EXHIBIT ONE

SAR REPORT

ITRONIX CORPORATION

APREL Laboratories

Certification Report on

Specific Absorption Rate (SAR) Experimental Analysis

Itronix Corporation

X-C 6250

Date: 4 November, 1998

51 Spectrum Way Nepean ON K2R 1E6
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CERTIFICATION REPORT

Subject: **Specific Absorption Rate (SAR) Experimental Analysis**

Product: **Itronix Corporation X-C 6250 Ruggedized Wireless Laptop**

Client: Research in Motion for Itronix Corporation

Address: Research in Motion Limited
295 Phillip Street
Waterloo, ON N2L-3W8

Itronix Corporation
801 South Stevens Street
Spokane, WA 99204

Project #: RIMB-Itronix XC 6250-3097

Prepared by: APREL Laboratories
51 Spectrum
Nepean, Ontario
K2R 1E6

Submitted By ________ Date: 04 Nov 98
Dr. Paul G. Cardinal
Director, Laboratories

Approved By ________ Date: Nov 4/98
Dr. Jacek J. Wojcik, P.Eng.

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Approved By ______________________ Date: ______________
Dr. Jacek J. Wojcik, P.Eng.

FCC ID:
Applicant: Itronix Corporation
Equipment: Ruggedized Wireless Laptop
Model: X-C 6250
Standard: FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on an Itronix Corporation Model X-C 6250 Ruggedized Wireless Laptop. The measurements were carried out in accordance with FCC 96-326. The desktop unit was evaluated for its maximum power level of 33 dBm (2 W).

The X-C 6250 was tested at high, middle and low frequencies, with the maximum SAR coinciding with the peak performance RF output power on channel 720 (middle, 899 MHz). Test data and graphs are presented in this report.

This unit as tested, and as it will be marketed and used (with a warning in the manual to keep bystanders at least 5cm., or 2", from the antenna), is found to be compliant with the FCC 96-326 requirement, for an uncontrolled RF exposure environment.

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1.0 INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of a sample of a Itronix Model X-C 6250 Ruggedized Wireless Laptop. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR laboratory can be seen in Figure 1. This report describes the results obtained.

2.0 APPLICABLE DOCUMENTS

The following documents are applicable to the work performed:

1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

2) ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

3) ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 97-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields".

3.0 EQUIPMENT UNDER TEST

- Itronix Model X-C 6250 Ruggedized Wireless Laptop, S/N 374666.

The XC6 antenna is a ½ wavelength, 2dBi antenna. It is inside a rotate-able plastic housing, and is attached to the upper right edge of the display screen. The antenna specifications supplied by the manufacturer can be found in Appendix A.

4.0 TEST EQUIPMENT

- Narda 8021B miniature E-field probe, S/N 04007, Asset # 301339.
- CRS Robotics A255 articulated robot arm, S/N RA2750, Asset # 301355.
- CRS Robotics C500 robotic system controller, S/N RC584, Asset # 201354.
- HP EPM-441A power meter, S/N GB37481303.
- APREL F-1 flat manikin, S/N 001.
- Tissue Recipe and Calibration Requirments, APREL procedure SSI/DRB-TP-D01-033.

5.0 TEST METHODOLOGY

1) The test methodology utilized in the certification of the Ruggedized Wireless Laptop complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992, (IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave).

2) The E-field is measured with a small isotropic probe (output voltage proportional to E^2).

3) The probe is moved precisely from one point to the next using the robot (1cm increments for wide area scanning and 0.5cm increments for the final measurements).

4) The probe travels in the homogeneous liquid simulating human tissue. Appendix C contains information about the recipe and properties of the simulated tissue used for these measurements.

5) The liquid is contained in a manikin simulating a portion of the human body.

6) The Ruggedized Wireless Laptop is positioned in a normal usage position.

7) All tests were performed with the highest power available from the sample Ruggedized Wireless Laptop, under transmit conditions.

More detailed descriptions of the test method is given in Section 6 when appropriate.

Figure 1.

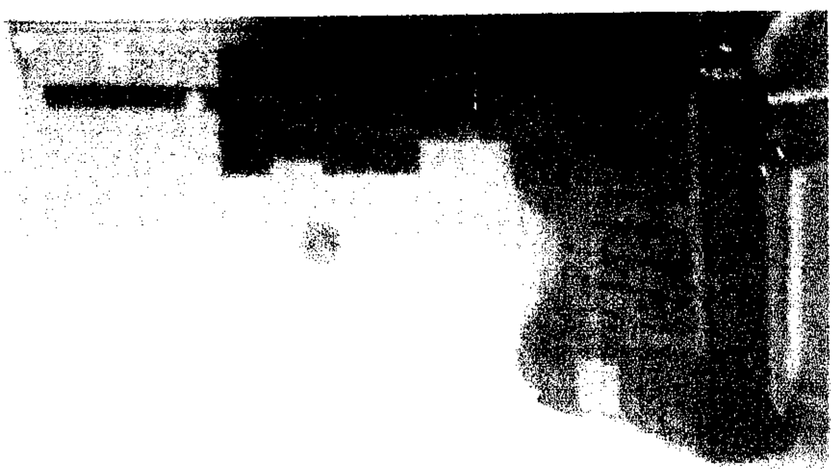

Figure 2.

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6.0 TEST RESULTS

6.1 Transmitter Characteristics

The Itronix X-C 6250 ruggedized wireless laptop has an integrated Research in Motion OEM radio-modem (FCC ID L6AR900M-2-O) which can operate with a variable duty cycle. When operated at the maximum duty cycle, the unit is unable to operate repeatably for more than 6-7 minutes. In order to perform SAR scans, the duty cycle was reduced to 40%, which allowed the operating time to typically exceed the 10 to 15 minutes required for the scans.

A battery-powered transmitter will consume energy from its batteries, which may affect its transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run (the battery is changed periodically between measurement). In the case of the X-C 6250 wireless laptop, which does not have an externally accessible feedpoint, a relative measurement was made with a power meter connected to an antenna adjacent to a fixture to hold the transmitter in a reproducible position. The following table shows the results for the five sets of results used for this report.

Scan		**Channel**	**Radiated Power (dBm)**		**Battery Status (%)**	
Type	*Height (mm)*		*Before*	*After*	*Before*	*After*
Area	2.5	L	5.3	-	67	60
Area	2.5	M	-	-	59	52
Area	2.5	H	-	-	51	45
Area	12.5	M	-	4.7	35	29
Zoom	12.5	M	5.3	-	68	61
Zoom	7.5	M	-	-	59	51
Zoom	2.5	M	-	4.7	49	41

6.2 SAR Measurements

1) RF exposure is expressed as a Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points as shown Fig.2. SAR is expressed as RF power per kilogram of mass, averaged in 1 cubic centimeter of tissue.

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2) The Itronix Model X-C 6250 was put into test mode for the SAR measurements by application software running on a laptop computer via commands to control the channel (H, M, L) and maximum operating power (nominally 33 dBm out of the radio-modem).

Figure 3 shows a contour plot of the SAR measurements for the Itronix Model X-C 6250 sample operating on the middle (M) channel. The presented values were taken 2.5 mm into the simulated tissue from the flat phantom's solid inner surface. Figures 1 and 2 show the flat phantom used in the measurements, with the Ruggedized Wireless Laptop against, or near, the simulated bystander body (the most likely body part to be in the vicinity of the transmitting antenna). The separation was 5.5cm for the data presented in Figure 3. The axis of the antenna, and the display, is aligned with the y-axis, while the keyboard is aligned with the x-axis. A grid is shown inside the flat phastom indicating the orientation of the x-y grid used, with the origin (0,0) towards the top left. The origin is scan dependent. The x-axis is positive towards the bottom and the y-axis is positive towards the right.

3) A different presentation of the same data is shown in Figure 4. This is a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualization aid.

4) The SAR adjacent to different surfaces of the wireless laptop was investigated for a 40% duty cycle, on the middle (720) channel. The surface being investigated was touching the bottom of the flat phantom.

Laptop Surface	**Highest Local SAR** (W/kg)
Keyboard	0.28
Lap (Bottom)	0.17
Right Edge with Antenna	2.76

Subsequent testing was performed with the right edge of the ruggedized wireless laptop parallel to the lower surface of the flat phantom.

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Local SAR 2.5mm Above Phantom Surface

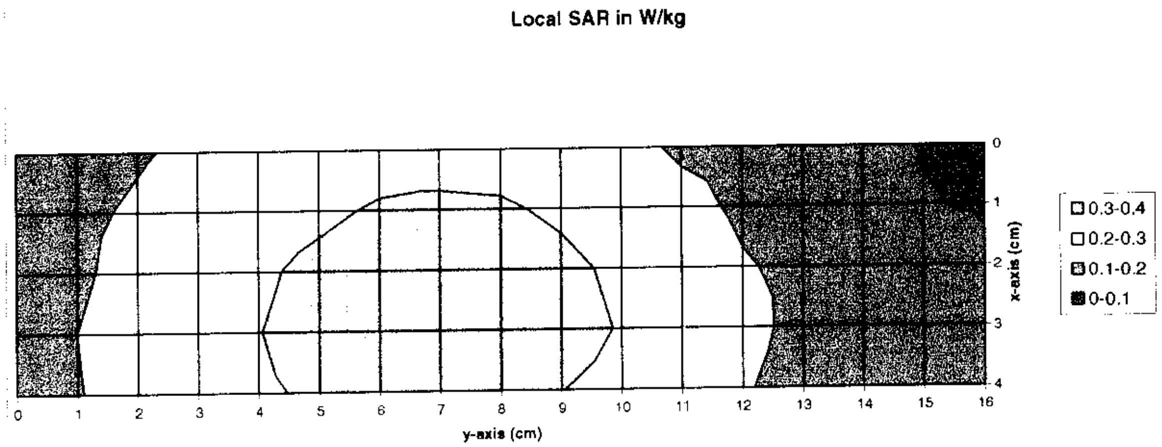

Figure 3

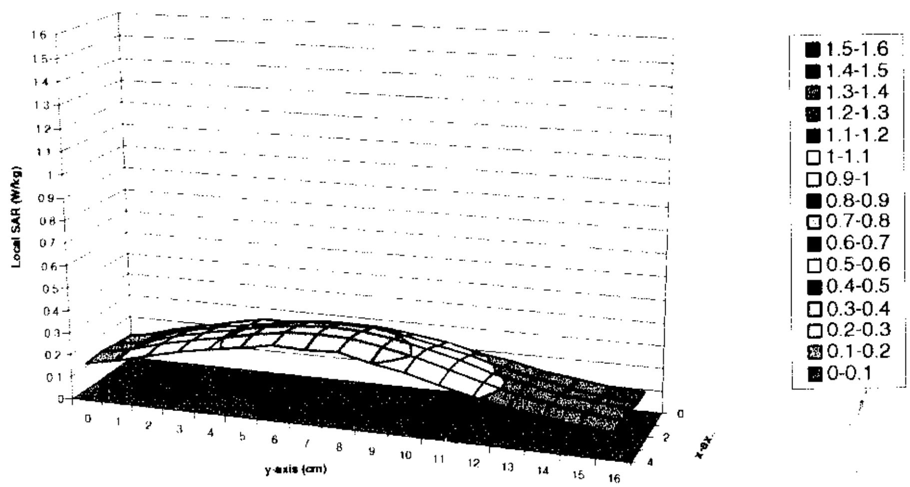

Figure 4

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5) Wide area scans were also performed on the low channel versus separation between the antenna-housing and the lower surface of the phantom. The peak single point SAR for the scans were:

Channel		Separation	Highest Local SAR
	(MHz)	(cm)	(W/kg)
M	899	0	2.76
M	899	1.1	3.83
M	899	4.5	0.56
M	899	5.1	0.40
M	899	5.5	0.33
M	899	5.8	0.30
M	899	6.3	0.26

Considering the anticipated scaling to the inner surface of the phantom, and for the maximum duty cycle, subsequent testing was performed with an antenna-housing to phantom separation of 5.5cm.

Figure 5 shows the data plotted as a function of separation and the exponential curves fit to all but the 0cm data (Microsoft Excel 97):

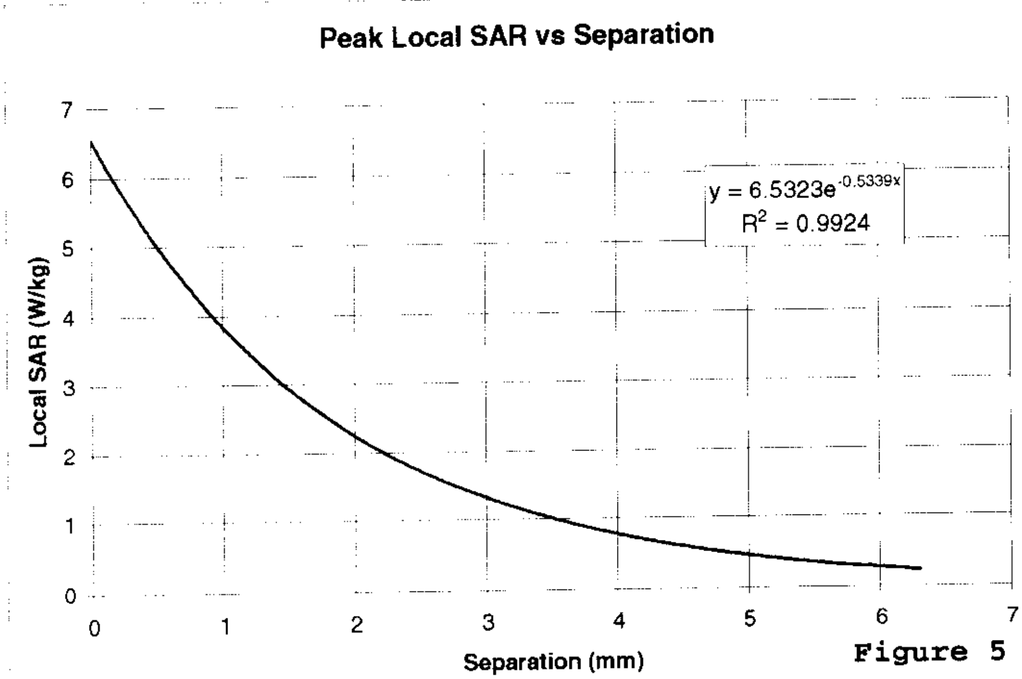

Figure 5

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6) Wide area scans were also performed for the low (480) and high (880) channels, with an antenna-housing separation of 5.5 mm from the lower surface of the phantom. The peak single point SAR for these scans were:

Channel		Highest Local SAR (W/kg)
	(MHz)	
Low (480)	896	0.33
Middle (720)	899	0.35
High (880)	901	0.35

Subsequent testing was performed with the ruggedized wireless laptop operating on its middle channel.

7) Area scan data was then obtained at 12.5 mm into the simulated brain tissue on the middle channel. These measurements are presented as a contour plot in Figure 6 and surface plot in Figure 7.

Figure 8 shows an overlay of the antenna-housing's outline, superimposed onto the composite contour plot. Three segments were required to cover the whole edge of the laptop since RF tranmission would typically shut down after 10-15 minutes. The separation between the wireless laptop's antenna and the bottom of the flat phantom was 5.5 cm, and the duty cycle was 40%. The first segment is similar to that shown previously as Figure 3.

Figures 3, 4, 6 and 7 show that there is a dominant peak, in the contour plots, that diminishes in magnitude with depth into the tissue simulation.

8) The middle channel (720) SAR peak was then explored on a refined 0.5cm grid in three dimensions. Figures 9, 10 and 11 show the measurements made at 2.5, 7.5 and 12.5 mm respectively. The SAR value averaged over 1 cm^3 was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured averaged over 1 cm^3 was determined from these measurements to be 0.308 W/kg

9) To extrapolate the maximum SAR value averaged over 1 cm^3 to the inner surface of the head phantom a series of measurements were made at a few (x,y) coordinates within the refined grid as a function of depth, with 2.5 mm spacing. Figure 12 shows the data gathered and the exponential curves fit to them (Microsoft Excel 97). The average exponential coefficient was determined to be (-0.054 ± 0.005) /mm.

Local SAR 12.5mm Above Phantom Surface

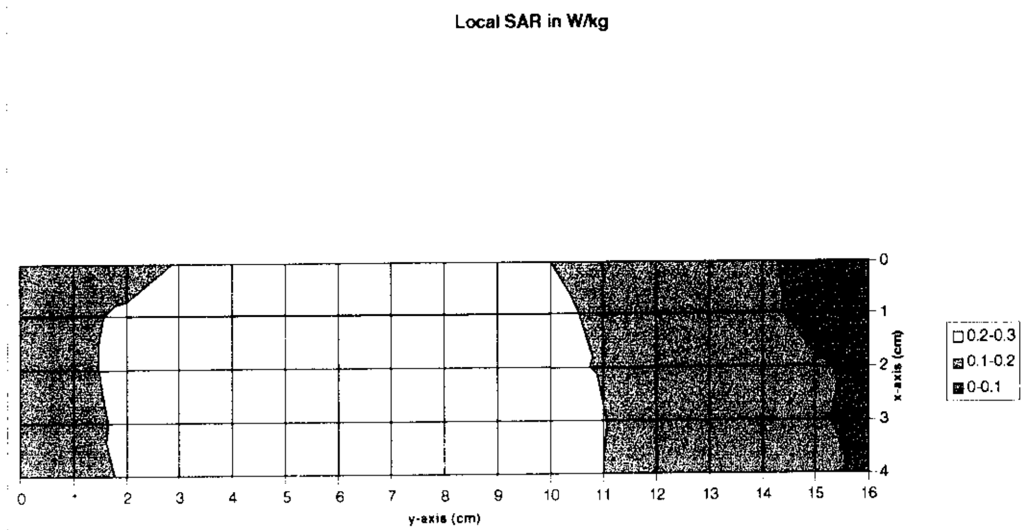

Figure 6

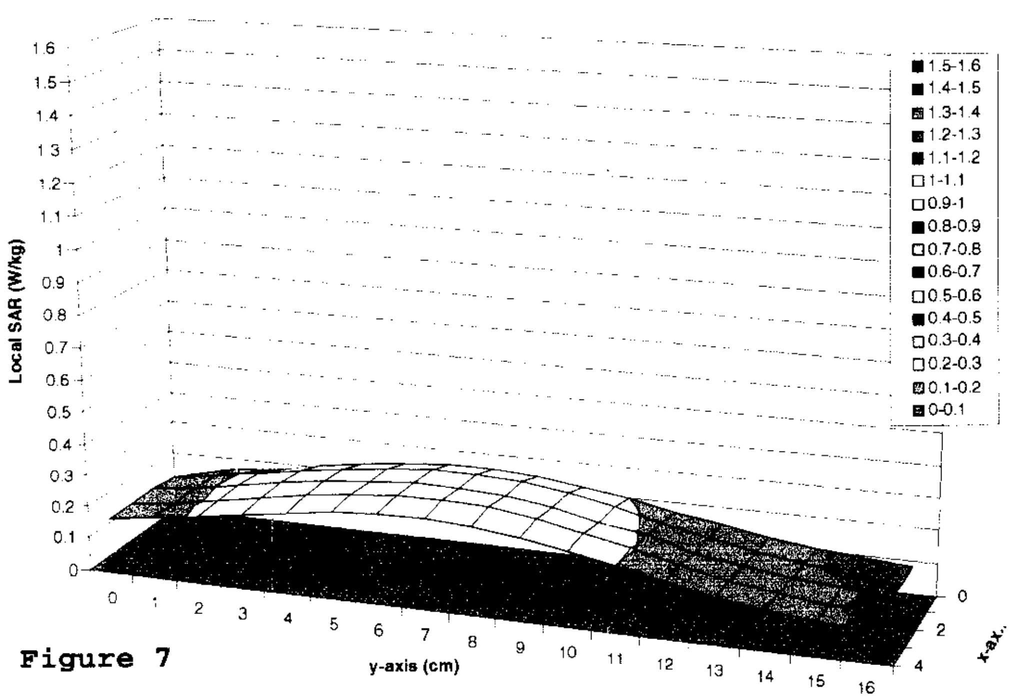

Figure 7

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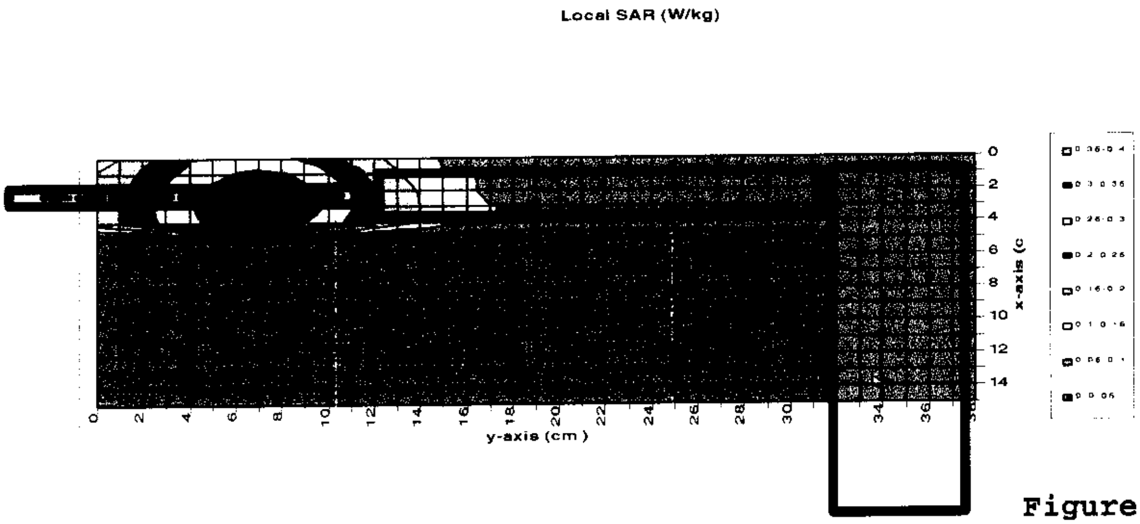

Figure 8

The distance from the probe tip to the inner surface of the flat phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the Narda 8021B miniature RF probe is 7 mm. The total extrapolation distance is 9.5 mm, the sum of these two.

Applying the exponential coefficient over the 9.5 mm to the maximum SAR value average over 1 cm^3 that was determined previously, we obtain **the maximum SAR value at the surface averaged over 1 cm^3** of <u>0.586 W/kg for a 40% duty cycle</u>.

10) A zoom scan at 2.5mm separation was also performed for the maximum duty cycle (nearly 100%). This was performed over the same area shown in Figure 9 (at 40%) but required the scan to be broken into 3 segments because of the short transmission duration (typically 6-7 minutes, but frequently less).

The maximum local SAR measured for a ~100% duty cycle was 0.71 W/kg, while the maximum local SAR for a 40% duty cycle was 0.35 W/kg. Applying this ratio we obtain **the maximum SAR value at the surface averaged over 1 cm^3** of <u>1.19 W/kg for a ~100% duty cycle</u>.

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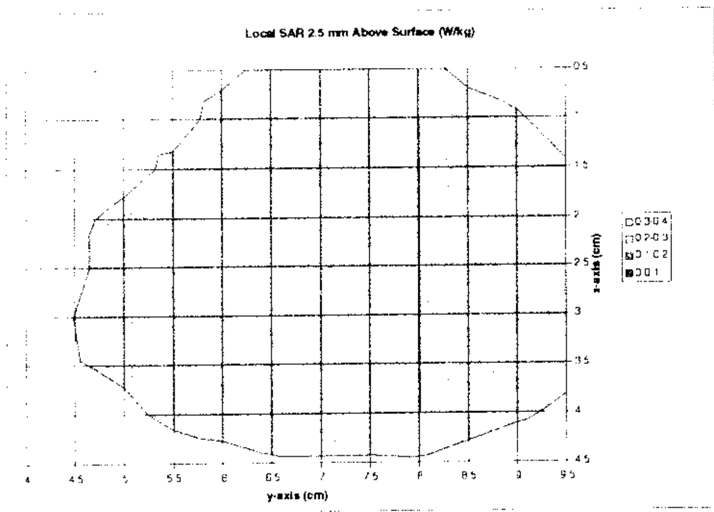

Figure 9

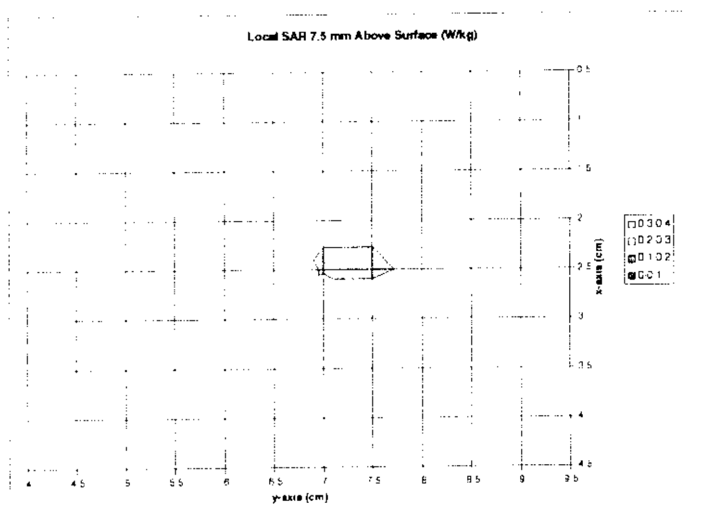

Figure 10

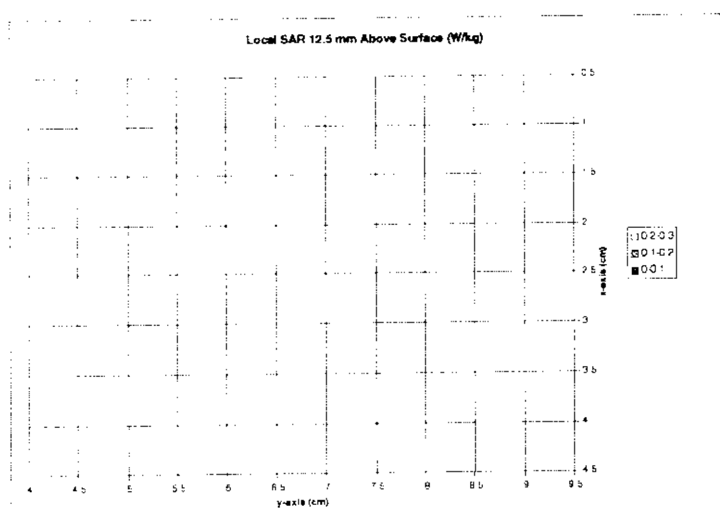

Figure 11

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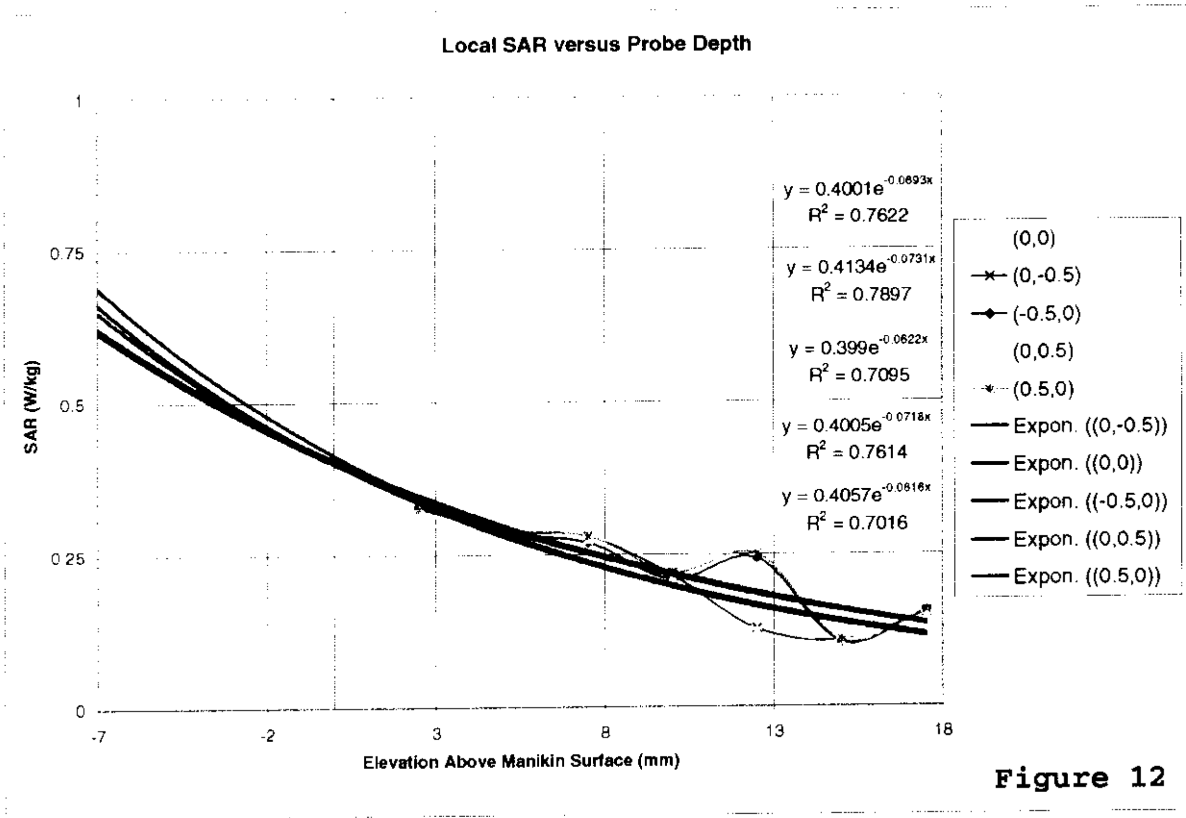


Figure 12

7.0 ANALYSIS

The measurements of highest local SAR versus separation of the antenna housing from the bottom of the phantom (Section 6.2.5) will enable the peak 1g SAR for a separation of 5.5 cm (previous section) to be extrapolated for smaller separations.

Reviewing Figure 5 (Peak Local SAR vs Separation) it is evident that the point at zero separation does not fit the pattern of the data for the other separations. If the data for separations other that 0 cm is fitted to an exponential equation we get:

$$\text{Peak Local SAR} = 6.5323\ e^{-0.5339\ \text{separation}}$$

A similar equation will exist for the peak 1g SAR versus separation:

$$\text{Peak 1g SAR} = k\ e^{-0.5339\ \text{separation}}$$

Using this equation with the previous section's data:

Peak 1g SAR = 1.19 W/kg
separation = 5.5 cm

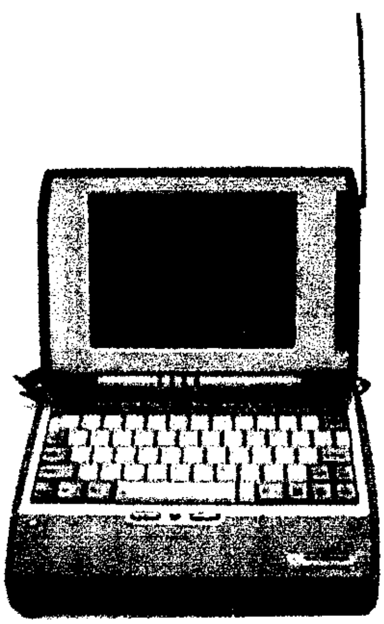
results in a k = 22.4 W/kg, which corresponds to the peak 1g SAR when the separation is zero. A more conservative peak 1g SAR of 1.5 W/kg would occur for a separation of 5.1cm.

8.0 CONCLUSIONS

The Itronix Corporation Model X-C 6250 Ruggedized Wireless Laptop will not expose the user to a maximum Specific Absorption Rate (SAR) exceeding the FCC 96-326 SAR safety guideline limit of 1.6W/kg. However, a bystander in the near proximity of the transmitting antenna may be exposed to such levels.

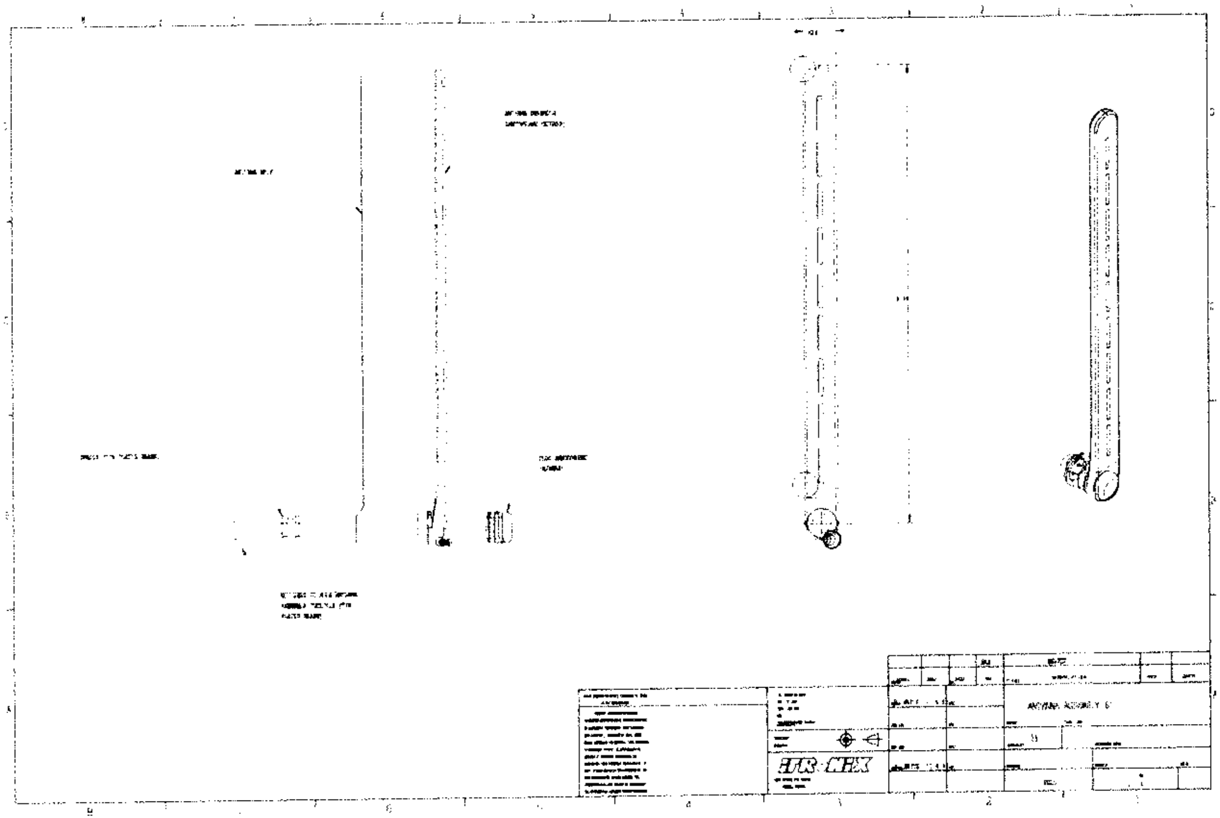
The maximum SAR averaged over 1g, determined at 899 MHz (middle channel - 720), with ~100 duty cycle, and for a separation between the antenna housing and the phantom of 5.5 cm, was determined to be 1.19 W/kg. The overall margin of uncertainty for this measurement is ±20.8%. The analysis of the previous section shows that a more conservative 1.5W/kg will not be exceeded for a separation exceeding 5.1 cm.

This unit as tested, and as it will be marketed and used (with a warning in the manual to keep bystanders at least 5cm, or 2", from the antenna), is found to be compliant with the FCC 96-326 requirement.



APPENDIX A

Manufacturer's Antenna Specifications



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APPENDIX B

Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	Specific to	Uncertainty	
Power variation due to battery condition	Transmitter	7.2%	
Extrapolation due to curve fit of SAR versus depth	Transmitter	15.9%	
Extrapolation due to depth measurement	Setup	3.3%	
Conductivity	Setup	6.0%	
Density	Setup	2.6%	
Tissue enhancement factor	Setup	7.0%	
Voltage measurement	Setup	3.8%	
Probe sensitivity factor	Setup	3.5%	
		20.8%	**RSS**

Note that the overall uncertainty is determined using the root sum square method (RSS).

APPENDIX C

Simulated Tissue Material Properties

The tissue mixture used was based on that presented SSI/DRB-TP-D01-033, "Tissue Recipe and Calibration Requirements".

Deionized water	45.3%
Sugar	54.3%
Salt	0.0%
HEC	0.3%
Bactericide	0.1%

Mass density, ρ — 1.30g/ml. (The density used to determine SAR from the measurements was the recommended 1040 kg/m^3 found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01.)

Dielectric parameters of the tissue material were determined using a Hewlett Packard 8510 network analyzer, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe. The dielectric properties are :

Dielectric constant, ε_r	48.5
Conductivity, σ	1.16 S/m
Tissue conversion factor, γ	6.5

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SIMULATION FLUID #	98052901
CALIBRATION DATE	9th Oct 98
CALIBRATED BY	Haile
Frequency Range	100MHz-1GHz
Frequency Calibrated	900 MHz
Tissue Type	Muscle

Position [cm]	Amplitude [dBm]	Phase [deg]	[deg]
0	-36.74	-155.8	-155.8
0.5	-38.12	165.55	-194.45
1	-39.56	126.63	-233.37
1.5	-40.83	87.05	-272.95
2	-42.34	47.8	-312.2
2.5	-43.55	8.71	-351.29
3	-44.81	-30.16	-390.16
3.5	-46.02	-68.94	-428.94
4	-47.23	-106.9	-466.9
4.5	-49	-146.15	-506.15
5	-50.44	-172.27	-532.27
5.5	-51.42	134.19	-585.81
6	-52.55	97.64	-622.36

ΔdB_1	-8.07	$Ddeg_1$	-234.36
ΔdB_2	-7.9	$Ddeg_2$	-234.49
ΔdB_3	-7.67	$Ddeg_3$	-233.53
ΔdB_4	-8.17	$Ddeg_4$	-233.2
ΔdB_5	-8.1	$Ddeg_5$	-220.07
ΔdB_6	-7.87	$Ddeg_6$	-234.52
ΔdB_7	-7.74	$Ddeg_7$	-232.2
ΔdB_{AVG} [dB]	-7.93	$Ddeg_{AVG}$ [deg]	-231.7671429
dB_{AVG} (α_{AVG}) [dB/cm]	-2.64	deg_{AVG} (β_{AVG}) [deg/cm]	-77.25571429
(α_{AVG}) [NP/cm]	-0.30437982	(β_{AVG}) [rad/cm]	-1.34836658

f [Hz]	9.00E+08
μ [H/cm]	1.25664E-08
ε_o [F/cm]	8.854E-14

ε_r

$\sigma_{effective}$ S/m

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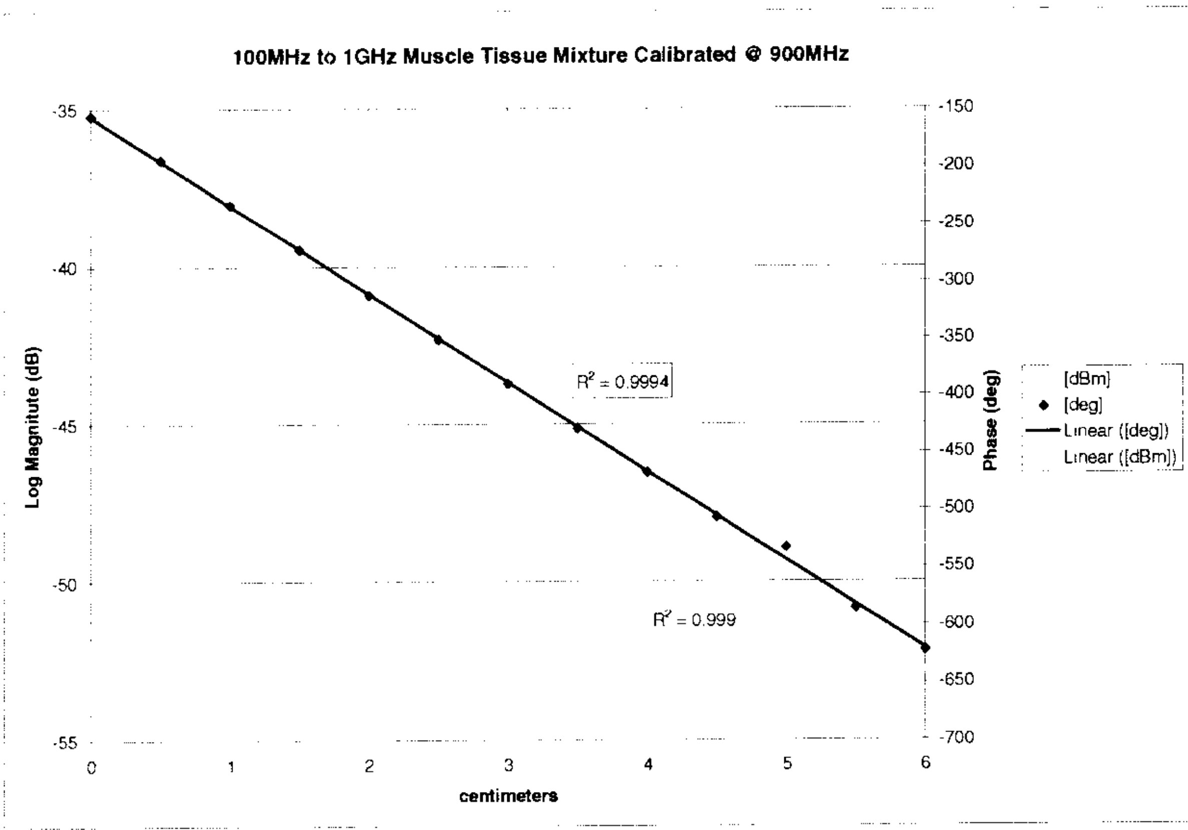

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899 MHz Data (Paul & Janusz)

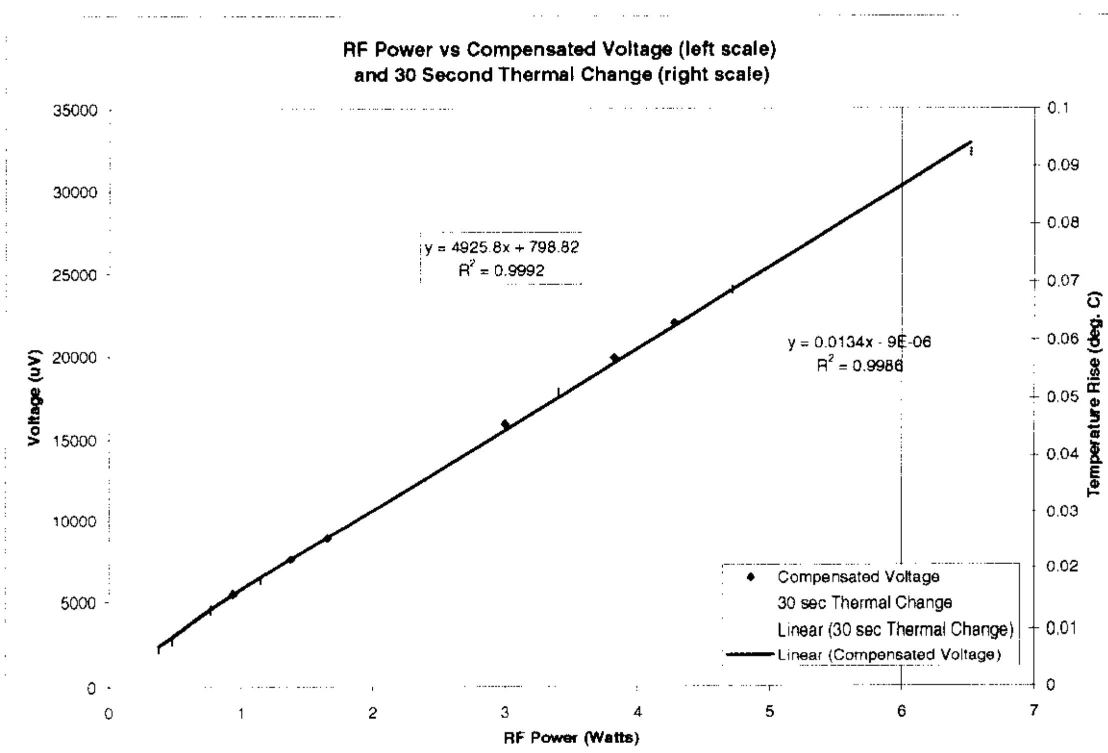
RF Power W	dBm	FBS	Ch0 uV	Ch1 uV	Ch2 uV	delta T (30 sec) deg C	Sum Vi/Ei	Thermal SAR W/kg
037325	2572	037	1538	513	610	00053	2443	049
0474242	2676	1.41	1880	610	732	00065	2956.1	060
0767361	2885	3.5	2979	903	1099	00096	4562	089
0939723	2973	438	3564	1074	1294	00128	5431.7	1.18
1.142878	3068	523	4072	1279	1468	00155	62486	1.43
1374042	3138	603	4897	1548	1788	00176	75459	163
1648162	3217	682	5771	1846	2070	00219	88795	203
2992285	3476	941	10449	3149	3809	00408	15940	377
3396253	3531	996	11694	3516	4248	00437	17816	404
3819443	3582	1047	13037	3965	4785	00523	19945	484
4275629	3631	1096	14380	4395	5298	00591	22051	547
4709773	3673	1138	15576	4810	5786	00622	23980	575
6516284	38.14	1279	20728	6567	7989	00866	32326	801

Directional Coupler factor 2535 - Asset 100251 cal file data (Janusz, ?)

Sensitivity (e) 0762 0659 0703 - Sensor Sensitivity in mV/(mW/cm2) 900 MHz cal (Janusz, 16 Sep 97)
η = 1.50 e 1.143 09885 10545

Density	13	g/cm³	1300	kg/m³	- Marion, summer 97
Conductivity	1167	mS/cm	1.167	S/m	- Antonio Ugaro, 27 May 98
Heat Capacity (c)	2775	J/C/g	2775	J/C/kg	- average of Balzano (2.7) and Kuster (2.85) values
Exposure Time	30	second	30	seconds	
Slope of Measure Voltage (m_V)	49258	uV/W	00049	V/W	
- standard error of m_V	4081	uV/W	4E-05	V/W	0.8%
Slope of Measure Temp Change (m_T)	00134	C/W	00134	C/W	
- standard error of m_T	00001	C/W	00001	C/W	1.1%

Tissue Conversion Factor (γ) **65**



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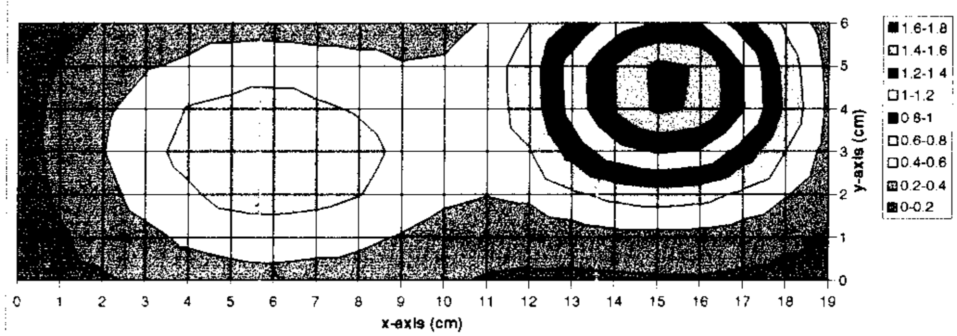
e-mail: info@aprel.com

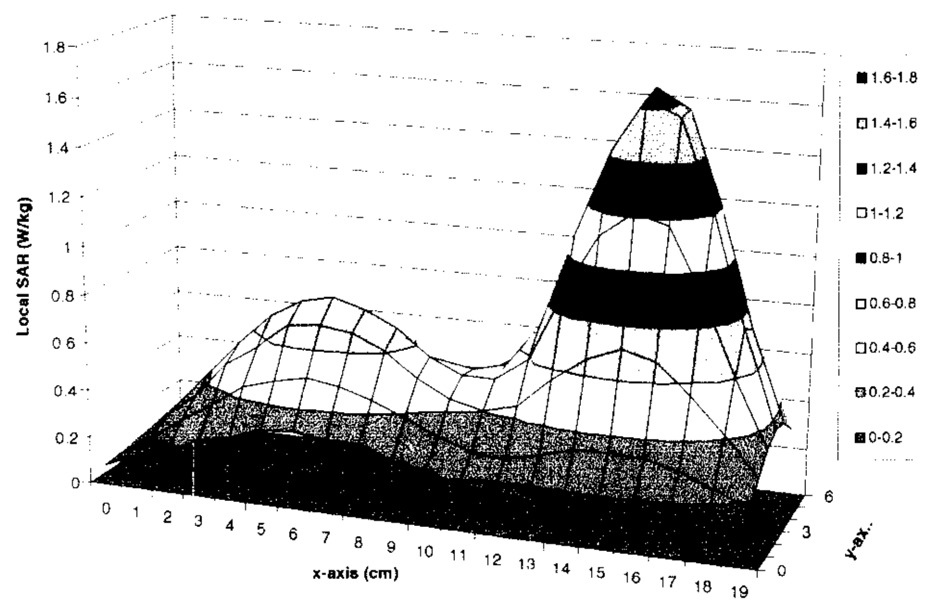
APPENDIX D

Validation Scans

835 MHz Reference Phone with Muscle Tissue in Flat Phantom
(Local SAR Area Scan 2.5 mm Above Surface - W/kg)



835 MHz Reference Phone with Muscle Tissue in Flat Phantom
(Area Scan 2.5 mm Above Surface)



51 Spectrum Way
Nepean, Ontario K2R 1E6

Tel. (613) 820 2730
Fax (613) 820 4161
e-mail: info@aprel.com

EXHIBIT TWO

MPE REPORT

External 3dB

Cushcraft Vehicle-Top

Mag Mounting Antenna

ITRONIX CORPORATION

Research · Testing · Consulting · Testing
Solutions for the Wireless Industry

APREL Since 1981

ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 3dB Cushcraft Vehicle-Top Mag-Mounting Antenna

FCC ID #:

MODEL: X-C 6250 Laptop and SN8962A Antenna

CLIENT: Research in Motion for Itronix Corporation

PROJECT #: RIMB-XC6250 Cushcraft SN8962A-3103

ADDRESS: Research in Motion Limited
295 Phillip Street
Waterloo, ON N2L 3W8

Itronix Corporation
801 South Stevens Street
Spokane, WA 99204

PREPARED BY: *APREL Laboratories, Regulatory Compliance Division*

APPROVED BY: [signature] DATE
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: [signature] DATE Nov 16/98
Dr. Jacek J. Wojcik, P.Eng.

51 Spectrum Way
Nepean, Ontario
K2R 1E6, Canada

Tel. (613) 820 2730
Fax (613) 820 4161
e-mail info@aprel.com

APREL Since 1981

ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 3dB Cushcraft Vehicle-Top Mag-Mounting Antenna

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APPROVED BY: ______________________ DATE: ______________________
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: ______________________ DATE: ______________________
Dr. Jacek J. Wojcik, P.Eng..

FCC ID:
Client : Research in Motion Limited for Itronix Corporation
Equipment : Ruggedized Wireless Laptop with Vehicle Cradle with External 3dB Cushcraft Vehicle-Top Mag-Mounting Antenna
Part No. : X-C 6250 Laptop and SN8962A Antenna
Serial No. : 37466

ENGINEERING SUMMARY

This report contains the results of the maximum permissible exposure (MPE) evaluation performed on the equipment under test (EUT) which was comprised of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 3dB Cushcraft Model SN8962A vehicle-rooftop mag-mounting antenna. The tests were carried out in accordance with the applicable requirements of FCC rules found in 47CFR §2.1091 and the standards ANSI/IEEE C95.1-1992 and C95.3-1992.

The methodology and results for the test are described in the appropriate section of this report.

The EUT will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.52 mW/cm^2.

TABLE OF CONTENTS

SECTION	TITLE	PAGE

ACRONYMS

EUT	Equipment Under Test
FCC	Federal Communications Commission
MPE	Maximum Permissible Exposure
N/A	Not Applicable
NTS	Not To Scale
OATS	Open Area Test Site
OEM	Original Equipment Manufacturer
QA	Quality Assurance
RIM	Research in Motion

1.0 INTRODUCTION

1.1 General

This report describes the Maximum Permissible Exposure (MPE) tests an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 3dB Cushcraft Model SN8962A vehicle-rooftop mag-mounting antenna, the combination hereinafter called the EUT (Equipment Under Test).

1.2 Scope

MPE evaluation was performed on the EUT in accordance with the requirements of the FCC rules for RF compliance found in 47CFR §2.1091 and the standard ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave. This Engineering Report contains the following:

1.2.1 Methodology as to how the tests were performed.
1.2.2 Test results and analysis.
1.2.3 Identification of the test equipment used for the testing.
1.2.4 Test set-up diagram.

1.3 Schedule

The MPE tests were completed on October 16, 1998.

2.0 APPLICABLE DOCUMENTS

FCC Rule Part 47CFR §2.1091

ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz.

ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

OET Bulletin 65 (Edition 97-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

3.0 TEST SAMPLE

The MPE tests described in this procedure was performed on:

- Itronix Model X-C 6250 Cross Country ruggedized wireless laptop (see specification sheets in Appendix A), S/N 374666, Config BBBEBAAADA-DZABA-ABP.
- Itronix Model CRDL, RF ASSY 208I vehicle cradle, P/N 50-0057-001 /4, S/N 303242.
- Cushcraft Model SN8962A 3dB vehicle-mag-mounting antenna (see specification sheets in Appendix B).

4.0 GENERAL REQUIREMENTS

4.1 Location of Test Facilities

The tests were performed by APREL Laboratories at APREL's test facility located in Nepean, Ontario, Canada. The laboratory operates a 3 and 10 meter Open Area Test Site (OATS) measurement facility. The test site is calibrated to ANSI C63.4-1992.

A description of the measurement facility in accordance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations. APREL's registration number is 31070/SIT(1300F2).

APREL is accredited by Standard Council of Canada, under the PALCAN program (ISO Guide 25). All equipment used is calibrated or verified in accordance with the intent of AQAP-6/MIL-STD-45662. APREL is also accredited by Industry Canada (formerly DOC) and recognized by the Federal Communications Commission (FCC).

4.2 Personnel

Radiation Hazard technical staff member, Heike Wuenschmann, carried out all MPE tests.

4.3 Failure Criteria

The equipment under test was considered to have failed if any of the following occurred:

> When the MPE limits exceeded those permitted by appropriate limits defined by the FCC.

4.4 Power Source Required

The following nominal DC Power was maintained during the test:

Voltage: 12 VDC.

4.5 Tolerance

The following tolerances on test conditions, exclusive of equipment accuracy, were maintained:

Voltage: ± 10%.

5.0 TEST INSTRUMENTATION & CALIBRATION

5.1 General

APREL Laboratories, located in Nepean, Ontario is equipped with the necessary instrumentation to ensure accurate measurement of all data recorded during the tests outlined in this document. To ensure continued accuracy, each instrument is re-calibrated at intervals established by APREL and based on standards traceable to the National and International Standards. Accuracy surveillance is a function of APREL Quality Assurance.

5.2 MPE Test Equipment Required

The test equipment required to perform the MPE testing was selected from the equipment available at APREL.

5.3 Calibration Requirements

All test equipment instrumentation required for MPE qualification testing was calibrated and controlled.

6.0 ELECTRICAL/MECHANICAL DESCRIPTION

The MPE Test Program was performed an Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Cushcraft vehicle-top mag-mounting antenna, the combination hereinafter called the EUT. The test sample consisted of the components supplied by the customer and described below.

6.1 Test Unit Description

The Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Cushcraft vehicle-rooftop mag-mounted 3dB antenna, consisted of the following components:

Part Number	Description
X-C 6250 398C	Itronix ruggedized wireless laptop
CRDL, RF ASSY 208I	Itronix vehicle cradle
SRB01519/9743D59235	RIM execution lock device for radio tools
SN8962A	Cushcraft vehicle-rooftop mag-mounted 3dB antenna
0820-0004	6 Gates 2V 25AH BC DC cells

6.2 MPE Test Setup

a) The EUT antenna shall be installed in the centre of a ground plane simulating the rooftop of a vehicle. The other components shall be located underneath this ground plane to simulate operation from inside of the vehicle (see Figures 6.2.1 and 6.2.2).

b) The vehicle simulator shall be positioned on the turntable in the OATS in such a way that the antenna will be located on the centre of rotation.

c) The EUT shall be connected to the 12 VDC power supply.

d) For the selection and placement of the measuring probe, the requirements of ANSI/IEEE C95.3-1992 shall be met.

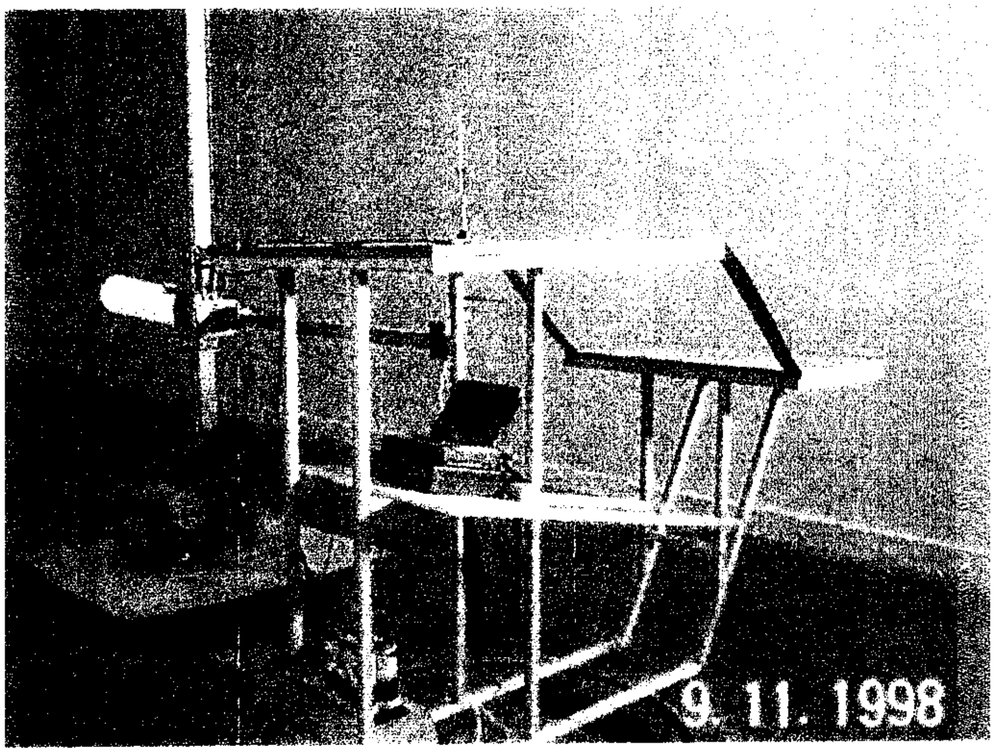


Figure 6.2.1. Photograph of the Setup.

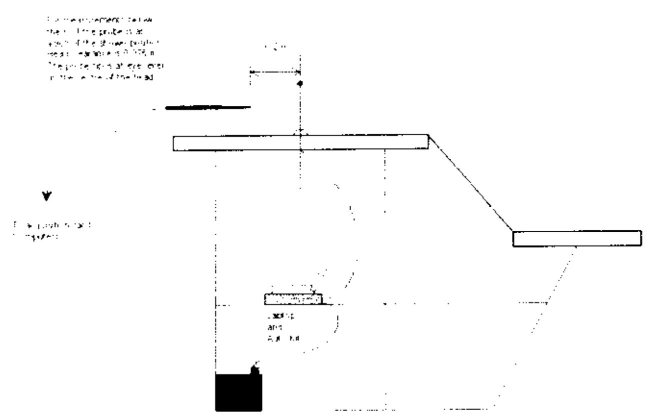


Figure 6.2.2. Elevation View of the Setup.

7.0 MAXIMUM PERMISSIBLE EXPOSURE (MPE) TEST

7.1 Purpose

This test method is used to verify that the EUT meets the MPE requirements as defined in the criteria for general population/uncontrolled exposure when operating at maximum power levels and in all operating modes.

7.2 Test Equipment

Description	Manufacturer	Model No.
E-Field Probe	Narda	8021B

7.3 Criteria

Power Density Limits – The EUT shall not generate a power density beyond the limits in the frequency band listed in the left hand column of Table 7.3.1, and the power density given in the right hand column. The power density shall be measured 20 cm from the radiating antenna axis above the vehicle-top simulating ground plane, as well as in the approximate location of the head of possible vehicle drivers or passengers below the ground plane (see Figure 7.3.1). The measured values shall be recorded.

Table 7.3.1

Power Density Limits
for General Population/Uncontrolled Exposure

Frequency Range	Power Density (mW/cm^2)
300 - 1500 MHz	f/1500

Note: f = frequency in MHz

The measurements shall be performed at one transmitting frequency, the highest of the high, middle or low channels, with the EUT operating at the full rated output power.

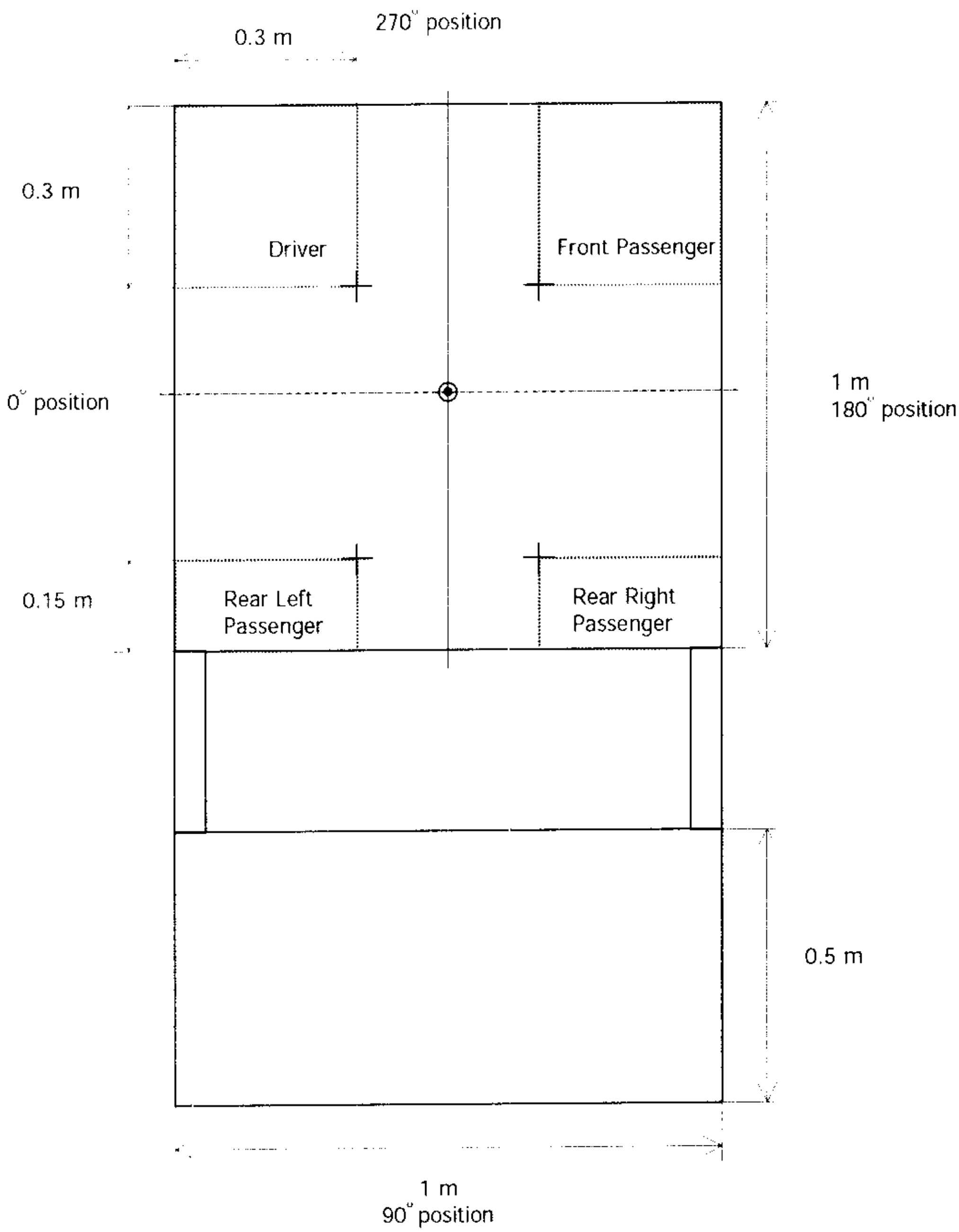


Figure 7.3.1. Plan View of Vehicle Simulator and Setup.

7.4 Test Procedure

a) The probe shall be positioned close to, and parallel to, the vehicle rooftop simulation with its tip 20 cm from the radiating antenna, and its axis normal to the antenna.

b) Rotate the turntable so that the probe is at the 0° position (see Figure 7.3.1).

c) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

d) Determine the location of the maximum power density: locate the maximum emissions by scanning vertically along the EUT's antenna. Take and record measurements of the power density at a number of points along the length of the antenna as well as just past its tip.

e) At every 45° of rotation take and record a measurement of the power density at the maximum power density height as for at least the following locations:

- half the maximum power density height
- height halfway between the maximum power density height and the tip of the radiating antenna
- just above the tip of the antenna

f) Turn off the EUT.

g) Position the probe under the vehicle rooftop simulating ground plane in the approximate location of the centre of the head of a potential driver of the simulated vehicle (see Figure 7.3.1).

h) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

i) Take and record the measurement of the power density at this location.

j) Turn off the EUT.

k) Repeat steps g) through j) for the positions of the other potential occupants of the simulated vehicle as shown in Figure 7.3.1.

7.5 Results

Table 7.5.1 presents the results of the measurements made along the length of the antenna in order to find the location of the maximum power density (the Cushcraft SN8962A antenna has a height of 35 cm). Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 12ft Cushcraft SN8962A antenna cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (6ft × 0.16 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

The data in Table 7.5.1 is presented in Figure 7.5.1.

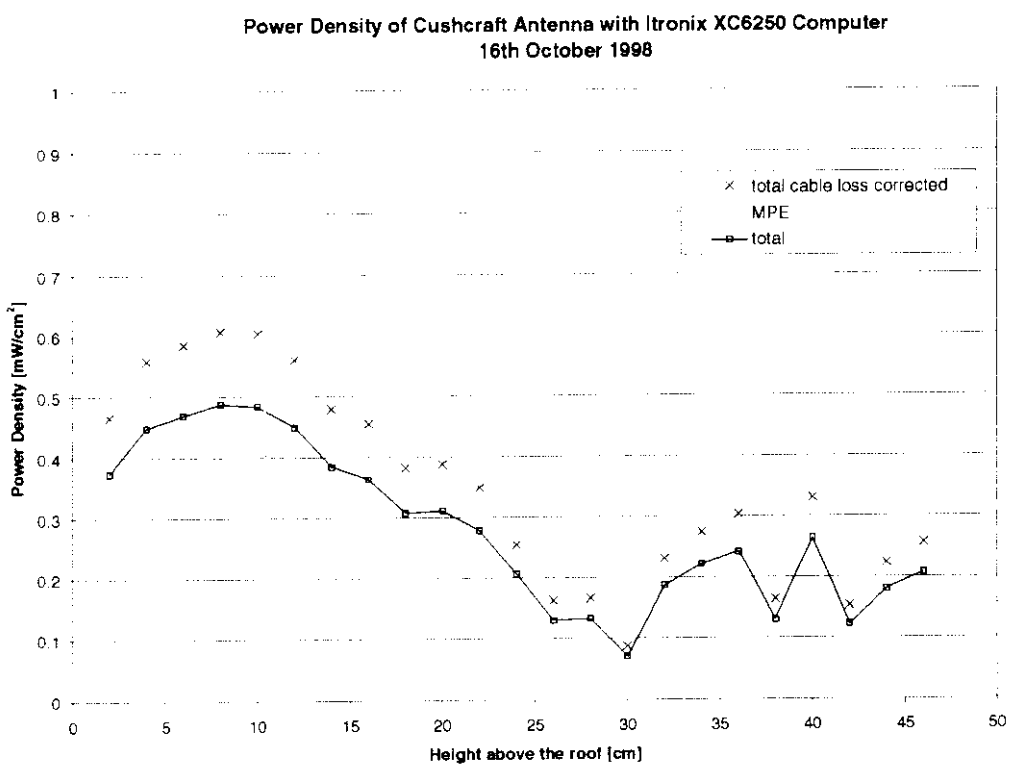


Figure 7.5.1

Table 7.5.1

Power Density Measured
at 0° as a Function of Height

Height	Total	Excess cable loss	Adjusted total	MPE Limit
[cm]	[mW/cm²]	[dB]	[mW/cm²]	[mW/cm²]
2	0.37	0.96	0.47	0.6
4	0.45	0.96	0.56	0.6
6	0.47	0.96	0.59	0.6
8	0.49	0.96	0.61	0.6
10	0.48	0.96	0.60	0.6
12	0.45	0.96	0.56	0.6
14	0.38	0.96	0.48	0.6
16	0.36	0.96	0.45	0.6
18	0.31	0.96	0.38	0.6
20	0.31	0.96	0.39	0.6
22	0.28	0.96	0.35	0.6
24	0.21	0.96	0.26	0.6
26	0.13	0.96	0.16	0.6
28	0.13	0.96	0.17	0.6
30	0.07	0.96	0.09	0.6
32	0.19	0.96	0.23	0.6
34	0.22	0.96	0.28	0.6
36	0.24	0.96	0.30	0.6
38	0.13	0.96	0.16	0.6
40	0.27	0.96	0.33	0.6
42	0.12	0.96	0.15	0.6
44	0.18	0.96	0.22	0.6
46	0.21	0.96	0.26	0.6

Table 7.5.2 presents the results of the measurements made around the antenna at every 45° of rotation. Column 1 shows the angle at which the measurements were taken and columns 2 through 5 show the final adjusted power density (see discussion surrounding Table 7.5.1) at the different measurement heights. The MPE value is determined by averaging the adjusted total power density along a vertical line up to the height of a tall typical individual, taken here as 6ft or 180cm. Since the height for the rooftop of the simulated vehicle is 143cm, then the averaging is over those measurements made between 0 and 37cm above the simulated vehicle rooftop. Column 6 shows the results of this averaging.

Table 7.5.2

Power Density Measured
at every 45° as a Function of Height

Angular Position [°]	Adjusted Total Power Density H1 [cm] 4 [mW/cm²]	H2 [cm] 10 [mW/cm²]	H3 [cm] 20 [mW/cm²]	H4 [cm] 40 [mW/cm²]	Average of Values up to 37 cm [mW/cm²]	MPE Limit [mW/cm²]
0	0.5583	0.6038	0.3877	0.3310	0.5166	0.6
45	0.3148	0.3853	0.2352	0.0130	0.3118	0.6
90	0.3391	0.2755	0.2439	0.1304	0.2861	0.6
135	0.5645	0.6134	0.3266	0.0052	0.5015	0.6
180	0.3081	0.4918	0.1607	0.2166	0.3202	0.6
225	0.1183	0.4140	0.1809	0.0574	0.2378	0.6
270	0.4401	0.4409	0.1970	0.0326	0.3593	0.6
315	0.4986	0.3776	0.2463	0.0004	0.3742	0.6
360	0.5583	0.6038	0.3877	0.3310	0.5166	0.6

The data in Table 7.5.2 is presented in Figure 7.5.2.

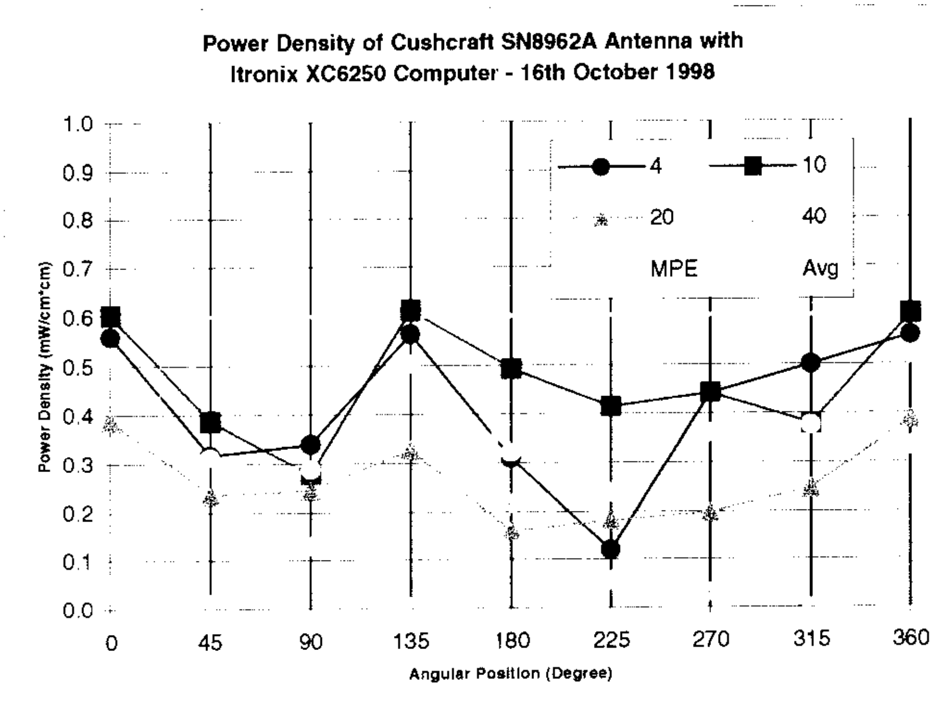

Power Density of Cushcraft SN8962A Antenna with
Itronix XC6250 Computer - 16th October 1998
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Power Density (mW/cm*cm)
0
45
90
135
180
225
270
315
360
Angular Position (Degree)
4
10
20
40
MPE
Avg

Figure 7.5.2.

Measurements were made below the simulated vehicle rooftop, in the approximate location of the centre of the head of potential occupants. It was assumed that this typical position occurred 17.5cm below the roof of the simulated vehicle (the clearance between the top of an occupant's head and a vehicle's roof is ~3" (7.5cm) and distance between the top of the head and the eyes is ~4" (10cm)). Figure 7.3.1 shows the location of measurements for the 4 potential occupants. Table 7.5.3 presents the results of the measurements. Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 12ft Cushcraft SN8962A antenna cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (6ft × 0.16 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

Table 7.5.3

Power Density Measured
at Position of Potential Vehicle Occupants

Position	Total	Excess cable loss	Adjusted Total	MPE Limit
	[mW/cm^2]	[dB]	[mW/cm^2]	[mW/cm^2]
driver	0.00	0.96	0.00	0.6
front passenger	0.02	0.96	0.02	0.6
rear left	0.00	0.96	0.00	0.6
rear right	0.00	0.96	0.01	0.6

8.0 CONCLUSION

The EUT consisting of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 3dB Cushcraft Model SN8962A vehicle-rooftop mag-mounting antenna will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.52 mW/cm^2.

APPENDIX A

Transmitter Specifications

X-C 6250

W E K N O W T H E R O A D™

A High Performance Wireless Worktool for Field Computing

Directly impact workforce productivity and profits with the Itronix X-C 6250 – a fully ruggedized, wireless computer designed specifically to deliver results in the most demanding field applications.

The X-C 6250 is built tough to withstand the shock of repeated drops and remain operational under extreme temperatures, vibration, liquid, and exposure to the elements. When equipped with wireless communications, highly mobile field workers can use the X-C 6250 to collect, communicate and manage account information in real time while at a customer's site. Sophisticated power management systems deliver computing and communications capabilities all day on a single battery, ensuring productivity. Additional features for field computing like the 6250's optional touch screen allow workers the flexibility and ergonomics of both pen and keyboard use in the same platform.

Reach the next plateau in servicing your customers with Itronix. The leader in mission-critical mobile computing solutions.

ITRONIX

GHLIGHTS

00MHz Intel Pentium
rocessor

ntegrated wireless data
ommunications

Conference quality
peakerphone

oth touch screen &
eyboard input

ully ruggedized,
otally sealed

xcellent outdoor
iewable display

ariety of carrying options
nd locking vehicle docks

ower management system
or all day battery use

.1GB or 3.2GB ruggedized
ard drive

Color and monochrome
isplays up to 10.4"

FEATURES AND SPECIFICATIONS

COMPACT SIZE/WEIGHT
- Length: 10.5" (26.7cm)
- Width: 7.5" or 8.1" (19.1 or 20.57cm) screen size dependent
- Depth: 3.0" (7.6cm)
- Weight: 6.9 or 7.18 lbs. (3.1 or 3.25 kg) screen size dependent

PROCESSOR/MEMORY
- 200MHz Pentium® with MMX technology
- 16 to 48 MB RAM

STORAGE
- 2.1GB or 3.2GB 2.5" ruggedized hard drive

POWER
- 3.5 Ahr high capacity NiMh battery pack
- Smart battery with accurate gas gauge
- 4 hour rapid charge

DISPLAY
- SVGA color 800 x 600 pixel 10.4" diagonal display (touch screen optional)
- VGA monochrome 640 x 480 pixel 8.2" diagonal transflective backlit display
- Shock mounted
- Long-life hinge
- Automatic temperature compensation

INPUT DEVICES
- Keyboard – 93% standard key spacing user replaceable
- Pointing Stick – pressure sensitive with two button input
- Touch Screen – optional passive pen or finger touch capable

OPERATING SYSTEM
- Microsoft® Windows® 95
- Microsoft® Pen Computing for Windows® 95

INTERFACES
- Powered 115Kbps 16550 compatible serial port
- ECP/EPP parallel port
- Built-in RJ-11 phone jack – externally accessible
- Accepts 2 Type I or II or 1 Type III PC cards
- External video connector

INTEGRATED WIRELINE COMMUNICATIONS
- Integrated microphone and speaker for voice communications
- 33.6 Kbps v.34 Group 3 fax/data modem

INTEGRATED WIRELESS COMMUNICATION OPTIONS
- CDPD/Cellular radio network for voice & data
- ARDIS network
- BellSouth Wireless Data network

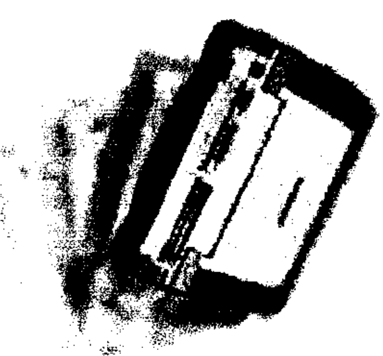
OPTIONS
- Vehicle charger with lighter adapter
- Stand alone spare battery pack charger
- Vehicle cradle with lock, power, and serial port
- External 3.5" floppy drive
- External CD-ROM
- External antenna option with vehicle cradle
- Carry cases for system and accessories
- Bar-Code laser scanners
- Vehicle cradle with CD-ROM

INTEGRATED TELEPHONE LINE TESTING OPTION
- T-BERD 109XC Subscriber Loop Analyzer accessed by software running under Windows® 95
- Full-function POTS subscriber line tester
- Time Domain Reflectometer (TDR)
- Narrowband TIMS
- Basic-rate ISDN tester

LONG-LIFE CASE DESIGN
- Die Cast Magnesium for all structural components
- Integrated Santoprene® shock absorption
- Case design integrates vehicle cradle connection
- Full environmental and RF seal
- Zinc door on PC cardslot

ENVIRONMENTAL CHARACTERISTICS
- Operating temperature range: -4° to 140° Fahrenheit (-20° to 60° Celsius)
- 54 repeated 1M drops on all surfaces, edges and corners per MIL STD 810E, 516.4, Proc. IV (30" with intergrated T-BERD 109XC)
- Rain at 4 in./hr. at approximately 40 psi for 40 minutes per axis for all axes per MIL STD 810E, 506.3, Proc. III
- Vibration of .04g^2/Hz over 20-1000Hz random

INTRINSIC SAFETY
- Class 1, Division 2, Group D



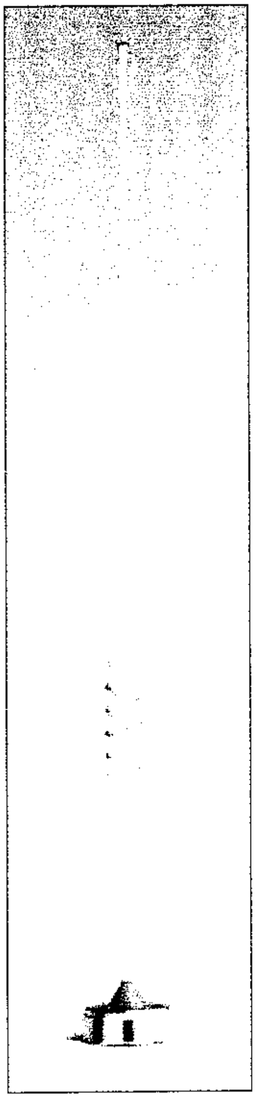
ITRONIX
Mobile Workforce Systems Company
A DYNATECH Company

V.1 3M 10/98
801 South Stevens Street, Spokane, WA 99204
509-624-6600 1-800-441-1309

APPENDIX B

Antenna Specifications

Economy Mobiles



Our economy mobiles are just right for many applications. These antennas feature a flexible stainless steel radiator and 100% contact with the mount. They are available in 3 dB or 0 dB gain. Our economy mobiles come with 14.5 feet (4.4 meters) of standard RG58A/U or Cushcraft low loss UltraLink® Cable. Available connectors include PL259, TNC, N and mini-UHF. These antennas cover the 806-960 MHz range with VSWR of less than 1.5:1 and feature hardware which will not seize in corrosive atmospheres.

Economy mobiles are available individually and in FastPaks which contain four identical antennas and all parts for easy inventory, convenience and economy.

ECONOMY MOBILES

- All-brass mounting hardware
- UltraLink® Cable or RG58A/U
- 100% contact with mount
- Black Teflon® or polished stainless steel whip

SPECIFICATION CHART

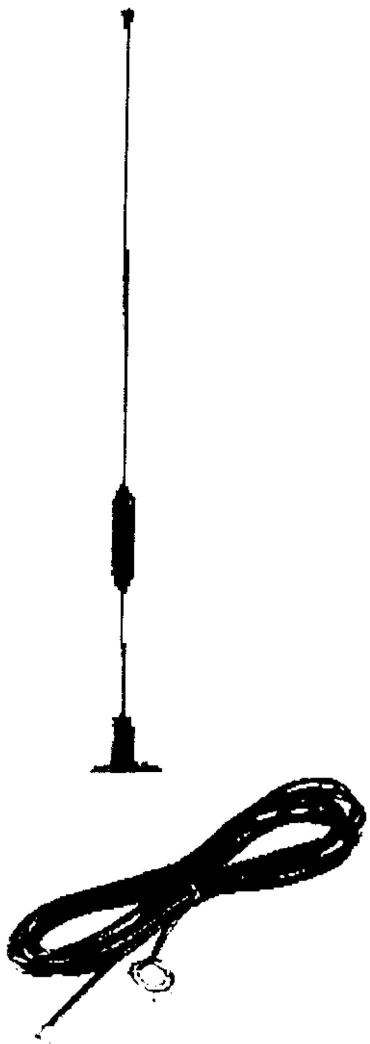
Model	800/900 Economy 0 dB Gain	800/900 Economy 3 dB Gain
Freq. Range, MHz	806-960	806-940
VSWR	<1.5:1	<1.5:1
Radiator	302SS	302SS
Spring	N/A	N/A
Hardware	Brass	Brass

800/900 MHz ECONOMY MOBILE SELECTOR CHART

Cable	Low Loss UltraLink®				RG58A/U					
Connector	UHF	N	TNC	MINI-UHF	UHF	N	TNC	MINI-UHF	ROD & BASE	ROD ONLY
806-860 3 dB Chrome	SN8062LU	SN8062LN	SN8062LTN	SN8062LM	SN8062U	SN8062N	SN8062TN	SN8062M	SN8062A	SN8062R
806-860 3 dB Black	SNB8062LU	SNB8062LN	SNB8062LTN	SNB8062LM	SNB8062U	SNB8062N	SNB8062TN	SNB8062M	SNB8062A	SNB8062R
825-896 3 dB Chrome	SN8252LU	SN8252LN	SN8252LTN	SN8252LM	SN8252U	SN8252N	SN8252TN	SN8252M	SN8252A	SN8252R
825-896 3 dB Black	SNB8252LU	SNB8252LN	SNB8252LTN	SNB8252LM	SNB8252U	SNB8252N	SNB8252TN	SNB8252M	SNB8252A	SNB8252R
896-940 3 dB Chrome	SN8962LU	SN8962LN	SN8962LTN	SN8962LM	SN8962U	SN8962N	SN8962TN	SN8962M	SN8962A	SN8962R
896-940 3 dB Black	SNB8962LU	SNB8962LN	SNB8962LTN	SNB8962LM	SNB8962U	SNB8962N	SNB8962TN	SNB8962M	SNB8962A	SNB8962R
806-896 0 dB Chrome	SN8061LU	SN8061LN	SN8061LTN	SN8061LM	SN8061U	SN8061N	SN8061TN	SN8061M	SN8061A	SN8061R
806-896 0 dB Black	SNB8061LU	SNB8061LN	SNB8061LTN	SNB8061LM	SNB8061U	SNB8061N	SNB8061TN	SNB8061M	SNB8061A	SNB8061R
896-940 0 dB Chrome	SN8961LU	SN8961LN	SN8961LTN	SN8961LM	SN8961U	SN8961N	SN8961TN	SN8961M	SN8961A	SN8961R
896-940 0 dB Black	SNB8961LU	SNB8961LN	SNB8961LTN	SNB8961LM	SNB8961U	SNB8961N	SNB8961TN	SNB8961M	SNB8961A	SNB8961R

CUSHCRAFT
COMMUNICATIONS ANTENNAS

Mobile Cellular, SMR, Data 800/900 MHz



Complete 3dB SuperFlex enc. coil antenna, standard NMO base w/cable and connector

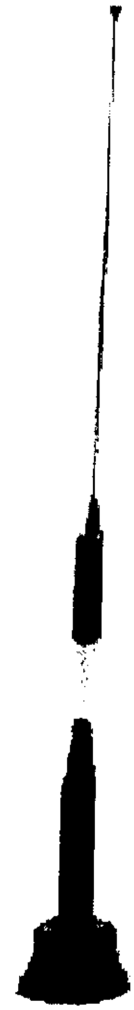
MODEL	FREQUENCY	CONNECTOR
NMO3E800BMPL	806-866 MHz	MPL
NMO3E800BTNC	806-866 MHz	TNC
NMO3E825BMPL	825-896 MHz	MPL
NMO3E825BTNC	825-896 MHz	TNC
NMO3E900BMPL	890-960 MHz	MPL
NMO3E900BTNC	890-960 MHz	TNC

SPECIFICATIONS	
GAIN	3dB
TYPE	5/8 over 1/4 wave
VSWR	1.5:1 or less
COLOR	Black
WHIP	.070, enc. coil
COAX	17' RG-58/U
BASE SIZE	1 5/8"
POWERRATING	200 watts
MAX HEIGHT	13 1/2"

NMO base w/heavy duty chrome spring and enc. coil whip

MODEL	FREQUENCY
NMO 800	806-866 MHz
NMO 825	825-896 MHz
NMO 900	890-960 MHz

SPECIFICATIONS	
GAIN	4.5dB
TYPE	5/8 over 1/2 wave
VSWR	1.5:1 or less
COLOR	Black/Chrome
WHIP	.100, enc. coil
COAX	Order separately
BASE SIZE	1 5/8"
POWERRATING	200 watts
MAX HEIGHT	12 3/4" H



NMO base w/heavy duty black spring and enc. coil whip

MODEL	FREQUENCY
NMO 800 B	806-866 MHz
NMO 825 B	825-896 MHz
NMO 900 B	890-960 MHz

SPECIFICATIONS	
GAIN	4.5dB
TYPE	5/8 over 1/2 wave
VSWR	1.5:1 or less
COLOR	Black/Chrome
WHIP	.100, enc. coil
COAX	Order separately
BASE SIZE	1 5/8"
POWERRATING	200 watts
MAX HEIGHT	12 3/4" H

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Proven and patented SX mobile technology offered in a closed coil application. This mobile antenna combines the features of the SX series including outstanding RF performance and a flexible base complete with integrated gaskets for moisture sealing. Contact your distributor to place an order or Cushcraft for more information at 1-800-258.-3860

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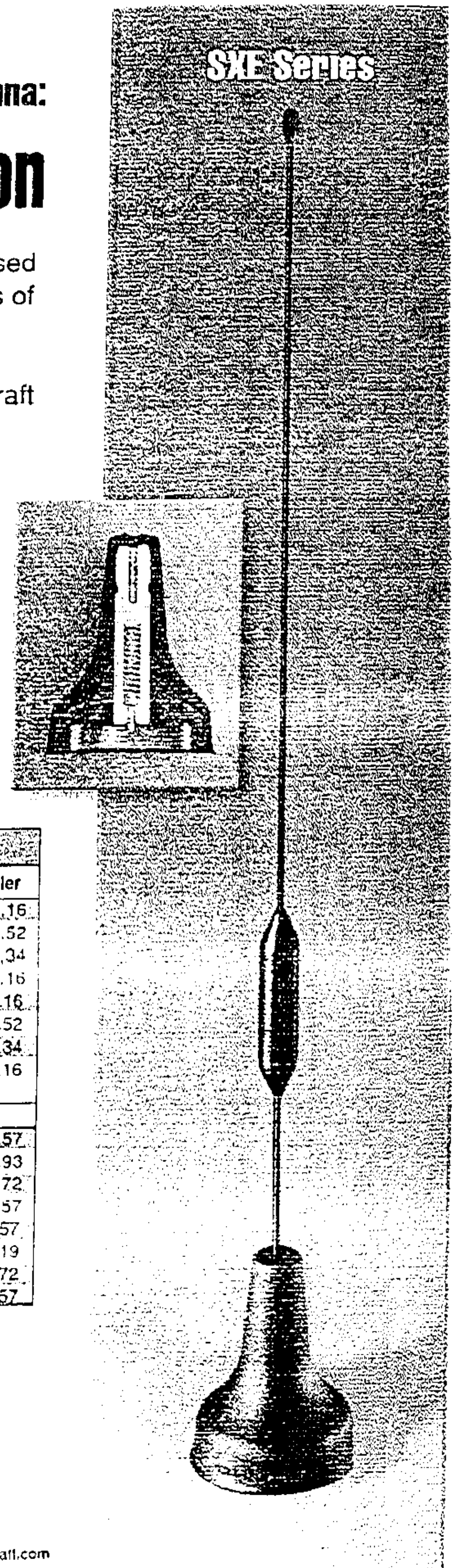
- **Patented Design**
- **Superior Moisture Resistance for Reliable Performance**
- **Ice Resistant**



ENCLOSED COIL, 3/4" MOUNT, 5/8 WAVE, 3 dB GAIN

WITH 14-1/2 FEET (4.4 M) WHITE ULTRALINK CABLE®		List	Dealer
SXE808LU	806-896 MHz with Teflon® UHF connector	$64	$26.16
SXE808LN	806-896 MHz with N-crimp connector	$70	$28.52
SXE808LTN	806-896 MHz with TNC-crimp connector	$69	$28.34
SXE808LM	806-896 MHz with Mini-UHF crimp connector	$64	$26.16
SXE908LU	896-960 MHz with Teflon® UHF connector	$64	$26.16
SXE908LN	896-960 MHz with N-crimp connector	$70	$28.52
→ SXE908LTN	896-960 MHz with TNC-crimp connector	$69	$28.34
SXE908LM	896-960 MHz with Mini-UHF crimp connector	$64	$26.16
WITH 14-1/2 FEET (4.4 M) RG58 CABLE			
SXE808U	806-896 MHz with Teflon® UHF connector	$59	$24.57
SXE808N	806-896 MHz with N-crimp connector	$65	$26.93
SXE808TN	806-896 MHz with TNC-crimp connector	$63	$26.72
SXE808M	806-896 MHz with Mini-UHF crimp connector	$59	$24.57
SXE908U	896-960 MHz with Teflon® UHF connector	$59	$24.57
SXE908N	896-960 MHz with N-crimp connector	$65	$26.19
SXE908TN	896-960 MHz with TNC-crimp connector	$65	$26.72
SXE908M	896-960 MHz with Mini-UHF crimp connector	$59	$24.57

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EXHIBIT THREE

MPE REPORT

External 5dB

Maxrad Vehicle-Top

Mounting Antenna

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ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 5dB Maxrad Vehicle-Top Mounting Antenna

FCC ID #:

MODEL: X-C 6250 Laptop and MUF9105SP Antenna

CLIENT: Itronix Corporation

PROJECT #: ITRB-X-C 6250 Maxrad MUF9105SP-3108

ADDRESS: 801 South Stevens Street
Spokane, WA
USA 99204

PREPARED BY: *APREL Laboratories, Regulatory Compliance Division*

APPROVED BY: Dr. Paul G. Cardinal, Director, Laboratory Operations   DATE: 13 Nov 98

RELEASED BY: Dr. Jacek J. Wojcik, P.Eng.   DATE: Nov 13/98

51 Spectrum Way
Nepean, Ontario
K2R 1E6, Canada

Tel. (613) 820 2730
Fax (613) 820 4161
e-mail: info@aprel.com

ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

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ADDRESS: 801 South Stevens Street
Spokane, WA
USA 99204

PREPARED BY: *APREL Laboratories,*
Regulatory Compliance Division

APPROVED BY: ______________________ DATE: ______________________
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: ______________________ DATE: ______________________
Dr. Jacek J. Wojcik, P.Eng..

FCC ID:
Client : Itronix Corporation
Equipment : Ruggedized Wireless Laptop with Vehicle Cradle with External 5dB Maxrad Vehicle-Top Mounting Antenna
Part No. : X-C 6250 Laptop and MUF9105SP Antenna
Serial No. : 37466

ENGINEERING SUMMARY

This report contains the results of the maximum permissible exposure (MPE) evaluation performed on the equipment under test (EUT) which was comprised of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Maxrad Model MUF9105SP vehicle-rooftop mounting antenna. The tests were carried out in accordance with the applicable requirements of FCC rules found in 47CFR §2.1091 and the standards ANSI/IEEE C95.1-1992 and C95.3-1992.

The methodology and results for the test are described in the appropriate section of this report.

The EUT will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.58 mW/cm^2.

TABLE OF CONTENTS

ACRONYMS

EUT	Equipment Under Test
FCC	Federal Communications Commission
MPE	Maximum Permissible Exposure
N/A	Not Applicable
NTS	Not To Scale
OATS	Open Area Test Site
OEM	Original Equipment Manufacturer
QA	Quality Assurance
RIM	Research in Motion

1.0 INTRODUCTION

1.1 General

This report describes the Maximum Permissible Exposure (MPE) tests an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Maxrad Model MUF9105SP vehicle-rooftop mounting antenna, the combination hereinafter called the EUT (Equipment Under Test).

1.2 Scope

MPE evaluation was performed on the EUT in accordance with the requirements of the FCC rules for RF compliance found in 47CFR §2.1091 and the standard ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave. This Engineering Report contains the following:

1.2.1 Methodology as to how the tests were performed.
1.2.2 Test results and analysis.
1.2.3 Identification of the test equipment used for the testing.
1.2.4 Test set-up diagram.

1.3 Schedule

The MPE tests were completed on November 6, 1998.

2.0 APPLICABLE DOCUMENTS

FCC Rule Part 47CFR §2.1091

ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz.

ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

OET Bulletin 65 (Edition 97-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

3.0 TEST SAMPLE

The MPE tests described in this procedure was performed on:

- Itronix Model X-C 6250 Cross Country ruggedized wireless laptop (see specification sheets in Appendix A), S/N 374666, Config BBBEBAAADA-DZABA-ABP.
- Itronix Model CRDL, RF ASSY 208I vehicle cradle, P/N 50-0057-001 /4, S/N 303242.
- Maxrad Model MUF9105SP 5dB vehicle-mounting antenna (see specification sheets in Appendix B).

4.0 GENERAL REQUIREMENTS

4.1 Location of Test Facilities

The tests were performed by APREL Laboratories at APREL's test facility located in Nepean, Ontario, Canada. The laboratory operates a 3 and 10 meter Open Area Test Site (OATS) measurement facility. The test site is calibrated to ANSI C63.4-1992.

A description of the measurement facility in accordance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations. APREL's registration number is 31070/SIT(1300F2).

APREL is accredited by Standard Council of Canada, under the PALCAN program (ISO Guide 25). All equipment used is calibrated or verified in accordance with the intent of AQAP-6/MIL-STD-45662. APREL is also accredited by Industry Canada (formerly DOC) and recognized by the Federal Communications Commission (FCC).

4.2 Personnel

Radiation Hazard technical staff member, Heike Wuenschmann, carried out all MPE tests.

4.3 Failure Criteria

The equipment under test was considered to have failed if any of the following occurred:

> When the MPE limits exceeded those permitted by appropriate limits defined by the FCC.

4.4 Power Source Required

The following nominal DC Power was maintained during the test:

Voltage: 12 VDC.

4.5 Tolerance

The following tolerances on test conditions, exclusive of equipment accuracy, were maintained:

Voltage: ± 10%.

5.0 TEST INSTRUMENTATION & CALIBRATION

5.1 General

APREL Laboratories, located in Nepean, Ontario is equipped with the necessary instrumentation to ensure accurate measurement of all data recorded during the tests outlined in this document. To ensure continued accuracy, each instrument is re-calibrated at intervals established by APREL and based on standards traceable to the National and International Standards. Accuracy surveillance is a function of APREL Quality Assurance.

5.2 MPE Test Equipment Required

The test equipment required to perform the MPE testing was selected from the equipment available at APREL.

5.3 Calibration Requirements

All test equipment instrumentation required for MPE qualification testing was calibrated and controlled.

6.0 ELECTRICAL/MECHANICAL DESCRIPTION

The MPE Test Program was performed an Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Maxrad vehicle-top mounting antenna, the combination hereinafter called the EUT. The test sample consisted of the components supplied by the customer and described below.

6.1 Test Unit Description

The Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Maxrad vehicle-rooftop mounted 5dB antenna, consisted of the following components:

Part Number	Description
X-C 6250 398C	Itronix ruggedized wireless laptop
CRDL, RF ASSY 208I	Itronix vehicle cradle
SRB01519/9743D59235	RIM execution lock device for radio tools
MUF9105SP	Maxrad vehicle-rooftop mounted 5dB antenna
0820-0004	6 Gates 2V 25AH BC DC cells

6.2 MPE Test Setup

a) The EUT antenna shall be installed in the centre of a ground plane simulating the rooftop of a vehicle. The other components shall be located underneath this ground plane to simulate operation from inside of the vehicle (see Figures 6.2.1 and 6.2.2).

b) The vehicle simulator shall be positioned on the turntable in the OATS in such a way that the antenna will be located on the centre of rotation.

c) The EUT shall be connected to the 12 VDC power supply.

d) For the selection and placement of the measuring probe, the requirements of ANSI/IEEE C95.3-1992 shall be met.

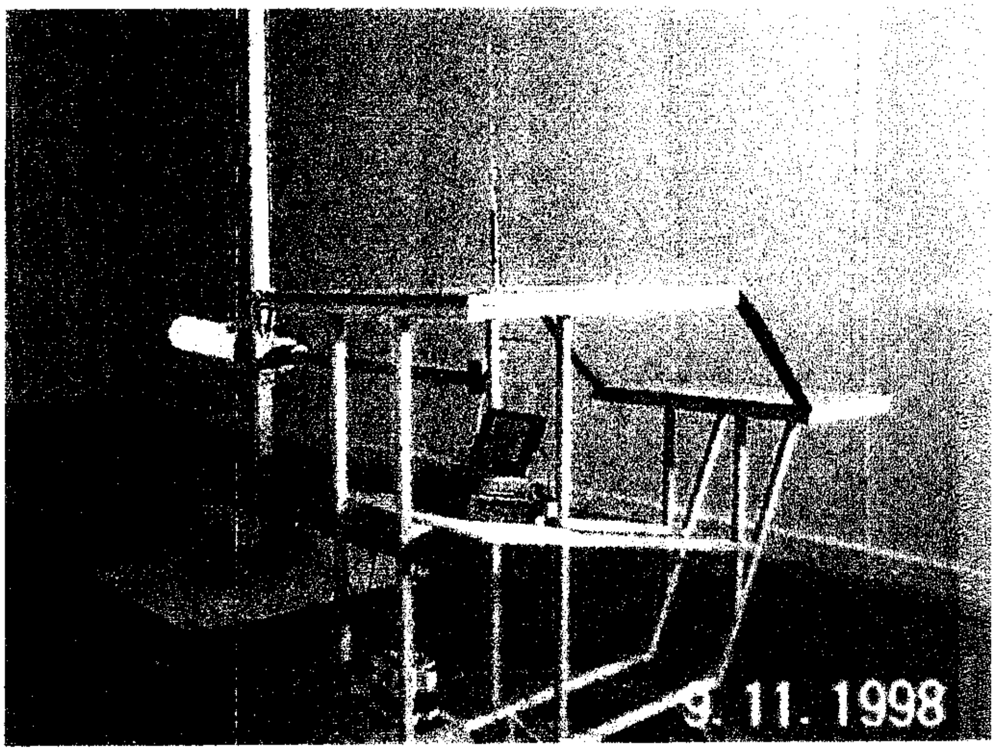


Figure 6.2.1. Photograph of the Setup.

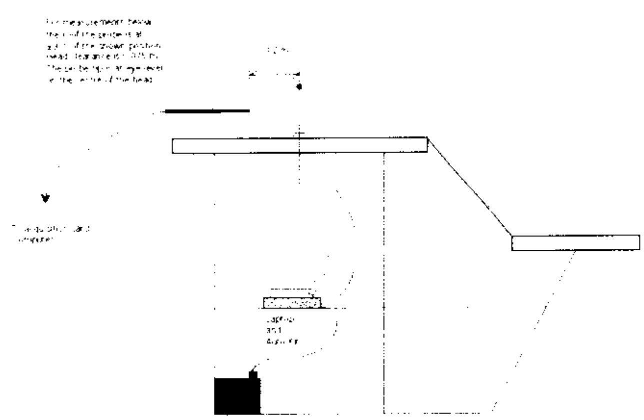


Figure 6.2.2. Elevation View of the Setup.

7.0 MAXIMUM PERMISSIBLE EXPOSURE (MPE) TEST

7.1 Purpose

This test method is used to verify that the EUT meets the MPE requirements as defined in the criteria for general population/uncontrolled exposure when operating at maximum power levels and in all operating modes.

7.2 Test Equipment

Description	Manufacturer	Model No.
E-Field Probe	Narda	8021B

7.3 Criteria

Power Density Limits – The EUT shall not generate a power density beyond the limits in the frequency band listed in the left hand column of Table 7.3.1, and the power density given in the right hand column. The power density shall be measured 20 cm from the radiating antenna axis above the vehicle-top simulating ground plane, as well as in the approximate location of the head of possible vehicle drivers or passengers below the ground plane (see Figure 7.3.1). The measured values shall be recorded.

Table 7.3.1

Power Density Limits
for General Population/Uncontrolled Exposure

Frequency Range	Power Density (mW/cm^2)
300 - 1500 MHz	f/1500

Note: f = frequency in MHz

The measurements shall be performed at one transmitting frequency, the highest of the high, middle or low channels, with the EUT operating at the full rated output power.

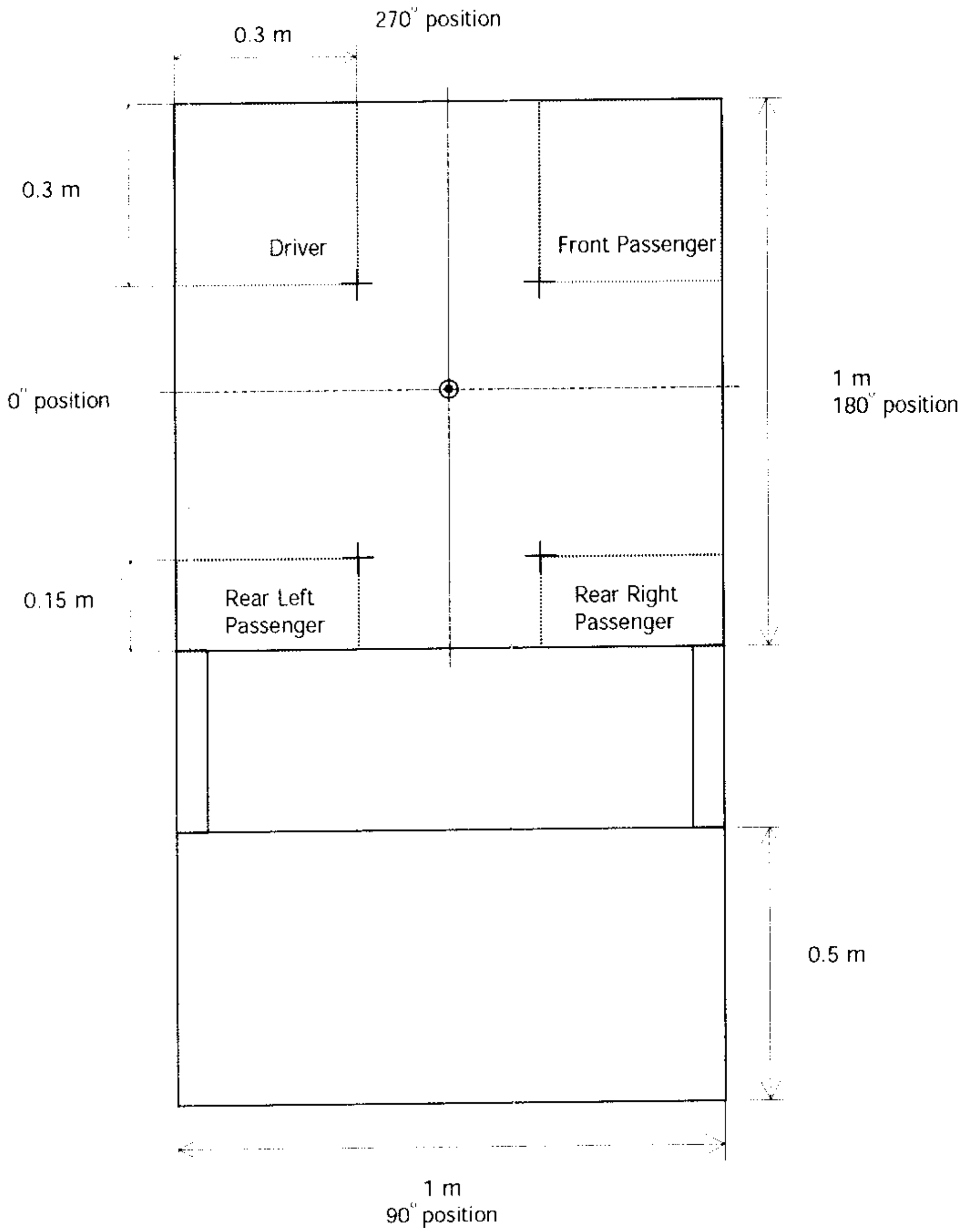


Figure 7.3.1. Plan View of Vehicle Simulator and Setup.

7.4 Test Procedure

a) The probe shall be positioned close to, and parallel to, the vehicle rooftop simulation with its tip 20 cm from the radiating antenna, and its axis normal to the antenna.

b) Rotate the turntable so that the probe is at the 0° position (see Figure 7.3.1).

c) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

d) Determine the location of the maximum power density: locate the maximum emissions by scanning vertically along the EUT's antenna. Take and record measurements of the power density at a number of points along the length of the antenna as well as just past its tip.

e) At every 45° of rotation take and record a measurement of the power density at the maximum power density height as for at least the following locations:

- half the maximum power density height
- height halfway between the maximum power density height and the tip of the radiating antenna
- just above the tip of the antenna

f) Turn off the EUT.

g) Position the probe under the vehicle rooftop simulating ground plane in the approximate location of the centre of the head of a potential driver of the simulated vehicle (see Figure 7.3.1).

h) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

i) Take and record the measurement of the power density at this location.

j) Turn off the EUT.

k) Repeat steps g) through j) for the positions of the other potential occupants of the simulated vehicle as shown in Figure 7.3.1.

7.5 Results

Table 7.5.1 presents the results of the measurements made along the length of the antenna in order to find the location of the maximum power density (the Maxrad MUF9105SP antenna has a height of 79 cm). Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 15.5ft Belden 8219 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (9.5ft × 0.138 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

The data in Table 7.5.1 is presented in Figure 7.5.1.

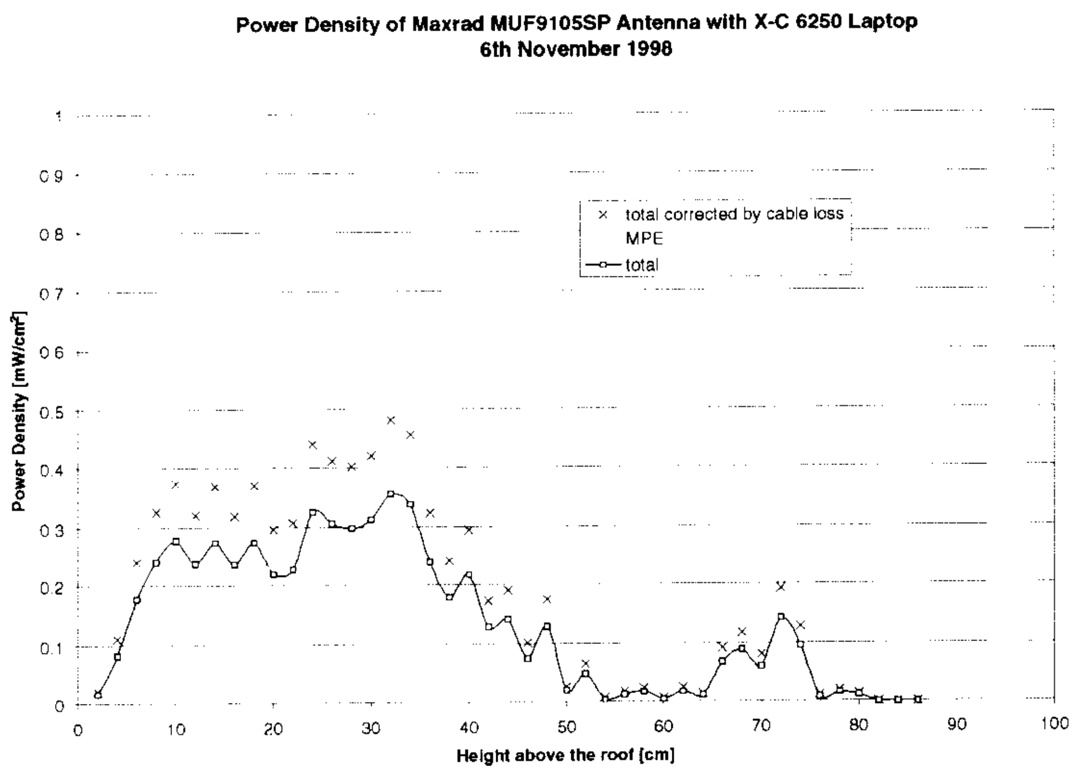


Figure 7.5.1

Table 7.5.1

Power Density Measured at 0° as a Function of Height

Height [cm]	Total [mW/cm^2]	Excess cable loss [dB]	Adjusted total [mW/cm^2]	MPE Limit [mW/cm^2]
2	0.02	1.31	0.02	0.6
4	0.08	1.31	0.11	0.6
6	0.18	1.31	0.24	0.6
8	0.24	1.31	0.33	0.6
10	0.28	1.31	0.37	0.6
12	0.24	1.31	0.32	0.6
14	0.27	1.31	0.37	0.6
16	0.24	1.31	0.32	0.6
18	0.27	1.31	0.37	0.6
20	0.22	1.31	0.30	0.6
22	0.23	1.31	0.31	0.6
24	0.33	1.31	0.44	0.6
26	0.30	1.31	0.41	0.6
28	0.30	1.31	0.40	0.6
30	0.31	1.31	0.42	0.6
32	0.36	1.31	0.48	0.6
34	0.34	1.31	0.46	0.6
36	0.24	1.31	0.32	0.6
38	0.18	1.31	0.24	0.6
40	0.22	1.31	0.29	0.6
42	0.13	1.31	0.17	0.6
44	0.14	1.31	0.19	0.6
46	0.07	1.31	0.10	0.6
48	0.13	1.31	0.18	0.6
50	0.02	1.31	0.03	0.6
52	0.05	1.31	0.07	0.6
54	0.01	1.31	0.01	0.6
56	0.01	1.31	0.02	0.6
58	0.02	1.31	0.02	0.6
60	0.01	1.31	0.01	0.6
62	0.02	1.31	0.02	0.6
64	0.01	1.31	0.01	0.6
66	0.07	1.31	0.09	0.6
68	0.09	1.31	0.12	0.6
70	0.06	1.31	0.08	0.6
72	0.14	1.31	0.19	0.6
74	0.09	1.31	0.13	0.6
76	0.01	1.31	0.01	0.6
78	0.02	1.31	0.02	0.6
80	0.01	1.31	0.01	0.6
82	0.00	1.31	0.00	0.6
84	0.00	1.31	0.00	0.6
86	0.00	1.31	0.00	0.6

Table 7.5.2 presents the results of the measurements made around the antenna at every 45° of rotation. Column 1 shows the angle at which the measurements were taken and columns 2 through 5 show the final adjusted power density (see discussion surrounding Table 7.5.1) at the different measurement heights. The MPE value is determined by averaging the adjusted total power density along a vertical line up to the height of a tall typical individual, taken here as 6ft or 180cm. Since the height for the rooftop of the simulated vehicle is 143cm, then the averaging is over those measurements made between 0 and 37cm above the simulated vehicle rooftop. Column 6 shows the results of this averaging.

Table 7.5.2

Power Density Measured
at every 45° as a Function of Height

Angular	Adjusted Total Power Density				Average	MPE Limit
Position	H1 [cm]	H2 [cm]	H3 [cm]	H4 [cm]	Values up	
	6	30	78	80	to 37 cm	
[°]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]
0	0.5067	0.6629	0.2976	0.0022	0.5848	0.6
45	0.2268	0.5231	0.2640	0.1125	0.3750	0.6
90	0.1754	0.3822	0.0154	0.1280	0.2788	0.6
135	0.3651	0.4296	0.0149	0.0095	0.3973	0.6
180	0.3323	0.4796	0.0173	0.0961	0.4059	0.6
225	0.3926	0.4809	0.0945	0.0683	0.4367	0.6
270	0.2928	0.3978	0.0041	0.1457	0.3453	0.6
315	0.2986	0.4133	0.0022	0.1357	0.3559	0.6
360	0.5067	0.6629	0.2976	0.0022	0.5848	0.6

The data in Table 7.5.2 is presented in Figure 7.5.2.

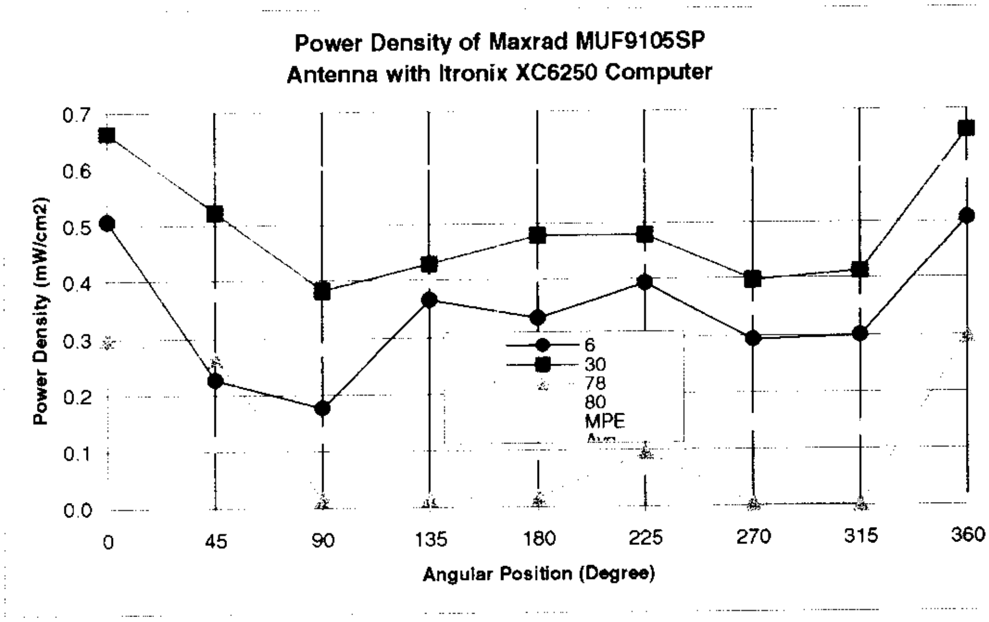

Power Density of Maxrad MUF9105SP
Antenna with Itronix XC6250 Computer
Power Density (mW/cm2)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
45
90
135
180
225
270
315
360
Angular Position (Degree)
6
30
78
80
MPE

Figure 7.5.2.

Measurements were made below the simulated vehicle rooftop, in the approximate location of the centre of the head of potential occupants. It was assumed that this typical position occurred 17.5cm below the roof of the simulated vehicle (the clearance between the top of an occupant's head and a vehicle's roof is ~3" (7.5cm) and distance between the top of the head and the eyes is ~4" (10cm)). Figure 7.3.1 shows the location of measurements for the 4 potential occupants. Table 7.5.3 presents the results of the measurements. Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 15.5ft Belden 8219 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (9.5ft × 0.138 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

Table 7.5.3

Power Density Measured
at Position of Potential Vehicle Occupants

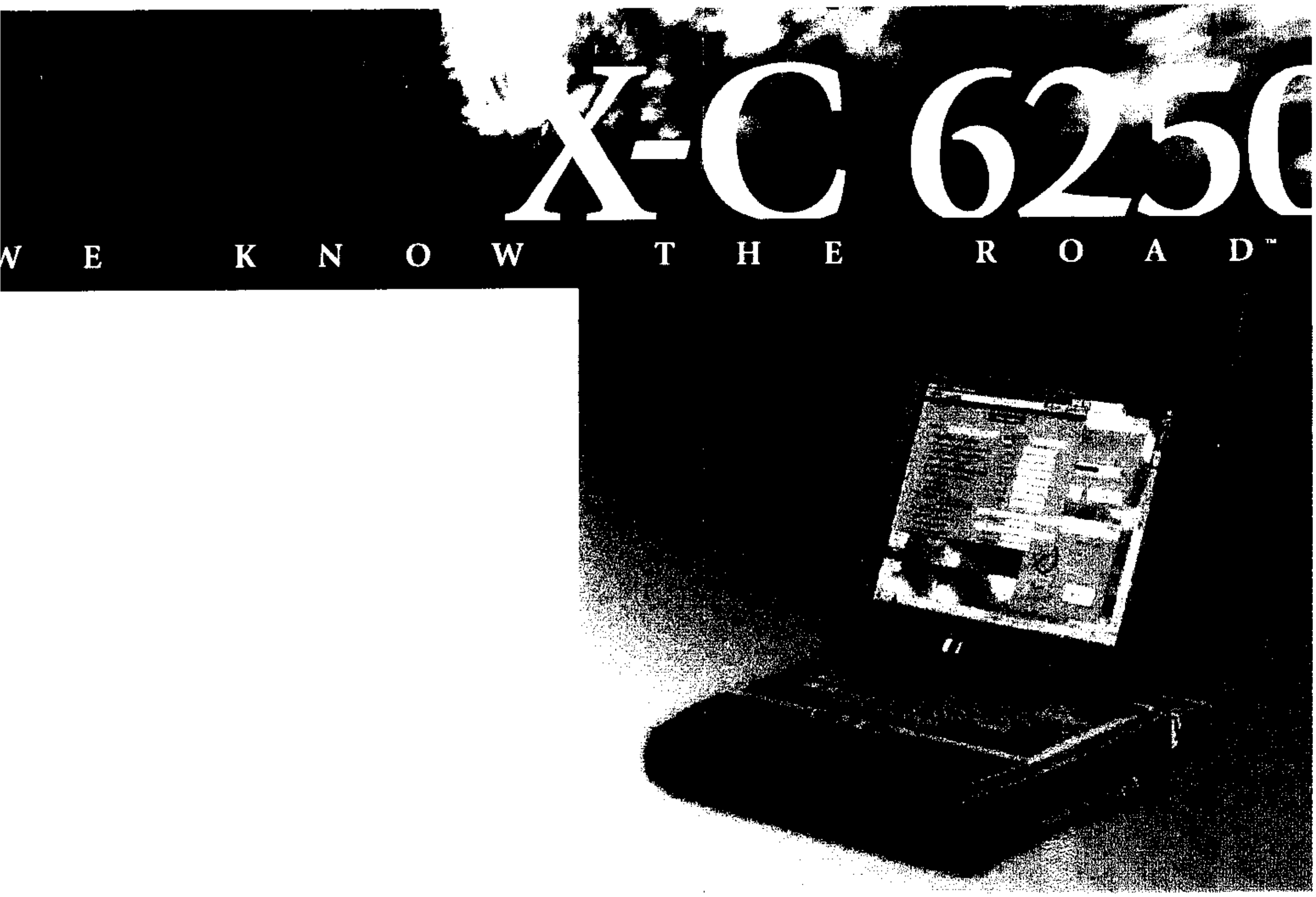
Position	Total	Excess	Adjusted	MPE
		cable	Total	Limit
		loss		
	[mW/cm^2]	[dB]	[mW/cm^2]	[mW/cm^2]
driver	0.01	1.31	0.02	0.6
front passe	0.00	1.31	0.00	0.6
rear left	0.00	1.31	0.00	0.6
rear right	0.00	1.31	0.00	0.6

8.0 CONCLUSION

The EUT consisting of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Maxrad Model MUF9105SP vehicle-rooftop mounting antenna will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.58 mW/cm^2.

APPENDIX A

Transmitter Specifications



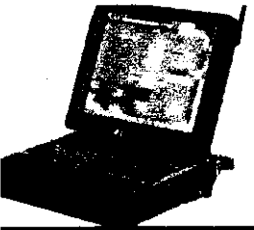
A High Performance Wireless Worktool for Field Computing

Directly impact workforce productivity and profits with the Itronix X-C 6250 – a fully ruggedized, wireless computer designed specifically to deliver results in the most demanding field applications.

The X-C 6250 is built tough to withstand the shock of repeated drops and remain operational under extreme temperatures, vibration, liquid, and exposure to the elements. When equipped with wireless communications, highly mobile field workers can use the X-C 6250 to collect, communicate and manage account information in real time while at a customer's site. Sophisticated power management systems deliver computing and communications capabilities all day on a single battery, ensuring productivity. Additional features for field computing like the 6250's optional touch screen allow workers the flexibility and ergonomics of both pen and keyboard use in the same platform.

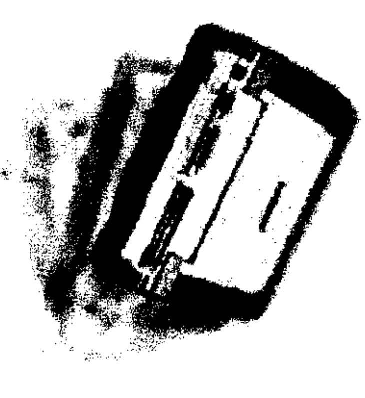
Reach the next plateau in servicing your customers with Itronix. The leader in mission-critical mobile computing solutions.

ITRONIX



GHLIGHTS

- 0MHz Intel Pentium ocessor
- tegrated wireless data mmunications
- nference quality eakerphone
- th touch screen & yboard input
- lly ruggedized, ally sealed
- cellent outdoor wable display
- riety of carrying options d locking vehicle docks
- wer management system all day battery use
- GB or 3.2GB ruggedized rd drive
- lor and monochrome splays up to 10.4″



FEATURES AND SPECIFICATIONS

COMPACT SIZE/WEIGHT
- Length: 10.5" (26.7cm)
- Width: 7.5" or 8.1" (19.1 or 20.57cm) screen size dependent
- Depth: 3.0" (7.6cm)
- Weight: 6.9 or 7.18 lbs. (3.1 or 3.25 kg) screen size dependent

PROCESSOR/MEMORY
- 200MHz Pentium® with MMX technology
- 16 to 48 MB RAM

STORAGE
- 2.1GB or 3.2GB 2.5" ruggedized hard drive

POWER
- 3.5 Ahr high capacity NiMh battery pack
- Smart battery with accurate gas gauge
- 4 hour rapid charge

DISPLAY
- SVGA color 800 x 600 pixel 10.4" diagonal display (touch screen optional)
- VGA monochrome 640 x 480 pixel 8.2" diagonal transflective backlit display
- Shock mounted
- Long-life hinge
- Automatic temperature compensation

INPUT DEVICES
- Keyboard – 93% standard key spacing user replaceable
- Pointing Stick – pressure sensitive with two button input
- Touch Screen – optional passive pen or finger touch capable

OPERATING SYSTEM
- Microsoft® Windows® 95
- Microsoft® Pen Computing for Windows® 95

INTERFACES
- Powered 115Kbps 16550 compatible serial port
- ECP/EPP parallel port
- Built-in RJ-11 phone jack – externally accessible
- Accepts 2 Type I or II or 1 Type III PC cards
- External video connector

INTEGRATED WIRELINE COMMUNICATIONS
- Integrated microphone and speaker for voice communications
- 33.6 Kbps v.34 Group 3 fax/data modem

INTEGRATED WIRELESS COMMUNICATION OPTIONS
- CDPD/Cellular radio network for voice & data
- ARDIS network
- BellSouth Wireless Data network

OPTIONS
- Vehicle charger with lighter adapter
- Stand alone spare battery pack charger
- Vehicle cradle with lock, power, and serial port
- External 3.5" floppy drive
- External CD-ROM
- External antenna option with vehicle cradle
- Carry cases for system and accessories
- Bar-Code laser scanners
- Vehicle cradle with CD-ROM

INTEGRATED TELEPHONE LINE TESTING OPTION
- T-BERD 109XC Subscriber Loop Analyzer accessed by software running under Windows® 95
- Full-function POTS subscriber line tester
- Time Domain Reflectometer (TDR)
- Narrowband TIMS
- Basic-rate ISDN tester

LONG-LIFE CASE DESIGN
- Die Cast Magnesium for all structural components
- Integrated Santoprene® shock absorption
- Case design integrates vehicle cradle connection
- Full environmental and RF seal
- Zinc door on PC cardslot

ENVIRONMENTAL CHARACTERISTICS
- Operating temperature range: -4° to 140° Fahrenheit (-20° to 60° Celsius)
- 54 repeated 1M drops on all surfaces, edges and corners per MIL STD 810E, 516.4, Proc. IV (30" with intergrated T-BERD 109XC)
- Rain at 4 in./hr. at approximately 40 psi for 40 minutes per axis for all axes per MIL STD 810E, 506.3, Proc. III
- Vibration of .04g²/Hz over 20-1000Hz random

INTRINSIC SAFETY
- Class 1, Division 2, Group D

ITRONIX
Mobile Workforce Systems Company
A DYNATECH Company

V.1 3M 10/98
801 South Stevens Street, Spokane, WA 99204
509-624-6600 1-800-441-1309

APPENDIX B

Antenna Specifications

388461

MAXRAD

State of the Art Antennas

PART NO:

MUF9105SP

MUF9105SP

896 – 940 MHZ,5DB GAIN,DUAL OPEN
COIL, ELE FEED ANT,CHROME,CENTER
TUNED 915 MHZ. <1.5:1 VSWR

ORDER (800) 323-9122 FAX (630) 372-8077

MUF 800/900 No Ground Plane Chrome Co

806-940 MHz, Unity/3dB/5dB Gain

Designed for installations that lack a suitable ground plane, these Unity, 3dB, and 5dB g pered loading coil jacket with chrome plated brass fittings and an optional heavy-duty s loaded matching network supports the collinear or trilinear rod sections above without t

Features:

- No ground plane required
- Rugged construction; optional heavy-duty shock spring
- Sleek, sturdy, sealed phasing coil design
- 1-1/8" -18 mounting threads mate with all 3/4" MAXRAD mounts

Electrical Specifications

Maximum Power:
150 Watts

VSWR at Resonant Point:
<1.5:1

Nominal Impedance:
50 Ohms

Antenna Type:
Unity - 1/4 wave
3dB - 5/8 wave over a 1/4 wave
5dB - Dual 5/8 wave over a 1/4 wave

Mechanical Specifications

Radiator Material:
.100" dia. stainless steel

Optional Spring:
Stainless steel

Phasing Coil Housing:
Molded polymer jacket with
chrome plated brass bu

Base Housing Coil:
Tapered jacket with co
brass bushings

800 MHz Antenna Heig
Unity- Approx. 7 1/2" at l
3dB- Approx. 17 3/4" at l
5dB- Approx. 27 3/4" at l

900 MHz Antenna Height:
Unity-Approx. 7 1/4" at l
3dB- Approx. 17 1/2" at l
5dB- Approx. 27 1/2"

MUF-8150NGP Series

Model #	Frequency Range	Factory Tuned Frequency	Rod/Coil Type	Gain	List Price Chrome Models	List Price Chrome Models w/ Spring	List ... M...
MUF-8150NGP(S)	806-866 MHz	815 MHz	Straight	Unity	$26.50	$36.50	[illegible]
MUF-8350NGP(S)	824-896 MHz	835 MHz	Straight	Unity	$26.50	$36.50	[illegible]
MUF-9000NGP(S)	896-940 MHz	898 MHz	Straight	Unity	$26.50	$36.50	[illegible]
MUF-8103NGP(S)	806-866 MHz	815 MHz	Collinear/Open	3dB	$30.97	$40.97	[illegible]
MUF-8003NGP(S)	806-866 MHz	815 MHz	Collinear/Closed	3dB	$36.25	$46.25	[illegible]
MUF-8303NGP(S)	824-896 MHz	835 MHz	Collinear/Open	3dB	$30.97	$40.97	
MUF-8323NGP(S)	824-896 MHz	835 MHz	Collinear/Closed	3dB	$36.25	$46.25	[illegible]
MUF-9103NGP(S)	896-940 MHz	898 MHz	Collinear/Open	3dB	$30.97	$40.97	[illegible]
MUF-9003NGP(S)	896-940 MHz	898 MHz	Collinear/Closed	3dB	$36.25	$46.25	[illegible]
MUF-8105NGP(S)	806-866 MHz	815 MHz	Trilinear/Open	5dB	$40.15	$50.15	[illegible]
MUF-8005NGP(S)	806-866 MHz	815 MHz	Trilinear/Closed	5dB	$45.90	$55.90	[illegible]
MUF-8305NGP(S)	824-896 MHz	835 MHz	Trilinear/Open	5dB	$40.15	$50.15	[illegible]
MUF-8325NGP(S)	824-896 MHz	835 MHz	Trilinear/Closed	5dB	$45.90	$55.90	[illegible]
MUF-9025NGP(S)	896-940 MHz	898 MHz	Trilinear/Open	5dB	$40.15	$50.15	[illegible]
MUF-9035NGP(S)	896-940 MHz	898 MHz	Trilinear/Closed	5dB	$45.90	$55.90	[illegible]

Suffix "S" indicates spring

EXHIBIT FOUR

MPE REPORT
External 4.5dB
Larsen Vehicle-Top
Mounting Antenna

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ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 4.5dB Larsen Vehicle-Top Mounting Antenna

FCC ID #:

MODEL: X-C 6250 Laptop and NMO 900 Antenna

CLIENT: Itronix Corporation

PROJECT #: ITRB-XC6250 Larsen NMO900-3106

ADDRESS: 801 South Stevens Street
Spokane, WA
USA 99204

PREPARED BY: *APREL Laboratories,*
Regulatory Compliance Division

APPROVED BY: [signature] DATE: 13 Nov 98
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: [signature] DATE: Nov 13/98
Dr. Jacek J. Wojcik, P.Eng.

51 Spectrum Way
Nepean, Ontario
K2R 1E6, Canada

Tel. (613) 820 2730
Fax (613) 820 4161
e-mail: info@aprel.com

ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 4.5dB Larsen Vehicle-Top Mounting Antenna

FCC ID #:

MODEL: X-C 6250 Laptop and NMO 900 Antenna

CLIENT: Itronix Corporation

PROJECT #: ITRB-XC6250 Larsen NMO900-3106

ADDRESS: 801 South Stevens Street
Spokane, WA
USA 99204

PREPARED BY: *APREL Laboratories,*
Regulatory Compliance Division

APPROVED BY: ______________________ DATE: ______________________
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: ______________________ DATE: ______________________
Dr. Jacek J. Wojcik, P.Eng..

FCC ID:
Client : Itronix Corporation
Equipment : Ruggedized Wireless Laptop with Vehicle Cradle with External 4.5dB Larsen Vehicle-Top Mounting Antenna
Part No. : X-C 6250 Laptop and NMO 900 Antenna
Serial No. : 37466

ENGINEERING SUMMARY

This report contains the results of the maximum permissible exposure (MPE) evaluation performed on the equipment under test (EUT) which was comprised of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 4.5dB Larsen Model NMO 900 vehicle-rooftop mounting antenna. The tests were carried out in accordance with the applicable requirements of FCC rules found in 47CFR §2.1091 and the standards ANSI/IEEE C95.1-1992 and C95.3-1992.

The methodology and results for the test are described in the appropriate section of this report.

The EUT will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.50 mW/cm^2.

TABLE OF CONTENTS

ACRONYMS

EUT	Equipment Under Test
FCC	Federal Communications Commission
MPE	Maximum Permissible Exposure
N/A	Not Applicable
NTS	Not To Scale
OATS	Open Area Test Site
OEM	Original Equipment Manufacturer
QA	Quality Assurance
RIM	Research in Motion

1.0 INTRODUCTION

1.1 General

This report describes the Maximum Permissible Exposure (MPE) tests an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 4.5dB Larsen Model NMO 900 vehicle-rooftop mounting antenna, the combination hereinafter called the EUT (Equipment Under Test).

1.2 Scope

MPE evaluation was performed on the EUT in accordance with the requirements of the FCC rules for RF compliance found in 47CFR §2.1091 and the standard ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave. This Engineering Report contains the following:

1.2.1 Methodology as to how the tests were performed.
1.2.2 Test results and analysis.
1.2.3 Identification of the test equipment used for the testing.
1.2.4 Test set-up diagram.

1.3 Schedule

The MPE tests were completed on November 9, 1998.

2.0 APPLICABLE DOCUMENTS

FCC Rule Part 47CFR §2.1091

ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz.

ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

OET Bulletin 65 (Edition 97-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

3.0 TEST SAMPLE

The MPE tests described in this procedure was performed on:

- Itronix Model X-C 6250 Cross Country ruggedized wireless laptop (see specification sheets in Appendix A), S/N 374666, Config BBBEBAAADA-DZABA-ABP.
- Itronix Model CRDL, RF ASSY 208I vehicle cradle, P/N 50-0057-001 /4, S/N 303242.
- Larsen Model NMO 900 4.5dB vehicle-mounting antenna (see specification sheets in Appendix B).

4.0 GENERAL REQUIREMENTS

4.1 Location of Test Facilities

The tests were performed by APREL Laboratories at APREL's test facility located in Nepean, Ontario, Canada. The laboratory operates a 3 and 10 meter Open Area Test Site (OATS) measurement facility. The test site is calibrated to ANSI C63.4-1992.

A description of the measurement facility in accordance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations. APREL's registration number is 31070/SIT(1300F2).

APREL is accredited by Standard Council of Canada, under the PALCAN program (ISO Guide 25). All equipment used is calibrated or verified in accordance with the intent of AQAP-6/MIL-STD-45662. APREL is also accredited by Industry Canada (formerly DOC) and recognized by the Federal Communications Commission (FCC).

4.2 Personnel

Radiation Hazard technical staff member, Heike Wuenschmann, carried out all MPE tests.

4.3 Failure Criteria

The equipment under test was considered to have failed if any of the following occurred:

> When the MPE limits exceeded those permitted by appropriate limits defined by the FCC.

4.4 Power Source Required

The following nominal DC Power was maintained during the test:

Voltage: 12 VDC.

4.5 Tolerance

The following tolerances on test conditions, exclusive of equipment accuracy, were maintained:

Voltage: ± 10%.

5.0 TEST INSTRUMENTATION & CALIBRATION

5.1 General

APREL Laboratories, located in Nepean, Ontario is equipped with the necessary instrumentation to ensure accurate measurement of all data recorded during the tests outlined in this document. To ensure continued accuracy, each instrument is re-calibrated at intervals established by APREL and based on standards traceable to the National and International Standards. Accuracy surveillance is a function of APREL Quality Assurance.

5.2 MPE Test Equipment Required

The test equipment required to perform the MPE testing was selected from the equipment available at APREL.

5.3 Calibration Requirements

All test equipment instrumentation required for MPE qualification testing was calibrated and controlled.

6.0 ELECTRICAL/MECHANICAL DESCRIPTION

The MPE Test Program was performed an Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Larsen vehicle-top mounting antenna, the combination hereinafter called the EUT. The test sample consisted of the components supplied by the customer and described below.

6.1 Test Unit Description

The Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Larsen vehicle-rooftop mounted 4.5dB antenna, consisted of the following components:

Part Number	Description
X-C 6250 398C	Itronix ruggedized wireless laptop
CRDL, RF ASSY 208I	Itronix vehicle cradle
SRB01519/9743D59235	RIM execution lock device for radio tools
NMO 900	Larsen vehicle-rooftop mounted 4.5dB antenna
0820-0004	6 Gates 2V 25AH BC DC cells

6.2 MPE Test Setup

a) The EUT antenna shall be installed in the centre of a ground plane simulating the rooftop of a vehicle. The other components shall be located underneath this ground plane to simulate operation from inside of the vehicle (see Figures 6.2.1 and 6.2.2).

b) The vehicle simulator shall be positioned on the turntable in the OATS in such a way that the antenna will be located on the centre of rotation.

c) The EUT shall be connected to the 12 VDC power supply.

d) For the selection and placement of the measuring probe, the requirements of ANSI/IEEE C95.3-1992 shall be met.

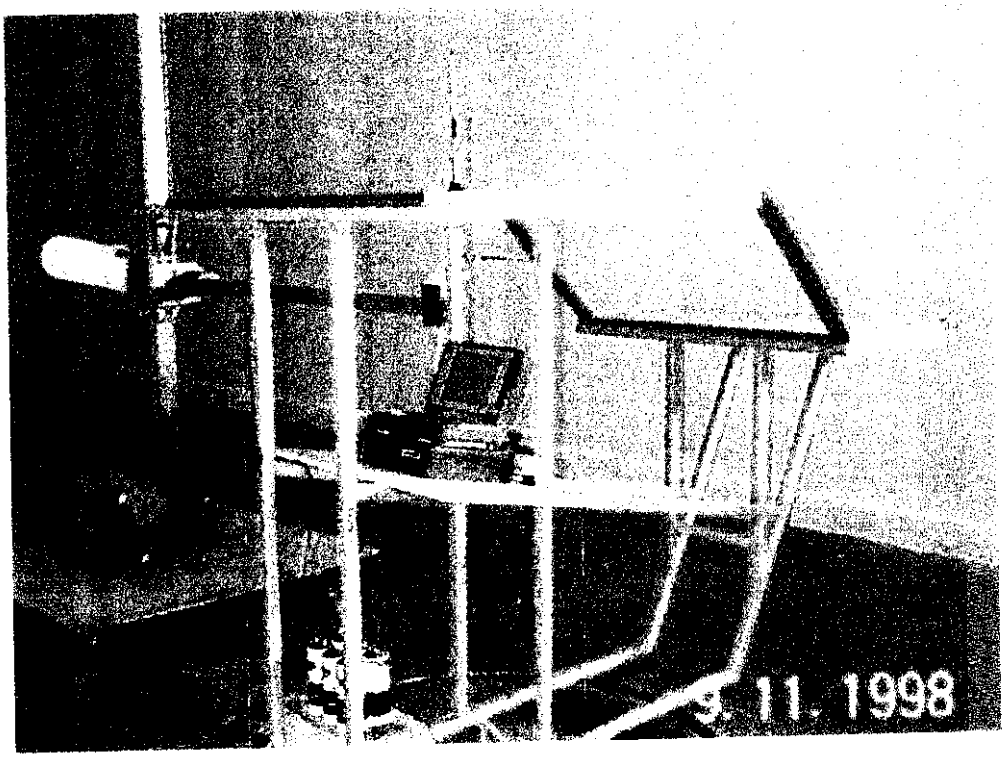


Figure 6.2.1. Photograph of the Setup.

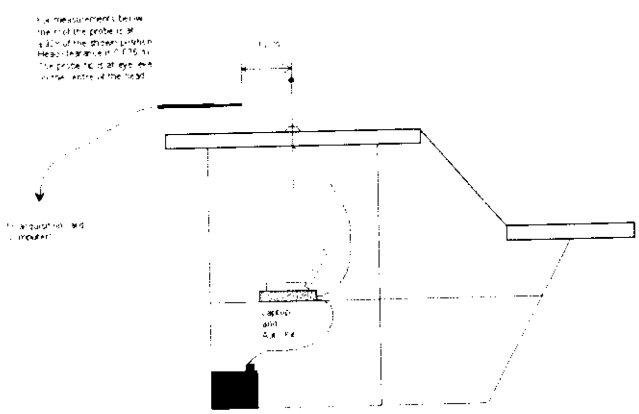


Figure 6.2.2. Elevation View of the Setup.

7.0 MAXIMUM PERMISSIBLE EXPOSURE (MPE) TEST

7.1 Purpose

This test method is used to verify that the EUT meets the MPE requirements as defined in the criteria for general population/uncontrolled exposure when operating at maximum power levels and in all operating modes.

7.2 Test Equipment

Description	Manufacturer	Model No.
E-Field Probe	Narda	8021B

7.3 Criteria

Power Density Limits – The EUT shall not generate a power density beyond the limits in the frequency band listed in the left hand column of Table 7.3.1, and the power density given in the right hand column. The power density shall be measured 20 cm from the radiating antenna axis above the vehicle-top simulating ground plane, as well as in the approximate location of the head of possible vehicle drivers or passengers below the ground plane (see Figure 7.3.1). The measured values shall be recorded.

Table 7.3.1

Power Density Limits
for General Population/Uncontrolled Exposure

Frequency Range	Power Density (mW/cm^2)
300 - 1500 MHz	f/1500

Note: f = frequency in MHz

The measurements shall be performed at one transmitting frequency, the highest of the high, middle or low channels, with the EUT operating at the full rated output power.

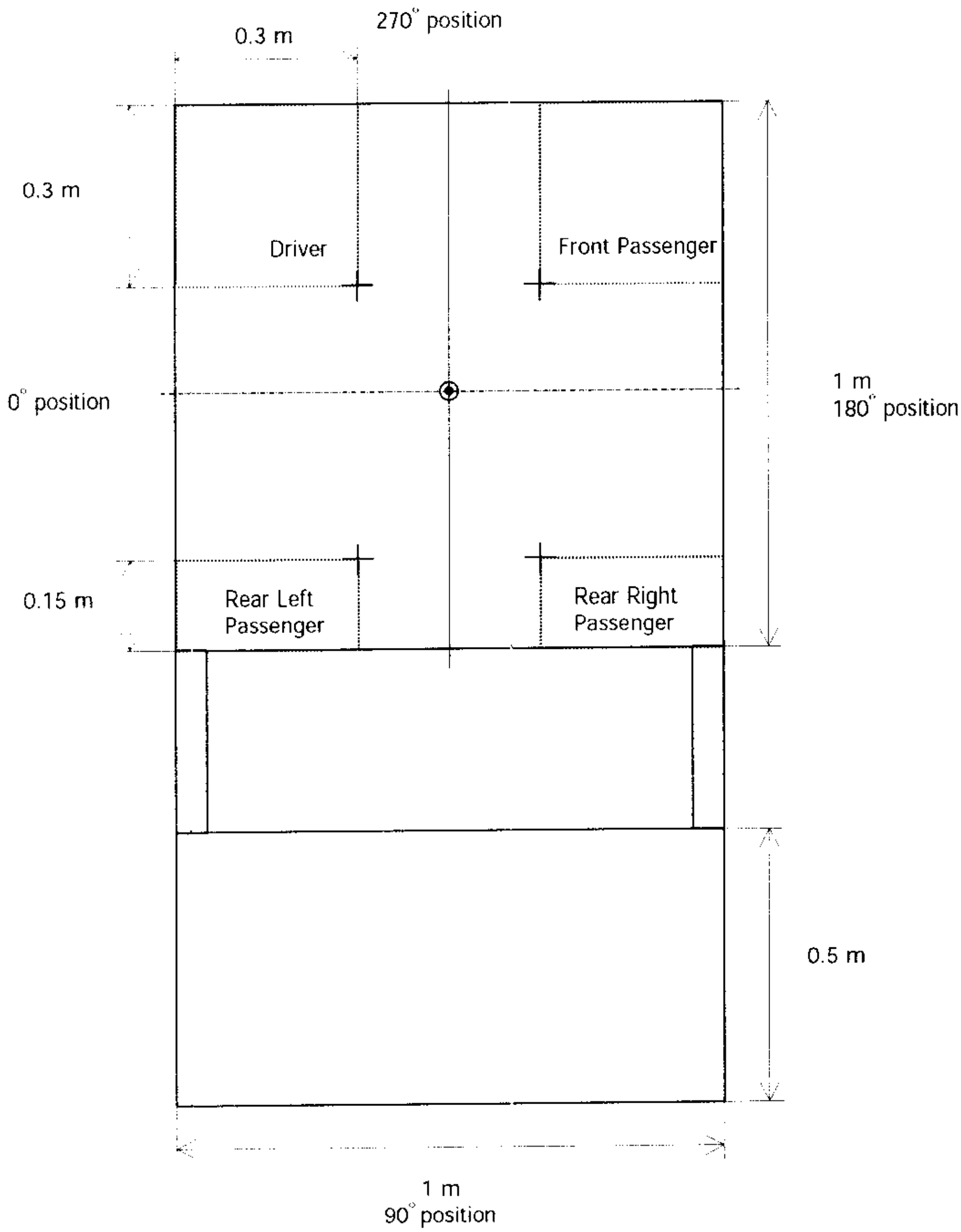


Figure 7.3.1. Plan View of Vehicle Simulator and Setup.

7.4 Test Procedure

a) The probe shall be positioned close to, and parallel to, the vehicle rooftop simulation with its tip 20 cm from the radiating antenna, and its axis normal to the antenna.

b) Rotate the turntable so that the probe is at the 0° position (see Figure 7.3.1).

c) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

d) Determine the location of the maximum power density: locate the maximum emissions by scanning vertically along the EUT's antenna. Take and record measurements of the power density at a number of points along the length of the antenna as well as just past its tip.

e) At every 45° of rotation take and record a measurement of the power density at the maximum power density height as for at least the following locations:

- half the maximum power density height
- height halfway between the maximum power density height and the tip of the radiating antenna
- just above the tip of the antenna

f) Turn off the EUT.

g) Position the probe under the vehicle rooftop simulating ground plane in the approximate location of the centre of the head of a potential driver of the simulated vehicle (see Figure 7.3.1).

h) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

i) Take and record the measurement of the power density at this location.

j) Turn off the EUT.

k) Repeat steps g) through j) for the positions of the other potential occupants of the simulated vehicle as shown in Figure 7.3.1.

7.5 Results

Table 7.5.1 presents the results of the measurements made along the length of the antenna in order to find the location of the maximum power density (the Larsen NMO 900 antenna has a height of 33 cm). Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 17ft Belden 8240 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (11ft × 0.16 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

The data in Table 7.5.1 is presented in Figure 7.5.1.

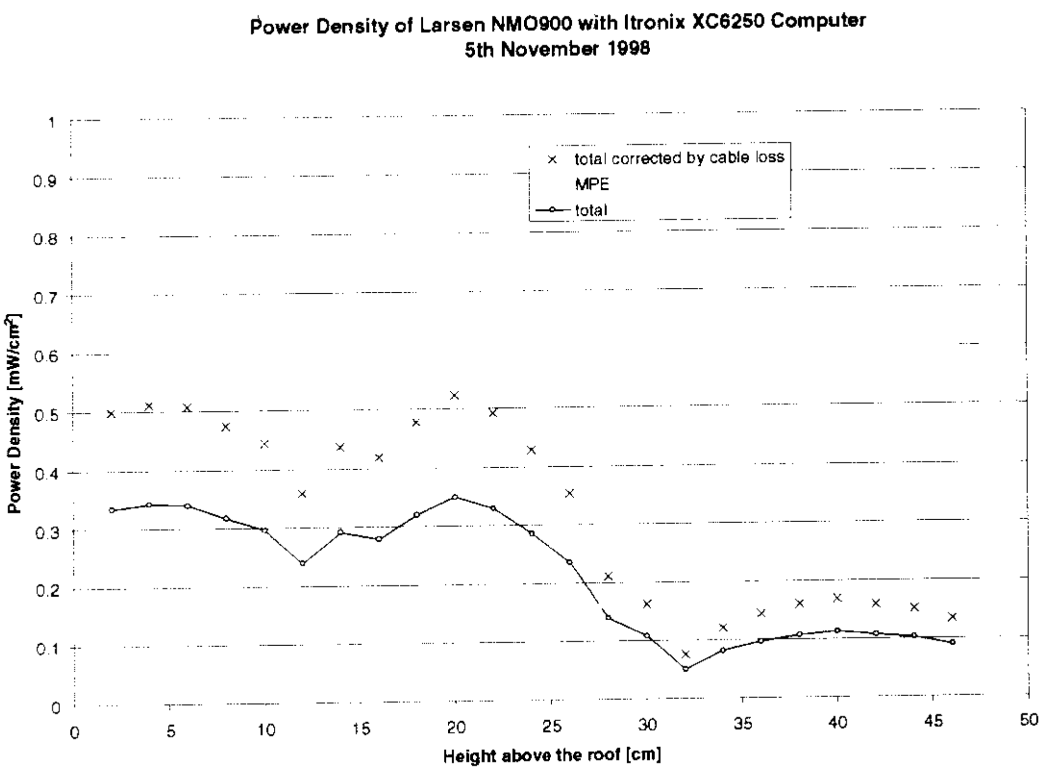


Figure 7.5.1

Table 7.5.1

Power Density Measured
at 0° as a Function of Height

Height	Total	Excess cable loss	Adjusted total	MPE Limit
[cm]	[mW/cm^2]	[dB]	[mW/cm^2]	[mW/cm^2]
2	0.33	1.76	0.50	0.6
4	0.34	1.76	0.51	0.6
6	0.34	1.76	0.51	0.6
8	0.32	1.76	0.47	0.6
10	0.30	1.76	0.44	0.6
12	0.24	1.76	0.36	0.6
14	0.29	1.76	0.44	0.6
16	0.28	1.76	0.42	0.6
18	0.32	1.76	0.48	0.6
20	0.35	1.76	0.52	0.6
22	0.33	1.76	0.49	0.6
24	0.29	1.76	0.43	0.6
26	0.24	1.76	0.35	0.6
28	0.14	1.76	0.21	0.6
30	0.11	1.76	0.16	0.6
32	0.05	1.76	0.08	0.6
34	0.08	1.76	0.12	0.6
36	0.10	1.76	0.14	0.6
38	0.11	1.76	0.16	0.6
40	0.11	1.76	0.17	0.6
42	0.11	1.76	0.16	0.6
44	0.10	1.76	0.15	0.6
46	0.09	1.76	0.13	0.6
48	0.08	1.76	0.11	0.6

Table 7.5.2 presents the results of the measurements made around the antenna at every 45° of rotation. Column 1 shows the angle at which the measurements were taken and columns 2 through 5 show the final adjusted power density (see discussion surrounding Table 7.5.1) at the different measurement heights. The MPE value is determined by averaging the adjusted total power density along a vertical line up to the height of a tall typical individual, taken here as 6ft or 180cm. Since the height for the rooftop of the simulated vehicle is 143cm, then the averaging is over those measurements made between 0 and 37cm above the simulated vehicle rooftop. Column 6 shows the results of this averaging.

Table 7.5.2

Power Density Measured
at every 45° as a Function of Height

Angular	Adjusted Total Power Density				Average of	
Position	H1 [cm]	H2 [cm]	H3 [cm]	H4 [cm]	Values up	MPE Limit
	8	26	34	40	to 37cm	
[°]	[mW/cm²]	[mW/cm²]	[mW/cm²]	[mW/cm²]	[mW/cm²]	[mW/cm²]
0	0.5067	0.6629	0.2976	0.0022	0.4890593	0.6
45	0.7064	0.2711	0.1246	0.0073	0.3673572	0.6
90	0.5866	0.0286	0.2664	0.3486	0.2938821	0.6
135	0.8492	0.2577	0.1252	0.1676	0.4106992	0.6
180	0.5059	0.6131	0.3878	0.2285	0.5022763	0.6
225	0.6602	0.2850	0.1852	0.2221	0.3767984	0.6
270	0.5035	0.4747	0.2455	0.3598	0.4078943	0.6
315	0.6738	0.4177	0.1362	0.2280	0.4092611	0.6
360	0.5067	0.6629	0.2976	0.0022	0.4890593	0.6

The data in Table 7.5.2 is presented in Figure 7.5.2.

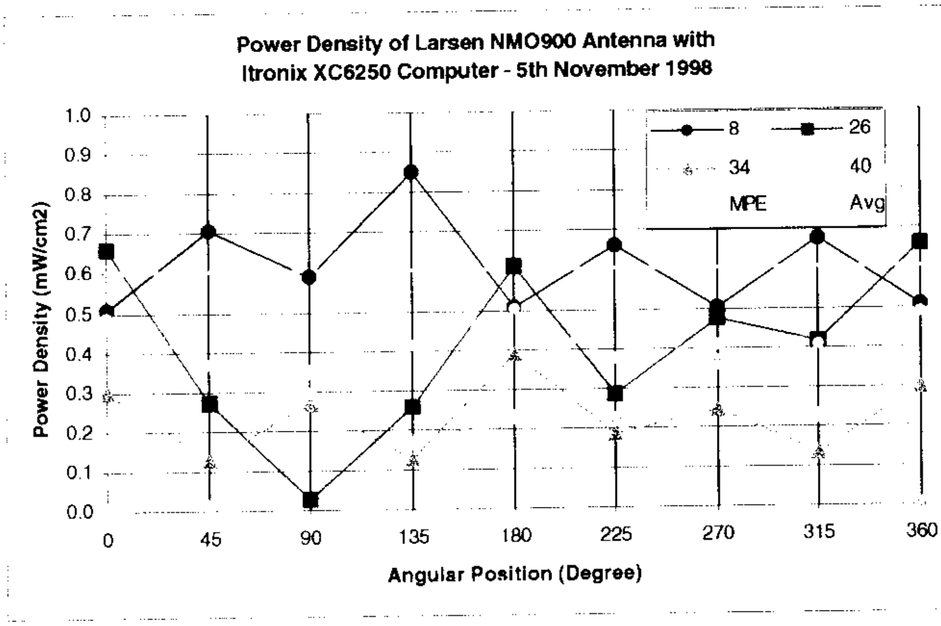

Power Density of Larsen NMO900 Antenna with
Itronix XC6250 Computer - 5th November 1998
Power Density (mW/cm2)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
45
90
135
180
225
270
315
360
Angular Position (Degree)
8
26
34
40
MPE
Avg

Figure 7.5.2.

Measurements were made below the simulated vehicle rooftop, in the approximate location of the centre of the head of potential occupants. It was assumed that this typical position occurred 17.5cm below the roof of the simulated vehicle (the clearance between the top of an occupant's head and a vehicle's roof is ~3" (7.5cm) and distance between the top of the head and the eyes is ~4" (10cm)). Figure 7.3.1 shows the location of measurements for the 4 potential occupants. Table 7.5.3 presents the results of the measurements. Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 17ft Belden 8240 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (11ft × 0.16 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

Table 7.5.3

Power Density Measured
at Position of Potential Vehicle Occupants

Position	Total	Excess cable loss	Adjusted Total	MPE Limit
	[mW/cm²]	[dB]	[mW/cm²]	[mW/cm²]
driver	0.01	1.76	0.02	0.6
front passe	0.02	1.76	0.03	0.6
rear left	0.01	1.76	0.01	0.6
rear right	0.01	1.76	0.02	0.6

8.0 CONCLUSION

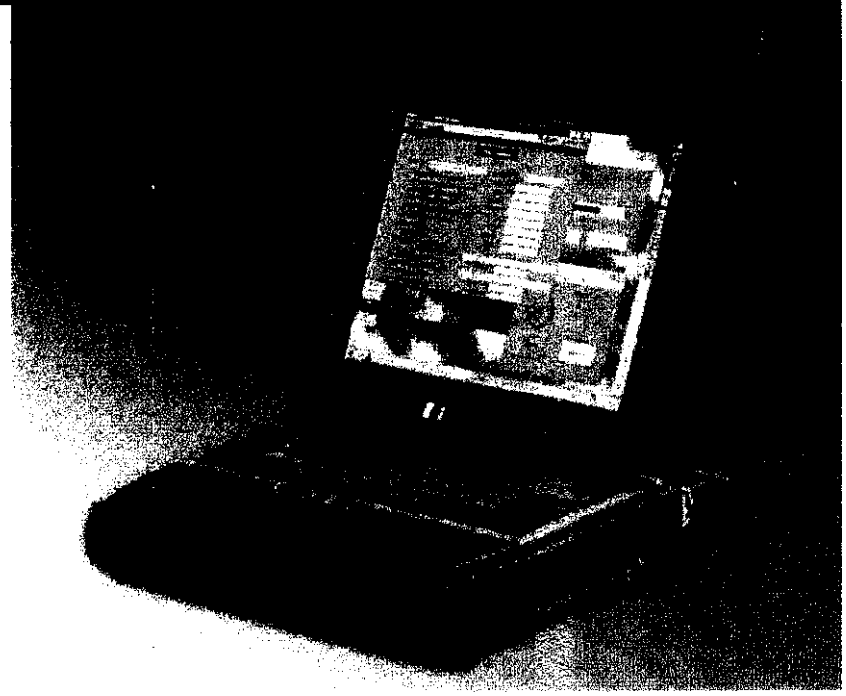
The EUT consisting of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 4.5dB Larsen Model NMO 900 vehicle-rooftop mounting antenna will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.50 mW/cm^2.

APPENDIX A

Transmitter Specifications

X-C 6250

W E K N O W T H E R O A D™



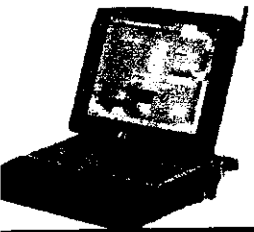
A High Performance Wireless Worktool for Field Computing

Directly impact workforce productivity and profits with the Itronix X-C 6250 – a fully ruggedized, wireless computer designed specifically to deliver results in the most demanding field applications.

The X-C 6250 is built tough to withstand the shock of repeated drops and remain operational under extreme temperatures, vibration, liquid, and exposure to the elements. When equipped with wireless communications, highly mobile field workers can use the X-C 6250 to collect, communicate and manage account information in real time while at a customer's site. Sophisticated power management systems deliver computing and communications capabilities all day on a single battery, ensuring productivity. Additional features for field computing like the 6250's optional touch screen allow workers the flexibility and ergonomics of both pen and keyboard use in the same platform.

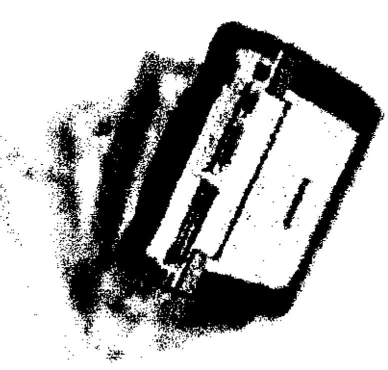
Reach the next plateau in servicing your customers with Itronix. The leader in mission-critical mobile computing solutions.

ITRONIX



GHLIGHTS

- 0MHz Intel Pentium rocessor
- ntegrated wireless data ommunications
- onference quality peakerphone
- oth touch screen & eyboard input
- ully ruggedized, otally sealed
- xcellent outdoor iewable display
- ariety of carrying options nd locking vehicle docks
- ower management system r all day battery use
- .1GB or 3.2GB ruggedized ard drive
- olor and monochrome isplays up to 10.4"



FEATURES AND SPECIFICATIONS

COMPACT SIZE/WEIGHT
- Length: 10.5" (26.7cm)
- Width: 7.5" or 8.1" (19.1 or 20.57cm) screen size dependent
- Depth: 3.0" (7.6cm)
- Weight: 6.9 or 7.18 lbs. (3.1 or 3.25 kg) screen size dependent

PROCESSOR/MEMORY
- 200MHz Pentium® with MMX technology
- 16 to 48 MB RAM

STORAGE
- 2.1GB or 3.2GB 2.5" ruggedized hard drive

POWER
- 3.5 Ahr high capacity NiMh battery pack
- Smart battery with accurate gas gauge
- 4 hour rapid charge

DISPLAY
- SVGA color 800 x 600 pixel 10.4" diagonal display (touch screen optional)
- VGA monochrome 640 x 480 pixel 8.2" diagonal transflective backlit display
- Shock mounted
- Long-life hinge
- Automatic temperature compensation

INPUT DEVICES
- Keyboard – 93% standard key spacing user replaceable
- Pointing Stick – pressure sensitive with two button input
- Touch Screen – optional passive pen or finger touch capable

OPERATING SYSTEM
- Microsoft® Windows® 95
- Microsoft® Pen Computing for Windows® 95

INTERFACES
- Powered 115Kbps 16550 compatible serial port
- ECP/EPP parallel port
- Built-in RJ-11 phone jack – externally accessible
- Accepts 2 Type I or II or 1 Type III PC cards
- External video connector

INTEGRATED WIRELINE COMMUNICATIONS
- Integrated microphone and speaker for voice communications
- 33.6 Kbps v.34 Group 3 fax/data modem

INTEGRATED WIRELESS COMMUNICATION OPTIONS
- CDPD/Cellular radio network for voice & data
- ARDIS network
- BellSouth Wireless Data network

OPTIONS
- Vehicle charger with lighter adapter
- Stand alone spare battery pack charger
- Vehicle cradle with lock, power, and serial port
- External 3.5" floppy drive
- External CD-ROM
- External antenna option with vehicle cradle
- Carry cases for system and accessories
- Bar-Code laser scanners
- Vehicle cradle with CD-ROM

INTEGRATED TELEPHONE LINE TESTING OPTION
- T-BERD 109XC Subscriber Loop Analyzer accessed by software running under Windows® 95
- Full-function POTS subscriber line tester
- Time Domain Reflectometer (TDR)
- Narrowband TIMS
- Basic-rate ISDN tester

LONG-LIFE CASE DESIGN
- Die Cast Magnesium for all structural components
- Integrated Santoprene® shock absorption
- Case design integrates vehicle cradle connection
- Full environmental and RF seal
- Zinc door on PC cardslot

ENVIRONMENTAL CHARACTERISTICS
- Operating temperature range: -4° to 140° Fahrenheit (-20° to 60° Celsius)
- 54 repeated 1M drops on all surfaces, edges and corners per MIL STD 810E, 516.4, Proc. IV (30" with intergrated T-BERD 109XC)
- Rain at 4 in./hr. at approximately 40 psi for 40 minutes per axis for all axes per MIL STD 810E, 506.3, Proc. III
- Vibration of $.04g^2$/Hz over 20-1000Hz random

INTRINSIC SAFETY
- Class 1, Division 2, Group D

ITRONIX
Mobile Workforce Systems Company
A DYNATECH Company

V.1 3M 10/98

801 South Stevens Street, Spokane, WA 99204
509-624-6600 1-800-441-1309

APPENDIX B

Antenna Specifications

NMO 900

CH SPG BASE/WH ENC4.5dB
890 – 960 MHz .100 DIA CHR
WHIP

Date Manufactured:
08/12/98

Larsen®

EXHIBIT FIVE

MPE REPORT
External 5dB
Larsen Vehicle-Top
Mounting Antenna

ITRONIX CORPORATION

Research · Training · Consulting · Testing
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APREL Since 1981

ENGINEERING REPORT

SUBJECT:	Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091
PRODUCT:	Ruggedized Wireless Laptop with Vehicle Cradle and External 5dB Larsen Vehicle-Top Mounting Antenna
FCC ID #:	
MODEL:	X-C 6250 Laptop and EF5T900SNMO Antenna
CLIENT:	Itronix Corporation
PROJECT #:	ITRB-XC6250 Larsen EF5T900SNMO-3107
ADDRESS:	801 South Stevens Street Spokane, WA USA 99204
PREPARED BY:	*APREL Laboratories,* *Regulatory Compliance Division*

APPROVED BY: Dr. Paul G. Cardinal, Director, Laboratory Operations DATE: 13 Nov 98

RELEASED BY: Dr. Jacek J. Wojcik, P.Eng. DATE: Nov 13/98

51 Spectrum Way
Nepean, Ontario
K2R 1E6 Canada

Tel. (613) 820 2730
Fax (613) 820 4161
e-mail: info@aprel.com

ENGINEERING REPORT

SUBJECT: Maximum Permissible Exposure Evaluation with Respect to FCC Rule Part 47CFR §2.1091

PRODUCT: Ruggedized Wireless Laptop with Vehicle Cradle and External 5dB Larsen Vehicle-Top Mounting Antenna

FCC ID #:

MODEL: X-C 6250 Laptop and EF5T900SNMO Antenna

CLIENT: Itronix Corporation

PROJECT #: ITRB-XC6250 Larsen EF5T900SNMO-3107

ADDRESS: 801 South Stevens Street
Spokane, WA
USA 99204

PREPARED BY: *APREL Laboratories,*
Regulatory Compliance Division

APPROVED BY: ____________________ DATE: ____________________
Dr. Paul G. Cardinal
Director, Laboratory Operations

RELEASED BY: ____________________ DATE: ____________________
Dr. Jacek J. Wojcik, P.Eng..

FCC ID:
Client : Itronix Corporation
Equipment : Ruggedized Wireless Laptop with Vehicle Cradle with External 5dB Larsen Vehicle-Top Mounting Antenna
Part No. : X-C 6250 Laptop and EF5T900SNMO Antenna
Serial No. : 37466

ENGINEERING SUMMARY

This report contains the results of the maximum permissible exposure (MPE) evaluation performed on the equipment under test (EUT) which was comprised of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Larsen Model EF5T900SNMO vehicle-rooftop mounting antenna. The tests were carried out in accordance with the applicable requirements of FCC rules found in 47CFR §2.1091 and the standards ANSI/IEEE C95.1-1992 and C95.3-1992.

The methodology and results for the test are described in the appropriate section of this report.

The EUT will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.44 mW/cm^2.

TABLE OF CONTENTS

ACRONYMS

EUT	Equipment Under Test
FCC	Federal Communications Commission
MPE	Maximum Permissible Exposure
N/A	Not Applicable
NTS	Not To Scale
OATS	Open Area Test Site
OEM	Original Equipment Manufacturer
QA	Quality Assurance
RIM	Research in Motion

1.0 INTRODUCTION

1.1 General

This report describes the Maximum Permissible Exposure (MPE) tests an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Larsen Model EF5T900SNMO vehicle-rooftop mounting antenna, the combination hereinafter called the EUT (Equipment Under Test).

1.2 Scope

MPE evaluation was performed on the EUT in accordance with the requirements of the FCC rules for RF compliance found in 47CFR §2.1091 and the standard ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave. This Engineering Report contains the following:

1.2.1 Methodology as to how the tests were performed.
1.2.2 Test results and analysis.
1.2.3 Identification of the test equipment used for the testing.
1.2.4 Test set-up diagram.

1.3 Schedule

The MPE tests were completed on November 11, 1998.

2.0 APPLICABLE DOCUMENTS

FCC Rule Part 47CFR §2.1091

ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz.

ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

OET Bulletin 65 (Edition 97-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

3.0 TEST SAMPLE

The MPE tests described in this procedure was performed on:

- Itronix Model X-C 6250 Cross Country ruggedized wireless laptop (see specification sheets in Appendix A), S/N 374666, Config BBBEBAAADA-DZABA-ABP.
- Itronix Model CRDL, RF ASSY 208I vehicle cradle, P/N 50-0057-001 /4, S/N 303242.
- Larsen Model EF5T900SNMO 5dB vehicle-mounting antenna (see specification sheets in Appendix B).

4.0 GENERAL REQUIREMENTS

4.1 Location of Test Facilities

The tests were performed by APREL Laboratories at APREL's test facility located in Nepean, Ontario, Canada. The laboratory operates a 3 and 10 meter Open Area Test Site (OATS) measurement facility. The test site is calibrated to ANSI C63.4-1992.

A description of the measurement facility in accordance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations. APREL's registration number is 31070/SIT(1300F2).

APREL is accredited by Standard Council of Canada, under the PALCAN program (ISO Guide 25). All equipment used is calibrated or verified in accordance with the intent of AQAP-6/MIL-STD-45662. APREL is also accredited by Industry Canada (formerly DOC) and recognized by the Federal Communications Commission (FCC).

4.2 Personnel

Radiation Hazard technical staff member, Heike Wuenschmann, carried out all MPE tests.

4.3 Failure Criteria

The equipment under test was considered to have failed if any of the following occurred:

> When the MPE limits exceeded those permitted by appropriate limits defined by the FCC.

4.4 Power Source Required

The following nominal DC Power was maintained during the test:

Voltage: 12 VDC.

4.5 Tolerance

The following tolerances on test conditions, exclusive of equipment accuracy, were maintained:

Voltage: ± 10%.

5.0 TEST INSTRUMENTATION & CALIBRATION

5.1 General

APREL Laboratories, located in Nepean, Ontario is equipped with the necessary instrumentation to ensure accurate measurement of all data recorded during the tests outlined in this document. To ensure continued accuracy, each instrument is re-calibrated at intervals established by APREL and based on standards traceable to the National and International Standards. Accuracy surveillance is a function of APREL Quality Assurance.

5.2 MPE Test Equipment Required

The test equipment required to perform the MPE testing was selected from the equipment available at APREL.

5.3 Calibration Requirements

All test equipment instrumentation required for MPE qualification testing was calibrated and controlled.

6.0 ELECTRICAL/MECHANICAL DESCRIPTION

The MPE Test Program was performed an Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Larsen vehicle-top mounting antenna, the combination hereinafter called the EUT. The test sample consisted of the components supplied by the customer and described below.

6.1 Test Unit Description

The Itronix ruggedized wireless laptop, containing a RIM 2 watt OEM radio-modem transceiver, equipped with a vehicle cradle and external Larsen vehicle-rooftop mounted 5dB antenna, consisted of the following components:

Part Number	Description
X-C 6250 398C	Itronix ruggedized wireless laptop
CRDL, RF ASSY 2081	Itronix vehicle cradle
SRB01519/9743D59235	RIM execution lock device for radio tools
EF5T900SNMO	Larsen vehicle-rooftop mounted 5dB antenna
0820-0004	6 Gates 2V 25AH BC DC cells

6.2 MPE Test Setup

a) The EUT antenna shall be installed in the centre of a ground plane simulating the rooftop of a vehicle. The other components shall be located underneath this ground plane to simulate operation from inside of the vehicle (see Figures 6.2.1 and 6.2.2).

b) The vehicle simulator shall be positioned on the turntable in the OATS in such a way that the antenna will be located on the centre of rotation.

c) The EUT shall be connected to the 12 VDC power supply.

d) For the selection and placement of the measuring probe, the requirements of ANSI/IEEE C95.3-1992 shall be met.

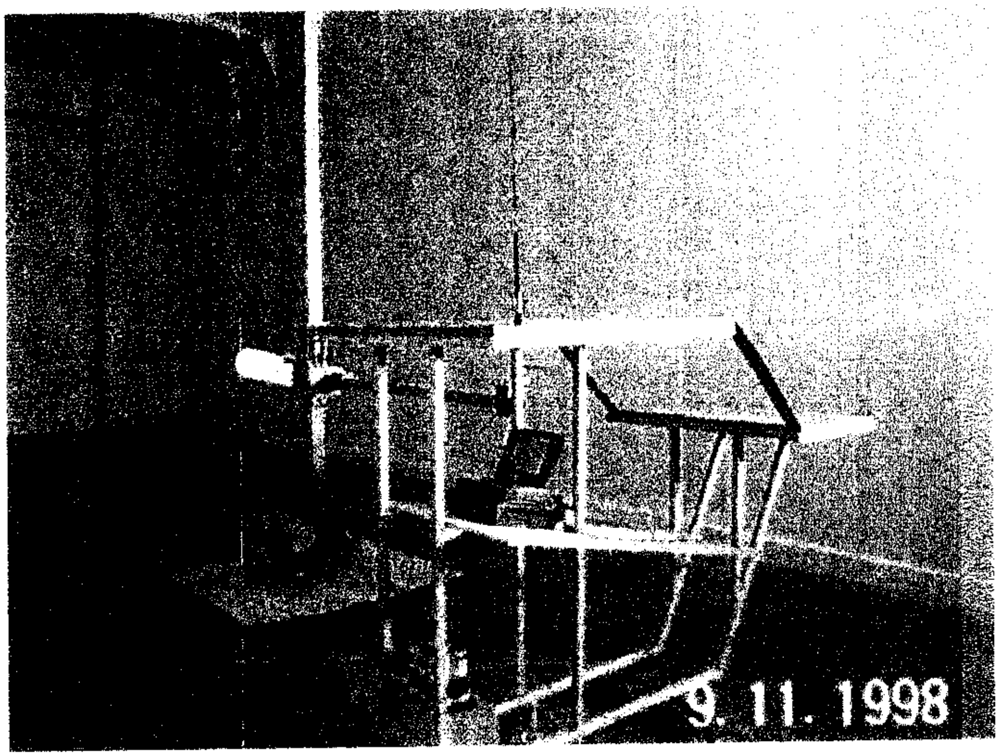


Figure 6.2.1. Photograph of the Setup.

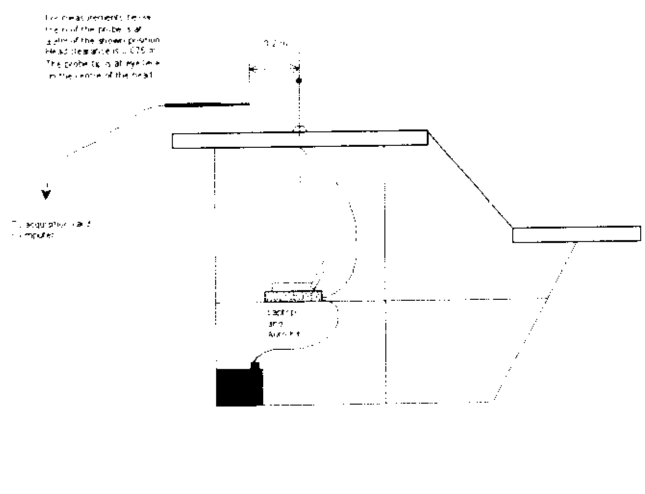


Figure 6.2.2. Elevation View of the Setup.

7.0 MAXIMUM PERMISSIBLE EXPOSURE (MPE) TEST

7.1 Purpose

This test method is used to verify that the EUT meets the MPE requirements as defined in the criteria for general population/uncontrolled exposure when operating at maximum power levels and in all operating modes.

7.2 Test Equipment

Description	Manufacturer	Model No.
E-Field Probe	Narda	8021B

7.3 Criteria

Power Density Limits – The EUT shall not generate a power density beyond the limits in the frequency band listed in the left hand column of Table 7.3.1, and the power density given in the right hand column. The power density shall be measured 20 cm from the radiating antenna axis above the vehicle-top simulating ground plane, as well as in the approximate location of the head of possible vehicle drivers or passengers below the ground plane (see Figure 7.3.1). The measured values shall be recorded.

Table 7.3.1

Power Density Limits
for General Population/Uncontrolled Exposure

Frequency Range	Power Density (mW/cm^2)
300 - 1500 MHz	f/1500

Note: f = frequency in MHz

The measurements shall be performed at one transmitting frequency, the highest of the high, middle or low channels, with the EUT operating at the full rated output power.

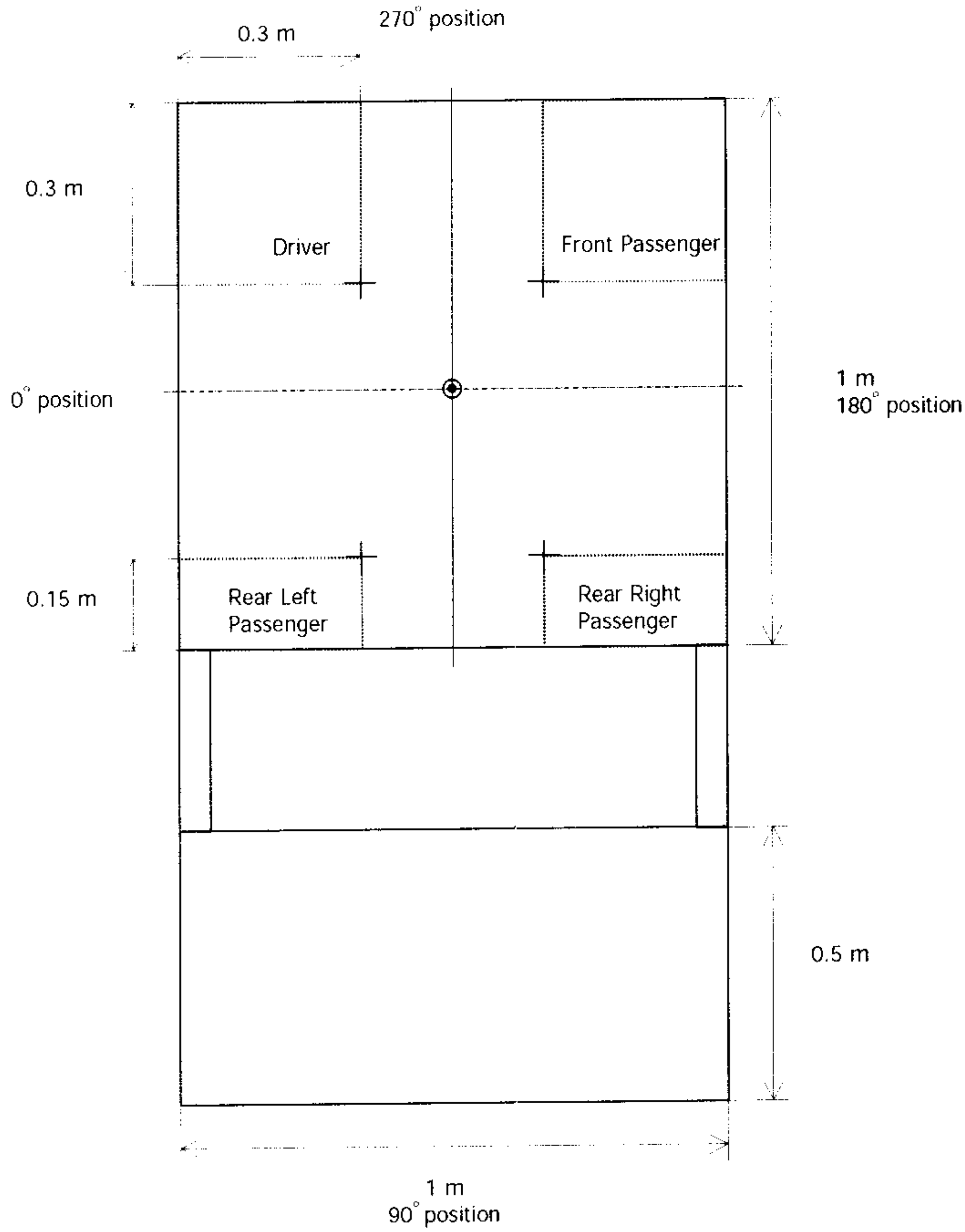


Figure 7.3.1. Plan View of Vehicle Simulator and Setup.

7.4 Test Procedure

a) The probe shall be positioned close to, and parallel to, the vehicle rooftop simulation with its tip 20 cm from the radiating antenna, and its axis normal to the antenna.

b) Rotate the turntable so that the probe is at the 0° position (see Figure 7.3.1).

c) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

d) Determine the location of the maximum power density: locate the maximum emissions by scanning vertically along the EUT's antenna. Take and record measurements of the power density at a number of points along the length of the antenna as well as just past its tip.

e) At every 45° of rotation take and record a measurement of the power density at the maximum power density height as for at least the following locations:

- half the maximum power density height
- height halfway between the maximum power density height and the tip of the radiating antenna
- just above the tip of the antenna

f) Turn off the EUT.

g) Position the probe under the vehicle rooftop simulating ground plane in the approximate location of the centre of the head of a potential driver of the simulated vehicle (see Figure 7.3.1).

h) Turn on the EUT and allow a sufficient time for stabilization. Turn on the transmitter and simulate normal operation conditions. Operate the transmitter at full rated output power.

i) Take and record the measurement of the power density at this location.

j) Turn off the EUT.

k) Repeat steps g) through j) for the positions of the other potential occupants of the simulated vehicle as shown in Figure 7.3.1.

7.5 Results

Table 7.5.1 presents the results of the measurements made along the length of the antenna in order to find the location of the maximum power density (the Larsen EF5T900SNMO antenna has a height of 88.5 cm). Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 15.5ft Belden 8219 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (9.5ft × 0.138 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

The data in Table 7.5.1 is presented in Figure 7.5.1.

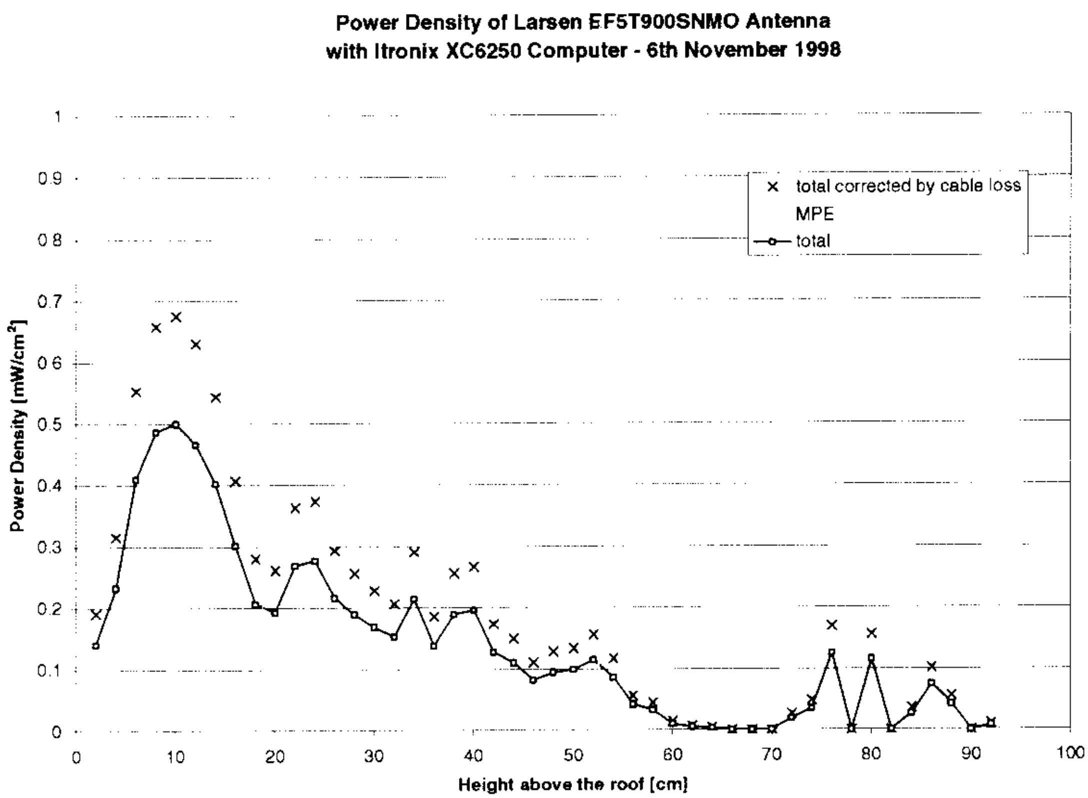


Figure 7.5.1

Table 7.5.1
Power Density Measured at 0° as a Function of Height

Height [cm]	Total [mW/cm^2]	Excess cable loss [dB]	Adjusted total [mW/cm^2]	MPE Limit [mW/cm^2]
2	0.14	1.31	0.19	0.6
4	0.23	1.31	0.32	0.6
6	0.41	1.31	0.55	0.6
8	0.49	1.31	0.66	0.6
10	0.50	1.31	0.68	0.6
12	0.47	1.31	0.63	0.6
14	0.40	1.31	0.54	0.6
16	0.30	1.31	0.41	0.6
18	0.21	1.31	0.28	0.6
20	0.19	1.31	0.26	0.6
22	0.27	1.31	0.36	0.6
24	0.28	1.31	0.37	0.6
26	0.22	1.31	0.29	0.6
28	0.19	1.31	0.26	0.6
30	0.17	1.31	0.23	0.6
32	0.15	1.31	0.21	0.6
34	0.21	1.31	0.29	0.6
36	0.14	1.31	0.19	0.6
38	0.19	1.31	0.26	0.6
40	0.20	1.31	0.27	0.6
42	0.13	1.31	0.17	0.6
44	0.11	1.31	0.15	0.6
46	0.08	1.31	0.11	0.6
48	0.09	1.31	0.13	0.6
50	0.10	1.31	0.13	0.6
52	0.11	1.31	0.16	0.6
54	0.09	1.31	0.12	0.6
56	0.04	1.31	0.06	0.6
58	0.03	1.31	0.04	0.6
60	0.01	1.31	0.01	0.6
62	0.01	1.31	0.01	0.6
64	0.00	1.31	0.00	0.6
66	0.00	1.31	0.00	0.6
68	0.00	1.31	0.00	0.6
70	0.00	1.31	0.00	0.6
72	0.02	1.31	0.03	0.6
74	0.04	1.31	0.05	0.6
76	0.13	1.31	0.17	0.6
78	0.00	1.31	0.00	0.6
80	0.12	1.31	0.16	0.6
82	0.00	1.31	0.00	0.6
84	0.03	1.31	0.04	0.6
86	0.07	1.31	0.10	0.6
88	0.04	1.31	0.06	0.6
90	0.00	1.31	0.00	0.6
92	0.01	1.31	0.01	0.6

Table 7.5.2 presents the results of the measurements made around the antenna at every 45° of rotation. Column 1 shows the angle at which the measurements were taken and columns 2 through 5 show the final adjusted power density (see discussion surrounding Table 7.5.1) at the different measurement heights. The MPE value is determined by averaging the adjusted total power density along a vertical line up to the height of a tall typical individual, taken here as 6ft or 180cm. Since the height for the rooftop of the simulated vehicle is 143cm, then the averaging is over those measurements made between 0 and 37cm above the simulated vehicle rooftop. Column 6 shows the results of this averaging.

Table 7.5.2

Power Density Measured
at every 45° as a Function of Height

Angular	Adjusted Total Power Density					Average of	MPE Limit
Position	H1 [cm]	H2 [cm]	H3 [cm]	H4 [cm]	H5 [cm]	Values up	
	5	10	20	36	90	to 37 cm	
[°]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]	[mW/cm^2]
0	0.3966	0.5849	0.3762	0.4212	0.0045	0.4447	0.6
45	0.4007	0.6686	0.2445	0.3459	0.0084	0.4150	0.6
90	0.2867	0.6417	0.2793	0.3036	0.0045	0.3778	0.6
135	0.3705	0.5279	0.1651	0.4182	0.1873	0.3704	0.6
180	0.3033	0.6182	0.1928	0.2348	0.1072	0.3373	0.6
225	0.2275	0.3763	0.1700	0.3635	0.1537	0.2843	0.6
270	0.2063	0.3386	0.0937	0.2373	0.0920	0.2190	0.6
315	0.1851	0.3009	0.0174	0.1111	0.0304	0.1536	0.6
360	0.3966	0.5849	0.3762	0.4212	0.0045	0.4447	0.6

The data in Table 7.5.2 is presented in Figure 7.5.2.

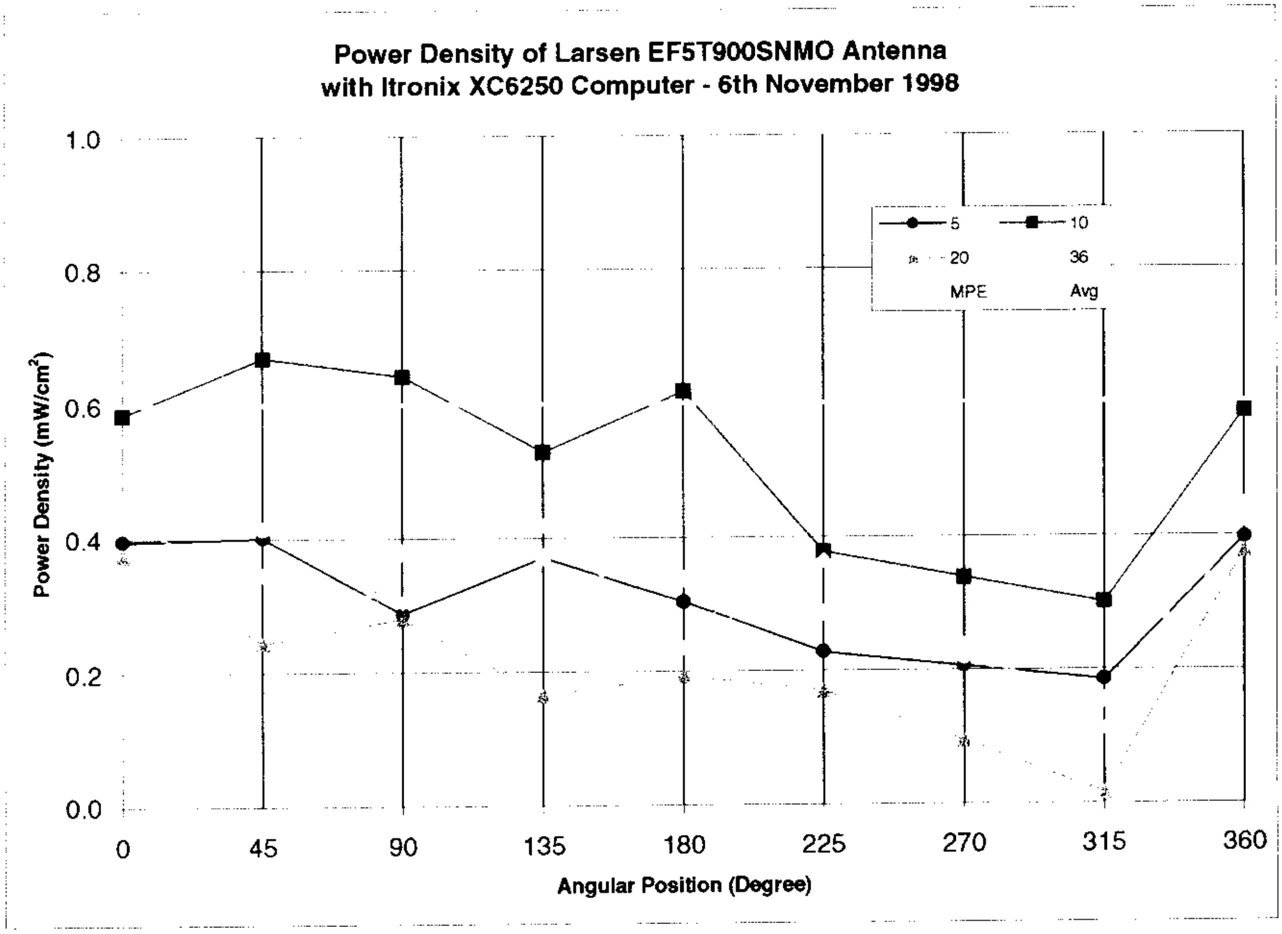

Power Density of Larsen EF5T900SNMO Antenna
with Itronix XC6250 Computer - 6th November 1998
1.0
0.8
0.6
0.4
0.2
0.0
Power Density (mW/cm²)
0
45
90
135
180
225
270
315
360
Angular Position (Degree)
5
10
20
36
MPE
Avg

Figure 7.5.2.

Measurements were made below the simulated vehicle rooftop, in the approximate location of the centre of the head of potential occupants. It was assumed that this typical position occurred 17.5cm below the roof of the simulated vehicle (the clearance between the top of an occupant's head and a vehicle's roof is ~3" (7.5cm) and distance between the top of the head and the eyes is ~4" (10cm)). Figure 7.3.1 shows the location of measurements for the 4 potential occupants. Table 7.5.3 presents the results of the measurements. Column 1 shows the height at which the measurements were taken and column 2 shows the result ("total" indicates that this is the sum of the power density measured by each of the three orthogonal sensors in the probe). The cable loss associated with the supplied 15.5ft Belden 8219 cable was adjusted to the nominal loss for a 6 foot length. Column 3 indicates the correction for the excess cable loss (9.5ft × 0.138 dB/ft) that was applied to measured power density (column 2) to obtain the final adjusted power density.

Table 7.5.3

Power Density Measured
at Position of Potential Vehicle Occupants

Position	Total	Excess cable loss	Adjusted Total	MPE Limit
	[mW/cm^2]	[dB]	[mW/cm^2]	[mW/cm^2]
driver	0.00	1.31	0.00	0.6
front passenger	0.00	1.31	0.00	0.6
rear left	0.01	1.31	0.01	0.6
rear right	0.00	1.31	0.00	0.6

8.0 CONCLUSION

The EUT consisting of an Itronix Model X-C 6250 ruggedized wireless laptop with a Model CRDL, RF ASSY vehicle cradle, and an external 5dB Larsen Model EF5T900SNMO vehicle-rooftop mounting antenna will not exceed the MPE requirements for the 896 - 901MHz band. The maximum power exposure level measured at 20cm was 0.44 mW/cm^2.

APPENDIX A

Transmitter Specifications

X-C 6250

W E K N O W T H E R O A D™

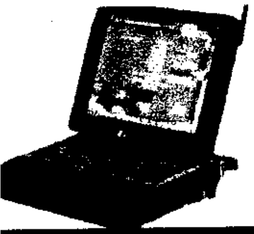
A High Performance Wireless Worktool for Field Computing

Directly impact workforce productivity and profits with the Itronix X-C 6250 – a fully ruggedized, wireless computer designed specifically to deliver results in the most demanding field applications.

The X-C 6250 is built tough to withstand the shock of repeated drops and remain operational under extreme temperatures, vibration, liquid, and exposure to the elements. When equipped with wireless communications, highly mobile field workers can use the X-C 6250 to collect, communicate and manage account information in real time while at a customer's site. Sophisticated power management systems deliver computing and communications capabilities all day on a single battery, ensuring productivity. Additional features for field computing like the 6250's optional touch screen allow workers the flexibility and ergonomics of both pen and keyboard use in the same platform.

Reach the next plateau in servicing your customers with Itronix. The leader in mission-critical mobile computing solutions.

ITRONIX



GHLIGHTS

-)0MHz Intel Pentium rocessor
- ıtegrated wireless data ›mmunications
- onference quality peakerphone
- oth touch screen & eyboard input
- ılly ruggedized, ›tally sealed
- xcellent outdoor ewable display
- ariety of carrying options ıd locking vehicle docks
- ›wer management system ›r all day battery use
- .1GB or 3.2GB ruggedized ard drive
- olor and monochrome isplays up to 10.4"

FEATURES AND SPECIFICATIONS

COMPACT SIZE/WEIGHT
- Length: 10.5" (26.7cm)
- Width: 7.5" or 8.1" (19.1 or 20.57cm) screen size dependent
- Depth: 3.0" (7.6cm)
- Weight: 6.9 or 7.18 lbs. (3.1 or 3.25 kg) screen size dependent

PROCESSOR/MEMORY
- 200MHz Pentium® with MMX technology
- 16 to 48 MB RAM

STORAGE
- 2.1GB or 3.2GB 2.5" ruggedized hard drive

POWER
- 3.5 Ahr high capacity NiMh battery pack
- Smart battery with accurate gas gauge
- 4 hour rapid charge

DISPLAY
- SVGA color 800 x 600 pixel 10.4" diagonal display (touch screen optional)
- VGA monochrome 640 x 480 pixel 8.2" diagonal transflective backlit display
- Shock mounted
- Long-life hinge
- Automatic temperature compensation

INPUT DEVICES
- Keyboard – 93% standard key spacing user replaceable
- Pointing Stick – pressure sensitive with two button input
- Touch Screen – optional passive pen or finger touch capable

OPERATING SYSTEM
- Microsoft® Windows® 95
- Microsoft® Pen Computing for Windows® 95

INTERFACES
- Powered 115Kbps 16550 compatible serial port
- ECP/EPP parallel port
- Built-in RJ-11 phone jack – externally accessible
- Accepts 2 Type I or II or 1 Type III PC cards
- External video connector

INTEGRATED WIRELINE COMMUNICATIONS
- Integrated microphone and speaker for voice communications
- 33.6 Kbps v.34 Group 3 fax/data modem

INTEGRATED WIRELESS COMMUNICATION OPTIONS
- CDPD/Cellular radio network for voice & data
- ARDIS network
- BellSouth Wireless Data network

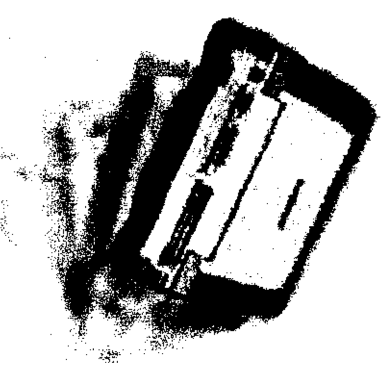
OPTIONS
- Vehicle charger with lighter adapter
- Stand alone spare battery pack charger
- Vehicle cradle with lock, power, and serial port
- External 3.5" floppy drive
- External CD-ROM
- External antenna option with vehicle cradle
- Carry cases for system and accessories
- Bar-Code laser scanners
- Vehicle cradle with CD-ROM

INTEGRATED TELEPHONE LINE TESTING OPTION
- T-BERD 109XC Subscriber Loop Analyzer accessed by software running under Windows® 95
- Full-function POTS subscriber line tester
- Time Domain Reflectometer (TDR)
- Narrowband TIMS
- Basic-rate ISDN tester

LONG-LIFE CASE DESIGN
- Die Cast Magnesium for all structural components
- Integrated Santoprene® shock absorption
- Case design integrates vehicle cradle connection
- Full environmental and RF seal
- Zinc door on PC cardslot

ENVIRONMENTAL CHARACTERISTICS
- Operating temperature range: -4° to 140° Fahrenheit (-20° to 60° Celsius)
- 54 repeated 1M drops on all surfaces, edges and corners per MIL STD 810E, 516.4, Proc. IV (30" with intergrated T-BERD 109XC)
- Rain at 4 in./hr. at approximately 40 psi for 40 minutes per axis for all axes per MIL STD 810E, 506.3, Proc. III
- Vibration of .04g^2/Hz over 20-1000Hz random

INTRINSIC SAFETY
- Class 1, Division 2, Group D



ITRONIX
Mobile Workforce Systems Company
A DYNATECH Company

V1 3M 10/98
801 South Stevens Street, Spokane, WA 99204
509-624-6600 1-800-441-1309

APPENDIX B

Antenna Specifications


EF5T900SNMO
ELEV FEED/WHP 5dB 896–
960 MHZ
Date Manufactured:
Larsen

MUF 800/900 MHz Chrome Coil Series

806-940 MHz, 3dB/5dB Gain

This MUF Series features our heavy-duty Low Profile Base with a tapered loading coil jacket, chrome fittings and an optional heavy-duty stainless steel spring. Available with either an open coil rod or our coil rod design.

Features:

- Low Profile double-sealed housing for maximum weatherproofing
- Triple plated brass fittings for superior performance and durability in the toughest environments
- Factory tuned for SMR; field tunable for Cellular models
- 1-1/8" -18 mounting threads mate with all 3/4" MAXRAD mounts

Electrical Specifications

Maximum Power:
150 Watts
VSWR at Resonant Point:
<1.5:1
Nominal Impedance:
50 Ohms
Antenna Type:
3dB - 5/8 wave over a 1/4 wave
5dB - Dual 5/8 wave over a 1/4 wave

Mechanical Specifications

Radiator Material:
.100" dia. stainless steel
Optional Spring:
Stainless steel
Phasing Coil Housing:
Molded polymer jacket with copper, nic chrome plated brass bushings
Base Coil Housing:
Molded tapered jacket with copper, nickel and chrome plated brass bushing
800 MHz Antenna Height:
3dB- Approx. 15 1/2" at lowest frequ
5dB- Approx. 25" at lowest frequency
900 MHz Antenna Height:
3dB- Approx. 14" at lowest frequency
5dB- Approx. 25" at lowest freq

MUF-8103 Series

Model #	Frequency Range	Factory Tuned Frequency	Rod/Coil Type	Gain	List Price Chrome Models	List Price Chrome Models w/ Spring	List Price Black Models	List Price Black Models w/ Spring
MUF-8103(S)	806-896 MHz	815 MHz	Collinear/Open	3dB	$24.14	$34.14	N/A	N/A
MUF-8003(S)	806-896 MHz	815 MHz	Collinear/Closed	3dB	$29.40	$39.40	N/A	N/A
MUF-9103(S)	896-940 MHz	898 MHz	Collinear/Open	3dB	$24.14	$34.14	N/A	N/A
MUF-9003(S)	896-940 MHz	898 MHz	Collinear/Closed	3dB	$29.40	$39.40	N/A	N/A
MUF-8105(S)	806-866 MHz	815 MHz	Trilinear/Open	5dB	$33.34	$43.44	N/A	N/A
MUF-8005(S)	806-866 MHz	815 MHz	Trilinear/Closed	5dB	$38.05	$48.05	N/A	N/A
MUF-8305(S)	825-896 MHz	835 MHz	Trilinear/Open	5dB	$33.34	$43.44	N/A	N/A
MUF-8325(S)	825-896 MHz	835 MHz	Trilinear/Closed	5dB	$38.05	$48.05	N/A	N/A
MUF-9025(S)	896-940 MHz	898 MHz	Trilinear/Open	5dB	$33.34	$43.44	N/A	N/A
MUF-9035(S)	896-940 MHz	898 MHz	Trilinear/Closed	5dB	$38.05	$48.05	N/A	N/A

Suffix "S" indicates spring

MUF-9105SP 915 MHz

EXHIBIT EIGHT

Aprel Tissue
Recipe and Calibration Requirements
SSI/DRB-TP-D0L-033

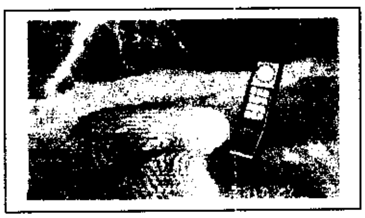
ITRONIX CORPORATION

Spectrum Sciences Institute
RF Dosimetry Research Board

Attention: all comments, suggestions, and inquiries should be addressed to
Dr. Jack J. Wojcik or Dr. Paul G. Cardinal
51 Spectrum Way., Nepean Ontario, K2R 1E6, Canada. tel.:(613)820-2730, fax:(613)820-4161
e-mail: inform@spectrum-sciences.org

Tissue Recipe and Calibration Requirements

SSI/DRB-TP-D01-033



PART of SAR Measurements Requirements

SSI/DRB-TP-D01-030

DRAFT

Prepared jointly with:

APREL

Near Field Measurements Laboratory

March 1998

- NOTICE -

This draft was prepared to assist the Dosimetry Research Board of SPECTRUM SCIENCES INSTITUTE and specifically the Working Group on SAR Measurements. It is submitted as a basis for discussion only, and is not binding on APREL Inc. Subsequent study may lead to revisions of the document, both in numerical values and/or form, and after continuing study and analysis, APREL Inc. specifically reserves the right to add to, or amend the content of this contribution.

TABLE OF CONTENTS

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1.0 INTRODUCTION

1.1 Purpose and Scope of the Standard

The purpose of this document is to standardize the recipe for simulated muscle and brain tissue, and the calibration of the simulated tissue. This Standard includes procedures to be followed in making and calibrating simulated biological tissues to be used for Specific Absorption Rate (SAR) measurements.

This Standard defines:

- the methodology and procedures to be followed in the laboratory calibration of the simulated tissues
- the hardware and software required, the test procedures, and, where applicable, the required limits for calibration of simulated tissues.

In addition to recipes for simulated brain and muscle tissues, this Standard also includes tests to determine the following parameters:

1. Density
2. Heat Capacity
3. Dielectric Constant and Conductivity

This Standard is part of a Certification Program Methodology as described in a separate document entitled "SSI/DBR TP-D01-030, Specific Absorption Rate (SAR) Standard For Portable Telecommunications Devices, March 1998". SSI/DBR TP-D01-033 contains specific criteria that must be met for SAR certification.

1.2 Test Facilities

All calibration work as described in this Standard shall be performed at an ISO/IEC Guide 25 accredited laboratory.

1.3 Test Personnel

Personnel performing the calibration will be experienced in relevant measurements (eg physical properties or RF characteristics) and supervised by a person proficient in SAR measurements.

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1.4 Test Equipment

The required test equipment, hardware and software, is identified is each individual procedure. Equipment may be substituted or updated from time to time. Should this occur, such change shall be noted in the test report. Equipment shall be calibrated to standards traceable to International Standards.

1.5 Standard Environmental Conditions

All measurements and calibration should be performed under normal laboratory conditions for physical properties and electrical characteristics as stipulated by ISO/IEC Guide 25. The nominal temperature for physical property measurements and for electrical characterization are 20°C and 23°C, respectively.

2.0 BACKGROUND

In order to perform measurements of specific absorption rates (SAR) of electromagnetic energy in human brain tissue, it is necessary to use models that simulate the electrical properties of real tissue. It is also important that those models are reproducible, long lasting, non-corrosive, and easy to produce and use. Mixtures have been developed that simulate the electrical properties of various biological tissues for various frequency ranges between 100 – 2,450 MHz. This mixture is a practical simulation of biological tissue, however, requires different proportions of sugar, water, salt, hydroxyethylcellulose (HEC) and a bactericide, for different frequency ranges. The solution is easy to produce, and fairly inexpensive. Its electrical properties can be altered to match many tissue types, at different frequencies. For certain frequency ranges, the conductivity of the mixture, even without the presence of salt, will be higher than some of the biological tissues. This will lead to a conservative overestimation of the SAR value. Another advantage of the solution is that its liquid form allows easy positioning of the E-field probe within the phantom. The shelf like of such simulated tissue is reasonably long (weeks) with the addition of the bactericide. Additional precautions (covering, stirring, filtering) may extend the useful to over six months.

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3.0 REFERENCES

- "Simulated Biological Materials for Electromagnetic Radiation Absorption Studies", G.W. Hartsgrove et al, Bioelectromagnetics, vol. 8, pp. 29-36, 1987.
- "Suggestions Prepared Following the CENELEC Document", N. Kuster et al, Attachment 9, Minutes IEEE Standards Coordinating Committee –34, Subcommittee – 2, May 2, 1997 meeting.
- "Calibration for Implantable E-field Probes in Human Equivalent Material", Narda Microwave Corporation, Feb. 11, 1997.
- Private communication, Motorola, Fort Lauderdale, FL and Libertyville, IL, 1997.
- "Compilation of the Dielectric Properties of Body Tissue at RF and Microwave Frequencies", C. Gabriel, Brooks Air Force Technical Report AL/OE-TR-1996-0037.

4.0 RECIPE AND PREPARATION

4.1 Ingredients

The following table contains recipes for simulated muscle and brain tissues for 100 MHz – 1GHz. This gives approximate quantities required to achieve electrical parameters specified in section in Section 5

Table 4.1

Simulated Tissue Ingredients		
Ingredient	Muscle Mixture	Brain Mixture
Water	52.4 %	40.6 %
Sugar	45.0 %	58.0 %
Salt	1.5 %	1.0 %
HEC	1.0 %	0.3 %
Bactericide	0.1 %	0.1 %

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The following table contains recipes for simulated muscle and brain tissues for 1.5 –2.5 GHz. This gives approximate quantities required to achieve electrical parameters specified in section in Section 5

Table 4.2

Simulated Tissue Ingredients	
Ingredient	Brain & Muscle Mixture
Water	45.3 %
Sugar	54.3 %
Salt	0.0 %
HEC	0.3 %
Bactericide	0.1 %

Common household salt and sugar are typically used.

4.2 Equipment

The following equipment will be needed to make the simulated tissue.

Table 4.3

Description	**Manufacturer**	**Model**
Graduated Cylinder	BOMEX	2000 ml
Storage Container	Various sources	20 l
Weight Scale	Pennsylvania Scale Co.	2 kg
Handling Containers	Various sources	various
Corrosion Resistant Mixing Device		

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4.3 Preparation

1. Select the appropriate simulated tissue type: Muscle or Brain.
2. From the Tables 4.1 or 4.2 above, determine the percentage of each ingredient for the volume of 20 liters, calculate the mass of each ingredient assuming that the density of the final solution is 1300 kg/m^3.
3. Verify that the storage container in which the ingredients will be mixed is clean.
4. Obtain the calculated amount of reverse-osmosis or de-ionized water.
5. Pour about 25% of the water into a glass beaker, heat it on a hot plate to almost boiling, and then add it to the cold water. The objective is to increase the temperature of the water to approximately 40" C (100-105°F).
6. Prepare the appropriate quantities of the dry ingredients in separate containers.
7. When the water is ready, slowly add salt and bacteriacide while stirring at low speed.
8. After the salt and bactericide is dissolved start adding sugar to the container while stirring continuously at low speed until totally dissolved.
9. Add the HEC slowly to avoid clumping. Continue to stir until the solution thickens.
10. Total stirring time should be 30-35 minutes.

5.0 MEASUREMENT OF THE DIELECTRIC CONSTANT AND CONDUCTIVITY OF SIMULATED TISSUE

5.1 Test Purpose

Before a batch of simulated tissue can be used for SAR measurements, its electrical characteristics (dielectric constant and conductivity) must be determined to ensure that the simulated tissue was properly made and will simulate the desired human characteristics. A coaxial slotted line with probe is used to measure RF amplitude and phase changes versus distance in the simulated tissue as shown below.

5.2 References

- "A Comparative Study of Four Open-Ended Coaxial Probe Models for Permittivity Measurements of Lossy Dielectric/Biological Materials at Microwave Frequencies" D.Berube, F.M.Ghannouchi, and P.Savard, 1996, IEEE Transactions on Microwave Theory and Technique 44:1928-34.
- "Broadband Calibration of E-Field Probes in Lossy Media." K.Meier, M.Burkhardt, T.Schmid, and N.Kuster, 1996, IEEE Transactions on Microwave Theory and Techniques. 44:1954-1962.

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- "Coaxial Line Reflection Methods for Measuring Dielectric Properties of Biological Substances at Radio and Microwave Frequencies – A Review", M.A. Stuchly and S.S. Stuchly, 1980, IEEE Transactions of Instrumentation and Measurement, 29:176-183.
- SAR Measurement Operational Guide, O.M. Garay and Q. Balzano, 1995, Motorola, Florida Corporate Electromagnetics Research Laboratory, Fort Lauderdale, Florida.
- FCC Dielec.exe computer program.
- CRC Handbook of Chemistry and Physics , R.C.Weast, M.J.Astle, and W.H.Beyer (Eds.), 1996, CRC Press Inc., Boca Raton, Florida.

5.3 Definitions

dielectric constant: the ratio of the capacity of a condenser with that substance as dielectric to the to the capacity of the same condenser with a vacuum for dielectric. It is a measure of the amount of electrical charge a given substance can withstand at a given electric field strength.

conductivity: the quantity of electricity transferred across unit area, per unit potential gradient, per unit time.

5.4 Standard Values Required

The dielectric constant and conductivity of simulated brain tissue should be 46.1 and 0.74 S/m^2, respectively.

Table 5.1

Tissue Ingredients			
Frequency (MHz)	Tissue Type	Dielectric Constant ε_r	Conductivity σ (S/m)
835	Brain	41.2	0.90
	Muscle	54.7	1.38
915	Brain		
	Muscle		
1900	Combined	41.0	1.70
2450	Combined		

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5.5 Test Equipment

Table 5.2

Description	Manufacturer	Model
Network Analyzer	Hewlett Packard	8510B
Slotted Line Carriage	Hewlett Packard	809B
Coaxial Termination	Hewlett Packard	908B
Slotted Line Probe	APREL	SLP-001
Miscellaneous Cables and Adapters	N/A	N/A

5.6 Test Configuration

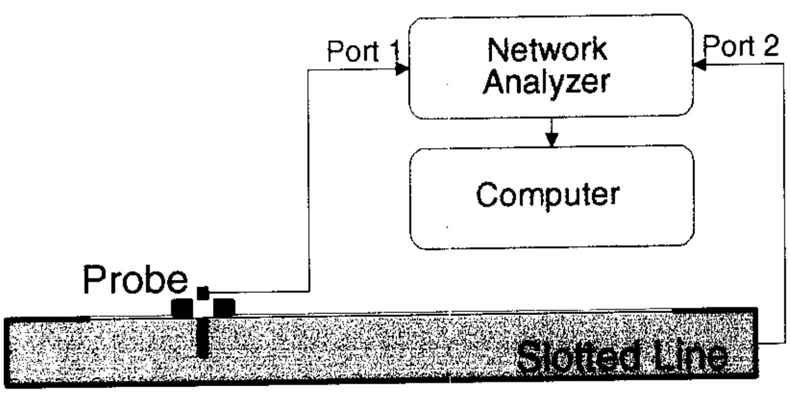

Figure 5.1

5.7 Test Procedure

1. Before using the slotted line, inspect it carefully to be sure the inside is clean and free of foreign matter.
2. Clean the area about 1 cm wide along each side of the slot. Similarly, clean the underside of the probe outer structure to ensure a good noise-free contact with the slotted line. Take care to avoid damage to the probe center conductor.

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3. Using a large syringe, draw up a sample of room temperature simulated tissue. Ensure that the sample is as free as possible of air bubbles, and inject the simulated tissue into the slot. Make sure that the slot is full of simulated tissue and free of air bubbles.
4. Connect Port 1 of the network analyzer to the probe, and Port 2 to the slotted line.
5. Insert the slotted line probe into the probe holder and tighter the thumbscrew.
6. Move the holder to the end nearest the input connector, making sure that the simulated tissue is flush with the outside surface of the line. Align one end of the probe marker with a line on the centimeter scale.
7. Set the network analyzer's frequency range to cover the measurement frequencies and select the S_{12} parameter.
8. Select port-to-port loss measurement and select averaging over a sufficient number of samples.
9. After averaging, place the marker at a frequency of interest and record the level in the table (one table per frequency) to the nearest 0.1dB.
10. Select phase measurement (averaging should be left on). Place the marker at a frequency of interest and record in the phase in the table (one per frequency) to the nearest 0.1°.
11. Move the probe 0.5cm toward the far end of the line.
12. Repeat steps 7 through 11 until 13 data points (corresponding to 6 cm) have been measured.

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5.8 Test Data Table

1. The level and phase can be recorded in the following table (use one copy per frequency):

Table 5.3

Frequency:		**Date:**	

Position (cm)	**Level (dB)**	**Phase (°)**
0.0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		

2. Execute the Fluid Calibration with Slotted Line.xls spreadsheet and enter the measured amplitude and phase data as recorded in the table(s). When the data are plotted (eg Figure 5.2), examine the linearity of the curves to judge the validity of the calculated dielectric constant and conductivity (eg Table 5.4). If only one point on a curve is out of line, re-measure just that point. If more than one point is wrong, repeat the entire measurement. Once the data are satisfactory, the calculated values should be compared with the values in Table 5.1.
3. The measured data, calculated values, and plot must be identified with the type of simulated tissue, date it was prepared, frequency, date and name of person conducting the measurements, and kept in a file.
4. The simulated tissue should be used soon after preparation and characterization of the dielectric properties, and stored so as to prevent evaporation of the water. After prolonged use, a sample should be taken for dielectric measurement to assure there has been no change in properties. In the absence of biological degradation and significant evaporation, the simulated tissue can be used for several months.

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Table 5.4

02-Feb-98	*Rob Acorn*	
Brain Mixture @	*835 MHz*	
Position [cm]	**Amplitude [dBm]**	**Phase [deg]**
0	-37.9	-74.4
0.5	-39.2	-106.6
1	-40.6	-140.8
1.5	-41.9	-174.3
2	-43.2	152.4
2.5	-44.6	117.7
3	-45.9	83.8
3.5	-47.2	51.4
4	-48.6	18
4.5	-50.1	-16.2
5	-51.5	-49.5
5.5	-52.7	-84.6
6	-53.9	-115.7
ε_r	41.73	
$\sigma_{effective}$ [S/cm]	1.103E-02	

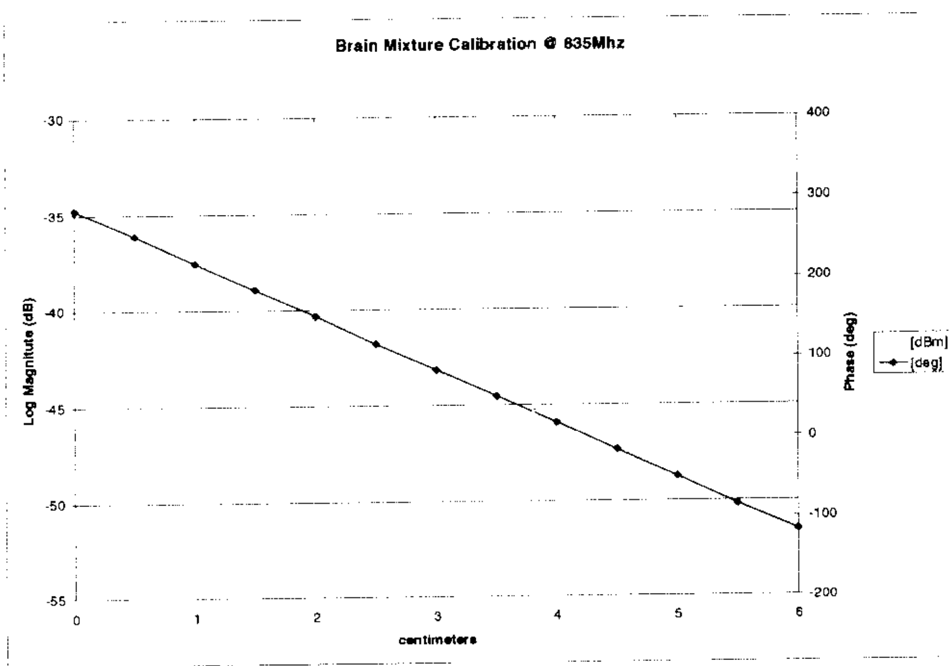

Figure 5.2

Comments and inquiries should be addressed to:
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5.9 Test Data Analysis

The data from the slotted line are used to determine the relative dielectric constant and effective conductivity (that includes contributions from both dielectric and ohmic processes) from the following relationships:

$$\varepsilon_r = \frac{\beta^2 - \alpha^2}{\omega^2 \mu \varepsilon_0} \tag{1}$$

$$\sigma_{effective} = \frac{2\alpha\beta}{\omega\mu} \tag{2}$$

α and β are determined by averaging, respectively, the attenuation (dB/cm) and phase shift (deg/cm) over the length of the slotted line. The attenuation and phase shift are each determined for seven pairs of points. Each of the pairs of points is from measurements separated by 3 cm. For example (using the data in Table 5.4), the attenuations and phase shifts at z=1 cm and z=6 cm define ΔdB_1 and Δdeg_1:

ΔdB_1 = Mag (z = 3 cm) - Mag (z =0 cm)

= -45.9 dB_m, - (-37.9 dB_m) = -8.0 dB, and

Δdeg_1 = Phase (z = 3 cm) - Phase (z =0 cm)

=83.8 deg - (285.6) deg = -201.8 deg.

In a similar fashion, obtain data for ΔdB_2 to ΔdB_6 and Δdeg_2 to Δdeg_6 and then average each series to get

$$\alpha_{avg}\,(dB/cm) = \frac{\sum_{n=1}^{7} \Delta dB_n}{7 \cdot 3}, \text{ and}$$

$$\beta_{avg}\,(deg/cm) = \frac{\sum_{n=1}^{7} \Delta deg_n}{7 \cdot 3}$$

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The values of α_{avg} and β_{avg} must be converted to units of (Np/cm) and (rad/cm) using these relations:

$$\alpha_{avg}\,(\text{Np/cm}) = \frac{\ln(10)\cdot \alpha_{avg}\,(\text{dB/cm})}{20}\text{, and}$$

$$\beta_{avg}\,(\text{rad/cm}) = \frac{\beta_{avg}\,(\text{deg/cm})\cdot \pi}{20}$$

Finally, use (1) and (2) to obtain ε_r and $\sigma_{effective}$ from α_{avg}, β_{avg}, and $\omega = 2\pi f$, where f is the frequency of the RF field.

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6.0 MEASUREMENT OF THE SPECIFIC HEAT CAPACITY OF SIMULATED TISSUE

6.1 Test Purpose

The specific heat capacity of the synthetic tissue liquid is required in the calibration of the miniaturized isotropic E-field probes used to measure the Specific Absorption Rate (SAR). A sample of the liquid is exposed to the known field of an RF radiation for a specific length of time. The liquid will be heated and this heat can be propagated by conduction, convection, and radiation. In the case of liquids heated from below, gravity convection is the main and predominant heating mechanism of the fluid mass.

6.2 References

- Introduction to Physics for Scientists and Engineers, F.J. Bueche, McGraw-Hill Book Company, New York, 1980.
- "The Specific Heats of Aqueous Sucrose Solutions", F.T. Gucker and F.D. Ayres, 1937, American Journal of Chemistry, 59:447-452.
- "Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones", Q. Balzano, O.M. Garay, and T.J. Manning, 1995, IEEE Transactions on Vehicular Technology, 44:390-403.
- "Broadband Calibration of E-Field Probes in Lossy Media", K. Meier, M. Burkhardt, T. Schmid, and N. Kuster, 1996, IEEE Transactions on Microwave Theory and Techniques, 44:1954-1962.
- SAR Measurement Operational Guide, O.M. Garay and Q. Balzano, 1995, Motorola, Florida Corporate Electromagnetics Research Laboratory, Fort Lauderdale, Florida.

6.3 Definition

specific heat capacity: the quantity of energy needed to raise the temperature of a unit mass by one degree.

6.4 Standard Value

For brain tissue simulating liquids the heat capacity should be 2.8 J/K/g ±5%.

6.5 Test Equipment

Table 6.1

Description	**Manufacturer**	**Model**
Differential Thermometer		
Containers (2)		500 ml
Thermally Insulated Vessel		
Weigh Scale	Pennsylvania Scale Co.	2 kg
Graduated Cylinder	BOMEX	2000 ml
Data Recorder		

6.6 Test Procedure

1. Obtain two containers that can be rapidly heated (e.g., glass or suitable plastic).
2. Fill one container with 250 ml of water; the other with the same mass of simulated tissue. The initial temperature of the water should be the same as that of the simulated tissue (±1°C). Since we are dealing with heating by electromagnetic sources at ambient temperature, it is essential that we eliminate the chance of any direct infrared heating of the temperature sensor.
3. To ensure this, position the tip of the sensor 2mm from the bottom of the center of the container.
4. Turn on the heat source and wait at least 5 minutes for its temperature to stabilize.
5. Record the initial temperature of the water.
6. Place the container of water 5mm above the center of the hot plate and monitor the temperature increase.
7. After 30 seconds of heating, the water temperature should have increased by at least 5°C. Record the time and temperature.
8. Remove the container from the heat source and place it in the thermally insulated vessel.

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9. Stir the liquid thoroughly and record the steady-state temperature 1-2 minutes after stirring.
10. Repeat the above procedure using the container of simulated tissue. Ensure that the container is placed on the same area of the hot plate, is heated for the identical length of time, and the steady-state temperature is recorded after the identical time interval.

6.7 Test Data Table

The temperatures can be recorded below.

Table 6.2

	Water (°C)			**Tissue (°C)**		
Trial	**Initial Temp**	**30 seconds**	**120 seconds**	**Initial Temp**	**30 seconds**	**120 seconds**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

6.8 Test Data Analysis

Since the heat capacity of water is $C_w = 1$ cal/°C/g with excellent approximation (~ 1 %) in the temperature range of interest, the heat capacity (C_s) of the solution is given by

$$C_S = C_W \frac{\Delta T_W}{\Delta T_S}$$

where ΔT_W is the temperature increase of water and ΔT_S the temperature increase of the solution. The ratio of the values, $\Delta T_W/\Delta T_S$, should be the same (within the sensitivity of

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the thermometer) at the end of the heating and stirring. This ensures that the liquids have been uniformly heated.

6.9 Rationale

$C \Delta T$ = Heat flow x time = Total Heating Energy

If the heat flow, sample mass, and absorption (heat transfer) are the same for both liquids, then

$C_W \Delta T_W = C_S \Delta T_S$

The heat flow and total heating are kept constant by using the same source for the same amount of time. If the heat transfer mechanisms for the two liquids are about the same, with insignificant differences in convective and conductive characteristics, then any differences in temperature increase are a direct measure of the specific heat capacity, C.

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7.0 MEASUREMENT OF THE DENSITY OF SIMULATED TISSUE

7.1 Test Purpose

Before a batch of simulated tissue can be used for SAR measurements, its density must be determined to ensure that the simulated tissue was properly made and will simulate the desired human characteristics.

7.2 References

- Introduction to Physics for Scientists and Engineers, F.J. Bueche, 1980, McGraw-Hill Book Company, New York.
- "Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones", Q. Balzano, O.M. Garay, and T.J. Manning, 1995, IEEE Transactions on Vehicular Technology, 44:390-403.
- "Broadband Calibration of E-Field Probes in Lossy Media", K. Meier, M. Burkhardt, T. Schmid, and N. Kuster, 1996, IEEE Transactions on Microwave Theory and Techniques, 44:1954-1962.

7.3 Definition

density: a measure of the mass contained in a unit volume of the substance.

7.4 Standard Value

For brain tissue simulating liquids the density should be 1.28 g/cm^3 ±2%.

7.5 Test Equipment

Description	Manufacturer	Model
Weigh Scale	Pennsylvania Scale Co.	2 kg
Graduated Cylinder	BOMEX	2000 ml

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7.6 Test Procedure

1. Obtain a clean, dry graduated cylinder.
2. Place the cylinder on a scale and record its mass when empty.
3. Pour a sample of the simulated tissue into the cylinder.
4. Weigh the cylinder with the simulated tissue to obtain a total mass.
5. Subtract the cylinder mass from the total mass to obtain the mass of the tissue.
6. Record the tissue volume and mass in the table below.
7. Clean and dry the cylinder and repeat this process for a total of 10 trials.

7.7 Test Data Table

1 The volume and mass can be recorded in the following table:

Mixture Frequency (MHz):		**Date:**	
Empty Measuring Container Mass (g):			
Trial	**Volume (ml)**	**Mass (g)**	**Density (g/ml)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

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7.8 Test Data Analysis

The data are used to determine the density of the simulated tissue by means of the following relation:

$$\rho = \frac{m - m_c}{v}$$

where ρ is the density (g/cm^3, Note:1 g/cm^3 = 1000 kg/m^3)
m is the mass of the container filled with simulated tissue (g)
m_c is the mass of the empty container (g)
v is the volume of the simulated tissue (1 cm^3 ≡ 1 ml).

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