



Certification Report on

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

Melard Technologies Inc.

**Sidearm ALL-Terrain Handheld PC™
Rugged handheld computer with integrated wireless
communication**

Test Date: October 16, 2000



MELB-Novatel Expedite CDPD Sidearm-3587

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CERTIFICATION REPORT

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

Product: Rugged handheld computer with integrated wireless communication

Model: Sidearm ALL-Terrain Handheld PC™

Client: Melard Technologies, Inc.

Address: 28 Kaysal Court
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Project #: MELB-Novatel Expedite CDPD Sidearm-3587

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Date: Jan 16/2001

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FCC ID: ESD-SA824894NE
 Applicant: Melard Technologies, Inc.
 Equipment: Rugged handheld computer with integrated wireless communication
 Model: Sidearm ALL-Terrain Handheld PC™
 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 Sidearm ALL-Terrain Handheld PC™ which incorporates a Novatel Expedite CDPD modem. The measurements were carried out in accordance with FCC 96-326. The Sidearm with a Novatel Expedite CDPD modem was evaluated for its maximum power level(0.372 ERQ). The duty factor of the radio modem is 100%.

The Sidearm with a Novatel Expedite CDPD modem was tested at low, middle and high channels for the keyboard up, keyboard down, right, and top sides. The maximum 10g SAR (1.75 W/kg) was found to coincide with the peak performance RF output power of channel 367 (middle, 836.01 MHz) for the right side of the device. (The hot spot is located on the antenna). Test data and graphs are presented in this report.

At a separation distance of 4 cm from the antenna of the device, the maximum 1g SAR is 0.49 W/kg. The manual will have a warning to keep bystanders, and parts of the user's body other than extremities, at least 4 cm away from the antenna.

Based on the test results and on how the device will be marketed and used, it is certified that the product meets the requirements as set forth in the above specifications, for uncontrolled RF exposure environment.

(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 Melard Sidearm wireless handheld PC which incorporates a Novatel Expedito CDPD modem. 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 C95.1-1999, 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. DEVICE UNDER INVESTIGATION

- Melard Sidearm wireless handheld PC, s/n 1001018, which incorporates a Novatel Expedito CDPD modem received on 16 October, 2000.

The Melard Sidearm wireless handheld PC will be called DUI (Device Under Investigation) in the following.

The antenna of the DUI is an 8.5' half-wavelength dipole antenna. The DUI nominally transmitted at 100% duty factor in the band of 824.04 MHz - 848.97 MHz. 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
- APREL F-2, flat manikin, s/n 002
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033
- R&S NRVS power meter, s/n 864268/017, Asset # 100851

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the DUI 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 A contains information about the 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 DUI is positioned with the surface under investigation against the phantom.



7. All tests were performed with the highest power available from the sample DUI 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 DUI will consume energy from its batteries, which may affect the DUI's transmission characteristics. In order to gauge this effect the output of the transmitter is sampled before and after each SAR run. In the case of this DUI, the conducted power was sampled. The following table shows the conducted RF power sampled before and after each of the sets of data used for the worst case SAR in this report.

Scan		Power Readings (dBm)		D (dB)	Battery #
Type	Height (mm)	Before	After		
Area	2.5	3.67	3.57	0.1	2
Area	12.5	3.68	3.67	0.01	2
Zoom	2.5 - 22.5	3.89	3.66	0.23	3
Depth	2.5 - 22.5	3.57	3.70	0.13	4

Table 1. Sampled Conducted RF Power



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 1. 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 DUI was put into test mode for the SAR measurements via hyperterminal using manufacturer supplied keypad commands to control the channel and maximum operating power (nominally 0.6W / 27.8dBm). The duty factor was 100%.
- 3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the DUI (channel 367, middle, 836.01 MHz, right side, 0.6W / 27.8dBm). It also shows an overlay of the DUI's outlines, superimposed onto the contour plot. The presented values were taken 2.5mm into the simulated tissue from the flat phantom's solid inner surface. Figure 1 shows the flat phantom used in the measurements. For the right side measurements, the back edge of the DUI was aligned with Y= 0 and the antenna of the DUI, with X= 22.

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

- 4) Wide area scans were performed for the low, middle and high channels on the keyboard up, keyboard down, right, and top sides of the DUI. The DUI was operating at maximum output power (0.6W / 27.8dBm) and 100% duty factor. The peak single point SAR for the scans were:



TYPE OF EXPOSURE	DUI side	Antenna distance to phantom (mm)	Channel			Peak Local SAR (W/kg)
			L/M/H	#	Freq (MHz)	
Hand Exposure	Keyboard up Side	22	middle	367	836.01	2.16
	Right Side	13	Low	991	824.04	1.95
	Right Side	13	Middle	367	836.01	2.72
	Right Side	13	High	799	848.97	2.39
	Keyboard down Side	32	middle	367	836.01	0.01
Bystander Exposure	Top Side	0	middle	367	836.01	3.96
			low	991	824.04	4.13
			high	799	848.97	3.44

Table 2. SAR Measurements

7. USER'S HAND EXPOSURE

All subsequent testing for hand exposure was performed on channel 367 (middle, 836.01 MHz), with the right side of the DUI facing up against the bottom of the phantom and the antenna 13 mm away from the phantom. This relates to the position and frequency found to provide the maximum measured SAR value.

- 1) Channel 367 (middle, 836.01MHz) was then explored on a refined 5 mm grid in three dimensions. The SAR value averaged over 10 grams was determined from these measurements by averaging the 125 points (5x5x5) comprising a 2 cm cube. The maximum SAR value measured averaged over 10 grams was determined from these measurements to be 1.27 W/kg.
- 2) To extrapolate the maximum SAR value averaged over 10 grams to the inner surface of the phantom a series of measurements were made at five (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. The average exponential coefficient was determined to be $(-0.0658 \pm 0.0011) / \text{mm}$.



- 3) 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 10 grams that was determined previously, we obtain the **maximum SAR value at the surface averaged over 10 grams, 1.75 W/kg**

8. BYSTANDER EXPOSURE

All subsequent testing for bystander exposure was performed on channel 991 (low, 824.04 MHz), with the top side of the DUI facing up against the bottom of the phantom and the antenna touching the phantom. This relates to the position and frequency found to provide the maximum measured SAR value.

- 1) Channel 991 (low, 824.04 MHz) was also explored on a refined 5 mm grid in three dimensions. 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 2.79 W/kg.
- 2) 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 five (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. The average exponential coefficient was determined to be $(-0.0658 \pm 0.0011) / \text{mm}$.
- 3) 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, 4.13 W/kg.**



- 4) Wide area scans were then performed for channel 367 (middle, 836.01 MHz) versus DUI separation from the bottom of the phantom. The peak single point SAR for the scans were:

DUI to phantom separation (mm)	Highest Local SAR (W/kg)
30	0.68
40	0.42
50	0.27

Table 3. SAR versus DUI-Phantom Separation

The measurements of highest local SAR versus separation of the DUI from the bottom of the phantom can be used to determine the SAR exposure of the bystander during operation of the DUI.

If the data for Figure 4 is fitted to an exponential equation we get:

$$\text{Peak Local SAR} = 5.1132 e^{-0.0574 * (\text{separation})}$$

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

$$\text{Maximum 1g SAR} = k e^{-0.0574 * (\text{separation})}$$

Using this equation with the previous data:

$$\begin{array}{lcl} \text{Maximum 1g SAR at the surface} & = & 4.13 \text{ W/kg} \\ \text{Tissue to DUI separation} & = & 3 \text{ mm,} \end{array}$$

results in a $k = 4.91 \text{ W/kg}$, which corresponds to the maximum 1g SAR when the separation is 0 mm. A conservative maximum 1g SAR of 1.32 W/kg (1.6 W/kg reduced by our measurement uncertainty, 11.8%) would occur for a separation of 22.9 mm from the antenna of the DUI.

At a standard separation distance of 4 cm, the maximum 1g SAR would be 0.49 W/kg.

9. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, determined at 836.01 MHz (middle channel, 367, right side, 0.6W / 27.8dBm) of the Melard Sidearm wireless handheld PC, which incorporates a Novatel Expedite CDPD modem is 1.75 W/kg. The overall margin of uncertainty for this measurement is $\pm 11.8\%$ (Appendix B). The SAR limit given in the FCC 96-326 Safety Guideline is 4 W/kg for uncontrolled hand exposure for the general population.

For a bystander or user exposing a part of the body other than the extremities, at a separation distance of 4 cm from the device, the maximum Specific Absorption Rate (SAR) averaged over 1 g is 0.49 W/kg. The SAR limit given in the FCC 96-326 Safety Guideline is 1.6 W/kg for uncontrolled partial body exposure of the general population. The minimum separation distance that will ensure that the limit minus the measurement uncertainty ($1.6 - 11.8\% = 1.32$ W/kg) is not exceeded, is 22.9 mm.

Considering the above, this unit as tested, and as it will be marketed and used, with a warning to keep bystanders and parts of the user other than extremities at least four cm away from the antenna, is found to be compliant with the FCC 96-326 requirement.



APPENDIX A. Measurement Setup, Tissue Properties and SAR Graphs

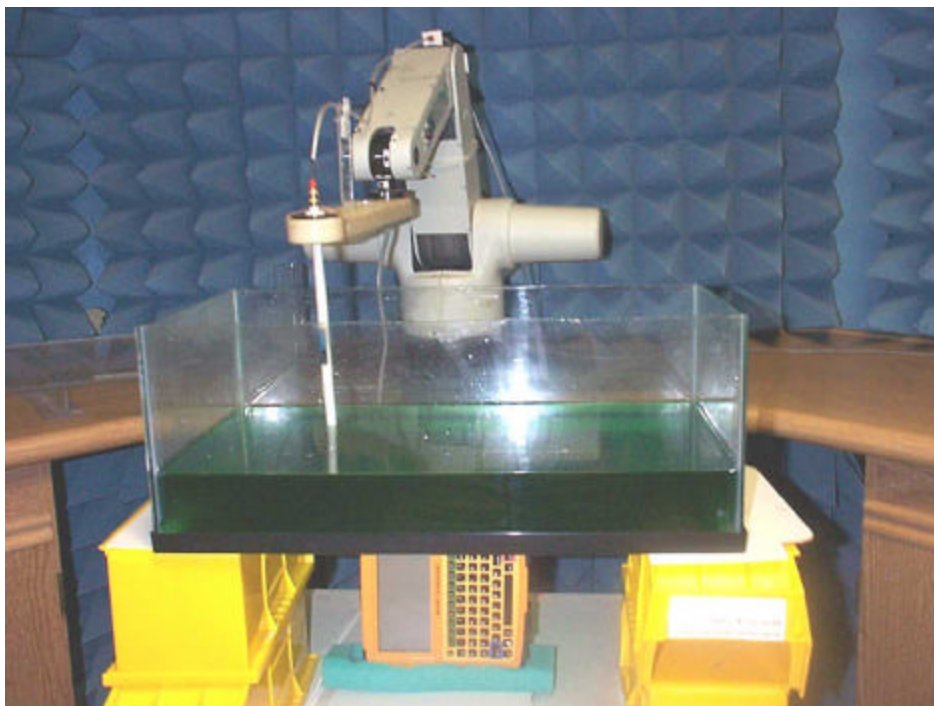


Figure 1. Setup

Simulated Muscle Tissue Material and Calibration Technique

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

	APREL	OET 65 Supplement	Δ (%) (OET)
Dielectric constant, ϵ_r	57.5	56.11	2.4%
Conductivity, σ [S/m]	1.06	9.46	11.9%
Tissue Conversion Factor, γ	9.1 @ 835	-	-

Table 4. Dielectric Properties of the Simulated Muscle Tissue at 835 MHz

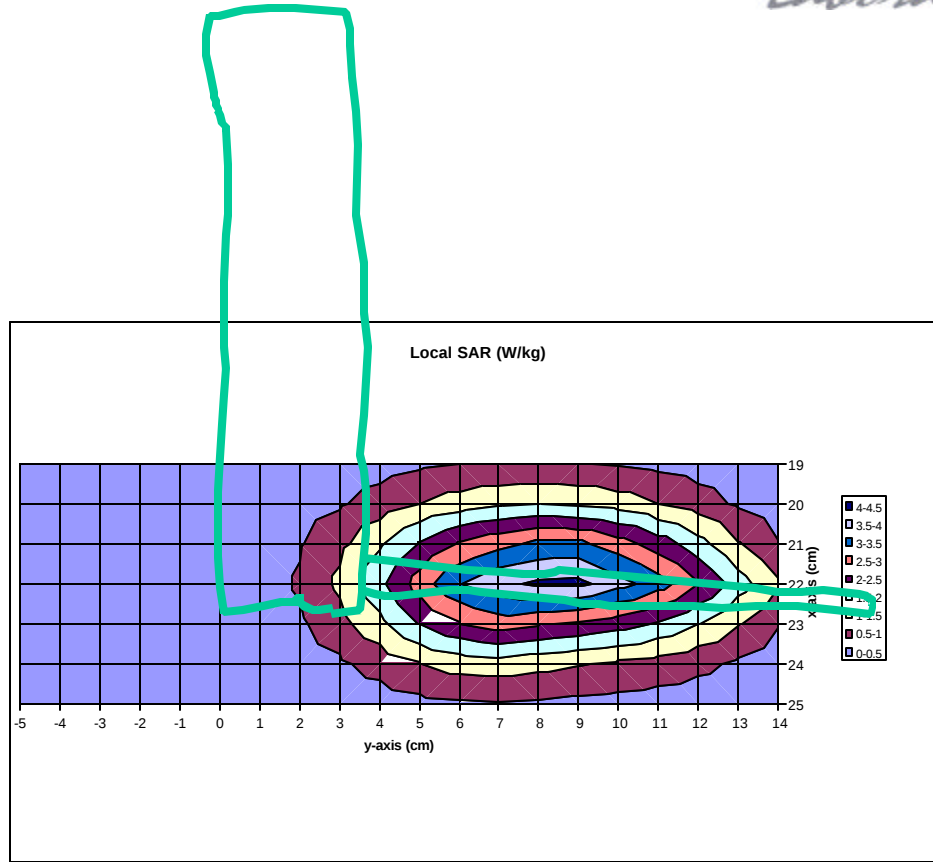


Figure 2. Contour Plot of the Area Scan 2.5mm Above Phantom Surface

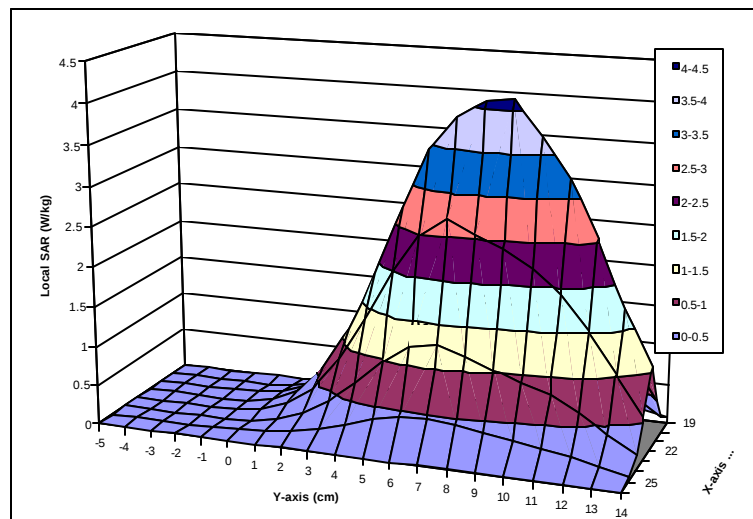


Figure 3. Surface Plot of the Area Scan 2.5mm Above Phantom Surface

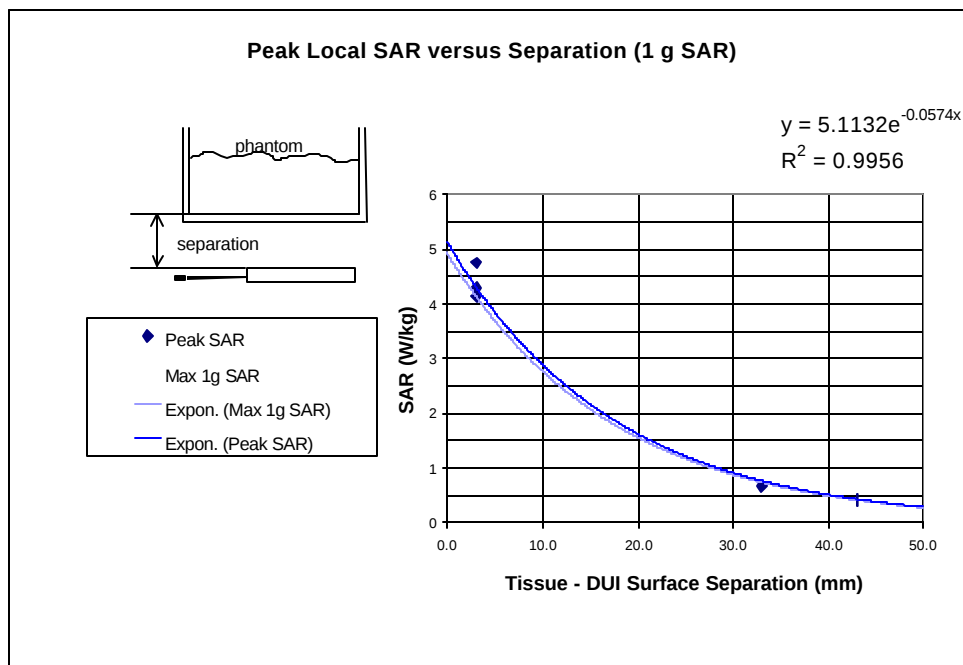


Figure 4. Peak Local SAR versus DUI Separation

APPENDIX B. Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty		
Type of Uncertainty	Specific to	Uncertainty
Power variation due to battery condition	DUI	2.7%
Extrapolation due to curve fit of SAR vs depth	DUI & Setup	3.5%
Extrapolation due to depth measurement	setup	3.2%
Conductivity	setup	6.0%
Density	setup	2.6%
Tissue enhancement factor	setup	7.0%
Voltage measurement	setup	2.5%
Probe sensitivity factor	setup	3.5%
		11.8% RSS

Table 5. Uncertainty Budget



APPENDIX C. Validation Scan on a Flat Phantom

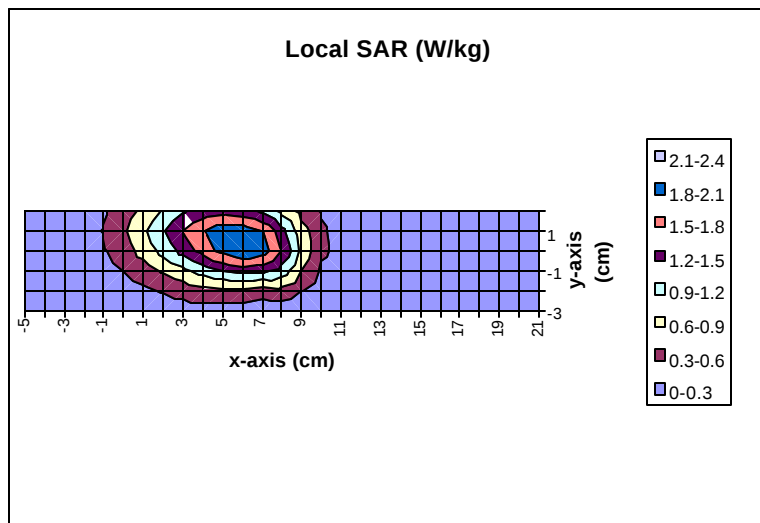


Figure 4. Contour Plot of the Reference Area Scan 2.5mm Above Phantom

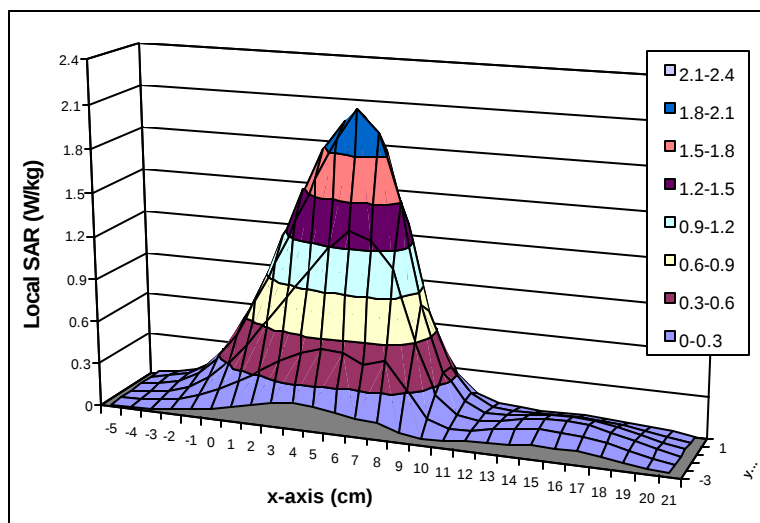


Figure 5. Surface Plot of the Reference Area Scan 2.5mm Above Phantom

APPENDIX D. Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: 301420

CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the
NCL CALIBRATION LABORATORIES by qualified personnel following recognized
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe

Manufacturer: APREL Laboratories/IDX Robotics Inc

Model No.: E-009

Serial No.: 115

Customer: APREL

Asset No.:301420

Calibration Procedure: SSI/DRB-TP-D01-032

Cal. Date: 9 November, 2000 Cal. Due Date: 8 November, 2001
Remarks: None

Calibrated By: _____

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