

# NCL CALIBRATION LABORATORIES

Calibration File No.: 1364-1375

Client.: IAC

## 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

Record of Calibration

Head and Body

Manufacturer: APREL Laboratories

**Model No.:** E-020

**Serial No.:** 500-00273

**Calibration Procedure:** D01-032-E020-V2, D22-012-Tissue, D28-002-Dipole

**Project No:** ISL-E020-5612

**Calibrated:** 1<sup>st</sup> October 2011

**Released on:** 5<sup>th</sup> October 2011

**Approved By:** Stuart Nicol

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

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

**NCL** CALIBRATION LABORATORIES

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Division of APREL  
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## Introduction

This Calibration Report reproduces the results of the calibration performed in line with the references listed below. Calibration is performed using accepted methodologies as per the references listed below. Probes are calibrated for air, and tissue and the values reported are the results from the physical quantification of the probe through meteorological practices.

## Calibration Method

Probes are calibrated using the following methods.

<1000MHz

TEM Cell for sensitivity in air

Standard phantom using temperature transfer method for sensitivity in tissue

>1000MHz

Waveguide\* method to determine sensitivity in air and tissue

\*Waveguide is numerically (simulation) assessed to determine the field distribution and power

The boundary effect for the probe is assessed using a standard flat phantom where the probe output is compared against a numerically simulated series of data points

## References

- IEEE Standard 1528 (2003) including Amendment 1  
IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1 (2006)  
Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures-Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2 Ed. 1.0 (2010-03)  
Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- TP-D01-032-E020-V2 E-Field probe calibration procedure
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

# NCL Calibration Laboratories

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## Conditions

Probe 500-00273 was a recalibration.

\*\*The probe was received in good working order, although at 1900MHz the uncertainty was higher than our standard (see note\*\*)

**Ambient Temperature of the Laboratory:** 22 °C +/- 1.5°C  
**Temperature of the Tissue:** 21 °C +/- 1.5°C  
**Relative Humidity:** < 60%

## Primary Measurement Standards

Instrument	Serial Number	Cal due date
Power meter Anritsu MA2408A	90025437	Nov.4, 2011
Power Sensor Anritsu MA2481D	103555	Nov 4, 2011
Attenuator HP 8495A (70dB)	1944A10711	Sept. 14, 2011
Network Analyzer Anritsu MT8801C	MB11855	Feb. 8, 2012

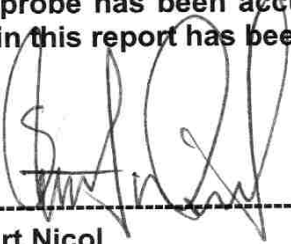
## Secondary Measurement Standards

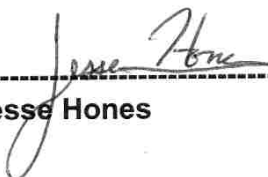
Signal Generator Agilent E4438C -506 MY55182336 June 7, 2012

## Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

**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**

**Probe Summary**

<b>Probe Type:</b>	E-Field Probe E020
<b>Serial Number:</b>	500-00273
<b>Frequency:</b>	As presented on page 5
<b>Sensor Offset:</b>	1.56
<b>Sensor Length:</b>	2.5
<b>Tip Enclosure:</b>	Composite*
<b>Tip Diameter:</b>	< 2.9 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

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## Calibration for Tissue (Head H, Body B)

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Calibration Uncertainty	Tolerance Uncertainty for 5%*	Conversion Factor
450 H	Head	X	X	X	X	X
450 B	Body	X	X	X	X	X
750 H	Head	X	X	X	X	X
750 B	Body	X	X	X	X	X
<b>850 H</b>	<b>Head</b>	<b>42.86</b>	<b>0.95</b>	<b>3.5</b>	<b>3.4</b>	<b>6.5</b>
<b>850 B</b>	<b>Body</b>	<b>53.71</b>	<b>1.04</b>	<b>3.5</b>	<b>3.4</b>	<b>6.4</b>
<b>900 H</b>	<b>Head</b>	<b>41.5</b>	<b>0.99</b>	<b>3.5</b>	<b>3.4</b>	<b>6.1</b>
<b>900 B</b>	<b>Body</b>	<b>53.25</b>	<b>1.04</b>	<b>3.5</b>	<b>3.4</b>	<b>6.3</b>
1450 H	Head	X	X	X	X	X
1450 B	Body	X	X	X	X	X
1500 H	Head	X	X	X	X	X
1500 B	Body	X	X	X	X	X
1640 H	Head	X	X	X	X	X
1640 B	Body	X	X	X	X	X
1750 H	Head	X	X	X	X	X
1750 B	Body	X	X	X	X	X
<b>1800 H</b>	<b>Head</b>	<b>36.85</b>	<b>1.35</b>	<b>3.5</b>	<b>2.7</b>	<b>5.5</b>
<b>1800 B</b>	<b>Body</b>	<b>52.38</b>	<b>1.5</b>	<b>3.5</b>	<b>2.7</b>	<b>5.4</b>
<b>1900 H</b>	<b>Head</b>	<b>38.21</b>	<b>1.46</b>	<b>3.5</b>	<b>2.7</b>	<b>5.7</b>
<b>1900 B</b>	<b>Body</b>	<b>52.1</b>	<b>1.59</b>	<b>3.5</b>	<b>2.7</b>	<b>5.4</b>
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
<b>2100 H</b>	<b>Head</b>	<b>39.8</b>	<b>1.49</b>	<b>3.5</b>	<b>2.9</b>	<b>5.0</b>
<b>2100 B</b>	<b>Body</b>	<b>53.0</b>	<b>1.58</b>	<b>3.5</b>	<b>2.9</b>	<b>4.9</b>
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
<b>2450 H</b>	<b>Head</b>	<b>38.2</b>	<b>1.84</b>	<b>3.5</b>	<b>3.5</b>	<b>4.65</b>
<b>2450B</b>	<b>Body</b>	<b>50.63</b>	<b>1.99</b>	<b>3.5</b>	<b>3.5</b>	<b>4.4</b>
2600 H	Head	X	X	X	X	X
2600 B	Body	X	X	X	X	X
3000 H	Head	X	X	X	X	X
3000 B	Body	X	X	X	X	X
3600 H	Head	X	X	X	X	X
3600 B	Body	X	X	X	X	X
5200 H	Head	X	X	X	X	X
5200 B	Body	X	X	X	X	X
5600 H	Head	X	X	X	X	X
5600 B	Body	X	X	X	X	X
5800 H	Head	X	X	X	X	X
5800 B	Body	X	X	X	X	X

### **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 spatial resolution uncertainty is less than 1.5% for 4.9mm diameter probe.  
The spatial resolution uncertainty is less than 1.0% for 2.5mm diameter probe.

### **DAQ-PAQ Contribution**

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 0.58mm the worst case evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

### **NOTES:**

\*The maximum deviation from the centre frequency when comparing the lower to upper range is listed.

\*\*1800MHz Head was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.

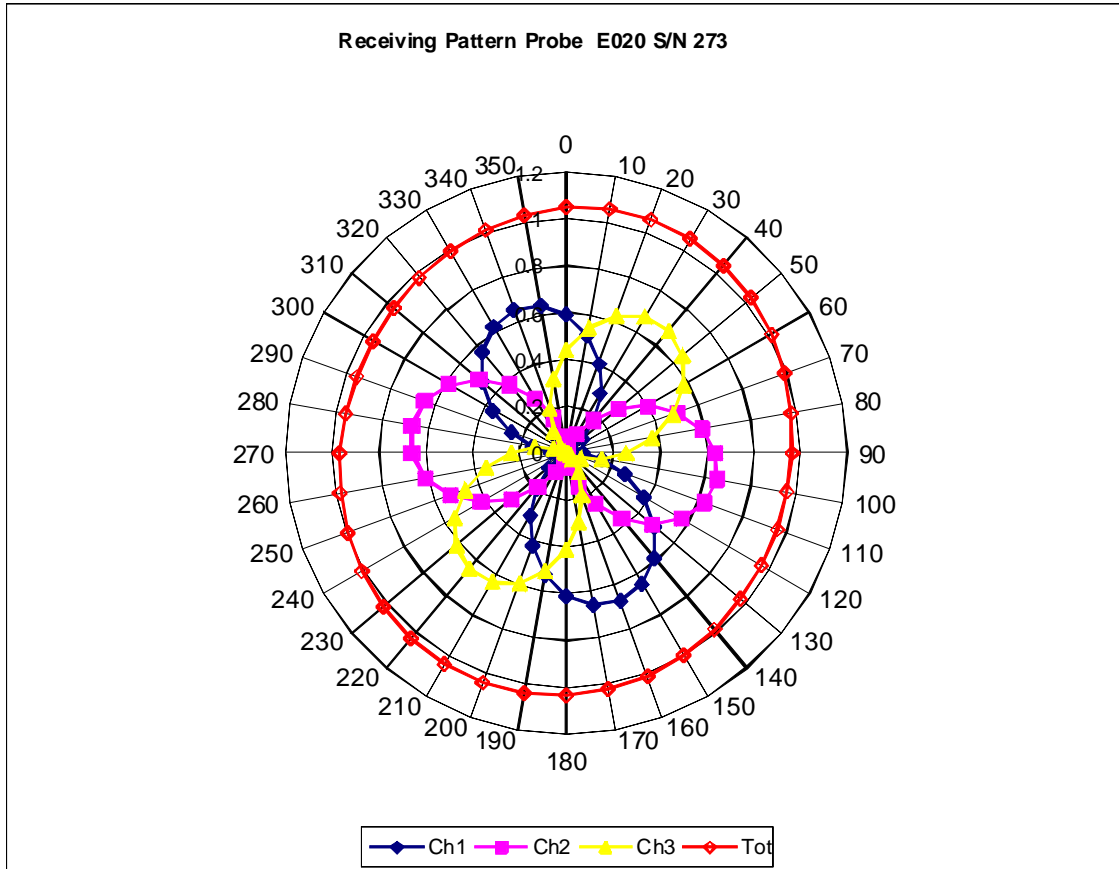
\*\*\*1800MHz Body was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.

\*\*\*\*1900MHz Body was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.

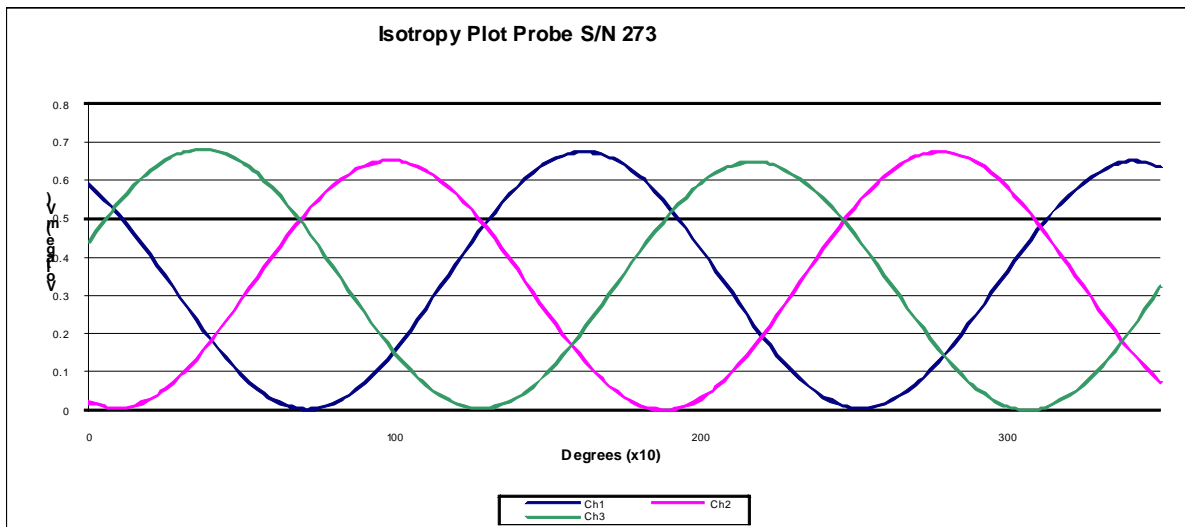
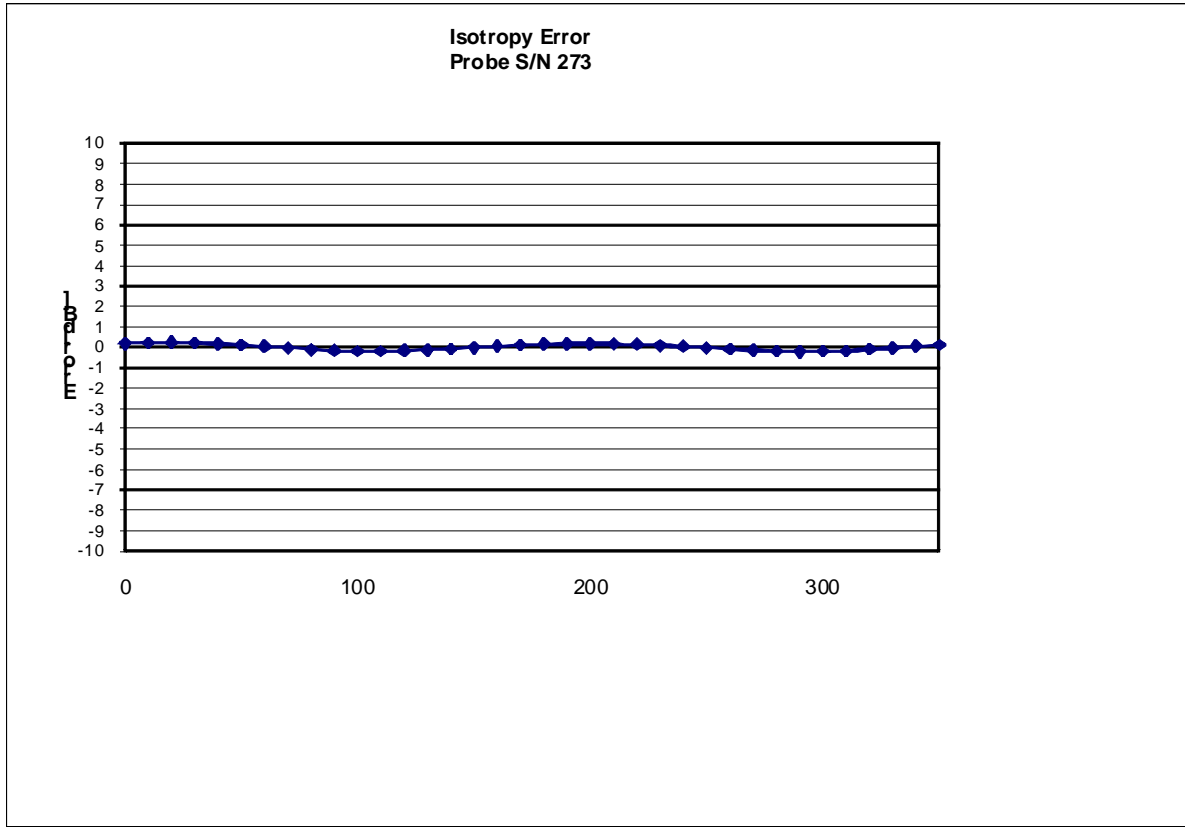
\*\*\*\*\*2450MHz Head was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.

\*\*\*\*\*2450MHz Body was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.

## Receiving Pattern Air



### Isotropy Error Air

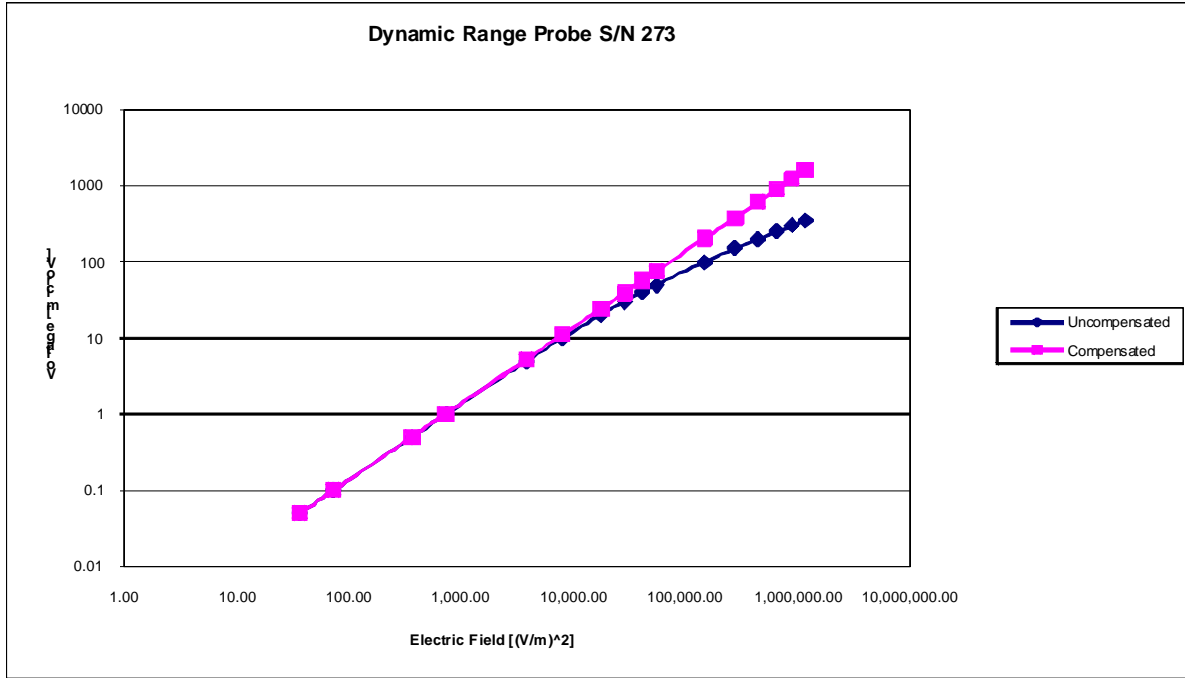


Isotropicity Tissue:

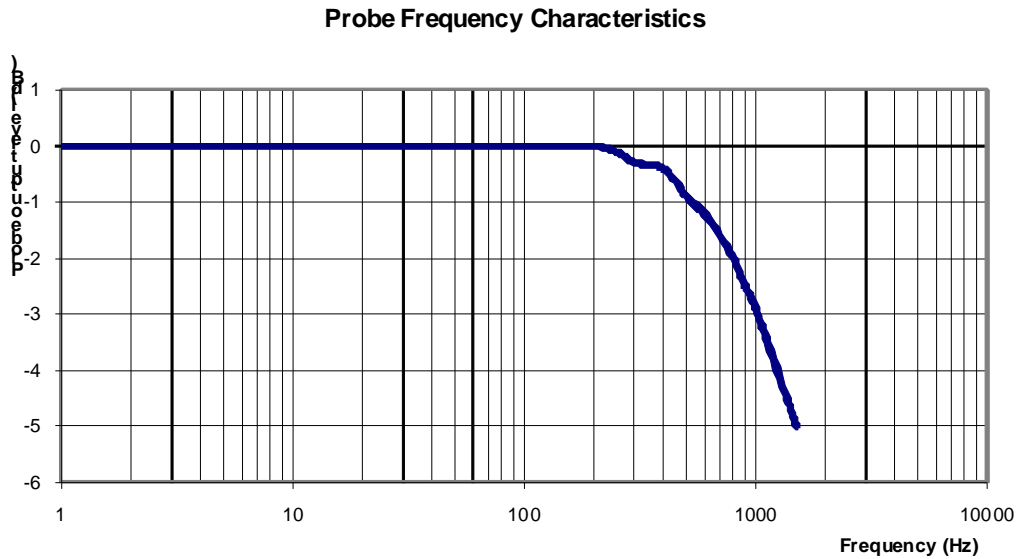
0.10 dB



## Dynamic Range



## Video Bandwidth



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

### 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 2011.