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EE 5337

Computational Electromagnetics (CEM)

Lecture #6

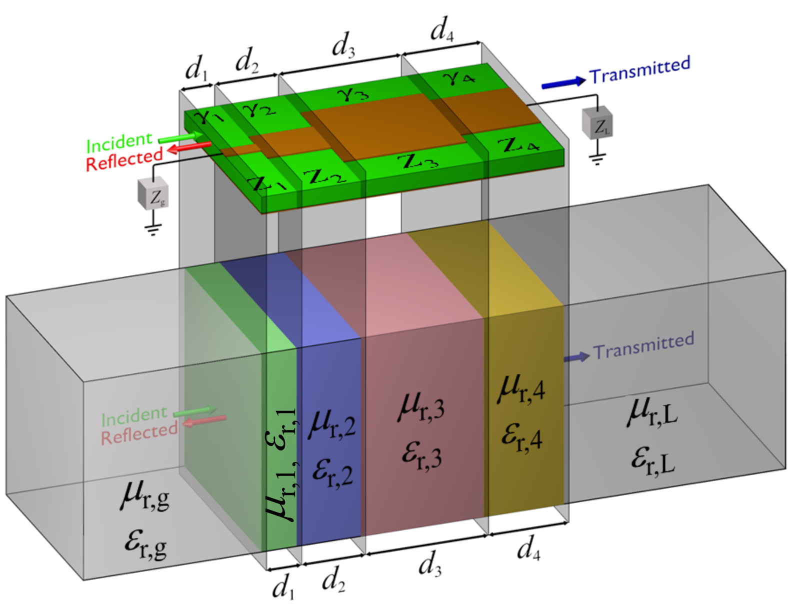
TMM Extras

Outline

- Circuit/Wave Equivalence

Circuit Wave Equivalence

Circuit-Wave Equivalence



Derivation (1 of 3)

We wish to derive equations that convert between the transmission line framework and the transfer matrix method framework.

$$\gamma, Z \leftrightarrow \mu_r, \varepsilon_r$$

Step 1 – Extract the complex refractive index n and complex impedance η from the complex propagation constant γ and characteristic impedance Z.

$$e^{-jk_0 nz} = e^{-\gamma z}$$

$$\downarrow$$

$$n = \frac{\gamma}{jk_0}$$

$$\eta = Z$$

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Derivation (2 of 3)

Step 2 – Relate the complex refractive index n and complex impedance η to the complex permittivity ε_r and complex permeability μ_r.

$$n = \sqrt{\mu_r \varepsilon_r} \qquad \eta = \eta_0 \sqrt{\frac{\mu_r}{\varepsilon_r}}$$

Step 3 – Solve the above equations for the complex permittivity ε_r and complex permeability μ_r.

$$\varepsilon_r = n\frac{\eta_0}{\eta} \qquad \mu_r = n\frac{\eta}{\eta_0}$$

Step 4 – Replace the complex refractive index n and complex impedance η with the complex propagation constant γ and characteristic impedance Z from Step 1.

$$\boxed{\varepsilon_r = \frac{\gamma}{j\omega\varepsilon_0 Z}} \qquad \boxed{\mu_r = \frac{\gamma Z}{j\omega\mu_0}}$$

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Derivation (3 of 3)

Step 5 – Solve the equations from Step 4 for the complex propagation constant γ and characteristic impedance Z.

$$\boxed{\gamma = jk_0\sqrt{\mu_r \varepsilon_r}}$$

$$\boxed{Z = \eta_0\sqrt{\frac{\mu_r}{\varepsilon_r}}}$$