Attenuation constant of the shielded microstrip-like transmission line

Elena Bozhevolnaya,
Development Department, LK A/S
Industriparken 32
2750 Ballerup
Denmark

Attenuation constant of the shielded microstrip-like transmission line is obtained on the basis of the time-frequency analysis. Electrostatics model has been employed to calculate a value of the characteristic impedance Z_0 used in attenuation constant calculation.

Electrostatic model (model0.pbm)

The line consists of 2 copper strip-like conductors (edge labels – El1 and El2) that are deposited on the polyethylene substrate (block label - Diel). The whole structure is protected by a screen (edge label – Shield) of the complicated geometry.

A zero voltage is applied on to the outer boundary (edge label - Boundary).

Method of calculation of the characteristic impedance Z_0 is based on the calculation of the mutual capacitance C_{12} between 2 electrodes and mutual capacitance C_{10} between an electrode and a shield.

C_{12} is determined by applying a voltage V= 1 [V] on the electrode 2 and a zero voltage on the shield. Then the total charge Q on the electrode 1 is calculated by means of QF, and C_{12} =Q [F/m]. Similarly, C_{10} is determined, but in this case both electrodes are placed under zero voltage and the shield has a voltage V = 1. One has to repeat the previous 2 runs with the only change: a substitution of the dielectric by air (electric permittivity should be assign a value of 1). Thus C_{12}^0 and C_{10}^0 are obtained.

At high frequencies, the shield is floating (not grounded) and influences the characteristic impedance of the line by increasing capacitive coupling of the electrodes. Finally,

$$Z_0 = \frac{2\cdot Z_{12}\cdot Z_{10}}{Z_{12}+2\cdot Z_{10}}, \text{ where } Z_{12}= \sqrt{\frac{\mu_0\varepsilon_0}{C_{12}\cdot C_{12}^0}}\ ; Z_{10}=\sqrt{\frac{\mu_0\varepsilon_0}{C_{10}\cdot C_{10}^0}}\ .$$

(Here, the known formulae $Z = \sqrt{L/C}$ and $L= \sqrt{\mu_0\varepsilon_0/C^0}$ are used actually).

Electrostatics model has been employed to calculate a value of the characteristic impedance Z_0, which is equal to 104 [Ohm] for the considered structure.

Time-harmonic magnetic model (model1.pbm)

The shielded transmission line is considered. The line consists of 2 copper strip-like conductors (block labels -Elec1 and Elec 2) that are rested on the polyethylene substrate (Diel). The whole structure, that includes partly an air (Air), is protected by a screen (Shield) of the complicated geometry.

By default, the outer boundary conditions are supposed to be a zero tangential field. This is due the fact that the extremely high frequency of 100 [MHz] applied in the FEM simulation forces an electromagnetic field to be completely bounded inside the screen.

For the given frequency 100 [MHz], time-harmonic magnetics enables to calculate:

1. Complex impedance *Z* via the voltage drops per unit length of each trace and the known current in the those;
2. Resistance *R* of the line: R = Real(Z) [Ohm/m].
3. Attenuation of the line: $\alpha = 869 \cdot 0.5 R/Z_0$ [dB/100m].