

Examples of HBEM application for multilayer problems solving

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Abstract—The hybrid boundary element method (HBEM) is developed at the Faculty of Electronic Engineering of Niš. The method is based on the combination between equivalent electrodes method (EEM) and boundary element method (BEM). As an illustration of the HBEM application, the method is used for several multilayer problems solving. The obtained results will be presented graphically, in the tables and compared with the finite method results as well as the values already reported in the literature.

Keywords—Coupled microstrip line; equivalent electrodes method (EEM); finite element method (FEM); hybrid boundary element method (HBEM); multilayer problems

I. INTRODUCTION

Multiconductor transmission lines in multilayered media can be analysed using the conformal mapping [1], the variational method [2], the Fourier transform method [3], the Fourier integral method [4], the generalized spectral domain analysis [5], the moving perfect electric wall method [6], the integral equation method [7], etc. An application of boundary element method (BEM) [8] usually contains singular and nearly singular integrals whose evaluation is difficult although original problems are not singular. In order to avoid numerical integrations, it is possible to substitute small boundary segments by total charges placed at their centres. The Green's function for the electric scalar potential of the charges, placed in the free space at the boundary of two dielectrics, is used and the proposed method is called the hybrid boundary element method (HBEM) [9].

This method presents a combination of the BEM and equivalent electrodes method (EEM). The basic idea is in replacing an arbitrary shaped electrode by equivalent electrodes (EEs), and an arbitrary shaped boundary surface between any two dielectric layers by discrete equivalent total charges per unit length placed in the air. The basic Green's function for the electric scalar potential of the charges placed in the free space at the boundary surface of two dielectrics is used. The method is based on the EEM, on the point-matching method (PMM) for the potential of the perfect electric conductor electrodes and for the normal component of the electric field at the boundary surface between any two dielectric layers.

The HBEM is applied, until now, to solve multilayered electromagnetic problems [10], grounding systems [11], for electromagnetic field determination in vicinity of cable terminations [12], as well as to calculate the microstrip lines parameters [13]. The HBEM can be also applied to analysis

of corona effects [14] and metamaterial structures [15].

As an illustration of the HBEM application, the method is used, in this paper, to analyze a few multilayer problems.

II. HBEM APPLICATION

The HBEM application is described in detail in [9]. In the full paper, the procedure for this method application will be shown. In this extended abstract, only two examples are analyzed using the HBEM and some of the obtained results will be presented.

A. Example 1 – Line charge in multilayered media

Consider a line charge placed in the area 1 near the area 2 of rectangular cross-section, Fig. 1.

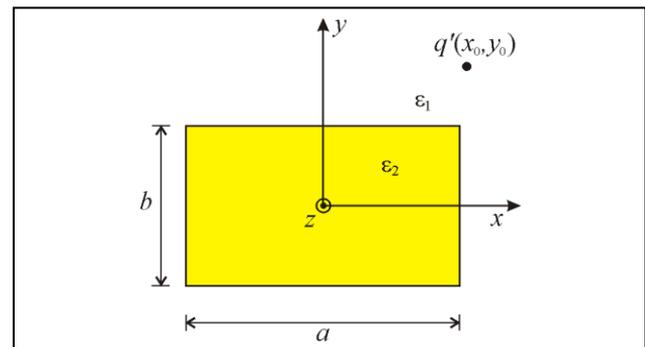


Figure 1. Line charge in multilayered media.

Applying the HBEM it is possible to determine the potential and electric field distribution in vicinity of the line charge. The equipotential curves are shown in Fig. 2, for parameters: $\epsilon_{r1} = 1$, $\epsilon_{r2} = 3$, $b/a = 0.5$, $x_0/a = 0.7$ and $y_0/a = 0.35$.

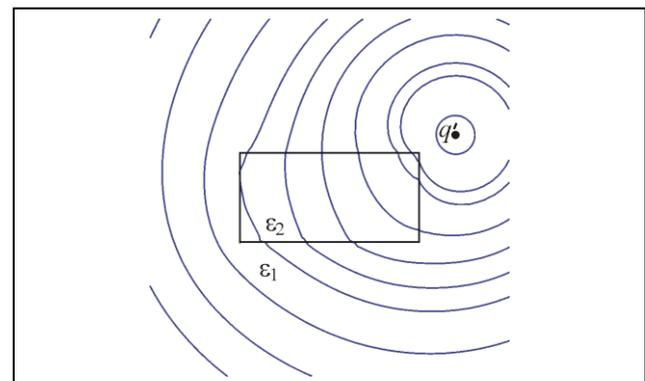


Figure 2. Equipotential contours in vicinity of line charge.

B. Example 2 – Coupled microstrip transmission line

One of the possible methods to reduce a decoupling between a two-conductor microstrip transmission line is by employing a rectangular dielectric notch between the conductors [16], Fig. 3. Applying the HBEM, it is possible to calculate the characteristic impedance and effective dielectric permittivity of this microstrip line.

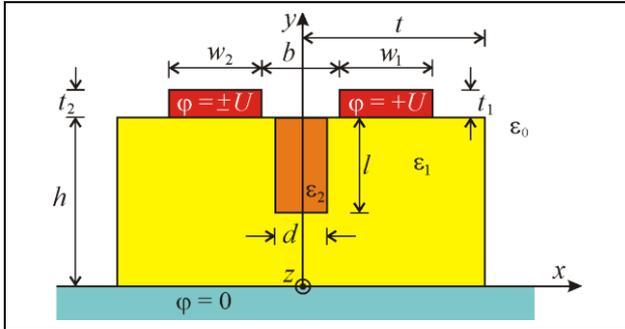


Figure 3. Two-conductor microstrip line.

Equipotential contours are shown in Figs. 4 and 5 for even and odd modes, respectively, for parameters:

$$\begin{aligned} \epsilon_{r1} = 2, \quad \epsilon_{r2} = 6, \quad h/w_1 = 2.0, \quad t_1/w_1 = 0.1, \\ w_2/w_1 = 1.0, \quad t_2/w_2 = 0.1, \quad d/w_1 = 0.5, \quad l/w_1 = 1.0, \\ t/w_1 = 2.5 \text{ and } b/w_1 = 1.0. \end{aligned}$$

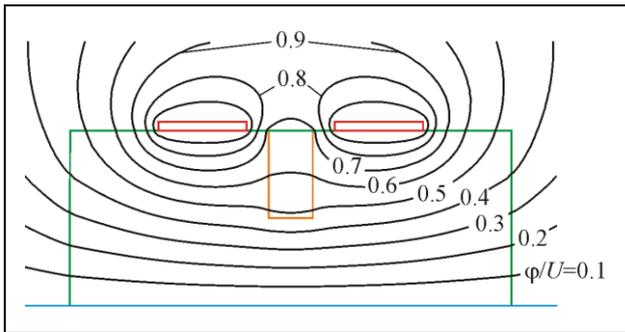


Figure 4. Equipotential contours (Even mode).

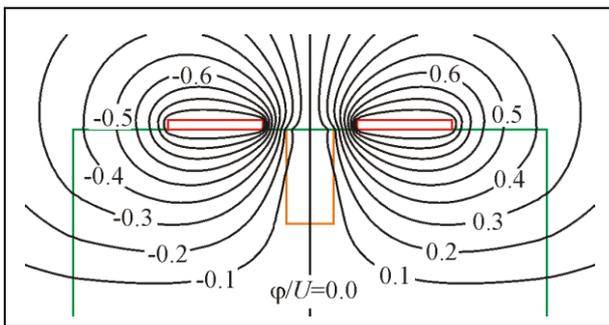


Figure 5. Equipotential contours (Odd mode).

III. CONCLUSION

The HBEM is applied to 2D analysis of multilayer problems. The obtained values have been compared with those obtained by the finite element method [17] and the values already reported in the literature. A very good agreement of the results is achieved.

Different from the finite element method, application of the HBEM always have a kernel matrix of diagonally dominant form. This leads to a better conditioned system of

linear equations and computation time several times shorter comparing to the case of finite element method application. That makes the application of hybrid boundary element method very efficient in the multilayer problems analysis.

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