ENGINEERING TEST REPORT

Noggin 500
Model No.: Noggin 500

FCC ID: QJQ-NOGGIN500

Applicant: **Sensors & Software Inc.**
1091 Brevik Place
Mississauga, Ontario
Canada, L4W 3R7

In Accordance With

FEDERAL COMMUNICATIONS COMMISSION (FCC)
PART 15, SUBPART F, SEC. 15.509
Technical Requirements for Low Frequency Imaging Systems operating at 500 MHz center frequency, 10 dB BW = 589.3 MHz

UltraTech's File No.: SES-012FCC15UWB

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: Sep. 04, 2002	
Report Prepared by: Tri Luu Issued Date: Sep. 04, 2002	Tested by: Manuel D'Oliveira at Ultratech Engineering And Mr. David Redman at Sensors Software Test Dates: July 24-25, 2002

- *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.*

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

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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	Photo # 1	OK
2	External Photos of EUT	Photos # 1 to 2	OK
3	Internal Photos of EUT	Photos of 1 to 11	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
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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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 500 MHz center frequency, 10 dB BW = 589.3 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	2001	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	1992	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	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1		Specification for Radio Disturbance and Immunity measuring apparatus and methods
FCC Public Notice DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval

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EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT:	
Name:	Sensors & Software Inc.
Address:	1091 Brevik Place Mississauga, Ontario Canada, L4W 3R7
Contact Person:	Mr. David Redman Phone #: 905-624-8909 Fax #: 905-624-9365 Email Address: dr@sensoft.ca

MANUFACTURER:	
Name:	Sensors & Software Inc.
Address:	1091 Brevik Place Mississauga, Ontario Canada, L4W 3R7
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	Noggin 500
Model Name or Number	Noggin 500
Serial Number	0000-0556-0003
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
RF Output Power Rating:	67.9 dBuV/m at 3 m or -27.3 dBm/MHz EIRP
Operating Frequency Range:	119 - 580 MHz (-10 dB points)
RF Output Impedance:	50 Ohms
Channel Spacing:	N/A
Pulse Repetition Frequency (PRF):	91.5 kHz
10 dB Bandwidth:	589.3 MHz
Modulation Type:	No modulation
Channel Spacing	N/A
Emission Designation:	589M3N0N
Oscillators' Frequencies:	18.432 MHz and 8 MHz
Antenna Connector Type:	Integral, permanently attached and enclosed inside the enclosure
Antenna Description:	Manufacturer: Sensor Software Type: Patented Dipole Frequency Range: 250-750 MHz

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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

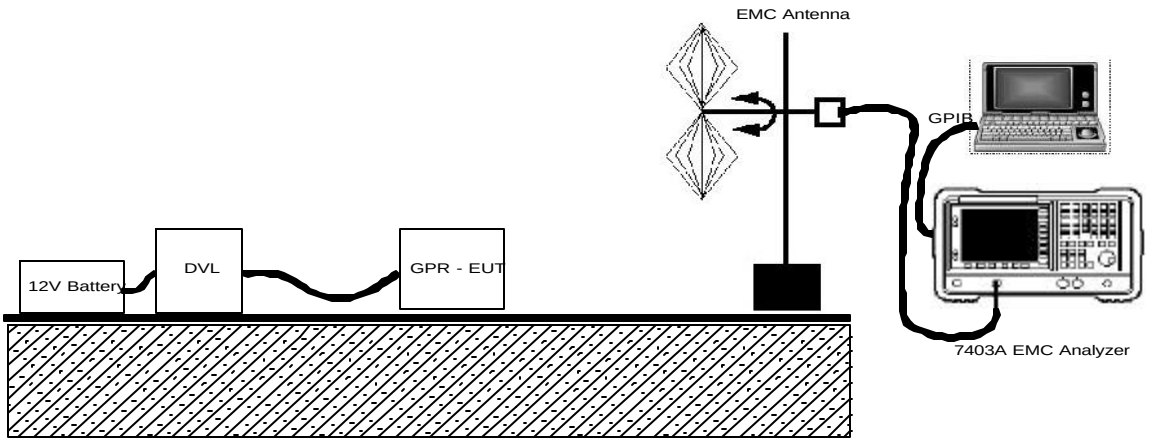

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EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

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
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

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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 960 MHz.	Conforms. The -10 dB Bandwidth showed the upper -10 dB point 580 MHz
(b)(1)	GPRs and wall imaging systems operated by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, or by construction companies	Conforms.
(b)(2)	Through-wall imaging systems operated by law enforcement, fire or emergency rescue organizations	N/A for this GPR Imaging Device
(b)(3)	Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of our rules.	Manufacturer's Declaration of acknowledgement of the Licensing Requirements under Provisions of FCC Part 90 Rules is attached with application
(b)(4)	The operation of imaging systems under this section requires coordination, as detailed in Section 15.525 of this chapter	Manufacturer's Declaration of acknowledgement of the Requirements per FCC Section 15.525 is attached with application
(g)	Imaging systems operating under the provisions of this section shall bear the following or similar statement, as adjusted for the specific provisions in paragraph (b) of this section, in a conspicuous location on the device: 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.	Please see the attached FCC ID label with this FCC Warning.

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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 960 MHz.

6.2.2. Method of Measurements

The 10 dB BW was measured with the EUT was placed on the 20" thick sand as intended operation and the measuring antenna was on the ground plane which was extended upto the EUT

- 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) Plot the rf emission bandwidth at its maximum value.
(7) Change measuring antenna to vertical polarization and repeated steps (1) through (6)

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

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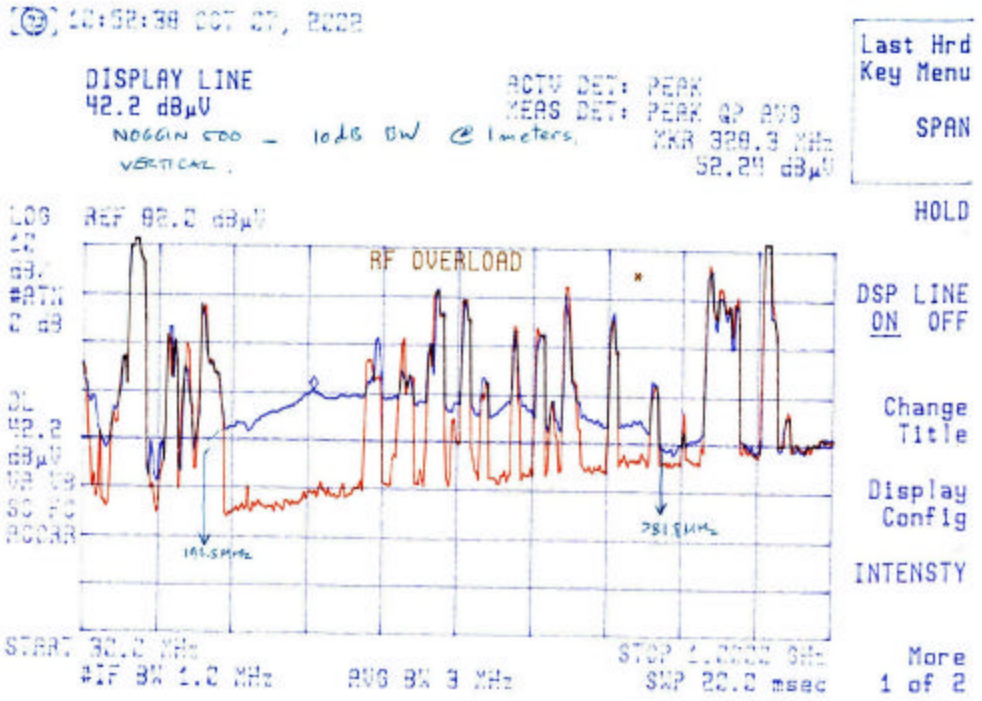
6.2.4. Test Data

CHANNEL FREQUENCY (MHz)	Rx Antenna Polarization (V/H)	10 dB Bandwidth (MHz)	Lower and Upper Frequencies at -20 dB Down Markers		-10 dB Upper Limit Frequency (MHz)	PASS/FAIL
			Lower (MHz)	Upper (MHz)		
500	V	589.3	192.5	781.8	960	PASS
500	H	577.1	161.0	738.1	960	PASS



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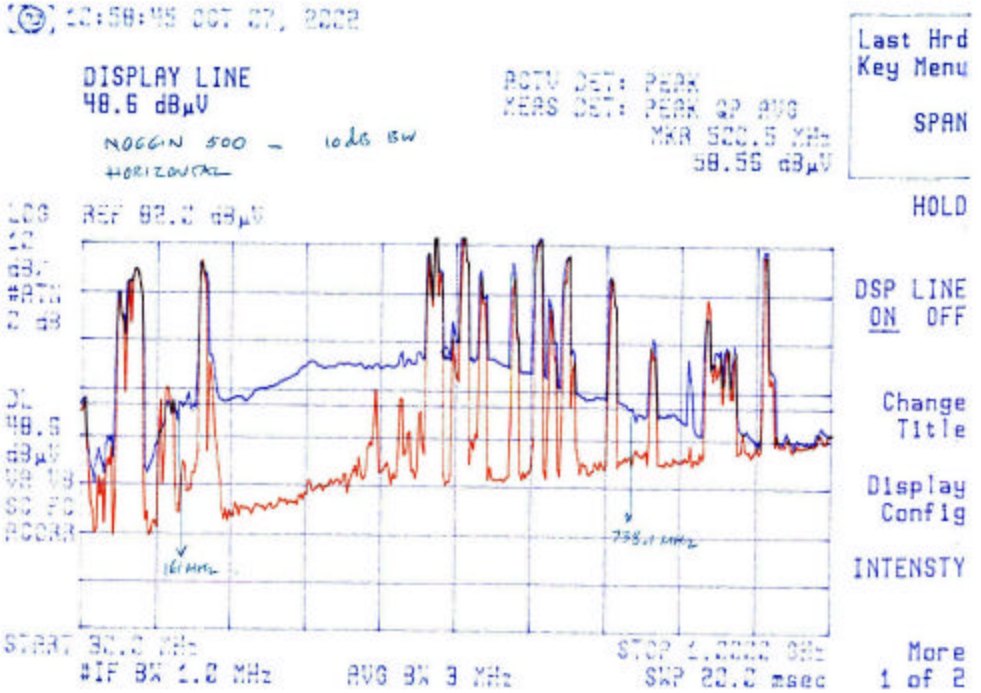
DISPLAY LINE
48.6 dBµV
NOGGIN 500 – 10dB BW
HORIZONTAL
MKR 522.5 MHz
58.55 dBµV
Last Hrd Key Menu
SPAN
HOLD
DSP LINE ON OFF
Change Title
Display Config
INTENSTY
More 1 of 2
#IF BW 1.0 MHz
AVG BW 3 MHz
SWP 22.0 msec

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)	10 kHz	30
1.705 - 30.0	30	10 kHz	30
30 - 88	100	100 kHz	3
88 - 216	150	100 kHz	3
216 - 960	200	100 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
Above 1990	-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 10,600 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) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M. That limit is 0 dBm EIRP/50MHz {or -24.4 dBm/3 MHz BW or 70.8 dBμV/m)}. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521(g) as follows:

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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

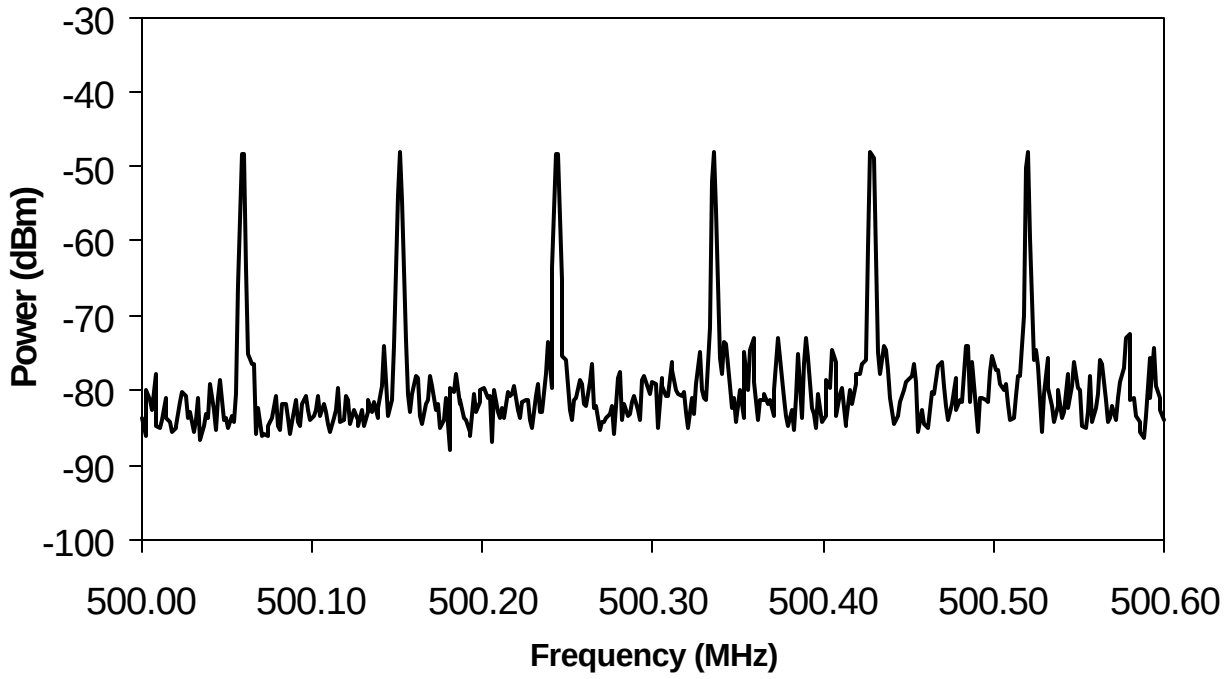
6.3.4. Photographs of Test Setup

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

6.3.5.1. Pulse Repetition Frequency

The boresite configuration used for measuring the radiated spectrum was also used to measure the PRF. The EMC analyzer was set to a small frequency spread centered near the peak of the radiated spectrum and the resolution bandwidth was set to 300 Hz..



PRF measurements for Noggin 500 system. Measured PRF was 91.5 kHz.

6.3.5.2. Radiated Emissions with the EUT in Direct Contact with the Sand Soil Ground Plane

- **Test Site**: The radiated emissions tests were performed on a medium to fine sand test site at Canadian Forces Base (CFB) Borden
- 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 5000 MHz and all emissions within 30 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 EMI Average Detector, RBW = 1MHz, VBW = 1MHz
- For frequencies fall inside 960-1610, 1610-1990 MHz bands, the emissions were measured using EMI RMS Average 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 EMI RMS Average 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 PEAK 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)
45.00	36.6	QP	0.120	V	40.0	-3.4	PASS	3
99.00	21.8	QP	0.120	H	43.5	-21.7	PASS	3
158.00	25.7	QP	0.120	H	43.5	-17.8	PASS	3
256.00	31.2	QP	0.120	H	46.0	-14.8	PASS	3
487.00	**55.1**	**PEAK**	**3.000**	**H**	**70.8**	**-15.7**	**PASS**	**3**
487.00	34.8	QP	0.120	V	46.0	-11.2	PASS	3
487.00	**55.1**	**PEAK**	**3.000**	**H**	**70.8**	**-15.7**	**PASS**	**3**
487.00	33.6	QP	0.120	H	46.0	-12.4	PASS	3
530.00	36.0	QP	0.120	H	46.0	-10.0	PASS	3
575.00	35.4	QP	0.120	V	46.0	-10.6	PASS	3
586.00	34.8	QP	0.120	H	46.0	-11.2	PASS	3
598.00	34.8	QP	0.120	H	46.0	-11.2	PASS	3
620.00	34.1	QP	0.120	V	46.0	-11.9	PASS	3
758.00	33.3	QP	0.120	V	46.0	-12.7	PASS	3
848.00	28.8	QP	0.120	H	46.0	-17.2	PASS	3
1170.00	-0.4	RMS	0.001	H	19.9	-20.3	PASS	3
1170.00	-0.6	RMS	0.001	V	19.9	-20.5	PASS	3
1190.00	-0.3	RMS	0.001	H	19.9	-20.2	PASS	3
1190.00	-0.4	RMS	0.001	V	19.9	-20.3	PASS	3
1210.00	1.7	RMS	0.001	H	19.9	-18.2	PASS	3
1210.00	-0.1	RMS	0.001	V	19.9	-20.0	PASS	3
1230.00	0.8	RMS	0.001	V	19.9	-19.1	PASS	3
1560.00	6.8	RMS	0.001	H	19.9	-13.1	PASS	3
1560.00	5.0	RMS	0.001	V	19.9	-14.9	PASS	3
1570.00	8.2	RMS	0.001	H	19.9	-11.7	PASS	3
1570.00	4.0	RMS	0.001	V	19.9	-15.9	PASS	3
1580.00	8.7	RMS	0.001	H	19.9	-11.2	PASS	3
1580.00	5.1	RMS	0.001	V	19.9	-14.8	PASS	3
1590.00	8.4	RMS	0.001	H	19.9	-11.5	PASS	3
1590.00	3.4	RMS	0.001	V	19.9	-16.5	PASS	3
1600.00	7.2	RMS	0.001	H	19.9	-12.7	PASS	3
1600.00	6.8	RMS	0.001	V	19.9	-13.1	PASS	3

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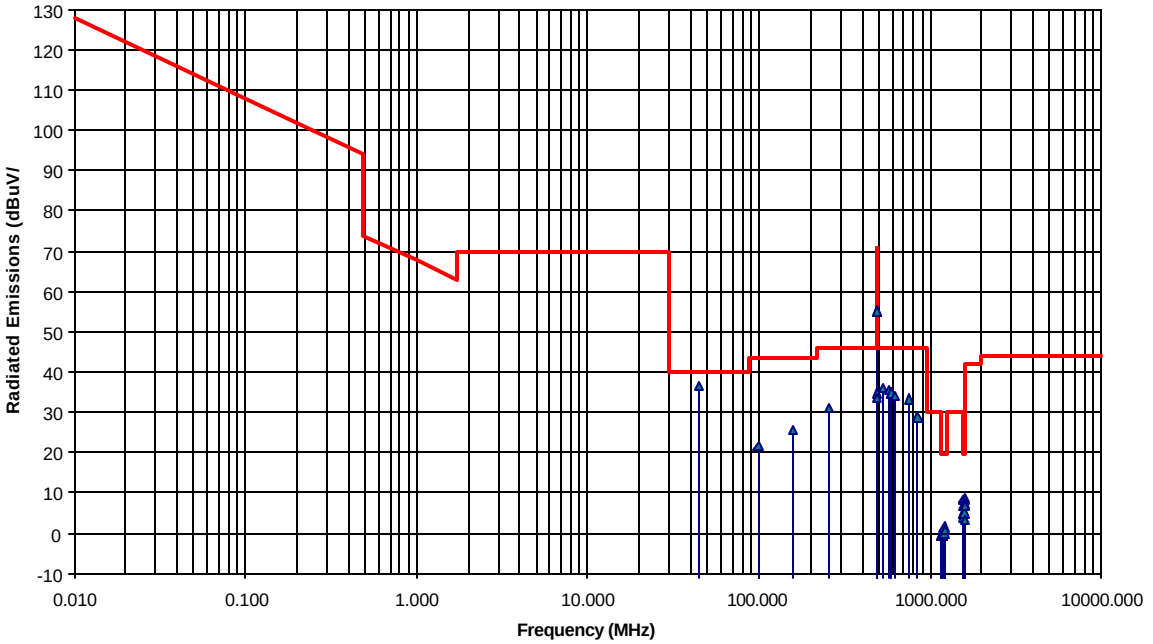
Transmitter Radiated Emissions Measurements at 3m OFTS
Sensors & Software Inc.
Noggin 500



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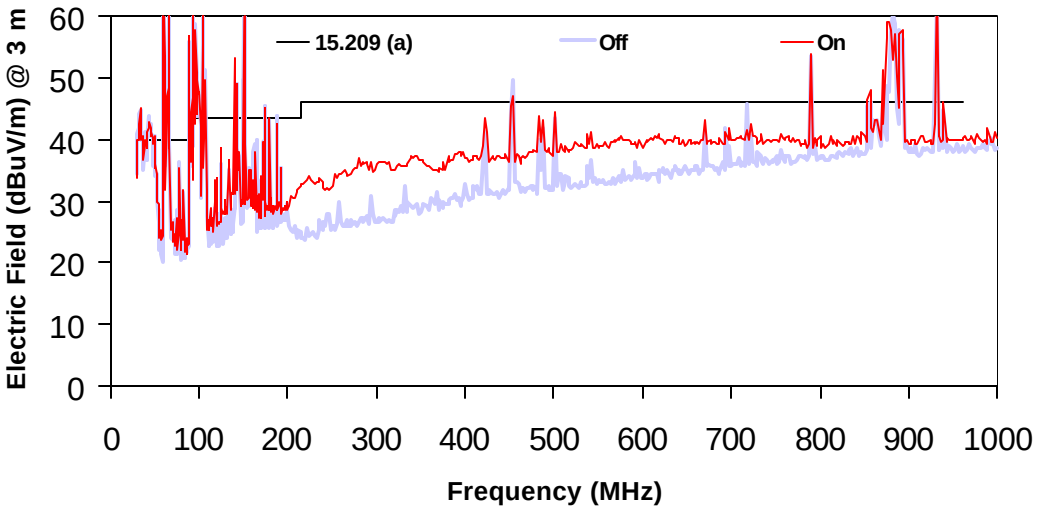
15.209 Tests

These measurements were performed with a separation of 3 m between the GPR transmitter and the EMC antenna. The data presented have a 4.7 dB correction factor added. Measurements were performed on sand at the CFB Borden test site.

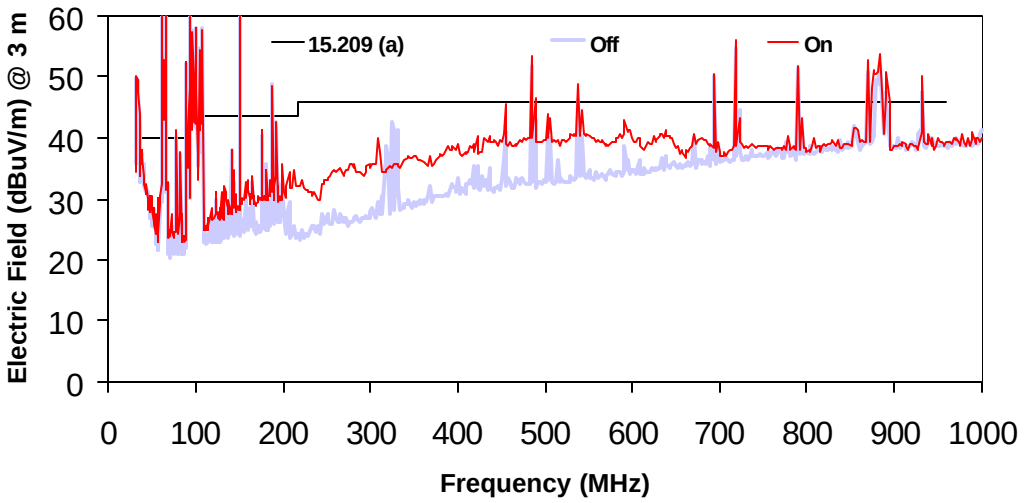
Test: 15.209

RBW: 120 kHz Sweep Time: 5 s Detector: Peak
Antenna: Vertical



Test: 15.209

RBW: 120 kHz Sweep Time: 5 s Detector: Peak
Antenna: Horizontal



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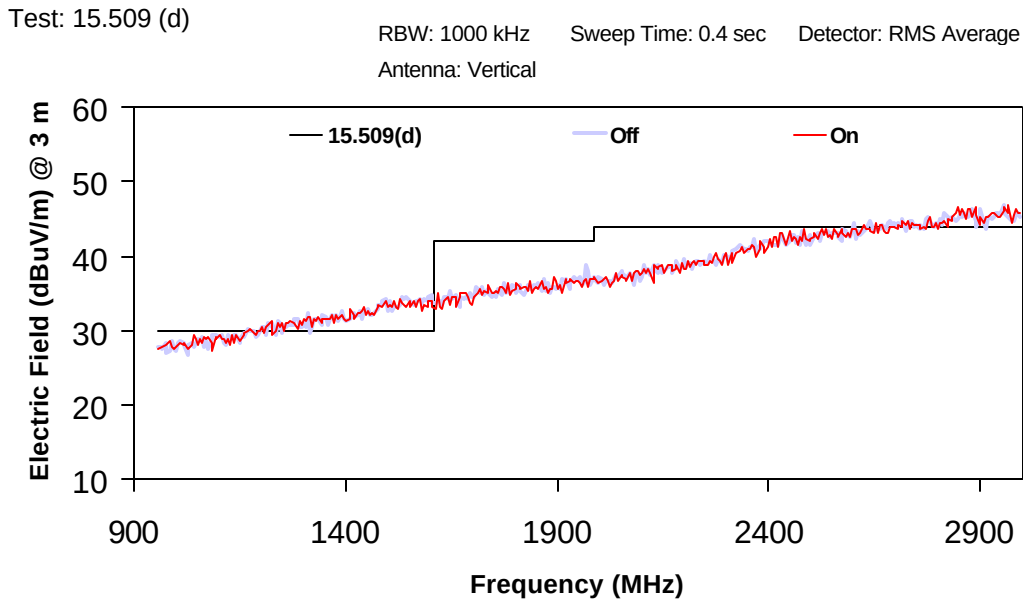
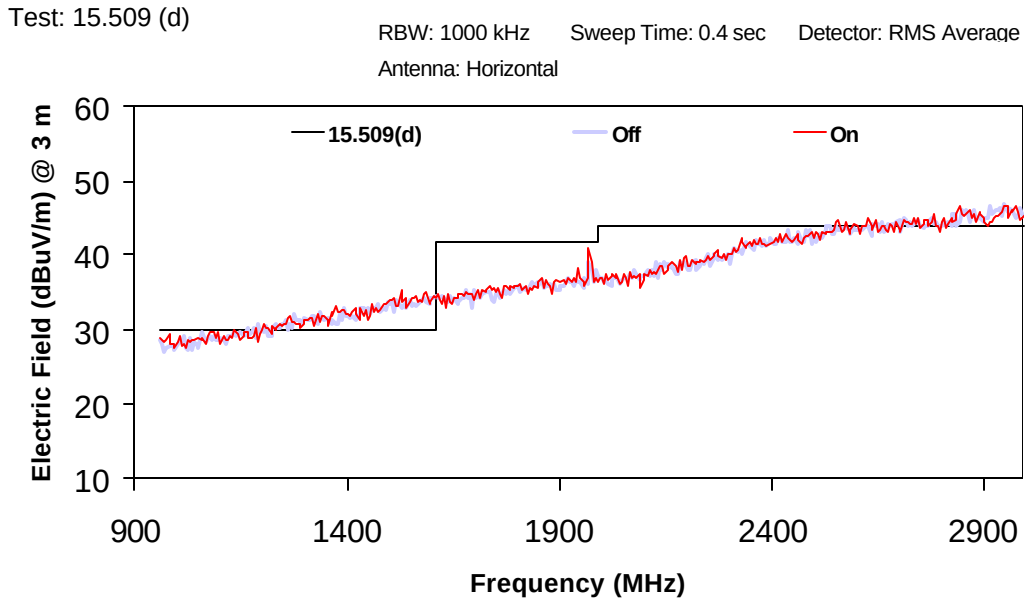
15.509 (d) Tests

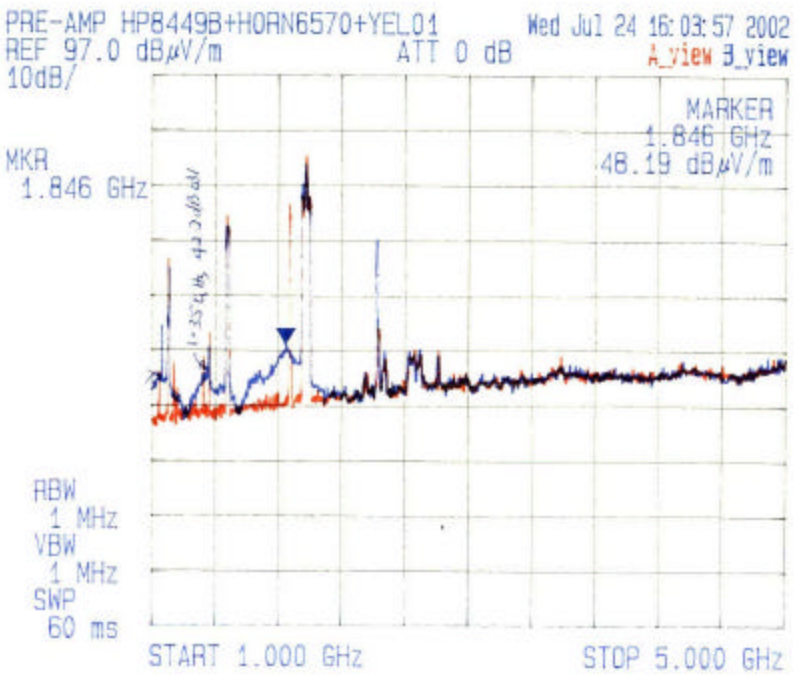
These measurements were performed with a separation of 1.0 m between the GPR transmitter and the EMC antenna and the results were converted to 3 meters distance by a factor of -9.5 dB. The closer separation between the transmitter and EMC antenna is required because of the low emissions levels with respect to the ambient levels. The data presented have a 4.7 dB correction factor added. Measurements were performed on sand at the CFB Borden test site.

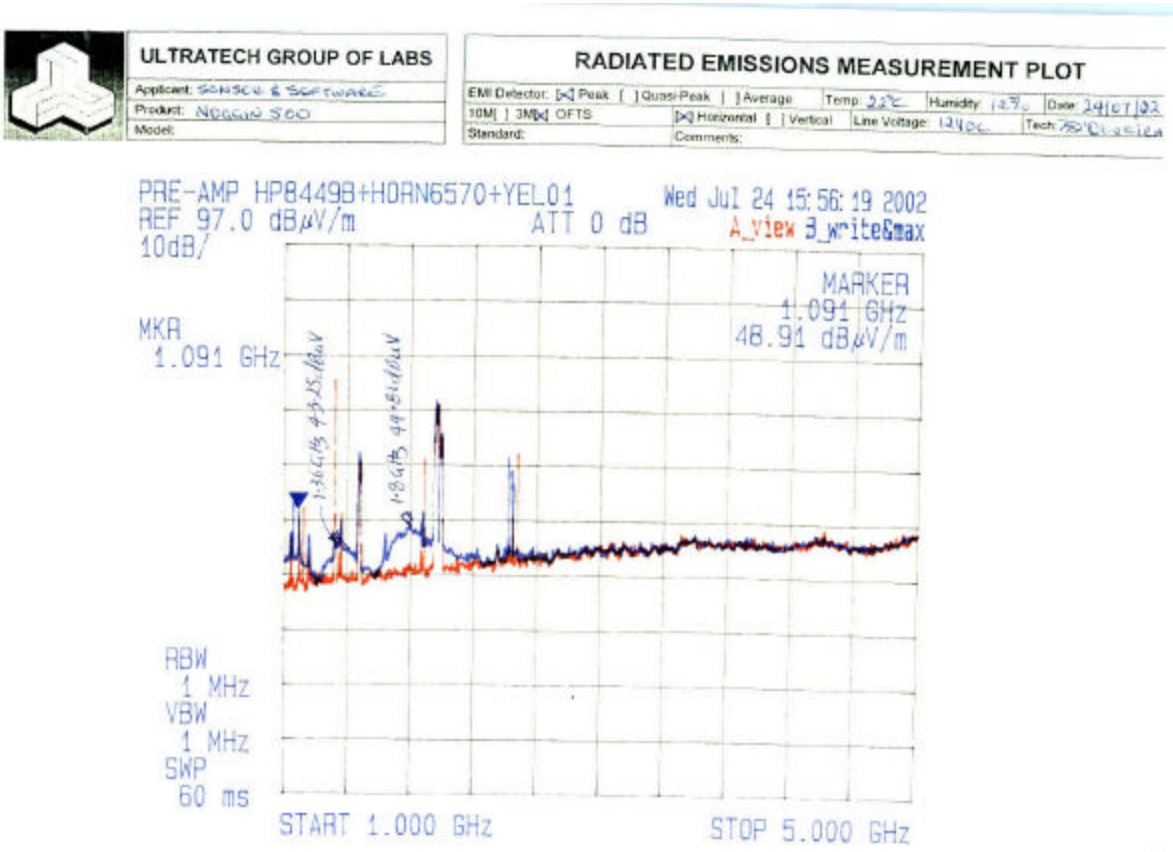




- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

ULTRATECH GROUP OF LABS	RADIATED EMISSIONS MEASUREMENT PLOT				
Applicant: Sensor & Software	EMI Detector: [X] Peak [ ] Quasi-Peak [ ] Average	Temp: 22°C	Humidity: 12%	Date: 24/07/02	
Product: Noggin 500	10M[ ] 3M[X] OFTS	[ ] Horizontal [X] Vertical	Line Voltage: 12 Vdc	Tech: [illegible]	
Model:	Standard:	Comments:			



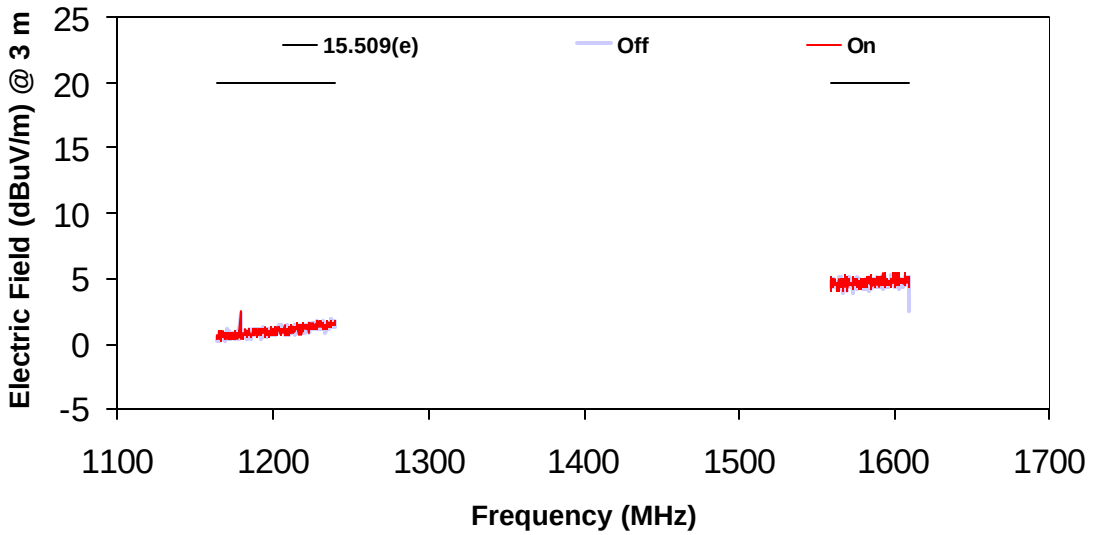

ULTRATECH GROUP OF LABS
Applicant: SENSOR & SOFTWARE
Product: NOGGIN 500
Model:
RADIATED EMISSIONS MEASUREMENT PLOT
EMI Detector: [x] Peak [ ] Quasi-Peak [ ] Average
Temp: 22°C
Humidity: 12%
Date: 24/07/02
10M[ ] 3M[x] OFTS
[x] Horizontal [ ] Vertical
Line Voltage: 124 VAC
Standard:
Comments:
PRE-AMP HP8449B+HORN6570+YEL01
Wed Jul 24 15:56:19 2002
REF 97.0 dBµV/m
ATT 0 dB
A_view B_write&max
10dB/
MARKER
1.091 GHz
48.91 dBµV/m
MKR
1.091 GHz
RBW
1 MHz
VBW
1 MHz
SWP
60 ms
START 1.000 GHz
STOP 5.000 GHz

15.509 (e) Tests

These measurements were performed with a separation of 1 m between the GPR transmitter and the EMC antenna and the results were converted to 3 meters distance by a factor of -9.5 dB. The closer separation between the transmitter and EMC antenna is required because of the low emissions levels with respect to the ambient levels. The data presented have a 4.7 dB correction factor added. Measurements were performed on sand at the CFB Borden test site.

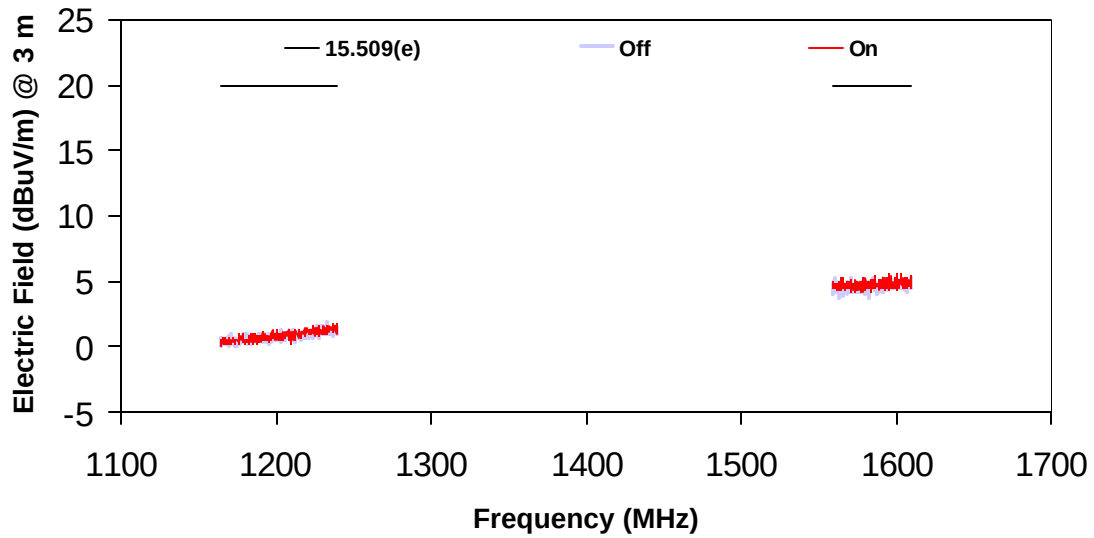
Test: 15.509 (e)

RBW: 1 kHz Sweep Time: 200 sec Detector: RMS Average
Antenna: Vertical



Test: 15.509 (e)

RBW: 1 kHz Sweep Time: 200 sec Detector: RMS Average
Antenna: Horizontal



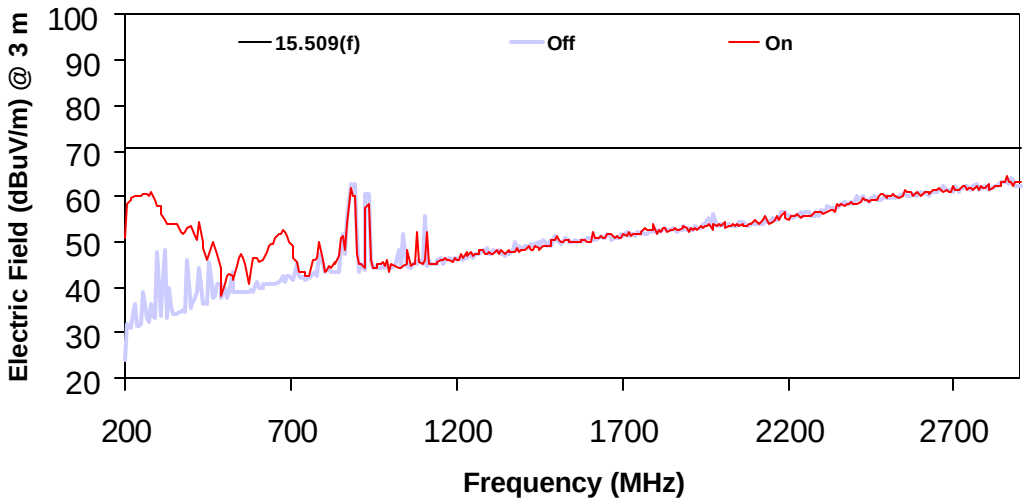
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: http://www.ultratech-labs.com

15.509 (f) Tests

These measurements were performed with a separation of 1 m between the GPR transmitter and the EMC antenna and the results were converted to 3 meters distance by a factor of -9.5 dB. The closer separation between the transmitter and EMC antenna is required because of the low emissions levels with respect to the ambient levels. The data presented have a 4.7 dB correction factor added. Measurements were performed on sand at the CFB Borden test site.

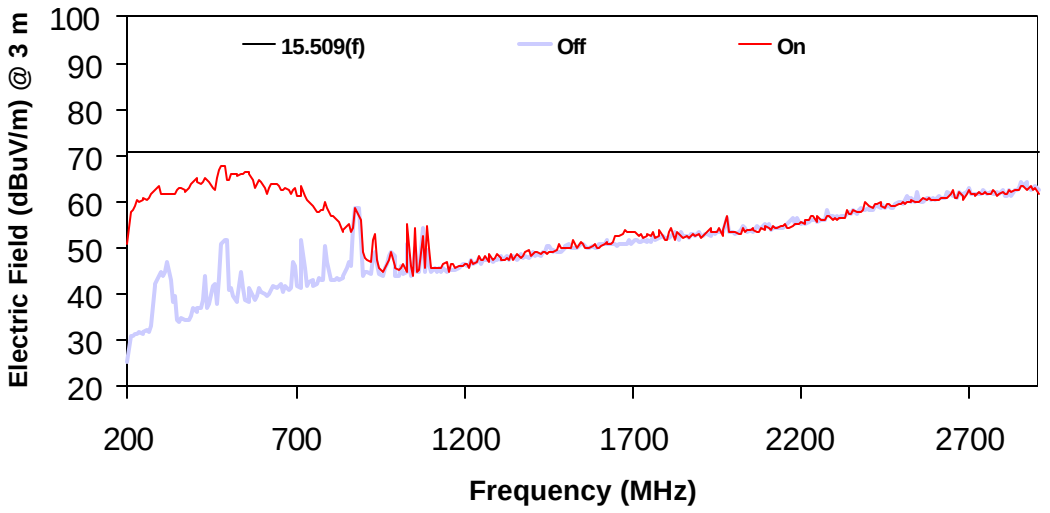
Test: 15.509 (f)

RBW: 3000 kHz Sweep Time: 5 sec Detector: Peak
Antenna: Vertical



Test: 15.509 (f)

RBW: 3000 kHz Sweep Time: 5 sec Detector: Peak
Antenna: Horizontal



- *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 PTROCEDURES

8.1. BACKGROUND

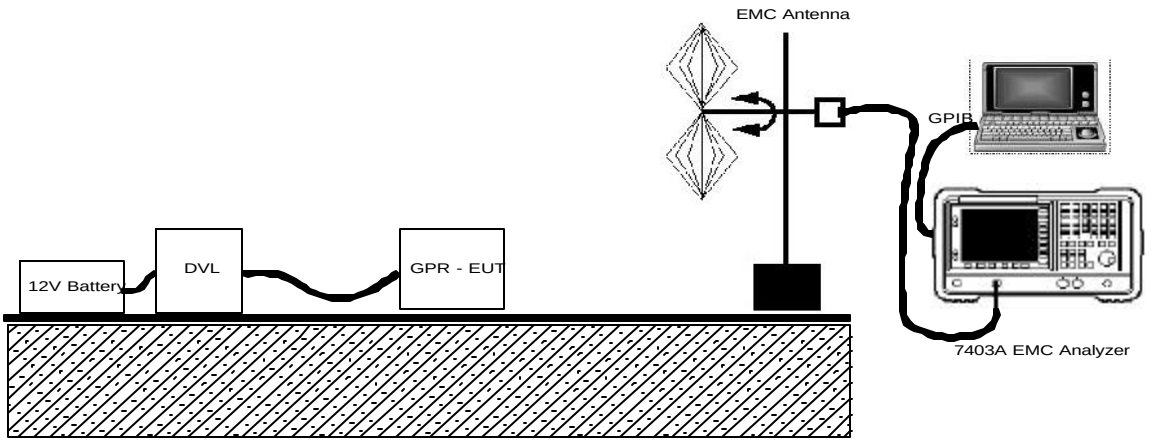
This section describes the procedures and equipment used to perform the emissions testing performed by SSI and Ultratech Engineering Labs Inc.. The focus of this measurement program was to characterize the complete emissions spectra.

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

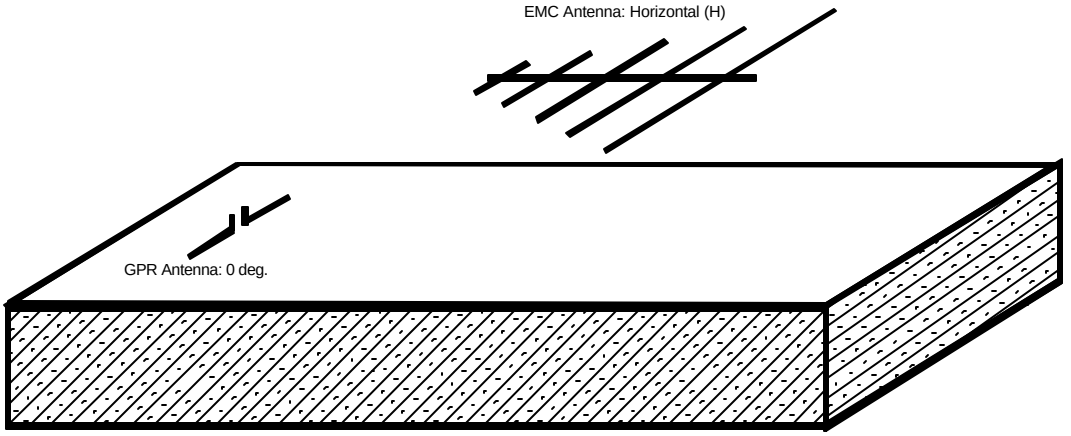
The radiated emissions tests were performed on a medium to fine sand test site at Canadian Forces Base (CFB) Borden. The emissions testing equipment was setup using a configuration similar to that shown in Figure 2-1 and Figure 2-2.

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

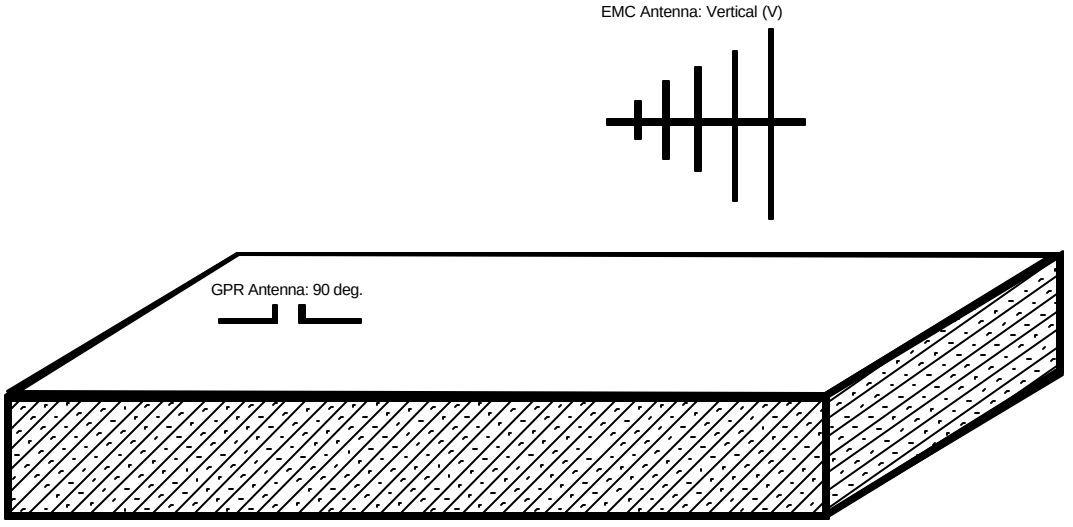


- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Figure 2-3: Endfire and broadside measurement modes.



Broadside Mode



Endfire Mode

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

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.

8.4. RMS AVERAGE AND PEAK DETECTION MODES

References to the RMS average measurements in the Report and Order specify the following:

15.521 (d): "The RMS average measurement is based on the use of a spectrum analyzer with a resolution bandwidth of 1 MHz, an RMS detector, and a 1 millisecond or less averaging time."

"RMS average field strength measurements, required for all frequencies above 960 MHz, shall be made using techniques to obtain true RMS average. This can be accomplished by using a spectrum analyzer that incorporates a RMS detector. The resolution bandwidth of the analyzer shall be set to 1 MHz, the RMS detector selected, and a video integration time of 1 ms or less is to be used."

The specific RMS average measurement procedure was not initially clear from these regulations but discussions with John Reed and Steve Jones of the FCC were used as a basis for the procedure used in this measurement program. Since our EMC analyzer (Agilent E74303A) has an RMS average mode, measurements were performed with a 400 ms sweep mode to collect 400 measurement points.

An Agilent engineers describes the operation in this mode as follows, implying that the integration time is 1 ms:
"Actually, when using the RMS Averaging detector the instrument will do a power averaging in each bucket by clocking the A/D at a higher rate than normal in order to get more samples per bucket. So, if the number of sweep points is set to 401 and the sweeptime is set to 401ms (for convenience sake) then each bucket would be sampled for 1ms."
This RMS average detector, required for the part 15.509 levels , was selected in the E7403A analyzer using the following menu commands:

Det/Demod ® Manual ® Average and BW/Avg ® More ® Avg Type ® Pwr Avg
The maximum emission levels specified in 15.209 are quasi-peak levels. These measurements are very time consuming to measure for a complete characterization of the spectrum. The peak levels, which are always higher were measured in this test program. A comparison of the peak and quasi-peak levels at 155 MHz, using the Noggin 500 MHz transmitting antenna, indicates that the peak levels are 4.5 to 6 dB higher than the quasi-peak levels.
The peak detector for the part 15.209 levels was set in the E7403A analyzer using the following menu commands:
Det/Demod ® Manual ® Peak

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

8.5. GROUND PLANE 4.7 DB CORRECTION FACTOR

For measurements performed without a ground plane below the EMC antenna, the 4.7 dB correction factor was added to the measured levels in this test report.

8.6. PULSE REPETITION FREQUENCY (PRF)

The boresite configuration used for measuring the radiated spectrum was also used to measure the PRF. The EMC analyzer was set to a small frequency spread centered near the peak of the radiated spectrum and the resolution band-width was set to 300 Hz..