

Appendix A

TEST GRAPHIC PLOTS



Graph 1

Direct contact SAR (10g)
Laptop Mode LCD Top LHS
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	10g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.24	0



SAR Data Report

Start : 9-Sep-03 11:52:35 pm
End : 9-Sep-03 11:59:13 pm
Code Version : 4.12
Robot Version: 0.00

Product Data:

Type : Dell PP10L 4054
Frequency : 2437 MHz
Transmit Pwr : 0.045 W
Antenna Type : Center Fed
Antenna Posn. : Internal

Measurement Data:

Phantom Name : Uni-Middle
Phantom Type : Uniphantom
Tissue Type : Muscle
Tissue Dielectric : 50.600
Tissue Conductivity : 2.010
Tissue Density : 1.000
Crest Factor : 1.000
Robot Name : CRS

Probe Data:

Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 2450 MHz
Tissue Type : Muscle
Calibrated Dielectric : 50.600
Calibrated Conductivity : 2.010
Probe Offset : 2.500 mm
Conversion Factor : 5.600
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm²)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : -5.36 3.12 -1.51

Sample:

Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec

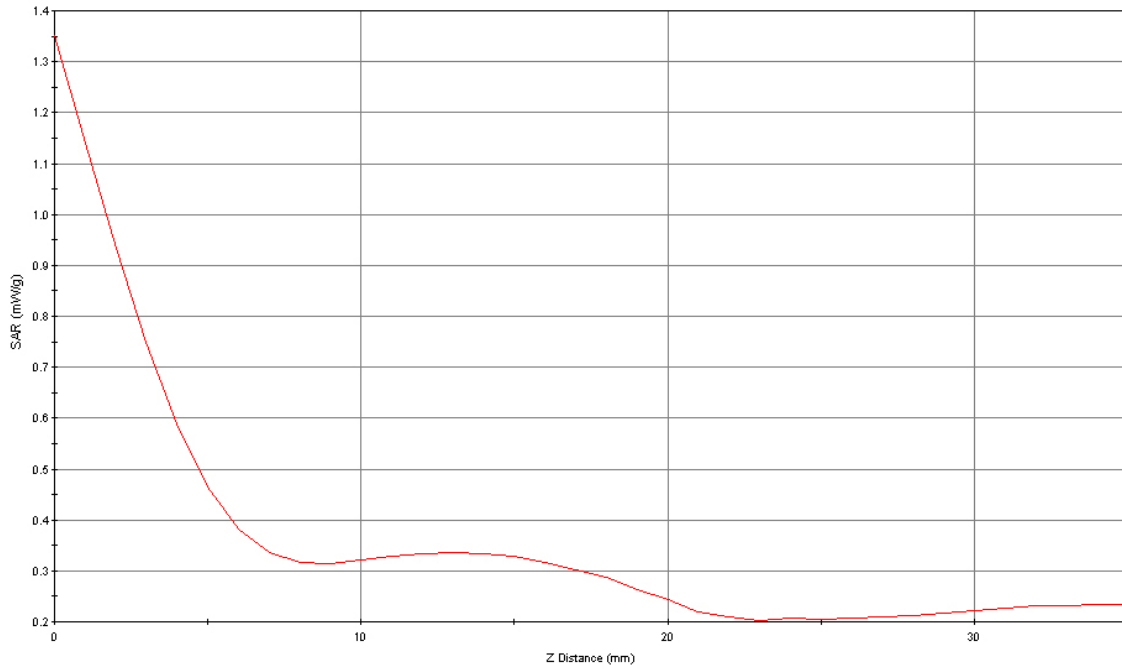
Comments:

Area Scan - Max Local SAR Value at x=11.0 y=-51.0 = 0.43 W/kg
Zoom Scan - Max Local SAR Value at x=10.0 y=-51.0 z=0.0 = 1.35 W/kg
Max 1g SAR at x=11.0 y=-50.0 z=0.0 = 0.54 W/kg
Max 10g SAR at x=11.0 y=-55.0 z=0.0 = 0.24 W/kg



Z Axis Scan

SAR - Z Axis
at Hotspot x:10.0 y:-51.0



Graph 2

Body SAR (1g)
Laptop Mode LCD Top LHS
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	1g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.54	0



SAR Data Report

Start : 9-Sep-03 11:52:35 pm
End : 9-Sep-03 11:59:13 pm
Code Version : 4.12
Robot Version: 0.00

Product Data:

Type : Dell PP10L 4054
Frequency : 2437 MHz
Transmit Pwr : 0.045 W
Antenna Type : Center Fed
Antenna Posn. : Internal

Measurement Data:

Phantom Name : Uni-Middle
Phantom Type : Uniphantom
Tissue Type : Muscle
Tissue Dielectric : 50.600
Tissue Conductivity : 2.010
Tissue Density : 1.000
Crest Factor : 1.000
Robot Name : CRS

Probe Data:

Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 2450 MHz
Tissue Type : Muscle
Calibrated Dielectric : 50.600
Calibrated Conductivity : 2.010
Probe Offset : 2.500 mm
Conversion Factor : 5.600
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm²)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : -5.36 3.12 -1.51

Sample:

Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec

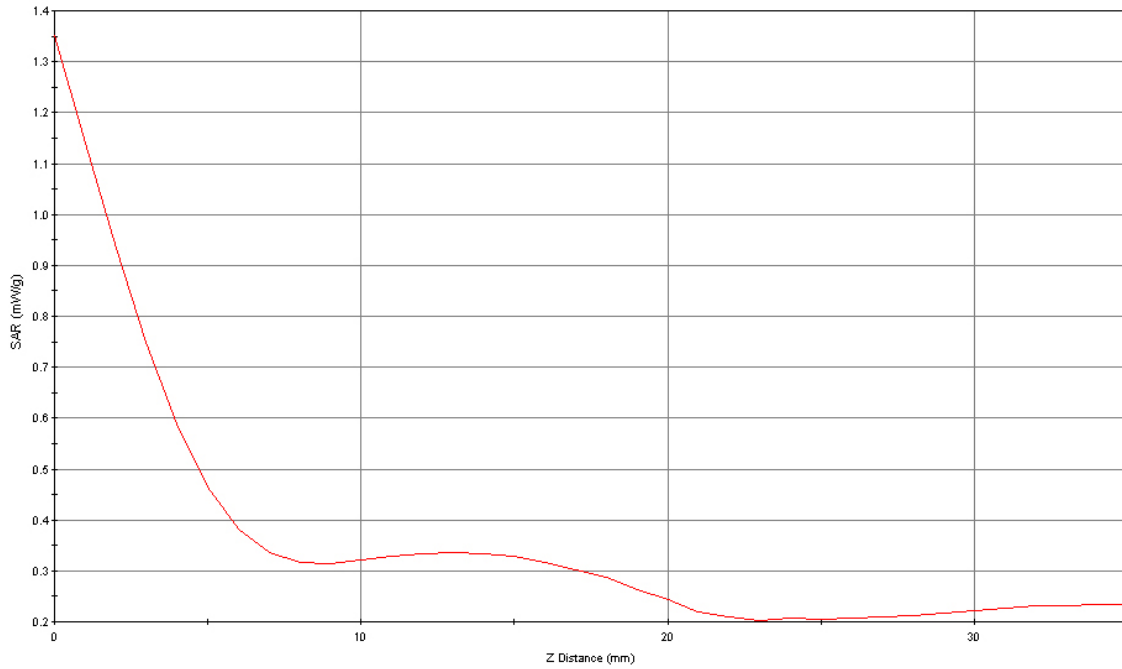
Comments:

Area Scan - Max Local SAR Value at x=11.0 y=-51.0 = 0.43 W/kg
Zoom Scan - Max Local SAR Value at x=10.0 y=-51.0 z=0.0 = 1.35 W/kg
Max 1g SAR at x=11.0 y=-50.0 z=0.0 = 0.54 W/kg
Max 10g SAR at x=11.0 y=-55.0 z=0.0 = 0.24 W/kg



Z Axis Scan

SAR - Z Axis
at Hotspot x:10.0 y:-51.0



Graph 3

Direct contact SAR (10g)
Laptop Mode LCD Front Side
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	10g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.06	0



Graph 4

Body SAR (1g)
Laptop Mode LCD Front Side
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	1g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.14	0



Graph 5

Direct contact SAR (10g)
 DUT LCD Left Side
 Distance 0 mm
 Mid Channel
 Frequency: 2437 MHz
 Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	10g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.04	0



Graph 6

Body SAR (1g)
DUT LCD Left Side
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	1g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.12	0



Graph 7

Direct contact SAR (10g)
 DUT Front Side
 Distance 0 mm
 Mid Channel
 Frequency: 2437 MHz
 Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	10g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.40	0



SAR Data Report

Start : 9-Sep-03 04:16:56 pm
End : 9-Sep-03 04:28:08 pm
Code Version : 4.12
Robot Version: 0.00

Product Data:

Type : Dell PP10L 4054
Frequency : 2437 MHz
Transmit Pwr : 0.045 W
Antenna Type : Center Fed
Antenna Posn. : Internal

Measurement Data:

Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Muscle
Tissue Dielectric : 50.600
Tissue Conductivity : 2.010
Tissue Density : 1.000
Crest Factor : 1.000
Robot Name : CRS

Probe Data:

Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 2450 MHz
Tissue Type : Muscle
Calibrated Dielectric : 50.600
Calibrated Conductivity : 2.010
Probe Offset : 2.500 mm
Conversion Factor : 5.600
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm²)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : -5.36 3.12 -1.51

Sample:

Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec

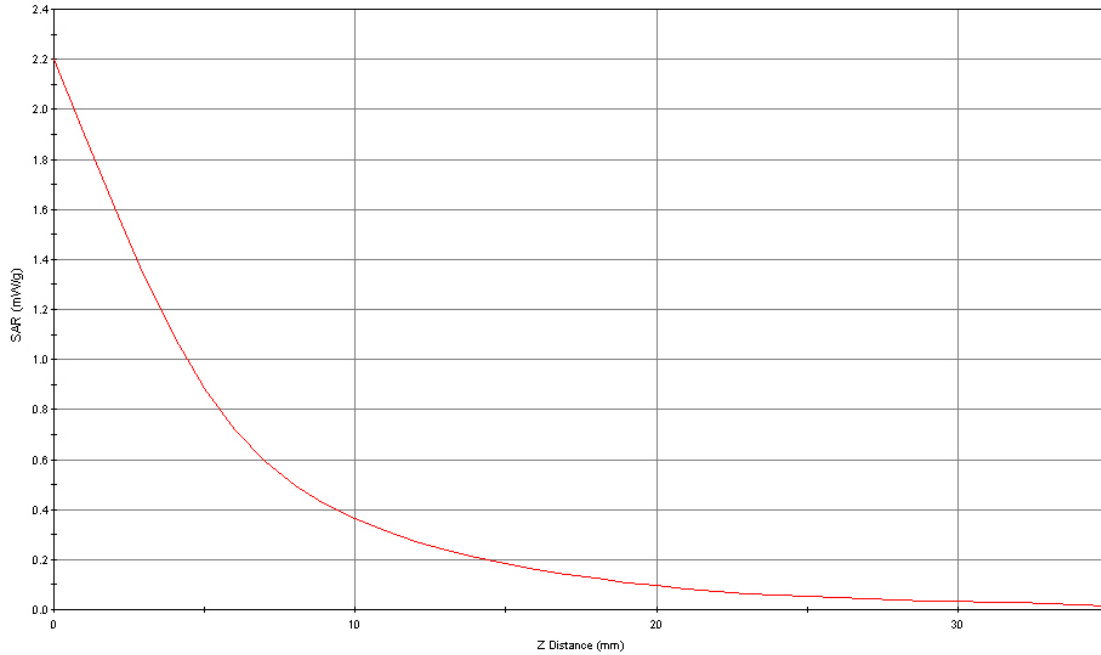
Comments:

Area Scan - Max Local SAR Value at x=9.0 y=-79.0 = 0.88 W/kg
Zoom Scan - Max Local SAR Value at x=9.0 y=-79.0 z=0.0 = 2.20 W/kg
Max 1g SAR at x=9.0 y=-77.0 z=0.0 = 0.99 W/kg
Max 10g SAR at x=9.0 y=-76.0 z=0.0 = 0.40 W/kg



Z Axis Scan

SAR - Z Axis
at Hotspot x:9.0 y:-79.0



Graph 8

Body SAR (1g)
DUT Front Side
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Duty Cycle 1



Date	Dielectric Constant ϵ_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	1g SAR (W/kg)	Power Drift
9/9/03	50.6	2.01	5.6	22.0	0.99	0



SAR Data Report

Start : 9-Sep-03 04:16:56 pm
End : 9-Sep-03 04:28:08 pm
Code Version : 4.12
Robot Version: 0.00

Product Data:

Type : Dell PP10L 4054
Frequency : 2437 MHz
Transmit Pwr : 0.045 W
Antenna Type : Center Fed
Antenna Posn. : Internal

Measurement Data:

Phantom Name : APREL-Uni
Phantom Type : Uniphantom
Tissue Type : Muscle
Tissue Dielectric : 50.600
Tissue Conductivity : 2.010
Tissue Density : 1.000
Crest Factor : 1.000
Robot Name : CRS

Probe Data:

Probe Name : 163
Probe Type : E Fld Triangle
Frequency : 2450 MHz
Tissue Type : Muscle
Calibrated Dielectric : 50.600
Calibrated Conductivity : 2.010
Probe Offset : 2.500 mm
Conversion Factor : 5.600
Diode Compression Pt : 76.0 mV
Probe Sensitivity : 0.580 0.580 0.580 mV/(mW/cm²)
Amplifier Gains : 20.00 20.00 20.00
Chan. Offset (mV) : -5.36 3.12 -1.51

Sample:

Rate: 6000 Samples/Sec
Count: 1000 Samples
NIDAQ Gain: 5
Scan Time: 166.7 msec

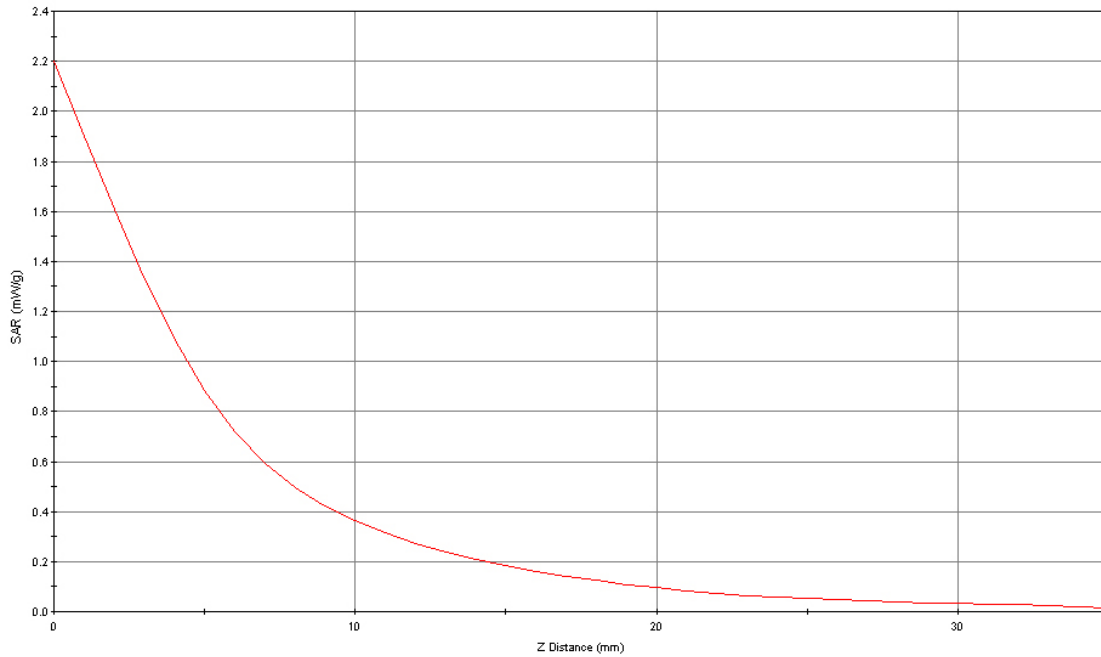
Comments:

Area Scan - Max Local SAR Value at x=9.0 y=-79.0 = 0.88 W/kg
Zoom Scan - Max Local SAR Value at x=9.0 y=-79.0 z=0.0 = 2.20 W/kg
Max 1g SAR at x=9.0 y=-77.0 z=0.0 = 0.99 W/kg
Max 10g SAR at x=9.0 y=-76.0 z=0.0 = 0.40 W/kg



Z Axis Scan

SAR - Z Axis
at Hotspot x:9.0 y:-79.0



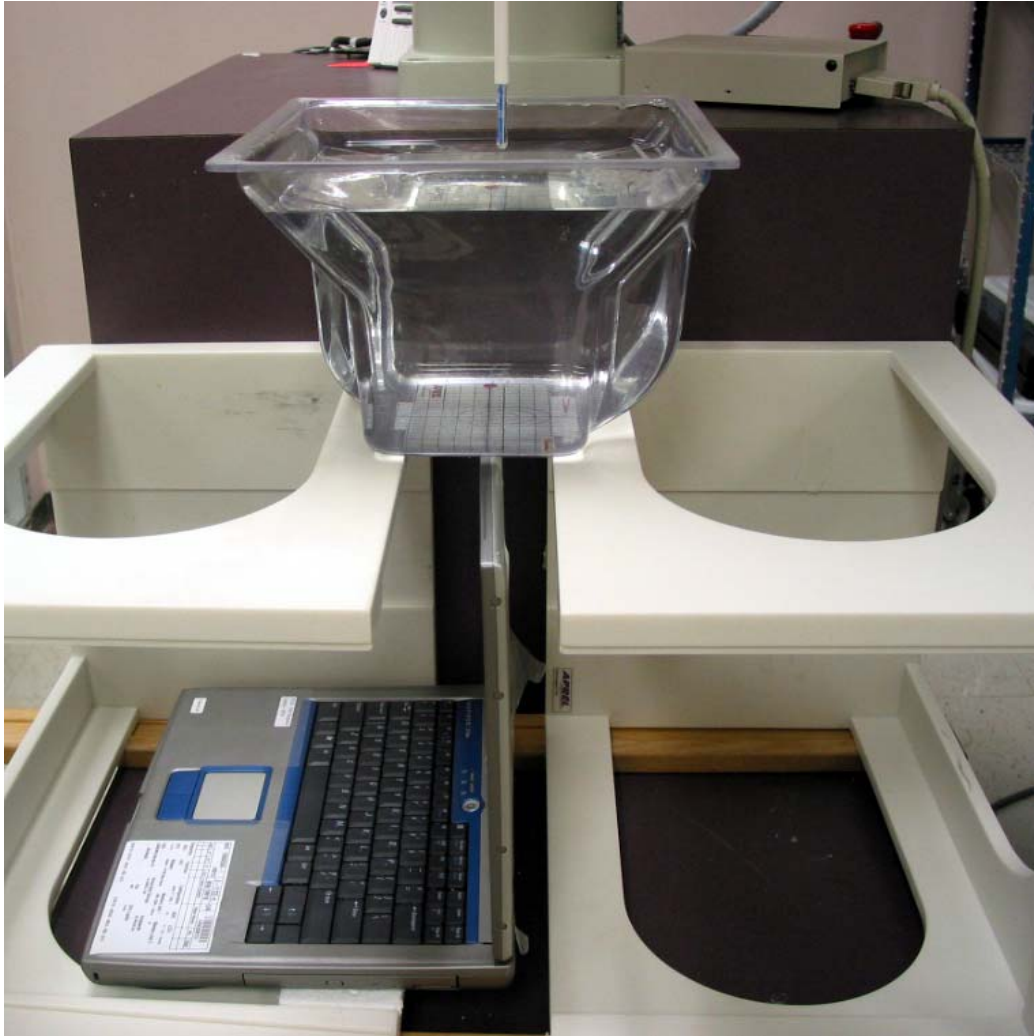
Appendix B

Setup Pictures



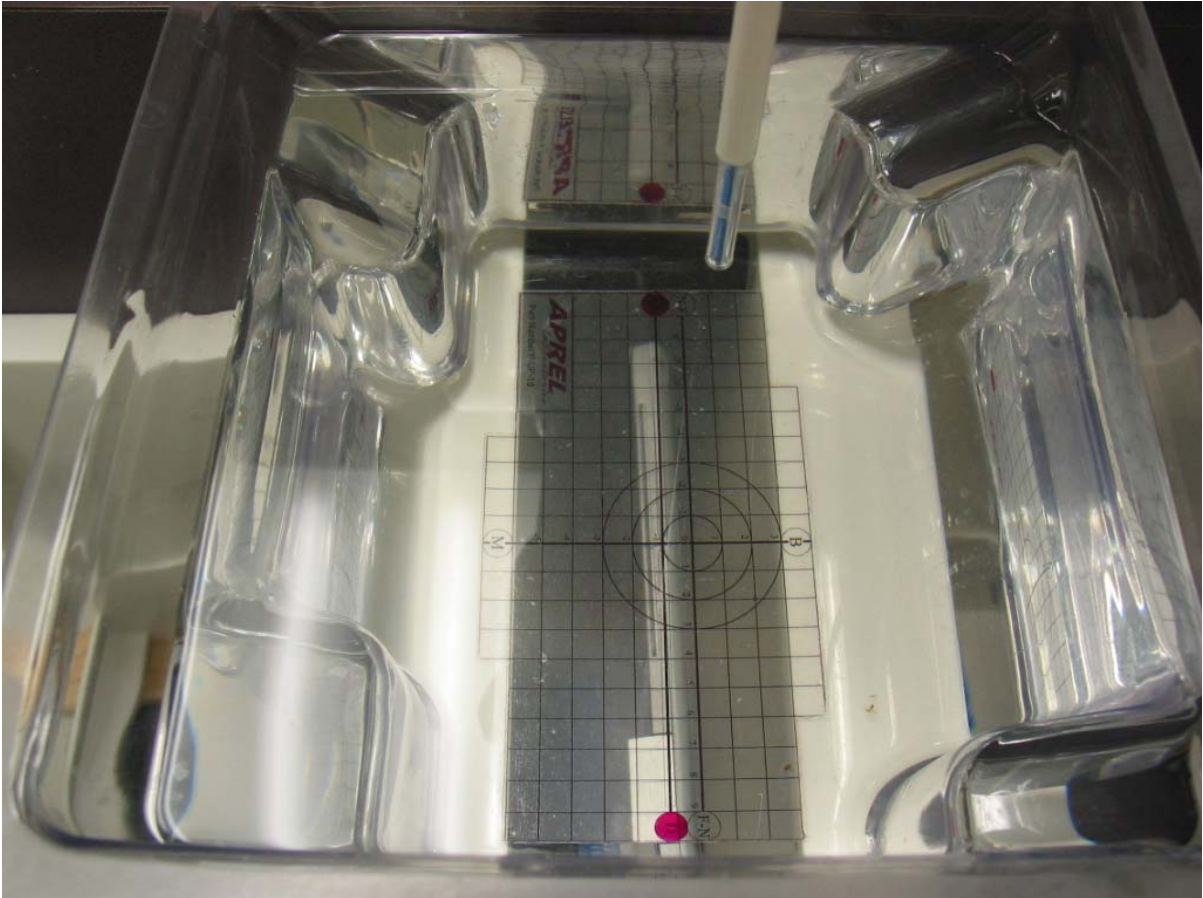
Picture 1

DUT Laptop Mode LCD Top LHS



Picture 2

DUT Laptop Mode LCD Top LHS



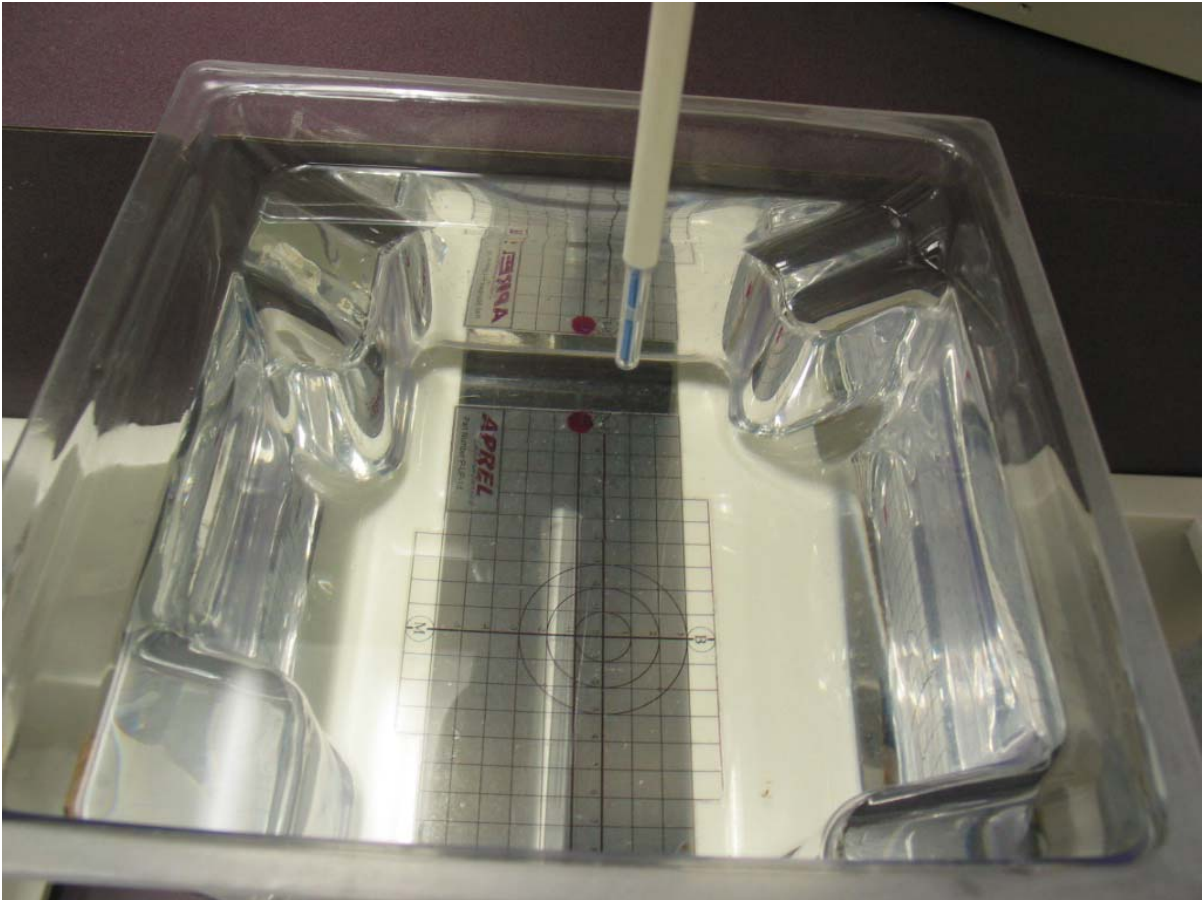
Picture 3

DUT Laptop Mode LCD Top RHS



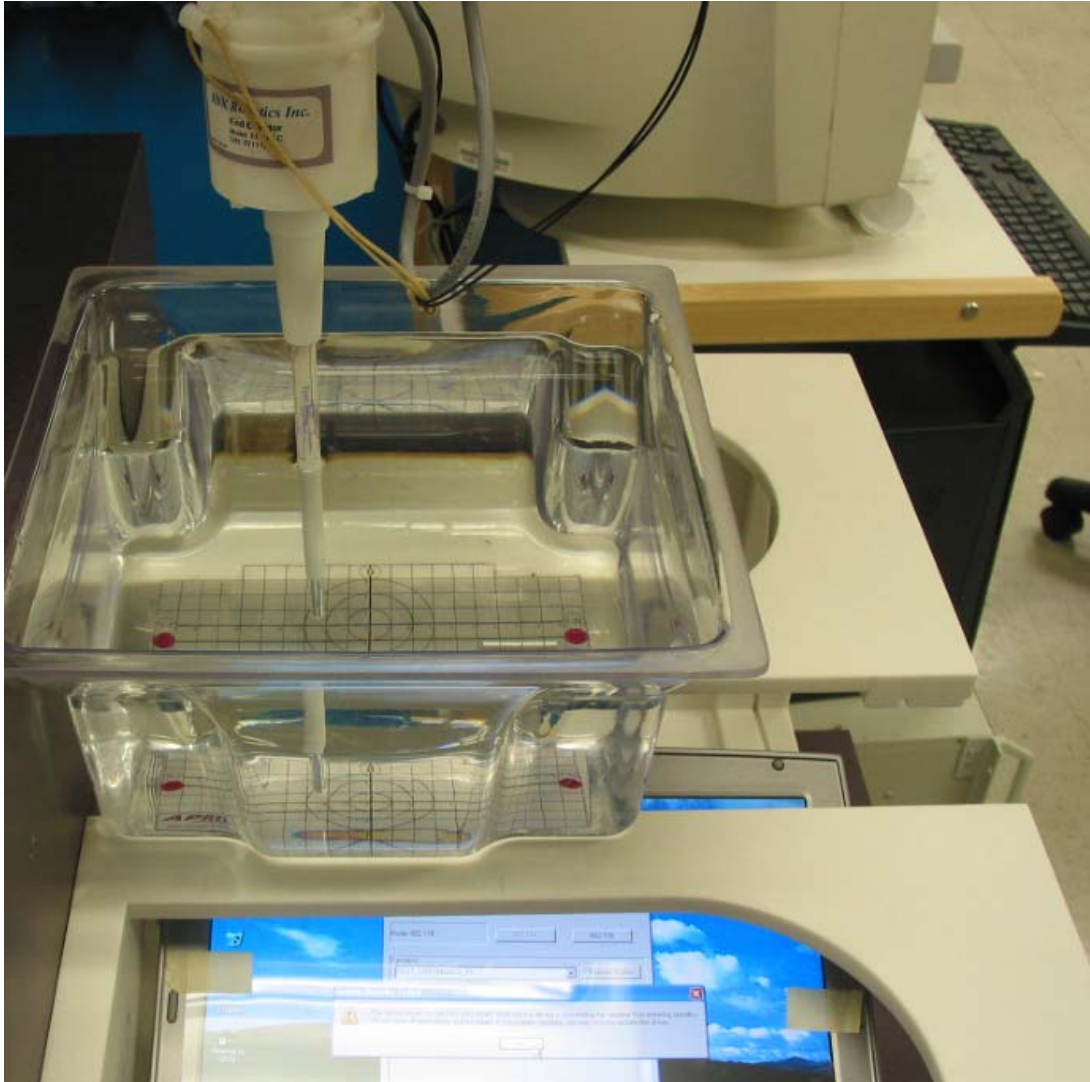
Picture 4

DUT Laptop Mode LCD Top RHS



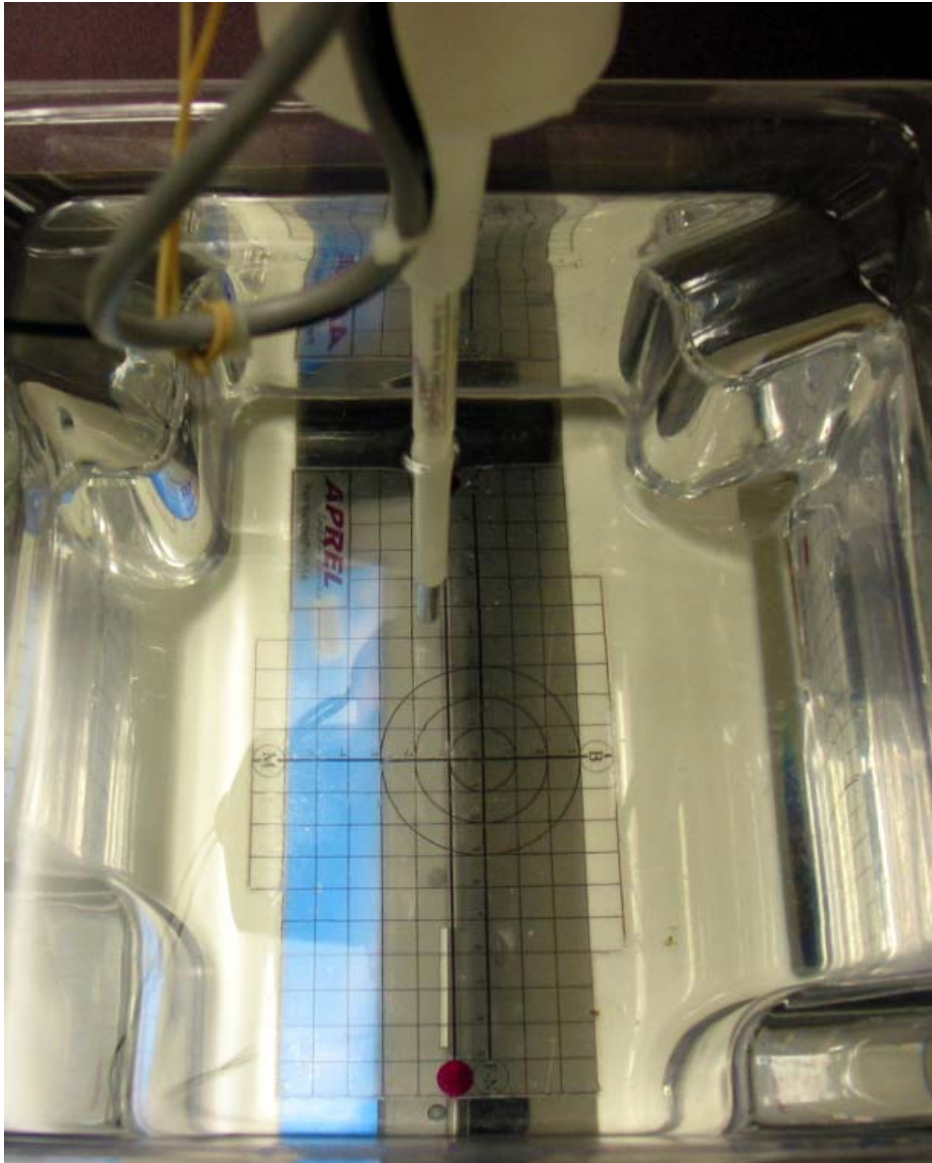
Picture 5

DUT Laptop Mode LCD Front Side



Picture 6

DUT Laptop Mode LCD Front Side



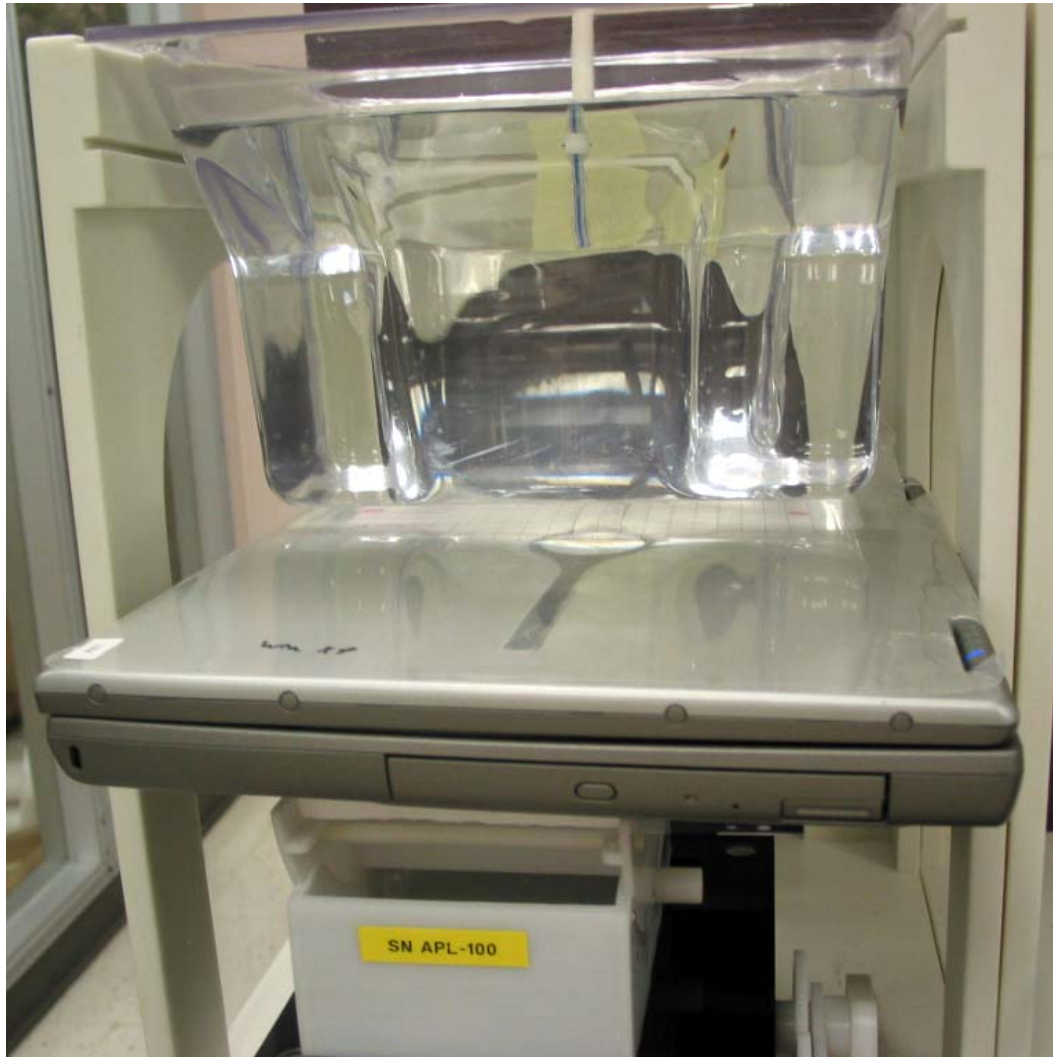
Picture 7

DUT Left Side



Picture 8

DUT Front Side



Picture 9

DUT Back Side

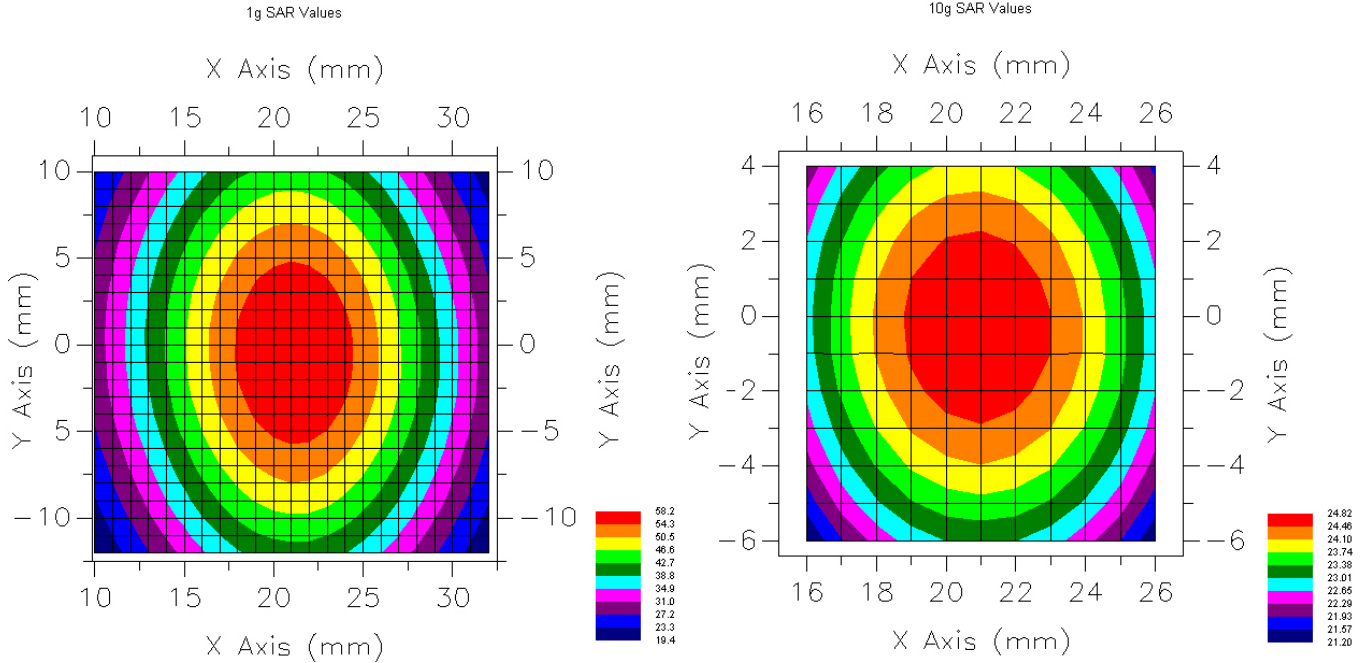


Appendix C

Validation Scan Results



VALIDATION SCAN



Date: 11 September 2003
 Frequency: 2450 MHz
 Tissue Type: Muscle
 Epsilon: 50.6
 Sigma: 2.01
 Tissue Calibration Date: 9 September 2003
 Conversion Factor: 5.6
 Input Power to Dipole: 1 W
 Duty Cycle: 1
 Distance from Dipole to Tissue: 10 mm
 Tissue Temperature: 22°C
 Tissue Depth: 15 cm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
51.5	52.4	-1.7

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
23.5	24.0	-2.1



Appendix D: Uncertainty Budget

Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside the Dell PP10L laptop

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	$\sqrt{3}$	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5	∞
Hemispherical Isotropy	E1.2	10.9	rectangular	$\sqrt{3}$	\sqrt{cp}	\sqrt{cp}	4.4	4.4	∞
Boundary Effect	E1.3	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6	∞
Linearity	E1.4	4.7	rectangular	$\sqrt{3}$	1	1	2.7	2.7	∞
Detection Limit	E1.5	1.0	rectangular	$\sqrt{3}$	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	$\sqrt{3}$	1	1	0.5	0.5	∞
Integration Time	E1.8	1.7	rectangular	$\sqrt{3}$	1	1	1.0	1.0	∞
RF Ambient Condition	E5.1	3.0	rectangular	$\sqrt{3}$	1	1	1.7	1.7	∞
Probe Positioner Mech. Restrictions	E5.2	0.4	rectangular	$\sqrt{3}$	1	1	0.2	0.2	∞
Probe Positioning with respect to Phantom Shell	E5.3	2.9	rectangular	$\sqrt{3}$	1	1	1.7	1.7	∞
Extrapolation and Integration	E4.2	3.7	rectangular	$\sqrt{3}$	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	0.0	rectangular	$\sqrt{3}$	1	1	0.0	0.0	∞
Phantom and Setup									
Phantom Uncertainty (shape and thickness tolerance)	E2.1	3.4	rectangular	$\sqrt{3}$	1	1	2.0	2.0	∞
Liquid Conductivity (target)	E2.2	3.1	rectangular	$\sqrt{3}$	0.7	0.5	1.3	0.9	∞
Liquid Conductivity (meas.)	E2.2	2.0	rectangular	$\sqrt{3}$	0.7	0.5	0.8	0.6	∞
Liquid Permittivity (target)	E2.2	4.0	rectangular	$\sqrt{3}$	0.6	0.5	1.4	1.2	∞
Liquid Permittivity (meas.)	E2.2	2.0	rectangular	$\sqrt{3}$	0.6	0.5	0.7	0.6	∞
Combined Uncertainty			RSS				9.0	8.9	∞
Combined Uncertainty (coverage factor = 2)			Normal (k=2)				18.0	17.8	∞





Appendix E

Probe Calibration Certificate



NCL CALIBRATION LABORATORIES

Calibration File No.: C-P-0265

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 2.45 GHz

Manufacturer: APREL Laboratories

Model No.: E-010

Serial No.: 163

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

Project No: Probe Cal Internal

Calibrated: November 5th 2002

Recalibration required: November 4th 2003

Released on: November 5th 2002

Released By: _____

NCL CALIBRATION LABORATORIES

51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6

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



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 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 is a working released probe.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C



CALIBRATION RESULTS SUMMARY

Probe Type: E-Field Probe E-010

Serial Number: 163

Frequency: 2450 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 1528

SENSITIVITY IN AIR

Channel X: 0.58 $\mu\text{V}/(\text{V}/\text{m})^2$

Channel Y: 0.58 $\mu\text{V}/(\text{V}/\text{m})^2$

Channel Z: 0.58 $\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression Point: 76 mV



SENSITIVITY IN BODY TISSUE

Frequency: 2450 MHz
Epsilon: 52.7(+/-5%) Sigma: 1.95 S/m (+/-10%)

ConvF

Channel X: 5.6

Channel Y: 5.6

Channel Z: 5.6

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

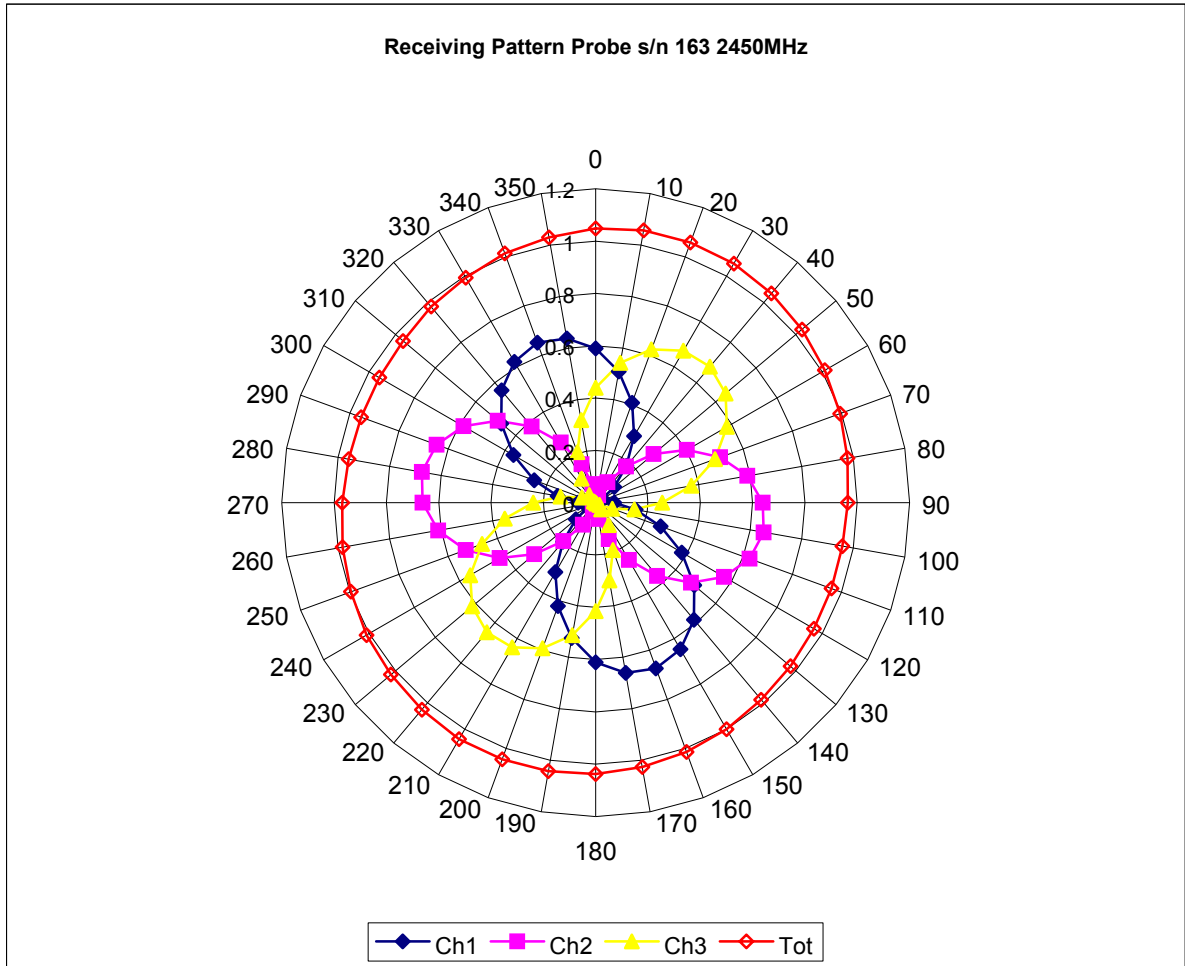
Boundary Effect:

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.

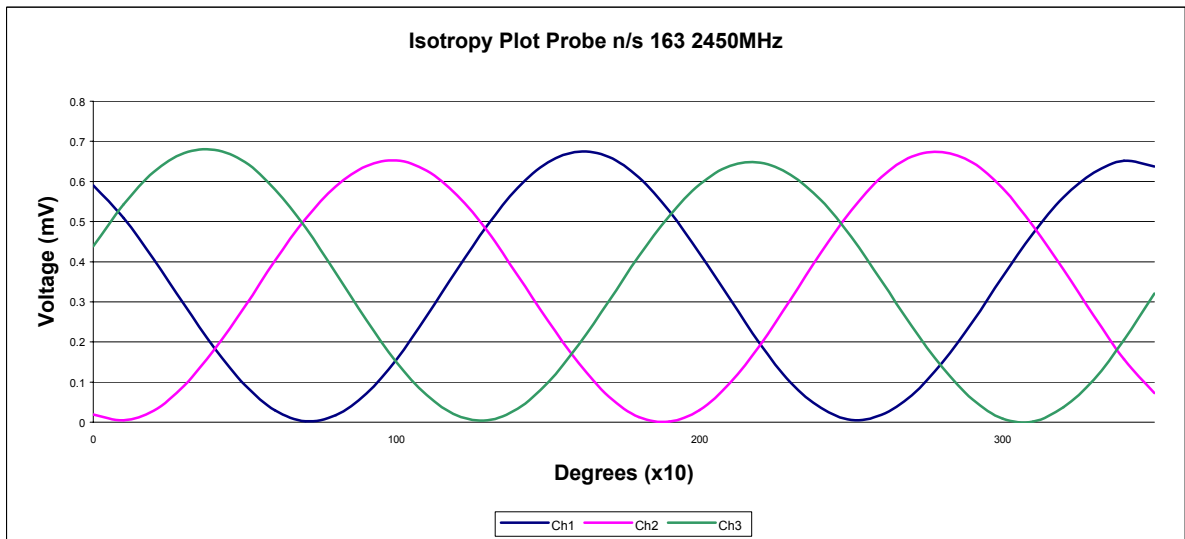
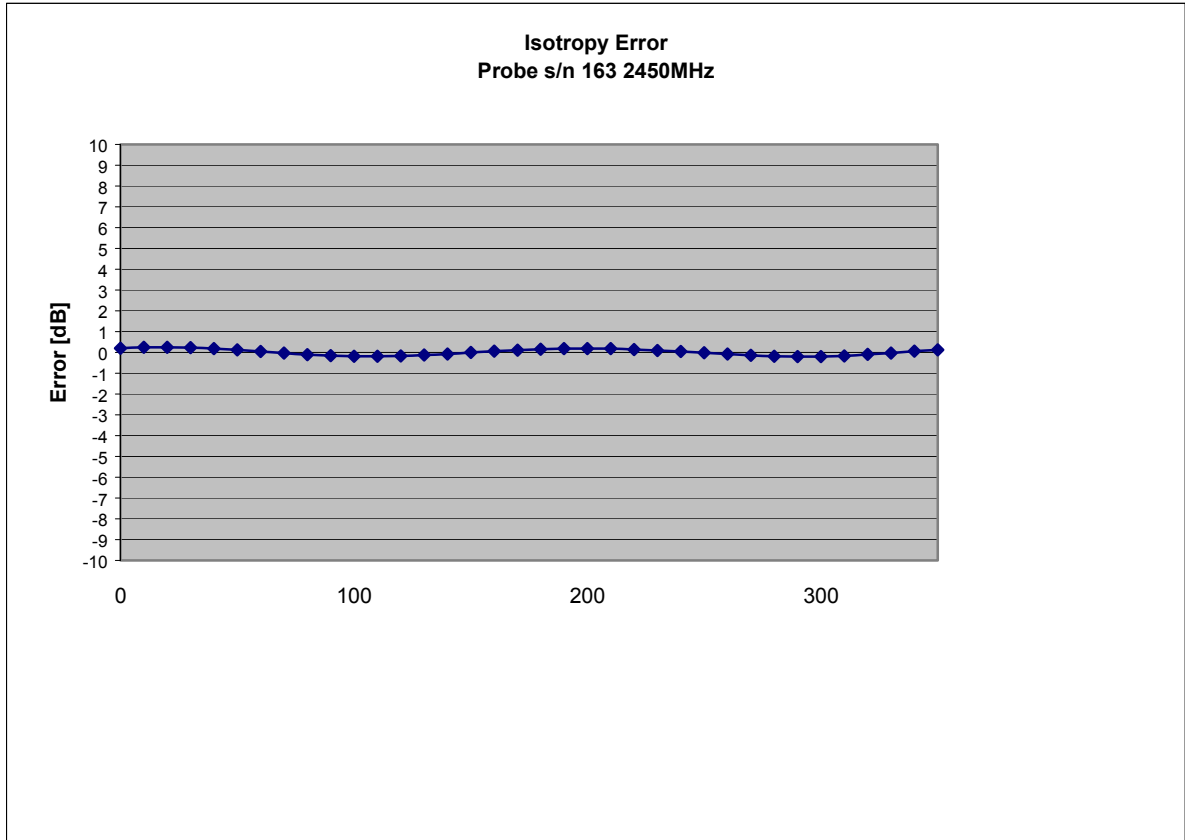
Spatial Resolution:

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.

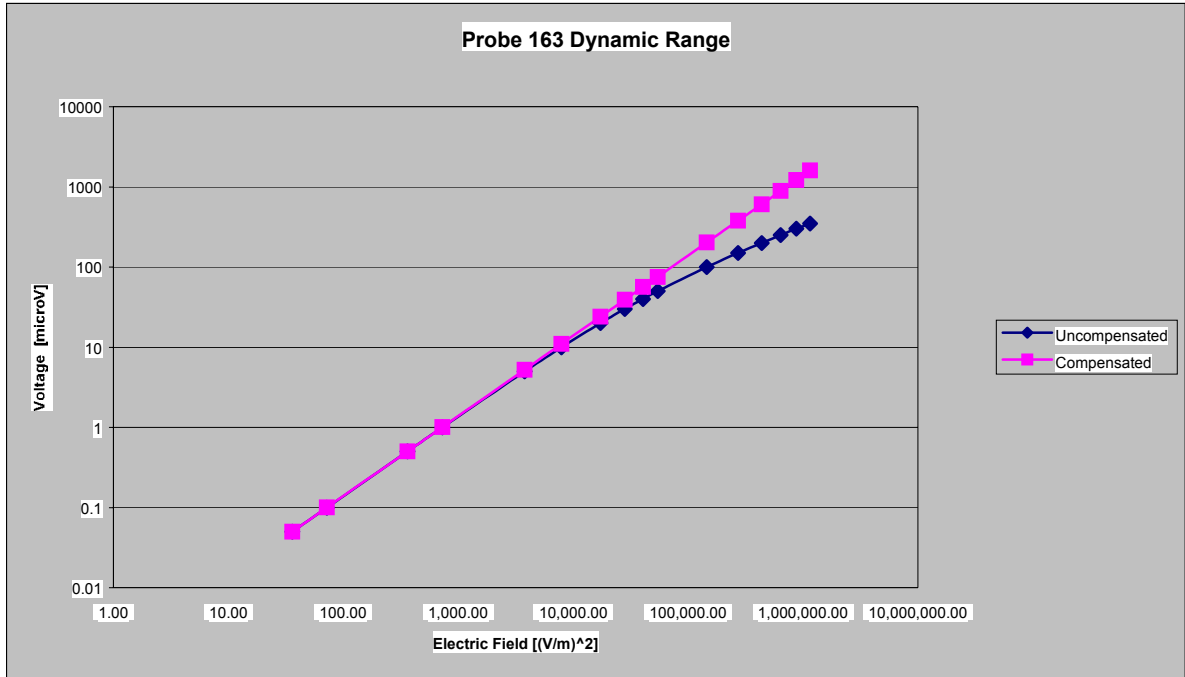
RECEIVING PATTERN 2450 MHZ (AIR)



ISOTROPY ERROR 2450 MHZ (AIR)

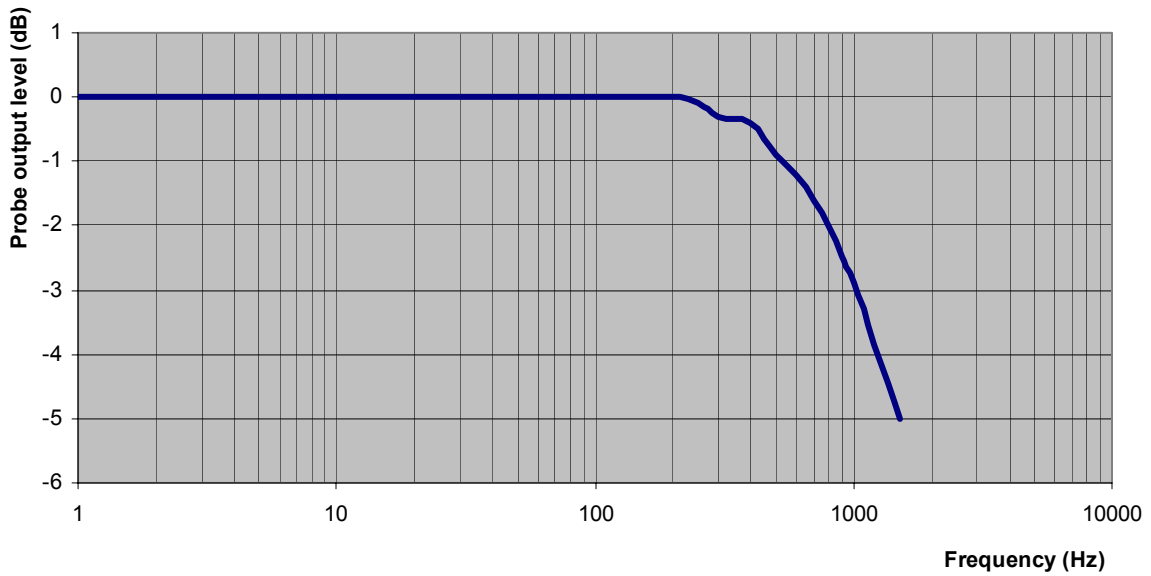


DYNAMIC RANGE



Video Bandwidth

Probe Frequency Characteristics



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



CONVERSION FACTOR UNCERTAINTY ASSESSMENT

Frequency: 2450 MHz

Epsilon: 52.7 (+/-5%) **Sigma:** 1.95 S/m (+/-10%)

ConvF

Channel X: **5.6** **7%(K=2)**

Channel Y: **5.6** **7%(K=2)**

Channel Z: 5.6 **7%(K=2)**

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

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



Appendix F

Dipole Calibration Certificate



NCL CALIBRATION LABORATORIES

Calibration File No: DC-0265

Project Number: Internal

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.

APREL Validation Dipole

Manufacturer: APREL Laboratories

Part number: D-2450-S-1

Frequency: 2.45 GHz

Serial No: ALCD-10

Customer: APREL

Calibrated: 15 November 2002
Released on: 14 November 2003

Released By: _____

NCL CALIBRATION LABORATORIES

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



7.0 CALIBRATION RESULTS SUMMARY

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

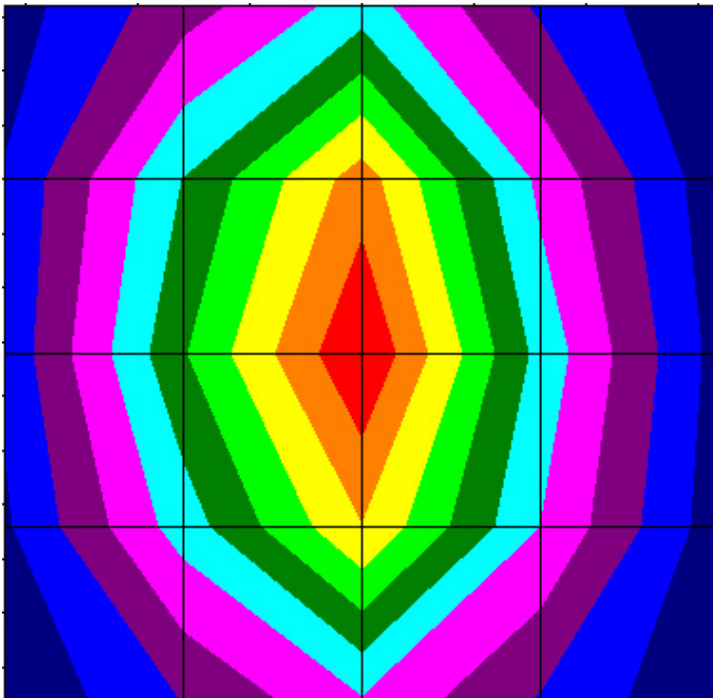
Length: 51.7 mm
Height: 30.8 mm

Electrical Specification

SWR: 1.181U
Return Loss: -21.4 dB
Impedance: 46.175

System Validation Results

Frequency	1 Gram	10 Gram	Peak
2.45 GHz	52.45	22.91	102.91



8.0 INTRODUCTION

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018. The results contained within this report are for Validation Dipole ALCD-10 at 2.45 GHz. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the IEEE mechanical specification. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALIDX-500, along with the APREL Reference E-010 130 MHz to 26 GHz E-Field Probe Serial Number 163.

9.0 REFERENCES

SSI-TP-018 Dipole Calibration Procedure
SSI-TP-016 Tissue Calibration Procedure
IEEE 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"

Conditions

Dipole ALCD-10 was a new Dipole taken from stock prior to calibration.

Ambient Temperature of the Laboratory: 24 °C +/- 0.5°C
Temperature of the Tissue: 20 °C +/- 0.5°C



10.0 DIPOLE CALIBRATION RESULTS

Mechanical Verification

IEEE Length	IEEE Height	Measured Length	Measured Height
51.5 mm	30.4 mm	51.7 mm	30.8 mm

Tissue Validation

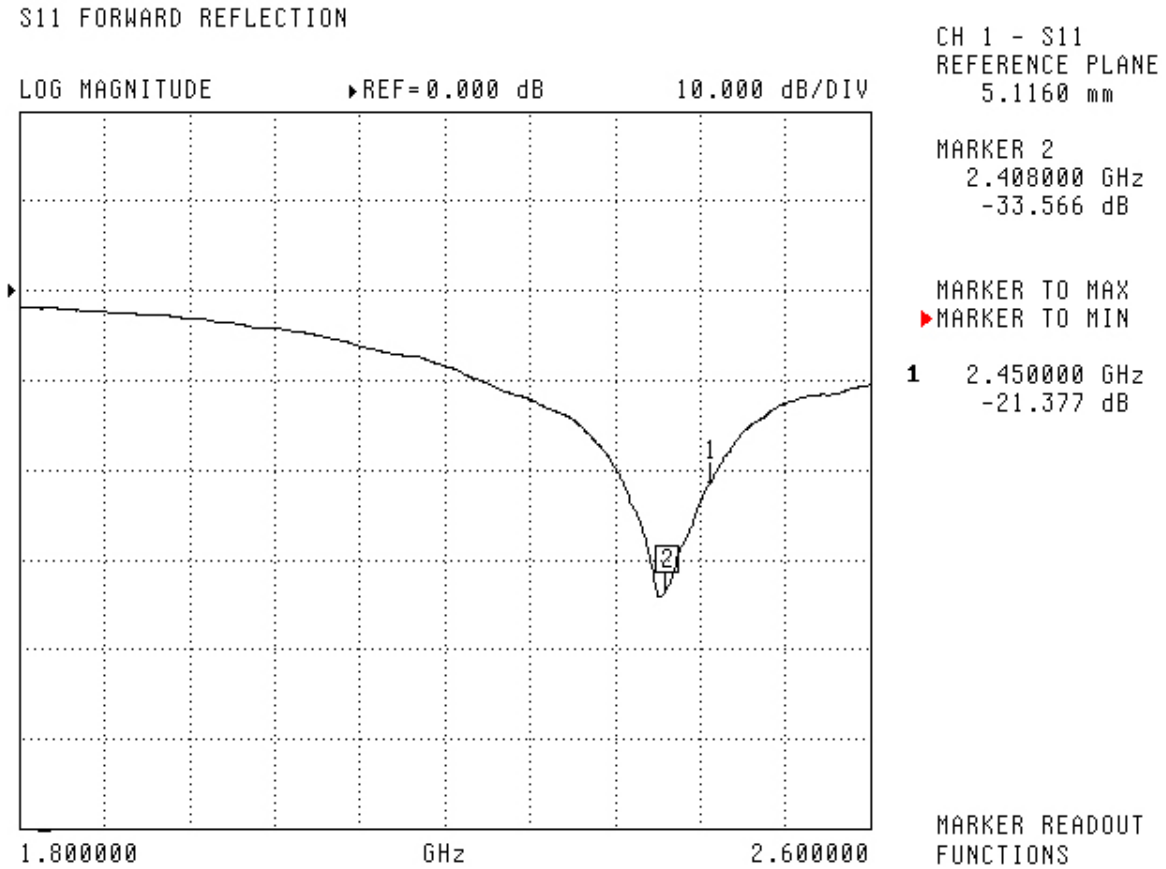
Head Tissue 2450 MHz	Measured
Dielectric constant, ϵ_r	39.2
Conductivity, σ [S/m]	1.82
Tissue Conversion Factor,	4.61

Electrical Calibration

Test	Result	IEEE Value
S11 R/L	-21.4	-21 dB
SWR	1.181U	-
Impedance	46.175 Ω	

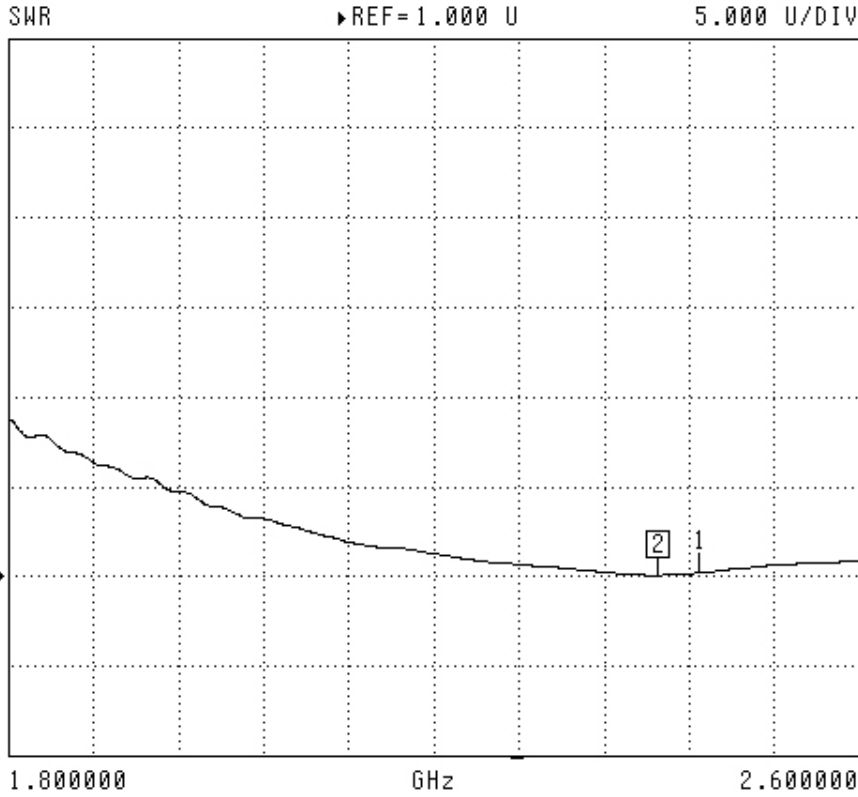
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss



SWR

S11 FORWARD REFLECTION



CH 1 - S11
REFERENCE PLANE
5.1160 mm

MARKER 2
2.411000 GHz
1.049 U

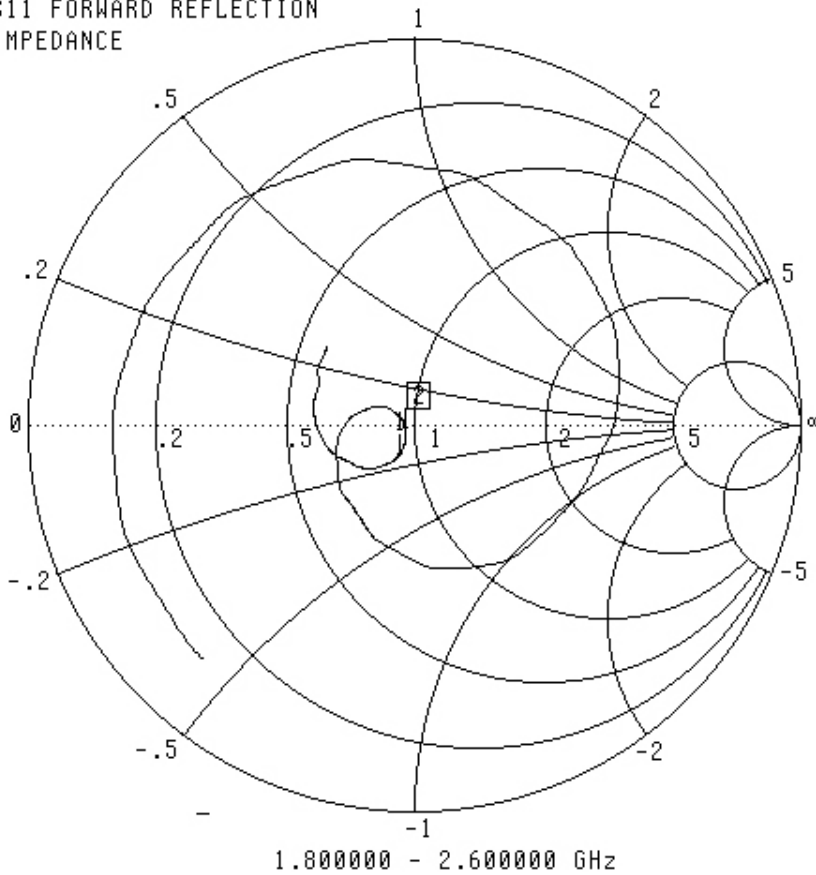
MARKER TO MAX
▶ MARKER TO MIN
1 2.450000 GHz
1.181 U

MARKER READOUT
FUNCTIONS



Smith Chart Dipole Impedance

S11 FORWARD REFLECTION
IMPEDANCE



CH 1 - S11
REFERENCE PLANE
5.1160 mm

MARKER 2
2.411000 GHz
48.080 Ω
-1.171 jΩ

MARKER TO MAX
▶ MARKER TO MIN
1 2.450000 GHz
46.175 Ω
-7.199 jΩ

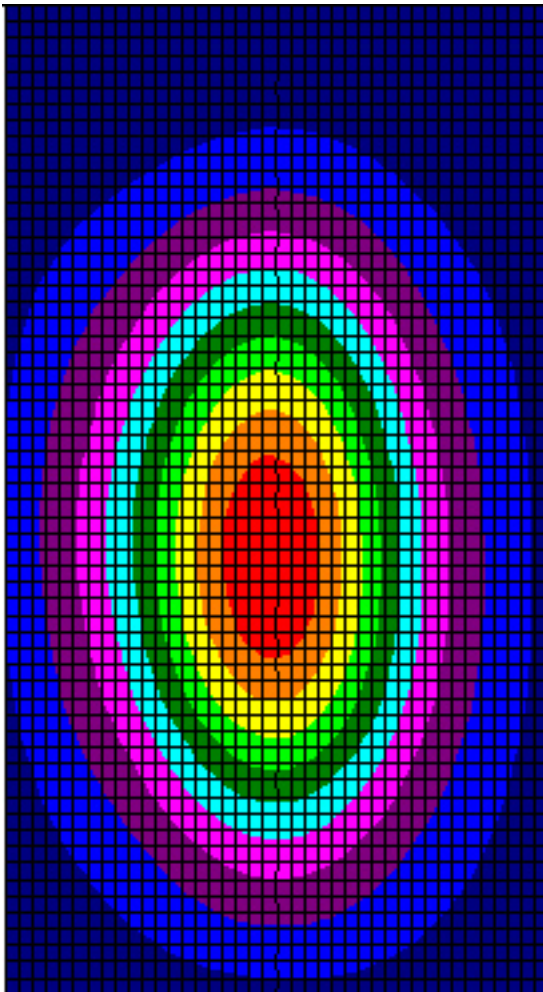
MARKER READOUT
FUNCTIONS



System Validation Results Using the Electrically Calibrated Dipole

Frequency	1 Gram	10 Gram	Peak Above Feed Point
2.45 GHz	52.45	22.91	102.91

The following Graphic Plot is the splined measurement result for the course scan.



11.0 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

