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Calibration reports

Please note that the validation dipole calibration cycle is every two years and that this Quality System decision has been accepted by our ISO 17025 auditors.

NCL CALIBRATION LABORATORIES

Calibration File No.: 1132

Client.: APREL

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

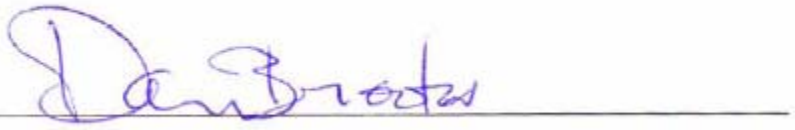
Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 225

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

Calibrated: 25th May 2011
Released: 25th May 2011

Released By: 

NCL CALIBRATION LABORATORIES

17 Bentley Ave
NEPEAN, ONTARIO
CANADA K2E 6T7

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 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 225 has been recalibrated and was found to be in good working order.

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.3, 2011
Power Sensor Anritsu MA2481D	103555	Nov 3, 2011
Attenuator HP 8495A (70dB)	1944A10711	Sept. 13, 2012
Network Analyzer Anritsu MT8801C	MB11855	Feb. 7, 2012

Secondary Measurement Standards

Signal Generator Agilent E4438C -506	MY55182336	June 7, 2011

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 this device has been accurately conducted and that all information contain within this report has been reviewed for accuracy.

Dan Brooks

Alain Tran

Calibration Results Summary

Probe Type:	E-Field Probe E-020
Serial Number:	225
Sensor Offset:	1.56 mm
Sensor Length:	2.5 mm
Tip Enclosure:	Ertalyte*
Tip Diameter:	**<**2.9 mm
Tip Length:	60 mm
Total Length:	290 mm

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	1.2 $\mu V/(V/m)^2$
Channel Y:	1.2 $\mu V/(V/m)^2$
Channel Z:	1.2 $\mu V/(V/m)^2$
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	***FC**					
450 B	***FC**					
750 H	***FC**					
750 B	*****					
835 H		41.83	0.92	**3.5**	**2.8**	**7**
835 B		57.19	0.94	**3.5**	**2.8**	**6.6**
900 H		41.63	0.96	**3.5**	**2.9**	**6.3**
900 B		53.89	1.02	**3.5**	**2.9**	**6.4**
1450 H	***FC**					
1450 B	***FC**					
1640 H	***FC**					
1640 B	***FC**					
1750 H		39.21	1.32	**3.5**	**3.1**	**4.5**
1750 B		52.01	1.48	**3.5**	**3.1**	**4.9**
1800 H		39.73	1.4	**3.5**	**3.1**	**5.5**
1800 B		52.89	1.51	**3.5**	**3.1**	**5.2**
1900 H		38.12	1.41	**3.5**	**3.1**	**5.6**
1900 B		51.52	1.57	**3.5**	**3.1**	**5.6**
2000 H		38.43	1.37	**3.5**	**3.1**	**5.8**
2000 B		52.29	1.45	**3.5**	**3.1**	**5.5**
2100 H		38.74	1.47	**3.5**	**3.2**	**5.3**
2100B		51.95	1.57	**3.5**	**3.2**	**5.2**
2450 H		37.87	1.82	**3.5**	**3.25**	**4.8**
2450B		50.84	1.92	**3.5**	**3.25**	**4.2**
2600 H		38.87	1.91	**3.5**	**3.8**	**4.7**
2600 B		51.95	2.08	**3.5**	**3.8**	**4.8**
3600 H		**37.74**	**3.01**	**3.5**	**3.8**	**4.41**
3600 B		**52.93**	**3.26**	**3.5**	**3.8**	**4**
5200 H		36.09	4.69	**3.5**	**4.1**	**3.3**
5200 B		49.25	5.27	**3.5**	**4.1**	**2.8**
5600 H		34.55	5.25	**3.5**	**4.1**	**2.8**
5600 B		47.73	5.88	**3.5**	**4.1**	**2.8**
5800 H		33.83	5.52	**3.5**	**4.1**	**2.8**
5800 B		47.12	6.17	**3.5**	**4.1**	**2.7**

*FC, Future Calibration, as required

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.

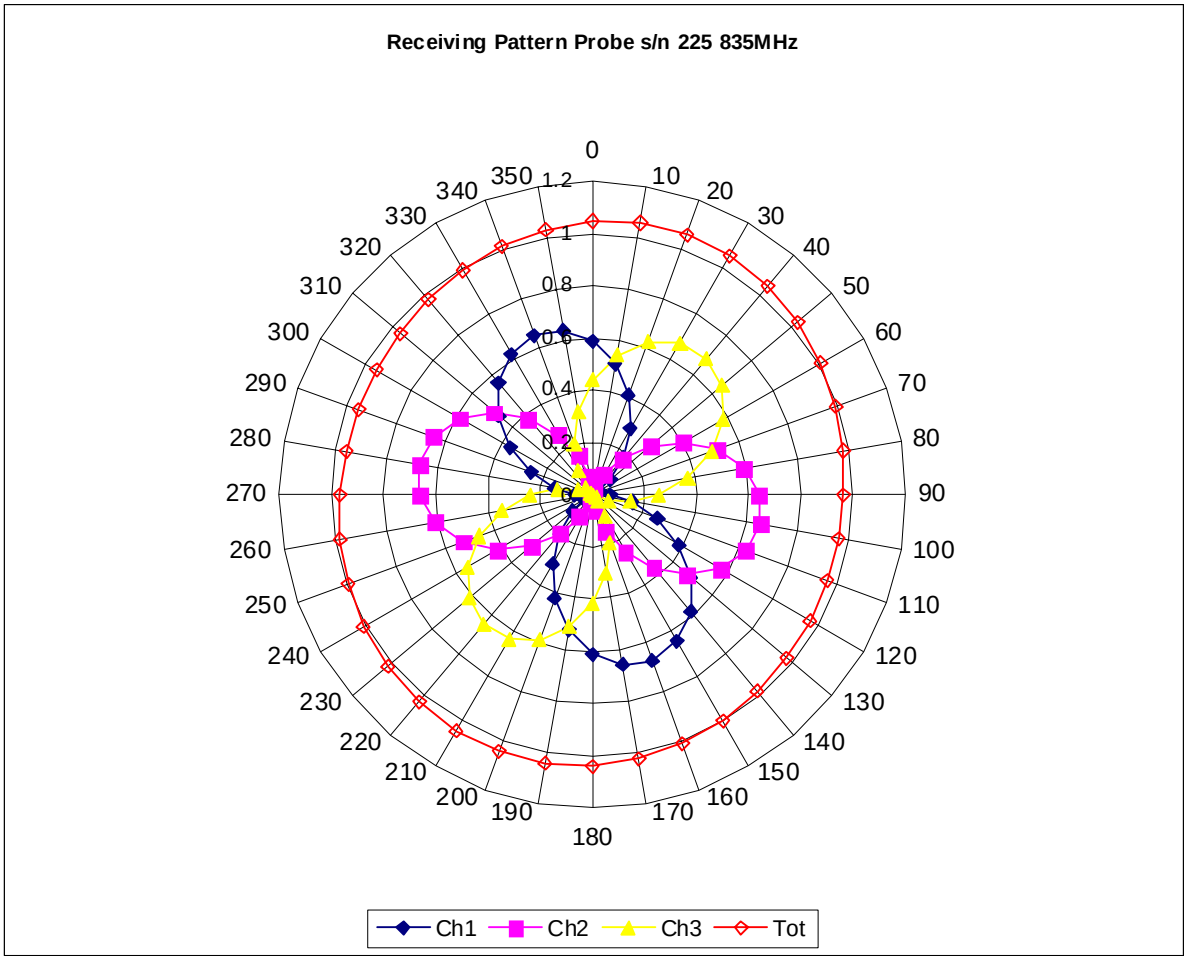
Boundary Effect:

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

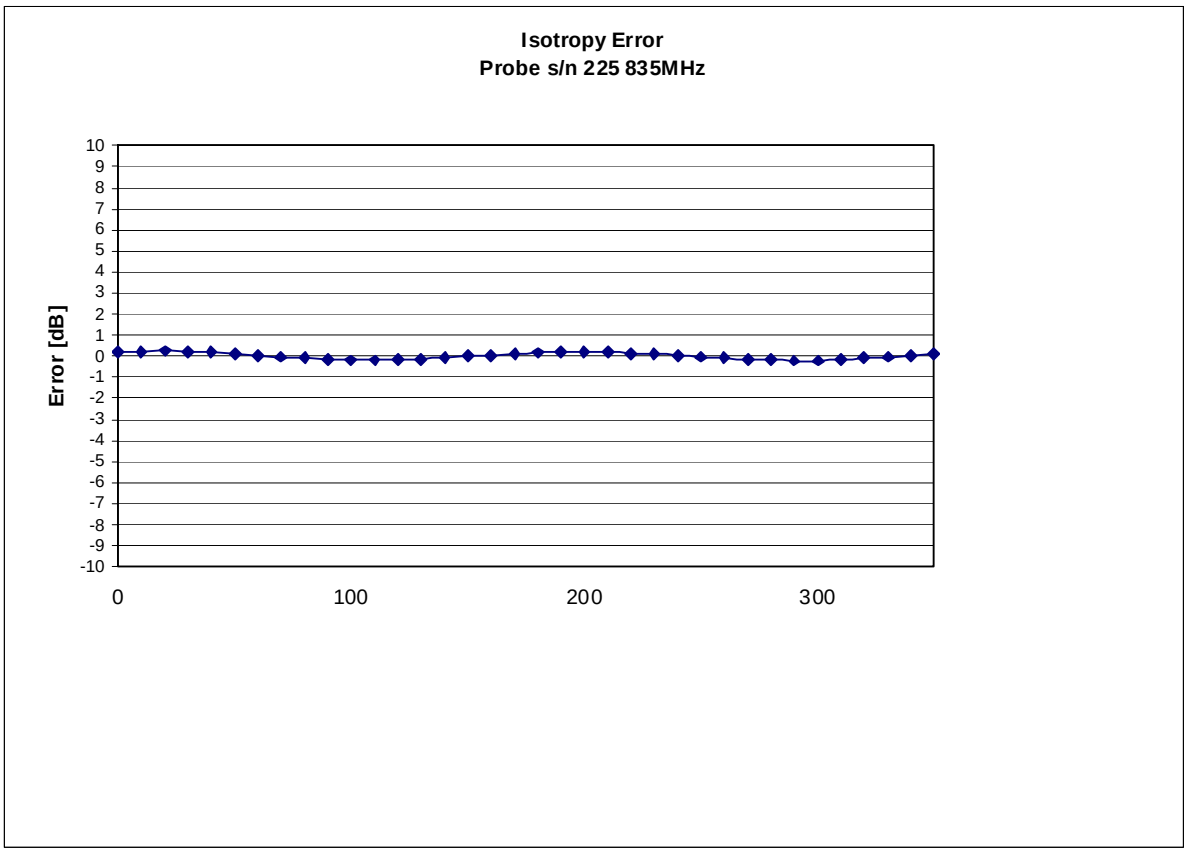
NOTES:

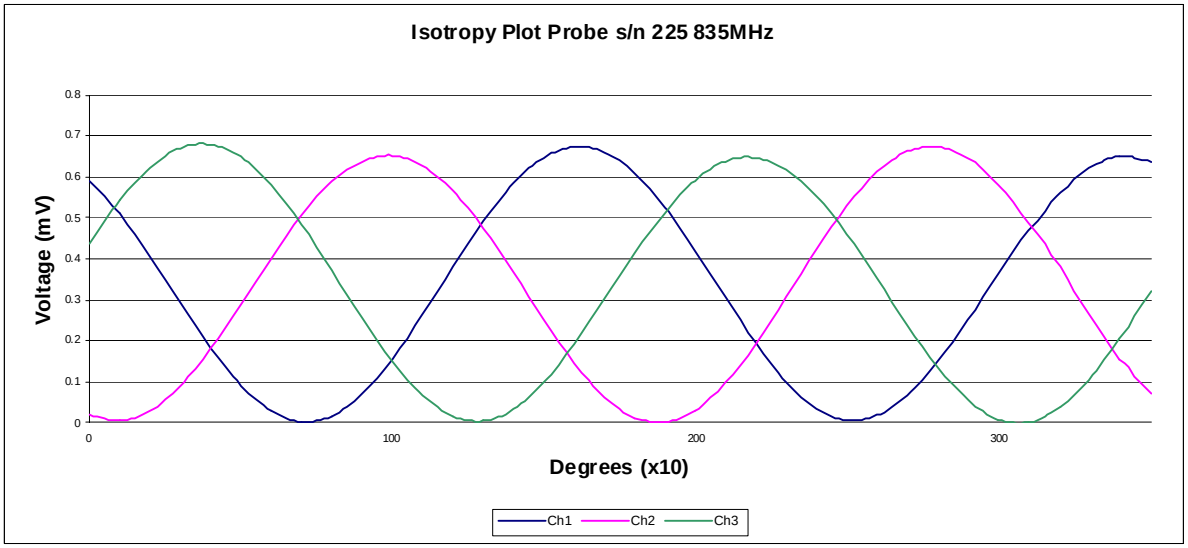
*The maximum deviation from the centre frequency when comparing the lower to upper range is listed.

Receiving Pattern Air



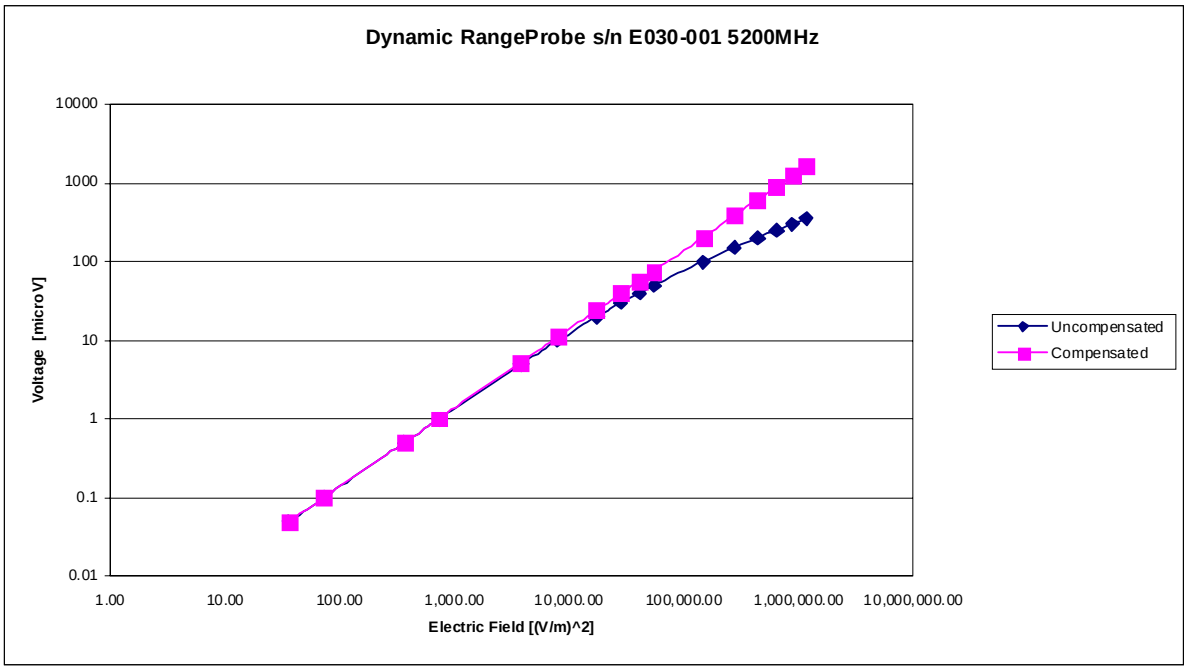
Isotropy Error 5200 MHz (Air)



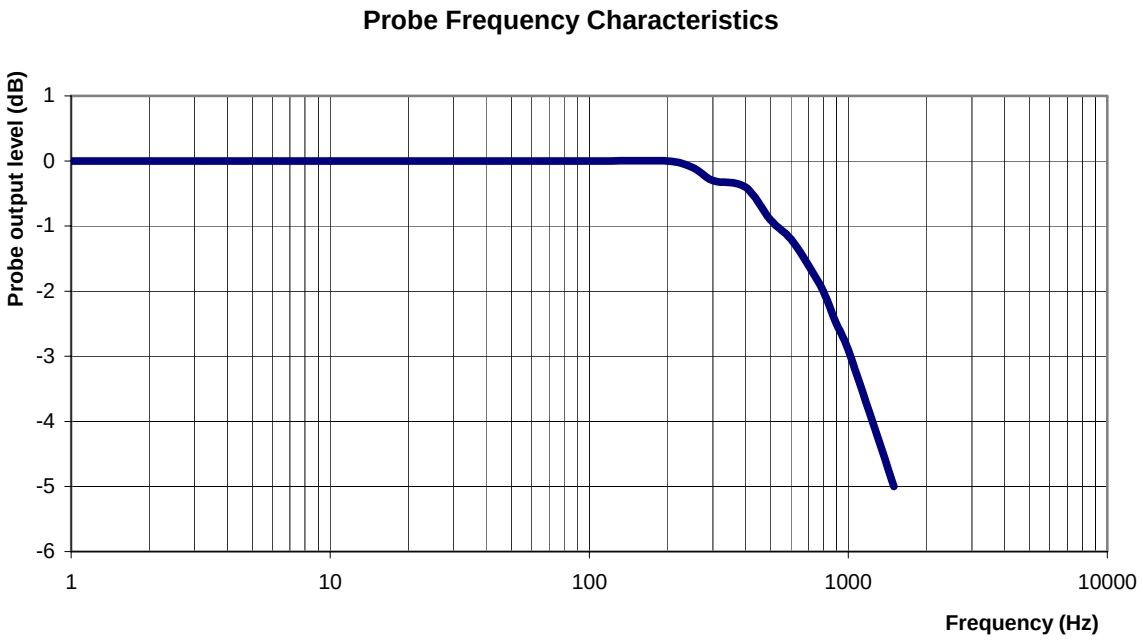


Isotropicity Tissue: 0.10 dB

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 2009.

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1203
Project Number: Internal

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
2450MHz Head & Body

Manufacturer: APREL Laboratories
Part number: ALS-D-2450-S-2
Frequency: 2450MHz
Serial No: 301581

Customer: APREL

Calibrated: 20th February 2011
Released on: 25h February 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 301581 was a recalibration.

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	245025437	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, 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: 51.5 mm
Height: 30.4 mm

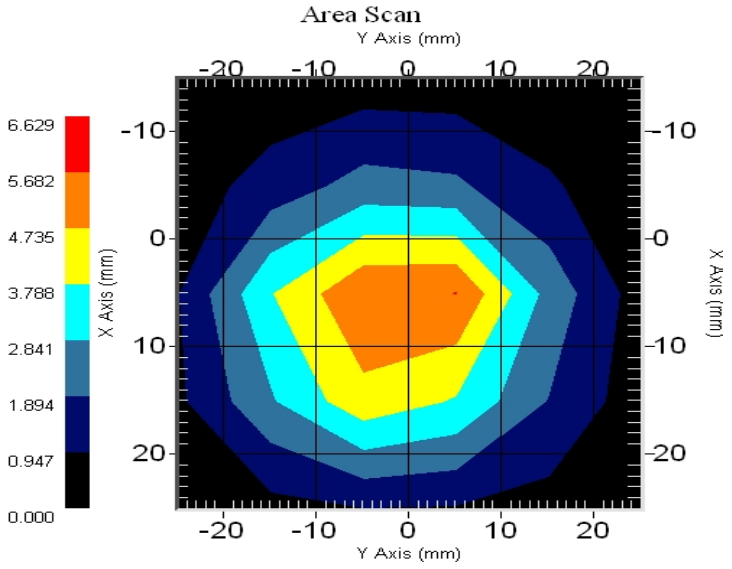
Electrical Specification 2450MHz

Tissue Type	Return Loss:	Impedance:	SWR:
Head	-36.573	50.472	1.032U
Body	-28.075	51.272	1.083U

System Validation Results

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	2450 MHz	52.456	23.603	108.940
Body	2450 MHz	52.592	24.461	104.910

2450MHz



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 220-00762. 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)
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- 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 301581 was a recalibration.

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

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

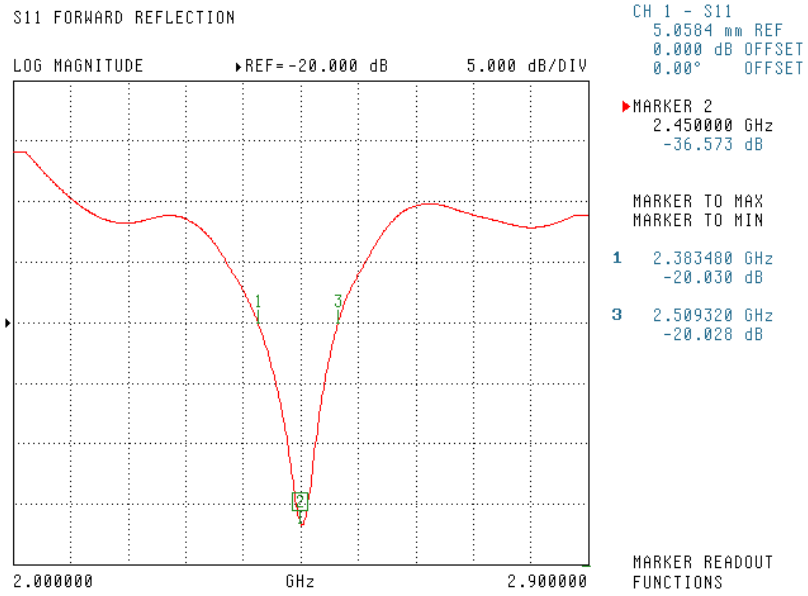
Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
TOTAL	**8.32% (16.64% K=2)**

Electrical Calibration

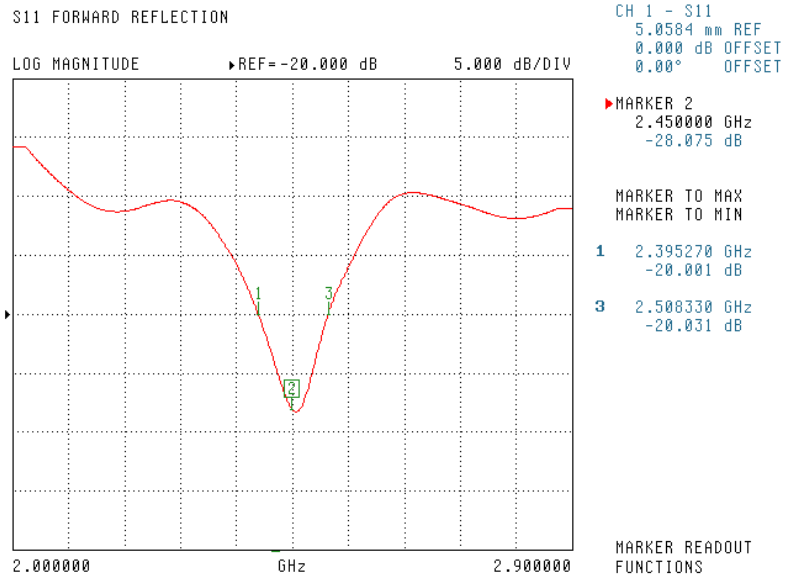
Electrical Specification 2450MHz

Tissue Type	Measured Epsilon	Measured Sigma
Head	37.87	1.82
Body	50.84	1.92

Head Tissue



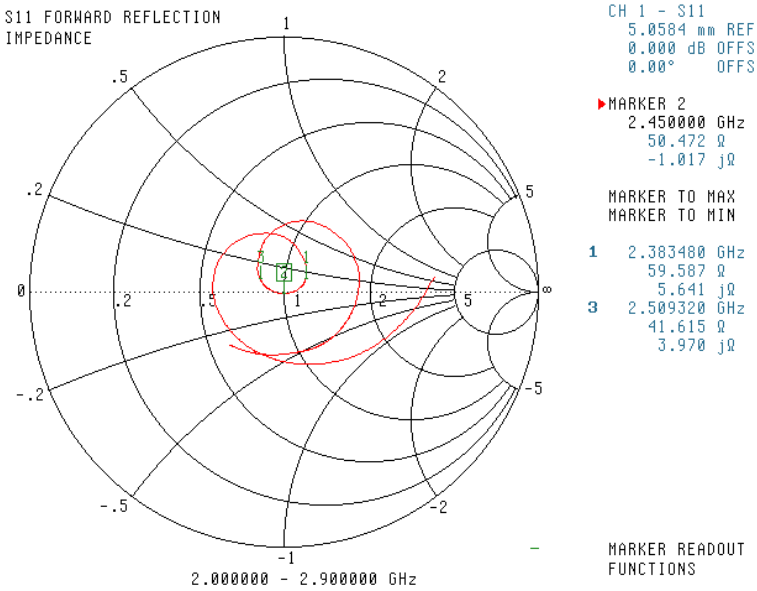
Body Tissue



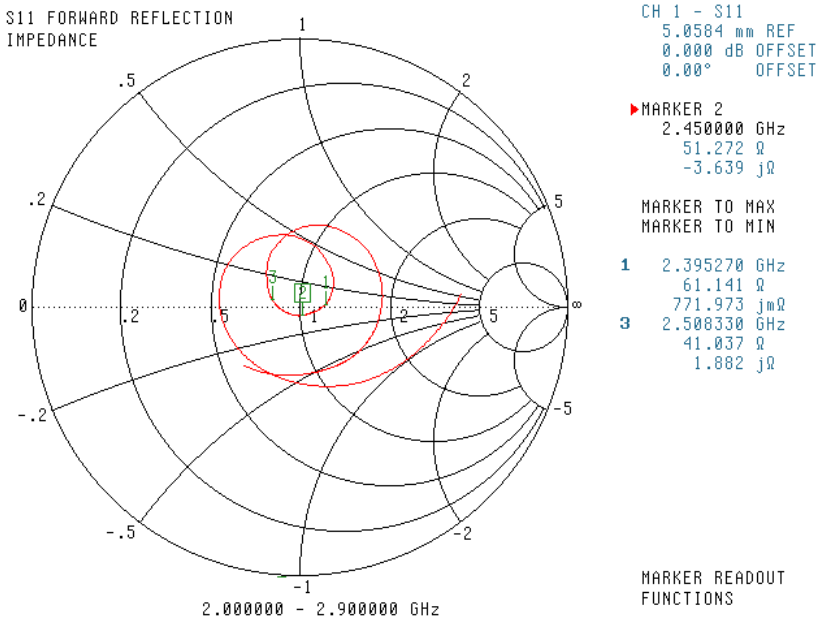
Electrical Specification 2450MHz
Impedance

Tissue Type	Measured Epsilon	Measured Sigma
Head	37.87	1.82
Body	50.84	1.92

Head Tissue



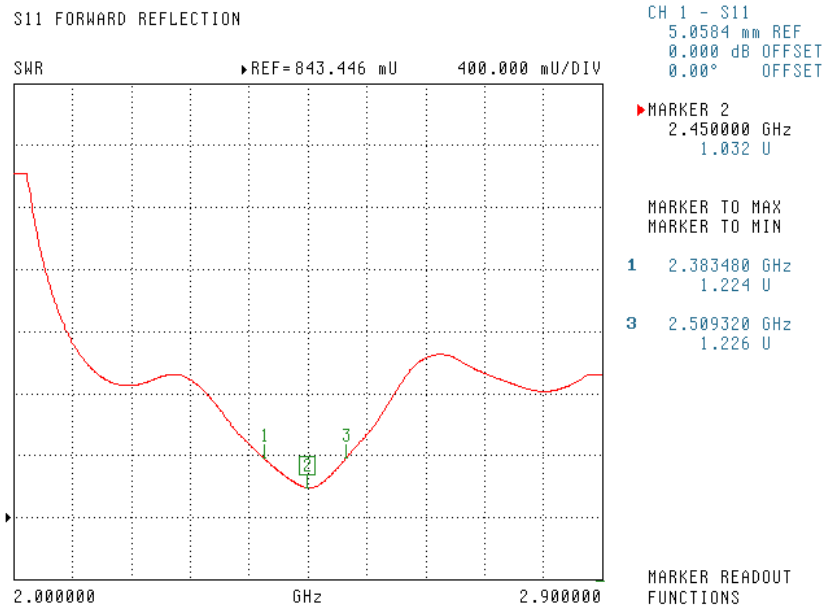
Body Tissue



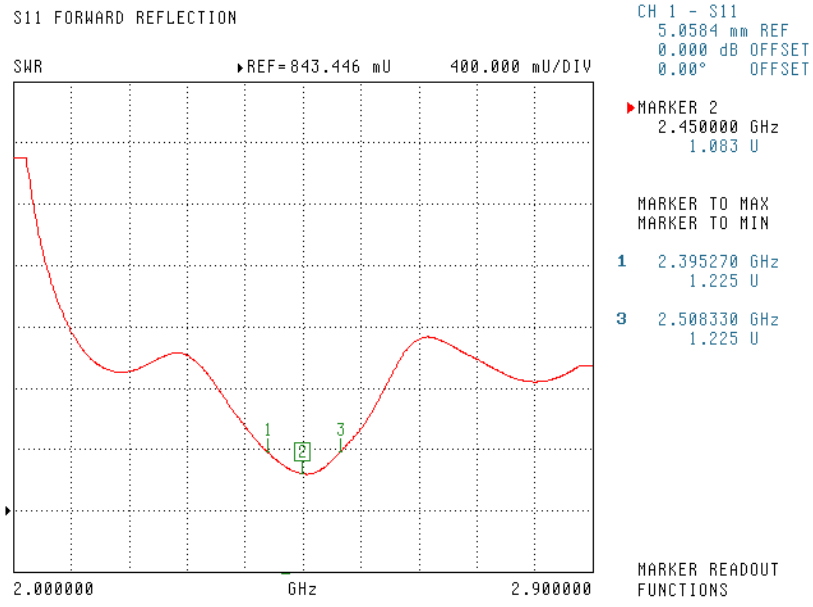
Electrical Specification 2450MHz
Standing Wave Ratio

Tissue Type	Measured Epsilon	Measured Sigma
Head	37.87	1.82
Body	50.84	1.92

Head Tissue



Body Tissue



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

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 2010.