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MODELLING OF A MICROSTRIP PATCH ANTENNA USING A HYBRID FDTD/PEEC METHOD

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Abstract

A hybrid technique combining FDTD and PEEC methods is applied to the prediction of radiation from printed structures. The predicted radiation patterns of a microstrip patch antenna are compared to those obtained using FDTD.

1 Introduction

The Finite Difference Time Domain (FDTD) method [1] is a widely used, versatile method for the electromagnetic analysis of large and complex structures. Over recent years many advances have been implemented in order to extend the range of applicability, particularly to small and curved metal structures. Nevertheless, for the analysis of structures such as Printed Circuit Boards (PCBs) and Integrated Circuits (ICs) the fine detail of the geometry presents severe obstacles to the use of the method.

In contrast to this, the PEEC approach is well suited to analyse electrically small structures with fine geometrical detail and can do so much faster than the FDTD method. However, as with other integral methods, it can suffer from numerical instability [2]. Also, retardation effects become significant when analysing structures whose size is significant compared with the wavelength of interest, since the time taken for the electromagnetic radiation to propagate through the structure has to be taken into account.

In a previous contribution [3] a new approach was introduced which enhances FDTD by including a generalisation of the "thin wire formalisms" originally introduced by Holland and Simpson [4] and further developed by several groups eg. [5] [6] including University of Bristol [7]. This was aimed at allowing complete circuits to be included within the FDTD method in a rigorous and efficient manner. In this contribution, it is shown that the radiation from a printed antenna can also be efficiently predicted using this method. This is particularly important when addressing EMC problems where near field radiation can cause interference with neighbouring systems.

2 The Hybrid method

The method is described in [3] and can be considered as an extension to the "thin-wire formalisms" [4] in such a way as to allow more complex structures, such as microstrip circuits, to be analysed. Alternatively it can be viewed as a hybrid between the FDTD method and the PEEC method [8]. In [3] it was shown that such a hybrid can overcome the disadvantages of the individual methods while maintaining their strengths. The fine detail is handled by the PEEC aspect of the hybrid while the longer range interactions are handled by the FDTD aspect. In this way there is no need to account for retardation in PEEC which is known to seriously complicate the method.

3 A microstrip patch antenna

As an example for investigating the method when applied to the prediction of radiation from a printed structure, a microstrip fed patch antenna was chosen. The resonant frequency is approximately 1.5GHz. The antenna was characterised using a basic FDTD method with a graded mesh designed to allow good resolution of the metal edges, including the narrow feed line and also by using the hybrid method with a much coarser mesh chosen to have a size of approximately $\lambda/10$ at the resonant frequency. Plan views of the antenna embedded in each of these meshes is given in Figure 1 and Figure 2.

It can be seen that the coarse mesh is not fine enough to resolve the feedline or the exact position of the edges of the patch adequately if the basic FDTD method is used.

The normalised radiation patterns in the two principal planes and for the two polarisations are shown in Figure 3 and Figure 4. In each case the results obtained by using FDTD with the graded grid and those obtained using the hybrid method with coarser grid are shown. It can be seen that, although there are some discrepancies, the results are encouraging.

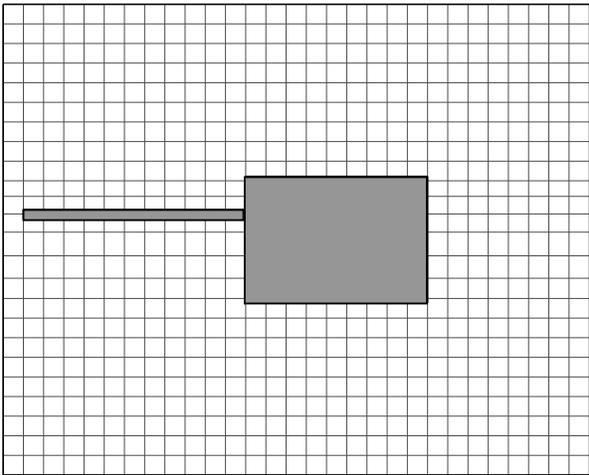


Figure 1 - The patch antenna in the coarse FDTD mesh

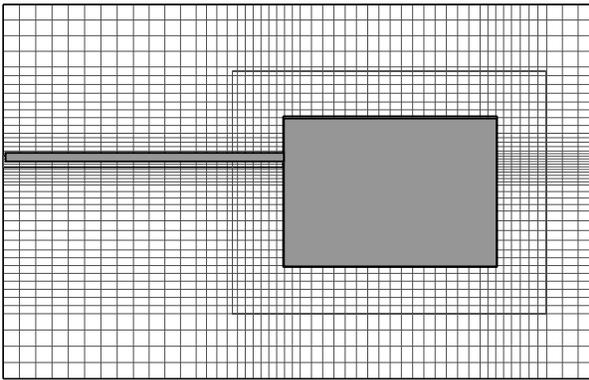


Figure 2 - The patch antenna in the graded FDTD mesh

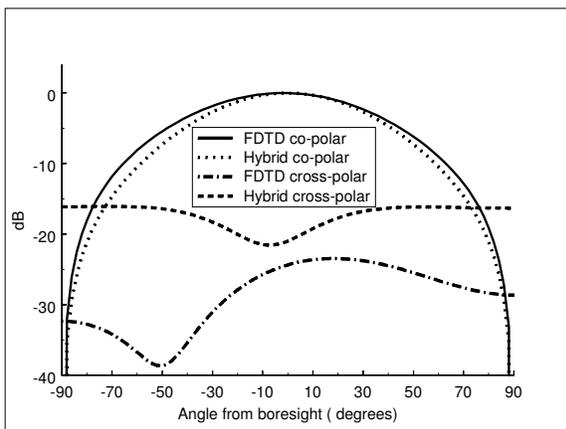


Figure 3 - H plane normalised radiation pattern

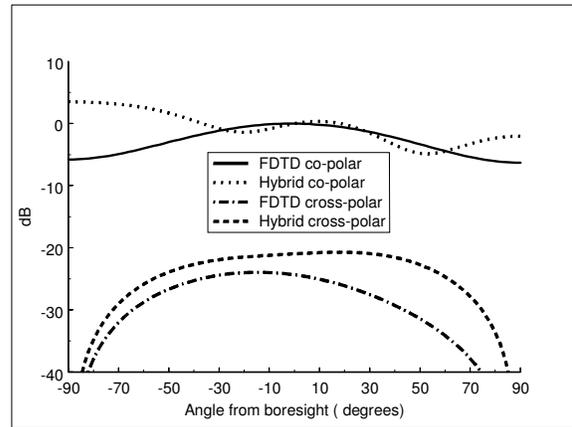


Figure 4 - E plane normalised radiation pattern

4 Conclusions

In this contribution it has been shown that the hybrid FDTD/PEEC approach is capable of predicting the behaviour of radiating printed structures. Future work will build upon this and be aimed at improving the accuracy.

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