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FCC & Industry Canada Certification Test Report
For the
Cooper Power Systems
RFN420FL Module

FCC ID: P9X-RFN420FL
IC: 6766A-RFN420FL

WLL JOB# **11672-01**
December 8, 2010

Prepared for:

Cooper Power Systems
20201 Century Blvd. Suite 250
Germantown, MD 20874

Prepared By:

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

ACCLASS ACCREDITED TESTING

Testing Certificate AT-1448

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Prepared by:

James Ritter
Compliance Engineer

Reviewed by:

Steven D. Koster
EMC Operations Manager

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 (10/2009) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 issue 7 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Cooper Power Systems RFN420FL 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 RFN420FL 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 8, 2010

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1 Introduction

1.1 Compliance Statement

The Cooper Power Systems RFN420FL Module complies with the limits for a Direct Sequence Spread Spectrum Transmitter device under FCC Part 15.247 (10/2009) 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 with FCC Public Notice FCC97-114, Guidance on Measurements for Direct Sequence Spread Spectrum Systems & KDB558074: "Measurement of Digital Transmission Systems operating under Section 15.247." The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Cooper Power Systems 20201 Century Blvd. Suite 250 Germantown, MD 20874
Purchase Order Number:	31350
Quotation Number:	65786A

1.4 Test Dates

Testing was performed on the following date(s):	10/25/2010 to 12/3/2010

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 RFN420fL is a radio communications device designed for use in L+G Focus meters. It can also be used in Cooper Power Systems Gateways and Relay Nodes. The RFN420fL 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 915 FHSS radio is covered in a separate report.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Cooper Power Systems
FCC ID:	P9X-RFN420FL
IC:	6766A-RFN420FL
Model:	RFN420FL
FCC Rule Parts:	§15.247
Industry Canada:	RSS210
Frequency Range:	2405 – 2475MHz
Maximum Output Power:	20.84 dBm (121.34mW)
Modulation:	DSSS(QPSK)
Occupied Bandwidth:	1.65MHz
Maximum Spurious TX:	344.8uV/m @3m – 7425MHz
Maximum Spurious RX:	65.7uV/m @3m -1000MHz
Emission Designator:	1M65G1D
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 RFN420FL 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 RFN420FL 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.

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

FCC Public Notice FCC97-114, Guidance on Measurements for Direct Sequence 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.

KDB558074: “Measurement of Digital Transmission Systems operating under Section 15.247.”

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 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**
618	HP - 8563A	ANALYZER SPECTRUM	6/4/2011

Test Name:	**Radiated Emissions**		
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
626	ARA - DRG-118/A	ANTENNA HORN	6/3/2011
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/7/2011
528	AGILENT - E4446A	ANALYZER SPECTRUM	9/27/2011
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHZ	3/24/2012
281	ITC - 21A-3A1	WAVEGUIDE 4.51-10.0GHZ	3/24/2012
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	12/29/2010
69	HP - 85650A	ADAPTER QP	7/1/2011
71	HP - 85685A	PRESELECTOR RF	7/1/2011
73	HP - 8568B	ANALYZER SPECTRUM	7/1/2011
283	ITC - 21KU-3A1	WAVEGUIDE 9.8-20.5GHZ	3/24/2012

Test Name:	**Conducted Emissions Voltage**		
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
125	SOLAR - 8028-50-TS-24-BNC	LISN	7/10/2011
126	SOLAR - 8028-50-TS-24-BNC	LISN	7/10/2011
51	HP - 11867A	LIMITER RF	CNR
69	HP - 85650A	ADAPTER QP	7/1/2011
73	HP - 8568B	ANALYZER SPECTRUM	7/1/2011
71	HP - 85685A	PRESELECTOR RF	7/1/2011
125	SOLAR - 8028-50-TS-24-BNC	LISN	7/10/2011

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]	6dB Bandwidth	Pass
15.247 (2)(b)(3)	RSS-210 [A8.4]	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	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	Pass
RX/Digital Test Summary (Direct Sequence Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	Pass
15.209	RSS-210 sect 2.6	General Field Strength Limits	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. The lowest and highest data rates for each modulation type were evaluated.

For Direct Sequence Spread Spectrum Systems, FCC Part 15.247 requires the minimum 6 dB bandwidth using a 100 kHz Resolution bandwidth be greater than 500 kHz.

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

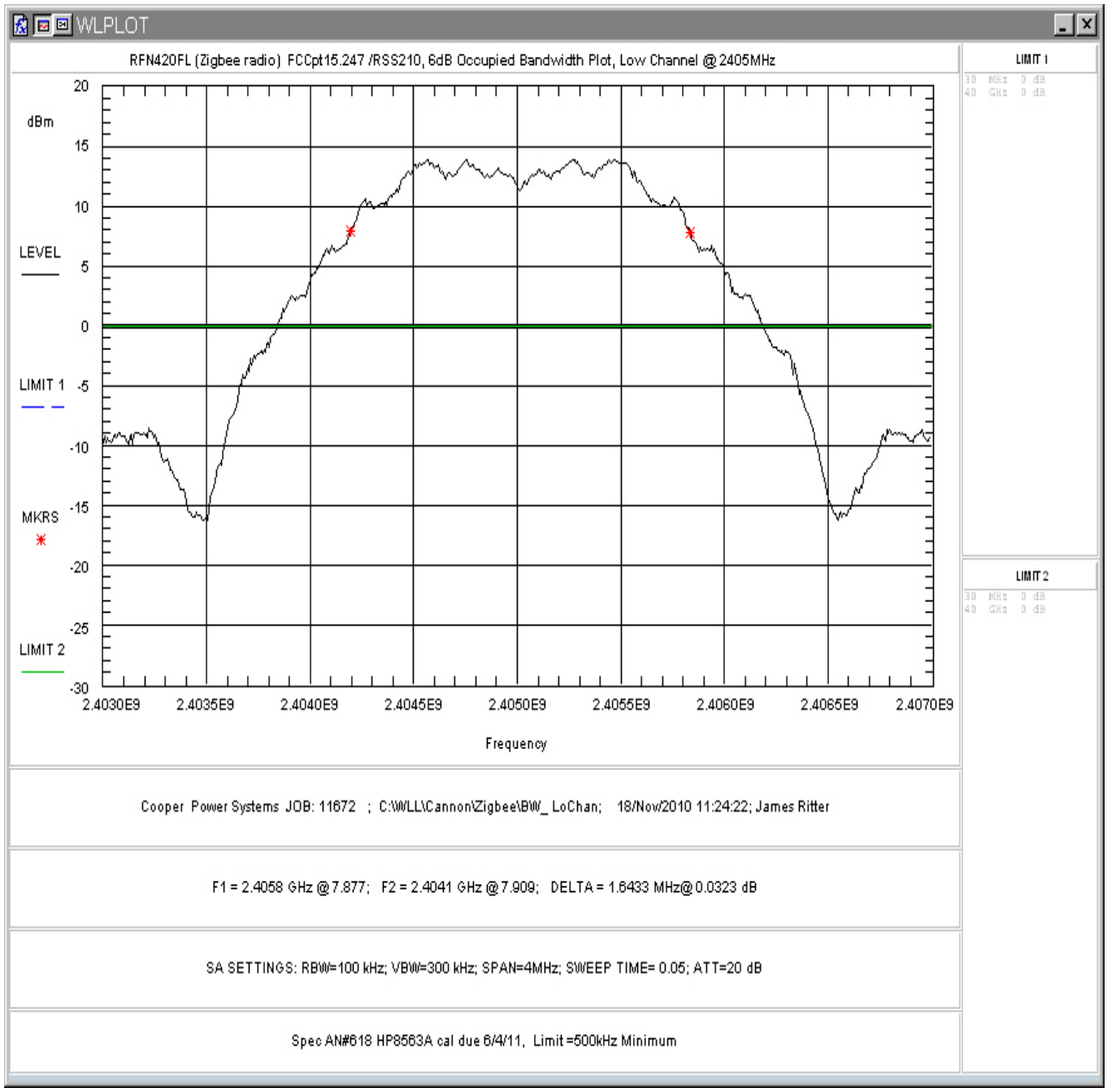


Figure 1: Occupied Bandwidth, Low Channel

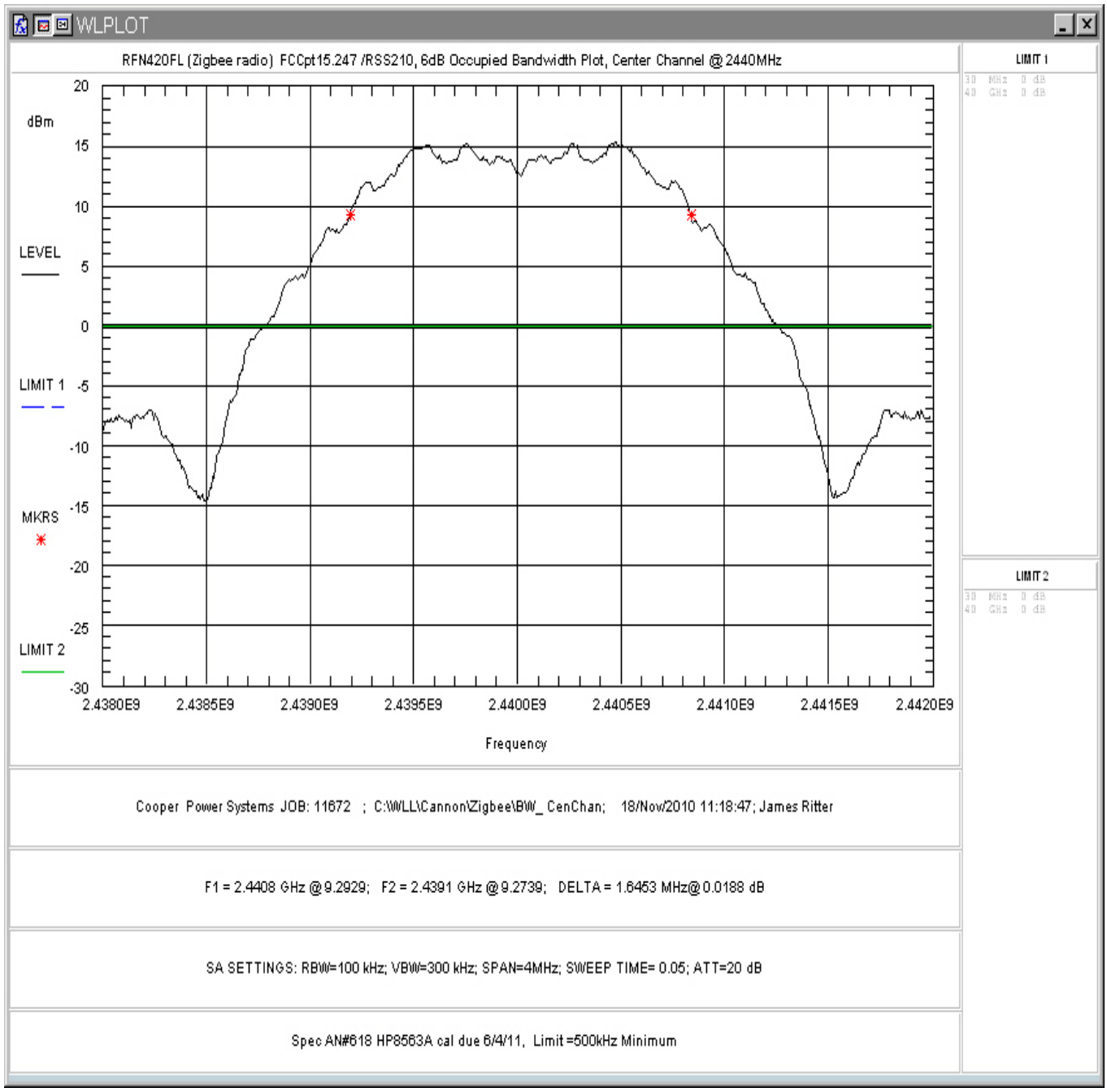


Figure 2: Occupied Bandwidth, Center Channel

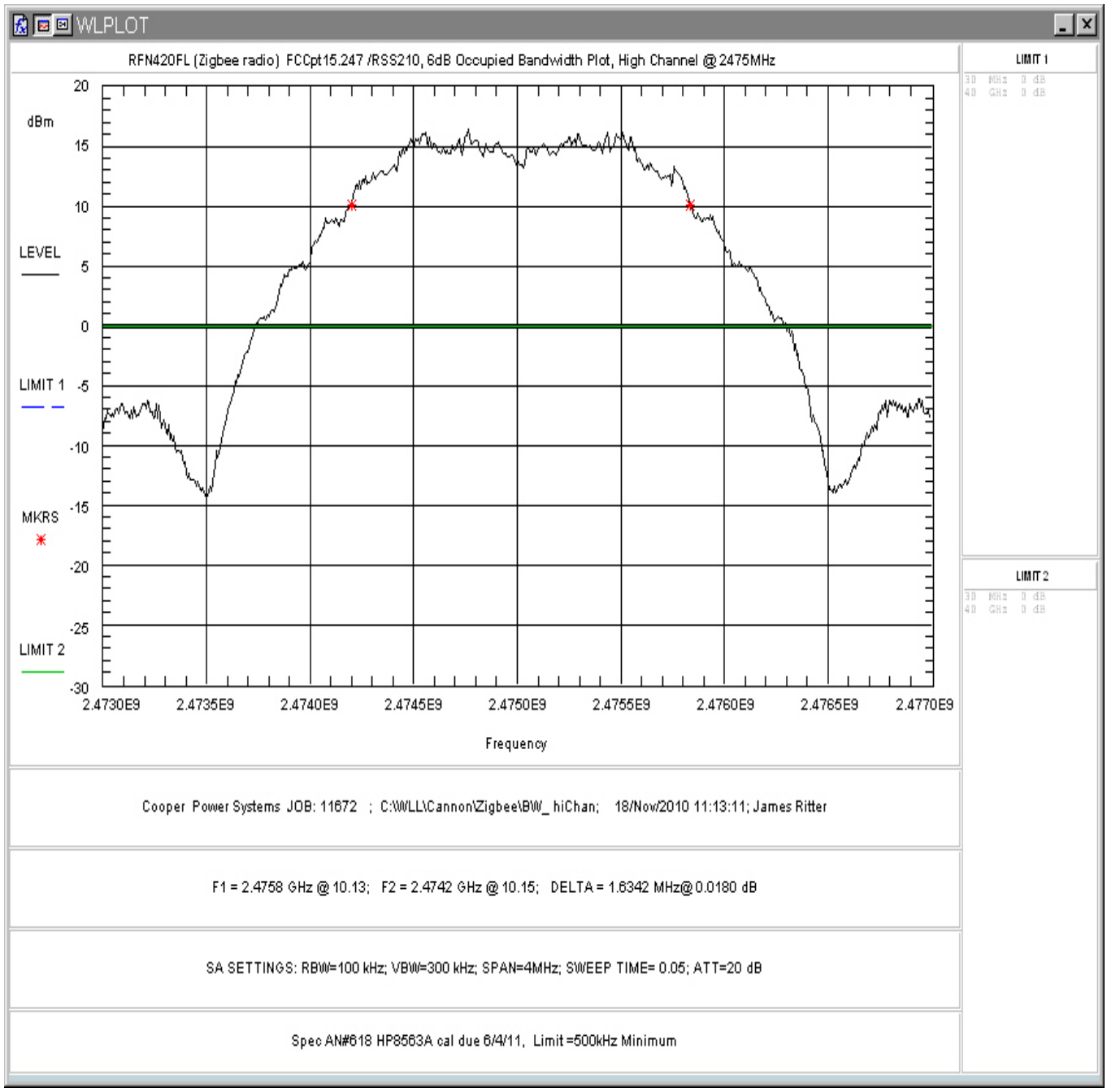


Figure 3: Occupied Bandwidth, High Channel

Table 5 provides a summary of the Occupied Bandwidth Results.

Table 5: Occupied Bandwidth Results

Frequency	Bandwidth	Limit	Pass/Fail
Low Channel (11): 2405MHz	1.64MHz	>500kHz	Pass
Mid Channel (18): 2440MHz	1.65MHz	>500kHz	Pass
High Channel (25): 2475MHz	1.63MHz	>500kHz	Pass

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.

Table 6: RF Power Output

Frequency	Level	Limit	Pass/Fail
Low Channel (11): 2405MHz	18.11 dBm	30 dBm	Pass
Center Channel (18): 2440MHz	19.61 dBm	30 dBm	Pass
High Channel (25): 2475MHz	20.84 dBm	30 dBm	Pass

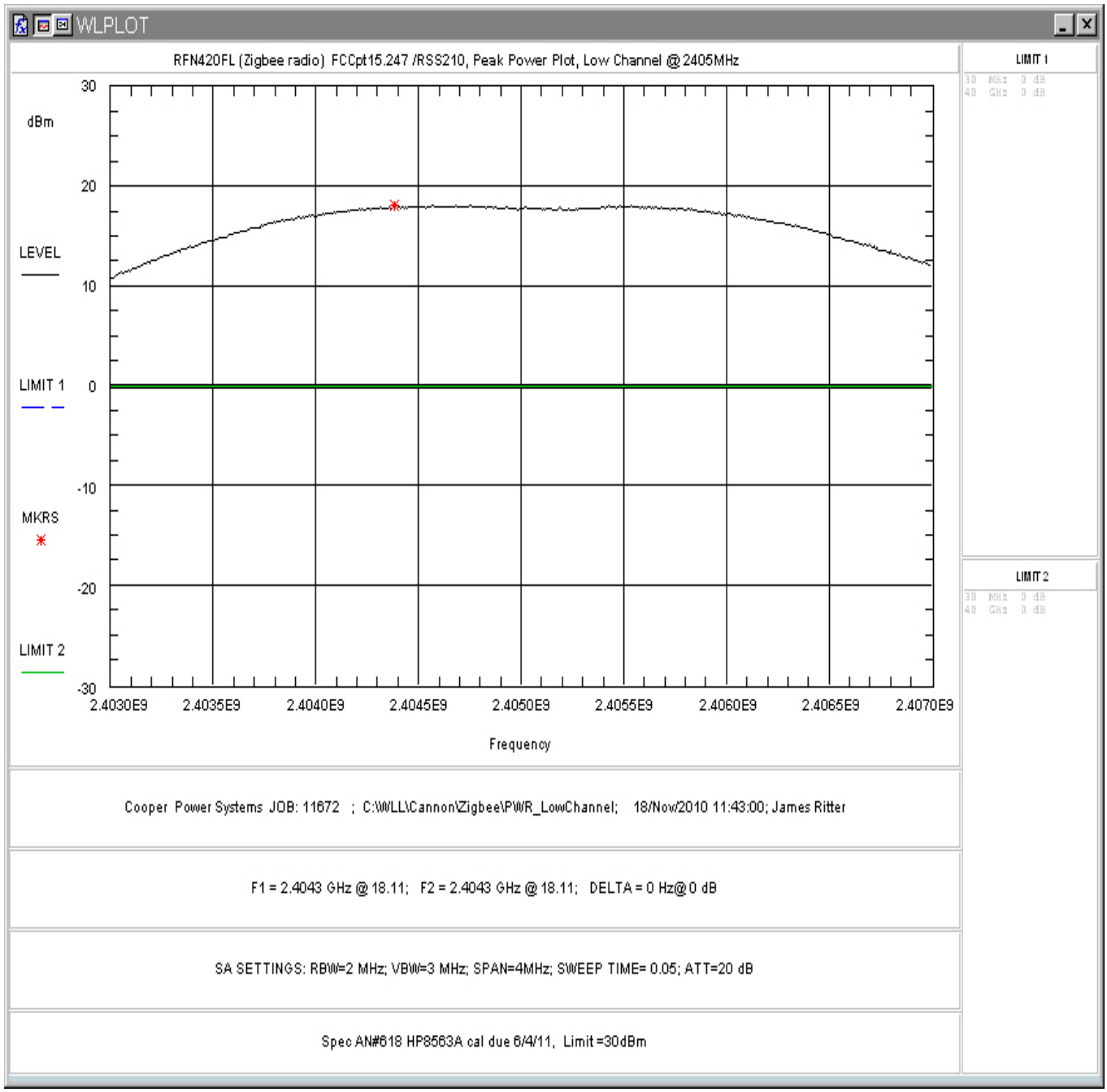


Figure 4: RF Peak Power, Low Channel

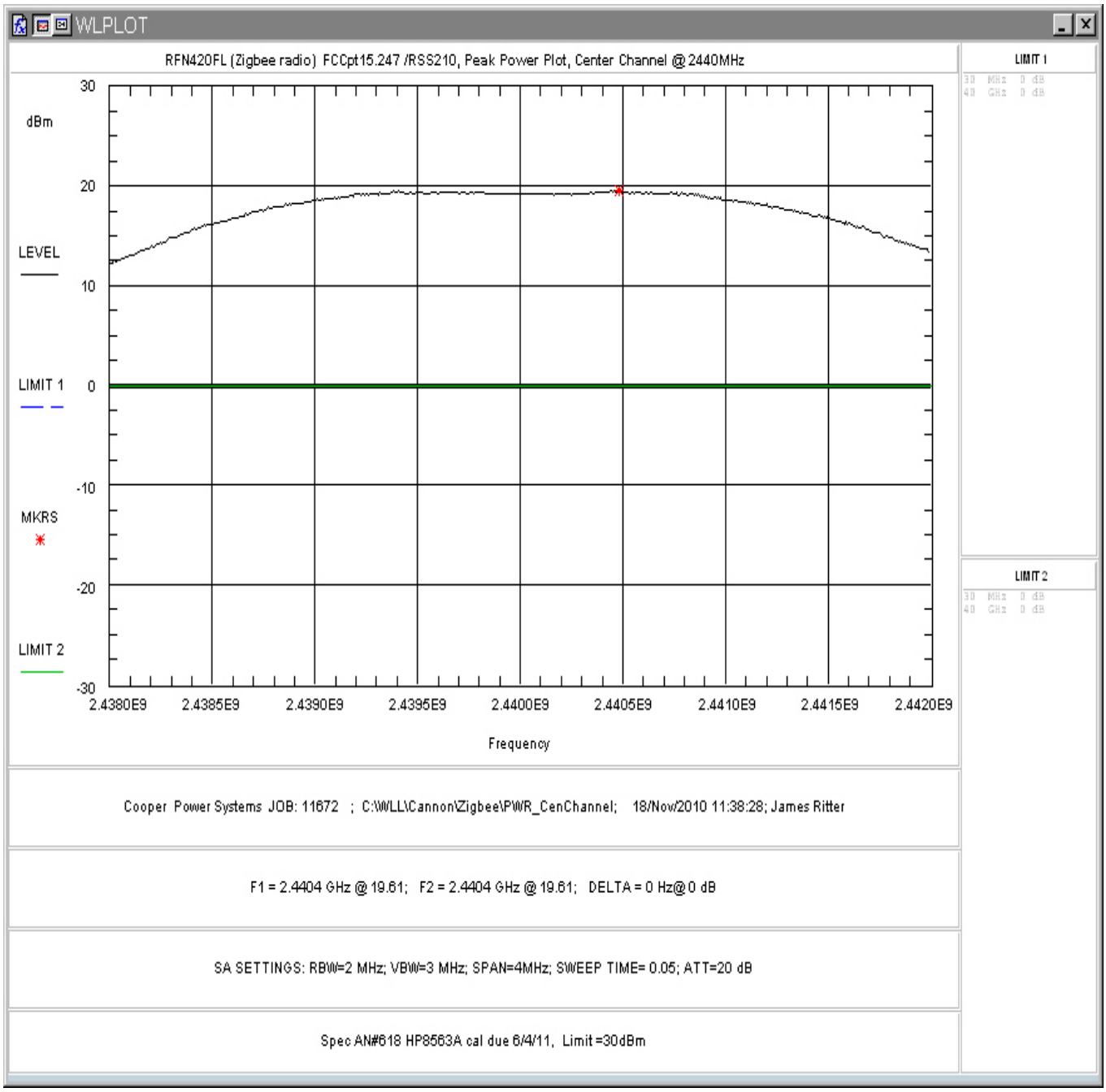


Figure 5: RF Peak Power, Center Channel

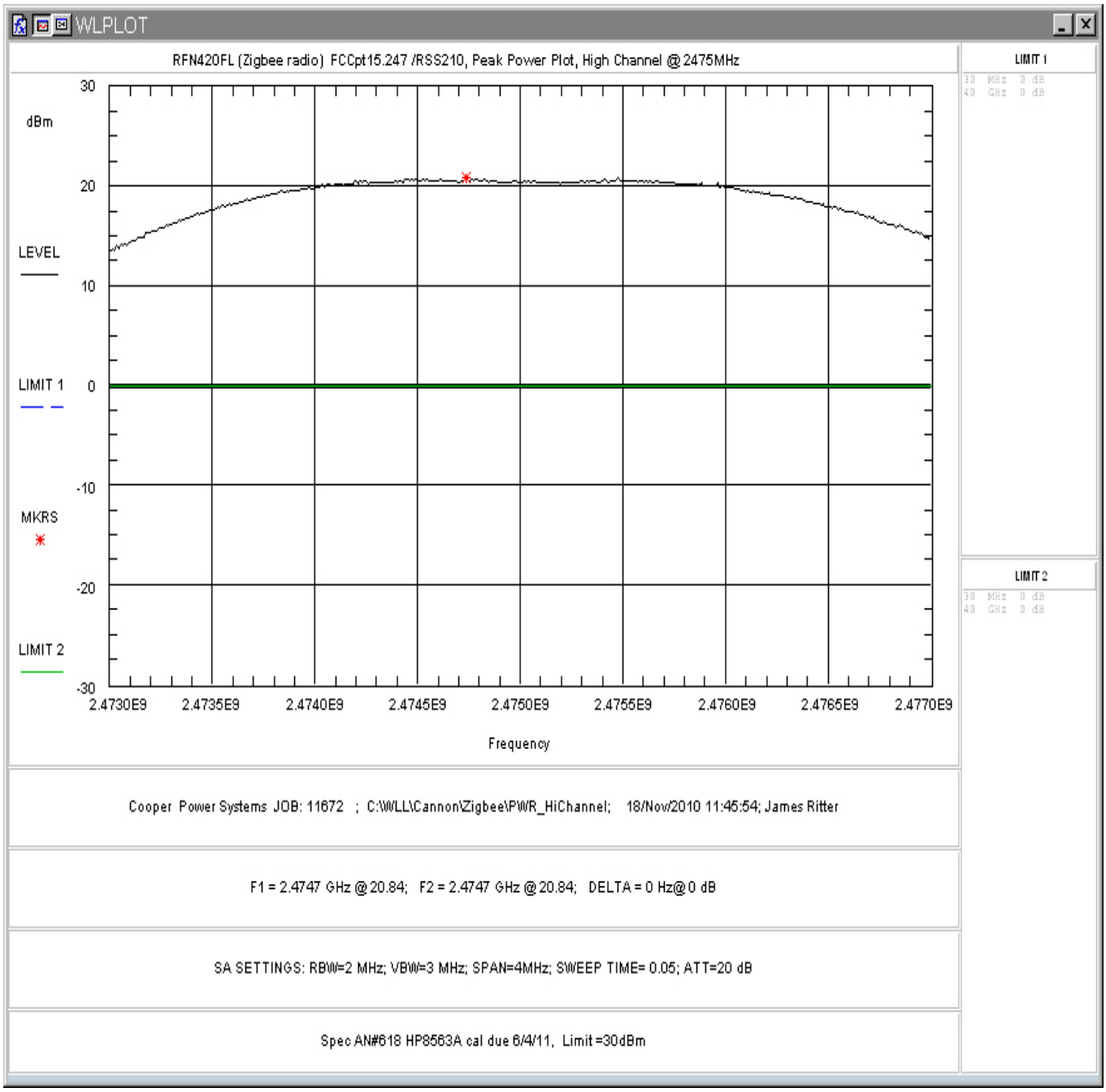


Figure 6: RF Peak Power, High Channel

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 PSD Option 1 of "Measurement of Digital Transmission Systems operating under 15.247" (March 23, 2005).

The spectrum analyzer was set to peak detect mode with a RBW of 3kHz and a VBW of 10kHz. 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	3.46 dBm	8 dBm	Pass
Center Channel (18): 2440MHz	4.45 dBm	8 dBm	Pass
High Channel (25): 2475MHz	6.34 dBm	8 dBm	Pass

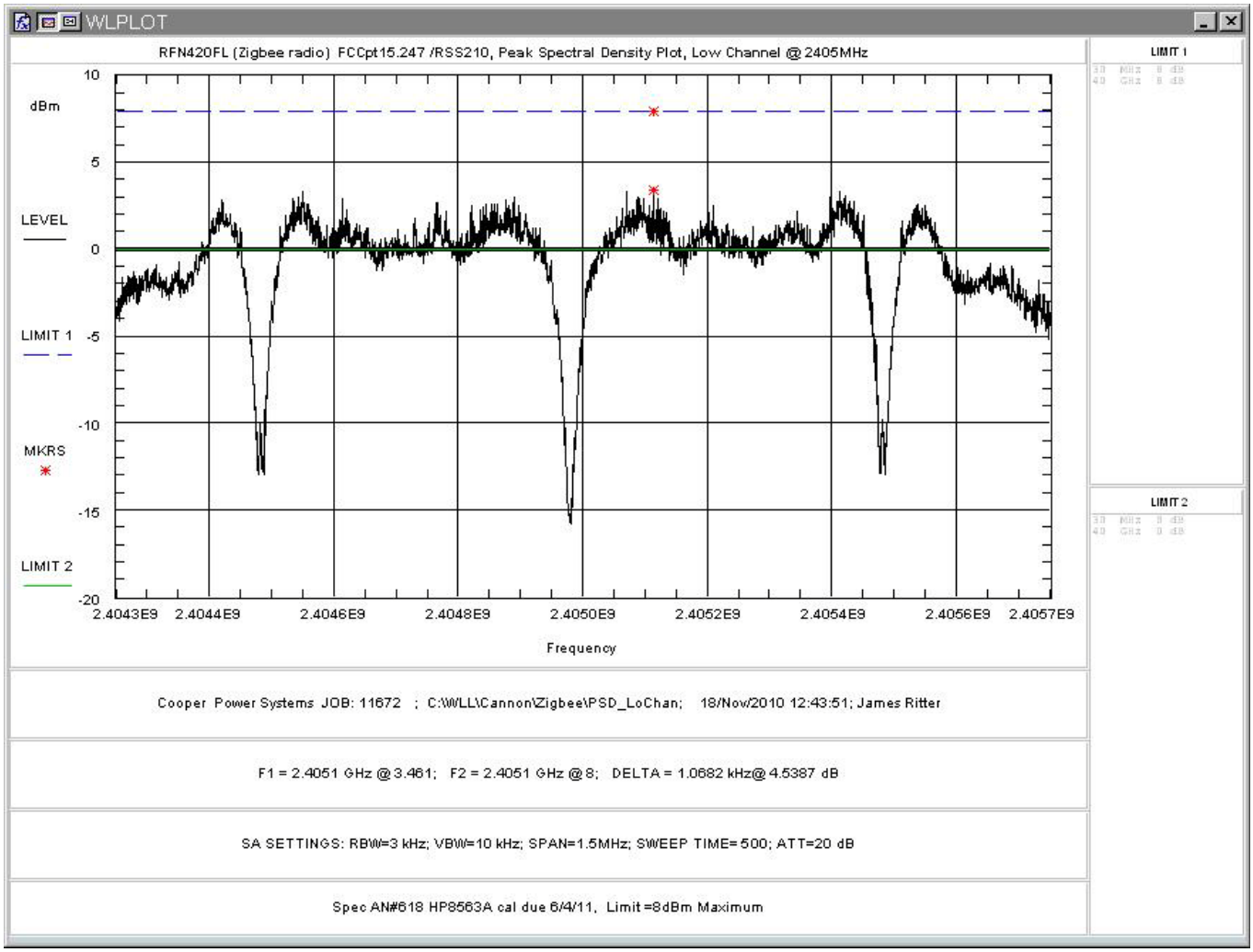


Figure 7: Power Spectral Density, Low Channel

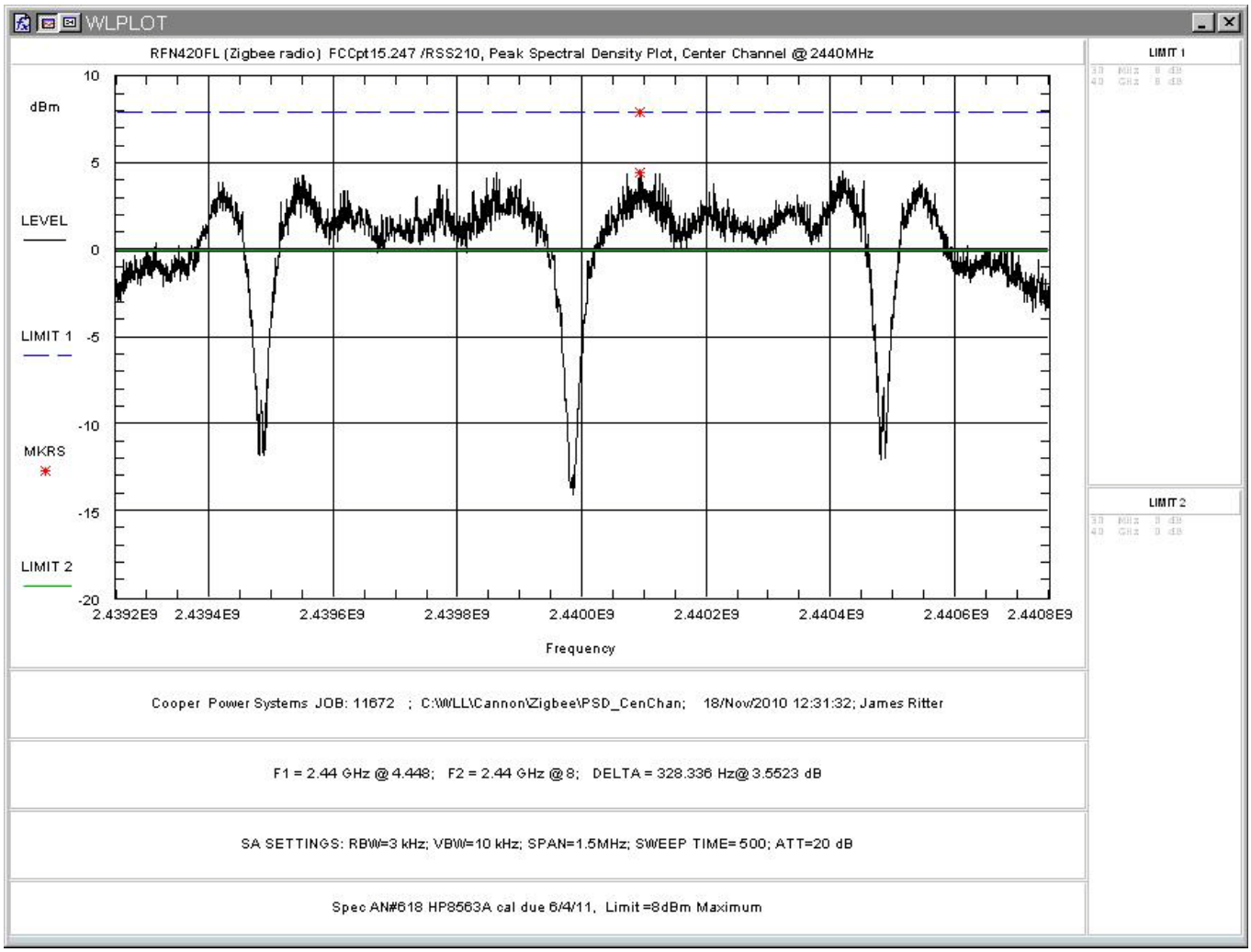


Figure 8: Power Spectral Density, Center Channel

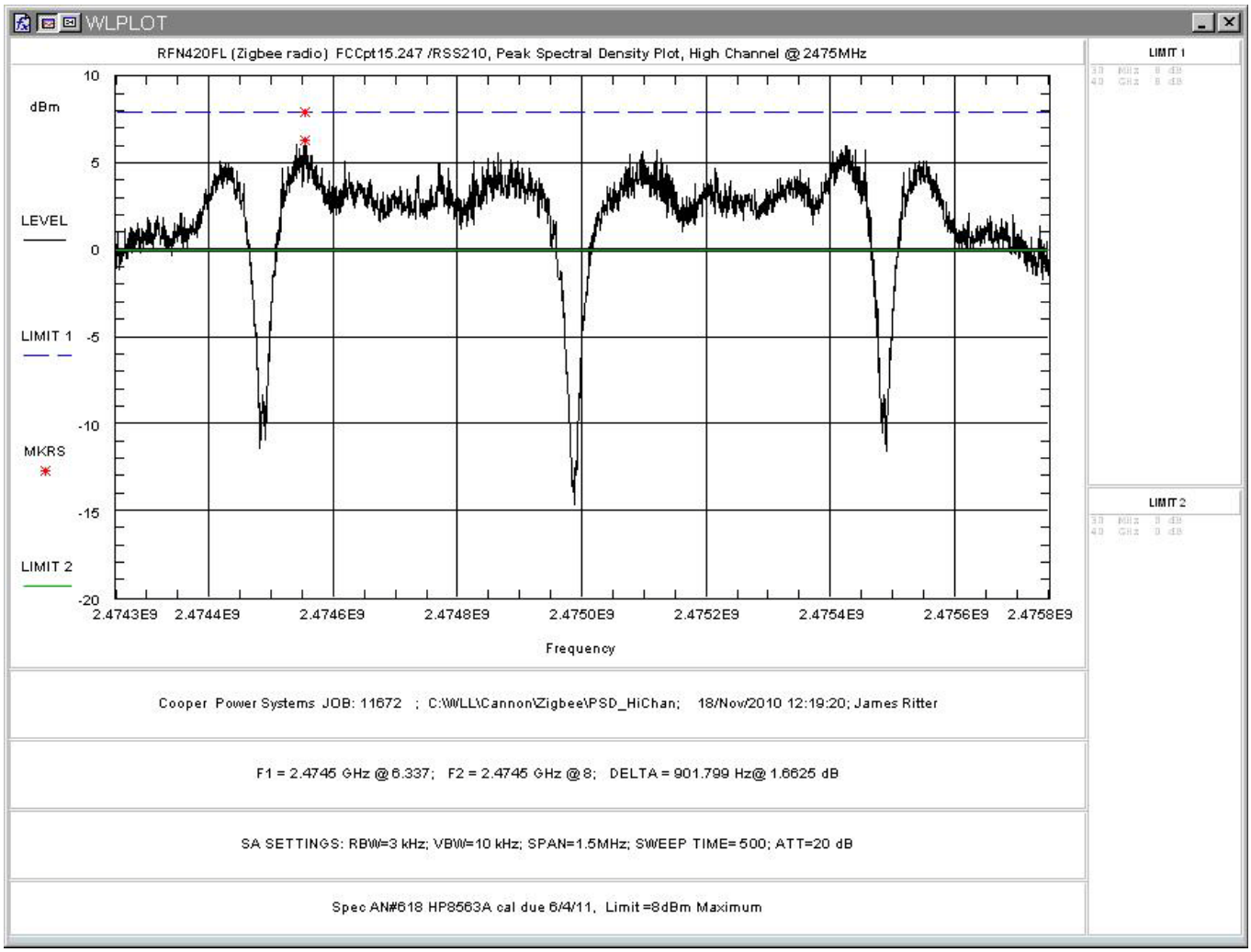


Figure 9: Power Spectral Density, High Channel

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 20 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.

The following are plots of the conducted spurious emissions data.

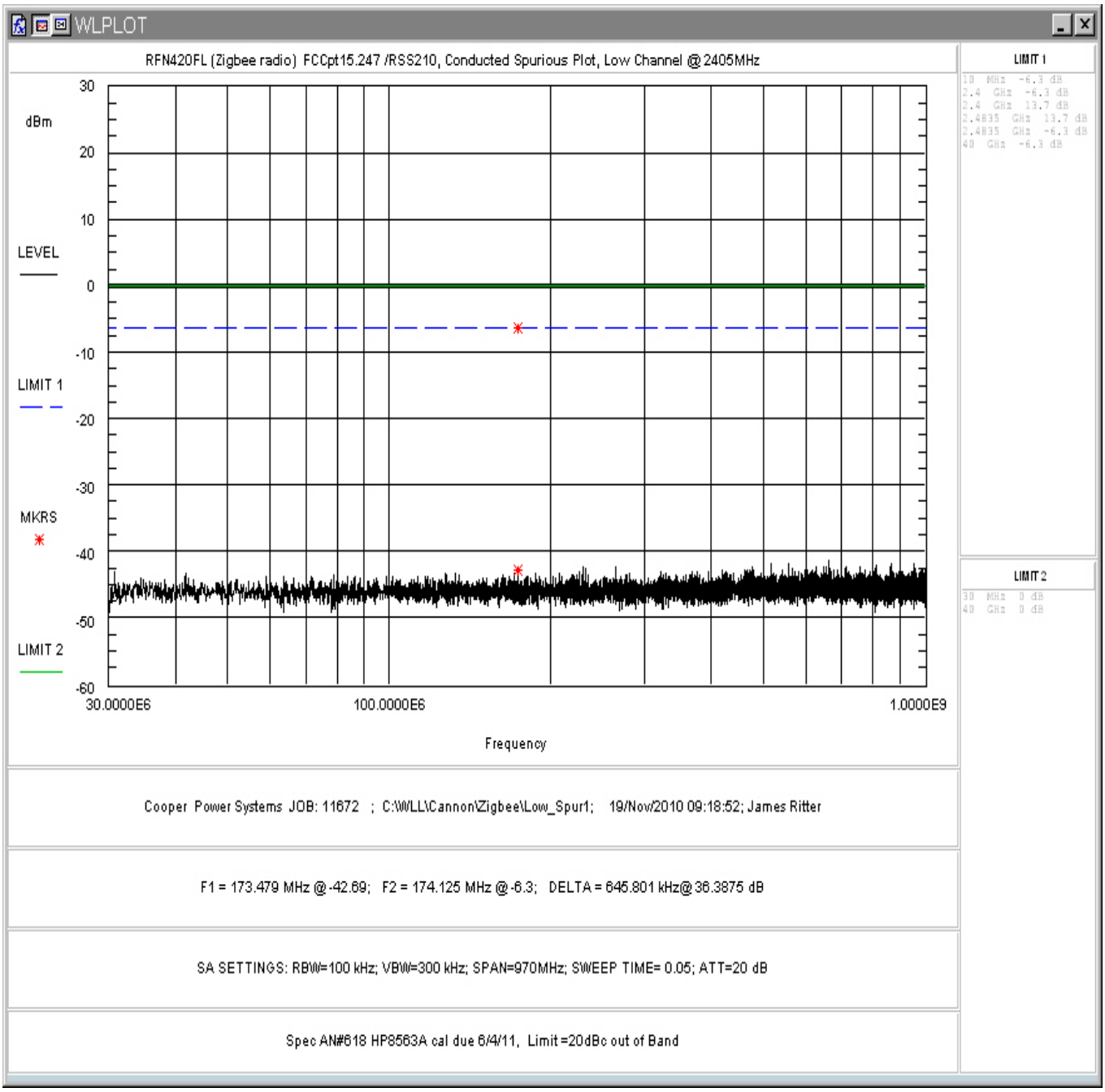


Figure 10: Conducted Spurious Emissions, Low Channel, 30 - 1000MHz

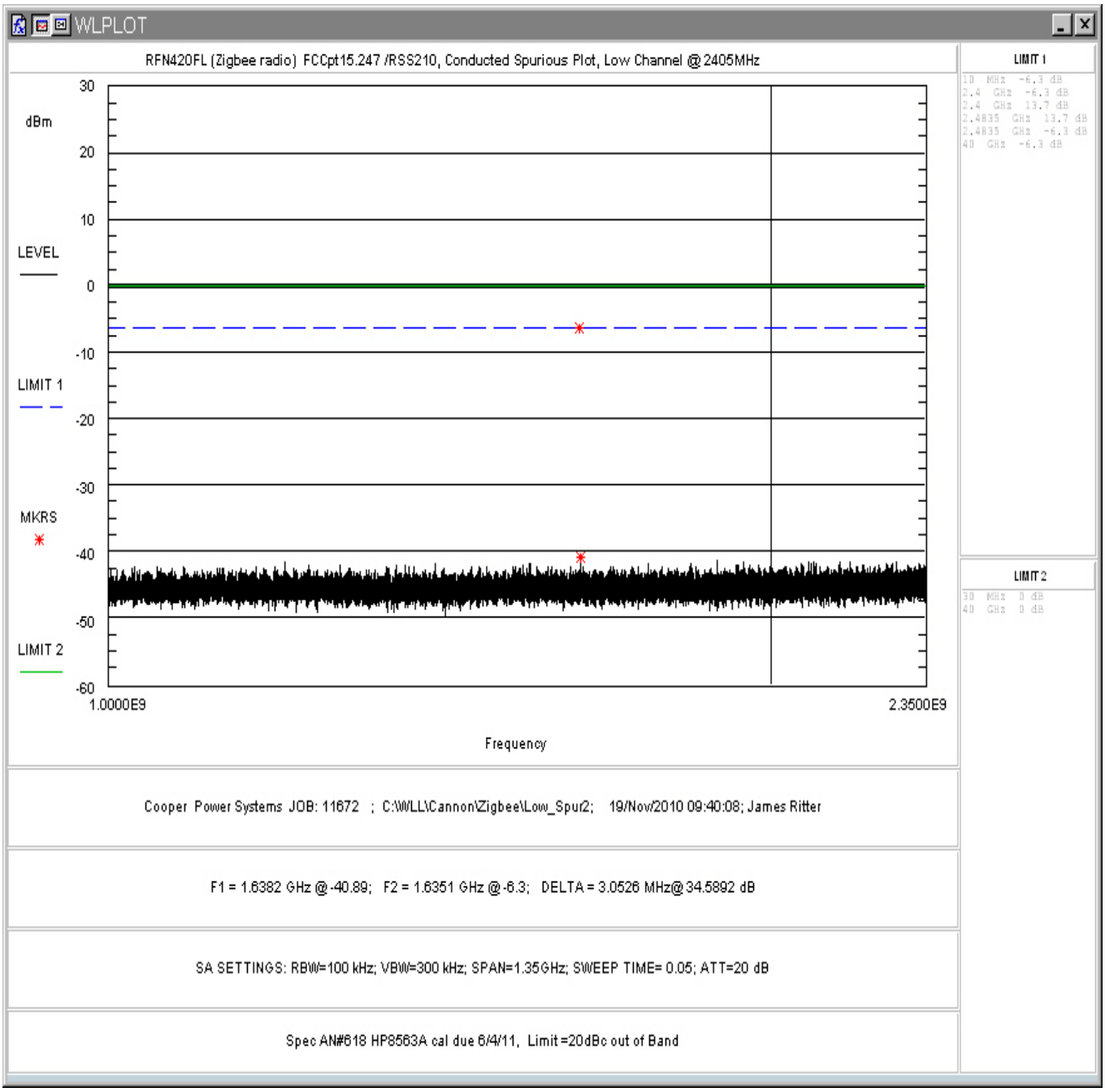


Figure 11: Conducted Spurious Emissions, Low Channel, 1 – 2.35GHz

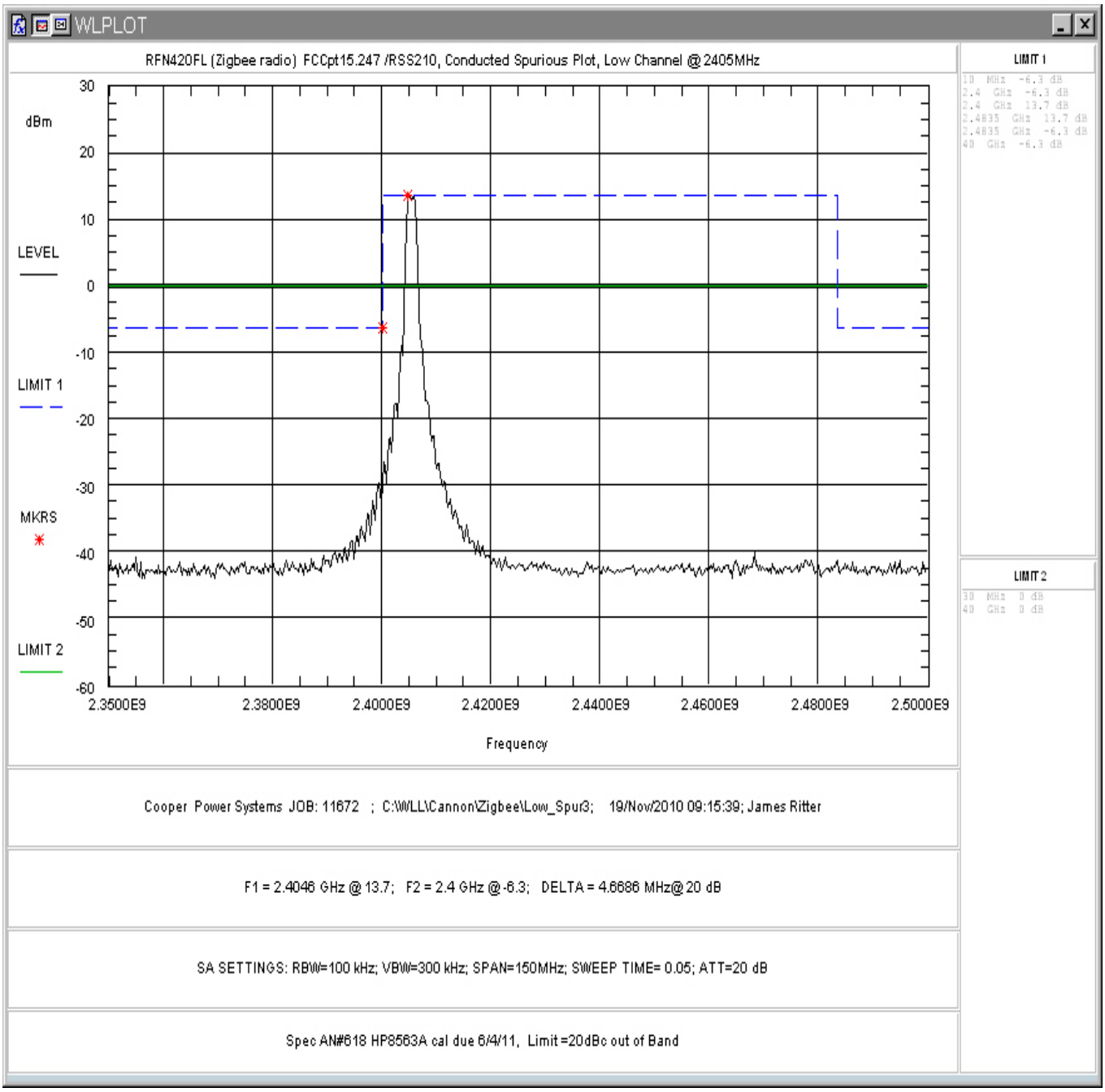


Figure 12: Conducted Spurious Emissions, Low Channel, 2.35 – 2.5GHz

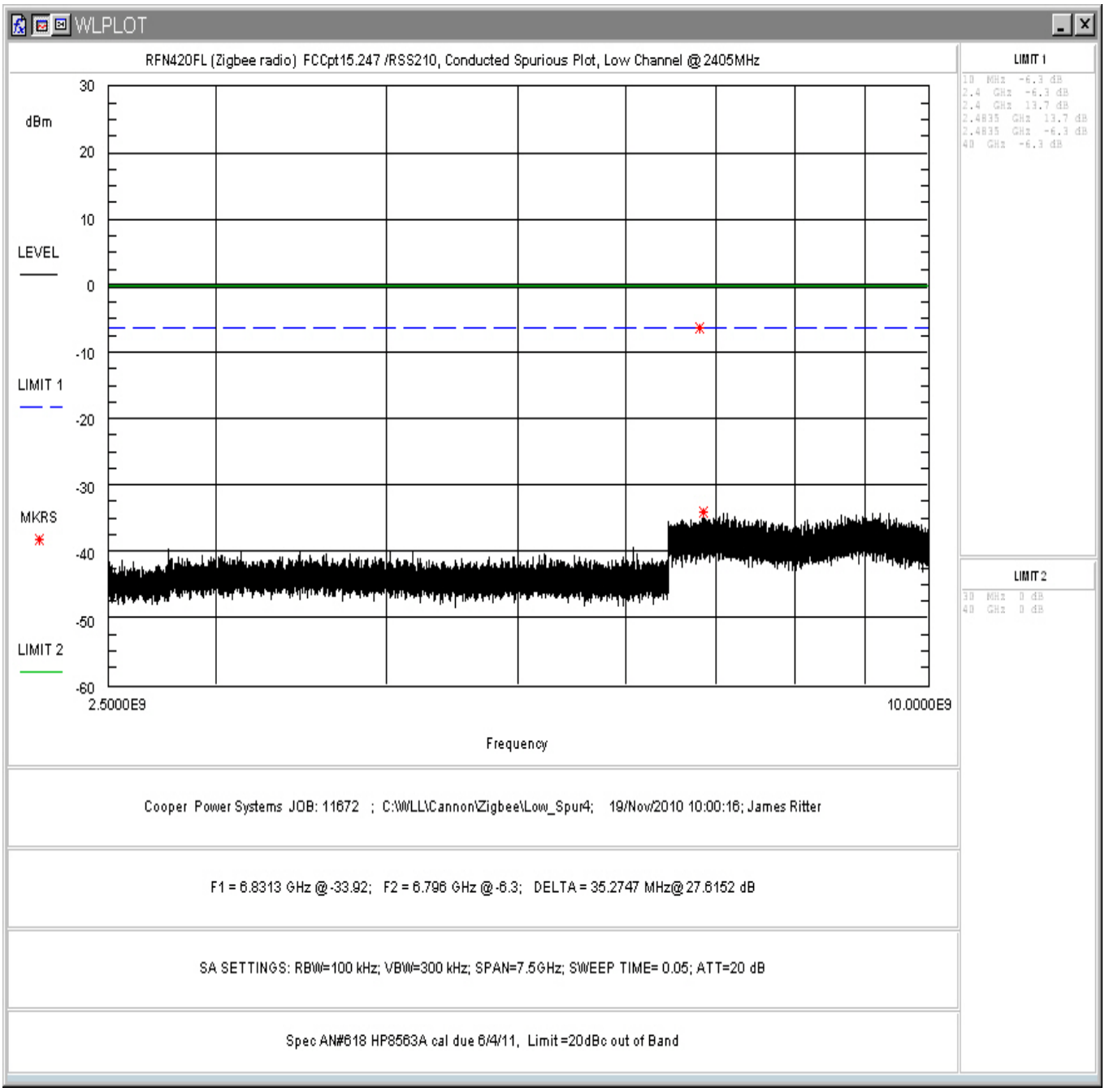


Figure 13: Conducted Spurious Emissions, Low Channel, 2.5 - 10GHz

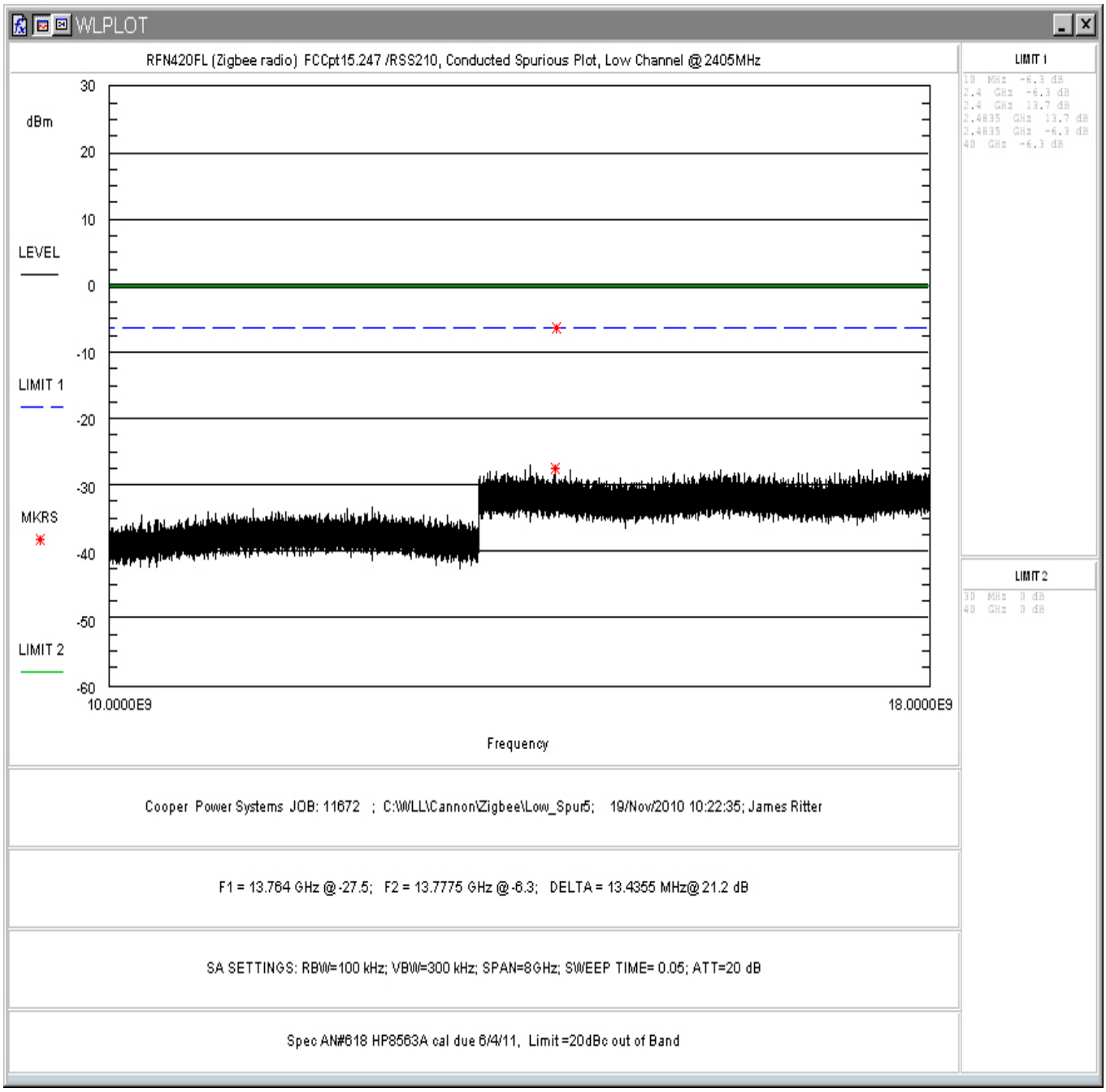


Figure 14: Conducted Spurious Emissions, Low Channel, 10 - 18GHz

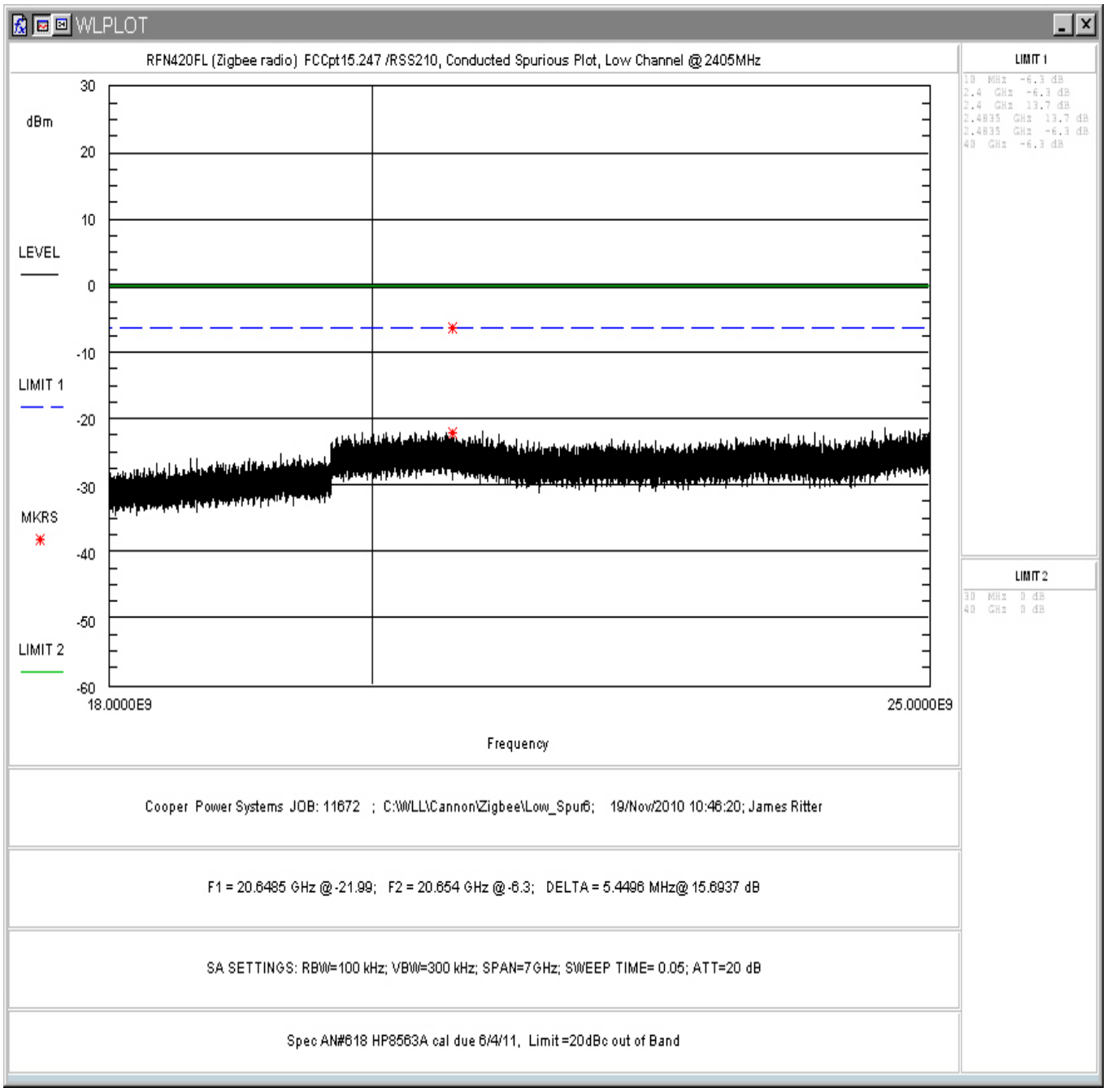


Figure 15: Conducted Spurious Emissions, Low Channel, 18 - 25GHz

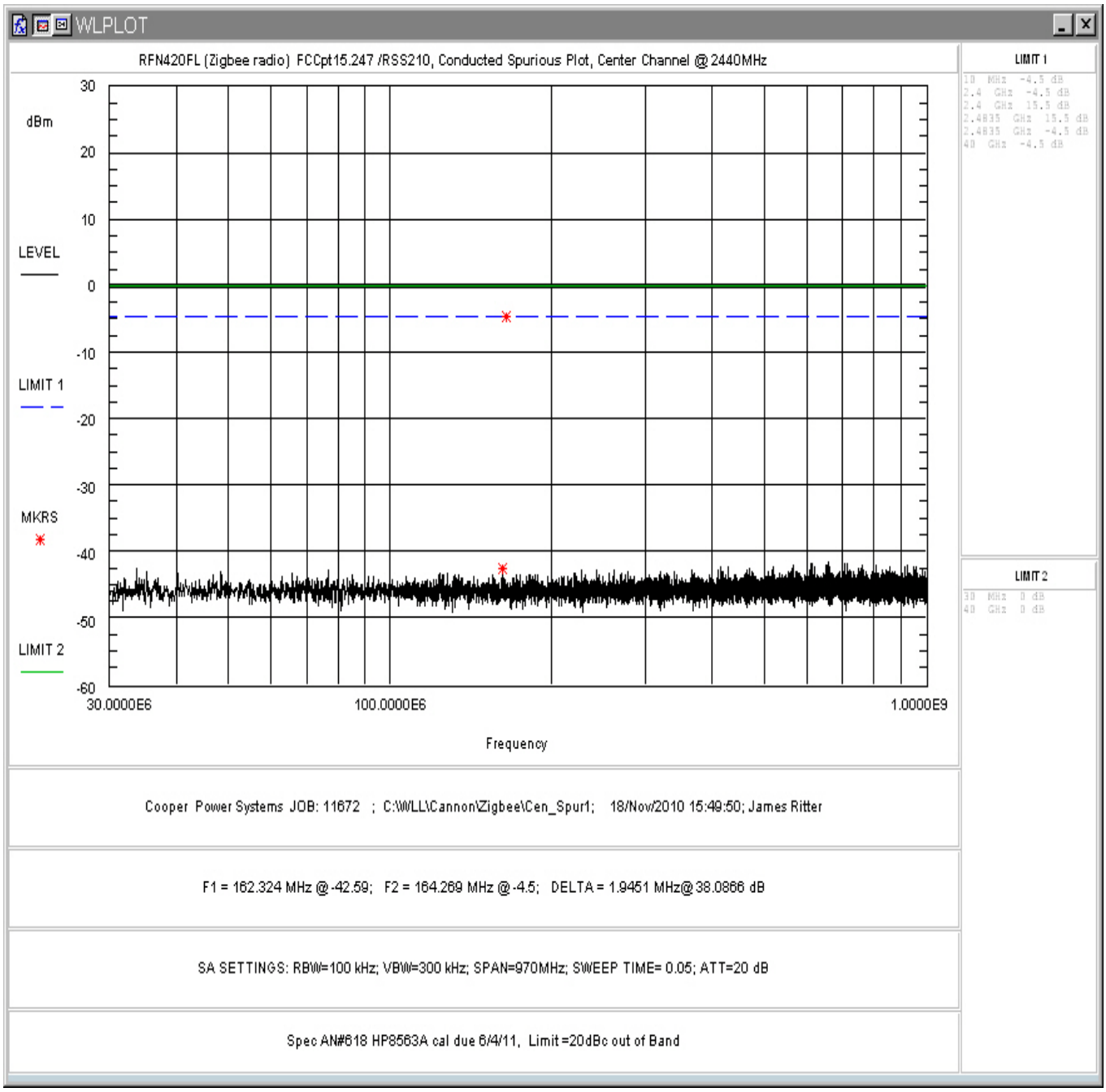


Figure 16: Conducted Spurious Emissions, Center Channel, 30 – 1000MHz

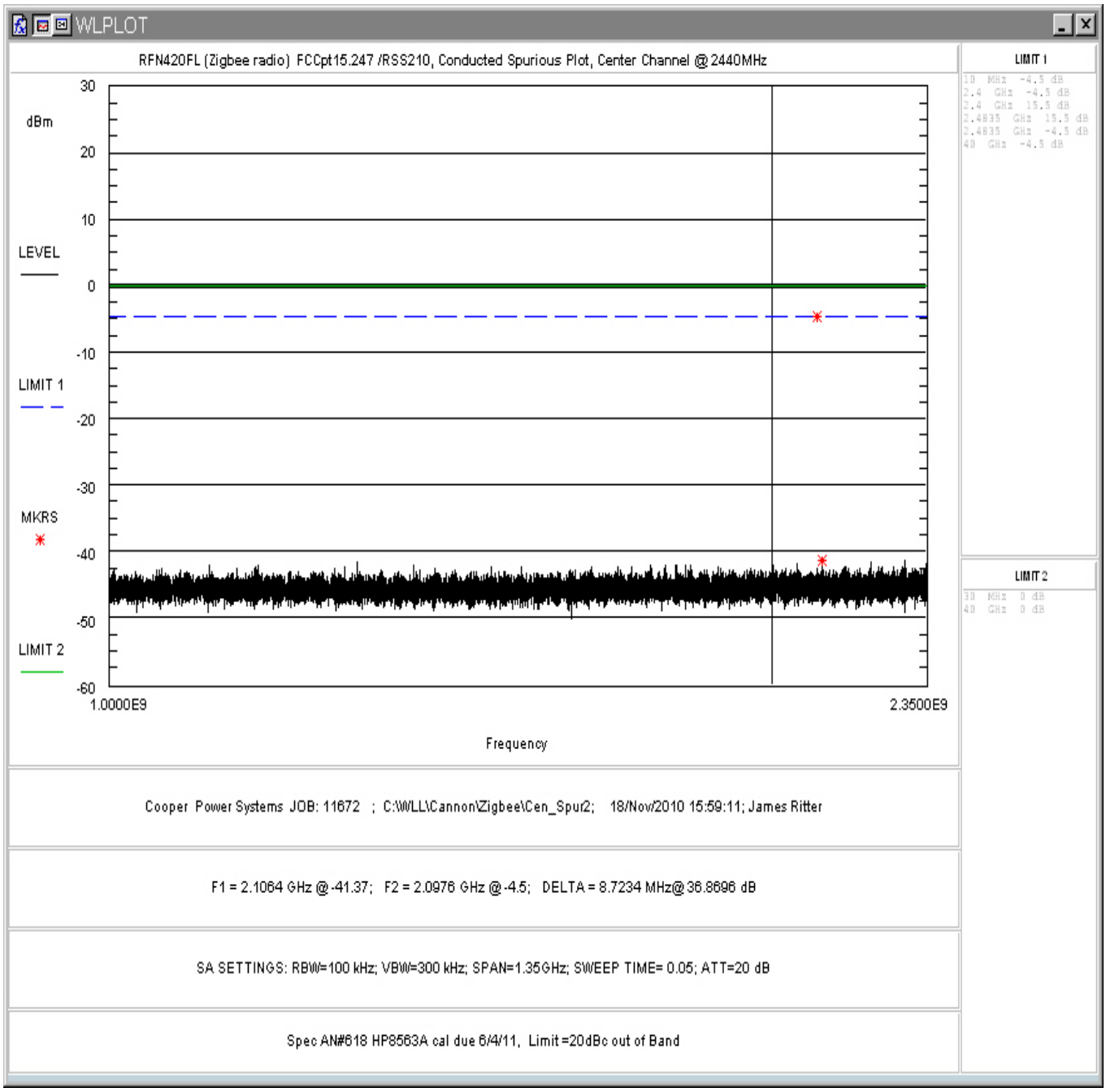


Figure 17: Conducted Spurious Emissions, Center Channel, 1 – 2.35GHz

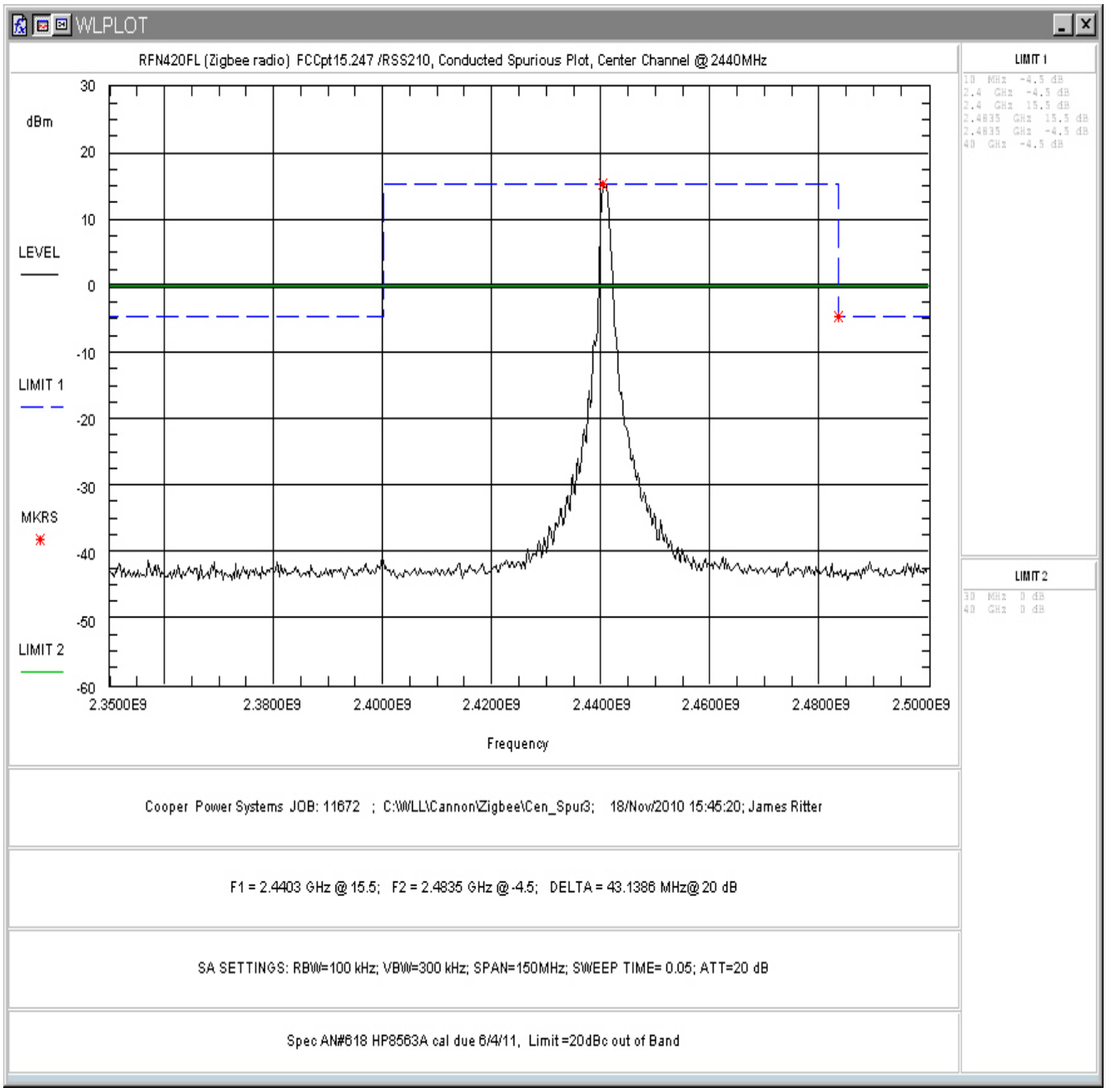


Figure 18: Conducted Spurious Emissions, Center Channel, 2.35 – 2.5GHz

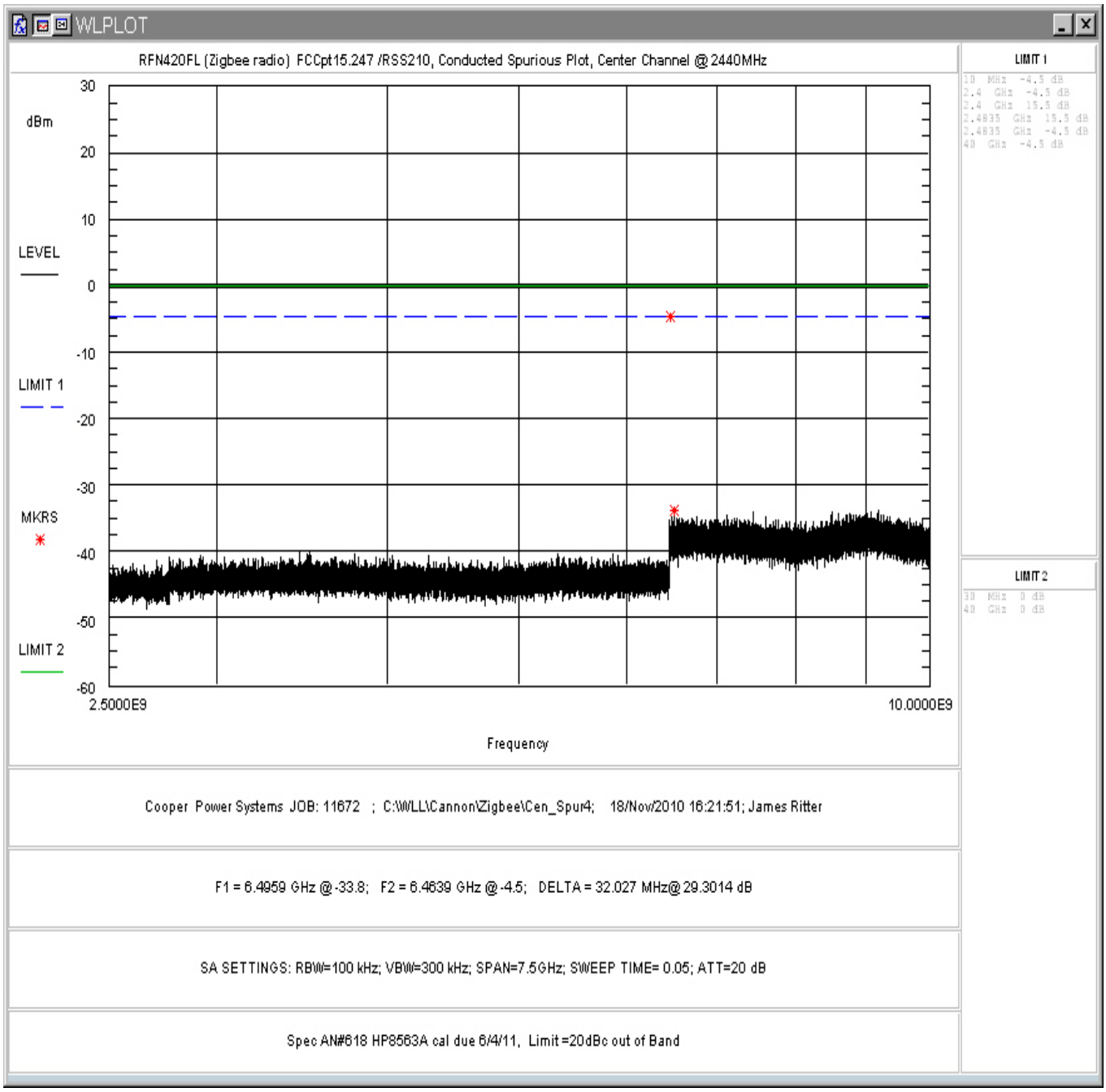


Figure 19: Conducted Spurious Emissions, Center Channel, 2.5 – 10GHz

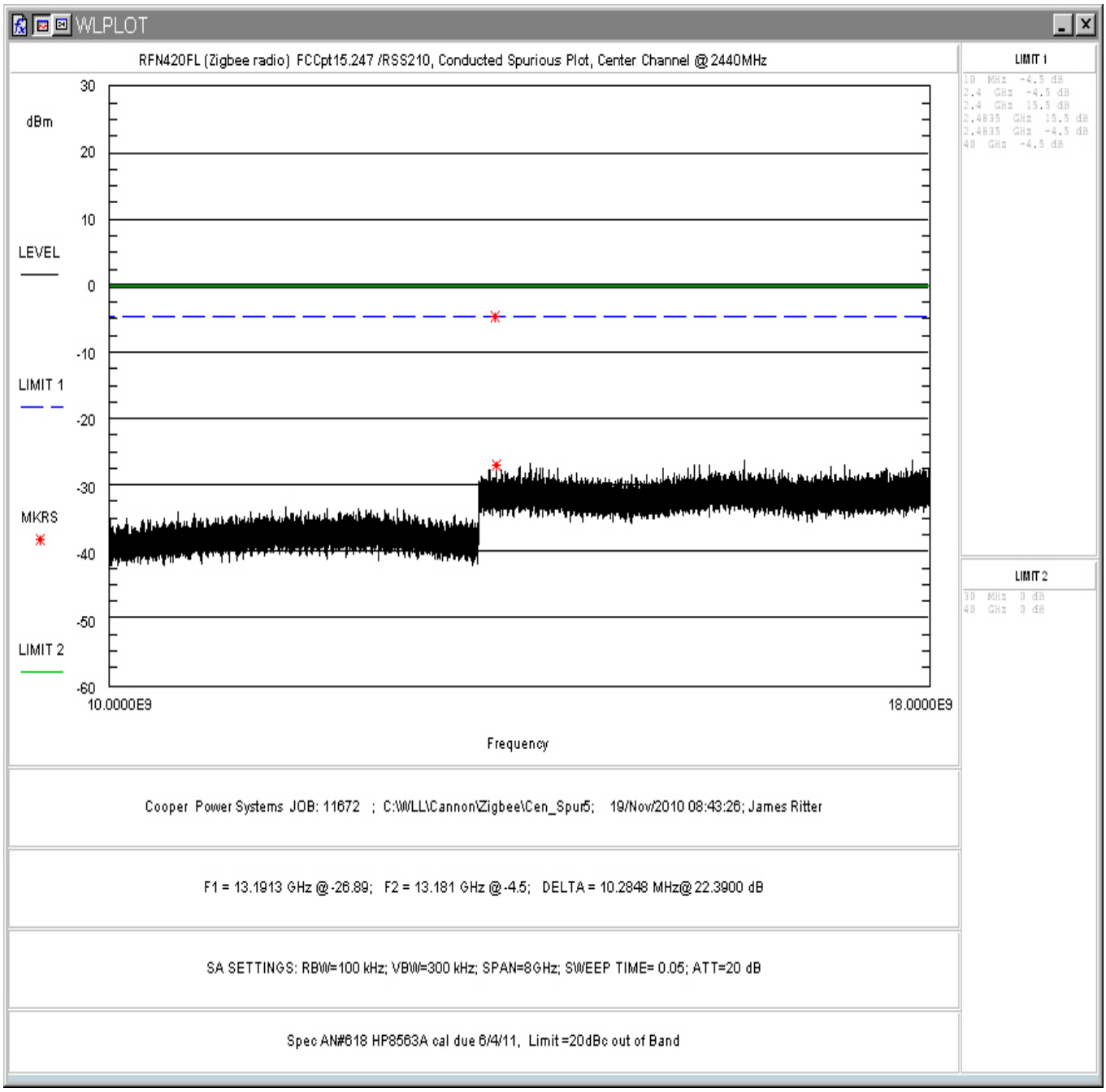


Figure 20: Conducted Spurious Emissions, Center Channel, 10 -18GHz

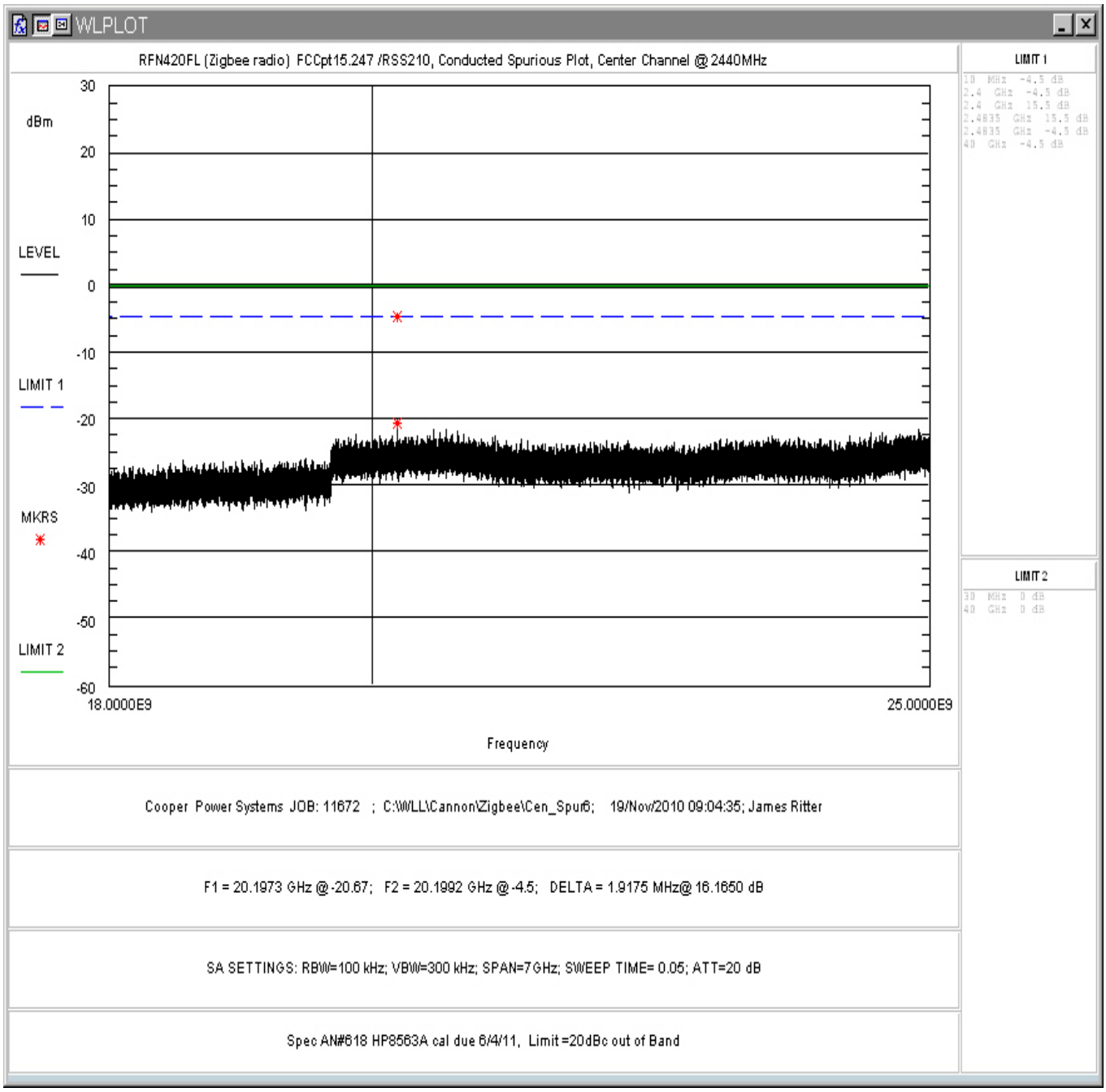


Figure 21: Conducted Spurious Emissions, Center Channel, 18 – 25GHz

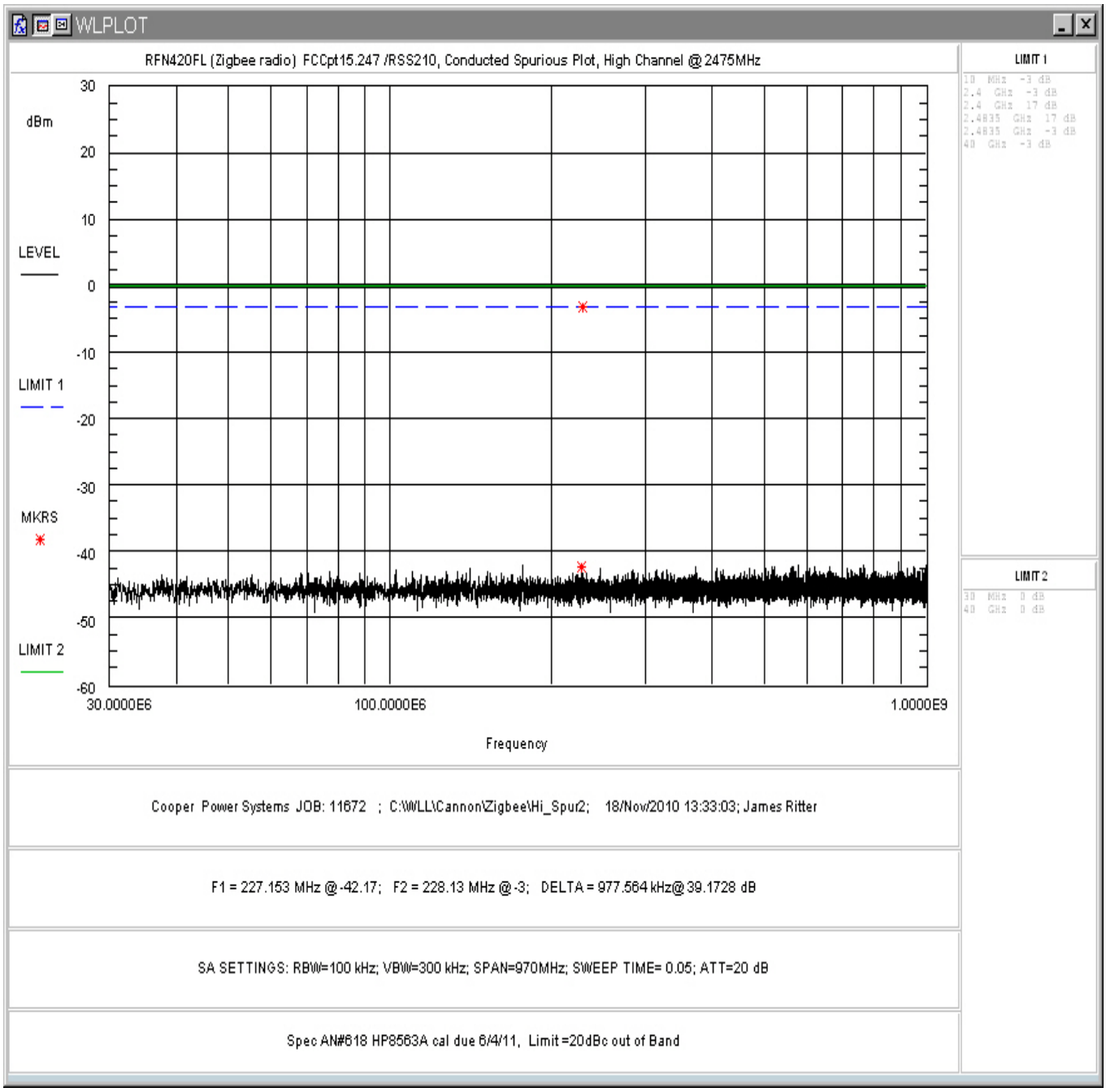


Figure 22: Conducted Spurious Emissions, High Channel, 30 - 1000MHz

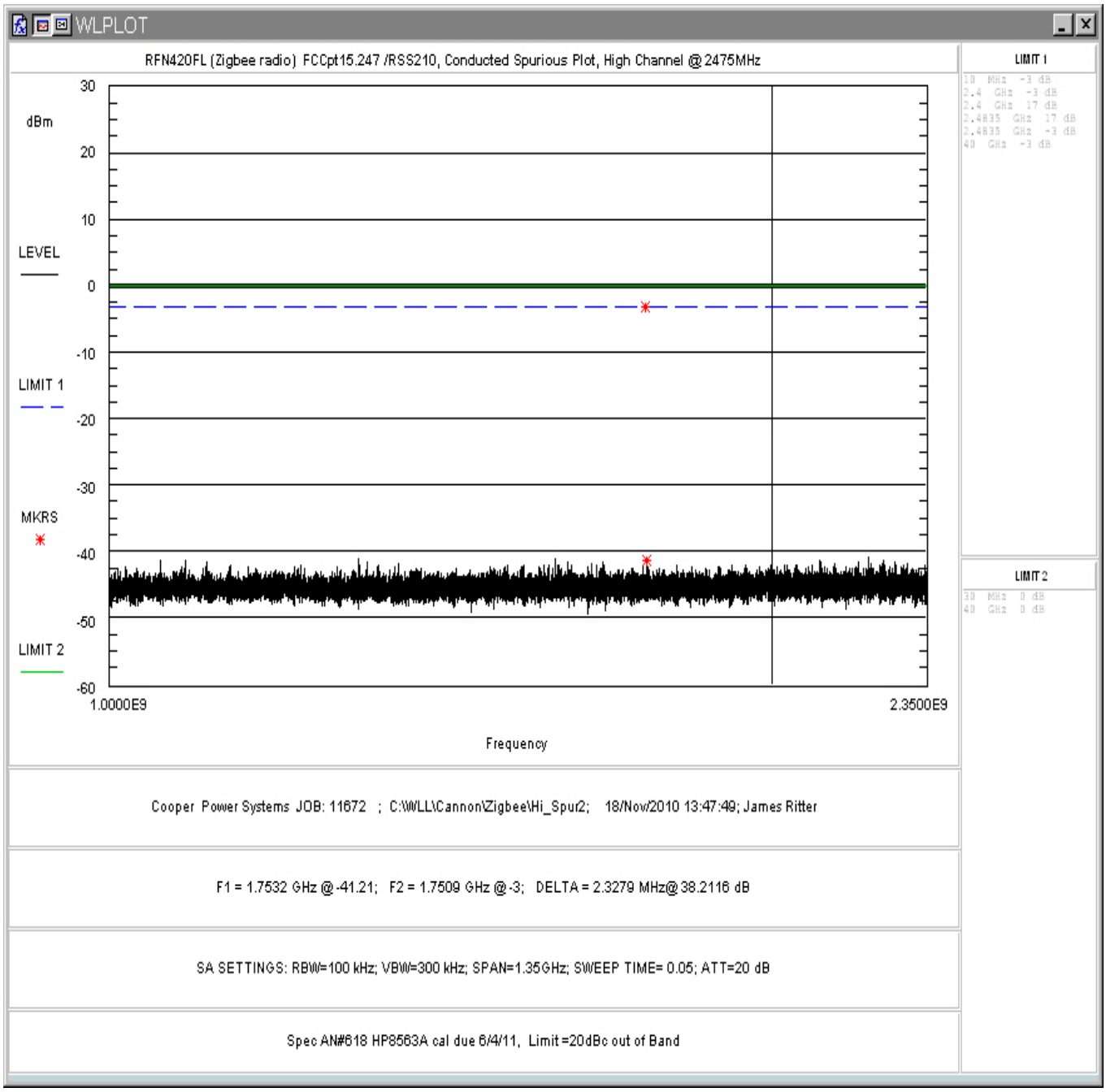


Figure 23: Conducted Spurious Emissions, High Channel, 1 – 2.35GHz

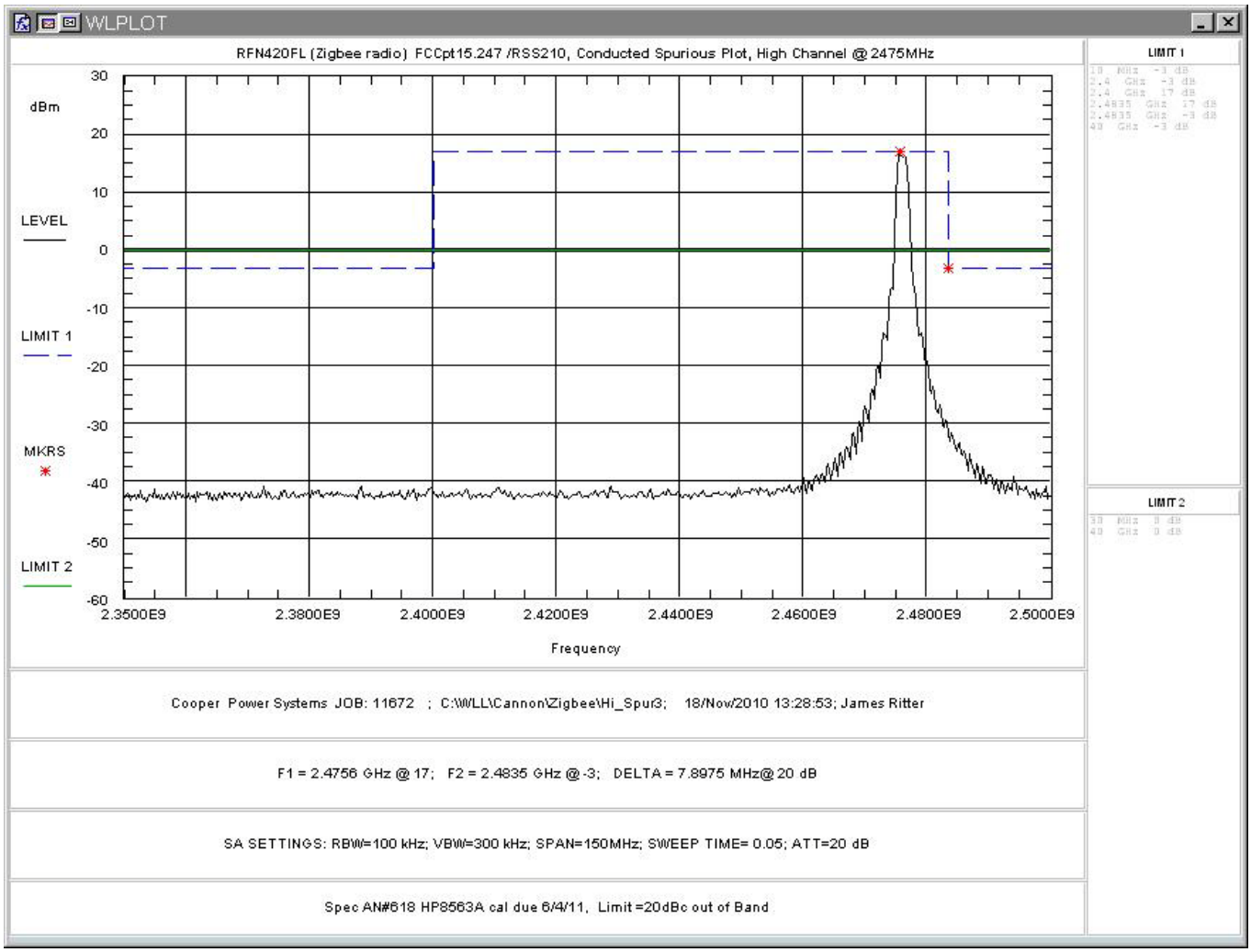


Figure 24: Conducted Spurious Emissions, High Channel, 2.35 – 2.5GHz

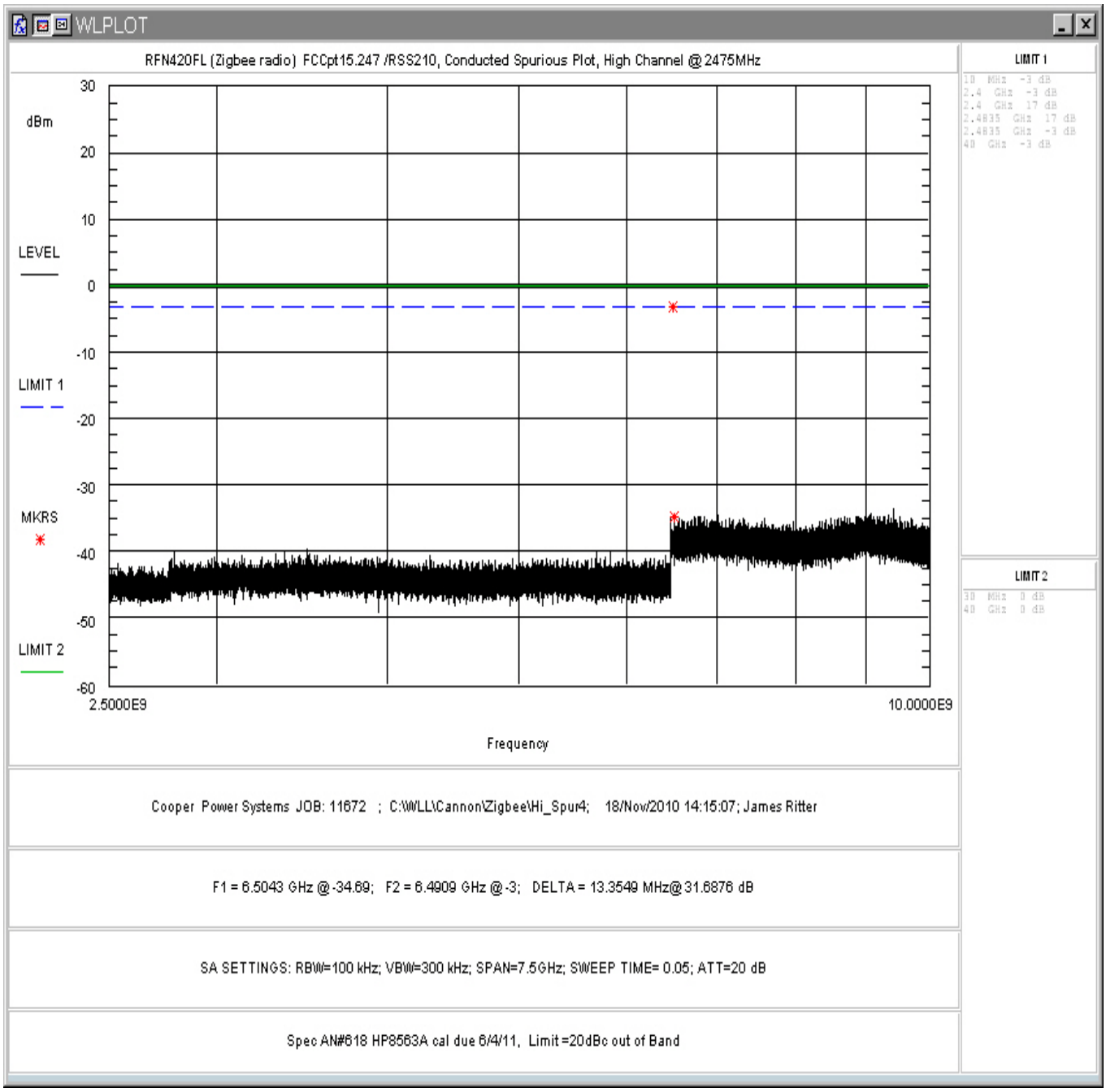


Figure 25: Conducted Spurious Emissions, High Channel, 2.5 - 10GHz

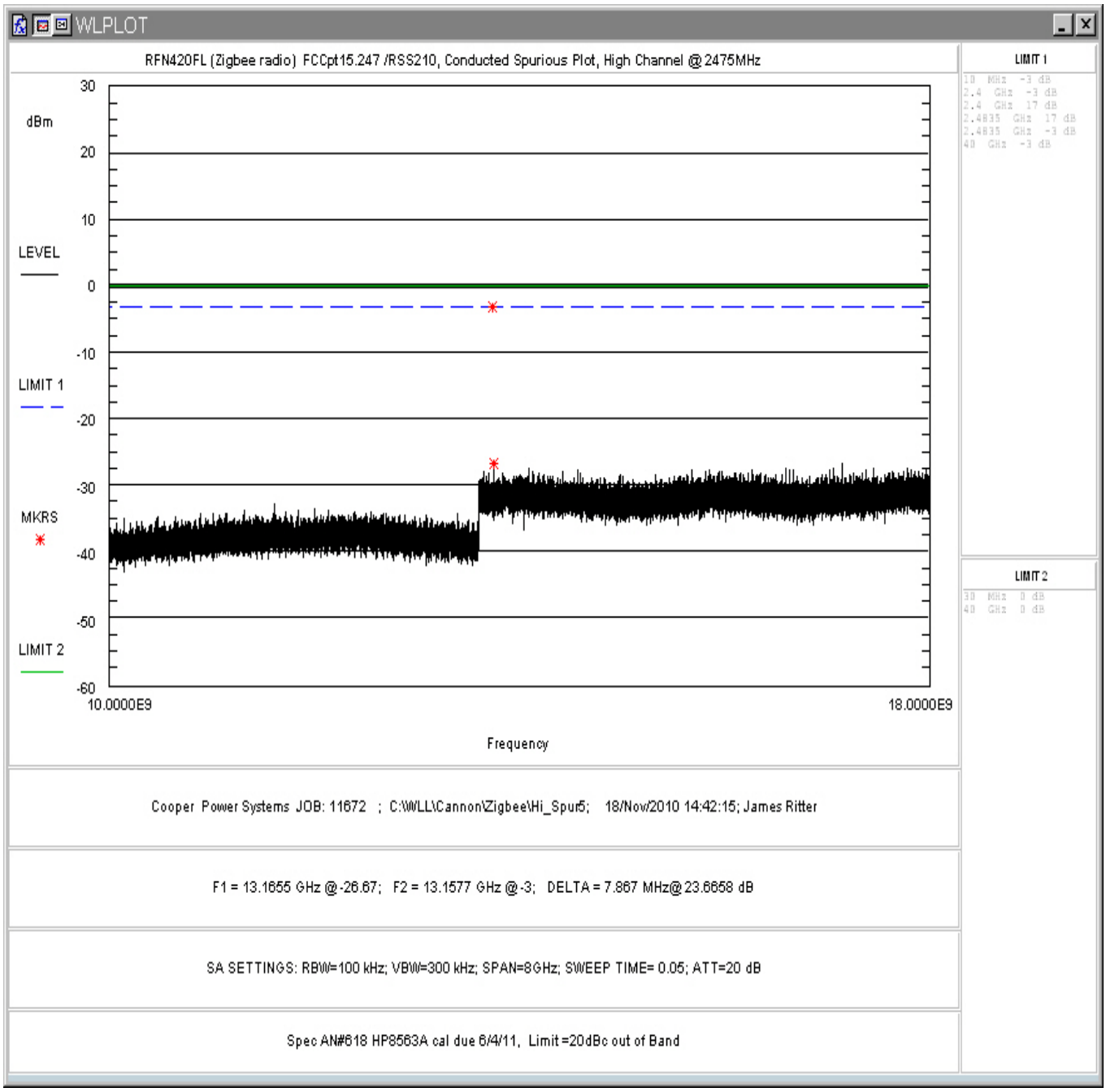


Figure 26: Conducted Spurious Emissions, High Channel, 10 - 18GHz

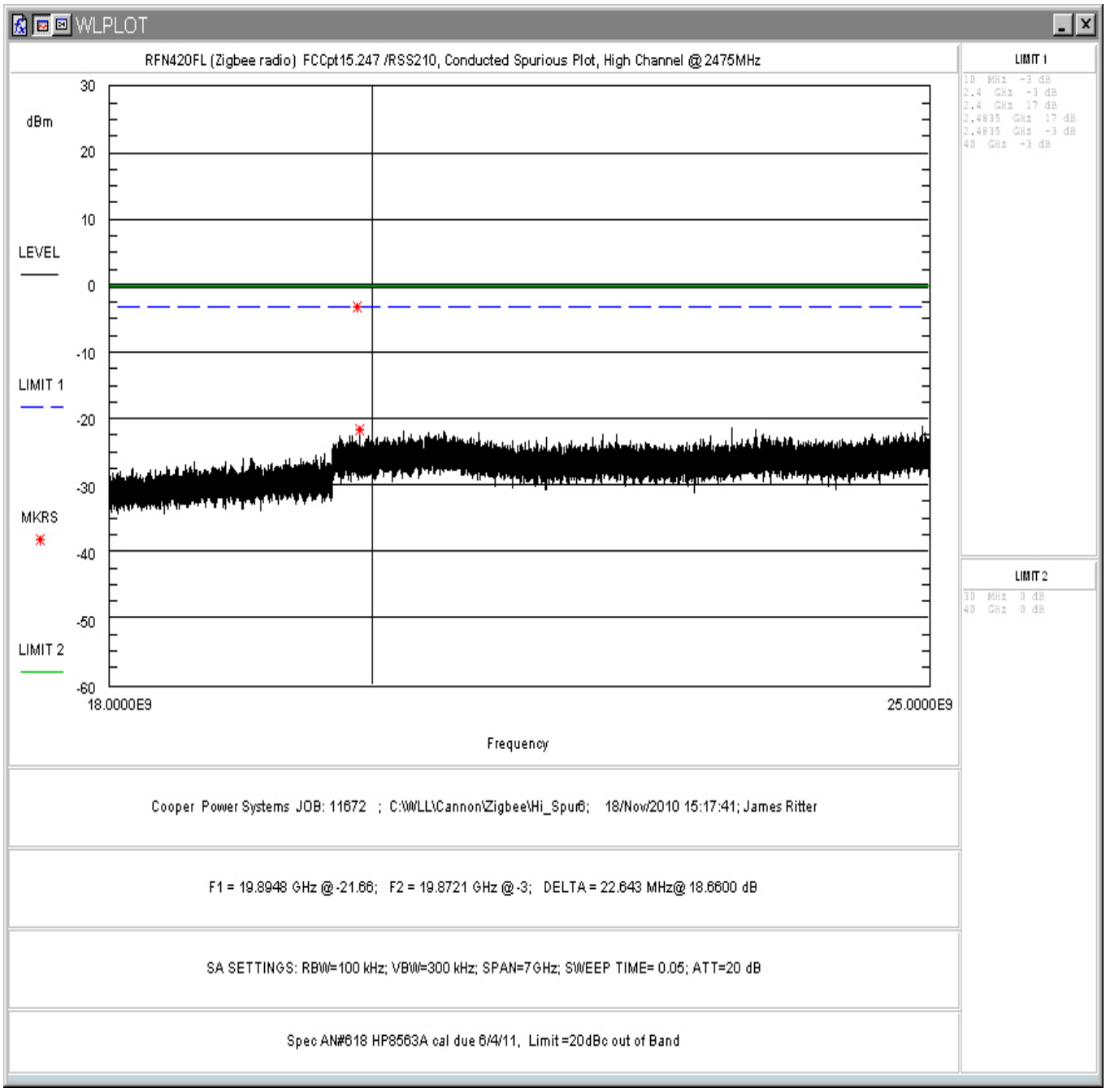


Figure 27: Conducted Spurious Emissions, High Channel, 18 - 25GHz

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

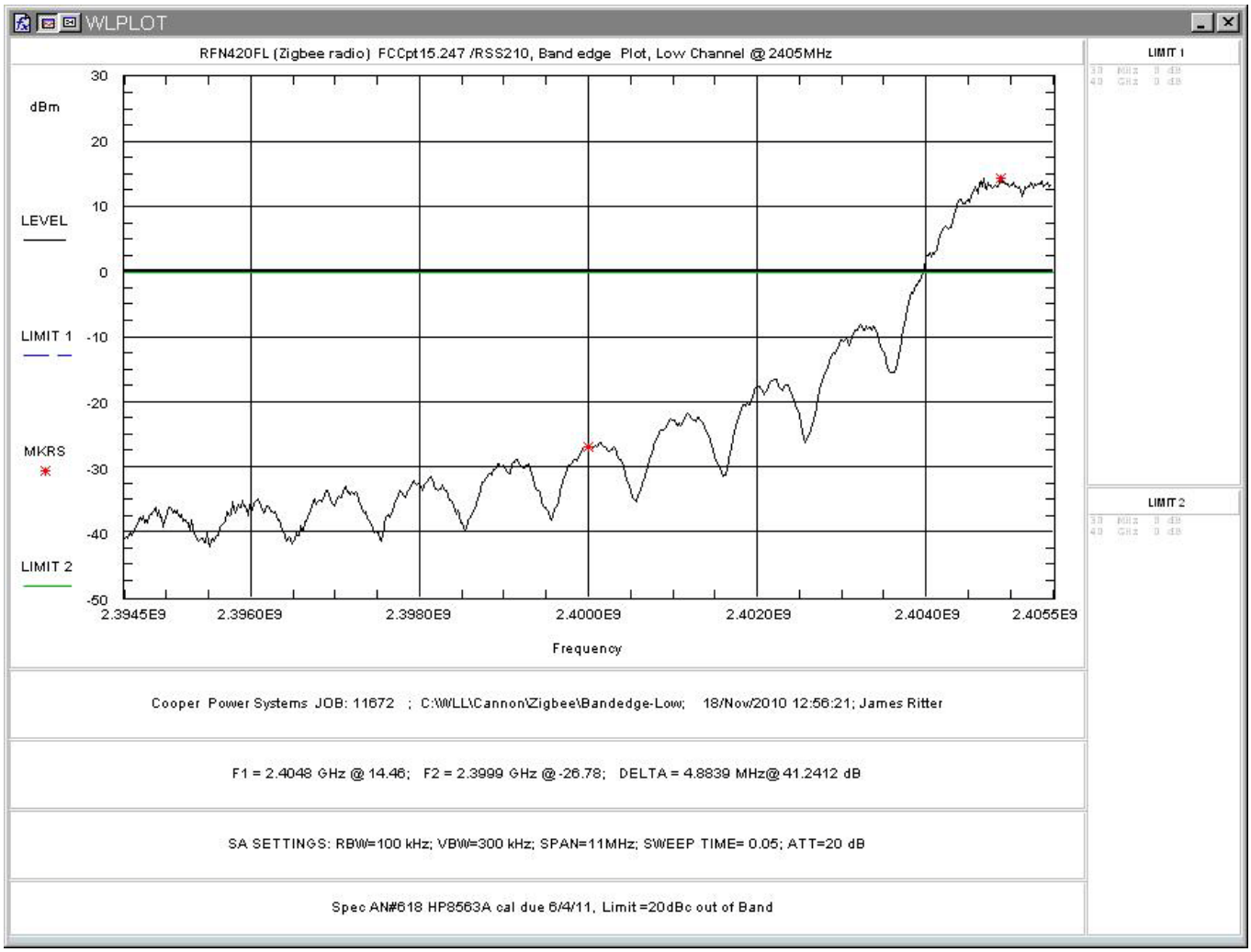


Figure 28: Lower Band-edge, Low Channel

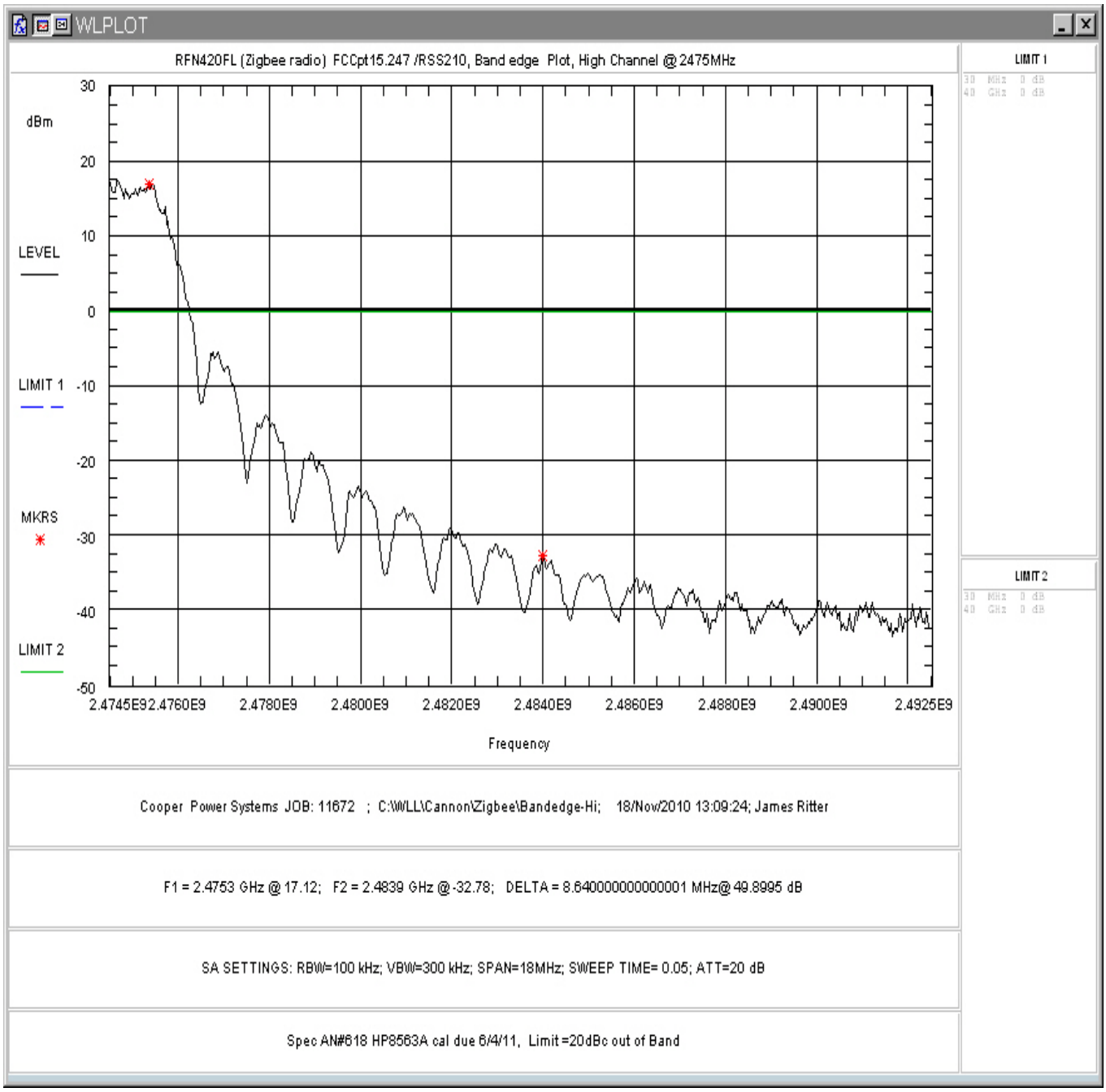


Figure 29: Upper band-edge, High Channel

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 7 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

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	45.6	17.8	10.4	0.5	56.5	28.7	66.0	56.0	-9.5	-27.3
0.180	42.1	25.4	10.4	0.5	53.0	36.3	64.5	54.5	-11.5	-18.2
0.454	40.5	30.9	10.3	0.4	51.2	41.6	56.8	46.8	-5.6	-5.2
0.942	34.8	22.5	10.5	0.4	45.6	33.3	56.0	46.0	-10.4	-12.7
1.457	33.7	20.7	10.7	0.4	44.7	31.7	56.0	46.0	-11.3	-14.3
28.634	27.9	15.6	12.3	3.0	43.2	30.9	60.0	50.0	-16.8	-19.1

PHASE

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	45.7	9.7	10.4	0.7	56.8	20.8	66.0	56.0	-9.2	-35.2
0.180	43.0	19.3	10.4	0.7	54.1	30.4	64.5	54.5	-10.4	-24.1
0.454	23.3	11.9	10.3	0.4	34.1	22.7	56.8	46.8	-22.8	-24.2
0.742	17.4	6.2	10.4	0.4	28.2	17.0	56.0	46.0	-27.8	-29.0
14.190	21.5	11.9	11.5	1.7	34.7	25.1	60.0	50.0	-25.3	-24.9
28.413	30.8	17.1	12.3	4.3	47.4	33.7	60.0	50.0	-12.6	-16.3

Table 9: Conducted Emissions Data 230VAC, Transmit On

NEUTRAL

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)
0.269	42.2	33.6	10.4	0.5	53.0	44.4	61.1	51.1	-8.1	-6.7
0.410	41.6	28.4	10.3	0.4	52.3	39.1	57.6	47.6	-5.4	-8.6
0.797	39.3	23.2	10.4	0.4	50.1	34.0	56.0	46.0	-5.9	-12.0
1.770	37.6	17.9	10.7	0.4	48.7	29.0	56.0	46.0	-7.3	-17.0
5.254	27.5	14.9	11.1	0.4	39.0	26.4	60.0	50.0	-21.0	-23.6
28.480	25.3	14.9	12.3	3.0	40.6	30.2	60.0	50.0	-19.4	-19.8

PHASE

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)
0.170	38.0	17.2	10.4	0.7	49.1	28.3	65.0	55.0	-15.8	-26.6
0.266	33.0	18.0	10.4	0.6	43.9	28.9	61.2	51.2	-17.3	-22.3
0.464	24.7	11.9	10.3	0.4	35.4	22.6	56.6	46.6	-21.2	-24.0
0.799	20.9	5.4	10.4	0.4	31.7	16.2	56.0	46.0	-24.3	-29.8
13.970	19.5	10.8	11.5	1.7	32.7	24.0	60.0	50.0	-27.3	-26.0
28.665	27.4	15.5	12.3	4.3	44.0	32.1	60.0	50.0	-16.0	-17.9

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 with KDB558074: "Measurement of Digital Transmission Systems operating under 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).

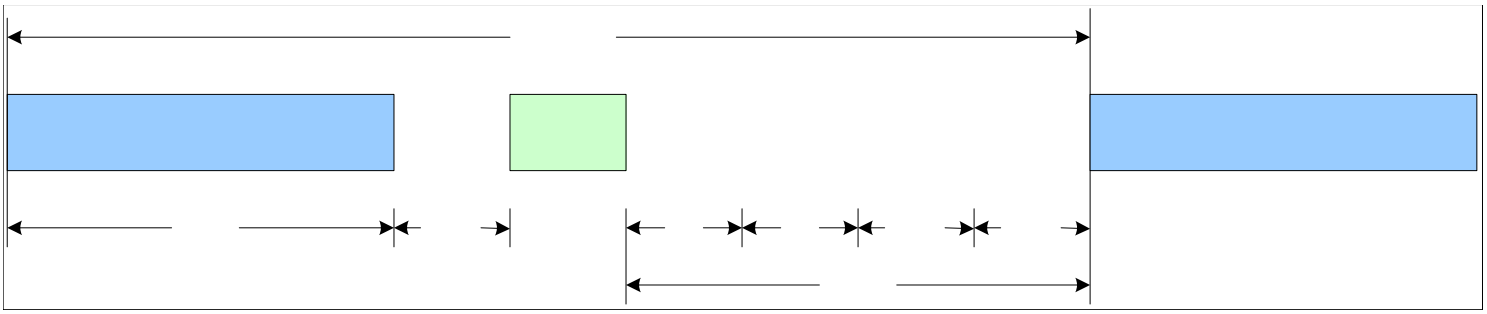
This EUT is allowed -7.4dB of correction based on a 42% duty cycle with a worst case transmit time of 42.56mSec per 100mSec. The EUT was set to a continuously modulated mode and the duty cycle correction added to the Average measurement Radiated emission measurements for the harmonics and band edges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



Long Frame Scenario:

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
	9.8814229
Number of RX / TX cycles in 100ms	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
Peak										
4810.00	V	180.00	3.61	50.56	4.3	0.0	553.2	5000.0	-19.1	
12025.00	V	180.00	2.80	44.27	16.4	0.0	1075.5	5000.0	-13.3	
2390.00	V	190.00	2.27	59.88	-2.1	0.0	777.5	5000.0	-16.2	bandedge
2483.50	V	200.00	2.47	55.72	-2.0	0.0	484.7	5000.0	-20.3	bandedge
Average										
4810.00	V	180.00	3.61	39.54	4.3	-7.4	66.4	500.0	-17.5	
12025.00	V	180.00	2.80	31.51	16.4	-7.4	105.6	500.0	-13.5	
2390.00	V	190.00	2.27	49.11	-2.1	-7.4	96.0	500.0	-14.3	bandedge
2483.50	V	200.00	2.47	42.60	-2.0	-7.4	45.7	500.0	-20.8	bandedge
Non-Harmonics										
38.18	V	90.00	1.00	10.10	14.2	0.0	16.4	100.0	-15.7	
73.25	V	0.00	1.22	16.60	10.7	0.0	23.1	100.0	-12.7	
109.81	V	0.00	1.10	8.90	15.0	0.0	15.6	150.0	-19.6	
112.95	V	165.00	1.20	12.90	15.3	0.0	25.7	150.0	-15.3	
133.50	V	10.00	1.23	7.30	14.8	0.0	12.8	150.0	-21.4	
165.13	V	180.00	1.53	10.30	14.2	0.0	16.8	150.0	-19.0	
255.56	V	270.00	2.73	12.90	14.5	0.0	23.5	200.0	-18.6	
275.24	V	90.00	1.85	5.40	16.5	0.0	12.5	200.0	-24.1	
1000.00	V	180.00	3.20	46.87	-10.6	0.0	65.1	500.0	-17.7	
1541.89	V	0.00	2.27	46.89	-7.2	0.0	96.3	500.0	-14.3	
Peak										
4810.00	H	180.00	3.25	49.25	4.3	0.0	475.7	5000.0	-20.4	
12025.00	H	200.00	2.07	44.27	16.4	0.0	1075.5	5000.0	-13.3	
2390.00	H	90.00	3.36	59.41	-2.1	0.0	736.6	5000.0	-16.6	bandedge
2483.50	H	200.00	3.20	55.76	-2.0	0.0	486.9	5000.0	-20.2	bandedge
Average										
4810.00	H	180.00	3.25	37.57	4.3	-7.4	52.9	500.0	-19.5	
12025.00	H	200.00	2.07	31.23	16.4	-7.4	102.2	500.0	-13.8	
2390.00	H	90.00	3.36	48.65	-2.1	-7.4	91.0	500.0	-14.8	bandedge
2483.50	H	200.00	3.20	42.42	-2.0	-7.4	44.7	500.0	-21.0	bandedge

Non-Harmonics										
38.18	H	90.00	3.90	4.30	14.2	0.0	8.4	100.0	-21.5	
73.25	H	0.00	3.81	8.90	10.7	0.0	9.5	100.0	-20.4	
109.81	H	0.00	3.76	12.50	15.0	0.0	23.7	150.0	-16.0	
112.95	H	10.00	3.80	7.40	15.3	0.0	13.6	150.0	-20.8	
133.50	H	190.00	3.45	5.20	14.8	0.0	10.0	150.0	-23.5	
165.13	H	90.00	3.45	5.90	14.2	0.0	10.1	150.0	-23.4	
255.56	H	170.00	2.25	5.30	14.5	0.0	9.8	200.0	-26.2	
275.24	H	90.00	2.55	6.10	16.5	0.0	13.5	200.0	-23.4	
1000.00	H	45.00	3.44	47.12	-10.6	0.0	67.1	500.0	-17.5	
1541.89	H	45.00	3.59	50.36	-7.2	0.0	143.6	500.0	-10.8	

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
Peak										
4880.00	V	90.00	2.44	48.47	4.9	0.0	464.1	5000.0	-20.6	
7320.00	V	170.00	2.64	60.62	9.1	0.0	3055.6	5000.0	-4.3	
12200.00	V	180.00	3.00	43.65	16.6	0.0	1034.2	5000.0	-13.7	
2390.00	V	180.00	2.39	55.42	-2.1	0.0	465.3	5000.0	-20.6	bandedge
2483.50	V	190.00	2.06	54.30	-2.0	0.0	411.6	5000.0	-21.7	bandedge
Average										
4880.00	V	90.00	2.44	36.78	4.9	-7.4	51.5	500.0	-19.7	
7320.00	V	170.00	2.64	48.81	9.1	-7.4	334.7	500.0	-3.5	
12200.00	V	180.00	3.00	30.95	16.6	-7.4	102.2	500.0	-13.8	
2390.00	V	180.00	2.39	42.79	-2.1	-7.4	46.4	500.0	-20.7	bandedge
2483.50	V	190.00	2.06	42.73	-2.0	-7.4	46.3	500.0	-20.7	bandedge
Non-Harmonics										
38.18	V	90.00	1.00	10.10	14.2	0.0	16.4	100.0	-15.7	
73.25	V	0.00	1.22	16.60	10.7	0.0	23.1	100.0	-12.7	
109.81	V	0.00	1.10	8.90	15.0	0.0	15.6	150.0	-19.6	
112.95	V	165.00	1.20	12.90	15.3	0.0	25.7	150.0	-15.3	
133.50	V	10.00	1.23	7.30	14.8	0.0	12.8	150.0	-21.4	
165.13	V	180.00	1.53	10.30	14.2	0.0	16.8	150.0	-19.0	
255.56	V	270.00	2.73	12.90	14.5	0.0	23.5	200.0	-18.6	
275.24	V	90.00	1.85	5.40	16.5	0.0	12.5	200.0	-24.1	
1000.00	V	180.00	2.01	46.90	-10.6	0.0	65.4	500.0	-17.7	

1500.32	V	10.00	1.93	52.73	-7.8	0.0	176.7	500.0	-9.0	
Peak										
4880.00	H	180.00	3.49	48.83	4.9	0.0	483.7	5000.0	-20.3	
7320.00	H	190.00	3.42	60.89	9.1	0.0	3152.1	5000.0	-4.0	
12200.00	H	170.00	2.76	44.04	16.6	0.0	1081.7	5000.0	-13.3	
2390.00	H	180.00	2.67	54.35	-2.1	0.0	411.4	5000.0	-21.7	bandedge
2483.50	H	190.00	2.51	54.66	-2.0	0.0	429.0	5000.0	-21.3	bandedge
Average										
4880.00	H	180.00	3.49	37.19	4.9	-7.4	54.0	500.0	-19.3	
7320.00	H	190.00	3.42	48.73	9.1	-7.4	331.6	500.0	-3.6	
12200.00	H	170.00	2.76	31.65	16.6	-7.4	110.8	500.0	-13.1	
2390.00	H	180.00	2.67	42.65	-2.1	-7.4	45.6	500.0	-20.8	bandedge
2483.50	H	190.00	2.51	42.63	-2.0	-7.4	45.8	500.0	-20.8	bandedge
Non-Harmonics										
38.18	H	90.00	3.90	4.30	14.2	0.0	8.4	100.0	-21.5	
73.25	H	0.00	3.81	8.90	10.7	0.0	9.5	100.0	-20.4	
109.81	H	0.00	3.76	12.50	15.0	0.0	23.7	150.0	-16.0	
112.95	H	10.00	3.80	7.40	15.3	0.0	13.6	150.0	-20.8	
133.50	H	190.00	3.45	5.20	14.8	0.0	10.0	150.0	-23.5	
165.13	H	90.00	3.45	5.90	14.2	0.0	10.1	150.0	-23.4	
255.56	H	170.00	2.25	5.30	14.5	0.0	9.8	200.0	-26.2	
275.24	H	90.00	2.55	6.10	16.5	0.0	13.5	200.0	-23.4	
1000.00	H	190.00	2.25	46.81	-10.6	0.0	64.7	500.0	-17.8	
1500.32	H	180.00	2.22	49.98	-7.8	0.0	128.7	500.0	-11.8	

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
Peak										
4950.00	V	180.00	3.17	52.81	5.3	0.0	800.3	5000.0	-15.9	
7425.00	V	190.00	2.81	60.75	9.7	0.0	3312.0	5000.0	-3.6	
12375.00	V	190.00	1.55	42.69	16.9	0.0	956.4	5000.0	-14.4	
2390.00	V	180.00	2.80	62.10	-2.1	0.0	1004.0	5000.0	-13.9	bandedge
2483.50	V	180.00	2.56	71.57	-2.0	0.0	3005.8	5000.0	-4.4	bandedge
Average										

4950.00	V	180.00	3.17	42.40	5.3	-7.4	103.0	500.0	-13.7	
7425.00	V	190.00	2.81	48.50	9.7	-7.4	344.8	500.0	-3.2	
12375.00	V	190.00	1.55	31.28	16.9	-7.4	109.7	500.0	-13.2	
2390.00	V	180.00	2.80	43.90	-2.1	-7.4	52.7	500.0	-19.5	bandedge
2483.50	V	180.00	2.56	59.93	-2.0	-7.4	335.7	500.0	-3.5	bandedge
Non-Harmonics										
38.18	V	90.00	1.00	10.10	14.2	0.0	16.4	100.0	-15.7	
73.25	V	0.00	1.22	16.60	10.7	0.0	23.1	100.0	-12.7	
109.81	V	0.00	1.10	8.90	15.0	0.0	15.6	150.0	-19.6	
112.95	V	165.00	1.20	12.90	15.3	0.0	25.7	150.0	-15.3	
133.50	V	10.00	1.23	7.30	14.8	0.0	12.8	150.0	-21.4	
165.13	V	180.00	1.53	10.30	14.2	0.0	16.8	150.0	-19.0	
255.56	V	270.00	2.73	12.90	14.5	0.0	23.5	200.0	-18.6	
275.24	V	90.00	1.85	5.40	16.5	0.0	12.5	200.0	-24.1	
1000.00	V	90.00	2.17	46.94	-10.6	0.0	65.7	500.0	-17.6	
Peak										
4950.00	V	90.00	3.02	50.95	5.3	0.0	646.1	5000.0	-17.8	
7425.00	V	190.00	2.83	58.15	9.7	0.0	2455.2	5000.0	-6.2	
12375.00	V	190.00	2.46	43.46	16.9	0.0	1045.1	5000.0	-13.6	
2390.00	V	270.00	3.10	54.40	-2.1	0.0	413.7	5000.0	-21.6	bandedge
2483.50	V	80.00	3.23	69.00	-2.0	0.0	2235.9	5000.0	-7.0	bandedge
Average										
4950.00	H	90.00	3.02	39.43	5.3	-7.4	73.2	500.0	-16.7	
7425.00	H	190.00	2.83	46.09	9.7	-7.4	261.3	500.0	-5.6	
12375.00	H	190.00	2.46	31.09	16.9	-7.4	107.3	500.0	-13.4	
2390.00	H	270.00	3.10	42.44	-2.1	-7.4	44.5	500.0	-21.0	bandedge
2483.50	H	80.00	3.23	56.09	-2.0	-7.4	215.8	500.0	-7.3	bandedge
Non-Harmonics										
38.18	H	90.00	3.90	4.30	14.2	0.0	8.4	100.0	-21.5	
73.25	H	0.00	3.81	8.90	10.7	0.0	9.5	100.0	-20.4	
109.81	H	0.00	3.76	12.50	15.0	0.0	23.7	150.0	-16.0	
112.95	H	10.00	3.80	7.40	15.3	0.0	13.6	150.0	-20.8	
133.50	H	190.00	3.45	5.20	14.8	0.0	10.0	150.0	-23.5	
165.13	H	90.00	3.45	5.90	14.2	0.0	10.1	150.0	-23.4	
275.24	H	90.00	2.55	6.10	16.5	0.0	13.5	200.0	-23.4	
255.56	H	170.00	2.25	5.30	14.5	0.0	9.8	200.0	-26.2	
1000.00	H	190.00	3.00	46.92	-10.6	0.0	65.5	500.0	-17.7	

4.8 Receiver Radiated Spurious Emissions: (RSS-210 sect 2.6)

The EUT must comply with the requirements for radiated spurious emissions that fall within the restricted bands. These emissions must meet the limits RSS-210 section 2.6.

4.8.1 Test Procedure

The EUT must comply with the requirements for radiated spurious emissions while in receiver mode to the 3rd of the highest tunable frequency or local oscillator. These emissions must meet the limits specified in RSS210 section 2.6.

Test Arrangement: Table Top

Compliance Limits for Receivers	
Frequency	**Limits**
30-88 MHz	100 µV/m
88-216 MHz	150 µV/m
216-960 MHz	200 µV/m
>960MHz	500 µV/m

4.8.2 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 units were scanned from 30-7500MHz.

The unit was pre-scanned in 3 orthogonal positions with full testing performed in the worst case position. The data was the same for all antenna types and was reported with the 8dBi antenna attached. No emissions were noted above those shown.

The emissions were measured using the following resolution bandwidths:

Table 15: Spectrum Analyzer Settings

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

Table 16: Radiated Emission Test Data, Receive Only

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)
35.90	V	90.00	1.00	6.70	16.0	13.6	100.0	-17.3
53.19	V	90.00	1.10	9.00	7.9	7.0	100.0	-23.1
62.18	V	270.00	1.00	10.30	10.3	10.7	100.0	-19.4
82.79	V	170.00	1.16	10.10	10.2	10.3	100.0	-19.7
114.39	V	180.00	1.21	8.70	15.4	16.1	150.0	-19.4
133.48	V	180.00	1.31	5.60	14.8	10.5	150.0	-23.1
171.25	V	90.00	1.40	7.50	14.0	11.9	150.0	-22.0
184.69	V	270.00	1.85	6.90	13.7	10.7	150.0	-23.0
208.60	V	290.00	2.40	9.40	13.3	13.6	150.0	-20.8
235.90	V	300.00	2.51	7.80	13.6	11.8	200.0	-24.6
255.56	V	270.00	2.73	12.90	14.5	23.5	200.0	-18.6
275.25	V	180.00	2.38	8.70	16.5	18.2	200.0	-20.8
1000.00	V	90.00	2.17	46.94	-10.6	65.7	500.0	-17.6
53.19	H	0.00	3.84	6.30	7.9	5.1	100.0	-25.8
62.18	H	180.00	3.48	6.60	10.3	7.0	100.0	-23.1
85.82	H	10.00	3.53	5.80	10.0	6.2	100.0	-24.2
114.39	H	90.00	3.85	6.30	15.4	12.2	150.0	-21.8
171.25	H	180.00	3.27	11.50	14.0	18.8	150.0	-18.0
208.60	H	90.00	2.97	10.40	13.3	15.3	150.0	-19.8
235.90	H	190.00	1.59	9.80	13.6	14.9	200.0	-22.6
255.56	H	10.00	1.79	7.50	14.5	12.6	200.0	-24.0
275.25	H	0.00	1.31	6.50	16.5	14.2	200.0	-23.0
1000.00	H	190.00	3.00	46.92	-10.6	65.5	500.0	-17.7

No emissions noted above 1GHz

4.9 Transceiver Co-location Attestation

The 902-928 transceiver antenna (except for the 8dBi omni whip) may be located within 20cm of the Zigbee transceiver antenna, which is located on the same module. 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 30MHz to 25GHz verifying that all spurious 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