SKT **SK TECH CO., LTD.**

Certificate of Compliance

Test Report No.:	**SKTTRT-050718-012**		
NVLAP CODE:	**200220-0**		
Applicant:	**MOVON CORPORATION**		
Applicant Address:	6Fl. Hyunjuk Bldg., 140-28, Samseong-dong, Gangnam-Gu, Seoul, 135-090 Korea		
Manufacturer:	**MOVON CORPORATION**		
Manufacturer Address:	6Fl. Hyunjuk Bldg., 140-28, Samseong-dong, Gangnam-Gu, Seoul, 135-090 Korea		
Device Under Test:	**Bluetooth Headset**		
FCC ID:	**TDU-MF120**	**Model No.:**	**MF-120**
Receipt No.:	SKTEU05-0465	**Date of receipt:**	July 7, 2005
Date of Issue:	July 18, 2005		
Location of Testing:	**SK TECH CO., LTD.** 820-2, Wolmoon-Ri, Wabu-Up, Namyangju-Si, Kyunggi-Do, Korea		
Test Procedure:	**ANSI C63.4**		
Test Specification:	**47CFR, Part 15 Rules**		
Equipment Class:	**DSS - Part 15 Spread Spectrum Transmitter**		
Test Result:	The above-mentioned device has been tested and passed.		

Tested & Reported by: *Jong-Soo, Yoon*

2005.07.18

Signature *Date*

Approved by: *Jae-Kyung, Bae*

2005.07.18

Signature *Date*

Other Aspects:	**-**
Abbreviations:	**· OK, Pass = passed · Fail = failed · N/A = not applicable**

☞

- **This test report is not permitted to copy partly without our permission.**
- **This test result is dependent on only equipment to be used.**
- **This test result is based on a single evaluation of one sample of the above mentioned.**
- **This test report must not be used to claim product endorsement by NVLAP or any agency of the U.S Government.**
- **We certify that this test report has been based on the measurement standards that is traceable to the national or International standards.**

NVLAP Lab. Code: 200220-0

>> CONTENTS <<

1. GENERAL

These tests were performed using the test procedure outlined in ANSI C63.4, 2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.247 for Spread Spectrum Transmitter. The EUT (Equipment Under Test) has been shown to be capable of compliance with the applicable technical standards.

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

2. TEST SITE

SK TECH Co., Ltd.

2.1 Location

820-2, Wolmoon Ri, Wabu-Up, Namyangju-Si, Kyunggi-Do, Korea

This test site is in compliance with ISO/IEC 17025 for general requirements for the competence of testing and calibration laboratories.
This laboratory is accredited by NVLAP for NVLAP Lab. Code: 200220-0 and DATech for DAR-Registration No.: TTI-P-G155/97-10

2.2 List of Test and Measurement Instruments

Description	Manufacturer	Model #	Serial #	
Spectrum Analyzer	Agilent	E4405B	US40520856	☒
EMC Spectrum Analyzer	Agilent	E7405A	US40240203	☒
EMI Test Receiver	Rohde&Schwarz	ESVS10	825120/013	☒
EMI Test Receiver	Rohde&Schwarz	ESVS10	834468/008	☒
EMI Test Receiver	Rohde&Schwarz	ESHS10	825120/013	☒
EMI Test Receiver	Rohde&Schwarz	ESHS10	834468/008	☒
Artificial Mains Network	Rohde&Schwarz	ESH3-Z5	836679/018	☒
Pre-amplifier	HP	8447F	3113A05153	☒
Pre-amplifier	HP	8349B	2644A03250	☒
Power Meter	Agilent	E4418B	3318A13916	
Power Sensor	HP	8485A	3318A13916	
VHF Precision Dipole Antenna (TX & RX)	Schwarzbeck	VHAP	1014 & 1015	
UHF Precision Dipole Antenna (TX & RX)	Schwarzbeck	UHAP	989 & 990	
Loop Antenna	Schwarzbeck	HFH2-Z2	863048/019	
TRILOG Broadband Antenna	Schwarzbeck	VULB9160	3141	☒
Biconical Antenna	Schwarzbeck	VHA9103	2265	☒
Log-Periodic Antenna	Schwarzbeck	UHALP9107	1819	☒
Horn Antenna	AH Systems	SAS-200/571	304	☒
Horn Antenna	ETS-LINDGREN	3115	00040723	
Horn Antenna	ETS-LINDGREN	3115	00056768	
Vector Signal Generator	Agilent	E4438C	MY42080359	
Signal Generator	HP	8349B	2644A03250	
DC Power Supply	HP	6634A	2926A-01078	☒
DC Power Supply	HP	6268B	2542A-07856	
Digital Multimeter	HP	HP3458A	2328A14389	☒
PCS Interface	HP	83236B	3711J00881	
CDMA Mobile Test Set	HP	8924C	US35360253	
Hygro/Thermo Graph	SATO	PC-5000TRH-II	-	☒
Temperature/Humidity Chamber	All Three	ATH-50M	20030425	

2.3 Test Date

Date of Application : July 7, 2005

Date of Test : July 15, 2005 ~ July 16, 2005

2.4 Test Environment

See each test item's description.

3. DESCRIPTION OF THE EQUIPMENT UNDER TEST

The product specification described herein was obtained from the product data sheet or user's manual.

3.1 Rating and Physical Characteristics

Type / Model No.	Bluetooth Headset / MF-120
Power source	DC 3.7V (Polymer Lithium-ion battery), AC/DC adaptor
Local Oscillator or X-Tal	X-Tal: 16 MHz
Transmit Frequency	2402 ~ 2480 MHz (1MHz step, 79 channels)
Antenna Type	Integral SMD chip antenna (Model No.: MFAH_REV1.0, Gain 0 dBi)
Type of Modulation	FHSS (GFSK)
RF Output power	< 4dBm
External Ports	- DC Charging Jack AC/DC Adaptor supplied with the EUT MODEL: U045020D12, Manufacturer: PEN PAO INDUSTRIAL CO., LTD. Input: AC 120V 60 Hz 6.5W Output: 4.5VDC 200mA

3.2 Equipment Modifications

None

3.3 Submitted Documents

Block diagram

Schematic diagram

Antenna Specification

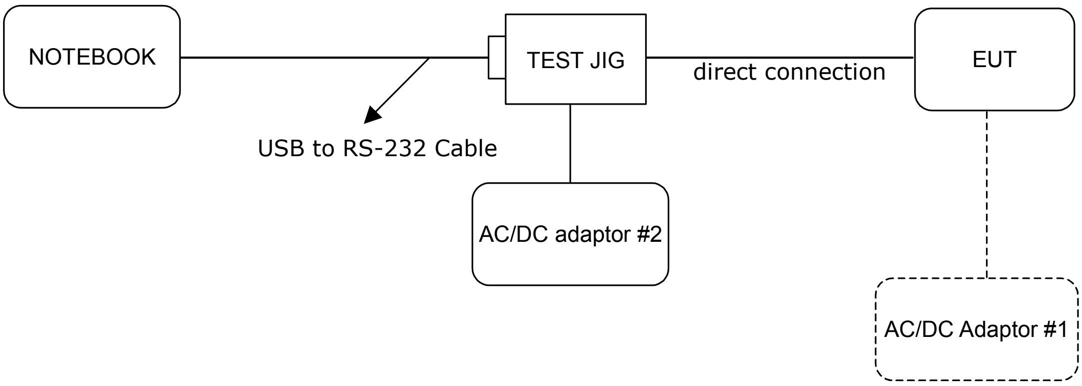
Part List

User manual

4. MEASUREMENT CONDITIONS

4.1 Description of test configuration

The measurements were taken in continuous transmitting mode using the TEST JIG provided by the applicant for controlling the EUT via UART interface so that the operating frequency of the EUT could be changed with the frequency hopping turned off.



** During Conducted Emissions measurements, AC/DC Adaptor was used with 3.7V_{DC} Li-ion battery and the EUT was operated in normal operational condition without TEST JIG.

4.2 List of Peripherals

Equipment Type	Manufacturer	Model	Cable Description
Bluetooth Headset (EUT)	MOVON CORPORATION	MF-120	-
AC/DC Adaptor #1	PEN PAO INDUSTRIAL CO., LTD.	U045020D12	1.8m, Unshielded power line
AC/DC Adaptor #2 **	Kangwon Elec.	KWS-0205060	1.8m, Unshielded power line
Notebook PC	Trigem	Dreambook	1.8m, Shielded, USB to RS-232 Cable
TEST JIG **	MOVON CORPORATION	-	-

** For control of RF module via UART interface in the EUT.

4.3 Uncertainty

Measurement Item	Combined Standard Uncertainty Uc	Expanded Uncertainty U = KUc (K = 2)
Conducted RF power	± 1.49 dB	±2.98dB
Radiated disturbance	± 2.37 dB	±4.74dB
Conducted disturbance	± 1.47 dB	±2.94dB

5. TEST AND MEASUREMENTS

Summary of Test Results

Requirement	CFR 47 Section	Report Section	Test Result
Antenna Requirement	15.203, 15.247(b)(4)	5.1	PASS
Maximum Peak Output Power	15.247(b)(1), (4)	5.2	PASS
Carrier Frequency Separation	15.247(a)(1)	5.3	PASS
20dB Channel Bandwidth	15.247(a)(1)	5.4	PASS
Number of Hopping Channels	15.247(a)(iii), 15.247(b)(1)	5.5	PASS
Time of Occupancy (Dwell Time)	15.247(a)(iii)	5.6	PASS
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a), 15.109(a)	5.7	PASS
Peak Power Spectral Density	15.247(e)	5.8	PASS
Conducted Emissions	15.207(a), 15.107(a)	5.9	PASS
RF Exposure	15.247(i), 1.1307(b)(1)	5.10	PASS

5.1 ANTENNA REQUIREMENT

5.1.1 Regulation

According to §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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

And according to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.1.2 Result: PASS

The transmitter has an integral SMD chip antenna. The directional gain of the antenna is typically 0 dBi.

5.2 MAXIMUM PEAK OUTPUT POWER

5.2.1 Regulation

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

According to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.2.2 Test Procedure

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode with RBW = 3 MHz.
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

5.2.3 Test Results: PASS

Table 1: Measured values of the Maximum Peak Output Power (Conducted)

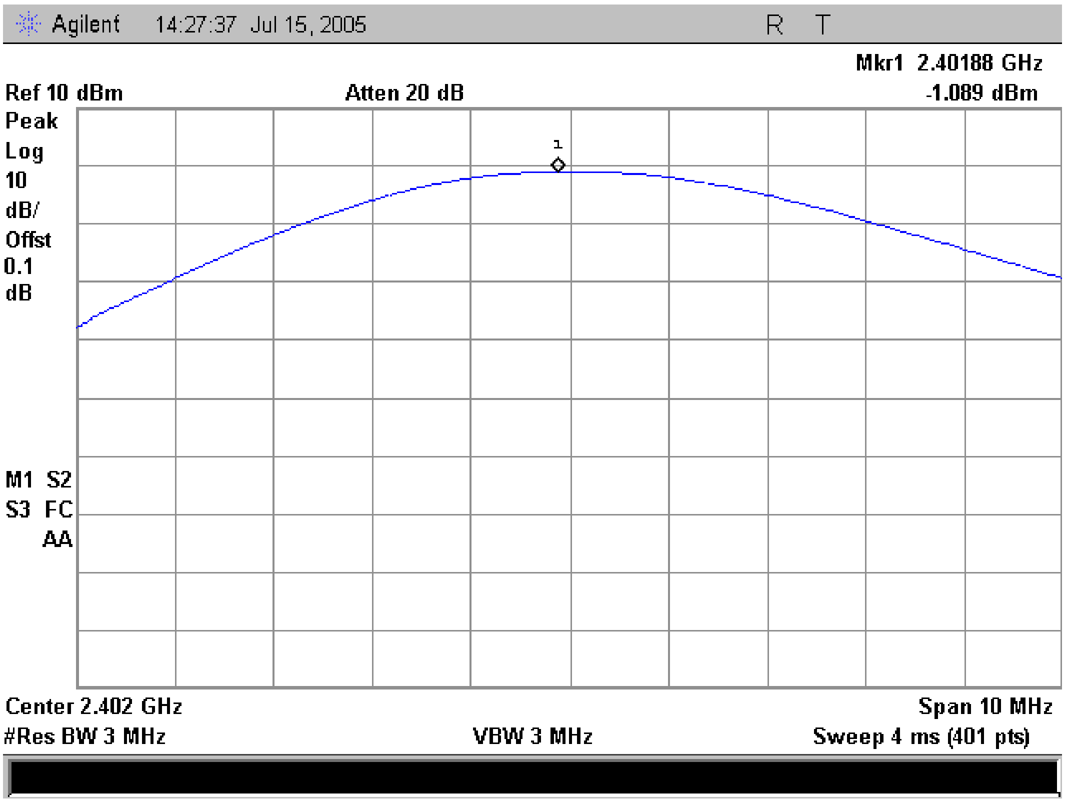
Operating Frequency	Resolution Bandwidth	Cable Loss	Reading	Limit
2402 MHz	3 MHz	0.1 dB	-1.089 dBm (0.778 mW)	30 dBm (1 W)
2441 MHz	3 MHz	0.1 dB	-1.309 dBm (0.740 mW)	30 dBm (1 W)
2480 MHz	3 MHz	0.1 dB	-1.859 dBm (0.652 mW)	30 dBm (1 W)

Cable Loss was included in Reading as Offset.

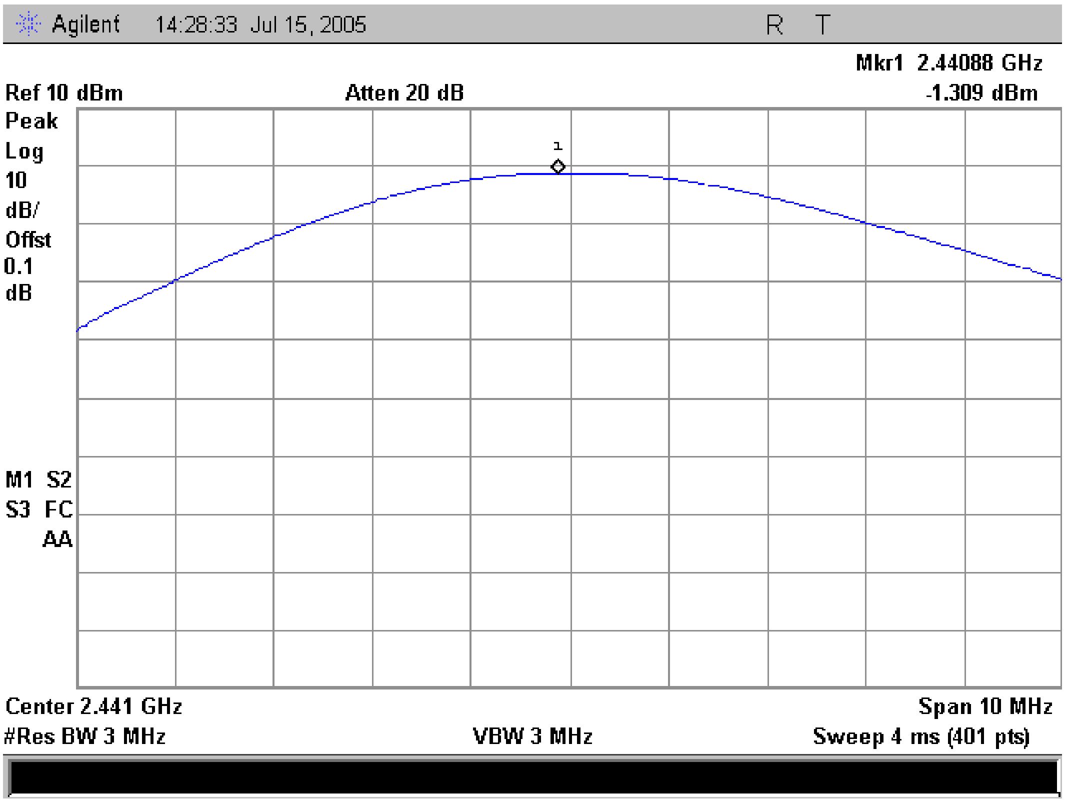
NOTE: Since the directional gain of the SMD chip antenna declared by manufacturer (G_{ANT} = 0 dBi) does not exceed 6.0 dBi, there was no need to reduce the output power.

Figure 1. Plot of the Maximum Peak Output Power (Conducted)

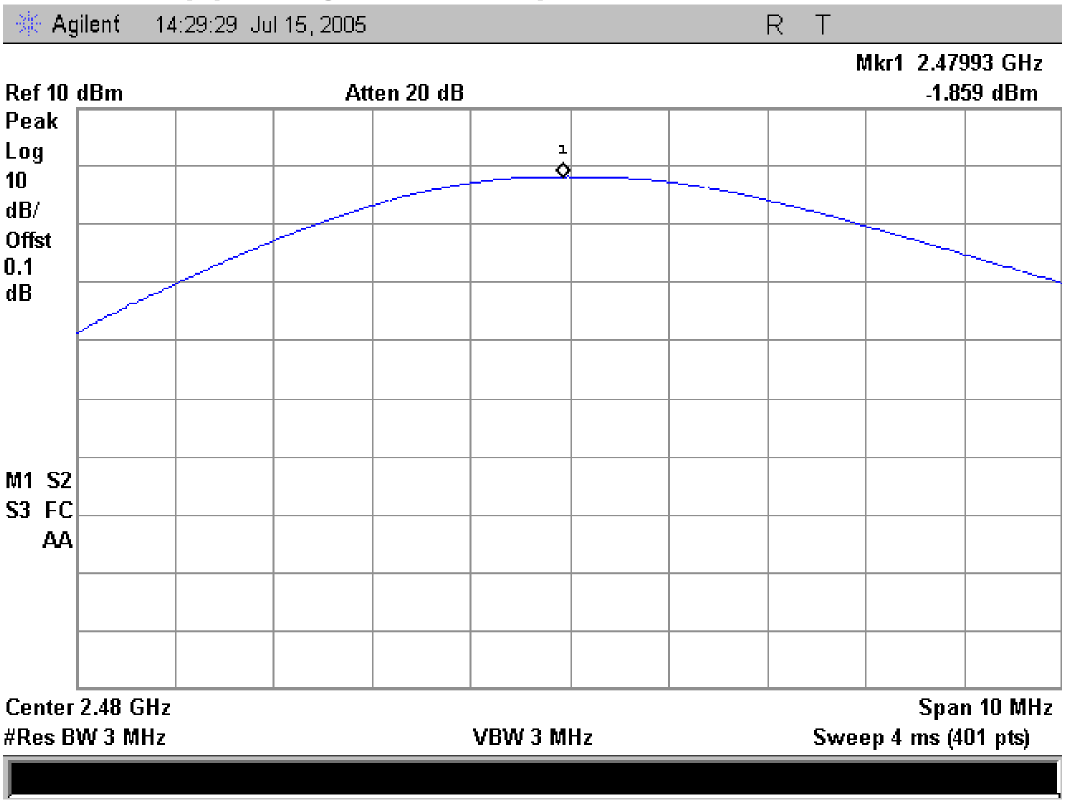
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



5.3 CARRIER FREQUENCY SEPARATION

5.3.1 Regulation

According to §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. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

5.3.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface, and then set the spectrum analyzer to MAX HOLD mode.
4. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
5. Repeat above procedures until all frequencies measured were complete.

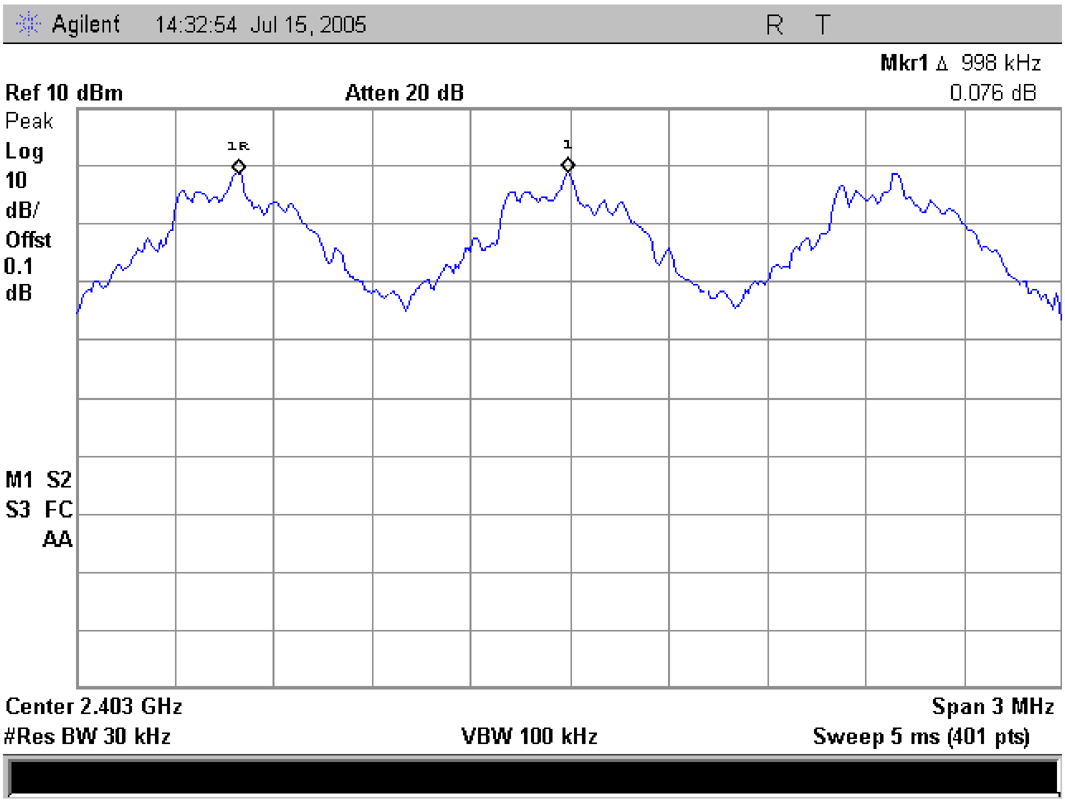
5.3.3 Test Results: PASS

Table 2: Measured values of the Carrier Frequency Separation (Conducted)

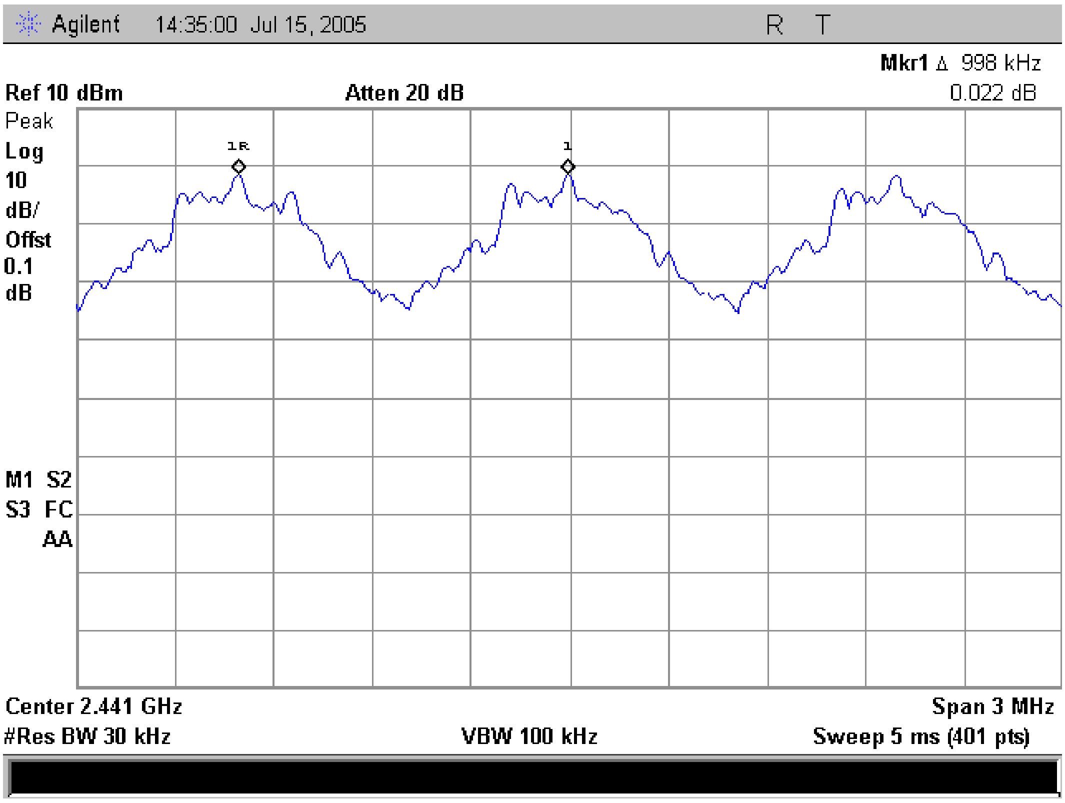
Operating frequency	Carrier frequency separation	Limit
2402 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth
2441 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth
2480 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth

Figure 2. Plot of the Carrier Frequency Separation (Conducted)

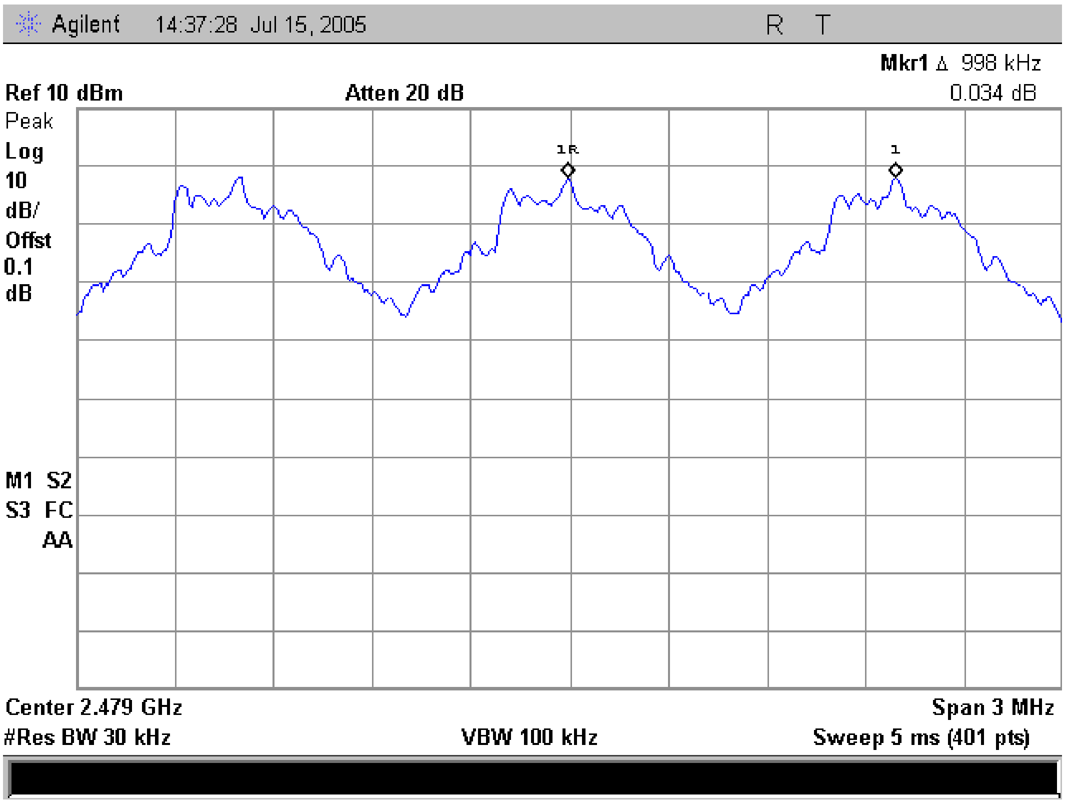
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



5.4 20dB CHANNEL BANDWIDTH

5.4.1 Regulation

According to §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. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

5.4.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode and then set a reference level on it equal to the highest peak value.
5. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
6. Repeat above procedures until all frequencies measured were complete.

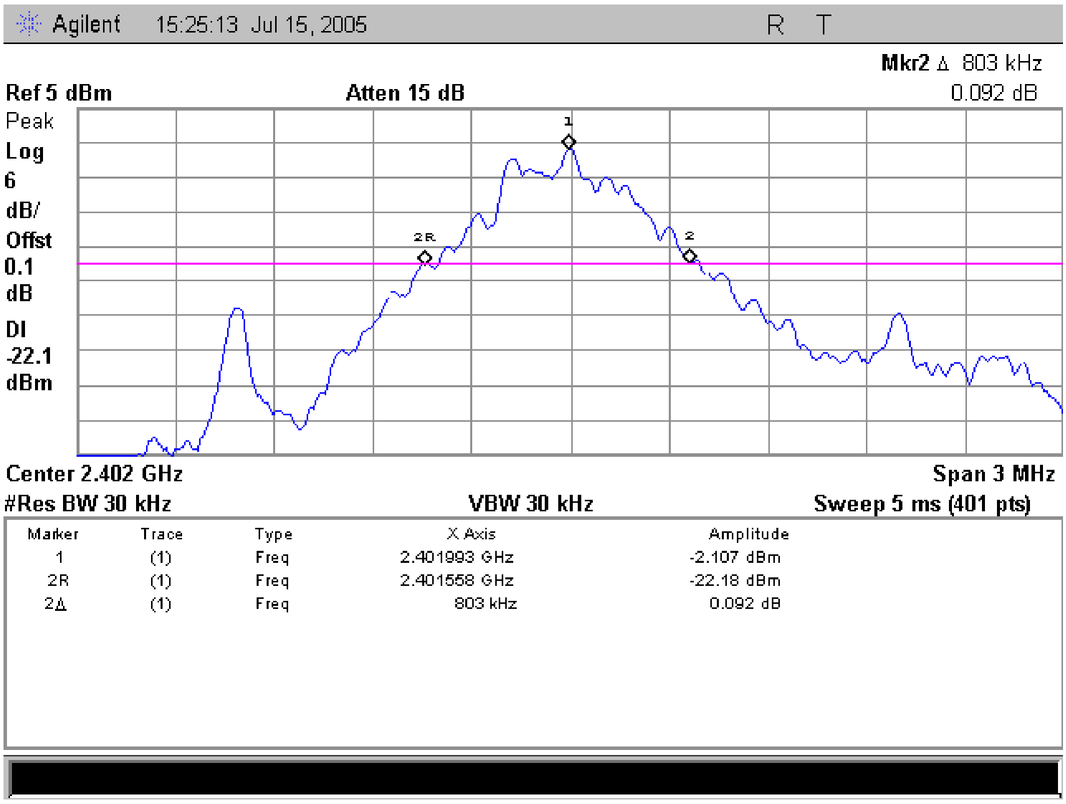
5.4.3 Test Results: PASS

Table 3: Measured values of the 20dB Channel Bandwidth (Conducted)

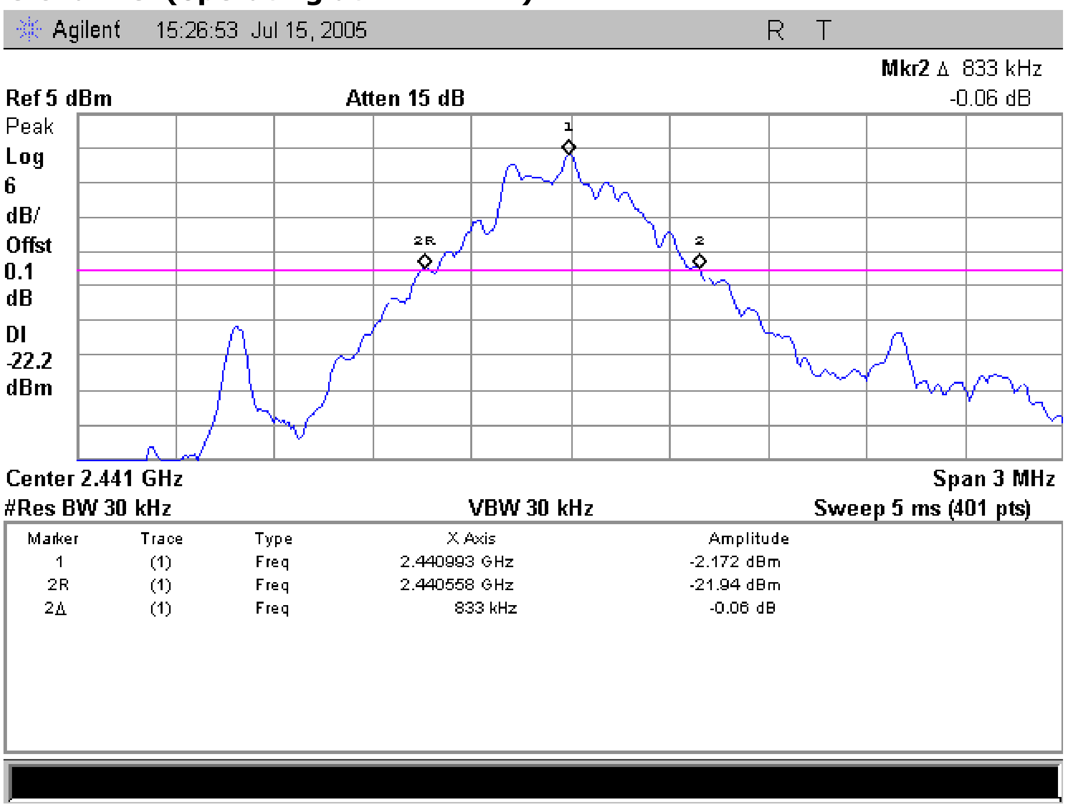
Operating frequency	20dB Channel bandwidth	Limit
2402 MHz	803 kHz	< 1 MHz
2441 MHz	833 kHz	< 1 MHz
2480 MHz	833 kHz	< 1 MHz

Figure 3. Plot of the 20dB Channel Bandwidth (Conducted)

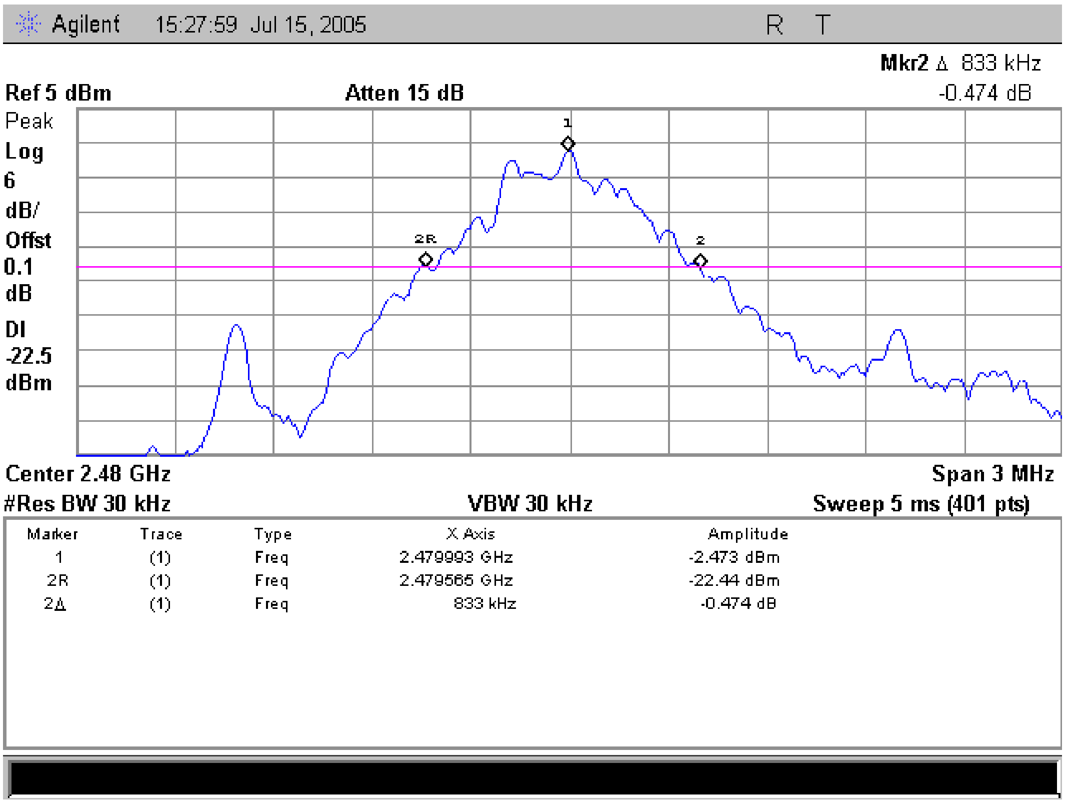
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



5.5 NUMBER OF HOPPING CHANNELS

5.5.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2400-2483.5 MHz 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.

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

5.5.2 Test Procedure

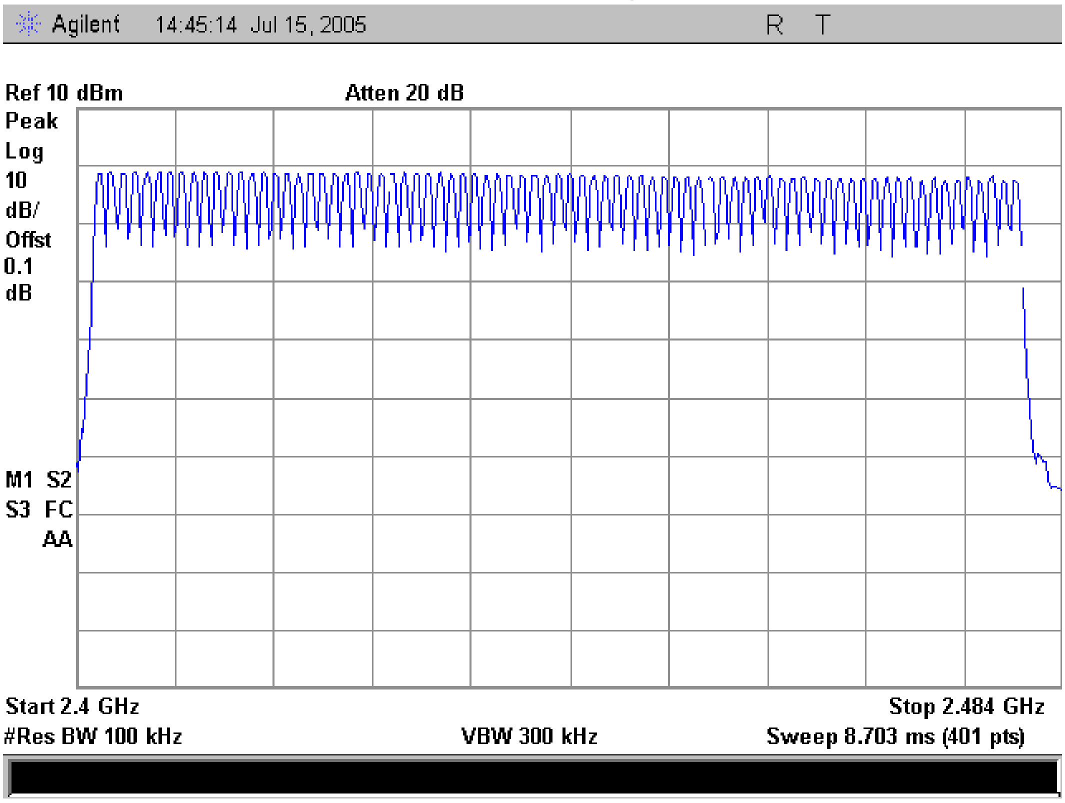
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set the hopping function enabled by controlling it via UART interface.
4. Set the spectrum analyzer MAX HOLD and record the number of hopping channels.

5.5.3 Test Results: PASS

Table 4: Measured values of the Number of Hopping Channels (Conducted)

Operating frequency	Number of hopping channels	Limit
2402 - 2480 MHz	79	≥ 15

Figure 4. Plot of the Number of Hopping Channels (Conducted)



5.6 TIME OF OCCUPANCY (DWELL TIME)

5.6.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2400-2483.5 MHz 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.

5.6.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface.
4. Set the spectrum analyzer to ZERO SAPN centered on the hopping channel with RBW = 1MHz, and then measure the dwell time using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.
7. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

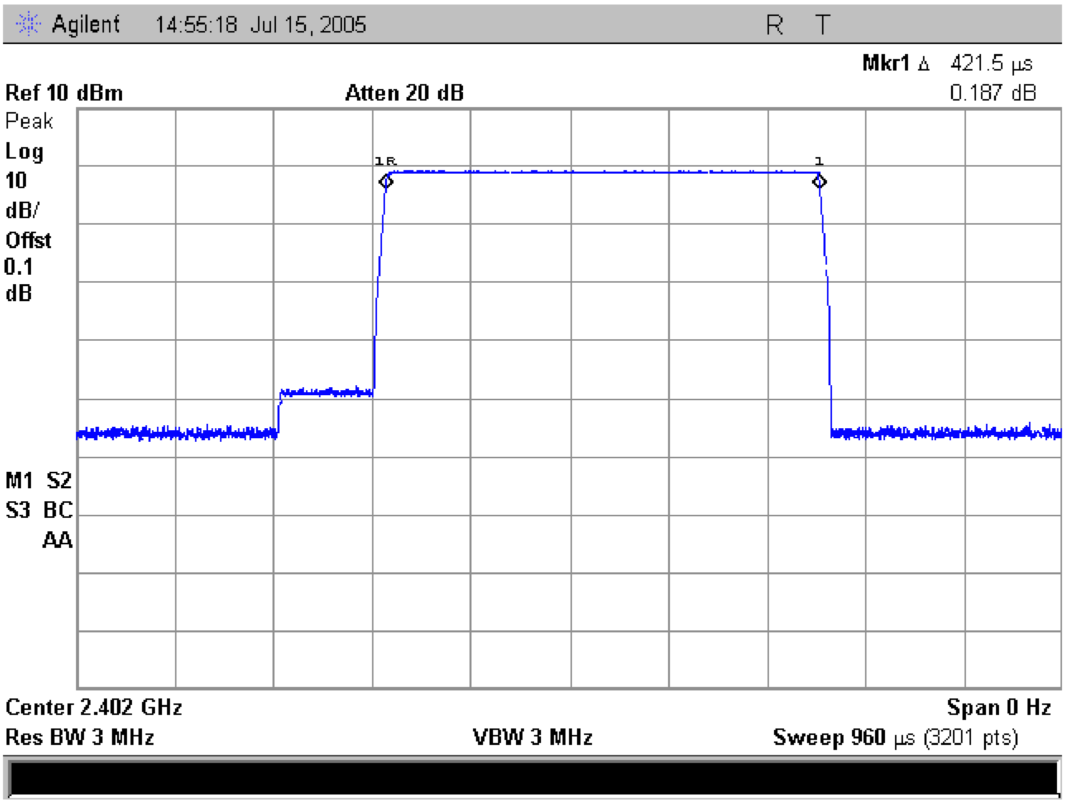
5.6.3 Test Results: PASS

Table 5: Measured values of the Time of Occupancy (Conducted)					
Operating frequency	Reading	Hopping rate	Number of Channels	Actual	Limit
2402 MHz	0.4215 ms	800 hops/s	79	0.1349 seconds	0.4 seconds
2441 MHz	0.4215 ms	800 hops/s	79	0.1349 seconds	0.4 seconds
2480 MHz	0.4215 ms	800 hops/s	79	0.1349 seconds	0.4 seconds

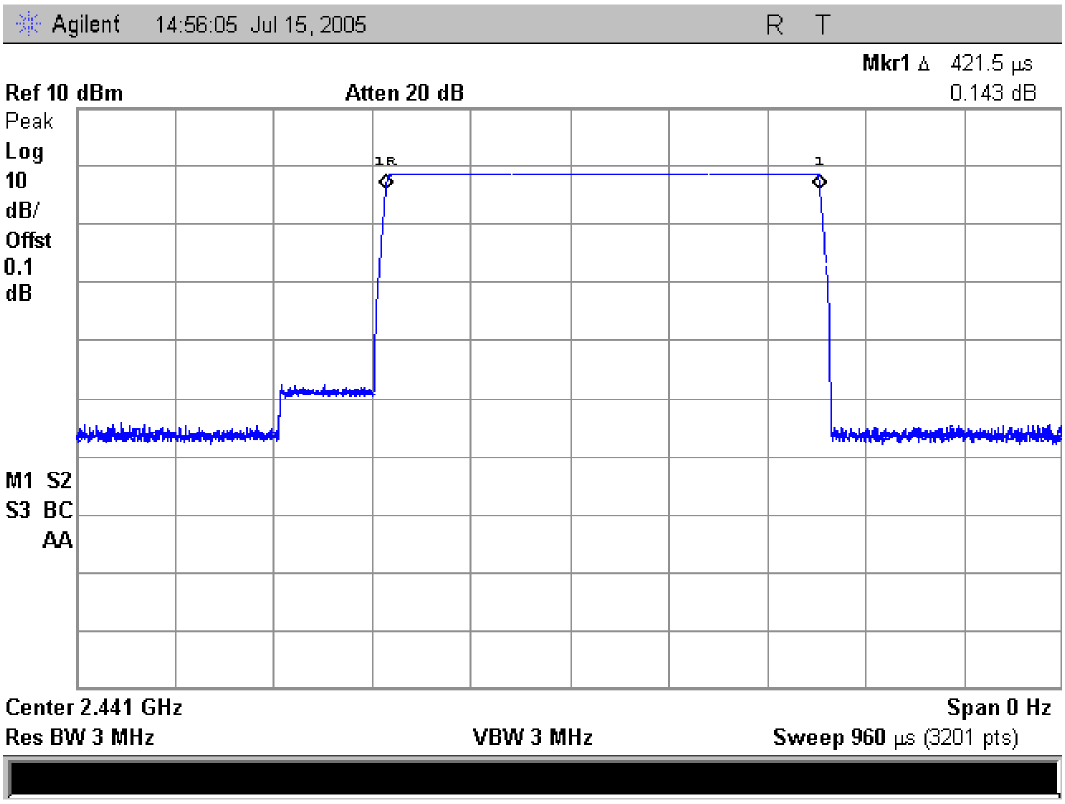
Actual = Reading × (Hopping rate / Number of channels) × Test period
Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]
NOTE: The EUT makes worst case 1600 hops per second or 1 time slot has a length of 625μs with 79 channels. A DH1 Packet needs 1 time slot for transmitting and 1 time slot for receiving. Then the EUT makes worst case 800 hops per second with 79 channels.

Figure 5. Plot of the Time of Occupancy (Conducted)

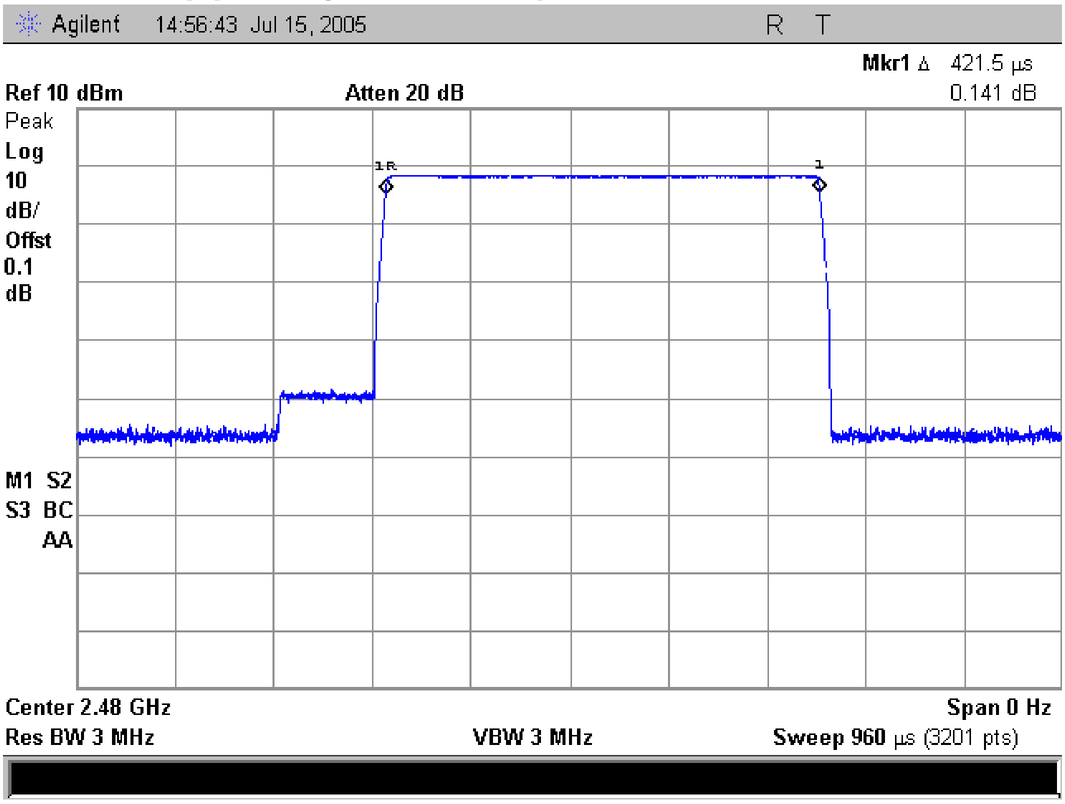
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



5.7 SPURIOUS EMISSIONS, BAND EDGE, AND RESTRICTED BANDS

5.7.1 Regulation

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 emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

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

Frequency (MHz)	Field strength (μV/m @ 3m)	Field strength (dBμV/m @ 3m)
30–88 88–216 216–960 Above 960	100 150 200 500	40.0 43.5 46.0 54.0

According to §15.109(a), for an unintentional device, except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the above table.

** The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1000 MHz are based on the average value of measured emissions.

5.7.2 Test Procedure

1) Spurious RF Conducted Emissions:

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode with RBW = 100kHz, VBW = 100kHz and wide SPAN enough to capture the peak level of the in-band emission and all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic.

5. Set the marker on the peak of any spurious emission, and then measure the peak level of the emissions marked, using the spectrum analyzer with RBW = 100kHz, VBW = 100kHz, and SPAN = 100MHz.
6. Repeat above procedures until all frequencies measured were complete.

2) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the TRILOG broadband antenna, and from 1000 MHz to 18000 MHz using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.

5.7.3 Test Results: PASS

Table 6: Measured values of the RF antenna port emissions (Conducted)

Frequency [MHz]	Reading [dBm]	Cable Loss [dB]	Actual [dBm]	Limit [dBm]	Margin [dB]
Lowest Channel (operating at 2402 MHz)					
2402.0	-1.276	0.1	-1.176	-	-
2400.0	-52.48	0.1	-52.38	-21.176	31.20
2390.0	-64.00	0.1	-63.90	-21.176	42.72
4804.0	-55.44	0.2	-55.24	-21.176	34.06
Middle Channel (operating at 2441 MHz)					
2441.0	-1.537	0.1	-1.602	-	-
4882.0	-58.69	0.2	-58.49	-21.602	36.88
Highest Channel (operating at 2480 MHz)					
2480.0	-2.131	0.1	-2.031	-	-
1240.3	-57.94	0.1	-57.84	-22.031	35.80
2483.5	-61.35	0.1	-61.25	-22.031	39.21
2500.0	-64.74	0.1	-64.64	-22.031	42.60
4960.0	-56.65	0.2	-56.45	-22.031	34.41

Actual = Reading + Cable Loss
Remark "---" means the emission level was too low to be measured or in the noise floor.
NOTE: All the Reading values were taken using Spectrum Analyzer with RBW=100 kHz, VBW=100 kHz, and SPAN=100 MHz

Table 7: Measured values of the Field strength of spurious emission (Radiated)

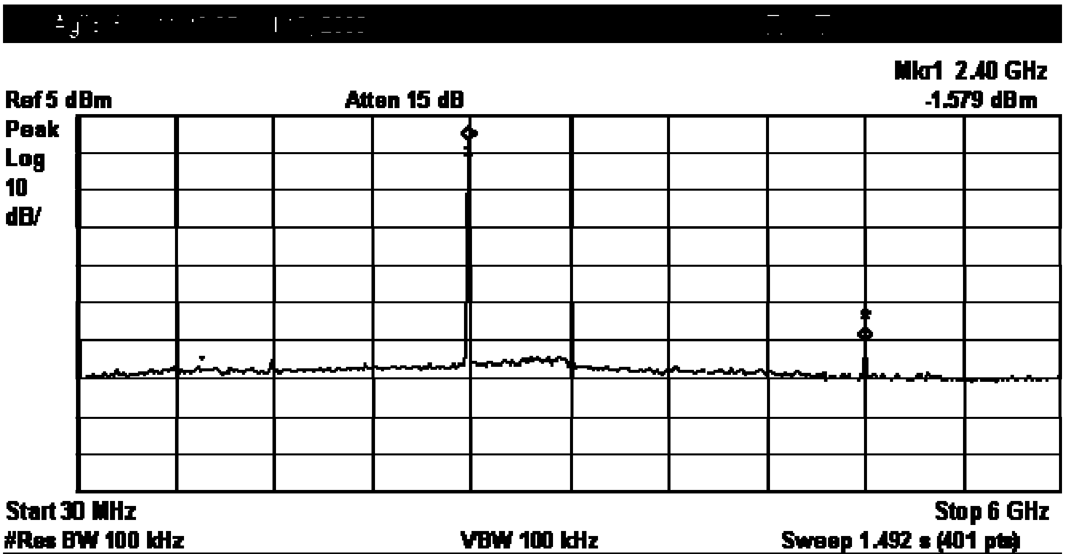
Frequency [MHz]	Receiver Bandwidth [kHz]	Pol. [V/H]	Antenna Height [m]	Table Angle [°]	Reading [dB(μV)]	Amp Gain [dB]	AF / CL [dB(1/m)]	Actual [dB(μV/m)]	Limit [dB(μV/m)]	Margin [dB]
Quasi-peak data, emissions below 1000 MHz										
-	120									
			No Spurious Radiated Emissions Found							
AVERAGE data, emissions above 1000 MHz										
2402.0	1000	H	1.0	100	71.99	30.1	29.2/7.4	78.49	-	-
2390.0	1000	H	1.0	100	27.89	30.1	29.2/7.4	34.39	54.0	19.61
2480.0	1000	H	1.0	10	73.24	30.1	29.2/7.4	79.74	-	-
2483.5	1000	H	1.0	10	31.79	30.1	29.2/7.4	38.29	54.0	15.71
2500.0	1000	H	1.0	10	31.21	30.1	29.2/7.4	37.71	54.0	16.29
PEAK data, emissions above 1000 MHz										
2402.0	1000	H	1.0	100	81.53	30.1	29.2/7.4	88.03	-	-
2390.0	1000	H	1.0	100	50.70	30.1	29.2/7.4	57.20	74.0	16.80
2480.0	1000	H	1.0	10	82.70	30.1	29.2/7.4	89.20	-	-
2483.5	1000	H	1.0	10	50.21	30.1	29.2/7.4	56.71	74.0	17.29
2500.0	1000	H	1.0	10	50.69	30.1	29.2/7.4	57.19	74.0	16.81

Margin (dB) = Limit – Actual
[Actual = Reading – Amp Gain + AF + CL]
1. H = Horizontal, V = Vertical Polarization
2. AF/CL = Antenna Factor and Cable Loss

NOTE: The spectrum was scanned from 30 MHz to 18 GHz. All emissions not reported were more than 20 dB below the specified limit or in the noise floor. The measured data in the above table include the spurious radiated emissions that do not fall in the restricted bands.

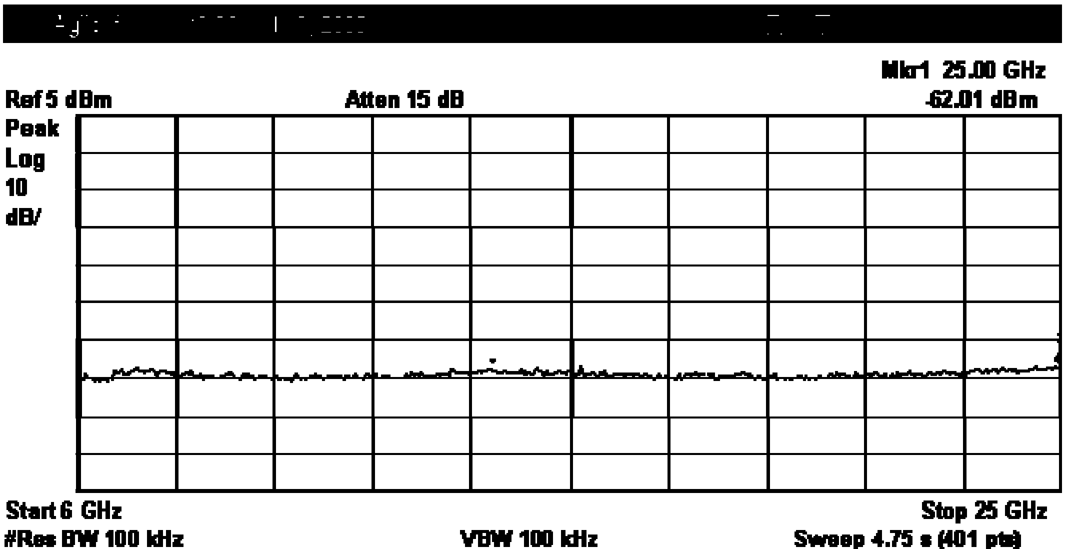
Figure 6. Plot of the RF antenna port emissions (Conducted)

Lowest Channel (operating at 2402 MHz): 30MHz ~ 6GHz



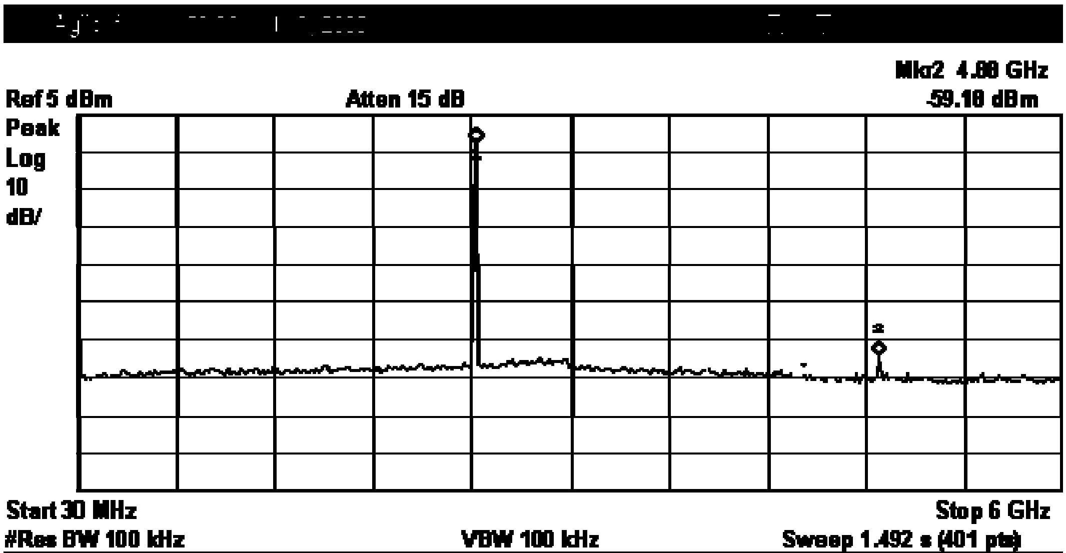
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.40 GHz	-1.579 dBm
2	(1)	Freq	4.81 GHz	-56.44 dBm

Lowest Channel (operating at 2402 MHz): 6GHz ~ 25GHz



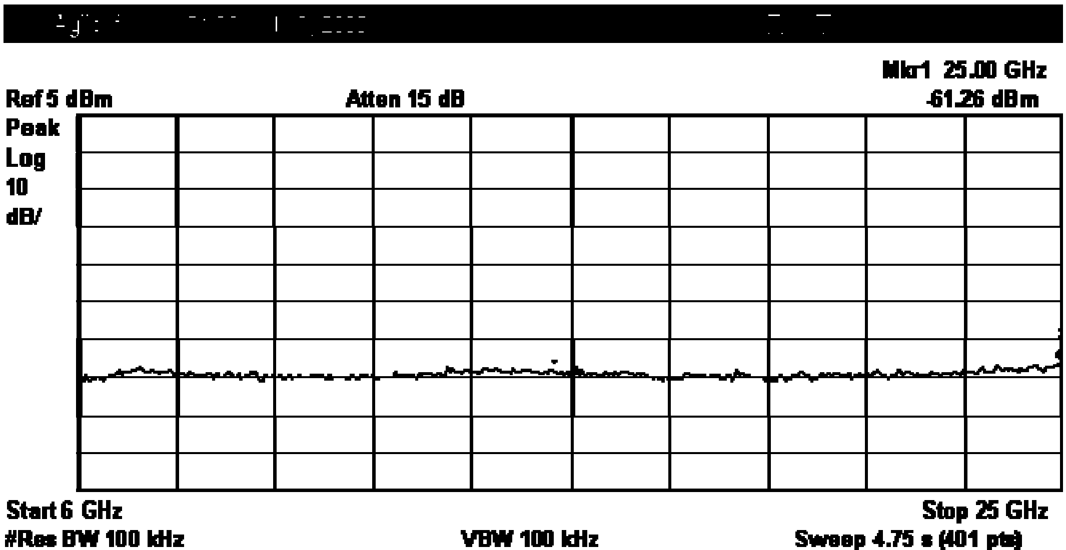
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	25.00 GHz	-62.01 dBm

Middle Channel (operating at 2441 MHz): 30MHz ~ 6GHz



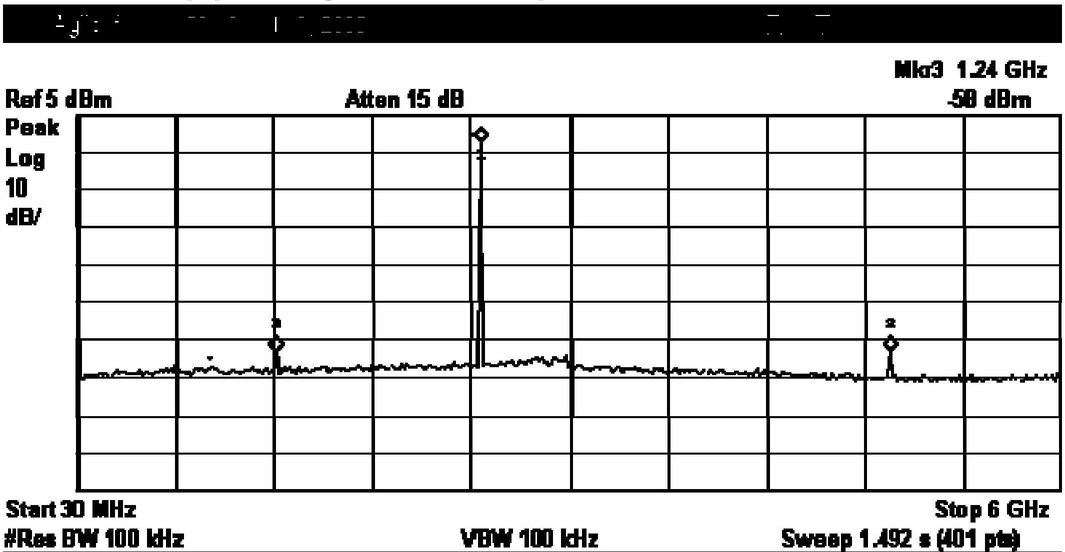
Maker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.45 GHz	-2.457 dBm
2	(1)	Freq	4.88 GHz	-59.18 dBm

Middle Channel (operating at 2441 MHz): 6GHz ~ 25GHz



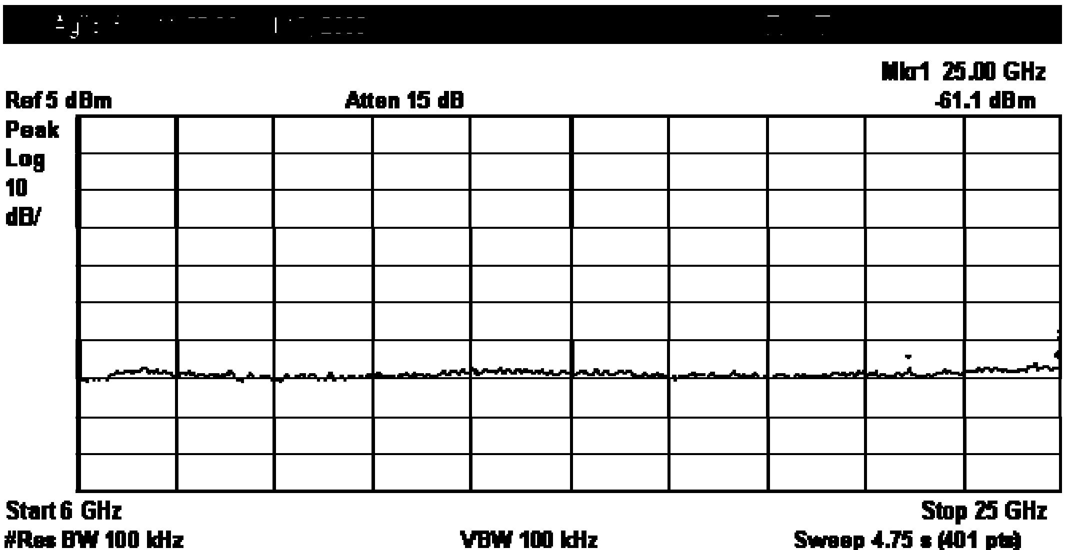
Maker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	25.00 GHz	-61.26 dBm

Highest Channel (operating at 2480 MHz): 30MHz ~ 6GHz



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.48 GHz	-2.284 dBm
2	(1)	Freq	4.96 GHz	-57.95 dBm
3	(1)	Freq	1.24 GHz	-58 dBm

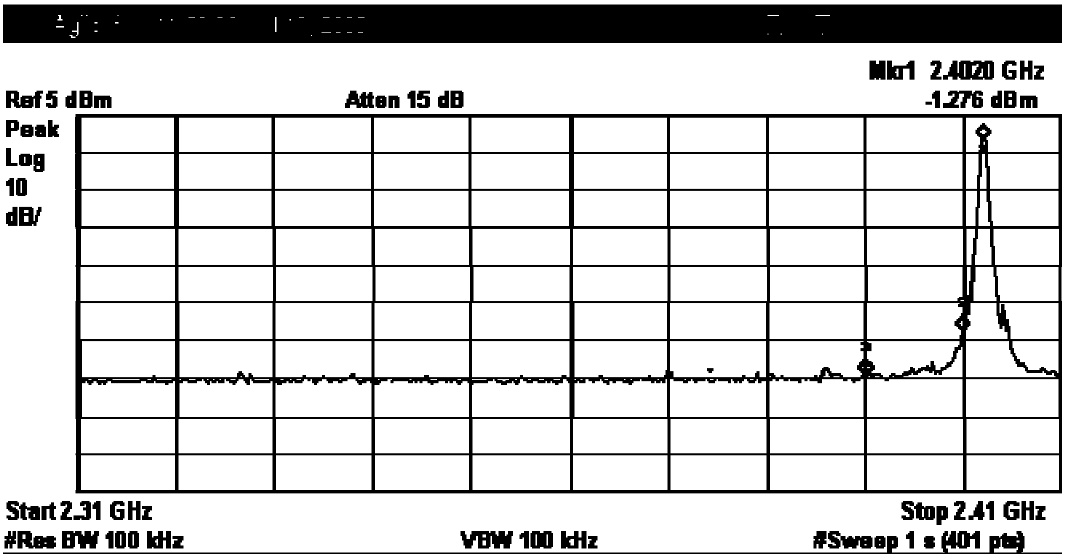
Highest Channel (operating at 2480 MHz): 6GHz ~ 25GHz



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	25.00 GHz	-61.1 dBm

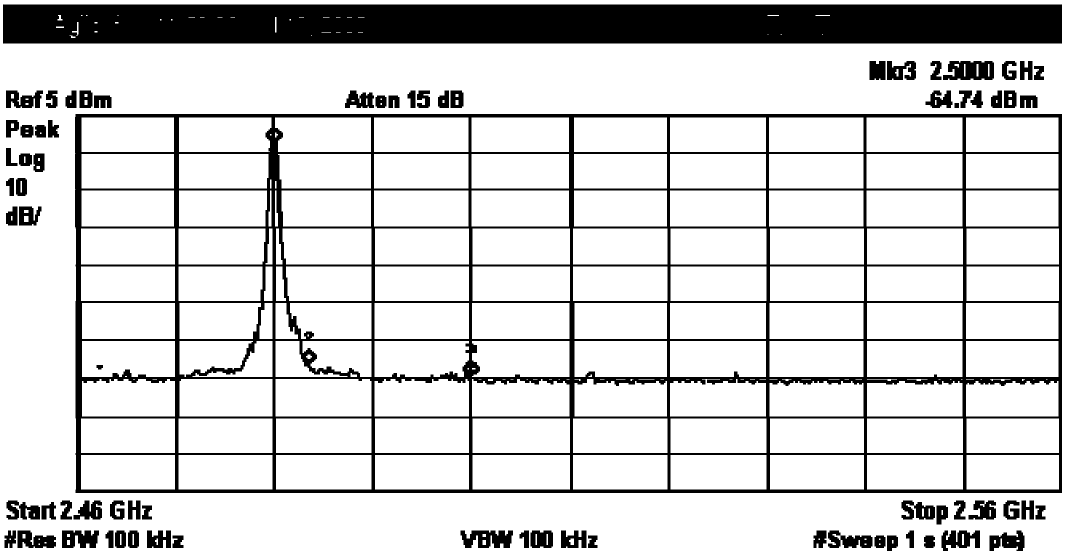
Figure 7. Plot of the Band Edge (Conducted)

Lowest Channel (operating at 2402 MHz)



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4020 GHz	-1.276 dBm
2	(1)	Freq	2.4000 GHz	-52.48 dBm
3	(1)	Freq	2.3900 GHz	-64 dBm

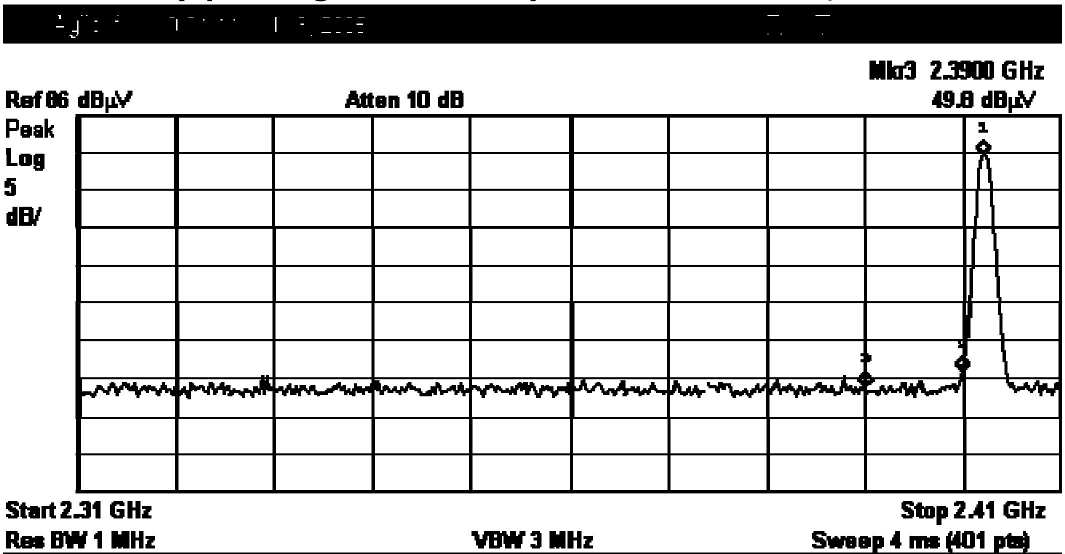
Highest Channel (operating at 2480 MHz)



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4800 GHz	-2.131 dBm
2	(1)	Freq	2.4835 GHz	-51.35 dBm
3	(1)	Freq	2.5000 GHz	-64.74 dBm

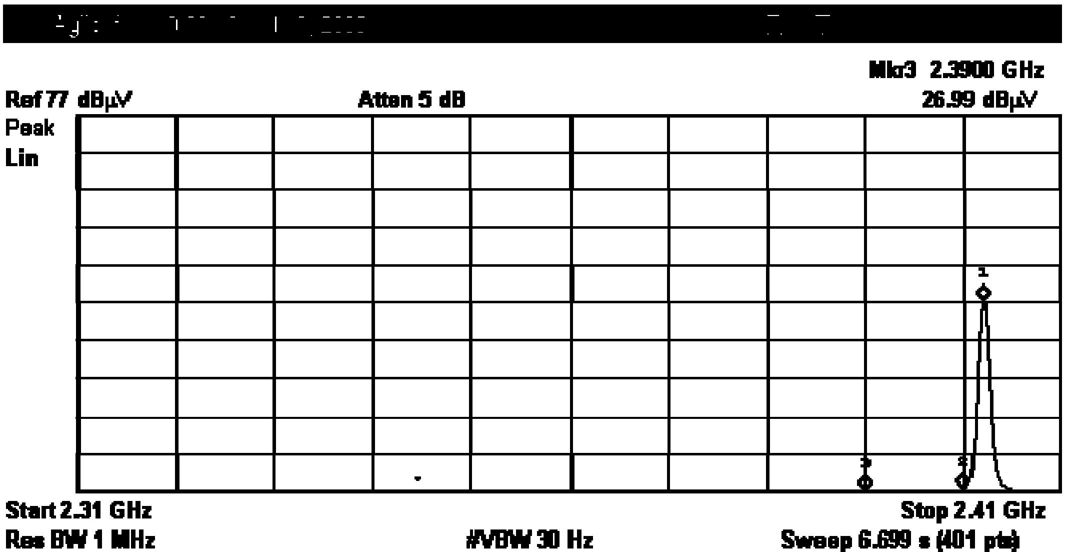
Figure 8. Plot of the Band Edge (Radiated)

Lowest Channel (operating at 2402 MHz): 2310 ~ 2390 MHz, PEAK



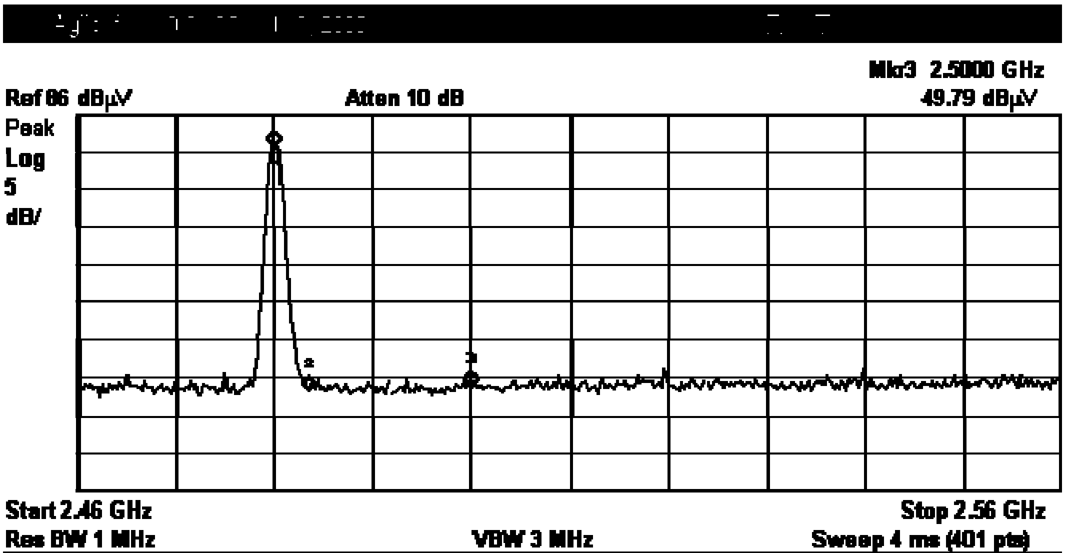
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4020 GHz	80.63 dBµV
2	(1)	Freq	2.4000 GHz	51.81 dBµV
3	(1)	Freq	2.3900 GHz	49.8 dBµV

Lowest Channel (operating at 2402 MHz): 2310 ~ 2390 MHz, AVERAGE



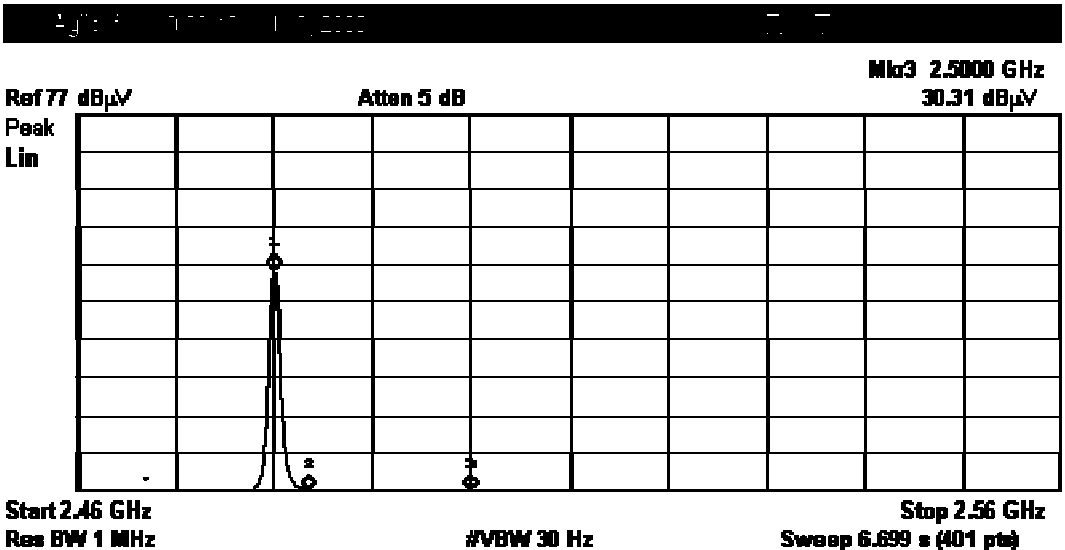
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4020 GHz	71.09 dBµV
2	(1)	Freq	2.4000 GHz	34.96 dBµV
3	(1)	Freq	2.3900 GHz	26.99 dBµV

Highest Channel (operating at 2480 MHz): 2483.5 ~ 2500MHz, PEAK



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4800 GHz	81.8 dBµV
2	(1)	Freq	2.4835 GHz	49.31 dBµV
3	(1)	Freq	2.5000 GHz	49.79 dBµV

Highest Channel (operating at 2480 MHz): 2483.5 ~ 2500MHz, AVERAGE



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.4800 GHz	72.34 dBµV
2	(1)	Freq	2.4835 GHz	30.89 dBµV
3	(1)	Freq	2.5000 GHz	30.31 dBµV

5.8 PEAK POWER SPECTRAL DENSITY

5.8.1 Regulation

According to §15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.8.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode with RBW = 3kHz.
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

5.8.3 Test Results: PASS

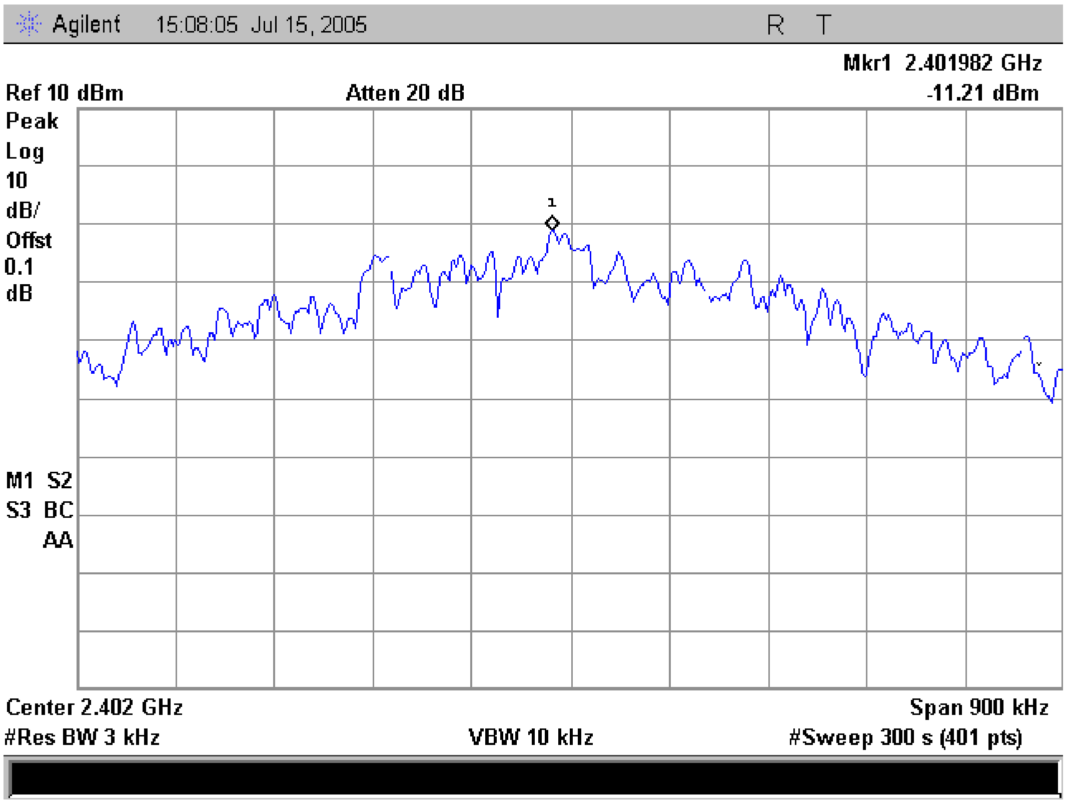
Table 8: Measured values of the Peak Power Spectral Density (Conducted)

Operating frequency	Cable Loss	Reading	Limit
2402 MHz	0.1 dB	-11.21 dBm	8.0 dBm
2441 MHz	0.1 dB	-11.99 dBm	8.0 dBm
2480 MHz	0.1 dB	-12.76 dBm	8.0 dBm

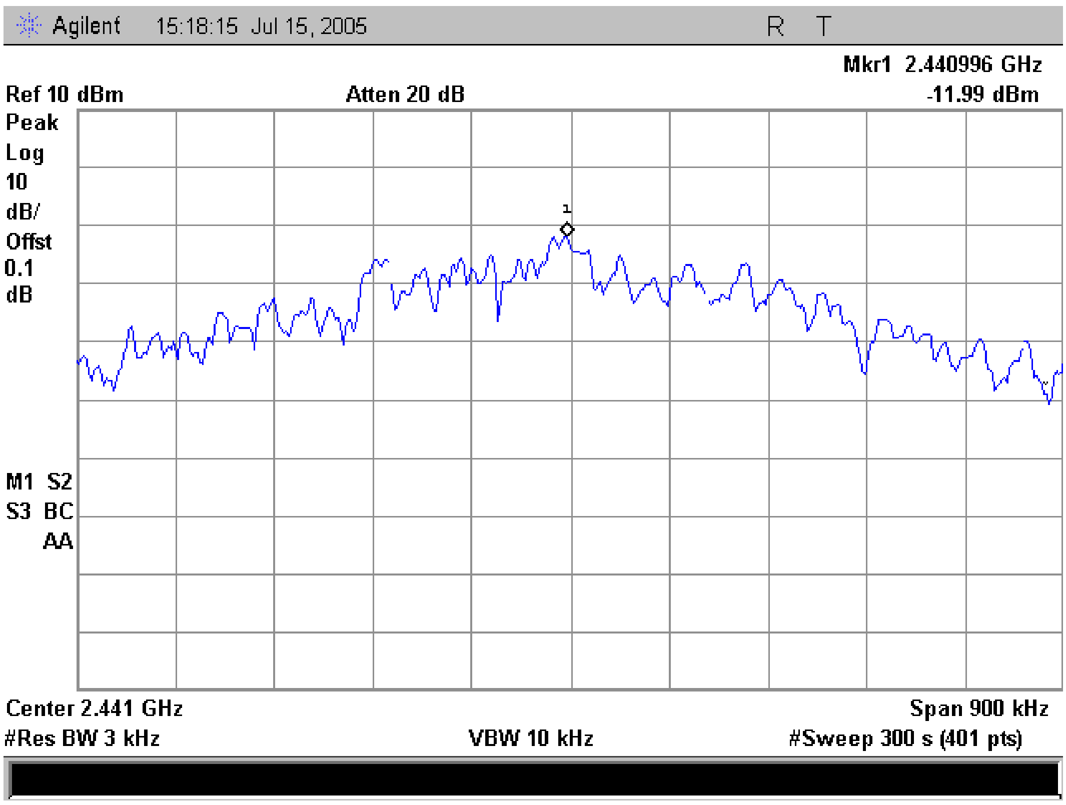
Cable Loss was included in Reading as Offset.

Figure 9. Plot of the Peak Power Spectral Density (Conducted)

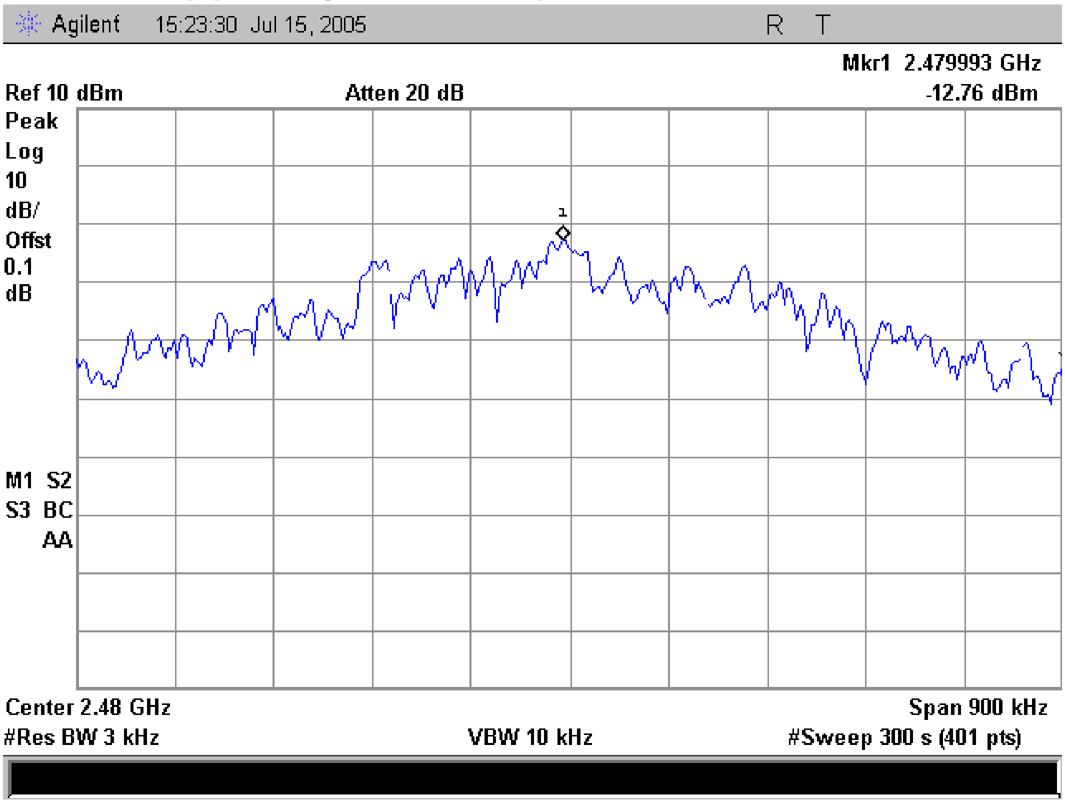
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



5.9 CONDUCTED EMISSIONS

5.9.1 Regulation

According to §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 50μH/50Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Qausi-peak	Average
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency.

According to §15.107(a), for unintentional device, except for Class A digital devices, line conducted emission limits are the same as the above table.

5.9.2 Test Procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

5.9.3 Test Results: PASS

Table 9: Measured values of the Conducted Emissions

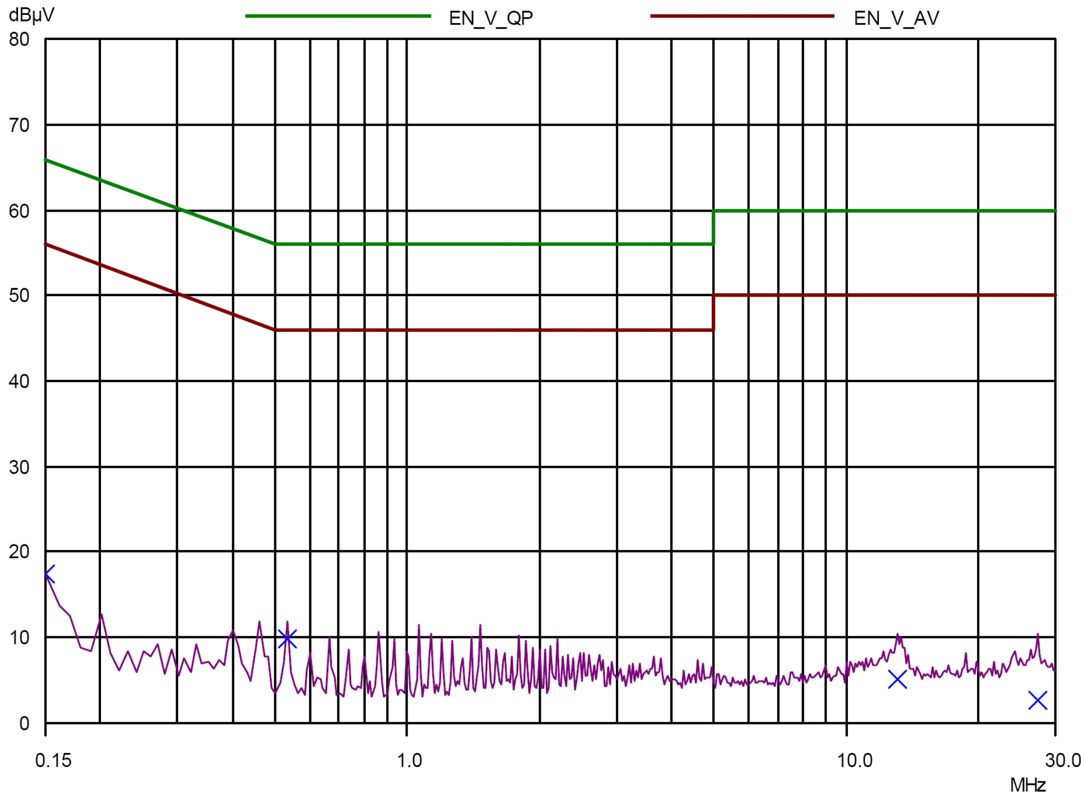
Frequency [MHz]	Reading [dBμV]		CF/CL [dB]	Actual [dBμV]		Limit [dBμV]		Margin [dB]	
	Qp	Ave		Qp	Ave	Qp	Ave	Qp	Ave
LINE – PE									
0.15	17.37	---	0.09/0.0	17.46	---	66.00	56.00	48.54	---
0.53	9.90	---	0.10/0.1	10.10	---	56.00	46.00	45.90	---
13.01	5.06	---	0.56/0.6	6.22	---	60.00	50.00	53.78	---
27.15	2.69	---	0.84/0.7	4.23	---	60.00	50.00	55.77	---
NEUTRAL – PE									
0.15	17.37	---	0.13/0.0	17.50	---	66.00	56.00	48.50	---
0.53	7.52	---	0.15/0.1	7.77	---	56.00	46.00	48.23	---
12.94	4.50	---	0.43/0.6	5.53	---	60.00	50.00	54.47	---
27.27	4.26	---	0.57/0.7	5.53	---	60.00	50.00	54.47	---

Margin (dB) = Limit – Actual
[Actual = Reading + CF + CL]
1. Remark "---" means the level is undetectable or the Qausi-peak value is lower than the limit of Average.
2. CF/CL = Correction Factor and Cable Loss
3. Qp = Quasi-peak, Ave = Average value

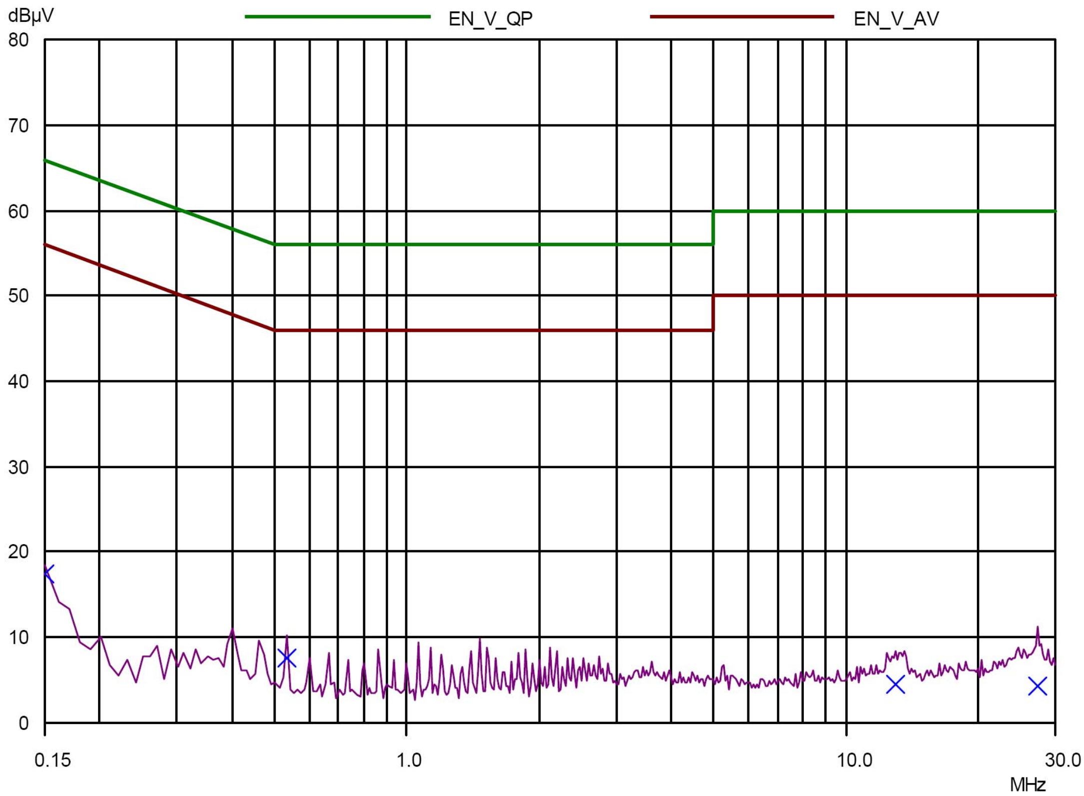
NOTE: The frequency range was scanned from 150 kHz to 30 MHz. All emissions not reported were more than 20 dB below the specified limit.

Figure 10. Plot of the Conducted Emissions

Line – PE (Quasi-Peak reading)



Neutral – PE (Quasi-Peak reading)



5.10 RF Exposure

5.10.1 Regulation

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Limits for Maximum Permissive Exposure: According to §1.1310 and §2.1091, RF exposure is calculated.

Frequency Range	Electric Field Strength [V/m]	Magnetic Field Strength [A/m]	Power Density [mW/cm^2]	Averaging Time [minute]
Limits for General Population/Uncontrolled Exposure				
0.3 ~ 1.34	614	1.63	*(100)	30
1.34 ~ 30	824/f	2.19/f	*(180/f^2)	30
30 ~ 300	27.5	0.073	0.2	30
300 ~ 1500	/	/	f/1500	30
1500 ~ 15000	/	/	1.0	30

f = frequency in MHz, * = Plane-wave equivalent power density

MPE (Maximum Permissive Exposure) Prediction

Predication of MPE limit at a given distance: Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

$$\left(\Rightarrow R = \sqrt{PG/4\pi S}\right)$$

S = power density [mW/cm^2]
P = power input to antenna [mW]
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna [cm]

EUT: Maximum peak output power = -1.089[dBm] (= 0.778 [mW]) & Antenna gain = 0 [dBi]	
100mW, at 20cm from an antenna 6[dBi]	$S = PG/4\pi R^2 = 100 \times 3.98 / (4 \times \pi \times 400)$ $= 0.0792$ [mW/cm^2] < 1.0 [mW/cm^2]
0.778mW, at 20cm from the antenna 0 [dBi]	$S = PG/4\pi R^2 = 0.0002$ [mW/cm^2] < 1.0 [mW/cm^2]
0.778mW, at 2.5cm from the antenna 0 [dBi]	$S = PG/4\pi R^2 = 0.0099$ [mW/cm^2] < 1.0 [mW/cm^2]
0.778mW, at 0.3cm from the antenna 0 [dBi]	$S = PG/4\pi R^2 = 0.6879$ [mW/cm^2] < 1.0 [mW/cm^2]

NOTE: The antenna used for the EUT is an integral SMD chip antenna. The calculated values of MPE for the EUT show that MPE is safe beyond 0.3 cm from the antenna.

5.10.2 RF Exposure Compliance Issue

The EUT is categorically excluded from routine environmental because it operates at very low power level. The equipment is deemed to comply with the SAR or MPE limits without testing due to this very low power level. The maximum RF EIRP output from the EUT is less than 0.8mW. Therefore no warning labels, no RF exposure warnings in the manual or other protection measures are required for the EUT.