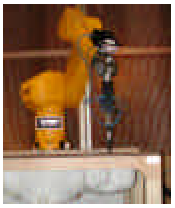
**PCTEST ENGINEERING LABORATORY, INC.**
6660 – B Dobbin Road · Columbia, MD 21045 · USA
Telephone 410.290.6652 / Fax 410.290.6654
http://www.pctestlab.com (email: randy@pctestlab.com)



# CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

**APPLICANT NAME & ADDRESS:**
Matsushita Electric Industrial Co., Ltd.
1006 Oaza Kadoma, Kadoma
Osaka, 571 JAPAN

**DATE & LOCATION OF TESTING:**
Dates of Tests: September 22-23, 2003
Test Report S/N: SAR.230922457-R1.ACJ
Test Site: PCTEST Lab, Columbia MD
Project No.: ITPD-03-F018A

| | |
|---|---|
| **FCC ID:** | **ACJ9TGCF-183** |
| **APPLICANT:** | **Matsushita Electric Industrial Co., Ltd.** |

| | |
|---|---|
| EUT Type: | Panasonic Toughbook CF-18 w/ Alps Blue Tooth Kit Module<br>Model: CF-WTB181 and Intel WLAN Model: WM3B2100 |
| Tx Frequency: | 2412 – 2462 MHz (DTS)/ 2402 – 2480 MHz (FHSS) |
| Rx Frequency: | 2412 – 2462 MHz (DTS)/ 2402 – 2480 MHz (FHSS) |
| Max. RF Output Power: | 0.45 mW (16.5 dBm) Conducted (WLAN)<br>0.0182 W (12.6 dBm) Conducted (Bluetooth) |
| Max. SAR Measurement: | 0.618 W/kg DTS Bystander Body SAR (WLAN + Bluetooth)<br>0.009 W/kg DTS Laptop/ LCD Closed Body SAR (WLAN + Bluetooth)<br>0.006 W/kg DTS Laptop/ LCD Flip Body SAR (WLAN + Bluetooth)<br>0.255 W/kg DTS Laptop/ LCD Panel Body SAR (WLAN + Bluetooth) |
| Trade Name/Model(s): | *CF-18* |
| 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: #3FKSA00414] |
| Antenna Type: | Inverted-F Type |
| Operating Positions: | Lap upright, tablet |

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. P1528 (D1.2, April 2003).

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 has been tested for SAR compliance for portable configurations. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter except the Bluetooth described in this filing. End-users must be provided with 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 ($r$). 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).**

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

where:

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

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

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

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

# 2. SAR MEASUREMENT SETUP

## Robotic System

Measurements are performed using the 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.

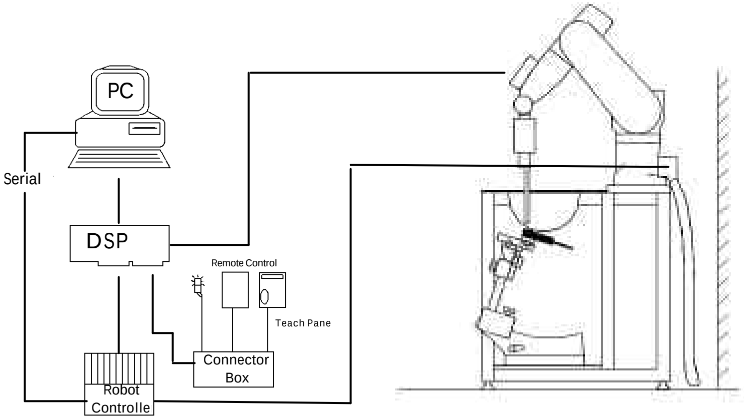


**Figure 2.1 SAR Measurement System Setup**

## System Electronics

The DAE3 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 ET3DV6, 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 2.5 GHz |
| | In brain and muscle simulating tissue at |
| | Frequencies of 450 MHz, 835 MHz, 900 MHz |
| | 1900MHz, 2450MHz |
| Frequency: | 10 MHz to > 2.5 GHz; Linearity: ± 0.2 dB |
| | (30 MHz to 2.5 GHz) |
| Directivity: | ± 0.2 dB in HSL (rotation around probe axis) |
| | ± 0.4 dB in HSL (rotation normal probe axis) |
| Dynamic: | 5 :W/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: 6.8 mm |
| | Distance from probe tip to dipole centers: 2.7 mm |
| Application: | General dosimetry up to 2.5 GHz |
| | Compliance tests of mobile phones |
| | Fast automatic scanning in arbitrary phantoms |

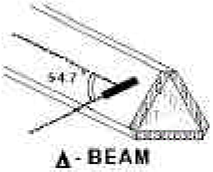


Figure 3.1 Triangular Probe Configuration

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).

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

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;

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

where:

$\sigma$ = simulated tissue conductivity,

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

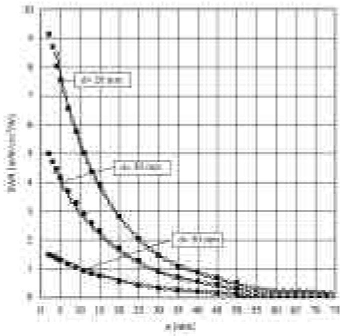


**Figure 4.1 E-Field and Temperature measurements at 900MHz [7]**

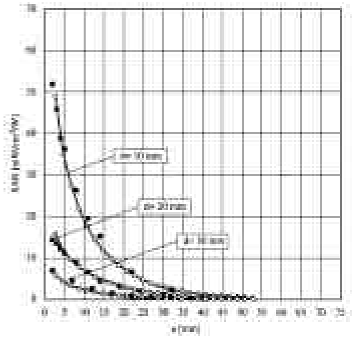


**Figure 4.2 E-Field and temperature measurements at 1.9GHz [7]**

**NOTE:** *The temperature calibration was not performed by PCTEST. For information use only.*

# 5. PHANTOM & EQUIVALENT TISSUES

## SAM Phantom

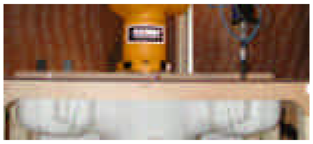


**Figure 5.1 SAM Twin Phantom**

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 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 [13].(see Fig. 5.2)

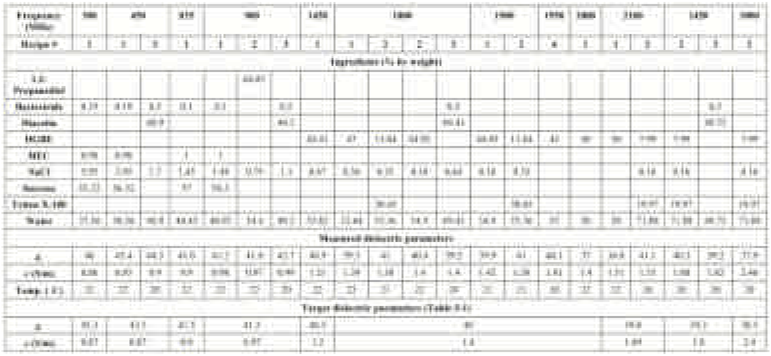


**Table 5.1 Composition of the Brain & Muscle Tissue Equivalent Matter**

## 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 |

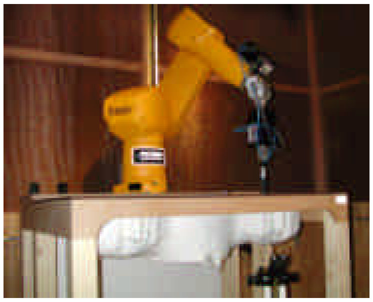


**Figure 6.1 DASY4 Test System**

### 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<br>Link to DAE3<br>16 bit A/D converter for surface detection system<br>serial link to robot<br>direct emergency stop output for robot |

### E-Field Probes

| | |
|---|---|
| **Model:** | ET3DV6 S/N: 1560 |
| **Construction:** | Triangular core fiber optic detection system |
| **Frequency:** | 10 MHz to 2.5 GHz |
| **Linearity:** | ± 0.2 dB (30 MHz to 2.5 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):
   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.


Figure 7.1 Sample SAR Area Scan

## Specific Anthropomorphic Mannequin (SAM) Specifications

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM 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.

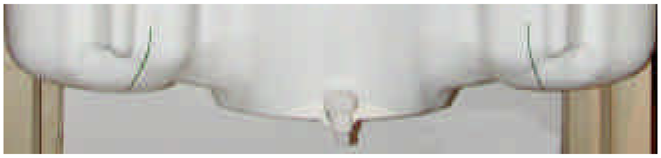


Figure 7.2 SAM Twin Phantom shell

# 8. TEST CONFIGURATION POSITIONS

## Lap Top Configurations

Body-worn operating configurations are tested with the notebook positioned touching against a flat phantom (lap) in a normal use configuration. Body dielectric parameters are used.

In addition to the typical lap position test configuration, a bystander position (See Figure 8.2) is also evaluated for RF safety. The antenna is placed 0 cm from the flat phantom from the antenna side of the notebook. This ensures that any other part of the body or other bodies touching the transmitting antenna on the notebook meets RF exposure compliance.

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.

**Figure 8.1**

**Body SAR Lap Test Configuration**

**Figure 8.2**

**Body SAR Bystander Test Configuration**

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

## Uncontrolled Environment

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

## Controlled Environment

CONTROLLED ENVIRONMENTS are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Table 9.1. Safety Limits for Partial Body Exposure [2]**

| | HUMAN EXPOSURE LIMITS | |
|---|---|---|
| | UNCONTROLLED ENVIRONMENT<br>General Population<br>(W/kg) or (mW/g) | CONTROLLED ENVIRONMENT<br>General Population<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.

# 10. MEASUREMENT UNCERTAINTIES

| a | b | c | d | e= f(d,k) | f | g | h = cxf/e | i = cxg/e | k |
|---|---|---|---|---|---|---|---|---|---|
| **Uncertainty Component** | **Sec.** | **Tol. (± %)** | **Prob. Dist.** | **Div.** | **$c_i$ (1 - g)** | **$c_i$ (10 - g)** | **1 - g $u_i$ (± %)** | **10 - g $u_i$ (± %)** | **$v_i$** |
| **Measurement System** | | | | | | | | | |
| Probe Calibration | E1.1 | 4.8 | N | 1 | 1 | 1 | 4.8 | 4.8 | ∞ |
| Axial Isotropy | E1.2 | 4.7 | R | $\sqrt{3}$ | 0.7 | 0.7 | 1.9 | 1.9 | ∞ |
| Hemishperical Isotropy | E1.2 | 9.6 | R | $\sqrt{3}$ | 0.7 | 0.7 | 3.9 | 3.9 | ∞ |
| Boundary Effect | E1.3 | 1.0 | R | $\sqrt{3}$ | 1 | 1 | 0.6 | 0.6 | ∞ |
| Linearity | E1.4 | 4.7 | R | $\sqrt{3}$ | 1 | 1 | 2.7 | 2.7 | ∞ |
| System Detection Limits | E1.5 | 1.0 | R | $\sqrt{3}$ | 1 | 1 | 0.6 | 0.6 | ∞ |
| Readout Electronics | E1.6 | 1.0 | N | 1 | 1 | 1 | 1.0 | 1.0 | ∞ |
| Response Time | E1.7 | 0.8 | R | $\sqrt{3}$ | 1 | 1 | 0.5 | 0.5 | ∞ |
| Integration Time | E1.8 | 2.6 | R | $\sqrt{3}$ | 1 | 1 | 1.5 | 1.5 | ∞ |
| RF Ambient Conditions | E5.1 | 3.0 | R | $\sqrt{3}$ | 1 | 1 | 1.7 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | E5.2 | 0.4 | R | $\sqrt{3}$ | 1 | 1 | 0.2 | 0.2 | ∞ |
| Probe Positioning w/ respect to Phantom | E5.3 | 2.9 | R | $\sqrt{3}$ | 1 | 1 | 1.7 | 1.7 | ∞ |
| Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation | E4.2 | 1.0 | R | $\sqrt{3}$ | 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 | $\sqrt{3}$ | 1 | 1 | 2.9 | 2.9 | ∞ |
| **Phantom & Tissue Parameters** | | | | | | | | | |
| Phantom Uncertainty (Shape & Thickness tolerances) | E2.1 | 4.0 | R | $\sqrt{3}$ | 1 | 1 | 2.3 | 2.3 | ∞ |
| Liquid Conductivity - deviation from target values | E2.2 | 5.0 | R | $\sqrt{3}$ | 0.64 | 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 | $\sqrt{3}$ | 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. 1528-200x (Jan. 2002)

# 11. SYSTEM VERIFICATION

## Tissue Verification

**Table 11.1 Simulated Tissue Verification [5]**

| MEASURED TISSUE PARAMETERS | | | | | |
|---|---|---|---|---|---|
| Date(s) | 09-22-03 | 2450MHz Brain | | 2450MHz Muscle | |
| Liquid Temperature (°C) | 23.1 | Target | Measured | Target | Measured |
| Dielectric Constant: ε | | 39.20 | 38.76 | 52.70 | 53.75 |
| Conductivity: σ | | 1.800 | 1.79 | 1.950 | 1.86 |

## Test System Validation

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

**Table 11.2 System Validation [5]**

| System Validation<br>TARGET & MEASURED | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date:** | **Amb. Temp (°C)** | **Liquid Temp (°C)** | **Input Power (W)** | **Tissue** | **Targeted SAR1g (mW/g)** | **Measured SAR1g (mW/g)** | **Deviation (%)** |
| 09-22-03 | 22.5 | 20.6 | **0.250** | **2450 MHz Brain** | **13.1** | 12.93 | 1.29 |
| 09-23-03 | 22.4 | 20.5 | **0.250** | **2450 MHz Brain** | **13.1** | 12.88 | 1.68 |

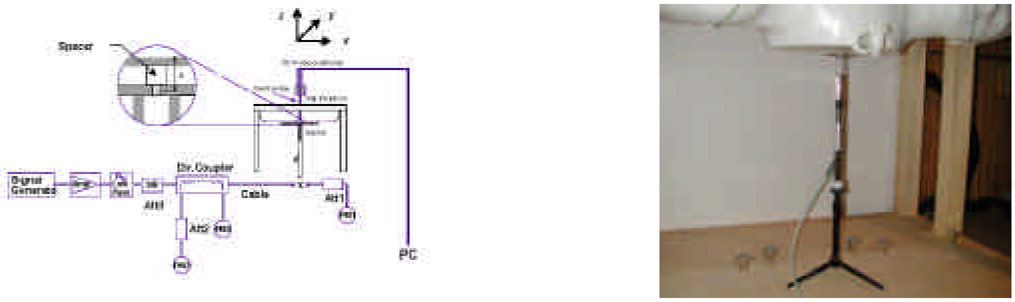
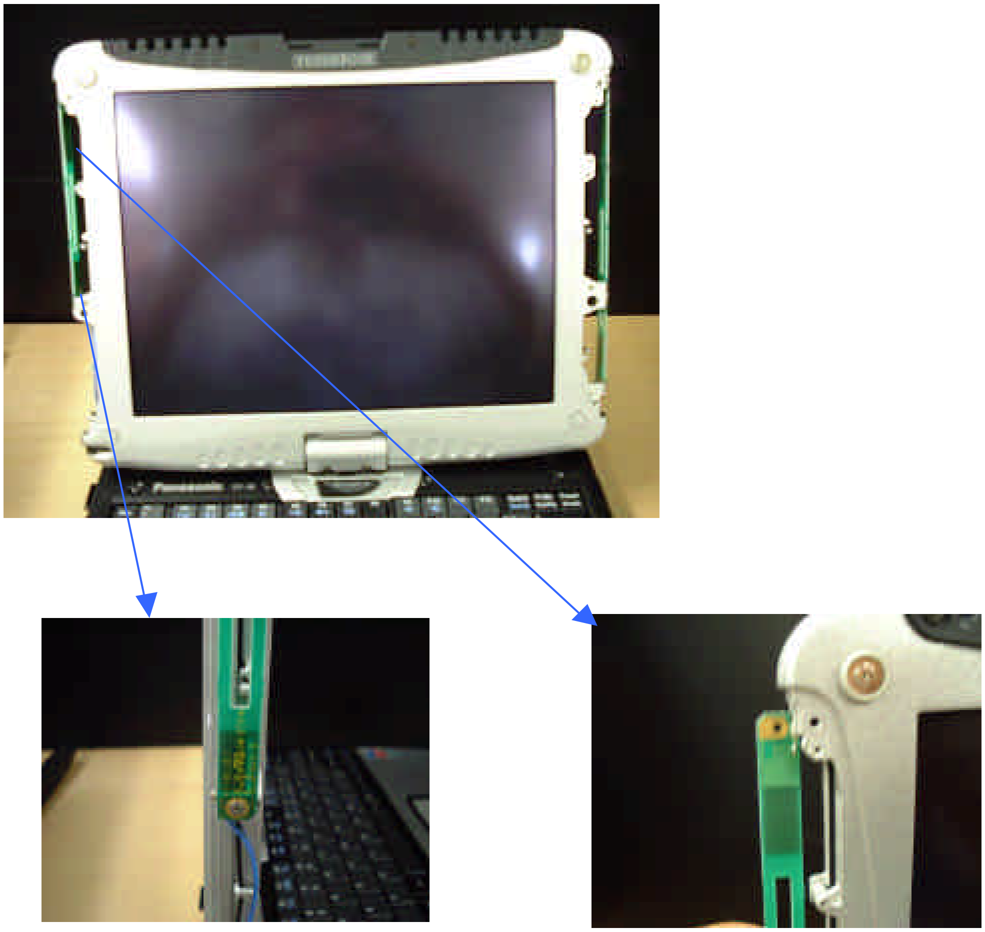


**Figure 11.1 Dipole Validation Test Setup**

# 12. ANTENNA LOCATION/DESCRIPTION



**Bluetooth Antenna (Inverted F Type)**

**WLAN Antenna (Inverted F Type)**

# 13. SAR TEST DATA SUMMARY

## See Measurement Result Data Pages

## Procedures Used To Establish Test Signal

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

# SAR DATA SUMMARY

Mixture Type: 2450MHz Muscle

## 13.1 MEASUREMENT RESULTS (Body SAR – Bystander Position)

| FREQUENCY | | Modulation | Begin / End POWER[‡] (dBm) | | Data Rate (Mbps) | Bluetooth Frequency | | Modulation | Begin/ End Power (dBm) | | SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | MHz | Ch. | | | | |
| 2437 | 06 | DSSS | 16.52 | 16.55 | 1 | 2402 | 01 | FHSS | - | - | 0.543 |
| 2437 | 06 | DSSS | 16.56 | 16.53 | 5.5 | 2441 | 40 | FHSS | - | - | 0.462 |
| 2437 | 06 | DSSS | 16.50 | 16.48 | 11 | 2480 | 79 | FHSS | - | - | 0.506 |
| | | | | | | | | | | | |
| 2412 | 01 | DSSS | 16.55 | 16.50 | 1 | 2402 | 01 | FHSS | 12.60 | 12.55 | 0.548 |
| 2437 | 06 | DSSS | 16.44 | 16.51 | 1 | 2441 | 40 | FHSS | 12.12 | 12.26 | 0.545 |
| 2462 | 11 | DSSS | 16.52 | 16.56 | 1 | 2480 | 79 | FHSS | 12.25 | 12.32 | 0.618 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT**<br>**Spatial Peak**<br>**Uncontrolled Exposure/General Population** | | | | | | **Body**<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 antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings. Standard & Extended Batteries are options.

   [‡]Power Measured ☒ Conducted ☐ ERP ☐ EIRP
4. SAR Measurement System ☒ DASY4 ☐ IDX

   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
5. SAR Configuration ☐ Head ☒ Body ☐ Hand
6. Test Signal Call Mode ☒ Manu. Test Codes ☐ Base Station Simulator
7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15.1 cm. ± 0.1
9. The frequency hopping function of the device was disabled during the measurement
10. 0.0 cm spacing for all configurations (touch mode)

Alfred Cirwithian
Vice President Engineering

**Figure 13.1 Body SAR Test Setup -- Bystander Position --**

# SAR DATA SUMMARY (Continued)

Mixture Type: 2450MHz Muscle

## 13.2 MEASUREMENT RESULTS (Body SAR – Laptop/ LCD Close)

| WLAN Frequency | | Modulation | Begin / End POWER‡ | | Data Rate | Blue Tooth Frequency | | Modulation | Begin/ End Power | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | (dBm) | | (Mbps) | MHz | Ch. | | (dBm) | | (W/kg) |
| 2412 | 01 | DSSS | 16.43 | 16.46 | 1 | 2402 | 01 | FHSS | 12.56 | 12.37 | 0.00882 |
| 2437 | 06 | DSSS | 16.51 | 16.54 | 1 | 2441 | 40 | FHSS | 12.27 | 12.08 | 0.00971 |
| 2462 | 11 | DSSS | 16.50 | 16.54 | 1 | 2480 | 79 | FHSS | 12.18 | 12.10 | 0.00940 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT**<br>**Spatial Peak**<br>**Uncontrolled Exposure/General Population** | | | | | | **Body**<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 antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings. Standard & Extended Batteries are options.

| | | | |
|---|---|---|---|
| ‡Power Measured | ☒ Conducted | ☐ ERP | ☐ EIRP |
| 4. SAR Measurement System | ☒ DASY4 | ☐ IDX | |
| Phantom Configuration | ☐ Left Head | ☒ Flat Phantom | ☐ Right Head |
| 5. SAR Configuration | ☐ Head | ☒ Body | ☐ Hand |
| 6. Test Signal Call Mode | ☒ Manu. Test Codes | ☐ Base Station Simulator | |

7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15.1 cm. ± 0.1

Alfred Cirwithian
Vice President Engineering

Figure 13.2 Body SAR Test Setup
-- Laptop/ LCD Close Position --

# SAR DATA SUMMARY (Continued)

Mixture Type: 2450MHz Muscle

## 13.3 MEASUREMENT RESULTS (Body SAR – Laptop/ LCD Flip)

| WLAN Frequency | | Modulation | Begin / End POWER‡ | | Data Rate | Blue Tooth Frequency | | Modulation | Begin/ End Power | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | (dBm) | | (Mbps) | MHz | Ch. | | (dBm) | | (W/kg) |
| 2412 | 01 | DSSS | 16.45 | 16.49 | 1 | 2402 | 01 | FHSS | 12.28 | 12.14 | 0.00639 |
| 2437 | 06 | DSSS | 16.55 | 16.52 | 1 | 2441 | 40 | FHSS | 12.22 | 12.31 | 0.00362 |
| 2462 | 11 | DSSS | 16.52 | 16.50 | 1 | 2480 | 79 | FHSS | 12.03 | 12.16 | 0.00494 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT**<br>**Spatial Peak**<br>**Uncontrolled Exposure/General Population** | | | | | | **Body**<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 antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings. Standard & Extended Batteries are options.

‡Power Measured ☒ Conducted ☐ ERP ☐ EIRP

4. SAR Measurement System ☒ DASY4 ☐ IDX

Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head

5. SAR Configuration ☐ Head ☒ Body ☐ Hand
6. Test Signal Call Mode ☒ Manu. Test Codes ☐ Base Station Simulator
7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15.1 cm. ± 0.1

Alfred Cirwithian
Vice President Engineering

**Figure 13.3 Body SAR Test Setup**
**-- Laptop/ LCD Flip Position --**

# SAR DATA SUMMARY (Continued)

Mixture Type: 2450MHz Muscle

## 13.4 MEASUREMENT RESULTS (Body SAR – Laptop/ LCD Panel)

| WLAN Frequency MHz | WLAN Frequency Ch. | Modulation | Begin / End POWER‡ (dBm) | | Data Rate (Mbps) | Blue Tooth Frequency MHz | Blue Tooth Frequency Ch. | Modulation | Begin/ End Power (dBm) | | SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2412 | 01 | DSSS | 16.47 | 16.44 | 1 | 2402 | 01 | FHSS | 12.13 | 12.00 | 0.204 |
| 2437 | 06 | DSSS | 16.51 | 16.48 | 1 | 2441 | 40 | FHSS | 12.37 | 12.24 | 0.252 |
| 2462 | 11 | DSSS | 16.50 | 16.52 | 1 | 2480 | 79 | FHSS | 12.16 | 12.03 | 0.255 |
| **ANSI / IEEE C95.1 1992 - SAFETY LIMIT**<br>**Spatial Peak**<br>**Uncontrolled Exposure/General Population** | | | | | | **Body**<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 antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings. Standard & Extended Batteries are options.

‡Power Measured ☒ Conducted ☐ ERP ☐ EIRP

4. SAR Measurement System ☒ DASY4 ☐ IDX

Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head

5. SAR Configuration ☐ Head ☒ Body ☐ Hand
6. Test Signal Call Mode ☒ Manu. Test Codes ☐ Base Station Simulator
7. Tissue parameters and temperatures are listed on the SAR plots.
8. Liquid tissue depth is 15.1 cm. ± 0.1

Alfred Cirwithian
Vice President Engineering

**Figure 13.4 Body SAR Test Setup**
**-- Laptop/ LCD Panel Position --**

# 14. SAR TEST EQUIPMENT

## Equipment Calibration

Table 15.1 Test Equipment Calibration

| EQUIPMENT SPECIFICATIONS | | |
|---|---|---|
| **Type** | **Calibration Date** | **Serial Number** |
| Stäubli Robot RX60L | February 2003 | 599131-01 |
| Stäubli Robot Controller | February 2003 | PCT592 |
| Stäubli Teach Pendant (Joystick) | February 2003 | 3323-00161 |
| Micron Computer, 450 MHz Pentium III, Windows NT | February 2003 | PCT577 |
| SPEAG EDC3 | February 2003 | 321 |
| SPEAG DAE3 | February 2003 | 330 |
| SPEAG E-Field Probe ET3DV6 | September 2002 | 1560 |
| SPEAG Dummy Probe | February 2003 | PCT583 |
| SPEAG SAM Twin Phantom V4.0 | February 2003 | PCT666 |
| SPEAG Light Alignment Sensor | February 2003 | 205 |
| PCTEST Validation Dipole D300V2 | September 2002 | PCT301 |
| SPEAG Validation Dipole D835V2 | September 2002 | PCT512 |
| SPEAG Validation Dipole D1900V2 | September 2002 | PCT613 |
| Brain Equivalent Matter (300MHz) | September 2003 | PCTBEM601 |
| Brain Equivalent Matter (835MHz) | September 2003 | PCTBEM101 |
| Brain Equivalent Matter (1900MHz) | September 2003 | PCTBEM301 |
| Brain Equivalent Matter (2450MHz) | September 2003 | PCTBEM901 |
| Muscle Equivalent Matter (300MHz) | September 2003 | PCTMEM701 |
| Muscle Equivalent Matter (835MHz) | September 2003 | PCTMEM201 |
| 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.<br><12mW/kg/<3%of SAR | January 2003 | Anechoic Room PCT01 |

NOTE:

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

# 15. CONCLUSION

## Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.[3]

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