Abstracts

A Parallel-Plate Waveguide Approach to Microminiaturized, Planar Transmission Lines for Integrated Circuits

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The parallel-plate waveguide with a two-layer loading medium, a conducting semiconductor substrate, and a relatively thin dielectric layer approximates the interconnections in many integrated systems if the fringing fields are ignored. The fundamental mode of this structure is an E mode which is a surface wave. Its propagation behavior is analyzed in this paper and the equations are evaluated by highly accurate numerical methods. The semiconducting substrate is characterized by its dielectric constant and conductivity. A critical conductivity sigma/sub min/ exists and is related to the cross sectional and material parameters. If the substrate conductivity is given by sigma/sub min/ then the attenuation constant of the line is a minimum. The same value of conductivity yields minimum phase distortion at maximum bandwidth. If the conductivity is larger than sigma/sub min/ the substrate acts as a poor conductor with associated skin effect; if it is smaller, lossy dielectric behavior results. Analysis shows that it is appropriate to subdivide the frequency range into three intervals. The lowest-frequency interval is characterized by propagation which resembles diffusion. This is caused by the loss in the dielectric layer. The next frequency range extends to some upper frequency which is determined by substrate conductivity and the cross-sectional dimensions. In this interval, the phase velocity of the fundamental mode is controlled by the ratio of dielectric to semiconductor thickness, which, if typical interconnections are considered, implies a very low velocity. This property indicates that the structure can serve as a delay line. Further increases in frequency result in higher phase velocities. Skin effect and dielectric loss behavior describe the propagation in this third interval.

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