TEST REPORT

of

FCC Part 15 Subpart C §15.247

FCC ID: TQ8-AC111TMAN

Equipment Under Test	:	DIGITAL CAR AUDIO SYSTEM
Model Name	:	AC111TMAN
Serial No.	:	N/A
Applicant	:	Hyundai MOBIS Co., Ltd.
Manufacturer	:	Hyundai MOBIS Co., Ltd.
Date of Test(s)	:	2012.12.27 ~ 2013.01.03
Date of Issue	:	2013.01.03

In the configuration tested, the EUT complied with the standards specified above.

Tested By:	**Alvin Kim**	Date	2013.01.03
Approved By:	**Feel Jeong**	Date	2013.01.03

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1. General Information

1.1. Testing Laboratory

SGS Korea Co., Ltd. (Gunpo Laboratory)
- Wireless Div. 3FL, 18-34, Sanbon-dong, Gunpo-si, Gyeonggi-do, Korea 435-040 (Lab)
- Wireless Div. 1FL, 18-34, Sanbon-dong, Gunpo-si, Gyeonggi-do, Korea 435-040 (Chamber)

All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.

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1.2. Details of Applicant

Applicant : Hyundai MOBIS Co., Ltd.
Address : 80-9, Mabook-Dong, Giheung-Gu Yongin-Shi, Gyunggi-Do, 446-912, South Korea
Contact Person : Kim, Jong-Tae
Phone No. : +82 31 260 0092

1.3. Description of EUT

Kind of Product	DIGITAL CAR AUDIO SYSTEM
Model Name	AC111TMAN
Serial Number	N/A
Power Supply	DC 14.4 V (Used on vehicle battery)
Frequency Range	2 402 ㎒ ~ 2 480 ㎒
Modulation Technique	GFSK, π/4DQPSK, 8DPSK
Number of Channels	79
Antenna Type	Chip antenna
Antenna Gain	3.5 dB i

1.4. Declaration by the manufacturer

- Adaptive Frequency Hopping is supported and use at least 20 channels

1.5. Information about the FHSS characteristics:

1.5.1. Pseudorandom Frequency Hopping Sequence

The channel is represented by a pseudo-random hopping sequence hopping through the 79 RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master; the phase in the hopping sequence is determined by the Bluetooth clock of the master. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The nominal hop rate is 1 600 hops/s.

1.5.2. Equal Hopping Frequency Use

All Bluetooth units participating in the piconet are time and hop-synchronized to the channel.

1.5.3. System Receiver Input Bandwidth

Each channel bandwidth is 1 ㎒

1.5.4. Equipment Description

15.247(a)(1) that the rx input bandwidths shift frequencies in synchronization with the transmitted

15.247(g): In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.

15.247(h): In accordance with the Bluetooth Industry Standard, the system does not coordinate it channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

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1.6. Test Equipment List

Equipment	Manufacturer	Model	S/N	Cal Date	Cal Interval	Cal Due.
Signal Generator	R&S	SMBV100A	255834	Jul. 02, 2012	Annual	Jul. 02, 2013
Signal Generator	R&S	SMR40	100272	Aug. 23, 2012	Annual	Aug. 23, 2013
Spectrum Analyzer	Agilent	N9030A	US51350132	Oct. 30, 2012	Annual	Oct. 30, 2013
Bluetooth Tester	Anritsu	MT8852B	1219006	Jul. 19, 2012	Annual	Jul. 19, 2013
Directional Coupler	KRYTAR	152613	127447	Apr. 04, 2012	Annual	Apr. 04, 2013
Power Divider	MCLI	PS2-206	23514	Jun. 02, 2012	Annual	Jun. 02, 2013
High Pass Filter	Wainwright	WHK3.0/18G-10SS	344	Jul. 12, 2012	Annual	Jul. 12, 2013
Low Pass Filter	Mini circuits	NLP-1200+	V8979400903-2	Mar. 30, 2012	Annual	Mar. 30, 2013
Power Meter	Agilent	E4416A	GB41292123	Mar. 29, 2012	Annual	Mar. 29, 2012
Power Sensor	Agilent	E9327A	US40441371	Mar. 30. 2012	Annual	Mar. 30. 2013
DC Power Supply	Agilent	6553A	MY40000695	Jul. 02, 2012	Annual	Jul. 02, 2013
Preamplifier	H.P.	8447F	2944A03909	Jul. 04, 2012	Annual	Jul. 03, 2013
Preamplifier	R&S	SCU18	10117	Jan. 14, 2013	Annual	Jan. 14, 2014
Preamplifier	MITEQ Inc.	JS44-18004000-35-8P	1546891	Jul. 12, 2012	Annual	Jul. 12, 2013
Test Receiver	R&S	ESU26	100109	Feb. 21, 2012	Annual	Feb. 21, 2013
Bilog Antenna	SCHWARZBECK MESSELEKTRONIK	VULB9163	396	May 12, 2011	Biennial	May 12, 2013
Horn Antenna	R&S	HF906	100326	Nov. 23, 2011	Biennial	Nov. 23, 2013
Horn Antenna	SCHWARZBECK MESSELEKTRONIK	BBHA9170	BBHA9170431	May 15, 2012	Biennial	May 15, 2014
Antenna Master	INN-CO	MM4000	N/A	N.C.R.	N/A	N.C.R.
Turn Table	INN-CO	DS 1200S	N/A	N.C.R.	N/A	N.C.R.
Anechoic Chamber	SY Corporation	L × W × H (9.6 m × 6.4 m × 6.6 m)	N/A	N.C.R.	N/A	N.C.R.
Loop Antenna	R&S	HFH2-Z2	100118	Aug 24, 2011	Biennial	Aug 24, 2013

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1.7. Summary of Test Results

The EUT has been tested according to the following specifications:

APPLIED STANDARD:FCC Part15 subpart C		
Section	**Test Item**	**Result**
15.205(a) 15.209 15.247(d)	Transmitter Radiated Spurious Emissions Conducted Spurious Emission	Complied
15.247(a)(1)	20 dB Bandwidth	Complied
15.247(b)(1)	Maximum Peak Output Power	Complied
15.247(a)(1)	Frequency Separation	Complied
15.247(a)(1)(iii)	Number of Hopping Frequency	Complied
15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Complied
15.247(i) 1.1307(b)(1)	Maximum Permissible Exposure (Exposure of Humans to RF Fields)	Complied

1.8. Sample calculation

Where relevant, the following sample calculation is provided:

1.8.1. Conducted test

Offset value (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)

1.8.2. Radiation test

Field strength level (dBμV/m) = Measured level (dBμV) + Antenna factor (dB) + Cable loss (dB) – amplifier gain (dB)

1.9. Test report revision

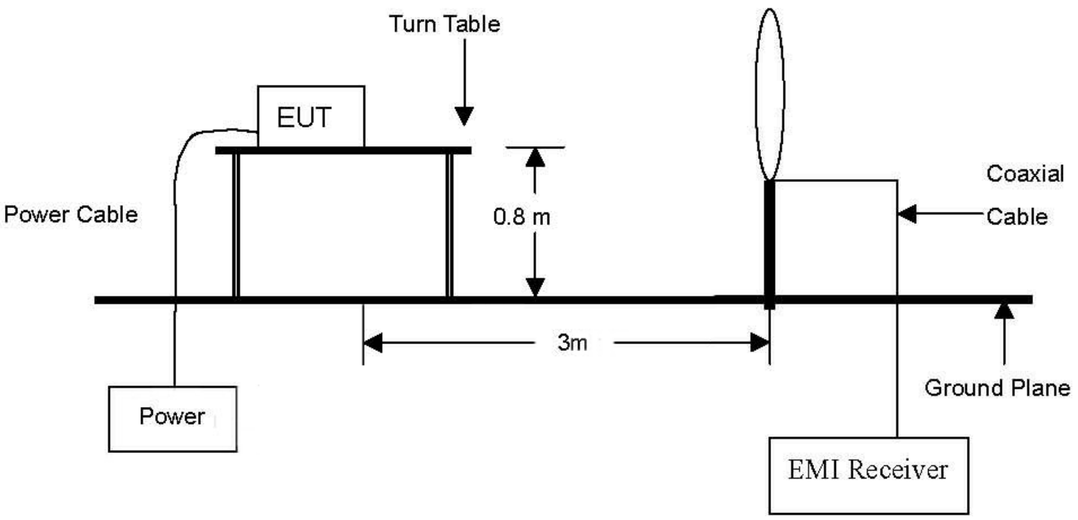
Revision	Report number	Description
0	F690501/RF-RTL006100	Initial

2. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

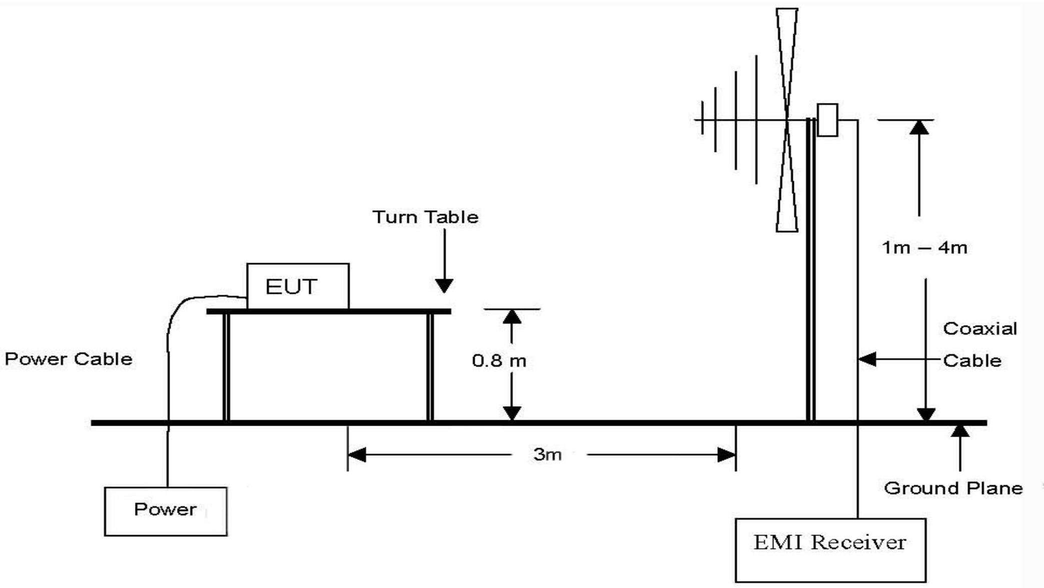
2.1. Test Setup

2.1.1. Transmitter Radiated Spurious Emissions

The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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



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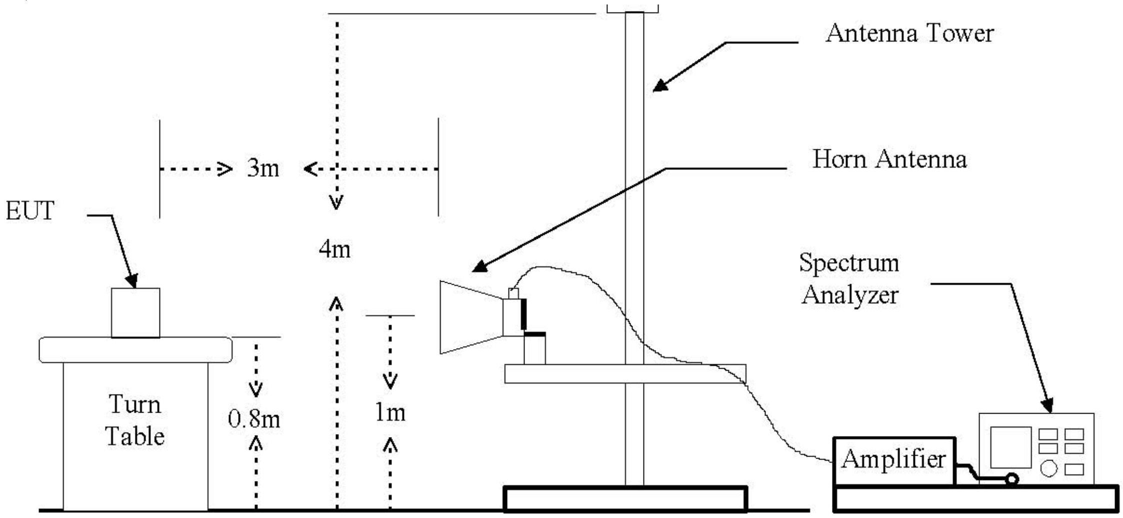
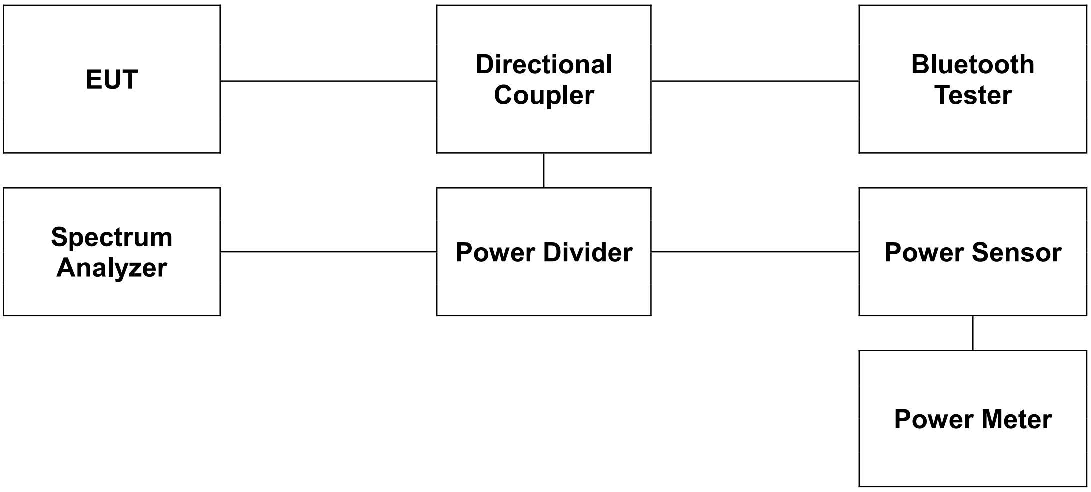
The diagram below shows the test setup that is utilized to make the measurements for emission .The spurious emissions were investigated form 1 ㎓ to the 10th harmonic of the highest fundamental frequency or 40 ㎓, whichever is lower.



2.1.2. Conducted Spurious Emissions



2.2. 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))

According to § 15.209(a), Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table：

Frequency (㎒)	Distance (Meters)	Field Strength (㏈ μV/m)	Field Strength (μV/m)
0.009 – 0.490	300	-	2400/F(㎑)
0.490 – 1.705	30	-	24000/F(㎑)
1.705 – 30.0	30	29.5	30
30 – 88	3	40.0	100
88 – 216	3	43.5	150
216 – 960	3	46.0	200
Above 960	3	54.0	500

2.3. Test Procedures

Radiated emissions from the EUT were measured according to the dictates of DA000705 and ANSI C63.4 2003

2.3.1. Test Procedures for Radiated Spurious Emissions

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 3 meter away from the interference-receiving antenna.
3. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
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 table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
6. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

NOTE ;

All data rates and modes were investigated for radiated spurious emissions. Only the radiated emissions of the configuration that produced the worst case emissions are reported in this section.

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Peak detection (PK) and 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.
4. When Average result is different from peak result over 20 dB (over-averaging), According to 15.35 (c), as a “duty cycle correction factor”, pulse averaging with 20 log(duty cycle) has to be used.
5. To get a maximum emission level from the EUT, the EUT is manipulated through three orthogonal planes.

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2.3.2. Test Procedures for Conducted Spurious Emissions

2.3.2.1. Band-edge Compliance of RF Conducted Emissions

The transmitter output was connected to the spectrum analyzer.
Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation.
RBW ≥ 100 ㎑
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

2.3.2.2. Spurious RF Conducted Emissions

The transmitter output was connected to the spectrum analyzer.
RBW = 100 ㎑
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

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2.4. Test Results

Ambient temperature : (24 ± 2) ℃
Relative humidity : 47 % R.H.

2.4.1. Spurious Radiated Emission (Worst case configuration_ 8DPSK mode, 3 Mbps, Low channel)

The frequency spectrum from 9 ㎑ to 1 000 ㎒ was investigated. Emission levels are not reported much lower than the limits by over 30 ㏈. All reading values are peak values.

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP + CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
160.0	45.30	Peak	H	8.9	-25.2	29.0	43.5	14.5
180.0	46.6	Peak	H	10.0	-25.1	31.5	43.5	12.0
200.0	45.0	Peak	H	11.0	-24.8	31.2	43.5	12.3
230.0	41.6	Peak	H	12.0	-24.5	29.1	46.0	16.9
365.0	49.0	Peak	H	13.4	-25.0	37.4	46.0	8.6
365.0	47.6	Peak	V	13.4	-25.0	36.0	46.0	10.0
435.0	39.8	Peak	V	14.5	-24.6	29.7	46.0	16.3
Above 500.0	Not detected	-	-	-	-	-	-	-

Remark:

1. All spurious emissions at channels are almost the same below 1 ㎓, so that middle channel was chosen at representative in final test.
2. Actual = Reading + AF + AMP + CL

2.4.2. Spurious Radiated Emission

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

Operating Mode: GFSK (1 Mbps)

A. Low Channel (2 402 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 401.98	48.78	Peak	V	28.05	7.22	84.05	Fundamental	
*2 390.00	23.60	Peak	V	28.05	7.18	58.83	74.00	15.17
*2 390.00	11.89	Average	V	28.05	7.18	47.12	54.00	6.88

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.63	55.33	Peak	V	30.19	-34.90	50.62	64.05	13.43
*4 803.78	51.45	Peak	V	32.28	-32.72	51.01	74.00	22.99
*4 803.78	34.10	Average	V	32.28	-32.72	33.66	54.00	20.34

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B. Middle Channel (2 441 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 440.99	53.37	Peak	V	28.08	7.31	88.76	Fundamental	

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.63	55.32	Peak	V	30.19	-34.90	50.61	68.76	18.15
*4 881.50	51.93	Peak	V	32.85	-32.36	52.42	74.00	21.58
*4 881.50	34.29	Average	V	32.85	-32.36	34.78	54.00	19.22

C. High Channel (2 480 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 479.99	48.60	Peak	V	28.30	7.37	84.27	Fundamental	
*2 483.50	22.98	Peak	V	28.31	7.37	58.66	74.00	15.34
*2 483.50	12.11	Average	V	28.31	7.37	47.79	54.00	6.21

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.62	55.26	Peak	V	30.19	-34.90	50.55	64.27	13.72
*4 959.91	49.60	Peak	V	33.31	-32.34	50.57	74.00	23.43
*4 959.91	33.44	Average	V	33.31	-32.34	34.41	54.00	19.59

Operating Mode: 8DPSK (3 Mbps)

A. Low Channel (2 402 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 401.99	49.55	Peak	V	28.05	7.22	84.92	Fundamental	
*2 390.00	22.88	Peak	V	28.05	7.18	58.11	74.00	15.89
*2 390.00	11.90	Average	V	28.05	7.18	47.13	54.00	6.87

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.62	55.30	Peak	V	30.19	-34.90	50.59	64.92	14.33
*4 824.18	40.20	Peak	V	32.31	-32.66	39.85	74.00	34.15
*4 824.18	27.70	Average	V	32.31	-32.66	27.35	54.00	26.65

B. Middle Channel (2 441 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 440.99	53.44	Peak	V	28.08	7.31	88.83	Fundamental	

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.63	55.25	Peak	V	30.19	-34.90	50.54	68.83	18.29
*4 881.50	48.69	Peak	V	32.85	-32.36	49.18	74.00	24.82
*4 881.50	32.16	Average	V	32.85	-32.36	32.65	54.00	21.35

C. High Channel (2 480 ㎒)

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 479.99	48.13	Peak	V	28.30	7.37	83.80	Fundamental	
*2 483.50	23.15	Peak	V	28.31	7.37	58.83	74.00	15.17
*2 483.50	12.11	Average	V	28.31	7.37	47.79	54.00	6.21

Radiated Emissions			Ant	Correction Factors		Total	FCC Limit	
Frequency (㎒)	Reading (dB㎶)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
3 145.62	55.31	Peak	V	30.19	-34.90	50.60	63.80	13.20
*4 959.97	45.90	Peak	V	33.31	-32.34	46.87	74.00	27.13
*4 959.97	30.56	Average	V	33.31	-32.34	31.53	54.00	22.47

Remarks:

1. "*" means the restricted band.
2. Measuring frequencies from 1 ㎓ to the 10^{th} 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 + AF + AMP + CL

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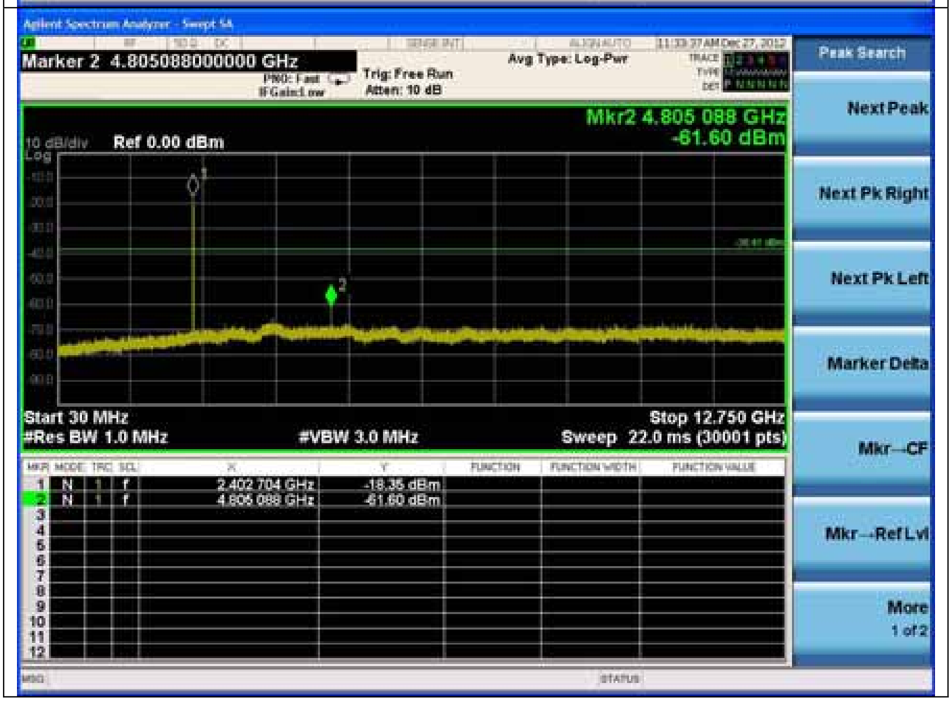
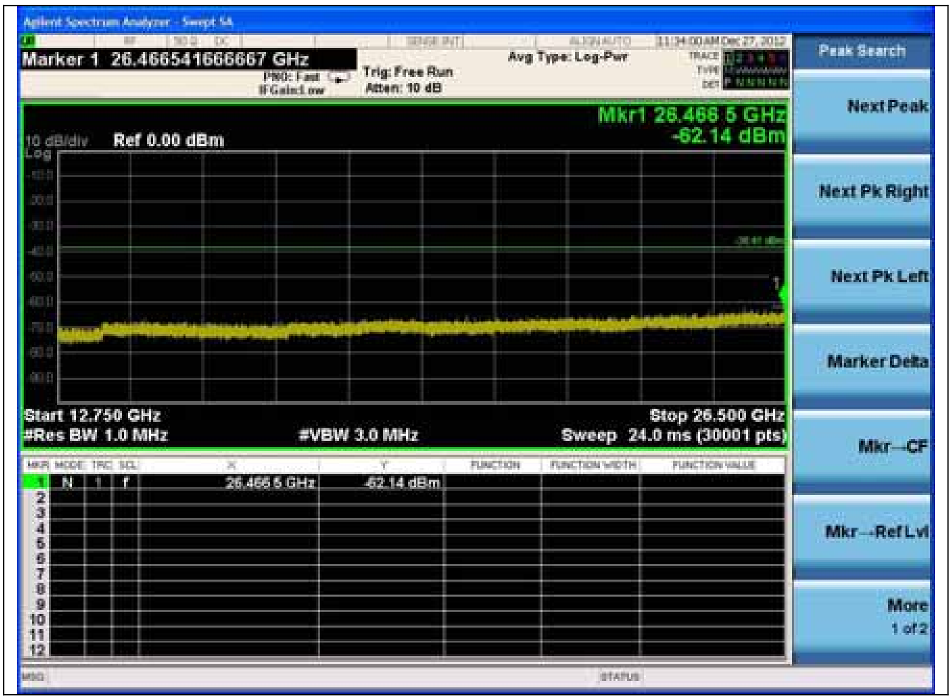
2.4.3. Spurious RF Conducted Emissions: Plot of Spurious RF Conducted Emission

Operating Mode: GFSK(1 Mbps)

Low Channel

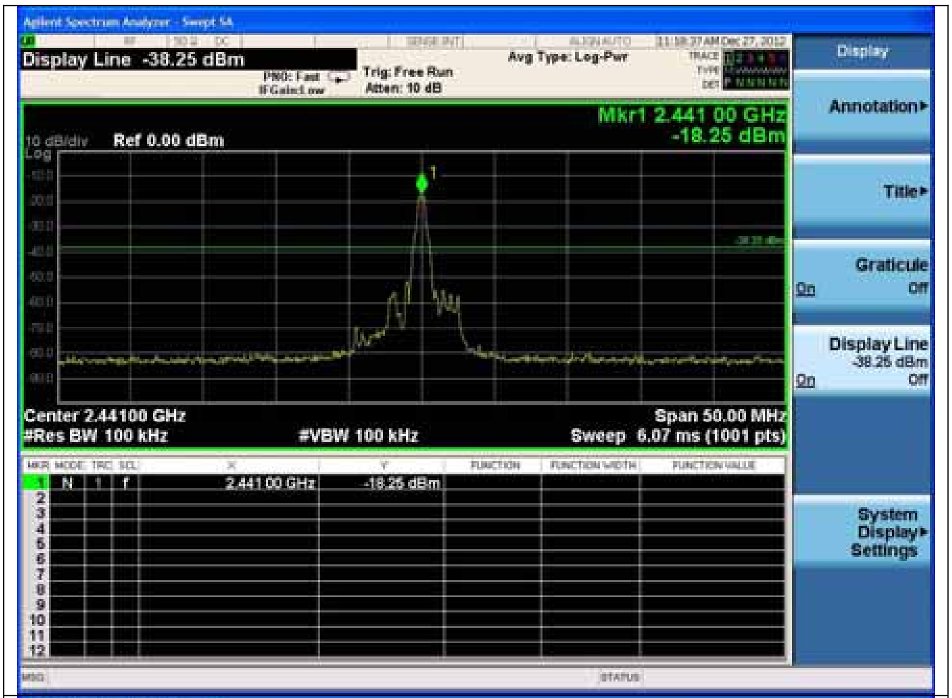


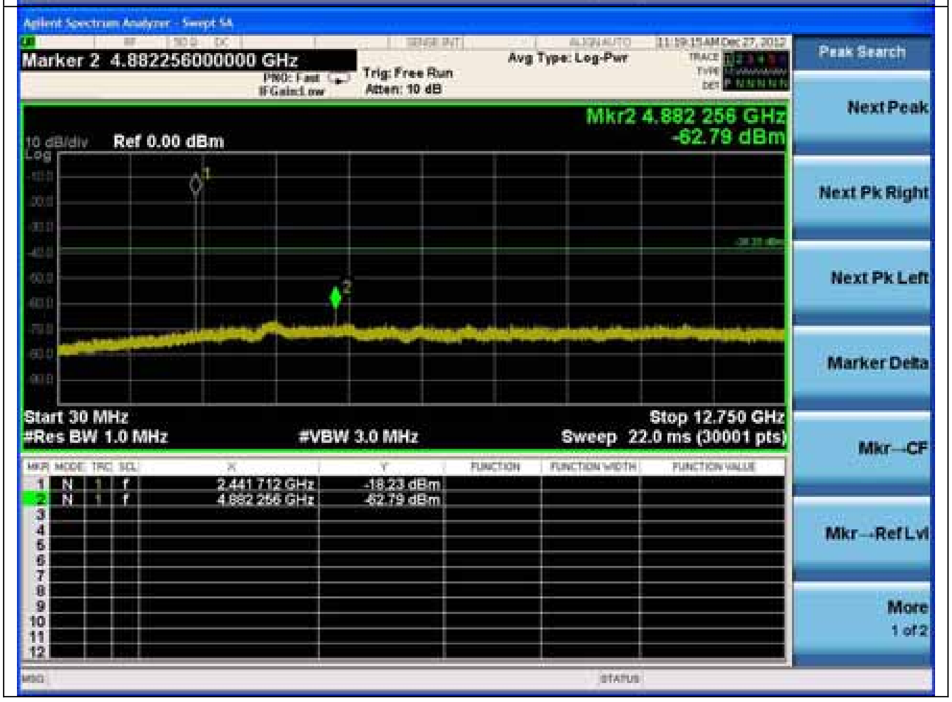


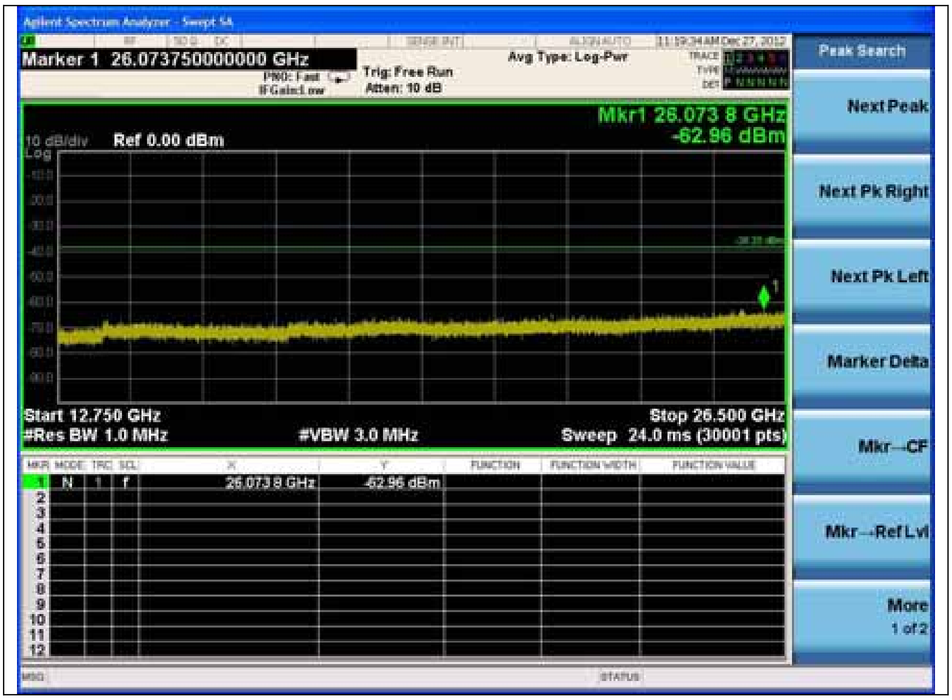
Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (㎒)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
2 390.0	-82.42	20.38	-62.04
2 400.0	-55.10	20.38	-34.72
4 805.1	-61.60	23.43	-38.17
26 466.5	Noise level	-	-

Middle Channel



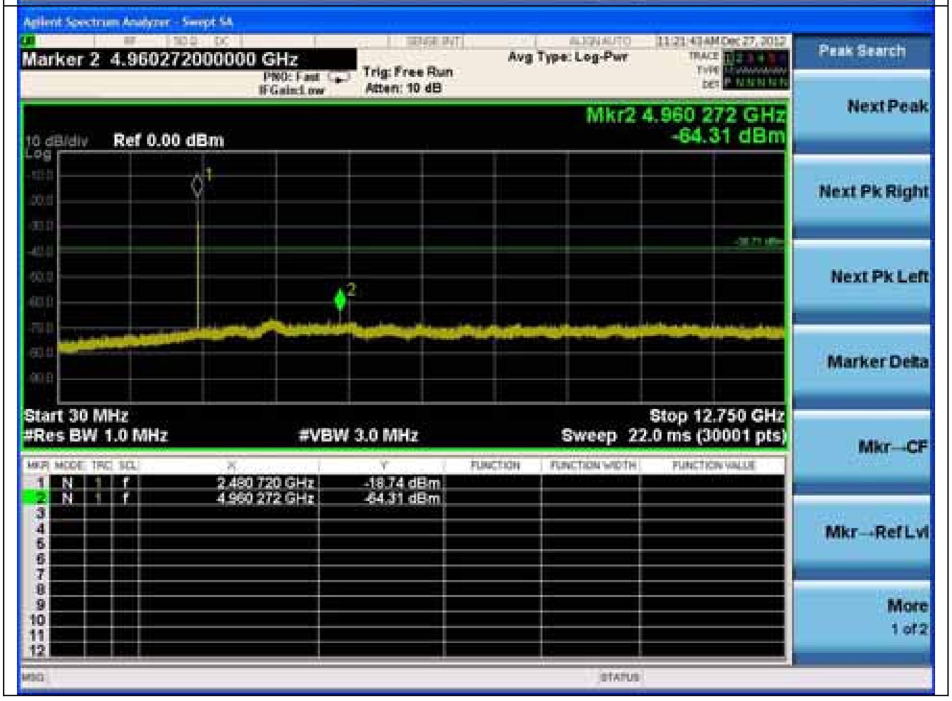


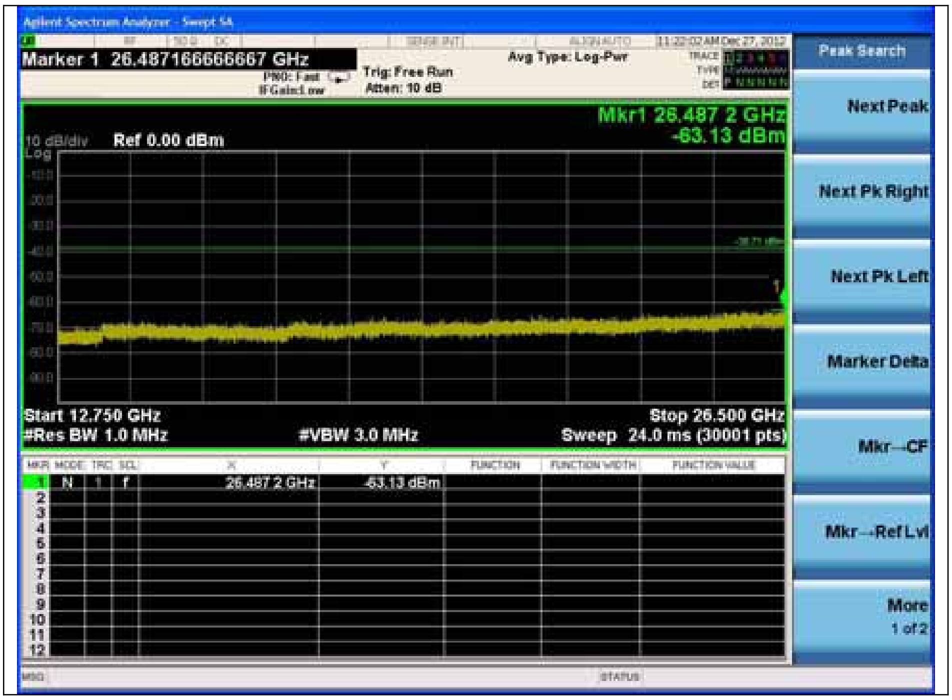


Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (㎒)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
4 882.3	-62.79	23.43	-39.36
26 073.8	Noise level	-	-

High Channel

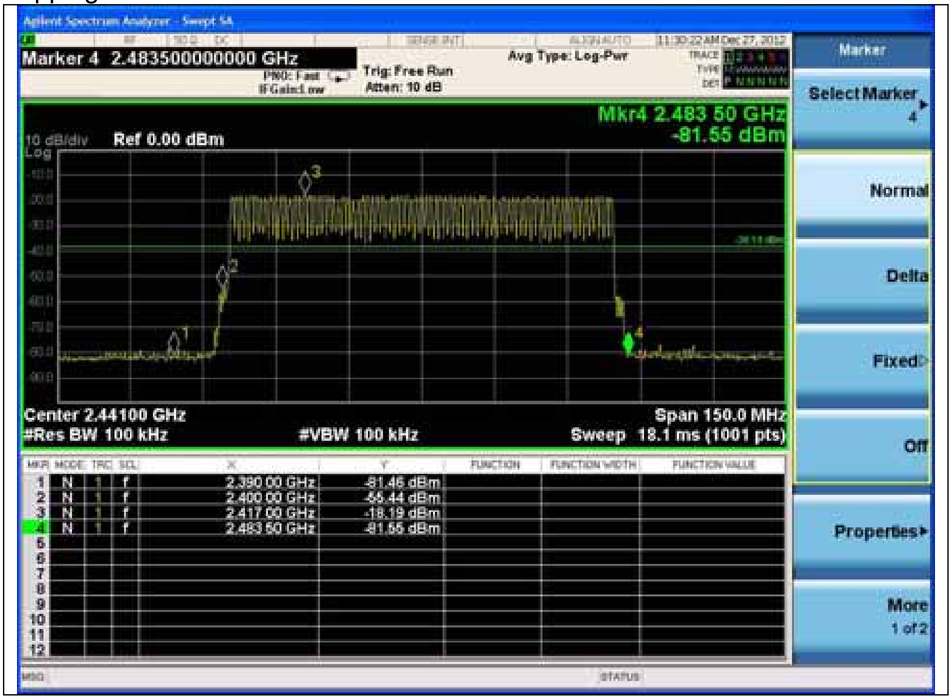




Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (MHz)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
2 483.5	-79.02	20.70	-58.32
4 960.3	-64.31	23.43	-40.88
26 487.2	Noise level	-	-

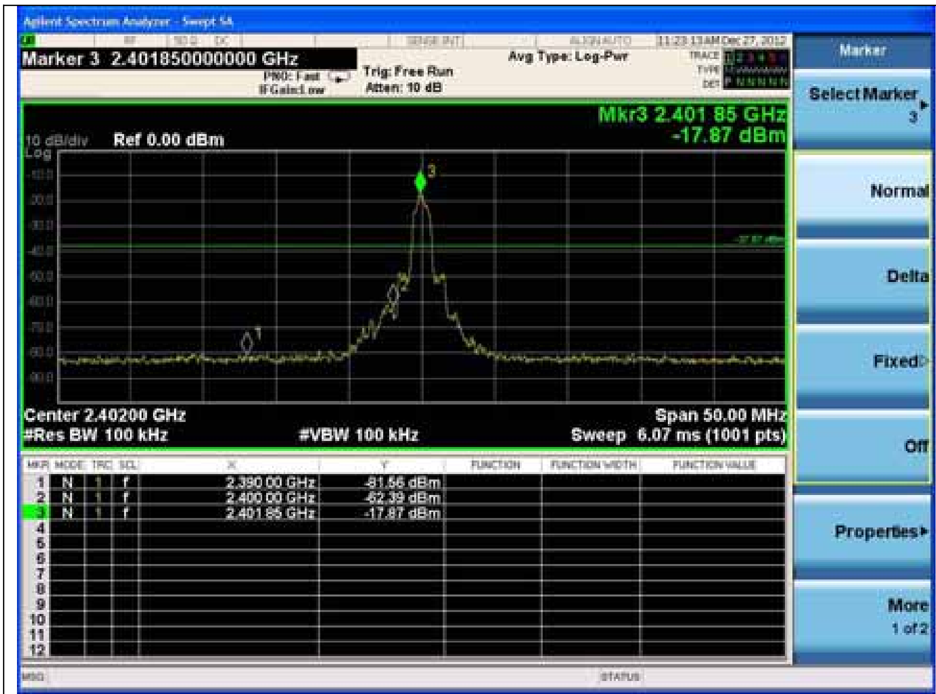
Band edge at Hopping

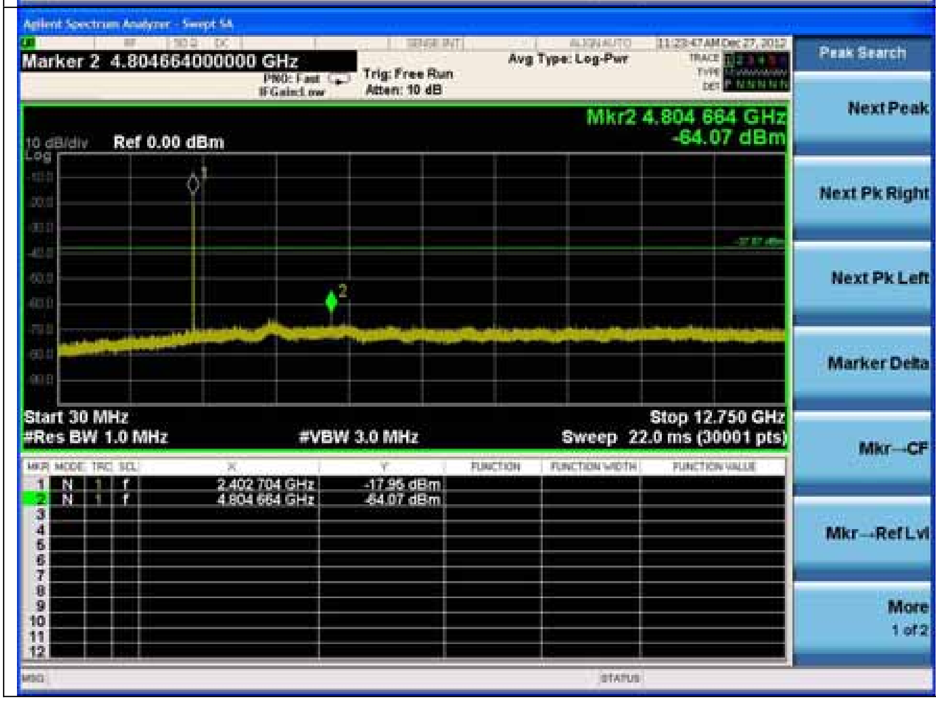


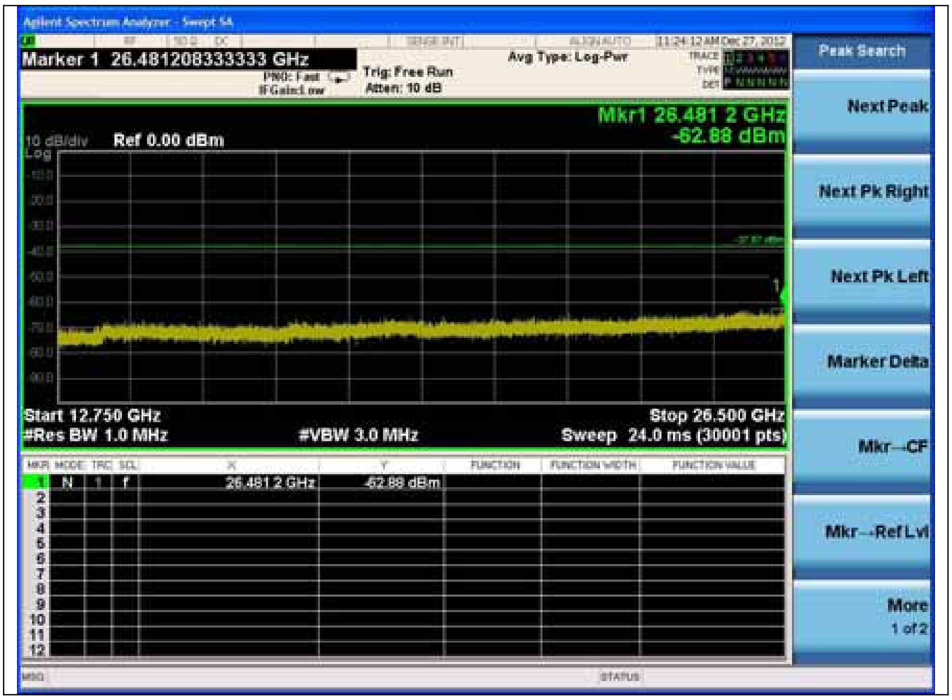
Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (MHz)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
2 390.0	-81.46	20.38	-61.08
2 400.0	-55.44	20.38	-35.06
2 483.5	-81.55	20.70	-60.85

Operating Mode : 8DPSK(3 Mbps)
Low Channel







Note:
Offset (㏈) = Directional Coupler(㏈) + Power Divider (㏈) + Cable loss (㏈)
Final Result (㏈ m) = Reading values (㏈ m) + Spurious offset (㏈)

Frequency (㎒)	Reading values (㏈ m)	Spurious offset (㏈)	Final Result (㏈ m)
2 390.0	-81.56	20.38	-61.18
2 400.0	-62.39	20.38	-42.01
4 804.7	-64.07	23.43	-40.64
26 481.2	Noise level	-	-

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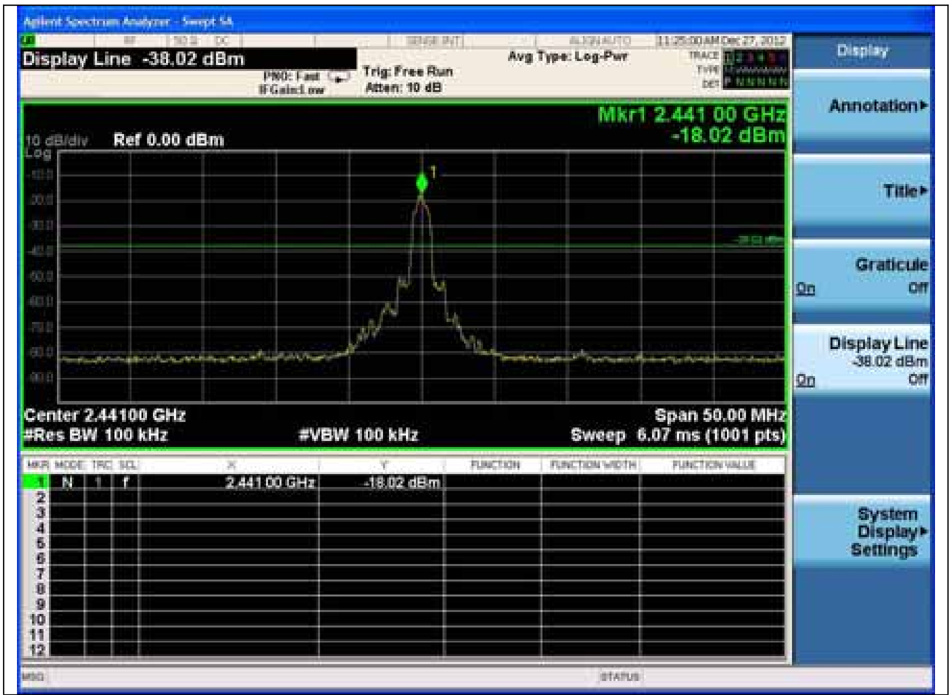
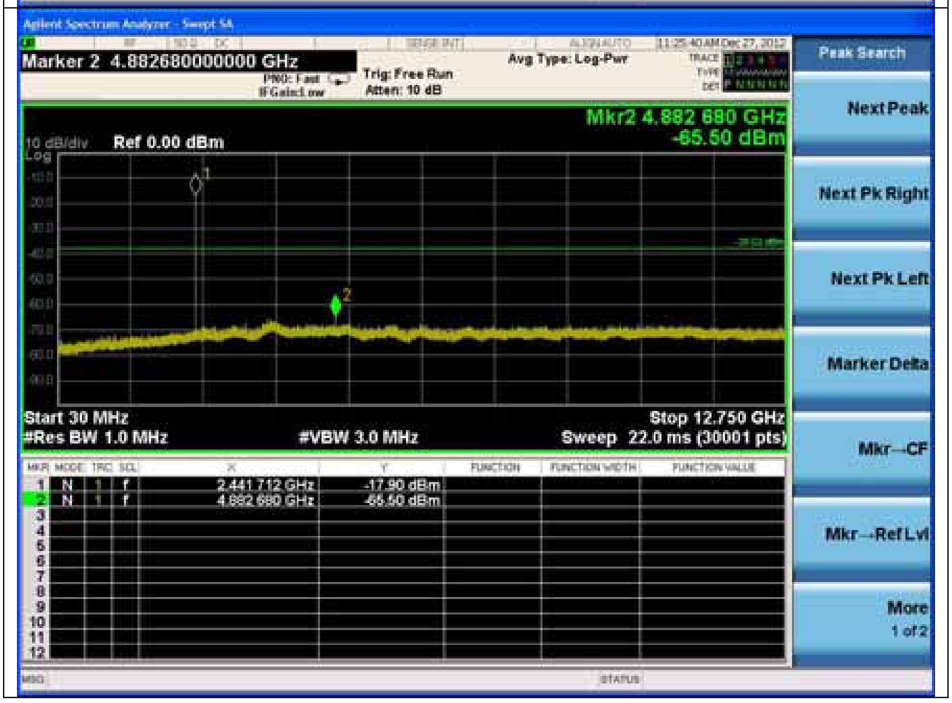
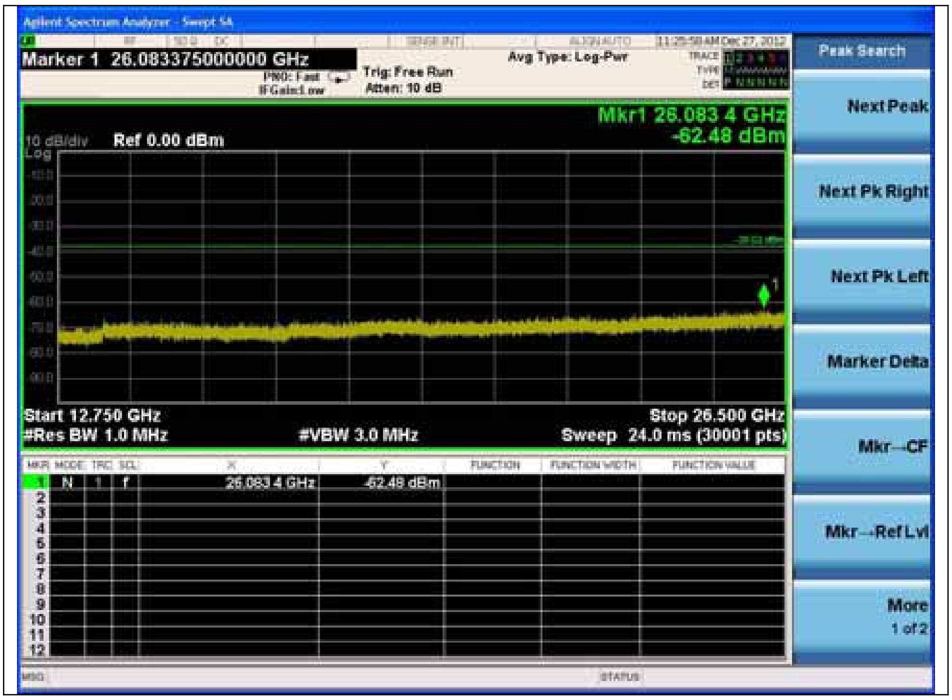
Middle Channel



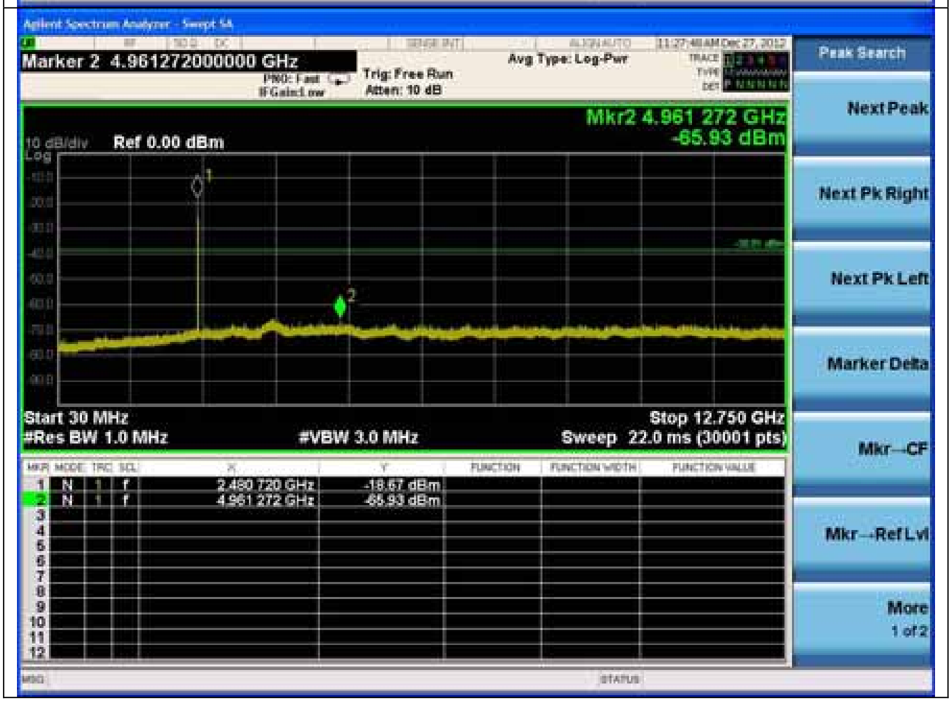


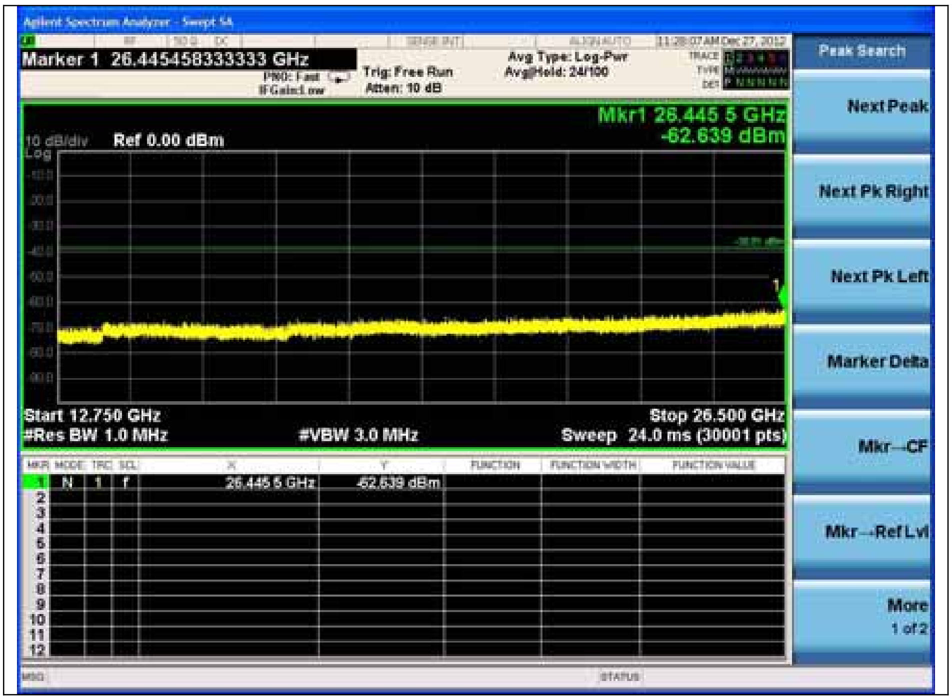


Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (MHz)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
4 882.7	-65.50	23.43	-42.07
26 083.4	Noise level	-	-

High Channel

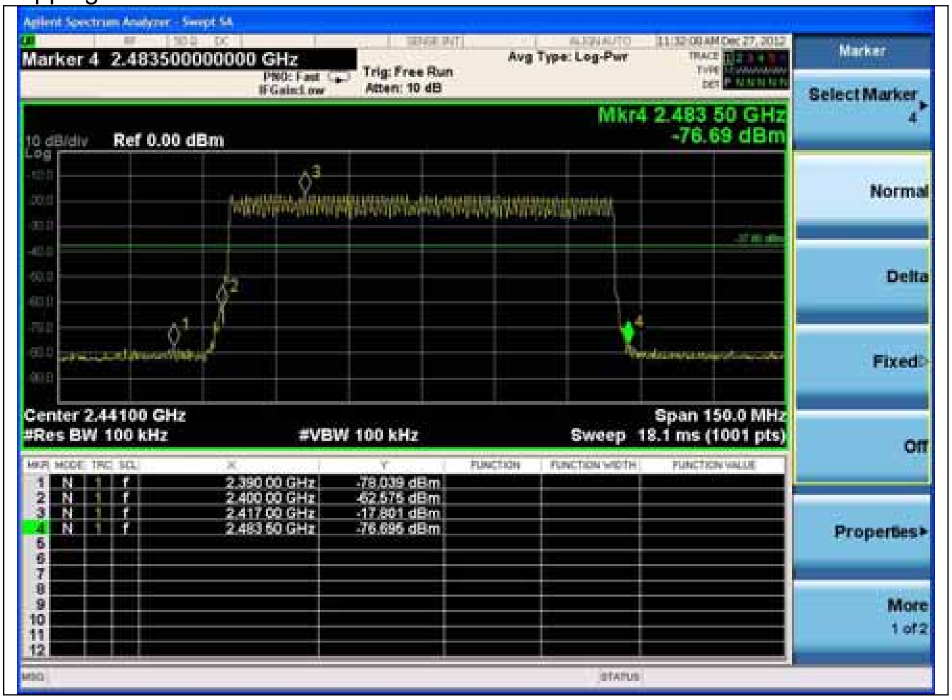




Note:
Offset (㏈) = Directional Coupler(㏈) + Power Divider (㏈) + Cable loss (㏈)
Final Result (㏈ m) = Reading values (㏈ m) + Spurious offset (㏈)

Frequency (㎒)	Reading values (㏈ m)	Spurious offset (㏈)	Final Result (㏈ m)
2 483.5	-75.22	20.70	-54.52
4 961.3	-65.93	23.43	-42.50
26 445.5	-62.64	Noise level	-

Band edge at Hopping

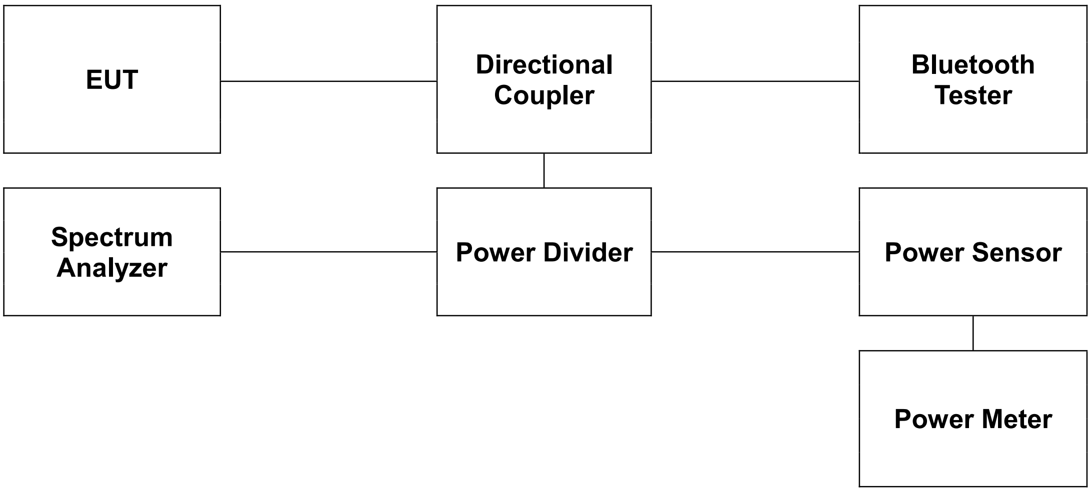


Note:
Offset (dB) = Directional Coupler(dB) + Power Divider (dB) + Cable loss (dB)
Final Result (dB m) = Reading values (dB m) + Spurious offset (dB)

Frequency (㎒)	Reading values (dB m)	Spurious offset (dB)	Final Result (dB m)
2 390.0	-78.04	20.38	-57.66
2 400.0	-62.58	20.38	-42.20
2 483.5	-76.70	20.70	-56.00

3. 20 dB Bandwidth Measurement

3.1. Test Setup



3.2. Limit

Limit: Not Applicable

3.3. Test Procedure

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section.

The test follows DA-000705.
The 20 dB band width was measured with a spectrum analyzer connected to RF antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency.

Use the following spectrum analyzer setting :

Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel.
RBW = greater than 1 % of the 20 dB bandwidth
VBW ≥ RBW
Sweep = auto
Detector = peak
Trace = max hold

The marker-to-peak function to set the mark to the peak of the emission. Use the marker-delta function to measure 20 dB down one side of the emission. Reset the 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 20 dB bandwidth of the emission.

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3.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Data Rate	Channel	Channel Frequency (㎒)	20 ㏈ Bandwidth (㎒)
GFSK	1 Mbps	Low	2 402	0.91
		Middle	2 441	0.91
		High	2 480	0.83
8DPSK	3 Mbps	Low	2 402	1.20
		Middle	2 441	1.19
		High	2 480	1.19

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20 ㏈ Bandwidth

Operating Mode: GFSK

Low Channel

Middle Channel

High Channel

Operating Mode: 8DPSK

Low Channel

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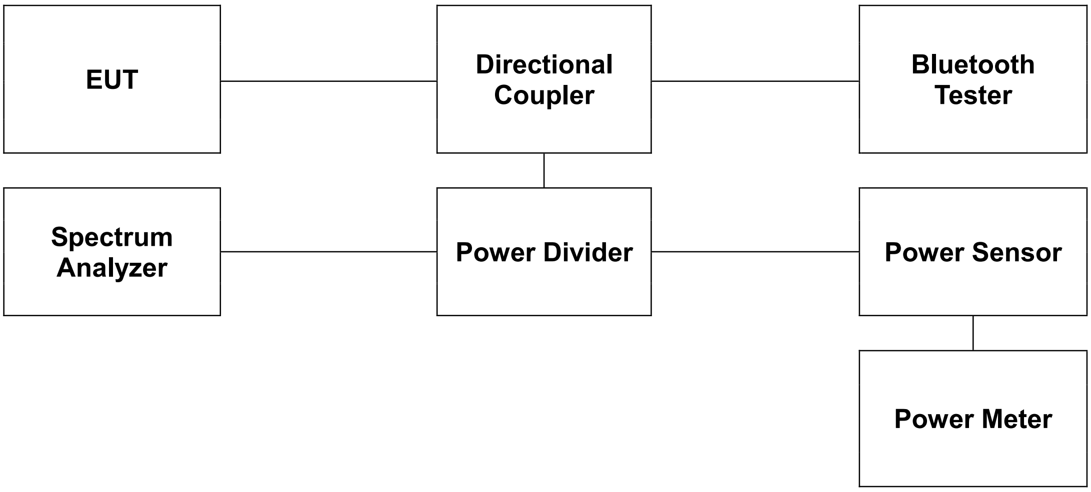
Middle Channel

High Channel

4. Maximum Peak Output Power Measurement

4.1. Test Setup



4.2. 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 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 ㎒ employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 – 5 805 ㎒ band: 1 Watt.

4.3. Test Procedure

All data rates and modes were investigated for this test. The test follows DA000705. Using the power sensor instead of a spectrum analyzer.

1. Place the EUT on the table and set it in the transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Power sensor.
3. Measure peak & average power each channel.

4.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Data Rate	Channel	Channel Frequency (㎒)	Attenuator + Cable offset (dB)	Average Power Result (dB m)	Peak Power Result (dB m)	Peak Power Limit (dB m)
GFSK	1 Mbps	Low	2 402	20.22	0.86	2.16	30.00
		Middle	2 441	20.39	1.08	2.38	30.00
		High	2 480	2.43	0.59	1.90	30.00
π/4DQPSK	2 Mbps	Low	2 402	20.22	0.41	3.46	30.00
		Middle	2 441	20.39	0.19	3.34	30.00
		High	2 480	20.43	-0.59	2.71	30.00
8DPSK	3 Mbps	Low	2 402	20.22	0.42	3.57	30.00
		Middle	2 441	20.39	0.18	3.41	30.00
		High	2 480	20.43	-0.59	2.76	30.00

Remark:
In the case of AFH, the limit for peak power is 0.125 W

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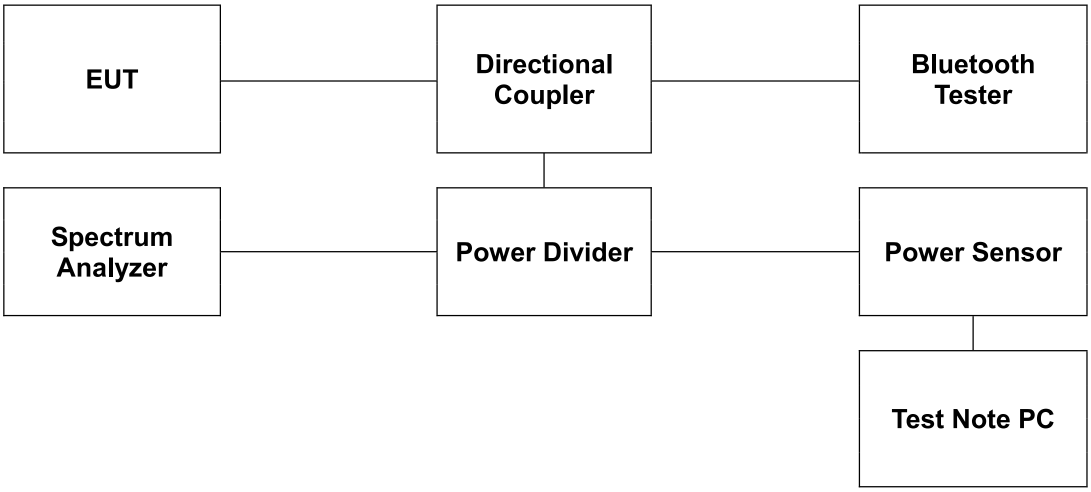
5. Hopping Channel Separation

5.1. Test Setup



5.2. 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 is greater, provided the systems operate with an output power no greater than 125 ㎽.

5.3. Test Procedure

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section. The test follows DA000705.

The device is operating in hopping mode between 79 channels and also supporting Adaptive Frequency Hopping with hopping between 20 channels. As compared with each operating mode, 79 channels are chosen as a representative for test.
Use the following spectrum analyzer settings:

Span = wide enough to capture the peaks of two adjacent channels.
RBW = 1 % of the span.
VBW = RBW
Sweep = auto
Detector = peak
Trace = max hold.

Allow the trace to stabilize. Use the marker-delta function to determine the between the peaks of the adjacent channels.

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5.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Channel (Middle)	Adjacent Hopping Channel Separation (㎑)	Two-third of 20 ㏈ Bandwidth (㎑)	Minimum Bandwidth (㎑)
GFSK	2 441 ㎒	1 000	607	25
8DPSK	2 441 ㎒	1 000	793	25

Note;
Measurement is made with EUT operating in hopping mode between 79 channels providing a worse case scenario as compared to AFH mode hopping between 20 channels.

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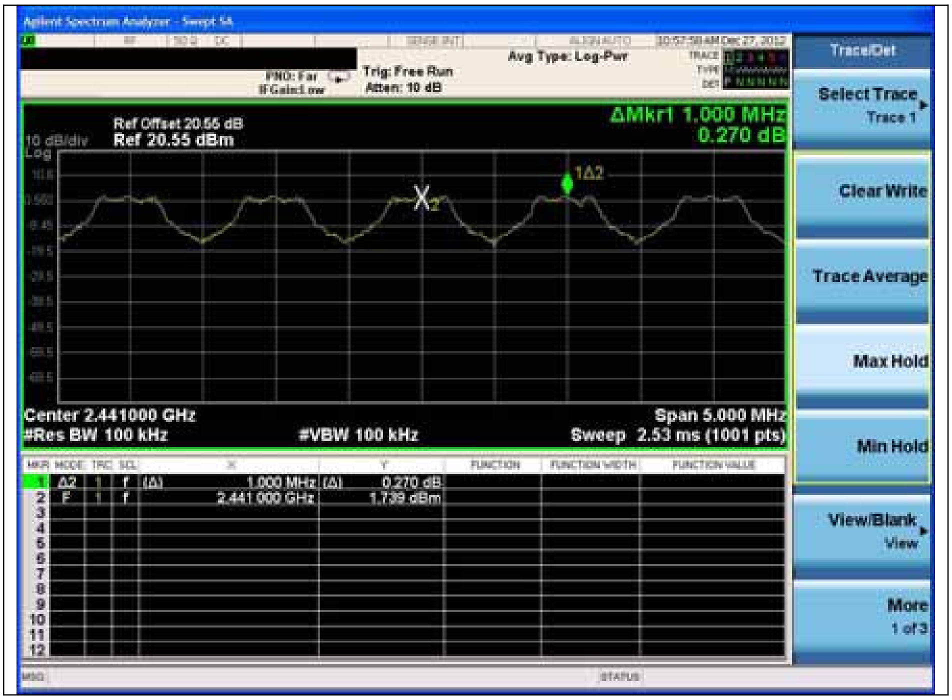
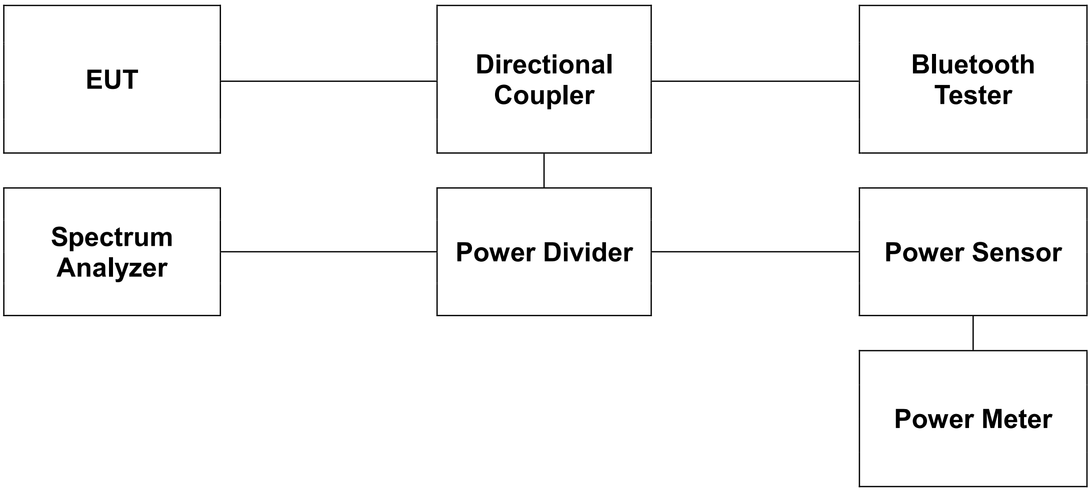
Operating Mode: GFSK



Operating Mode: 8DPSK

6. Number of Hopping Frequency

6.1. Test Setup



6.2. Limit

§15.247(a)(1)(iii), Frequency hopping systems in the 2 400–2 483.5 ㎒ band shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

6.3. Test Procedure

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section. The test follows DA000705.

The device supports Adaptive Frequency Hopping and will use a minimum of 20 channels of the 79 available channels.

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

1. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna the port to the Spectrum analyzer
3. Set spectrum analyzer Start = 2 400 ㎒, Stop = 2 441.5 ㎒, Sweep=sweep and Start = 2 441.5 ㎒, Stop = 2 483.5 ㎒, Sweep = sweep. Detector = peak.
4. Set the spectrum analyzer as RBW, VBW = 300 ㎑.
5. Max hold, allow the trace to stabilize and count how many channel in the band.

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6.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

Remark:
Measurement is made with EUT operating in hopping mode between 79 channels providing a worse case scenario as compared to AFH mode hopping between 20 channels.

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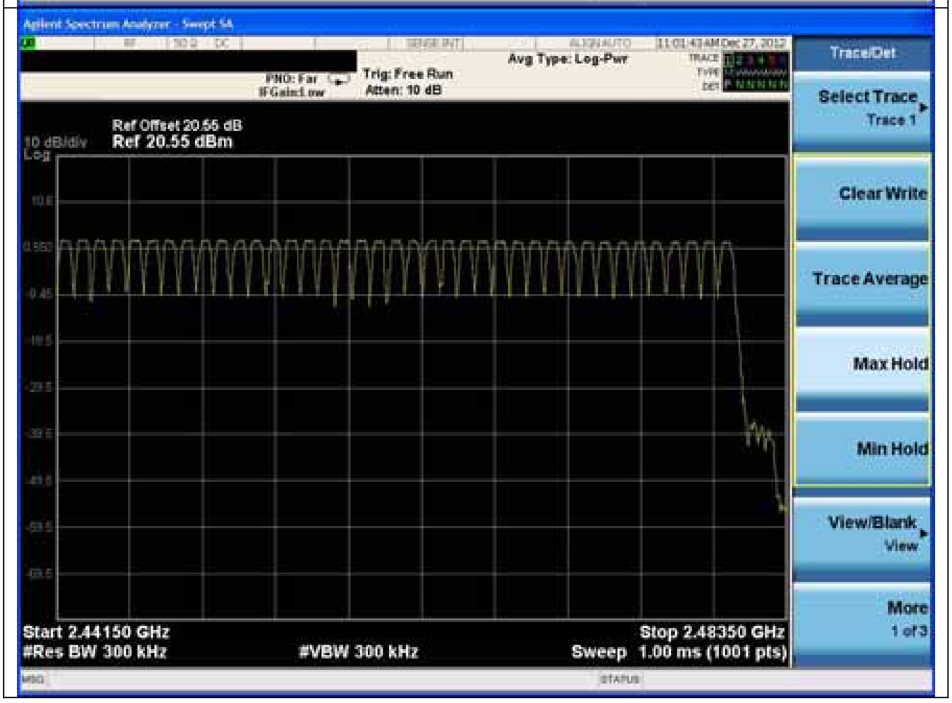
Operating Mode: GFSK



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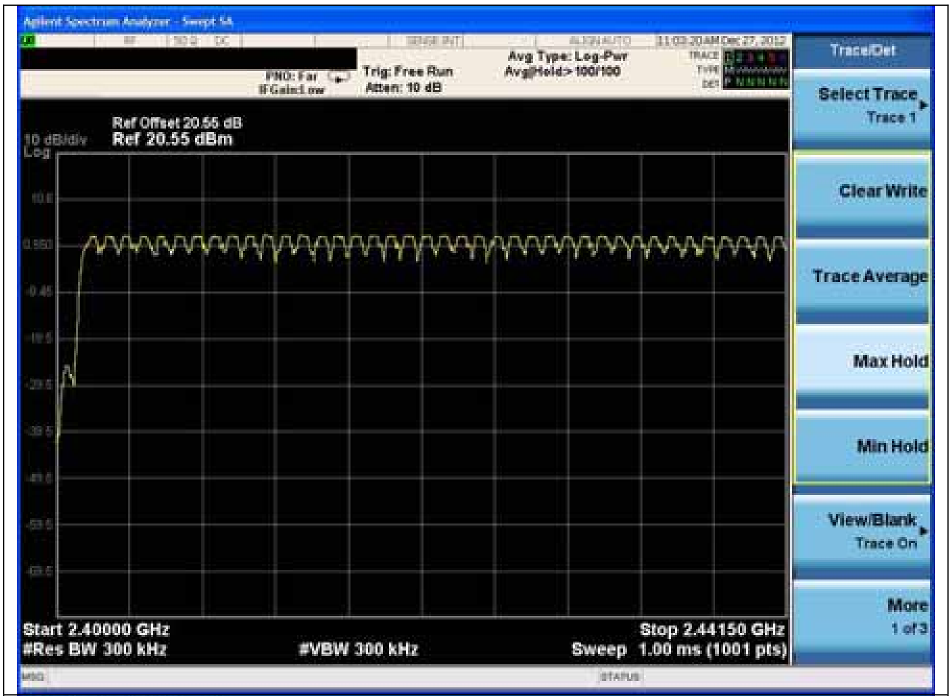
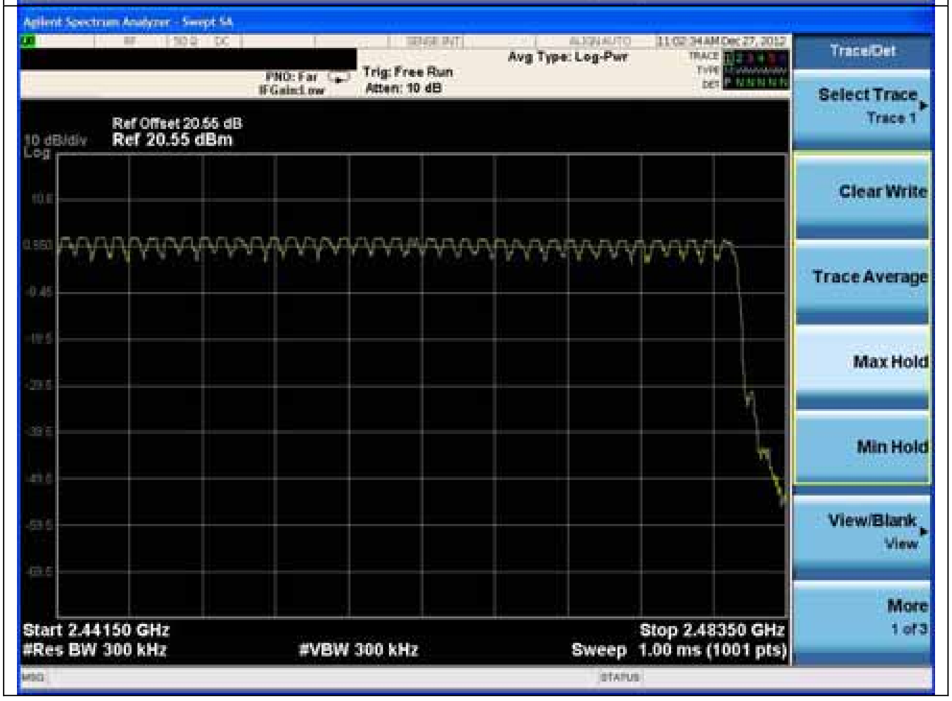
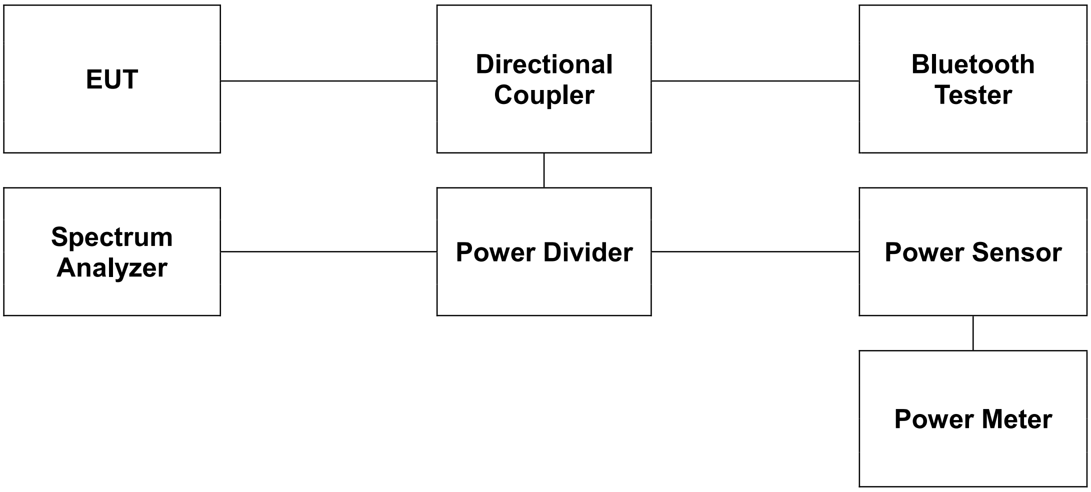
Operating Mode : 8DPSK





7. Time of Occupancy (Dwell Time)

7.1. Test Set up



7.2. 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)

***Adaptive Frequency Hopping**

A period time = 0.4(s) * 20 = 8 (s)

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7.3. Test Procedure

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section. The test follows DA000705.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable.
3. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
4. The Bluetooth has 3 type of payload, DH1, DH3, DH5 and 3-DH1, 3-DH3, 3-DH5.The hopping rate is insisted of 1 600 per second.

The EUT must have its hopping function enabled. Use the following spectrum analyzer setting:

Span = zero span, centered on a hopping channel
RBW = 1 ㎒
VBW = RBW
Sweep = as necessary to capture the entire dwell time per hopping channel
Detector = peak
Trace = max hold
Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation repeat this test for each variation.

7.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

7.4.1. Packet Type: DH1, 3-DH1

Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	0.40	128.00	400
8DPSK	2 441 ㎒	0.41	131.20	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK, 0.40 × {(1600 ÷ 2) / 79} × 31.6 = 128.00 ㎳
In case of 8DPSK, 0.41 × {(1600 ÷ 2) / 79} × 31.6 = 131.20 ㎳

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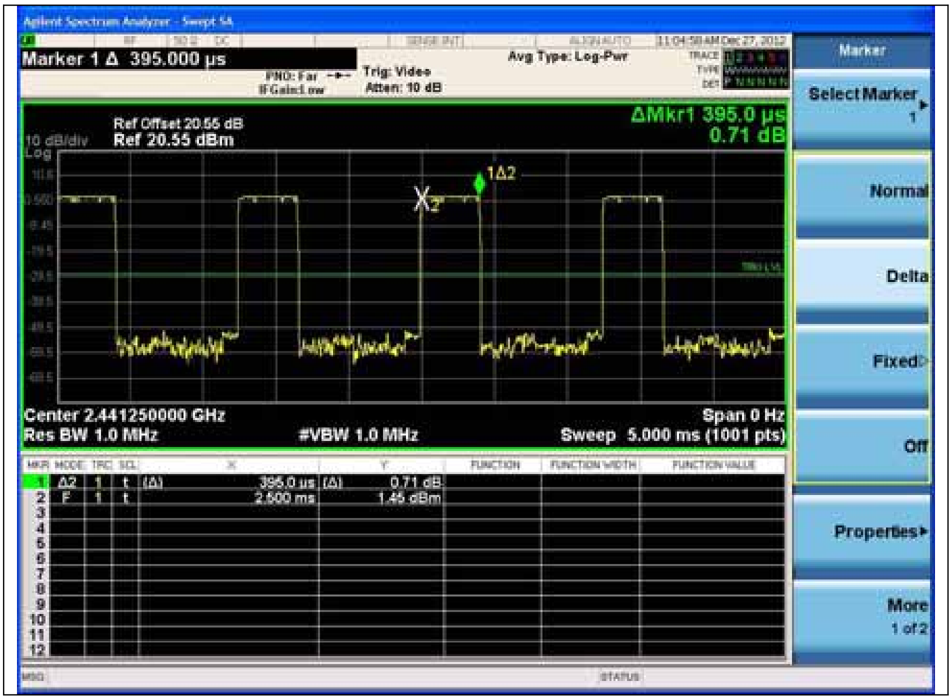
Operating Mode: GFSK



Operating Mode: 8DPSK

7.4.2. Packet Type: DH3, 3-DH3

Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	1.65	264.00	400
8DPSK	2 441 ㎒	1.66	265.60	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK 1.65 × {(1600 ÷ 4) / 79} × 31.6 = 264.00 ㎳
In case of 8DPSK 1.66 × {(1600 ÷ 4) / 79} × 31.6 = 265.60 ㎳

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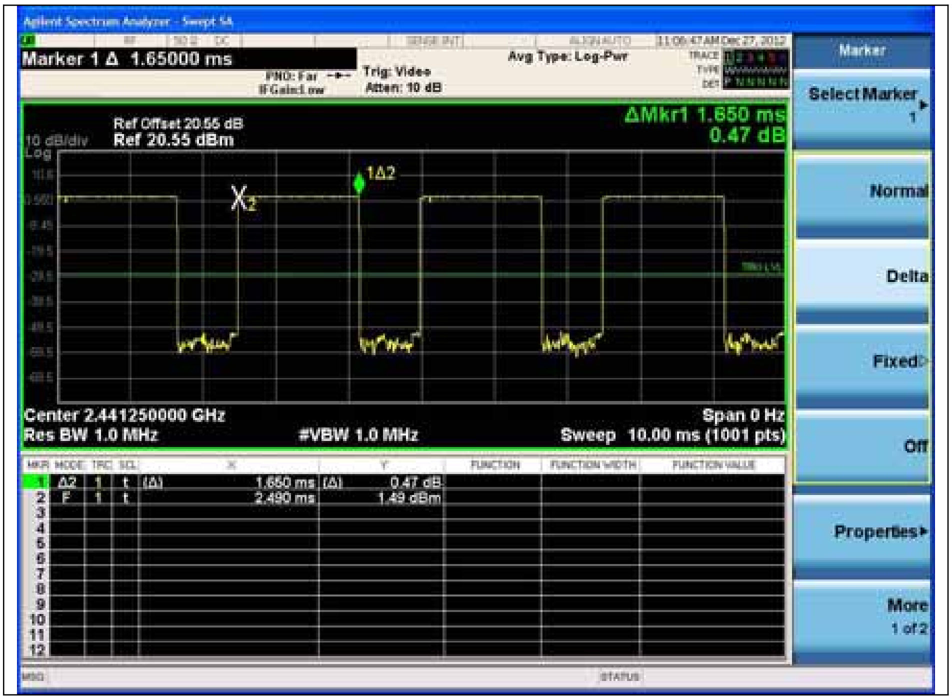
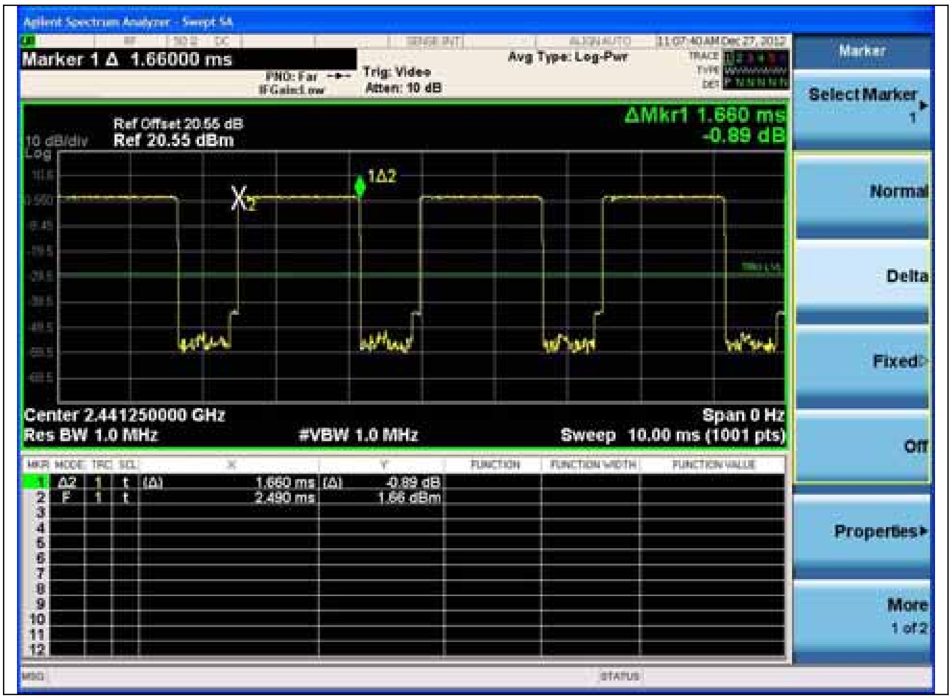
Operating Mode: GFSK



Operating Mode: 8DPSK

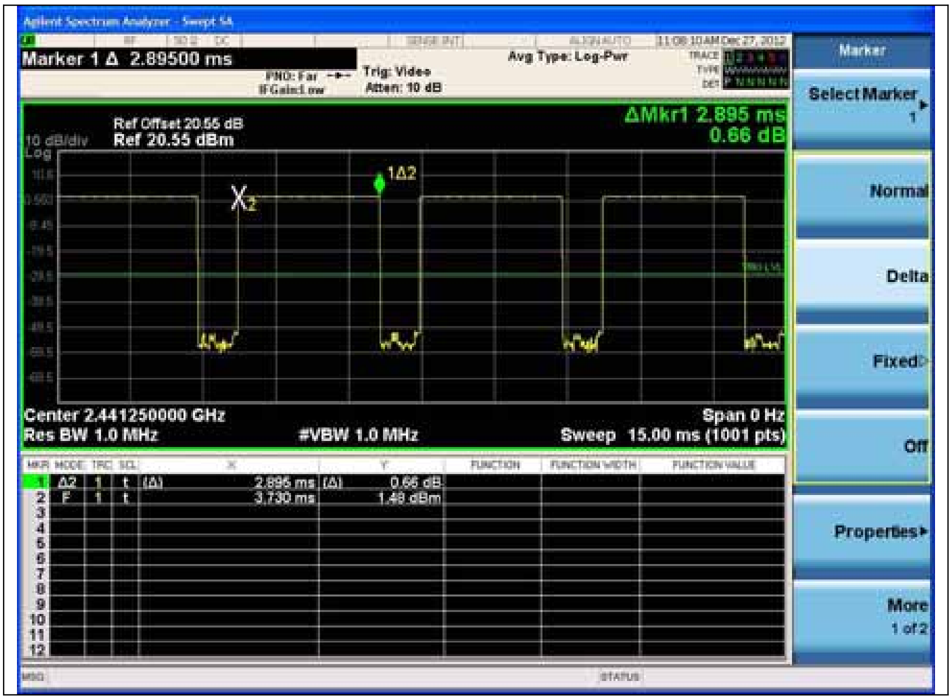


7.4.3. Packet Type: DH5, 3-DH5

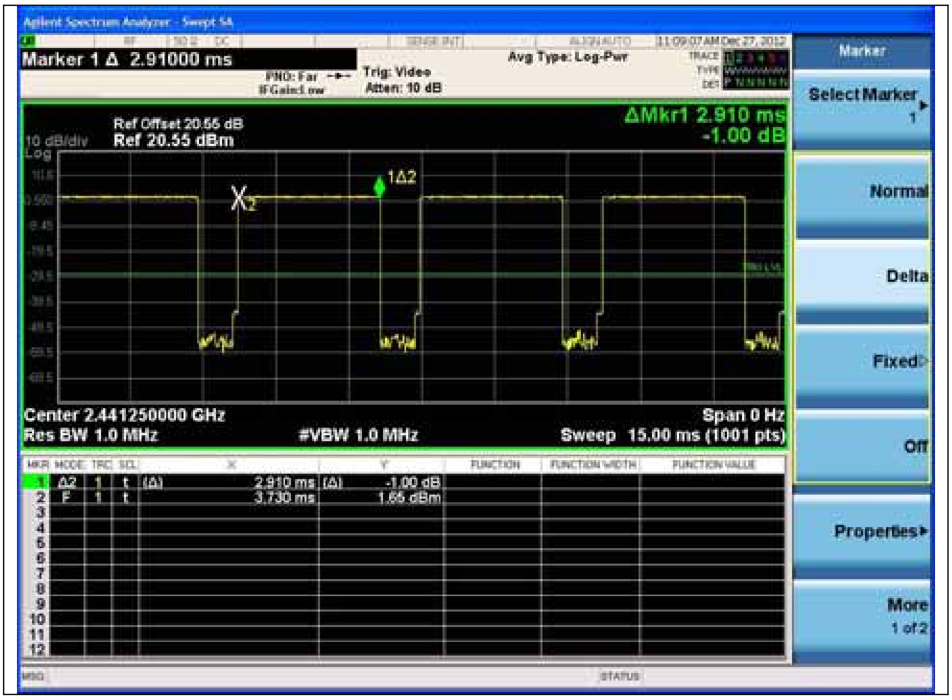
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	2.90	309.33	400
8DPSK	2 441 ㎒	2.91	310.40	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK, 2.90 × {(1600 ÷ 6) / 79} × 31.6 = 309.33 ㎳
In case of 8DPSK, 2.91 × {(1600 ÷ 6) / 79} × 31.6 = 310.40 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

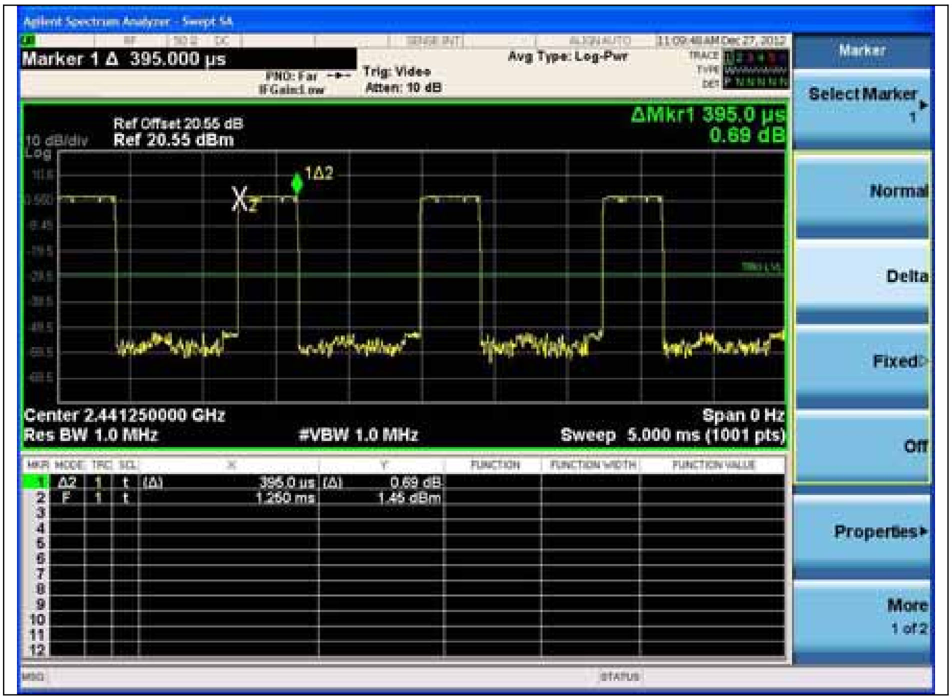


7.4.4. Packet Type: DH1, 3-DH1 (Adaptive Frequency Hopping)

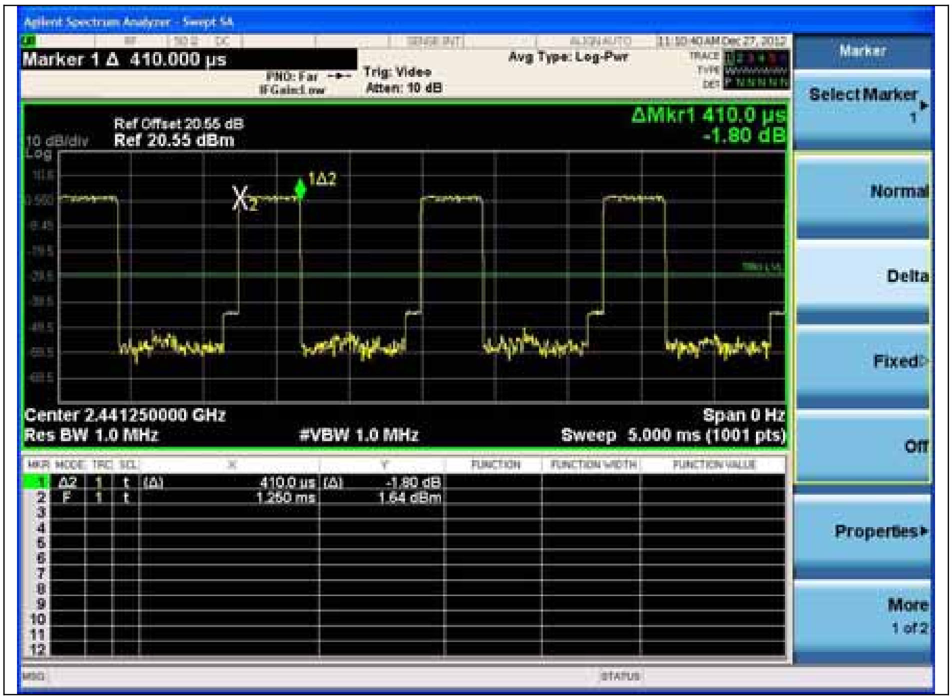
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	0.40	128.00	400
8DPSK	2 441 ㎒	0.41	131.20	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK 0.40 × {(1600 ÷ 2) / 20} × 8 = 128.00 ㎳
In case of 8DPSK, 0.41 × {(1600 ÷ 2) / 20} × 8 =131.20 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.5. Packet Type: DH3, 3-DH3 (Adaptive Frequency Hopping)

Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	1.64	262.40	400
8DPSK	2 441 ㎒	1.66	265.60	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK, 1.64 × {(1600 ÷ 4) / 20} × 8 = 262.40 ㎳
In case of 8DPSK, 1.66 × {(1600 ÷ 4) / 20} × 8 = 265.60 ㎳

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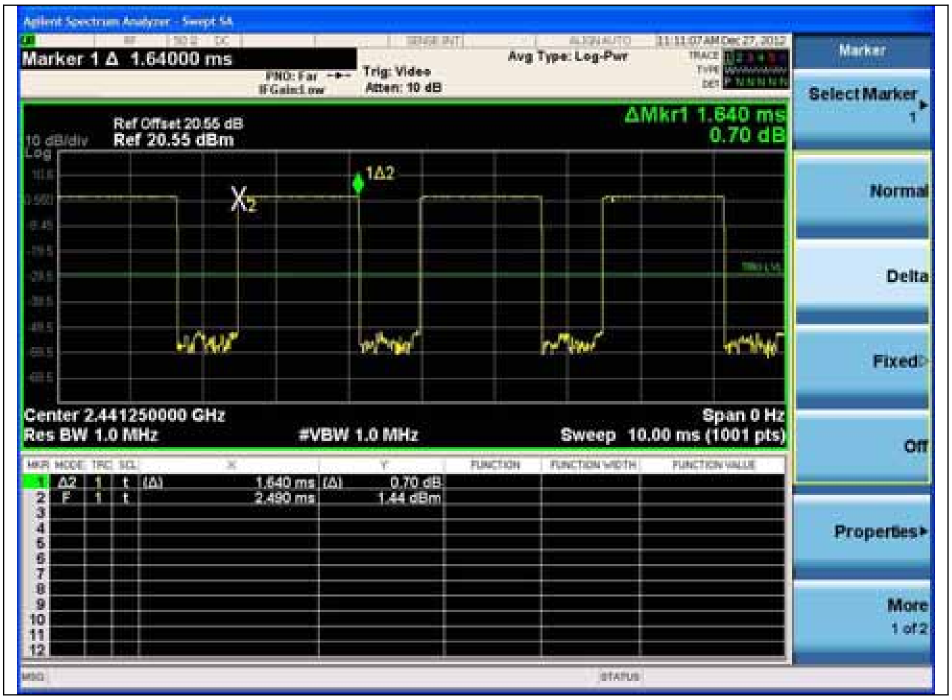
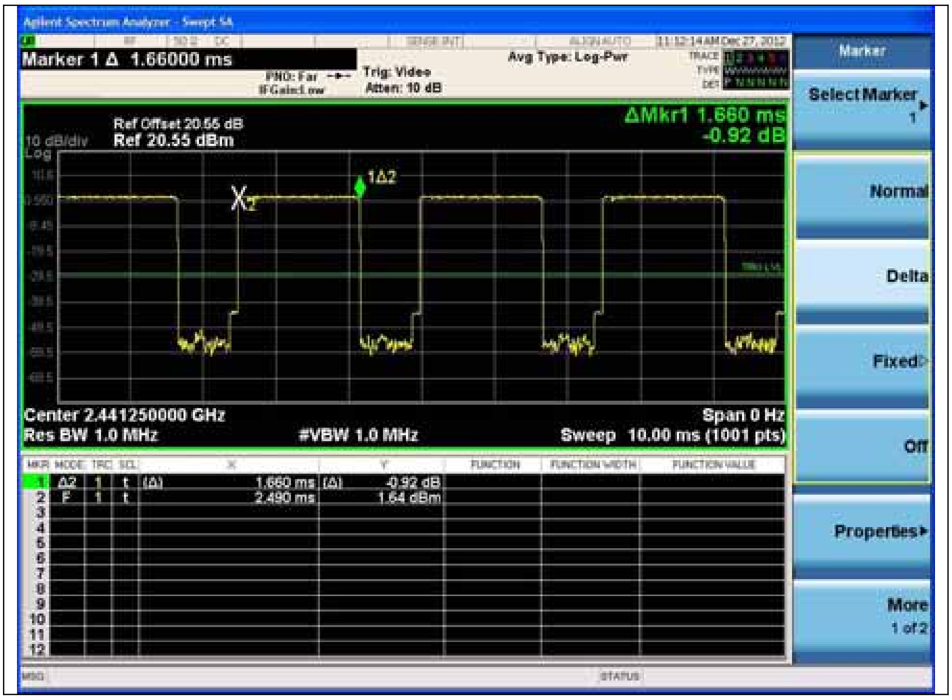
Operating Mode: GFSK



Operating Mode: 8DPSK



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7.4.6. Packet Type: DH5, 3-DH5 (Adaptive Frequency Hopping)

Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	2.90	309.33	400
8DPSK	2 441 ㎒	2.91	310.40	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK, 2.90 {(1600 ÷ 6) / 20} × 8 = 309.33 ㎳
In case of 8DPSK, 2.91 {(1600 ÷ 6) / 20} × 8 = 310.40 ㎳

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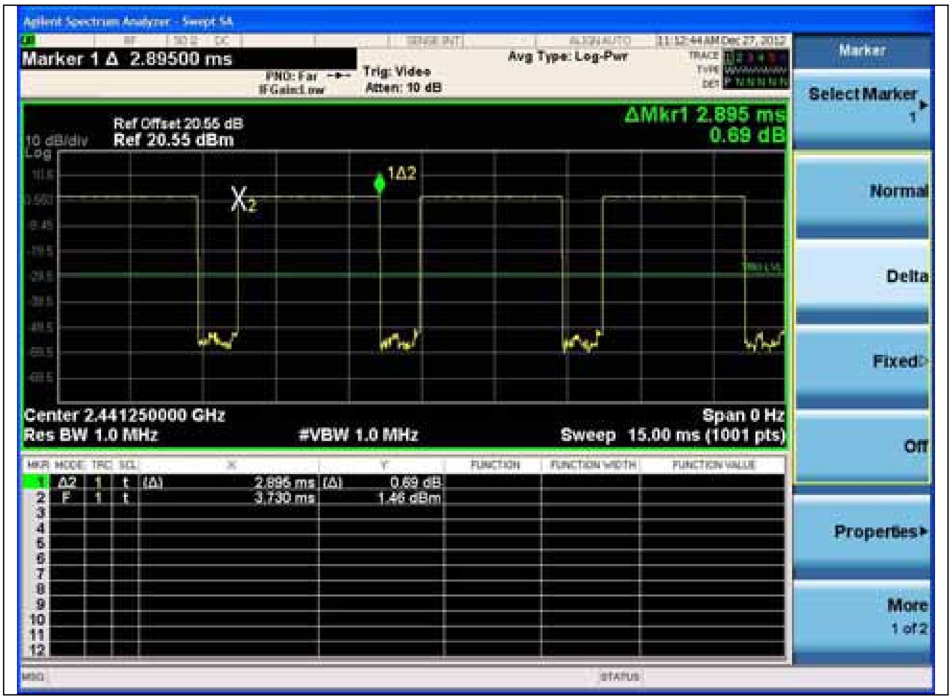
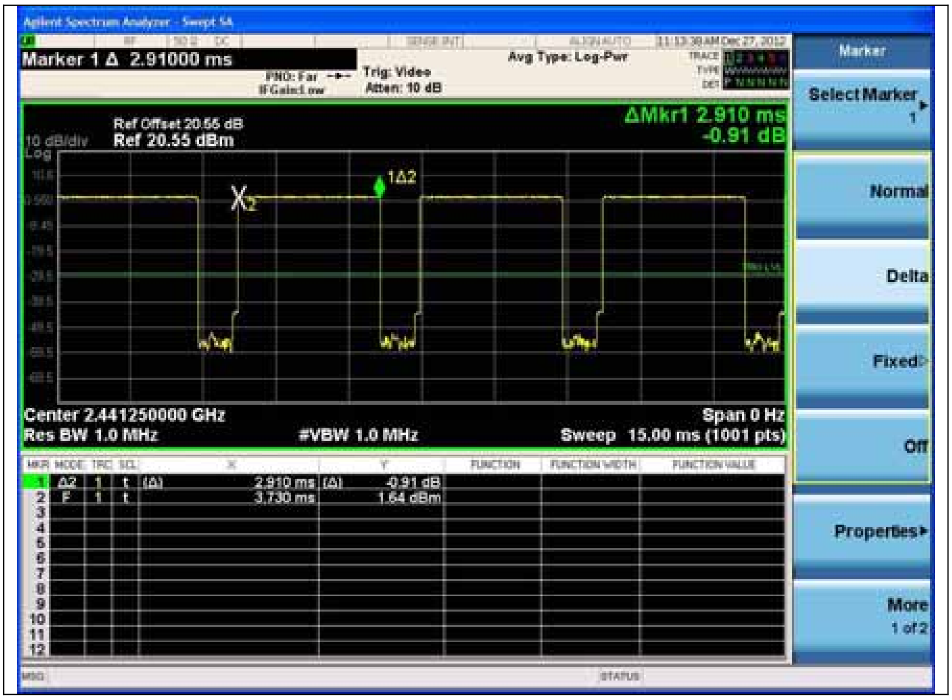
Operating Mode: GFSK



Operating Mode: 8DPSK



8. Antenna Requirement

8.1. Standard Applicable

For intentional device, according to FCC 47 CFR Section §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. And according to FCC 47 CFR Section §15.247 (b) if transmitting antennas of directional gain greater than 6 ㏈i are used, the power shall be reduced by the amount in ㏈ that the gain of the antenna exceeds 6 ㏈i.

8.2. Antenna Connected Construction

Antenna used in this product is Integral type with gain of 3.5 ㏈i.

9. RF Exposure Evaluation

9.1 Environmental evaluation and exposure limit according to FCC CFR 47 part 1, 1.1307(b), 1.1310

According to FCC 1.1310 : The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in §1.1307(b)

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (㎒)	Electric Field Strength(V/m)	Magnetic Field Strength (A/m)	Power Density (㎽/㎠)	Average Time
(A) Limits for Occupational /Control Exposures				
300 – 1 500	--	--	F/300	6
1 500 – 100 000	--	--	5	6
(B) Limits for General Population/Uncontrol Exposures				
300 – 1 500	--	--	F/1500	6
1 500 – 100 000	**--**	**--**	**1**	**30**

9.1.1. Friis transmission formula: Pd = (Pout*G)/(4*pi*R^2)

Where Pd = power density in ㎽/㎠

Pout = output power to antenna in ㎽

G = gain of antenna in linear scale

Pi = 3.1416

R = distance between observation point and center of the radiator in ㎝

Pd the limit of MPE, 1 ㎽/㎠. If we know the maximum gain of the antenna and the total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

9.1.2. Test Result of RF Exposure Evaluation

Test Item : RF Exposure Evaluation Data
Test Mode : Normal Operation

9.1.3. Output Power into Antenna & RF Exposure Evaluation Distance

FHSS: GFSK

Channel	Channel Frequency (MHz)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Duty Cycle (%)	Power Density at 20 cm (mW/cm²)	Limits (mW/cm²)
Low	2 402	0.86	3.5	77	0.000 418	1
Middle	2 441	1.08	3.5	77	0.000 440	1
High	2 480	0.59	3.5	77	0.000 393	1

FHSS: π/4DQPSK

Channel	Channel Frequency (MHz)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Duty Cycle (%)	Power Density at 20 cm (mW/cm²)	Limits (mW/cm²)
Low	2 402	0.41	3.5	78	0.000 382	1
Middle	2 441	0.19	3.5	78	0.000 363	1
High	2 480	-0.59	3.5	78	0.000 303	1

FHSS: 8DPSK

Channel	Channel Frequency (MHz)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Duty Cycle (%)	Power Density at 20 cm (mW/cm²)	Limits (mW/cm²)
Low	2 402	0.42	3.5	78	0.000 383	1
Middle	2 441	0.18	3.5	78	0.000 362	1
High	2 480	-0.59	3.5	78	0.000 303	1

Note :
1. The power density Pd (5th column) at a distance of 20 cm calculated from the friis transmission formula is far below the limit of 1 mW/cm².