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FCC & Industry Canada Certification Test Report
For the
Cooper Power Systems
RFN420CL(1W) MODULE

FCC ID: P9X-420CL1W
IC: 6766A-420CL1W

WLL JOB# **12766 Rev.1**
December 13, 2012
Re-issued January 2, 2013

Prepared for:

Cooper Power Systems
910 Clopper Rd. Ste 201S
Gaithersburg, MD, 20878

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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Reviewed by:

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Abstract

This report has been prepared on behalf of Cooper Power Systems to support the attached Application for Equipment Authorization. The test report and application are submitted for a Direct Sequence Spread Spectrum Transmitter under Part 15.247 (10/2010) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 issue 8 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Cooper Power Systems RFN420CL(1W) 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 ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

The Cooper Power Systems RFN420CL(1W) Module complies with the limits for a Direct Sequence Spread Spectrum Transmitter under FCC Part 15.247 and Industry Canada RSS-210.

Revision History	Description of Change	Date
Rev 0	Initial Release	December 13, 2012
Rev 1	Corrected Model name in Table 1 page 3 section 2.1 to state RFN420CL(1W). On page 3 section 2.3 a line was added stating that the unit was set to transmit continuously (Duty Cycle >98%).	January 2, 2013

Table of Contents

Abstract ii
1 Introduction 1
1.1 Compliance Statement 1
1.2 Test Scope 1
1.3 Contract Information 1
1.5 Test and Support Personnel 1
1.6 Abbreviations 2
2 Equipment Under Test 3
2.1 EUT Identification & Description 3
2.2 Test Configuration 3
2.3 Testing Algorithm 3
2.4 Test Location 4
2.5 Measurements 4
2.5.1 References 4
2.6 Measurement Uncertainty 4
3 Test Equipment 7
4 Test Results 9
4.1 Test Summary 9
4.2 Occupied Bandwidth: (FCC Part §15.247 (2)) 10
4.3 RF Power Output: (FCC Part §15.247(b)) 14
4.4 Power Spectral Density (Section §15.247(e)) 18
4.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §15.247(c)) 22
4.5.1 Band Edge Compliance 41
4.6 AC Conducted Emissions (FCC Part §15.207) 43
4.6.1 Requirements 43
4.6.2 Test Procedure 43
4.6.3 Test Data 43
4.7 Radiated Spurious Emissions: (FCC Part §15.205 & §15.209) 46
4.7.1 Test Procedure 46
4.8 Transceiver Co-location Attestation 52

List of Tables

Table 1: Device Summary 3
Table 2: Expanded Uncertainty List 6
Table 3: Test Equipment List 7
Table 4: Test Summary 9
Table 5: Occupied Bandwidth Results 10
Table 6: RF Power Output 14
Table 7: Power Spectral Density 18
Table 8: Conducted Emissions Data 120VAC, Transmit On 44
Table 9: Conducted Emissions Data 230VAC, Transmit On 45
Table 10: Spectrum Analyzer Settings 46
Table 11: Duty Cycle Calculations 47
Table 12: Radiated Emission Test Data, Low Channel (Restricted Bands) 49

Table 13: Radiated Emission Test Data, Center Channel (Restricted Bands) 50
Table 14: Radiated Emission Test Data, High Channel (Restricted Bands) 51

List of Figures

Figure 1: Occupied Bandwidth, Low Channel 11
Figure 2: Occupied Bandwidth, Center Channel 12
Figure 3: Occupied Bandwidth, High Channel 13
Figure 4: RF Peak Power, Low Channel 15
Figure 5: RF Peak Power, Center Channel 16
Figure 6: RF Peak Power, High Channel 17
Figure 7: Power Spectral Density, Low Channel 19
Figure 8: Power Spectral Density, Center Channel 20
Figure 9: Power Spectral Density, High Channel 21
Figure 10: Conducted Spurious Emissions, Low Channel, 30 - 1000MHz 23
Figure 11: Conducted Spurious Emissions, Low Channel, 1 – 2.35GHz 24
Figure 12: Conducted Spurious Emissions, Low Channel, 2.3 – 2.5GHz 25
Figure 13: Conducted Spurious Emissions, Low Channel, 2.5 - 10GHz 26
Figure 14: Conducted Spurious Emissions, Low Channel, 10 - 18GHz 27
Figure 15: Conducted Spurious Emissions, Low Channel, 18 - 25GHz 28
Figure 16: Conducted Spurious Emissions, Center Channel, 30 – 1000MHz 29
Figure 17: Conducted Spurious Emissions, Center Channel, 1 – 2.3GHz 30
Figure 18: Conducted Spurious Emissions, Center Channel, 2.35 – 2.5GHz 31
Figure 19: Conducted Spurious Emissions, Center Channel, 2.5 – 10GHz 32
Figure 20: Conducted Spurious Emissions, Center Channel, 10 -18GHz 33
Figure 21: Conducted Spurious Emissions, Center Channel, 18 – 25GHz 34
Figure 22: Conducted Spurious Emissions, High Channel, 30 - 1000MHz 35
Figure 23: Conducted Spurious Emissions, High Channel, 1 – 2.3GHz 36
Figure 24: Conducted Spurious Emissions, High Channel, 2.3 – 2.5GHz 37
Figure 25: Conducted Spurious Emissions, High Channel, 2.5 - 10GHz 38
Figure 26: Conducted Spurious Emissions, High Channel, 10 - 18GHz 39
Figure 27: Conducted Spurious Emissions, High Channel, 18 - 25GHz 40
Figure 28: Lower Band-edge, Low Channel 41
Figure 29: Upper band-edge, High Channel 42

1 Introduction

1.1 Compliance Statement

The Cooper Power Systems RFN420CL(1W) Module complies with the limits for a Direct Sequence Spread Spectrum Transmitter device under FCC Part 15.247 (10/2010) and Industry Canada RSS-210 issue 8.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with "OET 558074 D01 DTS Meas Guidance v02". The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Cooper Power Systems 910 Clopper Rd. Ste 201S Gaithersburg, MD, 20878
Purchase Order Number:	4504981014
Quotation Number:	67208

1.4 Test Dates

Testing was performed on the following date(s):	11/26/2012 to 12/7/2012

1.5 Test and Support Personnel

Washington Laboratories, LTD	James Ritter
Client Representative	Steve Seymour

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 RFN420CL(1W) is a radio communications device designed for use in Itron C2SX and C2SXD meters. It enables communication between the meter and a remotely located Gateway or Relay Node device using an RF mesh network. The RFN420CL(1W) provides a 915 MHz radio interface to an RF mesh network, and a Zigbee interface for HAN applications.

This report covers only the Zigbee radio, the 915MHz band FHSS radio is covered in a separate report.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Cooper Power Systems
FCC ID:	P9X-420CL1W
IC:	6766A-420CL1W
Model:	RFN420CL(1W)
FCC Rule Parts:	§15.247
Industry Canada:	RSS210 issue 8
Frequency Range:	2405 – 2475MHz
Maximum Output Power:	21.07 dBm (127.9mW)
Modulation:	DSSS(QPSK)
Occupied Bandwidth:	1.84MHz
Maximum Spurious TX:	397.7uV/m @ 3m -7425MHz (with unit tuned to 2475MHz)
Maximum Spurious RX:	NA (receiver above 960MHz)
Emission Designator:	1M84G1D
Keying:	Automatic
Type of Information:	Data
Number of Channels:	15
Antenna Connector	integral
Antenna Type	0 dBi wire antenna
Power Output Level	Fixed
Interface Cables:	None (plug- in board)
Power Source & Voltage:	120/230VAC

2.2 Test Configuration

The Cooper Power Systems RFN420CL(1W) Module, Equipment Under Test (EUT), was operated from a 115Vac power supply. Programming commands were sent from a support laptop via an ember ISA3 InSight port adaptor to a header on the EUT module.

2.3 Testing Algorithm

The RFN420CL(1W) Module was programmed for DSSS operation from a support laptop via an Ember ISA3 InSight port adaptor to a header on the EUT module. The Insight windows program allowed entry for channel selection during testing.

The EUT was set to transmit continuously (Duty cycle >98%) for all tests. Radiated duty cycle correction data was provided courtesy of Ember Corporation (manufacturer of DTS transmitter).

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

OET 558074 D01 DTS Meas Guidance v02, “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247” 10/4/2012

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:	**Bench Conducted RF Tests**	:	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
728	AGILENT - 8564EC	SPECTRUM ANALYZER 30HZ - 40GHZ	3/15/2013
528	AGILENT - E4446A	ANALYZER SPECTRUM	8/30/2013

Test Name:	**Radiated Emissions**	Test Date:	**12/06/2012**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/12/2013
71	HP - 85685A	PRESELECTOR RF	6/27/2013
73	HP - 8568B	ANALYZER SPECTRUM	6/27/2013
69	HP - 85650A	ADAPTER QP	6/27/2013
528	AGILENT - E4446A	ANALYZER SPECTRUM	8/30/2013
626	ARA - DRG-118/A	ANTENNA HORN	6/16/2013
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHZ	5/29/2014
281	ITC - 21A-3A1	WAVEGUIDE 4.51-10.0GHZ	5/29/2014
283	ITC - 21KU-3A1	WAVEGUIDE 9.8-20.5GHZ	4/19/2014
742	PENN ENGINEERING - WR284	2.2-4.15GHZ BANDPASS FILTER	5/29/2014
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/24/2013

Test Name:	**Conducted Emissions Voltage**	Test Date:	**12/06/2012**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
69	HP - 85650A	ADAPTER QP	6/27/2013
73	HP - 8568B	ANALYZER SPECTRUM	6/27/2013
71	HP - 85685A	PRESELECTOR RF	6/27/2013
125	SOLAR - 8028-50-TS-24-BNC	LISN	6/28/2013
126	SOLAR - 8028-50-TS-24-BNC	LISN	6/28/2013

4 Test Results

4.1 Test Summary

The Table Below shows the results of testing for compliance with a Direct Sequence Spread Spectrum System in accordance with FCC Part 15.247. Full results are shown in beginning in Section 4.2.

Table 4: Test Summary

TX Test Summary (Direct Sequence Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (2)	RSS-210 [A8. 2 (a)]	6dB Bandwidth	Pass
15.247 (2)(b)(3)	RSS-210 [A8.4 (4)]	Transmit Output Power	Pass
15.247 (e)	RSS-210 [A8.2 (b)]	Power Spectral Density	Pass
15.247 (d)	RSS-210 [A8. 5]	Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-210 Sect.2.2 RSS-Gen 7.2.2	General Field Strength Limits (Restricted Bands)	Pass
15.207	RSS-Gen [7.2.4]	AC Conducted Emissions	Pass

4.2 Occupied Bandwidth: (FCC Part §15.247 (2))

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

For Direct Sequence Spread Spectrum Systems, FCC Part 15.247 requires the minimum 6 dB bandwidth be at least 500 kHz.

OET 558074 Section 7 Option 1 method of measuring the bandwidth was used which required a spectrum analyzer be set up with a RBW of between 1 and 5% of the DTS bandwidth. A max hold of the peak plot was taken and measured between the 6dB down from peak points.

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
Low Channel (11): 2405MHz	1.840 MHz	=>500kHz	Pass
Mid Channel (18): 2440MHz	1.840 MHz	=>500kHz	Pass
High Channel (25): 2475MHz	1.680MHz	=>500kHz	Pass

Cooper Systems, Job 12766, RFN420CL(1W) Zigbee Radio, 6dB Bandwidth Plot, Low Channnel (11) @ 2405MHz
Limit=500KHz minimum, Measured = 1.840MHz

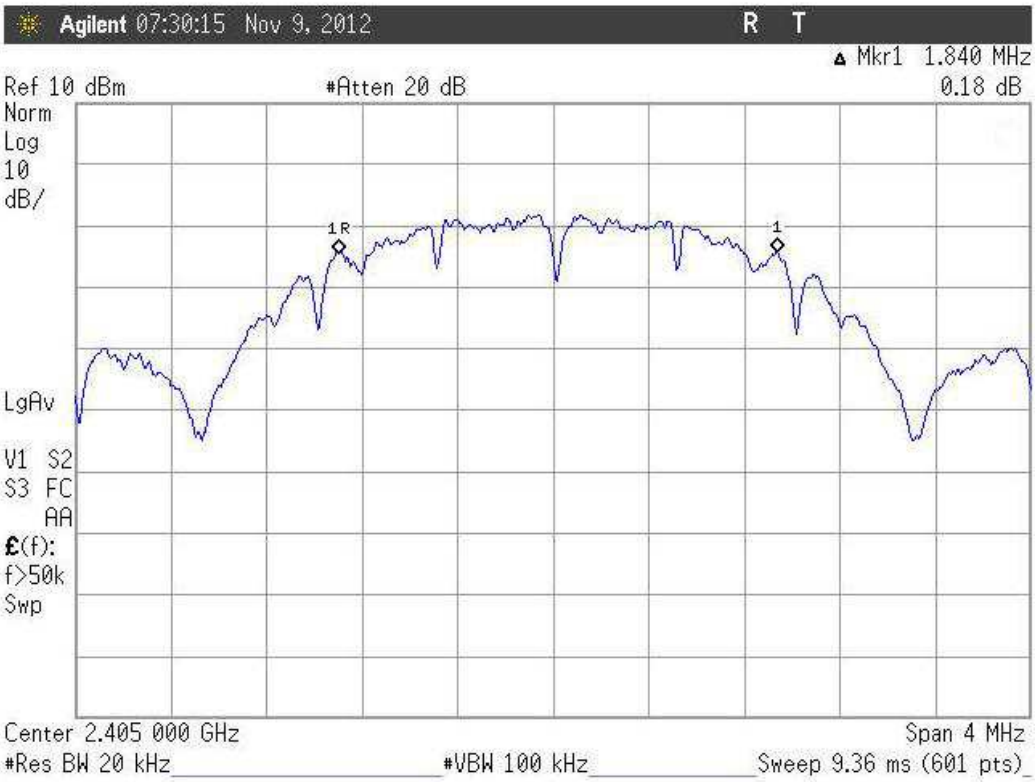


Figure 1: Occupied Bandwidth, Low Channel

Figure 2: Occupied Bandwidth, Center Channel

Figure 3: Occupied Bandwidth, High Channel

4.3 RF Power Output: (FCC Part §15.247(b))

To measure the output power the modulation was started while the frequency dwelled on a low, center and high channels. The output from the transmitter was connected to an attenuator and then to the input of an RF spectrum analyzer. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system. Peak Power was measured.

OET 558074 Section 8 Option 1 method of measuring the Peak Power was used which required a spectrum analyzer be set up with a RBW greater than the DTS bandwidth. A max hold of the peak plot was taken and measured at the highest point.

Table 6: RF Power Output

Frequency	Level	Limit	Pass/Fail
Low Channel (11): 2405MHz	21.05 dBm	30 dBm	Pass
Center Channel (18): 2440MHz	21.07 dBm	30 dBm	Pass
High Channel (25): 2475MHz	20.71 dBm	30 dBm	Pass

Figure 4: RF Peak Power, Low Channel

Figure 5: RF Peak Power, Center Channel

Figure 6: RF Peak Power, High Channel

4.4 Power Spectral Density (Section §15.247(e))

Measurements for power spectral density were taken in accordance with 15.247(e). The measurements were performed using OET 558074 Section 9 Option 1 The spectrum analyzer was set to peak detect mode with a RBW of 3kHz ,VBW of 10kHz across a 2.76MHz span using an auto sweeptime.

The highest level detected across any 3kHz band for continuous transmission was then recorded and compared to the limit 8dBm. The following table and plots give the results for power spectral density testing.

Table 7: Power Spectral Density

Frequency	Peak Level	Limit	Pass/Fail
Low Channel (11): 2405MHz	4.96 dBm	8 dBm	Pass
Center Channel (18): 2440MHz	5.93 dBm	8 dBm	Pass
High Channel (25): 2475MHz	4.30 dBm	8 dBm	Pass

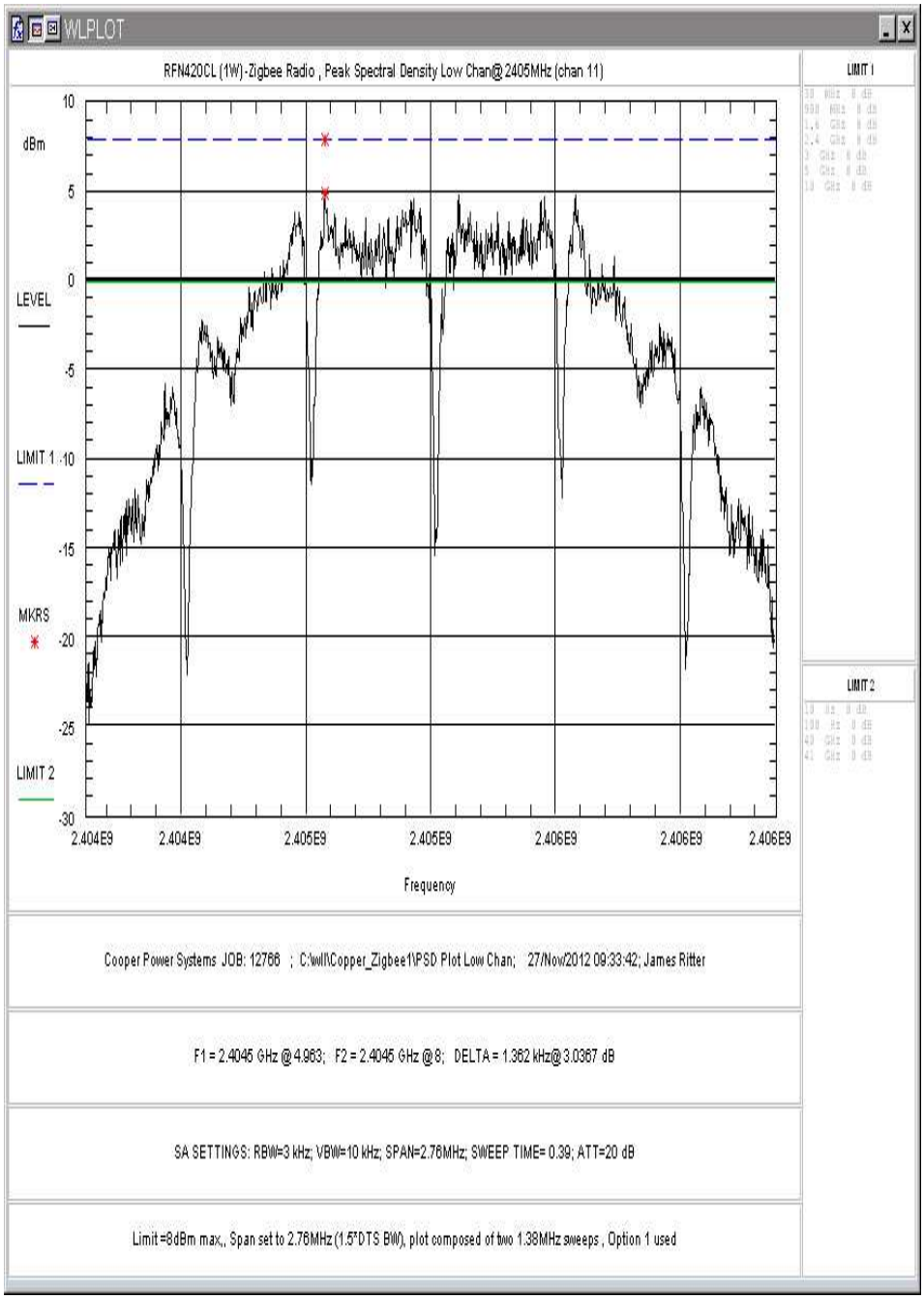


Figure 7: Power Spectral Density, Low Channel

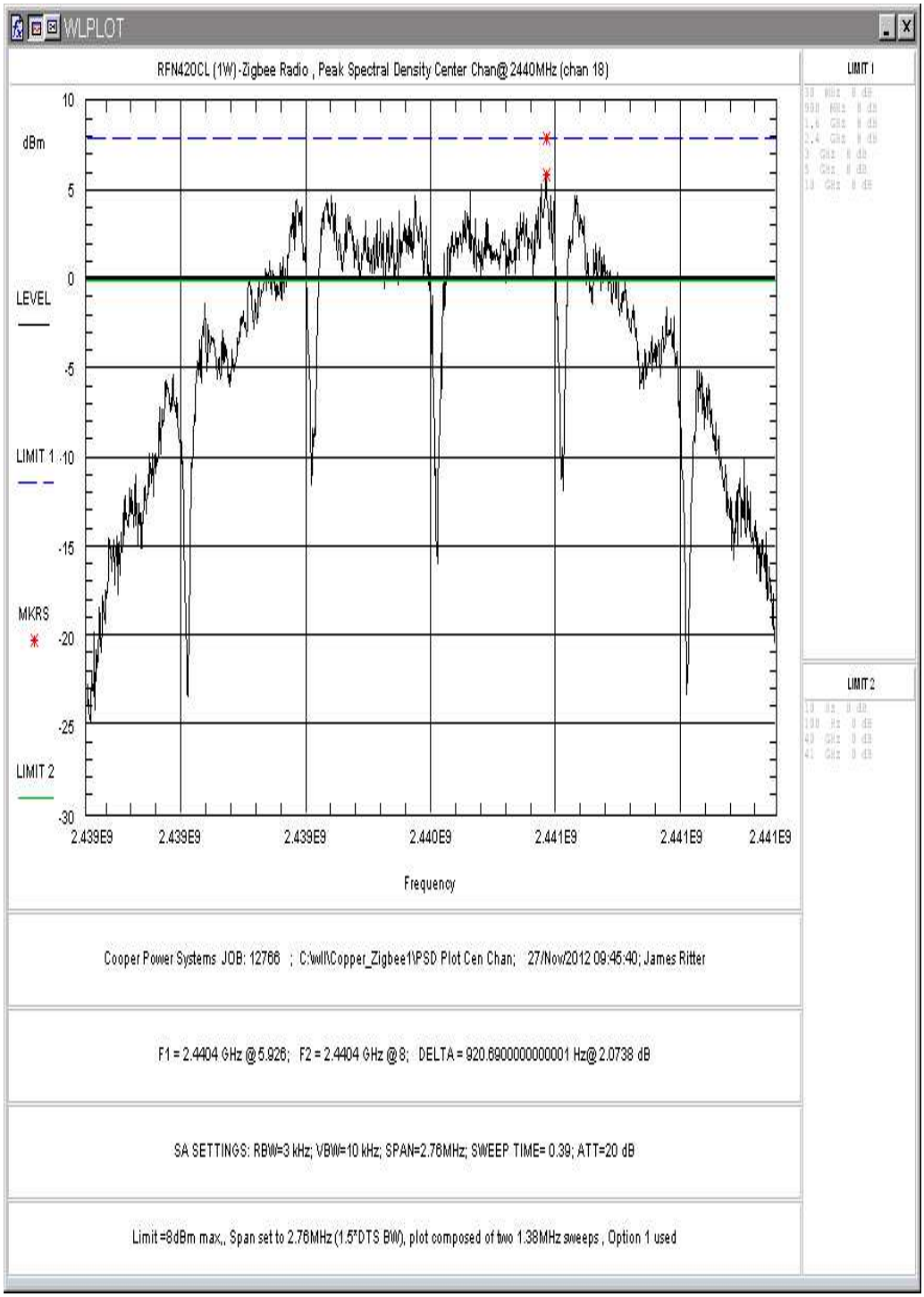


Figure 8: Power Spectral Density, Center Channel

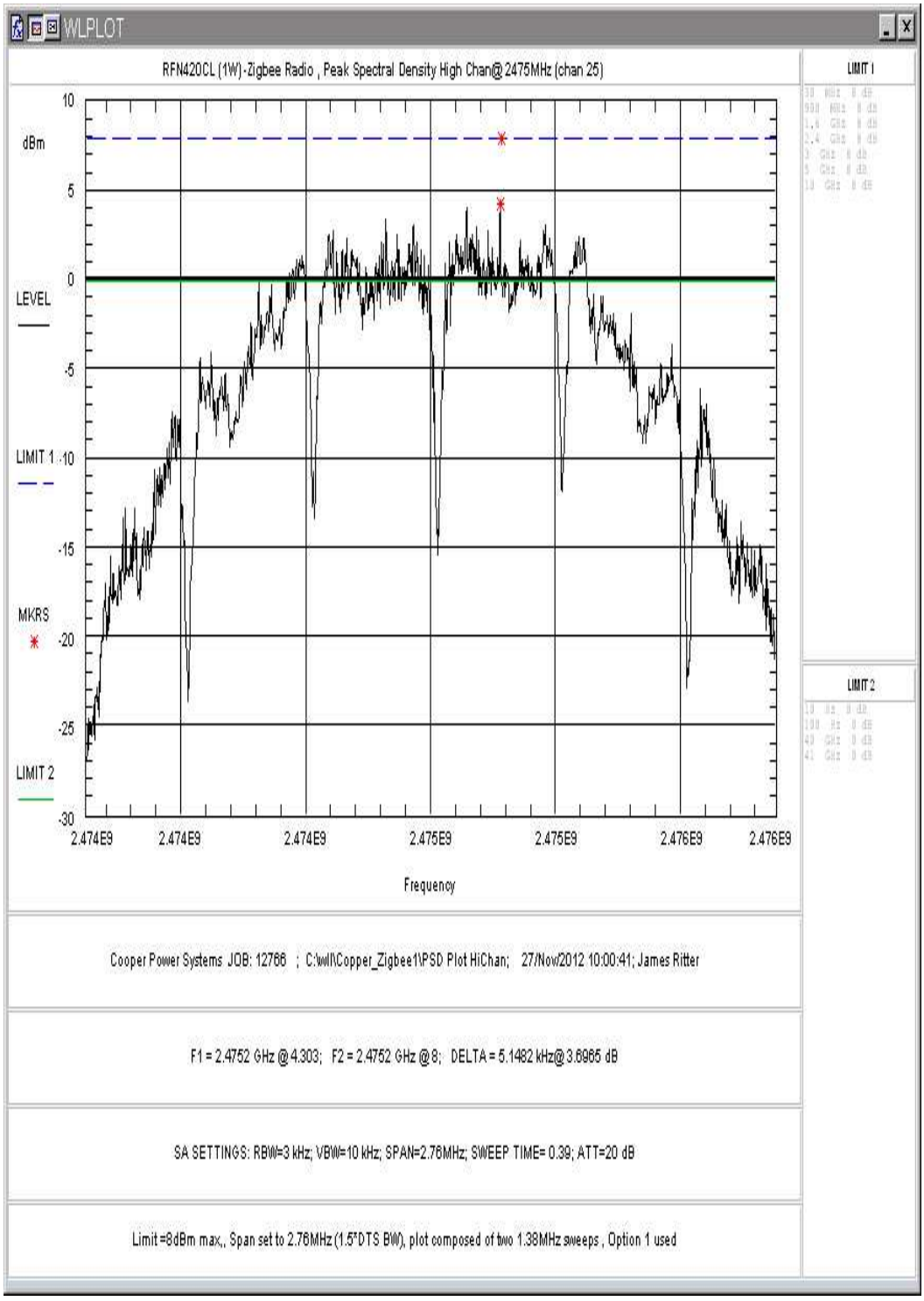


Figure 9: Power Spectral Density, High Channel

4.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §15.247(c))

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 300 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.

The following are plots of the conducted spurious emissions data.

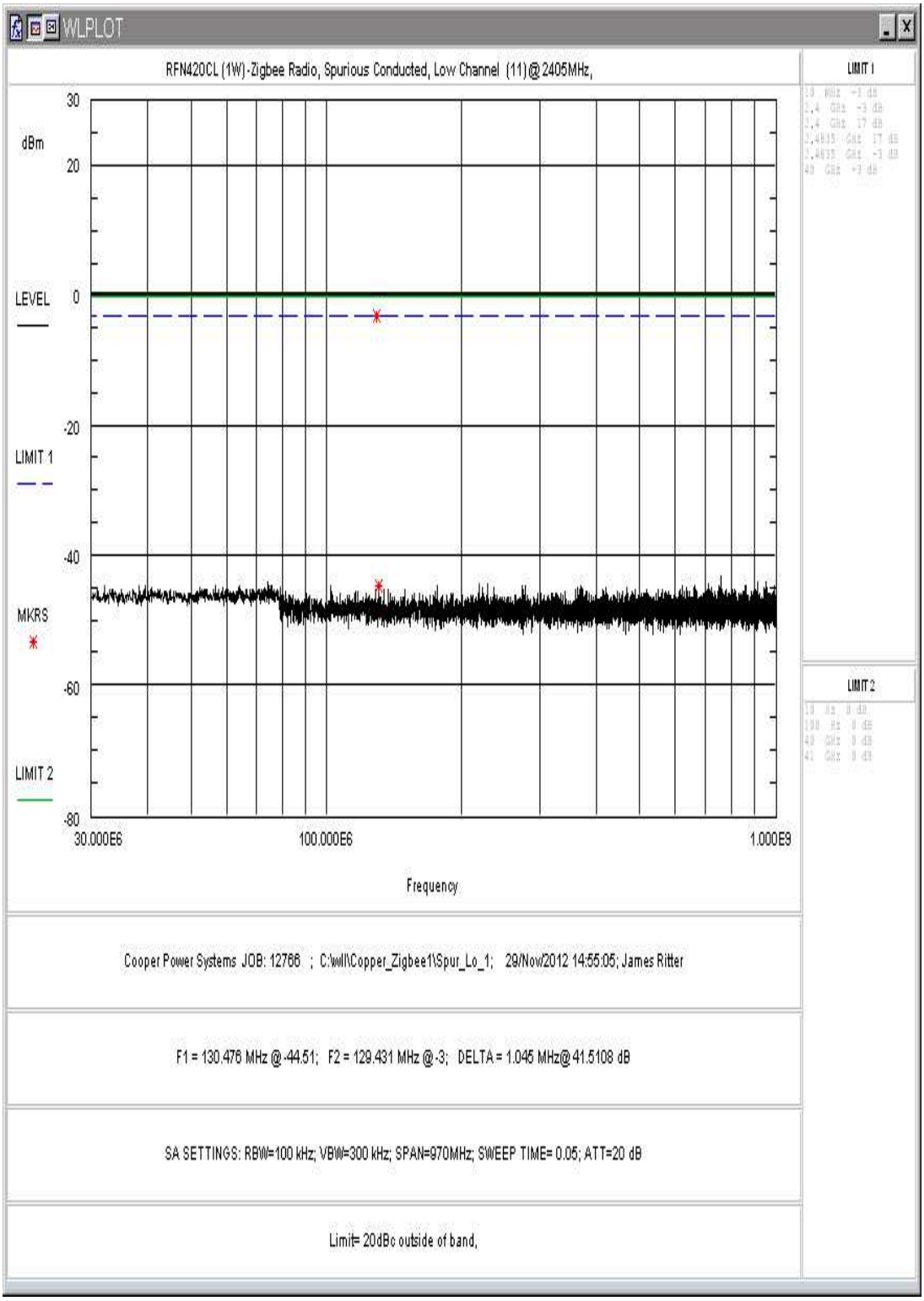


Figure 10: Conducted Spurious Emissions, Low Channel, 30 - 1000MHz

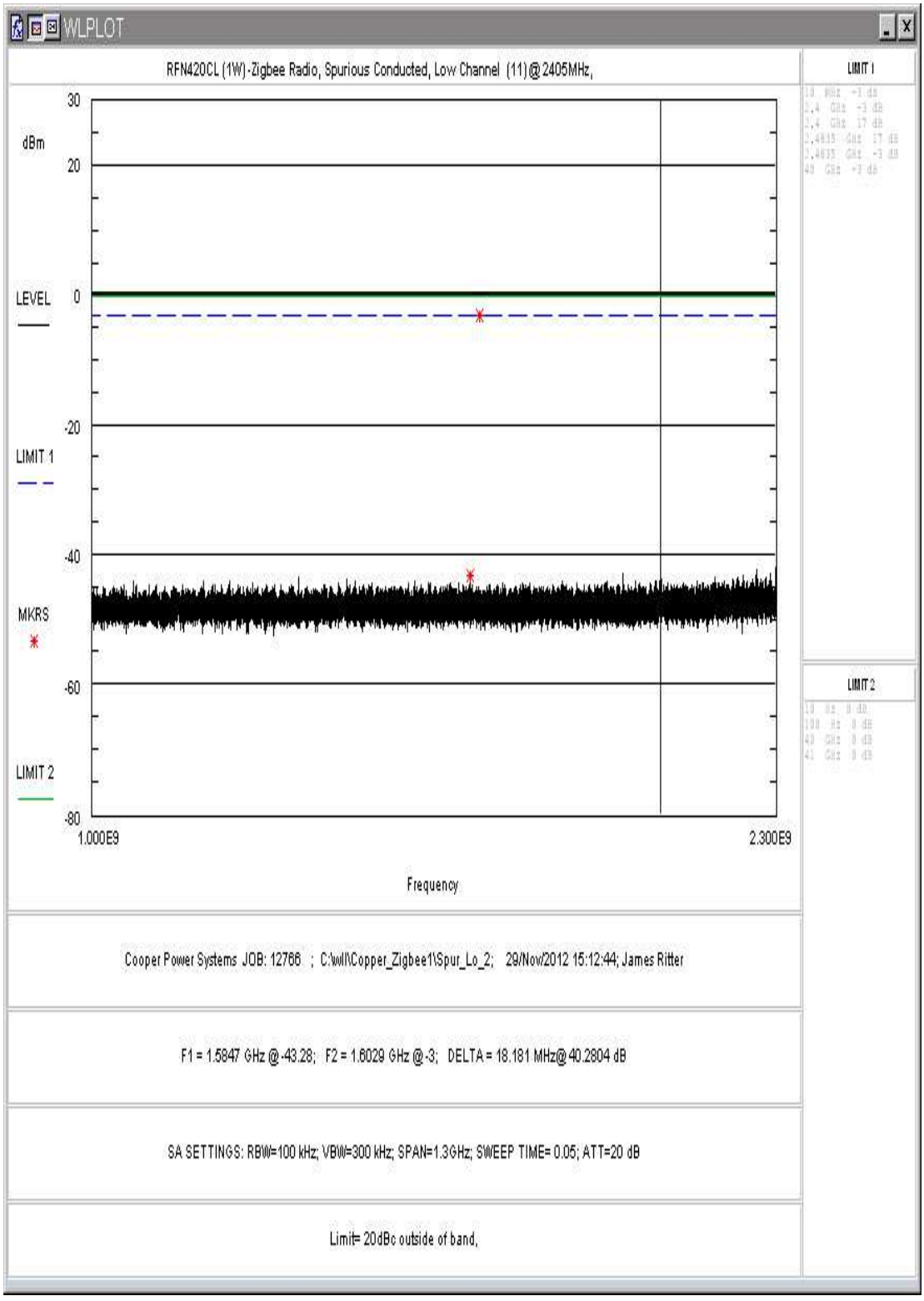


Figure 11: Conducted Spurious Emissions, Low Channel, 1 – 2.35GHz

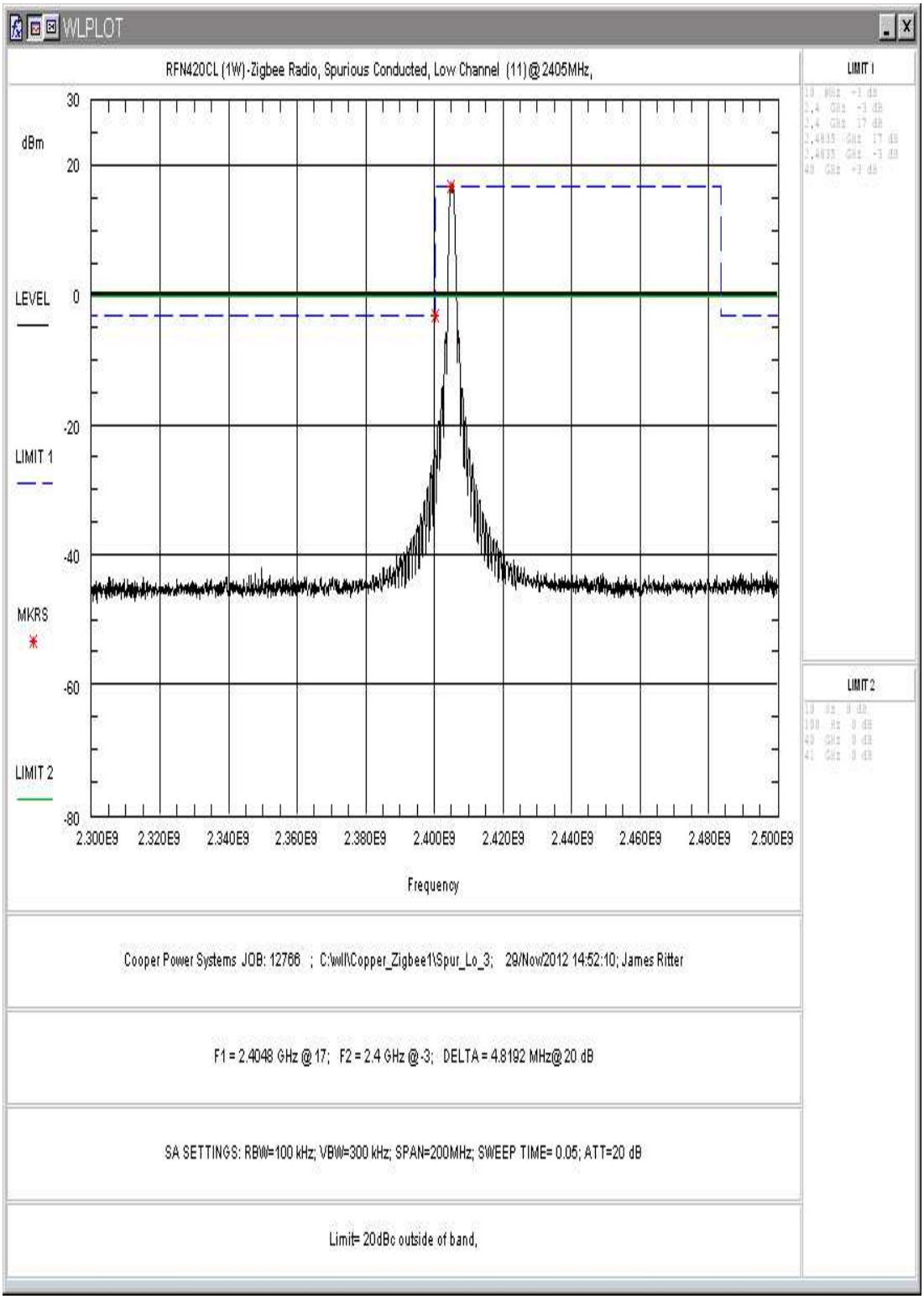


Figure 12: Conducted Spurious Emissions, Low Channel, 2.3 – 2.5GHz

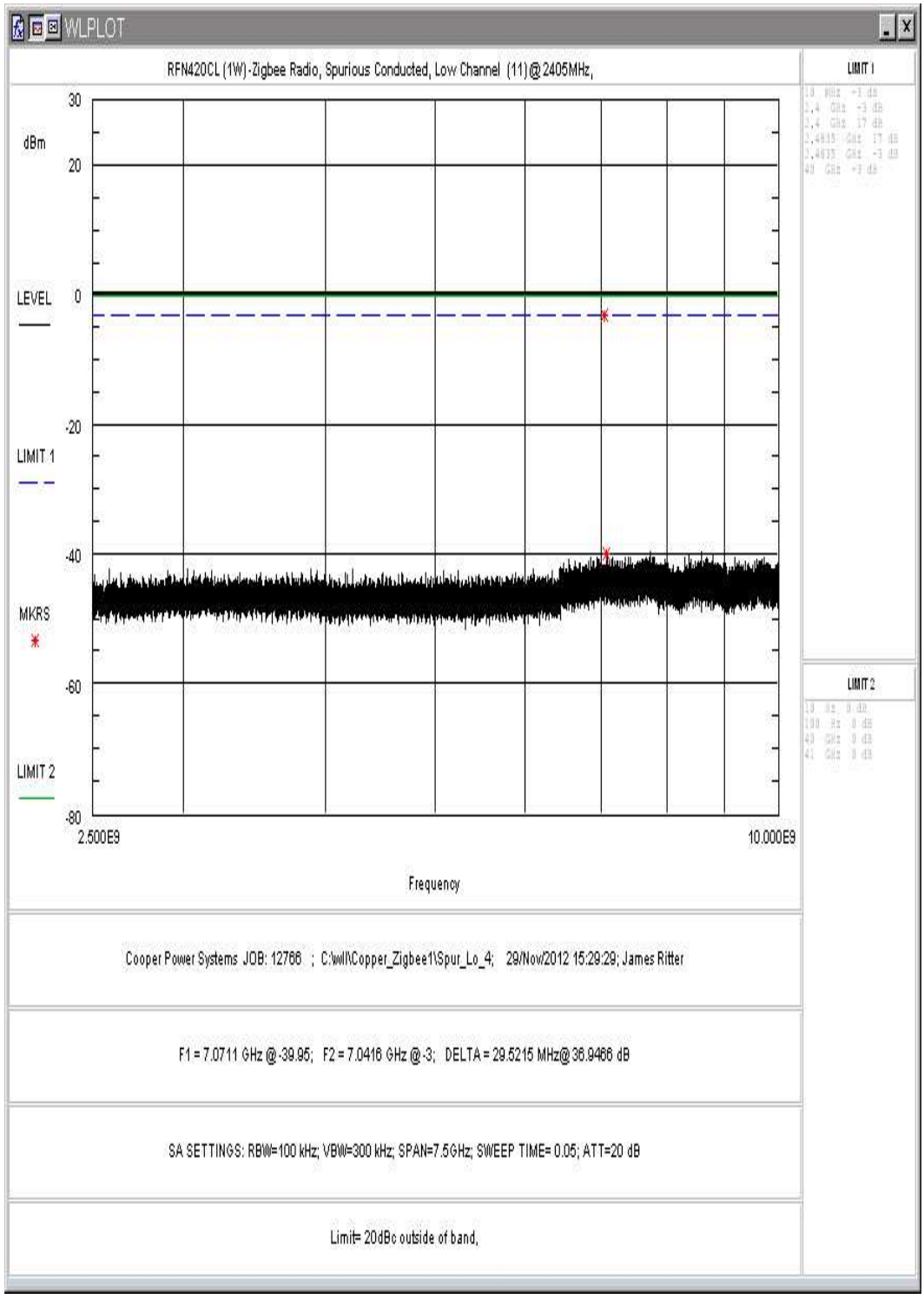


Figure 13: Conducted Spurious Emissions, Low Channel, 2.5 - 10GHz

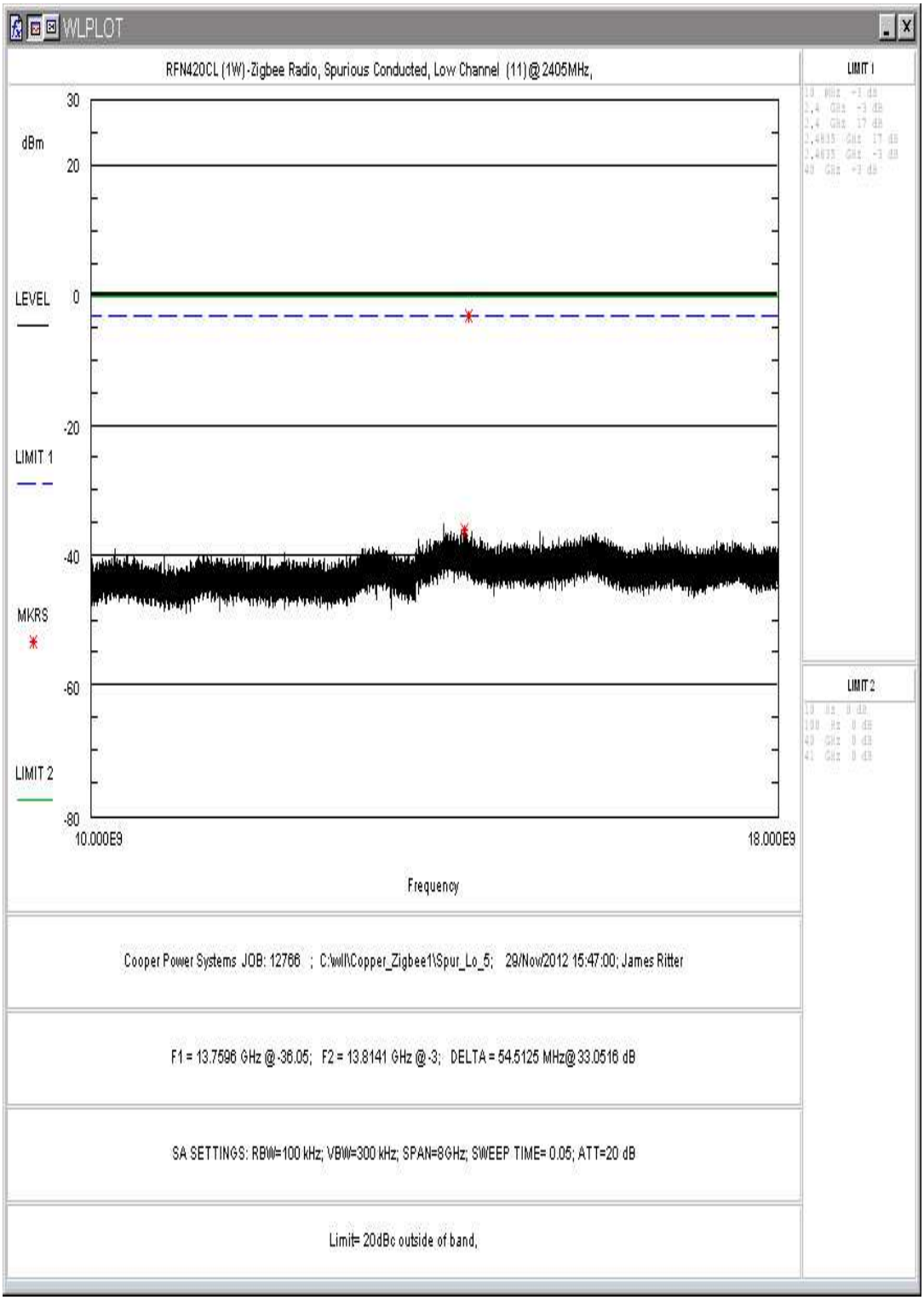


Figure 14: Conducted Spurious Emissions, Low Channel, 10 - 18GHz

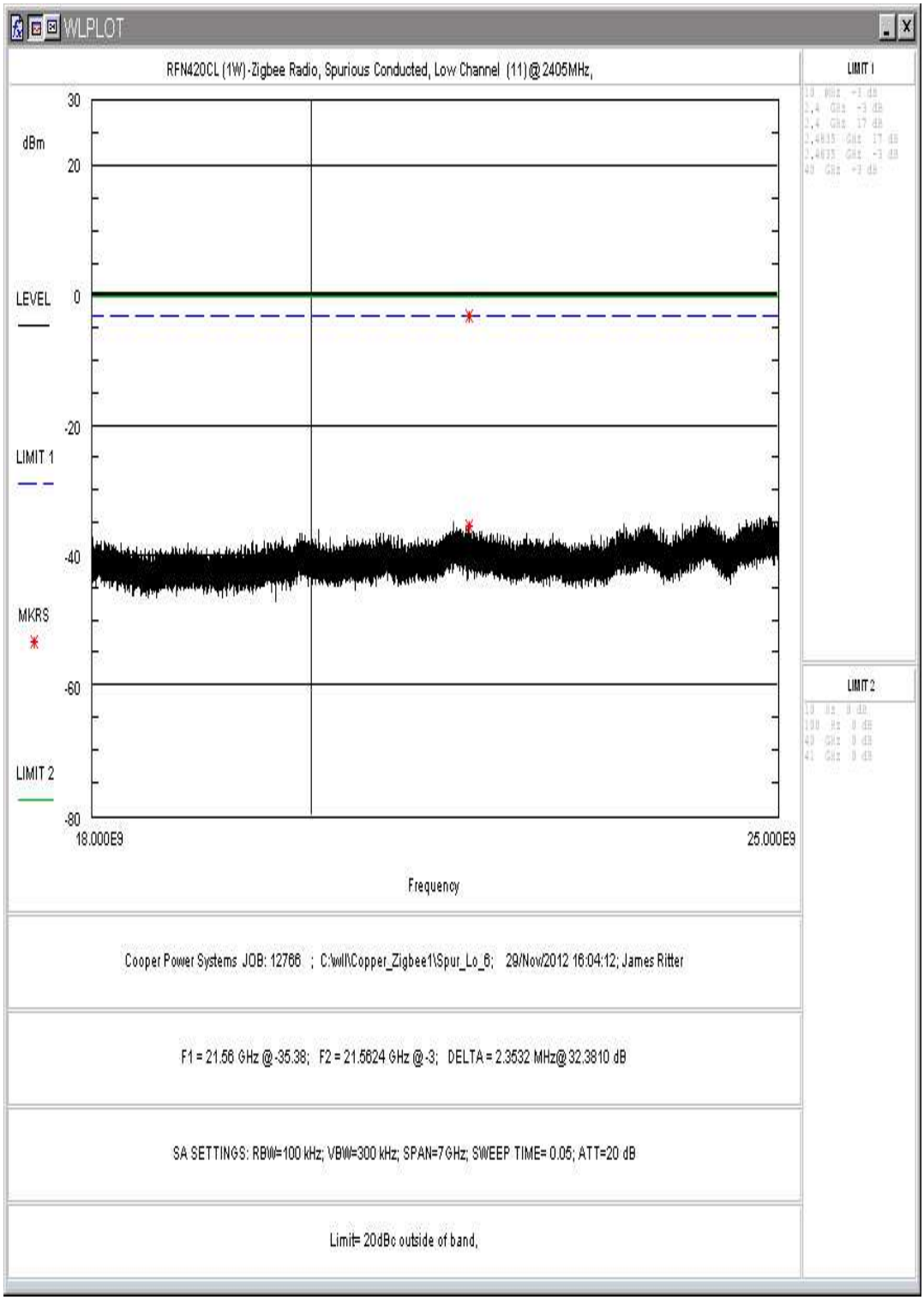


Figure 15: Conducted Spurious Emissions, Low Channel, 18 - 25GHz

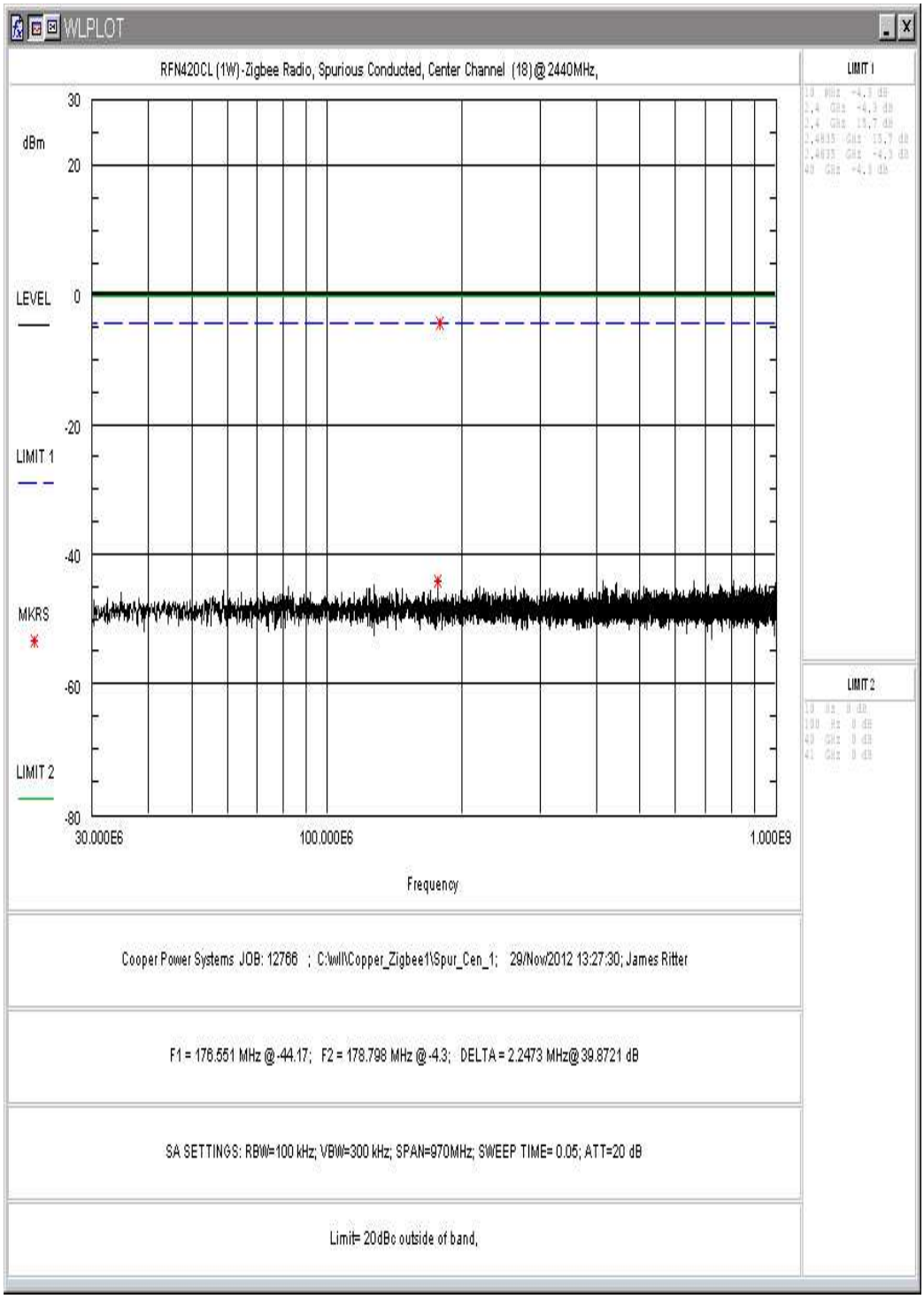


Figure 16: Conducted Spurious Emissions, Center Channel, 30 – 1000MHz

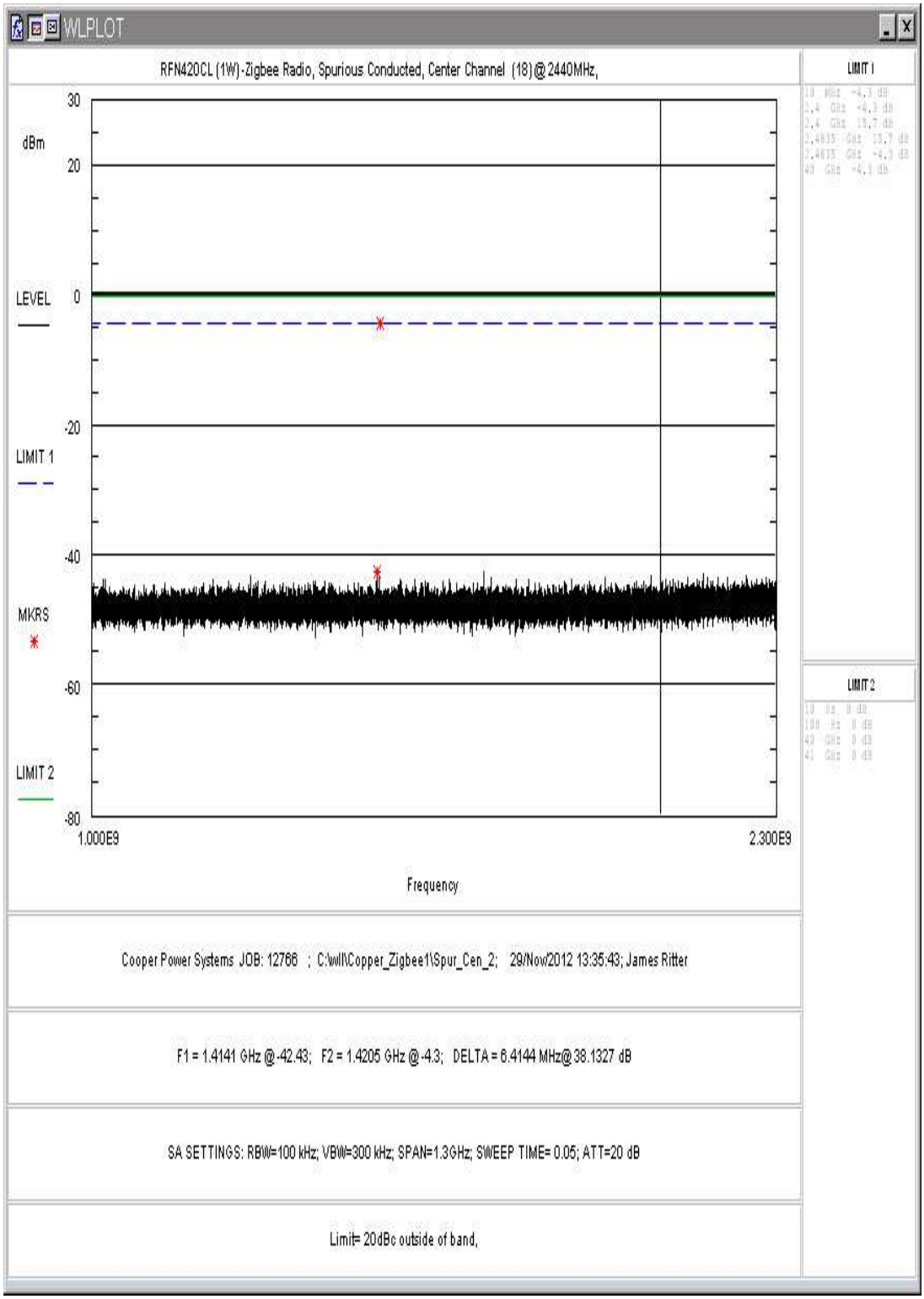


Figure 17: Conducted Spurious Emissions, Center Channel, 1 – 2.3GHz

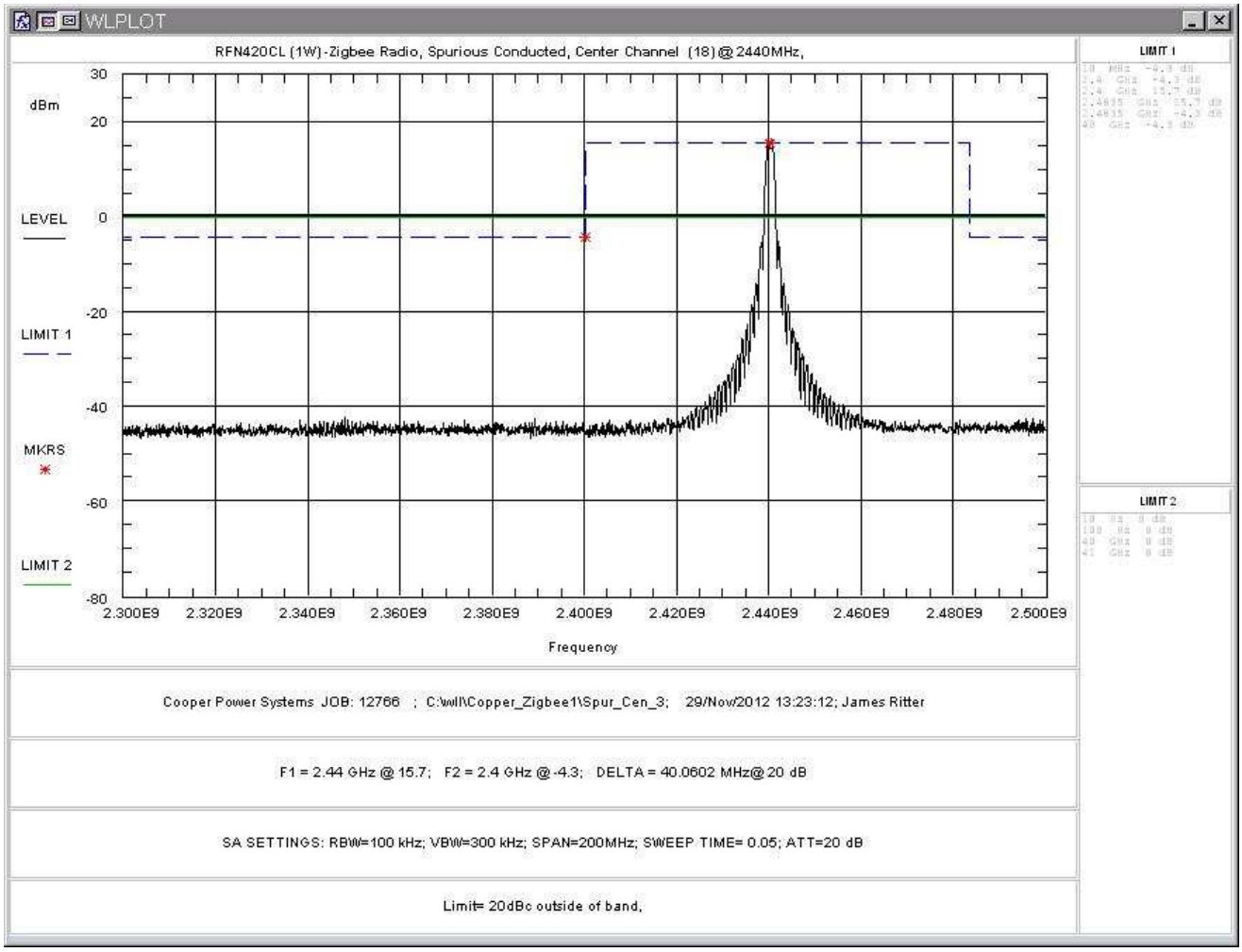


Figure 18: Conducted Spurious Emissions, Center Channel, 2.35 – 2.5GHz

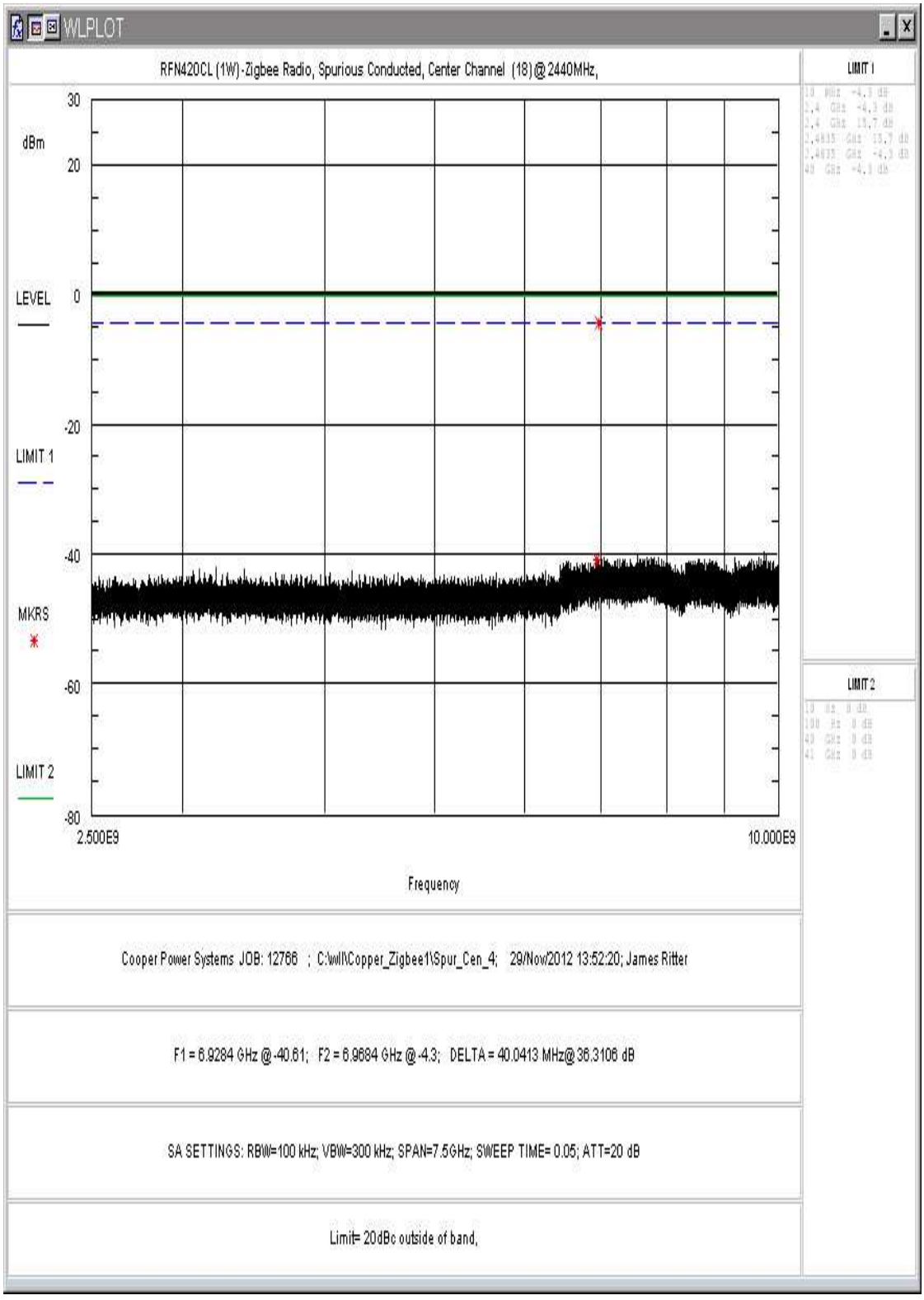


Figure 19: Conducted Spurious Emissions, Center Channel, 2.5 – 10GHz

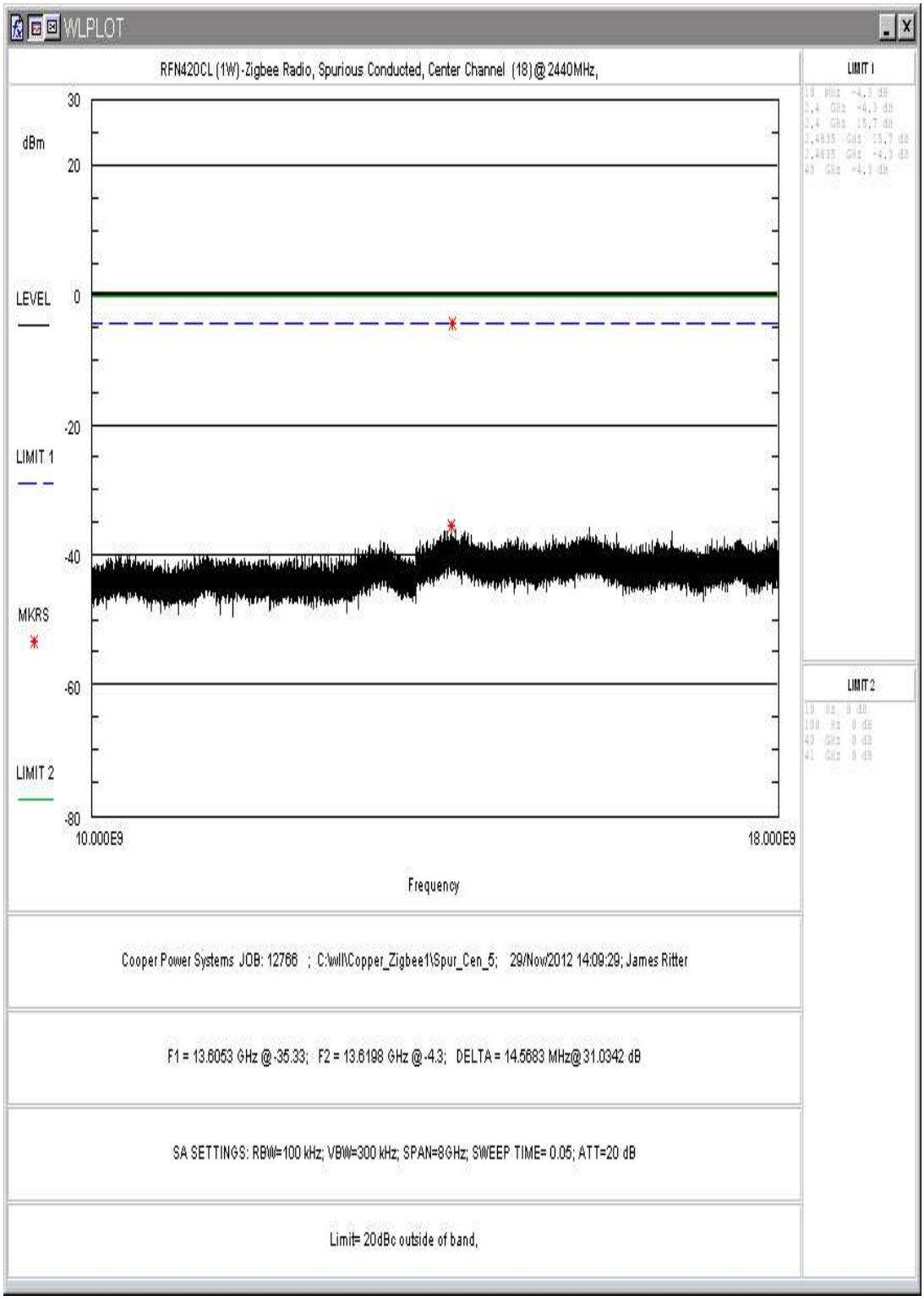


Figure 20: Conducted Spurious Emissions, Center Channel, 10 -18GHz

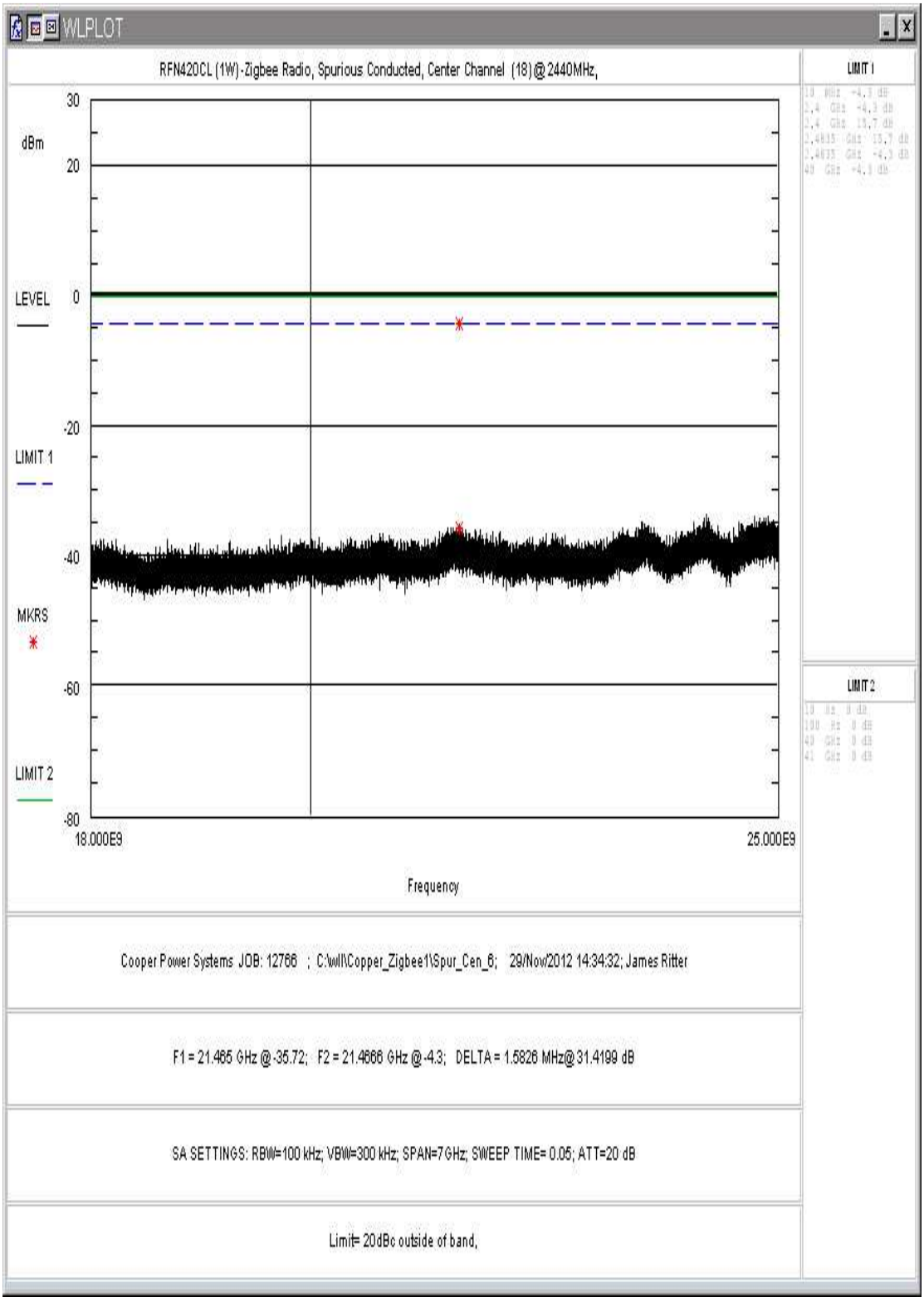


Figure 21: Conducted Spurious Emissions, Center Channel, 18 – 25GHz

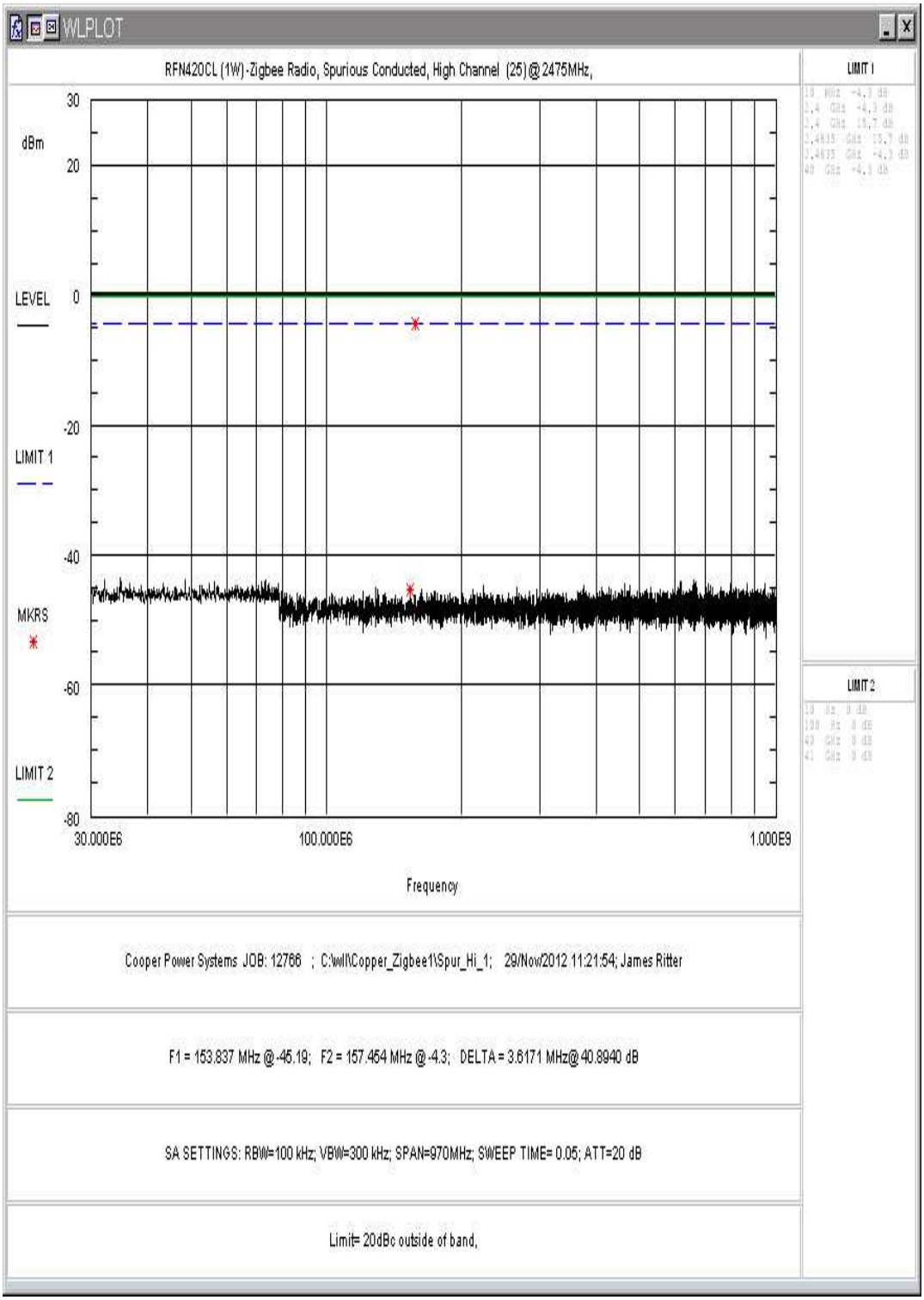


Figure 22: Conducted Spurious Emissions, High Channel, 30 - 1000MHz

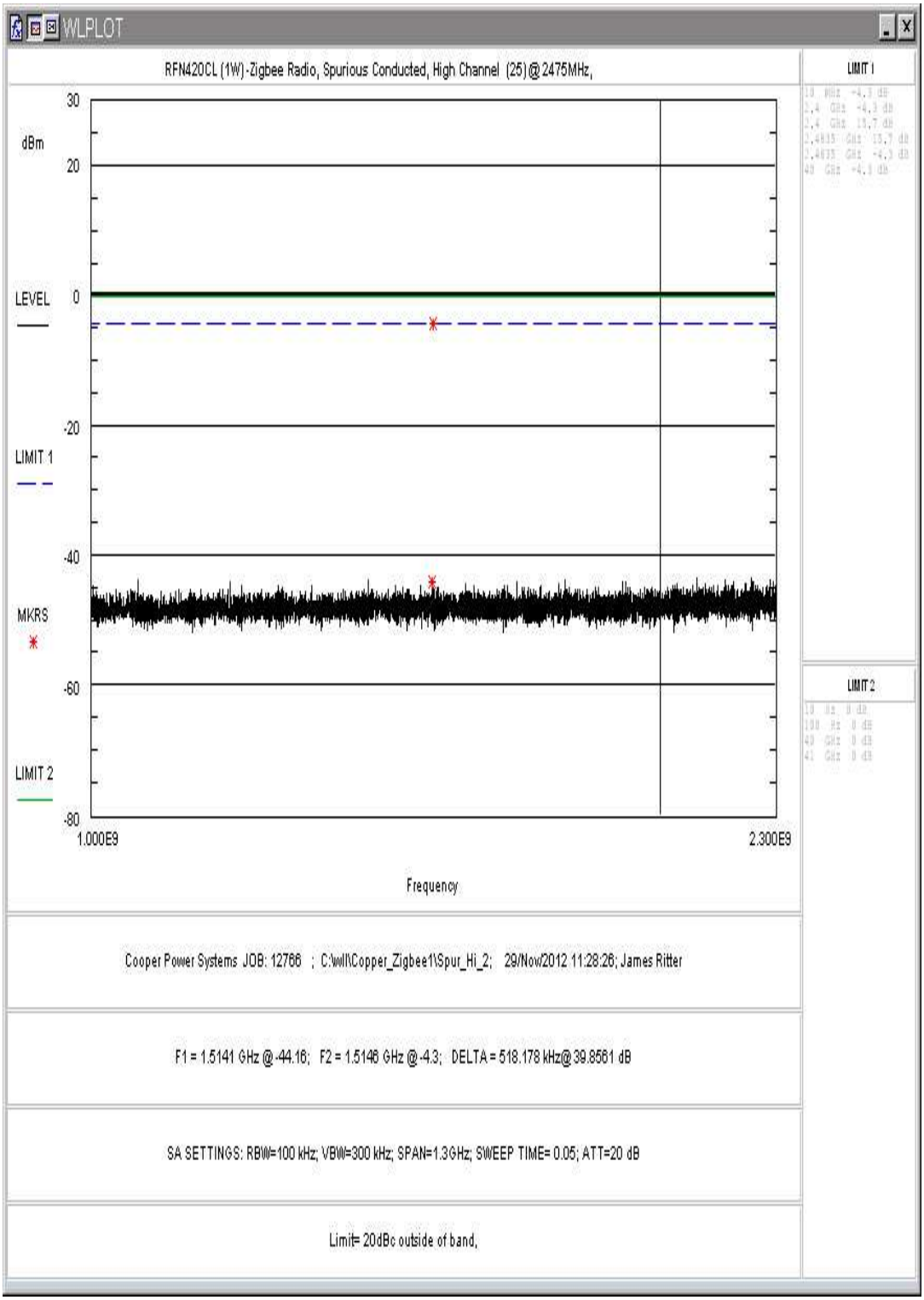


Figure 23: Conducted Spurious Emissions, High Channel, 1 – 2.3GHz

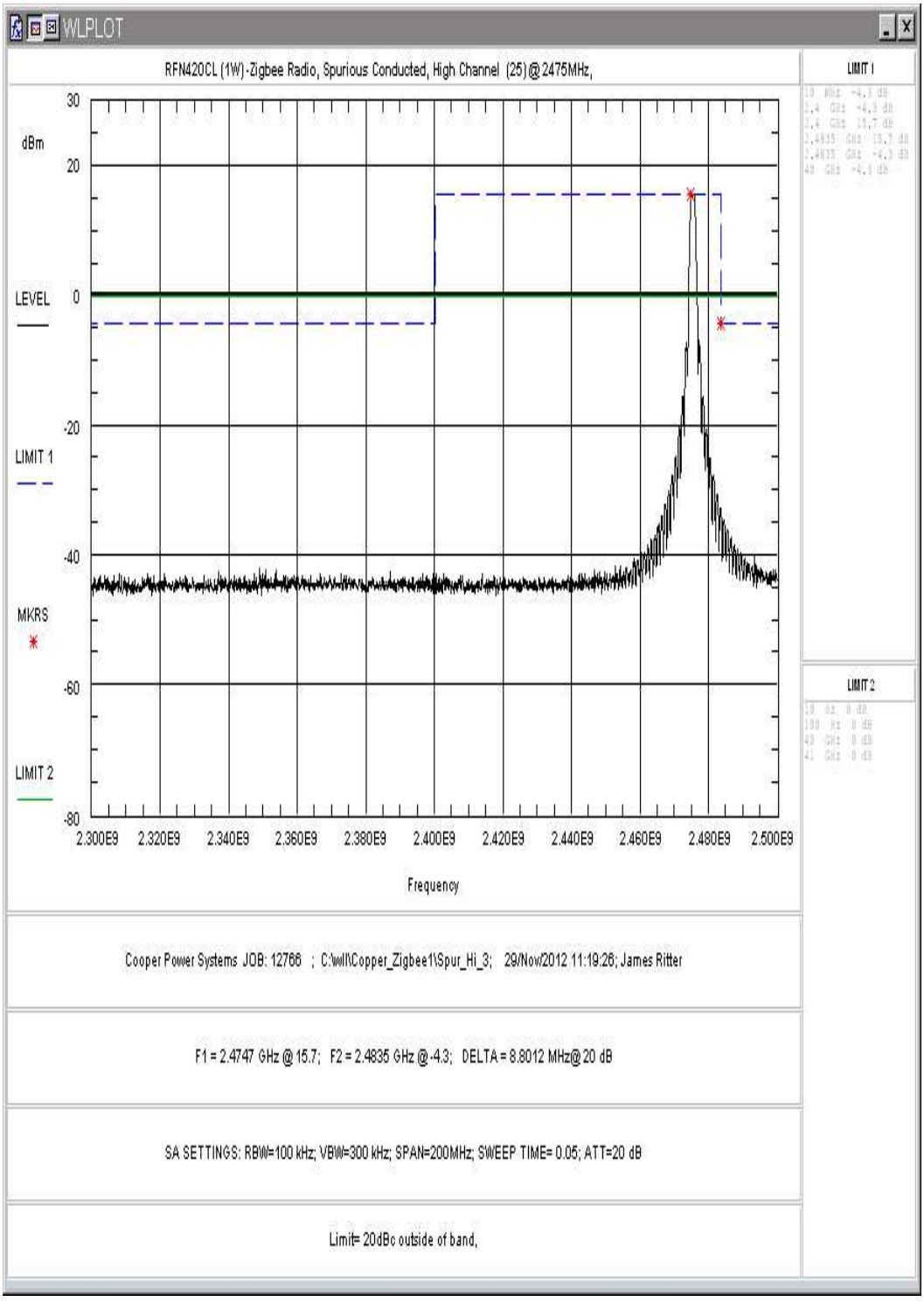


Figure 24: Conducted Spurious Emissions, High Channel, 2.3 – 2.5GHz

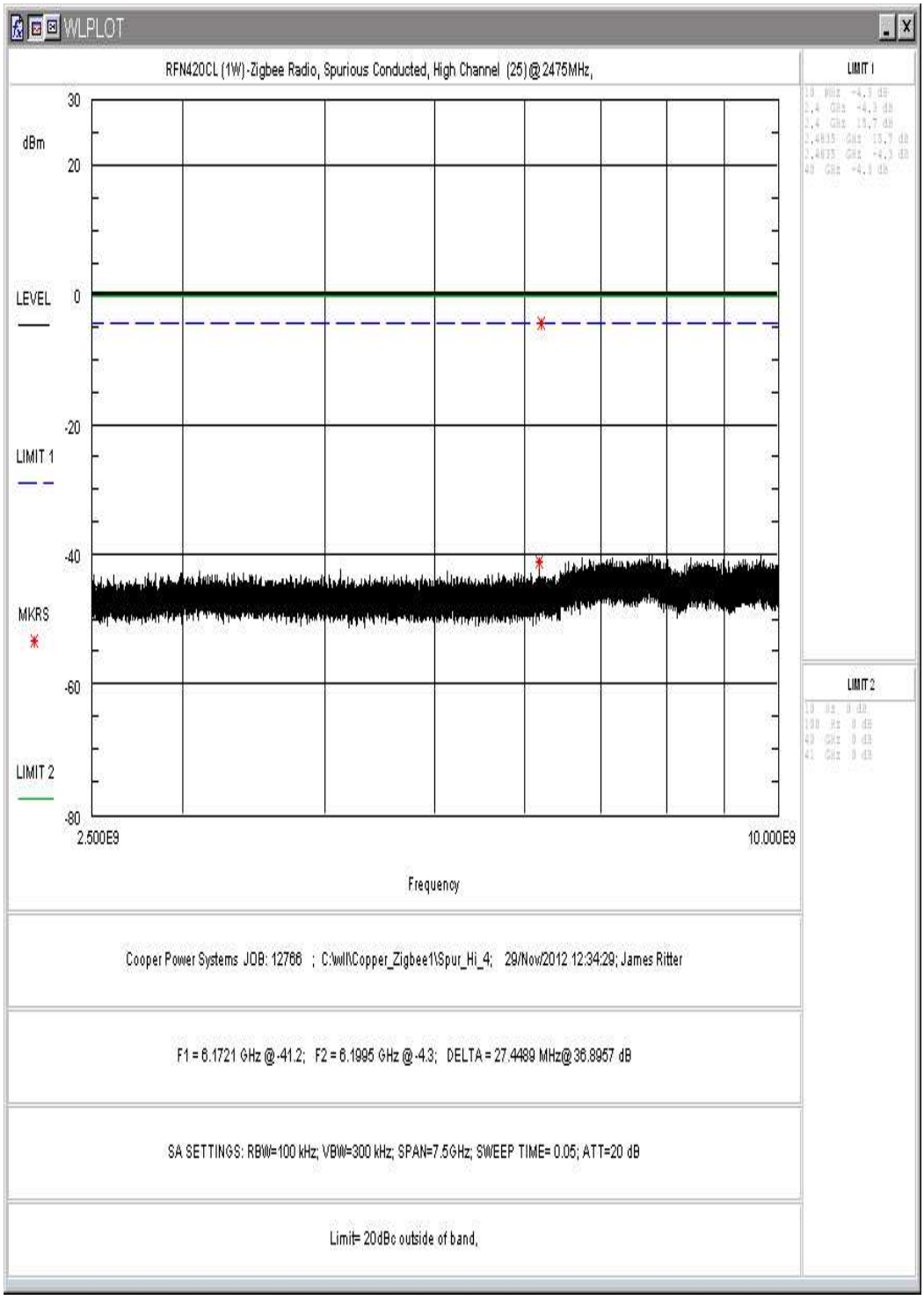


Figure 25: Conducted Spurious Emissions, High Channel, 2.5 - 10GHz

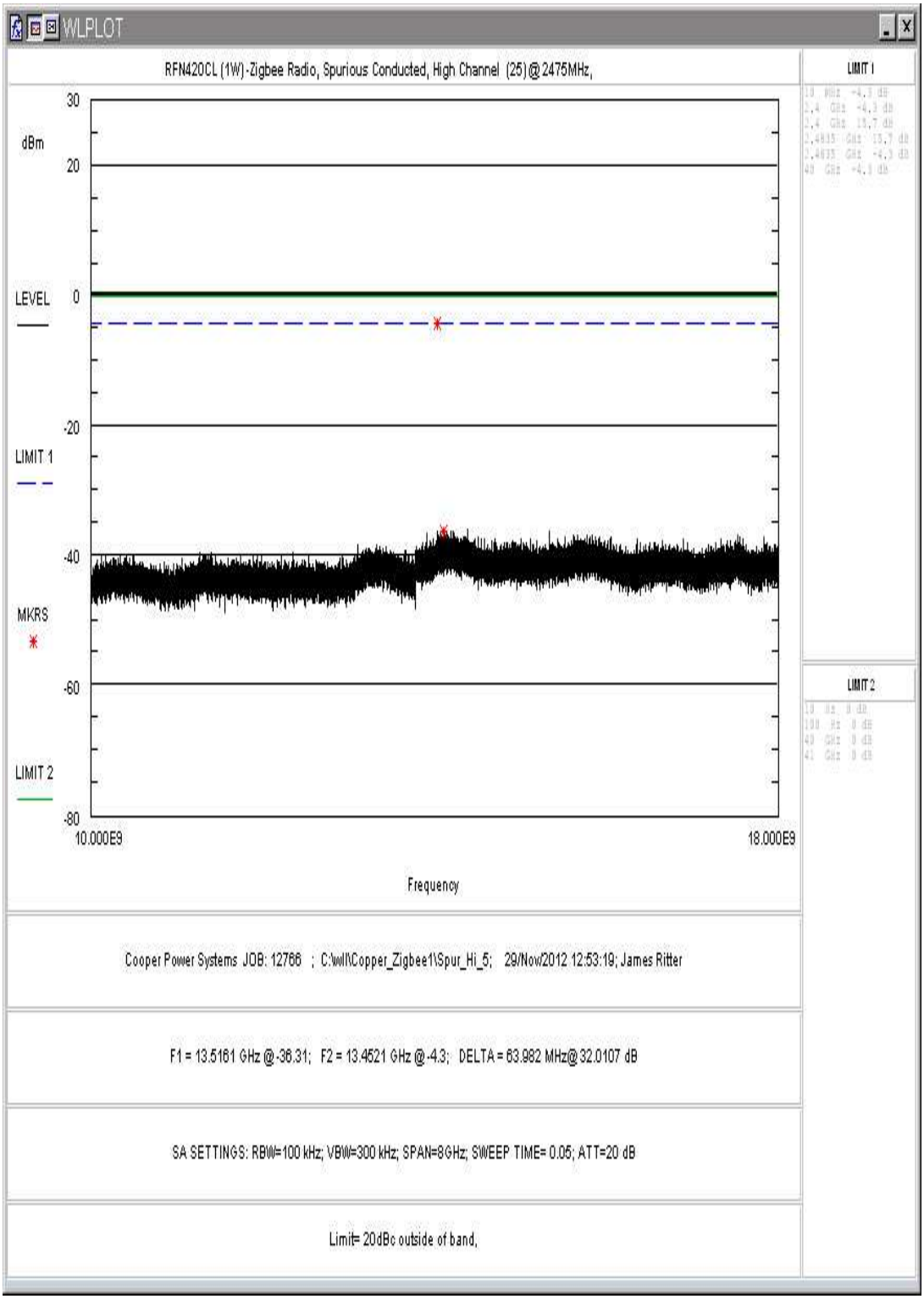


Figure 26: Conducted Spurious Emissions, High Channel, 10 - 18GHz

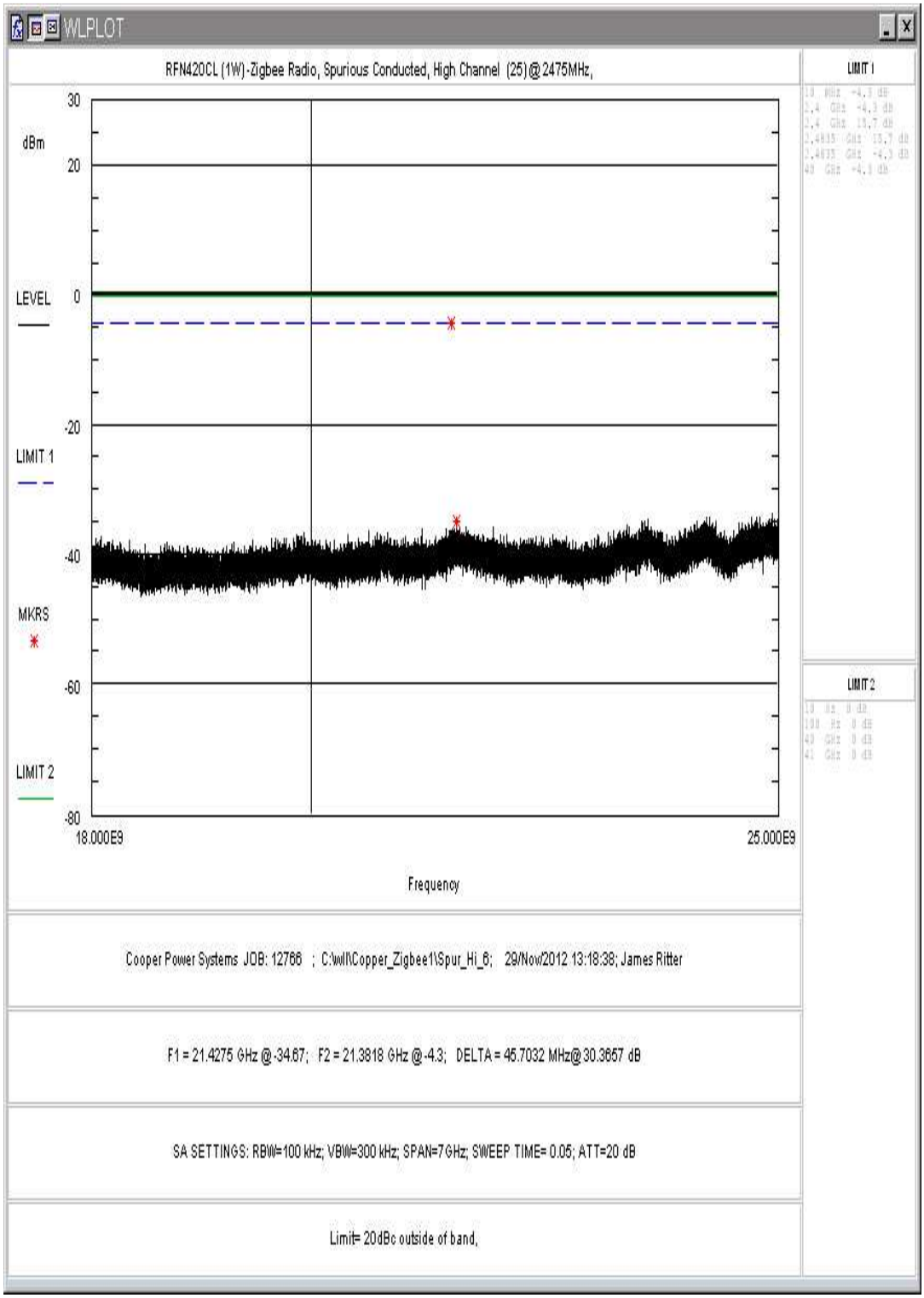


Figure 27: Conducted Spurious Emissions, High Channel, 18 - 25GHz

4.5.1 Band Edge Compliance

Close-up plots of the upper and lower channels with respect to the nearest authorized band-edges are provided below. The tests were performed in the same manner as the above conducted spurious emissions tests

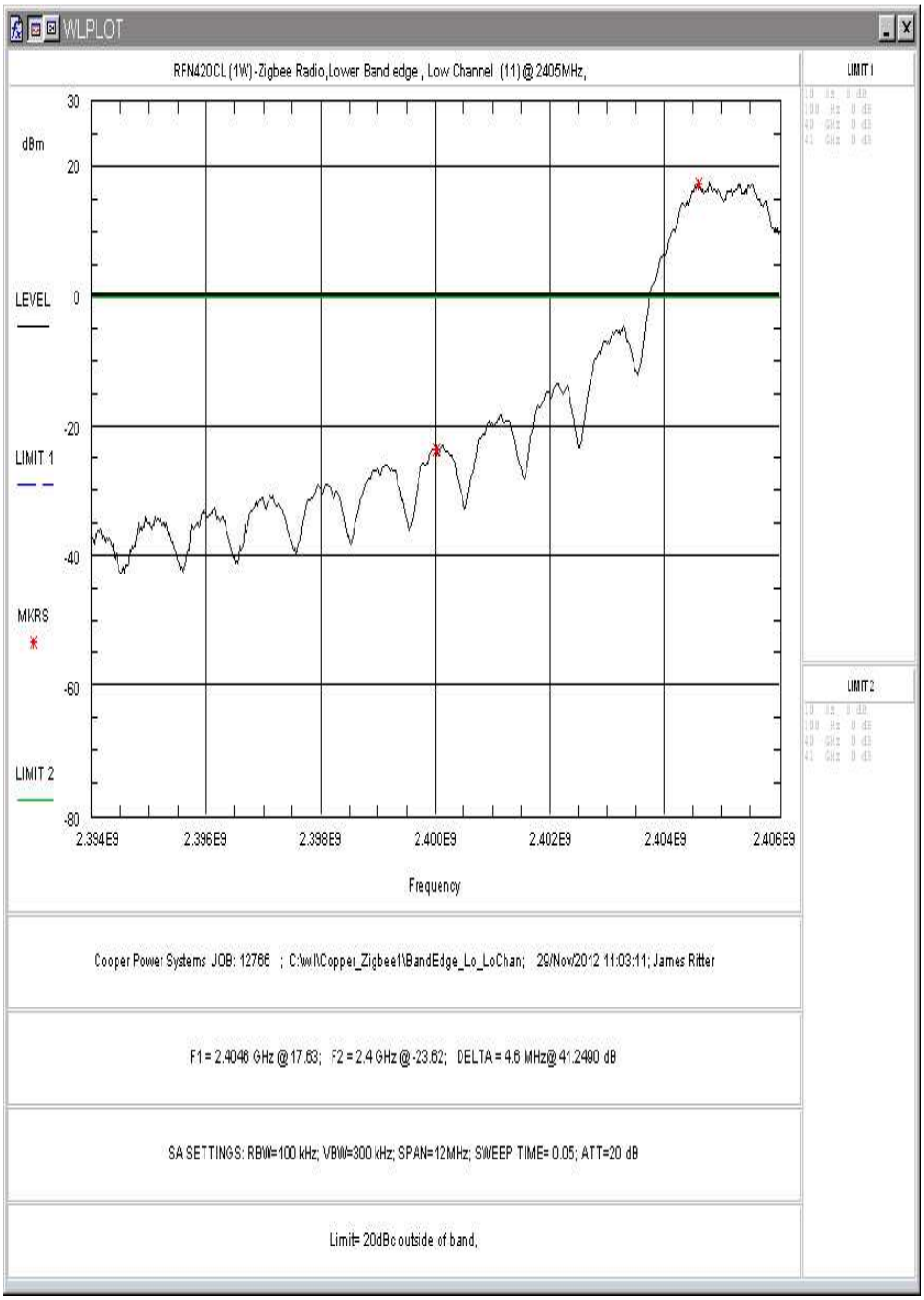


Figure 28: Lower Band-edge, Low Channel

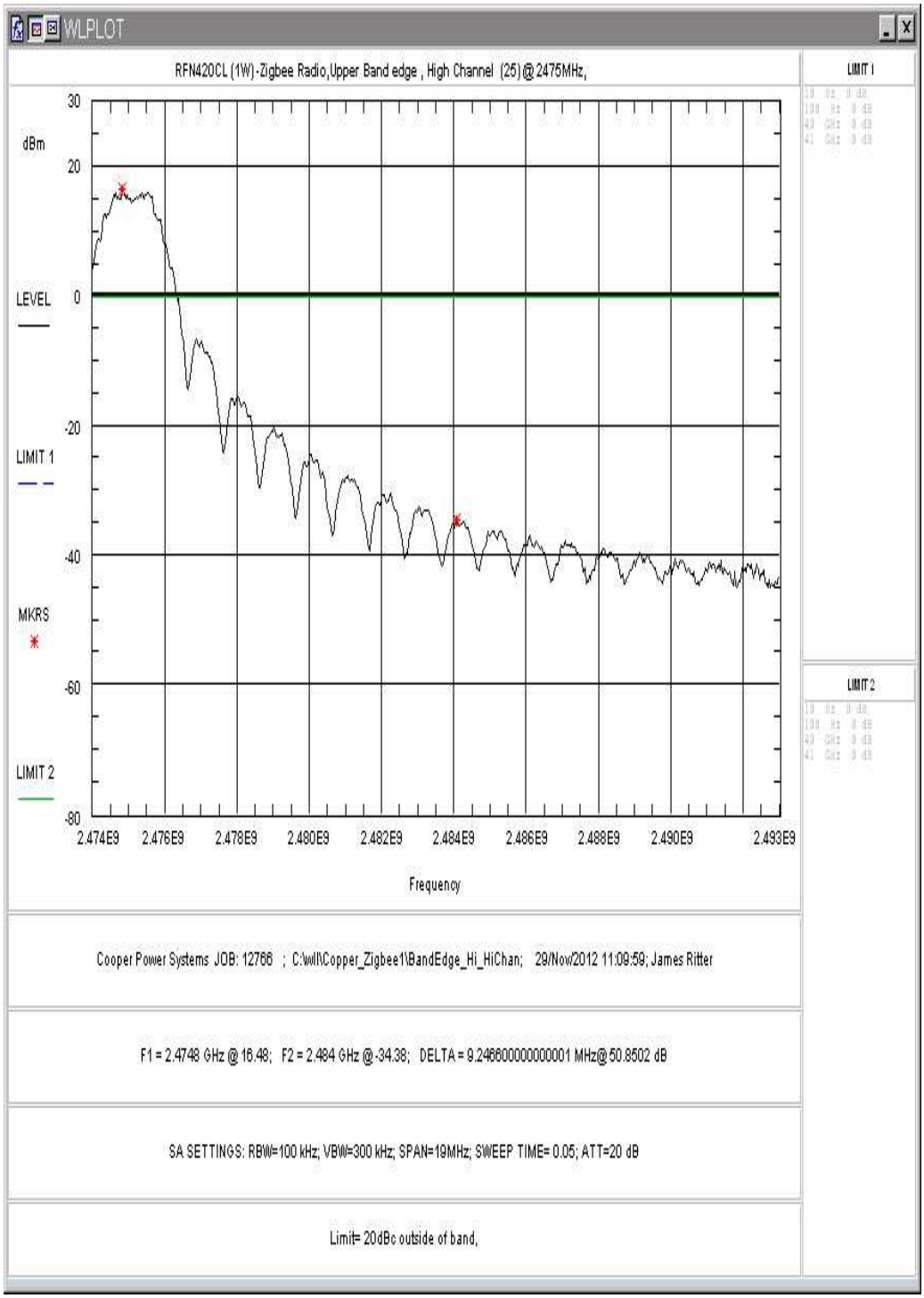


Figure 29: Upper band-edge, High Channel

4.6 AC Conducted Emissions (FCC Part §15.207)

4.6.1 Requirements

Test Arrangement: Table Top

Compliance Standard: FCC Class B

FCC Compliance Limits		
Frequency	**Quasi-peak**	**Average**
0.15 - 0.5MHz	66 to 56dBµV	56 to 46dBµV
0.5 - 5MHz	56dBµV	46dBµV
5 - 30MHz	60dBµV	50dBµV

4.6.2 Test Procedure

The EUT was placed on an 80 cm high 1 X 1.5 m non-conductive table above a ground plane. Power to the EUT was provided through a Solar Corporation 50 Ω/50 µH Line Impedance Stabilization Network bonded to a 3 X 2 meter ground plane. The LISN has its AC input supplied from a filtered AC power source. Power was supplied to the peripherals through a second LISN. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Power and data cables were moved about to obtain maximum emissions.

The 50 Ω output of the LISN was connected to the input of the spectrum analyzer and the emissions in the frequency range of 150 kHz to 30 MHz were measured. The detector function was set to quasi-peak, peak, or average as appropriate, and the resolution bandwidth during testing was at least 9 kHz, with all post-detector filtering no less than 10 times the resolution bandwidth. For average measurements the post-detector filter was set to 10 Hz.

At frequencies where quasi-peak or peak measurements comply with the average limit, no average measurements need be performed.

At frequencies where quasi-peak or peak measurements comply with the average limit, no average measurements need be performed. The Conducted emissions level to be compared to the FCC limit is calculated as shown in the following example.

Example:

Spectrum Analyzer Voltage: VdBµV

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Electric Field: EdBµV = V dBµV + LISN dB + CF dB

4.6.3 Test Data

The EUT complied with the Class B Conducted Emissions requirements. This system runs off of 100-240VAC providing 12VDC. Table 8 provides the test results for phase and neutral line power line conducted emissions.

As this unit contains 2 radios, Zigbee 2400MHz Band and 902-928MHz band, emissions were tested with both radios transmitting as a worst case.

Table 8: Conducted Emissions Data 120VAC, Transmit On

NEUTRAL- 120V

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.156	22.0	2.2	10.1	1.0	33.1	13.3	65.7	55.7	-32.5	-42.3
0.273	19.5	10.8	10.1	0.7	30.2	21.5	61.0	51.0	-30.8	-29.5
0.415	20.9	10.5	10.1	0.5	31.5	21.1	57.5	47.5	-26.0	-26.4
1.239	18.0	5.2	10.2	0.7	28.9	16.1	56.0	46.0	-27.1	-29.9
5.220	28.8	6.9	10.8	1.2	40.7	18.8	60.0	50.0	-19.3	-31.2
9.500	26.5	5.2	11.1	1.2	38.8	17.5	60.0	50.0	-21.2	-32.5

PHASE-120V

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.156	22.8	1.2	10.1	0.6	33.5	11.9	65.7	55.7	-32.1	-43.7
0.273	17.5	10.5	10.1	0.5	28.1	21.1	61.0	51.0	-33.0	-30.0
0.415	16.7	7.1	10.1	0.4	27.2	17.6	57.5	47.5	-30.4	-30.0
1.239	12.3	3.1	10.2	0.5	23.0	13.8	56.0	46.0	-33.0	-32.2
5.220	8.9	2.2	10.8	0.8	20.5	13.8	60.0	50.0	-39.5	-36.2
9.500	9.1	1.6	11.1	1.0	21.2	13.7	60.0	50.0	-38.8	-36.3

Table 9: Conducted Emissions Data 230VAC, Transmit On

NEUTRAL-230V

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.150	27.0	4.7	10.1	1.1	38.2	15.9	66.0	56.0	-27.8	-40.1
0.276	24.1	13.1	10.1	0.6	34.8	23.8	60.9	50.9	-26.1	-27.1
0.411	25.6	11.6	10.1	0.5	36.2	22.2	57.6	47.6	-21.4	-25.4
1.689	20.5	4.3	10.4	1.0	31.9	15.7	56.0	46.0	-24.1	-30.3
7.450	25.9	6.8	11.2	1.3	38.4	19.3	60.0	50.0	-21.6	-30.7
15.190	22.0	3.7	11.5	1.0	34.4	16.1	60.0	50.0	-25.6	-33.9

PHASE-230V

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.150	28.0	6.2	10.1	0.7	38.8	17.0	66.0	56.0	-27.2	-39.0
0.276	25.3	14.0	10.1	0.5	35.9	24.6	60.9	50.9	-25.1	-26.4
0.411	22.8	9.2	10.1	0.4	33.3	19.7	57.6	47.6	-24.3	-27.9
1.689	15.2	1.5	10.4	0.8	26.4	12.7	56.0	46.0	-29.6	-33.3
7.450	20.3	0.5	11.2	0.8	32.3	12.5	60.0	50.0	-27.7	-37.5
15.190	19.7	3.9	11.5	0.8	32.0	16.2	60.0	50.0	-28.0	-33.8

4.7 Radiated Spurious Emissions: (FCC Part §15.205 & §15.209)

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.

4.7.1 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 C63.4-2003. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The unit was pre-scanned in 3 orthogonal positions with full testing performed in the worst case position.

The emissions were measured using the following resolution bandwidths:

Table 10: Spectrum Analyzer Settings

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>100 kHz
>1000 MHz	1 MHz	10 Hz (Avg.), 1MHz (Peak)

Worst case emissions are presented.

4.7.1.1 Duty Cycle Corrections

In accordance Section 15.247 and FCC part 15.35 systems that are normally pulsed are allowed a duty cycle correction based on the calculation: 20 Log_{10}([longest transmission time in any 100ms window]/100ms).

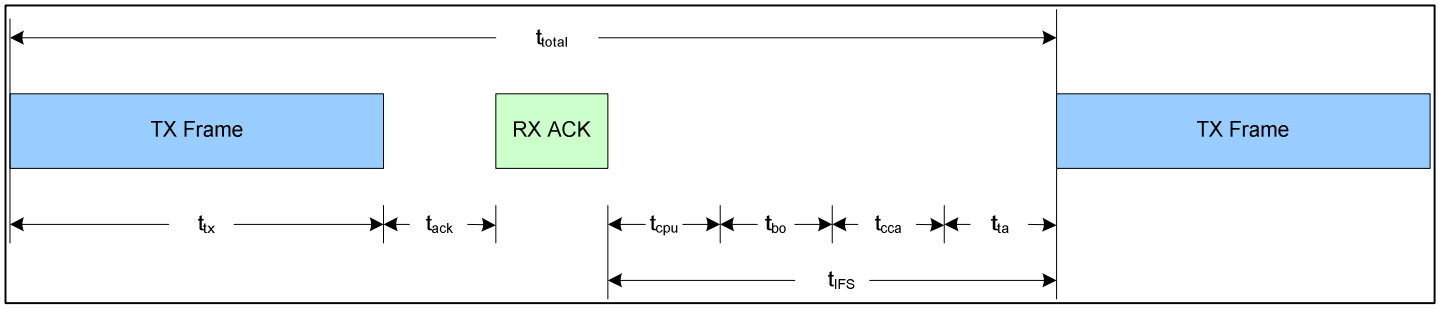
This EUT is allowed -7.4dB of correction based on a 42% duty cycle with a worst case transmit time of 42.56mSec per 100mSec. The EUT was set to a continuously modulated mode and the duty cycle correction added to the average measurement radiated emission measurements for the harmonics and band edges of the transmitted signal.

The transmit time was provided by the Zigbee manufacturer and is re-printed below with the permission of Ember Corporation.

Table 11: Duty Cycle Calculations

IEEE 802.15.4-2003 2.4 GHz PHY Constants

Data Rate	250000	bits / sec	
	31250	bytes / sec	
Symbols/byte	2	sym / bytes	
Symbol Timing	62500	sym / sec	
	0.000016	sec / sym	
Byte Timing	0.000032	sec / byte	
PHY PSDU	6	bytes	4 Preamble, SPD, Length
Max Length	127	bytes	
Total Packet Length	133	bytes	
Maximum Time TX PKT	0.004256	sec	



1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

MAC-Level Calculation (LIFS)

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	40	sym	
Backoff Period	20	sym	
Maximum Backoff	31		Random between 0 and 31
Backoff Required	2		
Backoff Time	300	sym	Average at 15

Transmit Time	
TX Time (Packet)	0.004256

Total TX Time (sec)	0.004256

NOT Transmit time (RX or Idle)		
Wait for ACK (tack)	0.000192	
RX Time (ACK)	0.000352	
Backoff Time (tbo)	0.0048	(Backoff Time * Backoff Period)
CPU Processing (tcpu)	0.0002	(0.2ms average on EM2xx running EmberZNet)
CCA Assessment (tcca)	0.000128	(averaged over 8 symbols in RX Mode)
Turn Around Time (RX to TX)	0.000192	(After CCA, Radio turns over to TX in 12 symbols)
Total Off Time (sec)	0.005864	

Total Time (ttotal)	0.01012
Number of RX / TX cycles in 100ms	9.8814229 2

Worse Case (100ms window)

TX Frame 10 times	0.04256
RX or IDLE 10 Times	0.05864
Sum	0.1012

MAC TX Duty Cycle (On /total)	42.06%		Represents theoretical ZigBee / MAC performance (This number should be used for FCC compliance testing.)

Table 12: Radiated Emission Test Data, Low Channel (Restricted Bands)

TX channel 11 @ 2405MHz

	Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Duty Cycle Correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
	4810.00	V	90.00	2.73	44.54	3.4	0.0	250.8	5000.0	-26.0	Peak
	12025.00	V	0.00	3.09	44.65	19.5	0.0	1616.1	5000.0	-9.8	Peak
Band edge	2390.00	V	180.00	2.73	26.55	31.6	0.0	811.7	5000.0	-15.8	Peak
Band edge	2483.50	V	190.00	3.10	27.13	32.4	0.0	947.6	5000.0	-14.4	Peak
	4810.00	V	90.00	2.73	33.97	3.4	-7.4	31.7	500.0	-24.0	Average
	12025.00	V	0.00	3.09	32.15	19.5	-7.4	163.5	500.0	-9.7	Average
Band edge	2390.00	V	180.00	2.73	14.70	31.6	-7.4	88.5	500.0	-15.0	Average
Band edge	2483.50	V	190.00	3.10	15.10	32.4	-7.4	101.2	500.0	-13.9	Average
	Non Harmonics										
	108.59	V	135.00	1.00	9.90	14.2	0.0	16.0	150.0	-19.5	Average
	166.37	V	325.00	1.00	11.30	14.0	0.0	18.4	150.0	-18.2	Average
	240.00	V	235.00	1.00	15.00	14.7	0.0	30.4	200.0	-16.3	Average
	4810.00	H	190.00	2.57	44.90	3.4	0.0	261.4	5000.0	-25.6	Peak
	12025.00	H	180.00	300.00	42.25	19.5	0.0	1226.0	5000.0	-12.2	Peak
Band edge	2390.00	H	290.00	2.65	27.98	31.6	0.0	957.0	5000.0	-14.4	Peak
Band edge	2483.50	H	270.00	2.80	25.60	32.4	0.0	794.6	5000.0	-16.0	Peak
	4810.00	H	190.00	2.57	31.80	3.4	-7.4	24.7	500.0	-26.1	Average
	12025.00	H	180.00	300.00	31.93	19.5	-7.4	159.4	500.0	-9.9	Average
Band edge	2390.00	H	290.00	2.65	14.93	31.6	-7.4	90.9	500.0	-14.8	Average
Band edge	2483.50	H	270.00	2.80	14.40	32.4	-7.4	93.4	500.0	-14.6	Average
	Non Harmonics										
	240.00	H	0.00	1.50	13.00	14.7	0.0	24.2	200.0	-18.4	

Table 13: Radiated Emission Test Data, Center Channel (Restricted Bands)

TX Channel 18 @ 2440MHz

	Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Duty Cycle Correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
	4880.00	V	180.00	3.25	46.79	3.6	0.0	329.1	5000.0	-23.6	Peak
	7320.00	V	190.00	2.85	58.50	9.6	0.0	2526.7	5000.0	-5.9	Peak
	12200.00	V	180.00	2.81	47.88	20.0	0.0	2471.3	5000.0	-6.1	Peak
band edge	2390.00	V	170.00	2.50	28.61	31.6	0.0	1028.9	5000.0	-13.7	Peak
Band edge	2483.50	V	190.00	2.70	28.10	32.4	0.0	1059.6	5000.0	-13.5	Peak
	4880.00	V	180.00	3.25	35.80	3.6	-7.4	39.6	500.0	-22.0	Average
	7320.00	V	190.00	2.85	47.33	9.6	-7.4	297.9	500.0	-4.5	Average
	12200.00	V	180.00	2.81	36.66	20.0	-7.4	289.7	500.0	-4.7	Average
Band edge	2390.00	V	170.00	2.50	15.50	31.6	-7.4	97.0	500.0	-14.2	Average
Band edge	2483.50	V	190.00	2.70	14.84	32.4	-7.4	98.2	500.0	-14.1	Average
	Non Harmonics										
	108.59	V	135.00	1.00	9.90	14.2	0.0	16.0	150.0	-19.5	Average
	166.37	V	325.00	1.00	11.30	14.0	0.0	18.4	150.0	-18.2	Average
	240.00	V	235.00	1.00	15.00	14.7	0.0	30.4	200.0	-16.3	Average
	4880.00	H	270.00	2.71	45.93	3.6	0.0	298.1	5000.0	-24.5	Peak
	7320.00	H	90.00	2.75	58.90	9.6	0.0	2645.8	5000.0	-5.5	Peak
	12200.00	H	190.00	2.58	46.93	20.0	0.0	2215.2	5000.0	-7.1	Peak
Band edge	2390.00	H	190.00	2.65	26.16	31.6	0.0	776.0	5000.0	-16.2	Peak
Band edge	2483.50	H	180.00	2.80	28.87	32.4	0.0	1157.8	5000.0	-12.7	Peak
	4880.00	H	270.00	2.71	32.80	3.6	-7.4	28.0	500.0	-25.0	Average
	7320.00	H	90.00	2.75	47.30	9.6	-7.4	296.9	500.0	-4.5	Average
	12200.00	H	190.00	2.58	36.28	20.0	-7.4	277.3	500.0	-5.1	Average
Band edge	2390.00	H	190.00	2.65	14.73	31.6	-7.4	88.8	500.0	-15.0	Average
Band edge	2483.50	H	180.00	2.80	14.82	32.4	-7.4	98.0	500.0	-14.2	Average
	Non Harmonics										
	240.00	H	0.00	1.50	13.00	14.7	0.0	24.2	200.0	-18.4	

Table 14: Radiated Emission Test Data, High Channel (Restricted Bands)

TX Channel 25 @2475MHz

	Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Duty Cycle Correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
	4950.00	V	180.00	2.89	53.18	3.8	0.0	703.5	5000.0	-17.0	Peak
	7425.00	V	180.00	2.92	62.00	9.5	0.0	3755.0	5000.0	-2.5	Peak
	12375.00	V	200.00	2.73	45.58	20.4	0.0	1980.8	5000.0	-8.0	Peak
Band edge	2390.00	V	180.00	2.95	27.98	31.6	0.0	957.0	5000.0	-14.4	Peak
Band edge	2483.50	V	90.00	2.70	35.60	32.4	0.0	2512.6	5000.0	-6.0	Peak
	Non Harmonics										
	108.59	V	135.00	1.00	9.90	14.2	0.0	16.0	150.0	-19.5	Average
	166.37	V	325.00	1.00	11.30	14.0	0.0	18.4	150.0	-18.2	Average
	240.00	V	235.00	1.00	15.00	14.7	0.0	30.4	200.0	-16.3	Average
	4950.00	V	180.00	2.89	41.27	3.8	-7.4	76.2	500.0	-16.3	Average
	7425.00	V	180.00	2.92	49.90	9.5	-7.4	397.7	500.0	-2.0	Average
	12375.00	V	200.00	2.73	32.11	20.4	-7.4	179.2	500.0	-8.9	Average
Band edge	2390.00	V	180.00	2.95	15.67	31.6	-7.4	98.9	500.0	-14.1	Average
Band edge	2483.50	V	90.00	2.70	24.00	32.4	-7.4	281.9	500.0	-5.0	Average
		V				#N/A		#N/A	#N/A	#N/A	
	4950.00	H	190.00	3.49	54.09	3.8	0.0	781.2	5000.0	-16.1	Peak
	7425.00	H	190.00	3.49	54.09	9.5	0.0	1510.5	5000.0	-10.4	Peak
	12375.00	H	190.00	2.83	44.75	20.4	0.0	1800.3	5000.0	-8.9	Peak
Band edge	2390.00	H	2.95	190.00	25.91	31.6	0.0	754.0	5000.0	-16.4	Peak
Band edge	2483.50	H	90.00	2.87	25.30	32.4	0.0	767.6	5000.0	-16.3	Peak
	4950.00	H	190.00	3.49	45.50	3.8	-7.4	123.9	500.0	-12.1	Average
	7425.00	H	190.00	3.49	45.50	9.5	-7.4	239.7	500.0	-6.4	Average
	12375.00	H	190.00	2.83	32.92	20.4	-7.4	196.7	500.0	-8.1	Average
bandedge	2390.00	H	2.95	190.00	13.10	31.6	-7.4	73.6	500.0	-16.6	Average
bandedge	2483.50	H	90.00	2.87	15.54	32.4	-7.4	106.4	500.0	-13.4	Average
	Non Harmonics										
	240.00	H	0.00	1.50	13.00	14.7	0.0	24.2	200.0	-18.4	

4.8 Transceiver Co-location Attestation

The 902-928 transceiver antenna (except for the 6dBi omni whip) may be located within 20cm of the Zigbee transceiver antenna, which is located on the same circuit board. Testing was performed to measure any potential spurious interactions between these 2 devices. The 902-928 MHz radio was tested with the highest gain of the antennas that could be used within 20cm of the Zigbee antenna (TRA9023NP - Antenex Phantom 902-928MHz, 3dBi). This testing was performed in a radiated fashion with both transceivers continuously transmitting on a stationary frequency. The module was then scanned from up to 25GHz verifying that intermodulation products that fall within the restricted bands remain under class B limits. This device complied with this requirement. Plots of this data are held at Washington laboratories.