NCL CALIBRATION LABORATORIES

Calibration File No.: 1364-1375

Client.: IAC

C E R T I F I C A T E OF 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.

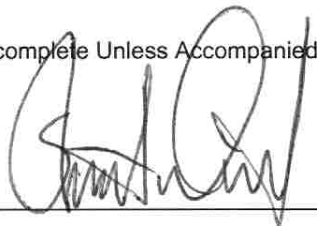
Equipment: Miniature Isotropic RF Probe
Record of Calibration
Head and Body
Manufacturer: APREL Laboratories
Model No.: E-020
Serial No.: 500-00273

Calibration Procedure: D01-032-E020-V2, D22-012-Tissue, D28-002-Dipole
Project No: ISL-E020-5612

Calibrated: 1st October 2011
Released on: 5th October 2011

Approved By: Stuart Nicol

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

Released By: 

NCL CALIBRATION LABORATORIES
303 Terry Fox Drive, Suite 102
Kanata, Ontario
CANADA K2K 3J1
Division of APREL
TEL: (613) 435-8300
FAX: (613) 435-8306

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 meteorgical 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

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.

Stuart Nicol

Jesse Hones

Probe Summary

Probe Type:	E-Field Probe E020
Serial Number:	500-00273
Frequency:	As presented on page 5
Sensor Offset:	1.56
Sensor Length:	2.5
Tip Enclosure:	Composite*
Tip Diameter:	< 2.9 mm
Tip Length:	55 mm
Total Length:	289 mm

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	1.2 μV/(V/m)^2
Channel Y:	1.2 μV/(V/m)^2
Channel Z:	1.2 μV/(V/m)^2
Diode Compression Point:	95 mV

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
850 H	**Head**	**42.86**	**0.95**	**3.5**	**3.4**	**6.5**
850 B	**Body**	**53.71**	**1.04**	**3.5**	**3.4**	**6.4**
900 H	**Head**	**41.5**	**0.99**	**3.5**	**3.4**	**6.1**
900 B	**Body**	**53.25**	**1.04**	**3.5**	**3.4**	**6.3**
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
1800 H	**Head**	**36.85**	**1.35**	**3.5**	**2.7**	**5.5**
1800 B	**Body**	**52.38**	**1.5**	**3.5**	**2.7**	**5.4**
1900 H	**Head**	**38.21**	**1.46**	**3.5**	**2.7**	**5.7**
1900 B	**Body**	**52.1**	**1.59**	**3.5**	**2.7**	**5.4**
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
2100 H	**Head**	**39.8**	**1.49**	**3.5**	**2.9**	**5.0**
2100 B	**Body**	**53.0**	**1.58**	**3.5**	**2.9**	**4.9**
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
2450 H	**Head**	**38.2**	**1.84**	**3.5**	**3.5**	**4.65**
2450B	**Body**	**50.63**	**1.99**	**3.5**	**3.5**	**4.4**
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 MΩ.

Boundary Effect:

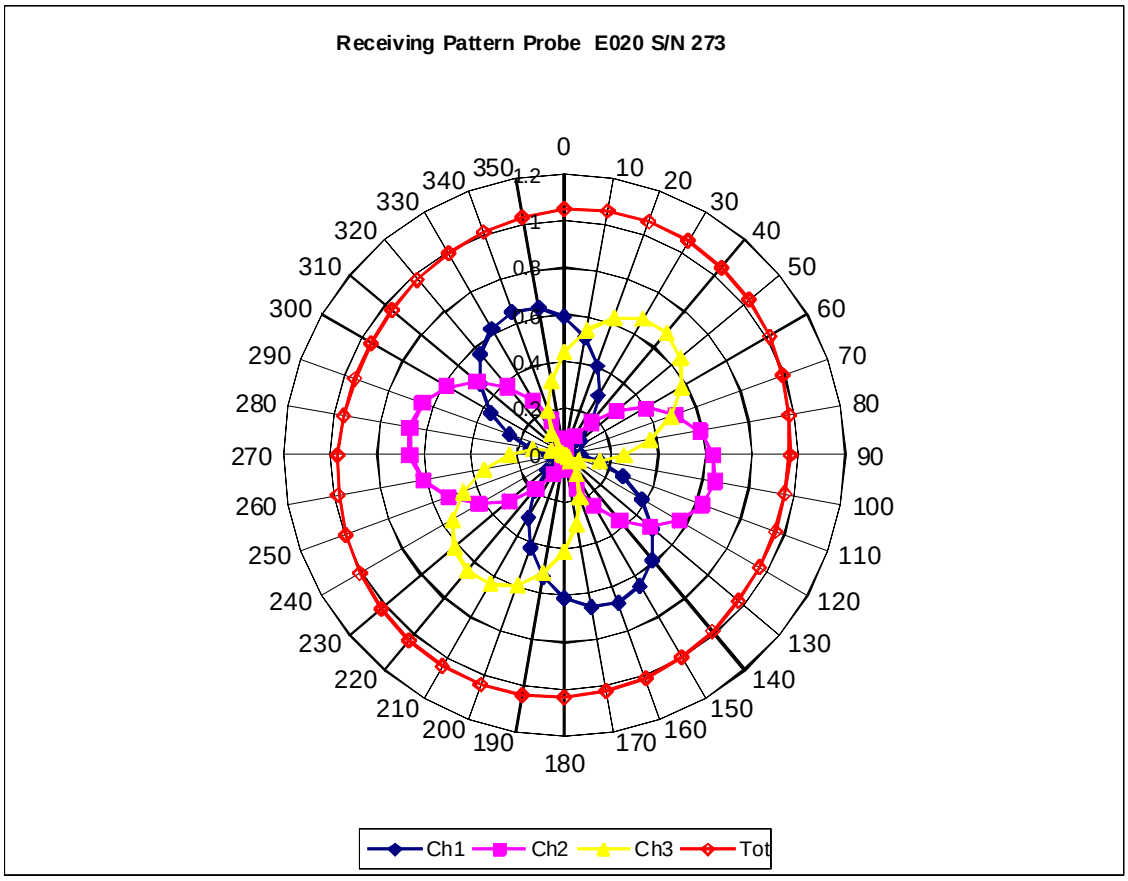
For a distance of 0.58mm the worst case evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

NOTES:

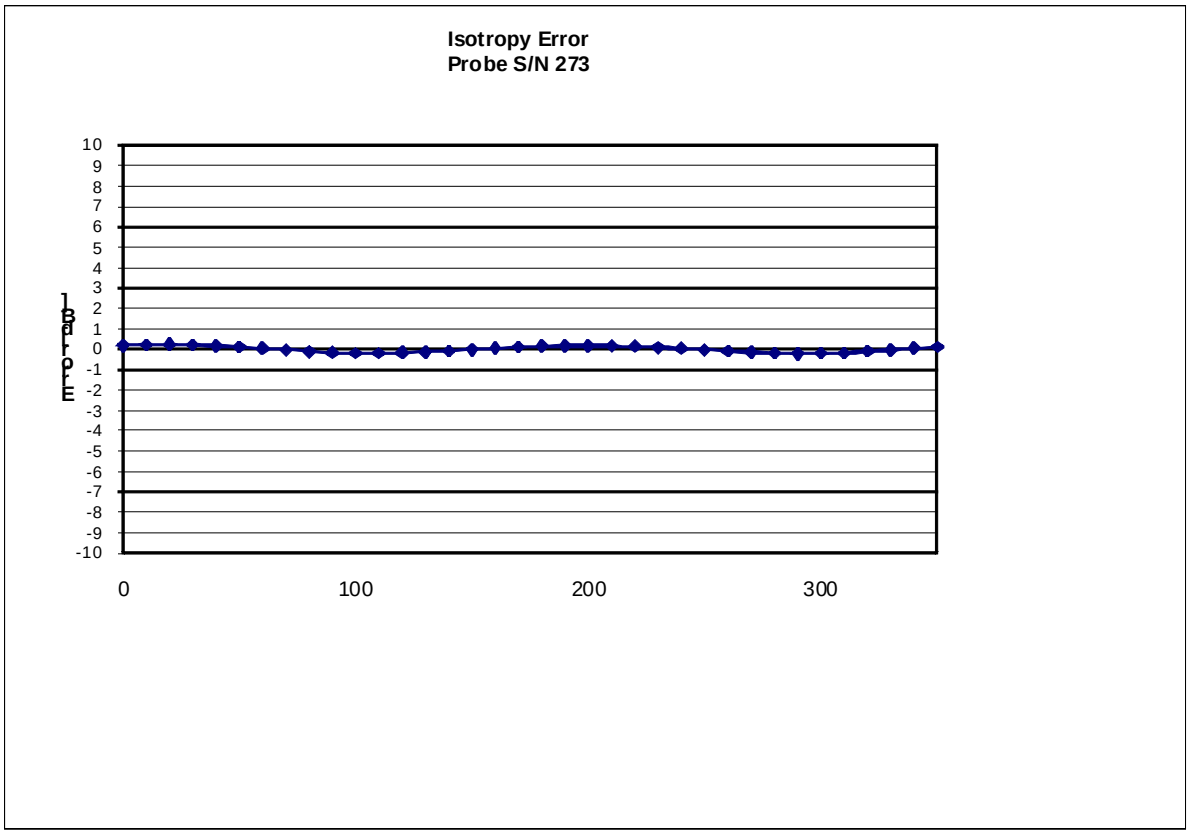
*The maximum deviation from the centre frequency when comparing the lower to upper range is listed.

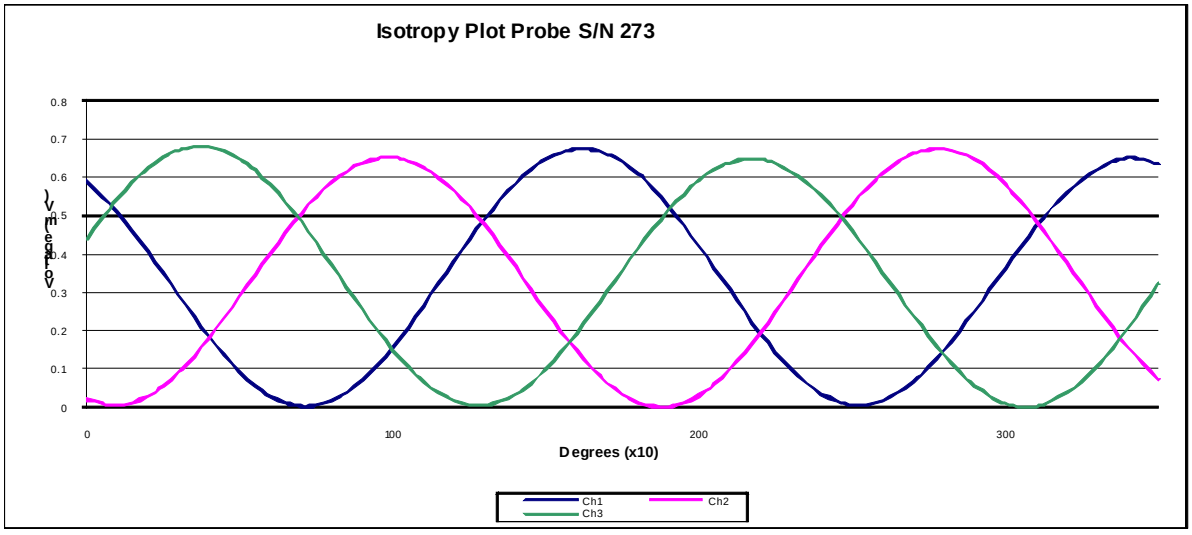
**1800MHz Head was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.
***1800MHz Body was evaluated at close to the 10% allowable deviation; the deviation has now been normalized to within 2%.
****1900MHz Body was evaluated at close to the 10% allowable 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



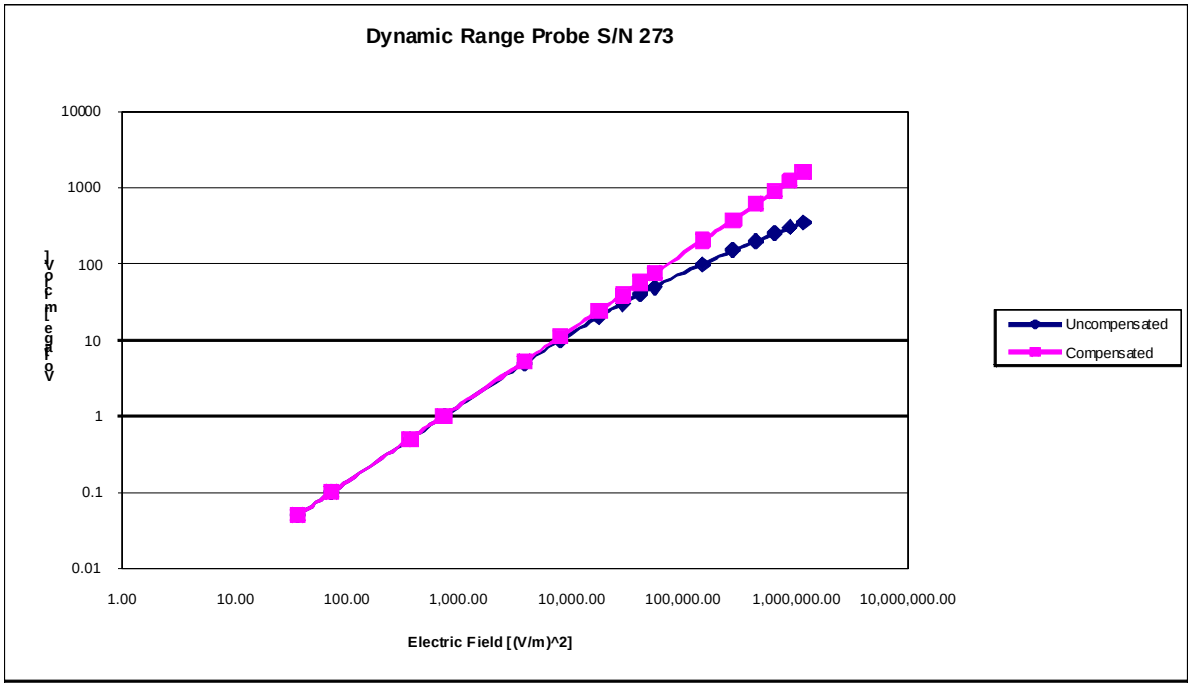
Isotropy Error Air



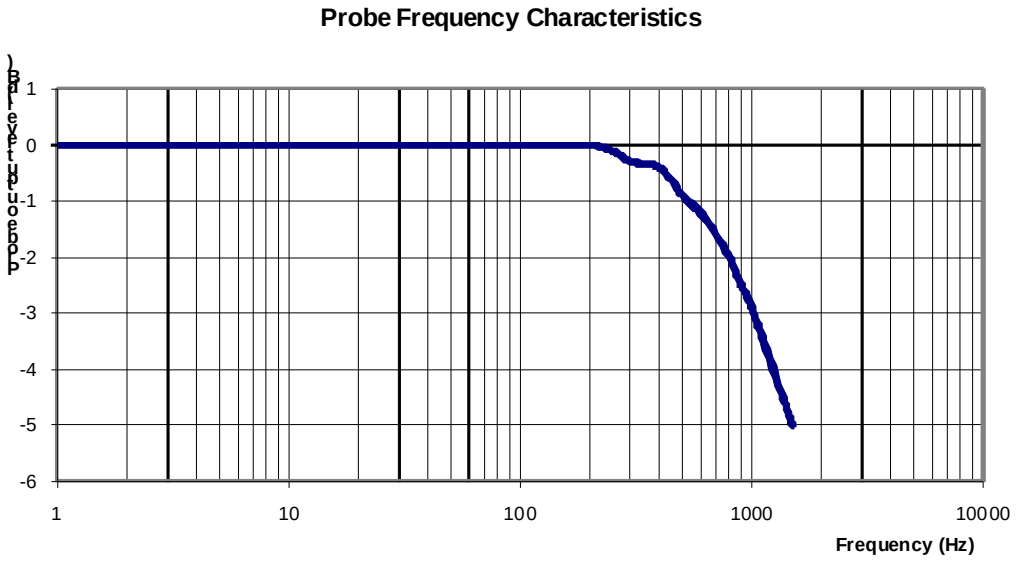


Isotropicity Tissue: 0.10 dB

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.

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1217/18
Project Number: SGL-IAC-DC-5582-93

C E R T I F I C A T E OF 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
835MHz Head & Body

Manufacturer: APREL Laboratories
Part number: ALS-D-835-S-2
Frequency: 835MHz
Serial No: 180-00556

Customer: IAC

Calibrated: 17th May 2011
Released on: 27th May 2011

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

Released By: _____

NCL CALIBRATION LABORATORIES
303 Terry Fox Drive, Suite 102
Kanata, Ontario
CANADA K2K 3J1
Division of APREL
TEL: (613) 435-8300
FAX: (613) 435-8306

Conditions

Dipole 180-00556 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 device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.

Stuart Nicol

C. Teodorian

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Power meter Anritsu MA2408A	90025437	Nov.4, 2010
Power Sensor Anritsu MA2481D	103555	Nov 4, 2010
Attenuator HP 8495A (70dB)	1944A10711	Sept. 14, 2010
Network Analyzer Anritsu MT8801C	MB11855	Feb. 8, 2011

Secondary Measurement Standards

Signal Generator Agilent E4438C -506	MY55182336	June 7, 2011

This page has been reviewed for content and attested to by signature within this document.

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

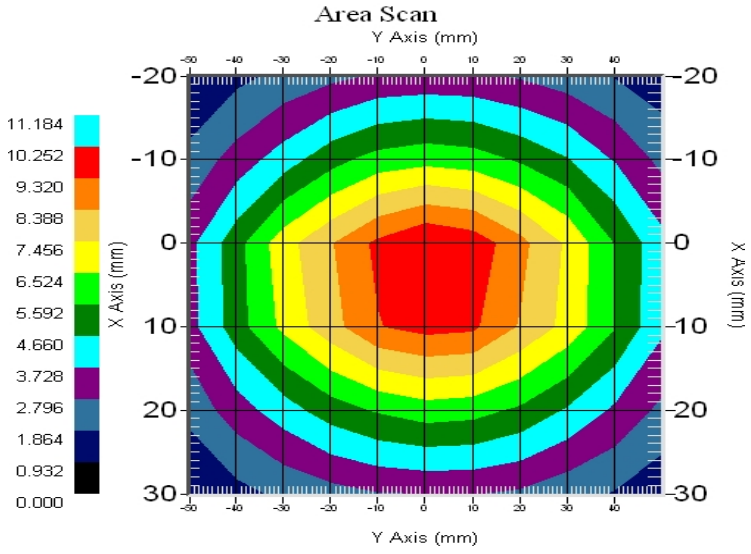
Electrical Specification 835MHz

Tissue Type	Return Loss:	Impedance:	SWR:
Head	-26.655	51.666	1.102U
Body	-22.106	57.482	1.177U

System Validation Results

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	835 MHz	9.590	6.003	15.013
Body	835 MHz	9.981	6.006	15.013

835MHz



This page has been reviewed for content and attested to by signature within this document.

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 180-00556. 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

- 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

Conditions

Dipole 180-00556 was a re-calibration.

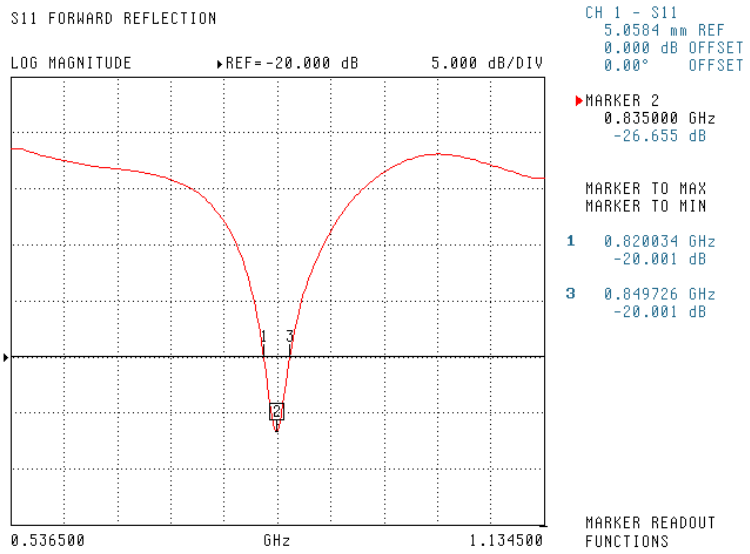
Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 20 °C +/- 0.5°C

Electrical Calibration

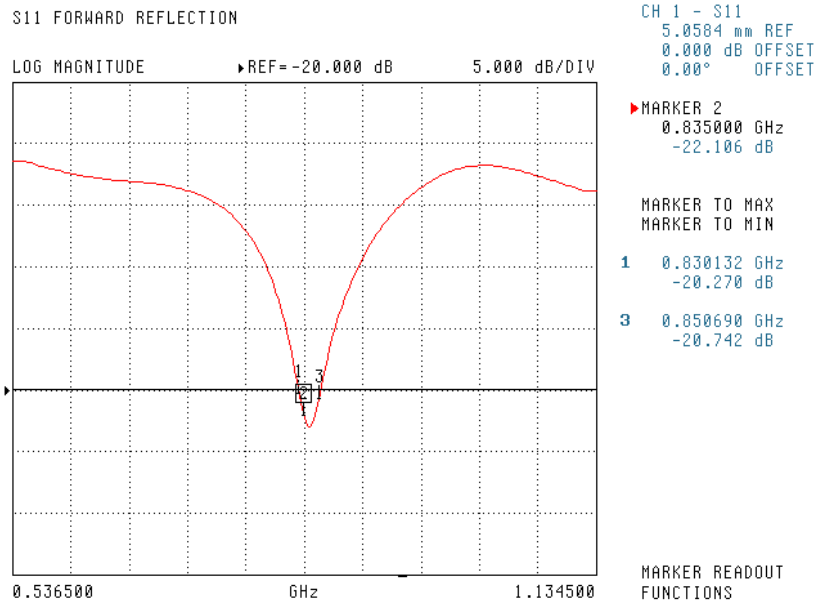
Electrical Specification 835MHz

Tissue Type	Measured Epsilon	Measured Sigma
Head	41.09	0.89
Body	53.15	0.95

Head Tissue



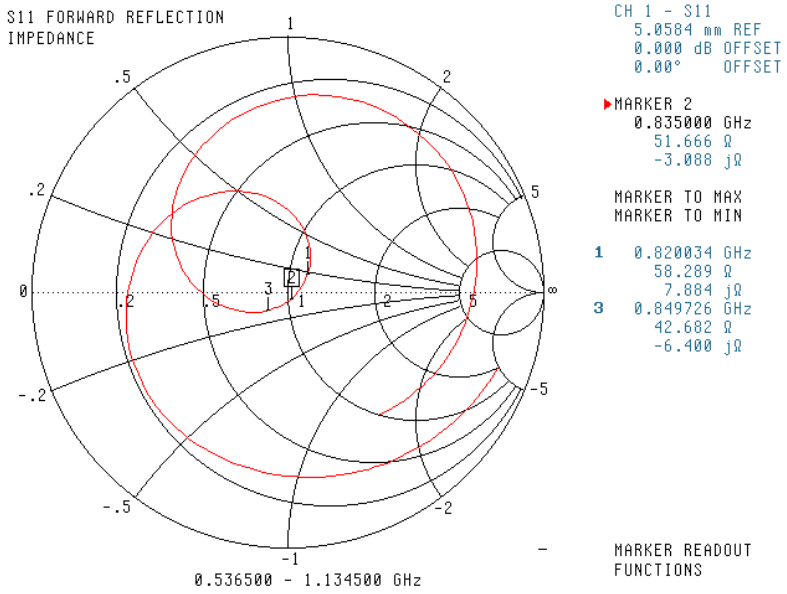
Body Tissue



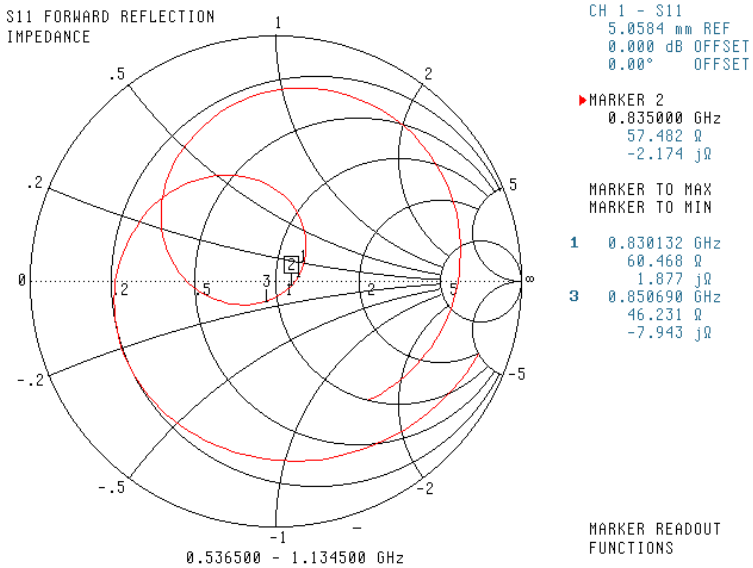
Electrical Specification 835MHz
Impedance

Tissue Type	Measured Epsilon	Measured Sigma
Head	41.09	0.89
Body	53.15	0.95

Head Tissue



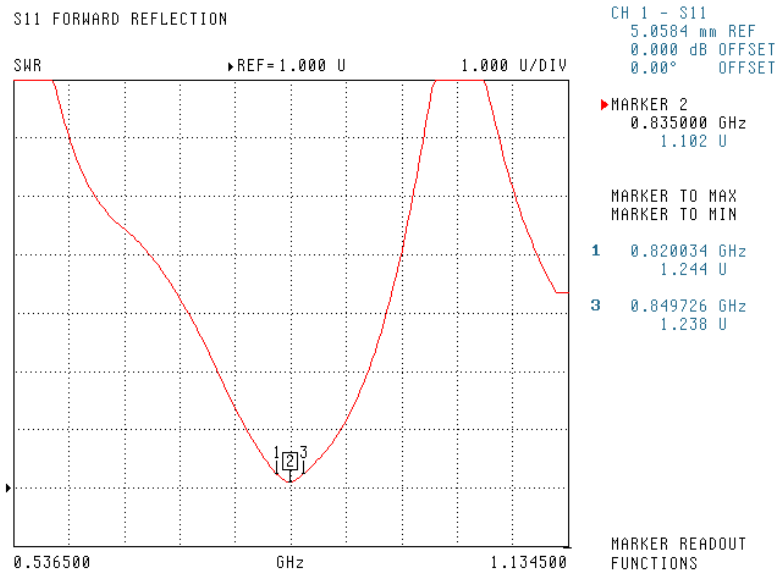
Body Tissue



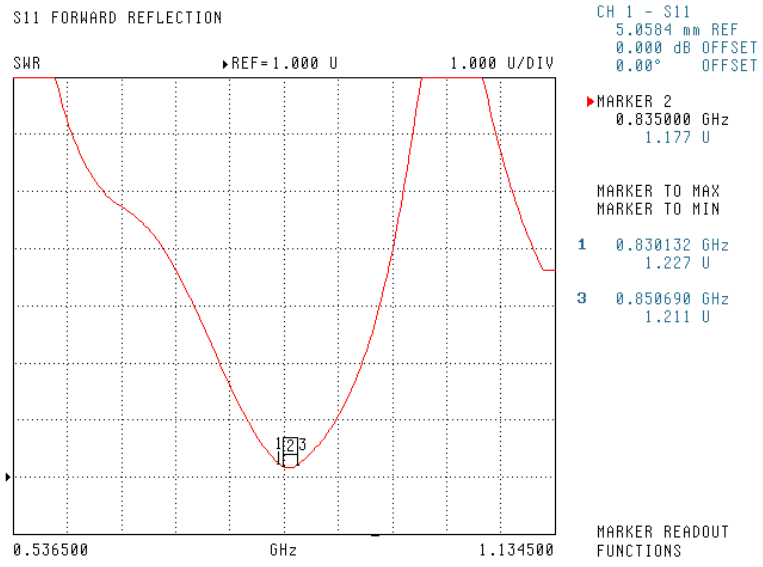
Electrical Specification 835MHz
Standing Wave Ratio

Tissue Type	Measured Epsilon	Measured Sigma
Head	41.09	0.89
Body	53.15	0.95

Head Tissue



Body Tissue



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.

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1224/5
Project Number: SGL-IAC-DC-5582-93

C E R T I F I C A T E OF 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
1900MHz Head & Body

Manufacturer: APREL Laboratories
Part number: ALS-D-1900-S-2
Frequency: 1900MHz
Serial No: 210-00707

Customer: IAC

Calibrated: 16th May 2011
Released on: 27th May 2011

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

Released By: _____

NCL CALIBRATION LABORATORIES
303 Terry Fox Drive, Suite 102
Kanata, Ontario
CANADA K2K 3J1
Division of APREL
TEL: (613) 435-8300
FAX: (613) 435-8306

Conditions

Dipole 210-00707 was a new dipole taken from stock.

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

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Power meter Anritsu MA2408A	190025437	Nov.4, 2010
Power Sensor Anritsu MA2481D	103555	Nov 4, 2010
Attenuator HP 8495A (70dB)	1944A10711	Sept. 14, 2010
Network Analyzer Anritsu MT8801C	MB11855	Feb. 8, 2011

Secondary Measurement Standards

Signal Generator Agilent E4438C -506	MY55182336	June 7, 2011

This page has been reviewed for content and attested to by signature within this document.

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

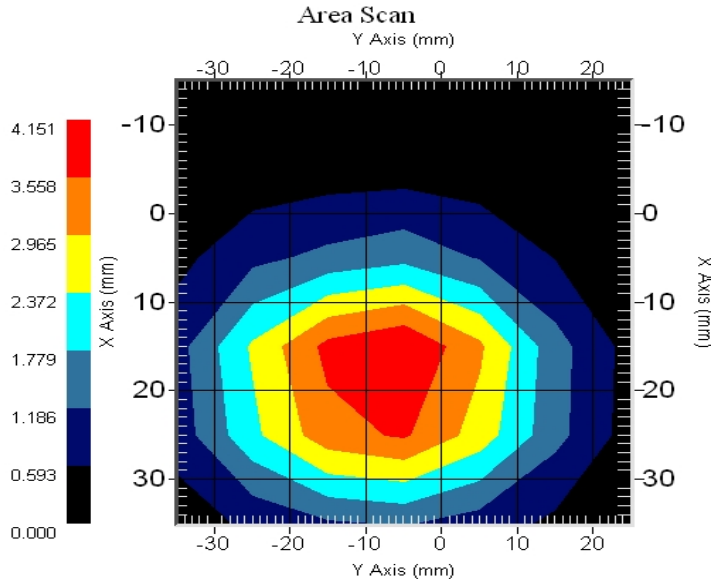
Electrical Specification 1900MHz

Tissue Type	Return Loss:	Impedance:	SWR:
Head	-31.943	51.262	1.055U
Body	-25.099	57.750	1.119U

System Validation Results

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	1900 MHz	39.378	19.668	77.268
Body	1900 MHz	39.654	19.668	77.268

1900MHz



This page has been reviewed for content and attested to by signature within this document.

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 210-00707. 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

- 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

Conditions

Dipole 210-00707 was a new dipole taken from stock.

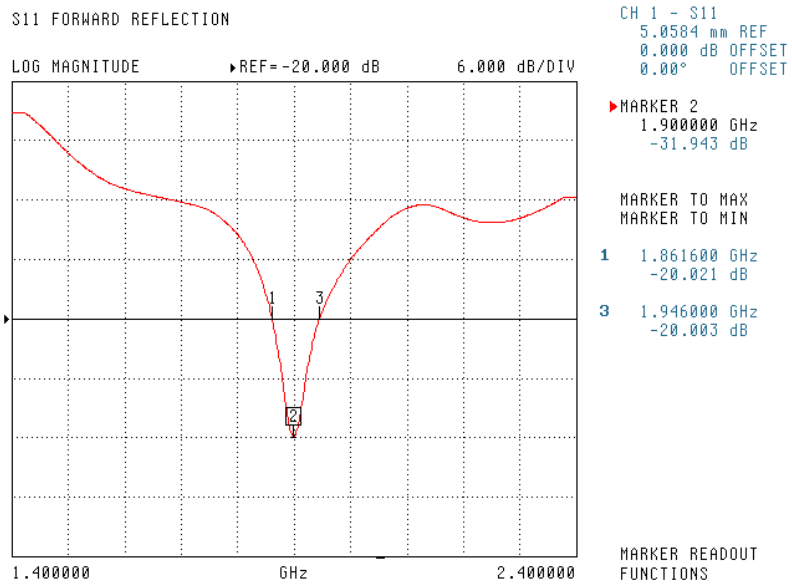
Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 20 °C +/- 0.5°C

Electrical Calibration

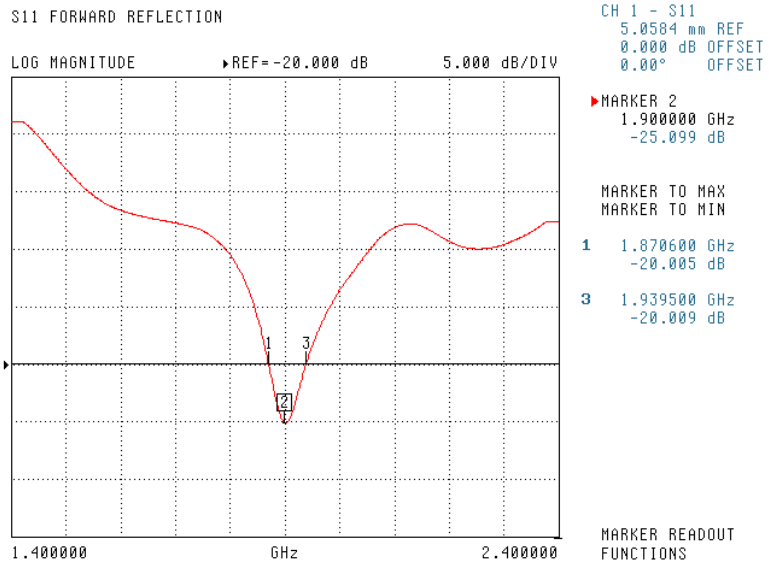
Electrical Specification 1900MHz

Tissue Type	Measured Epsilon	Measured Sigma
Head	38.12	1.41
Body	51.52	1.57

Head Tissue



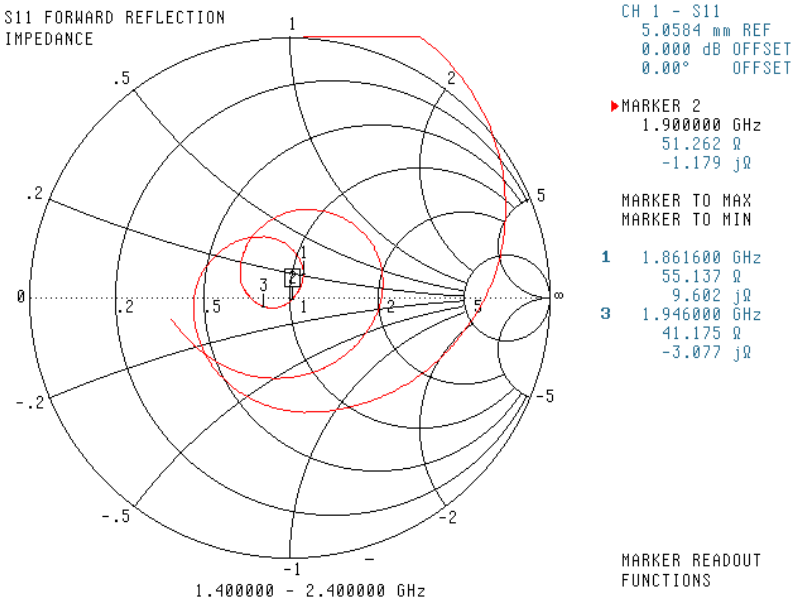
Body Tissue



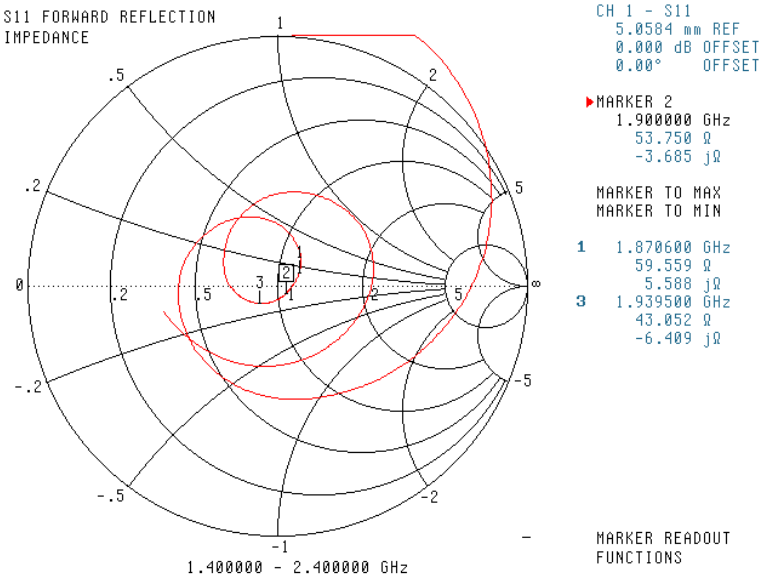
Electrical Specification 1900MHz
Impedance

Tissue Type	Measured Epsilon	Measured Sigma
Head	38.12	1.41
Body	51.52	1.57

Head Tissue



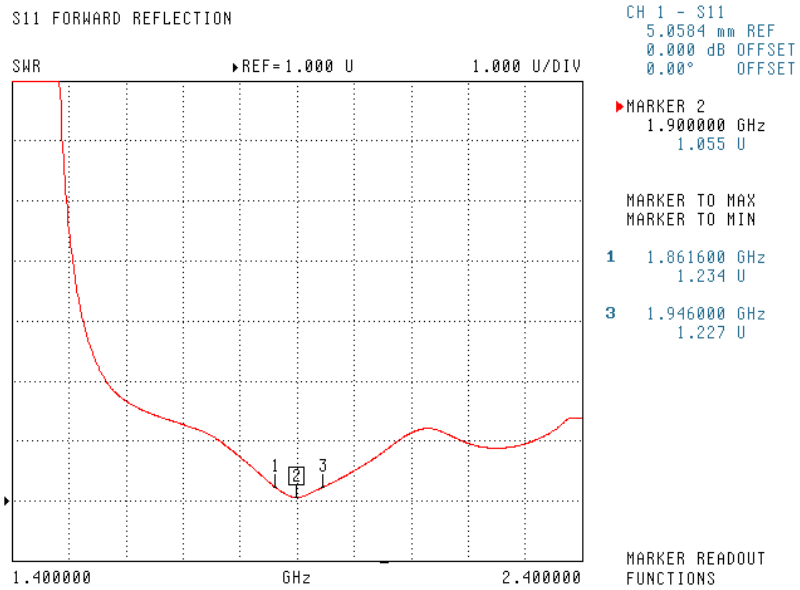
Body Tissue



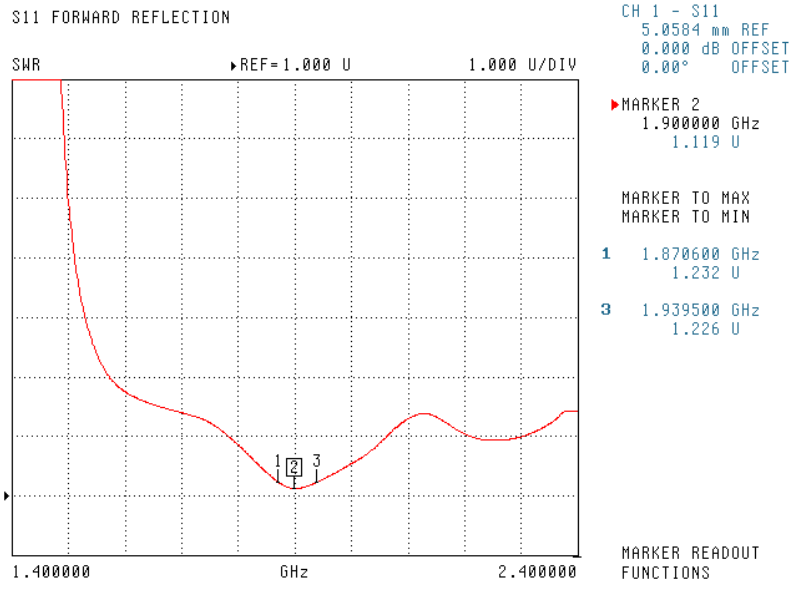
Electrical Specification 1900MHz
Standing Wave Ratio

Tissue Type	Measured Epsilon	Measured Sigma
Head	38.12	1.41
Body	51.52	1.57

Head Tissue



Body Tissue



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.