

## SAR Test Report

Operator : 123  
Validation Date : 08-Jul-2004  
Measurement Date : 08-Jul-2004  
Starting Time : 08-Jul-2004 09:56:58 PM  
End Time : 08-Jul-2004 10:06:47 PM  
Scanning Time : 589 secs

Product Data  
Device Name : Molokai  
Serial No. : #5035  
Type : Other  
Model : WM3A2100  
Frequency : 2450.00 MHz  
Max. Transmit Pwr : 0.025 W  
Drift Time : 0 min(s)  
Length : 127  
Width : 94  
Depth : 0  
Antenna Type : Internal  
Power Drift-Start : 0.01  
Power Drift-Finish : 0.00  
Power Drift : 0.01

Phantom Data  
Name : APREL-Uni  
Type : Uni-Phantom  
Size : 280 x 280 x 200  
Serial No. : User Define  
Location : Center  
Description : Uni

Tissue Data  
Type : Body  
Serial No. : 2450  
Frequency : 2450 MHz  
Calibration Date : 08-Jul-2004  
Temperature : 22 °C  
Ambient Temp. : 22 °C  
Humidity : 80 RH%  
Epsilon : 49.56 F/m  
Sigma : 1.92 S/m  
Density : 1000 kg/cu. m

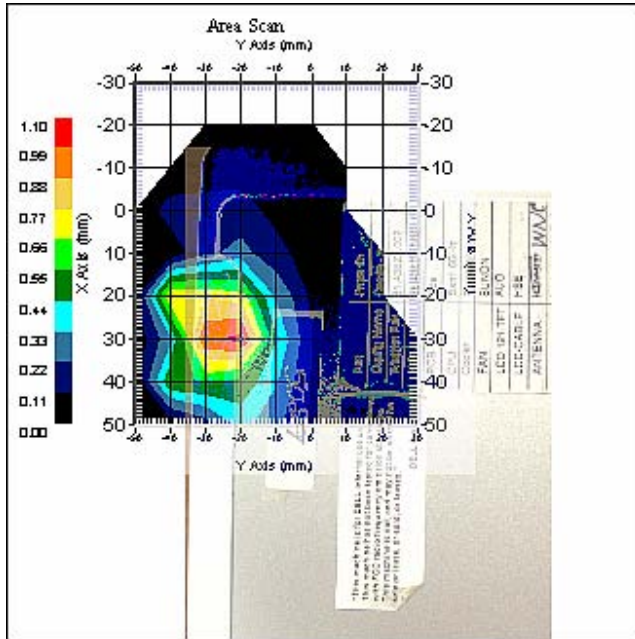
Probe Data  
Name : APREL Probe 212  
Model : E020  
Type : E-Field Triangle  
Serial No. : 212  
Calibration Date : 04-Jun-2004  
Frequency : 2450 MHz  
Duty Cycle Factor : 1  
Conversion Factor : 3.3  
Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{sq. m})$   
Compression Point : 95  
Offset : 1.56

## Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Set-up Date : 08-Jul-2004  
Set-up Time : 5:22:34 PM

## Other Data

DUT Position : Touch  
Separation : 0  
Channel : Mid - 2437



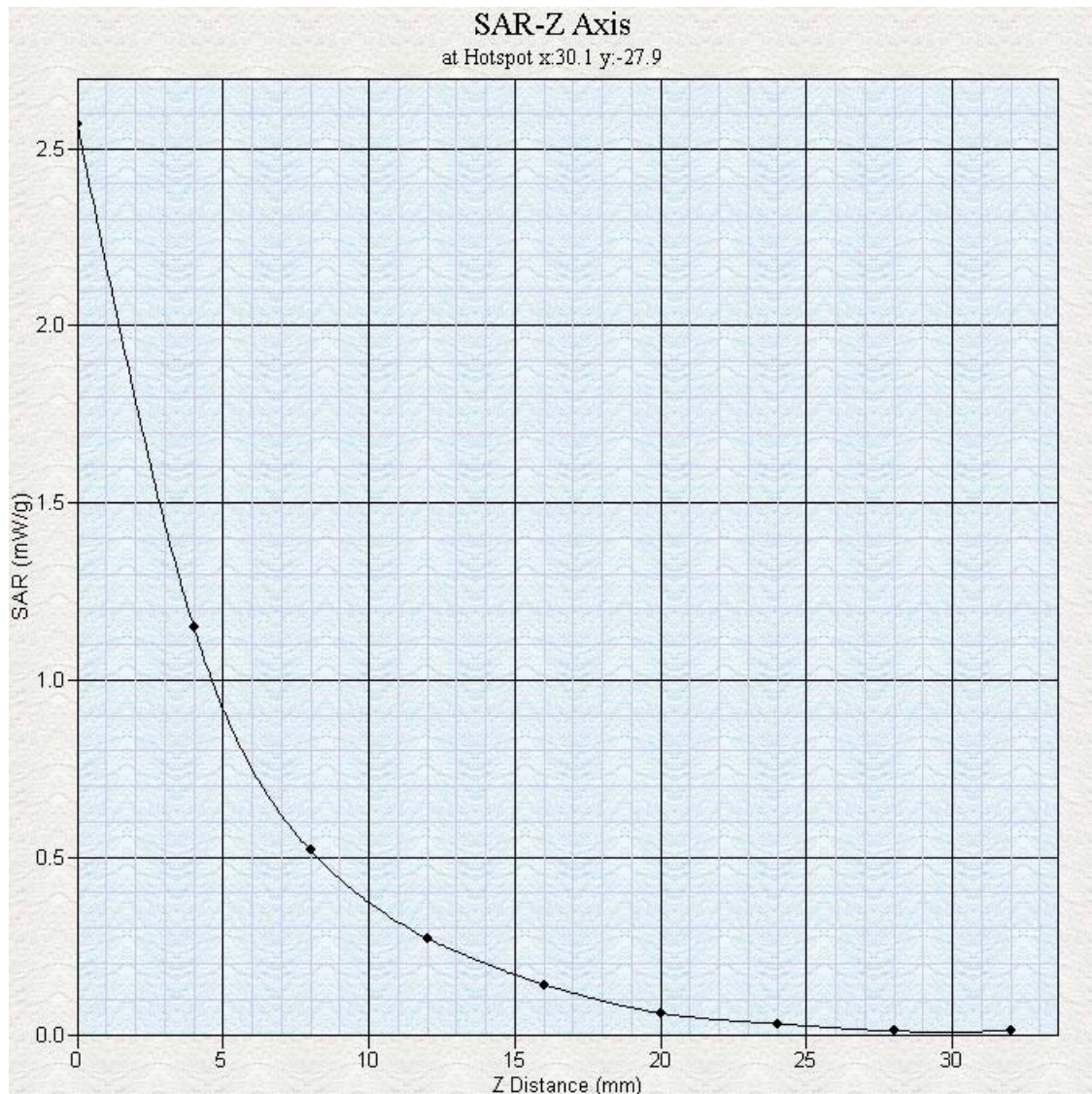
1 gram SAR value : 1.00 W/kg  
10 gram SAR value : 0.43 W/kg  
Area Scan Peak SAR : 1.01  
Zoom Scan Peak SAR : 2.57

## Exposure Assessment Measurement Uncertainty

| Source of Uncertainty                            | Tolerance Value | Probability Distribution | Divisor    | $c_1^1$ (1-g)            | $c_1^1$ (10-g)           | Standard Uncertainty (1-g) | Standard Uncertainty (10-g) |
|--------------------------------------------------|-----------------|--------------------------|------------|--------------------------|--------------------------|----------------------------|-----------------------------|
| Measurement System                               |                 |                          |            |                          |                          |                            |                             |
| Probe Calibration                                | 3.5             | normal                   | 1          | 1                        | 1                        | 3.5                        | 3.5                         |
| Axial Isotropy                                   | 3.7             | rectangular              | $\sqrt{3}$ | $(1-\frac{cp}{2})^{1/2}$ | $(1-\frac{cp}{2})^{1/2}$ | 1.5                        | 1.5                         |
| Hemispherical Isotropy                           | 10.9            | rectangular              | $\sqrt{3}$ | $\sqrt{cp}$              | $\sqrt{cp}$              | 4.4                        | 4.4                         |
| Boundary Effect                                  | 1.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.6                        | 0.6                         |
| Linearity                                        | 4.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.7                        | 2.7                         |
| Detection Limit                                  | 1.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.6                        | 0.6                         |
| Readout Electronics                              | 1.0             | normal                   | 1          | 1                        | 1                        | 1.0                        | 1.0                         |
| Response Time                                    | 0.8             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.5                        | 0.5                         |
| Integration Time                                 | 1.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 1.0                        | 1.0                         |
| RF Ambient Condition                             | 3.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 1.7                        | 1.7                         |
| Probe Positioner Mech.                           | 0.4             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.2                        | 0.2                         |
| Restriction                                      |                 |                          |            |                          |                          |                            |                             |
| Probe Positioning with respect to Phantom Shell  | 2.9             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.1                        | 2.1                         |
| Extrapolation and Integration                    | 3.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.1                        | 2.1                         |
| Test Sample Positioning                          | 4.0             | normal                   | 1          | 1                        | 1                        | 4.0                        | 4.0                         |
| Device Holder Uncertainty                        | 2.0             | normal                   | 1          | 1                        | 1                        | 2.0                        | 2.0                         |
| Drift of Output Power                            | 0.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.0                        | 0.0                         |
| Phantom and Setup                                |                 |                          |            |                          |                          |                            |                             |
| Phantom Uncertainty(shape & thickness tolerance) | 3.4             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.0                        | 2.0                         |
| Liquid Conductivity(target)                      | 13.0            | rectangular              | $\sqrt{3}$ | 0.7                      | 0.5                      | 5.3                        | 3.8                         |
| Liquid Conductivity(meas.)                       | 0.2             | rectangular              | $\sqrt{3}$ | 0.7                      | 0.5                      | 0.1                        | 0.1                         |
| Liquid Permittivity(target)                      | 2.0             | rectangular              | $\sqrt{3}$ | 0.6                      | 0.5                      | 0.8                        | 0.6                         |
| Liquid Permittivity(meas.)                       | 5.0             | rectangular              | $\sqrt{3}$ | 0.6                      | 0.5                      | 1.7                        | 1.4                         |
| Combined Uncertainty                             |                 | RSS                      |            |                          |                          | 10.3                       | 9.5                         |
| Combined Uncertainty (coverage factor=2)         |                 | Normal(k=2)              |            |                          |                          | 20.6                       | 19.1                        |



## Z-Axis Plot



## SAR Test Report

Operator : 123  
 Validation Date : 08-Jul-2004  
 Measurement Date : 08-Jul-2004  
 Starting Time : 08-Jul-2004 10:12:51 PM  
 End Time : 08-Jul-2004 10:22:36 PM  
 Scanning Time : 585 secs

Product Data  
 Device Name : Molokai  
 Serial No. : #5035  
 Type : Other  
 Model : WM3A2100  
 Frequency : 2450.00 MHz  
 Max. Transmit Pwr : 0.025 W  
 Drift Time : 0 min(s)  
 Length : 127  
 Width : 94  
 Depth : 0  
 Antenna Type : Internal  
 Power Drift-Start : 0.00  
 Power Drift-Finish: 0.00  
 Power Drift : 0.00

Phantom Data  
 Name : APREL-Uni  
 Type : Uni-Phantom  
 Size : 280 x 280 x 200  
 Serial No. : User Define  
 Location : Center  
 Description : Uni

Tissue Data  
 Type : Body  
 Serial No. : 2450  
 Frequency : 2450 MHz  
 Calibration Date : 08-Jul-2004  
 Temperature : 22 °C  
 Ambient Temp. : 22 °C  
 Humidity : 80 RH%  
 Epsilon : 49.56 F/m  
 Sigma : 1.92 S/m  
 Density : 1000 kg/cu. m

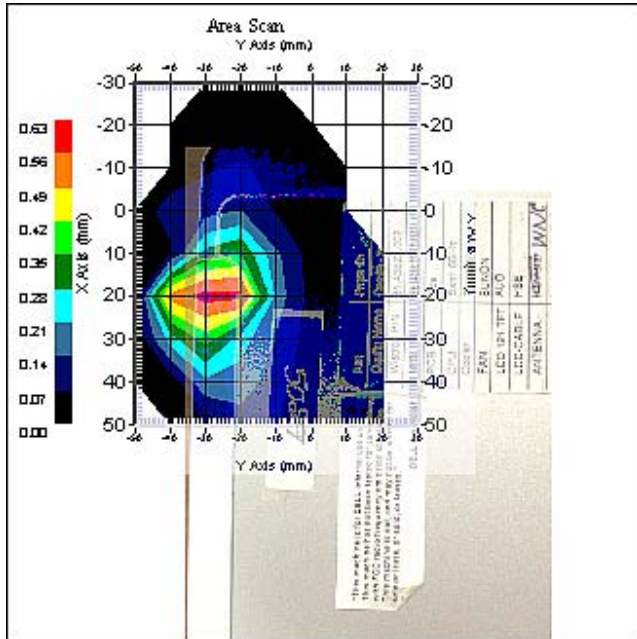
Probe Data  
 Name : APREL Probe 212  
 Model : E020  
 Type : E-Field Triangle  
 Serial No. : 212  
 Calibration Date : 04-Jun-2004  
 Frequency : 2450 MHz  
 Duty Cycle Factor: 1  
 Conversion Factor: 3.3  
 Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{sq. m})$   
 Compression Point: 95  
 Offset : 1.56

## Measurement Data

Crest Factor : 1  
 Scan Type : Complete  
 Set-up Date : 08-Jul-2004  
 Set-up Time : 5:22:34 PM

## Other Data

DUT Position : Touch  
 Separation : 0  
 Channel : High - 2462



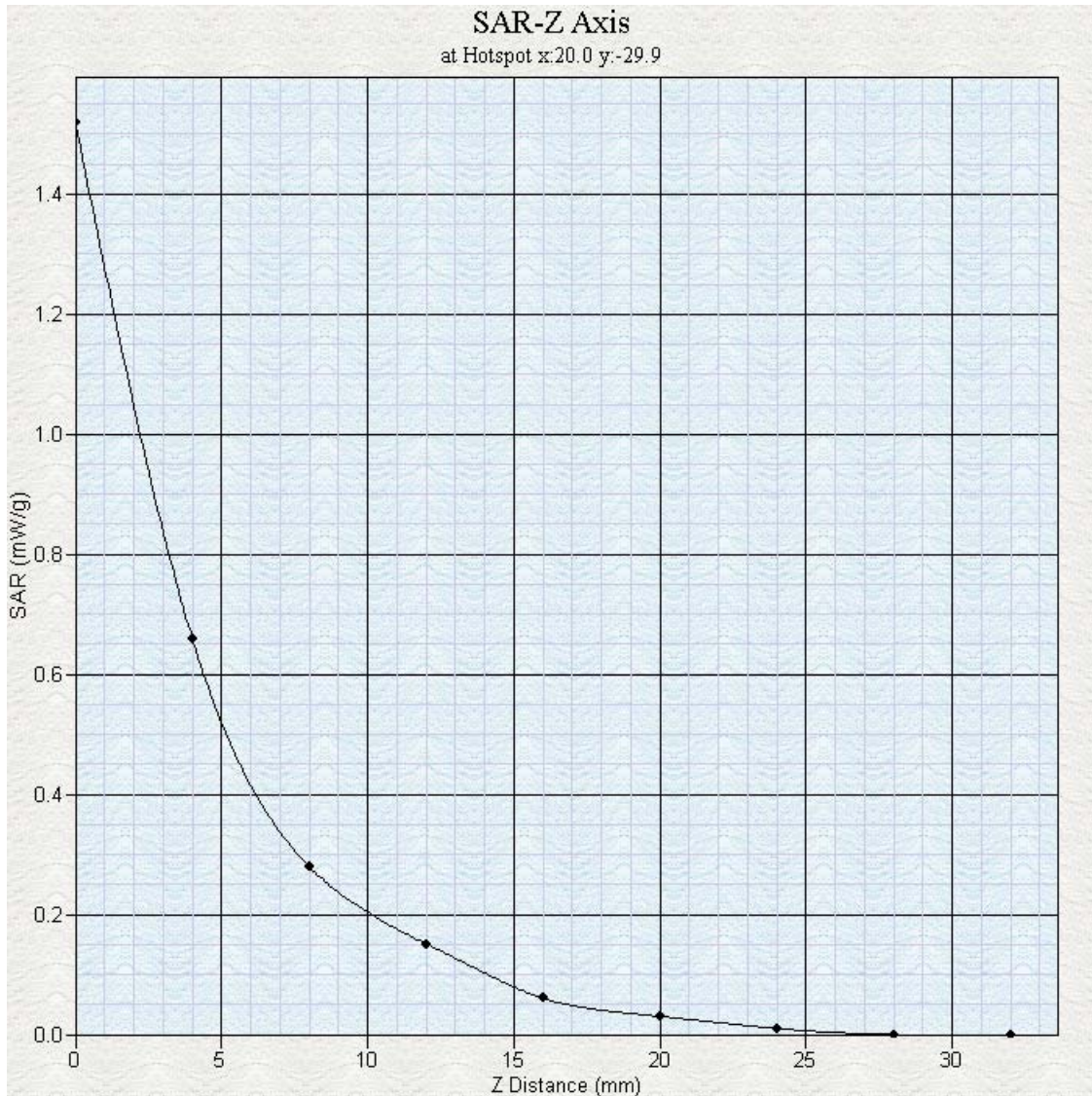
1 gram SAR value : 0.56 W/kg

## Exposure Assessment Measurement Uncertainty

| Source of Uncertainty                            | Tolerance Value | Probability Distribution | Divisor    | $c_1^1$ (1-g)            | $c_1^1$ (10-g)           | Standard Uncertainty (1-g) | Standard Uncertainty (10-g) |
|--------------------------------------------------|-----------------|--------------------------|------------|--------------------------|--------------------------|----------------------------|-----------------------------|
| Measurement System                               |                 |                          |            |                          |                          |                            |                             |
| Probe Calibration                                | 3.5             | normal                   | 1          | 1                        | 1                        | 3.5                        | 3.5                         |
| Axial Isotropy                                   | 3.7             | rectangular              | $\sqrt{3}$ | $(\frac{1-cp}{2})^{1/2}$ | $(\frac{1-cp}{2})^{1/2}$ | 1.5                        | 1.5                         |
| Hemispherical Isotropy                           | 10.9            | rectangular              | $\sqrt{3}$ | $\sqrt{cp}$              | $\sqrt{cp}$              | 4.4                        | 4.4                         |
| Boundary Effect                                  | 1.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.6                        | 0.6                         |
| Linearity                                        | 4.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.7                        | 2.7                         |
| Detection Limit                                  | 1.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.6                        | 0.6                         |
| Readout Electronics                              | 1.0             | normal                   | 1          | 1                        | 1                        | 1.0                        | 1.0                         |
| Response Time                                    | 0.8             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.5                        | 0.5                         |
| Integration Time                                 | 1.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 1.0                        | 1.0                         |
| RF Ambient Condition                             | 3.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 1.7                        | 1.7                         |
| Probe Positioner Mech.                           | 0.4             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.2                        | 0.2                         |
| Restriction                                      |                 |                          |            |                          |                          |                            |                             |
| Probe Positioning with respect to Phantom Shell  | 2.9             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.1                        | 2.1                         |
| Extrapolation and Integration                    | 3.7             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.1                        | 2.1                         |
| Test Sample Positioning                          | 4.0             | normal                   | 1          | 1                        | 1                        | 4.0                        | 4.0                         |
| Device Holder Uncertainty                        | 2.0             | normal                   | 1          | 1                        | 1                        | 2.0                        | 2.0                         |
| Drift of Output Power                            | 0.0             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 0.0                        | 0.0                         |
| Phantom and Setup                                |                 |                          |            |                          |                          |                            |                             |
| Phantom Uncertainty(shape & thickness tolerance) | 3.4             | rectangular              | $\sqrt{3}$ | 1                        | 1                        | 2.0                        | 2.0                         |
| Liquid Conductivity(target)                      | 13.0            | rectangular              | $\sqrt{3}$ | 0.7                      | 0.5                      | 5.3                        | 3.8                         |
| Liquid Conductivity(meas.)                       | 0.2             | rectangular              | $\sqrt{3}$ | 0.7                      | 0.5                      | 0.1                        | 0.1                         |
| Liquid Permittivity(target)                      | 2.0             | rectangular              | $\sqrt{3}$ | 0.6                      | 0.5                      | 0.8                        | 0.6                         |
| Liquid Permittivity(meas.)                       | 5.0             | rectangular              | $\sqrt{3}$ | 0.6                      | 0.5                      | 1.7                        | 1.4                         |
| Combined Uncertainty                             |                 | RSS                      |            |                          |                          | 10.3                       | 9.5                         |
| Combined Uncertainty (coverage factor=2)         |                 | Normal(k=2)              |            |                          |                          | 20.6                       | 19.1                        |



### Z-Axis Plot



**Appendix B**  
**Probe Calibration Certificate**

Project number: Intel-Dell-WM3A2200B-5031  
FCC ID: ID:E2K24CLNS

Page 49 of 61

51 Spectrum Way  
Nepean, Ontario  
Canada K2R 1E6  
© 2004 APREL Laboratories



Tel: (613) 820-2730  
Fax: (613) 820-4161  
Info@aprel.com  
www.aprel.com

**NCL CALIBRATION LABORATORIES**

Calibration File No.: CP-339

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 2450 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: 4<sup>th</sup> June 2004

Released on: 4<sup>th</sup> June 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.

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



## Calibration Results Summary

|                       |                     |
|-----------------------|---------------------|
| <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:** 3.3

**Channel Y:** 3.3

**Channel Z:** 3.3

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

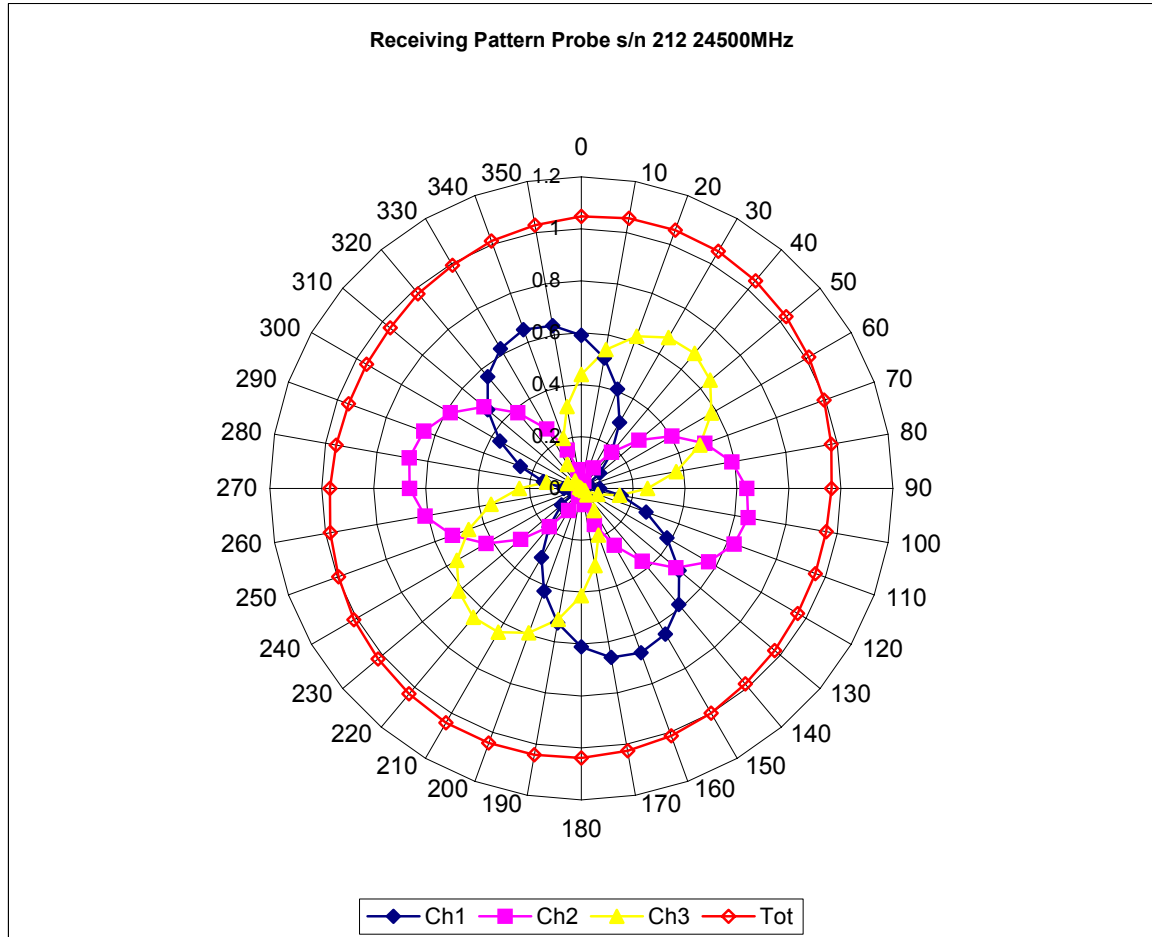
### **Boundary Effect:**

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.

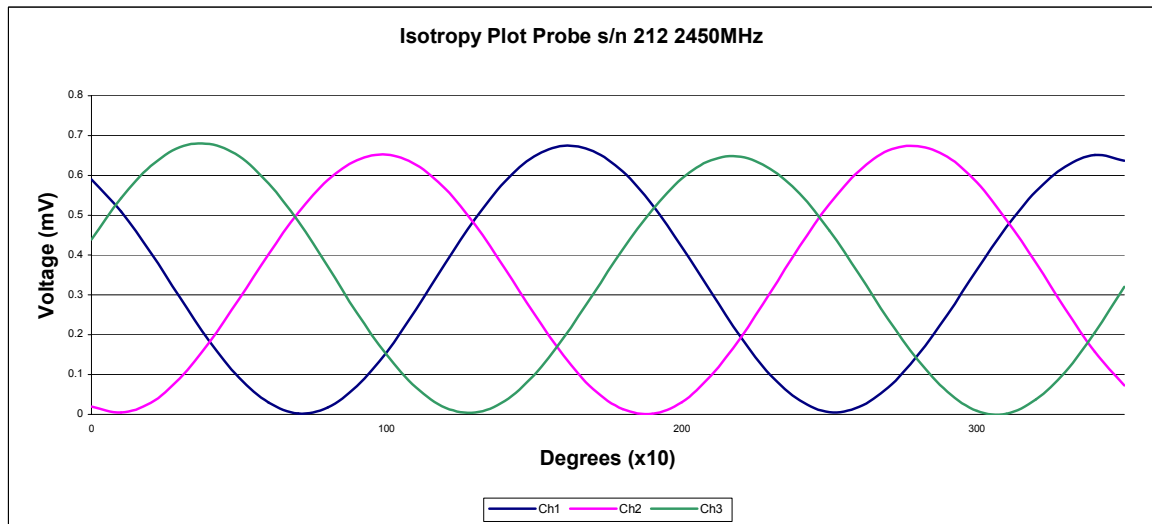
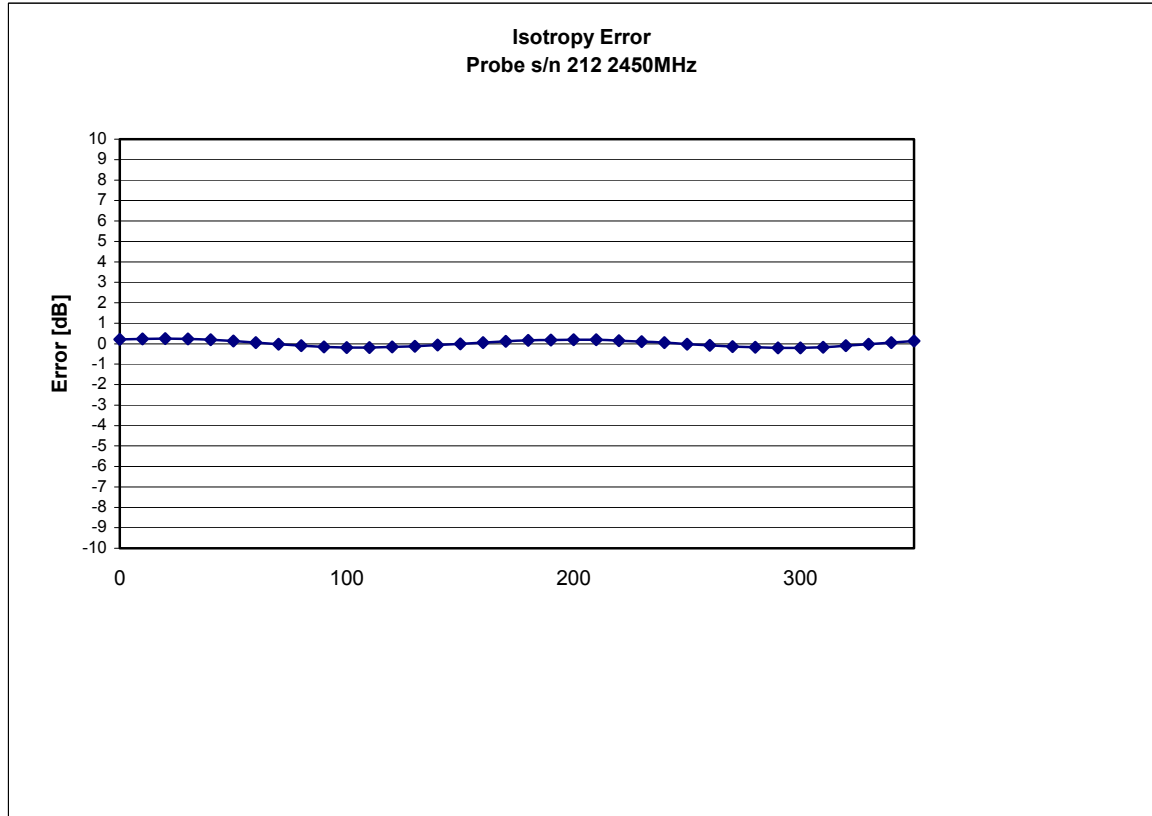
### **Spatial Resolution:**

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)



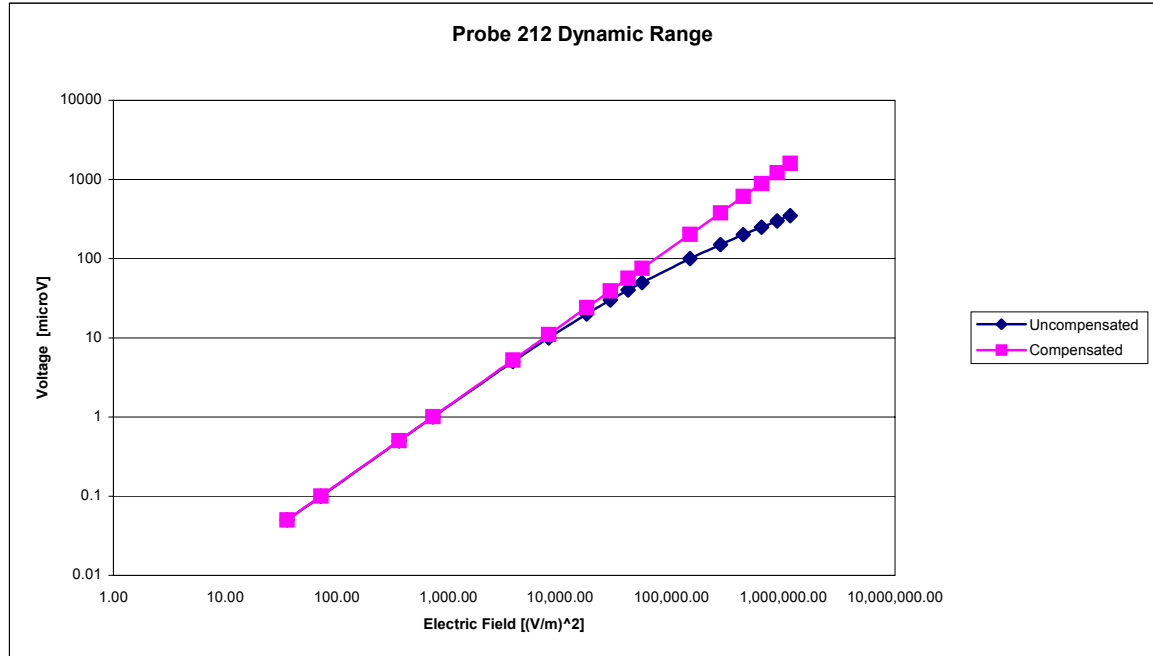
## Isotropy Error 2450 MHz (Air)



**Isotropy:**

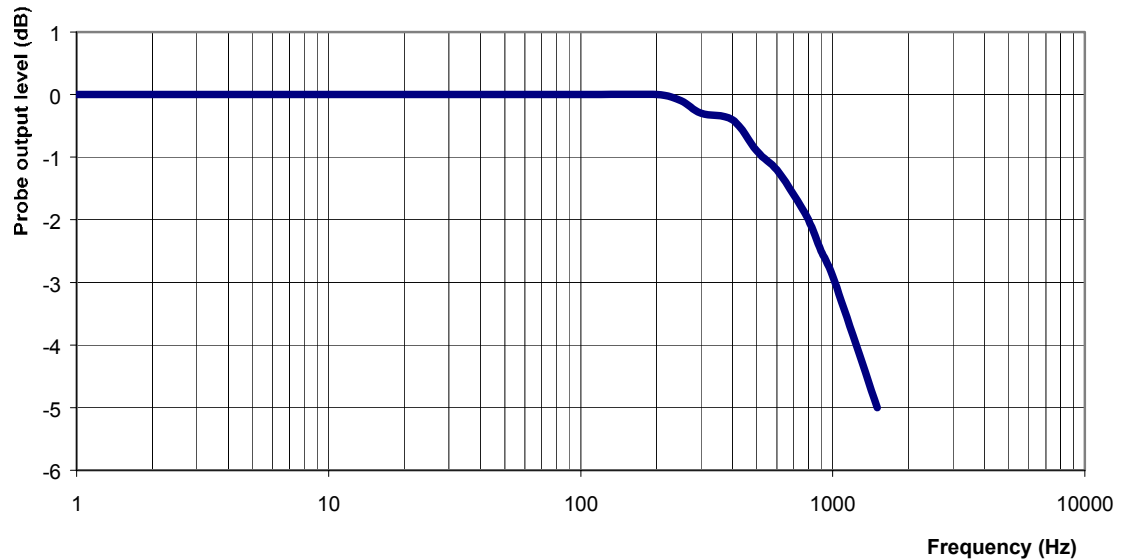
0.10 dB

## 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:** 3.3 7% (K=2)

**Channel Y:** 3.3 7% (K=2)

**Channel Z:** 3.3 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 2004.



**Appendix C**  
**Dipole Calibration Certificate**

Project number: Intel-Dell-WM3A2200B-5031  
FCC ID: ID:E2K24CLNS

51 Spectrum Way  
Nepean, Ontario  
Canada K2R 1E6  
© 2004 APREL Laboratories



Page 60 of 61

Tel: (613) 820-2730  
Fax: (613) 820-4161  
Info@aprel.com  
www.aprel.com

**NCL CALIBRATION LABORATORIES**

Calibration File No: DC-0265

Project Number: Internal

**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.

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**

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

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

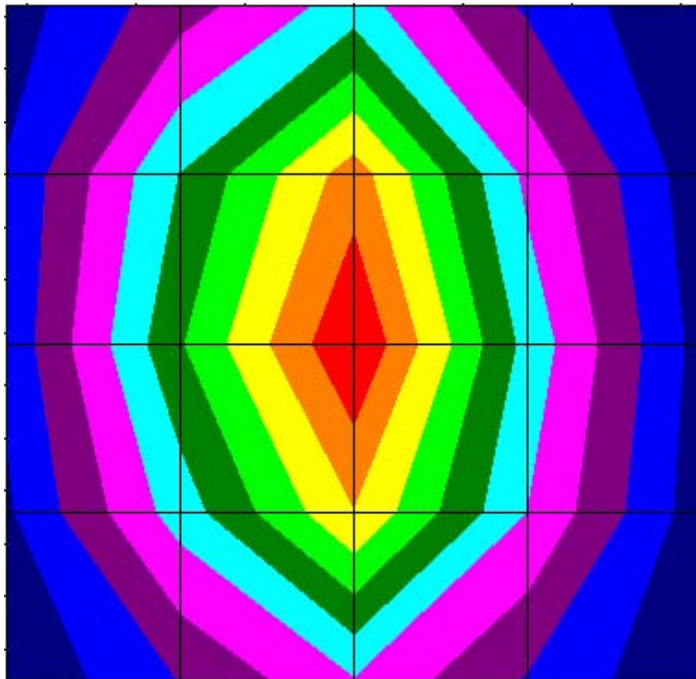
**Length:** 51.7 mm  
**Height:** 30.8 mm

### 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 |
|-------------|-------------|-----------------|-----------------|
| 49.56 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

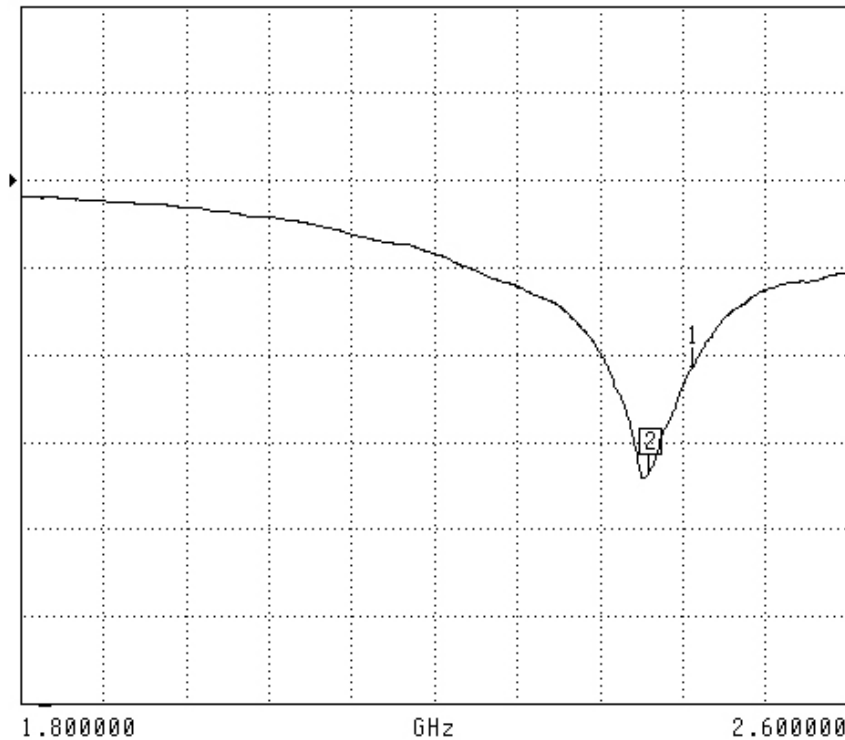
| Test      | Result          | IEEE Value |
|-----------|-----------------|------------|
| S11 R/L   | -21.4           | -21 dB     |
| SWR       | 1.181U          | -          |
| Impedance | 46.175 $\Omega$ |            |

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

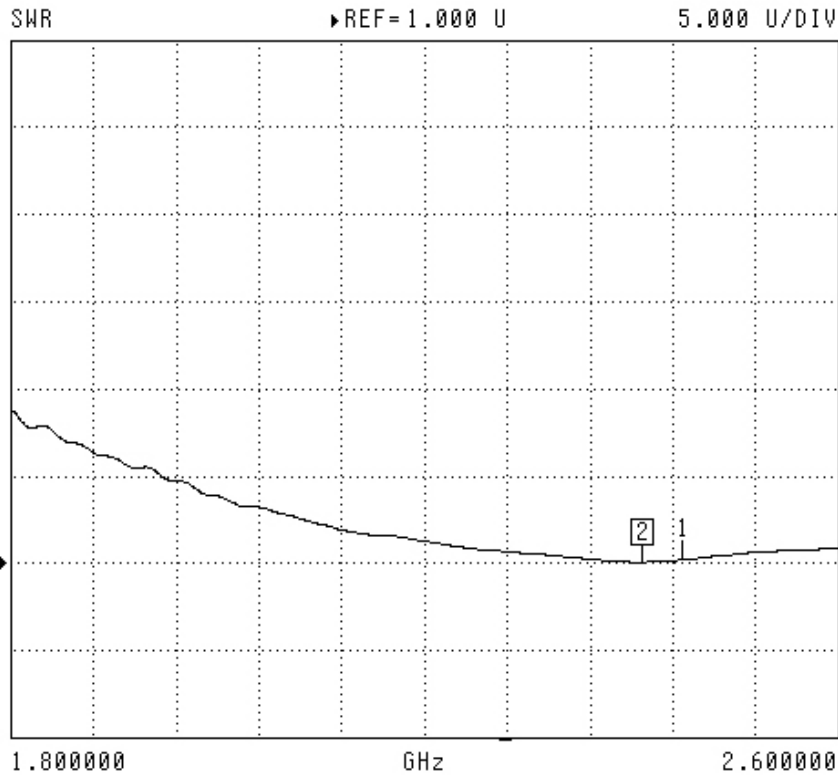
MARKER TO MAX  
▶ MARKER TO MIN

1 2.450000 GHz  
-21.377 dB

MARKER READOUT  
FUNCTIONS

## SWR

S11 FORWARD REFLECTION



CH 1 - S11  
REFERENCE PLANE  
5.1160 mm

MARKER 2  
2.411000 GHz  
1.049 U

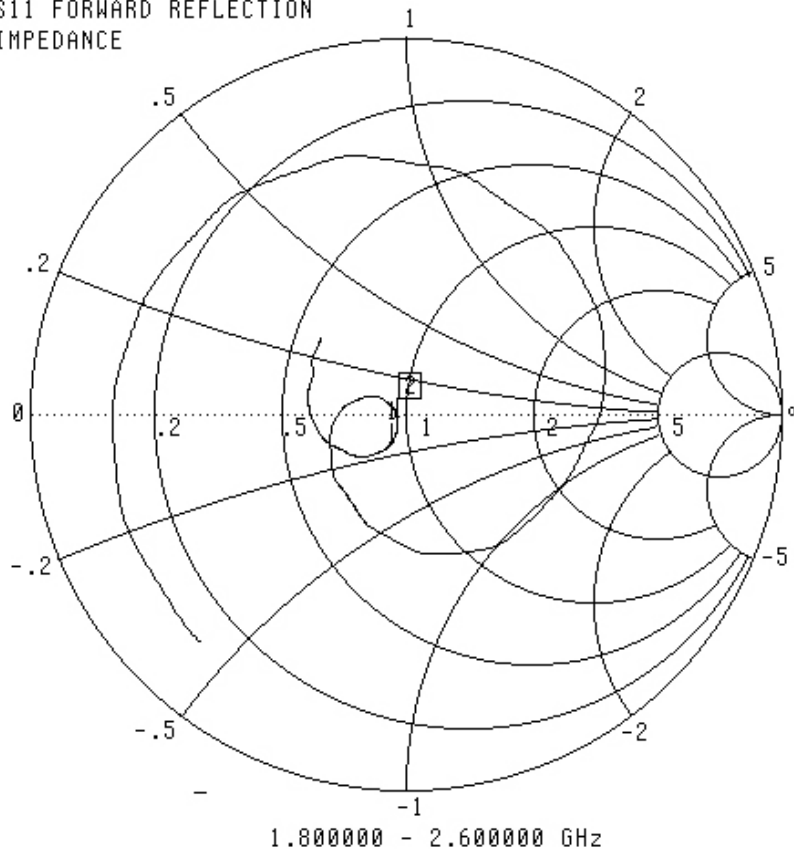
MARKER TO MAX  
▶ MARKER TO MIN

**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  $\Omega$   
-1.171 j $\Omega$

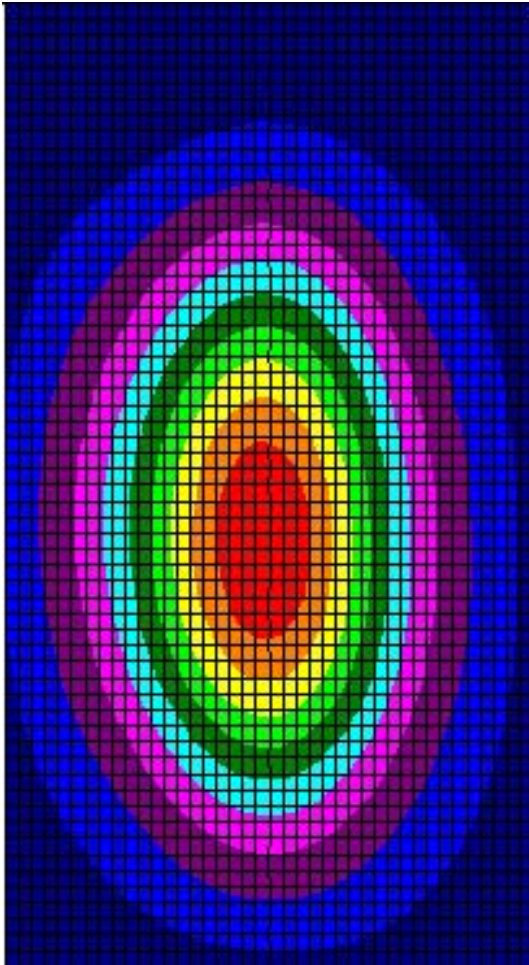
MARKER TO MAX  
▶ MARKER TO MIN  
**1** 2.450000 GHz  
46.175  $\Omega$   
-7.199 j $\Omega$

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.



## 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 2003

