

EE 3113

INTRODUCTION INTO RF

CIRCUIT DESIGN

Lecture Notes for A-term 1999

LECTURE 22

Prof. R. Ludwig

Department of Electrical and Computer Engineering

Worcester Polytechnic Institute

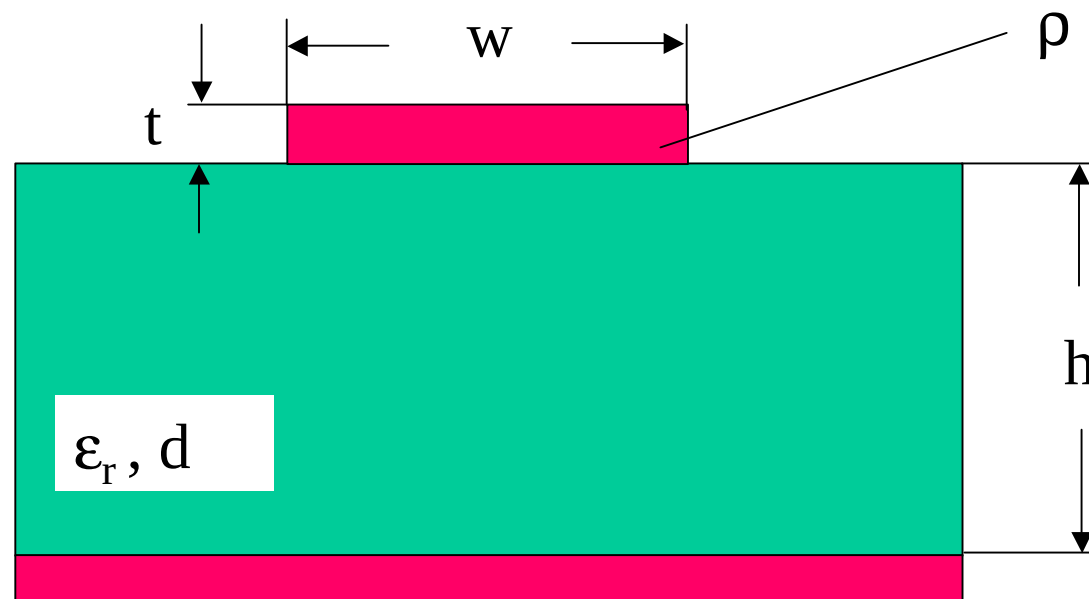
Worcester, MA 01609

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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 ϵ_r
 - PCB board height $\mathbf{h}$, strip width $\mathbf{w}$, thickness $\mathbf{t}$
 - resistivity ρ and loss tangent $\mathbf{d}$

Key parameter designations



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:

$$v_p = \frac{c}{\sqrt{e_r}} \longrightarrow \frac{c}{\sqrt{e_{eff}}}$$

$$Z_0 \longrightarrow Z_0 = \frac{60}{\sqrt{e_{eff}}} \ln\left(8 \frac{h}{w} + \frac{1}{4} \frac{w}{h}\right) \quad w/h \leq 1$$

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

Numerical evaluation (Manuscript, page 70):

$$Z_0(\epsilon_r) = F_1(w/h) \text{ and } \epsilon_{eff}(\epsilon_r) = F_2(w/h)$$

Microstrip lines have two sources of losses

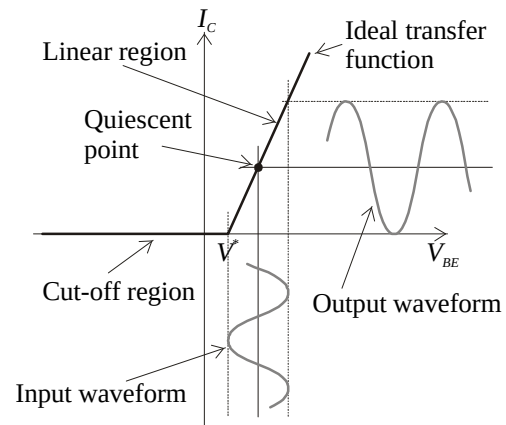
$$P^+(z) = \frac{1}{2} \frac{|V^+|^2}{Z_0} e^{-2(a_d + a_c)z}$$

Dielectric losses α_d (which are typically small)
and

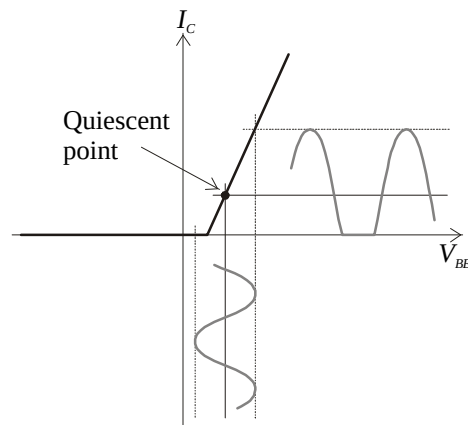
Conduction losses α_c (which can be significant)

Depending on frequency, one may have to deal with radiation losses as well!

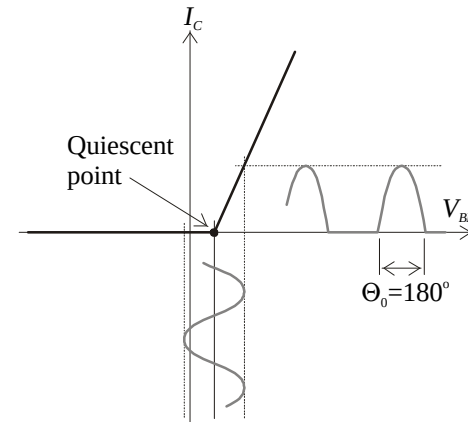
Classes of amplifier operation



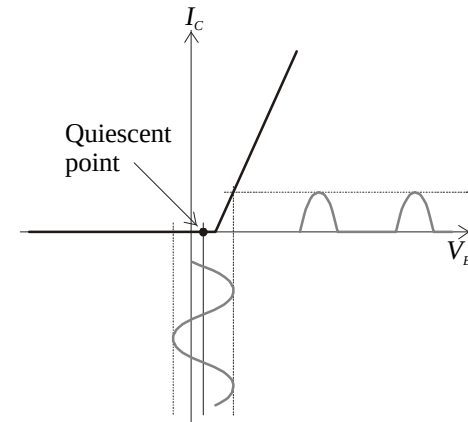
Class A



Class AB



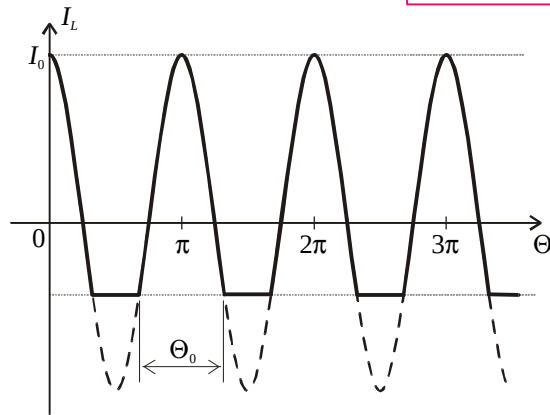
Class B



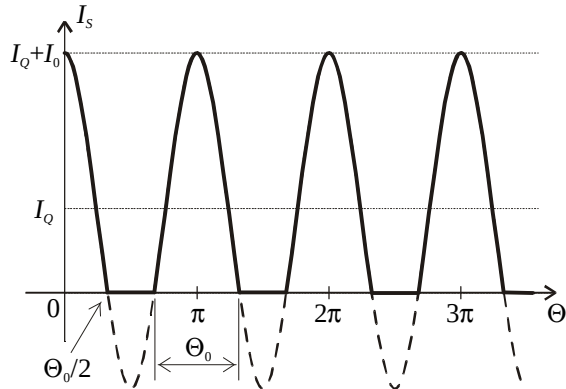
Class C

Efficiency of an amplifier

$$h = \frac{\text{RF Power}}{\text{Source Power}} = \frac{P_{RF}}{P_S} 100\%$$



Current through load



Current from the power supply

$$h = - \frac{\Theta_0 - \sin \Theta_0}{2[\Theta_0 \cos(\Theta_0 / 2) - 2 \sin(\Theta_0 / 2)]}$$

