CERTIFICATION REPORT

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

Product: **Netwave AirSurfer™ Pro Wireless LAN PCMCIA Card**

Client: Netwave Technologies

Address: 6663 Owens Drive
Pleasanton, CA
94588

Project # NETB-AirSurferPro-3014

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

Submitted By original signed by
Dr. Paul G. Cardinal
Director, Laboratories

Date: 14 July, 1998

Approved By original signed and stamped by
Dr. Jacek J. Wojcik, P.Eng.

Date: 14 July, 1998

FCC ID:	NALASPRO
Applicant:	Netwave Technologies
Equipment:	Wireless LAN PCMCIA Card
Model:	AirSurfer Pro
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 a Netwave Technologies AirSurfer Pro Wireless LAN PCMCIA Card. The measurements were carried out in accordance with FCC 96-326. The handset was evaluated at its nominal maximum power level of 22dBm (158mW).

The AirSurfer Pro PCMCIA card was tested at high, middle and low frequencies, with the maximum SAR channel 7 (mid). Test data and graphs are presented in this report.

Based on the test results, it is certified that the product meets the requirements as set forth in the above specification, 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 Netwave Technologies AirSurfer Pro Wireless LAN PCMCIA Card. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. The 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

- Netwave Technologies AirSurfer Pro Wireless LAN PCMCIA Card, (sample 1).
- Netwave Technologies AirSurfer Pro Wireless LAN PCMCIA Card, (sample 2).

The transmit antenna is a monopole type with approximately –2dBi gain. The antenna specifications supplied by the manufacturer can be found in Appendix A.

Sample 2's antenna was disabled and an RF connector was connected to the antenna feedpoint in order to be able to monitor the battery condition before and after each SAR scan.

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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.
- Rohde & Schwarz NRVS, power meter, S/N 864268/017, Asset # 100851.
- Rohde & Schwarz NRV-Z7, power sensor, S/N 862509/006, Asset # 100852.
- APREL F-1, Flat Manikin, S/N 001.
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033.

5.0 TEST METHODOLOGY

1) The test methodology utilized in the certification of the Wireless LAN PCMCIA Card 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.

5) The liquid is contained in a flat manikin simulating a human lap.

6) The PCMCIA card is inserted into a laptop computer and this is positioned in a normal usage position against the lap simulating flat manikin.

7) All tests were performed with the highest power available from the sample PCMCIA wireless LAN card, under transmit conditions.

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

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Figure 1.

Figure 2.

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6.0 TEST RESULTS

6.1 Handset Characteristics

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 a modified transmitter (sample 2) is sampled before and after each SAR run (the battery is changed after each measurement). In the case of the Netwave Technologies AirSurfer Pro wireless LAN PCMCIA card, operating at a 50% duty cycle, average RF power measurements were made with a R&S RF power meter. The following table shows the results for the 8 sets of results used for this report.

Scan		**Channel**	**Power Before dBm**	**Power After dBm**	**Change dBm**
Type	*Height (mm)*				
Area	2.5	L	9.0	9.0	0.0
Area	2.5	M	9.0	9.0	0.0
Area	2.5	H	9.0	9.0	0.0
Area	2.5	M	9.0	9.0	0.0
Area	12.5	M	9.0	9.0	0.0
Zoom	12.5	M	9.0	9.0	0.0
Zoom	7.5	M	9.0	9.0	0.0
Zoom	2.5	M	9.0	9.0	0.0

These values should be interpreted as relative values since the R&S RF power meter is not a wide band peak power meter suitable for spread spectrum devices.

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.

2) The Netwave Technologies AirSurfer Pro was put into test mode for the SAR measurements using manufacturer supplied keyboard commands to control the channel (H, M, L) and maximum operating power (nominally 22dBm or 158mW).

3) Figure 2 shows the flat phantom used in the measurements, with the laptop computer with the inserted PCMCIA wireless LAN card against the manikin. In

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order to see the PCMCIA card this view shows the laptop oriented to simulate RF exposure of the hand, with the screen removed. To perform SAR scans of the simulated lap the laptop, with screen attached, is turned upside down under the flat phantom.

A grid is shown inside the phantom indicating the orientation of the x-y grid used.. The origin (0,0) is scan dependant but is generally located just off the top left corner of the PCMCIA card. The x-axis is positive towards the bottom and the y-axis is positive towards the right.

4) Wide area scans were performed for the low (1), middle (7) and high (14) channels. The presented values were taken 2.5 mm into the simulated tissue from the flat phantom's solid inner surface. The peak single point SAR for the scans were:

Scan Type	**Channel**	**Peak Local SAR (W/kg)**
Area	L	0.0327
Area	M	0.0451
Area	H	0.0147

The channel producing the highest local SAR was used in subsequent investigations

5) Figure 3 shows a contour plot of the SAR measurements for the Netwave AirSurfer Pro PCMCIA wireless LAN card (sample 1). The presented values were taken 2.5 mm into the simulated tissue from the flat phantom's solid inner surface.

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.

Similar data was obtained 12.5 mm into the simulated tissue. These measurements are presented as a contour plot in Figure 5 and surface plot in Figure 6.

Figure 7 shows overlays of the PCMCIA card's outline and a portion of the laptop's outline, superimposed onto the contour plot previously shown as Figure 5.

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

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6) The low channel (1) SAR peak was then explored on a refined 0.5cm grid in three dimensions. Figures 8, 9 and 10 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 0.028 W/kg

7) To extrapolate the maximum SAR value averaged over 1 cm^3 to the inner surface of the head phantom a series of measurements were as a function of depth. Figure 11 shows the data gathered and the exponential curves fit to them (Microsoft Excel 97). The average exponential coefficient was determined to be -0.0593 /mm with an R^2 value of 0.9983.

The distance from the probe tip to the inner surface of the head 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 0.049 W/kg.

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Local SAR 2.5mm Above Phantom Surface

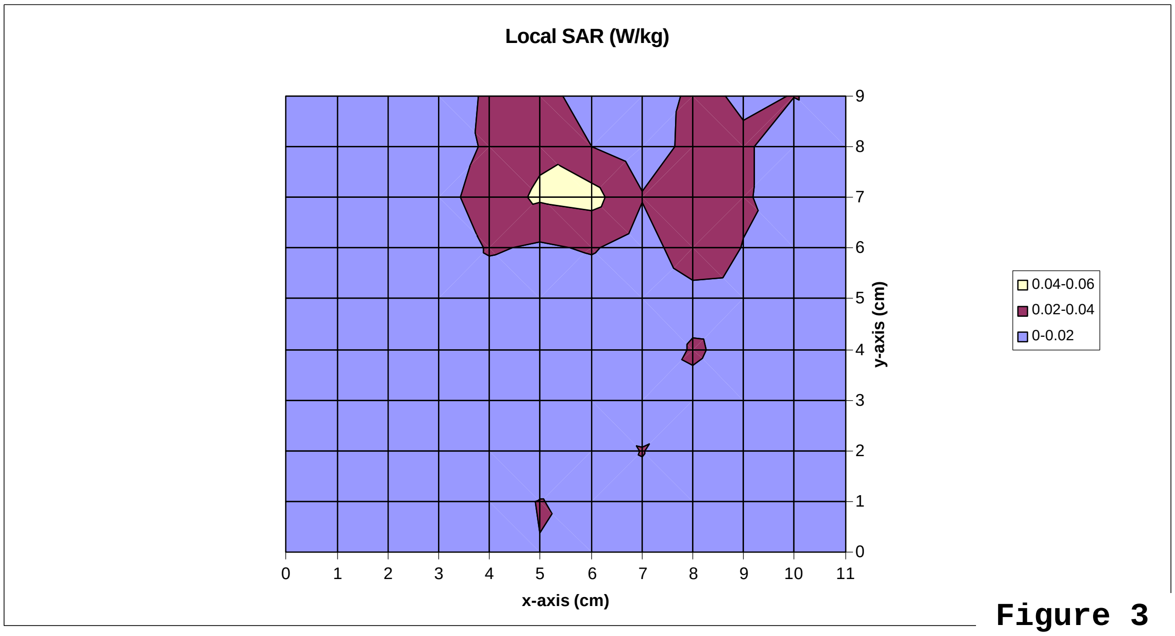

Figure 3

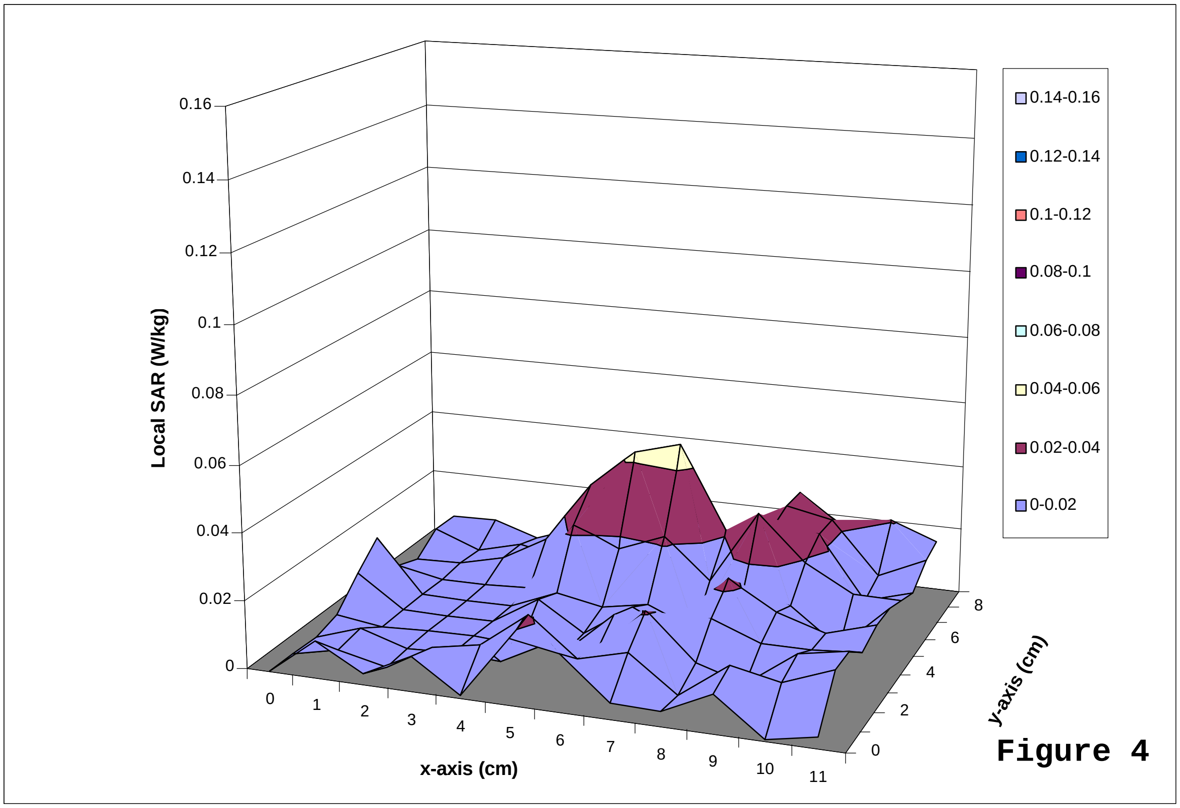

Figure 4

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Local SAR 12.5mm Above Phantom Surface

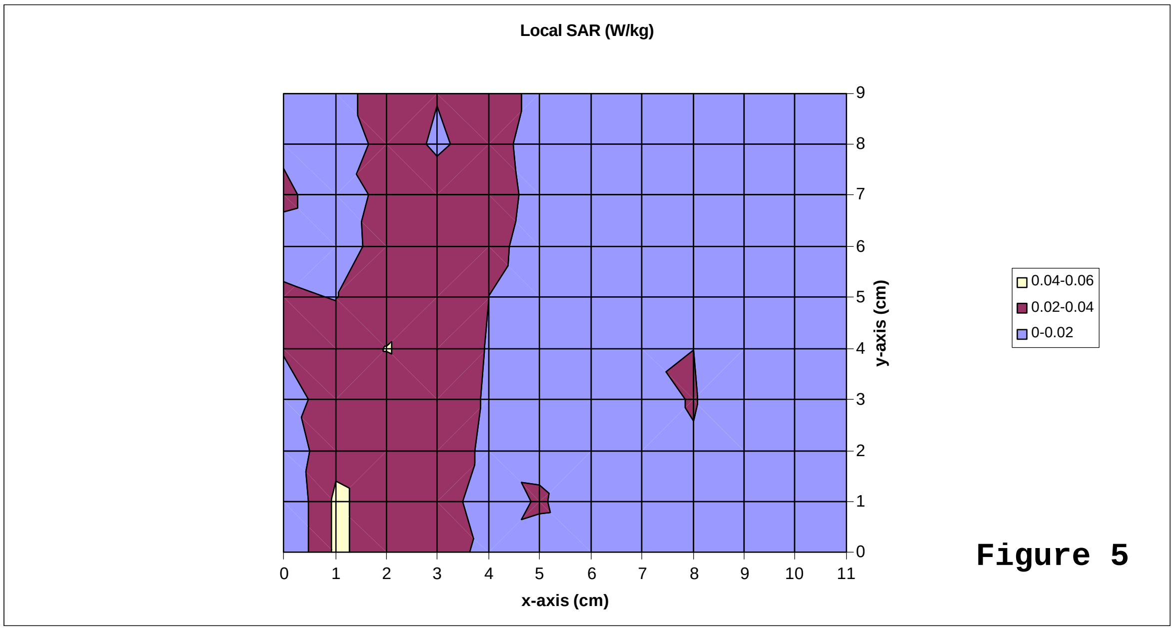

Figure 5

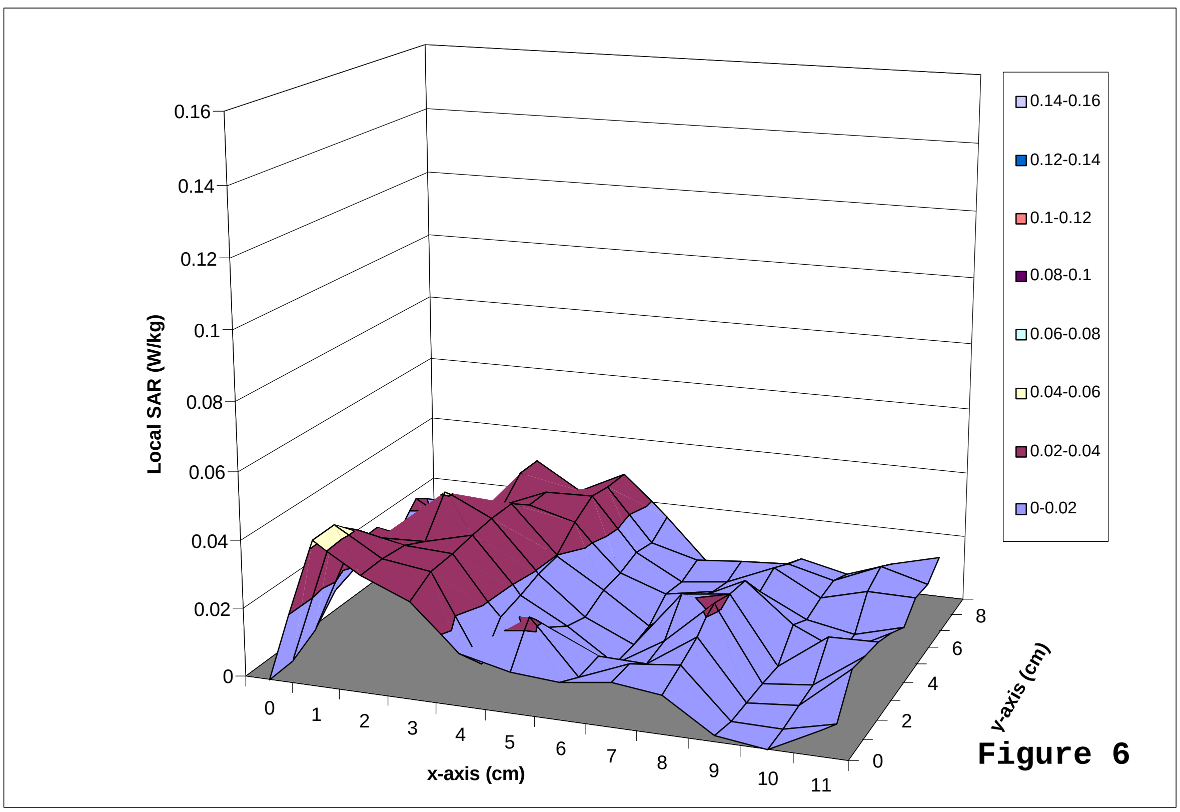

Figure 6

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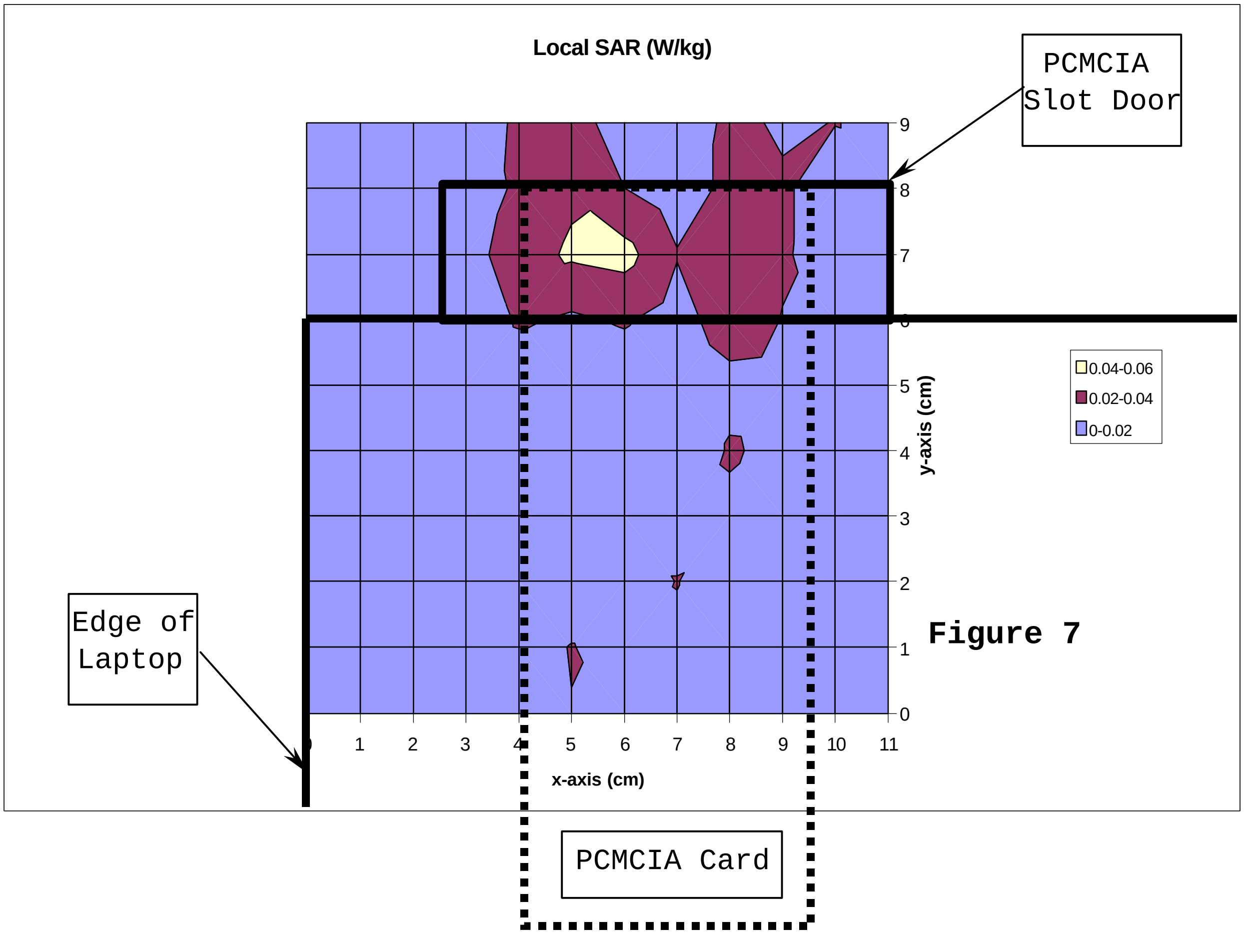

Figure 7

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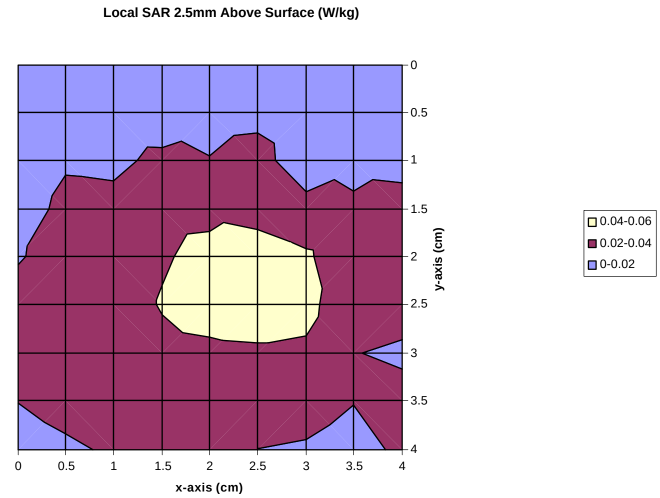

Figure 8

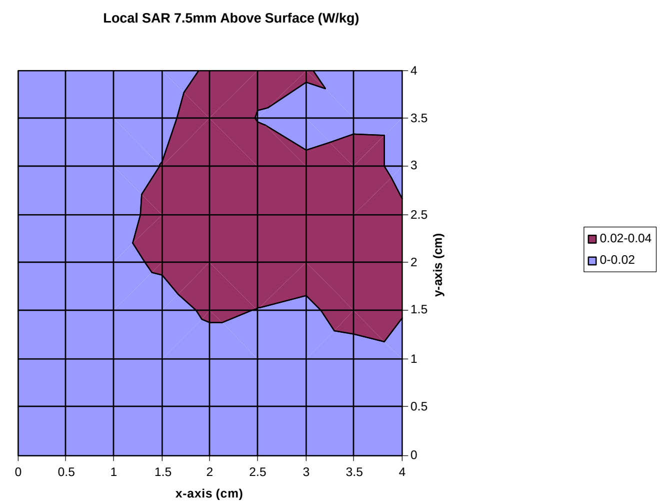

Figure 9

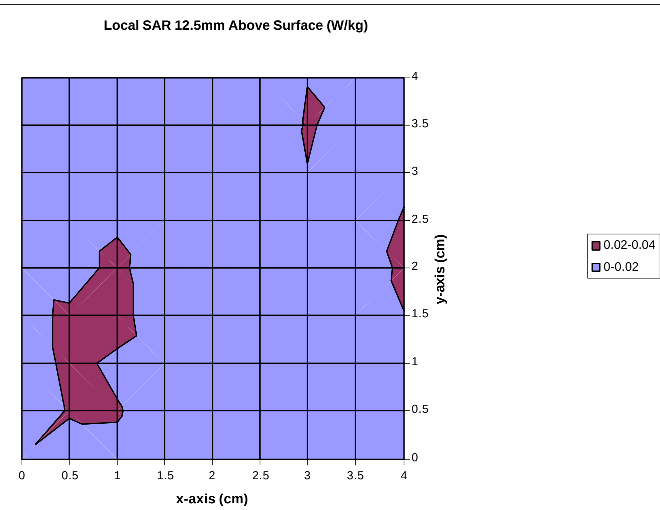

Figure 10

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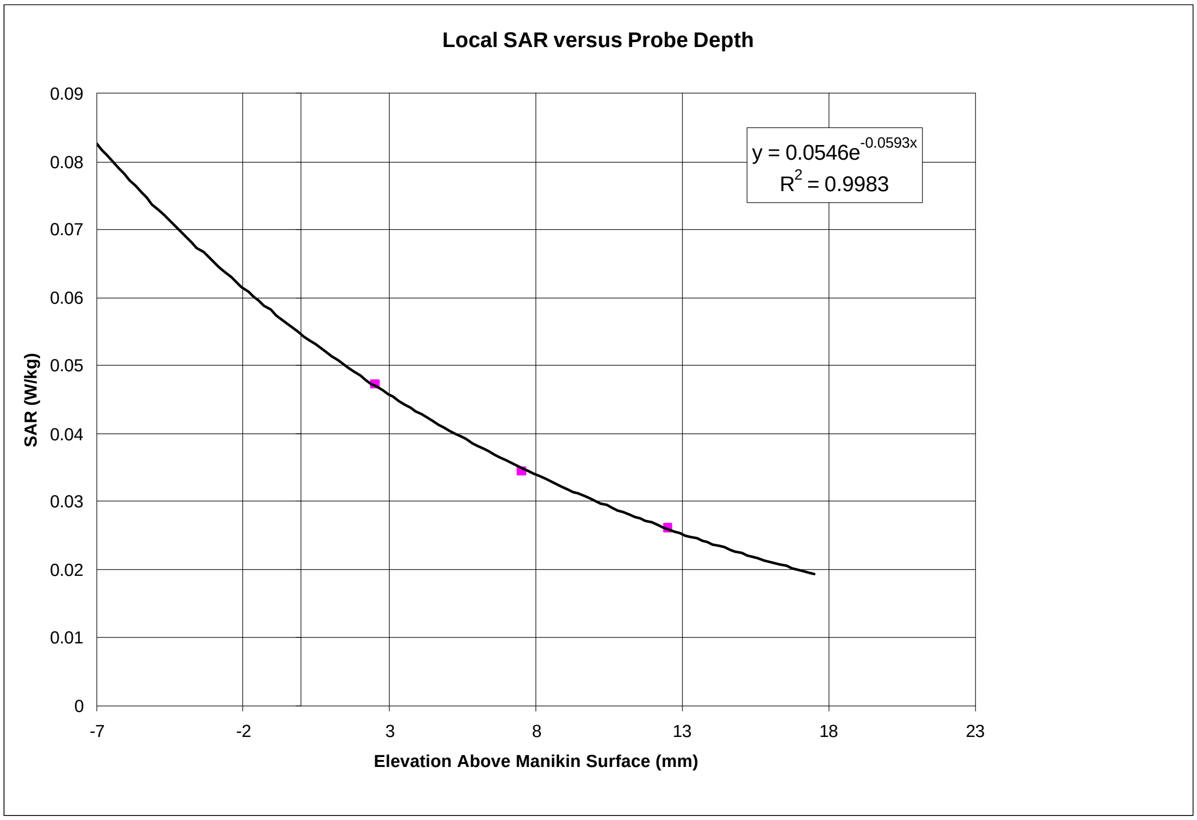

Figure 11.

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7.0 CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1g, determined on channel 7 (M), of the Netwave Technologies AirSurfer Pro Wireless LAN PCMCIA Card, is 0.049 W/kg when operating at a 50% duty cycle.. With a 100% duty cycle the maximum 1g SAR would be extrapolated to be 0.097 W/kg. The overall margin of uncertainty for this measurement is ±34.9%. The SAR limit given in the FCC 96-326 safety guideline is 1.6 W/kg. This unit as tested is found to be compliant with this requirement.

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APPENDIX A

Manufacturer's Antenna Specifications

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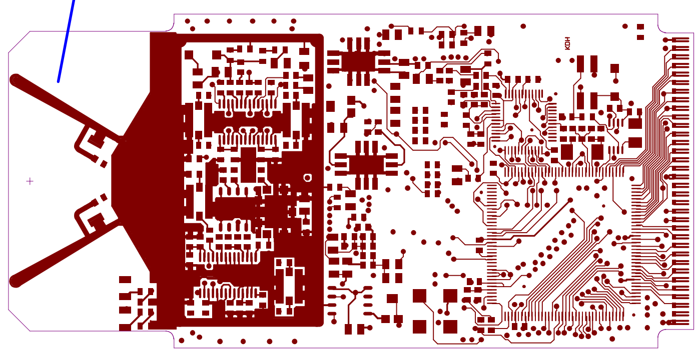
REVISIONS

REV.	DESCRIPTION	ECN	DATE	APPR.
8	First Engineering Release			
9	Updates for rev 9 PCB			

Transmit antenna is a monopole type with approximately -2 dBi gain.



Netwave AirSurfer Pro

SHEET 1 LAYER 1 METAL TOP VIEW

GERBER Merge of:
1010r9.GTL
1010r9.G3
1010r9.G9

REFERENCE DRAWNG 200-1010-001 Rev 2

Netwave 6663 Owens Drive Pleasanton CA. 94588

Document Title: Redstone DS Artwork Film View Source

Size: A | Document Number: 210-1010-001 | Rev: 9

Scale: 1:1 | Sheet 1 of 8

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES

Materials

Finish

DO NOT SCALE DRAWING

Approvals | Date
Drawn:
Checked:
Des Engr
Quality:
Production:
Data Control:

APPENDIX B

Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	**Specific to**	**Uncertainty**	
Power variation due to battery condition	PCMCIA wireless LAN card	0%	
Extrapolation due to curve fit of SAR versus depth	PCMCIA wireless LAN card	23.5%	
Extrapolation due to depth measurement	Setup	2.9%	
Conductivity	Setup	6.0%	
Density	Setup	2.6%	
Tissue enhancement factor	Setup	7.0%	
Voltage measurement	Setup	23.5%	
Probe sensitivity factor	Setup	3.5%	
		34.9%	**RSS**

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

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APPENDIX C

Tissue Simulated Material and Calibration Technique

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%
HEC	0.3%
Bactericide	0.1%

Mass density, ρ 1.30g/ml. (The density used to determine SAR from the measurements was the recommended 1.04kg/m^{3,} found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01.)

Dielectric parameters of the synthetic 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	34.0
Conductivity, σ	2.365S/m
Enhancement factor, γ	11.9

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Calibration Date: 10-Jun-98
Frequency: 2450 MHz
By: Antonio Utano

Mixture Type: Brain/Muscle
Date:
By:

Position [cm]	Amplitude [dBm]	Phase [deg]	[deg]
0	-40.385	147.63	147.63
0.5	-43.639	57.908	57.908
1	-46.922	-31.45	-31.45
1.5	-50.105	-117.86	-117.86
2	-53.246	153.52	-206.48
2.5	-56.582	63.285	-296.715
ΔdB_1	-9.72	Δdeg_1	-265.49
ΔdB_2	-9.607	Δdeg_2	-264.388
ΔdB_3	-9.66	Δdeg_3	-265.265
ΔdB_{AVG} [dB]	-9.66	Δdeg_{AVG} [deg]	-265.05
dB_{AVG} (α_{AVG}) [dB/cm]	-6.44	deg_{AVG} (β_{AVG}) [deg/cm]	-176.70
(α_{AVG}) [NP/cm]	-0.7416115	(β_{AVG}) [rad/cm]	-3.08396964
f [Hz]	2.45E+09		
μ [H/cm]	1.2566E-08		
ε_o [F/cm]	8.854E-14		
ε_r	33.99		
$\sigma_{effective}$ [S/cm]	2.365E-02		

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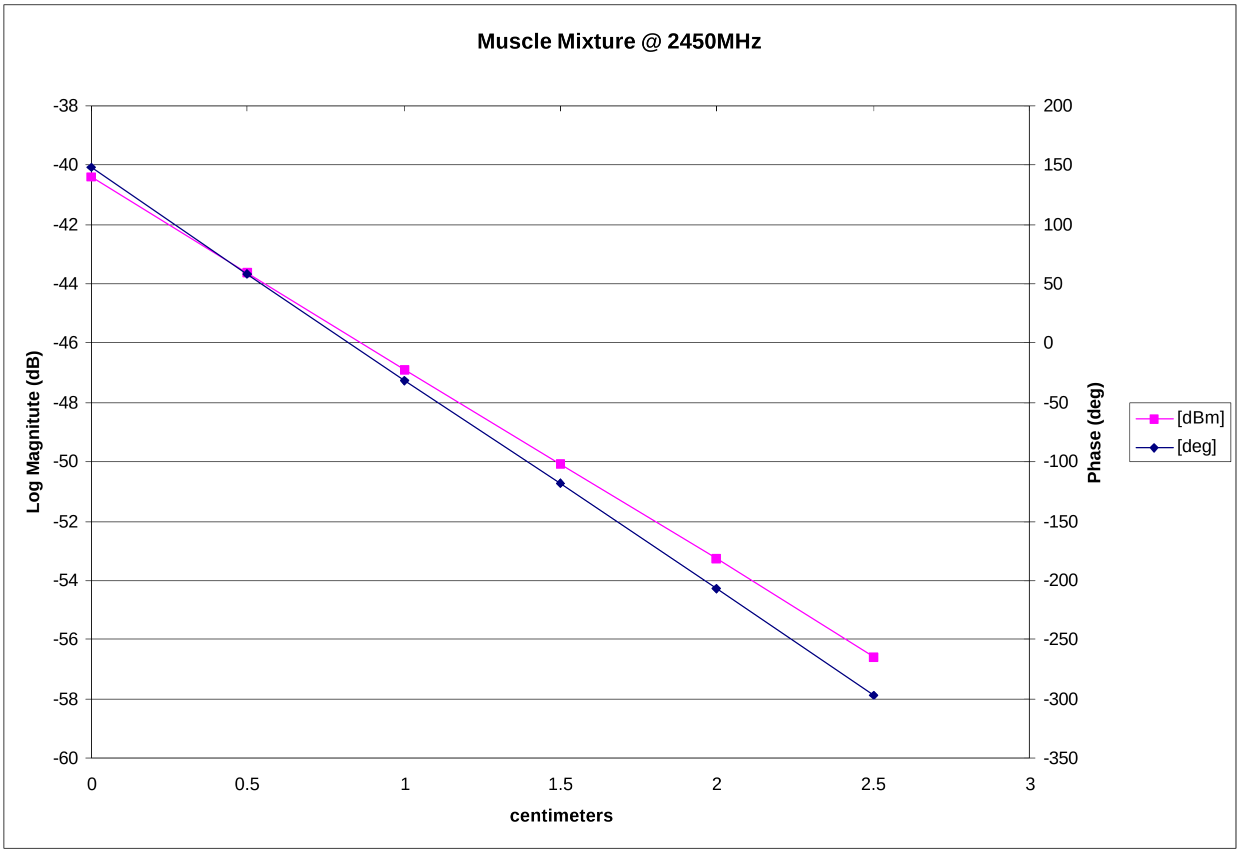

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1900	**MHz Data (Paul & Antonio)**								
						delta T	**Sum**		**Thermal**
RF Power			**Ch0**	**Ch1**	**Ch2**	**(30 sec)**	**Vi/Ei**		**SAR**
W	dBm	R&S	uV	uV	uV	deg. C			W/kg
0.236592	23.74	-5.46	200	579	232	0.0017	1260.51		0.16
0.298538	24.75	-4.45	216	690	302.5	0.0038	1509.09		0.35
0.371535	25.7	-3.5	244	802	350.5	0.0047	1744.05		0.43
0.451856	26.55	-2.65	287	947	409	0.0061	2051.66		0.56
0.570164	27.56	-1.64	361	1206	510.5	0.0065	2593.78		0.60
0.719449	28.57	-0.63	444.5	1486.5	615	0.0085	3177.89		0.79
0.912011	29.6	0.4	548	1809	741	0.0104	3866.2		0.96
1.199499	30.79	1.59	722.5	2408.5	986.5	0.0121	5138.76		1.12
1.465548	31.66	2.46	869	2910.5	1213.5	0.0133	6232.82		1.23
Directional Coupler factor			19.2	dB (Asset 100251 cal file data (Janusz, 21 Jul 96))					
Additional inline attenuation			10	dB					
		Sensitivity (e)	0.55	0.54	0.51	- Sensor Sensitivity in mV/ (mW/cm^2): 2450 MHz cal (Janusz, 16 Sep 97)			
		η = 1.50 e	0.825	0.81	0.765				
Density				1.3	g/cm^3	1300	kg/m^3	- Marcin, summer 97	
Conductivity				23.65	mS/cm	2.365	S/m	- Antonio Utano, 10 Jun 98	
Heat Capacity (c)				2.775	J/C/g	2775	J/C/kg	- average of Balzano (2.7) and Kuster (2.85) values	
Exposure Time				30	seconds	30	seconds		
Slope of Measure Voltage (m_V)				4048.71	uV/W	0.00405	V/W		
- standard error or m_V				38.9591	uV/W	3.9E-05	V/W		1.0%
Slope of Measure Temp Change (m_T)				0.00897	C/W	0.00897	C/W		
- standard error or m_T				0.00079	C/W	0.00079	C/W		8.8%
Tissue Conversion Factor (γ)				**11.9**					

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SAR Certified

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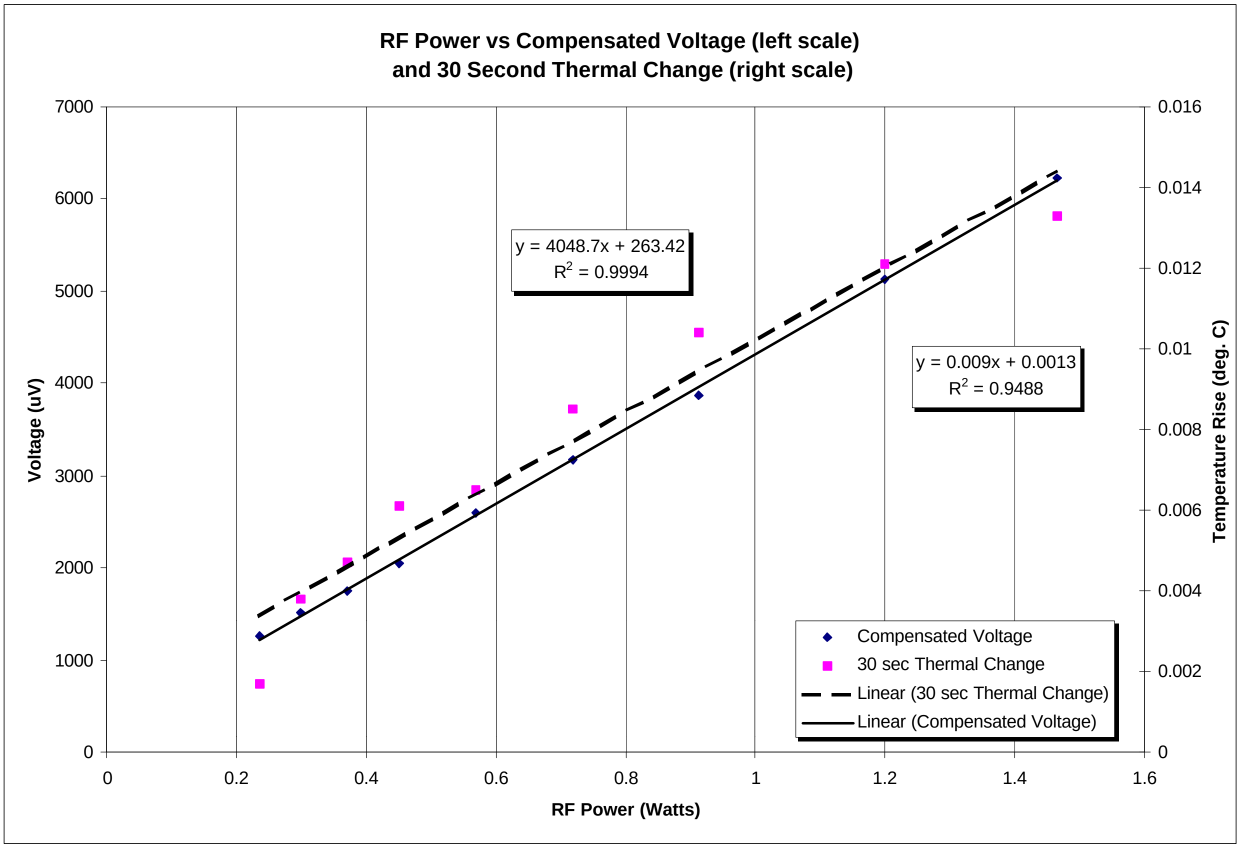

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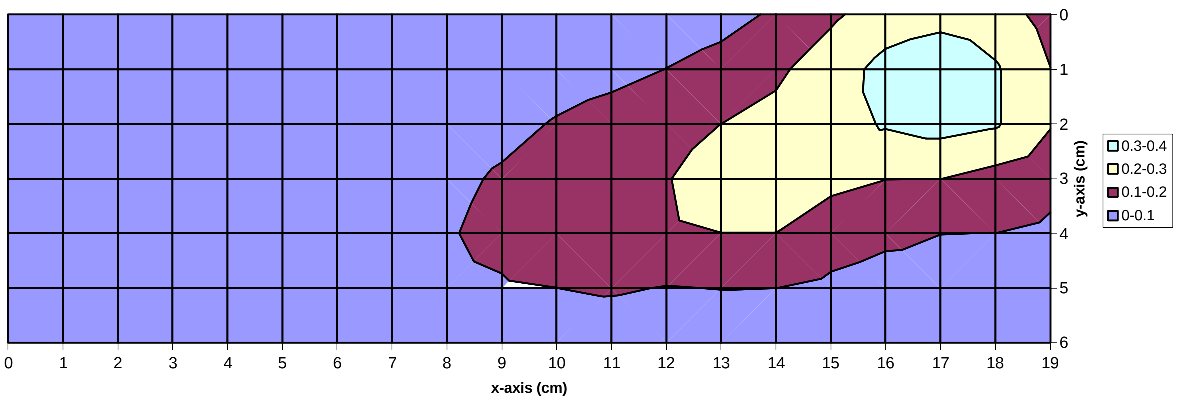
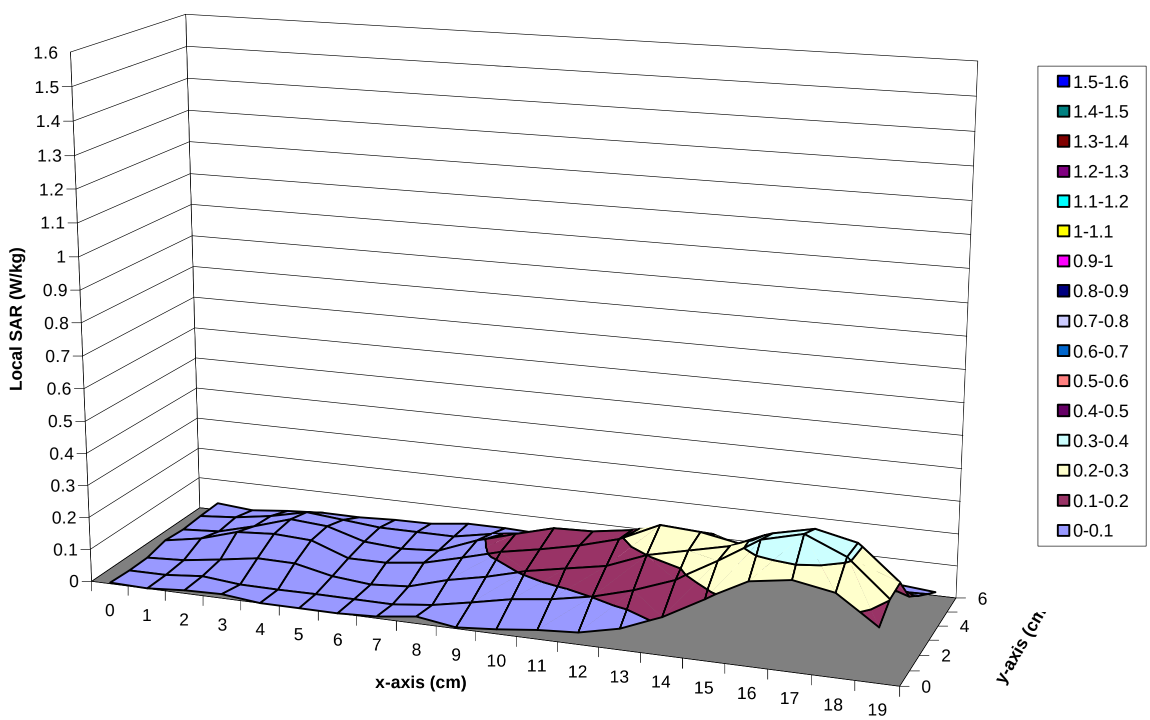
APPENDIX D

Validation Scans

Reference PCS Telephone (1900MHz, 30dBm)
SAR Scan with Flat Phantom (W/kg)



Reference PCS Telephone (1900MHz, 30dBm)
SAR Scan with Flat Phantom



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