



## 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](http://www.hct.co.kr)



### CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

**Manufacture;**

TTI International Limited  
Unit 1106-1110, 11/F. Star House, 3 Salisbury Road,  
Tsimshatsui, Kowloon, Hong Kong  
FRN : 0012797494

Date of Issue: March 06, 2007

Test Report No.: HCT-SAR07-0301

Test Site: HYUNDAI CALIBRATION & CERTIFICATION  
TECHNOLOGIES CO., LTD.

FRN: 0005866421

**FCC ID** :

**U32GMRS7015**

**APPLICANT** :

TTI International Limited

**EUT Type:** 22 CH Combination FRS/GMRS Transceiver.  
**Model(s):** GMRS7015RC  
**Tx Frequency:** 462.5500 MHz – 462.7250 MHz (GMRS)  
462.5625 MHz – 467.7125 MHz (FRS)  
**Max. SAR Measurement(s):** 1.344 mW/g(1g) GMRS Body SAR  
**Max. RF Output Power:** 0.6223 W ERP(27.94dBm)GMRS ; 0.1345 W ERP(21.29dBm) FRS  
**Conducted Power:** 2.11W (33.24dBm) GMRS ; 0.540 (27.2dBm) FRS  
**Emission Designator:** 10K2F3E  
**Channel Capacity:** 22  
**Application Type:** Certification  
**Trade Name(s):** TTI  
**FCC Rule Part(s):** §95(A)(B), 2(J)

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled Environment Occupational exposure limits specified in ANSI/ IEEE Std. C95.1- 2005 and had been tested in accordance with the measurement procedures specified in ANSI FCC/OET Bulletin 65 Supplement C and IEEE Std. 1528-2003. (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)

**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 .....	6-7
5.1 E-FIELD PROBE CALIBRATION PROCESS .....	8
6.1 PHANTOM, HOLDER, & EQUIVALENT TISSUE .....	9
7.1 SYSTEM SPECIFICATIONS .....	10
8.1 MEASUREMENT PROCESS .....	11
9.1 ANSI/ IEEE C95.1 - 2005 RF EXPOSURE LIMITS .....	12
10.1 MEASUREMENT UNCERTAINTIES .....	13
11.1 TEST DATA SUMMARY .....	14-15
12.1 SAR TEST EQUIPMENT LIST .....	16
13.1 CONCLUSION .....	17
14.1 REFERENCES .....	18

APPENDIX A – SAR TEST PLOTS

APPENDIX B – TEST SETUP PHOTOGRAPHS

APPENDIX C – EUT PROFILE PHOTOGRAPHS

APPENDIX D – DIPOLE VALIDATION PLOTS

APPENDIX E – PROBE CALIBRATION DATA

APPENDIX F – DIPOLE CALIBRATION DATA

# SAR MEASUREMENT REPORT

## 1.1 SCOPE

Environmental evaluation measurements of specific absorption rate <sup>1</sup> (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).<sup>2</sup>

### 1. 2 Applicant

**Company Name :** TTI International Limited.  
**Address :** Unit 1106-1110, 11/F. Star House, 3 Salisbury Road,  
Tsimshatsui, Kowloon, Hong Kong  
**Attention :** N.T KIM / Managing Director

- FCC ID: U32GMRS7015
- EUT Type: 22 CH Combination FRS/GMRS Transceiver -Prototype.
- Trade Name: TTI
- Model(s): GMRS7015RC
- Tx Frequency: 462.5500 MHz – 462.7250 MHz (GMRS)  
462.5625 MHz – 467.7125 MHz (FRS)
- Application Type: Certification
- Modulation(s): FM
- Power Supply: (x5) AAA Alkaline batteries (1.5VDC)  
Manufacture( : Energize / : Duracell / : Bexel  
: Audiovox BATTERY 1.2V 650mAh)
- Place of Test(s): Hyundai C- TECH. SAR Lab.
- Date(s) of Tests: March 05, 2007
- Report No.: HCT-SAR07-0301

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

<sup>2</sup> IEEE/ANSI Std. C95.1-2005 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 C95.1-2005 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 ( $\rho$ ). 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:

$\sigma$	=	conductivity of the tissue-simulant material (S/m)
$\rho$	=	mass density of the tissue-simulant material (kg/m <sup>3</sup> )
$E$	=	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 DASY4 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 HP Pentium 4 3.0GHz computer with Windows XP system and SAR Measurement Software DASY4, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit 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.

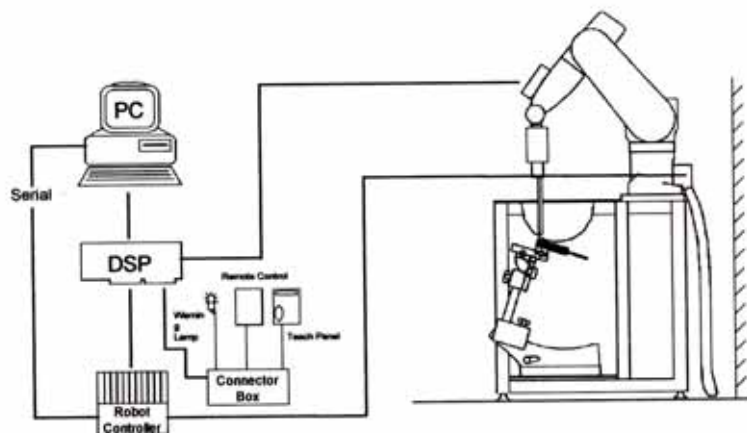


Figure 3. HCT SAR Lab. Test Measurement Set-up

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in [5].

## 4.1 DASY4 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 $\pm 8\%$ )
Frequency	10 MHz to > 6 GHz; Linearity: $\pm 0.2$ dB (30 MHz to 3 GHz)
Directivity	$\pm 0.2$ dB in brain tissue (rotation around probe axis) $\pm 0.4$ dB in brain tissue (rotation normal probe axis)
Dynamic	5 uW/g to > 100 mW/g;
Range Linearity:	$\pm 0.2$ dB
Surface Detection	$\pm 0.2$ 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 multifiber 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 DASY4 software reads the reflection during a software approach and looks for the maximum using a 2<sup>nd</sup> order fitting. The approach is stopped at reaching the maximum.



## 5.1 E-FIELD PROBE CALIBRATION PROCESS

### 5.2 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 below 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:

$\Delta t$  = exposure time (30 seconds),

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

$\Delta T$  = temperature increase due to RF exposure.

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

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

where:

$\sigma$  = simulated tissue conductivity,

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

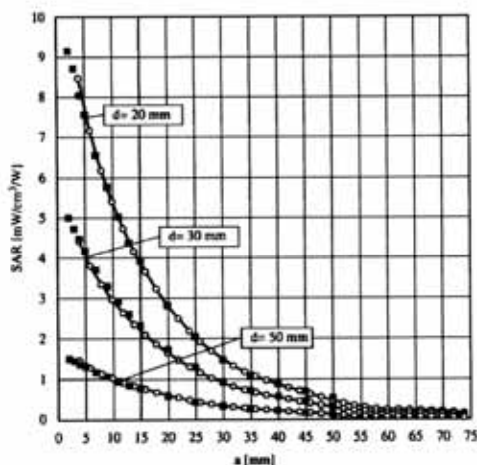


Figure 6. E-Field and Temperature measurements at 900MHz[5]

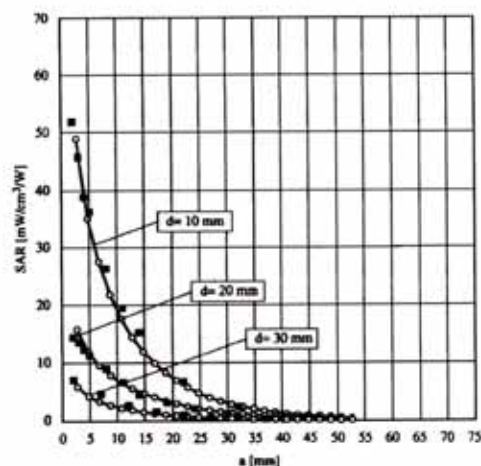


Figure 7. E-Field and temperature measurements at 1.8GHz [5]

### 5.3 Data Extrapolation

The DASY4 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  
 $\sigma$  = conductivity in [mho/m] or [Siemens/m]  
 $\rho$  = equivalent tissue density in g/cm<sup>3</sup>

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

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

with  $P_{free}$  = equivalent power density of a plane wave in W/cm<sup>2</sup>  
 $E_{tot}$  = total electric field strength in V/m



## 6.1 PHANTOM & EQUIVALENT TISSUES

### 6.2 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)

### 6.3 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 bactericide 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. Hartsgrrove [11].

Ingredients (%by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7

Table 1. Composition of the Tissue Equivalent Matter

### 6.4 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 repeatably 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

## 7.1 SYSTEM SPECIFICATIONS

### 7.2 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 IV  
**Clock Speed:** 3.0 MHz  
**Operating System:** Windows XP  
**Data Card:** DASY4 PC-Board  
**Data Converter**  
**Features:** Signal Amplifier, multiplexer, A/D converter, and control logic  
**Software:** DASY4 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 DAE4  
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]	Liquid	Liquid Temp [°C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
450MHz	Head	21.5	$\epsilon_r$	43.5	45.5	+4.60	±5%
			$\sigma$	0.87	0.853	-1.95	±5%
	Body	21.5	$\epsilon_r$	56.7	56.1	-1.06	±5%
			$\sigma$	0.94	0.95	+1.06	±5%

## 8.1 MEASUREMENT PROCESS

### 8.2 System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at 450MHz by using the system validation kit.

Freq. [MHz]	Liquid	Liquid Temp [°C]	SAR Average	Target Value (mW/g)	Measured Value (mW/g)	Deviation [%]	Limit [%]
450 MHz	Head	21.5	1 g	4.9	4.98	+1.63	$\pm 10\%$

### 8.3 Dosimetric Assessment Setup

The evaluation was performed with the following procedure:

- 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.
- 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.
- Around this point, a volume of 32mm x 32mm x 34mm was assessed by measuring 5 x 5 x 5 points. On this basis of this data set, the spatial peak SAR value was evaluated with the following procedure:
  - 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.
  - 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.
  - All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

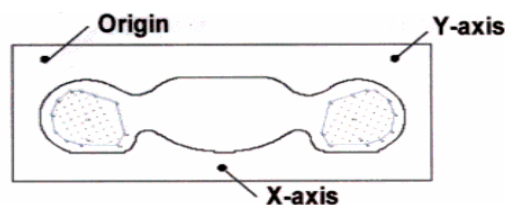


Fig. 10. SAR Measurement Point in Area Scan

## 9.1 ANSI/ IEEE C95.1 - 2005 RF EXPOSURE LIMITS

HUMAN EXPOSURE	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT Occupational (W/kg) or (mW/g)
<b>SPATIAL PEAK SAR *</b> (Brain)	1.60	8.00
<b>SPATIAL AVERAGE SAR **</b> (Whole Body)	0.08	0.40
<b>SPATIAL PEAK SAR ***</b> (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).

## 10.1 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  $\pm 1$  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  $\pm 2$ dB can be expected.[3]

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

Error Description	Uncertainty value (%)	Probability Distribution	Divisor	ci	ci^2	Standard Uncertainty (%)	Stand Uncert^2	(Stand Uncert^2) X (ci^2)	Vi & Veff
1. Measurement System									
Probe Calibration	11	Normal	2.00	1	1	5.50	30.25	30.25	∞
Axial Isotropy	4.7	Rectangular	1.73	0.7	0.49	2.71	7.36	3.61	∞
Hemispherical Isotropy	9.6	Rectangular	1.73	0.7	0.49	5.54	30.72	15.05	∞
Linearity	4.7	Rectangular	1.73	1	1	2.71	7.36	7.36	∞
System Detection limits	1.0	Rectangular	1.73	1	1	0.58	0.33	0.33	∞
Boundary effect	1.0	Rectangular	1.73	1	1	0.58	0.33	0.33	∞
Response time	0.8	Rectangular	1.73	1	1	0.46	0.21	0.21	∞
RF Ambient conditions	3.0	Rectangular	1.73	1	1	1.73	3.00	3.00	∞
Readout Electronics	0.3	Normal	1.00	1	1	0.30	0.09	0.09	∞
Integration time	2.6	Rectangular	1.73	1	1	1.50	2.25	2.25	∞
Probe positioner	0.4	Rectangular	1.73	1	1	0.23	0.05	0.05	∞
Probe positioning	2.9	Rectangular	1.73	1	1	1.67	2.80	2.80	∞
Maximum SAR evaluation	1.0	Rectangular	1.73	1	1	0.58	0.33	0.33	∞
Total							65.69		
2. Test Sample Related									
Device Positioning	1.77	Normal	1.00	1	1	1.77	3.13	3.13	9
Device Holder	3.6	Normal	1.00	1	1	3.60	12.96	12.96	∞
Power Drift	5.0	Rectangular	1.73	1	1	2.89	8.33	8.33	∞
Total							24.43		
3. Phantom and Setup									
Phantom Uncertainty	4.0	Rectangular	1.73	1	1	2.31	5.33	5.33	∞
Liquid conductivity (target)	5.0	Rectangular	1.73	0.5	0.25	2.89	8.33	2.08	∞
Liquid conductivity (measurement error)	2.5	Normal	1.00	0.5	0.25	2.50	6.25	1.56	∞
Liquid permittivity (target)	5.0	Rectangular	1.73	0.5	0.25	2.89	8.33	2.08	∞
Liquid permittivity (measurement error)	2.5	Normal	1.00	0.5	0.25	2.50	6.25	1.56	∞
Total							12.63		
Combined standard uncertainty	10.14					Total	102.74		
Expanded uncertainty =(confidence interval of 95.45 %)	20.3	± 20.3 % (Coverage Factor of k = 2)							

Table 3. Breakdown of Errors [18]

## 11.1 SAR TEST DATA SUMMARY

Mixture Type: 450 MHz  
Dielectric Constant: 45.5  
Conductivity: 0.853  
Phantom Position: Face  
Closest Distance (between E-Probe & Phone): 2.5 cm

## 11.2 Measurement Results (Mouth/ Face SAR)

Channel / Freq. (MHz)	Mode	Ant.	Battery Manufa- cture	Power (W)			Measured SAR 1g (W/Kg)		Max. Power Drift (dB)	Scaled SAR 1g (W/Kg)	
				Initial	End	Power Drift (dB)	100% Duty Cycle	50% Duty Cycle		100% Duty Cycle	50% Duty Cycle
1 (462.5625)	GMRS	Fixed	Energizer	2.100	1.726	-0.85	1.680	0.840	-0.87	2.053	1.026
15 (462.5500)	GMRS	Fixed	Energizer	2.060	1.695	-0.85	1.450	0.725	-0.87	1.772	0.886
22 (462.7250)	GMRS	Fixed	Energizer	2.040	1.690	-0.82	1.530	0.765	-0.87	1.869	0.935
8 (467.5625)	FRS	Fixed	Energizer	0.540	0.523	-0.14	0.295	0.148	-0.87	0.360	0.180
1 (462.5625)	GMRS	Fixed	Duracell	2.110	1.791	-0.71	1.570	0.785	-0.87	1.918	0.959
1 (462.5625)	GMRS	Fixed	Bexel	2.050	1.746	-0.70	1.420	0.710	-0.87	1.735	0.867
1 (462.5625)	GMRS	Fixed	Audiovox	1.810	1.571	-0.61	1.570	0.785	-0.87	1.918	0.959
ANSI/ IEEE C95.1 2005 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population							Mouth/ Face 1.6 W/kg (mW/g) Averaged over 1 gram				

### NOTES:

Measured Depth of Simulating Tissue: 15.0cm / Liquid Temperature: 21.5

- The SAR values found were below the maximum limit of 1.6 W/kg (uncontrolled exposure).
- The highest face-held SAR value found was 1.026 W/kg(based 50% duty cycle & 2.0 mm phantom).
- The EUT was tested for face-held SAR with a 2.5cm separation distance between the front of the EUT and the outer surface of the planer phantom.
- Battery Type ☒ Standard (x4) AAA Alkaline batteries (1.5VDC)
- Power Measured ☒ Conducted ☐ EIRP ☐ ERP
- SAR Measurement System ☒ SPEAG
- SAR Configuration ☒ Face/ Mouth ☐ Body ☐ Hand
- SAR Measurement Time: 25 minutes

*Ki Soo Kim*

Report prepared by : Ki-Soo Kim

Manager of Product Compliance Team



## 11.1 SAR TEST DATA SUMMARY

Mixture Type: 450 MHz  
Dielectric Constant: 56.1  
Conductivity: 0.95  
Phantom Position: Body  
Closest Distance (between E-Probe & Phone): 2.0 cm

### 11.3 Measurement Results (Body SAR)

Channel / Freq. (MHz)	Mode	Ant.	Battery Manu- facture	Power (W)			Measured SAR 1g (W/Kg)		Max. Power Drift (dB)	Scaled SAR 1g (W/Kg)	
				Initial	End	Power Drift (dB)	100% Duty Cycle	50% Duty Cycle		100% Duty Cycle	50% Duty Cycle
1 (462.5625)	GMRS	Fixed	Energizer	2.100	1.731	-0.84	2.080	1.040	-0.87	2.541	1.271
15 (462.5500)	GMRS	Fixed	Energizer	2.060	1.761	-0.68	2.200	1.100	-0.87	2.688	1.344
22 (462.7250)	GMRS	Fixed	Energizer	2.040	1.673	-0.86	2.110	1.055	-0.87	2.578	1.289
8 (467.5625)	FRS	Fixed	Energizer	0.540	0.531	-0.07	0.566	0.283	-0.87	0.692	0.346
15 (462.5500)	GMRS	Fixed	Duracell	2.070	1.696	-0.87	2.140	1.070	-0.87	2.615	1.307
15 (462.5500)	GMRS	Fixed	Bexel	2.030	1.690	-0.80	2.110	1.055	-0.87	2.578	1.289
15 (462.5500)	GMRS	Fixed	Audiovox	1.810	1.700	-0.27	1.870	0.935	-0.87	2.285	1.142
ANSI/ IEEE C95.1 2005 – Safety Limit Spatial Peak Uncontrolled Exposure/ General Population							Body 1.6 W/kg (mW/g) Averaged over 1 gram				

#### NOTES:

Measured Depth of Simulating Tissue: 15.0cm/ Liquid Temperature: 21.5

- The SAR values found were below the maximum limit of 1.6 W/kg (uncontrolled exposure).
- The highest body SAR value found was 1.344W/kg(based 50% duty cycle & 2.0 mm phantom).
- The EUT was tested for body SAR with a 2.0 cm separation distance between the front of the EUT and the outer surface of the planer phantom.
- Battery Type ☒ Standard (x4) AAA Alkaline batteries (1.5VDC)
- Power Measured ☒ Conducted ☐ EIRP ☐ ERP
- SAR Measurement System ☒ SPEAG
- SAR Configuration ☐ Face/ Mouth ☒ Body ☐ Hand
- SAR Measurement Time: 25 minutes

*Ki Soo Kim*

Report prepared by : Ki-Soo Kim

Manager of Product Compliance Team

## 12.1 SAR TEST EQUIPMENT

Manufacturer	Type / Model	S/N	Calib. Date	Calib. Interval	Calib. Due
Staubli	Robot RX90L	F01/ 5K09A1/A/01	N/A	N/A	N/A
Staubli	Robot ControllerCS7MB	F99/5A82A1/C/01	N/A	N/A	N/A
Staubli	Teach Pendant (Joystick)	D221340.01	N/A	N/A	N/A
HP	Pavilion t000_puffer	KRJ51201TV	N/A	N/A	N/A
SPEAG	DAE3V1	466	01/25/07	Annual	01/25/08
SPEAG	DAE4V1	447	11/17/06	Annual	11/17/07
SPEAG	E-Field Probe ET3DV6	1609	03/23/06	Annual	03/23/07
SPEAG	E-Field Probe ET3DV6	1798	08/25/06	Annual	08/25/07
SPEAG	SAM Phantom	-	N/A	N/A	N/A
SPEAG	Light Alignment Sensor	265	N/A	N/A	N/A
SPEAG	Validation Dipole D835V2	441	08/14/06	Annual	08/14/07
SPEAG	Validation Dipole D900V2	121	03/15/06	Annual	03/15/07
SPEAG	Validation Dipole D1800V2	2d007	08/16/06	Annual	08/16/07
SPEAG	Validation Dipole D1900V2	5d032	03/14/06	Annual	03/14/07
SPEAG	Validation Dipole D2450V2	743	01/17/07	Annual	01/17/08
Agilent	Power Meter(F) E4419B	MY40330223	11/08/06	Annual	11/08/07
Agilent	Power Sensor(G) 8481	MY41090870	11/21/06	Annual	11/21/07
HP	Signal Generator 8664A	3744A02069	04/11/06	Annual	04/11/07
EM POWER	Power Amp BBS3Q7ELU	1013-D/C-0127	04/05/06	Annual	04/05/07
HP	Network Analyzer 8753ES	JP39240221	04/06/06	Annual	04/06/07
HP	Dielectric Probe Kit 85070C	00721521	-		-
HP	Dual Directional Coupler 778D	16072	11/09/06	Annual	11/09/07
R&S	Base Station CMU200	838207/050	11/14/06	Annual	11/14/07
Agilent	Base Station E5515C	US41070189	05/03/06	Annual	05/03/07
Tescom	Bluetooth TC-3000	3000A490112	01/22/07	Annual	01/22/08

## **13.1 CONCLUSION**

---

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the ANSI/IEEE C95.1 2005.

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. Pokovic, 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. Hartsgrrove, 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 Hochschule ZØrich, Dosimetric Evaluation of the Cellular Phone.