Washington Laboratories, Ltd.
www.wll.com
7560 Lindbergh Drive . Gaithersburg, MD 20879
301.216.1500 . info@wll.com

FCC Part 25 Test Report

For the

Orbcomm Inc.

OG2 MODULE
FCC ID: XGS-ORBCOG2BAM1

WLL REPORT# **13348-01 Rev 0**

April 15, 2014

Prepared for:

Orbcomm Inc.
22265 Pacific Blvd – Ste. 200
Sterling, VA, 20166-6801

Prepared By:
Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ACLASS ACCREDITED TESTING

Testing Certificate AT-1448

FCC Part 25 Test Report
For the
Orbcomm Inc.

OG2 MODULE
FCC ID: XGS-ORBCOG2BAM1

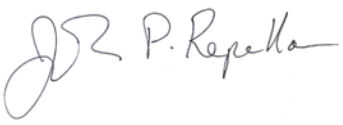
WLL REPORT# **13348-01 Rev 0**

April 15, 2014

Prepared by:

James Ritter
Compliance Engineer

Reviewed by:



John P. Repella
EMC & Wireless Lab Manager

Abstract

This report has been prepared on behalf of Orbcomm Inc. OG2 Module to support compliance of a Satellite Earth Station under Part 25 of the FCC Rules. This Part 25 Test Report documents the test configuration and test results for the Orbcomm Inc. OG2 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. Washington Laboratories, Ltd. has been accepted by the FCC and approved by the Washington Laboratories; Ltd. is accredited by ACLASS under Testing Certificate AT-1448 as an independent FCC test laboratory.

The Orbcomm Inc. OG2 module complies with the limits for a Satellite Earth Station device under FCC Part 25.

Revision History	Reason	Date
Rev 0	Initial Release	April 15, 2014

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The Orbcomm Inc. OG2 Module complies with the limits for a Satellite Earth Station device under FCC Part 25.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Deviations to the Standard

None

1.4 Contract Information

Customer:	Orbcomm Inc. 22265 Pacific Blvd – Ste. 200 Sterling, VA, 20166-6801
Purchase Order Number:	2890
Quotation Number:	67769

1.5 Test Dates

Testing was performed on the following date(s):	3/12/2014 to 4/2/2014

1.6 Test and Support Personnel

Washington Laboratories, LTD	James Ritter
Customer Representative	Dean Brickerd

1.7 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	**Decibel**
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 OG2 module is a Low Earth Orbiting Satellite Modem operating in the 148.025MHz – 150.025MHz Band at 2.4 kbps. The unit tested was a stand-alone transceiver module. The OG2 is DC powered and can be set to operate at 6-16 volts.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Orbcomm Inc.
Model:	OG2 module
FCC ID:	XGS-ORBCOG2BAM1
FCC Rule Parts:	§25
Frequency Range:	148.25-150.25 MHz
Maximum EIRP (in a 4 kHz BW) Conducted	8.34dBW at antenna port, 10.74dBW with 2.4dBi antenna
Modulation:	symmetric differential phase shift keying (SDPSK)
Occupied Bandwidth (20dB):	3.4kHz
Authorized Bandwidth	25kHz
Keying:	Automatic
Type of Information:	Data 2400 uplink bps, 4800 downlink bps
Power Output Level	Fixed
Antenna Connector	Ufl or smb
Antenna	External 2.4dBi gain ,1/4 wave whip
Power Source & Voltage:	12VDC +/-10% from host unit, regulated on module

2.2 Test Configuration

The OG2 module was soldered to a host test fixture circuit board. This test fixture board had a SMA antenna port, VDC input port, and two db9 connector ports for programming that provided the required interface to the module. The test fixture board was screwed to a plastic test fixture box. Test mode (200msec transmit, 3 seconds off). The SMA antenna port was connected to a spectrum analyzer through suitable attenuators for the measurements required for this testing.

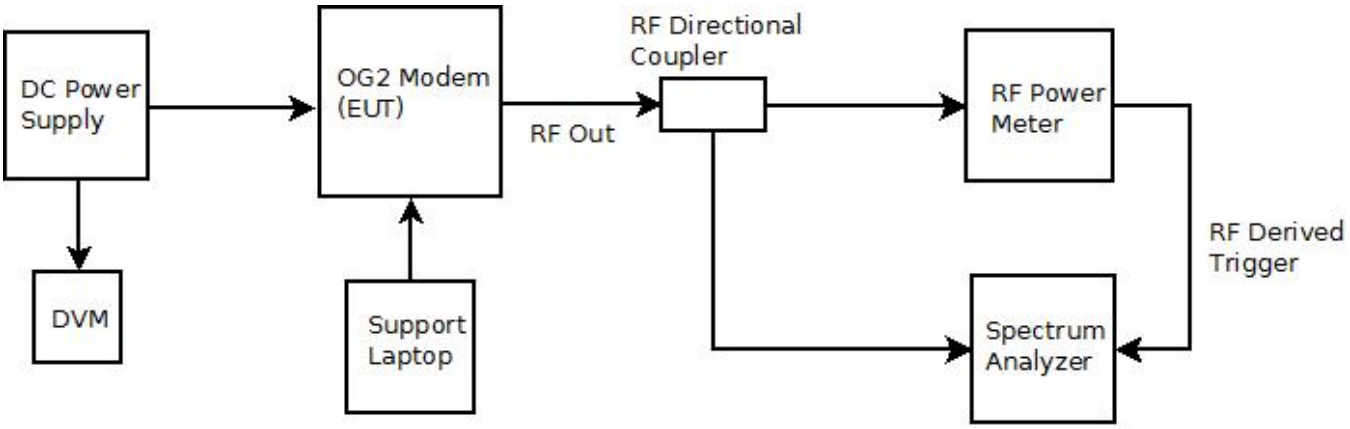


Figure 1: Test Setup Diagram

2.3 Testing Algorithm

The OG2 module was configured with a laptop computer connected through the RS232 data port. An external power supply provided DC power to the unit. A Client test program (EMS_Test) on the support laptop was used to program the EUT to operate on the test frequencies in a carrier on and carrier off mode. The carrier on mode consisted of transmit bursts of 200ms with a 3 second off time. The EUT was tested at maximum power and a maximum data rate. The EUT has the capability of transmitting on//.

- Low Channel 148.025MHz –limited testing (Power, Bandwidth)
- Center Channel 149MHz- full testing
- High Channel C: 150.025MHz- limited testing (Power, Bandwidth)

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 Testing Certificate AT-1448 as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

TIA-603-C Land Mobile FM or PM Communications Equipment Measurement and Performance Standard

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

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 (R2012) 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
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC	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

WLL Asset #	Manufacturer Model/Type	Function	Cal. Due
	Conducted Antenna Bench Measurements		
00528	AGILENT - E4446A	ANALYZER SPECTRUM	4/28/2014
00605	AGILENT HP - N1911A	POWER METER	4/30/2014
00728	AGILENT - 8564EC	SPECTRUM ANALYZER 30HZ - 40GHZ	5/22/2014
00152	WERLATONE - WERLATONE C5081	COUPLER DIRECTIONAL COUPLER	3/18/2015
00470	NARDA - 3222-16	COUPLER DIRECTIONAL 1 -18GHZ	10/10/2014
00606	AGILENT HP - N1921A	POWER SENSOR	4/30/2014
00641	HQ POWER - NONE	0-50V 5AMP DC SUPPLY	CNR
00773	FLUKE - 115	TRUE RMS MULTIMETER	2/6/2015
	Frequency Stability		
00776	TENNY - TJR-A-WS4	1.22 CUFT	1/20/2015
00117	RACAL DANA - 1992 -	COUNTER - FREQUENCY	2/7/2016
00641	HQ POWER - NONE	0-50V 5AMP DC SUPPLY	CNR
00773	FLUKE - 115	TRUE RMS MULTIMETER	2/6/2015
	Radiated Emissions		
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/17/2016
69	HP - 85650A	ADAPTER QP	1/9/2015
802	HP - 8568B	SPECTRUM ANALYZER	1/9/2015
71	HP - 85685A	PRESELECTOR RF	1/9/2015
528	AGILENT - E4446A	ANALYZER SPECTRUM	4/28/2014
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/13/2014
7	ARA - LPB-2520	ANTENNA BICONILOG ANTENNA	10/10/2014
477	HP - 8648C	GENERATOR RF SIGNAL	2/11/2015

4 Test Results

4.1 RF Power Output

4.1.1 Maximum Peak Power in any 4 kHz bandwidth

The power was measured conducted into a spectrum analyzer. The RBW was set to 3kHz (a correction of 10Log (4kHz/3kHz) =1.2 dB was added). Conducted output (not including 2.4dBi antenna gain) is shown below.

No maximum RF peak power limit exists for this band (148-150.05MHz) per Part 25.

Table 4: RF Peak Power Output per 4 kHz Bandwidth

Channel	Frequency (MHz)	Peak power/4kHz (dBm)	Peak power/4kHz (dBW)	Limit (dBW)	Pass/Fail
10	148.025	37.84	7.84	NA	Pass
400	149.000	38.34	8.34	NA	Pass
810	150.025	37.76	7.76	NA	Pass

Maximum EIRP with a 2.4dBi antenna= 10.74dBW

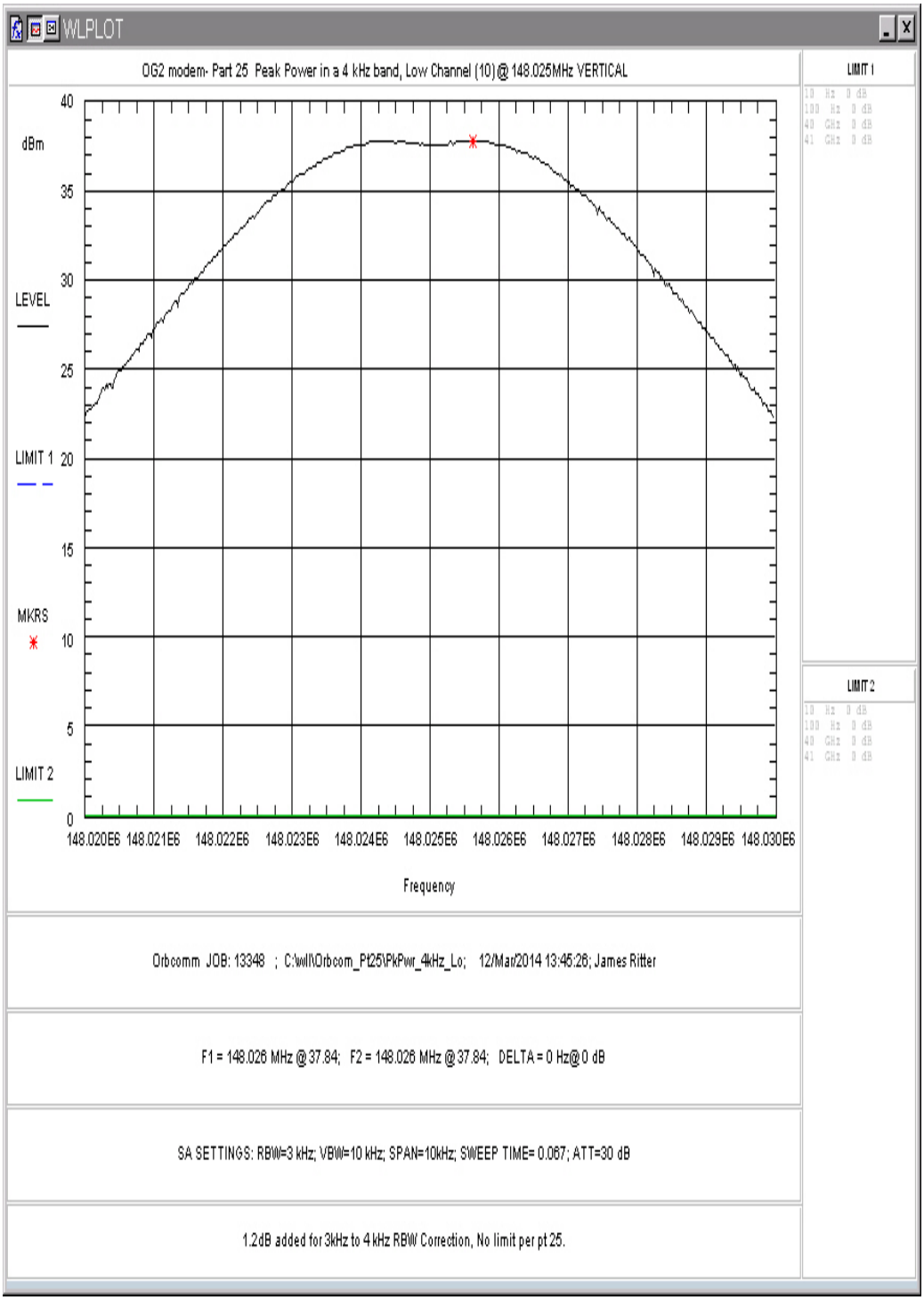


Figure 2: Peak Power in any 4 kHz: Low Channel @ 148.025MHz

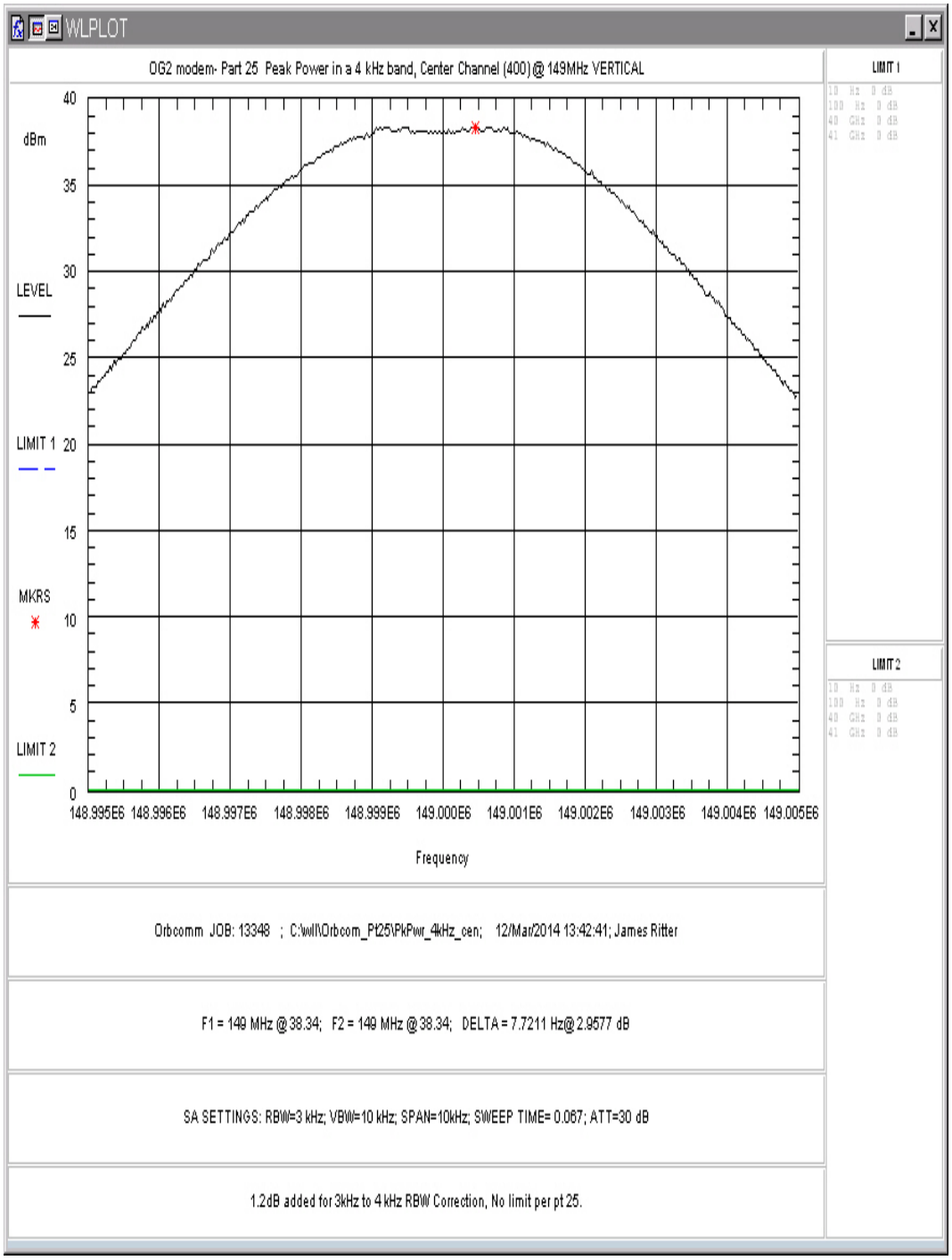


Figure 3: Peak Power in any 4 kHz: Center Channel @ 149MHz

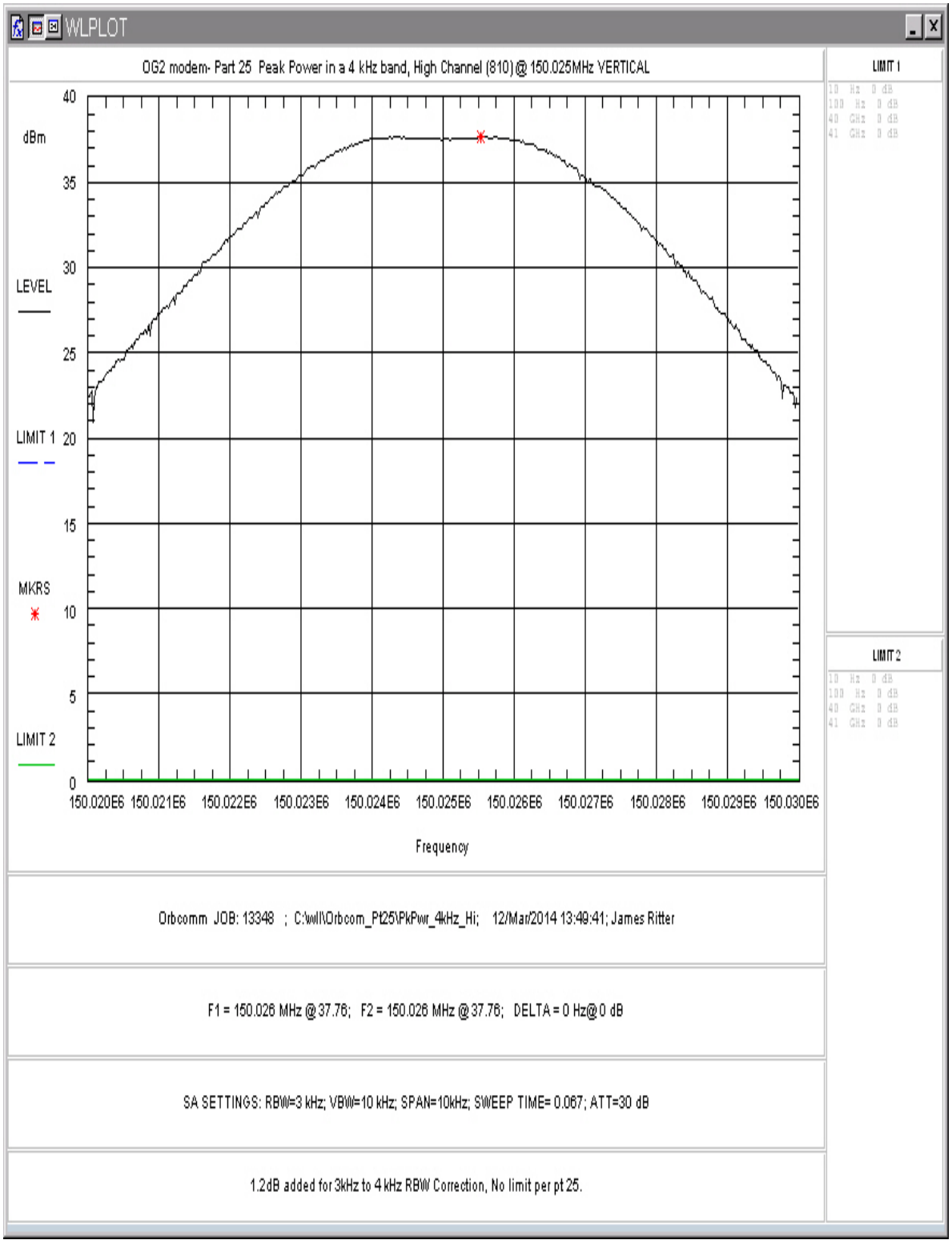


Figure 4: Peak Power in any 4 kHz: High Channel @ 150.025MHz

4.2 20dB Occupied Bandwidth

Occupied bandwidth (20dB) was performed by coupling the output of the EUT antenna port to the input of a spectrum analyzer.

Table 5: 20dB Occupied Bandwidth Results

Frequency (MHz)	Bandwidth (kHz)
148.025	3.298
149.000	3.362
150.025	3.404

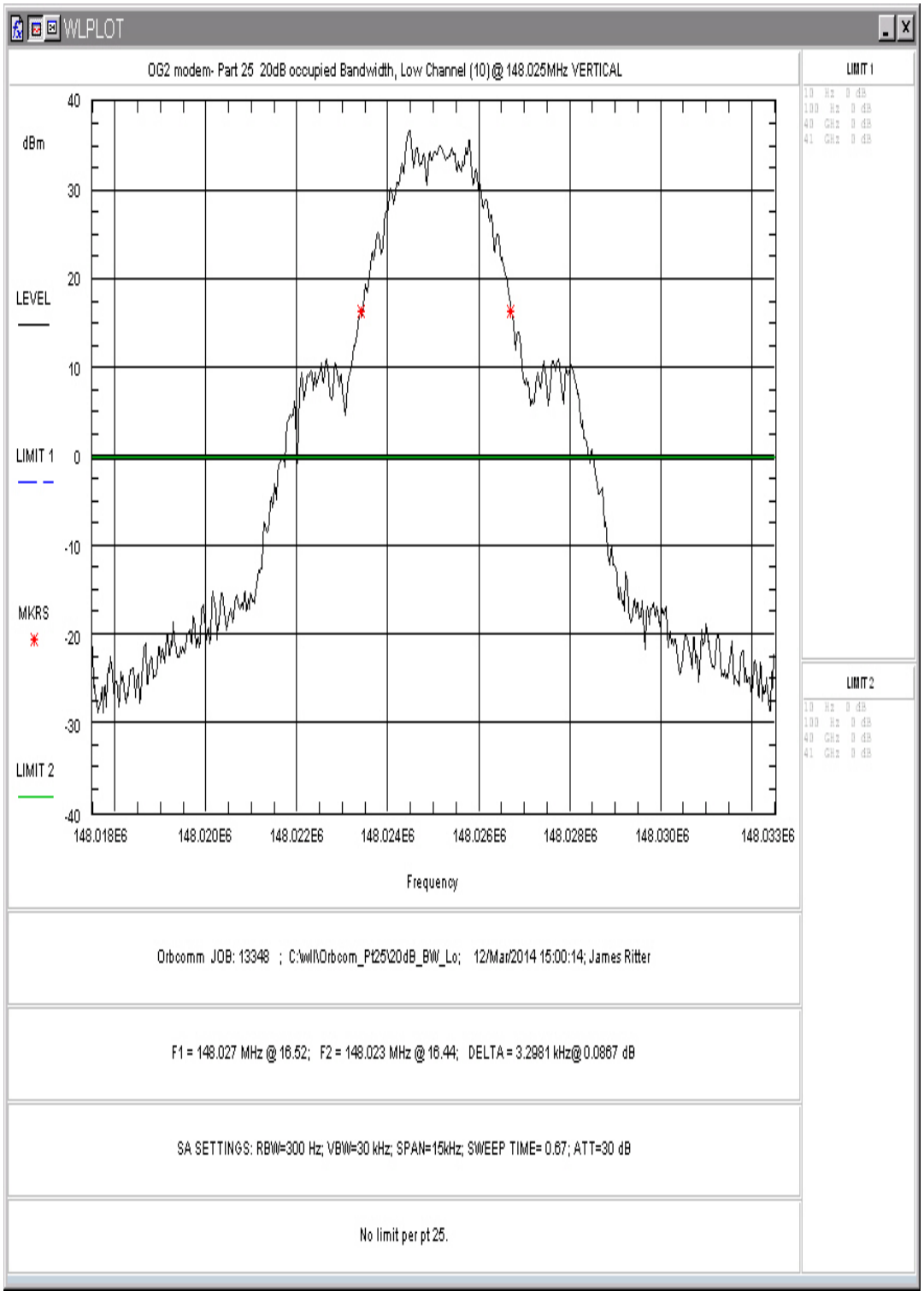


Figure 5: Occupied Bandwidth, Low Channel @ 148.025MHz

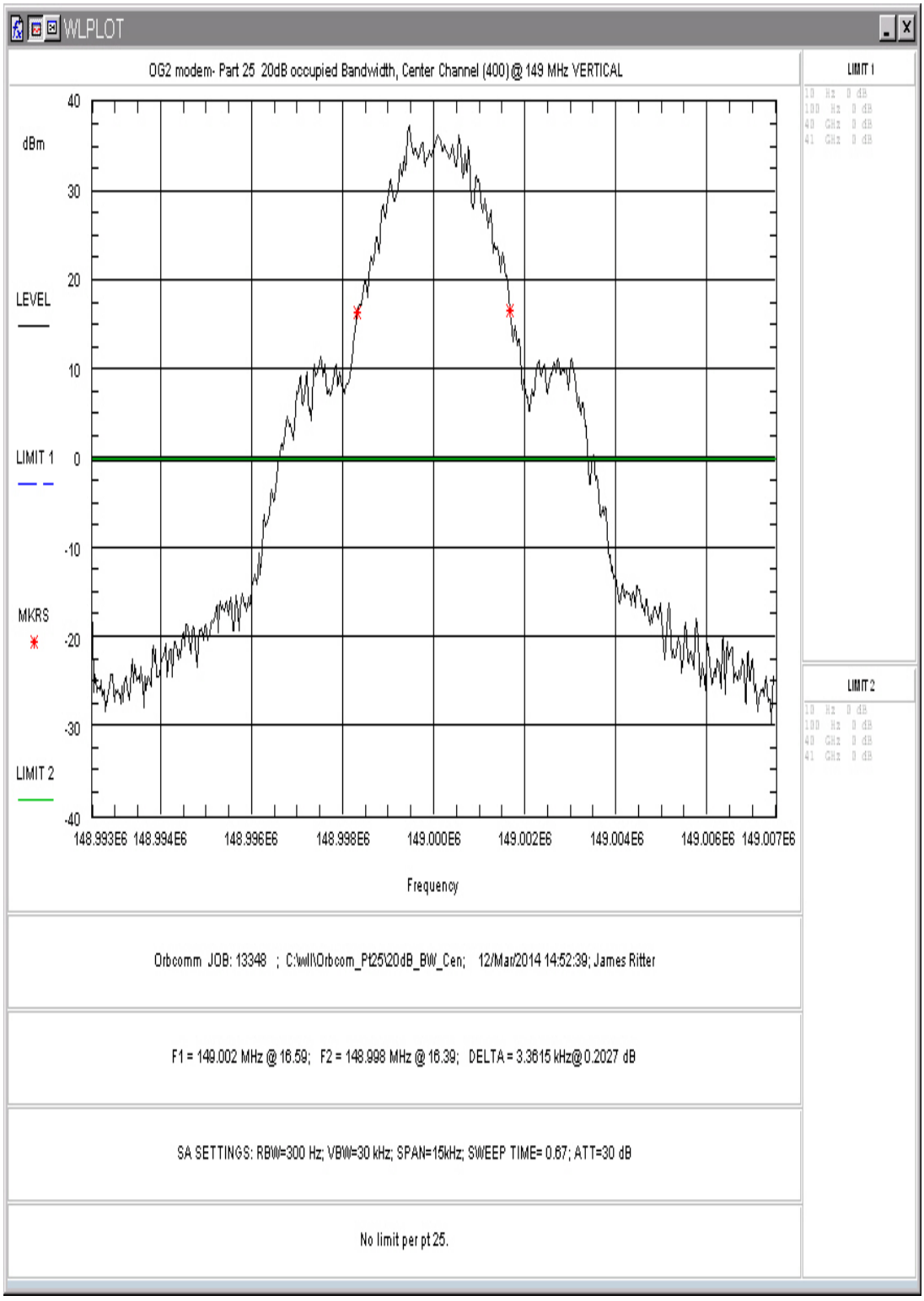


Figure 6: Occupied Bandwidth, Center Channel @ 149MHz

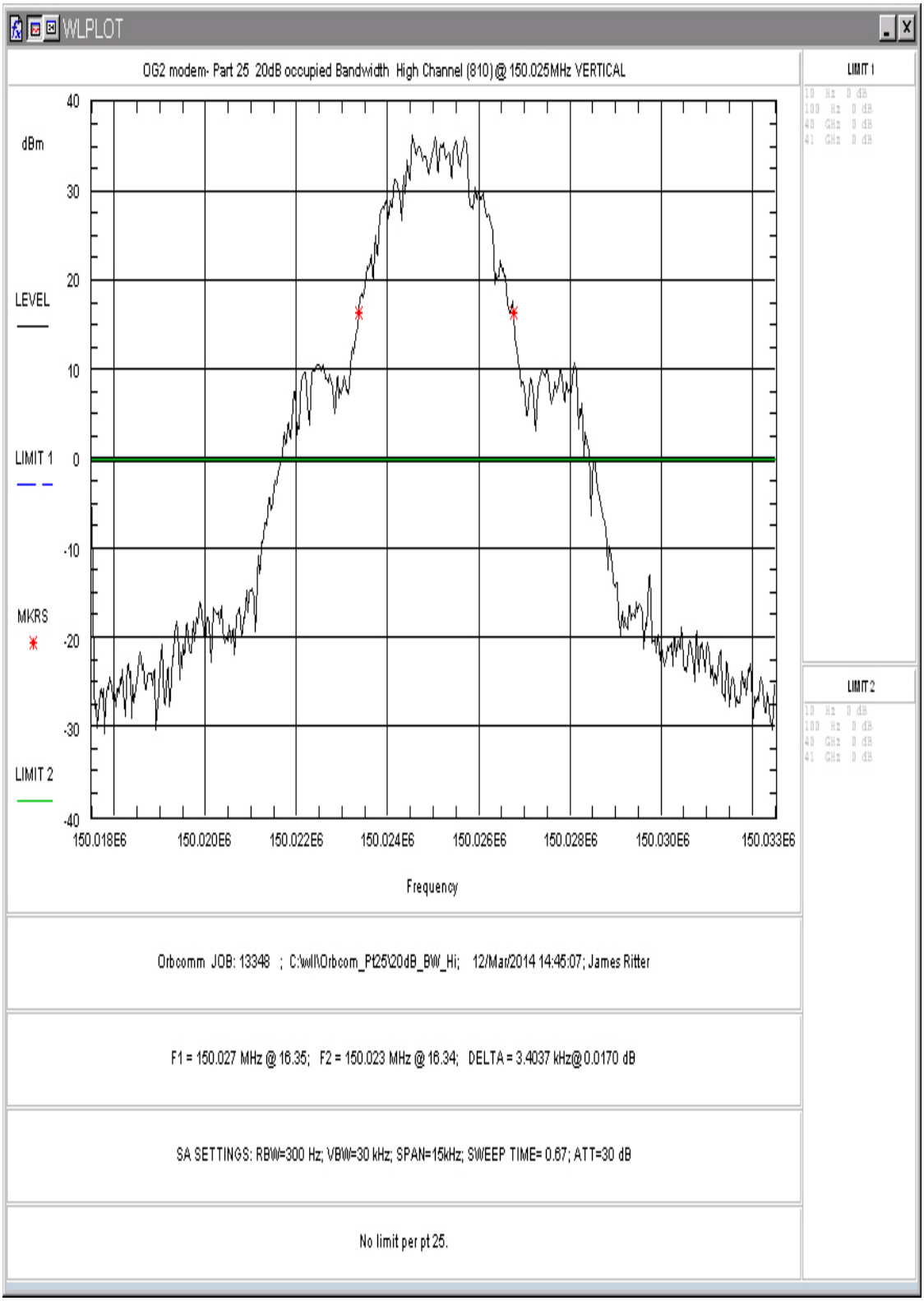


Figure 7: Occupied Bandwidth, High Channel @ 150.025MHz

4.3 Authorized Bandwidth

The authorized bandwidth was declared by the manufacturer as 25kHz. This value includes the necessary spectral components of the transmission signal.

4.4 Conducted Spurious Emission Limitations per FCC Part 25.202(f)

Spurious emissions must comply with the requirements of §25.202 (f) of FCC. The limits for the spurious emissions for FCC Part 25 are as follows:

FCC Part 25.202(f):

Spurious emissions must comply with the requirements of §25.202(f). The limits for the spurious emissions are as follows:

The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts.

4.4.1 Test Procedure

For the FCC Part 25 requirements the unit was set to transmit at 149.00MHz and the emissions were measured at the antenna port from 30MHz to the tenth Harmonic of the transmit frequency and compared to the emission mask specified in FCC Part 25.202(f). The authorized bandwidth used in the calculations for the limit was 25kHz. For signals located outside of 250 percent away from the authorized bandwidth a larger RBW (10kHz) was used as this would present a worst case reading, any signals in this range within 6dB of the limit was investigated at the 4kHz required bandwidth.

A correction of 1.2 dB was added to the in-band signal to correct for the use of a 3kHz RBW setting.

The use of a computer program appended multiple sweeps in order to present a larger sweep plot while keeping the spectrum analyzer number of points within the maximum limits (number of points * RBW).

Channel 400 @ 149MHz was investigated for compliance with this section.

4.4.2 Test Results

The EUT complies with the emissions mask requirements FCC Part 25.202(f). Figure 8 through Figure 12 show the plots of the emissions mask for FCC Part 25.202(f).

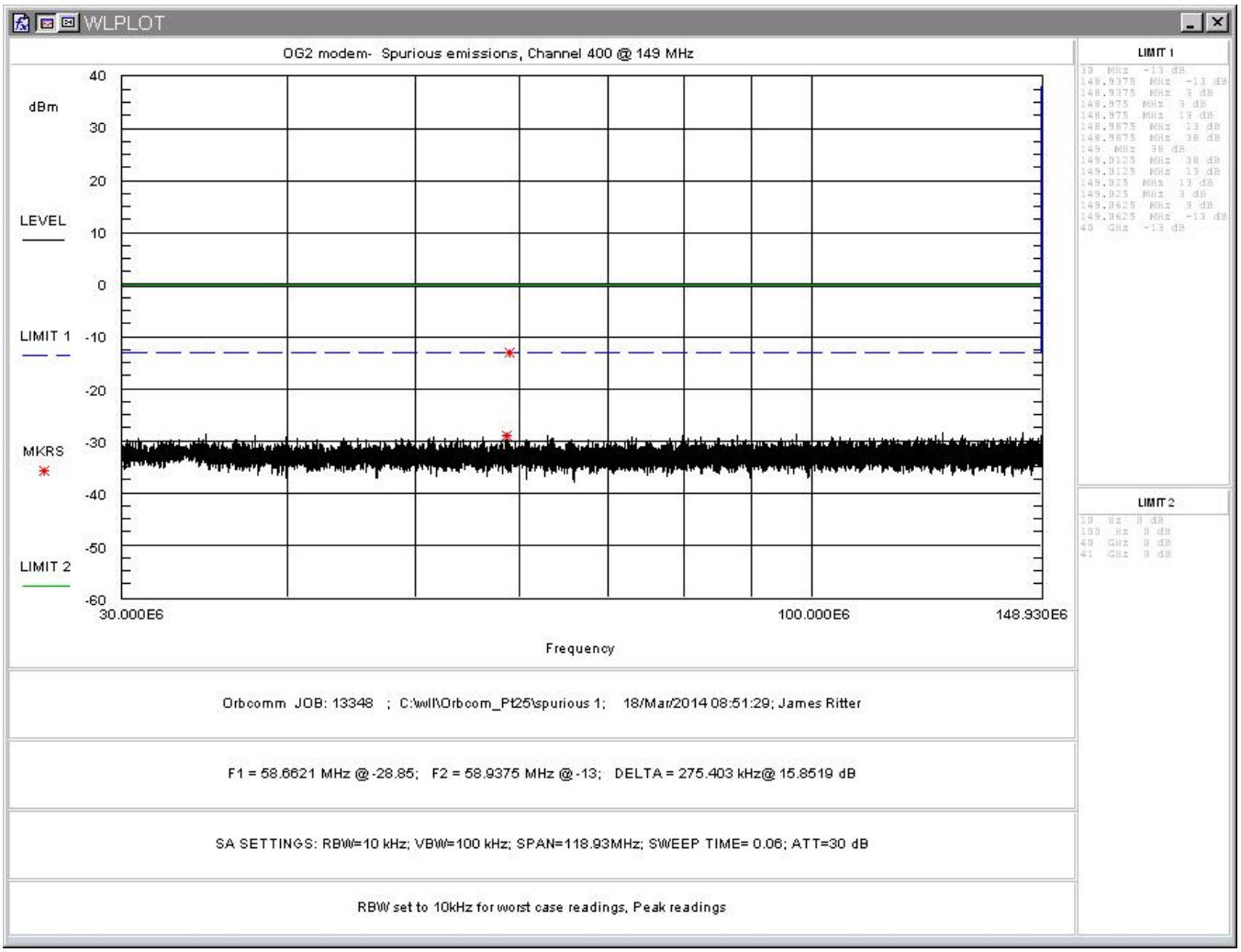


Figure 8: Conducted Spurious Emissions Data, 30MHz -148.93MHz

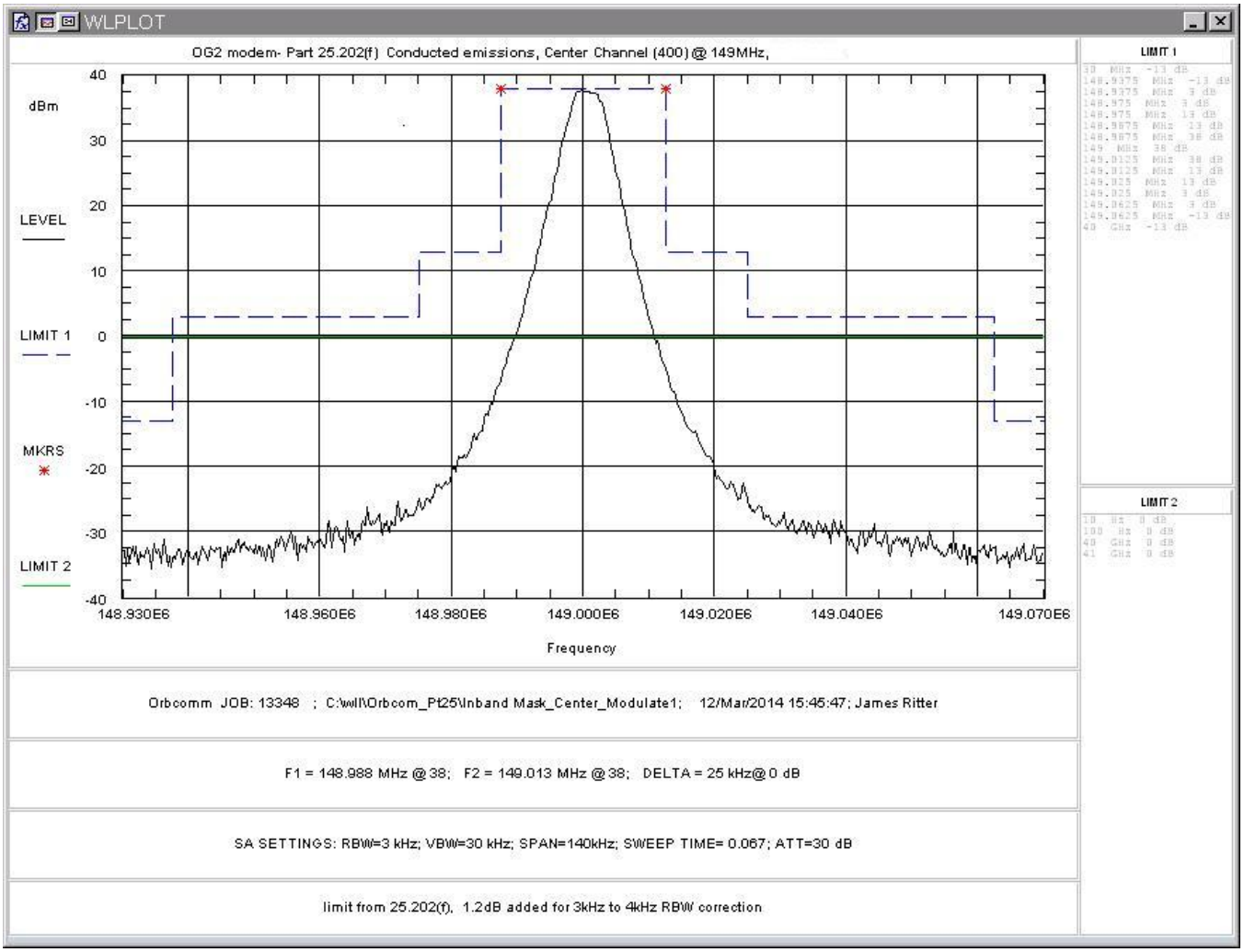


Figure 9: Conducted Spurious Emissions Data 148.93MHz -149.07MHz

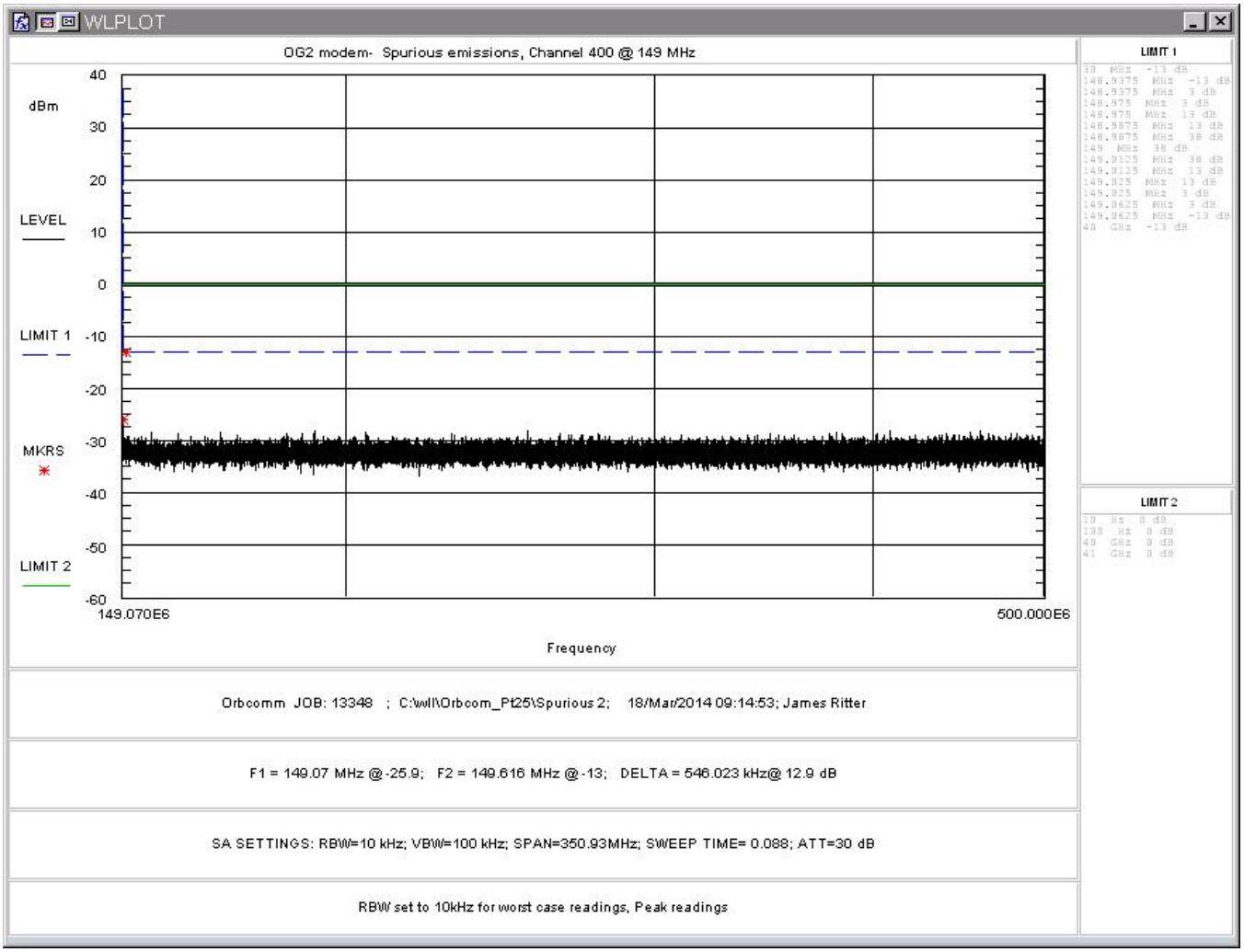


Figure 10: Conducted Spurious Emissions Data, 149.07MHz – 500MHz

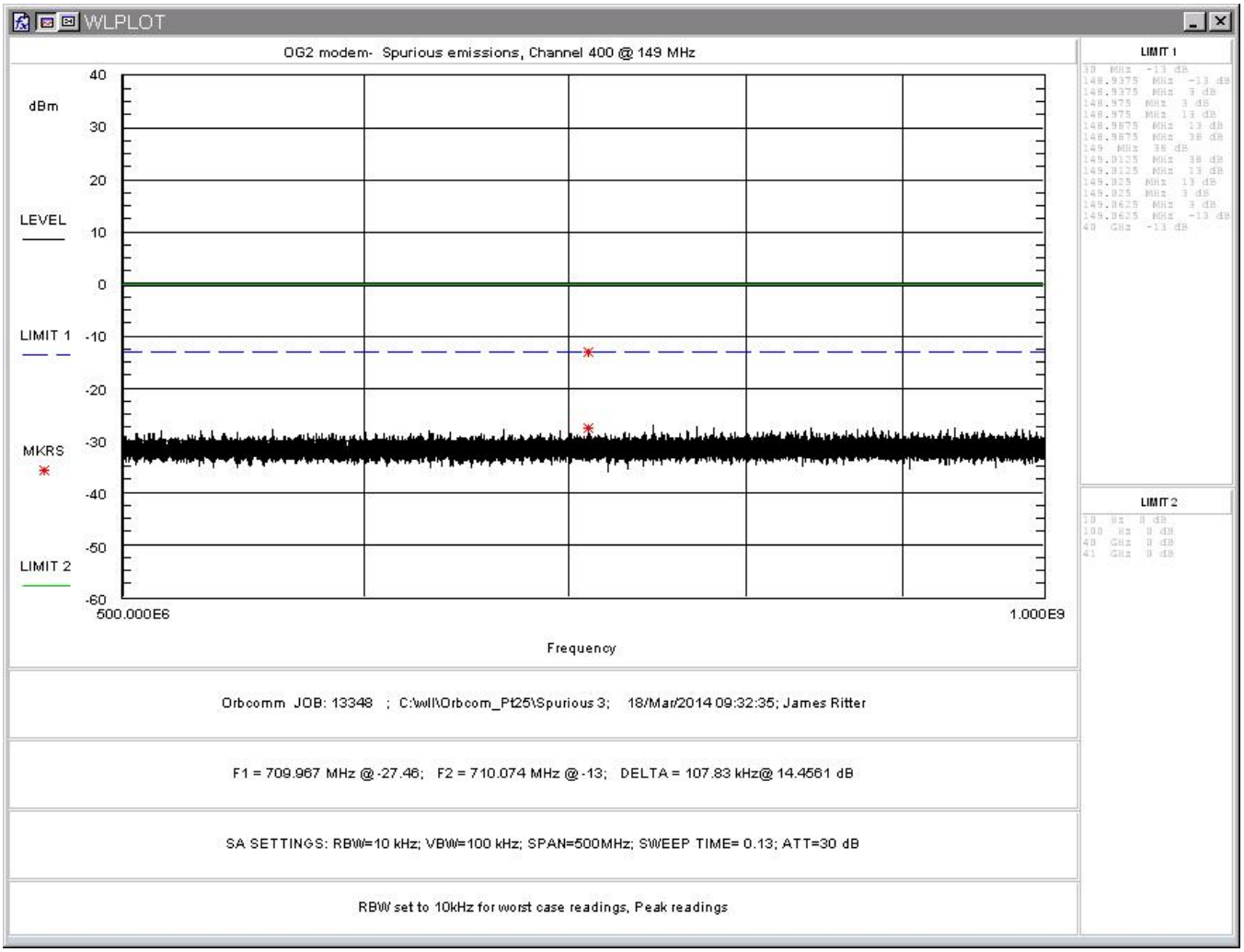


Figure 11: Conducted Spurious Emissions Data, 500MHz – 1000MHz

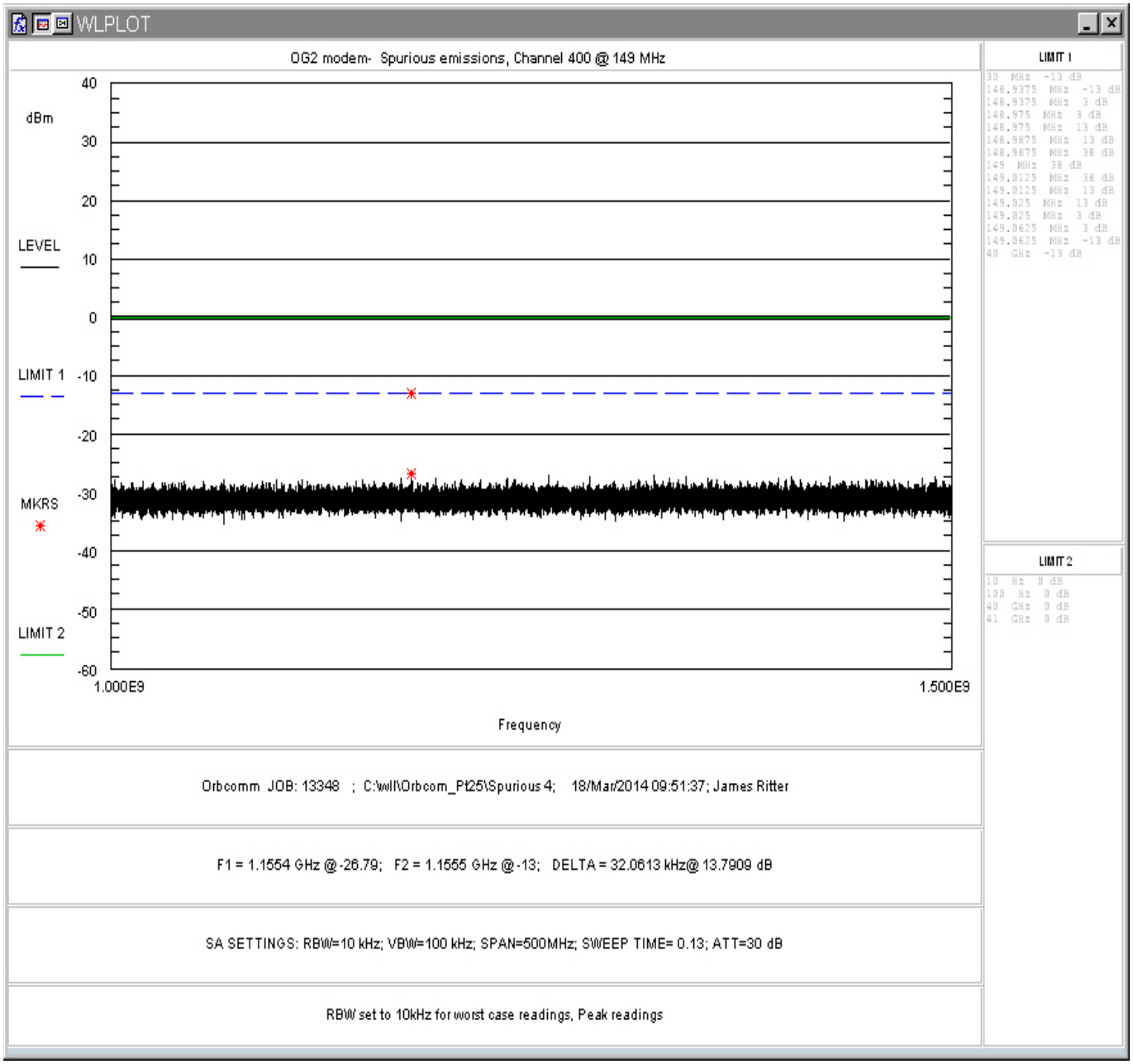


Figure 12: Conducted Spurious Emissions Data, 1GHz – 1.5GHz

4.5 Radiated Spurious Emissions: EIRP Data (FCC §25.202(f))

Case radiated spurious emissions must comply with the requirements of §25.202 (f) of FCC. The limits for the spurious emissions are as follows:

FCC Part 25.202(f):

Radiated spurious emissions must comply with the requirements of §25.202(f). The limits for the spurious emissions are as follows:

The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;

Based on the power measured, the limit for emissions removed from the center frequency by more than 250% of the authorized bandwidth will be:

$$\text{Limit (dBm)} = 21.13(\text{dBm}) - (43 + 10\text{Log}(.130\text{W})) = -13\text{dBm}$$

This section covers emissions detected at more than 250% removed from the authorized bandwidth.

4.5.1 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 EUT RF output port was terminated into a suitable termination. As the EUT is a module the unit was evaluated in 3 orthogonals to discover worst case emissions. The center channel (400) was set to transmit at 149MHz.

Where emissions were detected, the EIRP levels were determined using the method of signal substitution. The unit was verified in 3 orthogonals with the worst case displayed.

4.5.2 Test Results

The frequency range of 30 MHz to 1.49 GHz was measured and the data presented below. The EUT complied with this limit.

Table 6: Radiated Emissions

Chan 400

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
41.96	V	50.0	1.0	16.5	-52.3	-54.5	15.8	-13.1	-67.7	-13	-54.7
149.00	V	0.0	1.2	51.9	-27.9	-31.8	8.7	5.0	-26.8	NA	FUND
298.00	V	10.0	1.6	28.5	-53.4	-58.7	13.8	5.9	-52.9	-13	-39.9
447.00	V	100.0	1.6	27.0	-48.4	-55.1	16.1	7.1	-48.0	-13	-35.0
745.00	V	0.0	1.8	13.1	-55.8	-64.7	20.9	6.8	-57.9	-13	-44.9
894.00	V	0.0	1.8	17.0	-49.2	-59.0	21.7	7.6	-51.4	-13	-38.4
900.00	V	300.0	2.3	17.5	-47.8	-57.6	21.8	7.5	-50.1	-13	-37.1
993.29	V	350.0	1.3	14.1	-48.6	-59.0	23.3	6.8	-52.2	-13	-39.2
1043.00	V	200.0	2.7	59.1	-51.9	-54.1	24.8	5.7	-48.4	-13	-35.4
1192.00	V	190.0	2.4	66.3	-39.7	-42.1	25.6	6.1	-36.0	-13	-23.0
1341.00	V	190.0	2.7	62.2	-43.2	-45.4	25.6	7.2	-38.2	-13	-25.2
1490.00	V	180.0	2.6	50.1	-58.4	-60.6	25.4	8.2	-52.4	-13	-39.4
41.96	H	180.0	3.0	13.9	-49.7	-51.9	15.8	-13.1	-65.1	-13	-52.1
149.00	H	90.0	1.8	55.4	-28.3	-32.2	8.7	5.0	-27.2	NA	FUND
216.00	H	270.0	1.5	20.2	-59.6	-64.2	12.3	4.6	-59.7	-13	-46.7
298.00	H	220.0	1.3	36.6	-44.0	-49.3	13.8	5.9	-43.5	-13	-30.5
447.00	H	180.0	2.4	31.1	-43.5	-50.2	16.1	7.1	-43.1	-13	-30.1
745.00	H	190.0	2.4	11.6	-55.6	-64.5	20.9	6.8	-57.7	-13	-44.7
993.29	H	180.0	1.3	14.7	-45.0	-55.4	23.3	6.8	-48.6	-13	-35.6
1043.00	H	170.0	3.2	58.7	-48.8	-51.0	24.8	5.7	-45.3	-13	-32.3
1192.00	H	200.0	3.0	61.4	-46.2	-48.6	25.6	6.1	-42.5	-13	-29.5
1341.00	H	240.0	2.9	52.9	-50.5	-52.7	25.6	7.2	-45.5	-13	-32.5
1490.00	H	190.0	2.5	48.6	-58.3	-60.5	25.4	8.2	-52.3	-13	-39.3

4.6 Frequency Stability: (FCC Part §2.1055)

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances. Per §25.202(d) the frequency tolerance shall be maintained within 0.001% of the reference frequency.

Note: The OG2 Module is required to receive a nominal 12VDC from its host unit. The EUT has its own internal regulators.

4.6.1 Test Procedure

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 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.

In addition the DC voltage level (at ambient temperature) was varied to 85% and 115% of its nominal voltage.

The RF carrier frequency shall not depart from the reference frequency (reference frequency is the frequency at 20ºC and rated supply voltage) in excess of 0.001%.

The unit was tested on Channel 400 transmitting at 148MHz.

4.6.2 Test Results

The EUT complies with the temperature stability requirements of FCC §25.202 (d). Test results are given in Table 7.

Table 7: Frequency Stability Test Data

Limit: 0.001%

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	148.999250	0.0	0
-30	148.999148	-102.0	0.000068
-20	148.999143	-107.0	0.000072
-10	148.999151	-99.0	0.000066
0	148.999168	-82.0	0.000055
10	148.999211	-39.0	0.000026
20	148.999209	-41.0	0.000028
30	148.999215	-35.0	0.000023
40	148.999238	-12.0	0.000008
50	148.999249	-1.0	0.000001

Voltage (Volts)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Voltage (Volts)
Nominal (12VDC)	148.999248	0	0.0	12VDC
At 85% (10.2VDC)	148.999253	-5	0.000003	10.9VDC
At 115% (13.8VDC)	148.999258	-10	0.000007	13.8VDC