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

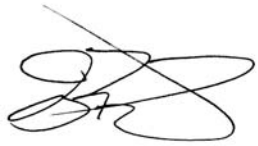
Shure Incorporated		Dates of Test:	April 13, 2011
5800 W. Touhy Avenue		Test Report Number:	SAR.20110406
Niles, IL 60714			

FCC ID:	DD4AXT100A
IC Certificate:	616A-ATX100A
Model(s):	AXT100 J5
Test Sample:	Engineering Unit Same as Production
Serial No.:	Eng 2
Equipment Type:	Wireless Microphone
Classification:	Portable Transmitter Next to Body
TX Frequency Range:	578 – 638 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	578 MHz – 20.01 dB Conducted
Signal Modulation:	FM
Antenna Type (Length):	Delta Electronics Manuf. Corp.; Model 95C12544
Application Type:	Certification
FCC Rule Parts:	Part 2, 74

This wireless mobile and/or portable device has been shown to be compliant for localized specific absorption rate (SAR) for uncontrolled environment/general exposure 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

ACCREDITED
Certificate # 2387.01

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1. Introduction

This measurement report shows compliance of the Shure Incorporated Model AXT100 J5 FCC ID: DD4AXT100A with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 616A-AXT100A 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 (ρ).

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

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

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

where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m^3)

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 pendent 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.

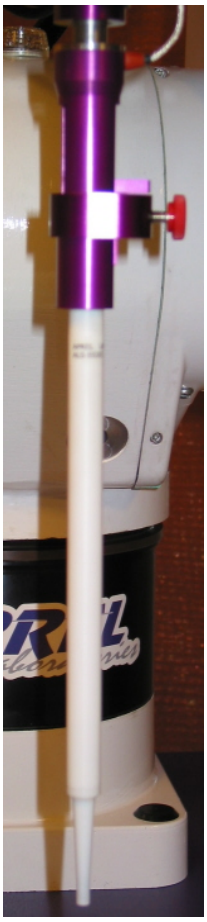
System Description

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 Aprel 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).

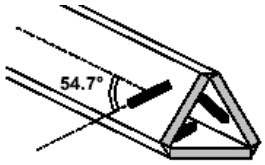
The overall uncertainty for the methodology and algorithms the ALSAS-10-U used during the SAR calculation was evaluated using the data from IEEE 1528 f3 algorithm:

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

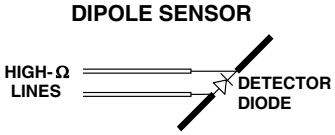
The probe used during the measurement process has been assessed to provide values for diode compression. These values are calculated during the probe calibration exercise and are used in the mathematical calculations for the assessment of SAR.

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 ± 0.05 mm and the precision of the APREL bottom detection device is ± 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 ± 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 ± 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 ≤3 GHz with a cube scan of 5x5x8 yields a volume of 32x32x28 mm^3. For devices >3 GHz and <4.5 GHz, the cube scan of 9x9x9 yields a volume of 32x32x24 mm^3. For devices ≥4.5 GHz, the cube scan of 7x7x12 yields a volume of 24x24x22 mm^3.

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

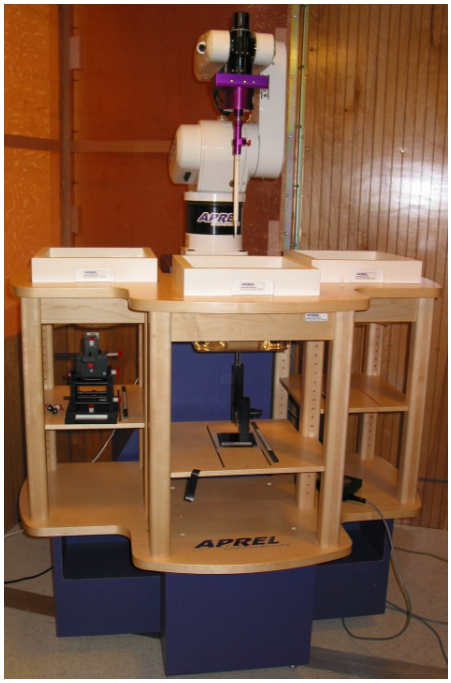
Features:	Signal Amplifier, End Effector, DAC
Software:	ALSAS 10-U Software

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 90th percentile adult male head dimensions as tabulated by the US Army. The SAM phantom shell is bisected along the mid sagittai 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 issue dielectric parameters computed from the 4-Cole-Cole equations.

Table 5.1 Typical Composition of Ingredients for Tissue

Ingredients		Simulating Tissue
		608 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	56.08
Conductivity (S/m)	Target	0.95

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[1] Head	1.60	8.00
SPATIAL AVERAGE SAR[2] Whole Body	0.08	0.40
SPATIAL PEAK SAR[3] Hands, Feet, Ankles, Wrists	4.00	20.00

[1] 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.
[2] The Spatial Average value of the SAR averaged over the whole body.
[3] 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	∞
Axial Isotropy	3.7	rectangular	√3	0.7	0.7	1.5	1.5	∞
Hemispherical Isotropy	10.9	rectangular	√3	0.7	0.7	4.4	4.4	∞
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6	∞
Linearity	4.7	rectangular	√3	1	1	2.7	2.7	∞
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6	∞
Readout Electronics	1.0	normal	1	1	1	1.0	1.0	∞
Response Time	0.8	rectangular	√3	1	1	0.5	0.5	∞
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0	∞
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7	∞
Probe Positioner Mech. Restriction	0.4	rectangular	√3	1	1	0.2	0.2	∞
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7	∞
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1	∞
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	√3	1	1	2.4	2.4	∞
Phantom and Setup								
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0	∞
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4	∞
Liquid Conductivity(meas.)	0.5	normal	1	0.7	0.5	0.4	0.3	5
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4	∞
Liquid Permittivity(meas.)	1.0	normal	1	0.6	0.5	0.6	0.5	5
Combined Uncertainty		RSS				9.6	9.4	>500
Combined Uncertainty (coverage factor=2)		Normal(k=2)				19.1	18.8	>500

8. System Validation

Tissue Verification

Table 8.1 Measured Tissue Parameters

		608 MHz Body		
Date(s)		Apr. 13, 2011		
Liquid Temperature (˚C)	20.0	Target	Measured	Deviation
Dielectric Constant: ε		56.08	55.72	- 0.64%
Conductivity: σ		0.95	0.97	+ 2.11%

See Appendix A for data printout.

Test System Verification

Prior to assessment, the system is verified to the ±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

	Dipole Used	Test Frequency	Targeted SAR_{1g} (W/kg) Per Probe Cal.	Measure SAR_{1g} (W/kg)	Tissue Used for Verification	Deviation (%)
13-Apr-2011	835 MHz	600 MHz	2.140	2.170	Body	+ 1.40%

See Appendix A for data plots.

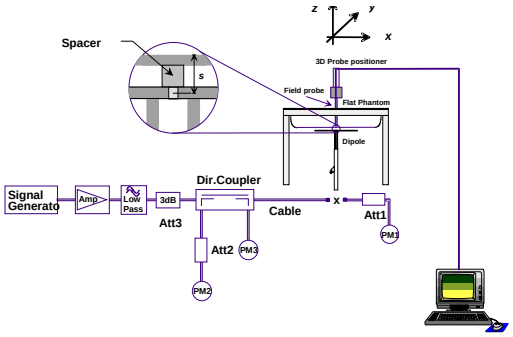


Figure 8.1 Dipole Validation Test Setup

Note: KDB 450824 D01 & D02 was applied for frequency tolerance and dipole calibrations.

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

The conducted 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 ((end/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 device was tested with the belt clip and the mic in place with the clip set up to the phantom.

608 MHz				
Freq	**Channel**	**Data Rate**	**Antenna**	**Power**
578	L	N/A	Main	20.01
608	M	N/A	Main	19.96
638	H	N/A	Main	19.82

Maximum Conduct Power Measurements

SAR Data Summary – 608 MHz Body

MEASUREMENT RESULTS							
Gap	Frequency		Modulation	End Power	SAR (W/kg)		
	MHz	Ch.		(dBm)	Measured	Drift (%)	Calculated with Drift
0 mm	578	L	FM	20.01	1.112	0.088	1.112
	608	M	FM	19.96	0.996	0.087	0.996
	638	H	FM	19.82	0.914	0.759	0.914

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
   SAR 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: If the drift was positive, the SAR value was not scaled down.

10. Test Equipment List

Table 11.1 Equipment Specifications

Type	Calibration Due Date	Serial Number
ThermoCRS Robot	N/A	RAF0338198
ThermoCRS Controller	N/A	RCF0338224
ThermoCRS Teach Pendant (Joystick)	N/A	STP0334405
IBM Computer, 2.66 MHz P4	N/A	8189D8U KCPR08N
Aprel E-Field Probe ALS-E020	09/22/2011	RFE-215
Aprel E-Field Probe ALS-E030	07/14/2011	E030-001
Aprel Dummy Probe	N/A	023
Aprel Left Phantom	N/A	RFE-267
Aprel Right Phantom	N/A	RFE-268
Aprel UniPhantom	N/A	RFE-273
Aprel Validation Dipole ALS-D-450-S-2 Head	01/12/2012	RFE-362
Aprel Validation Dipole ALS-D-450-S-2 Body	01/19/2012	RFE-362
Aprel Validation Dipole ALS-D-750-S-2 Head	01/14/2012	177-00501
Aprel Validation Dipole ALS-D-750-S-2 Body	11/15/2011	177-00501
Aprel Validation Dipole ALS-D-835-S-2 Head	01/14/2012	180-00561
Aprel Validation Dipole ALS-D-835-S-2 Body	11/16/2011	180-00561
Aprel Validation Dipole ALS-D-900-S-2 Head	01/12/2012	RFE-275
Aprel Validation Dipole ALS-D-900-S-2 Body	11/19/2011	RFE-275
Aprel Validation Dipole ALS-D-1900-S-2 Head	01/15/2012	210-00713
Aprel Validation Dipole ALS-D-1900-S-2 Body	11/16/2011	210-00713
Aprel Validation Dipole ALS-D-2450-S-2 Head	01/12/2012	RFE-278
Aprel Validation Dipole ALS-D-2450-S-2 Body	11/18/2011	RFE-278
Aprel Validation Dipole RFE-D-2600-S-2 Body	01/18/2012	RFE-121
Aprel Validation Dipole RFE-D-BB-S-2 Head	01/12/2012	235-00801
Aprel Validation Dipole RFE-D-BB-S-2 Body	02/09/2012	235-00801
Agilent (HP) 437B Power Meter	03/30/2012	3125U08837
Agilent (HP) 8481B Power Sensor	03/30/2012	3318A05384
Agilent N1911A Power Meter	03/30/2012	GB45100254
Agilent N1922A Power Sensor	03/30/2012	MY45240464
Advantest R3261A Spectrum Analyzer	03/30/2012	31720068
Agilent (HP) 8350B Signal Generator	03/31/2012	2749A10226
Agilent (HP) 83525A RF Plug-In	03/31/2012	2647A01172
Agilent (HP) 8753C Vector Network Analyzer	03/30/2012	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	03/31/2012	2904A00595
Agilent (HP) 8960 Base Station Sim.	03/25/2012	MY48360364
Aprel Dielectric Probe Assembly	N/A	0011
Head Equivalent Matter (450 MHz)	N/A	N/A
Head Equivalent Matter (835/900 MHz)	N/A	N/A
Head Equivalent Matter (1900 MHz)	N/A	N/A
Head Equivalent Matter (2450 MHz)	N/A	N/A
Body Equivalent Matter (450 MHz)	N/A	N/A
Body Equivalent Matter (750 MHz)	N/A	N/A
Body Equivalent Matter (835/900 MHz)	N/A	N/A
Body Equivalent Matter (1900 MHz)	N/A	N/A
Body Equivalent Matter (2450 MHz)	N/A	N/A
Body Equivalent Matter (2600 MHz)	N/A	N/A
Body Equivalent Matter (5200 MHz)	N/A	N/A
Body Equivalent Matter (5800 MHz)	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

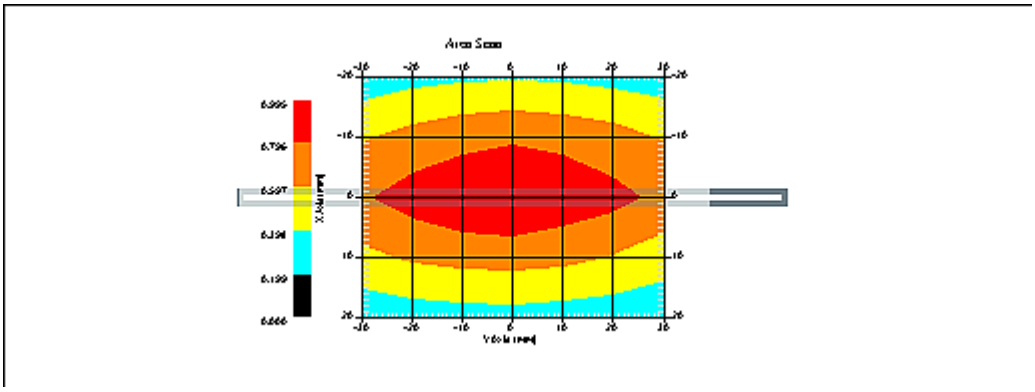
```
************************************************************
Test Result for UIM Dielectric Parameter
Wed 13/Apr/2011 03:42:43
Freq  Frequency(GHz)
FCC_eH      FCC Bulletin 65 Supplement C ( June 2001) Limits for Head Epsilon
FCC_sH      FCC Bulletin 65 Supplement C (June 2001) Limits for Head Sigma
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
0.5780	56.20	0.95	55.85	0.96
0.5880	56.16	0.95	55.81	0.96
0.5980	56.12	0.95	55.76	0.97
0.6080	56.08	0.95	55.72	0.97
0.6180	56.05	0.95	55.68	0.97
0.6280	56.01	0.95	55.64	0.98
0.6380	55.97	0.95	55.60	0.98

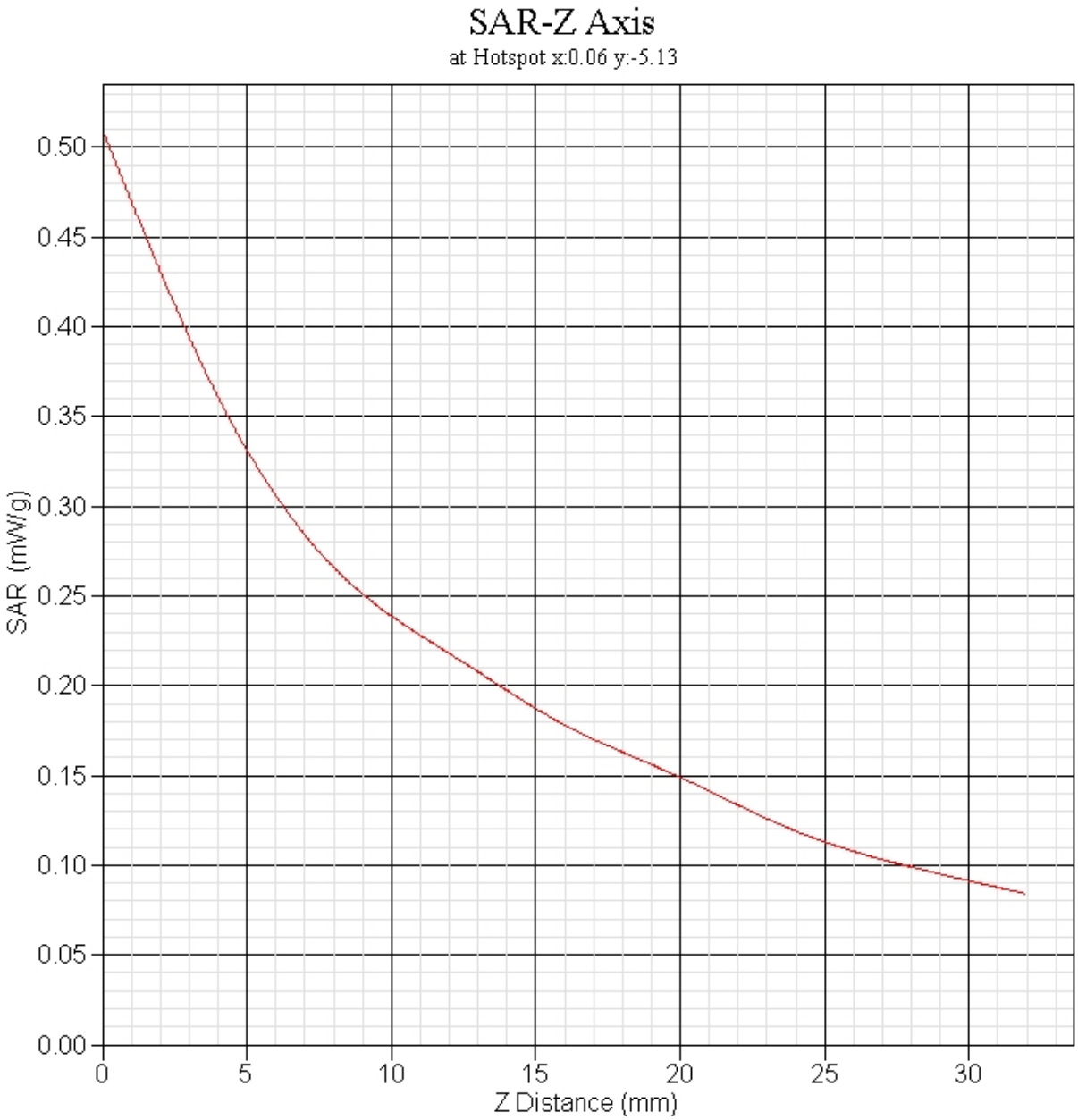
SAR Test Report

```
By Operator       : Jay
Measurement Date  : 13-Apr-2011
Starting Time     : 13-Apr-2011  04:00:41 PM
End Time          : 13-Apr-2011  04:15:49 PM
Scanning Time     : 908 secs

Product Data
Device Name       : Validation
Serial No.        : 835
Type              : Dipole
Model             : ALS-D-835-S-2
Frequency         : 835.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time        : 0 min(s)
Length            : 161 mm
Width             : 3.6 mm
Depth             : 89.8 mm
Antenna Type      : Internal
Orientation       : Touch
Power Drift-Start : 0.349 W/kg
Power Drift-Finish: 0.337 W/kg
Power Drift (%)   : -3.436

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.        : 600
Frequency         : 600.00 MHz
Last Calib. Date  : 13-Apr-2011
Temperature       : 20.00 °C
Ambient Temp.     : 23.00 °C
Humidity          : 49.00 RH%
Epsilon           : 55.47 F/m
Sigma             : 0.97 S/m
Density           : 1000.00 kg/cu. m

Probe Data
Name              : Probe 217 - RFEL
Model             : E020
Type              : E-Field Triangle
Serial No.        : 217
Last Calib. Date  : 21-Oct-2010
Frequency         : 600.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
Probe Sensitivity: 1.20  1.20  1.20   µV/(V/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.     : 25.00 °C
Set-up Date       : 13-Apr-2011
Set-up Time       : 9:21:48 AM
Area Scan         : 5x7x1 : 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    : 0.217 W/kg
10 gram SAR value   : 0.170 W/kg
Area Scan Peak SAR  : 0.351 W/kg
Zoom Scan Peak SAR  : 0.510 W/kg
```



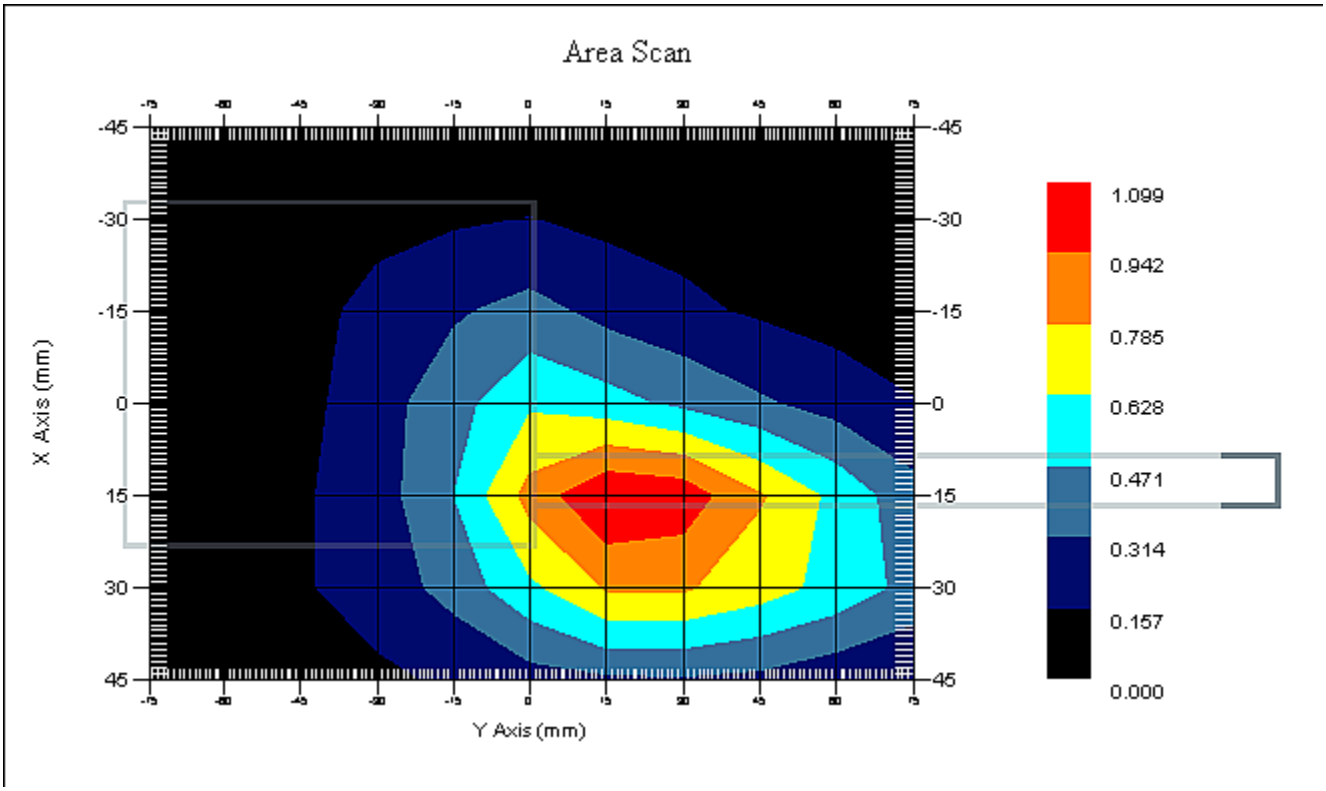
Appendix B – SAR Test Data Plots

Note: In all data sheets in Appendix B, the frequency noted in the 'Product Data' section is the frequency band which the device was transmitting. This frequency does not refer to the actual frequency and channel of the test. The channel is listed in the 'Other Data' section of the data sheet as Low, Mid or High. The actual test frequency is listed in Section 10 in each of the data summary sheets.

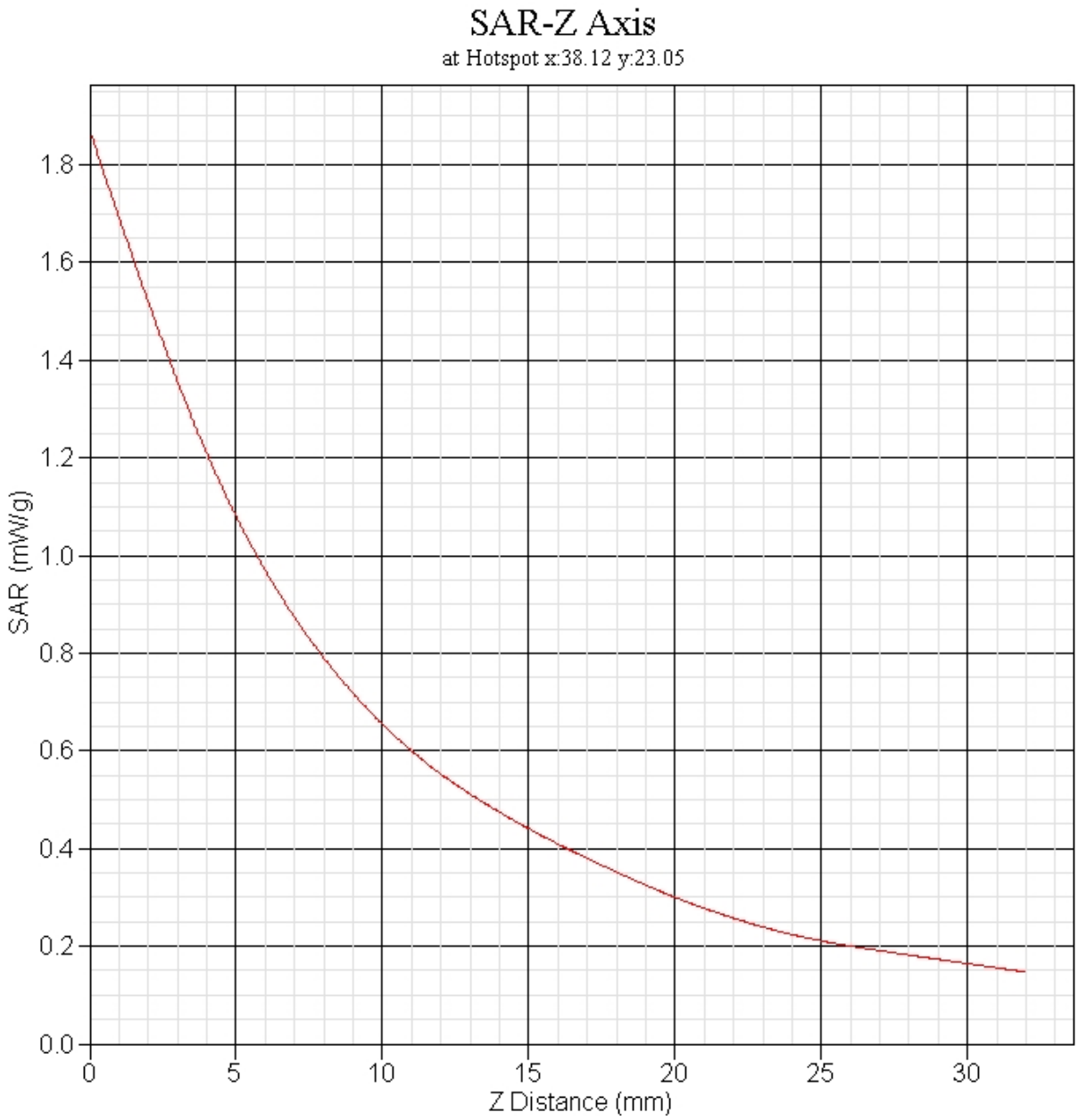
SAR Test Report

```
By Operator       : Jay
Measurement Date  : 13-Apr-2011
Starting Time     : 13-Apr-2011  04:50:32 PM
End Time          : 13-Apr-2011  05:13:46 PM
Scanning Time     : 1394 secs

Product Data
Device Name       : Shure
Serial No.        : Eng 2
Mode              : FM
Model             : AXT100 J5
Frequency         : 608.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time        : 0 min(s)
Length            : 77 mm
Width             : 68 mm
Depth             : 17 mm
Antenna Type      : Stub
Orientation       : Back
Power Drift-Start : 0.363 W/kg
Power Drift-Finish: 0.364 W/kg
Power Drift (%)   : 0.088

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.        : 608
Frequency         : 608.00 MHz
Last Calib. Date  : 13-Apr-2011
Temperature       : 20.00 °C
Ambient Temp.     : 23.00 °C
Humidity          : 54.00 RH%
Epsilon           : 55.72 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  : 21-Oct-2010
Frequency         : 600.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
Probe Sensitivity: 1.20  1.20  1.20   µV/(V/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       : 13-Apr-2011
Set-up Time       : 4:20:14 PM
Area Scan         : 7x11x1 : 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           : Low
```



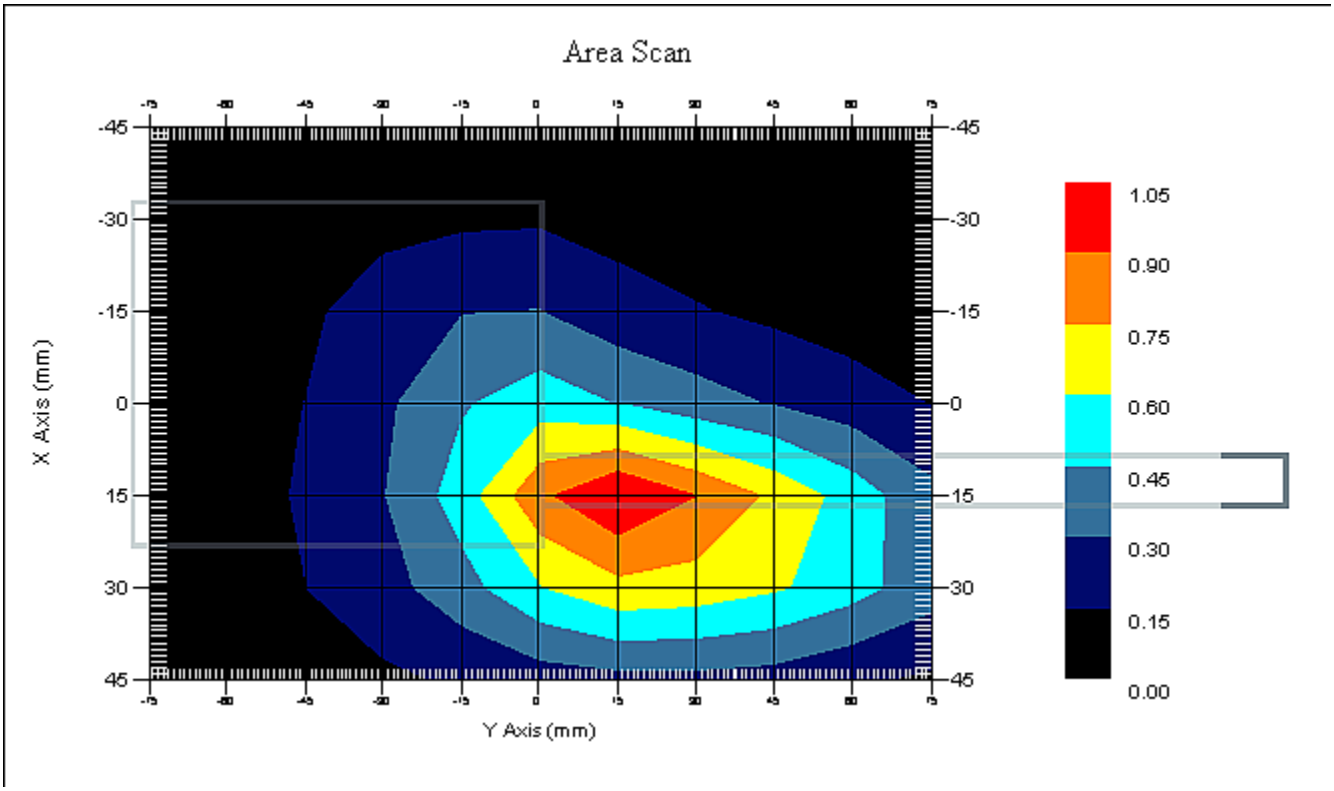

```
1 gram SAR value    : 1.112 W/kg
10 gram SAR value   : 0.627 W/kg
Area Scan Peak SAR  : 1.096 W/kg
Zoom Scan Peak SAR  : 1.871 W/kg
```



SAR Test Report

```
By Operator       : Jay
Measurement Date  : 13-Apr-2011
Starting Time     : 13-Apr-2011  04:21:47 PM
End Time          : 13-Apr-2011  04:45:00 PM
Scanning Time     : 1393 secs

Product Data
Device Name       : Shure
Serial No.        : Eng 2
Mode              : FM
Model             : AXT100 J5
Frequency         : 608.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time        : 0 min(s)
Length            : 77 mm
Width             : 68 mm
Depth             : 17 mm
Antenna Type      : Stub
Orientation       : Back
Power Drift-Start : 0.298 W/kg
Power Drift-Finish: 0.298 W/kg
Power Drift (%)   : 0.087

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.        : 608
Frequency         : 608.00 MHz
Last Calib. Date  : 13-Apr-2011
Temperature       : 20.00 °C
Ambient Temp.     : 23.00 °C
Humidity          : 54.00 RH%
Epsilon           : 55.72 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  : 21-Oct-2010
Frequency         : 600.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
Probe Sensitivity: 1.20  1.20  1.20   µV/(V/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       : 13-Apr-2011
Set-up Time       : 4:20:14 PM
Area Scan         : 7x11x1 : 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
```

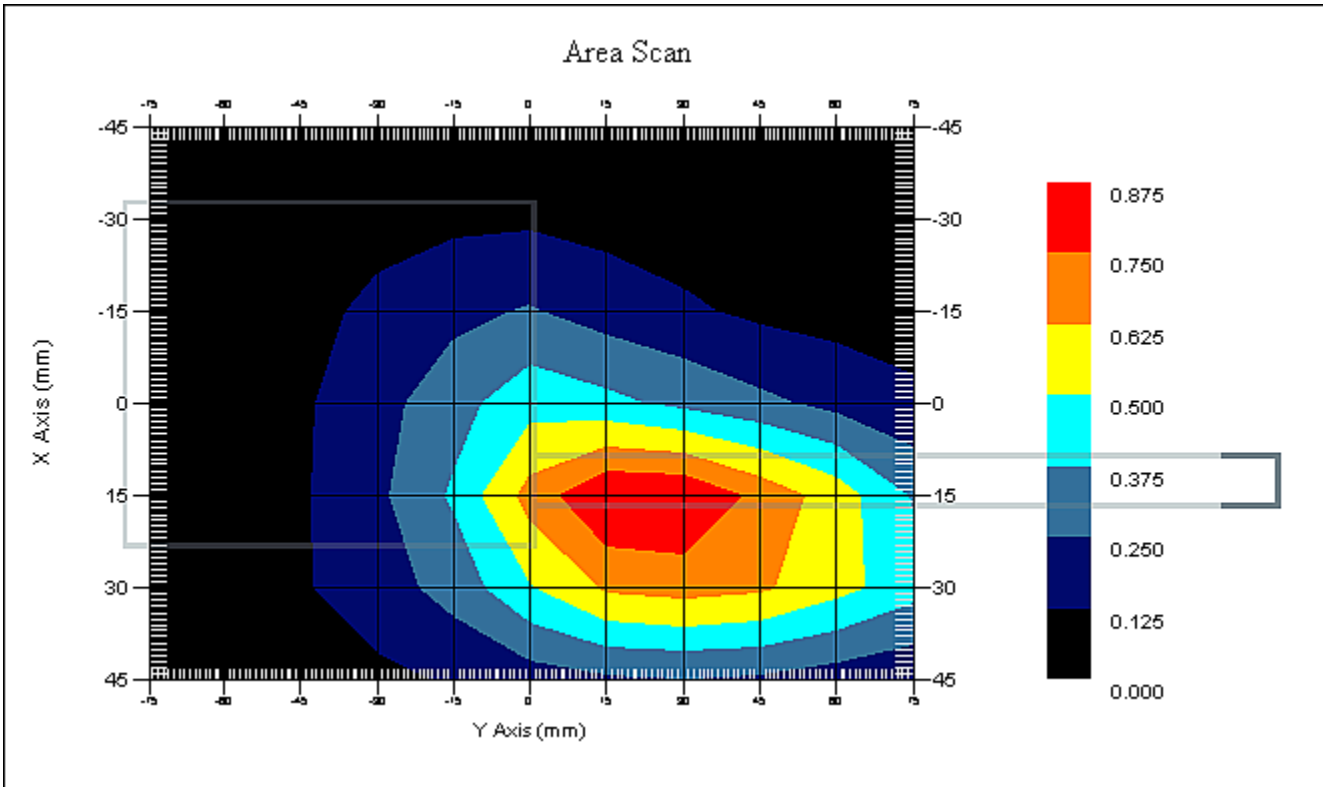



```
1 gram SAR value    : 0.996 W/kg
10 gram SAR value   : 0.562 W/kg
Area Scan Peak SAR  : 1.050 W/kg
Zoom Scan Peak SAR  : 1.721 W/kg
```

SAR Test Report

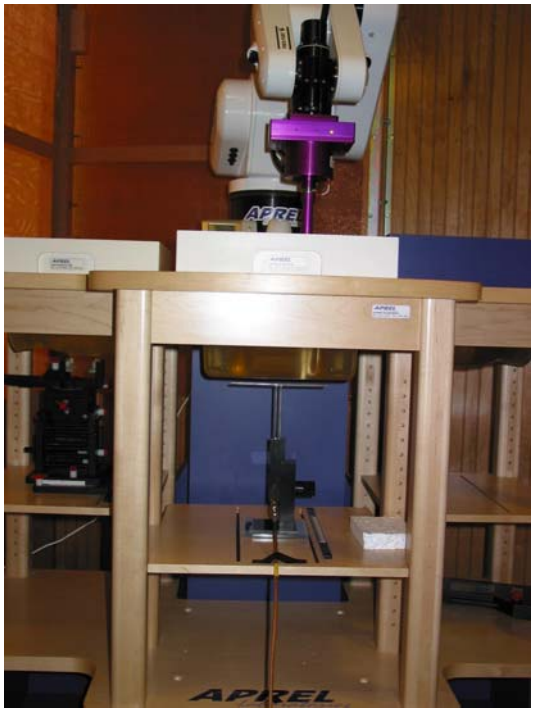
```
By Operator       : Jay
Measurement Date  : 13-Apr-2011
Starting Time     : 13-Apr-2011  05:19:59 PM
End Time          : 13-Apr-2011  05:43:08 PM
Scanning Time     : 1389 secs

Product Data
Device Name       : Shure
Serial No.        : Eng 2
Mode              : FM
Model             : AXT100 J5
Frequency         : 608.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time        : 0 min(s)
Length            : 77 mm
Width             : 68 mm
Depth             : 17 mm
Antenna Type      : Stub
Orientation       : Back
Power Drift-Start : 0.251 W/kg
Power Drift-Finish: 0.253 W/kg
Power Drift (%)   : 0.759

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.        : 608
Frequency         : 608.00 MHz
Last Calib. Date  : 13-Apr-2011
Temperature       : 20.00 °C
Ambient Temp.     : 23.00 °C
Humidity          : 54.00 RH%
Epsilon           : 55.72 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  : 21-Oct-2010
Frequency         : 600.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
Probe Sensitivity: 1.20  1.20  1.20   µV/(V/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       : 13-Apr-2011
Set-up Time       : 4:20:14 PM
Area Scan         : 7x11x1 : 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           : High
```

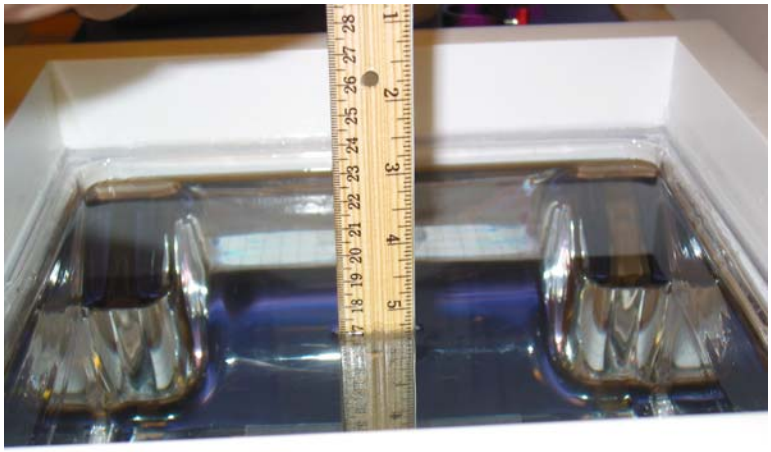



```
1 gram SAR value    : 0.914 W/kg
10 gram SAR value   : 0.514 W/kg
Area Scan Peak SAR  : 0.874 W/kg
Zoom Scan Peak SAR  : 1.541 W/kg
```

Appendix C – SAR Test Setup Photos



System Body Configuration



Body Tissue Depth

Back Test Position 0 mm Gap

Front of Device

Back of Device

Battery

Appendix D – Probe Calibration Data Sheets

NCL CALIBRATION LABORATORIES

Calibration File No.: CP-1089

Client.: RFEL

C E R T I F I C A T E OF C A L I B R A T I O N

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

Equipment: Miniature Isotropic RF Probe 600 MHz
BODY Calibration
Manufacturer: APREL Laboratories
Model No.: E-020
Serial No.: 217

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2
Project No: RFEL-E020-CAL-5477

Calibrated: 21st October 2010
Released on: 28th October 2010

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary
This calibration has been conducted in line with the SCC ISO-IEC 17025 Scope of Accreditation
Accredited Laboratory Number 48

Released By: _____

NCL CALIBRATION LABORATORIES

51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6

Division of APREL Lab.
TEL: (613) 820-4988
FAX: (613) 820-4161

Introduction

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-020 217.

References

SSI/DRB-TP-D01-032-E020-V2 E-Field Probe 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”
SSI-TP-011 Tissue Calibration Procedure
IEC 62209 “Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures –Part 1 & 2: 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)”
IEEE 1309 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

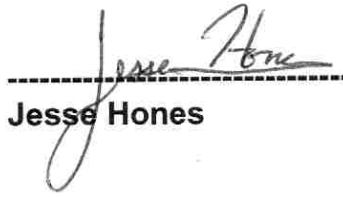
Conditions

Probe 217 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 probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.

Stuart Nicol



Jesse Hones

Calibration Results Summary

Probe Type:	E-Field Probe E-020
Serial Number:	217
Frequency:	600 MHz
Sensor Offset:	1.56 mm
Sensor Length:	2.5 mm
Tip Enclosure:	Ertalyte*
Tip Diameter:	**<**5 mm
Tip Length:	60 mm
Total Length:	290 mm

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

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

Sensitivity in Body Tissue

Frequency: 600 MHz

Epsilon: 56.11 (+/-5%) **Sigma:** 0.95 S/m (+/-5%)

ConvF

Channel X: 6.3 (calculated and experimentally validated)

Channel Y: 6.3 (calculated and experimentally validated)

Channel Z: 6.3 (calculated and experimentally validated)

Tissue sensitivity values are typically calculated using the load impedance of the APREL Laboratories Daq-Paq.

Conversion factors are calculated using a numerical simulation program (Remcon XFDTD) and validated based on numerical data derived using an 835MHz dipole excited with a 600MHz Gaussian signal. Tissue dielectric values used in the calculations were based on the FCC body tissue values as described in the FCC OET Supplement C document.

Numerical SAR Target Value:

Numerical Derived 1g SAR @ 600MHz: 2.140 W/kg

Experimental verification of the calculated CF values was conducted and the SAR value was shown to be within 3% of the numerically derived SAR Target Value (NSTV).

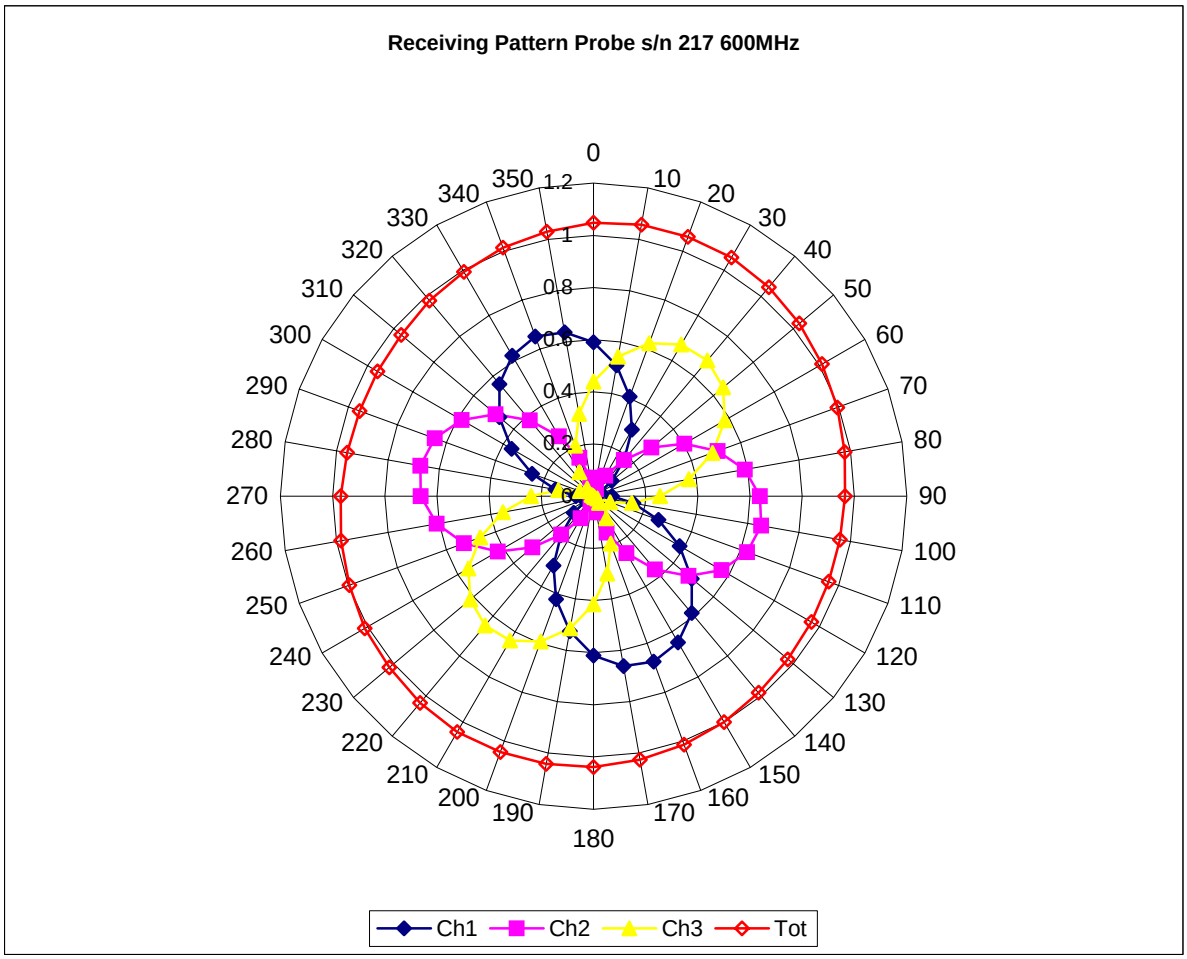
Boundary Effect:

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

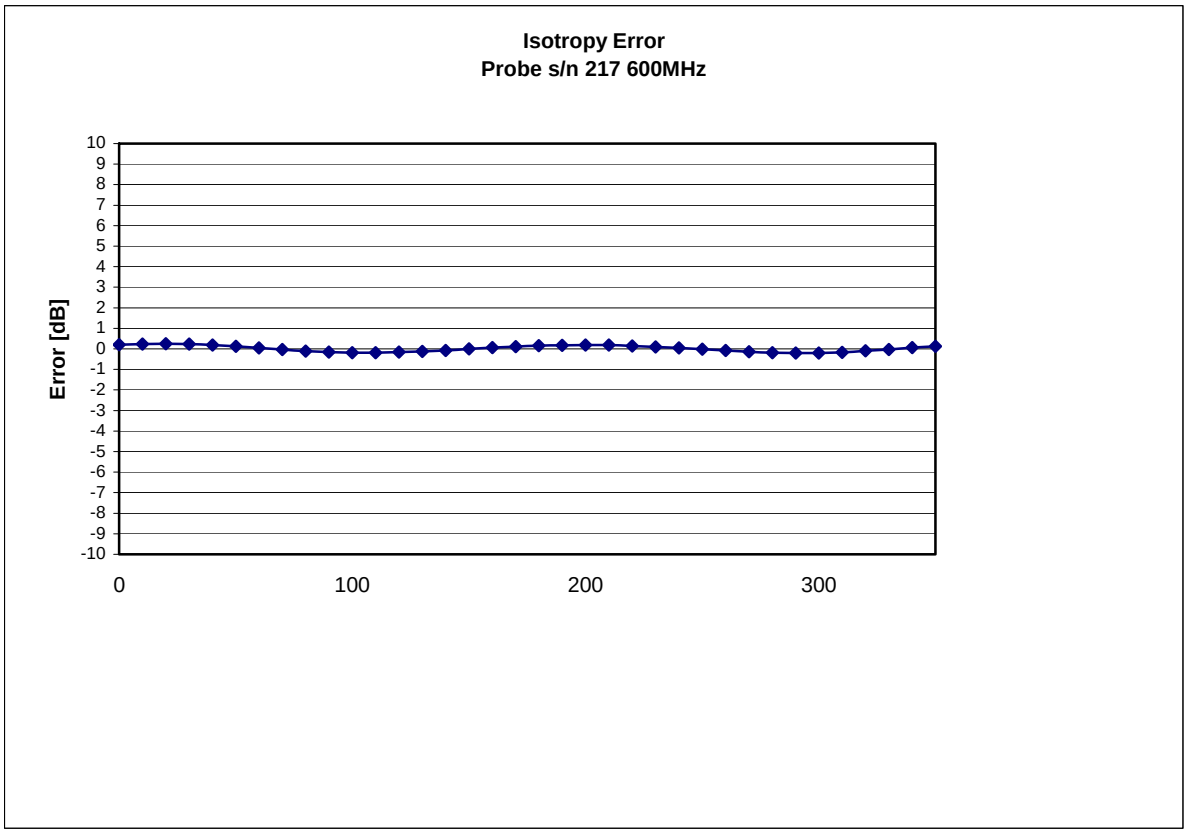
Spatial Resolution:

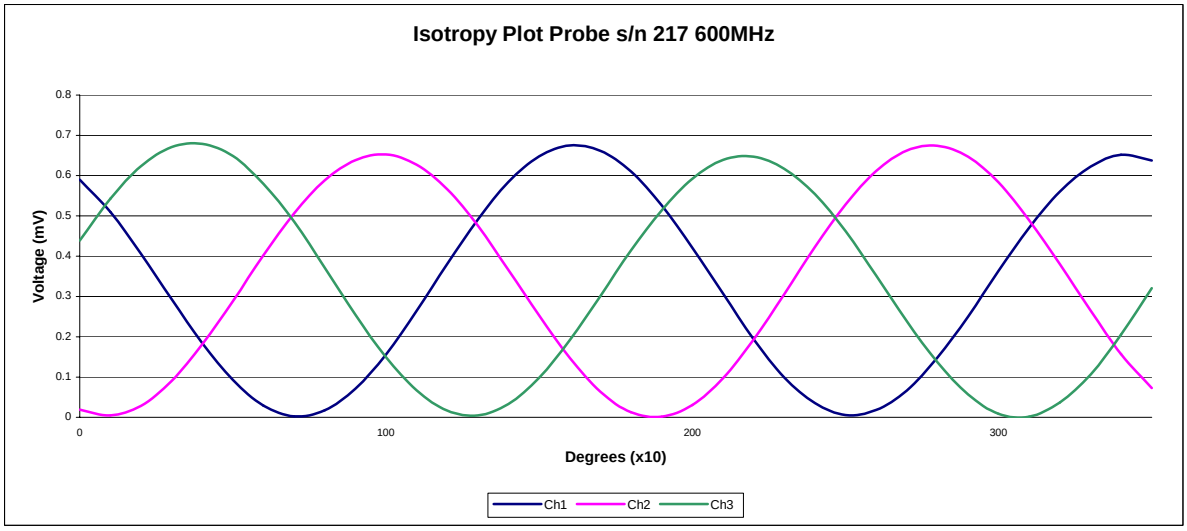
The measured probe tip diameter is 5 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

Receiving Pattern 600 MHz (Air)



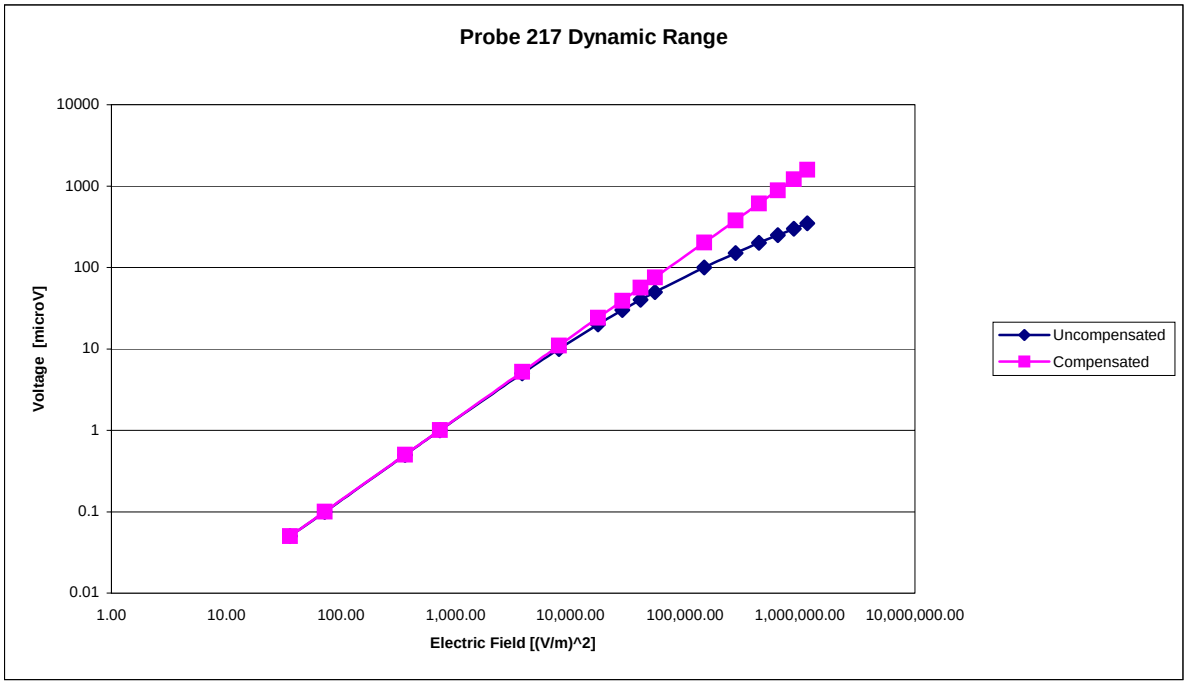
Isotropy Error 600 MHz (Air)



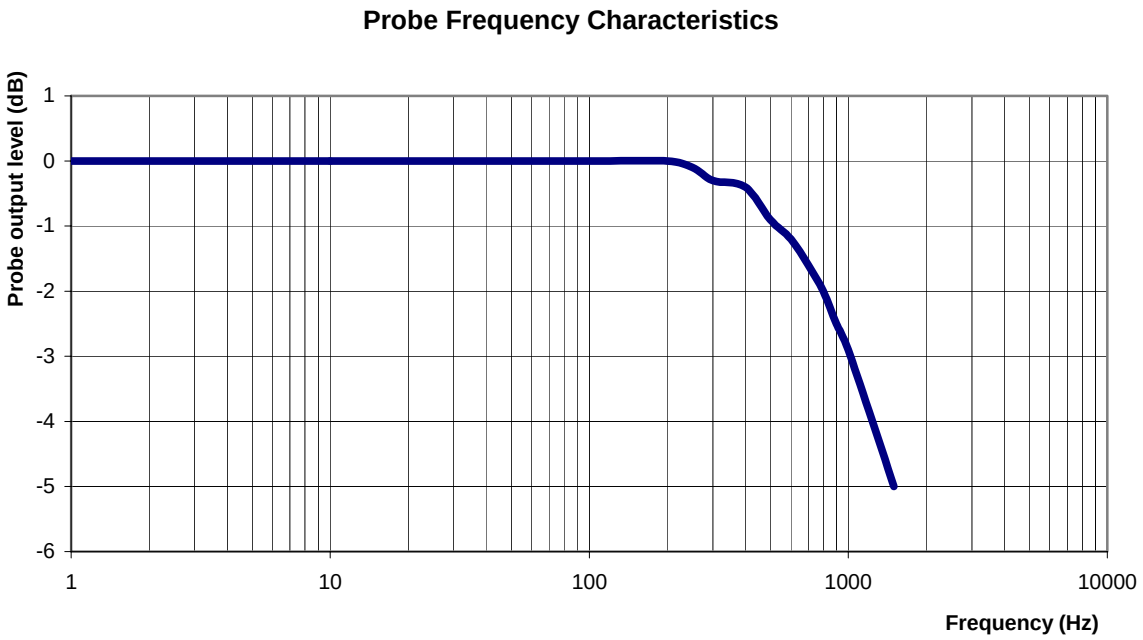


Isotropicity Tissue: 0.10 dB

Dynamic Range



Video Bandwidth



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

Conversion Factor Uncertainty Assessment

Sensitivity in Body Tissue

Frequency: 600 MHz

Epsilon: 56.11 (measured) **Sigma:** 0.95 S/m (measured)

ConvF

Channel X: 6.3 7%(K=2)

Channel Y: 6.3 7%(K=2)

Channel Z: 6.3 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Boundary Effect:

For a distance of 2.5mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

NOTE:

This calibration has been conducted using physical quantities for the tissue dielectrics and normalized against NSTV.

Consult page 4 for further details on methods used.

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.

Appendix E – Dipole Calibration Data Sheets

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1179
Project Number: RFEL-DC-835B-5549

C E R T I F I C A T E OF C A L I B R A T I O N

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

Validation Dipole

Manufacturer: APREL Laboratories
Part number: ALS-D-835-S-2
Frequency: 835 MHz
Serial No: 180-00561

Customer: RFEL
Body Calibration

Calibrated: 16th November 2010
Released on: 16th November 2010

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

Conditions

Dipole 180-00561 was a new 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

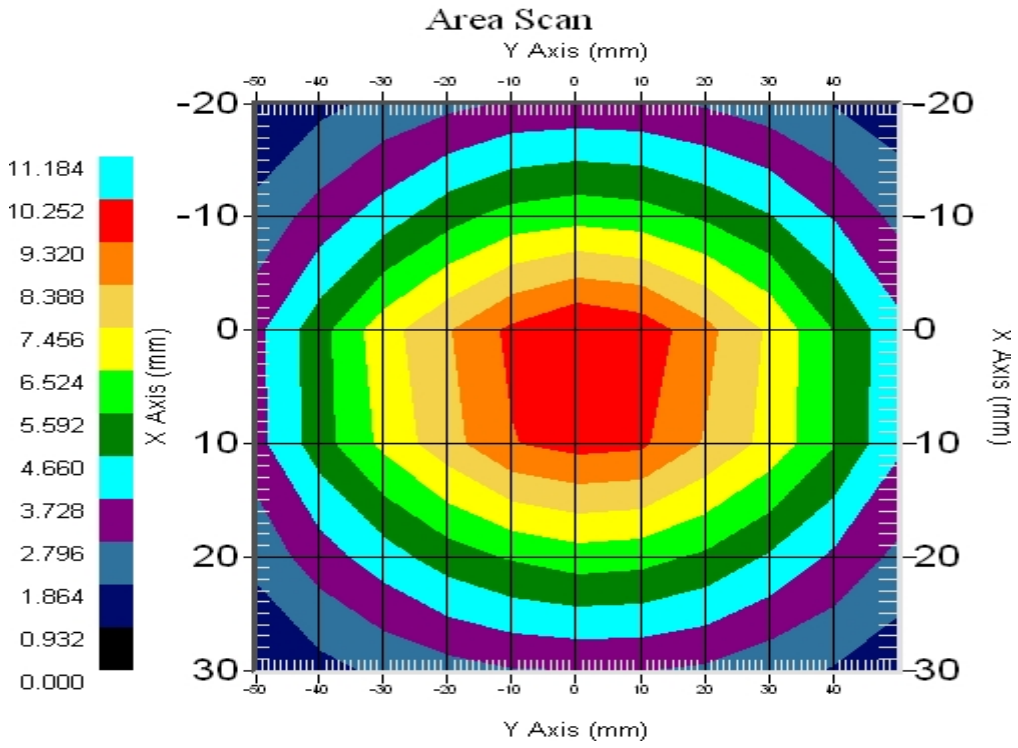
Length: 161.0 mm
Height: 89.8 mm

Electrical Specification

SWR: 1.143U
Return Loss: -24.058 dB
Impedance: 55.519 Ω

System Validation Results

Frequency	1 Gram	10 Gram	Peak
835 MHz	9.81	6.3	14.87



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 180-00561. 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 2225.

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 180-00561 was a new 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

APREL Length	APREL Height	Measured Length	Measured Height
161.0 mm	89.8 mm	162.1 mm	89.8 mm

Tissue Validation

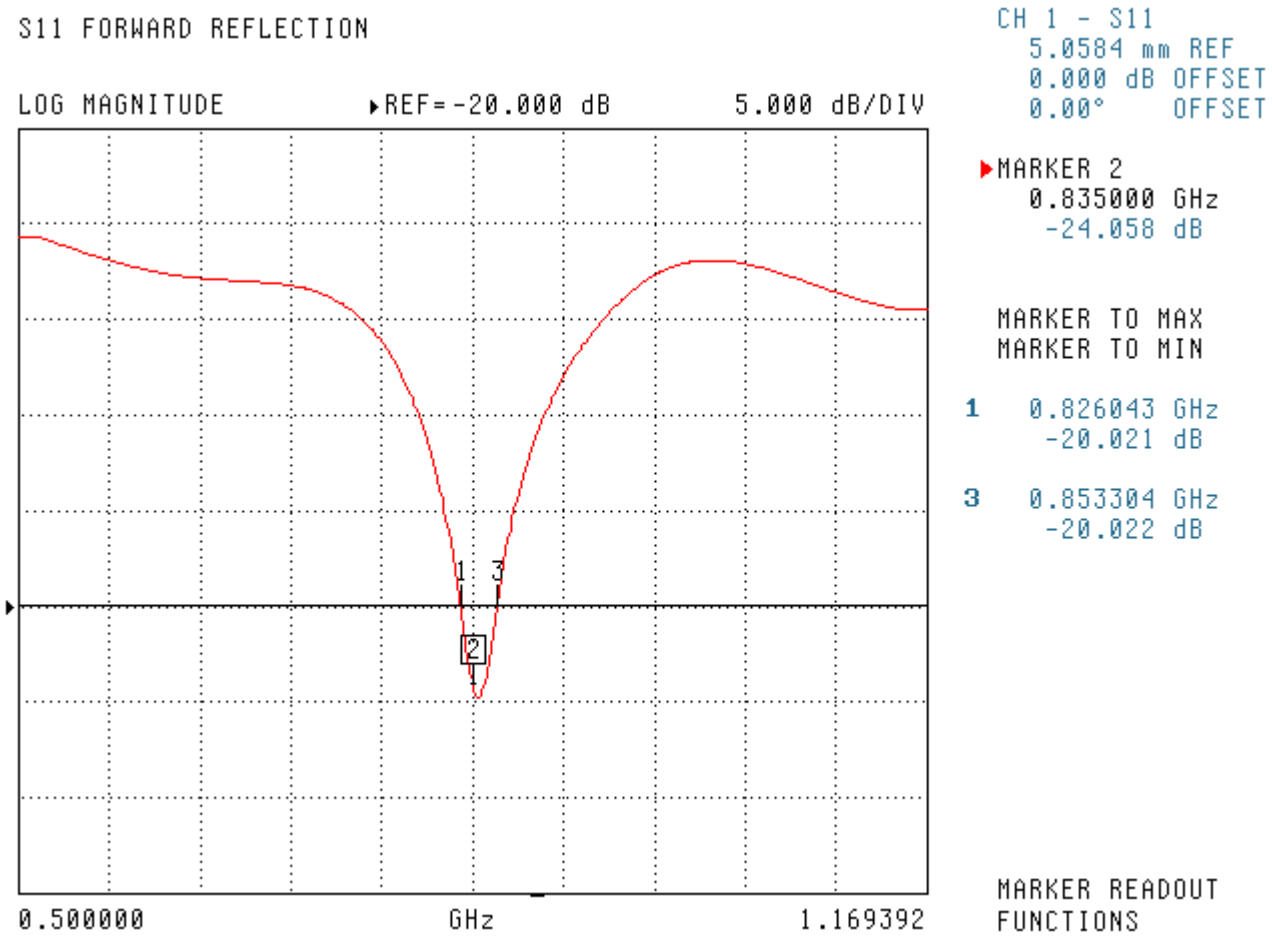
Body Tissue 835MHz	Measured
Dielectric constant, ε_r	57.19
Conductivity, σ [S/m]	0.97

Electrical Calibration

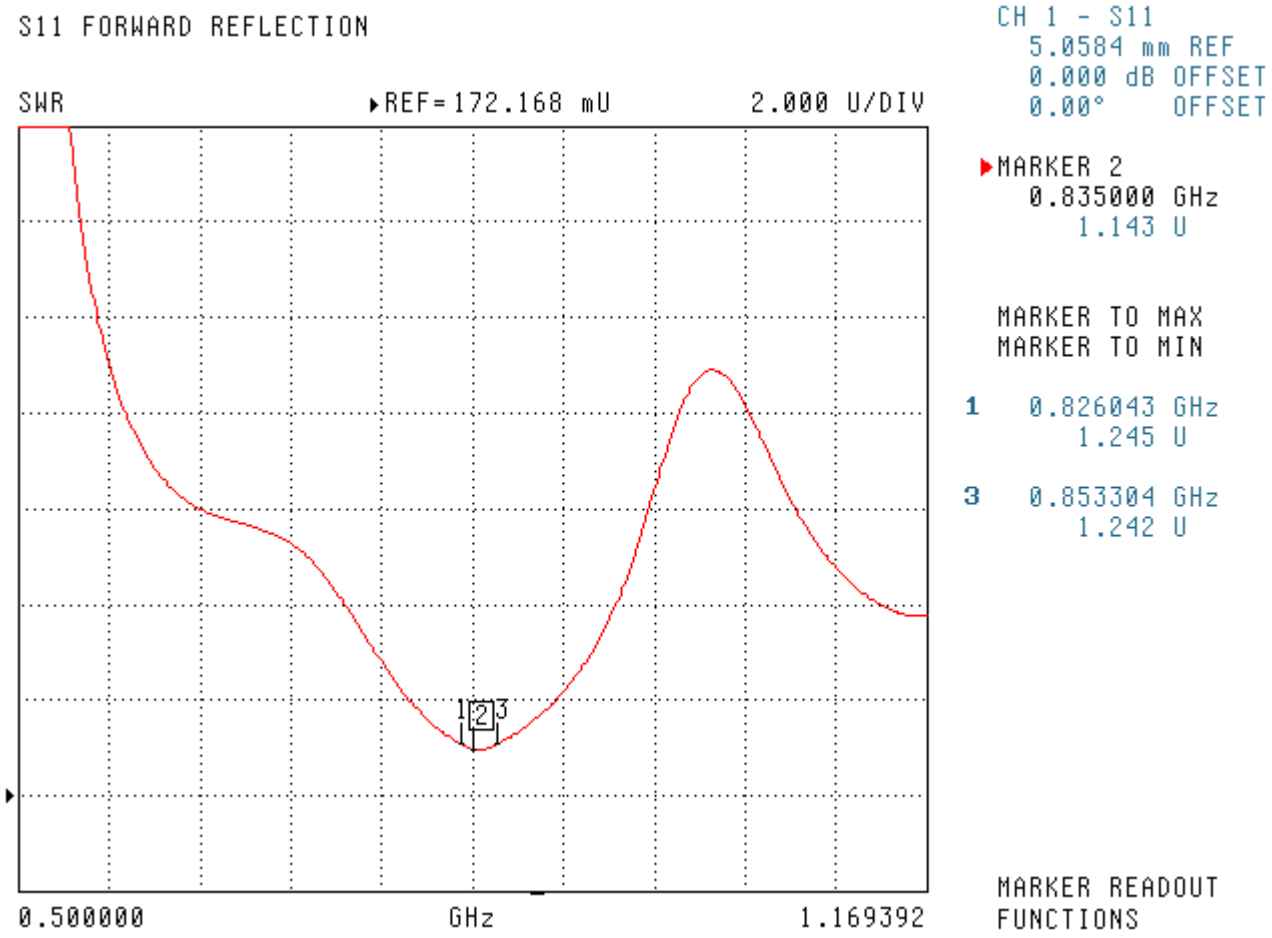
Test	Result
S11 RL	-24.058dB
SWR	1.143U
Impedance	55.519 Ω

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

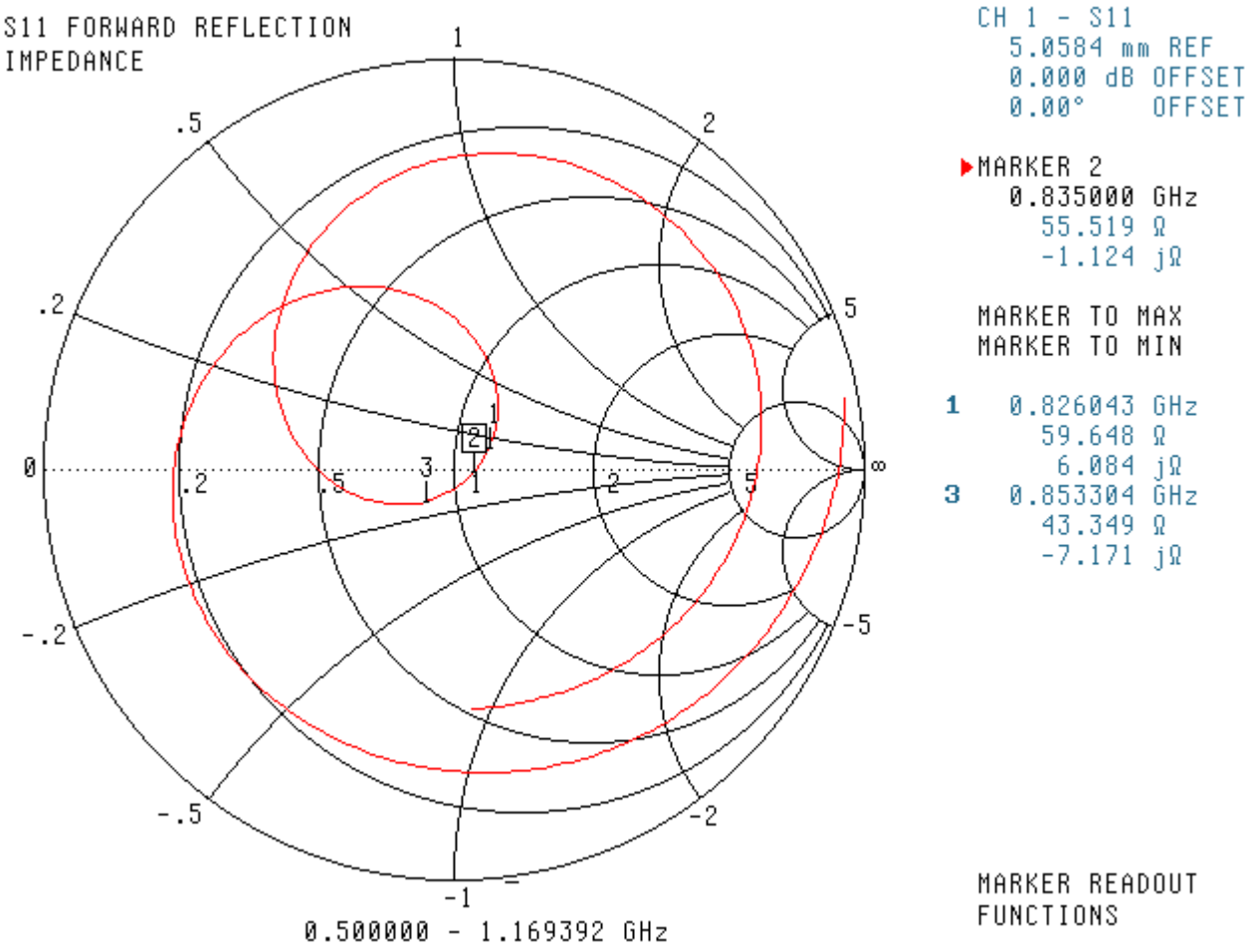
S11 Parameter Return Loss



SWR

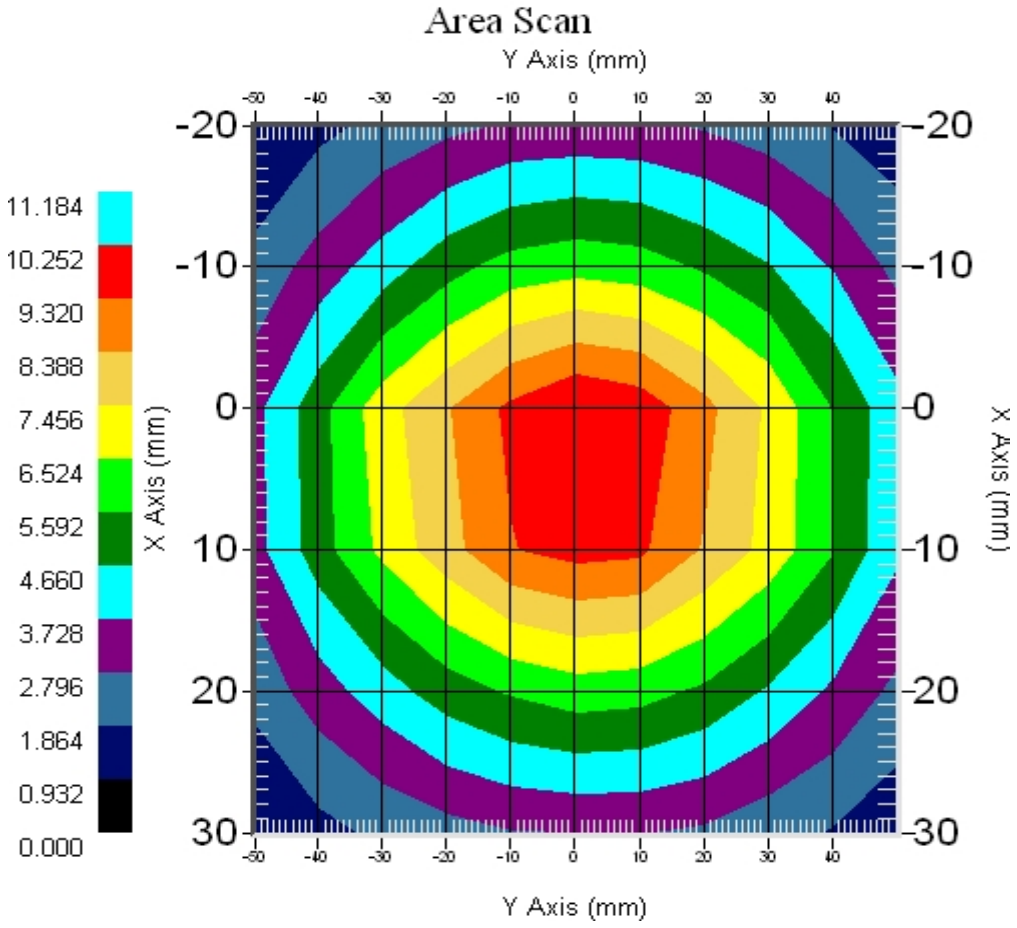


Smith Chart Dipole Impedance



System Validation Results Using the Electrically Calibrated Dipole

Body Tissue Frequency	1 Gram	10 Gram	Peak Above Feed Point
835 MHz	9.81	6.3	14.87



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.

Appendix F – Phantom Calibration Data Sheets

NCL CALIBRATION LABORATORIES

Calibration File No.: RFE-273

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 National Standards.

Thickness of the UniPhantom is 2 mm ± 10%
Pinna thickness is 6 mm ± 10%

Resolution:	0.01 mm	Calibrated to:	0.0 mm
Stability:	OK	Accuracy:	< 0.1 mm

Calibrated By: Karen K. Feb 17/04.

NCL CALIBRATION LABORATORIES
51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6

Division of APREL Lab.
TEL: (613) 820-4988
FAX: (613) 820-4161