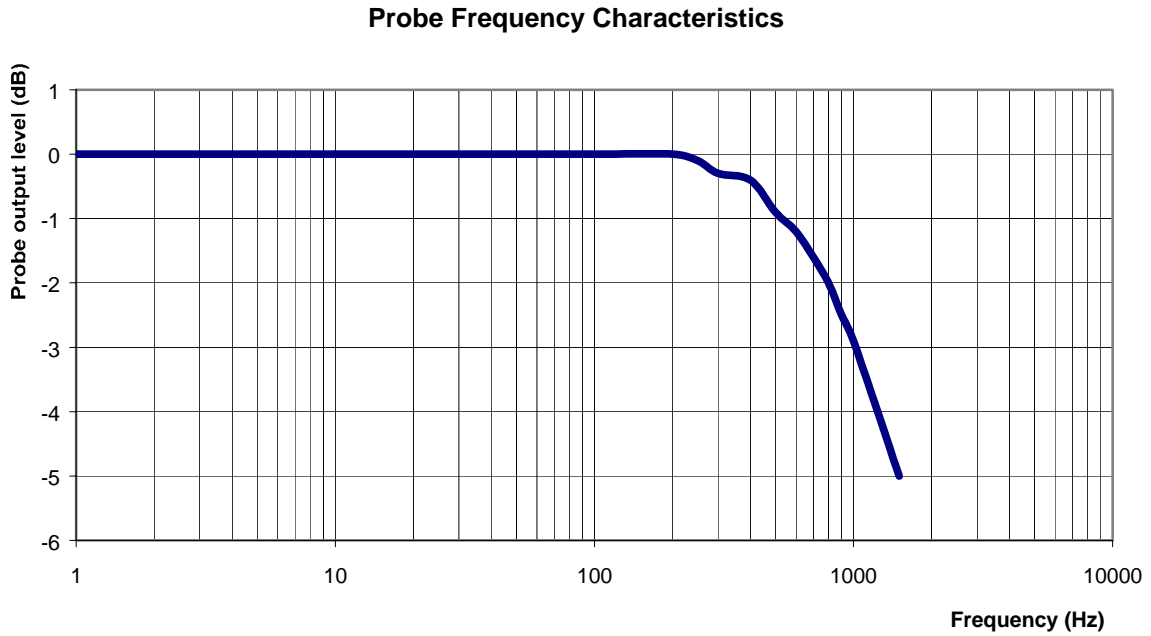


## Video Bandwidth



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

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5200MHz  
**Epsilon:** 43.4 (+/-5%)      **Sigma:** 5.7 S/m (+/-10%)

### **ConvF**

**Channel X:** 2.8      7%(K=2)

**Channel Y:** 2.8      7%(K=2)

**Channel Z:** 2.8      7%(K=2)

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

### **Boundary Effect:**

For a distance of 2.4mm 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 2005.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-609

Client.: RFEL

## 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 5800 MHz

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 215

BODY Calibration

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: RFEL-Probe-215-Calibration-5166

Calibrated: 10<sup>th</sup> June 2005  
Released on: 10<sup>th</sup> June 2005

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_ Signature On File

**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-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-020 215.

## **References**

SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "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-011 Tissue Calibration Procedure

## **Conditions**

Probe 215 was a new probe taken from stock prior to calibration.

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

**We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**

---

**Stuart Nicol**  
**Director Product Development**

---

**Janusz Lokaj**  
**Member of Engineering Staff**  
**(Calibration Engineer)**

## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-020
<b>Serial Number:</b>	215
<b>Frequency:</b>	5800 MHz
<b>Sensor Offset:</b>	1.56 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	<5 mm
<b>Tip Length:</b>	60 mm
<b>Total Length:</b>	290 mm

\*Resistive to recommended tissue recipes per IEEE-1528

## Sensitivity in Air

<b>Channel X:</b>	1.2 $\mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Y:</b>	1.2 $\mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Z:</b>	1.2 $\mu\text{V}/(\text{V}/\text{m})^2$
<b>Diode Compression Point:</b>	95 mV

## **Sensitivity in Body Tissue**

**Frequency:** 5800 MHz

**Epsilon:** 49.6 (+/-5%)      **Sigma:** 6.25 S/m (+/-10%)

### **ConvF**

**Channel X:** 2.1

**Channel Y:** 2.1

**Channel Z:** 2.1

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq.

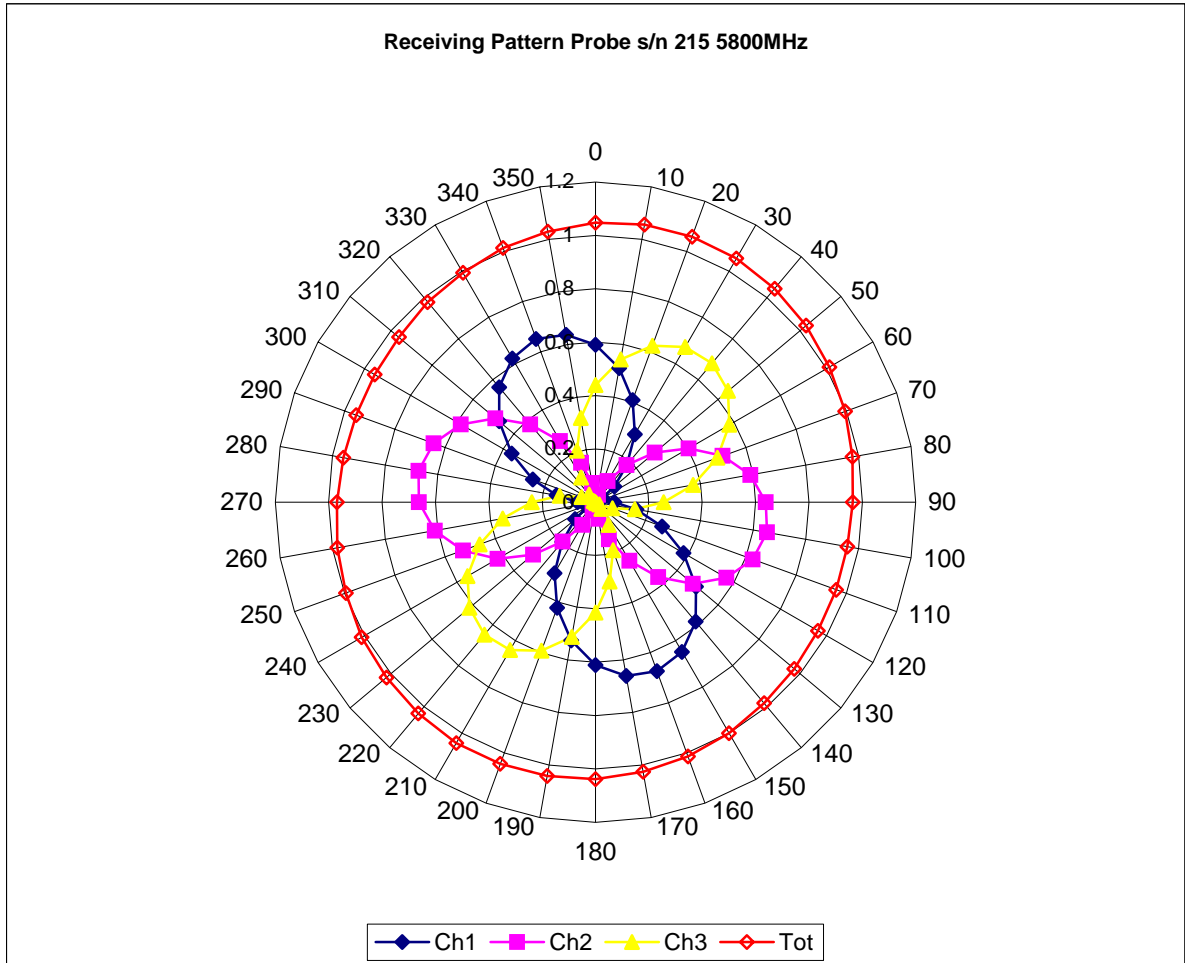
### **Boundary Effect:**

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 2.44mm.

### **Spatial Resolution:**

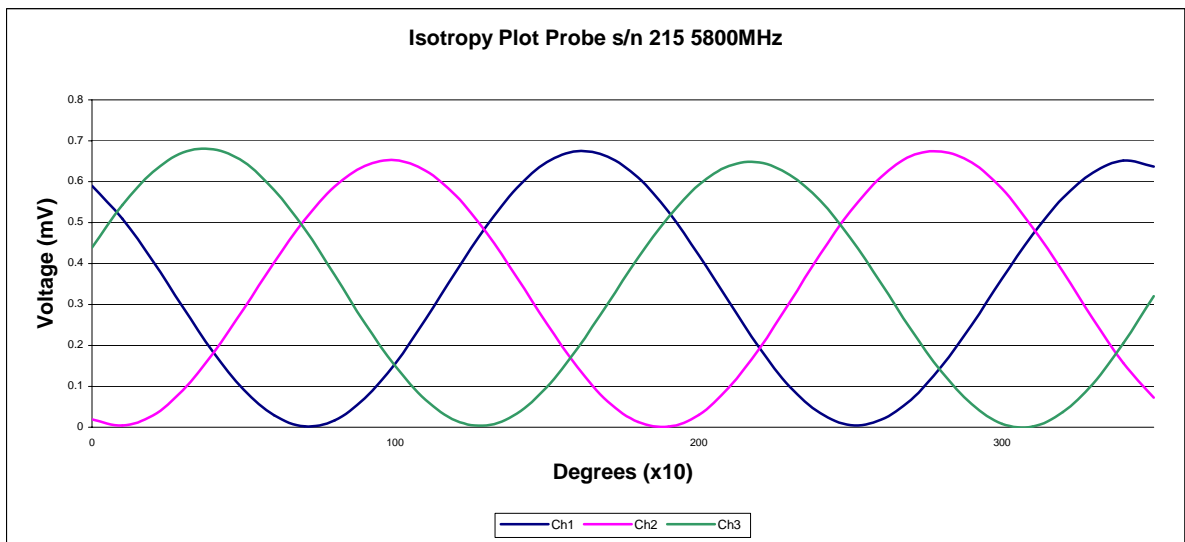
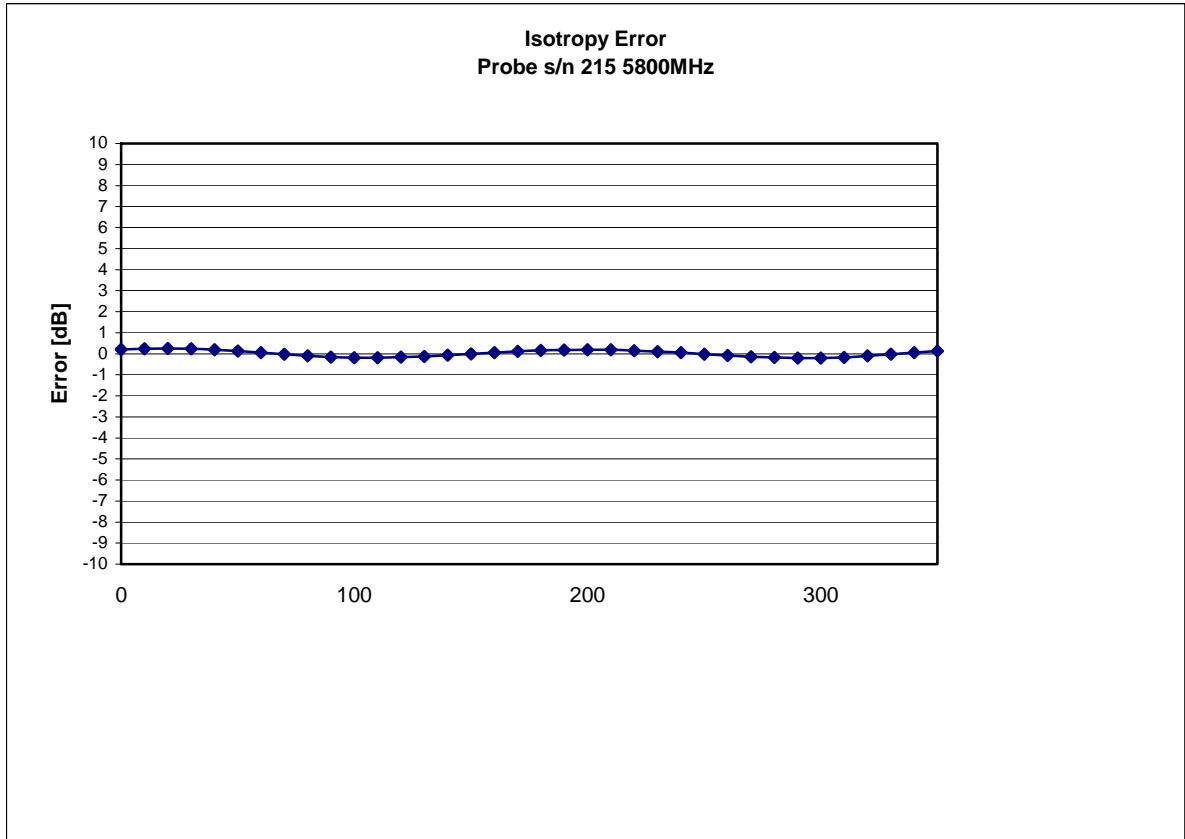
The measured probe tip diameter is 5 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

## Receiving Pattern 5800 MHz (Air)





### Isotropy Error 5800 MHz (Air)

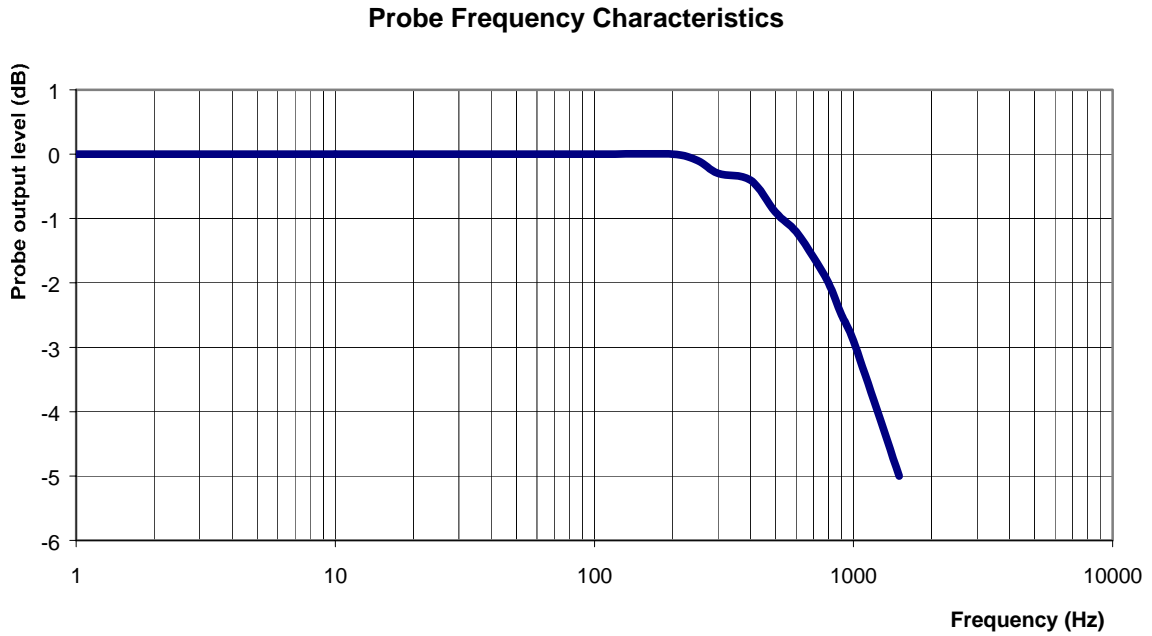


Isotropicity in Tissue:

0.10 dB



## Video Bandwidth



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

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5800MHz

**Epsilon:** 49.6 (+/-5%)

**Sigma:** 6.25 S/m (+/-10%)

### **ConvF**

**Channel X:** 2.1 7%(K=2)

**Channel Y:** 2.1 7%(K=2)

**Channel Z:** 2.1 7%(K=2)

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

### **Boundary Effect:**

For a distance of 2.4mm 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 2005.

## Appendix E – Dipole Calibration Data Sheets

## RF Exposure Lab, LLC

Calibration File No: CAL.20060203

# CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated at RF Exposure Lab, LLC by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

### Validation Dipole

Manufacturer: APREL Laboratories

Part Number: ALS-D-2450-S-2

Frequency: 2.4 GHz

Serial No: RFE-278

Manufactured: 20 February 2004  
Calibrated: 17 February 2006

Calibrated By: Signature on File  
Jay Moulton – Technical Manager

Approved By: Signature on File  
Tamara Moulton – Quality Manager



**RF EXPOSURE LAB, LLC**

2867 Progress Place, Suite 4D  
Escondido, CA 92029

Tel: (760) 737-3131  
FAX: (760) 737-9131

## Calibration Results Summary

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

### Mechanical Dimensions

**Length:** 51.5 mm  
**Height:** 30.5 mm

### Electrical Specifications

#### Head

**SWR:** 1.0994 U  
**Return Loss:** -28.139 dB  
**Impedance:** 53.471  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram
1.9 GHz	52.920	26.370

#### Body

**SWR:** 1.1373 U  
**Return Loss:** -31.923 dB  
**Impedance:** 53.338  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram
1.9 GHz	54.230	24.880



## Head Measurement Conditions

The measurements were performed in the Uni-Phantom filled with head simulating liquid of the following electrical parameters at 2450 MHz:

Relative Dielectricity	39.63	± 5%
Conductivity	1.82 mho/m	± 5%

The APREL Laboratories ALSAS system with a dosimetric E-field probe E-020 (SN:215, Conversion factor 4.6 at 2450 MHz) was used for the measurements.

The dipole was mounted so that the dipole feed point was positioned below the center marking of the flat phantom and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from the dipole center to the solution surface.

The coarse grid with a grid spacing of 10mm was aligned with the dipole. The 5x5x8 fine cube was chosen for cube integration. The dipole input power (forward power) was 100mW ± 3%. The results are normalized to 1W input power.

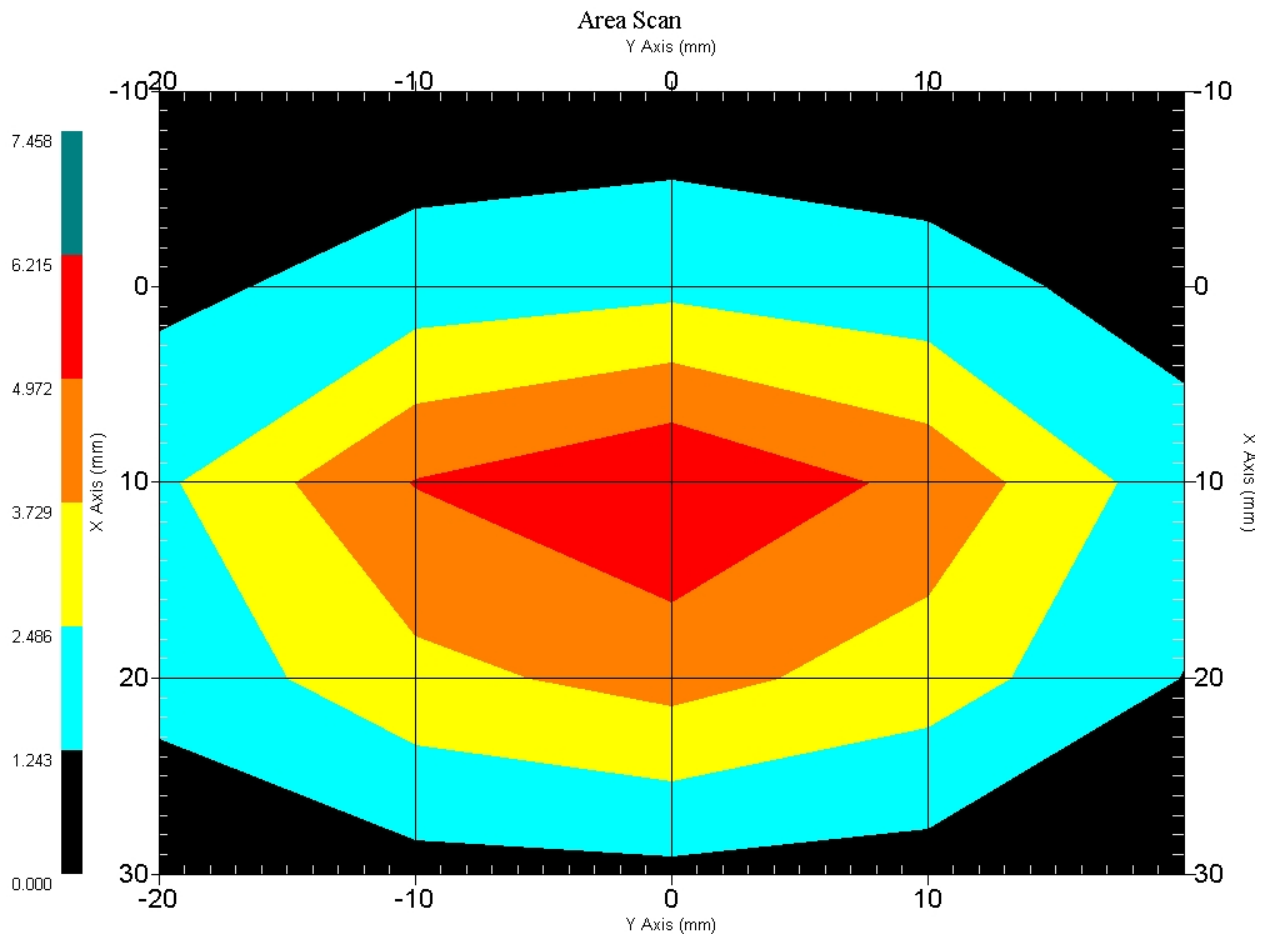
The laboratories environmental conditions were as follows during the calibration sequence.

Ambient Temperature of the Laboratory:	23 °C ± 1.0 °C
Temperature of the Tissue:	20 °C ± 1.0 °C
Relative Humidity:	42%

**SAR Measurement**

Standard SAR measurements were performed according to the measurement conditions described above. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR values measured with the dosimetric probe E-020 SN:215 and applying the advanced extrapolation are:

Averaged over 1 cm<sup>3</sup> (1 g) of tissue:                    52.920 mW/g ± 19.7% (k=2)<sup>1</sup>  
 Averaged over 10 cm<sup>3</sup> (10 g) of tissue:                    26.370 mW/g ± 19.4% (k=2)<sup>1</sup>



1 gram SAR value : 5.292 W/kg  
 10 gram SAR value : 2.637 W/kg  
 Area Scan Peak SAR : 6.215 W/kg  
 Zoom Scan Peak SAR : 10.080 W/kg

<sup>1</sup> validation uncertainty

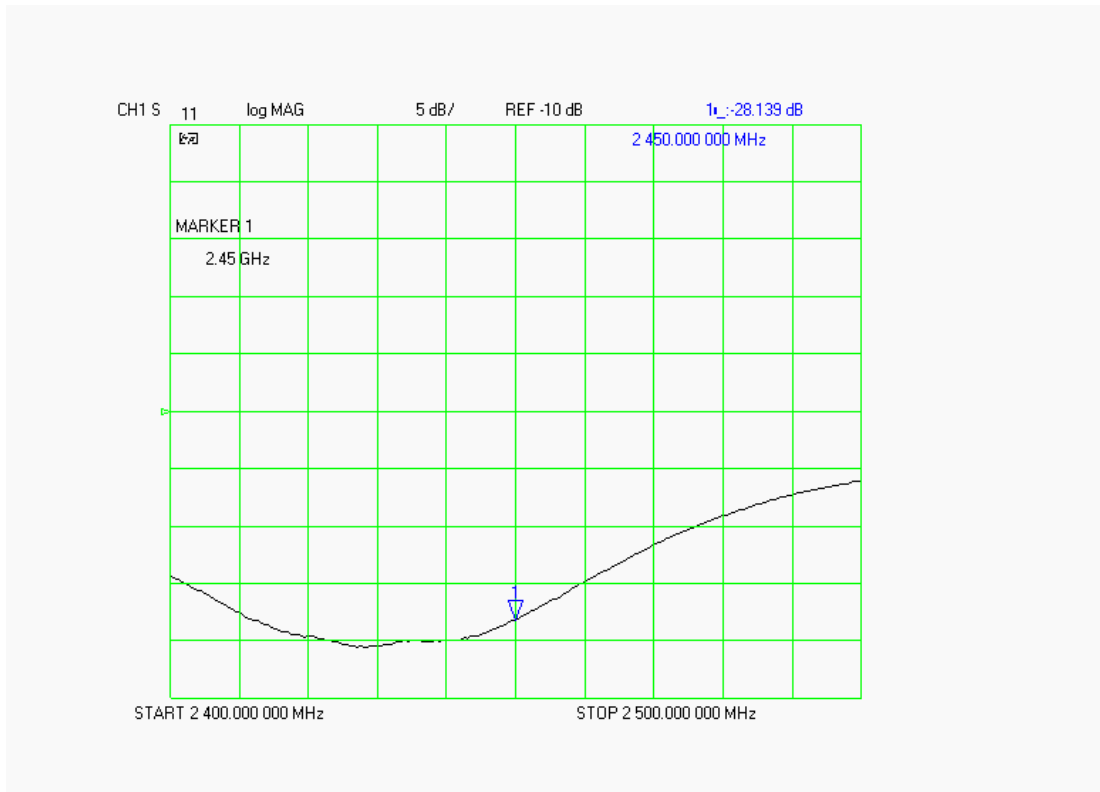
### Dipole Impedance and Return Loss

The impedance was measured at the SMA connector with a network analyzer. The dipole was positioned at the flat phantom sections according to measurement conditions stated above during impedance measurements.

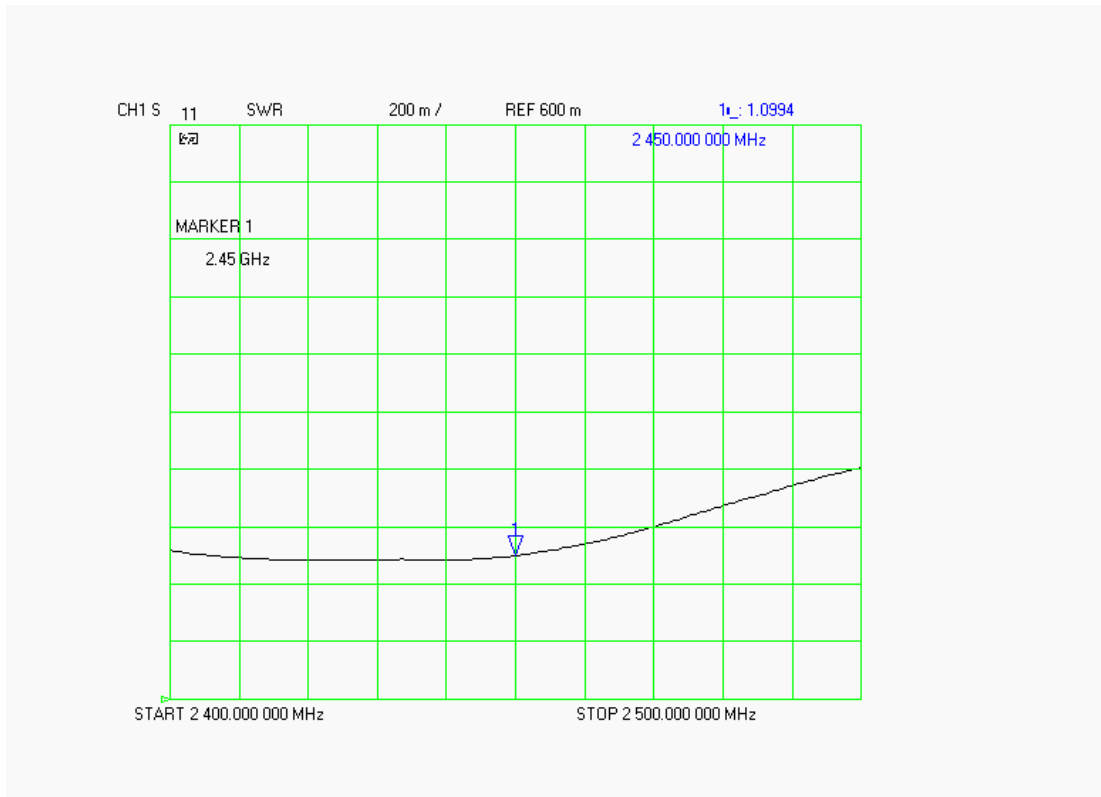
Test	Result
S11 R/L	-28.139 dB
SWR	1.0994 U
Impedance	53.471 $\Omega$

The following graphs are the results as displayed on the Vector Network Analyzer.

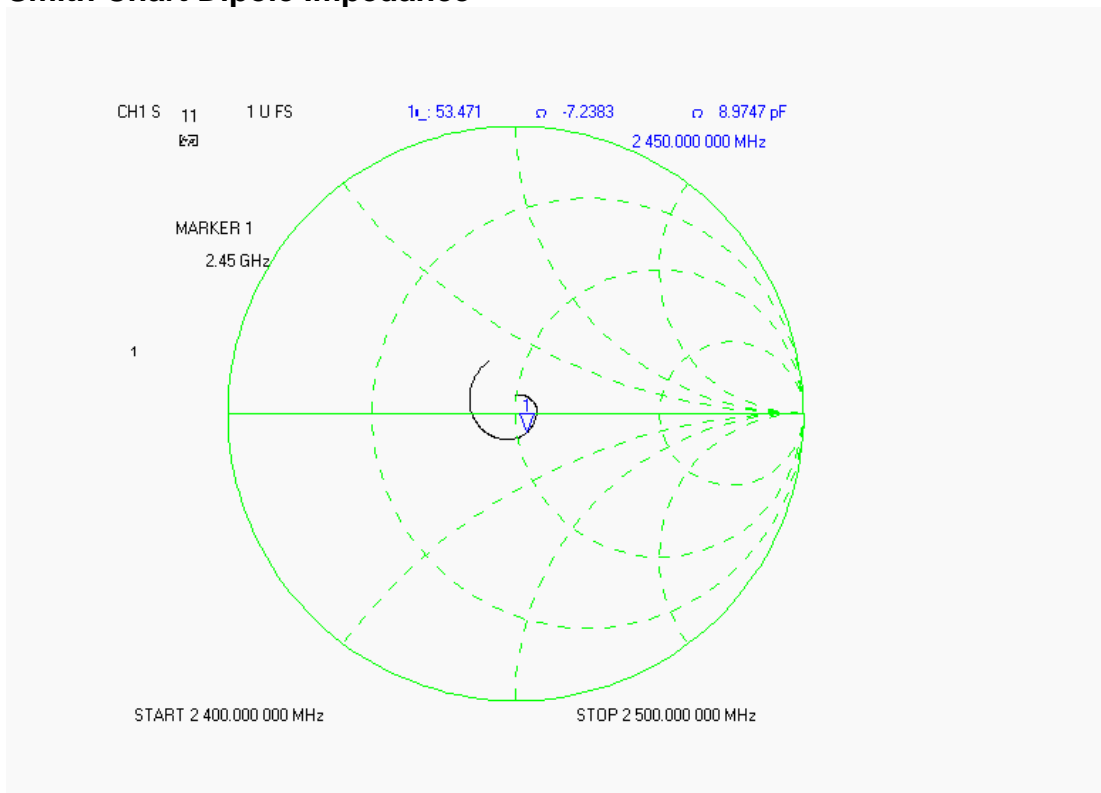
### S11 Parameter Return Loss



### SWR



### Smith Chart Dipole Impedance



## Body Measurement Conditions

The measurements were performed in the Uni-Phantom filled with body simulating liquid of the following electrical parameters at 2450 MHz:

Relative Dielectricity	51.09	± 5%
Conductivity	1.96 mho/m	± 5%

The APREL Laboratories ALSAS system with a dosimetric E-field probe E-020 (SN:215, Conversion factor 4.6 at 2450 MHz) was used for the measurements.

The dipole was mounted so that the dipole feed point was positioned below the center marking of the flat phantom and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from the dipole center to the solution surface.

The coarse grid with a grid spacing of 10mm was aligned with the dipole. The 5x5x8 fine cube was chosen for cube integration. The dipole input power (forward power) was 100mW ± 3%. The results are normalized to 1W input power.

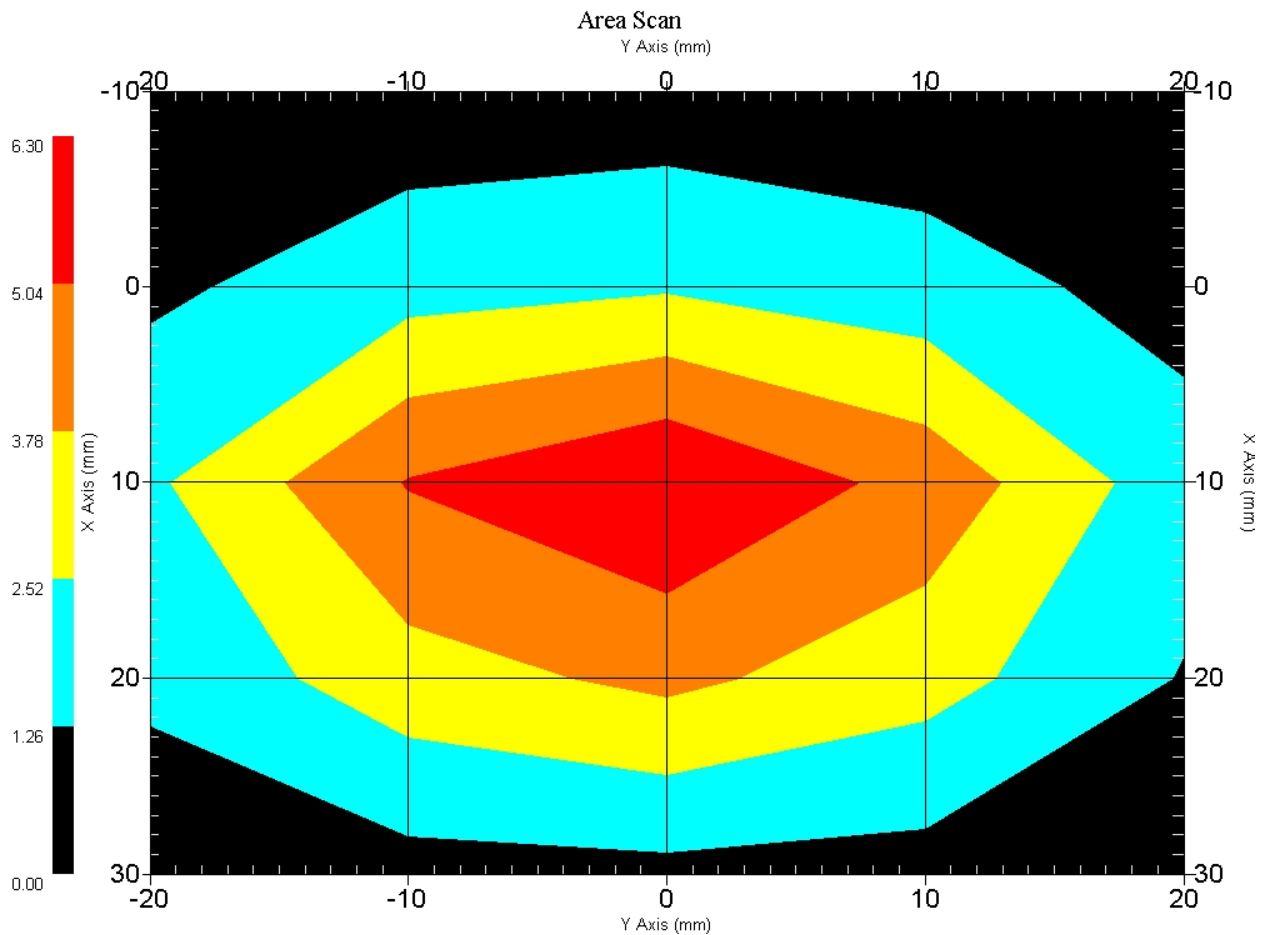
The laboratories environmental conditions were as follows during the calibration sequence.

Ambient Temperature of the Laboratory:	20 °C ± 1.0 °C
Temperature of the Tissue:	20 °C ± 1.0 °C
Relative Humidity:	43%

**SAR Measurement**

Standard SAR measurements were performed according to the measurement conditions described above. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR values measured with the dosimetric probe E-020 SN:215 and applying the advanced extrapolation are:

Averaged over 1 cm<sup>3</sup> (1 g) of tissue:                    54.230 mW/g ± 18.8% (k=2)<sup>1</sup>  
 Averaged over 10 cm<sup>3</sup> (10 g) of tissue:                    24.880 mW/g ± 18.4% (k=2)<sup>1</sup>



1 gram SAR value : 5.423 W/kg  
 10 gram SAR value : 2.488 W/kg  
 Area Scan Peak SAR : 6.298 W/kg  
 Zoom Scan Peak SAR : 11.090 W/kg

<sup>1</sup> validation uncertainty

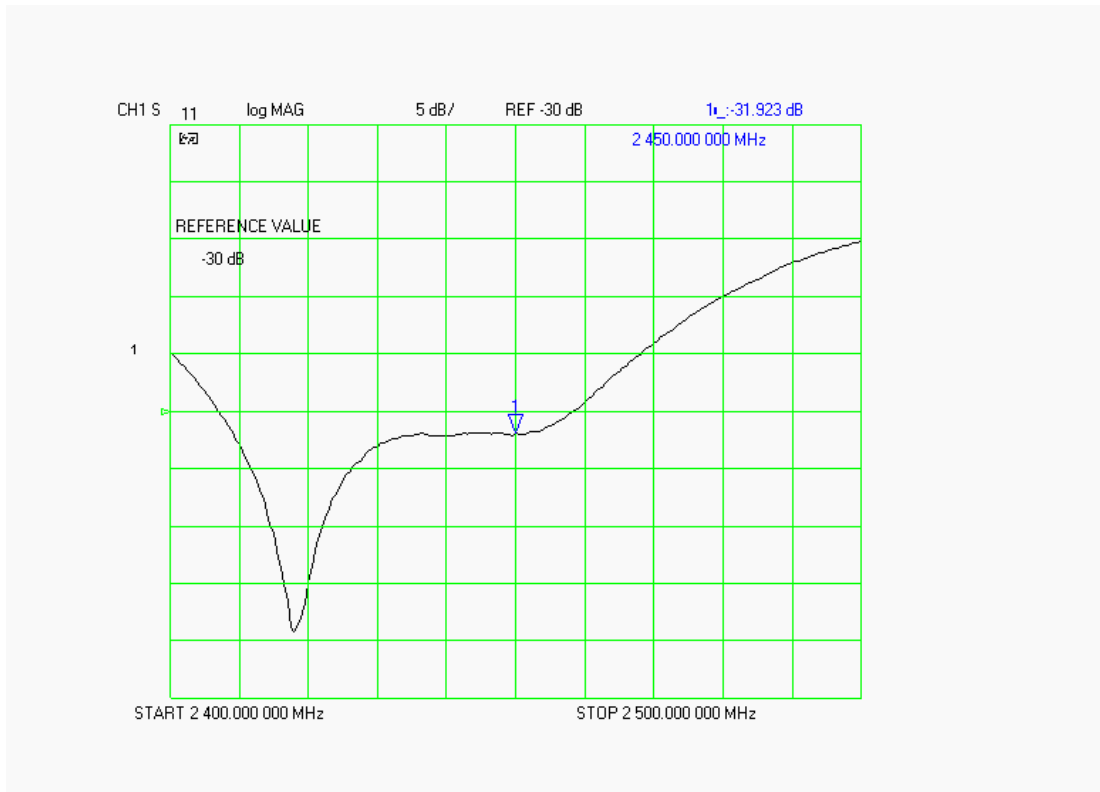
### Dipole Impedance and Return Loss

The impedance was measured at the SMA connector with a network analyzer. The dipole was positioned at the flat phantom sections according to measurement conditions stated above during impedance measurements.

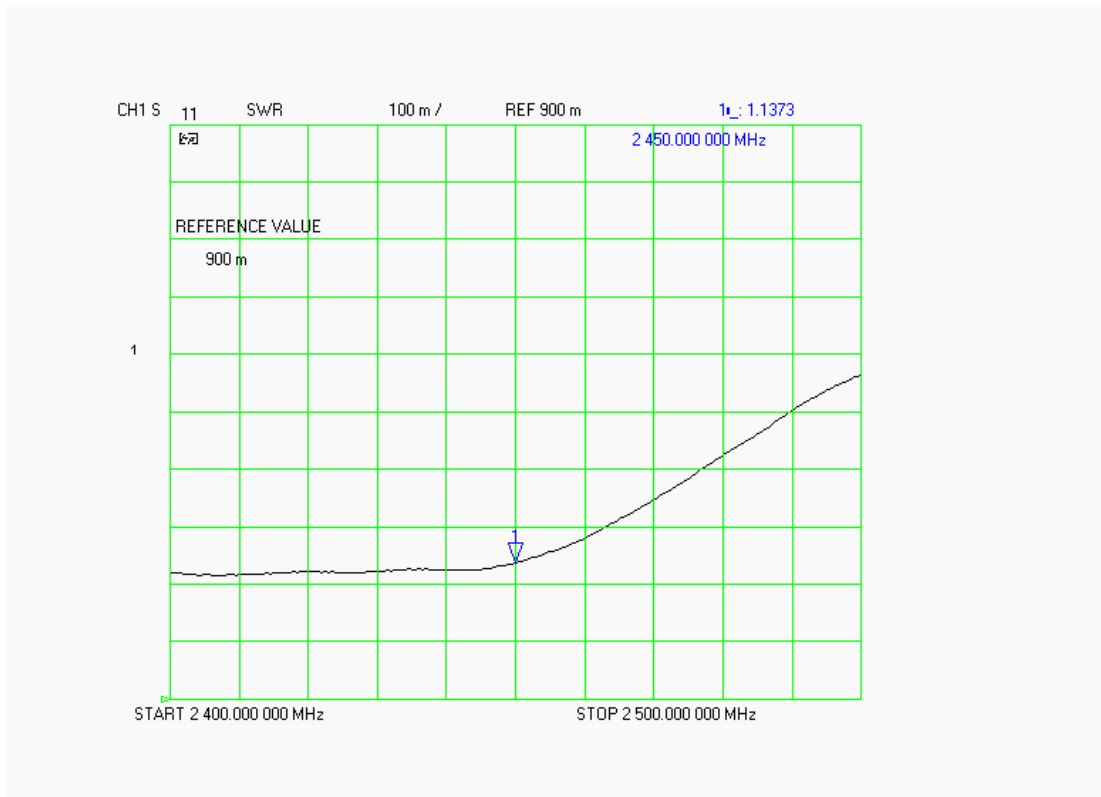
Test	Result
S11 R/L	-31.923 dB
SWR	1.1373 U
Impedance	53.338 $\Omega$

The following graphs are the results as displayed on the Vector Network Analyzer.

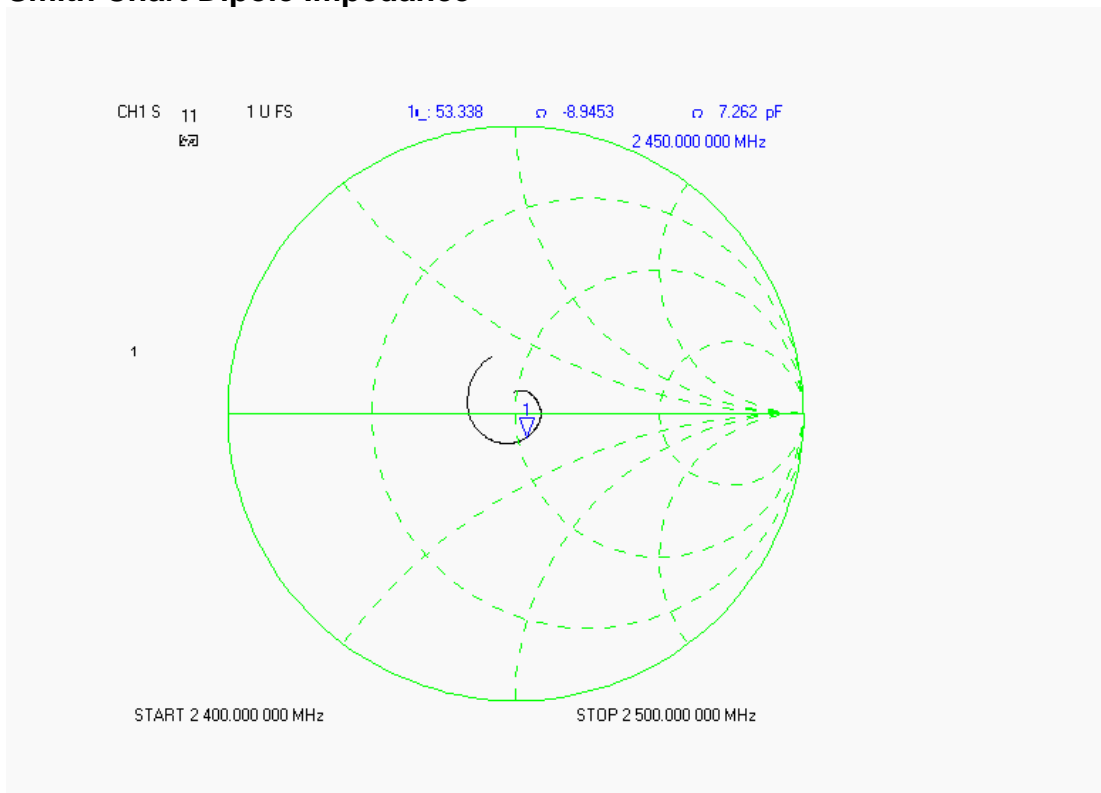
### S11 Parameter Return Loss



### SWR



### Smith Chart Dipole Impedance





**Test Equipment List**

Type	Calibration Due Date	Serial Number
ThermoCRS Robot	N/A	RAF0338198
ThermoCRS Controller	N/A	RCF0338224
ThermoCRS Teach Pendant (Joystick)	N/A	STP0334405
IBM Computer, 2.66 MHz P4	N/A	8189D8U KCPR08N
Apriel E-Field Probe ALS-E020	06/10/2006	RFE-215
Apriel E-Field Probe ALS-E020	01/25/2007	
Apriel UniPhantom	N/A	RFE-273
Agilent (HP) 437B Power Meter	12/12/2006	3125U08837
Agilent (HP) 8481B Power Sensor	12/19/2006	3318A05384
Agilent (HP) 8350B Signal Generator	03/03/2006	2749A10226
Agilent (HP) 83525A RF Plug-In	03/03/2006	2647A01172
Agilent (HP) 8753C Vector Network Analyzer	02/02/2007	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	02/02/2007	2904A00595
Apriel Dielectric Probe Assembly	N/A	0011
Microwave Power Devices 510-10E Amplifier	03/03/2006	6063-001
Microwave Power Devices 1020-9E Amplifier	03/03/2006	5618-1
Brain Equivalent Matter (835 MHz)	N/A	N/A
Brain Equivalent Matter (1900 MHz)	N/A	N/A
Brain Equivalent Matter (900 MHz)	N/A	N/A
Muscle Equivalent Matter (835 MHz)	N/A	N/A
Muscle Equivalent Matter (1900 MHz)	N/A	N/A
Muscle Equivalent Matter (900 MHz)	N/A	N/A
Muscle Equivalent Matter (2450 MHz)	N/A	N/A
Muscle Equivalent Matter (5200 MHz)	N/A	N/A

# NCL CALIBRATION LABORATORIES

Calibration File No: DC-591  
Project Number: RFEL-CAL-D-5258-5163

## 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.

RFEL Validation Dipole

Manufacturer: APREL Laboratories

Part number: ALS-D-5258-S-2

Frequency: 5.2GHz to 5.8GHz

Serial No: 5258-235-00801

Customer: RFEL

Calibrated: 24<sup>th</sup> May 2005  
Released on: 24<sup>th</sup> May 2005

Released By: \_\_\_\_\_

**NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
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CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4162

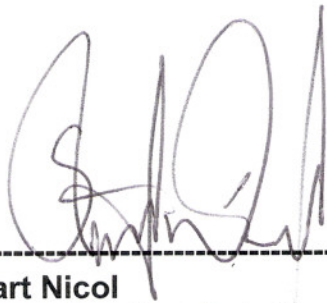
## Conditions

Dipole 5258-235-00801 was new and taken from stock prior to calibration.

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

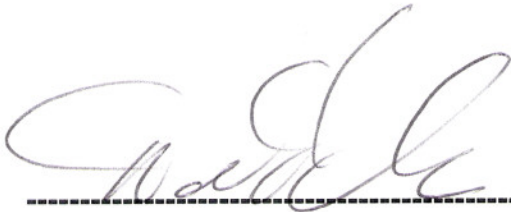
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**We the undersigned attest that to the best of our knowledge the calibration of this device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**



---

**Stuart Nicol**  
**Director Product Development**



---

**D. Brooks**  
**Member of Engineering Staff**  
**(Calibration Engineer)**

## Calibration Results Summary

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

### Mechanical Dimensions

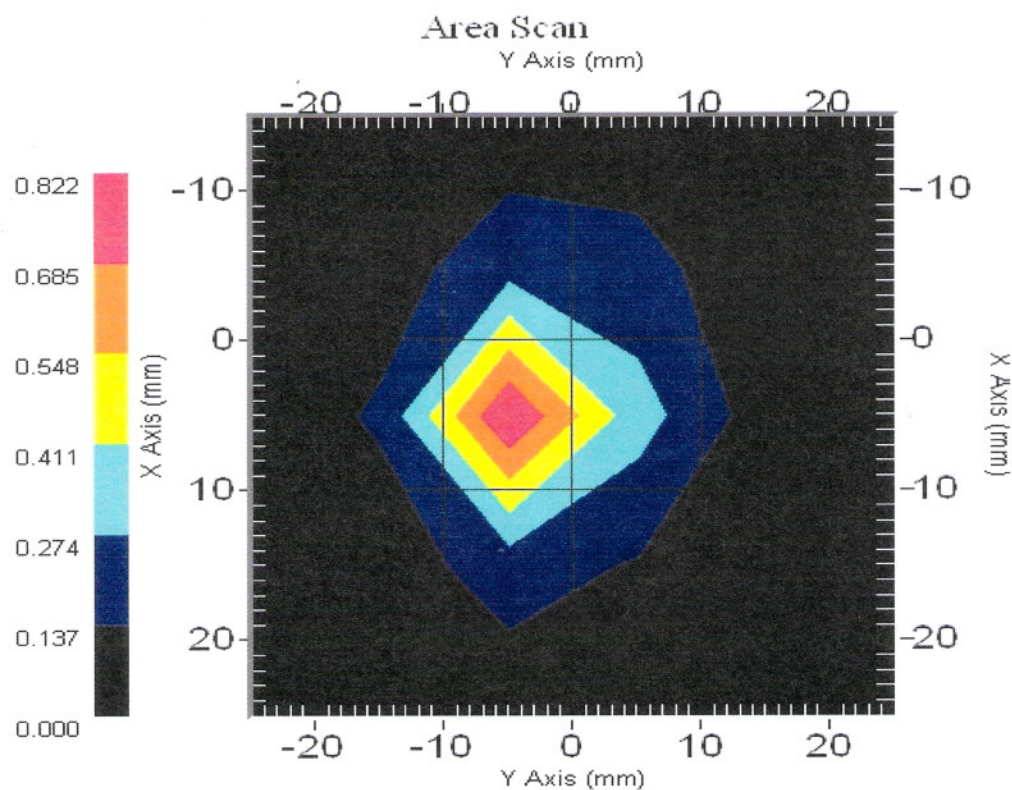
**Length:** 23.3 mm  
**Height:** 20.3 mm

### Electrical Specification

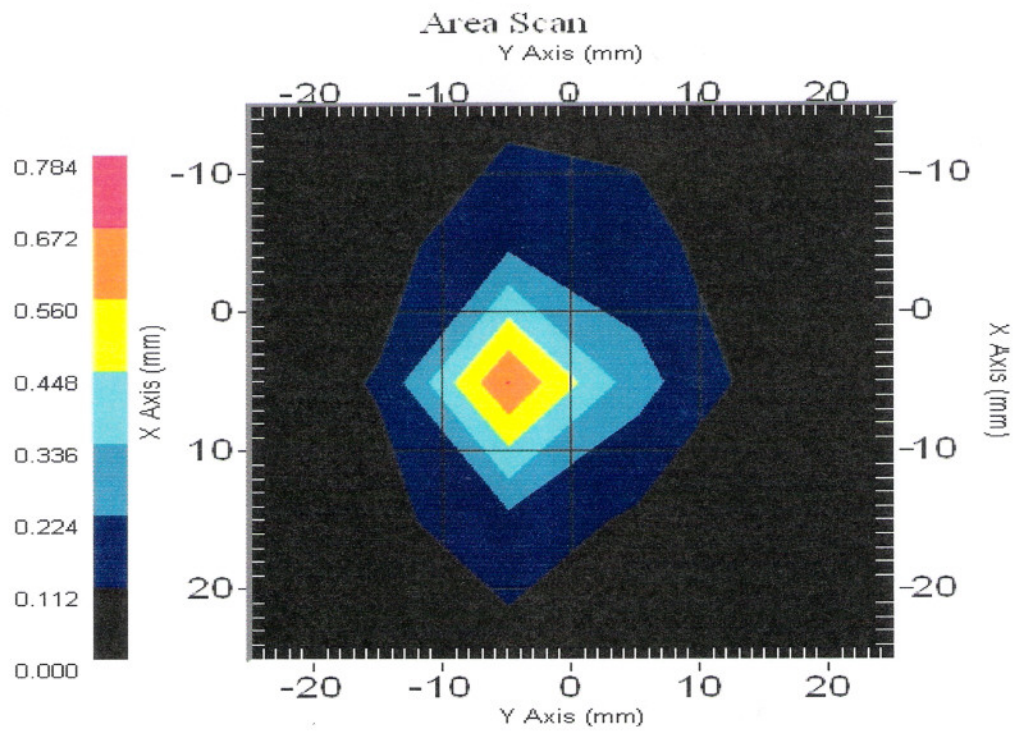
**SWR:** 1.22 U  
**Return Loss:** -20.0 dB  
**Impedance:** 50.0  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram	Peak
5200 MHz	62.9	17.9	223.1



Frequency	1 Gram	10 Gram	Peak
5800 MHz	58.3	18	207.1





## **Introduction**

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 5258-235-00801. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. 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 ALSAS-10U, along with APREL E-020 130 MHz to 26 GHz E-Field Probe Serial Number 212.

## **References**

SSI-TP-018-ALSAS Dipole Calibration Procedure  
SSI-TP-016 Tissue Calibration Procedure  
IEEE 1528 "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 5258-235-00801 was new taken from stock.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 20 °C +/- 0.5°C

## Dipole Calibration Results

### Tissue Validation

Head Tissue 5200 MHz	Measured
Dielectric constant, $\epsilon_r$	35.3
Conductivity, $\sigma$ [S/m]	5.30

Head Tissue 5800 MHz	Measured
Dielectric constant, $\epsilon_r$	35.3
Conductivity, $\sigma$ [S/m]	5.30

### Mechanical Verification

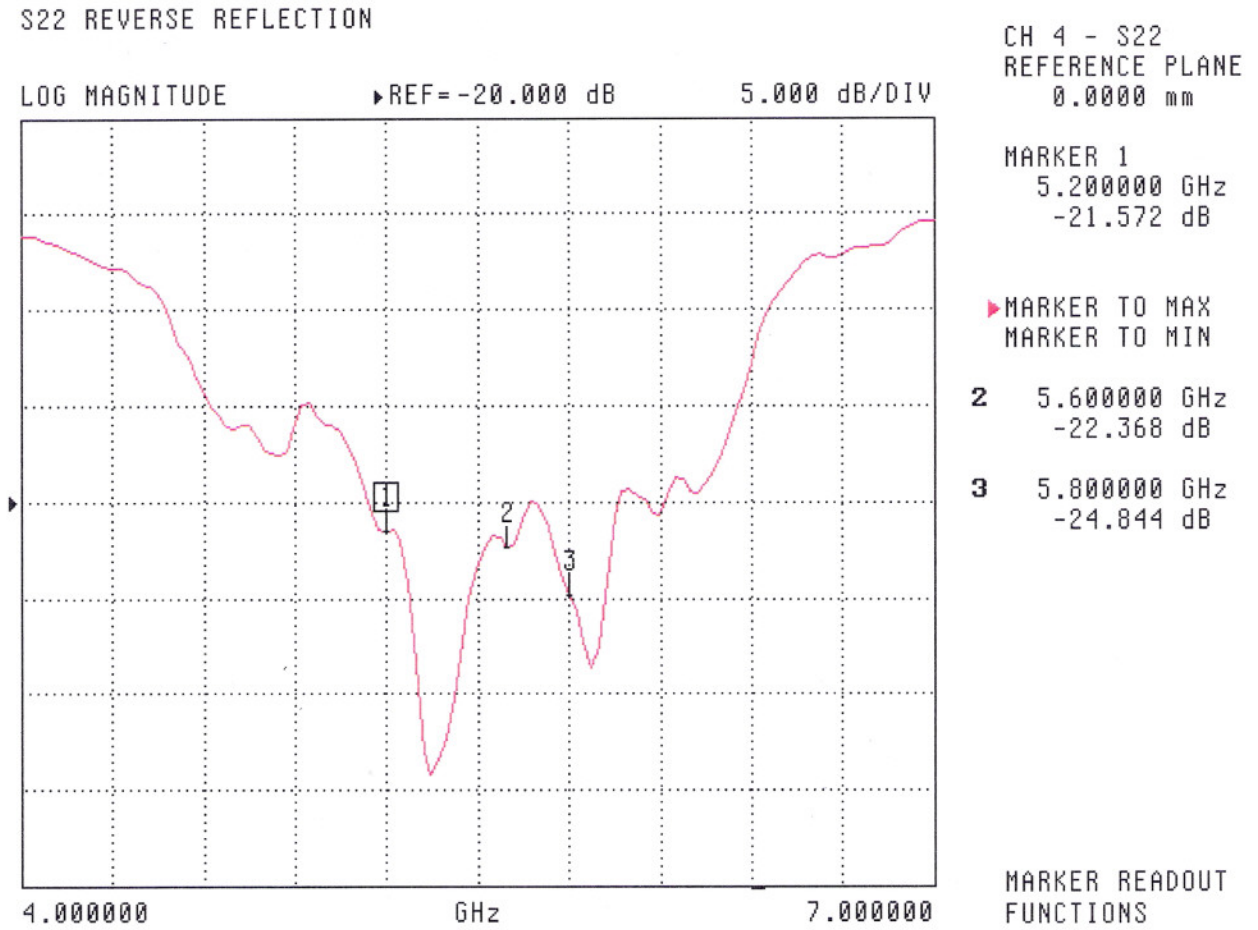
APREL Length	APREL Height	Measured Length	Measured Height
23.1 mm	20.7 mm	23.3 mm	20.3 mm

### Electrical Calibration

S11	5200MHz	5800MHz
RL (dB)	-21.6	-24.8
SWR	1.19	1.12
Impedance (ohms)	45.6	50.7

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

**S11 Parameter Return Loss**





**SWR**

S22 REVERSE REFLECTION

SWR                      ▶ REF=2.500 U                      500.000 mU/DIV



CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
5.200000 GHz  
1.189 U

▶ MARKER TO MAX  
MARKER TO MIN

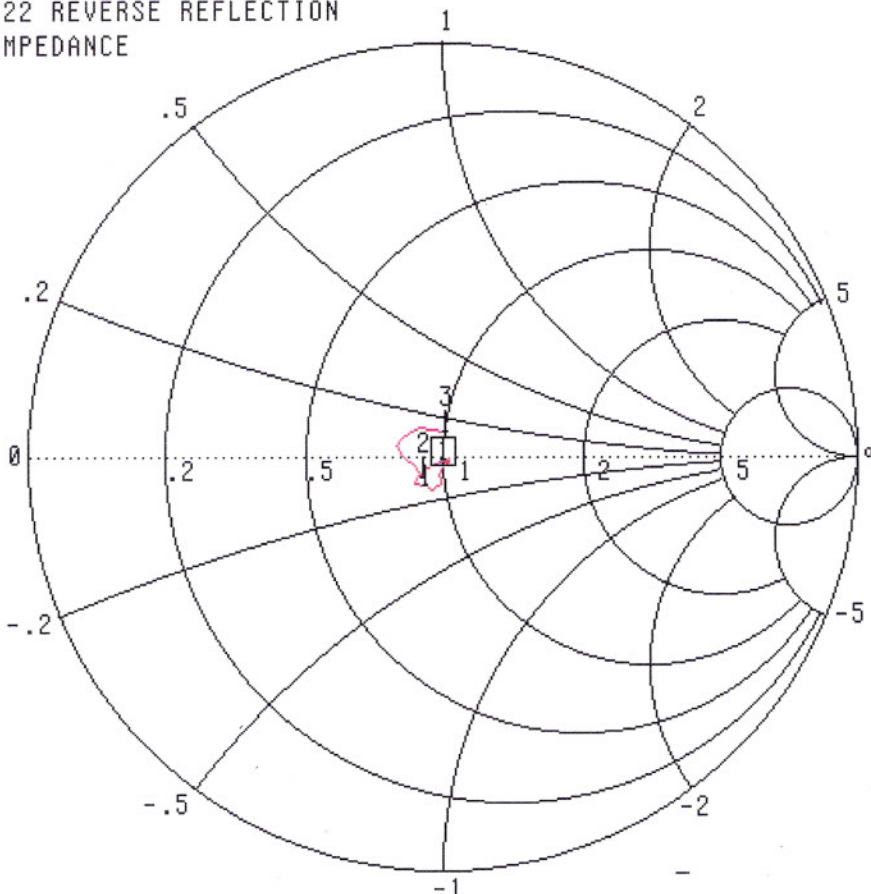
2 5.600000 GHz  
1.153 U

3 5.800000 GHz  
1.124 U

MARKER READOUT  
FUNCTIONS

### Smith Chart Dipole Impedance

S22 REVERSE REFLECTION  
IMPEDANCE



5.200000 - 5.800000 GHz

CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
5.200000 GHz  
45.566  $\Omega$   
-6.839  $j\Omega$

▶ MARKER TO MAX  
MARKER TO MIN

2 5.600000 GHz  
45.348  $\Omega$   
-4.725  $j\Omega$   
3 5.800000 GHz  
50.691  $\Omega$   
5.736  $j\Omega$

MARKER READOUT  
FUNCTIONS

## **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 2004

## Appendix F – Phantom Calibration Data Sheets

## NCL CALIBRATION LABORATORIES

Calibration File No.: RFE-273

# 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 National Standards.

Thickness of the UniPhantom is 2 mm  $\pm$  10%  
Pinna thickness is 6 mm  $\pm$  10%

Resolution:	0.01 mm	Calibrated to:	0.0 mm
Stability:	OK	Accuracy:	< 0.1 mm

Calibrated By: Karen K. Feb 17/04.

### **NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
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CANADA K2R 1E6

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