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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,



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

Encl



31040/SIT



C-1376



46390-2049



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00-034



entela

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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

Encl

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

Tested by: Manuel D'Oliveira, Ultratech Eng. Labs Inc
And David Redman Sensors & Software Inc.

Issued Date: April 12, 2004

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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00-034



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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

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File #: SES-020FCC15UWB

April 12, 2004

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

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:	<u>Ground penetrating radar (GPR) system</u> . 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:	<u>Ground penetrating radar (GPR) system.</u> 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 $\mu\text{V/m}$ in 1 MHz @ 3meters using 200 MHz Antenna • 2630.3 $\mu\text{V/m}$ @ 3 meters using 100 MHz Antenna • 741.31 $\mu\text{V/m}$ @ 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 <u>Note:</u> 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

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's antenna was placed on the 20" thick sand as its intended operation configuration.

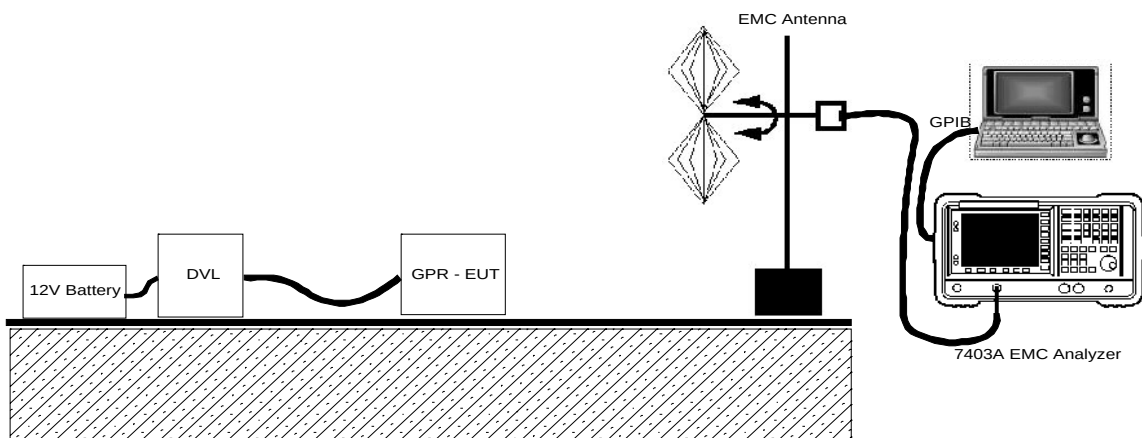


EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

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's antenna was placed on the 20" thick sand as its intended operation configuration.

- The spectrum analyzer shall be set 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 was moved up and down from 1 to 4 meters high to search for 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)



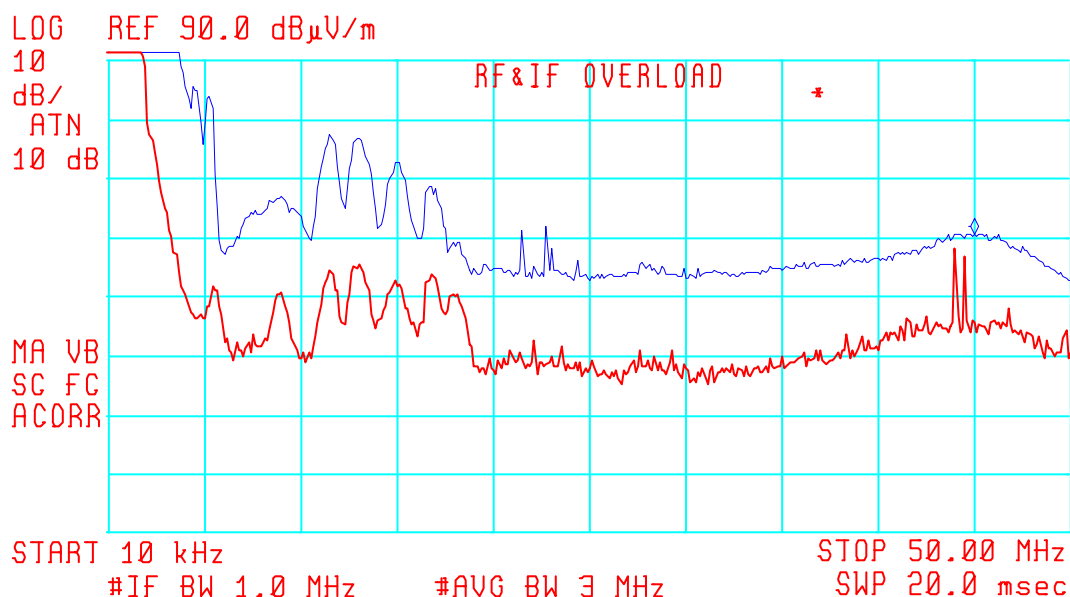
LOOP6502 15:08:18 OCT 30, 2002

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 45.00 MHz
60.34 dB μ V/m

Last Hrd
Key Menu

SPAN

Aux Conn
Control



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File #: SES-020FCC15UWB

April 12, 2004

- 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 dB μ V/m (Peak) / 45.1 dB μ V/m (QP)

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



3MVER 01:06:36 01 DEC 2003

MARKER

381.6 MHz

50.47 dB μ V/m

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 381.6 MHz

50.47 dB μ V/m

Last Hrd
Key Menu

SPAN

Aux Conn
Control

LOG REF 80.0 dB μ V/m

10
dB/
ATN
10 dB

DL
51.5
dB μ V/m
VA VB
SC FC
ACORR

PREAMP ON

START 30.0 MHz

#IF BW 1.0 MHz

#AVG BW 3 MHz

STOP 1.0000 GHz

SWP 20.0 msec

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

(72)

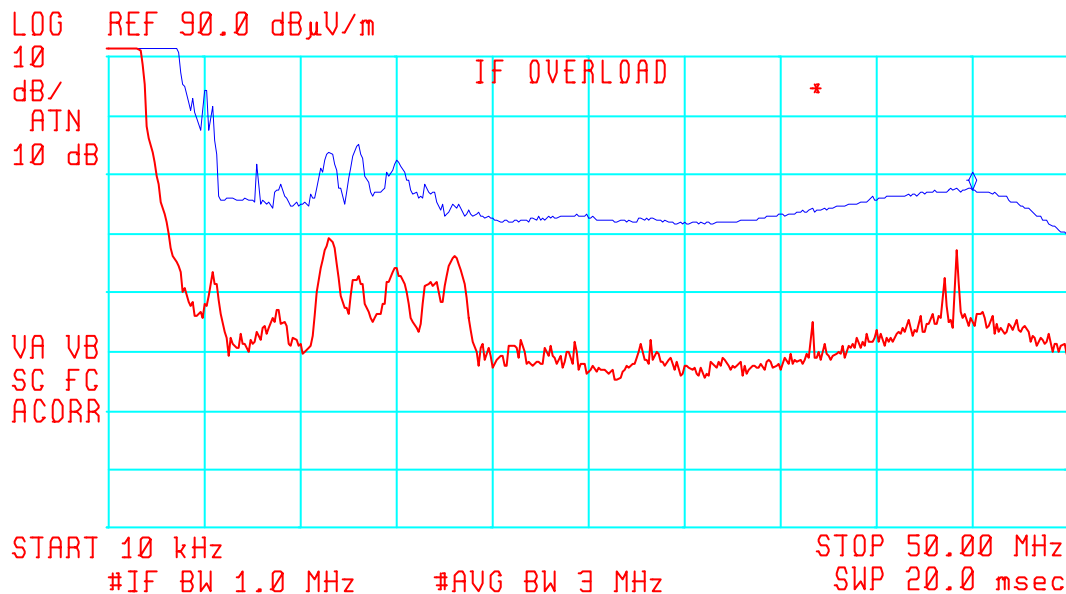
L00P6502 15:08:18 OCT 30, 2002

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 45.00 MHz
67.33 dB μ V/m

Last Hrd
Key Menu

SPAN

Aux Conn
Control



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April 12, 2004

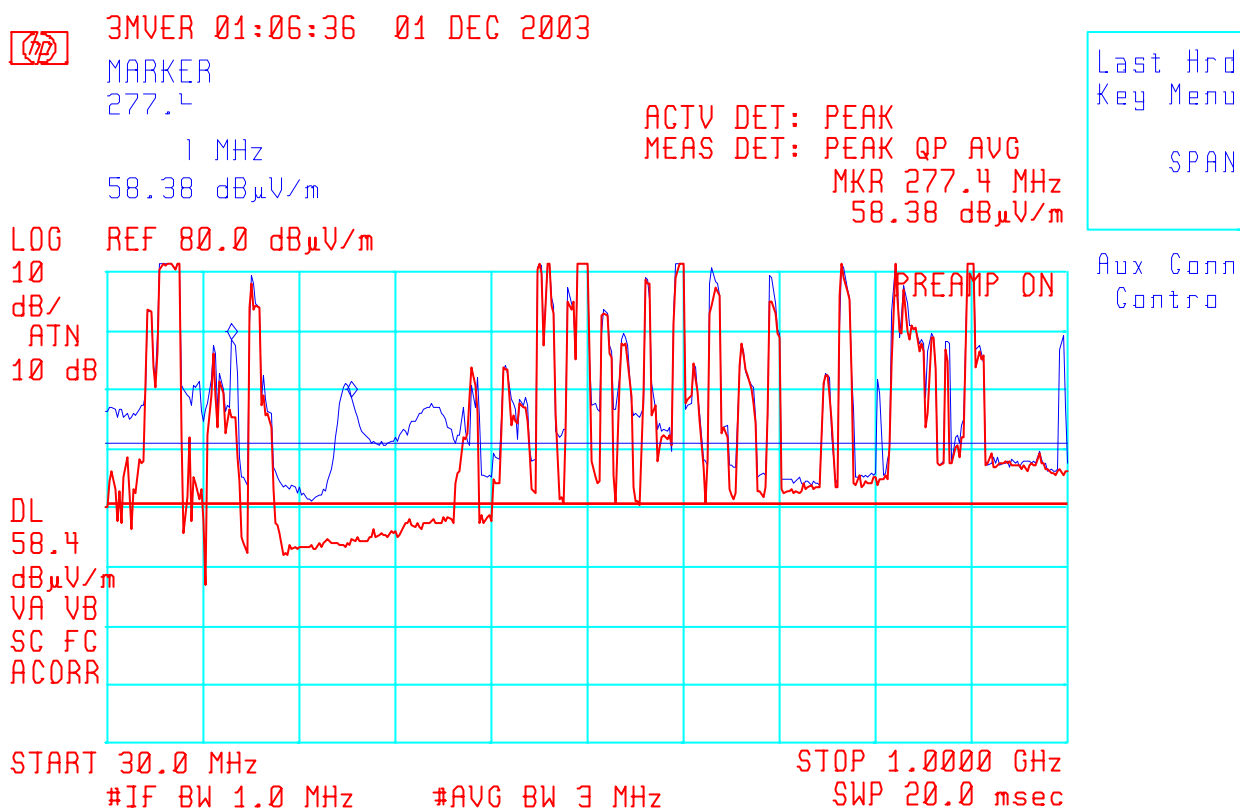
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

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 dB μ V/m (Peak) + ambient
 Maker 2: 277.4 MHz in large frequency span or 288.12 MHz in 0 Hz span,
 58.38 dB μ V/m Peak / 45.1 dB μ V/m (QP)

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

Note: Since 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.



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File #: SES-020FCC15UWB
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**Plot #3(a) - Lower 10 dB BW Point of the TLF with 50 MHz Antenna
(Antenna @ Vertical & Horizontal Polarizations)**



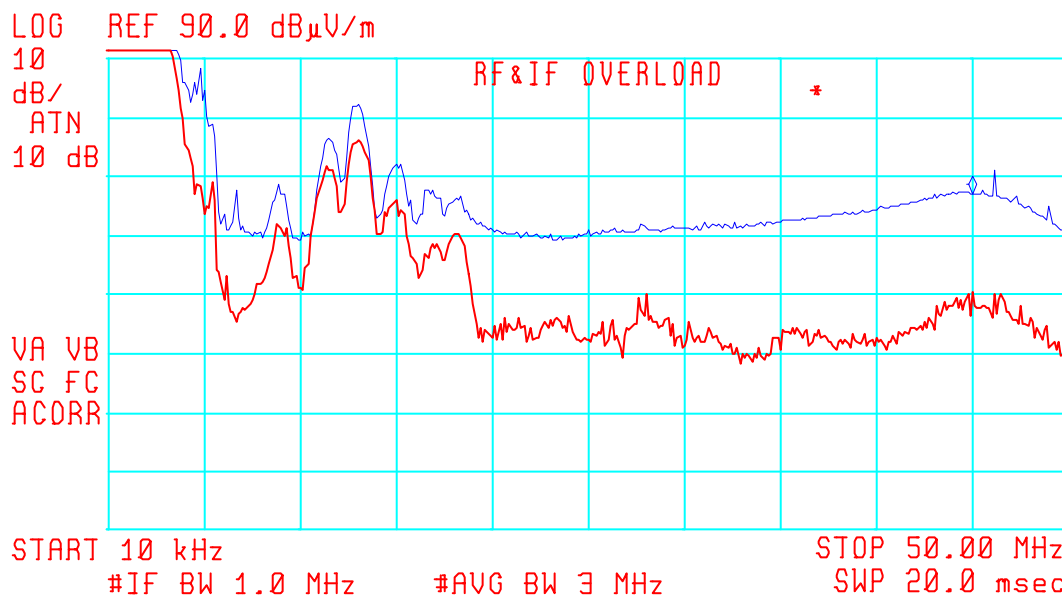
LOOP6502 15:08:18 OCT 30, 2002

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 45.00 MHz
67.21 dB μ V/m

Last Hrd
Key Menu

SPAN

Aux Conn
Control



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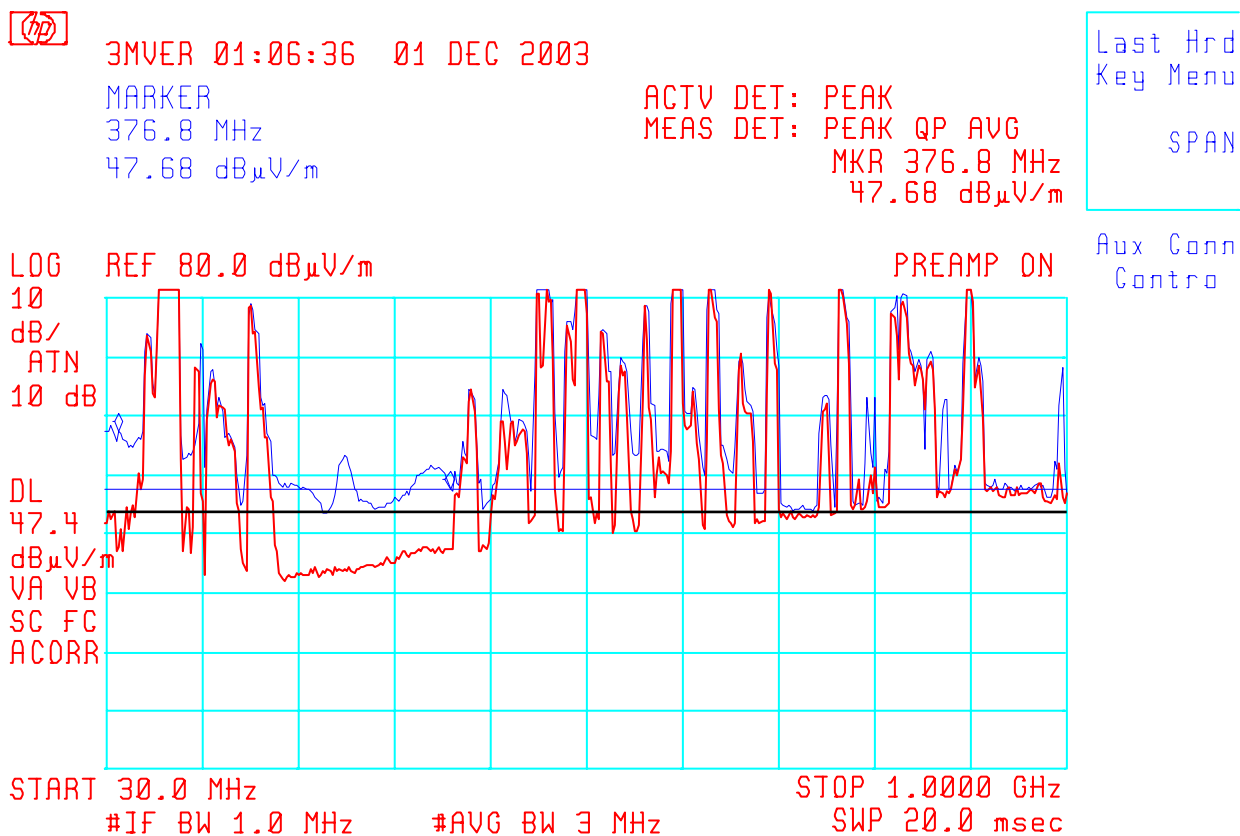
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

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

Marker 1: 42.1 MHz in large frequency span or 31 MHz in 0 Hz span
57.4 dB μ V/m (Peak) / 39.2 dB μ V/m (QP)

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

Note: Since 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.



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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 $E(dB_{\mu V/m}) = P(dBm \text{ EIRP}) + 95.2$. 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's 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 refer 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).

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The graph displays the radiated emissions of a Class B amplifier across a wide frequency range. The red line shows the emission level in dBuV/m, which starts at approximately 128 dBuV/m at 0.010 MHz and decreases to about 44 dBuV/m at 100,000 MHz. The blue arrows indicate the measured levels of the 5th, 7th, 9th, 11th, and 13th harmonics, which are significantly lower than the fundamental frequency emission.

Frequency (MHz)	Radiated Emissions (dBuV/m)	Component
0.010	128	Fundamental
0.100	108	Fundamental
0.500	94	Fundamental
0.500	73	Fundamental
1.000	68	Fundamental
1.500	63	Fundamental
1.500	70	Fundamental
30.000	70	Fundamental
30.000	40	Fundamental
100.000	40	Fundamental
100.000	43	Fundamental
300.000	43	Fundamental
300.000	46	Fundamental
1000.000	46	Fundamental
1000.000	30	Fundamental
1000.000	20	Fundamental
1000.000	20	Fundamental
1000.000	30	Fundamental
1000.000	42	Fundamental
10000.000	42	Fundamental
100000.000	44	Fundamental
30.000	37	5th Harmonic
30.000	28	5th Harmonic
300.000	44	7th Harmonic
300.000	38	7th Harmonic
500.000	44	9th Harmonic
500.000	38	9th Harmonic
700.000	41	11th Harmonic
700.000	34	11th Harmonic
1000.000	41	13th Harmonic
1000.000	34	13th Harmonic

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 refer 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)

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The graph displays the radiated emissions of a 100W transmitter across a frequency range from 0.01 MHz to 100,000 MHz. The y-axis represents the radiated emissions in dBuV/m, ranging from -10 to 130. The x-axis represents the frequency in MHz on a logarithmic scale. The red line shows the emission profile, which is a stepped function. It starts at 128 dBuV/m at 0.01 MHz, decreases to 94 dBuV/m at 0.5 MHz, then to 73 dBuV/m at 1 MHz, and continues with steps down to 40 dBuV/m at 30 MHz, up to 45 dBuV/m at 100 MHz, down to 30 dBuV/m at 1.5 MHz, and finally up to 44 dBuV/m at 3 MHz. Blue arrows indicate the noise floor at 30 dBuV/m from 30 MHz to 1.5 MHz.

Frequency (MHz)	Radiated Emissions (dBuV/m)
0.01	128
0.5	94
1	73
2	63
30	40
100	45
1.5	30
3	44

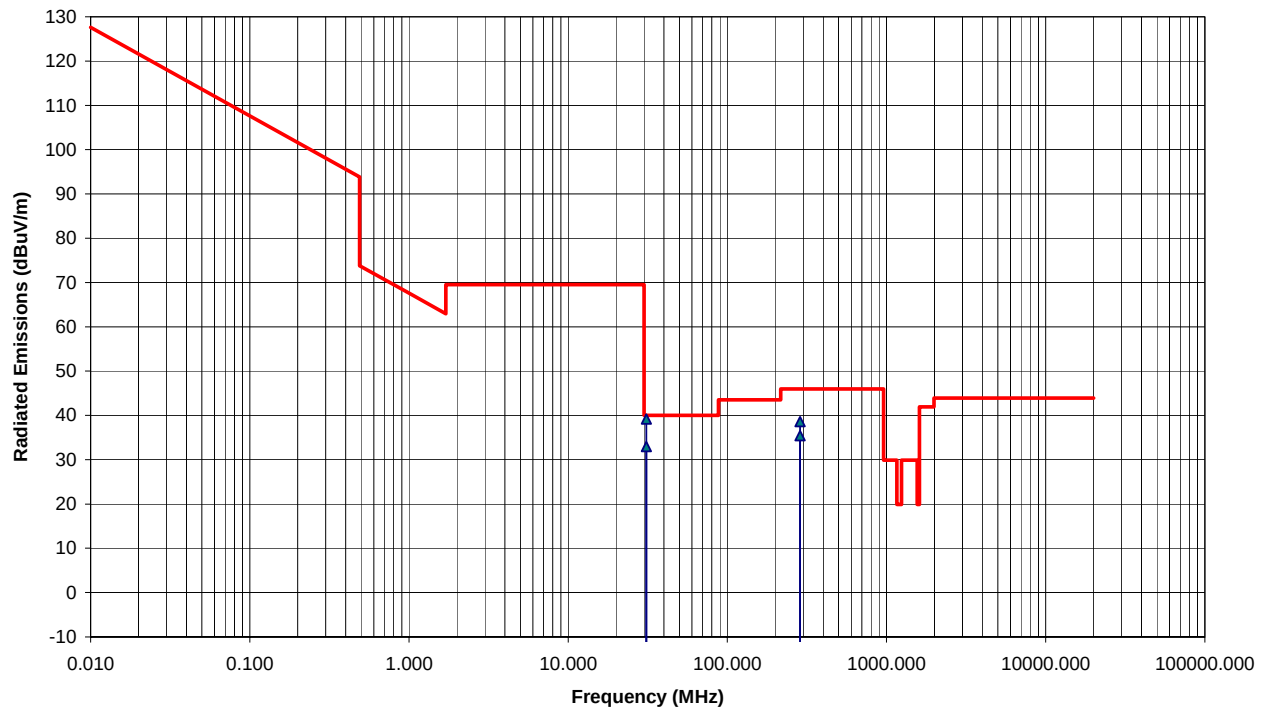
6.3.5.3. TLF with 50 MHz Antenna – Radiated Emissions at 3 meters distance

- **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 refer 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



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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 ($\pm$ 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 $\Gamma_R = 0.67(\text{Bi}) 0.3 (\text{Lp})$ Uncertainty limits $20\text{Log}(1+\Gamma_1\Gamma_R)$	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:

$$U = 2u_c(y) = 2x(+2.19) = +4.38 \text{ dB} \quad \text{And} \quad U = 2u_c(y) = 2x(-2.21) = -4.42 \text{ dB}$$

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.

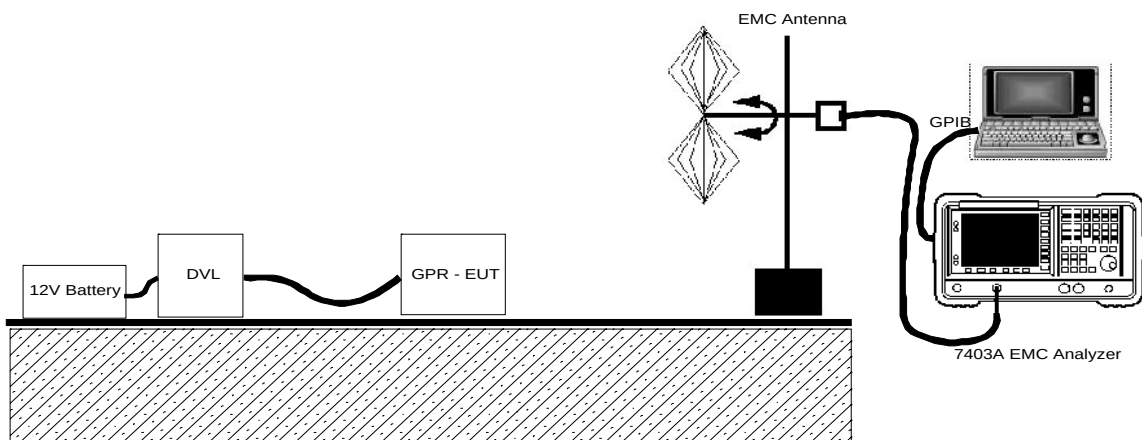
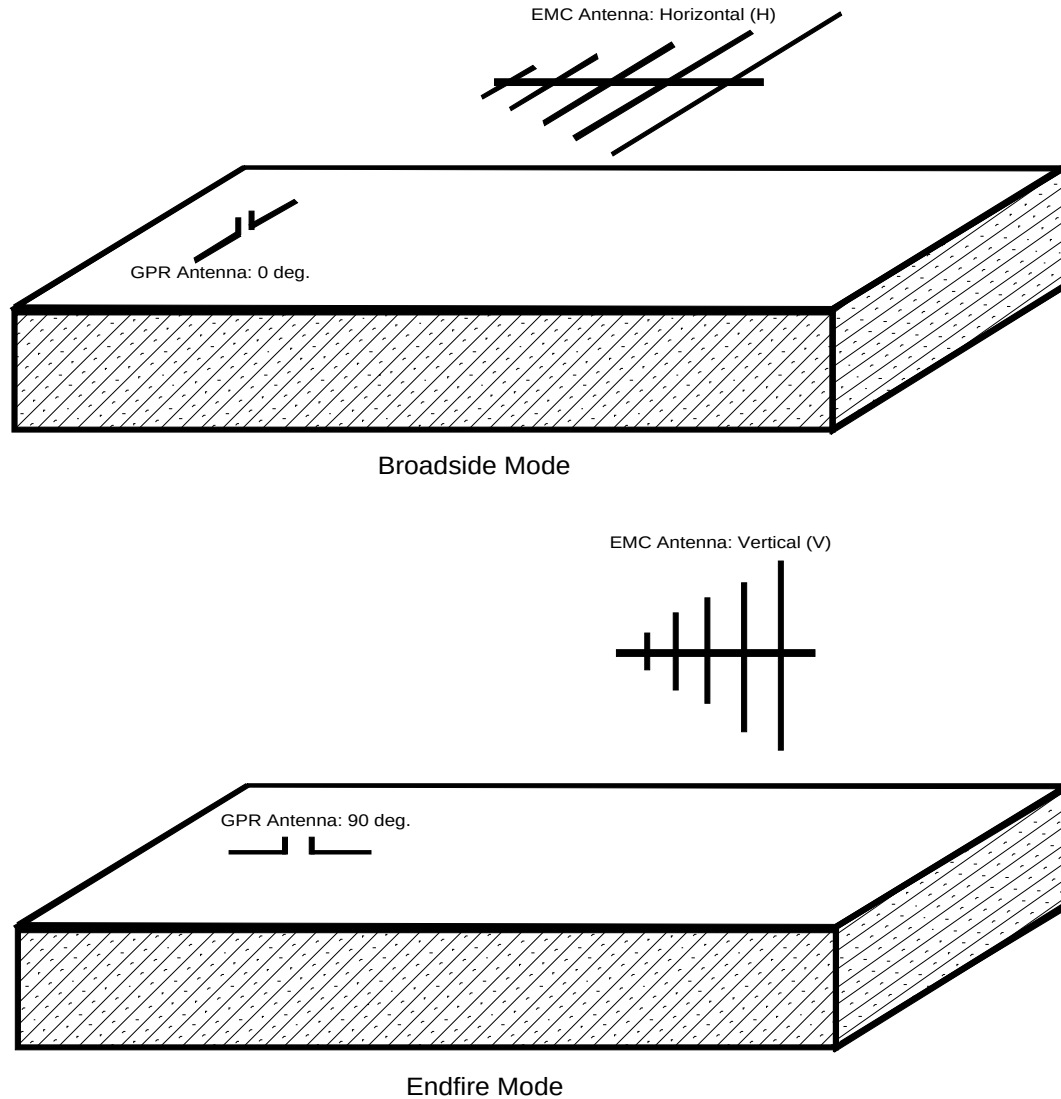


Figure 2-3: Endfire and broadside measurement modes.



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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 $20 \log(\text{RBW}/50)$. The limit is reduced from 0 dBm for a 50 MHz RBW to -24.4 dBm for a 3 MHz RBW or 70.8 dB μ V/m in 3 MHz BW measured at 3 meters.