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## Appendix B Calibration Files



# NCL CALIBRATION LABORATORIES

Calibration File No: DC-890  
Project Number: APREL-ALSAS 10U

## 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: ALS-D-5258-S-2

Frequency: 5.2GHz to 5.8GHz

Serial No: 5258-235-00802

Customer: APREL

Serial Number: ALS-BB-001

Calibrated: 24<sup>th</sup> May 2008  
Released on: 24<sup>th</sup> May 2008

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) 820-4162

## NCL Calibration Laboratories

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Division of APREL Laboratories.

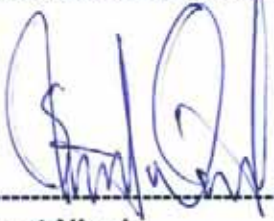
### Conditions

Dipole 5258-235-00802 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**



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**C. Teodorian**

## Calibration Results Summary

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

### Mechanical Dimensions

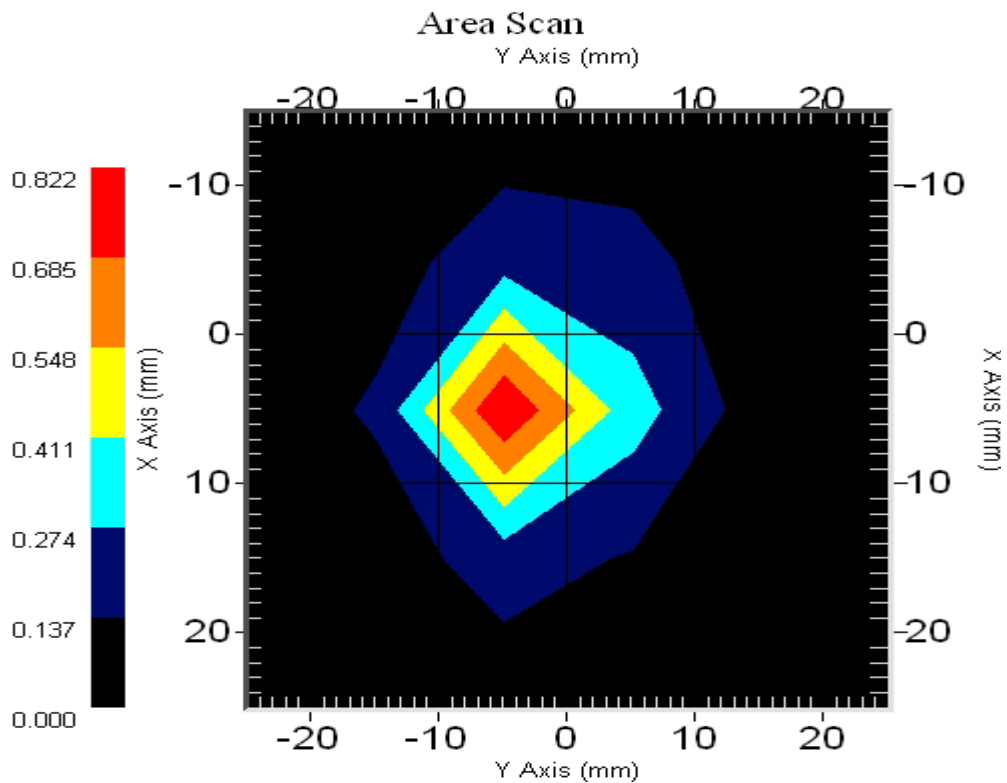
**Length:** 23.3 mm  
**Height:** 20.3 mm

### Electrical Specification

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

### System Validation Results

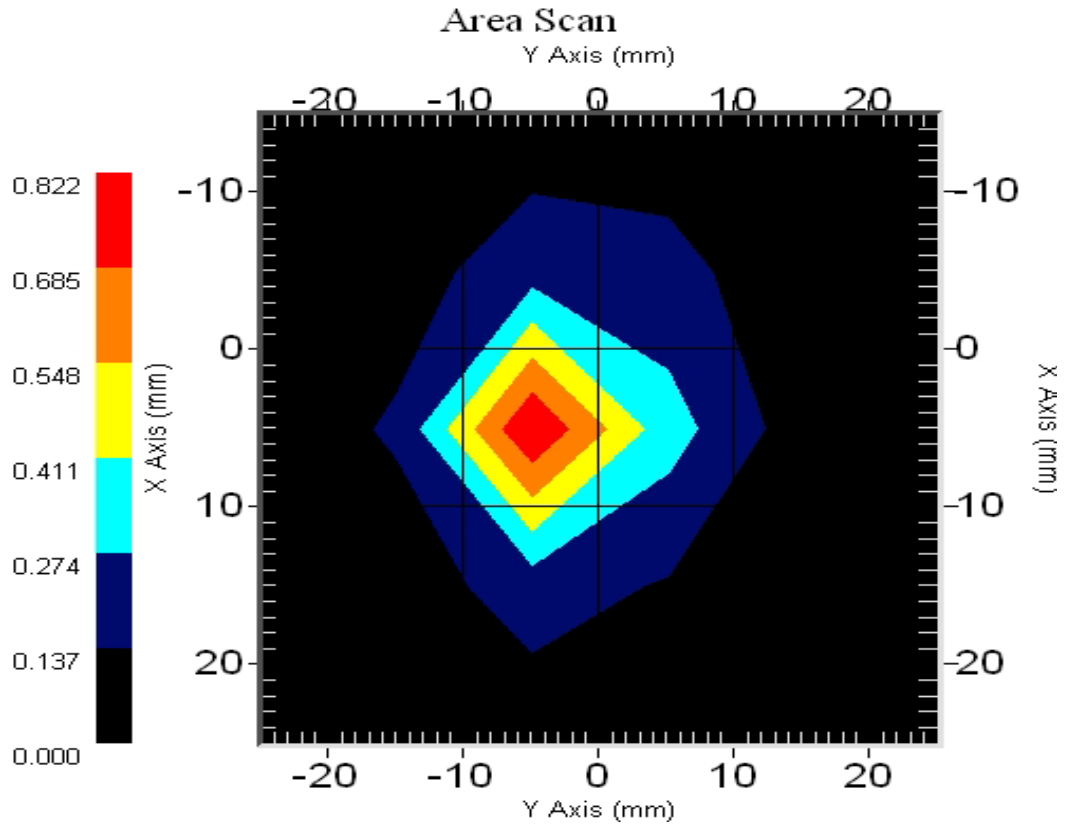
Frequency	1 Gram	10 Gram	Peak
5200 MHz	51.9	17.9	223.1



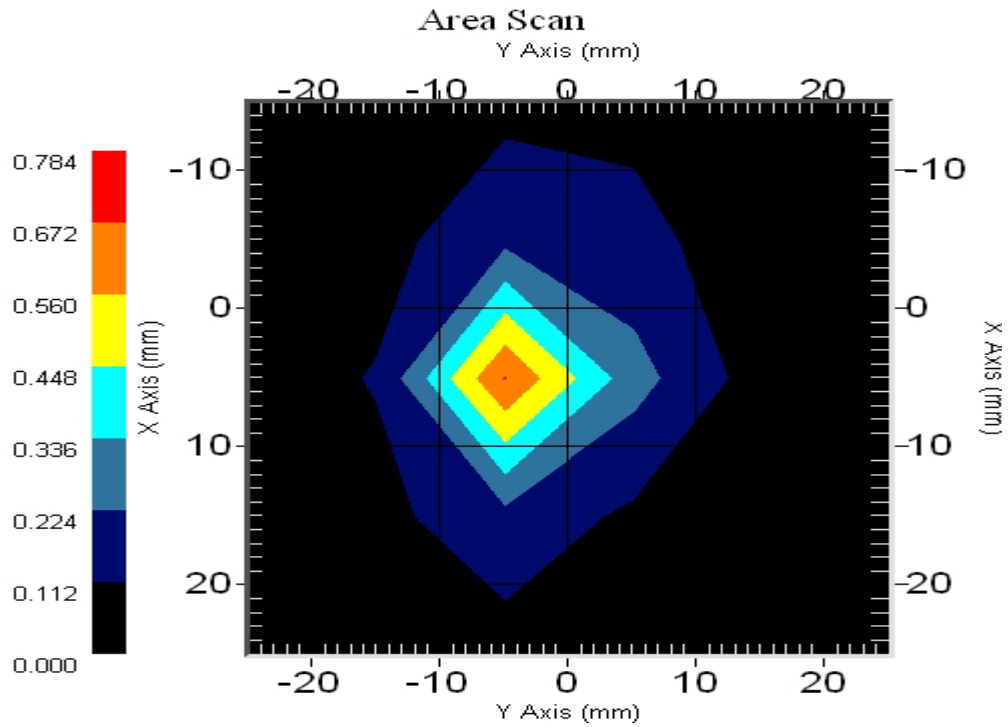
# NCL Calibration Laboratories

Division of APREL Laboratories.

Frequency	1 Gram	10 Gram	Peak
5600 MHz	52.97	18.2	243.1



Frequency	1 Gram	10 Gram	Peak
5800 MHz	48.97	17.2	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 5258-235-00802. 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-030 018 E-Field Probe.

## **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 5258-235-00802 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

<b>Head Tissue 5200 MHz</b>	<b>Measured</b>
Dielectric constant, $\epsilon_r$	47.0
Conductivity, $\sigma$ [S/m]	5.30

<b>Head Tissue 5600 MHz</b>	<b>Measured</b>
Dielectric constant, $\epsilon_r$	46.1
Conductivity, $\sigma$ [S/m]	5.78

<b>Head Tissue 5800 MHz</b>	<b>Measured</b>
Dielectric constant, $\epsilon_r$	46.7
Conductivity, $\sigma$ [S/m]	6.22

### Mechanical Verification

<b>APREL Length</b>	<b>APREL Height</b>	<b>Measured Length</b>	<b>Measured Height</b>
23.1 mm	20.7 mm	23.3 mm	20.3 mm

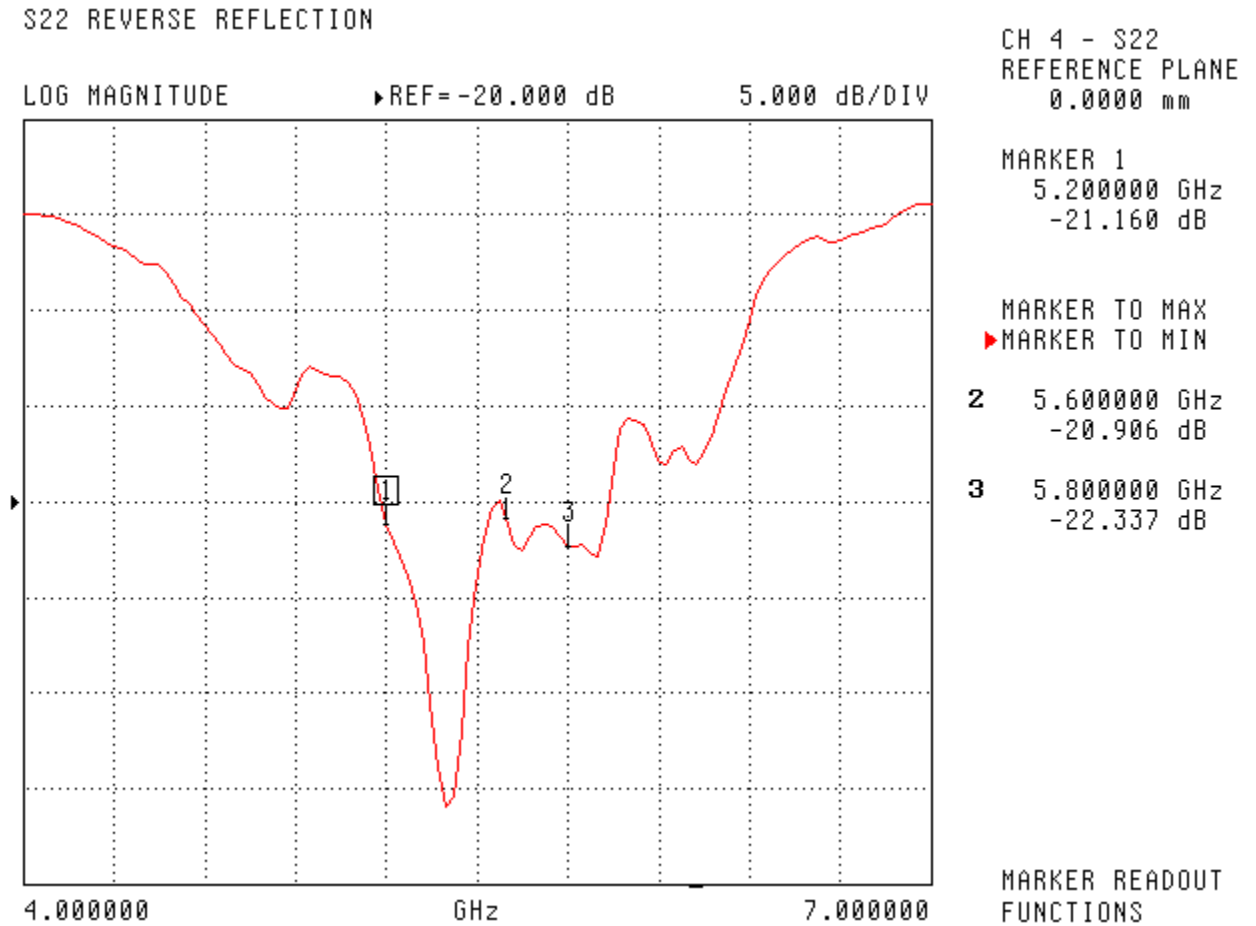
### Electrical Calibration

<b>S11</b>	<b>5200MHz</b>	<b>5800MHz</b>
<b>RL (dB)</b>	-21.16	-22.34
<b>SWR</b>	1.2	1.17
<b>Impedance (ohms)</b>	51.38	43.92



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

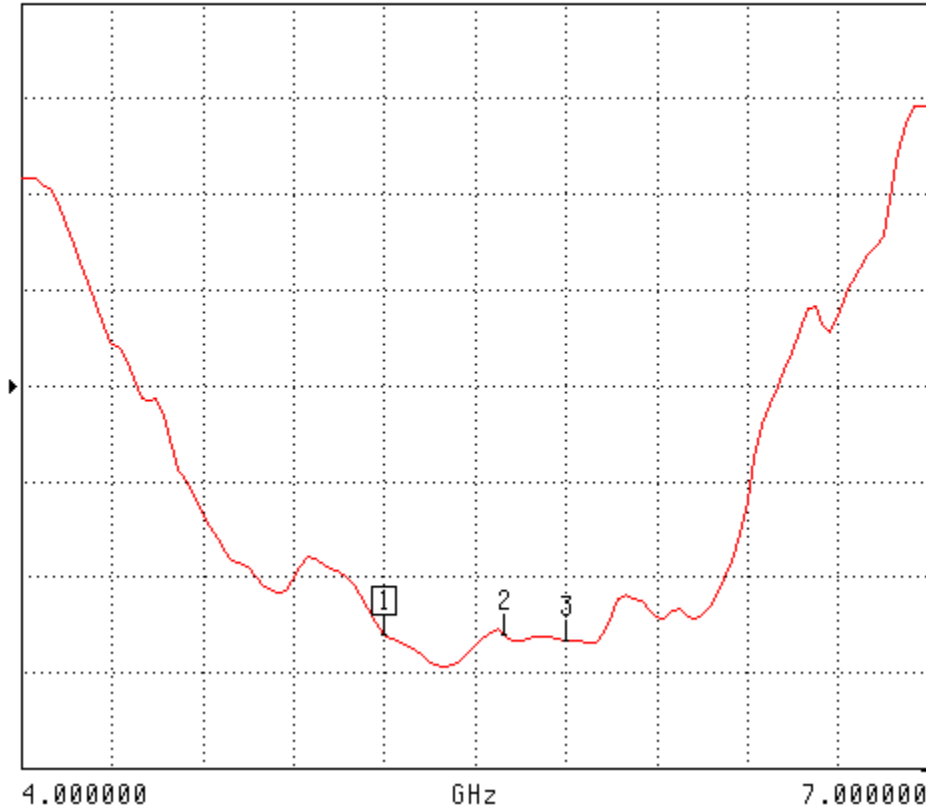
**S11 Parameter Return Loss**



SWR

S22 REVERSE REFLECTION

SWR REF=2.500 U 500.000 mU/DIV



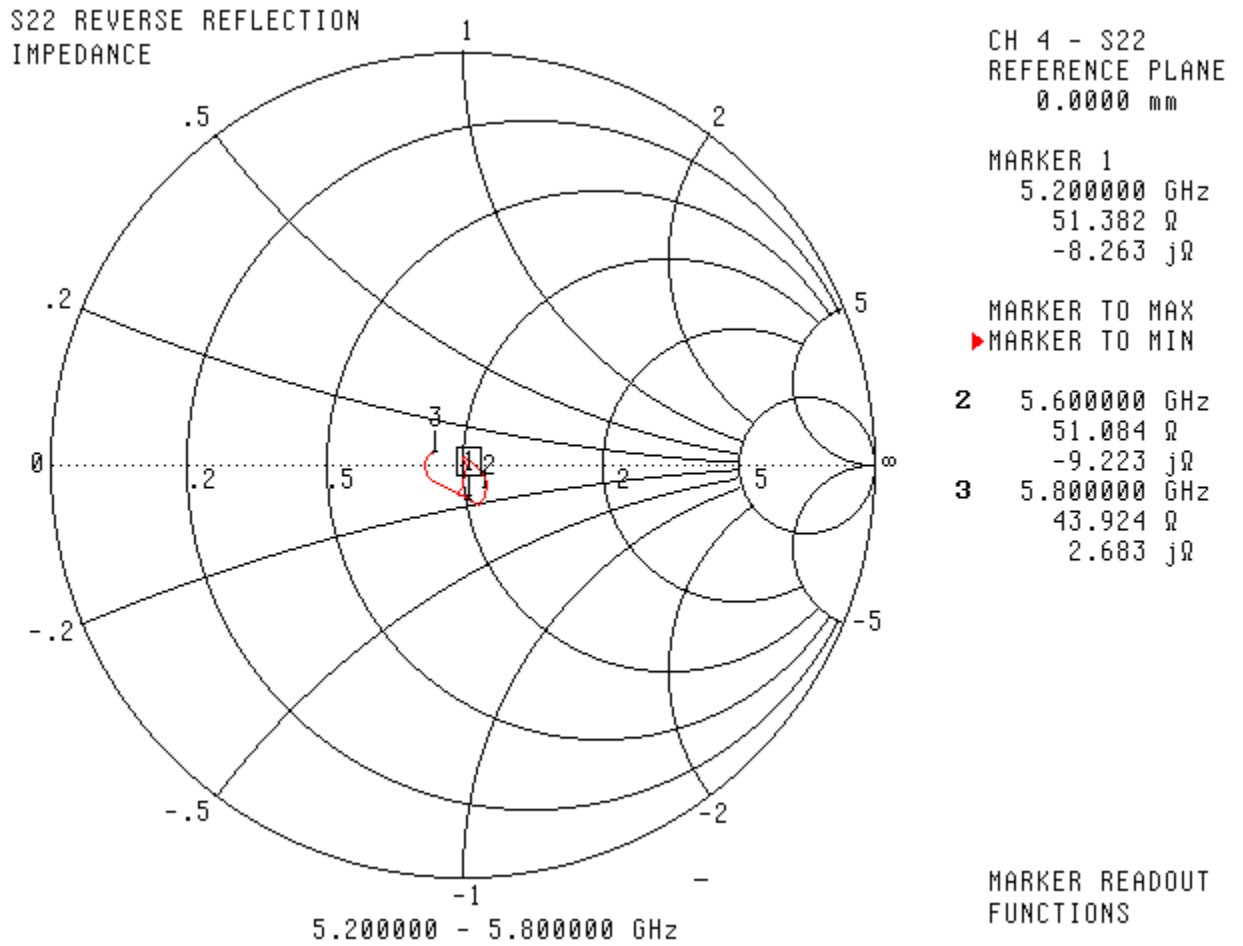
CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
5.200000 GHz  
1.199 U

MARKER TO MAX  
▶ MARKER TO MIN  
2 5.600000 GHz  
1.200 U  
3 5.800000 GHz  
1.165 U

MARKER READOUT  
FUNCTIONS

### Smith Chart Dipole Impedance



## **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: DC-889  
Project Number: APREL-ALSAS10U

## 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: ALS-D-2450-S-2

Frequency: 2450 MHz

Serial No: 301581

Customer: APREL

Calibrated: 4<sup>th</sup> May 2008  
Released on: 4<sup>th</sup> May 2008

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) 820-4162

## NCL Calibration Laboratories

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Division of APREL Laboratories.

### Conditions

Dipole 301581 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.



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**Stuart Nicol**



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**C. Teodorian**

## Calibration Results Summary

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

### Mechanical Dimensions

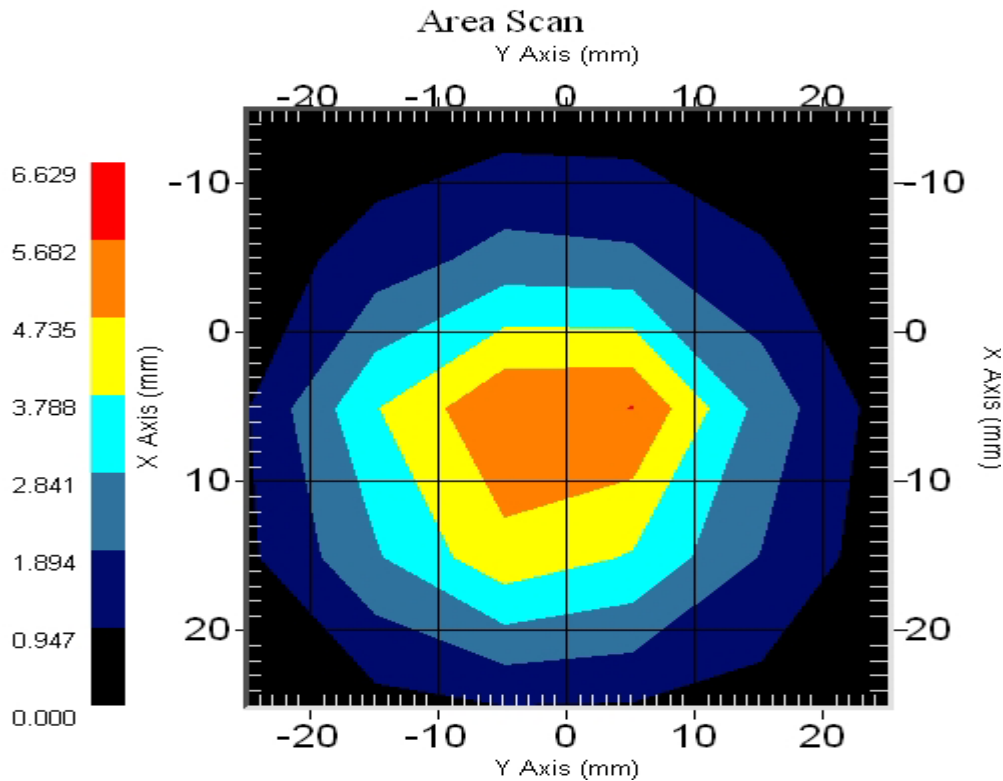
**Length:** 52.4 mm  
**Height:** 30.3 mm

### Electrical Specification

**SWR:** 1.056 U  
**Return Loss:** -32.0 dB  
**Impedance:** 50.2  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram	Peak
2450 MHz	53.1	24.4	101.8



## **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 301581. 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”

IEC-62209 “Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures”

Part 1: “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)”

IEC-62209 “Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures”

Part 2 *Draft*: “Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 30 MHz to 6 GHz)”

## **Conditions**

Dipole 301581 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

### Mechanical Verification

<b>APREL Length</b>	<b>APREL Height</b>	<b>Measured Length</b>	<b>Measured Height</b>
51.5 mm	30.4 mm	52.4 mm	30.3 mm

### Tissue Validation

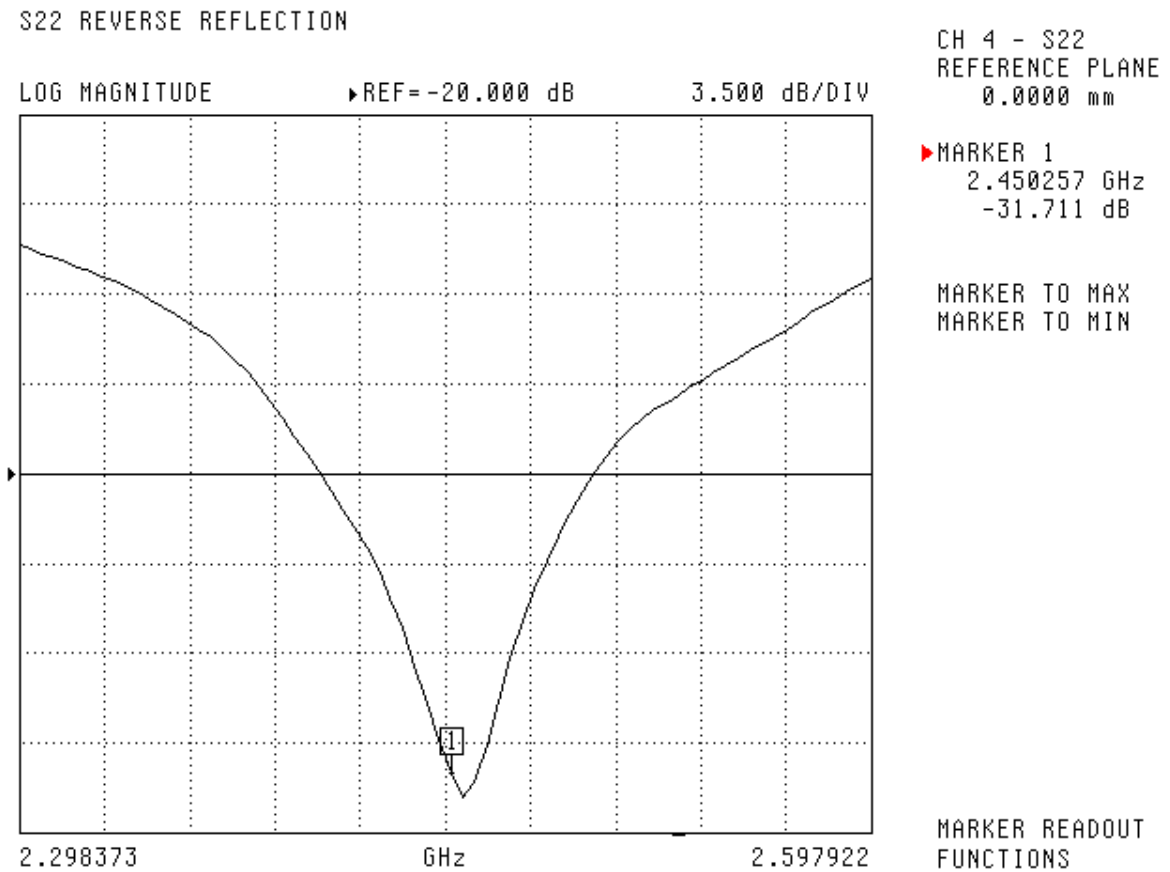
<b>Head Tissue 2450 MHz</b>	<b>Measured</b>
<b>Dielectric constant, <math>\epsilon_r</math></b>	39.2
<b>Conductivity, <math>\sigma</math> [S/m]</b>	1.80

**Electrical Calibration**

Test	Result
S11 R/L	-32.0 dB
SWR	1.05 U
Impedance	50.2 $\Omega$

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

**S11 Parameter Return Loss**



SWR

S22 REVERSE REFLECTION

SWR

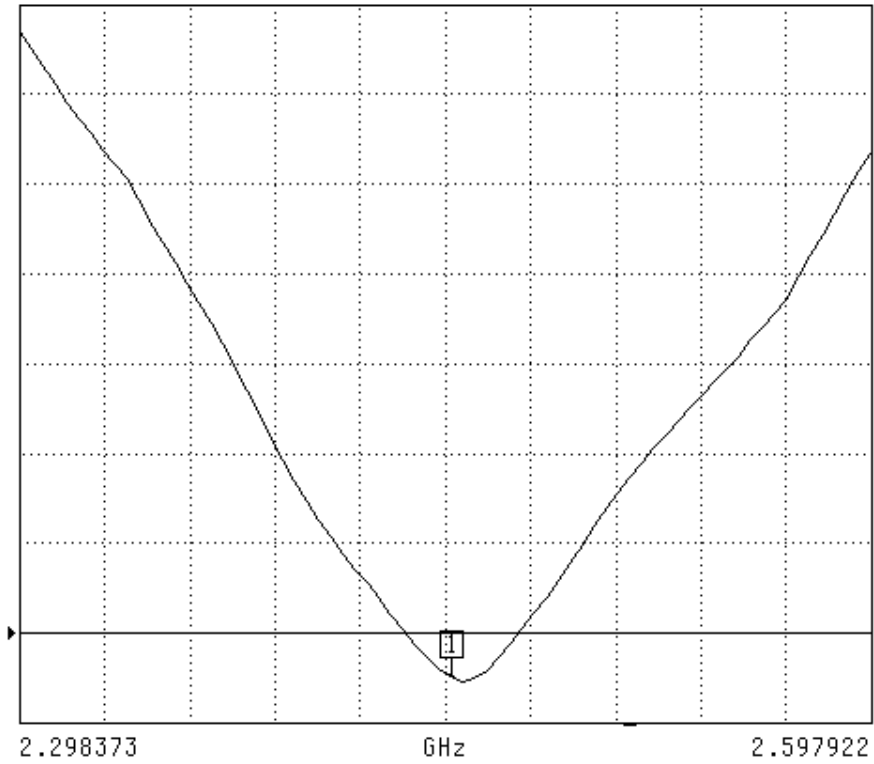
REF=1.100 U

100.000 mU/DIV

CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

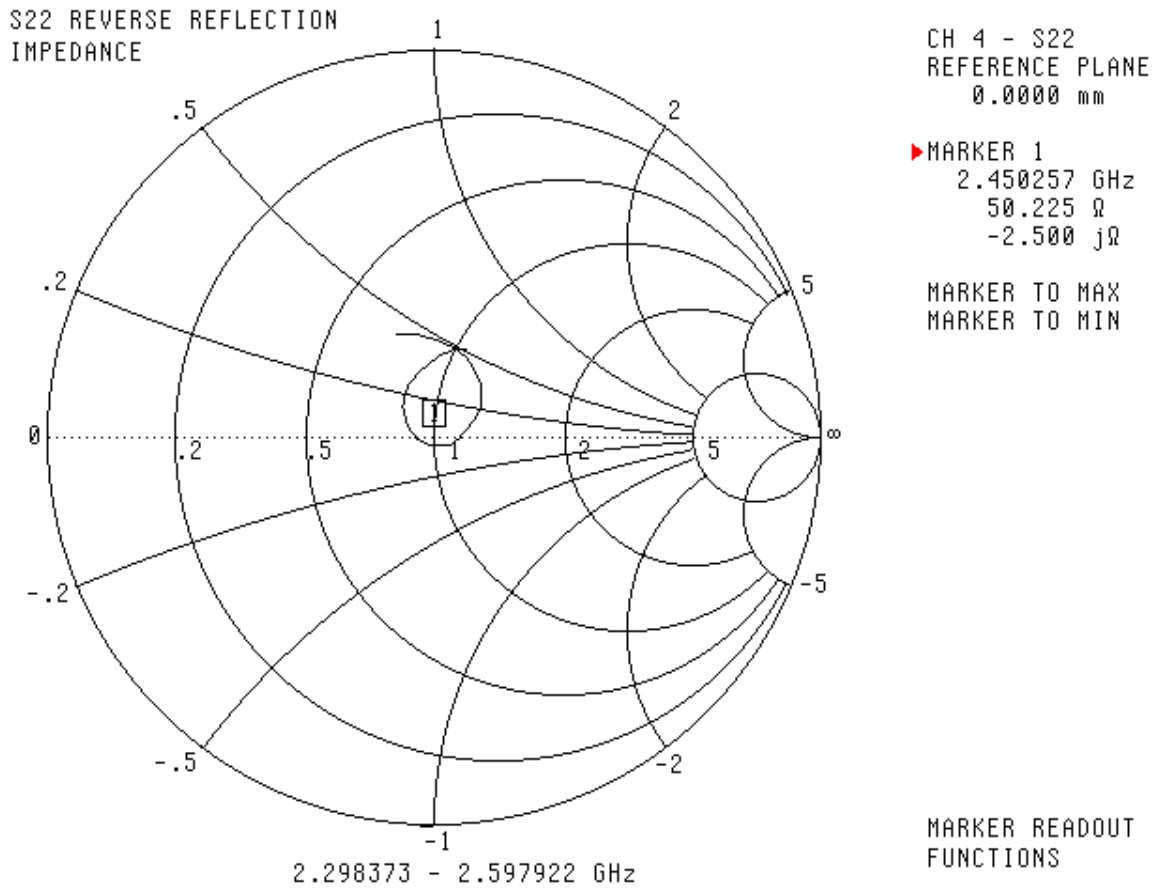
MARKER 1  
2.450257 GHz  
1.051 U

MARKER TO MAX  
MARKER TO MIN



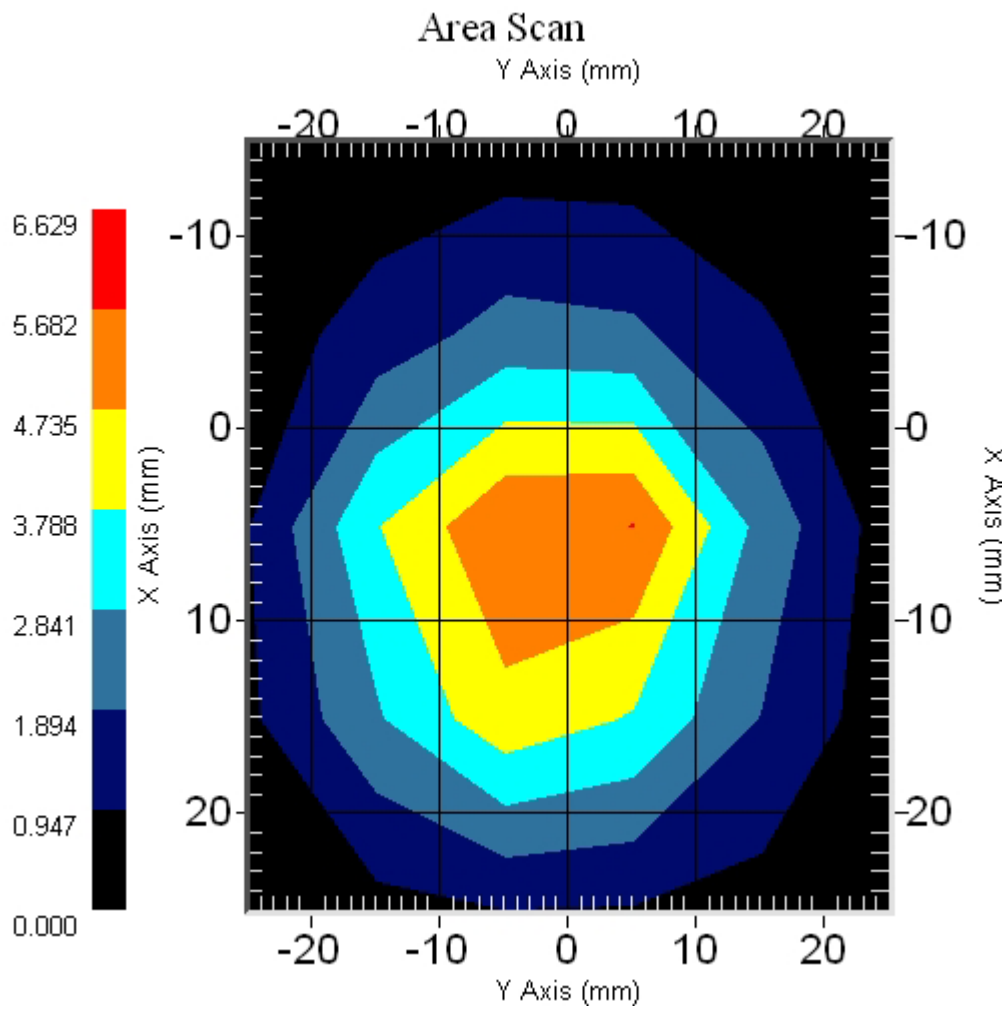
MARKER READOUT  
FUNCTIONS

### Smith Chart Dipole Impedance



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

Frequency	1 Gram	10 Gram	Peak
2450 MHz	53.1	24.4	101.8



## **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-887

Client.: APREL

## 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 5600 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

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

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008

Released on: 3<sup>rd</sup> May 2008

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-030 018.

## References

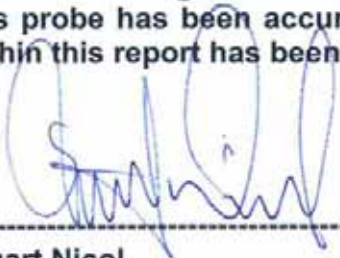
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

## Conditions

Probe 018 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**



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**Jesse Hones**



## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5600 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	<2.9 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 Measured**

**Frequency:** 5600 MHz

**Epsilon:** 46.0 (+/-10%)                      **Sigma:** 5.85 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 2.44mm.

### **Spatial Resolution:**

The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

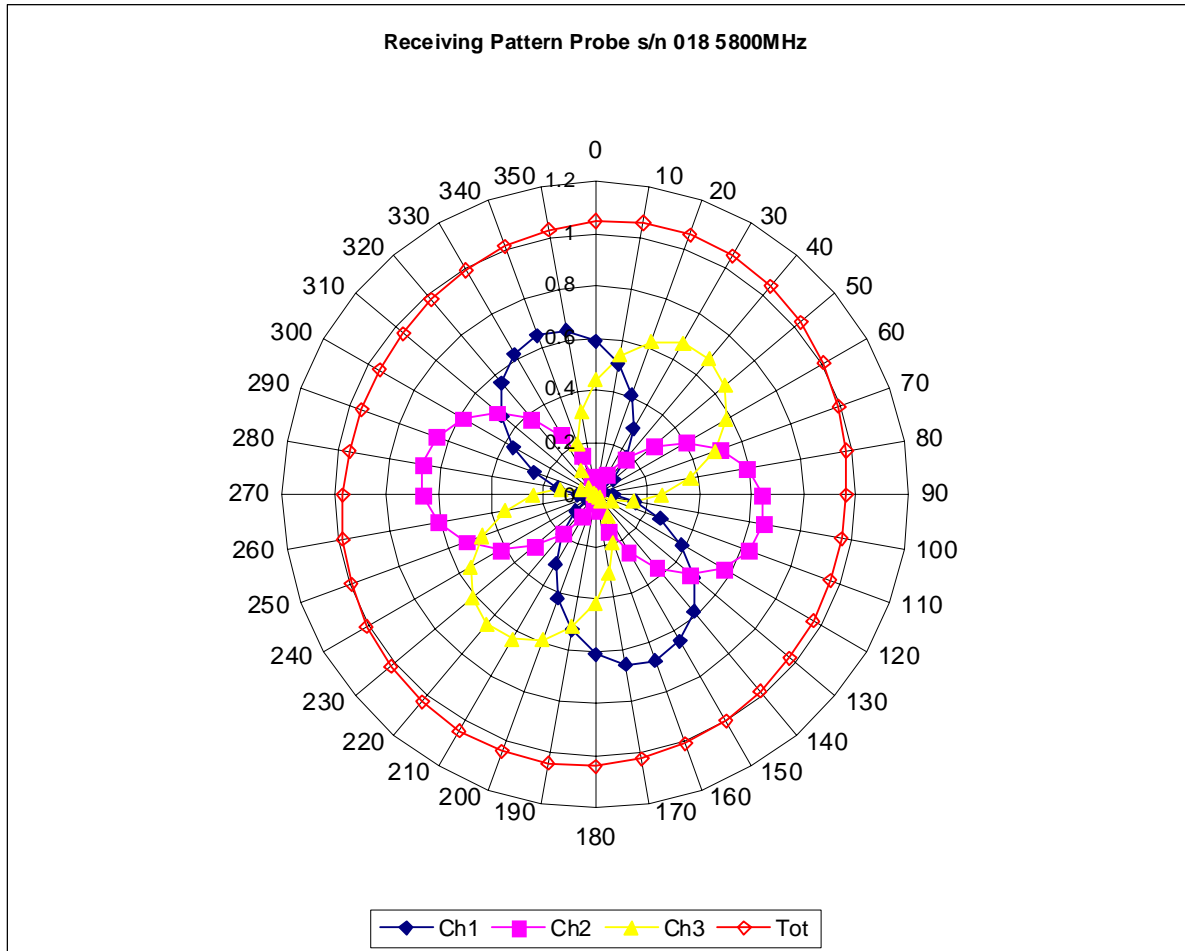
### **Broad Band Calibration:**

The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

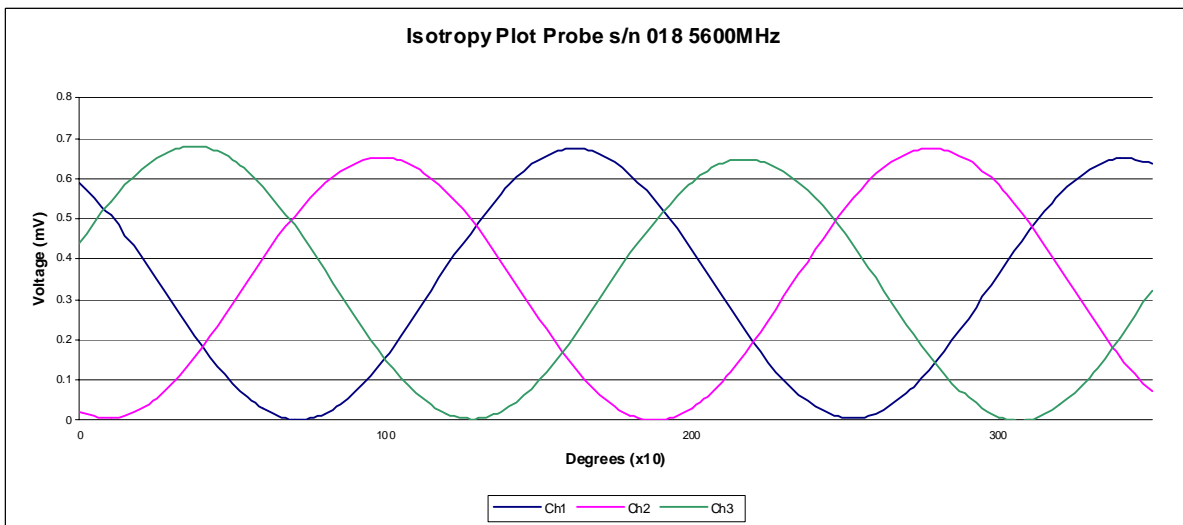
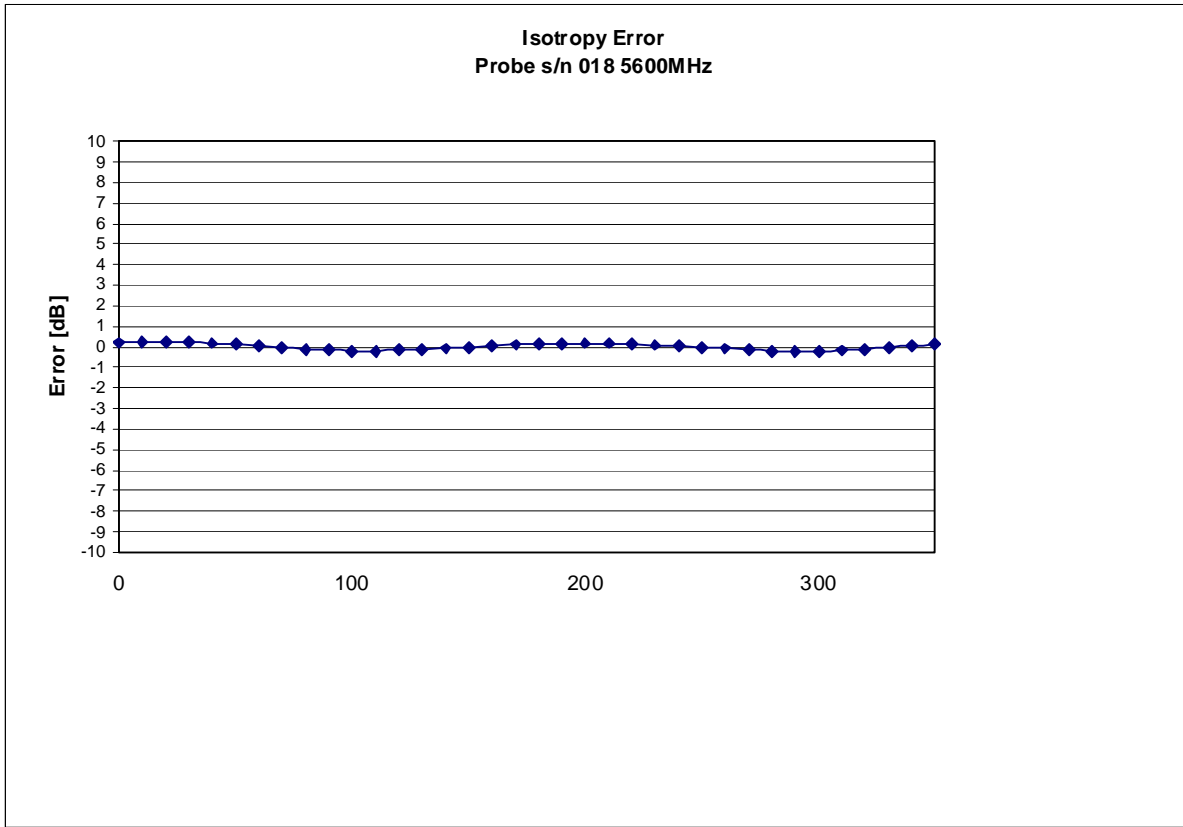
**Deviation at -40MHz:** -3.77%

**Deviation at +40MHz:** +4.28%

## Receiving Pattern 5600 MHz (Air)



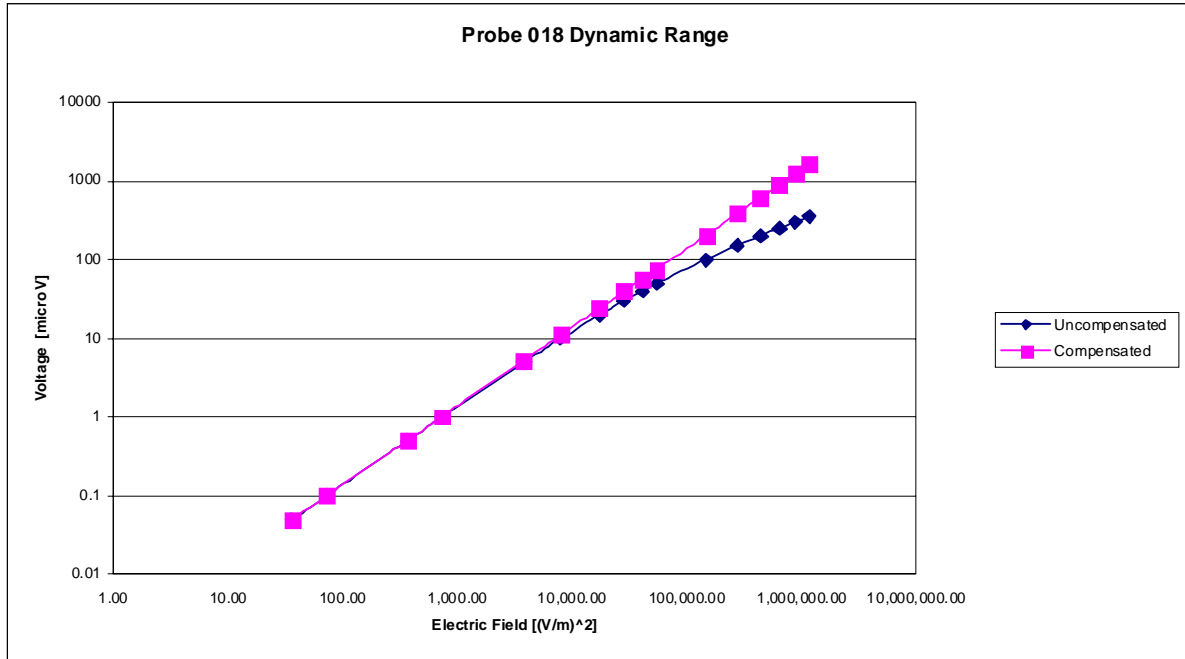
### Isotropy Error 5600 MHz (Air)



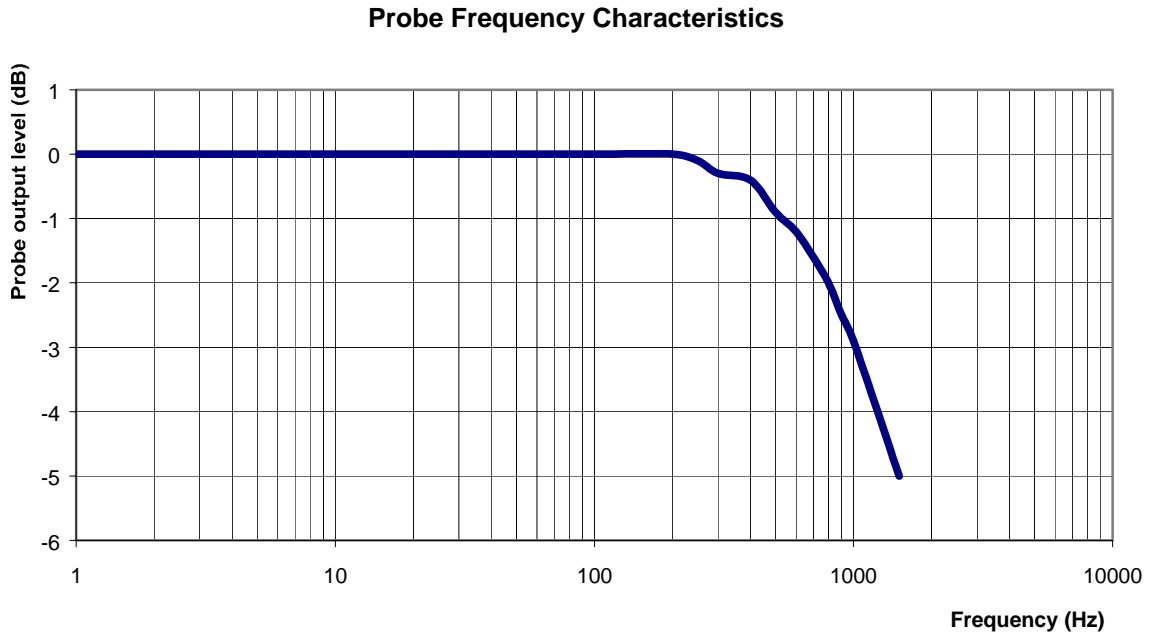
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



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

## **Conversion Factor Uncertainty Assessment**

### **Sensitivity in Body Tissue Measured**

**Frequency:** 5600 MHz

**Epsilon:** 46.0 (+/-10%)      **Sigma:** 5.85 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 M $\Omega$ .

#### **Boundary Effect:**

For a distance of 0.4mm 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-886

Client.: APREL

## 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 5200 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

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

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008

Released on: 3<sup>rd</sup> May 2008

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-030 018.

## References

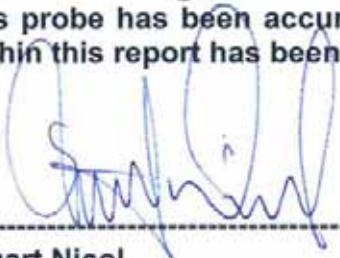
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

## Conditions

Probe 018 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**



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**Jesse Hones**

## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5200 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	<2.9 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:** 5200 MHz

**Epsilon:** 43.0 (+/-10%)                      **Sigma:** 5.75 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2

**Channel Y:** 3.2

**Channel Z:** 3.2

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 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

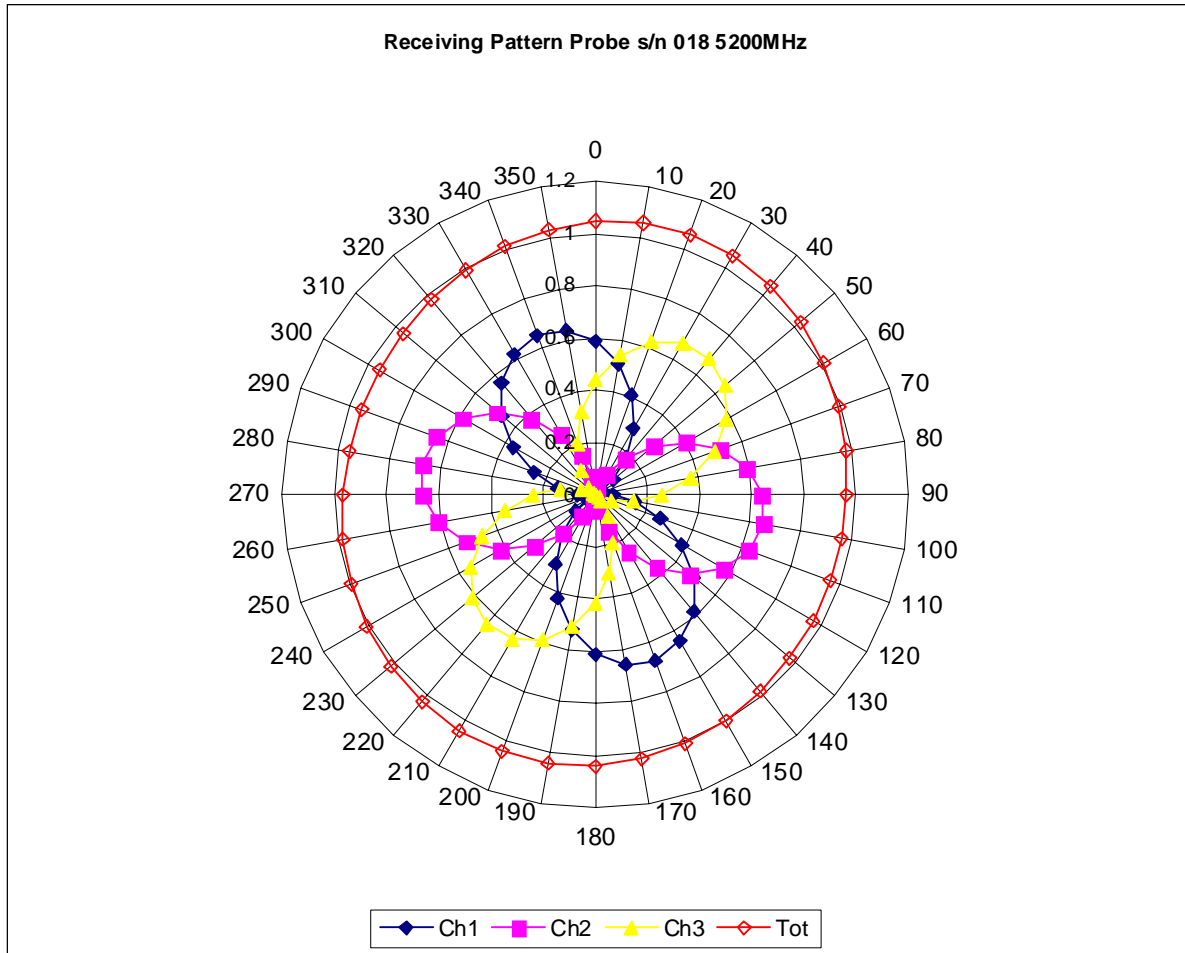
### **Broad Band Calibration:**

The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

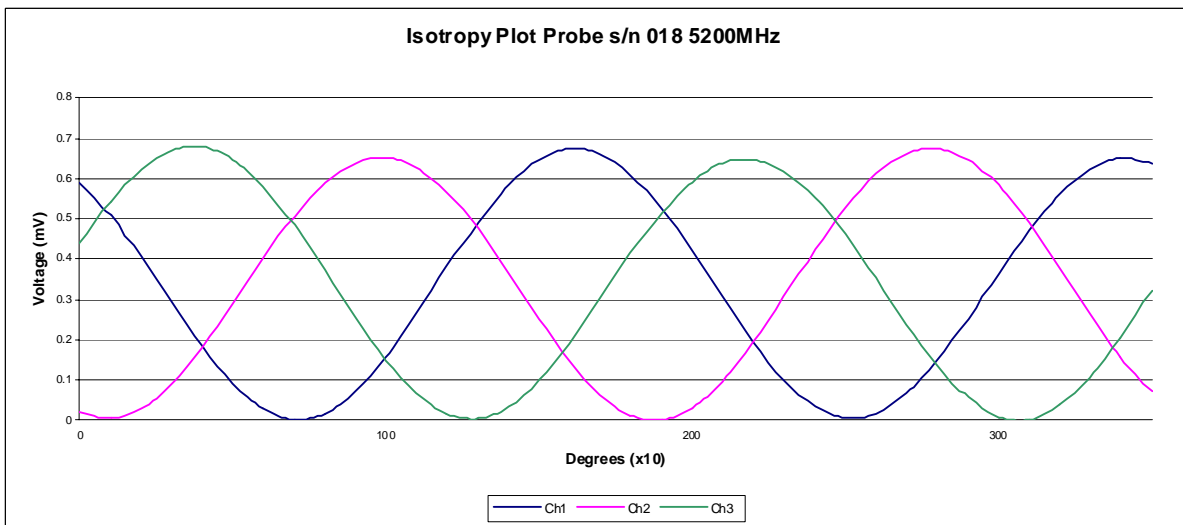
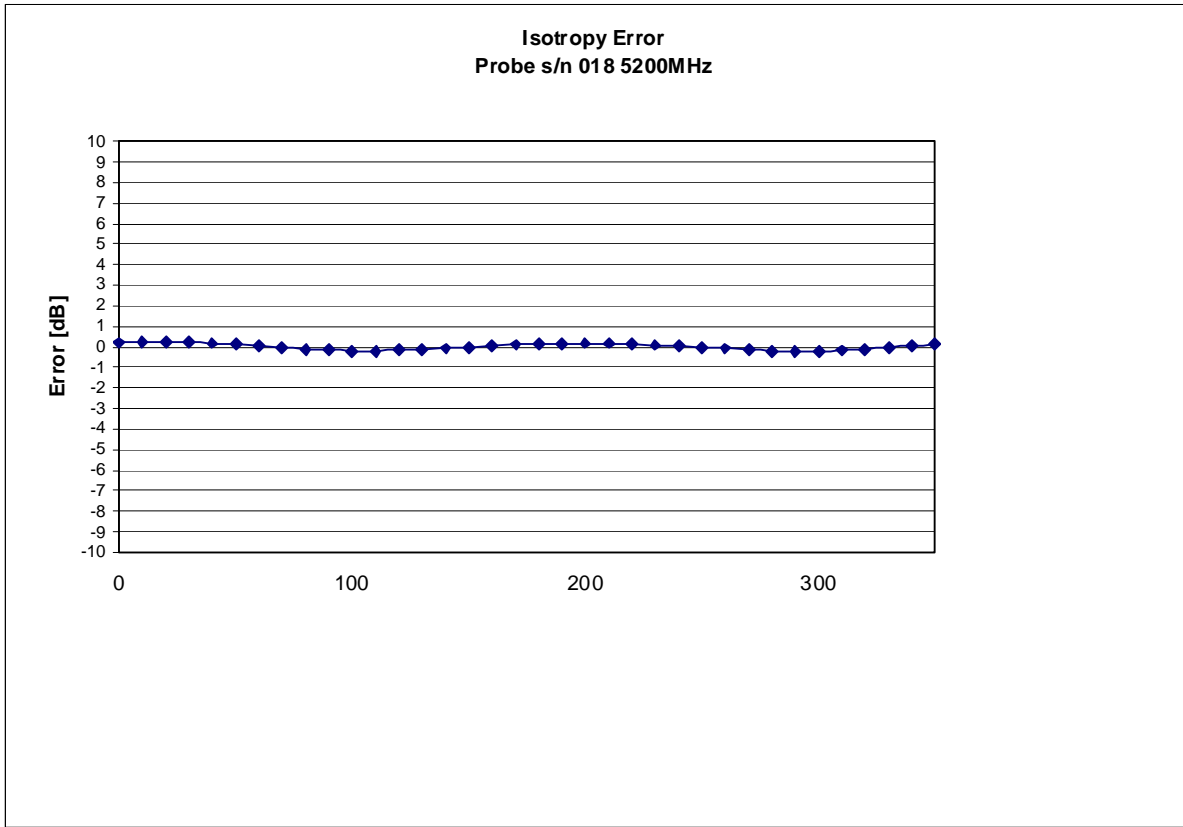
**Deviation at -40MHz:** -4.16%

**Deviation at +40MHz:** +2.78%

## Receiving Pattern 5200 MHz (Air)



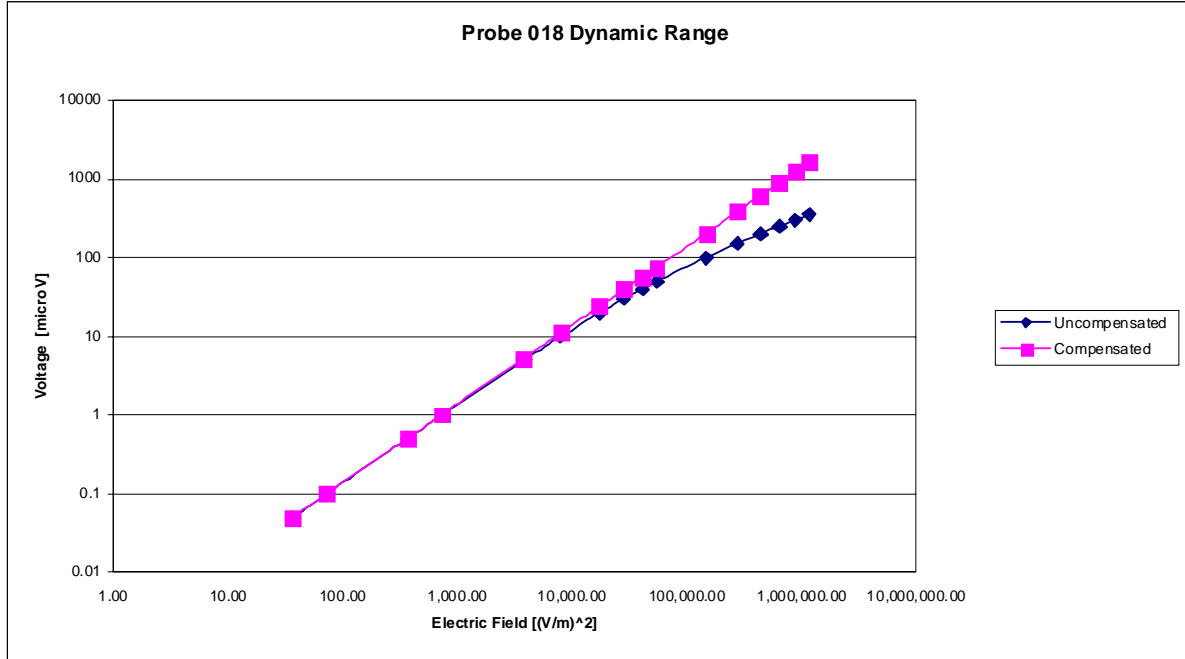
### Isotropy Error 5200 MHz (Air)



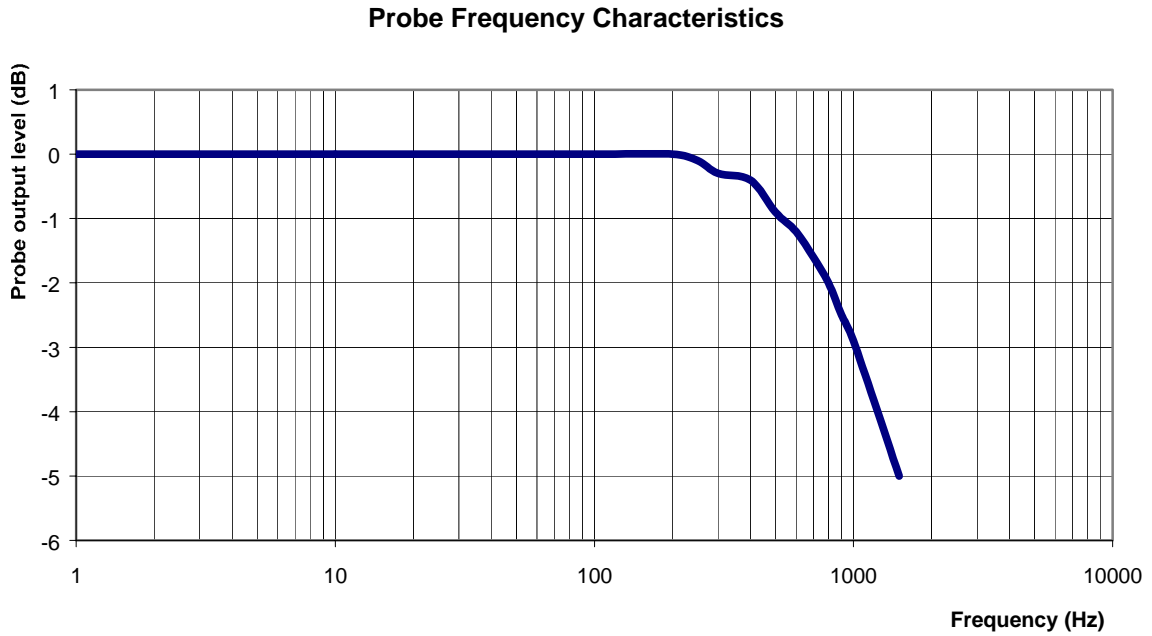
**Isotropicity in Tissue:**

**0.10 dB**

## Dynamic Range



## Video Bandwidth



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



## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5200MHz  
**Epsilon:** 43.0 (+/-10%)      **Sigma:** 5.75 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2      7%(K=2)

**Channel Y:** 3.2      7%(K=2)

**Channel Z:** 3.2      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 0.4mm 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-885

Client.: APREL

## 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.: E-030

Serial No.: 018

Calibration in Body Tissue

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

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008  
Released on: 3<sup>rd</sup> May 2008

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-030 018.

## References

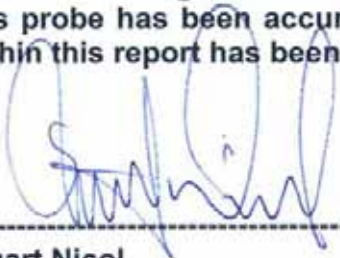
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

## Conditions

Probe 018 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.**



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**Stuart Nicol**



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**Jesse Hones**

## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	2450 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	<2.9 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:** 4.01

**Channel Y:** 4.01

**Channel Z:** 4.01

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq and corrected for broadband calibration factor.

### **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 1.44mm.

### **Spatial Resolution:**

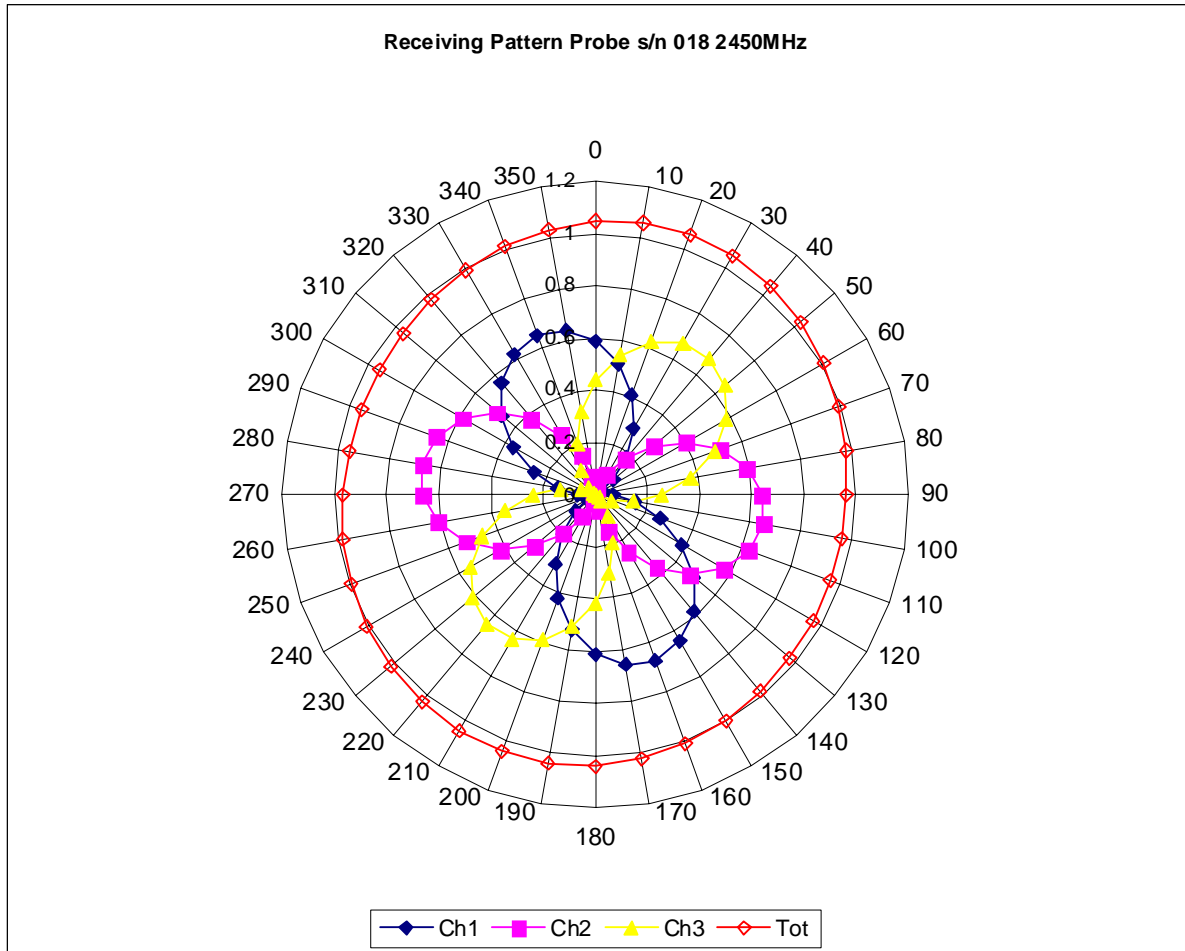
The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

### **Broad Band Calibration:**

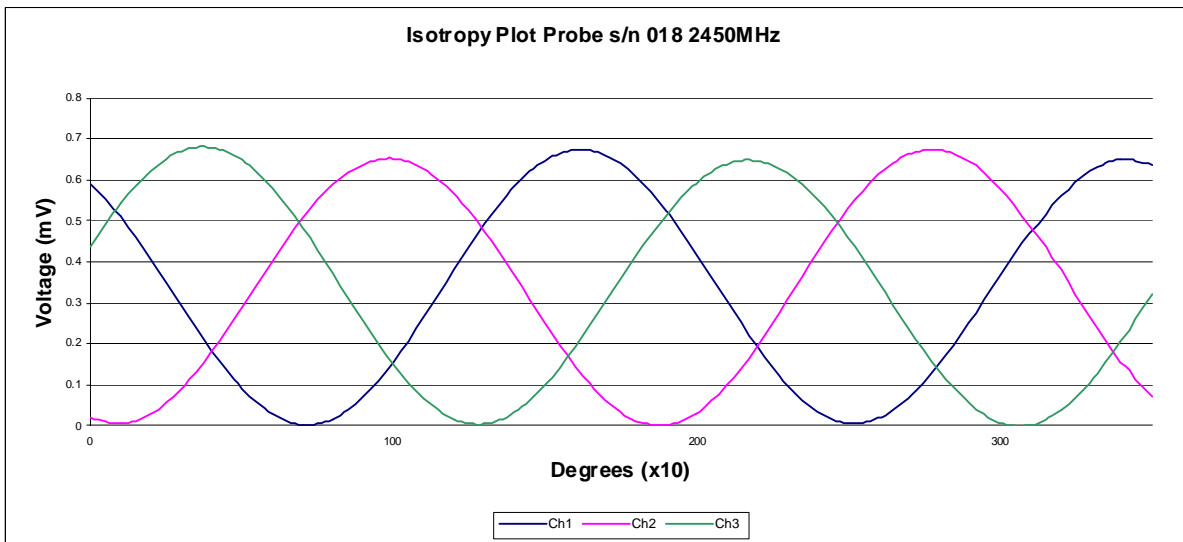
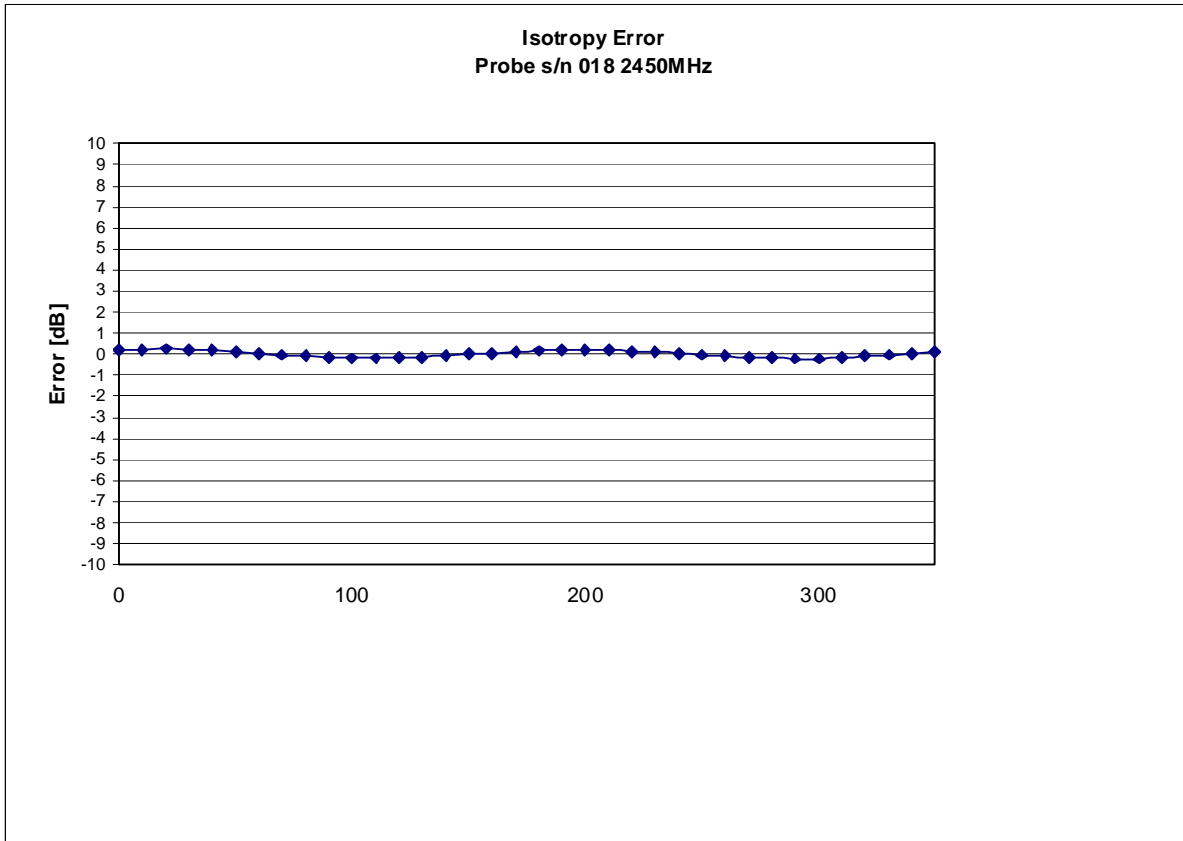
The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

**Deviation at -40MHz:** -1.56%  
**Deviation at +40MHz:** +1.3%

## Receiving Pattern 2450 MHz (Air)



### Isotropy Error 2450 MHz (Air)

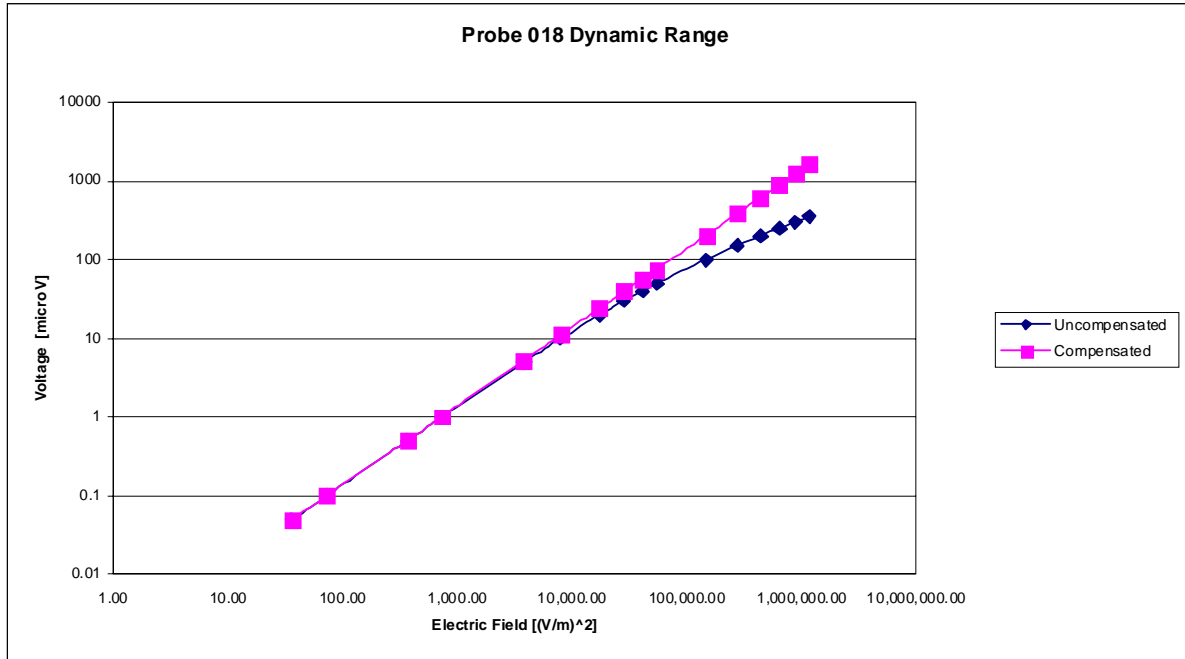


Isotropicity in Tissue:

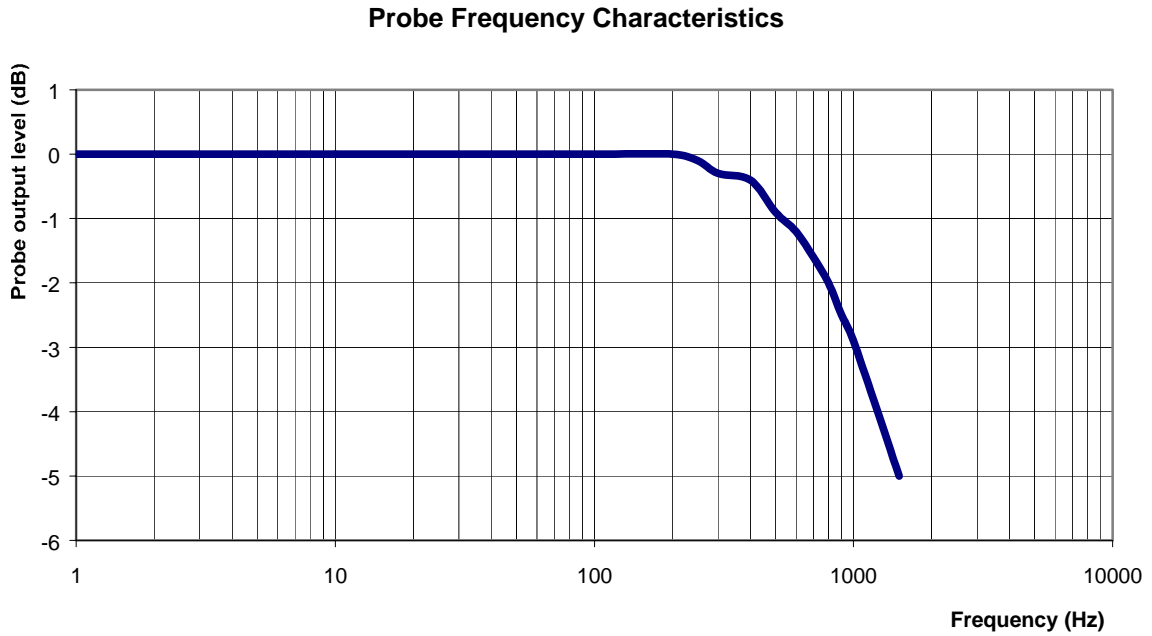
0.10 dB



## Dynamic Range



## Video Bandwidth



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

## **Conversion Factor Uncertainty Assessment**

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

### **ConvF**

**Channel X:** 4.01      7%(K=2)

**Channel Y:** 4.01      7%(K=2)

**Channel Z:** 4.01      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 0.4mm 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-888

Client.: APREL

## 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-030

Serial No.: 018

Calibration in Body Tissue

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

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008

Released on: 3<sup>rd</sup> May 2008

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

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

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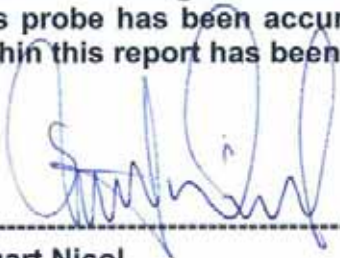
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## Calibration Results Summary

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5800 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	<2.9 mm
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## 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:** 48.2 (+/-10%)      **Sigma:** 6.0 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2

**Channel Y:** 3.2

**Channel Z:** 3.2

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq and corrected for broadband calibration factor.

### **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 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

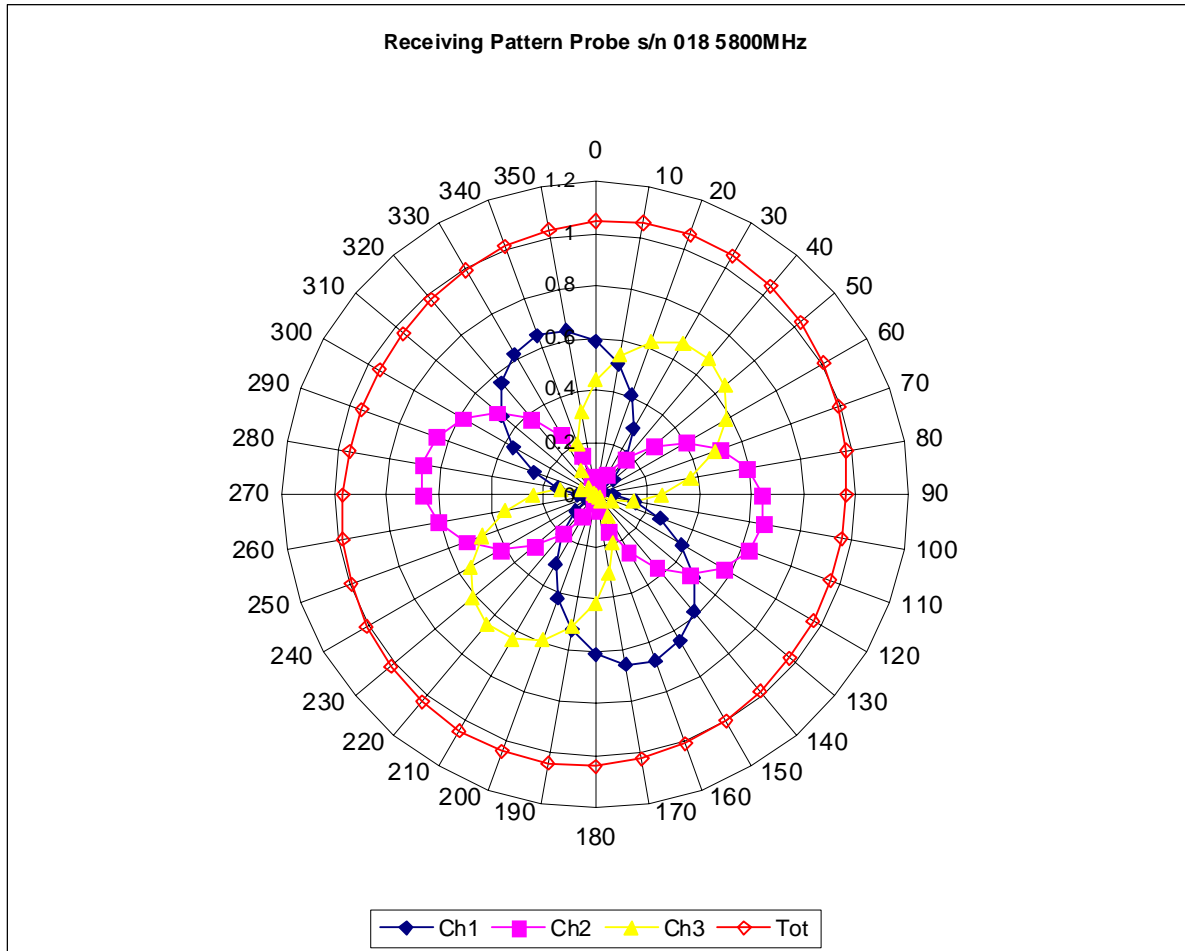
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The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

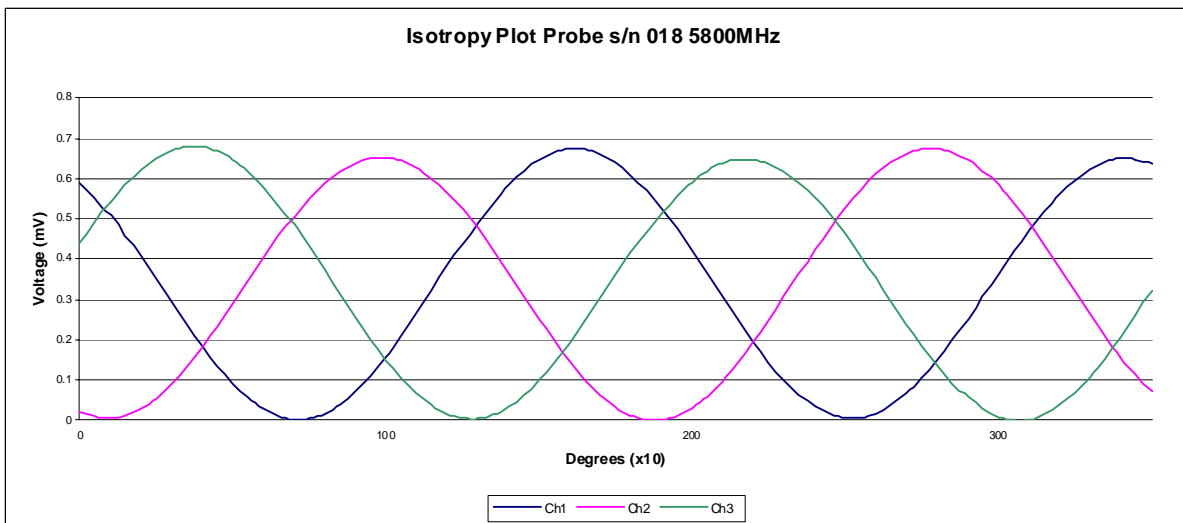
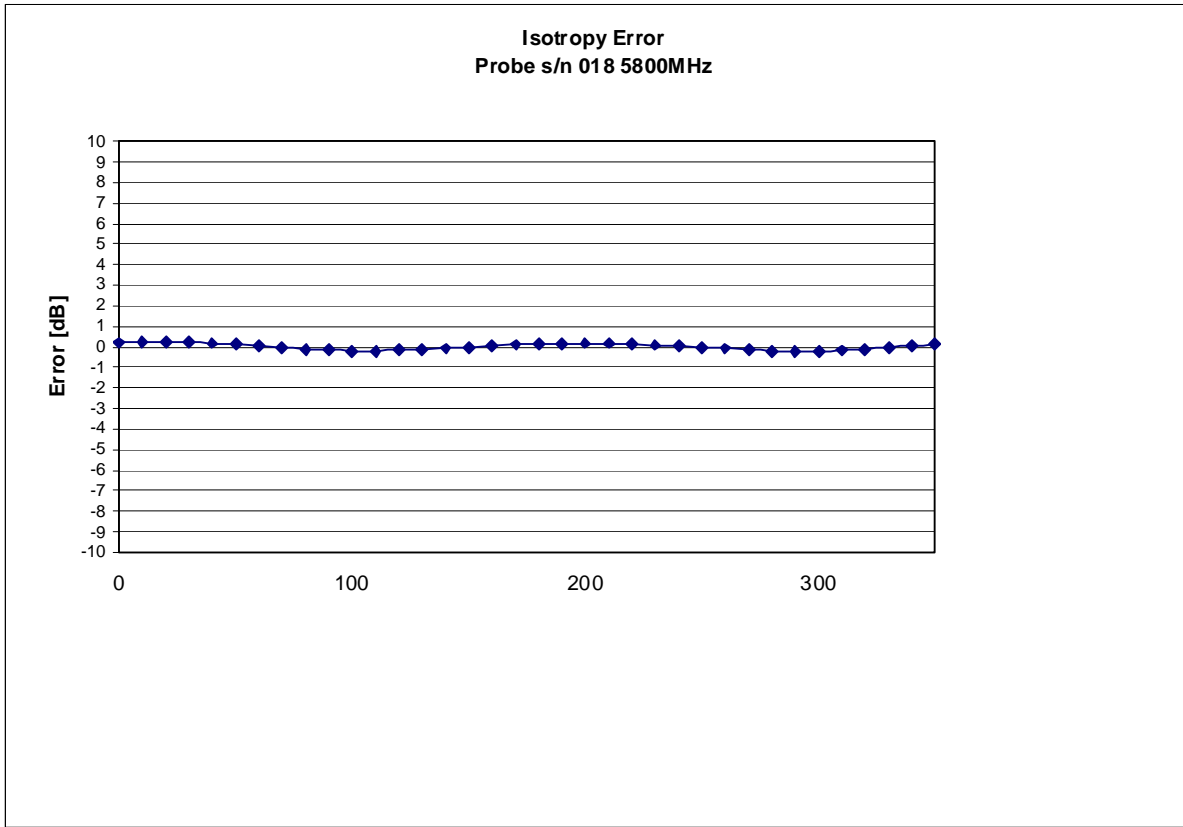
**Deviation at -40MHz:** -3.07%  
**Deviation at +40MHz:** +3.22%



## Receiving Pattern 5800 MHz (Air)



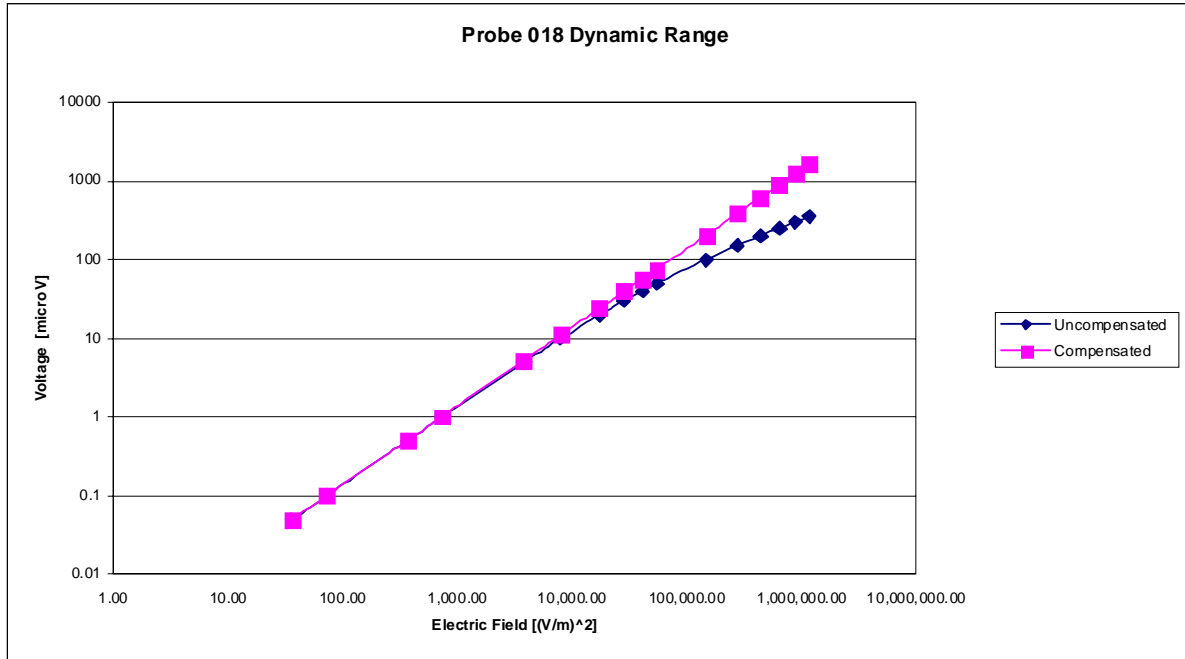
### Isotropy Error 5800 MHz (Air)



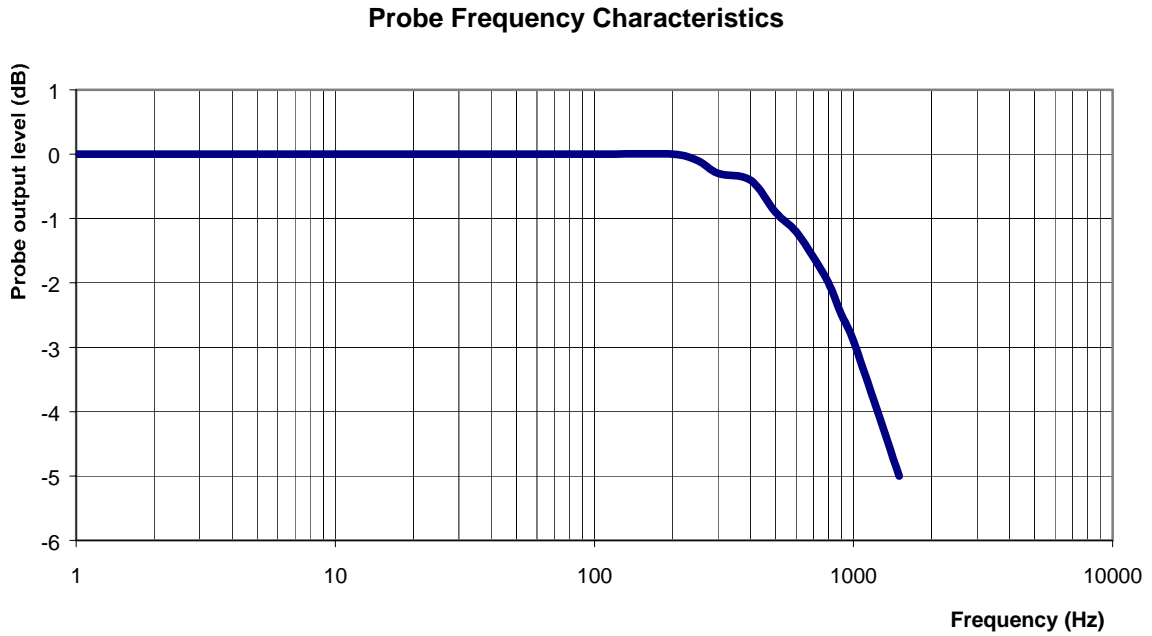
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



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

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5800MHz  
**Epsilon:** 48.2 (+/-10%)      **Sigma:** 6.0 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2      7%(K=2)

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