3.Plane Wave in Free Space

Starting from Maxwell's equation, we obtain similar set of differential equations to the transmission line equations.

propagating waves in +z direction:

$$E_x^+ = E_{x1} e^{j(\omega t - \beta z)}$$

$$H_y^+ = \frac{1}{Z_c} E_{x1} e^{j(\omega t - \beta z)}$$

phase velocity:

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{\varepsilon\mu}}$$

wave impedance:

$$\frac{E_x^+}{H_y^+} = \sqrt{\frac{\mu}{\varepsilon}} = \eta$$

4.Transmission Line Composed of Two Conductors

4.1 Electro-static model

The electromagnetic (EM) wave of TEM mode can be determined from an electro-static model.

4.2 Example of the calculation -- coaxial line

4.3 Strip line

approximate representation of characteristic impedance

4.4 Micro-strip line

a quasi TEM mode

approximate representation of characteristic impedance

5. Metallic Hollow Waveguide

5.1 Rectangular waveguide

EM field of TE and TM mode

orthogonal relation among eigen modes

5.2 Circular waveguide

EM field of TE and TM mode

5.3 Cut-off frequency

A cut-off frequency is determined by the dimensions of waveguide.