FLEXIBILITY IN THE CHOICE OF GREEN'S FUNCTION FOR THE BOUNDARY ELEMENT METHOD

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ABSTRACT

A more useful Green's function is choosen for quasi-static analysis of the shielded planar transmission lines by the bounary element method. The new employed Green's function satisfies the forced boundary conditions in a rectangular region. In this way, it is shown that not only the the integral path can be performed merely along the line where the strip locates, but the integral equation is also simplified. The proposed method is useful to characterize multilayered structure. Finite metallization thickness can also be treated.

Introduction

Recently, boundary element method has been caused much attention in the analysis of planar transmission lines in M.M.I.C. applications [1-4]. For quasistatic analysis, the wave equation in each region is converted into an integral over the associated boundary by way of Green's second identity. Usually, the free space Green's function is choosen as the adjoint field. In [4], we presented a modified boundary element method. The Green's function for a rectangular trough region was employed. Since the Green's function is forced to satisfy the boundary condition along the shielding plane, the boundary integral can thus be performed merely along the line where the strip locates. In this paper, it is investigated that a more useful Green's function can further be used to simplify the boundary integral equation. It can also be used to analyze the multilayered structure.

Taking microstripline as an example, the new employed Green's funtion satisfies the forced boundary conditions in a rectangular region. The rectangular contains three electric walls and one magnetic wall. For multilayered structure, a rectangular with two electrical walls and two magnetical walls is also needed.

Formulation

The cross section of a shielded microstripline by a perfect conductor is considered. In each region, the electric potential $\phi_i(x,y)$ (i=1,2) satisfies the Laplace's equation, and can be expressed as an integral over each associated boundary. In [4], we have shown that suitable choice of the fundamental solution (Green's function) will simplify the integral path along the interface plane only (1.e. along CBAF).

Although the Green's function in [4] reduces the integral path, it has one major drawback. Namely, it is not easy to extend to the multilayered structure. It is investigated below that this drawback can be avoided by a new Green's function. This new Green's function also leads to a simplified boundary integral equation.

In Fig.1, the subdomain S_i with contour Γ_i (i=1,2) is homogeneously filled with loss-free dielectric medium. Inside each region S_i(i=1,2), Laplace's equation

$$\nabla^2\phi_i=0 \qquad (1)$$

holds, where ϕ_i denotes the electrostatic potential. Green's second identity over S_i can be expressed as

$$\iint [\varphi_i(\nabla^2\phi_i)-(\phi_i\nabla^2\varphi_i)]ds_i$$

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$$=\oint [\varphi_i(\partial\phi_i/\partial n_i)-\phi_i(\partial\varphi_i/\partial n_i)]d\Gamma_i \qquad (2)$$

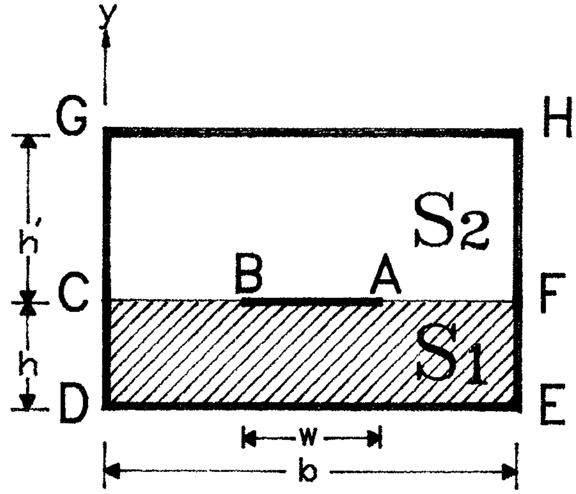

Fig.1 Cross section of a microstrip line.

where φ_i is a suitable adjoint field and $\partial/\partial n_i$ the derivative in the positive normal direction. In [4], φ_i was choosen to satisfy the boundary condition on the outside shielding plane. i.e. $\varphi_1=0$ along CDEF and $\varphi_2=0$ along CGHF. It is investigated that if we further requires that $\partial\varphi_i/\partial y=0$ along CBAF, many benifits can be taken from it. Note that $\phi_i=0$ along the grounding part in each region and $\partial\varphi_i/\partial y=0$ along the interface plane. Considering the limiting case, Eq.(2) now takes the following form

$$\phi_i(x,y=0)/\epsilon_i = \int \varphi_i(x,x';y=0)[\partial\phi/\partial n] \quad dx' \qquad (3)$$

, where n=y for i=1 and n=-y for i=2, ϵ_i is the permittivity in the i-th region. The integral path is along the interface plane only and the only unknown function in the integrand of the above equation is $\partial\phi/\partial n$, or the normal component of the electric field. Eq.(3) can be used to numerically solve for $\partial\phi/\partial n$, the procedures are well documented in the literature [1-4]. However, one may note that half work in calculating the matrix element from Eq.(3) can be saved as the integrand of Eq.(3) do not contains the scalar potential function.

Extention of the proposed method for quasi-static analysis of multilayered shielded structure is easy. For an N-th layered structure, the Green's function mentioned above can directly be used for the top and the bottom layer. For the remaining N-2 layers, the Green's function should satisfy the boundary conditions with two electrical walls in the outside shielding planes, while two magnetic walls are placed in the other two sides of a rectangular region.

Numerical Results

Table 1 shows the calculated results. Good agreements are found with the open literature.

Table 1

Comparison of characteristic impedance (Z_o) and normalized guided wavelength values with results by other method (Dimensions in mils, b=20h+w, h'=10h)

w	h	ϵ_r	Z_o [5]	Z_o this paper	λ_g/λ_o [5]	λ_g/λ_o this paper
10	67	2.9	165.9	163.5	0.693	0.695
15	14	4.7	67.2	67.4	0.546	0.547
22	19	4.3	67.2	67.4	0.567	0.565
20	31	4.7	84.4	83.7	0.554	0.568

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