HYUNDAI CALIBRATION & CERTIFICATION TECH. CO., LTD.

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CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

Bellwave Co., Ltd.
6th FL. Telson Venture Tower 949-3,
Dogok-Dong, Kangnam-Ku, Seoul 135-270 Korea

Date of Issue: May 7, 2005
Test Report No.: HCT-SAR05-0508
Test Site: HYUNDAI CALIBRATION & CERTIFICATION TECHNOLOGIES CO., LTD.
FRN: 0005866421

FCC ID : **SY6X101**

APPLICANT : **Bellwave Co., Ltd.**

EUT Type:	Dual-Band GSM Phone (GSM850/ GSM1900)- Prototype GPRS Class10 and GPRS Mode ClassB (GPRS and GSM but not simultaneously)
Tx Frequency:	824.20 — 848.80 MHz (GSM850) 1850.20 — 1909.80 MHz (GSM1900)
Rx Frequency:	869.20 — 893.80 MHz (GSM850) 1930.20 — 1989.80 MHz (GSM1900)
Max. RF Output Power:	0.942 W ERP GSM850 (29.74 dBm) / 0.676 W EIRP GSM1900 (28.30 dBm)
Trade Name/Model(s):	Bellwave / X101
FCC Classification:	Licensed Portable Transmitter Held to Ear (PCE)
Application Type:	Certification
FCC Rule Part(s):	§2.1093; FCC/ OET Bulletin Supplement C [July 2001]
Maximum SAR:	0.886W/kg GSM850 Head SAR; 0.229 W/kg GSM850 Body SAR; 0.707W/kg GSM1900 Head SAR; 0.313 W/kg GSM1900 Body SAR

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 ANSI/ IEEE Std. C95.3- 1992. (See Test Report).

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.

Hyundai C-Tech Co., Ltd. Certifies that no party to this application has been denied FCC benefits pursuant to section 5301 of the Anti- Drug Abuse Act of 1998, 21 U.S. C. 853(a)

Ki Soo Kim

Report prepared by : Ki-Soo Kim

Manager of Product Compliance Team

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SAR MEASUREMENT REPORT

1.1 SCOPE

Environmental evaluation measurements of specific absorption rate [1] (SAR) distributions in emulated human head and body tissues exposed to radio frequency (RF) radiation from wireless portable devices for compliance with the rules and regulations of the U.S. Federal Communications Commission (FCC).[2]

1. 2 Applicant

Company Name: Bellwave Co., Ltd

Address: 6th FL. Telson Venture Tower 949-3,Dogok-Dong, Kangnam-Ku, Seoul 135-270 Korea

Attention: Ju-won Seul

Tel. / Fax : 82- 2-3460-9785 / 82-2-3460-9736

E-Mail : maru-swj@bellwave.com

- EUT Type: Dual-Band GSM Phone (GSM850/ GSM1900)
  GPRS Class10 and GPRS Mode ClassB (GPRS and GSM,but not simultaneously)
- Trade Name: Bellwave
- Model(s): X101
- FCC ID: SY6X101
- Serial Number(s): SY620050500003
- Tx Frequency: 824.20 – 848.80 MHz (GSM850)
  1850.20 – 1909.80 MHz (GSM1900)
- Rx Frequency: 869.20 – 893.80 MHz (GSM850)
  1930.20 – 1989.80 MHz (GSM1900)
- Application Type: Certification
- FCC Classification: Licensed Portable Transmitter Held to Ear (PCE)
- FCC Rule Part(s): §2.1093; FCC/ OET Bulletin Supplement C [July 2001]
- Modulation(s): GSM
- Antenna Type: Fixed
- Date(s) of Tests: April 29, 2005 – May 2, 2005
- Place of Tests: Hyundai C-Tech. EMC Lab.
  Icheon, Kyounki-Do, KOREA
- Report Serial No.: HCT-SAR05-0508

Figure 1. SAR System

[1] Specific Absorption Rate (SAR) is a measure of the rate of energy absorption due to exposure to an RF transmitting source (wireless portable device).

[2] IEEE/ANSI Std. C95.1-1992 limits are used to determine compliance with FCC ET Docket 93-62.

2.1 INTRODUCTION

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency 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 Radio frequency Electromagnetic Fields," NCRP Report No. 86 (c) NCRP, 1986, Bethesda, MD 20814.[4] 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.

2.2 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 .

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

Figure 2. 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.[4]

3.1 SAR MEASUREMENT SET-UP

The Measurement System using the ESSAY-3 SAR Measurement System. The system was manufactured by EMF Safety Inc in Seoul, South Korea. It consists of an E-field probe, an electronic board with instrumentation amplifiers, optical (RF transparent) lines connecting the differential amplifiers to a computer, probe positioning robotics system (Samsung AS3), Pentium IV computer, SAM (Head Right, Head Left) and flat phantoms containing the simulated tissue and a holder assembly for the device under test. The robot is a six-axes for industrial purpose performing precise movements to scan and find the area of maximum electromagnetic field (EMF). The PC consists of the Pentium IV 1.4 GHz computer with Microsoft Windows 98/ME/2000/XP system and SAR measurement software ESSAY 3, data I/O interface card (PCI 6503), monitor, mouse, and keyboard. An electronic board performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, emergency stop, etc. The electro-optical coupler performs the conversion from the optical into digital electronic signal of the data receiving system (DRS) and transfers data to the plug-in card in PC.

The ESSAY-3 SAR Measurement System is based on a highly accurate computer-controlled robotic arm with positioning repeatability better than 0.1mm. The arm is used to position a highly sensitive E-field probe inside a human-shaped phantom filled with a liquid having the complex electrical characteristics of human brain or muscle tissue. The probe has an isotropic response and causes minimal field disturbance (RF transparency) by using low dielectric constants and highly resistive materials. This system satisfies the accuracy, reliability and efficiency demands of today's desired level of quality.

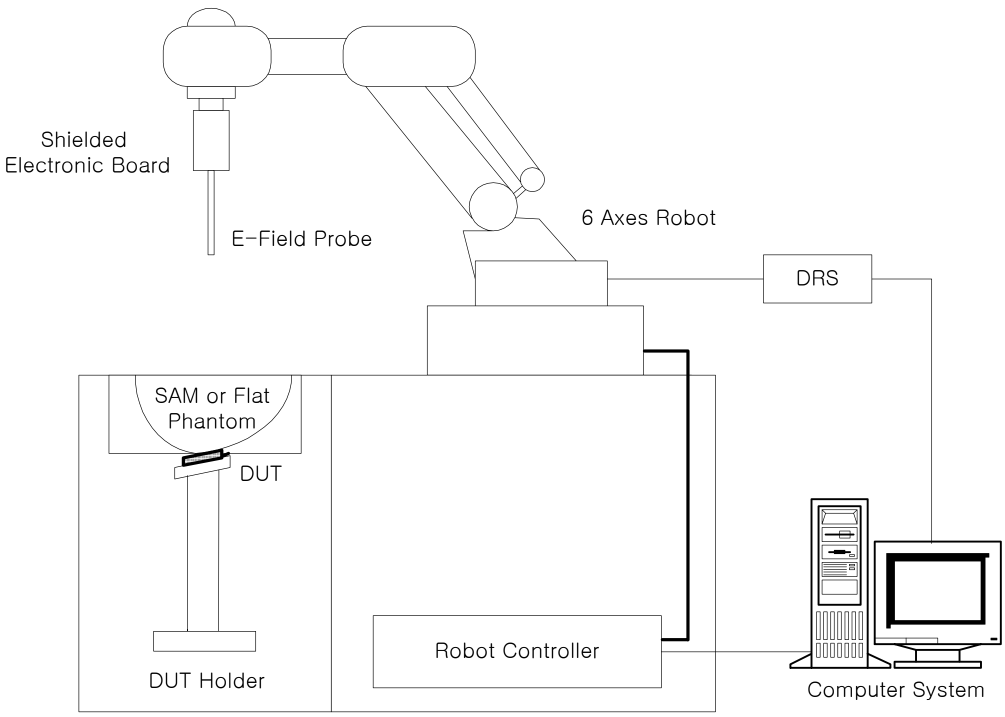


Figure 3. ESSAY-3 SAR Measurement Set-up in HCT SAR Lab

4.1 DASY3 E-FIELD PROBE SYSTEM

4.2 Specification of Triangular E-Field Probe

The E-field probe is a three-channel device used to measure RF electric fields. The sensors are three mutually orthogonal dipoles, each 1.0 to 2.5 mm in length. For each channel of the probe, the dipole and two high-impedance lines are vapor-deposited on a substrate. Located at the center of the dipole is a Schottky diode. The three substrates are mounted on a I-beam or triangular cross-section. The probe is enclosed in a protective sleeve to avoid contact with the corrosive elements of the simulated tissue. The total length of the probe is approximately 30 cm. The probe does not perturb significantly the field being measured. It is isotropic; that is, no matter how the probe is positioned physically relative to the E-field, the sum of the outputs of the three channels always gives about the same value. The probe is very fragile, can be damaged by mechanical shock, and should be safely stored when not in use.

Specification of Triangular E-Field Probe

Body materials	Dielectric constant 2.5, loss tangent 0.0004 at 10 GHz
Dimensions	30.0 cm length, body diameter 9.5 mm
Sensors	Gold plated Schottky diode
Connector	Miniature 7 pins
Dipole length	2.0 mm
Tip outer diameter	4.0 or 4.8 mm
Offset position of the dipole from the tip end	2.0 mm typical
Usable frequency band	10 MHz to 10 GHz
Spatial resolution of the sensor	$\leq$ 10 mm^3
DC line impedance	≈ 1 MΩ
Angular response	< ± 0.2 dB (isotropy)
Dynamic range	< 10 mW/kg ~ > 100 W/kg

Figure 4. E-Field Probe (Triangular) : Model ET20

5.1 EUT ARRANGEMENT

5.2 HEAD POSITION

The device was placed in a normal operating position with the Point A on the device, as illustrated in following drawing, aligned with the location of the RE(ERP) on the phantom. With the ear-piece pressed against the head, the vertical center line of the body of the handset was aligned with an imaginary plane consisting of the RE, LE and M. While maintaining these alignments, the body of the handset was gradually moved towards the cheek until any point on the mouth-piece or keypad contacted the cheek. This is a cheek/touch position. For ear/tilt position, while maintain the device aligned with the BM and FN lines, the device was pivot against ERP back for 15º or until the device antenna touch the phantom. Please refer to IEEE SC-2 P1528 illustration Below.

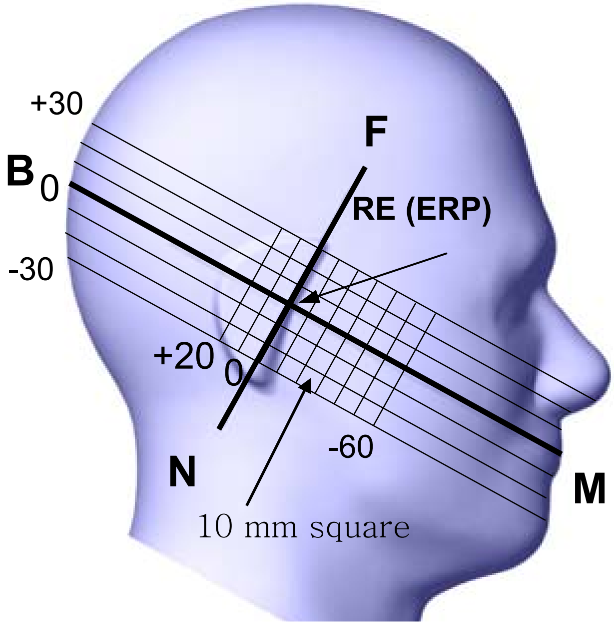


Figure 6. EUT Head Position

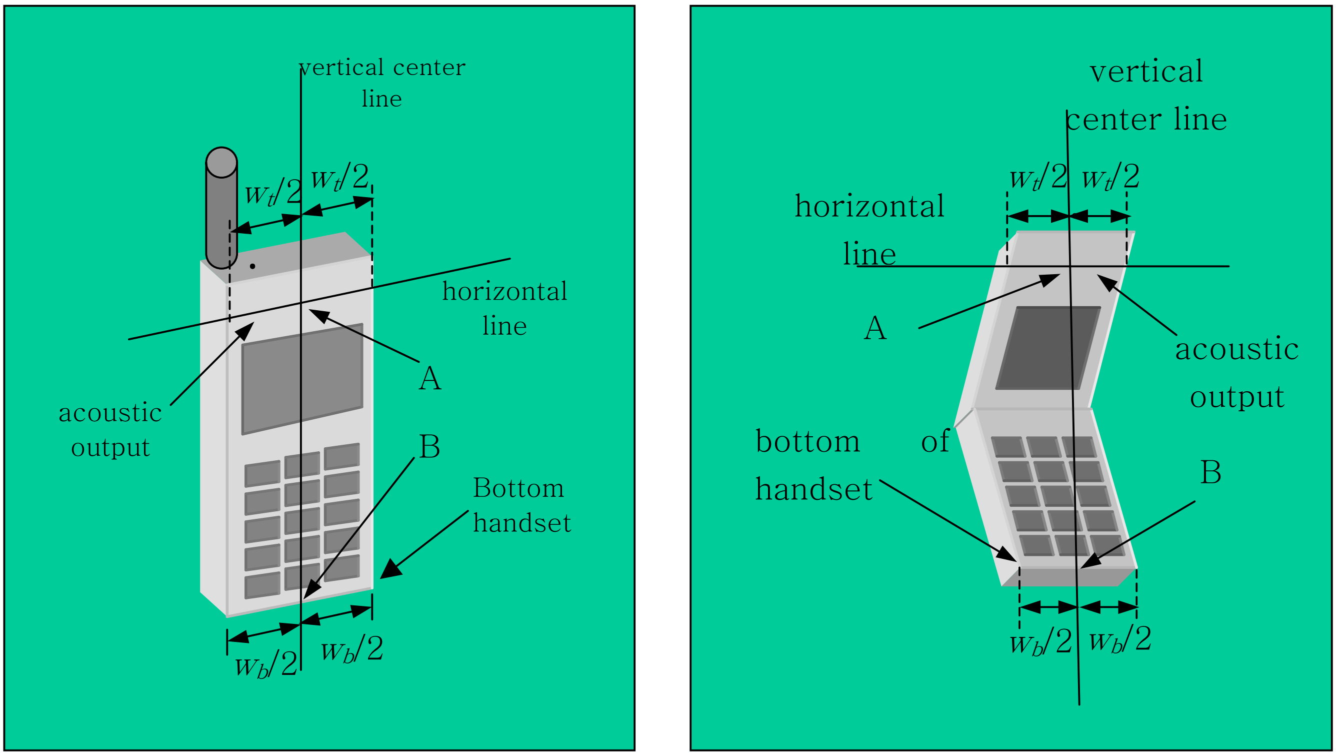


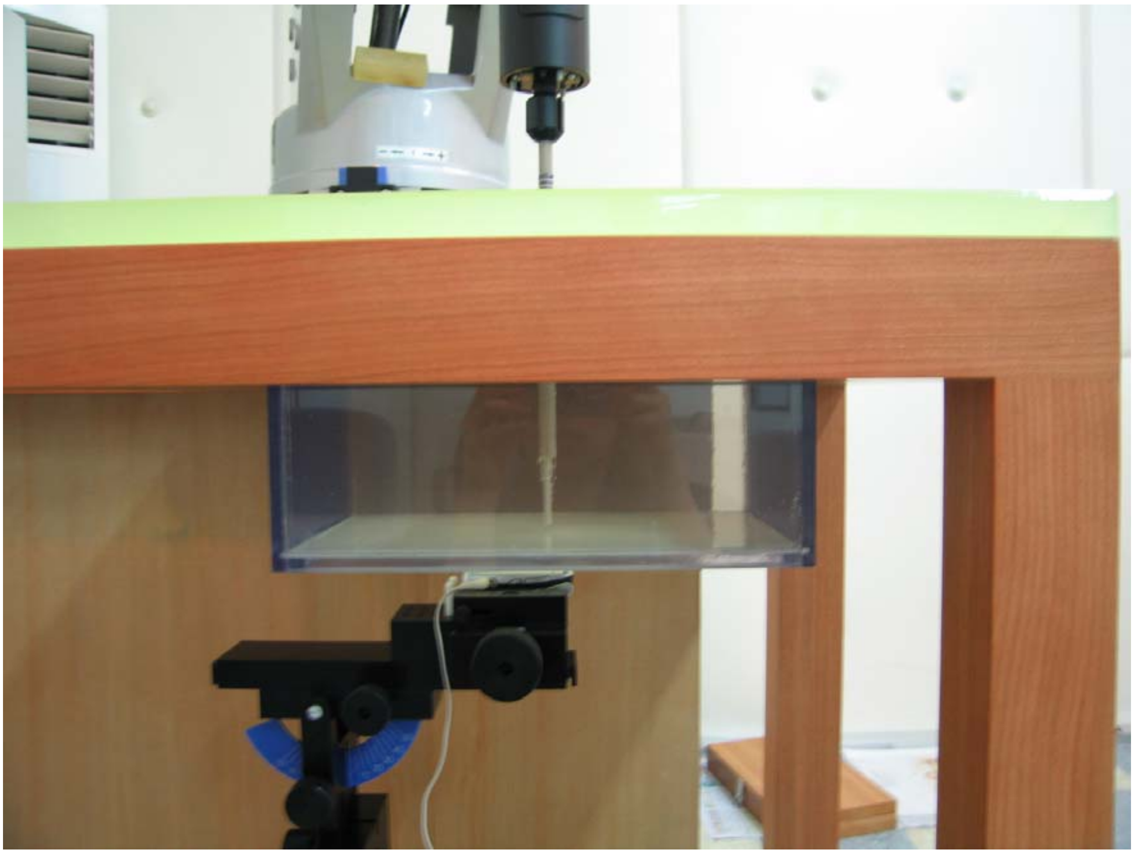
Figure 7. Device Test Position

5.3 BODY-WORN TEST SETUP

The body worn configuration is used for body-worn devices that have belt clip, holster or carrying case accessory. Typically, a holster, belt clip or carrying case is provided or available as an accessory item for supporting headset and body-worn operations. SAR may vary depending on the body separation distance provided by the type of accessory and batteries supplied for a phone. Generally, the design of the holster allows the phone to be positioned only with the keypad facing away from the phantom. Proper usage of the body worn accessory restricts the antenna to a specified distance away from the surface of the body. For this test the EUT is

□ Placed into the Body worn accessory and the accessory is positioned against the surface of the phantom in a normal operating position. (2mm separation phantom thickness)

■ Since this EUT does not supply any body worn accessory to the end user a distance of 15 mm from the EUT back surface to the liquid interface is configured for the generic test.



[Body without Holster Configuration]

Figure 8. Body Test Position

6.1 E-FIELD PROBE CALIBRATION PROCESS

6.2 E-Probe Calibration

A SAR measurement system is comprised of the probe, amplifiers, and data recording equipment. Presently available E-field probes are based on Schottky diode detectors. The measured signal at the probe output is a voltage proportional to E or E^2, depending on the magnitude of the electric field strength, which determines the operating point on the diode characteristic curve.

The isotropic probes consist of three small dipole sensors with detector diodes at their center gaps. The directivity patterns of such sensors are orthogonal, and the total E-field magnitude is proportional to the root-sum-square (RSS) of the three probe orthogonal components.

$$|E| = \sqrt{|E_1|^2 + |E_2|^2 + |E_3|^2} \quad (3\text{-}1)$$

In the square-law region of the diode characteristic curve, the sensor output voltage is proportional to the mean square of the corresponding field component. Beyond that range the output voltage is compressed and therefore requires linearization to achieve the required dynamic range [3-1]. Differences due to manufacturing tolerances will produce different sensitivities for each sensor, which is accounted for in calibration of isotropy.

$$|E| = \sqrt{\frac{V_1}{\gamma_1} + \frac{V_2}{\gamma_2} + \frac{V_3}{\gamma_3}} \quad (3\text{-}2)$$

where V_i is the open circuit voltage and γ_i in μV/(V/m)^2 is the sensitivity at port i, $(i = 1, 2, 3)$.
Probe calibration for SAR testing in liquid will produce either a SAR or an E-field conversion factor. Because SAR is proportional to liquid conductivity, a direct calibration in terms of SAR would be valid only for liquids with the exact same conductivity. The E-field sensitivity depends more on the liquid complex permittivity, and is less sensitive to the conductivity alone. Calibration in terms of E-field should have a broader range of validity, and is therefore preferred for routine SAR testing in which the tissue-equivalent liquid properties may vary slightly over time.
Probe calibration is usually done with either one-step or two-step methods. In the two-step method, the total field is given by:

$$|E|^2 = \sum_{i=1}^{3} |E_i|^2 = \sum_{i=1}^{3} \frac{f_i(V_i)}{\eta_i \psi_i} \quad (3\text{-}3)$$

Here, E_i (i = 1, 2, 3) are the components resulting from the projection of the E-field vector on the three orthogonal sensors, f_i (V_i) is a linearizing function of the rectified sensor signal V_i, η_i in [μV/(V/m)^2] is the sensitivity of dipole sensor i in air for the sensor aligned with the field vector, and ψ_i is the ratio of sensor response in air to response in the dielectric media (sometimes referred to as the conversion factor). This two-step method has also been called a three-step method [3-2], where the third step involves the linearizing function f_i (V_i). In the one-step methods described in other documents, such as IEEE P1528/D1.2, 2003 or BS EN50361, 2001, the total field is given by:

$$|E|^2 = \sum_{i=1}^{3} |E_i|^2 = \sum_{i=1}^{3} \frac{f_i(V_i)}{\gamma_i} \quad \text{(3-4)}$$

Here the η_i factors are included in the total in-tissue sensitivity γ_i. Probe calibrations are valid only when the sensors are sufficiently far away (at least one half of probe tip diameter) from any media boundaries. This one-step method is not applied in ESSAY 3 system up to now.

Procedures for probe calibration

For frequencies above 800 MHz, where rectangular waveguide dimensions are more practical, calibration in waveguide is recommended. This calibration setup consists of an appropriate size rectangular waveguide with its axis of propagation oriented vertically (*z*-direction) in Figure 3-4.
A dielectric separation slab allows the tissue-equivalent liquid to be filled from the top and provides electrical match from the empty waveguide section to the dielectric-filled section. The transverse field distribution in the liquid corresponds to the fundamental mode (TE_{10}) with an exponential decay in the vertical direction (*z*-axis). The liquid level is made deep enough to guarantee that reflections from the top liquid surface do not affect the calibration field. The SAR in the liquid can be determined from the waveguide dimensions, measurements of the forward and reflected power and the measured decay in the liquid

6.3 Data Extrapolation

The distance from the center of the sensor (diode) to the end of the protective tube is called the ‘probe offset’ or ‘sensor offset’. Boundary effects arise when the tip of an electric field probe approaches the interface between two dielectric media. It is known that the error due to boundary effects is very small if the distance between the probe tip and the surface is greater than half the probe diameter.

To compensate the distance sum of sensor offset and tip end separation from the dielectric surface, we use a 4^{th}-order polynomial functions curve fitting to obtain the peak surface value from the voltages measured at the distance from the deeper (inner) surface of the phantom (waveguide) with liquid. The field is measured as close as 1.5 ~ 3.0 mm from the dielectric surface and at every pre-defined separation distance such as 1 [mm] along the probe axis (z) to a distance of at least 40 mm. The appropriate curve is obtained from all the points measured and they are used to define an exponential decay of the energy density versus depth in the waveguide in Figure 5-2 or 5-4 with an analytic exponential field. If the DUT has many sources such as handheld devices, 4^{th}-order polynomial functions generally fit better than the exponential function.

In ESSAY 3 system, the probe diameter is 4.8 mm, so the measurement data after $z > (4.8 \text{ mm} / 2 + \text{dipole offset})$ can be used for the extrapolation in the region $0 < z \leqq (4.8/2 + \text{dipole offset})$[5-7].

7.1 PHANTOM & EQUIVALENT TISSUES

7.2 SAM Phantom

SAM Phantom (separated left and right)

Material	Fiber glass, relative permittivity less than 5 and loss tangent less than 0.05
Phantom shell	2 mm thickness with tolerance of less than ± 0.2 mm with respect to the SAM CAD file

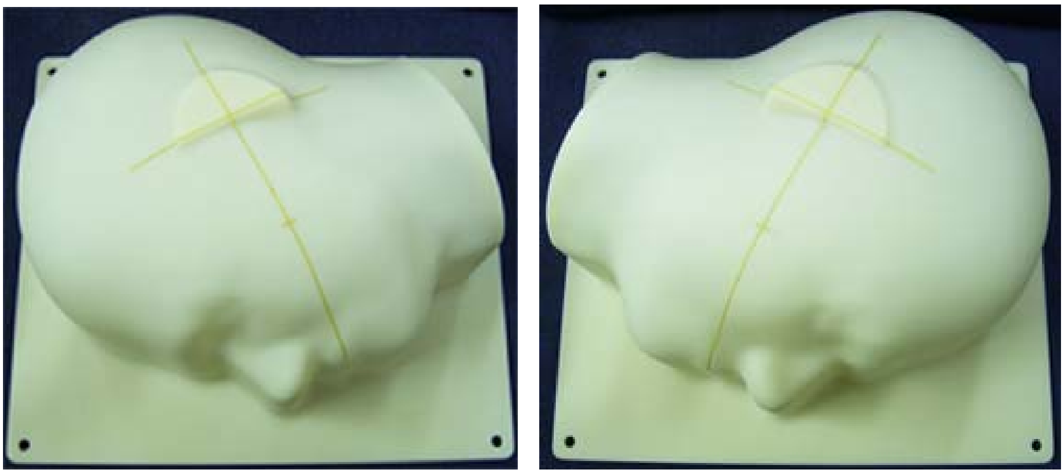


Figure 2-13 SAM Left Side(Model ES-SAM-L2) / SAM Right Side (Model ES-SAM-R2)

Flat Phantom

Material	Fiber glass, relative permittivity less than 5 and loss tangent less than 0.05
Thickness of bottom	2 mm ± < 0.2 mm
Size	42 cm(W) X 36 cm(D) X 19 cm(H) following IEEE P1528/D1.2 or and IEC 106/61/CDV

Figure 2-14 Flat Phantom : Model ES-FLAT-P1

7.3 Brain & Muscle Simulating Mixture Characterization

The brain and muscle mixtures consist of a viscous gel using hydrox-ethyl cellulose (HEC) gelling agent and saline solution (see Table 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 mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Hartsgrove [11].

Mixture (%)	850 MHz		1900 MHz	
	Head	Body	Head	Body
Water	41.45	52.4	54.90	69.91
Glycol	-	-	44.92	29.96
Sugar	56.0	45.0	-	-
Salt (NaCl)	1.45	1.40	0.18	0.13
Bactericide	0.1	0.1	-	-
HEC	1.0	1.0	-	-

Table 1. Composition of the Tissue Equivalent Matter

7.4 DUT Holder

Material	Polyoxymethylene (Acetal) (ε_r = 3.8, tan δ = 0.004 at 1 GHz), (Relative permittivity shall be less than 5, and loss tangent shall be less than 0.05.)
Height	Adjustable (20 cm ~ 25 cm)
Function	Provides versatile DUT position with high degree of position repeatability

Model ES-DUT-H1

Model ES-DUT-H2

Figure 2-16 DUT Holders

8.1 SYSTEM SPECIFICATIONS

8.2 Robotic System Specifications

Specifications

Robot

Robot type	Vertically articulated robot (Samsung Fara Robot AS3)
Degree of freedom	6 axes
Test payload	6 kgf (Weight of shield housing and robot arm end in Figure 2-8 is less than 1 kg.)
Position repeatability	< 0.1 mm with full test payload (6 kgf), < 0.01 mm with no payload
Motor type	DC servo motor
Body weight	58 kg
Arm length	Max. 858 mm
Power consumption	1.6 kVA

Robot Controller

CPU	Intel Pentium MMX-223, TM320C32-50
Memory	Flash ROM: 4 MB, DRAM: 16 MB, SRAM: 1 MB (battery backup)
I/O interface	1 CH RS-232C
User I/O	Input / Output(32 / 32)
User program editing	by teaching pendant or PC
Backup storage	3.5" FDD
Dimension	484 × 552 × 158 (W × D × H, mm)
Weight	22 kg
Power requirement	AC 220 V (± 10 %), 1.6 kVA, 50 / 60 Hz
Environmental requirement	0 ~ 40 ℃, 20 ~ 80 % relative humidity

Data Receiving System

Enclosure	Shielded for instrumentation amplifiers
Proximity sensor	Opto-mechanic with emergency stop, sampling 50 times/sec
Dynamic range	< 0.01 mV ~ > 400 mV (adjustable)
Input impedance	> 30 ㏁
Sampling rate	50 times/sec for each axis
Noise	< 0.01 mV typical RMS
Power source duration	> 100 hours of operation (9 V battery)
Data interface	Optical serial digital data, 16 bits

Receiver Box

Sensor lamp	Surface touching, Emergency stop
I/O cable	Optical fiber cable from electronic board, electrical wires to PC

Shield Housing / Probe Holder

Material	Polyoxymethylene (Acetal)
Outer diameter	60 mm (Shield Housing), 26 mm (Probe Holder)

Port Network Analyzer for Slotted Coaxial Line Measurement

Frequency range	300 kHz to 3.0 GHz (HP8753C together with HP85047A)
Format	Log magnitude, Linear magnitude, Phase, Smith chart

Simulated Tissue Measurement Kit

Type	Slotted coaxial line (in accordance with IEEE P1528/D1.2, 2003)
Length	Approx. 35 cm
Connector	SMA
Frequency range	50 MHz ~ 6 GHz
Software	Excel worksheet (included)

Computer

CPU	Pentium IV
Main memory	256 MB
Monitor	15 " LCD Color
Printer	Ink jet color

Software : Ver. 3.0

Control Panel	ESSAY-3 (User friendly interface)
Measurement	SAR (in liquid medium), E-field (in air)
Output data	E-field (V/m), 1 g / 10 g SAR (W/kg), Peak point SAR (W/kg)
Scan	Area, Zoom
Interpolation	Bicubic
Extrapolation	4^{th}-order least-square polynomial
Display	Field intensity contour by 2D or 3D.
Format	Predefined measurements procedures according to FCC guidelines (OET 65, etc.)
Logging	Record for every measurement in a text / excel file
Requirements	Microsoft Windows 98/ME/2000/XP
Robot control	Axes are coordinated for horizontal, vertical and rotational movements.
Probe orientation	Normal or arbitrary projection angle to the horizontal surface, or normal to the curved SAM phantom surface

Tissue Parameters

Freq. [MHz]	Date	Liquid	Liquid Temp [°C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
835 MHz	April 29, 2005	Head	21.5	ε_r	41.5	42.2	+1.69	±5%
				σ	0.90	0.86	-4.44	±5%
	April 29, 2005	Body	21.5	ε_r	55.2	53.9	-2.36	±5%
				σ	0.97	0.95	-2.06	±5%
1900 MHz	May 02, 2005	Head	21.8	ε_r	40.0	38.6	-3.5	±5%
				σ	1.40	1.44	+2.86	±5%
	May 02, 2005	Body	21.8	ε_r	53.3	52.4	-1.69	±5%
				σ	1.52	1.49	-1.97	±5%

9.1 MEASUREMENT PROCESS

9.2 System Verification

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

Freq. [MHz]	Liquid	Date	Liquid Temp [°C]	SAR Average	Target Value (mW/g)	Measured Value (mW/g)	Deviation [%]	Limit [%]
835 MHz S/N: 1012	Head	April 29, 2005	21.5	1 g	9.5	9.24	-2.74	±10%
1900MHz S/N: 1005	Head	May 2, 2005	21.8	1 g	39.7	39.96	+0.65	±10%

Peak spatial-average SAR evaluation procedure for each device configuration

Step 1*:* Power reference measurement (drift):

Prior to the SAR test, to monitor power variations during testing, local SAR is measured at a user-selected spatial reference point where SAR is above noise level. For example, this power reference point can be spaced 10 mm or less in the normal direction from the liquid-shell interface and within ± 10 mm transverse to the normal line at the ear reference point.

Step 2: *Area scan*

An *area scan* is performed according to the guidelines given in 8.5.1.

Step 3: *Zoom scan*

A *zoom scan* is performed according to the guidelines given in 8.5.2. If the cube volume within the *zoom scan* chosen to calculate the peak spatial-average SAR touches any limit of the *zoom scan* volume, the *zoom scan* is repeated with the center of the *zoom scan* volume shifted to the new maximum SAR location. For any secondary peaks found in the Step 2 *area scan* which are within 2 dB of the maximum peak and are not within this *zoom scan*, the Step 3 *zoom scan* is repeated.

Step 4: Power reference measurement

The local SAR is measured at exactly the same location as in Step 1. The absolute value of the measurement drift (the difference between the SAR measured in Step 4 and Step 1) is recorded in the uncertainty budget (Table 6-1). It is recommended that the drift be kept within ± 5 %.

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

HUMAN EXPOSURE	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT Occupational (W/kg) or (mW/g)
SPATIAL PEAK SAR * (Brain)	1.60	8.00
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.40
SPATIAL PEAK SAR *** (Hands / Feet / Ankle / Wrist)	4.00	20.00

Table 2. Safety Limits for Partial Body Exposure

NOTES:

* 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.

** The Spatial Average value of the SAR averaged over the whole-body.

*** 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.

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

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).

11.1 MEASUREMENT UNCERTAINTIES

Measurement uncertainties in SAR measurements are difficult to quantify due to several variables including biological, physiological, and environmental. However, we estimate the measurement uncertainties in SAR to be less than 15-25 % [16].
According to ANSI/IEEE C95.3, the overall uncertainties are difficult to assess and will vary with the type of meter and usage situation. However, accuracy's of 1 to ± 3 dB can be expected in practice, with greater uncertainties in near-field situations and at higher frequencies (shorter wavelengths), or areas where large reflecting objects are present. Under optimum measurement conditions, SAR measurement uncertainties of at least ± 2dB can be expected.[3]

a	b	c	d	e = f(d,k)	F	g	h = c x f / e	i = c x g / e	k
Uncertainty Component	Sec.	Tol. (± %)	Prob. Dist.	Div.	*ci* (1-g)	ci (10-g)	1-g *ui* (±%)	10-g *ui* (±%)	*vi*
Measurement System									
Probe Calibration	E2.1	4.8	N	1	1	1	4.8	4.8	∞
Axial Isotropy	E2.2	4.2	R	$\sqrt{3}$	$(1-c_p)^{1/2}$	$(1-c_p)^{1/2}$	1.7	1.7	∞
Hemispherical Isotropy	E2.2	10.0	R	$\sqrt{3}$	$\sqrt{c_p}$	$\sqrt{c_p}$	5.8	5.8	∞
Boundary Effect	E2.3	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Linearity	E2.4	4.2	R	$\sqrt{3}$	1	1	2.4	2.4	∞
System Detection Limits	E2.5	2.0	R	$\sqrt{3}$	1	1	1.2	1.2	∞
Readout Electronics	E2.6	1.0	N	1	1	1	1.0	1.0	∞
Response Time	E2.7	1.5	R	$\sqrt{3}$	1	1	0.9	0.9	∞
Integration Time	E2.8	4.3	R	$\sqrt{3}$	1	1	2.5	2.5	∞
RF Ambient Conditions	E6.1	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.5	R	$\sqrt{3}$	1	1	0.3	0.3	∞
Probe Positioning with respect to Phantom Shell	E6.3	3.6	R	$\sqrt{3}$	1	1	2.1	2.1	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Test sample Related									
Test Sample Positioning	E4.2	6.0	N	1	1	1	6.0	6.0	*11*
Device Holder Uncertainty	E4.1	5.0	N	1	1	1	5.0	5.0	*8*
Output Power Variation - SAR drift measurement	6.6.2	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									
Phantom Uncertainty (shape and thickness tolerances)	E3.1	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Liquid Conductivity Target - tolerance	E3.2	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
Liquid Conductivity - measurement uncertainty	E3.3	4.0	R	$\sqrt{3}$	0.64	0.43	1.5	1.0	5
Liquid Permittivity Target tolerance	E3.2	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E3.3	4.0	R	$\sqrt{3}$	0.6	0.49	1.4	1.1	5
Combined Standard Uncertainty			RSS				13.2	13.1	
Expanded Uncertainty (95% confidence interval)			*k=2*				±26.4	±26.2	

Table 3. Breakdown of Errors

12.1 SAR TEST DATA SUMMARY

Mixture Type: 835 MHz Head
Dielectric Constant: 42.2
Conductivity: 0.86

Ambient TEMPERATURE (°C)	22.0
Liquid TEMPERATURE (°C)	21.5
Relative HUMIDITY (%)	44
Atmospheric PRESSURE (kPa)	99.1

12.2 Measurement Results **(GSM850 Head SAR)**

Frequency		Modulation	Power		Phantom Position	Ant. Position	SAR(mW/g)
MHz	Chan.		PCL	Battery			
824.20	128(Low)	GSM850	5	Standard	Left Ear	Fixed	0.886
836.60	190(Middle)	GSM850	5	Standard		Fixed	0.836
849.80	251(High)	GSM850	5	Standard		Fixed	0.808
824.20	128(Low)	GSM850	5	Standard	Right Ear	Fixed	0.880
836.60	190(Middle)	GSM850	5	Standard		Fixed	0.832
849.80	251(High)	GSM850	5	Standard		Fixed	0.829
836.60	190(Middle)	GSM850	5	Standard	Left Tilt 15°	Fixed	0.245
836.60	190(Middle)	GSM850	5	Standard	Right Tilt 15°	Fixed	0.309
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population					Head 1.6 W/kg (mW/g) Averaged over 1 gram		

Measured Depth of Simulating Tissue: 15.0 cm

NOTES:

1. The test data reported are the worst-case SAR value with the antenna-head position set in a typical configuration. (Operation condition : flip cover open)
2. All modes of operation were investigated and the worst-case are reported.
3. Battery Type ☒ Standard ☐ Extended ☐ Fixed
4. Power Measured ☒ Conducted ☐ EIRP ☐ERP
5. SAR Measurement System ☒ EMF Safety
6. SAR Configuration ☒ Head ☐ Body ☐ Hand

7. Justification for reduced test configurations : per FCC/OET Supplement C (July, 2002), if the SAR measured at the middle channel for each test configuration (Left, right, cheek/touch, tile/ear, extended and retracted) is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s)

12.1 SAR TEST DATA SUMMARY

Ambient TEMPERATURE (°C)	22.3
Liquid TEMPERATURE (°C)	21.8
Relative HUMIDITY (%)	47
Atmospheric PRESSURE (kPa)	98.9

Mixture Type: 1900 MHz Head

Dielectric Constant: 38.6

Conductivity: 1.44

12.3 Measurement Results (GSM1900 Head SAR)

Frequency		Modulation	Power		Phantom Position	Ant. Position	SAR(mW/g)
MHz	Chan.		PCL	Battery			
1850.20	512(Low)	GSM1900	0	Standard	Left Ear	Fixed	0.565
1880.00	661(Middle)	GSM1900	0	Standard		Fixed	0.618
1909.80	810(High)	GSM1900	0	Standard		Fixed	0.634
1850.20	512(Low)	GSM1900	0	Standard	Right Ear	Fixed	0.593
1880.00	661(Middle)	GSM1900	0	Standard		Fixed	0.707
1909.80	810(High)	GSM1900	0	Standard		Fixed	0.642
1880.00	661(Middle)	GSM1900	0	Standard	Left Tilt 15°	Fixed	0.477
1880.00	661(Middle)	GSM1900	0	Standard	Right Tilt 15°	Fixed	0.529
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population					**Head 1.6 W/kg (mW/g)** Averaged over 1 gram		

Measured Depth of Simulating Tissue: 15.0 cm

NOTES:

1. The test data reported are the worst-case SAR value with the antenna-head position set in a typical configuration. (Operation condition : flip cover open)
2. All modes of operation were investigated and the worst-case are reported.
3. Battery Type ☒ Standard ☐ Extended ☐ Fixed
4. Power Measured ☒ Conducted ☐ EIRP ☐ERP
5. SAR Measurement System ☒ EMF Safety
6. SAR Configuration ☒ Head ☐ Body ☐ Hand
7. Justification for reduced test configurations : per FCC/OET Supplement C (July, 2002), if the SAR measured at the middle channel for each test configuration (Left, right, cheek/touch, tile/ear, extended and retracted) is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s)

12.1 SAR TEST DATA SUMMARY

Ambient TEMPERATURE (°C)	22.0
Liquid TEMPERATURE (°C)	21.5
Relative HUMIDITY (%)	44
Atmospheric PRESSURE (kPa)	99.1

Mixture Type: 835 MHz Body
Dielectric Constant: 53.9
Conductivity: 0.95

12.4 Measurement Results **(GSM850 Body SAR without Holster)**

Frequency		Modulation	Power		Separation Distance(cm) / Mobile Position	Ant. Position	SAR(mW/g)
MHz	Chan.		PCL	Battery			
824.20	128 (Low)	GSM850	5	Standard	1.5 (Back)	Fixed	0.160
836.60	190 Middle	GSM850	5	Standard	1.5 (Back)	Fixed	0.166
849.80	251 (High)	GSM850	5	Standard	1.5 (Back)	Fixed	0.156
836.60	190 Middle	GPRS	5	Standard	1.5 (Back)	Fixed	0.229
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population						**Body 1.6 W/kg (mW/g)** Averaged over 1 gram	

Measured Depth of Simulating Tissue: 15.0 cm

NOTES:

1. Operation condition : flip cover closed and connected with ear phone
2. All modes of operation were investigated and the worst-case are reported.
3. Battery condition is fully charged for all readings.
4. Battery Type ☒ Standard ☐ Extended ☐ Fixed
5. Power Measured ☒ Conducted ☐ EIRP ☐ERP
6. SAR Measurement System ☒ EMF Safety
7. SAR Configuration ☐ Head ☒ Body ☐ Hand

8. Justification for reduced test configurations : per FCC/OET Supplement C (July, 2002), if the SAR measured at the middle channel for each test configuration (Left, right, cheek/touch, tile/ear, extended and retracted) is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s)

12.1 SAR TEST DATA SUMMARY

Ambient TEMPERATURE (°C)	22.3
Liquid TEMPERATURE (°C)	21.8
Relative HUMIDITY (%)	47
Atmospheric PRESSURE (kPa)	98.9

Mixture Type: 1900 MHz Body
Dielectric Constant: 52.4
Conductivity: 1.49

12.5 Measurement Results (GSM1900 Body SAR Without Holster)

Frequency		Modulation	Power		Separation Distance(cm) / Mobile Position	Ant. Position	SAR(mW/g)
MHz	Chan.		PCL	Battery			
1850.20	512 (Low)	GSM1900	0	Standard	1.5 (Back)	Fixed	0.259
1880.00	661 (Middle)	GSM1900	0	Standard	1.5 (Back)	Fixed	0.313
1909.80	810 (High)	GSM1900	0	Standard	1.5 (Back)	Fixed	0.275
1880.00	661 (Middle)	GPRS	0	Standard	1.5 (Back)	Fixed	0.310
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population						**Body 1.6 W/kg (mW/g)** Averaged over 1 gram	

Measured Depth of Simulating Tissue: 15.0 cm

NOTES:

1. Operation condition : flip cover closed and connected with ear phone
2. All modes of operation were investigated and the worst-case are reported.
3. Battery condition is fully charged for all readings.
4. Battery Type ☒ Standard ☐ Extended ☐ Fixed
5. Power Measured ☒ Conducted ☐ EIRP ☐ERP
6. SAR Measurement System ☒ EMF Safety
7. SAR Configuration ☐ Head ☒ Body ☐ Hand

8. Justification for reduced test configurations : per FCC/OET Supplement C (July, 2002), if the SAR measured at the middle channel for each test configuration (Left, right, cheek/touch, tile/ear, extended and retracted) is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s)

13.1 SAR TEST EQUIPMENT

Type / Model	Calib. Date	S/N
Vertically articulated robot (Samsung Fara Robot AS3)	N/A	-
Robot Controller (Samsung SRCP-S)	N/A	-
Teaching Pendant (Samsung SRCP-OTP1A)	N/A	-
Dipole Antenna-ES-D-835	March 05	1012
Dipole Antenna-ES-D-1900	April 05	1005
DUT Holders	N/A	-
Dipole Antenna Holder	N/A	-
SAM Phantom (separated left and right)	N/A	-
Flat Phantom	N/A	-
Triangular E-Field Probe	March 05	03May-0026
Data Receiving System		
Robot Table	N/A	-
Phantom table	N/A	-

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

The following list of equipment was used to calibrate the brain equivalent material:

Power Meter(A)	E4419B	June 04	MY40511244
Power Sensor(A)	8481	June 04	MY41090680
Signal Generator	8664A (100kHz ~ 3GHz)	April 05	3744A02069
Power Amp	A0825-4343-R	Sep. 04	A00450
Network Analyzer	8752C (30kHz ~ 3GHz)	March 05	3410A02619
Dielectric Probe Kit	85070C	-	00721521
Dual Directional Coupler	778D	August 04	16072

14.1 CONCLUSION

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the ANSI/ IEEE C95.1 1992.

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.

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