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## Appendix B Probe Calibration Certificate





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**NCL CALIBRATION LABORATORIES**

Calibration File No.: CP-469

Client.: APREL

**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 5800 MHz

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 212

Body Calibration

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

Project No: Internal

Calibrated: 27<sup>th</sup> December 2004  
Released on: 27<sup>th</sup> December 2004

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

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-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-020 212.

## 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 212 was a new probe taken from stock prior to calibration.

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

## Calibration Results Summary



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<b>Probe Type:</b>	E-Field Probe E-020
<b>Serial Number:</b>	212
<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:** 50.6 (+/-5%)      **Sigma:** 1.98 S/m (+/-10%)

**ConvF**

**Channel X:** 5.0

**Channel Y:** 5.0

**Channel Z:** 5.0

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 2.4mm.

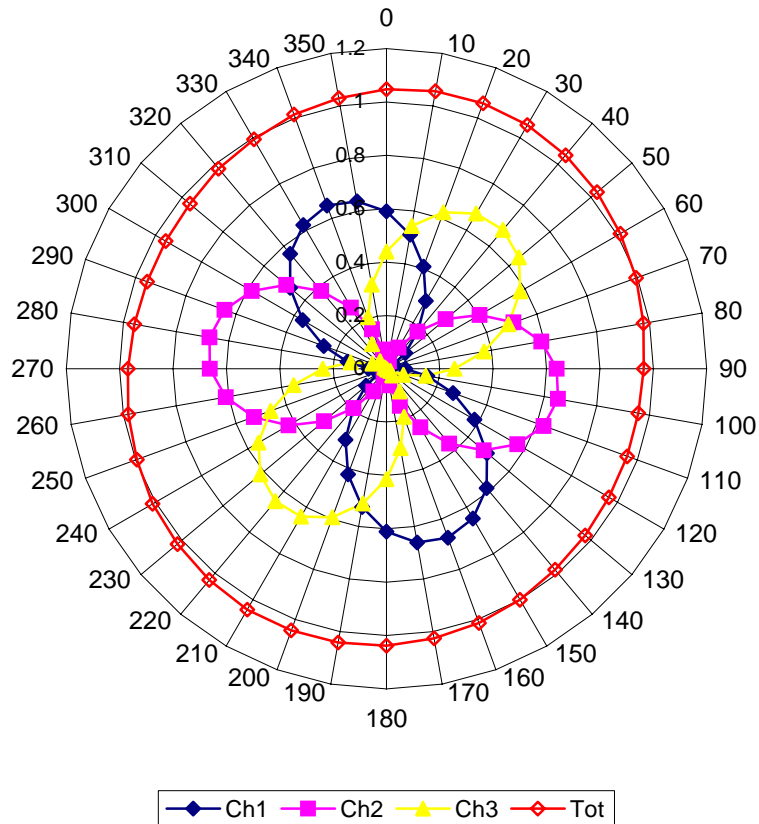
**Spatial Resolution:**

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.

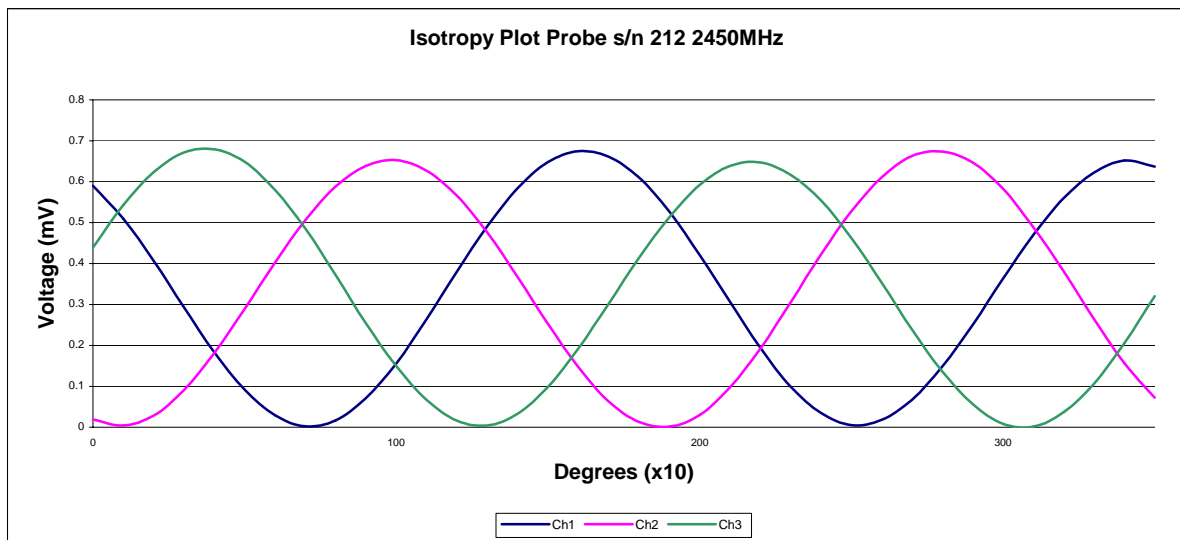
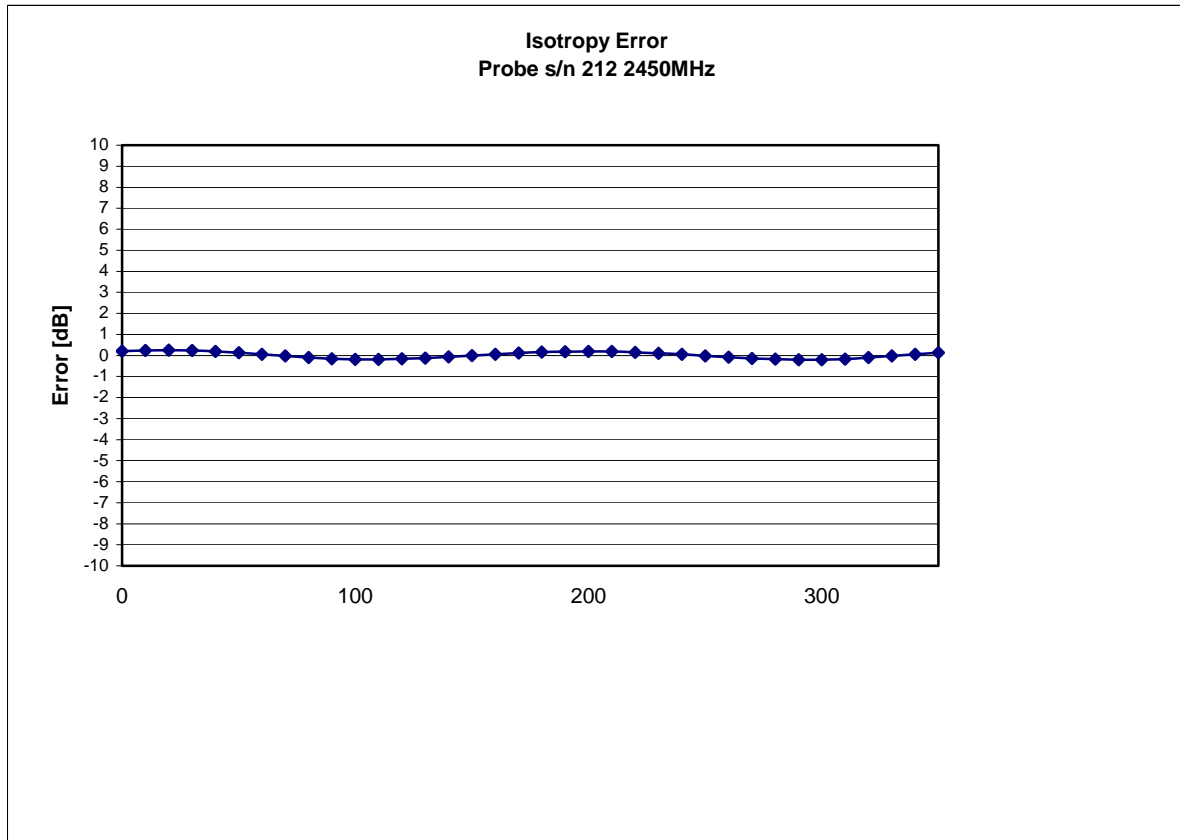
**Receiving Pattern 2450 MHz (Air)**



Receiving Pattern Probe s/n 212 24500MHz



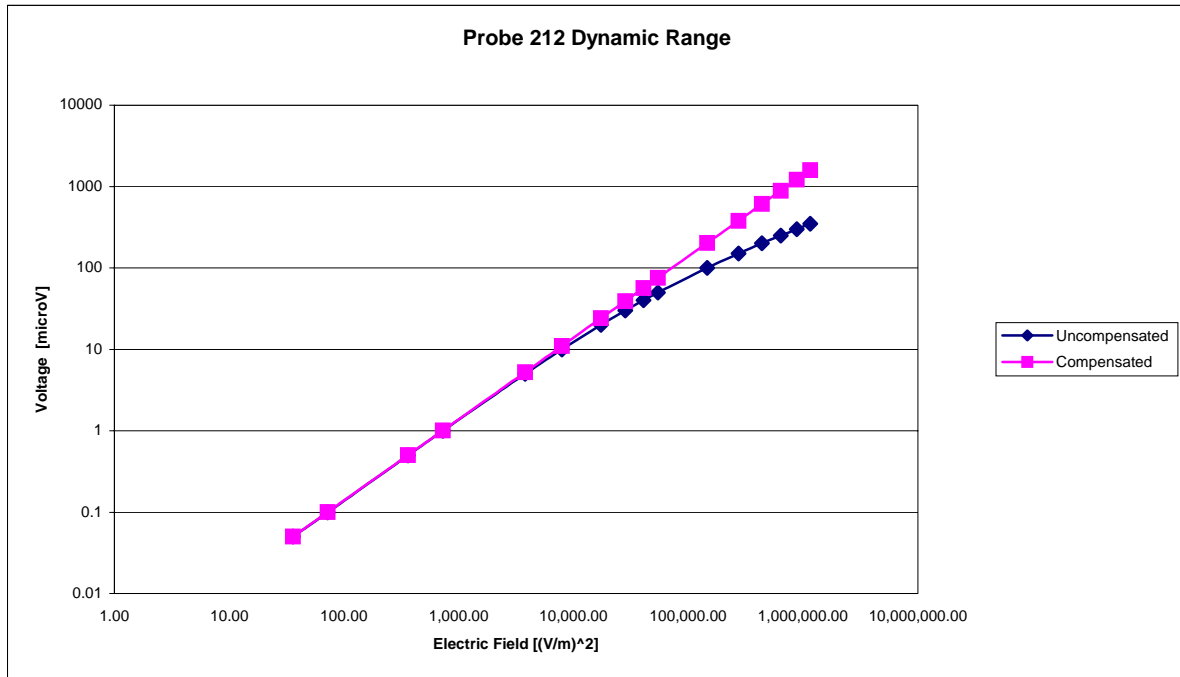
## Isotropy Error 2450 MHz (Air)



**Isotropy:** 0.10 dB



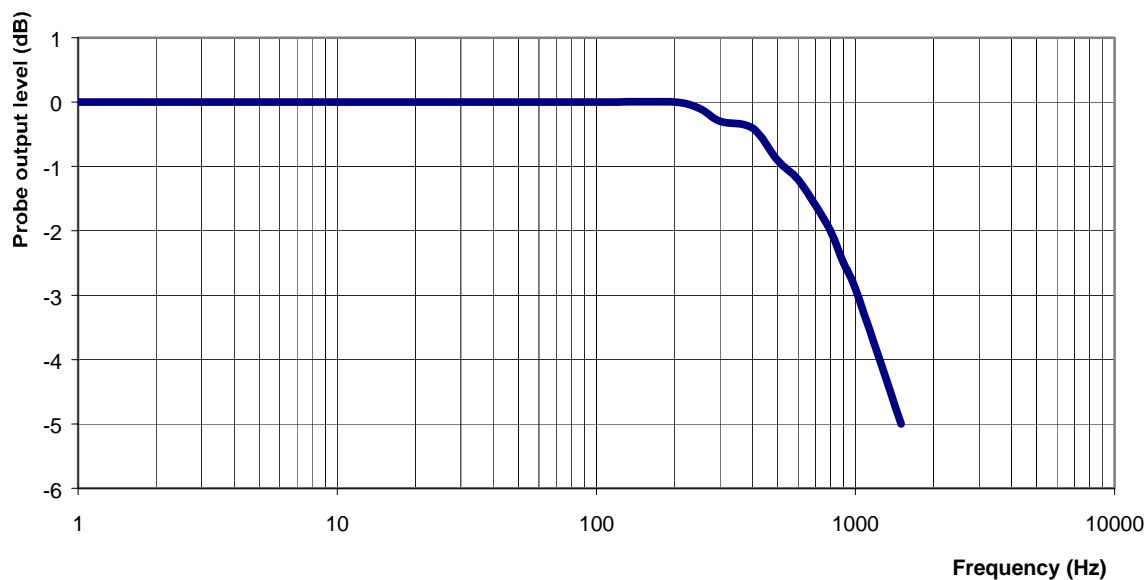
## Dynamic Range





## 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:** 2450MHz

**Epsilon:** 50.6 (+/-5%)

**Sigma:** 1.98 S/m (+/-10%)

### ConvF

**Channel X:** 5.0 7%(K=2)

**Channel Y:** 5.0 7%(K=2)

**Channel Z:** 5.0 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%.





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## 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.





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## Appendix C Dipole Calibration Certificate





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## 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: 14 November 2003  
Released on: 15 November 2003

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

### NCL CALIBRATION LABORATORIES

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## Calibration Results Summary

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

## Mechanical Dimensions

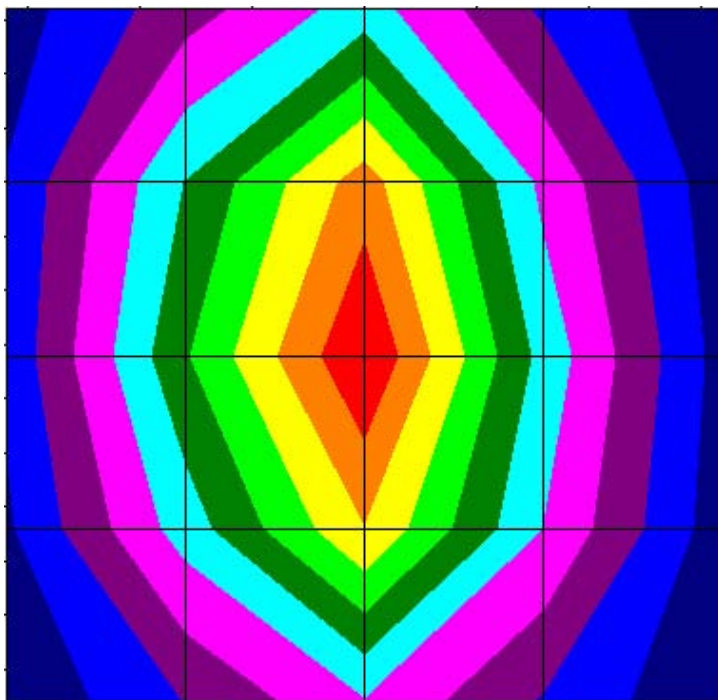
**Length:** 51.7 mm  
**Height:** 30.8 mm

## 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



## 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.

## 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





## 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, $\epsilon_r$	39.2
Conductivity, $\sigma$ [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 $\Omega$	

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

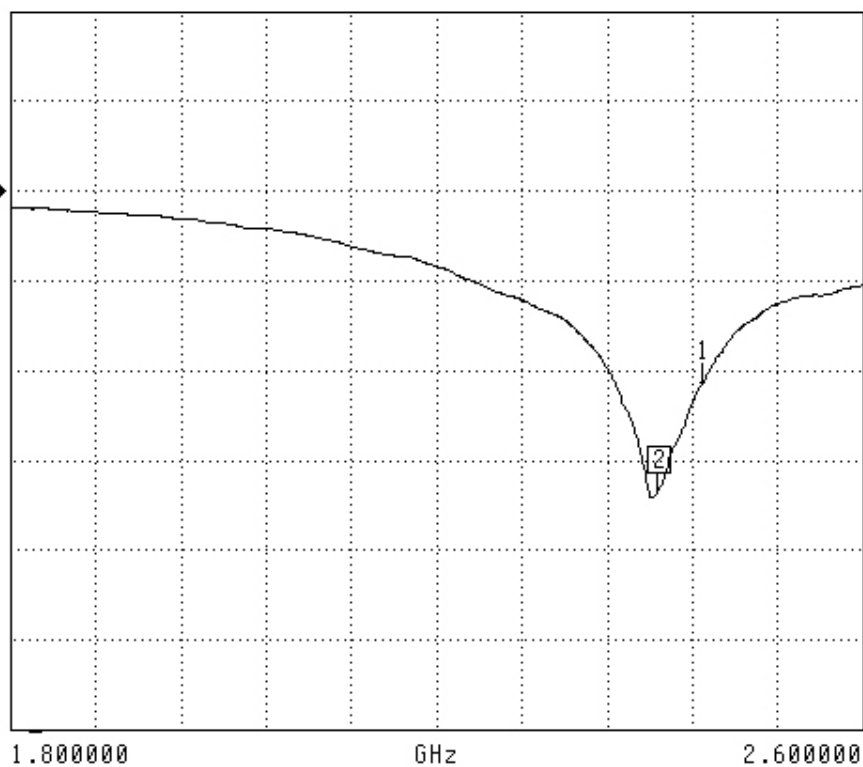
### S11 Parameter Return Loss

S11 FORWARD REFLECTION

LOG MAGNITUDE

REF=0.000 dB

10.000 dB/DIV



CH 1 - S11  
REFERENCE PLANE  
5.1160 mm

MARKER 2  
2.408000 GHz  
-33.566 dB

MARKER TO MAX  
▶ MARKER TO MIN  
**1** 2.450000 GHz  
-21.377 dB

MARKER READOUT  
FUNCTIONS



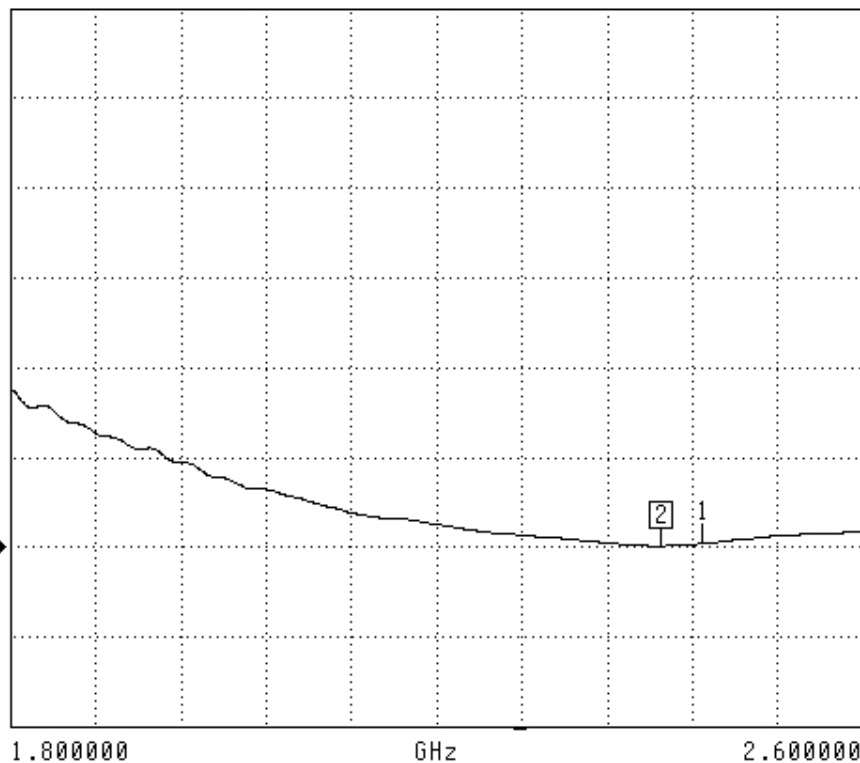
## SWR

S11 FORWARD REFLECTION

SWR

REF=1.000 U

5.000 U/DIV



CH 1 - S11  
REFERENCE PLANE  
5.1160 mm

MARKER 2  
2.411000 GHz  
1.049 U

MARKER TO MAX  
▶ MARKER TO MIN

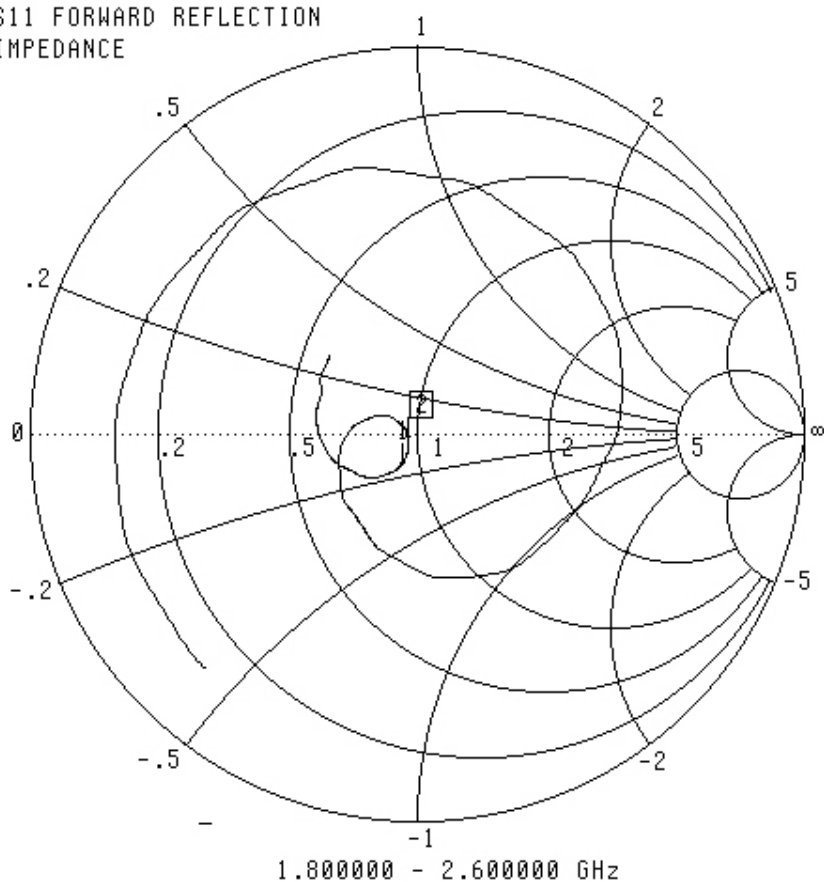
1 2.450000 GHz  
1.181 U

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

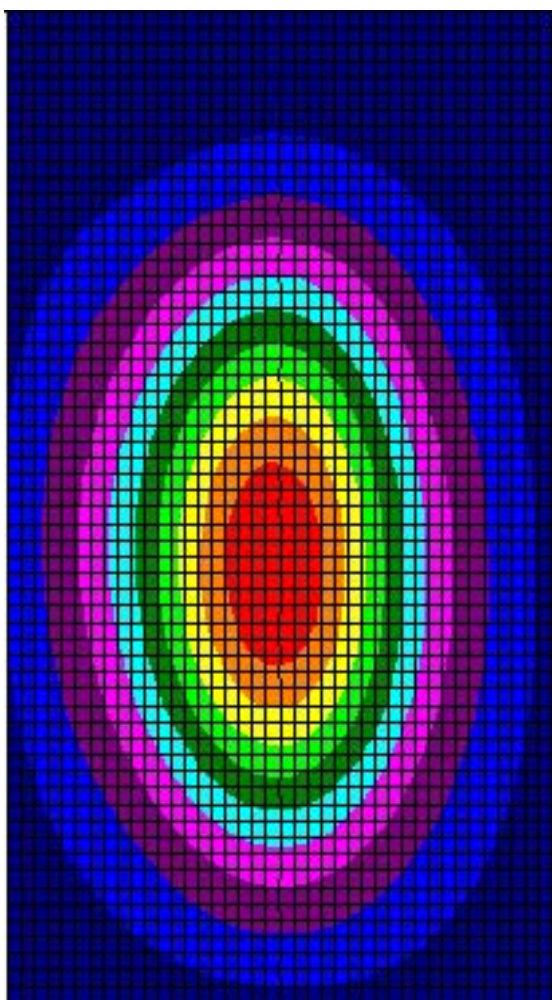
MARKER READOUT  
FUNCTIONS



## 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.





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## Test Equipment

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