THE FIRST ROMANIAN SAR MEASUREMENT FACILITY WILL BE OPERATIONAL IN 2009

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Abstract

The mobile telephony is the most important discovery ever from the viewpoint of the impact on interhuman communication. Though this technology makes life safer and easier, the electromagnetic fields emitted by the mobile phones raise some doubts on the possible risks they generate for human health, even if at international level there were established norms and recommendations for protection against electromagnetic fields. Mobile phones certification with a view to placing them on the market imposes, according to the present standards, the experimental determination of SAR factor (Specific Absorption Rate) by institutions independent of manufacturers.

The paper presents the SAREMF Project, financed by ANCS (National Authority for Scientific Research), by means of which a laboratory for SAR measurement at mobile phone terminals will be achieved for the first time in Romania.

After an analysis of the researches made in this field, it is presented an experimental evaluation method for the exposure to the electromagnetic radiation in the near field as well as the prospects the Romanian research will have due to the achievement of this investment.

1. INTRODUCTION

In the general context of the concern about the consequences of the electromagnetic pollution generated by the mobile telecommunication systems, of the unprecedented growth of terminals number and uncontrolled use by children (about 18 mil operational terminals in Romania in 2007 and about 320 mil in Europe) as well as of the base stations influence, at international level and lately at national one there were elaborated recommendations and norms for limiting the human exposure to electromagnetic fields (Table 1).

Mobile phones certification with a view to trading imposes, according to the present standards, the experimental determination of SAR factor (Specific Absorption Rate of electromagnetic field measured in W/kg of user's body weight) and its value limitation to the nationally and internationally regulated values considered non-dangerous (at the present knowledge level).

Table 1

Spread area of mobile phones at world level

Global GSM users	***1.054 billion***
Global CDMA Users	***202m***
Global CDMA2000 Users	***86.2m***
Total European users	***320m***
Total African users	***62m***
Total 3G users	***130m***
European Penetration	***70.2%***
GSM Countries on Air	***190***

Source : www.gsmworld.com

As regarding the domestic market of mobile phones, the state has the role of protecting the citizens in their position of consumers and of performing or financing studies and comparative tests according to EU Recommendation 1999/519/CE transposed in the Romanian legislation by Order. No. 1193/29/09/2006, issued by the Ministry of Public Health, Official Journal No. 895/3.11.2006

Unfortunately, in Romania there is no facility for SAR determination and the values written on terminals, according to the law, originate from the manufacturers and not from independent accredited laboratories. Other important functional characteristics like energy consumption, audio and emission/ reception properties are not checked in authorised laboratories either.

In EU countries and even in the countries that recently joined EU excepting Romania and Bulgaria, there are tens of independent laboratories specialised in SAR evaluation and full characterisation of the said terminals.

In this context, the existence of a laboratory specialised in SAR evaluation independently of the mobile phone operators becomes absolutely

necessary. This laboratory should be nationally accredited and internationally recognised and intended to:

- conformity evaluation and validation according to the in force European and international standards for the traded products, the second-hand ones inclusively;
- performing comparative studies and tests at international level (including participation in intercomparison circuits);
- creating conditions for the participation of Romanian scientific community in the development of modern communication systems with reduced electromagnetic pollution within the frame of some European projects.

This specialised laboratory is described hereinafter.

2. MOBILE PHONE USER EXPOSURE TO ELECTROMAGNETIC RADIATIONS

The mobile telephony is the most important discovery ever from the viewpoint of the impact on the communication between people. Its development will be unprecedented in the next period and according to some specialists in industrial prognosis, within 10 - 15 years the whole equipment will have the dimensions of a chip implantable in the human body (IEEE Spectrum nr. 10/2006).

Though this technology makes life easier and safer, the electromagnetic fields emitted by the mobile phones raise some doubts on the possible risks they generate for human health, even if at international level there were established norms and recommendations for human health protection against electromagnetic fields. These norms implemented in national regulations (in Romania by Order No. 1193/ 29.09.2006 of Ministry of Health and Family) are substantiated by a significant amount of experimental data as well as by permanently up-dated theoretical studies.

That is why, at World Health Organization, one of the important topics for health is "Electromagnetic Fields" within the frame of which ''International EMF Project'' is on the main position having as an aim the evaluation of the effects on human health and environment following the exposure to electric and magnetic fields in the frequency range 0 - 300 GHz. The project, launched ever since 1996, presented its own evaluation on these risks in 2007. From Europe, most EU countries (even Bulgaria but not Romania) as well as countries outside EU as Croatia and Russia participate in this extensive program approaching also the mobile telephony domain (www.who.int/topics/electromagnetic_fields/).

At European level, after two COST projects (European cooperation in the field of scientific and technical research that enables a European – level coordination of the researches financed from national sources) having the

electromagnetic fields as an objective (244 and 244 bis), the topic of EMF or EEMC (environmental electromagnetic compatibility) was not exhausted the need for a new action being obvious. In the last decades, the technological development leads to the change of the living and working conditions for most Europeans. Among other things, people's and also other occupational groups' exposure to electromagnetic radiations increased very much.

This situation was studied within the frame of COST 281 action in the period 2001-2006 (Romania did not join this action).

While COST 244 and 244 bis actions dealt with electric, magnetic and electromagnetic fields of extremely low frequencies, intermediate frequencies and less of high frequencies, due to public interest for mobile phones COST 281 action dealt with radio frequencies.

All these COST programs were concluded leaving many gaps but they represented a cooperation and contact basis for the participating countries.

The EU program "EMF-NET" on the effects of the exposure to electromagnetic fields, launched in 2004, is carried out up to 2008. The main aim of this program is to supply to the European political and public health authorities the scientific information necessary to define the policy with respect to electromagnetic fields. In the preliminary reports to the program, it is emphasised the importance of intensifying the researches in high frequency radiation domain under the form of experimental studies.

In order to be able to participate effectively in such programs, Romania should have adequate facilities and skilled researchers which have not happened up to the present, unfortunately.

The importance of the issues related to electromagnetic pollution results also from the levels of the research financing in EU (source is the French researcher Bernard Veyret):187 million Euro own funds and 16.7 million Euro EU funds.

Among the national programs of EU countries, it is to be noticed the important financings of Great Britain for the projects MTHR and TETRA (about 28 million Euro).

The facilities from the EMF domain began to be completed at the same time with the financing of the CEEX programs by means of which equipments for far field measurements with a value of about 2 milion Euro were especially purchased.

None of the Romanian financings had so far in view the achievement of an investment able to solve SAR measurement at mobile phones.

Project **SAREMF** (program "Capacities 2007", project No. 79) presented in this paper aims at solving one of the most important problems not solved yet – SAR measurement.

This measurement is performed exclusively in near field in completely different conditions than the far field measurement.

3. METHODS FOR EXPERIMENTAL EVALUATION OF THE EXPOSURE TO ELECTROMAGNETIC FIELD GENERATED BY MOBILE PHONES

The evaluation of the radiofrequency field exposure levels is a fundamental issue at present. The effects are different depending also on frequency as it follows from Table 2.

Table 2

Frequency range	**Stimulation type**	**Characteristic quantity**
50Hz-100kHz	Neuromuscular	Current density in the excited tissue [A/m^2]
100kHz-3GHz	Volume heating	Specific Absorption Rate (SAR) [w/kg]
3GHz-300GHz	Surface heating	Power density [w/m^2]

According to EC Recommendation 1999/519/CE, the restrictions regarding people exposure to time varying electric, magnetic and electromagnetic fields, based directly on the effects observed on health and for biological reasons are defined as "basic restrictions".

Depending on the electromagnetic field frequency, in the frequency range used by mobile phones, with a view to preventing a generalised thermal stress at body level and an excess local heating of the tissues, there are provided basic restrictions regarding SAR.

The Specific Absorption Rate (SAR) is the main dosimetric quantity for the evaluation of the human exposure both in near field (mobile terminals) as well as in far field (base stations). It is the power absorbed by the unit mass of the tissue defined as the time derivative of the incremental energy (dW) absorbed by an incremental mass (dm) contained in a volume element (dV) of given mass density (ρ) and has the general expression:

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho\, dV}\right) \qquad \text{[W/kg]} \qquad (1)$$

SAR evaluation in near field can be made either by means of the local electric/magnetic field or by means of the local temperature measured in a given volume (www.sfrp.asso.fr/MAN/pdf/Wiart.pdf).

SAR expressions become:

$$SAR = \frac{\sigma |E|^2}{\rho} \qquad (2)$$

respectively:

$$SAR = \frac{cdT}{dt} \tag{3}$$

where: - E is electric field strength (peak value);
- σ is the electrical conductivity of the sample (tissue);
- ρ is sample density;
- T is the absolute temperature of the sample.

However, electric field measurement is the favourite method for the industrial tests.

To be noticed that the measurement of the so called Maximum Permissible Exposure (MPE), determined by the power density [w/m^2], is accepted in the far field by the same recommendations instead of SAR measurement.

SAR limits applicable for mobile phones and other similar systems are prescribed in the source documents from USA (ANSI/IEEE C95.1) and Europe (ICNIRP).

There are used two limit values: a lower value for the exposure averaged on the entire human body and a higher value applicable for the local exposure of a particular area of the body (for example the head). This SAR for a body area is averaged over any 10 g of tissue in Europe and 1 g in USA defined as a tissue volume in the shape of a cube**.**

The said data are presented synthetically in Table 3.

Table 3

	Average/ whole body SAR	Localised SAR (head and trunk)	Averaging time	Averaging time
Europe	0,08 W/kg	2 W/kg	6 min.	10 g
USA	0,08 W/kg	1,6 W/kg	30 min	1 g

Since it is difficult to measure SAR directly in the human body, the standard procedure is based on phantoms use. In this case, a series of elements affecting the measured value appear, for ex.: the shape and electrical characteristics of the phantom, the shape and radiation characteristics of the field source especially the cell phone antenna and phantom relative position towards the source.

A high measuring accuracy is obtained by an as accurate as possible physical simulation of the real exposure.

Since, the most important mobile phones manufacturers are in USA (Motorola) respectively in Europe (Nokia), the new American (IEEE 1528) and European (EN 62209) standards are structured similarly, respectively harmonised, with minor variations one with respect to another.

All contain the following chapters:

- scope, references and details
- measuring system specification;
- used phantoms;
- measuring equipment inclusively the used miniature field probes;
- phantom scanning system;
- SAR evaluation protocol;
- measuring procedure;
- experimental data post-processing ;
- measurement uncertainty evaluation.

The most important aspects are the requirements on the measurement accuracy achieved by the test system and on the measuring method. A special characteristic of both standards consists in the explicit and detailed provision of the requirements for the evaluation of the measurement uncertainty budget and a limit for the maximum permissible uncertainty (about 3dB).

In this way, the requirements involve both the measuring equipment and the laboratory technical procedures.

The annexes to these standards contain important information for the laboratory as well as for the manufacturer of the measuring equipment.

In brief, the SAR measurement procedure is according to IEC 62209-1 cl.5.1:

"The test shall be performed using a miniature probe that is automatically positioned to measure the internal E-field distribution in a phantom model representing the human head exposed to the electromagnetic fields produced by wireless devices. From the measured E-field values, the SAR distribution and the maximum mass averaged SAR value shall be calculated."

The test equipment presented in Fig.1 under the form of block diagram includes components for mobile phone (test object) positioning and scanning system alignment, dielectric properties measurement for the liquid simulating the human tissues, check and validation of the measurement accuracy.

Two types of phantoms are used:

- specific anthropomorphic phantom (SAM) for mobile phones testing;
- flat phantom for the validation and testing of the wireless devices that are not held close to the ear.

Phantom enclosure and the liquids simulating the head tissue or other human body part tissues are subjected to some strict requirements and when the frequency band of the mobile phone is changed the liquid will be changed accordingly due to the working frequency influence on its complex permittivity.

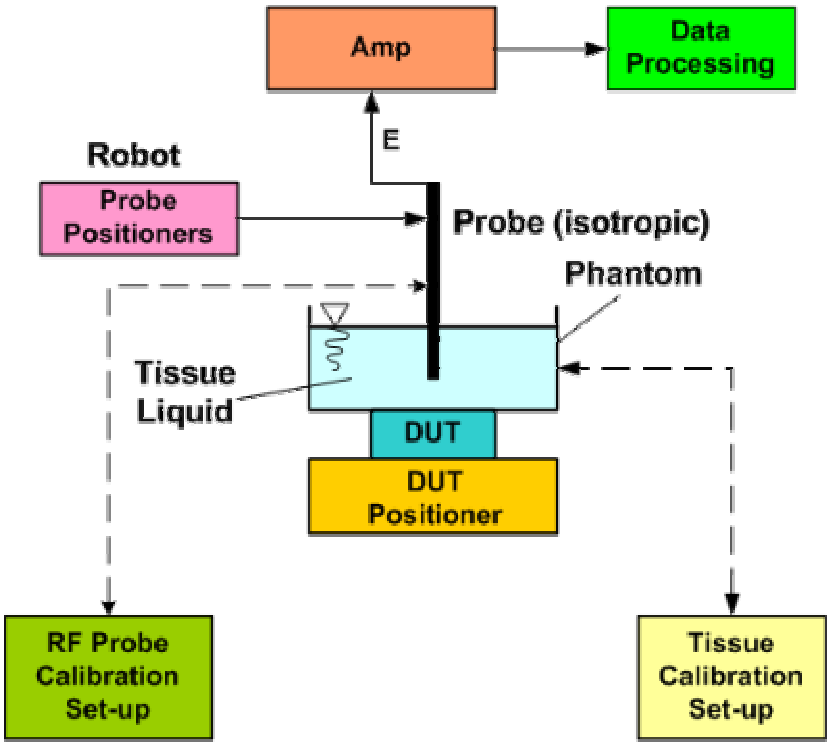

Fig 1. Block diagram of SAR dosimetry equipment

The robot for field probe positioning must be capable to scan the whole volume subjected to exposure with a view to achieving a three-dimensional measurement of SAR with a remarkable positioning accuracy of ±0,2 mm.

The miniature field probes have a special construction and very high linearity.

In order to calibrate the dipole antenna by means of which the excitation signal is sent to the mobile phone, it is used the circuit from Fig.2.

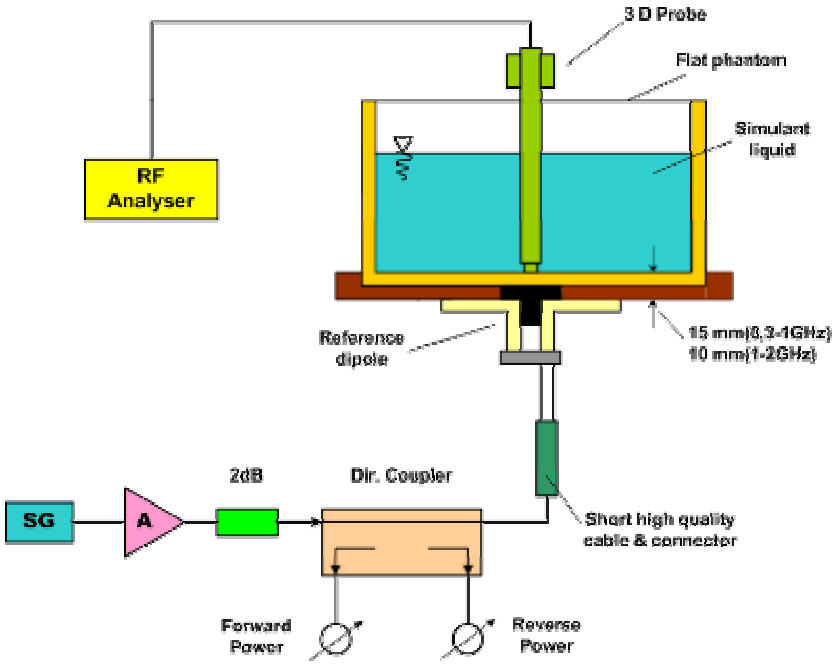

Fig.2 Calibration of Field Probe

All mentioned measuring system characteristics and many others make the acquisition of such a system to be expensive.

More than that, the whole measuring system must be introduced in an electromagnetically screened room.

4. CONCLUSIONS AND PROSPECTS

Achievement for the first time in Romania of a laboratory for SAR evaluation and certification at mobile phone terminals. Its putting into operation is provided for the end of 2009.

The laboratory will provide tests compliant with the in force international regulations and will have secured customers and benefits accordingly taking into account the development and rapid innovation of the wireless technology.

The laboratory will be able to carry on research activity in the following domains:

- Development of a Romanian expertise pole in bioelectromagnetism domain;

- Experimental dosimetry and numerical simulation;
- Development of testing technologies for small dimension mobile terminals (WLAN,Bluetooth,ZigBee etc);
- Study of pacemaker type modern implants;
- Evaluation of terminals conformity with the safety standards by calculating the radiated power flux density and comparing the experiment with the numerical simulation;

These concerns are highly actual and they could get the interest of the young researchers with respect to achieving theoretical researches with direct experimental check without which none scientific activity can be certified.

It is possible to ensure market surveillance in one of its most dynamic domains due to the fact that the new laboratory belong to an R&D National Institute.

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