HYUNDAI CALIBRATION & CERTIFICATION TECH. CO., LTD.

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CERTIFICATE OF COMPLIANCE (SAR EVALUATION)

Manufacture; Bonso Electronics Ltd. Unit 1106-1110, 11/F. Star House, 3 Salisbury Road, Tsimshatsui, Kowloon, Hong Kong FRN : 0012797494	Date of Issue: June 4, 2005 Test Report No.: HCT-SAR05-0604 Test Site: HYUNDAI CALIBRATION & CERTIFICATION TECHNOLOGIES CO., LTD. FRN : 0005866421

FCC ID　　　　:

APPLICANT　　:

OVVBS004
Bonso Electronics Ltd.

EUT Type:	22 CH Combination FRS/GMRS Transceiver.
Model(s):	BS004
Tx Frequency:	462.5500 MHz – 462.7250 MHz (GMRS)
	462.5625 MHz – 467.7125 MHz (FRS)
Max. SAR Measurement(s):	0.217 mW/g(1g) GMRS Face SAR ;
	0.169 mW/g(1g) GMRS Body SAR
Max. RF Output Power:	0.513W ERP(27.1 dBm)GMRS ;0.173 W ERP(22.4 dBm) FRS
Conducted Power:	0.494W (26.94dBm)GMRS ; 0.486W (26.87dBm) FRS
Emission Designator:	10K5F3E
Channel Capacity:	22
Application Type:	Certification
Trade Name(s):	Bonso
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‑ 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)

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 :	Bonso Electronics Ltd.
Address :	Unit 1106-1110, 11/F. Star House, 3 Salisbury Road, Tsimshatsui, Kowloon, Hong Kong
Attention :	Harry Lee / Director R/D & Engineering

- FCC ID: OVVBS004
- EUT Type: 22 CH Combination FRS/GMRS Transceiver. Prototype.
- Trade Name: Bonso
- Model(s):   BS004
- Tx Frequency: 462.5500 MHz – 462.7250 MHz (GMRS)

  462.5625 MHz – 467.7125 MHz (FRS)
- Application Type: Certification
- Modulation(s):   FM
- Max SAR Measurement: 0.217 mW/g(1g) GMRS Face SAR ;

  0.169 mW/g(1g) GMRS Body SAR

Figure 1. SAR System

- Max. RF Output Power: 0.513W ERP(27.1 dBm)GMRS ;0.173 W ERP(22.4 dBm) FRS
- Conducted Power: 0.494W (26.94dBm)GMRS ; 0.486W (26.87dBm) FRS
- Power Supply: (x4) AAA Alkaline batteries (1.5VDC)

  Manufacture(I : Energizer / II : Rocket / III: Duracell

       : LEXEL)
- Place of Test(s):   Hyundai C- TECH. EMC Lab.
- Date(s) of Tests: June 04, 2005
- Report No.:   HCT-SAR05-0604

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[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 .

$$S A R = \frac{d}{d t}\left(\frac{d U}{d m}\right) = \frac{d}{d t}\left(\frac{d U}{\rho \, d v}\right)$$

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.
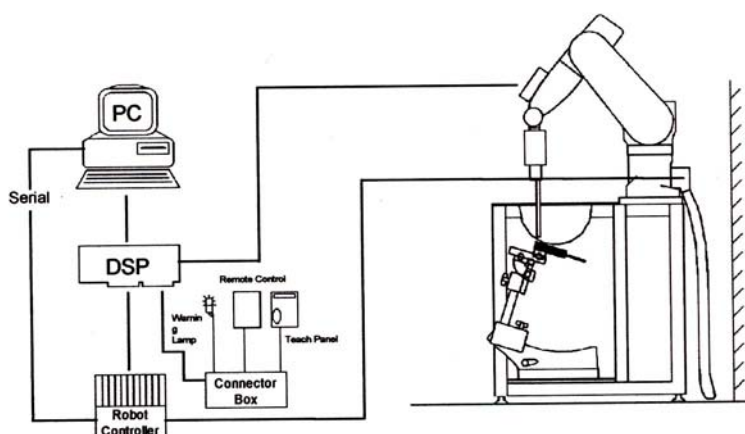

Figure 3. HCT SAR Lab. Test Measurement Set-up

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 $\pm$ 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
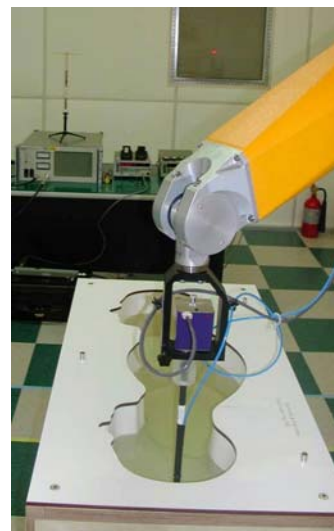
**Figure 4.Photograph of the probe
and the Phantom**

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 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 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 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,
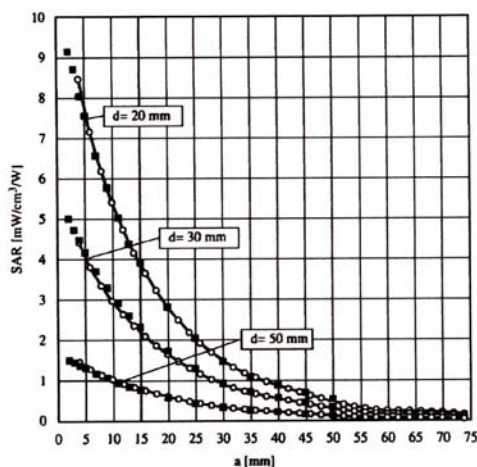
ρ = Tissue density (1.25 g/cm³ for brain tissue)

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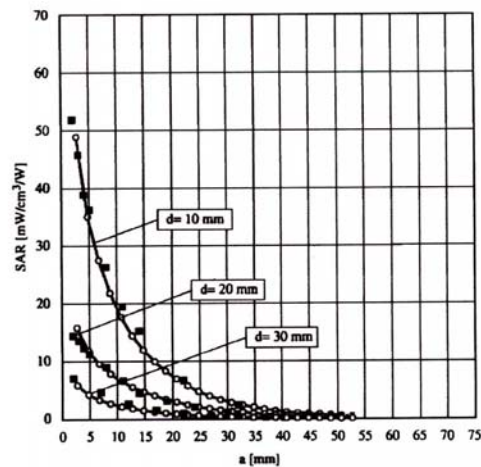

Figure 7.   E-Field and temperature measurements at 1.8GHz [5]

5.3 Data Extrapolation

The 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

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. See Figure 8.
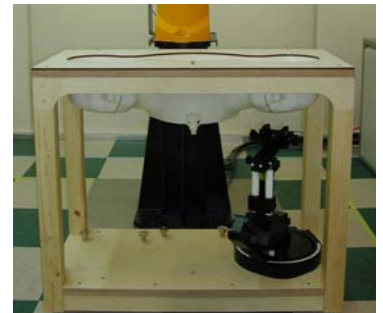

Figure 8. SAM Phantom

Shell Thickness	2 ± 0.1 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 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 %	FREQUENCY(Brain) 450 MHz	FREQUENCY(Body) 450 MHz
WATER	38.56	51.16
SUGAR	56.32	46.98
SALT	3.95	1.49
BACTERICIDE	0.19	0.05
HEC	0.98	0.52

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 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. 9. Device Holder