Certification Report on

Specific Absorption Rate (SAR)
Experimental Analysis

Chi Mei Communications Systems Inc.

Tri-Mode Cellular Phone
Bach

Test Date: December 2002

ITSD-CMS GSM 1900 Handset GPRS-3968A

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Experimental Analysis SAR Report

Subject: **Body & Direct Contact Specific Absorption Rate (SAR) Report**

FCC ID: QDJ-0212BAC01

Product: Tri-Mode Cellular Telephone

Model: Bach

Client: Chi Mei Communications Systems Inc

Address: C/O ITS Taiwan Ltd

Project #: ITSD-CMS GSM 1900 Handset GPRS-3968A

Prepared by: APREL Laboratories
51 Spectrum Way
Nepean, Ontario
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Approved by _____ Date: 10-01-03
Stuart Nicol
Director Product Development, Dosimetric R&D

Submitted by _____ Date: January 10, 2003
Jay Sarkar
Technical Director of Standards & Certification

Released by _____ Date: Jan 10/03
Dr. Jacek J. Wojcik, P. Eng.

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FCC ID: QDJ-0212BAC01
Applicant: Chi Mei Communications Systems Inc
Equipment: Tri-Mode Cellular Telephone
Model: Bach
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 CMCS Bach GPRS Tri-Mode Cellular Telephone (Handset), operating in PCS mode. The measurements were carried out in accordance with FCC 96-326. Scientific and technical procedures 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** of 29.7dBm using a secondary handset as supplied by the manufacturer with an SMA connector permanently attached so as to make conducted power measurements. The manufacturer has supplied APREL laboratories with a letter of attestation, stating that both models have been manufactured using the same production process. A copy of this letter is contained as an appendix. The CMCS Cellular Telephone can operate with GPRS but for the purpose of this analysis only one Tx slot was used with a 1/8 duty cycle. The end user shall not be able to change the duty cycle. The CMCS Bach GPRS Tri-Mode Cellular Telephone is a Handheld unit with an external antenna.

The CMCS Bach GPRS Tri-Mode Cellular Telephone was tested at low (ch#512), middle(ch#661) and high(ch#810) channels for body-worn exposure and direct contact SAR.

For body exposure, the maximum **1g SAR was found to be 0.37 W/kg** for the peak RF output power on the high channel (ch#810, 1909.8 MHz) with zero separation.

For direct contact exposure, the maximum **10g SAR was found to be 0.17 W/kg** for the peak RF output power on the high channel (ch#810, 1909.8 MHz) with zero separation.

The CMCS Bach GPRS Tri-Mode Cellular Telephone **will not be supplied** with either a belt-clip or holster for use with the headset (body-worn application).

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 evaluated.

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) for a sample CMCS Bach GPRS Tri-Mode Cellular Telephone (Handset). These tests were conducted at APREL Laboratories facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup is contained within this report.

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

- CMCS Bach Tri Mode GPRS Cellular Telephone , received on December 15th 2002.

The CMCS Bach GPRS Tri-Mode Cellular Telephone shall be called DUI (**D**evice **U**nder **I**nvestigation) in the following test report.

Table 1: Measured Transmitted Power

Frequency MHz	Channel #	L/M/H	Conducted Power
1850.2	512	Low	29.7
1880	661	Mid	29.7
1909.8	810	High	29.7

DUI: CMCS Bach Tri Mode GPRS Cellular Telephone

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4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-010, s/n 163
- ALIDX-500 Dosimetric SAR Measurement System
- APREL flat Phantom F1, Part # P-V-G8 (overall shell thickness 2mm)
- APREL 1.9 GHz Dipole
- APREL RF Amplifier
- Hewlett Packard Signal Generator
- Gigatronics Power Meter
- Gigatronics Power Sensor
- Hewlett Packard Dual Directional Coupler
- R&S CMD55 Radio Communications Testset

Table 2: Instrumentation

Instrument	Calibration Due	Asset Number/Serial Number
E-010 Probe	May 2003	163
ALIDX-500	March 2003	N/A
APREL Flat Phantom	N/A	APL-001
APREL UniPhantom	N/A	APL-085
APREL 2450MHz Dipole	CBT	N/A
APREL RF Amplifier	CBT	301467
HP-Signal Generator	September 2003	301468
Gigatronics Power Meter	September 2003	301393
Gigatronics Power Sensor	April 2003	301394
HP Directional Coupler	October 2003	100251
R&S CMD55	NCR	301496

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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 (0.05 mm 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 so as to ensure that the full duty-cycle of a pulse modulation device is covered during the sample. The following algorithm is an example of the function used by the system for linearization of the output for the probe.

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

The APREL E-Field probe is evaluated to establish the diode compression point.

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 1 g and 10 g averages.

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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.

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 evaluation of the CMCS handset. The methodology used for the system validation was taken from IEEE P-1528 section 7 (where applicable). Further details of the tissue used during the system validation are 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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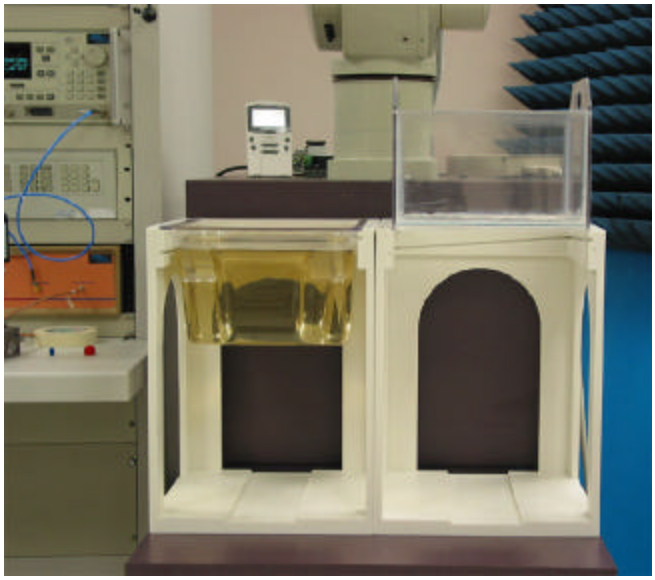
5.3 Body & Bystander Analysis

Measurements were made on the CMCS handset using the APREL Universal Phantom, on the low, mid, and high channels. The separation distance used was 0mm for the conservative SAR assessment.

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 were as presented in OET Supplement C.

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, and the APREL Dielectric Probe.

Table 3: Properties of the Tissue

BODY Tissue	APREL	Target Value	D (%)
Dielectric constant, ε_r	52.15	54	-3.4
Conductivity, σ [S/m]	1.45	1.45	-4.6
Tissue Conversion Factor,	5.8	-	-
Tissue Temperature (ºC)	20	-	-

Table 4: Tissue Calibration Instrumentation

Instrument	Calibration Due	Asset Number/Serial Number
Anritsu VNA	CBT	301382
APREL Dielectric Probe	CBT	-

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5.5 Methodology

1. The test methodology utilized in the analysis of the CMCS handset 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).

$$SAR = \frac{s\,|\mathbf{E}|^2}{r}$$

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 an initial conservative 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 a sample DUI which was provided by CMCS to APREL for conducted power measurements was connected to the R&S CMD55 and set to transmit continuously for 30 minutes, at the low, mid, and high channels.

The power was measured at the inception of the call between the DUI and the communications tester while transmitting at the desired channel at high power (1W 30 dB as per the PCS standard) and then measured again after 30 minutes. A final measurement was made using the above methodology on the device after 45 minutes and the results are presented in the table below.

Note

Two devices were presented to APREL, which the manufacturer has attested to being manufactured to the same production specifications. One of the devices was used to gauge conducted power drift prior to SAR analysis while the other was used during the SAR assessment.

Channel	Frequency MHz	Power at 30 Minutes dB	Power at 45 Minutes dB
512 Low	1850.2	29.7	29.6
661 Mid	1880	29.7	29.6
810 High	1909.8	29.7	29.6

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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 the R&S CMD55 radio communications test set, which emulates a base station. The CMD55 controls the DUI operation frequency, slot, and power during the SAR analysis.

3) Table 6 provides the details in tabular form of the full measurement analysis, which was performed on the DUI. Appendix A provides contour plots of the SAR measurements on the DUI. A digital image of the device is presented as an overlay superimposed onto the contour plot for visualization purposes in Appendix A.

4) Wide area scans were performed for the low, middle and high channels of the DUI while the device was positioned against the phantom with zero separation distance following the protocols contained in IEEE P-1528 and FCC Supplement C. The DUI was operating with maximum output power and a duty cycle of 1/8.

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6.3. DIRECT CONTACT SAR

All subsequent testing for the direct contact SAR (user's hand exposure) was performed on three channels (low: 1850.2 MHz, middle: 1880 MHz, high: 1909.8 MHz) at the optimum position - with the side (side up device closed) of the device where the antenna was located placed against the phantom at 0mm separation distance. The results are presented in Table 6.

1) The device had an initial area scan executed to establish the location of the peak SAR. A calculated resolution of 1 mm was used to determine the location for the maximum 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 extrapolation is used to compute the surface values and the 1 and 10-gram averages are then calculated.
5) Where two (or more) peaks with similar values are measured the location of the peaks is recorded. A refined grid is then created to asses each peak location individually, and the maximum value from the assessment is used to record conservative SAR for this report.
6) The highest conservative SAR value averaged over 10 grams for the direct contact exposure (user's hand exposure) analysis was found to be 0.21W/kg at the high channel 1909.8 MHz (Table 6).

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6.4. BODY EXPOSURE

All subsequent testing for body SAR was performed on three channels (low: 1850.2 MHz, middle: 1880 MHz, high: 1909.8 MHz) at the optimum position - with the antenna facing up at 0mm separation with the handset closed. The results are presented in Table 6.

1) The device had an initial area scan executed to establish the location of the peak SAR. A calculated resolution of 1mm was used to determine the location for the maximum 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 (1mm resolution) a fourth order polynomial is used to extrapolate the surface values and the 1 and 10-gram averages are then calculated.
5) Where two (or more) peaks with similar values are measured the location of the peaks is recorded. A refined grid is then created to asses each peak location individually, and the maximum value from the assessment is used to record conservative SAR for this report.
6) The highest conservative SAR value averaged over 1 gram for the body exposure was found to be 0.37W/kg at the high channel 1909.8 MHz with a 0 mm separation distance (Table 6).

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Table 6: SAR Measurement Results

Type of Exposure	DUI Side	Separation	Phantom	Channel			SAR (W/kg)
				L/M/H	Ch #	Freq (MHz)	
Body Exposure	Antenna Up	Zero	Uni	Low	512	1850.2	0.35 1g
	Antenna Up	Zero	Uni	Middle	661	1880	0.36 1g
	Antenna Up	Zero	Uni	High	810	1909.8	0.37 1g
	Antenna Down	Zero	Uni	Low	512	1850.2	0.20 1g
	Antenna Down	Zero	Uni	Middle	661	1880	0.22 1g
	Antenna Down	Zero	Uni	High	810	1909.8	0.29 1g
Direct Contact Exposure	Antenna Up RHS	Zero	Uni	Low	512	1850.2	0.19 10g
	Antenna Up RHS	Zero	Uni	Middle	661	1880	0.19 10g
	Antenna Up RHS	Zero	Uni	High	810	1909.8	0.21 10g

Note: No belt-clip was tested, or any additional separation distance due to the conservative measured SAR.

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7. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, measured on the high channel 1909.8 MHz for assessed for direct contact SAR, is 0.21 W/kg (direct contact SAR for the exposed extremities – hands, wrists, feet and ankles). The overall margin of uncertainty for this measurement is **±17.7% K=2 (**Appendix D). The SAR limit given in the FCC 96-326 Safety Guideline is 4.0 W/kg for direct contact exposure for the general population.

The maximum Specific Absorption Rate (SAR) averaged over 1 gram, measured on the low channel 1909.8 MHz for Body SAR at a separation distance of 0 mm is 0.37 W/kg. The overall margin of uncertainty for this measurement is **±17.8% K=2** (Appendix D). 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 18th, 2002

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Appendix A

TEST DATA AND GRAPHIC PLOTS

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SAR Data Report cmcs-High-body-antenna-up

Start : 16-Dec-02 04:32:50 pm
End : 16-Dec-02 04:58:56 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1909.8 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=30.0 y=-37.0 = 0.33 W/kg
Zoom Scan - Max Local SAR Value at x=30.0 y=-37.0 z=0.0 = 0.75 W/kg
Max 1g SAR at x=30.0 y=-37.0 z=0.0 = 0.37 W/kg
Max 10g SAR at x=30.0 y=-37.0 z=0.0 = 0.16 W/kg

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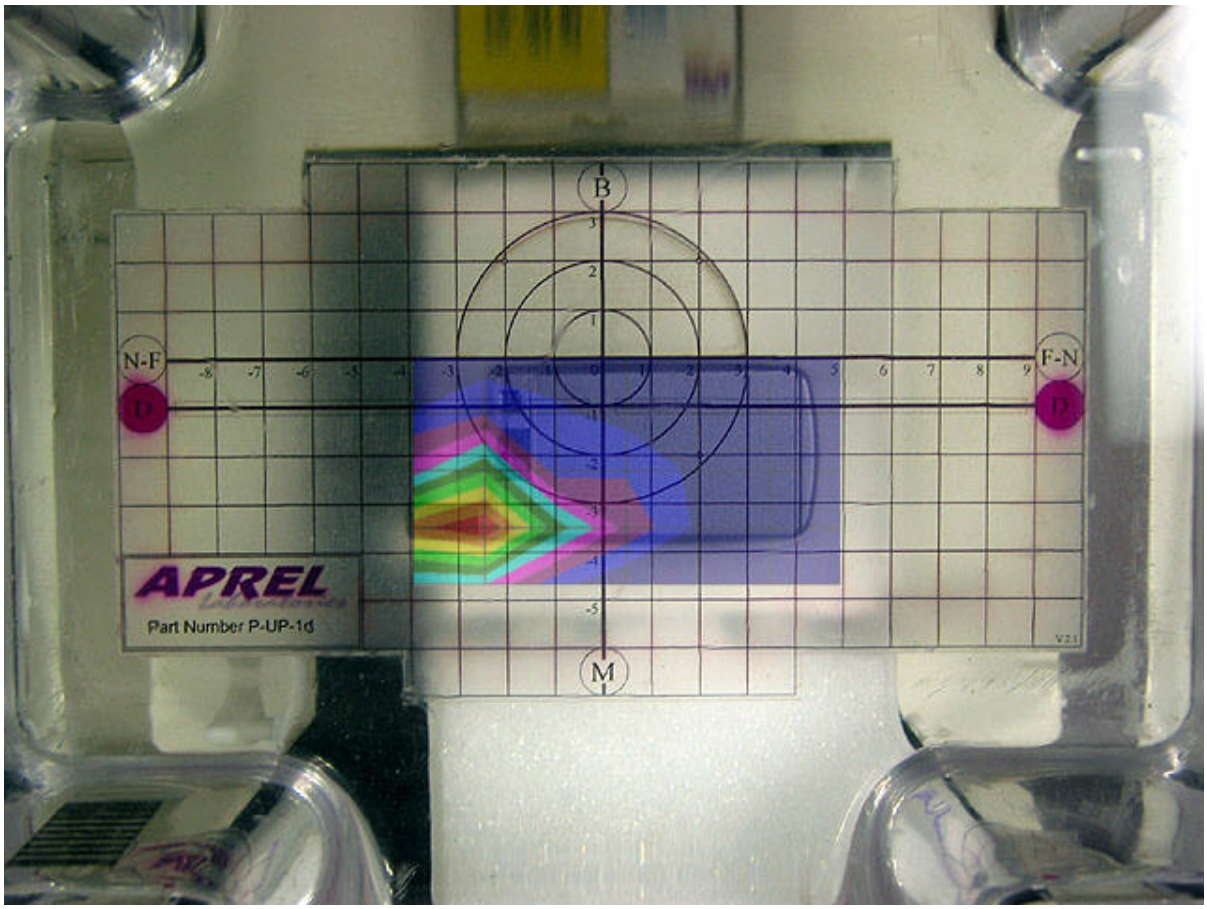
Graph 1 Body Antenna Up



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1909.8	810	20	Uni Zero	1.45	41.45	5.95	0.37

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SAR Data Report cmcs-Mid-body-antenna-up

Start : 16-Dec-02 02:32:50 pm
End : 16-Dec-02 02:58:56 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1850.2 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=29.0 y=-4.0 = 0.22 W/kg
Zoom Scan - Max Local SAR Value at x=28.0 y=-3.0 z=0.0 = 0.77 W/kg
Max 1g SAR at x=28.0 y=-3.0 z=0.0 = 0.36 W/kg
Max 10g SAR at x=27.0 y=-3.0 z=0.0 = 0.17 W/kg

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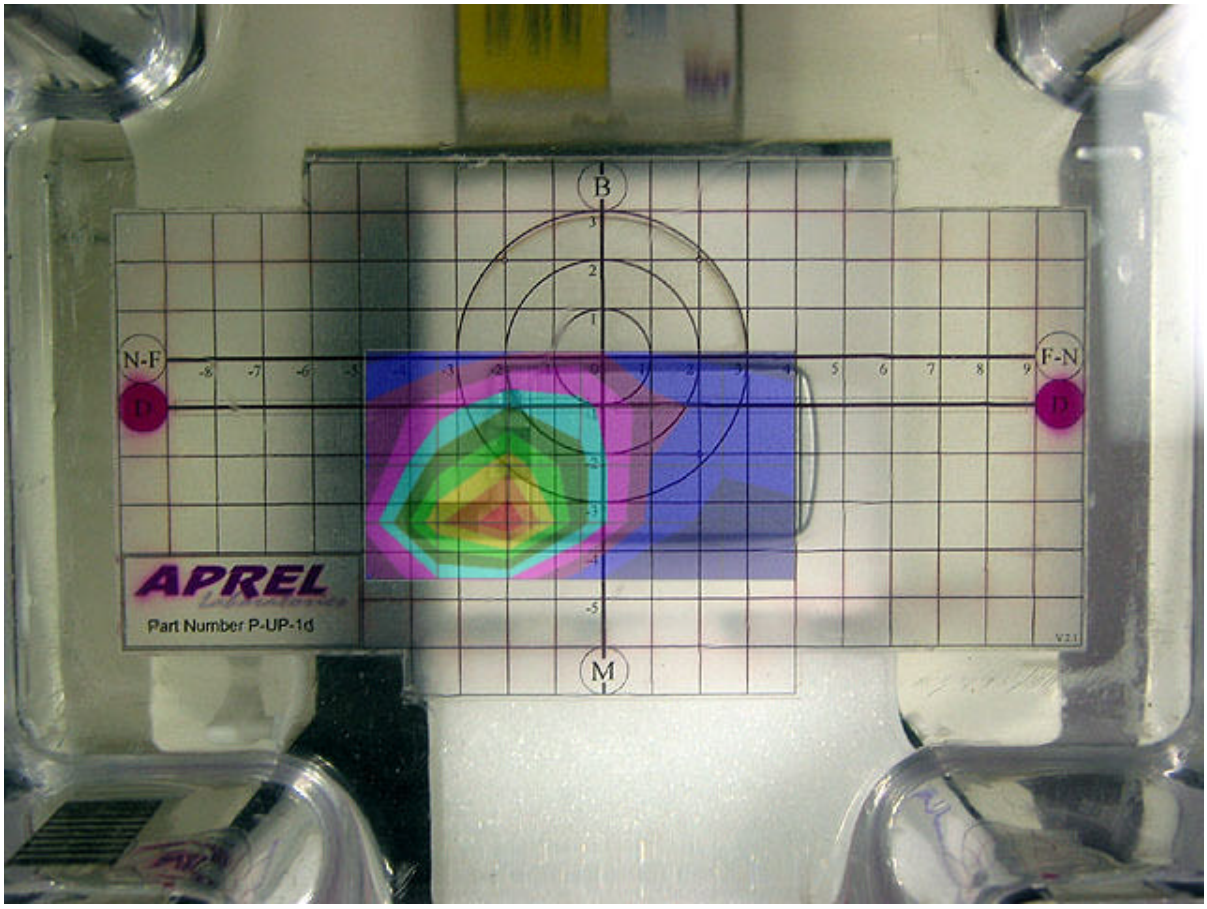
Graph 2 Body Antenna Up



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1880	661	20	Uni Zero	1.45	41.45	5.95	0.36

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SAR Data Report cmcs-low-body-antenna-up

Start : 16-Dec-02 01:32:50 pm
End : 16-Dec-02 01:38:56 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1850.2 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.32 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 0.73 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.35 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.16 W/kg

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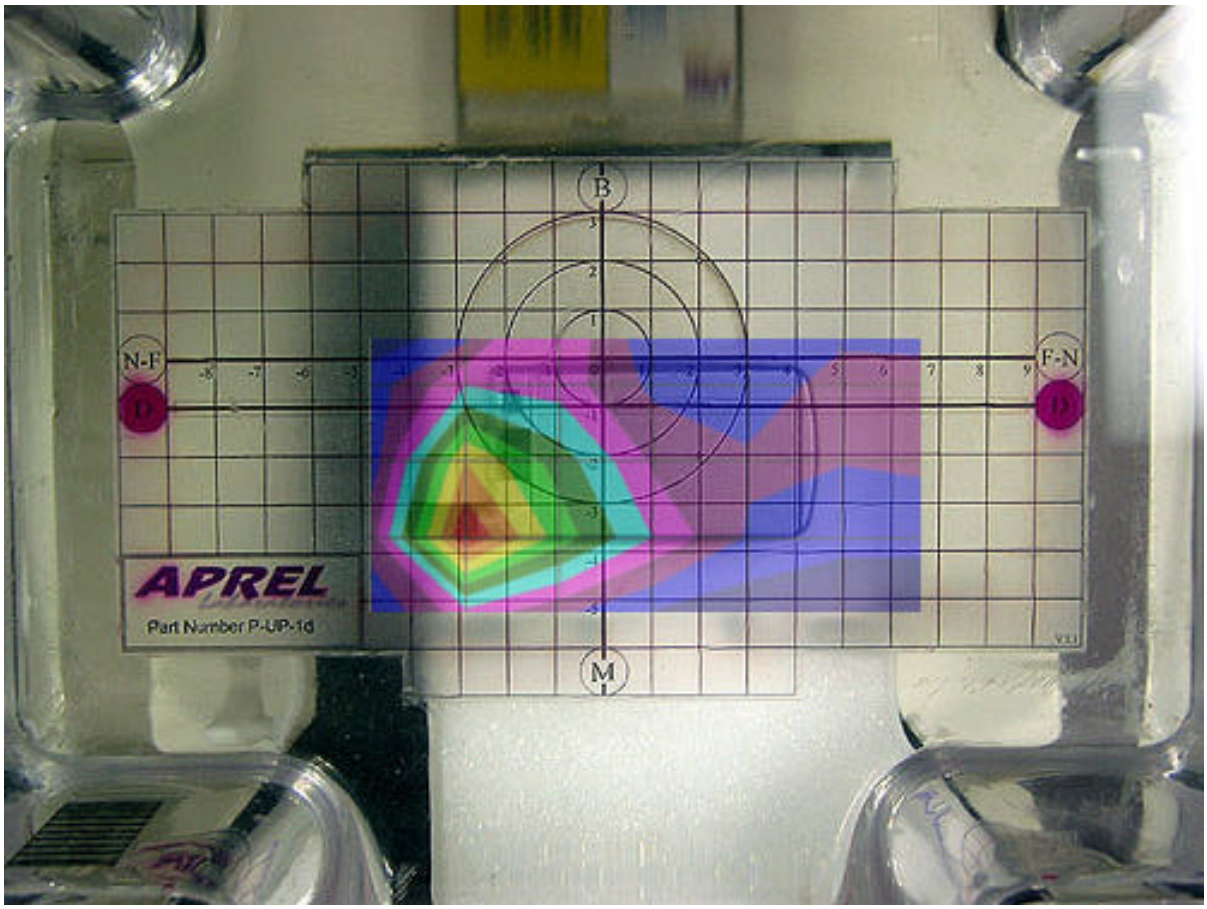
Graph 3 Body Antenna Up



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1850.2	512	20	Uni Zero	1.45	41.45	5.95	0.35

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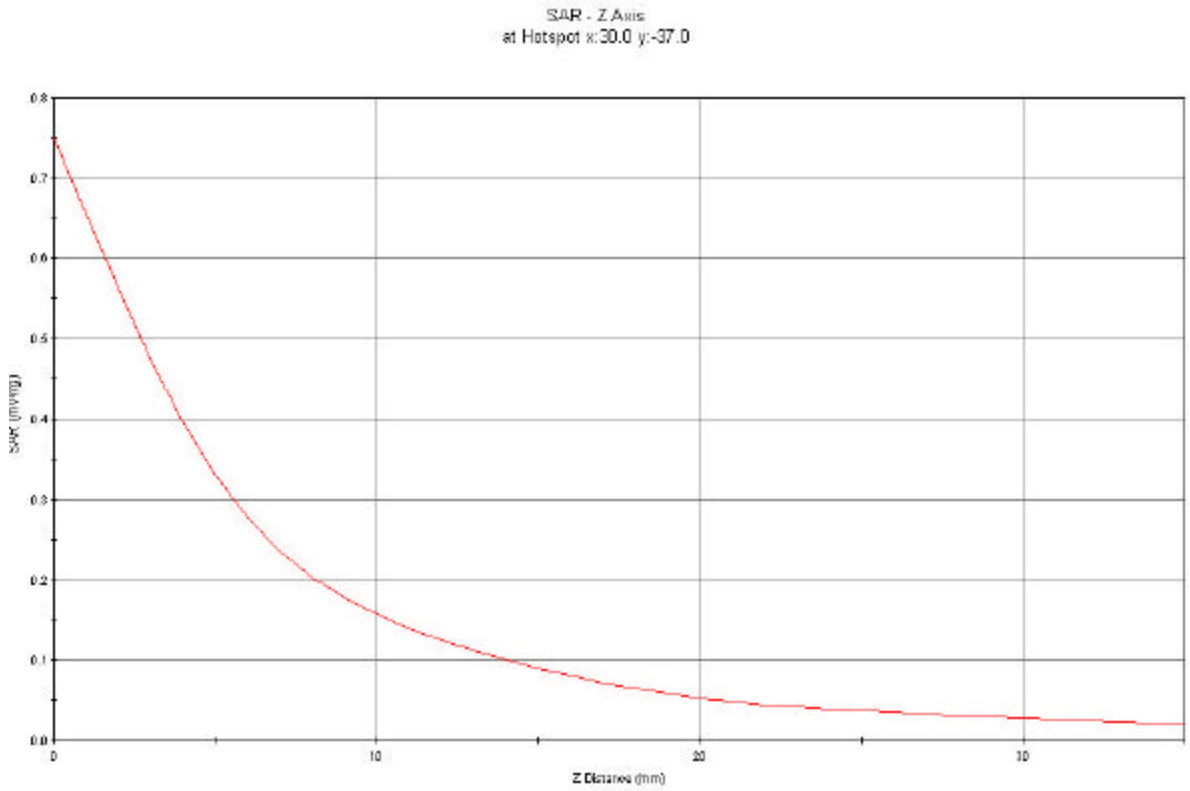
Body Analysis Z Height Conservative Scan High Channel 1909.8 MHz



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SAR Data Report cmcs-low-body-antenna-down

Start : 16-Dec-02 05:32:50 pm
End : 16-Dec-02 05:48:56 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1850.2 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.22 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 0.61 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.20 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.09 W/kg

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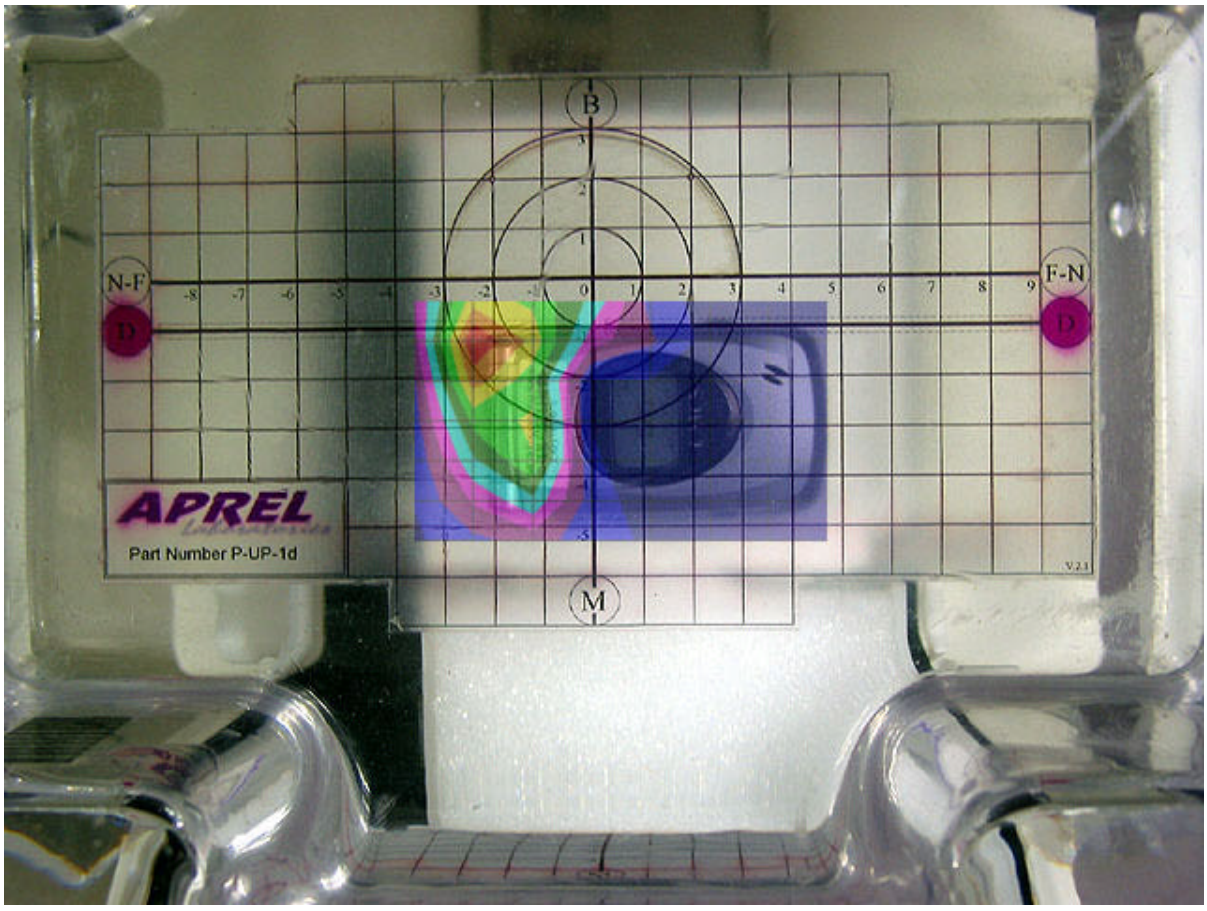
Graph 4 Body Antenna Down



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1850.2	512	20	Uni Zero	1.45	41.45	5.95	0.20

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SAR Data Report cmcs-mid-body-antenna-down

Start : 16-Dec-02 01:02:50 pm
End : 16-Dec-02 01:18:56 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1880 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.22 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 0.56 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.22 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.11 W/kg

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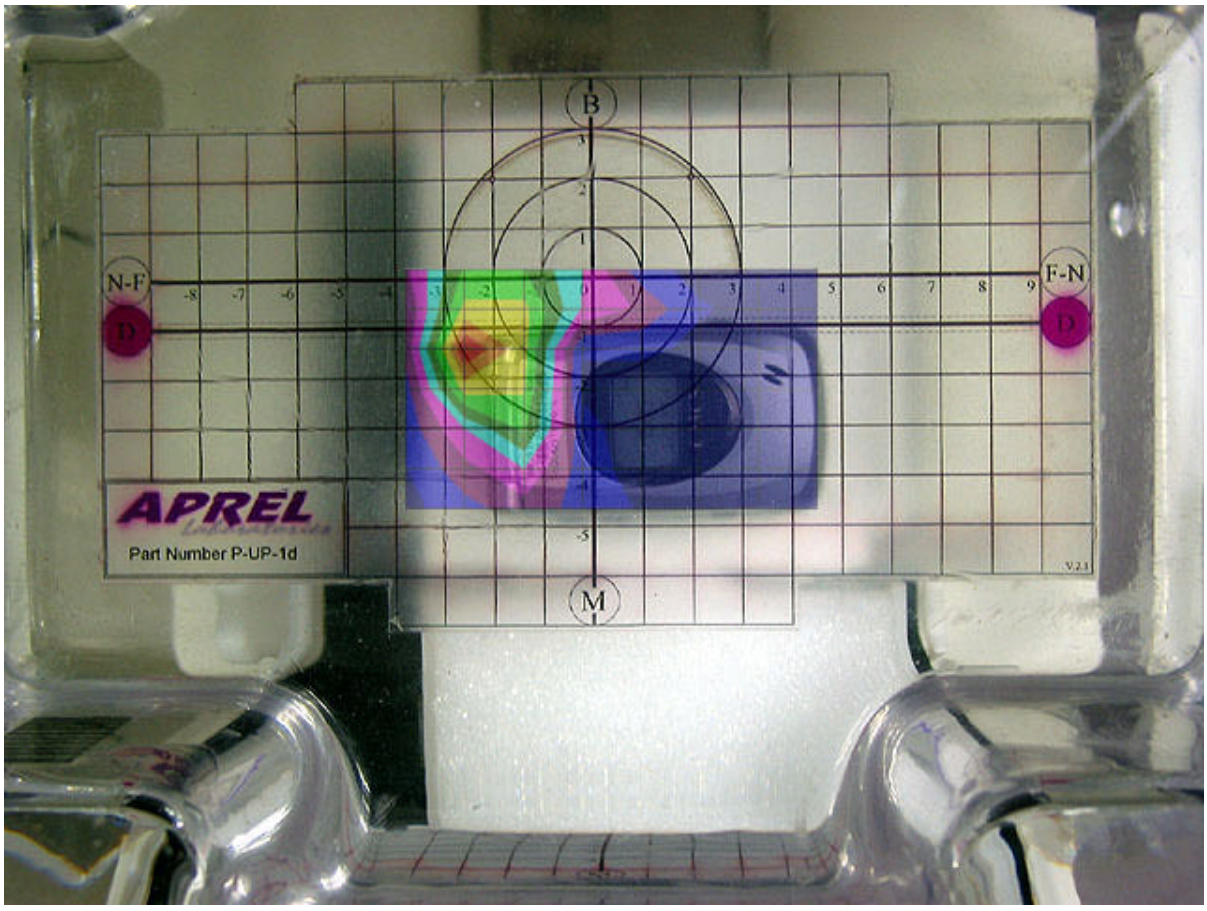
Graph 5 Body Antenna Down



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1880	661	20	Uni Zero	1.45	41.45	5.95	0.22

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SAR Data Report cmcs-high-body-antenna-down

Start : 16-Dec-02 11:35:40 am
End : 16-Dec-02 05:51:55 am
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1850.2 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1909.8 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.39 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 0.71 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.29 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.19 W/kg

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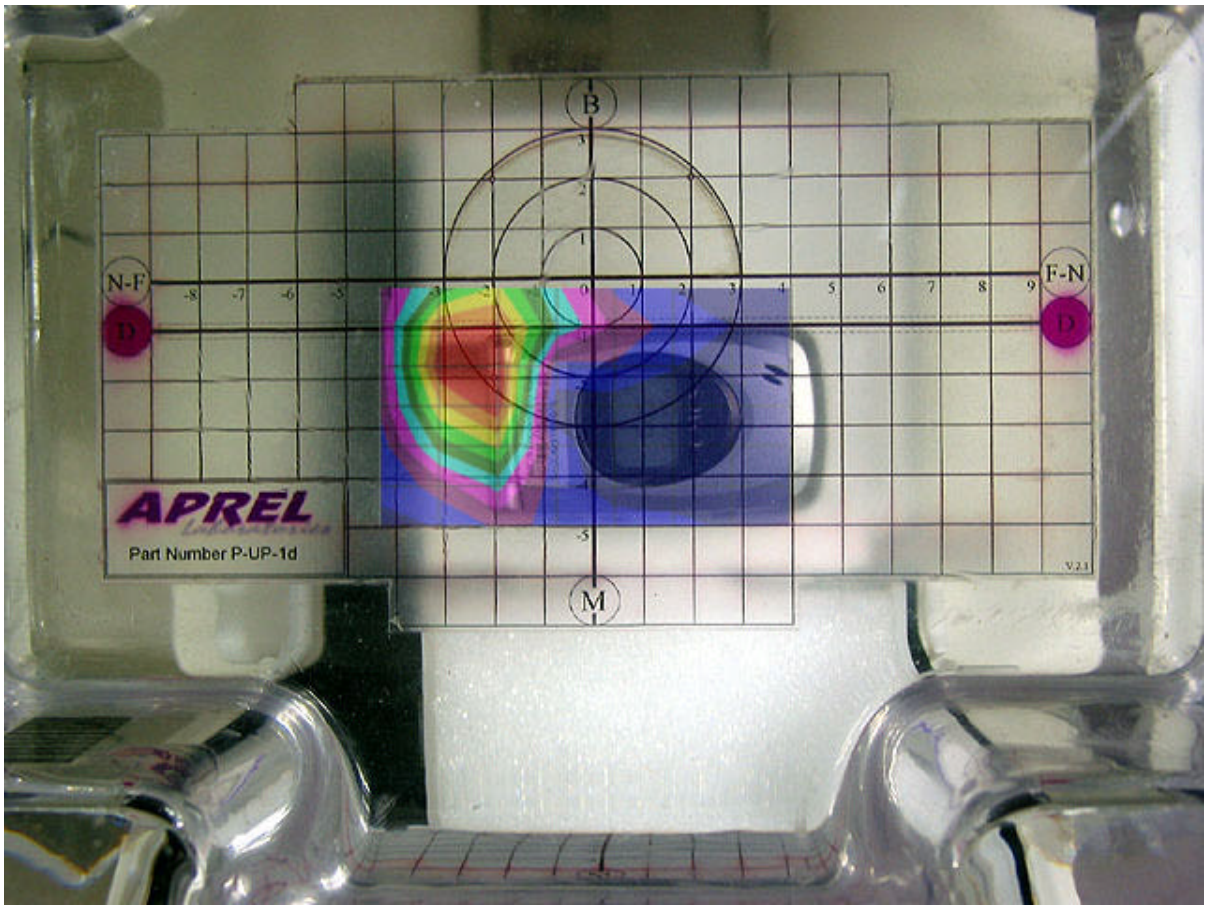
Graph 6 Body Antenna Down



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1880	661	20	Uni Zero	1.45	41.45	5.95	0.29

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SAR Data Report cmcs-low-hand-antenna-up

Start : 16-Dec-02 06:22:55 pm
End : 16-Dec-02 06:88:02 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1850.2 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.52 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 0.94 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.39 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.19 W/kg

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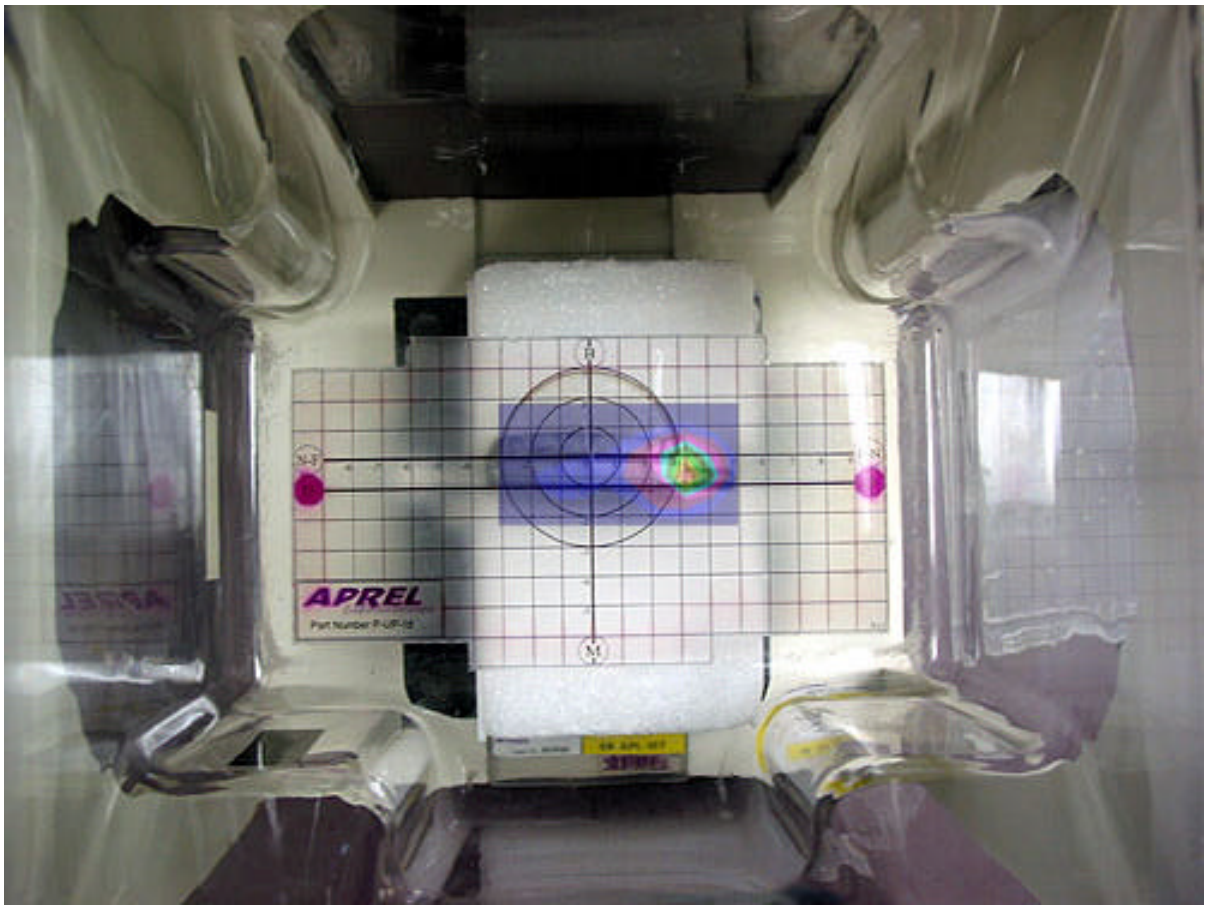
Graph 7 Direct Contact SAR (Device Side Up)



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	10g SAR
1850.2	661	20	Uni Zero	1.45	41.45	5.95	0.19

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SAR Data Report cmcs-high-hand-antenna-up

Start : 16-Dec-02 07:23:05 pm
End : 16-Dec-02 07:39:06 pm
Code Version : 4.12
Robot Version: 4.08

Product Data:
Type : CMCS
Model Number : Trimode
Serial Number : device1
Frequency : 1909.8 MHz
Transmit Pwr : 1 W
Antenna Type : Center fed
Antenna Posn. : Out

Measurement Data:
Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Body
Tissue Dielectric : 52.150
Tissue Conductivity : 1.450
Tissue Density : 1.000
Crest Factor : 8.000
Robot Name : CRS

Probe Data:
Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 1900 MHz
Tissue Type : Muscle
Calibrated Dielectric : 54.00
Calibrated Conductivity : 1.450
Probe Offset : 2.500 mm
Conversion Factor : 5.950
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm^2)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : 2.42 1.67 1.26

Sample:
Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec
Trigger Level 5.0 mV

Comments:
Area Scan - Max Local SAR Value at x=28.0 y=-34.0 = 0.61 W/kg
Zoom Scan - Max Local SAR Value at x=27.0 y=-34.0 z=0.0 = 1.01 W/kg
Max 1g SAR at x=27.0 y=-33.0 z=0.0 = 0.49 W/kg
Max 10g SAR at x=26.0 y=-31.0 z=0.0 = 0.21 W/kg

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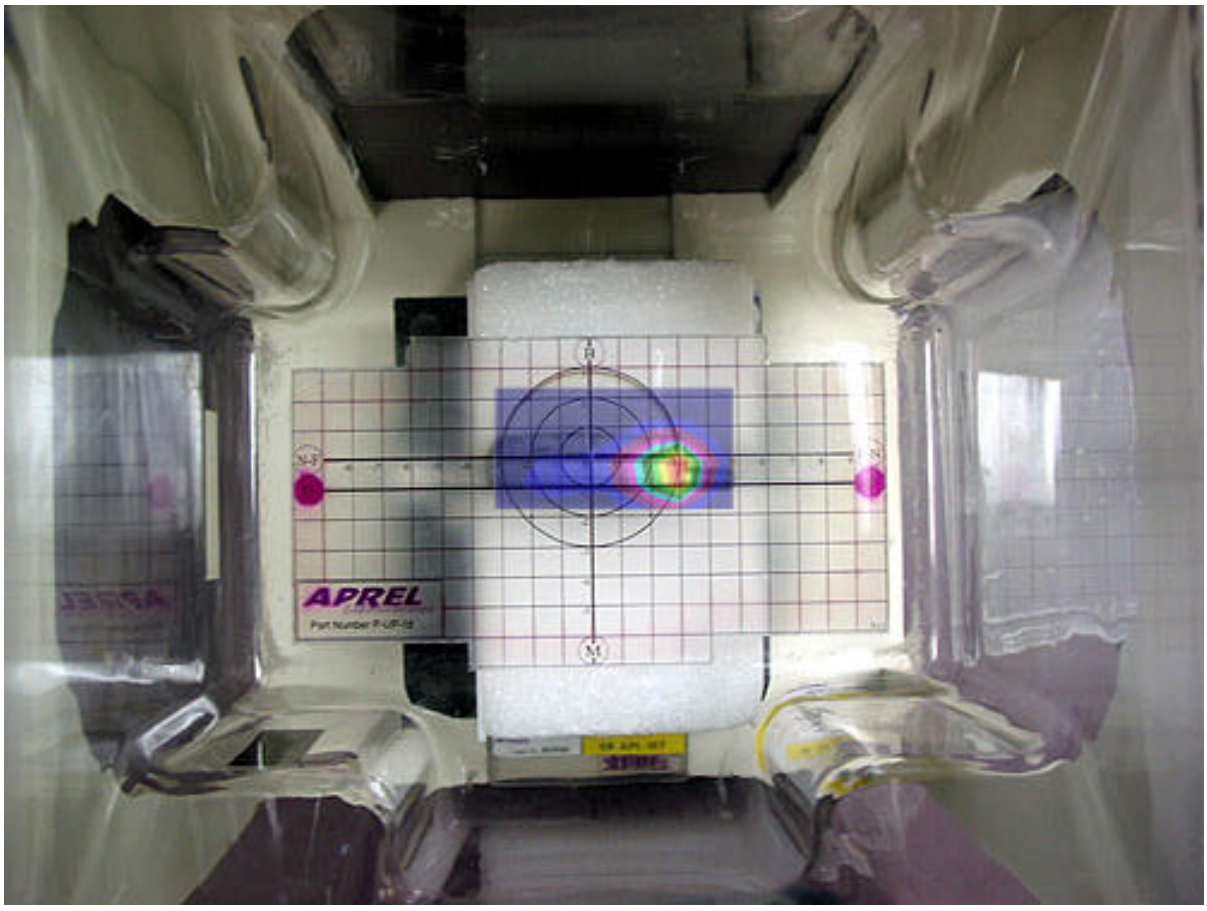
Graph 7 Direct Contact SAR (Device Side Up)



Frequency MHz	Channel	Tissue Temp °	Separation & Phantom	Sigma	Epsilon	Conv F	1g SAR
1909.8	880	20	Uni Zero	1.45	41.45	5.95	0.21

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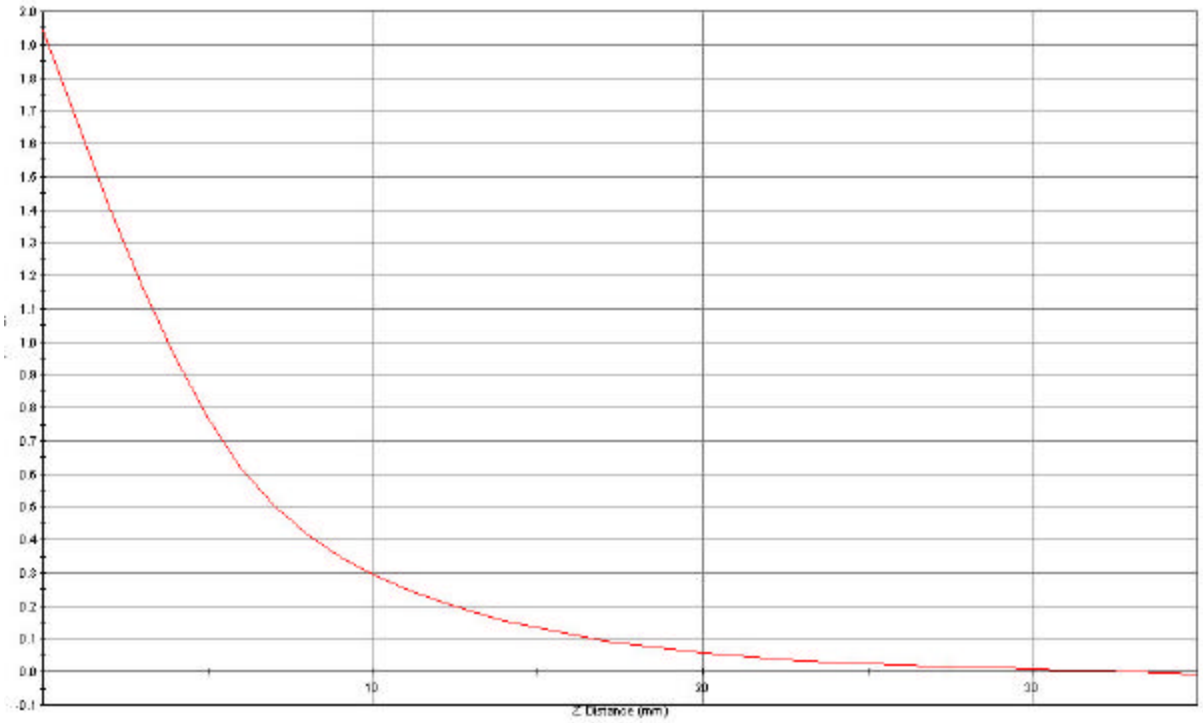
Direct Contact Analysis Z Height Conservative Scan High Channel 1909.8 MHz



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Appendix B

Test Setup Images

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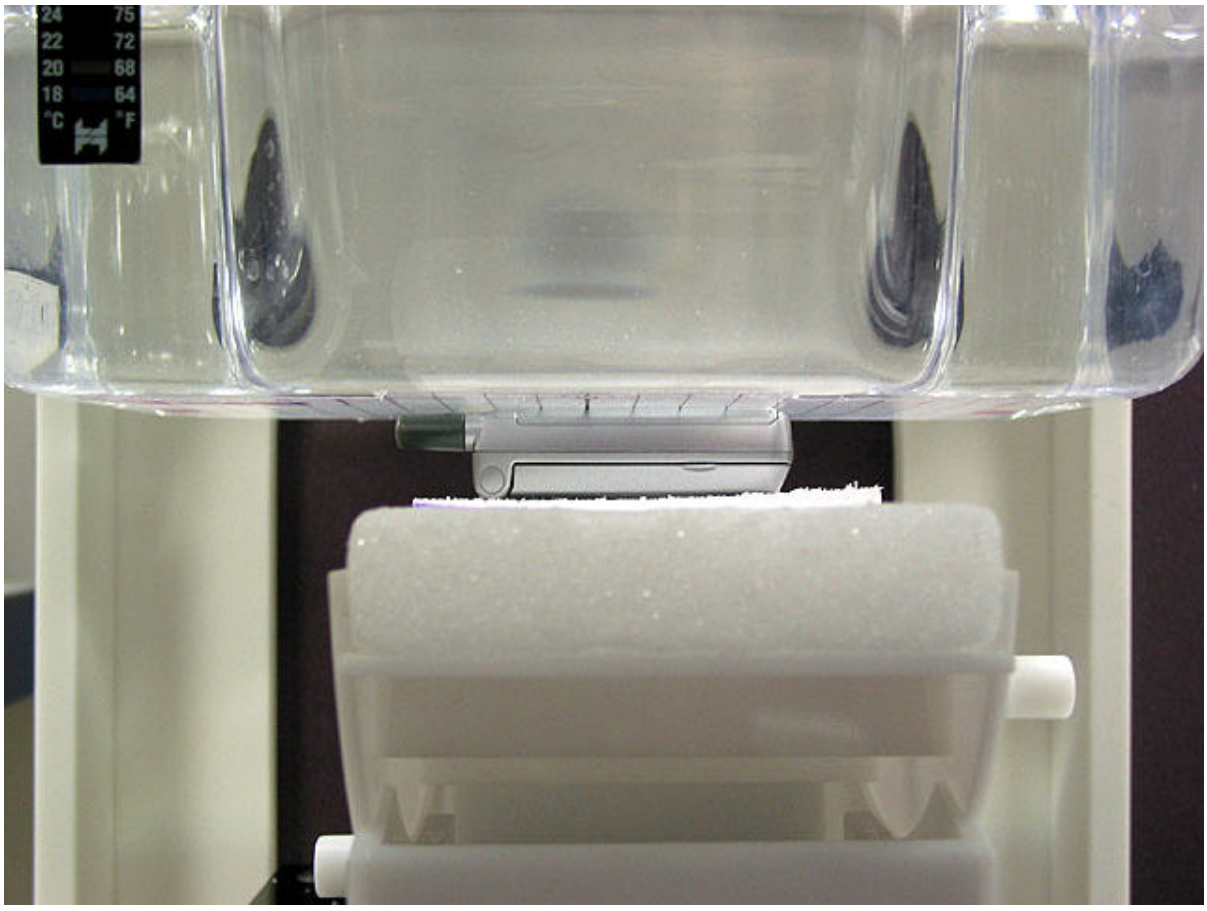
Universal Phantom Body/Direct Contact SAR



DUT Touch Side View Antenna Up

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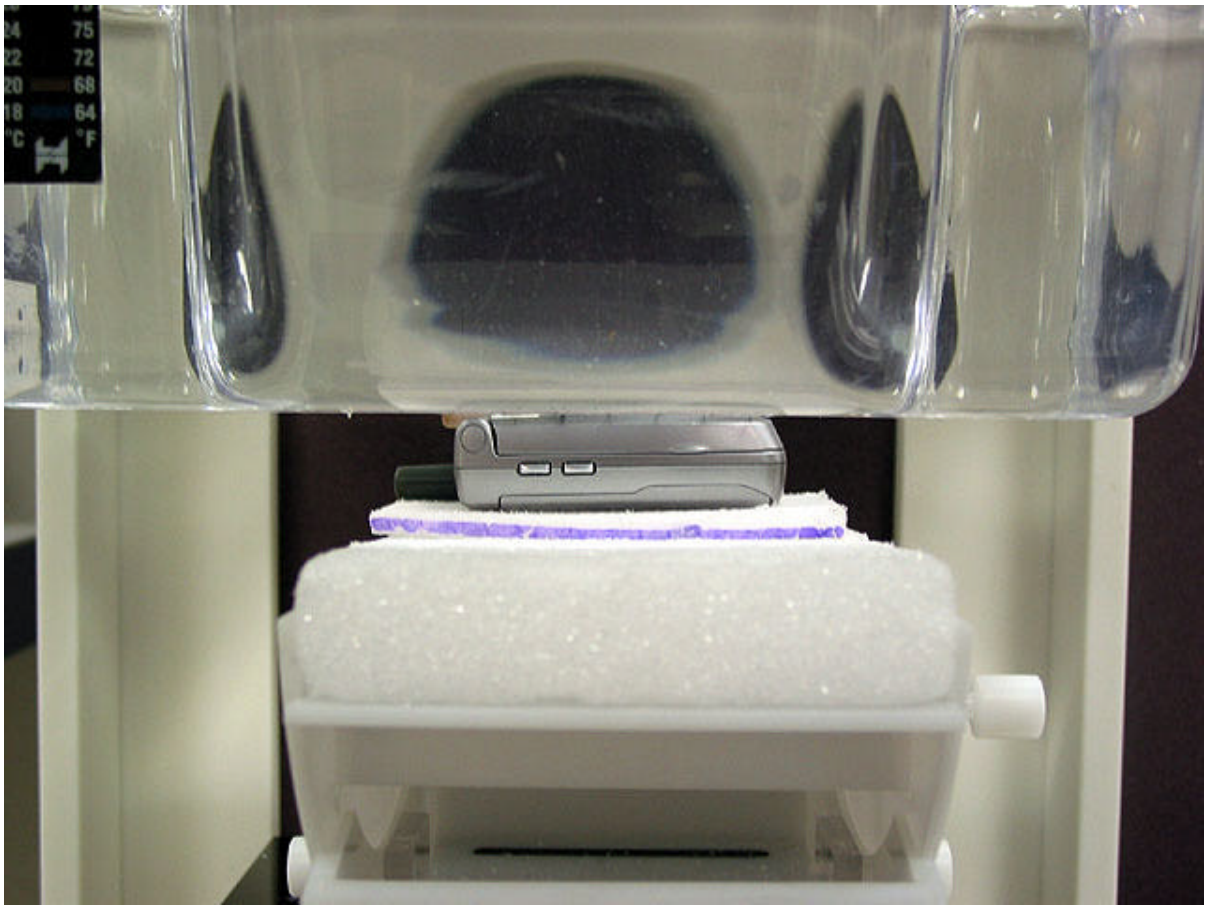
Universal Phantom Body/Direct Contact SAR



DUT Touch Side View Antenna Down

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Universal Phantom Body/Direct Contact SAR

DUT Touch Side View Antenna UP

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APPENDIX C: VALIDATION SCAN

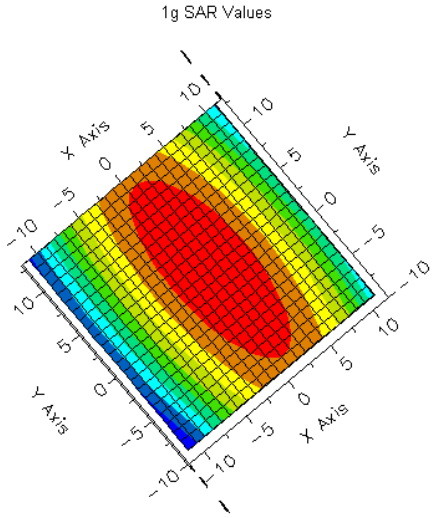

Figure 5. Contour Plot of 1 gram Validation Scan

Validation Date: 17 December 2002
Frequency: 1900 MHz
Tissue Type: Body
Conversion Factor: 5.85
Input Power to Dipole: 1 W
Distance from Dipole to Tissue: 10 mm
Tissue Temp: 20°C
Epsilon: 41.45
Sigma: 1.47
Tissue Deapth: 15 cm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
42	39.7	5.2

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
21	20.5	1

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Appendix D

UNCERTAINTY BUDGET

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Source of Uncertainty	Description (Annex)	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g)	Standard Uncertainty (10-g)	v_i^2 or v_{eff}
Measurement System									
Probe Calibration	E1.1	3.5	normal	1	1	1	3.5	3.5	
Axial Isotropy	E1.2	3.7	rectangular	3	$(1\text{-cp})^{1/2}$	(1-cp)1/2	1.5	1.5	
Hemispherical Isotropy	E1.2	10.9	rectangular	3	cp	cp	4.4	4.4	
Boundary Effect	E1.3	1.0	rectangular	3	1	1	0.6	0.6	
Linearity	E1.4	4.7	rectangular	3	1	1	2.7	2.7	
Detection Limit	E1.5	1.0	rectangular	3	1	1	0.6	0.6	
Readout Electronics	E1.6	1.0	normal	1	1	1	1.0	1.0	
Response Time	E1.7	0.8	rectangular	3	1	1	0.5	0.5	
Integration Time	E1.8	1.7	rectangular	3	1	1	1.0	1.0	
RF Ambient Condition	E5.1	3.0	rectangular	3	1	1	1.7	1.7	
Probe Positioner Mech. Restrictions	E5.2	0.4	rectangular	3	1	1	0.2	0.2	
Probe Positioning with respect to Phantom Shell	E5.3	2.9	rectangular	3	1	1	1.7	1.7	
Extrapolation and Integration	E4.2	3.7	rectangular	3	1	1	2.1	2.1	
Test Sample Positioning	E3.1.3	4.0	normal	1	1	1	4.0	4.0	11
Device Holder Uncertainty	E3.1.2	2.0	normal	1	1	1	2.0	2.0	8
Drift of Output Power	Section 5.6.2	1	rectangular	3	1	1	0.6	0.6	
Phantom and Setup									
Phantom Uncertainty (shape and thickness tolerance)	E2.1	3.4	rectangular	3	1	1	2.0	2.0	
Liquid Conductivity (target)	E2.2	5	rectangular	3	0.7	0.5	0	0	
Liquid Conductivity (meas.)	E2.2	2.0	rectangular	3	0.7	0.5	0.8	0.6	
Liquid Permittivity (target)	E2.2	3.6	rectangular	3	0.6	0.5	1.2	1	
Liquid Permittivity (meas.)	E2.2	2.0	rectangular	3	0.6	0.5	0.7	0.6	
Combined Uncertainty			RSS				9.1	9	
Combined Uncertainty **(coverage factor = 2)**			Normal (k=2)				17.8	17.7	

This uncertainty budget assessment was carried out in accordance with the methodology and format described in the document **IEEE Std 1528-200X: DRAFT Recommend Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques.**

The combined standard uncertainty is determined from the root-sum-square combination of the standard uncertainties of the individual components. The expanded uncertainty is computed by multiplying the combined standard uncertainty by a coverage factor = 2 to determine the total uncertainty at a 95% confidence level.

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Appendix E

Probe Calibration

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NCL CALIBRATION LABORATORIES

Calibration File No.: C-P-0249

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 1900 MHz

Manufacturer: APREL Laboratories
Model No.: E-010
Serial No.: 163

Calibration Procedure: SSI/DRB-TP-D01-032
Project No: Probe Cal Internal

Calibrated: May 8th 2002
Recalibration required: May 7th 2003
Released on: May 8th 2002

Released By: _____

NCL CALIBRATION LABORATORIES
51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6
Division of APREL Lab.
TEL: (613) 820-4988
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INTRODUCTION

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-010 163.

REFERENCES

SSI/DRB-TP-D01-032 E-Field Probe Calibration Procedure
IEEE P-1528 *DRAFT* "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"
SSI-TP-014 Tissue Calibration Procedure

Conditions

Probe 163 was a new probe taken from stock prior to calibration.

Ambient Temperature of the Laboratory: 23 °C +/- 0.5 °C
Temperature of the Tissue: 22 °C +/- 0.5 °C

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CALIBRATION RESULTS SUMMARY

Probe Type: E-Field Probe E-010

Serial Number: 163

Frequency: 1900 MHz

Sensor Offset: 2.4 mm

Sensor Length: **2.5 mm**

Tip Enclosure: **Glass***

Tip Diameter: **7 mm**

Tip Length: **40 mm**

Total Length: **290 mm**

*Resistive to recommended tissue recipes per IEEE-P1528

7. SENSITIVITY IN AIR

Channel X: 0.58 ìV/(V/m)^2
Channel Y: 0.58 ìV/(V/m)^2
Channel Z: 0.58 ìV/(V/m)^2

Diode Compression Point: 76 mV

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SENSITIVITY IN HEAD TISSUE

Frequency: 1900 MHz

Epsilon: 40.0(+/-5%) **Sigma:** 1.40 S/m (+/-10%)

ConvF

Channel X: 5.95

Channel Y: 5.95

Channel Z: 5.95

Tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Boundary Effect:

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.6mm.

Spatial Resolution:

The measured probe tip diameter is 7 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

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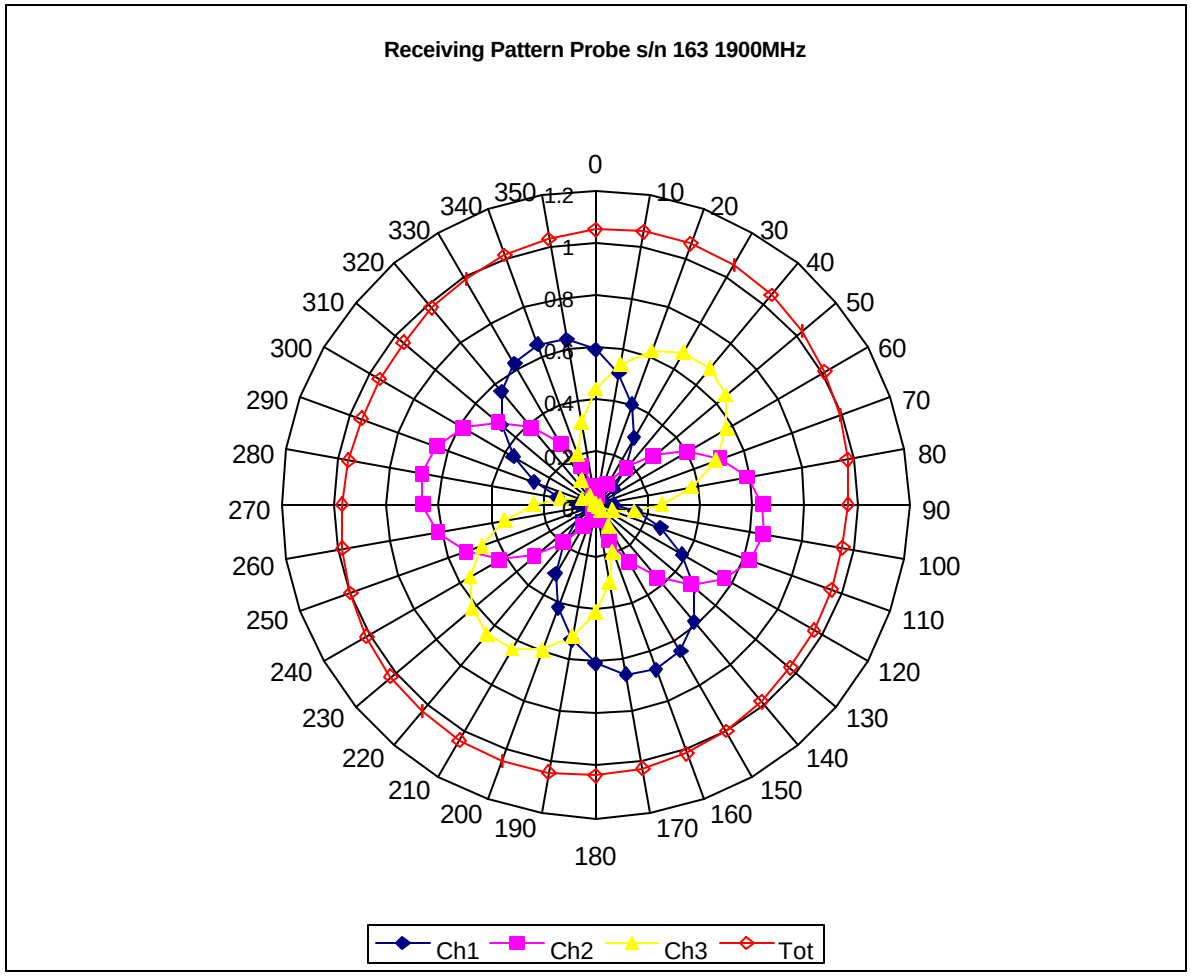
e-mail: info@aprel.com

RECEIVING PATTERN 1900 MHZ (AIR)



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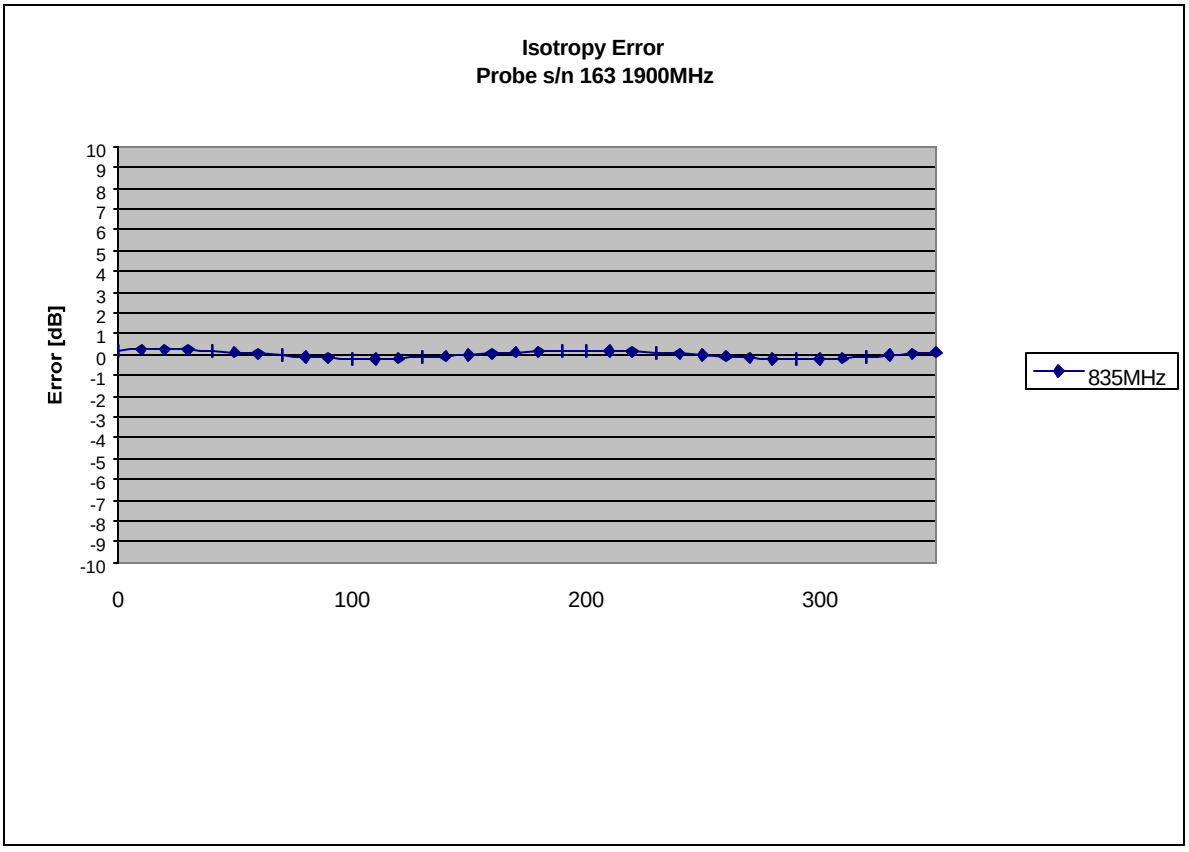
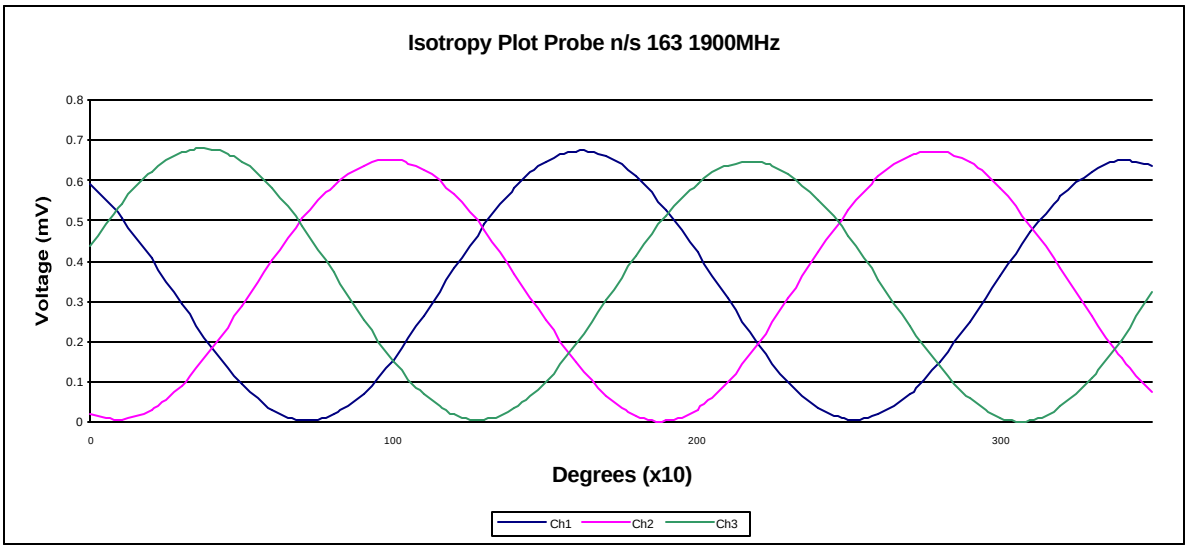
ISOTROPY ERROR 1900 MHZ (AIR)





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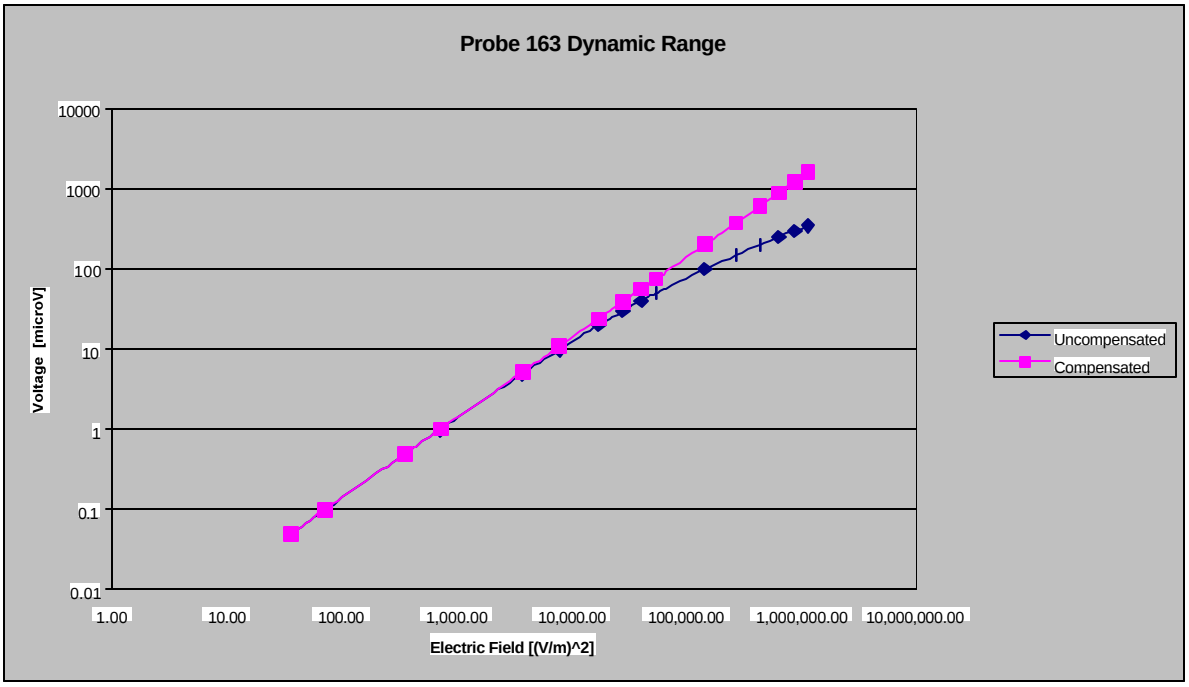
DYNAMIC RANGE



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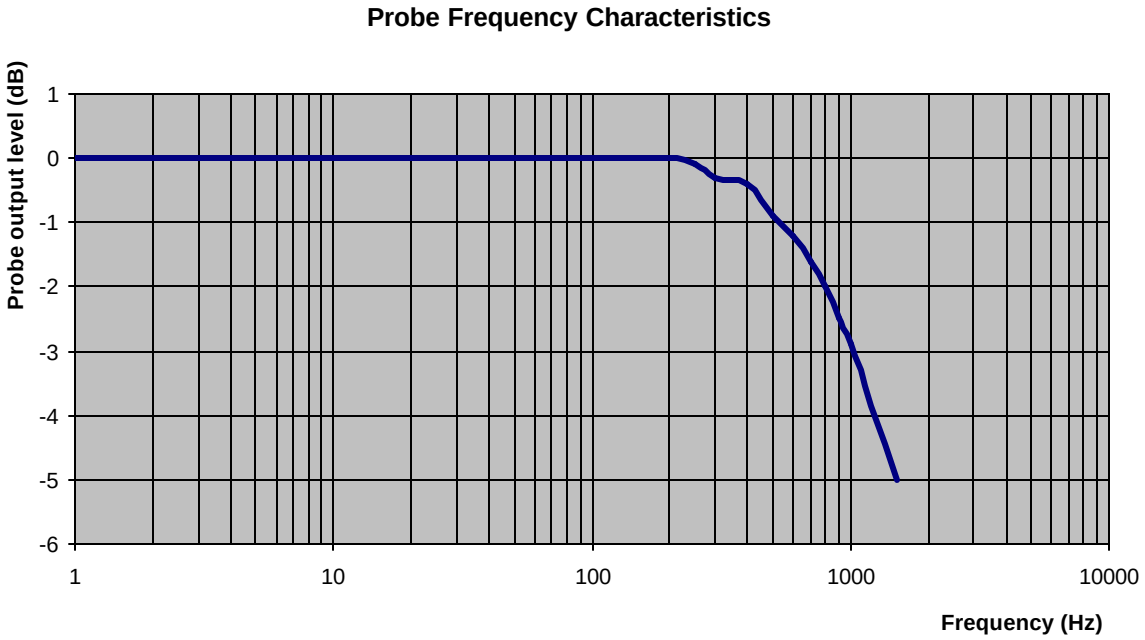
Video Bandwidth



Video Bandwidth at 500 Hz 1 dB
Video Bandwidth at 1.02 KHz: 3 dB

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CONVERSION FACTOR UNCERTAINTY ASSESSMENT

Frequency: 1900 MHz

Epsilon: 40.0 (+/-5%) **Sigma:** 1.40 S/m (+/-10%)

ConvF

Channel X: **5.95** **7%(K=2)**

Channel Y: **5.95** **7%(K=2)**

Channel Z: 5.95 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Boundary Effect:

For a distance of 2.6mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

TEST EQUIPMENT

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2002

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