The use of the Expanding Grid FDTD Technique for Simulation of CAD-derived Personal Wireless Telephones

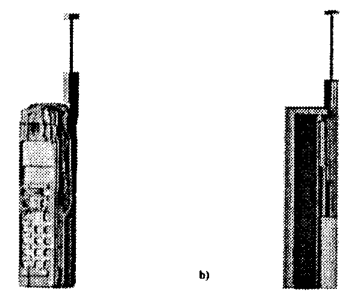
Adam Tinniswood, Gianluca Lazzi and Om. P. Gandhi
Department of Electrical Engineering, University of Utah
50 S CENTRAL CAMPUS DR RM 3280, SALT LAKE CITY UT
84112-9206, USA

Abstract - We have previously discussed our use of Computer Aided Design and Manufacturing (CAD/CAM) files for use in FDTD simulations of mobile communication devices. In this paper we address the problems involved with the description of the internal components of the mobile telephone. These are of particular importance as the outer plastic shell of the device is no longer metalized. This exposes the internal components and thus they should be included in the model which is used for numerical compliance testing of the device. The problem size when using CAD derived models can be somewhat larger than using a 'box' design as a higher resulution is required to maintain an accurate representation of the device. We also describe the use of an expanding grid FDTD algorithm to enable this large problem to be solved on a workstation.

Introduction

MOBILE telephones are now a part of everyday life for many people in both the United States and many other countries throughout the world. Following the recent decision by the U.S. Federal Communications Commission (FCC) the amount of power which can be absorbed in human tissue must not exceed 1.6 W/kg for any 1-g of tissue. Furthermore there is a requirement for compliance testing of all new personal wireless devices[1].

The use of numerical simulations is now of greater interest because of its important role in the development of new devices. The aim is to use FDTD techniques to give engineers the ability to determine whether the device will pass the national standards, whilst it is still in the design stage. The CAD file is useful as it can provide an accurate model of both the internal and external components of the device. Figure 1a shows an FDTD model imported from a CAD file of a commercial telephone.



a) b)

Figure 1: Two models of the telephone a) as imported from the CAD files and b) as derived from primitive shapes.

One of the limitations of this technique has been that it requires a high resolution to maintain the accuracy gained from the CAD file (as some of the plastic shells are thin they cannot be represented well if the resolution is too coarse). The result of this is a problem size which is not economically solvable on a normal UNIX workstation. Although our group regularly makes use of a parallel FDTD code running on an IBM-SP2, we have also applied an expanding-grid FDTD algorithm [2] for use specifically with these types of simulation.

The expanding grid FDTD code allows one area of the simulation to be carried out with a high resolution, whereas the cell size in other parts of the problem is much coarser. This is possible as when you move away from the region which requires a high resolution (in this case the coupled region), the cell size gradually increases to that in the coarser regions. This is possible because there is only a small volume of the whole problem which requires such a high resolution (of around 1mm). This volume is that where the telephone and the head are in closest proximity and is termed the coupled region.

In order to determine the accuracy of the CAD imported model and the expanding grid FDTD code we have run a series of simulations. The first comparison we make is between the CAD-derived telephone and a similar model derived from simple primitives (rectangles and cylinders) but representing the same device. This model is shown in figure 1b and the results are compared in Table 1.

Table 1: A comparison of the resuls from a numerical compliance testing simulation, using the CAD and the 'Box' derived telephones. The simulations were carried out at 1900 MHz, with the time-averaged power being normalized to 125 mW. In this case the telephone antenna is completely pulled out.

Antenna Up	Box Phone	CAD Phone	CAD Phone (EG)
1g SAR	0.64 W/kg	0.78 W/kg	0.79 W/kg
Power Absorbed in the Head	31.4 %	33.1 %	32.3 %
Power Absorbed in the Hand	18.1 %	18.4 %	18.0 %
Total Power Absorbed	49.5 %	51.5 %	50.3 %
Power Absorbed in the Ear (as a percentage of that in the head)	19.1 %	19.4 %	19.6 %

As can be seen from this table the results from the 'box' telephone (derived from primitives) and the CAD derived telephone are similar. The only major difference is in the 1-g SAR, which is a result of the accuracy of the area around the antenna. The simple rectangular shapes used in the primitive derived model allows for greater shielding around the antenna than the CAD derived model. The CAD-derived model more accurately represents the edges of many of the metallic components in the phone and thus provides less shielding.

The final column of Table 1 shows the results from the expanding grid FDTD code. Here we see that the results are almost exactly the same as those for the normal FDTD simulation. Finally in Table 2 we show the amount of memory required by normal FDTD- and the Expanding Grid techniques, the latter with and without use of the truncated model[3].

Table 2: The problem size of both the expanding-grid FDTD code, the truncated expanding grid FDTD code and the parallel FDTD code

	Problem Size(cells)	Memory (MBytes)	Saving Factor
Full Model	$250 \times 220 \times 200$ (12,100,000)	319	-
EG	$120 \times 100 \times 100$ (1,200,000)	32	10.1
TEG	$50 \times 100 \times 100$ (580,000)	16	20.9

Conclusions

We have demonstrated that using CAD files to derive models for use in FDTD simulations can be very useful. These files produce much greater accuracy than that available using either a simple plastic coated metal box design, or deriving the model from engineering drawings. They also minimise the amount of time which must be spent developing the model. For example, it can take as little as 30 minutes to go from getting the CAD files to having a model for use in an FDTD simulation. We have also shown that by using the expanding grid FDTD technique, this problem can be run on a normal workstation, while maintaining a high resolution in the coupled region.

References

[1] Federal Communication Commission, "Guidelines for Evaluating the Environmental Effects of Radio-frequency Radiation," FCC 96-326, August 1, 1996.

[2] B.Q.Gao and O.P.Gandhi, "An Expanding-grid Algorithm for the Finite-Difference Time-Domain Method," IEEE Transactions on Electromagnetic Compatibility, Vol. 34, pp. 277-283 1992.

[3] G.Lazzi and O.P.Gandhi, "Realistically tilted and truncated Anatomically-Based Models of the Human Head for Dosimetry of Mobile Telephones, " IEEE Transactions on Electromagnetic Compatibility, Vol. 39, pp 55-61, 1997.