ANALYSIS OF HAND-HELD PHONES USING THE FINITE INTEGRATION ALGORITHM

Richard Dlouhý
Dept. of Electromagnetic Field
Czech Technical University in Prague
Technická 2, 166 27 Praha 6
Czech Republic
email:richard@hf01.lhft.e-technik.uni-erlangen.de

Abstract

Two different hand-held phones operating at 1.8 GHz are numerically analyzed, applying a field calculation program MAFIA (MAxwell's equations using the Finite Integration Algorithm). One phone contains a Back-Mounted Microstrip Double Patch Antenna (BMMDPA), the other, for comparison a conventional monopole. Realistic models of the the handset, the head and the hand are used to gain a detailed understanding of the antenna properties, as well as of the antenna-tissue interaction.

Keywords:

BMMDPA, Model, Handset, Microstrip patch, Absorbed power, Antenna

1. Introduction

There is a growing public concern about possible health hazards caused by the use of handheld transceivers. Of course, this has an impact on the antenna development for such handsets. To get rid of the most often used, but unfavourable monopole antennas, various antenna configurations have been studied in the literature. Most of them are small, flat configurations which can be conveniently integrated with the handset. Among existing built-in antenna schemes much attention has been paid to planar inverted F antennas (PIFA) as described by Tokio [1] , Jensen and Rahmat-Samii [2], Jensen [3], Rahmat-Samii [4], and also radiation-coupled dual-L antennas (RCDLA), investigated by Fuhl et al [5], Shtrikman and Fruechting [7]. Recently, Ruoss and Landstorfer proposed a double-T slot antenna with reduced absorbed power in the human body [8]. However, their antenna is bulky and has a small bandwidth.

The limited bandwidth is also an unpleasant feature of microstrip patch antennas. Therefore, a second radiation-coupled patch is used in our work to overcome this difficulty without enhancing the thickness of the antenna.

It is the purpose of this paper to demonstrate that a backside-mounted microstrip double patch antenna (BMMDPA) is an alternative configuration with great advantages in terms of the absorbed power in the user's head, without an unacceptable degradation of other important antenna parameters. On contrary, the antenna efficiency, for example, is greatly enhanced for the microstrip structure compared to the monopole.

2. Model and Method

The structure of the BMMDPA and the model of the handset are given in Fig. 1.

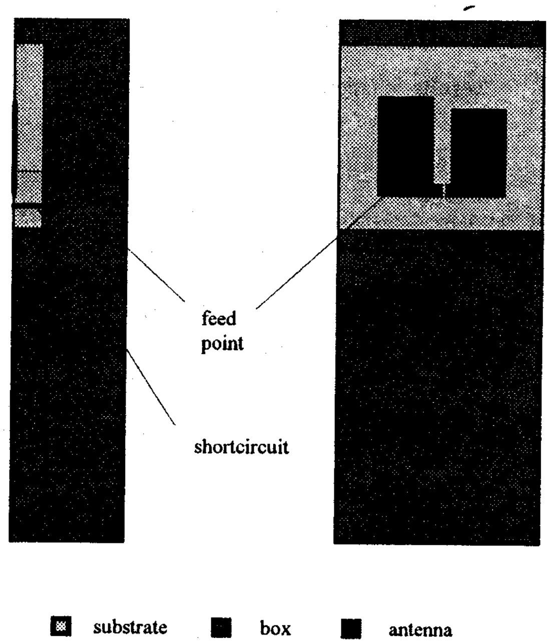

Fig. 1. Model of the handset with BMMDPA

For both antenna configurations the chassis is a conductive box with dimensions: 130 mm x 50 mm x 30 mm. The BMMDPA consists of two microstrip patches with the same width of 15 mm. The larger patch, which is connected to a coaxial line, has a length of 22 mm, the shorter with length of 18 mm. Both patches are short-circuited at one side, whereas the opposite side near the upper rim of the handset is open. The substrate with a dielectric constant of $\varepsilon_r = 2.0$ has a thickness of 8 mm.

In the other example, the monopole consists of a wire of length L = 41.6 mm, placed in the center of one small side of the box.

In order to obtain reliable results, the model of the head is derived from high resolution CT-data by transforming the original Housfield units into values for the permittivity and conductivity at the operating frequency. As indicated in Fig. 2, the model distinguishes five different tissues, the electrical parameters of which we taken from literature. For the limitation of CPU-time, a cell-size of 5x5x5 mm^3 is chosen.

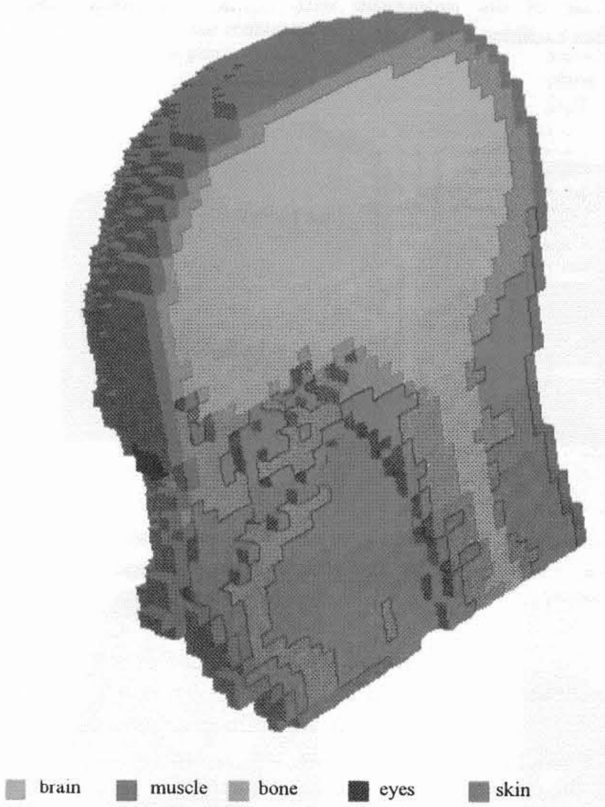

Fig. 2. Cut through the 3D-Model of the head

The whole configuration of the two handsets, together with the heads and the hands is illustrated in Fig. 3a) and 3 b).

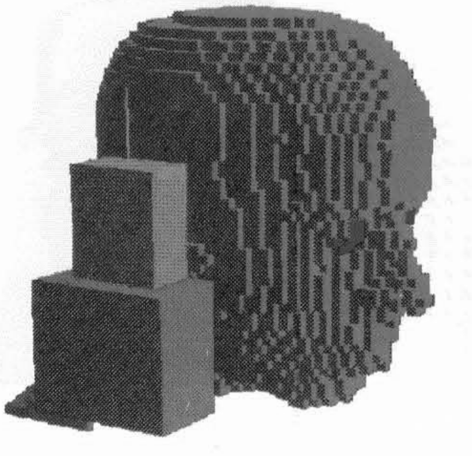

Fig. 3a). Handset with head and hand - Monopole

Calculations are performed applying the field evaluation program MAFIA, developed by Weiland et al. [6].

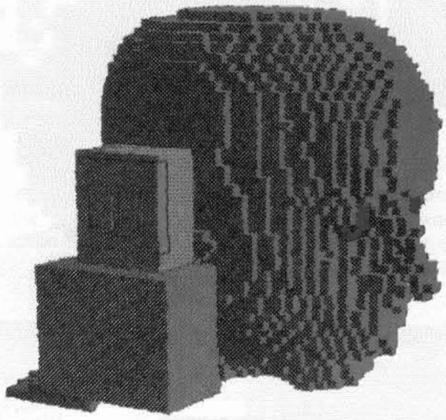

Fig. 3b). Handset with head and hand - BMMDPA

3. Results

For the handsets with monopole and microstrip antenna, the SAR-distributions in the heads and hands are given in Fig. 4a) b) and 5a) b) for two different cuts. In all cases the transmitted CW power is 1W.

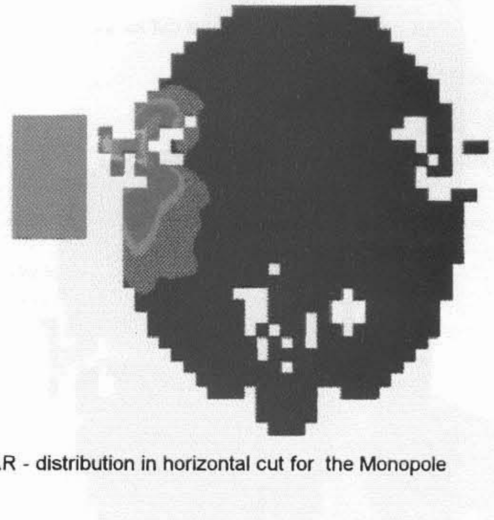

Fig. 4a). SAR - distribution in horizontal cut for the Monopole

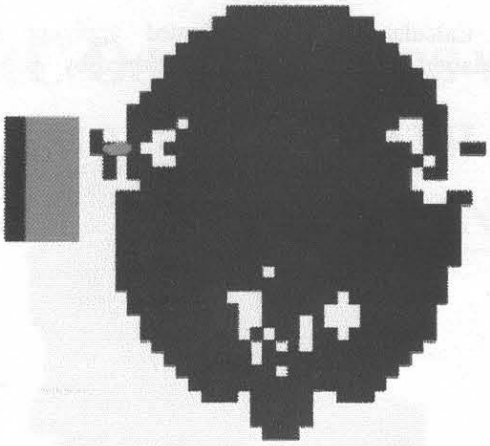

Fig. 4b). SAR - distribution in horizontal cut for the BMMDPA

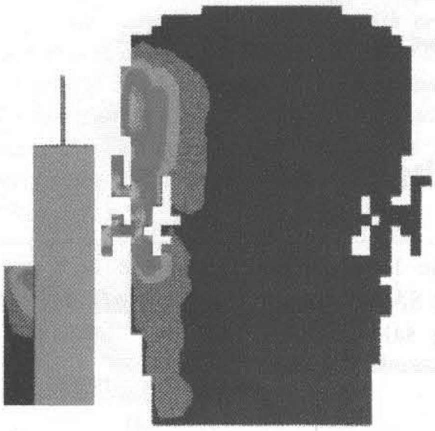

Fig. 5a). SAR - distribution in vercical cut for the Monopole

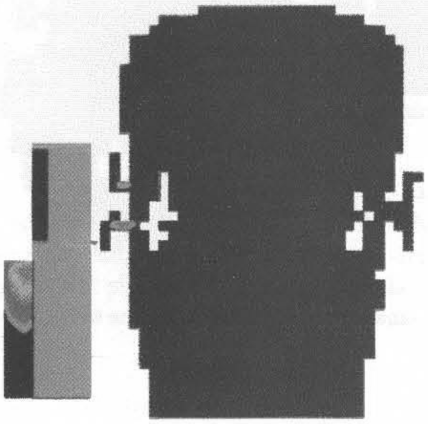

Fig. 5a). SAR - distribution in vertical cut for the BMMDPA

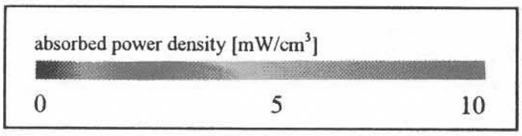

Fig. 6. Scale for the Fig.: 4a) b) and 5a) b).

As is clearly demonstrated, the peak power density absorbed in the head of the user is much smaller in the case of the BMMDPA. In the case of the monopole a relatively large amount of power is absorbed in the head, not only in the auricle, but also in the brain and along the cochlea.

The time averaged poynting vector for the monopole antenna is given in Fig 7a). The large amount of the power enters into head especially into brain and auricle. The main direction of the radiation is not full horizontally as in the case of the monopole with conductive plane. The handset radiates a little down.

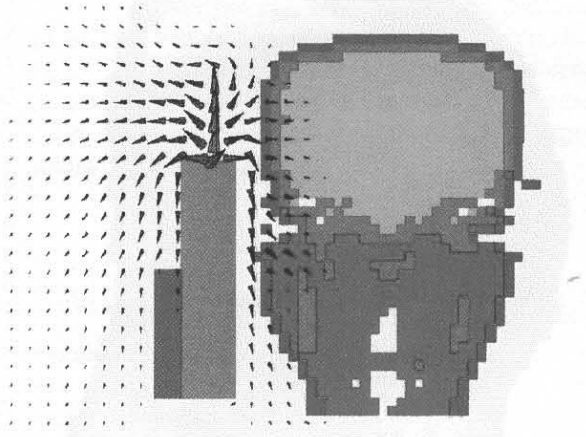

Fig. 7a). Power flow for the Monopole (time averaged poynting vector)

The power flow in the case of the BMMDPA in the same cut through the head as in previous figure is given in Fig. 7b). In comparison with the monopole antenna only very small part of power enters into head. On the other hand, the power entering into hand is larger in comparison with the monopole. Also in this case the main power flow is moved down from the clear horizontally direction

The logaritmic scale is the same for both figures {Fig. 7a) b)}.

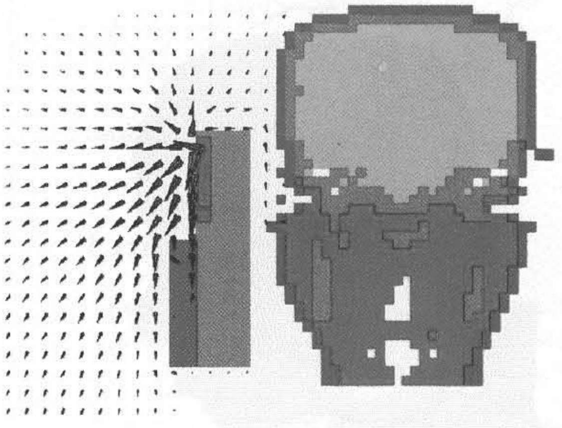

Fig. 7b). Power flow for the BMMDPA (time averaged poynting vector)

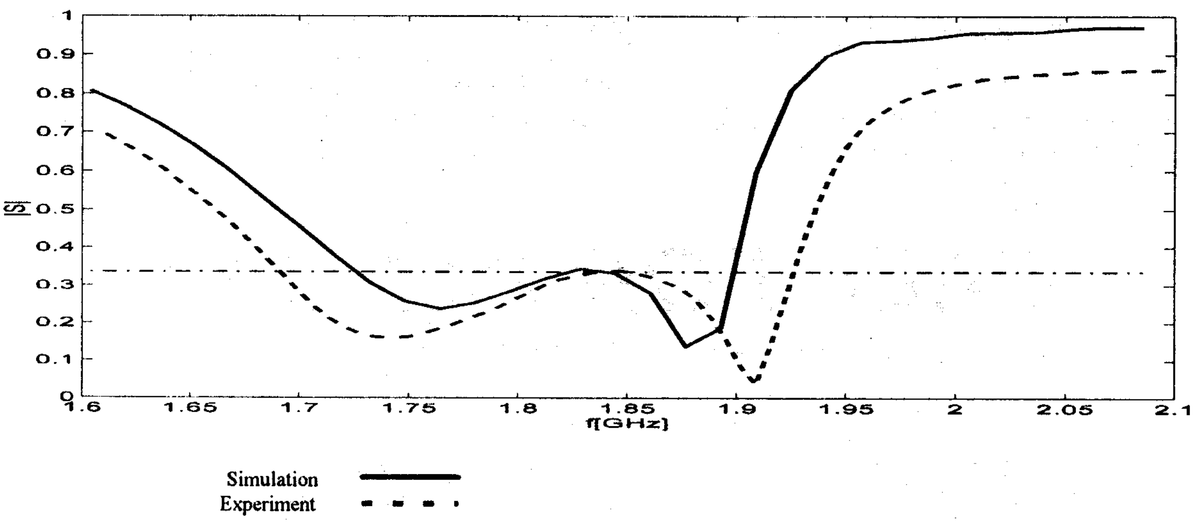

Fig. 8: Reflection coefficient of the model with BMMDPA

	Monopole	BMMDPA
absorbed power in the head	38 %	7 %
absorbed power in the hand	12 %	23 %
radiated power	50 %	68.3 %
conductor losses *	0 %	0.4 %
dielectric losses **	-	1.3 %

Table 1: Power balance for monopole and BMMDPA (* conductor: copper; ** tanδ = 0.001)

A conceal point of flat antennas for personal communication systems is bandwidth. To confirm the calculated results, both the simulated and the measured reflection coefficients are given in Fig. 8. For that purpose a model has been realized according to Fig. 1. The calculated and measured curves of Fig. 8 are obtained from realistic conditions with the handset in the hand of the ear.

Details about the radiated and absorbed power fractions are summarized in Table 1.

4. Conclusions

A backside-mounted microstrip double patch antenna (BMMDPA) offers a useful alternative to other antenna structures for portable phones. Thanks to the low permittivity, the high thickness of the substrate and the application of two radiation-coupled patches, the bandwidth of the BMMDPA is sufficiently large.

Compared to handsets with monopole antennas the following advantages can be stated:

*Reduced power in the head. The peak power densities are 10.6 mW/cm^3 and 1.5 mW/cm^3 for the monopole and the BMMDPA, respectively.

*Enhanced antenna efficiency of 70 % for the BMMDPA compared to 50 % for the monopole.

Up to now, most producers of handsets prefer monopole antennas or slight modifications.

However, as is demonstrated in this paper, this antenna type is disadvantageous from a medical point of view. Further, it wastes valuable battery energy only to heat the head.

References

[1] TAGA,T.: "Performance Analysis of a Built-in Planar Inverted F Antenna for 800 MHz Band Portable Radio Units, "IEEE Journal on Selected Areas in Communications, vol. SAC-5, no 5, June 1987.

[2] JENSEN, M.A. - RAHMAT-SAMII, Y.: "Performance Analysis of Antennas for Hand-Held Transceivers Using FDTD," IEEE Transactions on Antennas and Propagation, vol. 42, no. 8, August 1994.

[3] JENSEN, M.: "EM Interaction of Handset Antennas and a Human in Personal Communications," Proceeding of the IEEE, vol.83, no. 1, pp. 7-17, January 1995.

[4] RAHMAT-SAMII, Y.: "Antennas in Communications: Modern Development and Challenges," The Radio Science Bulletin, no.272, pp. 8-20, March 1995.

[5] FUHL, J. - NOWAK, P. - BONEK, E.: "Improved Internal Antenna for Hand-Held Terminals," Electronic Letters, vol. 30, no. 22, pp. 1816-1818, October 1994.

[6] WEILAND, T. et al.: "Finite Integration: Ein universell anwendbares Verfahren zur Berechnung elektromagnetischer Felder," VDE-Fachbericht 45, 109, 1993.

[7] SHTRIKMAN, I. - FRUECHTING, H.: "Comparative Study of Antennas for Hand-Held Telephones,"

[8] RUOSS, H.O. - LANDSTORFER, F.M.: "Slot antenna for hand held mobile telephones showing significantly reduced interaction with the human body" Electronic Letters, vol. 32, no. 6, pp. 513-514, March 1996.

About author...

Richard DLOUHÝ was born in Počátky, in 1970. He received the MSc. degree at Czech Technical University of Prague, in 1994. From October 1994 he is a postgraduate student at the Department of Electro magnitic Field of the CTU in Prague. From October 1995 he works in Laboratories for High Frequency Technology, University Erlangen-Nuernberg, Germany.