

## Appendix D – Probe Calibration Data Sheets

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1079

Client.: RFEL

## 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 835 MHz

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 217

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEL-E020-CAL-5477

Calibrated: 21<sup>st</sup> October 2009  
Released on: 28<sup>th</sup> October 2009

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary  
This calibration has been conducted in line with the SCC ISO-IEC 17025 Scope of Accreditation

Accredited Laboratory Number 48

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-020 217.

## References

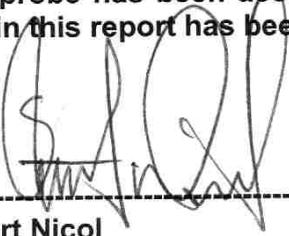
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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

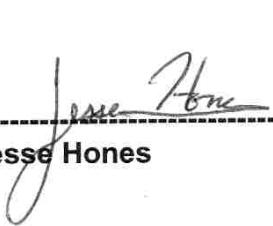
Probe 217 was a re-calibration.

**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.**



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**Stuart Nicol**



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**Jesse Hones**

## Calibration Results Summary

|                       |                     |
|-----------------------|---------------------|
| <b>Probe Type:</b>    | E-Field Probe E-020 |
| <b>Serial Number:</b> | 217                 |
| <b>Frequency:</b>     | 835 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 Measured****Frequency:** 835 MHz**Epsilon:** 54.9 (+/-5%) **Sigma:** 1.04 S/m (+/-5%)**ConvF****Channel X:** 6.1**Channel Y:** 6.1**Channel Z:** 6.1

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

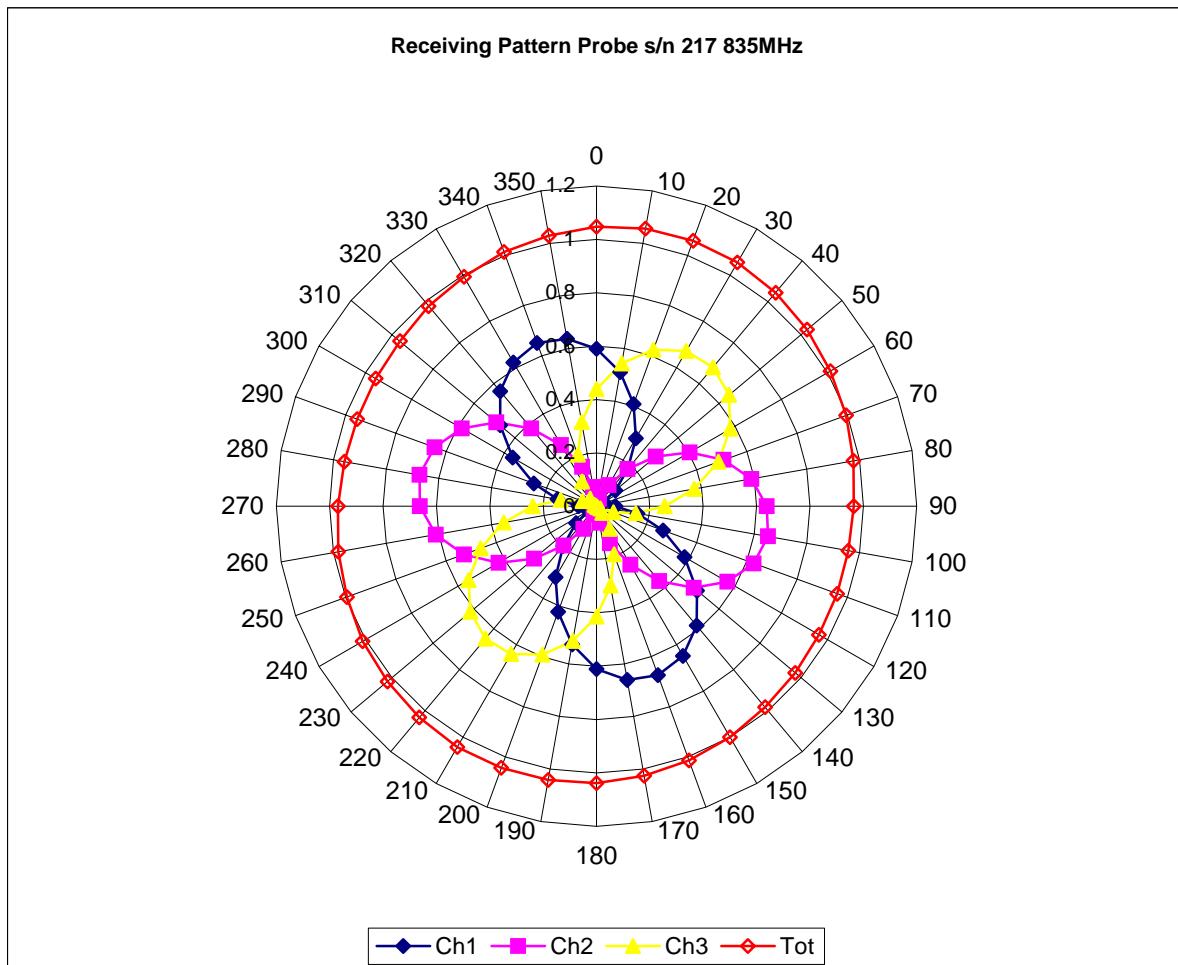
**Boundary Effect:**

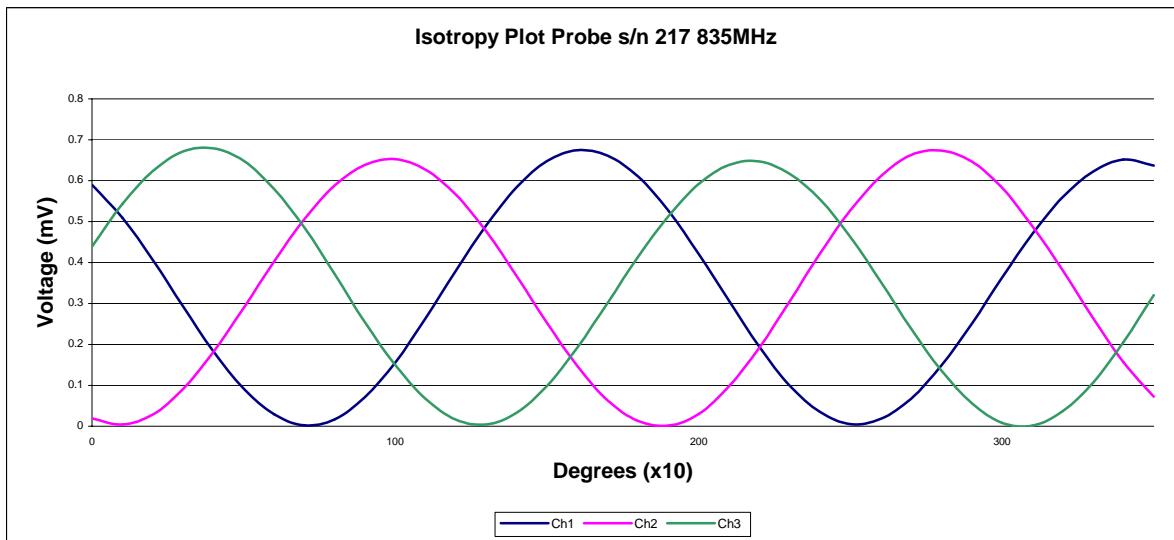
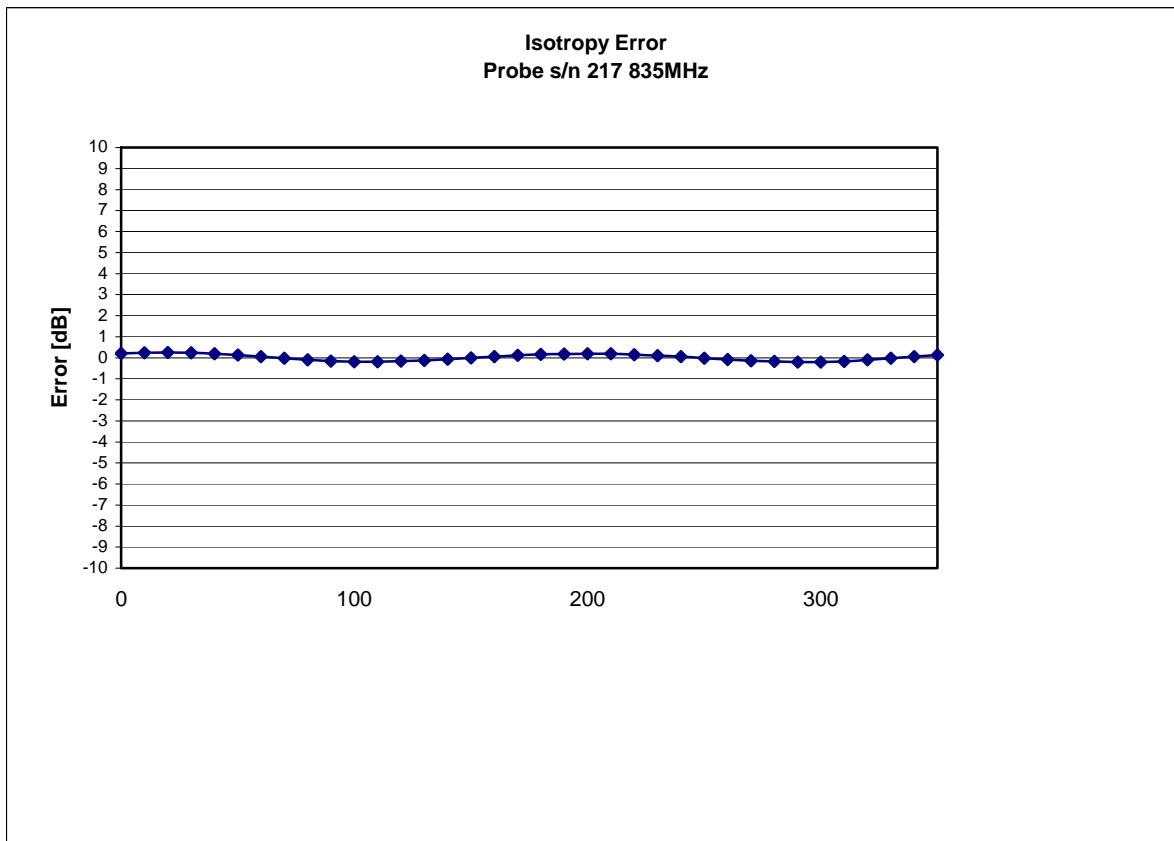
Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

**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.

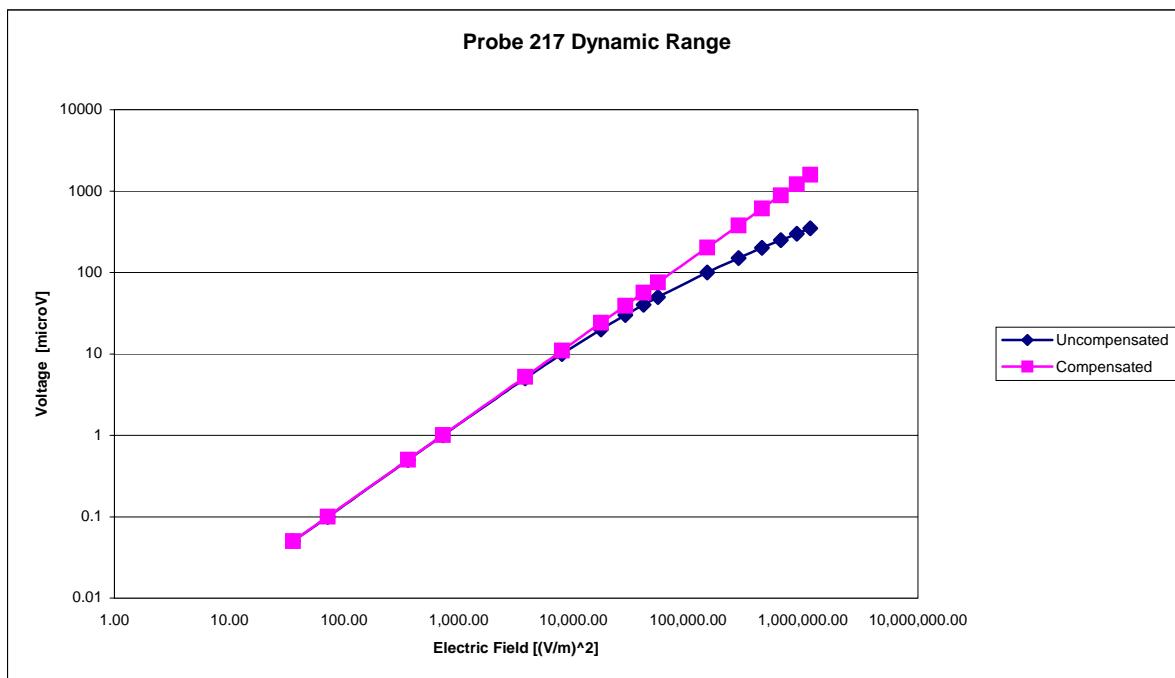
## Receiving Pattern 835 MHz (Air)



**Isotropy Error 835 MHz (Air)****Isotropicity Tissue:**

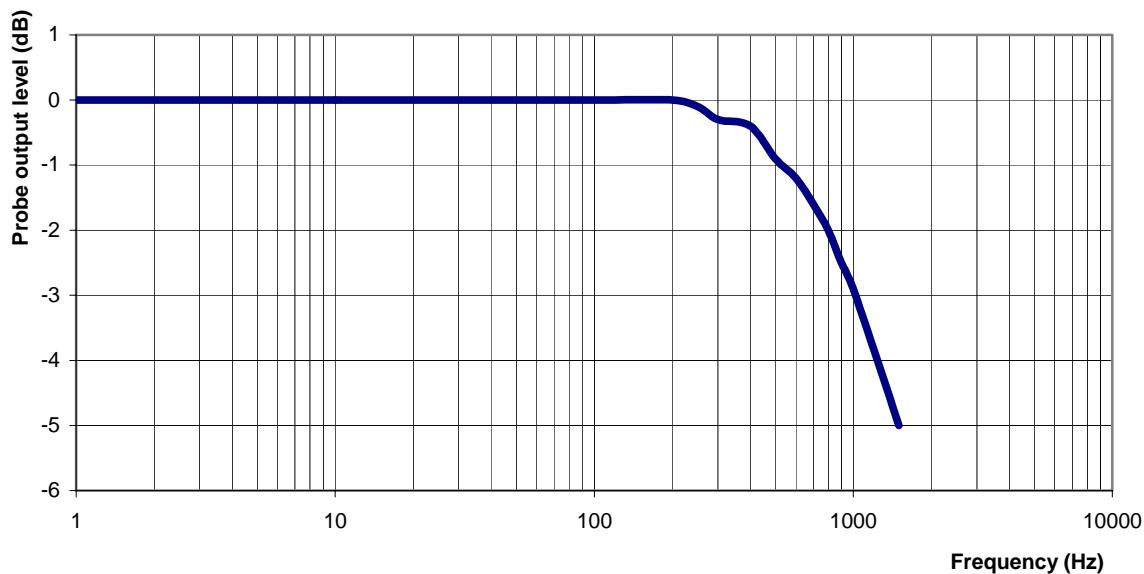
0.10 dB

## 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 Measured**

### **Sensitivity in Body Tissue**

**Frequency:** 835 MHz

**Epsilon:** 54.9 (+/-5%) **Sigma:** 1.04 S/m (+/-5%)

#### **ConvF**

**Channel X:** 6.1 7%(K=2)

**Channel Y:** 6.1 7%(K=2)

**Channel Z:** 6.1 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 2.5mm 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 2009.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1084

Client.: RFEL

## 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 1900 MHz

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 217

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEL-E020-CAL-5477

Calibrated: 21<sup>st</sup> October 2009  
Released on: 28<sup>th</sup> October 2009

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary  
This calibration has been conducted in line with the SCC ISO-IEC 17025 Scope of Accreditation

Accredited Laboratory Number 48

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

**NCL** CALIBRATION LABORATORIES

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FAX: (613) 820-4161

## **NCL Calibration Laboratories**

---

Division of APREL Laboratories.

### **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-020 217.

### **References**

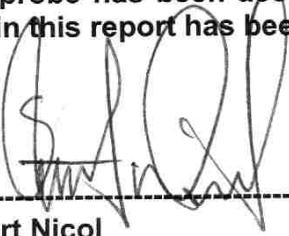
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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 217 was a re-calibration.

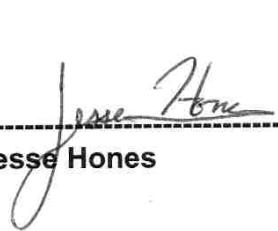
**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**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.**



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Stuart Nicol



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Jesse Hones

## Calibration Results Summary

|                       |                     |
|-----------------------|---------------------|
| <b>Probe Type:</b>    | E-Field Probe E-020 |
| <b>Serial Number:</b> | 217                 |
| <b>Frequency:</b>     | 1900 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 Measured****Frequency:** 1900 MHz**Epsilon:** 54.6 (+/-5%) **Sigma:** 1.55 S/m (+/-5%)**ConvF****Channel X:** 4.85**Channel Y:** 4.85**Channel Z:** 4.85

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

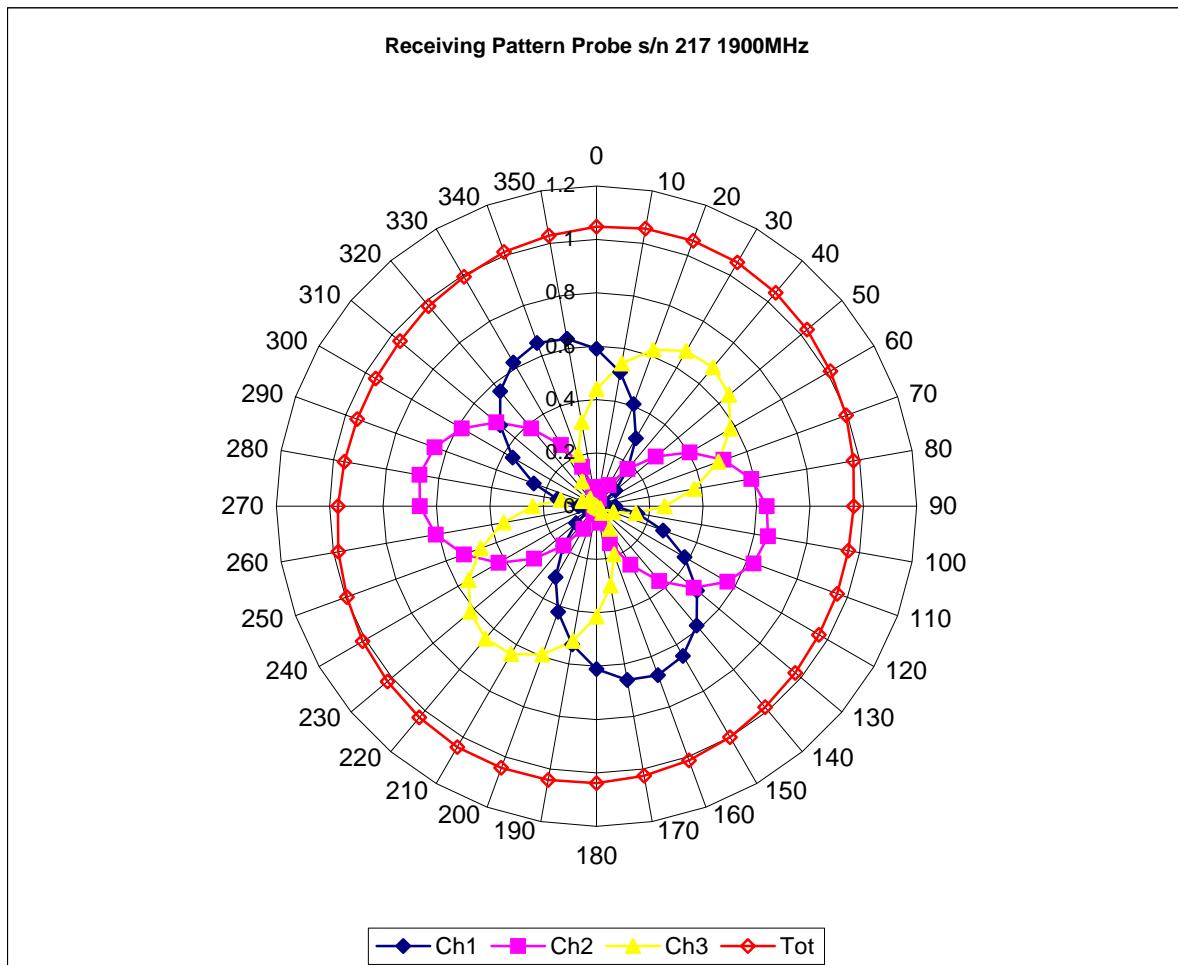
**Boundary Effect:**

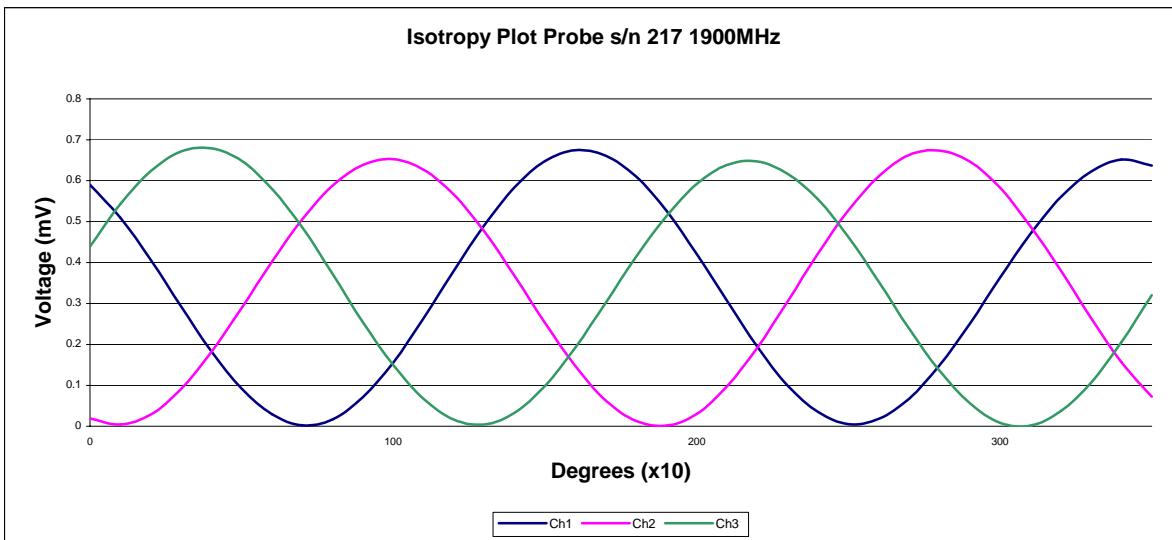
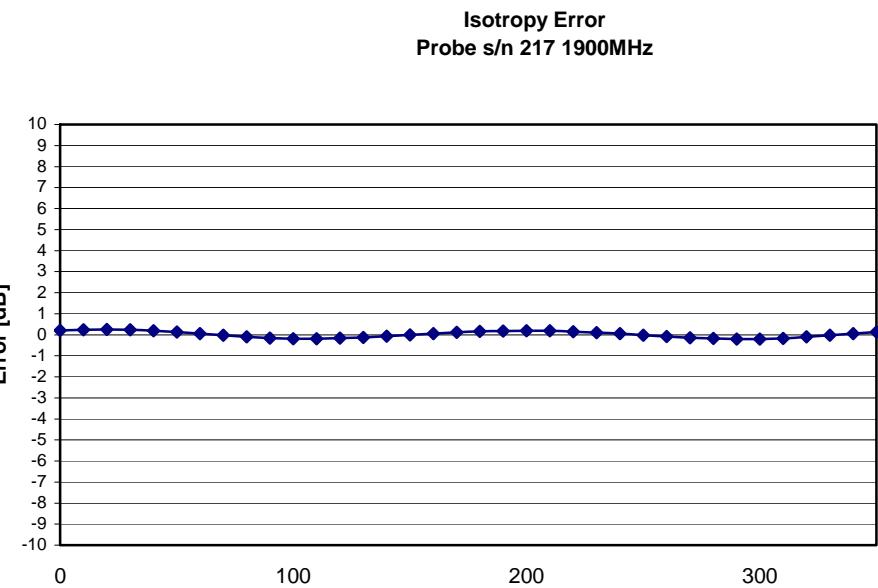
Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

**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.

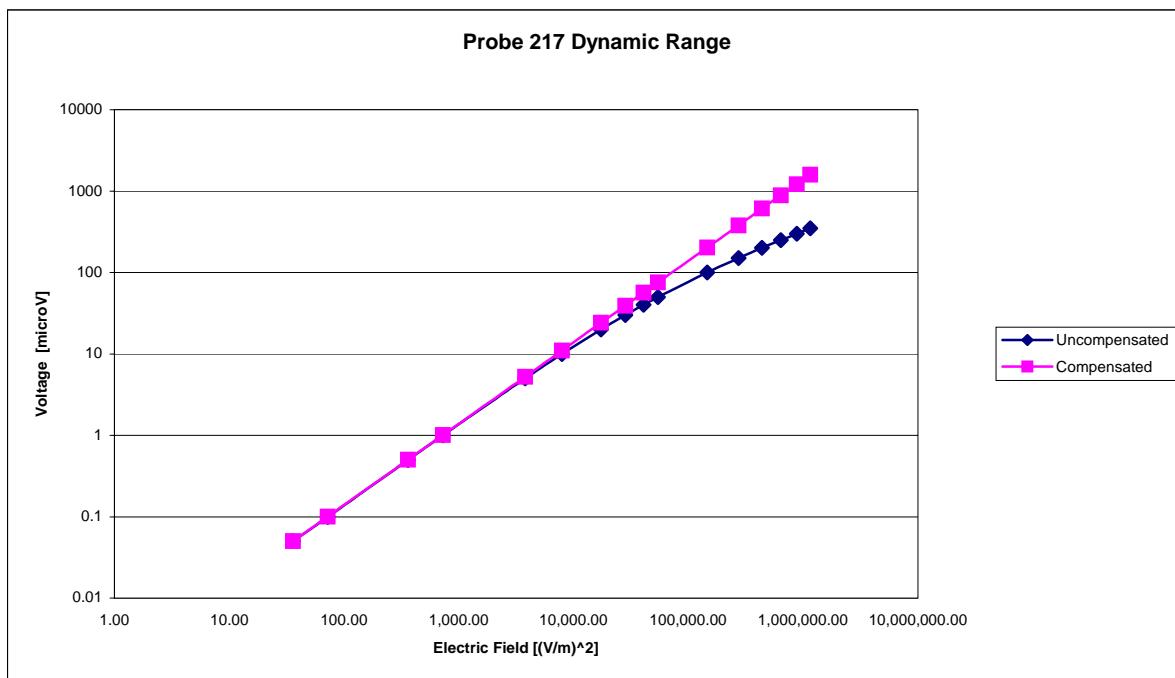
## Receiving Pattern 1900 MHz (Air)



**Isotropy Error 1900 MHz (Air)****Isotropicity Tissue:**

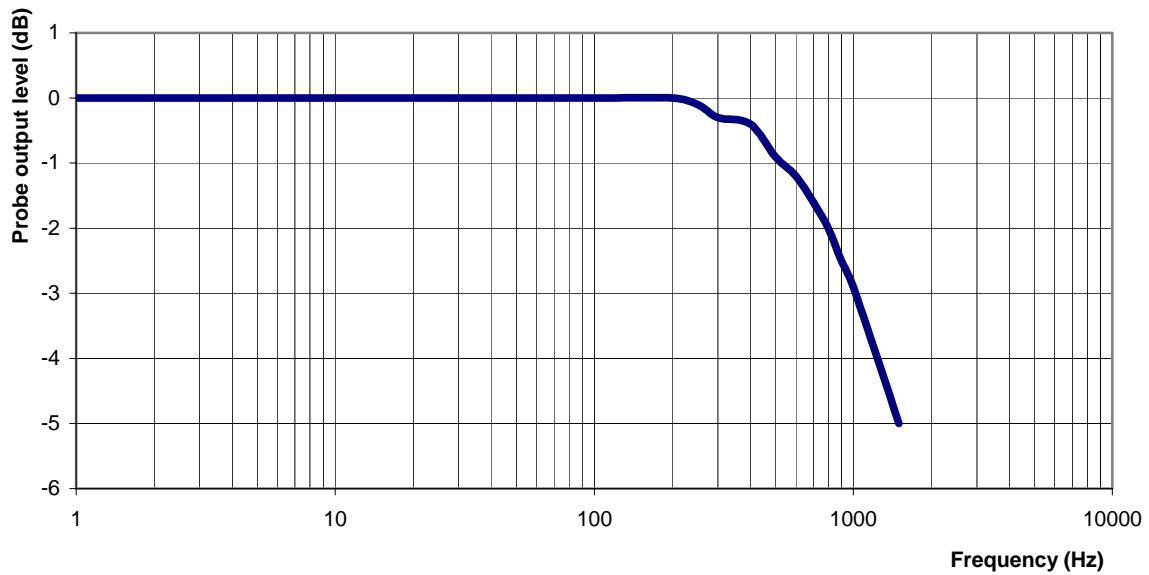
0.10 dB

## 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 Measured**

### **Sensitivity in Body Tissue**

**Frequency:** 1900 MHz

**Epsilon:** 54.6 (+/-5%) **Sigma:** 1.55 S/m (+/-5%)

#### **ConvF**

**Channel X:** 4.85 7%(K=2)

**Channel Y:** 4.85 7%(K=2)

**Channel Z:** 4.85 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 2.5mm 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 2009.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1086

Client.: RFEL

## 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

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 217

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEL-E020-CAL-5477

Calibrated: 21<sup>st</sup> October 2009  
Released on: 28<sup>th</sup> October 2009

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary  
This calibration has been conducted in line with the SCC ISO-IEC 17025 Scope of Accreditation

Accredited Laboratory Number 48

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

**NCL** CALIBRATION LABORATORIES

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

## **NCL Calibration Laboratories**

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Division of APREL Laboratories.

### **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-020 217.

### **References**

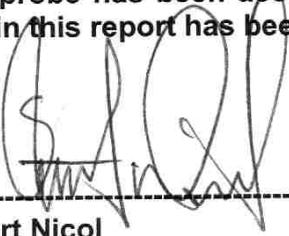
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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 217 was a re-calibration.

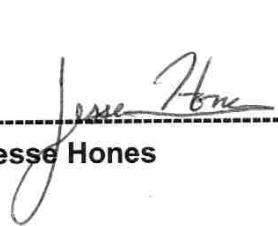
**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**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.**



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Stuart Nicol



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Jesse Hones

## Calibration Results Summary

|                       |                     |
|-----------------------|---------------------|
| <b>Probe Type:</b>    | E-Field Probe E-020 |
| <b>Serial Number:</b> | 217                 |
| <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 Measured****Frequency:** 2450 MHz**Epsilon:** 53.4 (+/-5%) **Sigma:** 1.95 S/m (+/-5%)**ConvF****Channel X:** 3.61**Channel Y:** 3.61**Channel Z:** 3.61

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

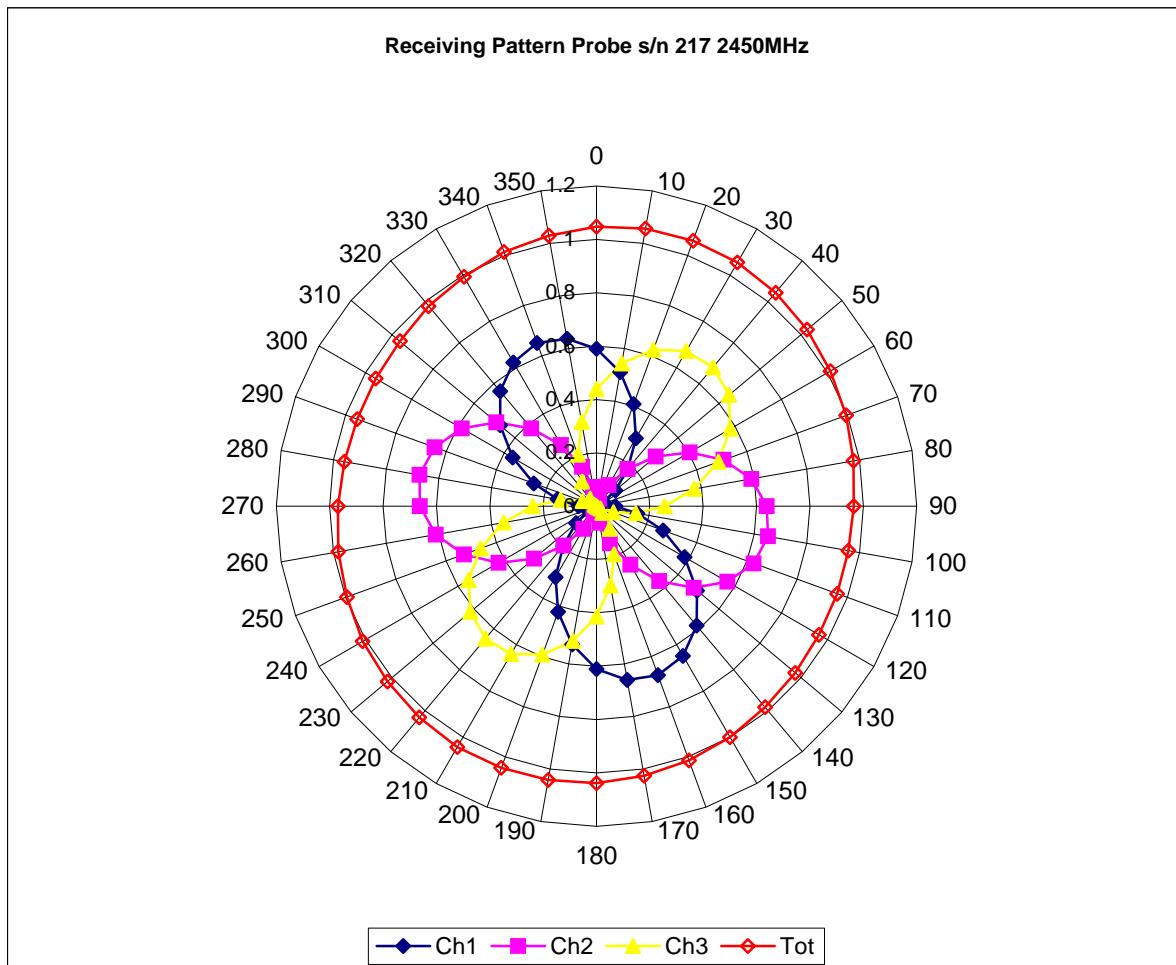
**Boundary Effect:**

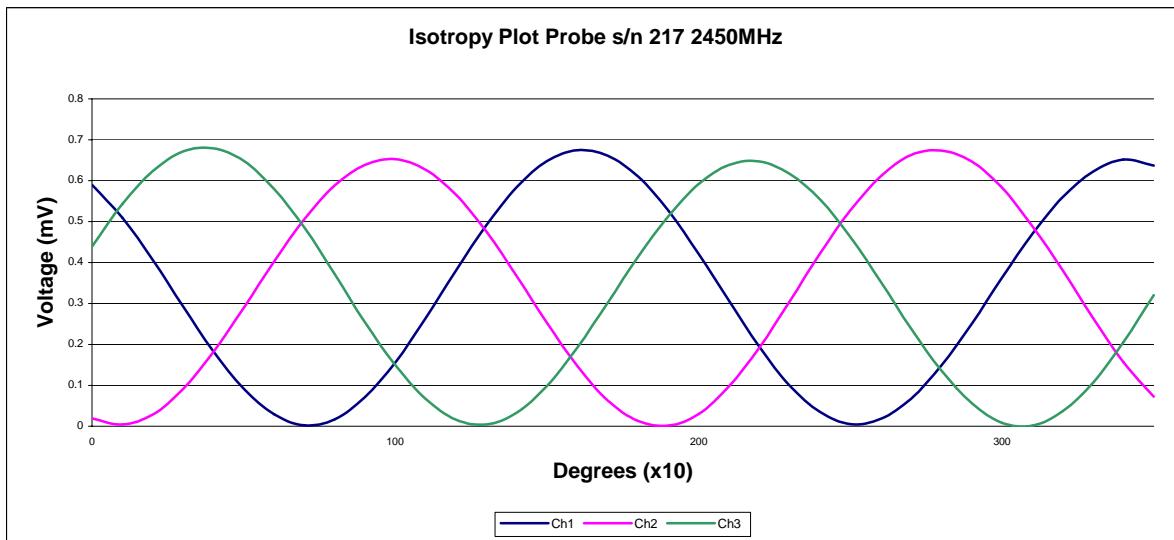
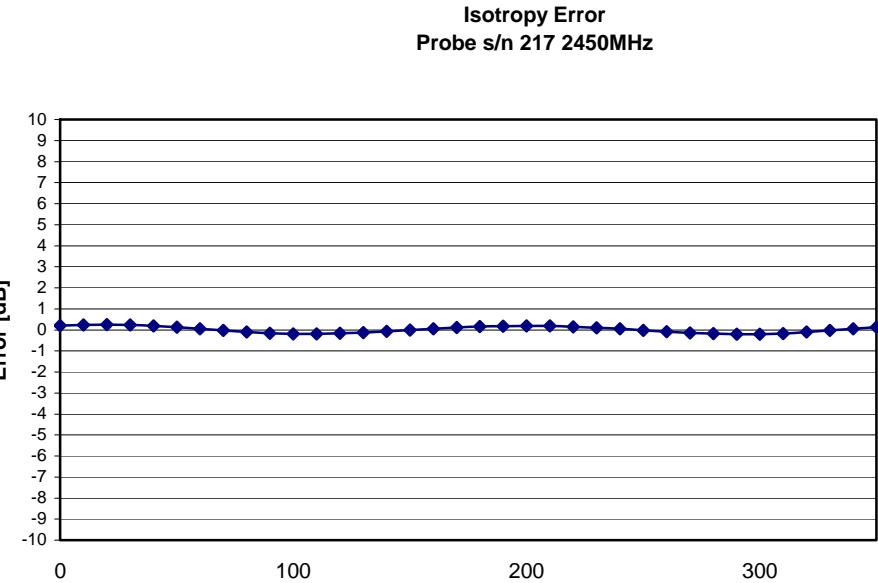
Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

**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.

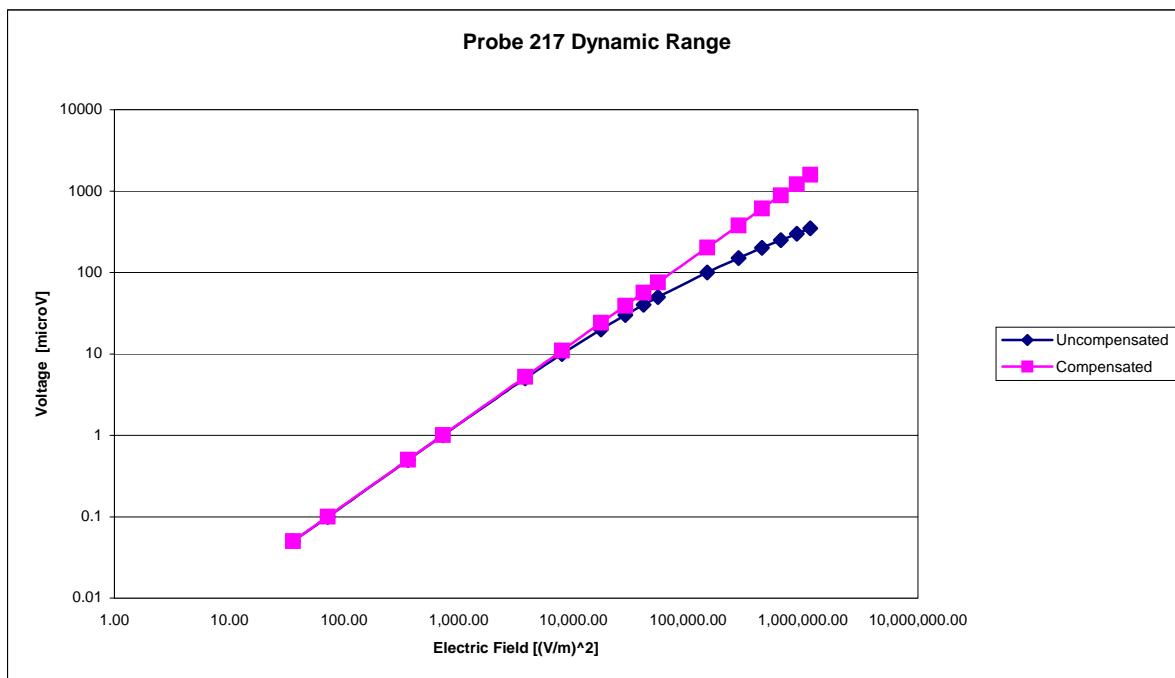
## Receiving Pattern 2450 MHz (Air)



**Isotropy Error 2450 MHz (Air)****Isotropicity Tissue:**

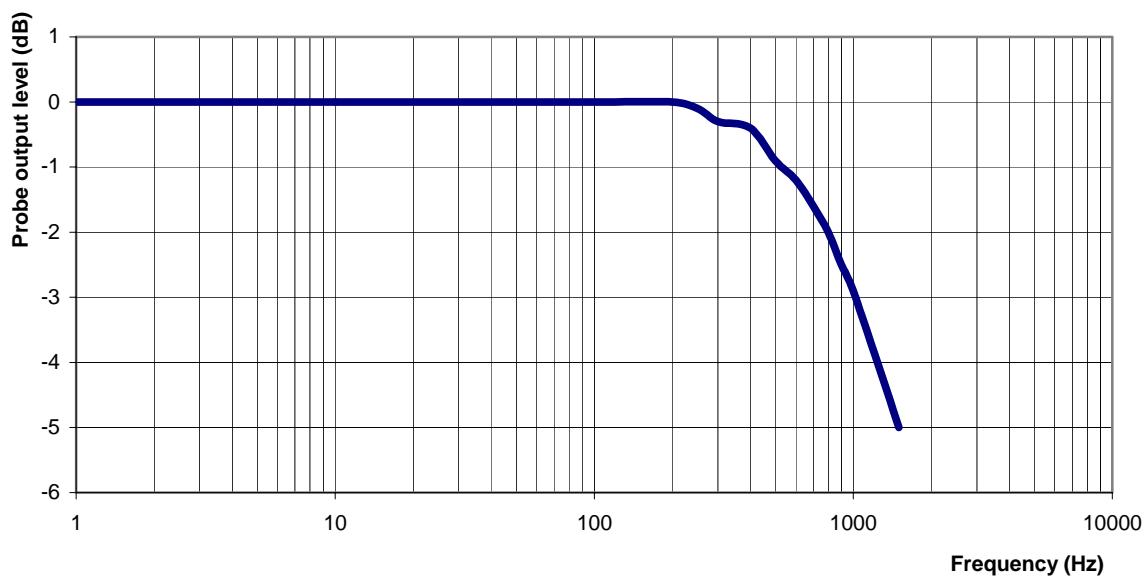
0.10 dB

## 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**

### **Sensitivity in Body Tissue**

**Frequency:** 2450 MHz

**Epsilon:** 53.4 (+/-5%) **Sigma:** 1.95 S/m (+/-5%)

#### **ConvF**

**Channel X:** 3.61 7%(K=2)

**Channel Y:** 3.61 7%(K=2)

**Channel Z:** 3.61 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 2.5mm 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 2009.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1004

Client.: RFEL

## 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 5200 MHz

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: E030-001

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEB-ALSE030-cal-5453

Calibrated: 9<sup>th</sup> July 2009  
Released on: 16<sup>th</sup> July 2009

APREL Laboratories Certified Under Laboratory 48 of SCC

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

## **NCL Calibration Laboratories**

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Division of APREL Laboratories.

### **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 E030-001.

### **References**

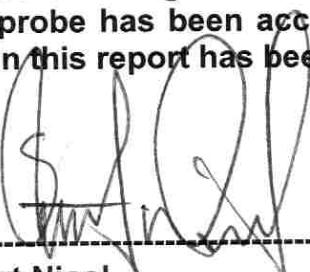
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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 E030-001 is a re-calibration.

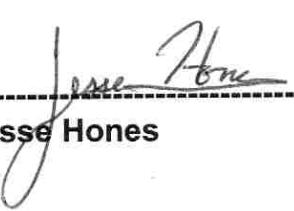
**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**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.**



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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> | E030-001            |
| <b>Frequency:</b>     | 5200 MHz            |
| <b>Sensor Offset:</b> | 1.06 mm             |
| <b>Sensor Length:</b> | 2.5 mm              |
| <b>Tip Enclosure:</b> | Composite*          |
| <b>Tip Diameter:</b>  | <2.5 mm             |
| <b>Tip Length:</b>    | 55 mm               |
| <b>Total Length:</b>  | 289 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:** 5200 MHz

**Epsilon:** 47.96      **Sigma:** 5.15 S/m

### **ConvF:**

**Channel X:** 4.4

**Channel Y:** 4.4

**Channel Z:** 4.4

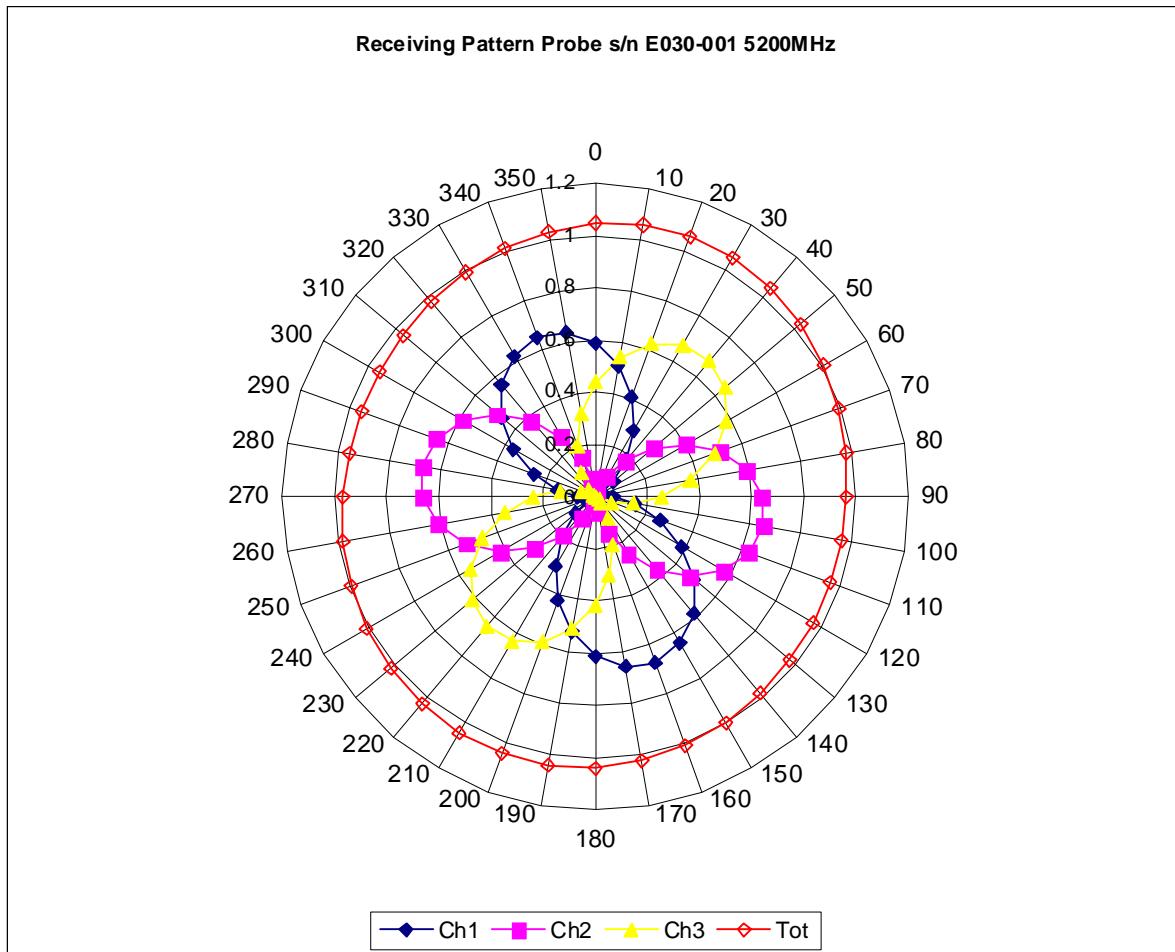
### **Boundary Effect:**

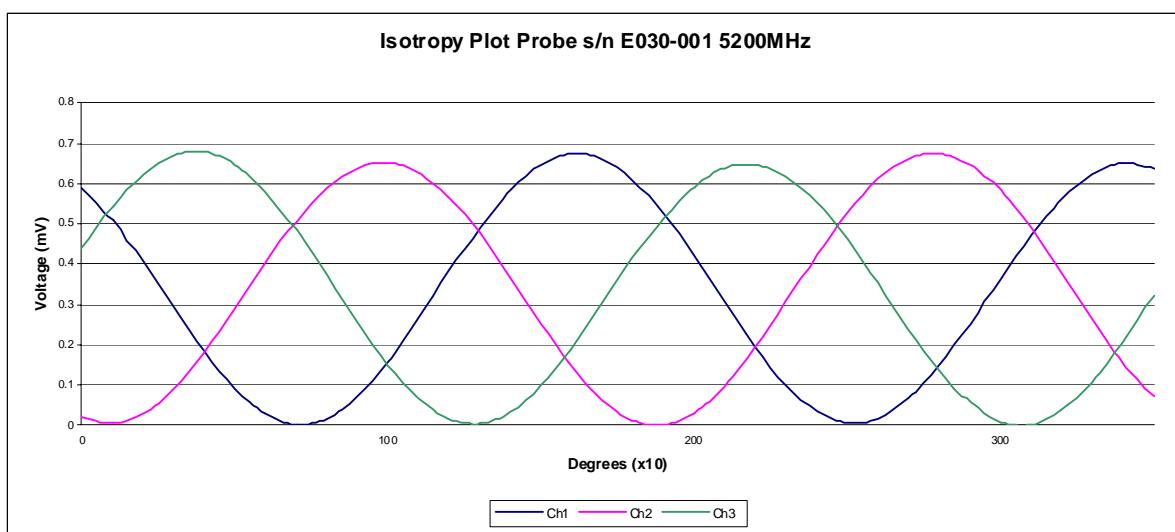
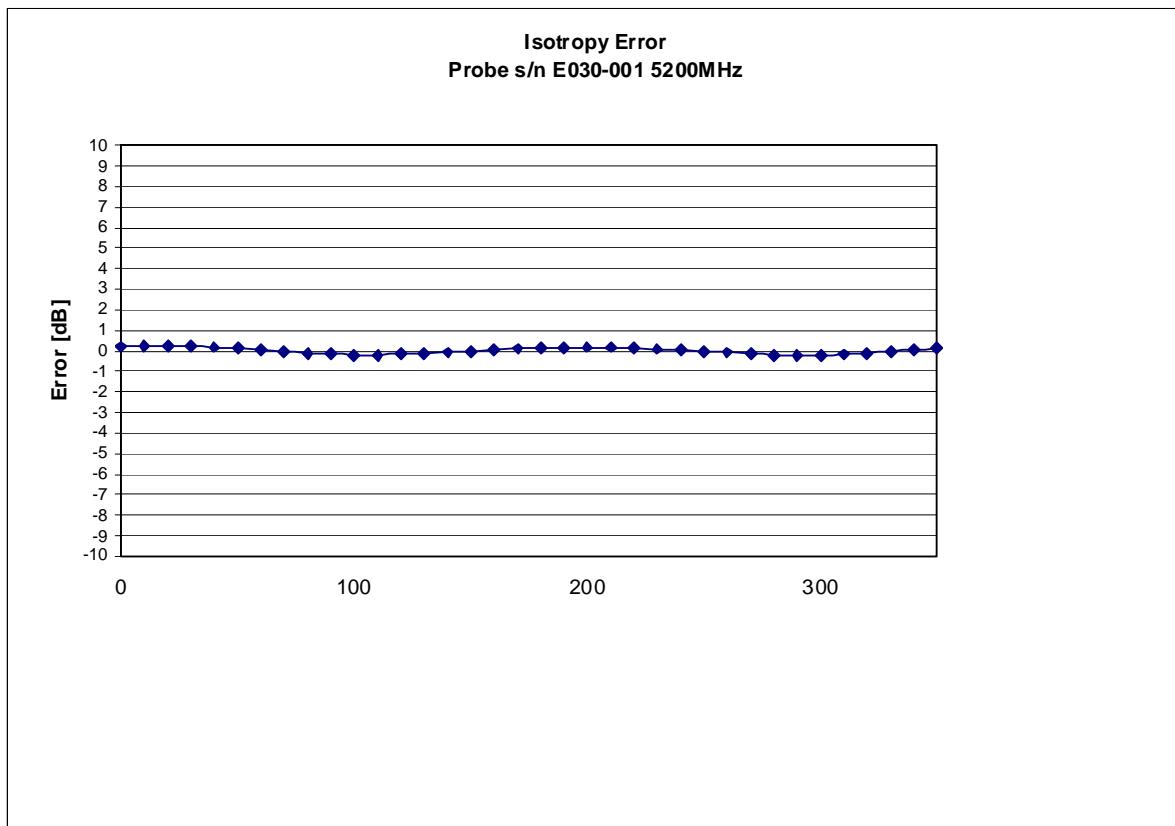
Uncertainty resulting from the boundary effect is less than 2.1% for the distance between the tip of the probe and the tissue boundary, when less than 0.58mm.

### **Spatial Resolution:**

The measured probe tip diameter is 2.5mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

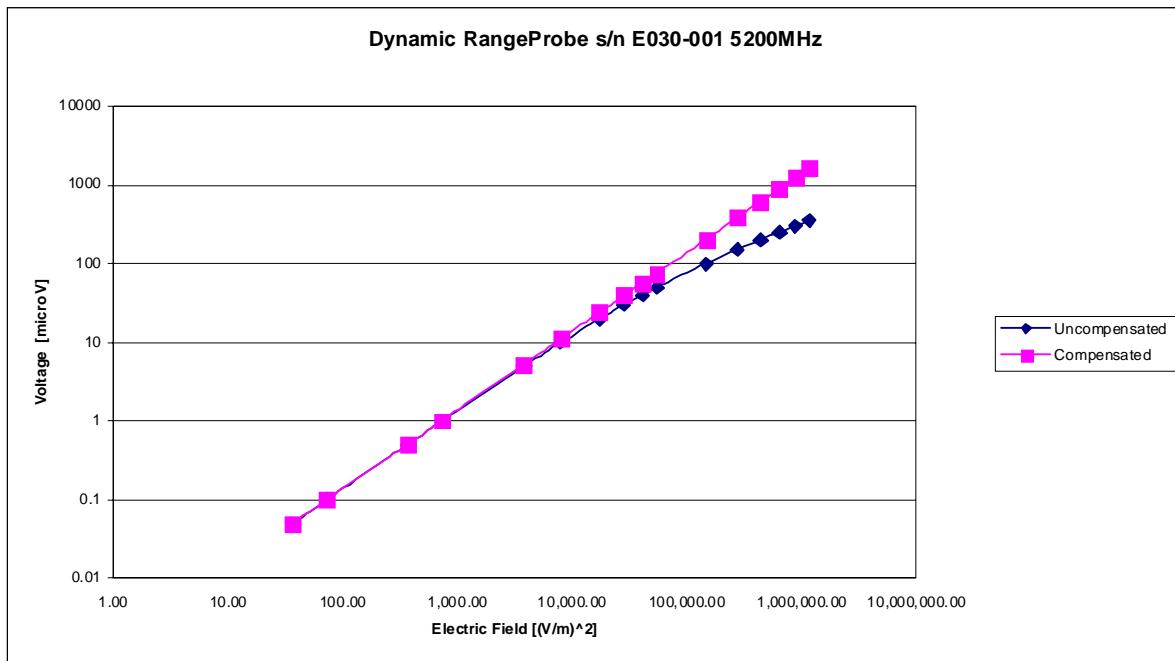
## Receiving Pattern 5200 MHz (Air)



**Isotropy Error 5200 MHz (Air)****Isotropicity Tissue:**

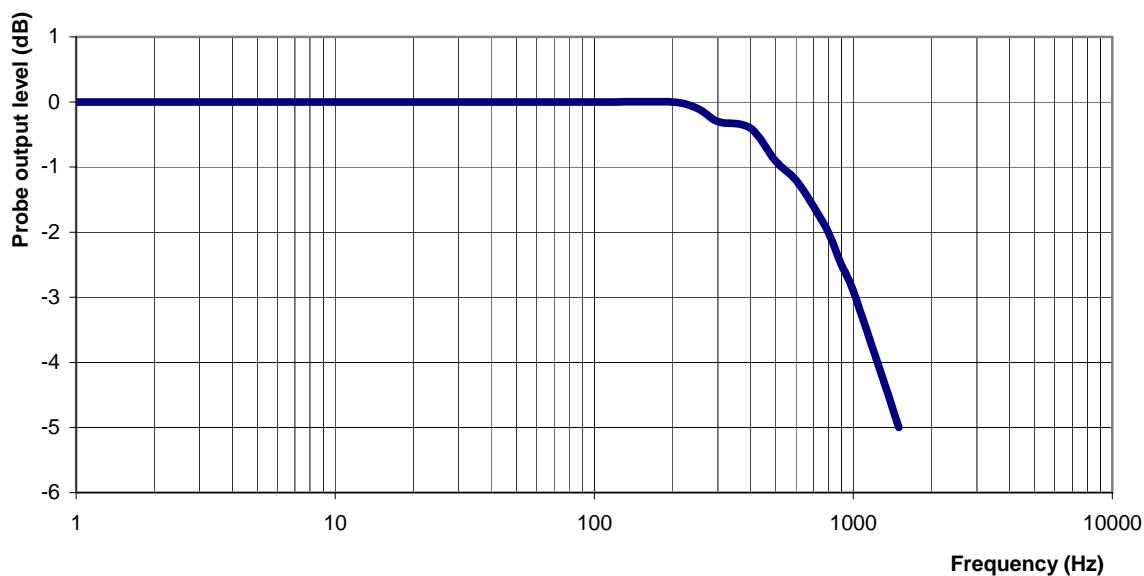
0.10 dB

## 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**

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

**Frequency:** 5200 MHz

**Epsilon:** 47.96      **Sigma:** 5.15 S/m

#### **ConvF**

**Channel X:** 4.4      7%(K=2)

**Channel Y:** 4.4      7%(K=2)

**Channel Z:** 4.4      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 0.58mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

## **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 2009.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1006

Client.: RFEL

## 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 5600 MHz

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: E030-001

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEB-ALSE030-cal-5453

Calibrated: 14<sup>th</sup> July 2009  
Released on: 16<sup>th</sup> July 2009

APREL Laboratories Certified Under Laboratory 48 of SCC

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

## **NCL Calibration Laboratories**

---

Division of APREL Laboratories.

### **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 E030-001.

### **References**

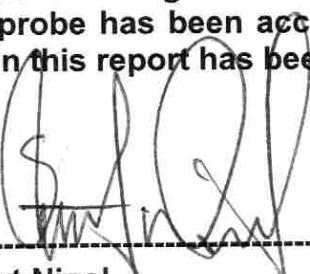
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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 E030-001 was a new probe.

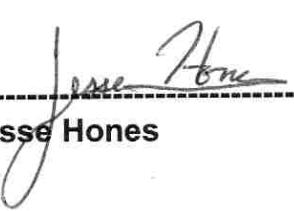
**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**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> | E030-001            |
| <b>Frequency:</b>     | 5600 MHz            |
| <b>Sensor Offset:</b> | 1.06 mm             |
| <b>Sensor Length:</b> | 2.5 mm              |
| <b>Tip Enclosure:</b> | Composite*          |
| <b>Tip Diameter:</b>  | <2.5 mm             |
| <b>Tip Length:</b>    | 55 mm               |
| <b>Total Length:</b>  | 289 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:** 46.76      **Sigma:** 5.84 S/m

### **ConvF:**

**Channel X:** 4.0

**Channel Y:** 4.0

**Channel Z:** 4.0

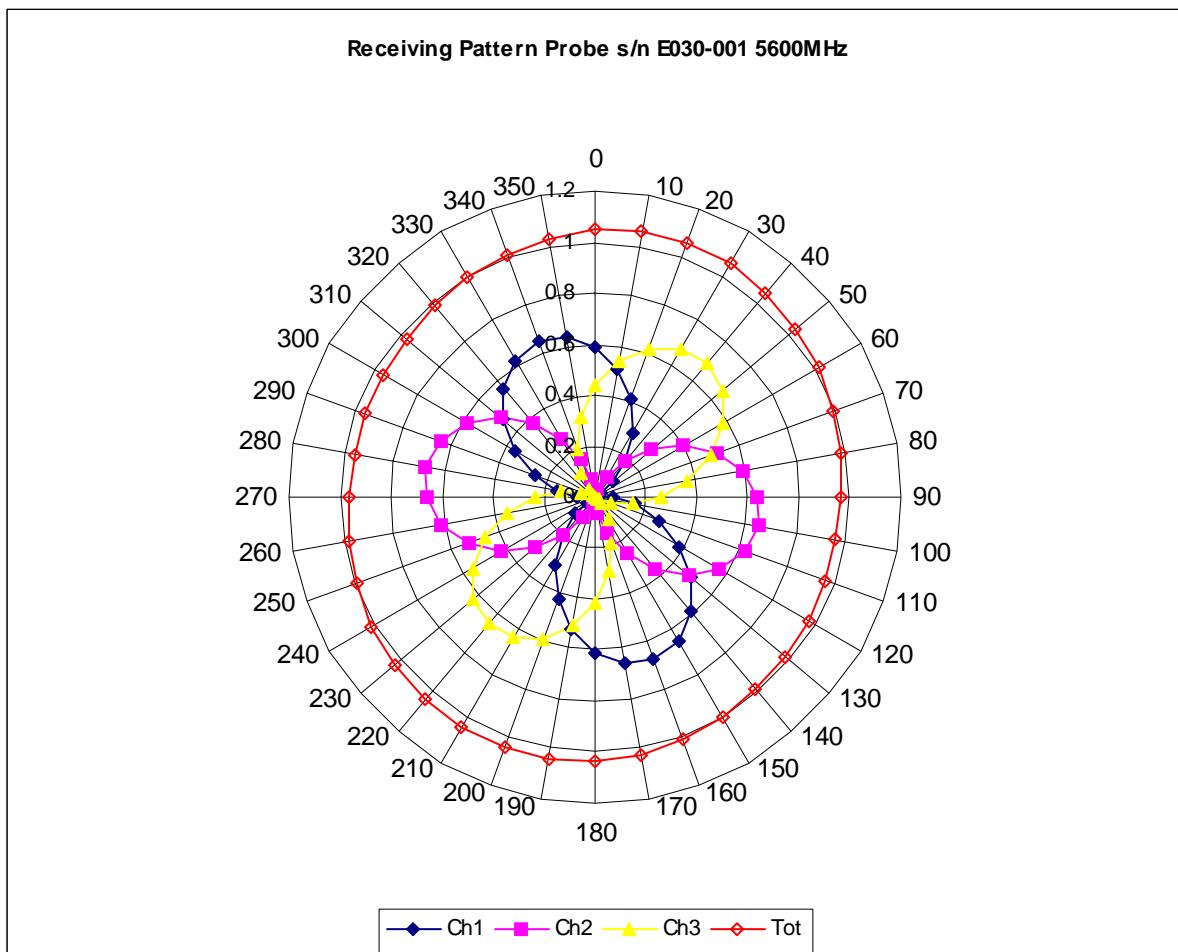
### **Boundary Effect:**

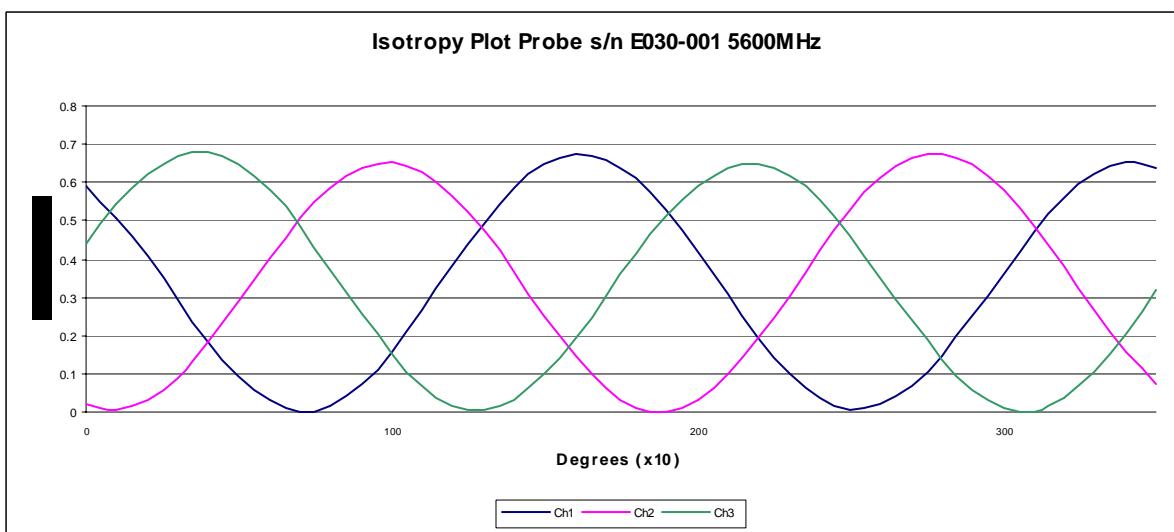
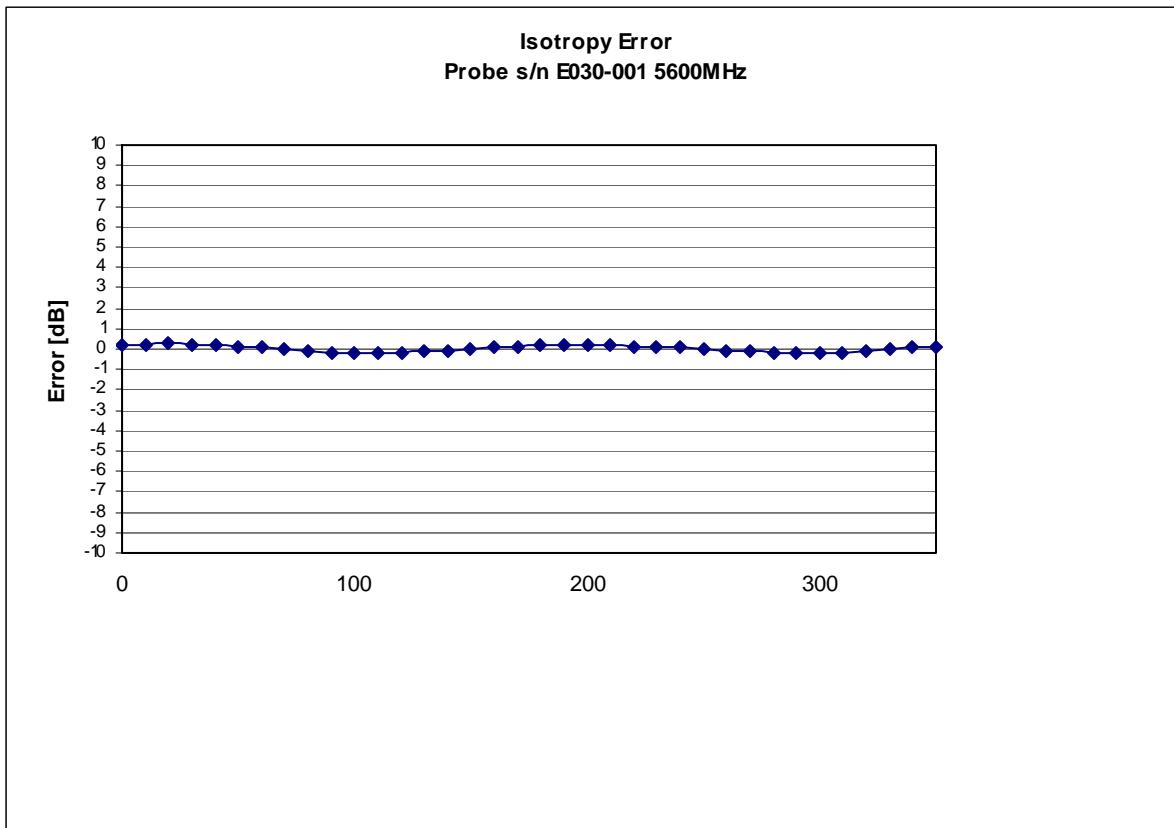
Uncertainty resulting from the boundary effect is less than 2.1% for the distance between the tip of the probe and the tissue boundary, when less than 0.58mm.

### **Spatial Resolution:**

The measured probe tip diameter is 2.5mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

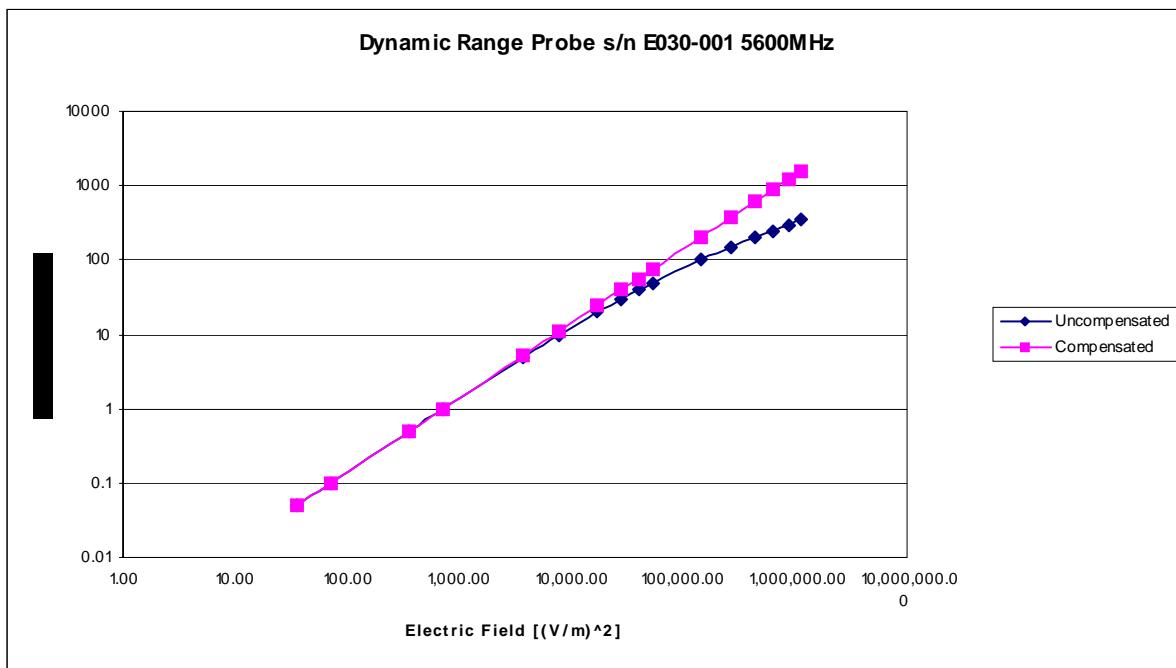
## Receiving Pattern 5600 MHz (Air)



**Isotropy Error 5600 MHz (Air)****Isotropicity Tissue:**

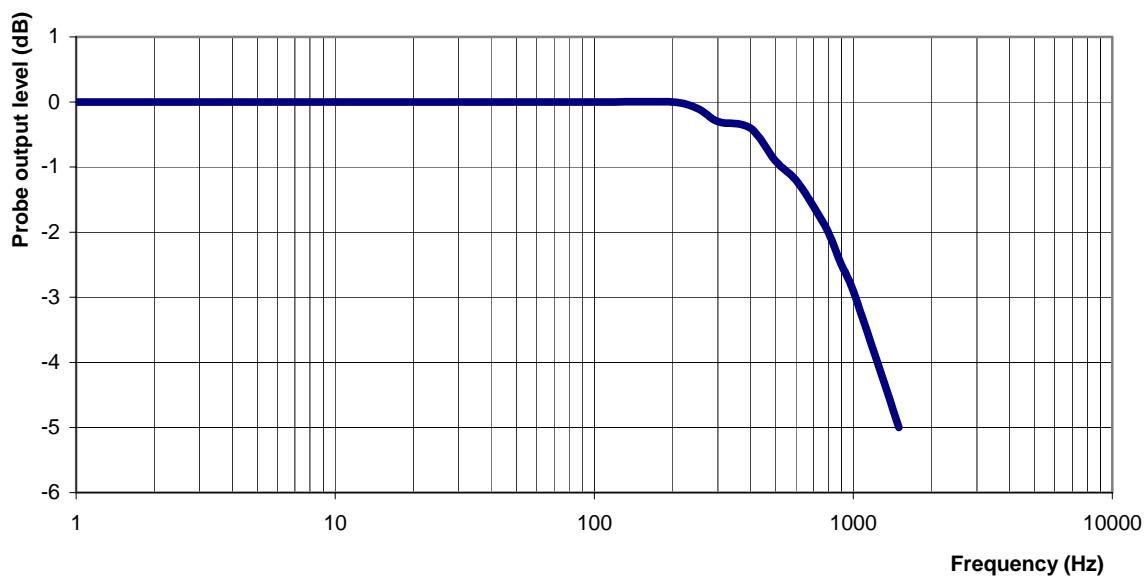
0.10 dB

## 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

## Sensitivity in Body Tissue Measured

**Frequency:** 5600 MHz

**Epsilon:** 46.76 **Sigma:** 5.84 S/m

## ConvF

**Channel X:** 4.0 7% (K=2)

**Channel Y:** 4.0 7% (K=2)

**Channel Z:** 4.0 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of  $5\text{ M}\Omega$ .

## Boundary Effect:

For a distance of 0.58mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

## **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 2009.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1008

Client.: RFEL

## 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

BODY Calibration

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: E030-001

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2  
Project No: RFEB-ALSE030-cal-5453

Calibrated: 15<sup>th</sup> July 2009  
Released on: 16<sup>th</sup> April 2009

APREL Laboratories Certified Under Laboratory 48 of SCC

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

## **NCL Calibration Laboratories**

---

Division of APREL Laboratories.

### **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 E030-001.

### **References**

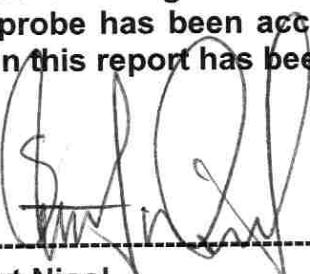
SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure  
IEC 62209 "Human exposure to radio frequency fields from hand-held and body-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 E030-001 was a new probe.

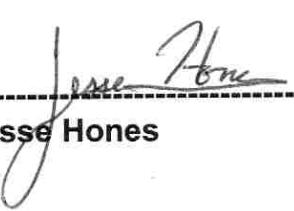
**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C  
**Temperature of the Tissue:** 21 °C +/- 0.5°C

**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> | E030-001            |
| <b>Frequency:</b>     | 5800 MHz            |
| <b>Sensor Offset:</b> | 1.06 mm             |
| <b>Sensor Length:</b> | 2.5 mm              |
| <b>Tip Enclosure:</b> | Composite*          |
| <b>Tip Diameter:</b>  | <2.5 mm             |
| <b>Tip Length:</b>    | 55 mm               |
| <b>Total Length:</b>  | 289 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:** 5800 MHz

**Epsilon:** 46.28      **Sigma:** 6.22 S/m

### **ConvF:**

**Channel X:** 4.2

**Channel Y:** 4.2

**Channel Z:** 4.2

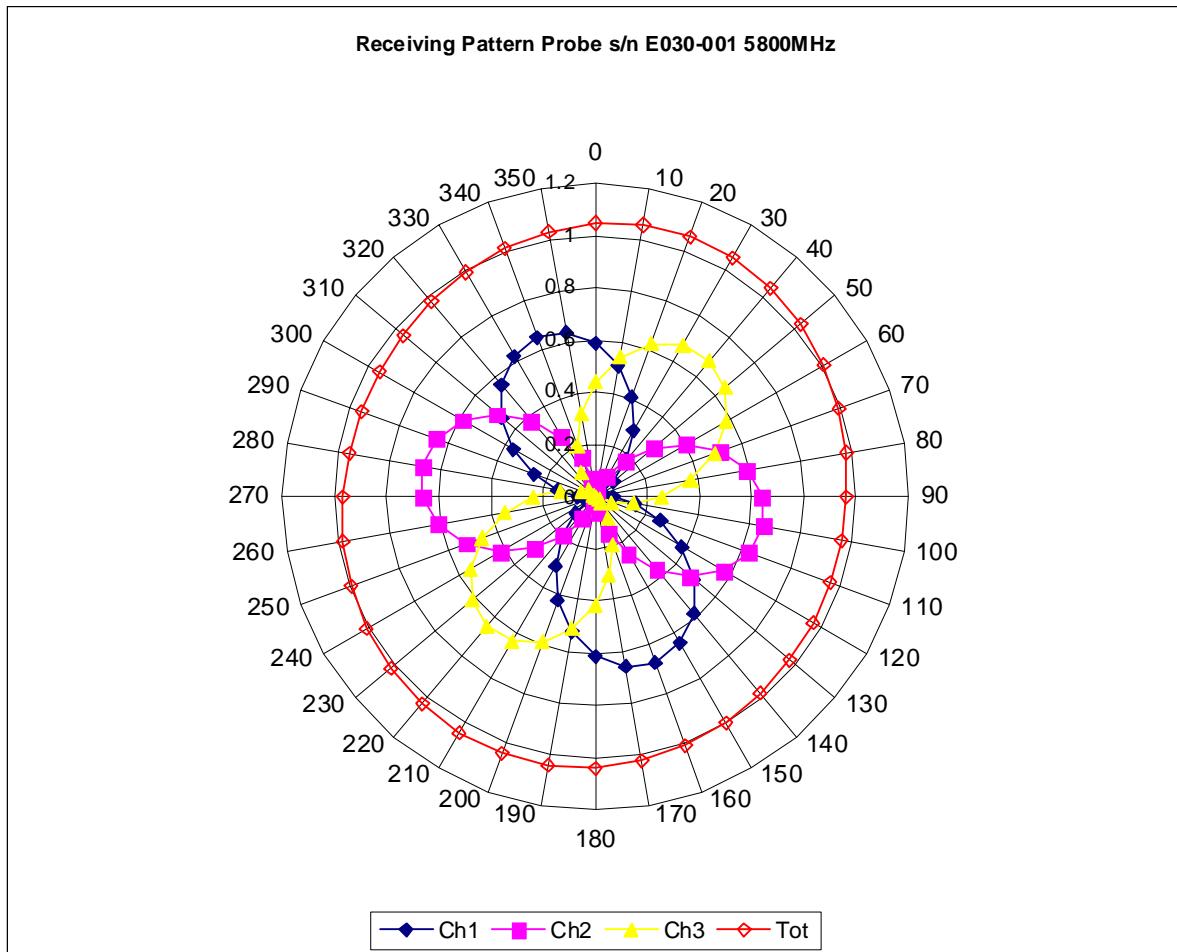
### **Boundary Effect:**

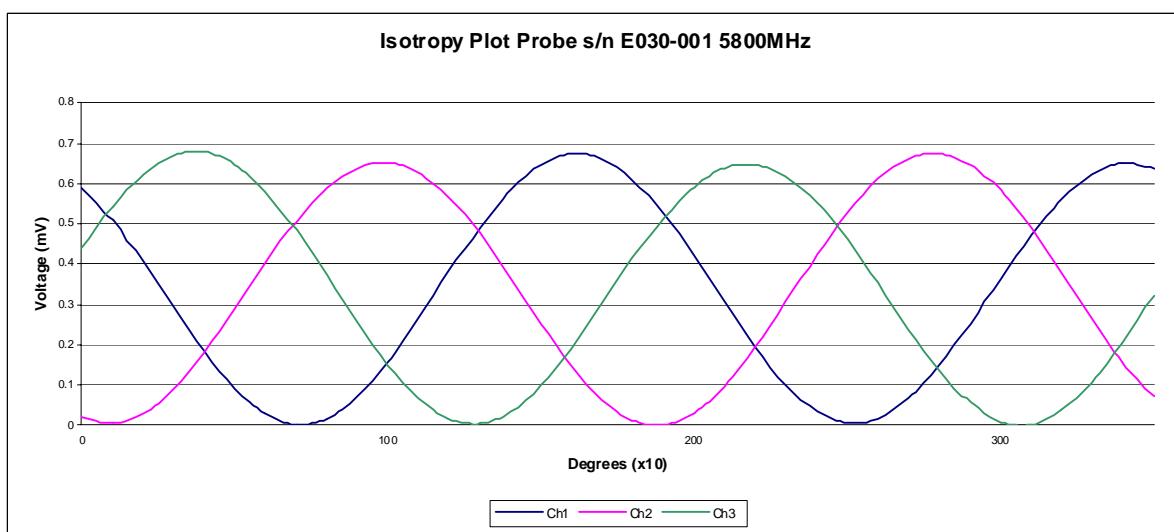
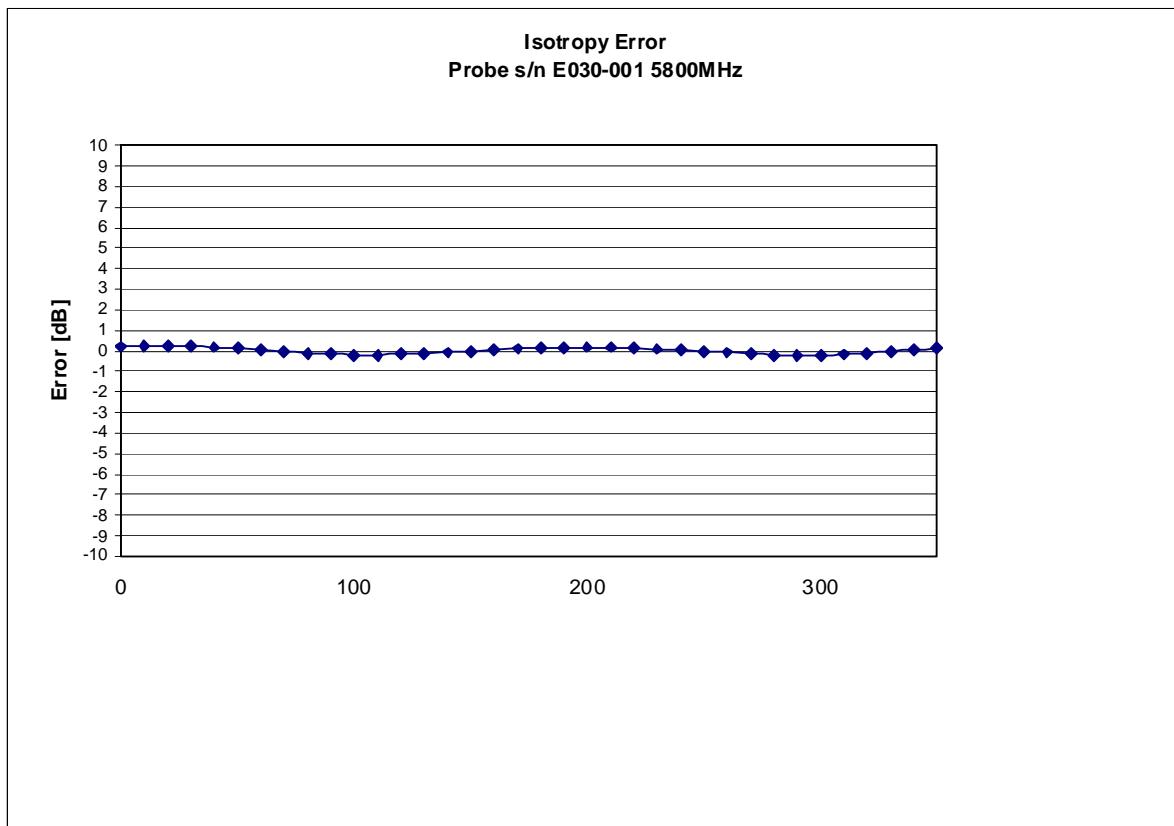
Uncertainty resulting from the boundary effect is less than 2.1% for the distance between the tip of the probe and the tissue boundary, when less than 0.58mm.

### **Spatial Resolution:**

The measured probe tip diameter is 2.5mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

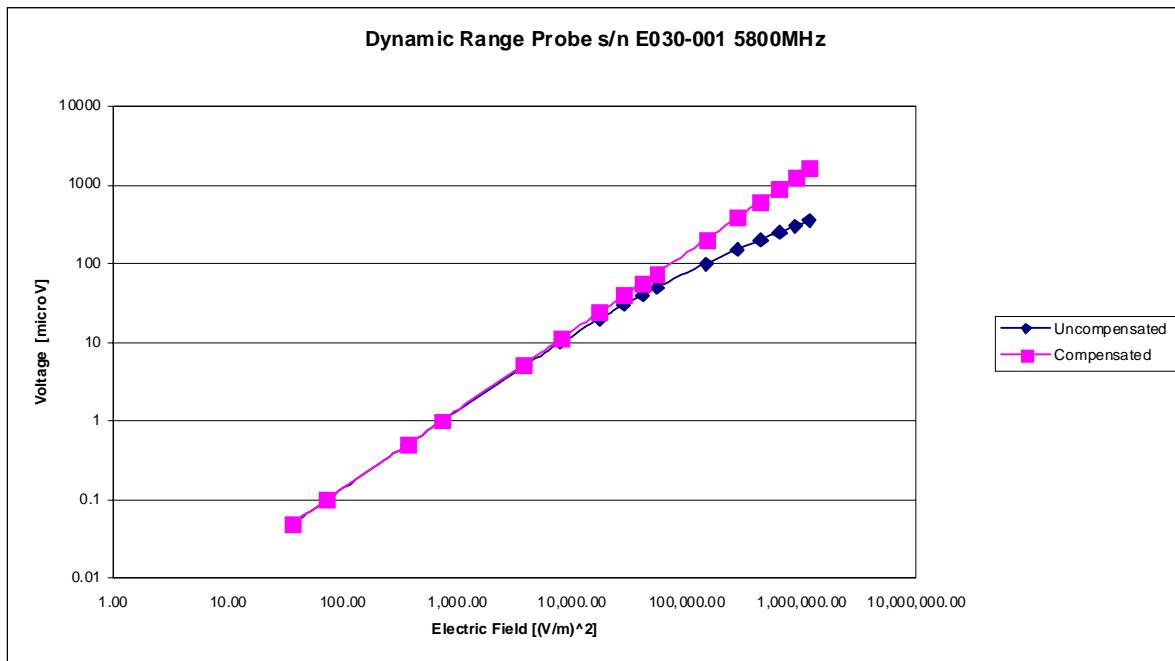
## Receiving Pattern 5800 MHz (Air)



**Isotropy Error 5800 MHz (Air)****Isotropicity Tissue:**

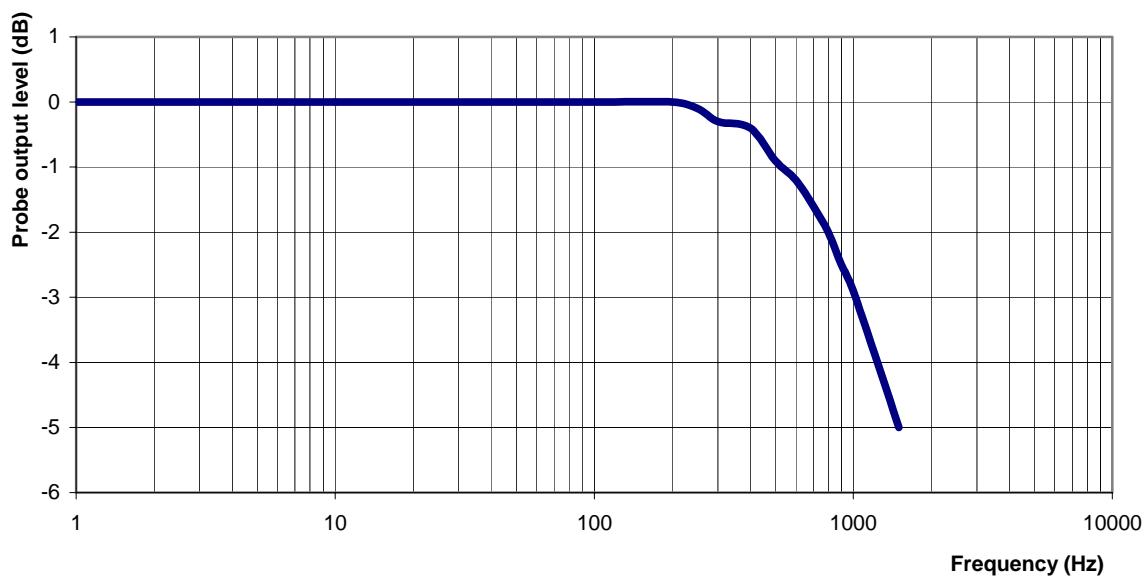
0.10 dB

## 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**

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

**Frequency:** 5800 MHz

**Epsilon:** 46.28      **Sigma:** 6.22 S/m

**ConvF**

**Channel X:** 4.2      7%(K=2)

**Channel Y:** 4.2      7%(K=2)

**Channel Z:** 4.2      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 0.58mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

## **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 2009.

## Appendix E – Dipole Calibration Data Sheets

## **NCL CALIBRATION LABORATORIES**

Calibration File No: DC-1114  
Project Number: RFEL-835-Dipole-5480

## **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.

Validation Dipole

Manufacturer: APREL Laboratories  
Part number: ALS-D-835-S-2  
Frequency: 835 MHz  
Serial No: 180-00561

Customer: RFEL

Calibrated: 14<sup>th</sup> January 2010  
Released on: 19<sup>th</sup> January 2010

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**

Division of APREL Laboratories.

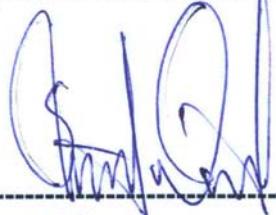
### **Conditions**

Dipole 180-00561 was a new 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.**

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**



**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

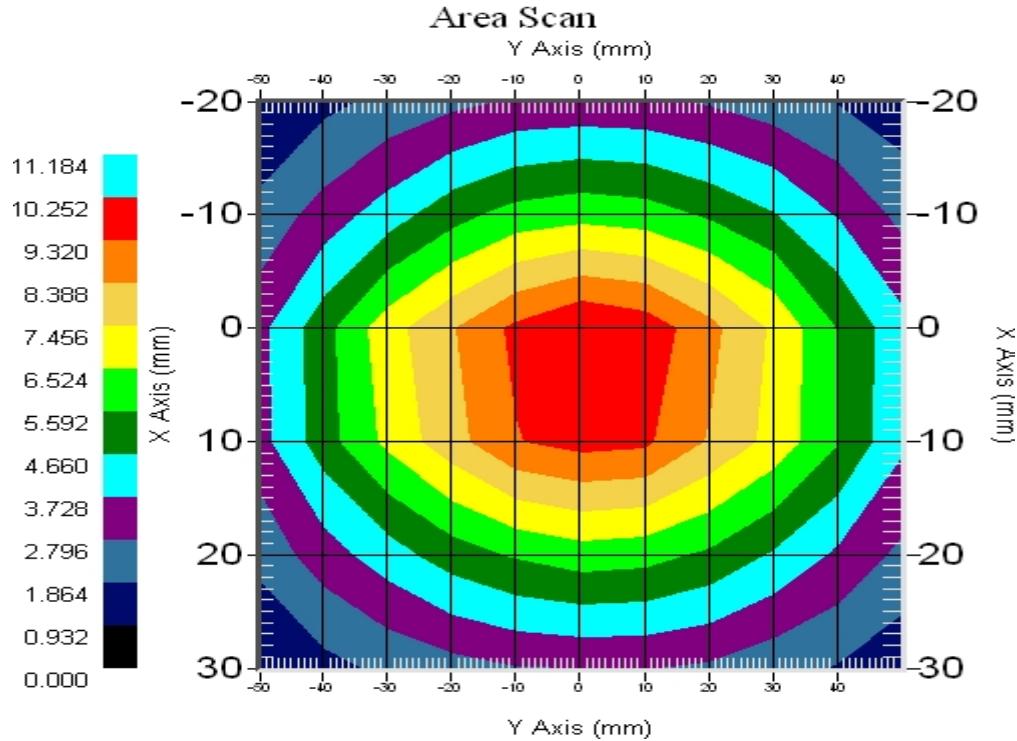
**Length:** 161.0 mm  
**Height:** 89.8 mm

### Electrical Specification

**SWR:** 1.009U  
**Return Loss:** -47.751 dB  
**Impedance:** 50.065  $\Omega$

### System Validation Results

| Frequency | 1 Gram | 10 Gram | Peak  |
|-----------|--------|---------|-------|
| 835 MHz   | 9.49   | 6.1     | 14.21 |



## 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 180-00561. 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 2225.

## 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 180-00561 was a new calibration.

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

**Temperature of the Tissue:** 20 °C +/- 0.5°C

## **NCL Calibration Laboratories**

Division of APREL Laboratories.

## **Dipole Calibration Results**

### **Mechanical Verification**

| <b>APREL Length</b> | <b>APREL Height</b> | <b>Measured Length</b> | <b>Measured Height</b> |
|---------------------|---------------------|------------------------|------------------------|
| 161.0 mm            | 89.8 mm             | 162.1 mm               | 89.8 mm                |

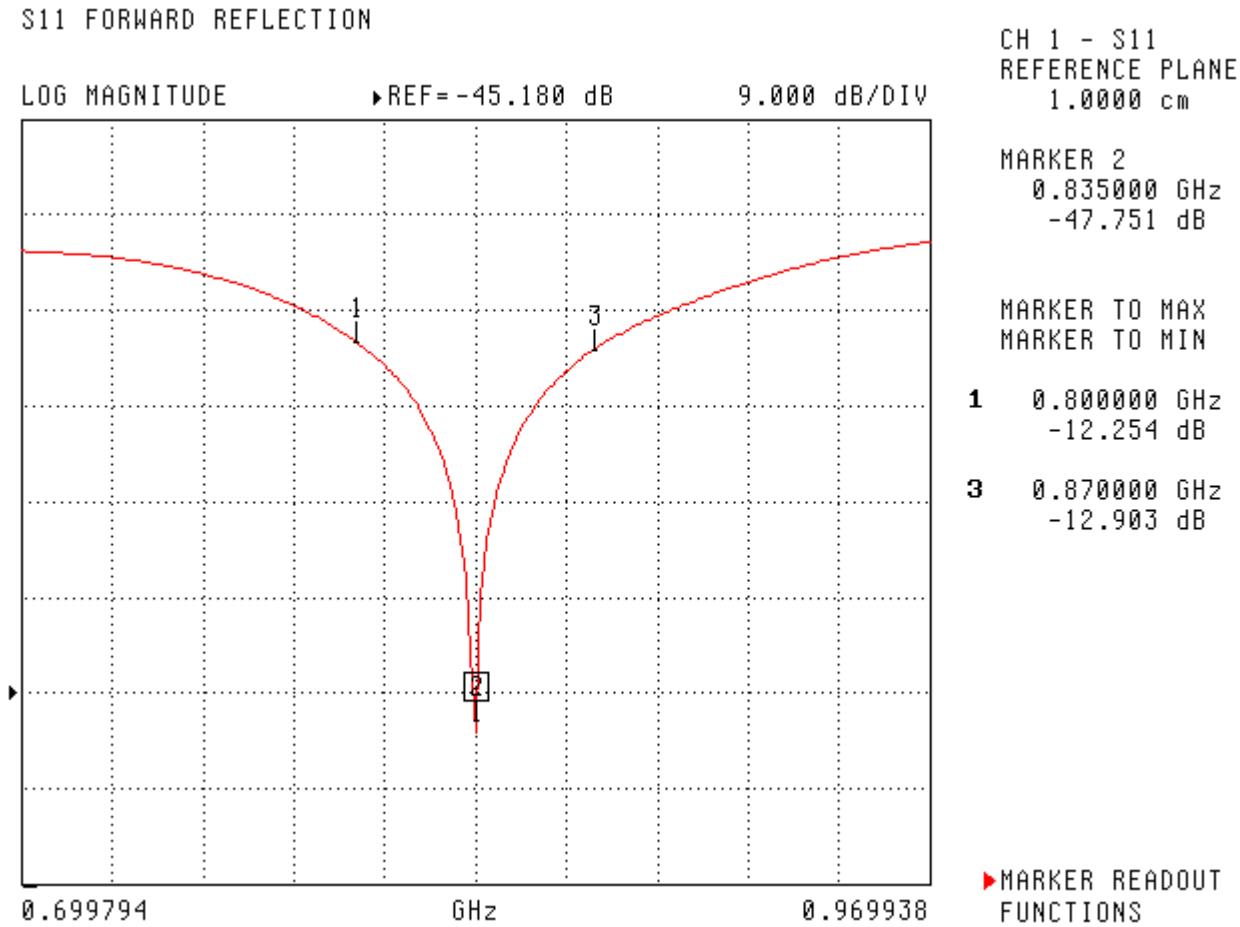
### **Tissue Validation**

| <b>Head Tissue 835MHz</b>                           | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 41.54           |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 0.91            |

**Electrical Calibration**

| Test      | Result          |
|-----------|-----------------|
| S11 RL    | -47.751dB       |
| SWR       | 1.009U          |
| Impedance | 50.065 $\Omega$ |

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

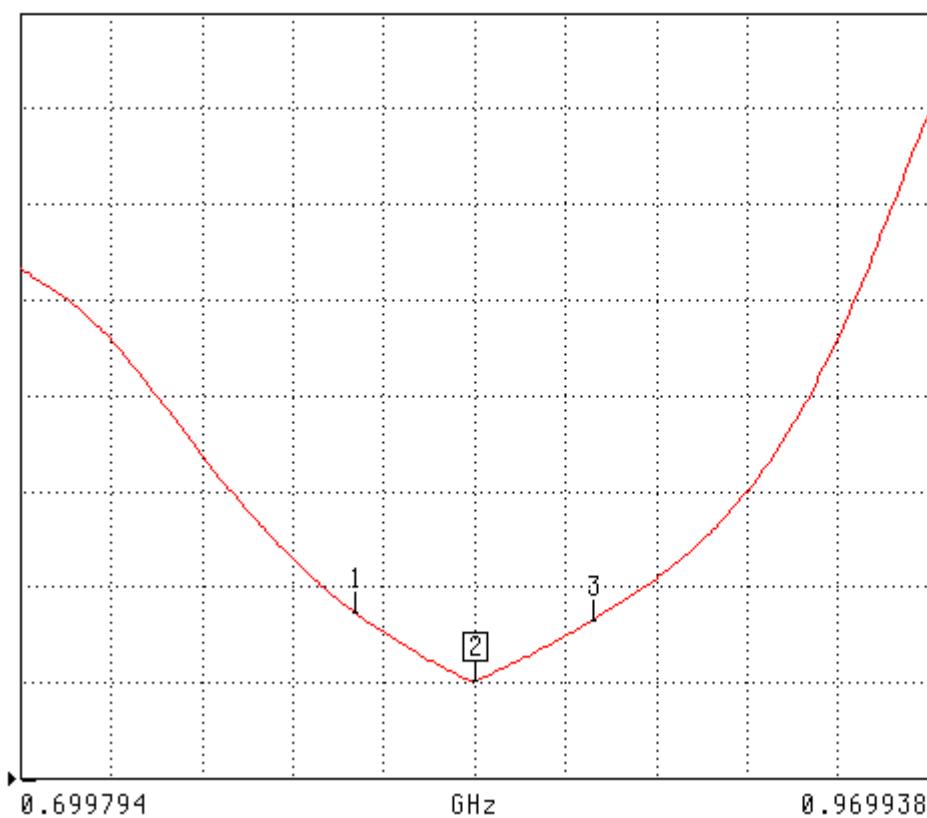
**S11 Parameter Return Loss**

**SWR****S11 FORWARD REFLECTION**

SWR

►REF = 97.512 mU

900.000 mU/DIV



CH 1 - S11  
REFERENCE PLANE  
1.0000 cm

MARKER 2  
0.835000 GHz  
1.009 U

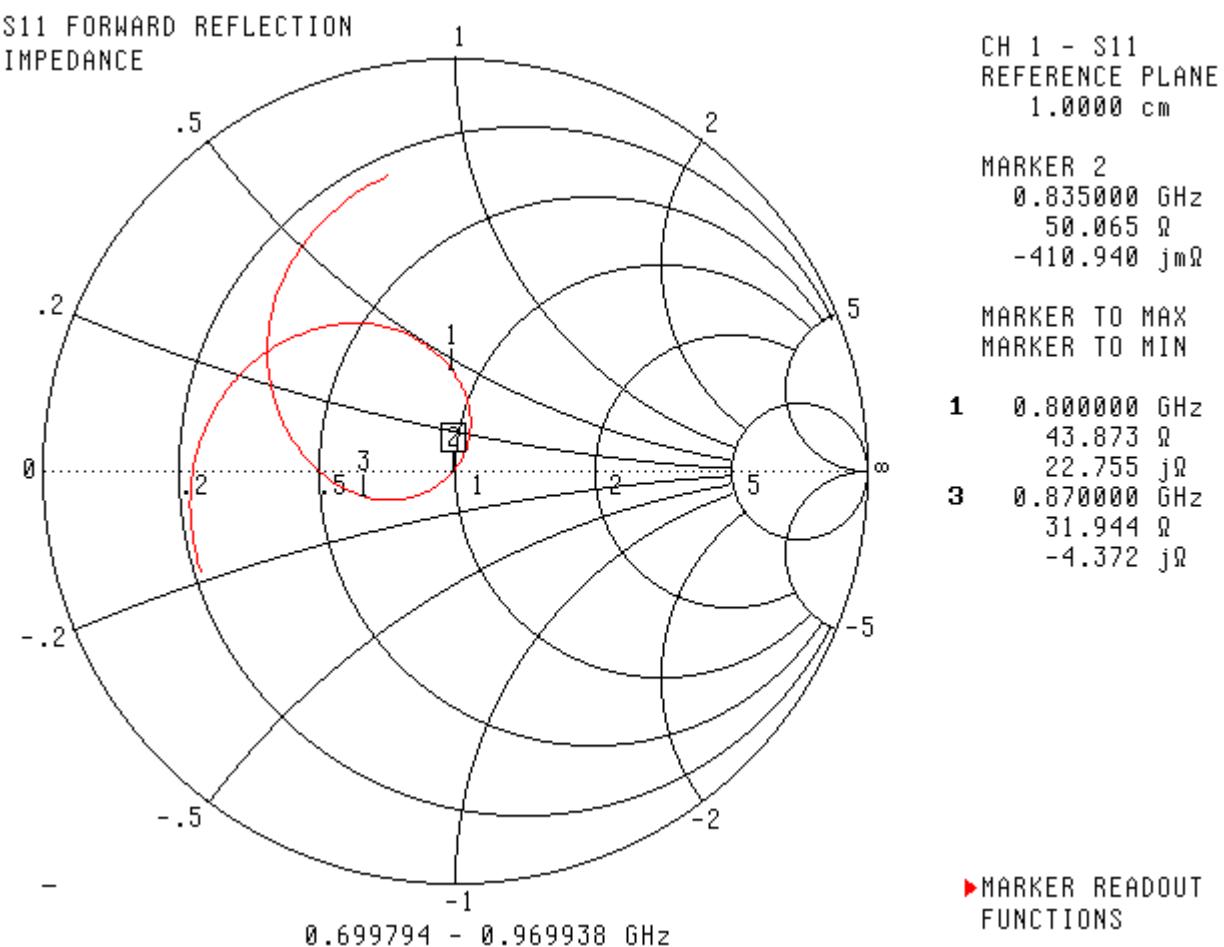
MARKER TO MAX  
MARKER TO MIN

1 0.800000 GHz  
1.645 U

3 0.870000 GHz  
1.585 U

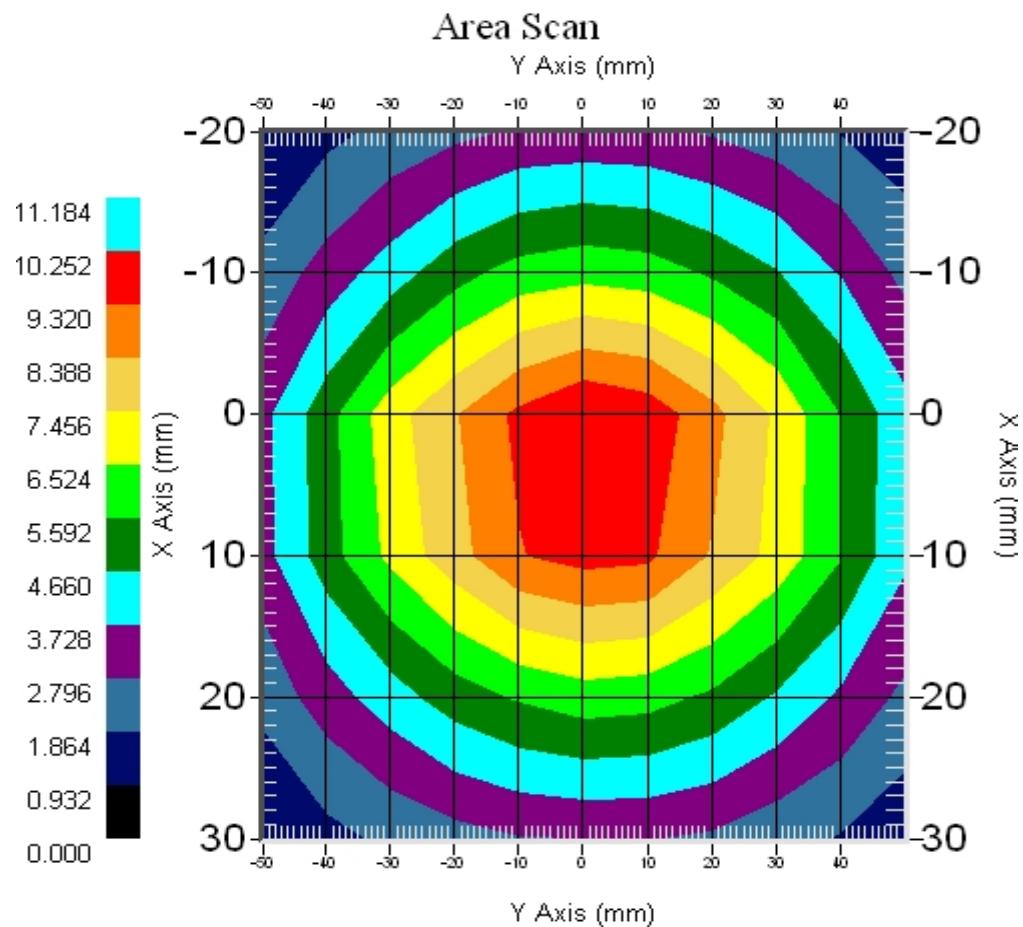
►MARKER READOUT  
FUNCTIONS

## Smith Chart Dipole Impedance



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

| Head Tissue Frequency | 1 Gram | 10 Gram | Peak Above Feed Point |
|-----------------------|--------|---------|-----------------------|
| 835 MHz               | 9.49   | 6.1     | 14.21                 |



## **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 2009.

## NCL CALIBRATION LABORATORIES

Calibration File No: DC-1115  
Project Number: RFEL-1900-Dipole-5481

## 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.

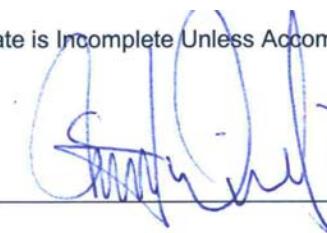
Validation Dipole

Manufacturer: APREL Laboratories  
Part number: ALS-D-1900-S-2  
Frequency: 1900 MHz  
Serial No: 210-00713

Customer: RFEL

Calibrated: 15<sup>th</sup> January 2010  
Released on: 19<sup>th</sup> January 2010

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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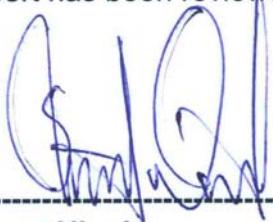
Division of APREL Laboratories.

### **Conditions**

Dipole 210-00713 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**



**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

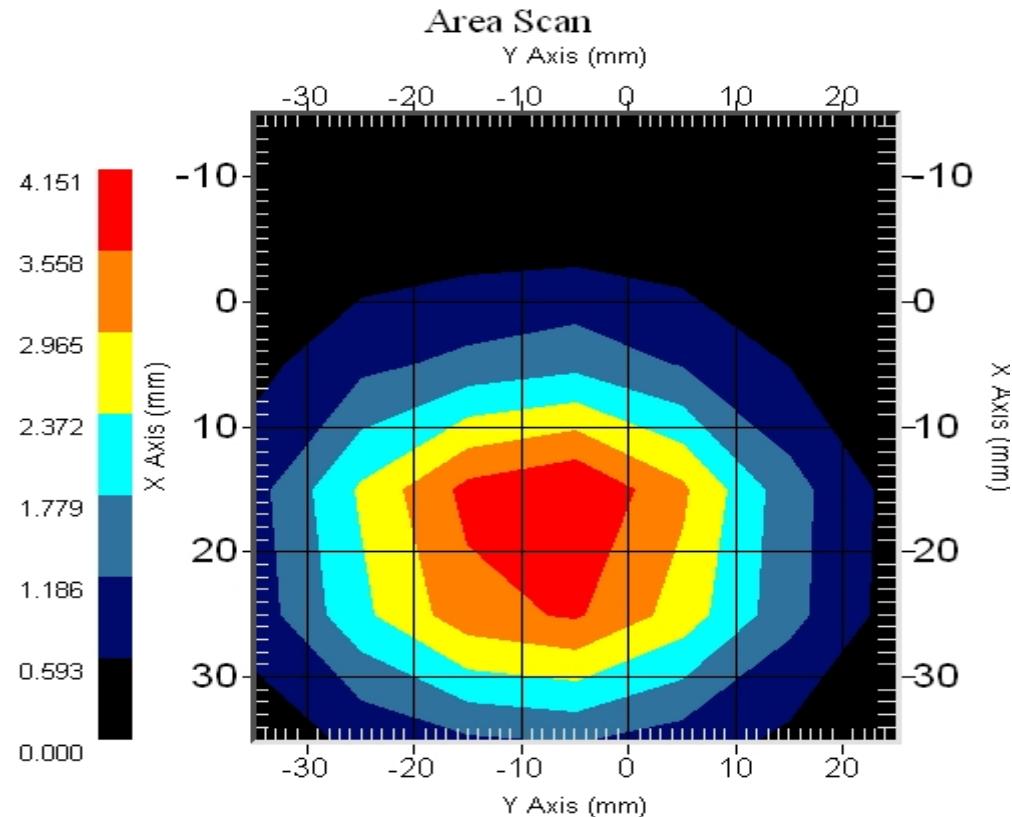
**Length:** 67.1 mm  
**Height:** 38.9 mm

### Electrical Specification

**SWR:** 1.011U  
**Return Loss:** -45.642dB  
**Impedance:** 50.194Ω

### System Validation Results

| Frequency | 1 Gram | 10 Gram | Peak |
|-----------|--------|---------|------|
| 1900 MHz  | 38.7   | 20.5    | 69.7 |



## 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 210-00713. 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 226.

## 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 210-00713 was new taken from stock.

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

**Temperature of the Tissue:** 20 °C +/- 0.5°C

## **NCL Calibration Laboratories**

Division of APREL Laboratories.

### **Dipole Calibration Results**

#### **Mechanical Verification**

| <b>APREL Length</b> | <b>APREL Height</b> | <b>Measured Length</b> | <b>Measured Height</b> |
|---------------------|---------------------|------------------------|------------------------|
| 68.0 mm             | 39.5 mm             | 67.1mm                 | 38.9 mm                |

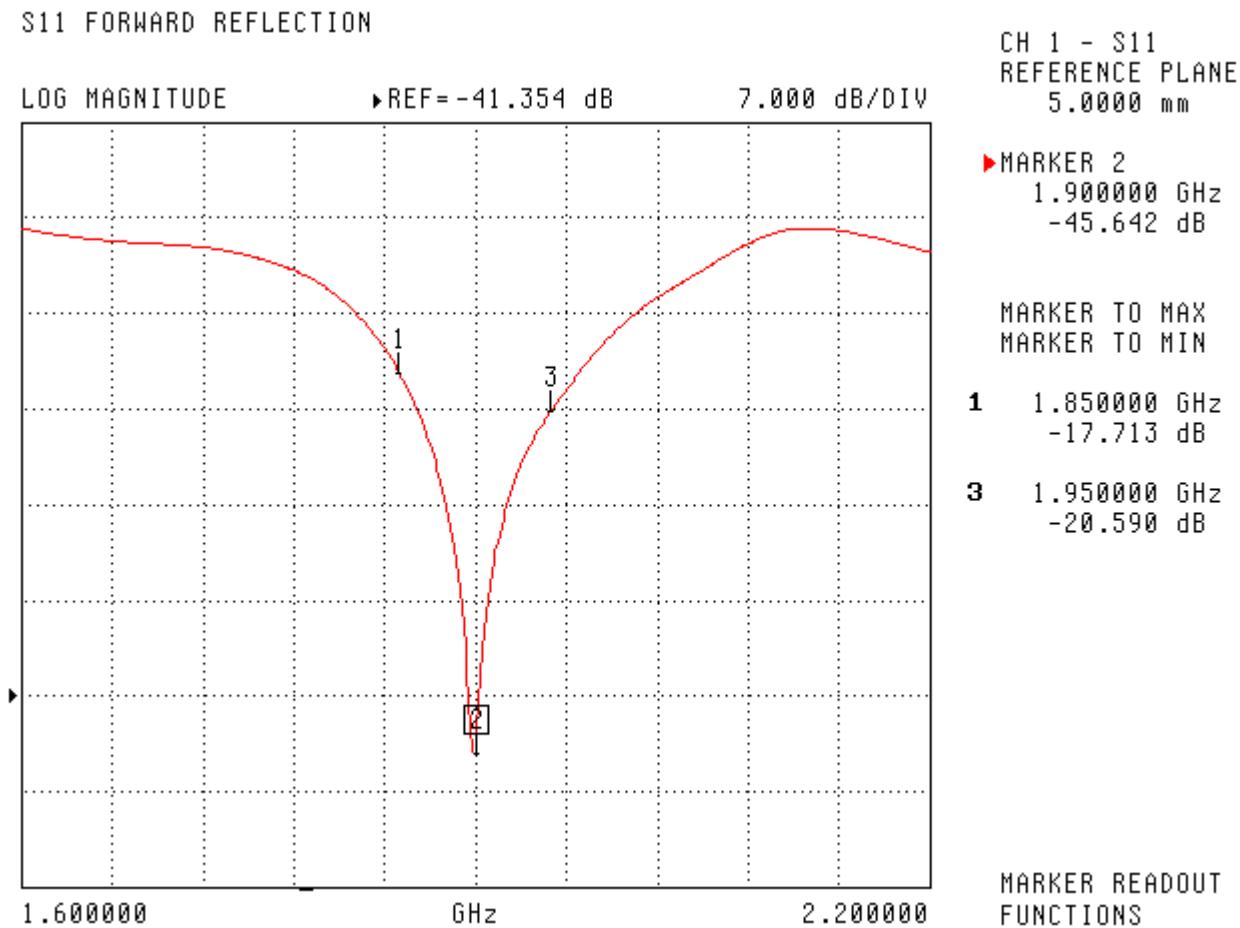
#### **Tissue Validation**

| <b>Head Tissue 1900 MHz</b>                         | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 40.03           |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 1.38            |

**Electrical Calibration**

| Test      | Result          |
|-----------|-----------------|
| S11 R/L   | -45.642dB       |
| SWR       | 1.011U          |
| Impedance | 50.194 $\Omega$ |

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

**S11 Parameter Return Loss**

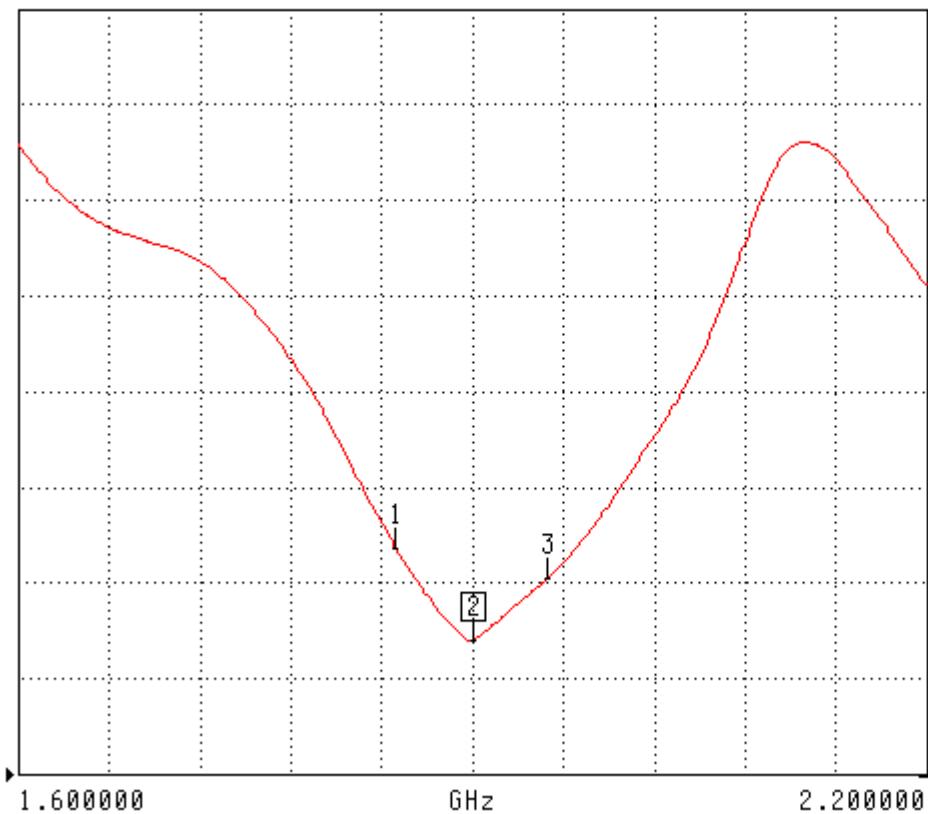
## SWR

S11 FORWARD REFLECTION

SWR

►REF=592.479 mU

300.000 mU/DIV



CH 1 - S11  
REFERENCE PLANE  
5.0000 mm

►MARKER 2  
1.900000 GHz  
1.011 U

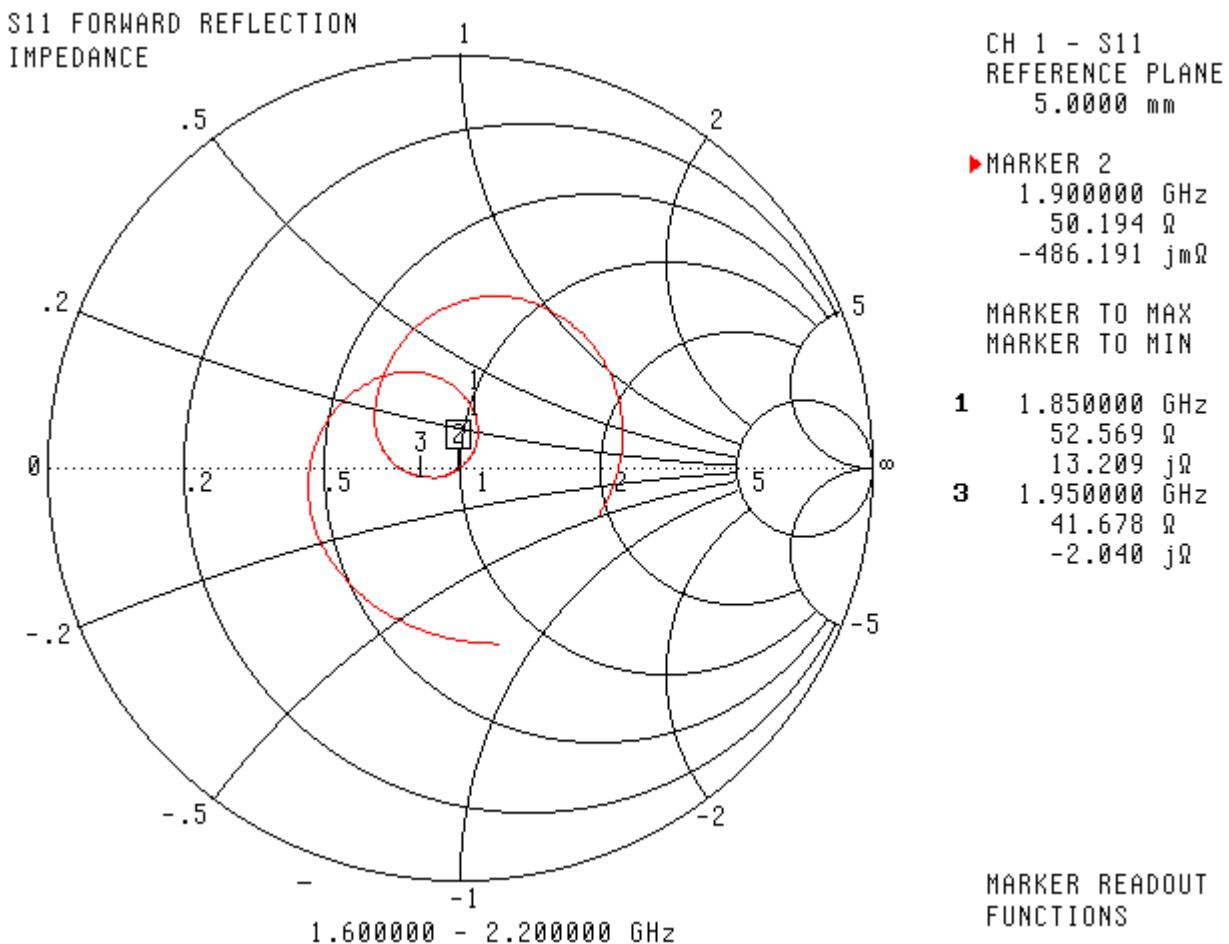
MARKER TO MAX  
MARKER TO MIN

1 1.850000 GHz  
1.299 U

3 1.950000 GHz  
1.206 U

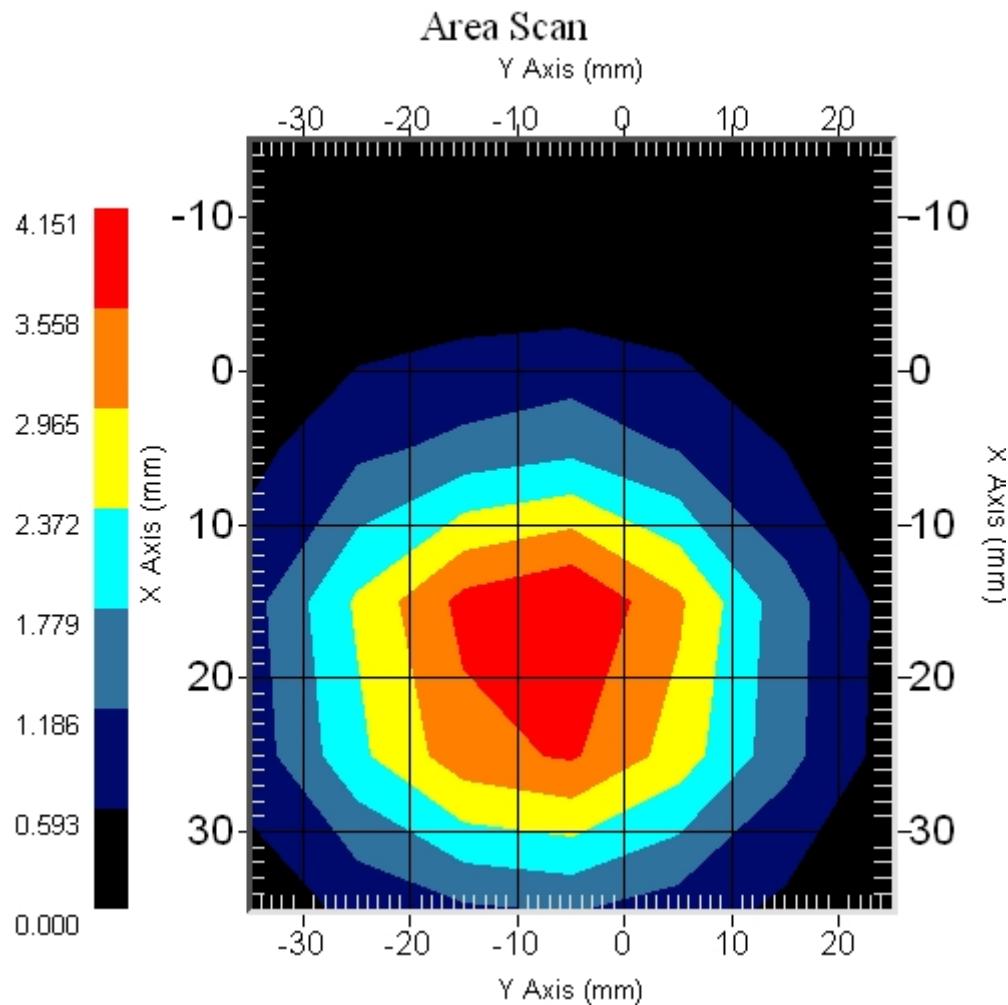
MARKER READOUT  
FUNCTIONS

## Smith Chart Dipole Impedance



## System Validation Results Using the Electrically Calibrated Dipole

| Head Tissue Frequency | 1 Gram | 10 Gram | Peak Above Feed Point |
|-----------------------|--------|---------|-----------------------|
| 1900 MHz              | 38.7   | 20.5    | 69.7                  |



## **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 2009.

## NCL CALIBRATION LABORATORIES

Calibration File No: DC-1109  
Project Number: RFEB-5495

## 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.

Validation Dipole

Manufacturer: APREL Laboratories

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

Frequency: 2450 MHz

Serial No: RFE-278

Customer: RFEL

Calibrated: 12<sup>th</sup> January 2010  
Released on: 12<sup>th</sup> January 2010

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**

---

Division of APREL Laboratories.

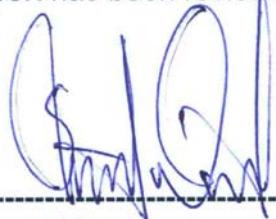
### **Conditions**

Dipole RFE-278 was a new 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.**

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**



**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**

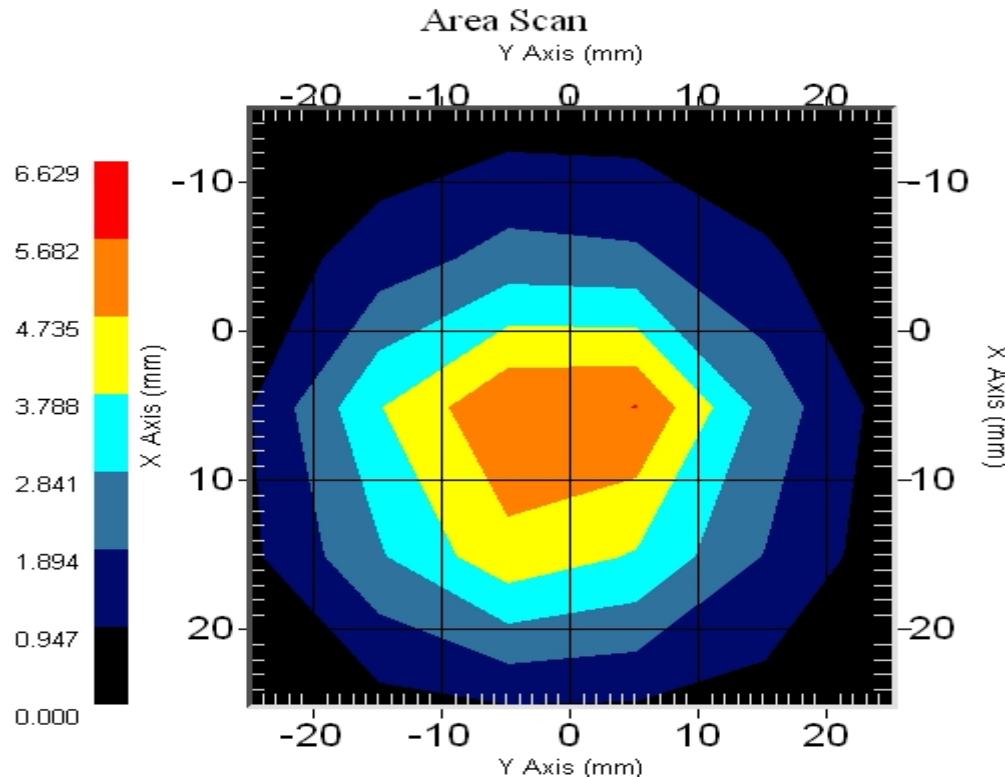
**Length:** 51.5 mm  
**Height:** 30.4 mm

## Electrical Specification

**SWR:** 1.070 U  
**Return Loss:** -29.451 dB  
**Impedance:** 50.710  $\Omega$

## System Validation Results @ 100mW

| Frequency | 1 Gram | 10 Gram | Peak  |
|-----------|--------|---------|-------|
| 2450 MHz  | 5.31   | 2.44    | 10.18 |



## 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 RFE-278. 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 226.

## 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 RFE-278 was a re-calibration.

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

**Temperature of the Tissue:** 20 °C +/- 0.5°C

## **NCL Calibration Laboratories**

Division of APREL Laboratories.

### **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             | 52.1 mm                | 31.0 mm                |

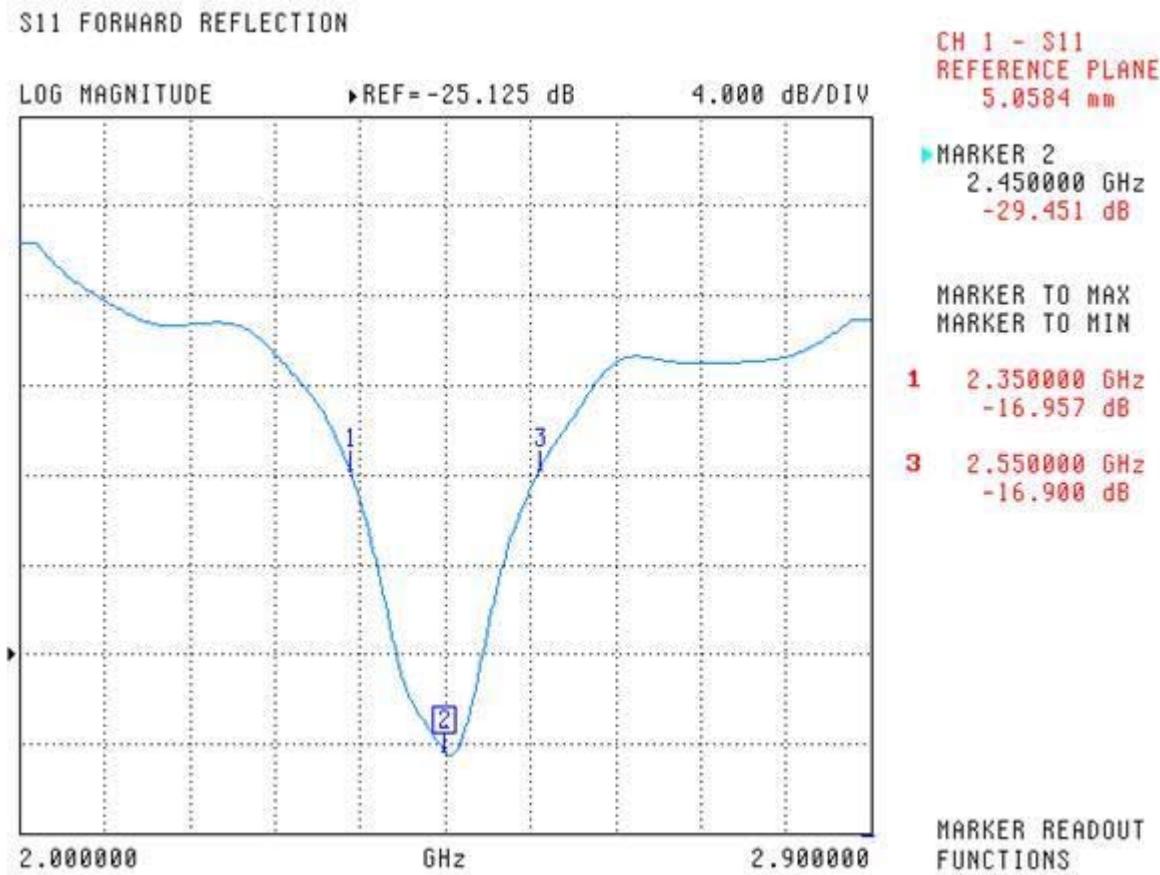
#### **Tissue Validation**

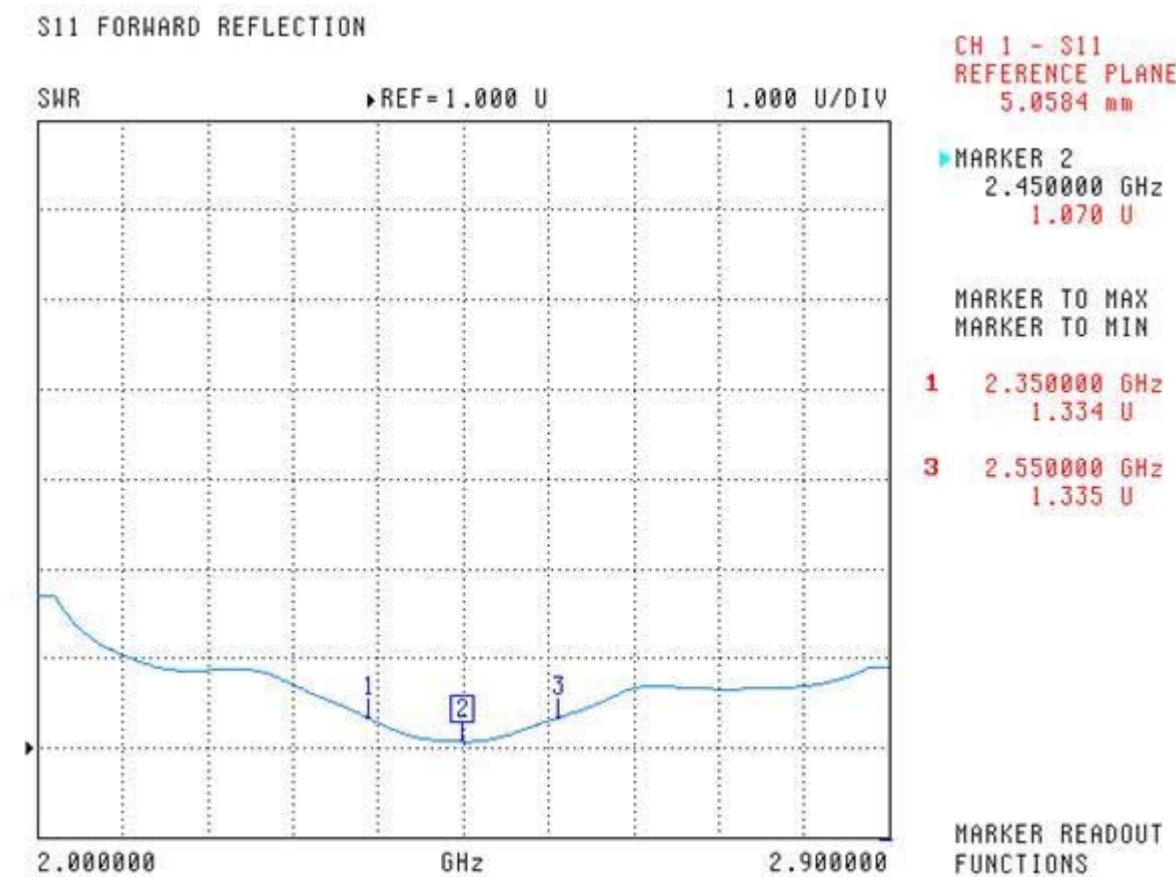
| <b>Head Tissue 2450 MHz</b>                         | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 39.8            |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 1.85            |

**Electrical Calibration**

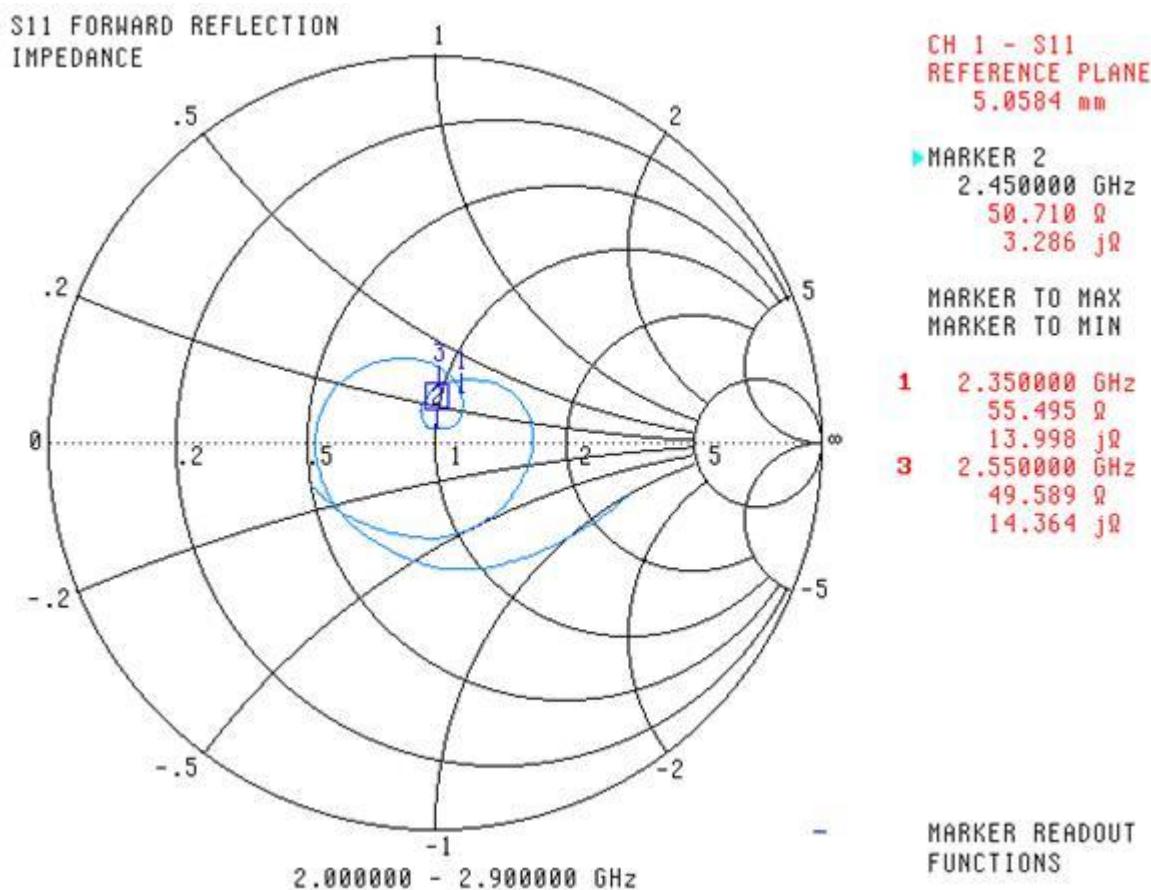
| Test      | Result          |
|-----------|-----------------|
| S11 R/L   | -29.451 dB      |
| SWR       | 1.070 U         |
| Impedance | 50.710 $\Omega$ |

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

**S11 Parameter Return Loss**

**SWR**

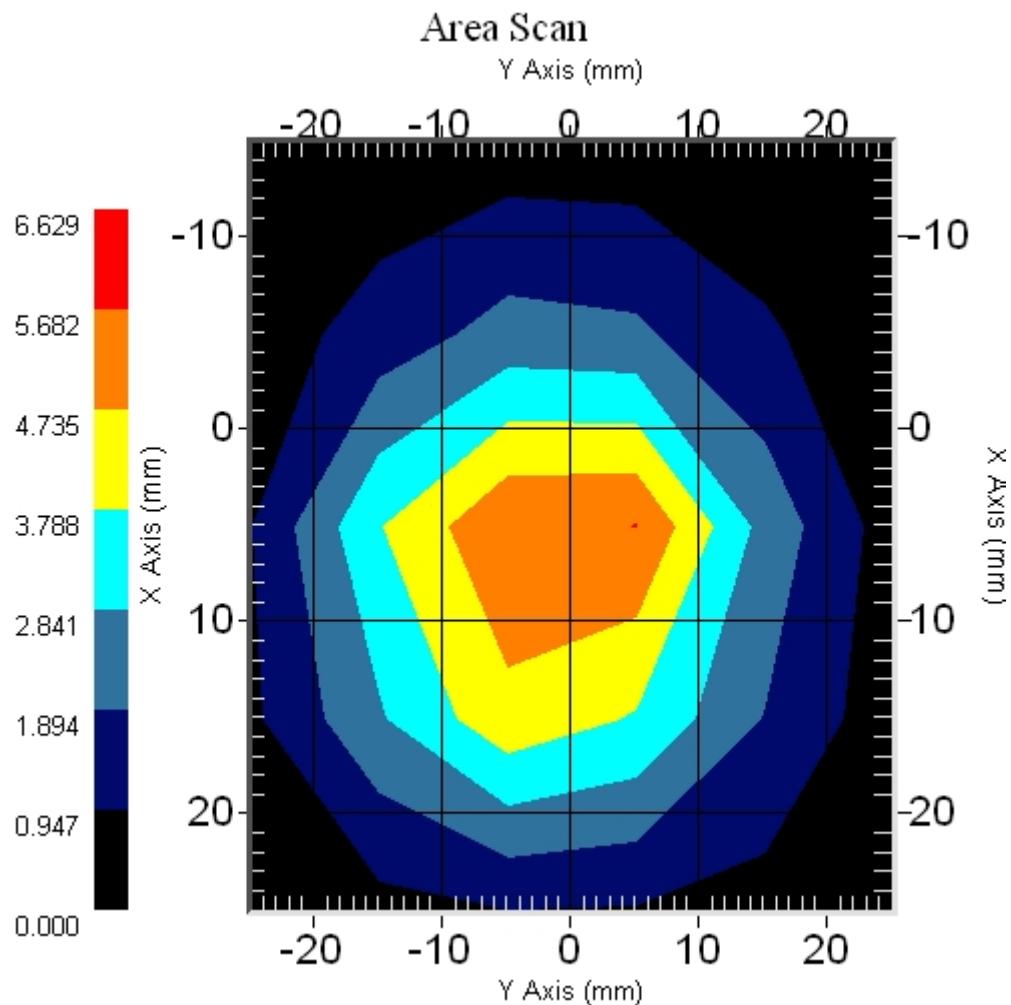
## Smith Chart Dipole Impedance



## System Validation Results Using the Electrically Calibrated Dipole

## Results @ 100mW

| Head Tissue Frequency | 1 Gram | 10 Gram | Peak Above Feed Point |
|-----------------------|--------|---------|-----------------------|
| 2450 MHz              | 5.31   | 2.44    | 10.18                 |



## **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 2009.

## NCL CALIBRATION LABORATORIES

Calibration File No: DC-1110, 1111, 1112  
Project Number: RFEB-5496, 5497, 5498

## 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.

Validation Dipole

Manufacturer: APREL Laboratories

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

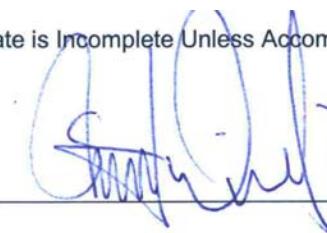
Frequency: 5200-5800 MHz

Serial No: 235-00801

Customer: RFEL

Calibrated: 12<sup>th</sup> January 2010  
Released on: 12<sup>th</sup> January 2010

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**

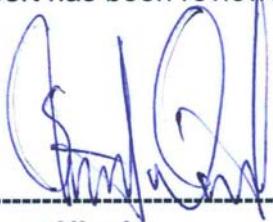
Division of APREL Laboratories.

### **Conditions**

Dipole 235-00801 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**



**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 mm  
**Height:** 21 mm

### **Electrical Specification 5200MHz**

**SWR:** 1.025 U  
**Return Loss:** -38.354 dB  
**Impedance:** 51.08  $\Omega$

### **Electrical Specification 5600MHz**

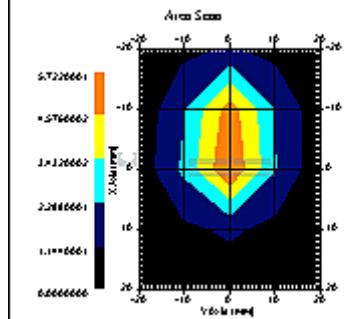
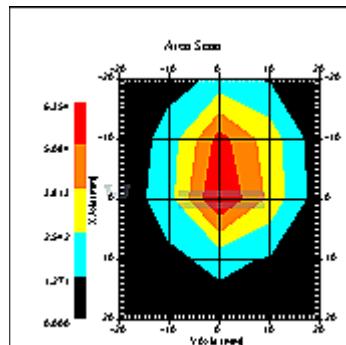
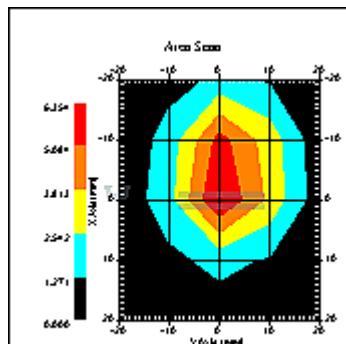
**SWR:** 1.025 U  
**Return Loss:** -38.3 dB  
**Impedance:** 49.303  $\Omega$

### **Electrical Specification 5800MHz**

**SWR:** 1.038 U  
**Return Loss:** -34.609 dB  
**Impedance:** 48.872  $\Omega$

**System Validation Results**

| Frequency | 1 Gram | 10 Gram | Peak |
|-----------|--------|---------|------|
| 5200 MHz  | 61.66  | 19.5    | -    |
| 5600 MHz  | 65.03  | 21.2    | -    |
| 5800 MHz  | 63.43  | 20.19   | -    |

**5200MHz****5600MHz****5800MHz**

## 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 235-00801. 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-030 130 MHz to 26 GHz E-Field Probe Serial Number 215.

## 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 235-00801 was a re-calibration.

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

**Temperature of the Tissue:** 20 °C +/- 0.5°C

## **NCL Calibration Laboratories**

Division of APREL Laboratories.

## **Dipole Calibration Results**

### **Mechanical Verification**

| <b>APREL Length</b> | <b>APREL Height</b> | <b>Measured Length</b> | <b>Measured Height</b> |
|---------------------|---------------------|------------------------|------------------------|
| 23 mm               | 21 mm               | 23 mm                  | 21 mm                  |

### **Tissue Validation**

| <b>Head Tissue 5200 MHz</b>                         | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 35.4            |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 4.8             |

| <b>Head Tissue 5600 MHz</b>                         | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 36.1            |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 5.17            |

| <b>Head Tissue 5800 MHz</b>                         | <b>Measured</b> |
|---|-----------------|
| <b>Dielectric constant, <math>\epsilon_r</math></b> | 35.8            |
| <b>Conductivity, <math>\sigma</math> [S/m]</b>      | 5.38            |

# NCL Calibration Laboratories

Division of APREL Laboratories.

## Electrical Calibration

### Electrical Specification 5200MHz

**SWR:** 1.025 U  
**Return Loss:** -38.354 dB  
**Impedance:** 51.08  $\Omega$

### Electrical Specification 5600MHz

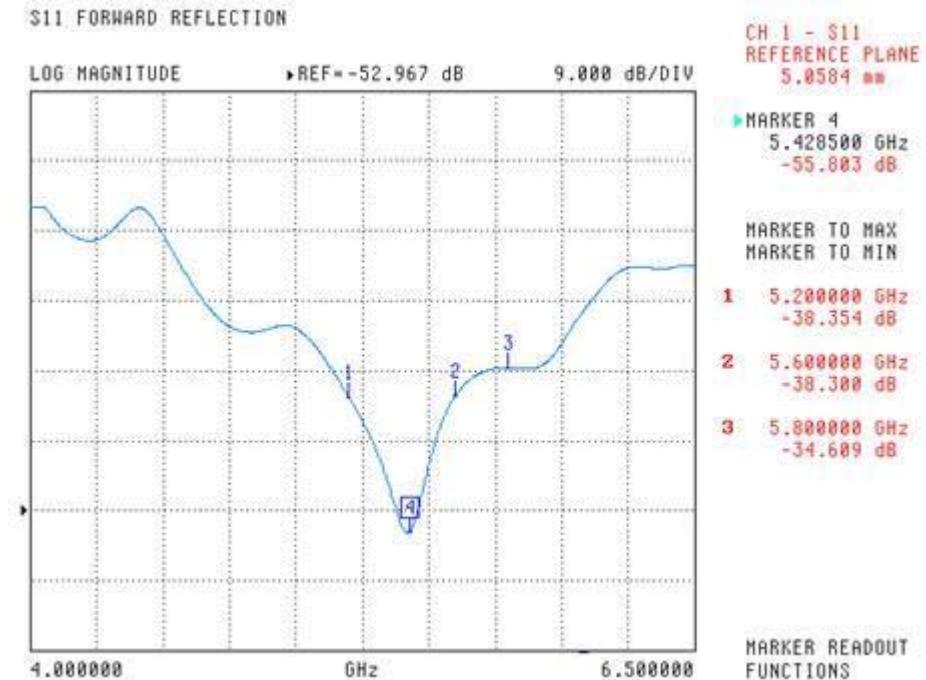
**SWR:** 1.025 U  
**Return Loss:** -38.3 dB  
**Impedance:** 49.303  $\Omega$

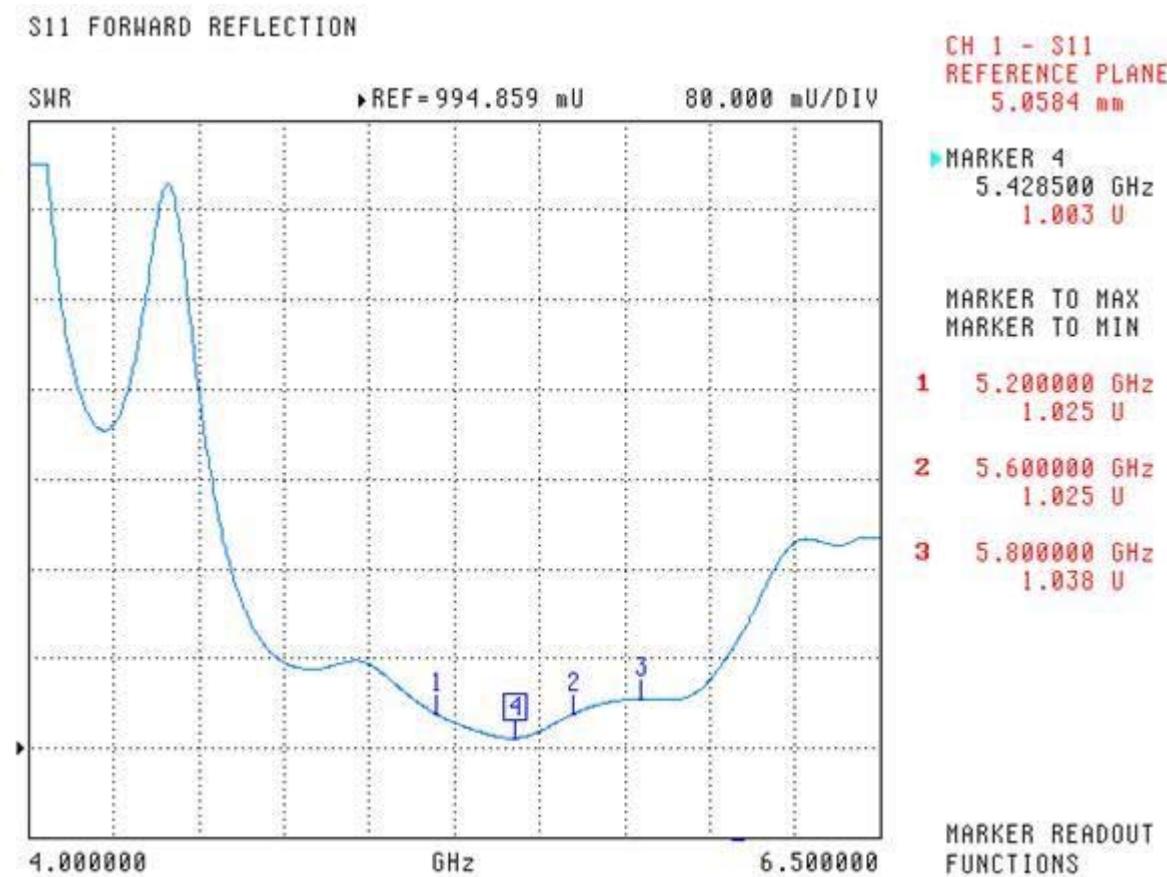
### Electrical Specification 5800MHz

**SWR:** 1.038 U  
**Return Loss:** -34.609 dB  
**Impedance:** 48.872  $\Omega$

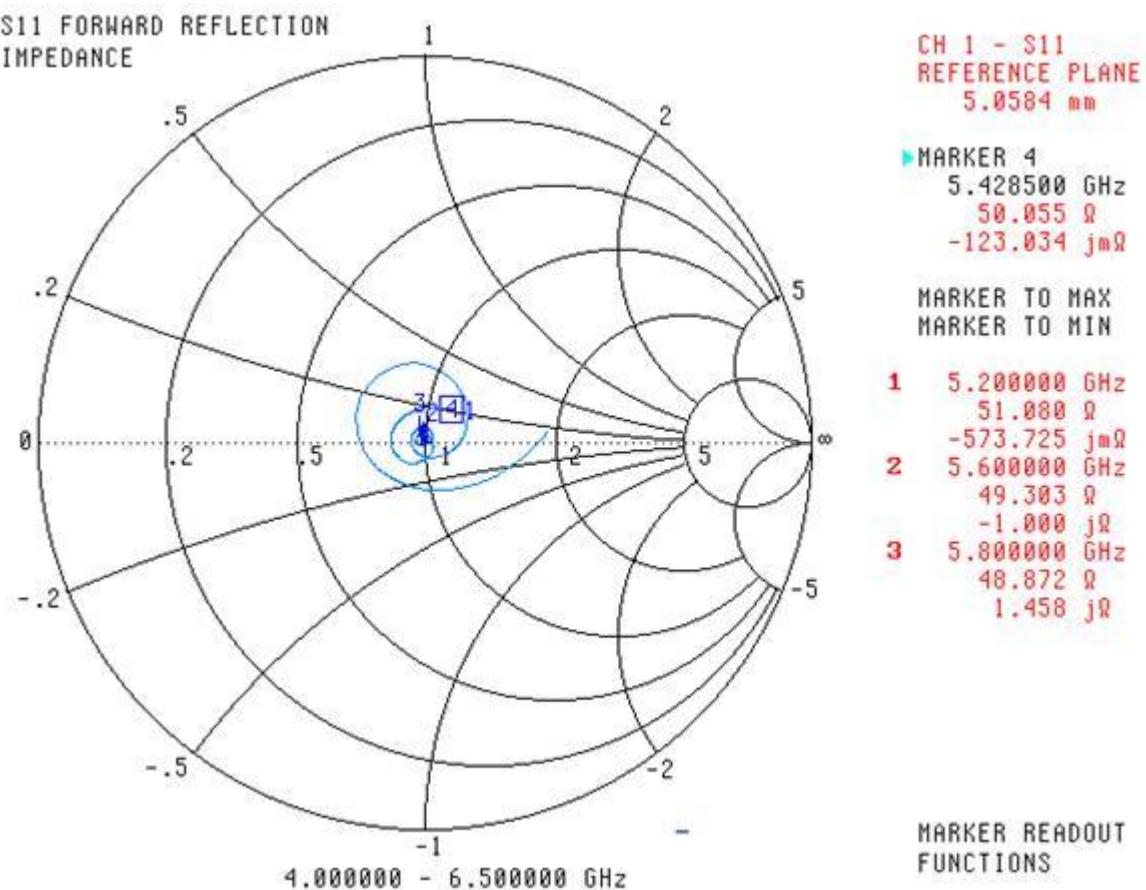
The Following Graphs are the results as displayed on the Vector Network Analyzer.

### S11 Parameter Return Loss



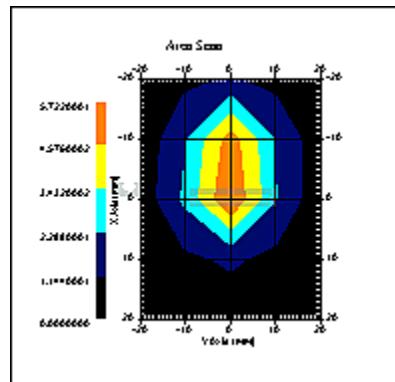
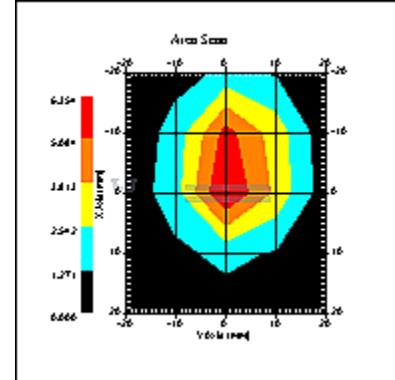
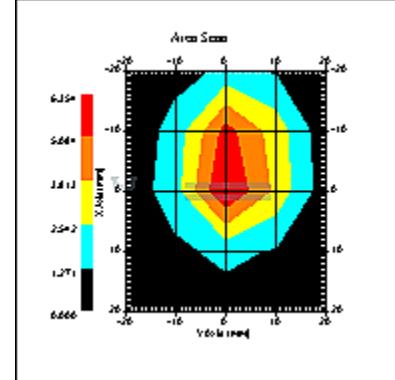
**SWR**

## Smith Chart Dipole Impedance



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

| Frequency | 1 Gram | 10 Gram | Peak |
|-----------|--------|---------|------|
| 5200 MHz  | 61.66  | 19.5    | -    |
| 5600 MHz  | 65.03  | 21.2    | -    |
| 5800 MHz  | 63.43  | 20.19   | -    |

**5200MHz****5600MHz****5800MHz**

## **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 2009.

## Appendix F – Phantom Calibration Data Sheets

## NCL CALIBRATION LABORATORIES

Calibration File No.: RFE-273

### 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 National Standards.

Thickness of the UniPhantom is 2 mm  $\pm$  10%  
Pinna thickness is 6 mm  $\pm$  10%

Resolution: 0.01 mm      Calibrated to: 0.0 mm  
Stability: OK      Accuracy: < 0.1 mm

Calibrated By:

Karen K.      Feb 17/04

### **NCL CALIBRATION LABORATORIES**

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

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TEL: (613) 820-4988  
FAX: (613) 820-4161