Loss Estimation of Finite Length Microstrip Line Using the FDTD Method

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Abstract

When the length of microstrip line is finite, some transmission losses are observed even for the lossless (zero conductor and dielectric loss) microstrip line. This paper discusses the mechanism of how these losses are generated. The surface wave loss and the radiation loss are evaluated by using FDTD via the Poynting vector.

1. Introduction

It is well known that both conductor loss and dielectric loss are essential factors in lossy microstrip line. On the other hand, lossless transmission line does not suffer from these losses at any length and frequency. When the line length is finite, however, some transmission losses are observed even for the lossless microstrip line. It means that a part of the input power is transformed into other modes, which may cause cross talk unexpected radiation, resonance etc, in PCB. This paper discusses the mechanism of how these losses are generated in the finite length microstrip line. The surface wave loss and the radiation loss are evaluated by using FDTD via the Poynting vector.

In Section 2 of this paper, a brief review of FDTD method adapted for lossless microstrip line analysis is presented together with models matched to the microstrip line of the voltage source and the load. The computation of the Poynting vector is also discussed in this section.

In Section 3, this method is used to analyze the lossless microstrip line structure with finite length to evaluate the efficiency of radiation wave power and the surface wave power relative to the maximum available power at the load.

2. Formulation of the Problem

2.1 Finite Difference Equation

The finite difference equations are derived directly from Maxwell's curl equations in the time-domain. For the lossless microstrip line, the strip and the ground plane are made of a perfect conductor ($\sigma = \infty$) that has zero thickness, and the substrate has a relative dielectric constant of ε_r. Maxwell's curl equations of this problem can be written as

$$\mu \frac{\partial \vec{H}}{\partial t} = -\nabla \times \vec{E} \qquad (1a)$$

$$\epsilon \frac{\partial \vec{E}}{\partial t} = \nabla \times \vec{H}. \qquad (1b)$$

To obtain discrete approximation of the continuous partial differential equations, the centered difference approximation is used on both the time and space first-order partial differences. The entire computation domain is the collection of all the unit cells. The dimensions of the unit cell along x, y and z directions are Δx, Δy and Δz, respectively. The node with subscript indices i, j and k corresponds to node number in x, y and z directions. This notation implicitly assumes the