Certification Report on

Specific Absorption Rate (SAR)
Experimental Analysis

Good Technology Inc

G100 Wireless Corporate Messaging Device

Test Date: March 2002

GDTB-G100-SAR-3879

51 Spectrum Way Nepean ON K2R 1E6
Tel: (613) 820-2730 Fax: (613) 820-4161
email: info@aprel.com

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Experimental Analysis SAR Report

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

Product: G100 Wireless Corporate Messaging Device

Model: G100

Client: Good Technology Inc

Address: 1032 Morse Avenue
Sunnyvale,
California 94089

Project #: GDTB-G100-SAR-3879

Telecommunications Approval Board - Spectrum Sciences Institute
SAR Certified
APREL Laboratories
G-100

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

Approved by ____________________ Date: 19th March 2002
Stuart Nicol
Director Product Development, Dosimetric R&D

Submitted by ____________________ Date: March 19, 2002
Jay Sarkar
Technical Director of Standards & Certification

Released by ____________________ Date: April 3/02.
Dr. Jacek J. Wojcik, P. Eng.

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Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com

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FCC ID: PX3G100
Applicant: Good Technology Inc
Equipment: Wireless Corporate Messaging Device
Model: G100
Standard: FCC 96 –326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation, OET Bulletin 65 Supplement C 01-01

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on the G100 Wireless Corporate Messaging Device. The measurements were carried out in accordance with FCC 96-326. The G100 Wireless Corporate Messaging Device was evaluated for its maximum power level 5.85 W (896-901 MHz) and 2.67 W (901-902 MHz) ERP with a 9% duty cycle.

The G100 Wireless Corporate Messaging Device enables mobile professionals to always stay up-to-date with their company email and groupware when away from their desks.

The G100 Wireless Corporate Messaging Device was tested at low, middle and high channels for the keyboard up, keyboard down, for body, and hand, exposure. The maximum 10g SAR (1.4 W/kg) was found to coincide with the peak performance RF output power Mid channel (899.0125 MHz) for the Keyboard Down of the device. The hot spot is located at the top left-hand side of the device, near the area of the internal antenna. The maximum 1g SAR (1.19 W/kg) was found to coincide with the peak performance RF output power for the low channel (896.0125 MHz) for the Keyboard Down of the device while attached to the holster. The hot spot is located at the top left-hand side of the device, near the area of the internal antenna. The conservative SAR was measured with a separation distance of 11mm from the device to the phantom (physical dimension of the holster). 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 the 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 G100 Wireless Corporate Messaging Device. 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."

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3. DEVICE UNDER INVESTIGATION

- G100 Wireless Corporate Messaging Device , s/n JW0208000123, received on March 7th, 2002.

The G100 Wireless Corporate Messaging Device shall be called DUI (Device Under Investigation) in the following test report.

Frequency	Channel	Power
896.0125 MHz	Low	2.8 W
899.0125 MHz	Mid	2.8 W
902 MHz	High	1.4 W

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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
- APREL flat Phantom F1, Part # P-V-G8 (overall shell thickness 2mm)
- APREL 900 MHz Dipole Asset # 301459
- APREL RF Amplifier, AL-RF-A
- Hewlett Packard Signal Generator Asset
- R&S Power Meter
- Hewlett Packard Dual Directional Coupler
- APREL Universal Phantom P-UP-1

Instrument	Calibration Due	Asset Number/ Serial Number
E-010 Probe	28 November 2002	154
ALIDX-500	August 2001	NA
APREL Flat Phantom	NA	APL-001
APREL UniPhantom	NA	APL-085
APREL 835 MHz Dipole	12 December 2003	301463
APREL RF Amplifier	NA	301467
HP-Signal Generator	12 November 2002	301463
R&S Power Meter	September 2002	301451
R&S Power Sensor	September 2002	301461
HP Directional Coupler	10 October 2002	100251

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5. SET UP

5.1 ALIDX-500 Measurement System

The image below shows the laboratory along with the ALIDX-500 Measurement system.

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 course 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 course scan area and the values are logged. The user predefines the sample rate for which the measurements are made where the sample rate is converted into the time domain which envelopes the whole cycle of the Tx function for the given device.

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 asses 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, & 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.

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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.

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5.2 Validation

A full system validation was run prior to the SAR testing. The methodology used for the system validation was taken from IEEE P-1528 section 7 (where applicable). Further details of the tissue used during system the validation is provided in section 6.3 Simulated Tissue. The results from the system validation are provided in Annex A Measurement Results.

The image below shows the setup used for the system validation.

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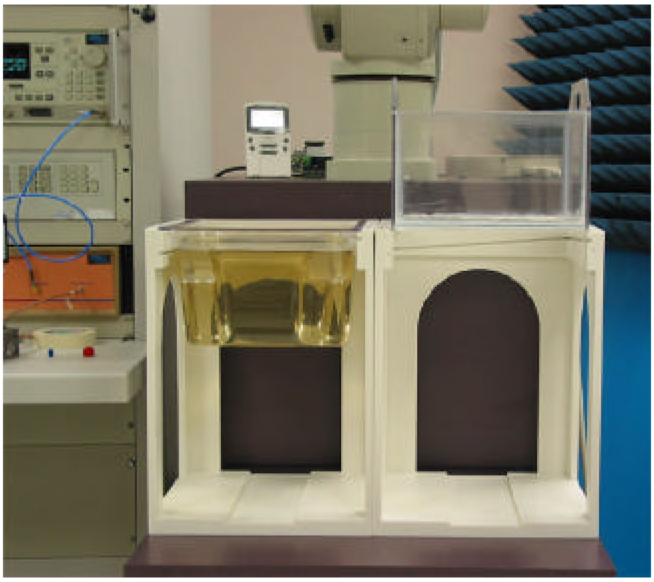
5.3 Body & Bystander Analysis

Measurements were made on the device using the APREL Universal Phantom, on the low, mid, and high channel of the device. The device was assed for the keyboard up and keyboard down permutations. The separation distance used was 0 mm for the conservative SAR assessment for the hand. A secondary assessment was executed on the device at the position and frequency for the conservative value using the supplied holster, which provided 11mm separation from the phantom. The results from this exercise are presented in section 6 test results.

The image below shows part of the setup used for body measurements.



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5.4 Simulated Tissue

The recipes used to make the simulated tissue was similar to those presented in "OET Supplement C" for body and consisted of the following ingredients,

BODY	Water	52.4%
	Salt	1.7%
	Sugar	44.68%
	HEC	1.0%
	PD7	0.02%

The density used to determine SAR from the measurements was the recommended 1.0 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 an Anritsu 37347A Vector Network Analyzer, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

BODY Tissue	APREL	Target Value	D (%)
Dielectric constant, ε_r	58	55	2
Conductivity, σ [S/m]	1.01	1.05	1
Tissue Conversion Factor,	4.8	-	-

Instrument	Calibration Due	Asset Number/Serial Number
Anritsu VNA	7 August 2002	Z0107643 TEMP
HP Slotted Line	NA	100195
APREL Slotted Line Probe	December 2002	APL-SLP-001

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5.5 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 (body).

   Section 5.4 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 conservative analysis for hand exposure. The DUI is positioned while located in the supplied holster against the phantom for body analysis.

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.

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6. TEST RESULTS

6.1. 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. The following table shows the RF power sampled before and after each scan.

Note

The power measurement is not conducted and only relative to a true pin on pin conducted measurement. The spectrum analyzer provides the technician with the functionality of viewing the actual received Tx Signal from the DUI. This allows the technician to monitor any drift in power during the test process, and as a result assess the delta if any. When the drift exceeds 5% the battery was recharged and the device re-measured.

TABLE 1. SAMPLED RF POWER

Type of Exposure	Scan Type	Power Readings (dBm)		D (dB)	Battery #
		Before	After		
Hand Exposure	Coarse	-14.56	-14.57	0.01	1
	Fine	-14.56	-14.57	0.01	1
Body Exposure	Coarse	-11.12	-11.16	0.04	1
	Fine - body	-11.12	-11.16	0.04	1

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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. 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 via communications software supplied by the manufacturer running on the DUI to control the channel and operating Tx power.

3) Appendix A provides contour plots for the SAR measurements on the DUI. Figure 1 provides the graphic plot for the conservative SAR measurement for hand analysis, while Figure 2 provides the conservative SAR measurement for body analysis.

4) Wide area scans were performed for the low, middle and high channels of the DUI. The DUI was operating at maximum output power (33 dB) with the duty cycle set at 9%. The DUI was placed up against the phantom during the test process. The phantom shell thickness is 2 mm overall.

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TABLE 2. SAR MEASUREMENTS

TYPE OF EXPOSURE	DUI side	Channel			Measured SAR	
		Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Hand	Keyboard Down	0mm	Middle	899.0125	3.95	1.4
Hand	Keyboard Down	0mm	High	901.9875	2.07	0.6
Hand	Keyboard Down	0mm	Low	896.0125	3.3	1.3
Body	Keyboard Down****	Holster	Middle	896.0125	0.86	0.40
	Keyboard Down****	Holster	Low	896.0125	1.19	0.45
	Keyboard Down****	Holster	High	901.9875	0.54	0.25
	Keyboard Down****	Holster	Middle	899.0125	0.95	0.43
	Keyboard Up****	Holster	Low	896.0125	0.79	0.34

******** Assessed at 11mm Separation (Dimension of Holster)
The Holster has metallic components used for the spring action.

6.3. USER'S HAND EXPOSURE

All subsequent testing for user's hand exposure was performed at Mid channel (899.0125 MHz) with the keyboard facing down from the phantom at 0mm separation distance. This relates to the position and frequency found to provide the maximum measured SAR value.

1) The device had an initial course scan executed to establish the location of the maximum peak SAR. A calculated resolution of 1mm was used to determine the location for the peak SAR.
2) The device was then explored on a refined 32 mm grid (Cube, Fine Scan) 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 a series of complex algorithms, which completes the matrix of calculated and measured values equivalent to a 1 mm resolution in the X, & Y planes.
3) The software runs a series of Lagrange functions to provide the data for the Z plane, which is inserted into the matrix.

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4) To complete the calculated matrix (1 mm resolution) a fourth order polynomial is used to extrapolate the surface values and the 1 and 10-gram averages are then calculated.

5) Conservative SAR value averaged over 10 grams for the hand analysis was found to be 1.4 W/kg.

6.4. BODY EXPOSURE

All subsequent testing for user's body exposure was performed at the Low channel (896.0125 MHz) with the keyboard facing out of the holster. The holster was up against the bottom of the phantom. This relates to the position and frequency found to provide the maximum measured SAR value.

1) The device had an initial course scan executed to establish the location of the maximum peak SAR. A calculated resolution of 1mm was used to determine the location for the peak SAR.
2) The device was then explored on a refined 32 mm grid (Cube, Fine Scan) 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 a series of complex algorithms, which completes the matrix of calculated and measured values equivalent to a 1 mm resolution in the X, & Y planes.
3) The software runs a series of Lagrange functions to provide the data for the Z plane, which is inserted into the matrix.
4) To complete the calculated matrix (1 mm resolution) a fourth order polynomial is used to extrapolate the surface values and the 1 and 10-gram averages are then calculated.
5) Conservative SAR value averaged over 1 gram for the body analysis was found to be 1.19 W/kg while attached to holster.

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7. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, determined for the Mid channel (899.0125 MHz) of the G100 Wireless Corporate Messaging Device , is 1.4 W/kg for the hand. The overall margin of uncertainty for this measurement is **±17.9%** (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 for the Low channel (896.0125 MHz) of the G100 Wireless Corporate Messaging Device is 1.19 W/kg. The overall margin of uncertainty for this measurement is **±17.9%** (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: March 7, 2002

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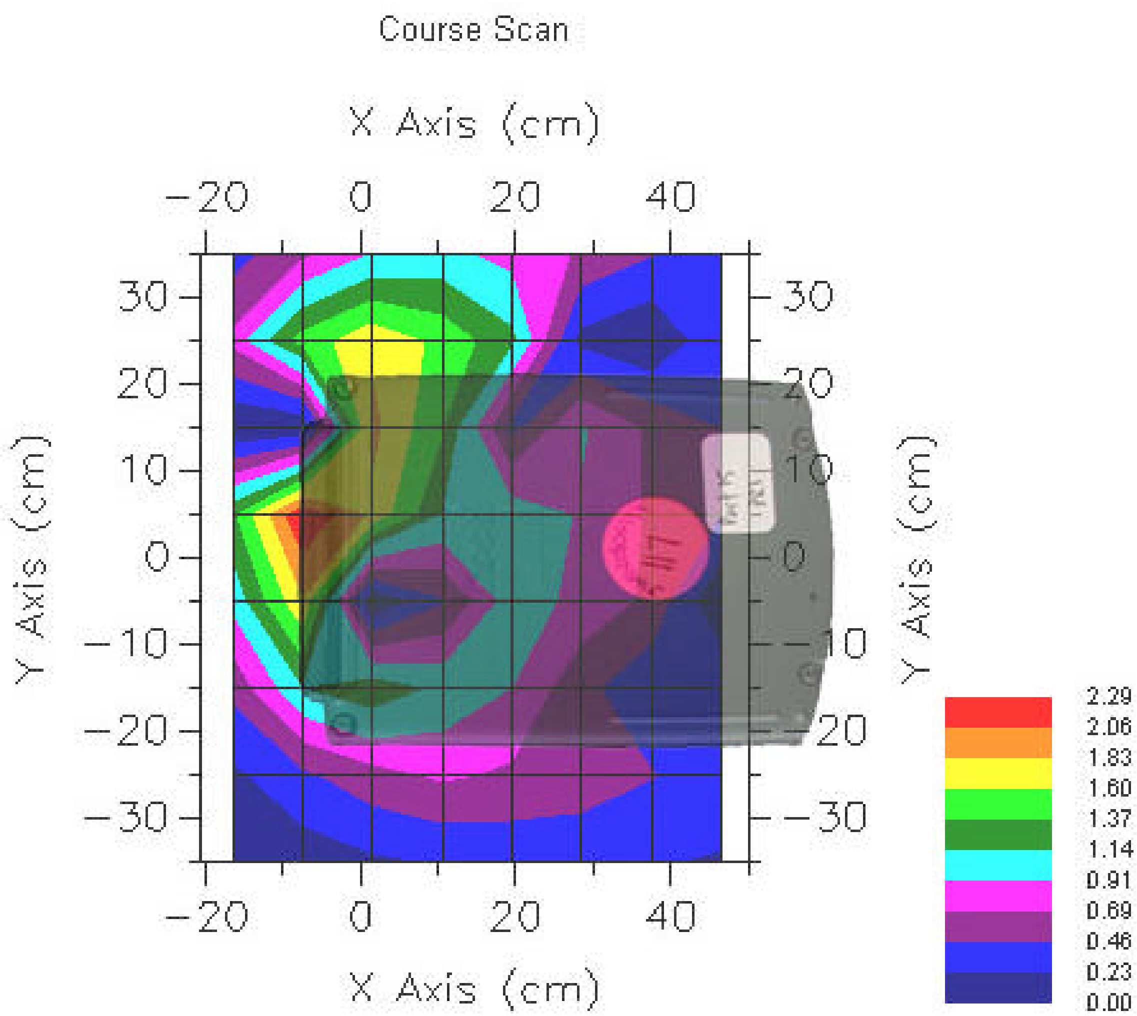
Appendix A: GRAPHIC PLOTS FOR SAR MEASUREMENTS

GRAPH 1

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Hand	Keyboard Down	0mm	Middle	899.0125	3.95	1.4



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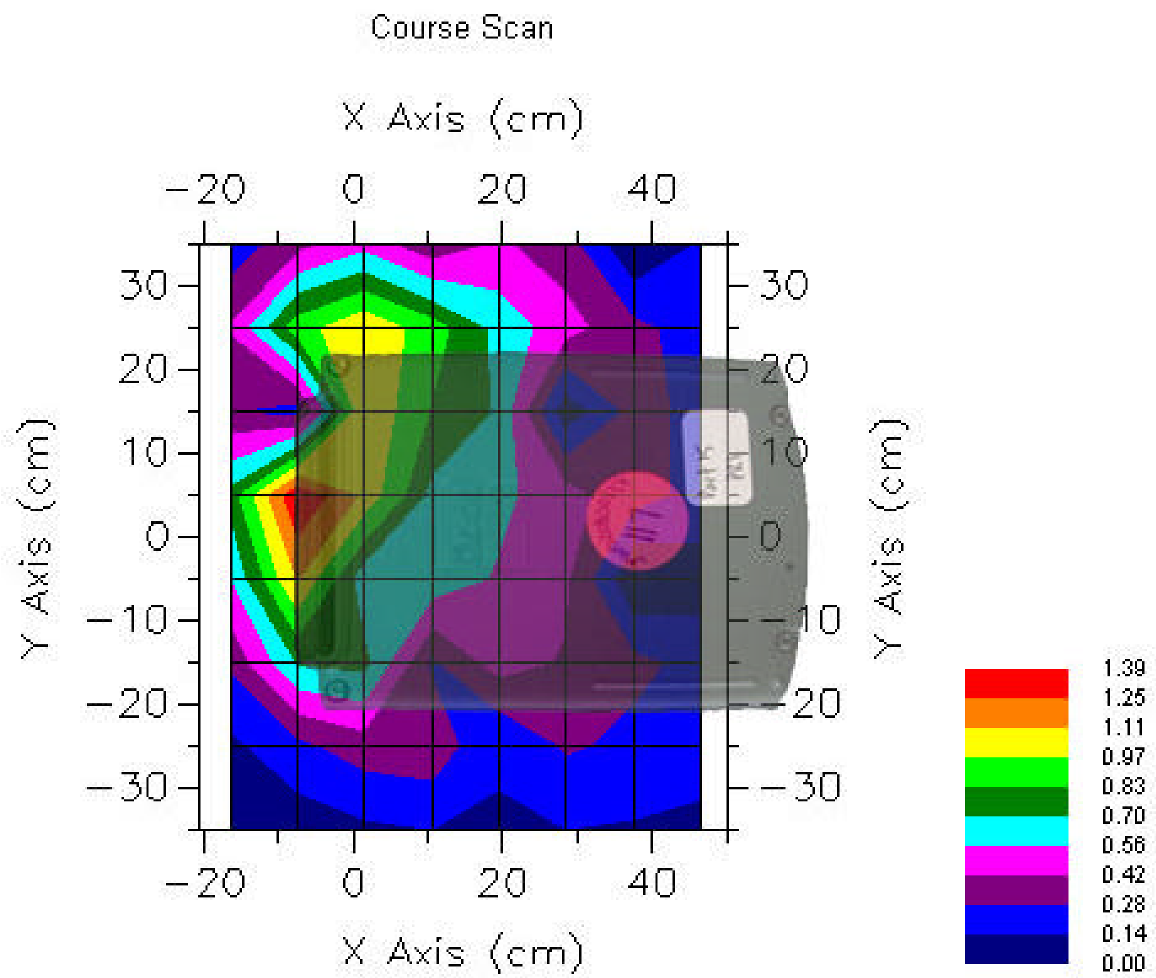
GRAPH 2

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Hand	Keyboard Down	0mm	High	901.9875	2.07	0.6



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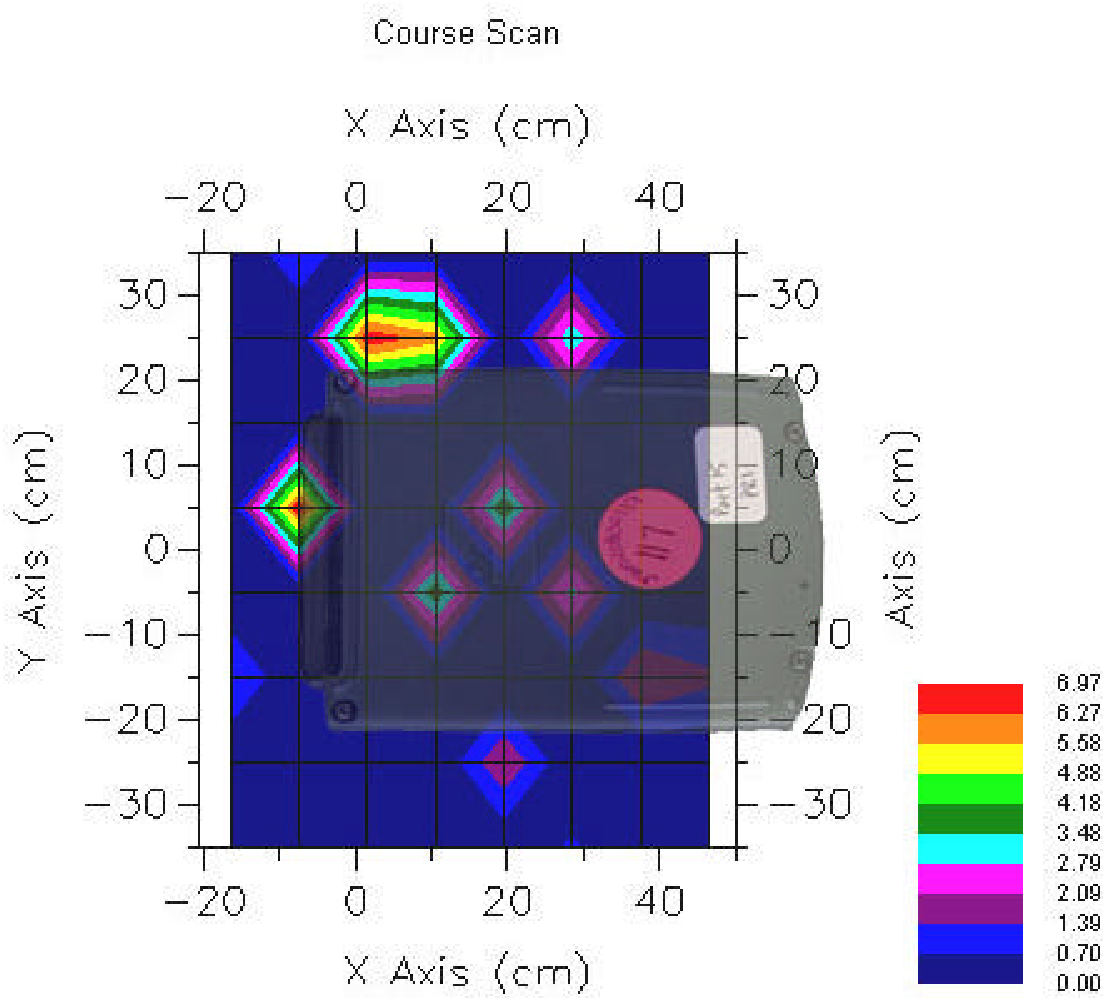
GRAPH 3

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Hand	Keyboard Down	0mm	Low	896.0125	3.3	1.3



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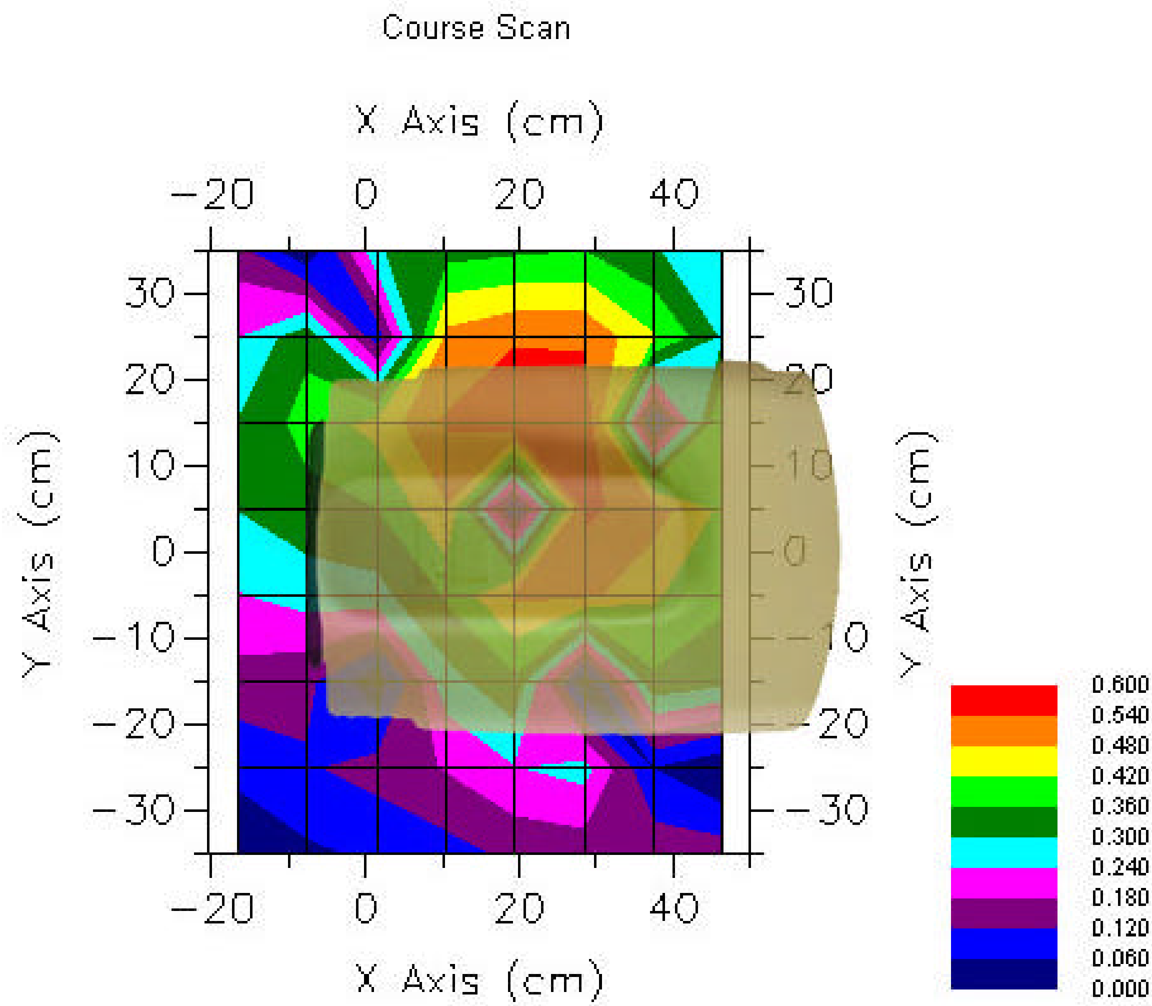
GRAPH 4

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Body	Keyboard Down****	Holster	Middle	896.0125	0.86	0.40



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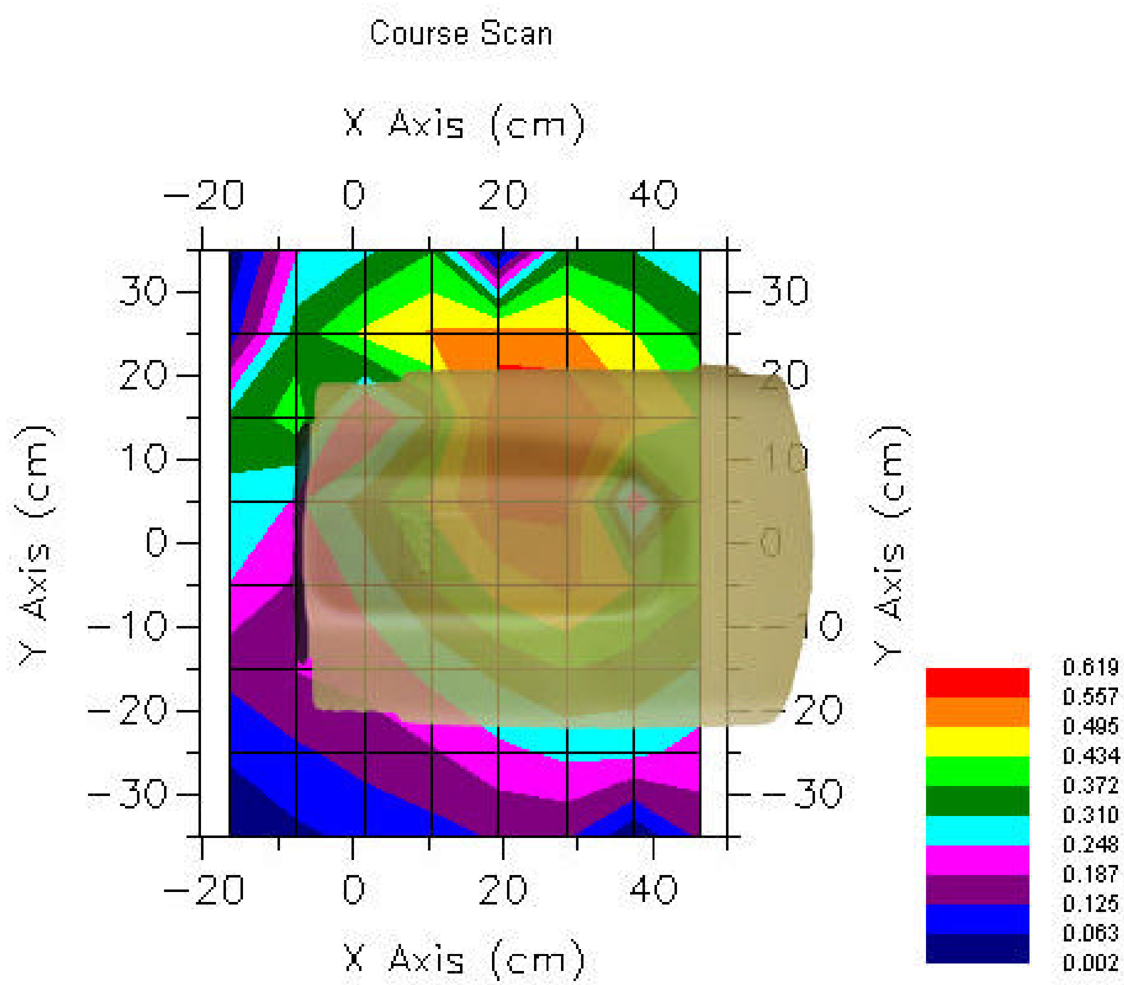
GRAPH 5

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Body	Keyboard Down****	Holster	Low	896.0125	1.19	0.45



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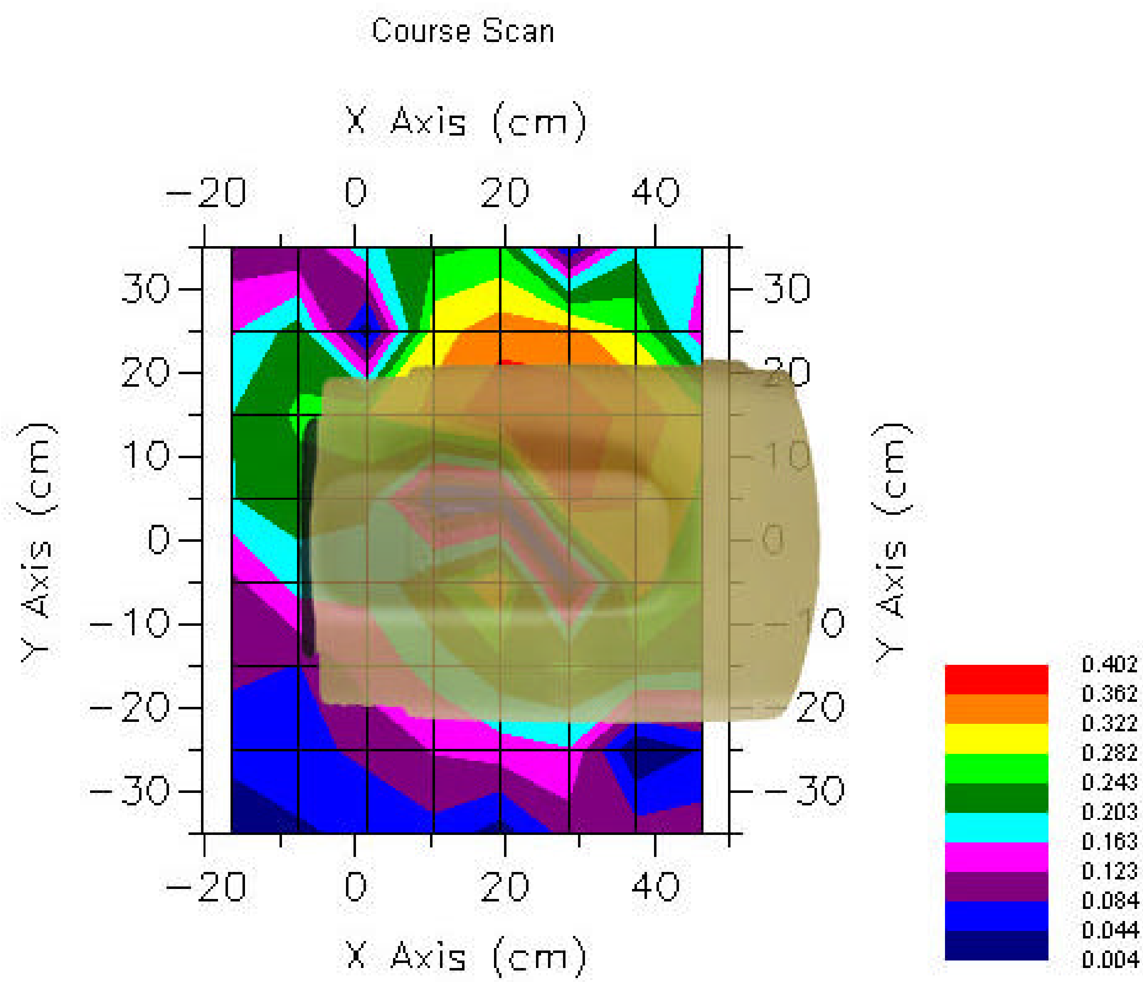
GRAPH 5

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Body	Keyboard Down****	Holster	High	901.9875	0.54	0.25



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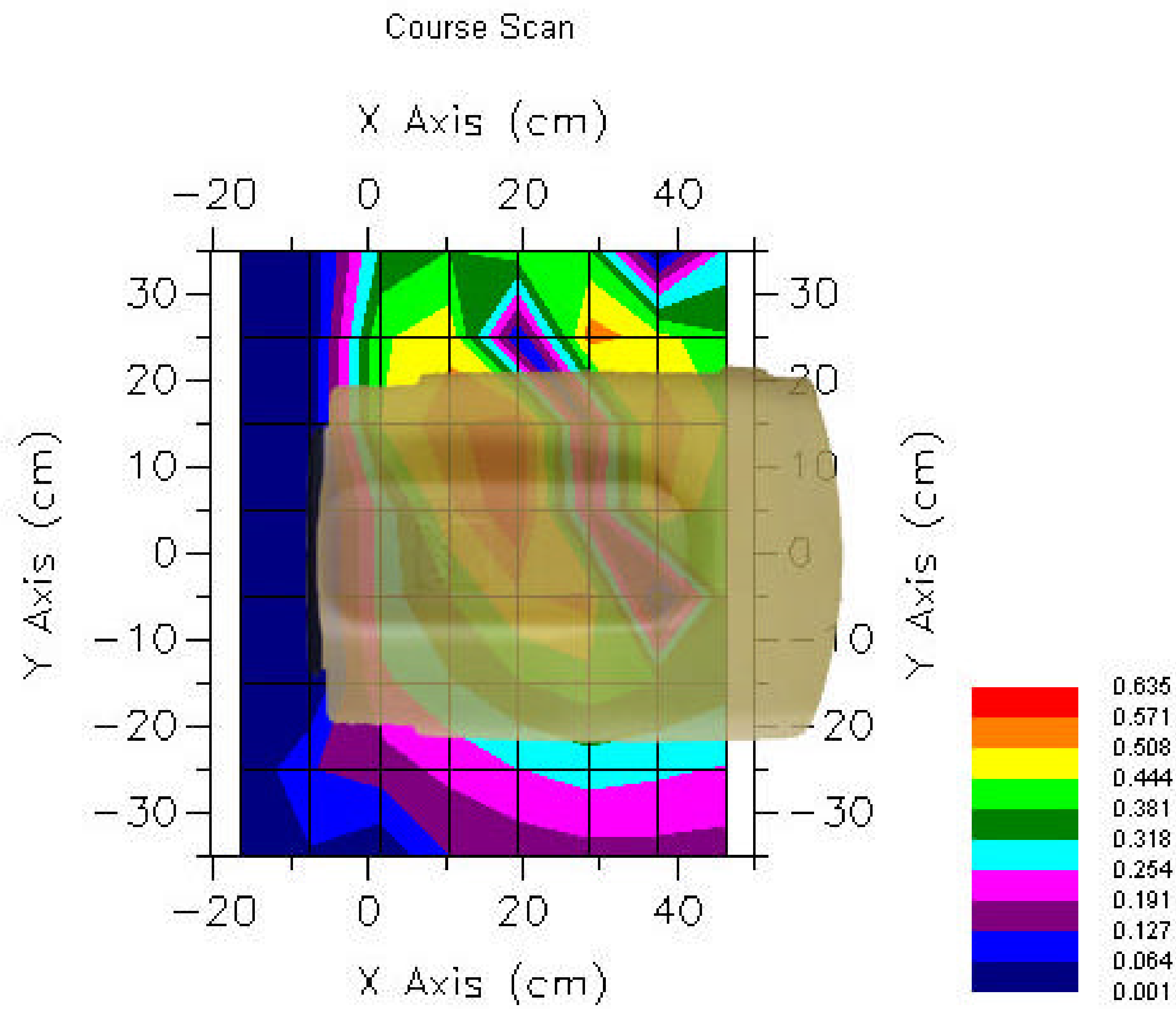
GRAPH 6

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Body	Keyboard Down****	Holster	Middle	899.0125	0.95	0.43



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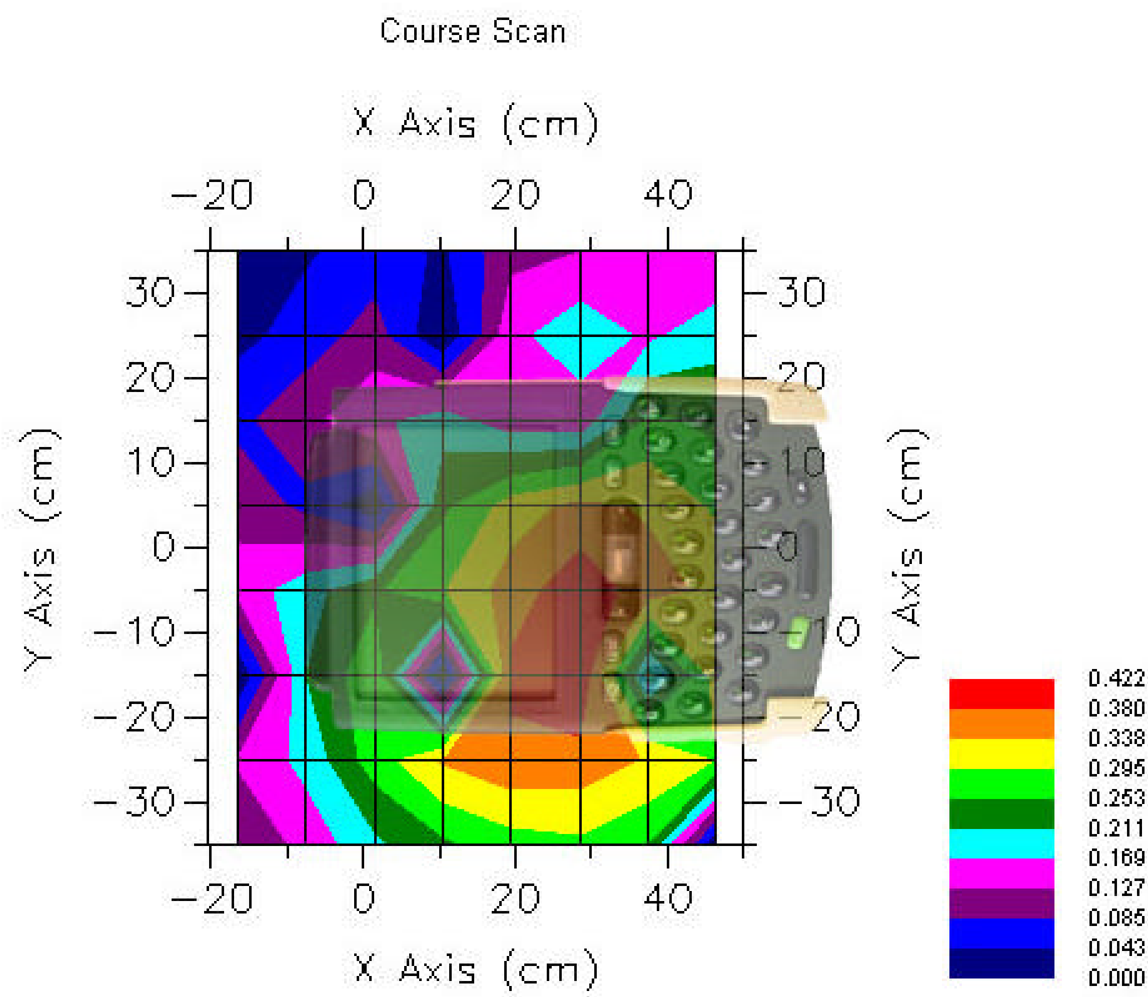
GRAPH 7

Exposure Type	Position	Holster Separation	L/M/H	Freq (MHz)	1g SAR	10g SAR
Body	Keyboard Up****	Holster	Low	896.0125	0.79	0.34



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VALIDATION SCAN

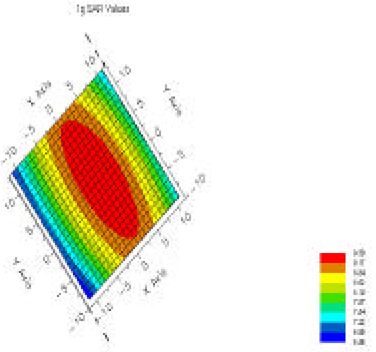

Figure 5. Contour Plot of 1 gram Validation Scan

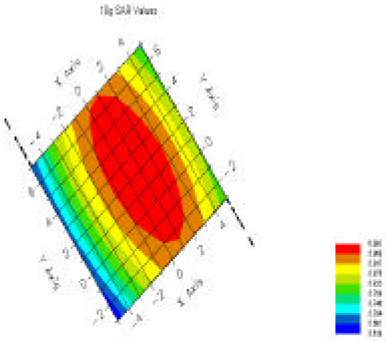

Figure 6. Surface Plot of 1 gram Validation

Frequency: 900 MHz
Input Power to Dipole: 1 W
Distance from Dipole to Tissue: 15 mm
Tissue Depth: 15 mm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
10.5	10.8	2

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
6.5	6.9	3

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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	1.0%
Permitivity	Setup	2.0%
Probe Calibration	Setup	6.0%
Probe Positioning	Setup	1.0%
Probe Isotropicity	Setup	2.5%
Other Setup Uncertainty (Ambient,,,)	Setup	4.0%
	17.9%	**Expanded Uncertainty K^2**

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Appendix C Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: 301485

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
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
CANADA K2R 1E6

Division of APREL Lab.
TEL: (613) 820-4988
FAX: (613) 820-4161

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ABBREVIATED RECORD FOR USE IN SAR REPORT

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:	Internal	
Calibration Procedure:	SSI/DRB-TP-D01-032	
Environmental Conditions:	Temp: 22.7 C	Humidity: 30% - 55%

EQUIPMENT 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 [º]
0.25	54.73

TISSUE TYPE [MHz]	FREQUENCY	DIELECTRIC CONSTANT	CONDUCTIVITY [S/m]	CONVERSION FACTOR [W/kg]
Brain	835	41.4	0.88	4.4
Brain	1900	39.59	1.36	7.900
Muscle	1900	51.83	1.48	8.100
Muscle	835	54.7	0.97	4.5

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

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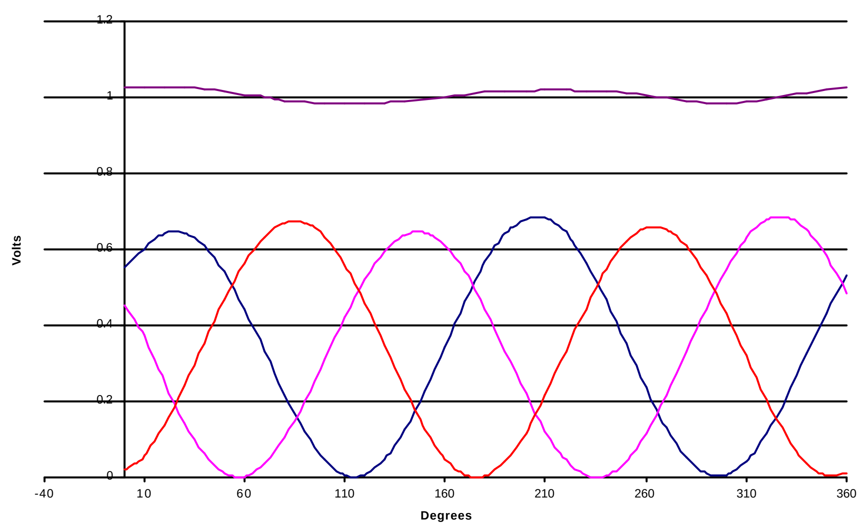
FREQUENCY MHz	ISOTROPICITY [%]	[dB]
835	2.20	0.095
1900	4.71	0.20



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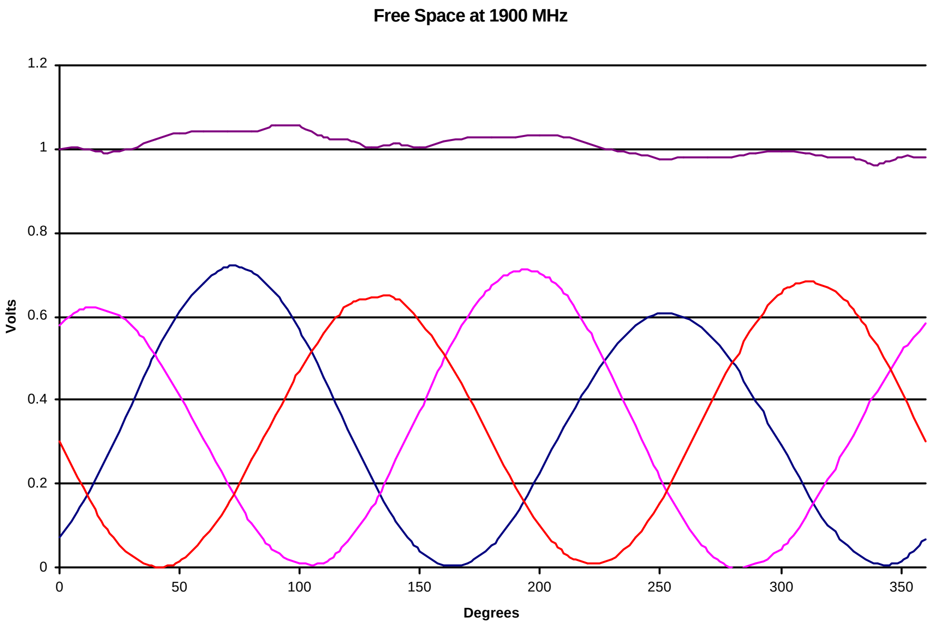

Validation Results:

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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