L.S. Compliance, Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012
262-375-4400 Fax: 262-375-4248

COMPLIANCE TESTING OF:

T-50 Repeater

PREPARED FOR:

RF Technologies
Mr. Mike Leigh
3125 North 126th Street
Brookfield, WI 53005

TEST REPORT NUMBER:

303402-TX

TEST DATE(S):

November 1ST through December 7th, 2003

All results of this report relate only to the items that were tested. This report is not to be reproduced, except in full, without written approval of L. S. Compliance, Inc.

Table of Contents

1. L. S. Compliance In Review

Brief Review of
L.S. Compliance
Accreditations and Listing's

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025 : 1999
with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: **1255.01**

Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: **90756**

Listing of 3 and 10 meter OATS based on Title 47CFR – Part 2.948
FCC Registration Number: **90757**

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-212 – Issue 1
File Number: **IC 3088-A**

On file, 3 and 10 Meter OATS based on RSS-212 – Issue 1
File Number: **IC 3088**

U. S. Conformity Assessment Body (CAB) Validation

Validated by the European Commission as a **U. S. Competent Body** operating under the U. S. /EU, Mutual Recognition Agreement (MRA) operating under the European Union Electromagnetic Compatibility –Council Directive 89/336/EEC, Article 10.2.
Date of Validation: **January 16, 2001**

Validated by the European Commission as a **U.S. Notified Body** operating under the U.S./EU, Mutual Recognition Agreement (MRA) operating under the European Union Telecommunication Equipment – Council Directive 99/5/EC, Annex V.

Date of Validation: **November 20, 2002**
Notified Body Identification Number: **1243**

2. A2LA Certificate of Accreditation

THE AMERICAN
ASSOCIATION
FOR LABORATORY
ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

L.S. COMPLIANCE, INC.
Cedarburg, WI

for technical competence in the field of

Electrical Testing

The accreditation covers the specific tests and types of tests listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratories" and any additional program requirements in the identified field of testing. Testing and calibration laboratories that comply with this International Standard also operate in accordance with ISO 9001 or ISO 9002 (1994).

Presented this 26th day of March 2003.

President
For the Accreditation Council
Certificate Number 1255.01
Valid to January 31, 2005

For tests or types of tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

3. A2LA Scope of Accreditation

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999

L.S. COMPLIANCE, INC.
W66 N220 Commerce Court
Cedarburg, WI 53012
James Blaha Phone: 262 375 4400

ELECTRICAL (EMC)

Valid to: January 31, 2005 Certificate Number: 1255-01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests:

Test	Test Method(s)
Emissions	
Conducted	
Continuous/Discontinuous	Code of Federal Regulations (CFR) 47, FCC Method Parts 15, 18 using ANSI C63.4; EN: 55011, 55022, 50081-1, 50081-2; CISPR: 11, 12, 14-1, 22; CNS 13438
Radiated	Code of Federal Regulations (CFR) 47, FCC Method Parts 15, 18 using ANSI C63.4; EN: 55011, 55022, 50081-1, 50081-2; CISPR: 11, 12, 14-1, 22; CNS 13438
Current Harmonics	IEC 61000-3-2; EN 61000-3-2
Voltage Fluctuations & Flicker	IEC 61000-3-3; EN 61000-3-3
Immunity	EN: 50082-1, 50082-2 EN 61000-6-2 CISPR: 14-2, 24
Conducted Immunity	
Fast Transients/Burst	IEC 61000-4-4; EN 61000-4-4
Surge	IEC: 61000-4-5; ENV 50142; EN 61000-4-5
RF Fields	IEC: 61000-4-6; ENV 50141; EN 61000-4-6
Voltage Dips/Interruptions	IEC 61000-4-11; EN 61000-4-11

Roxanne M. Robinson

(A2LA Cert. No. 1255-01) 05/13/03 Page 1 of 2

5301 Buckeystown Pike, Suite 350 • Frederick, MD 21704-8373 • Phone: 301-644 3248 • Fax: 301-662 2974

4. Validation Letter – U.S. Competent Body for EMC Directive 89/336/EEC

NIST CENTENNIAL 1901-2001

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

January 16, 2001

Mr. James J. Blaha
L.S. Compliance Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012-2636

Dear Mr. Blaha:

I am pleased to inform you that the European Commission has validated your organization's nomination as a U.S. Conformity Assessment Body (CAB) for the following checked (✓) sectoral annex(es) of the U.S.-EU Mutual Recognition Agreement (MRA).

(✓) Electromagnetic Compatibility-Council Directive 89/336/EEC, Article 10(2)
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III and IV
Identification Number:
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex V
Identification Number:

This validation is only for the location noted in the address block, unless otherwise indicated below.

(✓) Only the facility noted in the address block above has been approved.
( ) Additional EMC facilities:
( ) Additional R&TTE facilities:

Please note that an organization's validations for various sectors of the MRA are listed on our web site at http://ts.nist.gov/mra. You may now participate in the conformity assessment activities for the operational period of the MRA as described in the relevant sectoral annex or annexes of the U.S.-EU MRA document.

NIST will continue to work with you throughout the operational period. All CABs validated for the operational phase of the Agreement must sign and return the enclosed CAB declaration form, which states that each CAB is responsible for notifying NIST of any relevant changes such as accreditation status, liability insurance, and key staff involved with projects under the MRA. Please be sure that you fully understand the terms under which you are obligated to operate as a condition of designation as a CAB. As a designating authority, NIST is responsible for monitoring CAB performance to ensure continued competence under the terms of the MRA.

NIST

5. Signature Page

Prepared By:		**March 31, 2004**
	Teresa A. White, Document Coordinator	**Date**
Tested By:		**March 31, 2004**
	Abtin Spantman, EMC Engineer	**Date**
Approved By:		**March 31, 2004**
	Kenneth L. Boston, EMC Lab Manager **PE #31926 Licensed Professional Engineer** **Registered in the State of Wisconsin, United States**	**Date**

6. Product and General Information

Manufacturer:	RF Technologies
Model No.:	T-50 Tag
Serial No.:	S/N:02=continuous operation, S/N:06=normal operation
Description:	2.4 GHz to 5.7 GHz Upconverter-Repeater

7. Product Description

The RF Technologies, Inc. PinPoint™ asset tag is a 5.8 GHz identification tag that can be read by a PinPoint Cell Controller at distances up to a maximum range of 400 feet with an accuracy of +-10 feet.

Each tag has been programmed at the factory with a permanent 32-bit serial number allowing over 4 billion different tag ID's. The tag has a sealed battery and is expected to operate for over 3 years. The tag reports low battery when approximately 10% of the batteries life is remaining. The system can report the location of the tags that need to be replaced due to low batteries. The tag incorporates a tamper mechanism that signals users when someone has attempted to remove the tag from an asset. Several mounting options are available for attaching the tag to assets and personnel. The tag is 1.9" x 1.38" x .7". Parameters of the tag such as motion detection, chirp rates, and tamper detection can be programmed in the field allowing flexibility of existing tags.

PinPoint is the world's first Real Time Location System (RTLS). The system allows end-users the ability to locate, track, and secure their inventory or valuable assets. The hardware system uses Cell Controllers to continually track PinPoint's tags in real time. Using high –frequency radio signals, PinPoint can read tags at long distances (no line of sight is required) and track their movement within a facility or around its perimeter.

The entire system seamlessly connects to existing LAN architecture, and the Tags and Antennas do not interfere with existing radio systems. The Cell Controllers use standard chips and the Linux operating system and software is Windows based to support a wide variety of client systems.

The RF Technologies, Inc. PinPoint Cell Controller Antennas utilize high-frequency radio signals to communicate with PinPoint electronic Tags. The Antennas are connected to Cell Controllers. Cell Controllers provide power and signal to the antennae. Each Cell Controller can control up to 16 Antennas, which are used in sequence by the Cell Controller to send signals to tags and receive their responses. The Cell Controller sends a 2.4 GHz signal via the Antennas to all Tags in its coverage area. The Tags, via the Antennas, return a 5.8 GHz signal to the Cell Controllers. The return signal includes the Tag's serial number and other information. The Cell Controller can calculate the distance between the Tag and each Antenna by measuring the delay between the transmission of the 2.4 GHz signal and the reception of the 5.8 GHz signal. Working with Tag-Antenna-Distance data from several Antennas, the system can triangulate the location of a Tag. The Cell Controller Antennas are connected to the Cell Controllers through Coaxial Cables of various preset lengths. The Cell Controller rapidly cycles among its Antennas, and identifies all tags that are in radio range.

8. Test Requirements

The tests were performed in order to determine the compliance of the RF Technologies' T-50 Tag with limits contained in various provisions of Title 47 CFR, FCC Part 15, including 15.35, 15.109, 15.205, 15.207, and 15.249.

All radiated emissions tests were performed to measure the emissions in the frequency bands described by the above sections, and to determine whether said emissions are below the limits established by the above sections. These tests were performed in accordance with the procedure described in the American National Standard for methods of measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2001). Another document used as reference for the EMI receiver specification was the International Special Committee on Radio Interference CISPR 16-1 (2002). Measurement technique guidelines found in Appendix C to FCC 97-114 were also consulted.

The testing was performed in two parts. The first part of the testing covered the range of 30-18,000 MHz, and was performed at L.S. Compliance, Incorporated, with results contained in this report. The second part of the testing covered the range of 18,000-40,000 MHz, and was performed at Curtis-Straus, LLC, with results presented in report number ED0777-1, as presented by Curtis-Straus. The declaration of conformity is based on the findings of both reports.

9. DECLARATION OF CONFORMITY

The RF Technologies' T-50 Tag was found to **MEET** the requirements as described within the specification of Title 47 CFR FCC, Part 15.249, for a frequency modulated transmitter.

10. Introduction

Between November 1st and December 7th, 2003, a series of Radiated Emission tests were performed on the RF Technologies' T-50 Tag, here forth referred to as the "*Equipment Under Test*" or "*EUT*". Two units were tested, unit with serial number: 02 was prepared for continuous transmit operation, and unit with serial number: 06 was prepared for normal operation. These tests were performed using the procedures outlined in ANSI C63.4-2001 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.249 for an intentional radiator. These tests were performed by Abtin Spantman, EMC Engineer at L.S. Compliance, Incorporated.

11. Purpose

All Radiated and Conducted Emission tests upon the EUT were performed to measure the emissions in the frequency bands described in Title 47 CFR, FCC Part 15, including 15.35, 15.207, and 15.249 to determine whether these emissions are below the limits expressed within the standards. These tests were performed in accordance with the procedure described in the American National Standard for methods of measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2001). Another document used as a reference for the EMI Receiver specification was the Comite International Special Des Perturbations Radioelelectriques CISPR 16-1, 2002

12. Radiated Emissions Test

Test Setup

The test setup was assembled in accordance with Title 47, CRF FCC Part 15 and ANSI C63.4-2001. The EUT was placed on an 80cm high non-conductive pedestal centered on a flush mounted 2-meter diameter turntable inside the 3 Meter Semi-Anechoic, FCC listed Chamber located at L. S. Compliance, Inc., Cedarburg, Wisconsin. The EUT was operated in continuous transmit mode.

The EUT normally operates on a single 3.5 VDC, 750 mAH, Lithium battery, type 'LTC-7PN-S2', internally mounted, with contact-point ports for providing external power to the EUT. The EUT was investigated with the battery, and tested with a bench type power supply during the final testing because of the current demand during the continuous transmit operation.

The EUT converts incoming signals between 2400-2483.5 MHz into repeat transmissions in the 5725-5875 MHz band. In order to achieve this, an RF generator was operated at the lower 2400-2483.5 MHz to provide the reference input signal, while the measurements were made at all other frequencies. The EUT is responsive to any transmission in the 2400-2483.5 MHz band, and not limited to particular frequencies, therefore the test was performed at the band edges as well as throughout the band with a swept frequency reference generator.

The reference generator power level was set to 1 dB below the compression point of the EUT. The EUT compression point was determined empirically during the initial investigation of the EUT. The applicable radiated emission limits apply at a 3-meter measurement distance. Measurements above 6 GHz were performed at a 1-meter measurement distance. The calculations to determine the 3-meter limits are detailed in the following pages. Please refer to Appendix A for a list of the test equipment.

Test Procedure

Radiated Emission measurements were performed on the EUT in the 3 Meter Semi-Anechoic, FCC listed Chamber, located at L. S. Compliance, Inc. in Cedarburg, Wisconsin. The frequency range from 30 MHz to 18,000 MHz was scanned, and levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 Meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters separation from the test object during tests below 6 GHz, and at 1 meter separation during tests above 6 GHz. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double Ridged Wave-guide Horn Antenna was used from 1 GHz to 18 GHz. The maximum radiated emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities.

Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an N.I.S.T. traceable site. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and a HP 8546A EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the HP 8546A EMI Receiver database. As a result, the data taken from the HP 8546A EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The HP 8546A EMI Receiver was operated with a bandwidth of 120 kHz for measurements below 1 GHz, and a bandwidth of 1 MHz for measurements above 1 GHz. Both the Peak and Quasi-Peak Detector functions were utilized. From 6 GHz to 18 GHz, an Agilent E4407B Spectrum Analyzer was utilized along with the appropriate horn antenna.

CALCULATION OF RADIATED EMISSIONS LIMITS:

Field Strength of Fundamental Frequencies:

The fundamental emissions for an intentional radiator in the 5725-5875 MHz band, operating under FCC part 15.249 limits, must have a field strength no greater than 50 mV/m at 3 meters, and a harmonic field strength no greater than 500 μV/m at 3 meters. Spurious emissions outside the 5725-5875 MHz band shall be attenuated by at least 50 dB below the level of the fundamental, or meet the limits expressed in FCC part 15.209 under general emission limits.

Field Strength of Fundamental Frequencies is Limited to 50,000 μV/m, or 94 dBμV/m.

Field Strength of Harmonic and Spurious Frequencies is Limited by FCC 15.249(c)

The harmonic limit of –50 dBc with respect to the fundamental limit would be:

94 dBμV/m – 50 dB = 44 dBμV/m,

with the exception of where FCC 15.209 allows for a higher limit to be used.

Frequency (MHz)	3 m Limit (μV/m)	3 m Limit (dBμV/m)
5725-5875	50,000	94.0
30-88 ; 88-216	159	44.0
216-902 ; 928-960	500	46.0*
960-40,000	500	54.0*

The following table depicts the general radiated emission limits obtained from Title 47 CFR, part 15.209a, for radiated emissions measurements, including restricted band limits as expressed in 47 CFR, part 15.205.

Frequency (MHz)	3 m Limit (μV/m)	3 m Limit (dBμV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-40,000	500	54.0

Sample conversion from field strength μV/m to dBμV/m:

dBμV/m = 20 $\log_{10}$ (3m limit)

from 30 - 88 MHz for example: dBμV/m = 20 $\log_{10}$ (100)

40.0 dBμV/m = 20 $\log_{10}$ (100)

For measurements made at 1 meter, a 9.5 dB correction may be been invoked.

960 MHz to 40,000 MHz

500 μV/m or 54.0 dBμV/m at 3 meters

54.0 + 9.5 = 63.5 dBμV/m at 1 meter

Note: Limits are conservatively rounded to the nearest tenth of a whole number.

Summary of Results and Conclusions

Based on the procedures outlined in this report, and the test results, it can be determined that the EUT does **MEET** the emission requirements of Title 47 CFR, FCC Part 15.249, for a frequency modulated transmitter.

The enclosed test results pertain to the samples of the test item listed, and only for the tests performed per the data sheets. Any subsequent modification or changes to the test items could invalidate the data contained herein, and could therefore invalidate the findings of this report.

Justification for Duty Cycle Relaxation Allowance

A limit relaxation of 20 dB is envoked for this product based on the duty cycling of the device. The justification is presented here in brief, and can be found an appendix B in detail.

The tag spends most of its time in the idle state. During a 'chirp' interval when the tag "wakes up", it powers up the RF chip (ASIC), and applies the datagram modulation to the RF chip for a return transmission to the cell controller. The Tag builds the datagram packet while waiting for the RF chip to 'stabilize'.
After the datagram is sent, the Tag checks a number of status points and then finally returns to the "idle mode".

The Tag Datagram consists of 9 contiguous sections. The sections are the tag preamble, synchronization interval, the start sequence, the datagram version identifier, the tag serial number, the status bits, the tag data, the checksum and end bit. This datagram is sent once during the tag RF-on cycle. Each individual datagram bit spans 6 (pn) sequence lengths, and is ***ideally 19.05 μs*** in duration.

Each datagram bit is approximately 19 μsec, and the entire datagram, including preamble, is 127 bits. Therefore, ***the worst-case transmission length would be 2.42 ms out of ANY 100ms window in time***. Datagram bits are encoded using BPSK (binary-phase shift keying), so the bit phase changes for each '0' bit, and remains unchanged for a '1' bit.

The Duty Cycle Relaxation allowance would be calculated to be:

$$\text{Relaxation Factor Calculation} = 20 \times Log_{10}\left(\frac{2.42ms}{100ms}\right) = -32.3dB$$

Maximum Relaxation Factor Allowance = 20 dB

Measurement of Electromagnetic Radiated Emissions
Within the 3 Meter FCC Listed Chamber

Manufacturer: RF Technologies
Model No.: T-50
Serial No.: S/N:02=continuous operation, S/N:06=normal operation
Date of Test: November 1ST through December 7TH, 2003

Test Requirements: 15.249 and 15.205

Distance: 3 meter (f<6 GHz), 1 meter (F>6 GHz)	**Frequency Range** Inspected: 30 to 18,000 MHz
Configuration: Continuous Transmit	

Test Equipment Used:

Receiver: HP 8546A (Below 6 GHz),				Biconical Antenna: EMCO 93110B	
Receiver: Agilent E4407B (Above 6 GHz)				Log Periodic Antenna: EMCO 43146A	
Double-Ridged Wave Guide/Horn Antenna: EMCO 3115				Pyramidal Horn Antenna: EMCO 3160	
Detector(s) Used:	√	Peak	√	Quasi-Peak (f<1 GHz)	√ Average (f>1 GHz)

The following table depicts the level of significant radiated *Fundamental Emissions* measured at 3 meters distance from the EUT.
A Relaxation Factor of 20 dB is invoked in the corrected reading, based on the Duty Cycle of the transmissions.

Freq. of Fund. Emission (MHz)	Freq. Of Ref. Input (MHz)	Antenna Polarity	Antenna Height (m)	Azimuth (0^o 360^o)	EMI Meter Reading (dBuV/m)	Reading Corrected for Relaxation (dB)	15.249 Limit (dBuV/m)	Margin (dB)
5738	2380	V	1.65	0	61.0	41.0	54.0	13.0
5758	2400	V	1.65	0	82.8	62.8	94.0	31.2
5778	2420	V	1.65	0	82.7	62.7	94.0	31.3
5798	2440	V	1.65	0	83.5	63.5	94.0	30.5
5818	2460	V	1.65	0	82.3	62.3	94.0	31.7
5838	2480	V	1.65	0	84.1	64.1	94.0	29.9
5851	2493	V	1.65	0	63.2	43.2	94.0	50.8

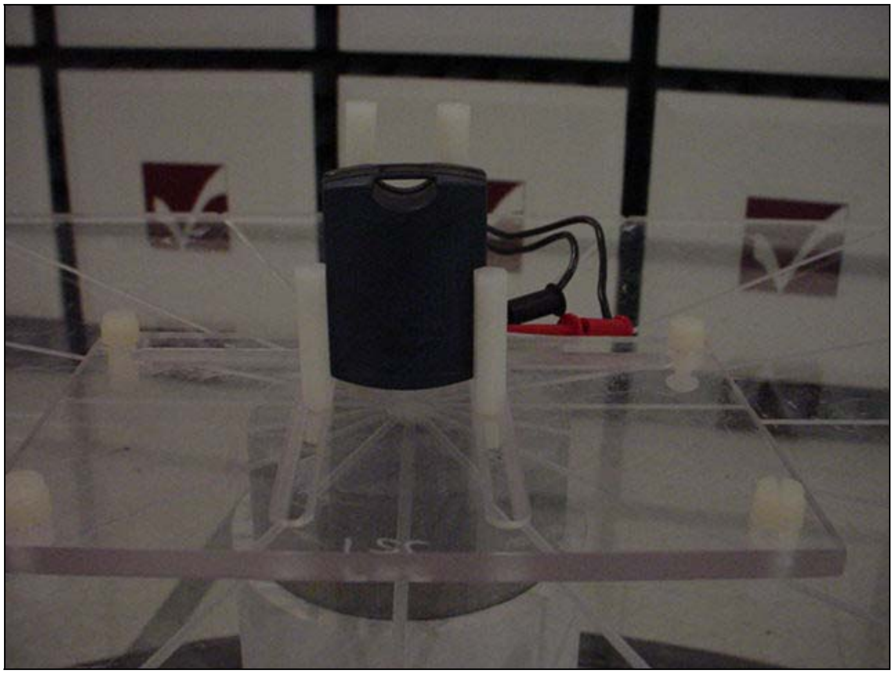
The following table depicts the level of significant radiated *Spurious Emissions* , measured at 1 meter distance from the EUT if above 6 GHz..
A Relaxation Factor of 20 dB is invoked in the corrected reading, based on the Duty Cycle of the transmissions.

Frequency (MHz)	Antenna Polarity	Antenna Height (m)	Azimuth (0^o 360^o)	EMI Meter Reading (dBuV/m)	Reading Corrected for Relaxation (dB)	15.249 Limit (dBuV/m)	Margin (dB)
6720	V	1.00	15	76.9	56.9	63.2	6.3

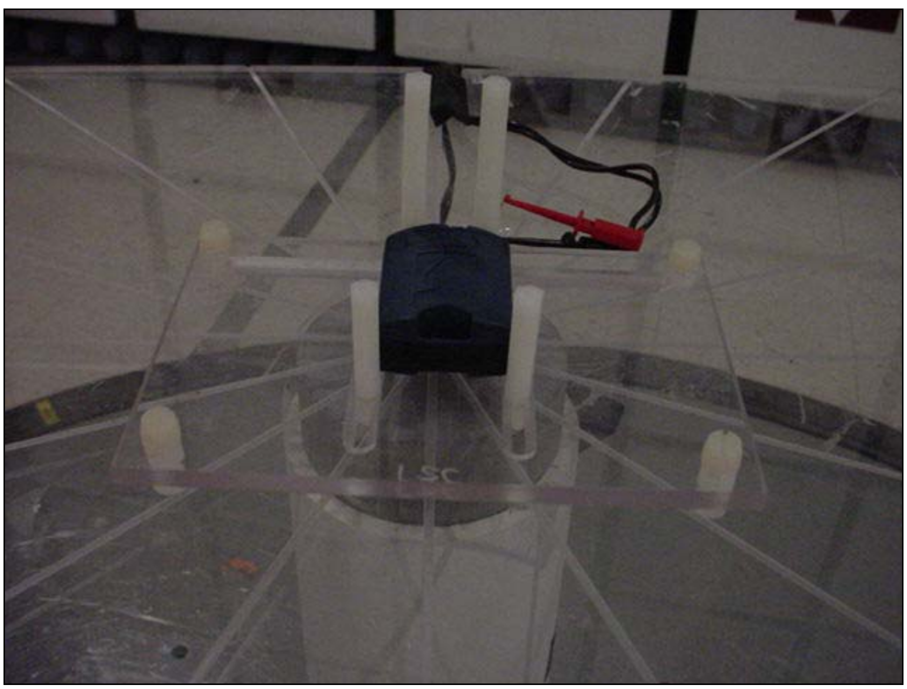
Notes:

1) All other emissions seen, other than noise floor, were greater than 20 dB below the limit.
2) All peak emissions seen were greater than 20 dB below the 74 dBμV/m limit, above 1 GHz.

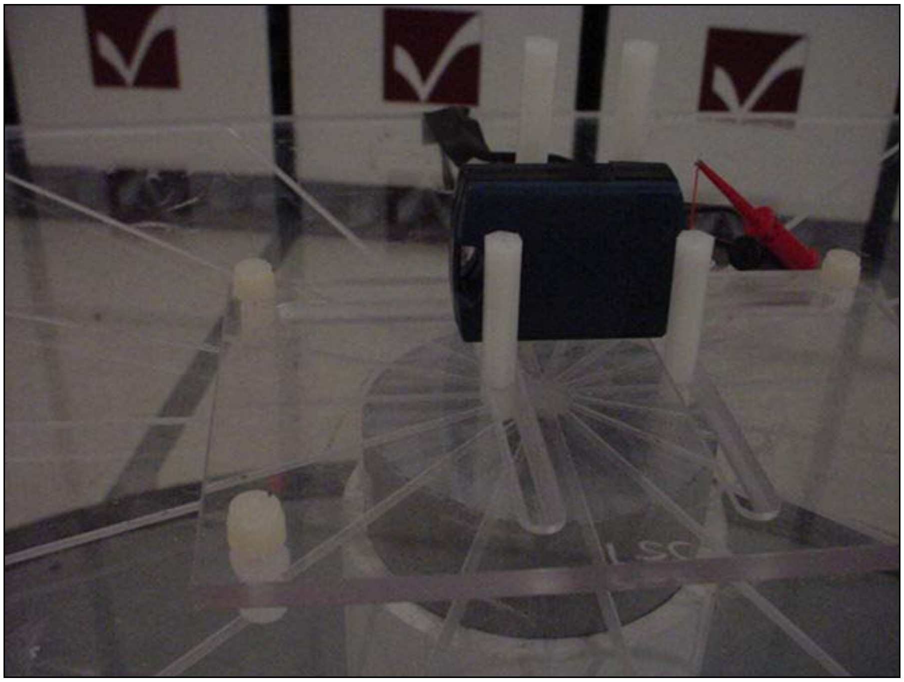
Photos Taken During Radiated Emission Testing



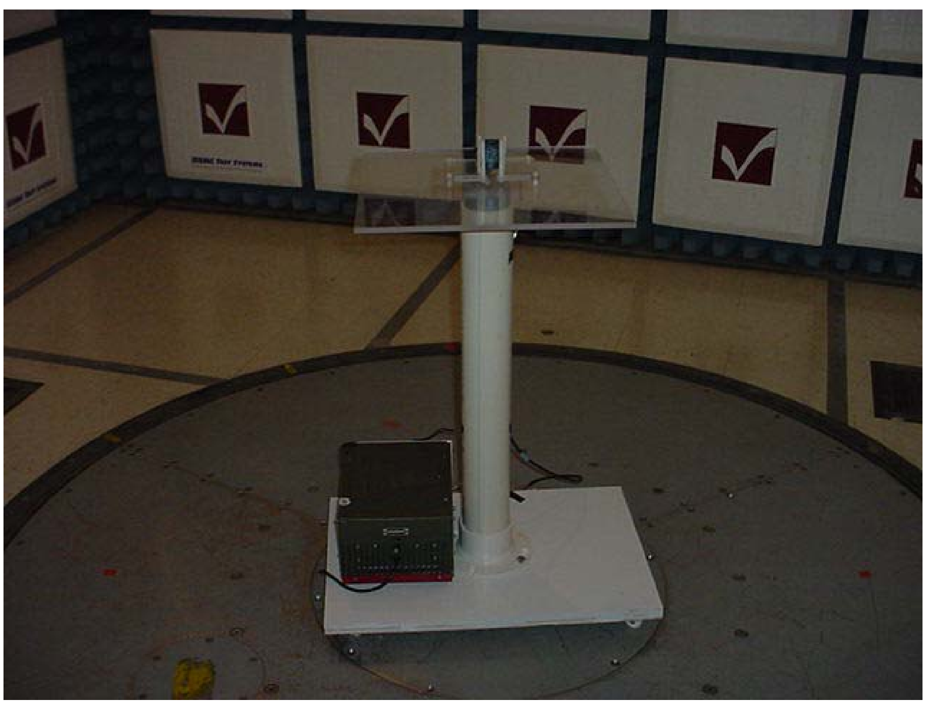
EUT in Vertical Orientation



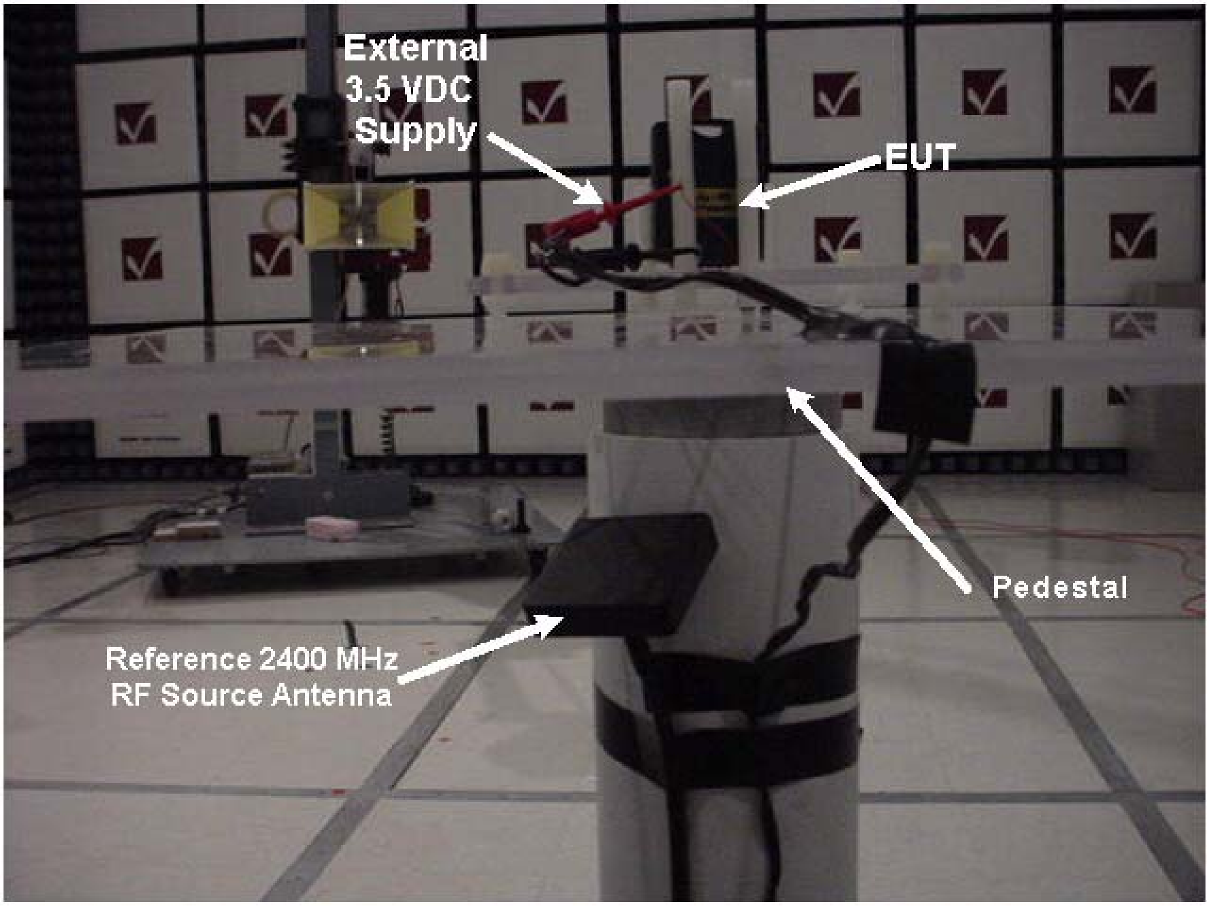
EUT in Horizontal Orientation



EUT in Side Orientation



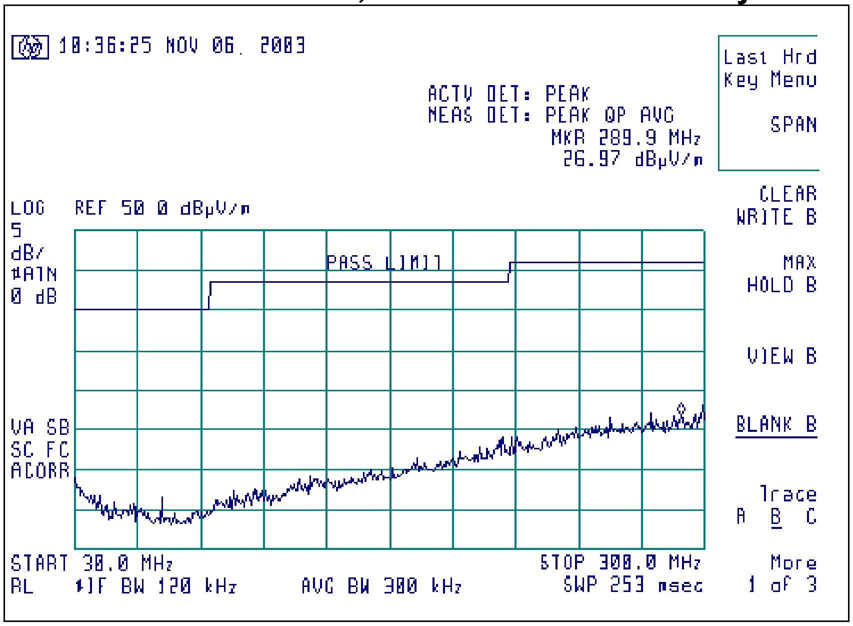
EUT Setup During Radiated Emission Testing



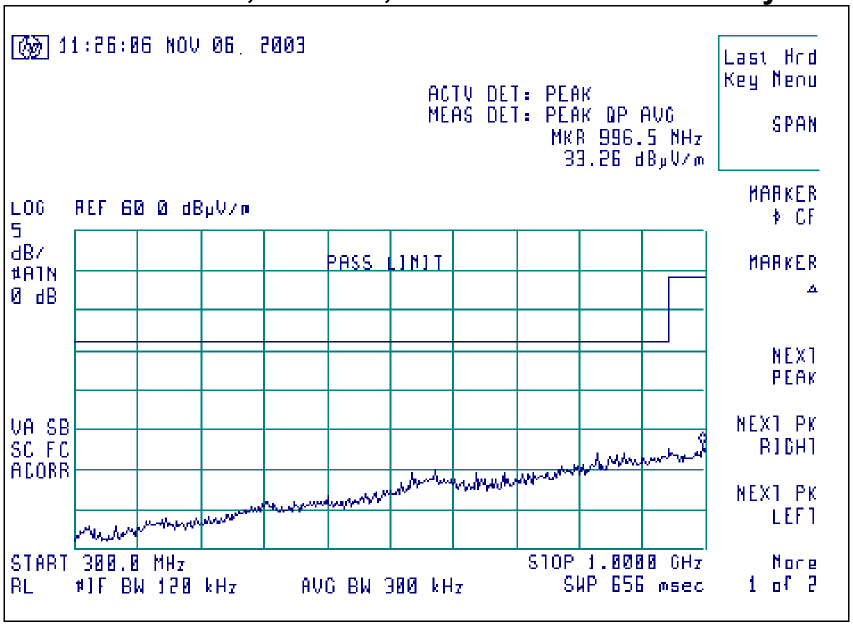
Rear View Detail of the EUT Setup During Radiated Emission Testing

Graphs made during Radiated Emission Testing

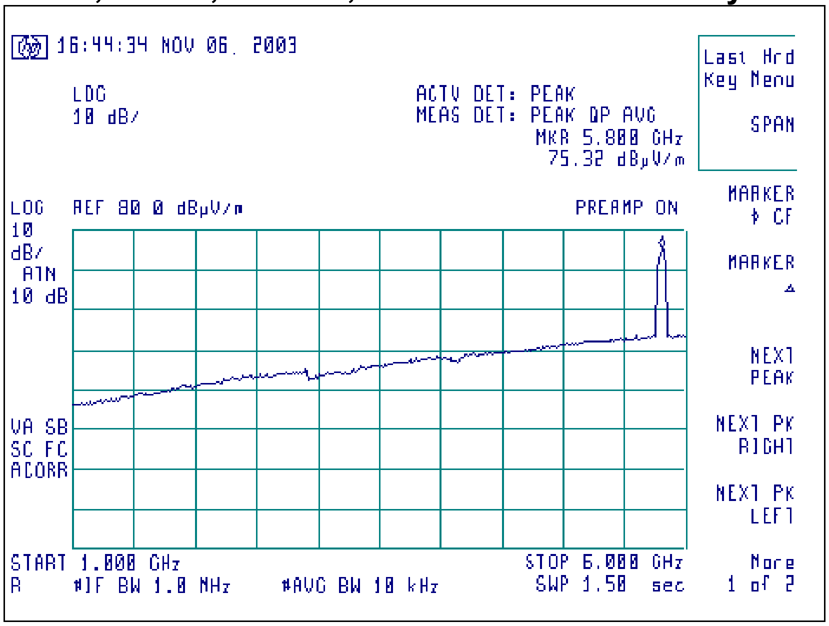
Signature Scan of Peak Radiated Emissions, at 3 meter 30 MHz - 300 MHz, Vertical Antenna Polarity.



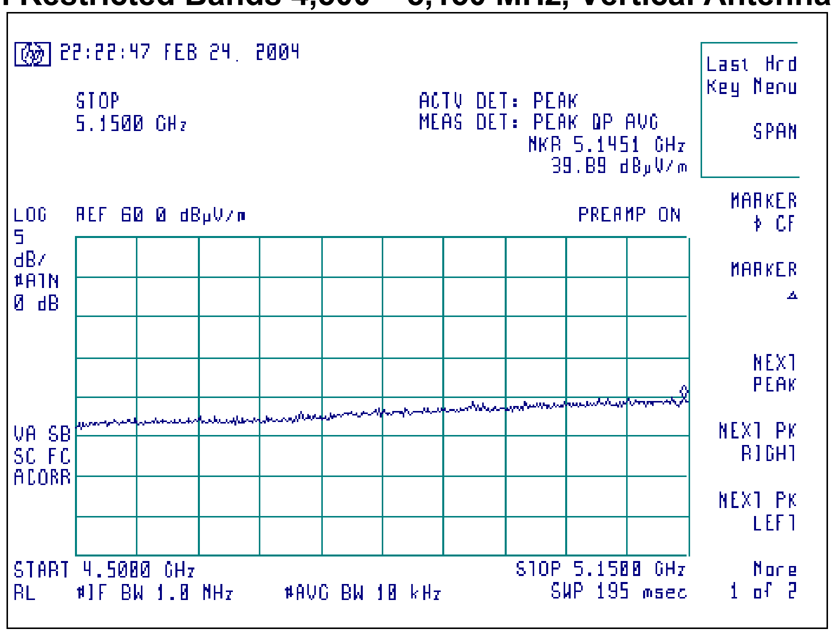
Signature Scan of Peak Radiated Emissions, at 3 meter 300 MHz – 1,000 MHz, Vertical Antenna Polarity.



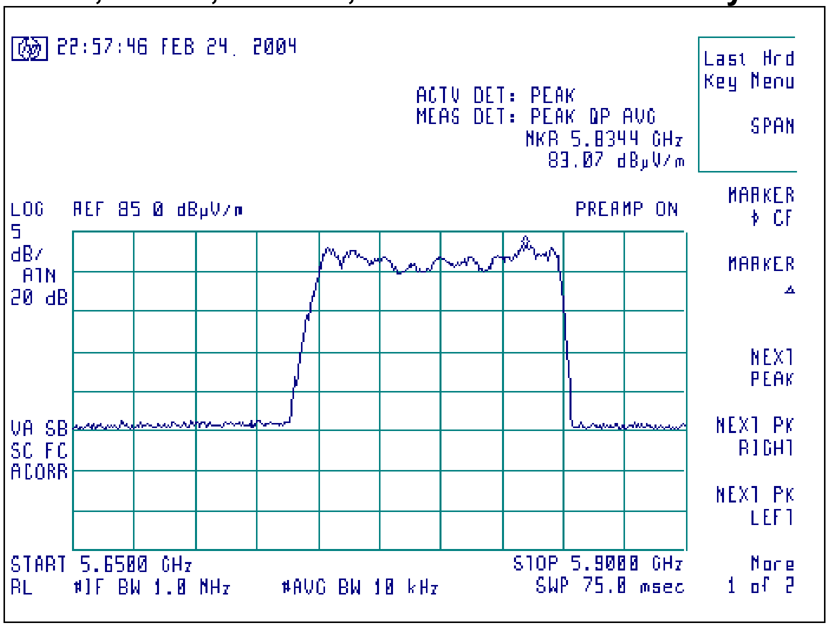
Signature Scan of Peak Radiated Emissions, at 3 meter 1,000 – 6,000 MHz, Vertical Antenna Polarity.



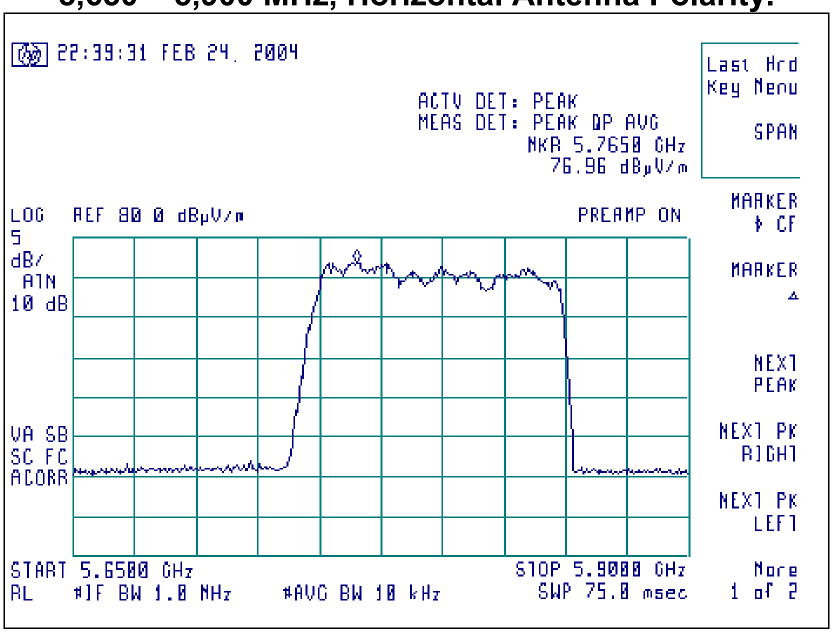
Signature Scan of Peak Radiated Emissions at 3 meters, Focus on Restricted Bands 4,500 – 5,150 MHz, Vertical Antenna Polarity.



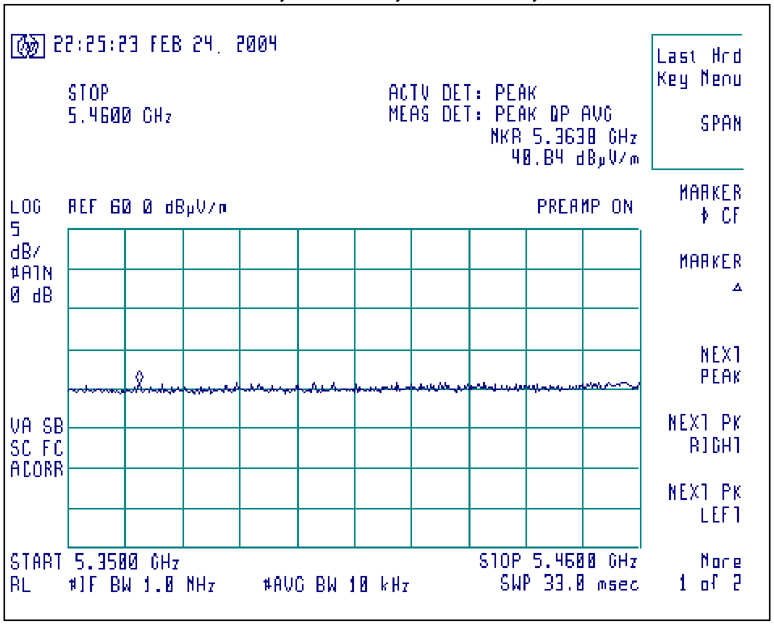
Close-up of Signature Scan of Peak Radiated Emissions, at 3 meter 5,650 – 5,900 MHz, Vertical Antenna Polarity.



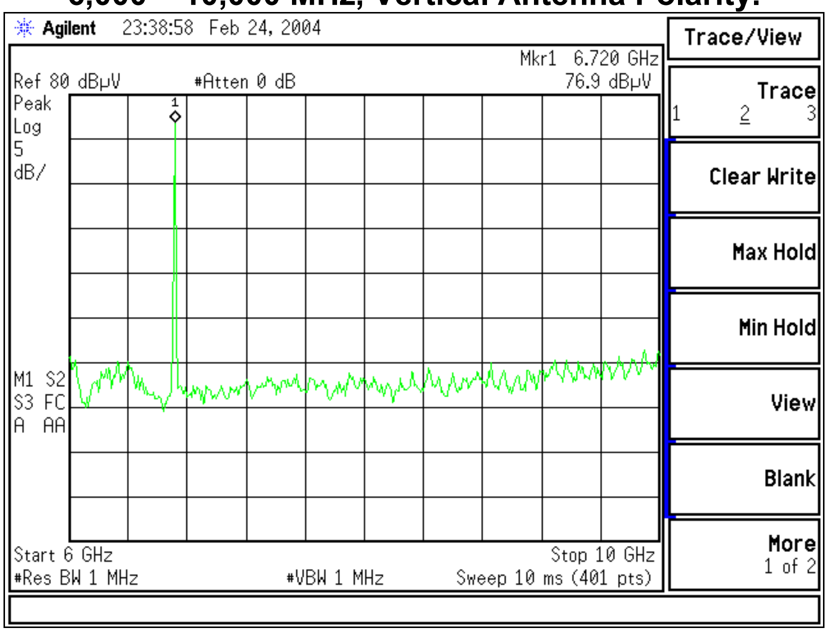
Close-up of Signature Scan of Peak Radiated Emissions, at 3 meter 5,650 – 5,900 MHz, Horizontal Antenna Polarity.



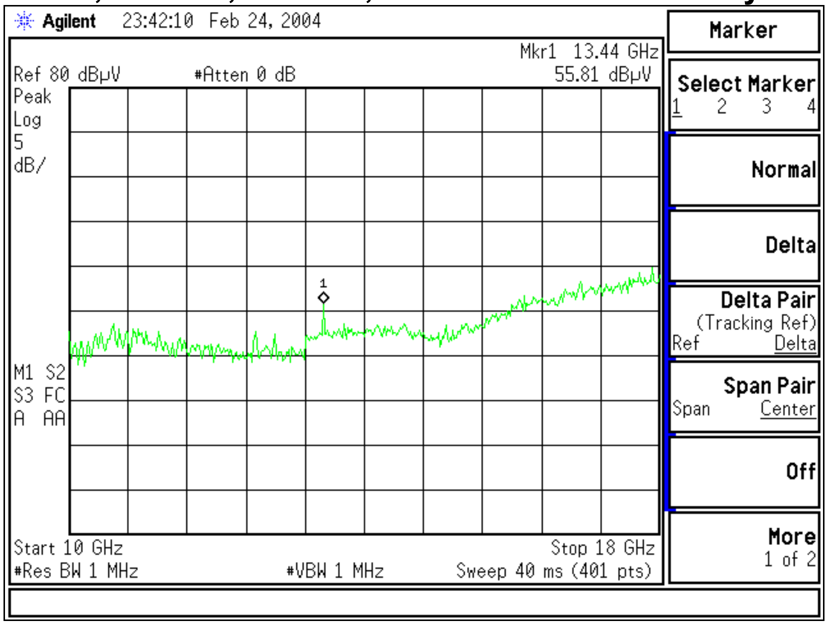
Signature Scan of Peak Radiated Emissions at 3 meters,
Focus on Restricted Bands 5,350 – 5,460 MHz, Vertical Antenna Polarity.



Signature Scan showing Peak Radiated Emissions, at 1 meter
6,000 – 10,000 MHz, Vertical Antenna Polarity.



Signature Scan showing Peak Radiated Emissions, at 1 meter 10,000 – 18,000 MHz, Vertical Antenna Polarity.



13. Conducted Emissions Test (AC Power Line)

The unit operates on one 'LTC-7PN-S2' Lithium type battery, permanently installed, and therefore does not require conducted AC mains emissions tests.

14. Frequency and Power Stability versus Voltage

The EUT's power output was measured, at a fixed frequency in the middle of the band, as the DC voltage provided to the EUT was varied over a +/- 15 % range from a nominal voltage of 3.5 VDC. This test was performed with the EUT in a fixed position with respect to the receiver, with only the DC input voltage changing during the test. The input reference signal was fixed at 2420 MHz. The power output was found to vary less than 1dB, at voltages above 3.5 VDC, and tends to drop with input voltages lower than 2.975 VDC, in a well behaved manner, until at which point the system ceased to operate completely. The frequency drifted less than 500 Hz, and there were no other anomalies or unexpected observable behavior.

Voltage	Measured Power	Measured Frequency
4.025	82.6 dBμV/m	5778.076475 MHz
3.500	82.0 dBμV/m	5778.076202 MHz
2.975	82.3 dBμV/m	5778.076070 MHz

Appendix A
Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	9/03/03	9/03/04
AA960031	HP	119474A	3107A01708	Transient Limiter	8/12/03	8/12/04
AA960063	EMCO	3160-09	9809-1120	18-26 GHz Horn	6/10/03	6/10/04
AA960077	EMCO	93110B	9702-2918	Biconical Antenna	9/02/03	9/02/04
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	9/02/03	9/02/04
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	11/14/03	11/14/04
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	11/04/03	11/04/04
EE960004	EMCO	2090	9607-1164	Device Controller	N/A	N/A
EE960013	HP	8546A	3617A00320	Receiver RF Section	9/04/03	9/04/04
EE960014	HP	85460A	3448A00296	Receiver Pre-Selector	9/04/03	9/04/04
EE960146	Advanced Microwave	WLA622-4	0123001	18-26 GHz Pre-amp	6/10/03	6/10/04
EE960147	Advanced Microwave	WLA612	0123101	5-18 GHz Pre-amp	6/10/03	6/10/04
N/A	LSC	Cable	0011	3 Meter ½” Armored Cable	6/19/03	6/19/04
N/A	LSC	Cable	0038	1 Meter RG 214 Cable	6/19/03	6/19/04
N/A	LSC	Cable	0050	10 Meter RG 214 Cable	6/19/03	6/19/04
N/A	Pasternack	Attenuator	N/A	10 dB Attenuator	6/19/03	6/19/04

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 Meter Chamber, Biconical Antenna	4.24 dB
Radiated Emissions	3 Meter Chamber, Log Periodic Antenna	4.80 dB
Radiated Emissions	10 Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10 Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Meter Chamber, 3 Volts/Meter	1.128 Volts/Meter
Conducted Immunity	3 Volt level	1.0 V

Appendix B
Data Format Details for Duty Cycle Relaxation Calculations

General:

The T50 Tag operates in the PinPoint Location System to provide the signal information that locates the Tag, and hence, the asset that the Tag is attached to. The Tag performs two basic functions:

'Transponder' for the location signal returned to the cell controller.
Modulation of the cell controller signal for Tag ID (and other information) to the cell controller.

The tag spends most of its time in the idle state. During the idle state the tag enters a number of sleep intervals (i.e. cycles of the watchdog timer). The selectable number of intervals determines when the Tag sends its information, commonly termed a 'chirp'.

During a 'chirp' interval the tag "wakes up", powers up its RF chip (ASIC), and applies the datagram modulation to the RF chip for return to the cell controller. The Tag builds the datagram packet while waiting for the RF chip to 'stabilize'.
After the datagram is sent, the Tag checks a number of status points and then finally returns to the "idle mode".

Tag Datagram:

The Tag Datagram consists of 9 contiguous sections. The sections are the tag preamble, synchronization interval, the start sequence, the datagram version identifier, the tag serial number, the status bits, the tag data, the checksum and end bit. This datagram is sent once during the tag RF-on cycle. Each individual datagram bit spans 6 (pn) sequence lengths.

T-50 Datagram Structure:

Tag Preamble 35 bits	*Rcvr Sync* 4 bits	Start seq. 3 bits	Version 4 bits	Tag ID (Serial Number) *32 bits*	Tag Status *8 bits*	*Tag Data* (future) *24 bits*	Checksum *16 bits*	End bit (1 bit)
111111111..1111	(1off/on) 111	010	***0001***	x....x	y...y	z...z	c...c	c

Tag Datagram Timing:

The Cell Controller modulates the outbound 2.4GHz signal with a 40MHz digital (PN) pattern. The PN pattern is 127 bits in length, giving a PN 'chirp' length of 3.175 usec. Each 'bit' of the Datagram is actually 6 of the PN sequence patterns, so the Datagram Bit is ideally 19.05 usec – as viewed from the Cell Controller. The Tag does not 'see' the PN pattern, as it is carried on the modulation signal that is 'transflected' to the 5.8GHz signal that is sent to the Cell Controller.

In the Tag view, the PIC microcontroller is running from a 4MHz resonator, and divides the clock by 4, so each PIC instruction cycle is 1 usec. This places each datagram bit at 19 usec, and the entire datagram, including preamble, is 127 bits. Therefore, the worst-case transmission length would be 2.413 msec out of ANY 100ms window in time. However, the datagram does not need to be stored in its entirety, it can be 'put together' as long as the bit timing is maintained. Datagram bits are encoded using BPSK (binary-phase shift keying), so the bit phase changes for each '0' bit, and remains unchanged for a '1' bit.

After the Tag send its Datagram, it checks the battery – as the battery is typically at its lowest after the transmission.

It then goes to ‘sleep’ to conserve power. This is done through a count of ‘sleep’ cycles maintained by the Tag to establish the off time until the next ‘chirp’. Prior to entering the ‘off-timer phase’, the microcontroller generates a random number that is used to modify the off time in a pseudo-random way to minimize collisions. Once the off-timer in the micro has been loaded, the micro puts itself into sleep mode. This completes the tag cycle.