Certificate of Compliance

Test Report No.:	**SKTTRT-051004-023**		
NVLAP CODE:	**200220-0**		
Applicant:	**INITIUM Co., Ltd.**		
Applicant Address:	# 901, Kins Tower, 25-1 Jungja, Bundang, Sungnam, Kyunggi, 463-811 Korea		
Manufacturer:	**INITIUM Co., Ltd.**		
Manufacturer Address:	# 901, Kins Tower, 25-1 Jungja, Bundang, Sungnam, Kyunggi, 463-811 Korea		
Device Under Test:	**Promi-ESD01**		
FCC ID:	**QOCPROMI-ESD01**	**Model No.:**	**Promi-ESD01**
Receipt No.:	SKTEU05-0572	**Date of receipt:**	August 29, 2005
Date of Issue:	October 04, 2005		
Location of Testing:	**SK TECH CO., LTD.** 820-2, Wolmoon-Ri, Wabu-Up, Namyangju-Si, Kyunggi-Do, Korea		
Test Procedure:	**ANSI C63.4, FCC Public Notice DA 00-705 (March 2000)**		
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*

2005.10.04

Signature *Date*

Approved by: *Jae-Kyung, Bae*

2005.10.04

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

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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 : August 29, 2005

Date of Test : September 08, 2005 ~ October 01, 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 of EUT	Bluetooth module
Type designation	Promi-ESD01
FCC ID	QOCPROMI-ESD01 During the tests, the EUT was not labeled with the FCC-label
Power source	DC 3.0 – 3.3V
Local Oscillator or X-Tal	X-Tal: 16 MHz
Transmit Frequency	2402 ~ 2480 MHz (1MHz step, 79 channels)
Antenna Type	External Helical antenna (Model WE-2400PO, Gain 2dBi)
Type of Modulation	FHSS (GFSK)
RF Output power	< 16dBm
Temperature range	-10 °C to + 70 °C
External Ports	2×6 Header (Power Input, UART interface; TX/RX)

3.2 Equipment Modifications

None

3.3 Submitted Documents

Block diagram

Schematic diagram

Antenna Specification

Part List

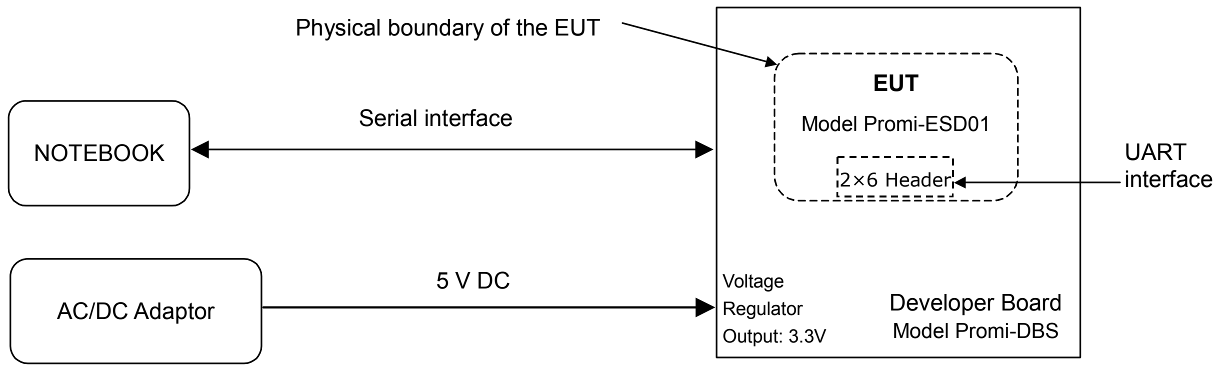
User manual

4. MEASUREMENT CONDITIONS

4.1 Description of test configuration

The Bluetooth module was connected to a Developer Board, Promi-DBS, which was supplied by the applicant. This Developer Board is equipped with a UART interface, a serial port interface for programming and digital input and output interfaces.

A NOTEBOOK PC with a terminal software, connected temporary to the UART interface of the EUT, was used for setting the equipment into the necessary operation mode. During the measurement procedures the NOTEBOOK PC was disconnected.



If not otherwise stated, for modulating the transmitter, a pseudo random bit sequence with a pattern type DH5 was used.

4.2 List of Peripherals

Equipment Type	Manufacturer	Model	Cable Description
Notebook PC	Trigem	Dreambook	1.8m, Shielded, USB to RS-232 Cable
AC/DC Adaptor	ANAM Electronics Inc.	AP1015-EU	1.8 m, Unshielded
Developer Board	INITIUM Co., Ltd.	Promi-DBS	1.2 m, Unshielded

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)	5.7	PASS
Peak Power Spectral Density	15.247(e)	5.8	PASS
Conducted Emissions	15.207(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 shall only be used with the tested antenna that has a unique antenna connector, reverse polarity SMA type. The directional gain of the antenna is typically 2 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 as follows:
   Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
   RBW > the 20 dB bandwidth of the emission being measured
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
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)

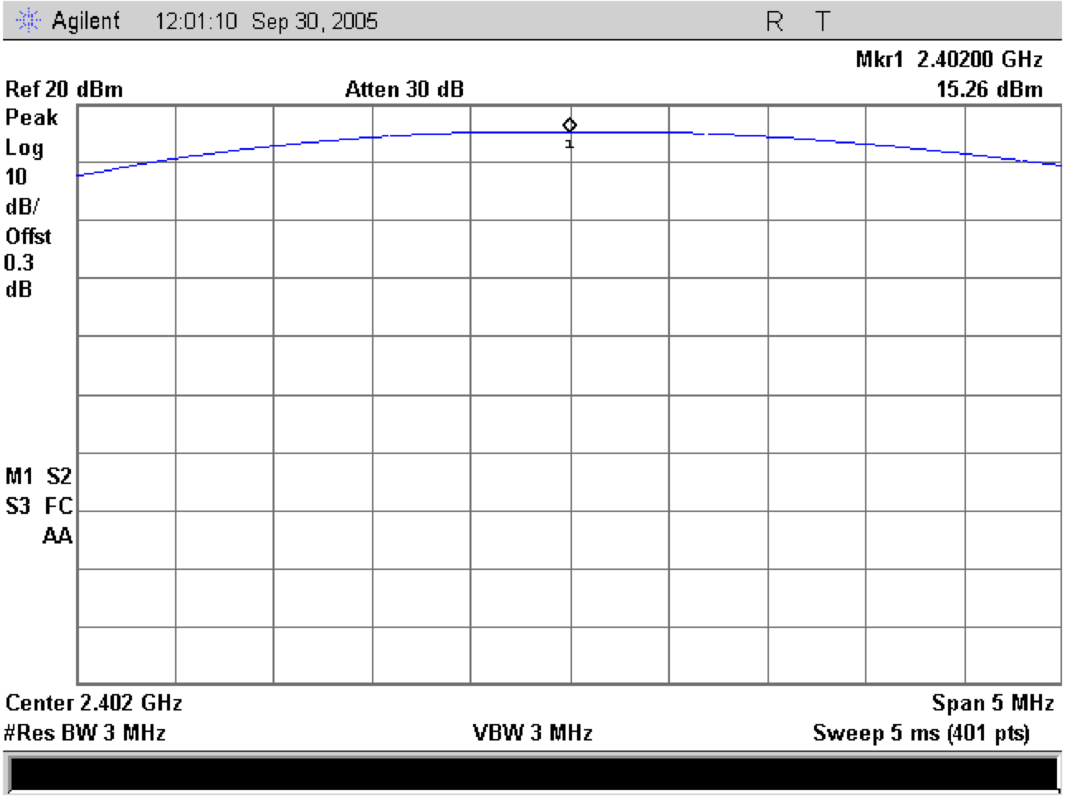
Operating Frequency	Resolution Bandwidth	Cable Loss	Reading	Limit
2402 MHz	3 MHz	0.3 dB	15.26 dBm (33.57 mW)	30 dBm (1 W)
2441 MHz	3 MHz	0.3 dB	15.38 dBm (34.51 mW)	30 dBm (1 W)
2480 MHz	3 MHz	0.3 dB	15.41 dBm (34.75 mW)	30 dBm (1 W)

Cable Loss was included in Reading as Offset.

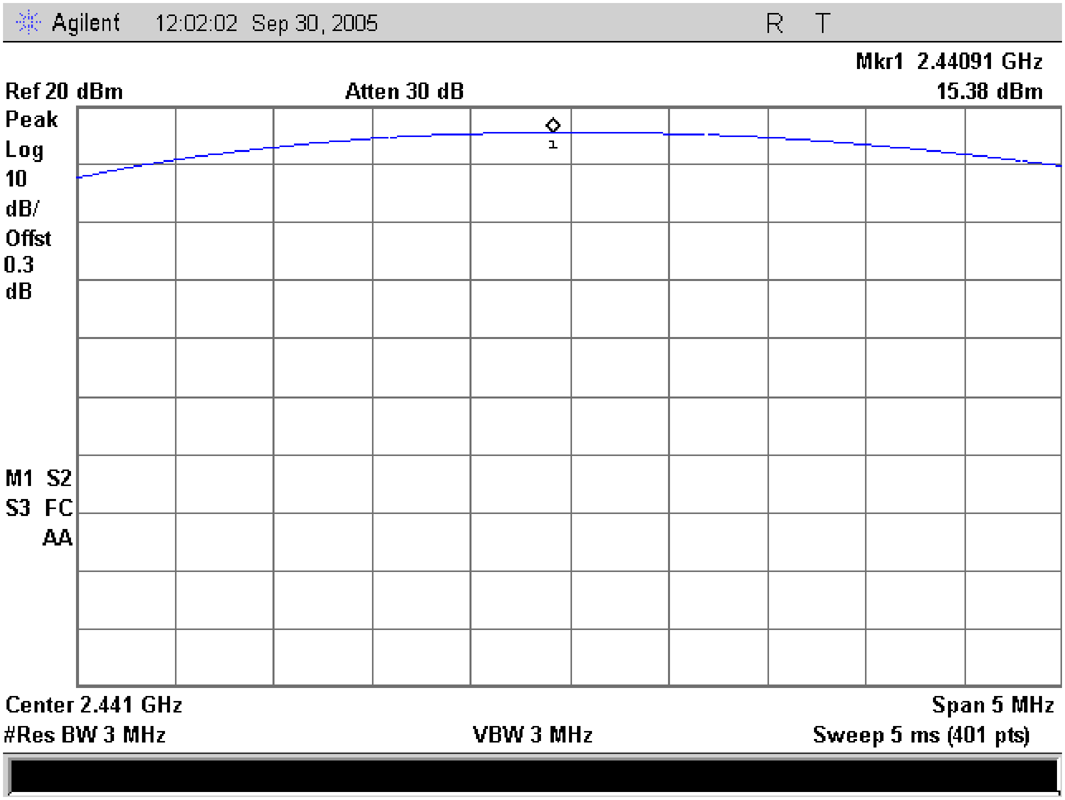
NOTE: Since the directional gain of the antenna declared by manufacturer (G_{ANT} = 2 dBi) does not exceed 6.0 dBi, there was no need to reduce the output power.

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

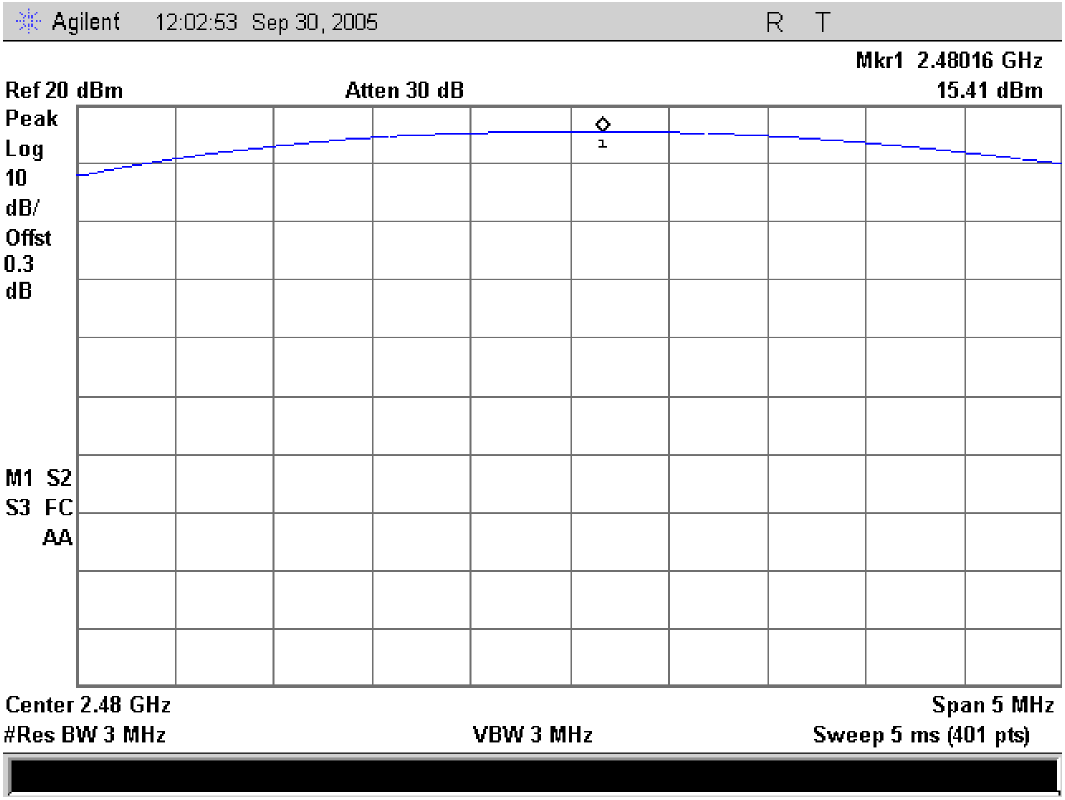
Lowest Channel (operating at 2402 MHz)



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.
4. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peaks of two adjacent channels
   Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span
   Video (or Average) Bandwidth (VBW) ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.

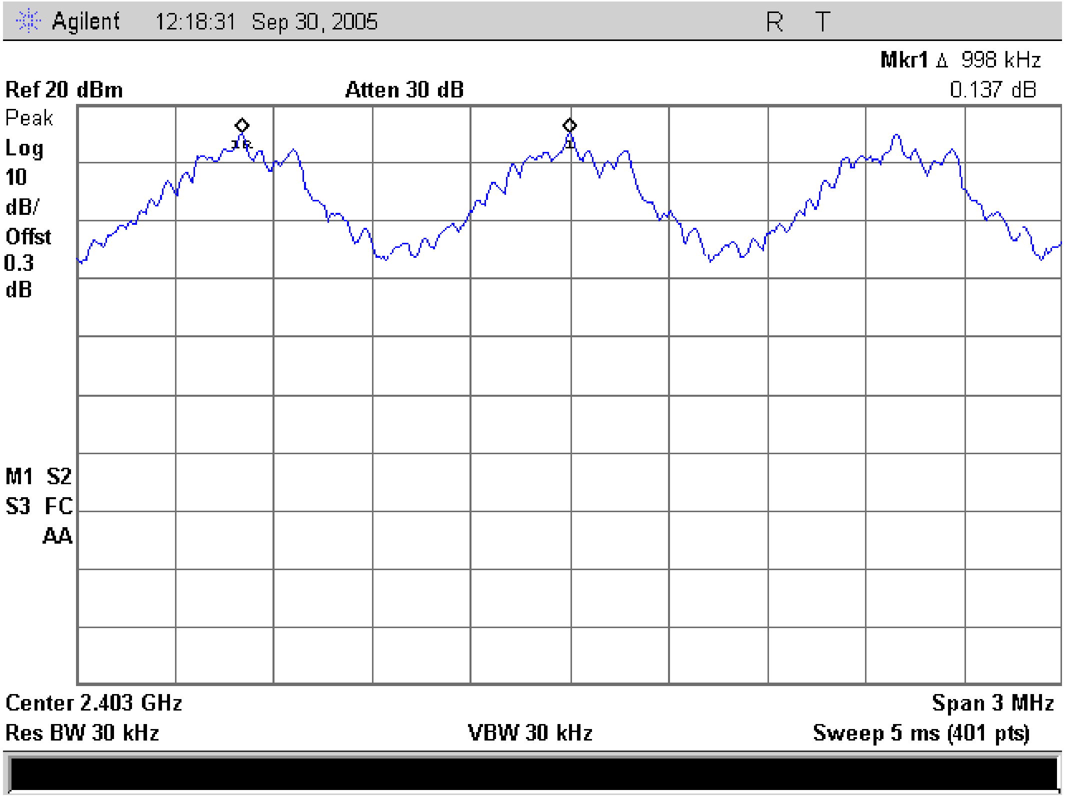
5.3.3 Test Results: PASS

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

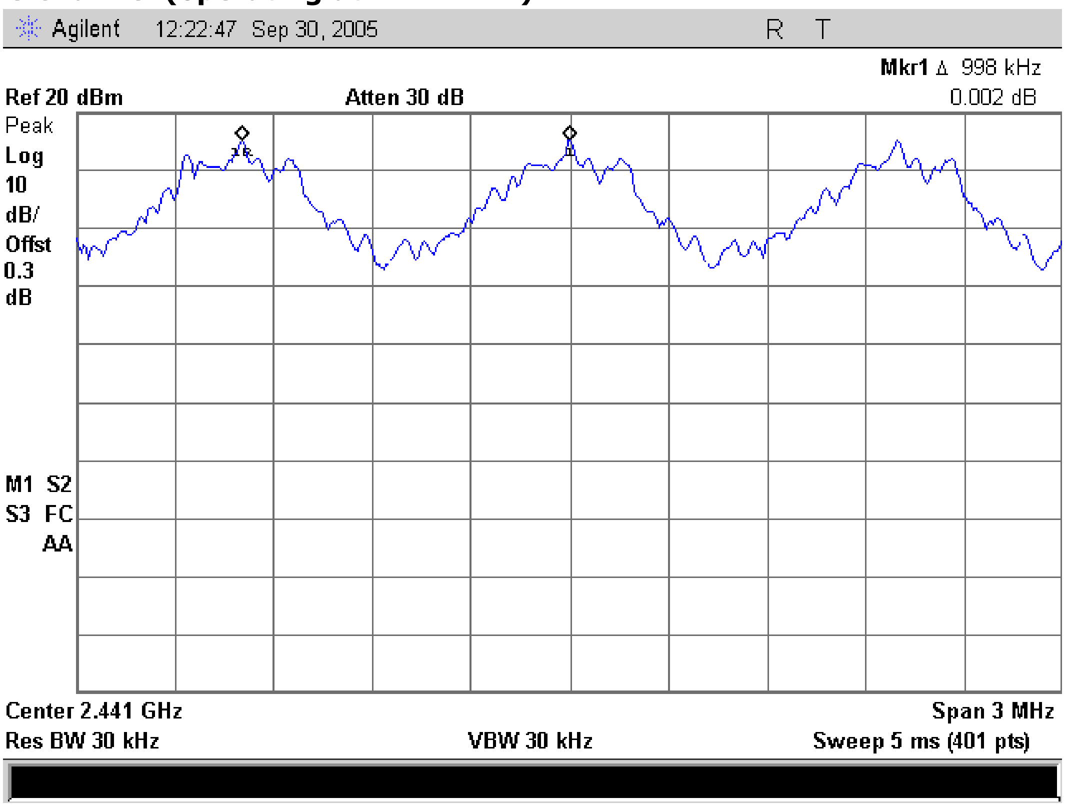
Operating frequency	Carrier frequency separation	Limit
2402 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth (953 kHz)
2441 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth (960 kHz)
2480 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth (968 kHz)

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

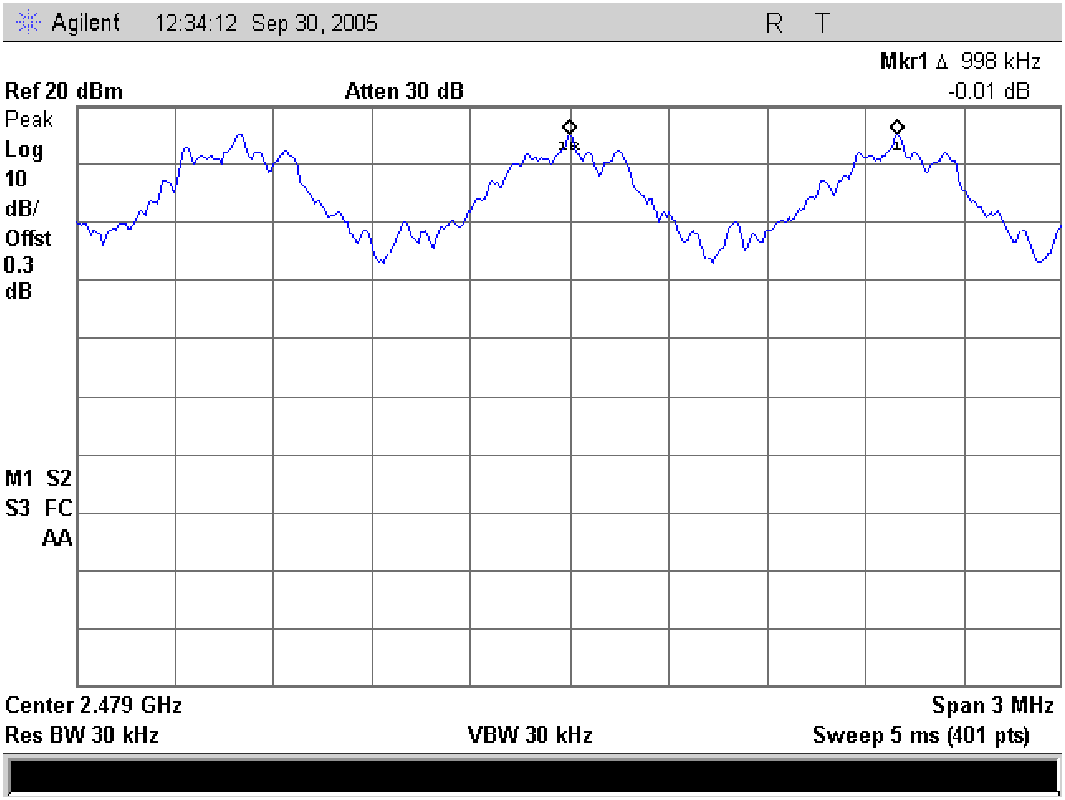
Lowest Channel (operating at 2402 MHz)



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 as follows:
   Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
   RBW ≥ 1% of the 20 dB bandwidth
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Set a reference level on it equal to the highest peak value.
6. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
7. Repeat above procedures until all frequencies measured were complete.

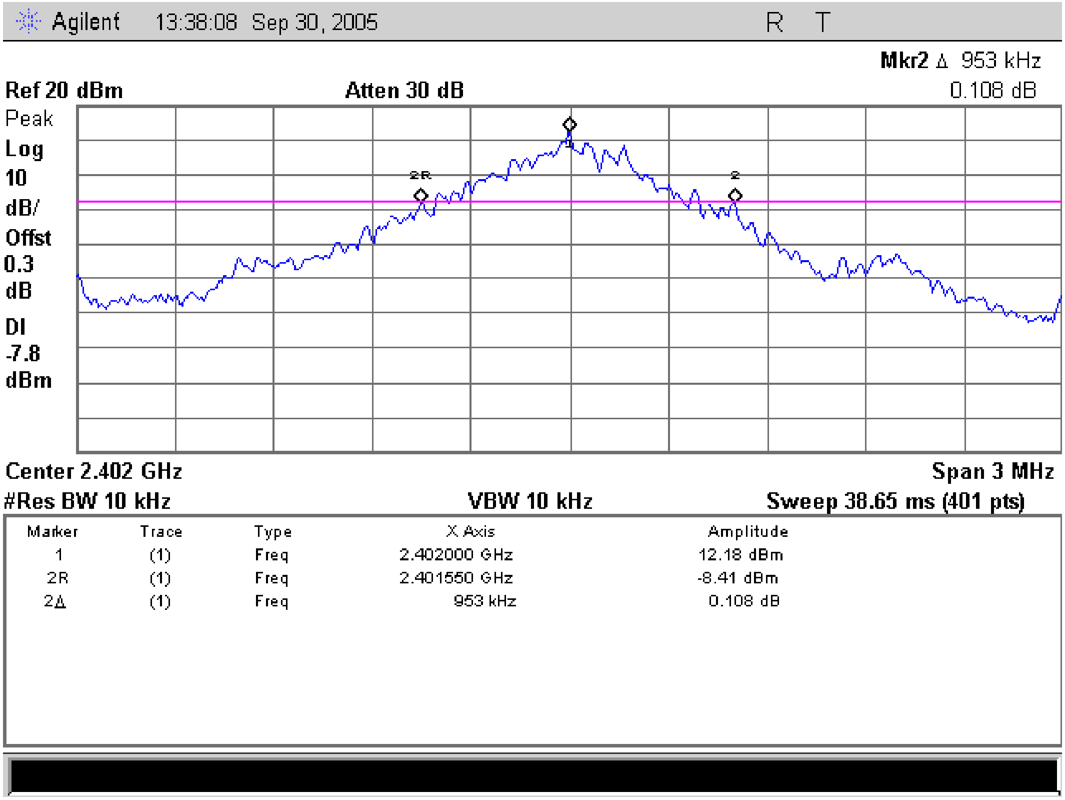
5.4.3 Test Results: PASS

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

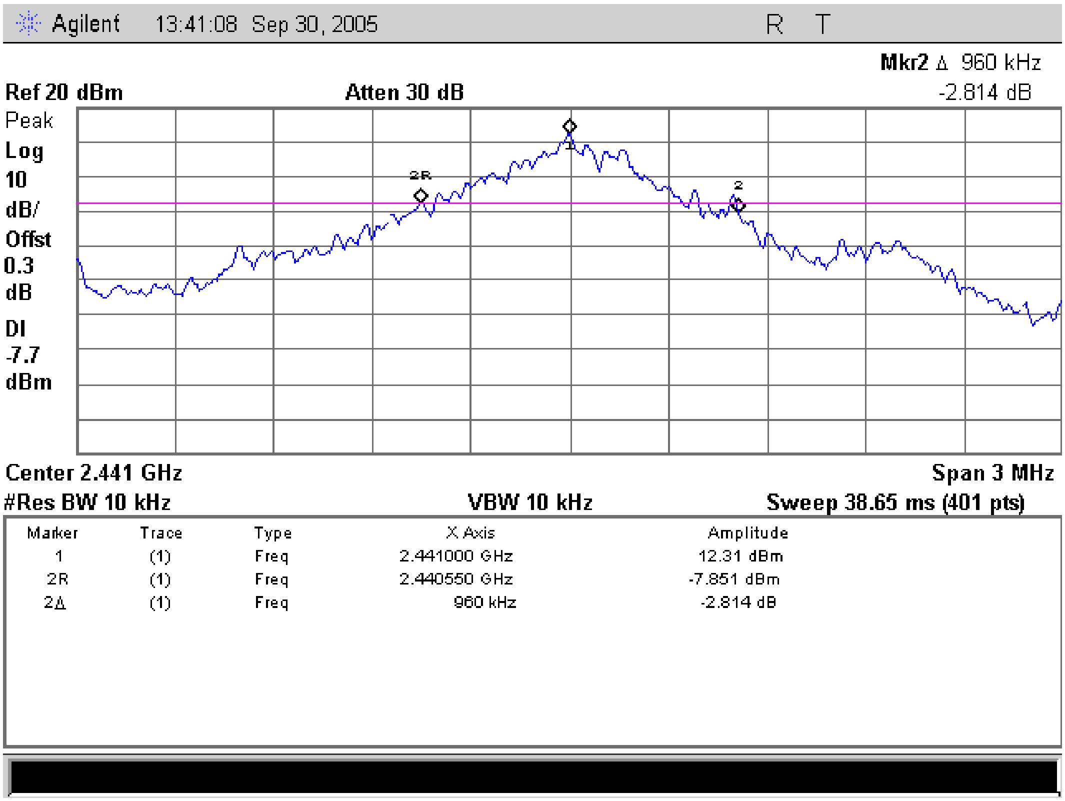
Operating frequency	20dB Channel bandwidth	Limit
2402 MHz	953 kHz	< 1 MHz
2441 MHz	960 kHz	< 1 MHz
2480 MHz	968 kHz	< 1 MHz

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

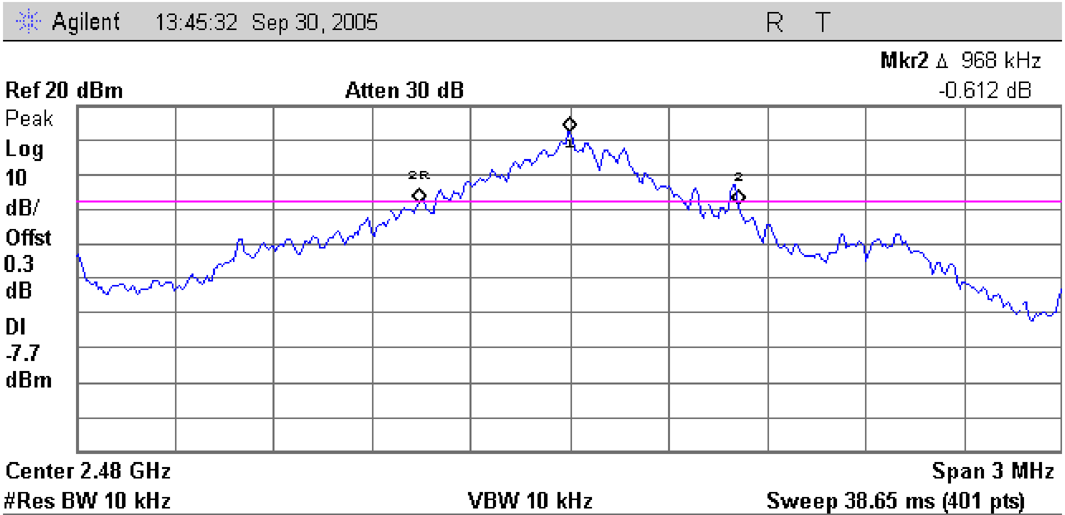
Lowest Channel (operating at 2402 MHz)



Middle Channel (operating at 2441 MHz)



Highest Channel (operating at 2480 MHz)



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.480000 GHz	12.27 dBm
2R	(1)	Freq	2.479543 GHz	-8.038 dBm
2Δ	(1)	Freq	968 kHz	-0.612 dB

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

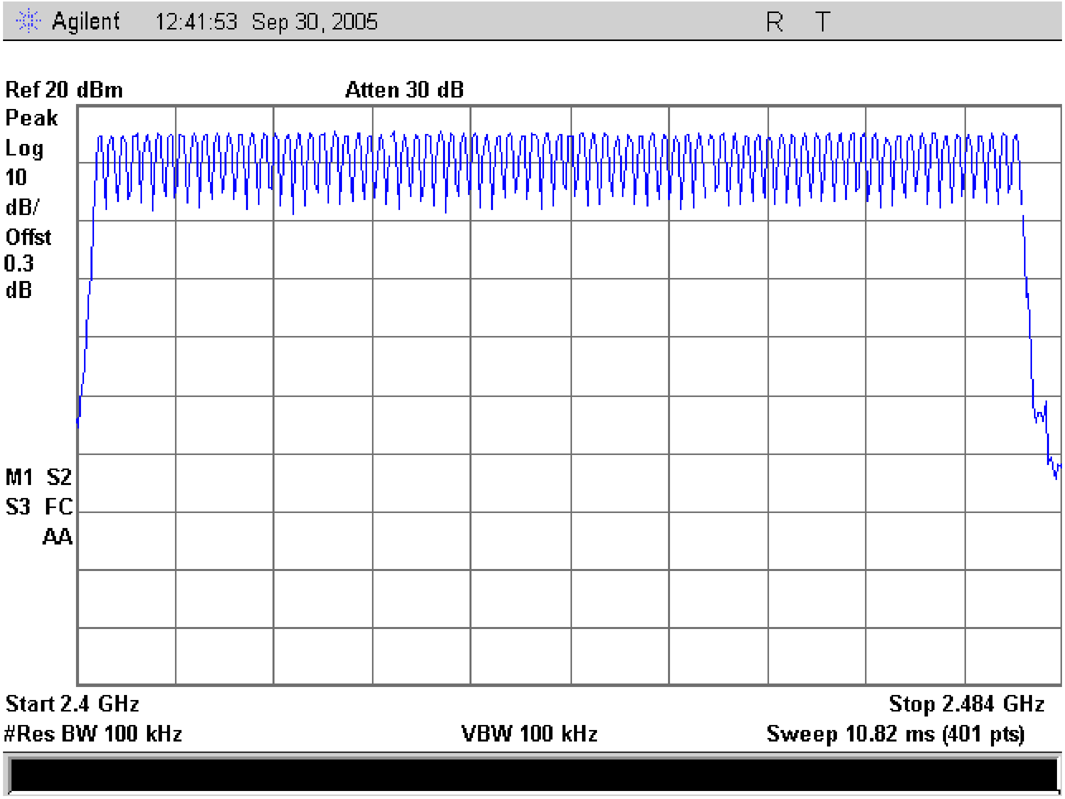
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set the hopping function enabled by controlling it via UART interface.
4. Set the spectrum analyzer as follows:
   Span = the frequency band of operation
   RBW ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. 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 as follows:
   Span = zero span, centered on a hopping channel
   RBW = 1 MHz
   VBW ≥ RBW
   Sweep = as necessary to capture the entire dwell time per hopping channel
   Detector function = peak
   Trace = max hold
5. 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

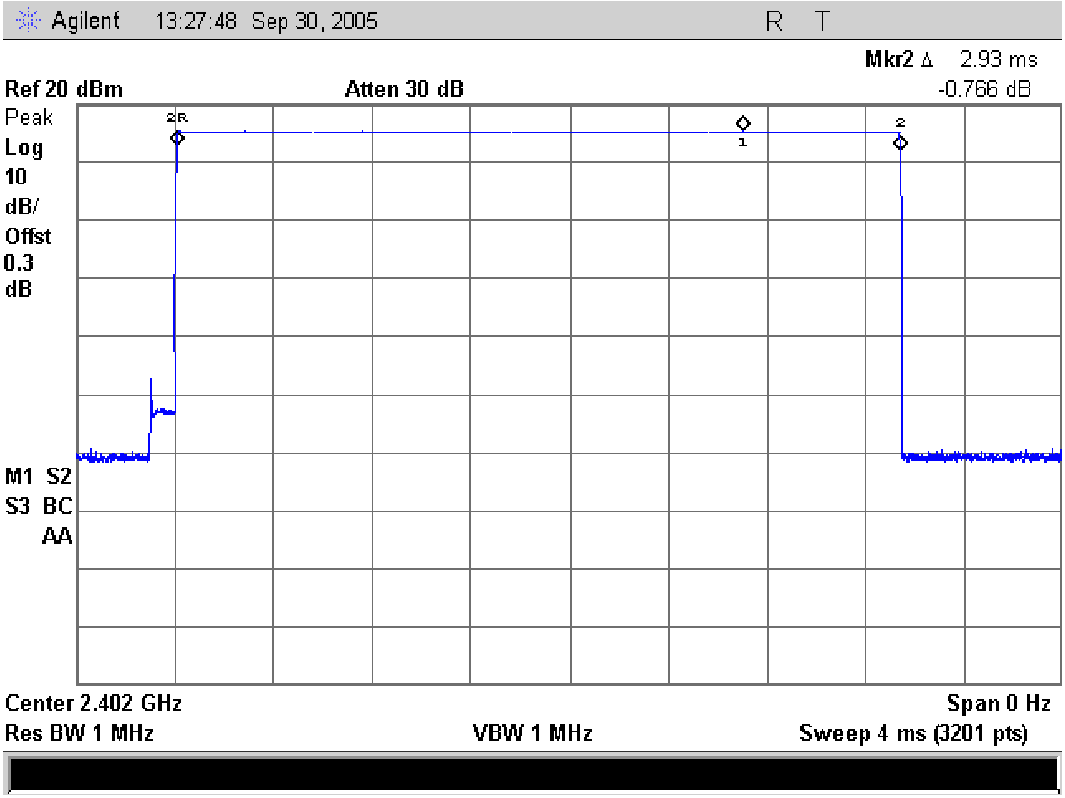
Table 5: Measured values of the Time of Occupancy (Conducted)

Operating frequency	Reading	Hopping rate	Number of Channels	Actual	Limit
2402 MHz	2.93 ms	266.667 hops/s	79	0.3125 seconds	0.4 seconds
2441 MHz	2.93 ms	266.667 hops/s	79	0.3125 seconds	0.4 seconds
2480 MHz	2.93 ms	266.667 hops/s	79	0.3125 seconds	0.4 seconds

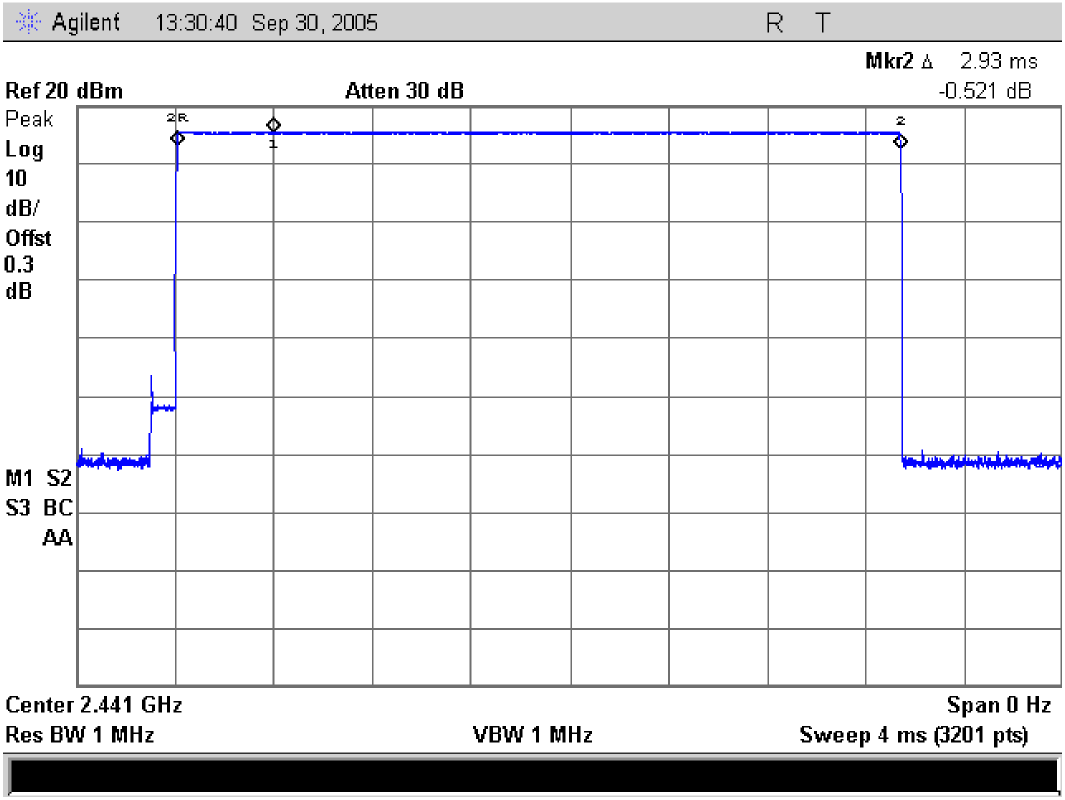
Actual = Reading × (Hopping rate / Number of channels) × Test period
Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]
NOTE: The EUT makes worst case 1600 hops per second or 1 time slot has a length of 625μs with 79 channels. A DH5 Packet needs 5 time slot for transmitting and 1 time slot for receiving. Then the EUT makes worst case 266.667 hops per second with 79 channels.

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

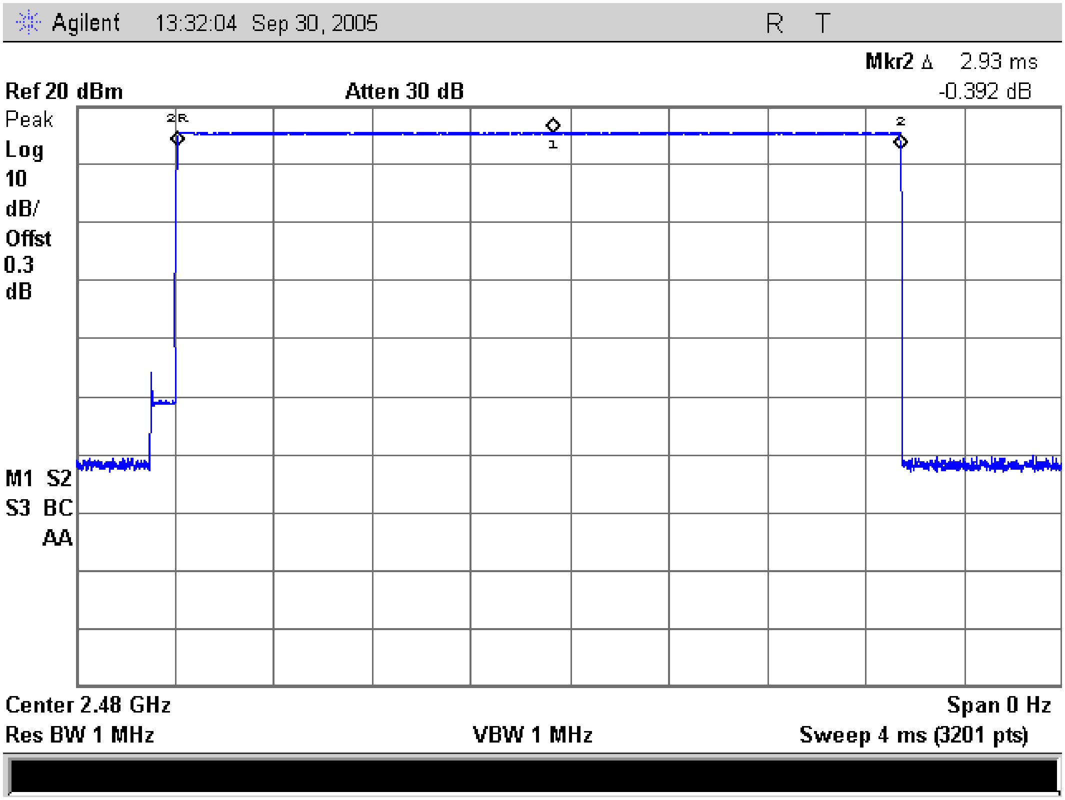
Lowest Channel (operating at 2402 MHz)



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	100	40.0
88–216	150	43.5
216–960	200	46.0
Above 960	500	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

<u>1) Band-edge Compliance of RF Conducted Emissions</u>

1. Set the spectrum analyzer as follows:
   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 ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the

in-band emission.

3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
   RBW = 100 kHz
   VBW ≥ 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.

3) 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.
7. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative “marker-delta” method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function as the above Spurious Radiated Emissions test procedure.
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and

the band-edge emission under investigation. Set the analyzer RBW to 1% of the total span (but never less than 30 kHz) with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not a field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.

3. Subtract the delta measured in step (2) from the field strengths measured in step (1). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by Section 15.205.
4. The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band-edge, where a "standard" bandwidth is the bandwidth specified by C63.4 for the frequency being measured. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, C63.4 specifies a measurement bandwidth of at least 1 MHz. Therefore you may use the "delta" technique for measuring emissions up to 2 MHz removed from the band-edge. Radiated emissions that are removed by more than two “standard” bandwidths must be measured as the above Spurious Radiated Emissions test procedure.

5.7.3 Test Results: PASS

Table 6: Band-edge Compliance

	Difference signal to peak [dB]	Field strength of this signal [dBμV/m]	Field strength of the band-edge[dBμV/m]	Limit [dBμV/m]	Margin [dB]
Upper	55.73	106.98 PK	51.25 PK	74.00 PK	22.75
		104.26 AV	48.53 AV	54.00 AV	5.47
Lower	50.29	107.56 PK	57.27 PK	87.56 PK	30.29
		104.55 AV	54.26 AV	84.55 AV	30.29

Margin (dB) = Limit – Field strength of the band-edge
PK = Peak, AV = Average value of the field strength

Table 7: 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	14.45	0.3	14.75	-	-
2498.3	-36.92	0.3	-36.62	-5.25	31.37
2514.5	-44.14	0.3	-43.84	-5.25	38.59
2530.6	-39.86	0.3	-39.56	-5.25	34.31
2546.8	-43.79	0.3	-43.49	-5.25	38.24
2553.0	-44.10	0.3	-43.80	-5.25	38.55
2562.2	-43.08	0.3	-42.78	-5.25	37.53
2594.5	-44.49	0.3	-44.19	-5.25	38.94
Middle Channel (operating at 2441 MHz)					
2441.0	14.64	0.3	14.94	-	-
2345.8	-44.79	0.3	-44.49	-5.06	39.43
2505.2	-40.91	0.3	-40.61	-5.06	35.55
2518.0	-42.04	0.3	-41.74	-5.06	36.68
2537.6	-37.37	0.3	-37.07	-5.06	32.01
2569.1	-39.53	0.3	-39.23	-5.06	34.17
2585.3	-44.69	0.3	-44.39	-5.06	39.33
2593.0	-43.72	0.3	-43.42	-5.06	38.36
2601.5	-44.38	0.3	-44.08	-5.06	39.02
Highest Channel (operating at 2480 MHz)					
2480.0	14.68	0.3	14.98	-	-
2325.2	-43.58	0.3	-43.28	-5.02	38.26
2384.4	-43.84	0.3	-43.54	-5.02	38.52
2544.1	-40.04	0.3	-39.74	-5.02	34.72
2557.6	-42.25	0.3	-41.95	-5.02	36.93
2576.2	-37.32	0.3	-37.02	-5.02	32.00
2608.3	-41.33	0.3	-41.03	-5.02	36.01
4960.0	-44.21	0.6	-43.91	-5.02	38.89

Actual = Reading + Cable Loss

Table 8: 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]
Lowest Channel (operating at 2402 MHz): PEAK DATA										
2402.0	1000	H	1.9	20	101.06	30.1	29.2/7.4	107.56	-	-
2498.3	1000	H	1.9	20	51.38	30.1	29.2/7.4	57.88	74.00	16.12
2514.5	1000	H	1.9	20	47.96	30.1	29.2/7.4	54.46	87.56	33.10
2530.6	1000	H	1.9	20	50.17	30.1	29.2/7.4	56.67	87.56	30.89
2546.8	1000	H	1.9	20	46.71	30.1	29.2/7.4	53.21	87.56	34.35
Lowest Channel (operating at 2402 MHz): AVERAGE DATA										
2402.0	1000	H	1.9	20	98.05	30.1	29.2/7.4	104.55	-	-
2498.3	1000	H	1.9	20	43.03	30.1	29.2/7.4	49.53	54.00	4.47
2514.5	1000	H	1.9	20	35.97	30.1	29.2/7.4	42.47	84.55	42.08
2530.6	1000	H	1.9	20	39.64	30.1	29.2/7.4	46.14	84.55	38.41
2546.8	1000	H	1.9	20	34.89	30.1	29.2/7.4	41.39	84.55	43.16
Middle Channel (operating at 2441 MHz): PEAK DATA										
2441.0	1000	H	1.8	15	100.61	30.1	29.2/7.4	107.11	-	-
2345.8	1000	H	1.8	15	47.86	30.1	29.2/7.4	54.36	74.00	19.64
2505.2	1000	H	1.8	15	50.73	30.1	29.2/7.4	57.23	87.11	29.88
2518.0	1000	H	1.8	15	50.56	30.1	29.2/7.4	57.06	87.11	30.05
2537.6	1000	H	1.8	15	51.72	30.1	29.2/7.4	58.22	87.11	28.89
2569.1	1000	H	1.8	15	48.98	30.1	29.2/7.4	55.48	87.11	31.63
2585.3	1000	H	1.8	15	46.99	30.1	29.2/7.4	53.49	87.11	33.62
Middle Channel (operating at 2441 MHz): AVERAGE DATA										
2441.0	1000	H	1.8	15	97.72	30.1	29.2/7.4	104.22	-	-
2345.8	1000	H	1.8	15	36.92	30.1	29.2/7.4	43.42	54.00	10.58
2505.2	1000	H	1.8	15	40.13	30.1	29.2/7.4	46.63	84.22	37.59
2518.0	1000	H	1.8	15	40.13	30.1	29.2/7.4	46.63	84.22	37.59
2537.6	1000	H	1.8	15	41.56	30.1	29.2/7.4	48.06	84.22	36.16
2569.1	1000	H	1.8	15	38.08	30.1	29.2/7.4	44.58	84.22	39.64
2585.3	1000	H	1.8	15	34.79	30.1	29.2/7.4	41.29	84.22	42.93

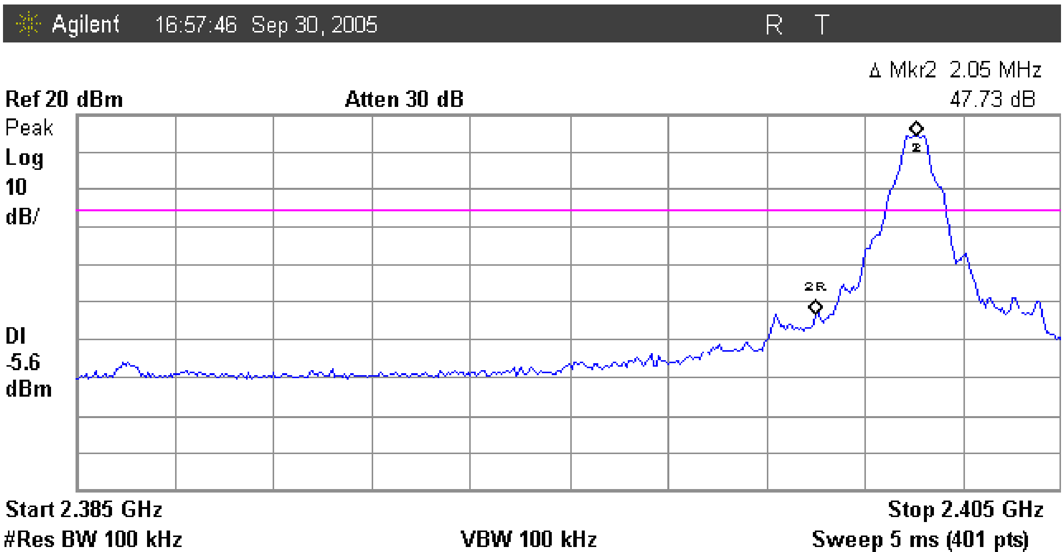
Margin (dB) = Limit – Actual
[Actual = Reading – Amp Gain + AF + CL]
1. H = Horizontal, V = Vertical Polarization
2. AF/CL = Antenna Factor and Cable Loss

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]
Highest Channel (operating at 2480 MHz): PEAK DATA										
2480.0	1000	H	1.8	20	100.48	30.1	29.2/7.4	106.98	-	-
2325.2	1000	H	1.8	20	47.44	30.1	29.2/7.4	53.94	74.00	20.06
2384.4	1000	H	1.8	20	49.21	30.1	29.2/7.4	55.71	74.00	18.29
2544.1	1000	H	1.8	20	51.51	30.1	29.2/7.4	58.01	86.98	28.97
2557.6	1000	H	1.8	20	48.59	30.1	29.2/7.4	55.09	86.98	31.89
2576.2	1000	H	1.8	20	50.97	30.1	29.2/7.4	57.47	86.98	29.51
2608.3	1000	H	1.8	20	48.02	30.1	29.2/7.4	54.52	86.98	32.46
Highest Channel (operating at 2480 MHz): AVERAGE DATA										
2480.0	1000	H	1.8	20	97.76	30.1	29.2/7.4	104.26	-	-
2325.2	1000	H	1.8	20	35.58	30.1	29.2/7.4	42.08	54.00	11.92
2384.4	1000	H	1.8	20	37.64	30.1	29.2/7.4	44.14	54.00	9.86
2544.1	1000	H	1.8	20	41.43	30.1	29.2/7.4	47.93	84.26	36.33
2557.6	1000	H	1.8	20	37.40	30.1	29.2/7.4	43.90	84.26	40.36
2576.2	1000	H	1.8	20	41.42	30.1	29.2/7.4	47.92	84.26	36.34
2608.3	1000	H	1.8	20	35.82	30.1	29.2/7.4	42.32	84.26	41.94

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.

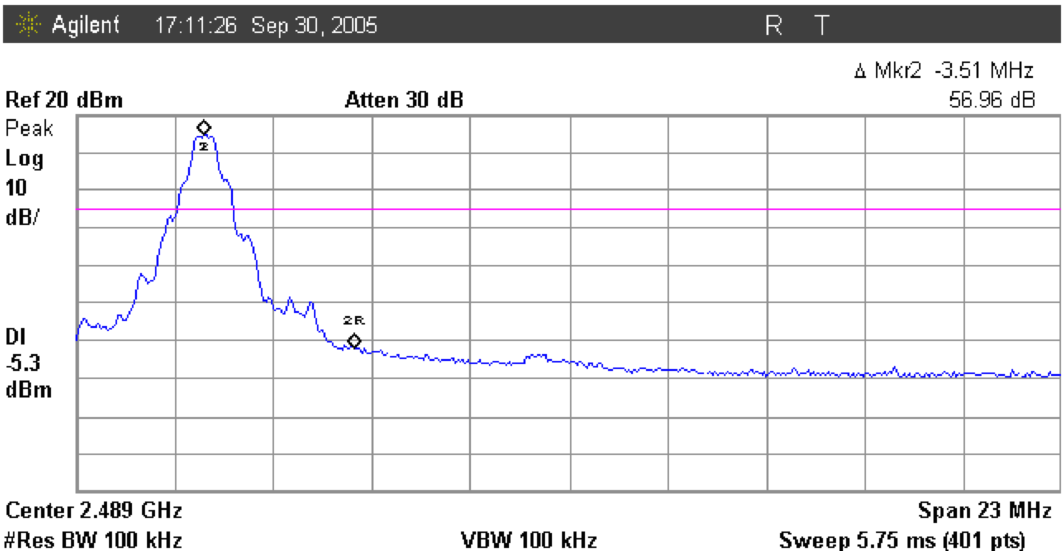
Figure 6. Plot of the Band Edge (Conducted)

Lower band-edge: Hopping DISENABLED



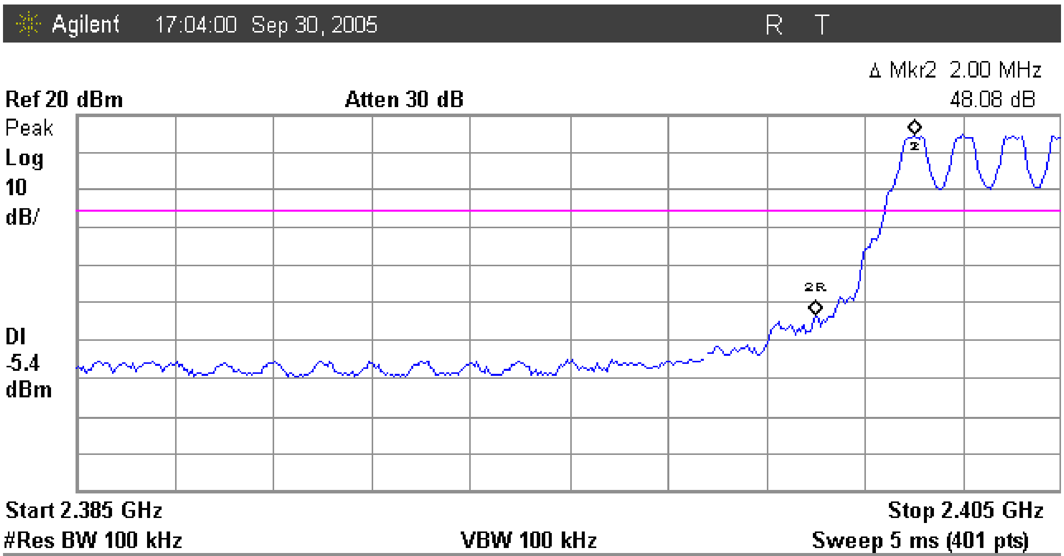
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.40205 GHz	14.45 dBm
2R	(1)	Freq	2.40000 GHz	-33.28 dBm
2Δ	(1)	Freq	2.05 MHz	47.73 dB

Upper band-edge: Hopping DISENABLED



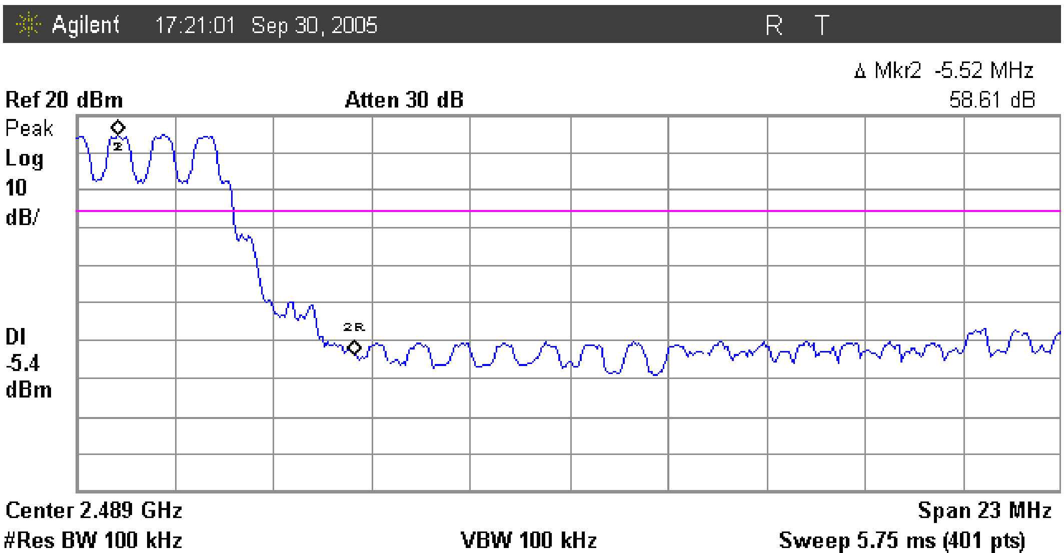
Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.47999 GHz	14.68 dBm
2R	(1)	Freq	2.48350 GHz	-42.28 dBm
2Δ	(1)	Freq	-3.51 MHz	56.96 dB

Lower band-edge: Hopping ENABLED



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.40200 GHz	14.57 dBm
2R	(1)	Freq	2.40000 GHz	-33.51 dBm
2Δ	(1)	Freq	2.00 MHz	48.08 dB

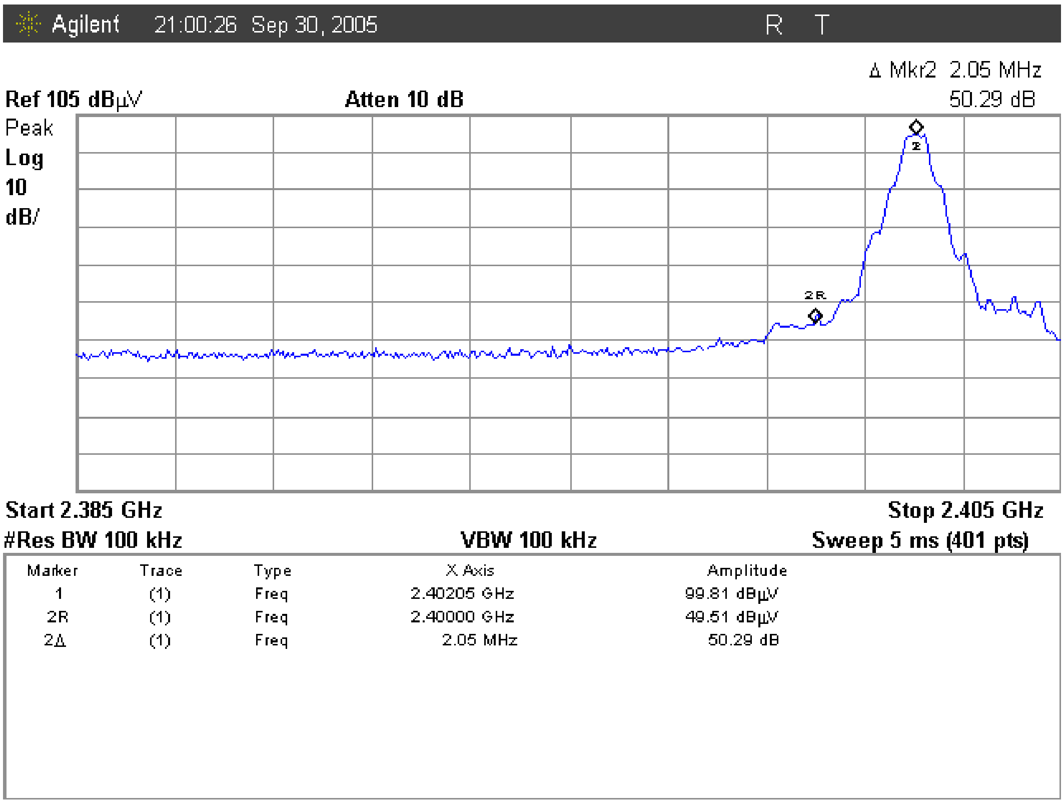
Upper band-edge: Hopping ENABLED



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	2.47798 GHz	14.63 dBm
2R	(1)	Freq	2.48350 GHz	-43.99 dBm
2Δ	(1)	Freq	-5.52 MHz	58.61 dB

Figure 7. Plot of the Band Edge (Radiated)

Lower band-edge: Marker-delta method



Upper band-edge: Marker-delta method

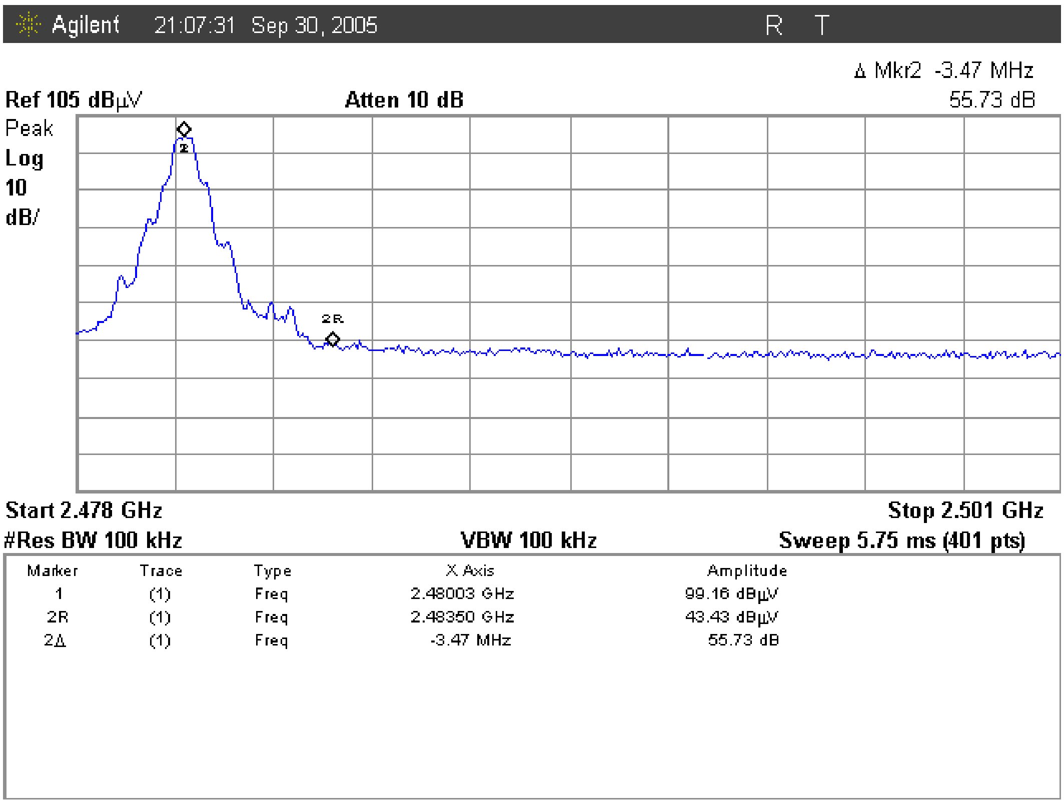
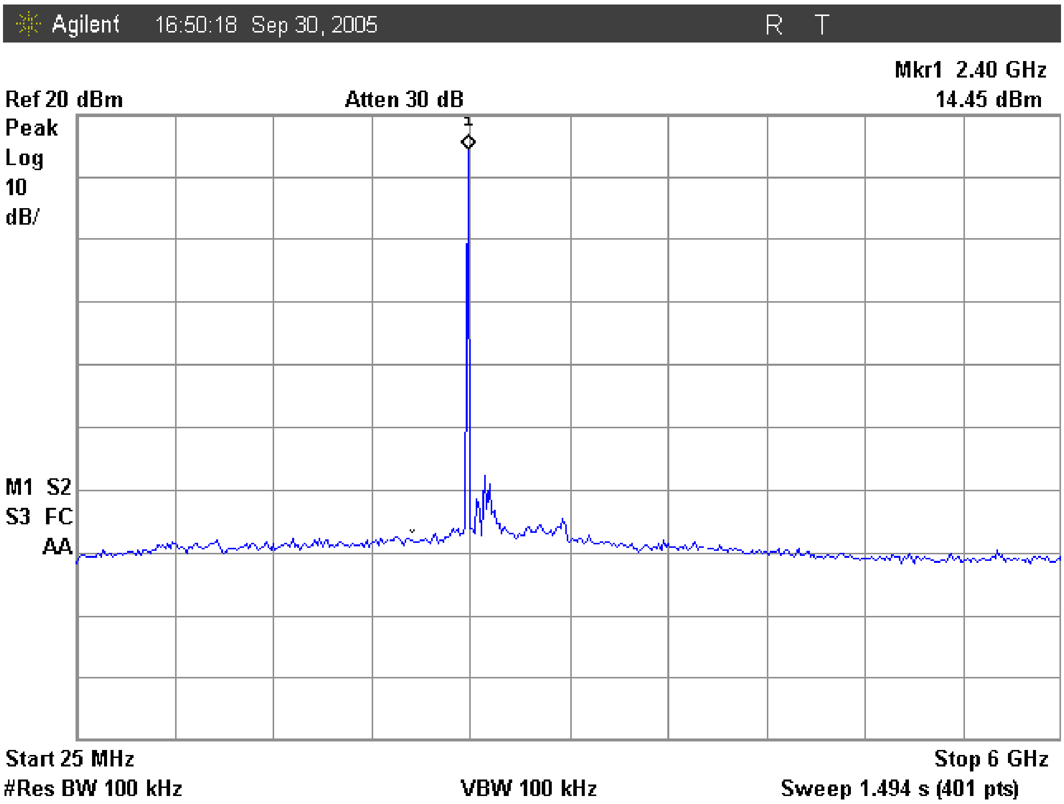
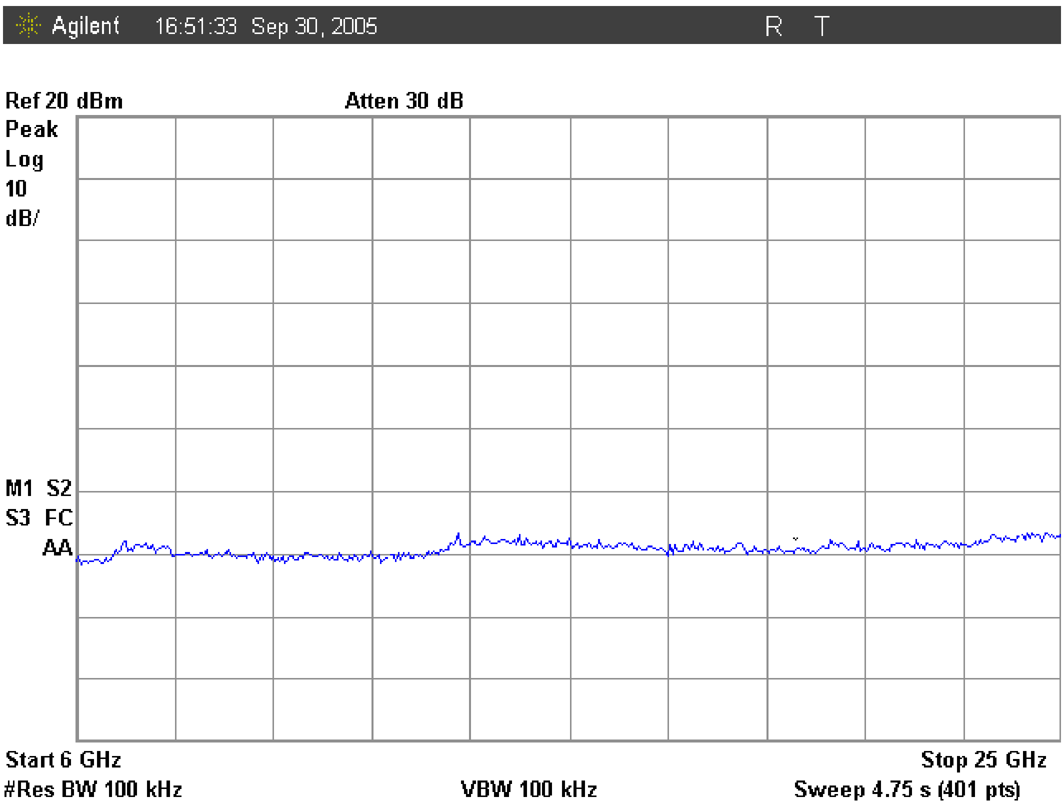


Figure 8. Plot of the RF antenna port emissions (Conducted)

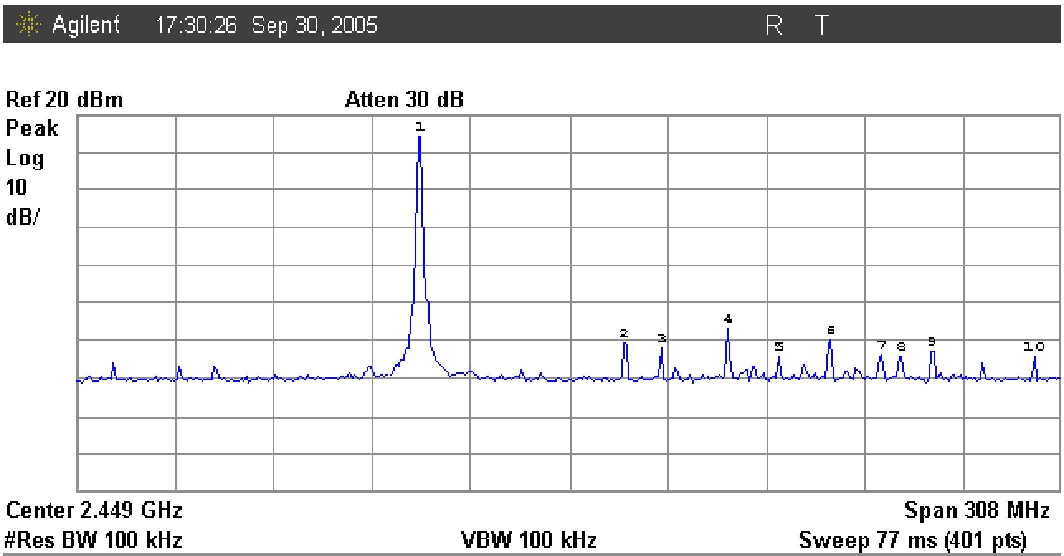
Lowest Channel (operating at 2402 MHz): 25MHz ~ 6GHz



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

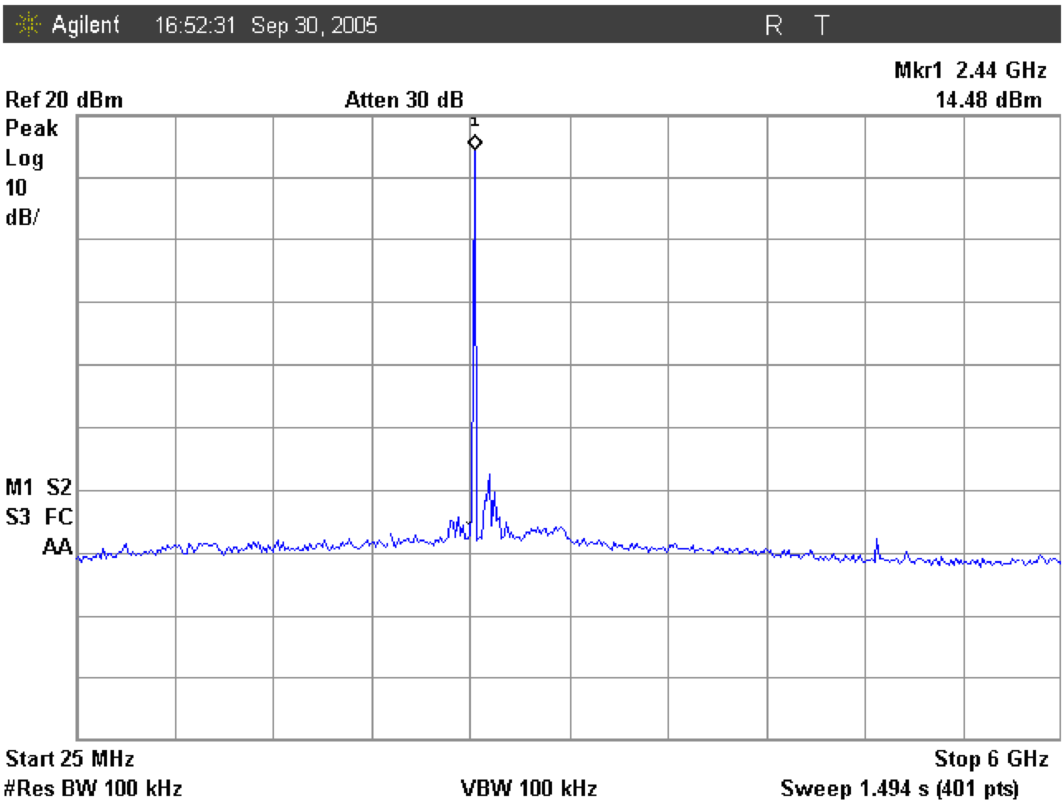


Lowest Channel (operating at 2402 MHz): in-band and vicinity emissions

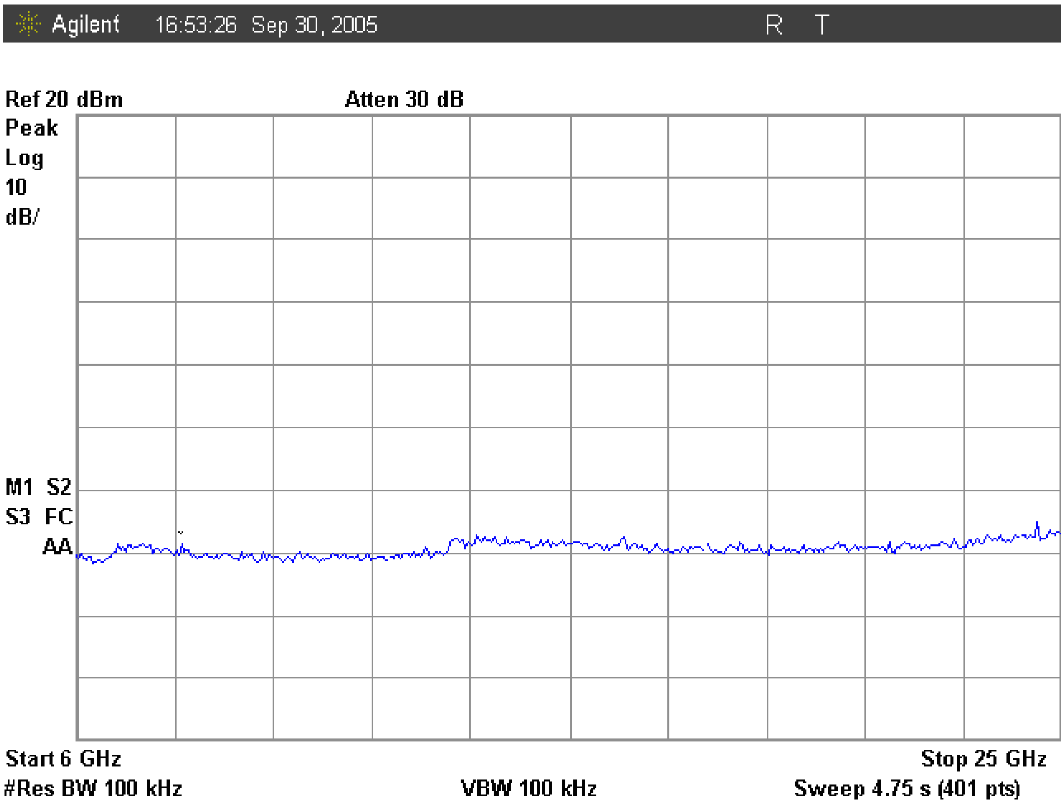


Pk	X Axis	Amplitude	Pk	X Axis	Amplitude
1	2.4028 GHz	14.39 dBm	6	2.5306 GHz	-39.86 dBm
2	2.4659 GHz	-40.98 dBm	7	2.5468 GHz	-43.79 dBm
3	2.4775 GHz	-42.25 dBm	8	2.5530 GHz	-44.1 dBm
4	2.4983 GHz	-36.92 dBm	9	2.5622 GHz	-43.08 dBm
5	2.5145 GHz	-44.14 dBm	10	2.5945 GHz	-44.49 dBm

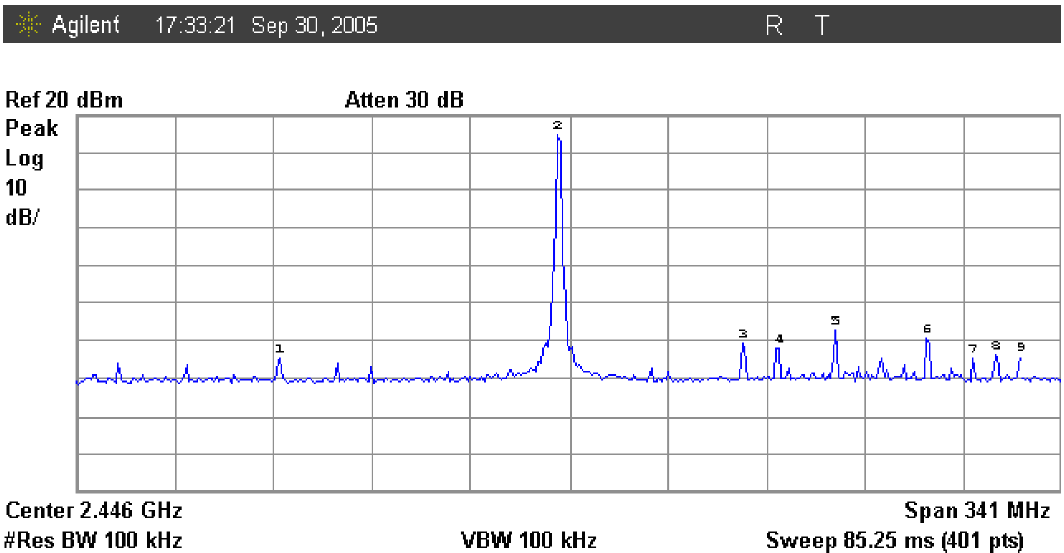
Middle Channel (operating at 2441 MHz): 25MHz ~ 6GHz



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

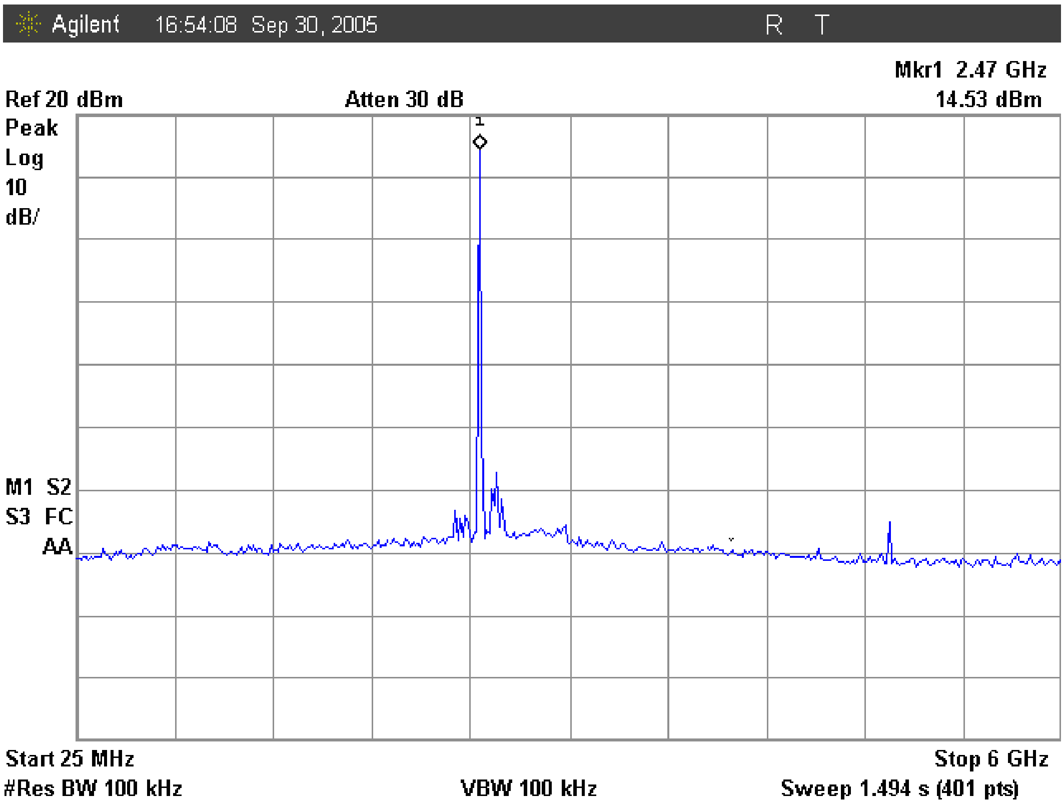


Middle Channel (operating at 2441 MHz): in-band and vicinity emissions

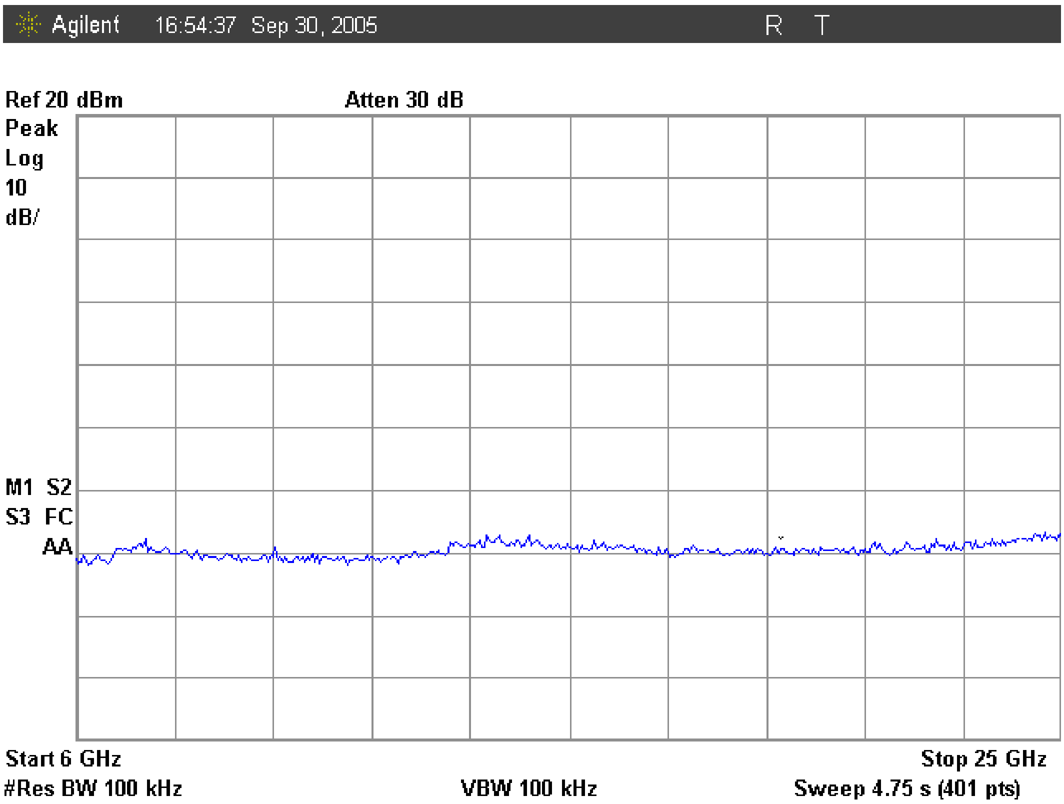


Pk	X Axis	Amplitude	Pk	X Axis	Amplitude
1	2.3458 GHz	-44.79 dBm	6	2.5691 GHz	-39.53 dBm
2	2.4412 GHz	14.56 dBm	7	2.5853 GHz	-44.69 dBm
3	2.5052 GHz	-40.91 dBm	8	2.5930 GHz	-43.72 dBm
4	2.5180 GHz	-42.04 dBm	9	2.6015 GHz	-44.38 dBm
5	2.5376 GHz	-37.37 dBm	10		

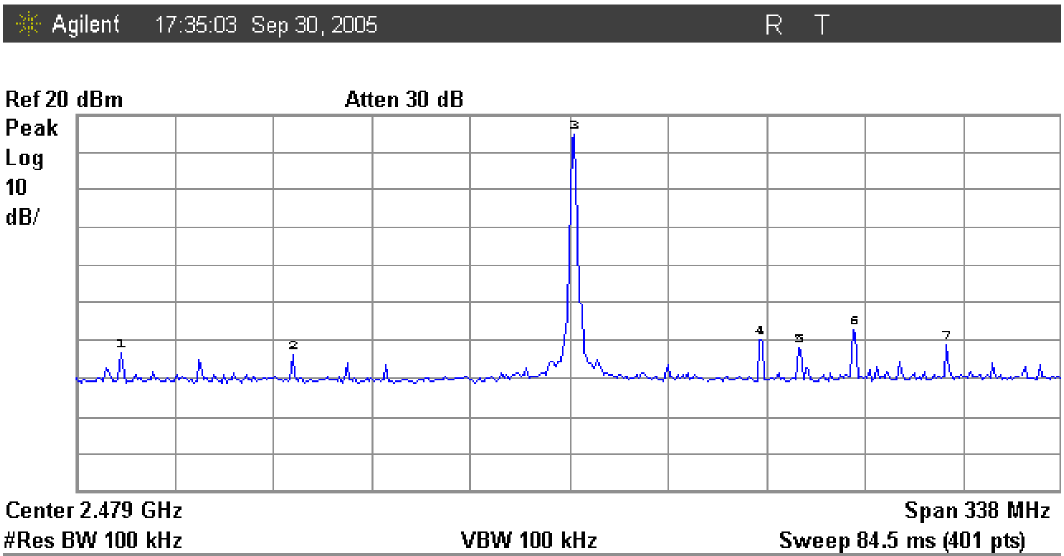
Highest Channel (operating at 2480 MHz): 25MHz ~ 6GHz



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



Highest Channel (operating at 2480 MHz): in-band and vicinity emissions



Pk	X Axis	Amplitude	Pk	X Axis	Amplitude
1	2.3252 GHz	-43.58 dBm	6	2.5762 GHz	-37.32 dBm
2	2.3844 GHz	-43.84 dBm	7	2.6083 GHz	-41.33 dBm
3	2.4807 GHz	14.53 dBm	8		
4	2.5441 GHz	-40.04 dBm	9		
5	2.5576 GHz	-42.25 dBm	10		

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

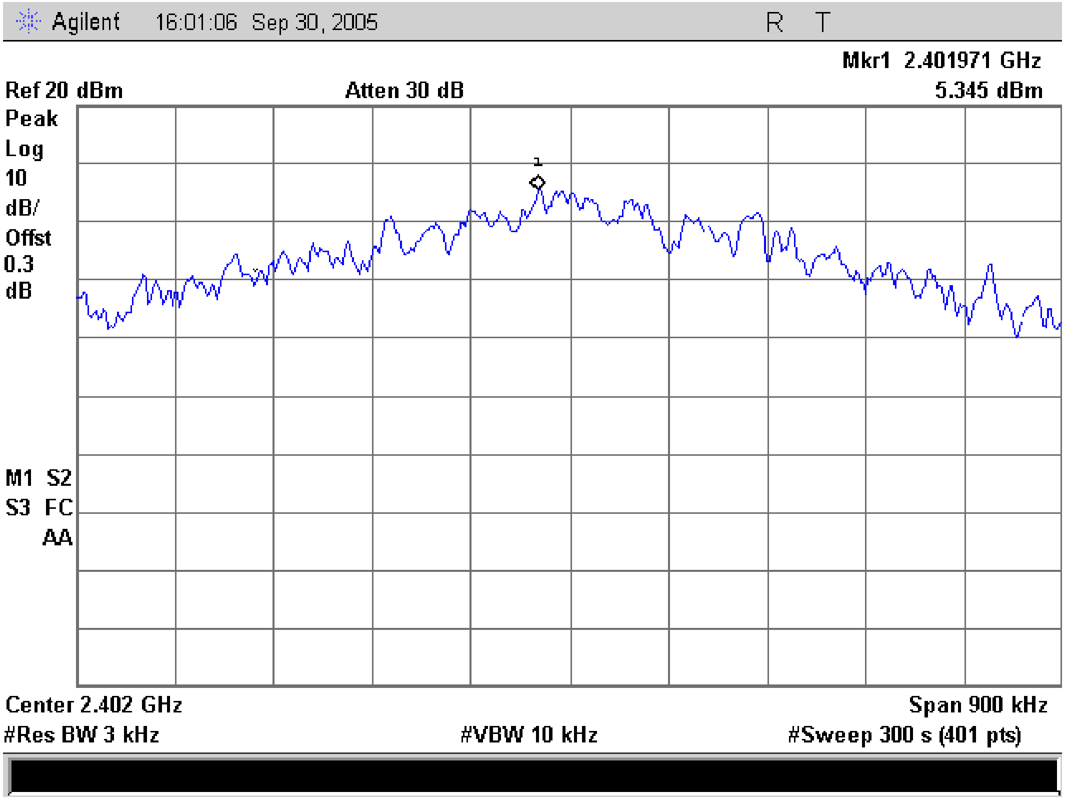
Table 8: Measured values of the Peak Power Spectral Density (Conducted)

Operating frequency	Cable Loss	Reading	Limit
2402 MHz	0.3 dB	5.345 dBm	8.0 dBm
2441 MHz	0.3 dB	5.681 dBm	8.0 dBm
2480 MHz	0.3 dB	6.570 dBm	8.0 dBm

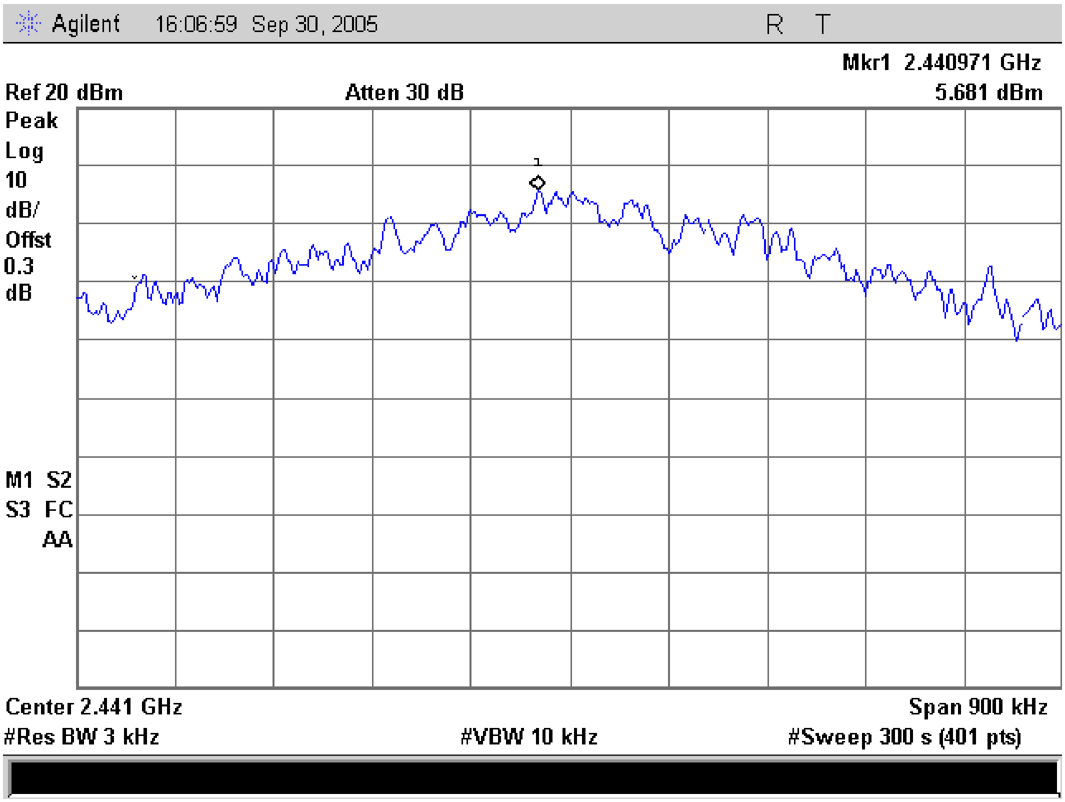
Cable Loss was included in Reading as Offset.

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

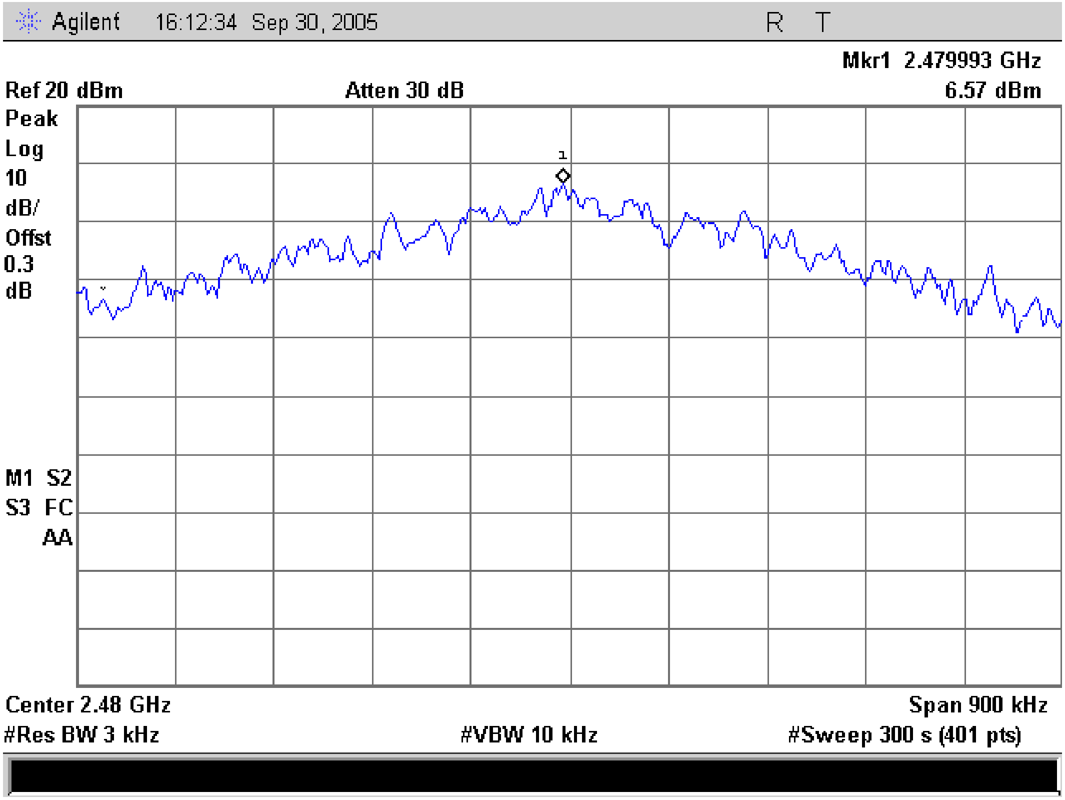
Lowest Channel (operating at 2402 MHz)



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: N/A

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	27.25	---	0.09/0.0	27.34	---	66.00	56.00	38.66	---
0.20	41.44	---	0.08/0.1	41.62	---	63.61	53.61	21.99	---
0.29	39.70	---	0.08/0.1	39.88	---	60.52	50.52	20.64	---
0.39	39.47	---	0.09/0.1	39.66	---	58.06	48.06	18.40	---
0.49	39.83	---	0.09/0.1	40.02	---	56.17	46.17	16.15	---
0.59	32.34	---	0.11/0.1	32.55	---	56.00	46.00	23.45	---
2.75	28.84	---	0.16/0.3	29.30	---	56.00	46.00	26.70	---
2.85	28.52	---	0.16/0.3	28.98	---	56.00	46.00	27.02	---
NEUTRAL – PE									
0.15	27.16	---	0.13/0.0	27.29	---	66.00	56.00	38.71	---
0.19	33.03	---	0.13/0.1	33.26	---	64.04	54.04	30.78	---
0.29	34.61	---	0.14/0.1	34.85	---	60.52	50.52	25.67	---
0.39	36.68	---	0.14/0.1	36.92	---	58.06	48.06	21.14	---
0.49	38.14	---	0.15/0.1	38.39	---	56.17	46.17	17.78	---
0.59	31.37	---	0.15/0.1	31.62	---	56.00	46.00	24.38	---
1.08	27.39	---	0.15/0.1	27.64	---	56.00	46.00	28.36	---
1.37	26.03	---	0.16/0.2	26.39	---	56.00	46.00	29.61	---

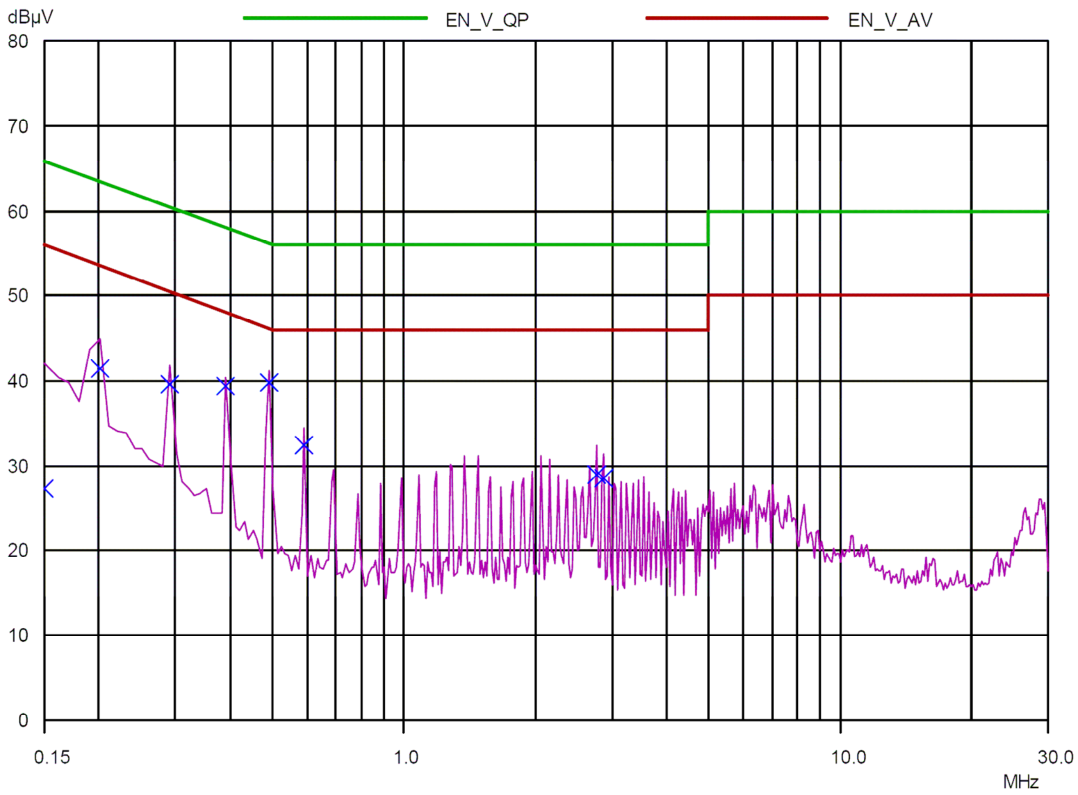
Margin (dB) = Limit – Actual
[Actual = Reading + CF + CL]

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

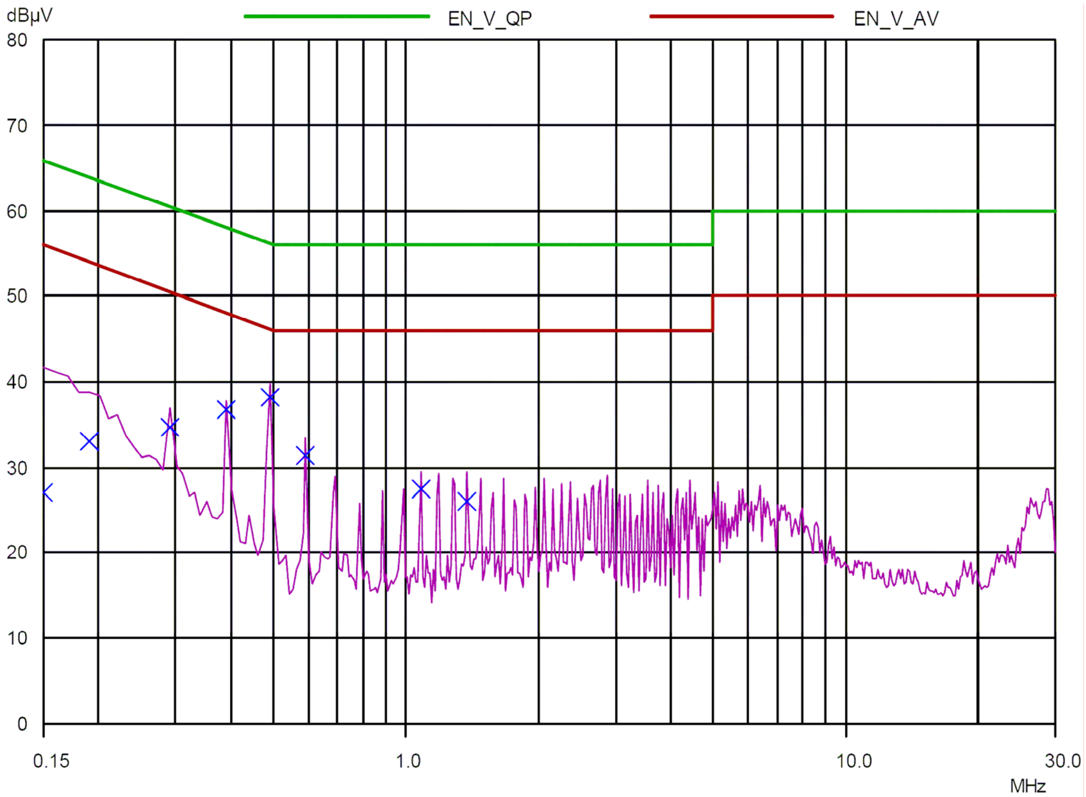
NOTE: The frequency range was scanned from 150 kHz to 30 MHz. All emissions not reported were more than 20 dB below the specified limit.

Figure 10. Plot of the Conducted Emissions

Line – PE (Quasi-Peak reading: '×' mark)



Neutral – PE (Quasi-Peak reading: '×' mark)



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 = 15.41[dBm] (= 34.75 [mW]) & Antenna gain = 2 [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]
34.75mW, at 20cm from the antenna 2 [dBi]	$S = PG/4\pi R^2 = 0.0110$ [mW/cm^2] < 1.0 [mW/cm^2]
34.75mW, at 5cm from the antenna 2 [dBi]	$S = PG/4\pi R^2 = 0.1753$ [mW/cm^2] < 1.0 [mW/cm^2]
34.75mW, at 2.5cm from the antenna 2 [dBi]	$S = PG/4\pi R^2 = 0.7012$ [mW/cm^2] < 1.0 [mW/cm^2]

NOTE: The antenna used for the EUT is a dedicated antenna. The calculated values of MPE for the EUT show that MPE is safe beyond 2.5 cm from the antenna.

5.10.2 RF Exposure Compliance Issue

The users manual for end users must include the following information in a prominent location "IMPORTANT NOTE: To comply with FCC RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter."