

# SAR EVALUATION REPORT

For

**Sepura plc**

Radio House, St. Andrews Road, Cambridge CB4 1GR UK

**FCC ID: XX6SEP8040**

<b>Report Type:</b> Class II Permissive Change	<b>Product Type:</b> DMR Two Way Radio
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<b>Report Number:</b> <u>RDG140821006-20BA1</u>	
<b>Report Date:</b> <u>2014-09-02</u>	
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**Note:** This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp.

Attestation of Test Results				
EUT Information		Company Name	Sepura plc	
		EUT Description	DMR Two Way Radio	
		Product S/N	7PR321408GA0792	
		FCC ID	XX6SEP8040	
		Model Number	SEP8340	
		Test Date	2014-08-30	
Frequency Band	Modulation	Max. SAR Level(s) Report		Limit (W/Kg)
400-470MHz	Digital	12.5kHz	Face up: 1.991 W/kg Body-Back: 2.835 W/kg	8
	Analog	12.5kHz	Face up: 1.723 W/kg (corrected by Multiplying 50%) Body-Back: 2.768 W/kg (corrected by Multiplying 50%)	
Applicable Standards		ANSI / IEEE C95.1: 2005 IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fileds,3 kHz to 300 GHz.		
		ANSI / IEEE C95.3: 2002 IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to SuchFields,100 kHz—300 GHz.		
		IEEE1528:2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques		
		KDB procedures KDB 447498 D01 v05r02: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies. KDB 865664 D01v01r03: SAR measurement 100 MHz to 6 GHz v01. KDB 643646D01 v01r01: SAR test Reduction Considerations for Occupational PTT Radios.		
<p><b>Note:</b> This wireless device has been shown to be capable of compliance for localized specific absorption rate (SAR) for Occupational/Controlled Exposure limits specified in ANSI/IEEE Standards and has been tested in accordance with the measurement procedures specified in IEEE 1528-2013 and RF exposure KDB procedures.</p> <p><b>The results and statements contained in this report pertain only to the device(s) evaluated.</b></p>				

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## DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1DG131225002-20	Original Report	2014-07-08
1	RSZ140821006-20BA1	Class II permissive Change Report	2014-09-02

This is a CIIPC application of the device, the differences between the original device and the current one are as follows:

1. Removing the display screen and keyboard (17 buttons) in the current device, they have the same main board and transmitter module between the original device and the current one.
2. Changing the model, the original models are SEP8040 and the new models are SEP8340.

For the change made to the device, all the worse case configuration was performed.

## EUT DESCRIPTION

This report has been prepared on behalf of Sepura plc and their product and their product, FCC ID: XX6SEP8040, Model: SEP8340 or the EUT (Equipment Under Test) as referred to in the rest of this report. The EUT is a DMR Two Way Radio.

### Technical Specification

<b>Product Type</b>	Portable
<b>Exposure Category:</b>	Occupational/Controlled Exposure
<b>Antenna Type(s):</b>	External Antenna
<b>Body-Worn Accessories:</b>	Belt Clip and Headset Cable
<b>Face-Head Accessories:</b>	None
<b>Modulation Type:</b>	FM/4FSK
<b>Frequency Band:</b>	400MHz-470MHz
<b>Conducted RF Power:</b>	36.49dBm
<b>EUT Dimensions (L*W*H):</b>	132mm (L)×64mm (W)×41mm (H)
<b>Dimensions for Standard Battery:</b>	116.2mm (L)×56mm (W)×16.2mm (H)
<b>Dimensions for High capacity Battery:</b>	116.2mm (L)×56mm (W)×19.2mm (H)
<b>Power Source:</b>	7.4V Rechargeable Li-ION Battery
<b>Normal Operation:</b>	Face Up and Body-worn

Accessories list			
Item	Product Name	Description	Part Number
1	Antenna	400-470MHz	300-01058
2	Standard Battery	7.4V Rechargeable Li-ION Battery ( Standard Battery) 2000mAh	300-01069
3	High capacity Battery	7.4V Rechargeable Li-ION Battery 2500mAh	300-01061
4	Body-worn Accessories	A Remote Speaker Microphone	300-00389
		A programming cable	300-00426
		A Belt clip	300-01062

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## REFERENCE, STANDARDS, AND GUIDELINES

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### **FCC:**

The Report and Order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 mW/g as recommended by the ANSI/IEEE standard C95.1-1992 [6] for an uncontrolled environment (Paragraph 65). According to the Supplement C of OET Bulletin 65 "Evaluating Compliance with FCC Guide-lines for Human Exposure to Radio frequency Electromagnetic Fields", released on Jun 29, 2001 by the FCC, the device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

This report describes the methodology and results of experiments performed on wireless data terminal. The objective was to determine if there is RF radiation and if radiation is found, what is the extent of radiation with respect to safety limits. SAR (Specific Absorption Rate) is the measure of RF exposure determined by the amount of RF energy absorbed by human body (or its parts) – to determine how the RF energy couples to the body or head which is a primary health concern for body worn devices. The limit below which the exposure to RF is considered safe by regulatory bodies in North America is 1.6 mW/g average over 1 gram of tissue mass.

### **CE:**

The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 2 mW/g as recommended by EN62209-1 for an uncontrolled environment. According to the Standard, the device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

This report describes the methodology and results of experiments performed on wireless data terminal. The objective was to determine if there is RF radiation and if radiation is found, what is the extent of radiation with respect to safety limits. SAR (Specific Absorption Rate) is the measure of RF exposure determined by the amount of RF energy absorbed by human body (or its parts) – to determine how the RF energy couples to the body or head which is a primary health concern for body worn devices. The limit below which the exposure to RF is considered safe by regulatory bodies in Europe is 2 mW/g average over 10 gram of tissue mass.

The test configurations were laid out on a specially designed test fixture to ensure the reproducibility of measurements. Each configuration was scanned for SAR. Analysis of each scan was carried out to characterize the above effects in the device.

**SAR Limits****FCC Limit (1g Tissue)**

<b>EXPOSURE LIMITS</b>	<b>SAR (W/kg)</b>	
	(General Population / Uncontrolled Exposure Environment)	(Occupational / Controlled Exposure Environment)
Spatial Average (averaged over the whole body)	0.08	0.4
Spatial Peak (averaged over any 1 g of tissue)	1.60	8.0
Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)	4.0	20.0

**CE Limit (10g Tissue)**

<b>EXPOSURE LIMITS</b>	<b>SAR (W/kg)</b>	
	(General Population / Uncontrolled Exposure Environment)	(Occupational / Controlled Exposure Environment)
Spatial Average (averaged over the whole body)	0.08	0.4
Spatial Peak (averaged over any 10 g of tissue)	2.0	10
Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)	4.0	20.0

Population/Uncontrolled Environments are defined as locations where there is the exposure of individual who have no knowledge or control of their exposure.

Occupational/Controlled Environments are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure (i.e. as a result of employment or occupation).

Occupational/Controlled environments Spatial Peak limit 8.0W/kg (FCC/IC) & 10 W/kg (CE) applied to the EUT.



## **FACILITIES**

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The test site used by Bay Area Compliance Laboratories Corp. (Shenzhen) to collect data is located at 6/F, the 3rd Phase of WanLi Industrial Building, Shi Hua Road, Fu Tian Free Trade Zone, Shenzhen, Guangdong, P.R. of China

## DESCRIPTION OF TEST SYSTEM

These measurements were performed with ALSAS 10 Universal Integrated SAR Measurement system from APREL Laboratories.

### ALSAS-10U System Description

ALSAS-10-U is fully compliant with the technical and scientific requirements of IEEE 1528, IEC 62209, CENELEC, ARIB, ACA, and the Federal Communications Commission. The system comprises of a six axes articulated robot which utilizes a dedicated controller. ALSAS-10U uses the latest methodologies. And FDTD modeling to provide a platform which is repeatable with minimum uncertainty.

### Applications

Predefined measurement procedures compliant with the guidelines of CENELEC, IEEE, IEC, FCC, etc are utilized during the assessment for the device. Automatic detection for all SAR maxima are embedded within the core architecture for the system, ensuring that peak locations used for centering the zoom scan are within a 1mm resolution and a 0.05mm repeatable position. System operation range currently available up-to 6 GHz in simulated tissue.

### Area Scans

Area scans are defined prior to the measurement process being executed with a user defined variable spacing between each measurement point (integral) allowing low uncertainty measurements to be conducted. Scans defined for FCC applications utilize a 10mm<sup>2</sup> step integral, with 1mm interpolation used to locate the peak SAR area used for zoom scan assessments.

Where the system identifies multiple SAR peaks (which are within 25% of peak value) the system will provide the user with the option of assessing each peak location individually for zoom scan averaging.

### Zoom Scan (Cube Scan Averaging)

The averaging zoom scan volume utilized in the ALSAS-10U software is in the shape of a cube and the side dimension of a 1 g or 10 g mass is dependent on the density of the liquid representing the simulated tissue. A density of 1000 kg/m<sup>3</sup> is used to represent the head and body tissue density and not the phantom liquid density, in order to be consistent with the definition of the liquid dielectric properties, i.e. the side length of the 1 g cube is 10mm, with the side length of the 10 g cube 21,5mm.

When the cube intersects with the surface of the phantom, it is oriented so that 3 vertices touch the surface of the shell or the center of a face is tangent to the surface. The face of the cube closest to the surface is modified in order to conform to the tangent surface.

The zoom scan integer steps can be user defined so as to reduce uncertainty, but normal practice for typical test applications (including FCC) utilize a physical step of 5x5x8 (8mmx8mmx5mm) providing a volume of 32mm in the X & Y axis, and 35mm in the Z axis.



## ALSAS-10U Interpolation and Extrapolation Uncertainty

The overall uncertainty for the methodology and algorithms the used during the SAR calculation was evaluated using the data from IEEE 1528 based on the example f3 algorithm:

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

## Isotropic E-Field Probe

The isotropic E-Field probe has been fully calibrated and assessed for isotropicity, and boundary effect within a controlled environment. Depending on the frequency for which the probe is calibrated the method utilized for calibration will change.

The E-Field probe utilizes a triangular sensor arrangement as detailed in the diagram below:



SAR is assessed with a calibrated probe which moves at a default height of 5mm from the center of the diode, which is mounted to the sensor, to the phantom surface (in the Z Axis). The 5mm offset height has been selected so as to minimize any resultant boundary effect due to the probe being in close proximity to the phantom surface.

The following algorithm is an example of the function used by the system for linearization of the output from the probe when measuring complex modulation schemes.

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

## Isotropic E-Field Probe Specification

<b>Calibration Method</b>	Frequency Dependent Below 1 GHz Calibration in air performed in a TEM Cell Above 1 GHz Calibration in air performed in waveguide
<b>Sensitivity</b>	$0.70 \mu\text{V}/(\text{V}/\text{m})^2$ to $0.85 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Dynamic Range</b>	0.0005 W/kg to 100 W/kg
<b>Isotropic Response</b>	Better than 0.1 dB
<b>Diode Compression Point (DCP)</b>	Calibration for Specific Frequency
<b>Probe Tip Diameter</b>	< 2.9 mm
<b>Sensor Offset</b>	1.56 (+/- 0.02 mm)
<b>Probe Length</b>	289 mm
<b>Video Bandwidth</b>	@ 500 Hz: 1 dB @ 1.02 kHz: 3 dB
<b>Boundary Effect</b>	Less than 2.1% for distance greater than 0.58 mm
<b>Spatial Resolution</b>	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

## Boundary Detection Unit and Probe Mounting Device

ALSAS-10U incorporates a boundary detection unit with a sensitivity of 0.05mm for detecting all types of surfaces. The robust design allows for detection during probe tilt (probe normalize) exercises, and utilizes a second stage emergency stop. The signal electronics are fed directly into the robot controller for high accuracy surface detection in lateral and axial detection modes (X, Y, & Z).

The probe is mounted directly onto the Boundary Detection unit for accurate tooling and displacement calculations controlled by the robot kinematics. The probe is connect to an isolated probe interconnect where the output stage of the probe is fed directly into the amplifier stage of the Daq-Paq.

## Daq-Paq (Analog to Digital Electronics)

ALSAS-10U incorporates a fully calibrated Daq-Paq (analog to digital conversion system) which has a 4 channel input stage, sent via a 2 stage auto-set amplifier module. The input signal is amplified accordingly so as to offer a dynamic range from 5 $\mu\text{V}$  to 800mV. Integration of the fields measured is carried out at board level utilizing a Co-Processor which then sends the measured fields down into the main computational module in digitized form via an RS232 communications port. Probe linearity and duty cycle compensation is carried out within the main Daq-Paq module.

<b>ADC</b>	12 Bit
<b>Amplifier Range</b>	20 mV to 200 mV and 150 mV to 800 mV
<b>Field Integration</b>	Local Co-Processor utilizing proprietary integration algorithms
<b>Number of Input Channels</b>	4 in total 3 dedicated and 1 spare
<b>Communication</b>	Packet data via RS232

### Axis Articulated Robot

ALSAS-10U utilizes a six axis articulated robot, which is controlled using a Pentium based real-time movement controller. The movement kinematics engine utilizes proprietary (Thermo CRS) interpolation and extrapolation algorithms, which allow full freedom of movement for each of the six joints within the working envelope. Utilization of joint 6 allows for full probe rotation with a tolerance better than 0.05mm around the central axis.



<b>Robot/Controller Manufacturer</b>	Thermo CRS
<b>Number of Axis</b>	Six independently controlled axis
<b>Positioning Repeatability</b>	0.05 mm
<b>Controller Type</b>	Single phase Pentium based C500C
<b>Robot Reach</b>	710 mm
<b>Communication</b>	RS232 and LAN compatible

### ALSAS Universal Workstation

ALSAS Universal workstation allows for repeatability and fast adaptability. It allows users to do calibration, testing and measurements using different types of phantoms with one set up, which significantly speeds up the measurement process.

### Universal Device Positioner

The universal device positioner allows complete freedom of movement of the EUT. Developed to hold a EUT in a free-space scenario any additional loading attributable to the material used in the construction of the positioner has been eliminated. Repeatability has been enhanced through the linear scales which form the design used to indicate positioning for any given test scenario in all major axes. A 15° tilt indicator is included for the of aid cheek to tilt movements for head SAR analysis. Overall uncertainty for measurements have been reduced due to the design of the Universal device positioner, which allows positioning of a device in as near to a free-space scenario as possible, and by providing the means for complete repeatability.

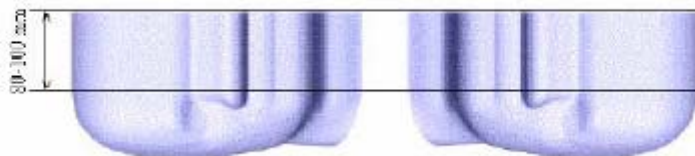


### Phantom Types

The ALSAS-10U allows the integration of multiple phantom types. SAM Phantoms fully compliant with IEEE 1528, Universal Phantom, and Universal Flat.

### APREL SAM Phantoms

The SAM phantoms developed using the IEEE SAM CAD file. They are fully compliant with the requirements for both IEEE 1528 and FCC Supplement C. Both the left and right SAM phantoms are interchangeable, transparent and include the IEEE 1528 grid with visible NF and MB lines.



**APREL Laboratories Universal Phantom**

The Universal Phantom is used on the ALSAS-10U as a system validation phantom. The Universal Phantom has been fully validated both experimentally from 30MHz to 6GHz and numerically using XFDTD numerical software.

The shell thickness is 2mm overall, with a 4mm spacer located at the NF/MB intersection providing an overall thickness of 6mm in line with the requirements of IEEE-1528.

The design allows for fast and accurate measurements, of handsets, by allowing the conservative SAR to be evaluated at on frequency for both left and right head experiments in one measurement.



### Tissue Dielectric Parameters for Head and Body Phantoms

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations described in Reference [12] and extrapolated according to the head parameters specified in P1528.

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton x-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (s/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

### Recommended Tissue Dielectric Parameters for Head and Body

Frequency (MHz)	Head Tissue		Body Tissue	
	$\epsilon_r$	$\sigma$ (S/m)	$\epsilon_r$	$\sigma$ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800-2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00



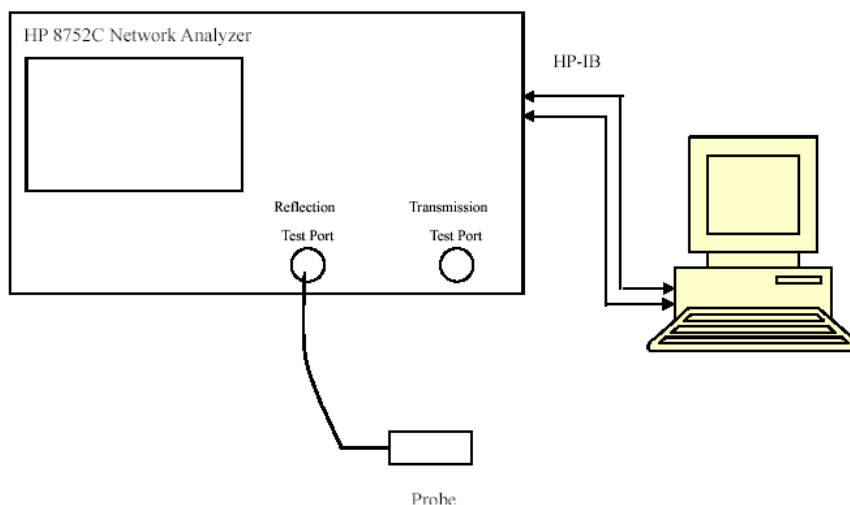
## EQUIPMENT LIST AND CALIBRATION

### Equipments List & Calibration Information

Equipment	Model	Calibration Date	S/N
CRS F3 robot	ALS-F3	N/A	RAF0805352
CRS F3 Software	ALS-F3-SW	N/A	N/A
CRS C500C controller	ALS-C500	N/A	RCF0805379
Probe mounting device & Boundary Detection Sensor System	ALS-PMDPS-3	N/A	120-00270
Universal Work Station	ALS-UWS	N/A	100-00157
Data Acquisition Package	ALS-DAQ-PAQ-3	2013-10-08	110-00212
Miniature E-Field Probe	E-020	2013-10-08	500-00283
Dipole, 450 MHz	ALS-D-450-S-2	2012-07-31	175-00503
Dipole Spacer	ALS-DS-U	N/A	250-00907
Device holder/Positioner	ALS-H-E-SET-2	N/A	170-00510
Left ear SAM phantom	ALS-P-SAM-L	N/A	130-00311
Right ear SAM phantom	ALS-P-SAM-R	N/A	140-00359
UniPhantom	ALS-UM-FLAT	N/A	153-00104
Simulated Tissue 450 MHz Head	ALS-TS-450-H	Each Time	260-01106
Simulated Tissue 450 MHz Body	ALS-TS-450-B	Each Time	260-02108
Power Amplifier	5S1G4	N/A	71377
Directional couple	DC6180A	2013-11-12	0325849
Attenuator	3dB	2014-05-08	5402
Network analyzer	8752C	2014-06-13	3410A02356
Dielectric probe kit	HP85070B	2014-06-13	N/A
Synthesized Sweeper	HP 8341B	2013-05-09	2624A00116
EMI Test Receiver	ESCI	2013-11-12	101120

## SAR MEASUREMENT SYSTEM VERIFICATION

### Liquid Verification



Liquid Verification Setup Block Diagram

### Liquid Verification Results

Frequency (MHz)	Liquid Type	Liquid Parameter		Target Value		Delta (%)		Tolerance (%)
		$\epsilon_r$	$\sigma$ (S/m)	$\epsilon_r$	$\sigma$ (S/m)	$\Delta\epsilon_r$	$\Delta\sigma$ (S/m)	
400.0125	Head	43.50	0.87	43.50	0.87	0.000	0.000	$\pm 5$
	Body	55.97	0.95	56.70	0.94	-1.287	1.064	$\pm 5$
418.0125	Head	43.46	0.89	43.50	0.87	-0.092	2.299	$\pm 5$
	Body	55.33	0.95	56.70	0.94	-2.416	1.064	$\pm 5$
435.0125	Head	43.41	0.87	43.50	0.87	-0.207	0.000	$\pm 5$
	Body	54.99	0.95	56.70	0.94	-3.016	1.064	$\pm 5$
450.0125	Head	43.46	0.87	43.50	0.87	-0.092	0.000	$\pm 5$
	Body	55.75	0.95	56.70	0.94	-1.675	1.064	$\pm 5$
469.9875	Head	43.43	0.89	43.50	0.87	-0.161	2.299	$\pm 5$
	Body	55.54	0.96	56.70	0.94	-2.046	2.128	$\pm 5$

\*Liquid Verification was performed on 2014-08-30

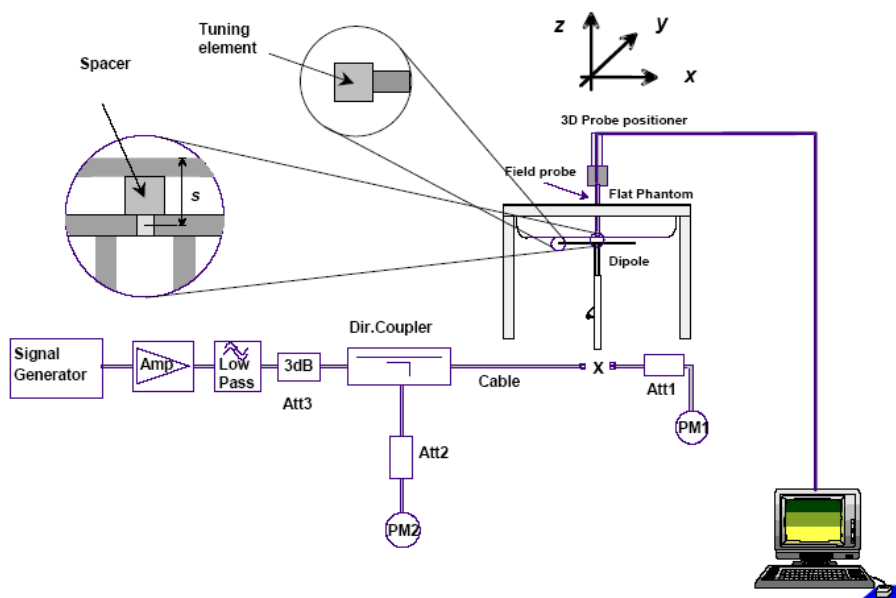
Please refer to the following tables.

450 Head Tissue				450 Body Tissue		
Frequency (MHz)	e'	e''		Frequency (MHz)	e'	e''
400.0	43.4989	39.2080		400.0	55.9656	42.8292
401.5	43.4856	39.0628		401.5	55.6236	42.9174
403.0	43.3923	39.3003		403.0	54.9571	42.6624
404.5	43.4457	39.1165		404.5	55.8558	42.2033
406.0	43.4547	39.0044		406.0	55.0607	42.1032
407.5	43.4626	38.7241		407.5	55.3213	41.9807
409.0	43.4972	39.0251		409.0	55.4201	41.9291
410.5	43.4737	38.9430		410.5	55.2344	41.6281
412.0	43.4725	38.5830		412.0	55.0783	41.4710
413.5	43.3857	38.5484		413.5	55.9941	41.2291
415.0	43.4496	38.6430		415.0	55.4478	40.9766
416.5	43.3891	38.5168		416.5	55.7285	40.8474
418.0	43.4623	38.3696		418.0	55.3269	40.9978
419.5	43.4194	37.2988		419.5	54.9094	40.7537
421.0	43.3808	37.0670		421.0	55.7319	40.4688
422.5	43.4834	37.1139		422.5	55.1684	40.2877
424.0	43.4509	37.1326		424.0	55.5255	40.2379
425.5	43.4723	36.9133		425.5	55.0138	40.1102
427.0	43.3906	36.9893		427.0	55.9452	40.4578
428.5	43.3713	36.8889		428.5	55.1884	39.8574
430.0	43.3731	37.0558		430.0	55.9239	39.7478
431.5	43.4925	36.7156		431.5	55.8972	39.4112
433.0	43.4964	36.4339		433.0	55.5759	39.3089
434.5	43.4147	35.5501		434.5	55.1383	39.2320
436.0	43.4078	36.1830		436.0	54.9382	39.3281
437.5	43.4390	36.1495		437.5	55.7336	39.3761
439.0	43.3672	36.1557		439.0	55.3743	39.3352
440.5	43.4948	36.2383		440.5	55.7621	39.4418
442.0	43.4138	36.1771		442.0	55.6204	38.3004
443.5	43.4719	35.8277		443.5	55.4153	38.2495
445.0	43.4020	35.8366		445.0	55.8726	37.8136
446.5	43.4930	35.9274		446.5	55.3901	37.9240
448.0	43.4614	35.6786		448.0	55.3272	37.8434
449.5	43.4344	34.6374		449.5	55.7897	37.6807
451.0	43.4896	34.4534		451.0	55.6989	38.0454
452.5	43.3866	34.5028		452.5	54.9120	37.6916
454.0	43.3809	34.2940		454.0	55.4226	37.5528
455.5	43.3970	34.3744		455.5	55.2692	37.4875
457.0	43.4693	34.2346		457.0	55.9963	37.4340
458.5	43.4007	34.0260		458.5	55.0234	37.4812
460.0	43.4751	34.0530		460.0	54.9599	37.2789
461.5	43.4897	33.9069		461.5	55.4170	37.2986
463.0	43.3667	33.9793		463.0	55.9785	37.2396
464.5	43.3843	33.7407		464.5	55.0732	37.1788
466.0	43.3742	33.8923		466.0	55.5857	36.9581
467.5	43.4300	33.6948		467.5	55.6826	37.1089
469.0	43.4273	33.6864		469.0	55.9459	36.8634
470.5	43.4165	34.6231		470.5	55.4278	37.6474

## System Accuracy Verification

Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of  $\pm 10\%$ . The validation results are tabulated below. And also the corresponding SAR plot is attached as well in the SAR plots files.

### System Verification Setup Block Diagram



### Probe and dipole antenna List and Detail

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
APREL	Probe	ALS-E-020	500-00283	2013-10-08	2014-10-07
APREL	Dipole antenna(450MHz)	ALS-D-450-S-2	175-00503	2012-07-31	2015-07-30

### System Accuracy Check Results

Date	Frequency (MHz)	Liquid Type	Measured SAR (W/Kg)		Target Value (W/Kg)	Delta (%)	Tolerance (%)
2014-08-30	450	Head	1g	4.712	4.572	3.062	$\pm 10$
		Body	1g	4.596	4.508	1.952	$\pm 10$

\*All SAR values are normalized to 1 Watt forward power.

**SAR SYSTEM VALIDATION DATA****Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****System Performance Check 450 MHz Head Liquid****Dipole 450 MHz; Type: ALS-D-450-S-2; S/N: 175-00503****Product Data**

Device Name : Dipole 450 MHz  
Serial No. : 175-00503  
Type : Dipole  
Model : ALS-D-450-S-2  
Frequency Band : 450  
Max. Transmit Pwr : 1 W  
Drift Time : 3 min(s)  
Power Drift-Start : 4.825 W/kg  
Power Drift-Finish : 4.803 W/kg  
Power Drift (%) : -0.491

**Phantom Data**

Name : APREL-Uni  
Type : Uni-Phantom  
Serial No. : System Default  
Location : Center  
Description : Default  
Phantom Data

**Tissue Data**

Type : Head  
Serial No. : 260-01106  
Frequency : 450.00MHz  
Last Calib. Date : 30-Aug-2014  
Temperature : 20.00 °C  
Ambient Temp. : 21.00 °C  
Humidity : 56.00 RH%  
Epsilon : 43.46 F/m  
Sigma : 0.87 S/m  
Density : 1000.00 kg/cu. m

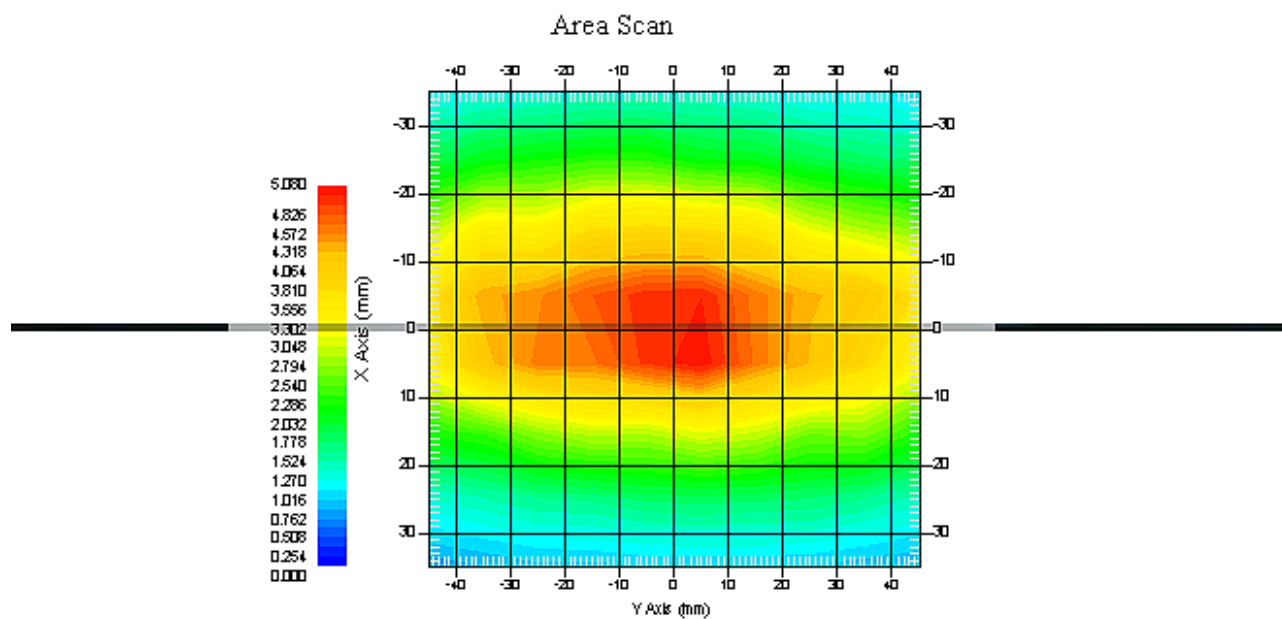
**Probe Data**

Name : E-Field  
Model : E-020  
Type : E-Field Triangle  
Serial No. : 500-00283  
Last Calib. Date : 08-Oct-2013  
Frequency Band : 450  
Duty Cycle Factor : 1  
Conversion Factor : 5.7  
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. : 21.00 °C  
Ambient Temp. : 21.00 °C  
Area Scan : 8x10x1 : Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

1 gram SAR value : 4.712 W/kg  
10 gram SAR value : 3.012 W/kg  
Area Scan Peak SAR : 4.997 W/kg  
Zoom Scan Peak SAR : 6.258 W/kg



#### 450 MHz System Validation with Head Tissue

**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****System Performance Check 450 MHz Body Liquid****Dipole 450 MHz; Type: ALS-D-450-S-2; S/N: 175-00503**

## Product Data

Device Name : Dipole 450 MHz  
Serial No. : 175-00503  
Type : Dipole  
Model : ALS-D-450-S-2  
Frequency Band : 450  
Max. Transmit Pwr : 1 W  
Drift Time : 3 min(s)  
Power Drift-Start : 4.693 W/kg  
Power Drift-Finish : 4.600 W/kg  
Power Drift (%) : -2.102

## Phantom Data

Name : APREL-Uni  
Type : Uni-Phantom  
Serial No. : System Default  
Location : Center  
Description : Default  
Phantom Data

## Tissue Data

Type : Body  
Serial No. : 260-02108  
Frequency : 450.00MHz  
Last Calib. Date : 30-Aug-2014  
Temperature : 20.00 °C  
Ambient Temp. : 21.00 °C  
Humidity : 56.00 RH%  
Epsilon : 55.75 F/m  
Sigma : 0.95 S/m  
Density : 1000.00 kg/cu. m

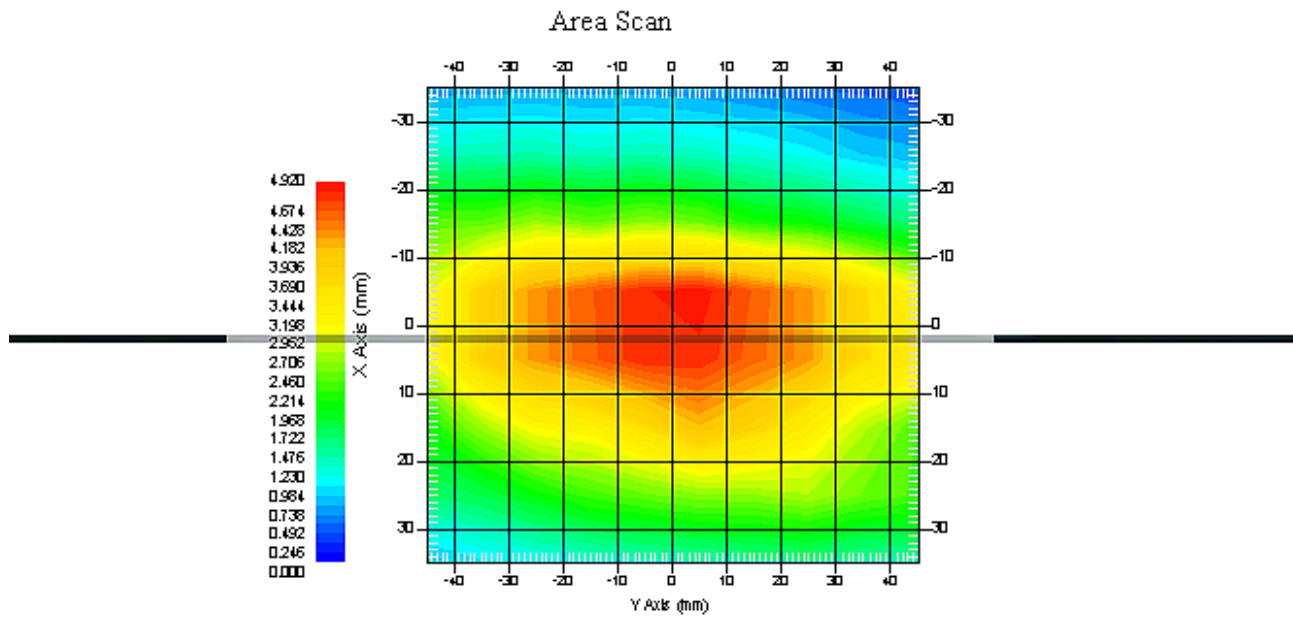
## Probe Data

Name : E-Field  
Model : E-020  
Type : E-Field Triangle  
Serial No. : 500-00283  
Last Calib. Date : 08-Oct-2013  
Frequency Band : 450  
Duty Cycle Factor : 1  
Conversion Factor : 5.8  
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. : 21.00 °C  
Ambient Temp. : 21.00 °C  
Area Scan : 8x10x1 : Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

1 gram SAR value : 4.596 W/kg  
10 gram SAR value : 2.985 W/kg  
Area Scan Peak SAR : 4.917 W/kg  
Zoom Scan Peak SAR : 6.334 W/kg



#### 450 MHz System Validation with Body Tissue

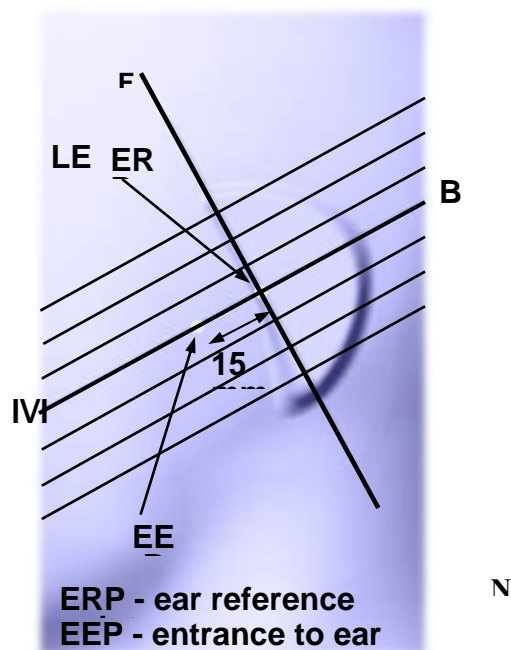
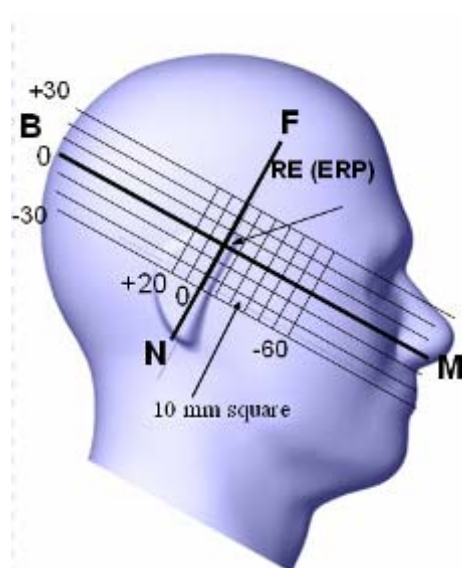


## EUT TEST STRATEGY AND METHODOLOGY

### Test Positions for Device Operating Next to a Person's Ear

This category includes most wireless handsets with fixed, retractable or internal antennas located toward the top half of the device, with or without a foldout, sliding or similar keypad cover. The handset should have its earpiece located within the upper  $\frac{1}{4}$  of the device, either along the centerline or off-centered, as perceived by its users. This type of handset should be positioned in a normal operating position with the "test device reference point" located along the "vertical centerline" on the front of the device aligned to the "ear reference point". The "test device reference point" should be located at the same level as the center of the earpiece region. The "vertical centerline" should bisect the front surface of the handset at its top and bottom edges. A "ear reference point" is located on the outer surface of the head phantom on each ear spacer. It is located 1.5 cm above the center of the ear canal entrance in the "phantom reference plane" defined by the three lines joining the center of each "ear reference point" (left and right) and the tip of the mouth.

A handset should be initially positioned with the earpiece region pressed against the ear spacer of a head phantom. For the SCC-34/SC-2 head phantom, the device should be positioned parallel to the "N-F" line defined along the base of the ear spacer that contains the "ear reference point". For interim head phantoms, the device should be positioned parallel to the cheek for maximum RF energy coupling. The "test device reference point" is aligned to the "ear reference point" on the head phantom and the "vertical centerline" is aligned to the "phantom reference plane". This is called the "initial ear position". While maintaining these three alignments, the body of the handset is gradually adjusted to each of the following positions for evaluating SAR:



## Cheek/Touch Position

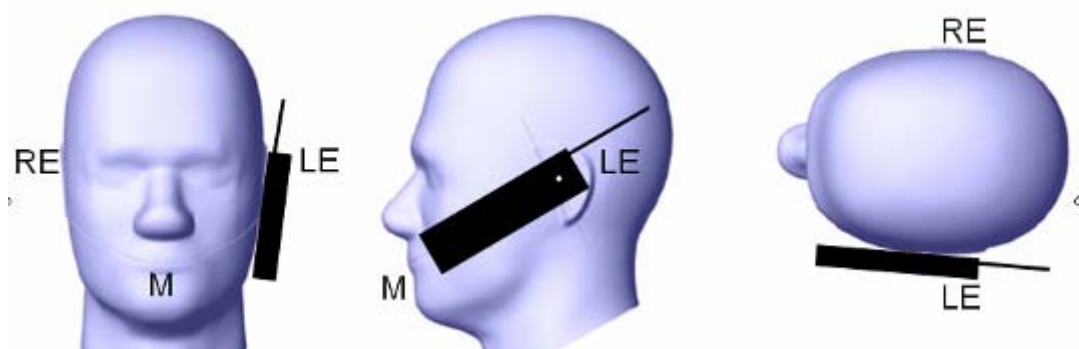
The device is brought toward the mouth of the head phantom by pivoting against the “ear reference point” or along the “N-F” line for the SCC-34/SC-2 head phantom.

This test position is established:

- When any point on the display, keypad or mouthpiece portions of the handset is in contact with the phantom.
- (or) When any portion of a foldout, sliding or similar keypad cover opened to its intended self-adjusting normal use position is in contact with the cheek or mouth of the phantom.

For existing head phantoms – when the handset loses contact with the phantom at the pivoting point, rotation should continue until the device touches the cheek of the phantom or breaks its last contact from the ear spacer.

### Cheek /Touch Position



## Ear/Tilt Position

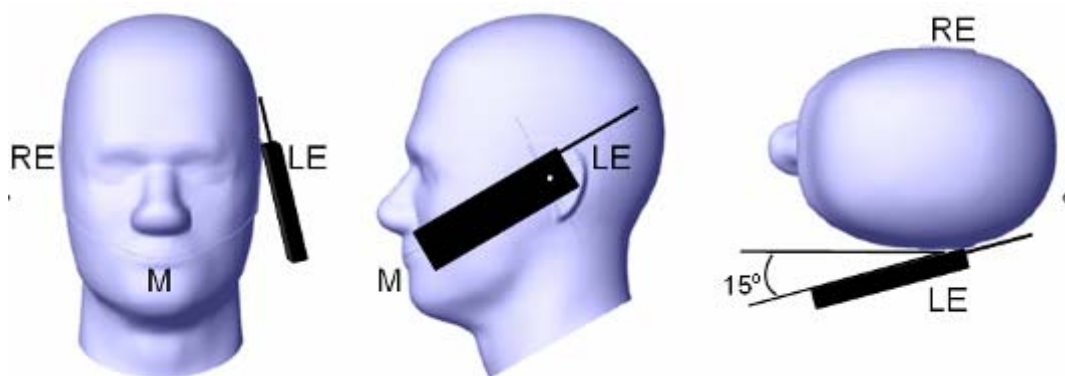
With the handset aligned in the “Cheek/Touch Position”:

1) If the earpiece of the handset is not in full contact with the phantom’s ear spacer (in the “Cheek/Touch position”) and the peak SAR location for the “Cheek/Touch” position is located at the ear spacer region or corresponds to the earpiece region of the handset, the device should be returned to the “initial ear position” by rotating it away from the mouth until the earpiece is in full contact with the ear spacer.

2) (otherwise) The handset should be moved (translated) away from the cheek perpendicular to the line passes through both “ear reference points” (note: one of these ear reference points may not physically exist on a split head model) for approximate 2-3 cm. While it is in this position, the device handset is tilted away from the mouth with respect to the “test device reference point” until the inside angle between the vertical centerline on the front surface of the phone and the horizontal line passing through the ear reference point is by 15° to 80°. After the tilt, it is then moved (translated) back toward the head perpendicular to the line passes through both “ear reference points” until the device touches the phantom or the ear spacer. If the antenna touches the head first, the positioning process should be repeated with a tilt angle less than 15° so that the device and its antenna would touch the phantom simultaneously. This test position may require a device holder or positioner to achieve the translation and tilting with acceptable positioning repeatability.

If a device is also designed to transmit with its keypad cover closed for operating in the head position, such positions should also be considered in the SAR evaluation. The device should be tested on the left and right side of the head phantom in the “Cheek/Touch” and “Ear/Tilt” positions. When applicable, each configuration should be tested with the antenna in its fully extended and fully retracted positions. These test configurations should be tested at the high, middle and low frequency channels of each operating mode; for example, AMPS, CDMA, and TDMA. If the SAR measured at the middle channel for each test configuration (left, right, Cheek/Touch, Tile/Ear, extended and retracted) is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s). If the transmission band of the test device is less than 10 MHz, testing at the high and low frequency channels is optional.

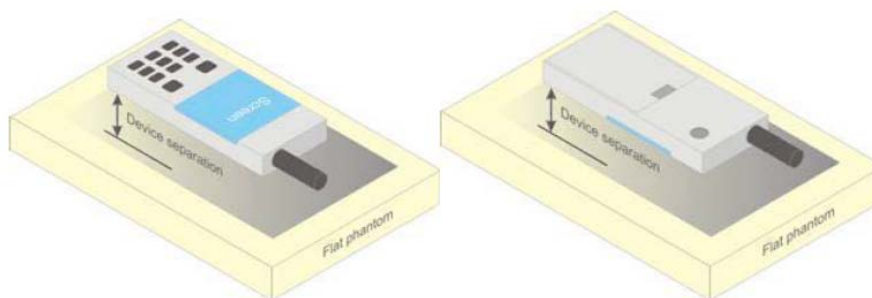
### **Ear /Tilt 15° Position**



### **Test positions for body-worn and other configurations**

Body-worn operating configurations should be tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in normal use configurations. Devices with a headset output should be tested with a headset connected to the device. When multiple accessories that do not contain metallic components are supplied with the device, the device may be tested with only the accessory that dictates the closest spacing to the body. When multiple accessories that contain metallic components are supplied with the device, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (e.g., the same metallic belt-clip used with different holsters with no other metallic components), only the accessory that dictates the closest spacing to the body must be tested.

Body-worn accessories may not always be supplied or available as options for some devices that are intended to be authorized for body-worn use. A separation distance of 1.5 cm between the back of the device and a flat phantom is recommended for testing body-worn SAR compliance under such circumstances. Other separation distances may be used, but they should not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.



**Figure 5 – Test positions for body-worn devices**

## SAR Evaluation Procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the SAR value at a fixed location above the ear point or central position was used as a reference value for assessing the power drop. The SAR at this point is measured at the start of the test and then again at the end of the testing.

Step 2: The SAR distribution at the exposed side of the head was measured at a distance of 4 mm from the inner surface of the shell. The area covered the entire dimension of the head or EUT and the horizontal grid spacing was 10 mm x 10 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation. The first Area Scan covers the entire dimension of the EUT to ensure that the hotspot was correctly identified.

Step 3: Around this point, a volume of 35 mm x 35 mm x 35 mm was assessed by measuring 7x 7 x 7 points. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:

- 1) The data at the surface were extrapolated, since the center of the dipoles is 1.2 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.3 mm. The extrapolation was based on a least square algorithm. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.
- 2) The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three one dimensional splines with the "Not a knot"-condition (in x, y and z-directions). The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the averages.

All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

Step 4: Re-measurement of the SAR value at the same location as in Step 1. If the value changed by more than 5%, the evaluation was repeated.

## Test methodology

IEEE1528:2013  
KDB 447498 D01 v05r02  
KDB 865664 D01v01r03  
KDB 643646D01 v01r01

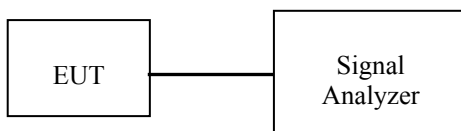
## CONDUCTED OUTPUT POWER MEASUREMENT

### Provision Applicable

The measured peak output power should be greater and within 5% than EMI measurement.

### Test Procedure

The RF output of the transmitter was connected to the input of the Signal Analyzer through sufficient attenuation.



**PTT**

### Maximum Output Power among production units

Max Target Power for Production Unit (dBm)	
PTT/Mode	Frequency (400-470MHz)
Analog-12.5K	36.50
Digital-12.5K	36.50

### Test Results:

Mode	Frequency Spacing (kHz)	Frequency (MHz)	Output(dBm)	Output Power(W)	Power level
Digital	12.5	400.0125	36.26	4.227	High
		418.0125	36.40	4.365	High
		435.0125	36.42	4.385	High
		450.0125	<b>36.49</b>	4.457	High
		469.9875	36.22	4.188	High
Analog	12.5	400.0125	36.18	4.150	High
		418.0125	36.35	4.315	High
		435.0125	36.36	4.325	High
		450.0125	<b>36.39</b>	4.355	High
		469.9875	36.18	4.150	High

## SAR MEASUREMENT RESULTS

This page summarizes the results of the performed dosimetric evaluation.

### SAR Test Data

#### Environmental Conditions

Temperature:	21 °C
Relative Humidity:	50%
ATM Pressure:	1002 mbar

\* Testing was performed by Wilson Chen on 2014-08-30

### Test Result:

#### Digital (Modulation 4FSK; Channel Spacing 12.5 kHz):

Frequency (MHz)	Battery	Power Drift (%)	Max. Meas. Power (dBm)	Max. Rated Power (dBm)	1 g SAR Value (W/Kg)			
					Scaled Factor	Meas. SAR	Scaled SAR	Plot
Face up (2.5cm)								
450.0125	High Capacity	-2.119	36.49	36.50	1.002	1.987	1.991	1#
Body-Back with Belt Clip (0.0cm)								
450.0125	Standard Capacity	-2.613	36.49	36.50	1.002	2.829	2.835	2#

#### Analog (Modulation FM; Channel Spacing 12.5 kHz):

Frequency (MHz)	Battery	Power Drift (%)	Max. Meas. Power (dBm)	Max. Rated Power (dBm)	1 g SAR Value (W/Kg)				
					Scaled Factor	Meas. SAR	Scaled SAR	50%	Plot
Face up (2.5cm)									
450.0125	High Capacity	1.327	36.39	36.50	1.026	3.359	3.446	1.723	3#
Body-Back with Belt Clip (0.0cm)									
450.0125	Standard Capacity	1.152	36.39	36.50	1.026	5.396	5.536	2.768	4#

#### Note:

1. When the 1-g SAR tested using the default battery and default accessories is  $\leq 3.5\text{W/Kg}$  (corrected by Multiplying 50% for FM mode), testing for other channels are optional.
2. For a analog PTT, only simplex communication technology was supported, so the SAR value need to be corrected by Multiplying 50%.
3. Passive body-worn and audio accessories generally do not apply to the head SAR of PTT radios.
4. The whole antenna and radiating structures that may contribute to the measured SAR or influence the SAR distribution has been included in the area scan.

**SAR Plots (Summary of the Highest SAR Values)****Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****Face-Up 2.5cm (Digital 12.5k-450.0125 MHz);****Measurement Data**

Modulation mode : 4FSK  
Crest Factor : 2  
Scan Type : Complete  
Area Scan : 16x8x1: Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
Power Drift-Start : 1.385 W/kg  
Power Drift-Finish : 1.357 W/kg  
Power Drift (%) : -2.119

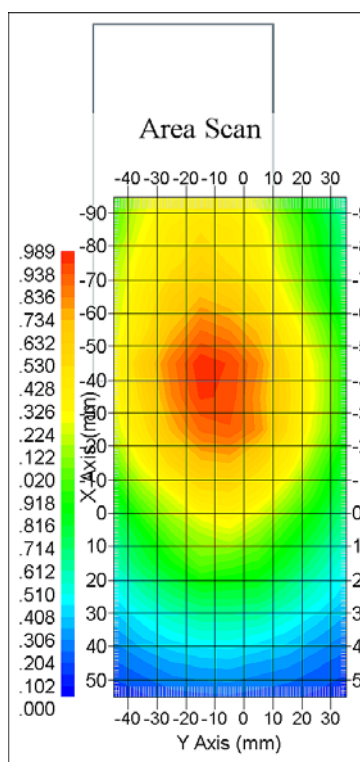
**Tissue Data**

Type : Head  
Frequency : 450.0125 MHz  
Epsilon : 43.46 F/m  
Sigma : 0.87 S/m  
Density : 1000.00 kg/cu. m

**Probe Data**

Serial No. : 500-00283  
Frequency Band : 450  
Duty Cycle Factor : 2  
Conversion Factor : 5.7  
Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point : 95.00 mV  
Offset : 1.56 mm

1 gram SAR value : 1.987 W/kg  
10 gram SAR value : 1.352 W/kg  
Area Scan Peak SAR : 1.981 W/kg  
Zoom Scan Peak SAR : 2.634 W/kg

**Plot 1#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****Body-Back 0.0cm (Digital 12.5k-450.0125 MHz);**

## Measurement Data

Modulation mode : 4FSK  
Crest Factor : 2  
Scan Type : Complete  
Area Scan : 16x8x1: Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
Power Drift-Start : 2.598 W/kg  
Power Drift-Finish : 2.531 W/kg  
Power Drift (%) : -2.613

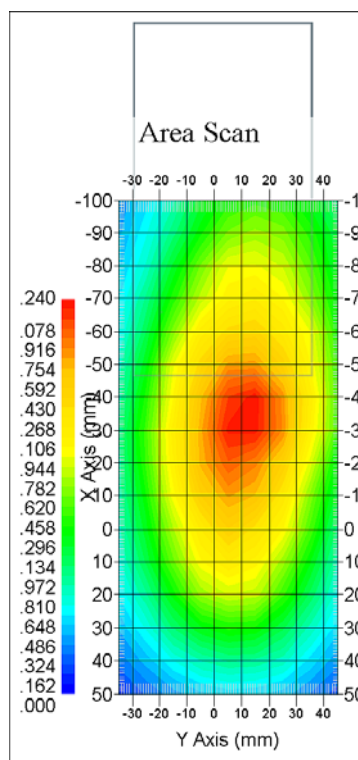
## Tissue Data

Type : Body  
Frequency : 450.0125 MHz  
Epsilon : 55.75 F/m  
Sigma : 0.95 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

Serial No. : 500-00283  
Frequency Band : 450  
Duty Cycle Factor : 2  
Conversion Factor : 5.8  
Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V}/\text{m})^2$   
Compression Point : 95.00 mV  
Offset : 1.56 mm

1 gram SAR value : 2.829 W/kg  
10 gram SAR value : 2.112 W/kg  
Area Scan Peak SAR : 3.127 W/kg  
Zoom Scan Peak SAR : 5.034 W/kg

**Plot 2#**



**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****Face-Up 2.5cm (Analog 12.5k-450.0125 MHz);**

## Measurement Data

Modulation mode : FM  
Crest Factor : 1  
Scan Type : Complete  
Area Scan : 16x8x1: Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
Power Drift-Start : 2.514 W/kg  
Power Drift-Finish : 2.542 W/kg  
Power Drift (%) : 1.327

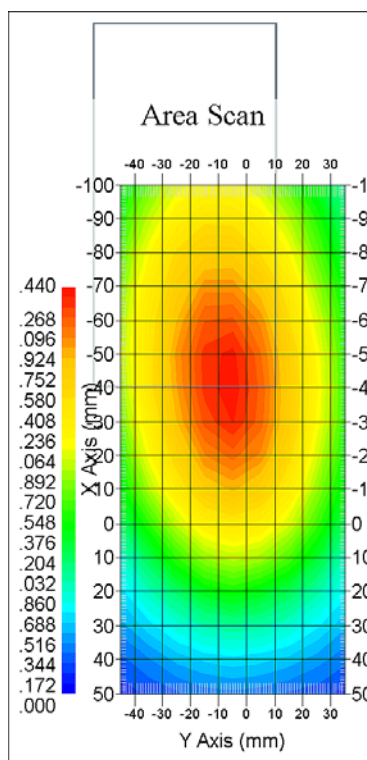
## Tissue Data

Type : Head  
Frequency : 450.0125 MHz  
Epsilon : 43.46 F/m  
Sigma : 0.87 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

Serial No. : 500-00283  
Frequency Band : 450  
Duty Cycle Factor : 1  
Conversion Factor : 5.7  
Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V/m})^2$   
Compression Point : 95.00 mV  
Offset : 1.56 mm

1 gram SAR value : 3.359 W/kg  
10 gram SAR value : 2.274 W/kg  
Area Scan Peak SAR : 3.437 W/kg  
Zoom Scan Peak SAR : 4.986 W/kg

**Plot 3#**

**Test Laboratory: Bay Area Compliance Lab Corp. (Shenzhen)****Standard Capacity Battery: Body-Back 0.0cm (Analog 12.5k-450.0125 MHz);**

## Measurement Data

Modulation mode : FM  
Crest Factor : 1  
Scan Type : Complete  
Area Scan : 11x8x1: Measurement x=10mm, y=10mm, z=4mm  
Zoom Scan : 7x7x7: Measurement x=5mm, y=5mm, z=5mm  
Power Drift-Start : 3.985 W/kg  
Power Drift-Finish : 4.029 W/kg  
Power Drift (%) : 1.152

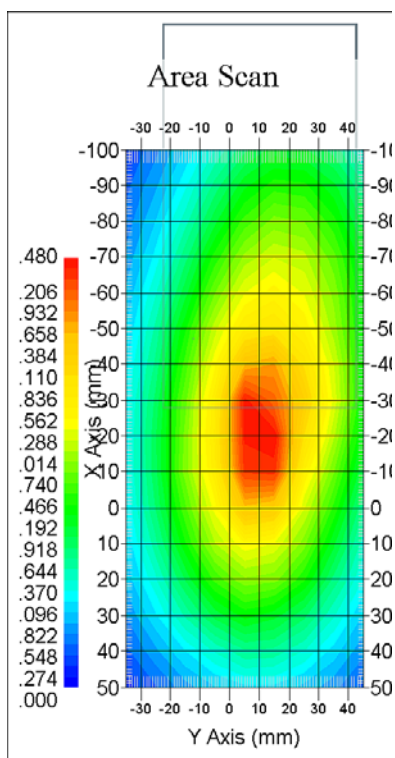
## Tissue Data

Type : Body  
Frequency : 450.0125 MHz  
Epsilon : 55.75 F/m  
Sigma : 0.95 S/m  
Density : 1000.00 kg/cu. m

## Probe Data

Serial No. : 500-00283  
Frequency Band : 450  
Duty Cycle Factor : 1  
Conversion Factor : 5.8  
Probe Sensitivity : 1.20 1.20 1.20  $\mu\text{V}/(\text{V/m})^2$   
Compression Point : 95.00 mV  
Offset : 1.56 mm

1 gram SAR value : 5.396 W/kg  
10 gram SAR value : 3.428 W/kg  
Area Scan Peak SAR : 5.477 W/kg  
Zoom Scan Peak SAR : 7.968 W/kg

**Plot 4#**

## APPENDIX A – MEASUREMENT UNCERTAINTY

The uncertainty budget has been determined for the measurement system and is given in the following Table.

### Measurement Uncertainty for 300MHz to 3GHz

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	$c_i^1$ (1-g)	$c_i^1$ (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
<b>Measurement System</b>							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	$\sqrt{3}$	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	$\sqrt{3}$	$\sqrt{cp}$	$\sqrt{cp}$	4.4	4.4
Boundary Effect	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Linearity	4.7	rectangular	$\sqrt{3}$	1	1	2.7	2.7
Detection Limit	1.0	rectangular	$\sqrt{3}$	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	$\sqrt{3}$	1	1	0.5	0.5
Integration Time	1.7	rectangular	$\sqrt{3}$	1	1	1.0	1.0
RF Ambient Condition -Noise	0.6	rectangular	$\sqrt{3}$	1	1	0.3	0.3
RF Ambient Condition - Reflections	3.0	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Probe Positioner Mech. Restrictions	0.4	rectangular	$\sqrt{3}$	1	1	0.2	0.2
<b>Restriction</b>							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	$\sqrt{3}$	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	$\sqrt{3}$	1	1	2.1	2.1
Test Sample Positioning	2.3	normal	1	1	1	2.3	2.3
Device Holder Uncertainty	6.215	normal	1	1	1	6.215	6.215
Drift of Output Power	4.627	rectangular	$\sqrt{3}$	1	1	2.67	2.67
<b>Phantom and Setup</b>							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	$\sqrt{3}$	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	$\sqrt{3}$	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	1.938	normal	1	0.7	0.5	1.36	0.97
Liquid Permittivity(target)	5.0	rectangular	$\sqrt{3}$	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	3.093	normal	1	0.6	0.5	1.86	1.55
Combined Uncertainty		RSS				10.78	10.55
Expanded uncertainty (coverage factor=2)		Normal(k=2)				21.56	21.10

## APPENDIX B – PROBE CALIBRATION CERTIFICATES

### NCL CALIBRATION LABORATORIES

Calibration File No.: PC-1537

Task No: BACL-5745

## CERTIFICATE OF CALIBRATION

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

Equipment: Miniature Isotropic RF Probe

Record of Calibration

Head and Body

Manufacturer: APREL Laboratories

Model No.: E-020

Serial No.: 500-00283

Calibration Procedure: D01-032-E020-V2, D22-012-Tissue, D28-002-Dipole  
Project No: BACL-5745

Calibrated: 8<sup>th</sup> October 2013

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

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

Released By:



Art Brennan, Quality Manager

### **NCL** CALIBRATION LABORATORIES

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

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

**NCL Calibration Laboratories**

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Division of APREL Inc.

**Introduction**

This Calibration Report reproduces the results of the calibration performed in line with the references listed below. Calibration is performed using accepted methodologies as per the references listed below. Probes are calibrated for air, and tissue and the values reported are the results from the physical quantification 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  
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  
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  
Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- TP-D01-032-E020-V2 E-Field probe calibration procedure
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

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Page 2 of 10

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

**NCL Calibration Laboratories**

Division of APREL Inc.

**Conditions**

Probe 500-00283 was a recalibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 1.5°C  
**Temperature of the Tissue:** 21 °C +/- 1.5°C  
**Relative Humidity:** < 60%

**Primary Measurement Standards**

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	May 14, 2015
Signal Generator HP 83640B	3844A00689	Feb 12, 2015

**Secondary Measurement Standards**


Network Analyzer Anritsu 37347C	002106	Feb. 20, 2015
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**Attestation**

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

**We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.**

  
-----  
Art Brennan, Quality Manager

  
-----  
Dan Brooks, Test Engineer

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

**NCL Calibration Laboratories**

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Division of APREL Inc.

**Probe Summary**

<b>Probe Type:</b>	E-Field Probe E020
<b>Serial Number:</b>	500-00283
<b>Frequency:</b>	As presented on page 5
<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

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**NCL Calibration Laboratories**

Division of APREL Inc.

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

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Standard Uncertainty (%)	Calibration Frequency Range (MHz)	Conversion Factor
450 H	Head	44.29	0.86	3.5	±50	5.7
450 B	Body	56.6	0.94	3.5	±50	5.8
750 H	Head	42.7	0.85	3.5	±50	5.6
750 B	Body	56.6	0.94	3.5	±50	5.5
835 H	Head	42.35	0.938	3.5	±50	5.9
835 B	Body	56.65	1.018	3.5	±50	5.9
900 H	Head	X	X	X	X	X
900 B	Body	X	X	X	X	X
1450 H	Head	X	X	X	X	X
1450 B	Body	X	X	X	X	X
1500 H	Head	X	X	X	X	X
1500 B	Body	X	X	X	X	X
1640 H	Head	X	X	X	X	X
1640 B	Body	X	X	X	X	X
1750 H	Head	38.51	1.36	3.5	±75	5.4
1750 B	Body	51.79	1.53	3.5	±75	5.3
1800 H	Head	38.26	1.41	3.5	±75	5.0
1800 B	Body	51.61	1.58	3.5	±75	5.0
1900 H	Head	38.03	1.36	3.5	±75	4.8
1900 B	Body	53.13	1.58	3.5	±75	4.5
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
2100 H	Head	X	X	X	X	X
2100 B	Body	X	X	X	X	X
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
2450 H	Head	37.64	1.88	3.5	±75	4.9
2450 B	Body	50.7	2.03	3.5	±75	4.3
2600 H	Head	X	X	X	X	X
2600 B	Body	X	X	X	X	X
3000 H	Head	X	X	X	X	X
3000 B	Body	X	X	X	X	X
3600 H	Head	X	X	X	X	X
3600 B	Body	X	X	X	X	X
5250 H	Head	34.65	4.8	3.5	±100	2.7
5250 B	Body	47.6	5.3	3.5	±100	2.6
5600 H	Head	33.2	5.15	3.5	±100	2.5
5600 B	Body	45.21	5.57	3.5	±100	2.2
5800 H	Head	32.72	5.38	3.5	±100	3.2
5800 B	Body	44.28	6.04	3.5	±100	2.5

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### **NCL Calibration Laboratories**

Division of APREL Inc.

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#### **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 $\Omega$ .

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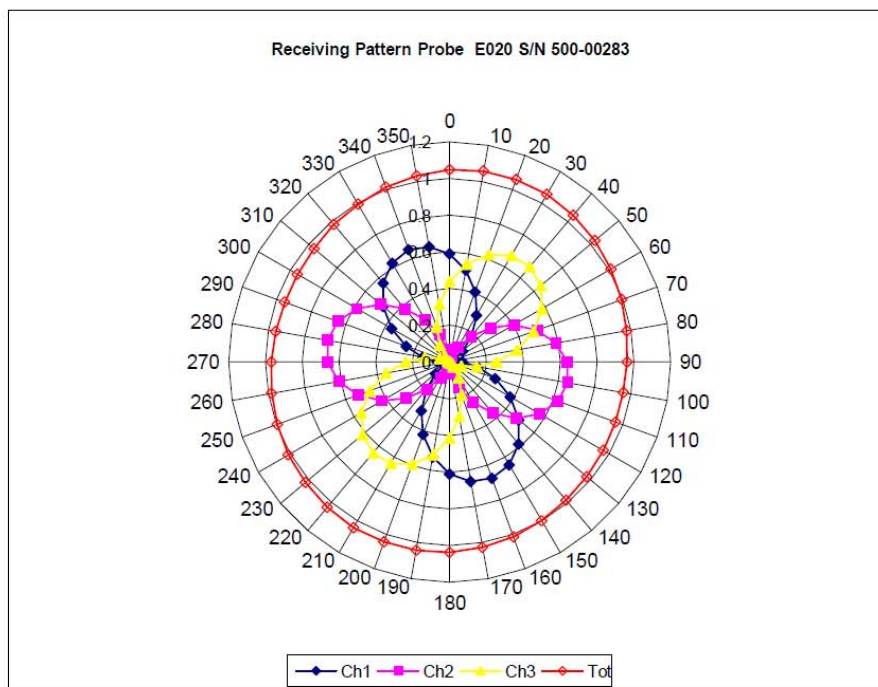
Page 6 of 10

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# NCL Calibration Laboratories

Division of APREL Inc.

## Receiving Pattern Air



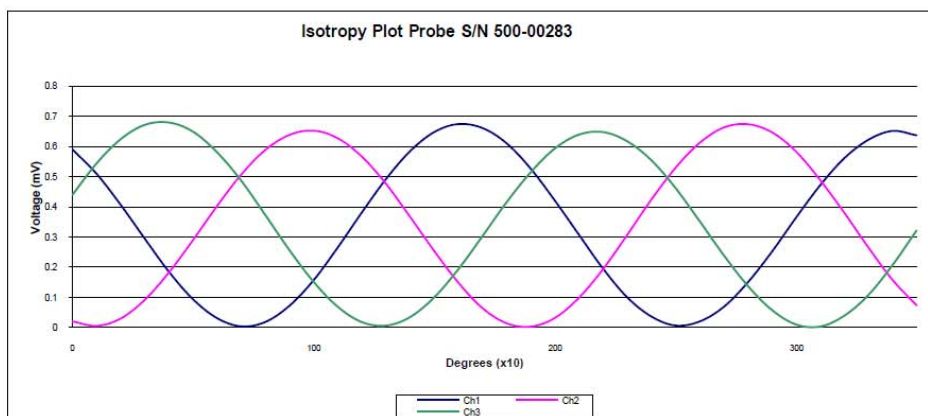
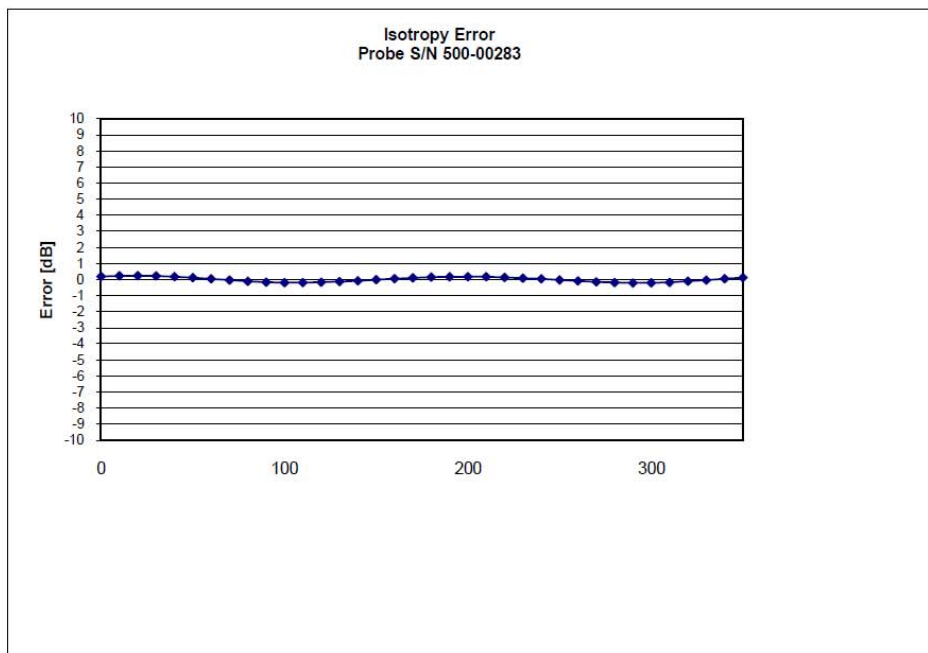
Page 7 of 10

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## **Isotropy Error Air**



**Isotropicity Tissue:**

0.10 dB

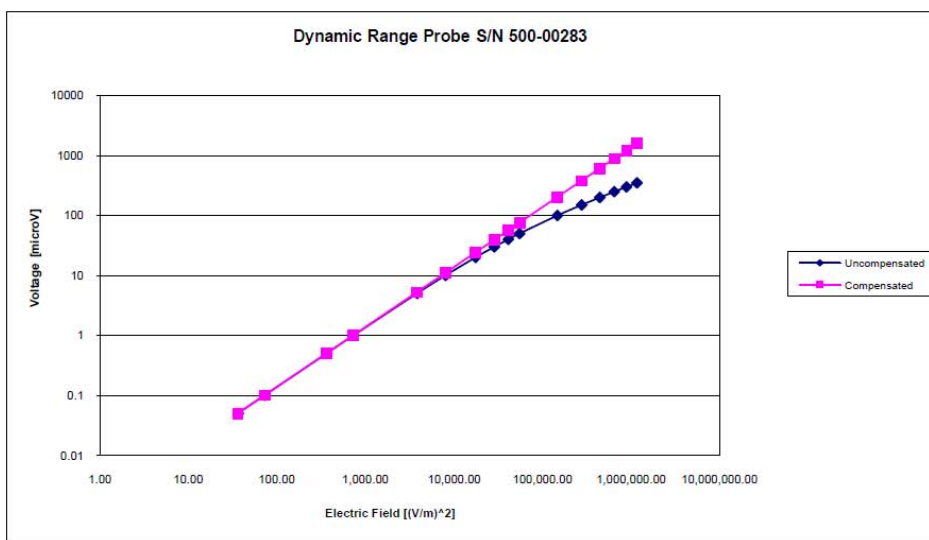
Page 8 of 10

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## NCL Calibration Laboratories

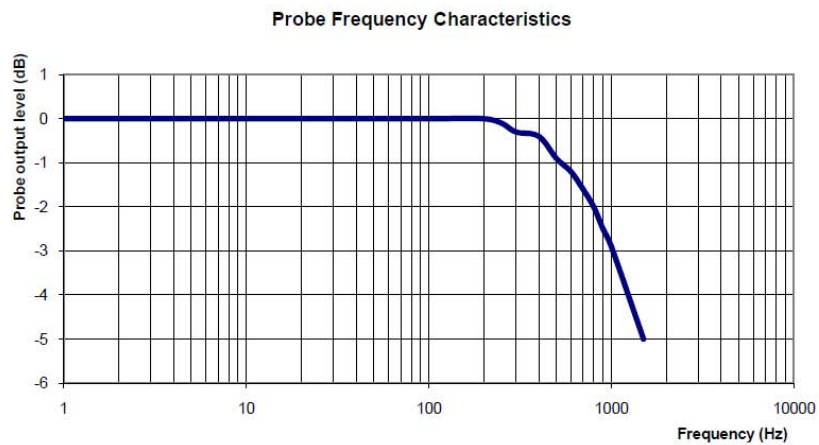
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## Dynamic Range



**NCL Calibration Laboratories**

Division of APREL Inc.

**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 2013.

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Page 10 of 10

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## APPENDIX C – DIPOLE CALIBRATION CERTIFICATES

### NCL CALIBRATION LABORATORIES

Calibration File No: DC-1426  
Project Number: BACL-5672

## 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: **175-00503**

Customer: Bay Area Compliance

Head and Body Calibration

Calibrated: 31st July 2012  
Released on: 2<sup>nd</sup> August 2012

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

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



Art Brennan, Quality Manager

### **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

**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Conditions**

Dipole 175-00503 was taken from stock for an original calibration..

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

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

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.



Art Brennan, Quality Manager



Dan Brooks, Test Engineer

**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**

	Head	Body
Return Loss	-30.726 dB	-33.258 dB
SWR	1.061 U	1.049 U
Impedance	50.600 $\Omega$	48.155 $\Omega$

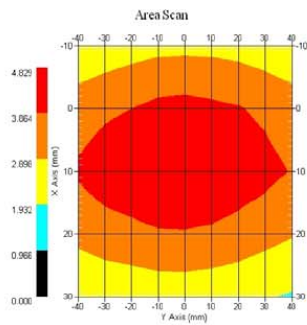
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**NCL Calibration Laboratories**

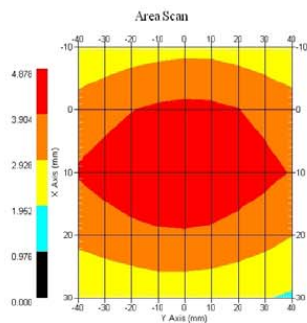
Division of APREL Laboratories.

**System Validation Results Head**

Frequency	1 Gram	10 Gram	Peak
450 MHz	4.572	2.952	6.746

**System Validation Results Body**

Frequency	1 Gram	10 Gram	Peak
450 MHz	4.508	2.959	6.656



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

---

**Introduction**

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 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**

Original calibration.

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

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

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**NCL Calibration Laboratories**

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**Dipole Calibration Results****Mechanical Verification**

APREL Length	APREL Height	Measured Length	Measured Height
280.0 mm	166.7 mm	280.0 mm	166.0 mm

**Tissue Validation**

Body Tissue 450MHz	Measured Head	Measured Body
Dielectric constant, $\epsilon_r$	<b>43.98</b>	<b>57.07</b>
Conductivity, $\sigma$ [S/m]	<b>0.9</b>	<b>0.92</b>

**Dipole Calibration uncertainty**

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

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

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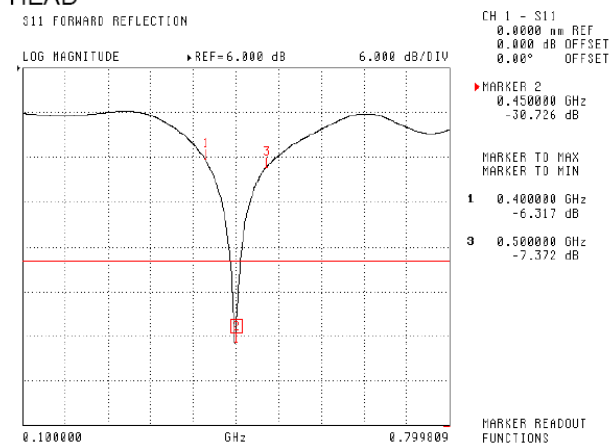
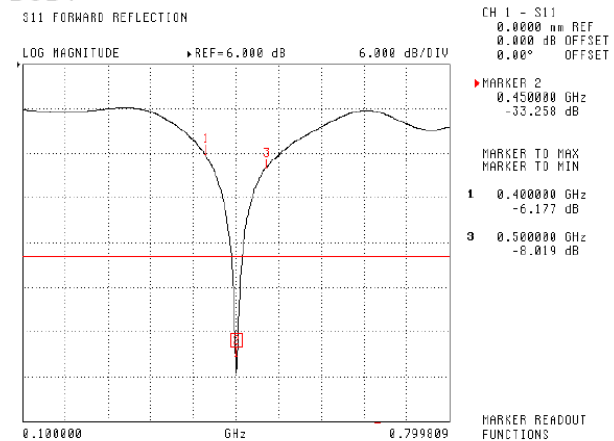
**NCL Calibration Laboratories**

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**Electrical Calibration**

Test	Result Head	Result Body
S11 R/L	-30.726 dB	-33.258 dB
SWR	1.061 U	1.049 U
Impedance	50.600 $\Omega$	48.155 $\Omega$

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

**S11 Parameter Return Loss****HEAD****BODY**

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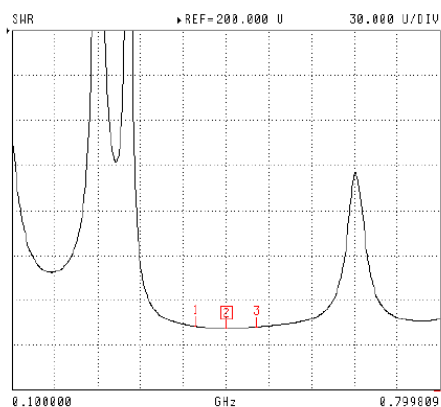
## NCL Calibration Laboratories

Division of APREL Laboratories.

### SWR

#### HEAD

S11 FORWARD REFLECTION



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

MARKER 2  
0.450000 GHz  
1.051 U

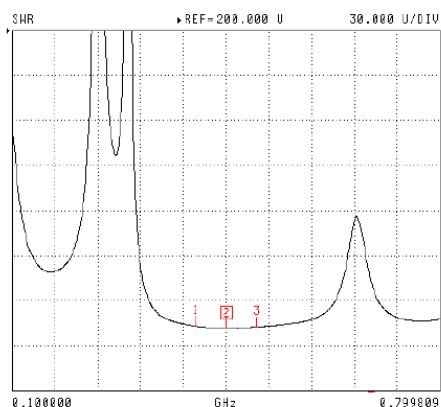
MARKER TO MAX  
MARKER TO MIN

1 0.400000 GHz  
2.872 U  
3 0.500000 GHz  
2.497 U

MARKER READOUT  
FUNCTIONS

#### BODY

S11 FORWARD REFLECTION



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

MARKER 2  
0.450000 GHz  
1.049 U

MARKER TO MAX  
MARKER TO MIN

1 0.400000 GHz  
2.931 U  
3 0.500000 GHz  
2.319 U

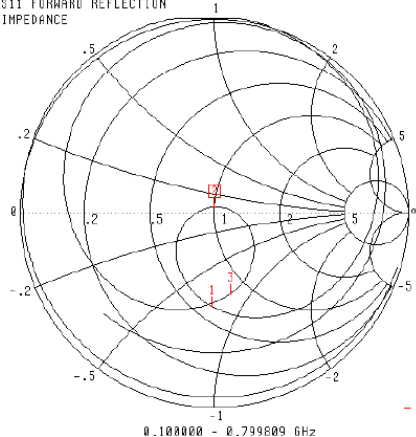
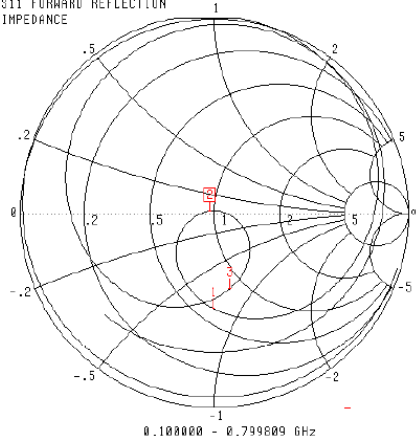
MARKER READOUT  
FUNCTIONS

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**NCL Calibration Laboratories**

Division of APREL Laboratories.

**Smith Chart Dipole Impedance****HEAD**S11 FORWARD REFLECTION  
IMPEDANCECH 1 - S11  
0.0000 nm REF  
0.000 dB OFFSET  
0.00° OFFSETMARKER 2  
0.450000 GHz  
50.600 Q  
2.584 jQMARKER TO MAX  
MARKER TO MIN1 0.400000 GHz  
30.609 Q  
-30.618 jQ  
3 0.500000 GHz  
40.424 Q  
-41.402 jQMARKER READOUT  
FUNCTIONS**BODY**S11 FORWARD REFLECTION  
IMPEDANCECH 1 - S11  
0.0000 nm REF  
0.000 dB OFFSET  
0.00° OFFSETMARKER 2  
0.450000 GHz  
40.155 Q  
995.105 jQMARKER TO MAX  
MARKER TO MIN1 0.400000 GHz  
30.609 Q  
-30.631 jQ  
3 0.500000 GHz  
42.524 Q  
-39.206 jQMARKER READOUT  
FUNCTIONS

**NCL Calibration Laboratories**

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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 2012.

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

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## 450MHz Dipole Calibration By BACL at 2013-12-20

### Mechanical Verification

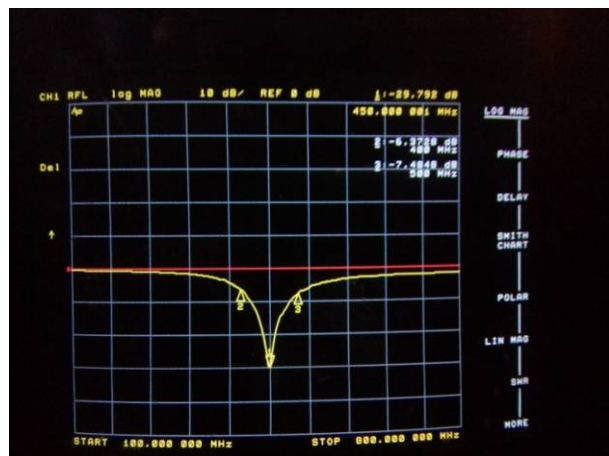
APREL Length	APREL Height	Measured Length	Measured Height
280.0 mm	166.7 mm	280.0 mm	166.6 mm

Tissue Type	Measured Return Loss	Measured Impedance
Head	-29.792 dB	50.896 $\Omega$
Body	-33.773 dB	47.662 $\Omega$

### Test Graphs:

Head Tissue

Return Loss :

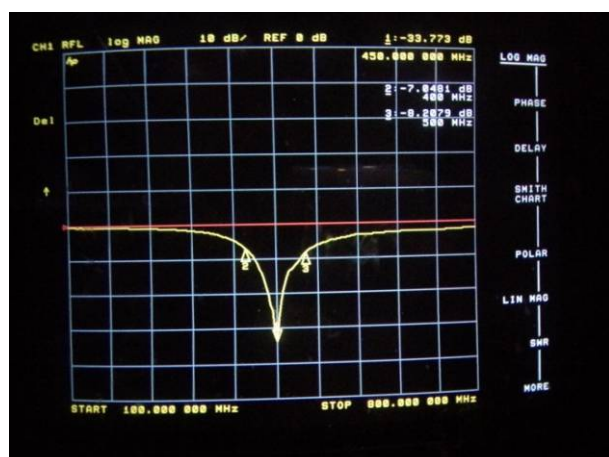


Impedance :



Body Tissue

Return Loss :

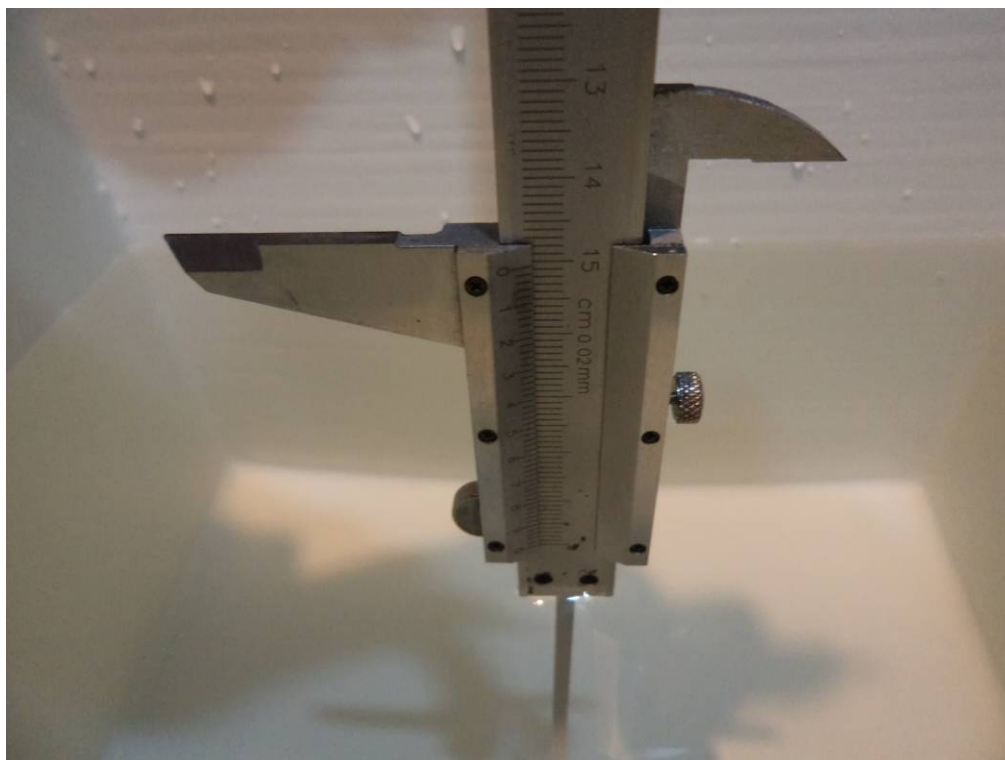


Impedance :

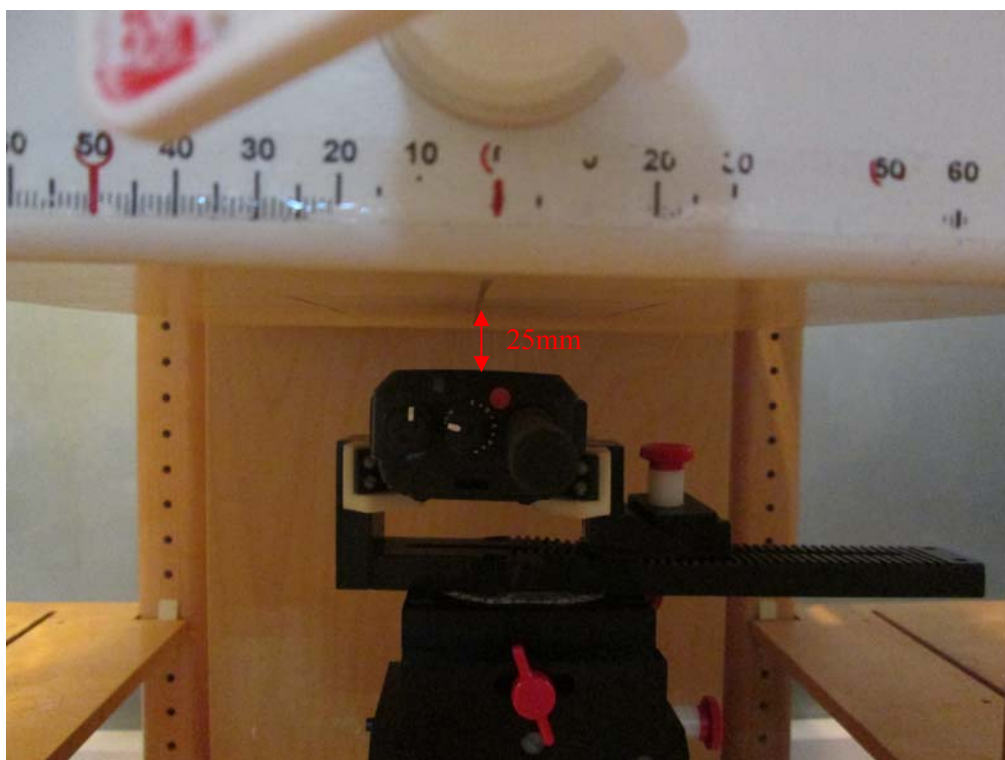


## APPENDIX D – EUT TEST POSITION PHOTOS

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



Face-Up 2.5 cm Separation to Flat Phantom





**Body-Back 0.0 cm Separation to Flat Phantom**



## APPENDIX E – EUT PHOTOS

---

**EUT – Front View**



**EUT – Back View**



**EUT-Left View**



**EUT-Right View**





**EUT-Top View**



**EUT-Bottom View**



### EUT–Uncover View



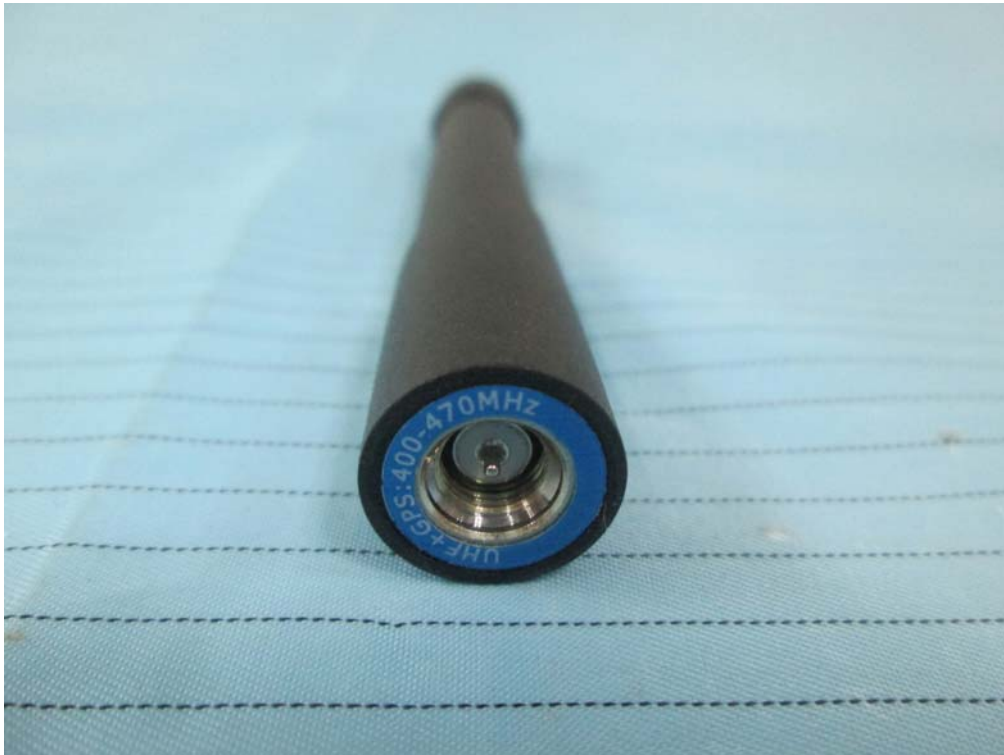
### Standard Battery View (2000mAh)



### High Capacity Battery View (2500mAh)



### EUT-Antenna View





**EUT – Belt Clip**



**EUT – Headset**



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## APPENDIX F – INFORMATIVE REFERENCES

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