Objectives

- How are microstriplines modeled?
- What type of amplifier classes exist?
- How is the efficiency of an amplifier defined?
Microstrip line Matching Networks

• Most commonly used in RF circuits
• Can be used up to approximately 20 GHz (for TEM modes)
• Microstrip lines require typically 6 parameters
  – dielectric constant $\varepsilon_r$
  – PCB board height $h$, strip width $w$, thickness $t$
  – resistivity $\rho$ and loss tangent $\delta$
Key parameter designations

\[
\varepsilon_r, \ d
\]

Don’t use:
\[
Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = ???
\]
Please keep in mind, there are two issues
A) phase velocity and B) characteristic impedance:

\[ v_p = \frac{c}{\sqrt{\varepsilon_r}} \rightarrow \frac{c}{\sqrt{\varepsilon_{eff}}} \]

\[ Z_0 \rightarrow Z_0 = \frac{60}{\sqrt{\varepsilon_{eff}}} \ln\left(8 \frac{h}{w} + \frac{1}{4} \frac{w}{h}\right) \quad w/h \leq 1 \]

\[ Z_0 = \frac{60}{\sqrt{\varepsilon_{eff}}} \frac{120\pi / \sqrt{\varepsilon_{eff}}}{w/h + 1.393 + 0.667\ln(w/h + 1.444)} \quad w/h \geq 1 \]

Numerical evaluation (Textbook, pages 64 - 69):

\[ Z_0(\varepsilon_r) = F_1(w/h) \quad \text{and} \quad \varepsilon_{eff}(\varepsilon_r) = F_2(w/h) \]
Microstrip lines have two sources of losses

\[ P^+(z) = \frac{1}{2} \frac{|V^+|^2}{Z_0} e^{-2(\alpha_d + \alpha_c)z} \]

Dielectric losses \( \alpha_d \) (which are typically small)

and

Conduction losses \( \alpha_c \) (which can be significant)

Depending on frequency, one may have to deal with radiation losses as well!
Classes of amplifier operation

Class A

Class AB

Class B

Class C
Efficiency of an amplifier

\[ \eta = \frac{\text{RF Power}}{\text{Source Power}} = \frac{P_{RF}}{P_S} \times 100\% \]

Current through load

Current from the power supply
\[ \eta = -\frac{\Theta_0 - \sin \Theta_0}{2[\Theta_0 \cos(\Theta_0 / 2) - 2\sin(\Theta_0 / 2)]} \]