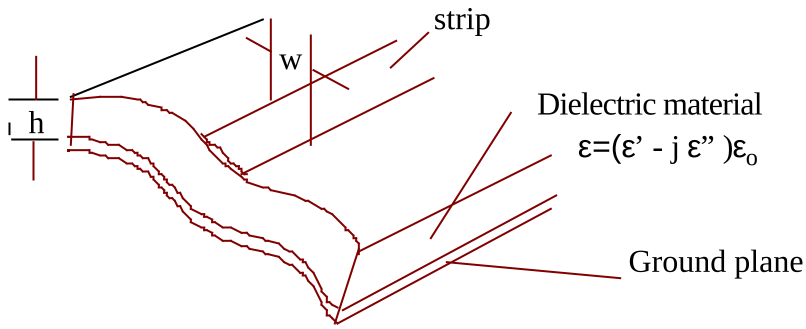
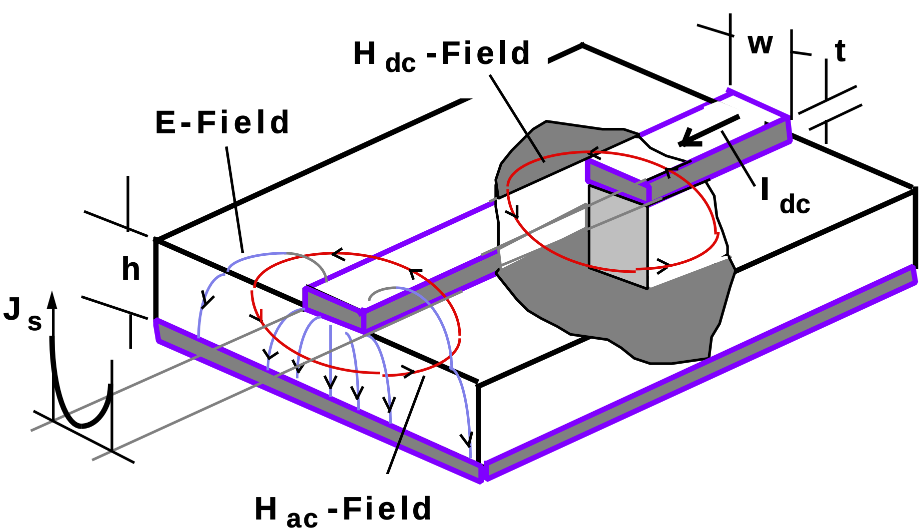
Microstrip Lines

One of the most commonly used planar transmission lines is the microstrip line which is shown in the following figure.

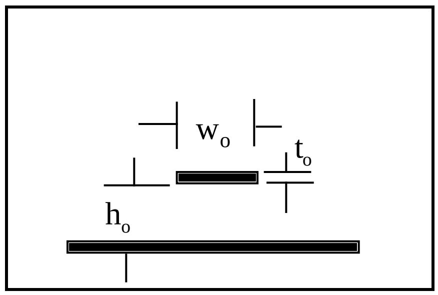




A dielectric sheet of thickness h_o and a dielectric permittivity ε is sandwiched between the metallic strip of width w_o and thickness t_o and a sheet of metal covering the whole bottom side of the dielectric substrate. This bottom metal sheet is known as the ground plane. Depending on the various dimensional parameters of the microstrip line, the characteristic impedance Z_c, the guide wavelength λ_g, attenuation constant α and the Q of the line can be calculated.

A microstrip line, where the strip is suspended in air (or vacuum) is shown in the figure below.

Neglecting losses in the conductors, this results in a purely TEM wave propagation. We assume that the static field problem can be solved (through a conformal transformation) and the **pertinent parameters**



$\mathbf{Z_o}$ = characteristic impedance

$\lambda_{\mathbf{o}}$ = guide wavelength

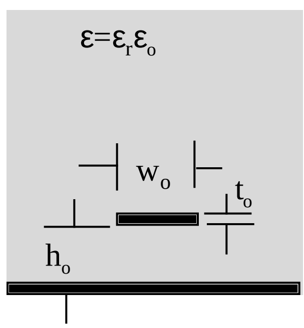
$\alpha_{\mathbf{o}}$ = attenuation constant

$\mathbf{Q_o}$ = quality factor

of the microstrip line can be calculated.

The propagation constant of the line will be given by

$$\beta = k_o = \omega\sqrt{\mu_o\varepsilon_o} = \frac{\omega}{c}$$



If on the other hand, the space above the ground plane is completely filled with a lossless dielectric material having $\varepsilon = \varepsilon_{\mathbf{r}}\,\varepsilon_{\mathbf{o}}$ where $\varepsilon_{\mathbf{r}}$ is the relative dielectric constant of the material, pertinent parameters are scaled by

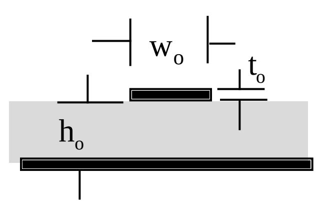
$\mathbf{Z} = \mathbf{Z_o} \;/\; \sqrt{\varepsilon_{\mathbf{r}}}$ = characteristic impedance

$\lambda = \lambda_{\mathbf{o}} \;/\; \sqrt{\varepsilon_{\mathbf{r}}}$ = guide wavelength

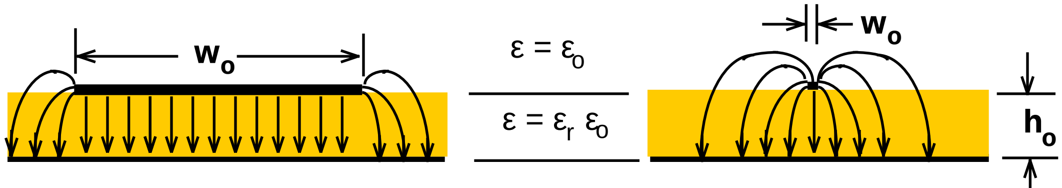
$\alpha = (\sqrt{\varepsilon_{\mathbf{r}}})\; \alpha_{\mathbf{o}}$ = attenuation constant

$\mathbf{Q} = \mathbf{Q_o} \;/\sqrt{\varepsilon_{\mathbf{r}}}$ = quality factor

$$\beta = \omega\sqrt{\mu_o\varepsilon_r\varepsilon_o} = k_o\sqrt{\varepsilon_r}$$



For the actual microstrip line, the dielectric material $\varepsilon = \varepsilon_r\varepsilon_o$ fills the region between the ground plane and the microstrip. In order to understand the effect of the partial dielectric material, two extreme cases can be considered.



(a) **(b)**

In (a), the width of the strip $w_o >> h_o$. In this case most of the fields are concentrated between the strip and the ground plane. Neglecting the fringing fields, $\varepsilon_{eff} \approx \varepsilon_r$. In (b) the strip $w_o << h_o$. Here the fringing fields extend into the air. For the extreme case where half of the fields are in the air and half are in the dielectric, effective dielectric constant can be written as $\varepsilon_{eff} \approx (\varepsilon_r+1) / 2$. Therefore, for other widths of the strip between these extremes, there will be an effective dielectric constant whose value falls in the region $(\varepsilon_r+1) / 2 \le \varepsilon_{eff} \le \varepsilon_r$.

For a microstrip line the pertinent parameters will be scaled by ε_{eff}

$$Z = Z_o / \sqrt{\varepsilon_{eff}} = \text{characteristic impedance}$$

$$\lambda = \lambda_o / \sqrt{\varepsilon_{eff}} = \text{guide wavelength}$$

$$\alpha = (\sqrt{\varepsilon_{eff}})\, \alpha_o = \text{attenuation constant}$$

$$Q = Q_o / (\sqrt{\varepsilon_{eff}}) = \text{quality factor}$$

$$\beta = \omega\sqrt{\mu_o \varepsilon_{eff} \varepsilon_o} = k_o\sqrt{\varepsilon_{eff}}$$