

Experimental Analysis SAR Report

Subject: **Specific Absorption Rate (SAR) Hand and Body Report**

Product: BlackBerry World Band

Model: R6020GW

Client: Research In Motion

Address: 305 Phillip Street
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Project #: RIMB-BlackBerry R6020GW-3842

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Applicant: Research In Motion
Equipment: BlackBerry World Band
Model: R6020GW
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 the Research In Motion R6020GW BlackBerry World Band operating in GSM mode . The measurements were carried out in accordance with FCC 96-326. Scientific and technical details as presented in IEEE P-1528 were also used for the assessment of the device tested. The Device Under Investigation (DUI) was evaluated for its maximum power level 30 dB (nominally). The duty cycle for the DUI is 12.5 %.

The DUI was tested at low, middle and high channels for the keyboard down and left side for hand exposure, and keyboard up side with the supplied holster with belt clip for body exposure. The maximum 10g SAR (2.20 W/kg) for hand exposure was found to coincide with the peak performance RF output power of channel 661, middle (1880 MHz) for the left side of the device. The maximum 1g SAR (0.32 W/kg) was found to coincide with the peak performance RF output power of channel 661, middle (1880 MHz) for the keyboard up side of the device using the supplied holster with belt clip.

The DUI was tested with and without the headset (model HDW-03458-002). It was found that the headset reduced SAR for all permutations; therefore the 1 and 10 gram analysis was performed without the headset.

The R6020GW has an internal antenna located on the left hand side of the device.

Test data and graphs are presented in this report.

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 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) for a sample R6020GW BlackBerry World Band. 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 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".
- 5) IEEE P-1528 Draft "Recommended Practice for Determining the Peak Spatial Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communication Devices: Experimental Techniques."

3. DEVICE UNDER INVESTIGATION

- R6020GW BlackBerry World Band, pre-production sample, received on December 5, 2001 .

The R6020GW BlackBerry World Band will be called DUI (Device Under Investigation) in the following test report.



4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-010, s/n 154, Asset # 301485
- ALIDX-500 Dosimetric SAR Measurement System
- Wavetek communication test instrument 4400M, s/n 1011020511057
- APREL flat Phantom F1, Part # P-V-G8 (overall shell thickness 2mm)
- APREL 1900 MHz Dipole, s/n 020, Asset # 301459
- APREL Microwave Power Amplifier 800-4200 MHz, AL-RFA-A, asset # 301467
- 83640B Hewlett Packard Signal Generator, s/n 3844A00689, asset #301468
- R&S Power Meter, s/n 864268/017, asset # 100851
- H-P 767D Dual Directional Coupler, s/n 00401637, asset # 100251

5. ALIDX-500 SPECIFICATION

The ALIDX-500 Dosimetric SAR Measurement System was developed jointly with APREL Laboratories and IDX Robotics for use within wireless development and the compliance environment. The system consists of a six axis articulated arm, and controller for precise probe positioning (0.05mm repeatability). Custom software has been developed to enable communications between the robot controller software and the host operating system.

An amplifier is located on the articulated arm, which is isolated from the custom designed end effector and robot arm. The end effector provides the mechanical touch detection functionality and probe connection interface. The amplifier is functionally validated within the manufacturers site and calibrated at NCL Calibration Laboratories. A Data Acquisition Card (DAC) is used to collect the signal as detected by the isotropic e-field probe. The DAC manufacturer calibrates the DAC to NIST standards. A formal validation is executed using all mechanical and electronic components to prove conformity of the measurement platform as a whole.



The ALIDX-500 has been designed to measure devices within the compliance environment to meet all recognized standards. The system also conforms to standards, which are currently being developed by the scientific and manufacturing community.

The coarse scan resolution is defined by the operator and reflects the requirements of the standard to which the device is being tested. Precise measurements are made within the predefined coarse scan area and the values are logged. The sample rate for which the measurements are made is also predefined and the default is set at 6000 samples per second divisible by 60 Hz, which acts as a secondary method for eliminating noise.

A complex algorithm is then used to calculate the values within the measured points down to a resolution of 1mm. The data from this process is then used to provide the coordinates from which the cube scan is created for the determination of the one and ten gram averages.

Cube scan averaging consists of a number of complex algorithms, which are used to calculate the one, and ten gram averages. The basis for the cube scan process is centered on the location where the maximum measured SAR value was found. When a secondary peak value is found which is within 60% of the initial peak value, the system will report this back to the operator who can then assess the need for further analysis of both the peak values prior to the one and ten gram cube scan averaging process. The algorithm consists of 3D cubic Spline, and Lagrange extrapolation to the surface, which form the matrix for calculating the measurement output for the one and ten gram average values. The resolution for the physical scan integral is user defined with a final calculated resolution down to 1mm.

In-depth analysis for the differential of the physical scanning resolution for the cube scan analysis has been carried out, to identify the optimum setting for the probe positioning steps, and this has been determined at 8mm increments on the X and Y planes. The reduction of the physical step increment increased the time taken for analysis but did not provide a better uncertainty or return on measured values.

Prior to the measurement process the operator can insert the parameters for which the physical measurements are made, defining the X, Y, and Z probe movement integrals. For the FCC compliance process both OET 65 "Supplement C" and the IEEE draft standard "P-1528" were used to define the measurement parameters used during the assessment of the device.

The final output from the system provides data for the area scan measurements, physical and splined (1mm resolution) cube scan with physical and calculated values (1mm resolution).



The overall uncertainty for the methodology and algorithms the ALIDX500 used during the SAR calculation was evaluated using the data from IEEE P-1528 f3 algorithm.

$$f_3(x, y, z) = A \frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2} \cdot \left(e^{-\frac{2z}{a}} + \frac{a^2}{2(a + 2z)^2} \right)$$

The probe used during the measurement process has been assessed to provide values for diode compression. These values are calculated during the probe calibration exercise and are used in the mathematical calculations for the assessment of SAR

6. TEST METHODOLOGY

1. The test methodology utilized 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).

$$SAR = \frac{\sigma |E|^2}{\rho}$$

3. The probe is moved precisely from one point to the next using the robot (10 mm increments for wide area scanning and 8 mm increments for zoom scanning in the X, Y directions) and (5.0 mm increments for the final depth profile measurement in the Z direction).
4. The probe travels in the homogeneous liquid simulating human tissue (muscle).

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 with an overall shell thickness of 2 mm.
6. The DUI is positioned with the surface under investigation against the phantom with no separation distance for hand analysis. For body analysis the DUI is tested with the supplied holster and belt clip.
7. All tests were performed with the highest power available from the sample DUI under transmit conditions.

More detailed descriptions of the test method are given in Section 6 where appropriate.



7. TEST RESULTS

7.1. TRANSMITTER CHARACTERISTICS

The battery-powered DUI will consume energy from its batteries, which may affect the DUI's transmission power characteristics. In order to gauge this effect the output of the transmitter is sampled before and after each SAR test. In the case of this DUI, the Tx power was sampled through out the test process. The following table shows the RF power sampled before and after each of the two sets of data used for the worst case SAR in this report.

Type of Exposure	Scan Type	Power Readings (dBm)		D (dB)	Battery #
		Before	After		
Hand Exposure	Coarse	30.27	30.1	0.17	9
	Fine	30.27	30.1	0.17	9
Body Exposure	Coarse	30.29	30.15	0.14	3
	Fine - body	30.29	30.15	0.14	3

Table 1. Sampled RF Power



7.2. 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. 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. The equation below is a representation of how SAR can theoretically equate.

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dV} \right)$$

- 2) The DUI was put into test mode for the SAR measurements by enabling a call via the Wavetek communications test instrument. A SIMM card was located in the DUI to enable the interaction between the Wavetek communications test instrument and the DUI. The Wavetek communications test instrument then sent out a command for the DUI to transmit at full power at the specified frequency.
- 3) Figures 2 & 4 in Appendix A show a contour plot of the SAR measurements for the DUI (channel 661, 1880 MHz) it also shows an overlay of the DUI's outlines, superimposed onto the contour plots.

A different presentation of the same data is shown in Appendix A Figures 3 & 5. This is a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualization aid.

- 4) Wide area scans were performed for the low, middle and high channels of the DUI. The DUI was operating at maximum output power (30 dB) with the duty cycle set at 12.5%. The DUI was placed in close proximity to the phantom for the keyboard up (while using the supplied holster and belt clip), keyboard down and left side permutations. The phantom shell thickness is 2 mm overall.



TYPE OF EXPOSURE	DUI side	Headset	Channel			Peak Local SAR (W/kg)
			L/MH	#	Freq (MHz)	
Body Exposure	Keyboard up side with belt clip	NO	Low	512	1850.2	0.20
	Keyboard up side with belt clip	NO	Middle	661	1880.0	0.23
	Keyboard up side with belt clip	NO	High	810	1909.8	0.23
	Keyboard up side with belt clip	YES	Low	512	1850.2	0.21
	Keyboard up side with belt clip	YES	Middle	661	1880.0	0.22
	Keyboard up side with belt clip	YES	High	810	1909.8	0.23
Hand Exposure	keyboard down side	NO	Low	512	1850.2	3.42
	Keyboard down side	NO	Middle	661	1880.0	3.26
	Keyboard down side	NO	High	810	1909.8	3.58
	keyboard down side	YES	Low	512	1850.2	3.61
	Keyboard down side	YES	Middle	661	1880.0	3.32
	Keyboard down side	YES	High	810	1909.8	3.97
	Left hand side	NO	Low	512	1850.2	4.00
	Left hand side	NO	Middle	661	1880.0	4.39
	Left hand side	NO	High	810	1909.8	3.62
	Left hand side	YES	Low	512	1850.2	3.92
	Left hand side	YES	Middle	661	1880.0	3.95
	Left hand side	YES	High	810	1909.8	3.86

Table 2. SAR Measurements



8. USER'S HAND EXPOSURE

All subsequent testing for user's hand exposure was performed on channel 661 (1880 MHz) with the left side of the DUI facing up against the bottom of the phantom with the headset not attached. This relates to the position and frequency found to provide the maximum measured SAR value.

- 1) Channel 661 (1880 MHz) was then explored on a refined 32 mm grid in three dimensions (X, Y & Z) measuring at 8 mm integrals X & Y and 5 mm integrals in the Z plane so as to create a physical measured point matrix. The system then runs the algorithms, which completes the matrix of calculated and measured values equivalent to a 1 mm resolution.
- 2) To establish the maximum SAR values averaged over 1 and 10 grams the software runs a series of Lagrange functions to provide the data for the Z plane.
- 3) From the calculated matrix which has a 1 mm resolution a fourth order polynomial is used to extrapolate the surface values. The maximum SAR value averaged over 10 grams was found to be 2.20 W/kg.

9. BODY EXPOSURE

All subsequent testing for user's body exposure was performed on channel 661 (1880 MHz) with the keyboard up side of the DUI facing up against the bottom of the phantom, using the supplied holster with belt clip and no headset. This relates to the position and frequency found to provide the maximum measured SAR value.

- 1) Channel 661 (1880 MHz) was then explored on a refined 32 mm grid in three dimensions (X, Y & Z) measuring at 8 mm integrals X & Y and 5 mm integrals in the Z axis so as to create a physical measured point matrix. The system then runs the algorithm, which creates a matrix of values equivalent to a 1 mm resolution.
- 2) To establish the maximum SAR values averaged over 1 and 10 grams the software runs a series of Lagrange functions to provide the data for the Z plane.
- 3) From the calculated matrix which has a 1 mm resolution a fourth order polynomial is used to extrapolate the surface values. The maximum SAR value averaged over 1 gram was found to be 0.32 W/kg.



10. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, determined at channel 661 (1880 MHz) of the R6020GW BlackBerry World Band, is 2.20 W/kg. The overall margin of uncertainty for this measurement is $\pm 18.7\%$ (Appendix B). The SAR limit given in the FCC 96-326 Safety Guideline is 4 W/kg for hand exposure for the general population.

The maximum Specific Absorption Rate (SAR) averaged over 1 gram, determined at channel 661 (1880 MHz) of the R6020GW BlackBerry World Band is 0.32 W/kg. The overall margin of uncertainty for this measurement is $\pm 18.7\%$ (Appendix B). The SAR limit given in the FCC 96-326 Safety Guideline is 1.6 W/kg for body exposure for the general population.

Considering the above, this unit as tested, and as it will be marketed and used, is found to be compliant with the FCC 96-326 requirement.

Tested by: KB _____

Date: December 6, 2001



APPENDIX A. Measurement Setup, Tissue Properties and SAR Graphs

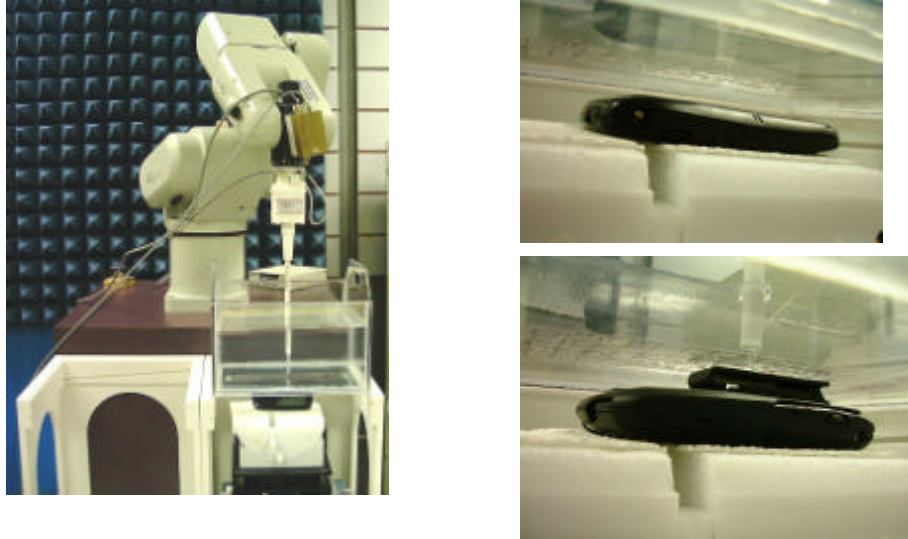


Figure 1. Setup

Simulated Tissue Material and Calibration Technique

The recipe used to make the tissue was based on that presented in “OET Supplement C” modified from the head recipe and consisted of the following ingredients:

- Water 54.9%
- Salt 0.18%
- DGBE 44.92%

The density used to determine SAR from the measurements was the recommended 1000 kg/m³ found in Appendix C of “Supplement C OET Bulletin 65, Edition 01-01”.

Dielectric parameters of the simulated 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.

	APREL	Target Value	Δ (%)
Dielectric constant, ε _r	51.83	54.0	-3.76
Conductivity, σ [S/m]	1.48	1.45	1.5
Tissue Conversion Factor, γ	7.9	-	-

Table 3. Dielectric Properties of the Simulated Muscle Tissue at 1900 MHz



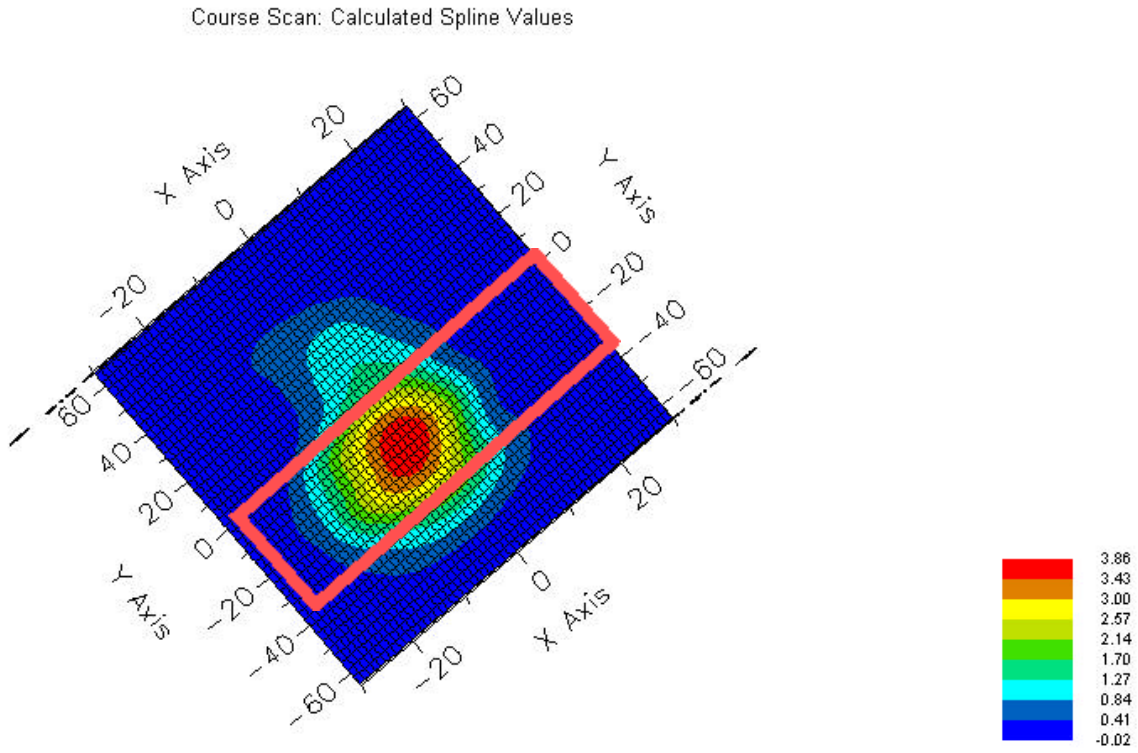


Figure 2. Contour Plot of Coarse Scan –

DUI Left Side for Hand exposure



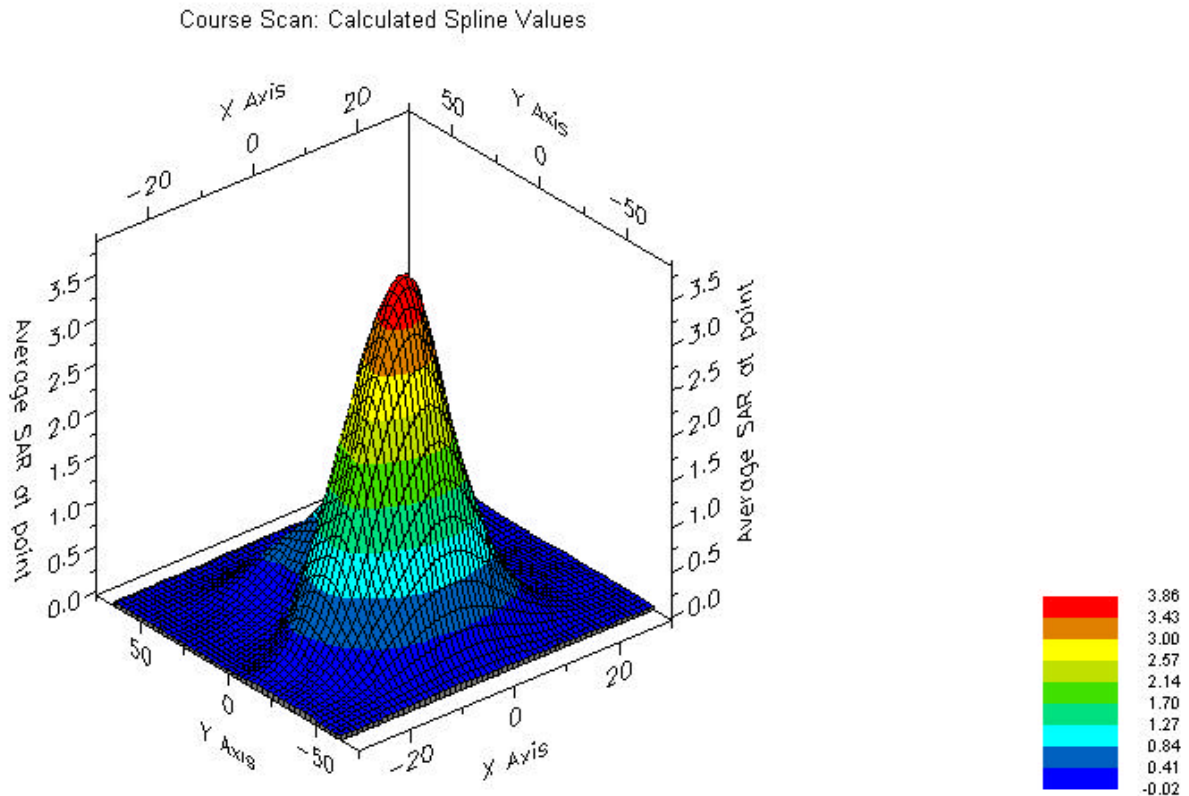
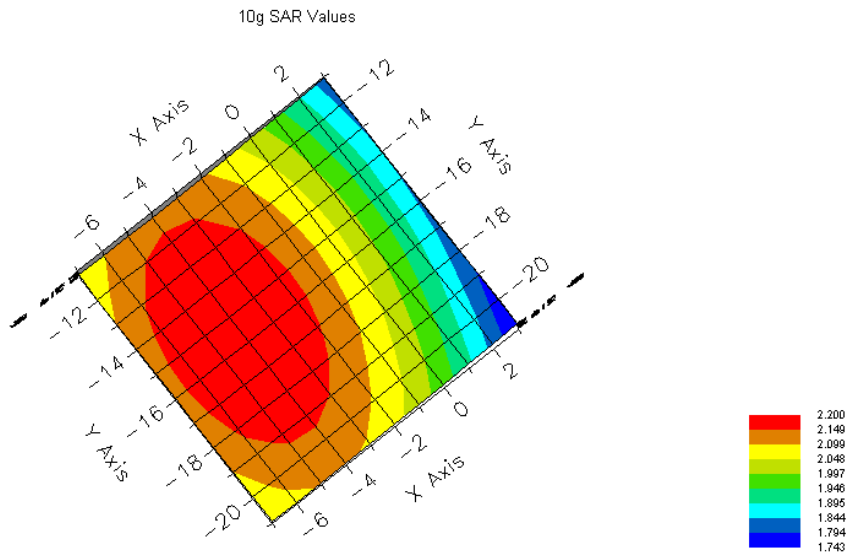


Figure 3. Surface Plot of Coarse Scan –

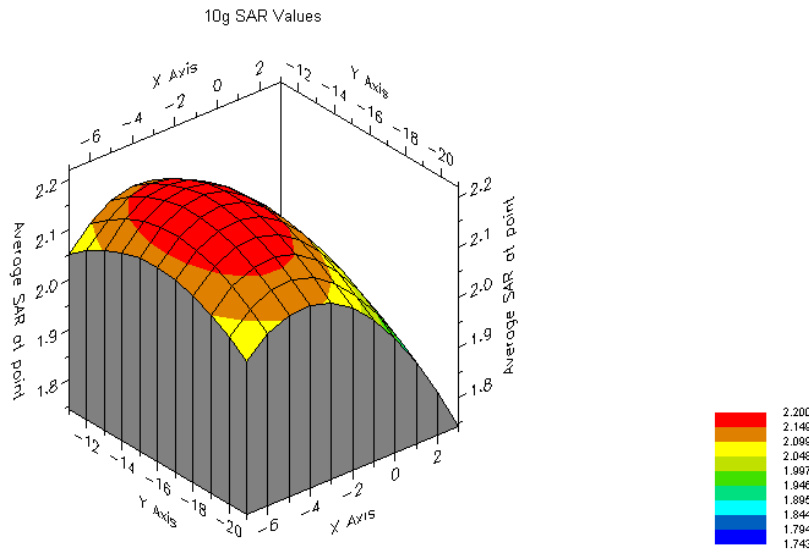
DUI Left Side for Hand exposure





**Figure 4. Contour Plot of 10 gram Scan -
DUI Left Side for Hand exposure**

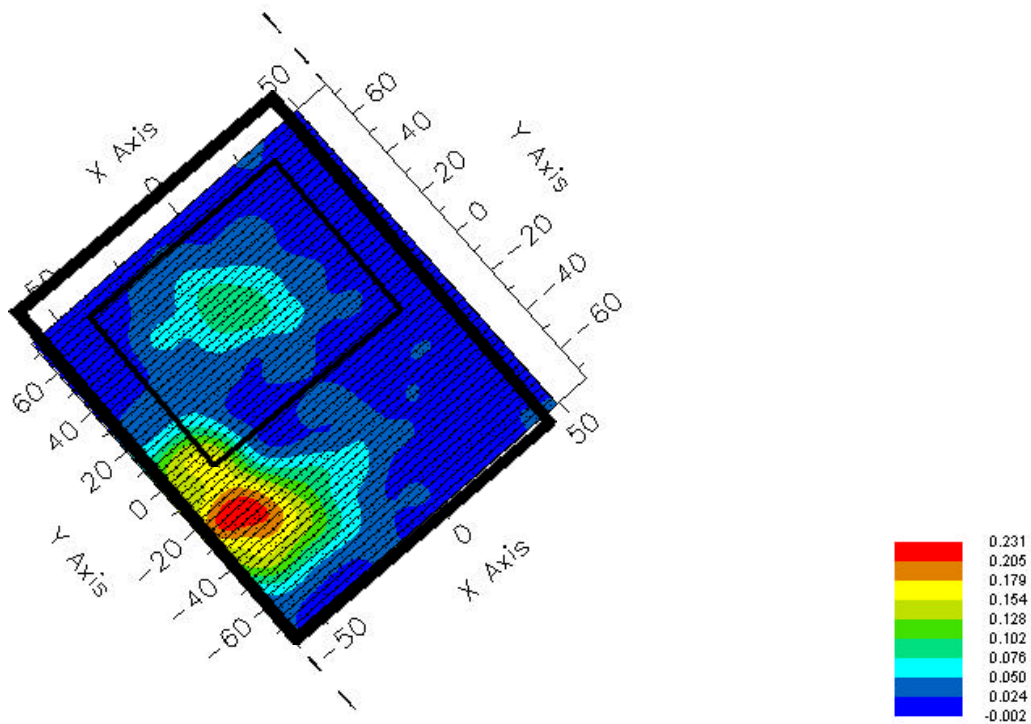




**Figure 5. Surface Plot of 10 gram Scan –
DUI Left Side for Hand exposure**

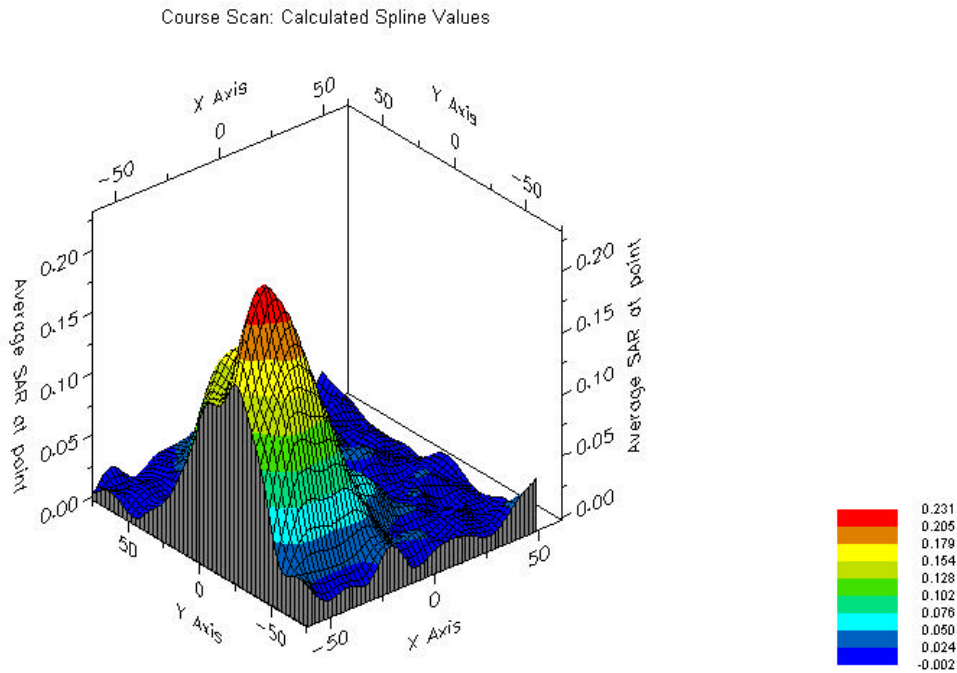


Course Scan: Calculated Spline Values



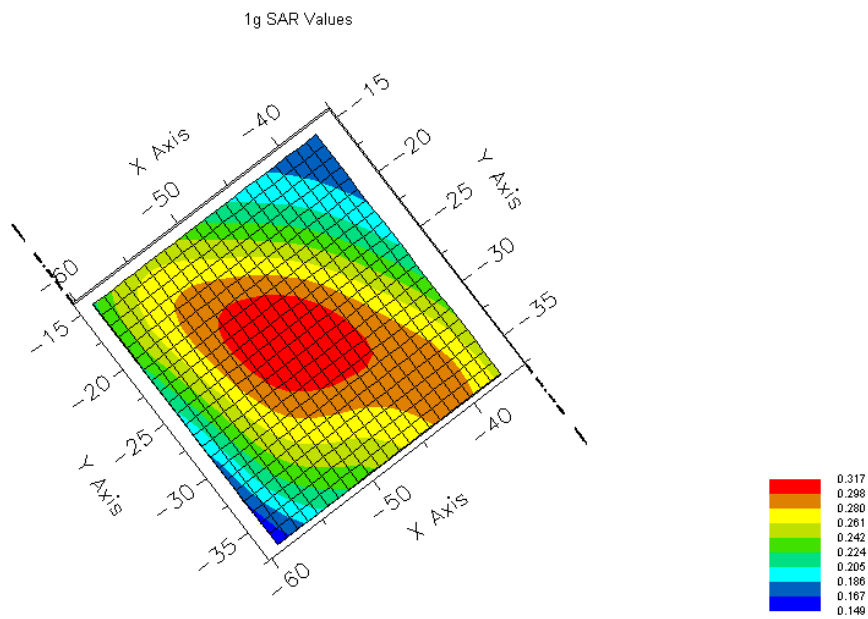
**Figure 6. Contour Plot Course Scan -
DUI Keyboard up Body Exposure**





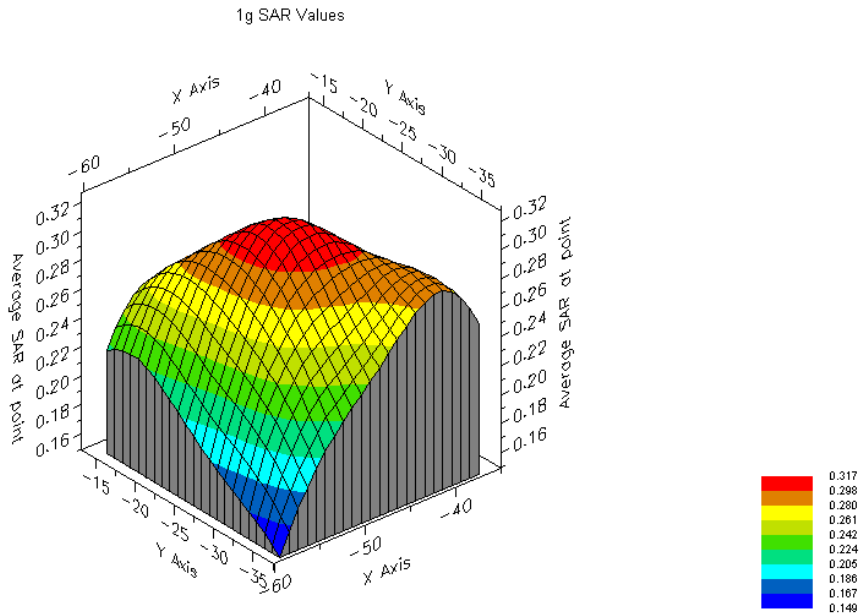
**Figure 7. Surface Plot Coarse Scan -
DUI Keyboard up Body Exposure**





**Figure 6. Contour Plot of 1 gram Scan -
DUI Keyboard up Body Exposure**





**Figure 7. Surface Plot of 1 gram Scan -
DUI Keyboard up Body Exposure**



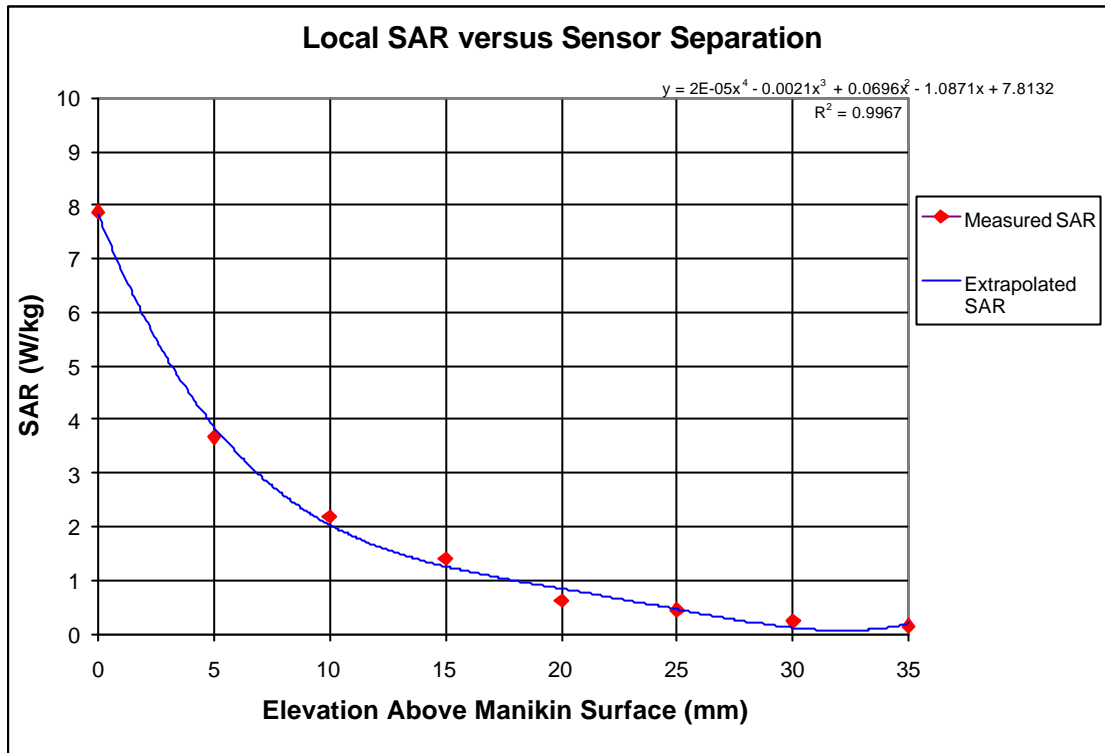


Figure 8. Local SAR versus Sensor Separation - 10g SAR (Hand)

The graph shows that there are no boundary effects. Similar results correspond to the Body measurements, which were performed on the same phantom and the same tissue. (The 10g SAR was the worst case).



APPENDIX B. Uncertainty Budget

Calculated Uncertainties		
Type of Uncertainty	Specific to	Uncertainty
Power variation due to battery condition	DUI	1.0%
Extrapolation due to depth measurement	Setup	3.8%
Conductivity	Setup	1.5%
Permittivity	Setup	4.0%
Probe Calibration	Setup	6.0%
Probe Positioning	Setup	1.0%
Probe Isotropy	Setup	1.5%
Other Setup Uncertainty (Ambient,,)	Setup	3.0%
18.7%		Expanded Uncertainty K²

Table 4. Uncertainty Budget



APPENDIX C. Validation Scan

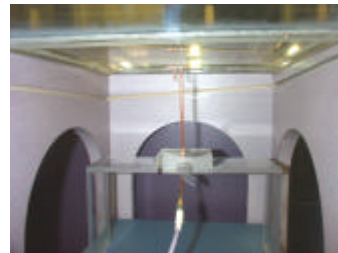
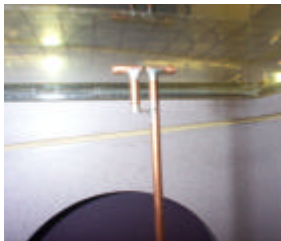
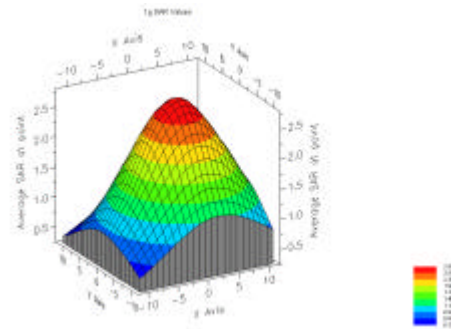
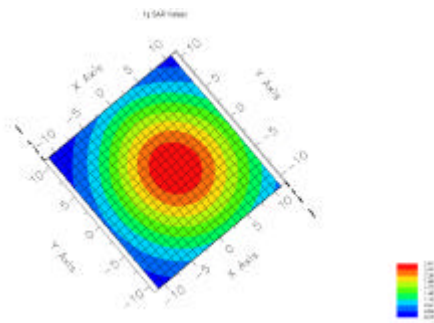


Figure 9. Contour Plot of 1 gram Validation Scan

Figure 10. Surface Plot of 1 gram Validation Scan

Figure 11. Dipole Under Phantom

Figure 12. Dipole Under Phantom

Frequency: 1900 MHz
 Input Power to Dipole: 1 W
 Distance from Dipole to Tissue: 10 mm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
40.87	39.7	-2.95%

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
20.83	20.5	-1.61



APPENDIX D. Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: 301485

C E R T I F I C A T E O F C A L I B R A T I O N

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

Model No.: E-010

Serial No.: 154

Customer: APREL

Asset No.: 301485

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

Cal. Date: 29 Nov, 2001 Cal. Due Date: 28 Nov, 2002
Remarks: None

Calibrated By: _____

NCL CALIBRATION LABORATORIES

51 SPECTRUM WAY
NEPEAN, ONTARIO
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Division of APREL Lab.
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FAX: (613) 820-4161



CALIBRATION RECORD

Customer: APREL

Asset No: 301485

Equipment Type: Miniature Isotropic RF Probe

Manufacturer: APREL Laboratories

Model No: E-010

Serial No: 154

Date: 29-Nov-01 Cal. Due: 28-Nov-02

Project No:

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

Environmental Conditions: Temp: 22.7 C Humidity: 30% - 55%

REFERENCES:

1. Directional Coupler, Hewlett Packard, model 767D, asset # 100251
2. RF Power Meter, Rohde & Schwarz, model NRVS, asset # 100851
3. RF Power Sensor, Rohde & Schwarz, model NRV-Z7, asset # 301461
4. Precision Guildline, Thermometer, asset # 301414
5. ALIDX-500 Near-Field Broadband Measurement System
6. APREL RF Power Amplifier, model M:AL-RFA-8
7. Signal Generator, Hewlett Packard, model 83640B
8. APREL Flat Phantom, model P-V-G2
9. APREL 835 MHz Dipole, asset#301463
10. APREL 1900 MHz Dipole, asset# 301459



CALIBRATION DATA

PHYSICAL PROBE DATA	
OFFSET [cm]	ANGLE [°]
0.25	54.73

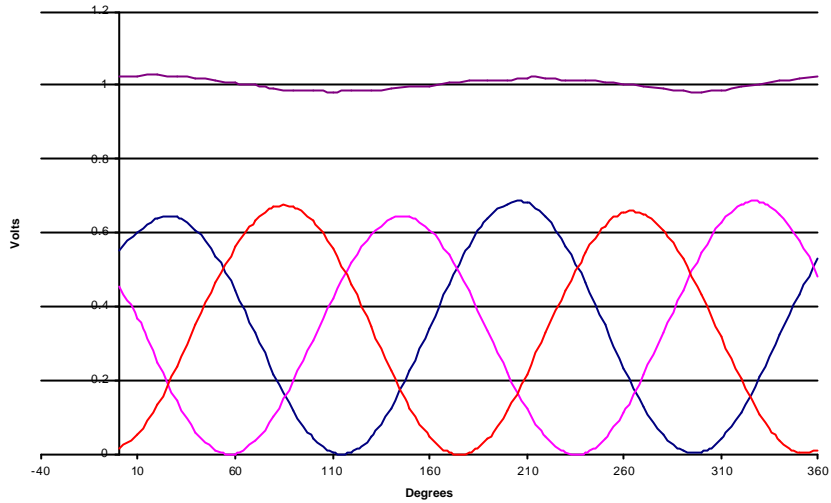
TISSUE TYPE [MHz]	FREQUENCY	DIELECTRIC CONSTANT	CONDUCTIVITY [S/m]	CONVERSION FACTOR [W/kg]
Brain	835	41.4	0.88	5.545
Brain	1900	39.59	1.36	7.900
Muscle	1900	51.83	1.48	8.100

Media Type	Frequency [MHz]	Sensitivity One	Sensitivity Two	Sensitivity Three
Air	835	1.378	1.439	1.250
Air	1900	2.886	2.954	2.651

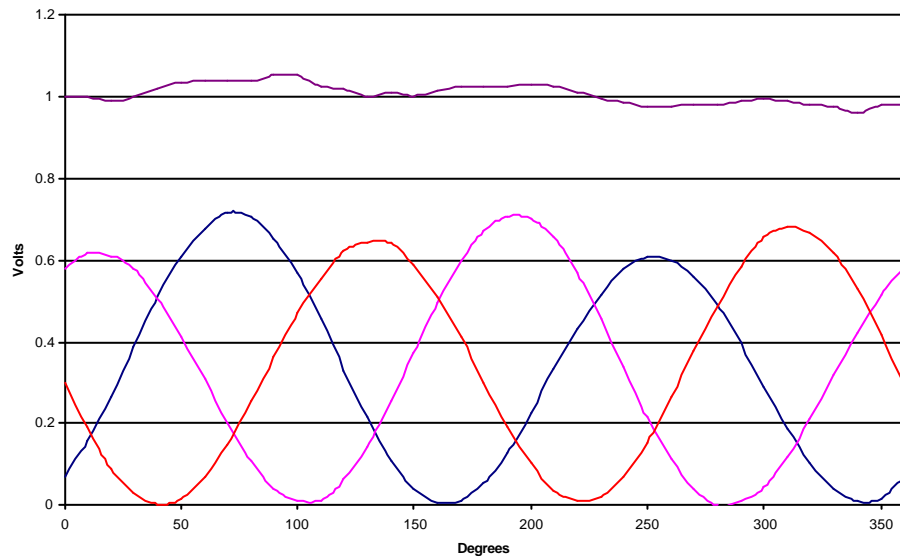
FREQUENCY MHz	ISOTROPICITY	
	[%]	[dB]
835	2.20	0.095
1900	4.71	0.20



Free Space at 835 MHz



Free Space at 1900 MHz



Validation Results:

Freq (MHz)	Power fed to dipole (W)	Distance from dipole to liquid (mm)	1 gram measured (W/Kg)	1 gram target (W/Kg)	Delta (%)	10 gram measured (W/Kg)	10 gram target (W/Kg)	Delta (%)
835	1	15	9.54	9.5	0.42	5.99	6.2	3.39
1900	1	10	38.32	39.7	-3.48	19.25	20.5	-6.1

