UltraTech
Group of Labs

31040/SIT

C-1376

Canada
46390-2049

NVLAP
200093-0

00-034

April 12, 2004

FEDERAL COMMUNICATIONS COMMISSION
7435 Oakland Mills Road
Columbia, MD 21046
USA

Subject: **FCC Certification Authorization Application under FCC ET Docket 98-153 & FCC Part 15, Subpart F, Sec. 15.509 - Technical Requirements for Low Frequency Imaging Systems operating at 50 MHz, 100 MHz or 200 MHz.**

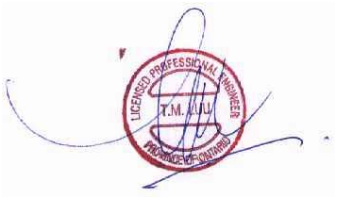
Product: **Pulse Ekko Pro (50 MHz, 100 MHz and 200 MHz)**
Model No.: **TLF**
FCC ID: **QJQ-PE-PRO-TLF**

Dear Sir/Madam

As appointed agent for Sensors & Software Inc., we would like to submit the application to the Federal Communications Commission for certification of the above product. Please review all necessary files uploaded to FCC OET site for detailed information.

If you have any queries, please do not hesitate to contact us.

Yours truly,



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00-034

April 12, 2004

Sensors & Software Inc.
1040 Stacey Court
Mississauga, Ontario
Canada, L4W 2X8

Attn.: **Mr. David Redman**

Subject: **FCC Certification Application Testing under FCC ET Docket 98-153 & FCC Part 15, Subpart F, Sec. 15.509 – Technical Requirements for Low Frequency Imaging Systems operating at 50 MHz, 100 MHz or 200 MHz**

Product: **Pulse Ekko Pro (50 MHz, 100 MHz and 200 MHz)**
Model No.: **TLF**
FCC ID: **QJQ-PE-PRO-TLF**

Dear Mr. Redman,

The product sample, as provided by you, has been tested and found to comply with **FCC ET Docket 98-153 & FCC Part 15, Subpart F, Sec. 15.509 - Technical Requirements for Low Frequency Imaging Systems operating at 50 MHz, 100 MHz or 200 MHz.**

Enclosed you will find copies of the engineering report. If you have any queries, please do not hesitate to contact us.

Yours truly,

Tri Minh Luu, P. Eng.,
V.P., Engineering

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ENGINEERING TEST REPORT

Pulse Ekko Pro (50 MHz, 100 MHz and 200 MHz)
Model No.: TLF

FCC ID: QJQ-PE-PRO-TLF

Applicant: **Sensors & Software Inc.**
1040 Stacey Court
Mississauga, Ontario
Canada, L4W 2X8

In Accordance With

FEDERAL COMMUNICATIONS COMMISSION (FCC)
PART 15, SUBPART F, SEC. 15.509
Technical Requirements for Low Frequency Imaging Systems operating at 50 MHz, 100 MHz or 200 MHz

UltraTech's File No.: SES-020FCC15UWB

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: July 09, 2003	
Report Prepared by: Tri Luu Issued Date: April 12, 2004	Tested by: Manuel D'Oliveira, Ultratech Eng. Labs Inc And David Redman Sensors & Software Inc. Test Dates: April 05-07, 2004

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

UltraTech

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EXHIBIT 1. SUBMITTAL CHECK LIST

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
	Test Report	• Exhibit 1: Submittal check lists • Exhibit 2: Introduction • Exhibit 3: Performance Assessment • Exhibit 4: EUT Operation and Configuration during Tests • Exhibit 5: Summary of test Results • Exhibit 6: Measurement Data • Exhibit 7: Measurement Uncertainty • Exhibit 8: Measurement Methods	OK
1	Test Setup Photos	Photos 1 to 6	OK
2	External Photos of EUT	Photos # 1 to 13	OK
3	Internal Photos of EUT	Photos of 1 to 13	OK
4	Cover Letters	• Letter from Ultratech for Certification Request	OK
5	Attestation Statements	• Manufacturer's Declaration of acknowledgement of the Licensing Requirements under Provisions of FCC Part 90 Rules is attached with application • Manufacturer's Declaration of acknowledgement of the Requirements per FCC Section 15.525 is attached with application • Letter from the Applicant to appoint Ultratech to act as an agent • Letter from the Applicant to request for Confidentiality Filing	OK OK OK OK
6	ID Label/Location Info	• ID Label • Location of ID Label	OK
7	Block Diagrams	Block Diagrams	OK
8	Schematic Diagrams	Schematic Diagrams	OK
9	Parts List/Tune Up Info	Parts List	OK
10	Operational Description	Operational Description	OK
11	RF Exposure Info	N/A	N/A
12	Users Manual	Users Manual	OK

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC ET Docket 98-153 & FCC Part 15, Subpart F, Section 15.509
Title	Revision of Part 15 of the Commission's Rules regarding Ultra-Wideband Transmission Systems.
Purpose of Test:	To gain FCC Certification Authorization for Technical Requirements for Low Frequency Imaging Systems operating at 50 MHz, 100 MHz or 200 MHz .
Test Procedures	Both conducted and radiated emissions measurements were conducted in accordance with FCC ET Docket 98-153 and American National Standards Institute ANSI C63.4 - 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.
Imaging System Classification of EUT:	Ground penetrating radar (GPR) system. A field disturbance sensor that is designed to operate only when in contact with the ground for the purpose of detecting or obtaining the images of buried objects or determining the physical properties within the ground. The energy from the GPR is intentionally directed down into the ground for this purpose

2.2. RELATED SUBMITAL(S)/GRANT(S)

None

2.3. NORMATIVE REFERENCES

Publication	YEAR	Title
FCC CFR Parts 0-19	2003	Code of Federal Regulations – Telecommunication
FCC ET Docket 98-153	April 22, 2002	FCC 02-48: Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems.
ANSI C63.4	2003	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
CISPR 22 & EN 55022	2003 2003	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1	2003	Specification for Radio Disturbance and Immunity measuring apparatus and methods

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT:	
Name:	Sensors & Software Inc.
Address:	1040 Stacey Court Mississauga, Ontario Canada, L4W 2X8
Contact Person:	Mr. David Redman Phone #: 905-624-8909 Fax #: 905-624-9365 Email Address: dr@sensoft.ca

MANUFACTURER:	
Name:	Sensors & Software Inc.
Address:	1040 Stacey Court Mississauga, Ontario Canada, L4W 2X8
Contact Person:	Mr. David Redman Phone #: 905-624-8909 Fax #: 905-624-9365 Email Address: dr@sensoft.ca

3.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name	Sensors & Software Inc.
Product Name	Pulse Ekko Pro (50 MHz, 100 MHz and 200 MHz)
Model Name or Number	TLF
Serial Number	Preproduction
Type of Equipment	Low Frequency Imaging Systems (GPR)
Input Power Supply Type	External 12 Volt Battery
Imaging System Classification:	Ground penetrating radar (GPR) system. A field disturbance sensor that is designed to operate only when in contact with the ground for the purpose of detecting or obtaining the images of buried objects or determining the physical properties within the ground. The energy from the GPR is intentionally directed down into the ground for this purpose

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Power Supply Requirement:	12 Vdc Battery
E-Field of the Fundamental RF Carrier:	• 1445.4 µV/m in 1 MHz @ 3meters using 200 MHz Antenna • 2630.3 µV/m @ 3 meters using 100 MHz Antenna • 741.31 µV/m @ 3 meters using 50 MHz Antenna
Operating Frequency Range:	• 10 kHz - 660 MHz using 200 MHz Antenna • 10 kHz - 612 MHz using 100 MHz Antenna • 10 kHz – 733 MHz using 50 MHz Antenna Note: There is no change in setting for rf output frequency and power level for operations of 50, 100 & 200 MHz. The only thing change is transmitter antenna.
Pulse Voltage Ratings for different antennas:	For 200 MHz Antenna: 72 Volts peak For 100 MHz Antenna: 44 Volts peak For 50 MHz Antennal: 20 Volts peak
RF Output Impedance:	50 Ohms
Channel Spacing:	N/A
Pulse Repetition Frequency (PRF):	100 kHz
Pulse Widths	• 60 ns for 200 MHz Antenna • 33 ns for 100 MHz Antenna • 18 ns for 50 MHz Antenna
10 dB Bandwidth:	• 660 MHz for 200 MHz Antenna • 612 MHz for 100 MHz Antenna • 733 MHz for 50 MHz Antenna
Modulation Type:	No modulation
Channel Spacing	N/A
Emission Designation:	• 660MN0N for 200 MHz Antenna • 612MN0N for 100 MHz Antenna • 733MN0N for 50 MHz Antenna
Oscillators' Frequencies:	8 MHz
Antenna Connector Type:	Integral, permanently attached and enclosed inside the enclosure
Antenna Description:	Manufacturer: Sensors & Software Inc. Type: Dipole Frequency Ranges: ▪ 50 MHz Antenna: 19-199 MHz ▪ 100 MHz Antenna: 18-277 MHz ▪ 200 MHz Antenna: 19-396 MHz

▪ *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	12 Vdc external battery supply, RSS-232, QSPI (high speed serial) Port	1	DB37	Shielded

3.5. ANCILLARY EQUIPMENT

None

3.6. GENERAL TEST SETUP

Remarks: All tests were performed with the EUT'a antenna was placed on the 20" thick sand as its intended operation configuration.

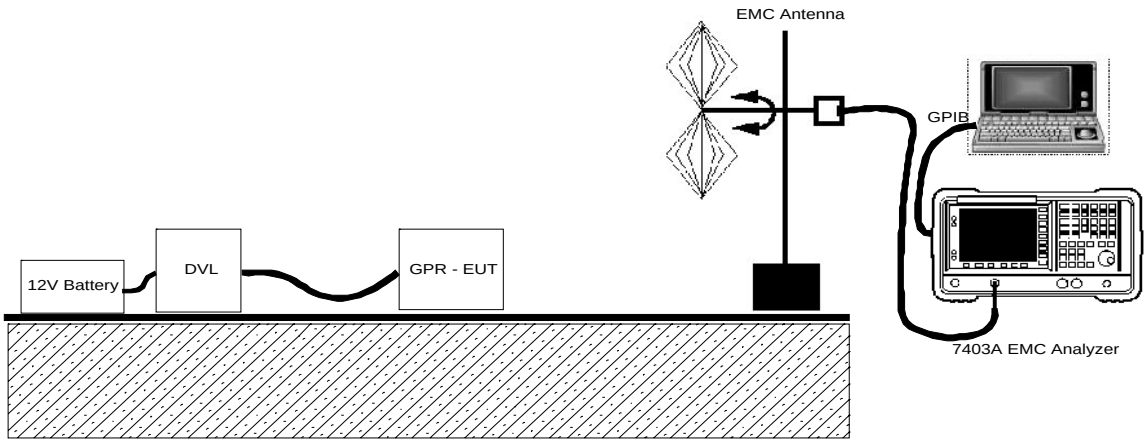


EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	12 Vdc Battery

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	The transmitter was turned and placed on the sand
Special Test Software:	N/A
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as an integral antenna equipment.

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
15.509(a), (b), (c)&(g)	Compliance with General Requirements for Low Frequency Imaging Systems	Yes
15.207	AC Power Line Conducted Emissions Measurements (Transmit & Receive)	N/A for battery operated device
15.509(a)	UBW 10 dB Bandwidth	Yes
15.509(d)&(e)	Transmitter Radiated Emissions - Fundamental, Harmonic and Spurious	Yes
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class A Digital Devices. The engineering test report can be provided upon FCC requests.		

5.2. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

EXHIBIT 6. TEST RESULTS

6.1. COMPLIANCE WITH GENERAL REQUIREMENTS @ FCC 15.509(A), (B), (C) & (G)

6.1.1. FCC Requirements & Compliance Statements:

FCC 15.509	Requirements	Compliance Statements
(a)	The UWB bandwidth of an imaging system operating under the provisions of this Section must be below 10.6 GHz	Conforms
(b)	Operation under the provisions of this section is limited to GPRs and wall imaging systems operated for purposes associated with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction. (1) Parties operating this equipment must be eligible for licensing under the provisions of part 90 of this chapter. (2) The operation of imaging systems under this section requires coordination, as detailed in § 15.525.	Conforms. This device is a GPR operated for the purpose of for purposes associated with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction Please refer to Manufacturer's acknowledgement of compliance with this rule. Please refer to Manufacturer's acknowledgement of compliance with this rule.
(c)	A GPR that is designed to be operated while being hand held and a wall imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.	Not applicable since this GPR is not a handheld device.

6.2. 10 DB OCCUPIED BANDWIDTH @ 15.509(A)

6.2.1. Limits

15.509(a) The upper 10 dB point of UWB bandwidth of an imaging system operating under the provisions of this Section must be below 10.6 GHz.

6.2.2. Method of Measurements

The 10 dB BW was measured with the EUT'a antenna was placed on the 20" thick sand as its intended operation configuration.

- The spectrum analyzer shall be se as follows:
  - Span: Minimum span to fully display the entire emission, approximately 3 x emission BW.
  - Resolution RBW: 1 MHz
  - Video VBW: 3 MHz
  - EMI Detector: Peak
  - Sweep Time: AUTO
  - Trace: Max-hold
  - Frequency span is large enough to display a full spectrum of the RF emission (fundamental)

- The spectrum analyzer was pre-entered with the following correction factors:

  - Antenna correction factor
  - Cable loss
  - Pre-amplifier gain

  and all measurements were corrected to these calibrated values

The EUT was located at 3 meters distance away from the measuring antenna and the RF emissions bandwidth was maximized by the following methods:

(1) Place the measuring antenna in horizontal polarization
(2) The EUT was initially placed in the manner that its antenna is in parallel with the measuring antenna.
(3) The measuring antenna as moved up and down form 1 to 4 meters high to search more the maximum 10 dB BW.
(4) At the maximum 10 dB BW with respect to the antenna height, the EUT was manually rotated in 360 degrees until the maximum 10 dB BW was observed.
(5) The measuring antenna gain was moved up and down from 1 to 4 meters again to ensure the maximum 10 dB BW measured.
(6) Change measuring antenna to vertical polarization and repeated steps (1) through (6) while the Spectrum Analyzer was still in MAXHOLD.
(7) Plot the 10 dB rf emission bandwidth in both horizontal and vertical polarization.

6.2.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Biconilog Antenna	EMCO	3142	10005	30 MHz to 2 GHz
Active Loop Antenna	EMCO	6507	8906-1167	1 kHz – 30 MHz

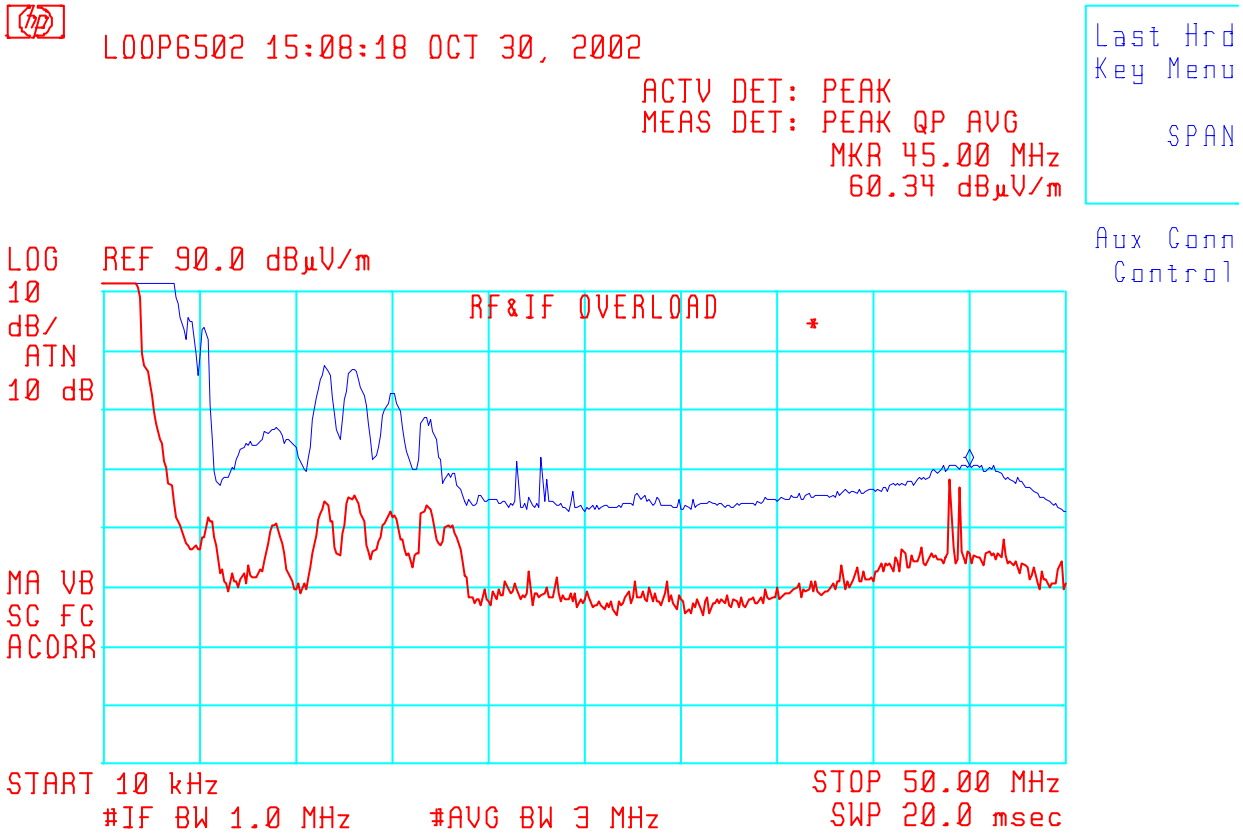
6.2.4. Test Data

Transmitter's Antenna Type	**Rx Antenna Polarization** (V/H)	**Zoom-in Peak Frequency** (MHz)	**10 dB Bandwidth V + H** (MHz)	**Lower and Upper Frequencies at - 10 dB Down Markers**		**Peak E-Field @3m (V+H)**	**PASS/FAIL**
				Lower (MHz)	Upper (MHz)	(dBµV/m) Per 1 MHz RBW	
200 MHz	V & H	288.12	660	0.01 *	660.0	63.2	Pass*
100 MHz	V & H	288.12	612	0.01 *	612.0	58.4	Pass*
50 MHz	V & H	31.0	773	0.01 *	733.0	57.4	Pass*

* The lower 10 dB is only an approximation due to effect of ambient noise from 10 kHz to 20 MHz

** The upper 10 dB points with different antennas were found to be below 10.6 GHz.

Plot #1(a) - Lower 10 dB BW Point of the TLF with 200 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)

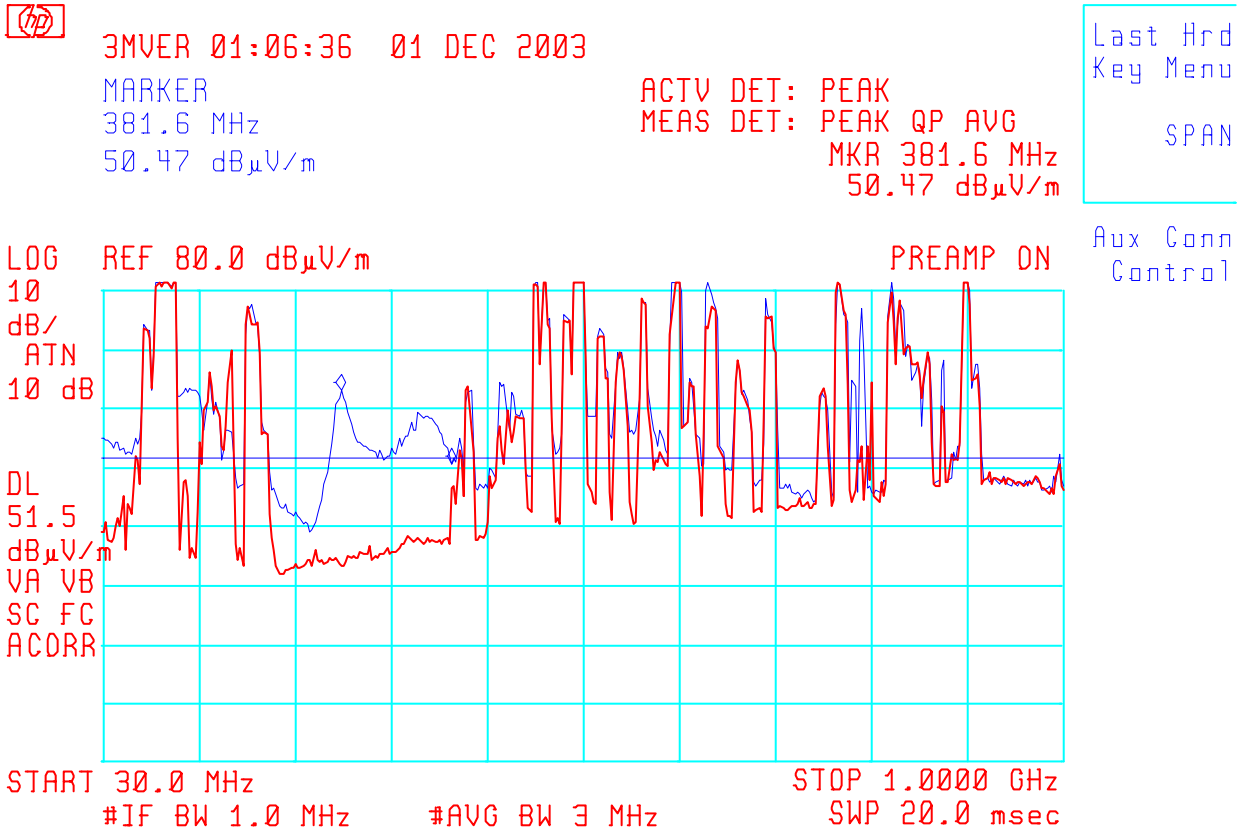


- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot #1(b) - Upper 10 dB BW Point of the TLF with 200 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)

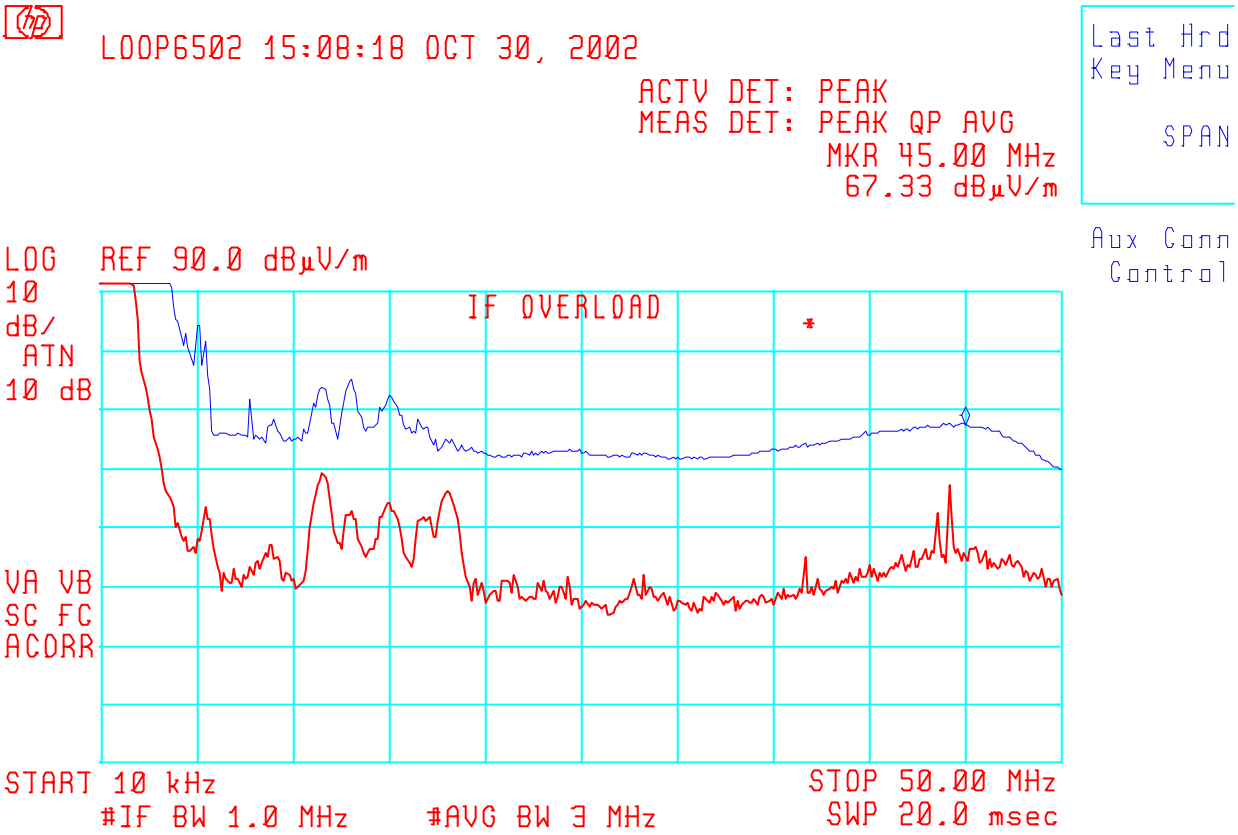
Maker 1: 270.1 MHz in large frequency span or 288.12 MHz in 0 Hz Span, 63.16 dBµV/m (Peak) / 45.1 dBµV/m (QP)

**** 10 dB Point down from the above peak is at 660 MHz approx.**



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot #2(a) - Lower 10 dB BW Point of the TLF with 100 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)



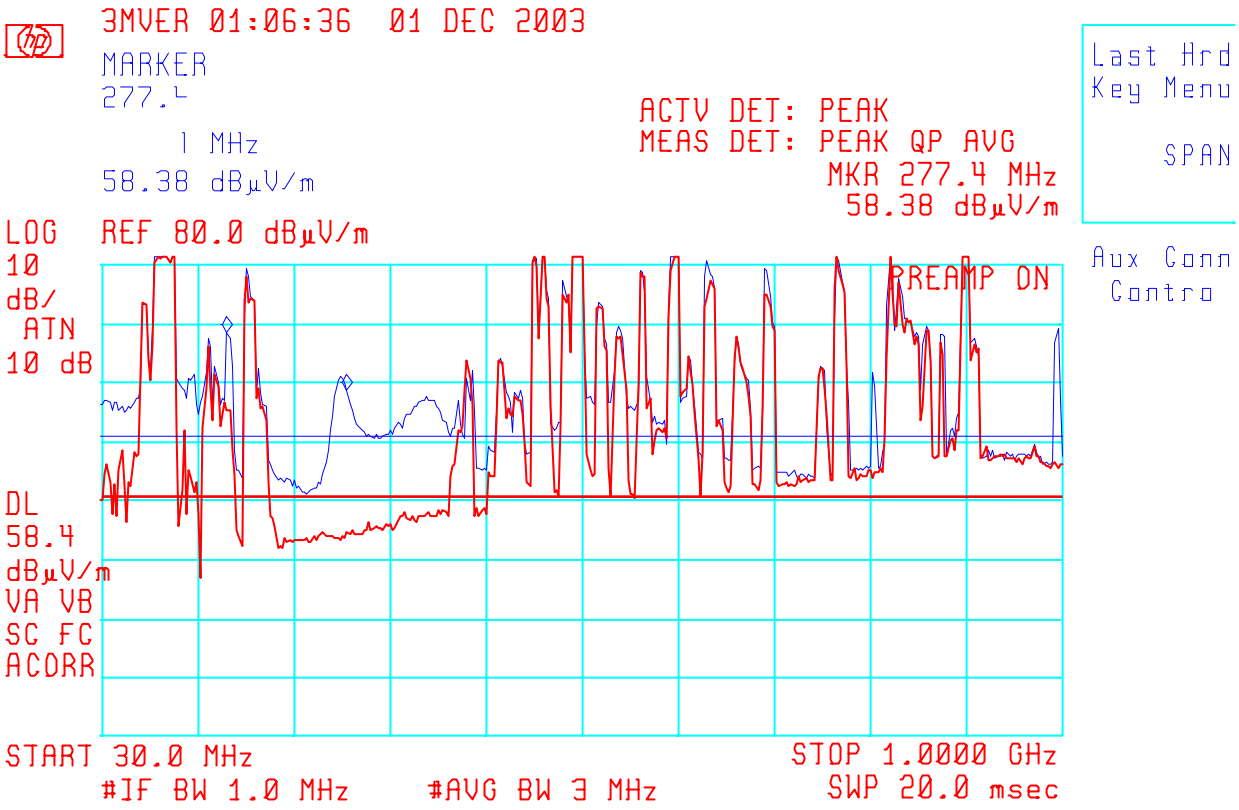
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot #2(b) - Upper 10 dB BW Point of the TLF with 100 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)

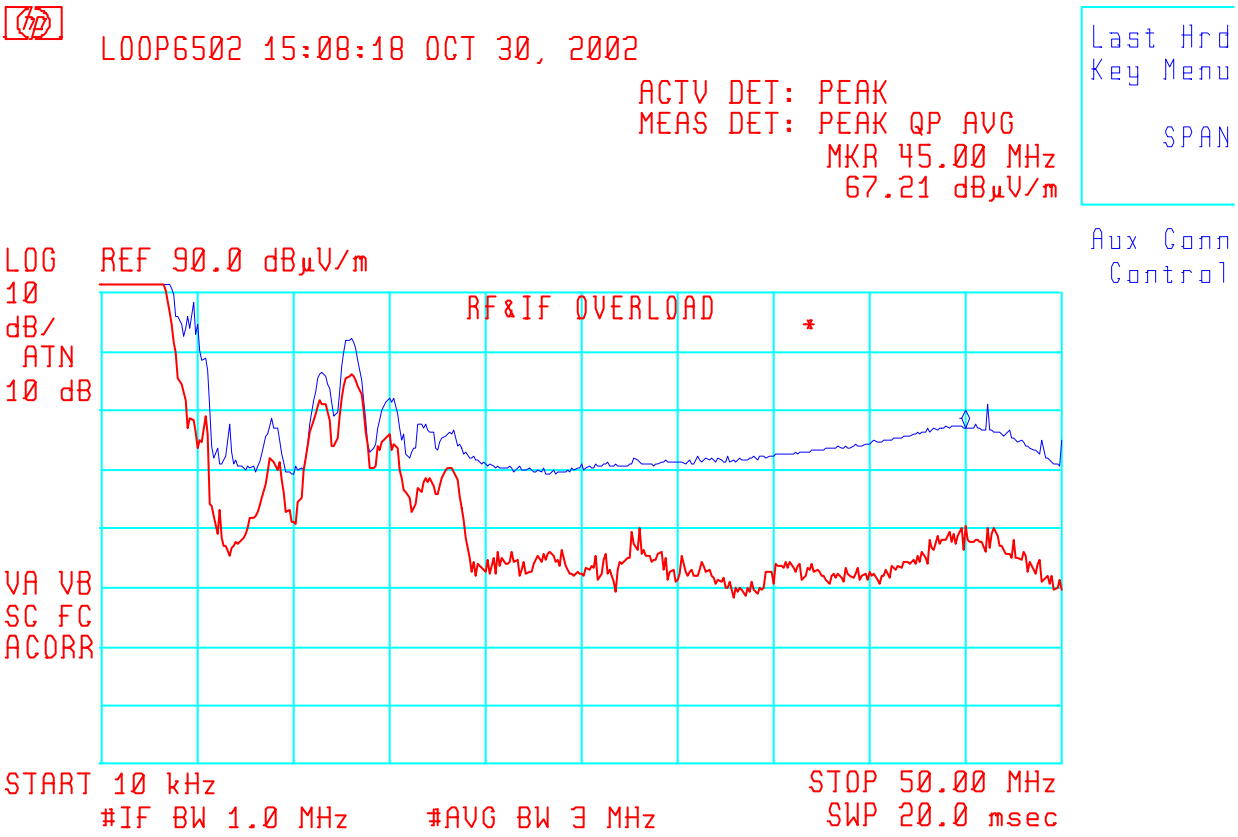
Maker 1: 156.1 MHz, 68.39 dBµV/m (Peak) + ambient
Maker 2: 277.4 MHz in large frequency span or 288.12 MHz in 0 Hz span, 58.38 dBµV/m Peak / 45.1 dBµV/m (QP)

**** 10 dB Point down from the above peak is at 612 MHz approx.**

Note: Sine the E-filed at 156.1 MHz @ Marker 1 was added up by OATS ambient noise, Marker 2 is used as a next peak for measuring 10 dB bandwidth.



Plot #3(a) - Lower 10 dB BW Point of the TLF with 50 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)



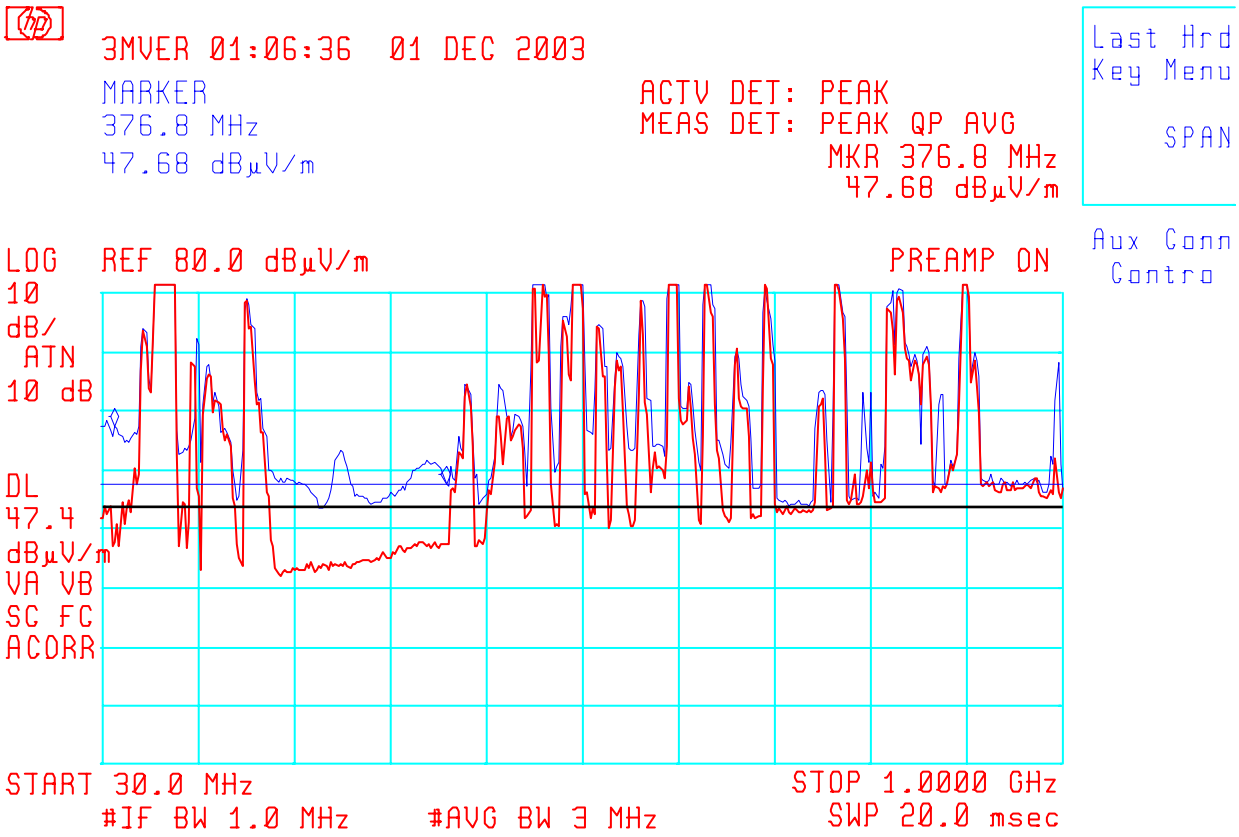
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot #3(b) - Upper 10 dB BW Point of the TLF with 50 MHz Antenna (Antenna @ Vertical & Horizontal Polarizations)

Maker 1: 42.1 MHz in large frequency span or 31 MHz in 0 Hz span
57.4 dBµV/m (Peak) / 39.2 dBµV/m (QP

**** 10 dB Point down from the above peak is at 733 MHz approx.**

Note: Sine the E-filed at 421 MHz @ Marker 1 was added up by OATS intermittent ambient noise in a large displayed frequency span, the peak at 125 MHz was used as a next peak for measuring 10 dB bandwidth.



6.3. TRANSMITTER SPURIOUS EMISSIONS (RADIATED @ 3 METERS) @ FCC 15.509(D), (E) & (F)

6.3.1. Limits

15.509(d) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209 of this chapter. 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:

FCC CFR 47, Part 15, Subpart C, Sec. 15.209(a) - Limits for Frequency below 960 MHz

FREQUENCY (MHz)	FIELD STRENGTH LIMITS (microvolts/m)	Measuring RBW	DISTANCE (Meters)
0.009 - 0.490	2,400 / F (KHz)	1 kHz	300
0.490 - 1.705	24,000 / F (KHz)	9 kHz	30
1.705 - 30.0	30	9 kHz	30
30 - 88	100	120 kHz	3
88 - 216	150	120 kHz	3
216 - 960	200	120 kHz	3

FCC CFR 47, Part 15, Subpart F, Sec. 15.509(d) - Limits for Frequency above 960 MHz

Frequency in MHz	EIRP Limits in dBm @ 1 MHz BW	Alternative E-Field Limits in dBm @ 3m @ 1 MHz BW
960-1610	-65.3	29.9
1610-1990	-53.3	41.9
1990-3100	-51.3	43.9
3100-10600	-41.3	53.9
Above 10600	-51.3	43.9

15.509(e) In addition to the radiated emission limits specified in the above table, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

FCC CFR 47, Part 15, Subpart F, Sec. 15.509(e) - Limits for Frequency above 960 MHz

Frequency in MHz	EIRP Limits in dBm @ 1 KHz	Alternative E-Field Limits in dBm @ 3m @ 1 KHz BW
1164-1240	-75.3	19.9
1559-1610	-75.3	19.9

15.509(f) For UWB devices where the frequency at which the highest radiated emission occurs, f_M, is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in § 15.521

15.521(g) When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, f_M. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBμV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

6.3.2. Method of Measurements

Refer to Exhibit 8, of this test report, FCC ET Docket 98-152 and **ANSI 63.4-1992** for detailed radiated emissions measurement procedures.

6.3.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz to 32 GHz with external mixer for frequency above 32 GHz
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz
Rod Antenna	EMCO	3301B		30 Hz to 50 MHz
Biconical Antenna	Agilent	11955A		30 Mhz to 300 MHz
Log Periodic	Agilent	11966N		300 MHz to 5.0 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz

6.3.4. Photographs of Test Setup

Refer to the Photographs #1 in Annex 1 for setup and arrangement of equipment under tests and its ancillary equipment.

6.3.5. Test Data

Remarks: All tests were performed with the EUT'a antenna was placed on the 20" thick sand as its intended operation configuration.

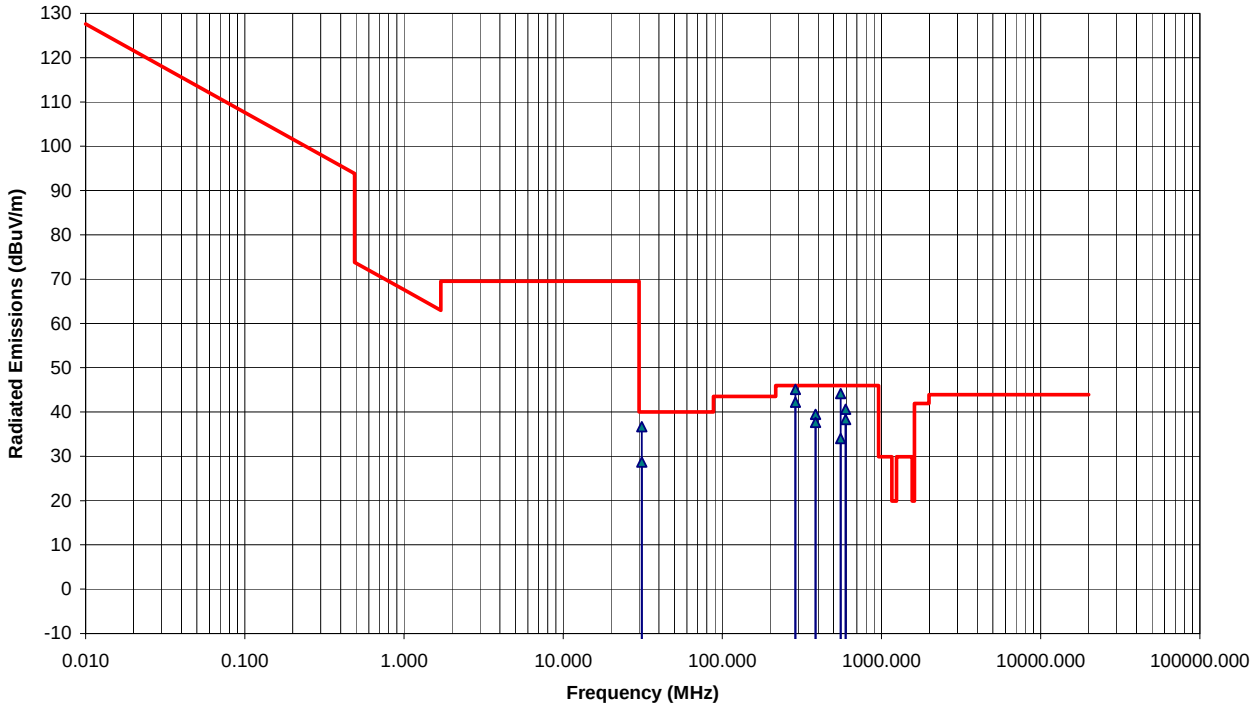
6.3.5.1. TLF with 200 MHz Antenna – Radiated Emissions at 3 meters distance

- **Test Site**: The radiated emissions tests were performed at Ultratech's OATS. The EUT was placed on a 20" thick medium fine sand.
- Tests were performed with the EUT in contact with the ground as its intended use. Operation of EUT, which is elevated above the ground, is not permitted by manufacturer, Please prefer to Users Manual for operation instruction.
- The emissions were scanned from 10 kHz to 2 GHz and all emissions within 20 dB below the limits were recorded.
- For frequency below 906 MHz, the emissions were measured using the EMI Quasi-Peak Detector, RBW =120 kHz, VBW = 1 MHz
- For Frequency above 960 MHz and outside the below frequency bands, the emissions were measured using RMS Detector, RBW = 1MHz, VBW = 1MHz
- For frequencies fall inside 960-1610, 1610-1990 MHz bands, the emissions were measured using RMS Detector, RBW = 1 MHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.
- For frequencies fall inside 1164-1240 and 1559-1610 MHz, the emissions were measured using RMS Detector, RBW = 1 KHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.

FREQUENCY (MHz)	RF LEVEL LEVEL (dBuV/m)	EMI DETECTOR (PEAK/QP/RMS)	RBW (MHz)	ANTENNA PLANE (H/V)	LIMIT 15.209 * 15.509 (dBuV/m)	LIMIT MARGIN (dB)	PASS/ FAIL	Distance (m)
31.17	36.7	QP	0.120	V	40.0	-3.3	PASS	3
31.17	28.7	QP	0.120	H	40.0	-11.3	PASS	3
* 270.10	37.5	QP	0.120	V	46.0	-8.5	PASS	3
* 270.10	36.7	QP	0.120	H	46.0	-9.3	PASS	3
* 288.12	45.1	QP	0.120	V	46.0	-0.9	PASS	3
* 288.12	42.2	QP	0.120	H	46.0	-3.8	PASS	3
385.55	39.5	QP	0.120	V	46.0	-6.5	PASS	3
385.55	37.7	QP	0.120	H	46.0	-8.3	PASS	3
553.48	44.2	QP	0.120	V	46.0	-1.8	PASS	3
553.48	34.0	QP	0.120	H	46.0	-12.0	PASS	3

*** Note:** .In zoom-in measurement, for example 0 Hz @ QP, the actual peak was found to be 288.12 MHz instead of 277.1 MHz as shown in Plot 1(b) measured in a very large frequency span (30-1000 MHz).

Transmitter Radiated Emissions Measurements at 3m OFTS
Sensors & Software Inc.
Pulse Ekko 100 with 200 MHz Antenna



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

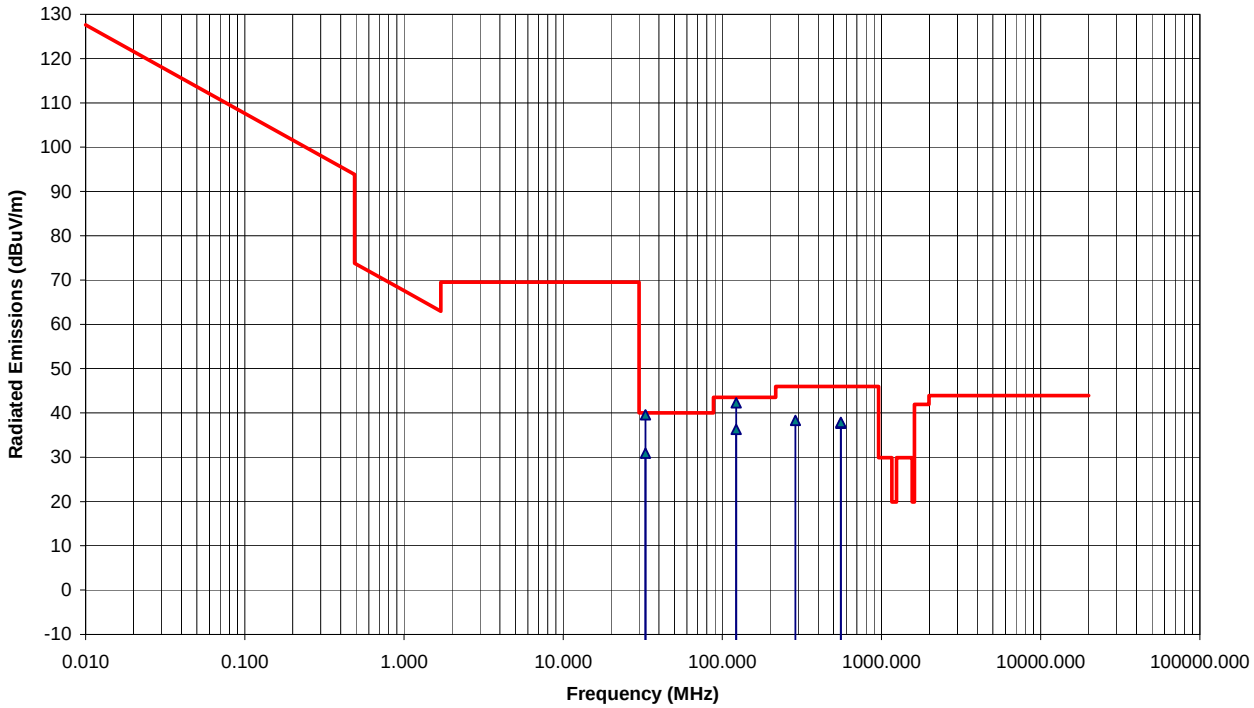
6.3.5.2. TLF with 100 MHz Antenna – Radiated Emissions at 3 meters distance

- **Test Site**: The radiated emissions tests were performed at Ultratech's OATS. The EUT was placed on a 20" thick medium fine sand.
- Tests were performed with the EUT in contact with the ground as its intended use. Operation of EUT, which is elevated above the ground, is not permitted by manufacturer, Please prefer to Users Manual for operation instruction.
- The emissions were scanned from 10 kHz to 2 GHz and all emissions within 20 dB below the limits were recorded.
- For frequency below 906 MHz, the emissions were measured using the EMI Quasi-Peak Detector, RBW =120 kHz, VBW = 1 MHz
- For Frequency above 960 MHz and outside the below frequency bands, the emissions were measured using RMS Detector, RBW = 1MHz, VBW = 1MHz
- For frequencies fall inside 960-1610, 1610-1990 MHz bands, the emissions were measured using RMS Detector, RBW = 1 MHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.
- For frequencies fall inside 1164-1240 and 1559-1610 MHz, the emissions were measured using RMS Detector, RBW = 1 KHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.

FREQUENCY (MHz)	RF LEVEL LEVEL (dBuV/m)	EMI DETECTOR (PEAK/QP/RMS)	RBW (MHz)	ANTENNA PLANE (H/V)	LIMIT 15.209 * 15.509 (dBuV/m)	LIMIT MARGIN (dB)	PASS/ FAIL	Distance (m)
32.86	39.6	QP	0.120	V	40.0	-0.4	PASS	3
32.86	30.9	QP	0.120	H	40.0	-9.1	PASS	3
122.22	42.3	QP	0.120	V	43.5	-1.2	PASS	3
122.22	36.3	QP	0.120	H	43.5	-7.2	PASS	3
* 156.10	40.6	QP	0.120	V	43.5	-2.9	PASS	3
* 156.10	39.2	QP	0.120	H	46.0	-4.3	PASS	3
288.12	35.4	QP	0.120	V	46.0	-10.6	PASS	3
288.12	38.3	QP	0.120	H	46.0	-7.7	PASS	3
555.32	37.7	QP	0.120	V	46.0	-8.3	PASS	3
555.32	37.9	QP	0.120	H	46.0	-8.1	PASS	3

* **Note**: The measurement at this frequency is not considered as peak as zoom-in span because of the OATS ambient noise (64.6 dBuV/m at maximized position)

Transmitter Radiated Emissions Measurements at 3m OFTS
Sensors & Software Inc.
Pulse Ekko 100 with 100 MHz Antenna



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

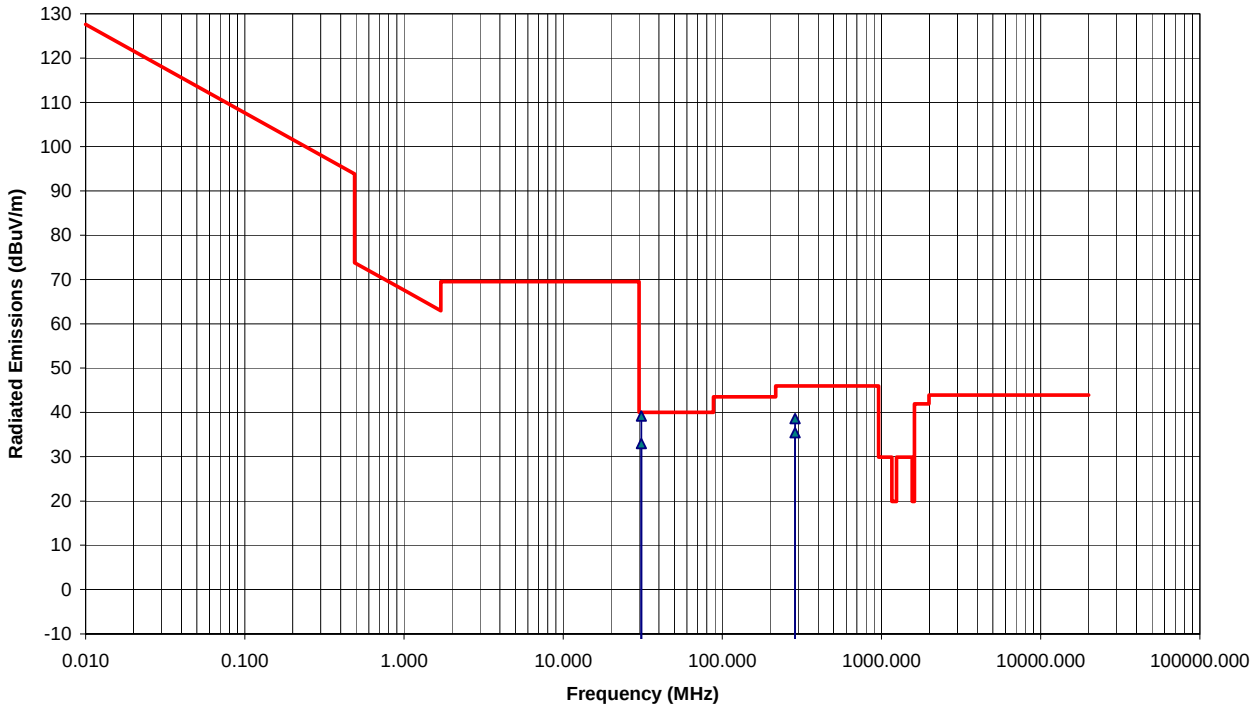
6.3.5.3. TLF with 50 MHz Antenna – Radiated Emissions at 3 meters distance

- **Test Site**: The radiated emissions tests were performed at Ultratech's OATS. The EUT was placed on a 20" thick medium fine sand.
- Tests were performed with the EUT in contact with the ground as its intended use. Operation of EUT, which is elevated above the ground, is not permitted by manufacturer, Please prefer to Users Manual for operation instruction.
- The emissions were scanned from 10 kHz to 2 GHz and all emissions within 20 dB below the limits were recorded.
- For frequency below 906 MHz, the emissions were measured using the EMI Quasi-Peak Detector, RBW =120 kHz, VBW = 1 MHz
- For Frequency above 960 MHz and outside the below frequency bands, the emissions were measured using RMS Detector, RBW = 1MHz, VBW = 1MHz
- For frequencies fall inside 960-1610, 1610-1990 MHz bands, the emissions were measured using RMS Detector, RBW = 1 MHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.
- For frequencies fall inside 1164-1240 and 1559-1610 MHz, the emissions were measured using RMS Detector, RBW = 1 KHz, VBW = 1 MHz. The measurements were performed at 1 meter distance since they were not measurable at 3 meters, the results were converted to equivalence at 3 meters by a correction factor of -9.5 dB.

FREQUENCY (MHz)	RF LEVEL LEVEL (dBuV/m)	EMI DETECTOR (PEAK/QP/RMS)	RBW (MHz)	ANTENNA PLANE (H/V)	LIMIT 15.209 * 15.509 (dBuV/m)	LIMIT MARGIN (dB)	PASS/ FAIL	Distance (m)`
* 31.00	39.2	QP	0.120	V	40.0	-0.8	PASS	3
* 31.00	33.0	QP	0.120	H	40.0	-7.0	PASS	3
286.30	38.6	QP	0.120	V	46.0	-7.4	PASS	3
286.30	35.4	QP	0.120	H	46.0	-10.6	PASS	3
376.80	32.8	QP	0.120	V	46.0	-13.2	PASS	3
376.80	30.2	QP	0.120	H	46.0	-15.8	PASS	3
418.00	32.1	QP	0.120	H	46.0	-13.9	PASS	3

*** Note**: In zoom-in measurement, , for example 0 Hz @ QP, the actual peak was found to be 31 MHz instead of 42.1 MHz as shown in Plot 3(b) measured in a very large frequency span (30-1000 MHz)

Transmitter Radiated Emissions Measurements at 3m OFTS
Sensors & Software Inc.
Pulse Ekko 100 with 50 MHz Antenna



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	±1.0	±1.0
Cable Loss Calibration	Normal (k=2)	±0.3	±0.5
EMI Receiver specification	Rectangular	±1.5	±1.5
Antenna Directivity	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center variation	Rectangular	0.0	±0.2
Antenna factor frequency interpolation	Rectangular	±0.25	±0.25
Measurement distance variation	Rectangular	±0.6	±0.4
Site imperfections	Rectangular	±2.0	±2.0
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67$(Bi) 0.3 (Lp) Uncertainty limits $20\text{Log}(1\pm\Gamma_1\Gamma_R)$	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k=2 is used:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

EXHIBIT 8. EMISSIONS TEST PROCEDURES

8.1. BACKGROUND

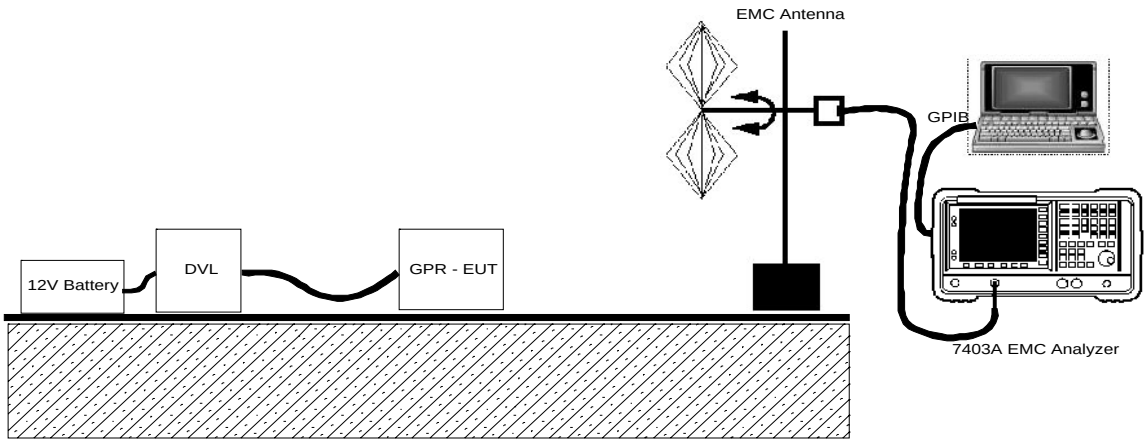
This section describes the procedures and equipment used to perform the emissions testing performed by Ultratech Engineering Labs Inc.. The focus of this measurement program was to characterize the complete emissions spectra.

Measurements were performed with the GPR transmitting antenna directly on the ground sand surface as the EUT's intended operation for measuring the unintentional radiated emissions.

8.2. TEST SITES

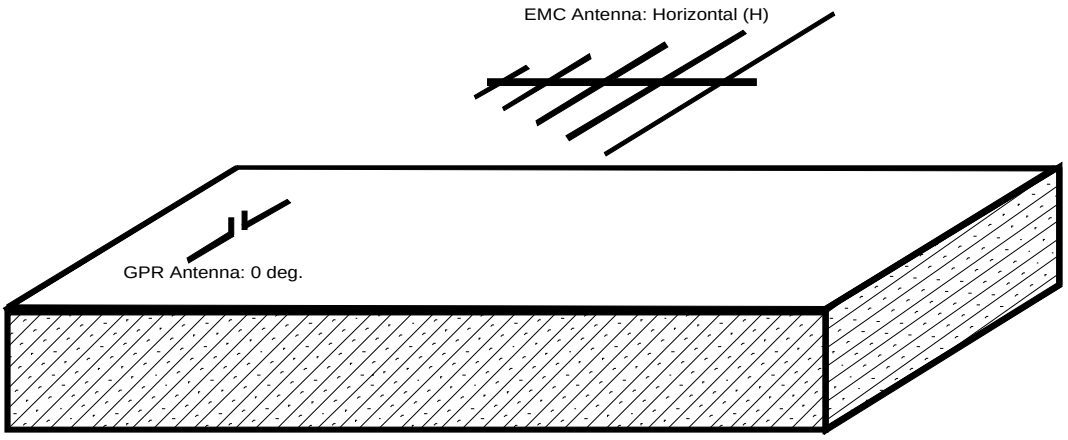
The radiated emissions tests were performed on a medium to fine sand test site at the facility of Ultratech Engineering Labs Inc.. The emissions testing equipment was setup using a configuration similar to that shown in Figure 2-1 and Figure 2-2.

Figure 2-1: Block diagram of EMC measurement configuration for radiated emissions testing.

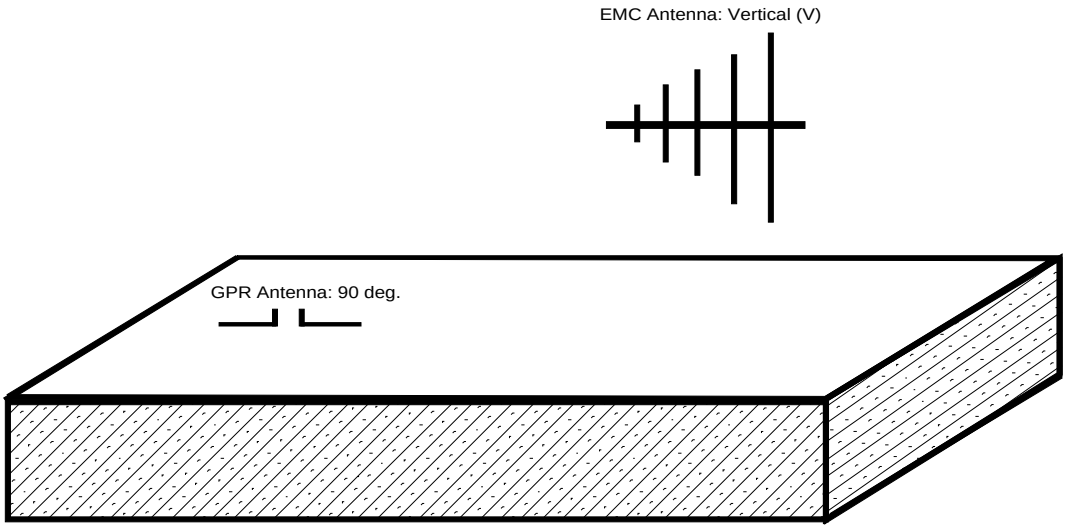


- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Figure 2-3: Endfire and broadside measurement modes.



Broadside Mode



Endfire Mode

8.3. EMISSIONS TEST CONFIGURATIONS

All tested GPR systems were measured using these test configurations with the GPR transmitter on (transmitting) and off (not transmitting). The GPR transmitters were operated at their highest pulse repetition frequencies (PRF). Two main antenna orientation configurations were employed during the EMC testing. In the broadside configuration the EMC antenna direction is horizontal and parallel to the GPR transmitting dipole direction In the endfire mode the GPR transmitting dipole is horizontal and rotated 90° with respect to the direction in the broadside mode and the EMC antenna is oriented in the vertical direction as indicated in Figure 2-3.

The GPR transmitting antenna was rotated in the horizontal plane to confirm that the indicated endfire and broadside modes produced the highest emissions.

To meet the limit requirements of part 15.509(f) (0 dBm in a resolution bandwidth (RBW) of 50 MHz) a 3 MHz RBW was used. As stated in 15.521 (g) this is acceptable if the peak EIRP limit is reduced to 20 log(RBW/50). The limit is reduced from 0 dBm for a 50 MHz RBW to -24.4 dBm for a 3 MHz RBW or 70.8 dBμV/m in 3 MHz BW measured at 3 meters.