HYUNDAI CALIBRATION & CERTIFICATION TECH. CO., LTD.

PRODUCT COMPLIANCE DIVISION
SAN 136-1, AMI-RI , BUBAL-EUP, ICHEON-SI, KYOUNGKI-DO, 467-701, KOREA
TEL : +82 31 639 8518 FAX : +82 31 639 8525 www.hct.co.kr

CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

AL Communication Co., Ltd.
11-32, 5-Ga, Dangsan-Dong, Youngdeungpo-Gu,
Seoul 150-045, Korea

FRN: 0010357853

Date of Issue : February 24, 2004
Test Report No.: HCT-SAR04-0204
Test Site: HYUNDAI CALIBRATION & CERTIFICATION TECHNOLOGIES CO., LTD.
FRN: 0005866421

FCC ID : **RURACH-700**

APPLICANT : **Al Communication Co., Ltd.**

EUT Type:	Single-Mode CDMA Phone
Tx Frequency:	824.70 — 848.31 MHz (CDMA)
Rx Frequency:	869.70 — 893.31 MHz (CDMA)
Max. RF Output Power:	0.220 ERP CDMA (23.42dBm)
Max. RF Output Power:	0.282W CDMA (24.5dBm) / Conducted
Trade Name/Model(s):	ALCOMM / ACH-700
FCC Classification:	Non-Broadcast Transmitter Held to Ear (TNE)
Application Type:	Certification
FCC Rule Part(s):	§2.1093; FCC/ OET Bulletin Supplement C [July 2001]
Maximum SAR:	1.300 W/kg CDMA Brain SAR
	0.338 W/kg CDMA 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

This report only responds to the tested sample and may not be reproduced, except in full, without written approval of the HCT Co., Ltd.

Table of Contents

1.1 SCOPE ---------- 3

2.1 INTRODUCTION / SAR DEFINITION ---------- 4

3.1 SAR MEASUREMENT SET-UP ---------- 5

4.1 E-FIELD PROBE SYSTEM ---------- 6

5.1 EUT ARRANGEMENT ---------- 7-8

6.1 E-FIELD PROBE CALIBRATION PROCESS ---------- 9-10

7.1 PHANTOM, HOLDER, & EQUIVALENT TISSUE ---------- 11

8.1 SYSTEM SPECIFICATIONS ---------- 12

9.1 MEASUREMENT PROCESS ---------- 13

10.1 ANSI/ IEEE C95.1 - 1992 RF EXPOSURE LIMITS ---------- 14

11.1 MEASUREMENT UNCERTAINTIES ---------- 15

12.1 TEST DATA SUMMARY ---------- 16-18

13.1 SAR TEST EQUIPMENT LIST ---------- 19

14.1 CONCLUSION ---------- 20

15.1 REFERENCES ---------- 21

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:	**AL Communication Co., Ltd.**
Address:	**11-32, 5-Ga, Dangsan-Dong, Youngdeungpo-Gu, Seoul 150-045, Korea**
Attention:	**Mr. Dong- Jin Lee**
Tel. / Fax :	**+82-2-2634-7599(ext.106) / +82-2-2634-7598**
E-Mail :	**djlee@alcomm.co.kr**

• EUT Type:	Single-Mode CDMA Phone
• Trade Name:	ALCOMM
• Model(s):	ACH-700
• FCC ID:	RURACH-700
• Serial Number(s):	RUR20040200001
• Tx Frequency:	824.70 — 848.31 MHz (CDMA)
• Rx Frequency:	869.70 — 893.31 MHz (CDMA)
• Application Type:	Certification
• FCC Classification:	Non-Broadcast Transmitter Held to Ear (TNE)
• FCC Rule Part(s):	§2.1093; FCC/ OET Bulletin Supplement C [July 2001]
• Modulation(s):	CDMA
• Antenna Type:	Fixed
• Max RF. Output Power:	0.220 W ERP CDMA (23.42 dBm)
• Date(s) of Tests:	February 16, 2004
• Place of Tests:	Hyundai G-Tech. EMC Lab. Icheon, Kyounki-Do, KOREA
• Report Serial No.:	HCT-SAR04-0204

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

These measurements are performed using the DASY3 automated dosimetric assessment system. It is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland. It 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.3).

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and remote control, is used to drive the robot motors. The PC consists of the Dell Pentium III 450 MHz computer with Windows NT 4.0 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 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.

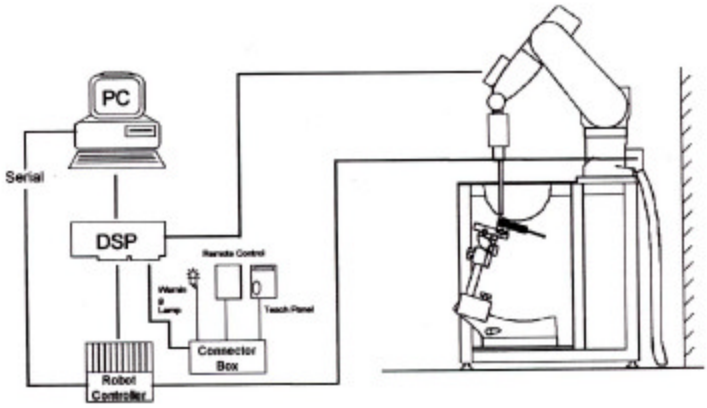


Figure 3. HCT SAR Lab. Test Measurement Set-up

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 [5].

4.1 DASY3 E-FIELD PROBE SYSTEM

4.2 ET3DV6 Probe Specification

Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection System Built-in shielding against static charges
Calibration	In air from 10 MHz to 2.5 GHz In brain and muscle simulating tissue at Frequencies of 450 MHz, 900 MHz and 1.8 GHz (accuracy :8%)
Frequency	10 MHz to > 6 GHz; Linearity: ? 0.2 dB (30 MHz to 3 GHz)
Directivity	0.2 dB in brain tissue (rotation around probe axis) 0.4 dB in brain tissue (rotation normal probe axis)
Dynamic	5 uW/g to > 100 mW/g;
Range Linearity:	0.2 dB
Surface Detection	0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces.
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 dissymmetry up to 3 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

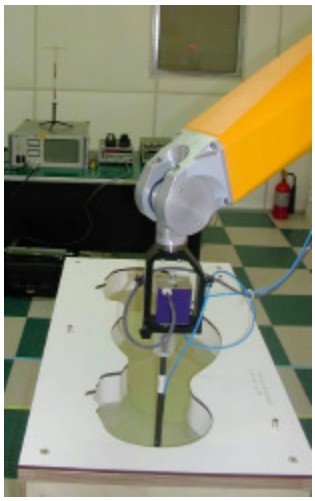


Figure 4.Photograph of the probe and the Phantom

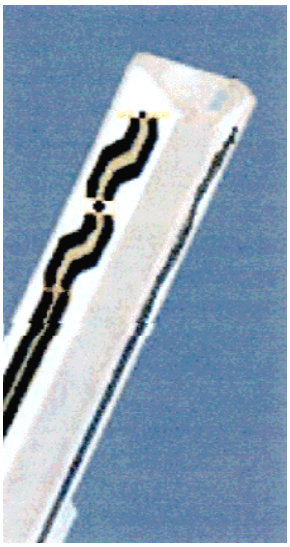


Figure 5. ET3DV6 E-field Probe

The SAR measurements were conducted with the dosimetric probe ET3DV6, designed in the classical triangular configuration [5] 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 mortifier line ending at the front of the probe tip. 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 a 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 2 nd order fitting. The approach is stopped at reaching the maximum.

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.

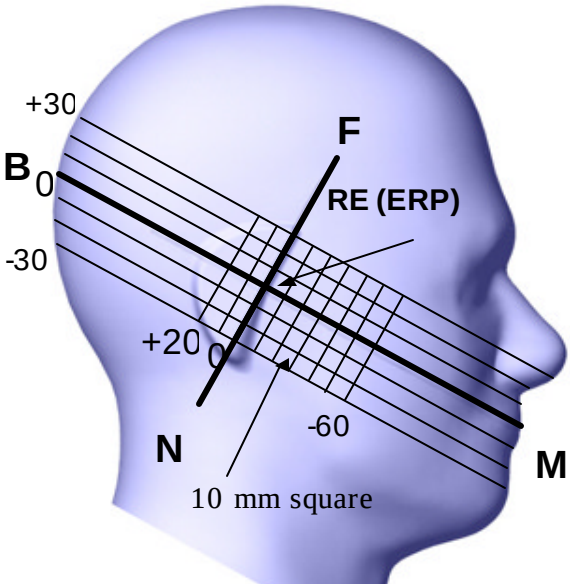


Figure 6. EUT Head Position

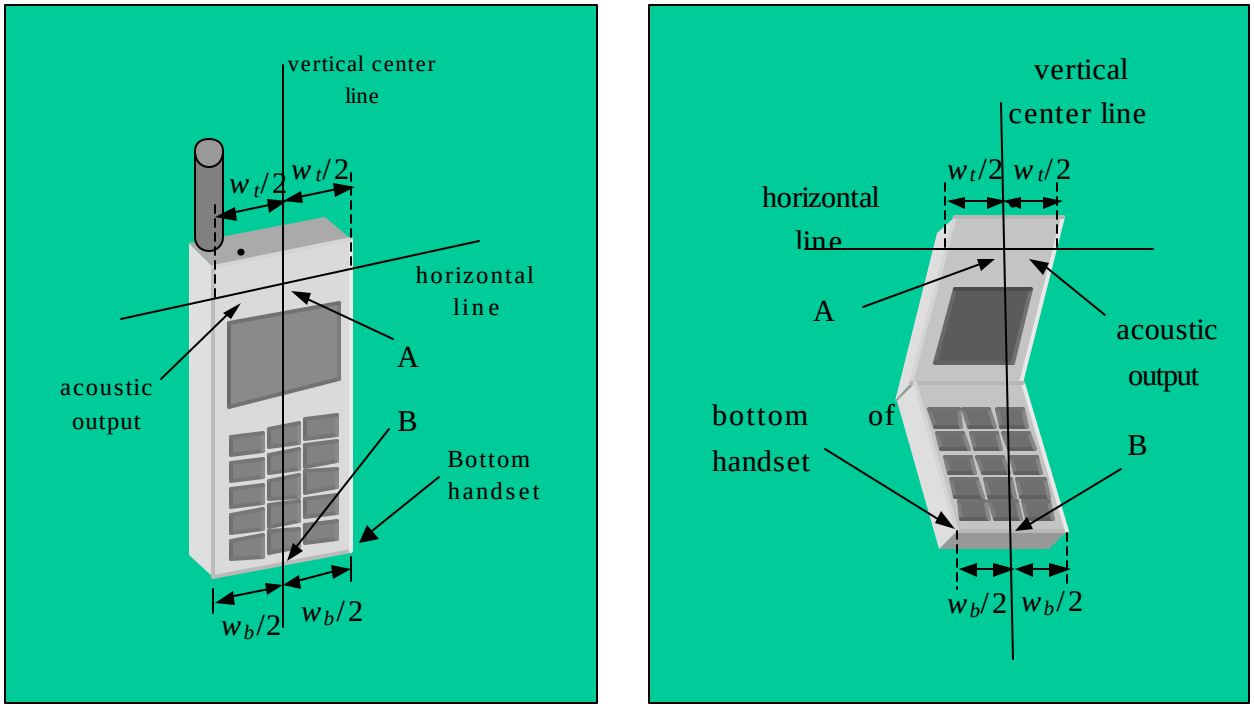


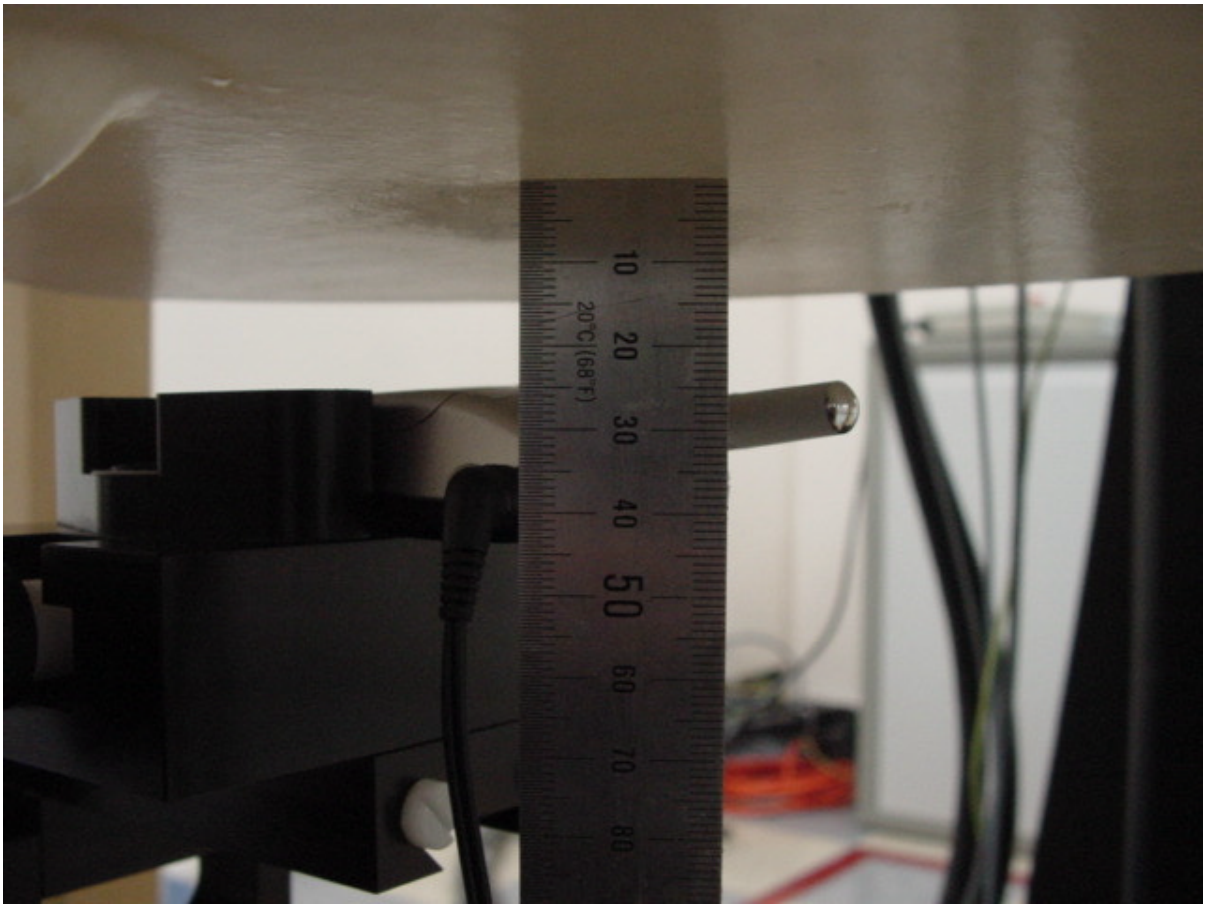
Figure 7. Device Test Position

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 25 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

Each probe is calibrated according to a dosimetric assessment procedure described in [6] with an accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in [7] 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.

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, 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 and at the proper orientation with the field. The probe is then rotated 360 degrees.

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.

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

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;

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

where:

σ = simulated tissue conductivity,

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

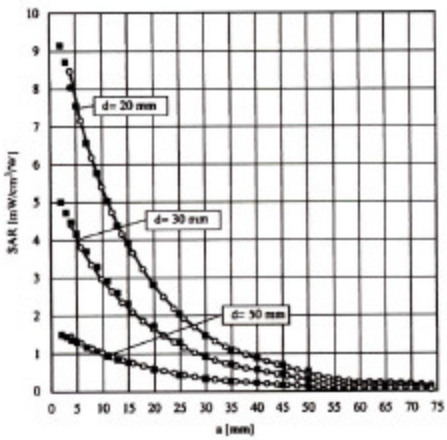


Figure 9. E-Field and Temperature measurements at 900MHz[5]

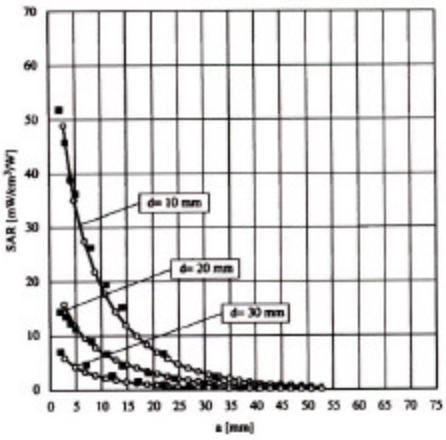


Figure 10. E-Field and temperature measurements at 1.8GHz [5]

6.3 Data Extrapolation

The DASY3 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode

to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as [8]:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with
V_i = compensated signal of channel i (i=x,y,z)
U_i = input signal of channel i (i=x,y,z)
cf = crest factor of exciting field (DASY parameter)
dcp_i = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with
V_i = compensated signal of channel i (i = x,y,z)
$Norm_i$ = sensor sensitivity of channel i (i = x,y,z)
$\mu V/(V/m)^2$ for E-field probes
ConvF = sensitivity of enhancement in solution
E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with
SAR = local specific absorption rate in W/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [Siemens/m]
ρ = equivalent tissue density in g/cm^3

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

with
P_{pwe} = equivalent power density of a plane wave in W/cm^2
E_{tot} = total electric field strength in V/m

7.1 PHANTOM & EQUIVALENT TISSUES

7.2 SAM Phantom

The SAM Phantom 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 [9][10]. 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.

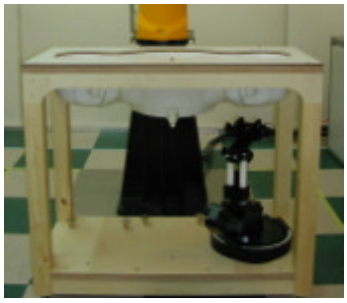


Figure 11. SAM Phantom

Shell Thickness	**2.0 mm**
Filling Volume	Volume Approx. 30 liters
Dimensions	810 x 1000 x 500 mm (H x L x W)

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 (%)	835 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 Device Holder for Transmitters

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

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produced infinite number of configurations [10]. To produce the Worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

Fig. 12. Device Holder

8.1 SYSTEM SPECIFICATIONS

8.2 Robotic System Specifications

Specifications

POSITIONER: Stäubli Unimation Corp. Robot Model: RX90LB
Repeatability: 0.02 mm
No. of axis: 6

Data Acquisition Electronic (DAE) System

Cell Controller
Processor: Pentium III
Clock Speed: 450 MHz
Operating System: Windows NT 4.0
Data Card: DASY3 PC-Board
Data Converter
Features: Signal Amplifier, multiplexer, A/D converter, and 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: 1798, S/N: 1609
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
Shell Material: Fiberglass
Thickness: 2.0 mm

Tissue Parameters

Freq. [MHz]	Date	Liquid	Liquid Temp [°C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
835 MHz	February 16, 2004	Head	21.3	εr	41.5	42.7	+2.89	±5%
				σ	0.90	0.90	0.00	±5%
	February 16, 2004	Body	21.3	εr	55.2	54.2	-1.81	±5%
				σ	0.97	1.00	+3.09	±5%

9.1 MEASUREMENT PROCESS

9.2 System Verification

Prior to assessment, the system is verified to the ±10% of the specifications at 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: 441	Head	February 16, 2004	21.3	?g	9.5	9.68	+1.89	±10%

9.3 Dosimetric Assessment Setup

The evaluation was performed with the following procedure:

1. The SAR value at a fixed location above the ear point was measured and was used as a reference value for assessing the power drop.
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. Based on this data, the area of the maximum absorption was determined by spline interpolation.
3. Around this point, a volume of 32mm x 32mm x 34mm 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:
   a. The data at the surface were 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 [13]. 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) [13][14]. 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 value, at the same location as procedure #1, was re-measured. If the value changed by more than 5%, the evaluation is repeated.

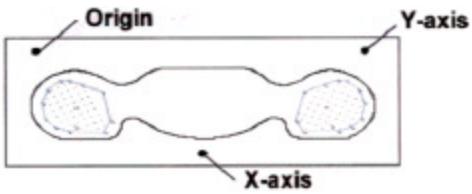


Fig. 13. SAR Measurement Point in Area Scan

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 1 5-25 % [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]

According to CENELEC [17], typical worst-case uncertainty of field measurements is 5 dB. For well-defined modulation characteristics the uncertainty can be reduced to ±3 dB.

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	ci 1 1g	Standard unc. (1g)	vi 2 or Veff
Measurement System						
Probe calibration	± 4.4	normal	1	1	± 4.4%	8
Axial isotropy of the probe	± 4.7	rectangular	v3	(1-cp) 1/2	± 1.9%	8
Sph. isotropy of the probe	± 9.6	rectangular	v3	(cp) 1/2	± 3.9%	8
Spatial resolution	±0.0	rectangular	v3	1	± 0.0%	8
Boundary effects	± 5.5	rectangular	v3	1	± 3.2%	8
Probe linearity	± 4.7	rectangular	v3	1	± 2.7%	8
Detection limit	± 1.0	rectangular	v3	1	± 0.6%	8
Readout electronics	± 1.0	normal	1	1	± 1.0%	8
Response time	± 0.8	rectangular	v3	1	± 0.5%	8
Integration time	± 1.4	rectangular	v3	1	± 0.8%	8
RF ambient conditions	± 3.0	rectangular	v3	1	± 1.7%	8
Mech. constrains of robot	± 0.4	rectangular	v3	1	± 0.2%	8
Probe positioning	± 2.9	rectangular	v3	1	± 1.7%	8
Extrap. and integration	± 3.9	rectangular	v3	1	± 2.3%	8
Test Sample Related						
Device positioning	± 6.0	normal	0.89	1	± 6.7%	12
Device holder uncertainty	± 5.0	normal	0.84	1	± 5.9%	8
Power drift	± 5.0	rectangular	v3	1	± 2.9%	8
Phantom and Setup						
Phantom uncertainty	± 4.0	rectangular	v3	1	± 2.3%	8
Liquid conductivity (target)	± 5.0	rectangular	v3	0.6	± 1.7%	8
Liquid conductivity (meas.)	± 10.0	rectangular	v3	0.6	± 3.5%	8
Liquid permittivity (target)	± 5.0	rectangular	v3	0.6	± 1.7%	8
Liquid permittivity (meas.)	± 5.0	rectangular	v3	0.6	± 1.7%	8
Combined Standard Uncertainty					± 13.6%	
Expanded Standard Uncertainty(k=2)					**± 27.1%**	

Table 3. Breakdown of Errors

12.1 SAR TEST DATA SUMMARY

Mixture Type:	**835 MHz Brain**
Dielectric Constant:	**42.7**
Conductivity:	**0.9**

Ambient TEMPERATURE (°C)	22.4
Liquid TEMPERATURE (°C)	21.3
Relative HUMIDITY (%)	51
Atmospheric PRESSURE (kPa)	98.6

12.2 Measurement Results (CDMA Head SAR)

Frequency MHz	Frequency Chan.	Modulation	Conducted Power (dBm) Begin	Conducted Power (dBm) End	Battery	Phantom Position	Ant. Position	SAR(mW/g)
824.70	1013 (Low)	CDMA	24.5	24.5	Standard	Touch / Left Ear Tilt 15°	Fixed	1.300
835.89	0363 (Middle)	CDMA	24.5	24.4	Standard		Fixed	1.110
848.31	0777 (High)	CDMA	24.5	24.4	Standard		Fixed	1.090
824.70	1013 (Low)	CDMA	24.5	24.5	Standard	Touch / Right Ear	Fixed	1.170
835.89	0363 (Middle)	CDMA	24.5	24.5	Standard		Fixed	0.982
848.31	0777 (High)	CDMA	24.5	24.3	Standard		Fixed	1.250
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population						**Brain 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.
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 ☒ SPEAG
6. SAR Configuration ☒ Head ☐ Body ☐ Hand

Fig. 17. Head SAR Test Setup

Report prepared by : Ki-Soo Kim
Manager of Product Compliance Team

12.1 SAR TEST DATA SUMMARY

Mixture Type:	**835 MHz Brain**
Dielectric Constant:	**42.7**
Conductivity:	**0.9**

Ambient TEMPERATURE (°C)	22.4
Liquid TEMPERATURE (°C)	21.3
Relative HUMIDITY (%)	51
Atmospheric PRESSURE (kPa)	98.6

12.3 Measurement Results (CDMA Head SAR)

Frequency MHz	Frequency Chan.	Modulation	Conducted Power (dBm) Begin	Conducted Power (dBm) End	Battery	Phantom Position	Ant. Position	SAR(mW/g)
824.70	1013 (Low)	CDMA	24.5	24.5	Standard	Left Ear Tilt 15°	Fixed	1.210
835.89	0363 (Middle)	CDMA	24.5	24.5	Standard		Fixed	0.987
848.31	0777 (High)	CDMA	24.5	24.5	Standard		Fixed	0.985
824.70	1013 (Low)	CDMA	24.5	24.5	Standard	Right Ear Tilt 15°	Fixed	1.300
835.89	0363 (Middle)	CDMA	24.5	24.5	Standard		Fixed	0.976
848.31	0777 (High)	CDMA	24.5	24.5	Standard		Fixed	1.170
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population						**Brain 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.
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 ☒ SPEAG
6. SAR Configuration ☒ Head ☐ Body ☐ Hand

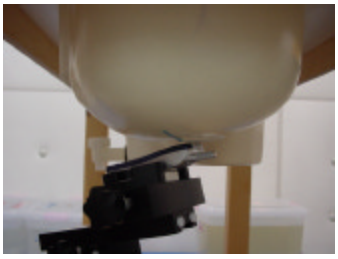


Fig. 17. Head SAR Test Setup

Ki Soo Kim

Report prepared by : Ki-Soo Kim
Manager of Product Compliance Team

12.1 SAR TEST DATA SUMMARY

Mixture Type:	**835 MHz Muscle**
Dielectric Constant:	**54.2**
Conductivity:	**1.00**

Ambient TEMPERATURE (°C)	22.4
Liquid TEMPERATURE (°C)	21.3
Relative HUMIDITY (%)	51
Atmospheric PRESSURE (kPa)	98.6

12.4 Measurement Results (CDMA Body SAR Without Holster)

Frequency		Modulation	Conducted Power (dBm)		Battery	Separation Distance (cm)	Ant. Position	SAR(mW/g)
MHz	Chan.		Begin	End				
824.70	1013 (Low)	CDMA	24.5	24.5	Standard	**2.5cm** without Holster	Fixed	0.338
835.89	0363 (Middle)	CDMA	24.5	24.5	Standard		Fixed	0.273
848.31	0777 (High)	CDMA	24.5	24.5	Standard		Fixed	0.219
ANSI/ IEEE C95.1 1992 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population						**Brain 1.6 W/kg (mW/g)** Averaged over 1 gram		

Measured Depth of Simulating Tissue: 15.0 cm

NOTES:

1. All modes of operation were investigated and the worst-case are reported.
2. Battery condition is fully charged for all readings.
3. Battery Type ☒ Standard ☐ Extended ☐ Fixed
4. Power Measured ☒ Conducted ☐ EIRP ☐ERP
5. SAR Measurement System ☒ SPEAG
6. SAR Configuration ☐ Head ☒ Body ☐ Hand

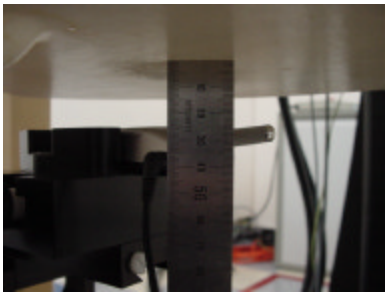


Fig. 19. Body SAR Test Setup without Holster

Report prepared by : Ki-Soo Kim
Manager of Product Compliance Team

13.1 SAR TEST EQUIPMENT

Type / Model	Calib. Date	S/N
Staubli Robot RX90L	N/A	F01/ 5K09A1/A/01
Staubli Robot Controller CS7MB	N/A	F99/5A82A1/C/01
Staubli Teach Pendant (Joystick)	N/A	D221340.01
Dell OptiPlex GX100	N/A	HY4640
Windows NT 4.0	N/A	-
SPEAG DAE3V1	June 03	447
SPEAG E-Field Probe ET3DV6	January. 04	1609
SPEAG Dummy Probe	N/A	-
SPEAG SAM Phantom	N/A	-
SPEAG Light Alignment Sensor	N/A	265
SPEAG Validation Dipole D 450V2	July 02	1007
SPEAG Validation Dipole D835V2	August 03	441
SPEAG Validation Dipole D 900V2	January 02	062
SPEAG Validation Dipole D1800V2	August 03	2d007
Robot Table	N/A	-
Phone Holder	N/A	-
A/B Power Indicator	N/A	-
Remote Power Switch	N/A	-
Phantom Cover D9F09QG0009	N/A	-

NOTE:
The E-field probe was calibrated by SPEAG, 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) HP 438A	July 03	2822A05909
Power Sensor(A) HP8481B	August 03	3318A08777
Power Meter(B) HP 438A	Nov. 03	2427A00963
Power Sensor(B) HP8481A	Oct. 03	2349A37617
Signal Generator 2031 (10kHz ~ 2.7GHz)	Feb. 03	119331/037
Power Amp A0825-4343-R	Sep. 03	A00450
Network Analyzer HP-8752C (300kHz ~ 3GHz)	Feb. 03	3410A02619
Dielectric Probe Kit HP85070C	N/A	00721521
Dual Directional Coupler	July 03	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.

15.1 REFERENCES:

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio frequency Radiation, Aug. 1996.

[2] ANSI/IEEE C95.1 - 1991, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300kHz to 100GHz, New York: IEEE, Aug. 1992

[3] ANSI/IEEE C95.3 - 1991, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, 1992.

[4] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.

[5] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.

[6] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 120-124.

[7]K. Pokovi°, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.

[8] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.

[9] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Head Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.

[10] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.

[11] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectro magnetics, Canada: 1987, pp. 29-36.

[12] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.

[13] W. Gander, Computer mathematick, Birkhaeuser, Basel, 1992.

[14] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recepies in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.

[15] Federal Communications Commission, OET Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Supplement C, Dec. 1997.

[16] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.

[17] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz - 300GHz, Jan. 1995.

[18] Prof. Dr. Niels Kuster, ETH, EidgenØssische Technische Hoschschule Zòrich, Dosimetric Evaluation of the Cellular Phone.