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FCC Certification Test Report
For the
Mueller Systems
UWMR

FCC ID: SM6-UWMR

WLL JOB# **12172-01 Rev.1**
August 29, 2011

Re-issued October 7, 2011

Prepared for:

Mueller Systems
48 Leona Drive
Middleboro, MA 02346

Prepared By:

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

ACCREDITED TESTING

Testing Certificate AT-1448

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Prepared by:

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Abstract

This report has been prepared on behalf of Mueller Systems to support the attached Application for Equipment Authorization. The test report and application are submitted for a Mobile Transmitter under Part 101 (10/2010) of the FCC Rules and Regulations. This Certification Test Report documents the test configuration and test results for the Mueller Systems UWMR.

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 ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

The Mueller Systems UWMR complies with the limits for a Transmitter device under FCC Part 101.

Revision History	Description of Change	Date
Rev 0	Initial Release	August 29, 2011
Rev 1	Added 101.113 statement	October 7, 2011

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1.0 Introduction

1.1 Compliance Statement

The Mueller Systems UWMR complies with the limits for Transmitter device under FCC Part 101 (10/2010).

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with the 2009 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:	Mueller Systems 48 Leona Drive Middleboro, MA 02346
Purchase Order Number:	766993
Quotation Number:	66398

1.4 Test Dates

Testing was performed on the following date(s):	8/12/11 - 8/18/11

1.5 Test and Support Personnel

Washington Laboratories, LTD	Steven Dovell
Client Representative	Edward C. Parish

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

2.0 Equipment Under Test

2.1 EUT Identification & Description

The Mueller Systems Universal Water Meter Receiver (UWMR) is a mobile 64 channel 902MHz to 928 MHz receiver packaged with a +36dBm 952MHz to 960MHz transmitter. The transmitter operates under Part 101 (private radio, MAS) of the FCC regulations and when activated, will transmit a carrier modulated by a low frequency tone. A license is required for operation and the carrier frequency and tone are programmed at the factory and not changeable by the operator or customer. The receiver can have up to 64 FSK receivers programmed for simultaneous reception of individually programmed channels. Optionally, a second receiver can be attached to the UWMR through the receiver output port, controlled by the serial port and powered by the auxiliary power port. The UWMR is designed for mobile operation and operates from a 12V vehicle supply. The UWMR is supplied with a 900MHz 5dB gain magnetic mount antenna for both the transmitter and the receivers.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Mueller Systems
FCC ID:	SM6-UWMR
Model:	UWMR
FCC Rule Parts:	§101
TX Frequency Range:	952MHz – 960MHz
RX Frequency Range:	902MHz – 928MHz
Maximum Output Power:	4.37W (36.4dBm)
Modulation:	AM double Sideband No Suppressed Carrier
Occupied Bandwidth:	1.52kHz
Keying:	Automatic, Manual
Type of Information:	Data
Number of Channels:	1
Power Output Level	Fixed
Antenna Connector	F
Antenna Type	5dBi external Whip
Interface Cables:	Power, USB, Antenna
Power Source & Voltage:	12VDC
Emissions Designator	1K52A2D

2.2 Test Configuration

The UWMR was configured to continuously transmit at 956MHz with a 50Hz modulation tone.

2.3 Testing Algorithm

The UWMR was programmed to transmit a signal via a laptop running Hyper-terminal.

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 ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

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

$k \leq 2$ 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

3.0 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: **08/18/2011**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
69	HP - 85650A	ADAPTER QP	6/28/2012
71	HP - 85685A	PRESELECTOR RF	6/26/2012
73	HP - 8568B	ANALYZER SPECTRUM	6/26/2012
28	EMCO - 3146	ANTENNA LOG PERIODIC	12/21/2012
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	1/12/2012
626	ARA - DRG-118/A	ANTENNA HORN	6/16/2013
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/4/2012
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	2/15/2013
528	AGILENT - E4446A	ANALYZER SPECTRUM	9/27/2011
Test Name: **Bench Conducted Emissions**			Test Date: **08/17/2011**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
618	HP - 8563A	ANALYZER SPECTRUM	7/15/2012
Test Name: **Temperature Stability**			Test Date: **8/12/2011**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
117	RACAL DANA	COUNTER, FREQUENCY	3/19/2012
646	FLUKE 87	TRUE RMS MULTIMETER	2/16/2012
Na	RATELCO 2046B	DC POWER SUPPLY	Na
669	Tenney	Temperature chamber	7/12/2012

4.0 Test Results

4.1 RF Power Output: (FCC Part §2.1046)

To measure the output power the unit set to 956MHz modulated at 50Hz. 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 4: RF Power Output

Frequency	Level	Limit	Pass/Fail
952MHz	36.40 dBm	44 dBm	Pass
956MHz	35.69 dBm	44 dBm	Pass
960MHz	35.24 dBm	44 dBm	Pass

As per CFR 101.113, in no event shall the average equivalent isotropically radiated power (EIRP), as referenced to an isotropic radiator, exceed the level of 14dBW (44dBm). With the maximum conducted transmit level of 36.4dBm; the maximum gain antenna cannot exceed 33.6dBi.

Note: With the maximum conducted output power of 36.4dBm any antenna used must have less than 7.6 dBi gain in order to remain in compliance with this rule part. The antenna supplied with this unit is 5dBi for a total EIRP of 41.4dBm (11.4dBW)

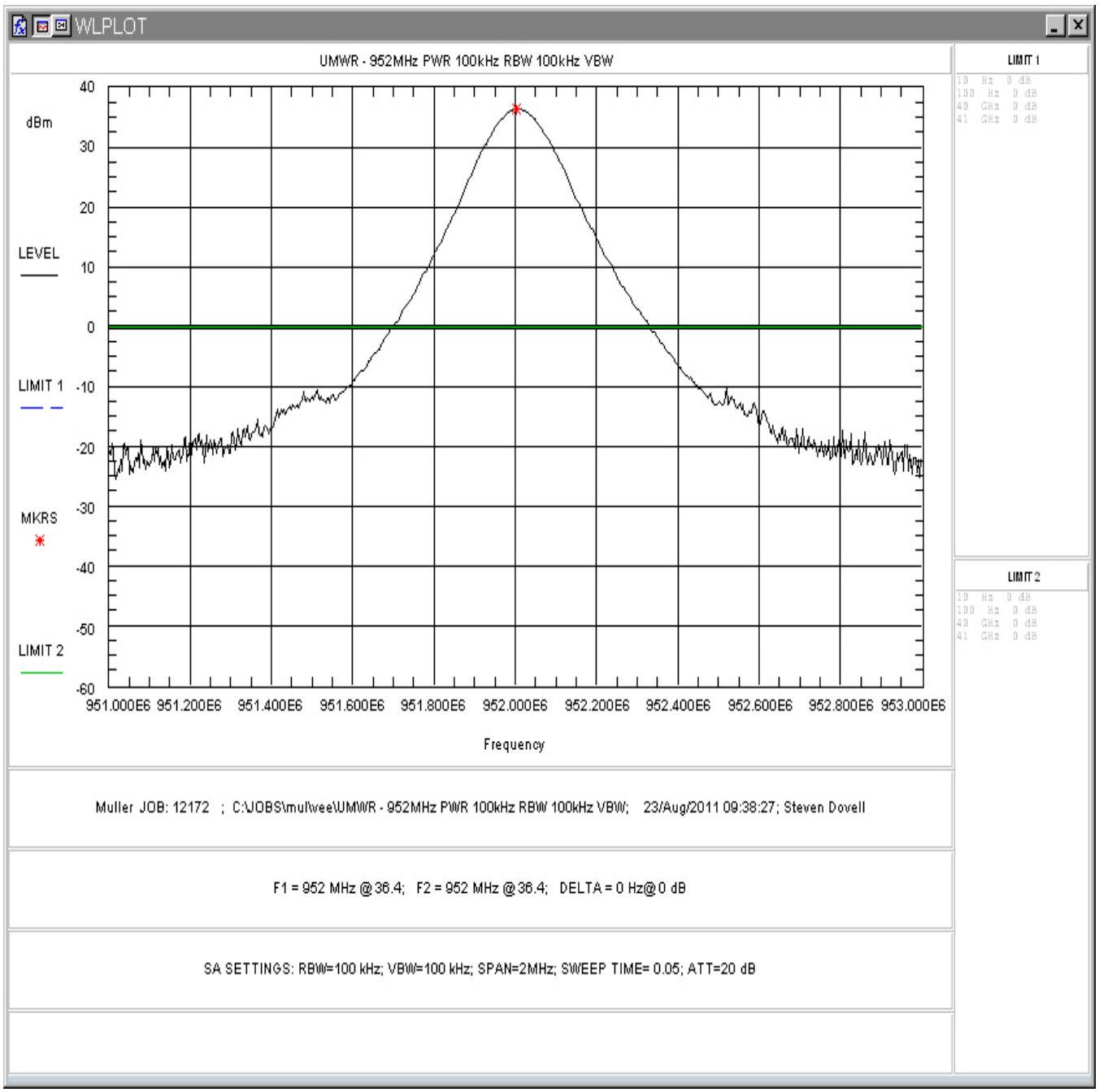

Figure 1: RF Peak Power - 952MHz

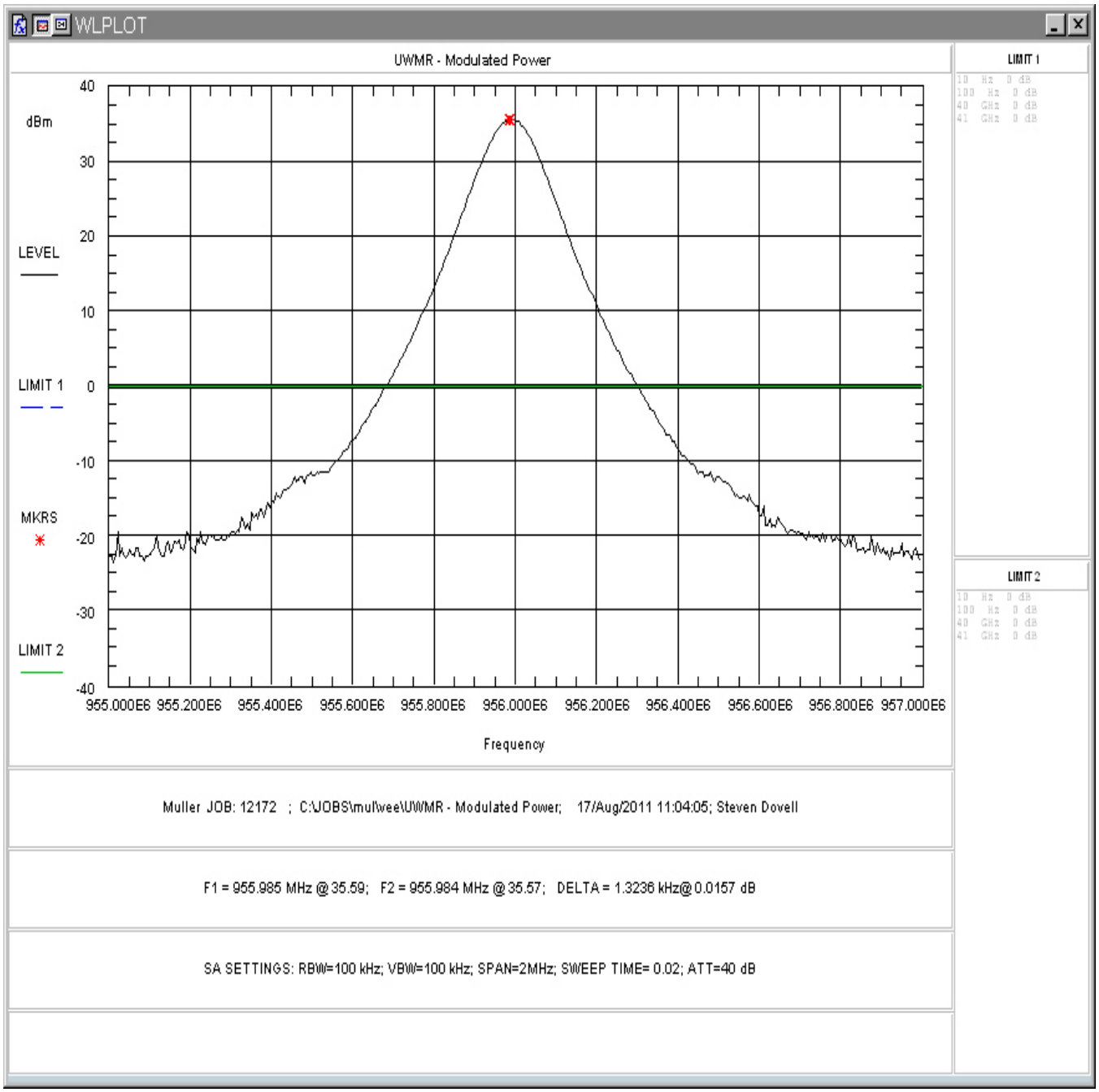

Figure 2: RF Peak Power – 956MHz

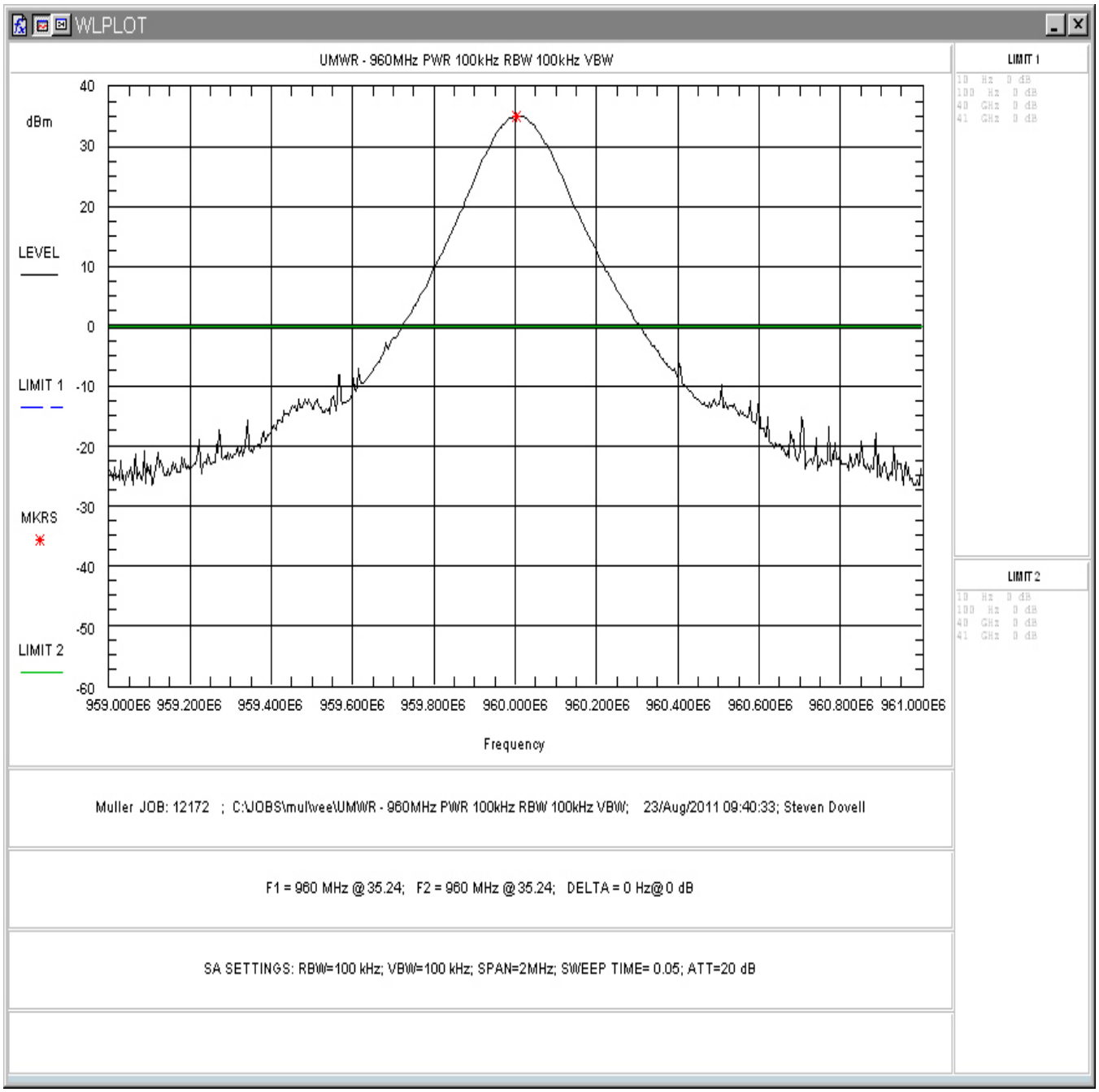

Figure 3: RF Peak Power – 960MHz

4.2 Emission Designator: (FCC Part §2.201)

The emission designator is determined from the necessary bandwidth, the type of modulation and the information conveyed in the signal.

- First symbol, type of modulation of the main carrier: A
- Second symbol, nature of the signal modulating the main carrier: 2
- Third Symbol, type of information to be transmitted: D

The necessary bandwidth, B_n is taken to be the bandwidth of the signal: for 1.523 kHz Bandwidth we have 1K52A2D.

4.3 Occupied Bandwidth: (FCC Part §2.1049) Limit 101.109

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

At full modulation, the occupied bandwidth was measured as shown:

Table 5 provides a summary of the Occupied Bandwidth Results.

Table 5: Occupied Bandwidth Results

Frequency	Bandwidth	Limit	Pass/Fail
952MHz	1.5235KHz	12.5kHz	Pass
956MHz	1.5032kHz	12.5kHz	Pass
960MHz	1.48031kHz	12.5kHz	Pass

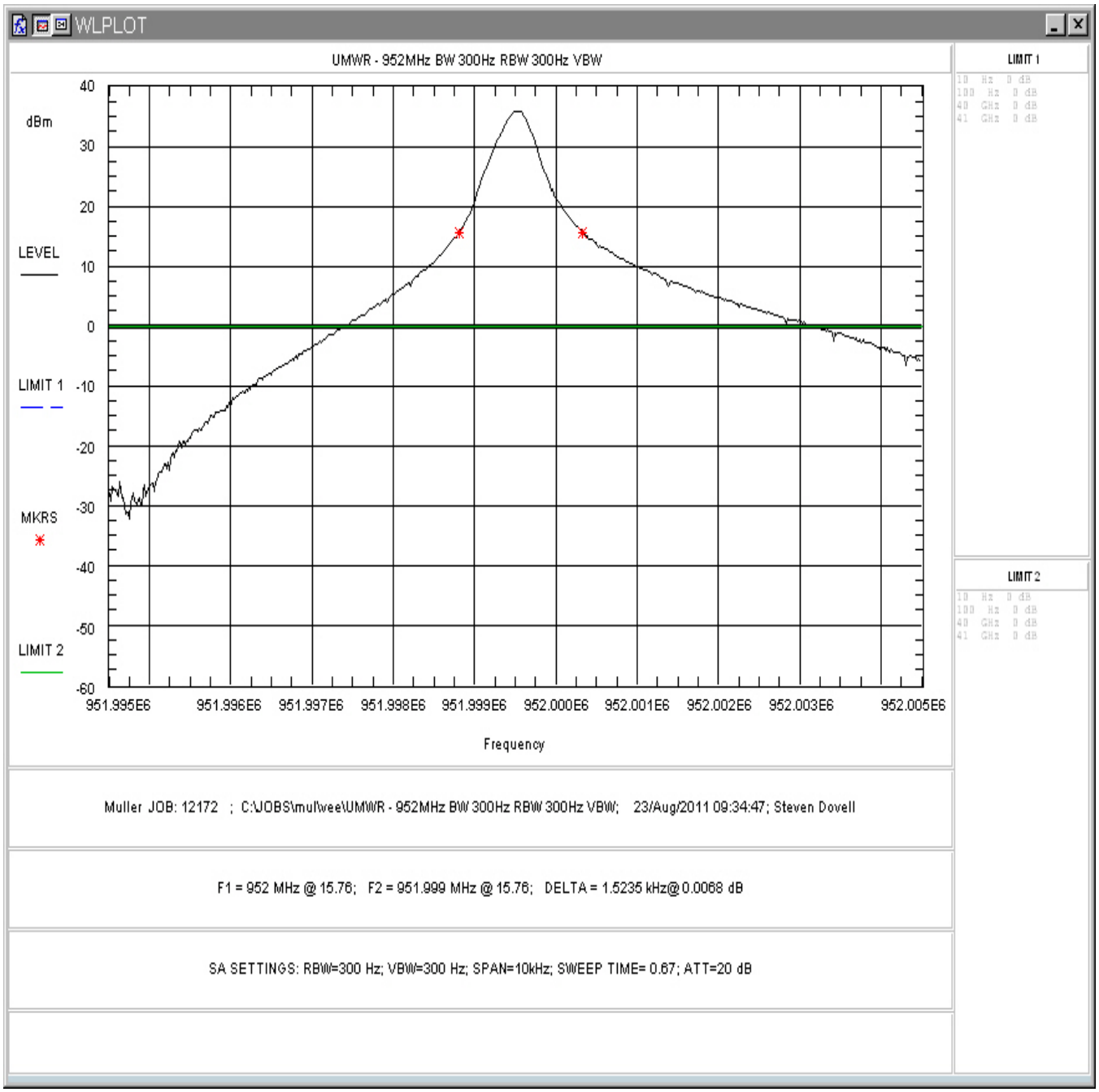

Figure 4: Occupied Bandwidth – 952MHz

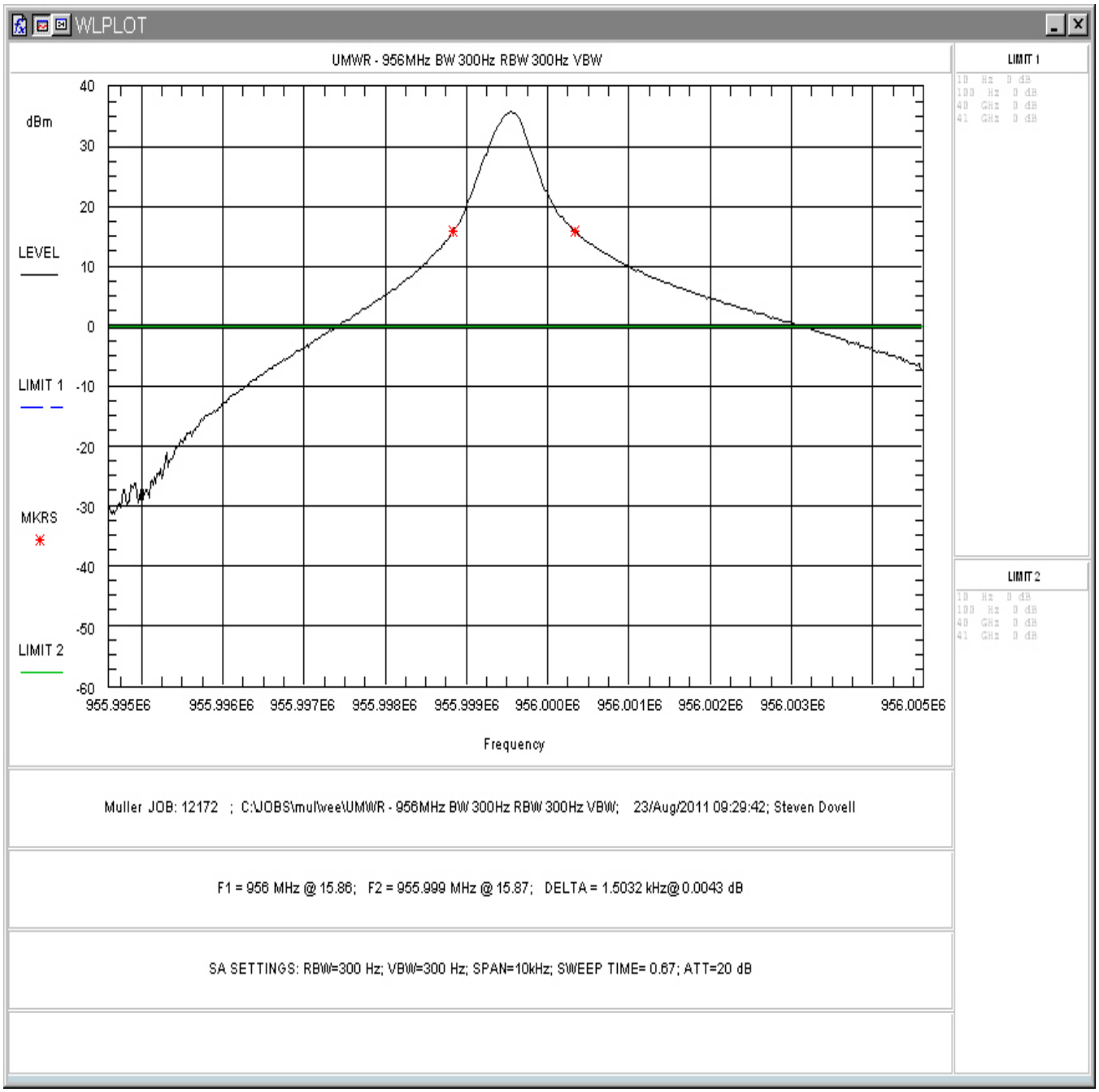

Figure 5: Occupied Bandwidth – 956MHz

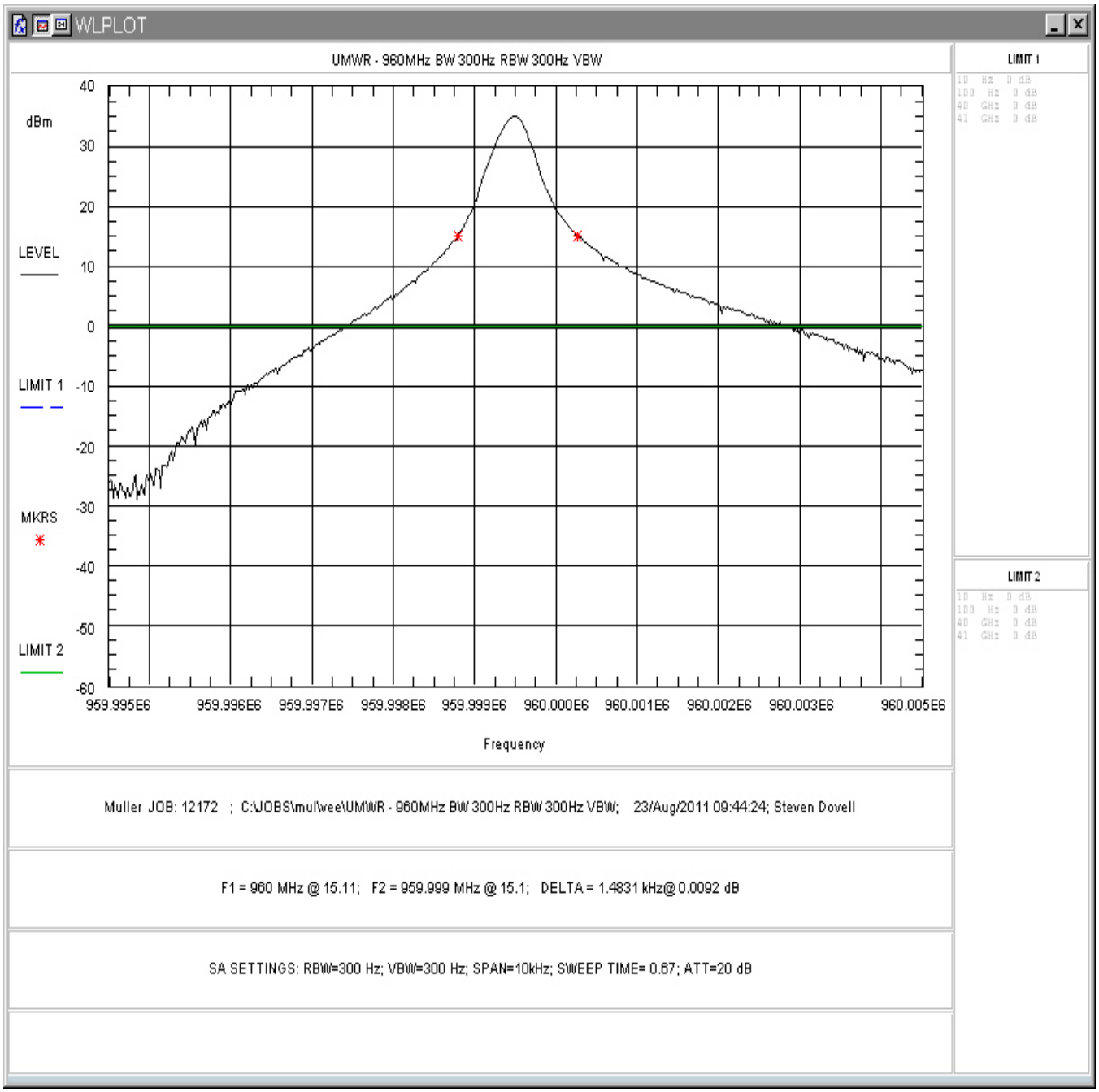

Figure 6: Occupied Bandwidth – 960MHz

4.4 Modulation Characteristics (FCC Part §2.1047) Limit 101.111 a(5)

The limit as specified in FCC Part 101.111 a(5) states:

(5) When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a 12.5 KHz bandwidth, the power of any emission must be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule:

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in KHz) of more than 2.5 KHz up to and including 6.25 KHz: At least 53 log (fd/2.5) decibels;

(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in KHz) of more than 6.25 KHz up to and including 9.5 KHz: At least 103 log (fd/3.9) decibels;

(iii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in KHz) of more than 9.5 KHz up to and including 15 KHz: At least 157 (fd/5.3) decibels; and

(iv) On any frequency removed from the center of the authorized bandwidth by a displacement frequency greater than 15 KHz: At least 50 plus 10 log (P) or 70 decibels, whichever is the lesser attenuation (= -20 dBm)

The unit was set to transmit an unmodulated carrier and the peak limit measured with the spectrum analyzer. The limits were calculated and the limit line determined. The unit was then set to transmit a modulated signal and the modulated signal was measured and plotted against the limit line.

Figure 7 and Figure 8 show the measured modulation characteristics.

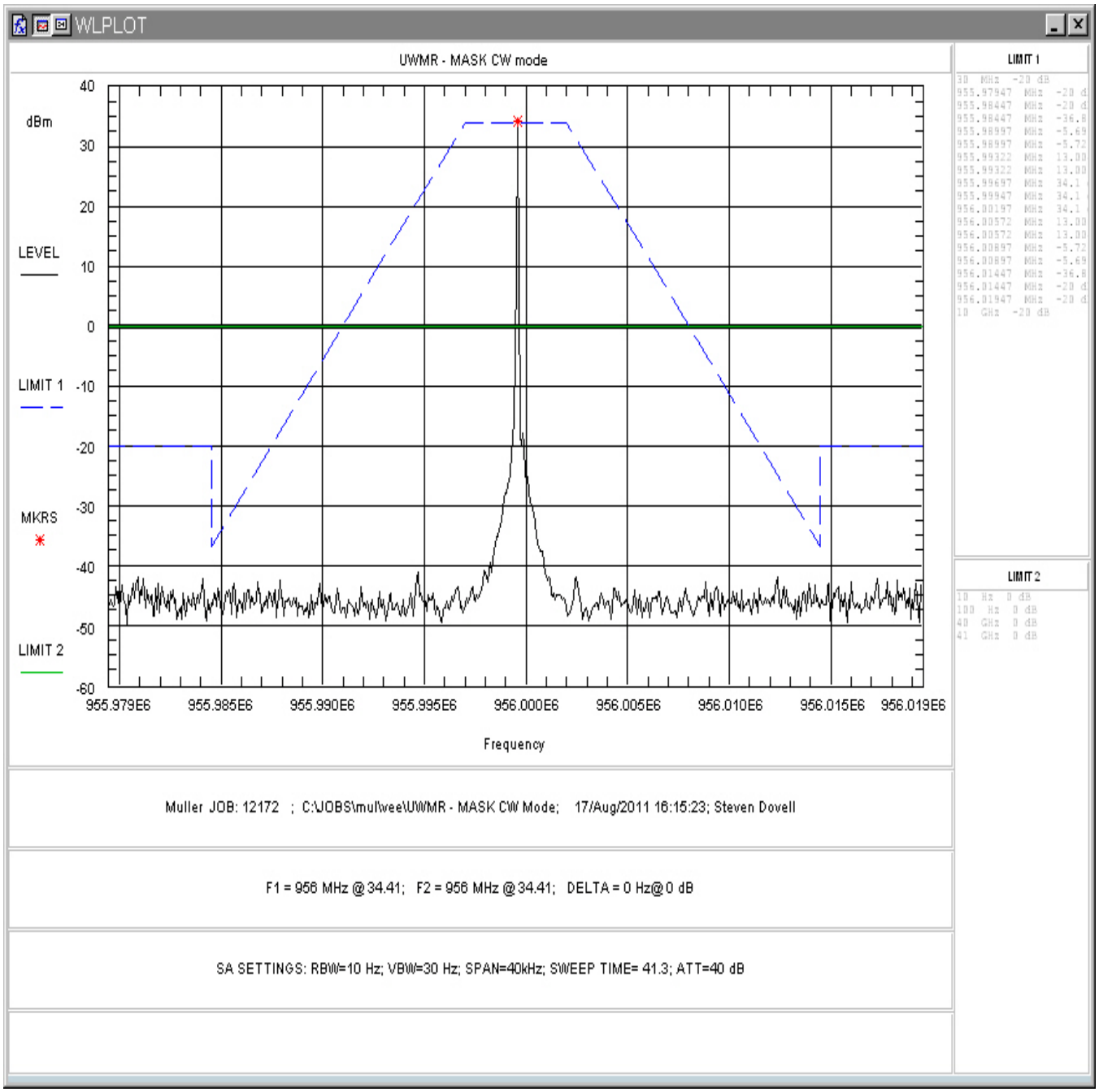

Figure 7: Modulation Characteristics: CW Power

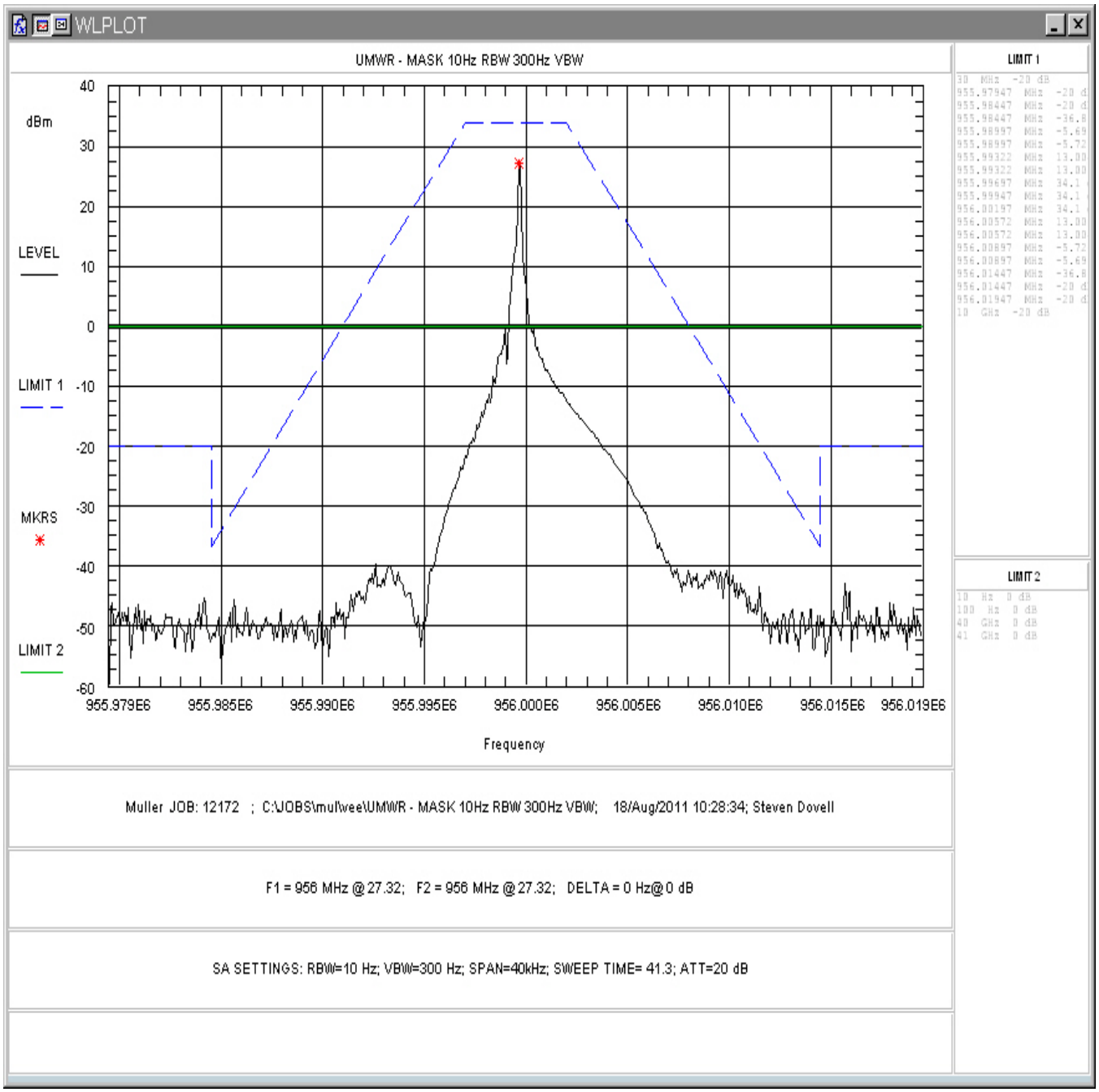

Figure 8: Modulation Characteristics: Modulated Signal

4.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §2.1051) Limit 101.111a(5)

The EUT must comply with requirements for spurious emissions at the antenna terminals. On any frequency removed from the center of the authorized bandwidth by a displacement frequency greater than 15 KHz: At least 50 plus 10 log (P) or 70 decibels, whichever is the lesser attenuation (= -20 dBm)

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through an appropriate 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. The emissions outside of the allocated frequency band were then scanned from 30MHz up to 10GHz.

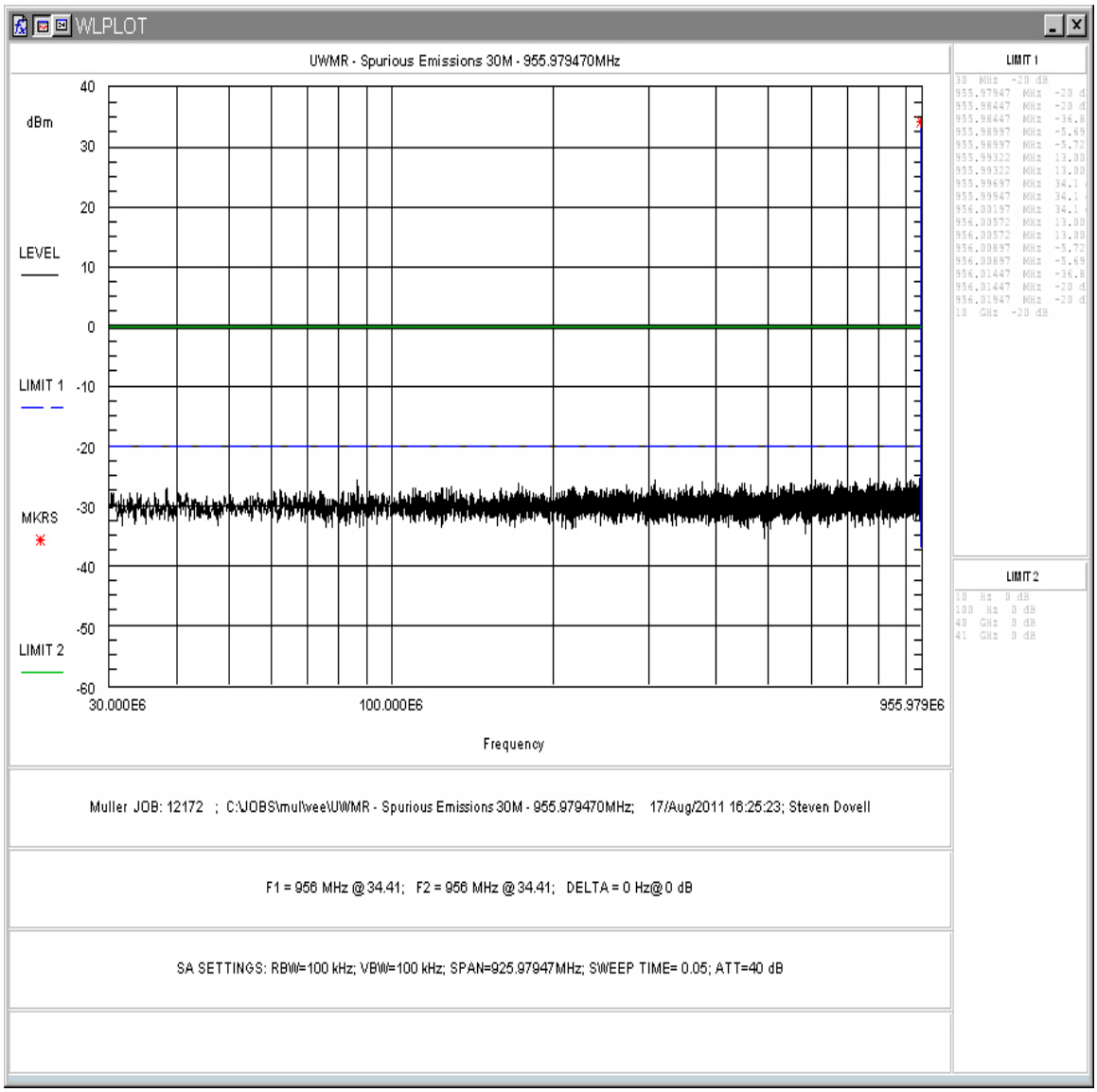

Figure 9: UWMR - Spurious Emissions 30M - 955.979470MHz

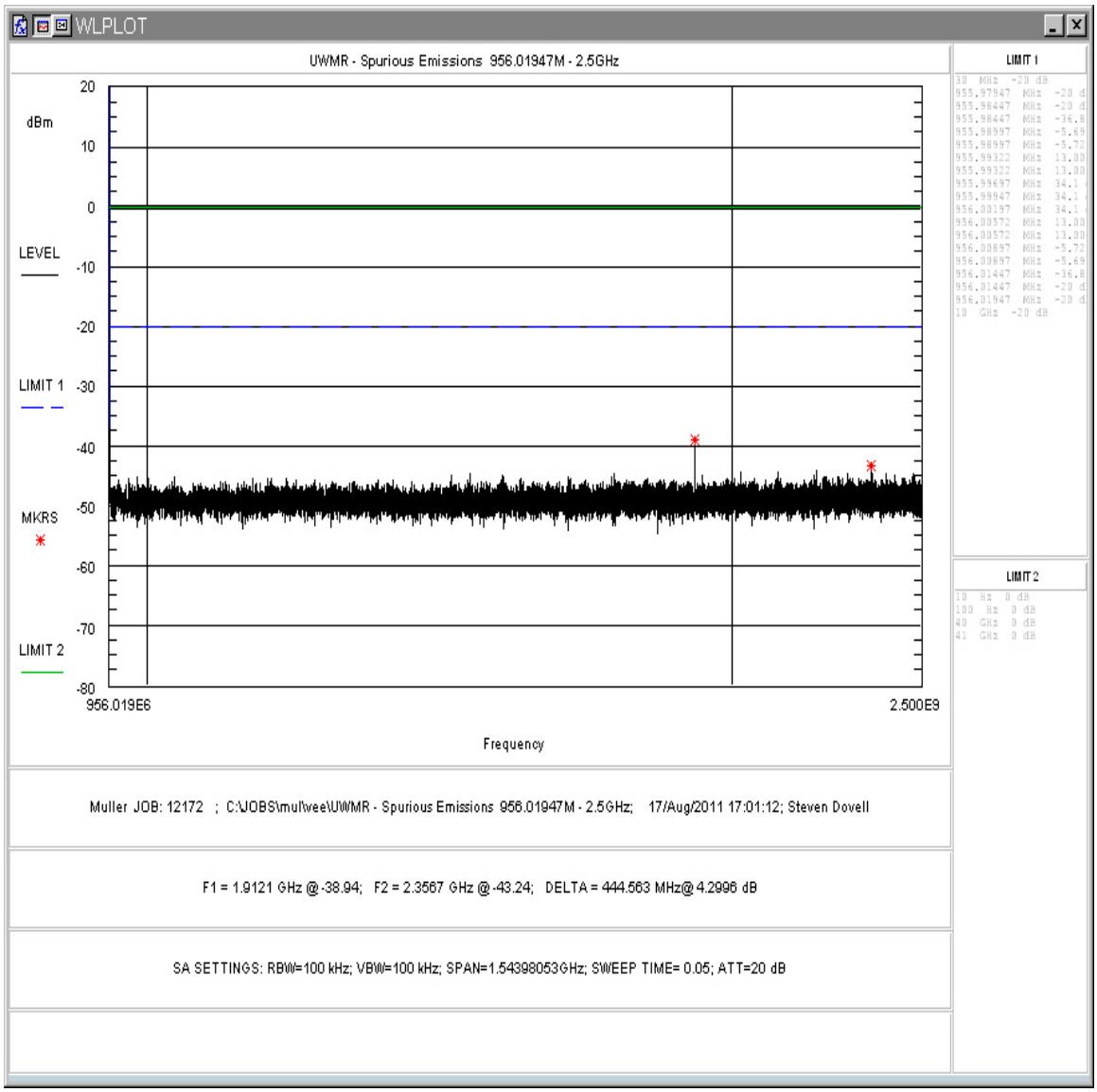

Figure 10: UWMR - Spurious Emissions 956.01947M - 2.5GHz

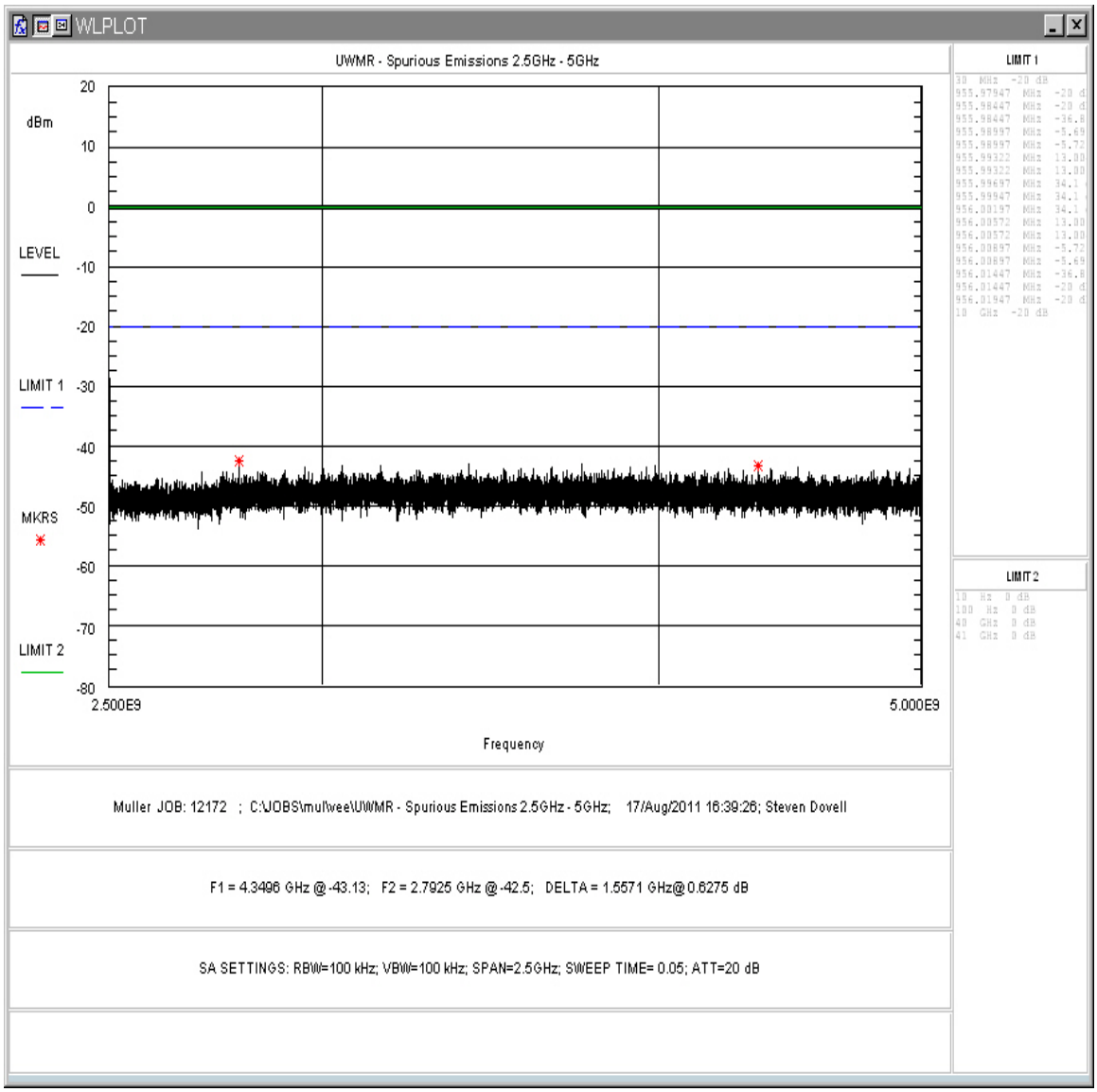

Figure 11: UWMR - Spurious Emissions 2.5GHz - 5GHz

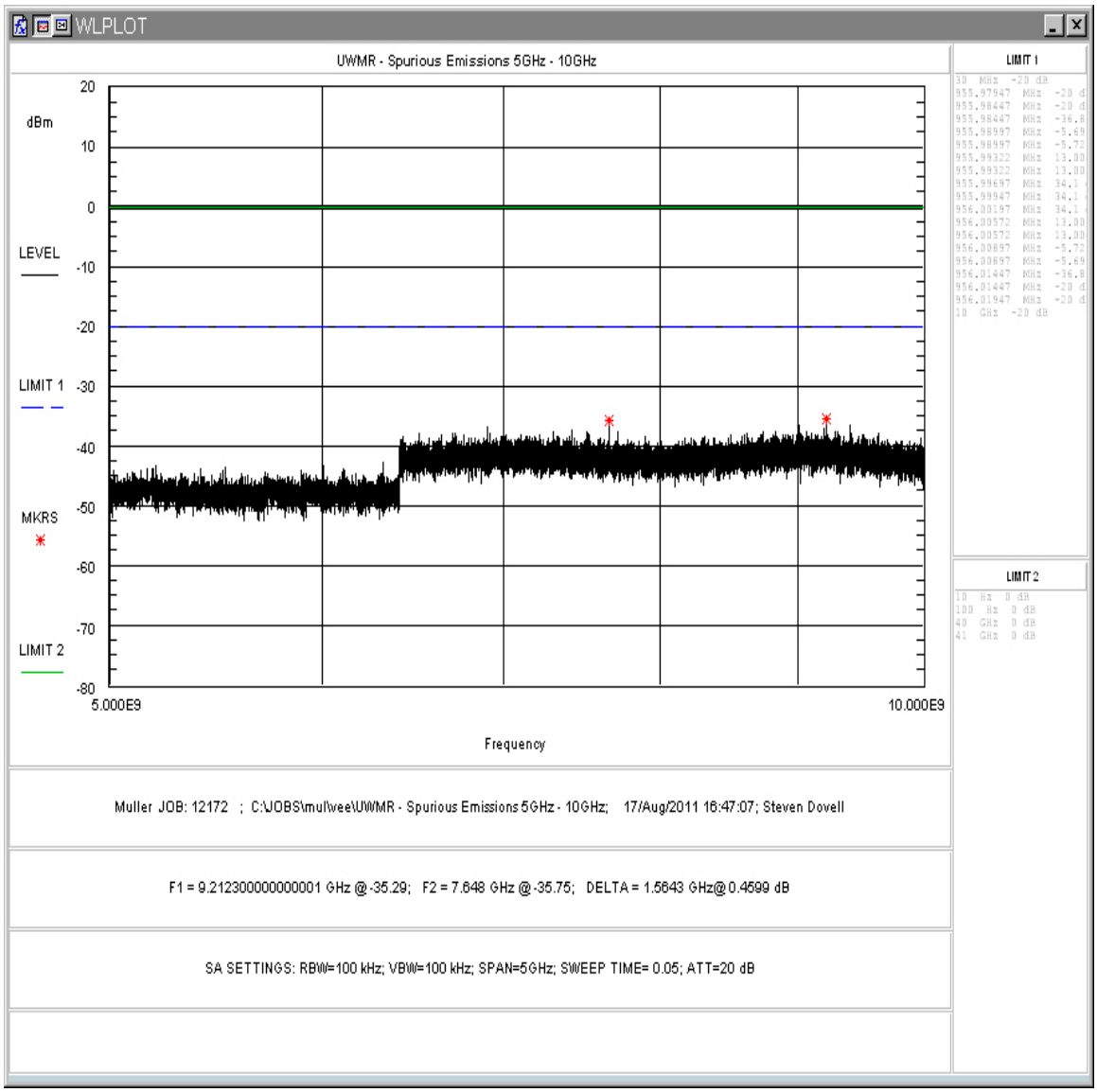

Figure 12: UWMR - Spurious Emissions 5GHz - 10GHz

4.6 Antenna power conduction limits for receivers. FCC § 15.111

4.7 FCC Part 15.11 states:

(a) In addition to the radiated emission limits, receivers that operate (tune) in the frequency range 30 to 960 MHz and CB receivers that provide terminals for the connection of an external receiving antenna may be tested to demonstrate compliance with the provisions of § 15.109 with the antenna terminals shielded and terminated with a resistive termination equal to the impedance specified for the antenna, provided these receivers also comply with the following: With the receiver antenna terminal connected to a resistive termination equal to the impedance specified or employed for the antenna, the power at the antenna terminal at any frequency within the range of measurements specified in § 15.33 shall not exceed 2.0 nanowatts.

The EUT receive antenna was removed and the cable was connected directly into a spectrum analyzer. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 100 kHz. The emissions outside of the allocated frequency band were then scanned from 30 MHz up to 10 GHz.

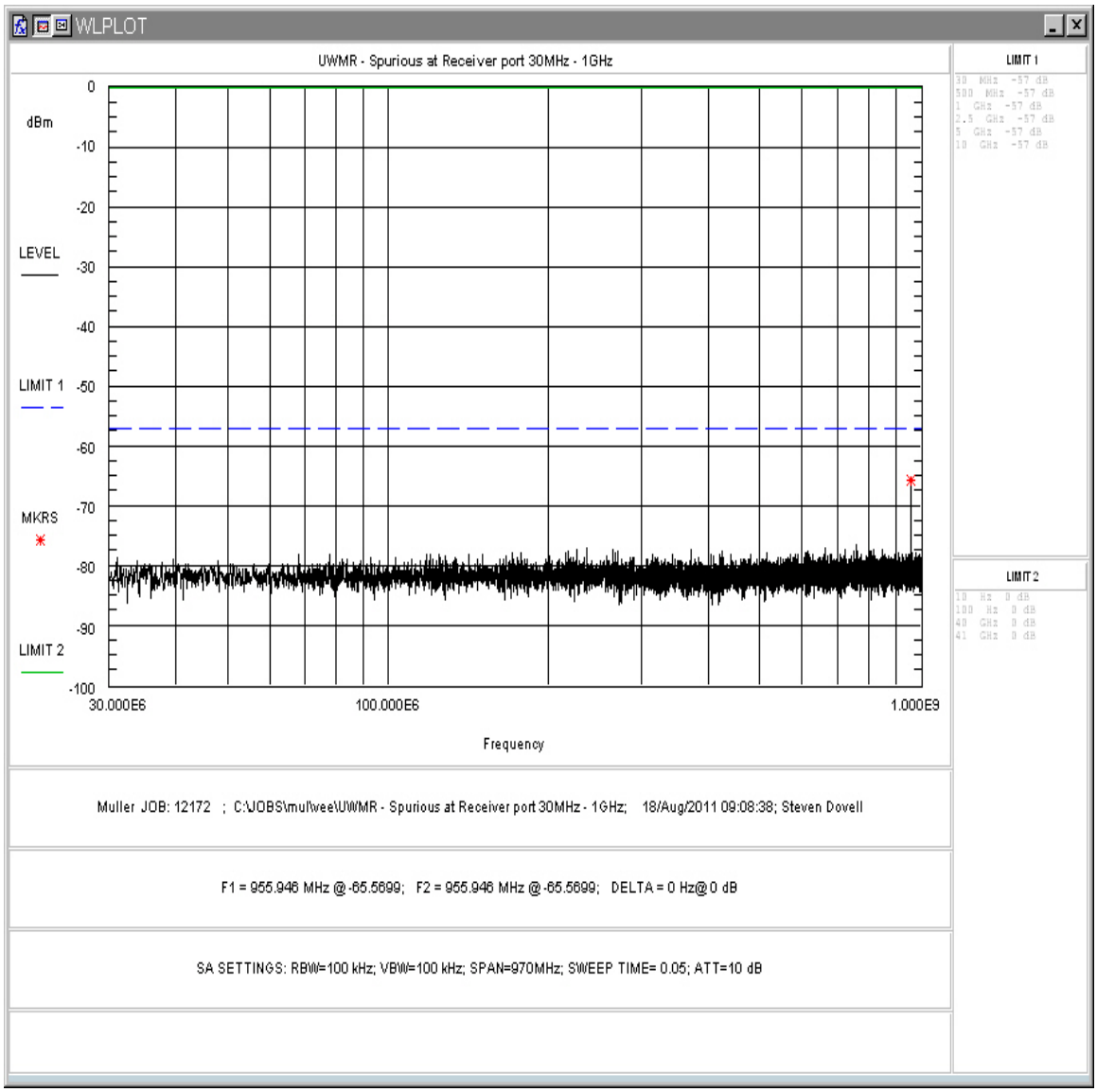

Figure 13: UWMR - Spurious at Receiver port 30MHz - 1GHz

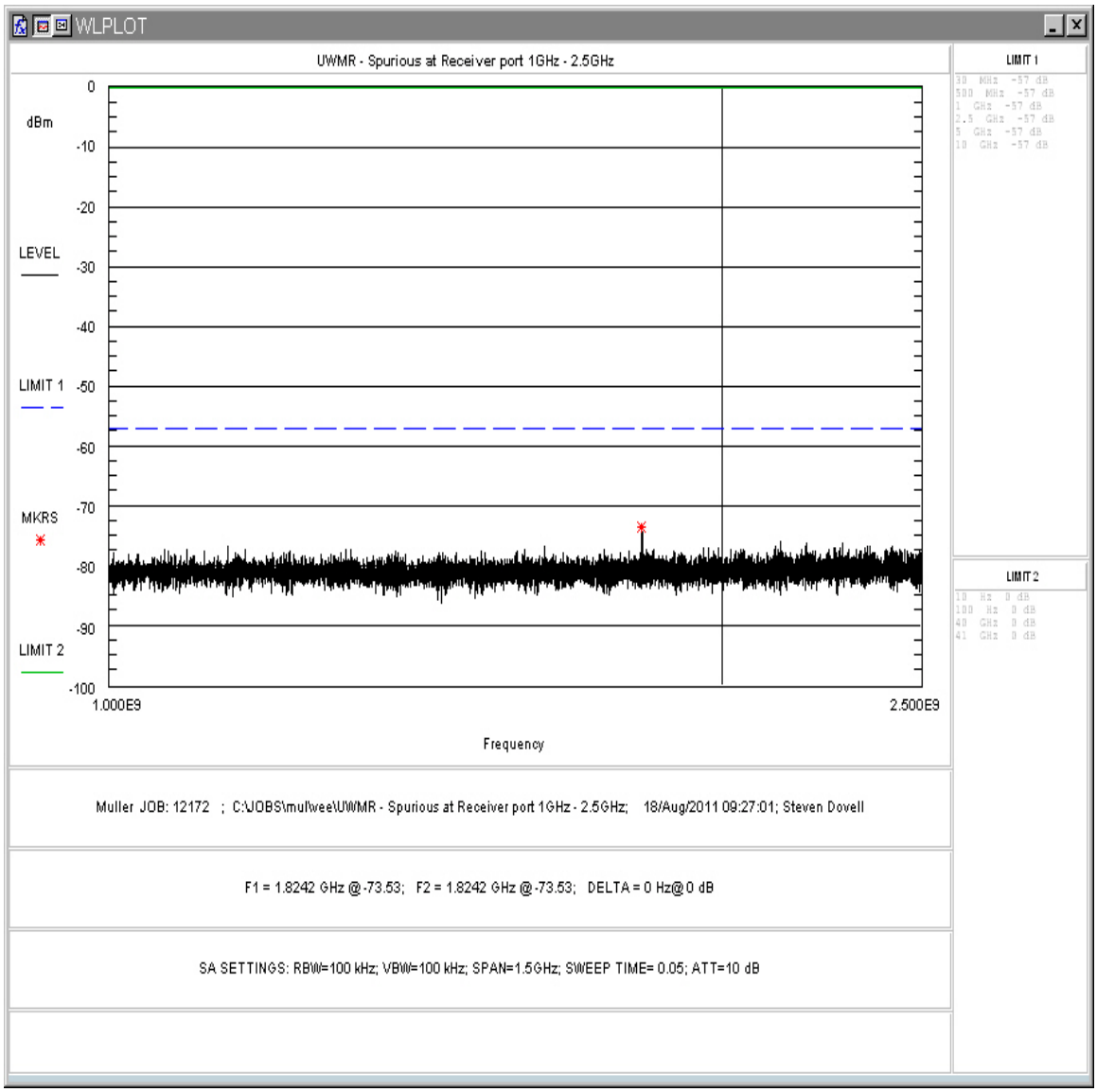

Figure 14: UWMR - Spurious at Receiver port 1GHz - 2.5GHz

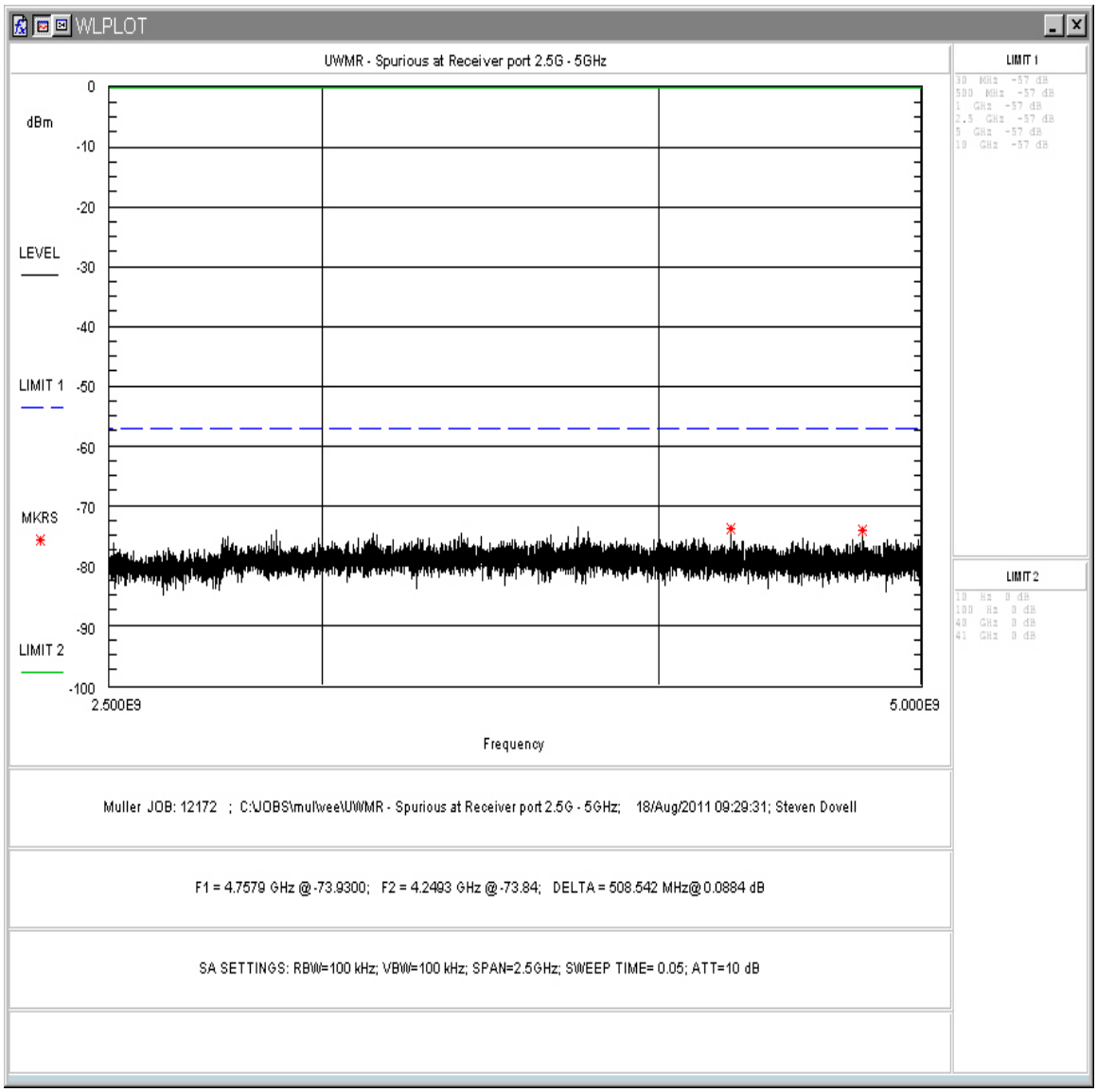

Figure 15: UWMR - Spurious at Receiver port 2.5G - 5GHz

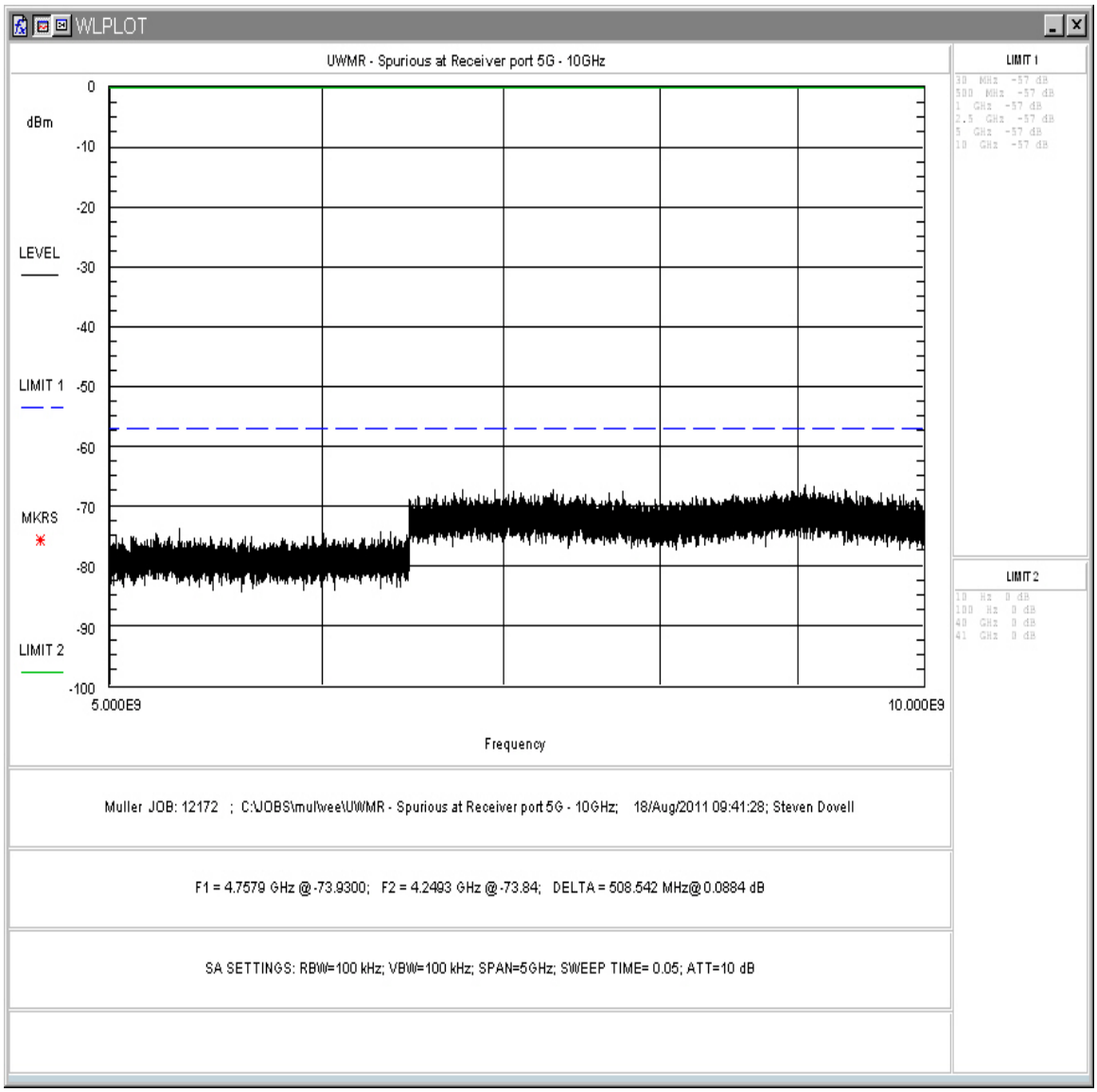

Figure 16: UWMR - Spurious at Receiver port 5G - 10GHz

4.8 Radiated Spurious Emissions: (FCC Part §2.1053)

The EUT must comply with the requirements for radiated spurious emissions that fall within the restricted bands. These emissions must meet the limits specified in §15.209 and §15.35(b) for peak measurements.

Class B Radiated Emissions limits with the antenna in place were used instead of case radiated EIRP. This Class B Radiated Emissions limit is a more stringent limit (devices do not need to be below class B limits) when compared to the Radiated EIRP limit, therefore, the device is considered to pass if they meet these limits.

4.8.1 Test Procedure

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 C63.4-2009. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The emissions were measured using the following resolution bandwidths:

Table 6: Spectrum Analyzer Settings

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>100 kHz
>1000 MHz	1 MHz	<30 Hz (Avg.), 1MHz (Peak)

Table 7: Radiated Emission Test Data TX on

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
108.74	V	270.00	1.00	8.20	13.8	12.6	150.0	-21.5	
128.94	V	90.00	1.00	12.20	15.7	24.9	150.0	-15.6	
960.00	V	200.00	1.17	17.30	29.7	224.3	500.0	-7.0	
2868.00	V	45.00	1.40	45.10	-2.6	133.3	5000.0	-31.5	Peak
3824.00	V	0.00	1.40	43.50	-1.3	128.2	5000.0	-31.8	Peak
4780.00	V	0.00	1.40	42.20	-0.6	120.8	5000.0	-32.3	Peak
5736.00	V	0.00	1.40	42.50	-1.0	118.8	5000.0	-32.5	Peak
7648.00	V	0.00	1.40	43.70	-1.4	130.2	5000.0	-31.7	Peak
2868.00	H	45.00	1.40	32.10	-2.6	29.9	500.0	-24.5	Average
3824.00	H	0.00	1.40	31.50	-1.3	32.2	500.0	-23.8	Average
4780.00	H	0.00	1.40	31.20	-0.6	34.0	500.0	-23.3	Average
5736.00	H	0.00	1.40	30.77	-1.0	30.8	500.0	-24.2	Average
7648.00	H	0.00	1.40	31.70	-1.4	32.7	500.0	-23.7	Average
108.70	H	250.00	4.00	14.20	13.8	25.0	150.0	-15.6	
128.96	H	45.00	4.00	9.80	15.7	18.9	150.0	-18.0	
960.00	H	90.00	1.51	9.70	29.7	93.5	500.0	-14.6	
2868.00	H	90.00	1.93	44.30	-2.6	121.6	500.0	-12.3	Peak
3824.00	H	0.00	1.93	43.10	-1.3	122.5	500.0	-12.2	Peak
4780.00	H	0.00	1.93	43.45	-0.6	139.5	500.0	-11.1	Peak
5736.00	H	0.00	1.93	43.20	-1.0	128.8	500.0	-11.8	Peak
7648.00	H	0.00	1.93	44.20	-1.4	138.0	500.0	-11.2	Peak
2868.00	H	90.00	1.93	31.70	-2.6	28.5	500.0	-24.9	Average
3824.00	H	0.00	1.93	31.55	-1.3	32.4	500.0	-23.8	Average
4780.00	H	0.00	1.93	31.50	-0.6	35.2	500.0	-23.0	Average
5736.00	H	0.00	1.93	31.60	-1.0	33.9	500.0	-23.4	Average
7648.00	H	0.00	1.93	31.80	-1.4	33.1	500.0	-23.6	Average

4.9 Frequency Stability: (FCC Part §2.1055)

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances.

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The EUT is powered by DC voltage supplied externally. The manufacturer's power requirements for the EUT include the following:

Low DC Voltage of 10.8 VDC (manufacturer's specification)

High DC Voltage of 13.8 VDC (manufacturer's specifications)

The frequency stability of the transmitter was examined at the voltage extremes and for the temperature range of -30°C to +50°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the frequency counter. The EUT was configured with the following for all measurements: This unit is compliant to the 0.00015% limit.

Table 8: Frequency Deviation as a Function of Temperature

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	955.999693	0.0	0
-30	956.000287	594.0	0.0000621
-20	956.000264	571.0	0.0000597
-10	956.000191	498.0	0.0000521
0	956.000341	648.0	0.0000678
10	955.999385	-308.0	0.0000322
20	955.999873	180.0	0.0000188
30	955.999613	-80.0	0.0000084
40	955.999709	16.0	0.0000017
50	955.999517	-176.0	0.0000184

Table 9: Frequency Deviation as a Function of Voltage

Voltage (Volts)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Voltage (Volts)
At rated	955.999693	0	0.0	12VDC
At 85%	955.999730	-37	0.0000039	10.8VDC
At 115%	955.999736	-43	0.0000045	13.8VDC