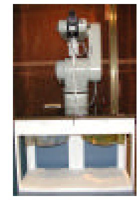
PCTEST ENGINEERING LABORATORY, INC.

6660 – B Dobbin Road · Columbia, MD 21045 · USA
Telephone 410.290.6652 / Fax 410.290.6654
http://www.pctestlab.com (email: randy@pctestlab.com)



CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

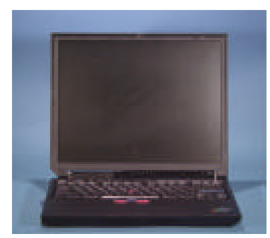
APPLICANT NAME & ADDRESS:
IBM Japan, Ltd.
1623-14, Shimotsuruma, Yamato-shi
Kangawa 242-8502, Japan
Attn: Takeshi Asami, Consumer & OEM Product

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 (20.0 dBm)**
Max. SAR Measurement:	**1.17 W/kg DSSS Body SAR**
Trade Name/Model(s):	***IBM/* ThinkPad R32 w/ Wireless LAN**
FCC Classification:	**Part 15 Spread Spectrum Transmitter (DSS)**
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

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 (r). 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).

$$SAR = \frac{d}{dt}\left(\frac{dU}{dm}\right) = \frac{d}{dt}\left(\frac{dU}{r\,dv}\right)$$

Figure 1.1
SAR Mathematical Equation

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

$$SAR = s E^2 / r$$

where:

s = conductivity of the tissue-simulant material (S/m)

r = mass density of the tissue-simulant material (kg/m^3)

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]

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

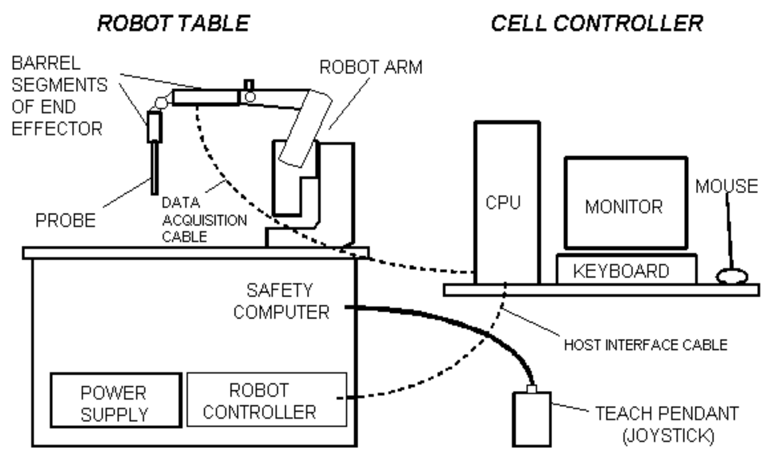


Figure 2.1
SAR Measurement System Setup

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).

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^2 (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

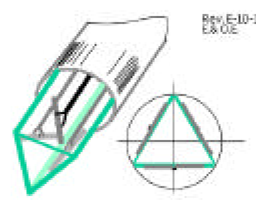


Figure 3.2
Triangular Probe Configuration

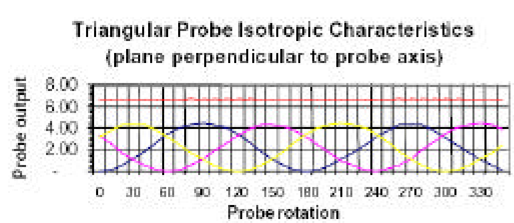


Figure 3.3
Probe Characteristics

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 ($1mW/cm^2$) 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 $1mW/cm^2$.

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).

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

where:

Δt = exposure time (30 seconds),

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

ΔT = temperature increase due to RF exposure.

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;

$$SAR = \frac{|E|^2 \cdot s}{r}$$

where:

σ = simulated tissue conductivity,

ρ = Tissue density ($1.25\ g/cm^3$ for brain tissue)

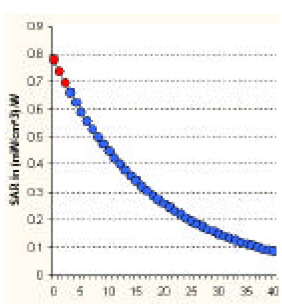


Figure 4.1 E-Field and Temperature measurements at 900MHz

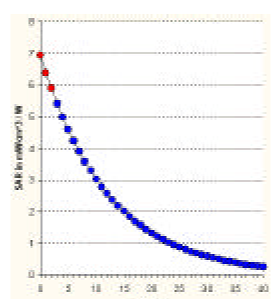


Figure 4.2 E-Field and temperature measurements at 1.9GHz

5. PHANTOM & EQUIVALENT TISSUES

SAM Phantom

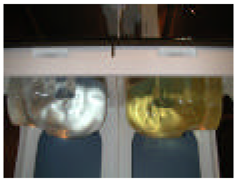


Figure 5.1
SAM Phantoms

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 [7][8]. 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

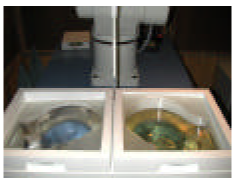


Figure 5.2
Head Simulated Tissue

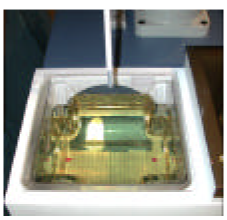


Figure 5.3
Body/Muscle Simulated Tissue

The brain and muscle mixtures consist of a viscous gel using hydroxethylcellulose (HEC) gelling agent and saline solution (see Table 6.1). Preservation with a bacteriacide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 have been incorporated in the following table. Other head and body tissue parameters that have not been specified in P1528 are derived from the issue dielectric parameters computed from the 4-Cole-Cole equations. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Hartsgrove [9].(see Table 5.1)

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   Sugar: 98⁺% Pure Sucrose
Water: De-ionized, 16 MΩ⁺ resistivity   HEC: Hydroxyethyl Cellulose
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 [8]. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

6. TEST SYSTEM SPECIFICATIONS

Automated Test System Specifications

Positioner

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

Figure 6.1
ALIDX-500 Test System

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

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 ± 0.2 mm

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 90th 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 minimized 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

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.

Figure 9.5 Body Belt Clip & Holster Configurations

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.

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

1 The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2 The Spatial Average value of the SAR averaged over the whole body.
3 The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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**
Measurement System									
Probe Calibration	E1.1	6.0	N	1	1	1	6.0	6.0	∞
Axial Isotropy	E1.2	4.88	R	√3	0.5	0.5	1.4	1.4	∞
Hemishperical Isotropy	E1.2	9.6	R	√3	0.5	0.5	2.8	2.8	∞
Boundary Effect	E1.3	11.0	R	√3	1	1	6.4	6.4	∞
Linearity	E1.4	4.7	R	√3	1	1	2.7	2.7	∞
System Detection Limits	E1.5	1.0	R	√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	√3	1	1	0.5	0.5	∞
Integration Time	E1.8	1.7	R	√3	1	1	1.0	1.0	∞
RF Ambient Conditions	E5.1	1.2	R	√3	1	1	0.7	0.7	∞
Probe Positioner Mechanical Tolerance	E5.2	0.4	R	√3	1	1	0.2	0.2	∞
Probe Positioning w/ respect to Phantom Shell	E5.3	2.9	R	√3	1	1	1.7	1.7	∞
Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation	E4.2	3.9	R	√3	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E3.2.1	10.6	R	√3	1	1	6.1	6.1	11
Device Holder Uncertainty	E3.1.1	8.7	R	√3	1	1	5.0	5.0	8
Output Power Variation - SAR drift measurement	5.6.2	5.0	R	√3	1	1	2.9	2.9	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E2.1	4.0	R	√3	1	1	2.3	2.3	∞
Liquid Conductivity - deviation from target values	E2.2	5.0	R	√3	0.7	0.5	2.0	1.4	∞
Liquid Conductivity - measurement uncertainty	E2.2	10.0	R	√3	0.7	0.5	4.0	2.9	∞
Liquid Permittivity - deviation from target values	E2.2	5.0	R	√3	0.6	0.5	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E2.2	5.0	R	√3	0.6	0.5	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				14.4	14.0	
Expanded Uncertainty (k=2) (95% CONFIDENCE LEVEL)							28.8	28.0	

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

11. SYSTEM VERIFICATION

Tissue Verification

Table 11.1 Simulated Tissue Verification

MEASURED TISSUE PARAMETERS									
Date(s)	02/18/02	835MHz Brain		835MHz Muscle		2450MHz Brain		2450MHz Muscle	
Liquid Temperature (°C)	23.5	Target	Measured	Target	Measured	Target	Measured	Target	Measured
Dielectric Constant: ε		41.50	N/A	40.29	N/A	39.2	39.40	52.7	52.00
Conductivity: σ		0.900	N/A	1.44	N/A	1.800	1.88	1.950	1.92

Test System Validation

Prior to assessment, the system is verified to the ±10% of the specifications at 2450MHz by using the system validation kit(s). (Graphic Plots Attached)

Table 11.2 System Validation

	SYSTEM DIPOLE VALIDATION TARGET & MEASURED			
System Validation Kit: D-835S, S/N: 103	835MHz Brain	Targeted SAR_{1g} (mW/g) 2.375	Measured SAR_{1g} (mW/g) **N/A**	Deviation (%) **N/A**
System Validation Kit: D-2450S, S/N: 105	2450MHz Brain	Targeted SAR_{1g} (mW/g) 13.1	Measured SAR_{1g} (mW/g) **12.99**	Deviation (%) + 0.84

Figure 11.1 Dipole Validation Test Setup

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.

SAR DATA SUMMARY

Mixture Type: 2450MHz Muscle

13.1 MEASUREMENT RESULTS (DSSS Body SAR)

FREQUENCY		Modulation	Begin / End POWER‡			Separation Distance (cm)	Antenna Position	SAR (W/kg)
MHz	Ch.		(W)		Battery			
2412	1	DSSS	0.100	0.100	Laptop	Touch	Fixed	**1.17**
2437	6	DSSS	0.100	0.100	Laptop	Touch	Fixed	**0.75**
2462	11	DSSS	0.100	0.100	Laptop	Touch	Fixed	**0.73**
2412	1	DSSS	0.100	0.100	Laptop	0.2	Fixed	**0.64**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Muscle** **1.6 W/kg (mW/g)** averaged over 1 gram		

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.

‡Power Measured ☒ Conducted ☐ ERP ☐ EIRP

4. SAR Measurement System ☐ DASY3 ☒ IDX ☐

Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head

5. SAR Configuration ☐ Head ☒ Body ☐ Hand
6. Test Signal Call Mode ☒ Software ☐ Base Station Simulator

Randy Ortanez
President

Figure 13.1
BODY SAR Test Setup

14. SAR TEST EQUIPMENT

Equipment Calibration

Table 14.1 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	PCTBEM501
Muscle Equivalent Matter (2450MHz)	April 2002	PCTMEM601
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.

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]

16. REFERENCES

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.

[2] ANSI/IEEE C95.1 - 1991, *American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300kHz to 100GHz*, New York: IEEE, Aug. 1992.

[3] ANSI/IEEE C95.3 - 1991, *IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave*, New York: IEEE, 1992.

[4] Federal Communications Commission, OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01), *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, July 2001.

[5] IEEE Standards Coordinating Committee 34 – IEEE Std. 1528-200X (Draft 6.1 – July 2001), *Draft Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques.*

[6] NCRP, National Council on Radiation Protection and Measurements, *Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields*, NCRP Report No. 86, 1986. Reprinted Feb. 1995.

[7] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, *The Dependence of EM Energy Absorption upon Human Head Modeling at 900 MHz*, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.

[8] N. Kuster and Q. Balzano, *Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz*, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.

[9] G. Hartsgrove, A. Kraszewski, A. Surowiec, *Simulated Biological Materials for Electromagnetic Radiation Absorption Studies*, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.

[10] Q. Balzano, O. Garay, T. Manning Jr., *Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones*, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.

[11] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, *Numerical Recepies in C,* The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.

[12] Federal Communications Commission, OET Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Supplement C, Dec. 1997.

[13] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.

SAR Data Report 02041208

```
  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              : PCT25
  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^2)
  Amplifier Gains   :  20.00   20.00   20.00
```

Sample:

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

Comments:

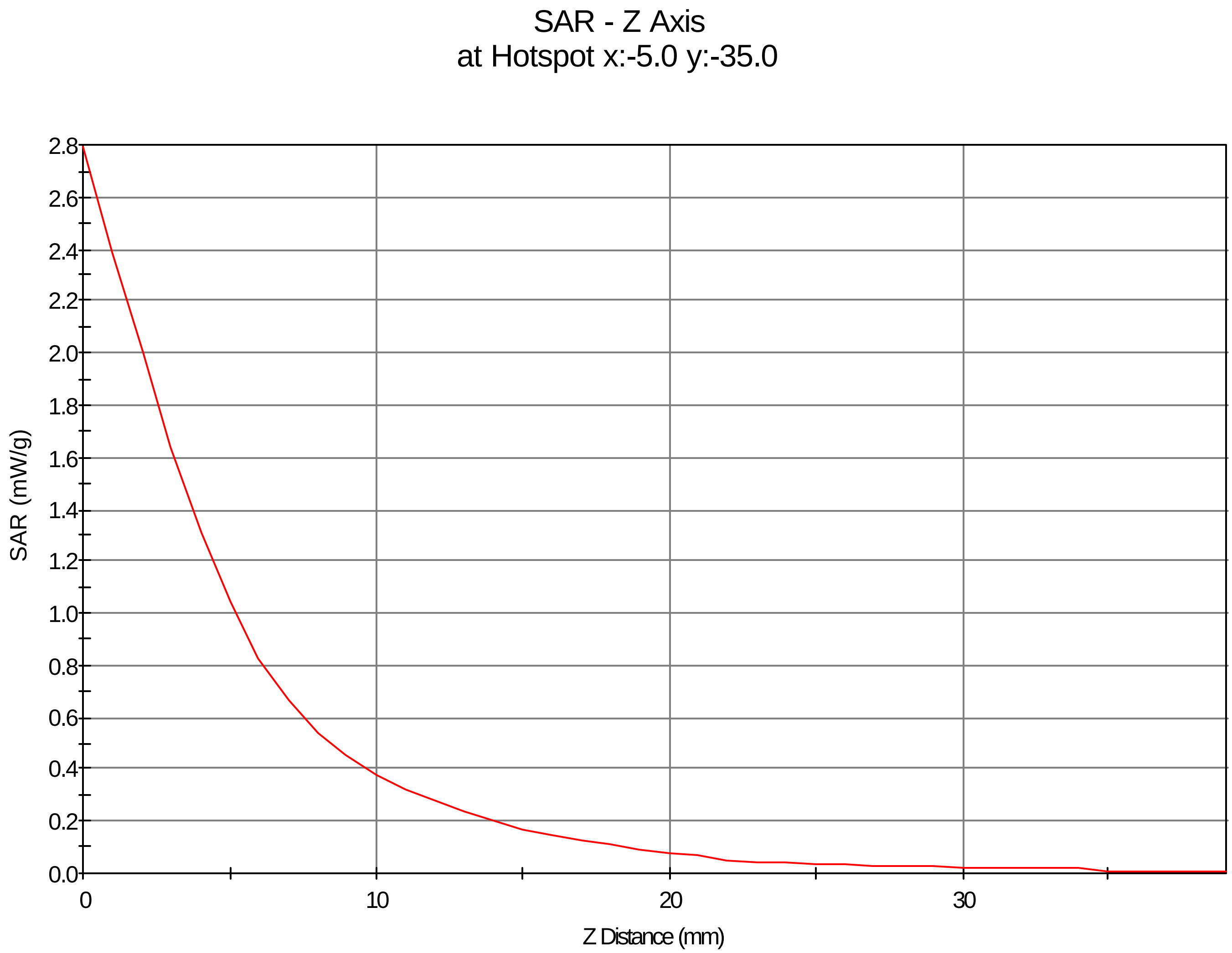
```
  IBM Thinkpad R32 Series w/ Integrated Wireless LAN
  CH-1  (11 MBps)
  CF=1; Amb. Temp= 21.3 'C; Liq. Temp=21.1 'C
```

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

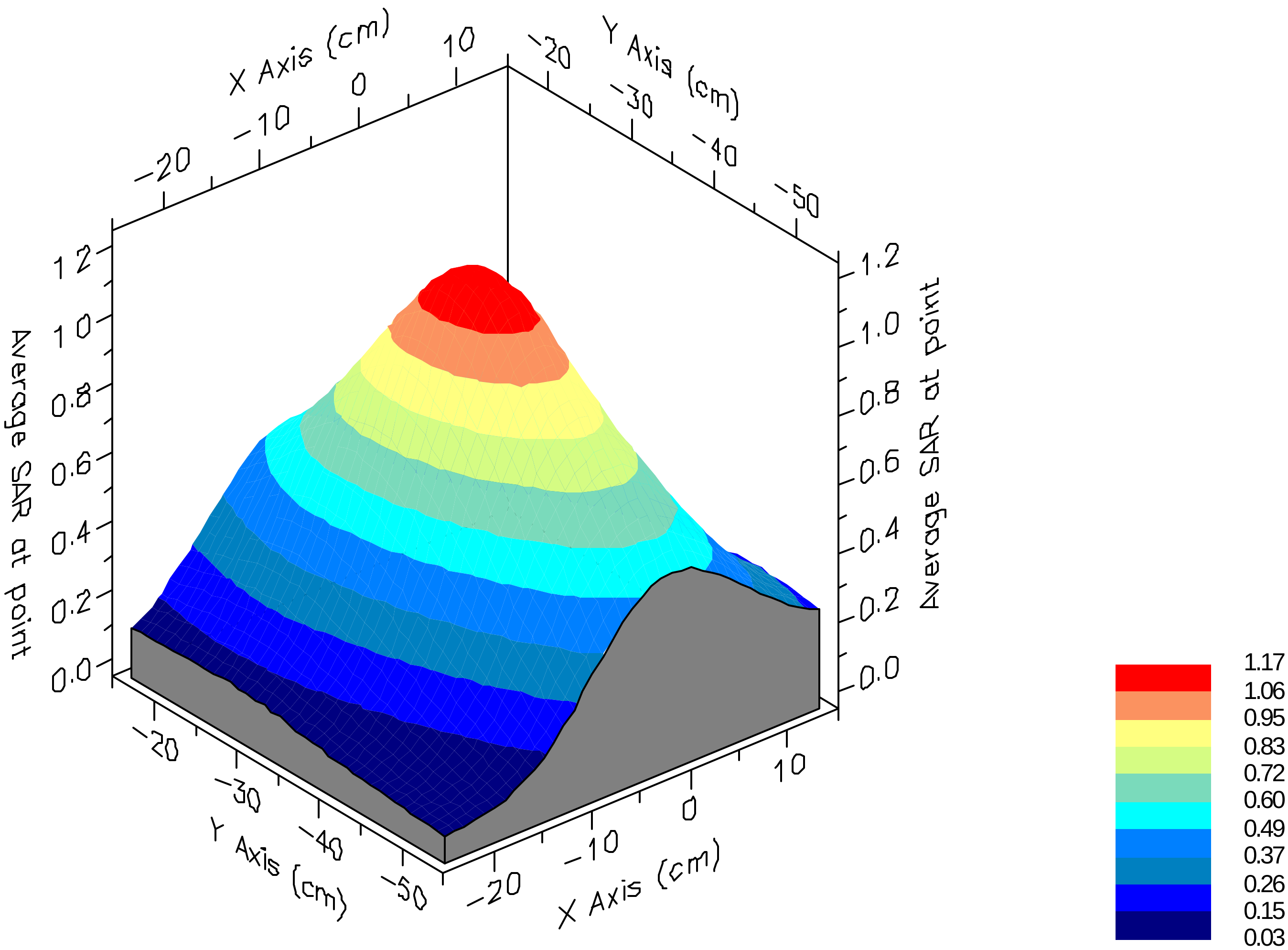
Zoom Scan - Max Peak SAR Value at x=-5.0 y=-35.0 z=0.0 = 2.79 W/kg

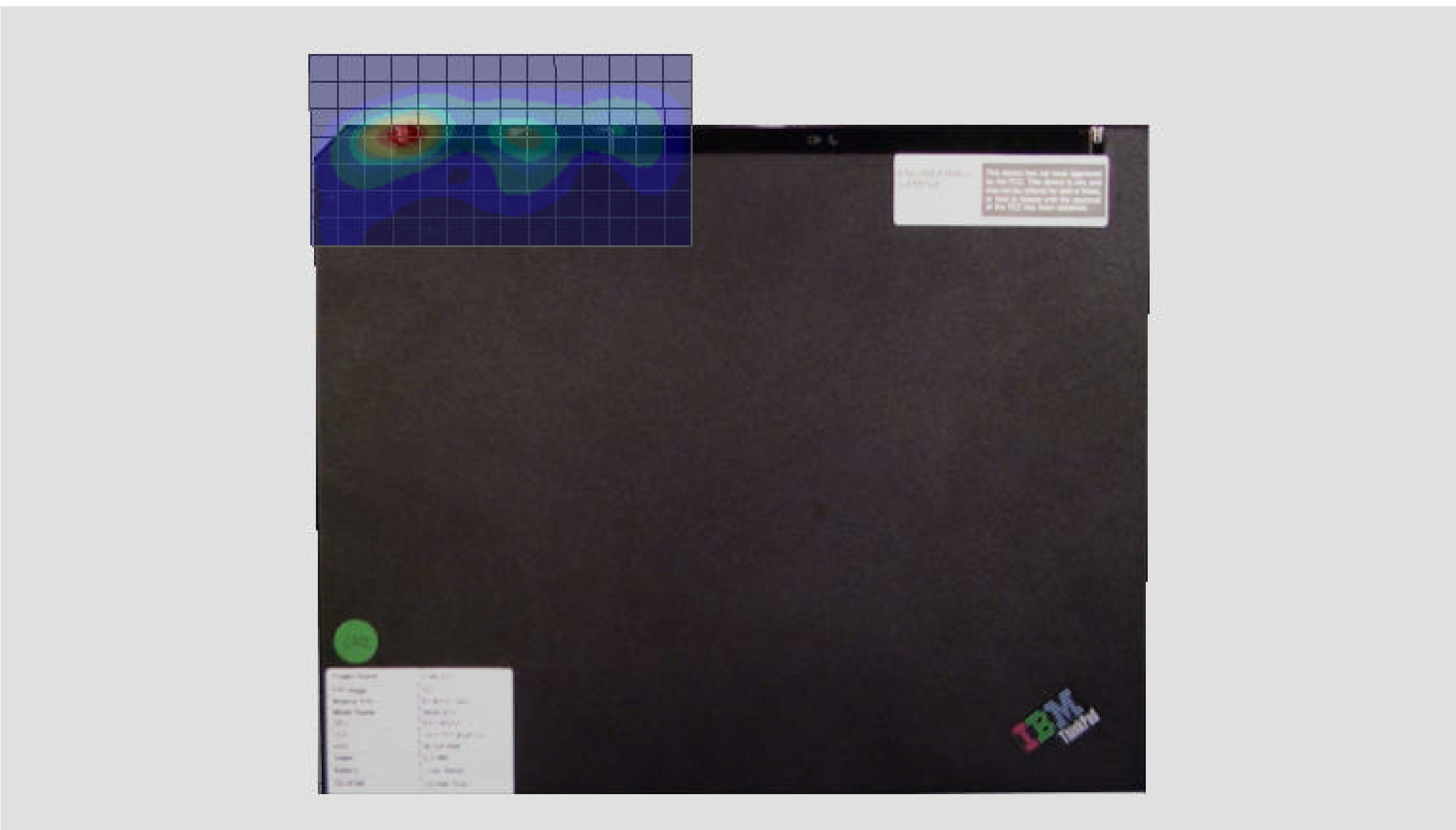
Max 1g SAR at x=-5.0 y=-35.0 z=0.0 = 1.17 W/kg

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
SAR (mW/g)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
Z Distance (mm)

1g SAR Values




IBM

SAR Data Report 02041202

```
  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               : PCT25
  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^2)
  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

```
SAR Data Report 02041204

  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               : PCT25
  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^2)
  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
```

SAR Data Report 02041209

```
  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               : PCT25
  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^2)
  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

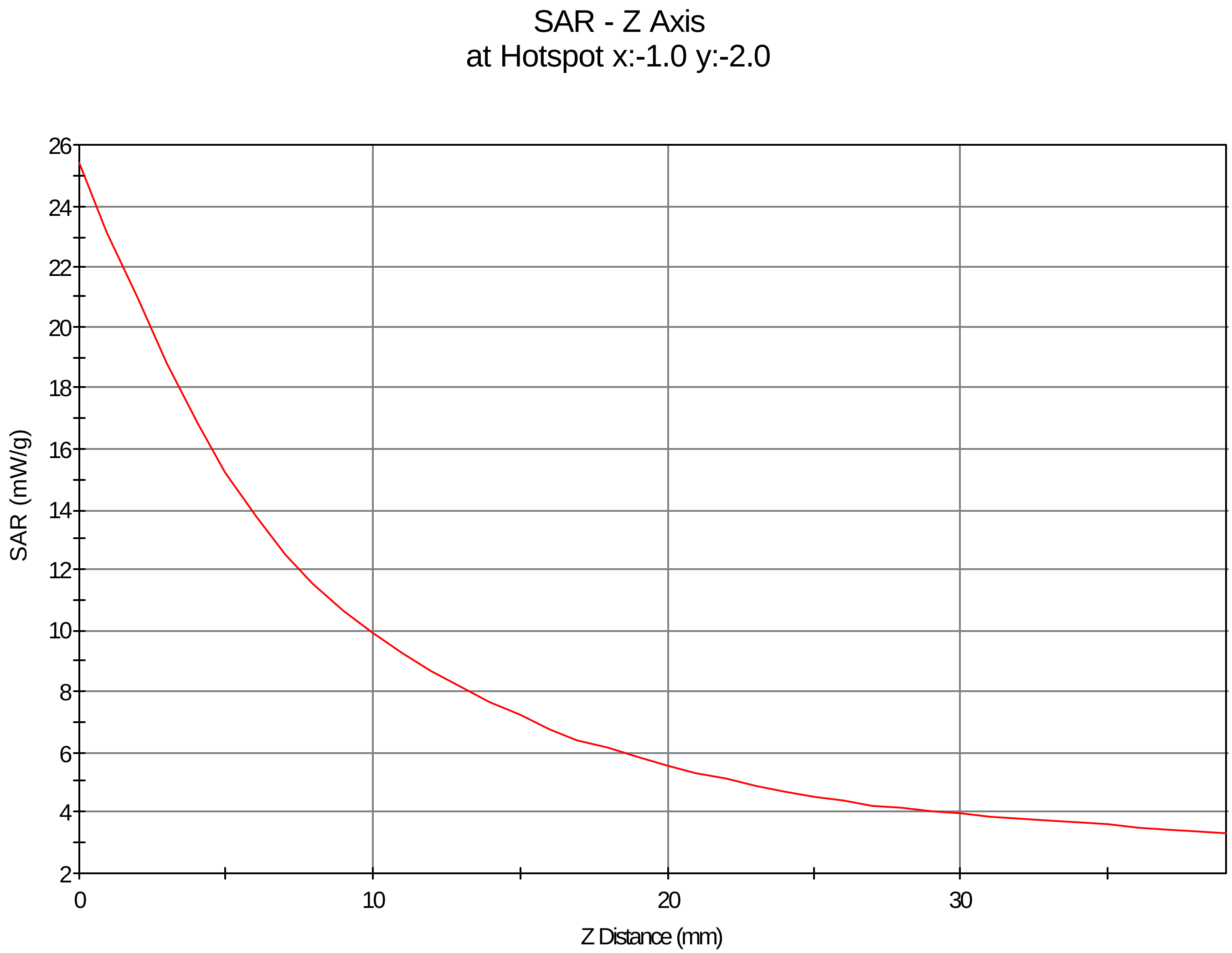
Area Scan - Max Peak SAR Value at x=-4.0 y=-45.0 = 0.60 W/kg

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

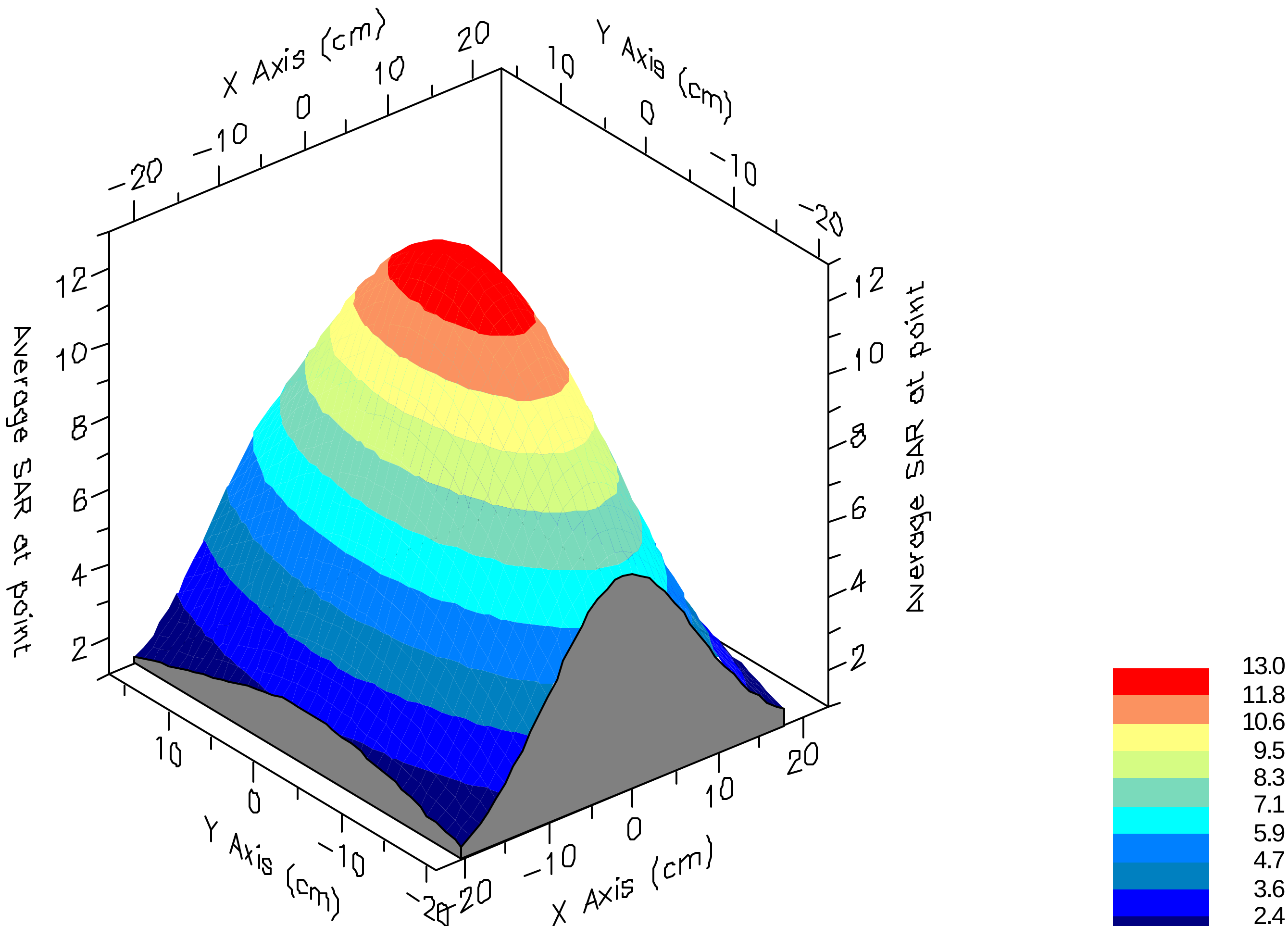
Max 10g SAR at x=-2.0 y=-44.0 z=0.0 = 0.28 W/kg

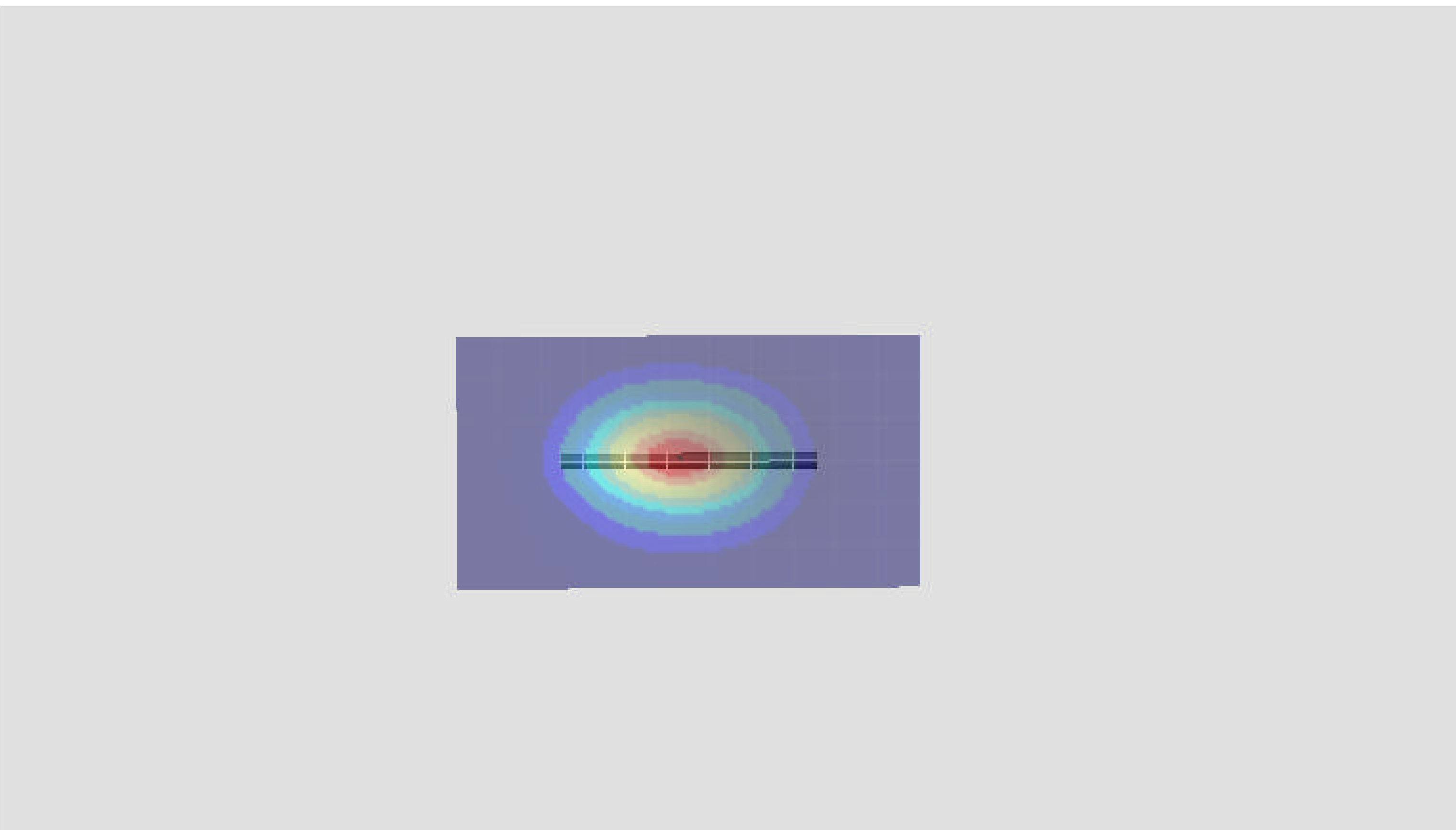
```
SAR Data Report 02041201

  Start        :  12-Apr-02 09:32:48 am
  End          :  12-Apr-02 09:44:50 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^2)
  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.=21.3'C; Liq. Temp.=21.0'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 = 25.42 W/kg

Max 1g SAR at x=-1.0 y=-2.0 z=0.0 = 12.99 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:  -2.23 %
1g Nominal   = 13.1, Error:  -0.84 %
10g Nominal  = 8.5, Error:  2.00 %
```



SAR - Z Axis
at Hotspot x:-1.0 y:-2.0
SAR (mW/g)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
10
20
30
Z Distance (mm)

1g SAR Values





NCL CALIBRATION LABORATORIES

Calibration File No.: IDXB-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

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:	IDXB-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

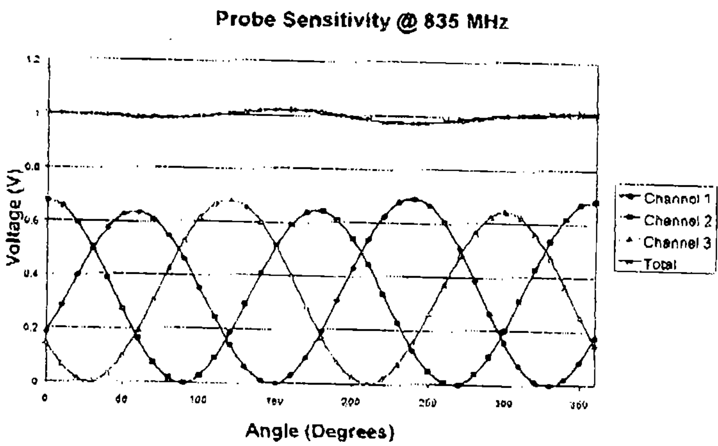
CALIBRATION DATA

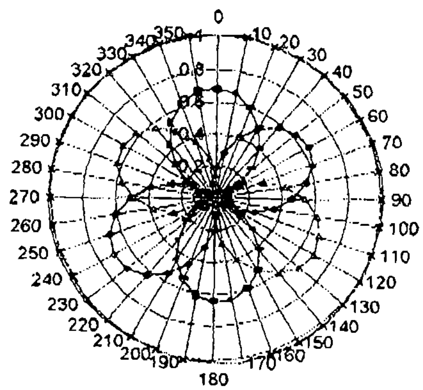
PHYSICAL PROBE DATA	
OFFSET [cm]	ANGLE [°]
0.24	54.73

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

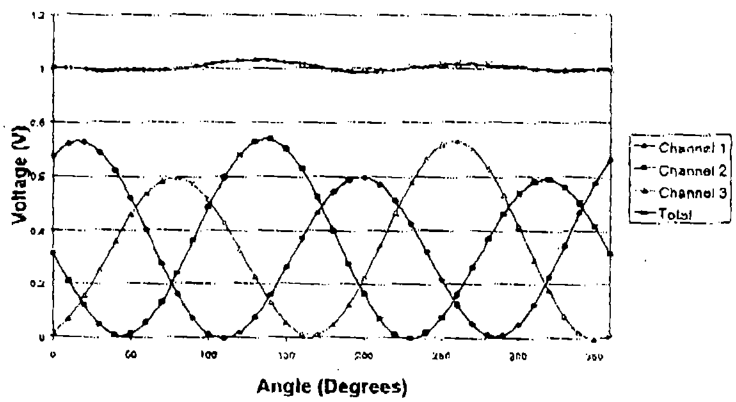
FREQUENCY MHz	ISOTROPICITY [%]	[dB]
835	2.28	0.098
1900	2.33	0.100
2450	3.06	0.130

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

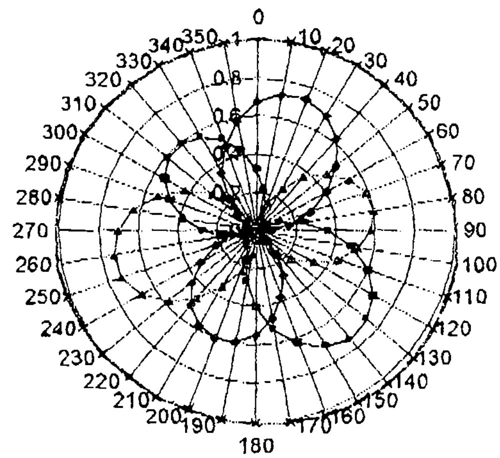




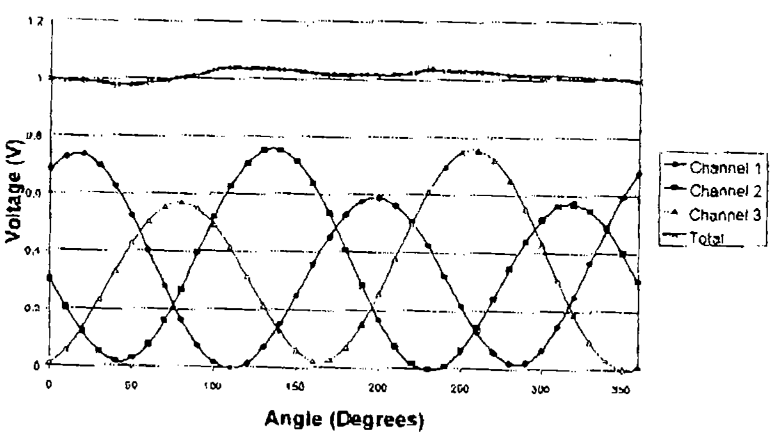
Probe Sensitivity @ 1900 MHz



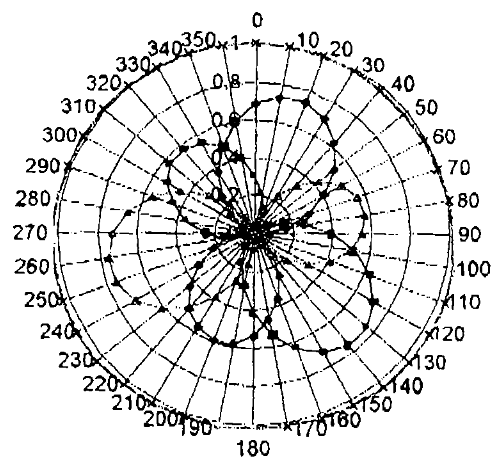
Probe Isotropicity @ 1900 MHz



Probe Sensitivity @ 2450 MHz



Probe Isotropicity @ 1900 MHz



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

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