ANALYSIS OF MICROSTRIP ANTENNAS USING MOMENT METHOD

Martin Štumpf
Master Degree Programme (4), FEEC BUT
E-mail: xstump00@stud.feec.vutbr.cz

Supervised by: Zbyněk Raida
E-mail: raida@feec.vutbr.cz

ABSTRACT

In this paper, the method of moments in the frequency domain (MoM-FD) is used to analyze a simple microstrip antenna of a rectangular shape in Matlab. Rao-Wilton-Glisson (RWG) basis functions are used to approximate the current density on the PEC surface of the microstrip antenna.

1. INTRODUCTION

Microstrip antennas consist of a conducting patch on the top surface of a dielectric substrate. On the bottom surface of a dielectric substrate, a continuous metalic layer plays the role of the ground plane.

For an approximate analysis of the patch antenna, a cavity model or a wire grid model can be used. In order to perform more accurate analysis, Maxwell's equations in the differential form have to be numerically solved by the finite difference method (FDM) or by the finite element method (FEM). In case of the integral formulation of the problem, the method of moments (MoM) can be applied. This paper concentrates on the exploitation of the MoM-FD only.

The moment method is mainly used for the numerical solution of integral equations. MoM is of the variational nature. As a result, the integral equation is converted to a matrix equation.

2. NUMERICAL SOLUTION

The intensity of the scattered electric field $\mathbf{E}_s$ can be computed from the scalar potential V and the vector potential $\mathbf{A}$ [1]:

$$\mathbf{E}_S = - \ \omega \ - 7 \ , \tag{1}$$

A contribution of the current surface density $\mathbf{J}_s$ to the antenna radiation is described by the vector potential [1]

$$\mathbf{A}(\mathbf{r}) = \int_S \mathbf{G}_A(\mathbf{r}\,|\,\mathbf{r}') \cdot \mathbf{J}_s(\mathbf{r}')\, dS' . \tag{2}$$

A contribution of the charge surface density σ_S to the antenna radiation is described by the scalar potential [1]

$$V(\mathbf{r}) = \int_S G_V(\mathbf{r}\,|\,\mathbf{r}')\, \sigma_s(\mathbf{r}')\, dS' . \tag{3}$$

In the relations (2) and (3), $\mathbf{G}_A$ is the dyadic Green's function, G_V is the scalar Green's function, **r** denotes the position vector of the observation point (the scattered field is computed here), **r**' is the position vector of the source point (currents and charges in the role of radiation sources are located here), and S is the surface of the analyzed structure.

The surface charge density is related to the surface current density by the continuity theorem [1]:

$$\nabla \cdot \mathbf{J}_s = -j\omega\sigma_s . \tag{4}$$

The integral equation (1) is called electric field equation (EFIE). With the respect of the boundary condition $(\mathbf{E}_{tot})_{tan} = 0$ on S , it will be numerically solved by MoM-FD, where $\mathbf{E}_{tot}$ is the total electric field intensity on the surface of the antenna.

For the numerical modeling of planar antennas RWG basis functions are convenient to be used. The surface current distribution on the surface S of a microstrip antenna can be approximated by [2]:

$$\mathbf{J} \approx \sum_{n=1}^{N} I_n \mathbf{f}_n(\mathbf{r}), \tag{5}$$

where N is the number of interior edges and I_n is the unknown coefficient, which may be interpreted as the normal component of current density flowing past the n-th edge. The RWG basis function $\mathbf{f}_n(\mathbf{r})$ is defined on a triangular pair surface segment as follows [2]:

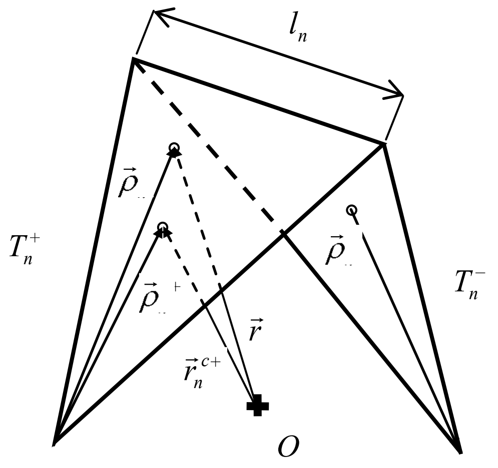

Fig. 1: RWG basis function.

$$\mathbf{f}_n(\mathbf{r}) = \begin{cases} \dfrac{l_n}{2A_n^{\pm}} \boldsymbol{\rho}_n^{\pm} & \vec{r} \text{ in } T_n^{\pm} \\ 0 & \text{otherwise} \end{cases} . \tag{6}$$

Here, l_n is the length of the n-th common edge of the triangle pair $T_n^{\pm}$, $\boldsymbol{\rho}_n^{\pm}$ are the position vectors and $A_n^{\pm}$ denotes the areas of the triangles $T_n^{\pm}$ (See Fig. 1).

When the expansion and the testing procedure are carried out the linear system of equations is obtained.

3. RESULTS

The microstrip antenna of the dimensions (0.20 x 0.20) m was analyzed in Matlab. The height of the substrate was 1.6 mm with the relative permittivity $\varepsilon_r = 1$. The simple feeding model was used to simulate the probe feed (Fig. 2). The 3-D model of the microstrip antenna was covered by 2106 triangles with 3067 interior edges. The impedance characteristics are depicted in Fig. 3. The microstrip antenna is in the resonance at the frequency $f = 0.905$ GHz. At this frequency the input impedance is real, $\boldsymbol{Z} = 91\ \Omega$.

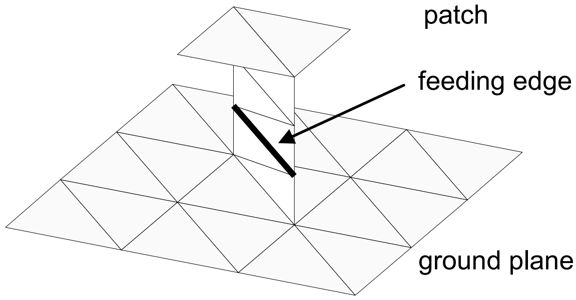

Fig. 2: Feeding model.

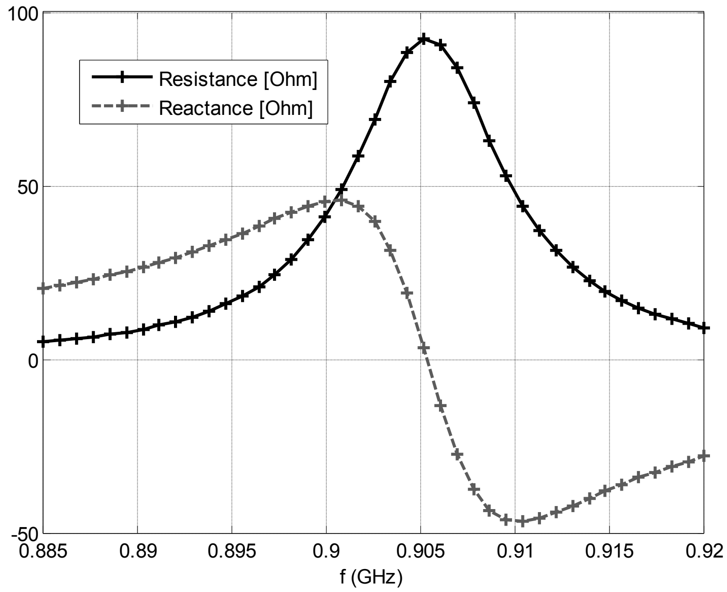

Fig. 3: Input impedance of microstrip antenna.

REFERENCES

[1] Černohorský, D., Raida, Z., Škvor, Z., Nováček, Z. Analýza a optimalizace mikrovlnných struktur. Brno: VUTIUM, 1999, ISBN 80-214-1512-6

[2] Rao, S. M., Wilton, D. R., Glisson, A. W. Electromagnetic scattering by surfaces of arbitrary shape. IEEE Transactions on Antennas Propagation, 1982, vol. 30, no. 5, p. 409-418.