Certification Report on

Specific Absorption Rate (SAR) Experimental Analysis

Com-Net Ericsson Critical Radio Systems

EDACS 300P

Test Date: 8 June, 2000

CNEB-EDACS 300P at face-3456

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APREL Laboratories

CERTIFICATION REPORT

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

Product: FM Portable Radio

Model: EDACS 300P

Client: Com-Net Ericsson Critical Radio Systems

Address: Mountain View Road
Lynchburg, VA
24501 USA

Project #: CNEB-EDACS 300P at Face-3456

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories A063- EDACS 300P

Prepared by: APREL Laboratories
51 Spectrum Way
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Tested by Delia Zapata H. Date: 14 June 2000
Delia M. Zapata, BSEE

Submitted by Paul G Cardinal Date: 14-June 00
Dr. Paul G. Cardinal
Director, Laboratories

Approved by [signature] Date: June 14/2000
Dr. Jacek J. Wojcik, P. Eng.

REGISTERED PROFESSIONAL ENGINEER J. J. Wojcik PROVINCE OF ONTARIO

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FCC ID: OWDTR0001-E
Applicant: Com-Net Ericsson Critical Radio Systems
Equipment: FM Portable Radio
Model: EDACS 300P
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 Com-Net Ericsson model EDACS 300P FM Portable Radio. The measurements were carried out in accordance with FCC 96-326. The FM Portable Radio was evaluated at its maximum nominal power level (3.20 W (35.1 dBm) on the EDACS band, and 2.64 W (34.2 dBm) on the talk-around band).

The FM Portable Radio was tested at high, middle, and low frequencies on channels 1 (806.025 MHz), 4 (821.0125 MHz) and 7 (860.15 MHz), with both types of batteries (BKB-191-212/1-P1A (thin) and BKB-191-212/2-P1A (thick)) and both antennas offered (quarter wavelength and half wavelength). The maximum SAR was found to coincide with the peak performance RF output power of channel 1 (806.025 MHz) with the quarter-wavelength antenna and thin battery. Test data and graphs are presented in this report.

Based on the test results and on how the device will be used, it is certified that the product meets the requirements as set forth in the above specifications, for an occupational/controlled RF exposure environment for partial body exposure.

The results presented in this report relate only to the sample tested.

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of a sample of a Com-Net Ericsson model EDACS 300P FM Portable Radio. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

2. 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 Radio Frequency Electromagnetic Fields".

3. EQUIPMENT UNDER TEST

- Com-Net Ericsson model EDACS 300P FM Portable Radio, SN 0016, received on 5 June 2000.
- Antenna and battery options shown in Appendix B.

The FM Portable Radio will be called DUT (device under test) in the following.

This is a PTT device which can operate in the frequency range 806-824 MHz EDACS transmit band and the 851-870 MHz talk-around transmit band with a maximum output power setting of 3.20 W on the EDACS band and 2.64 W on the talk-around band.

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One of two antennas may be attached to the right side at the top of the device. One of the antennas is a λ/4 end fed whip, 95 mm long, while the other antenna is a λ/2 centre fed whip, 178 mm long. Photographs of the DUT, batteries and antennas can be found in Appendix B. See the manufacturer's submission documentation for drawings and more design details.

4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-009, s/n 115, Asset # 301420
- CRS Robotics A255 articulated robot arm, s/n RA2750, Asset # 301335
- CRS Robotics C500 robotic system controller, s/n RC584, Asset # 301334
- HP 438A power meter, s/n 2502A01684, Asset # 301417
- HP 8482A power sensor, s/n 2652A1512B, Asset #301418
- APREL F-1, flat manikin, s/n 001
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the DUT complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.
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 (10 mm increments for wide area scanning, 5 mm increments for zoom scanning, and 2.5 mm increments for the final depth profile measurement).
4. The probe travels in the homogeneous liquid simulating human tissue. Appendix D contains information about the recipe and properties of the simulated tissue used for these measurements.

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

6. The DUT is positioned with its keyboard side 30 mm away from the bottom of the phantom.

7. All tests were performed with the highest power available from the sample DUT, under transmit conditions.

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

6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The battery-powered DUT will consume energy from its batteries, which may affect the DUT's transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run. In the case of this DUT, the conducted power was sampled. A power meter was connected to the antenna feed point. The following table shows the conducted RF power sampled before and after the six sets of data used for the worst case SAR in this report.

Scan		Conducted Power Readings (dBm)		D (dBm)	Battery #
Type	**Height (mm)**	**Before**	**After**		
Area	2.5	10.99	10.87	-0.12	Thin 3
Area	12.5	10.93	10.88	-0.05	Thin 3
Zoom	2.5	11.01	-	-	Thin 1
Zoom	7.5	-	-	-	Thin 1
Zoom	12.5	-	10.99	-0.02	Thin 1
Depth	2.5 – 22.5	10.99	10.93	-0.06	Thin 2

NOTE: These readings do not include the 23.9 dB of attenuation, cable and adapter losses nor the sensor correction factor.

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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 in Appendix A Figure 2. SAR is expressed as RF power per kilogram of mass, averaged in 10 grams of tissue for the extremities and 1 gram of tissue elsewhere.

2) The DUT was put into test mode for the SAR measurements by turning it on at maximum operating power and pressing the up and down buttons to control the channel.

3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the DUT (806.025 MHz, channel 1, with $\lambda/4$ antenna). The presented values were taken 2.5 mm into the simulated tissue from the Universal Head-Arm's (UH-a) solid inner surface. Figures 1 and 2 in Appendix A show the UH-a used in the measurements. A grid is shown inside of the UH-a indicating the orientation of the x-y grid used, with x = 0 at the top of the volume control knob and the antenna aligned with y = 1 (Figure 2). The x-axis is positive towards the left and the y-axis is positive towards the bottom.

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

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

   Figure 10 in Appendix A shows an overlay of the DUT's outlines, superimposed onto the contour plot previously shown as Figure 3.

   Figures 3 through 6 in Appendix A 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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4) Wide area scans were performed for channels 1 (806.025 MHz), 2 (821.0125 MHz) and 7 (860.15 MHz), with both types of batteries (thin and thick) and both antennas offered (quarter wavelength and half-wavelength). The DUT was tested with its keyboard side 30 mm away from the bottom of the phantom. The peak single point SAR for the scans were:

Antenna Type λ/2, λ/4	**Battery Type ****	**Channel**		**Highest SAR [W/kg]**
		#	**Frequency [MHz]**	
λ/4	thick	1	806.025	1.79
λ/4	thick	4	821.0125	1.78
λ/4	thick	7	860.15	1.32
l/4	**thin**	**1**	**806.025**	**2.20**
λ/4	thin	4	821.0125	2.12
λ/4	thin	7	860.15	1.56
λ/2	thick	1	806.025	1.2
λ/2	thick	4	821.0125	1.14
λ/2	thick	7	860.15	0.74
λ/2	thin	1	806.025	0.91
λ/2	thin	4	821.0125	1.11
λ/2	thin	7	860.15	0.59

All subsequent testing was performed on channel 1 (806.025 MHz) with the λ/4 antenna.

5) The channel 1 (806.025 MHz) SAR peak was then explored on a refined 0.5 mm grid in three dimensions. Figures 7, 8 and 9 show the measurements made at 2.5, 7.5 and 12.5 mm respectively. The SAR value averaged over 1 gram was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured averaged over 1 gram was determined from these measurements to be 1.55 W/kg.

6) To extrapolate the maximum SAR value averaged over 1 gram to the inner surface of the phantom a series of measurements were made at a few (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. Figure 11 in Appendix A shows the data gathered and the exponential curves fit to them. The average exponential coefficient was determined to be (-0.0526± 0.0007) / mm.

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The distance from the probe tip to the inner surface of the phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the APREL Triangular Dosimetric Probe Model E-009 is 2.3 mm. The total extrapolation distance is 4.8 mm, the sum of these two.

Applying the exponential coefficient over the 4.8 mm to the maximum SAR value averaged over 1 gram that was determined previously, we obtain **the maximum SAR value at the surface averaged over 1 gram** of 1.995 W/kg.

7. DISCUSSION

The factory tolerance for setting the power level of the FM Portable Radio is ±0.20 W. The DUT could then have an absolute maximum power of 3.40W. It was determined by proportional scaling of the maximum power to 3.40W that the device would produce an estimated maximum 1g SAR of 2.12 W/kg.

The most appropriate nose protrusion to use for SAR measurements is an open question. The DOD Handbook 743A defines Nose Protrusion as “the maximum anterior protrusion of the nose”; it is their dimension 137. In Table 137b they show the percentiles in centimetres for various series of measurements, a portion of which is included in the following table:

No.	**Series**	**Percentiles in Centimeters**		
		5th	**95th**	**99th**
1	US Army Men (1988)	1.5	2.3	2.4
2	USAF Basic Trainees (1965)	1.8	2.8	3.0
3	US Navy Aviators (1964)	1.9	2.7	3.0
4	USAF Flying Personnel (1950)	1.8	2.7	3.0
5	CWS Face Study (1945)	1.7	2.6	2.8
6	US Army Women (1988)	1.5	2.2	2.4

The SAR measurements reported herein have used a 30mm separation between the face simulating phantom and the DUT. This actually corresponds to 32-33mm between the DUT and the liquid head simulation when the phantom’s shell thickness of 2-3mm is included (see Figure 12). This would be equivalent to 1cm in front of the tip of the nose for the average of the most 1988 US Army 95th percentile data, i.e. series 1 and 6.

A series of wide area SAR scans were performed on the worst channel (channel 1, 806.025 MHz) versus the separation between the DUT and the tissue simulation. These will enable the maximum 1g SAR for a separation of 33 mm to be interpolated

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for other separations between the plane of the face simulation and the surface of the DUT. The peak single point SAR for each scan were:

DUT – tissue simulation separation (mm)	Highest local SAR (W/kg)
19	3.06
29	2.62
33	1.88

Figure 13 in Appendix A shows the data plotted as a function of separation and the curves fit to them. Note that the data obtained from the area, zoom and depth scans for the worst channel, reported elsewhere in this report, are also included in the figure. The 5th and 95th percentile nose protrusions from the DOD-Handbook data for the 1988 US Army (average of men and women) are indicated on the figure.

If the data for Figure 12 is fitted to an exponential equation we get for the DUT data:

$$\text{Peak Local SAR} = 5.960\ e^{-0.033 * (\text{separation})}$$

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

$$\text{Maximum 1g SAR} = k\ e^{-0.033 * (\text{separation})}$$

Using this equation with:

Maximum 1g SAR determined above = 2.12 W/kg
Tissue simulation – DUT separation = 33 mm

results in a k = 6.248 W/kg, which corresponds to the maximum 1g SAR when the separation is 0mm. The estimated maximum 1g SAR at a separation corresponding to the DUT touching a 5th percentile nose from the 1988 US Army data (15mm) would be 3.81 W/kg, which is well below the FCC partial body limit of 8.0 W/kg for occupational or controlled exposure.

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8. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1 g, determined at 806.025 MHz (channel 1), for the Com-Net Ericsson Critical Radio Systems EDACS 300P FM Portable Radio, is 2.12 W/kg. Since this is a PTT device, its maximum effective duty factor is 50%, resulting in an effective maximum 1g SAR of 1.06 W/kg. The overall margin of uncertainty for this measurement is ± 11.1 % (Appendix C). The SAR limit given in the FCC 96-326 safety guideline is 8 W/kg for occupational/controlled exposure. The product under investigation will be used in an occupational/controlled environment with user training which will be indicated in the manufacturer's documentation.

Considering the above, this unit as tested, and as it will be marketed and used (with user training), is found to be compliant with this requirement.

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APPENDIX A

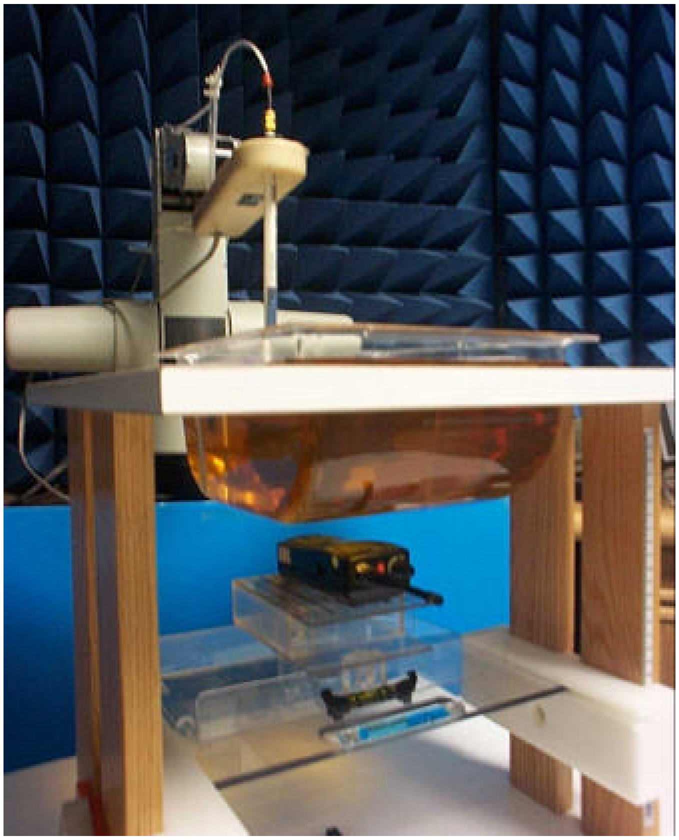

Figure 1

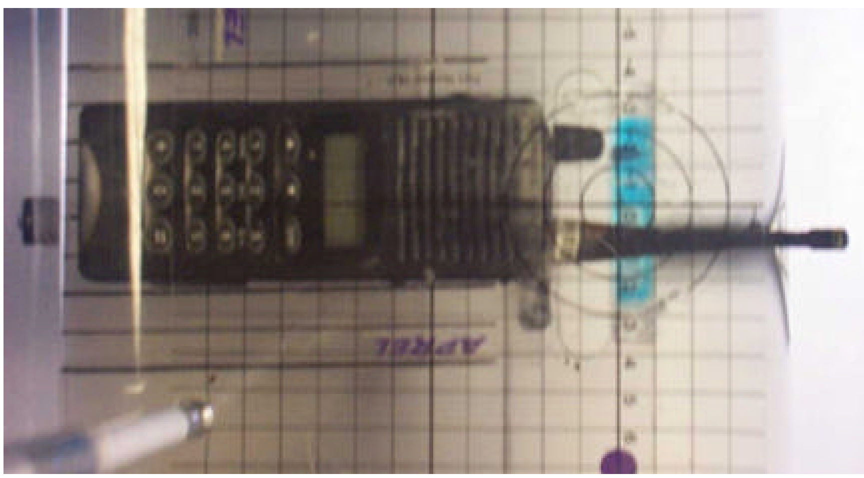

Figure 2

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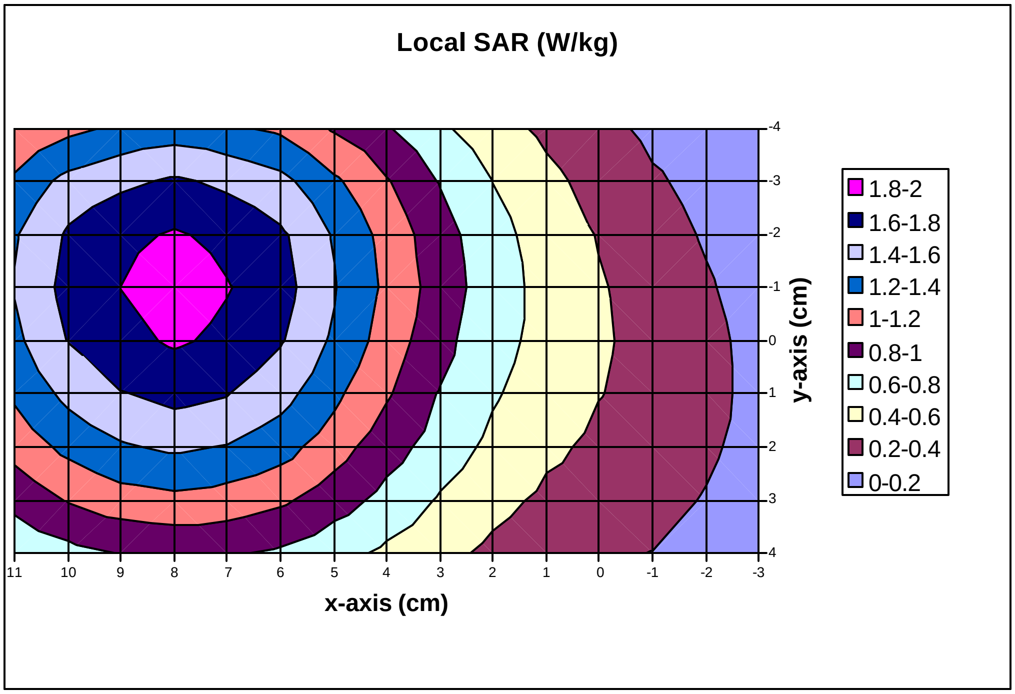

Figure 3. Area Scan 2.5mm Above Surface

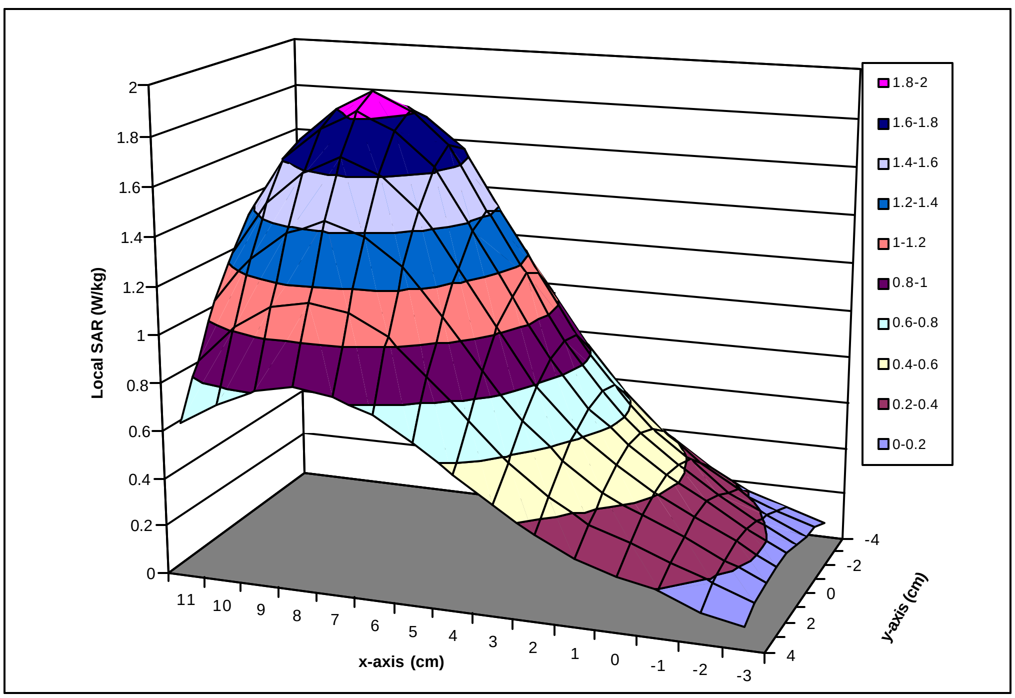

Figure 4. Area Scan 2.5mm Above Surface

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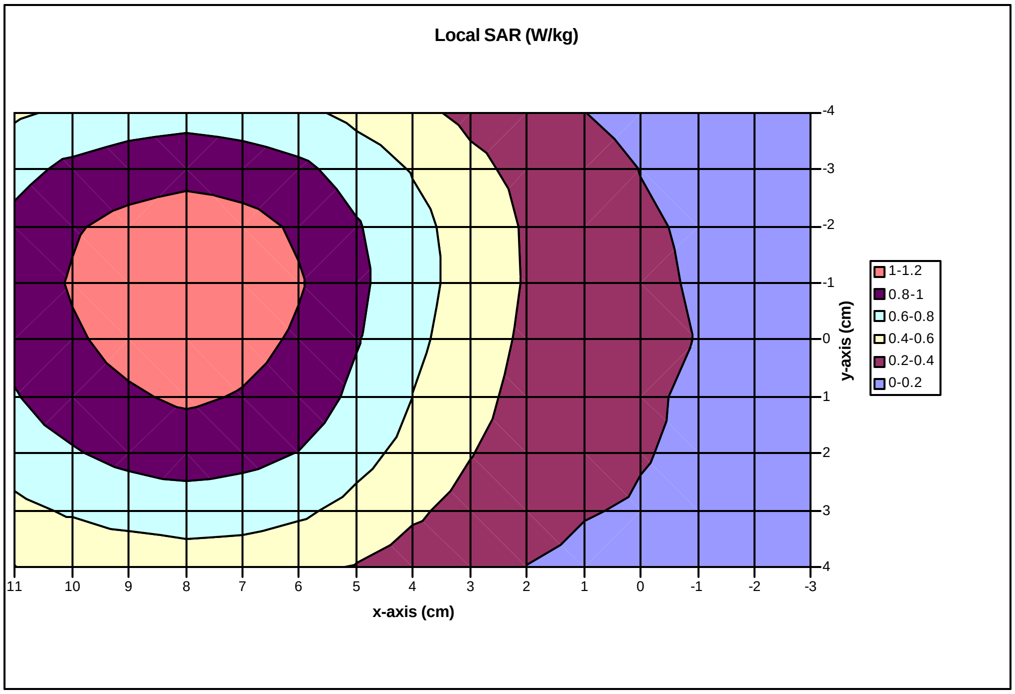

Figure 5. Area Scan 12.5mm Above Surface

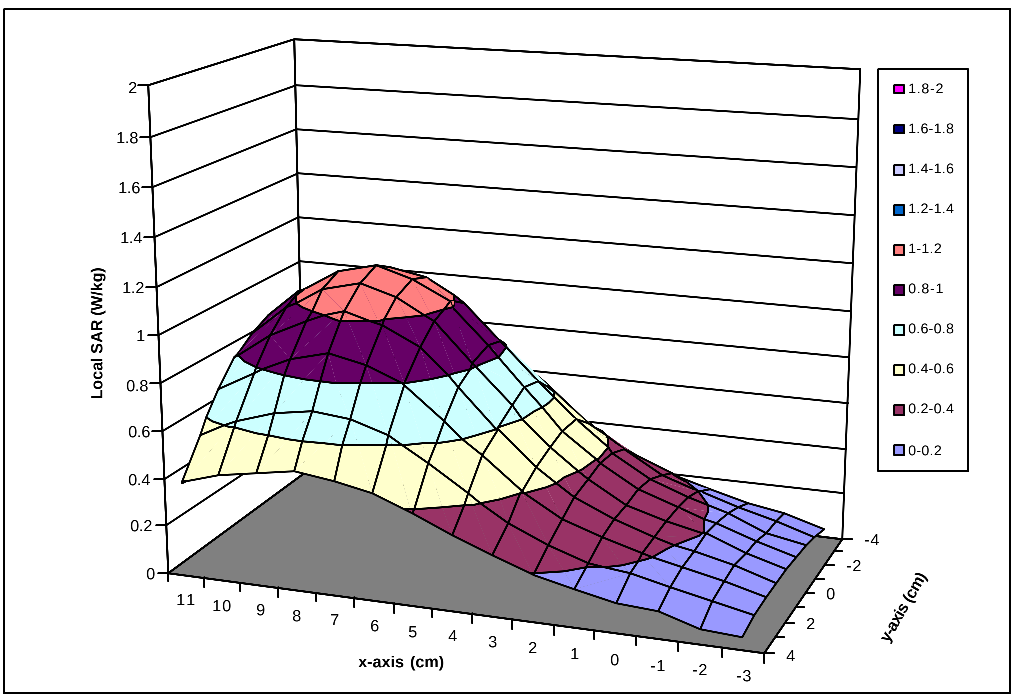

Figure 6. Area Scan 12.5mm Above Surface

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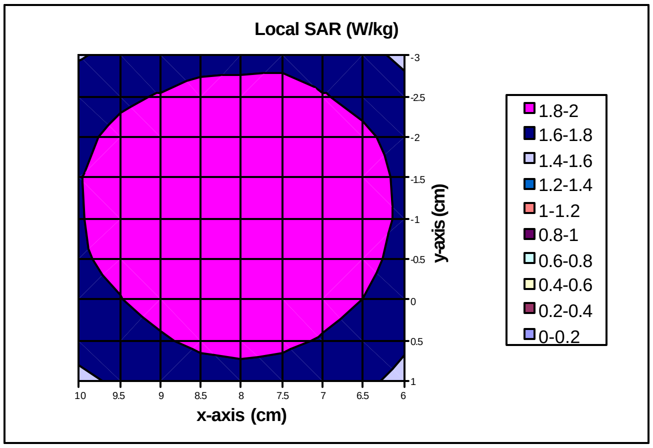

Figure 7. Zoom Scan 2.5mm Above Surface

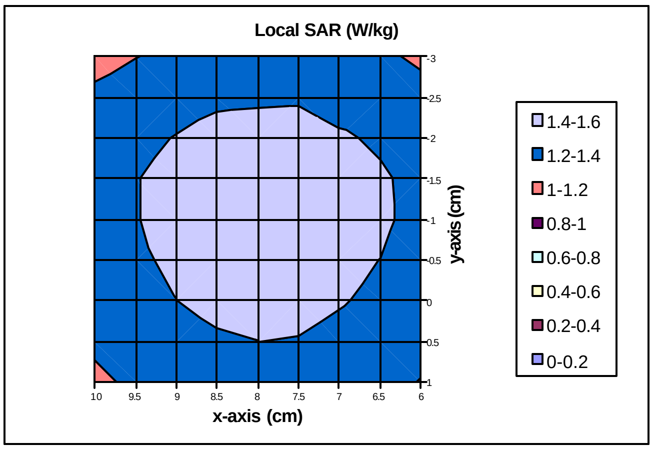

Figure 8. Zoom Scan 7.5mm Above Surface

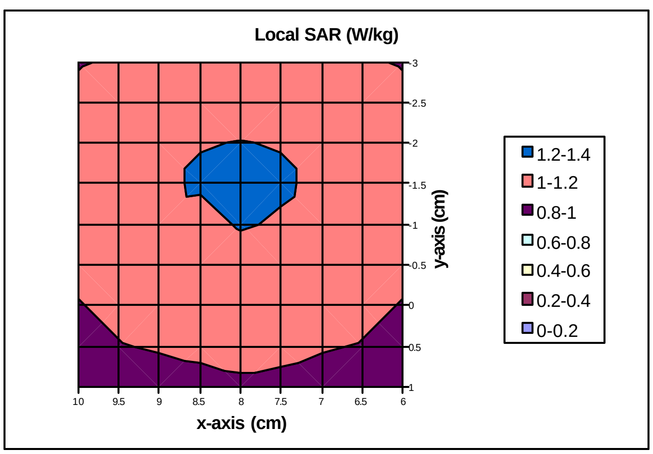

Figure 9. Zoom Scan 12.5mm Above Surface

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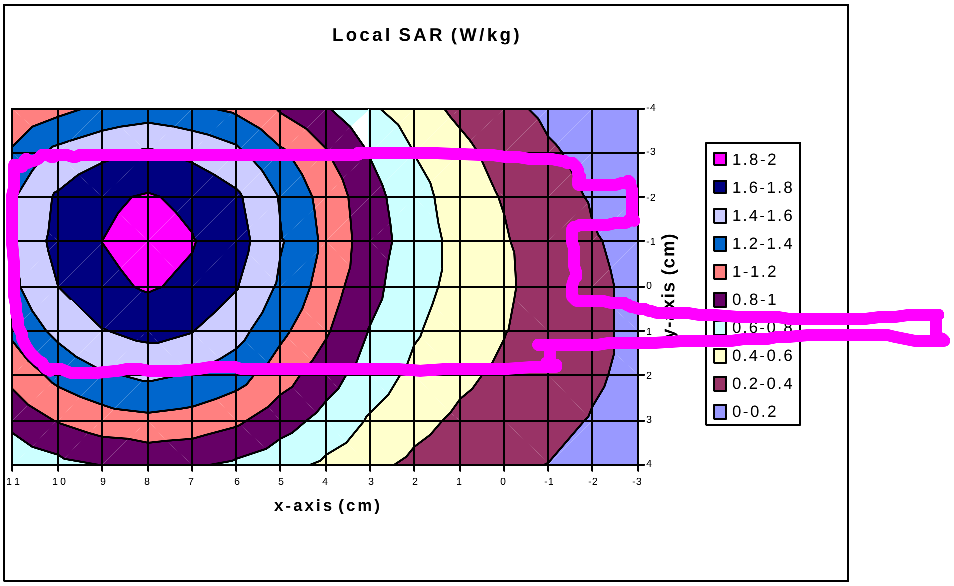

Figure 10

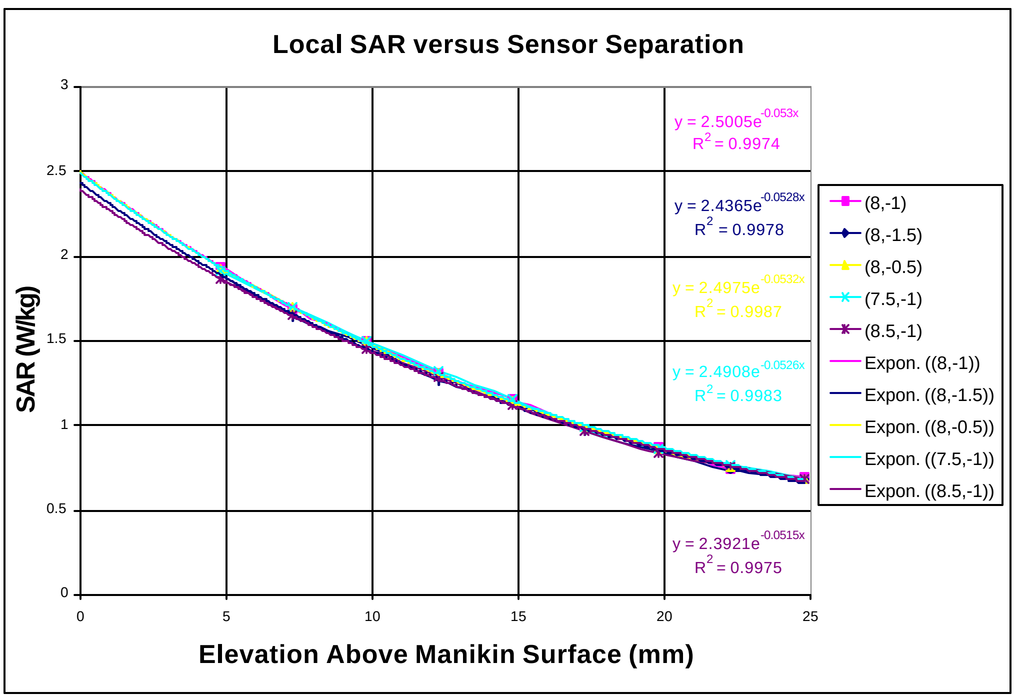

Figure 11

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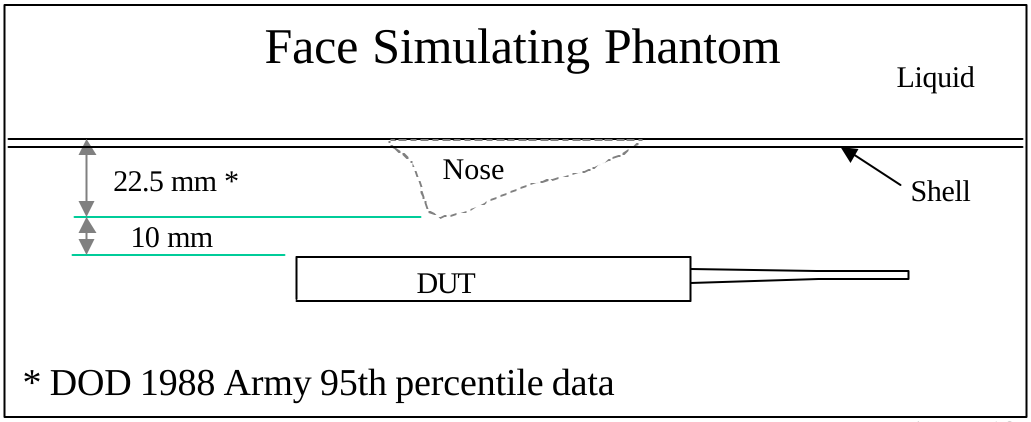

Figure 12

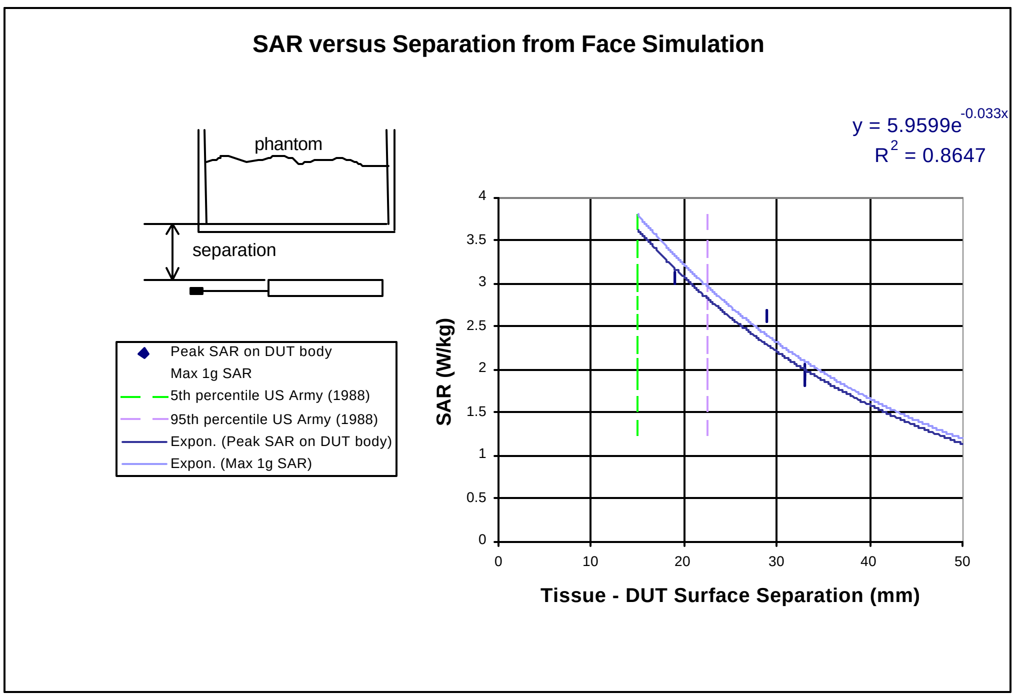

Figure 13

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APPENDIX B

Manufacturer's Specifications

Com-Net Ericsson
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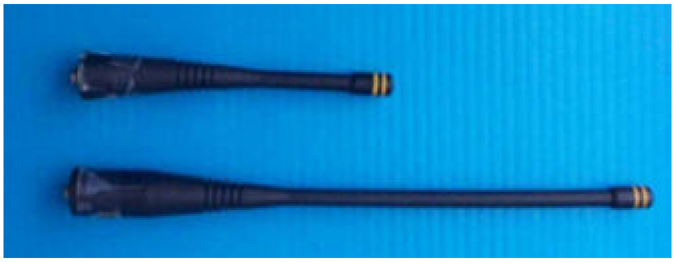
Portable Radio, with a λ/4
antenna and thin battery



TYPES OF ANTENNAS
Helical λ/4 antenna S/N 11445 (top)
Helical λ/2 antenna S/N 11580 (bottom)

TYPES OF BATTERIES
"Thick" BKB-191-212/2-P1A (left)
"Thin" BKB-191-212/1-P1A (right)

(See manufacturer's submission documentation for drawings and more design details)

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APPENDIX C

Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	Specific to	Uncertainty	
Power variation due to battery condition	phone	0.7%	
Extrapolation due to curve fit of SAR vs depth	phone	2.6%	
Extrapolation due to depth measurement	setup	2.6%	
Conductivity	setup	6.0%	
Density	setup	2.6%	
Tissue enhancement factor	setup	7.0%	
Voltage measurement	setup	2.3%	
Probe sensitivity factor	setup	3.5%	
		11.1%	RSS

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APPENDIX D

Simulated Tissue Material and Calibration Technique

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

De-ionised water	40.6 %
Sugar	58.0 %
Salt	1.0 %
HEC	0.3 %
Bactericide	0.1 %

Mass density, ρ — 1.30 g/ml
(The density used to determine SAR from the measurements was the recommended 1030 kg/m^3 found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01)

Dielectric parameters of the simulated tissue material were determined using a Hewlett Packard 8510 Network Analyser, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

The dielectric properties are:

835MHz	APREL	OET 65 Supplement	Δ / % (OET)
Dielectric constant, ε_r	47.1	46.1	2.1%
Conductivity, σ/ [S/m]	0.92	0.74	24.5%
Tissue Conversion Factor, γ	8.0	-	-

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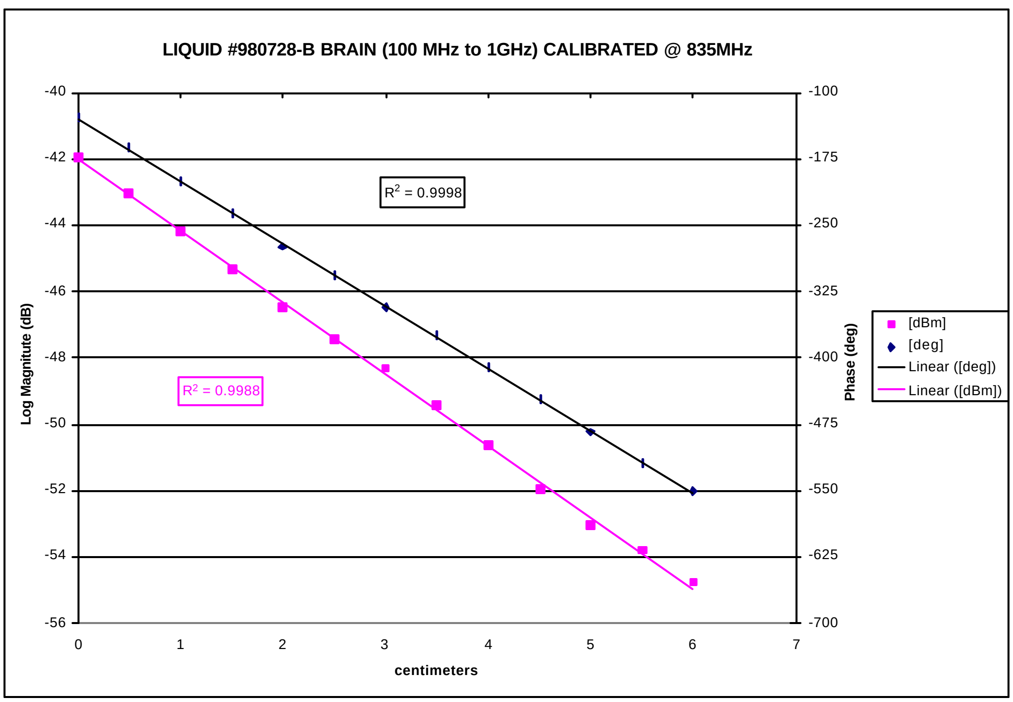
SIMULATION FLUID #	**980728-B**
CALIBRATION DATE	**5-Jun-00**
CALIBRATED BY	**Delia Zapata**
Frequency Range	**100MHz-1GHz**
Frequency Calibrated	**835MHz**
Tissue Type	**BRAIN**

Position	Amplitude	Phase	
[cm]	[dBm]	[deg]	[deg]
0	-41.936	-128.92	-128.92
0.5	-43.018	-161.44	-161.44
1	-44.195	160.11	-199.89
1.5	-45.326	123.32	-236.68
2	-46.488	86.133	-273.867
2.5	-47.42	53.334	-306.666
3	-48.311	17.666	-342.334
3.5	-49.396	-14.846	-374.846
4	-50.65	-49.619	-409.619
4.5	-51.93	-85.668	-445.668
5	-53.055	-123.6	-483.6
5.5	-53.787	-158.31	-518.31
6	-54.75	169.34	-550.66

ΔdB_1	-6.375	Δdeg_1	-213.414
ΔdB_2	-6.378	Δdeg_2	-213.406
ΔdB_3	-6.455	Δdeg_3	-209.729
ΔdB_4	-6.604	Δdeg_4	-208.988
ΔdB_5	-6.567	Δdeg_5	-209.733
ΔdB_6	-6.367	Δdeg_6	-211.644
ΔdB_7	-6.439	Δdeg_7	-208.326
ΔdB_{AVG} [dB]	-6.46	$Ddeg_{AVG}$ [deg]	-210.7485714
$dB_{AVG}(\alpha_{AVG})$ [dB/cm]	-2.15	$deg_{AVG}(\beta_{AVG})$ [deg/cm	-70.24952381
(α_{AVG}) [NP/cm]	-0.24771978	(β_{AVG}) [rad/cm]	-1.226085488

f [Hz]	8.35E+08
μ [H/cm]	1.25664E-08
ε_o [F/cm]	8.854E-14

			D
ε_r	**47.1**		2.1%
$\sigma_{effective}$	**0.92**	**S/m**	24.5%



Project #: CNEB-EDACS 300P at Face-3456
51 Spectrum Way
Nepean, Ontario, K2R 1E6
Tel. (613) 820-2730
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835 MHz Data (Heike & Tony) Brain with E-115

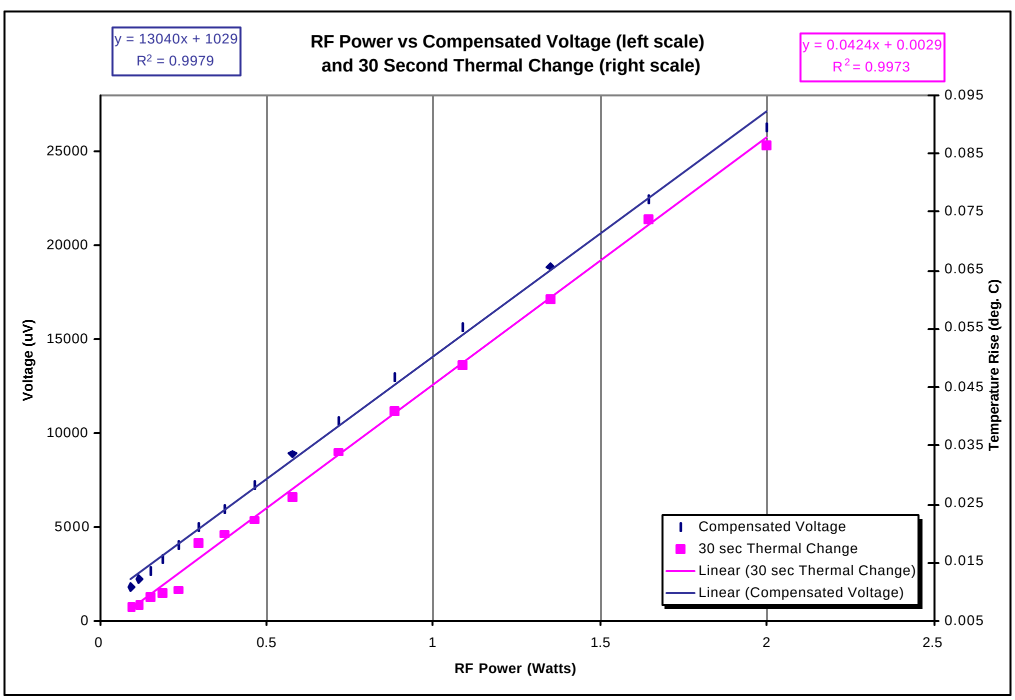
						delta T	Sum		Thermal
RF Power			Ch0	Ch1	Ch2	(30 sec	Vi/Ei		SAR
W	dBm	R&S	uV	uV	uV	deg.C			W/kg
0.09572	19.81	-26.08	757	1221	2588	0.0073	1804.3		0.68
0.11995	20.79	-25.1	903	1489	3174	0.0079	2199.4		0.73
0.15171	21.81	-24.08	1099	1831	3955	0.009	2720.6		0.83
0.18967	22.78	-23.11	1343	2246	4883	0.0098	3347.7		0.91
0.23714	23.75	-22.14	1611	2759	6006	0.0103	4099.9		0.95
0.29648	24.72	-21.17	1978	3394	7373	0.0185	5035.9		1.71
0.37325	25.72	-20.17	2637	3516	8911	0.0199	5958.4		1.84
0.46345	26.66	-19.23	3198	4272	10815	0.0223	7232.4		2.06
0.5781	27.62	-18.27	3955	5273	13281	0.0262	8903.1		2.42
0.71614	28.55	-17.34	4517	6299	16016	0.0339	10612		3.14
0.88308	29.46	-16.43	5835	7813	19263	0.0408	13017		3.77
1.08643	30.36	-15.53	7080	9473	23022	0.0487	15652		4.50
1.34896	31.3	-14.59	8643	11548	27588	0.0601	18896		5.56
1.64437	32.16	-13.73	10400	13818	32495	0.0739	22429		6.84
1.99986	33.01	-12.88	12354	16357	37866	0.0866	26330		8.01

Directional Coupler factor 25.89 dB (Asset 100251 cal file data (Janusz, 21 Jul 96))
Additional inline attenuation 20 dB

Sensitivity (e) 1.658 1.721 1.68 - Sensor Sensitivity in mV/(mW/c
η = 1.50 e 2.487 2.5815 2.52

Density	1.3	g/cm³	1300	kg/m³	-Tony, summer 99
Conductivity	8.9	mS/cm	0.89	S/m	- Heike 8-Jul-99
Heat Capacity (c)	2.775	J/C/g	2775	J/C/kg	
Exposure Time	30	seconds	30	seconds	
Slope of Measure Voltage (m_V)	13040	uV/W	0.013	V/W	
- standard error or m_V	167.42	uV/W	0.0002	V/W	1.3%
Slope of Measure Temp Change (m_T)	0.0424	C/W	0.0424	C/W	
- standard error or m_T	0.0006	C/W	0.0006	C/W	1.4%

Tissue Conversion Factor (γ)	8.0



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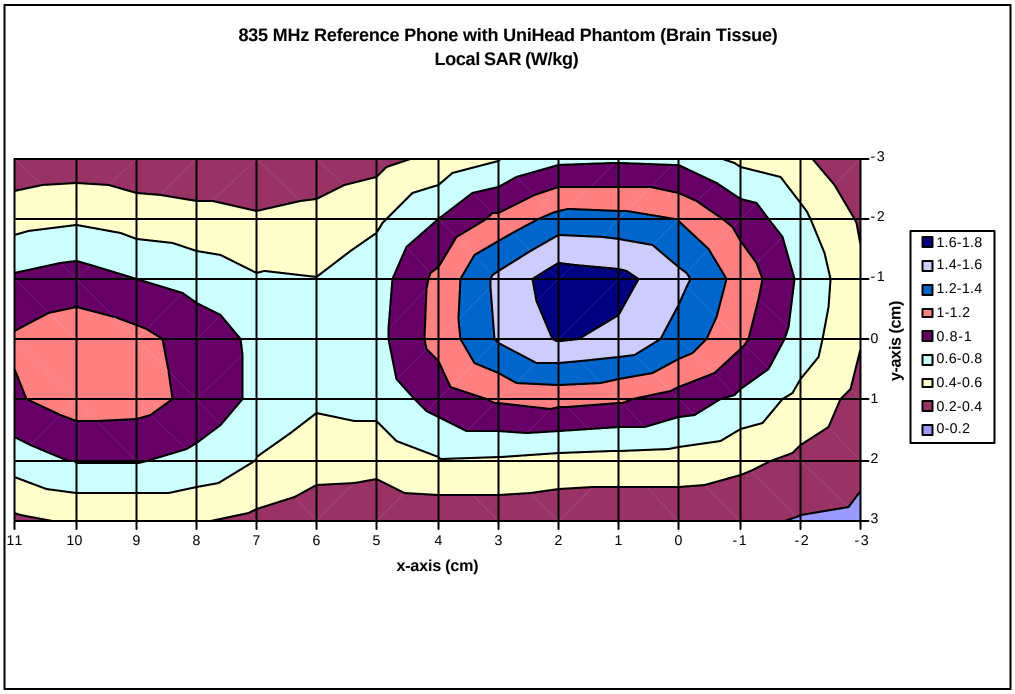
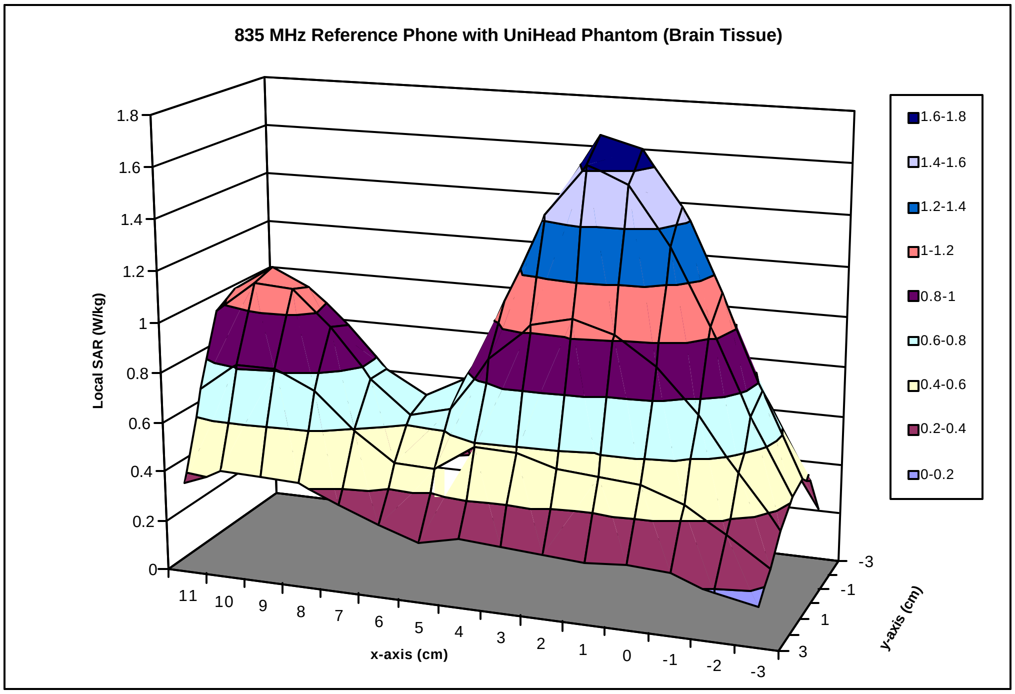
APPENDIX E

Validation Scans





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