ELEC 412 RF

& Microwave Engineering

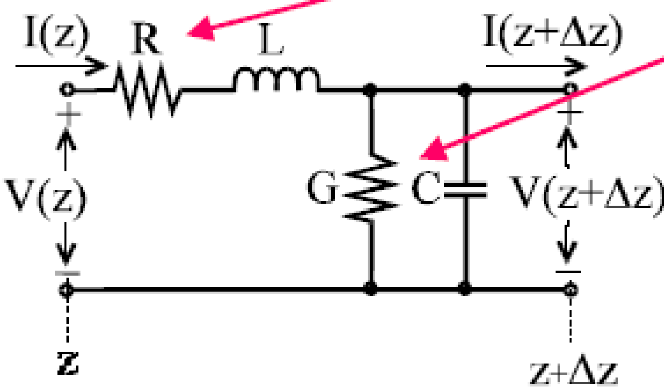
Fall 2004

Lecture 3

Lossless Transmission Line Model

- Line representation

Lossless implies:
R = G = 0!



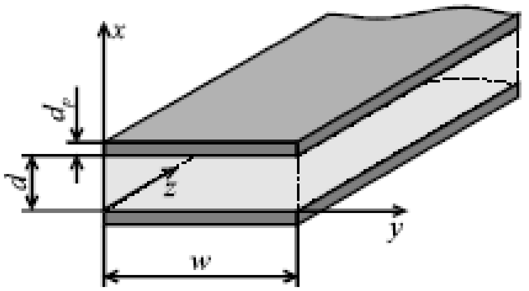
Characteristic impedance:

$$Z_0 = \sqrt{\frac{(R + j\omega L)}{(G + j\omega C)}}$$

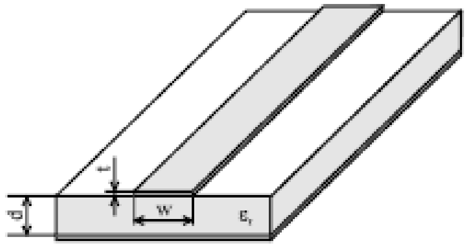
Note: R, L, G, C are given per unit length and depend on geometry

Transmission Line Parameters for different line types

	2-wire	coax	parallel-plate
R	$\frac{1}{\pi a \sigma \delta}$	$\frac{1}{2\pi\sigma\delta}(\frac{1}{a}+\frac{1}{b})$	$\frac{2}{w\sigma\delta}$
L	$\frac{\mu}{\pi} ch^{-1}(\frac{D}{2a})$	$\frac{\mu}{2\pi}\ln(\frac{b}{a})$	$\mu \frac{d}{w}$
G	$\frac{\pi\sigma}{ch^{-1}(D/(2a))}$	$\frac{2\pi\sigma}{\ln(b/a)}$	$\sigma \frac{w}{d}$
C	$\frac{\pi\varepsilon}{ch^{-1}(D/(2a))}$	$\frac{2\pi\varepsilon}{\ln(b/a)}$	$\varepsilon \frac{w}{d}$

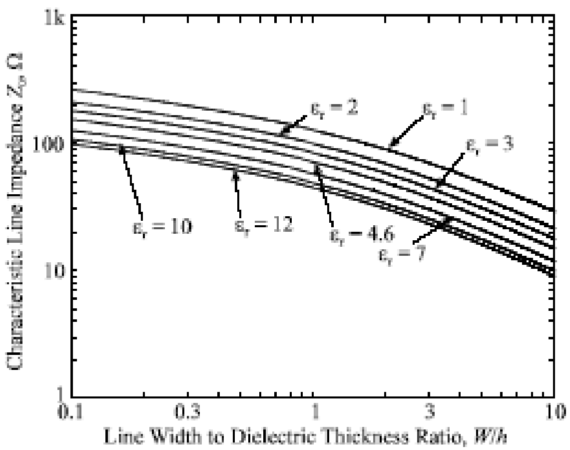


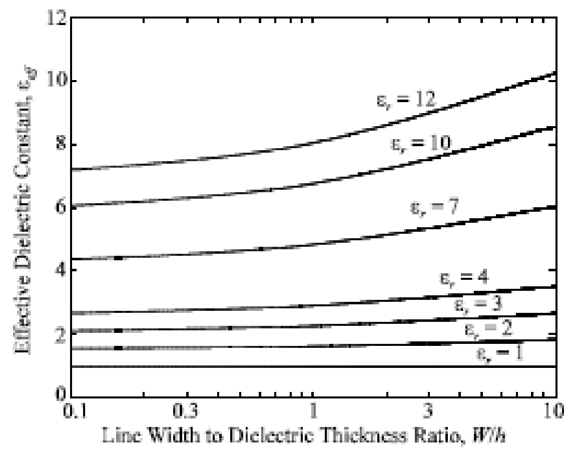
Microstrip line



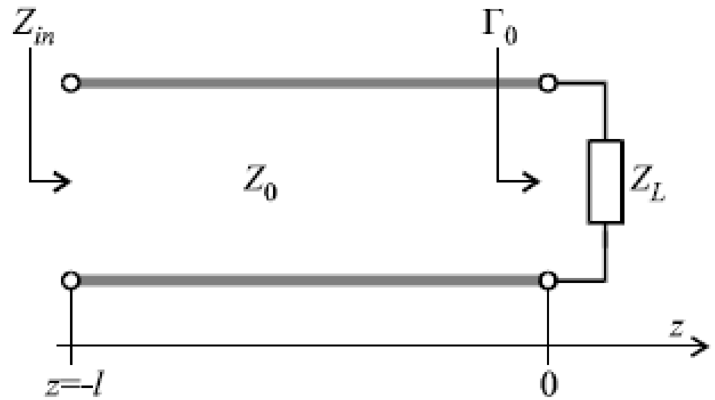
$$Z_0 = \frac{\sqrt{\mu_0/\varepsilon_0}}{2\pi\sqrt{\varepsilon_{eff}}}\ln\left(8\frac{h}{W}+\frac{W}{4h}\right), W/h<1$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[(1+12h/W)^{-1/2}+0.04(1-W/h)^2\right]$$





What is a voltage reflection coefficient?



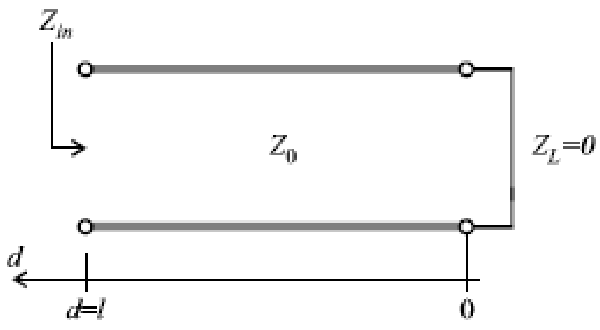
Reflection coefficient at the load location

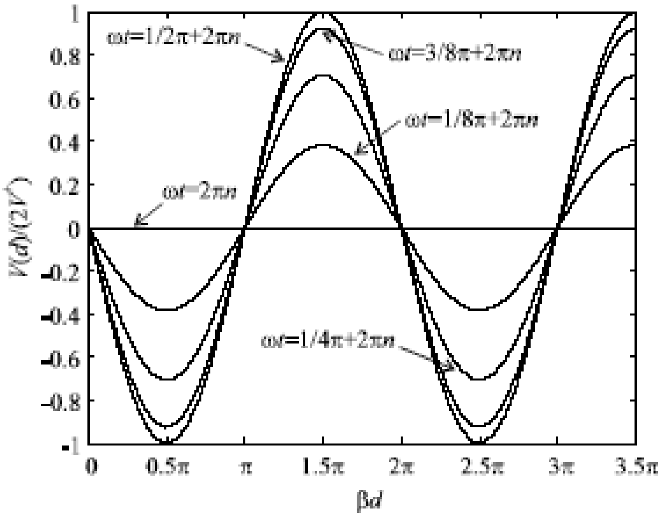
$$\Gamma_0 = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\Gamma_0 = 1 \quad (Z_L \to \infty)$$

$$\Gamma_0 = -1 \quad (Z_L \to 0)$$

Standing Waves



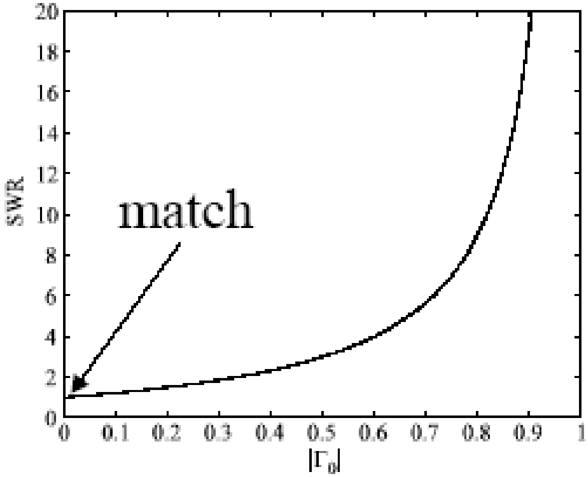


$$V(d) = V^+(e^{+j\beta d} - e^{-j\beta d})$$

$$v(d,t) = 2V^+ \sin(\beta d)\cos(\omega t + \pi/2)$$

Standing wave ratio

$$SWR = \frac{|V_{max}|}{|V_{min}|} = \frac{|I_{max}|}{|I_{min}|} = \frac{1+|\Gamma_0|}{1-|\Gamma_0|}$$



SWR is a measure of mismatch of the load to the line

SWR=1 (matched) or SWR $\rightarrow \infty$ (total mismatch)