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:
LG ELECTRONICS INC.
Communication Terminal Research Lab
459-9, Kasan-dong, Keumchun-Ku
Seoul 153-023, Korea
Attn: E.S. Park, Research Engineer

DATE & LOCATION OF TESTING:
Dates of Tests: March 29-30, 2002
Test Report S/N: SAR. 220325205.BEJ
Test Site: PCTEST Lab, Columbia MD U.S.A.

FCC ID:	**BEJBD4000**
APPLICANT:	**LG ELECTRONICS INC.**

EUT Type:	**Dual-Mode Cellular Phone (AMPS/CDMA)**
Tx Frequency:	**824.04 – 848.97 MHz (AMPS) / 824.70 – 848.31 MHz (CDMA)**
Rx Frequency:	**869.04 – 893.97 MHz (AMPS) / 869.70 – 893.31 MHz (CDMA)**
Max. RF Output Power:	**0.322 W ERP AMPS (25.073 dBm) / 26.5 dBm Conducted** **0.226 W ERP CDMA (23.533 dBm) / 25.0 dBm Conducted**
Max. SAR Measurement:	**0.960W/kg AMPS Head SAR; 1.270W/kg AMPS Body SAR;** **0.545W/kg CDMA Head SAR; 0.697W/kg CDMA Body SAR;**
Trade Name/Model(s):	***LG-BD4000***
FCC Classification:	**Non-Broadcast Transmitter held to ear (TNE)**
FCC Rule Part(s):	**§2.1093; FCC/OET Bulletin 65 Supplement C [July 2001]**
Application Type:	**Certification**
Test Device Serial No.:	***identical* prototype**

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1-1992 and had been tested in accordance with the measurement procedures specified in FCC/OET Bulletin 65 Supplement C (2001) and IEEE Std. 1528-200X (Draft 6.4, July 2001).

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

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

Randy Ortanez
President

1. INTRODUCTION / SAR DEFINITION

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

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

SAR Definition

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

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

Figure 1.1
SAR Mathematical Equation

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

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

where:

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

ρ = 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 DASY3 automated dosimetric assessment system. The DASY3 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 Micron Pentium III 500 MHz computer with Windows NT system and SAR Measurement Software DASY3, 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.

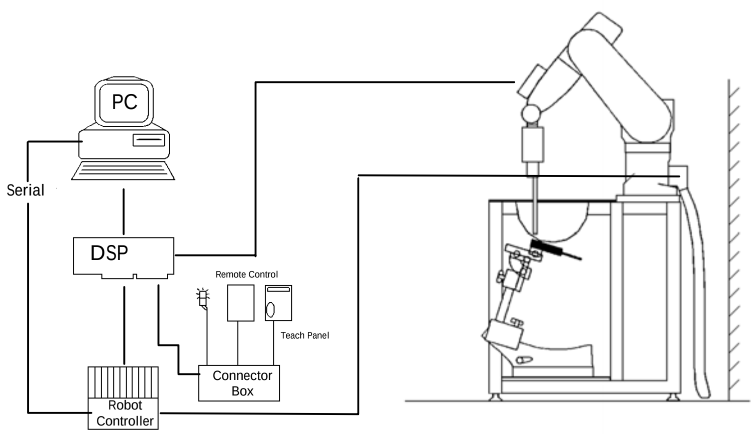

Figure 2.1 SAR Measurement System Setup

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. DASY3 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 DASY3 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 and 2450MHz
Frequency:	10 MHz to > 3 GHz; Linearity: ± 0.2 dB
	(30 MHz to 3 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 3 GHz
	Compliance tests of mobile phones
	Fast automatic scanning in arbitrary phantoms

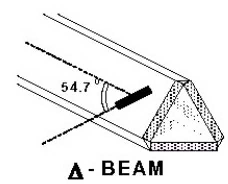

Figure 3.1 Triangular Probe Configuration

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:

Δt = exposure time (30 seconds),

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

ΔT = temperature increase due to RF exposure.

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

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

where:

σ = simulated tissue conductivity,

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

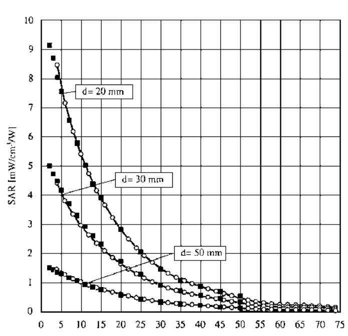

Figure 4.1 E-Field and Temperature measurements at 900MHz [7]

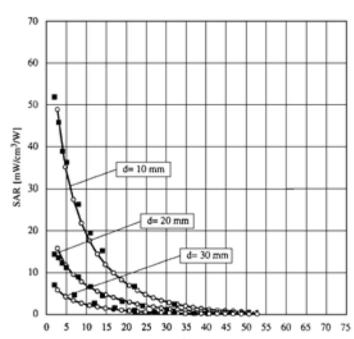

Figure 4.2 E-Field and temperature measurements at 1.9GHz [7]

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

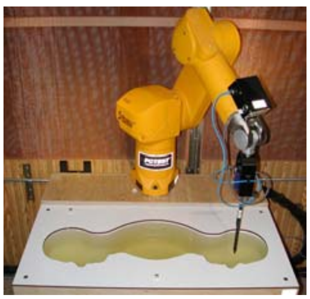

Figure 5.2 Simulated Tissue

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 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

INGREDIENTS		SIMULATING TISSUE			
		835MHz Brain	835MHz Muscle	1900MHz Brain	1900MHz Muscle
Mixture Percentage					
WATER		41.45	52.50	54.90	40.40
DGBE		0.000	0.000	44.92	0.000
SUGAR		56.00	45.00	0.000	58.00
SALT		1.450	1.400	0.180	0.500
BACTERIACIDE		0.100	0.100	0.000	0.100
HEC		1.000	1.000	0.000	1.000
Dielectric Constant	Target	41.50	55.20	40.00	53.30
Conductivity (S/m)	Target	0.900	0.970	1.400	1.520

Device Holder for Transmitters

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).

Figure 5.2 Mounting Device

* 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 DASY3 Test System

Data Acquisition Electronic (DAE) System

Cell Controller

Processor: Pentium III
Clock Speed: 450 MHz
Operating System: Windows NT
Data Card: DASY3 PC-Board

Data Converter

Features: Signal Amplifier, multiplexer, A/D converter, & control logic
Software: DASY3 software
Connecting Lines: Optical downlink for data and status info.
Optical uplink for commands and clock

PC Interface Card

Function: 24 bit (64 MHz) DSP for real time processing
Link to DAE3
16 bit A/D converter for surface detection system
serial link to robot
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 6 GHz
Linearity: ± 0.2 dB (30 MHz to 3 GHz)

Phantom

Phantom: SAM Twin Phantom (V4.0)
Shell Material: Fiberglass
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 20mm x 20mm.
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 5 x 5 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):

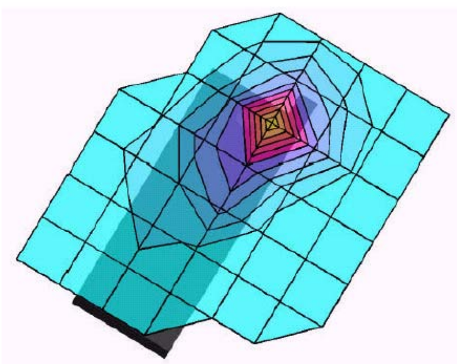

Figure 7.1 Sample SAR Area Scan

   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.

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. DEFINITION OF REFERENCE POINTS

EAR Reference Point

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

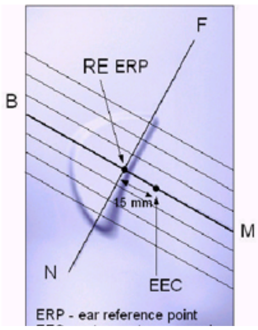

Figure 8.2 Close-up side view of ERPs

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

Handset Reference Points

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

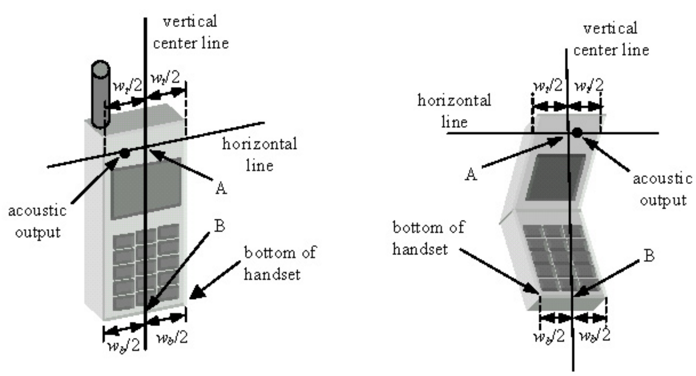

Figure 8.3 Handset Vertical Center & Horizontal Line Reference Points

9. TEST CONFIGURATION POSITIONS

Positioning for Cheek/Touch

1. The test device was positioned with the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 9.1), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

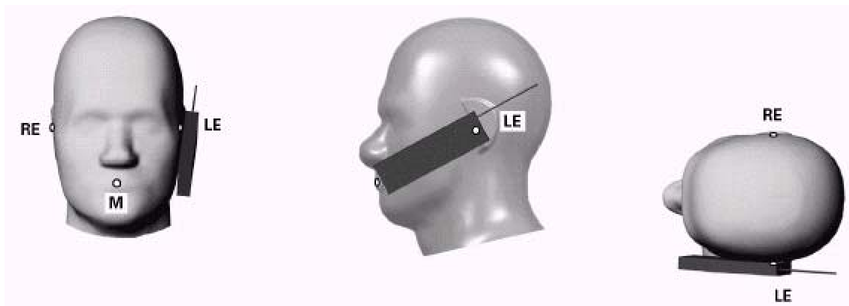

Figure 9.1 Front, Side and Top View of Cheek/Touch Position

2. The handset was translated towards the phantom along the line passing through RE & LE until the handset touches the ear.
3. While maintaining the handset in this plane, the handset was rotated around the LE-RE line until the vertical centerline was in the plane normal to MB-NF including the line MB (reference plane).
4. The phone was hen rotated around the vertical centerline until the phone (horizontal line) was symmetrical was respect to the line NF.
5. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, the handset was rotated about the line NF until any point on the handset made contact with a phantom point below the ear (cheek). See Figure 9.2)

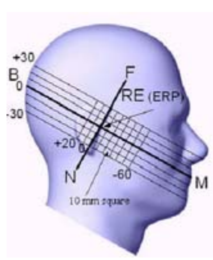

Figure 9.2 Side view w/ relevant markings

9. TEST CONFIGURATION POSITIONS (Continued)

Positioning for Ear / 15° Tilt

With the test device aligned in the "Cheek/Touch Position":

1. While maintaining the orientation of the phone, the phone was retracted parallel to the reference plane far enough to enable a rotation of the phone by 15degree.
2. The phone was then rotated around the horizontal line by 15 degree.
3. While maintaining the orientation of the phone, the phone was moved parallel to the reference plane until any part of the phone touches the head. (In this position, point A was located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact was at any location other than the pinna, the angle of the phone would then be reduced. The tilted position was obtained when any part of the phone was in contact of the ear as well as a second part of the phone was in contact with the head (see Figure 9.3).

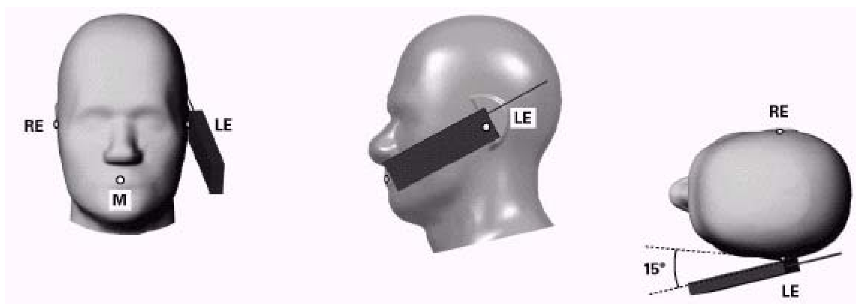

Figure 9.3 Front, Side and Top View of Ear/15° Tilt Position

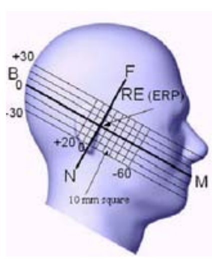

Figure 9.4 Side view w/ relevant markings

9. TEST CONFIGURATION POSITIONS (Continued)

Body Holster /Belt Clip Configurations

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

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are supplied with the device, the device is tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

Figure 9.5 Body Belt Clip & Holster Configurations

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

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

In all cases SAR measurements are performed to investigate the worst-case positioning. Worst-case positioning is then documented and used to perform Body SAR testing.

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

10. ANSI/IEEE C95.1 - 1992 RF EXPOSURE LIMITS

Uncontrolled Environment

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

Controlled Environment

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

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

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

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

11. MEASUREMENT UNCERTAINTIES

a	b	c	d	e= f(d,k)	f	g	h = cxf/e	i = cxg/e	k
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1 - g)**	**c_i (10 - g)**	**1 - g u_i (± %)**	**10 - g u_i (± %)**	**v_i**
Measurement System									
Probe Calibration	E1.1	3.0	N	1	1	1	6.0	6.0	∞
Axial Isotropy	E1.2	4.88	R	$\sqrt{3}$	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.8	1.8	∞
Hemishperical Isotropy	E1.2	9.6	R	$\sqrt{3}$	$\sqrt{c_p}$	$\sqrt{c_p}$	3.7	3.7	∞
Boundary Effect	E1.3	11.0	R	$\sqrt{3}$	1	1	6.4	6.4	∞
Linearity	E1.4	4.7	R	$\sqrt{3}$	1	1	3.4	3.4	∞
System Detection Limits	E1.5	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Readout Electronics	E1.6	1.0	R	1	1	1	1.0	1.0	∞
Response Time	E1.7	0.8	R	$\sqrt{3}$	1	1	0.3	0.3	∞
Integration Time	E1.8	1.7	R	$\sqrt{3}$	1	1	0.2	0.2	∞
RF Ambient Conditions	E5.1	1.2	R	$\sqrt{3}$	1	1	0.7	0.7	∞
Probe Positioner Mechanical Tolerance	E5.2	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
Probe Positioning w/ respect to Phantom	E5.3	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Extrapolation, Interpolation & Integration Algorithms for Max. SAR Evaluation	E4.2	3.9	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E3.2.1		R	$\sqrt{3}$	1	1	6.1	6.1	11
Device Holder Uncertainty	E3.1.1		R	$\sqrt{3}$	1	1	5.0	5.0	8
Output Power Variation - SAR drift measurement	5.6.2	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E2.1	4.0	R	$\sqrt{3}$	1	1	2.1	2.1	∞
Liquid Conductivity - deviation from target values	E2.2	5.0	R	$\sqrt{3}$	0.7	0.5	2.0	1.4	∞
Liquid Conductivity - measurement uncertainty	E2.2	10.0	R	$\sqrt{3}$	0.7	0.5	4.0	2.9	∞
Liquid Permittivity - deviation from target values	E2.2	5.0	R	$\sqrt{3}$	0.6	0.5	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E2.2	5.0	R	$\sqrt{3}$	0.6	0.5	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				14.7	14.3	
Expanded Uncertainty (k=2) (95% CONFIDENCE LEVEL)							29.4	28.6	

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

12. SYSTEM VERIFICATION

Tissue Verification

Table 12.1 Simulated Tissue Verification [5]

MEASURED TISSUE PARAMETERS									
Date(s)	03/25/02	835MHz Brain		835MHz Muscle		1900MHz Brain		1900MHz Muscle	
Liquid Temperature (°C)	23.0	Target	Measured	Target	Measured	Target	Measured	Target	Measured
Dielectric Constant: ε		41.50	43.50	55.20	56.90	40.00	N/A	53.30	N/A
Conductivity: σ		0.900	0.870	0.970	0.930	1.400	N/A	1.520	N/A

Test System Validation

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

Table 12.2 System Validation [5]

SYSTEM DIPOLE VALIDATION TARGET & MEASURED				
System Validation Kit: D-835V2, S/N: 406	835MHz Brain	Targeted SAR_{1g} (mW/g) 2.375	Measured SAR_{1g} (mW/g) **2.41**	Deviation (%) **+ 1.5**
System Validation Kit: D-1900V2, S/N: 502	1900MHz Brain	Targeted SAR_{1g} (mW/g) 9.925	Measured SAR_{1g} (mW/g) **N/A**	Deviation (%) **N/A**

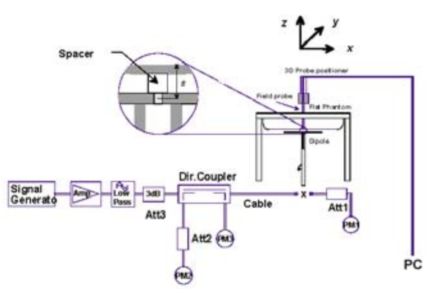

Figure 12.1 Dipole Validation Test Setup

13. SAR TEST DATA SUMMARY

See Measurement Result Data Pages

Procedures Used To Establish Test Signal

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

Device Test Conditions

The handset 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.

EUT Handset Reference Points

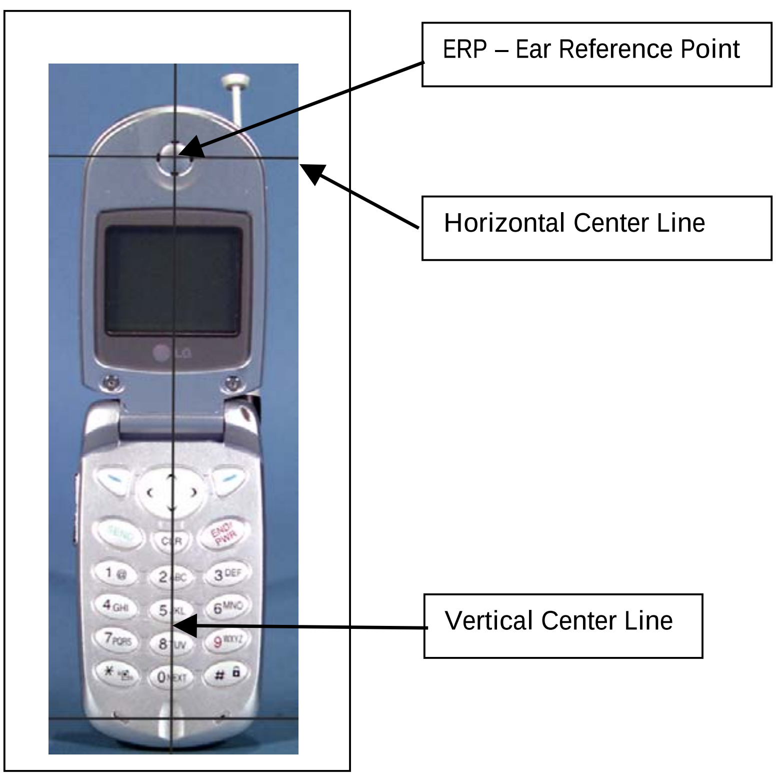

Figure 13.1 Handset Reference Points

SAR DATA SUMMARY

Mixture Type: 835MHz Brain

14.1 MEASUREMENT RESULTS (AMPS Right Head SAR – Touch)

FREQUENCY		Modulation	Begin / End POWER‡			Device Test Position	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
824.04	0991	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.562**
824.04	0991	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.733**
836.49	0383	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.639**
836.49	0383	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.960**
848.97	0799	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.343**
848.97	0799	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.529**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Brain** **1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

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

	‡Power Measured	☒ Conducted	☐ ERP	☐ EIRP
4.	SAR Measurement System	☒ DASY3	☐ IDX	☐
	Phantom Configuration	☐ Left Head	☐ Flat Phantom	☒ Right Head
5.	SAR Configuration	☒ Head	☐ Body	☐ Hand
6.	Test Signal Call Mode	☒ Manu. Test Codes	☐ Base Station Simulator	

7. Tissue parameters and temperatures are listed on the SAR plots.

Randy Ortanez
President

Figure 14.1 Right Head SAR Test Setup
-- Cheek / Touch Position --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Brain

14.2 MEASUREMENT RESULTS (AMPS Right Head SAR – Tilt)									
FREQUENCY		Modulation	Begin / End POWER‡			Device Test Position	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
836.49	0383	AMPS	26.5	26.5	Standard	Ear / 15° Tilt	In	**0.141**
836.49	0383	AMPS	26.5	26.5	Standard	Ear / 15° Tilt	Out	**0.189**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Brain** **1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

1. The test data reported are the worst-case SAR value with the antenna-head position set in a typical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings.
   ‡Power Measured ☒ Conducted ☐ ERP ☐ EIRP
4. SAR Measurement System ☒ DASY3 ☐ IDX ☐
   Phantom Configuration ☐ Left Head ☐ Flat Phantom ☒ Right Head
5. SAR Configuration ☒ Head ☐ Body ☐ Hand
6. Test Signal Call Mode ☒ Manu. Test Codes ☐ Base Station Simulator
7. Tissue parameters and temperatures are listed on the SAR plots.

Randy Ortanez
President

Figure 14.2 Right Head SAR Test Setup
-- Ear / 15° Tilt Position --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Brain

14.3 MEASUREMENT RESULTS (AMPS Left Head SAR - Touch)

FREQUENCY		Modulation	Begin / End POWER‡			Device Test Position	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
824.04	0991	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.567**
824.04	0991	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.689**
836.49	0383	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.711**
836.49	0383	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.888**
848.97	0799	AMPS	26.5	26.5	Standard	Cheek / Touch	In	**0.386**
848.97	0799	AMPS	26.5	26.5	Standard	Cheek / Touch	Out	**0.531**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population						**Brain 1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

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

‡Power Measured	☒ Conducted	☐ ERP	☐ EIRP
4. SAR Measurement System	☒ DASY3	☐ IDX	☐
Phantom Configuration	☒ Left Head	☐ Flat Phantom	☐ Right Head
5. SAR Configuration	☒ Head	☐ Body	☐ Hand
6. Test Signal Call Mode	☒ Manu. Test Codes	☐ Base Station Simulator	

7. Tissue parameters and temperatures are listed on the SAR plots.

Randy Ortanez
President

Figure 14.3 Left Head SAR Test Setup
-- Cheek / Touch Position --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Brain

14.4 MEASUREMENT RESULTS (AMPS Left Head SAR – Tilt)								
FREQUENCY		Modulation	Begin / End POWER‡			Device Test Position	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
836.49	0383	AMPS	26.5	26.5	Standard	Ear / 15° Tilt	In	**0.163**
836.49	0383	AMPS	26.5	26.5	Standard	Ear / 15° Tilt	Out	**0.258**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Brain** **1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

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

‡Power Measured	☒ Conducted	☐ ERP	☐ EIRP
4. SAR Measurement System	☒ DASY3	☐ IDX	☐
Phantom Configuration	☒ Left Head	☐ Flat Phantom	☐ Right Head
5. SAR Configuration	☒ Head	☐ Body	☐ Hand
6. Test Signal Call Mode	☒ Manu. Test Codes	☐ Base Station Simulator	

7. Tissue parameters and temperatures are listed on the SAR plots.

Randy Ortanez
President

Figure 14.4 Left Head SAR Test Setup
-- Ear / 15° Tilt Position --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Brain

14.5 MEASUREMENT RESULTS (CELLULAR CDMA Right Head SAR – Touch)

FREQUENCY		Modulation	Begin / End POWER‡			Device Test Position	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
824.70	1013	CDMA	25.0	25.0	Standard	Cheek / Touch	In	**0.420**
824.70	1013	CDMA	25.0	25.0	Standard	Cheek / Touch	Out	**0.530**
836.49	0383	CDMA	25.0	25.0	Standard	Cheek / Touch	In	**0.395**
836.49	0383	CDMA	25.0	25.0	Standard	Cheek / Touch	Out	**0.545**
848.31	0777	CDMA	25.0	25.0	Standard	Cheek / Touch	In	**0.288**
848.31	0777	CDMA	25.0	25.0	Standard	Cheek / Touch	Out	**0.382**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Brain** **1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

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

‡Power Measured	☒ Conducted	☐ ERP	☐ EIRP
4. SAR Measurement System	☒ DASY3	☐ IDX	☐
Phantom Configuration	☐ Left Head	☐ Flat Phantom	☒ Right Head
5. SAR Configuration	☒ Head	☐ Body	☐ Hand
6. Test Signal Call Mode	☒ Manu. Test Codes	☐ Base Station Simulator	

7. Tissue parameters and temperatures are listed on the SAR plots.

Randy Ortanez
President

Figure 14.5 Right Head SAR Test Setup
-- Cheek / Touch Position --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Muscle

14.6 MEASUREMENT RESULTS (AMPS Body SAR w/o Holster)

FREQUENCY		Modulation	Begin / End POWER‡			Separation Distance (cm) ‡‡	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
824.04	0991	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	In	**0.686**
824.04	0991	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	Out	**1.010**
836.49	0383	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	In	**0.822**
836.49	0383	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	Out	**1.270**
848.97	0799	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	In	**0.470**
848.97	0799	AMPS	26.5	26.5	Standard	1.5 [w/o Holster]	Out	**0.667**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population						**Muscle 1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

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

‡Power Measured	☒ Conducted	☐ ERP	☐ EIRP
4. SAR Measurement System	☒ DASY3	☐ IDX	☐
Phantom Configuration	☐ Left Head	☒ Flat Phantom	☐ Right Head
5. SAR Configuration	☐ Head	☒ Body	☐ Hand
6. Test Signal Call Mode	☒ Manu. Test Codes	☐ Base Station Simulator	
7. ‡‡Test Configuration	☐ With Holster	☒ Without Holster	

8. Tissue parameters and temperatures are listed on the SAR plots.
9. Both sides of the phone were tested and the worst-case side is reported.

Randy Ortanez
President

Figure 14.6 Body SAR Test Setup -- w/o Holster --

SAR DATA SUMMARY (Continued)

Mixture Type: 835MHz Muscle

14.7 MEASUREMENT RESULTS (CELLULAR CDMA Body SAR w/o Holster)								
FREQUENCY		Modulation	Begin / End POWER‡			Separation Distance (cm) ‡‡	Antenna Position	SAR (W/kg)
MHz	Ch.		(dBm)		Battery			
836.49	0383	CDMA	25.0	25.0	Standard	1.5 [w/o Holster]	In	**0.425**
836.49	0383	CDMA	25.0	25.0	Standard	1.5 [w/o Holster]	Out	**0.697**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population						**Muscle 1.6 W/kg (mW/g)** averaged over 1 gram		

NOTES:

1. The test data reported are the worst-case SAR value with the antenna-head position set in atypical configuration. Test procedures used are according to FCC/OET Bulletin 65, Supp.C [July 2001].
2. All modes of operation were investigated, and worst-case results are reported.
3. Battery is fully charged for all readings.
   ‡Power Measured ☒ Conducted ☐ ERP ☐ EIRP
4. SAR Measurement System ☒ DASY3 ☐ IDX ☐
   Phantom Configuration ☐ Left Head ☒ Flat Phantom ☐ Right Head
5. SAR Configuration ☐ Head ☒ Body ☐ Hand
6. Test Signal Call Mode ☒ Manu. Test Codes ☐ Base Station Simulator
7. ‡‡Test Configuration ☐ With Holster ☒ Without Holster
8. Tissue parameters and temperatures are listed on the SAR plots.
9. Both sides of the phone were tested and the worst-case side is reported.

Randy Ortanez
President

Figure 14.7 Body SAR Test Setup -- w/o Holster --

15. SAR TEST EQUIPMENT

Equipment Calibration

Table 15.1 Test Equipment Calibration

EQUIPMENT SPECIFICATIONS			
Type		**Calibration Date**	**Serial Number**
Stäubli Robot RX60L		February 2002	599131-01
Stäubli Robot Controller		February 2002	PCT592
Stäubli Teach Pendant (Joystick)		February 2002	3323-00161
Micron Computer, 450 MHz Pentium III, Windows NT		February 2002	PCT577
SPEAG EDC3		February 2002	321
SPEAG DAE3		February 2002	330
SPEAG E-Field Probe ET3DV6		February 2002	1560
SPEAG Dummy Probe		February 2002	PCT583
SPEAG SAM Twin Phantom V4.0		February 2002	PCT666
SPEAG Light Alignment Sensor		February 2002	205
SPEAG Validation Dipole D1900V2		February 2002	PCT613
Brain Equivalent Matter (835MHz)		March 2002	PCTBEM101
Brain Equivalent Matter (1900MHz)		N/A	PCTBEM301
Muscle Equivalent Matter (835MHz)		March 2002	PCTMEM201
Muscle Equivalent Matter (1900MHz)		N/A	PCTMEM401
Microwave Amp. Model: 5S1G4, (800MHz - 4.2GHz)		January 2002	22332
Gigatronics 8651A Power Meter		January 2002	1835299
HP-8648D (9kHz ~ 4GHz) Signal Generator		January 2002	PCT530
Amplifier Research 5S1G4 Power Amp		January 2002	PCT540
HP-8753E (30kHz ~ 3GHz) Network Analyzer		January 2002	PCT552
HP85070B Dielectric Probe Kit		January 2002	PCT501
Ambient Noise/Reflection, etc.	<12mW/kg/<3%of SAR	January 2002	Anechoic Room PCT01

NOTE:

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

16. CONCLUSION

Measurement Conclusion

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

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

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Probe ET3DV6

SN: 1560

Manufactured:	December 1,2000
Calibrated:	February 20,2002

Calibrated for System DASY3

PCTEST Calibration Laboratory

Approved By:

Alfred Cirwithian
Vice President Engineering

ET3DV6 SN: 1560

DASY3 – Parameters of Probe: ET3DV6 SN:1560

Sensitivity in Free Space

NormX	**1.48** µV/(V/m)^2	
NormY	**1.51** µV/(V/m)^2	
NormZ	**1.43** µV/(V/m)^2	

Diode Compression

DCP X	98 mV
DCP X	98 mV
DCP X	98 mV

Sensitivity in Tissue Simulating Liquid

Head **835 MHz Brain** e_r **= 41.5** ± **5%** s **= 0.90** ± **5% mho/m**

ConvF X = **6.78**
ConvF Y = **6.78**
ConvF Z = **6.78**

Boundary Effect:
Alpha **0.30**
Depth **2.90**

Body **835 MHz Brain** e_r **= 56.2** ± **5%** s **= 0.95** ± **5% mho/m**

ConvF X = **6.52** ± 7% (k=2)
ConvF Y = **6.52** ± 7% (k=2)
ConvF Z = **6.52** ± 7% (k=2)

Boundary Effect:
Alpha **0.30**
Depth **2.90**

Head **1900 MHz Brain** e_r **= 40.0** ± **5%** s **= 1.40** ± **5% mho/m**

ConvF X = **5.16**
ConvF Y = **5.16**
ConvF Z = **5.16**

Boundary Effect:
Alpha **0.48**
Depth **2.40**

Body **1900 MHz Muscle** e_r **= 54.2** ± **5%** s **= 1.50** ± **5% mho/m**

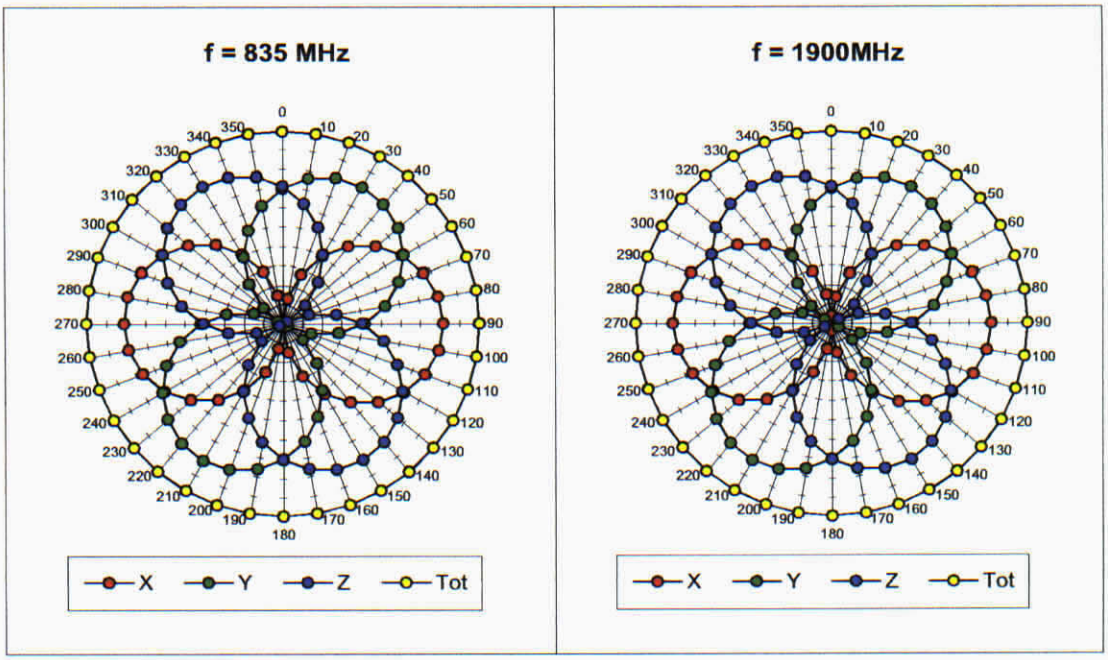
ConvF X = **4.70** ± 7% (k=2)
ConvF Y = **4.70** ± 7% (k=2)
ConvF Z = **4.70** ± 7% (k=2)

Boundary Effect:
Alpha **0.48**
Depth **2.40**

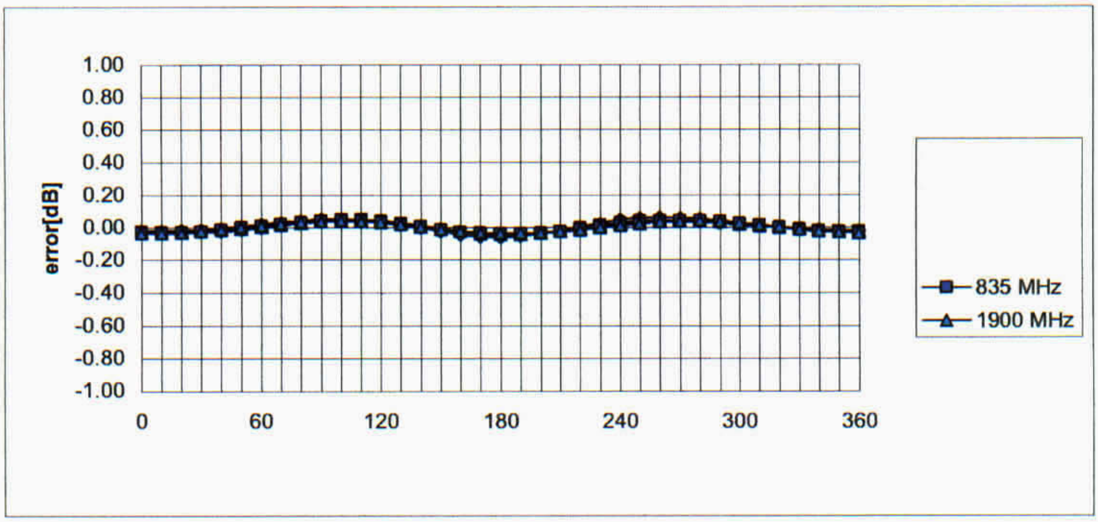
Sensor Offset

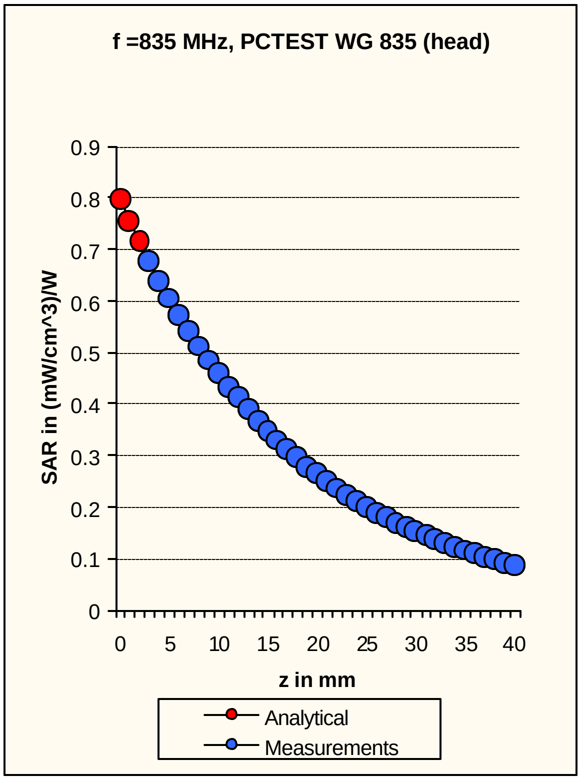
Probe Tip to Sensor Center	**2.7**	mm
Optical Surface Detection	2.0 ± 0.2	mm

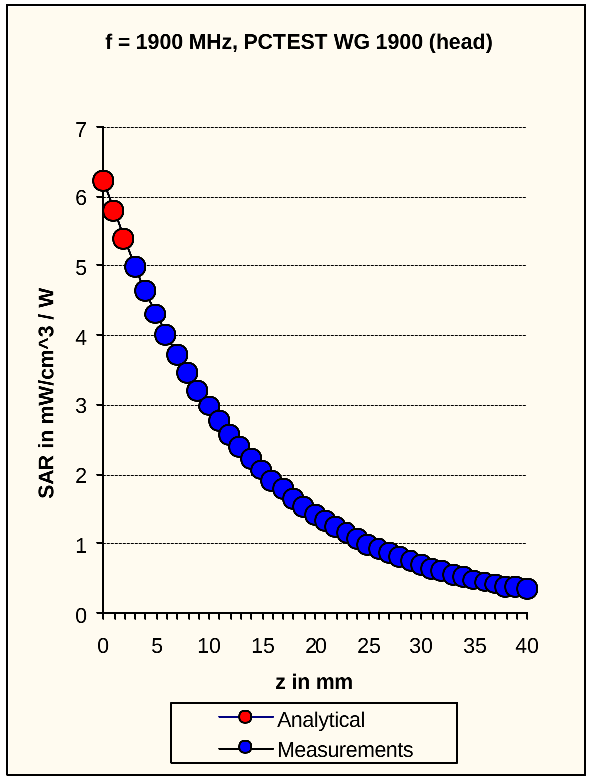
ET3DV6 SN:1560



Isotropy Error (ϕ), θ = 0°







Conversion Factor Assessment for *DASY3* SAR Measurement System

ET3DV6 S/N: 1560

835 MHz Brain

e_r = 42 ± 5% **s = 0.90 ± 5% mho/m**

ConvF X = **6.78** ± 7% (k=2)
ConvF Y = **6.78** ± 7% (k=2)
ConvF Z = **6.78** ± 7% (k=2)

Boundary Effect:
Alpha **0.30**
Depth **2.90**

1900 MHz Brain

e_r = 40 ± 5% **s = 1.40 ± 5% mho/m**

ConvF X = **5.16** ± 7% (k=2)
ConvF Y = **5.16** ± 7% (k=2)
ConvF Z = **5.16** ± 7% (k=2)

Boundary Effect:
Alpha **0.48**
Depth **2.40**

Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

Certificate of conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 BA
Series No	TP-1002 and higher
Manufacturer / Origin	Untersee Composites Hauptstr. 69 CH-8559 Fruthwilen Switzerland

Tests

The series production process used allows the limitation to test of first articles.
Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series units (called samples).

Test	Requirement	Details	Units tested
Shape	Compliance with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness	Compliant with the requirements according to the standards	2mm +/- 0.2mm in specific areas	First article, Samples
Material parameters	Dielectric parameters for required frequencies	200 MHz – 3 GHz Relative permittivity < 5 Loss tangent < 0.05.	Material sample TP 104-5
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards	Liquid type HSL 1800 and others according to the standard.	Pre-series, First article

Standards

[1] CENELEC EN 50361
[2] IEEE P1528-200x draft 6.5
[3] IEC PT 62209 draft 0.9
(*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of [1] and [3].

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standard [1] and draft standards [2] and [3].

Date 18.11.2001

Signature / Stamp

Schmid & Partner Engineering AG
Zeughausstrasse 43, CH-8004 Zurich
Tel. +41 1 245 97 00, Fax +41 1 245 97 79

7. SAR Measurement System Validation

7.1 Introduction

This section provides procedures for the following three levels of SAR measurement systemverification:

a) System performance checking

b) System validation

c) Interlaboratory comparison.

The objectives and applications of these different levels of verification procedures are as follows:

System performance checking (*system check*) provides a simple, fast, and reliable test method that can be performed daily or before every SAR measurement. The objective here is to ascertain that the system components are still within laboratory calibration limits, including drift effects. This test requires a flat phantom and a Standard Source, e.g., a half-wave dipole.

System validation[1] provides means of system-level validation. The test system utilizes a flat phantom and a reference dipole (see Annex F). Thus, *system validation* verifies the system accuracy against its specifications and does not include the uncertainty due to the use of anthropomorphic phantoms nor does it include the uncertainty due to handset positioning variability. This test is performed annually (e.g., after probe calibration), before measurements related to interlaboratory comparison, and every time modifications have been made to the system, such as a new software release, different readout electronics or different types of probes.

Interlaboratory comparisons provide laboratories with a reference handset and a standard anthropomorphic phantom to quantify the global measurement uncertainty. This allows the data scatter due to the human-like phantom and due to handset positioning effects to be evaluated. This test is used to compare the accuracy and precision performance of various laboratories.

7.2 System Performance Check

7.2.1 Purpose

The purpose of the system performance check (*system check*) is to verify that the system operates within its specifications. The *system check* is a simple check of repeatability to make sure that the system works correctly at the time of the compliance test. It is not a verification of the system with respect to external standards. The *system check* should detect possible short time drift and errors in the system, such as:

a) changes in the liquid parameters (e.g. due to water evaporation or temperature change)

b) component failures

c) component drift

---

[1] In other international standards (e.g., CENELEC, IEC), the term System Validation may be used to refer to tests using reference handsets with the standard anthropomorphic phantom.

d) operator errors in the setup or software parameters

e) adverse conditions in system configuration

The *system check* is a complete 1 g or 10 g averaged SAR measurement in a simplified test system with a standard source (see 7.2.3). The instrumentation and procedures in the *system check* are the same as those used for the compliance tests. The *system check* must be performed using the same liquid as in the compliance test and at a chosen fixed frequency that is within ± 10% of the compliance test mid-band frequency. The *system check* is performed prior to compliance tests and the result must always be within ± 10% of the target value corresponding to the test frequency, liquid and the source used. The target values are 1 g or 10 g averaged SARs measured by any system on which *system validation* has been performed using the *system check* test system in Figure 7.1. These target values should be determined using a controlled standard source.

7.2.2 Phantom

The test system uses a flat phantom as specified in 4.5.3.

7.2.3 Standard Source

The phantom should be irradiated using a standard source for the required frequency (e.g., a half-wave dipole or patch antenna). The reference dipoles used for *system validation* (see Annex F) can also be used for the *system check*, but are not required. To ensure good SAR measurement repeatability, standard sources should be selected with good positioning repeatability, mechanical and electrical stability, and impedance matching. The standard source should have a return loss better than -20 dB (measured in the test system) at the test frequency to reduce the uncertainty in the power measurement. In the following positioning instructions, a half-wave dipole is used as an example of a standard source.

A half-wave dipole should be positioned below the bottom of the phantom and centered with its axis parallel to the longest side of the phantom. The distance between the liquid filled phantom bottom surface and the dipole center, *s*, (see Fig. 7.1) should be specified for each test frequency. A low loss and low dielectric constant spacer should be used to establish the correct distance between the top surface of the dipole and the bottom surface of the phantom. For other standard sources, the distance *s* should be defined according to the source structure.To ensure good repeatability, the same dipoles (or other controlled sources) and spacers shall always be used for *system check.* The acceptable tolerance of distance *s* should be within ± 0.2 mm.

7.2.4 Standard Source Input Power Measurement

The uncertainty of the power to the source must be as small as possible. This requires the use of a test system with directional couplers and power meters during the *system check.* The recommended test system is shown in Figure 7.1 (which uses a half-wave dipole as an example of a standard source).

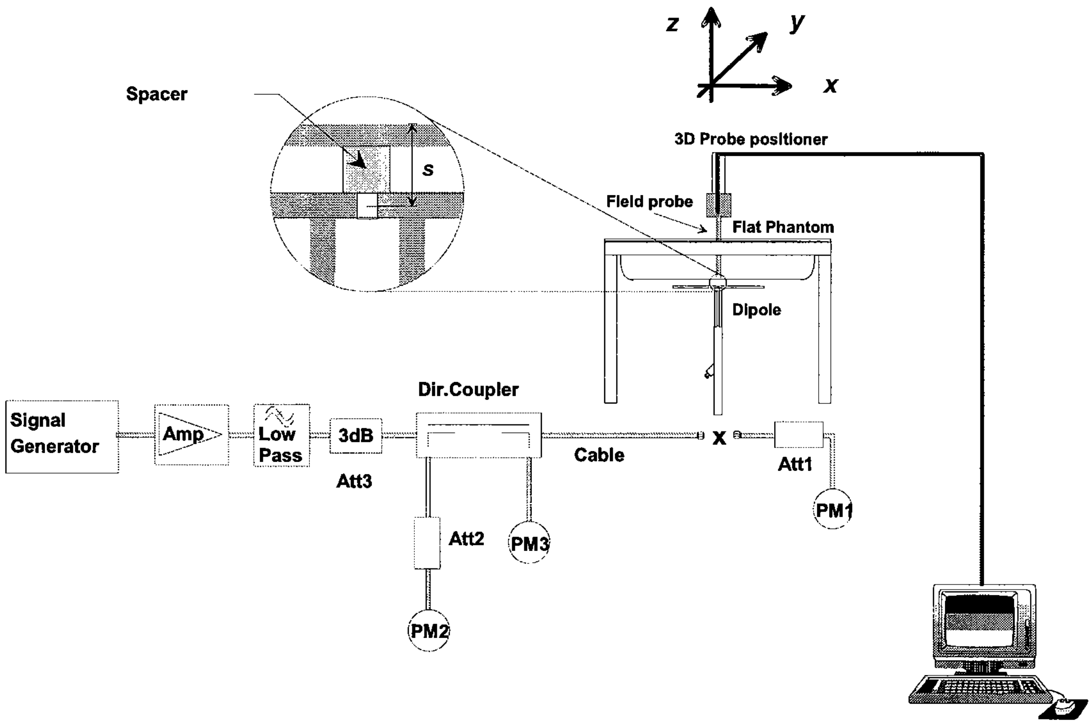


Figure 7.1 – Test system for the system performance check

First the power meter PM1 (including attenuator Att1) is connected to the cable to measure the forward power at the location of the dipole connector (X). The signal generator is adjusted for the desired forward power at the dipole connector (taking into account the attenuation of Att1) as read by power meter PM2. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter PM2. If the signal generator does not allow adjustment in 0.01dB steps, the remaining difference at PM2 must be taken into consideration (e.g., by scaling the measured SAR values versus the forward power difference) . PM3 records the reflected power from the dipole to ensure that the reflected power is at least 20dB below the forward power.

The component and instrumentation requirements are as follows:

a) The signal generator and amplifier should be stable to within 2 % (short term stability after warm-up). The forward power to the dipole should be high enough to produce SAR exceeding the lower detection limit of the probe system (see Annex A4). The recommended 1 g averaged SAR range is 0.4-8 W/kg. If the signal generator can deliver 15 dBm or more, an amplifier is generally not necessary. Some high power amplifiers should not be operated at a level far below their maximum output power, e.g., a 100 W power amplifier operated at 250 mW output power can be quite noisy. An attenuator between the signal generator and amplifier is recommended to protect the amplifier input.

b) The low pass filter inserted after the amplifier reduces the effect of harmonics and noise from the amplifier. For most amplifiers in normal operation the filter is not necessary.

c) The attenuator after the amplifier improves the source matching and the accuracy of the power sensor. (Consult the power meter manual.)

d) The directional coupler (recommended -20 dB coupling coefficient) is used to monitor the forward power and adjust the signal generator output for constant forward power. A medium-quality coupler is sufficient because the loads (dipole and power head) are both well-matched.

e) The power meters PM2 and PM3 should have low drift and a resolution of 0.01 dBm, but otherwise the accuracy has negligible impact on the power setting. (Absolute calibration is not required.)

f) The power meter PM1 and attenuator Att1 must be high-quality components. These should be calibrated, preferably together. The attenuator (-10 dB) improves the accuracy of the power reading. (Some high-power heads come with a built-in calibrated attenuator.) The exact attenuation of the attenuator at the test frequency must be known; many attenuators vary up to 0.2 dB from the specified value.

g) Use the same power level for PM1 test as used for the actual measurement to avoid linearity and range switching errors in the power meters PM2 and PM3. If the power level is changed, the power level setting procedure should be repeated.

h) The dipole must be connected directly to the cable at location “X”. If the power meter has a different connector system, use high-quality adapters.

7.2.5 System Check Procedure

The *system check* is a complete 1 g or 10 g averaged *SAR* measurement. The measured 1 g (or 10 g) averaged SAR value is normalized to the target input power of the standard source and compared with the previously recorded target 1 g (or 10 g) value corresponding to the measurement frequency, the Standard Source and specific phantom. The acceptable tolerance must be determined for each *system check* and should be within ± 10% of previously recorded *system check* target values.

7.3 System Validation

7.3.1 Purpose

The *system validation* procedure tests the system against reference SAR values, and the performance of probe, readout electronics and software. The test system utilizes a flat phantom and a reference dipole. Thus, the *system validation* process does not include data scatter due to the use of anthropomorphic phantoms, or uncertainty due to handset positioning variability.

System validation is performed before each test, or when a new system is put into operation, or whenever modifications have been made to the system, such as a new software release, different readout electronics or different types of probes. *System validation* should be done after the probe calibration has taken place.

The objective of this clause is to provide a methodology for SAR measurement verification. Since *SAR* measurement equipment and calibration techniques can vary widely between various laboratories, a validation methodology is needed to verify the system accuracy against its specifications. Numerically calculated reference SAR values are listed in Table 7.1.

7.3.2 Phantom

The flat phantom described for the system performance check (see Figure 7.1) is also used for the *system validation* tests. The *system validation* must be performed using head tissue equivalent liquids having dielectric properties as defined in Table 4.1.

7.3.3 Reference Dipole Source

The phantom should be irradiated using a reference dipole specified in Annex F for the required frequency. The reference dipoles are defined for the specific phantom shell dielectric parameters and thickness indicated in Table 7.2. The reference dipole should be positioned below the bottom of the phantom and centered with its axis parallel to the longest side of the phantom. A low loss and low dielectric constant spacer can be used to establish the correct distance between the top surface of the reference dipole and the bottom surface of the phantom. The spacer should not change the measured 1 g and 10 g averaged SAR values more than 1 %. The distance between the liquid filled phantom bottom surface and the reference dipole center (designated *s*) is specified within 0.2 mm for each test frequency. The reference dipole should have a return loss better than –20 dB (measured in the test system) at the test frequency to reduce the uncertainty in the power measurement.

For the reference dipoles described in Annex F, the spacing distance *s* is given by:

a) s = 15mm ± 0.2 mm for 300 MHz $\leq f \leq$ 1000 MHz:

b) s = 10mm ± 0.2 mm for 1000 MHz $< f \leq$ 3000 MHz

The reference dipole arms shall be parallel to the flat surface of the phantom within a tolerance of ± 2 degrees or less (see Figure 7.1). This can be assured by carefully positioning the empty phantom and the reference dipole to horizontal level using a waterpas.

7.3.4 Reference Dipole Input Power Measurement

The input power measurement test system described for the system performance check (7.2.4) is also used for *system validation* tests.

7.3.5 System Validation Procedure

System validation is used for verifying the accuracy of the probe and readout electronics, and performance of the software. Device positioning and head phantom shape errors are not considered. The *system validation* procedure consists of six steps. Step (a) is the most important part of the *system validation* procedure and shall be done every time. Steps (b)-(f) (recommended) offer a means for quick and simple validation of probe, readout electronics, and software performance. These additional tests should be done any time system components have been modified (e.g., new software release, new readout electronics, new probe type, etc.). The *system validation* procedure is as follows:

a) **SAR evaluation:** A complete 1 g or 10 g averaged SAR measurement is performed. The reference dipole input power is adjusted to produce a 1 g averaged SAR value falling in the range of 0.4 W/kg to 8 W/kg. The 1 g or 10 g averaged SAR is measured at frequencies in Table 7.1 within the range to be used in compliance tests. The results are normalized to 1 W forward input power and compared with the reference SAR value for the reference dipole and flat phantom shown in columns 2 and 3 of Table 7.1. The difference from the reference value given in Table 7.1 should be less than the standard uncertainty determined in Clause 6 (Table 6.2).

b) **Extrapolation routine:** Local SAR values are measured along a vertical axis directly above the Reference Dipole feed point using the same point spacing as used for the evaluation of the peak spatial average SAR. This measurement is repeated along another vertical axis with a 2 cm horizontal offset (*y* direction – see Fig. 7.1) along the dipole from the reference dipole feed point. SAR values at the phantom surface are extrapolated and compared with the numerical values given in columns 4 and 5 of Table 7.1. The difference from the reference values given in Table 7.1 should be less than the extrapolation standard uncertainty item in Table 6.2.

c) **Probe linearity:** The measurements in step (a) are repeated using different reference dipole input power levels. The power levels are selected for each frequency are selected to produce 1 g averaged SAR values of approximately 8 W/kg, 1.6 W/kg, and 0.4 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized values from step (a). The difference between these values should be less than the probe linearity standard uncertainty item in Table 6.2.

d) **Modulation response:** The measurements in step (a) are repeated with pulse-modulated signals having a duty factor of 0.1 and pulse repetition rate of 10 Hz. The power is adjusted to produce a 1 g-averaged SAR of approximately 8 W/kg with a CW signal. The measured SAR values are normalized to 1 W forward input power and duty factor of 1, and compared with the 1 W normalized values from step (a). The difference between these values should be less than the linearity standard uncertainty item in Table 6.2.

e) **System offset:** The measurements in (a) are repeated with a reference dipole input forward power that produces a 1 g averaged SAR of approximately 0.05 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized values from step (a). The difference between these values should be less than the probe linearity standard uncertainty item in Table 6.2.

f) **Probe axial isotropy:** The probe is placed directly above the reference dipole center at a measurement distance of approximately 5 mm from the phantom inner surface. The probe (or reference dipole) is rotated around its axis at least 180° in steps no larger than 15°. The maximum and minimum SAR readings are recorded. The difference between these values should be less than the probe axial isotropy standard uncertainty item in Table 6.2.

NOTE: The *system validation* is neither an alternative procedure to the probe calibration nor to the uncertainty assessment of Clause 6. The probe and the readout electronics shall be calibrated regularly according to the procedures given in Clause 3 and Annex A. Probe hemispherical isotropy is not considered in the test system for *system validation.*

7.3.6 Reference SAR values

In the *system validation* test, the reference dipole constructed for the frequency f_i (described in Annex F) should produce the numerical reference peak spatial-average SAR values shown in columns 2 and 3 of Table 7.1, within the uncertainty of the system. Columns 4 and 5 of Table 7.1 are used to validate the system extrapolation routines, as described in 7.3.5. The reference SAR values have been calculated using the finite-difference time-domain method [Yee, 1966]. The values in columns 4 and 5 for frequencies between 835 and 3000 MHz have been experimentally verified by using 4^{th}-order polynomial extrapolation [to be determined]. The values for frequencies between 300 and 450 MHz will be experimentally verified in the next revision of the standard. The parameters for the lossless phantom shellused in the simulations (dimensions, shell thickness and permittivity), and the distance *s* between the reference dipole and liquid are given in Table 7.2. The dielectric properties used for the liquid are defined in Table 4.1 and the dimensions of the reference dipoles are shown in Table F1.

Table 7.1 – Numerical reference SAR values for reference dipole and flat phantom. All values are normalized to a forward power of 1 W.

Frequency (MHz)	1 g SAR	10 g SAR	local SAR at surface (above feedpoint)	local SAR at surface (y=2cm offset from feedpoint)
300	3.0	2.0	4.4	2.1
450	4.9	3.3	7.2	3.2
835	9.5	6.2	14.1	4.9
900	10.8	6.9	16.4	5.4
1450	29.0	16.0	50.2	6.5
1800	38.1	19.8	69.5	6.8
1900	39.7	20.5	72.1	6.6
2000	41.1	21.1	74.6	6.5
2450	52.4	24.0	104.2	7.7
3000	63.8	25.7	140.2	9.5

Table 7.2 – Parameters used for calculation of reference SAR values in Table 7.1

Frequency (MHz)	Phantom shell thickness (mm)	Phantom shell permittivity	Phantom dimensions (mm) x, y, z	Reference dipole distance *s* (mm) from the liquid
300	6.3	3.7	1000, 800, 170	15
450	6.3	3.7	700, 600, 170	15
835	2.0	3.7	360, 300, 150	15
900	2.0	3.7	360, 300, 150	15
1450	2.0	3.7	240, 200, 150	10
1800	2.0	3.7	220, 160, 150	10

835MHz Brain Dipole Validation

SAM Phantom; Flat Section; Probe:ET3DV6 - SN1560; ConvF(6.78,6.78,6.78)

Med. Parameters 835 MHz Brain: σ = 0.87 mho/m ε_r = 43.5 ρ = 1.00 g/cm^3; Antenna Position -- Out; Crest Factor 1.0

SAR (1g): 2.41 mW/g, SAR (10g): 1.56 mW/g

835MHz Brain Dipole Validation (D835V2 S/N: 406)

Frequency: 835 MHz; Antenna Input Power: 250 [mW]; Ambient Temp. = 22.2°C / Meas. Tissue Temp. = 22.1°C

PCTEST Brain Tissue Simulating Liquid [03/29/2002]