Washington Laboratories, Ltd.

FCC & Industry Canada Certification Test Report
For the
Symbol Technologies, Inc.
Model RF1224

FCC ID: H9PRF1224
IC: 1549D-RF1224

WLL JOB# **9197**
June 2006

Prepared for:

Symbol Technologies, Inc
One Symbol Plaza MS A-13
Holtsville, NY 11742

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

FCC & Industry Canada Certification Test Report
for the
Symbol Technologies, Inc
APEX RFID
FCC ID: H9PRF1224
IC ID: 1549D-RF1224

June 2006

WLL JOB# 9197

Prepared by: Gregory M. Snyder
Chief EMC Engineer

Reviewed by: Steven D. Koster
EMC Operations Manager

Abstract

This report has been prepared on behalf of Symbol Technologies, Inc to support the attached Application for Equipment Authorization. The test report and application are submitted for the Symbol Technologies APEX Mobile RFID Reader. The device contains an RFID reader operating at 902 – 928MHz band, Bluetooth module, and an 802.11a/b/g WLAN module.

The RFID Reader has previously been certified (FCC ID: NTTWJMPR7XXX). The original test report covers the testing at the antenna port for this device. As the antenna has changed radiated emissions testing was performed and is reported within.

The 802.11a/b/g module has also been previously certified (FCC ID: H9P2121160). All test data previously reported is covered in the original test reports. Data provided in this report are to cover the radiated emissions testing for the module using different antennas.

Full testing of the Bluetooth device to §15.247 of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 of Industry Canada has been performed and is reported within.

Collocation testing was also performed to ensure that no intermodulation products were created as a result of the proximity of the radios.

Testing was performed on an Open Area Test Site (OATS) of 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. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. 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 Symbol Technologies, Inc APEX RF1224 complies with the limits for a Frequency Hopping Spread Spectrum Transmitter, Bluetooth device, and 802.11a/b/g device under FCC Part 15.247, 15.407 and Industry Canada RSS-210/RSS-GEN.

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The Symbol Technologies, Inc APEX RF1224 complies with the limits for a Frequency Hopping Spread Spectrum Transmitter, Bluetooth device, and 802.11a/b/g device under FCC Part 15.247 and Industry Canada RSS-210/RSS-GEN.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal for the Bluetooth device) emissions were performed. All measurements were performed in accordance with FCC Public Notice DA 00-705 and the 2003 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Symbol Technologies, Inc One Symbol Plaza MS A-13 Holtsville, NY 11742
Purchase Order Number:	4500555508
Quotation Number:	62658-E

1.4 Test Dates

Testing was performed on the following date(s):	5/16/2006 – 6/2/2006

1.5 Test and Support Personnel

Washington Laboratories, LTD	James Ritter; John Repella
Client Representative	Alan Parrish

1.6 Test Summary

The following tables are a brief summary of the tests performed on the Symbol Technologies Model APEX RF1224.

Bluetooth Device: 2402 – 2480MHz

Section	Requirement	Report Section	Pass/Fail
15.247(a)	Dwell Time and Time of Occupancy Duty Cycle Correction Calculation	4.1	Pass
15.247(b)	Output Power	4.2	Pass
2.1049	Occupied Bandwidth	4.3	Pass
15.247(a)(1)	Channel Spacing and Number of Hop Channels	4.4	Pass
15.247(d)	Conducted Spurious Emissions	4.5	Pass
15.247(e)	RF Peak Power Spectral Density	4.6	Pass
15.247(c)	Radiated Spurious Emissions	4.7	Pass
RFID Device			
15.247(c)	Radiated Spurious Emissions	5.1	Pass
WLAN Device			
15.247(c)	Radiated Spurious Emissions	6.1	Pass
Collocation	Radiated Spurious Emissions	7	Pass
15.207	AC Powerline Conducted Emissions	7.1	Pass

2 Equipment Under Test

2.1 EUT Identification & Description

The Symbol Technologies, Inc APEX RFID is a Mobile RFID Reader system designed for use on forklifts and other mobile warehouse equipment. The RFID Reader is an already approved EPC Generation 2 reader (FCC ID: NTTWJMPR7XXX). The APEX also contains an 802.11 WLAN device, also approved (FCC ID: H9P2121160) for communications and a V1.2 Bluetooth module for peripheral connectivity.

Table 1. Device Summary

ITEM	DESCRIPTION
Manufacturer:	Symbol Technologies, Inc
FCC ID:	FCC ID: H9PRF1224
IC:	IC: 1549D-RF1224
Model:	APEX RFID
FCC Rule Parts:	§15.247, §15.407
Industry Canada:	RSS210, RSS-GEN
Frequency Range:	Bluetooth: 2402 – 2480M RFID: 902.91 – 927.29M WLAN: 2412-2462, 5180-5240, 5260-5320, 5745-5805, 5825-5830M
Bluetooth:	
Maximum Output Power:	1.75mW (Bluetooth)
Occupied Bandwidth:	950.375kHz
Keying:	Automatic
Type of Information:	Data
Number of Channels:	79
Power Output Level	Fixed
Antenna Connector	Integral Antenna
Antenna Type	PCB
Power Source & Voltage:	7.2V Rechargeable Lithium ION, 120Vac/DC Power Supply

2.2 Test Configuration

The APEX RFID was configured with a support laptop to control the radios and an AC/DC power supply (Symbol Model SYM4-2). During the radiated emissions for the RFID device the unit was connected to the external RFID panel antenna as opposed to the integrated antenna. The RFID antenna port uses a reverse "N-Type" connector. The external RFID antenna is an Andrew Model RFID-90-CRW 6dBi antenna. The Bluetooth and WLAN antennas are integral antennas and can not be changed.

2.3 Testing Algorithm

All settings of the APEX RFID was performed through the USB connection to the laptop PC. The RFID application software allowed control of the RFID device for setting the channels. A "CeCTxRx" application was used for controlling the WLAN 802.11 device and the BTRegtest was used for controlling the Bluetooth device. During the co-location testing all applications were utilized to get the radios operating simultaneously.

Worst case emission levels are provided in the test results data.

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. 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. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. 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.

2.5 Measurements

2.5.1 References

FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

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

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. For the purposes of the measurements performed by Washington Laboratories, the measurement uncertainty is ±2.3 dB. This has been calculated for a *worst-case situation* (radiated emissions measurements performed on an open area test site).

The following measurement uncertainty calculation is provided:

$$\text{Total Uncertainty} = (A^2 + B^2 + C^2)^{1/2}/(n-1)$$

where:

A = Antenna calibration uncertainty, in dB = 2 dB

B = Spectrum Analyzer uncertainty, in dB = 1 dB

C = Site uncertainty, in dB = 4 dB

n = number of factors in uncertainty calculation = 3

Thus, Total Uncertainty = $0.5\ (2^2 + 1^2 + 4^2)^{1/2} = \pm 2.3$ dB.

3 Test Equipment

Table 2 shows a list of the test equipment used for measurements along with the calibration information.

Table 2. Test Equipment List

WLL Asset #	Manufacturer Model/Type	Function	Cal. Due
0072	HP 8568B	SPECTRUM ANALYZER	6/30/2006
0068	HP 85650A	QUASI-PEAK ADAPTER	6/30/2006
0070	HP 85685A	RF PRESELECTOR	6/30/2006
0557	SCHAFFNER, CBL6141A	ANTENNA	12/1/2006
0125	SOLAR 8028-50-TS-BNC	LISN	1/21/2007
0126	SOLAR 8028-50-TS-BNC	LISN	1/21/2007
0428	SUNOL JB1	BICONILOG ANTENNA	1/23/2007
0004	ARA DRG118/A	MICROWAVE HORN ANTENNA	2/2/2007
0074	HEWLETT-PACKARD 8593A	SPECTRUM ANALYZER	10/4/2006
0522	HEWLETT-PACKARD 8449B	MICROWAVE PREAMP	5/4/2007
0425	ARA, DRG-118/A	MICROWAVE HORN ANTENNA	1/17/2007
0528	AGILENT 4446A	4446A SPECTRUM ANALYZER	6/27/2006
0280	ITC, 21C-3A1	WAVEGUIDE	2/7/2007
0281	ITC, 21A-3A1	WAVEGUIDE	2/7/2007
209	NARDA, V638	STANDARD GAIN ANTENNA	12/25/2008
210	NARDA, V637	STANDARD GAIN ANTENNA	12/25/2008

4 Test Results (Bluetooth Transmitter)

4.1 Duty Cycle Correction

In accordance with the FCC Public Notice DA 00-705 and Pt 15.209 the spurious radiated harmonic emissions measurements may be adjusted using a duty cycle correction factor in addition to video averaging if the dwell time per channel of the hopping signal is less than 100 ms.

The duty cycle correction factor is calculated by:

20 x LOG (dwell time/100 ms)

Figure 4-1 through Figure 4-4 are the plots of the dwell time for the transmitter. Based on these plots, the worst case mode is DH5 with a dwell time per hop of 2.933ms. Therefore the total dwell time per 100 ms is 5.866ms. This corresponds to a duty cycle correction of -24.63dB, however, the maximum allowed duty cycle correction is 20dB.

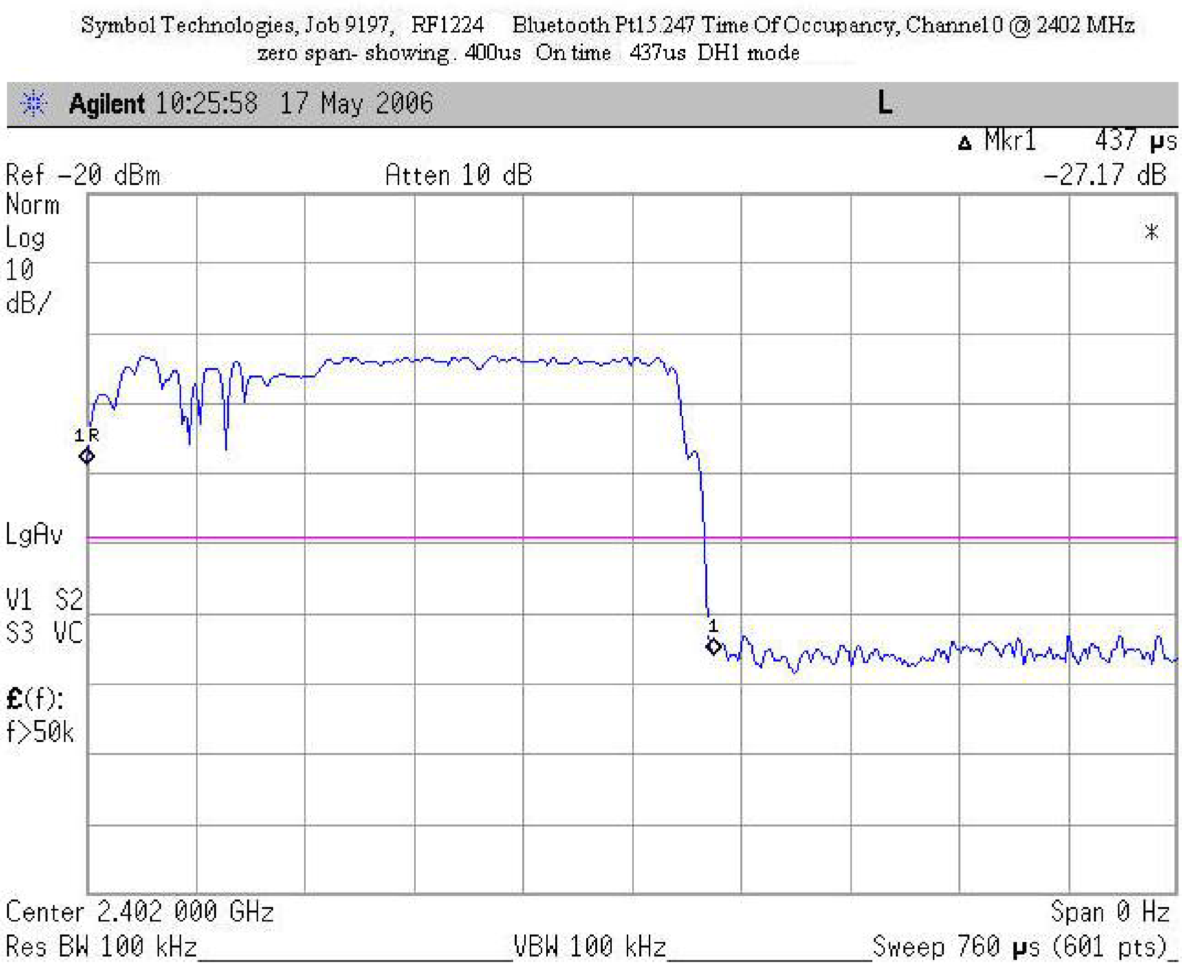

Figure 4-1. Duty Cycle Plot, Pulse Width, DH1 Mode

Figure 4-2. Duty Cycle Plot, Pulse Width, DH3 Mode

Symbol Technologies, Job 9197, Bluetooth Pt15.247 Time Of Occupancy, Channel 0 @ 2402 MHz
zero span- showing 2.933ms On time DH5 MODE

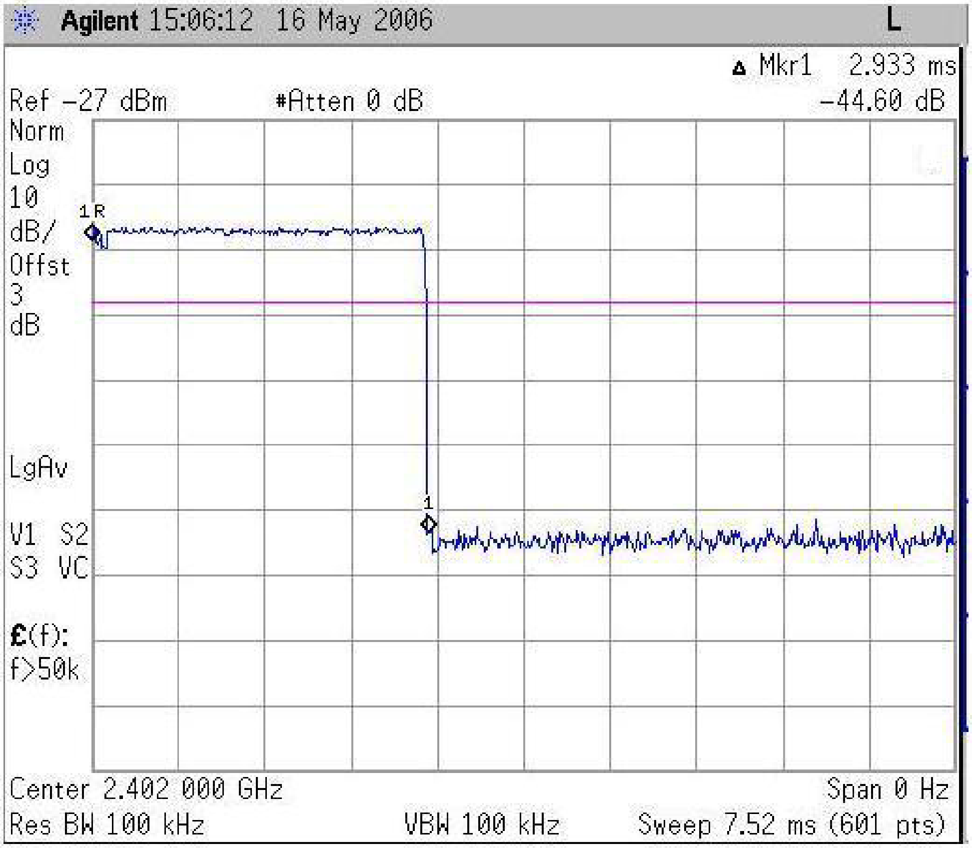

Figure 4-3. Duty Cycle Plot, Pulse Width, DH5 Mode

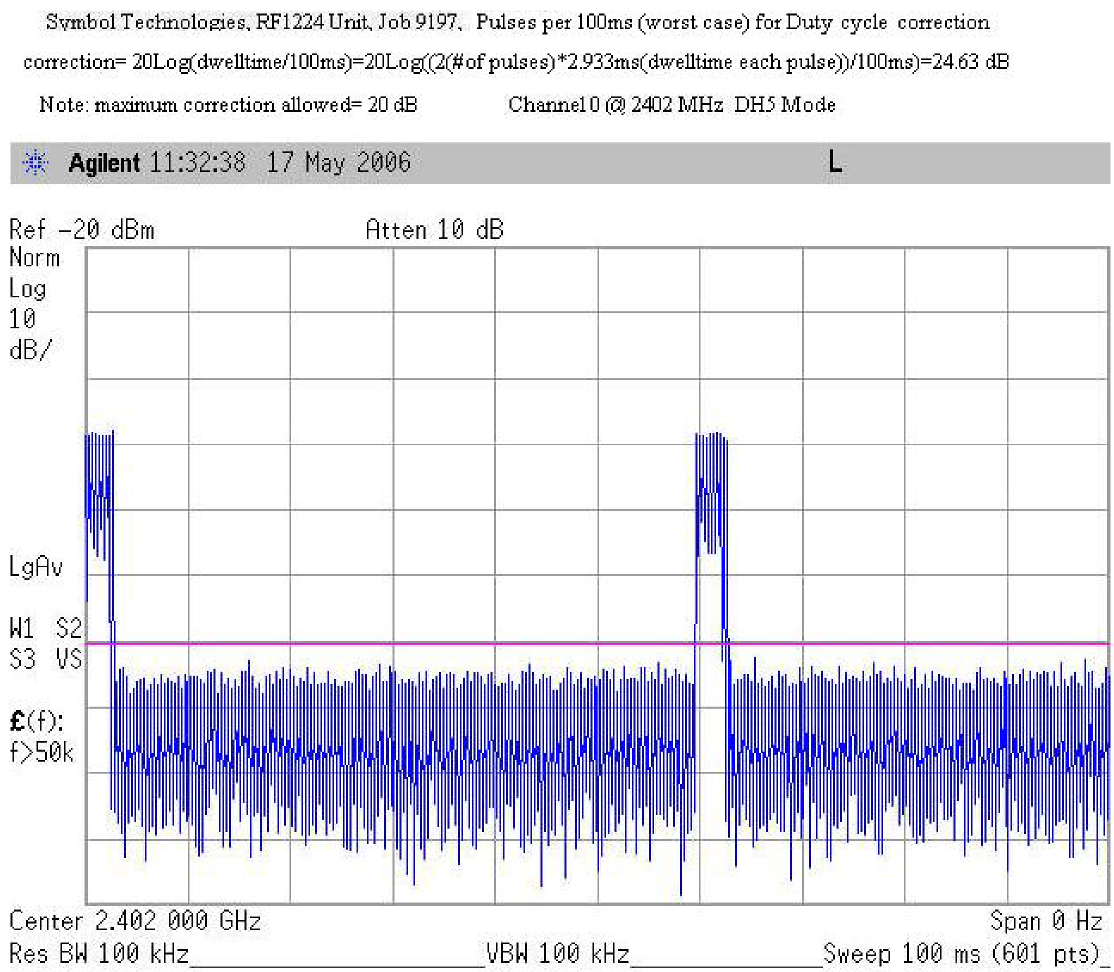

Figure 4-4. Duty Cycle Plot, Worst Case 100ms, DH5 Mode

In accordance with FCC 15.247(a)(1)(iii) the occupancy time of any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds times the number of channels.

For this EUT:

79 Channels/Frequencies X 0.4 seconds = 31.6 seconds (Limit = 0.4 seconds per 31.6 seconds, per channel).

The following occupancy times are calculated from data shown in Figure 4-5 through Figure 4-7.

DH1 Mode: 104 ms/31.6 s. interval, based on 237 pulses of 437 µs.

DH3 Mode: 230 ms/31.6 s. interval, based on 133 pulses of 1.724 ms.

DH5 Mode: 305 ms/31.6 s. interval, based on 104 pulses of 2.933 ms.

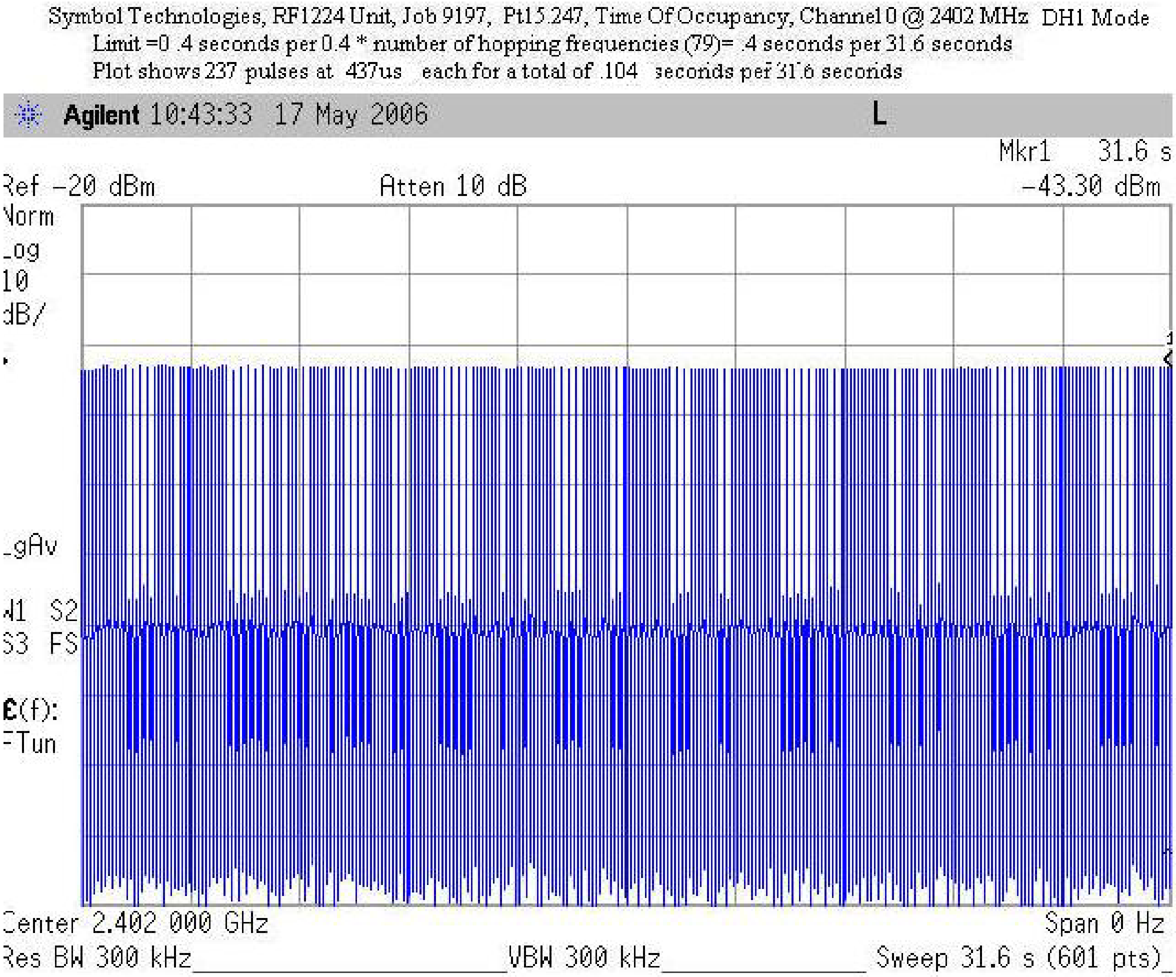

Figure 4-5: Time of Occupancy, 31.6 sec, DH1 Mode

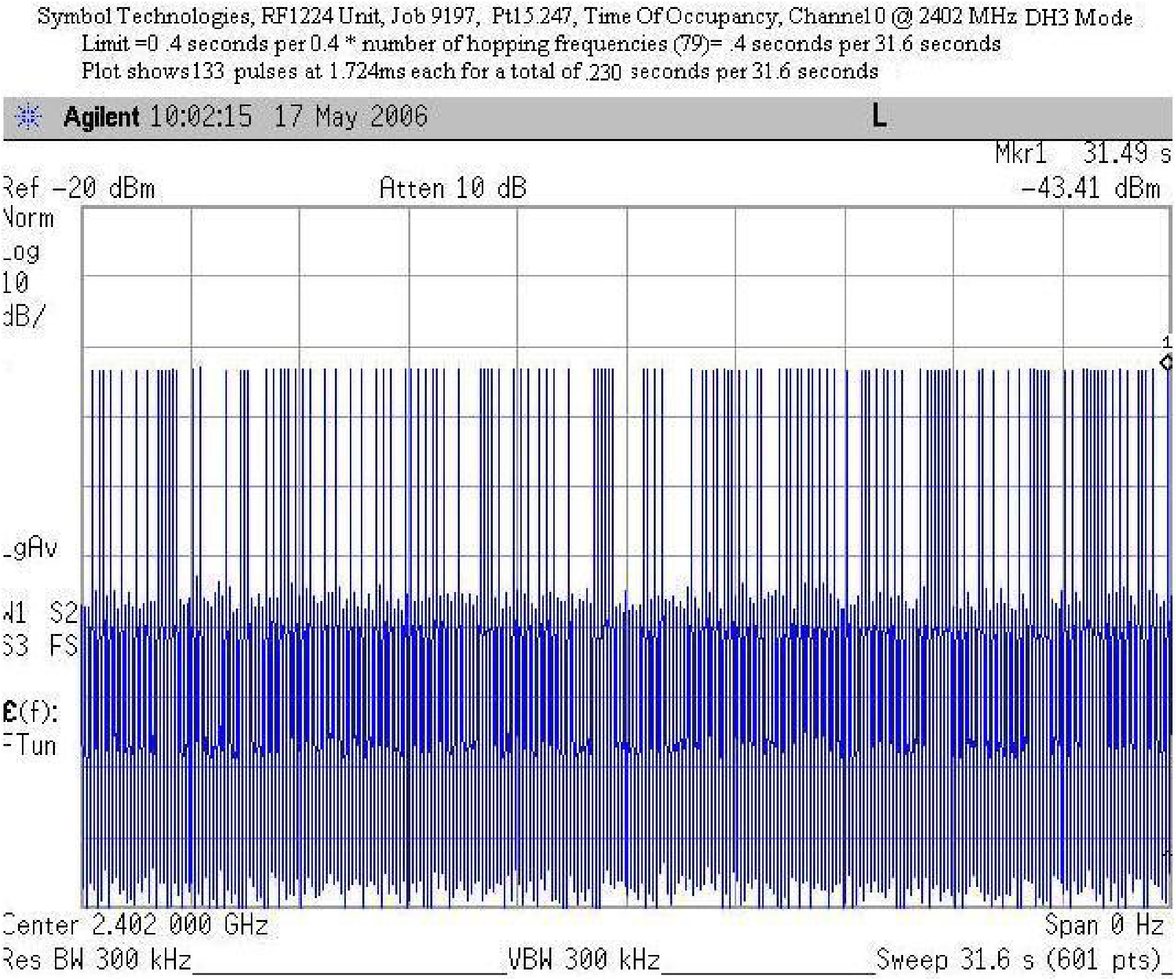

Figure 4-6: Time of Occupancy, 31.6 sec, DH3 Mode

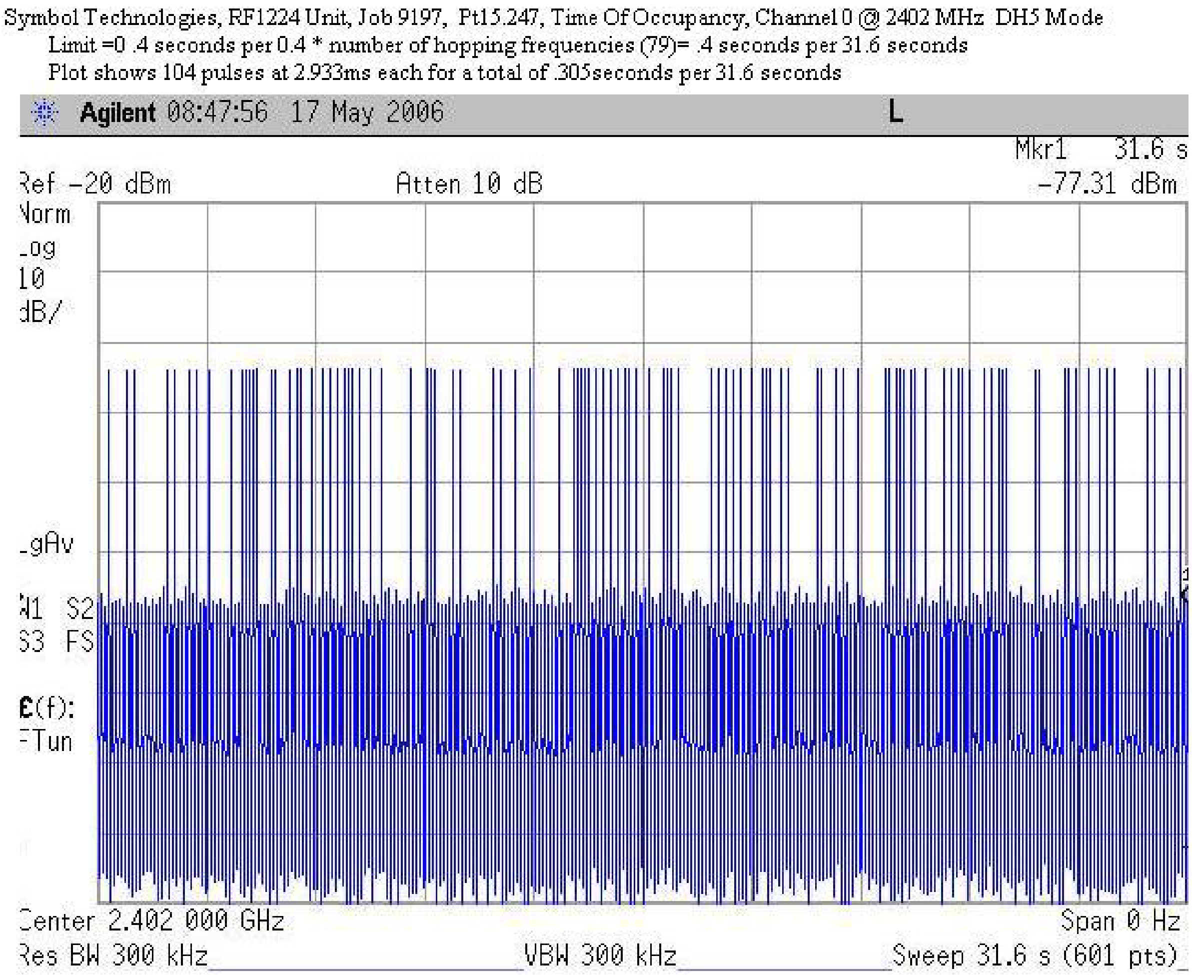

Figure 4-7: Time of Occupancy, 31.6 sec, DH5 Mode

4.2 RF Power Output: (FCC Part §2.1046)

To measure the output power the hopping sequence was stopped with no modulation while the frequency dwelled on a low, high and middle channel. The output from the transmitter was connected to a power meter and the transmit power was recorded. Table 3 lists the output power readings.

Table 3. RF Power Output

Frequency	Level dBm (m*Watts*)	Limit dBm (m*Watts*)	Results
Low Channel 2402 MHz	1.67 (*1.47*)	30 (*1000*)	Pass
Mid Channel 2440 MHz	2.44 (*1.75*)	30 (*1000*)	Pass
High Channel 2476 MHz	1.51 (*1.42*)	30 (*1000*)	Pass

4.3 Occupied Bandwidth: (FCC Part §2.1049)

Occupied bandwidth was performed by connecting the output of the EUT to the input of a spectrum analyzer. The transmitter occupied bandwidth was measured in the DH1, DH3, and DH5 modes.

At full modulation, the occupied bandwidth was measured as shown in Figure 4-8 through Figure 4-16.

Table 4 provides a summary of the Occupied Bandwidth Results.

Table 4. Occupied Bandwidth Results

Frequency	Mode	Bandwidth	Pass/Fail
2402	DH1	937.357kHz	Pass
2402	DH3	921.074kHz	Pass
2402	DH5	934.255kHz	Pass
2441	DH1	900.272kHz	Pass
2441	DH3	937.827Hz	Pass
2441	DH5	947.138kHz	Pass
2480	DH1	950.375kHz	Pass
2480	DH3	900.000kHz	Pass
2480	DH5	925.000kHz	Pass

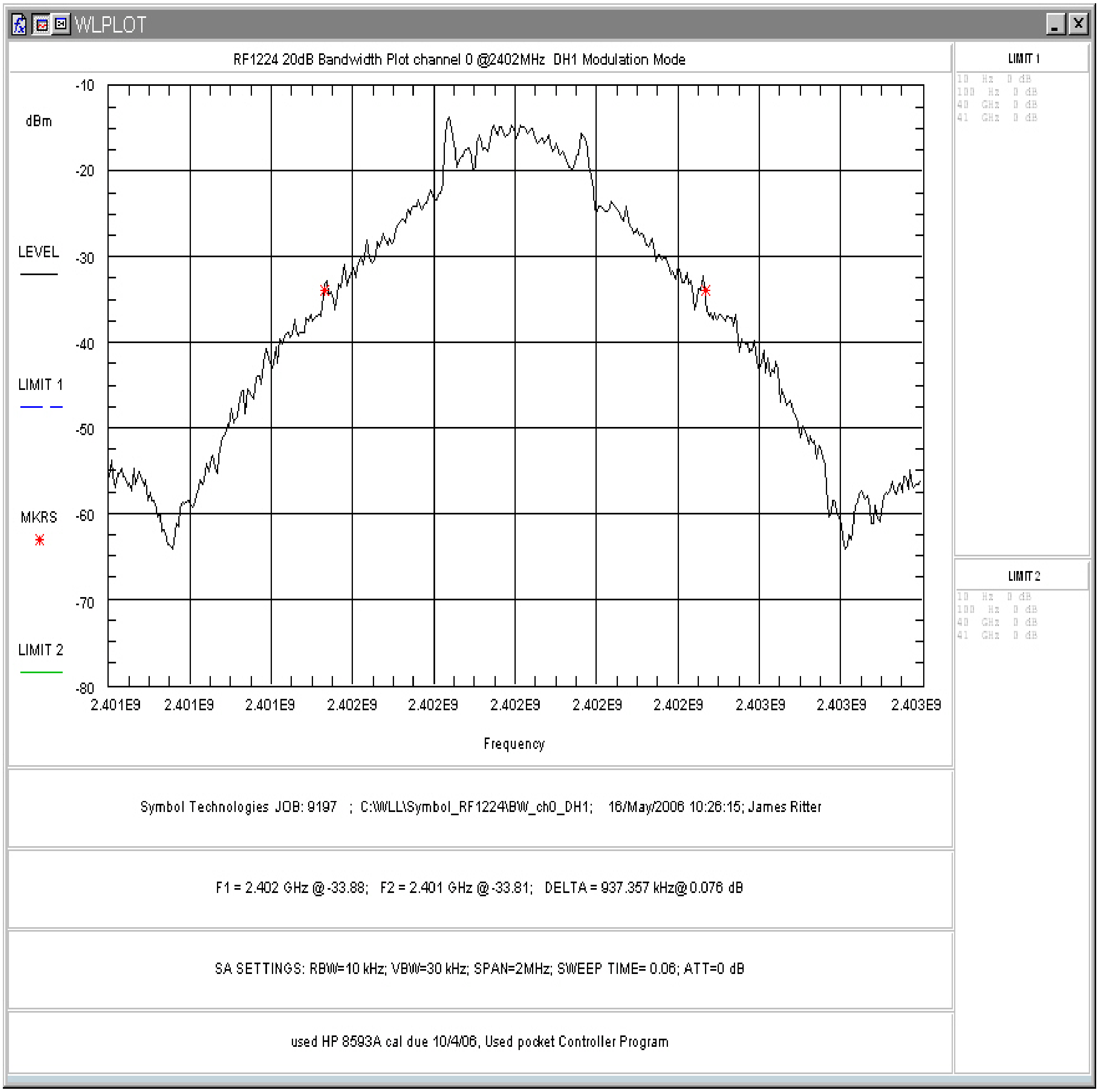

Figure 4-8. Occupied Bandwidth, Low Channel, DH1 Mode

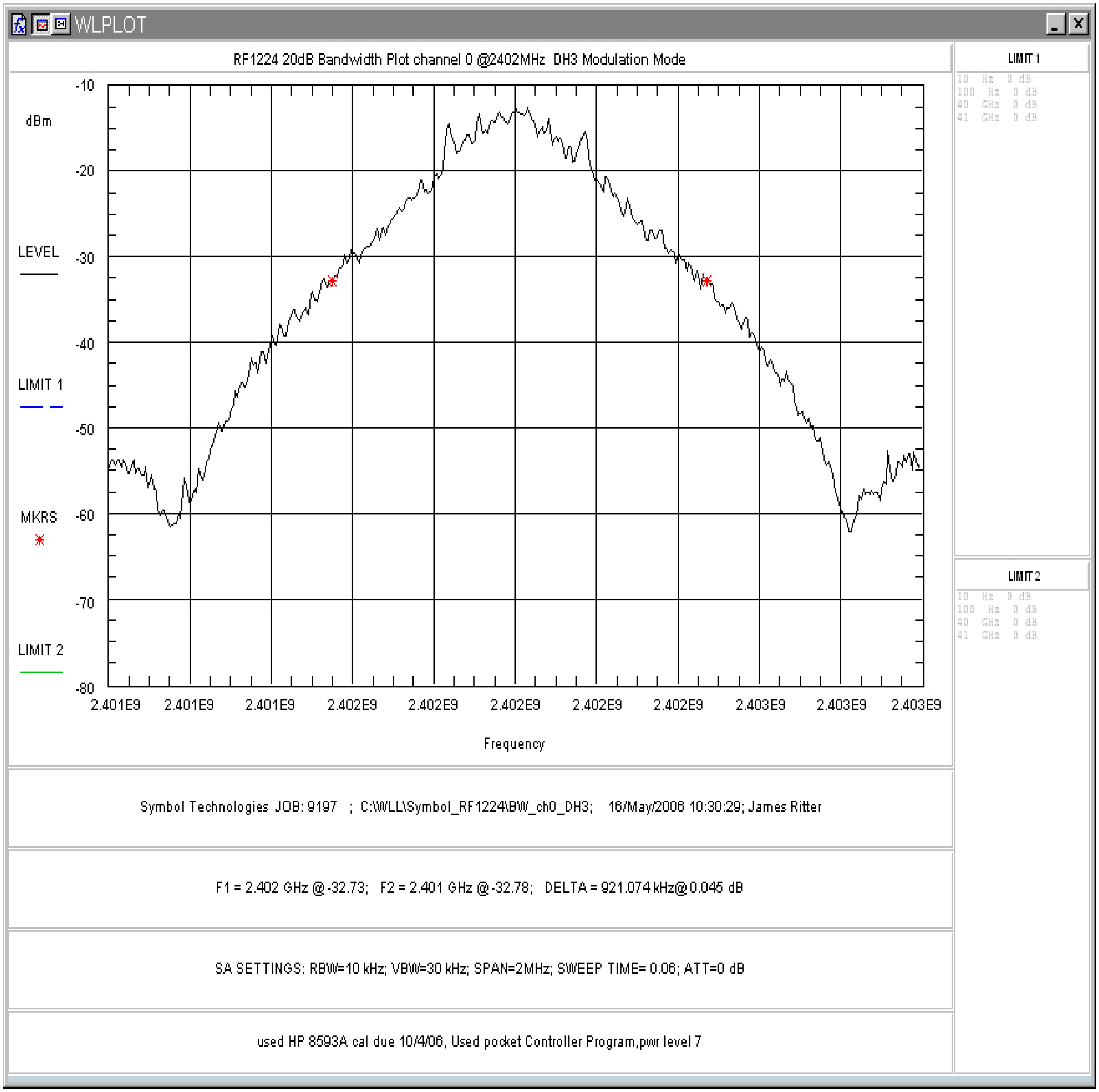

Figure 4-9. Occupied Bandwidth, Low Channel, DH3 Mode

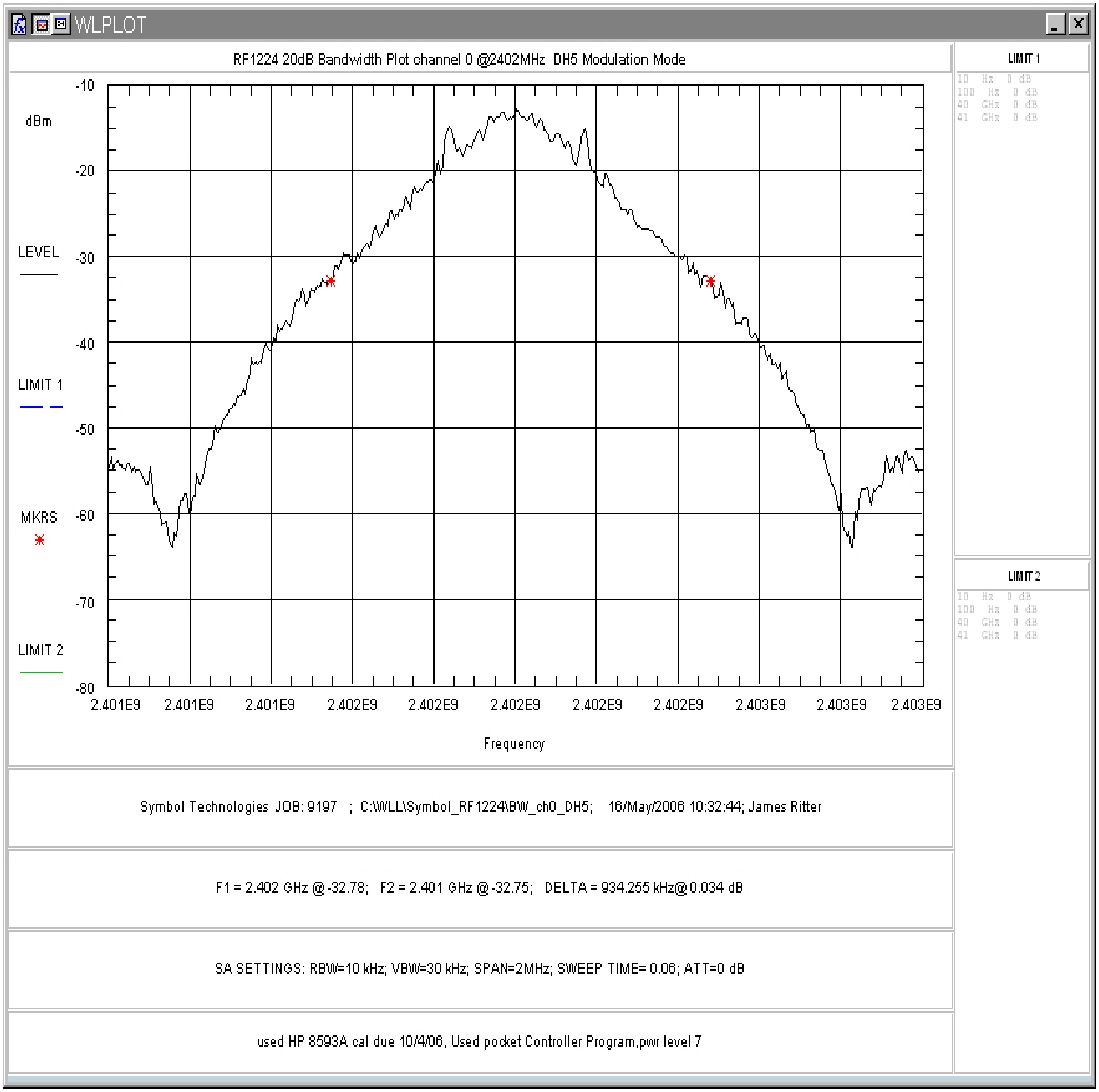

Figure 4-10. Occupied Bandwidth, Low Channel, DH5 Mode

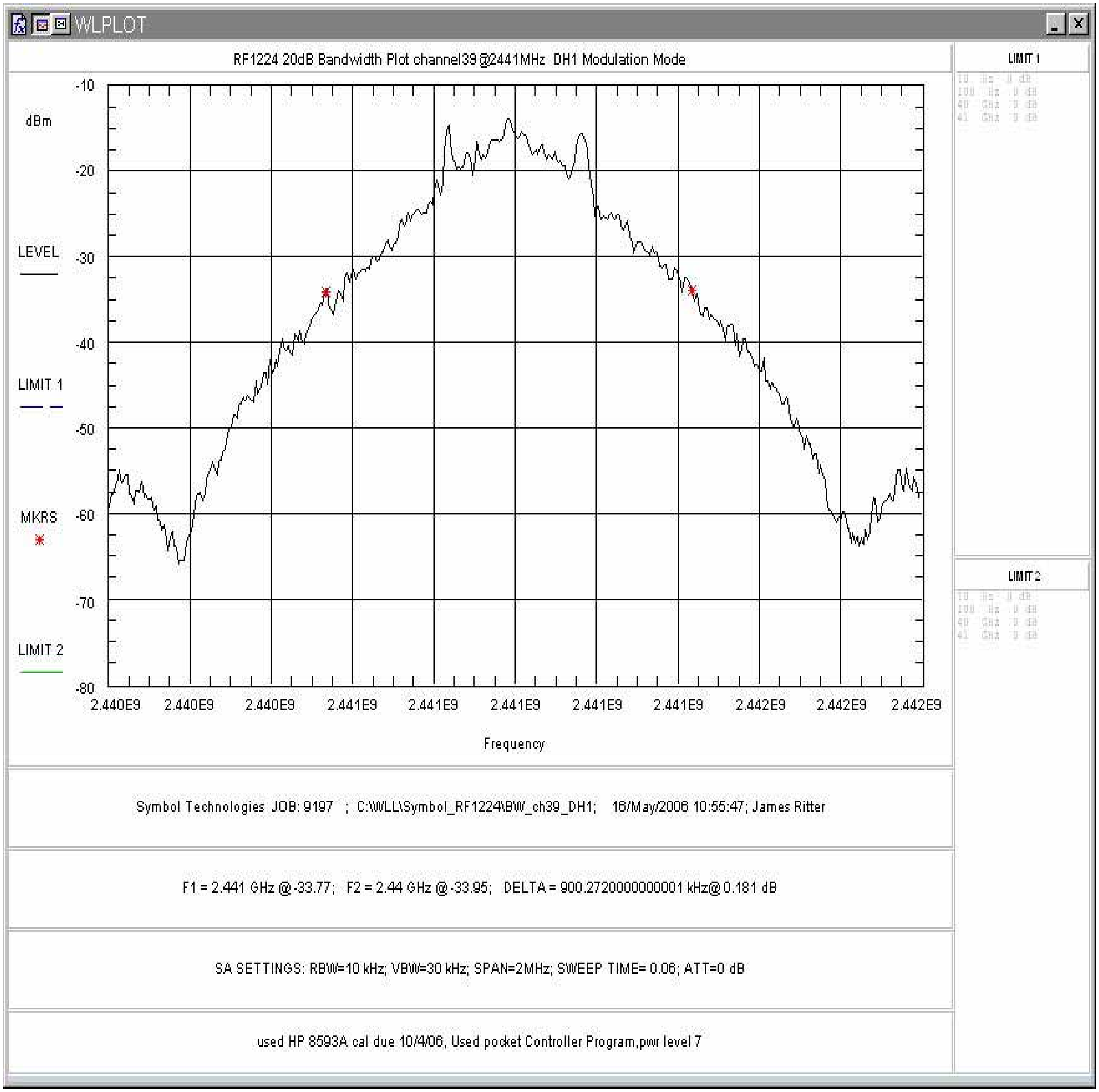

Figure 4-11. Occupied Bandwidth, Mid Channel, DH1 Mode

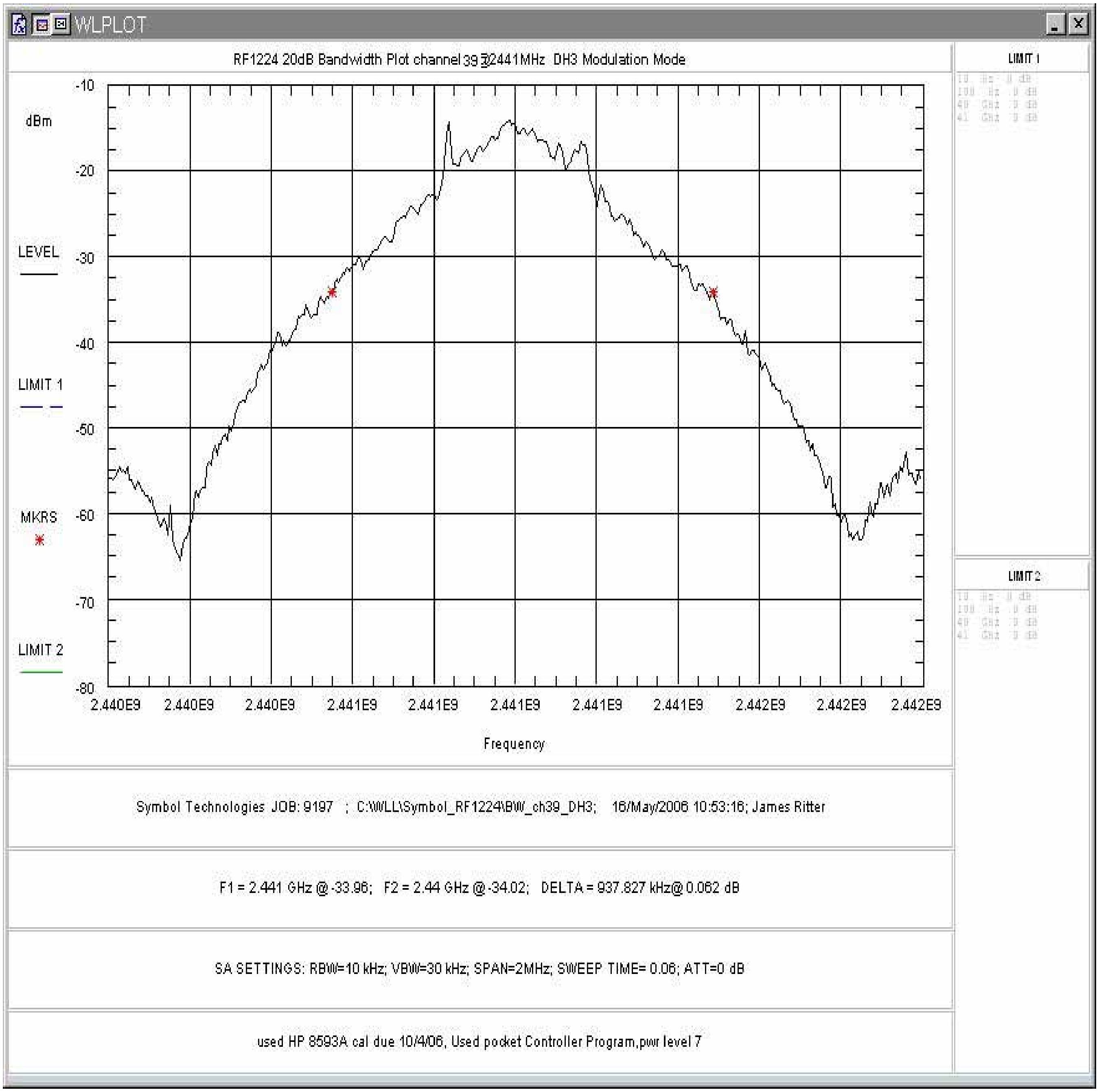

Figure 4-12. Occupied Bandwidth, Mid Channel, DH3 Mode

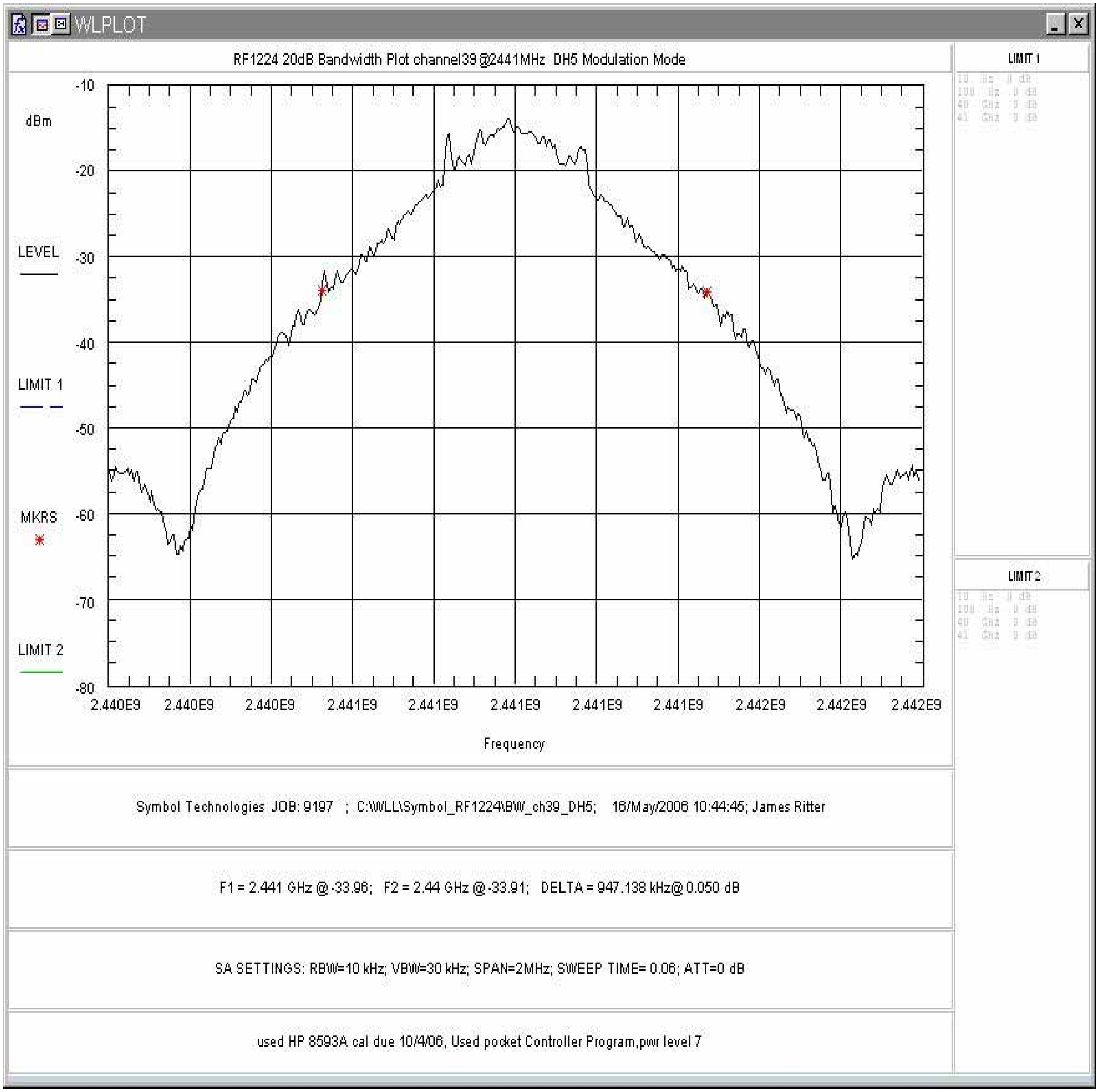

Figure 4-13. Occupied Bandwidth, Mid Channel, DH5 Mode

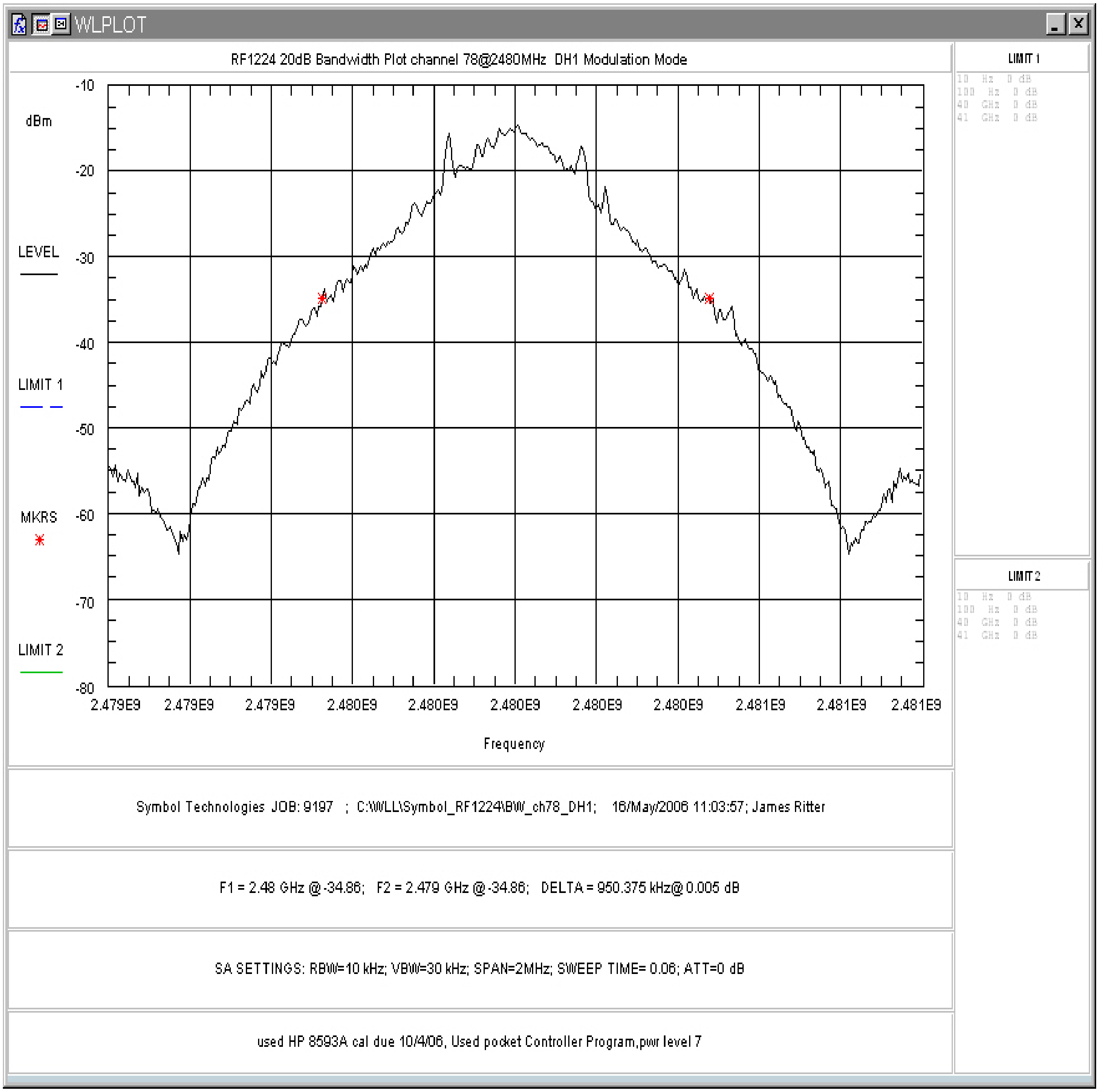

Figure 4-14. Occupied Bandwidth, High Channel, DH1

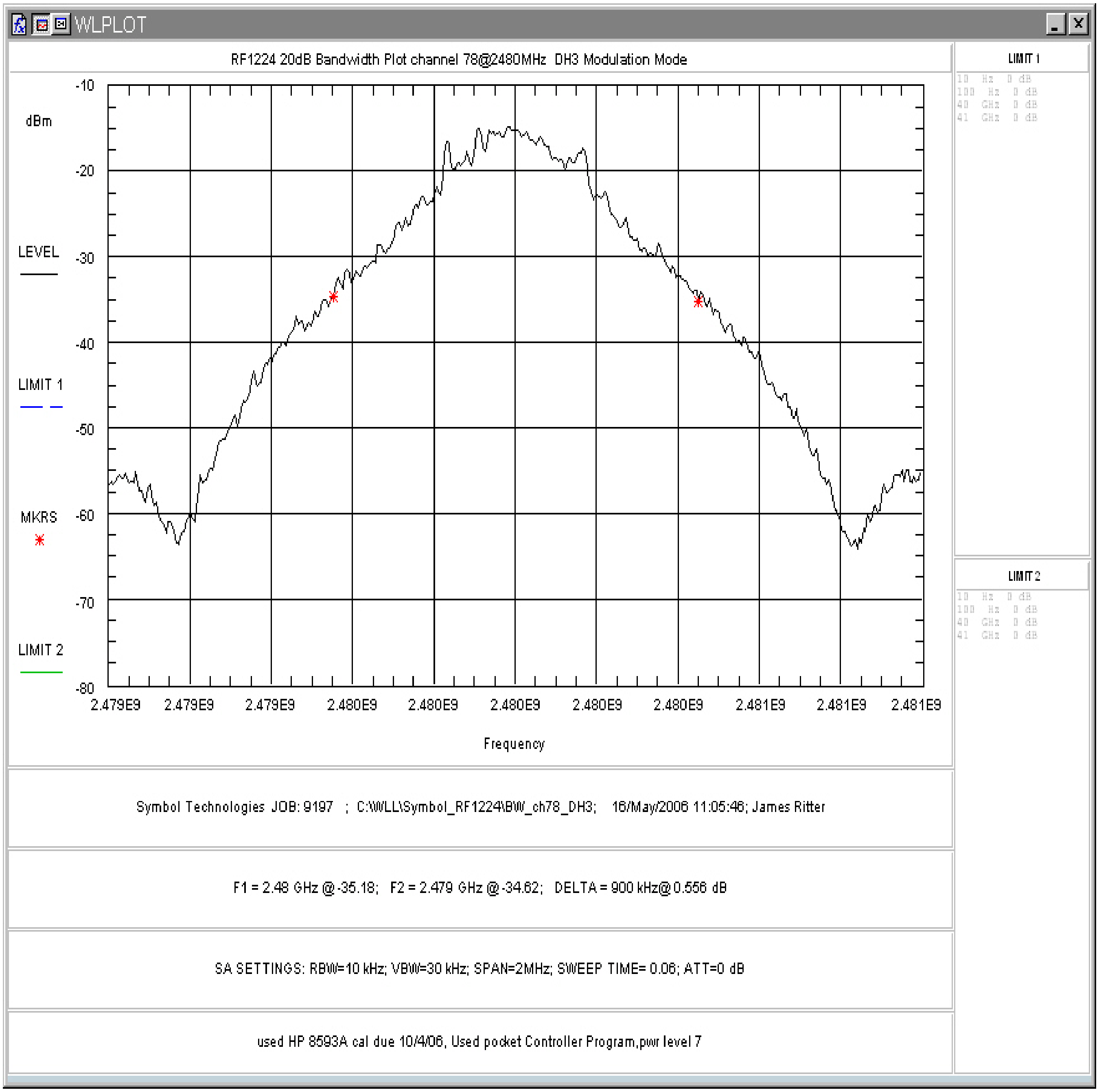

Figure 4-15. Occupied Bandwidth, High Channel, DH3

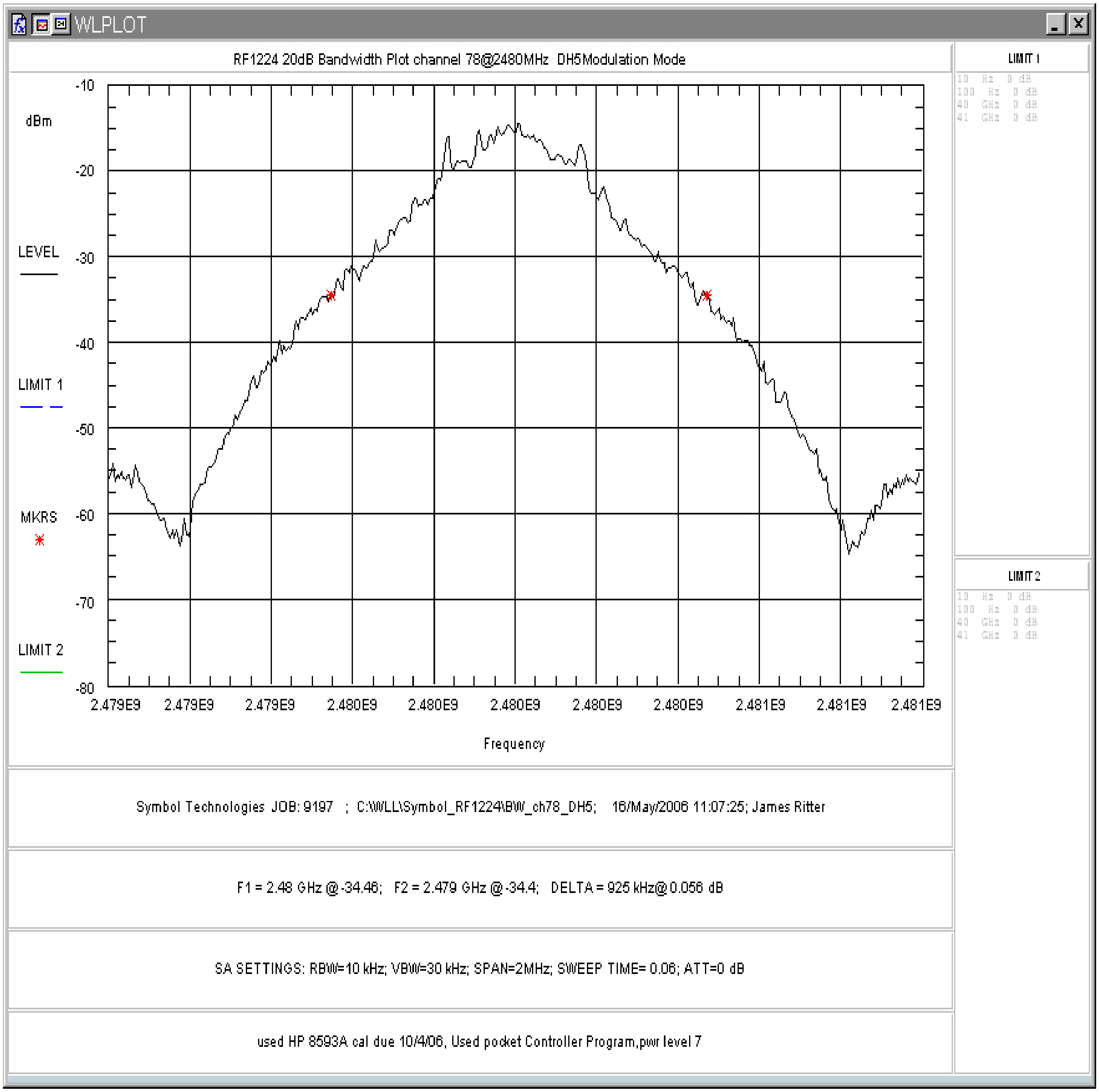

Figure 4-16. Occupied Bandwidth, High Channel, DH5

4.4 Channel Spacing and Number of Hop Channels (FCC Part §15.247(a)(1))

Per the FCC requirements, frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20 dB bandwidth, whichever is greater. The maximum 20dB bandwidth measured is 950.375kHz so the channel spacing must be more than 950.375kHz. In addition, for a 2.4GHz the number of hopping channels shall be stated.

A receive antenna was placed near the EUT for measuring the Channel Separation and Number of Channels. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 100 kHz. The channel spacing of 2 adjacent channels was measured using a spectrum analyzer span setting of 2MHz. Also, the number of hopping channels was measured from 2.4GHz to 2.483GHz.

The following are plots of the channel spacing and number of hopping channels data. The channel spacing was measured to be 1.019MHz and the number of channels used is 79.

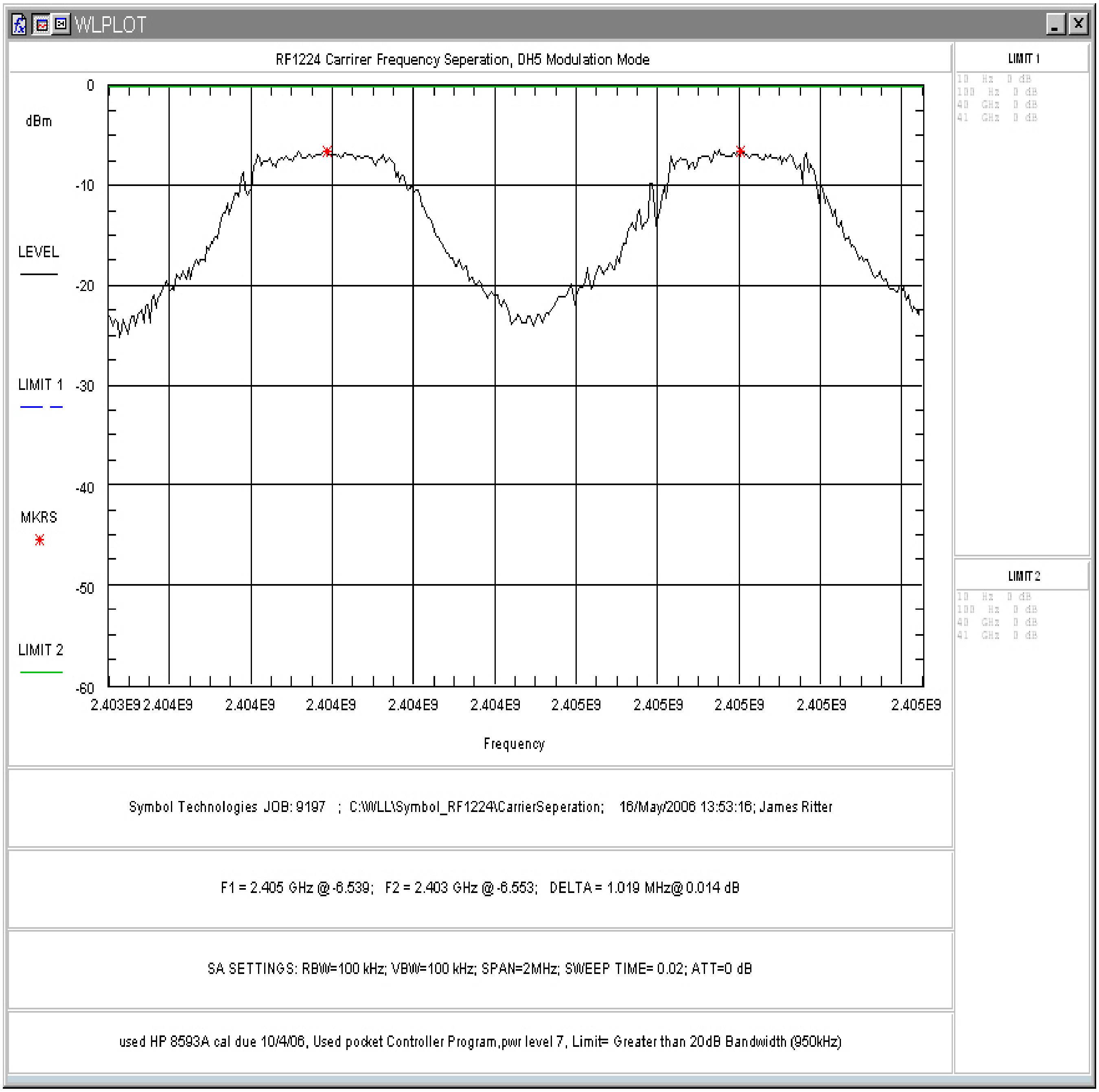

Figure 4-17, Channel Separation, 1.019MHz

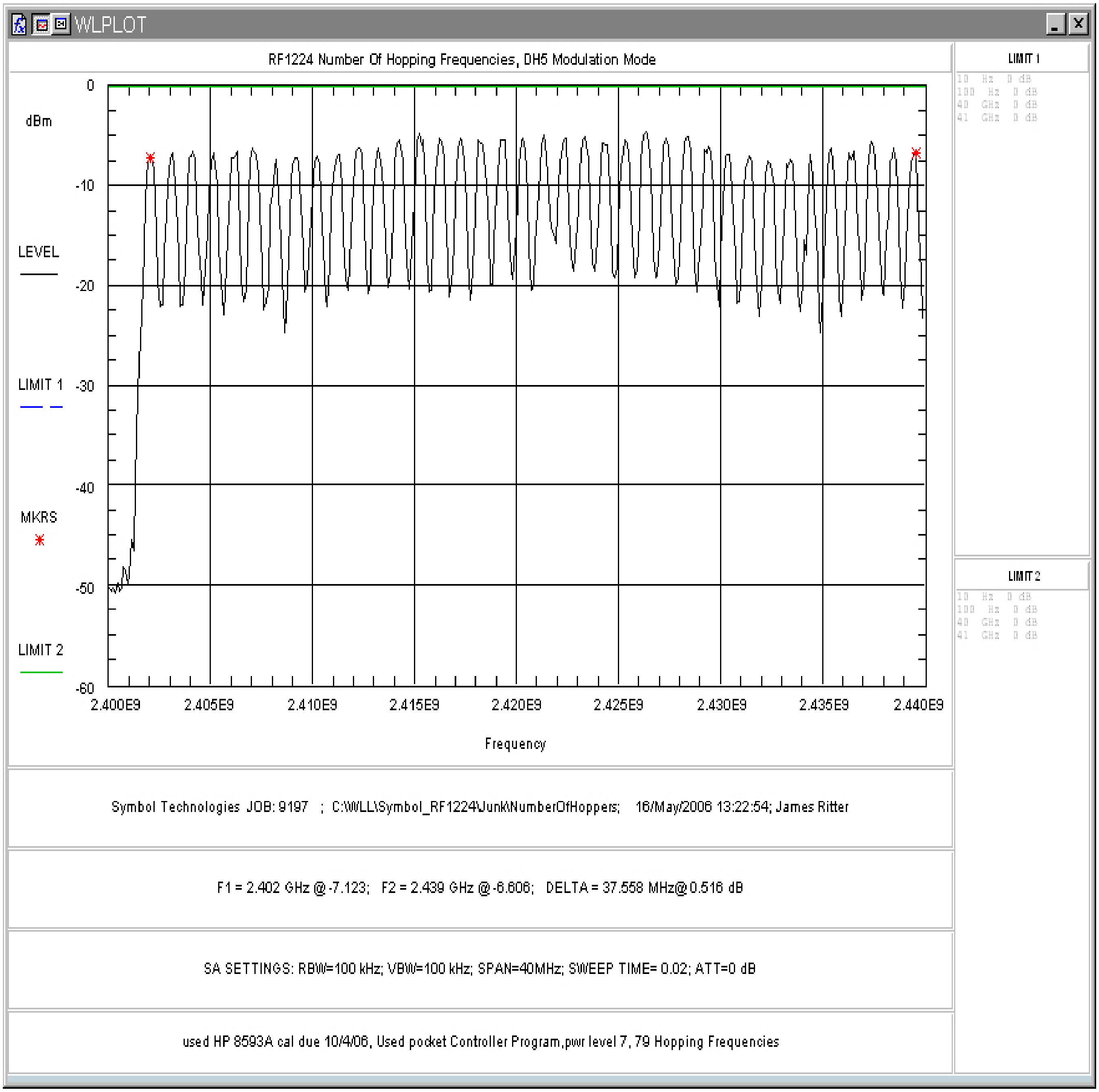

Figure 4-18, Number of Channels, Plot 1

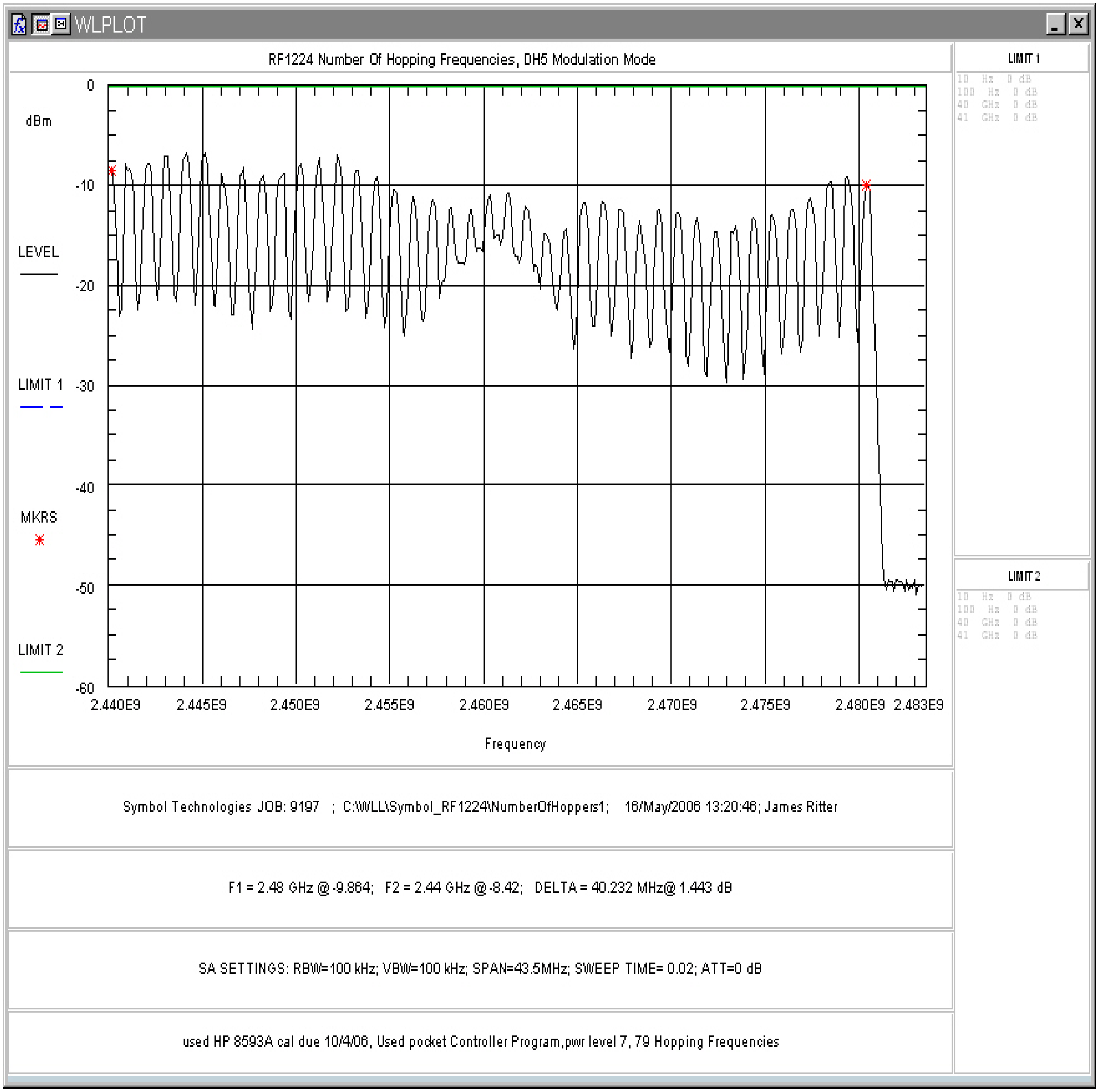

Figure 4-19, Number of Channels, Plot 2

4.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §2.1051)

The EUT must comply with requirements for spurious emissions at antenna terminals. Per §15.247(c) all spurious emissions in any 100 kHz bandwidth outside the frequency band in which the spread spectrum device is operating shall be attenuated 20 dB below the highest power level in a 100 kHz bandwidth within the band containing the highest level of the desired power.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 100 kHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit (20 dB below the carrier frequency amplitude). The emissions outside of the allocated frequency band were then scanned from 30 MHz up to the tenth harmonic of the carrier.

Conducted spurious emissions testing was performed in the DH1 mode for the high channel, DH3 mode for the middle channel, and DH5 mode for the low channel with the hopping disabled. Additionally, the bandedge conducted emissions testing was performed with the hopping activated.

The following are plots of the conducted spurious emissions data. Bandedge plots are shown in Figure 4-38 through Figure 4-49.

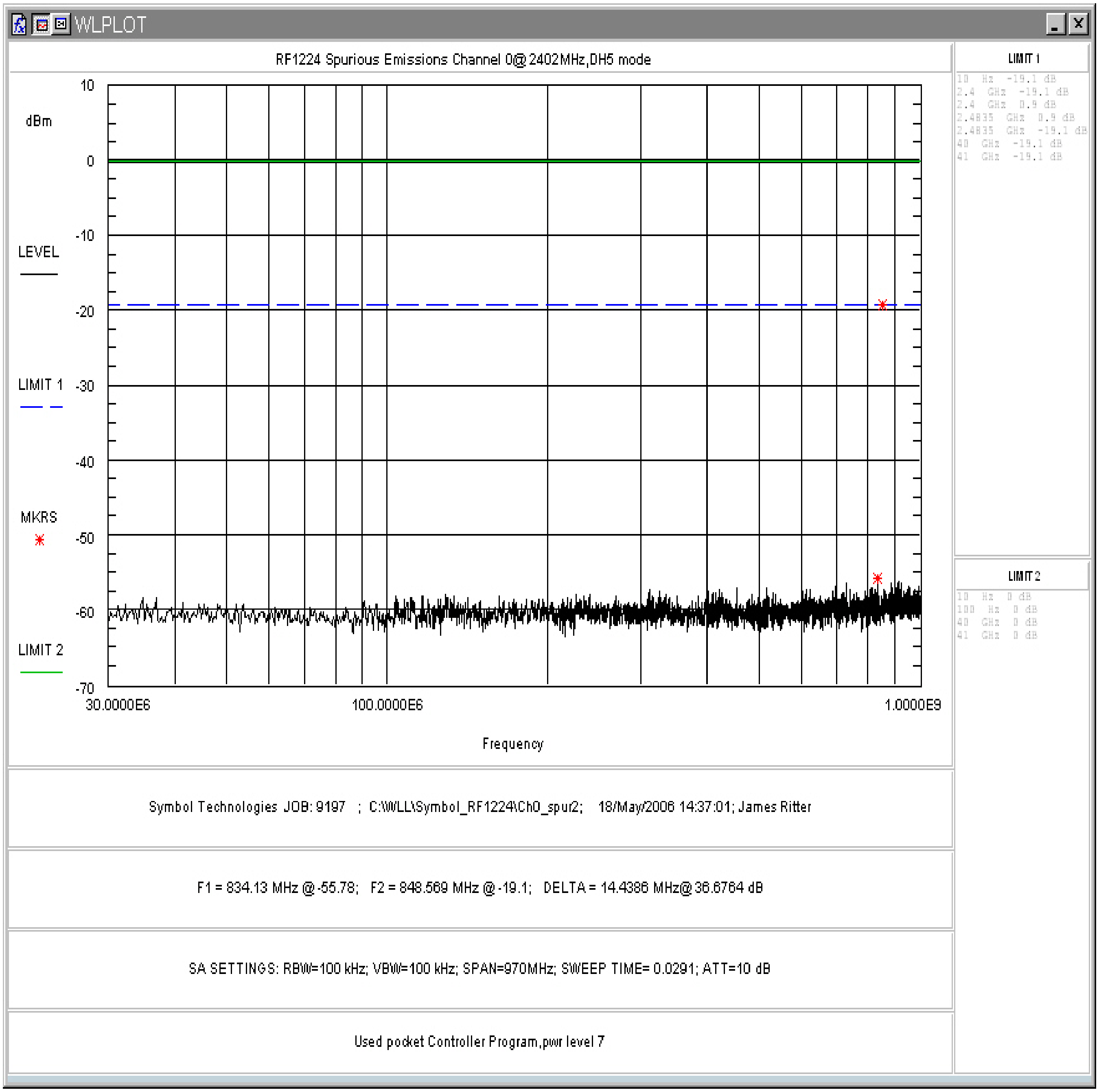

Figure 4-20. Conducted Spurious Emissions, Low Channel, DH5 Mode, 30 - 1000MHz

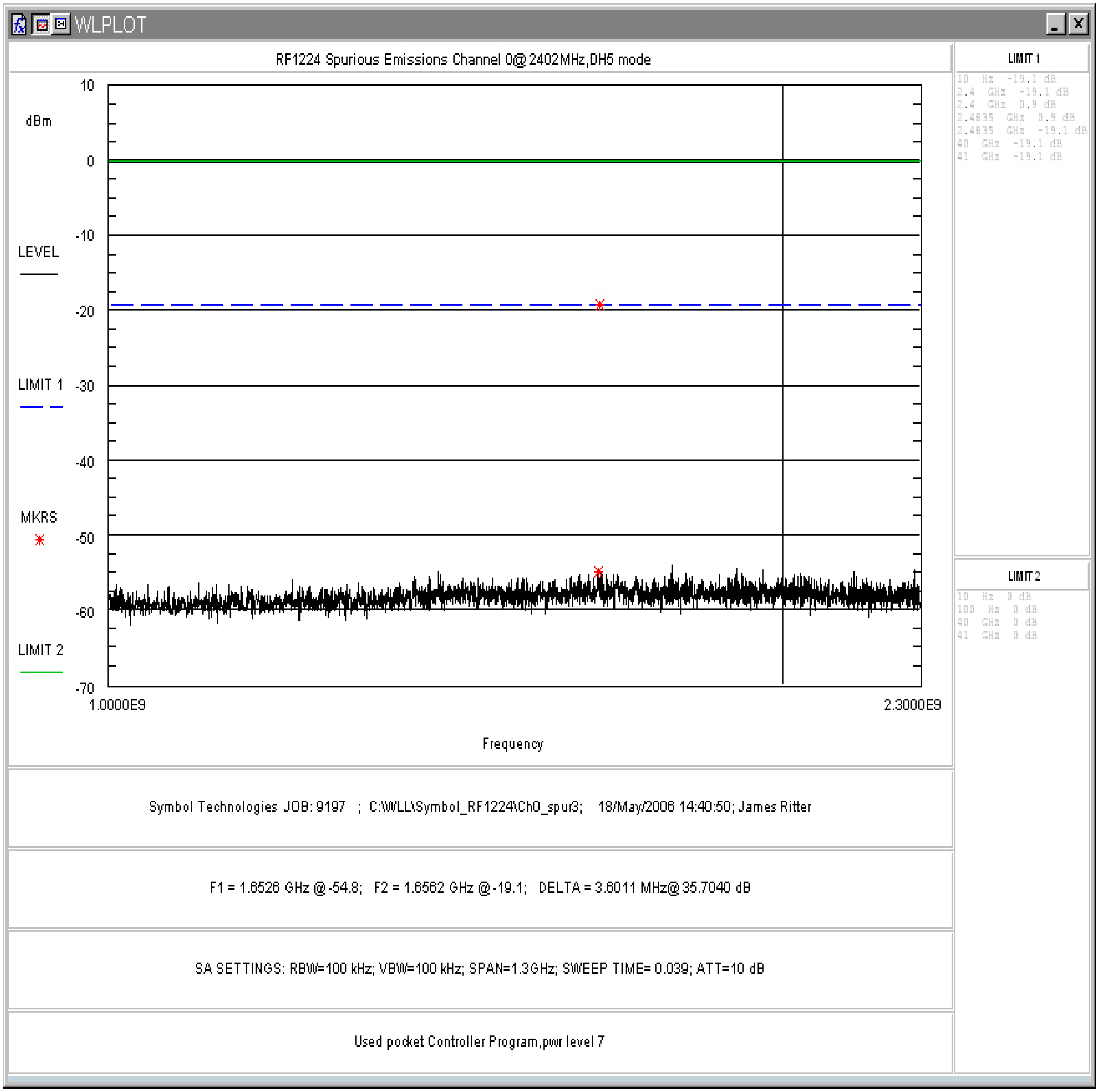

Figure 4-21. Conducted Spurious Emissions, Low Channel, DH5 Mode, 1 – 2.3GHz

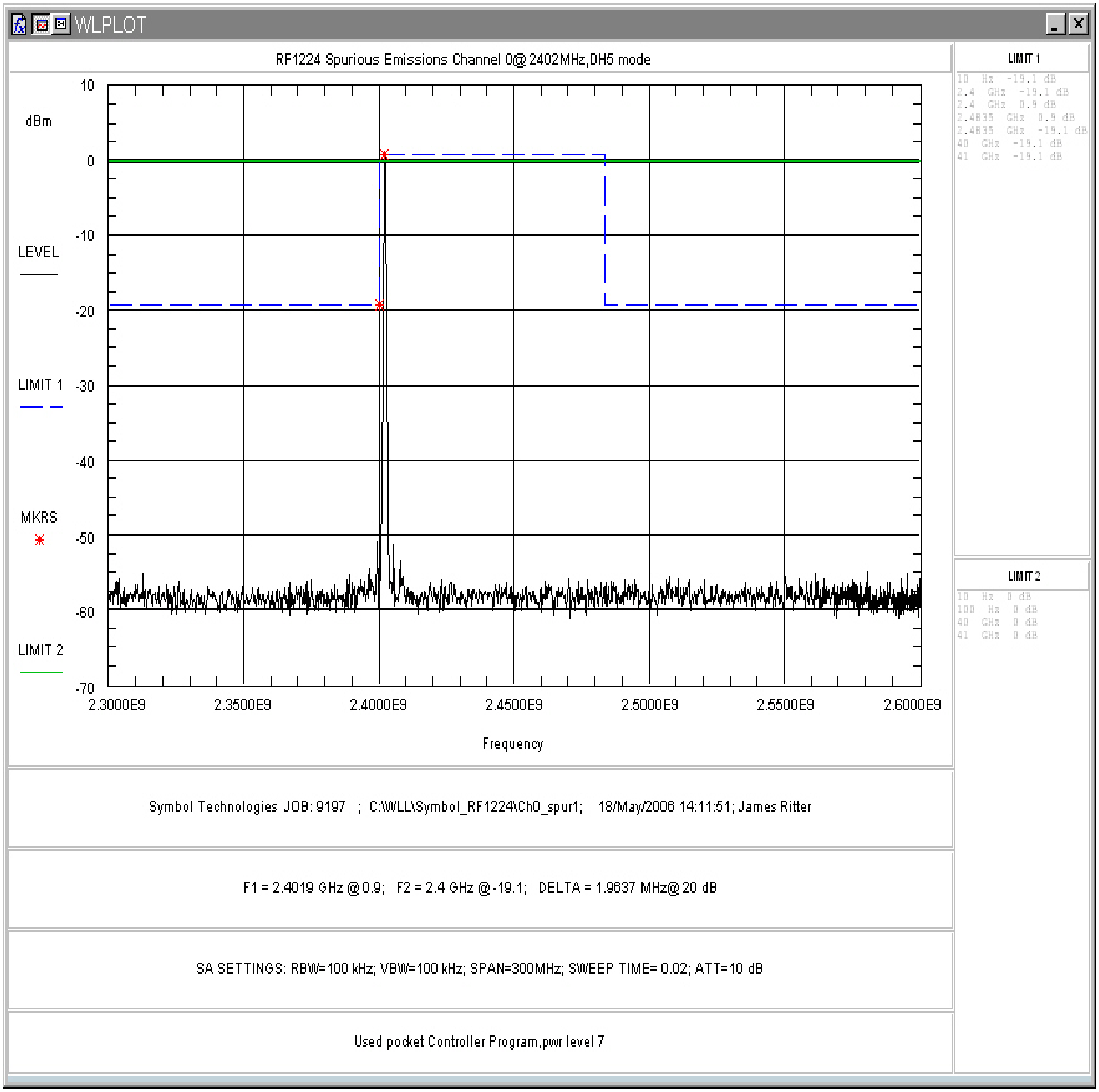

Figure 4-22. Conducted Spurious Emissions, Low Channel, DH5 Mode, 2.3 – 2.6GHz

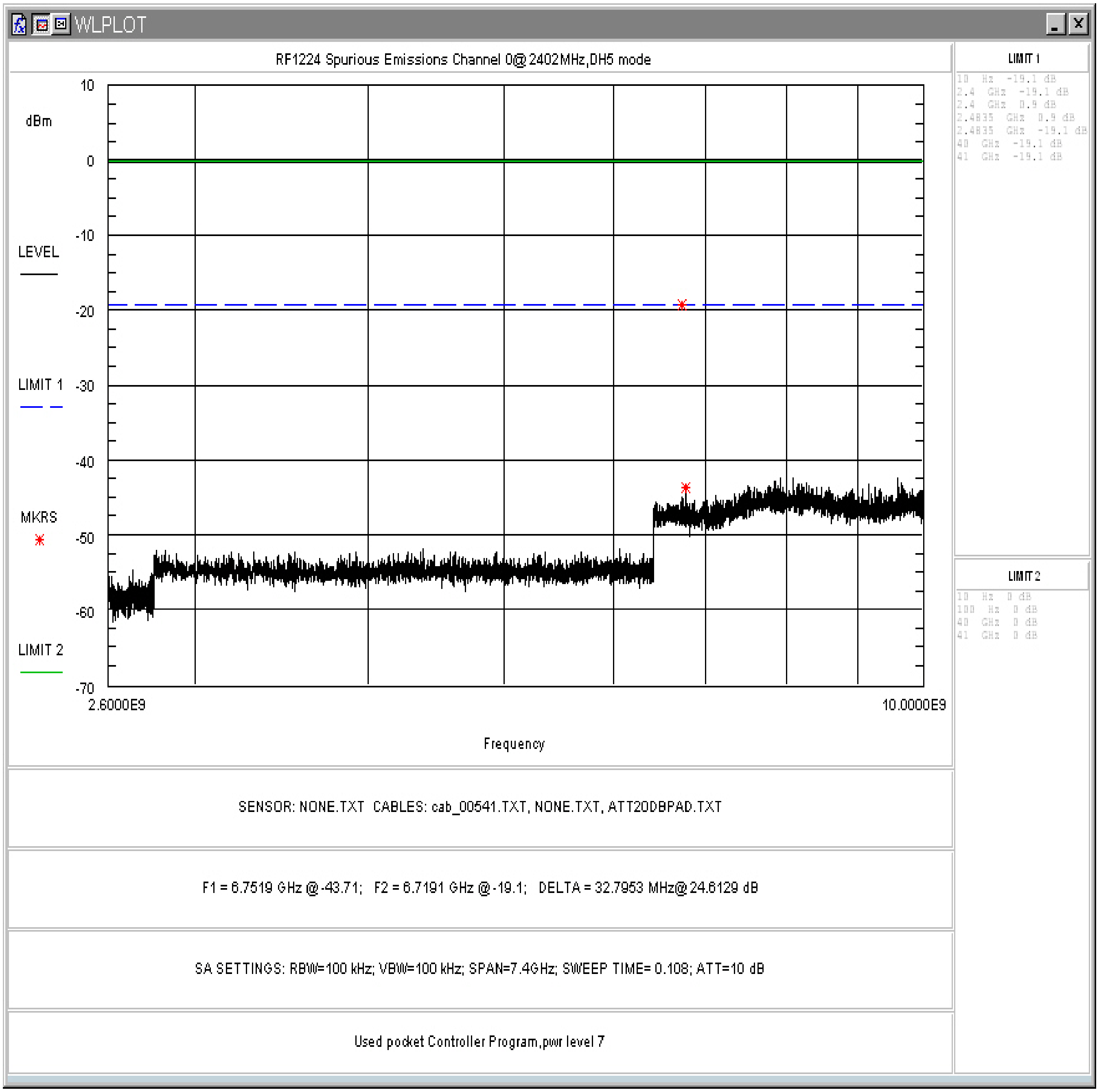

Figure 4-23. Conducted Spurious Emissions, Low Channel, DH5 Mode, 2.6 - 10GHz

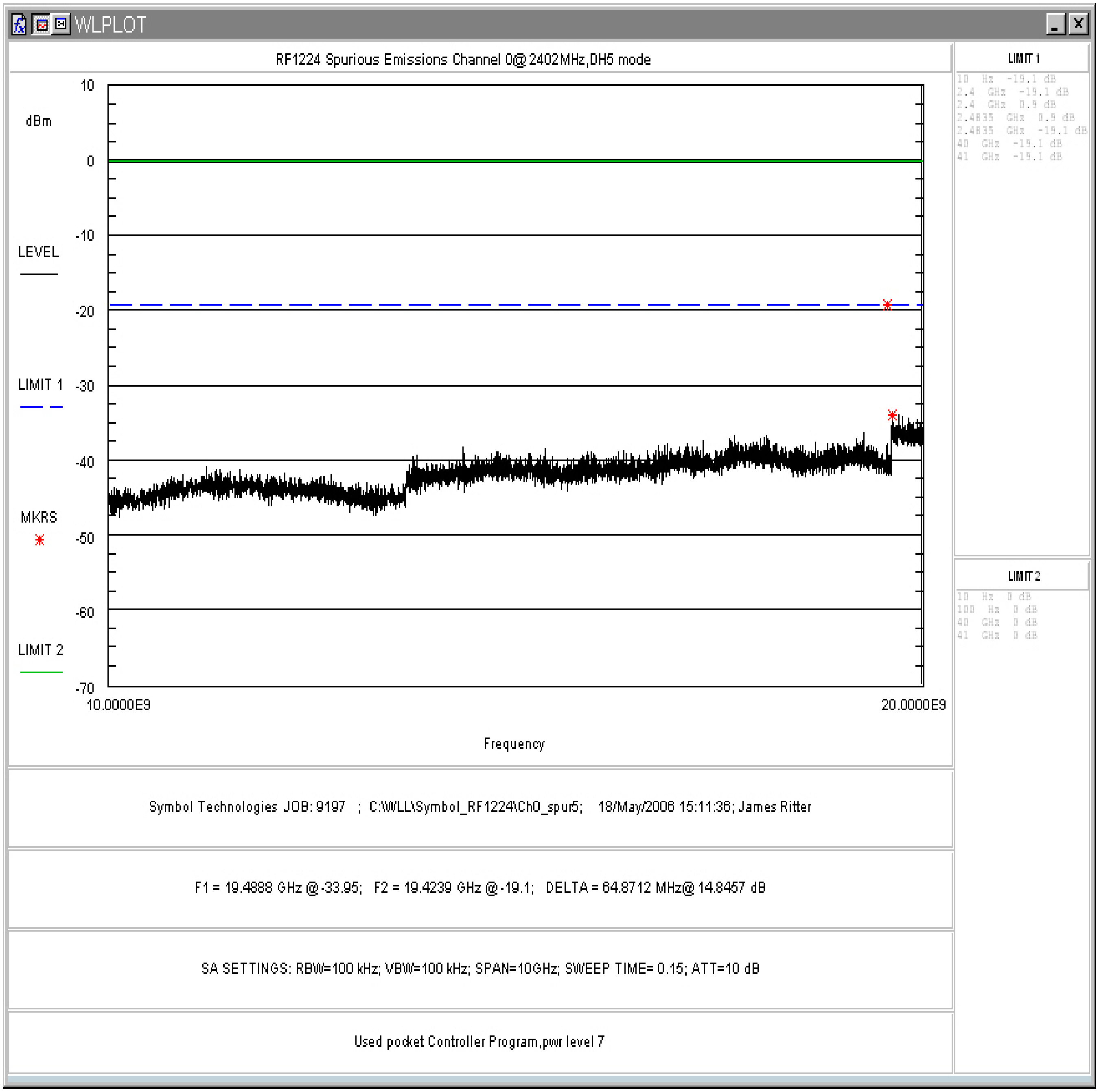

Figure 4-24. Conducted Spurious Emissions, Low Channel, DH5 Mode, 10 - 20GHz

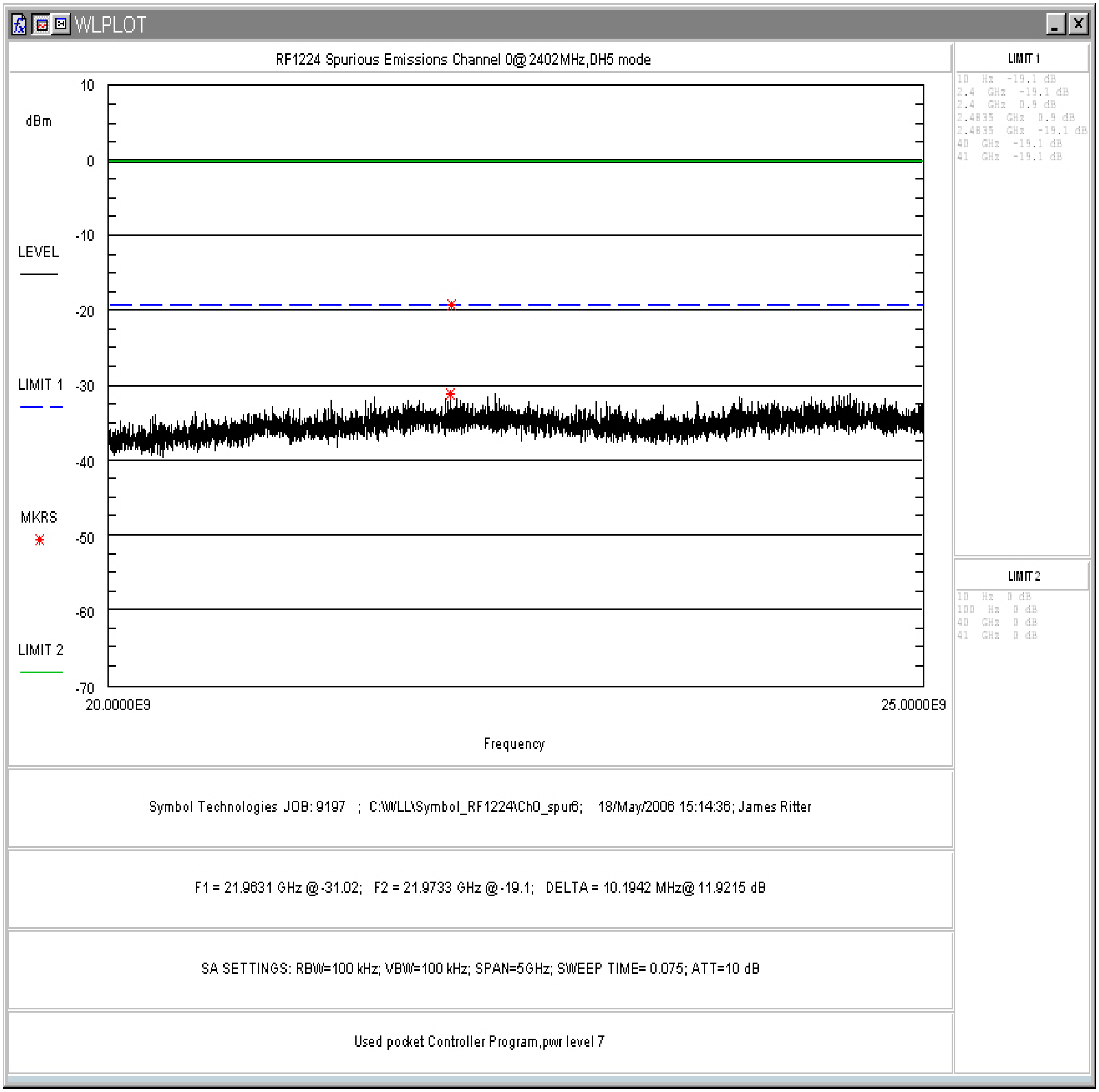

Figure 4-25. Conducted Spurious Emissions, Low Channel, DH5 Mode, 20 - 25GHz

