# TEST REPORT

**Report Number: 5100_report_revC.doc**
**Project Number: 3025094**

**Date: 11/20/2002**
**Date(s) of Test: November 7, 8,** 19-20, 2002

**Evaluation of the**
**Model number: 5100**

**To**

**CFR 47 Part 15 Subpart F**

**For**
**Geophysical Survey Systems**

Test Performed by:
Intertek Testing Services

70 Codman Hill Rd.
Boxborough, MA 01719

Test Authorized by:
Geophysical Survey Systems

13 Klein Rd
PO Box
Salem, NH 03079

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## EXECUTIVE SUMMARY

Testing performed for Geophysical Survey Systems
Model Number:

| Test Description | FCC Rules Section | Results | Page # |
|---|---|---|---|
| UWB bandwidth <960MHz<br>GPR operated by law enforcement, etc.<br>Eligible for licensing (Part 90)<br>Cease operation 10 seconds after release | 15.509 (a)-(c) | | 10 |
| Quasi-peak emissions IAW 15.209 | 15.509(d) | | 13 |
| RMS emissions >960MHz | 15.509(d) | | 15 |
| RMS emissions in GPS bands | 15.509(e) | | 17 |
| Emission at frequency of highest emission | 15.509(f) | | 11 |
| Label indicating restricted operation | 15.509(g) | | 21 |
| Prohibited use<br>Unique antenna<br>Frequency of maximum emission within UWB bandwidth<br>Measurement frequency range | 15.521 | | 10 |
| Coordination with FCC and NTIA | 15.525 | | 22 |

# 1. INTRODUCTION

## 1.1. Client Information

Geophysical Survey Systems

13 Klein Rd
PO Box
Salem, NH 03079

Contact: Alan Schutz
Title: Engineering Director

## 1.2. Test Plan Reference

47 CFR Part 15 Subpart F – Ultra-wideband operation
FCC 02-48 FCC First Report and Order Revision of Part 15 of the Commission’s rules Regarding Ultra-Wideband Transmission Systems; Appendix F – Measurement Procedures; 22 April 2002

## 1.3. Equipment Under Test (EUT)

The Equipment Under Test (EUT) is a low frequency imaging device operating as a Ground Penetrating Radar (GPR). A quality assurance model was received in good condition on 11/6/02.

### 1.3.1 System Support Equipment

Description: Control System
Manufacturer: Geophysical Survey Systems, Inc.
Model No.: SIR-20
Serial No.: Not Applicable

Description: Survey Systems AC Adapter
Manufacturer: Sceptre
Part No.: PS-1586A
Serial No.: SPU130-106

### 1.3.2 Cables

| QTY | Description | Shield Description | Hood Description | Length (m) |
|---|---|---|---|---|
| 1 | AC Power cord | None | Plastic | 2 |
| 1 | AC Adapter cable | None | Plastic | 2 |
| 1 | Control Cable | Braid | Metal/360º Termination | 15 |
| 1 | Marker Cable | Braid | Metal/360º Termination | 1 |

### 1.3.3 System Block Diagram

Figure 1-1 shows a block diagram of the test setup.

### 1.3.4 Justification

The system was configured for testing in a typical fashion (as a customer would normally use it), and in the confines as outlined in C63.4 (1992).

Initial testing was performed to maximize emissions. The system was rotated every 45°, the antenna height was varied from 1 meter to 4 meters above the ground, and the antenna polarization was changed. The EUT azimuth of maximum emissions was recorded.

During final testing, the antenna height was varied from 1 meter to 4 meters above the ground, and the antenna polarization was changed. This step by step procedure for maximizing emissions led to the data in this report. For measurements using the horn antenna, the horn was tilted to aim at the EUT. At antenna height of 1-2.5m, the horn was angled at $10^o$ below horizontal ($25^o$ if antenna distance =1m). At antenna height of 2.5-4m, the horn was angled at $35^o$ below horizontal ($55^o$ if antenna distance =1m).

Radiated emissions were tested in the frequency range up to at least $f_C$+3/PW where, for model 5100:
PW~1ns;
$f_C$=494.65;
$f_{max}$=277.8.

### 1.3.5 Mode(s) of Operation

The EUT was configured above a sand pit of approximately 3m x 3m x 1.2m. The EUT was set to transmit continuously with its normal operational characteristics. The EUT was programmed to operate at a pulse repetition rate (PRR) of 200kHz.

## 1.4. Modifications required for compliance

No modifications were made to the EUT by Intertek Testing Services during these tests.

## 2. TEST ENVIRONMENT

### 2.1. Test facility

The test site used during testing was made in according with FCC Part 15F. The test site was constructed with a dimension of 9 ft x 9 ft x 48 inches deep. The whole area was filled with dry sand. The equipment under test (EUT) was placed directly on the sand while the receiving antenna was placed on the blacktop at a distance of 3m from the closest point of the EUT. A groundplane with a dimension of 96.5inch X 96.5inch was placed between the EUT and receiving antenna and connected to earth ground via a ground rod.

### 2.2. Test Equipment

The following equipment settings were used to make measurements for emissions testing:

| Description | Manufacturer | Model | Serial # | Cal Due |
|---|---|---|---|---|
| EMI Receiver | Hewlett Packard | 8542E | 3520A00125 | 12/07/02 |
| Horn Antenna | EMCO | 3115 | 9512-4632 | 10/09/02 |
| Biconolog Antenna | EMCO | 3142 | 9711-1223 | 10/08/02 |
| Spectrum Analyzer | Tektronix | 2784 | B010153 | 1/11/03 |
| Pre-Amp | Miteq | NSP-4000-NF | 507145 | 9/27/03 |
| Pre-Amp | CTT | ALM/100-5030-329 | 34510 | 4/5/03 |
| Pre-amp | Hewlett Packard | 8447 | PRE6 | 11/15/03 |
| High Frequency Cables | Huber + Suhner, Inc | Sucoflex 104PEA | CBLSHF203 | 4/1/03 |
| High Frequency Cables | Huber + Suhner, Inc. | Sucoflex 104PEA | CBLSHF103 | 4/1/03 |

### 2.3. Sample Calculations

The following sample calculations were performed to determine compliance with the respective requirements

#### 2.3.1 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF + NG - AG

where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB/m
AG = Amplifier Gain in dB
NG = No Groundplane Factor in dB (0dB if ground plane is used)

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows:

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB, cable factor of 1.6 dB, and no groundplane factor of 4.7 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 36.7 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB

NG = 4.7 dB
AG = 29.0 dB
FS = 36.7 dBμV/m

Level in μV/m = $[10^{(36.7\ dB\mu V/m)/20)}]$ = 68.4 μV/m

### 2.3.2 EIRP Calculation

In the frequency range above 960MHz, the field strength in dBμV/m measured at 3m is converted to EIRP in dBm as follows:

$dBm/m^2 = dB\mu V/m - 90 - 10*\log 377$

$dBm = dBm/m^2 + 10*\log(4*\pi*3^2) = dB\mu V/m - 90 - 10*\log 377 + 10*\log(4*\pi*3^2)$

dBm = dBμV/m – 95.2

### 2.3.3 RMS calculation

All RMS measurements >960MHz were taken with the following spectrum analyzer settings:

RBW = 1MHz (or 1kHz in GPS band)
VBW = 7MHz
Detector = Sample
Sweep time = 1ms

At each frequency measured above 960MHz (where RMS values are specified) the spectrum analyzer was set up with the appropriate measurement bandwidth (1MHz or 1kHz) in 'zero-span' mode. The maximum signal level was captured and the waveform was downloaded to the computer. A total of 1000 points were acquired at each frequency. The RMS level at the measurement frequency was calculated as follows:

$mW_{RMS} = \mathrm{sqrt}((P_1^2 + P_2^2 + \ldots + P_x^2)/x)$ where:

$mW_{RMS}$ = RMS power in a 1msec interval at measurement frequency
x =1 to 1000 (number of analyzer samples)
$P_x$ = Power at each time sample (1ms/1000 = 1μsec)

Using this RMS power at the analyzer, EIRP at each frequency was calculated as described above.

## 2.4. Measurement Uncertainty

Compliance of the product is based on the measured value. However, the measurement uncertainty is included for informational purposes.

The expanded uncertainty (k = 2) for radiated emissions from 30 to 1000 MHz has been determined to be:
±4.2 dB at 10m
±5.5 dB at 3m

The expanded uncertainty (k = 2) for radiated emissions from 1 to 18 GHz has been determined to be:
±4.6 dB at 3m
±4.5 dB at 1m

The expanded uncertainty (k = 2) for radiated emissions from 18 to 40 GHz has been determined to be:
±4.2 dB at 1m

The expanded uncertainty (k = 2) for mains conducted emissions from 150 kHz to 30 MHz has been determined to be:
±2.6 dB

# 3. ULTRA WIDEBAND OPERATION

## 3.1. Operational Limitations (section 15.521)

The EUT is subject to the following limitations related to GPR. The client has been informed of these requirements.

a. pursuant to 15.203 and 15.204, the EUT must use a permanently attached antenna or an antenna that uses a unique connector. Additionally, no 'after-market' amplifiers or antenna modifications may be made without further demonstration of system compliance.
b. Emissions not intended to be radiated from the transmitter's antenna must comply with section 15.209
c. Manufacturer (or representative) is responsible for ensuring that EUT is marketed only to:
   - law enforcement
   - fire or emergency organizations
   - scientific research institutes
   - commercial mining companies
   - construction companies

## 3.2. UWB Bandwidth (section 15.503(a))

The UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated UWB emission. The upper boundary is designated $f_H$ and the lower boundary is designated $f_L$. The frequency at which the highest radiated emission occurs is designated $f_M$.

### 3.2.1 Requirement (low-frequency imaging systems)

The UWB bandwidth of low frequency imaging systems must be contained below 960MHz.

### 3.2.2 Test Procedure

1) With the EUT set up as specified in 1.3 above, set up the log periodic antenna at a distance of 3m from the EUT. Using the analyzer/receiver, measure emissions from the EUT at frequencies above 26MHz.
2) Maximize the emissions by varying the antenna height from 1 – 4m and changing antenna polarization.
3) Record all emissions from the EUT. Due to the broadband nature of the emissions, significant care must be taken to capture the true spectrum of the emission. This may require measurements with extremely narrow sweep widths.
4) Verify that the measured spectrum allows resolution of levels 10dB below the maximum level, both above and below the frequency of maximum emission.
5) If necessary, use the loop antenna to measure below 26MHz, or the horn antenna to measure above 2GHz. (If EUT emissions can not be determined using the loop, an active monopole antenna can be used. *Use caution when using the rod antenna. As it is omni-directional it is much more susceptible to false readings from ambient signals.*)

### 3.2.3 Test Results

The model 5100 complies with the requirement. The frequency of maximum emission ($f_M$) is 277.8MHz. The lower boundary frequency ($f_L$) is 31MHz. The upper boundary frequency ($f_H$) is 958.3MHz. See Figure 3.2-1. (Note that due to ambient emissions, the lowest measurable frequency is 17MHz. At this frequency, the emission level is 9dB below the level at $f_M$.) No signals were detected below 28MHz.

## 3.3. Center Frequency (section 15.503(b))

The center frequency, $f_C$, of a UWB device is defined as $(f_H + f_L)/2$.

### 3.3.1 Requirement

The center frequency, $f_C$, is used to define the fractional bandwidth as well as the minimum required measurement band.

### 3.3.2 Test Procedure
The center frequency, $f_C$, is determined from the data obtained in 3.2 above.

### 3.3.3 Test Results
From 3.2:
$f_L$= 31MHz
$f_H$=958.3MHz

The center frequency $f_C$=(958.3 + 31)/2=494.65MHz

## 3.4. Fractional Bandwidth (section 15.503(c-d))
The fractional bandwidth of a device is defined as:
$BW_f = (f_H - f_L)/f_C$

### 3.4.1 Requirement
A UWB transmitter is one that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

### 3.4.2 Test Procedure
The fractional bandwidth is determined using the frequencies defined in 3.2 and 3.3 above.

### 3.4.3 Test Results
From 3.2 and 3.3:
$f_L$= 31MHz
$f_H$=958.3MHz
$f_C$=494.65MHz

The fractional bandwidth $BW_f$=**1.87**. The 5100 qualifies as a UWB device because the UWB bandwidth is >500MHz.

## 3.5. Peak Emissions 50MHz Resolution Bandwidth (Section 15.509(f))
The peak emission as defined by this section is the emission (in EIRP) contained within a 50MHz bandwidth centered on the frequency at which the highest radiated emission occurs, $f_M$.

Peak radiated emission measurements shall be made using a spectrum analyzer with a 3 MHz resolution bandwidth and no less than a 3 MHz video bandwidth. The analyzer should be used in a maximum-hold trace mode. The peak power level expressed in a 3 MHz bandwidth and the frequency at which this level was measured shall be reported in the application for certification.

### 3.5.1 Limit
The peak emission in a 50MHz bandwidth centered on $f_M$ must be limited to a maximum of 0dBm EIRP.

### 3.5.2 Test Procedure
1) Using the results of 3.2 above, determine the frequency of maximum emissions $f_M$.
2) With the EUT set up as specified in 1.3 above, set up the log periodic antenna at a distance of 3m from the EUT.
3) Using the analyzer/receiver, measure emissions from the EUT at $f_M$.
4) Place the analyzer/receiver as follows:
   - max hold
   - peak detector
   - RBW=3MHz

- VBW=7MHz
- Span=0

5) Maximize the emissions by varying the antenna height from 1 – 4m and changing antenna polarization. Maximize the emission by rotating the EUT in $45^o$ increments.
6) Record the peak emissions from the EUT.

### 3.5.3 Test Results

The peak emission (using a 3MHz RBW) from the EUT at 277.8MHz is -45.6dBm EIRP.

dBm = -48.3 @3m
AF = 13.4dB
Bandwidth correction factor (BW)= 20*log(50/3)=24.4
Preamp factor (PF)= 22.5
Cable factor (CF)=0

EIRP(3MHz) =dBm + AF – PF + CF + 107 – 95.2
= -48.3 + 13.4 – 22.5 + 0 + 11.8
= -45.6dBm @ RBW=3MHz

Peak limit at RBW=3MHz (per 15.521(g)) = 0dBm + 20*log(3/50) = -24.4dBm EIRP
Margin at f=277.8 MHz is –24.4 – (-45.6)=21.2dB

# 4. RADIATED EMISSIONS

## 4.1. Section 5.209(d) Quasi-Peak

### 4.1.1 Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (MHz) | Field Strength (ìV/m) | Field Strength (dBìV/m) | Measurement distance (m) |
|---|---|---|---|
| 0.009 - 0.490 | 2400/f(kHz) | 67.6-20*log(f(kHz)) | 300 |
| 0.490 - 1.705 | 24000/f(kHz) | 87.6-20*log(f(kHz)) | 30 |
| 1.705 - 30.0 | 30 | 29.5 | 30 |
| 30 - 88 | 100 | 40 | 3 |
| 88 - 216 | 150 | 43.5 | 3 |
| 216 - 960 | 200 | 46 | 3 |

(a) In the emission table above, the tighter limit applies at the band edges.
(b) The level of any unwanted emissions from an intentional radiator shall not exceed the level of the fundamental emission.
(c) The limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency.

### 4.1.2 Test Procedure

Procedures for measurement in the frequency range of below 960 MHz are those used to show compliance with FCC Section 15.209.

1) Set the antenna to the measurement distance specified in the applicable standard.
2) With the analyzer bandwidth set to 120kHz, monitor the frequency range <960 MHz using a peak detector mode. It is recommended to demodulate the received signals for convenient discrimination of ambient emissions from those emanating from the EUT.
3) Upon detection of a suspect signal note its amplitude and frequency.
4) Manipulate EUT system cables to maximize emission levels. At each measurement frequency, maximize the emission by rotating the EUT in 45$^o$ increments.
5) Move the antenna over the range 1m – 4m to maximize the suspected highest amplitude observation and proceed.
6) Change the polarity of the antenna and repeat steps (2) and (3). Compare the resulting suspected highest amplitude signal with that found for the other polarity. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.
7) The effects of various modes of operation shall be examined. Examine all possible operating modes and, if possible, vary the modes while steps (2) – (6) are being performed.
8) After completing steps (2) through (7), record the final EUT configuration, mode of operation, and cable configuration to use for the remaining radiated emission test.
9) Verify that all components of the measurement system (antenna, cables, and analyzer) have valid calibration tags and are within the prescribed calibration interval. If an out-of-calibration condition exists, notify the supervisor. Verify that the site is clear of reflecting objects.
10) Check the calibration of the analyzer, using either its internal calibration signal or an external source.
11) With the resolution bandwidth set to 120kHz and using peak detector mode, set the span of analyzer to that consistent with resolving individual emissions.
12) Re-maximize emissions from the EUT (rotating the EUT in 45$^o$ increments) at the worst-case combinations of frequency, antenna height and polarization. Use small variations in placement consistent with the applicable standard.

13) Increment the span of the analyzer such that the EUT spectrum <960MHz is measured. At the worst-case combinations of EUT operating mode, azimuth, frequency and antenna height and polarization, record the field strength measurements using the Peak detector mode. At least 6 emissions that are within 20dB of the applicable limit shall be recorded. (This method applies to emissions that are not intended to be radiated from the transmitter's antenna. Any emissions that are intended to be transmitted via the antenna are instead measured using the procedures of section 4.2 and 4.3 herein.) At each of these frequencies, record the final field strength measured using a Quasi-Peak detector. Record the values of the parameters listed in this paragraph.
14) Verify that all emissions recorded in step (13) comply with the limits shown in Section 4.1.1.
15) Document the final emissions configuration of the EUT, using either photographs or diagrams.

### 4.1.3 Test Results

The following table shows the final results of measurements made in accordance with FCC Subpart 15.209 and the above procedure. No signals detected <30MHz.

| | | | | | |
|---|---|---|---|---|---|
| Company | Geophysical | Model #: | 510 | | |
| Engineer: | Kouma Sinn | Location: | Site 2 | Serial #: | |
| Project #: | NA | | Detector: | 8542E QP | |
| Date: | 11/8/2002; 11/20/02RFM | | Antenna: | LOG4 LOOP2 | |
| Standard: | FCC Part 15 Subpart F | Preamp: | None | | |
| Class: Low freq GPR | Group: | None | Cable(s): | 2C, 3MPRIME_MAR02 | |
| Limit dist: | 3m | | Test dist.: | 3m | |
| Volt/freq | Power from SIR-20 | Freq.range | 100k-960MHz | | |

| Notes # | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB |
|---|---|---|---|---|---|---|---|---|---|---|
| bb | V | 3.20E+07 | 11.2 | 15.3 | 0.6 | 0.0 | 0.0 | 27.1 | 40.0 | -12.9 |
| bb | V | 4.28E+07 | 15.4 | 10.4 | 0.8 | 0.0 | 0.0 | 26.5 | 40.0 | -13.5 |
| bb | V | 5.00E+07 | 14.0 | 8.3 | 0.9 | 0.0 | 0.0 | 23.2 | 40.0 | -16.8 |
| bb | V | 5.22E+07 | 15.4 | 8.0 | 1.0 | 0.0 | 0.0 | 24.4 | 40.0 | -15.6 |
| bb | V | 6.23E+07 | 18.1 | 6.9 | 1.1 | 0.0 | 0.0 | 26.1 | 40.0 | -13.9 |
| bb | V | 6.99E+07 | 19.4 | 6.3 | 1.1 | 0.0 | 0.0 | 26.8 | 40.0 | -13.2 |
| bb | V | 7.47E+07 | 19.7 | 6.6 | 1.1 | 0.0 | 0.0 | 27.5 | 40.0 | -12.5 |
| bb | V | 9.50E+07 | 13.9 | 7.8 | 1.4 | 0.0 | 0.0 | 23.0 | 43.5 | -20.5 |
| bb | V | 1.07E+08 | 10.3 | 7.5 | 1.4 | 0.0 | 0.0 | 19.2 | 43.5 | -24.3 |
| bb | V | 1.18E+08 | 11.3 | 6.9 | 1.5 | 0.0 | 0.0 | 19.7 | 43.5 | -23.8 |
| bb | V | 1.33E+08 | 10.0 | 6.7 | 1.6 | 0.0 | 0.0 | 18.3 | 43.5 | -25.2 |
| bb | V | 1.71E+08 | 8.7 | 9.2 | 1.9 | 0.0 | 0.0 | 19.7 | 43.5 | -23.8 |
| bb | V | 1.86E+08 | 9.6 | 9.9 | 2.0 | 0.0 | 0.0 | 21.4 | 43.5 | -22.1 |
| bb | V | 1.99E+08 | 9.2 | 10.4 | 2.1 | 0.0 | 0.0 | 21.6 | 43.5 | -21.9 |
| bb | V | 2.16E+08 | 8.4 | 11.3 | 2.2 | 0.0 | 0.0 | 21.8 | 43.5 | -21.7 |
| bb | V | 2.73E+08 | 13.0 | 13.1 | 2.5 | 0.0 | 0.0 | 28.6 | 46.0 | -17.4 |
| ctt | V | 4.03E+08 | 31.4 | 16.7 | 3.3 | 35.0 | 0.0 | 16.4 | 46.0 | -29.6 |
| ctt | V | 4.48E+08 | 27.7 | 17.3 | 3.6 | 35.0 | 0.0 | 13.6 | 46.0 | -32.4 |
| ctt | V | 4.78E+08 | 24.5 | 18.3 | 3.7 | 35.0 | 0.0 | 11.6 | 46.0 | -34.4 |
| ctt | V | 4.97E+08 | 24.2 | 18.4 | 3.8 | 35.0 | 0.0 | 11.4 | 46.0 | -34.6 |
| ctt | V | 5.20E+08 | 24.4 | 18.8 | 3.9 | 35.0 | 0.0 | 12.1 | 46.0 | -33.9 |
| ctt | V | 5.34E+08 | 27.5 | 19.1 | 3.9 | 35.0 | 0.0 | 15.4 | 46.0 | -30.6 |

| | Ant. | | | Antenna | Cable | Pre-amp | Distance | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Notes | Pol. | Frequency | Reading | Factor | Loss | Factor | Factor | Net | Limit | Margin |
| # | (V/H) | MHz | dB(uV) | dB(1/m) | dB | dB | dB | dB(uV/m) | dB(uV/m) | dB |
| ctt | V | 5.82E+08 | 27.2 | 19.9 | 4.1 | 35.0 | 0.0 | 16.2 | 46.0 | -29.8 |
| ctt | V | 5.96E+08 | 28.1 | 20.5 | 4.1 | 35.0 | 0.0 | 17.8 | 46.0 | -28.2 |
| ctt | V | 6.00E+08 | 28.0 | 20.7 | 4.2 | 35.0 | 0.0 | 17.9 | 46.0 | -28.1 |
| ctt | V | 6.47E+08 | 29.7 | 20.9 | 4.5 | 35.0 | 0.0 | 20.1 | 46.0 | -25.9 |
| ctt | V | 6.83E+08 | 26.9 | 21.5 | 4.7 | 35.0 | 0.0 | 18.0 | 46.0 | -28.0 |
| ctt | V | 7.37E+08 | 25.9 | 22.3 | 4.9 | 35.0 | 0.0 | 18.1 | 46.0 | -27.9 |
| ctt | V | 8.31E+08 | 24.7 | 22.9 | 5.3 | 35.0 | 0.0 | 17.8 | 46.0 | -28.2 |
| ctt | V | 8.66E+08 | 37.6 | 23.3 | 5.3 | 35.0 | 0.0 | 31.2 | 46.0 | -14.8 |
| ctt | V | 9.13E+08 | 26.9 | 23.7 | 5.4 | 35.0 | 0.0 | 21.0 | 46.0 | -25.0 |
| ctt | V | 9.59E+08 | 28.1 | 24.1 | 5.7 | 35.0 | 0.0 | 22.9 | 46.0 | -23.1 |

## 4.2. Section 15.509(d) RMS >960MHz

### 4.2.1 Limit

The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz. RMS average field strength measurements, required for all frequencies above 960 MHz, shall be made using techniques to obtain true RMS average.

| Frequency MHz | EIRP dBm |
|---|---|
| 960-1610 | -65.3 |
| 1610-1990 | -53.3 |
| Above 1990 | -51.3 |

### 4.2.2 Test Procedure

1) Set up the EUT above the sand at a height typical of normal installation. Record the height.
2) Operate the EUT in a continuous mode during all tests. (e.g. – If the EUT uses a gated transmitter, configure it such that the transmitter is gated on continuously).
3) Set up the log-periodic antenna in horizontal polarization at a distance of 3m from the EUT.
4) Rotate the EUT 45º. Set the analyzer to max hold and adjust the height of the measuring antenna from 1-4m and vary the polarization. Record the maximum level and the angle of rotation if it is higher than the level measured in the previous step. Continue to rotate the EUT in 45º increments until the maximum orientation is determined.
5) Set up the analyzer as follows:
   RBW=1MHz
   VBW=7MHz
   Detector=SAMPLE
   Sweep=1ms
   Frequency=960MHz
6) Refer to document UWB_Work_instruction.doc for details on software use.
7) Operate the analyzer in a mode and frequency range that allows discrimination of signal from the EUT vs. ambient. Record the exact frequency and set it to the center frequency.
8) Set the analyzer to zero-span. Using single sweep, trigger the sweep until the display contains at least 10 pulses of the EUT transmitter.
9) Maximize the emission by rotating the EUT in 45º increments.
10) Acquire and save the data from the analyzer using the procedure in UWB_Work_instruction.doc.
11) Repeat 8) through 10) at 970MHz, 980MHz, 990MHz, 1000MHz.

12) Replace the log-periodic antenna with the EMCO 3115 horn antenna.
13) Rotate the antenna to an inclination of –10°.
14) Determine the five frequencies ($f_1$ – $f_5$) of maximum radiation above 960MHz using the results of 3.2 above. If there are no clear peaks above 1000MHz, use the frequencies in the following table:

| | |
|---|---|
| $f_1$ | 1028MHz |
| $f_2$ | 1114MHz |
| $f_3$ | 1260MHz |
| $f_4$ | 1410MHz |
| $f_5$ | 1580MHz |
| $f_6$ | 2000MHz |
| $f_7$ | 2500MHz |

15) Set the analyzer frequency to $f_1$. Operate the analyzer in a mode and frequency range that allows discrimination of signal from the EUT vs. ambient. Record the exact frequency and set it to the center frequency.
16) Set the analyzer to max hold and adjust the height of the measuring antenna from 1-2.5m and vary the polarization. Maximize the emission by rotating the EUT in 45° increments. Record the maximum level.
17) Rotate the antenna to an inclination of –35° and adjust the height of the measuring antenna from 2.5-4m and vary the polarization.
18) Set the antenna height & orientation to the maximum determined in 16) and/or 17) above.
19) Set the analyzer to zero-span.
20) Maximize the emission by rotating the EUT in 45° increments.
21) Acquire and save the data using the procedure in UWB_Work_instruction.doc.
22) Repeat 15) through 21) at $f_2$ through $f_5$ and in 1MHz bands around each.
23) Using the detailed procedure in UWB_Work_instruction.doc, record the data points to determine the RMS levels as described in 2.2.3 above.

**4.2.3 Test Results**

Raw data for each frequency point consists of 1000 samples. Tables of raw data are not presented here. An explanation of calculations is contained in 2.2.3 above. A table of final data follows:

| | | | | | |
|---|---|---|---|---|---|
| Company | Geophysical | Model #: | 5100 | | |
| Engineer: | R. Martin | Location: | Site 2 | Serial #: | |
| Project #: | 3025094 | | Detector: | Tek 2784 sample | |
| Date: | 11/19-20/2002 | | Antenna: | LOOP2;LOG2; HORN2 | |
| Standard: | FCC Part 15 Subpart F | Preamp: | None | | |
| Class low freq GPR: | Group: | None | Cable(s): | CBLSHF203; CBL028 | |
| Limit dist: | 3m | | Test dist.: | 3m | |
| Volt/freq | Power from SIR-20 | Freq.range | 100k-3GHz | | |

| | | dBm | AF | preamp | cable loss | result | limit | margin | |
|---|---|---|---|---|---|---|---|---|---|
| 9.74E+08 | 6.42E-08 | -7.19E+01 | 2.43E+01 | 3.50E+01 | 2.60E+00 | -6.82E+01 | -6.53E+01 | -2.93 | |
| 9.80E+08 | 6.42E-08 | -7.19E+01 | 2.43E+01 | 3.50E+01 | 2.60E+00 | -6.82E+01 | -6.53E+01 | -2.93 | |
| 9.92E+08 | 6.57E-08 | -7.18E+01 | 2.43E+01 | 3.50E+01 | 2.60E+00 | -6.81E+01 | -6.53E+01 | -2.82 | |
| 1.00E+09 | 4.55E-08 | -7.34E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -7.25E+01 | -6.53E+01 | -7.22 | |
| 1.01E+09 | 1.43E-07 | -6.84E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -6.75E+01 | -6.53E+01 | -2.24 | |
| 1.03E+09 | 3.48E-08 | -7.46E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -7.37E+01 | -6.53E+01 | -8.39 | |
| 1.11E+09 | 3.08E-08 | -7.51E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -7.42E+01 | -6.53E+01 | -8.92 | |
| 1.26E+09 | 3.03E-08 | -7.52E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -7.43E+01 | -6.53E+01 | -8.99 | |
| 1.41E+09 | 3.03E-08 | -7.52E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -7.43E+01 | -6.53E+01 | -8.99 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.58E+09 | 3.25E-08 | -7.49E+01 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -7.28E+01 | -6.53E+01 | -7.48 | |
| 2.00E+09 | 3.25E-08 | -7.49E+01 | 2.77E+01 | 3.81E+01 | 4.20E+00 | -6.93E+01 | -5.13E+01 | -17.98 | noise |
| 2.50E+09 | 3.25E-08 | -7.49E+01 | 2.87E+01 | 3.79E+01 | 4.20E+00 | -6.81E+01 | -5.13E+01 | -16.78 | noise |
| 3.00E+09 | 3.65E-08 | -7.44E+01 | 3.06E+01 | 3.78E+01 | 4.20E+00 | -6.56E+01 | -5.13E+01 | -14.27 | noise |

A plot of the final data is shown in Figure 4.2-1.

## 4.3. Section 15.5509(e) RMS GPS bands

### 4.3.1 Limit

The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1kHz. RMS average field strength measurements, required for all frequencies above 960 MHz, shall be made using techniques to obtain true RMS average.

| Frequency MHz | EIRP dBm |
|---|---|
| 1164 – 1240 | -75.3 |
| 1559 - 1610 | -75.3 |

### 4.3.2 Test Procedure

1) Set up the EUT above the sand at a height typical of normal installation. Record the height.
2) Operate the EUT in a continuous mode during all tests. (e.g. – If the EUT uses a gated transmitter, configure it such that the transmitter is gated on continuously).
3) Set up the analyzer as follows:
   RBW=1kHz
   VBW=7MHz
   Detector=SAMPLE
   Sweep=1ms
   Frequency=1164MHz
4) Set up the horn antenna in horizontal at a distance of 3m from the EUT. Rotate the antenna to an inclination of –10$^o$. Set the analyzer to max hold and adjust the height of the measuring antenna from 1-2.5m and vary the polarization. Record the maximum level.
5) Rotate the EUT 45º. Set the analyzer to max hold and adjust the height of the measuring antenna from 1-4m and vary the polarization. Record the maximum level and the angle of rotation if it is higher than the level measured in the previous step. Continue to rotate the EUT in 45$^o$ increments until the maximum orientation is determined.
6) Rotate the antenna to an inclination of –35$^o$ and adjust the height of the measuring antenna from 2.5-4m and vary the polarization. Record the maximum level.
7) Maximize the emission by rotating the EUT in 45$^o$ increments
8) Operate the analyzer in a mode and frequency range that allows discrimination of signal from the EUT. Record the exact frequency and set it to the center frequency.
9) Refer to ITS document UWB_Work_instruction.doc for details on software use.
10) Set the analyzer to zero-span. Using single sweep, trigger the sweep until the display contains at least 10 pulses of the EUT transmitter.
11) Maximize the emission by rotating the EUT in 45$^o$ increments.
12) Acquire the data from the analyzer and save, using procedure in UWB_Work_instruction.doc
13) Repeat 4) through 12) at the following frequencies:

| Frequency (MHz) |
|---|
| 1.179E+09 |
| 1.194E+09 |
| 1.209E+09 |
| 1.224E+09 |
| 1.240E+09 |
| 1.559E+09 |
| 1.569E+09 |
| 1.579E+09 |
| 1.589E+09 |
| 1.599E+09 |
| 1.610E+09 |

### 4.3.3 Test Results

Raw data for each frequency point consists of 1000 samples. Tables of raw data are not presented here. An explanation of calculations is contained in 2.2.3 above. A table of final data follows:

| | | | | | |
|---|---|---|---|---|---|
| Company | Geophysical | Model #: | 5100 | | |
| Engineer: | R. Martin | Location: | Site 2 | Serial #: | |
| Project #: | 3025094 | | Detector: | Tek 2784 sample | |
| Date: | 11/20/2002 | | Antenna: | HORN2 | |
| Standard: | FCC Part 15 Subpart F | Preamp: | None | | |
| Class | Low freq GPR | | Cable(s): | CBLSHF203; CBL028 | |
| Limit dist: | 3m | | Test dist.: | 3m | |
| Volt/freq | Power from SIR-20 | Freq.range | 1164 – 1610MHz | | |

| f(MHz) | mWRMS | dBm | AF | preamp | Cable loss | result | limit LF | margin |
|---|---|---|---|---|---|---|---|---|
| 1.16E+09 | 1.07E-10 | -9.97E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -9.88E+01 | -75.3 | -23.52 |
| 1.18E+09 | 5.44E-11 | -1.03E+02 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -1.02E+02 | -75.3 | -26.44 |
| 1.19E+09 | 1.21E-10 | -9.92E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -9.83E+01 | -75.3 | -22.96 |
| 1.21E+09 | 1.38E-10 | -9.86E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -9.77E+01 | -75.3 | -22.40 |
| 1.22E+09 | 1.38E-10 | -9.86E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -9.77E+01 | -75.3 | -22.40 |
| 1.24E+09 | 1.38E-10 | -9.86E+01 | 2.44E+01 | 3.79E+01 | 2.60E+00 | -9.77E+01 | -75.3 | -22.40 |
| 1.56E+09 | 1.38E-10 | -9.86E+01 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -9.65E+01 | -75.3 | -21.20 |
| 1.57E+09 | 1.38E-10 | -9.86E+01 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -9.65E+01 | -75.3 | -21.20 |
| 1.58E+09 | 3.34E-11 | -1.05E+02 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -1.03E+02 | -75.3 | -27.37 |
| 1.59E+09 | 6.42E-11 | -1.02E+02 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -9.98E+01 | -75.3 | -24.52 |
| 1.60E+09 | 8.11E-11 | -1.01E+02 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -9.88E+01 | -75.3 | -23.51 |
| 1.61E+09 | 3.28E-11 | -1.05E+02 | 2.57E+01 | 3.80E+01 | 2.60E+00 | -1.03E+02 | -75.3 | -27.44 |

A plot of the final data is shown in Figure 4.3-1.

## 4.4. Test Setup Photographs

Photographs of the test setup are submitted as a separate exhibit with the filename 5100_setup.doc

# 5. AC MAINS CONDUCTED EMISSIONS

### 5.1.1 Limit

The following table shows the line-conducted emission limits for FCC Part 15 Subpart B Section 15.107:

**Class B**

| Frequency (MHz) | Conducted Limit | |
|---|---|---|
| | mV | dBmV |
| 0.45 to 30 | 250 | 48 |

### 5.1.2 Test Procedure

1) All conducted voltage measurements shall be made on each current-carrying conductor at the plug end of the EUT power cord or calibrated extension by the use of mating plugs and receptacles on the EUT and LISN/AMN if used. Equipment shall be tested with power cords that are normally used or that have electrical and shielding characteristics that are the same as those cords normally used. For those measurements using a LISN/AMN, the 50 Ω measuring port is terminated by a 50 Ω receiver or a 50 Ω resistive load. Hence all 50 Ω measuring ports of the LISN/AMN are terminated by 50 Ω. **CAUTION: Observe safety precautions appropriate to hazardous mains or power line voltages, such as de-energizing circuits and tagging/lockout procedures.**
2) The EUT shall be placed 40 cm from the vertical ground plane 40 cm away from the rear of the EUT.
3) The EUT should be set up in its typical configuration
4) Each EUT current-carrying power lead, except the ground (safety) lead, shall be individually connected through a LISN/AMN to the input power source. **Note especially the supply of the appropriate power voltage and frequency.** All unused 50 Ω connectors of the LISN/AMN shall be resistively terminated when not connected to the measuring instrument. When the test configuration comprises multiple units that have their own individual power cords, AC power line conducted emissions measurements shall be performed with the line cord of the EUT connected to one LISN/AMN that is connected to the receiver. Those power cords for the units in the remainder of the configuration not under measurement shall be connected to a multiple outlet, which in turn shall be connected to a LISN/AMN different from the LISN/AMN used for the power cord of the EUT. Adapters connected between the EUT power cord plug and the LISN/AMN power socket shall be less than 20cm long and contain only one plug and one outlet.
5) The excess length of the lead between the EUT and the LISN/AMN receptacle (or mains outlet where a LISN/AMN cannot be used) shall be folded back and forth at the center of the lead to form a bundle not exceeding 40cm in length. If the EUT does not have a flexible power lead, it shall be placed at a distance of 80cm from the LISN/AMN (or mains outlet where a LISN/AMN cannot be used) and connected to it by a lead or appropriate conection no longer than 1m. Measurements shall be made at the LISN/AMN end of this lead or connection.
6) The LISN/AMN housing, receiver case ground, conducting ground plane and vertical conducting surface (if any) shall be bonded together. Care shall be taken to assure an adequate RF bonding of the LISN/AMN to the conducting ground plane.
7) Set the receiver bandwidth to the correct value for the measurement frequency range and monitor the entire frequency range for which a limit is specified (or a subset) using a peak detector mode.
8) For each mode of operation of the EUT and for each current-carrying conductor, manipulate the system cables or wires to produce the highest amplitude signal relative to the limit. Record the final EUT configuration, mode of operation, cable configuration and current-carrying conductor that produced the highest emissions relative to the test limit.
9) Based on the preliminary scan of the EUT, select the one EUT and cable or wire configuration and mode of operation that produced the emission with the highest amplitude relative to the applicable limit. If the EUT is relocated from a preliminary test site to a final test site, the highest emissions shall be re-maximized at the final test location, by cable manipulation within the constraints of the

applicable standard. If no preliminary scan was performed, the worst-case configuration must be determined during the course of the final scan.

10) Set the receiver to quasi-peak detector mode. Set the span of the receiver to the maximum consistent with resolving individual emissions. Record the six highest emissions relative to the limit for all the current-carrying conductors of the power cords that comprise the EUT, over the frequency range specified in the relevant standard.
11) Document the final emissions configuration of the EUT, using either photographs and/or diagrams.

#### 5.1.3 Test Results

This section was not applicable to the model 5100. The only AC power line was that for the control system which was previously found compliant with FCC Part 15B Class A devices.

## 6. LABELING AND INSTRUCTION MANUAL

Prior to marketing, the EUT shall be labeled in accordance with 15.19. In addition to the application of the FCC ID, the following statement shall be permanently affixed in a conspicuous location:

> This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

In addition, the following statement shall be permanently affixed in a conspicuous location:

> Operation of this device is restricted to law enforcement, fire and rescue officials, scientific research institutes, commercial mining companies, and construction companies. Operation by any other party is a violation of 47 U.S.C. § 301 and could subject the operator to serious legal penalties.

## 7. OPERATING COORDINATION (15.525)

GSSI shall inform the users of UWB devices that they are required to provide usage information to the National Telecommunication and Information Administration, including company contact information and proposed geographical area of operation. Further details of the submittals are found in 47 CFR subsection 15.525.

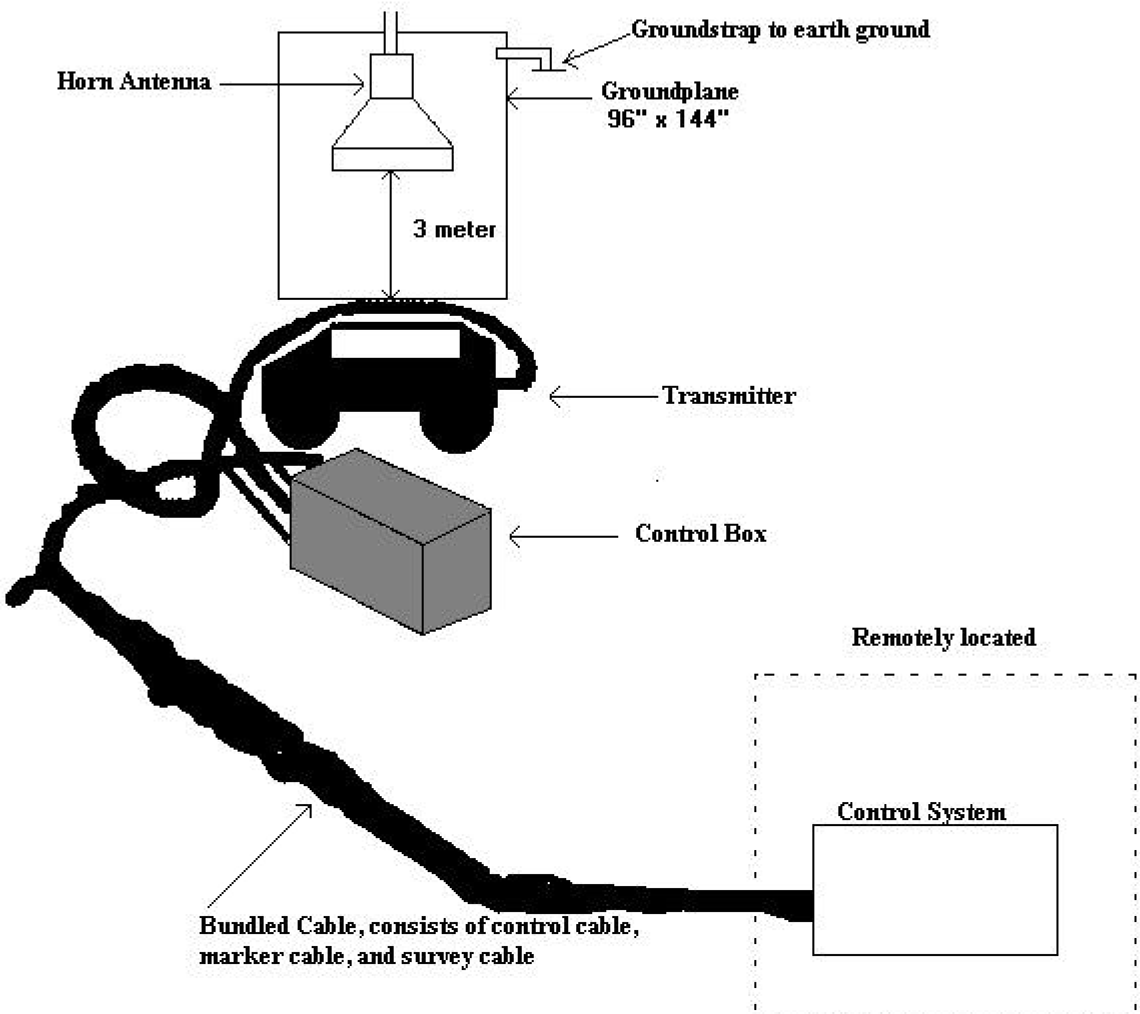


FIGURE 1.3-1 TEST SETUP BLOCK DIAGRAM (M/N 5100)

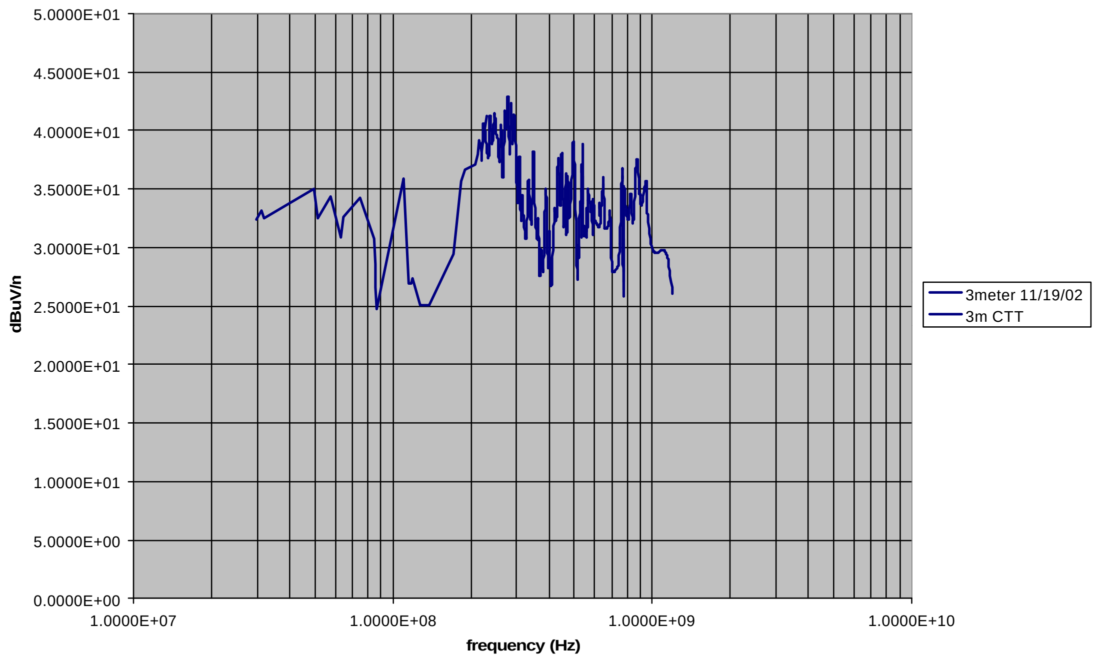


FIGURE 3.2-1 5100 10DB BANDWIDTH

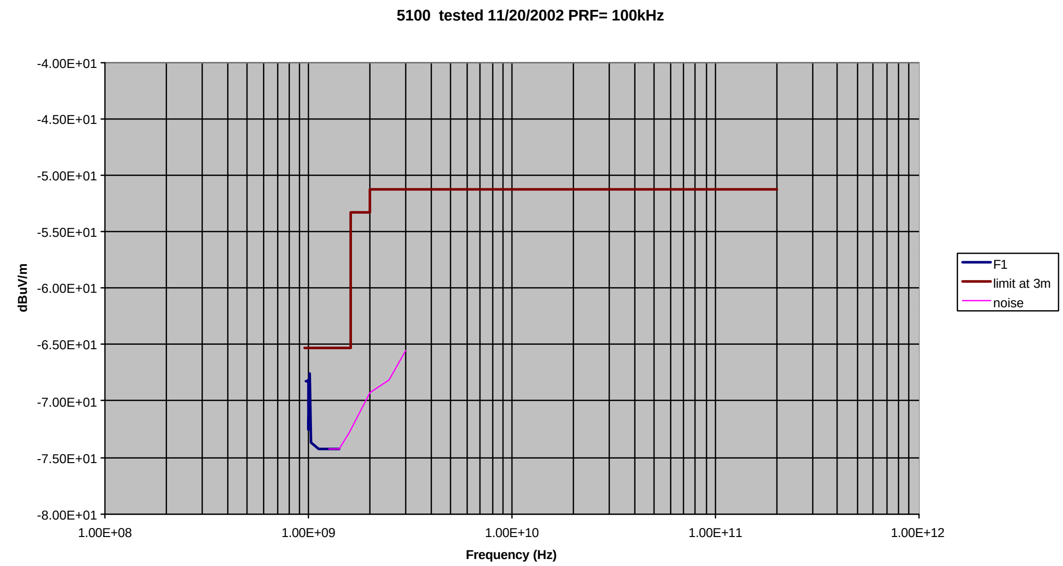


FIGURE 4.2-1 5100 RMS (RBW=1MHZ)

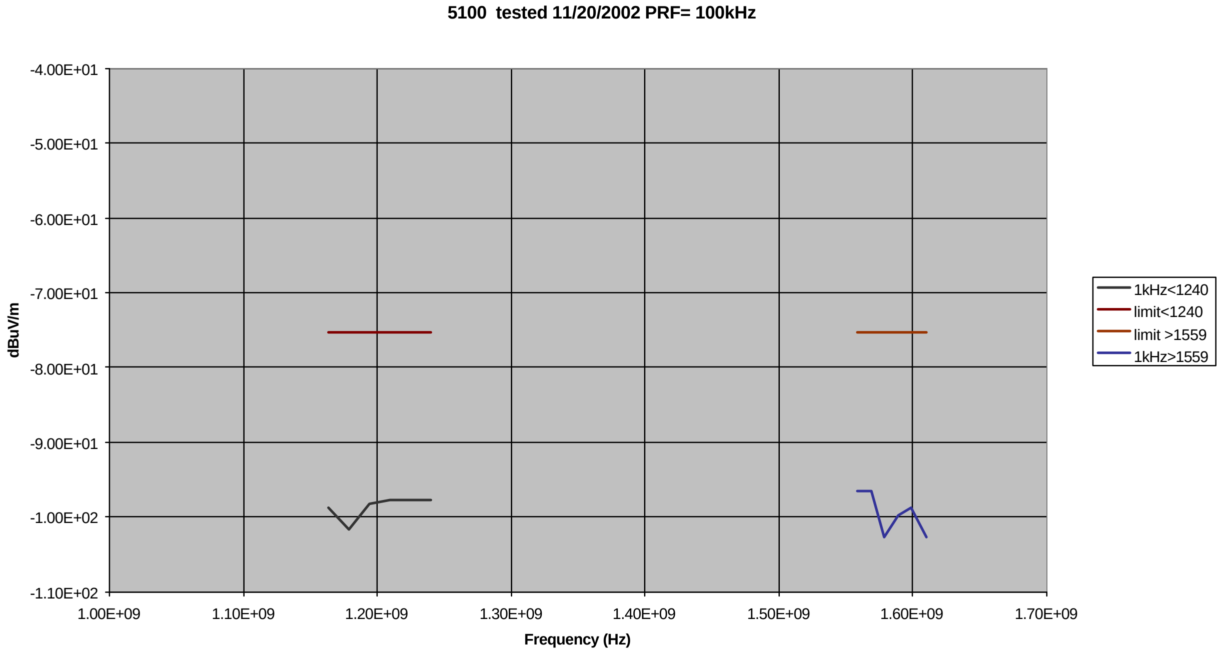


FIGURE 4.3-1 5100 RMS (GPS; RBW=1KHZ)