

# RF Exposure Lab

802 N. Twin Oaks Valley Road, Suite 105 • San Marcos, CA 92069 • U.S.A.

TEL (760) 471-2100 • FAX (760) 471-2121

<http://www.rfexposurelab.com>

## CERTIFICATE OF COMPLIANCE SAR EVALUATION

Lectrosonic, Inc.  
581 Laser Road NE  
Rio Rancho, NM 87124

Dates of Test:  
Test Report Number:

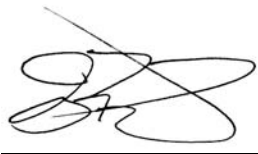
June 4, 2012  
SAR.20120603  
Revision A

FCC ID:	DBZWME
IC Certificate:	8024A-WME
Model(s):	WM E
Test Sample:	Engineering Unit Same as Production
Serial No.:	Various (See Data Sheets)
Equipment Type:	Wireless Microphone
Classification:	Portable Transmitter Next to Body
TX Frequency Range:	470.1 – 495.6 MHz; 486.4 – 511.9 MHz; 512.0 – 537.5 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	23.97 dBm Radiated
Signal Modulation:	FM
Antenna Type (Length):	Dependent on Transmit Band
Application Type:	Certification
FCC Rule Parts:	Part 2, 74
KDB Test Methodology:	KDB 447498
Industry Canada:	RSS-102, Safety Code 6
Maximum SAR Value:	0.437
Separation Distance:	0 mm

This wireless mobile and/or portable device has been shown to be compliant for localized specific absorption rate (SAR) for controlled environment limits specified in ANSI/IEEE Std. C95.1-1992 and had been tested in accordance with the measurement procedures specified in IEEE 1528-2003, OET Bulletin 65 Supp. C, KDB447498, RSS-102 and Safety Code 6 (See test report).

I attest to the accuracy of the data. All measurements were performed by myself or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RF Exposure Lab, LLC certifies that no party to this application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 853(a).



Jay M. Moulton  
Vice President



Certificate # 2387.01

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## 1. Introduction

This measurement report shows compliance of the Lectrosonic Inc. Model WM E FCC ID: DBZWME with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 8024A-WME with RSS102 & Safety Code 6. The FCC have adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on August 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC regulated portable devices. [1], [6]

The test procedures, as described in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [2], ANSI C95.3 – 2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields [3], FCC OET Bulletin 65 Supp. C – 2001 [4], IEEE Std.1528 – 2003 Recommended Practice [5], and Industry Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz were employed.

### SAR Definition [5]

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy ( $dW$ ) absorbed by (dissipated in) an incremental mass ( $dm$ ) contained in a volume element ( $dV$ ) of a given density ( $\rho$ ).

$$SAR = \frac{d}{dt} \left( \frac{dW}{dm} \right) = \frac{d}{dt} \left( \frac{dW}{\rho dV} \right)$$

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

where:

$\sigma$  = conductivity of the tissue (S/m)

$\rho$  = mass density of the tissue (kg/m<sup>3</sup>)

$E$  = rms electric field strength (V/m)

## 2. SAR Measurement Setup

### Robotic System

The measurements are conducted utilizing the ALSAS-10-U automated dosimetric assessment system. The ALSAS-10-U is designed and manufactured by Aprel Laboratories in Nepean, Ontario, Canada. The system utilizes a Robcomm 3 robot manufactured by ThermoCRS located in Michigan USA.

### System Hardware

The system consists of a six axis articulated arm, controller for precise probe positioning (0.05 mm repeatability), a power supply, a teach pendant for teaching area scans, near field probe, an IBM Pentium 4™ 2.66 GHz PC with Windows XP Pro™, and custom software developed to enable communications between the robot controller software and the host operating system.

An amplifier is located on the articulated arm, which is isolated from the custom designed end effector and robot arm. The end effector provides the mechanical touch detection functionality and probe connection interface. The amplifier is functionally validated within the manufacturer's site and calibrated at NCL Calibration Laboratories. A Data Acquisition Card (DAC) is used to collect the signal as detected by the isotropic e-field probe. The DAC manufacturer calibrates the DAC to NIST standards. A formal validation is executed using all mechanical and electronic components to prove conformity of the measurement platform as a whole.

### System Description

The ALSAS-10-U has been designed to measure devices within the compliance environment to meet all recognized standards. The system also conforms to standards, which are currently being developed by the scientific and manufacturing community.

The course scan resolution is defined by the operator and reflects the requirements of the standard to which the device is being tested. Precise measurements are made within the predefined course scan area and the values are logged.

The user predefines the sample rate for which the measurements are made so as to ensure that the full duty-cycle of a pulse modulation device is covered during the sample. The following algorithm is an example of the function used by the system for linearization of the output for the probe.

$$V_i = U_i + U_i^2 \bullet \frac{cf}{dcp_i}$$



The April E-Field probe is evaluated to establish the diode compression point.

A complex algorithm is then used to calculate the values within the measured points down to a resolution of 1mm. The data from this process is then used to provide the co-ordinates from which the cube scan is created for the determination of the 1 g and 10 g averages.

Cube scan averaging consists of a number of complex algorithms, which are used to calculate the one, and ten gram averages. The basis for the cube scan process is centered on the location where the maximum measured SAR value was found. When a secondary peak value is found which is within 60% of the initial peak value, the system will report this back to the operator who can then assess the need for further analysis of both the peak values prior to the one and ten-gram cube scan averaging process. The algorithm consists of 3D cubic Spline, and Lagrange extrapolation to the surface, which form the matrix for calculating the measurement output for the one and ten gram average values. The resolution for the physical scan integral is user defined with a final calculated resolution down to 1mm.

In-depth analysis for the differential of the physical scanning resolution for the cube scan analysis has been carried out, to identify the optimum setting for the probe positioning steps, and this has been determined at 8mm increments on the X, & Y planes. The reduction of the physical step increment increased the time taken for analysis but did not provide a better uncertainty or return on measured values.

The final output from the system provides data for the area scan measurements, physical and splined (1mm resolution) cube scan with physical and calculated values (1mm resolution).

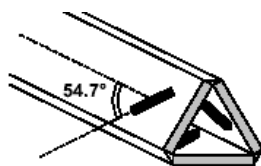
The overall uncertainty for the methodology and algorithms the ALSAS-10-U used during the SAR calculation was evaluated using the data from IEEE 1528 f3 algorithm:

$$f_3(x, y, z) = A \frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2} \left( e^{-\frac{2z}{a}} + \frac{a^2}{2(a + 2z)^2} \right)$$

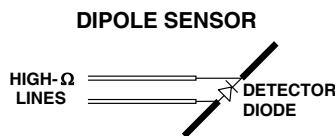
The probe used during the measurement process has been assessed to provide values for diode compression. These values are calculated during the probe calibration exercise and are used in the mathematical calculations for the assessment of SAR.

## E-Field Probe

The E-field probe used by RF Exposure Lab, LLC, has been fully calibrated and assessed for isotropic, and boundary effect. The probe utilizes a triangular sensor arrangement as detailed in the diagram below right.



**Δ-BEAM**



The SAR is assessed with the probe which moves at a default height of 4mm from the center of the diode, which is mounted to the sensor, to the phantom surface (Z height). The diagram above right shows how the center of the sensor is defined with the location of the diode placed at the center of the dipole. The 4mm default in the Z axis is the optimum height for assessing SAR where the boundary effect is at its least, with the probe located closest to the phantom surface (boundary).

The manufacturer specified precision of the robot is  $\pm 0.05$  mm and the precision of the APREL bottom detection device is  $\pm 0.1$  mm. These precisions are calibrated and tested in the manufacturing process of the bottom detection device. A constant distance is maintained because the surface of the phantom is dynamically detected for each point. The surface detection algorithm corrects the position of the robot so that the probe rests on the surface of the phantom. The probe is then moved to the measurement location 2.44 mm above the phantom surface resulting in the probe center location to be at 4.0 mm above the phantom surface. Therefore, the probe sensor will be at 4.0 mm above the phantom surface  $\pm 0.1$  mm for each SAR location for frequencies below 3 GHz. The probe is moved to the measurement location 1.44 mm above the phantom surface resulting in the probe center location to be at 2.0 mm above the phantom surface. Therefore, the probe sensor will be at 2.0 mm above the phantom surface  $\pm 0.1$  mm for each SAR location for frequencies above 3 GHz.

The probe boundary effect compensation cannot be disabled in the ALSAS-10U testing system. The probe tip will always be at least half a probe tip diameter from the phantom surface. For frequencies up to 3 GHz, the probe diameter is 5 mm. With the sensor offset set at 1.54 mm (default setting), the sensor to phantom gap will be 4.0 mm which is greater than half the probe tip diameter. For frequencies greater than 3 GHz, the probe diameter is 3 mm. With the sensor offset set at 0.56 mm (default setting), the sensor to phantom gap will be 3.0 mm which is greater than half the probe tip diameter.

The separation of the first 2 measurement points in the zoom scan is specified in the test setup software. For frequencies below 3 GHz, the user must specify a zoom scan resolution of less than 6 mm in the z-axis to have the first two measurements within 1 cm of the surface. The z-axis is set to 4 mm as shown on each of the data sheets in Appendix B. For frequencies above 3 GHz, the user must specify a zoom scan resolution of less than 3 mm in the z-axis to have the first two measurements within 5 mm of the surface. The z-axis is set to 2 mm as shown on each of the data sheets in Appendix B.

The zoom scan volume for devices  $\leq 3$  GHz with a cube scan of 5x5x8 yields a volume of 32x32x28 mm<sup>3</sup>. For devices  $>3$  GHz and  $<4.5$  GHz, the cube scan of 9x9x9 yields a volume of 32x32x24 mm<sup>3</sup>. For devices  $\geq 4.5$  GHz, the cube scan of 7x7x12 yields a volume of 24x24x22 mm<sup>3</sup>.

### 3. Robot Specifications

#### Specifications

Positioner: ThermoCRS, Robot Model: Robocomm 3  
Repeatability: 0.05 mm  
No. of axis: 6

#### Data Acquisition Card (DAC) System

##### Cell Controller

Processor: Pentium 4™  
Clock Speed: 2.66 GHz  
Operating System: Windows XP Pro™

##### Data Converter

Features: Signal Amplifier, End Effector, DAC  
Software: ALSAS 10-U Software

#### E-Field Probe

Model: Various See Probe Calibration Sheet  
Serial Number: Various See Probe Calibration Sheet  
Construction: Triangular Core Touch Detection System  
Frequency: 10MHz to 6GHz

#### Phantom

Phantom: Uniphantom, Right Phantom, Left Phantom



## **4. Probe and Dipole Calibration**

See Appendix D and E.



## 5. Phantom & Simulating Tissue Specifications

### SAM Phantom



The Aprel system utilizes three separate phantoms. Each phantom for SAR assessment testing is a low loss dielectric shell, with shape and dimensions derived from the anthropomorphic data of the 90<sup>th</sup> percentile adult male head dimensions as tabulated by the US Army. The SAM phantom shell is bisected along the mid sagittal plane into right and left halves. The perimeter sidewalls of each phantom half is extended to allow filling with liquid to a depth of 15 cm that is sufficient to minimize reflections from the upper surface [5]. The Uni-Phantom is used to conduct body measurements and held to face measurements. The depth of the phantom allows for 15 cm of tissue material to be filled within the phantom. See photos in Appendix C.

### Head & Body Simulating Mixture Characterization

The head and body mixtures consist of the material based on the table listed below. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. Body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations.

**Table 5.1 Typical Composition of Ingredients for Tissue**

Ingredients		Simulating Tissue
		450 MHz Body
Mixing Percentage		
Water		51.16
Sugar		46.78
Salt		1.49
HEC		0.52
Bactericide		0.05
DGBE		0.00
Dielectric Constant	Target	56.70
Conductivity (S/m)	Target	0.94

### Device Holder



In combination with the SAM phantom, the mounting device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can easily, accurately, and repeatably be positioned according to the FCC specifications. The device holder can be locked at different phantom locations (left head, right head, and uni-phantom).

## **Body Worn Configurations**

Body-worn operating configurations are tested in a normal use configuration. Body dielectric parameters are used.

In all cases SAR measurements are performed to investigate the worst-case positioning. Worst-case positioning is then documented and used to perform Body SAR testing. All test position spacings are documented.

In order for users to be aware of the body-worn operating requirements for meeting RF exposure compliance, operating instructions and cautions statements are included in the user's manual.

## 6. ANSI/IEEE C95.1 – 1992 RF Exposure Limits [2]

### Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

### Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Table 6.1 Human Exposure Limits**

	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIROMENT Professional Population (W/kg) or (mW/g)
SPATIAL PEAK SAR <sup>1</sup> Head	1.60	8.00
SPATIAL AVERAGE SAR <sup>2</sup> Whole Body	0.08	0.40
SPATIAL PEAK SAR <sup>3</sup> Hands, Feet, Ankles, Wrists	4.00	20.00

<sup>1</sup> The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

<sup>2</sup> The Spatial Average value of the SAR averaged over the whole body.

<sup>3</sup> The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

## 7. Measurement Uncertainty

### Exposure Assessment Measurement Uncertainty

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) %	$v_i$
Measurement System								
Probe Calibration	3.5	normal	1	1	1	3.5	3.5	$\infty$
Axial Isotropy	3.7	rectangular	$\sqrt{3}$	0.7	0.7	1.5	1.5	$\infty$
Hemispherical Isotropy	10.9	rectangular	$\sqrt{3}$	0.7	0.7	4.4	4.4	$\infty$
Boundary Effect	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6	$\infty$
Linearity	4.7	rectangular	$\sqrt{3}$	1	1	2.7	2.7	$\infty$
Detection Limit	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6	$\infty$
Readout Electronics	1.0	normal	1	1	1	1.0	1.0	$\infty$
Response Time	0.8	rectangular	$\sqrt{3}$	1	1	0.5	0.5	$\infty$
Integration Time	1.7	rectangular	$\sqrt{3}$	1	1	1.0	1.0	$\infty$
RF Ambient Condition	3.0	rectangular	$\sqrt{3}$	1	1	1.7	1.7	$\infty$
Probe Positioner Mech. Restriction	0.4	rectangular	$\sqrt{3}$	1	1	0.2	0.2	$\infty$
Probe Positioning with respect to Phantom Shell	2.9	rectangular	$\sqrt{3}$	1	1	1.7	1.7	$\infty$
Extrapolation and Integration	3.7	rectangular	$\sqrt{3}$	1	1	2.1	2.1	$\infty$
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0	7
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0	2
Drift of Output Power	4.2	rectangular	$\sqrt{3}$	1	1	2.4	2.4	$\infty$
Phantom and Setup								
Phantom Uncertainty (shape & thickness tolerance)	3.4	rectangular	$\sqrt{3}$	1	1	2.0	2.0	$\infty$
Algorithm for correcting SAR for deviations in permittivity and conductivity	1.2	Normal	1	1	0.84	1.2	0.97	$\infty$
Liquid Conductivity (target)	5.0	rectangular	$\sqrt{3}$	0.7	0.5	2.0	1.4	$\infty$
Liquid Conductivity (meas.)	0.5	normal	1	0.7	0.5	0.4	0.3	5
Liquid Permittivity (target)	5.0	rectangular	$\sqrt{3}$	0.6	0.5	1.7	1.4	$\infty$
Liquid Permittivity (meas.)	1.0	normal	1	0.6	0.5	0.6	0.5	5
Combined Uncertainty		RSS				9.8	9.6	>500
Combined Uncertainty (coverage factor=2)		Normal (k=2)				19.4	19.1	>500

## 8. System Validation

### Tissue Verification

**Table 8.1 Measured Tissue Parameters**

		450 MHz Body	
Date(s)		Jun. 4, 2011	
Liquid Temperature (°C)	20.0	Target	Measured
Dielectric Constant: $\epsilon$		56.70	56.59
Conductivity: $\sigma$		0.94	0.96

See Appendix A for data printout.

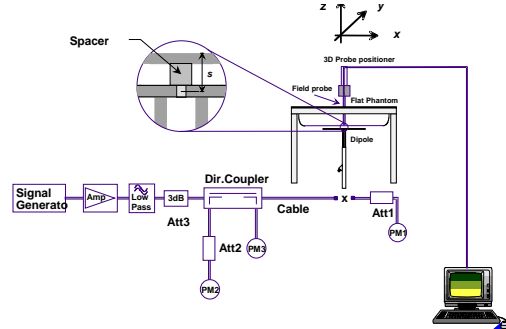
### Test System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at the test frequency by using the system kit. Power is normalized to 1 watt. (Graphic Plots Attached)

**Table 8.2 System Dipole Validation Target & Measured**

	Test Frequency	Targeted SAR <sub>1g</sub> (W/kg)	Measure SAR <sub>1g</sub> (W/kg)	Tissue Used for Verification	Deviation (%)
04-Jun-201	450 MHz	5.05	4.79	Body	- 5.15

See Appendix A for data plots.



**Figure 8.1 Dipole Validation Test Setup**

Note: KDB 450824 D02 was applied for dipole calibrations.

SAR Correction Calculation per EN62209.

$$\Delta SAR = c_{\epsilon} \Delta \epsilon_r + c_{\sigma} \Delta \sigma = (-0.21)(-0.19) + (0.78)(2.13) = + 1.70$$

$$c_{\epsilon} = -7.854 \times 10^{-4} (0.450)^3 + 9.402 \times 10^{-3} (0.450)^2 - 2.742 \times 10^{-2} (0.450) - 0.2026 = - 0.21$$

$$c_{\sigma} = 9.804 \times 10^{-3} (0.450)^3 - 8.661 \times 10^{-2} (0.450)^2 + 2.981 \times 10^{-2} (0.450) + 0.7829 = +0.78$$

With a positive  $\Delta SAR$ , the SAR results shall not be corrected per IC notice 2012-DRS0529.

## 9. SAR Test Data Summary

### See Measurement Result Data Pages

See Appendix B for SAR Test Data Plots.  
 See Appendix C for SAR Test Setup Photos.

### Procedures Used To Establish Test Signal

The device was either placed into simulated transmit mode using the manufacturer’s test codes or the actual transmission is activated through a base station simulator or similar equipment. See data pages for actual procedure used in measurement.

### Device Test Condition

Output power measurements were performed after the completion of all SAR measurements to insure the integrity of the unit. The power drift of each test is measured at the start of the test and again at the end of the test. The drift percentage is calculated by the formula  $((\text{end}/\text{start})-1)*100$  and rounded to three decimal places. The drift percentage is calculated into the resultant SAR value on the data sheet for each test.

The testing was conducted on the front and back of the device. The device was tested at mid channel for each configuration. All testing was conducted per KDB 447498.

E Band				
Freq	Channel	Data Rate	Antenna	Power
470.1	7F	N/A	Main	23.97
504.0	60	N/A	Main	23.87
537.5	FF	N/A	Main	23.97

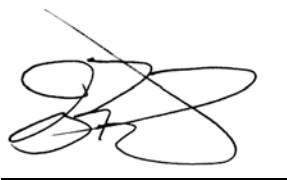
**Maximum Power Measurements**

**SAR Data Summary – E Band Body Position**

MEASUREMENT RESULTS								
Gap	Block	Frequency		Position	Modulation	Battery	End Power	SAR (W/kg)
		MHz	Ch.				(dBm)	
0 mm	BL470	482.9	80	Back	FM	AA	23.97	0.340
		482.9	80	Front	FM	AA	23.97	0.362
	BL19	499.1	7F	Back	FM	AA	23.87	0.437
		499.1	7F	Front	FM	AA	23.87	0.374
	BL20	524.7	7F	Back	FM	AA	23.97	0.322
		524.7	7F	Front	FM	AA	23.97	0.270

**Body**  
**1.6 W/kg (mW/g)**  
averaged over 1 gram

1. Battery is fully charged for all tests.  
 Power Measured  Conducted  ERP  EIRP
2. SAR Measurement  
 Phantom Configuration  Left Head  Uniphantom  Right Head  
 Tissue Configuration  Head  Body
3. Test Signal Call Mode  Test Code  Base Station Simulator
4. Test Configuration  With Belt Clip  Without Belt Clip  N/A
5. Tissue Depth is at least 15.0 cm



Jay M. Moulton  
 Vice President

Note: SAR Tested on the Mid channel. When the measured channel is 3 dB or more below the limit the remaining channels are not required to be tested per KDB 447498 section 1) e). The testing was conducted the front and back of the device. All testing was conducted per KDB 447498 and OET Bulletin 65. See the photos in Appendix C for a pictorial of the setup and labeling of the test locations.

## 10. Test Equipment List

**Table 10.1 Equipment Specifications**

Type	Calibration Due Date	Calibration Done Date	Serial Number
ThermoCRS Robot	N/A	N/A	RAF0338198
ThermoCRS Controller	N/A	N/A	RCF0338224
ThermoCRS Teach Pendant (Joystick)	N/A	N/A	STP0334405
IBM Computer, 2.66 MHz P4	N/A	N/A	8189D8U KCPR08N
Apral E-Field Probe ALS-E020	09/07/2012	09/07/2011	RFE-217
Apral E-Field Probe ALS-E030	07/15/2012	07/15/2011	E030-001
Apral Dummy Probe	N/A	N/A	023
Apral Left Phantom	N/A	N/A	RFE-267
Apral Right Phantom	N/A	N/A	RFE-268
Apral UniPhantom	N/A	N/A	RFE-273
Apral Validation Dipole ALS-D-450-S-2 Head	01/12/2013	01/12/2010	RFE-362
Apral Validation Dipole ALS-D-450-S-2 Body	01/19/2013	01/19/2011	RFE-362
Apral Validation Dipole ALS-D-750-S-2 Head	01/14/2013	01/14/2010	177-00501
Apral Validation Dipole ALS-D-750-S-2 Body	11/15/2012	11/15/2010	177-00501
Apral Validation Dipole ALS-D-835-S-2 Head	01/14/2013	01/14/2010	180-00561
Apral Validation Dipole ALS-D-835-S-2 Body	11/16/2012	11/16/2010	180-00561
Apral Validation Dipole ALS-D-900-S-2 Head	01/12/2013	01/12/2010	RFE-275
Apral Validation Dipole ALS-D-900-S-2 Body	11/19/2012	11/19/2010	RFE-275
Apral Validation Dipole ALS-D-1900-S-2 Head	01/15/2013	01/15/2010	210-00713
Apral Validation Dipole ALS-D-1900-S-2 Body	11/16/2012	11/16/2010	210-00713
Apral Validation Dipole ALS-D-2450-S-2 Head	01/12/2013	01/12/2010	RFE-278
Apral Validation Dipole ALS-D-2450-S-2 Body	11/18/2012	11/18/2010	RFE-278
Apral Validation Dipole RFE-D-2600-S-2 Body	01/18/2013	01/18/2010	RFE-121
Apral Validation Dipole RFE-D-BB-S-2 Head	01/12/2013	01/12/2010	235-00801
Apral Validation Dipole RFE-D-BB-S-2 Body	02/09/2013	02/09/2011	235-00801
Agilent N1911A Power Meter	03/29/2013	03/29/2012	GB45100254
Agilent N1922A Power Sensor	03/29/2013	03/29/2012	MY45240464
Advantest R3261A Spectrum Analyzer	03/29/2013	03/29/2012	31720068
Agilent (HP) 8350B Signal Generator	03/29/2013	03/29/2012	2749A10226
Agilent (HP) 83525A RF Plug-In	03/29/2013	03/29/2012	2647A01172
Agilent (HP) 8753C Vector Network Analyzer	03/29/2013	03/29/2012	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	04/03/2013	04/03/2012	2904A00595
Agilent (HP) 8960 Base Station Sim.	04/05/2014	04/05/2012	MY48360364
Apral Dielectric Probe Assembly	N/A	N/A	0011
Head Equivalent Matter (450 MHz)	N/A	N/A	N/A
Head Equivalent Matter (835/900 MHz)	N/A	N/A	N/A
Head Equivalent Matter (1900 MHz)	N/A	N/A	N/A
Head Equivalent Matter (2450 MHz)	N/A	N/A	N/A
Body Equivalent Matter (450 MHz)	N/A	N/A	N/A
Body Equivalent Matter (750 MHz)	N/A	N/A	N/A
Body Equivalent Matter (835/900 MHz)	N/A	N/A	N/A
Body Equivalent Matter (1900 MHz)	N/A	N/A	N/A
Body Equivalent Matter (2450 MHz)	N/A	N/A	N/A
Body Equivalent Matter (2600 MHz)	N/A	N/A	N/A
Body Equivalent Matter (5200 MHz)	N/A	N/A	N/A
Body Equivalent Matter (5800 MHz)	N/A	N/A	N/A



## 11. Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

## 12. References

- [1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation, August 1996
- [2] ANSI/IEEE C95.1 – 1992, American National Standard Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300kHz to 100GHz, New York: IEEE, 1992.
- [3] ANSI/IEEE C95.3 – 1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, 1992.
- [4] Federal Communications Commission, OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, June 2001.
- [5] IEEE Standard 1528 – 2003, IEEE Recommended Practice for Determining the Peak-Spatial Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, October 2003.
- [6] Industry Canada, RSS – 102e, Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), March 2010.
- [7] Health Canada, Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz, 2009.

## Appendix A – System Validation Plots and Data

```

*****
Test Result for UIM Dielectric Parameter
Mon 04/Jun/2012 10:23:25
Freq Frequency(GHz)
FCC_eH FCC Bulletin 65 Supplement C ( June 2001) Limits for Head Epsilon
FCC_sH FCC Bulletin 65 Supplement C (June 2001) Limits for Head Sigma
FCC_eB FCC Limits for Body Epsilon
FCC_sB FCC Limits for Body Sigma
Test_e Epsilon of UIM
Test_s Sigma of UIM
*****

```

Freq	FCC_eB	FCC_sB	Test_e	Test_s
0.4200	57.00	0.94	56.84	0.93
0.4300	56.90	0.94	56.75	0.94
0.4400	56.80	0.94	56.67	0.95
0.4500	56.70	0.94	56.59	0.96
0.4600	56.66	0.94	56.50	0.96
0.4700	56.62	0.94	56.42	0.97
0.4800	56.58	0.94	56.36	0.97
0.4829	56.57	0.94	56.33	0.97*
0.4900	56.54	0.94	56.27	0.98
0.4991	56.51	0.94	56.23	0.98*
0.5000	56.51	0.94	56.23	0.98
0.5100	56.47	0.94	56.19	0.98
0.5200	56.43	0.95	56.14	0.99
0.5247	56.41	0.95	56.12	0.99*
0.5300	56.39	0.95	56.10	0.99
0.5400	56.35	0.95	56.07	0.99

\* value interpolated

**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 10:34:53 AM  
End Time : 04-Jun-2012 10:52:17 AM  
Scanning Time : 1044 secs

## Product Data

Device Name : Validation  
Serial No. : 450  
Type : Dipole  
Model : ALS-D-450-S-2  
Frequency : 450.00 MHz  
Max. Transmit Pwr : 0.1 W  
Drift Time : 0 min(s)  
Length : 270 mm  
Width : 3.6 mm  
Depth : 166.7 mm  
Antenna Type : Internal  
Orientation : Touch  
Power Drift-Start : 0.498 W/kg  
Power Drift-Finish: 0.483 W/kg  
Power Drift (%) : -3.010

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 450  
Frequency : 450.00 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.59 F/m  
Sigma : 0.96 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

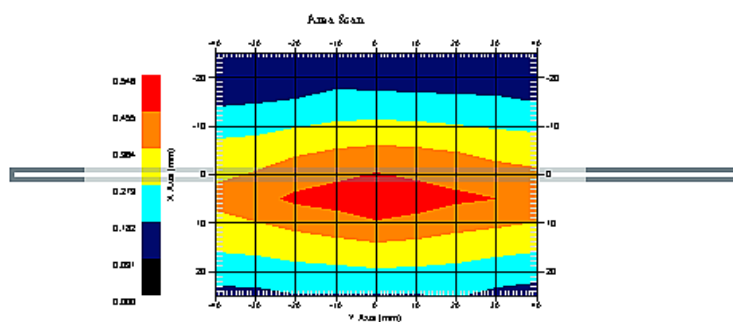
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 11:01:10 AM  
Area Scan : 6x9x1 : Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

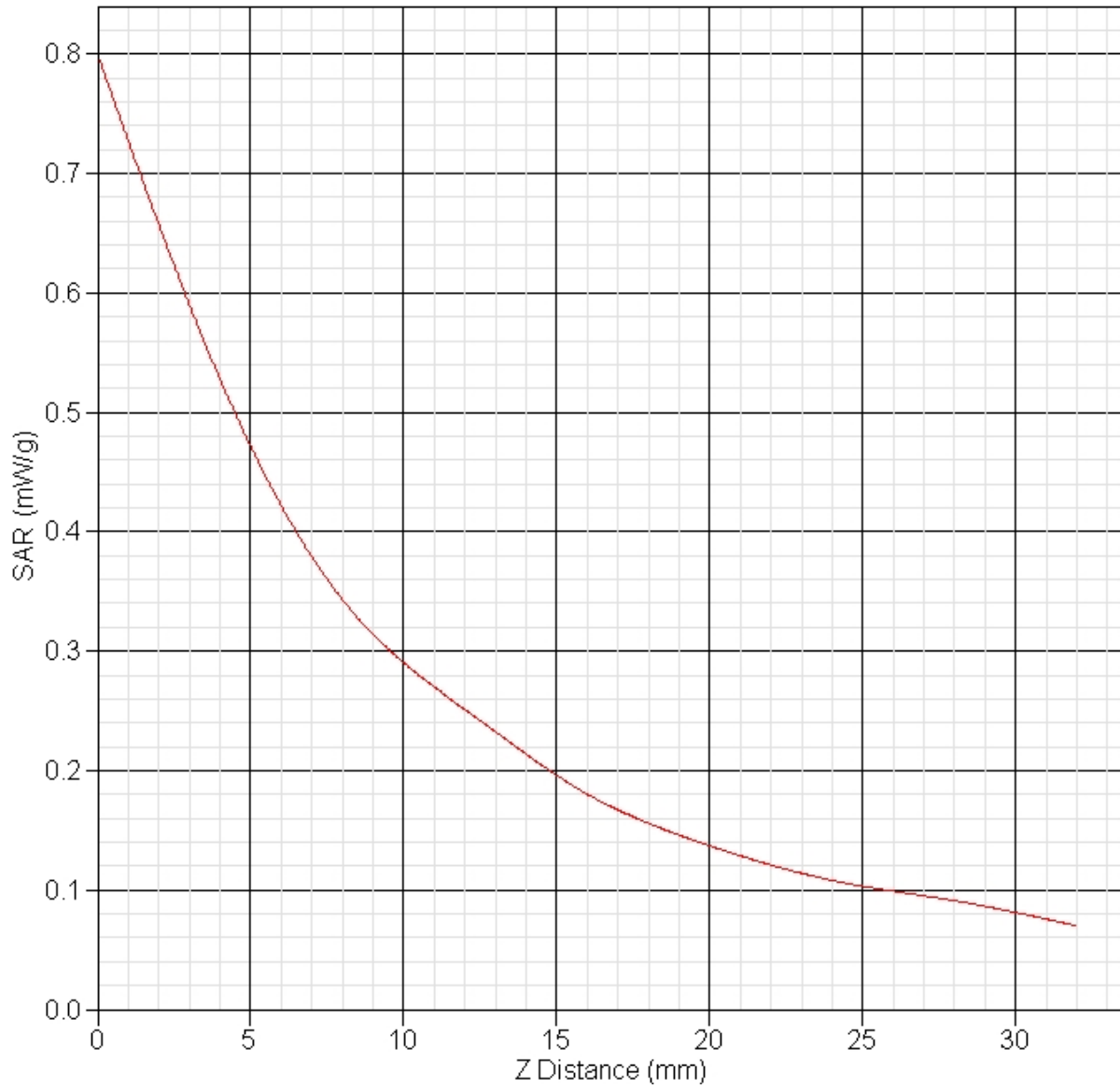
### Other Data

DUT Position : Touch  
Separation : 15 mm  
Channel : Mid



1 gram SAR value : 0.479 W/kg  
10 gram SAR value : 0.332 W/kg  
Area Scan Peak SAR : 0.537 W/kg  
Zoom Scan Peak SAR : 0.796 W/kg

**SAR-Z Axis**  
at Hotspot x:5.25 y:-0.17



## **Appendix B – SAR Test Data Plots**

**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 11:19:37 AM  
End Time : 04-Jun-2012 11:41:35 AM  
Scanning Time : 1318 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 118  
Mode : FM  
Model : WM E-BL470  
Frequency : 482.90 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Back  
Power Drift-Start : 0.134 W/kg  
Power Drift-Finish: 0.133 W/kg  
Power Drift (%) : -0.924

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 482  
Frequency : 482.90 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.33 F/m  
Sigma : 0.97 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
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

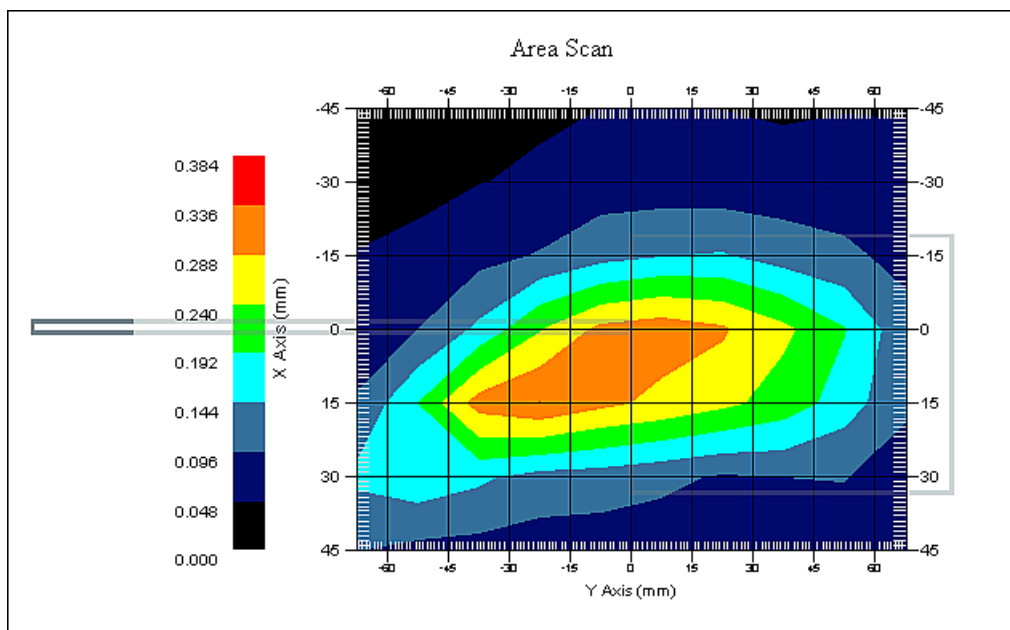


### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 12:39:32 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

### Other Data

DUT Position : Back  
Separation : 0 mm  
Channel : Mid



1 gram SAR value : 0.340 W/kg  
10 gram SAR value : 0.218 W/kg  
Area Scan Peak SAR : 0.337 W/kg  
Zoom Scan Peak SAR : 0.550 W/kg

**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 11:48:53 AM  
End Time : 04-Jun-2012 12:10:20 PM  
Scanning Time : 1287 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 118  
Mode : FM  
Model : WM E-BL470  
Frequency : 482.90 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Front  
Power Drift-Start : 0.202 W/kg  
Power Drift-Finish: 0.210 W/kg  
Power Drift (%) : 3.720

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 482  
Frequency : 482.90 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.33 F/m  
Sigma : 0.97 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

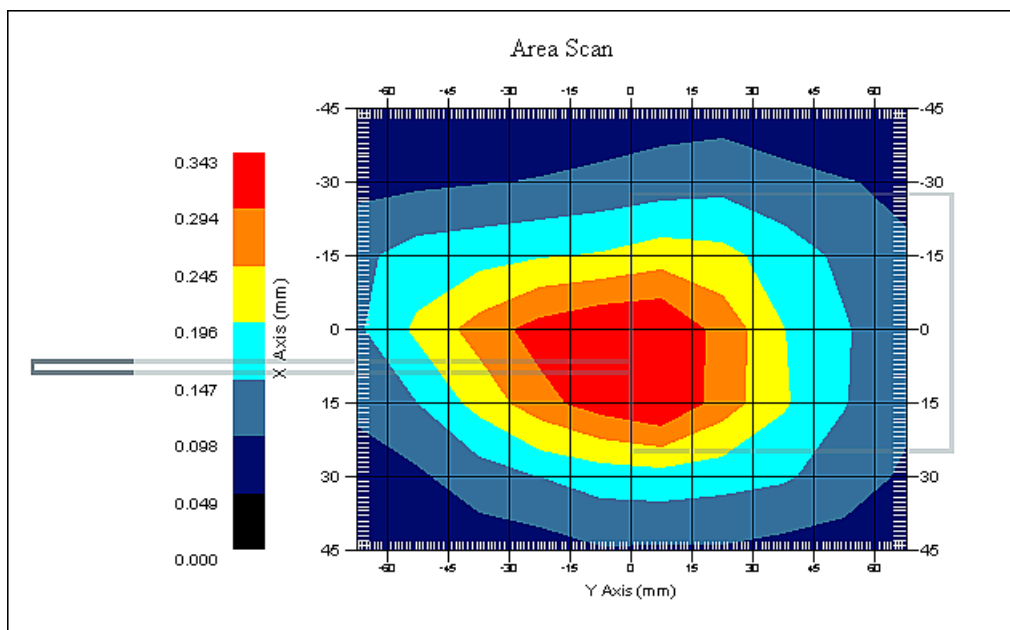
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 12:39:32 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

### Other Data

DUT Position : Front  
Separation : 0 mm  
Channel : Mid



1 gram SAR value : 0.362 W/kg  
10 gram SAR value : 0.249 W/kg  
Area Scan Peak SAR : 0.343 W/kg  
Zoom Scan Peak SAR : 0.520 W/kg

**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 12:46:14 PM  
End Time : 04-Jun-2012 01:08:07 PM  
Scanning Time : 1313 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 101  
Mode : FM  
Model : WM E-BL19  
Frequency : 499.10 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Back  
Power Drift-Start : 0.134 W/kg  
Power Drift-Finish: 0.136 W/kg  
Power Drift (%) : 1.089

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 499  
Frequency : 499.10 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.23 F/m  
Sigma : 0.98 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

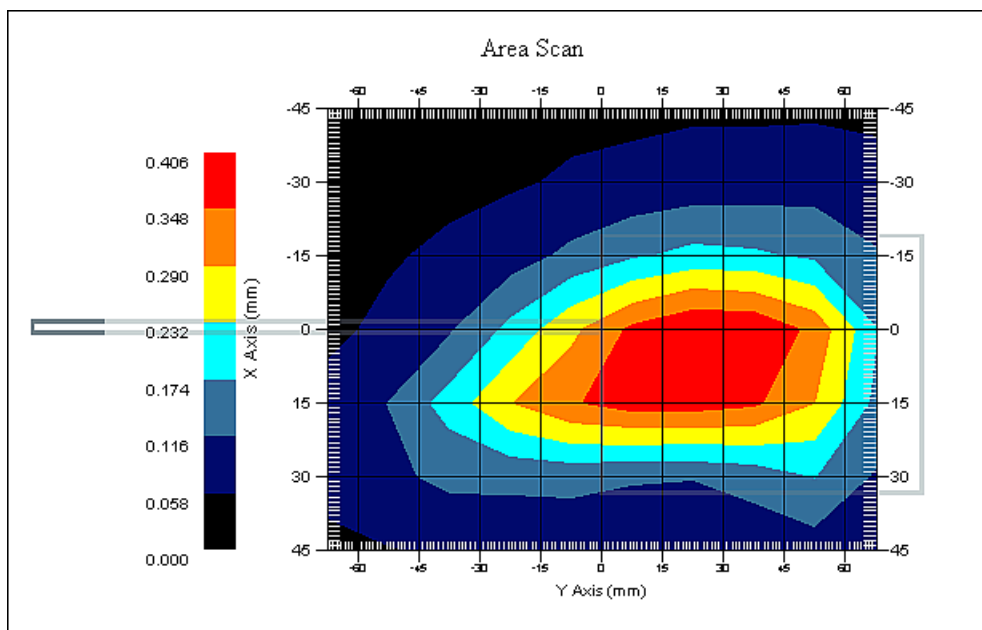
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 1:06:03 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

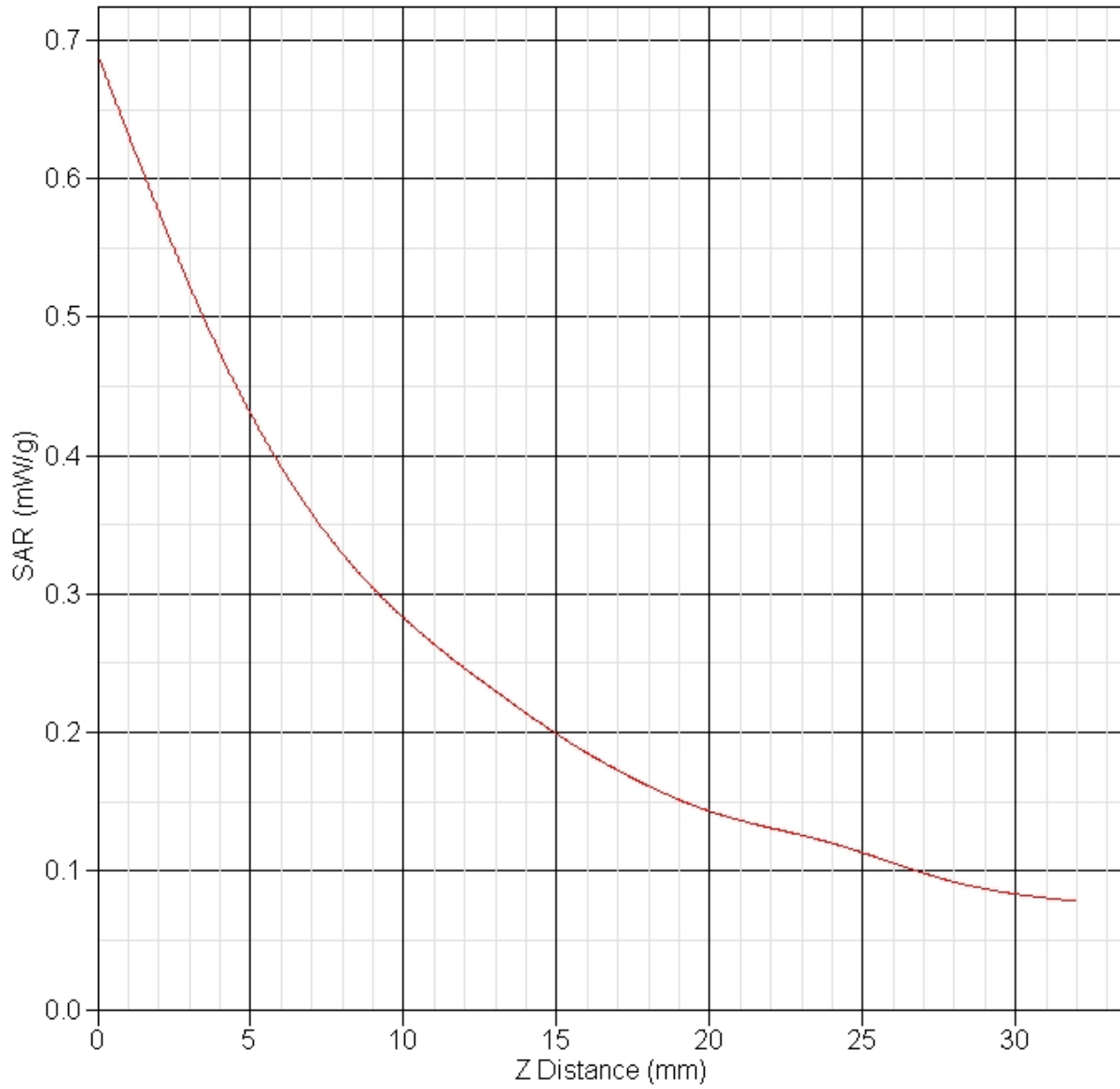
### Other Data

DUT Position : Back  
Separation : 0 mm  
Channel : Mid



1 gram SAR value : 0.437 W/kg  
10 gram SAR value : 0.269 W/kg  
Area Scan Peak SAR : 0.406 W/kg  
Zoom Scan Peak SAR : 0.690 W/kg

**SAR-Z Axis**  
at Hotspot x:23.14 y:31.05



**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 01:13:48 PM  
End Time : 04-Jun-2012 01:35:32 PM  
Scanning Time : 1304 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 101  
Mode : FM  
Model : WM E-BL19  
Frequency : 499.10 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Front  
Power Drift-Start : 0.217 W/kg  
Power Drift-Finish: 0.224 W/kg  
Power Drift (%) : 3.437

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 499  
Frequency : 499.00 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.23 F/m  
Sigma : 0.98 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

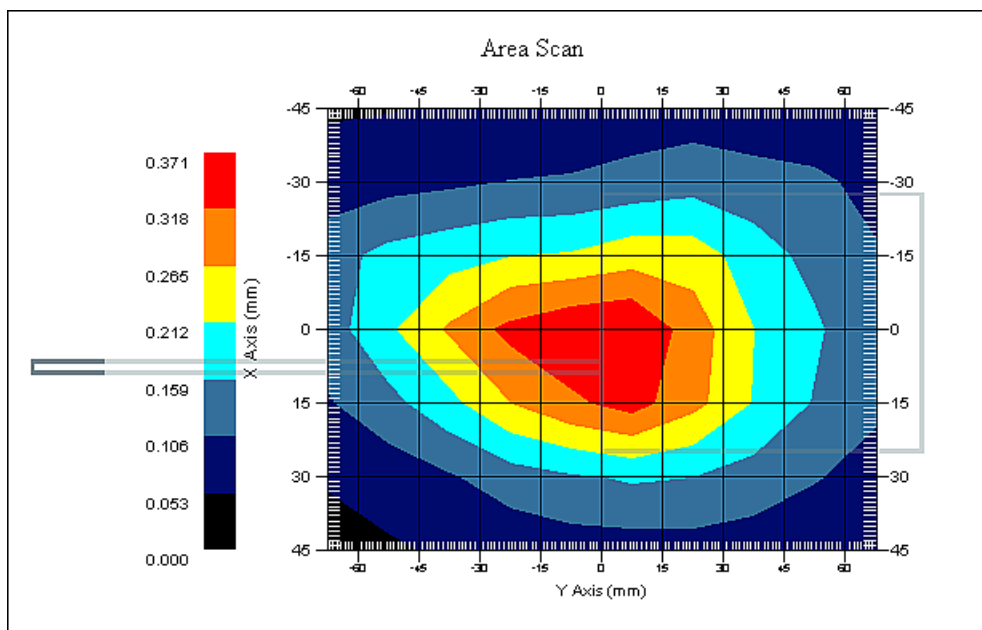
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 1:06:03 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

### Other Data

DUT Position : Front  
Separation : 0 mm  
Channel : Mid



1 gram SAR value : 0.374 W/kg  
10 gram SAR value : 0.259 W/kg  
Area Scan Peak SAR : 0.368 W/kg  
Zoom Scan Peak SAR : 0.530 W/kg



**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 02:11:24 PM  
End Time : 04-Jun-2012 02:33:14 PM  
Scanning Time : 1310 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 103  
Mode : FM  
Model : WM E-BL20  
Frequency : 524.70 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Back  
Power Drift-Start : 0.124 W/kg  
Power Drift-Finish: 0.123 W/kg  
Power Drift (%) : -0.810

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 524  
Frequency : 524.70 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.12 F/m  
Sigma : 0.99 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

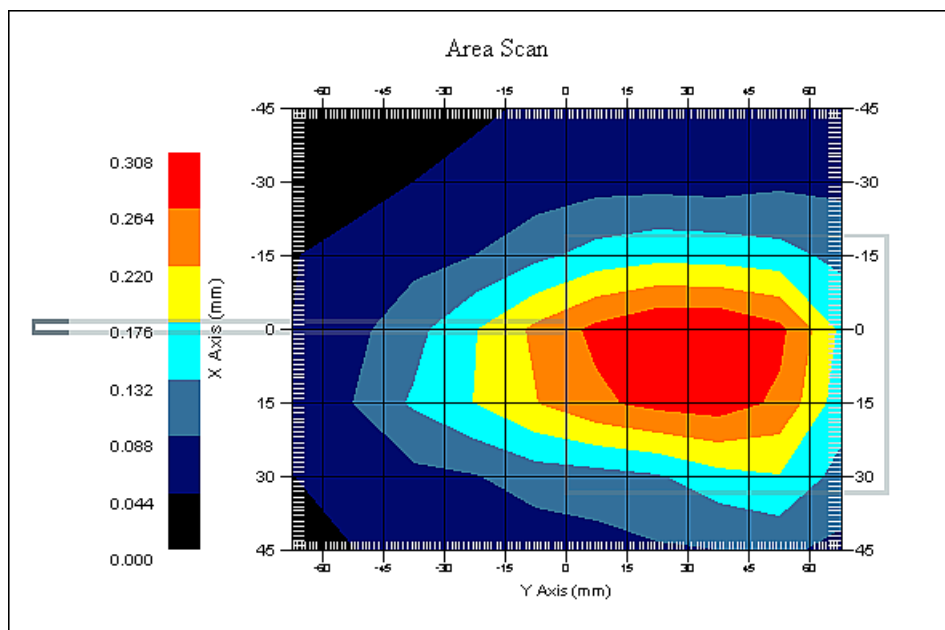
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 1:30:45 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

### Other Data

DUT Position : Back  
Separation : 0 mm  
Channel : Mid



1 gram SAR value : 0.322 W/kg  
10 gram SAR value : 0.213 W/kg  
Area Scan Peak SAR : 0.307 W/kg  
Zoom Scan Peak SAR : 0.470 W/kg

**SAR Test Report**

By Operator : Jay  
Measurement Date : 04-Jun-2012  
Starting Time : 04-Jun-2012 02:37:54 PM  
End Time : 04-Jun-2012 02:59:23 PM  
Scanning Time : 1289 secs

## Product Data

Device Name : Lectrosonics  
Serial No. : 103  
Mode : FM  
Model : WM E-BL20  
Frequency : 524.70 MHz  
Max. Transmit Pwr : 0.25 W  
Drift Time : 0 min(s)  
Length : 76 mm  
Width : 64 mm  
Depth : 18 mm  
Antenna Type : Stub  
Orientation : Front  
Power Drift-Start : 0.160 W/kg  
Power Drift-Finish: 0.161 W/kg  
Power Drift (%) : 0.626

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Size (mm) : 280 x 280 x 200  
Serial No. : System Default  
Location : Center  
Description : Uni-Phantom

## Tissue Data

Type : BODY  
Serial No. : 524  
Frequency : 524.70 MHz  
Last Calib. Date : 04-Jun-2012  
Temperature : 20.00 °C  
Ambient Temp. : 23.00 °C  
Humidity : 49.00 RH%  
Epsilon : 56.12 F/m  
Sigma : 0.99 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

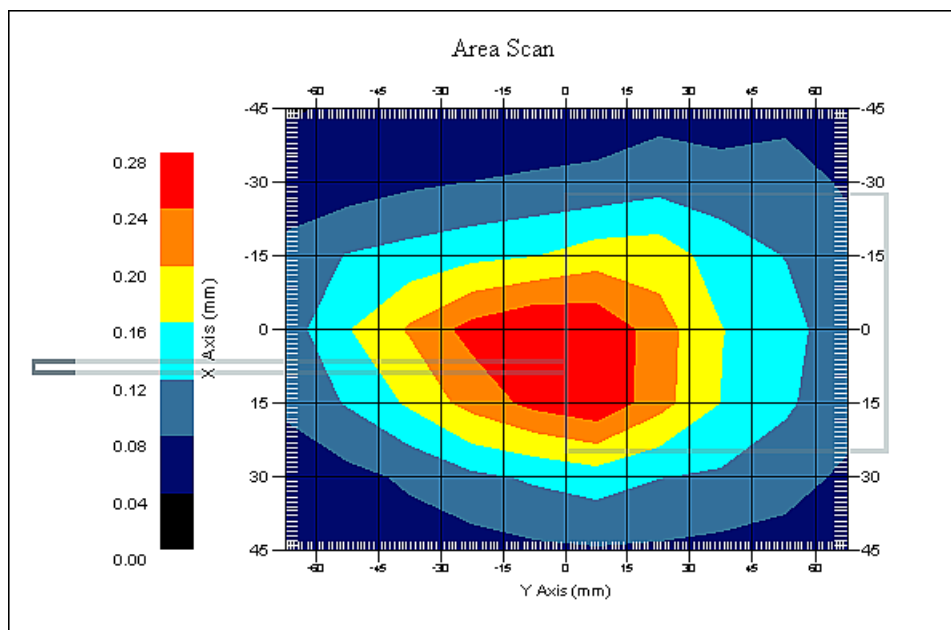
Name : RFEL 217  
Model : E020  
Type : E-Field Triangle  
Serial No. : 217  
Last Calib. Date : 07-Sep-2011  
Frequency : 450.00 MHz  
Duty Cycle Factor: 1  
Conversion Factor: 6  
Probe Sensitivity: 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point: 95.00 mV  
Offset : 1.56 mm

### Measurement Data

Crest Factor : 1  
Scan Type : Complete  
Tissue Temp. : 20.00 °C  
Ambient Temp. : 23.00 °C  
Set-up Date : 04-Jun-2012  
Set-up Time : 1:30:45 PM  
Area Scan : 7x10x1 : Measurement x=15mm, y=15mm, z=4mm  
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm

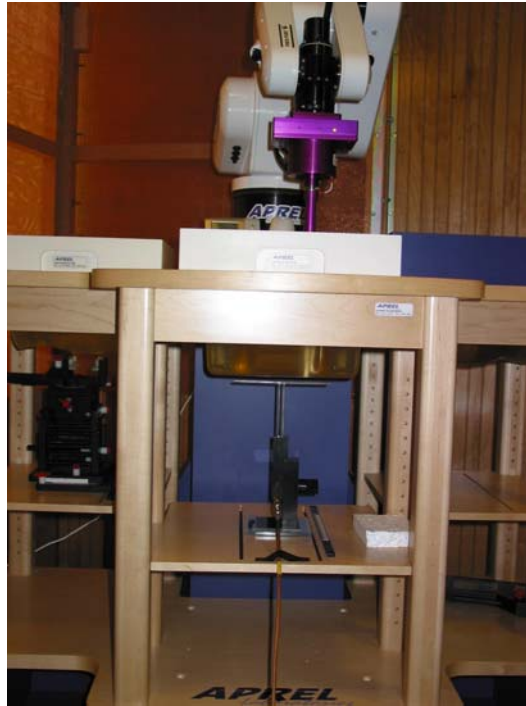
### Other Data

DUT Position : Front  
Separation : 0 mm  
Channel : Mid

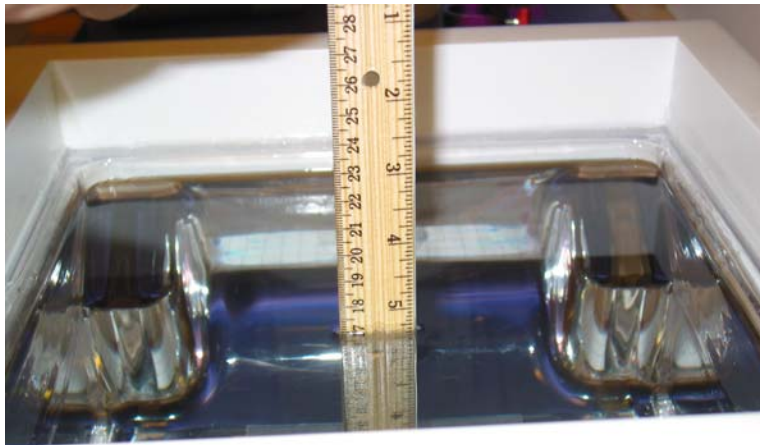


1 gram SAR value : 0.270 W/kg  
10 gram SAR value : 0.202 W/kg  
Area Scan Peak SAR : 0.277 W/kg  
Zoom Scan Peak SAR : 0.420 W/kg

## Appendix C – SAR Test Setup Photos



**System Body Configuration**



**Body Tissue Depth**



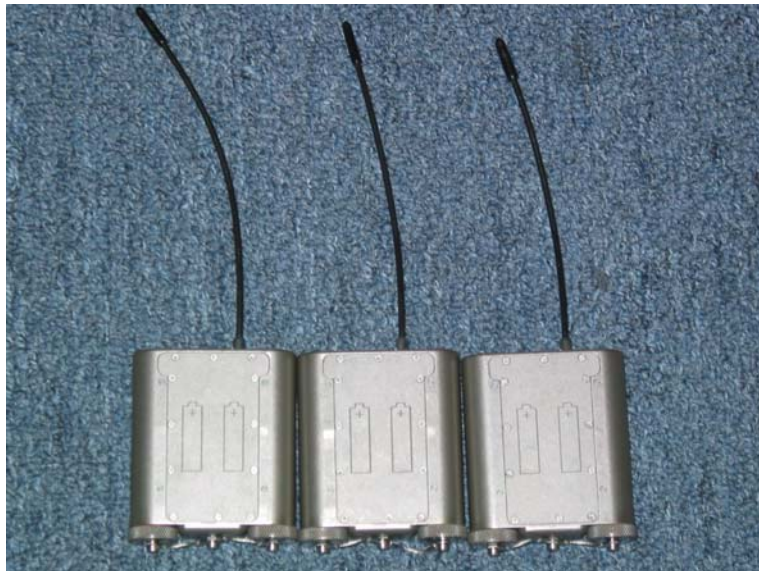
**Back Test Position 0 mm Gap**



**Front Test Position 0 mm Gap**



**Front of Devices**



**Back of Devices**

## Appendix D – Probe Calibration Data Sheets



# NCL CALIBRATION LABORATORIES

Calibration File No.: PC1333-1350

Client.: RFEL

## CERTIFICATE OF CALIBRATION

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

Equipment: Miniature Isotropic RF Probe

Record of Calibration

Head and Body

Manufacturer: APREL Laboratories

**Model No.:** E-020

**Serial No.:** 217

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

**Project No:** RFEL-PC-5620

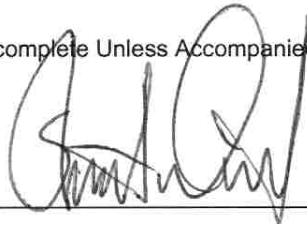
**Calibrated:** 7<sup>th</sup> September 2011

**Released on:** 7<sup>th</sup> September 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 meteorological practices.

## Calibration Method

Probes are calibrated using the following methods.

<1000MHz

TEM Cell for sensitivity in air

Standard phantom using temperature transfer method for sensitivity in tissue

>1000MHz

Waveguide\* method to determine sensitivity in air and tissue

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

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

## References

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

# NCL Calibration Laboratories

Division of APREL Inc.

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## Conditions

Probe 217 was a re-calibration.

**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 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

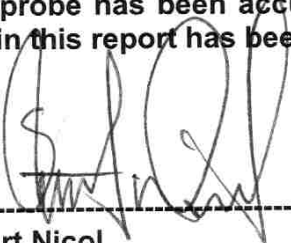
## Secondary Measurement Standards

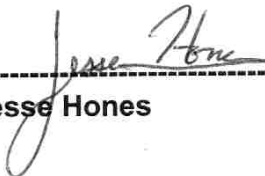
Signal Generator Agilent E4438C -506 MY55182336 June 7, 2011

## 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**

<b>Probe Type:</b>	E-Field Probe E020
<b>Serial Number:</b>	217
<b>Frequency:</b>	450MHz
<b>Sensor Offset:</b>	1.56
<b>Sensor Length:</b>	2.5
<b>Tip Enclosure:</b>	Composite*
<b>Tip Diameter:</b>	< 2.9 mm
<b>Tip Length:</b>	55 mm
<b>Total Length:</b>	289 mm

\*Resistive to recommended tissue recipes per IEEE-1528

**Sensitivity in Air**

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

# NCL Calibration Laboratories

Division of APREL Inc.

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

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Calibration Uncertainty	Tolerance Uncertainty for 5%*	Conversion Factor
<b>450 H</b>	<b>Head</b>	<b>45.31</b>	<b>0.91</b>	<b>4.1</b>	<b>3.6</b>	<b>5.8</b>
<b>450 B</b>	<b>Body</b>	<b>56.77</b>	<b>0.99</b>	<b>4.1</b>	<b>3.6</b>	<b>6.0</b>
<b>650 B</b>	<b>Body</b>	<b>57.42</b>	<b>0.91</b>	<b>3.96</b>	<b>3.5</b>	<b>6.2</b>
<b>750 H</b>	<b>Head</b>	<b>42.16</b>	<b>0.87</b>	<b>3.94</b>	<b>3.5</b>	<b>6.2</b>
<b>750 B</b>	<b>Body</b>	<b>55.54</b>	<b>0.94</b>	<b>3.94</b>	<b>3.4</b>	<b>6.3</b>
<b>835 H</b>	<b>Head</b>	<b>42.5</b>	<b>0.93</b>	<b>3.5</b>	<b>3.4</b>	<b>6.4</b>
<b>835 B</b>	<b>Body</b>	<b>56.37</b>	<b>0.954</b>	<b>3.5</b>	<b>3.4</b>	<b>6.4</b>
<b>900 H</b>	<b>Head</b>	<b>41.89</b>	<b>1.0</b>	<b>3.5</b>	<b>3.4</b>	<b>6.1</b>
<b>900 B</b>	<b>Body</b>	<b>53.68</b>	<b>1.05</b>	<b>3.5</b>	<b>3.4</b>	<b>6.1</b>
1450 H	Head	X	X	X	X	X
1450 B	Body	X	X	X	X	X
1500 H	Head	X	X	X	X	X
1500 B	Body	X	X	X	X	X
<b>1640 H</b>	<b>Head</b>	<b>39.0</b>	<b>1.25</b>	<b>3.5</b>	<b>2.7</b>	<b>5.2</b>
<b>1640 B</b>	<b>Body</b>	<b>52.03</b>	<b>1.39</b>	<b>3.5</b>	<b>2.7</b>	<b>5.0</b>
1735 H	Head	X	X	X	X	X
<b>1735 B</b>	<b>Body</b>	<b>51.68</b>	<b>1.5</b>	<b>3.5</b>	<b>2.7</b>	<b>5.2</b>
<b>1800 H</b>	<b>Head</b>	<b>38.38</b>	<b>1.39</b>	<b>3.5</b>	<b>2.7</b>	<b>4.9</b>
<b>1800 B</b>	<b>Body</b>	<b>51.54</b>	<b>1.56</b>	<b>3.5</b>	<b>2.7</b>	<b>5.1</b>
<b>1900 H</b>	<b>Head</b>	<b>38.4</b>	<b>1.43</b>	<b>3.5</b>	<b>2.7</b>	<b>4.9</b>
<b>1900 B</b>	<b>Body</b>	<b>52.08</b>	<b>1.59</b>	<b>3.5</b>	<b>2.7</b>	<b>4.8</b>
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
<b>2450 H</b>	<b>Head</b>	<b>38.2</b>	<b>1.82</b>	<b>3.5</b>	<b>3.5</b>	<b>3.91</b>
<b>2450B</b>	<b>Body</b>	<b>51.74</b>	<b>1.96</b>	<b>3.5</b>	<b>3.5</b>	<b>3.94</b>
2600 H	Head	X	X	X	X	X
<b>2600 B</b>	<b>Body</b>	<b>51.18</b>	<b>2.16</b>	<b>3.5</b>	<b>3.5</b>	<b>4.0</b>
3000 H	Head	X	X	X	X	X
3000 B	Body	X	X	X	X	X
3600 H	Head	X	X	X	X	X
3600 B	Body	X	X	X	X	X
5200 H	Head	X	X	X	X	X
5200 B	Body	X	X	X	X	X
5600 H	Head	X	X	X	X	X
5600 B	Body	X	X	X	X	X
5800 H	Head	X	X	X	X	X
5800 B	Body	X	X	X	X	X

**Boundary Effect:**

Uncertainty resulting from the boundary effect is less than 2.1% for the distance between the tip of the probe and the tissue boundary, when less than 0.58mm.

**Spatial Resolution:**

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

**DAQ-PAQ Contribution**

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

**Boundary Effect:**

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

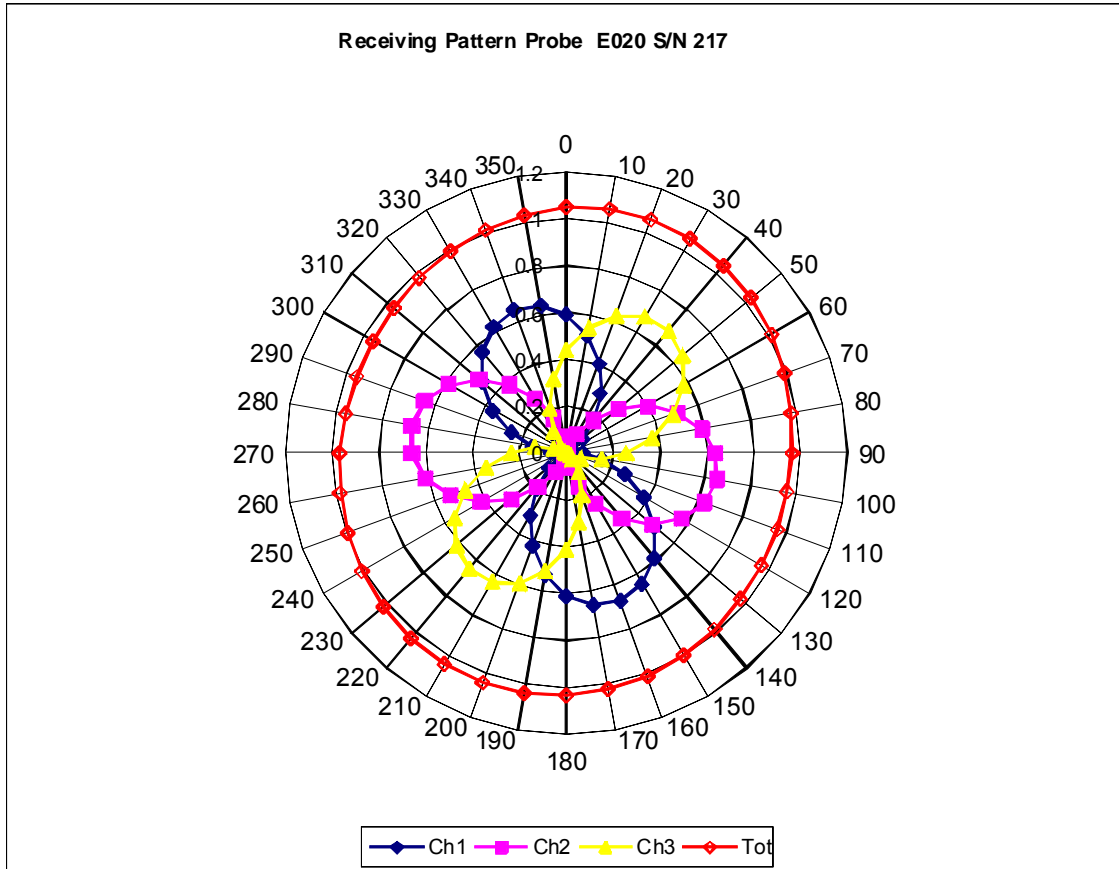
**NOTES:**

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

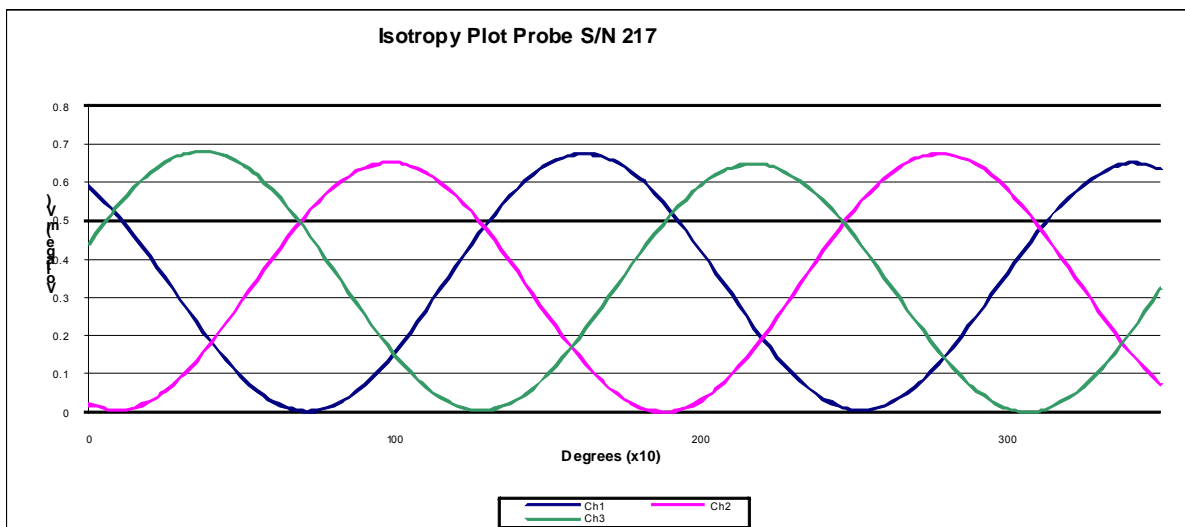
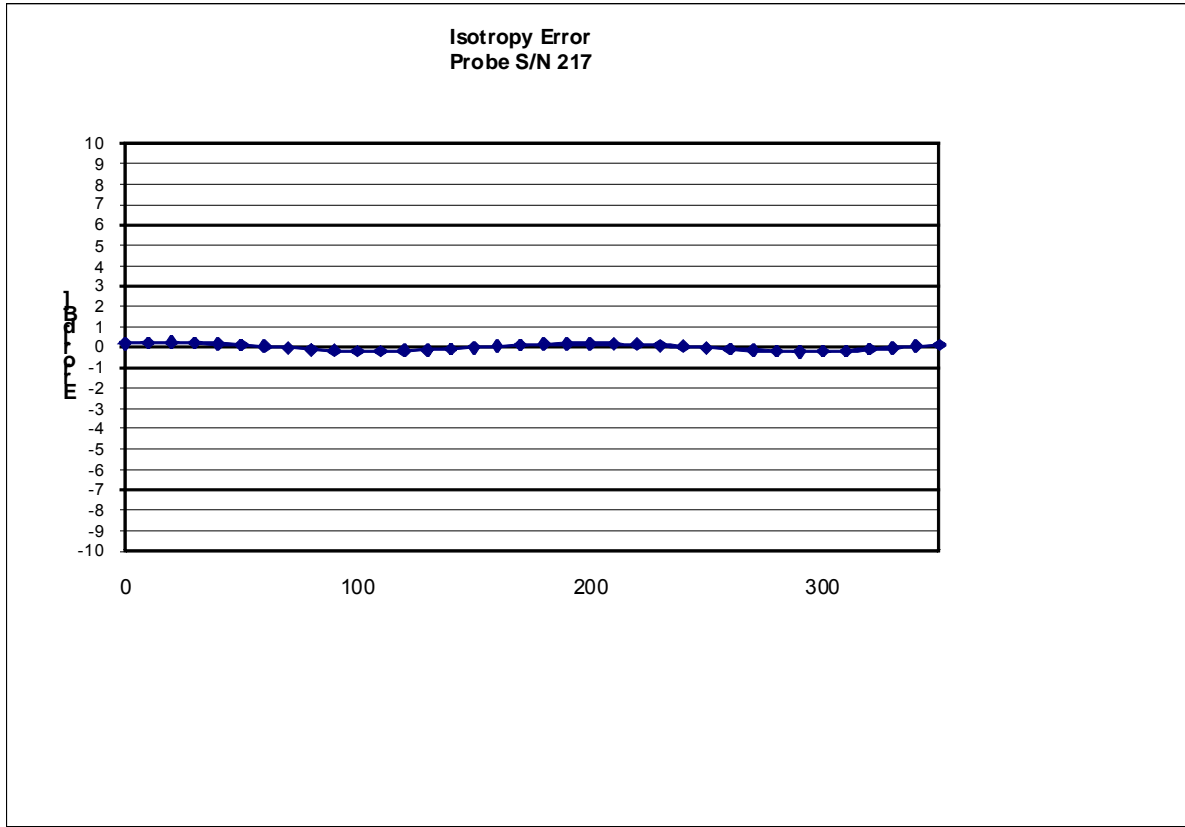
The probe was received in good condition.

Probe was calibrated on new DAC-PAQ.

## Receiving Pattern Air



## Isotropy Error

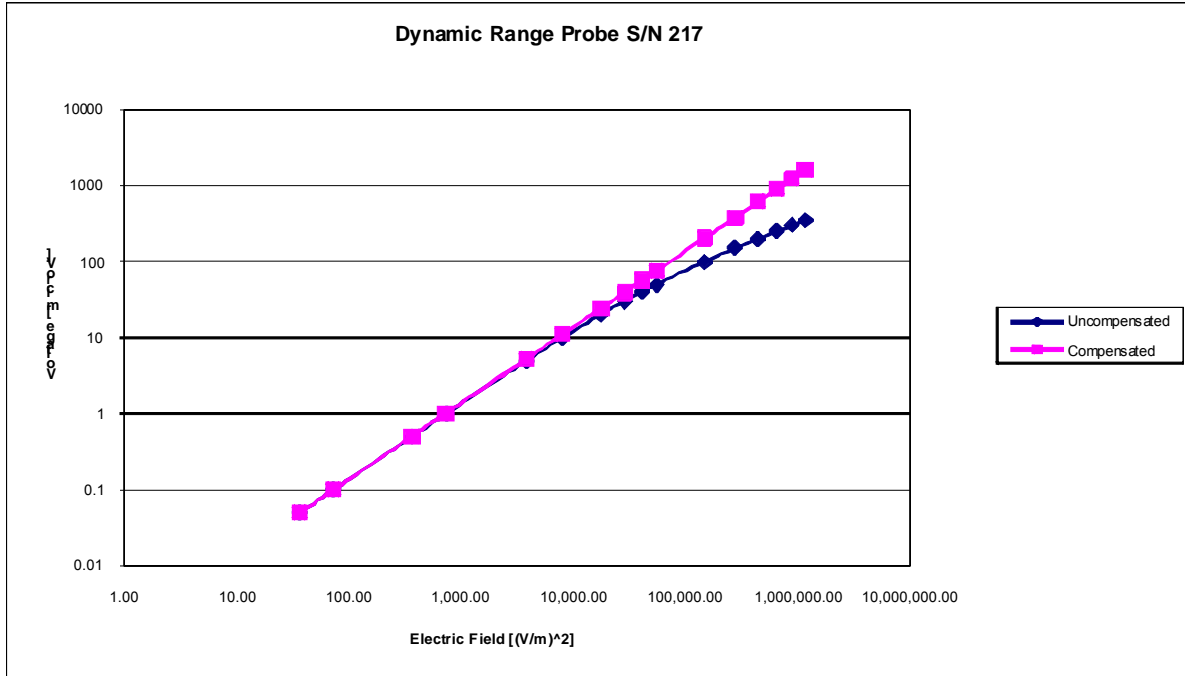


**Isotropicity Tissue:**

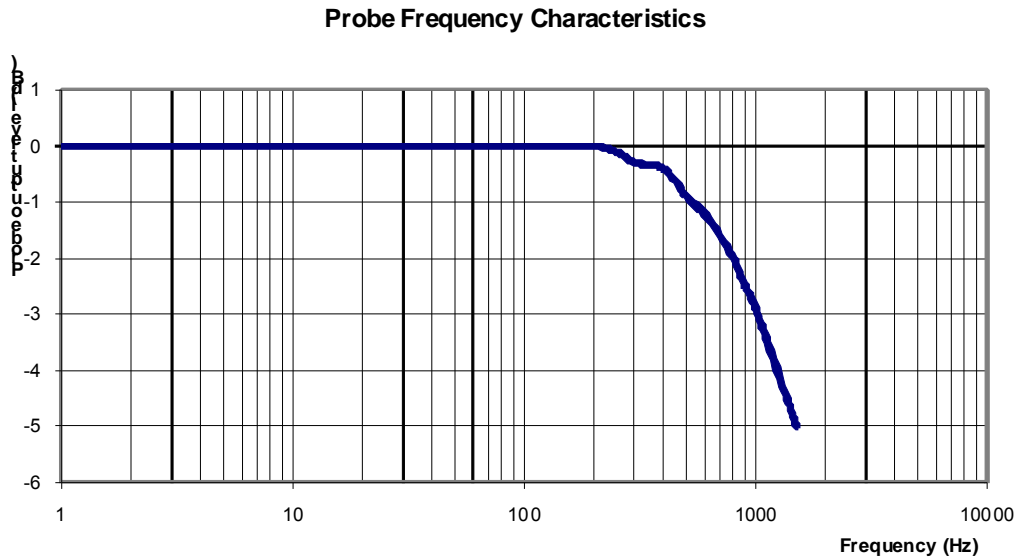
**0.12 dB**



## 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.

## Appendix E – Dipole Calibration Data Sheets

# NCL CALIBRATION LABORATORIES

Calibration File No: DC-1183

Project Number: RFEB-5554

## 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

Manufacturer: APREL Laboratories

Part number: ALS-D-450-S-2

Frequency: 450 MHz

Serial No: RFE-362

Customer: RFEL

Body Calibration

Calibrated: 19<sup>th</sup> January 2011  
Released on: 19<sup>th</sup> January 2011

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

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

**NCL CALIBRATION LABORATORIES**

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4162

## NCL Calibration Laboratories

---

Division of APREL Laboratories.

### Conditions

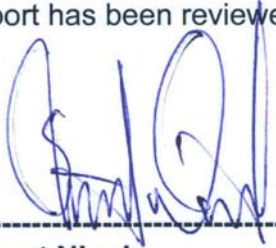
Dipole RFE-362 was a re-calibration.

**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.**

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**

## Calibration Results Summary

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

### Mechanical Dimensions

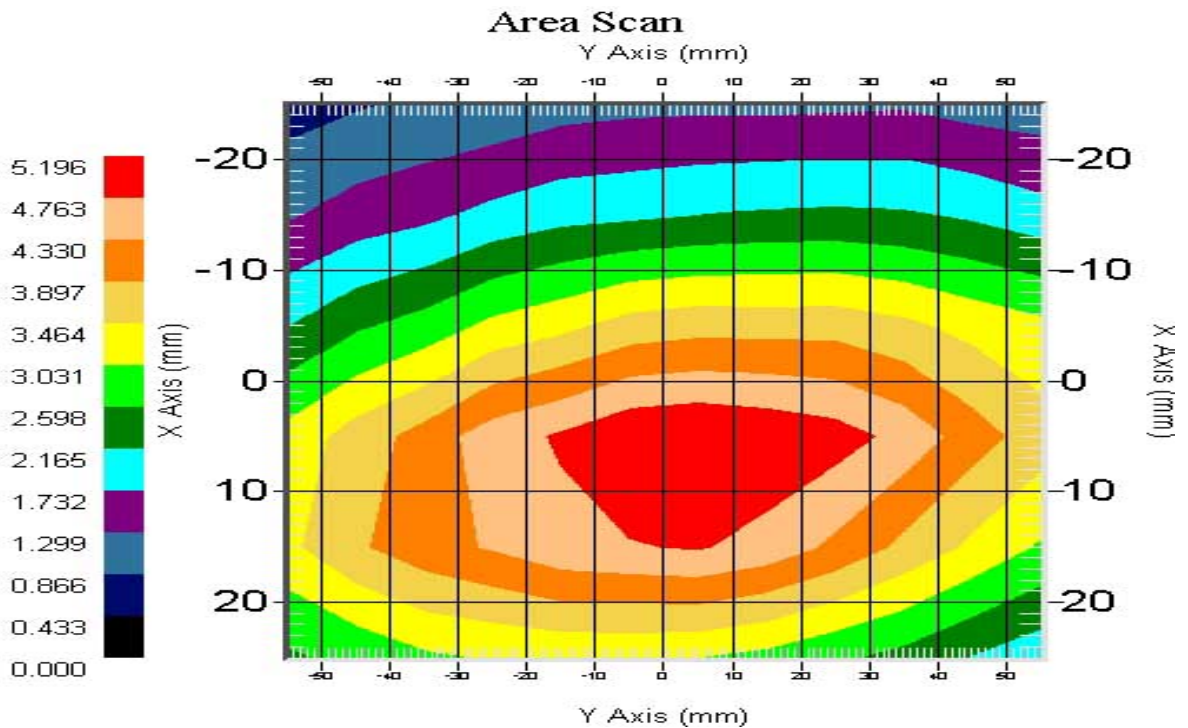
**Length:** 270.0 mm  
**Height:** 166.7 mm

### Electrical Specification

**SWR:** 1.024 U  
**Return Loss:** -38.354 dB  
**Impedance:** 49.416  $\Omega$

### System Validation Results Body

Frequency	1 Gram	10 Gram	Peak
450 MHz	5.05	3.41	7.5



## **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 RFE-362. 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-020 130 MHz to 26 GHz E-Field Probe Serial Number 212.

## **References**

SSI-TP-018-ALSAS Dipole Calibration Procedure

SSI-TP-016 Tissue Calibration Procedure

IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"

## **Conditions**

Dipole RFE-362 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 Results

### Mechanical Verification

<b>APREL Length</b>	<b>APREL Height</b>	<b>Measured Length</b>	<b>Measured Height</b>
280.0 mm	166.7 mm	280.0 mm	166.0 mm

### Tissue Validation

<b>Body Tissue 450MHz</b>	<b>Measured</b>
<b>Dielectric constant, <math>\epsilon_r</math></b>	56.7
<b>Conductivity, <math>\sigma</math> [S/m]</b>	0.94

### 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>





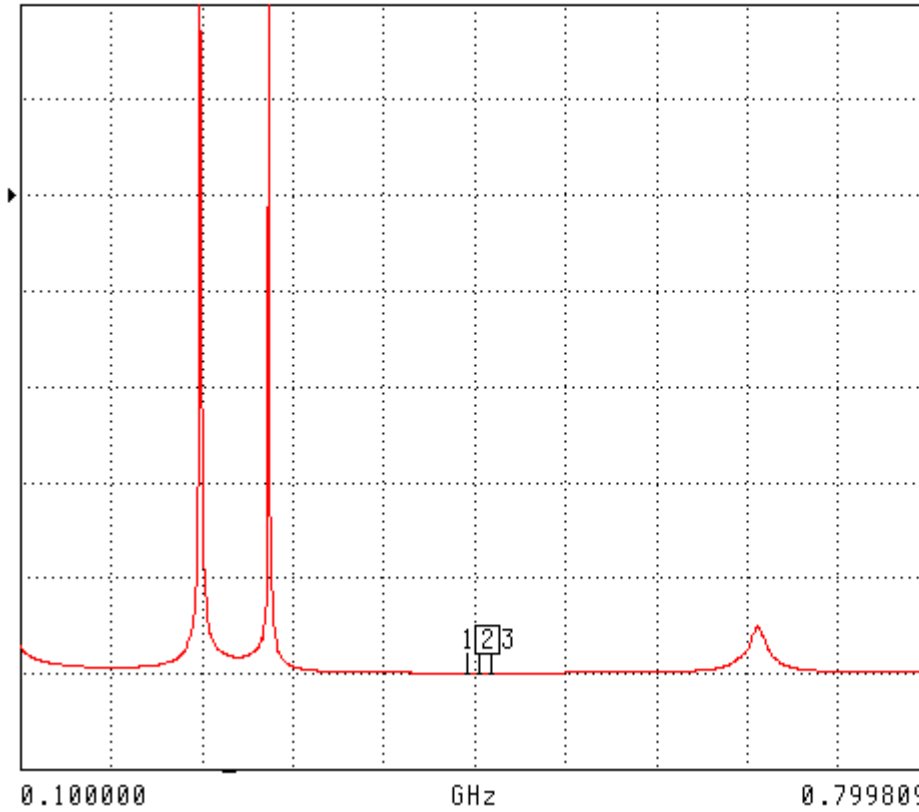
SWR

S11 FORWARD REFLECTION

SWR

REF=3.000 KU

600.000 U/DIV



CH 1 - S11  
0.0000 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

MARKER 2  
0.453564 GHz  
1.024 U

MARKER TO MAX  
MARKER TO MIN

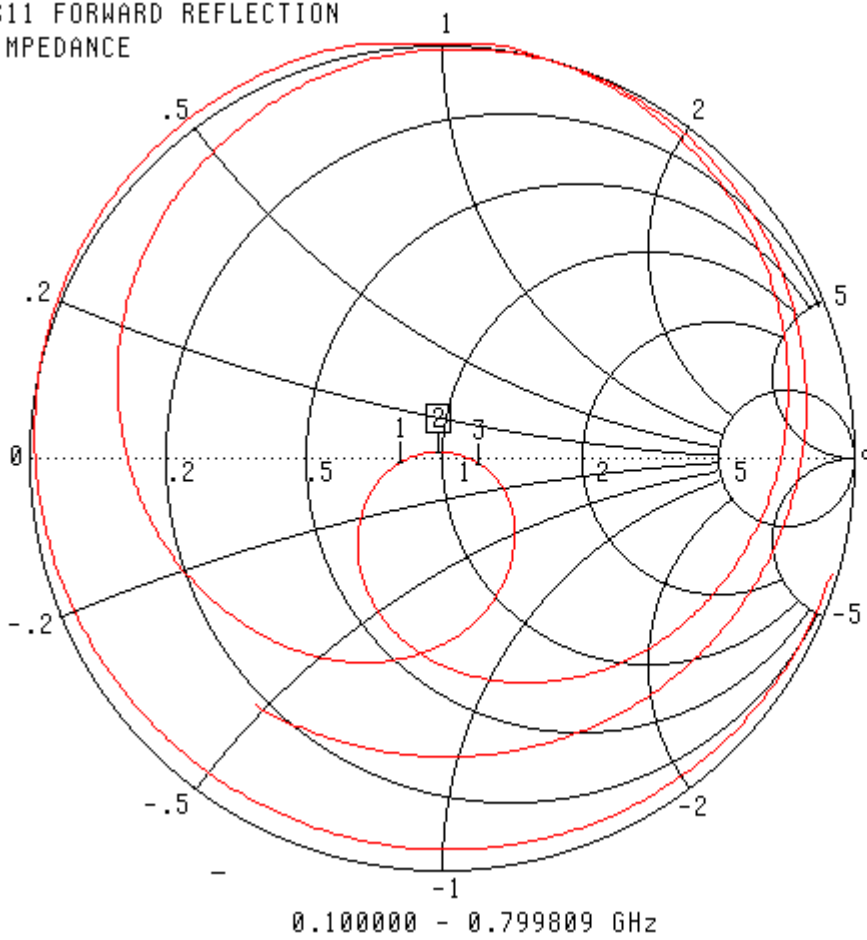
1 0.445682 GHz  
1.215 U

3 0.462572 GHz  
1.211 U

MARKER READOUT  
FUNCTIONS

## Smith Chart Dipole Impedance

S11 FORWARD REFLECTION  
IMPEDANCE



CH 1 - S11  
0.0000 mm REF  
0.000 dB OFFSET  
0.00° OFFSET

▶ MARKER 2  
0.453564 GHz  
49.416 Ω  
1.050 jΩ

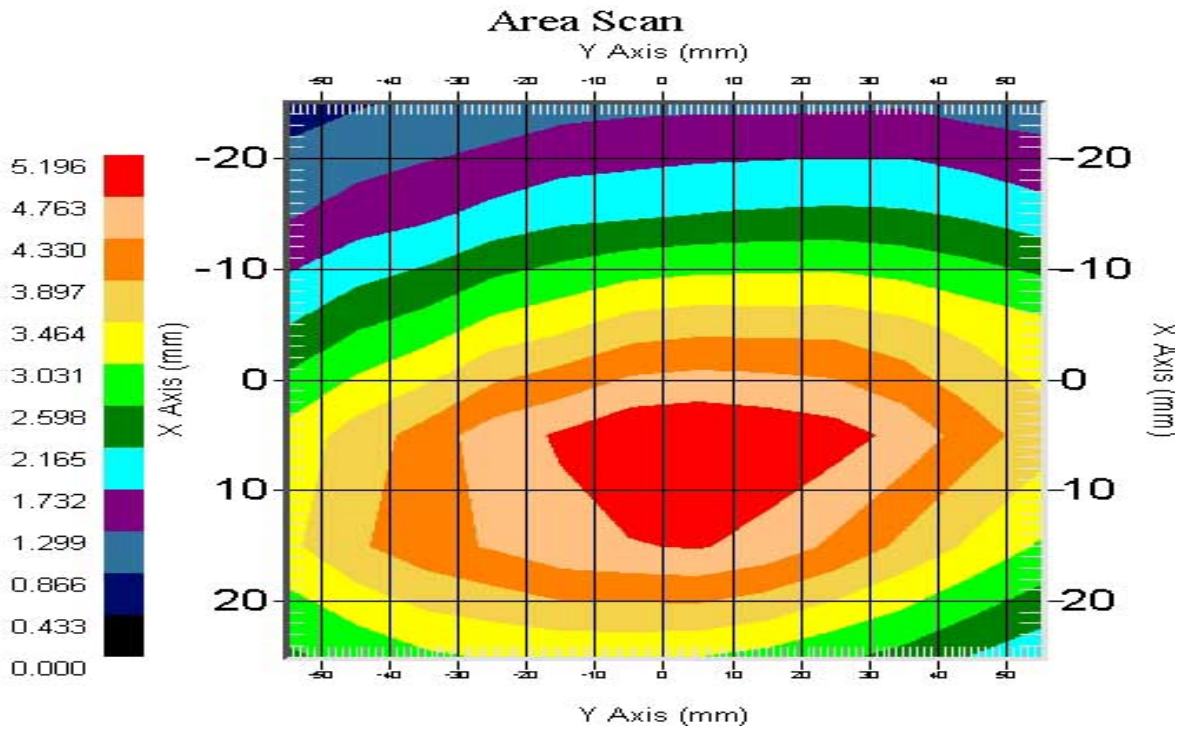
MARKER TO MAX  
MARKER TO MIN

**1** 0.445682 GHz  
41.231 Ω  
-1.179 jΩ  
**3** 0.462572 GHz  
60.300 Ω  
-2.109 jΩ

MARKER READOUT  
FUNCTIONS

System Validation Results Using the Electrically Calibrated Dipole

Body Tissue Frequency	1 Gram	10 Gram	Peak Above Feed Point
450 MHz	5.05	3.41	7.5



## 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 2010.

### Extended Calibration

Usage of SAR dipoles calibrated less than 2 years ago but more than 1 year ago were confirmed in maintaining return loss ( $< -20$  dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB Publication 450824:

<b>ALS-D-450-S-2 SN: RFE-362</b>				
<b>Date of Measurement</b>	<b>Return Loss (dB)</b>	<b><math>\Delta\%</math></b>	<b>Impedance (<math>\Omega</math>)</b>	<b><math>\Delta\%</math></b>
1/19/2011	-38.354		49.416	
1/12/2012	-38.241	-0.3	49.328	-0.2

## Appendix F – Phantom Calibration Data Sheets

# RF EXPOSURE LAB, LLC

Calibration File No.: CAL.20080601

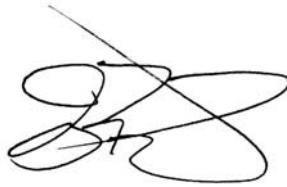
## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the **RF Exposure Lab, LLC** facility by qualified personnel following recognized Procedures and using transfer standards traceable to National Standards.

**Thickness of the Phantom is 6 mm  $\pm$  10%**  
**Size : 600 mm x 450 mm x 200 mm**  
**Ellipse of 2mm Thickness: 350 mm x 200 mm**  
**Material : High Density Polyethylene**

Resolution: 0.01 mm  
Stability: OK

Calibrated to: 0.0 mm  
Accuracy: < 0.1 mm



Calibrated by: \_\_\_\_\_

Date: June 10, 2008

 **RF Exposure Lab**

802 N. Twin Oaks Valley Rd., Suite 105  
San Marcos, CA 92069  
Phone: (760) 471-2100  
Fax: (760) 471-2121