



## **Appendix D. Probe Calibration Data**

**Miniature Isotropic RF Probe**

**M/N: ALS-E-020**

**S/N: 265**

**2450 MHz Head Calibration**

**2450 MHz Body Calibration**

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-879

Client: QUIETEK

## 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 2450 MHz

Manufacturer: APREL Laboratories

Model No.: ALS-E-020

Serial No.: 265

HEAD Calibration

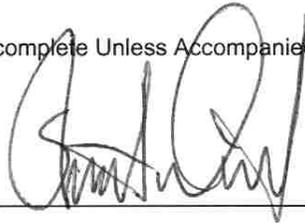
Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: QTKB-ALS-E20-CAL-5335

Calibrated: 9<sup>th</sup> May 2008  
Released on: 9<sup>th</sup> May 2008

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

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



**NCL** CALIBRATION LABORATORIES

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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-020 265.

## 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 Head Due to Wireless Communications Devices: Experimental Techniques"

SSI-TP-011 Tissue Calibration Procedure

IEC 62209 "Human exposure to radio frequency fields from hand-held and Head-mounted wireless communication devices – Human models, instrumentation, and procedures –Part 1 & 2: Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 300 MHz to 3 GHz)"

IEEE 1309 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

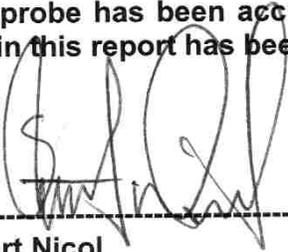
## Conditions

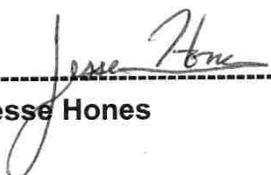
Probe 265 is a re-calibration.

**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**

  
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**Jesse Hones**

## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-020
<b>Serial Number:</b>	265
<b>Frequency:</b>	2450 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 Head Tissue**

**Frequency:** 2450 MHz

**Epsilon:** 39.2 (+/-5%)      **Sigma:** 1.80 S/m (+/-5%)

### **ConvF**

**Channel X:** 3.67

**Channel Y:** 3.67

**Channel Z:** 3.67

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

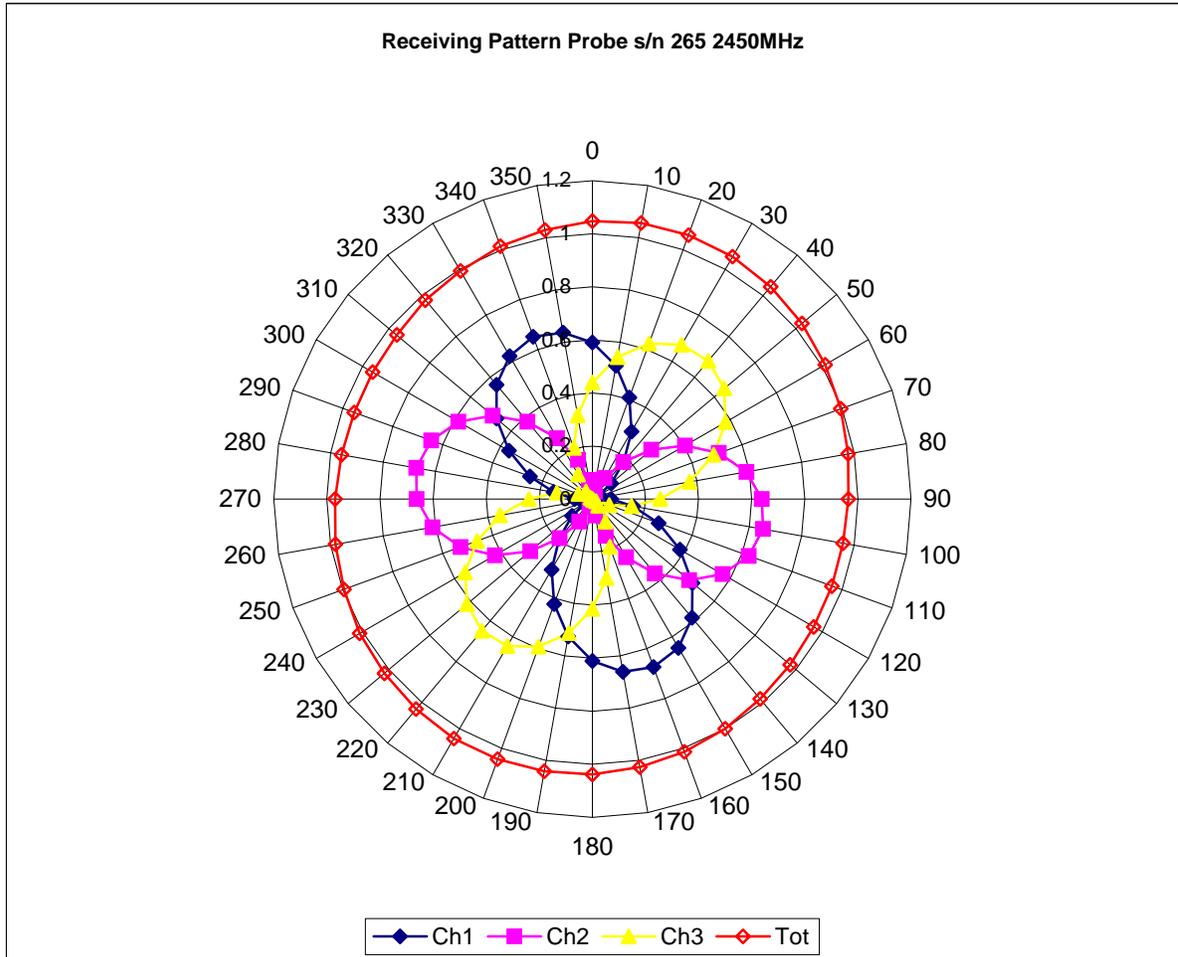
### **Boundary Effect:**

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.

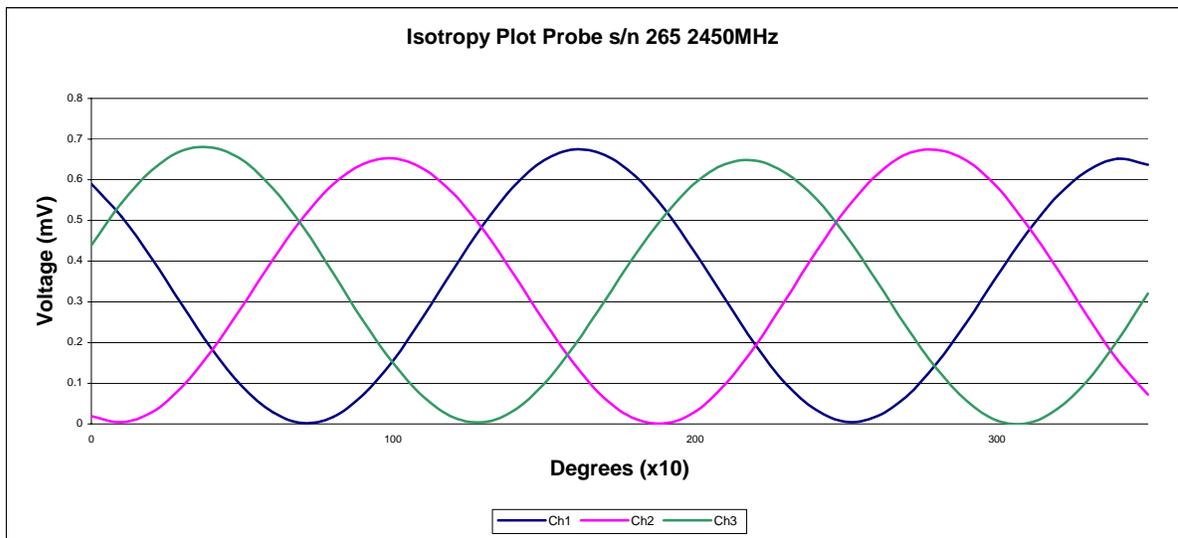
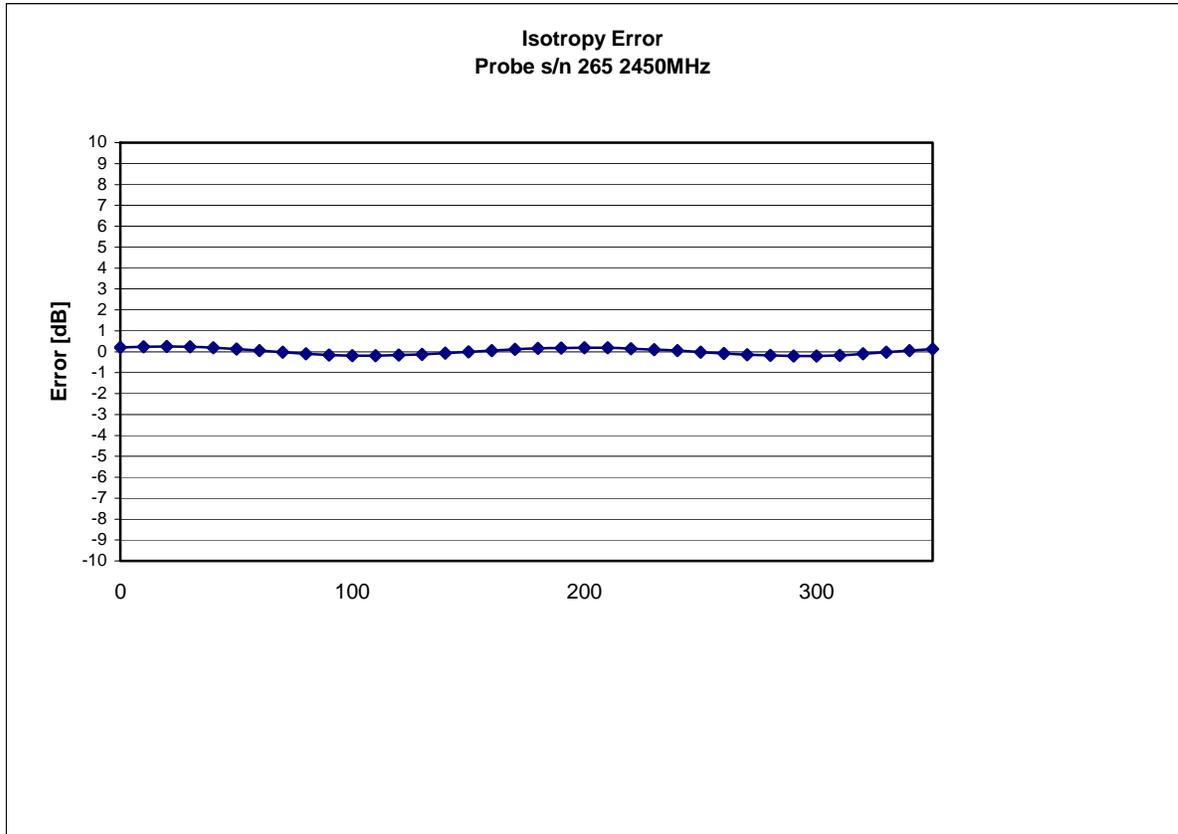
### **Spatial Resolution:**

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 2450 MHz (Air)



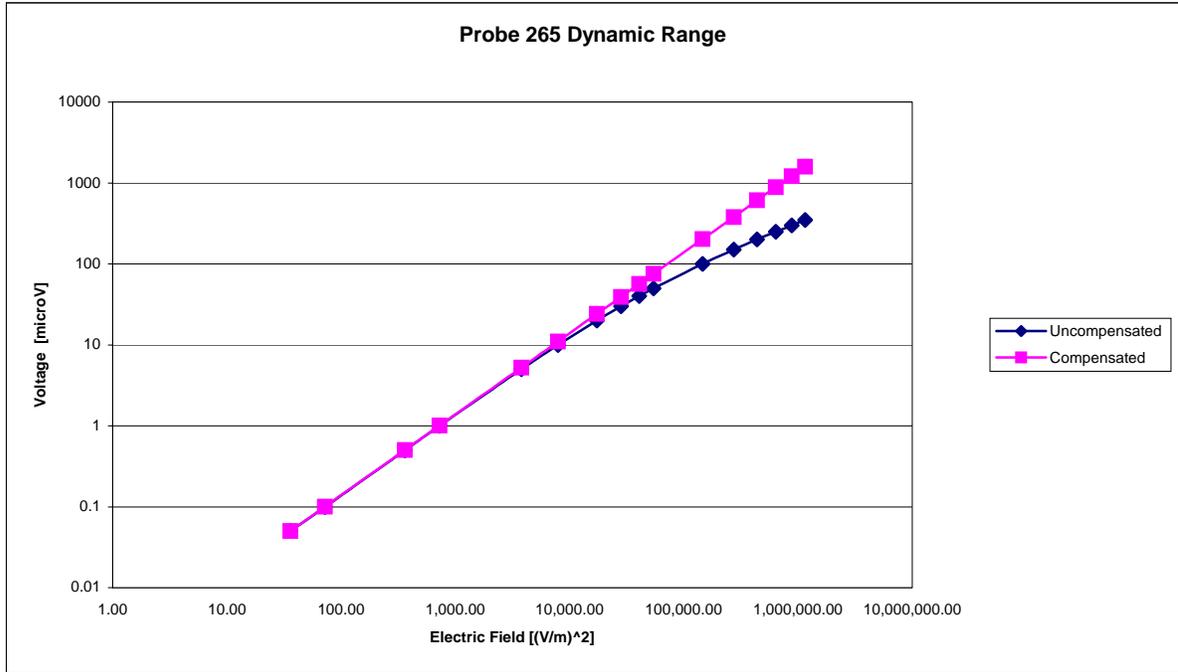
### Isotropy Error 2450 MHz (Air)



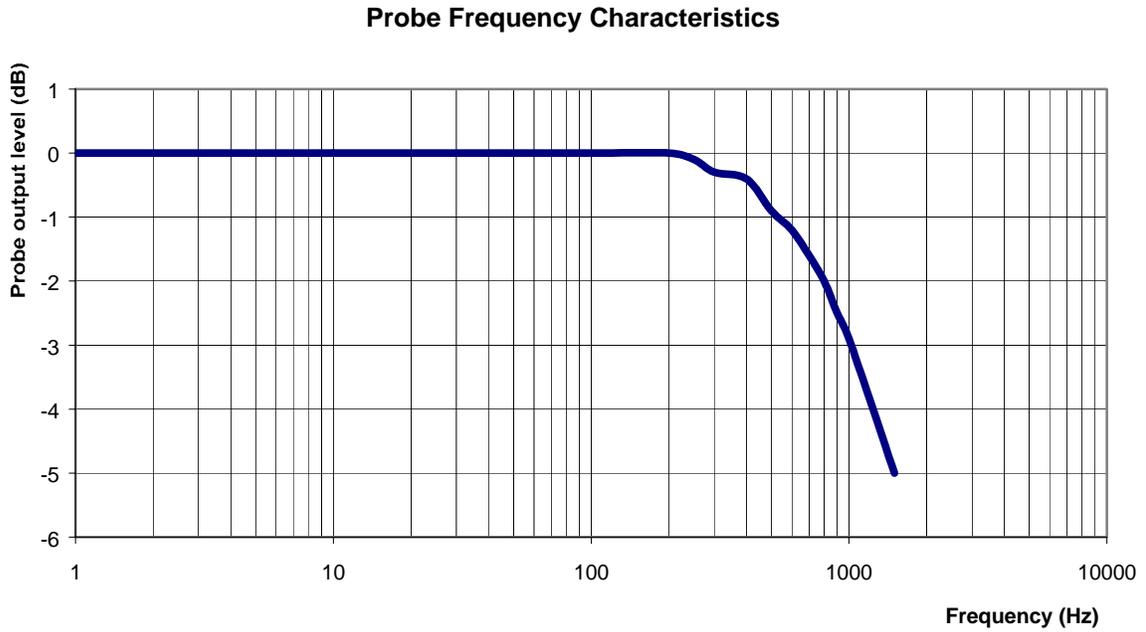
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



**Video Bandwidth at 500 Hz**            1 dB  
**Video Bandwidth at 1000 Hz**        3 dB

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 2450MHz  
**Epsilon:** 39.2 (+/-5%)      **Sigma:** 1.80 S/m (+/-5%)

### **ConvF**

**Channel X:** 3.67      7%(K=2)

**Channel Y:** 3.67      7%(K=2)

**Channel Z:** 3.67      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 2.4mm 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 2008.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-880

Client: QUIETEK

## 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 2450 MHz

Manufacturer: APREL Laboratories

Model No.: ALS-E-020

Serial No.: 265

BODY Calibration

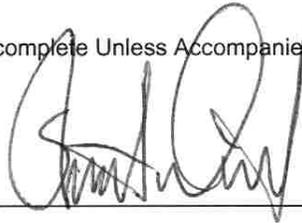
Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: QTKB-ALS-E20-CAL-5335

Calibrated: 9<sup>th</sup> May 2008  
Released on: 9<sup>th</sup> May 2008

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

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



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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-020 265.

## 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 Head Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and Head-mounted wireless communication devices – Human models, instrumentation, and procedures –Part 1 & 2: Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 300 MHz to 3 GHz)"  
IEEE 1309 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

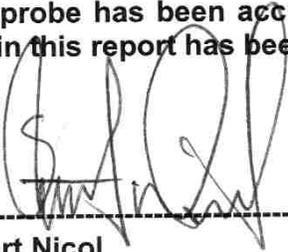
## Conditions

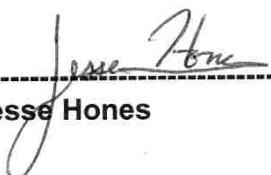
Probe 265 is a re-calibration.

**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**

  
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**Jesse Hones**

## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-020
<b>Serial Number:</b>	265
<b>Frequency:</b>	2450 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:** 2450 MHz

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

### **ConvF**

**Channel X:** 3.55

**Channel Y:** 3.55

**Channel Z:** 3.55

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

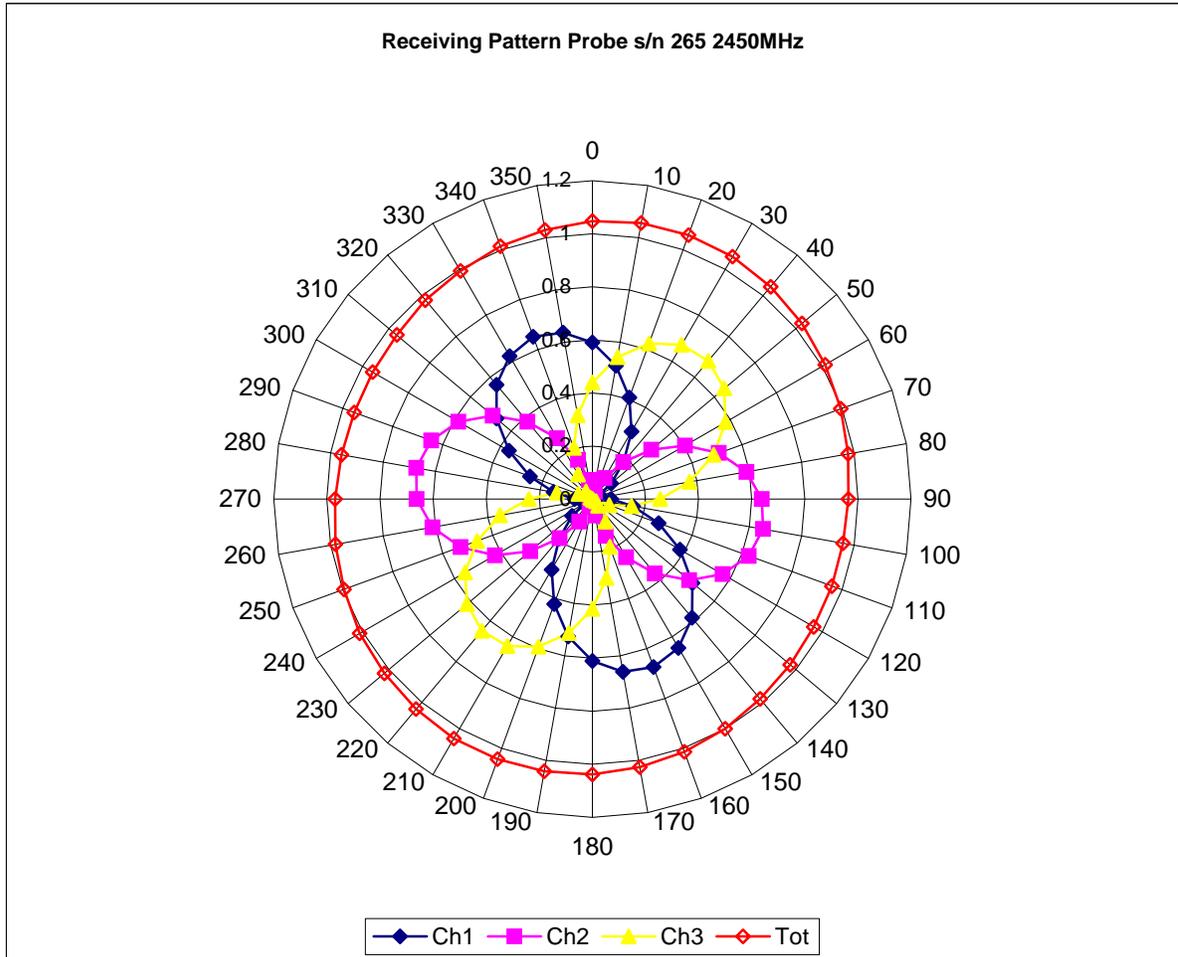
### **Boundary Effect:**

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.

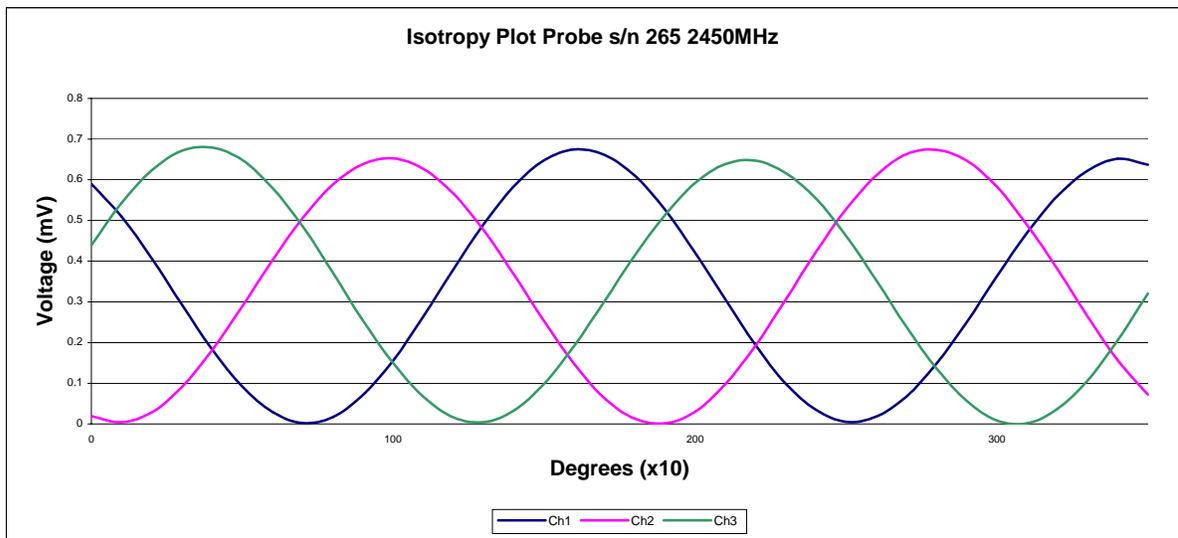
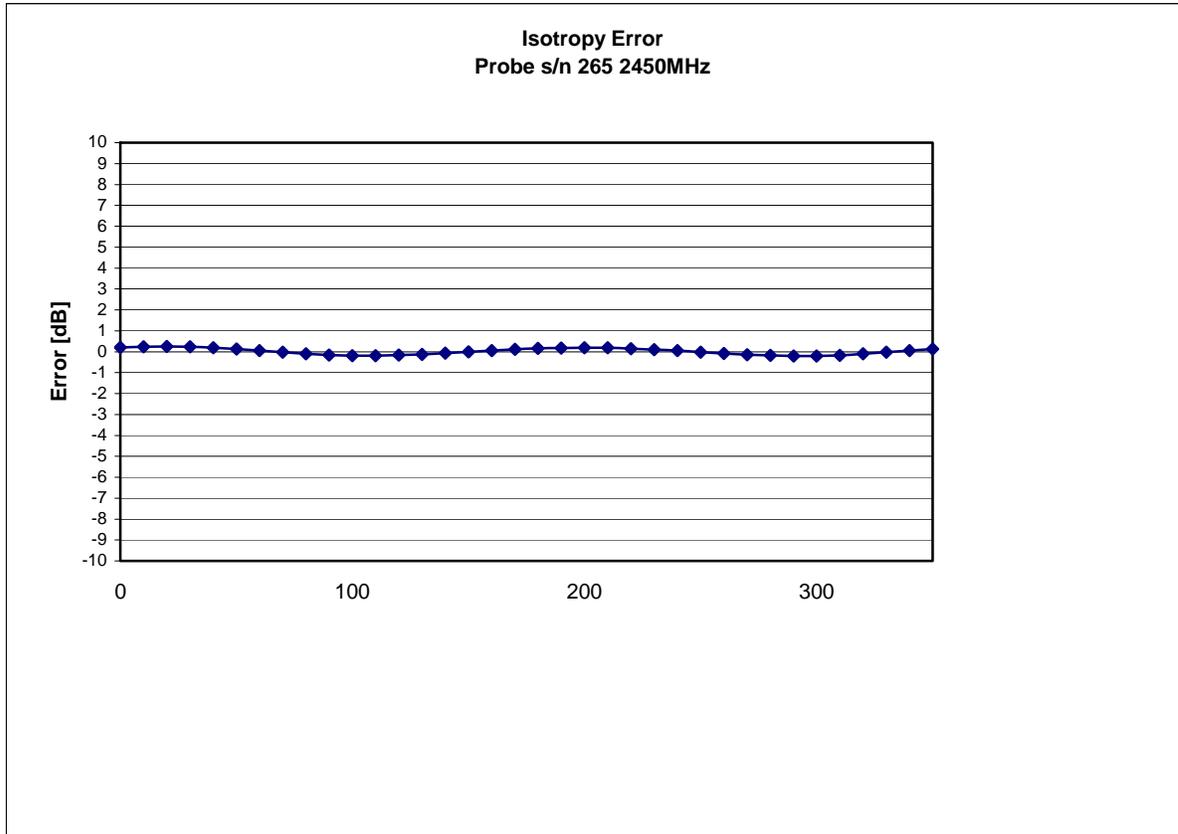
### **Spatial Resolution:**

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 2450 MHz (Air)



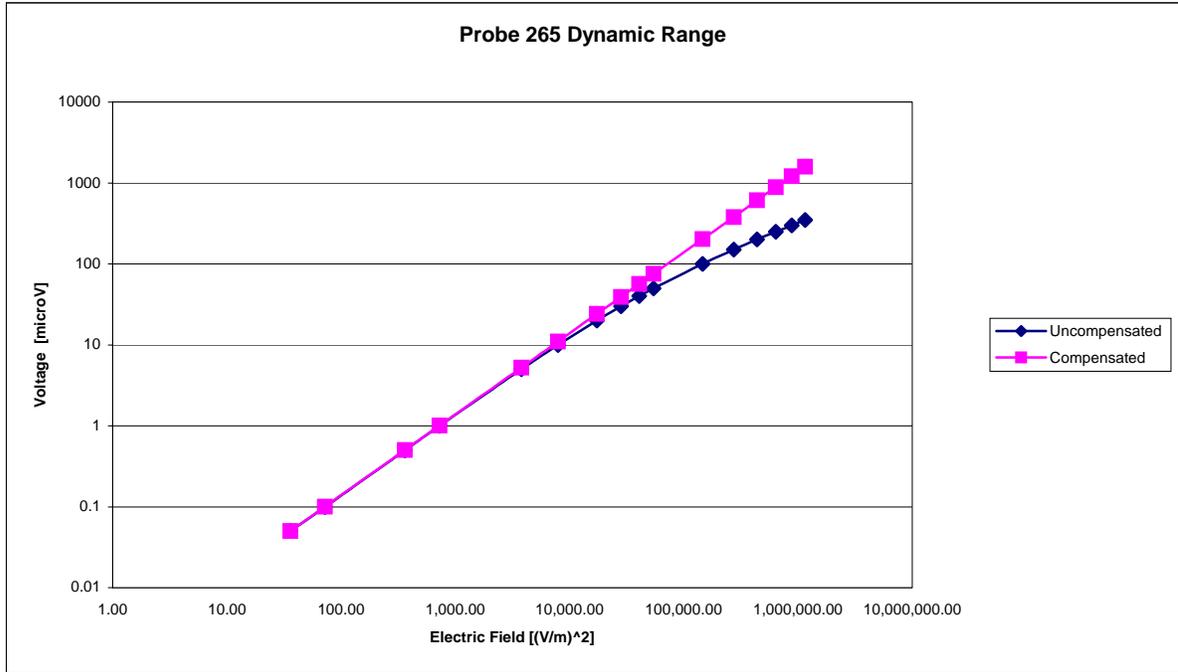
### Isotropy Error 2450 MHz (Air)



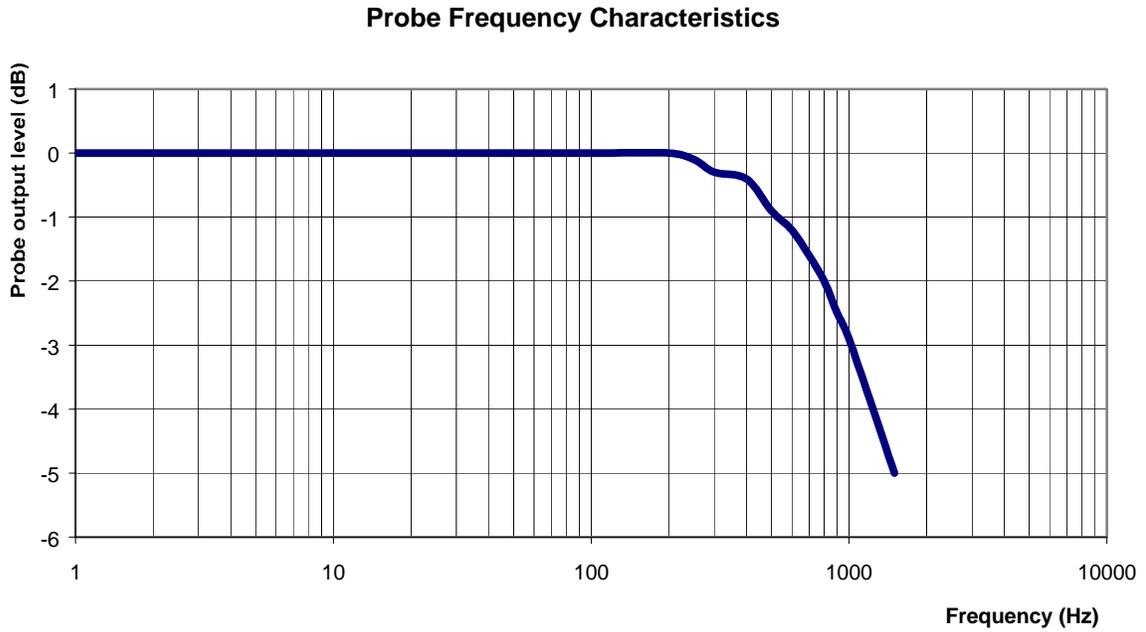
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



**Video Bandwidth at 500 Hz**            1 dB  
**Video Bandwidth at 1000 Hz**        3 dB

## **Conversion Factor Uncertainty Assessment**

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

### **ConvF**

**Channel X:** 3.55      7%(K=2)

**Channel Y:** 3.55      7%(K=2)

**Channel Z:** 3.55      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 2.4mm 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 2008.



## **Appendix E. Dipole Calibration**

**Validation Dipole 2450 MHz**

**M/N: ALS-D-2450-S-2**

**S/N: QTK-319**

# NCL CALIBRATION LABORATORIES

Calibration File No: DC-891

## 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.

Quietek Validation Dipole

Manufacturer: APREL Laboratories

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

Frequency: 2.45 GHz

Serial No: QTK-319

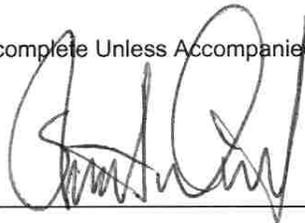
Customer: Quietek

Project Number: QTKB-Dipole-CAL-5336

Calibrated: 9<sup>th</sup> May 2008  
Released on: 9<sup>th</sup> May 2008

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

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



**NCL CALIBRATION LABORATORIES**

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

## Calibration Results Summary

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

### Mechanical Dimensions

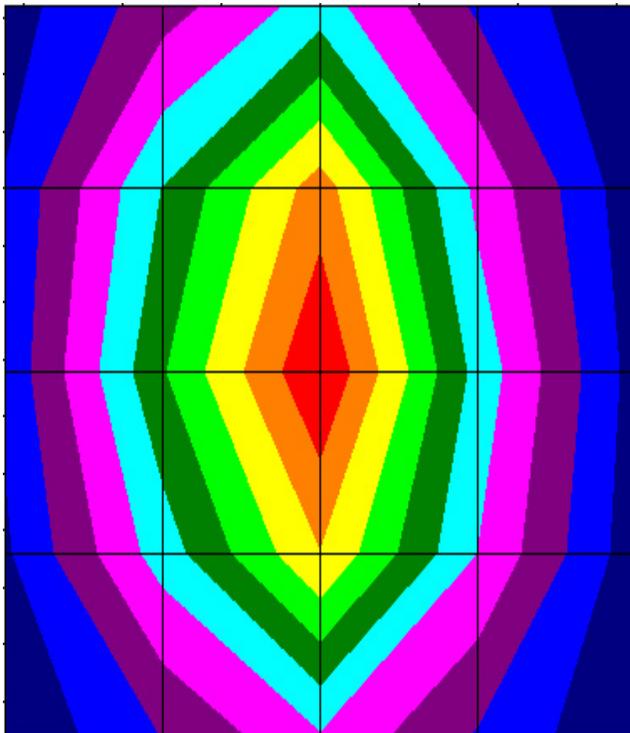
**Length:** 53.5 mm  
**Height:** 30.4 mm

### Electrical Specification

**SWR:** 1.19 U  
**Return Loss:** -20.8 dB  
**Impedance:** 49.4  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram	Peak
2.45 GHz	48.07	25.65	95.6



## Conditions

Dipole 319 is a recalibration.

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

## References

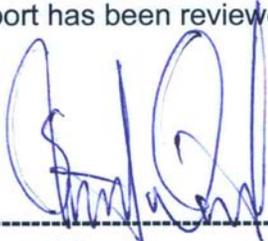
SSI-TP-018-ALSAS Dipole Calibration Procedure

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"

IEC 62209 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures –Part 1 & Part 2: Procedure to determine the specific absorption rate (SAR) for mobile wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)

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**



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**C. Teodorian**

## **Dipole Calibration Results**

### **Mechanical Verification**

<b>IEEE Length</b>	<b>IEEE Height</b>	<b>Measured Length</b>	<b>Measured Height</b>
51.5 mm	30.4 mm	53.5 mm	30.4 mm

### **Tissue Validation**

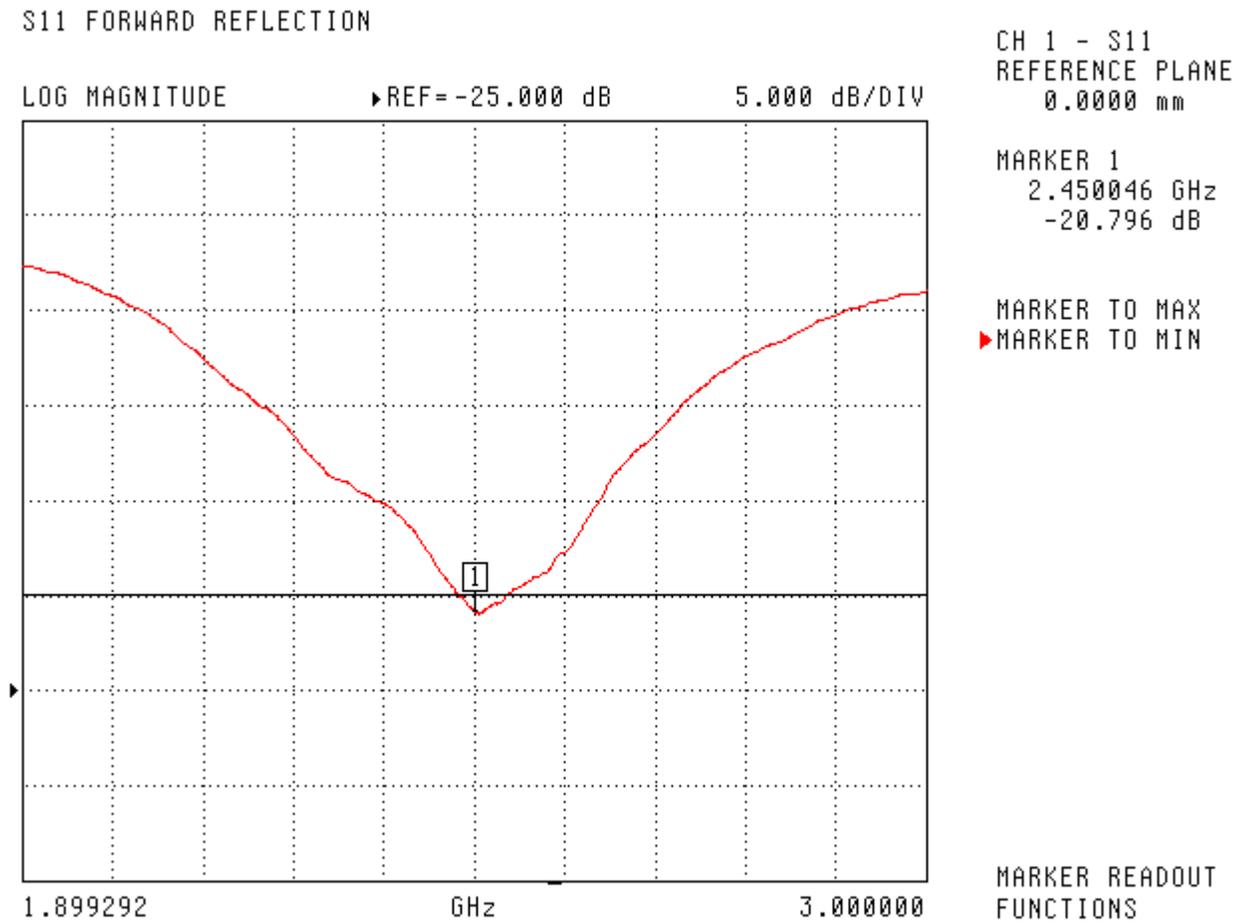
<b>Head Tissue 2450 MHz</b>	<b>Measured</b>
<b>Dielectric constant, <math>\epsilon_r</math></b>	40.1
<b>Conductivity, <math>\sigma</math> [S/m]</b>	1.78

**Electrical Calibration**

Test	Result
S11 R/L	-20.8 dB
SWR	1.2 U
Impedance	49.4 $\Omega$

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

**S11 Parameter Return Loss**



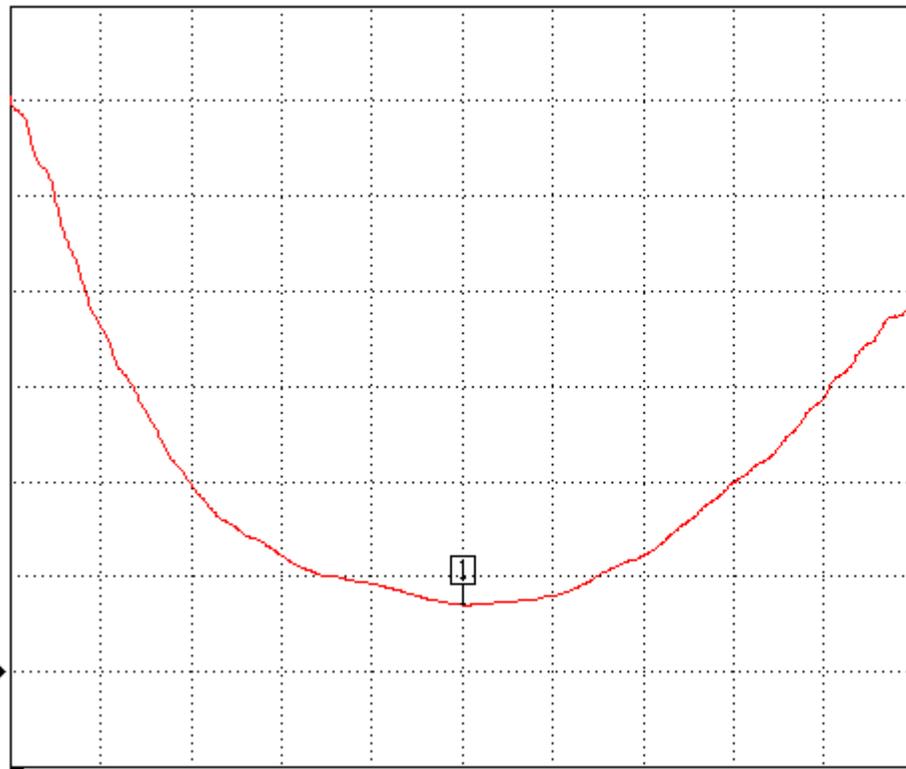
SWR

S11 FORWARD REFLECTION

SWR

REF=500.000 mU

1.000 U/DIV



CH 1 - S11  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
2.450046 GHz  
1.199 U

MARKER TO MAX  
▶ MARKER TO MIN

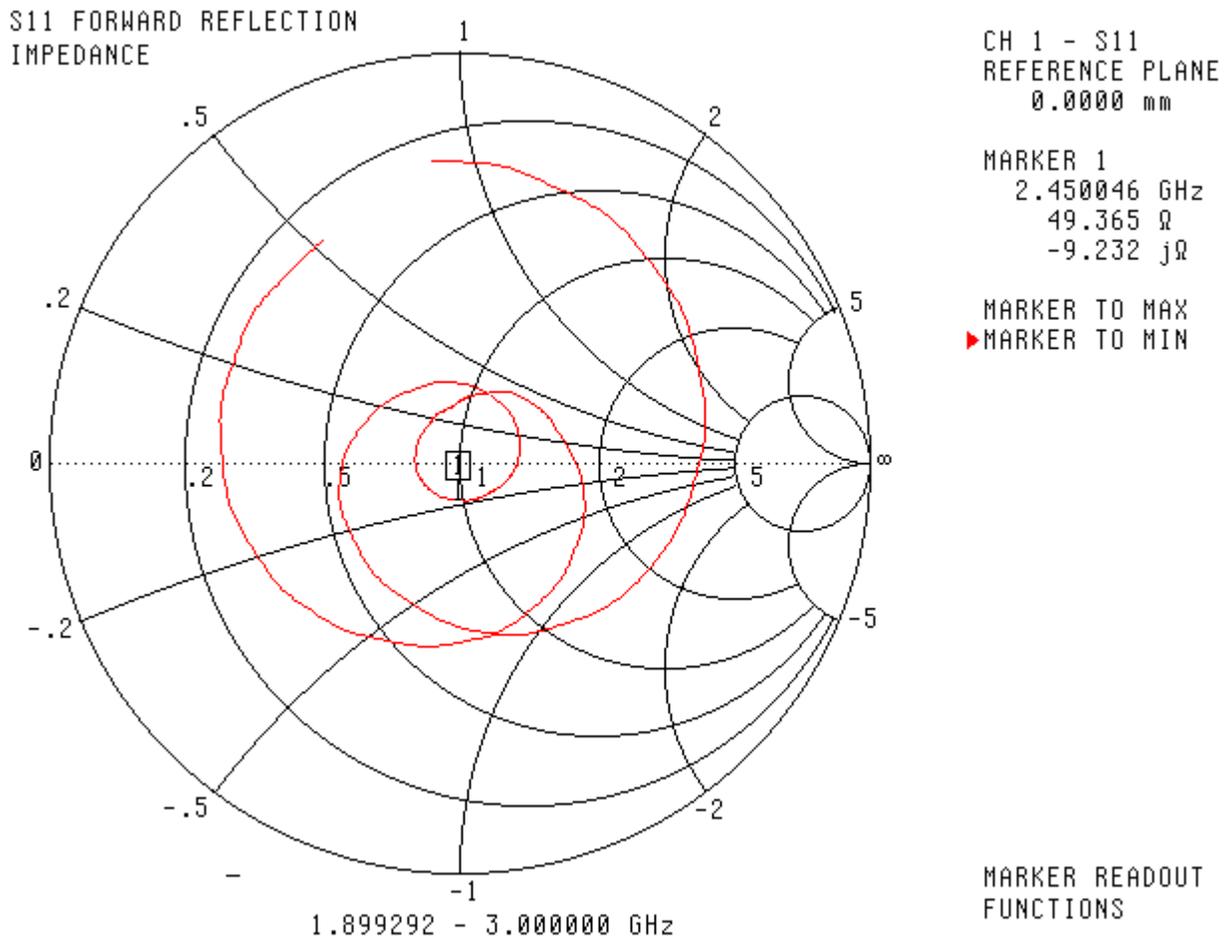
1.899292

GHz

3.000000

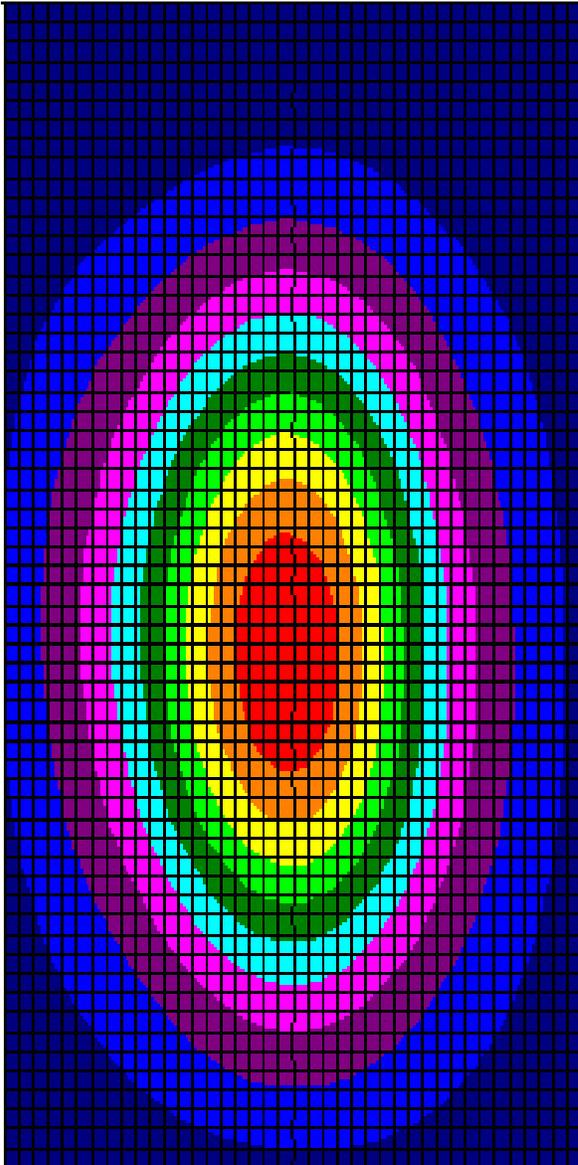
MARKER READOUT  
FUNCTIONS

## Smith Chart Dipole Impedance



**System Validation Results Using the Electrically Calibrated Dipole**

<b>Frequency</b>	<b>1 Gram</b>	<b>10 Gram</b>	<b>Peak Above Feed Point</b>
2.45 GHz	48.07	25.65	95.6



## **NCL Calibration Laboratories**

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Division of APREL Laboratories.

### **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 2008.