FCC Certification Test Report

FCC Certification Test Report
for
Pulse~LINK Inc.
Model: PL3301
FCC ID: SUAPL3301

October 10, 2007

Prepared for:

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FCC Certification Test Report
for the
Pulse~LINK Inc.
Ultra Wideband Transceiver
FCC ID: SUAPL3301

Prepared by: _____
Steven Dovell
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Reviewed by: _____
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Abstract

This report has been prepared on behalf of Pulse~LINK Inc. to support the attached Application for Equipment Authorization. The test report and application are submitted for a Handheld Ultra Wideband Transceiver under Part 15 Subpart F of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Pulse~LINK Inc. Model: PL3301.

This report reflects testing performed on the Pulse~LINK UWB device in accordance with the FCC Report & Order No. 04-352 referencing the waiver for emission tests procedures for UWB devices.

Testing was performed at Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code: 200066-0) as an independent FCC test laboratory.

The Pulse~LINK Inc. UWB/MINIPCI complies with the requirements for a Handheld Ultra Wideband Transceiver device under Part 15 Subpart F of the FCC Rules and Regulations.

The device is a module which connects to Mini-PCI format connector.

The RF output is via a MMCX connector to a defined antenna.

This submission is for **modular approval** of Model: PL3301.

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1 Introduction

1.1 Compliance Statement

The Pulse~LINK Inc. UWB/MINIPCI transceiver complies with the limits for a Handheld UWB transmitter device under Part 15 Subpart F of the FCC Rules and Regulations under the UWB Waiver.

Table 1-1. Summary of Test Results

FCC Rule Part	Test Description	Pass/Fail/Comments	Reference Section
15.519(a)	Handheld Operation Limitations	Pass	4.1
15.519(b)	UWB Bandwidth	Pass	4.2
15.519(c) and 15.209	Radiated Emissions	Pass	4.3
15.519(d),	Radiated Emissions in GPS Bands	Pass	4.4
15.519(e)	Peak Emissions within a 50 MHz Bandwidth	Pass	4.5

1.2 Test Scope

Tests for radiated and conducted emissions were performed. All measurements were performed according to the following documents:

- ANSI C63.4-2003, American National Standard for Methods of Measurement of Radio-Noise Emissions form Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- CFR 47, Part 15 Subpart F – Ultra Wideband Operation, Dec. 12, 2003
- First Report & Order FCC ET Docket 98-153, FCC 02-48 - Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmissions Systems, Appendix F - Measurement Procedures , February 14, 2002 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-02-48A1.pdf)
- Second Report and Order and Second Memorandum Opinion and Order ET Docket No. 98-153, FCC 04-285, December 15, 2004 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-285A1.pdf)
- In the matter of Petition for Waiver of the Part 15 UWB Regulations Filed by the Multi-band OFDM Alliance Special Interest Group, ET Docket No. 04-352, FCC 05-58, March 10, 2005 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-05-58A1.pdf)

The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

Additionally, the EUT was examined according to the requirements for unlicensed modular transmitter approval as detailed in the following regulations:

- Part 15 Unlicensed Modular Transmitter Approval, DA 00-1407, June 26, 2000 (http://www.fcc.gov/Bureaus/Engineering_Technology/Public_Notices/2000/da001407.doc)
- Second Report and Order FCC ET Docket 03-201 Modifications of Parts 2 and 15 of the Commission's Rules for unlicensed devices and equipment approval, April 17, 2007 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-56A1.doc)

1.3 Test Dates

October 8-10, 2007

1.4 Test Location

Washington Laboratories, Gaithersburg, MD.

1.5 Test and Support Personnel

Washington Laboratories, LTD	Steven Dovell
Customer	Raj Sengottaiyan

2 Equipment Under Test (EUT)

2.1 EUT Identification & Description

The Pulse~LINK UWB/PL3301 is a wireless UWB product that provides a link for high speed video and audio data using UWB digital modulation techniques operating under the waiver described in ET Docket No. 04-352, March 10, 2005.

Table 2-1. Device Summary

ITEM	DESCRIPTION
Manufacturer:	Pulse~LINK Inc.
FCC ID Number	SUAPL3301
EUT Name:	UWB/MINIPCI; Rev B
Model:	PL3301
FCC Rule Parts:	Part 15 Subpart F, §15.519
Frequency Range:	Fixed
Modulation:	Digital Modulation
Necessary Bandwidth:	The lower -10dB frequency, fL=3509MHz The upper -10dB frequency, fH= 4766MHz 10dB occupied bandwidth fH – fL = 4766 -3509 MHz = 1257 MHz
Maximum power in 8 MHz	-24.44 dBm at 4.303 GHz
Keying:	Automatic
Type of Information:	Data
Number of Channels:	1
Antenna Type	End Fed Dipole (Omron) 0dBi
Interface Cables:	Connected to internal mini-PCI; MMCX connector for antenna cable
Power Source & Voltage:	3.3 VDC and 5VDC from Host

2.2 Test Configuration

2.2.1 Device configuration

The device was powered from an AC/DC Adapter supplying 3.3 Volts and 5 Volts. The unit was configured using a serial (RS-232) connection to run in each mode. The PL3301 was operated at data rates, code and code lengths, and frame sizes shown in Table 2-2 below. As theory predicts, the transmitted spectrum was found to be identical between different data rates

that use the same code—i.e. for the pairs of 42 and 84 Mbps (code B), and for 169 and 338 Mbps (code C), and for 675 and 1000 Mbps (no code). The spectrum was found to be independent of frame size. Therefore, the test results are shown only for data rates of 21, 42, 169, and 675 Mbps where the frame size was set to 4-k bytes.

Table 2-2. Data Rates, Codes, and Frame Sizes

DATA RATE Mbps	CODE & LENGHT	Frame Sizes k-bytes (k=1024)
21	A, 64 bit	1, 2, 4, 8, 16, 32, 64
42	B, 16 bits	1, 2, 4, 8, 16, 32, 64
84	B, 16 bits	1, 2, 4, 8, 16, 32, 64
169	C, 4 bits	1, 2, 4, 8, 16, 32, 64
338	C, 4 bits	1, 2, 4, 8, 16, 32, 64
675	1 bit	1, 2, 4, 8, 16, 32, 64
1000	1 bit	1, 2, 4, 8, 16, 32, 64

The antenna is an end fed dipole-style antenna with broadband response and linear polarity.

2.2.2 Test Equipment Configuration

Correction factors for (1) the antenna, (2) the preamplifier, (3) the cable, and (4) the distance between the device and the test antenna, were entered into the Spectrum Analyzer so that all plots and markers read directly in EIRP. The instrument does the following calculation, where P_r is the power measured by the analyzer (dBm), G_r is the antenna gain (dB) of the receiving antenna connected to the analyzer, L is the cable loss (dB) used to connect between the receiving antenna to the analyzer, r is the measurement range in meters, λ is the wavelength in meters, and the resulting measured *EIRP* is in dBm.

$$EIRP = P_r - G_r + 20\log(4\pi r) - 20\log(\lambda) + L$$

The range-factor in the transducer table is simply the two middle terms that account for the range and frequency. For example, tests done at 1 meters used calibration factors based on 1m calibration data on the antenna, and a 1m path, while tests done at 3 meters used calibration factors based on 3m calibration data on the antenna, and a 3m path.

To provide accuracy consistent with an EMI receiver that steps in increments of .4 RBW, the spectrum analyzer setup used a combination of (a) the span, (b) the number of points, and (c) the sweep speed, to provide at least 3.5 equally spaced measurements across an RBW (i.e. increments between measurement points of less than .286 RBW), and to provide a 1 ms RMS averaging time.

2.3 Testing Algorithm

The unit was placed into its normal operating mode, using the data rates listed in Table 2-2.

2.4 Test Location

All measurements herein were performed at Washington Laboratories. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories is accredited to ISO Guide 17025 under NIST NVLAP Laboratory accreditation program.

2.5 Measurements

2.5.1 References

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

FCC Report and Order, FCC 02-48, Appendix F

ET Docket No. 04-352 March 10, 2005 FCC Adopts Waiver of its Emission Measurement Procedures for Ultra-Wideband Transmission Systems

3 Test Equipment

Table 3-1 shows a list of the test equipment used for measurements along with the calibration information.

Table 3-1: Test Equipment List

Manufacturer	Model/Type	Function	Identification	Cal. Due
Agilent	E4446A	Spectrum Analyzer	ASSET NO. 00528	2/15/2008
A.H. Systems	SAS-571	0.7-18GHz Double Ridge Horn Antenna – 1m & 3m calibration 5/28/2003	SN-521	5/28/08
B&Z Inc.	Custom	.01-20 GHz, 2 dB NF, 40 dB gain, Pre-Amplifier	N/A	10/04/2008
Narda	V638	Horn Antenna	Asset No. 00210	12/25/2008
Narda	V637	Horn Antenna	Asset No. 00209	12/25/2008
A.H., SYSTEMS	PAM1840	Pre-amplifier, 18-40 GHz	Asset No. 00453	03/28/2008

4 Test Results

4.1 Operation Limitations, §15.519(a)

Operation under the provisions of §15.519 is limited to UWB devices that are relatively small devices that are primarily hand held while being operated and do not employ a fixed infrastructure. The limitations include:

(1) A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

(2) The use of antennas mounted on outdoor structures, e.g., antennas mounted on the outside of a building or on a telephone pole, or any fixed outdoors infrastructure is prohibited. Antennas may be mounted only on the hand held UWB device.

(3) UWB devices operating under 15.519 may operate indoors or outdoors.

4.1.1 Test Procedure

The device was put into its normal operating mode while is emissions were being monitored in a zero-span mode with a sweep speed of 15 seconds. The time between the start of transmissions, and the transmissions stopping was measured.

4.1.2 Test Results

The time it took to cease transmissions was measured and found to be less than 10 seconds.

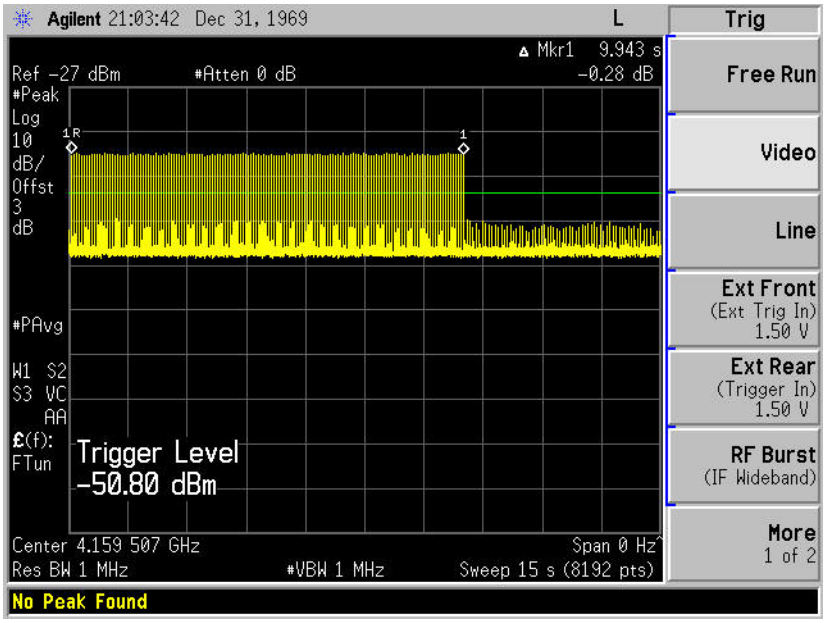

Figure 4-1. Zero-Span Sweep Showing <10 seconds to Halt of Transmissions

4.2 Occupied Bandwidth, §15.517(b)

The UWB bandwidth of a UWB system operating under the provisions of Section 15.517 must be contained between 3,100 MHz and 10,600 MHz.

4.2.1 Test Procedure

The bandwidth was measured using the Agilent spectrum analyzer with the receiving antenna located 3m from the EUT and the EUT oriented toward the receiving antenna to obtain a maximum reading on the spectrum analyzer.

The resolution bandwidth of the spectrum analyzer was set to 1 MHz and the frequency range was set from 3.012 GHz to 5.3 GHz. Note that the frequency range would have been set from 3.1 GHz to 10.6 GHz, however, the EUT does not occupy that large of a span, and stopping at 5.3 GHz provides better resolution of the signal being measured. All corrections for the antenna, pre-amp and cable were programmed into the spectrum analyzer along with the Part 15, Subpart F emission mask, thus directly displaying power spectral density versus frequency.

4.2.2 Test Results

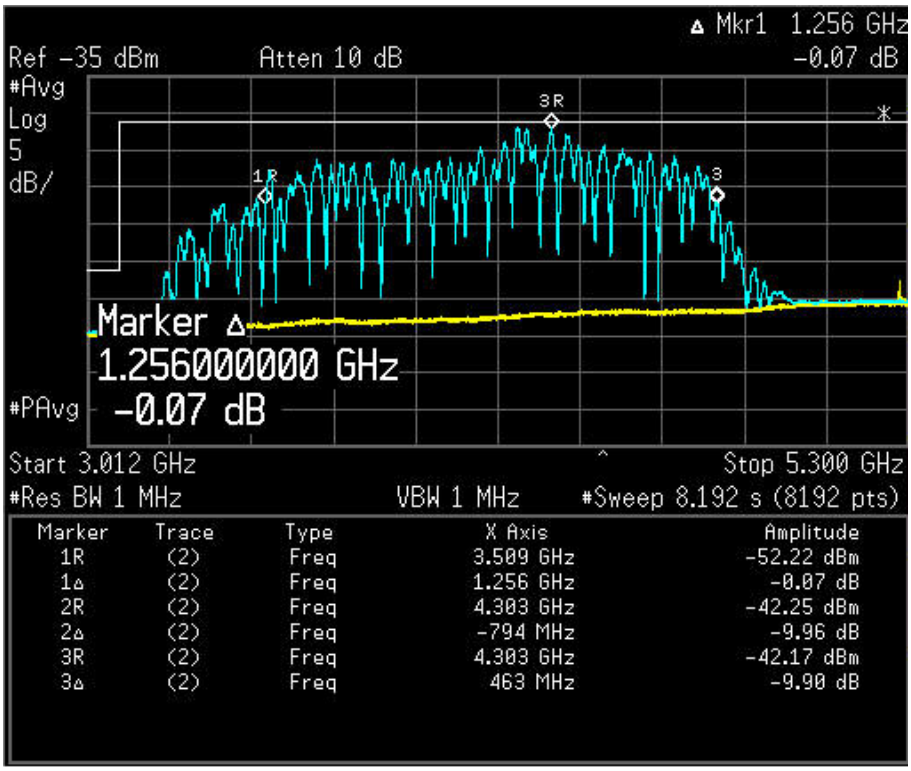

Figure 4-2. Occupied Bandwidth Measured at 675 Mbps Mode

The lower -10dB frequency, f_L=3509MHz

The upper -10dB frequency, f_H= 4766MHz

The 10dB occupied bandwidth was measured at $f_H - f_L$ = 4766MHz-3509MHz = 1257MHz.

The occupied bandwidth was measured at each of the data rates and packet sizes shown in Table 2-2. As mentioned with respect to section 2.2.1 "Device Configuration," the transmitted

spectrum is independent of frame size and substantially identical for data rates using the same code. Therefore, the test results are shown only for the representative data rate of 675 Mbps with the frame size set to 4-k bytes.

4.3 Radiated Spurious Emissions, §15.247(c) and §15.209

Radiated emissions below 960 MHz must comply with the emission limits of §15.209. Emissions above 960 MHz must comply with the average limits given in the following table when measured with a 1 MHz resolution bandwidth, using an RMS detector, with a 1ms RMS averaging duration.

Table 4-1. EIRP Limit Radiated Spurious Emissions

Frequency in MHz	EIRP Limit in dBm
960 - 1610	-75.3
1610 – 1990	-53.3
1990 - 3100	-51.3
3100 – 10600	-41.3
Above 10600	-51.3

4.3.1 Test Procedure

For measurements below 960 MHz, the EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

For emission measurements below 960MHz the following bandwidths were used.

Frequency Range	Resolution Bandwidth	Video Bandwidth
30 MHz-960 MHz	120 kHz	>120 kHz

Measurements below 960MHz were made with a spectrum analyzer which was equipped with a Quasi-peak detector.

For measurements from 960 MHz to 10.6 GHz, the spectrum analyzer was set in 8-bands according to Table 4-2. These settings provide 1ms RMS averaging duration and 4 measurement points per RBW with a 1 MHz RBW.

Table 4-2. Spectrum Analyzer Settings for .96 – 18 GHz

Band	Start-Stop Frequency	Span (GHz)	Number of Points	Sweep Time (sec)	RMS Averaging Time	RBW	Points per RBW	Detector
1	0.96-3.1	2.14	8192	8.192	1 ms	1 MHz	3.83	RMS
2	3.0-5.3	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
3	5.2-7.5	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
4	7.4-9.7	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
5	9.6-11.9	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
6	11.8-14.1	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
7	14.0-16.3	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS
8	16.3-18.5	2.3	8192	8.192	1 ms	1 MHz	3.56	RMS

Peak measurements from 960M to 1GHz and 10.6 GHz to 40 GHz were made using a spectrum analyzer with a 1 MHz resolution bandwidth. Testing above 1 GHz was performed at a 1m test distance.

4.3.2 EIRP Measurements

Measurements in excess of 1GHz are presented below. There are a number of spectral lines that exceed the limits. These emissions have been investigated and determined that they are emissions from digital circuitry and not from the UWB source.

Several additional supplemental plots are provided in the appendix to this report. These plots show the emissions spectra with the unit completely turned off (“Ambient”) and with the radio transmitter “OFF”, but with the digital circuitry enabled.

Hence, the "over-limit” emission lines were found to be digital emissions.

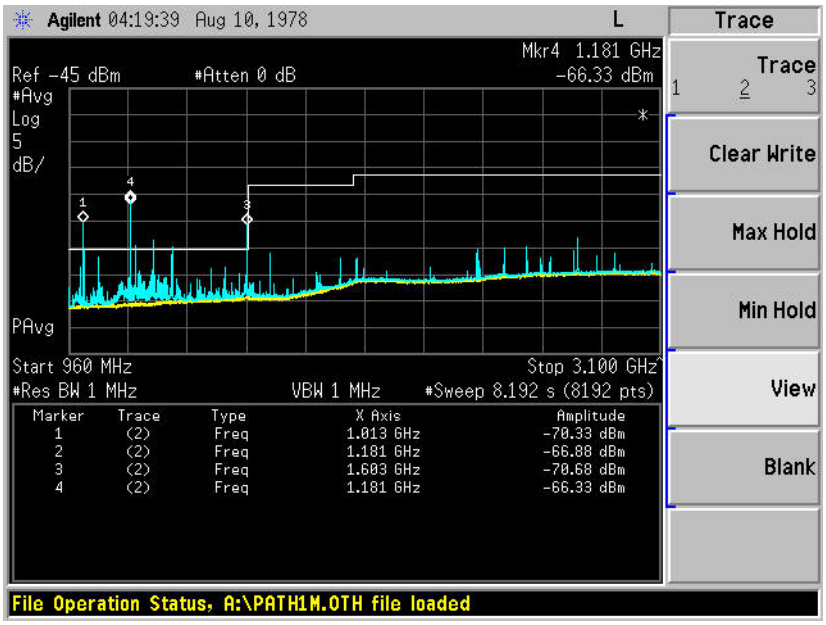

Figure 4-3. Radiated Emission Test Data, 0.960-3.1 GHz. Horizontal

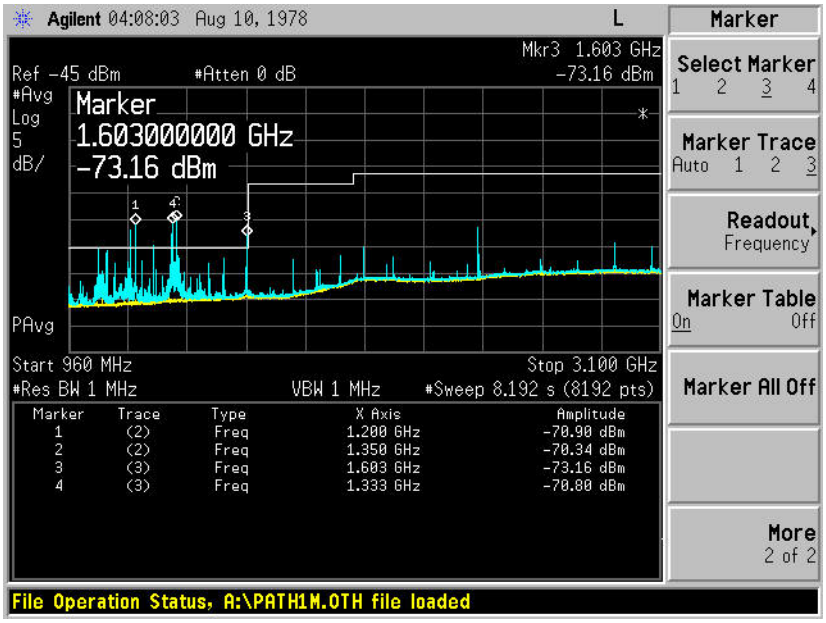

Figure 4-4. Radiated Emission Test Data, 0.960-3.1 GHz. Vertical

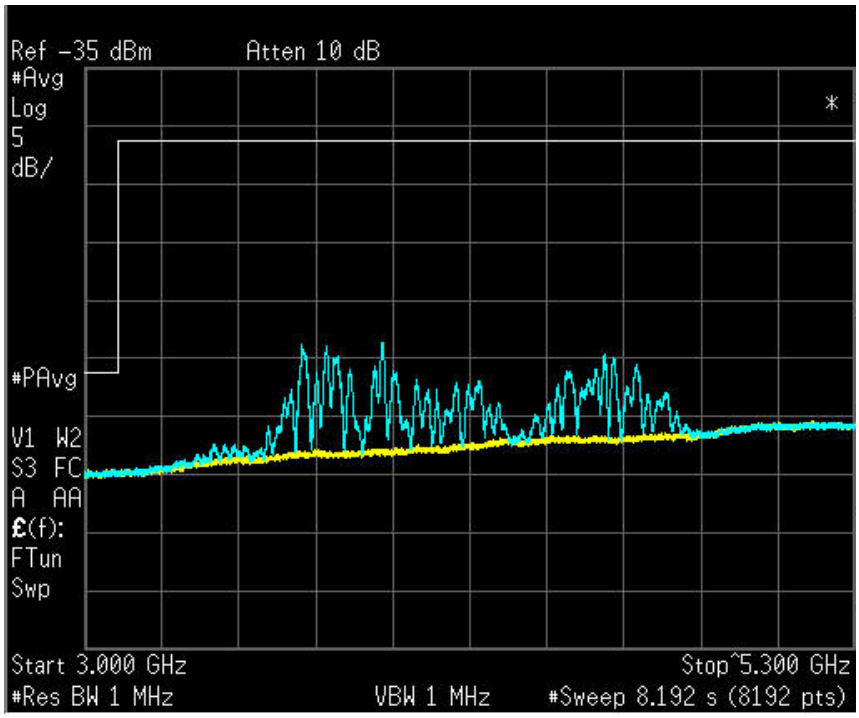

Figure 4-5. Radiated Emission Test Data, 3.1-5.3 GHz. Horizontal

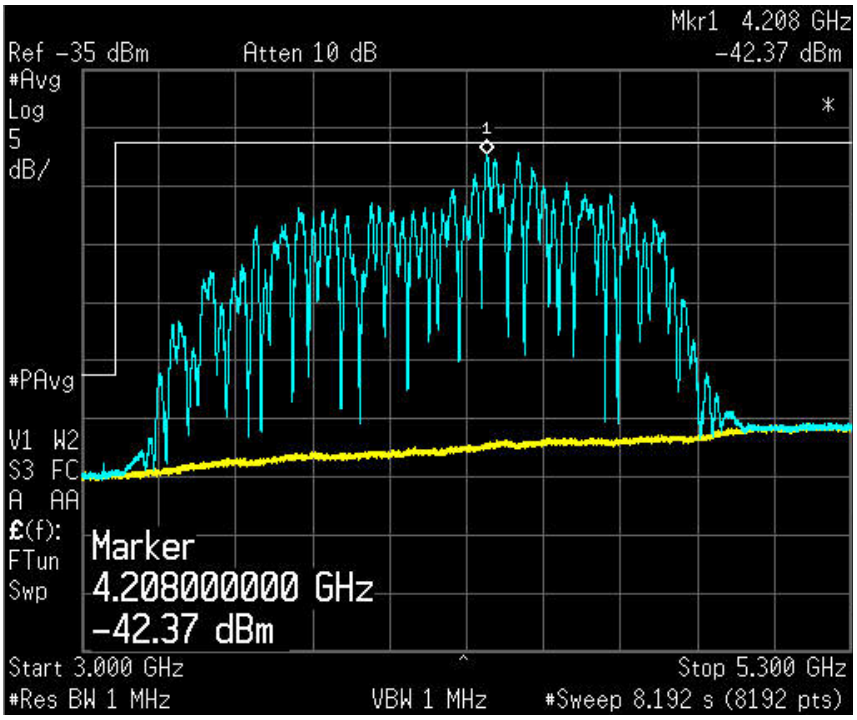

Figure 4-6. Radiated Emission Test Data, 3.1-5.3 GHz. Vertical

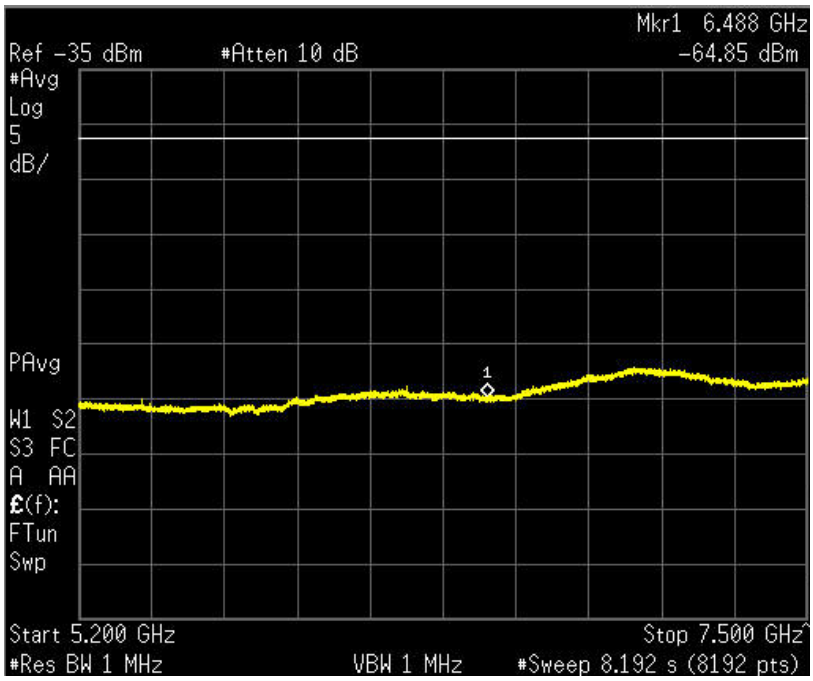

Figure 4-7. Radiated Emission Test Data, 5.2-7.5 GHz.

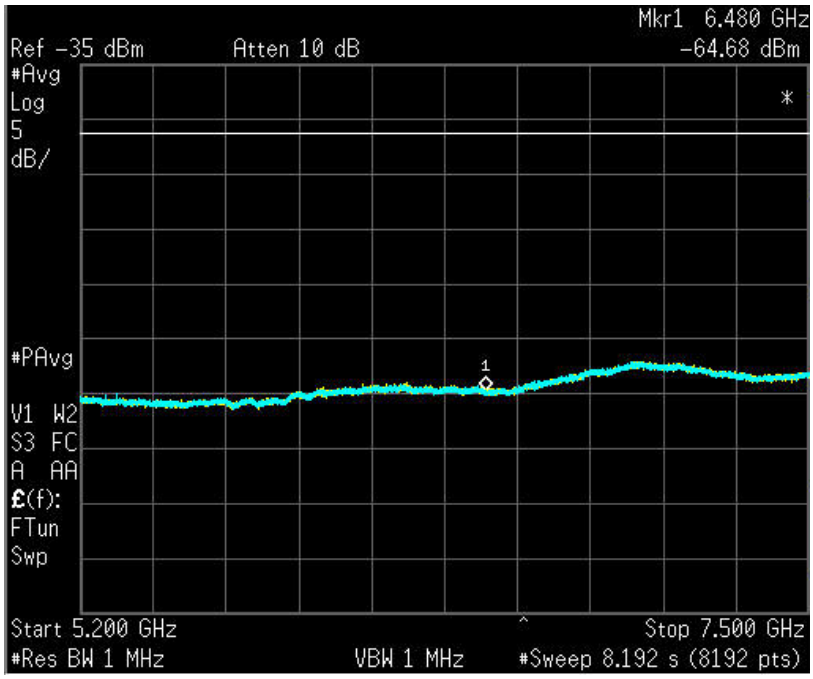

Figure 4-8. Radiated Emission Test Data, 5.2-7.5 GHz. Vertical

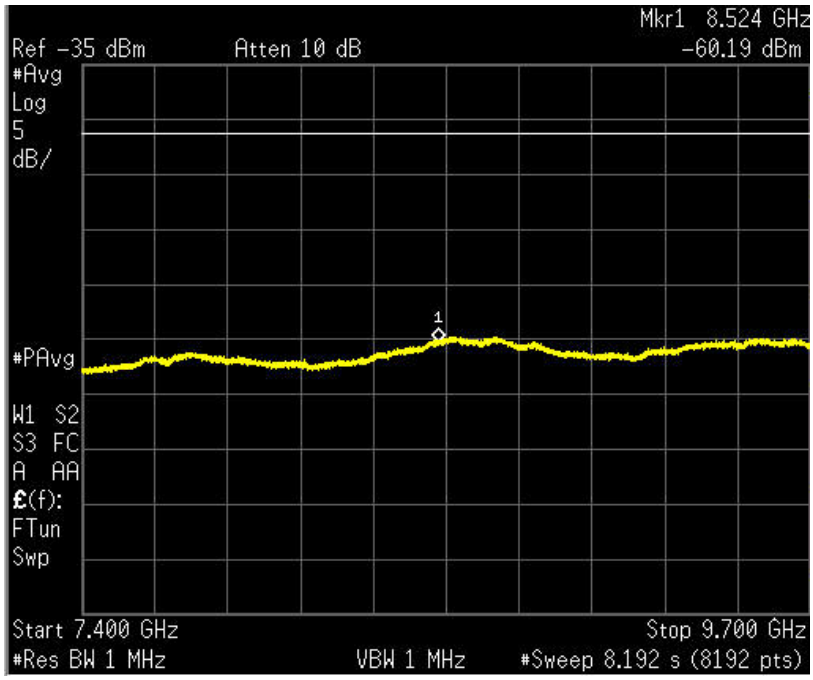

Figure 4-9. Radiated Emission Test Data, 7.4-9.7 GHz.

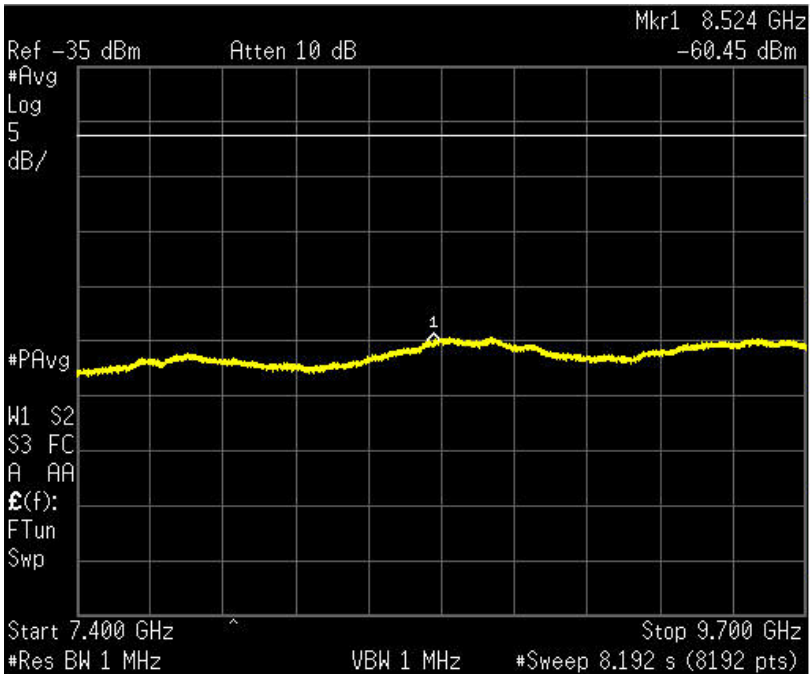

Figure 4-10. Radiated Emission Test Data, 7.4-9.7GHz. Vertical

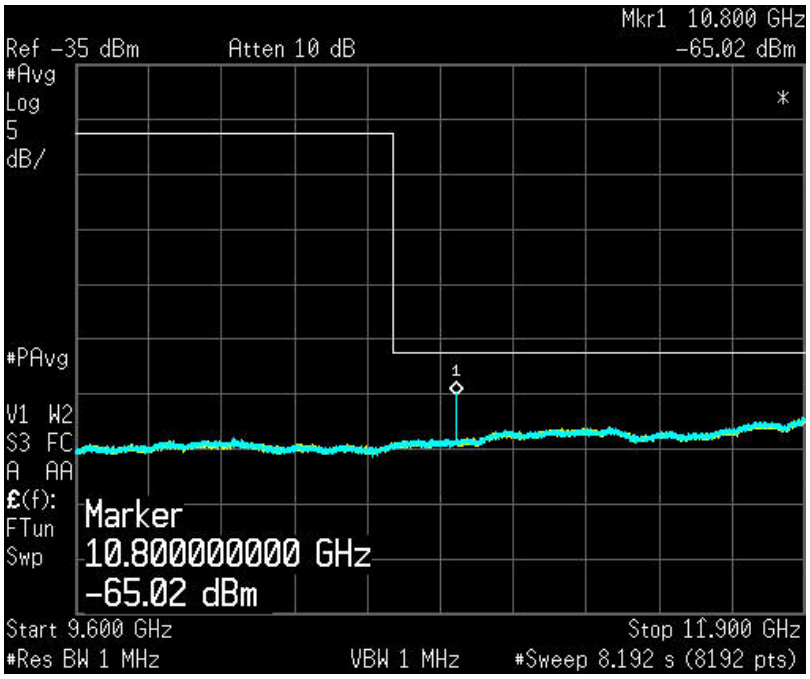

Figure 4-11. Radiated Emission Test Data, 9.6 -11.9 GHz.

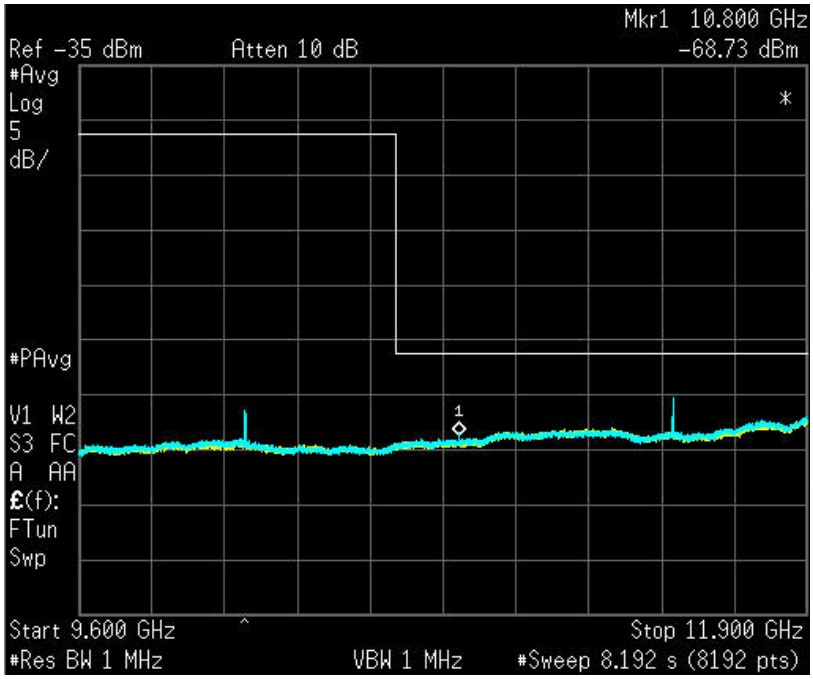

Figure 4-12. Radiated Emission Test Data, 9.6 -11.9 GHz.

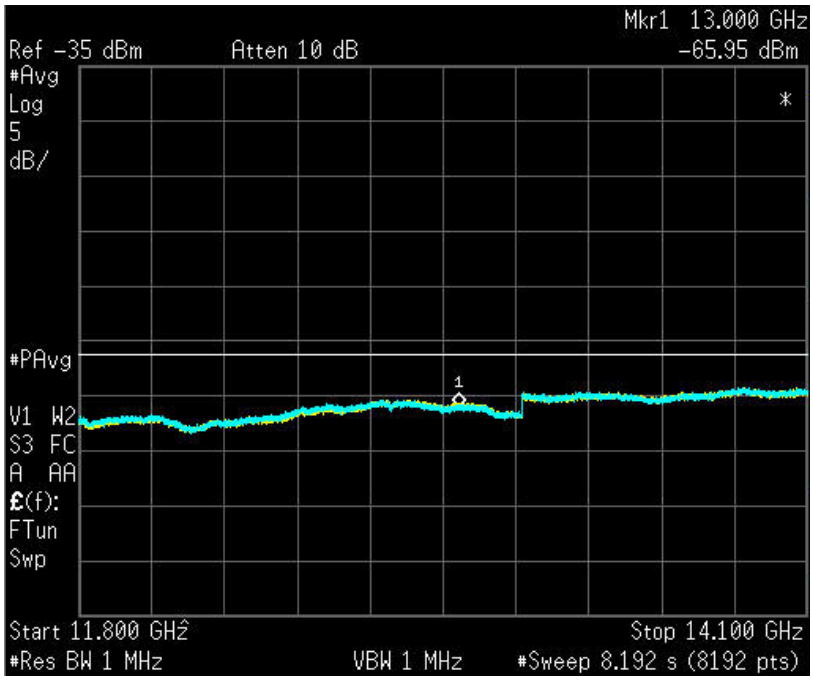

Figure 4-13. Radiated Emission Test Data, 11.8 -14.1GHz. Horizontal

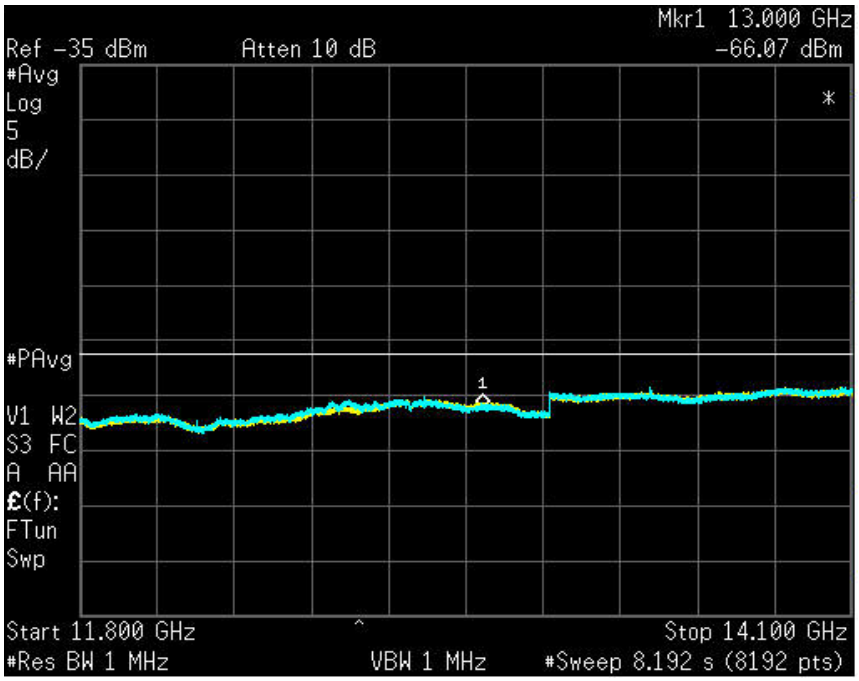

Figure 4-14. Radiated Emission Test Data, 11.8 -14.1GHz. Vertical

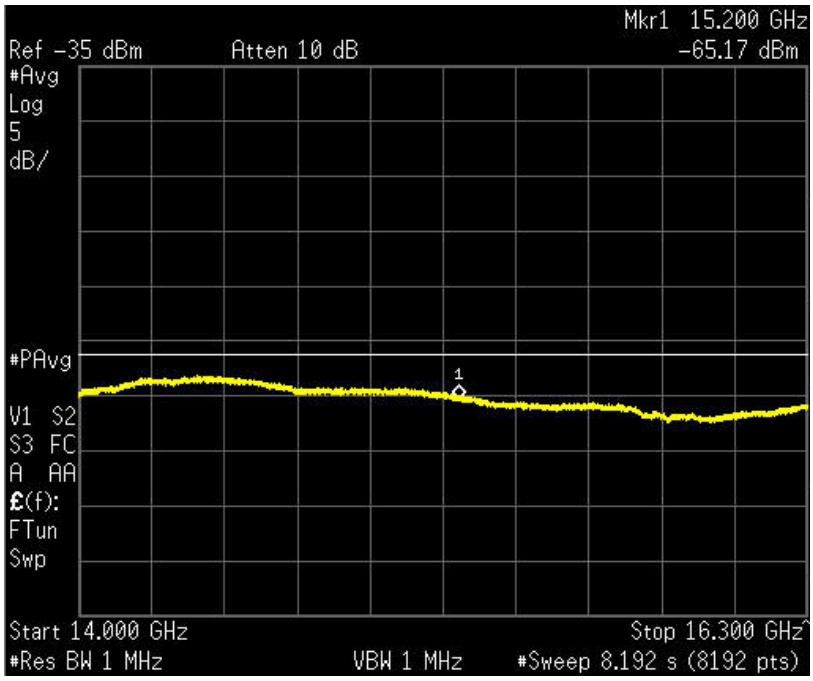

Figure 4-15. Radiated Emission Test Data, 14 -16.3GHz, Horizontal

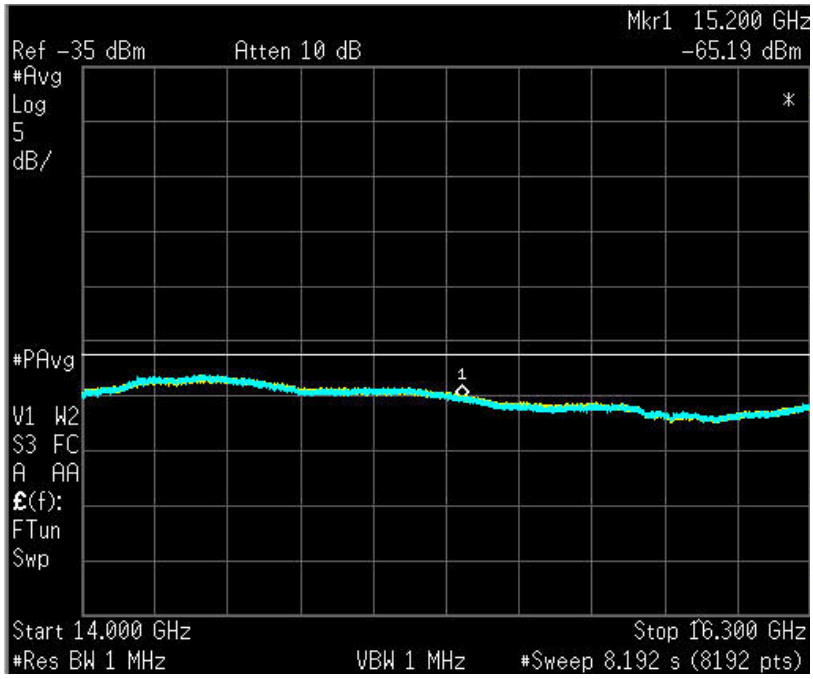

Figure 4-16. Radiated Emission Test Data, 14 -16.3GHz, Vertical

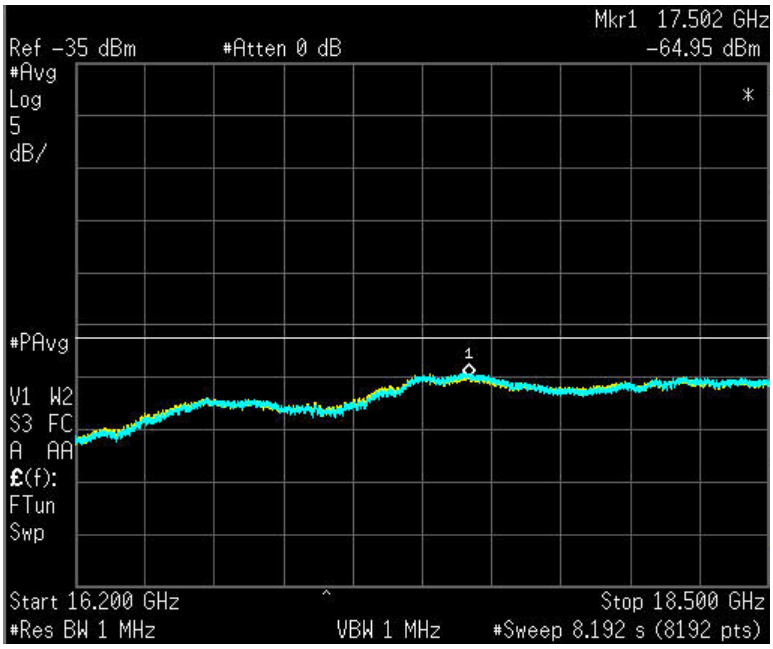

Figure 4-17. Radiated Emission Test Data, 16.2 -18.5GHz, Horizontal

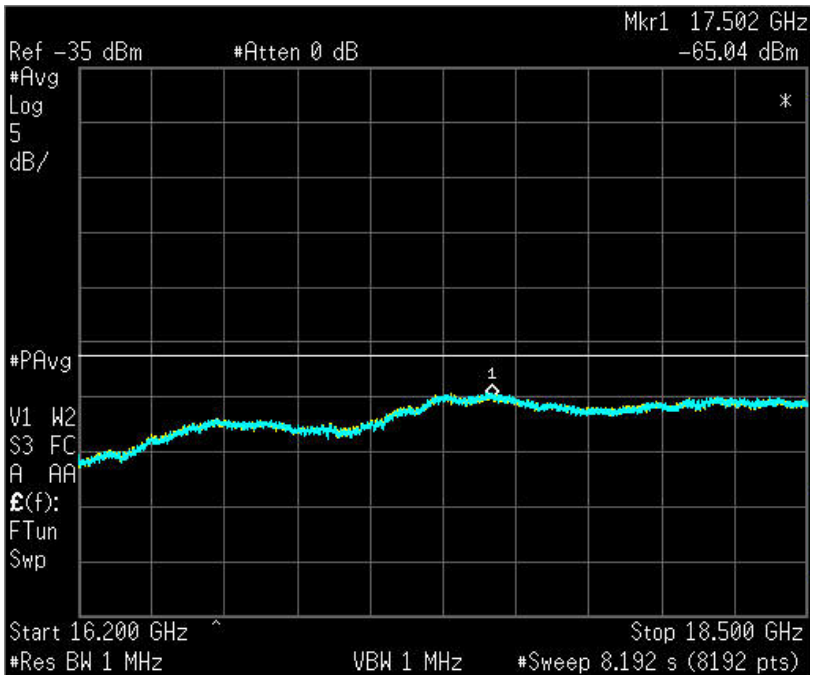

Figure 4-18. Radiated Emission Test Data, 16.2 -18.5GHz, Vertical

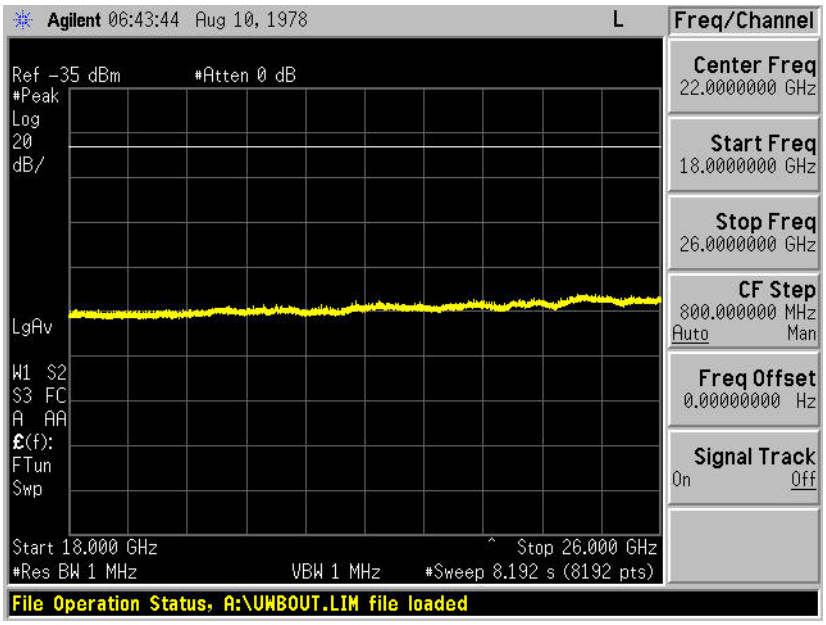

Figure 4-19. Radiated Emission Test Data, 18-26.5 GHz. Horizontal

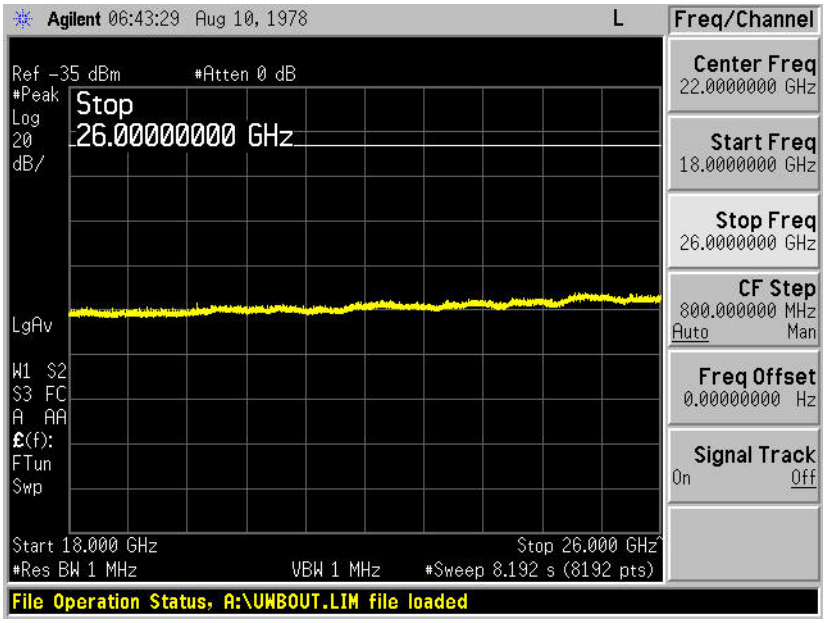

Figure 4-20. Radiated Emission Test Data, 18-26.5 GHz. Vertical

The following charts show the EIRP measurements to 40 GHz. Measurement sensitivity decreases with frequency. The measurements in the 37GHz range are not emissions from the device per se, but represent the limit of the measurement equipment in those ranges. No UWB emissions were found in those bands.

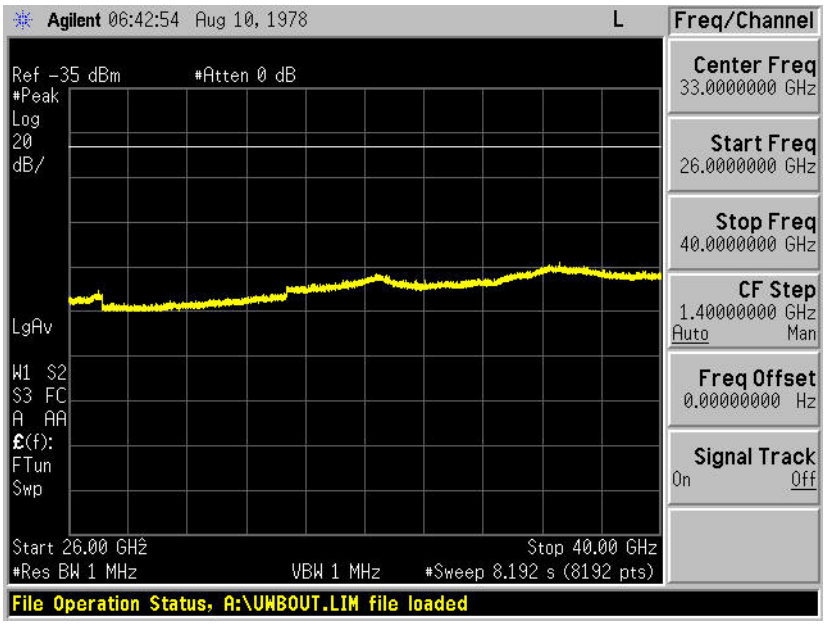

Figure 4-21. Radiated Emission Test Data, 26.5-40 GHz. Horizontal

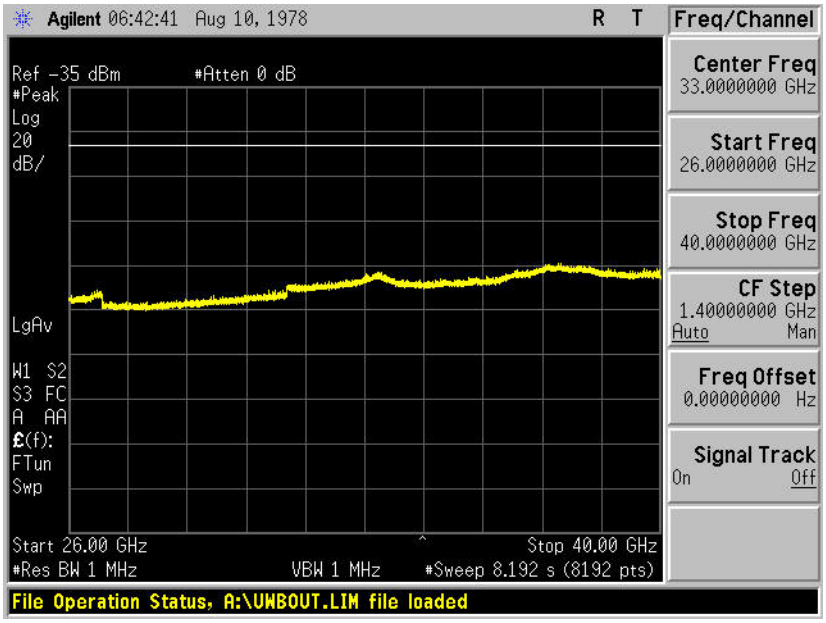

Figure 4-22. Radiated Emission Test Data, 26.5-40 GHz. Vertical

4.4 Radiated Emissions in GPS Bands, §15.519(d)

The radiated emissions of a UWB system operating under the provisions of Section 15.519 shall not exceed the following average limits when measured with a resolution bandwidth of no less than 1 kHz:

Frequency (MHz)	EIRP (dBm)
1164 – 1240	-85.3
1559 - 1610	-85.3

4.4.1 Test Procedure

The radiated emissions were measured with the receiving antenna located 1m from the EUT using the Agilent spectrum analyzer. The analyzer was set to provide 1ms RMS averaging time, using the frequency ranges, number of points per sweep, and sweep speed according to Table 4-3.

Table 4-3. Spectrum Analyzer Settings For GPS Bands

Frequency GHz	Span MHz	Number of Points	Sweep Time (sec)	RMS Averaging Time	Points Per RBW	RBW	Points per RBW	Detector
1.164-1.202	38M	7600	7.6	1 ms	4	20kHz*	4	RMS
1.202-1.24	38M	7600	7.6	1 ms	4	20kHz*	4	RMS
1.558-1.585	27M	5400	5.4	1 ms	4	20kHz*	4	RMS
1.585-1612	27M	5400	5.4	1 ms	4	20kHz*	4	RMS

The unit was checked with the modulation codes as described in Section 2.2.1

4.4.2 Test Results

The Pulse~LINK UWB device with the Omron Antenna complies with the requirements of §15.519(d).

There are a number of spectral lines that exceed the limits. These emissions have been investigated and determined that they are emissions from digital circuitry and not from the UWB source. Hence, the "over-limit" emission lines were found to be digital emissions

Plots of the detected emissions are included in the following figures, where the different trace colors represent the instrumentation noise floor (EUT off) (yellow), the digital emissions (EUT on but not transmitting) (blue), and UWB emissions plus background of the digital emissions and instrumentation noise (pink). These are summarized below.

Table 4-4. Color Legend For Spectrum Plots

Trace Color	Measurement	EUT State
Yellow	Instrumentation Noise Floor	EUT off
Blue	Background Digital Noise +Instrumentation Noise Floor	EUT on but not transmitting
Pink	UWB Transmitter + Digital Noise + Background Instrument +	EUT on and transmitting

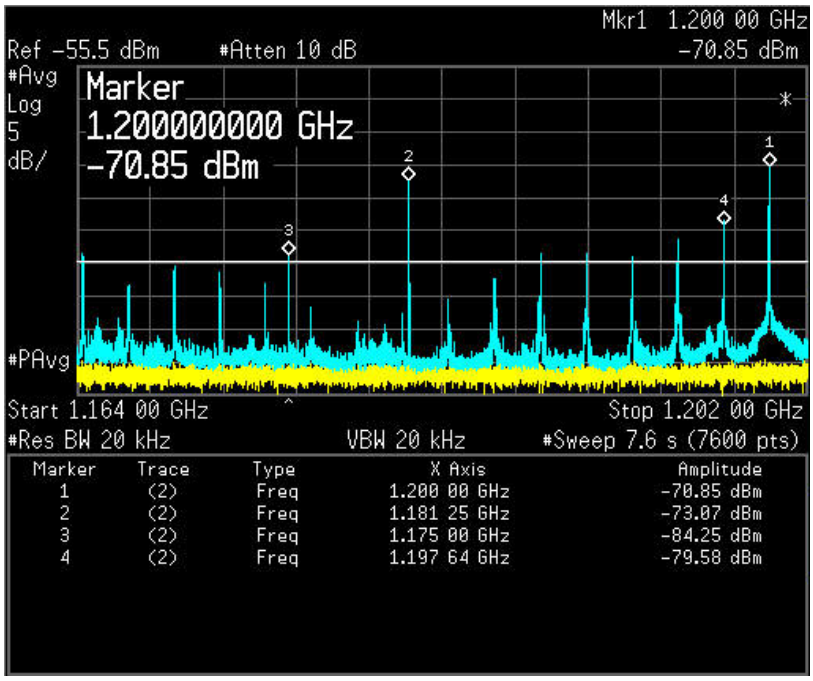

Figure 4-23. Radiated Emission Test Data, GPS Bands 1164-1202 MHz. Horizontal

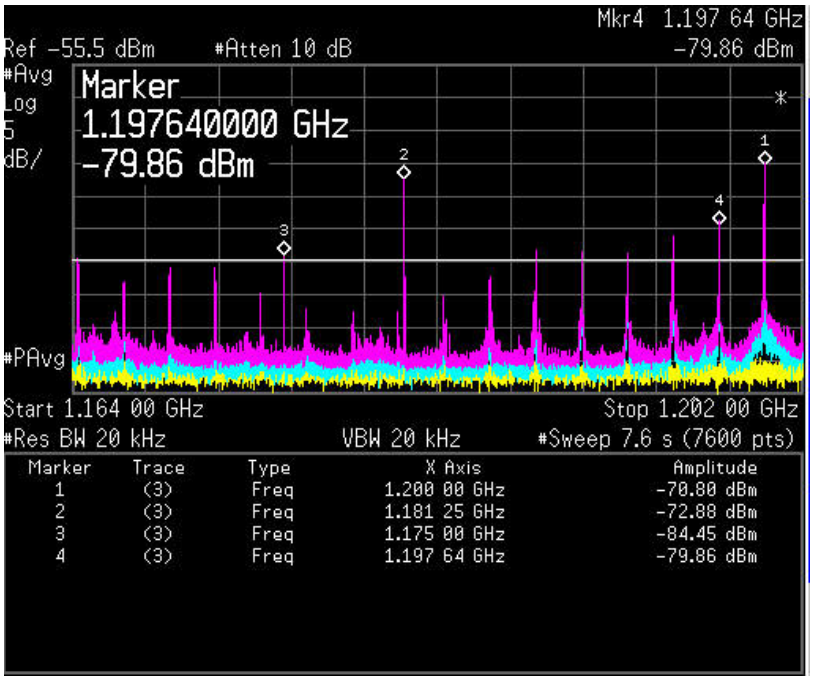

Figure 4-24. Radiated Emission Test Data, GPS Bands 1164-1202 MHz. Horizontal

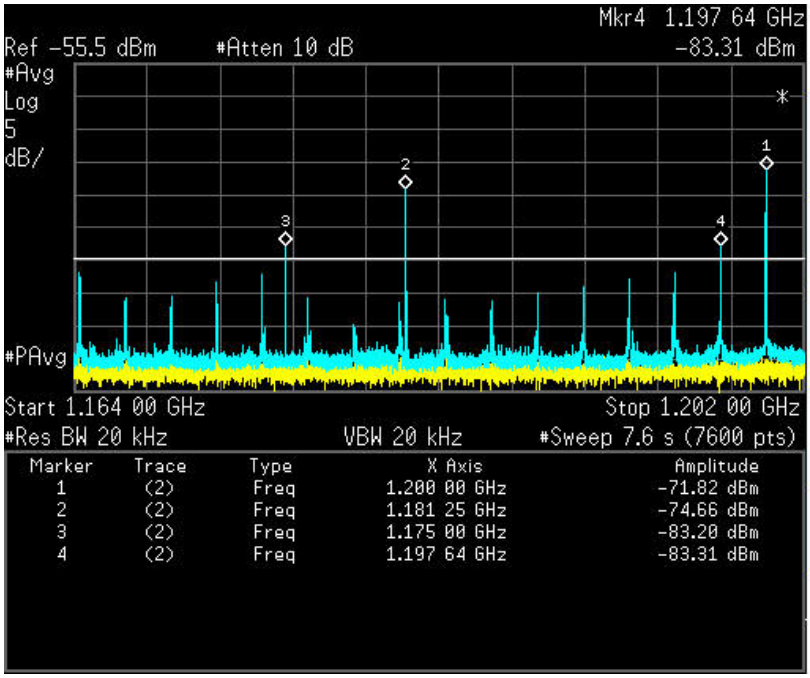

Figure 4-25. Radiated Emission Test Data, GPS Bands 1164-1202 MHz. Vertical

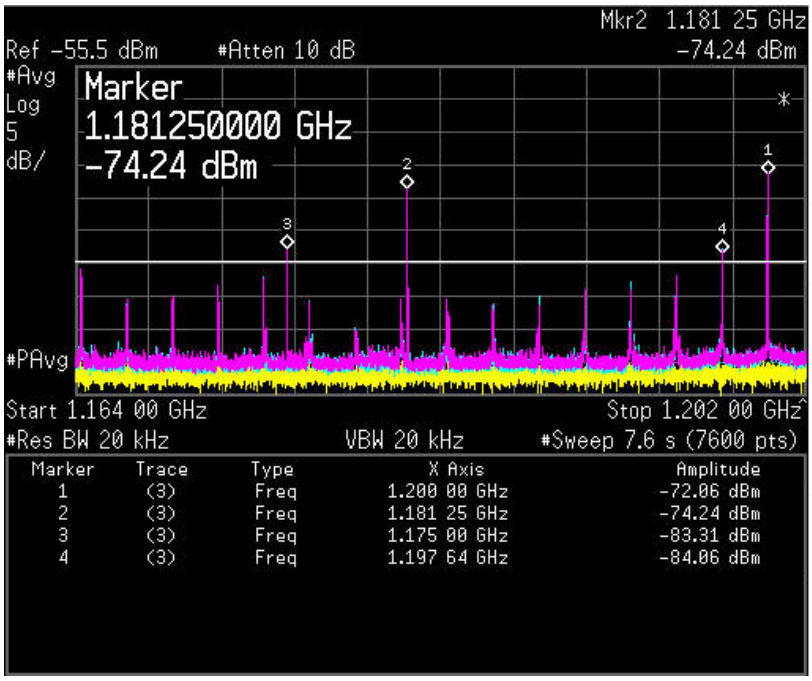

Figure 4-26. Radiated Emission Test Data, GPS Bands 1164-1202 MHz. Vertical

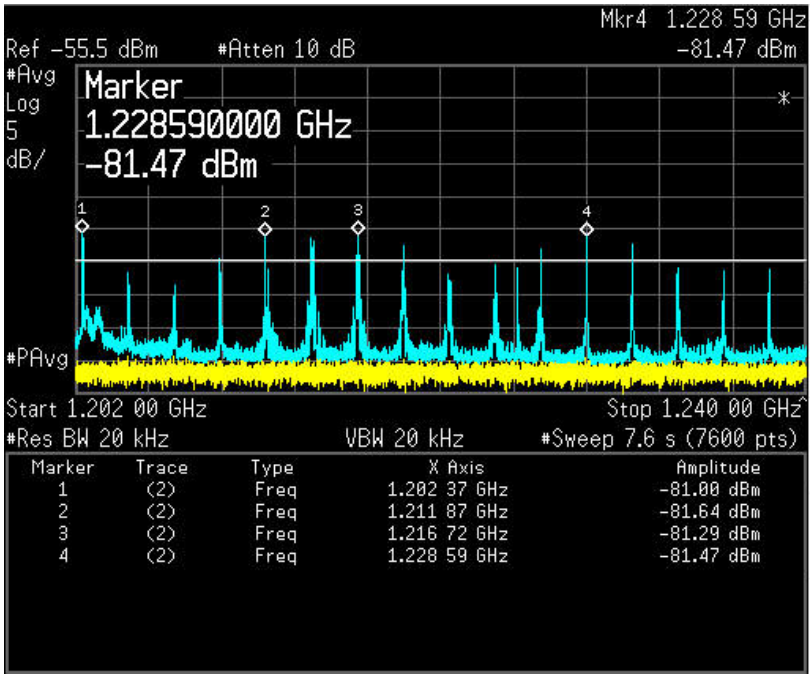

Figure 4-27. Radiated Emission Test Data, GPS Bands 1202-1240 MHz. Horizontal

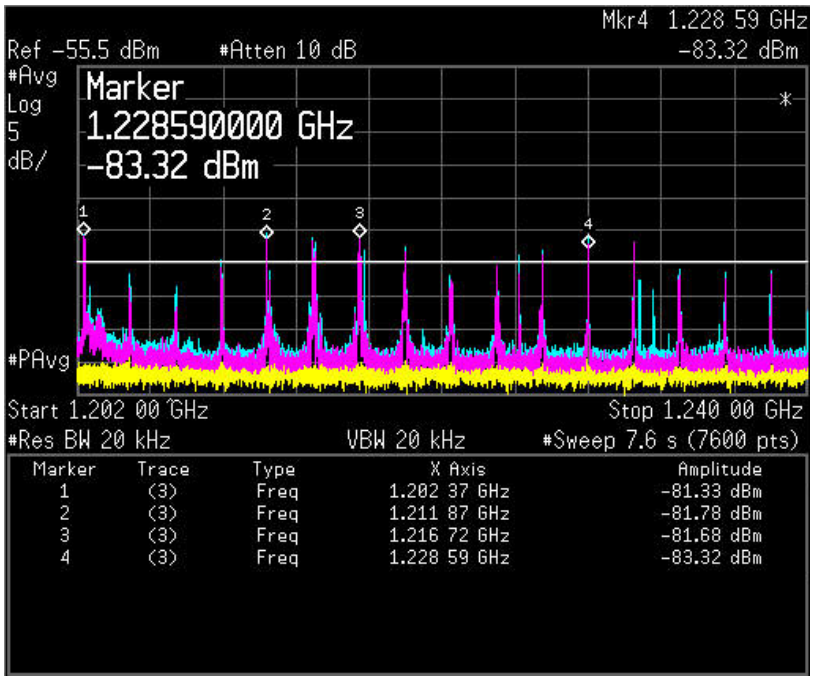

Figure 4-28. Radiated Emission Test Data, GPS Bands 1202-1240 MHz. Horizontal

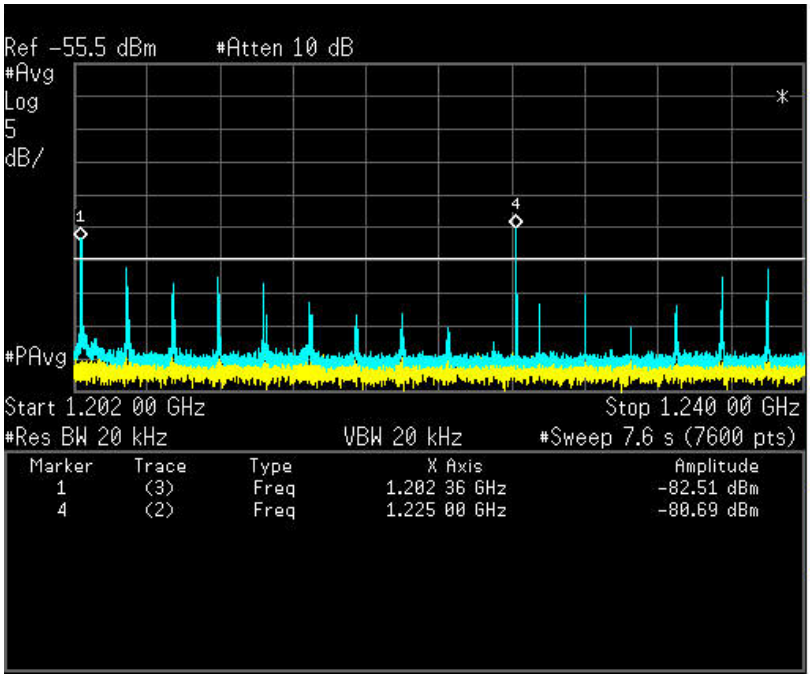

Figure 4-29. Radiated Emission Test Data, GPS Bands 1202-1240 MHz. Vertical

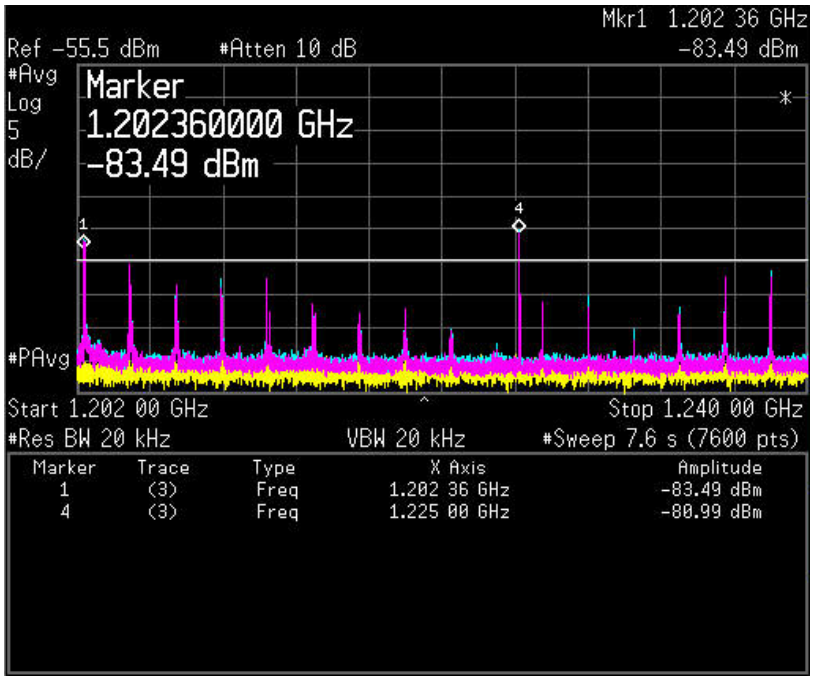

Figure 4-30. Radiated Emission Test Data, GPS Bands 1202-1240 MHz. Vertical

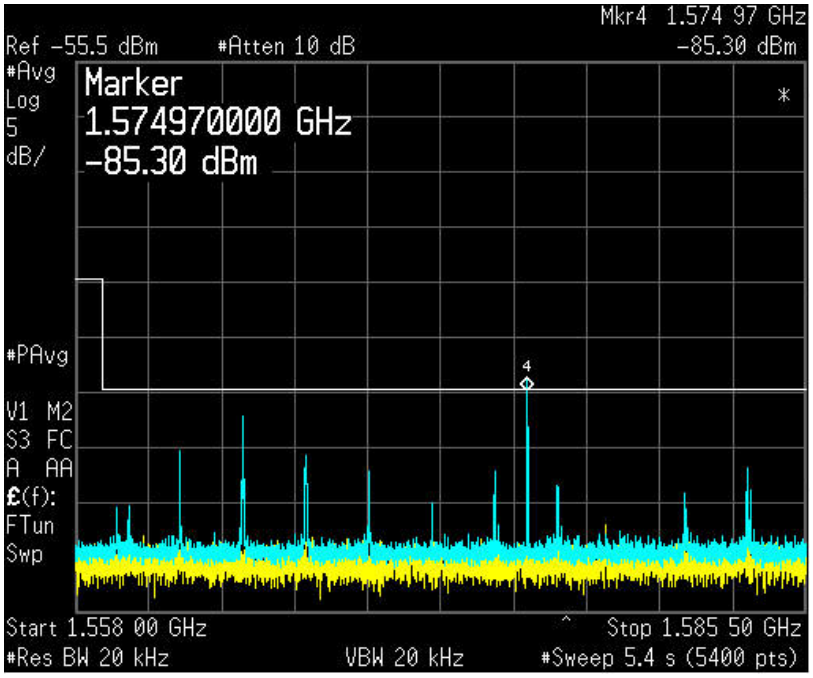

Figure 4-31. Radiated Emission Test Data, GPS Bands 1558-1585 MHz. Horizontal

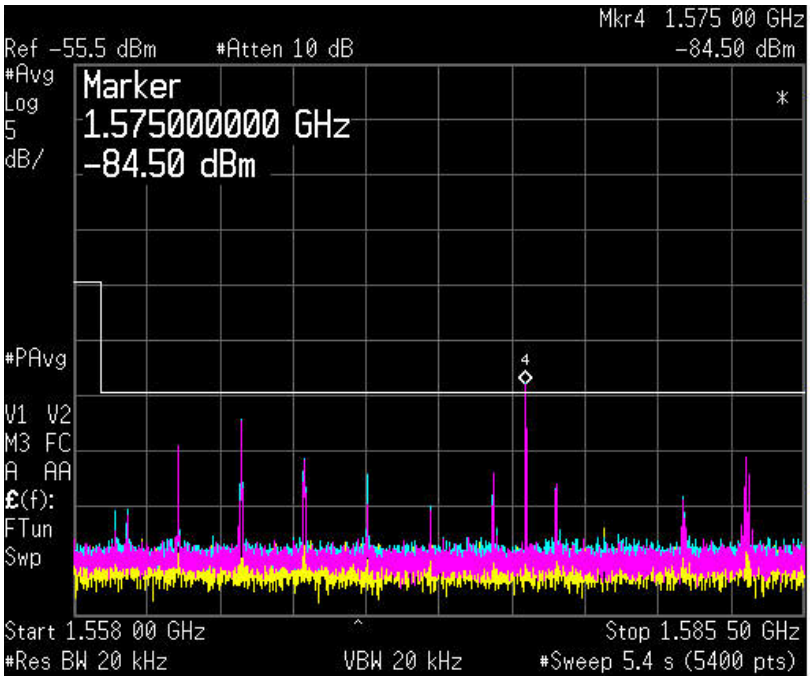

Figure 4-32. Radiated Emission Test Data, GPS Bands 1558-1585 MHz. Horizontal

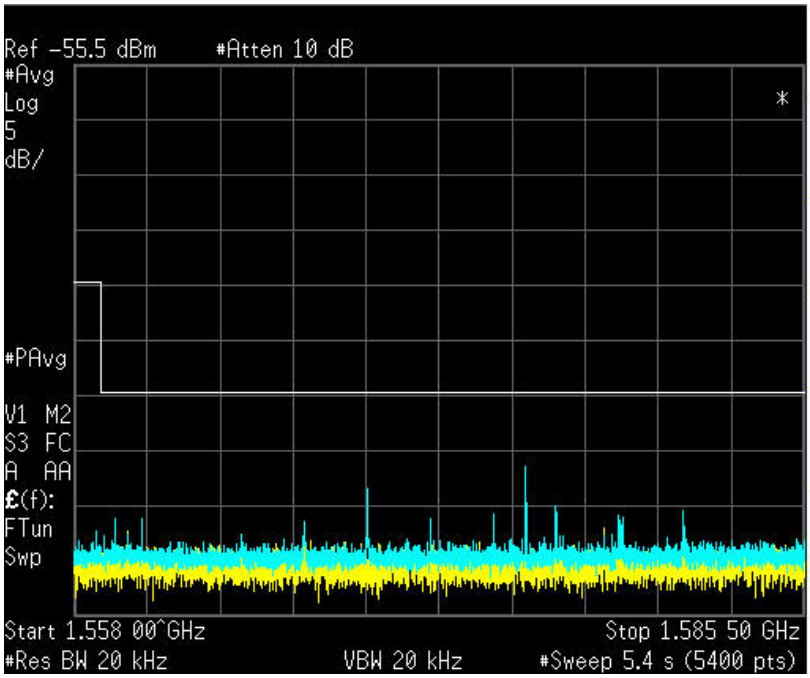

Figure 4-33. Radiated Emission Test Data, GPS Bands 1558-1585 MHz. Vertical

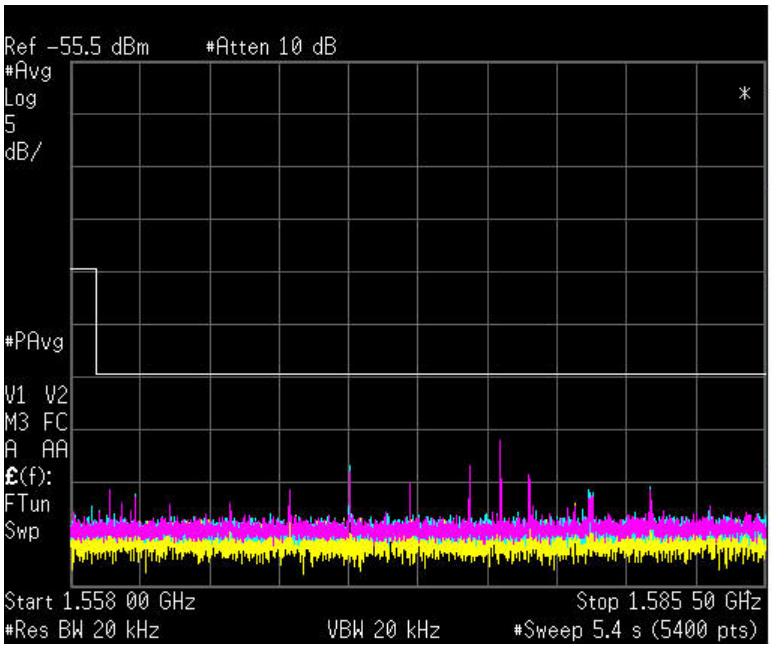

Figure 4-34. Radiated Emission Test Data, GPS Bands 1558-1585 MHz. Vertical

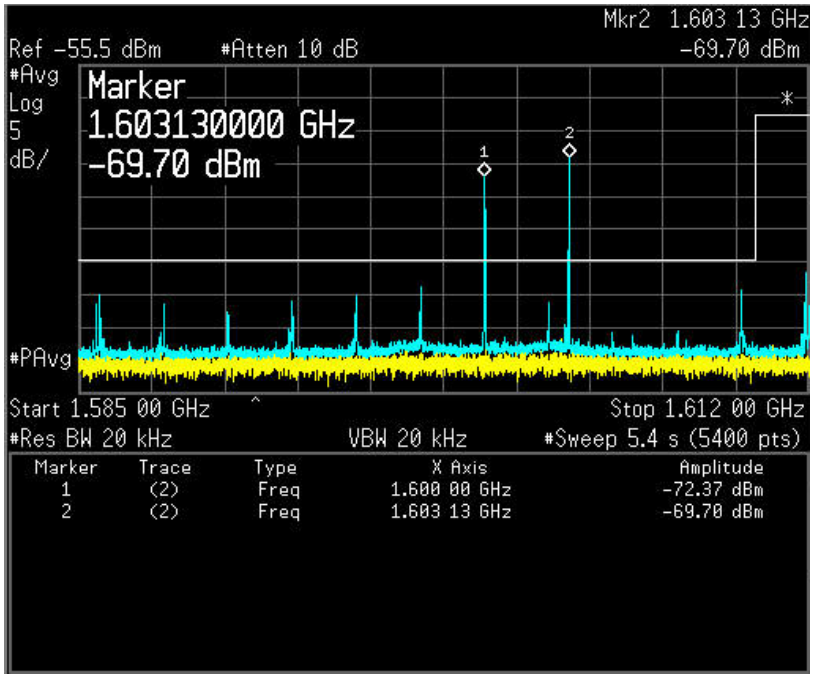

Figure 4-35. Radiated Emission Test Data, GPS Bands 1585-1612 MHz. Horizontal

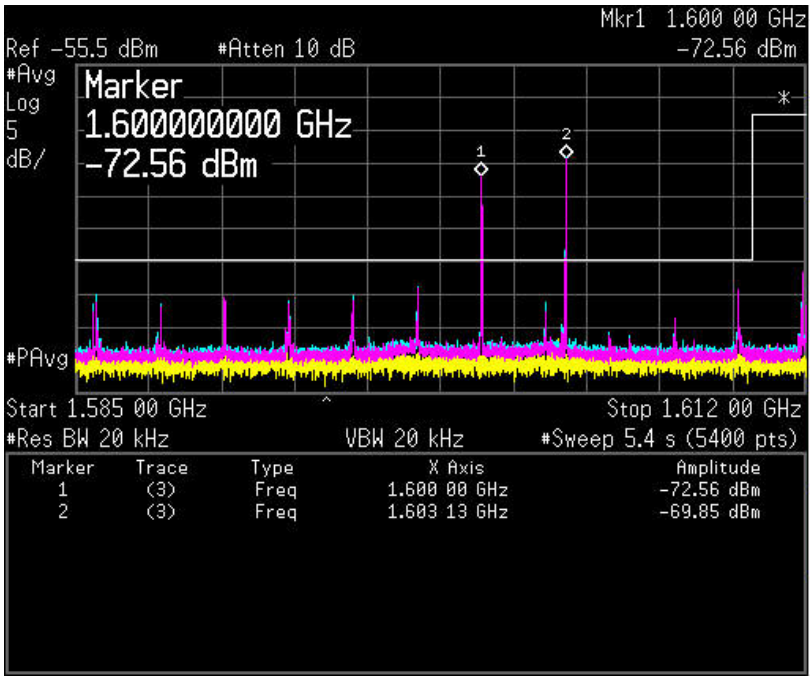

Figure 4-36. Radiated Emission Test Data, GPS Bands 1585-1612 MHz. Horizontal

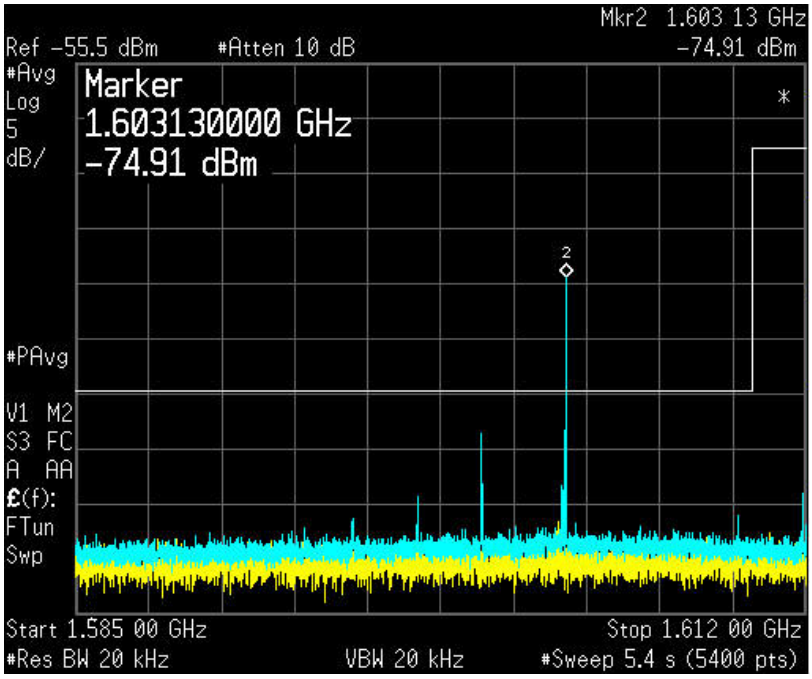

Figure 4-37. Radiated Emission Test Data, GPS Bands 1585-1612 MHz. Vertical

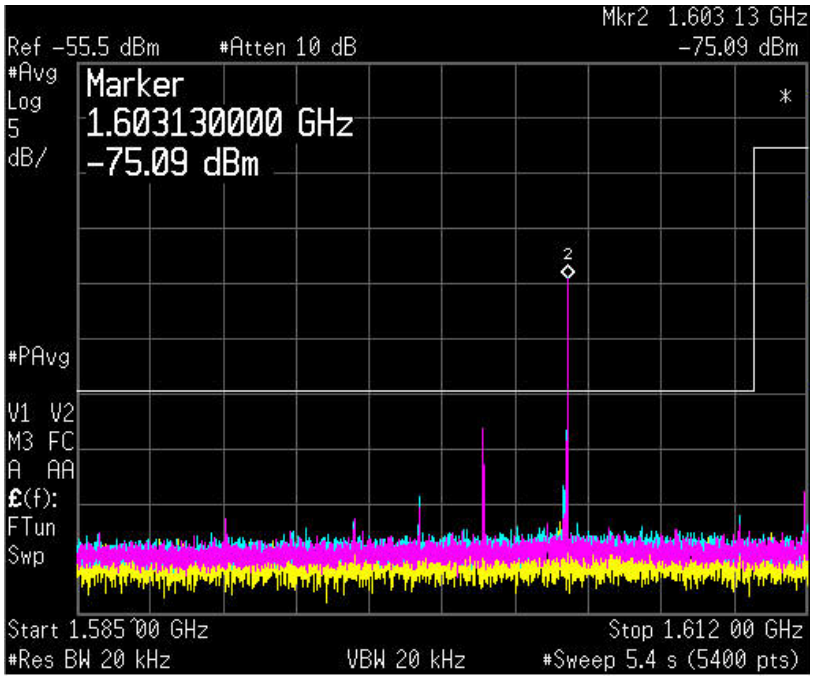

Figure 4-38. Radiated Emission Test Data, GPS Bands 1585-1612 MHz. Vertical

4.5 Peak Emissions within a 50 MHz Bandwidth, §15.519(e)

The limit on the peak EIRP emissions, centered on the frequency at which the highest radiated emissions occurs, fM, is 20 log (RBW/50) dBm, where RBW is the resolution bandwidth in megahertz used to take the measurement, and where the RBW used must be between 1 MHz and 50 MHz.

4.5.1 Test Procedure

The measurements were performed at a distance of 3m. The UWB spectrum was investigated over the occupied bandwidth frequency range. The Agilent spectrum analyzer was set to an RBW and VBW of 8MHz and the peak-detector was selected. Using an 8 MHz RBW, the peak limit is:

$$20^* \log (8/50) = -15.8\text{dBm EIRP}$$

A limit line at -15.8dBm EIRP was placed on the display of the spectrum analyzer.

4.5.2 Test Results

The UWB device complies with the requirements of §15.519(e). Plots of the peak emissions are included in Figure 4-39, below, where the worst case peak was 8.6 dB below the limit.

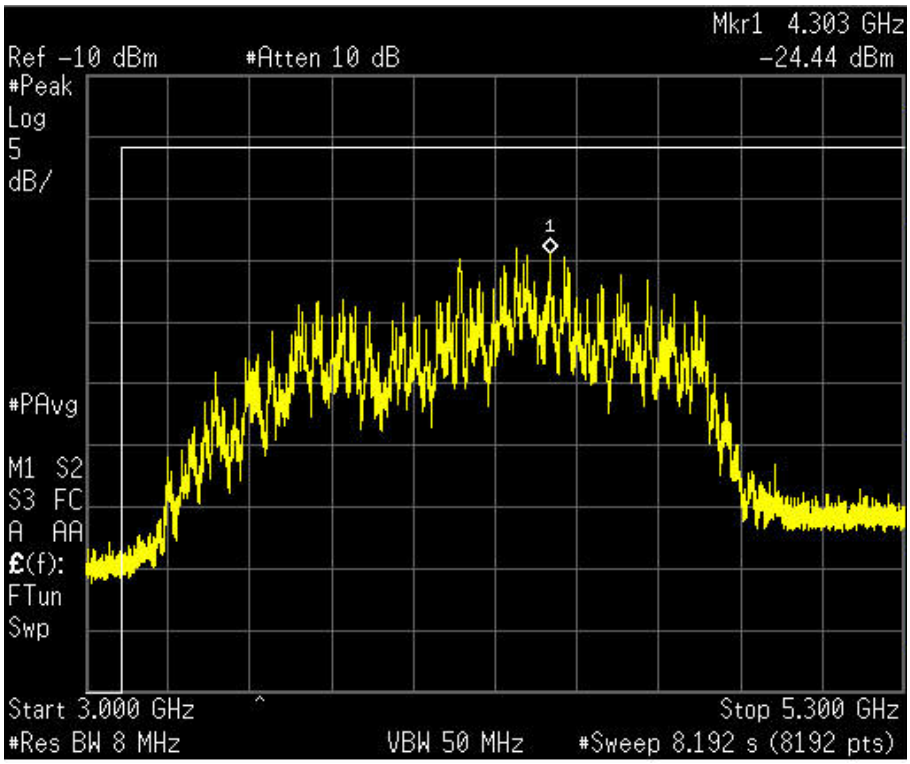

Figure 4-39. Peak Emissions within an 8 MHz RBW

4.6 Conducted Emissions, §15.207

The EUT is a module. As such, when it is used, it is contained within another device that supplies its power. The device containing the module can be handheld and is either battery operated or has been independently tested for conducted emissions. Therefore, no conducted test was performed.