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DROP-SHAPED MONOPOLE ANTENNA AND ITS INTERACTION WITH THE USER'S HEAD

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ABSTRACT

This paper is dedicated to the EMC/EMI problems from the standpoint of the efficient and safe mobile equipment antenna structures development and to investigation of the influence of such antennas on the user's head. The dielectric monopole drop-shaped antenna has been proposed and the numerical investigations of its behavior taking into account its interaction with the feeding cable and user's head have been carried out. The corresponding EM problem is solved using Method of Auxiliary Sources (MAS) [1].

INTRODUCTION

For the antennas used in the modern personal communicational systems it is necessary to be small in size and have wideband radiation. For the real radiating systems simulation in the framework of EMC problems it is very important to take into account the interaction of the under study subsystem with the surrounding objects – in case of antenna these are the user's head, free space and the feeding cable.

In this paper we consider a drop shaped monopole antenna fed by the coaxial cable located in the close proximity of the user's head. The head is simulated by the IEEE Standard Head Model. The problem of obtaining a good matching of the antenna both with the feeding cable and free space has been resolved throughout the proper choice of the antenna shape. Also an attention was paid to the SAR distribution in the user's tissues. Based on MAS [1] the engineer-oriented software package has been created to perform the necessary numerical experiments.

NUMERICAL RESULTS

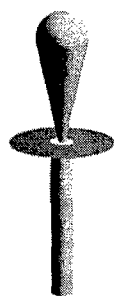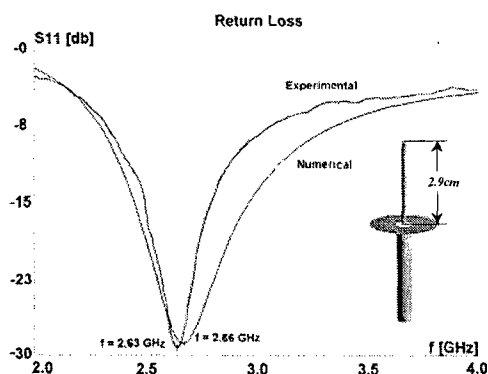In the [2,3] the drop shaped antenna covered with thin dielectric layer has been introduced and its diffraction properties have been investigated. The next stage of such type of an antenna development is a real antenna-cable structure simulation (Fig.1). In this paper the antenna of a certain type has been investigated and its properties versus its shape and material

Fig.1 Antenna geometry

Fig. 2. Comparison of the numerical and experimental measurements

parameters have been investigated. Varying the antenna shape one can control the Q-factor, while the dielectric layer of high permittivity helps to keep the antenna size small and shift the resonant frequency down.

The first step was investigation of a simplified flagpole antenna and comparison of the calculated data with that measured experimentally. Fig.2 shows the return loss versus frequency for this antenna.

Next, the numerical investigation of the given drop shaped antenna structure dependence on the various material and geometrical parameters have been performed. Fig.3 shows antenna return loss versus frequency for different antenna's width having its height fixed. In this
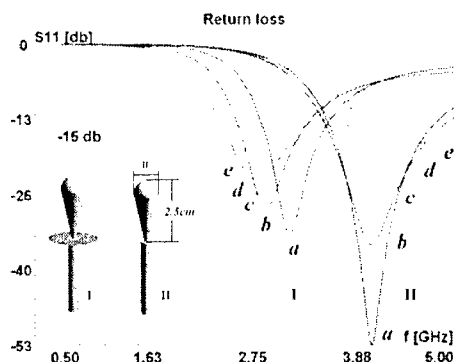
Fig. 3 Return loss versus frequency for different antenna's width
a)0.13cm b)0.4cm c)0.6cm d)0.8cm e)1.0cm

Fig.4 Near field distribution at the resonance frequency

figure there are two curve families corresponding to the two presented geometries of antennas. The leftmost and rightmost families correspond to the geometry I and II respectively. In the first case the cable is separated from the antenna by the metallic disk while in the second case antenna is directly connected to the cable. The numerical experiment shows that in the first case the resonance frequencies are shifted to the left compared to the second one. With the increase of antenna width the radiation band also increases and the radiation efficiency diminishes. In Fig.4 the near field at the resonance frequency for the case **II** is presented. Analysis of the near field structure have shown the absence of the reactive component in it that means that the antenna is well matched with the cable and free space.

Under the certain optimal choice of antenna's shape it is possible to increase the radiation frequency band. From the obtained results one can see that the resonance frequencies for the presented antenna (3.0-4.0 GHz) do not fit into to the current standards for mobile communications (0.9-2.8 GHz). In order to conform to them the electrical size of the antenna should be enlarged. This is possible by covering the antenna with the thin dielectric layer of high permittivity. In order to obtain good matching between the dielectric layer and the free space it is necessary for the corresponding wave impedance at the antenna surface to be equal to that of the free space. This can be achieved by the suitable choice of the layer's material parameters. Modern technology is able to provide a material with the negative permittivity. The created software allows for such media to be simulated.

The next aim of the investigations was to study the influence of the antenna on the user's head. The one of the main demands antenna must satisfy is the safety to the user -
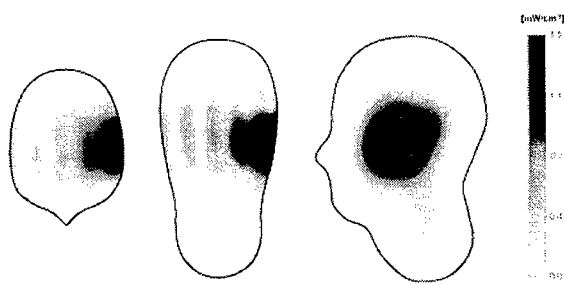
Fig.5 SAR distribution inside head at 1.0GHz   Fig.6 Radiation pattern

i.e. the SAR in the user's tissues must conform existing standards and be as low as possible. As a head model an IEEE Standard Head has been taken. Its averaged material parameters are $\varepsilon=45$, $\sigma=0.9S/m$. The Fig.5 and Fig.6 show the SAR distribution in different sections and radiated pattern when using a conventional monopole-style antenna at 1.0GHz. The absorbed energy in the head is approximately 70% of the feeding power. An optimized antenna structure for the SAR minimization has been developed. The corresponding results will be also presented.

CONCLUSION

The presented antenna configuration allows one development of the desired antenna structure, conforming to the EMC demands and possibly other restrictions applied. The radiating capabilities of the presented antenna prototype on its material and geometrical properties dependence have been studied. The real antenna-cable-head system has been investigated and EMC and SAR issues considered.

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