An Efficient Integral-Equation Approach for a Coaxial Probe Feed on an Infinite Microstrip Line

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This work will present and discuss a formulation of the electric field integral equation (EFIE) for an infinite microstrip line excited by a vertical probe, where the surface currents on both the strip and the probe are taken as unknowns. The EFIE is enforced over the finite surface of the probe in addition to the infinite surface of the strip. The entire structure (probe + microstrip line) is excited by a disc of azimuthal magnetic surface current located on the ground plane at the bottom of the probe, which models the excitation of the probe by the TEM mode in a practical coaxial cable feed.

In a direct moment-method solution, the infinite nature of the microstrip line would result in many unknowns on the surface of the line. This is especially true at high frequency, where the continuous-spectrum current on the line may extend to appreciable distances from the source. An alternative is to use a semi-analytical formulation in which a Fourier transform (FT) in the longitudinal (z) direction is applied. Such an approach has been previously used to solve for the current excitation on an infinite microstrip line by a gap voltage source. For the gap source the method yields the FT of the strip surface current $\tilde{\mathbf{J}}_s(x, k_z)$ in closed form when the transverse transverse (x) profile of the FT of the surface current on the line is described by a single basis function, and a small matrix equation that must be solved to obtain $\tilde{\mathbf{J}}_s(x, k_z)$ when multiple basis functions are used. The strip surface current $\mathbf{J}_s(x, z)$ is then obtained by a numerical integration in the k_z plane to perform the inverse FT.

The main difficulty in the probe-excitation problem is that the metallic probe breaks the translation symmetry in the longitudinal direction. However, the equivalence principle may be applied, in which the metal probe is removed and the (unknown) surface currents on the probe are retained. The infinite strip is then viewed as being excited by both the magnetic surface current on the ground plane and the probe surface current. The FT technique may then be applied to treat the infinite strip surface. The transverse current profile of the FT of the strip current is represented by a small set of basis functions, and the unknown probe current is also expanded into a set of basis functions for the unknown vertical (y) dependence of the probe current. This results in a system of linear equations that can be directly solved to obtain the probe current and the FT of the strip surface current.

Results will be presented to show the nature of the current excited on the microstrip line by the probe at high frequency. Results will also compare with those obtained by using simpler models in which the current profile on the probe is assumed to be known. Assumed profiles include the uniform current, the cosine profile, and the profile obtained by consideration of the probe in an infinite parallel-plate waveguide.