# PCTEST ENGINEERING LABORATORY, INC.

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# CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

**APPLICANT NAME & ADDRESS:**
Matsushita Electric Industrial Co., Ltd.
1006 Oaza Kadoma, Kadoma,
Osaka, 571 JAPAN
Attn: Rich Mullen (PSCD, MECA)
Yutaka Miyake (ITPD)

**DATE & LOCATION OF TESTING:**
Dates of Tests: May 26-27, 2003
Test Report S/N: SAR.230519235.ACJ
Test Site: PCTEST Lab, Columbia, MD USA
Project No: ITPD-03-F011A

| | |
|---|---|
| **FCC ID:** | **ACJ9TGCF-T21** |
| **APPLICANT:** | **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.** |

| | |
|---|---|
| EUT Type: | Panasonic TOUGHBOOK CF-T2 w/ Intel WLAN Model: WM3B2100 |
| Tx Frequency: | 2412 – 2462 MHz (DTS) |
| Rx Frequency: | 2412 – 2462 MHz (DTS) |
| Max. RF Output Power: | 45 mW (16.5 dBm) Conducted; 0.052 W (17.2 dBm) EIRP |
| Max. SAR Measurement: | 0.91W/kg DTS Body SAR (Bystander Position)<br>0.88 W/kg DTS Body SAR (Top Position)<br>0.63 W/kg DTS Body SAR (Lap Position) |
| Trade Name/Model(s): | *PANASONIC CF-T2* |
| FCC Classification: | FCC Part 15 Digital Transmission System (DTS) |
| FCC Rule Part(s): | §2.1093; FCC/OET Bulletin 65 Supplement C [July 2001] |
| Application Type: | Certification |
| Test Device Serial No.: | Identical Prototype [S/N: #2LKSA01298] |

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 had been tested in accordance with the measurement procedures specified in FCC/OET Bulletin 65 Supplement C (2001) and IEEE Std. 1528-200X (Draft 6.5, January 15, 2002).

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.

Grant Conditions: Power output is conducted. This device is authorized to operate with a specific computer as described in this filing and has been tested for SAR compliance for portable configurations. This device must not be co-located or operating with any other antenna or transmitter. End-users must be provided with antenna installation and transmitter operating conditions for satisfying RF exposure compliance.

*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.*

Alfred Cirwithian
Vice President Engineering

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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).

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

**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$^3$)
$E$ = 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]



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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

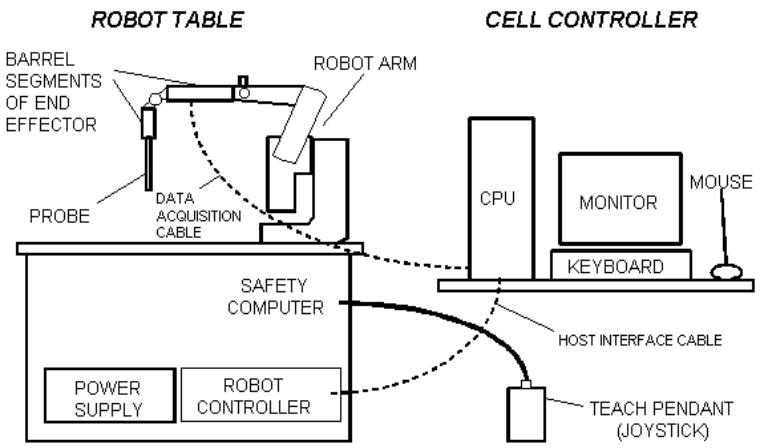


**Figure 2.1**
**SAR Measurement System Setup**

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 – 6.0 GHz |
| Calibration: | In air from 10 MHz to 6.0 GHz |
| | In brain and muscle simulating tissue at Frequencies from 835 up to 5800MHz |
| 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 |

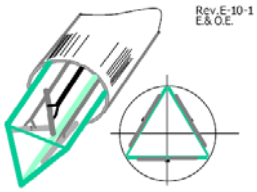


**Figure 3.2**
**Triangular Probe Configuration**

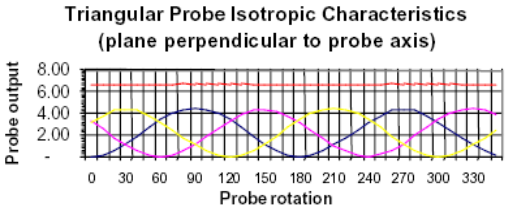


**Figure 3.3**
**Probe Characteristics**



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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 (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.

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

where:

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

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

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

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;

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

where:

σ = simulated tissue conductivity,

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

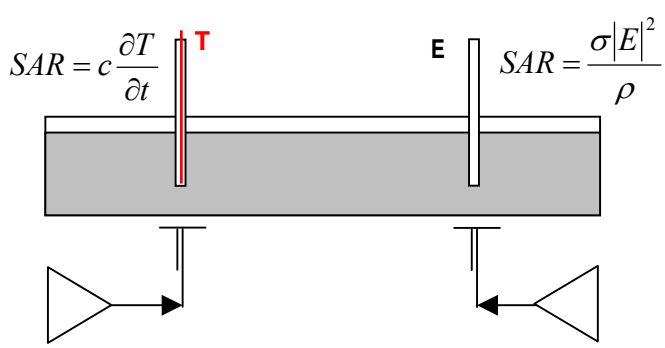


**Figure 4.1 Temperature Assessment Test Configuration**



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# 5. PHANTOM & EQUIVALENT TISSUES

**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**

The brain and muscle mixtures consist of a viscous gel using hydroxethylcellullose (HEC) gelling agent and saline solution (see Table 6.1). Preservation with a bactericide 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)

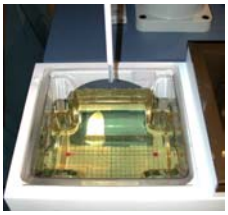

**Figure 5.3**
**Body/Muscle Simulated Tissue**

| (% 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 | 58.55 | 73.2 |
| Salt (NAC1) | 3.95 | 1.49 | 1.45 | 1.4 | 1.35 | 0.76 | 0.18 | 0.5 | 0.11 | 0.4 |
| Sugar | 56.32 | 46.78 | 56.0 | 45.0 | 56.0 | 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 |
| Bacteride | 0.19 | 0.05 | 0.1 | 0.1 | 0.27 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Triton X-100 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 35.38 | 0.0 |
| DGBE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.92 | 0.0 | 6.96 | 26.7 |

**Table 5.1**

**Composition of the Brain & Muscle Tissue Equivalent Matter**

**Figure 5.4**
**Device Positioner**

## Device Holder

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.



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# 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 |

**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<br>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: PCT003 |
| **Construction:** | Triangular core absolute encoder system |
| **Frequency:** | 10 MHz to 6.0 GHz |

**Phantom**

| | |
|---|---|
| **Phantom:** | SAM Phantoms (Left & Right) |
| **Shell Material:** | Vivac Composite |
| **Thickness:** | 2.0 ± 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$^{th}$ 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.

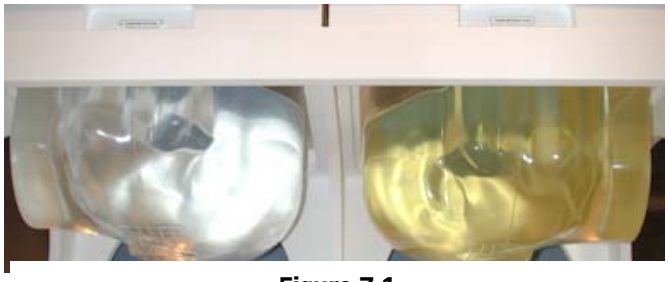

**Figure 7.1**
**Left and Right SAM Phantom shells**



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# 8. DEFINITION OF REFERENCE POINTS

## EAR Reference Point (ERP)

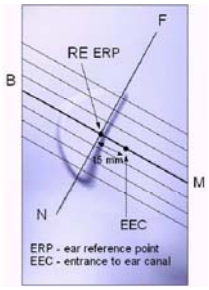


**Figure 8.2 Close-up side view of ERPs**

Figure 8.1 shows the front, back and side views of the SAM Twin Phantom. The point "M" is the reference point for the center of the mouth, "LE" is the left ear reference point (ERP), and "RE" is the right ERP. The ERPs are 15mm posterior to the entrance to the ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 9.2. The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front) is perpendicular to the reference plane and passing through the RE (or LE) is called the Reference Pivoting Line (see Figure 8.2). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5].

**Figure 8.1 Front, back and side view of SAM Twin Phantom**

## Handset Reference Points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the "test device reference point" located along the "vertical centerline" on the front of the device aligned to the "ear reference point" (See Fig. 8.3). The "test device reference point" was than located at the same level as the center of the ear reference point. The test device was positioned so that the "vertical centerline" was bisecting the front surface of the handset at it's top and bottom edges, positioning the "ear reference point" on the outer surface of the both the left and right head phantoms on the ear reference point.

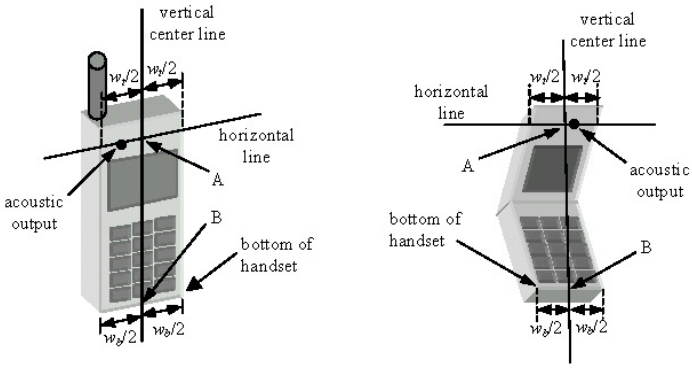


**Figure 8.3 Handset Vertical Center & Horizontal Line Reference Points**



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# 9. TEST CONFIGURATION POSITION

## Body Holster /Belt Clip Configurations

Body-held or Body-worn devices are tested with the EUT positioned against a flat phantom in a normal use configuration (see figure 9.1). SAR test for body-held devices are configured for lap-held, bystander, and/ or any other typical configurations. Other body-held or body-worn configurations are investigated and tested and the worst-case configurations are reported.

**Figure 9.1 Body Held 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. A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Accessories for Body-held or 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-held or 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-held or body-worn operating requirements for meeting RF exposure compliance, operating instructions and cautions statements must be included in the user's manual.



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# 10. 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.



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# 11. 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 | 11.36 | R | é3 | 1 | 1 | 6.56 | 6.56 | ¸ |
| Axial Isotropy | E1.2 | 3.37 | R | é3 | 0.5 | 0.5 | 0.97 | 0.97 | ¸ |
| Hemispherical Isotropy | E1.2 | 5.16 | R | é3 | 1 | 1 | 3.0 | 3.0 | ¸ |
| Boundary Effect | E1.3 | 4.7 | R | é3 | 1 | 1 | 2.7 | 2.7 | ¸ |
| Linearity | E1.4 | 5.88 | R | é3 | 1 | 1 | 3.4 | 3.4 | ¸ |
| System Detection Limits | E1.5 | 1.0 | R | é3 | 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 | é3 | 1 | 1 | 0.5 | 0.5 | ¸ |
| Integration Time | E1.8 | 1.7 | R | é3 | 1 | 1 | 1.0 | 1.0 | ¸ |
| RF Ambient Conditions | E5.1 | 1.2 | R | é3 | 1 | 1 | 0.7 | 0.7 | ¸ |
| Probe Positioner Mechanical Tolerance | E5.2 | 0.4 | R | é3 | 1 | 1 | 0.2 | 0.2 | ¸ |
| Probe Positioning w/ respect to Phantom Shell | E5.3 | 2.9 | R | é3 | 1 | 1 | 1.7 | 1.7 | ¸ |
| Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation | E4.2 | 3.9 | R | é3 | 1 | 1 | 2.3 | 2.3 | ¸ |
| **Test Sample Related** | | | | | | | | | |
| Test Sample Positioning | E3.2.1 | 10.6 | R | é3 | 1 | 1 | 6.1 | 6.1 | 11 |
| Device Holder Uncertainty | E3.1.1 | 8.7 | R | é3 | 1 | 1 | 5.0 | 5.0 | 8 |
| Output Power Variation - SAR drift measurement | 5.6.2 | 5.0 | R | é3 | 1 | 1 | 2.9 | 2.9 | ¸ |
| **Phantom & Tissue Parameters** | | | | | | | | | |
| Phantom Uncertainty (Shape & Thickness tolerances) | E2.1 | 4.0 | R | é3 | 1 | 1 | 2.3 | 2.3 | ¸ |
| Liquid Conductivity - deviation from target values | E2.2 | 5.0 | R | é3 | 0.7 | 0.5 | 2.0 | 1.4 | ¸ |
| Liquid Conductivity - measurement uncertainty | E2.2 | 10.0 | R | é3 | 0.7 | 0.5 | 4.0 | 2.9 | ¸ |
| Liquid Permittivity - deviation from target values | E2.2 | 5.0 | R | é3 | 0.6 | 0.5 | 1.7 | 1.4 | ¸ |
| Liquid Permittivity - measurement uncertainty | E2.2 | 5.0 | R | é3 | 0.6 | 0.5 | 1.7 | 1.4 | ¸ |
| **Combined Standard Uncertainty (k=1)** | | | RSS | | | | 13.62 | 13.17 | |
| **Expanded Uncertainty (k=2)** (95% CONFIDENCE LEVEL) | | | | | | | 27.23 | 26.35 | |

The above measurement uncertainties are according to IEEE Std. 1528-200X (January, 2002)



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# 12. SYSTEM VERIFICATION

## Tissue Verification

**Table 12.1 Simulated Tissue Verification**

| MEASURED TISSUE PARAMETERS | | | | | |
|---|---|---|---|---|---|
| Date(s) | 05/27/03 | 2450MHz Brain | | 2450MHz Muscle | |
| Liquid Temperature (°C) | 21.0 | Target | Measured | Target | Measured |
| Dielectric Constant: ε | | 39.20 | 41.0 | 52.70 | 52.86 |
| Conductivity: σ | | 1.800 | 1.87 | 1.950 | 2.00 |

## Test System Verification

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

**Table 12.2 System Verification**

| SYSTEM DIPOLE VERIFICATION TARGET & MEASURED (Measured at 0.100 W) | | | | |
|---|---|---|---|---|
| System Validation Kit: D-2450S, S/N: 105 | 2450MHz Brain | *Targeted $SAR_{1g}$ (mW/g)* 5.24 | *Measured $SAR_{1g}$ (mW/g)* ***4.81*** | Deviation (%) **- 8.16** |

**Figure 12.1 Dipole Validation Test Setup**



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# 13. SAR TEST DATA SUMMARY

## See Measurement Result Data Pages

## Procedures Used To Establish Test Signal

The device was placed into continuous transmit mode in DTS mode using the manufacturer's software. Such test signals offer a consistent means for testing SAR and are recommended for evaluating SAR [4].

## Device Test Conditions

The internal transmitting device is powered through the host computer. In order to verify that the device was tested at full power, the base station simulator was used during each SAR measurement to maintain the output power. If a power deviation of more than 5% occurred, the test was repeated.



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# 14. SAR DATA SUMMARY

**Mixture Type:** **2450MHz Muscle**

## 14.1 MEASUREMENT RESULTS (DTS Body SAR – Bystander Position)

| FREQUENCY | | Modulation | Begin / End POWER‡ | | Test Position | Separation Distance (cm) | Antenna | SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | dBm | | | | | |
| 2412 | 01 | DTS | 16.66 | 16.63 | Edge | 0.40 cm | Fixed | **0.78** |
| 2437 | 06 | DTS | 17.00 | 16.90 | Edge | 0.40 cm | Fixed | **0.91** |
| 2462 | 11 | DTS | 16.78 | 16.70 | Edge | 0.40 cm | Fixed | **0.87** |
| **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. Data Transfer Rate is at 11 MBps.
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 | ☐ | Left Head |
| 5. | SAR Configuration | ☐ | Head | ☒ | Body | ☐ | Hand |
| 6. | Test Signal Call Mode | ☒ | Software | ☐ | Base Station Simulator | | |

7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15 cm. ± 0.1

Alfred Cirwithian
Vice President Engineering

**Figure 14.1 Body SAR Bystander Test Setup**



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# 14. SAR DATA SUMMARY

**Mixture Type:** **2450MHz Muscle**

## 14.2 MEASUREMENT RESULTS (DTS Body SAR – Top Position)

| FREQUENCY | | Modulation | Begin / End POWER‡ | | Test Position WLAN | Separation Distance (cm) | Antenna | SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | dBm | | | | | |
| 2412 | 01 | DTS | 16.70 | 16.66 | Keyboard | Touch | Fixed | **0.65** |
| 2437 | 06 | DTS | 16.96 | 16.89 | Keyboard | Touch | Fixed | **0.88** |
| 2462 | 11 | DTS | 16.70 | 16.59 | Keyboard | Touch | Fixed | **0.84** |
| **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. Data Transfer Rate is at 11 MBps.
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 | ☐ Left Head | |
| 5. SAR Configuration | ☐ Head | ☒ Body | ☐ Hand | |
| 6. Test Signal Call Mode | ☒ Software | ☐ Base Station Simulator | | |

7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15 cm. ± 0.1

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Vice President Engineering

**Figure 14.2 Body SAR Top Position Test Setup**



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# 14. SAR DATA SUMMARY

**Mixture Type:** **2450MHz Muscle**

## 14.3 MEASUREMENT RESULTS (DTS Body SAR – Lap Position)

| FREQUENCY | | Modulation | Begin / End POWER‡ | | Test Position | Separation Distance (cm) | Antenna | SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | dBm | | | | | |
| 2412 | 01 | DTS | 16.71 | 16.60 | Lap | Touch | Fixed | **0.53** |
| 2437 | 06 | DTS | 17.01 | 16.94 | Lap | Touch | Fixed | **0.63** |
| 2462 | 11 | DTS | 16.65 | 16.55 | Lap | Touch | Fixed | **0.54** |
| **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. Data Transfer Rate is at 11 MBps.
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 | ☐ Left Head | |
| 5. SAR Configuration | ☐ Head | ☒ Body | ☐ Hand | |
| 6. Test Signal Call Mode | ☒ Software | ☐ Base Station Simulator | | |

7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15 cm. ± 0.1

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Vice President Engineering

**Figure 14.3 Body SAR Lap Position Test Setup**



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# 15. SAR TEST EQUIPMENT

## Equipment Calibration

**Table 15.1 Test Equipment Calibration**

| EQUIPMENT SPECIFICATIONS | | |
|---|---|---|
| **Type** | **Calibration Date** | **Serial Number** |
| CRS Robot F3 | February 2003 | RAF0134133 |
| CRS C500C Motion Controller | February 2003 | RCB0003303 |
| CRS Teach Pendant (Joystick) | February 2003 | STP0132231 |
| DELL Computer, Pentium 4 1.6 GHz, Windows 2000™ | February 2003 | 4PJZ111 |
| E-Field Probe E-010 | January 2003 | PCT003 |
| Right Ear SAM Phantom (P-SAM-R) | February 2003 | 94X-113 |
| Left Ear SAM Phantom (P-SAM-L) | February 2003 | 94X-019 |
| Flat SAM Phantom (P-SAM-FLAT) | February 2003 | 94X-097 |
| IDX Robot End Effector (EE-103-C) | February 2003 | 07111223 |
| IDX Probe Amplifier | February 2003 | 07111113 |
| Validation Dipole D-835S | February 2003 | PCT640 |
| Validation Dipole D-1900S | February 2003 | PCT641 |
| Brain Equivalent Matter (835MHz) | May 2003 | PCTBEM101 |
| Brain Equivalent Matter (1900MHz) | May 2003 | PCTBEM301 |
| Brain Equivalent Matter (2450MHz) | May 2003 | PCTBEM501 |
| Muscle Equivalent Matter (835MHz) | May 2003 | PCTMEM201 |
| Muscle Equivalent Matter (1900MHz) | May 2003 | PCTMEM401 |
| Muscle Equivalent Matter (2450MHz) | May 2003 | PCTMEM601 |
| Microwave Amp. Model: 5S1G4, (800MHz - 4.2GHz) | January 2003 | 22332 |
| Gigatronics 8651A Power Meter | January 2003 | 1835299 |
| HP-8648D (9kHz ~ 4GHz) Signal Generator | January 2003 | PCT530 |
| Amplifier Research 5S1G4 Power Amp | January 2003 | PCT540 |
| HP-8753E (30kHz ~ 3GHz) Network Analyzer | January 2003 | PCT552 |
| HP85070B Dielectric Probe Kit | January 2003 | PCT501 |
| Ambient Noise/Reflection, etc. January 2003 | January 2003 | Anechoic Room PCT01 |

NOTE:
Dipole Validation measurement was 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.



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# 16. 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]



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# 17. 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 6.5 – January 2002), *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.

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[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.

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# EXHIBIT J – SAR TEST DATA



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SAR Data Report 03052720

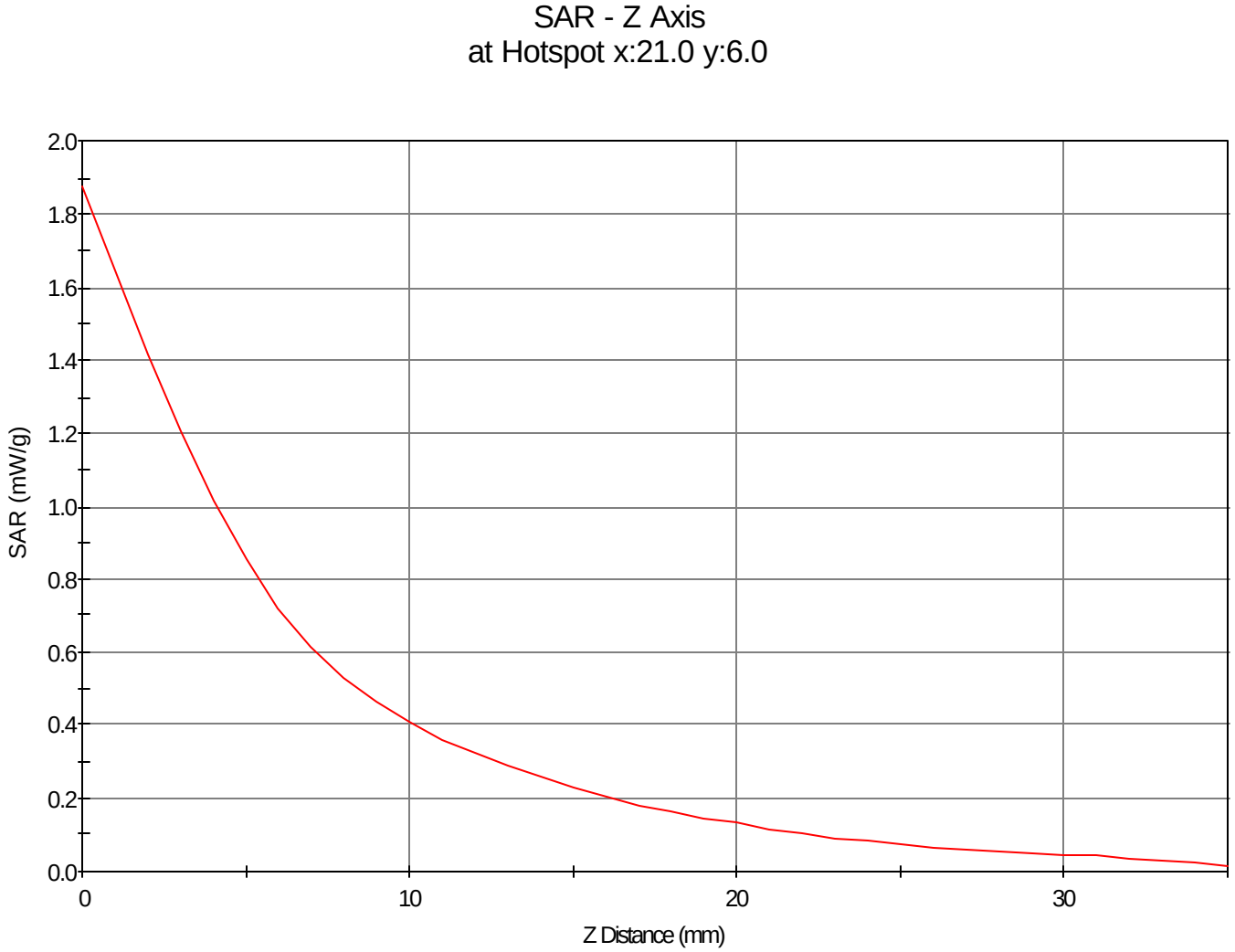
```
  Start        : 27-May-03 04:25:20 pm
  End          : 27-May-03 04:31:16 pm
  Code Version : 4.08
  Robot Version: 4.08

Product Data:
  Type             : PANASONIC
  Model Number     : CF-T2
  Serial Number    : 2LKSA01298
  Frequency        : 2437 MHz
  Transmit Pwr     : 0.047 W
  Antenna Type     : Patch
  Antenna Posn.    : Internal

Measurement Data:
  Phantom Name        : SAM-FLAT-B
  Phantom Type        : Uniphantom
  Tissue Type         : Muscle
  Tissue Dielectric   : 52.860
  Tissue Conductivity : 2.000
  Tissue Density      : 1.000
  Robot Name          : CRS

Probe Data:
  Probe Name              : PCT003
  Probe Type              : E Fld Triangle
  Frequency               : 2440 MHz
  Tissue Type             : Muscle
  Calibrated Dielectric   : 52.300
  Calibrated Conductivity :  1.990
  Calibrated Density      :  1.000
  Probe Offset            :  2.400 mm
  Conversion Factor       :  9.900
  Probe Sensitivity :  2.075   2.820   2.456   mV/(mW/cm^2)
  Amplifier Gains   :  20.00   20.00   20.00

Sample:
  Rate:         6000 Samples/Sec
  Count:        1000 Samples
  NIDAQ Gain:   5

Comments:
  DSS Mode CH-06
  Body (Bystander)
  CF=1; Amb. Temp= 22.0 'C; Liq. Temp=21.3 'C
```

Area Scan - Max Peak SAR Value at x=22.0 y=7.0 = 0.73 W/kg

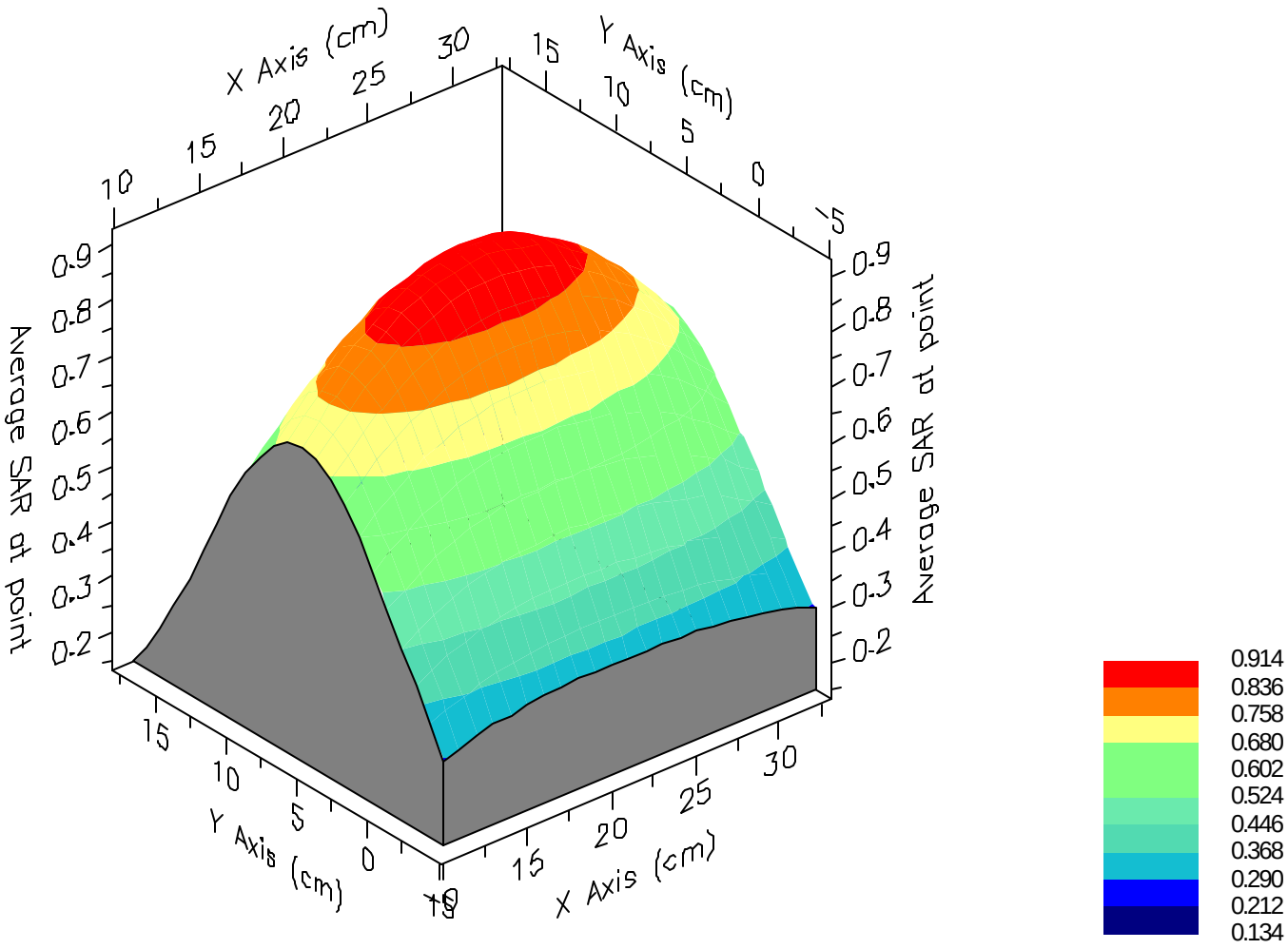
Zoom Scan - Max Peak SAR Value at x=21.0 y=6.0 z=0.0 = 1.87 W/kg

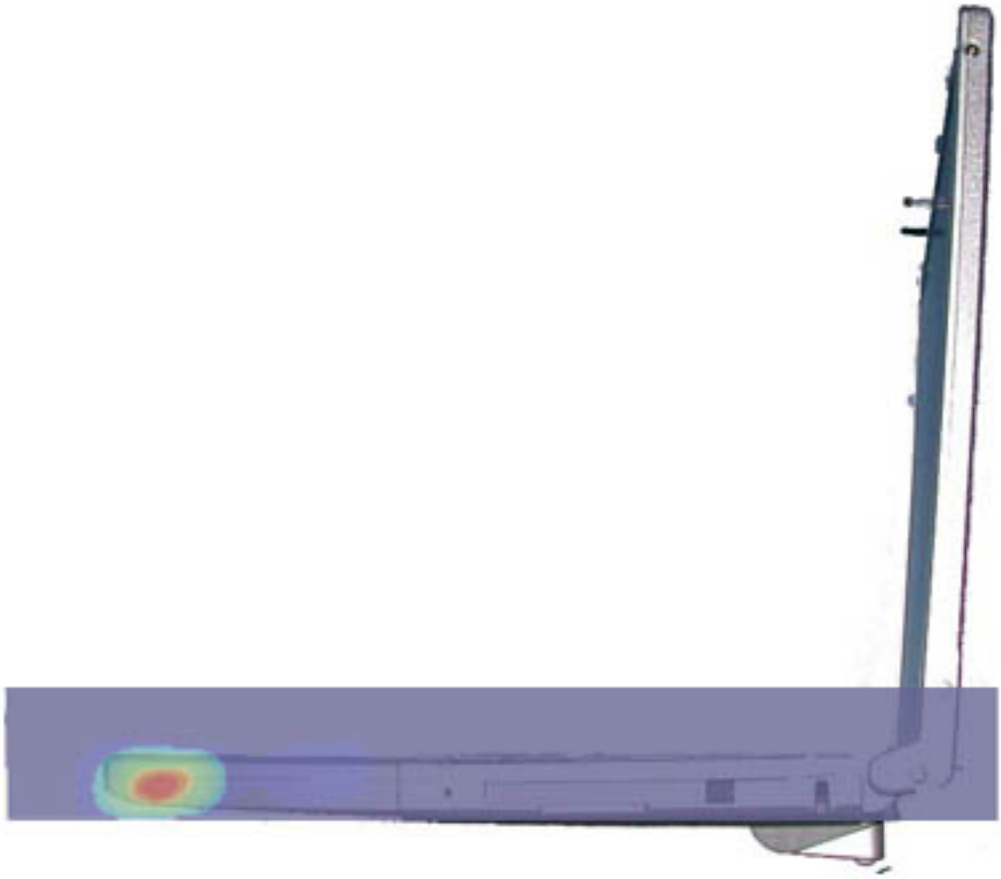
Max 1g SAR at x=22.0 y=7.0 z=0.0 = 0.91 W/kg

Max 10g SAR at x=22.0 y=6.0 z=0.0 = 0.38 W/kg


SAR - Z Axis
at Hotspot x:21.0 y:6.0
SAR (mW/g)
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





SAR Data Report 03052709

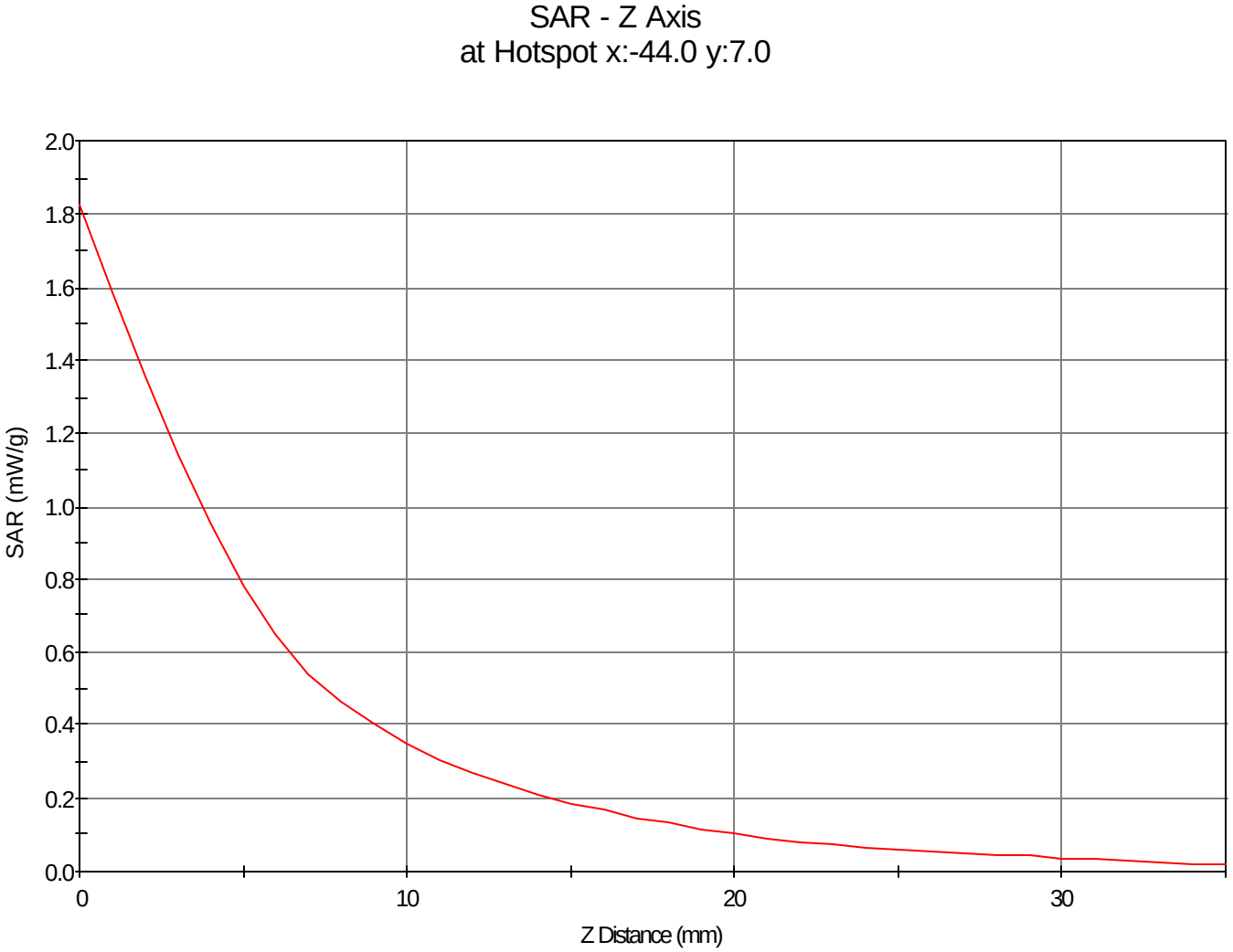
```
  Start        : 27-May-03 02:55:56 pm
  End          : 27-May-03 03:01:32 pm
  Code Version : 4.08
  Robot Version: 4.08

Product Data:
  Type             : PANASONIC
  Model Number     : CF-T2
  Serial Number    : 2LKSA01298
  Frequency        : 2437 MHz
  Transmit Pwr     : 0.047 W
  Antenna Type     : Patch
  Antenna Posn.    : Internal

Measurement Data:
  Phantom Name        : SAM-FLAT-B
  Phantom Type        : Uniphantom
  Tissue Type         : Muscle
  Tissue Dielectric   : 52.860
  Tissue Conductivity : 2.000
  Tissue Density      : 1.000
  Robot Name          : CRS

Probe Data:
  Probe Name              : PCT003
  Probe Type              : E Fld Triangle
  Frequency               : 2440 MHz
  Tissue Type             : Muscle
  Calibrated Dielectric   : 52.300
  Calibrated Conductivity :  1.990
  Calibrated Density      :  1.000
  Probe Offset            :  2.400 mm
  Conversion Factor       :  9.900
  Probe Sensitivity :  2.075   2.820   2.456   mV/(mW/cm^2)
  Amplifier Gains   :  20.00   20.00   20.00

Sample:
  Rate:         6000 Samples/Sec
  Count:        1000 Samples
  NIDAQ Gain:   5

Comments:
  DSS Mode CH-06
  Body (Top)
  CF=1; Amb. Temp= 22.0 'C; Liq. Temp=21.3 'C
```

Area Scan - Max Peak SAR Value at x=-45.0 y=6.0 = 0.85 W/kg

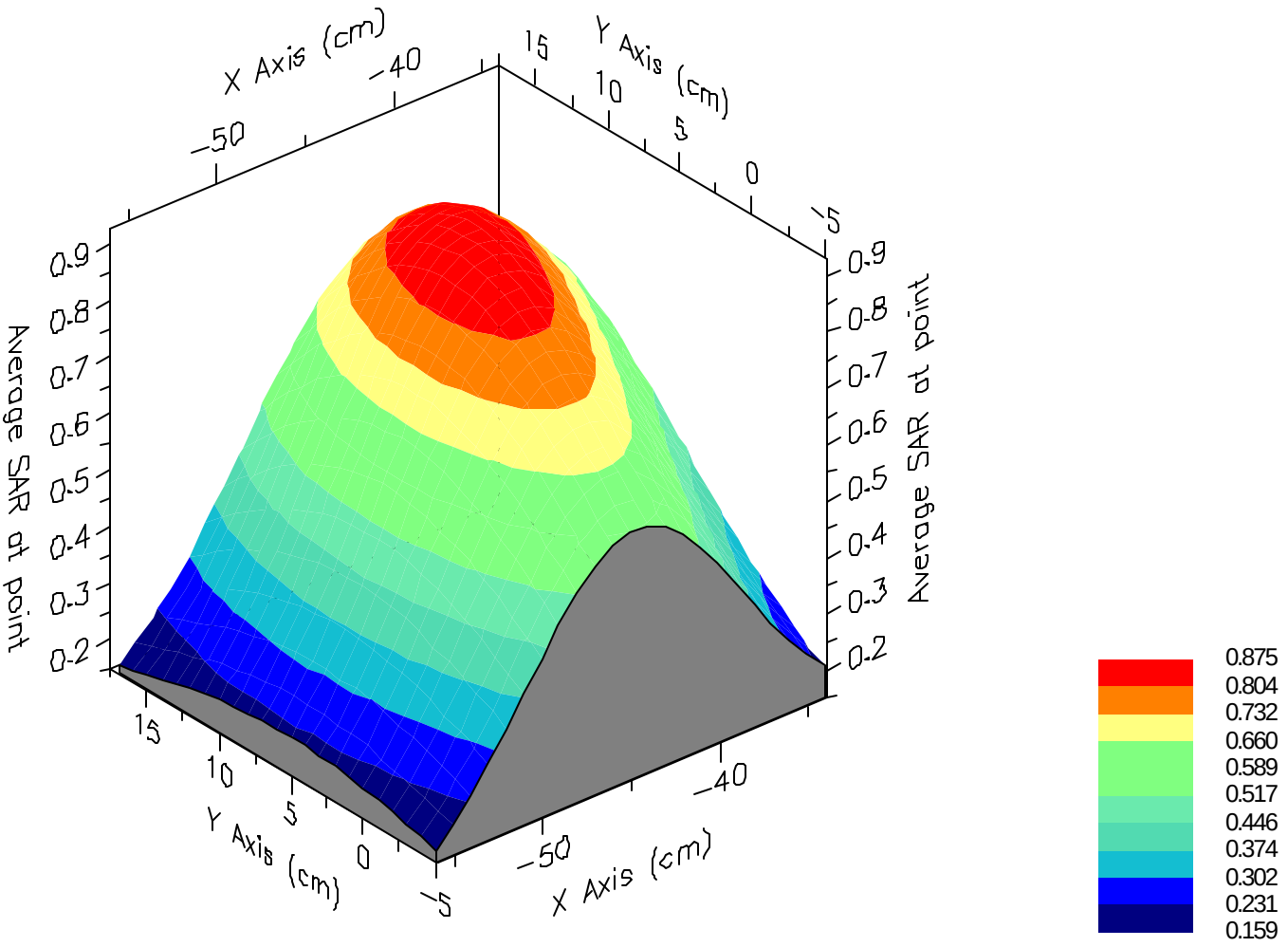
Zoom Scan - Max Peak SAR Value at x=-44.0 y=7.0 z=0.0 = 1.83 W/kg

Max 1g SAR at x=-43.0 y=9.0 z=0.0 = 0.88 W/kg

Max 10g SAR at x=-41.0 y=10.0 z=0.0 = 0.38 W/kg


SAR - Z Axis
at Hotspot x:-44.0 y:7.0
SAR (mW/g)
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



SAR Data Report 03052715

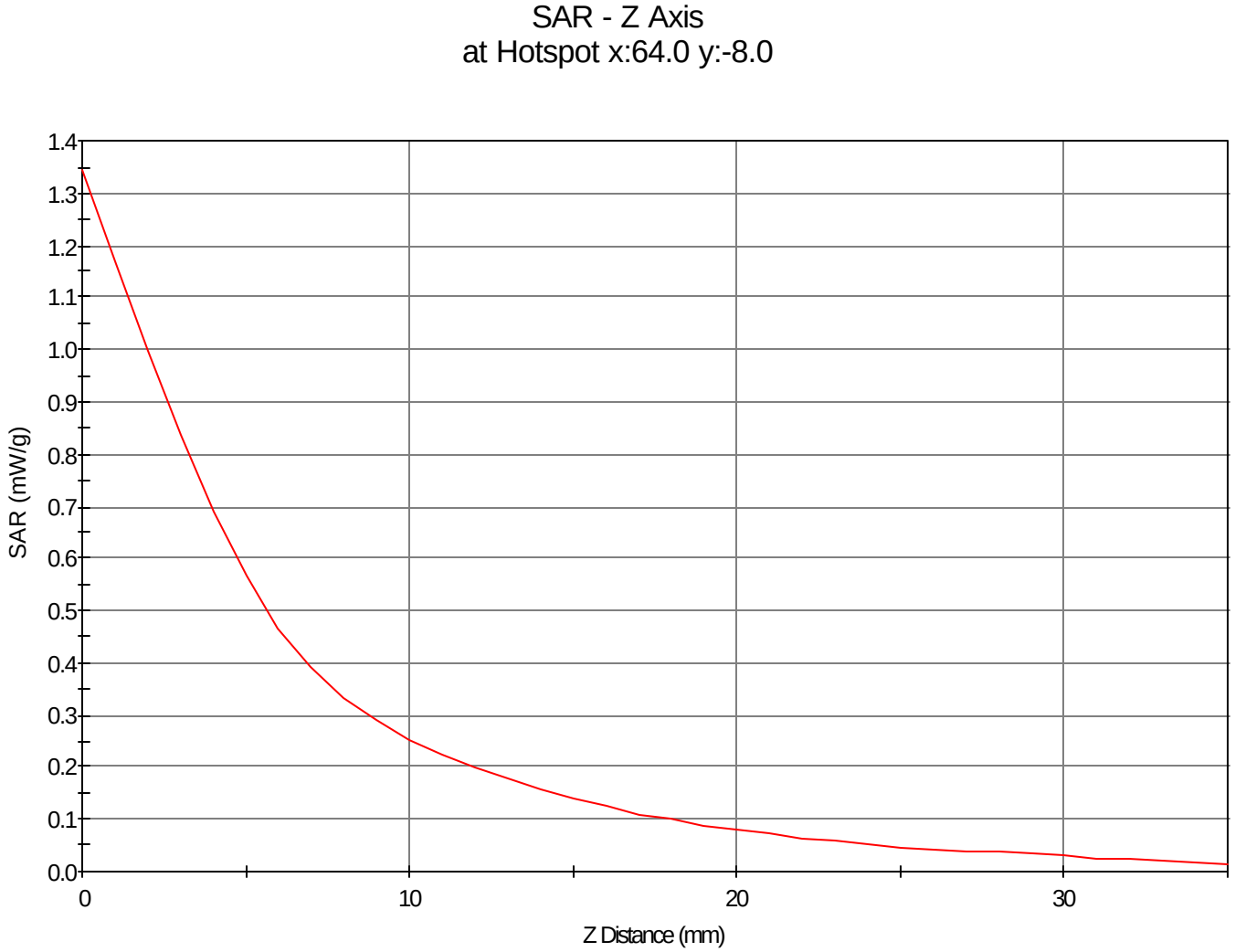
```
  Start        : 27-May-03 03:50:15 pm
  End          : 27-May-03 03:56:37 pm
  Code Version : 4.08
  Robot Version: 4.08

Product Data:
  Type             : PANASONIC
  Model Number     : CF-T2
  Serial Number    : 2LKSA01298
  Frequency        : 2437 MHz
  Transmit Pwr     : 0.047 W
  Antenna Type     : Patch
  Antenna Posn.    : Internal

Measurement Data:
  Phantom Name        : SAM-FLAT-B
  Phantom Type        : Uniphantom
  Tissue Type         : Muscle
  Tissue Dielectric   : 52.860
  Tissue Conductivity : 2.000
  Tissue Density      : 1.000
  Robot Name          : CRS

Probe Data:
  Probe Name              : PCT003
  Probe Type              : E Fld Triangle
  Frequency               : 2440 MHz
  Tissue Type             : Muscle
  Calibrated Dielectric   : 52.300
  Calibrated Conductivity :  1.990
  Calibrated Density      :  1.000
  Probe Offset            :  2.400 mm
  Conversion Factor       :  9.900
  Probe Sensitivity :  2.075   2.820   2.456   mV/(mW/cm^2)
  Amplifier Gains   :  20.00   20.00   20.00

Sample:
  Rate:         6000 Samples/Sec
  Count:        1000 Samples
  NIDAQ Gain:   5

Comments:
  DSS Mode CH-6
  Body (Lap)
  CF=1; Amb. Temp= 22.0 'C; Liq. Temp=21.3 'C
```

Area Scan - Max Peak SAR Value at x=64.0 y=-7.0 = 0.50 W/kg

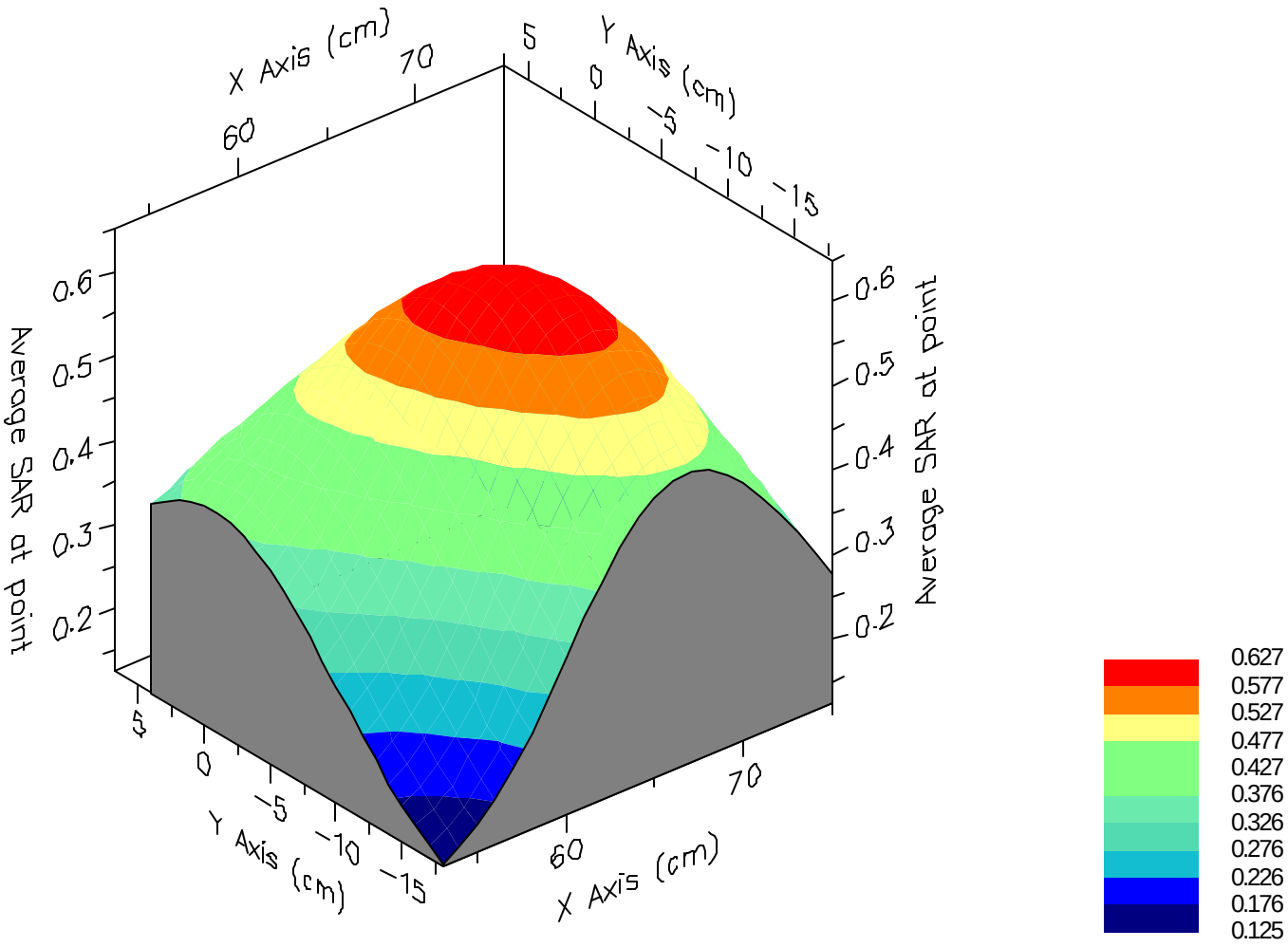
Zoom Scan - Max Peak SAR Value at x=64.0 y=-8.0 z=0.0 = 1.34 W/kg

Max 1g SAR at x=65.0 y=-8.0 z=0.0 = 0.63 W/kg

Max 10g SAR at x=64.0 y=-7.0 z=0.0 = 0.27 W/kg


SAR - Z Axis
at Hotspot x:64.0 y:-8.0
SAR (mW/g)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
Z Distance (mm)

1g SAR Values



# EXHIBIT L – DIPOLE VALIDATION



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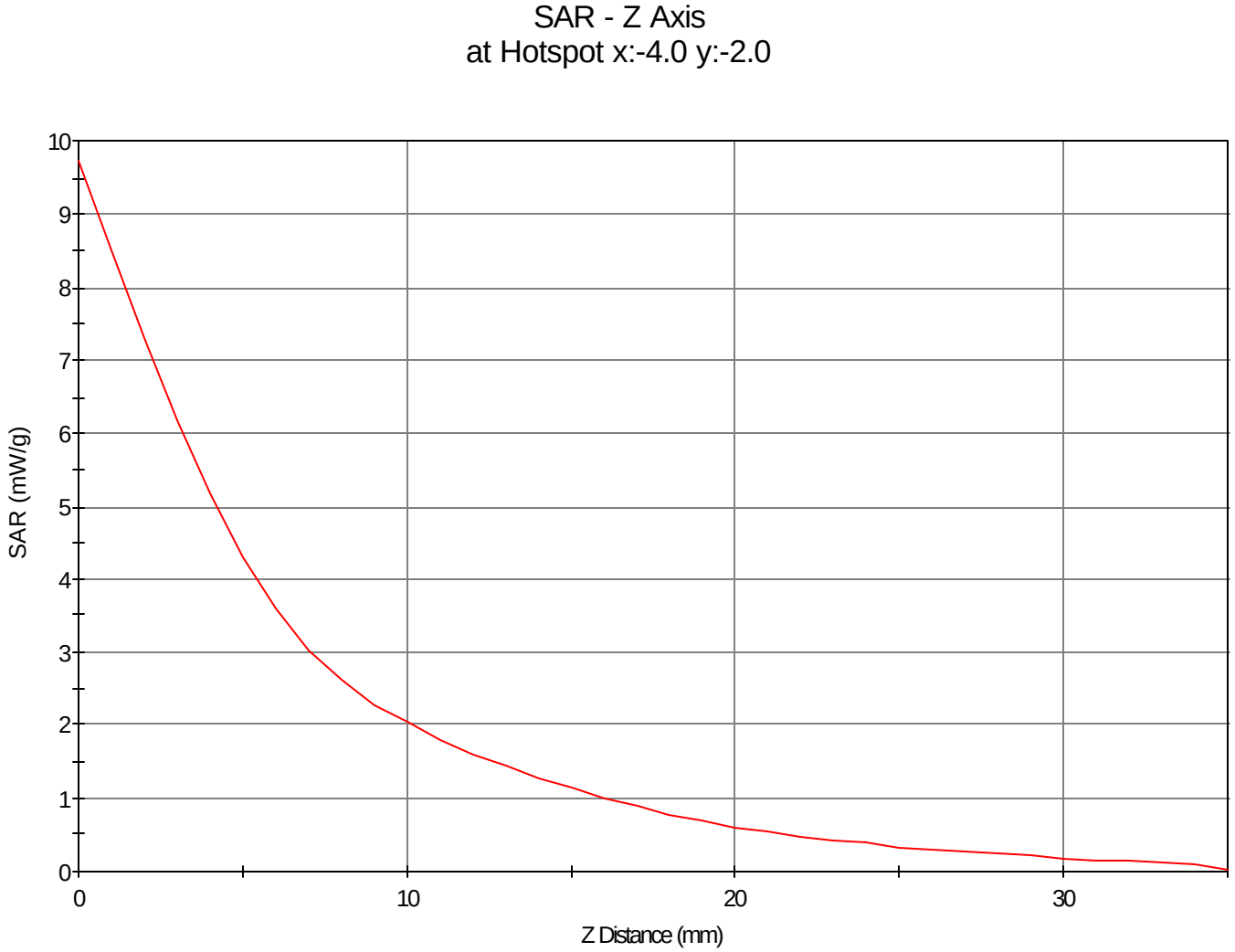
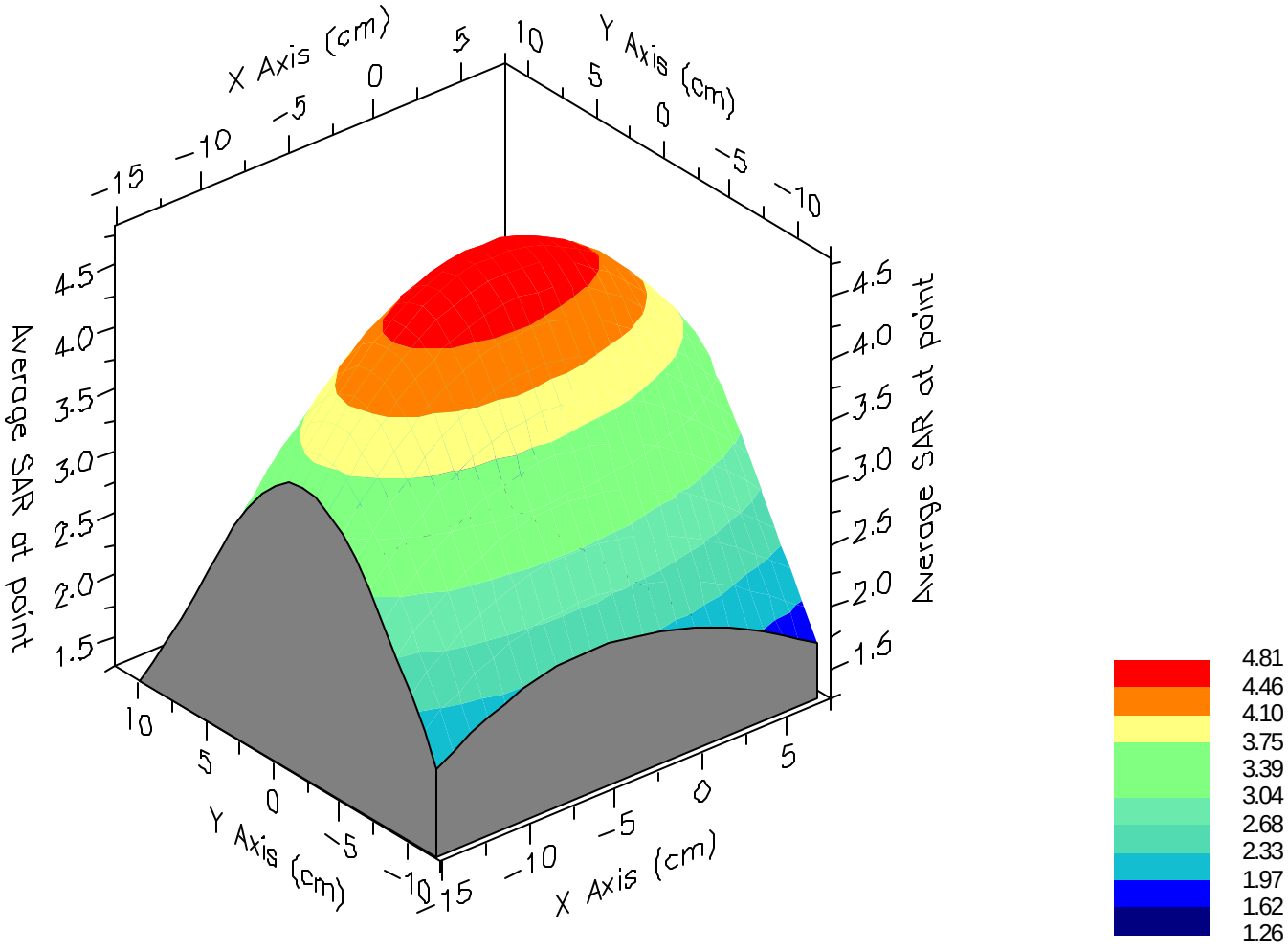
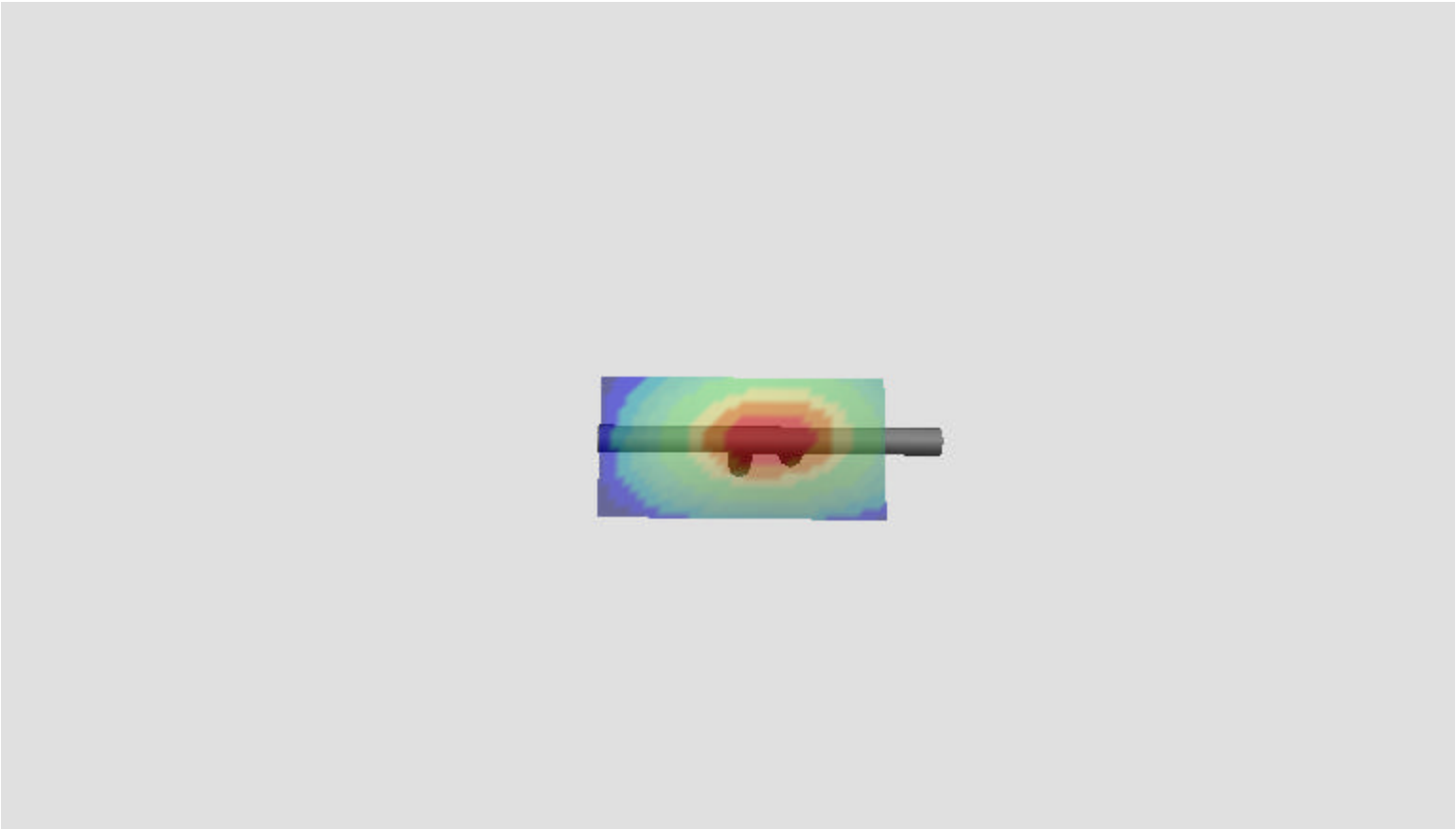
SAR Data Report 03052701

```
  Start        : 27-May-03 11:27:12 am
  End          : 27-May-03 11:31:23 am
  Code Version : 4.08
  Robot Version: 4.08

Product Data:
  Type             : Verification
  Model Number     : E-010
  Serial Number    : PCT003
  Frequency        : 2440 MHz
  Transmit Pwr     : 0.100 W
  Antenna Type     : Dipole
  Antenna Posn.    : Validation

Measurement Data:
  Phantom Name        : SAM-FLAT-B
  Phantom Type        : Uniphantom
  Tissue Type         : Brain
  Tissue Dielectric   : 41.000
  Tissue Conductivity : 1.870
  Tissue Density      : 1.000
  Robot Name          : CRS

Probe Data:
  Probe Name              : PCT003
  Probe Type              : E Fld Triangle
  Frequency               : 2440 MHz
  Tissue Type             : Brain
  Calibrated Dielectric   : 39.340
  Calibrated Conductivity :  1.770
  Calibrated Density      :  1.300
  Probe Offset            :  2.400 mm
  Conversion Factor       :  8.800
  Probe Sensitivity :  2.075   2.820   2.456   mV/(mW/cm^2)
  Amplifier Gains   :  20.00   20.00   20.00

Sample:
  Rate:         6000 Samples/Sec
  Count:        1000 Samples
  NIDAQ Gain:   5

Comments:
  Verification

  CF=1; Amb. Temp= 22.0 'C; Liq. Temp=21.1 'C



Area Scan - Max Peak SAR Value at x=-4.0 y=-1.0 = 4.23 W/kg

Zoom Scan - Max Peak SAR Value at x=-4.0 y=-2.0 z=0.0 = 9.74 W/kg

Max 1g SAR at x=-4.0 y=-2.0 z=0.0 = 4.81 W/kg

Max 10g SAR at x=-4.0 y=-2.0 z=0.0 = 2.12 W/kg

Validation Results at 0.10 W:
Peak Nominal = 10.4, Error:  -6.52 %
1g Nominal   = 5.2, Error:  -8.16 %
10g Nominal  = 2.4, Error:  -11.64 %
```


SAR - Z Axis
at Hotspot x:-4.0 y:-2.0
SAR (mW/g)
Z Distance (mm)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30

1g SAR Values





# EXHIBIT M – PROBE CALIBRATION



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# Probe E-010

# SN: PCT003

Manufactured: November 4, 2002
Calibrated: January 3, 2003

Calibrated for the IDX System

PCTEST Calibration Laboratory

Approved By:

Alfred Cirwithian
Vice President Engineering

Calibration is performed according to IEEE Std. P1528-200X, Sec. 7 Draft 6.5 (2001)
and all test equipment used are traceable to U.S. NIST.

Calibration Laboratory
6660-B Dobbin Road
Columbia, Maryland 21045 USA

# Calibration Summary

Model: E-010
S/N: PCT003

| OFFSET (cm) | ANGLE (deg) |
|---|---|
| 0.24 | 54.73 |

| Tissue Type | Frequency (MHz) | Dielectric Constant $e_r$ | Conductivity (S/m) $s$ | Conversion Factor $g_x, g_y, g_z$ |
|---|---|---|---|---|
| Brain | 835 | 40.00 | 0.91 | 7.20 |
| Brain | 1880 | 40.20 | 1.41 | 4.05 |
| Brain | 2440 | 39.34 | 1.77 | 8.80 |
| Brain | 5300 | 37.10 | 4.84 | 3.20 |
| Brain | 5800 | 36.00 | 5.28 | 2.30 |
| Muscle | 835 | 55.70 | 0.98 | 7.70 |
| Muscle | 1900 | 53.90 | 1.48 | 4.40 |
| Muscle | 2440 | 52.30 | 1.99 | 9.90 |
| Muscle | 5300 | 48.80 | 5.43 | 3.45 |
| Muscle | 5800 | 48.50 | 6.05 | 2.50 |

| Frequency (MHz) | Isotropy | |
|---|---|---|
| | % | dB |
| 835 | 3.49 | 0.15 |
| 1880 | 5.35 | 0.23 |
| 2440 | 4.02 | 0.17 |
| 5300 | 4.85 | 0.21 |
| 5800 | 4.93 | 0.21 |

**Boundary Effect** < 2%, 2.6 mm from probe tip to phantom

**Diode Compression Point:** 76 mV

**Environmental Conditons:**

Temperature: 23.34 °C
Relative Humidity: 34%
Barometer: 100.1 kPa

---

This probe was calibrated under the IEEE Std 1309-1966, *IEEE Standard for Calibration of Electromagnetic Field Sensors and Probes, Exluding Antennas, from 9 kHz to 40 GHz*.

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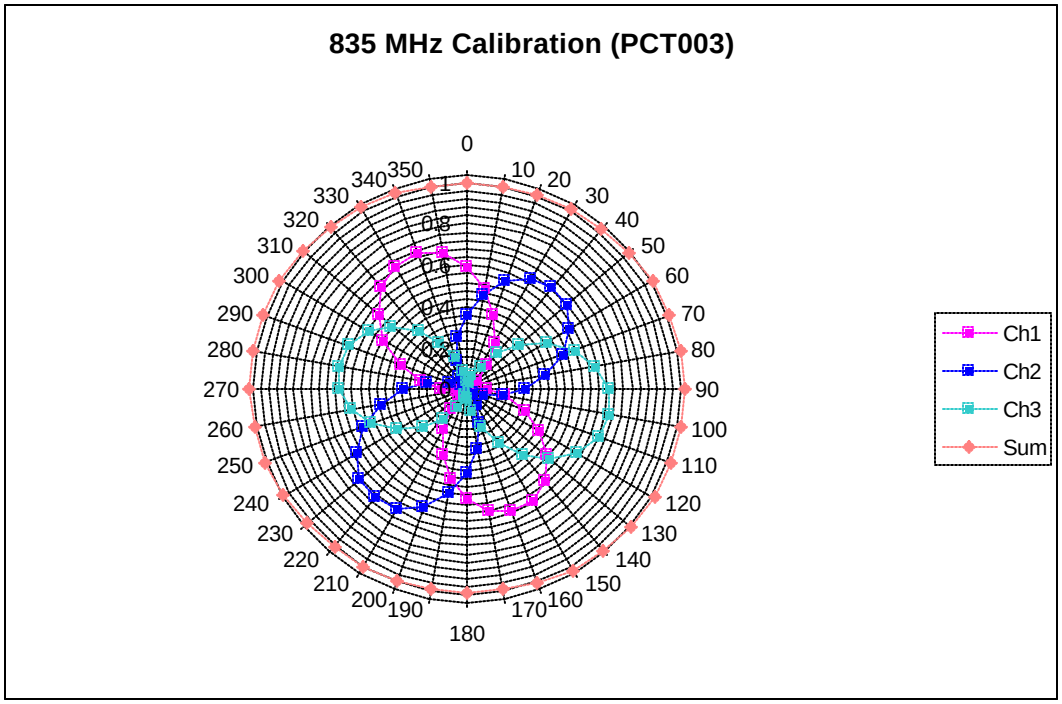


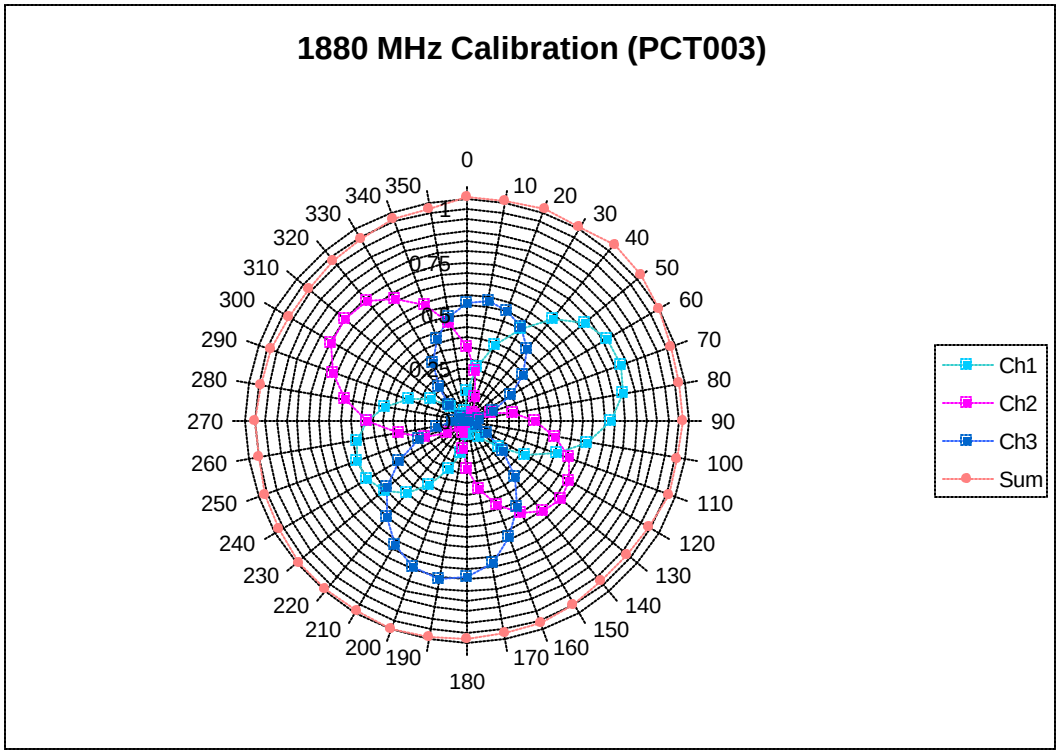


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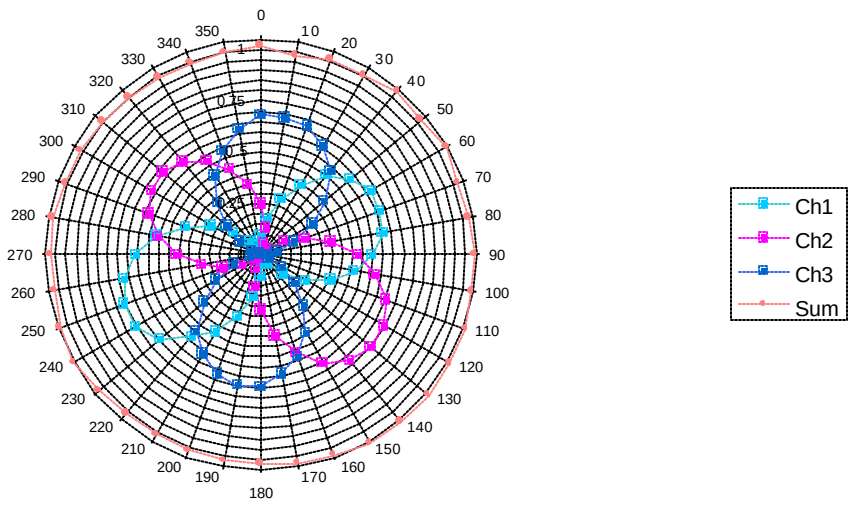
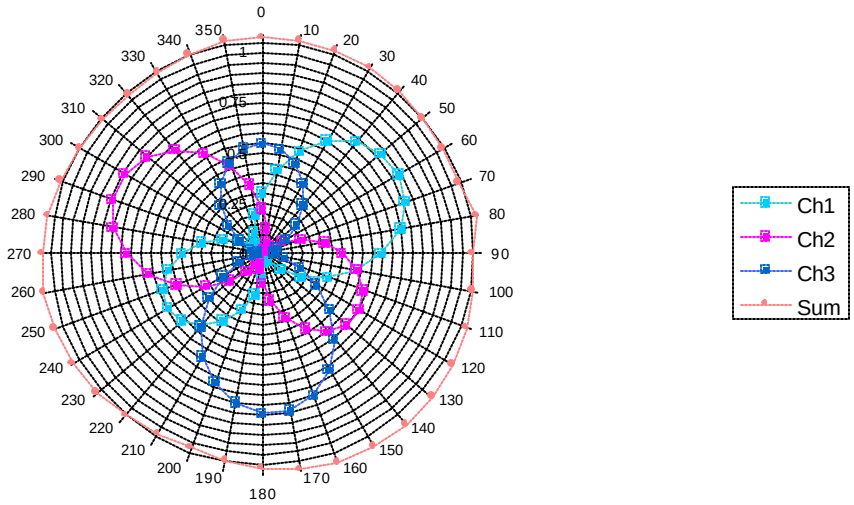
## 2440 MHz Calibration (PCT003)




## 5300 MHz Calibration (PCT003)

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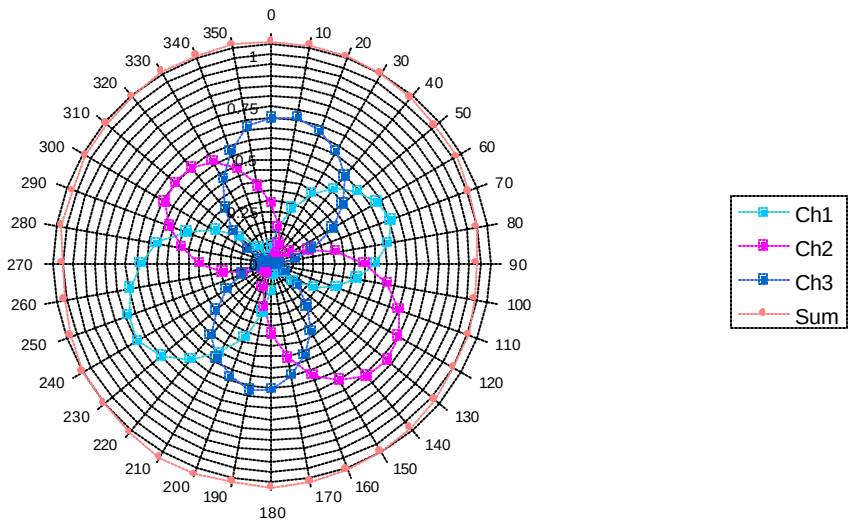
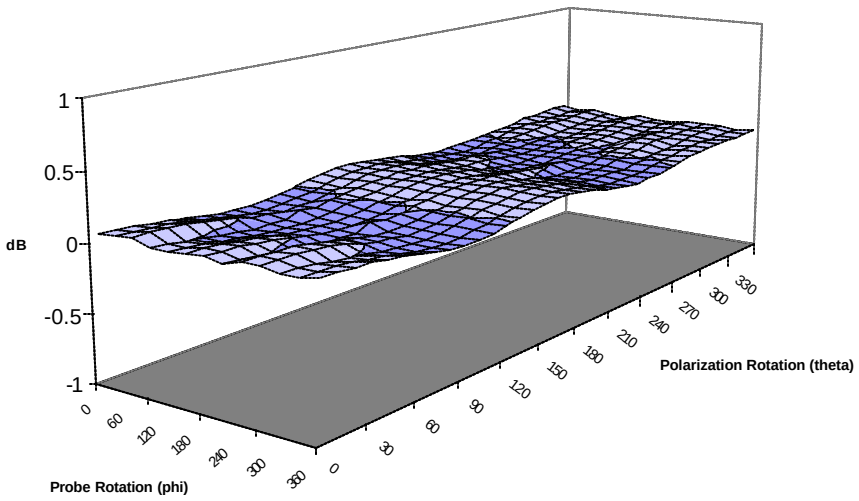
## 5800 MHz Calibration (PCT003)




## Verification of Isotropy for PCT003

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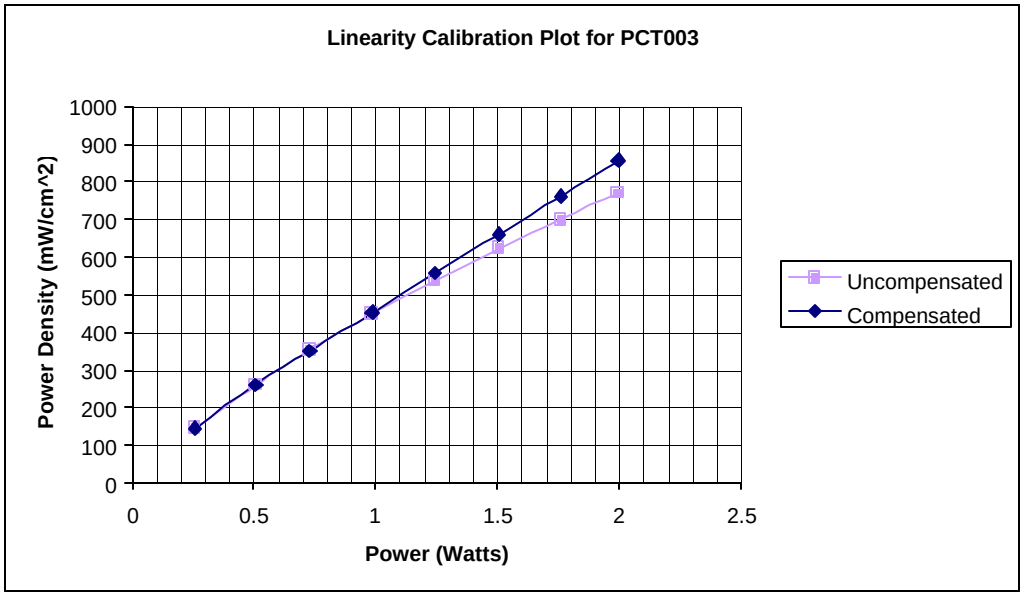


## Probe Physical Characteristics

| | |
|---|---|
| Serial Number: | PCT003 |
| Sensor Offset: | 2.4 mm |
| Sensor Length: | 2.5 mm |
| Tip Enclosure: | Glass |
| Tip Diameter: | 7 mm |
| Tip Length: | 40 mm |
| Total Length: | 290 mm |

CALIBRATED BY: _____ DATE: 01/15/03

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## Test Equipment

The test equipment used during the probe calibration are listed as follows:

| EQUIPMENT SPECIFICATIONS | | |
|---|---|---|
| Type | Calibration Date | Asset Number/ 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 | 4PJZ111 |
| E-Field Probe E-010 | January 2003 | PCT003 |
| Flat SAM Phantom (P-SAM-FLAT) | February 2002 | 94X-097 |
| IDX Robot End Effector (EE-103-C) | February 2002 | 07111223 |
| IDX Probe Amplifier | February 2002 | 07111113 |
| Validation Dipole D-835S | October 2002 | PCT441 |
| Validation Dipole D-1900S | October 2002 | PCT541 |
| Validation Dipole D-2450S | October 2002 | PCT641 |
| Validation Dipole D-5000S | November 2002 | PCT741 |
| HP-778D Dual-Directional Coupler (0.1 ~ 2.0 GHz) | November 2002 | PCT664 |
| MicroCircuits Directional Coupler (4.0 ~ 8.0 GHz) | November 2002 | PE2204-6 |
| Amplifier Research 5S1G4 Power Amp | January 2003 | PCT540 |
| IFI T184-10 Power Amplifier (4.0 ~ 18.0 GHz) | December 2002 | 5957 |
| Agilent E8241A (250kHz ~ 20GHz) Signal Generator | November 2002 | US42110432 |
| HP-8648D (9kHz ~ 4 GHz) Signal Generator | January 2003 | PCT526 |
| HP-8753E (30kHz ~ 6GHz) Network Analyzer | January 2003 | PCT552 |
| HP85070B Dielectric Probe Kit | January 2003 | PCT501 |
| IFI CC110EXX TEM Cell (DC to 2000 MHz) | January 2003 | PCT498 |
| EMCO 3115 Horn Antenna (2.0 ~ 18.0 GHz) | August 2002 | PCT496 |
| Guidline 5150 Precision Dual-Thermometer | November 2002 | 66145 |

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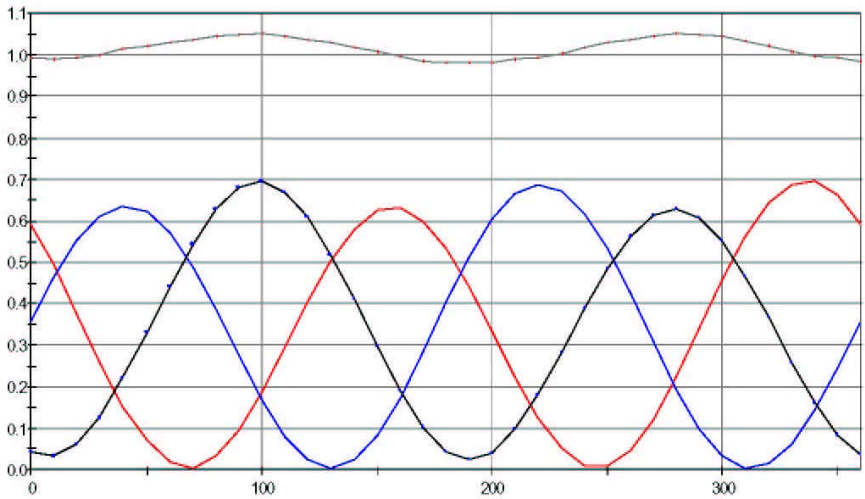
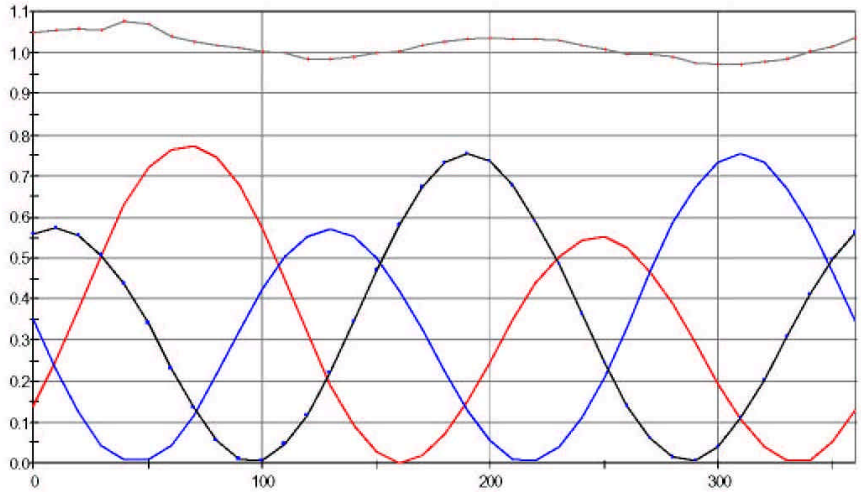
TEM Calibration Plot
Date: 3-Jan-03 05:19:17 pm
Probe Name: PCT003
Frequency: 835
Sensitivity: Ch1: 2.439 Ch2: 2.706 Ch3: 2.822 mV/(mW/cm^2)
Isotropicity: 3.49% 0.15 db Min=0.981 Max=1.051




TEM Calibration Plot
Date: 3-Jan-03 05:52:39 pm
Probe Name: PCT003
Frequency: 1880
Sensitivity: Ch1: 4.794 Ch2: 5.895 Ch3: 5.327 mV/(mW/cm^2)
Isotropicity: 5.35% 0.23 db Min=0.971 Max=1.078

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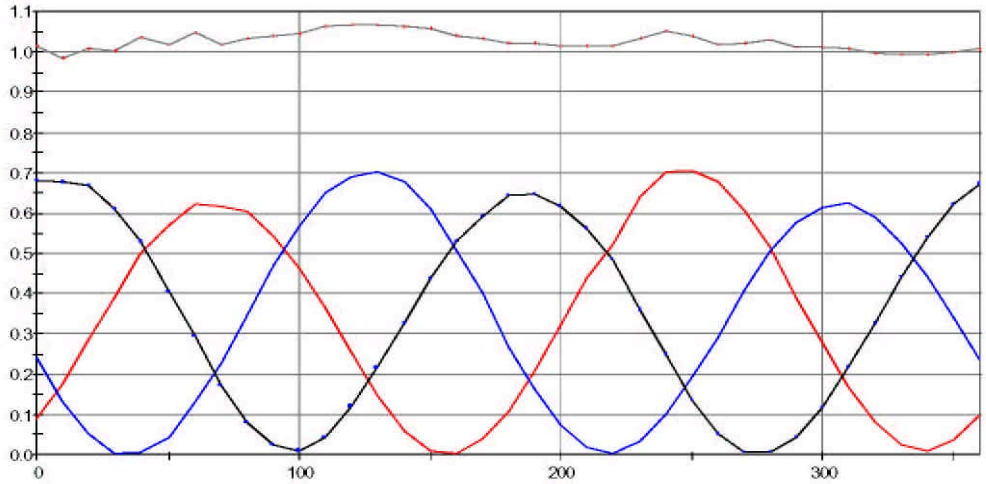
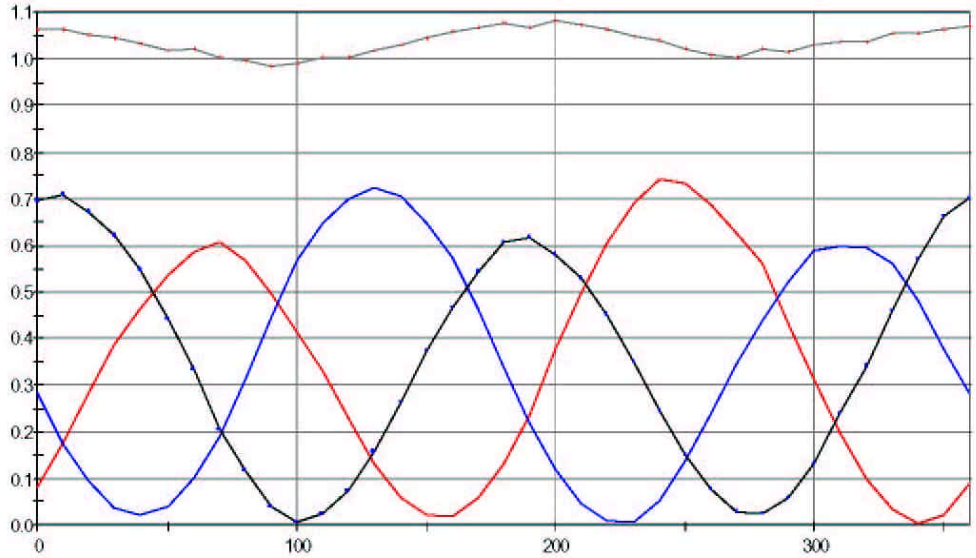
TEM Calibration Plot
Date: 3-Jan-03 10:10:11 am
Probe Name: PCT003
Frequency: 2440
Sensitivity: Ch1: 2.075 Ch2: 2.820 Ch3: 2.456 mV/(mW/cm^2)
Isotropicity: 4.02% 0.17 db Min=0.985 Max=1.066




TEM Calibration Plot
Date: 3-Jan-03 10:31:24 am
Probe Name: PCT003
Frequency: 5300
Sensitivity: Ch1: 1.939 Ch2: 2.177 Ch3: 2.062 mV/(mW/cm^2)
Isotropicity: 4.85% 0.21 db Min=0.984 Max=1.081

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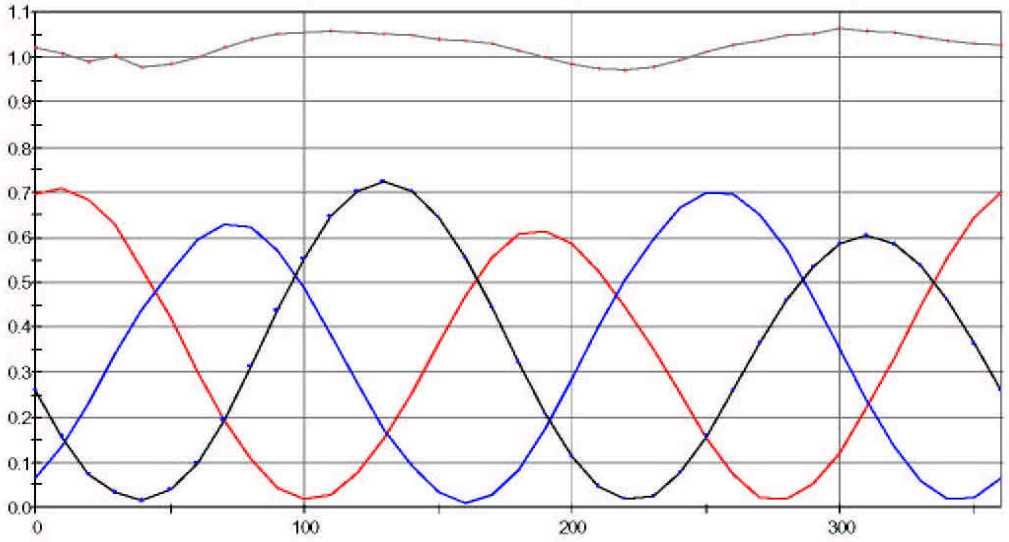
TEM Calibration Plot
Date: 3-Jan-02 12:06:18 pm
Probe Name: PCT003
Frequency: 5800
Sensitivity: Ch1: 0.6759 Ch2: 0.8082 Ch3: 0.7596 mV/(mW/cm^2)
Isotropicity: 4.93% 0.21 db Min=0.973 Max=1.082




**CALIBRATED BY:** _____ **DATE:** 01/15/03

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