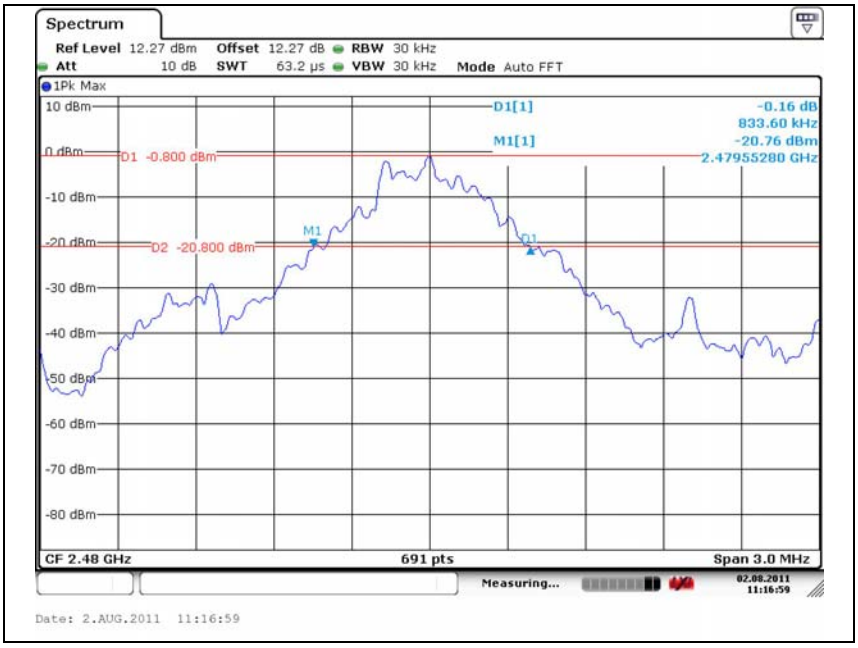
A. Low channel



B. Middle channel

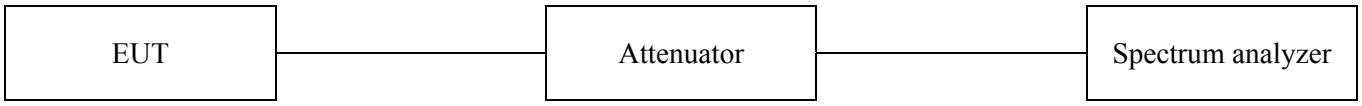


C. High channel



2.1.4 Time of occupancy (Dwell time)

Test setup



Test procedure

1. Use the following spectrum analyzer setting
   Center frequency: 2 441 ㎒
   Span = Zero span, centered on a hopping channel
   RBW = 1 ㎒
   VBW = 1 ㎒ (≥ 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 1 600 per second.

Limit

15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 ~ 2 483.5 ㎒ 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)

Test results

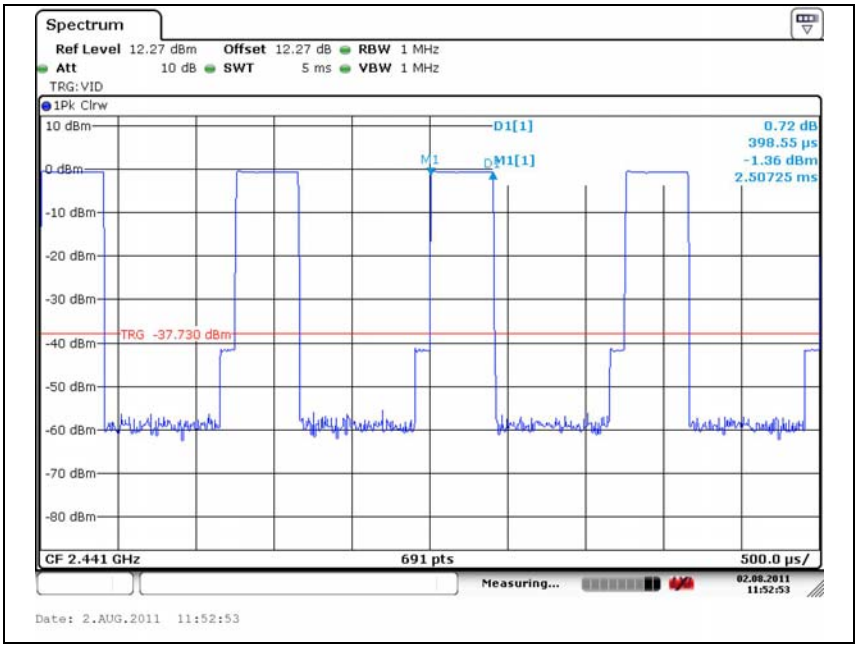
Time of occupancy on the TX channel in 31.6 sec
= time domain slot length × (hop rate ÷ number of hop per channel) × 31.6

Operation mode: GFSK

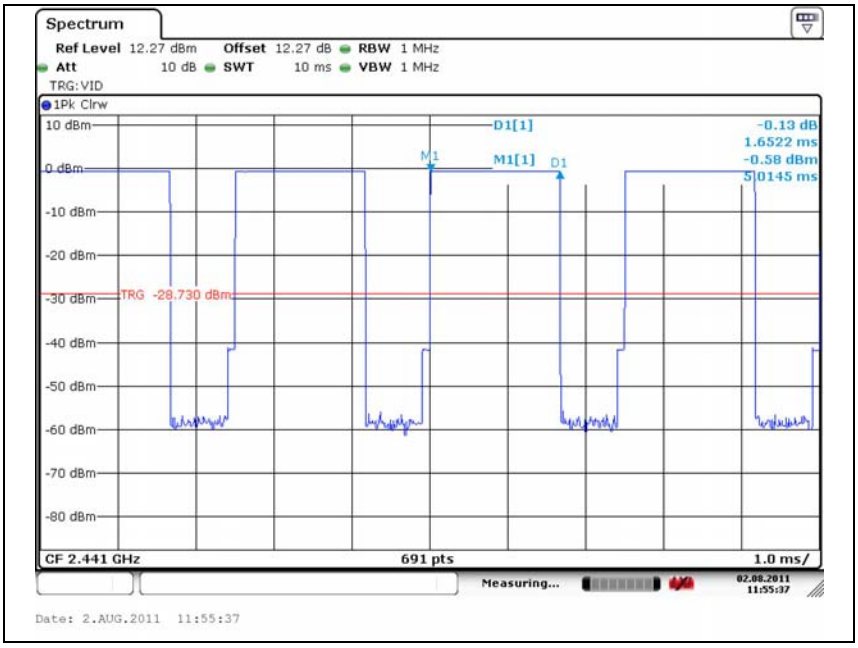
Packet type	Frequency (㎒)	Dwell Time (ms)	Time of occupancy on the Tx channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx channel in 31.6 sec (ms)
DH1	2 441	0.398	127.36	400
DH3	2 441	1.652	264.32	400
DH5	2 441	2.898	309.12	400

※ Remark:
DH1: Dwell time (ms) × [(1 600 ÷ 2) ÷ 79] × 31.6(s) = Time of occupancy (ms)
DH3: Dwell time (ms) × [(1 600 ÷ 4) ÷ 79] × 31.6(s) = Time of occupancy (ms)
DH5: Dwell time (ms) × [(1 600 ÷ 6) ÷ 79] × 31.6(s) = Time of occupancy (ms)

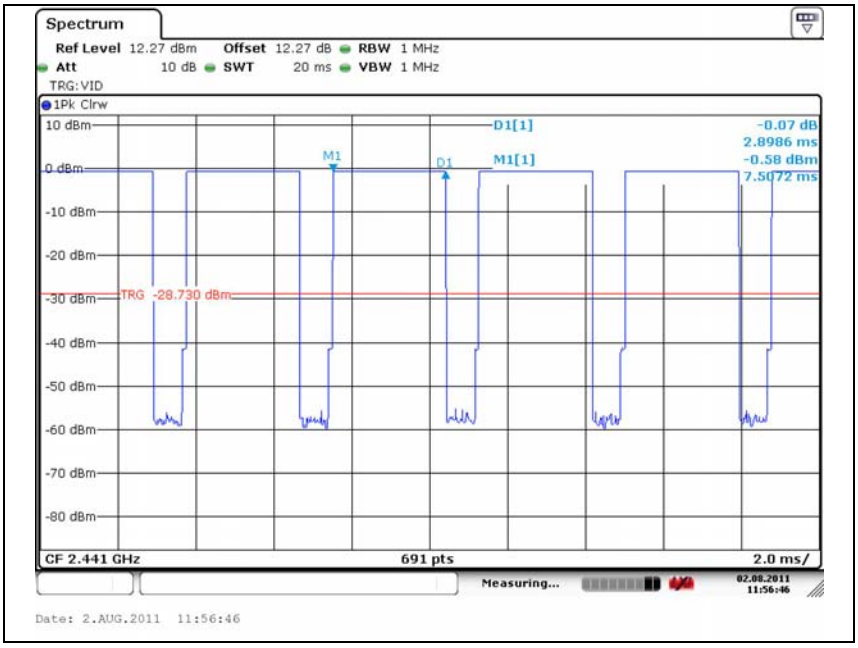
A. Packet type: DH1



B. Packet type: DH3

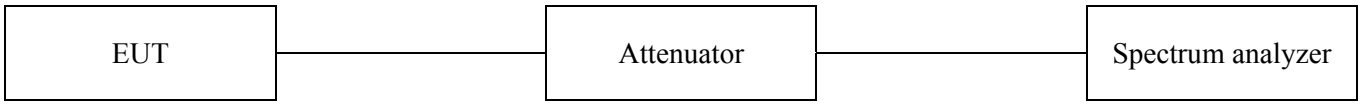


C. Packet type: DH5



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 ㎒ (Approximately 5 times the 20 ㏈ bandwidth, centered on a hopping channel)
   RBW = 1 ㎒ (the 20 ㏈ bandwidth of the emission being measured)
   VBW = 1 ㎒ (≥ 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.

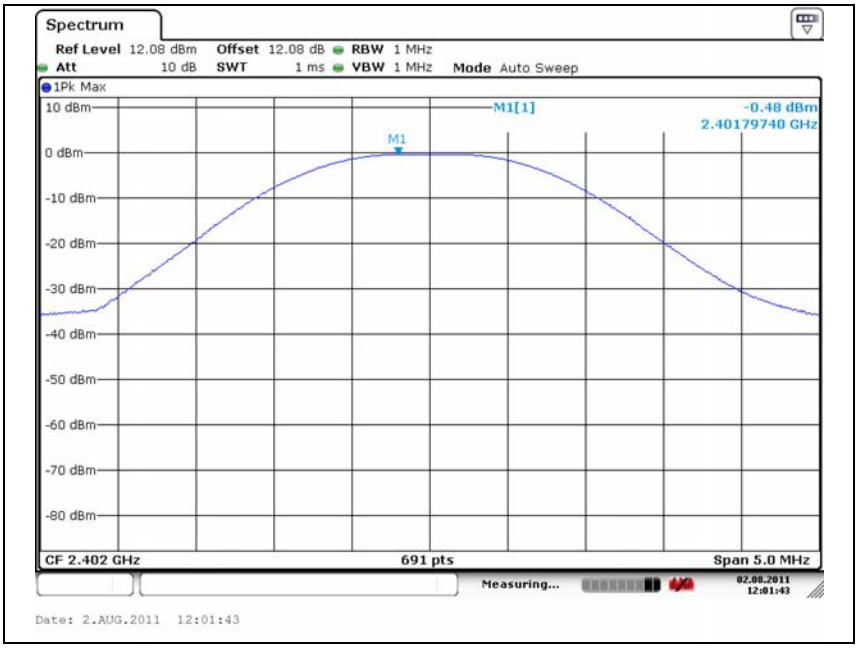
Limit

According to §15.247(b)(3), for systems using digital modulation in the 902 ~ 928 ㎒, 2 400 ~2 483.5 ㎒, and 5 725 ~ 5 850 ㎒ band: 1 Watt.

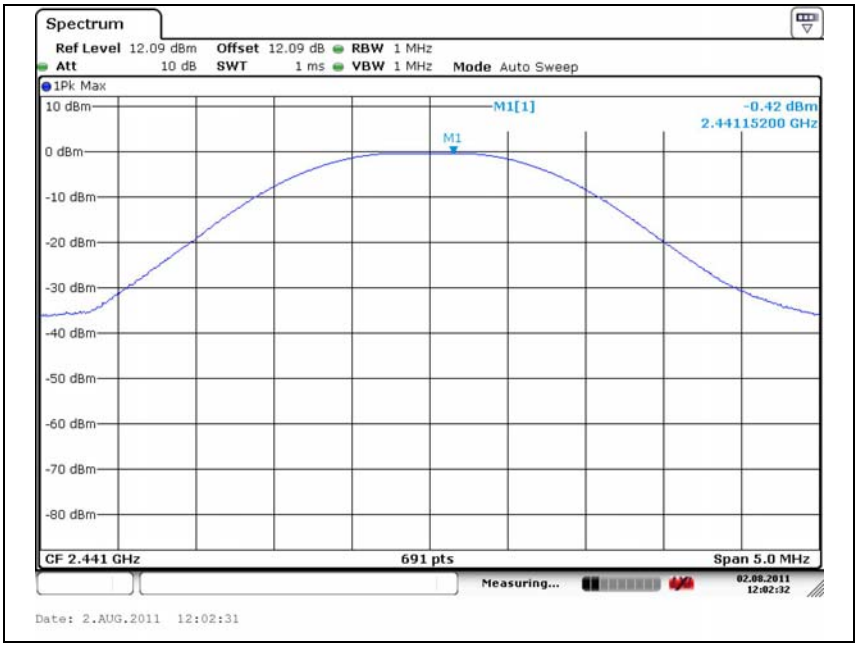
Test results

Operation mode	Frequency(㎒)	Output power (dBm)	Limit (dBm)
GFSK	2 402	-0.48	30
	2 441	-0.42	30
	2 480	-0.02	30

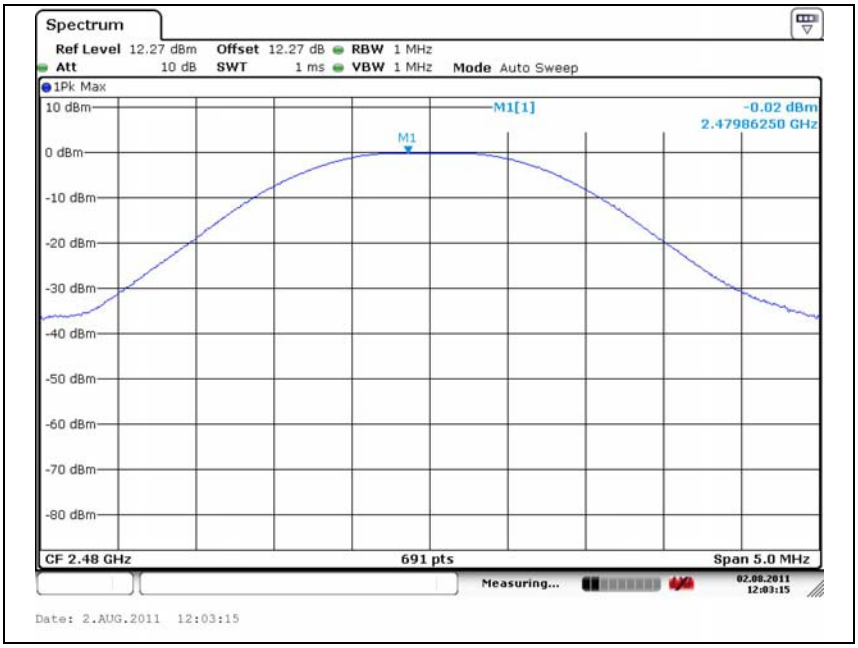
A. Low channel



B. Middle channel

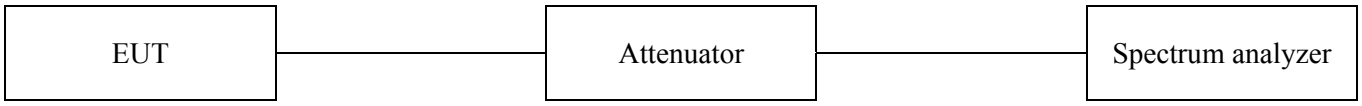


C. High channel



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 ㎑
   VBW = 100 ㎑ (≥ 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 on 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

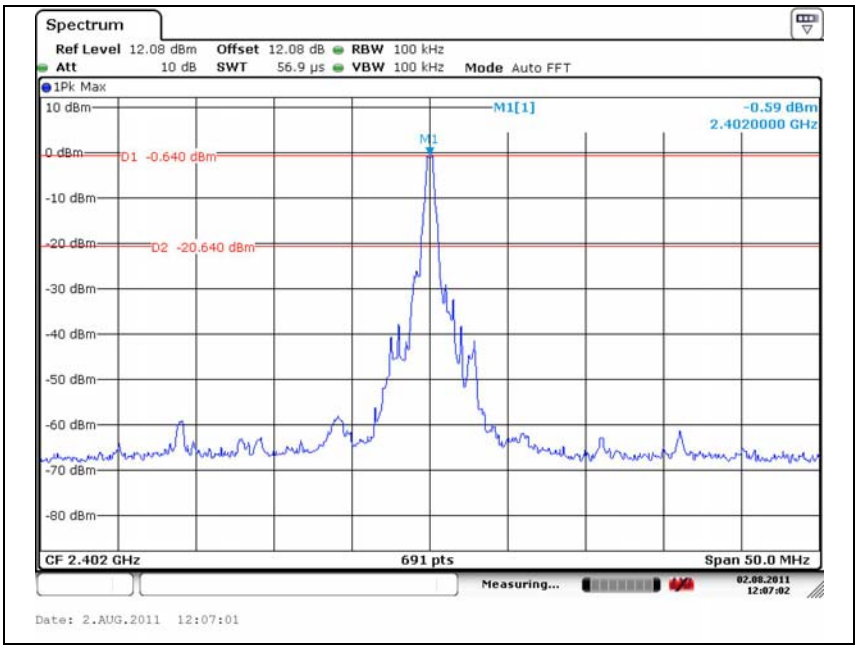
1. Use the following spectrum analyzer setting
   Center frequency: Lowest, middle and highest channels
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions(e.g,. harmonics) from the lowest frequency generated in the EUT up through the 10^{th} harmonics.
   RBW = 100 ㎑
   VBW = 100 ㎑ (≥ 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.

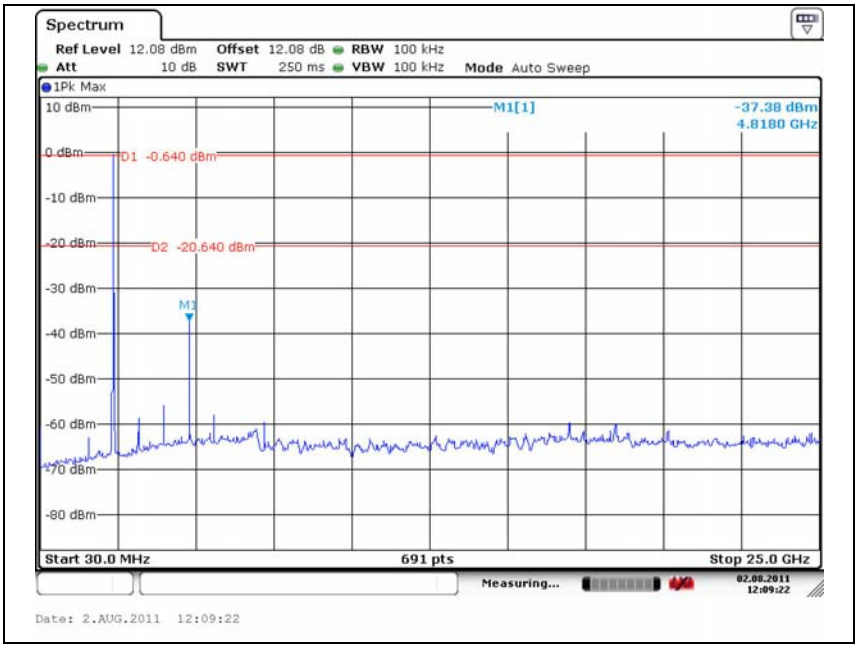
Limit

According to 15.247(d), in any 100 ㎑ 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 ㏈ below that in the 100 ㎑ 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 ㏈ instead of 20 ㏈. 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))

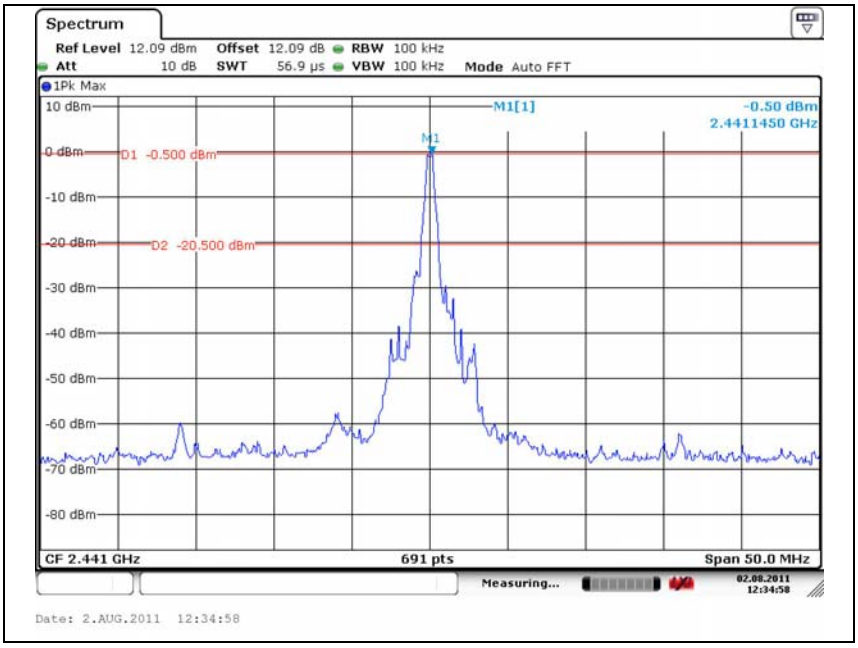
Test results

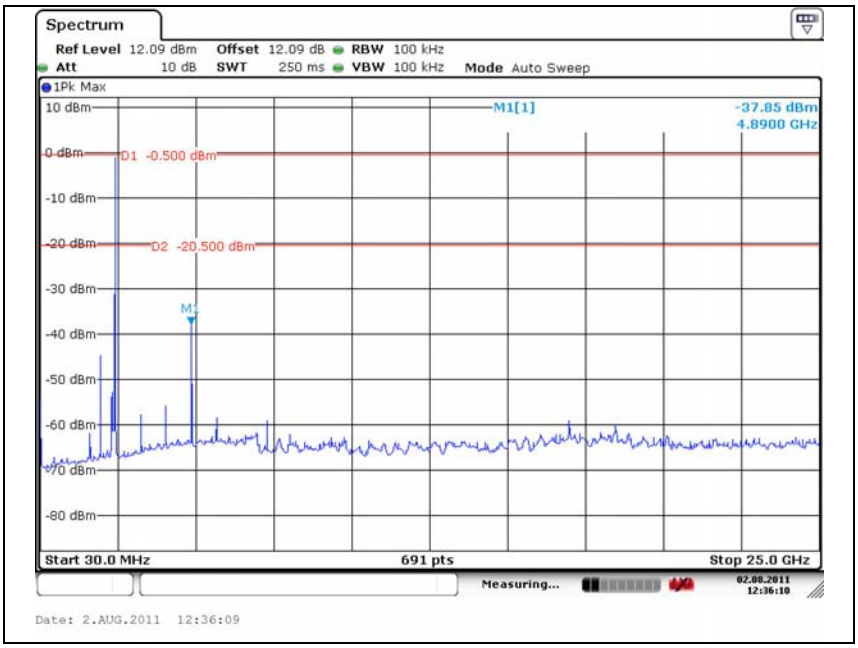
A. Low channel



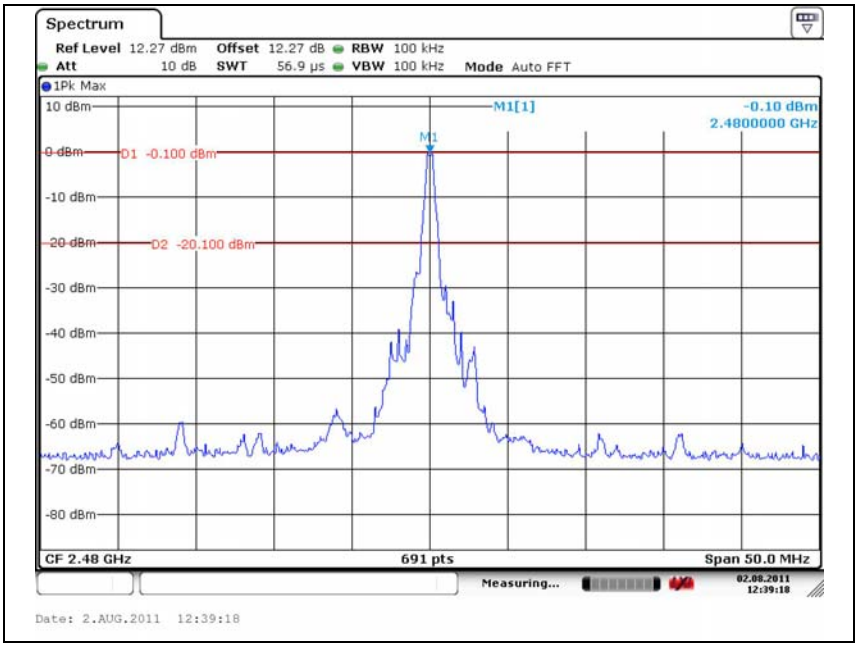


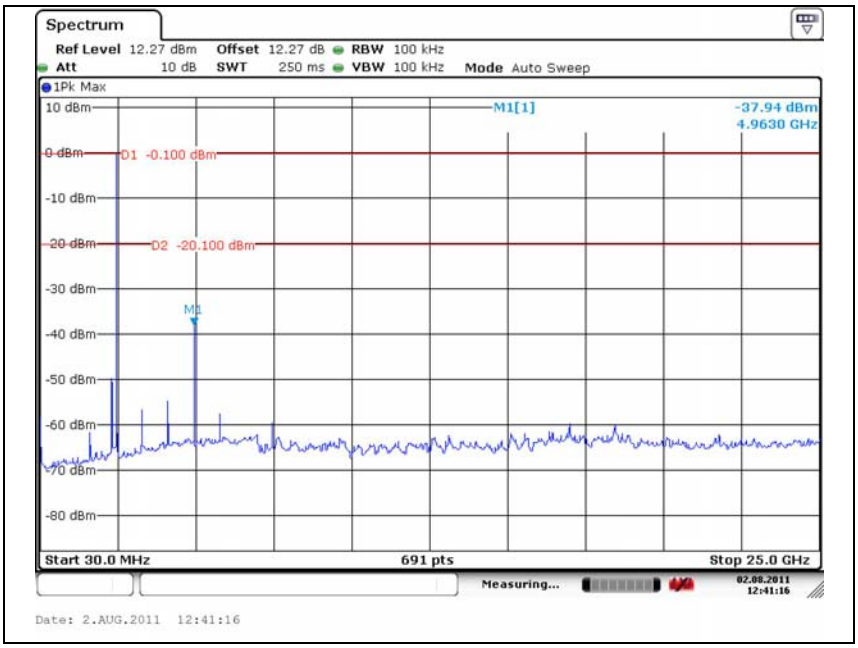
B. Middle channel



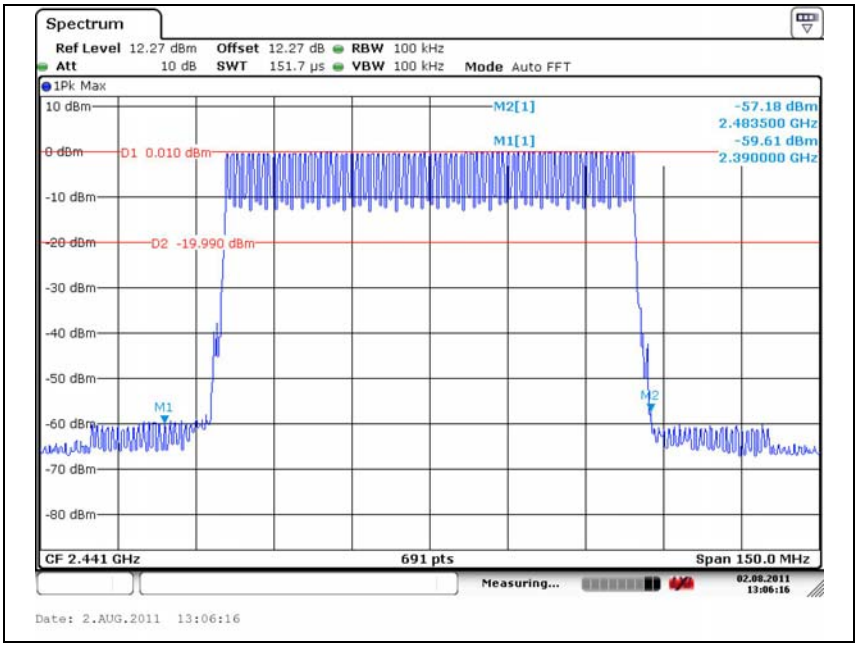


C. High channel





D. Band edge (Hopping mode)



2.1.7 Radiated spurious emission & band edge

Test location

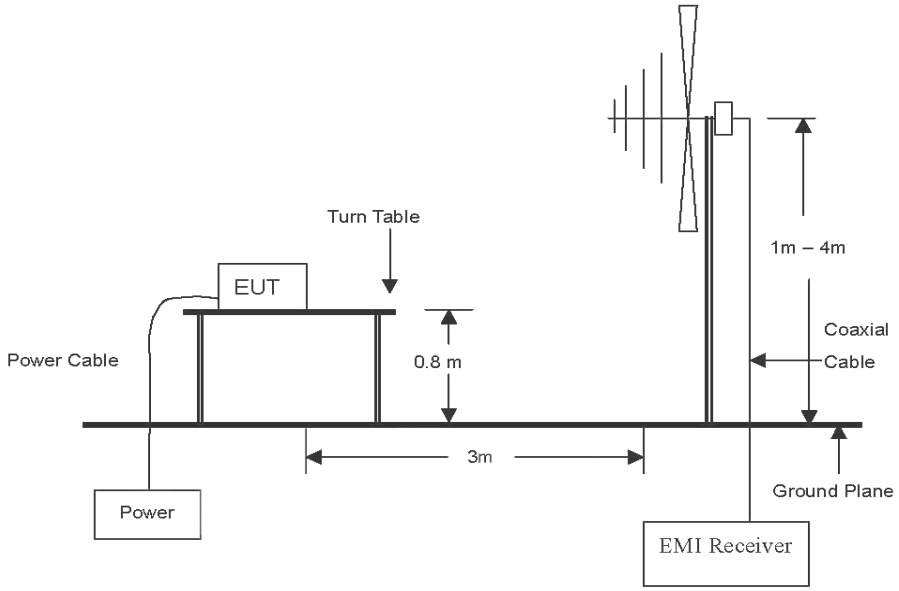
Testing was performed at a test distance of 3 meter Open Area Test Site

Test procedures

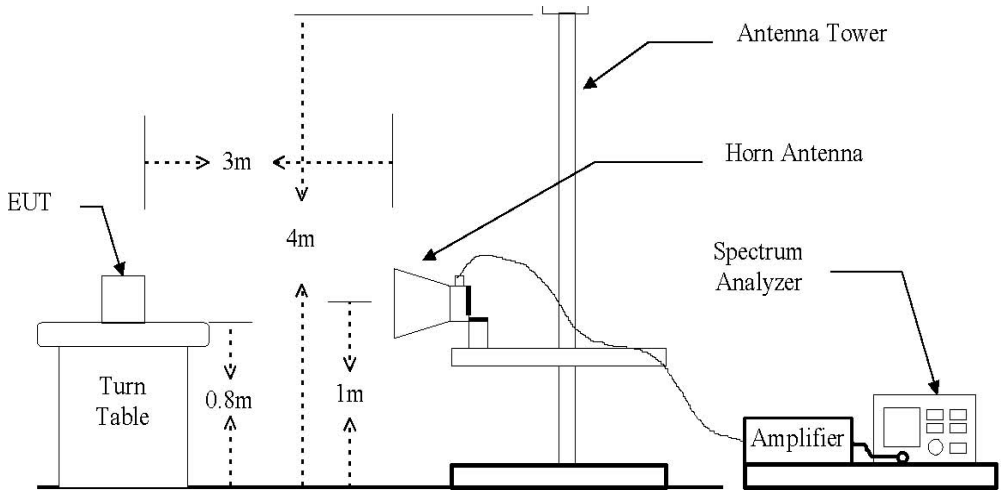
The height of the measuring antenna was varied between 1 to 4 m and the table was rotated a full revolution in order to obtain maximum values of the electric field intensity.
The measurement was made in both the vertical and horizontal polarization, and the maximum value is presented in the report.

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

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



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 ㎓ to 24 ㎓ 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 (㎒)	Distance (Meters)	Radiated (dB㎶/m)	Radiated (㎶/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

Test results (Below 1 000 ㎒)

The frequency spectrum from 30 ㎒ to 1 000 ㎒ was investigated. Emission levels are not reported much lower than the limits by over 20 ㏈.

Radiated emissions		Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (㏈㎶)	Pol.	Ant. factor (㏈/m)	Cable (㏈)	Actual (㏈㎶/m)	Limit (㏈㎶/m)	Margin (㏈)
176.0	9.01	H	13.62	2.50	25.13	43.5	18.37
196.5	10.77	H	11.18	2.67	24.62	43.5	18.88
326.3	9.42	H	14.33	3.56	27.31	46	18.69
436.0	8.07	V	16.60	4.22	28.89	46	17.11

※ Remark

1. All spurious emission at channels are almost the same below 1 ㎓, 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.

Test results (Above 1 000 ㎒)

A. Low channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 390	50.49	Peak	H	28.31	-38.02	40.78	74.00	33.22
2 390	51.04	Peak	V	28.31	-38.02	41.33	74.00	32.67
4 804	55.81	Peak	V	33.91	-34.11	55.61	74.00	18.39
4 804	44.13	Average	V	33.91	-34.11	43.93	54.00	10.07
4 804	58.17	Peak	H	33.91	-34.11	57.97	74.00	16.03
4 804	43.58	Average	H	33.91	-34.11	43.38	54.00	10.62

B. Middle channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
4 882	59.25	Peak	H	34.16	-33.92	59.49	74.00	14.51
4 882	45.81	Average	H	34.16	-33.92	46.05	54.00	7.95
4 882	59.23	Peak	V	34.16	-33.92	59.47	74.00	14.53
4 882	46.01	Average	V	34.16	-33.92	46.25	54.00	7.75

C. High channel

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 483.5	50.11	Peak	H	28.50	-37.81	40.80	74.00	33.20
2 483.5	50.22	Peak	V	28.50	-37.81	40.91	74.00	33.09
4 960	57.17	Peak	V	34.42	-33.73	57.86	74.00	16.14
4 960	45.10	Average	V	34.42	-33.73	45.79	54.00	8.21
4 960	57.43	Peak	H	34.42	-33.73	58.12	74.00	15.88
4 960	45.17	Average	H	34.42	-33.73	45.86	54.00	8.14

※ Remark

1. "*" means the restricted band.
2. Measuring frequencies from 1 ㎓ to the 10th harmonic of highest fundamental frequency.
3. Radiated emissions measured in frequency above 1 000 ㎒ 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.

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.

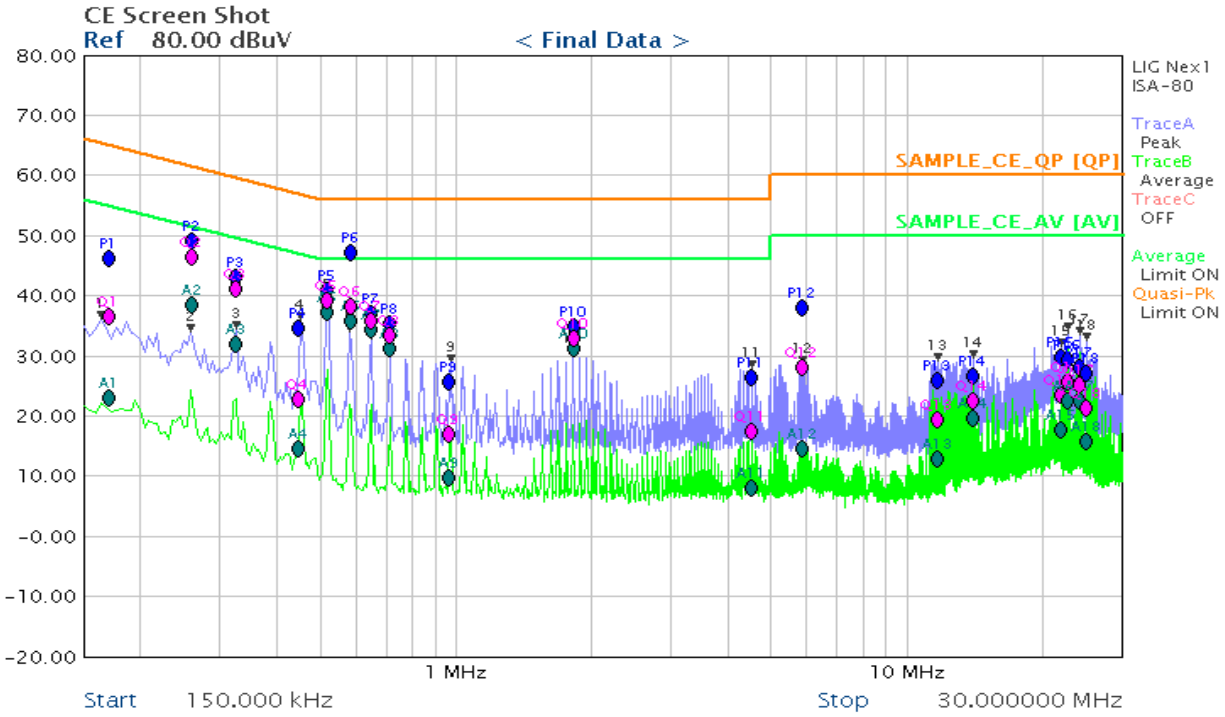
Frequency of Emission (MHz)	Conducted limit (dBuV/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

※ Remark
Decreases with the logarithm of the frequency.

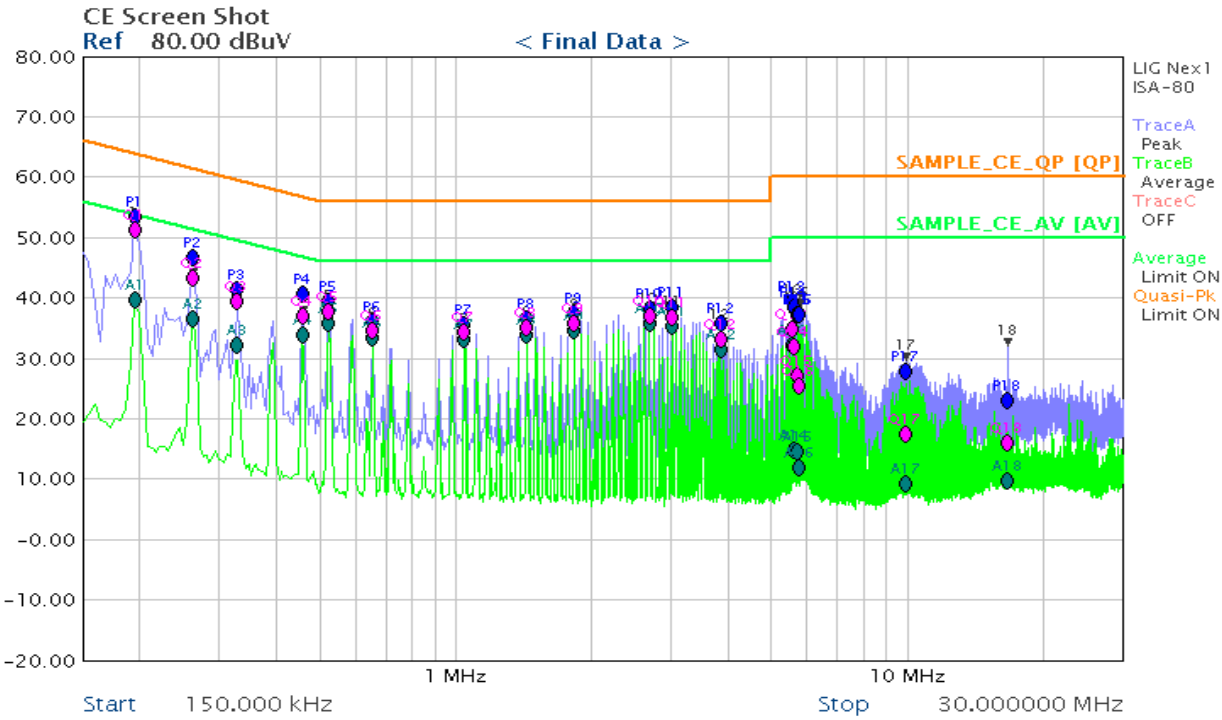
Test results

Frequency (MHz)	Correction		Phase Hot/ Neutral	Quasi peak			Average		
	LISN	Cable Loss		Reading	Result	Limit	Reading	Result	Limit
0.196	9.772	0.104	N	41.354	51.230	**64**	29.684	39.560	**54**
0.261	9.764	0.100	H	36.516	46.380	**61**	28.446	38.310	**51**
0.262	9.764	0.100	N	33.366	43.230	**61**	26.426	36.290	**51**
0.327	9.760	0.100	H	31.140	41.000	**60**	22.050	31.910	**50**
0.328	9.757	0.100	N	29.553	39.410	**60**	22.123	31.980	**50**
0.459	9.750	0.100	N	26.940	36.790	**57**	23.830	33.680	**47**
0.522	9.760	0.100	H	29.290	39.150	**56**	27.240	37.100	**46**
0.526	9.750	0.100	N	27.740	37.590	**56**	25.810	35.660	**46**
0.587	9.760	0.100	H	28.290	38.150	**56**	25.770	35.630	**46**
1.839	9.760	0.100	N	25.900	35.760	**56**	24.560	34.420	**46**
2.692	9.774	0.100	N	26.896	36.770	**56**	25.846	35.720	**46**
3.020	9.780	0.100	N	26.840	36.720	**56**	25.190	35.070	**46**
5.577	9.796	0.100	N	24.714	34.610	**60**	22.084	31.980	**50**
5.635	9.796	0.100	N	21.934	31.830	**60**	4.804	14.700	**50**
5.702	9.797	0.100	N	17.023	26.920	**60**	4.563	14.460	**50**
5.888	9.809	0.100	H	18.131	28.040	**60**	4.551	14.460	**50**
14.010	9.850	0.190	H	12.350	22.390	**60**	9.380	19.420	**50**
22.695	9.990	0.100	H	15.490	25.580	**60**	12.220	22.310	**50**

[Hot]



[Neutral]



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
Attenuator	HP	8491B	2012-05-04
Preamplifier	A.H.	PAM-0118	2012-05-04
EMI Test Receiver	R&S	ESHS10	2012-05-09
LISN	R&S	ENV216	2012-02-16

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook	Samsung electronics	R159	ZKPA93AS900167D
Notebook	Fujitsu	A6020	FPC03209CZ

Test setup photo and configuration

Radiated field emissions

AC conducted emission