COMPARATIVE STUDY OF SAR VALUES FOR THE GSM 900 AND GSM 1800 FREQUENCY BANDS

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Abstract: *The reason for this study is to present the results of the SAR (Specific Absorption Rate) measurements for a mobile phone EUT (Equipment under Test) that works on the GSM 900 and 1800 bandwidths, to compare these results with current standards and to extract practical conclusions of the way in which we must protect ourselves from electromagnetic radiation. In order to accomplish the experiment, special equipment and specific software for these measurements were used. This equipment is meant to simulate human tissue and real conditions for the mobile phone to work.*
Keywords: *SAR, GSM, standard, EUT, OpenSAR, Kuka robot*

1. INTRODUCTION

The electromagnetic radiation to which the human body is exposed represents an extremely serious problem and this is the reason why measuring methods for the amount of radiation absorbed by the tissues were created.

SAR is a parameter introduced to measure the rate of absorption of energy by the human body when it is exposed to a radio frequency electromagnetic field.

For an equipment to be valued on the market, it has to correspond to certain standards in which the SAR limits are specified.

So a mobile phone is in compliance with the requirements of the test standard if SAR measurement results are lower or equal to the limit.

This limit is specified for the maximum emission power of the mobile phone and it is checked in the laboratory. Even so, in real conditions, the SAR value varies.

SR EN 50360 [1] test standard applies to all broadcasting devices that are used near the human body ear. It is a product standard that was introduced to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz - 3 GHz).

The exposure limit is found in the European Council Recommendations 1999/519 / EC from the 12th of July 1999 [3].

Alternatively, the limit set by the International Commission on Protection from Non-Ionizing Emissions (ICNIRP) can be applied: "Guidelines for limiting exposure in time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)", April 1998.

2. THE MEASUREMENT SET UP

2.1 SAR dosimetry evaluation system. The dosimetry evaluation system used for measurements is able to determine the distribution of SAR inside a SAM (Specific Anthropomorphic Mannequin) phantom [4] that complies with European and American standards (EN 50361, IEEE 1528).

The system consists of a robot (Kuka KR5) [5], a robot controller (Kuka KRC2sr), an electric field probe calibrated for use in liquids, a "twin" phantom, an "elliptic flat" phantom, a fluid simulating the human tissue, a EUT clamping device and the OpenSAR software [7].

The phantom is a container (shell) made out of a low loss and low permittivity material, embedded in a mass of wood. Dosimetry assessment can be made for EUT left or right ear utilization. The amount of fluid required to fill the phantom is around 20 liters.

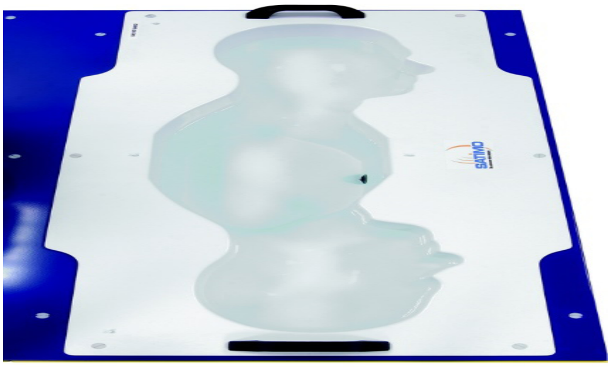


Fig. 1 The SAM phantom

The electric field probe has a triangular cross section. On each side there is a dipole which is connected to a Schottky diode with low levels of detection. Due to the high sensitivity of the probe, its output voltage is measured without amplification. The electric field probe corresponds to CENELEC and IEEE recommendations for measuring electromagnetic fields of mobile phones, base stations and radiating devices.

The EUT clamping device is constructed of a low loss and low permittivity material. It allows movement along the axes Ox, Oy, Oz or rotation around the phantom ear for precise positioning of the EUT.

The OpenSAR software controls the robot movement, it determines local SAR values, and calculates SAR values, averaged at 10 g and 1 g of tissue.

2.2 SAR measurement procedure. The OpenSAR software was used to measure the SAR for the mobile terminal and included the following steps: measuring the liquid; dosimetry evaluation system checking and the effective measurement of the SAR value.

The steps above were completed at each running frequency of the EUT for each measured radio channel (low, middle and high), using two measuring locations (left head, right head) and two EUT positions (cheek and tilt).

The fluid measurement. The dielectric properties of the fluid that simulates the human tissue are calculated before measuring the SAR, at the same temperature. The electrical permittivity ε and conductivity σ are measured and the obtained values must match the tolerance of ± 5% from the values specified in the standard.

Dosimetry evaluation system checking. Before measuring the mobile phone SAR value, a checking that the dosimetry evaluation system operates according to the technical specifications was performed. This check is a SAR measurement using a scheme where the signal comes from a sinusoidal signal generator and is emitted by a dipole antenna.

This measurement is the "validation" of the test system. Components and measurement procedures for verifying performance are the same as those used in actual measurements. The result of this verification must be within ± 20% from the prescribed standard value.

As an example, checking of the SAR dosimetry evaluation system (GSM 900 band, channel 62CH - uplink) performance is presented below. This procedure was performed also for the GSM 1800 band 698CH (1747.4 MHz - uplink).

The experimental conditions include: signal – continuous wave CW (crest factor: 1); channel – middle; EUT position – dipole; frequency – 902.4 MHz; relative permittivity (real part) – 41,746; relative permittivity (imaginary part) – 18.625; conductivity (S/m) – 0,933.

The SAR 10g (for 10g of human tissue) measured value was 6.09216 (W/Kg) and the standard reference SAR is 6.9 (W/Kg), so the difference represents -11.74% (within the limits). This maximum value was obtained for the position X = 0; Y = 1, as can be seen in the figure representing the surface SAR below. For this specific position, the volume SAR was determined, scanning the Z axis. The results are shown in the Fig. 4 (the limit SAR 10g is 2 (W/Kg)).

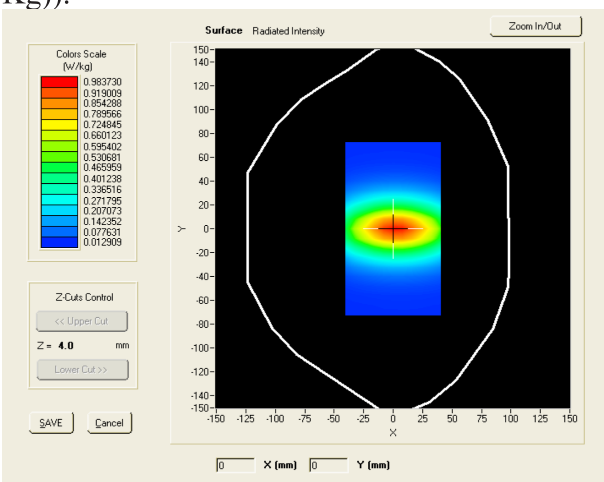


Fig. 2 Surface SAR

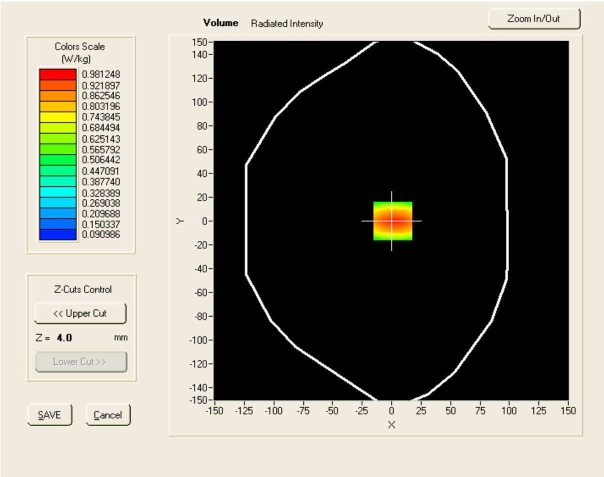


Fig. 3 Volume SAR

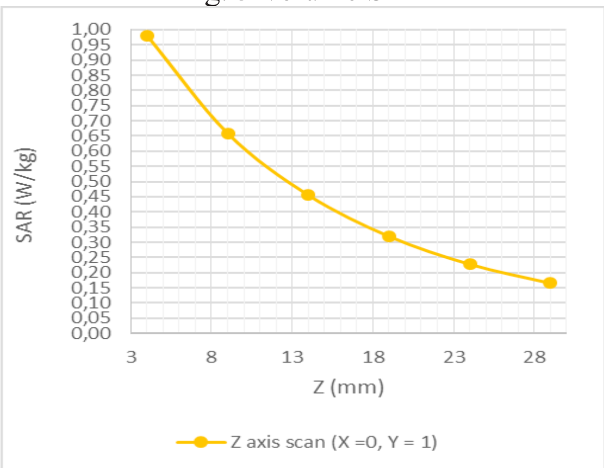


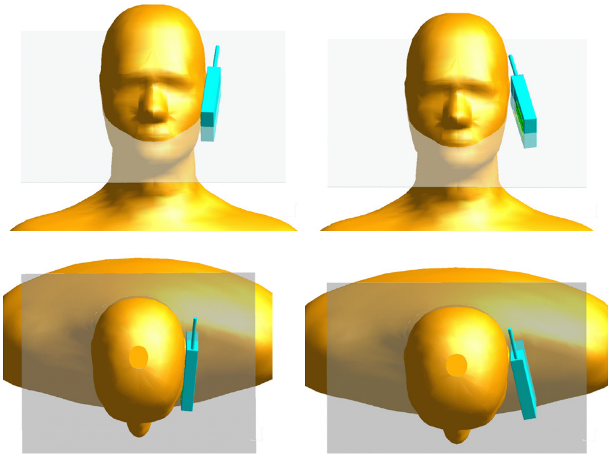
Fig. 4 SAR 10g values, GSM 900, CH62, dosimetry evaluation system performance

The effective measurement of the SAR value. The EUT is used with its internal transmitter, antenna(s), battery and accessories supplied by the manufacturer. The battery was fully charged before each test and there were no external connections to it. The output power and frequency were controlled with a GSM base station simulator (Rohde & Schwarz CMU 200).

For each position of the tested mobile phone, the following steps were done:

- Establish a radio connection with the base station simulator at EUT maximum power;
- Measurement of the SAR values in a network of equally spaced points on a surface located at a constant distance from the inner surface of the phantom;
- Measurement of the SAR values in equidistant points in a cube;
- Calculating the average value of the measured SAR data and comparing with the limit.

The mobile phone was placed in cheek and tilt positions, at the right "ear" or left "ear" of the phantom and measurements were performed at each transmitting band frequencies, respecting the required conditions.



"Cheek" position "Tilt" position

Fig. 5

Description of the interpolation / extrapolation method. The top of the probe has not been in contact with the inner surface of the phantom to minimize measurement errors.

Local SAR values are highest on the inner surface of the phantom and a method of extrapolation applies for their assessment.

The extrapolation is based on the measured data approximation using an order 4 polynomial, determined by the method of least squares. Local SAR values are extrapolated starting from the liquid surface with a step of 1 mm.

The measurements were performed in a limited time due to the battery life of the EUT. To reduce the measurement duration, the measuring step should be higher. It can vary between 5 mm and 8 mm. But for an accurate assessment of the maximum SAR value averaged over 10 grams and 1 gram a fine resolution of the scan in three dimensions is required.

Interpolation is used to obtain a sufficiently fine resolution. The measured data and the extrapolated SAR values are interpolated and on a grid with a step of 1 mm with a three dimensional "thin plate" spline algorithm.

3. EXPERIMENTAL RESULTS

Mobile phone SAR measurement ("Right Cheek" position, GSM 900 band, 62CH channel) is presented below as an example. The other measurements were performed in the same initial conditions: measured temperature - 27 ± 0.5 ºC (imposed values 18 ºC ÷ 28 ºC); measured atmospheric pressure 1008 ±5 mbar; measured relative humidity 49 ± 2%.

Used equipment: SAR dosimetry evaluation system, type Comosar Twins, manufacturer SATIMO France.

Possible kinds of operation of the equipment under measurement: waiting; conversation; communication via Bluetooth, WiFi, etc.

Operating procedure used during these measurements: a GSM communication has been established between the mobile phone under test and the base station simulator CMU200 for measuring the specific absorption rate (SAR).

The "Right Cheek" GSM 900 experimental conditions include: phantom – right head; EUT position – cheek; signal – TDMA (crest factor: 8.0); channel – middle; frequency – 902.4 MHz (uplink); relative permittivity (real part) – 41.746; relative permittivity (imaginary part) – 18.625; conductivity (S/m) – 0.933.

3.1 The results of the SAR measurement

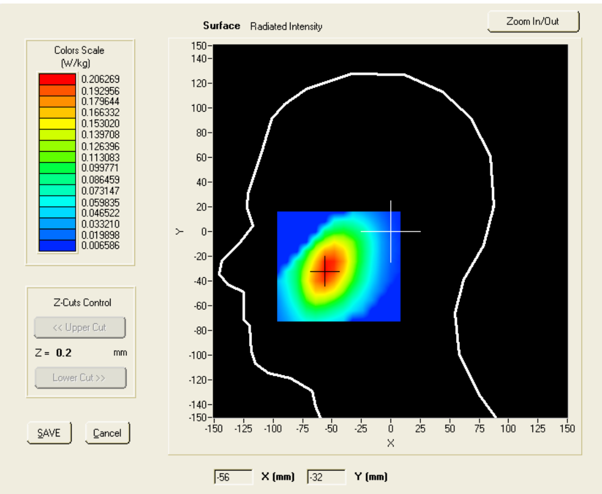


Fig. 6 Surface SAR – Right Cheek, GSM 900

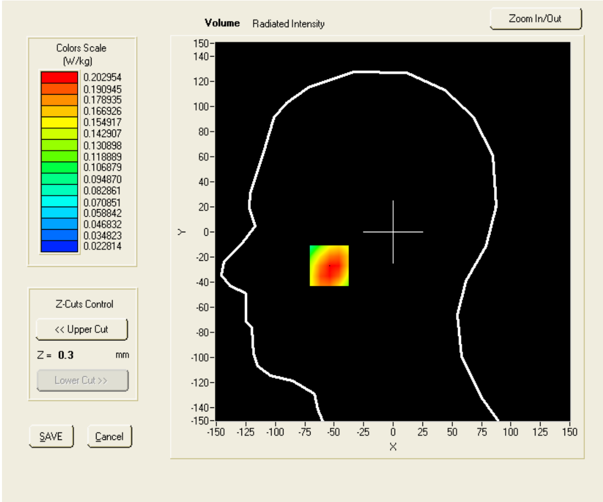


Fig. 7 Volume SAR– Right Cheek, GSM 900

The maximum SAR 10g value (0.143648 W/Kg < 2 W/Kg) has been obtained for X= -54.00, Y= -27.00. For this maximum position the volume SAR has been determined (900 Right Cheek curve from the Fig. 8 below). Also, the same kind of pictures (from Fig. 6 and Fig. 7) have been completed by the computer for each SAR measurement set and the SAR curves are represented in the Fig. 8.

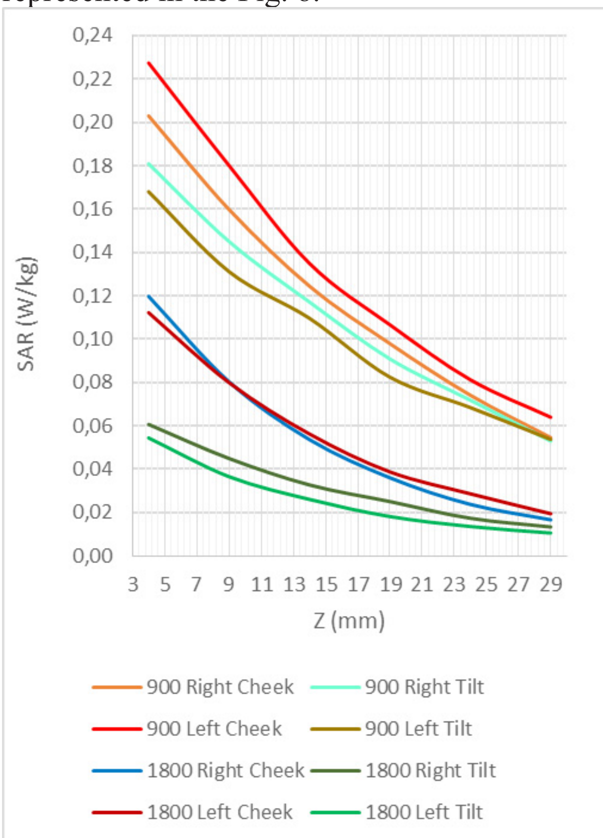


Fig. 8 SAR values obtained for different mobile phone positions and operating frequencies

Analyzing the curves obtained in the above figure, we can see that the highest values of SAR (for the specific mobile phone under test) were obtained for the GSM 900 band. Of course, the phone position (cheek or tilt) has to be taken into account, and if it is used for left or right ear.

To see which are the SAR values in the points of maximum obtained on 62CH and 698CH, the curves in the Fig. 9 were plotted, where the mobile phone emitted on other channels. The results show once again that the SAR value is higher in the GSM 900 band.

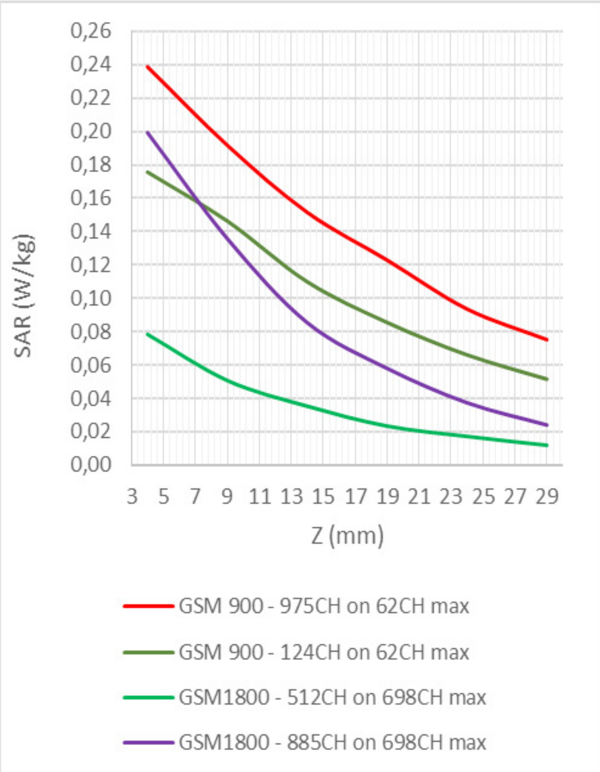


Fig. 9 SAR values obtained on different channels for the maximum position found on 62CH and 698CH

Fig. 10 The SAR measurement equipment and the EUT under test

CONCLUSIONS & FUTURE WORK

This paper shows a set of SAR measurements done on a single mobile phone. We have noticed that the highest values were obtained in the GSM 900, where the maximum emission powers had to be bigger in order to cover macro cells.

In reality, for a lowest possible SAR reading, but also for preserving battery life, the emission power is kept as low as possible.

From the SAR point of view, the tilt position is more advantageous than the cheek position, especially if, for protection, the antenna is placed on the lower part of the device, in order for it to be further away from the human brain.

In the future, more sets of measurements on more types of phones will be done and the results will be compared. There will be parametric variations and the influence on SAR values will be noticed. Either way, it's predictable that a mobile phone with smaller SAR values (declared by the manufacturer) does not necessarily offer the user better protection from the electromagnetic radiation as a device with higher declared SAR value. In real working conditions, the SAR values vary depending on propagation conditions, as well as the way in which the phone is used by its owner.

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