



## **Appendix D. Probe Calibration**

**Miniature Isotropic RF Probe**

**M/N: ALS-E-020**

**S/N: 264**

**2450MHz Head Calibration**

**2450MHz Body Calibration**



## **Appendix E. Dipole Calibration Data**

**Validation Dipole 2450MHz**

**P/N: ALS-D-2450-S-2**

**S/N: QTK-319**

## NCL CALIBRATION LABORATORIES

Calibration File No: DC-409-1  
Project Number: QTKB-Dipole Cal-5228

# CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Quietek Validation Dipole

Manufacturer: APREL Laboratories

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

Frequency: 2.45 GHz

Serial No: QTK-319

Customer: Quietek

Calibrated: 15 June 2006  
Released on: 15 June 2006

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



## **NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
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CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4888  
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## Calibration Results Summary

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

### Mechanical Dimensions

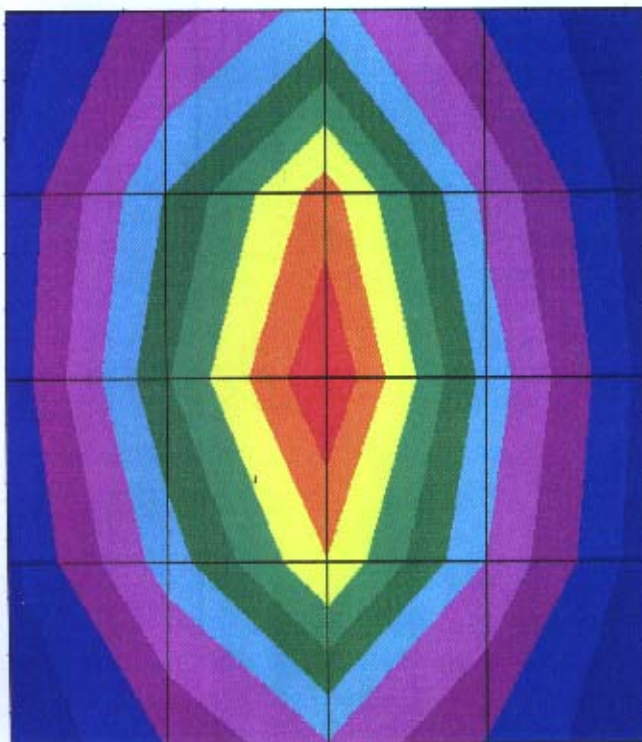
**Length:** 53.5 mm  
**Height:** 30.4 mm

### Electrical Specification

**SWR:** 1.21 U  
**Return Loss:** -20.7 dB  
**Impedance:** 47.7  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram	Peak
2.45 GHz	48.07	25.65	95.6



## **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 QTK-319. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the IEEE/APREL 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 QTK 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"

## **Conditions**

Dipole QTK-319 was received for calibration.

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

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



## Dipole Calibration Results

### Mechanical Verification

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

### Tissue Validation

Body Tissue 2450 MHz	Measured
Dielectric constant, $\epsilon_r$	52.5
Conductivity, $\sigma$ [S/m]	1.78





## NCL Calibration Laboratories

Division of APREL Laboratories.

### Electrical Calibration

Test	Result
S11 R/L	-20.7 dB
SWR	1.21 U
Impedance	47.7 $\Omega$

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

### S11 Parameter Return Loss

S22 REVERSE REFLECTION

LOG MAGNITUDE

REF = -20.000 dB

5.000 dB/DIV



CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
2.451466 GHz  
-20.669 dB

MARKER TO MAX  
MARKER TO MIN

MARKER READOUT  
FUNCTIONS

## SWR

S22 REVERSE REFLECTION

SWR

REF=1.500 U

600.000 mU/DIV



CH 1 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
2.451466 GHz  
1.208 U

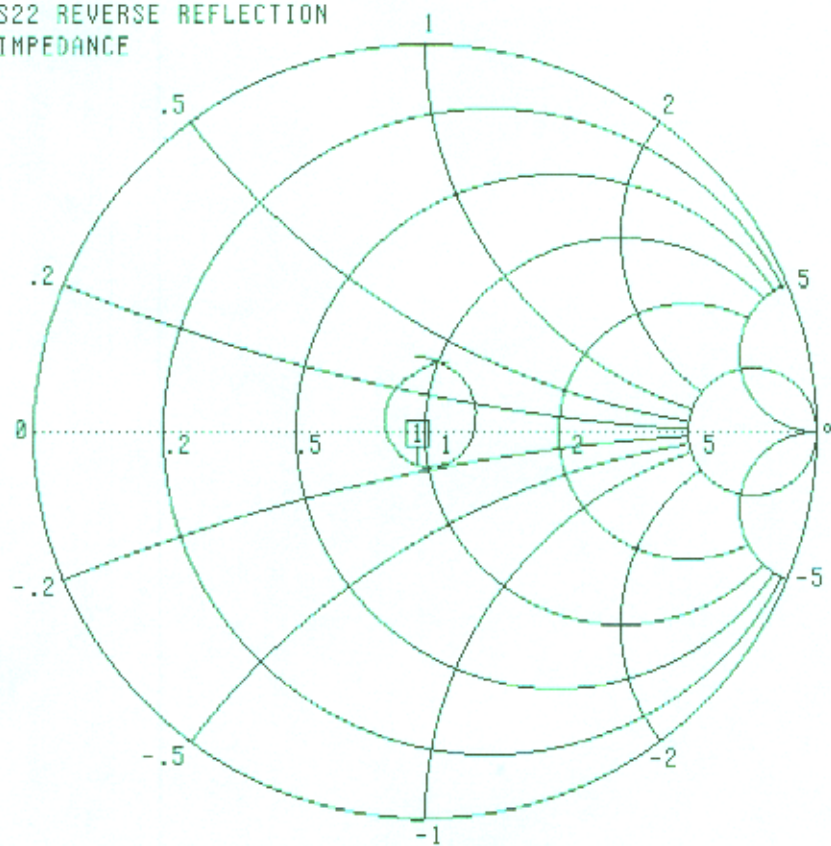
MARKER TO MAX  
MARKER TO MIN

MARKER READOUT  
FUNCTIONS



## Smith Chart Dipole Impedance

S22 REVERSE REFLECTION  
IMPEDANCE



2.299474 - 2.599236 GHz

CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

▶ MARKER 1  
2.451466 GHz  
47.685  $\Omega$   
-8.889 j $\Omega$

MARKER TO MAX  
MARKER TO MIN

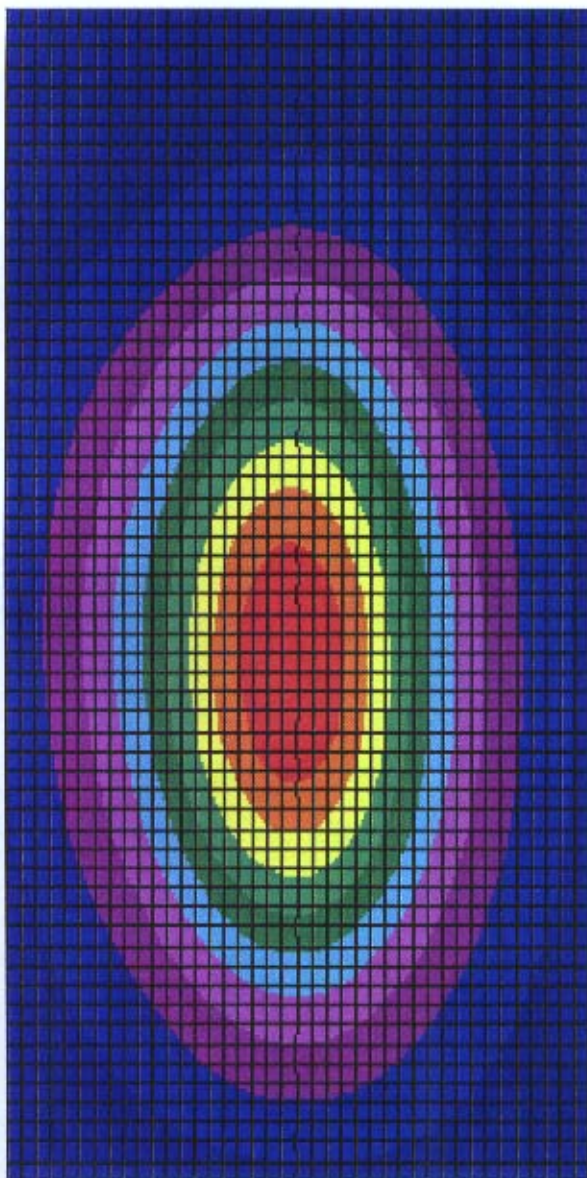
MARKER READOUT  
FUNCTIONS

*[Signature]*

*[Signature]*

System Validation Results Using the Electrically Calibrated Dipole

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



*[Signature]*

*[Signature]*

## **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



# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-825

Client: QUIETEK

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 2450 MHz

Manufacturer: APREL Laboratories

Model No.: ALS-E-020

Serial No.: 264

HEAD Calibration

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

Project No: QTKB-E-Probe-5305

Calibrated: 22<sup>nd</sup> August 2007

Released on: 4<sup>th</sup> September 2007

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

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

**NCL** CALIBRATION LABORATORIES

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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-020 264.

## References

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

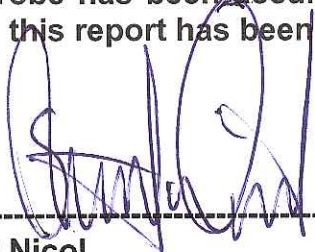
## Conditions

Probe 264 was a re-calibration.

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

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

We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.



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**Stuart Nicol**



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**J. Hones**



## **Calibration Results Summary**

<b>Probe Type:</b>	E-Field Probe E-020
<b>Serial Number:</b>	264
<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 Head Tissue**

**Frequency:** 2450 MHz

**Epsilon:** 39.2 (+/-5%)      **Sigma:** 1.80 S/m (+/-5%)

### **ConvF**

**Channel X:** 5.0

**Channel Y:** 5.0

**Channel Z:** 5.0

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

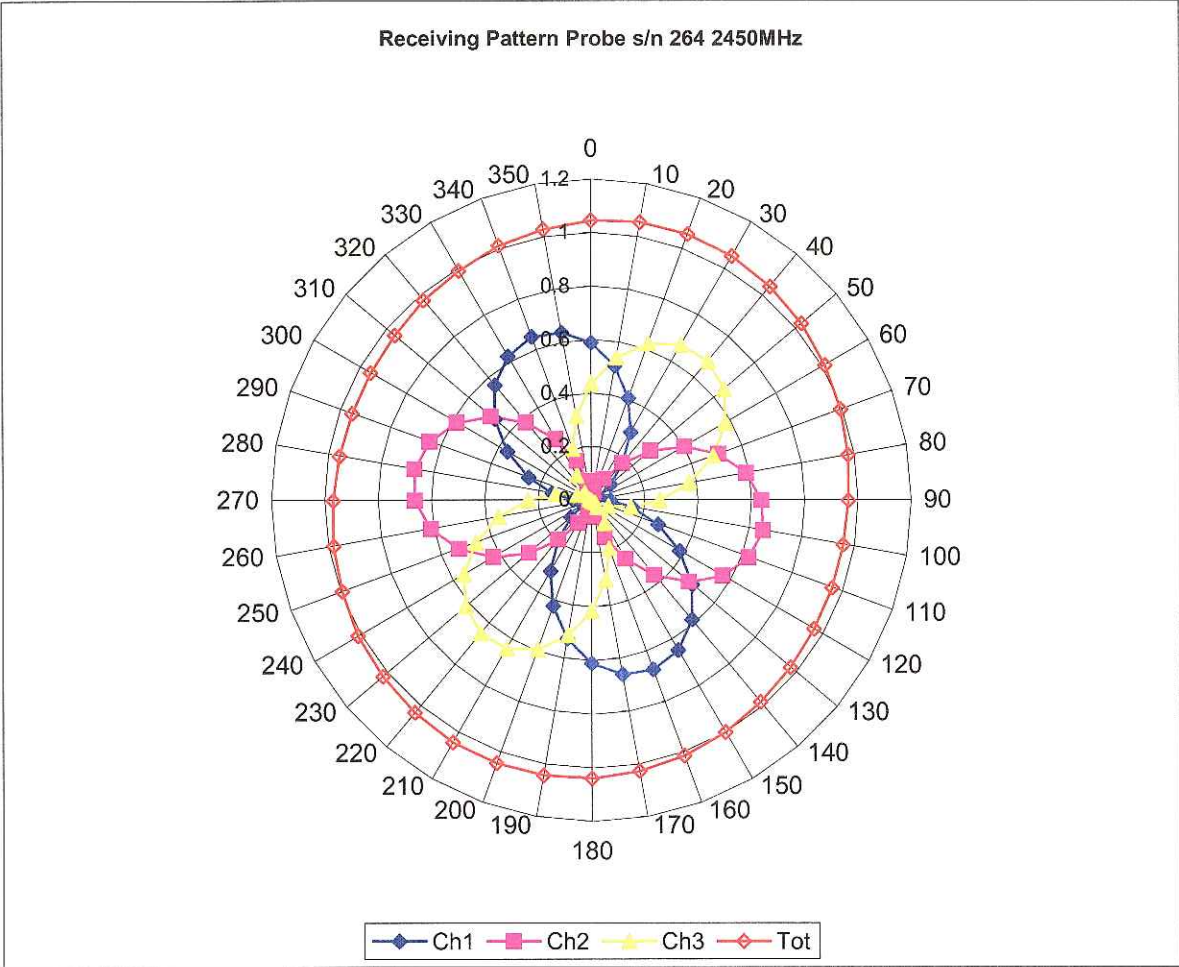
## **Boundary Effect:**

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

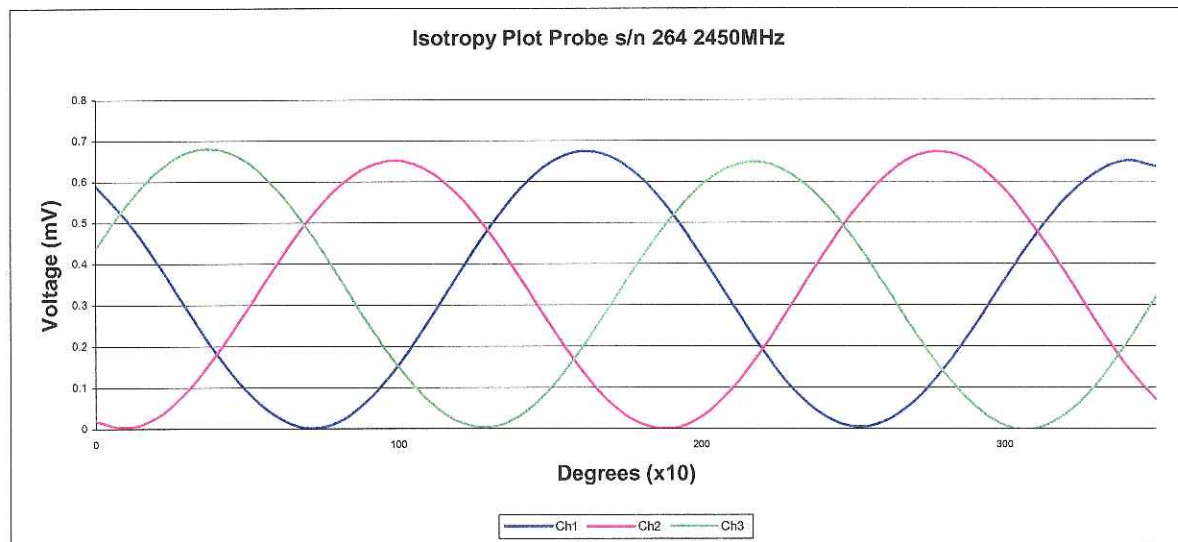
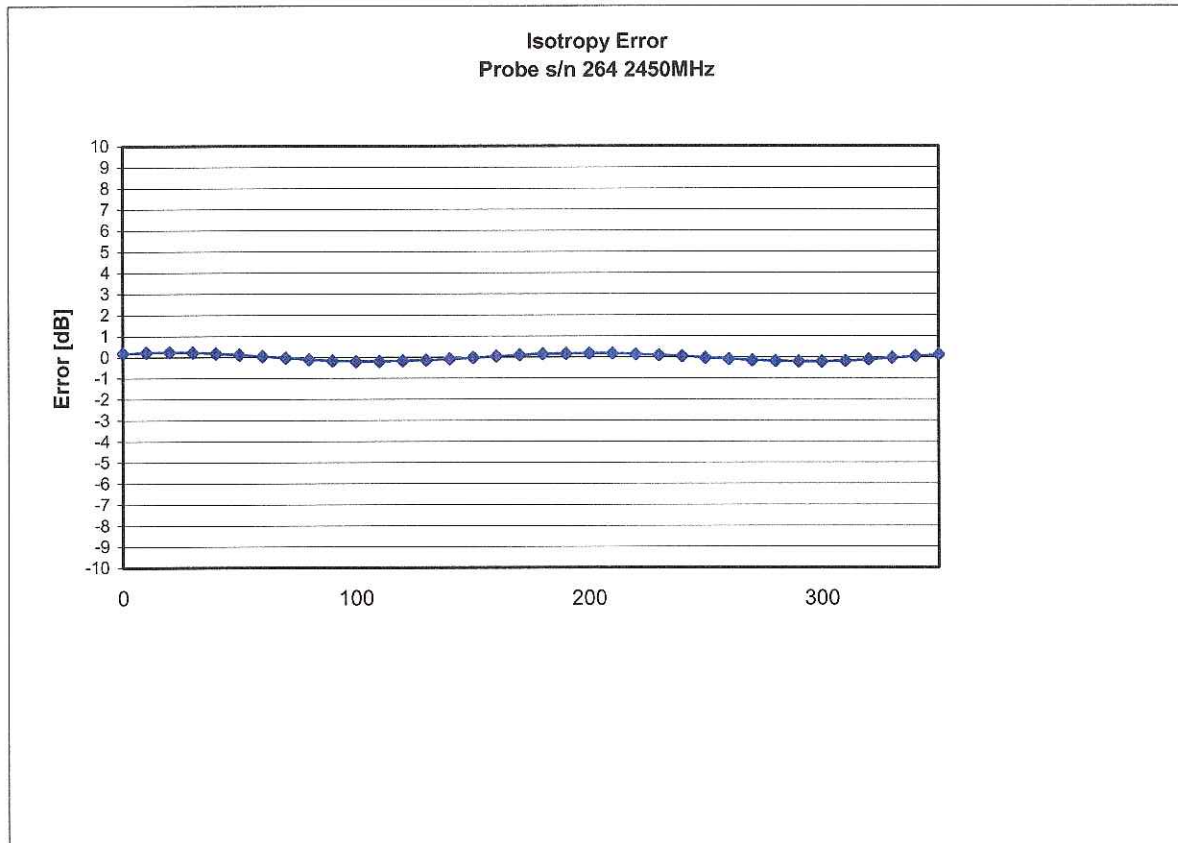
## **Spatial Resolution:**

The measured probe tip diameter is 5 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

Receiving Pattern 2450 MHz (Air)



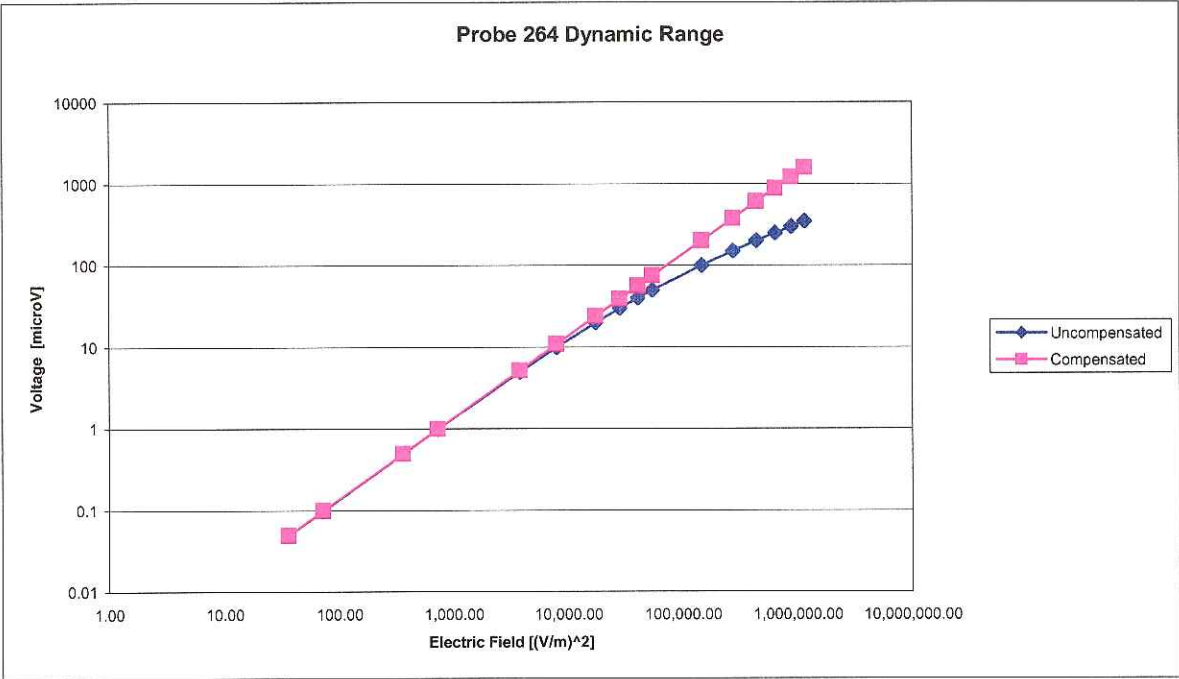
## Isotropy Error 2450 MHz (Air)



Isotropy in Tissue:

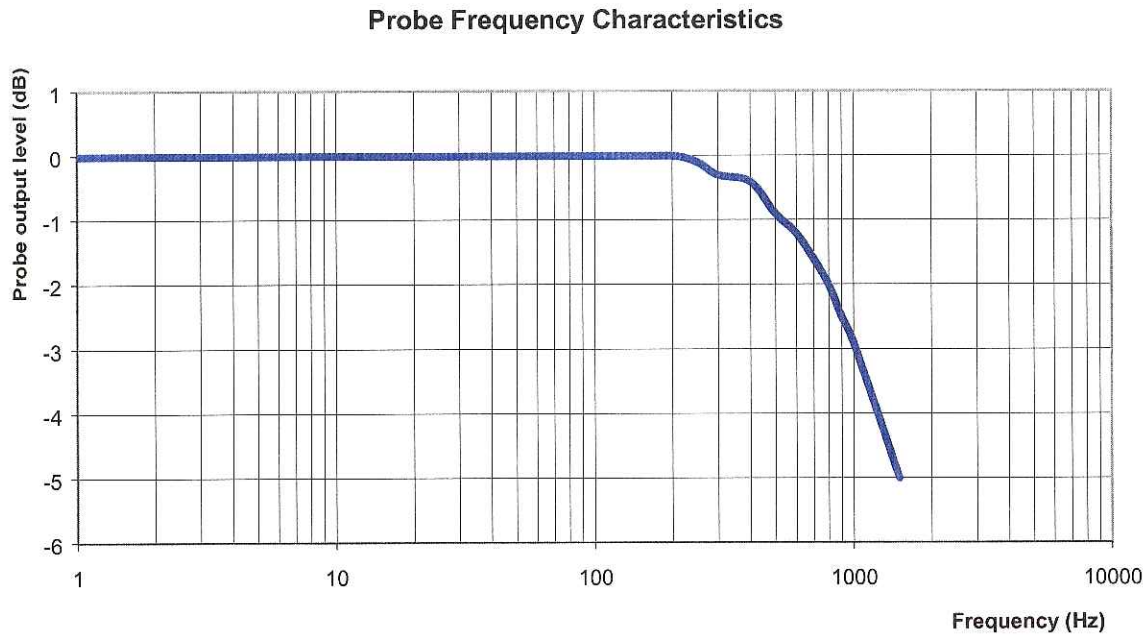
0.10 dB

Dynamic Range





**Video Bandwidth**



Video Bandwidth at 500 Hz	1 dB
Video Bandwidth at 1000 Hz	3 dB

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 2450MHz

**Epsilon:** 39.2 (+/-5%)      **Sigma:** 1.80 S/m (+/-5%)

### **ConvF**

**Channel X:** 5.0      7%(K=2)

**Channel Y:** 5.0      7%(K=2)

**Channel Z:** 5.0      7%(K=2)

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

### **Boundary Effect:**

For a distance of 2.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2007.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-832

Client: QUIETEK

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 2450 MHz

Manufacturer: APREL Laboratories

Model No.: ALS-E-020

Serial No.: 264

BODY Calibration

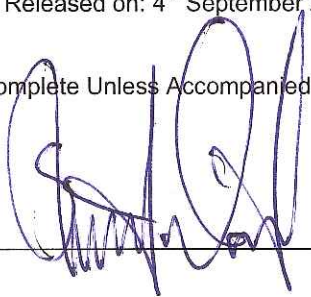
Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: QTKB-E-Probe-5305

Calibrated: 21<sup>st</sup> August 2007  
Released on: 4<sup>th</sup> September 2007

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

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



**NCL** CALIBRATION LABORATORIES

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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-020 264.

## References

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

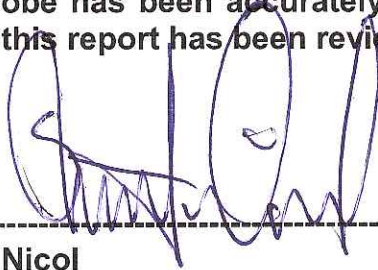
## Conditions

Probe 264 was a re-calibration.

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

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

**We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**



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**Stuart Nicol**



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**J. Hones**



## **Calibration Results Summary**

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

\*Resistive to recommended tissue recipes per IEEE-1528

## **Sensitivity in Air**

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

## **Sensitivity in Body Tissue**

**Frequency:** 2450 MHz

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

### **ConvF**

**Channel X:** 5.2

**Channel Y:** 5.2

**Channel Z:** 5.2

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

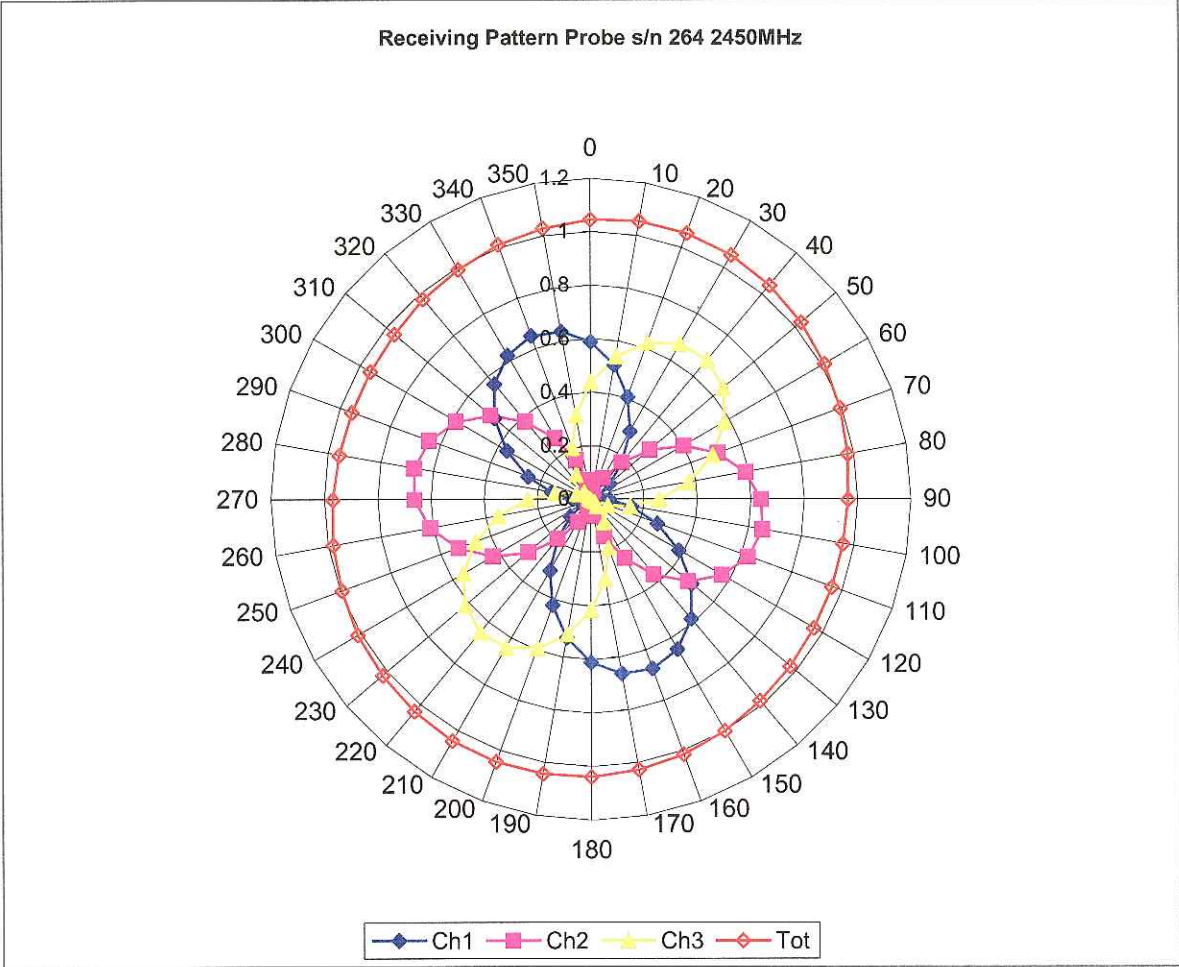
## **Boundary Effect:**

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

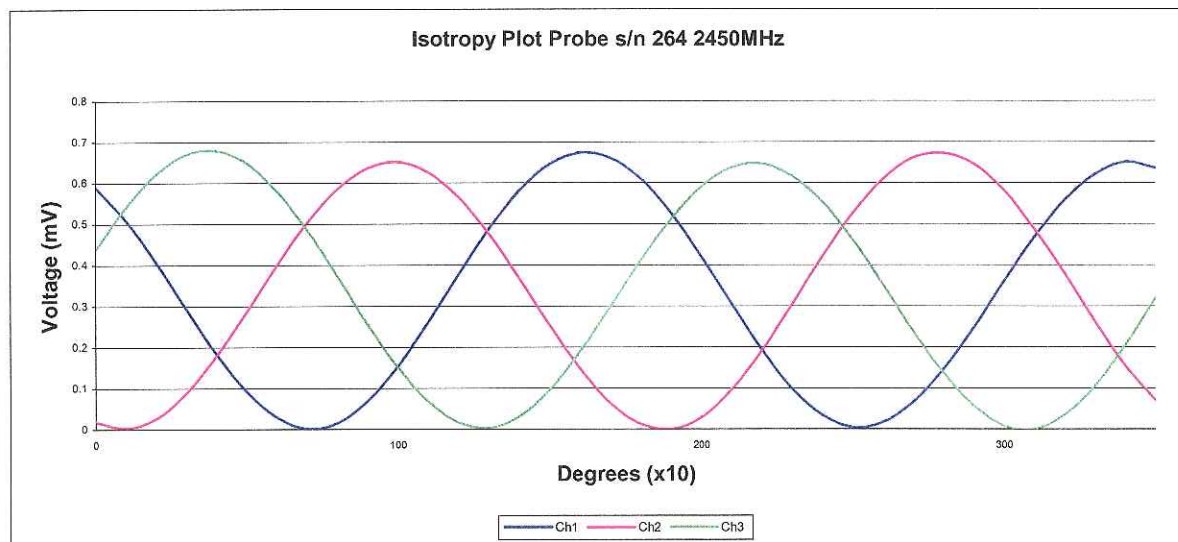
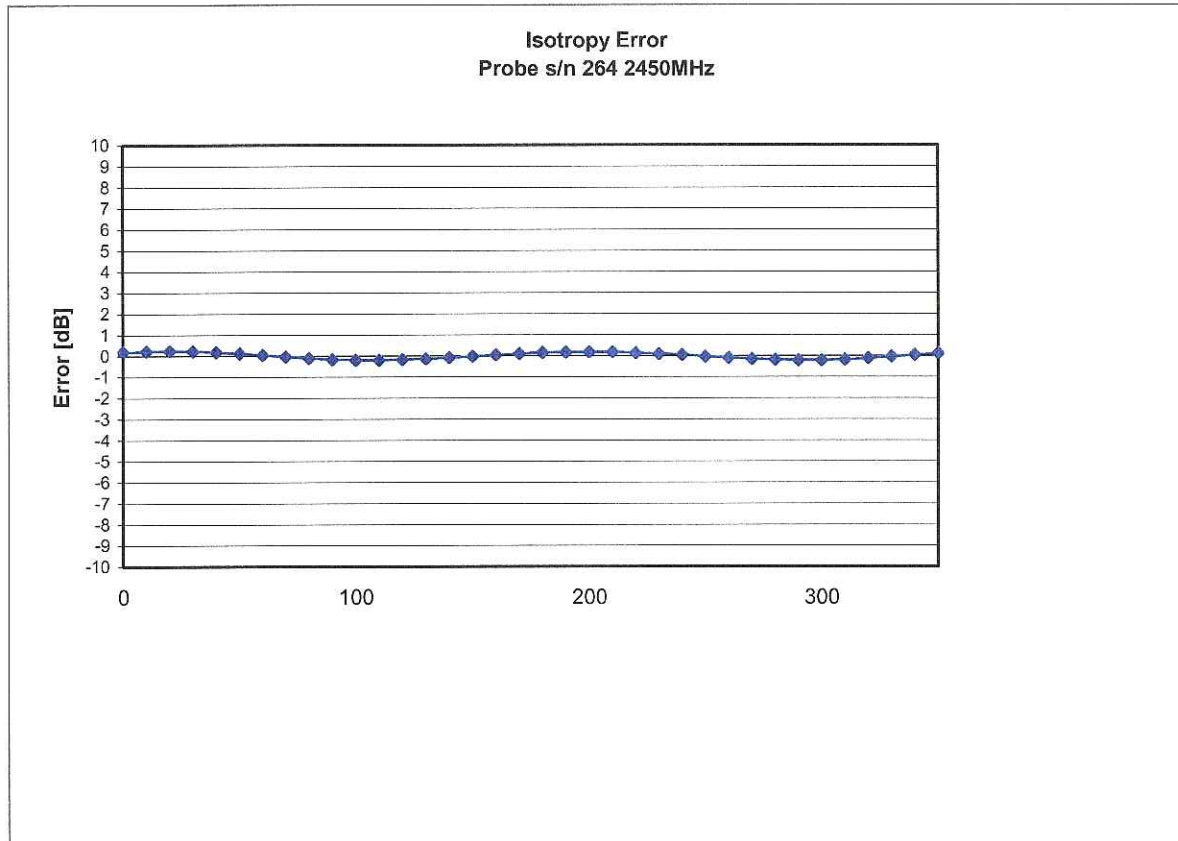
## **Spatial Resolution:**

The measured probe tip diameter is 5 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

Receiving Pattern 2450 MHz (Air)



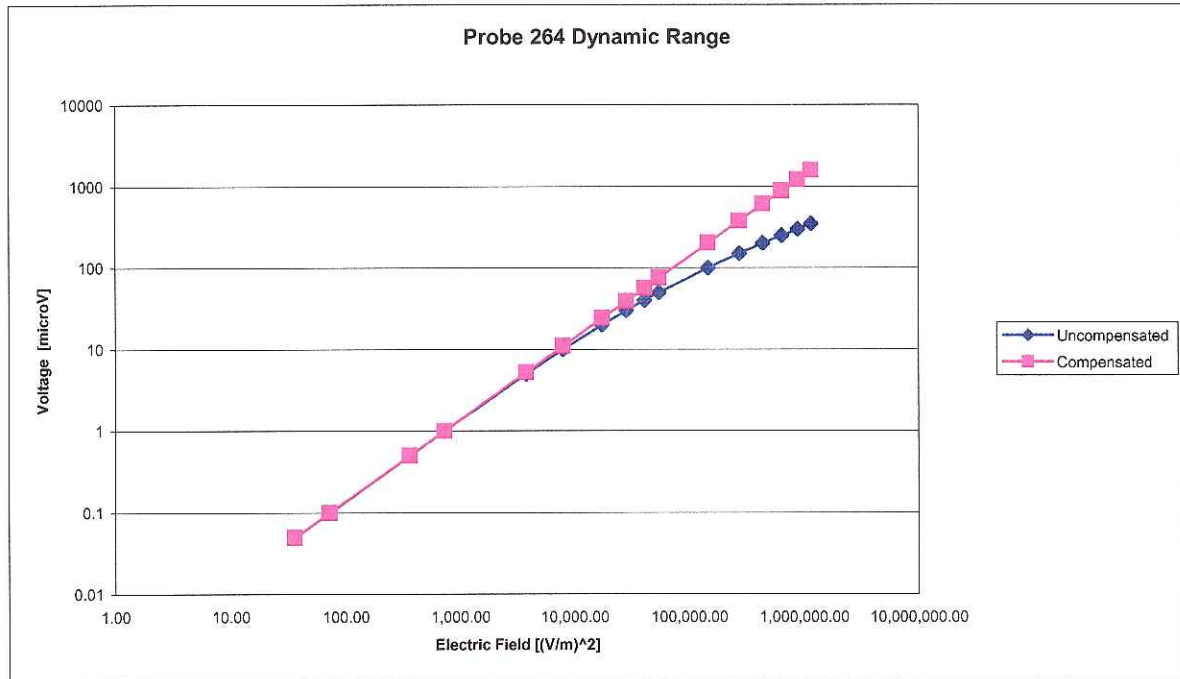
## Isotropy Error 2450 MHz (Air)



Isotropy in Tissue:

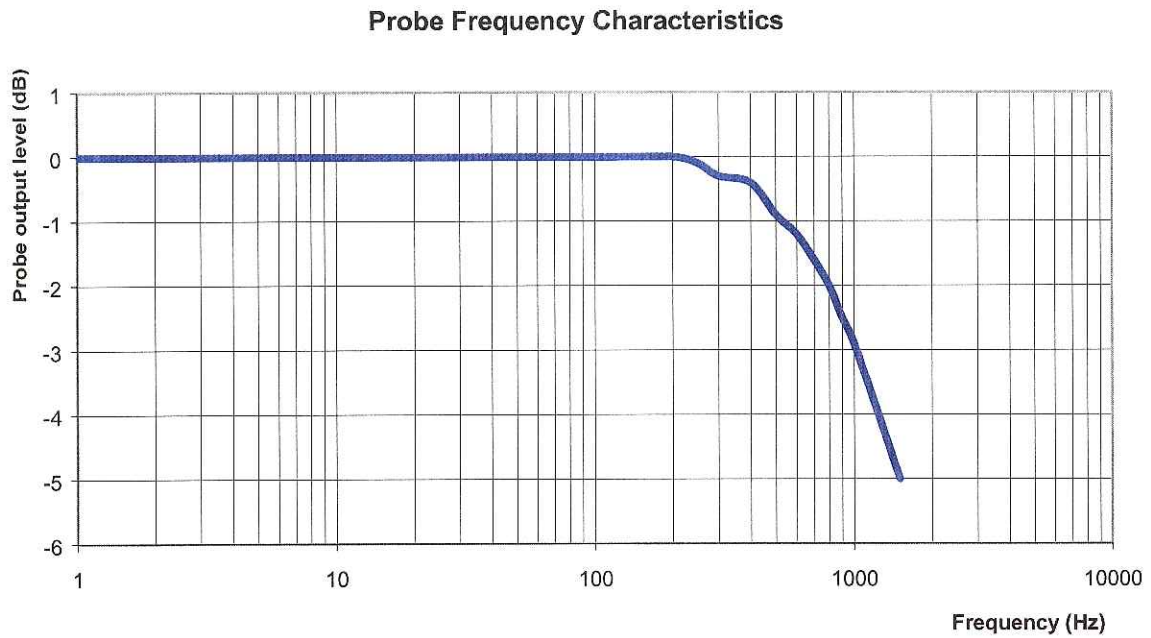
0.10 dB

## Dynamic Range





## Video Bandwidth



<b>Video Bandwidth at 500 Hz</b>	<b>1 dB</b>
<b>Video Bandwidth at 1000 Hz</b>	<b>3 dB</b>

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 2450MHz

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

### **ConvF**

**Channel X:** 5.2 7%(K=2)

**Channel Y:** 5.2 7%(K=2)

**Channel Z:** 5.2 7%(K=2)

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

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For a distance of 2.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

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