

**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Back (1732.5 MHz Mid Channel)**

Measurement Data

Test mode : 1RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 10x10x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.643 W/kg  
 Power Drift-Finish : 0.655 W/kg  
 Power Drift (%) : 1.866

Tissue Data

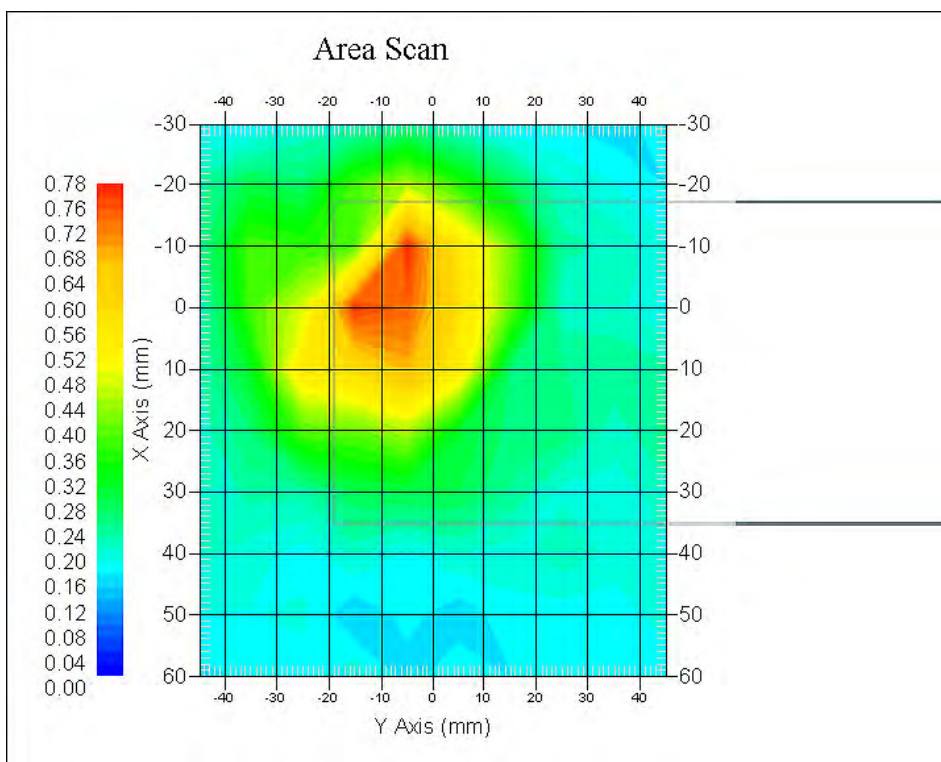
Type : Body  
 Frequency : 1732.5 MHz  
 Epsilon : 53.86 F/m  
 Sigma : 1.50 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V/m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.776 W/kg  
 10 gram SAR value : 0.438 W/kg  
 Area Scan Peak SAR : 0.780 W/kg  
 Zoom Scan Peak SAR : 0.957 W/kg

**Plot 50#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Back (1745.0 MHz High Channel)**

Measurement Data

Test mode : 1RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 10x10x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.563 W/kg  
 Power Drift-Finish : 0.566 W/kg  
 Power Drift (%) : 0.533

Tissue Data

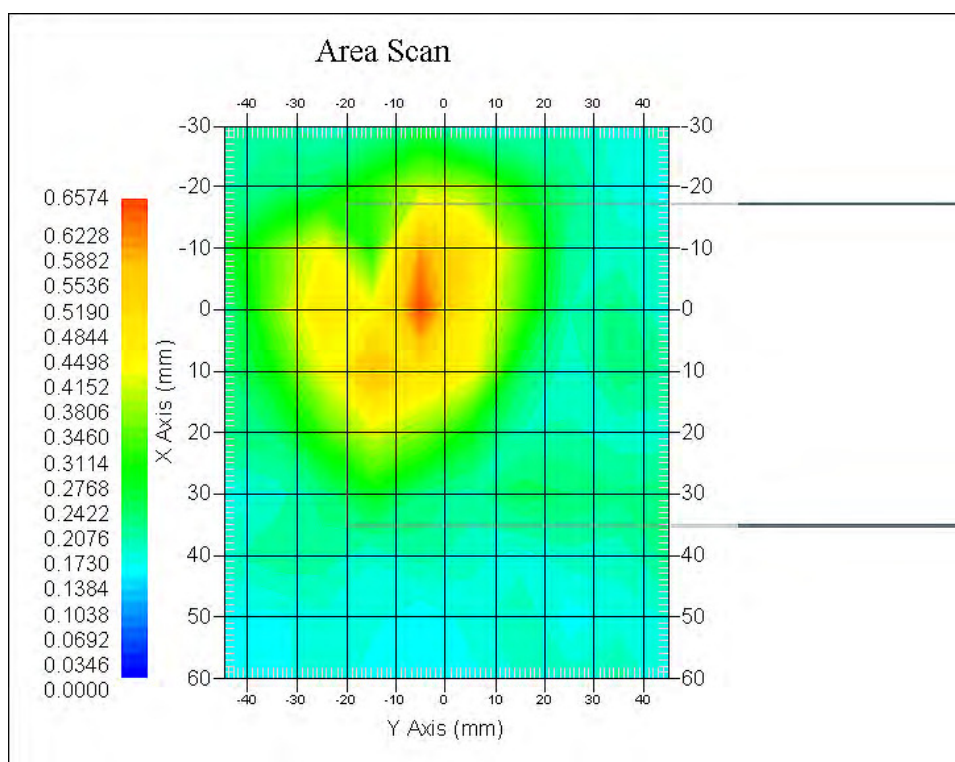
Type : Body  
 Frequency : 1745.0 MHz  
 Epsilon : 53.99 F/m  
 Sigma : 1.52 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.649 W/kg  
 10 gram SAR value : 0.353 W/kg  
 Area Scan Peak SAR : 0.657 W/kg  
 Zoom Scan Peak SAR : 0.957 W/kg

**Plot 51#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Back (1720.0 MHz Low Channel)**

Measurement Data

Test mode : 50RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 10x10x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.522 W/kg  
 Power Drift-Finish : 0.524 W/kg  
 Power Drift (%) : 0.383

Tissue Data

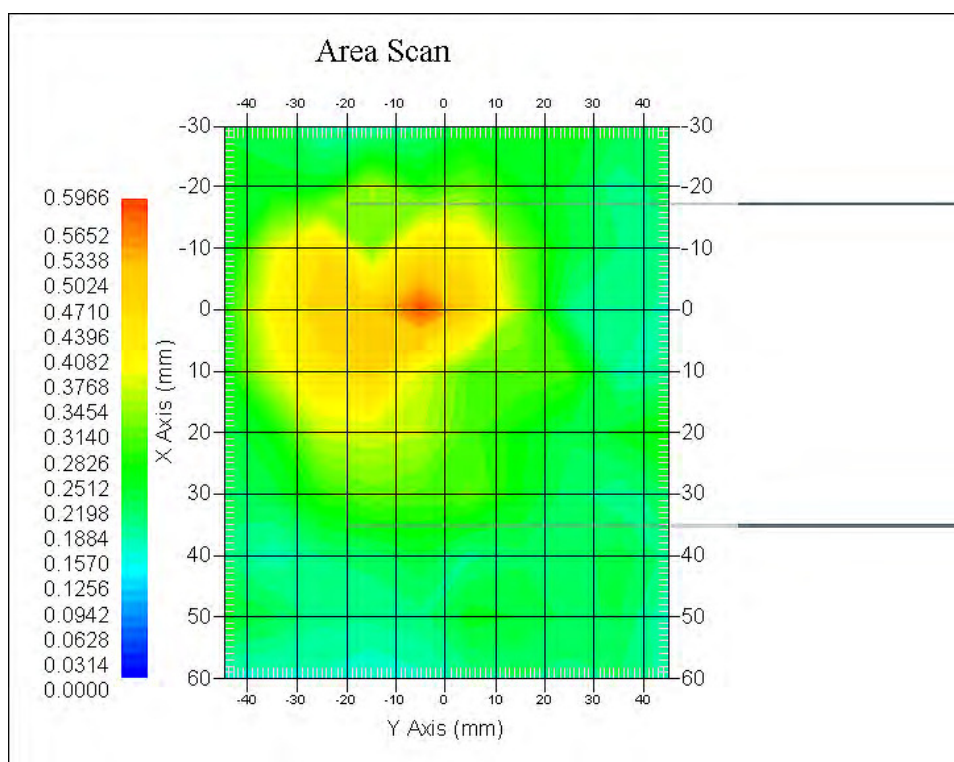
Type : Body  
 Frequency : 1720.0 MHz  
 Epsilon : 53.93 F/m  
 Sigma : 1.53 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.593 W/kg  
 10 gram SAR value : 0.418 W/kg  
 Area Scan Peak SAR : 0.596 W/kg  
 Zoom Scan Peak SAR : 0.889 W/kg

**Plot 52#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Left (1732.5 MHz Middle Channel)**

Measurement Data

Test mode : 1RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.195 W/kg  
 Power Drift-Finish : 0.194 W/kg  
 Power Drift (%) : -0.513

Tissue Data

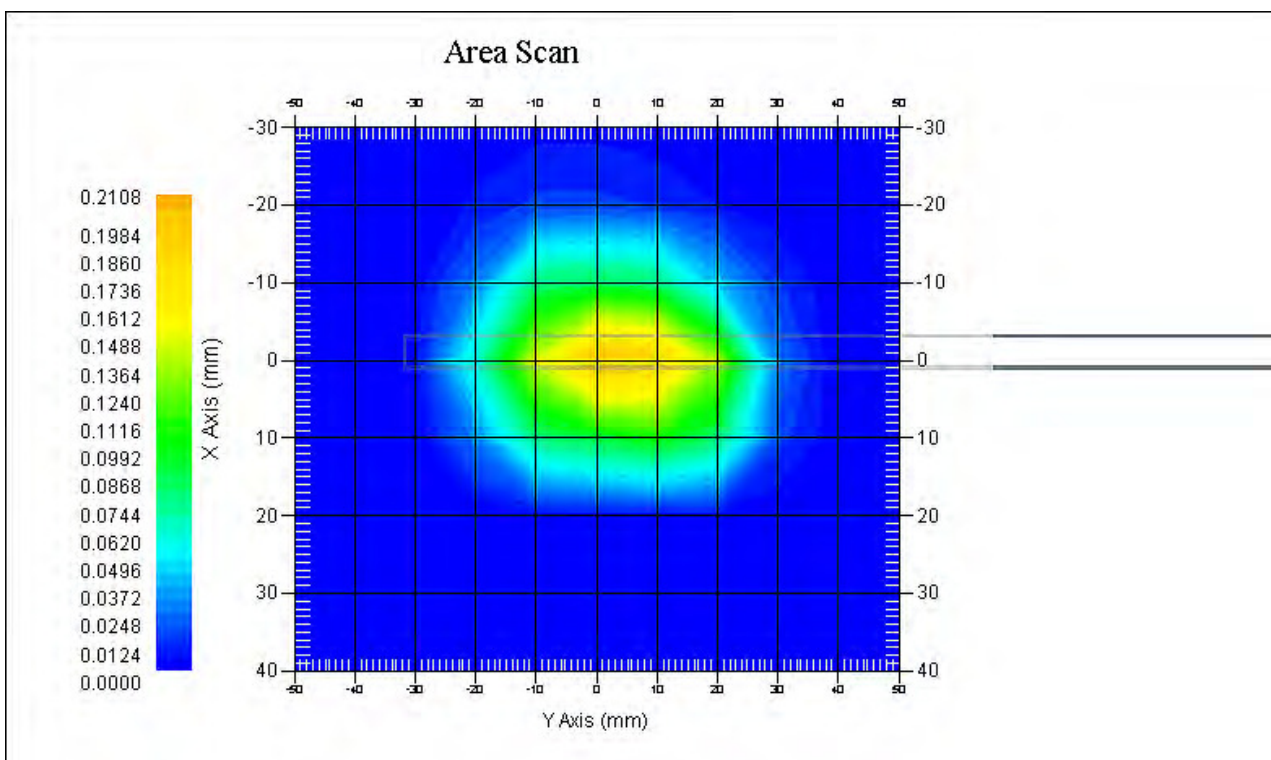
Type : Body  
 Frequency : 1732.5 MHz  
 Epsilon : 53.86 F/m  
 Sigma : 1.50 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.193 W/kg  
 10 gram SAR value : 0.098 W/kg  
 Area Scan Peak SAR : 0.210 W/kg  
 Zoom Scan Peak SAR : 0.352 W/kg

**Plot 53#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Left (1720.0 MHz Low Channel)**

Measurement Data

Test mode : 50RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.178 W/kg  
 Power Drift-Finish : 0.175 W/kg  
 Power Drift (%) : -1.685

Tissue Data

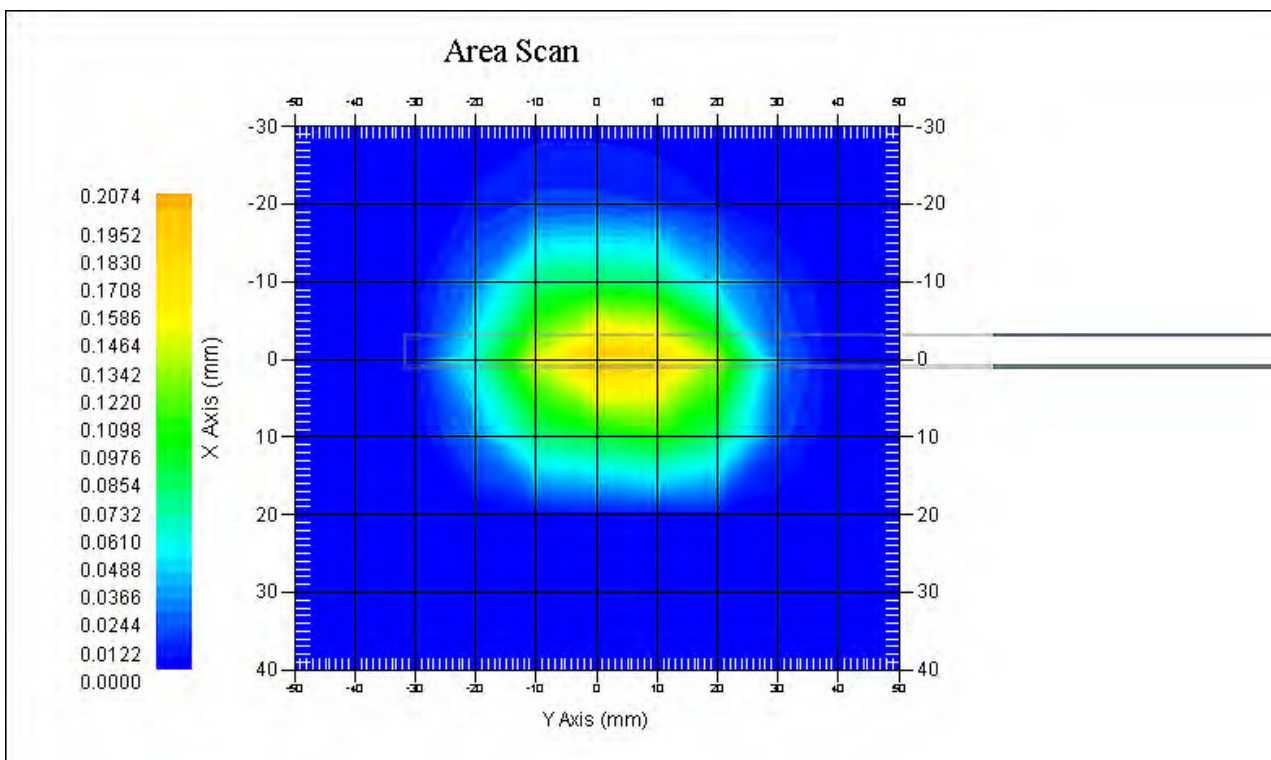
Type : Body  
 Frequency : 1720.0 MHz  
 Epsilon : 53.93 F/m  
 Sigma : 1.53 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.183 W/kg  
 10 gram SAR value : 0.078 W/kg  
 Area Scan Peak SAR : 0.207 W/kg  
 Zoom Scan Peak SAR : 0.414 W/kg

**Plot 54#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Right (1732.5 MHz Middle Channel)**

Measurement Data

Test mode : 1RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.177 W/kg  
 Power Drift-Finish : 0.175 W/kg  
 Power Drift (%) : -1.130

Tissue Data

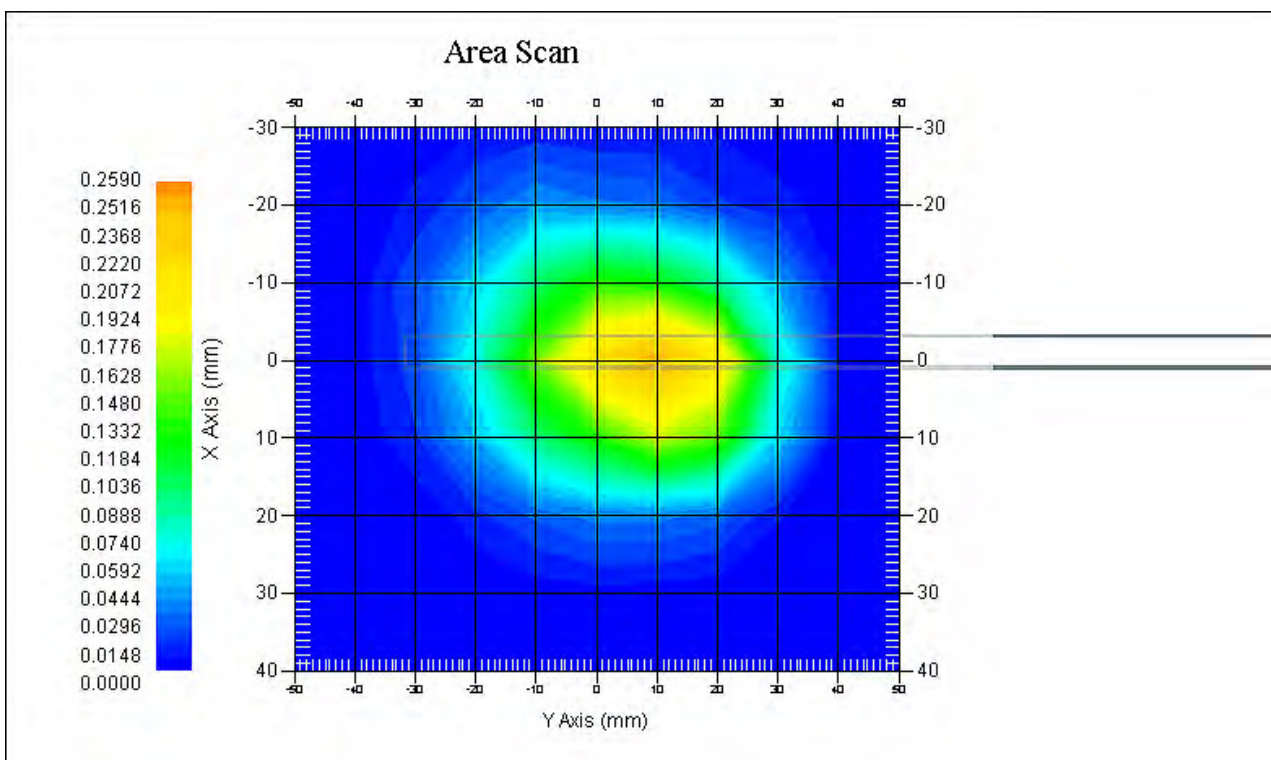
Type : Body  
 Frequency : 1732.5 MHz  
 Epsilon : 53.86 F/m  
 Sigma : 1.50 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.233 W/kg  
 10 gram SAR value : 0.118 W/kg  
 Area Scan Peak SAR : 0.259 W/kg  
 Zoom Scan Peak SAR : 0.523 W/kg

**Plot 55#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Right (1720.0 MHz Low Channel)**

Measurement Data

Test mode : 50RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.187 W/kg  
 Power Drift-Finish : 0.188 W/kg  
 Power Drift (%) : 0.535

Tissue Data

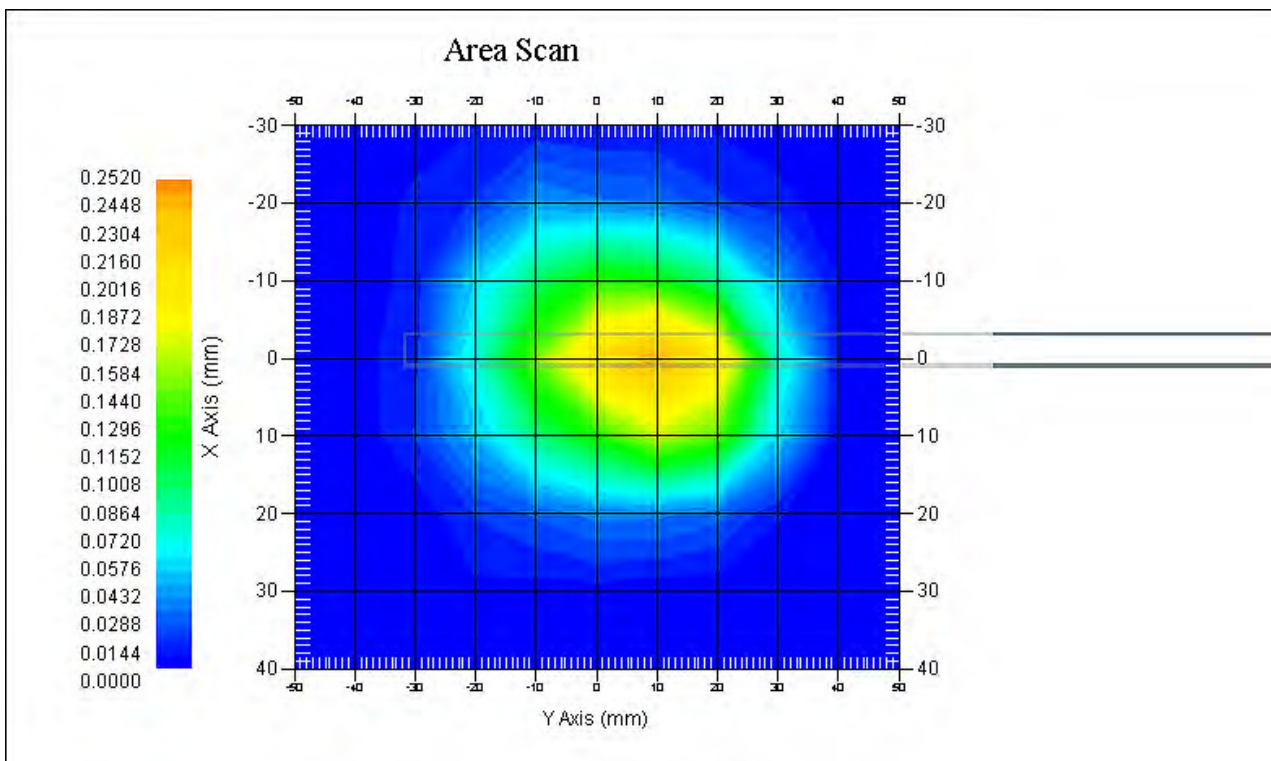
Type : Body  
 Frequency : 1720.0 MHz  
 Epsilon : 53.93 F/m  
 Sigma : 1.53 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.224 W/kg  
 10 gram SAR value : 0.113 W/kg  
 Area Scan Peak SAR : 0.252 W/kg  
 Zoom Scan Peak SAR : 0.374 W/kg

**Plot 56#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Bottom (1732.5 MHz Middle Channel)**

Measurement Data

Test mode : 1RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.298 W/kg  
 Power Drift-Finish : 0.295 W/kg  
 Power Drift (%) : -1.011

Tissue Data

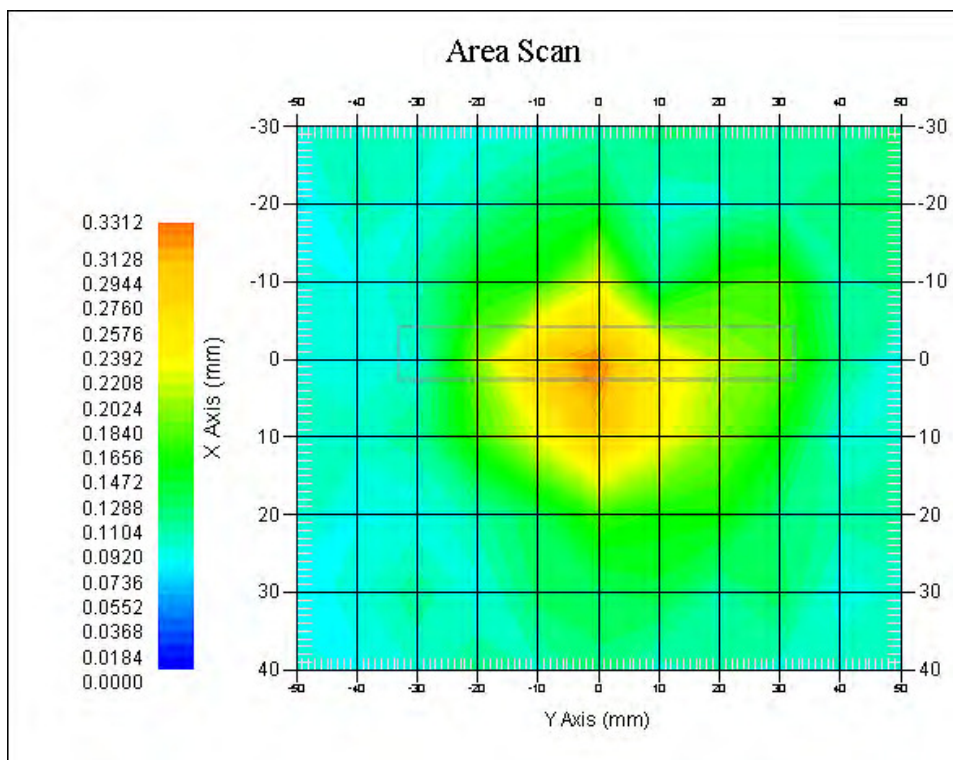
Type : Body  
 Frequency : 1732.5 MHz  
 Epsilon : 53.86 F/m  
 Sigma : 1.50 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.307 W/kg  
 10 gram SAR value : 0.158 W/kg  
 Area Scan Peak SAR : 0.331 W/kg  
 Zoom Scan Peak SAR : 0.514 W/kg

**Plot 57#**





**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**LTE Band 4; Body-Bottom (1720.0 MHz Low Channel)**

Measurement Data

Test mode : 50RB  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 8x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 5x5x7: Measurement x=8mm, y=8mm, z=5mm  
 Power Drift-Start : 0.325 W/kg  
 Power Drift-Finish : 0.324 W/kg  
 Power Drift (%) : -0.308

Tissue Data

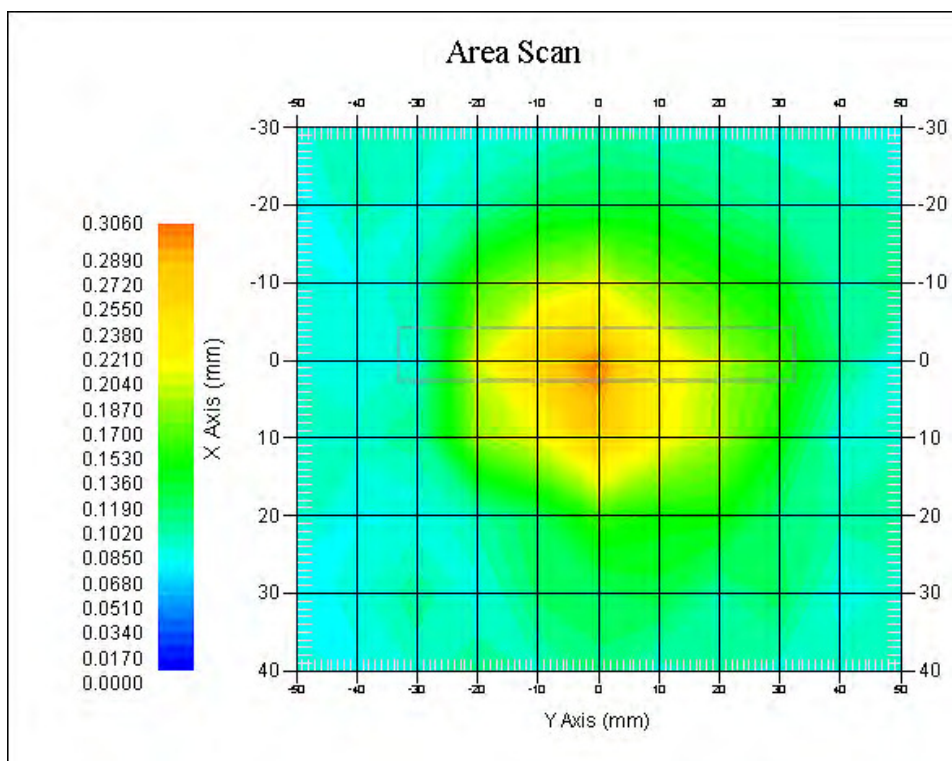
Type : Body  
 Frequency : 1720.0 MHz  
 Epsilon : 53.93 F/m  
 Sigma : 1.53 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 1750  
 Duty Cycle Factor : 1  
 Conversion Factor : 5.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.281 W/kg  
 10 gram SAR value : 0.145 W/kg  
 Area Scan Peak SAR : 0.306 W/kg  
 Zoom Scan Peak SAR : 0.474 W/kg

**Plot 58#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**802.11B; Body-Worn-Back (2462.0 MHz High Channel)**

Measurement Data

Test mode : 802.11B  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 9x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
 Power Drift-Start : 0.008 W/kg  
 Power Drift-Finish : 0.008 W/kg  
 Power Drift (%) : -0.573

Tissue Data

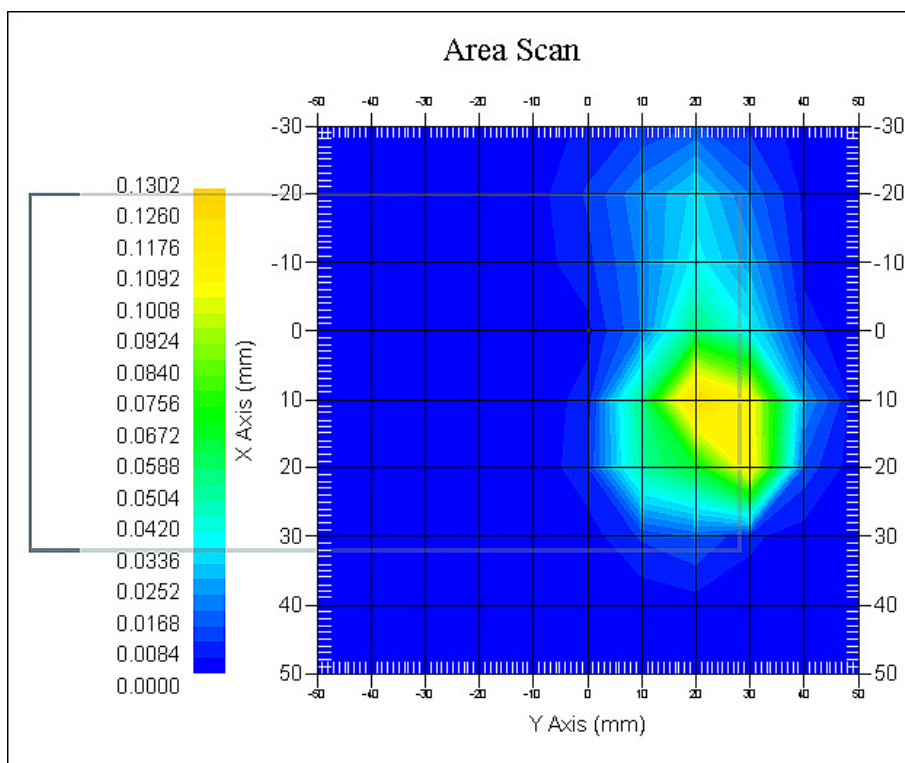
Type : Body  
 Frequency : 2462.0 MHz  
 Epsilon : 52.64 F/m  
 Sigma : 1.96 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 2450  
 Duty Cycle Factor : 1  
 Conversion Factor : 4.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.117 W/kg  
 10 gram SAR value : 0.051 W/kg  
 Area Scan Peak SAR : 0.130 W/kg  
 Zoom Scan Peak SAR : 0.307 W/kg

**Plot 59#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**802.11B; Body-Worn-Left (2462.0 MHz High Channel)**

Measurement Data

Test mode : 802.11B  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 9x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
 Power Drift-Start : 0.007 W/kg  
 Power Drift-Finish : 0.007 W/kg  
 Power Drift (%) : -0.128

Tissue Data

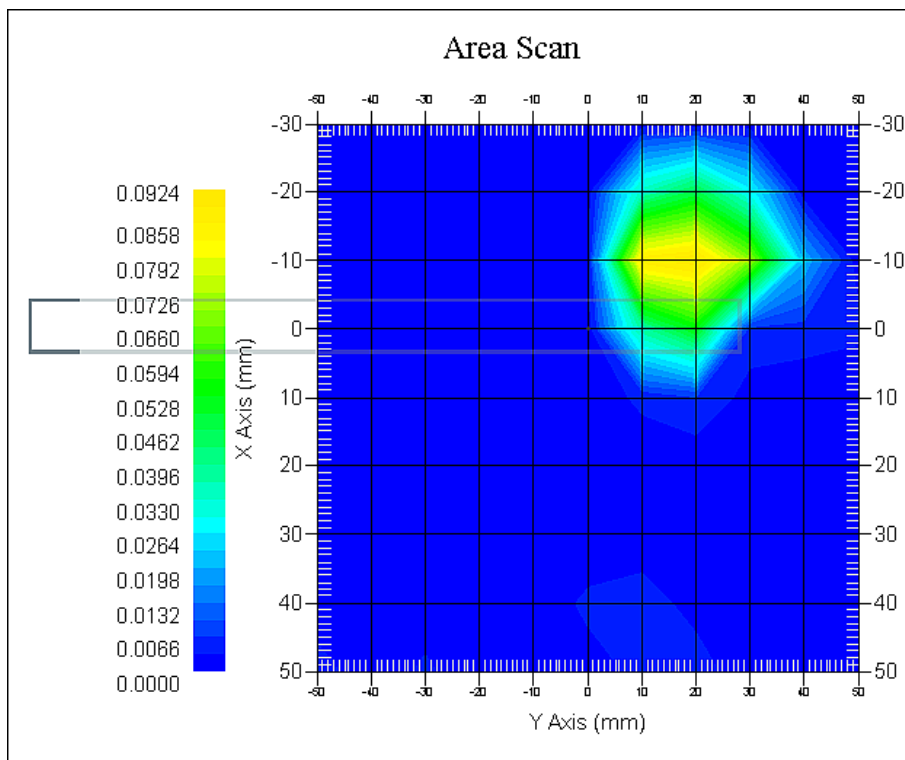
Type : Body  
 Frequency : 2462.0 MHz  
 Epsilon : 52.64 F/m  
 Sigma : 1.96 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 2450  
 Duty Cycle Factor : 1  
 Conversion Factor : 4.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.087 W/kg  
 10 gram SAR value : 0.040 W/kg  
 Area Scan Peak SAR : 0.092 W/kg  
 Zoom Scan Peak SAR : 0.123 W/kg

**Plot 60#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)**

**802.11B; Body-Worn-Top (2462.0 MHz High Channel)**

Measurement Data

Test mode : 802.11B  
 Crest Factor : 1  
 Scan Type : Complete  
 Area Scan : 9x11x1: Measurement x=10mm, y=10mm, z=4mm  
 Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
 Power Drift-Start : 0.001 W/kg  
 Power Drift-Finish : 0.001 W/kg  
 Power Drift (%) : 0.123

Tissue Data

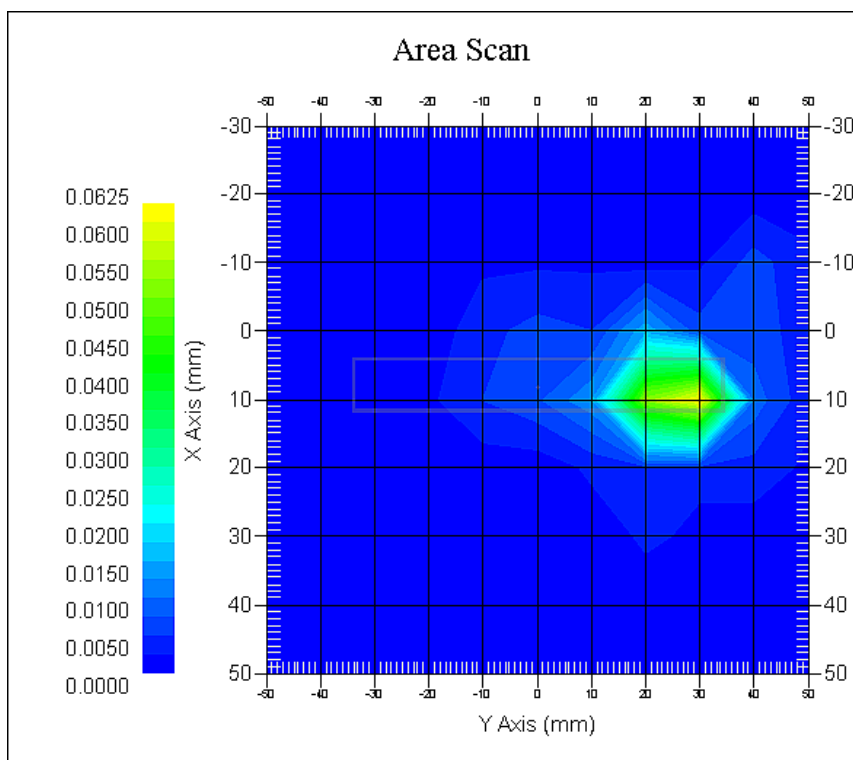
Type : Body  
 Frequency : 2462.0 MHz  
 Epsilon : 52.64 F/m  
 Sigma : 1.96 S/m  
 Density : 1000.00 kg/cu. m

Probe Data

Serial No. : 500-00283  
 Frequency Band : 2450  
 Duty Cycle Factor : 1  
 Conversion Factor : 4.3  
 Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
 Compression Point : 95.00 mV  
 Offset : 1.56 mm

1 gram SAR value : 0.057 W/kg  
 10 gram SAR value : 0.020 W/kg  
 Area Scan Peak SAR : 0.062 W/kg  
 Zoom Scan Peak SAR : 0.088 W/kg

**Plot 61#**



## APPENDIX A MEASUREMENT UNCERTAINTY

According to **IEEE1528:2013**, the uncertainty budget has been determined for the Head SAR measurement system and is given in the following Table.

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	$c_i^1$ (1-g)	$c_i^1$ (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
<b>Measurement System</b>							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	$\sqrt{3}$	$(1-cp)^{1/2}$	$(\frac{1-cp}{2})^1$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	$\sqrt{3}$	$\sqrt{cp}$	$\sqrt{cp}$	4.4	4.4
Boundary Effect	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Linearity	4.7	rectangular	$\sqrt{3}$	1	1	2.7	2.7
Detection Limit	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	$\sqrt{3}$	1	1	0.5	0.5
Integration Time	1.7	rectangular	$\sqrt{3}$	1	1	1.0	1.0
RF Ambient Condition -Noise	0.6	rectangular	$\sqrt{3}$	1	1	0.3	0.3
RF Ambient Condition - Reflections	3.0	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Probe Positioner Mech. Restrictions	0.4	rectangular	$\sqrt{3}$	1	1	0.2	0.2
Probe Positioning with respect to Phantom Shell	2.9	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	$\sqrt{3}$	1	1	2.1	2.1
<b>Test sample related</b>							
Test sample positioning	2.0	normal	1	1	1	2.0	2.0
Device Holder Uncertainty	4.0	normal	1	1	1	6.215	6.215
Drift of Output Power	5.0	rectangular	$\sqrt{3}$	1	1	2.67	2.67
<b>Phantom and Setup</b>							
Phantom Uncertainty	3.4	rectangular	$\sqrt{3}$	1	1	2.0	2.0
SAR correction in permittivity and conductivity	1.2	normal	1	1	0.85	1.2	1.0
Liquid conductivity measurement	5.0	normal	1	0.78	0.71	3.9	3.6
Liquid permittivity measurement	5.0	normal	1	0.25	0.29	1.3	1.5
conductivity—temperature	1.1	rectangular	$\sqrt{3}$	0.78	0.71	0.5	0.5
permittivity—temperature	1.3	rectangular	$\sqrt{3}$	0.23	0.23	0.2	0.2
Combined Uncertainty		RSS				10.78	10.55
Expanded uncertainty (coverage factor=2)		Normal(k=2)				21.56	21.10

According to **IEC62209-2:2010**, the uncertainty budget has been determined for the Body SAR measurement system and is given in the following Table.

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	$c_i^1$ (1-g)	$c_i^1$ (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
<b>Measurement System</b>							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	$\sqrt{3}$	1	1	1.5	1.5
Boundary Effect	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Linearity	4.7	rectangular	$\sqrt{3}$	1	1	2.7	2.7
Detection Limit	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	$\sqrt{3}$	1	1	0.5	0.5
Integration Time	1.7	rectangular	$\sqrt{3}$	1	1	1.0	1.0
RF Ambient Condition -Noise	0.6	rectangular	$\sqrt{3}$	1	1	0.3	0.3
RF Ambient Condition - Reflections	3.0	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Probe Positioner Mech. Restrictions	0.4	rectangular	$\sqrt{3}$	1	1	0.2	0.2
Probe Positioning with respect to Phantom Shell	2.9	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	$\sqrt{3}$	1	1	2.1	2.1
<b>Test sample related</b>							
Test sample positioning	2.0	normal	1	1	1	2.0	2.0
Device Holder Uncertainty	4.0	normal	1	1	1	6.215	6.215
Drift of Output Power	5.0	rectangular	$\sqrt{3}$	1	1	2.67	2.67
<b>Phantom and Setup</b>							
Phantom Uncertainty	3.4	rectangular	$\sqrt{3}$	1	1	2.0	2.0
SAR correction in permittivity and conductivity	1.2	normal	1	1	0.84	1.2	1.0
Liquid conductivity measurement	5.0	normal	1	0.78	0.71	3.9	3.6
Liquid permittivity measurement	5.0	normal	1	0.23	0.26	1.3	1.5
conductivity—temperature	1.1	rectangular	$\sqrt{3}$	0.78	0.71	0.5	0.5
permittivity—temperature	1.3	rectangular	$\sqrt{3}$	0.23	0.26	0.2	0.2
Combined Uncertainty		RSS				9.58	9.49
Expanded uncertainty (coverage factor=2)		Normal(k=2)				19.16	18.98

## APPENDIX B – PROBE CALIBRATION CERTIFICATES

### NCL CALIBRATION LABORATORIES

Calibration File No.: PC-1654

Task No: BACL-5805

## 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 Inc.

Model No.: ALS-E020

Serial No.: 500-00283

Calibration Procedure: D01-032-E020-V2, D22-012-Tissue, D28-002-Dipole  
Project No: BACL-5805

Calibrated: 12<sup>th</sup> December 2015  
Released on: 14<sup>th</sup> December 2015

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

Released By:



Art Brennan, Quality Manager

### **NCL** CALIBRATION LABORATORIES

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OTTAWA, ONTARIO  
CANADA K2K 3J1

Division of APREL Lab.  
TEL: (613) 435-8300  
FAX: (613) 435-8306

**NCL Calibration Laboratories**

Division of APREL, Inc.

**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.

**Calibration Method**

Probes are calibrated using the following methods.

<800 MHz

TEM Cell for sensitivity in air

Standard phantom using temperature transfer method for sensitivity in tissue

>800 MHz

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 1528:2013  
IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- IEC 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 62209-2:2010  
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 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz



**NCL Calibration Laboratories**

Division of APREL Inc.

**Conditions**

Probe 500-00283 was a recalibration.

**Ambient Temperature of the Laboratory:** 20 °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 Tektronix USB	11C940	Apr 2, 2017
Signal Generator Agilent E4438C	MY45094463	Dec 11, 2017

**Secondary Measurement Standards**


Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
---------------------------------	--------	--------------

**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 subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.**

  
 -----  
**Art Brennan, Quality Manager**

  
 -----  
**Dan Brooks, Test Engineer**

**NCL Calibration Laboratories**

Division of APREL, Inc.

**Probe Summary**

**Probe Type:** E-Field Probe E-020  
**Serial Number:** 500-00283  
**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  
**Diode Compression Point:** 95 mV

**Sensitivity in Air**

Frequency Range	Channel X, $\mu\text{V}/(\text{V}/\text{m})^2$	Channel Y, $\mu\text{V}/(\text{V}/\text{m})^2$	Channel Z, $\mu\text{V}/(\text{V}/\text{m})^2$	Tolerance, $\mu\text{V}/(\text{V}/\text{m})^2$
450 MHz	1.212	1.205	1.199	$\pm 0.004$
750 MHz, 835 MHz 900 MHz	1.212	1.21	1.209	$\pm 0.004$
1 GHz – 4 GHz	1.21	1.21	1.207	$\pm 0.004$
5 GHz – 6 GHz	1.2	1.192	1.19	$\pm 0.005$

\*Resistive to recommended tissue recipes per IEEE-1528

**NCL Calibration Laboratories**

Division of APREL, Inc.

Calibration for Tissue (Head H, Body B)

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Standard Uncertainty (%)	Calibration Frequency Range (MHz)	Conversion Factor
450 H	Head	43.5	0.84	3.5	±50	5.7
450 B	Body	56.77	0.93	3.5	±50	5.8
750 H	Head	42.92	0.92	3.5	±50	6.0
750 B	Body	55.57	0.93	3.5	±50	5.9
835 H	Head	43.44	0.94	3.5	±50	5.9
835 B	Body	54.91	1.00	3.5	±50	5.9
900 H	Head	41.05	1.01	3.5	±50	6.0
900 B	Body	54.86	1.04	3.5	±50	5.9
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	38.58	1.36	3.5	±75	5.4
1750 B	Body	51.5	1.52	3.5	±75	5.3
1800 H	Head	X	X	X	X	X
1800 B	Body	X	X	X	X	X
1900 H	Head	40.72	1.37	3.5	±75	4.8
1900 B	Body	52.29	1.58	3.5	±75	4.8
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
2100 H	Head	X	X	X	X	X
2100 B	Body	X	X	X	X	X
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
2450 H	Head	37.35	1.85	3.5	±75	4.8
2450 B	Body	53.26	1.96	3.5	±75	4.3
3000 H	Head	X	X	X	X	X
3000 B	Body	X	X	X	X	X
3600 H	Head	37.24	3.14	3.5	±100	4.4
3600 B	Body	50.23	3.81	3.5	±100	4.1
5250 H	Head	35.05	4.65	3.5	±100	3.1
5250 B	Body	46.24	5.11	3.5	±100	2.9
5600 H	Head	34.95	5.06	3.5	±100	3.0
5600 B	Body	45.95	5.73	3.5	±100	2.4
5800 H	Head	34.57	5.27	3.5	±100	3.1
5800 B	Body	46.01	6.10	3.5	±100	2.6

**NCL Calibration Laboratories**

Division of APREL, Inc.

**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.

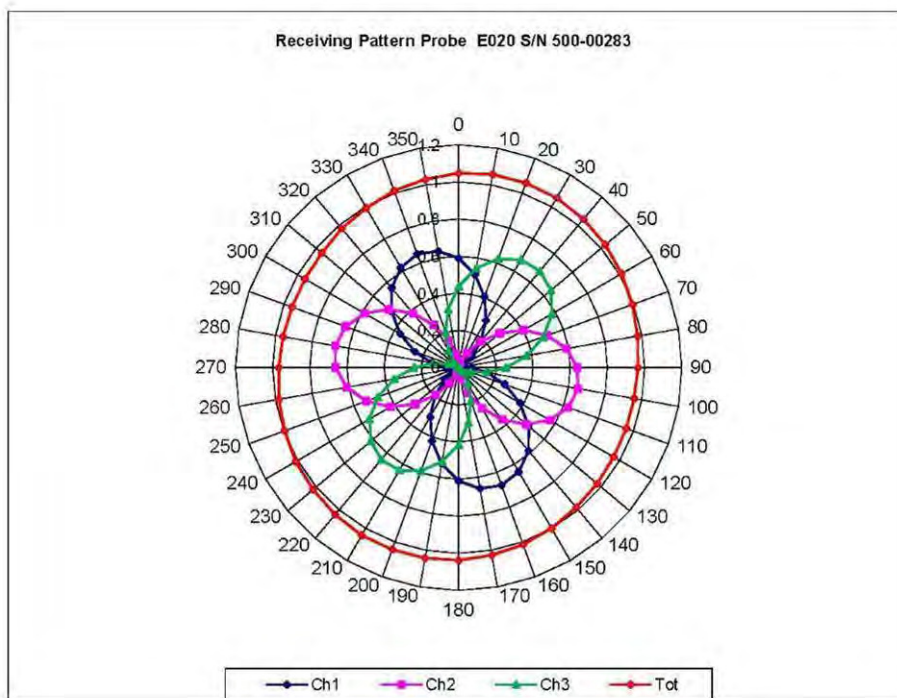
**Probe Calibration Uncertainty**

Uncertainty component	Tolerance (± %)	Probability distribution	Divisor	Standard uncertainty (± %)
Incident or forward power	2.5	R	√3	1.44
Reflected power	2	R	√3	1.15
Liquid conductivity measurement	1	R	√3	0.58
Liquid permittivity measurement	1	R	√3	0.58
Liquid conductivity deviation	1.5	R	√3	0.87
Liquid permittivity deviation	1.5	R	√3	0.87
Frequency deviation	2.25	R	√3	1.30
Field homogeneity	2.5	R	√3	1.44
Field-probe positioning	2.5	R	√3	1.44
Field-probe linearity	1.55	R	√3	0.89
<b>Combined standard uncertainty</b>		RSS		<b>3.50</b>

**NCL Calibration Laboratories**

Division of APREL, Inc.

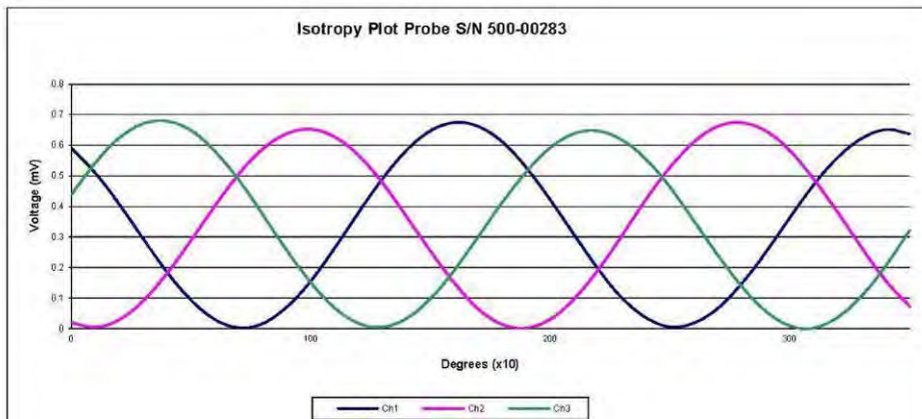
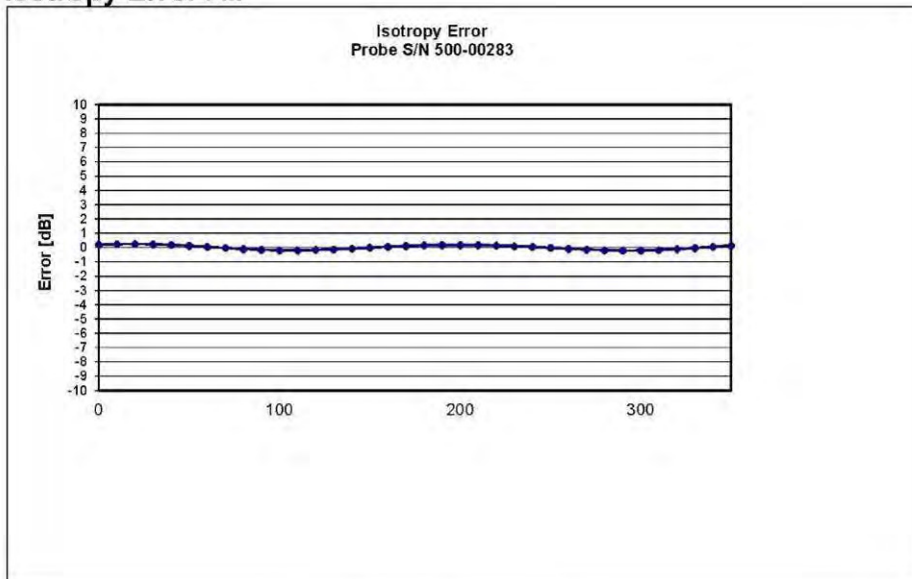
**Receiving Pattern Air**



**NCL Calibration Laboratories**

Division of APREL, Inc.

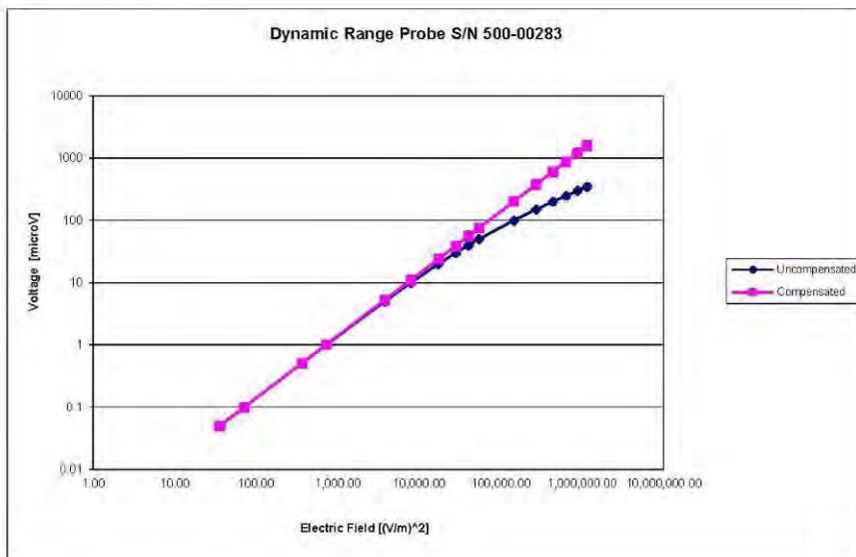
**Isotropy Error Air**



**NCL Calibration Laboratories**

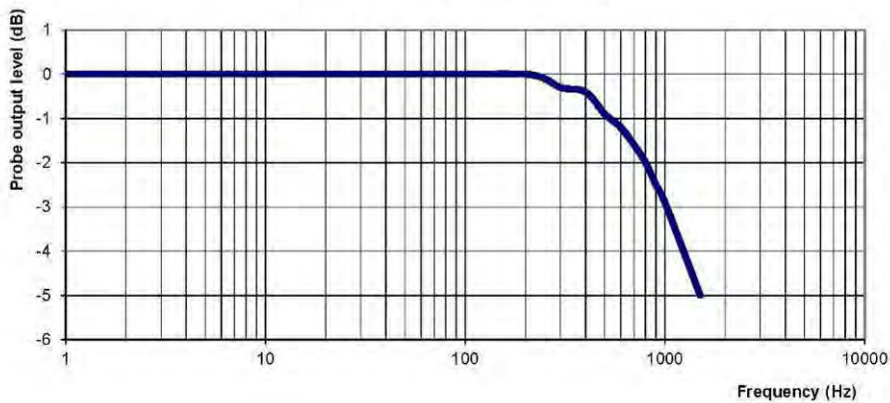
Division of APREL, Inc.

**Dynamic Range**



**Video Bandwidth**

**Probe Frequency Characteristics**



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

Page 9 of 10  
 This page has been reviewed for content and attested to on Page 2 of this document.

Probe S/N 500-00283

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## APPENDIX C DIPOLE CALIBRATION CERTIFICATES

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### NCL CALIBRATION LABORATORIES

Calibration File No: DC-1599  
Project Number: BAC-dipole-cal-5779

## 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.

Validation Dipole(Head and Body)


Manufacturer: APREL Laboratories  
Part number: ALS-D-835-S-2  
Frequency: 835 MHz  
Serial No: 180-00558

Customer: Bay Area Compliance Laboratory (China)

Calibrated: 8<sup>th</sup> October 2014  
Released on: 8<sup>th</sup> October 2014

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

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



Art Brennan, Quality Manager

### **NCL** CALIBRATION LABORATORIES

Suite 102, 303 Terry Fox Dr.  
Kanata, ONTARIO  
CANADA K2K 3J1

Division of APREL Lab.  
TEL: (613) 435-8300  
FAX: (613)435-8306



**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Conditions**

Dipole 180-00558 was received with a damaged connection for a re-calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C**Temperature of the Tissue:** 21 °C +/- 0.5°C**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 subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.



Art Brennan, Quality Manager



Maryna Nesterova Calibration Engineer

**Primary Measurement Standards**

<b>Instrument</b>	<b>Serial Number</b>	<b>Cal due date</b>
Tektronix USB Power Meter	11C940	May 14, 2015
Network Analyzer Anritsu 37347C	002106	Feb. 20, 2015

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Calibration Results Summary**

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

**Mechanical Dimensions**

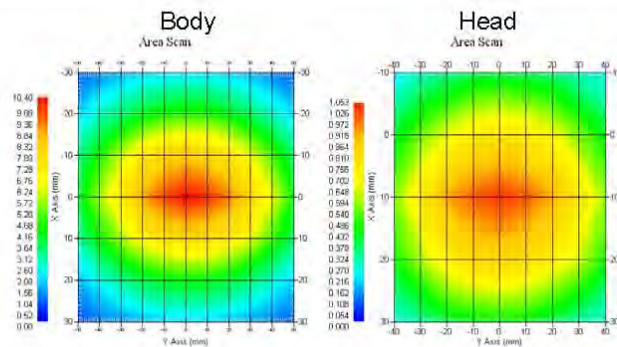
Length: 162.2 mm  
 Height: 89.4 mm

**Electrical Specification**

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	835 MHz	1.066 U	-30.344 dB	49.001 Ω
Body	835 MHz	1.089 U	-28.118 dB	53.117 Ω

**System Validation Results**

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	835 MHz	9.773	6.174	14.713
Body	835 MHz	9.736	6.297	14.513



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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**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 180-00558. 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 30 MHz to 6 GHz E-Field Probe Serial Number 225.

**References**

- SSI-TP-018-ALSAS Dipole Calibration Procedure
- SSI-TP-016 Tissue Calibration Procedure
- IEEE 1528:2013 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques"
- IEC-62209-1:2006 "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-62209-2:2010 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures" Part 2: "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)"
- D28-002 Procedure for validation of SAR system using a dipole

**Conditions**

Dipole 180-00558 was repaired prior to this calibration. The repair reliability depends upon correct usage of the dipole.

**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.

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

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Dipole Calibration Results**

**Mechanical Verification**

APREL Length	APREL Height	Measured Length	Measured Height
161.0 mm	89.8 mm	162.2 mm	89.4 mm

**Electrical Verification**

Tissue Type	Return Loss:	SWR:	Impedance:
Head	-30.344 dB	1.066 U	49.001 Ω
Body	-28.118 dB	1.089 U	53.117 Ω □

**Tissue Validation**

	Dielectric constant, $\epsilon_r$	Conductivity, $\sigma$ [S/m]
Head Tissue 835MHz	43.42	0.94
Body Tissue 835MHz	55.77	1.01

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

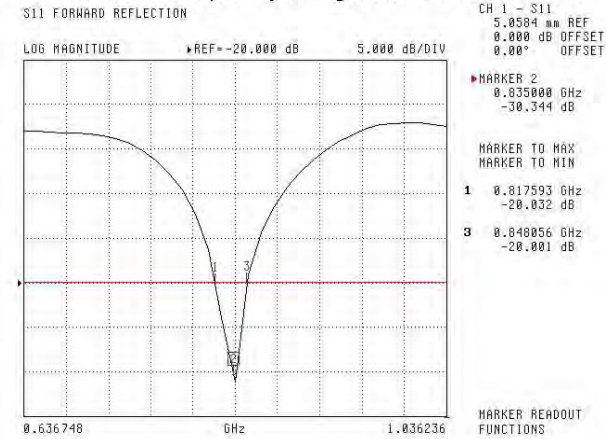
**NCL Calibration Laboratories**

Division of APREL Laboratories.

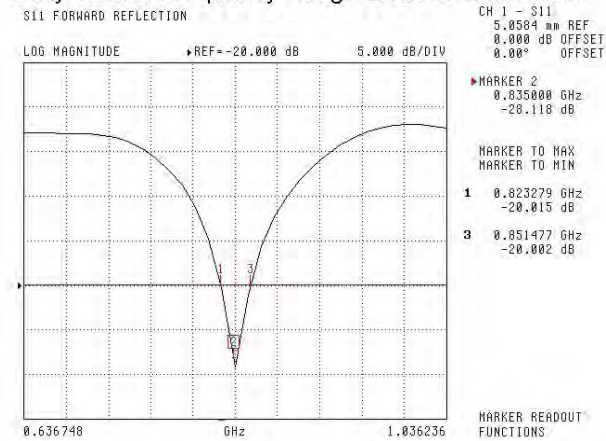
The Following Graphs are the results as displayed on the Vector Network Analyzer.

**S11 Parameter Return Loss**

Head Tissue: Frequency Range 0.817 to 0.848 GHz



Body Tissue: Frequency Range 0.823 to 0.851 GHz

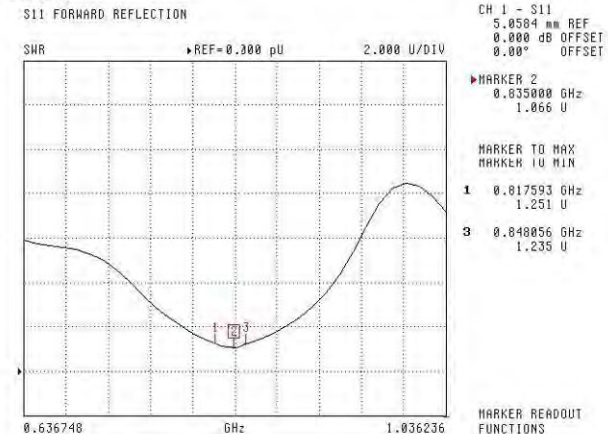


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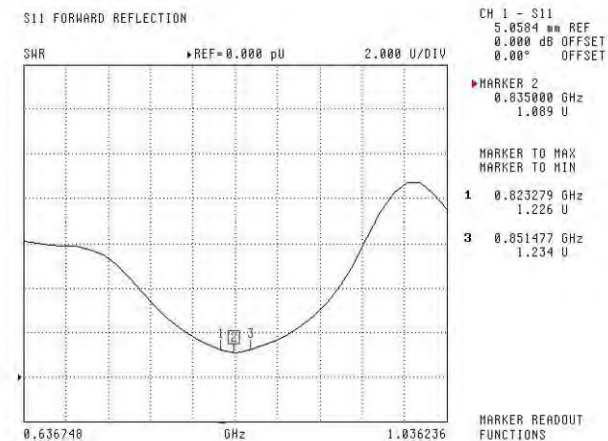
**NCL Calibration Laboratories**

Division of APREL Laboratories.

**SWR**  
**Head**



**Body**



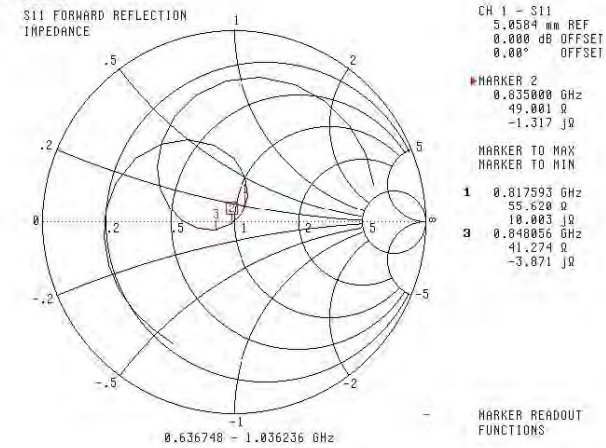
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**NCL Calibration Laboratories**

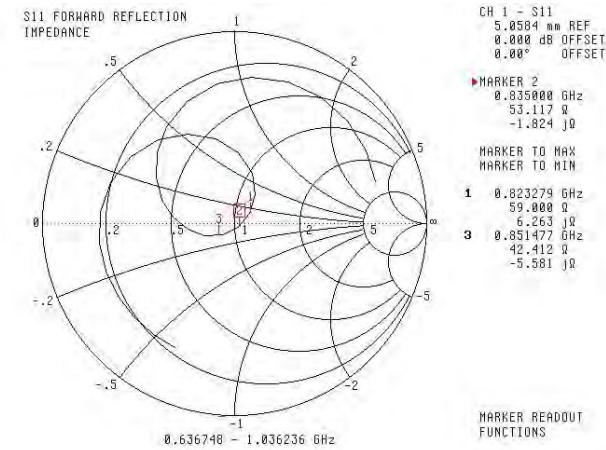
Division of APREL Laboratories.

**Smith Chart Dipole Impedance**

**Head**



**Body**



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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**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 2014.

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

9



**NCL CALIBRATION LABORATORIES**

Calibration File No: DC-1531  
Project Number: BACL-5745

**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.

BACL Head & Body Validation Dipole


Manufacturer: APREL Laboratories  
Part number: ALS-D-1750-S-2  
Frequency: 1750 MHz  
Serial No: 198-00304

Customer: ISL

Calibrated: 8<sup>th</sup> October, 2013  
Released on: 8<sup>th</sup> October, 2013

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

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



Art Brennan, Quality Manager

**NCL CALIBRATION LABORATORIES**

Suite 102, 303 Terry Fox Dr,  
OTTAWA, ONTARIO  
CANADA K2K 3J1

Division of APREL Lab.  
TEL: (613) 435-8300  
FAX: (613) 435-8306

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Conditions**

Dipole 198-00304 was an original 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 subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

  
-----  
Art Brennan, Quality Manager

  
-----  
Constantin Teodorian, Test Engineer

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Calibration Results Summary**

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

**Mechanical Dimensions**

Length: 75 mm  
 Height: 42 mm

**Electrical Calibration**

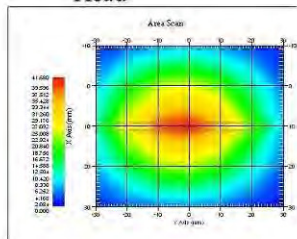
Test	Result Head	Result Body
S11 R/L	-25.567	-20.548 dB
SWR	1.111U	1.207 U
Impedance	53.637Ω	55.929 Ω

**System Validation Results, 1750 MHz**

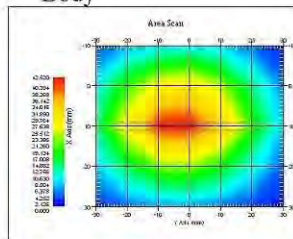
	1g	10g
Head	37.02	18.99
Body	36.65	18.85

Type	Epsilon	Sigma
Head	38.51	1.36
Body	51.79	1.53

Head



Body



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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**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. 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**

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

This was an original calibration taken from stock.

**Dipole Calibration uncertainty**

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

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

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Dipole Calibration Results**

**Mechanical Verification**

Measured Length	Measured Height
75 mm	42 mm

**Tissue Validation**

Frequency	Permittivity $\epsilon$	Conductivity $\sigma$
1750 Head	38.23	1.38
1750 Body	52.86	1.54

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

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**NCL Calibration Laboratories**

Division of APREL Laboratories.

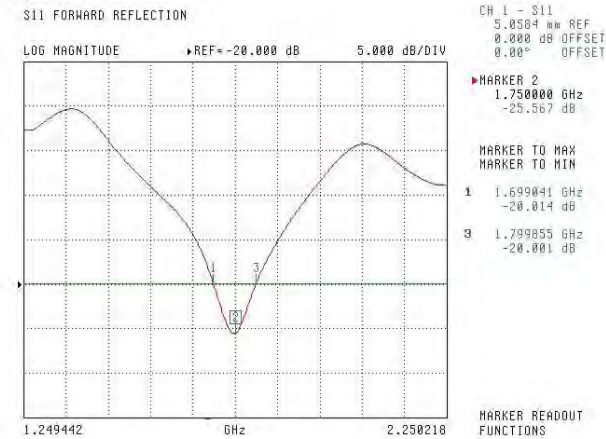
**Electrical Calibration**

Test	Result Head	Result Body
S11 R/L	-25.567	-20.548 dB
SWR	1.111U	1.207 U
Impedance	53.637Ω	55.929 Ω

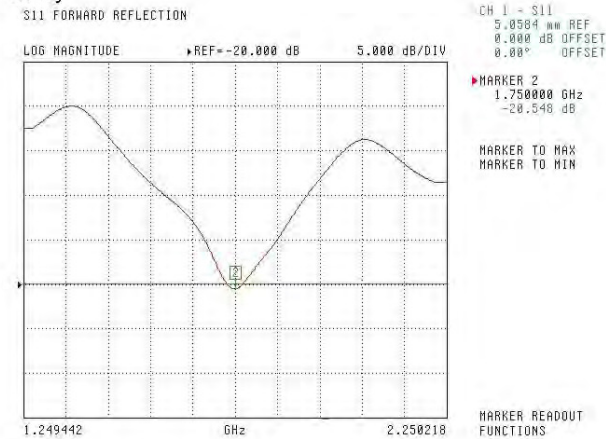
The Following Graphs are the results as displayed on the Vector Network Analyzer.

**S11 Parameter Return Loss**

**Head**



**Body**

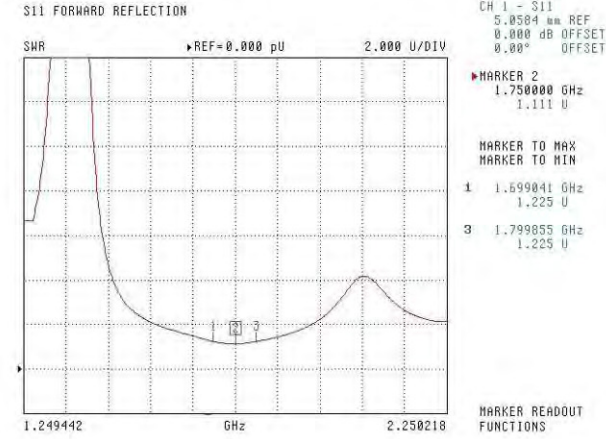


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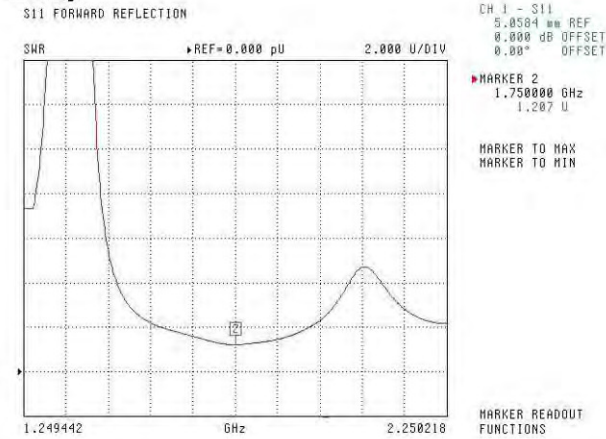
**NCL Calibration Laboratories**

Division of APREL Laboratories.

**SWR  
Head**



**Body**



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

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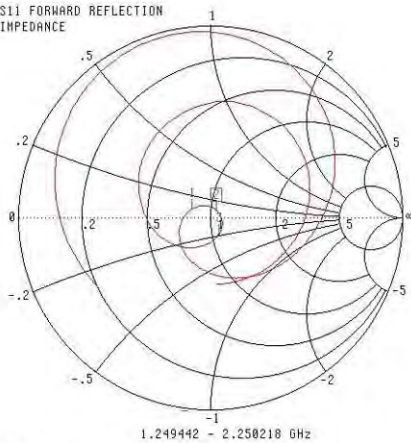
**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Smith Chart Dipole Impedance**

**Head**

S11 FORWARD REFLECTION  
IMPEDANCE



CH 1 - S11  
5.0584 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

MARKER 2  
1.750000 GHz  
53.637 Ω  
3.752 jΩ

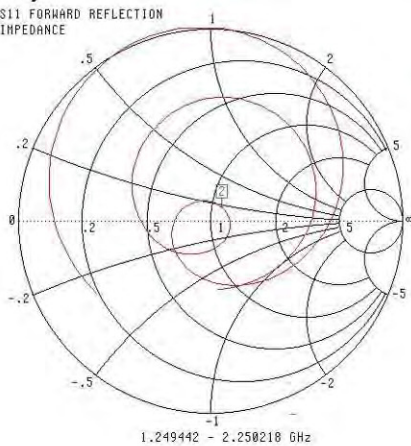
MARKER TO MAX  
MARKER TO MIN

- 1 1.699041 GHz  
41.539 Ω  
3.495 jΩ
- 3 1.799055 GHz  
54.266 Ω  
-9.661 jΩ

MARKER READOUT  
FUNCTIONS

**Body**

S11 FORWARD REFLECTION  
IMPEDANCE



CH 1 - S11  
5.0584 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

MARKER 2  
1.750000 GHz  
55.929 Ω  
7.816 jΩ

MARKER TO MAX  
MARKER TO MIN

MARKER READOUT  
FUNCTIONS

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



**NCL Calibration Laboratories**

Division of APREL Laboratories.

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**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 2013

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

9

**NCL CALIBRATION LABORATORIES**

Calibration File No: DC-1601  
Project Number: BAC-dipole -cal-5779

**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.

Validation Dipole (Head & Body)

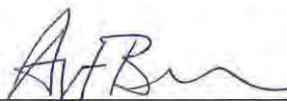
Manufacturer: APREL Laboratories  
Part number: ALS-D-1900-S-2  
Frequency: 1900 MHz  
Serial No: 210-00710

Customer: Bay Area Compliance Laboratory (China)

Calibrated: 9<sup>th</sup> October, 2014  
Released on: 9<sup>th</sup> October, 2014

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

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



Art Brennan, Quality Manager

**NCL CALIBRATION LABORATORIES**

Suite 102, 303 Terry Fox Dr.  
Kanata, ONTARIO  
CANADA K2K 3J1

Division of APREL Lab.  
TEL: (613) 435-8300  
FAX: (613)435-8306

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Conditions**

Dipole 210-00710 was received in good condition and was a re-calibration.

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

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

**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 subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.



Art Brennan, Quality Manager



Maryna Nesterova Calibration Engineer

**Primary Measurement Standards**

<b>Instrument</b>	<b>Serial Number</b>	<b>Cal due date</b>
Tektronix USB Power Meter	11C940	May 14, 2015
Network Analyzer Anritsu 37347C	002106	Feb. 20, 2015

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Calibration Results Summary**

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

**Mechanical Dimensions**

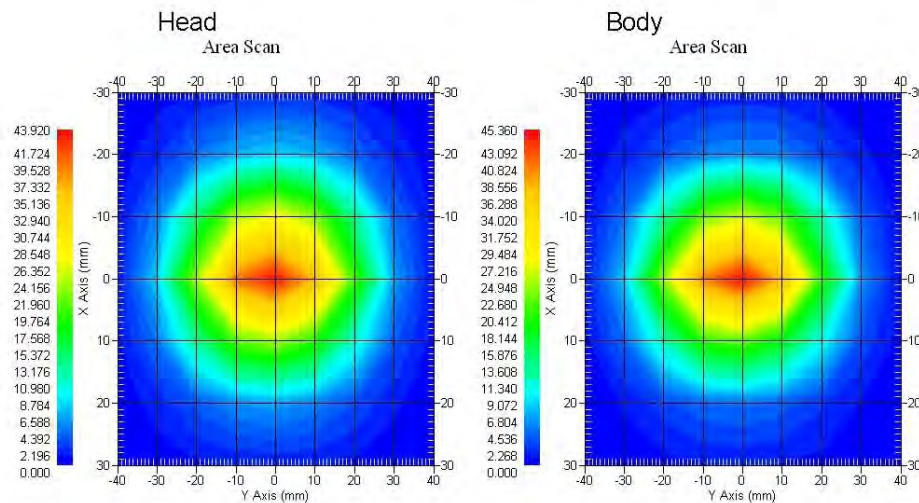
**Length:** 67.1 mm  
**Height:** 38.9 mm

**Electrical Specification**

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	1900MHz	1.084 U	-27.92 dB	52.247 Ω
Body	1900MHz	1.128 U	-24.40 dB	52.618 Ω

**System Validation Results**

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	1900 MHz	39.481	20.44	73.364
Body	1900 MHz	39.715	20.552	73.565



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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**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 210-00710. 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 30 MHz to 6 GHz E-Field Probe Serial Number 225.

**References**

- SSI-TP-018-ALSAS Dipole Calibration Procedure
- SSI-TP-016 Tissue Calibration Procedure
- IEEE 1528:2013 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques"
- IEC-62209-1:2006 "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-62209-2:2010 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures"  
Part 2: "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)"
- D28-002 Procedure for validation of SAR system using a dipole

**Conditions**

Dipole 210-00710 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.

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

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**Dipole Calibration Results**

**Mechanical Verification**

APREL Length	APREL Height	Measured Length	Measured Height
68.0 mm	39.5 mm	67.1mm	38.9 mm

**Electrical Validation**

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	1900MHz	1.084 U	-27.92 dB	52.247 Ω
Body	1900MHz	1.128 U	-24.40 dB	52.618 Ω

**Tissue Validation**

	Dielectric constant, $\epsilon_r$	Conductivity, $\sigma$ [S/m]
Head Tissue 1900MHz	40.20	1.38
Body Tissue 1900MHz	52.63	1.46

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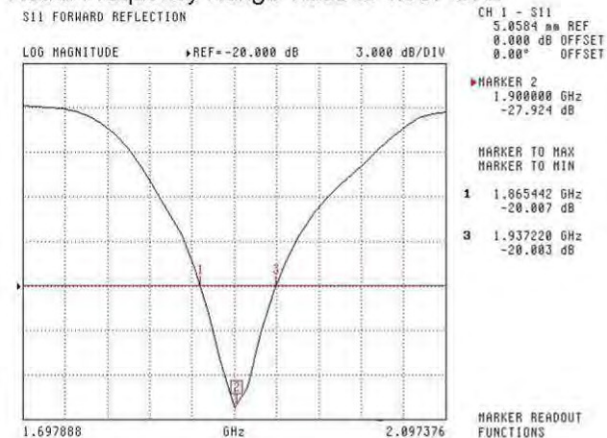
**NCL Calibration Laboratories**

Division of APREL Laboratories.

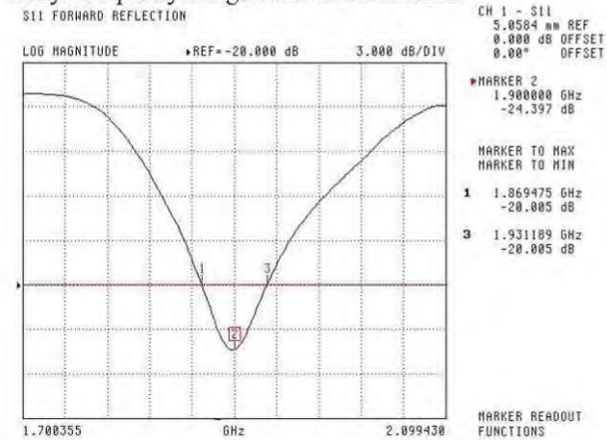
The Following Graphs are the results as displayed on the Vector Network Analyzer.

**S11 Parameter Return Loss**

Head: Frequency Range 1.865 to 1.937 GHz



Body: Frequency Range 1.869 to 1.931 MHz

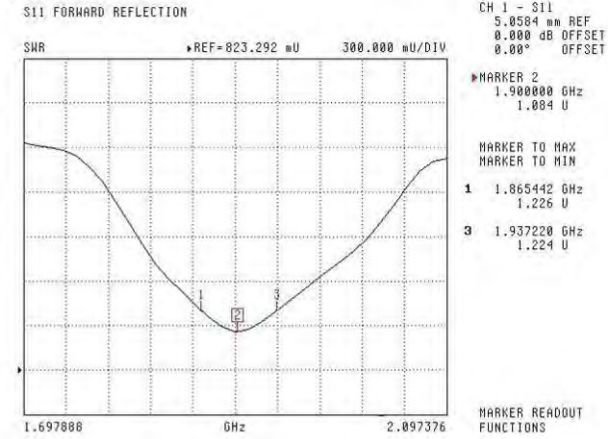


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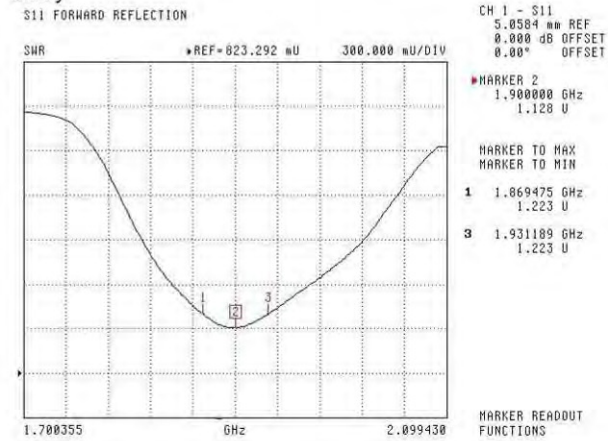
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**SWR**

**Head**



**Body**



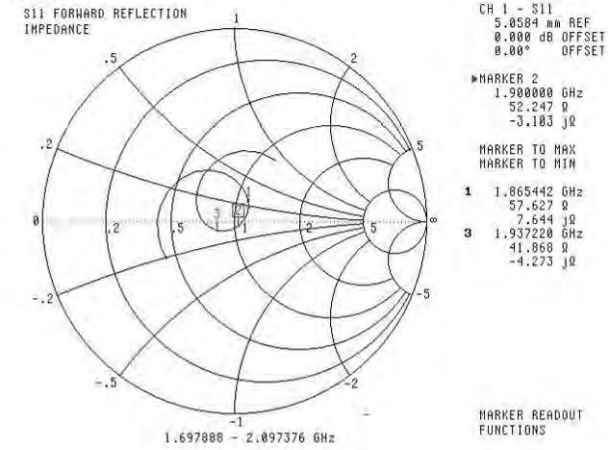
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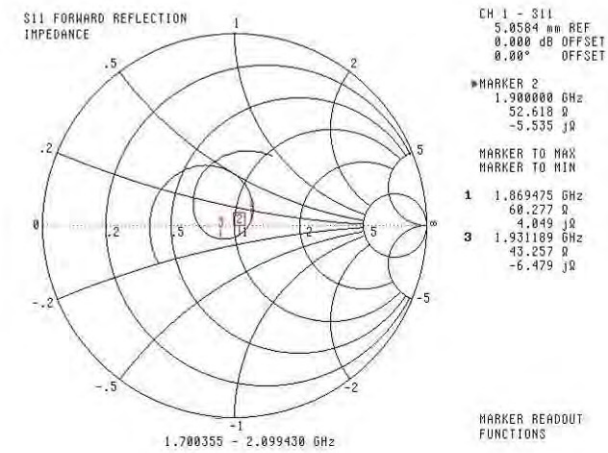
**NCL Calibration Laboratories**  
 Division of APREL Laboratories.

**Smith Chart Dipole Impedance**

**Head**



**Body**



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**NCL Calibration Laboratories**

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**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 2014

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9

**NCL CALIBRATION LABORATORIES**

Calibration File No: DC-1602  
Project Number: BAC-dipole-cal-5779

**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.


Validation Dipole (Head & Body)

Manufacturer: APREL Laboratories  
Part number: ALS-D-2450-S-2  
Frequency: 2450 MHz  
Serial No: 220-00758

Customer: Bay Area Compliance Laboratory

Calibrated: 9<sup>th</sup> October, 2014  
Released on: 9<sup>th</sup> October, 2014

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

Released By:   
Art Brennan, Quality Manager

**NCL CALIBRATION LABORATORIES**

Suite 102, 303 Terry Fox Dr.  
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Division of APREL Lab.  
TEL: (613) 435-8300  
FAX: (613)435-8306

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Conditions**

Dipole 220-00758 was received in good condition and was a re-calibration.

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

**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 subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

  
 -----  
 Art Brennan, Quality Manager

  
 -----  
 Maryna Nesterova Calibration Engineer

**Primary Measurement Standards**

<b>Instrument</b>	<b>Serial Number</b>	<b>Cal due date</b>
Tektronix USB Power Meter	11C940	May 14, 2015
Network Analyzer Anritsu 37347C	002106	Feb. 20, 2015

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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Calibration Results Summary**

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

**Mechanical Dimensions**

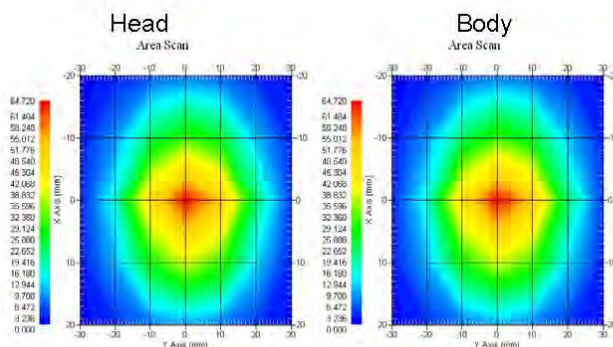
Length: 52.4 mm  
 Height: 30.3 mm

**Electrical Specification**

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	2450 MHz	1.014 U	-45.184 dB	50.006Ω
Body	2450 MHz	1.070 U	-29.453 dB	50.672 Ω

**System Validation Results**

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	2450 MHz	54.916	25.327	111.97
Body	2450 MHz	52.418	24.691	103.91



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

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**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 220-00758. 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 30 MHz to 6 GHz E-Field Probe Serial Number 225.

**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 220-00758 was a re-calibration.

**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.

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

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

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Division of APREL Laboratories.

**Dipole Calibration Results**

**Mechanical Verification**

APREL Length	APREL Height	Measured Length	Measured Height
51.5 mm	30.4 mm	52.4 mm	30.3 mm

**Electrical Specification**

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	2450 MHz	1.014 U	-45.184 dB	50.006Ω
Body	2450 MHz	1.070 U	-29.453 dB	50.672 Ω

**Tissue Validation**

	Dielectric constant, $\epsilon_r$	Conductivity, $\sigma$ [S/m]
Head Tissue 2450MHz	37.26	1.84
Body Tissue 2450MHz	53.61	1.90

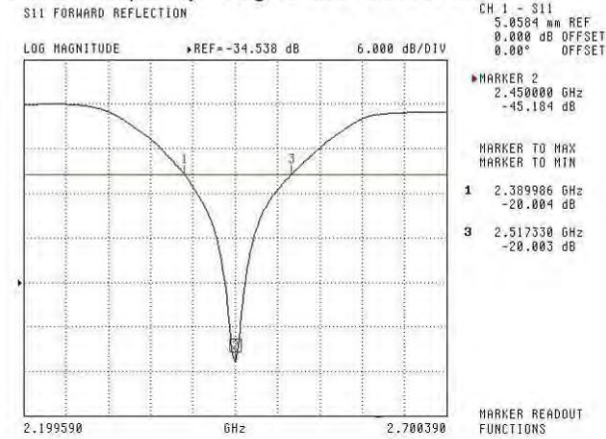
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 Division of APREL Laboratories.

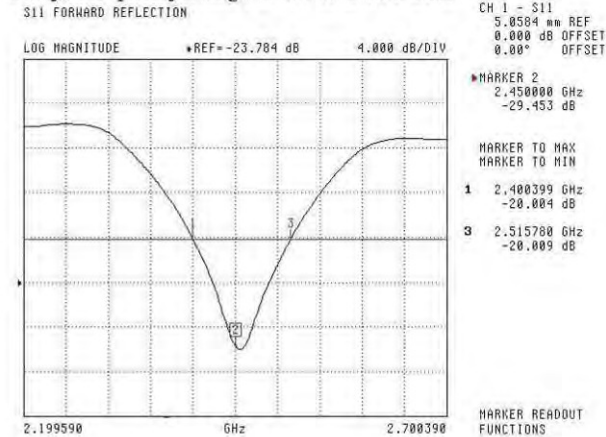
The Following Graphs are the results as displayed on the Vector Network Analyzer.

**S11 Parameter Return Loss**

Head: Frequency Range 2.390 to 2.517 GHz



Body: Frequency Range 2.400 to 2.516 GHz



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

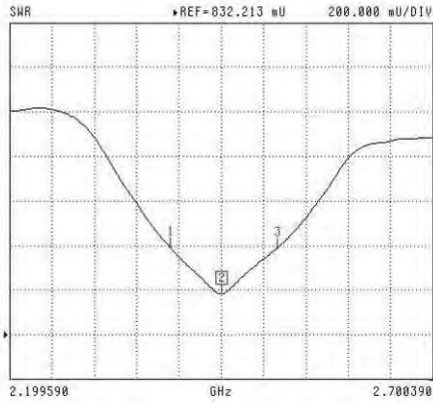


**NCL Calibration Laboratories**  
Division of APREL Laboratories.

**SWR**

**Head**

S11 FORWARD REFLECTION



CH 1 - S11  
5.0584 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

\*MARKER 2  
2.450000 GHz  
1.014 U

MARKER TO MAX  
MARKER TO MIN

- 1 2.389986 GHz  
1.223 U
- 3 2.517330 GHz  
1.223 U

MARKER READOUT  
FUNCTIONS

**Body**

S11 FORWARD REFLECTION



CH 1 - S11  
5.0584 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

\*MARKER 2  
2.450000 GHz  
1.070 U

MARKER TO MAX  
MARKER TO MIN

- 1 2.400399 GHz  
1.223 U
- 3 2.515780 GHz  
1.223 U

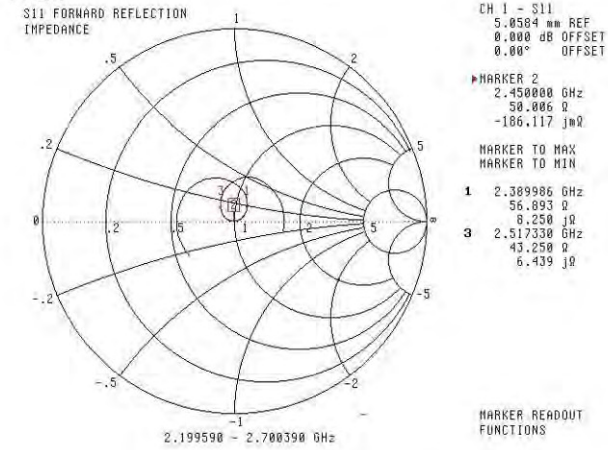
MARKER READOUT  
FUNCTIONS

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

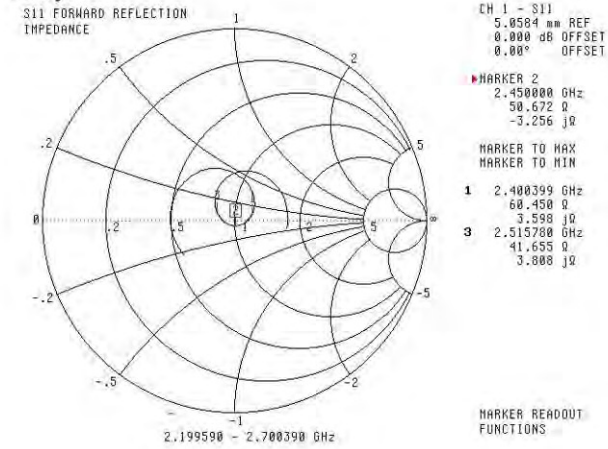
**NCL Calibration Laboratories**  
 Division of APREL Laboratories.

**Smith Chart Dipole Impedance**

**Head**



**Body**



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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Test Equipment**

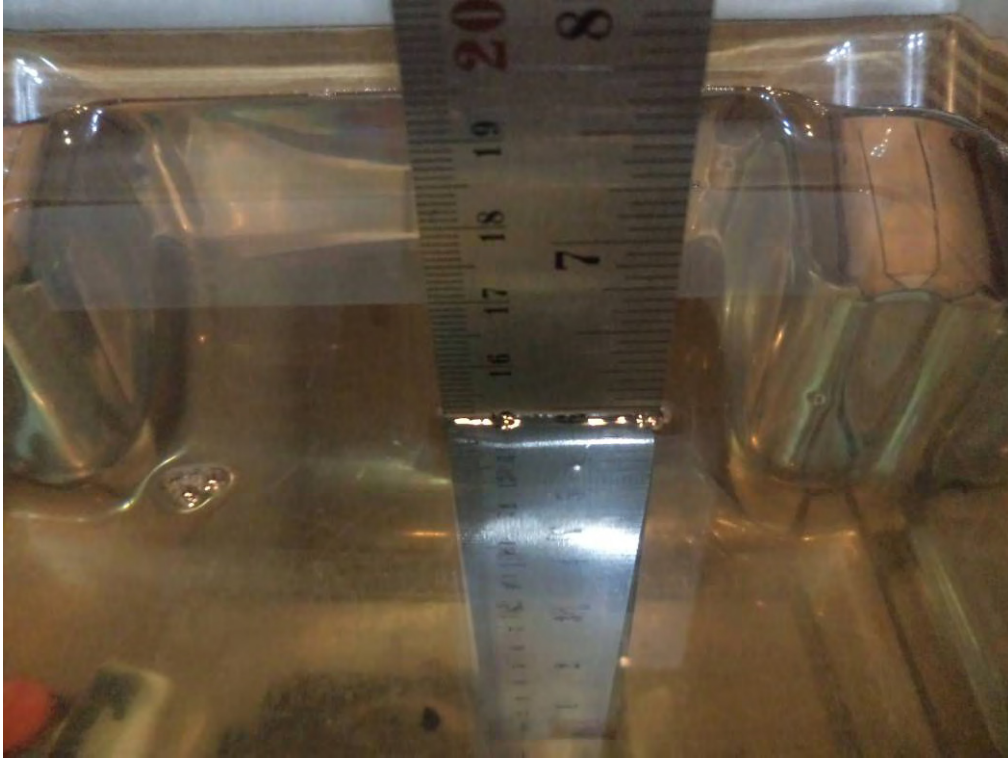
The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2014.

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

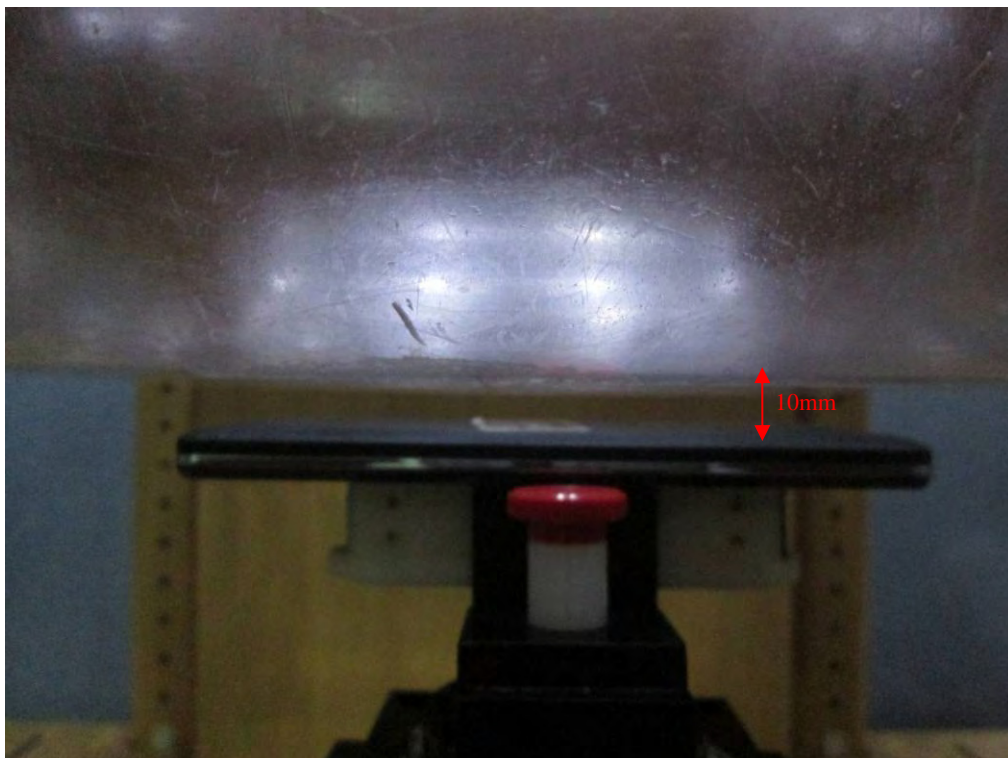
9

## APPENDIX D EUT TEST POSITION PHOTOS

Liquid depth  $\geq 15\text{cm}$



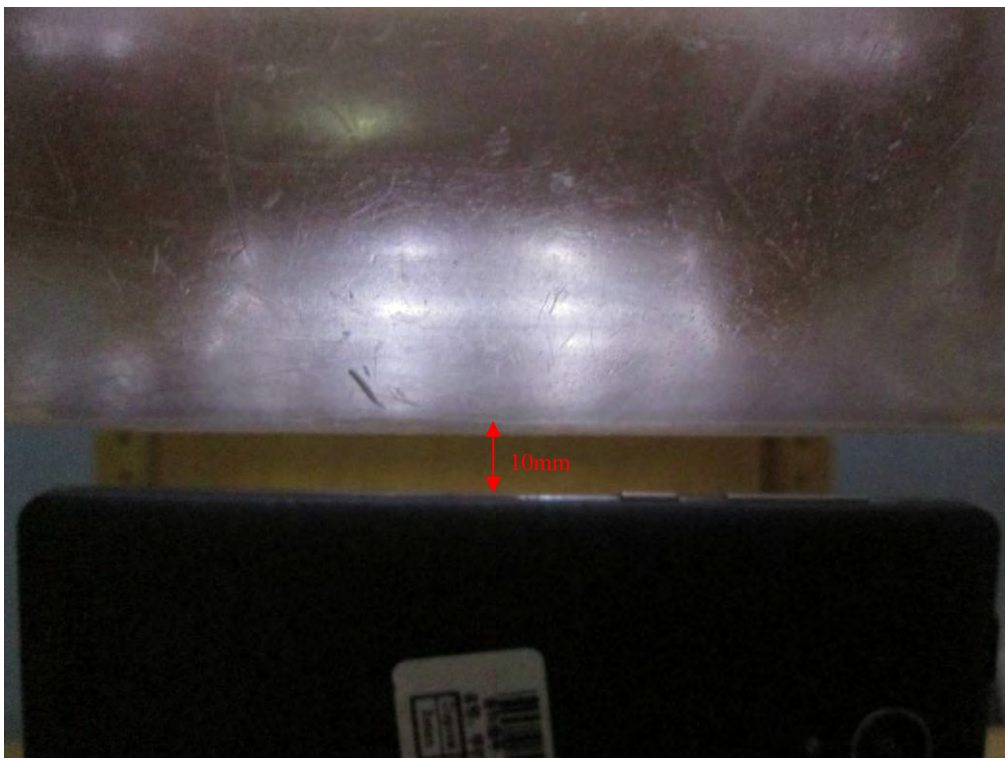
Body-worn Back Setup Photo (10mm)



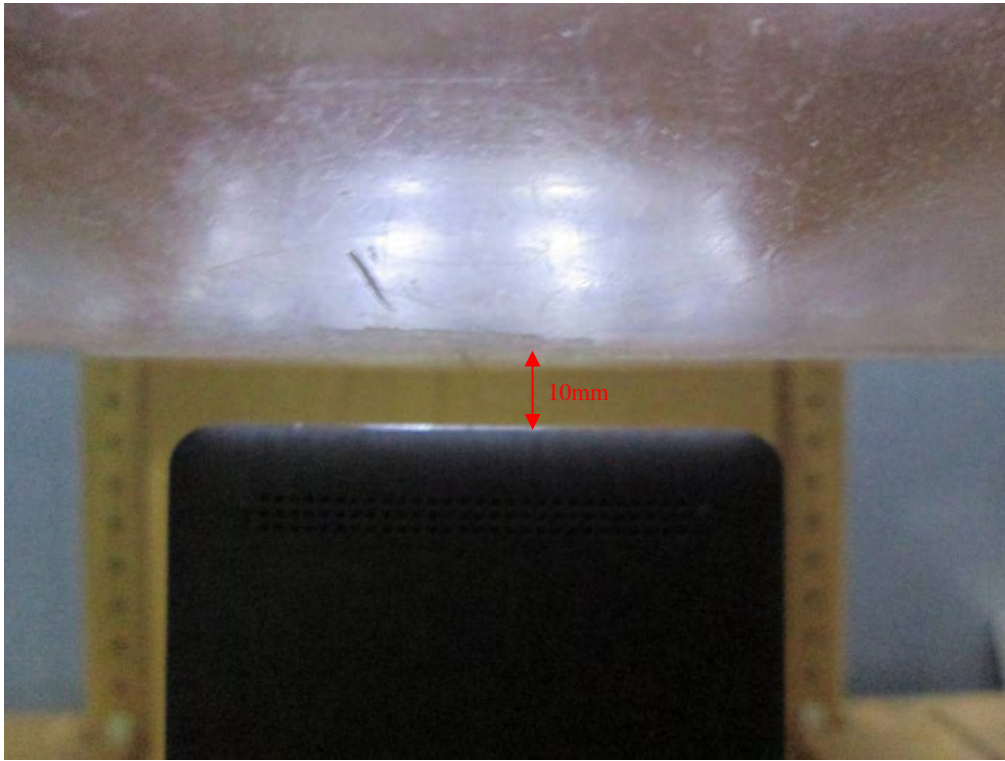
**Body-worn Left Setup Photo (10mm)**



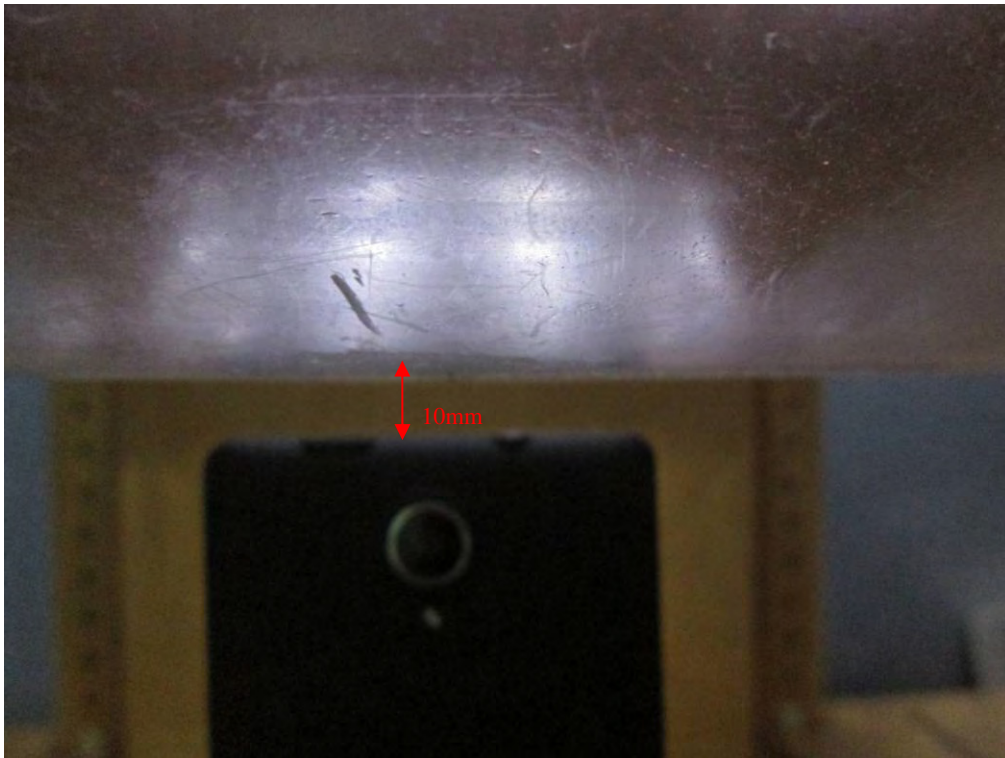
**Body-worn Right Setup Photo (10mm)**



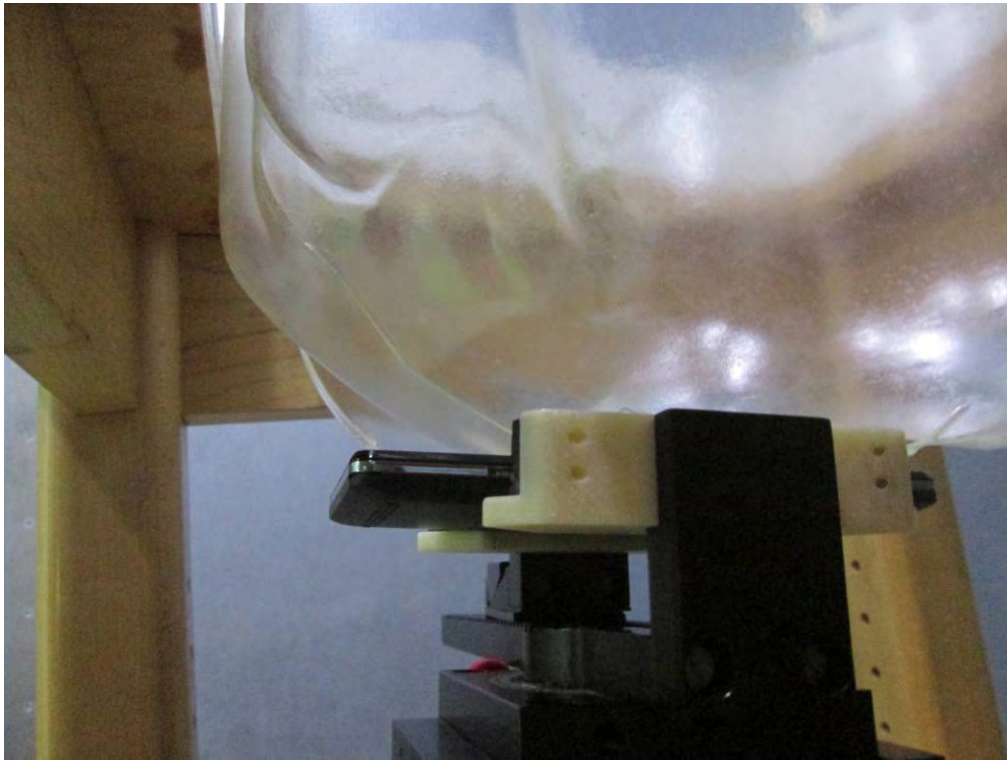
**Body-worn Bottom Setup Photo (10mm)**



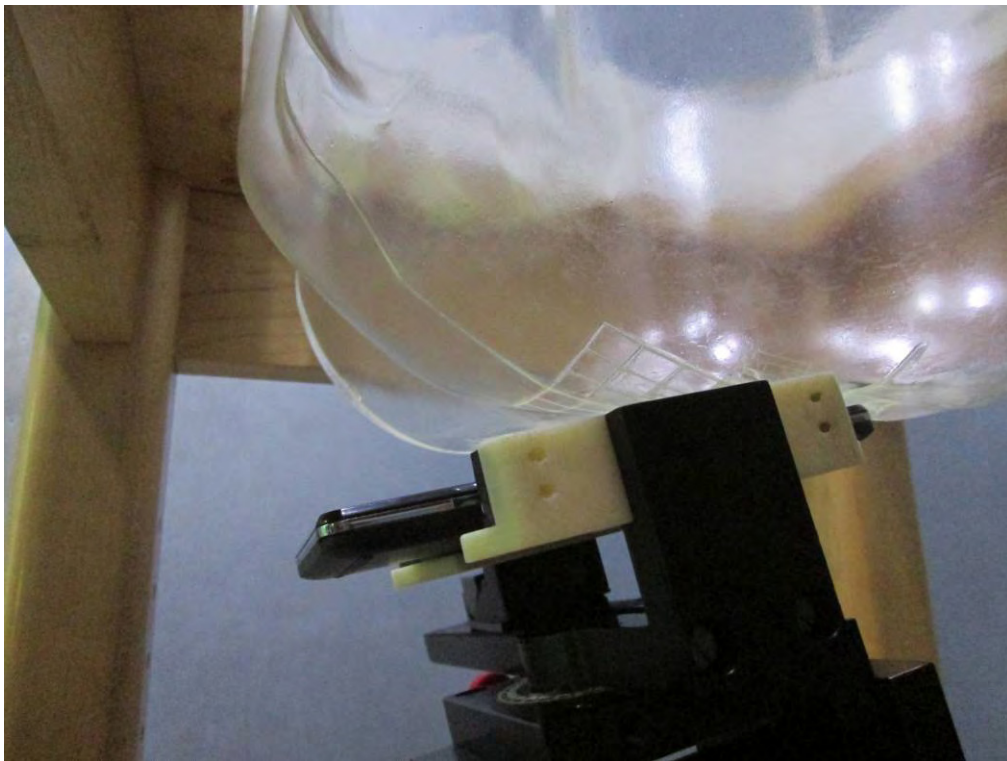
**Body-worn Top Setup Photo (10mm)**



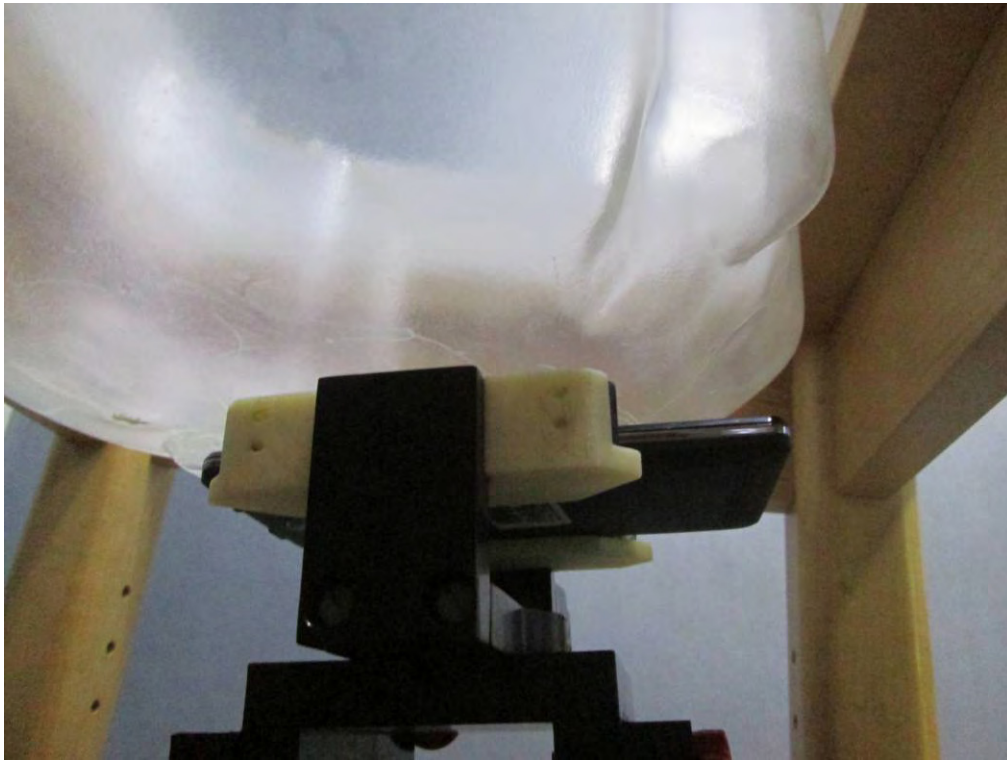
**Left Head Touch Setup Photo**



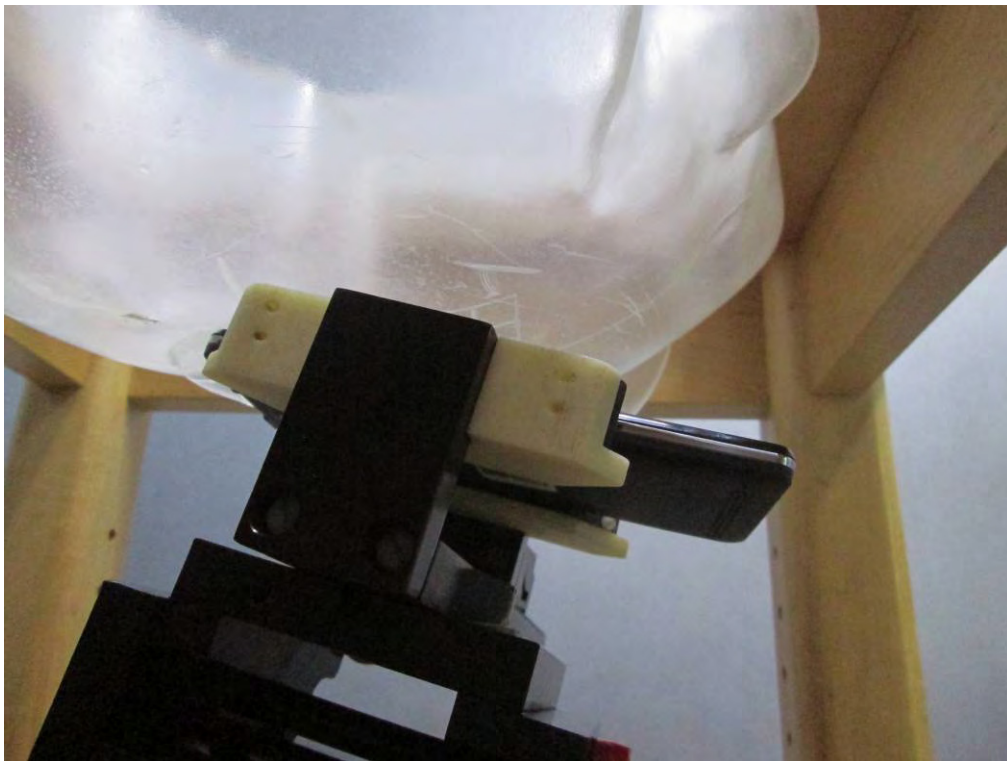
**Left Head Tilt Setup Photo**



**Right Head Touch Setup Photo**



**Right Head Tilt Setup Photo**





## APPENDIX E EUT PHOTOS

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**EUT – Front View**



**EUT – Rear View**



**EUT – Left Side View**



**EUT – Right Side View**



**EUT – Top View**



**EUT – Bottom View**



**EUT – Uncover View**



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## APPENDIX F INFORMATIVE REFERENCES

---

- [1] Federal Communications Commission, "Report and order: Guidelines for evaluating the environmental effects of radiofrequency radiation", Tech. Rep. FCC 96-326, FCC, Washington, D.C. 20554, 1996.
- [2] David L. Means Kwok Chan, Robert F. Cleveland, "Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields", Tech. Rep., Federal Communication Commission, Office of Engineering & Technology, Washington, DC, 1997.
- [3] Thomas Schmid, Oliver Egger, and Niels Kuster, "Automated E-field scanning system for dosimetric assessments", IEEE Transactions on Microwave Theory and Techniques, vol. 44, pp. 105-113, Jan. 1996.
- [4] Niels Kuster, Ralph Kastle, and Thomas Schmid, "Dosimetric evaluation of mobile communications equipment with known precision", IEICE Transactions on Communications, vol. E80-B, no. 5, pp. 645-652, May 1997.
- [5] CENELEC, "Considerations for evaluating of human exposure to electromagnetic fields (EMFs) from mobile telecommunication equipment (MTE) in the frequency range 30MHz - 6GHz", Tech. Rep., CENELEC, European Committee for Electrotechnical Standardization, Brussels, 1997.
- [6] ANSI, ANSI/IEEE C95.1-1992: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, The Institute of Electrical and Electronics Engineers, Inc., New York, NY 10017, 1992.
- [7] Katja Pokovic, Thomas Schmid, and Niels Kuster, "Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies", in ICECOM '97, Dubrovnik, October 15-17, 1997, pp. 120-24.
- [8] Katja Pokovic, Thomas Schmid, and Niels Kuster, "E-field probe with improved isotropy in brain simulating liquids", in Proceedings of the ELMAR, Zadar, Croatia, 23-25 June, 1996, pp. 172-175.
- [9] Volker Hombach, Klaus Meier, Michael Burkhardt, Eberhard Kuhn, and Niels Kuster, "The dependence of EM energy absorption upon human head modeling at 900 MHz", IEEE Transactions on Microwave Theory and Techniques, vol. 44, no. 10, pp. 1865-1873, Oct. 1996.
- [10] Klaus Meier, Ralf Kastle, Volker Hombach, Roger Tay, and Niels Kuster, "The dependence of EM energy absorption upon human head modeling at 1800 MHz", IEEE Transactions on Microwave Theory and Techniques, Oct. 1997, in press.
- [11] W. Gander, Computermathematik, Birkhaeuser, Basel, 1992.
- [12] W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second Edition, Cambridge University Press, 1992. Dosimetric Evaluation of Sample device, month 1998 9
- [13] NIS81 NAMAS, "The treatment of uncertainty in EMC measurement", Tech. Rep., NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, 1994.
- [14] Barry N. Taylor and Christ E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Tech. Rep., National Institute of Standards and Technology, 1994. Dosimetric Evaluation of Sample device, month 1998 10.

\*\*\*\*\* END OF REPORT \*\*\*\*\*