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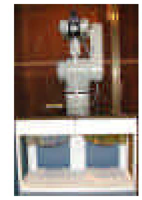

# CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

## Class II (FCC / RSS-102)

**APPLICANT NAME & ADDRESS:**
**Lenovo (United States) Incorporated**
**New Orchard Rd,**
**Armonk, NY 10504**

**DATE & LOCATION OF TESTING:**
**Dates of Tests: May 26-31, 2006**
**Test Report S/N: 0605260413**
**Test Site: PCTEST Lab, Columbia, MD USA**
**IC Lab File No.: IC 2451**

| | |
|---|---|
| **FCC ID:** | **S2L20030500CMR** |
| **IC CERTIFICATION NUMBER:** | **5903D-T60H786U** |
| **APPLICANT NAME:** | **Lenovo (United States) Incorporated** |

| | |
|---|---|
| **EUT Type:** | **Lenovo Laptop PC ThinkPad R32 Series Model: T60H786-U with 802.11b/g WLAN Adapter** |
| **Tx Frequency:** | **2412 – 2462 MHz** |
| **Max. RF Output Power:** | **0.0526 W Conducted** |
| **Max. SAR Measurement:** | **0.061 W/kg 802.11b Body SAR (Laptop); 0.238 W/kg 802.11b Body SAR (Bystander); 0.050 W/kg 802.11g Body S AR (Laptop); 0.254 W/kg 802.11g Body SAR (Bystander)** |
| **Trade Name/Model(s):** | ***T60H786-U*** |
| **FCC Rule Part(s):** | **§2.1093; FCC/OET Bulletin 65 Supplement C [July 2001]** |
| **Industry Canada Rule(s):** | **RSS-102 (SAR), Safety Code 6 Health Canada** |
| **Application Type:** | **Certification** |
| **Test Device Serial No.:** | **Identical Prototype [S/N: AA-GGFV8]** |
| **Original Grant Date:** | **March 24, 2004** |

**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), IEEE Std. P1528-2003 and Industry Canada RSS-102.**

**I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.**

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

Randy Ortanez
President

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# 1. INTRODUCTION / SAR DEFINITION

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

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

## SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (*dU*) absorbed by (dissipated in) an incremental mass (*dm*) contained in a volume element (*dV*) of a given density ($r$). 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).

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

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

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

SAR = $s\,\mathbf{E}^2 / r$

where:

| | | |
|---|---|---|
| $s$ | = | conductivity of the tissue-simulant material (S/m) |
| $r$ | = | mass density of the tissue-simulant material (kg/m$^3$) |
| $\mathbf{E}$ | = | 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 DASY4 automated dosimetric assessment system. The DASY4 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Pentium III computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. 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

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Gateway Pentium 4 2.53 GHz computer with Windows XP system and SAR Measurement Software DASY4, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

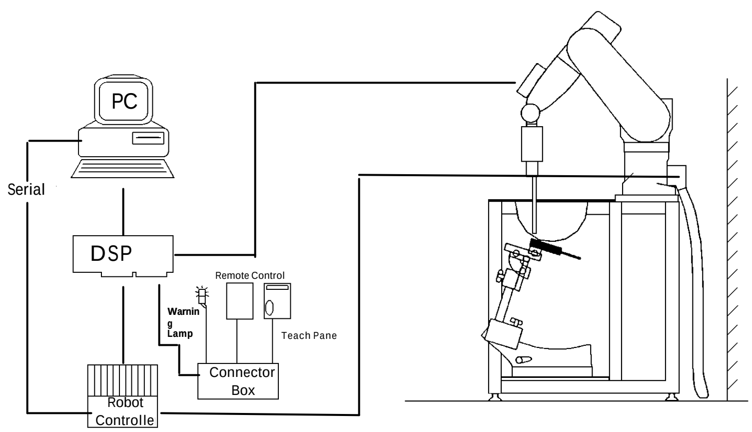


**Figure 2.1 SAR Measurement System Setup**

## System Electronics

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in [7].

# 3. DASY4 E-FIELD PROBE SYSTEM

## Probe Measurement System

Figure 3.1 DAE System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration [7] (see Fig. 3.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip (see Fig. 3.3). It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY4 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting (see Fig.3.1). The approach is stopped at reaching the maximum.

## Probe Specifications

| | |
|---|---|
| Calibration: | In air from 10 MHz to 6 GHz |
| | In brain and muscle simulating tissue at |
| | Frequencies of 150 MHz, 450 MHz, 835 MHz, 900 MHz, 1900MHz, 2450MHz, 5300MHz, & 5800MHz |
| Frequency: | 10 MHz to > 6 GHz; Linearity: ± 0.2 dB |
| | (30 MHz to 6 GHz) |
| Directivity: | ± 0.2 dB in HSL (rotation around probe axis) |
| | ± 0.4 dB in HSL (rotation normal probe axis) |
| Dynamic: | 5 mW/g to > 100 mW/g; |
| Range: | Linearity: ± 0.2 dB |
| Dimensions: | Overall length: 330 mm |
| | Tip length: 16 mm |
| | Body diameter: 12 mm |
| | Tip diameter: 3 mm |
| | Distance from probe tip to dipole centers: 2 mm |
| Application: | General dosimetry up to 6 GHz |
| | Compliance tests of mobile phones |
| | Fast automatic scanning in arbitrary phantoms |

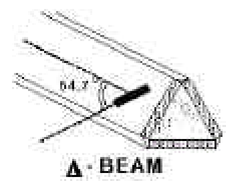


Figure 3.1 Triangular Probe Configuration

Figure 3.2 Probe Thick-Film Technique

## 4. Probe Calibration Process

### Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure described in [8] with accuracy better than +/-10%. The spherical isotropy was evaluated with the procedure described in [9] and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe is tested.

### Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz (see Fig. 4.1), and in a waveguide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

### 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:*

$\Delta t$ = *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;*

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

*where:*

$s$ = *simulated tissue conductivity,*

$r$ = *Tissue density (1.25 g/cm³ for brain tissue)*

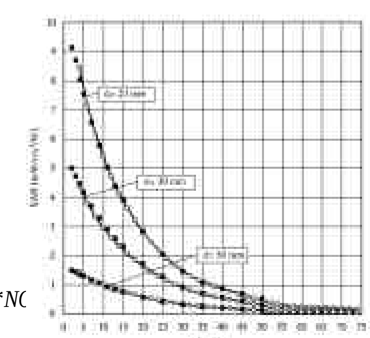

Figure 4.1 E-Field and Temperature measurements at 900MHz [7]

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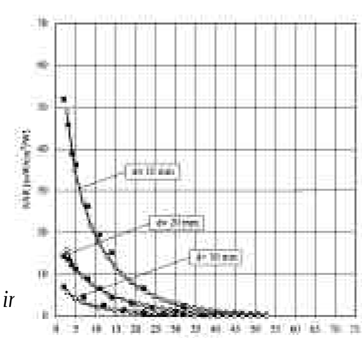


Figure 4.2 E-Field and temperature measurements at 1.9GHz [7]

# 5. PHANTOM & EQUIVALENT TISSUES

## SAM Phantom

**Figure 5.1 SAM Twin Phantom**

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users [11][12]. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 5.1)

## Brain & Muscle Simulating Mixture Characterization

**Figure 5.2 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 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 bee specified in P1528 are derived from the tissue 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 [13].(see Fig. 5.2)

**Table 5.1 Composition of the Brain & Muscle Tissue Equivalent Matter**

| Ingredient (% 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 |
| 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 | 0.0 | 26.7 |

## Device Holder for Transmitters

**Figure 5.2 Mounting Device**

In combination with the SAM Twin Phantom V4.0, the Mounting Device (see Fig. 5.2) enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can be easily, accurately, and repeatably be positioned according to the FCC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

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

# 6. TEST SYSTEM SPECIFICATIONS

## Automated Test System Specifications

**Positioner**

| | |
|---|---|
| **Robot:** | Stäubli Unimation Corp. Robot Model: RX60L |
| **Repeatability:** | 0.02 mm |
| **No. of axis:** | 6 |

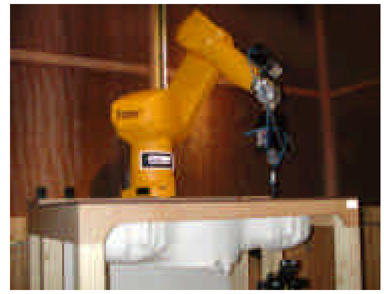


**Figure 6.1 DASY4 Test System**

**Data Acquisition Electronic (DAE) System**

**Cell Controller**

| | |
|---|---|
| **Processor:** | Pentium 4 |
| **Clock Speed:** | 2.53 GHz |
| **Operating System:** | Windows XP Professional |

**Data Converter**

| | |
|---|---|
| **Features:** | Signal Amplifier, multiplexer, A/D converter, & control logic |
| **Software:** | DASY4 software |
| **Connecting Lines:** | Optical downlink for data and status info.<br>Optical uplink for commands and clock |

**PC Interface Card**

**Function:** 24 bit (64 MHz) DSP for real time processing
Link to DAE4
16 bit A/D converter for surface detection system
serial link to robot
direct emergency stop output for robot

**E-Field Probes**

| | | |
|---|---|---|
| **Model:** | EX3DV4 | S/N: 3561 |
| **Construction:** | Triangular core | |
| **Frequency:** | 10 MHz to 6 GHz | |
| **Linearity:** | ± 0.2 dB (30 MHz to 6 GHz) | |

**Phantom**

| | |
|---|---|
| **Phantom:** | SAM Twin Phantom (V4.0) |
| **Shell Material:** | VIVAC Composite |
| **Thickness:** | 2.0 ± 0.2 mm |

# 7. DOSIMETRIC ASSESSMENT & PHANTOM SPECS

## Measurement Procedure

The evaluation was performed using the following procedure:

1. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.
2. The SAR distribution at the exposed side of the head was measured at a distance of 3.9mm from the inner surface of the shell. The area covered the entire dimension of the head and the horizontal grid spacing was 15mm x 15mm.
3. Based on the area scan data, the area of the maximum absorption was determined by spline interpolation. Around this point, a volume of 32mm x 32mm x 34mm (fine resolution volume scan, zoom scan) was assessed by measuring 7 x 7 x 7 points. On this basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see Fig. 7.1):

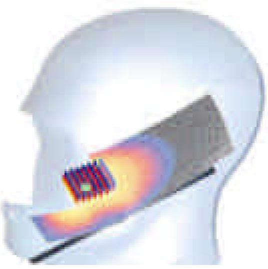


Figure 7.1 Sample SAR Area Scan

a. The data at the surface was extrapolated, since the center of the dipoles is 2.7mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.2mm. The extrapolation was based on a least square algorithm [15]. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.

b. The maximum interpolated value was searched with a straight-forward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1g or 10g) were computed using the 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the "Not a knot" condition (in x, y, and z directions) [15][16]. The volume was integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

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

4. The SAR reference value, at the same location as procedure #1, was re-measured. If the value changed by more than 5%, the evaluation is repeated.

**Deviation from measurement procedure - None**

## 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 Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. 7.2). 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.

**Figure 7.2 SAM Twin Phantom shell**

# 8. 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<br>General Population<br>(W/kg) or (mW/g) | CONTROLLED ENVIRONMENT<br>Occupational<br>(W/kg) or (mW/g) |
| SPATIAL PEAK SAR 1<br>Brain | 1.60 | 8.00 |
| SPATIAL AVERAGE SAR 2<br>Whole Body | 0.08 | 0.40 |
| SPATIAL PEAK SAR 3<br>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.

# 9. 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 | 4.8 | N | 1 | 1 | 1 | 4.8 | 4.8 | ∞ |
| Axial Isotropy | E1.2 | 4.7 | R | √3 | 0.7 | 0.7 | 1.9 | 1.9 | ∞ |
| Hemishperical Isotropy | E1.2 | 9.6 | R | √3 | 0.7 | 0.7 | 3.9 | 3.9 | ∞ |
| Boundary Effect | E1.3 | 1.0 | R | √3 | 1 | 1 | 0.6 | 0.6 | ∞ |
| 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 | N | 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 | 2.6 | R | √3 | 1 | 1 | 1.5 | 1.5 | ∞ |
| RF Ambient Conditions | E5.1 | 3.0 | R | √3 | 1 | 1 | 1.7 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | E5.2 | 0.4 | R | √3 | 1 | 1 | 0.2 | 0.2 | ∞ |
| Probe Positioning w/ respect to Phantom | E5.3 | 2.9 | R | √3 | 1 | 1 | 1.7 | 1.7 | ∞ |
| Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation | E4.2 | 1.0 | R | √3 | 1 | 1 | 0.6 | 0.6 | ∞ |
| **Test Sample Related** | | | | | | | | | |
| Test Sample Positioning | E3.2.1 | 2.9 | N | 1 | 1 | 1 | 2.9 | 2.9 | 145 |
| Device Holder Uncertainty | E3.1.1 | 3.6 | N | 1 | 1 | 1 | 3.6 | 3.6 | 5 |
| 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 | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| Liquid Conductivity - measurement uncertainty | E2.2 | 2.5 | N | 1 | 0.64 | 0.43 | 1.6 | 1.1 | ∞ |
| 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 | 2.5 | N | 1 | 0.6 | 0.5 | 1.5 | 1.2 | ∞ |
| **Combined Standard Uncertainty (k=1)** | | | RSS | | | | 10.3 | 10.0 | |
| **Expanded Uncertainty (k=2)** (95% CONFIDENCE LEVEL) | | | | | | | 20.6 | 20.1 | |

The above measurement uncertainties are according to IEEE Std. 1528 - 2003.

# 10. SAR TEST DATA SUMMARY

## See Measurement Result Data Pages

## Procedures Used To Establish Test Signal

The device was placed into continuous transmit mode in WLAN mode, using software test codes. Such test signals offer a consistent means for testing SAR and are recommended for evaluating SAR [4].

## Device Test Conditions

The device was powered through the battery. In order to verify that the device was tested at full power, conducted output power measurements were performed before the evaluation at the maximum power set on the base station simulator to confirm the output power. If a power deviation of more than 5% occurred, the test was repeated.

# 11. SAR TEST EQUIPMENT

## Equipment Calibration

**Table 13.1 Test Equipment Calibration**

| EQUIPMENT SPECIFICATIONS | | |
|---|---|---|
| **Type** | **Cal Due** | **Serial Number** |
| Staubli Robot RX60L | Oct 2007 | 599131-01 |
| Staubli Robot Controller | Oct 2007 | PCT592 |
| Staubli Teach Pendant (Joystick) | Oct 2007 | 3323-00161 |
| Gateway Computer, 2.52GHz/768MB,Windows-XP | N/A | PCT678 |
| SPEAG EDC3 | Oct 2007 | 321 |
| SPEAG DAE4 | Sep 2006 | 649 |
| SPEAG DAE4 | Aug 2006 | 665 |
| SPEAG E-Field Probe EX3DV4 | Aug 2006 | 3561 |
| SPEAG Dummy Probe | Oct 2006 | PCT583 |
| SPEAG SAM Twin Phantom V4.0 | Oct 2006 | PCT666 |
| SPEAG Light Alignment Sensor | Oct 2006 | 205 |
| SPEAG Validation Dipole D835V2 | Feb 2007 | PCT512 |
| SPEAG Validation Dipole D1900V2 | Feb 2007 | PCT613 |
| Rohde & Schwarz CMD80 Base Station Simulator | Jun 2006 | 830805/005 |
| Rohde & Schwarz CMU200 Base Station Simulator | Oct 2006 | 650378 |
| Agilent 8960 Test Communications Set | Jan 2007 | GB43193972 |
| SPEAG Freespace 1900MHz Dipole | Feb 2007 | 1002 |
| SPEAG Freespace 2450 MHz Dipole | Feb 2007 | 1004 |
| ETS Freespace 835 MHz Dipole | Feb 2007 | A005 |
| SPEAG Freespace 835 MHz Dipole | Feb 2007 | 1003 |
| SPEAG Freespace H-Field Probe | Aug 2006 | 6170 |
| SPEAG Freespace E-Field Probe | Aug 2006 | 2353 |
| MW Amp. Model: 5S1G4, (800MHz - 4.2GHz) | Jan 2007 | 22332 |
| Gigatronics 8651A Power Meter | Jan 2007 | 1835299 |
| Gigatronics 80701A Sensor(50MHz-18GHz) | Jan 2007 | PCT606 |
| HP-8648D (9kHz ~ 4GHz) Signal Generator | Jan 2007 | PCT530 |
| HP-8241A (-18GHz) Signal Generator | Jan 2007 | |
| Amplifier Research 5S1G4 AMP | Jan 2007 | PCT540 |
| HP-8753E (30kHz ~ 3GHz) Network Analyzer | Jun 2006 | PCT552 |
| HP85070B Dielectric Probe Kit | Jun 2006 | PCT501 |
| Ambient Noise/Reflection, etc. (<12mW/kg/<3%of SAR) | N/A | 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.

# 12. CONCLUSION

## Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC and Industry Canada. 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]

# 13. 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. 1528-2003), *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.

# EXHIBIT A. SYSTEM VERIFICATION

## Tissue Verification

**Table A.1 Simulated Tissue Verification**

| MEASURED TISSUE PARAMETERS | | | | |
|---|---|---|---|---|
| | 2450MHz Brain | | 2450MHz Muscle | |
| | Target | Measured | Target | Measured |
| Dielectric Constant: ε | 39.20 | 38.41 | 52.70 | 53.42 |
| Conductivity: σ | 1.80 | 1.82 | 1.95 | 1.93 |

## Test System Validation

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 A.2 System Validation**

| System Validation TARGET & MEASURED | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date:** | **Amb. Temp (°C)** | **Liquid Temp(°C)** | **Input Power (W)** | **Tissue** | **Targeted $SAR_{1g}$ (mW/g)** | **Measured $SAR_{1g}$ (mW/g)** | **Deviation (%)** |
| 05/31/2006 | 23.5 | 21.7 | **0.100** | **2450 MHz Brain** | **5.24** | **5.39** | 2.86% |

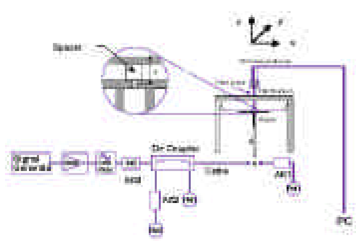


**Figure A.0 Dipole Validation Test Setup**

# EXHIBIT A. SAR DATA SUMMARY

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

## A.1 MEASUREMENT RESULTS (IEEE 802.11b, Laptop Position)

| FREQUENCY | | Modulation | POWER | | Data Rate | Separation Distance (cm) ⌗ | Test Position | Antenna | SAR |
|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | Start | End | (Mbps) | | | | (W/kg) |
| 2437 | 6 | DSSS | 16.43 | 16.62 | 1 | 0.0 cm | Laptop | Auxiliary | 0.0559 |
| 2437 | 6 | DSSS | 16.65 | 16.90 | 2 | 0.0 cm | Laptop | Auxiliary | **0.0608** |
| 2437 | 6 | DSSS | 16.52 | 16.49 | 5.5 | 0.0 cm | Laptop | Auxiliary | 0.0564 |
| 2437 | 6 | DSSS | 16.47 | 16.72 | 11 | 0.0 cm | Laptop | Auxiliary | 0.0561 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population** | | | | | | **Muscle<br>1.6 W/kg (mW/g)**<br>averaged over 1 gram | | | |

**NOTES:**

1. The test data reported are the worst-case SAR value with the lap held 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 including all data bit rates and worst-case results are reported.
3. SAR Measurement System ☒ DASY4 ☐ IDX

   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
4. SAR Configuration ☐ Head ☒ Body ☐ Hand
5. Test Signal Call Mode ☒ Software ☐ Base Station Simulator
6. Tissue parameters and temperatures are listed on the SAR plots.
7. Liquid tissue depth is 15.1 cm. ± 0.1

Randy Ortanez
President

# EXHIBIT A. SAR DATA SUMMARY (Continued)

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

| A.2 MEASUREMENT RESULTS (IEEE 802.11b, Bystander Position) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Modulation | POWER | | Data Rate | Separation Distance (cm) ⌗ | Test Position | Antenna | SAR |
| MHz | Ch. | | Start | End | (Mbps) | | | | (W/kg) |
| 2437 | 6 | DSSS | 16.65 | 16.77 | 2 | 1.5 cm | Bystander-Left Side | Auxiliary | 0.0359 |
| 2437 | 6 | DSSS | 16.65 | 16.37 | 2 | 1.5 cm | Bystander-Back Side | Auxiliary | **0.2380** |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Muscle<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | |

**NOTES:**

1. The test data reported are the worst-case SAR value with the lap held 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 including all data bit rates and worst-case results are reported.
3. SAR Measurement System ☒ DASY4 ☐ IDX

   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
4. SAR Configuration ☐ Head ☒ Body ☐ Hand
5. Test Signal Call Mode ☒ Software ☐ Base Station Simulator
6. Tissue parameters and temperatures are listed on the SAR plots.
7. Liquid tissue depth is 15.1 cm. ± 0.1

Randy Ortanez
President

# EXHIBIT A. SAR DATA SUMMARY (Continued)

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

## A.3 MEASUREMENT RESULTS (IEEE 802.11g, Laptop Position)

| FREQUENCY | | Modulation | POWER | | Data Rate | Separation Distance (cm) ‡ | Test Position | Antenna | SAR |
|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | Start | End | (Mbps) | | | | (W/kg) |
| 2437 | 6 | OFDM | 16.84 | 17.10 | 6 | 0.0 cm | Laptop | Auxiliary | 0.0474 |
| 2437 | 6 | OFDM | 16.88 | 17.13 | 9 | 0.0 cm | Laptop | Auxiliary | **0.0501** |
| 2437 | 6 | OFDM | 16.84 | 17.10 | 12 | 0.0 cm | Laptop | Auxiliary | 0.0490 |
| 2437 | 6 | OFDM | 16.80 | 16.91 | 18 | 0.0 cm | Laptop | Auxiliary | 0.0474 |
| 2437 | 6 | OFDM | 16.79 | 16.82 | 24 | 0.0 cm | Laptop | Auxiliary | 0.0477 |
| 2437 | 6 | OFDM | 16.76 | 17.02 | 36 | 0.0 cm | Laptop | Auxiliary | 0.0477 |
| 2437 | 6 | OFDM | 16.73 | 17.05 | 48 | 0.0 cm | Laptop | Auxiliary | 0.0335 |
| 2437 | 6 | OFDM | 16.70 | 16.80 | 54 | 0.0 cm | Laptop | Auxiliary | 0.0253 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population** | | | | | | | **Muscle<br>1.6 W/kg (mW/g)**<br>averaged over 1 gram | | |

**NOTES:**

1. The test data reported are the worst-case SAR value with the lap held 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 including all data bit rates and worst-case results are reported.
3. SAR Measurement System ☒ DASY4 ☐ IDX

   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
4. SAR Configuration ☐ Head ☒ Body ☐ Hand
5. Test Signal Call Mode ☒ Software ☐ Base Station Simulator
6. Tissue parameters and temperatures are listed on the SAR plots.
7. Liquid tissue depth is 15.1 cm. ± 0.1

Randy Ortanez
President

# EXHIBIT A. SAR DATA SUMMARY

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

## A.4 MEASUREMENT RESULTS (IEEE 802.11g, Bystander Position)

| FREQUENCY | | Modulation | POWER | | Data Rate | Separation Distance (cm) ‡ | Test Position | Antenna | SAR |
|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | Start | End | (Mbps) | | | | (W/kg) |
| 2412 | 1 | OFDM | 16.88 | 17.20 | 9 | 1.5 cm | Bystander- Left Side | Auxiliary | 0.0308 |
| 2437 | 6 | OFDM | 16.88 | 16.98 | 9 | 1.5 cm | Bystander – Back Side | Auxiliary | **0.2540** |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT**<br>**Spatial Peak**<br>**Uncontrolled Exposure/General Population** | | | | | | **Muscle**<br>**1.6 W/kg (mW/g)**<br>averaged over 1 gram | | | |

**NOTES:**

1. The test data reported are the worst-case SAR value with the lap held 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 including all data bit rates and worst-case results are reported.
3. SAR Measurement System ☒ DASY4 ☐ IDX

   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
4. SAR Configuration ☐ Head ☒ Body ☐ Hand
5. Test Signal Call Mode ☒ Software ☐ Base Station Simulator
6. Tissue parameters and temperatures are listed on the SAR plots.
7. Liquid tissue depth is 15.1 cm. ± 0.1
8. * Front View

Randy Ortanez
President

# ATTACHMENT A – SAR TEST DATA

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

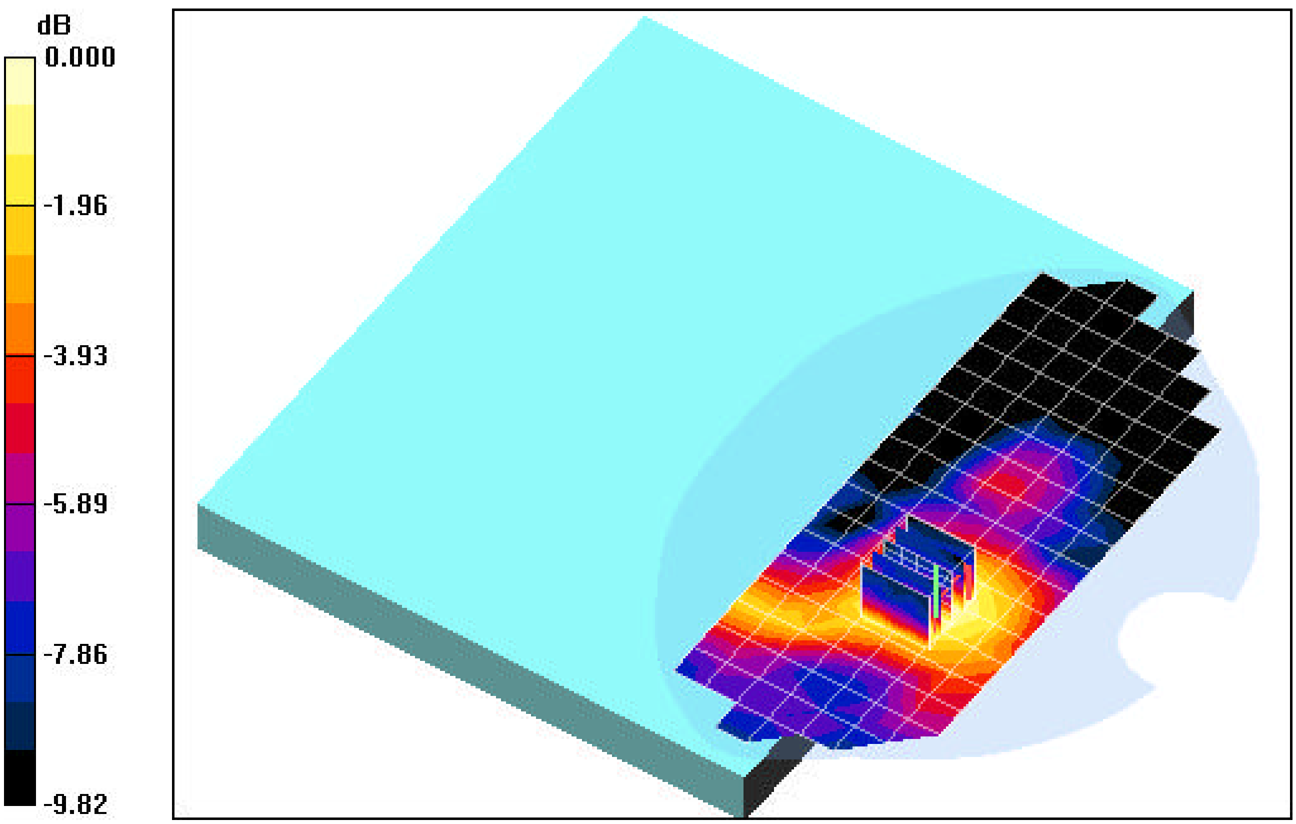
Communication System: IEEE 802.11b; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11b Mode, Laptop position, Ch.06, 2Mbps, Auxiliary Antenna**

**Area Scan (8x22x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 5.37 V/m
Peak SAR (extrapolated) = 0.107 W/kg
**SAR(1 g) = 0.061 mW/g; SAR(10 g) = 0.038 mW/g**




0 dB = 0.070mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

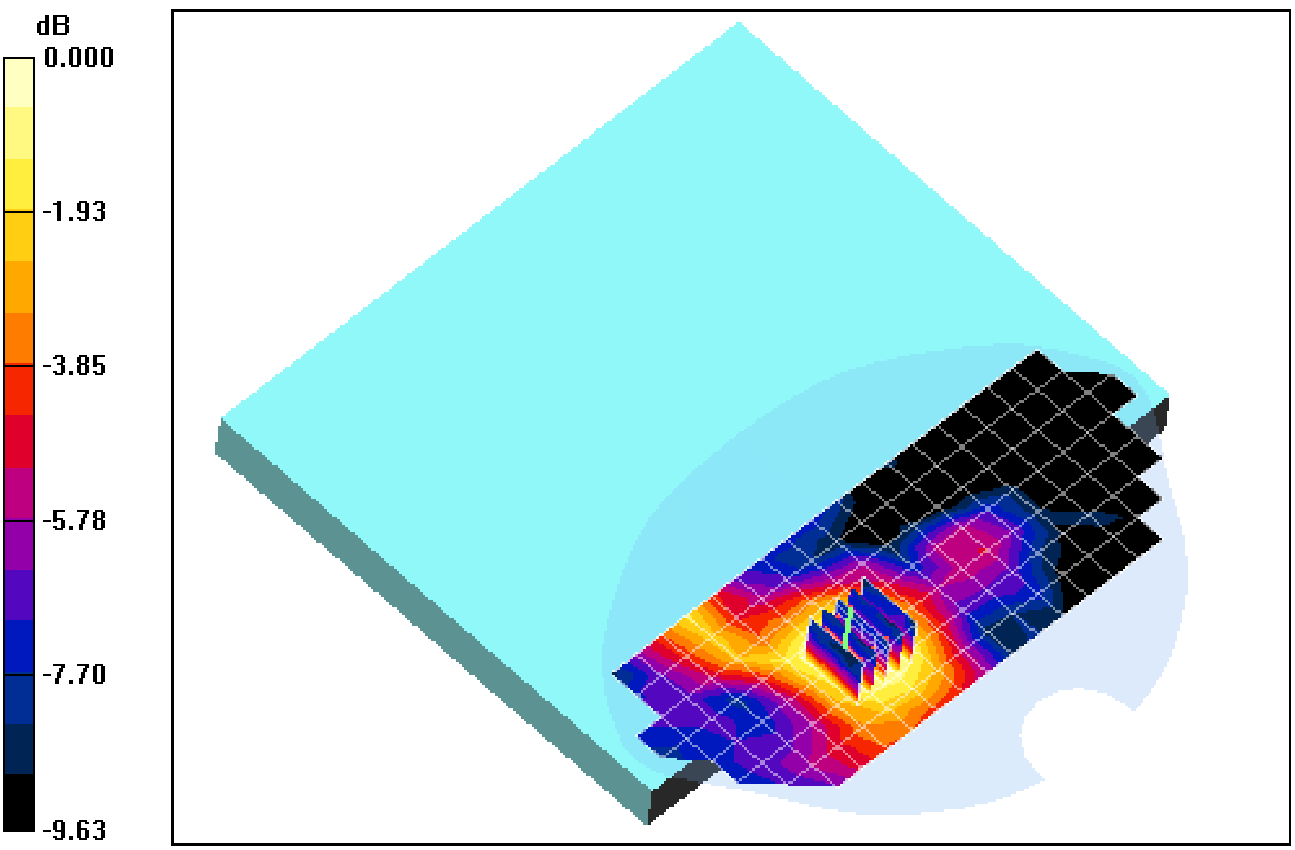
Communication System: IEEE 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11g Mode, Laptop position, Ch.06, 9Mbps, Auxiliary Antenna**

**Area Scan (8x22x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 5.13 V/mdB
Peak SAR (extrapolated) = 0.087 W/kg
**SAR(1 g) = 0.050 mW/g; SAR(10 g) = 0.032 mW/g**




0 dB = 0.058mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; Serial: AA-GGF8V**
**Conducted Power 17.0dBm**

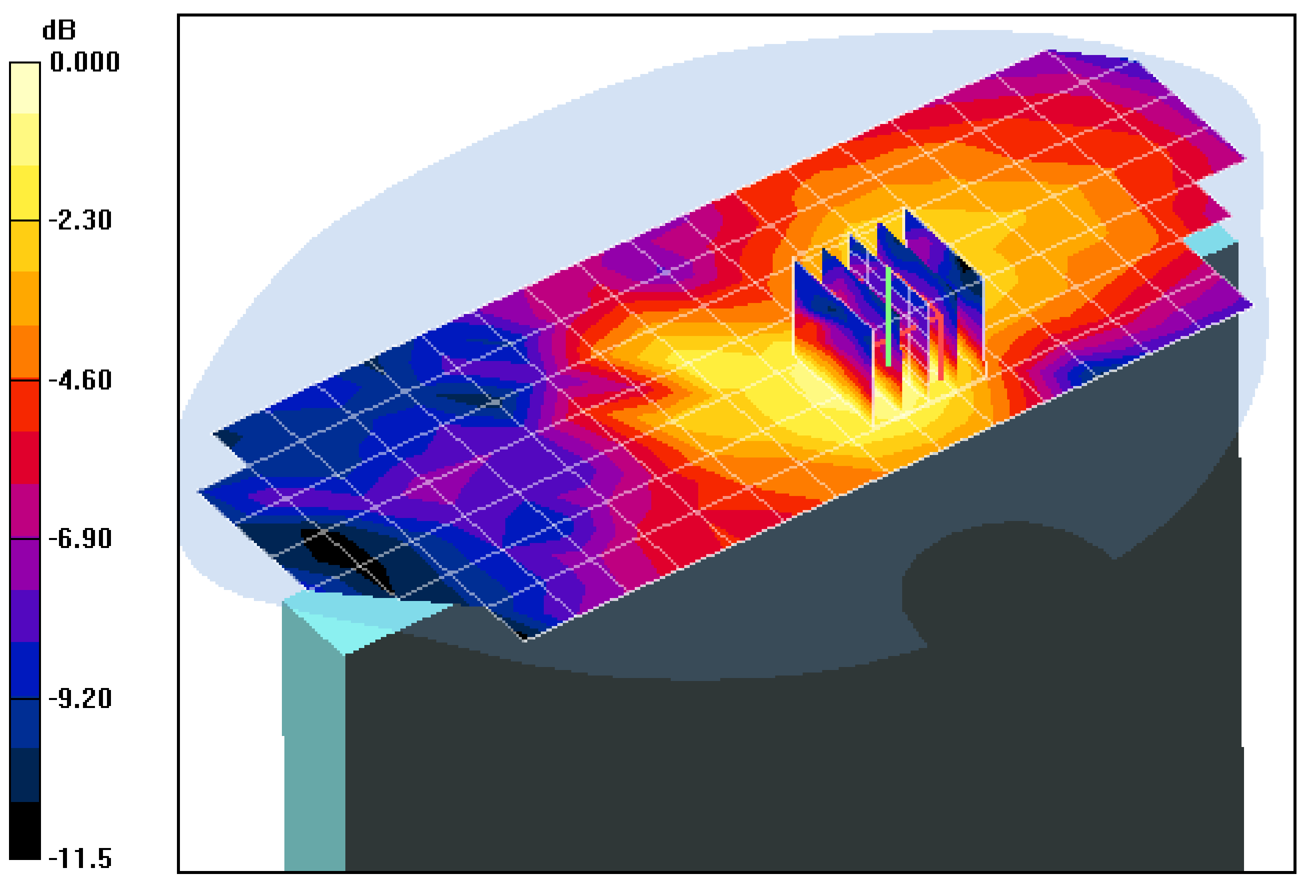
Communication System: IEEE 802.11b; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/$m^3$)
Phantom section: Flat Section; Space 1.5cm

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11b Mode; Bystander position, Leftside, Mid.ch, 2 Mbps, Auxiliary Antenna**

**Area Scan (8x21x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 3.55 V/m
Peak SAR (extrapolated) = 0.063 W/kg
**SAR(1 g) = 0.036 mW/g; SAR(10 g) = 0.022 mW/g**




0 dB = 0.044mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

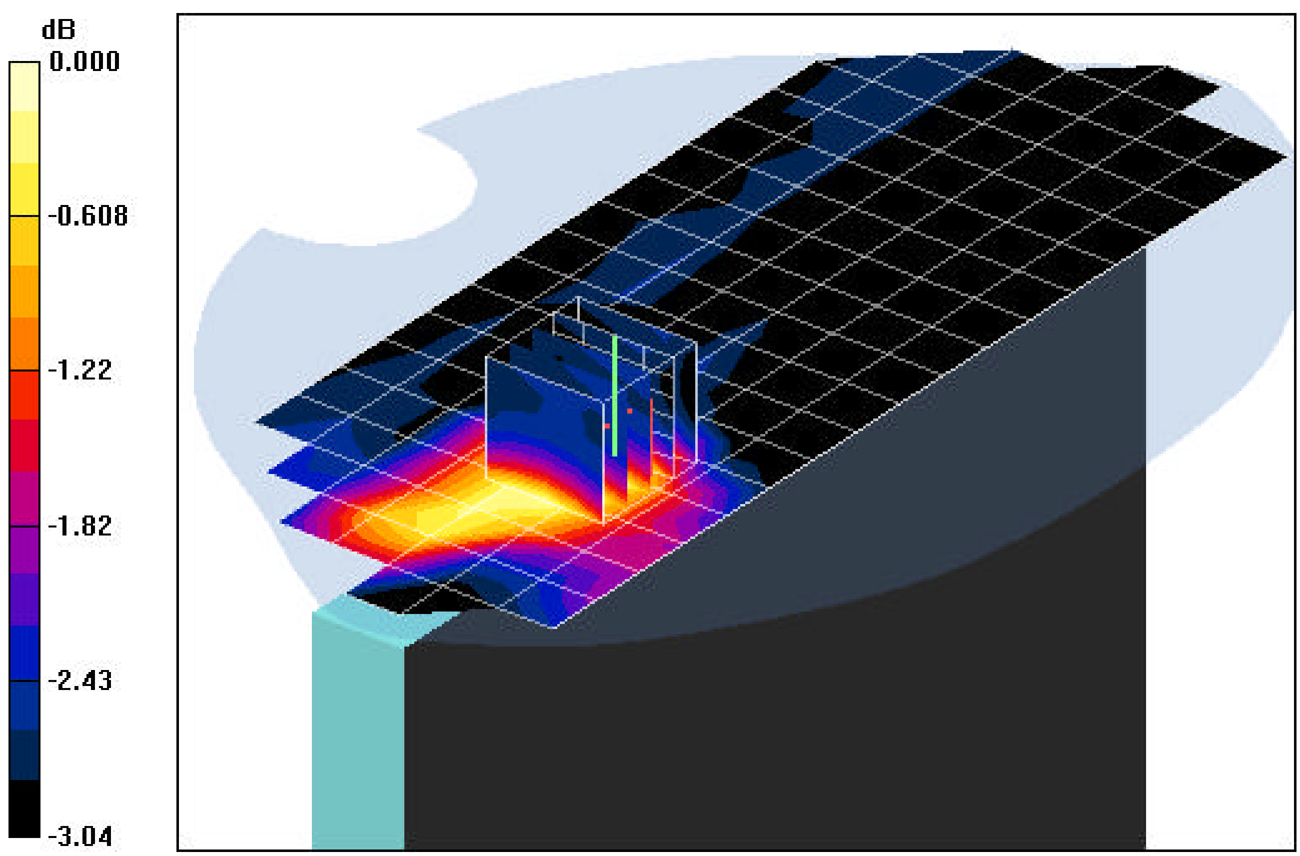
Communication System: IEEE 802.11b; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section; Space: 1.5cm from DUT to Flat Phantom

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11b Mode, Bystander position, Backside, Ch.06, 2 Mbps, Auxiliary Antenna**

**Area Scan (8x22x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 9.34 V/m
Peak SAR (extrapolated) = 0.363 W/kg
**SAR(1 g) = 0.238 mW/g; SAR(10 g) = 0.190 mW/g**




0 dB = 0.262mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

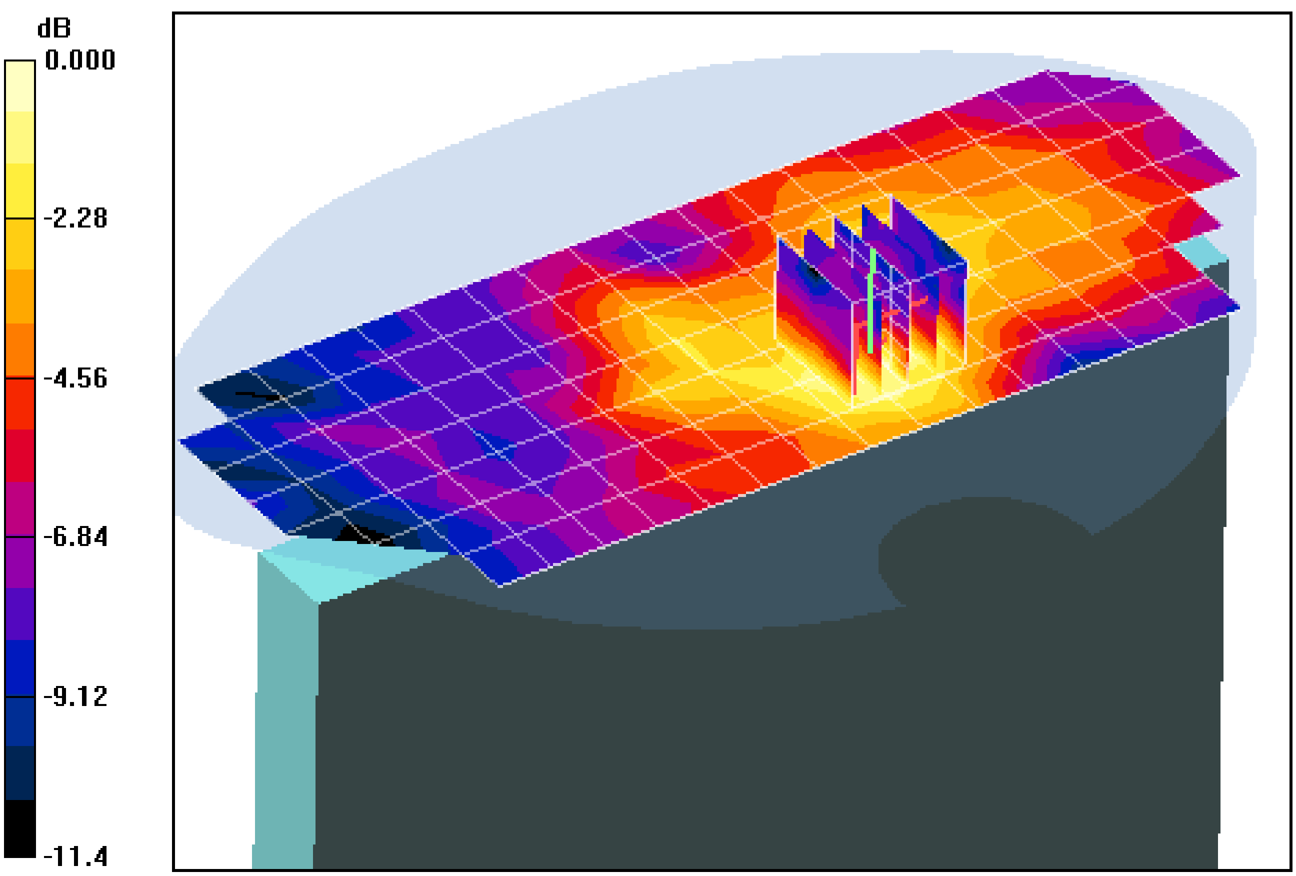
Communication System: IEEE 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section; Space 1.5cm

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11g Mode; Bystander position, Mid.ch, 9Mbps, Auxiliary Antenna**

**Area Scan (8x21x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 4.09 V/m
Peak SAR (extrapolated) = 0.052 W/kg
**SAR(1 g) = 0.031 mW/g; SAR(10 g) = 0.019 mW/g**




0 dB = 0.037mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

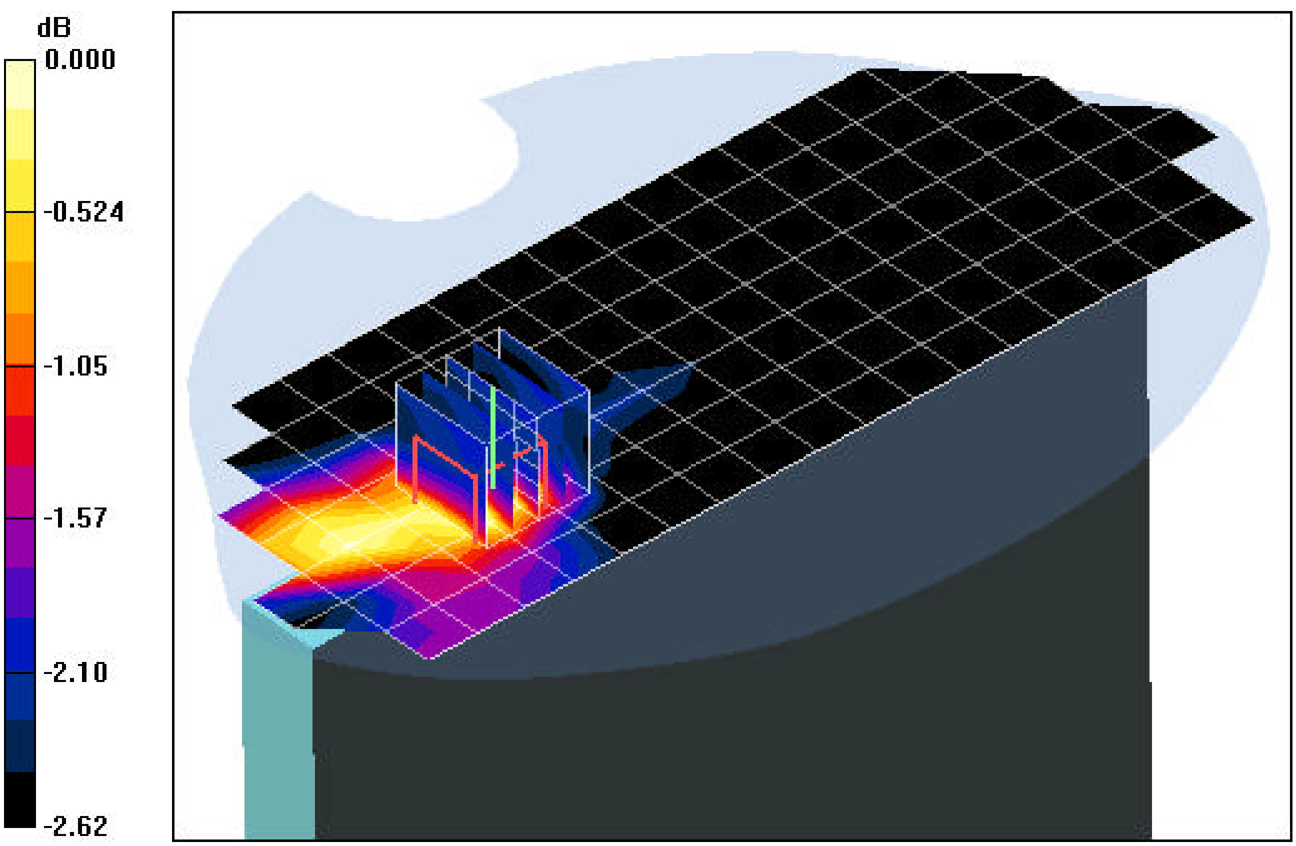
Communication System: IEEE 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section; Space: 1.5cm from DUT to Flat Phantom

Test Date: 05-31-20063; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**IEEE 802.11g Mode, Bystander position, Backside, Ch.06, 9Mbps, Auxiliary Antenna**

**Area Scan (8x22x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 8.93 V/m
Peak SAR (extrapolated) = 0.384 W/kg
**SAR(1 g) = 0.254 mW/g; SAR(10 g) = 0.207 mW/g**




0 dB = 0.278mW/g

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Lenovo ThinkPad R32; Type: WLAN 802.11bg Mini PCI card; SN: AA-GGF8V**
**Conducted Power: 17.0dBm**

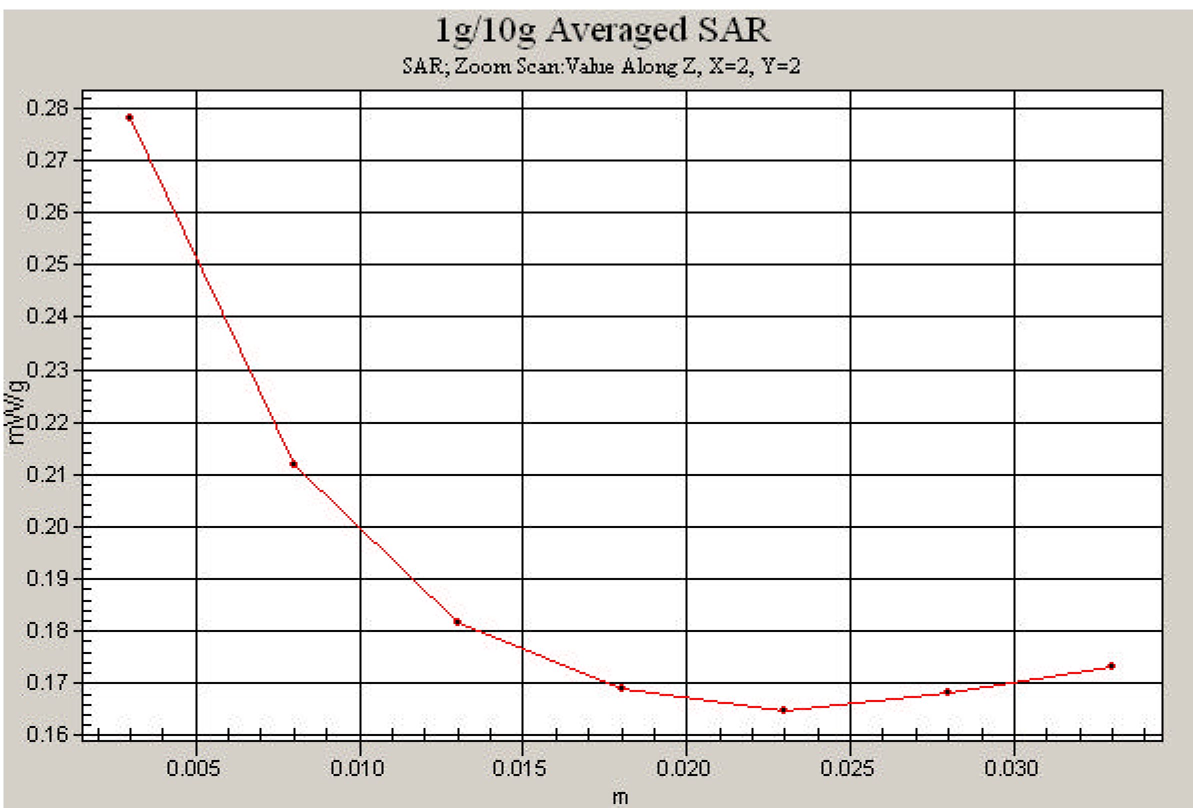
Communication System: IEEE 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: 2450 Muscle ($\sigma$ = 1.93 mho/m, $\varepsilon_r$ = 53.42, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section; Space: 1.5cm from DUT to Flat Phantom

Test Date: 05-31-2006; Ambient Temp: 23.8°C; Tissue Temp: 21.5°C

Probe: EX3DV4 - SN3561; ConvF(6.3, 6.3, 6.3); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

## IEEE 802.11g Mode, Bystander position, Backside, Ch.06, 9Mbps, Auxiliary Antenna

**Area Scan (8x22x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 8.93 V/m
Peak SAR (extrapolated) = 0.384 W/kg
**SAR(1 g) = 0.254 mW/g; SAR(10 g) = 0.207 mW/g**



# ATTACHMENT C – DIPOLE VALIDATION

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 2450 MHz; Type: D2450V2; SN: 719**

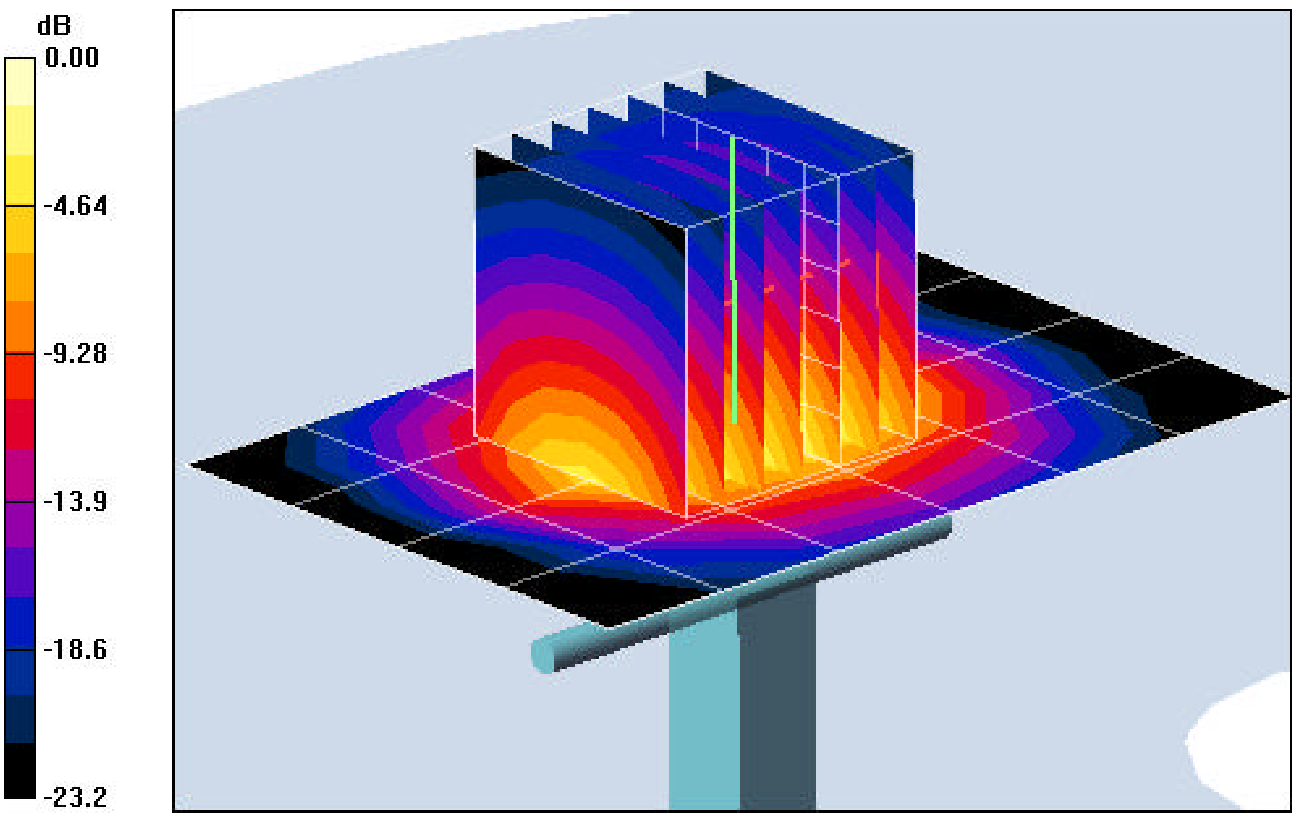
Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 Brain ($\sigma$ = 1.82 mho/m, $\varepsilon_r$ = 38.41, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section

Test Date: 05-31-2006; Ambient Temp: 23.5°C; Tissue Temp: 21.7°C

Probe: EX3DV4 - SN3561; ConvF(6.37, 6.37, 6.37); Calibrated: 8/24/2005
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn649; Calibrated: 9/13/2005
Phantom: SAM Main; Type: SAM 4.0; Serial: TP:1197
Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

## 2450MHz Dipole Validation

**Area Scan (5x7x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Input Power = 20.0 dBm (100mW)
**SAR(1 g) = 5.39 mW/g; SAR(10 g) = 2.68 mW/g**
Target SAR(1 g) = 5.24 mW/g; Deviation = +2.86%




0 dB = 7.76mW/g

# ATTACHMENT D – PROBE CALIBRATION

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

**Client** **PC Test**

**Certificate No: EX3-3561_Aug05**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | EX3DV4 - SN:3561 |
| Calibration procedure(s) | QA CAL-01.v5 and QA CAL-14.v2<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | August 24, 2005 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41495277 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41498087 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 11-Aug-05 (METAS, No. 251-00499) | Aug-06 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467) | May-06 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 11-Aug-05 (METAS, No. 251-00500) | Aug-06 |
| Reference Probe ES3DV2 | SN: 3013 | 7-Jan-05 (SPEAG, No. ES3-3013_Jan05) | Jan-06 |
| DAE4 | SN: 654 | 29-Nov-04 (SPEAG, No. DAE4-654_Nov04) | Nov-05 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (SPEAG, in house check Dec-03) | In house check: Dec-05 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov 05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Katja Pokovic | Technical Manager | |
| Approved by: | Niels Kuster | Quality Manager | |

Issued: August 24, 2005

**Glossary:**

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) CENELEC EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz - 3 GHz), July 2001

**Methods Applied and Interpretation of Parameters:**

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

# Probe EX3DV4

## SN:3561

Manufactured: February 14, 2005
Calibrated: August 24, 2005

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

# DASY - Parameters of Probe: EX3DV4 SN:3561

## Sensitivity in Free Space[A] / Diode Compression[B]

| | | | | |
|---|---|---|---|---|
| NormX | **0.430** ± 10.1% | $\mu V/(V/m)^2$ | DCP X | **90** mV |
| NormY | **0.470** ± 10.1% | $\mu V/(V/m)^2$ | DCP Y | **90** mV |
| NormZ | **0.430** ± 10.1% | $\mu V/(V/m)^2$ | DCP Z | **90** mV |

## Sensitivity in Tissue Simulating Liquid (Conversion Factors)

**Please see Page 8.**

## Boundary Effect

**TSL 900 MHz Typical SAR gradient: 5 % per mm**

| Sensor Center to Phantom Surface Distance | | **2.0 mm** | **3.0 mm** |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 3.8 | 1.5 |
| $SAR_{be}$ [%] | With Correction Algorithm | 0.0 | 0.0 |

**TSL 1810 MHz Typical SAR gradient: 10 % per mm**

| Sensor Center to Phantom Surface Distance | | **2.0 mm** | **3.0 mm** |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 4.7 | 2.8 |
| $SAR_{be}$ [%] | With Correction Algorithm | 1.1 | 0.8 |

## Sensor Offset

Probe Tip to Sensor Center **1.0** mm

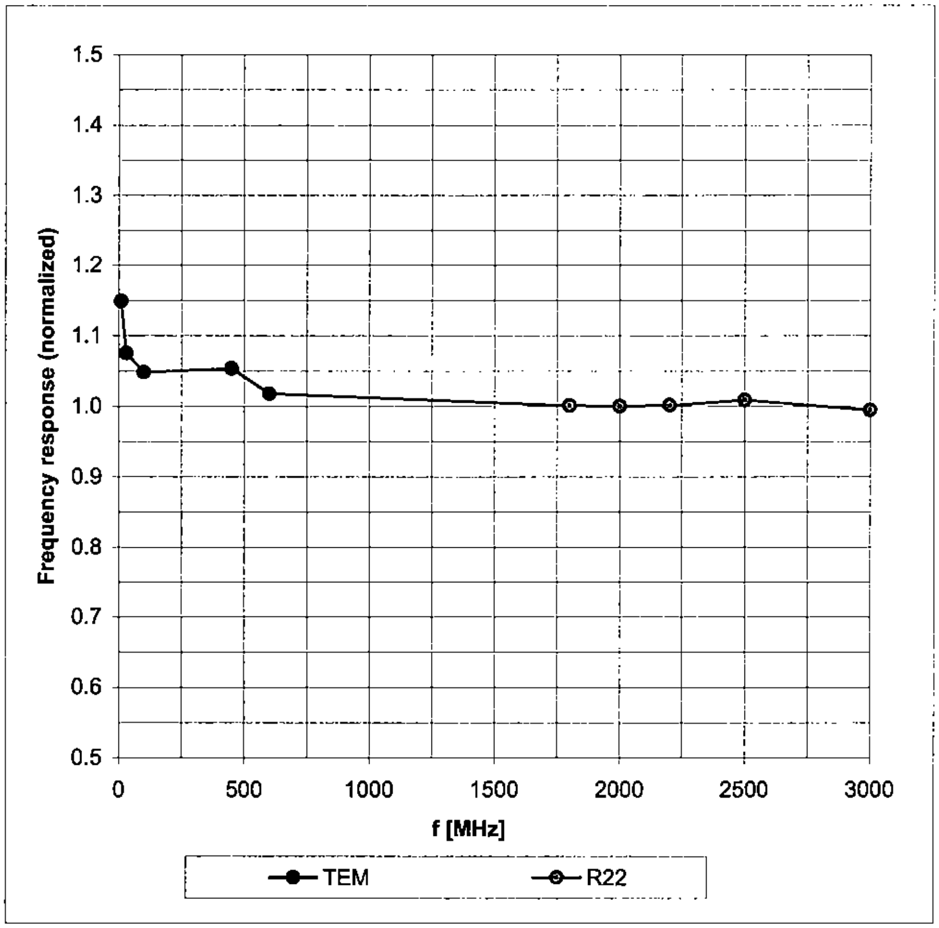
**The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.**

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Page 8).

[B] Numerical linearization parameter: uncertainty not required.

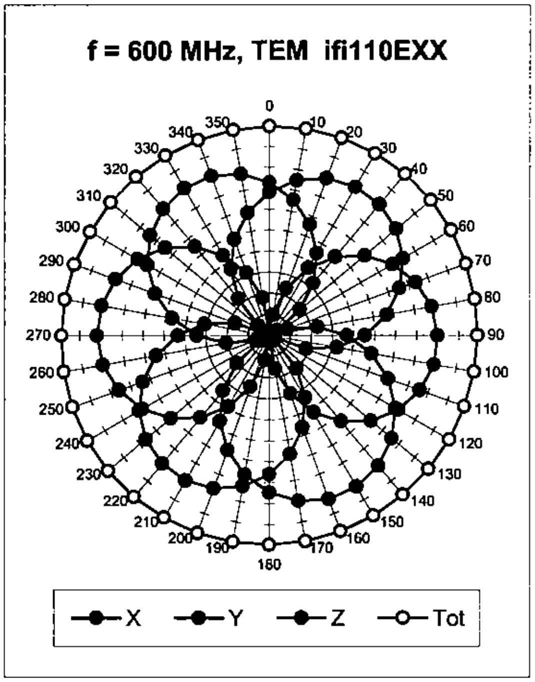
# Frequency Response of E-Field

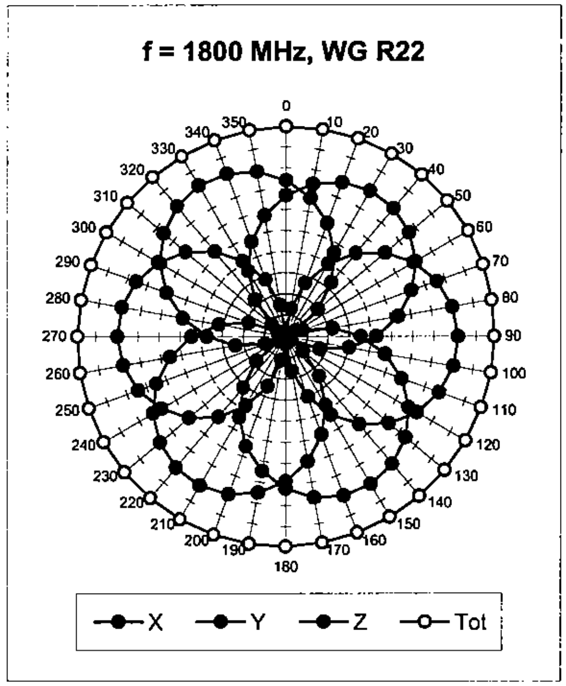
(TEM-Cell:ifi110 EXX, Waveguide: R22)

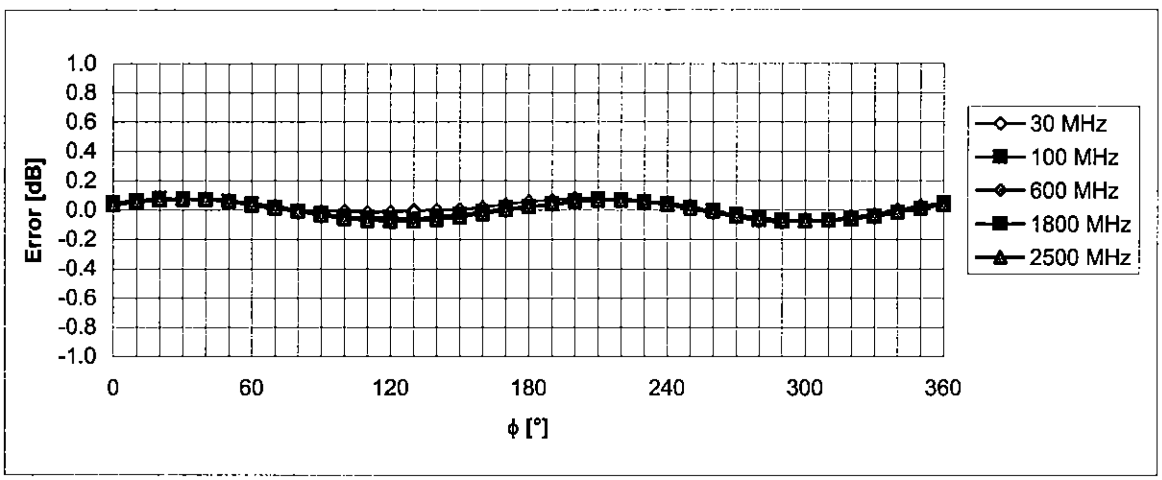



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern ($\phi$), $\vartheta = 0°$



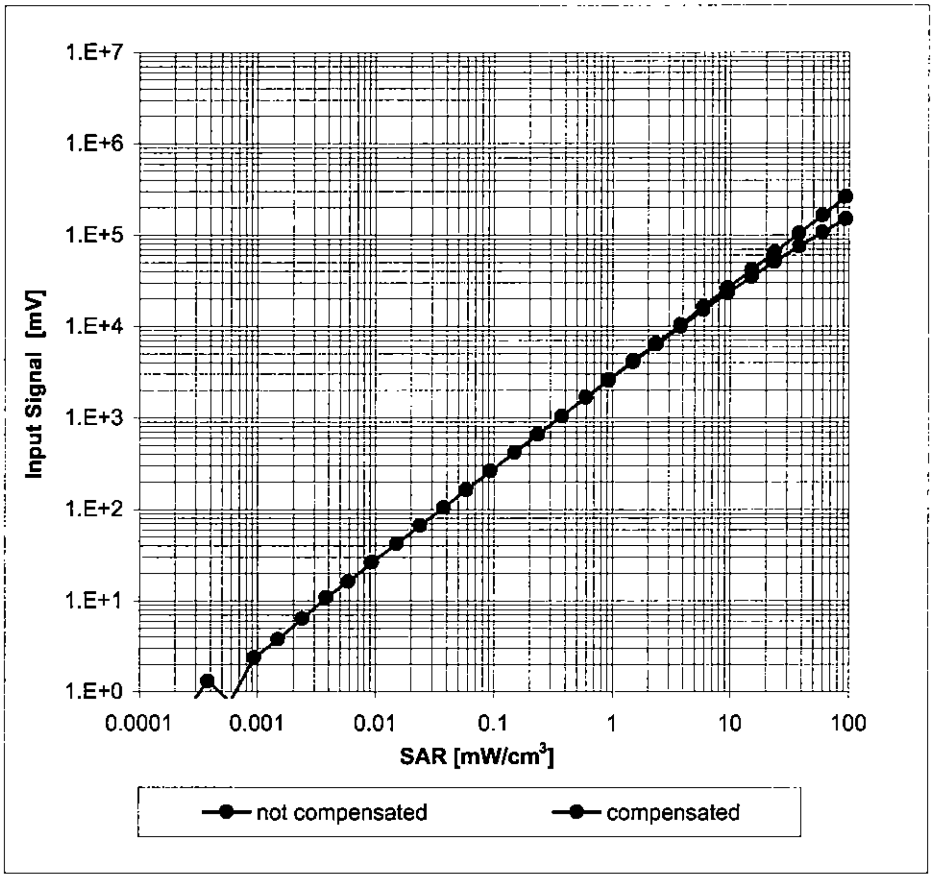



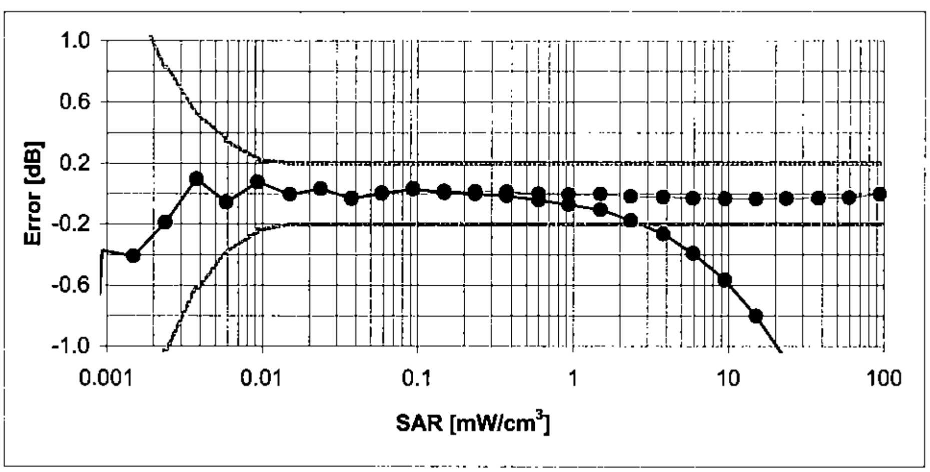




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)

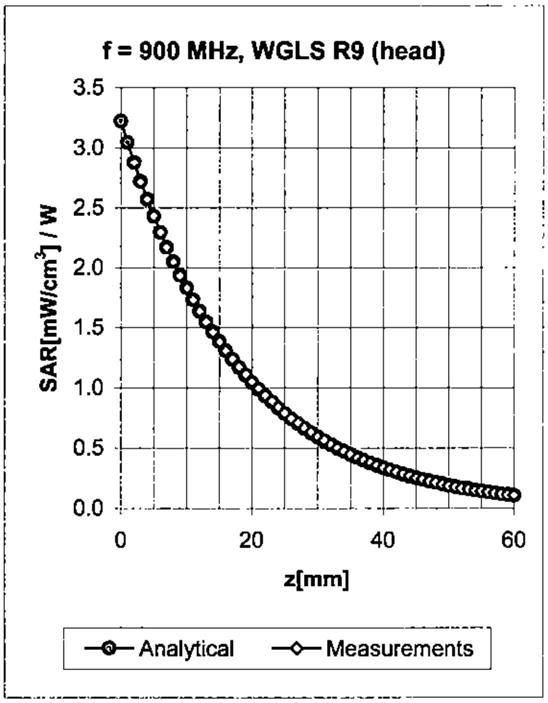
**(Waveguide R22, f = 1800 MHz)**

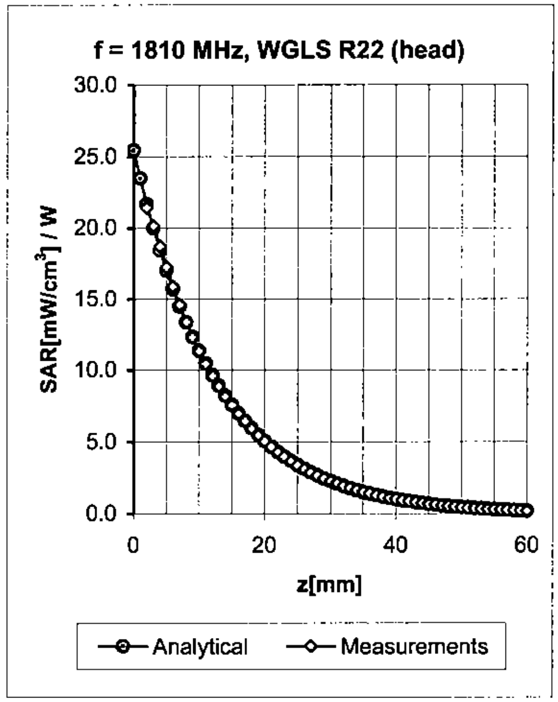



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment



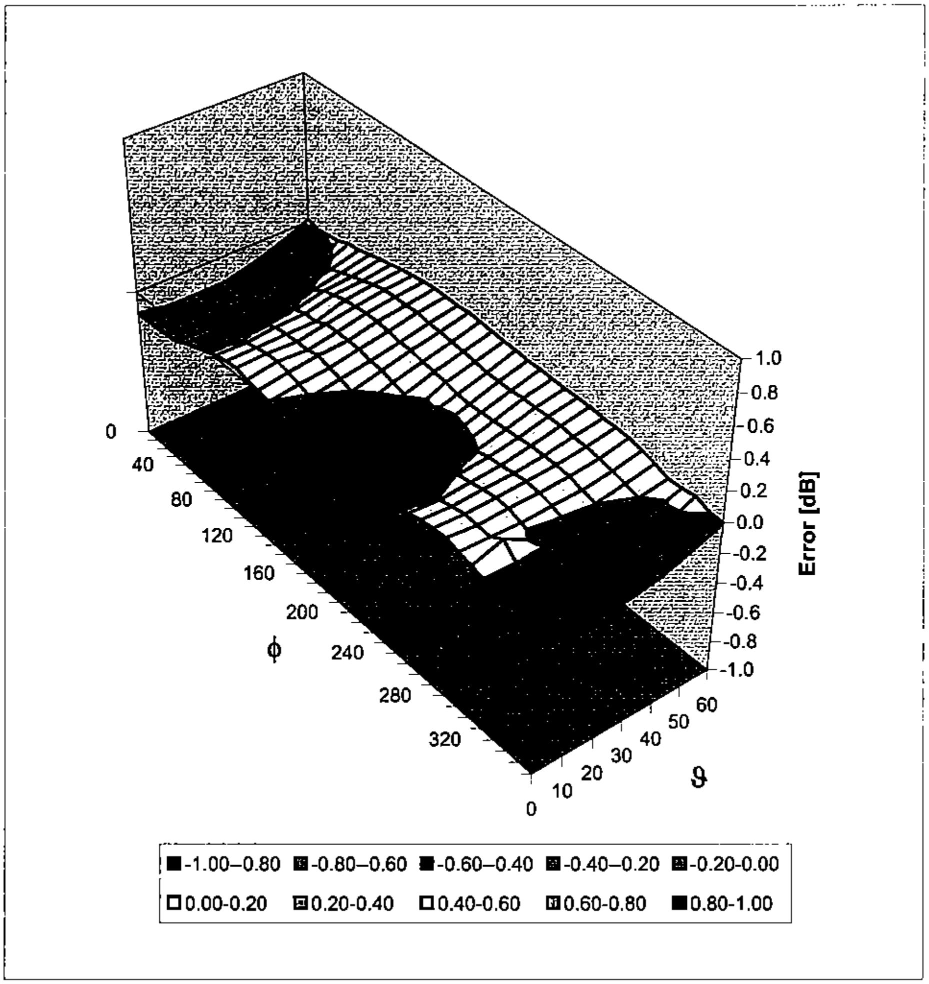




| f [MHz] | Validity [MHz][C] | TSL | Permittivity | Conductivity | Alpha | Depth | ConvF | Uncertainty |
|---|---|---|---|---|---|---|---|---|
| 900 | ± 50 / ± 100 | Head | 41.5 ± 5% | 0.97 ± 5% | 0.21 | 1.13 | 7.91 | ± 11.0% (k=2) |
| 1810 | ± 50 / ± 100 | Head | 40.0 ± 5% | 1.40 ± 5% | 0.47 | 0.94 | 7.04 | ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Head | 39.2 ± 5% | 1.80 ± 5% | 0.61 | 0.71 | 6.37 | ± 11.8% (k=2) |
| 900 | ± 50 / ± 100 | Body | 55.0 ± 5% | 1.05 ± 5% | 0.32 | 0.93 | 7.90 | ± 11.0% (k=2) |
| 1810 | ± 50 / ± 100 | Body | 53.3 ± 5% | 1.52 ± 5% | 0.34 | 1.60 | 6.48 | ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Body | 52.7 ± 5% | 1.95 ± 5% | 0.75 | 0.62 | 6.30 | ± 11.8% (k=2) |

[C] The validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2). The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

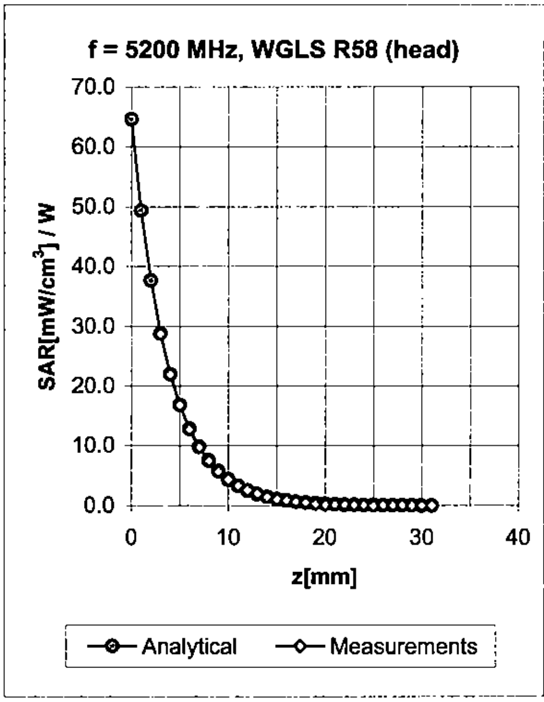
# Deviation from Isotropy in HSL

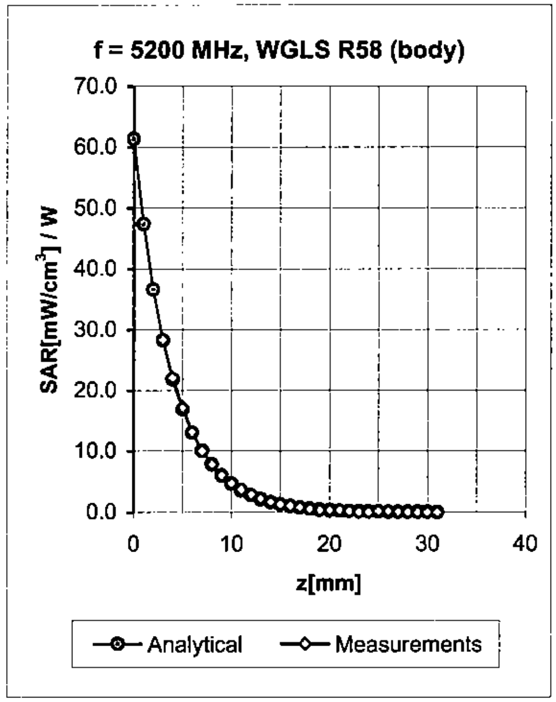
**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# Appendix[D]




| f [MHz][D] | Validity [MHz] | TSL | Permittivity | Conductivity | Alpha | Depth | ConvF | Uncertainty |
|---|---|---|---|---|---|---|---|---|
| 5200 | ± 50 | Head | 36.0 ± 5% | 4.76 ± 5% | 0.49 | 1.36 | 4.26 | ± 13.6% (k=2) |
| 5800 | ± 50 | Head | 35.3 ± 5% | 5.27 ± 5% | 0.52 | 1.42 | 3.75 | ± 13.6% (k=2) |
| 5200 | ± 50 | Body | 49.0 ± 5% | 5.30 ± 5% | 0.50 | 1.63 | 4.10 | ± 13.6% (k=2) |
| 5800 | ± 50 | Body | 48.2 ± 5% | 6.00 ± 5% | 0.49 | 1.70 | 3.63 | ± 13.6% (k=2) |

[D] Accreditation for ConvF assessment above 3000 MHz is currently applied for.