An efficient modelling of microstrip antenna

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Summary

For microstrip antenna modelling, Generalized pencil of function (GPOF) method is used to avoid numerical integration of highly oscillatory integrals representing electric field due to a current source in a layered dielectric medium. An efficient and accurate implementation of GPOF method is affected by subtracting the poles singularities in computation arising from the interfaces just above and below a current source (microstrip) as well as of the interface if a source lies on it. Numerical examples show the high accuracy of GPOF method through annihilation procedure.

Introduction

In modelling microstrip antenna in a layered dielectric medium we need to compute electric field $\bar{E}(\bar{r})$ at a field point $\bar{r}$ due to a source current $\bar{J}(\bar{r}')$ at $\bar{r}'$:

$$\bar{E}(\bar{r}) = \int_{S'} \pi(\bar{r},\bar{r}')\bar{J}(\bar{r}')\mathrm{d}S'. \tag{1}$$

Here S' is a current surface. The representation of $\pi(\bar{r},\bar{r}')$ is given by the following:

$$\pi(\bar{r},\bar{r}') = \frac{1}{2\pi}\int_0^\infty \tilde{\pi}(\bar{r},\bar{r}')\lambda J_0(\lambda\rho)\mathrm{d}\lambda. \tag{2}$$

Here ρ is the horizontal separation between the field point and the source point, and λ is an integration variable. J_0 is the Bessel function of first kind and of zero order. Due to the pole singularities in $\tilde{\pi}(\bar{r},\bar{r}')$, computation of equation (2) becomes time consuming.

Computational Procedure

For reduced singularity, we modify equation (2) to the following form:

$$\pi(\bar{r},\bar{r}') = \frac{1}{2\pi}\int_0^\infty [\lambda(\tilde{\pi}(\bar{r},\bar{r}') - \tilde{\pi}(\mathrm{half})]J_0(\lambda\rho)\mathrm{d}\lambda + I(\mathrm{half}). \tag{3}$$

The subtracted term in the above integral is added through $I(\mathrm{half})$ which is written as

$$I(\mathrm{half}) = \frac{1}{2\pi}\int_0^\infty [\sum_{ID=IS-1}^{IS+1} \frac{1}{\bar{\sigma}(ID-1)\gamma(ID) + \bar{\sigma}(ID)\gamma(ID-1)}]\lambda J_0(\lambda\rho)\mathrm{d}\lambda. \tag{4}$$

Here IS denotes a layer at a source level $Z(IS)$ and $\bar{\sigma}$ and γ are conductivity and propagation constant of a layer. The annihilating procedure in equation (3) reduces pole singularities in computing the integral. $I(\mathrm{half})$ is evaluated analytically (given elsewhere)

Numerical computation

A fast recursive scheme has been developed to compute $\tilde{\pi}(\bar{r},\bar{r}')$ (cf. eqation (3)). Using GPOF method we obtain M pairs of complex residues a_i and complex poles b_i for the approximation $\lambda(\tilde{\pi}_{(x',z')} - \tilde{\pi}(\mathrm{half})) = \sum_{i=0}^{M} a_i \exp(\lambda b_i)$. Substituting this approximation in equation (3), application of Lipschitz's integral yields analytical solution of the integral in equation (3). Approximation in equation (5) is crucial for accuracy of the present computation. Annihilation procedure in equation (3) provides convergence in the GPOF method approximation. Using a unit current source in a large number of layered dielectric models, we have computed this approximation. A maximum error of less than 0.5% is achieved. Several models of microstrip antennas in layered dielectric are computed. It is seen that currents in a microstrip antenna is larger compared to currents in an antenna in free-space, .

Conclusion:

Subtracting pole singularities in electric field computations, GPOF method provides an efficient and accurate tool for modelling microstrip antennas. Adding the subtracted terms through the analytical solution, poles relating to surface waves are implicitly included in the computation. In contrast to an antenna in free-space in which only vortex currents exist, poloidal currents, in addition to the vortex currents, are fed into a microstrip antenna through the supporting dielectric medium. Thus, compared to a free-space antenna, a larger magnitude of current is generated in a microstrip antenna .