



# PCTEST ENGINEERING LABORATORY, INC.

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## CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

### APPLICANT NAME & ADDRESS:

IBM Japan, Ltd.  
1623-14, Shimotsuruma, Yamato-shi  
Kangawa 242-8502, Japan  
Attn: Takeshi Asami, Consumer & OEM Product

### DATE & LOCATION OF TESTING:

Dates of Tests: April 10-12, 2002  
Test Report S/N: SAR.220412167.IBM  
Test Site: PCTEST Lab, Columbia, MD USA

FCC ID:

AN0DS1WSHR

APPLICANT:

IBM Japan, Ltd.

EUT Type: 2.4 GHz Integrated Cisco Wireless LAN  
in IBM Thinkpad R32 Series

Tx Frequency: 2412 – 2462 MHz

Rx Frequency: 2412 – 2462 MHz

Max. RF Output Power: 0.100 Watts (21.3dBm)

Max. SAR Measurement: 1.17 W/kg DSSS Body SAR

Trade Name/Model(s): IBM/ ThinkPad R32 w/ Wireless LAN

FCC Classification: Licensed Portable Transmitter Held to Ear (PCE)

FCC Rule Part(s): §2.1093; FCC/OET Bulletin 65 Supplement C [July 2001]

Application Type: Certification

Test Device Serial No.: *Identical* prototype

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1-1992 and has been tested in accordance with the measurement procedures specified in ANSI/IEEE Std. C95.3-1992 and IEEE Std. 1528-200X (Draft 6.4, July 2001).

I attest to the accuracy of data. All measurements reported herein were performed by me 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.



PCTEST certifies that no party to this application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 862.

  
\_\_\_\_\_  
Randy Ortanez  
President



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## 1. INTRODUCTION / SAR DEFINITION

The FCC has adopted the guidelines for evaluating the environmental effects of radiofrequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.[1]

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in *IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*. (c) 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017.[2] The measurement procedure described in *IEEE/ANSI C95.3-1992 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave*[3] is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields*, NCRP Report No. 86 (c) NCRP, 1986, Bethesda, MD 20814.[6] SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

### **SAR Definition**

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy ( $dU$ ) absorbed by (dissipated in) an incremental mass ( $dm$ ) contained in a volume element ( $dV$ ) of a given density ( $\rho$ ). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Fig. 1.1).

$$SAR = \frac{d}{d t} \left( \frac{dU}{dm} \right) = \frac{d}{d t} \left( \frac{dU}{\rho dV} \right)$$

**Figure 1.1**  
**SAR Mathematical Equation**

**SAR is expressed in units of Watts per Kilogram (W/kg).**

$$SAR = \sigma E^2 / \rho$$

where:

**$\sigma$**  = conductivity of the tissue-simulant material (S/m)

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

**$E$**  = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.[6]

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## 2. SAR MEASUREMENT SETUP

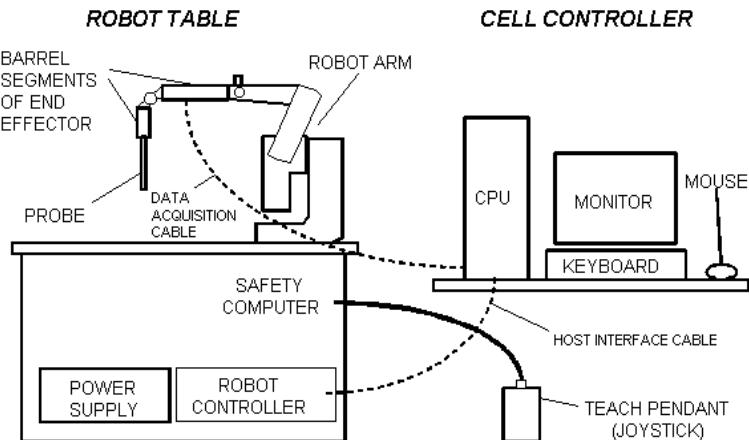
### Robotic System

Measurements are performed using the ALIDX-500 automated dosimetric assessment system. The ALIDX-500 is made by IDX Robotics, Inc. (IDX) in the United States and consists of high precision robotics system (CRS), robot controller, Pentium 4 computer, near-field probe, probe alignment sensor, and the Left and Right SAM phantoms containing the head/brain equivalent tissue, and the flat phantoms for body/muscle equivalent. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

### System Hardware

The Robot table consists of the power supply, robot controller, safety computer, teach pendant (joystick), six-axis robot arm, and the probe. The cell controller consists of DELL Dimension 4300 Pentium-4 1.6 GHz computer with Windows 2000 system and SAR Measurement software, National Instruments analog card, monitor, keyboard, and mouse. The robot controller is connected to the cell controller to communicate between the two computers. The probe data is connected to the cell controller via data acquisition cables.

### System Electronics



**Figure 2.1**  
**SAR Measurement System Setup**

When the Robot is in the home position, the Y-axis of the coordinate system parallels the line of intersection between the tabletop and the long axis of the Robot's Large Shoulder. The Teach Pendant may be used to establish the X,Y coordinate directions by depressing the 0-X and 0-Y MOTOR/AXIS switches while in axis mode.

The robot is first taught to position the probe sensor following a specific pattern of points. In the first sweep the sensor enclosure touches the inside of the phantom head. The SAR is measured on a defined grid of points that are concentrated on the surface of the head closest to the antenna of the transmitting device (EUT).

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### 3. ALIDX-500 E-FIELD PROBE SYSTEM

#### Probe Measurement System



Fig 3.1  
IDX System

The near-field probe is an implantable isotropic E-field probe that measures the voltages proportional to the  $|E|^2$  (electric) or  $|H|^2$  (magnetic) fields. The probe is enclosed in a hollow glass protective cylinder 9-mm. outer diameter, 0.5 mm. thickness and 30 cm. in length. The E-probe contains three electrically small array of orthogonal dipoles strategically placed to provide greater accuracy and to compensate for near-field spatial gradients. The probe contains diodes that are placed over the gap of the dipoles to improve RF detection. The electrical signal detected by each diode is amplified by three DC amplifiers and are contained in a shielded container in the robot end effector so its performance is not affected by the presence of incident electromagnetic fields (see Fig. 3.1).

#### Probe Specifications

Frequency Range:	10 kHz – 3.0 GHz
Calibration:	In air from 10 MHz to 3.0 GHz
	In brain and muscle simulating tissue at Frequencies of 835 MHz, 1900MHz and 2450MHz
Sensitivity:	3.5 mV/mW/cm <sup>2</sup> (air – typical)
DC Resistance:	300 kohm
Isotropic Response:	0.25 dB
Dynamic Range:	10 mW/kg – 100 W/kg
Resistance to Pull:	25 N
Probe Length:	290 mm
Probe Tip Material:	Glass
Probe Tip Length:	40 mm
Probe Tip Diameter:	7 ± 0.2 mm
Application:	SAR Dosimetry Testing HAC (Hearing Aid Compatibility) Compliance tests of mobile phones

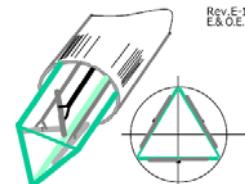


Figure 3.2  
Triangular Probe Configuration

Triangular Probe Isotropic Characteristics  
(plane perpendicular to probe axis)

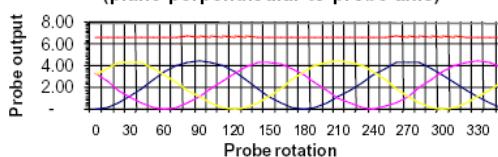


Figure 3.3  
Probe Characteristics

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## 4. Probe Calibration Process

### Dosimetric Assessment Procedure

Each E-Probe/Probe amplifier combination has unique calibration parameters. A TEM calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the Probe to a known E-field density ( $1\text{mW/cm}^2$ ) using an RF Signal generator, TEM cell, and RF Power Meter. The SAR measurement software is used for Probe calibration.

### Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or some other methodologies above 1 GHz for free space. For the free space calibration, we place the probe in the volumetric center of the cavity and at the proper orientation with the field. We then rotate the probe 360 degrees until the three channels show the maximum reading. The power density readings equates to  $1\text{mW/cm}^2$ .

### Temperature Assessment

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe (see Fig. 4.2).

$$\text{SAR} = C \frac{\Delta T}{\Delta t}$$

where:

$\Delta t$  = exposure time (30 seconds),

$C$  = heat capacity of tissue (brain or muscle),

$\Delta T$  = temperature increase due to RF exposure.

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

where:

$\sigma$  = simulated tissue conductivity,

$\rho$  = Tissue density ( $1.25\text{ g/cm}^3$  for brain tissue)

SAR is proportional to  $\Delta T / \Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place. Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

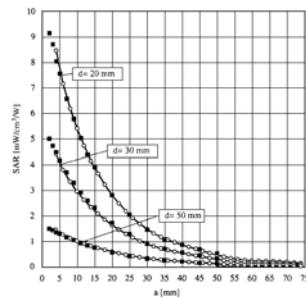


Figure 4.1 E-Field and Temperature measurements at 900MHz [7]

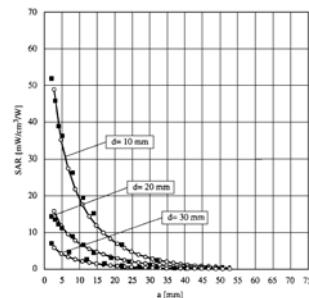


Figure 4.2 E-Field and temperature measurements at 1.9GHz [7]

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## 5. PHANTOM & EQUIVALENT TISSUES

### SAM Phantom



Figure 5.1  
SAM Phantoms

The Left and Right SAM Phantoms are constructed of a vivac composite integrated in a corian stand. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users [11][12]. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 5.1)

### Brain & Muscle Simulating Mixture Characterization



Figure 5.2  
Head Simulated  
Tissue

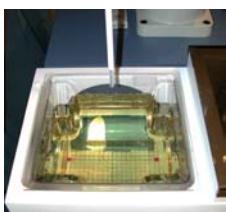


Figure 5.3  
Body/Muscle  
Simulated Tissue

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

Salt: 99% Pure Sodium Chloride  
 Water: De-ionized, 16 MΩ<sup>2</sup> resistivity  
 DGBE: 99% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]  
 Triton X-100 (ultra pure): Polyethylene glycol mono [4-(1,1, 3, 3-tetramethylbutyl)phenyl] ether

Table 5.1  
Composition of the Brain & Muscle Tissue Equivalent Matter

### Device Holder



Figure 5.4  
Device Positioner

In combination with the SAM Phantom, the EUT Holder (see Fig. 6.2) enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. Device positioning is accurate and repeatable according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

\* Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations [12]. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

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## 6. TEST SYSTEM SPECIFICATIONS

### Automated Test System Specifications

#### Positioner

**Robot:** CRS Robotics, Inc. Robot Model: F3  
**Repeatability:**  $\pm 0.05$  mm (0.002 in.)  
**No. Of axes:** 6



#### Data Acquisition Electronic (DAE) System

##### Cell Controller

**Processor:** Pentium 4  
**Clock Speed:** 1.6 GHz  
**Operating System:** Windows 2000™ Professional  
**Data Card:** NI DAQ Card (in CPU)

##### Data Converter

**Software:** IDX Flexware  
**Connecting Lines:** Data Acquisition Cable  
 RS-232 Host Interface Cable  
**Sampling Rate:** 6000 samples/sec

Figure 6.1  
ALIDX-500 Test System

#### E-Field Probes

**Model:** E-010 S/N: PCT25  
**Construction:** Triangular core absolute encoder system  
**Frequency:** 10 MHz to 3.0 GHz

#### Phantom

**Phantom:** SAM Phantoms (Left & Right)  
**Shell Material:** Vivac Composite  
**Thickness:** 2.0  $\pm$  0.2 mm

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## 7. DOSIMETRIC ASSESSMENT & PHANTOM SPECS

### Measurement Procedure

The measurement procedure consists of the process parameters, probe parameters, EUT product data, and measurement scans (teach points). The measurement procedure is a set of predefined points to be scanned and measured by the probe, DC amplified and processed by the cell controller. The corresponding voltages determined by the electric and magnetic fields are extrapolated to determine peak SAR value.

The SAR Measurement System measures field strength by employing two different types of systematic measurement scans; a coarse scan and a fine scan. Coarse and fine scans measure field strength in a rectangular area within the XY plane (a plane parallel to the top of the Robot Table). The measurement area is divided into a grid of small squares defined by equally spaced grid lines. During an actual measurement process, the probe moves along grid lines systematically recording the field strength at grid line intersections. Typically, after a coarse scan is completed, a fine scan is conducted at the peak field strength value (hot spot) that was measured in the coarse scan. The fine scan has a greater resolution (smaller grid squares) than the coarse scan, and covers only a fraction of the measurement area in the coarse scan.

### Specific Anthropomorphic Mannequin (SAM) Specifications

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90<sup>th</sup> percentile adult male head dimensions as tabulated by the US Army. The SAM Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. 7.1). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimize reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface. The SAM shell thickness is  $2.0 \pm 0.2$  mm.



**Figure 7.1**  
**Left and Right SAM Phantom shells**

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## 8. TEST CONFIGURATION POSITIONS

### Body Holster /Belt Clip Configurations

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 9.5). A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are supplied with the device, the device is tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (i.e. 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 is tested.

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration where a separation distance between the back of the device and the flat phantom is used. All test position spacings are documented.

Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessory(ies), including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

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.

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



Figure 9.5 Body Belt Clip & Holster Configurations

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## 9. ANSI/IEEE C95.1 - 1992 RF EXPOSURE LIMITS

### 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 10.1. Safety Limits for Partial Body Exposure [2]

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

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.

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## 10. MEASUREMENT UNCERTAINTIES

a	b	c	d	e = f(d,k)	f	g	h = cxf/e	i = cxg/e	k
Uncertainty Component	Sec.	Tol. (± %)	Prob. Dist.	Div.	$c_i$ (1 - g)	$c_i$ (10 - g)	$1 - g$ $u_i$ (± %)	$10 - g$ $u_i$ (± %)	$v_i$
<b>Measurement System</b>									
Probe Calibration	E1.1	3.0	N	1	1	1	6.4	6.4	∞
Axial Isotropy	E1.2	4.88	R	$\sqrt{3}$	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	2.0	2.0	∞
Hemispherical Isotropy	E1.2	9.6	R	$\sqrt{3}$	$\sqrt{c_p}$	$\sqrt{c_p}$	3.9	3.9	∞
Boundary Effect	E1.3	11.0	R	$\sqrt{3}$	1	1	6.4	6.4	∞
Linearity	E1.4	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
System Detection Limits	E1.5	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Readout Electronics	E1.6	1.0	R	1	1	1	1.0	1.0	∞
Response Time	E1.7	0.8	R	$\sqrt{3}$	1	1	0.3	0.3	∞
Integration Time	E1.8	1.7	R	$\sqrt{3}$	1	1	1.0	1.0	∞
RF Ambient Conditions	E5.1	1.2	R	$\sqrt{3}$	1	1	0.7	0.7	∞
Probe Positioner Mechanical Tolerance	E5.2	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
Probe Positioning w/ respect to Phantom Shell	E5.3	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation	E4.2	3.9	R	$\sqrt{3}$	1	1	2.3	2.3	∞
<b>Test Sample Related</b>									
Test Sample Positioning	E3.2.1		R	$\sqrt{3}$	1	1	6.0	6.0	11
Device Holder Uncertainty	E3.1.1		R	$\sqrt{3}$	1	1	5.0	5.0	8
Output Power Variation - SAR drift measurement	5.6.2	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
<b>Phantom &amp; Tissue Parameters</b>									
Phantom Uncertainty (Shape & Thickness tolerances)	E2.1	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Liquid Conductivity - deviation from target values	E2.2	5.0	R	$\sqrt{3}$	0.7	0.5	2.0	1.4	∞
Liquid Conductivity - measurement uncertainty	E2.2	10.0	R	$\sqrt{3}$	0.7	0.5	4.0	2.9	∞
Liquid Permittivity - deviation from target values	E2.2	5.0	R	$\sqrt{3}$	0.6	0.5	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E2.2	5.0	R	$\sqrt{3}$	0.6	0.5	1.7	1.4	∞
<b>Combined Standard Uncertainty (k=1)</b>			RSS				14.8	14.4	
<b>Expanded Uncertainty (k=2)</b> (95% CONFIDENCE LEVEL)							29.4	28.9	

The above measurement uncertainties are according to IEEE Std. 1528-200x (July, 2001)

PCTEST™ SAR TEST REPORT	PCTEST	FCC CERTIFICATION	IBM	Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 12 of 18

## 11. SYSTEM VERIFICATION

### Tissue Verification

Table 12.1 Simulated Tissue Verification

MEASURED TISSUE PARAMETERS									
Date(s)	02/18/02	1900MHz Brain		1900MHz Muscle		2450MHz Brain		2450MHz Muscle	
Liquid Temperature (°C)	23.5	Target	Measured	Target	Measured	Target	Measured	Target	Measured
Dielectric Constant: $\epsilon$	41.50	N/A	40.29	N/A	40.00	39.40	53.30	52.00	
Conductivity: $\sigma$	0.900	N/A	1.44	N/A	1.400	1.88	1.520	1.92	

### Test System Validation

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at 835MHz and 1900MHz by using the system validation kit(s). (Graphic Plots Attached)

Table 12.2 System Validation

SYSTEM DIPOLE VALIDATION TARGET & MEASURED				
System Validation Kit: D-835S, S/N: 103	835MHz Brain	Targeted SAR <sub>1g</sub> (mW/g) 2.375	Measured SAR <sub>1g</sub> (mW/g) N/A	Deviation (%) N/A
System Validation Kit: D-2450S, S/N: 105	2450MHz Brain	Targeted SAR <sub>1g</sub> (mW/g) 13.1	Measured SAR <sub>1g</sub> (mW/g) 13.0	Deviation (%) + 0.8

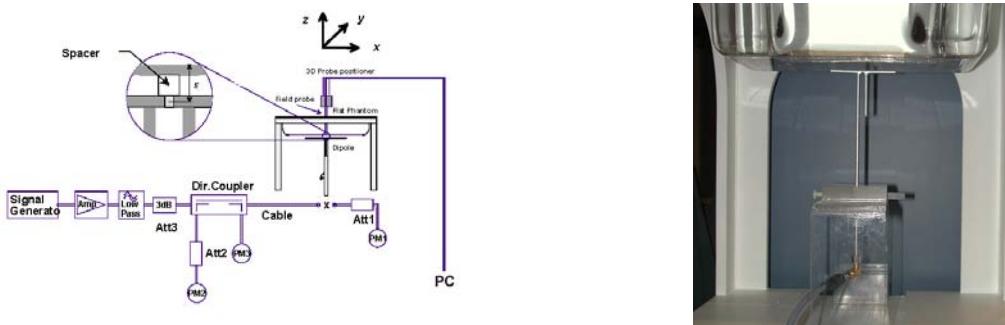


Figure 12.1 Dipole Validation Test Setup

PCTEST™ SAR TEST REPORT	FCC CERTIFICATION			Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 13 of 18

## 12. SAR TEST DATA SUMMARY

### See Measurement Result Data Pages

#### Procedures Used To Establish Test Signal

The notebook was placed into simulated call mode (highest data rate 11MBps) using manufacturers test codes. Such test signals offer a consistent means for testing SAR and are recommended for evaluating SAR [4]. When test modes are not available or inappropriate for testing a handset, the actual transmission is activated through a base station simulator or similar equipment. See data pages for actual procedure used in measurement.

#### Device Test Conditions

The notebook is battery operated. Each SAR measurement was taken with a fully charged battery. In order to verify that the device was tested at full power, conducted output power measurements were performed before and after each SAR measurement to confirm the output power. If a conducted power deviation of more than 5% occurred, the test was repeated.

PCTEST™ SAR TEST REPORT	FCC CERTIFICATION			Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 14 of 18

## SAR DATA SUMMARY

Mixture Type: 2450MHz Muscle

13.1 MEASUREMENT RESULTS (DSSS Body SAR) – 11 MBps							
FREQUENCY		Modulation	Begin / End POWER <sup>‡</sup>		Separation Distance (cm)	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)	Battery			
2412	1	DSSS	0.100	0.100	Laptop	Touch	Fixed
2437	6	DSSS	0.100	0.100	Laptop	Touch	Fixed
2462	11	DSSS	0.100	0.100	Laptop	Touch	Fixed
2412	1	DSSS	0.100	0.100	Laptop	0.2	Fixed
2412	1	DSSS	0.100	0.100	Laptop	Touch	Fixed
ANSI / IEEE C95.1 1992 - SAFETY LIMIT						Muscle 1.6 W/kg (mW/g) averaged over 1 gram	
Spatial Peak							
Uncontrolled Exposure/General Population							

**NOTES:**

1. The test data reported are the worst-case SAR value with the antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings.

<sup>‡</sup>Power Measured

4. SAR Measurement System	<input checked="" type="checkbox"/> Conducted	<input type="checkbox"/> ERP	<input type="checkbox"/> EIRP
Phantom Configuration	<input type="checkbox"/> DASY3	<input checked="" type="checkbox"/> IDX	<input type="checkbox"/>
5. SAR Configuration	<input type="checkbox"/> Left Head	<input checked="" type="checkbox"/> Flat Phantom	<input type="checkbox"/> Right Head
6. Test Signal Call Mode	<input type="checkbox"/> Head	<input checked="" type="checkbox"/> Body	<input type="checkbox"/> Hand
	<input checked="" type="checkbox"/> Manu. Test Codes	<input type="checkbox"/> Base Station Simulator	

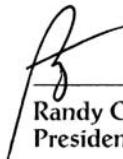
  
Randy Ortanez  
President



Figure 13.1 11 MBps BODY SAR Test Setup

PCTEST™ SAR TEST REPORT	PCTEST	FCC CERTIFICATION	IBM	Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 15 of 18

## 14. SAR TEST EQUIPMENT

### Equipment Calibration

Table 15.1 Test Equipment Calibration

EQUIPMENT SPECIFICATIONS		
Type	Calibration Date	Serial Number
CRS Robot F3	February 2002	RAF0134133
CRS C500C Motion Controller	February 2002	RCB0003303
CRS Teach Pendant (Joystick)	February 2002	STP0132231
DELL Computer, Pentium 4 1.6 GHz, Windows 2000™	February 2002	
E-Field Probe E-010	February 2002	PCT001
E-Field Probe E-010	February 2002	PCT002
E-Field Probe E-010	January 2002	PCT25
Right Ear SAM Phantom (P-SAM-R)	February 2002	
Left Ear SAM Phantom (P-SAM-L)	February 2002	
IDX Robot End Effector (EE-103-C)	February 2002	07111223
IDX Probe Amplifier	February 2002	07111113
Validation Dipole D-835S	February 2002	PCT640
Validation Dipole D-1900S	February 2002	PCT639
Brain Equivalent Matter (2450MHz)	April 2002	PCTBEM101
Brain Equivalent Matter (1900MHz)	April 2002	PCTBEM301
Muscle Equivalent Matter (2450MHz)	April 2002	PCTMEM201
Muscle Equivalent Matter (1900MHz)	April 2002	PCTMEM401
Microwave Amp. Model: 5S1G4, (800MHz - 4.2GHz)	January 2002	22332
Gigatronics 8651A Power Meter	January 2002	1835299
HP-8648D (9kHz ~ 4GHz) Signal Generator	January 2002	PCT530
Amplifier Research 5S1G4 Power Amp	January 2002	PCT540
HP-8753E (30kHz ~ 3GHz) Network Analyzer	January 2002	PCT552
HP85070B Dielectric Probe Kit	January 2002	PCT501
Ambient Noise/Reflection, etc.	<12mW/kg/<3%of SAR	January 2002

NOTE:

The E-field probe was calibrated by IDX, by temperature measurement procedure. Dipole Validation measurement is performed by PCTEST Lab. before each test. The brain simulating material is calibrated by PCTEST using the dielectric probe system and network analyzer to determine the conductivity and permittivity (dielectric constant) of the brain-equivalent material.

PCTEST™ SAR TEST REPORT	PCTEST Engineering Laboratory, Inc.	FCC CERTIFICATION	IBM	Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 16 of 18

## 15. CONCLUSION

### Measurement 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 are very complex phenomena that depend 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.[3]

PCTEST™ SAR TEST REPORT		FCC CERTIFICATION			Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM		Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 17 of 18

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PCTEST™ SAR TEST REPORT		FCC CERTIFICATION			Reviewed by: Quality Manager
SAR Filename: SAR.220412167.IBM	Test Dates: April 10-12, 2002	Phone Type: THINKPAD R32 Series	FCC ID: AN0DS1WSHR	Page 18 of 18	

## **ATTACHMENT A – SAR TEST DATA**

---

Start : 12-Apr-02 11:39:02 am  
End : 12-Apr-02 11:51:58 am  
Code Version : 4.08  
Robot Version: 4.08

## Product Data:

Type : IBM  
Model Number : R32 SERIES  
Serial Number : AA-GD43G  
Frequency : 2412 MHz  
Transmit Pwr : 0.100 W  
Antenna Type : Inverted F  
Antenna Posn. : Internal

## Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Muscle  
Tissue Dielectric : 52.000  
Tissue Conductivity : 1.920  
Tissue Density : 1.000  
Robot Name : CRS

## Probe Data:

Probe Name : PCT001  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Muscle  
Calibrated Dielectric : 52.200  
Calibrated Conductivity : 1.950  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.500  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

## Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

## Comments:

IBM Thinkpad R32 Series w/ Integrated Wireless LAN  
CH-1 (11 MBps)  
CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C

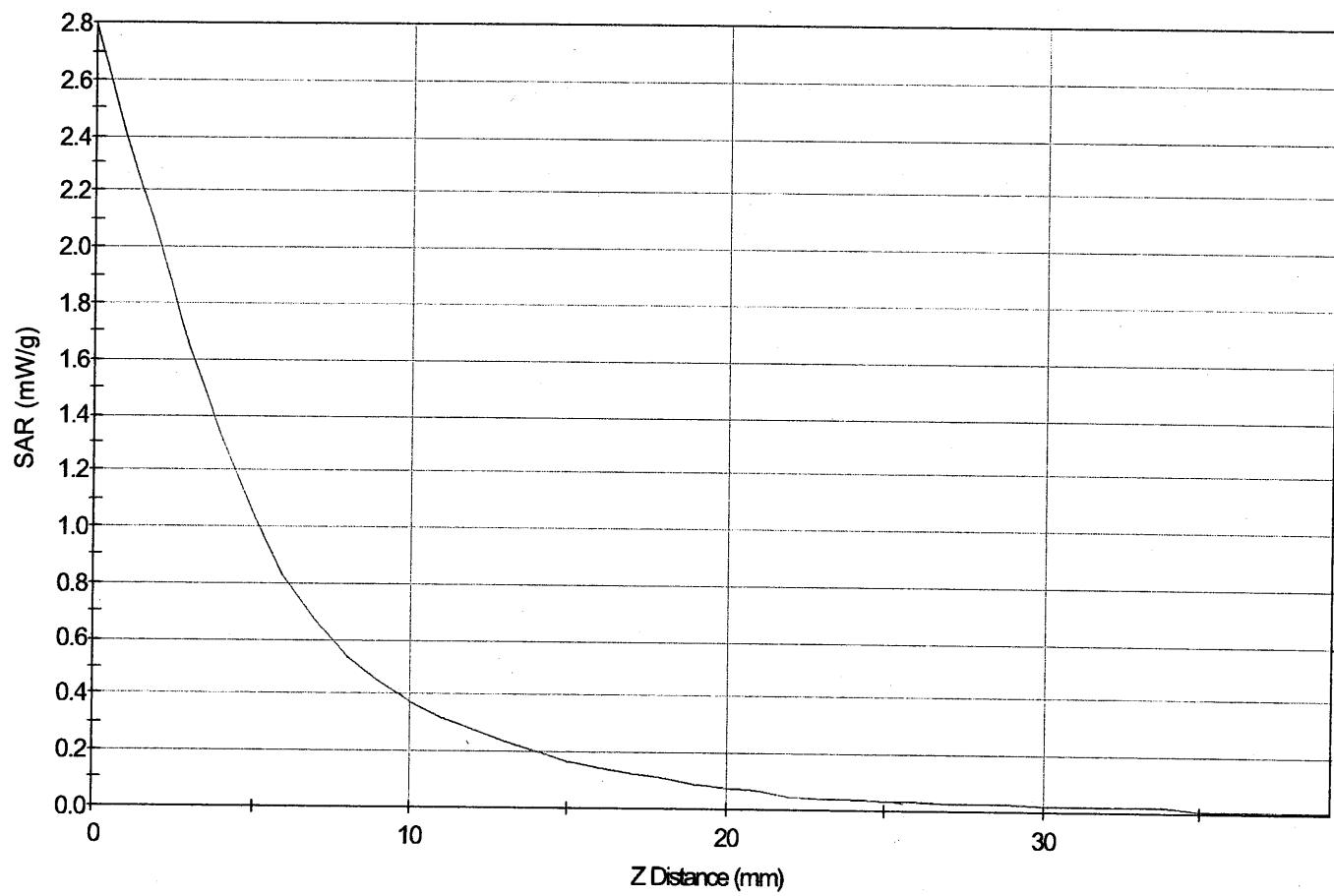
Area Scan - Max Peak SAR Value at x=-5.0 y=-35.0 = 0.98 W/kg

Zoom Scan - Max Peak SAR Value at x=-5.0 y=-35.0 z=0.0 = 2.79 W/kg

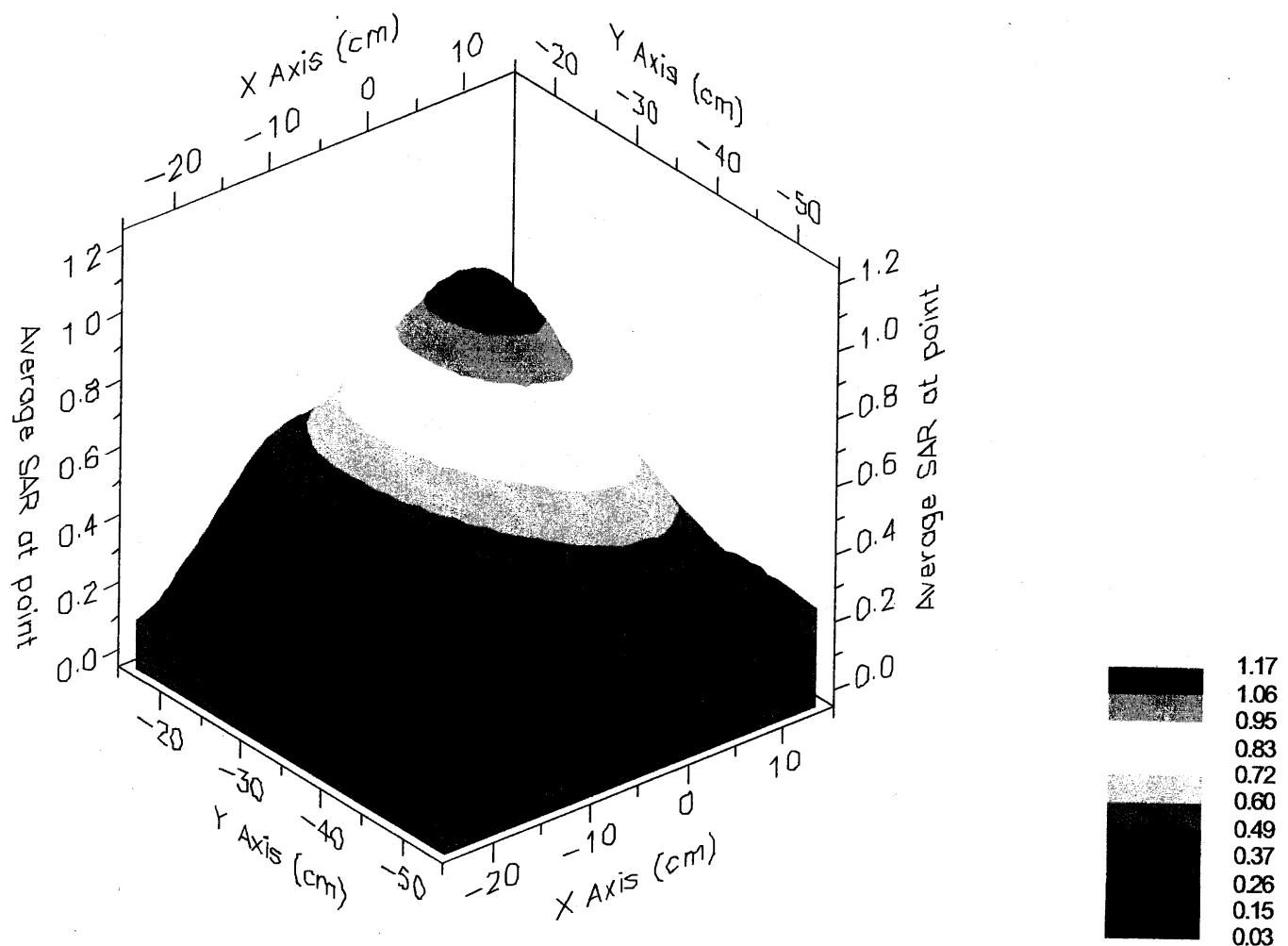
Max 1g SAR at x=-5.0 y=-35.0 z=0.0 = 1.17 W/kg

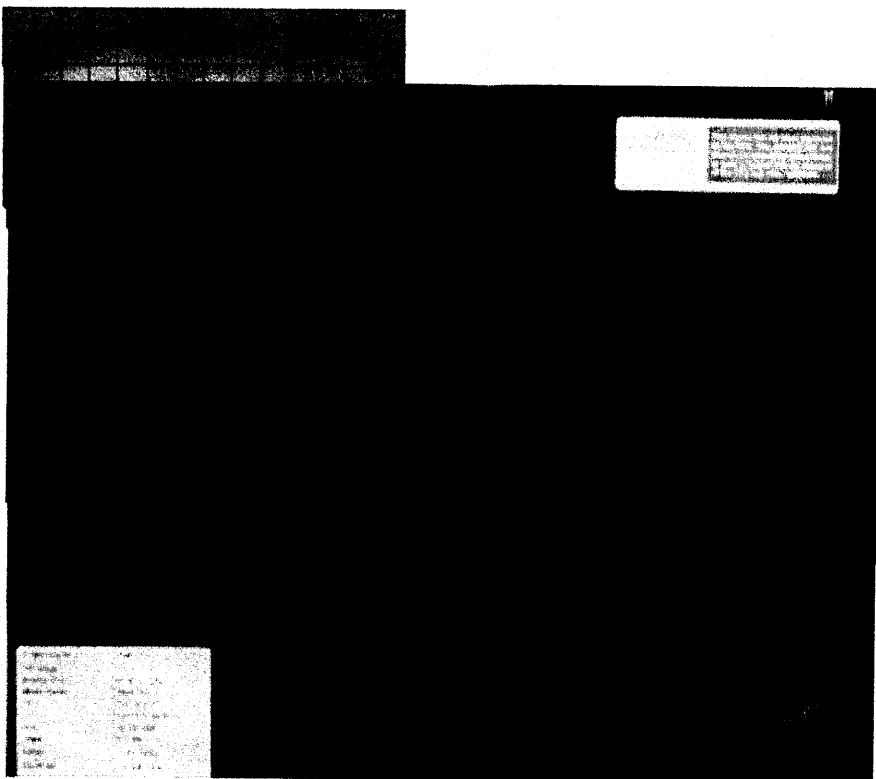
Max 10g SAR at x=-4.0 y=-36.0 z=0.0 = 0.44 W/kg

SAR - Z Axis  
at Hotspot x:-5.0 y:-35.0



### 1g SAR Values





Start : 12-Apr-02 10:23:58 am  
End : 12-Apr-02 10:37:07 am  
Code Version : 4.08  
Robot Version: 4.08

Product Data:

Type : IBM  
Model Number : R32 SERIES  
Serial Number : AA-GD43G  
Frequency : 2437 MHz  
Transmit Pwr : 0.100 W  
Antenna Type : Inverted F  
Antenna Posn. : Internal

Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Muscle  
Tissue Dielectric : 52.000  
Tissue Conductivity : 1.920  
Tissue Density : 1.000  
Robot Name : CRS

Probe Data:

Probe Name : PCT001  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Muscle  
Calibrated Dielectric : 52.200  
Calibrated Conductivity : 1.950  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.500  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

Comments:

IBM Thinkpad R32 Series w/ Integrated Wireless LAN  
CH-06 (11 MBps)  
CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C

Area Scan - Max Peak SAR Value at x=-5.0 y=-40.0 = 0.71 W/kg

Zoom Scan - Max Peak SAR Value at x=-5.0 y=-39.0 z=0.0 = 1.62 W/kg

Max 1g SAR at x=-4.0 y=-39.0 z=0.0 = 0.75 W/kg

Max 10g SAR at x=-3.0 y=-39.0 z=0.0 = 0.29 W/kg

Start : 12-Apr-02 10:39:02 am  
End : 12-Apr-02 10:51:58 am  
Code Version : 4.08  
Robot Version: 4.08

## Product Data:

Type : IBM  
Model Number : R32 SERIES  
Serial Number : AA-GD43G  
Frequency : 2462 MHz  
Transmit Pwr : 0.100 W  
Antenna Type : Inverted F  
Antenna Posn. : Internal

## Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Muscle  
Tissue Dielectric : 52.000  
Tissue Conductivity : 1.920  
Tissue Density : 1.000  
Robot Name : CRS

## Probe Data:

Probe Name : PCT001  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Muscle  
Calibrated Dielectric : 52.200  
Calibrated Conductivity : 1.950  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.500  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

## Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

## Comments:

IBM Thinkpad R32 Series w/ Integrated Wireless LAN  
CH-11 (11 MBps)  
CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C

Area Scan - Max Peak SAR Value at x=-5.0 y=-40.0 = 0.60 W/kg

Zoom Scan - Max Peak SAR Value at x=-4.0 y=-40.0 z=0.0 = 1.72 W/kg

Max 1g SAR at x=-4.0 y=-40.0 z=0.0 = 0.73 W/kg

Max 10g SAR at x=-3.0 y=-40.0 z=0.0 = 0.27 W/kg

Start : 12-Apr-02 10:53:07 am  
End : 12-Apr-02 11:06:09 am  
Code Version : 4.08  
Robot Version: 4.08

Product Data:

Type : IBM  
Model Number : R32 SERIES  
Serial Number : AA-GD43G  
Frequency : 2412 MHz  
Transmit Pwr : 0.100 W  
Antenna Type : Inverted F  
Antenna Posn. : Internal

Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Muscle  
Tissue Dielectric : 52.000  
Tissue Conductivity : 1.920  
Tissue Density : 1.000  
Robot Name : CRS

Probe Data:

Probe Name : PCT001  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Muscle  
Calibrated Dielectric : 52.200  
Calibrated Conductivity : 1.950  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.500  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

Comments:

IBM Thinkpad R32 Series w/ Integrated Wireless LAN  
CH-1 (2 MBps)  
CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C

Area Scan - Max Peak SAR Value at x=-5.0 y=-41.0 = 0.83 W/kg

Zoom Scan - Max Peak SAR Value at x=-5.0 y=-41.0 z=0.0 = 2.20 W/kg

Max 1g SAR at x=-5.0 y=-40.0 z=0.0 = 0.98 W/kg

Max 10g SAR at x=-5.0 y=-39.0 z=0.0 = 0.38 W/kg

Start : 12-Apr-02 02:08:54 pm  
End : 12-Apr-02 02:22:20 pm  
Code Version : 4.08  
Robot Version: 4.08

## Product Data:

Type : IBM  
Model Number : R32 SERIES  
Serial Number : AA-GD43G  
Frequency : 2412 MHz  
Transmit Pwr : 0.100 W  
Antenna Type : Inverted F  
Antenna Posn. : Internal

## Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Muscle  
Tissue Dielectric : 52.000  
Tissue Conductivity : 1.920  
Tissue Density : 1.000  
Robot Name : CRS

## Probe Data:

Probe Name : PCT001  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Muscle  
Calibrated Dielectric : 52.200  
Calibrated Conductivity : 1.950  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.500  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

## Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

## Comments:

IBM Thinkpad R32 Series w/ Integrated Wireless LAN  
CH-1 (11 MBps), 2mm spacing  
CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C

Area Scan - Max Peak SAR Value at x=-4.0 y=-45.0 = 0.60 W/kg

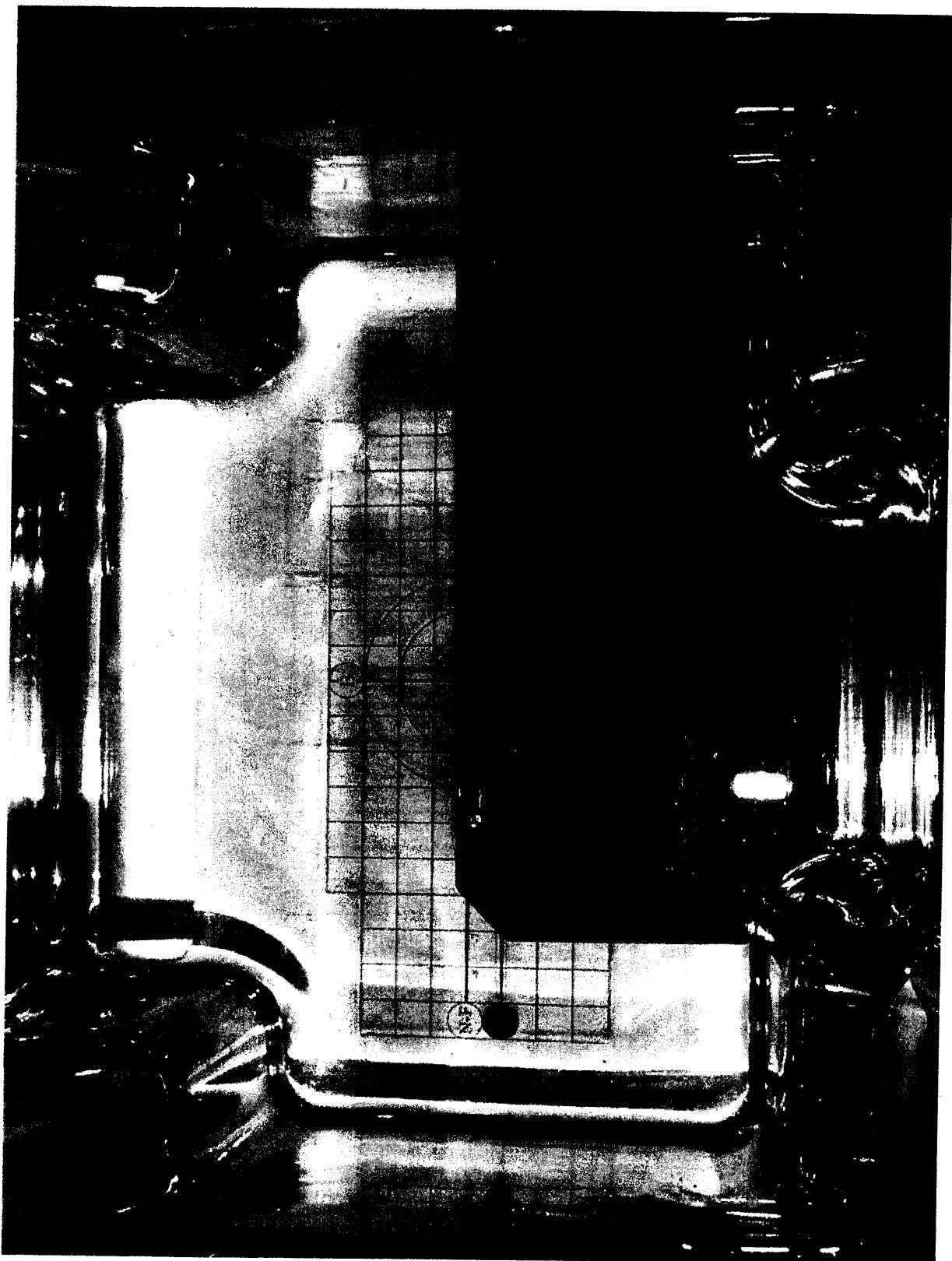
Zoom Scan - Max Peak SAR Value at x=-3.0 y=-50.0 z=0.0 = 1.26 W/kg

Max 1g SAR at x=-3.0 y=-44.0 z=0.0 = 0.64 W/kg

Max 10g SAR at x=-2.0 y=-44.0 z=0.0 = 0.28 W/kg

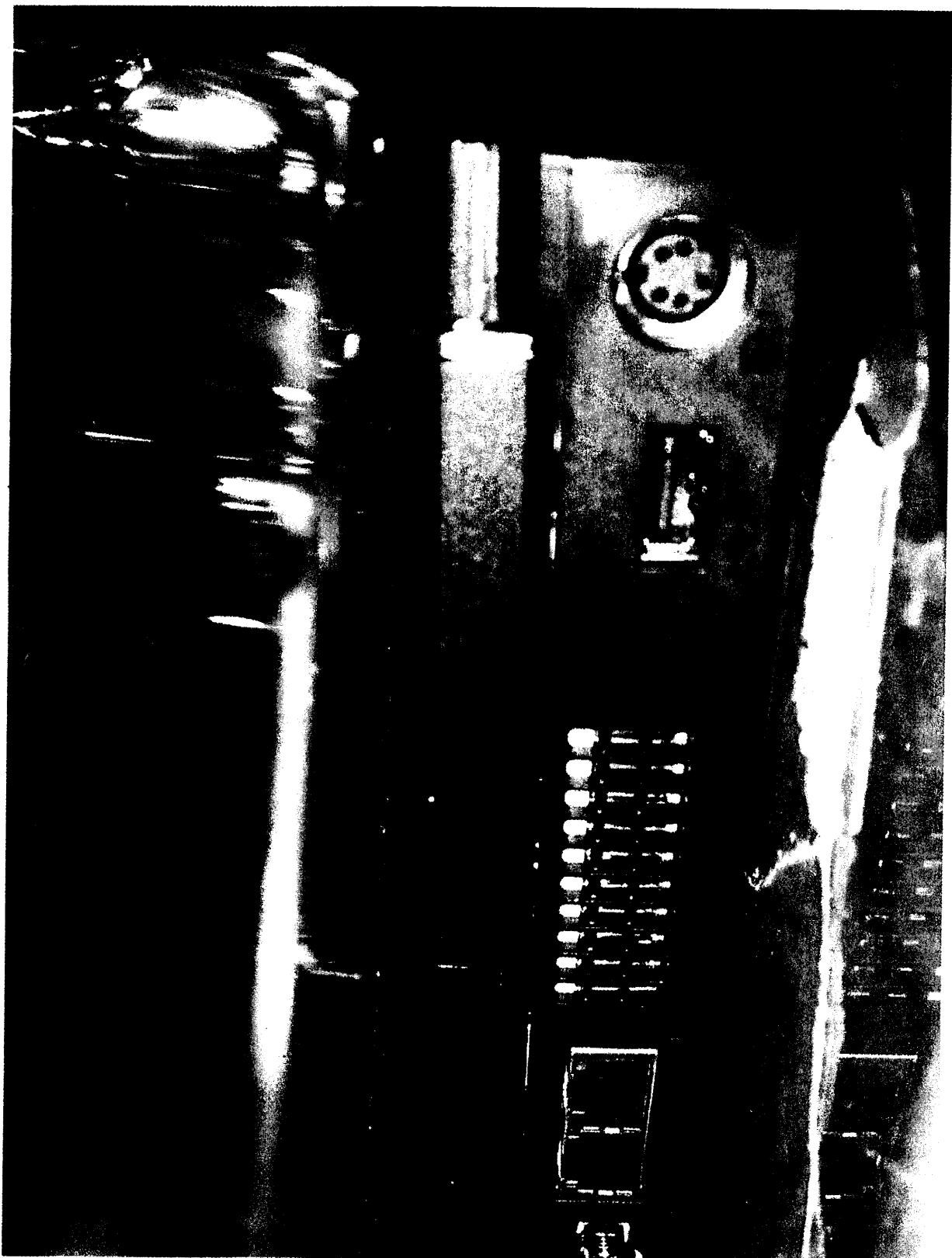
## **ATTACHMENT B – SAR TEST SETUP PHOTOGRAPHS**

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*IBM Thinkpad Model: R32 Series  
Thinkpad with 2.4GHz Integrated Cisco Wireless LAN*



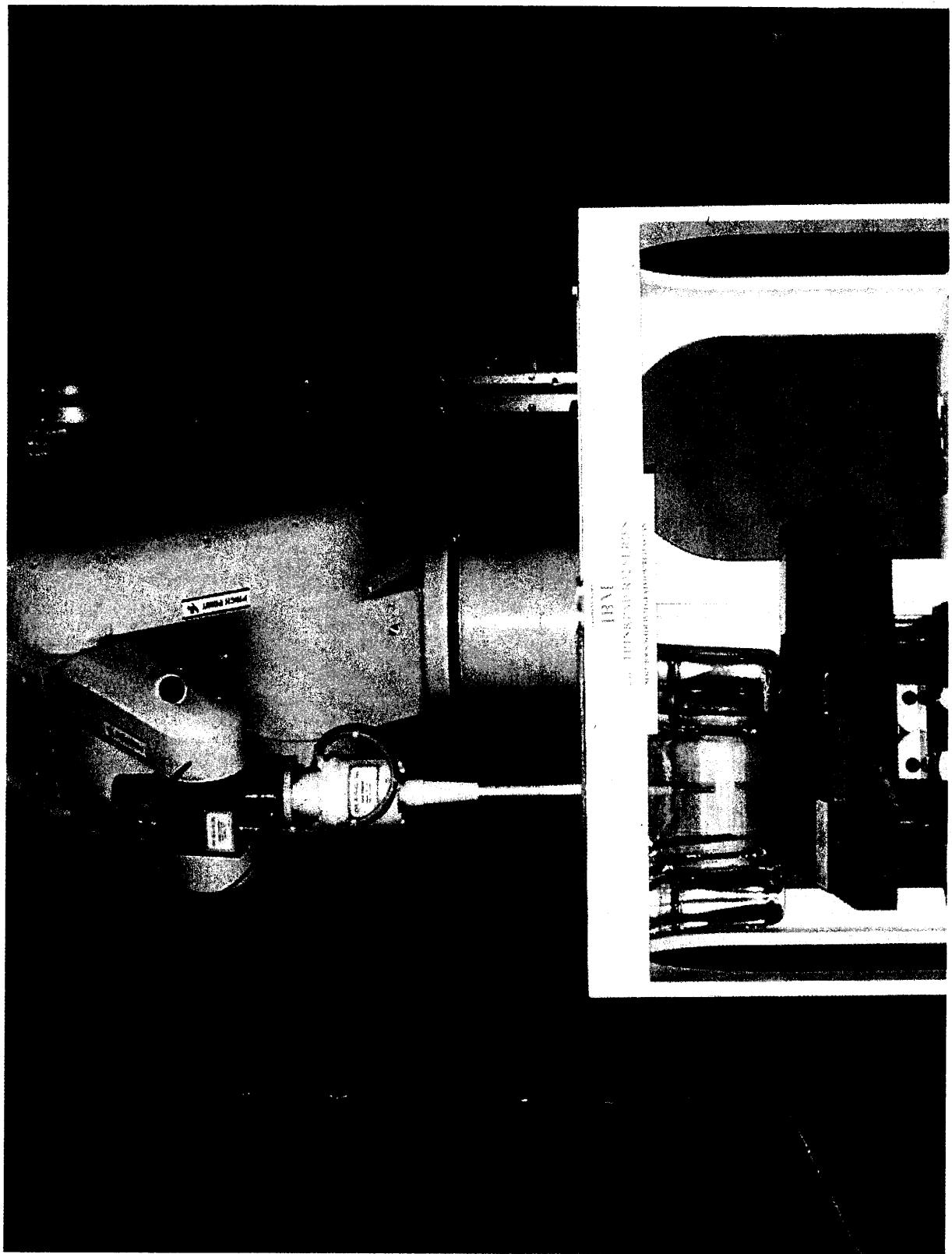
© 2002 PCTEST Lab

*IBM Thinkpad Model: R32 Series  
Thinkpad with 2.4GHz Integrated Cisco Wireless LAN*



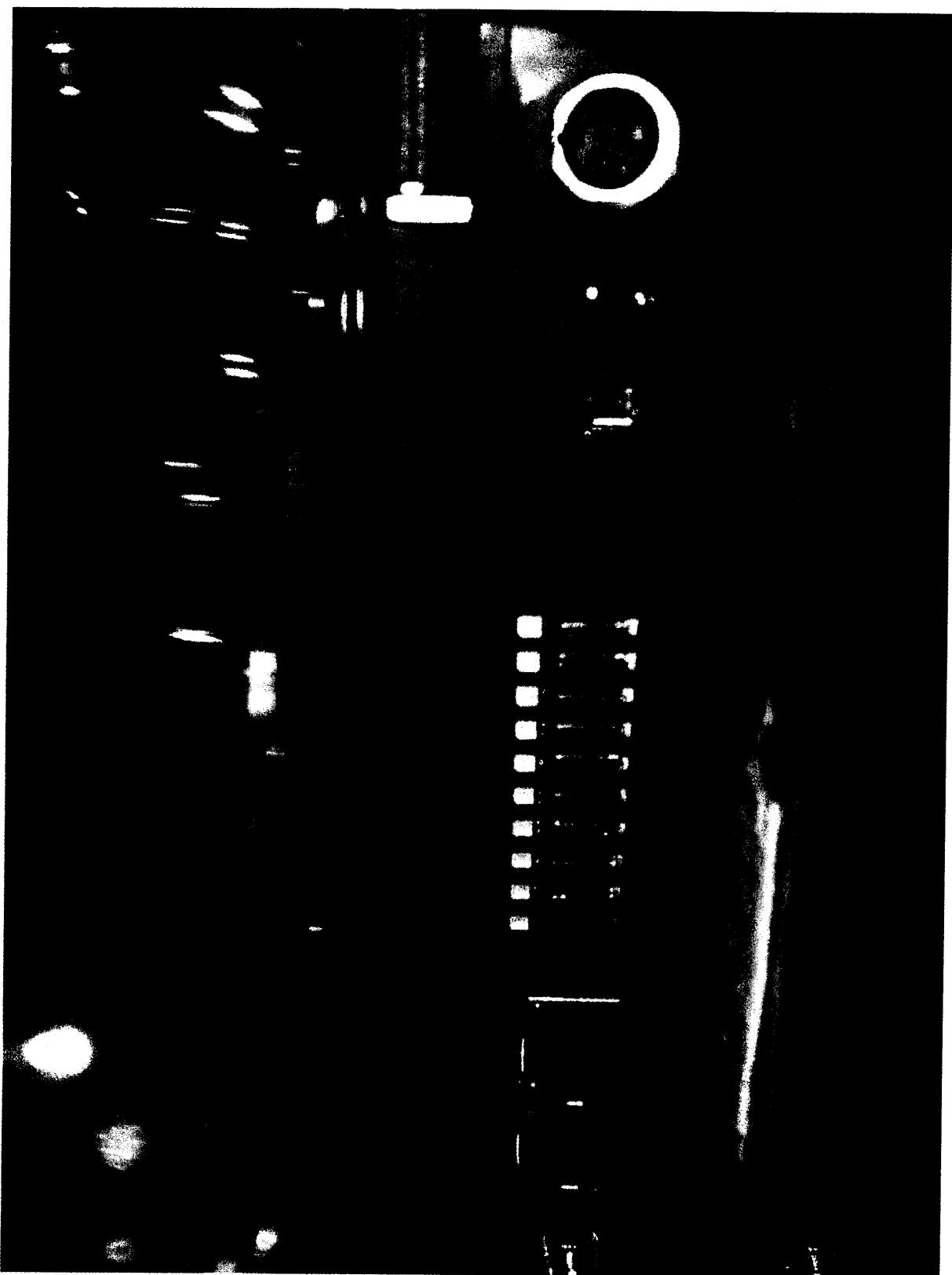
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*IBM Thinkpad Model: R32 Series  
Thinkpad with 2.4GHz Integrated Cisco Wireless LAN*



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*IBM Thinkpad Model: R32 Series  
Thinkpad with 2.4GHz Integrated Cisco Wireless LAN*



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*IBM Thinkpad Model: R32 Series  
Thinkpad with 2.4GHz Integrated Cisco Wireless LAN*

## **ATTACHMENT C – DIPOLE VALIDATION PLOTS**

---

Start : 25-Mar-02 08:25:49 am  
End : 25-Mar-02 08:37:52 am  
Code Version : 4.08  
Robot Version: 4.08

## Product Data:

Type : Validation  
Frequency : 2450 MHz  
Transmit Pwr : 0.250 W  
Antenna Type : Dipole

## Measurement Data:

Phantom Name : SAM-FLAT  
Phantom Type : Uniphantom  
Tissue Type : Brain  
Tissue Dielectric : 39.400  
Tissue Conductivity : 1.880  
Tissue Density : 1.000  
Robot Name : CRS

## Probe Data:

Probe Name : PCT25  
Probe Type : E Fld Triangle  
Frequency : 2450 MHz  
Tissue Type : Brain  
Calibrated Dielectric : 37.100  
Calibrated Conductivity : 1.840  
Calibrated Density : 1.000  
Probe Offset : 2.400 mm  
Conversion Factor : 16.400  
Probe Sensitivity : 0.753 0.726 0.683 mV/(mW/cm<sup>2</sup>)  
Amplifier Gains : 20.00 20.00 20.00

## Sample:

Rate: 6000 Samples/Sec  
Count: 100 Samples  
NIDAQ Gain: 5

## Comments:

2450 MHz Validation  
SN: 146  
CF=1; Amb. Temp.=22.01'C; Liq. Temp.=21.8'C

Area Scan - Max Peak SAR Value at x=-1.0 y=-2.0 = 15.33 W/kg

Zoom Scan - Max Peak SAR Value at x=-1.0 y=-2.0 z=0.0 = 25.43 W/kg

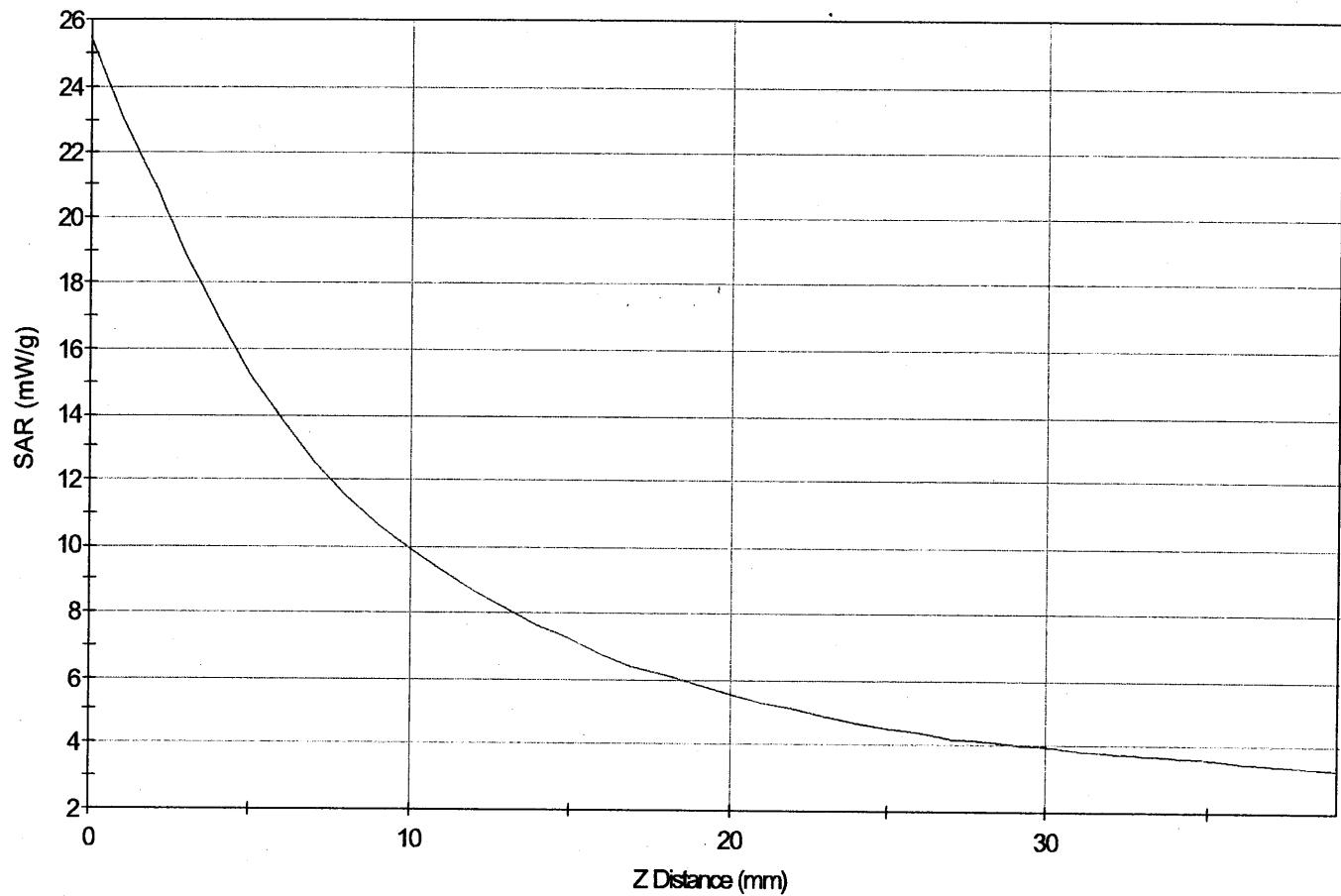
Max 1g SAR at x=-1.0 y=-2.0 z=0.0 = 13.00 W/kg

Max 10g SAR at x=-1.0 y=-2.0 z=0.0 = 8.67 W/kg

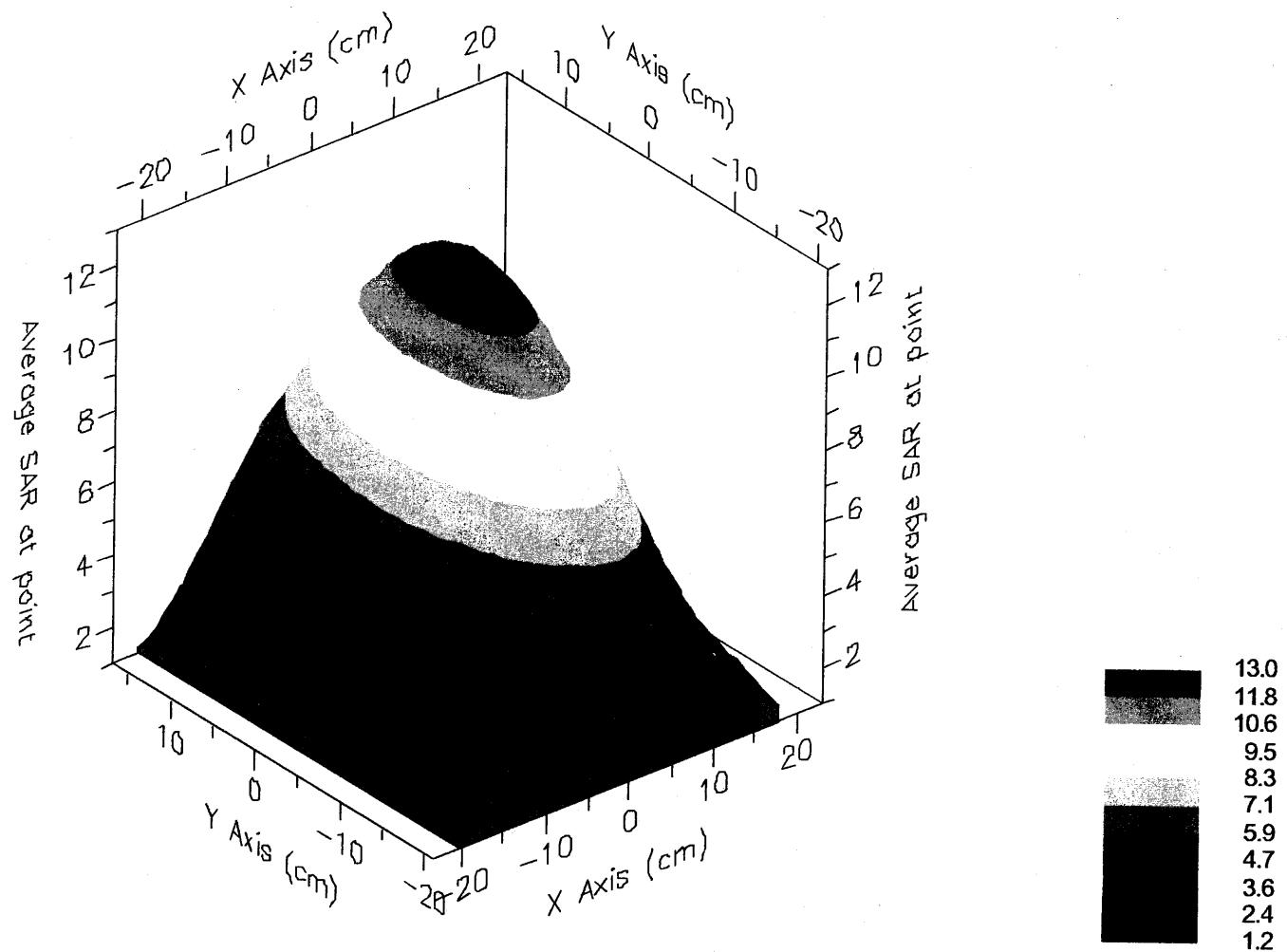
## Validation Results at 0.25 W:

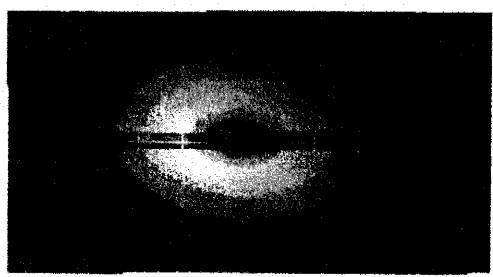
Peak Nominal = 26.0, Error: -2.38 %  
1g Nominal = 13.1, Error: -0.80 %  
10g Nominal = 8.5, Error: 2.00 %

SAR - Z Axis  
at Hotspot x:-1.0 y:-2.0



### 1g SAR Values





## **ATTACHMENT D – PROBE CALIBRATION DATA**

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# Probe E-010

SN: PCT002

Manufactured:

October 19, 2001

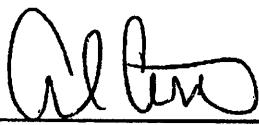
Calibrated:

February 4, 2002

Calibrated for the IDX System

PCTEST Calibration Laboratory

Approved By:



**Alfred Cirwithian**  
Vice President Engineering

# NCL CALIBRATION LABORATORIES

Calibration File No.: IDX-B-CAL-0051

## 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

Manufacturer: APREL Laboratories/IDX Robotics Inc

Model No.: E-010

Serial No.: 146

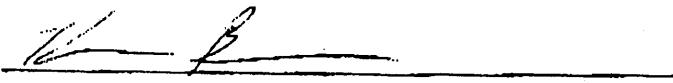
Customer: IDX Robotics Inc

Asset No.:

Calibration Procedure: SSI/DRB-TP-D01-032

Cal. Date: 04 January, 2002      Cal. Due Date: 03 January, 2003

Remarks: None

Calibrated By: 

### **NCL CALIBRATION LABORATORIES**

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

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

**NCL Calibration Laboratories**

Division of APREL Lab.

**CALIBRATION RECORD**

Customer: IDX Robotics Inc  
Asset No: N/A  
Equipment Type: Miniature Isotropic RF Probe  
Manufacturer: APREL Laboratories / IDX Robotics Inc.  
Model No: E-010  
Serial No: 146  
Date: 4-January-2002 Cal. Due: 3-January-2003  
Project No: IDX-B-E010 Probe -3855  
Calibration Procedure: SSI/DRB-TP-D01-032  
Environmental Conditions: Temp: 24.7°C Humidity: 30% - 55%

**REFERENCES:**

1. Directional Coupler, Hewlett Packard, model 767D, asset # 100251
2. RF Power Meter, Rohde & Schwarz, model NRVS, asset # 100851
3. RF Power Sensor, Rohde & Schwarz, model NRV-Z7, asset # 301461
4. Precision Guildline, Thermometer, asset # 301414
5. ALIDX-500 Near-Field Broadband Measurement System, asset #301471
6. APREL Microwave Power Amplifier 800-4200 MHz, AL-RFA-A, asset # 301467
7. 83640B Signal Generator, Hewlett Packard, s/n 3844A00689, asset #301468
8. Aprel Flat Phantom, model P-V-G2
9. Aprel 835 MHz Dipole, asset# 301463
10. Aprel 1900 MHz Dipole, asset# 301459
11. Aprel 2450 MHz Dipole, asset# 301470

**NCL Calibration Laboratories**

Division of APREL Lab.

**CALIBRATION DATA**

<b>PHYSICAL PROBE DATA</b>	
<b>OFFSET</b> [cm]	<b>ANGLE</b> [°]
0.24	54.73

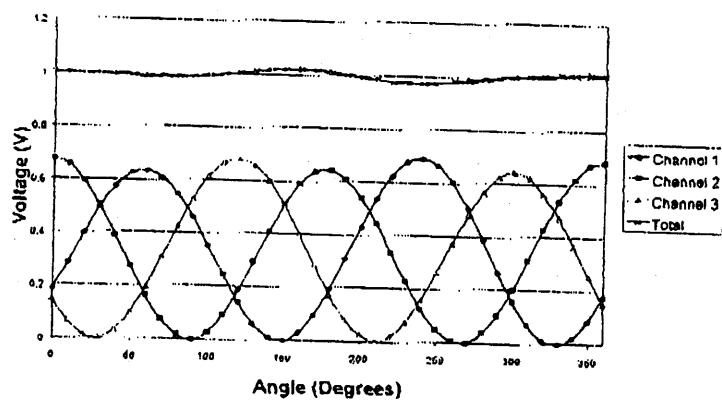
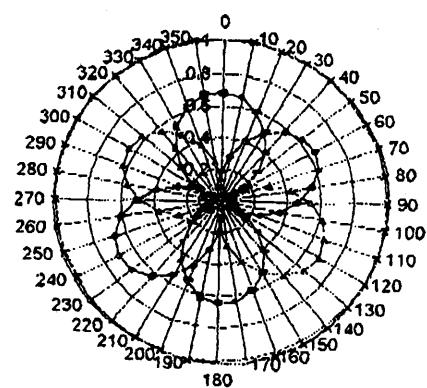
TISSUE TYPE [MHz]	FREQUENCY	DIELECTRIC CONSTANT	CONDUCTIVITY [S/m]	CONVERSION FACTOR [W/kg]
Head	835	40.7	0.89	5.3
Head	1900	37.2	1.36	6.5
Head	2450	37.1	1.84	16.4
Body	835	51.4	1.02	7.6
Body	1900	49.9	1.48	4.9
Body	2450	49.2	1.95	16.5

FREQUENCY MHz	ISOTROPICITY	
	[%]	[dB]
835	2.28	0.098
1900	2.33	0.100
2450	3.06	0.130

**NCL Calibration Laboratories**

Division of APREL Lab.

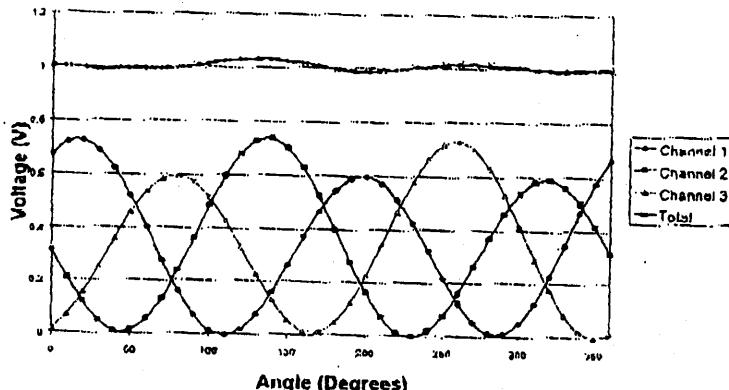
Media Type	Frequency [MHz]	Sensitivity One	Sensitivity Two	Sensitivity Three
Air	835	2.607	2.525	2.310
	1900	1.717	1.651	1.539
	2450	0.753	0.726	0.683

**Probe Sensitivity @ 835 MHz****Probe Isotropicity @ 835 MHz**

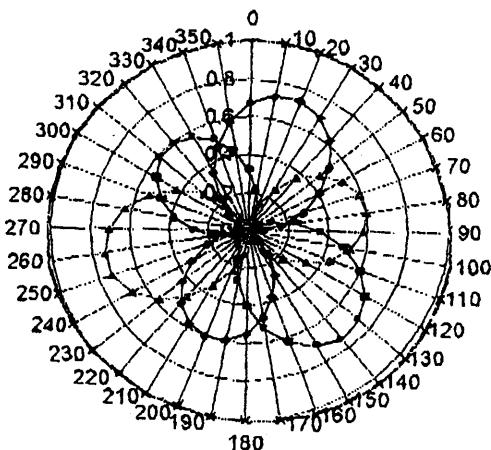
**NCL Calibration Laboratories**

Division of APREL Lab.

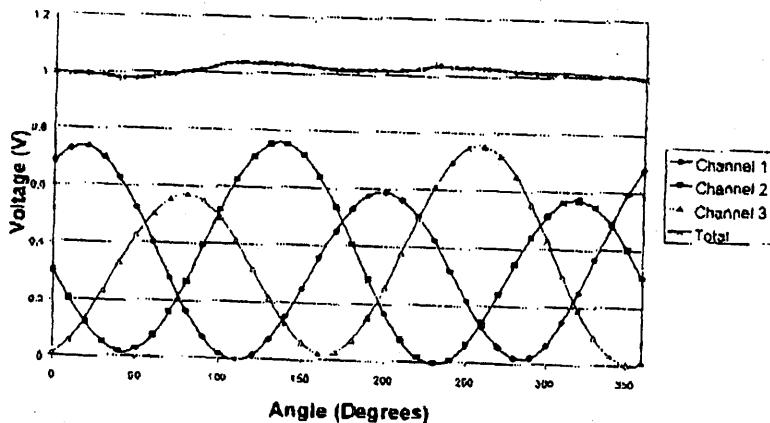
**Probe Sensitivity @ 1900 MHz**



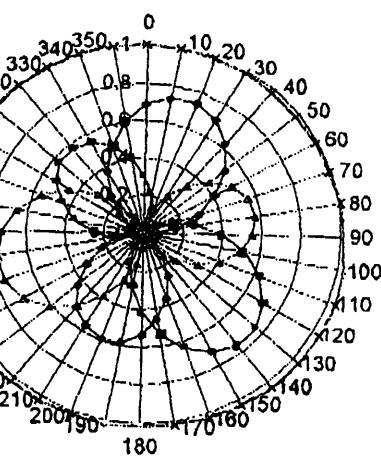
**Probe Isotropicity @ 1900 MHz**



**Probe Sensitivity @ 2450 MHz**



**Probe Isotropicity @ 1900 MHz**



**NCL Calibration Laboratories**

Division of APREL Lab.

**Diode Coeficients:****Head @ 835 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	17647.6932	2369.9381	75.3044	0.000	0.0114	0.000
Ch 2	10832.1943	2342.2166	72.3226	0.000	0.0118	0.000
Ch 3	9414.6867	2022.8348	70.5819	0.000	0.0122	0.000

**Head @ 1900 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	-2362.0677	637.0043	28.2909	0.000	0.0277	0.000
Ch 2	-1982.8538	638.6514	29.9573	0.000	0.0266	0.000
Ch 3	-1734.1836	521.2650	26.2919	0.000	0.0300	0.000

**Head @ 2450 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	-109.001	117.023	13.316	0.000	0.0605	0.000
Ch 2	-119.2711	147.7542	16.5049	0.000	0.0505	0.000
Ch 3	-82.0453	141.6560	16.9832	0.000	0.0497	0.000

**Body @ 835 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	21601.9208	2341.4606	78.4357	0.000	0.0110	0.000
Ch 2	20199.6316	2324.5954	77.3192	0.000	0.0112	0.000
Ch 3	16725.4970	1934.4608	72.9045	0.000	0.0119	0.000

**NCL Calibration Laboratories**

Division of APREL Lab.

**Body @ 1900 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	-1886.1061	634.6289	30.3410	0.000	0.0264	0.000
Ch 2	-1361.7386	609.2873	29.8092	0.000	0.0269	0.000
Ch 3	-1332.9929	530.4801	28.5545	0.000	0.0283	0.000

**Body @ 2450 MHz:**

Channel	Cn 1	Cn2	Cn3	Cn4	Mn	Bn
Ch 1	100.3391	136.3802	18.5429	0.000	0.0466	0.000
Ch 2	-119.2711	147.7542	16.5049	0.000	0.0505	0.000
Ch 3	-82.0453	141.6560	16.9832	0.000	0.0497	0.000

**ATTACHMENT E – COPY OF INTERNAL FHSS LAN RADIO CARD  
FCC GRANT**

---

FEDERAL COMMUNICATIONS  
COMMISSION  
WASHINGTON, D.C. 20554

GRANT OF EQUIPMENT  
AUTHORIZATION  
Certification

Symbol Technologies Inc  
One Symbol Plaza

Date of Grant: 07/31/2000

Holtsville, NY 11742

Application Dated: 04/27/2000

Attention: Sandy Mazzola

**NOT TRANSFERABLE**

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER H9PLA4121  
Name of Grantee Symbol Technologies Inc

Equipment Class: Part 15 Spread Spectrum  
Transmitter

Notes: Spectrum 24 HR WLAN PC  
Card

<u>Grant Notes</u>	<u>FCC Rule Parts</u>	<u>Frequency Range (MHz)</u>	<u>Output Watts</u>	<u>Frequency Tolerance</u>	<u>Emission Designator</u>
	15	2412 - 2462	0.135	PM	

This transmitter has 39 antenna configurations, as described in the filing - 35 antenna are for fixed-mount, handheld devices and other non-fixed mobile configurations, and 4 antenna are for portable configurations in specific devices. Grantee must ensure the specific installation instructions and operating requirements are provided to installers, end-users and other responsible parties of all product configurations operating with this transmitter for satisfying RF exposure requirements.

Mail To:

Norman Nelson, Sr. EMC Engineer  
Symbol Technologies, Inc.  
6480 Via Del Oro Drive  
San Jose, CA 95119-1208

EA97459