Interaction of a radio-handset and the head of its user at 1900 MHz

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Abstract: Interaction between a radio-handset and the body of its operator at 1900 MHz has been considered. Simple homogeneous and hetrogeneous models of the human head and a monopole mounted on a metalic box as the model of the radio-handset were used. Analysis has been conducted to find SAR (Specific Absorption Rate) and antenna input impedance and radiation pattern using the FDTD method, which is the method of promise in the field. It has been shown, both theoretically and experimentally, that simple homogeneous models are reliable to study the effects of the head on the radio-handset performance. In the case of SAR estimations, too, these models are applicable, although more detailed models may lead to better results.

Résumé: Ce projet traite de l'intéraction entre un opérateur et un appareil cellulaire à 1900 MHz. Pour cette étude, des modèles homogènes et hétrogènes simples de la tête et d'un monopole juxtaposé sur une boitier mtallique ont été considérés. Une analyse à l'aide de la méthode FDTD pour le calcule du SAR (Taux d'Absorption Spécifique), l'impédance d'entrée de l'antenne et le diagramme de rayonnement. Les résultats ont été vérifiés analytiquement et expérimentalement et il a été montré que les modèles homogènes sont adéquats pour l'étude des effets d'un appareil cellulaire sur les tissus humaines. Pour le cas du SAR, ces modèles permettant également d'obtenir un bon estimé mais les modélisations plus approfondies pourraient permettre d'obtenir des résultats plus complets.

The problem of the interaction between a radio-handset and its user is of interest and important from different points of view and at different levels of a single user, public, governemental bodies responsible for the radiation protection, industries producing the equipments, and research laboratories. A careful study of the interaction problem is a multidisciplinary project of coordinating the research of related disciplines, compiling, interpreting and circulating the emerging results among them to be used in further research. Among the disciplines involved in the study are epidemiology, which studies the links between the observed diseases and EM radiation in the environment, physiology, which studies the functioning of the human body at the levels of cells, organs, and physiological systems under different conditions, biophysics, which studies the effects of EM field on the cell structure and function using physical laws and models, and electromagnetics, which studies quantitatively the interaction problem to find the effects of the EM radiating equipment on the human operator and vice versa.

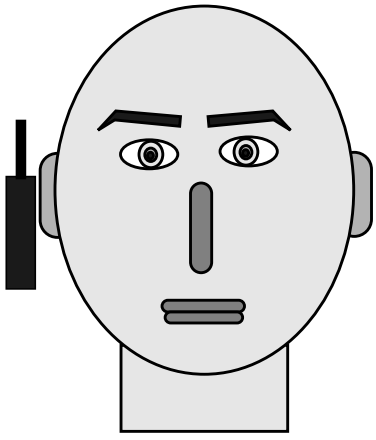
To the extent that an electromagnetic study of the interaction problem is concerned, Maxwell's equations under the suitable boundary conditions is the point of departure, but there are some other considerations, too, which complete the problem definition and determine its method of solution. The most important problems to be considered are: objects of study, models of human body and radiating system, and method of anlysis, as follows:

Objects of study-Objects of an electromagnetic analysis of the radio-handset operator interaction is to find the effects of the human body on the performance of the radio-handset on the one hand, and calculations of the deposited EM power in the body of the operator on the other hand. Calculations of the antenna input impedance and its radiation pattern in cases of isolation from the user and in proximity of its operator gives a quantitative measure of human body effects on the system. Estimation of the SAR (Specific Absorption Rate) in the human body provides us with an evaluation of the radiating system on the human body.

Model of human body-In an electromagnetic analysis of the problem, the human body is a complex and heterogeneous lossy dielectric object. There are variety of human body models used by researchers in the field, from simple homogeneous ones to complex anatomic models. It has already been indicated that human head is a very good approximation to the human body in these studies of the interaction problem.

Model of the radiating system-Among the radiating elements used in these studies are monopoles, dipoles, and most frequently monopoles mounted on a metalic box. There are some variations regarding the details of the models. Figure (1) shows a typical configuration of the system composed of the radio-handset and its user's head.

Figure (1)



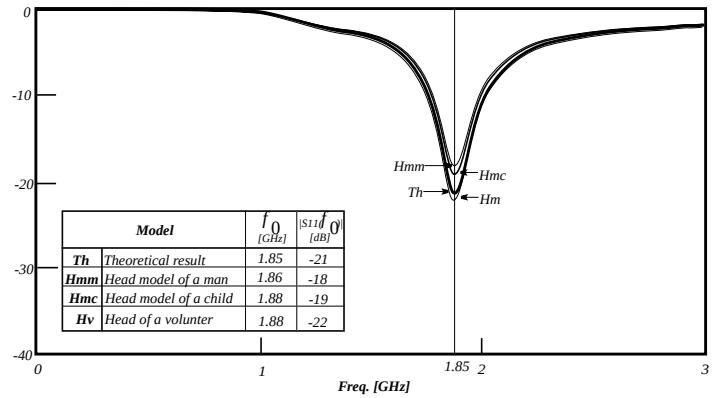
Method of study-At the first phase of these studies, analytical methods using simple models of human body were used. With rising the computing power and developement of efficient nume-

rical methods, numerical solutions based on integral equations (method of moments) and differential equations (finite difference method) have replaced, to a high degree, analytical methods. Today the FDTD method using finite difference equations and Yee cell algorithm is the method of promise, because it is the most suitable method to handle complex and heterogeneous objects. In additions, time responce study leading to frequncy responce of the system in a band of frequencies is a natural calculation with this method.

Our study is to evaluate these effects using simple head models, the FDTD method which has proved itself as the method of promise in the field, and at 1900 MHz for which there is not suficient reports untill now in spite of its importance.

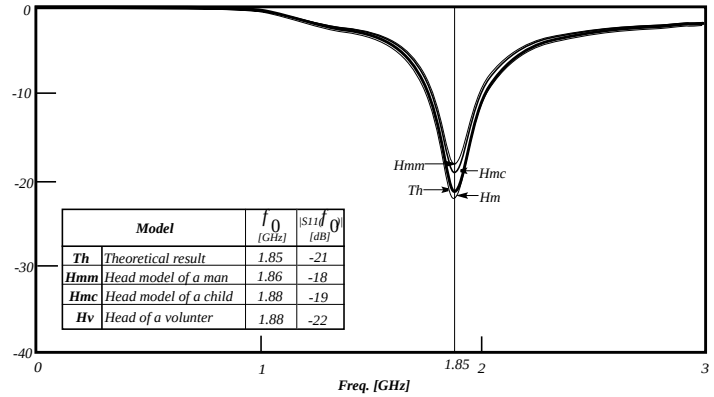
Some results-Figure (2) shows theoretical and experimental results for $|S_{11}(dB)|$ of the isolated radio-handset on the *0-3 GHz* band. The same results are indicated in the figure (3) for the radio-handset in proximity of the operator's head.

figure (3)



Model		f_0 [GHz]	$\|S11(f_0)\|$ [dB]
Th	*Theoretical result*	1.85	-21
Hmm	*Head model of a man*	1.86	-18
Hmc	*Head model of a child*	1.88	-19
Hv	*Head of a volunter*	1.88	-22

figure (3)



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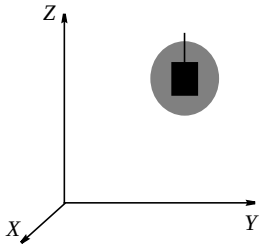
There is good agreements between theoretical calculations and experimental results in two cases of isolated radio-handset, figure (2), and radio-handset head model system, figure (3). Figure (4) shows the YZ plane radiation pattern of the isolated radio-handset in comparison with the case of proximity with its operator.

Figure (4)



***ir:** isolated radio-handset*
***rh:** radio-handset and head model*

Gain in the YZ cut with and without operator