# Experimental Analysis SAR Report

| | |
|---|---|
| Subject: | **Specific Absorption Rate (SAR) Head Report** |
| Product: | BlackBerry World Band |
| Model: | R6020GW |
| Client: | Research In Motion |
| Address: | 305 Phillip Street<br>Waterloo Ontario N2L 3W8 |
| Project #: | RIMB-BlackBerry R6020GW-3841 |

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories R6020GW

Prepared by APREL Laboratories
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Approved by ______________________________ Date: _________________
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FCC ID: L6AR6020GW
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 with phone capability, operating in GSM mode. The measurements were carried out in accordance with FCC 96-326 Supplement C 01-01. 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 set by the GSM standard at a value of one in eight and is restricted by the operational characteristics of the DUI. The end user will not be able to change the duty cycle.

The DUI was tested at low, middle and high channels for the right and left sides of the head in both the touch and tilt positions.

The maximum 1g SAR (1.28 W/kg) was found to coincide with the peak performance RF output power of channel 661, middle (1880 MHz) for the left head side in the touch position.

Test data and graphs are presented in this report.

Based on the test results and on how the device shall 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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## TABLES AND FIGURES




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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 shall be called DUI (Device Under Investigation) in the following test report.


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# 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 SAM Phantom Right Head, Part# P-SAM-R, s/n APL-109 (overall shell thickness 2-6mm)
- APREL SAM Phantom Left Head, Part# P-SAM-L, s/n 94X019 (overall shell thickness 2-6mm)
- 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

# 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.


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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 devisable 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 co-ordinates 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).


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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 $E^2$).

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

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 (head).

   Appendix A contains information about the properties of the simulated tissue used for these measurements.

5. The liquid is contained in SAM phantoms simulating a portion of the human head one for the left side and another for the right side. The overall shell thickness of the phantoms is 2-6 mm.

6. For the touch position the DUI is positioned with the surface under investigation against the phantom with no separation distance. To achieve this the intersection of the MB/ERP line and the acoustic output of the DUI is used to line up device prior to testing. The device is then positioned using views from above and to the sides of the DUI. At this point the DUI is raised and brought into contact with the SAM Phantom where a minimum of three points of the DUI are in contact with the phantom. The angle of this position is then noted and referenced for repeatability.


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7. For tilt position the recorded angle used during the touch assessment is then used to provide the details in which the +15° position can be achieved. The device is placed into the touch position and then lowered so that the +15° position can be achieved. Once the change in angle has been made the device is then raised and compensation made for the displacement of the acoustic output in respect to the intersection of the MB/NF line in for the "X" axis is executed. (For details, IEEE Std 1528-200X 4.5.2).

8. 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 gage 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 | | |
| Head Exposure | Coarse | 30.36 | 30.15 | 0.21 | 4 |
| | Fine | 30.36 | 30.15 | 0.21 | 4 |

**Table 1. Sampled RF Power**


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## 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 theoretically equates.

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

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 in both the touch and tilt positions using the right and left SAM phantoms. The DUI was operating at maximum output power (30 dB) with the duty cycle set at 12.5%.


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| TYPE OF EXPOSURE | DUI side | Tilt/Touch | RHS/LHS | Channel | | | Peak Local SAR (W/kg) |
|---|---|---|---|---|---|---|---|
| | | | | L/M/H | # | Freq (MHz) | |
| Head Exposure | Keyboard up side | Touch | LHS | Low | 512 | 1850.2 | 0.83 |
| | Keyboard up side | Touch | LHS | Middle | 661 | 1880.0 | 0.99 |
| | Keyboard up side | Touch | LHS | High | 810 | 1909.8 | 0.87 |
| | Keyboard up side | Tilt | LHS | Low | 512 | 1850.2 | 0.14 |
| | Keyboard up side | Tilt | LHS | Middle | 661 | 1880.0 | 0.15 |
| | Keyboard up side | Tilt | LHS | High | 810 | 1909.8 | 0.13 |
| | Keyboard up side | Touch | RHS | Low | 512 | 1850.2 | 0.42 |
| | Keyboard up side | Touch | RHS | Middle | 661 | 1880.0 | 0.65 |
| | Keyboard up side | Touch | RHS | High | 810 | 1909.8 | 0.62 |
| | Keyboard up side | Tilt | RHS | Low | 512 | 1850.2 | 0.22 |
| | Keyboard up side | Tilt | RHS | Middle | 661 | 1880.0 | 0.22 |
| | Keyboard up side | Tilt | RHS | High | 810 | 1909.8 | 0.24 |

**Table 2. SAR Measurements**

## 8. USER'S HEAD EXPOSURE

All subsequent testing for user's head exposure was performed on channel 661 (1880 MHz) with the left SAM Phantom and the DUI in the touch position. 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 in all planes.

2) To establish the maximum SAR values averaged over 1 gram the software runs a series of Lagrange functions to provide the data for the Z plane.


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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 1.28 W/kg.

# 9. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1 gram, determined at channel 661 (1880 MHz) of the R6020GW BlackBerry World Band is 1.28 W/kg. The overall margin of uncertainty for this measurement is ±17% (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: ________________________ Date: December 6, 2001


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# APPENDIX A. Measurement Setup, Tissue Properties and SAR Graphs

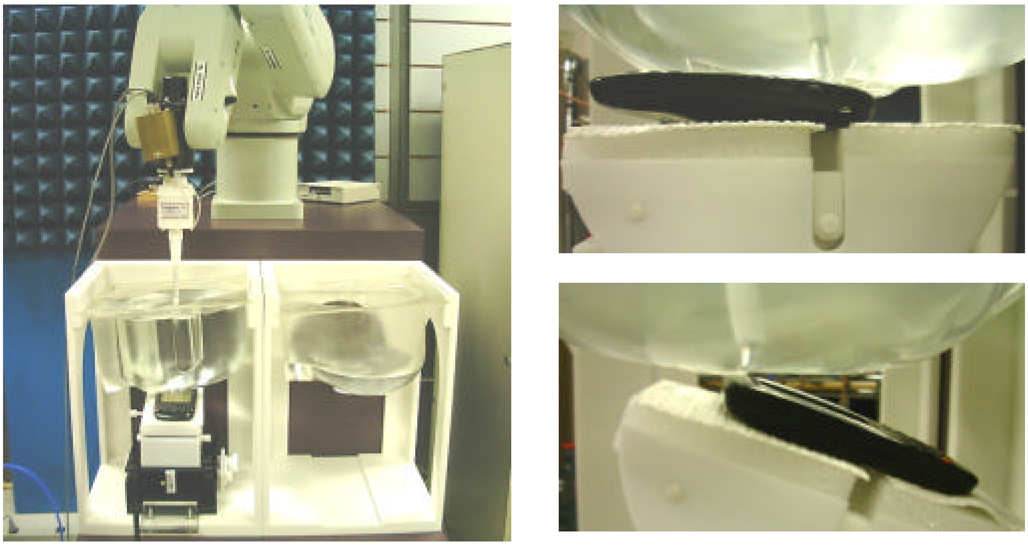

**Figure 1. Setup**

## Simulated Tissue Material and Calibration Technique

The recipe used to make the tissue was taken from IEEE P-1528 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/m$^3$ 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 | $\Delta$ (%) |
|---|---|---|---|
| Dielectric constant, $\varepsilon_r$ | 39.59 | 40.0 | -1.03 |
| Conductivity, $\sigma$ [S/m] | 1.36 | 1.40 | -2.86 |
| Tissue Conversion Factor, $\gamma$ | 7.9 | - | - |

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


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Course Scan: Calculated Spline Values

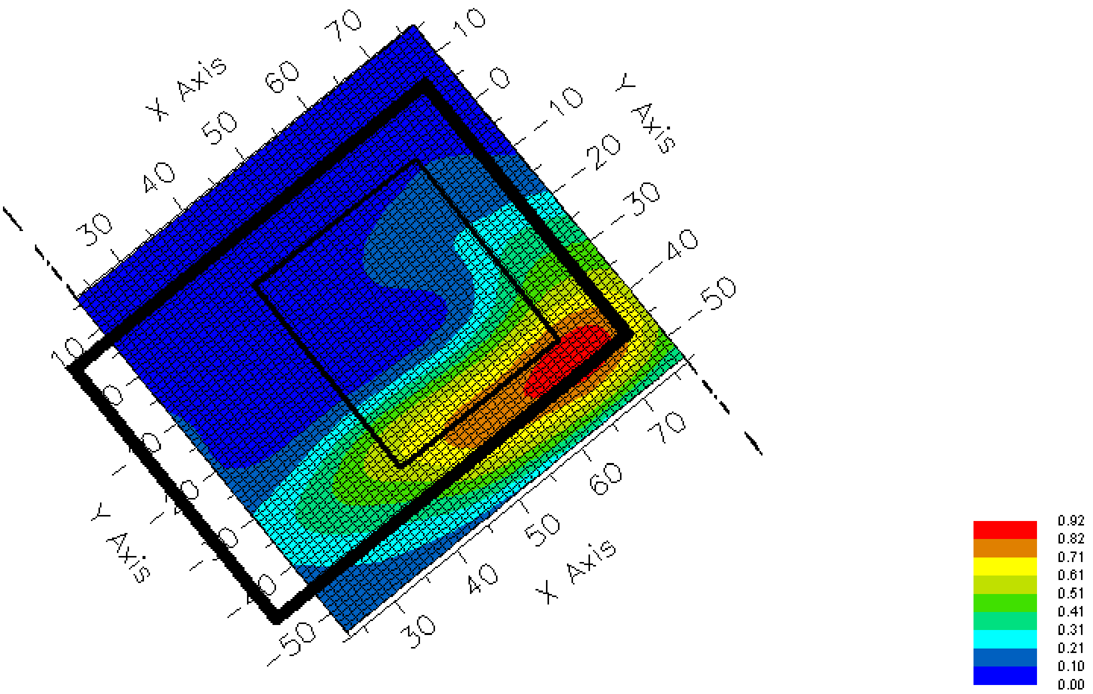


**Figure 2. Contour Plot of Coarse Scan With DUI**


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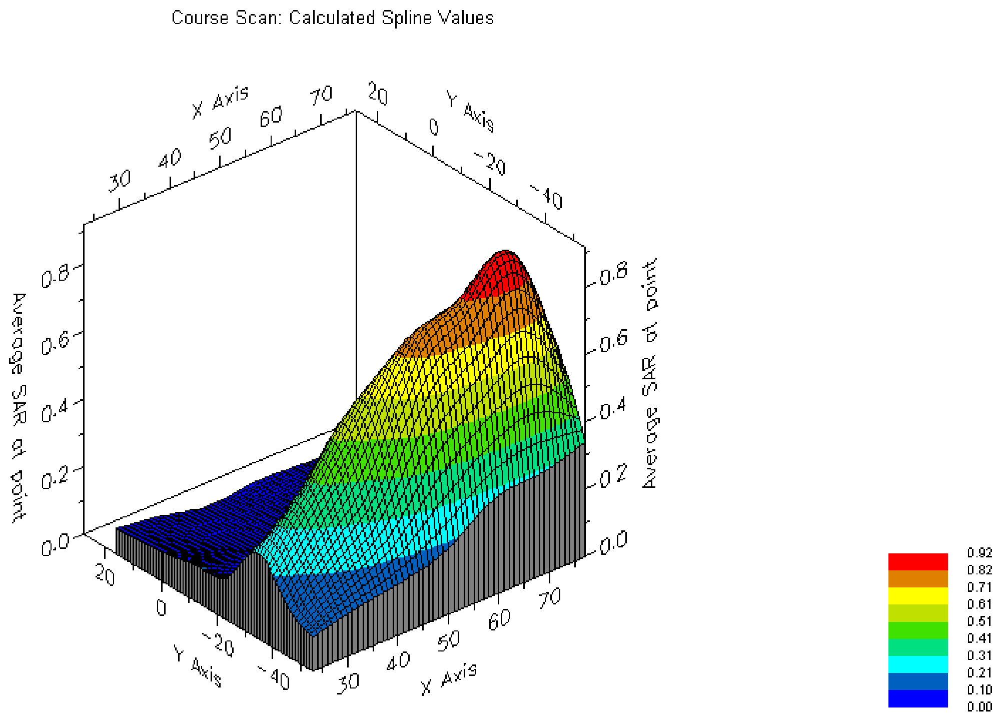


**Figure 3. Surface Plot of Coarse Scan**


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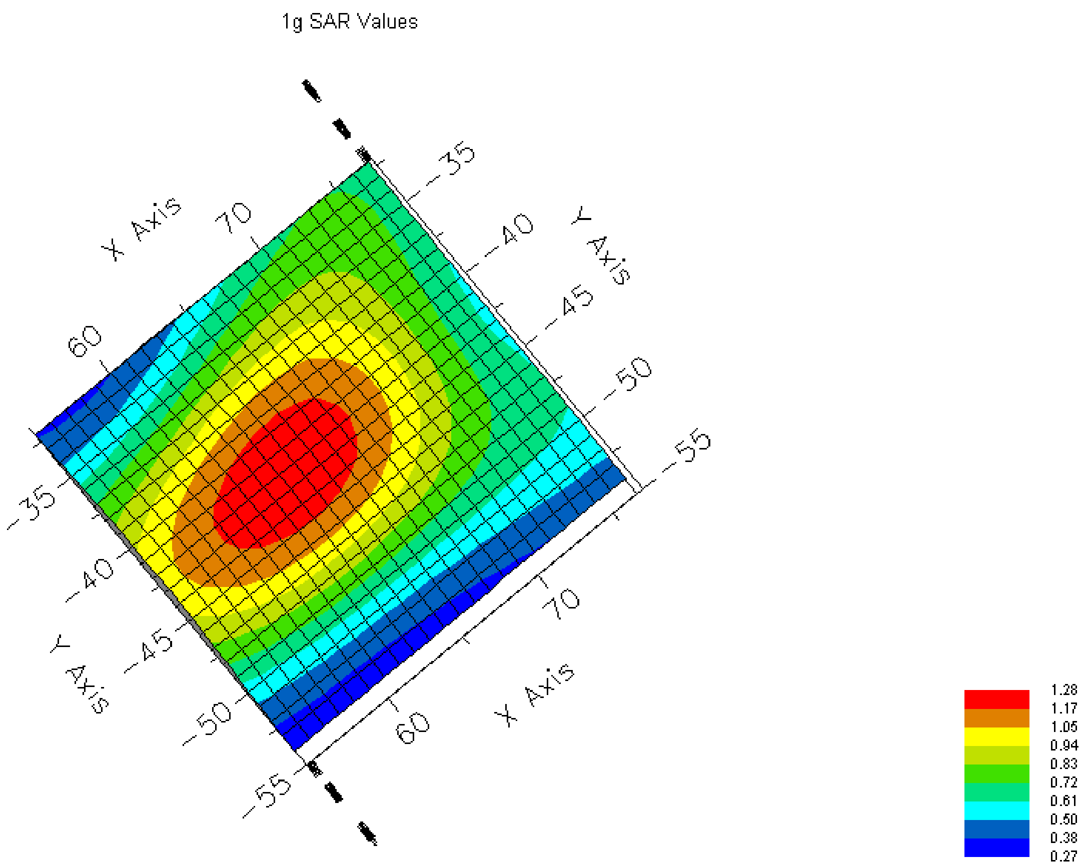


**Figure 4. Contour Plot of 1 gram Scan**


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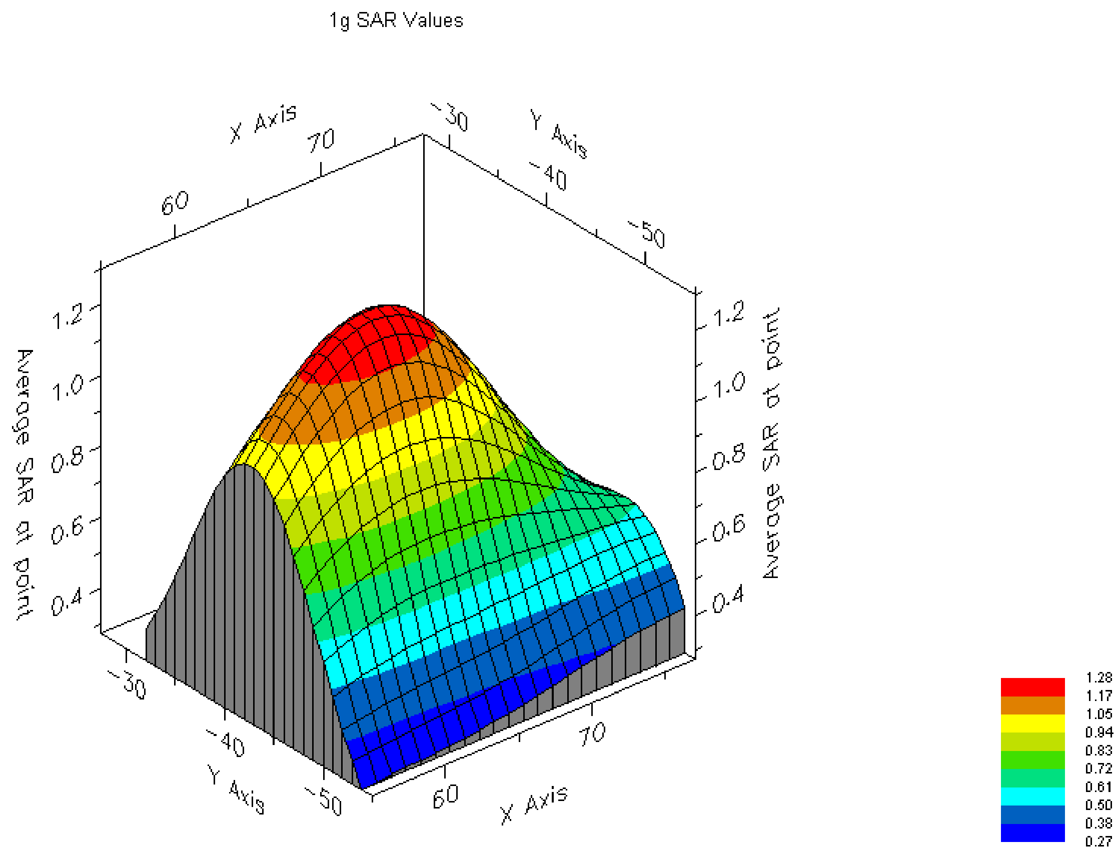


**Figure 5. Surface Plot of 1 gram Scan**


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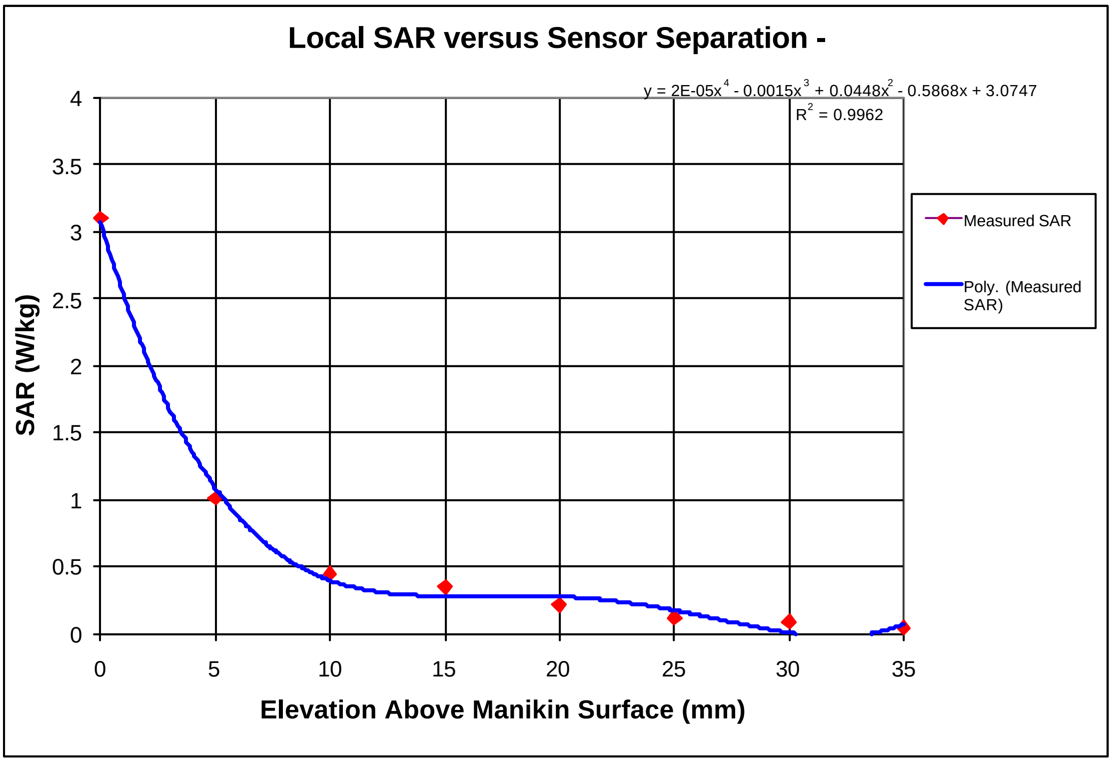


**Figure 6. Local SAR versus Sensor Separation (Head)**


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# APPENDIX B. Uncertainty Budget

| Calculated Uncertainties | | |
|---|---|---|
| **Type of Uncertainty** | **Specific to** | **Uncertainty** |
| Power variation due to battery condition | DUI | 0% |
| Extrapolation due to depth measurement | Setup | 3.8% |
| Conductivity | Setup | 2.9% |
| Permitivity | Setup | 1.0% |
| Probe Calibration | Setup | 6.0% |
| Probe Positioning | Setup | 1.0% |
| Probe Isotropicity | Setup | 1.5% |
| Other Setup Uncertainty (Ambient,,,) | Setup | 3.0% |
| | **17%** | **Expanded Uncertainty $K^2$** |

**Table 4. Uncertainty Budget**


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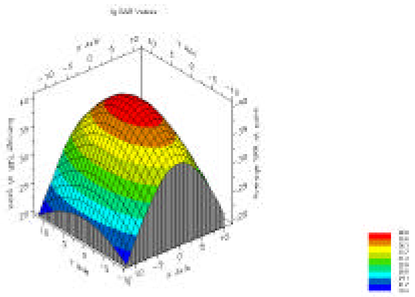
# APPENDIX C. Validation Scan



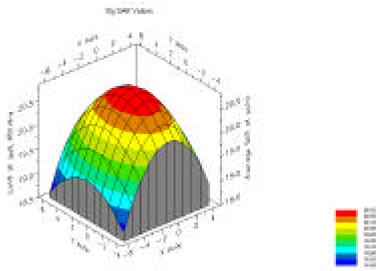


**Figure 7.**

**Contour Plot of 1 gram Validation Scan**

**Figure 8.**

**Surface Plot of 10 gram Validation Scan**

**Figure 9. 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 |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# 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**

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# 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


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## 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 | ISOTROPICITY | |
|---|---|---|
| MHz | [%] | [dB] |
| 835 | 2.20 | 0.095 |
| 1900 | 4.71 | 0.20 |


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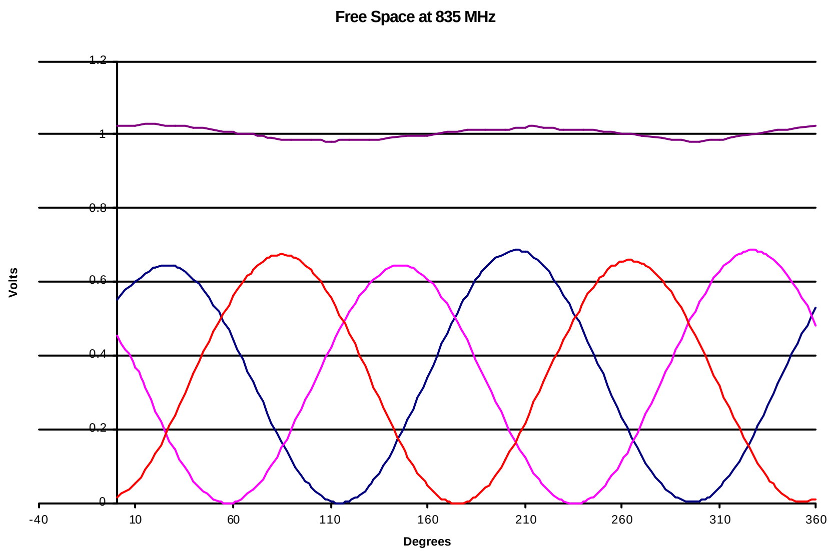


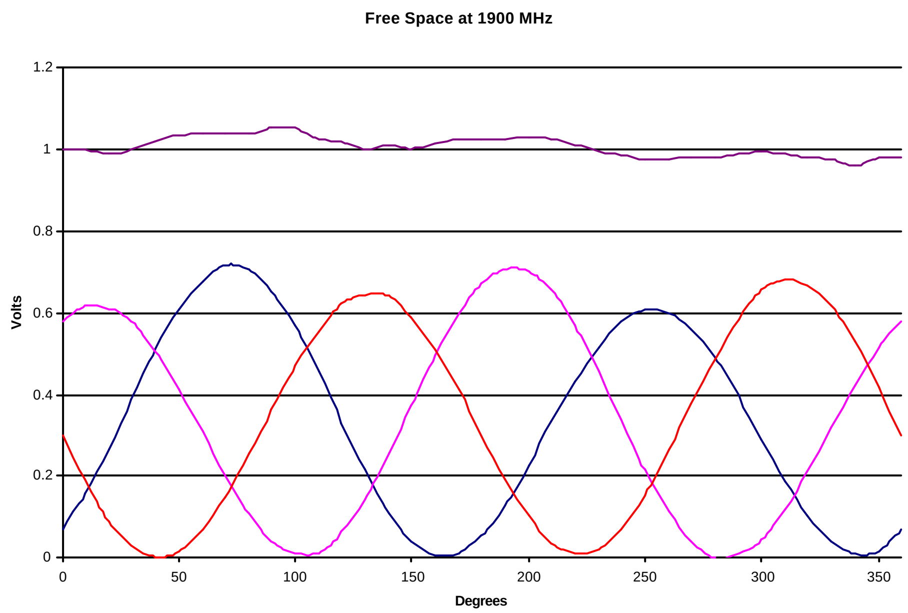



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**Validation Results:**

| 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 |


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