## Attenuation constant of the shielded microstrip-like transmission line

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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 (model 0.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,

$$Z_0 = \frac{2 \cdot Z_{12} \cdot Z_{10}}{Z_{12} + 2 \cdot Z_{10}} \text{, where } Z_{12} = \sqrt{\frac{\mu_0 \epsilon_0}{C_{12} \cdot C_{12}}^0} \text{; } Z_{10} = \sqrt{\frac{\mu_0 \epsilon_0}{C_{10} \cdot C_{10}}^0} \text{.}$$

(Here, the known formulae  $Z = \sqrt{L/C}$  and  $L = \sqrt{\mu_0 \epsilon_0/C^0}$  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:  $\alpha = 869.0.5 \text{R/Z}_0 \text{ [dB/100m]}.$