



Appendix D. Probe Calibration

Miniature Isotropic RF Probe

M/N: ALS-E-020

S/N: 264

2450MHz Body Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: CP-832

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.: 264

BODY Calibration

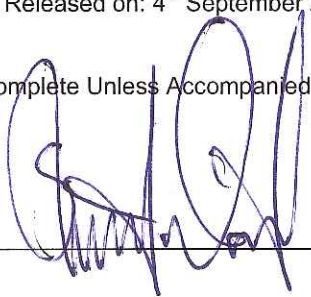
Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: QTKB-E-Probe-5305

Calibrated: 21st August 2007
Released on: 4th September 2007

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

Released By: _____



NCL CALIBRATION LABORATORIES

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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-020 264.

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

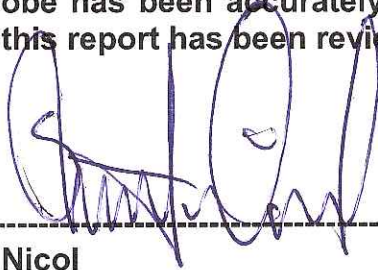
Conditions

Probe 264 was 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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Calibration Results Summary

Probe Type:	E-Field Probe E-020
Serial Number:	264
Frequency:	2450 MHz
Sensor Offset:	1.56 mm
Sensor Length:	2.5 mm
Tip Enclosure:	Ertalyte*
Tip Diameter:	<5 mm
Tip Length:	60 mm
Total Length:	290 mm

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

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

Sensitivity in Body Tissue

Frequency: 2450 MHz

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

ConvF

Channel X: 5.2

Channel Y: 5.2

Channel Z: 5.2

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

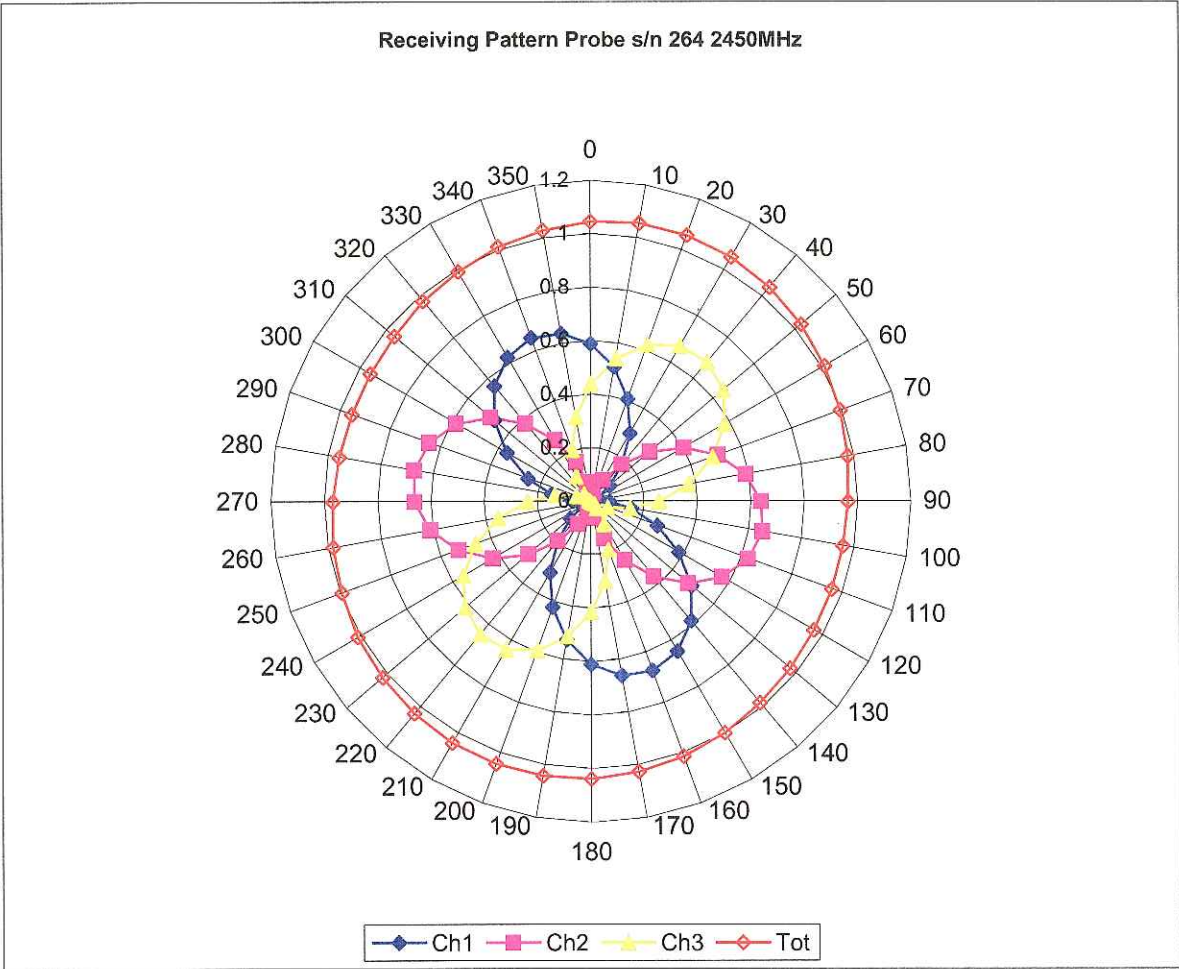
Boundary Effect:

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.

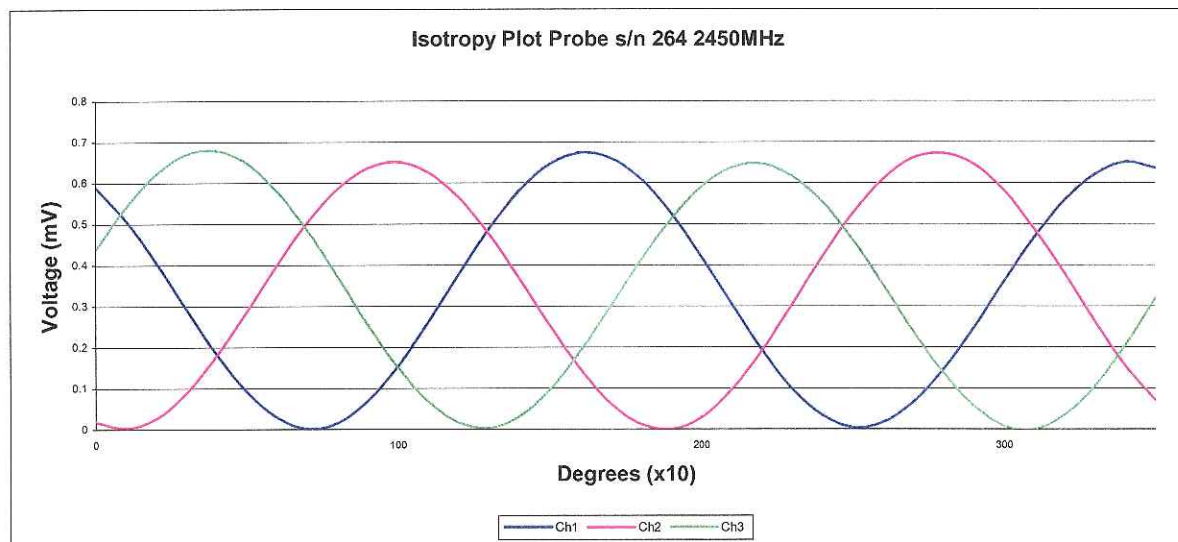
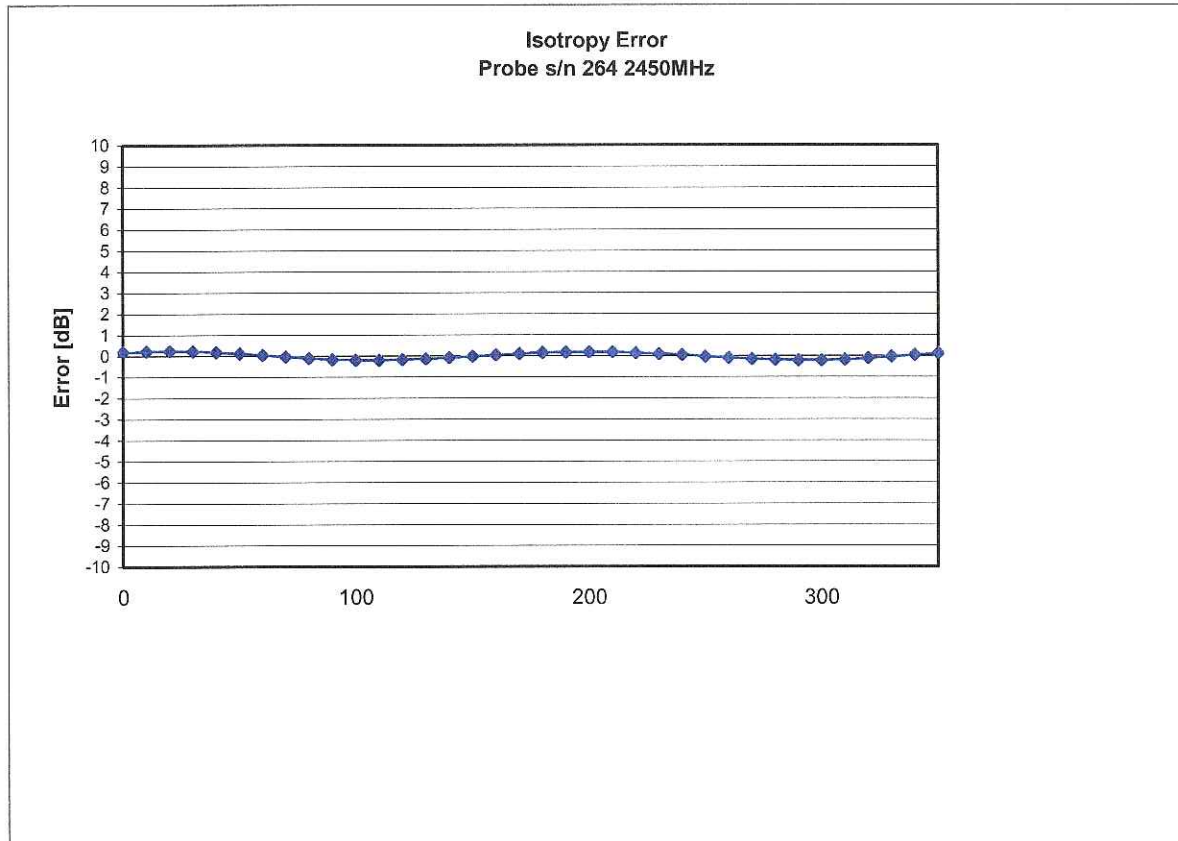
Spatial Resolution:

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)



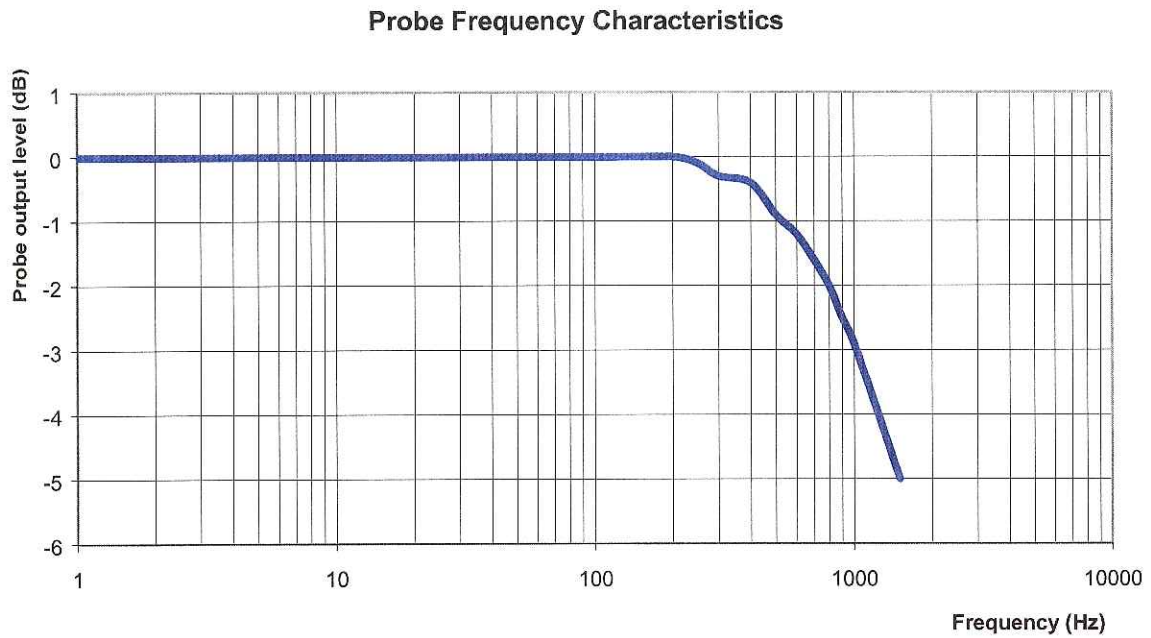
Isotropy in Tissue:

0.10 dB

Figure 1 is a log-log plot titled "Probe 264 Dynamic Range". The y-axis is labeled "Voltage [microV]" and ranges from 0.01 to 10000. The x-axis is labeled "Electric Field [(V/m)^2]" and ranges from 1.00 to 10,000,000.00. Two data series are plotted: "Uncompensated" (blue line with diamond markers) and "Compensated" (pink line with square markers). The compensated data shows a much wider dynamic range, extending to higher electric field values than the uncompensated data.

Electric Field [(V/m)^2]	Uncompensated Voltage [microV]	Compensated Voltage [microV]
40	-	0.05
80	-	0.1
400	-	0.5
800	-	1.0
4000	-	5.0
8000	-	10.0
20000	20	25
40000	40	40
60000	60	60
80000	80	80
100000	100	100
200000	200	200
400000	400	400
600000	600	600
800000	800	800
1000000	1000	1000
1200000	1200	1200
1400000	1400	1400
1600000	1600	1600
1800000	1800	1800
2000000	2000	2000
2200000	2200	2200
2400000	2400	2400
2600000	2600	2600
2800000	2800	2800
3000000	3000	3000
3200000	3200	3200
3400000	3400	3400
3600000	3600	3600
3800000	3800	3800
4000000	4000	4000
4200000	4200	4200
4400000	4400	4400
4600000	4600	4600
4800000	4800	4800
5000000	5000	5000
5200000	5200	5200
5400000	5400	5400
5600000	5600	5600
5800000	5800	5800
6000000	6000	6000
6200000	6200	6200
6400000	6400	6400
6600000	6600	6600
6800000	6800	6800
7000000	7000	7000
7200000	7200	7200
7400000	7400	7400
7600000	7600	7600
7800000	7800	7800
8000000	8000	8000
8200000	8200	8200
8400000	8400	8400
8600000	8600	8600
8800000	8800	8800
9000000	9000	9000
9200000	9200	9200
9400000	9400	9400
9600000	9600	9600
9800000	9800	9800
10000000	10000	10000

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: 5.2 7%(K=2)

Channel Y: 5.2 7%(K=2)

Channel Z: 5.2 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 2.4mm 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 2007.



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

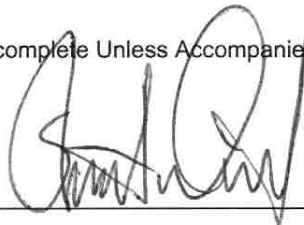
Customer: Quietek

Project Number: QTKB-Dipole-CAL-5336

Calibrated: 9th May 2008
Released on: 9th May 2008

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

Released By: _____



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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

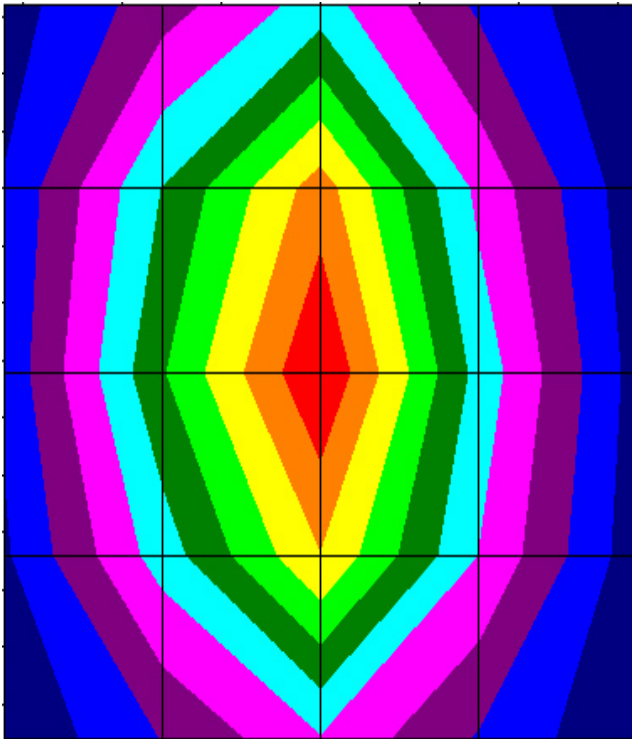
Length: 53.5 mm
Height: 30.4 mm

Electrical Specification

SWR: 1.19 U
Return Loss: -20.8 dB
Impedance: 49.4 Ω

System Validation Results

Frequency	1 Gram	10 Gram	Peak
2.45 GHz	48.07	25.65	95.6

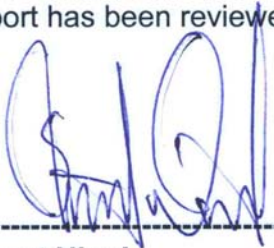


Conditions

Dipole 319 is a recalibration.

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

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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Dipole Calibration Results

Mechanical Verification

IEEE Length	IEEE Height	Measured Length	Measured Height
51.5 mm	30.4 mm	53.5 mm	30.4 mm

Tissue Validation

Body Tissue 2450 MHz	Measured
Dielectric constant, ϵ_r	52.5
Conductivity, σ [S/m]	1.78

Electrical Calibration

Test	Result
S11 R/L	-20.8 dB
SWR	1.2 U
Impedance	49.4 Ω

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

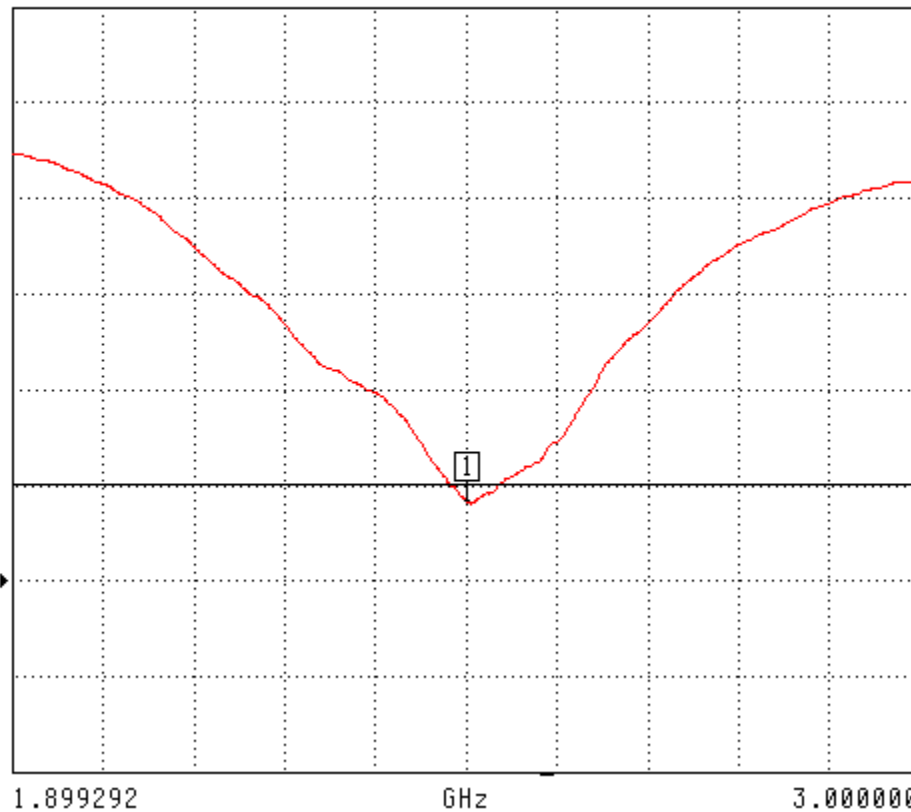
S11 Parameter Return Loss

S11 FORWARD REFLECTION

LOG MAGNITUDE

REF = -25.000 dB

5.000 dB/DIV



CH 1 - S11
REFERENCE PLANE
0.0000 mm

MARKER 1
2.450046 GHz
-20.796 dB

MARKER TO MAX
▶ MARKER TO MIN

MARKER READOUT
FUNCTIONS

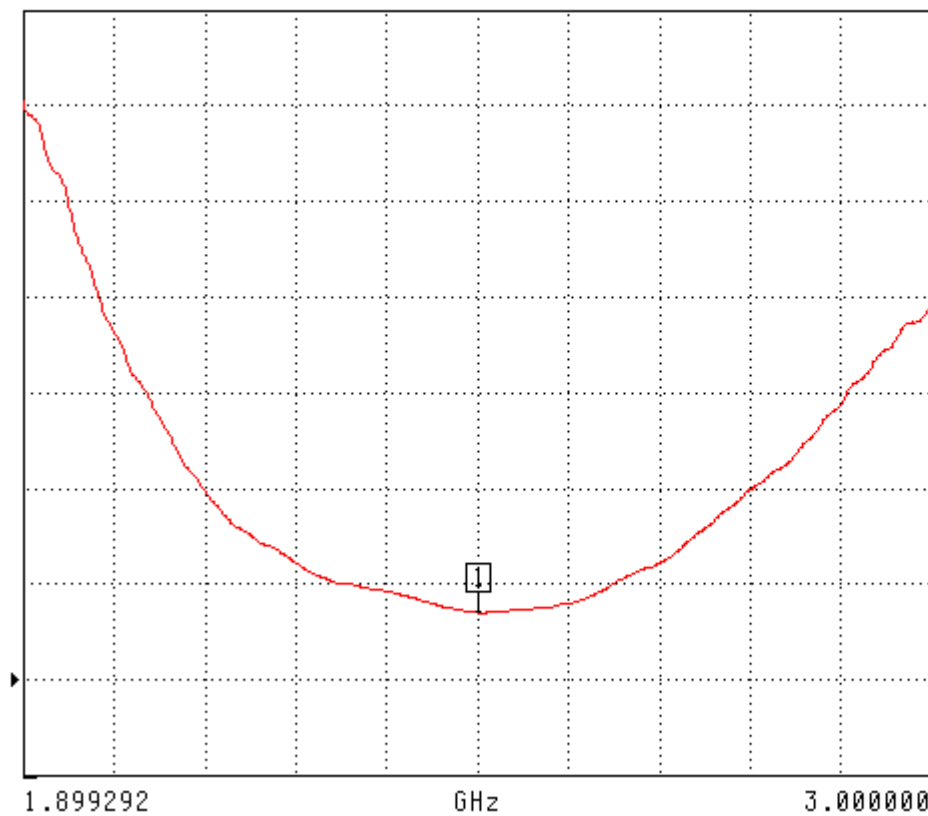
SWR

S11 FORWARD REFLECTION

SWR

REF=500.000 mU

1.000 U/DIV



CH 1 - S11
REFERENCE PLANE
0.0000 mm

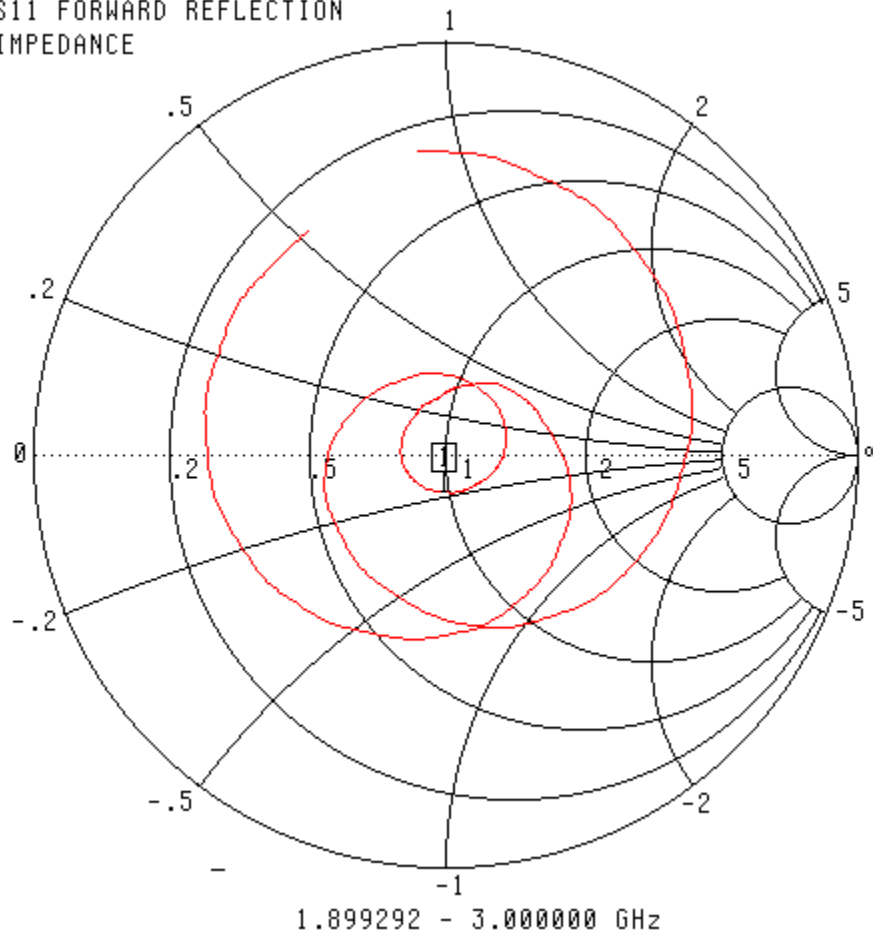
MARKER 1
2.450046 GHz
1.199 U

MARKER TO MAX
▶ MARKER TO MIN

MARKER READOUT
FUNCTIONS

Smith Chart Dipole Impedance

S11 FORWARD REFLECTION
IMPEDANCE



CH 1 - S11
REFERENCE PLANE
0.0000 mm

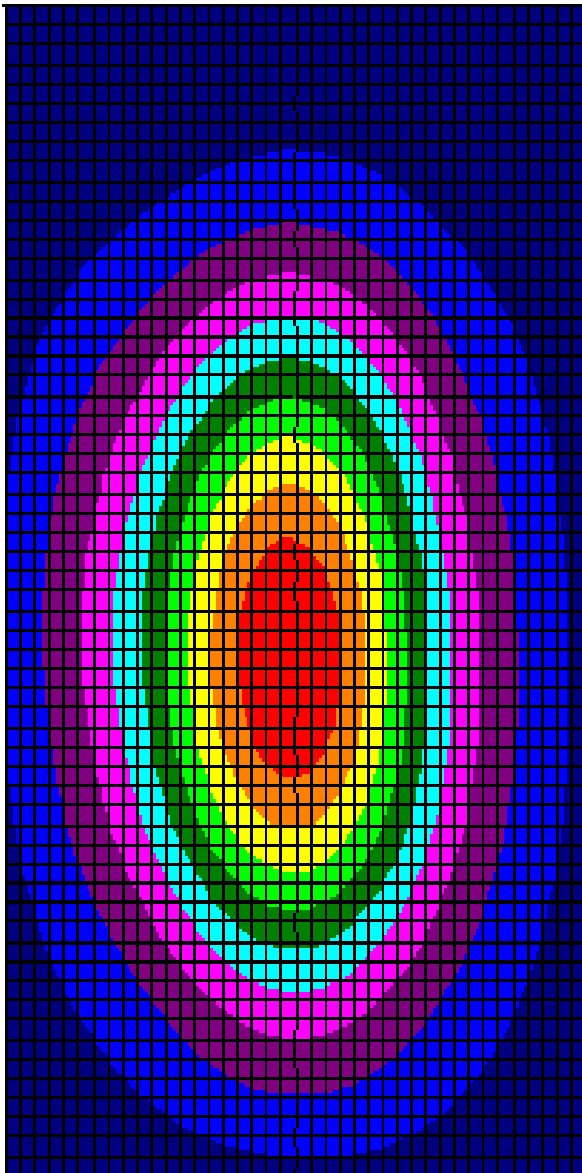
MARKER 1
2.450046 GHz
49.365 Ω
-9.232 $j\Omega$

MARKER TO MAX
▶ MARKER TO MIN

MARKER READOUT
FUNCTIONS

System Validation Results Using the Electrically Calibrated Dipole

Frequency	1 Gram	10 Gram	Peak Above Feed Point
2.45 GHz	48.07	25.65	95.6



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.