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FCC & Industry Canada Certification Test Report

For the

Datamatic, Ltd

D4100F Radio Module

FCC ID: ODYD4100F

IC: 4421A-D4100F

WLL JOB# **11275-01 Rev 1**
January 7, 2010
Re-issued January 18, 2010

Prepared for:
Datamatic, Ltd
3600 K Ave
Plano, TX, 75074 USA

Prepared By:

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

ACCREDITED
Testing Certificate 2675.01

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Prepared by:

James Ritter
EMC Compliance Engineer

Reviewed by:

Steven D. Koster
EMC Operations Manager

Abstract

This report has been prepared on behalf of Datamatic Ltd to support the attached Application for Equipment Authorization. The test report and application are submitted for a Frequency Hopping Spread Spectrum Transmitter under Part 15.247 (10/2008) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 issue7 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Datamatic, Ltd D4100F Radio Module.

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 the American Association for Laboratory Accreditation (A2LA) under Certificate 2675.01 as an independent FCC test laboratory.

The Datamatic, Ltd D4100F Radio module complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 and Industry Canada RSS-210.

Revision History	Description of Change	Date
Rev 0	Initial Release	January 7, 2010
Rev 1	A description of the instrumentation detector functions was added to the Receiver emissions section on page 76	January 18, 2010

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1 Introduction

1.1 Compliance Statement

The Datamatic, Ltd D4100F radio module complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247, 15.212 (10/2008) and Industry Canada RSS-210 issue 7.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Datamatic, Ltd 3600 K Ave Plano, TX, 75074 USA
Purchase Order Number:	DATAM-2000006522
Quotation Number:	65245

1.4 Test Dates

Testing was performed on the following date(s):	12/16/2009 to 12/18/2009

1.5 Test and Support Personnel

Washington Laboratories, LTD	James Ritter
Customer Representative	Ken Derry

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**ere**s**
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**c**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**m**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 Equipment Under Test

2.1 EUT Identification & Description

The Datamatic, Ltd D4100F radio module is a 902.5 – 927 MHz transceiver for use in water utility mesh networks. This EUT has 2 transmit modes of operation a normal 'Mesh Mode' and an alternative 'Driveby mode (Star or Fence Read)'. The EUT will always be powered from a battery pack unit.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Datamatic, Ltd
FCC ID:	ODYD4100F
IC:	4421A-D4100F
Model:	D4100F RADIO MODULE
FCC Rule Parts:	§15.247
Industry Canada:	RSS210 Issue 7
Frequency Range:	902.5 - 927MHz
Maximum Output Power:	21.66 dBm (0.1466 W)
Modulation:	FHSS FSK
99% Occupied Bandwidth:	133.7kHz (Mesh Mode) 260.1kHz (Driveby Mode {Star or Fence Read})
Keying:	Automatic, Manual
Type of Information:	Data
Number of Channels:	50
Power Output Level	Fixed
Antenna Connector	Internal
Antenna Type	Integral helical antenna
Antenna Gain:	1dBi
Interface Cables:	Unshielded sensor cable
Power Source & Voltage:	Dual 3.6V Lithium Thionylchloride Battery
Receiver spurious	16.8uV/m @ 3m- 37.87MHz
Transmitter spurious	349.9 uV/m @ 3m – 4512.5MHz
Emissions Designator	260KFXD

2.2 Test Configuration

The D4100F radio module was configured with an integral antenna. A test port on the module circuit board was connected to a support laptop to run the test configurations. The sensor cables were left un-terminated for this test

2.3 Testing Algorithm

The D4100F radio module was programmed via a support laptop to continuously transmit on 902.5, 915, and 927MHz. The unit was also programmed to hop it its normal operating mode. The EUT has 2 modes of operation a normal 'Mesh Mode' and an alternative 'Driveby Mode', both modes were evaluated for compliance.

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 the American Association for Laboratory Accreditation (A2LA) under Certificate 2675.01 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 Methods of Measurement of Radio Noise 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. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a, b, c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where U = expanded uncertainty

k = coverage factor

k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 2 below.

Table 2: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	4.55 dB

3 Test Equipment

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

Table 3: Test Equipment List

Test Name: **Radiated Emissions**		Test Date: **12/17/2009**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
618	HP 8563A	Analyzer, Spectrum	04/10/2010
66	HP, 8449B	Pre-Amplifier, RF. 1-26.5GHz	07/21/2010
337	WLL, 1.2-5GHz	Filter, Band Pass	02/19/2010
66	HP, 8449B	Pre-Amplifier, RF. 1-26.5GHz	07/21/2010
626	ARA, DRG-118/A	Antenna, Horn	06/03/2011
644	Sunol Science JB1 925-833-9936	BiConalog Antenna	12/29/2009
69	HP, 85650A	Adapter, QP	06/28/2010
71	HP, 85685A	Preselector, RF	06/28/2010
73	HP, 8568B	Analyzer, Spectrum	06/28/2010

Test Name: **Bench conducted**		Test Date: **12/18/2009**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
618	HP 8563A	Analyzer, Spectrum	04/10/2010

4 Test Summary

The Table Below shows the results of testing for compliance with a Digital Transmission System in accordance with FCC Part 15.247:2007 and RSS210e issue 7. Full results are shown in section 5.

Table 4: Test Summary Table

TX Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (a)(1)(i)	RSS-210 [A8. 1 (c)]	20dB Bandwidth	Pass
15.247 (b)(2)	RSS-210 [A8.4 (1)]	Transmit Output Power	Pass
15.247 (a)(1)	RSS-210 [A8.1 (b)]	Channel Separation	Pass
15.247 (a)(1)(i)	RSS-210 [A8. 1 (c)]	Number of Channels =50 minimum	Pass
15.247 (a)(1)(i)	RSS-210 [A8. 1 (c)]	Time of Occupancy	Pass
15.247 (d)	RSS-210 [A8. 5]	Occupied BW / Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-210 Sect.2.2	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	NA (battery powered)
RX/Digital Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	NA (battery powered)
15.209	RSS-210 sect 2.6	General Field Strength Limits	Pass

5 Test Results

5.1 Time of Occupancy (15.247 (a)(1)(i) & RSS-210 [A8. 1 (c)])

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period for bandwidth less than 250 kHz (Mesh Mode) and not be greater than 0.4 seconds within a 10 second period for bandwidth greater than 250 kHz (Driveby Mode)

From Figures 1 and 2 it is determined that for Mesh mode:

Single pulse duration is 106.7ms

In a 20 s sweep period 1 pulses occurs, and

Therefore the total on time is 106.7ms

From Figures 3 and 4 it is determined that for driveby mode:

Single pulse duration is 40.67ms

In a 10 s sweep period 1 pulses occurs, and

Therefore the total on time is 40.67ms

The EUT complies with the requirement in both modes of operation.

Job 11275 Datamatic D4100 Water Firefly Rev F, Single Pulse On Time- Mesh Mode

Single pulse On Time = 106.7mSec

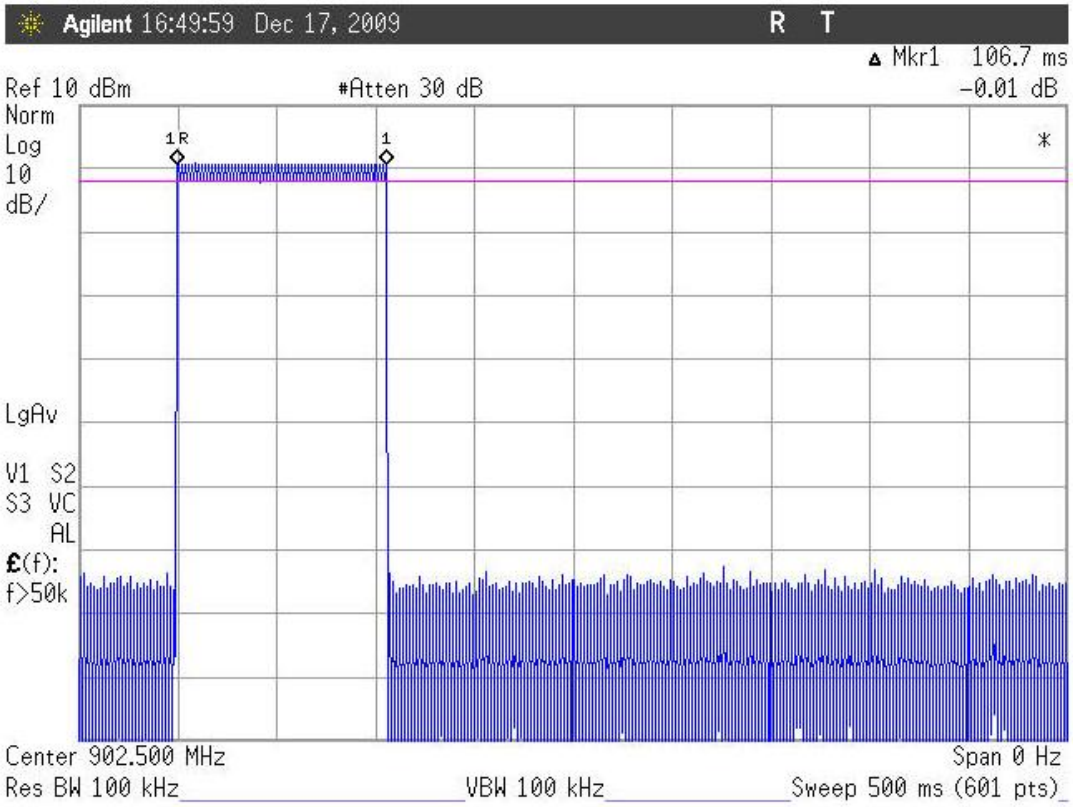

Figure 1: Duty Cycle Plot- Mesh Mode

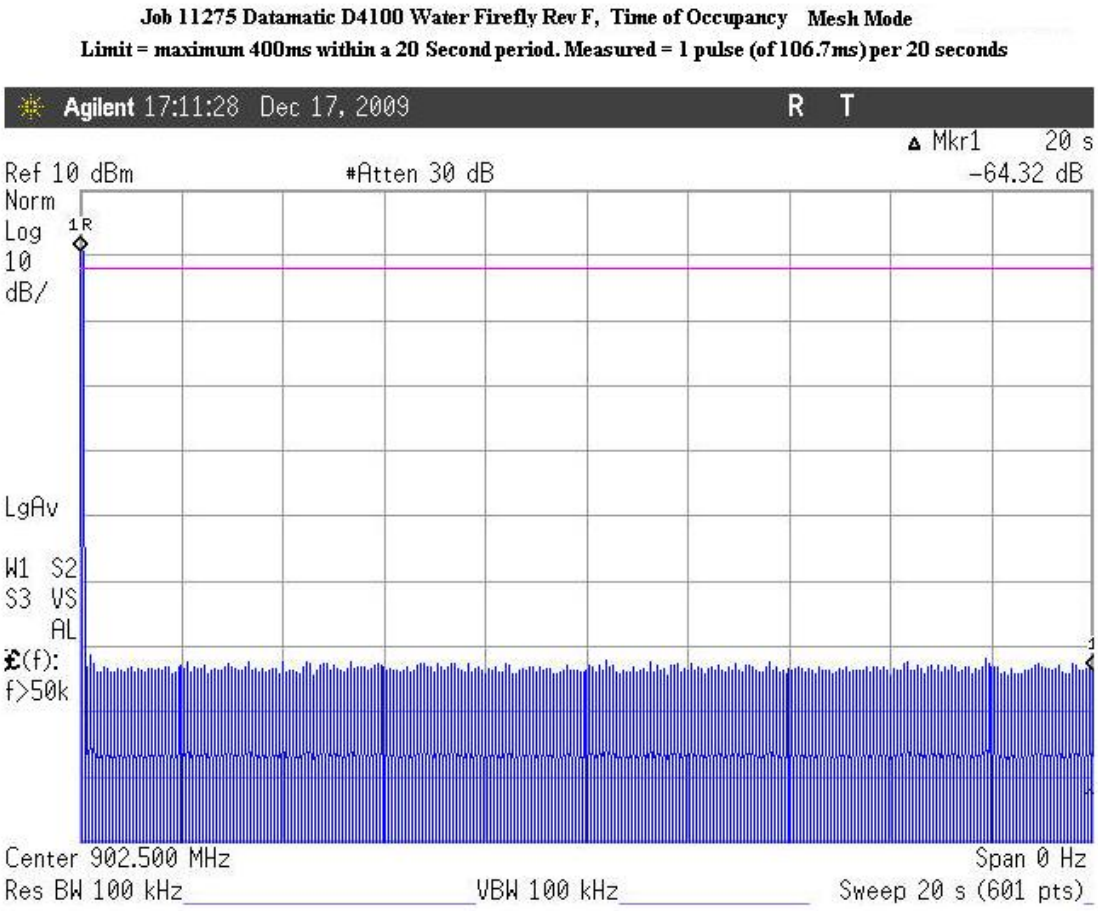

Figure 2: Time of Occupancy per 20 Seconds- Mesh Mode

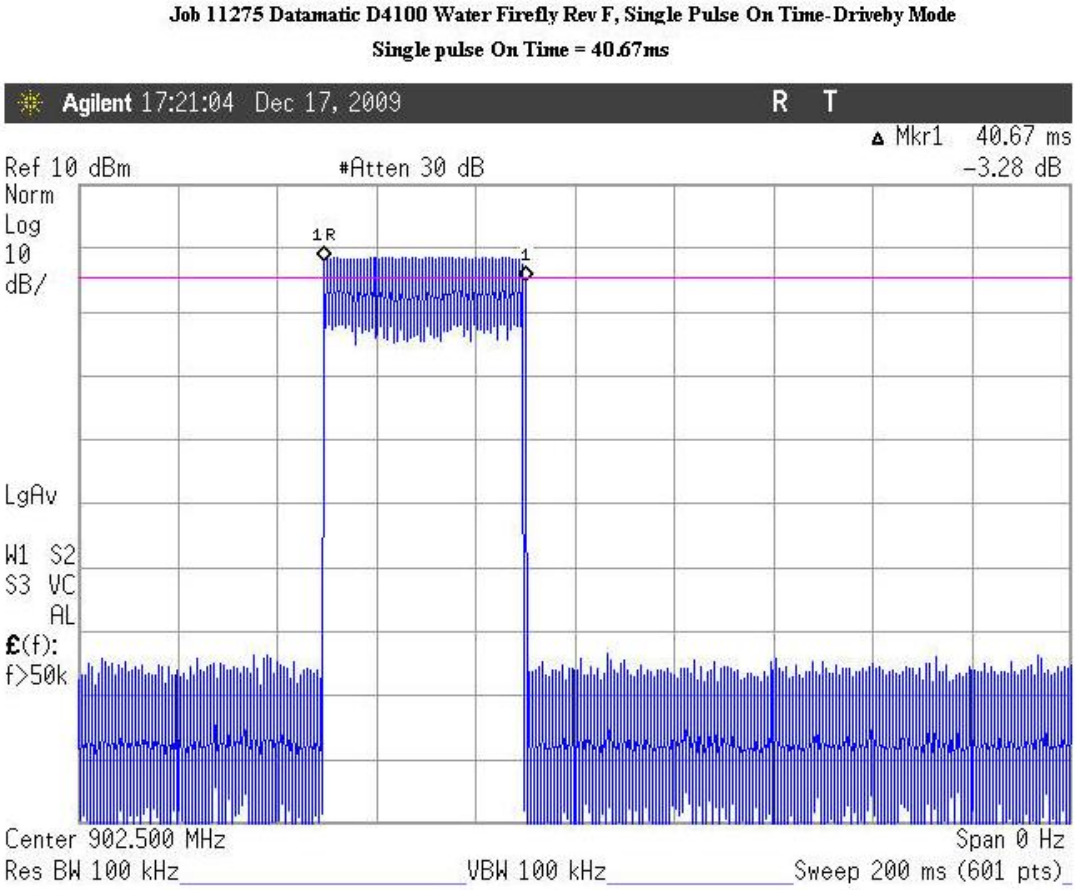

Figure 3: Duty Cycle- Driveby Mode

Job 11275 Datamatic D4100 Water Firefly Rev F, Time of Occupancy Driveby Mode
Limit = maximum 400ms within a 10 Second period (for Bandwidth >250kHz) Measured = 1 pulse (of 40.67ms) per 10 seconds

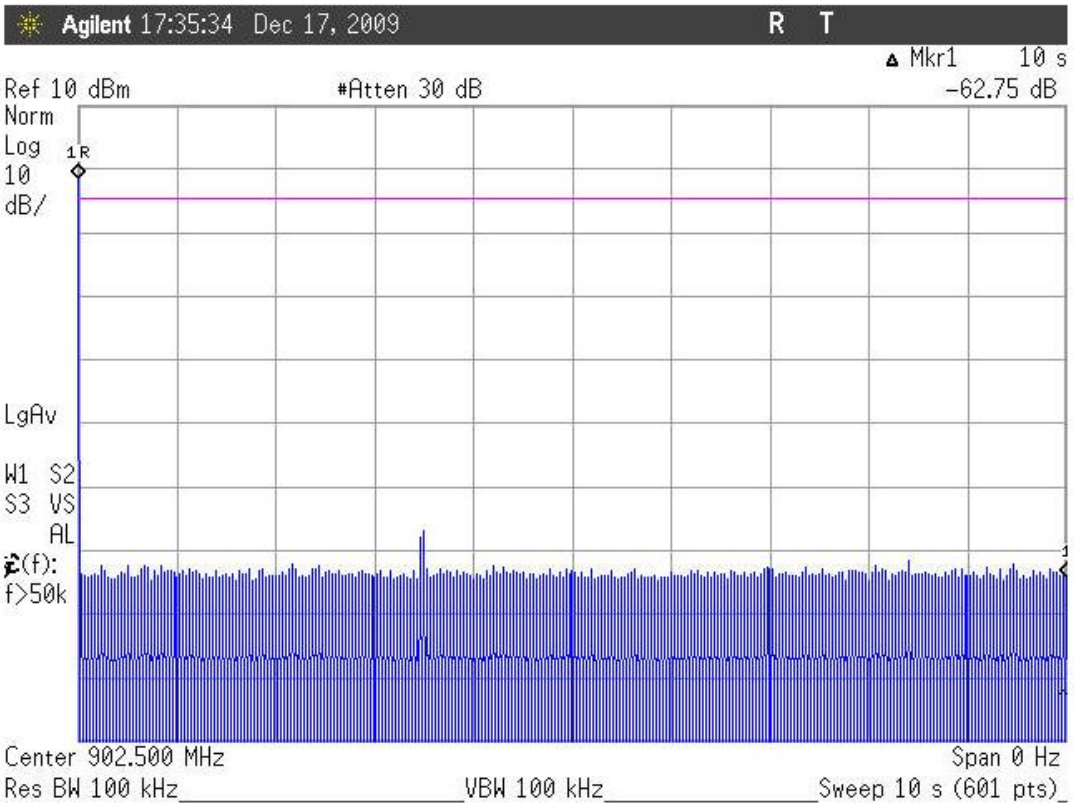

Figure 4: Time of Occupancy per 10 Seconds- Driveby Mode

5.2 RF Power Output: (15.247 (b)(2) & RSS-210 [A8.4 (1)])

To measure the output power the hopping sequence was stopped while the frequency dwelled on a low, high and Center channel. The output from the transmitter was connected to an attenuator and then to the input of the RF Spectrum Analyzer. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system.

Table 5: RF Power Output

Frequency	Mode	Level	Limit	Pass/Fail
Low Channel: 902.5MHz	Mesh	21.66 dBm	30 dBm	Pass
Center Channel: 915MHz	Mesh	21.48 dBm	30 dBm	Pass
High Channel: 927MHz	Mesh	21.06 dBm	30 dBm	Pass
Low Channel: 902.5MHz	Driveby	21.65 dBm	30 dBm	Pass
Center Channel: 915MHz	Driveby	21.48 dBm	30 dBm	Pass
High Channel: 927MHz	Driveby	21.06 dBm	30 dBm	Pass

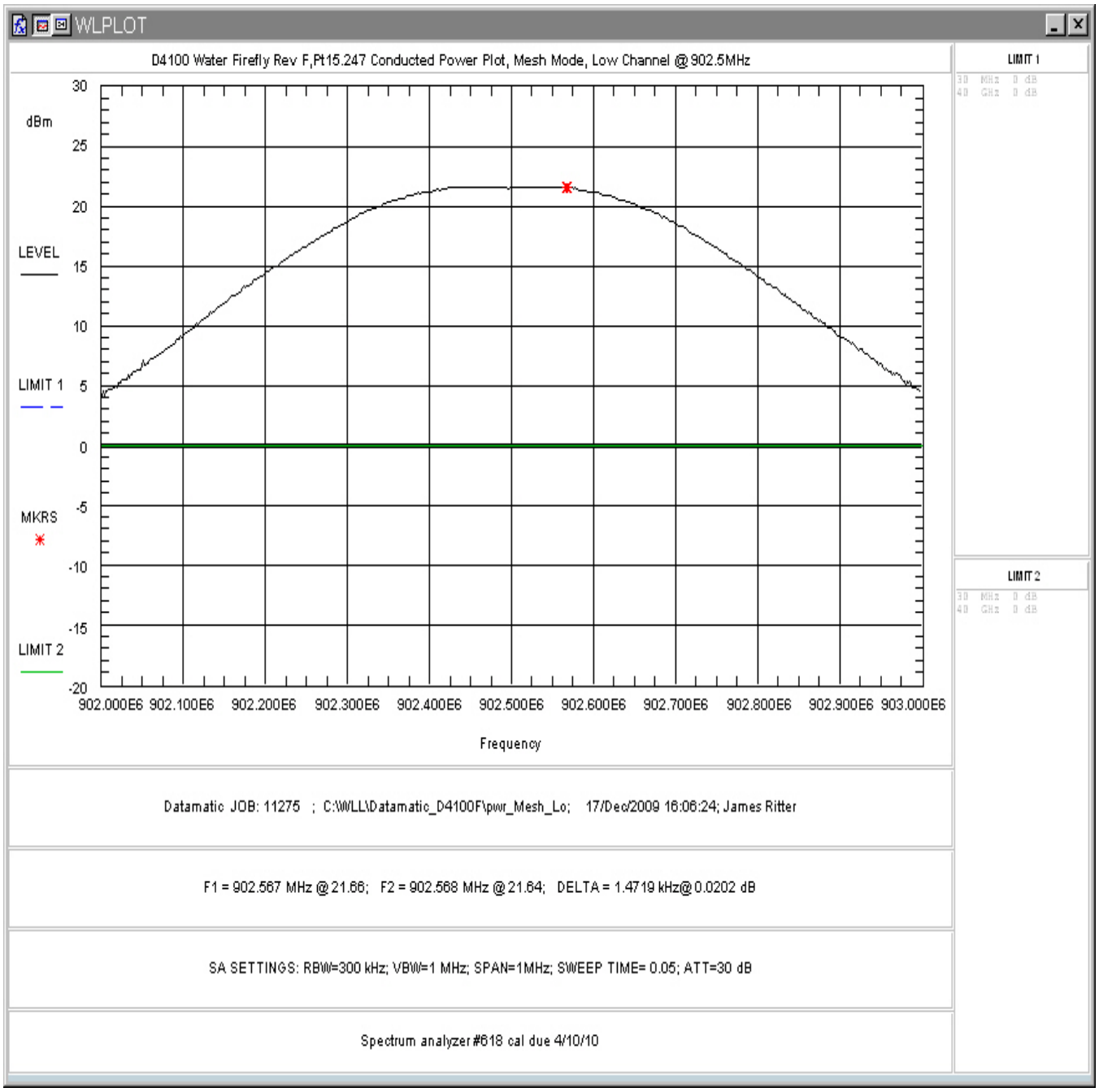

Figure 5: RF Peak Power, Low Channel, Mesh Mode

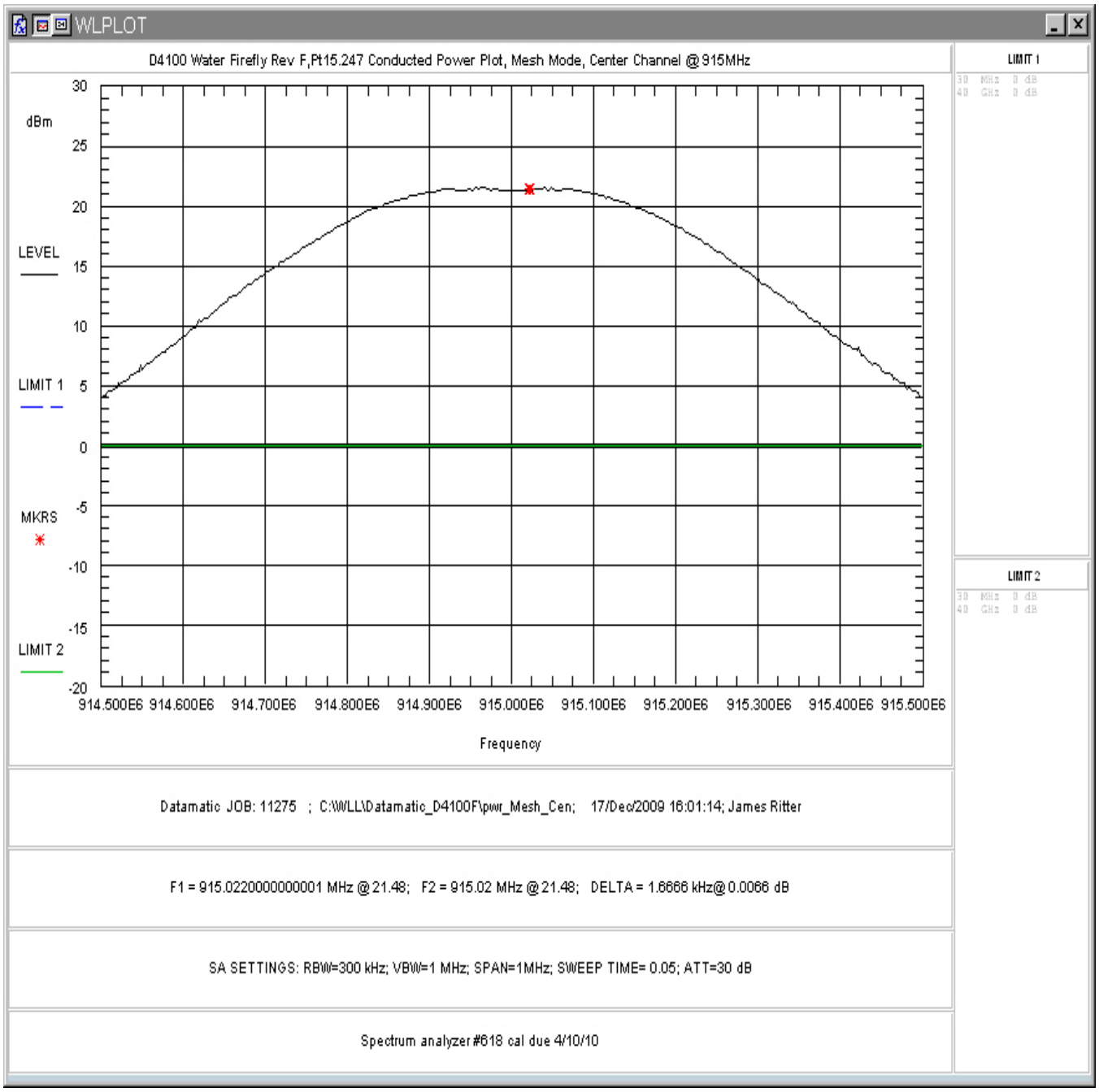

Figure 6: RF Peak Power, Center Channel, Mesh Mode

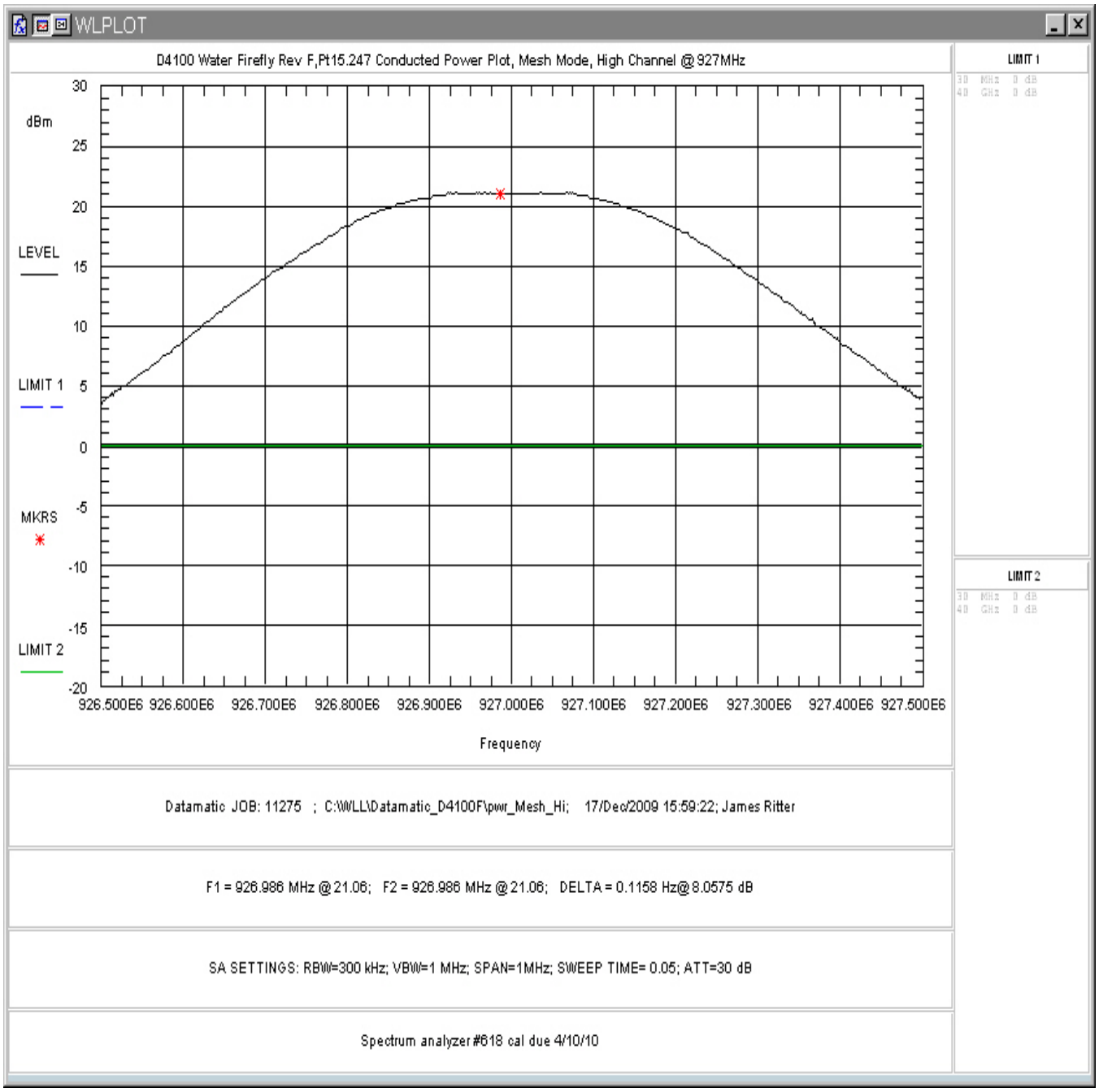

Figure 7: RF Peak Power, High Channel, Mesh Mode

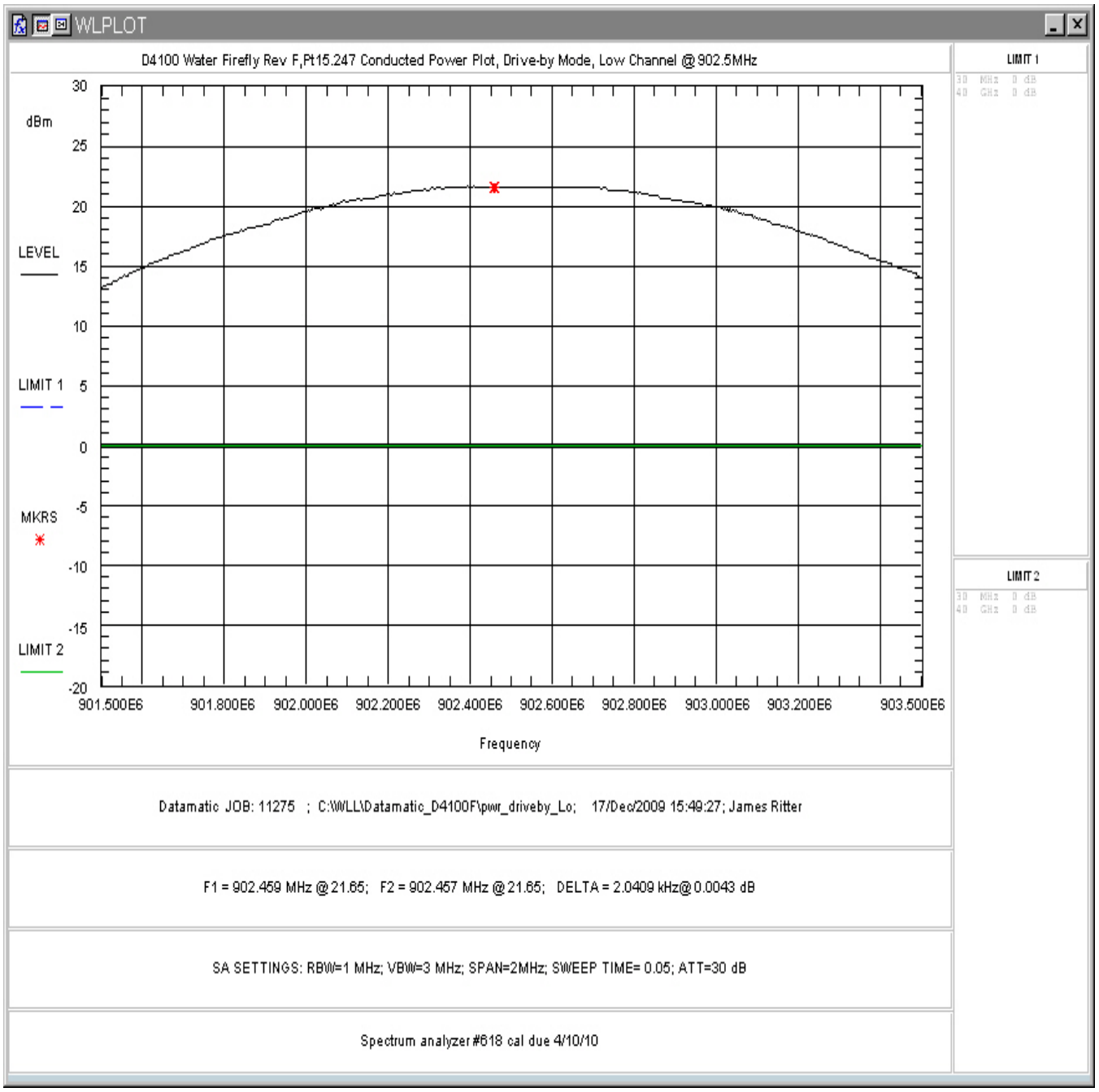

Figure 8: RF Peak Power, Low Channel, Driveby Mode

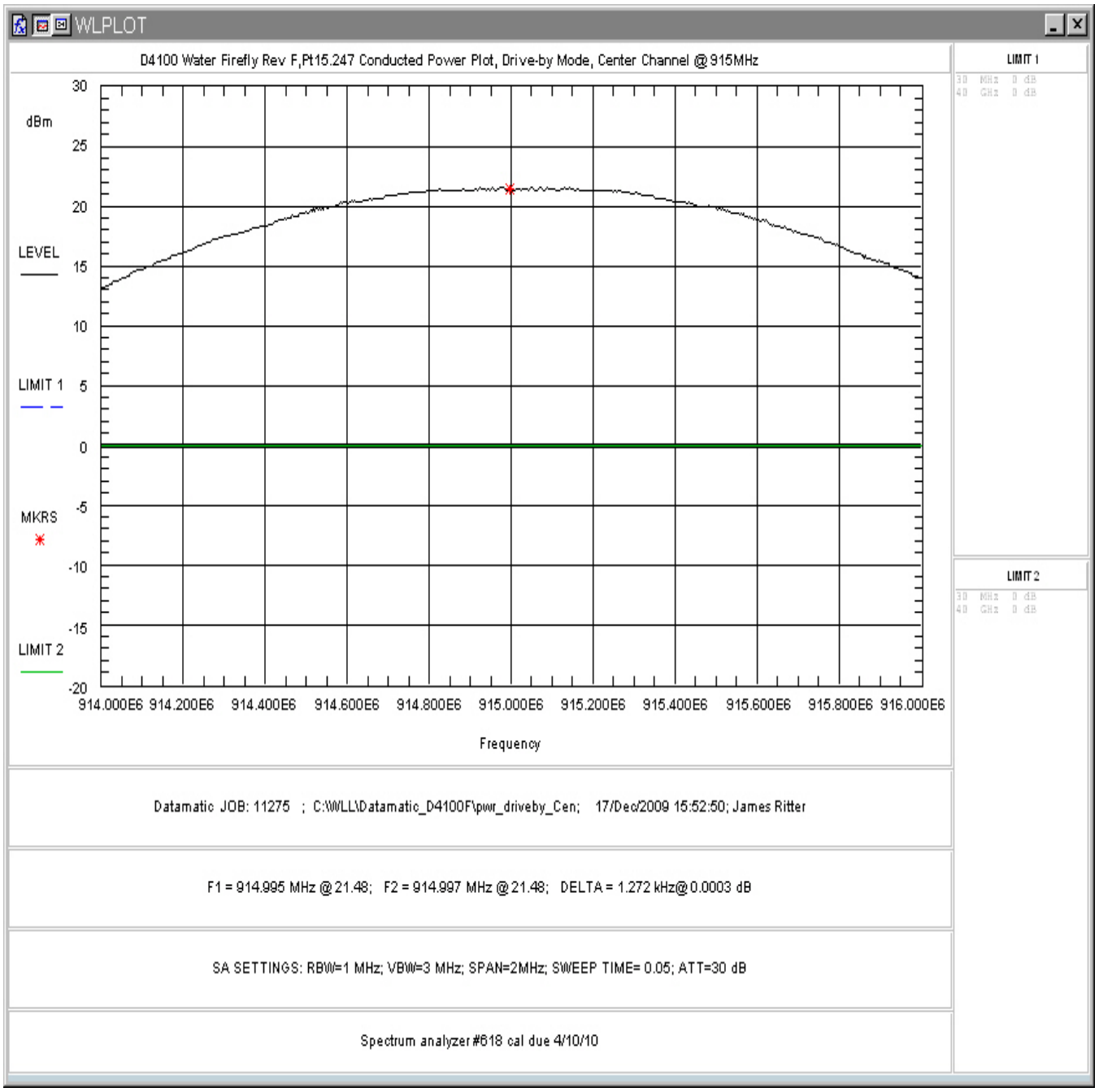

Figure 9: RF Peak Power, Center Channel, Driveby Mode

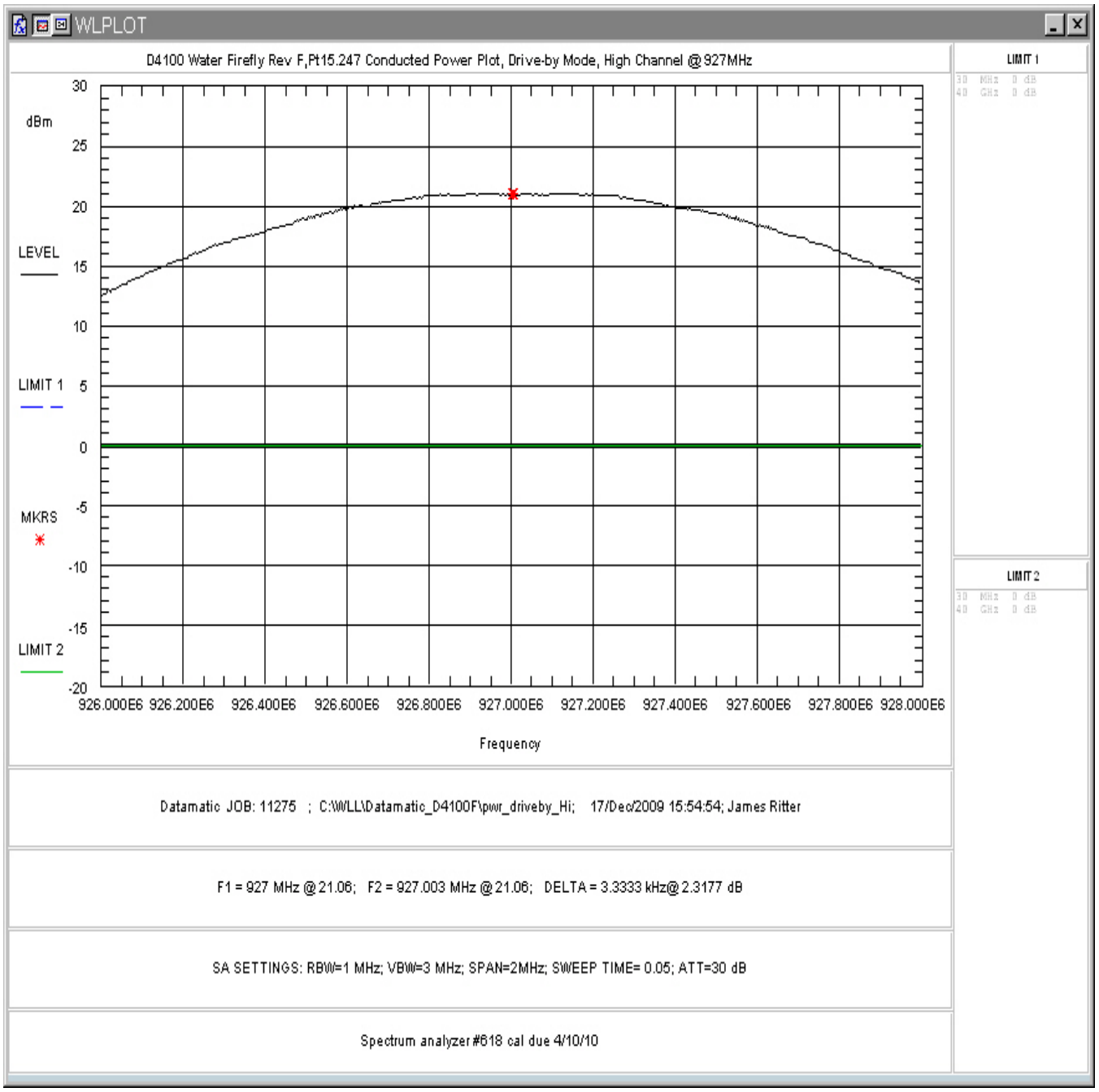

Figure 10: RF Peak Power, High Channel, Driveby Mode

5.3 99% Occupied Bandwidth: (For Industry Canada- Certification Filing)

The 99% Occupied Bandwidth Measurement was performed by coupling the output of the EUT to the input of a spectrum analyzer using the following procedure:

The spectrum analyzer was set to a resolution and video bandwidth far greater than the emission bandwidth and the peak of the signal was set to the top line of the analyzer using a sampling detector.

The analyzer resolution bandwidth was then reduced to between 1 and 3 % of the approximate emission bandwidth with the video bandwidth set to approximately 3 times the resolution bandwidth.

The marker was then placed on the trace at the point left of center that displays a value that is 20 dB below the value of the reference level. The delta marker is evoked and placed at the point to the right of center that displays 0 dB differential. The frequency differential is the occupied bandwidth. This result was used as part of the emission designator calculation.

Table 6: 99% Occupied Bandwidth Results

Frequency	Mode	Bandwidth (kHz)
Low Channel: 902.5MHz	Mesh	133.7
Center Channel: 915MHz	Mesh	133.2
High Channel: 927MHz	Mesh	133.6
Low Channel: 902.5MHz	Driveby	259.8
Center Channel: 915MHz	Driveby	260.1
High Channel: 927MHz	Driveby	259.9

Job 11275 Datamatic D4100F Radio Module, 99% Occupied Bandwidth, Mesh Mode, Low Channel @ 902.5MHz

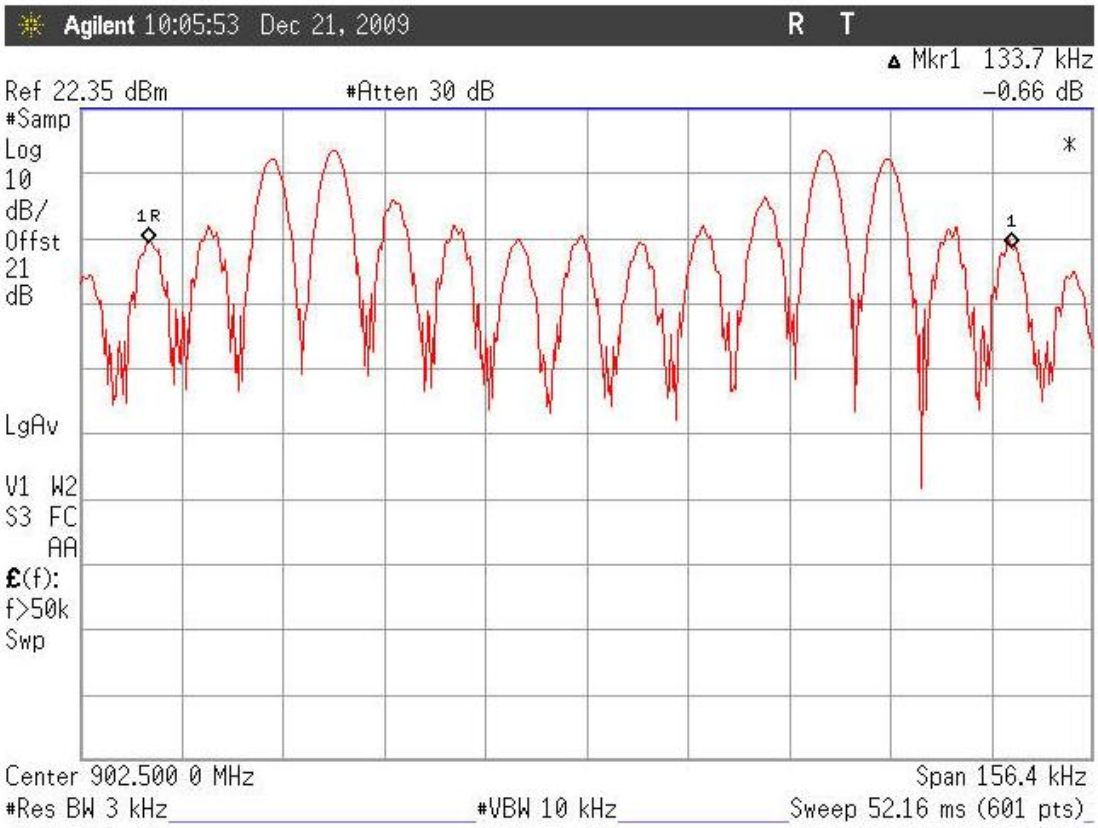

Figure 11: 99% Occupied Bandwidth, Low Channel, Mesh Mode

Job 11275 Datamatic D4100F Radio Module, 99% Occupied Bandwidth, Mesh Mode, Center Channel @ 915 MHz

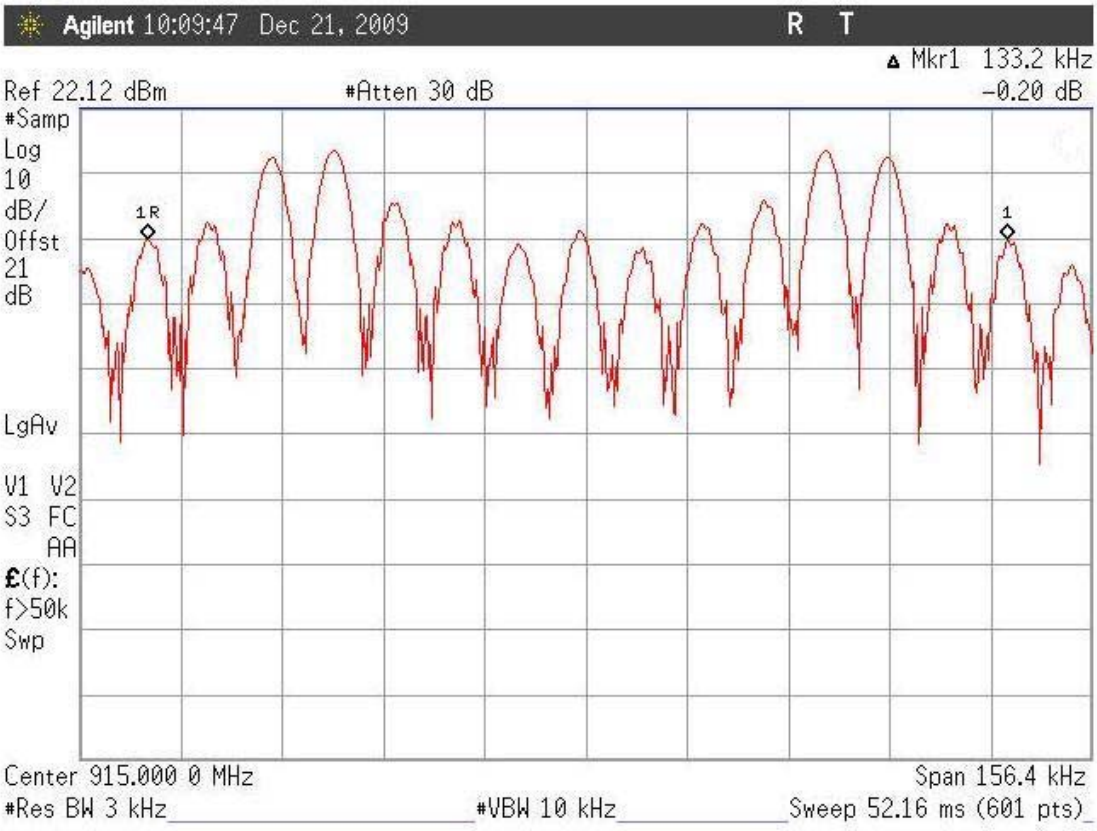

Figure 12: 99% Occupied Bandwidth, Center Channel, Mesh Mode

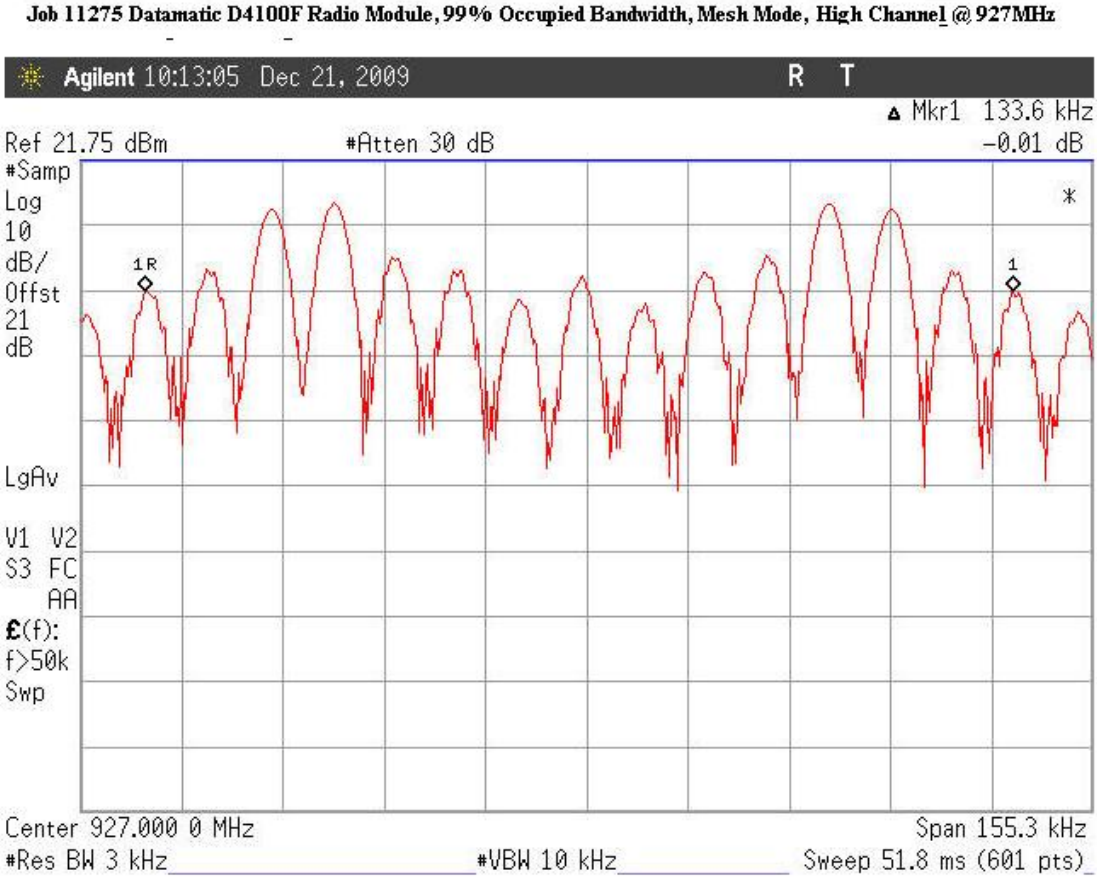

Figure 13: 99% Occupied Bandwidth, High Channel, Mesh Mode

Job 11275 Datamatic D4100F Radio Module, 99% Occupied Bandwidth, Driveby Mode, Low Channel @ 902.5MHz

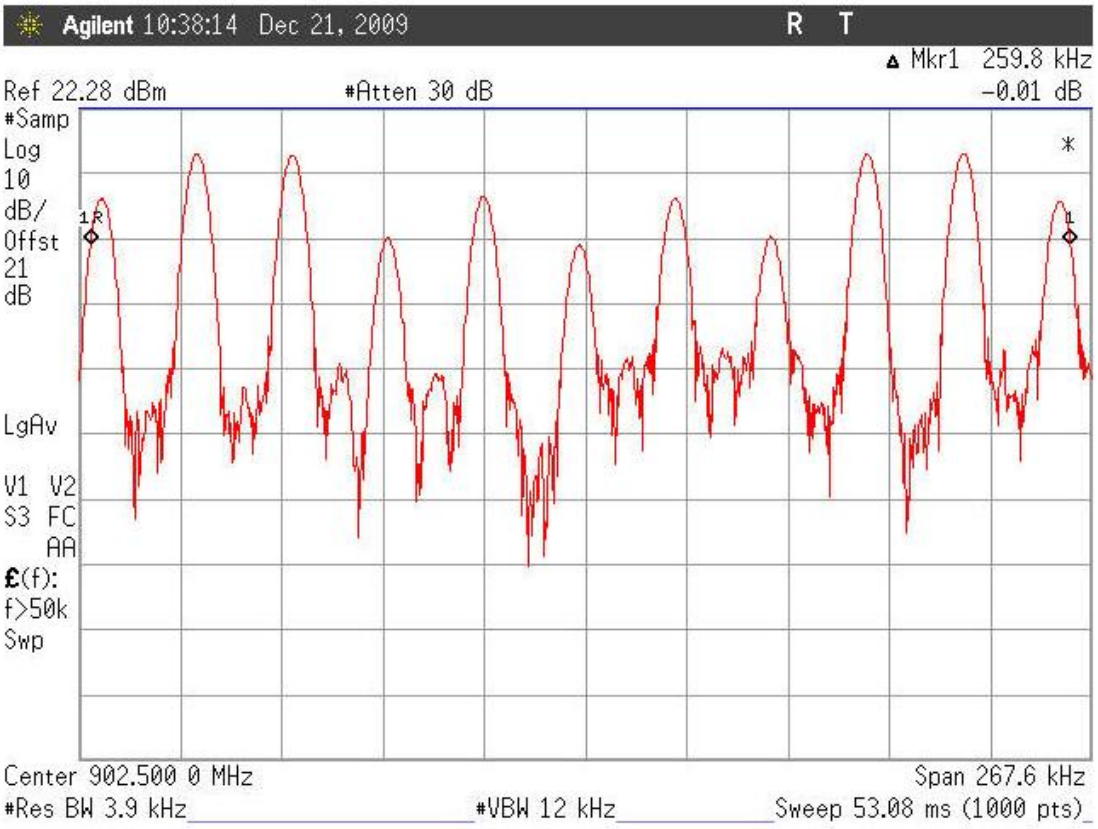

Figure 14: 99% Occupied Bandwidth, Low Channel, Driveby Mode

Job 11275 Datamatic D4100F Radio Module, 99% Occupied Bandwidth, Driveby Mode, Center Channel @ 915MHz

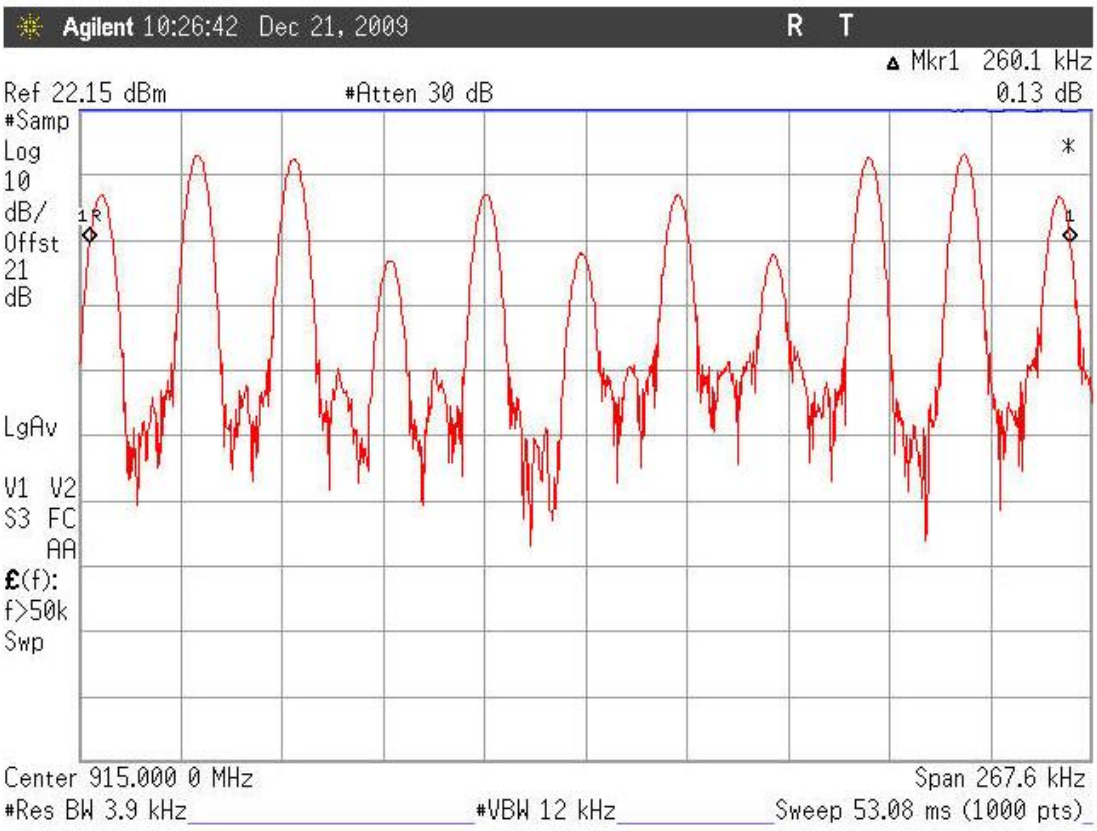

Figure 15: 99% Occupied Bandwidth, Center Channel, Driveby Mode

Job 11275 Datamatic D4100F Radio Module, 99% Occupied Bandwidth, Driveby Mode, High Channel @ 927MHz

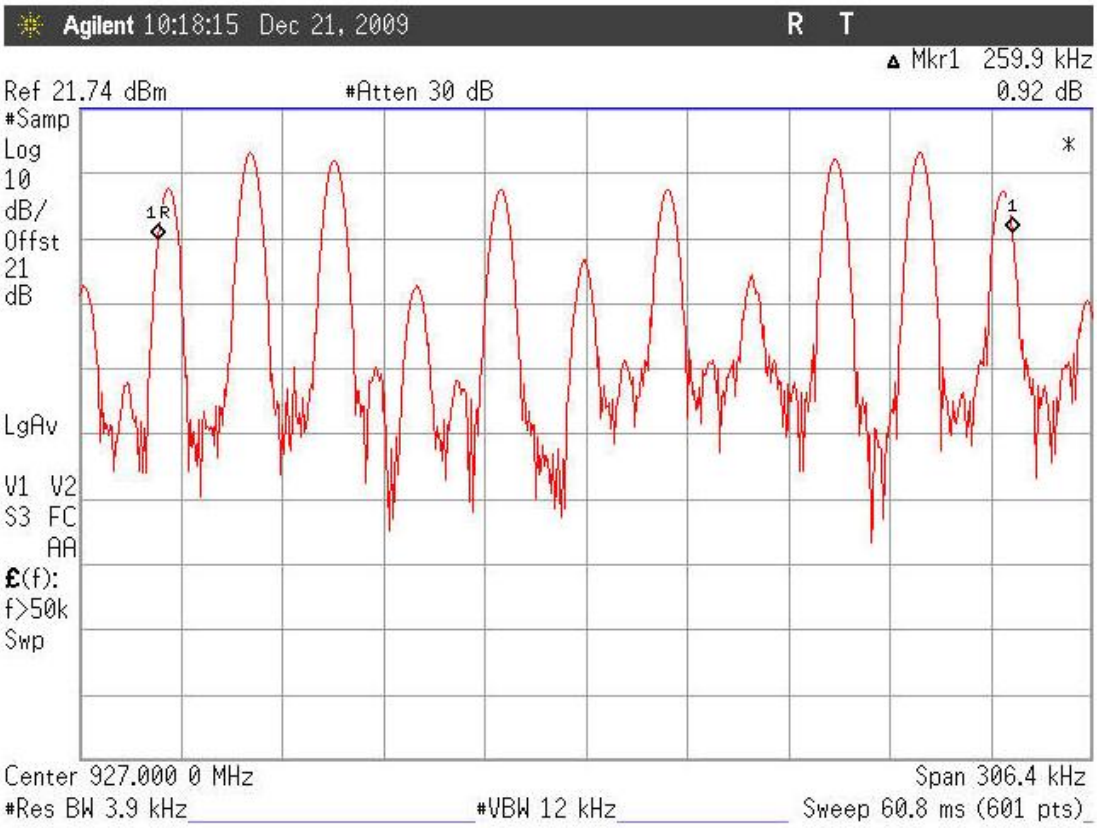

Figure 16: 99% Occupied Bandwidth, High Channel, Driveby Mode

5.4 20dB Emission Bandwidth : (15.247 (a) (1)(i) & RSS-210 [A8. 1 (c)])

20dB bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

For Frequency Hopping Spread Spectrum Systems, The maximum 20 dB bandwidth not exceed 500kHz.

At full modulation, the 20dB bandwidth for each mode was measured as shown:

Table 7 provides a summary of the 20dB bandwidth Results.

Table 7: 20dB bandwidth Results

Frequency	Mode	Bandwidth (kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.5MHz	Mesh	158.16	500	Pass
Center Channel: 915MHz	Mesh	155.80	500	Pass
High Channel: 927MHz	Mesh	157.31	500	Pass
Low Channel: 902.5MHz	Driveby	358.68	500	Pass
Center Channel: 915MHz	Driveby	292.92	500	Pass
High Channel: 927MHz	Driveby	309.70	500	Pass

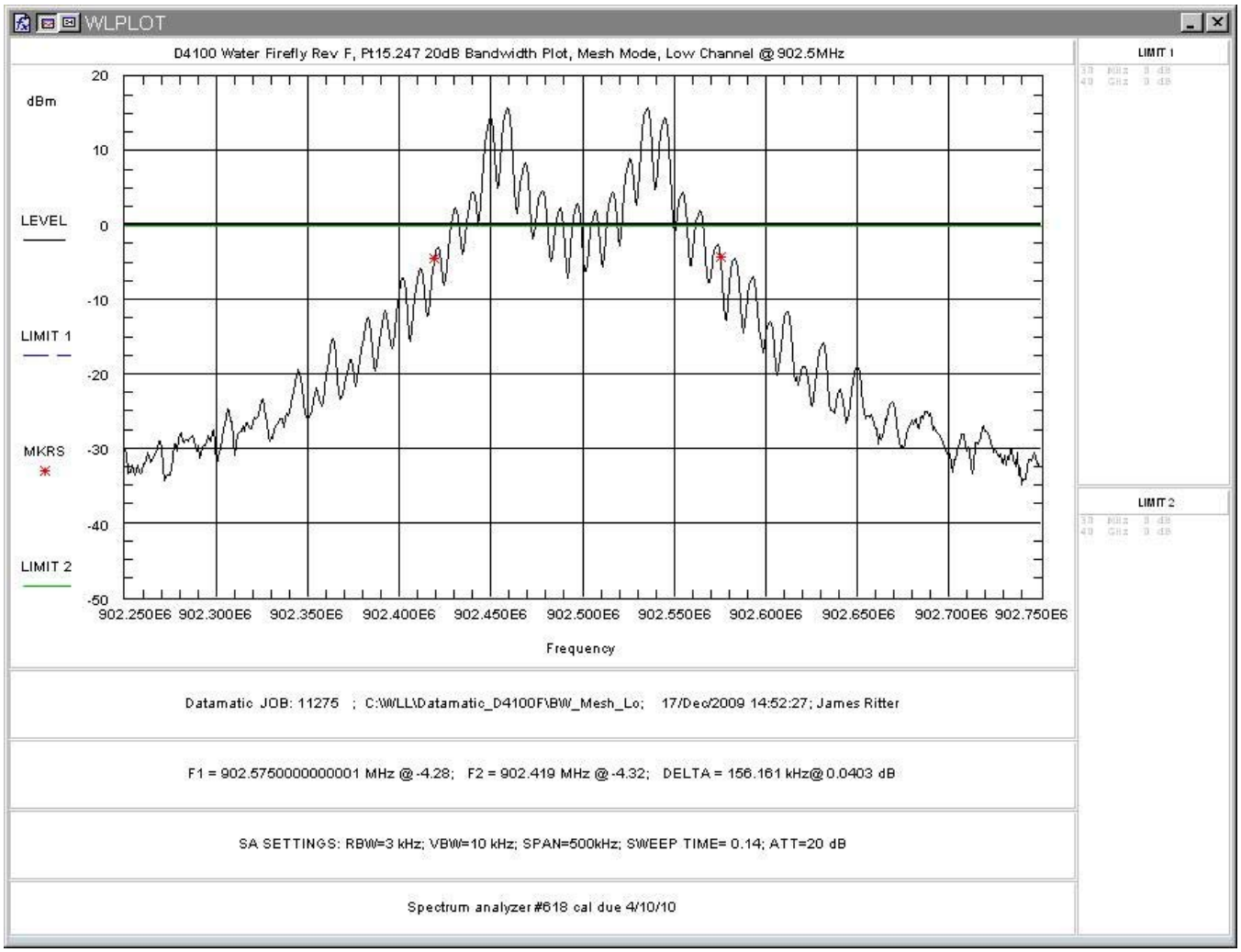

Figure 17: 20dB bandwidth, Low Channel, Mesh Mode

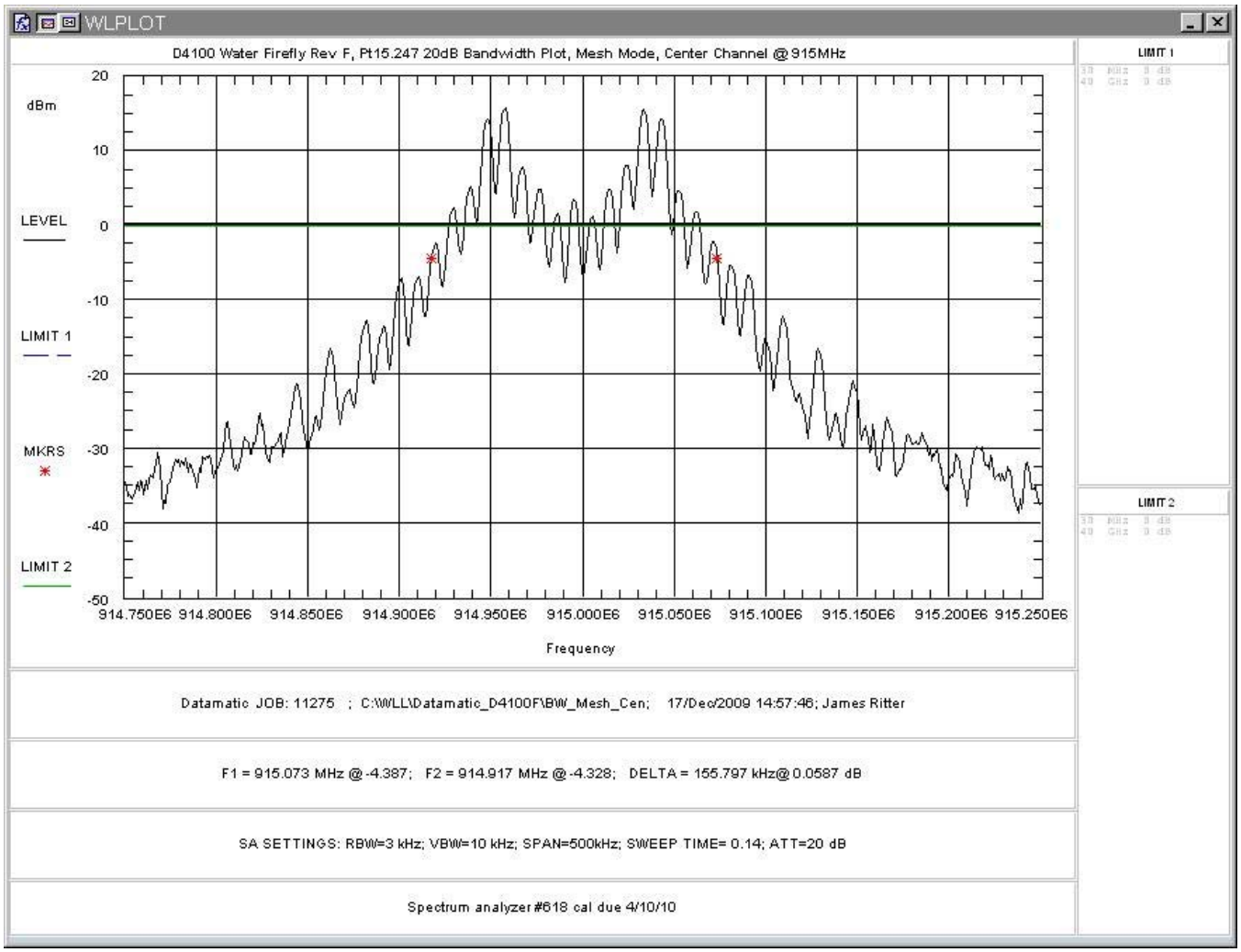

Figure 18: 20dB bandwidth, Center Channel, Mesh Mode

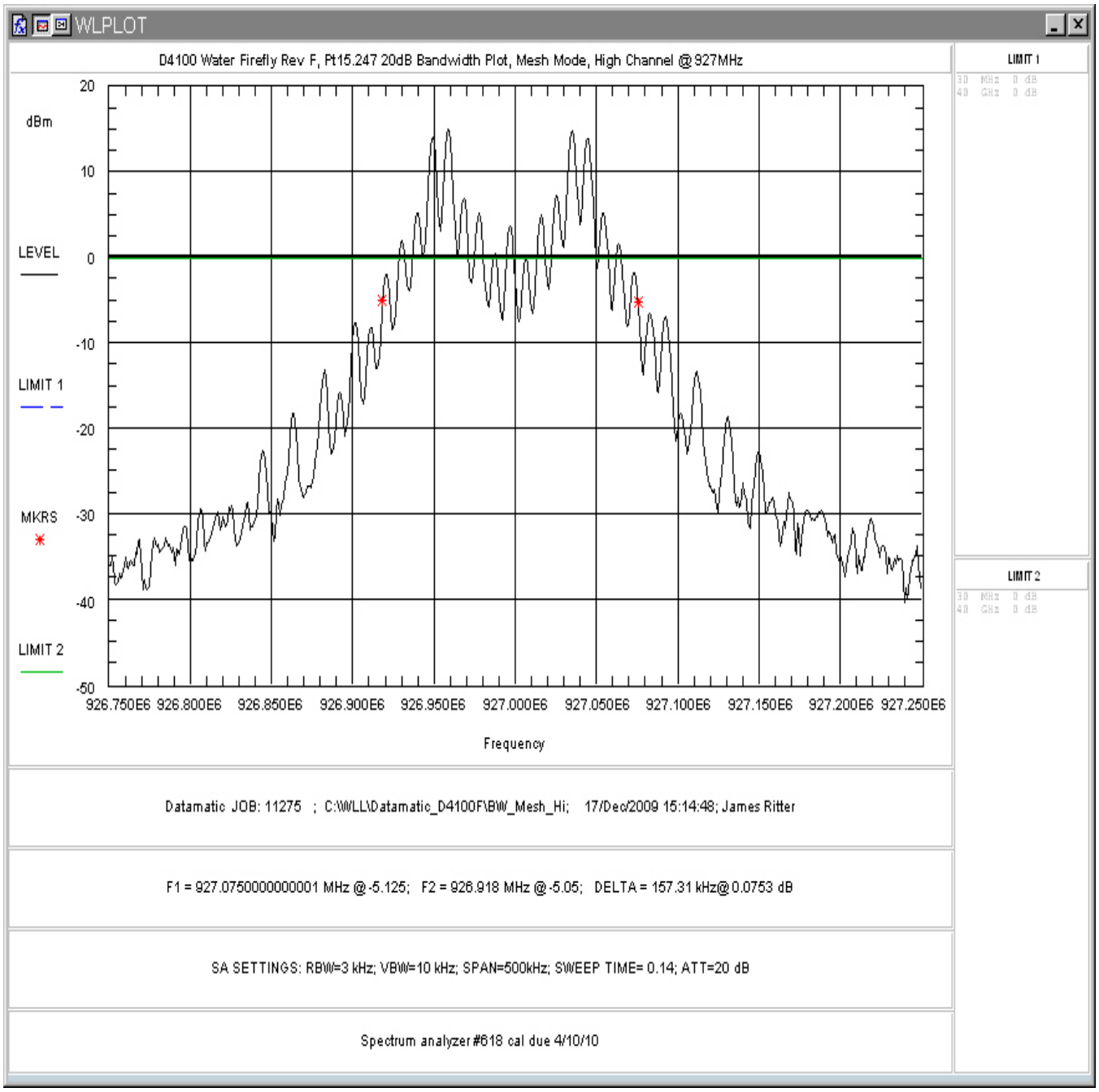

Figure 19: 20dB bandwidth, High Channel, Mesh Mode

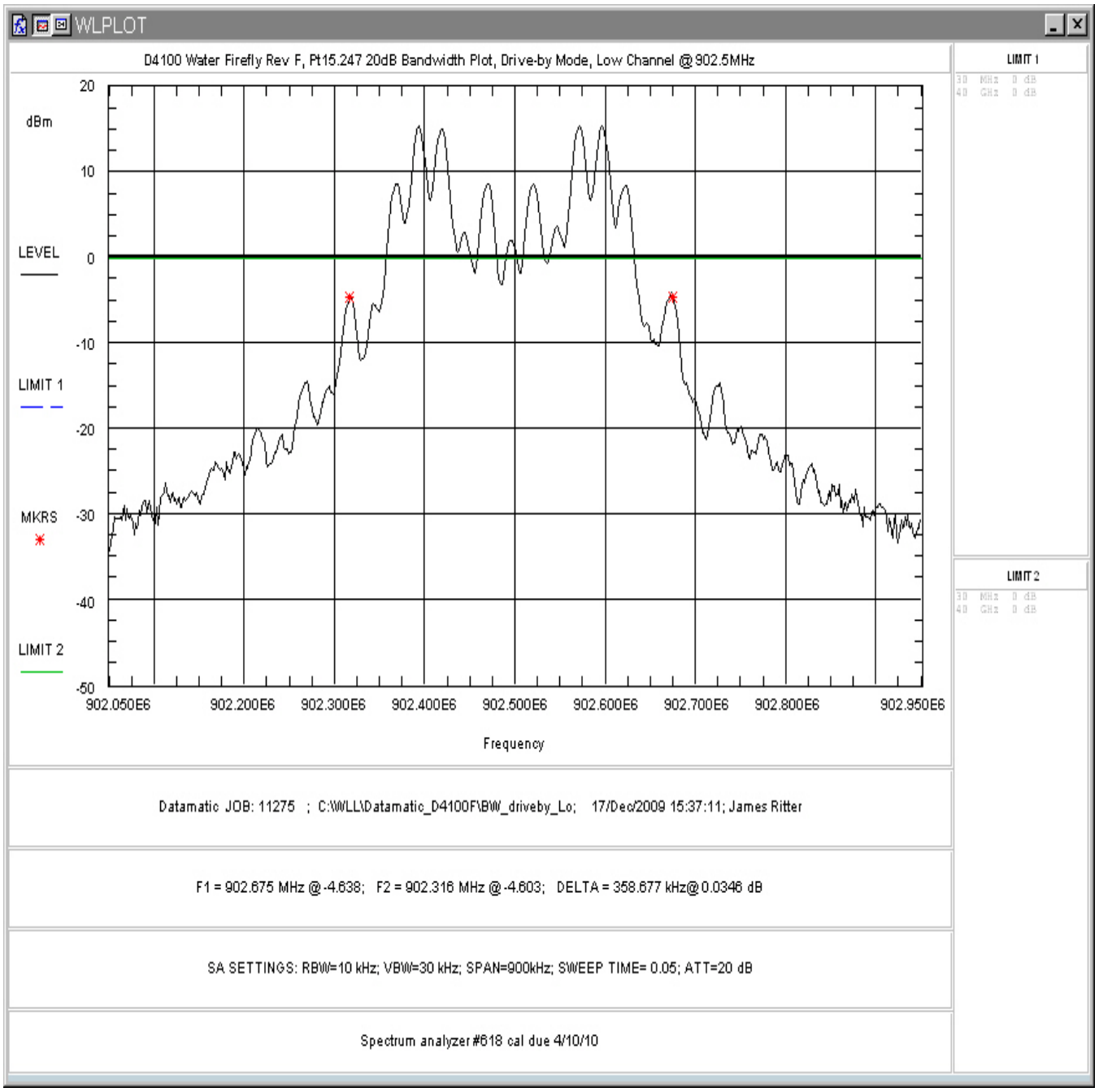

Figure 20: 20dB bandwidth, Low Channel, Driveby Mode

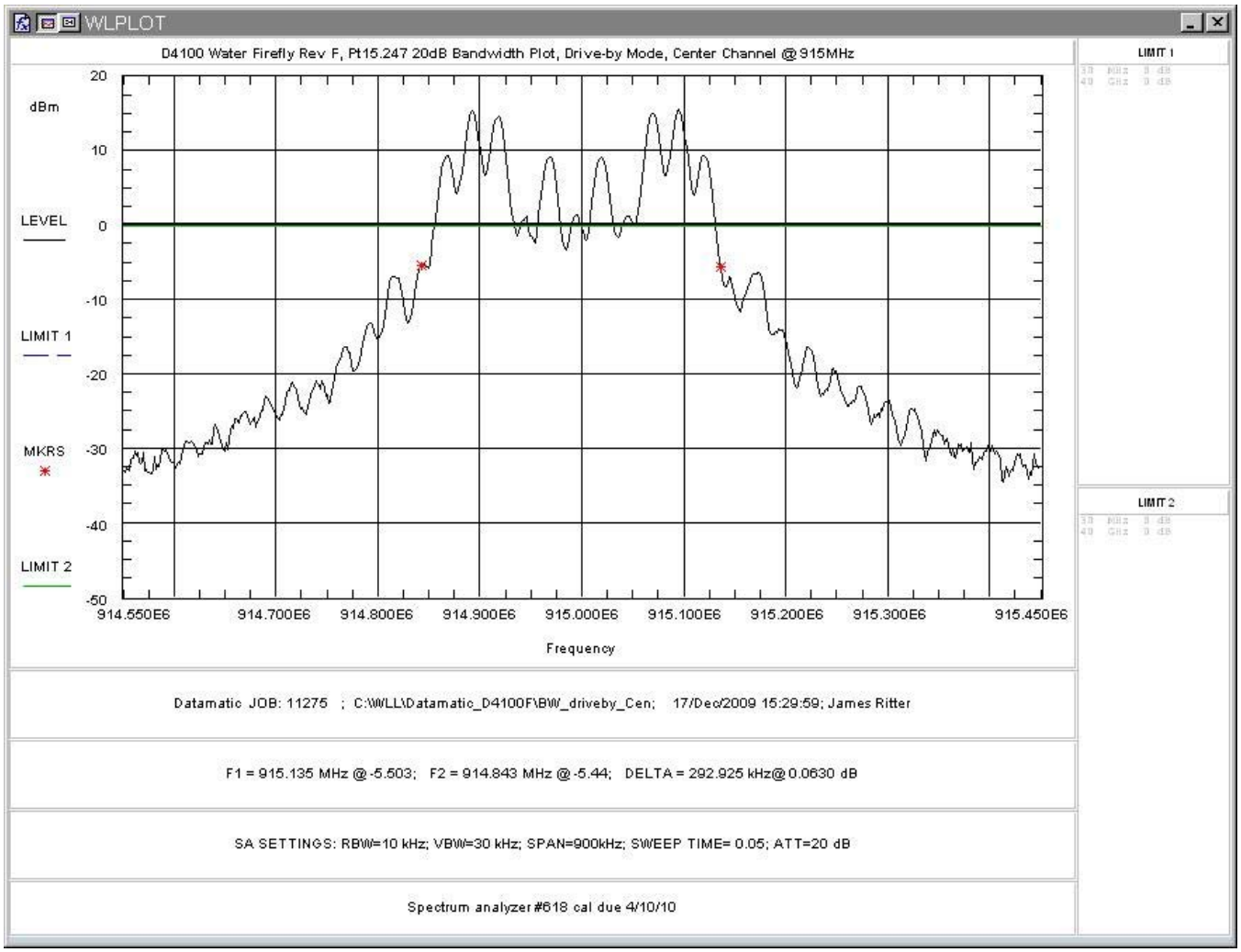

Figure 21: 20dB bandwidth, Center Channel, Driveby Mode

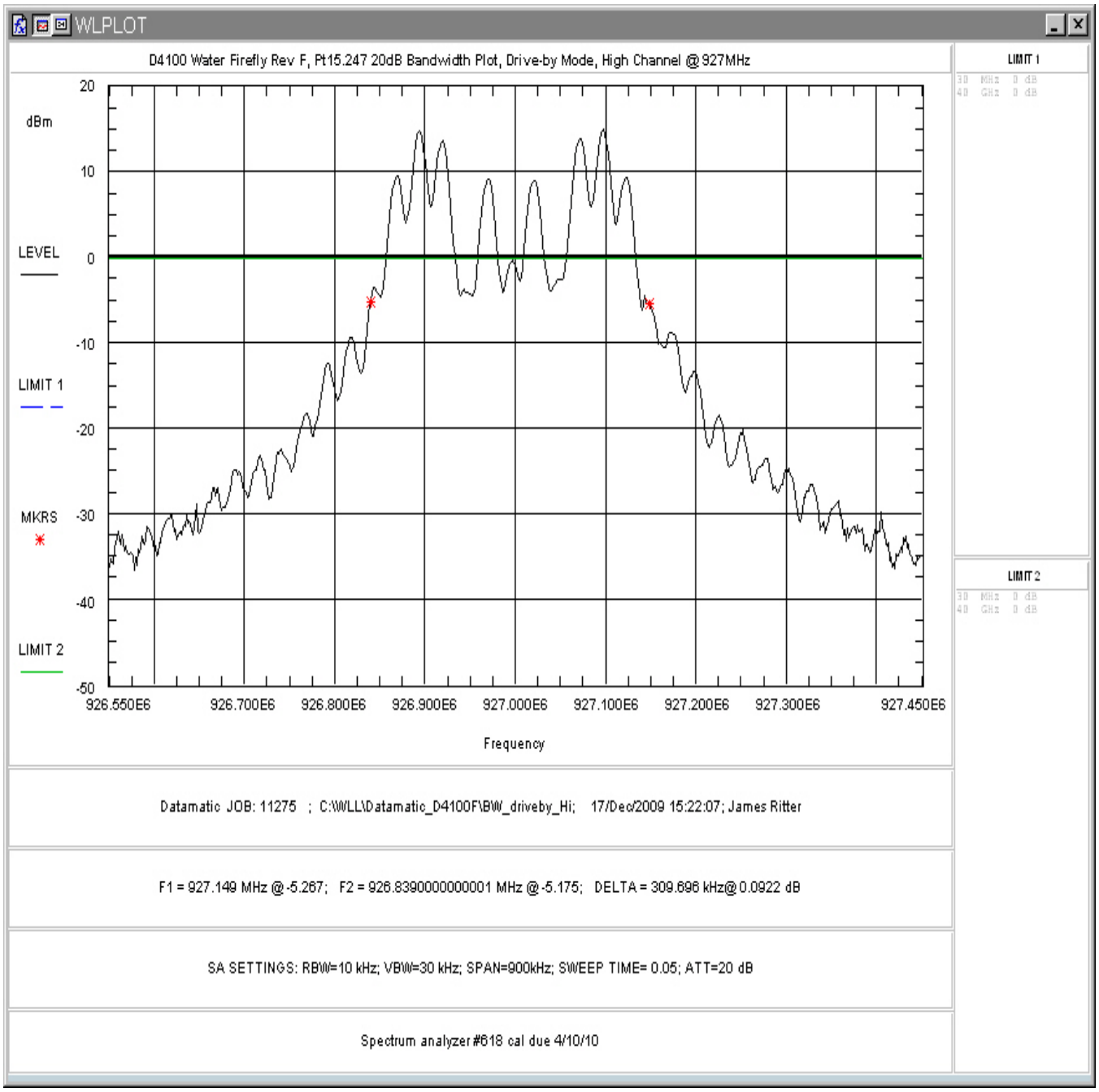

Figure 22: 20dB bandwidth, High Channel, Driveby Mode

5.5 Channel Spacing and Number of Hop Channels (FCC 15. 247(a)(1) & RSS-210 [A8.1 (b)(c)]

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth, whichever is greater. The 20dB bandwidth measured in Mesh Mode is 157.31kHz and in Driveby mode is 358.68kHz,so the channel spacing must be more than 358.68kHz In addition, for a 902-928MHz transmitter the number of hopping channels shall be at least 50 channels for bandwidths less than 250kHz and at least 25 for bandwidth grater than 250kHz..

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 30 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 1.5MHz. Also, the number of hopping channels was measured from 901MHz to 928.5MHz.

The following are plots of the channel spacing and number of hopping channels data. The channel spacing was measured to be 500 kHz and the number of channels used is 50.

Table 8: Channel Spacing Results

Mode	Measured Channel Spacing (kHz)	Minimum Limit (kHz)	Pass/Fail
Mesh	505	157.31	Pass
Driveby	507.5	358.68	Pass

Table 9: Number of Hopping Channels Results

Mode	Measured Channels	Minimum limit	Pass/Fail
Mesh	50	50	Pass
Driveby	50	25	Pass

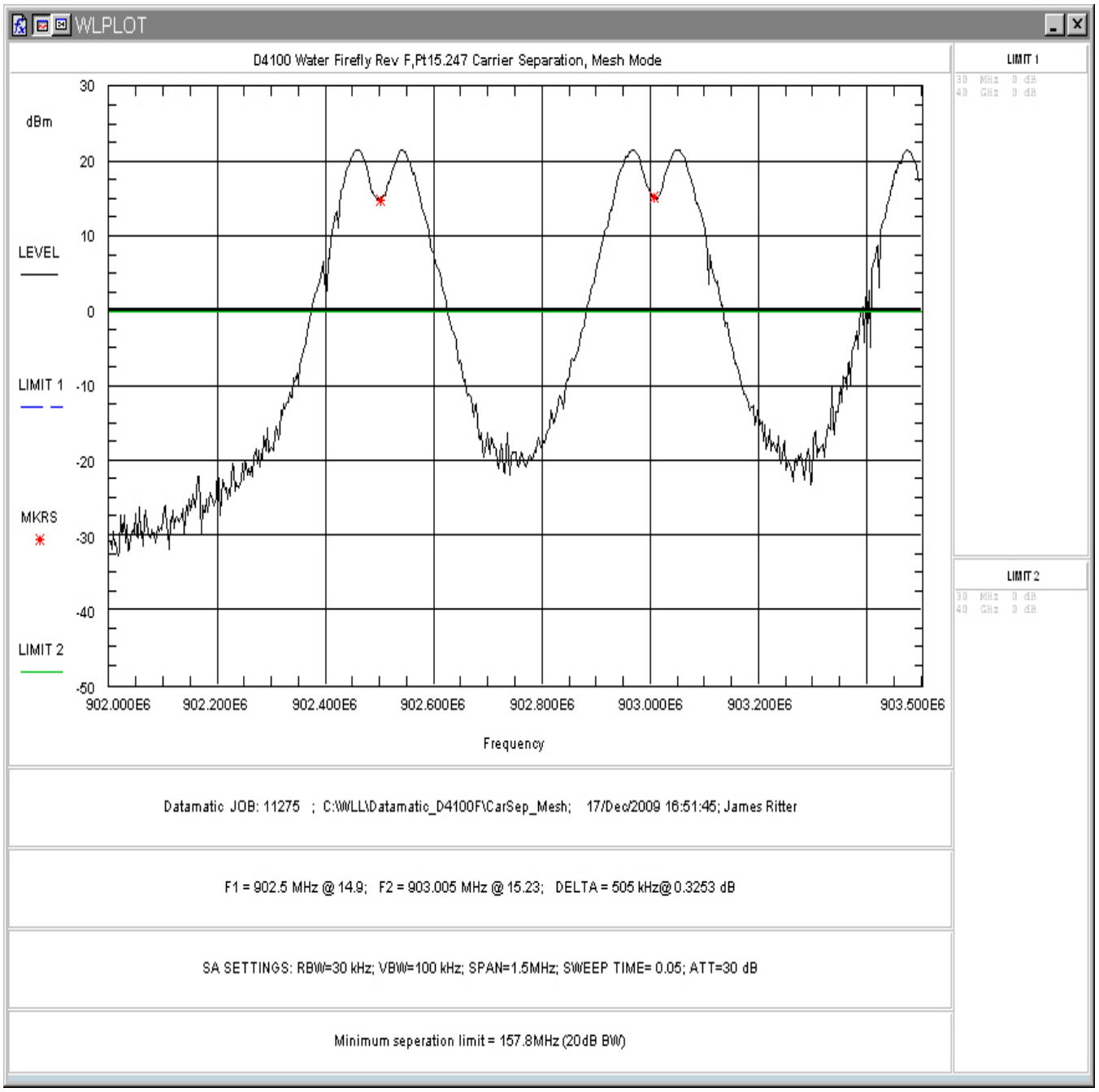

Figure 23: Channel Spacing. Mesh mode

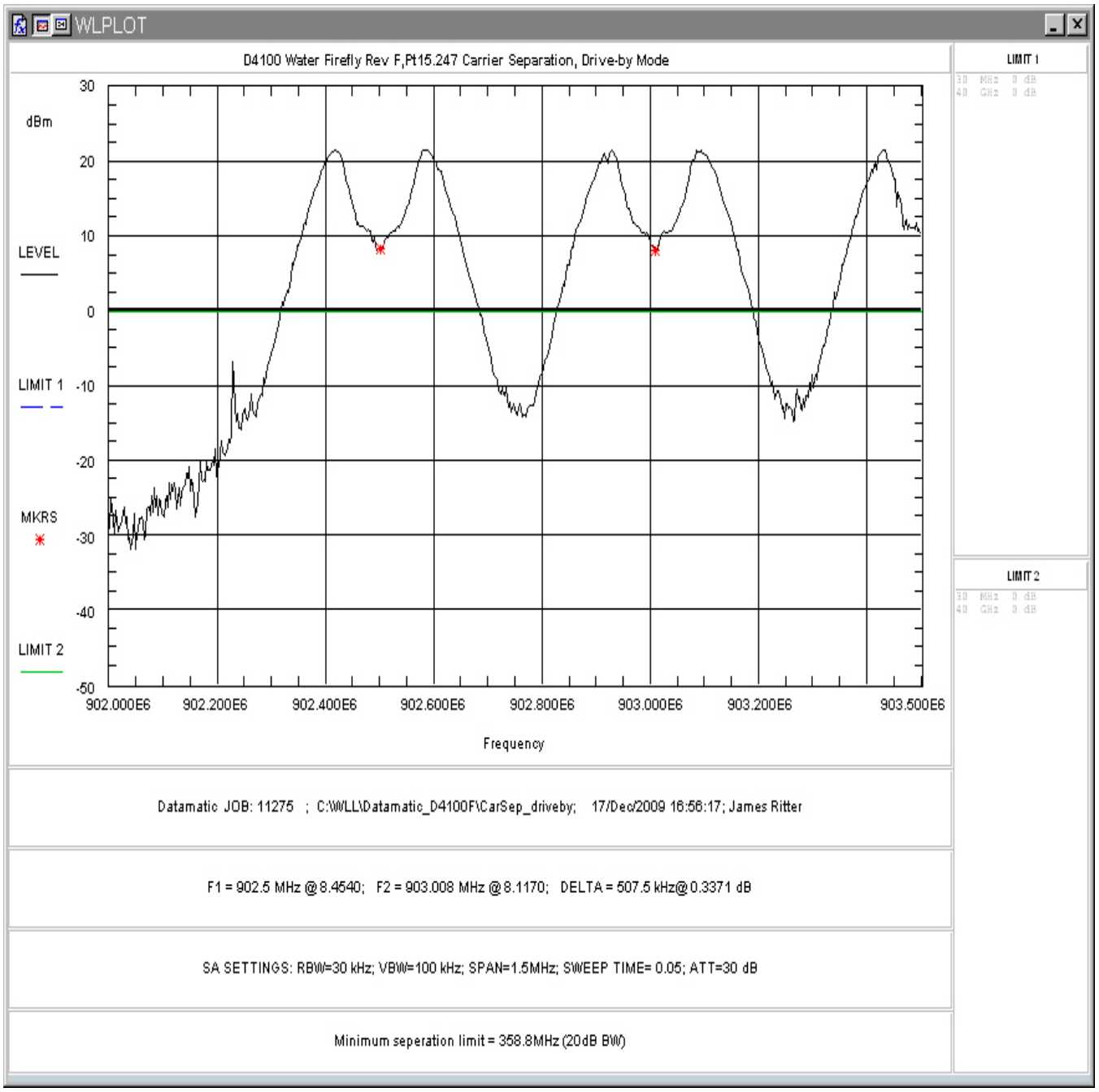

Figure 24: Channel Spacing. Driveby mode

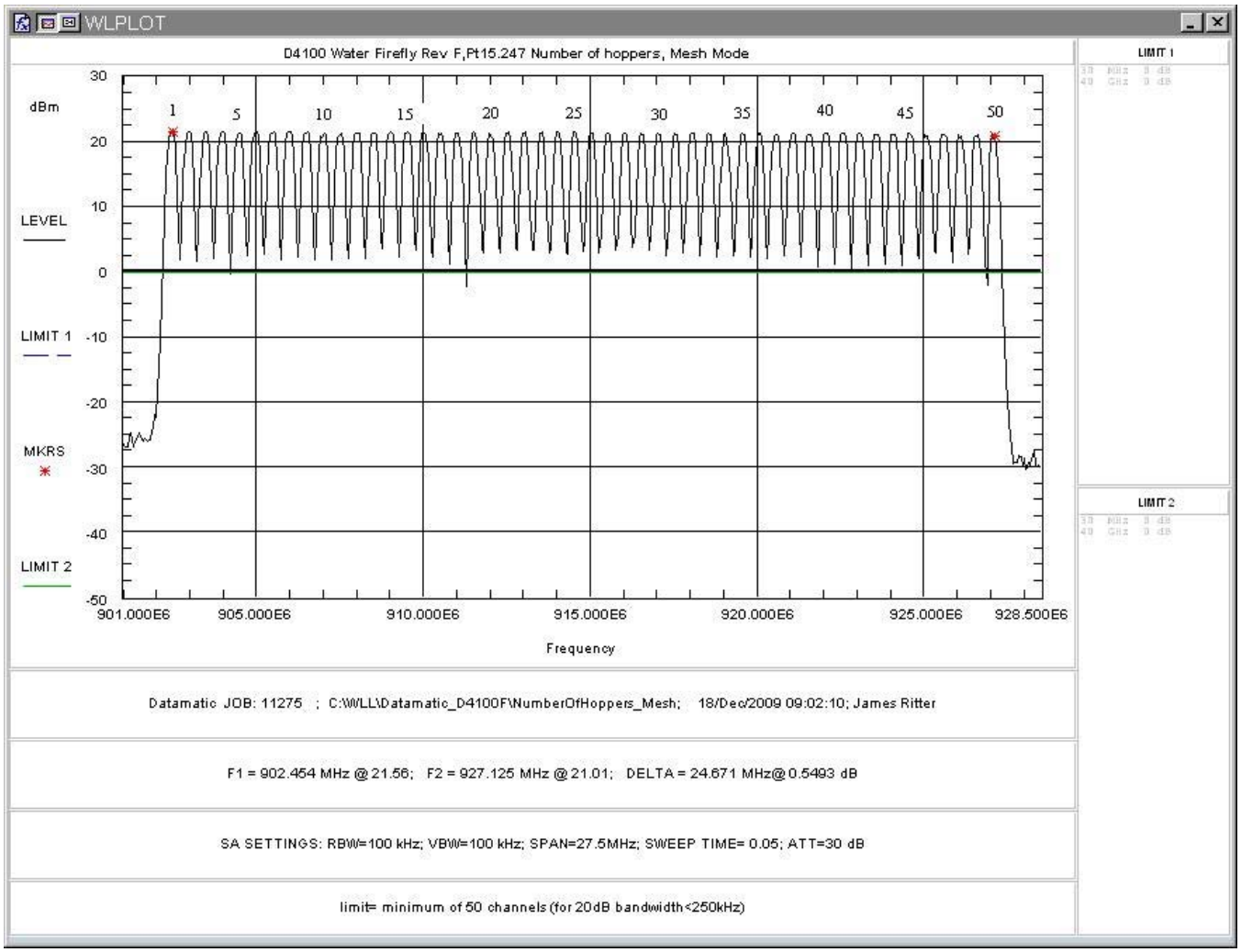

Figure 25: Number of Channels, Mesh Mode

