

ECE 523/421 – Analog Electronics

Lecture 26: Output Stages: Power Amplifiers

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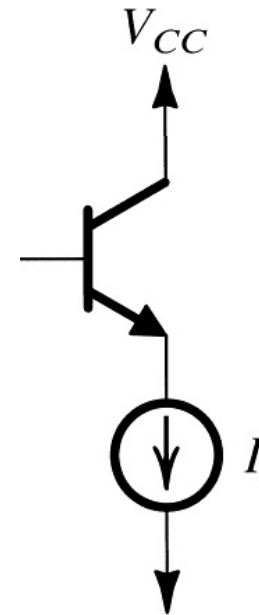
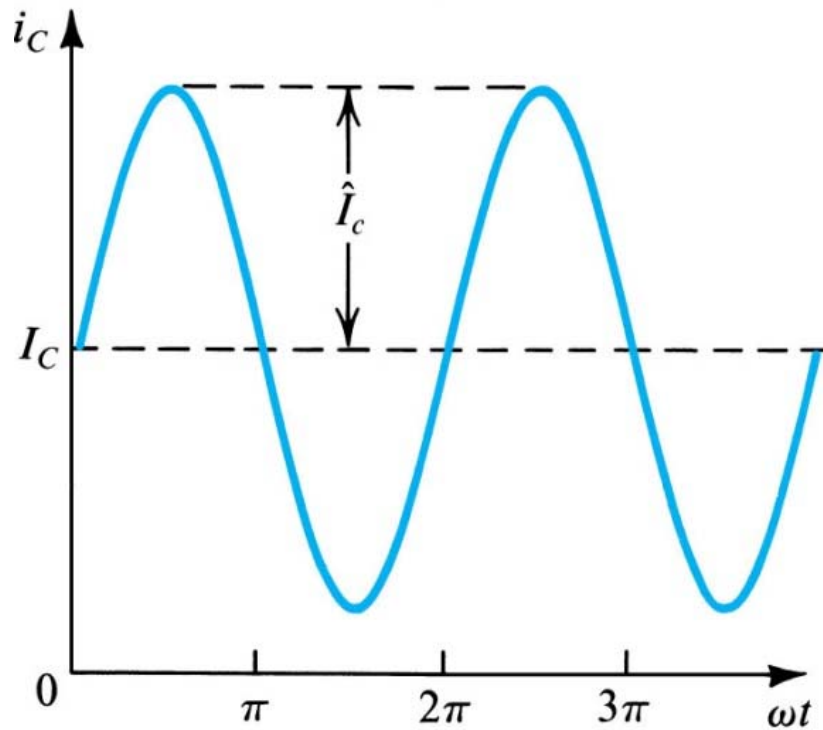
Review of Last Lecture

- ☐ Theory of Frequency compensation
- ☐ Implementation
- ☐ Miller Compensation

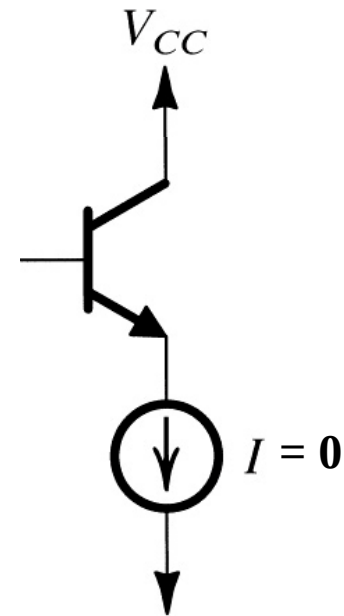
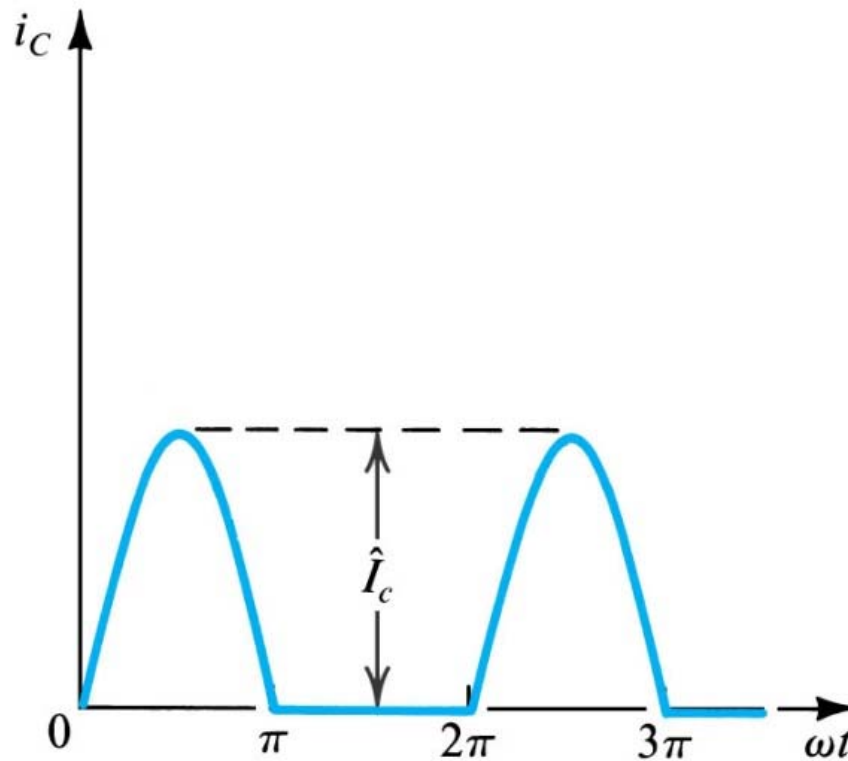
Today's Lecture

- ☐ **Classification of Output Stages**
- ☐ **Class A Power Amplifiers**
- ☐ **Class B and Class AB Power Amplifiers**

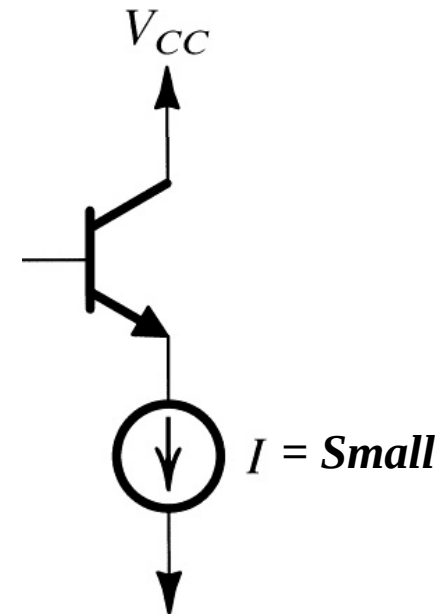
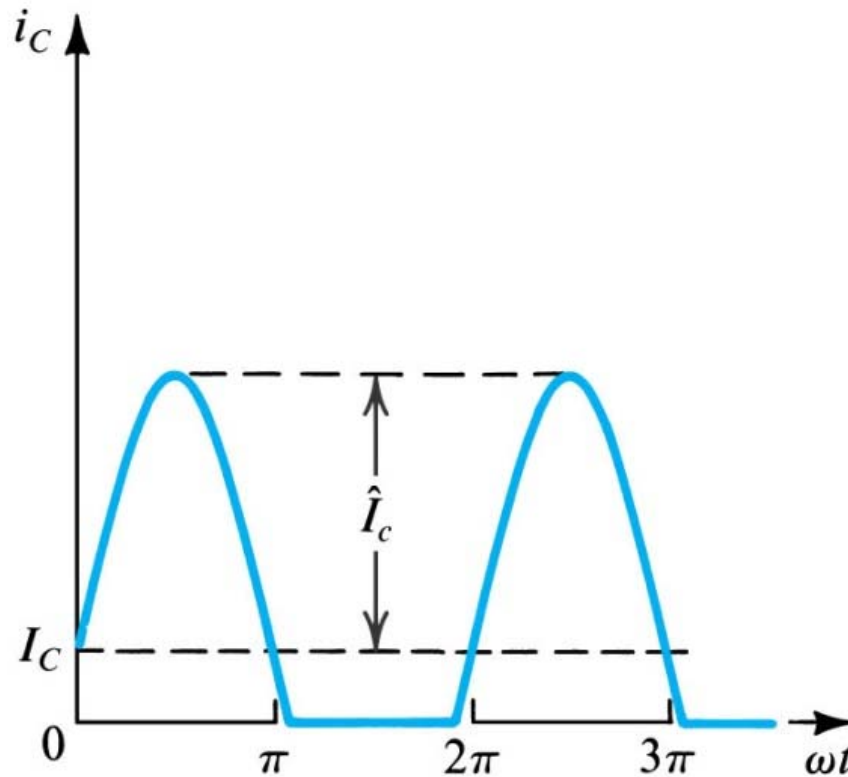
Class A Power Amplifier



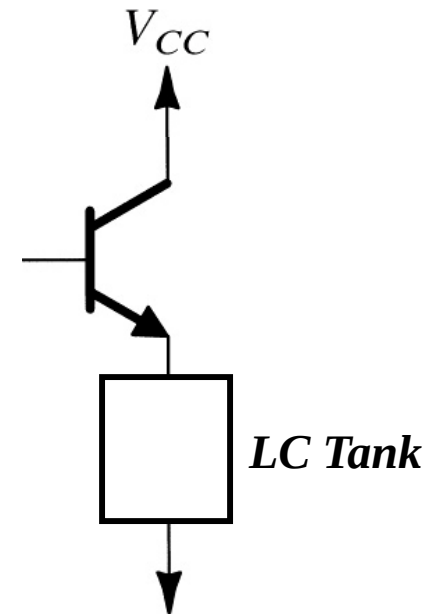
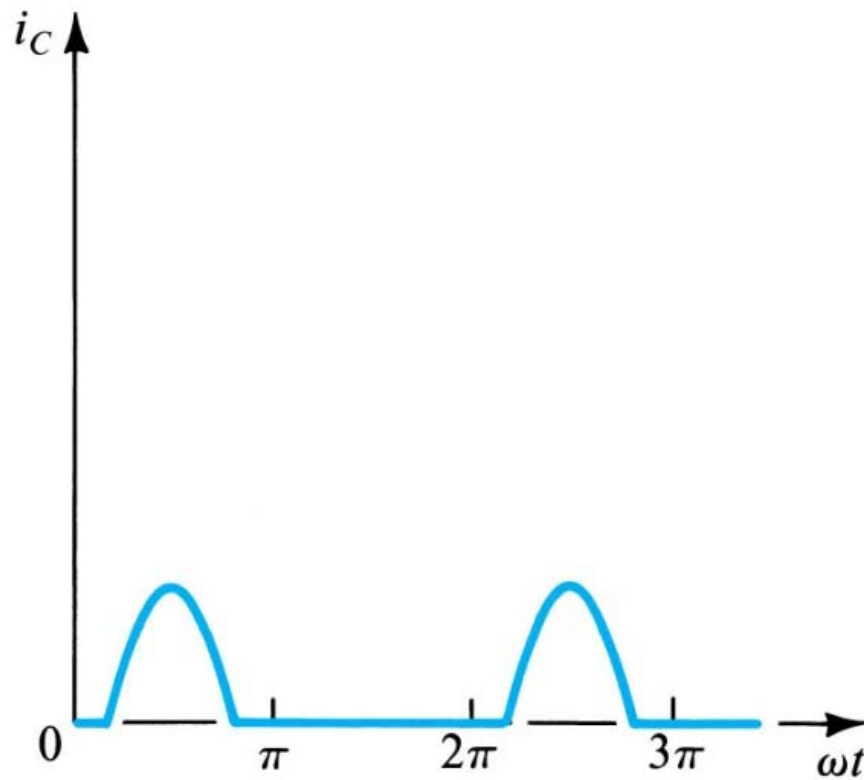
Class B Power Amplifier



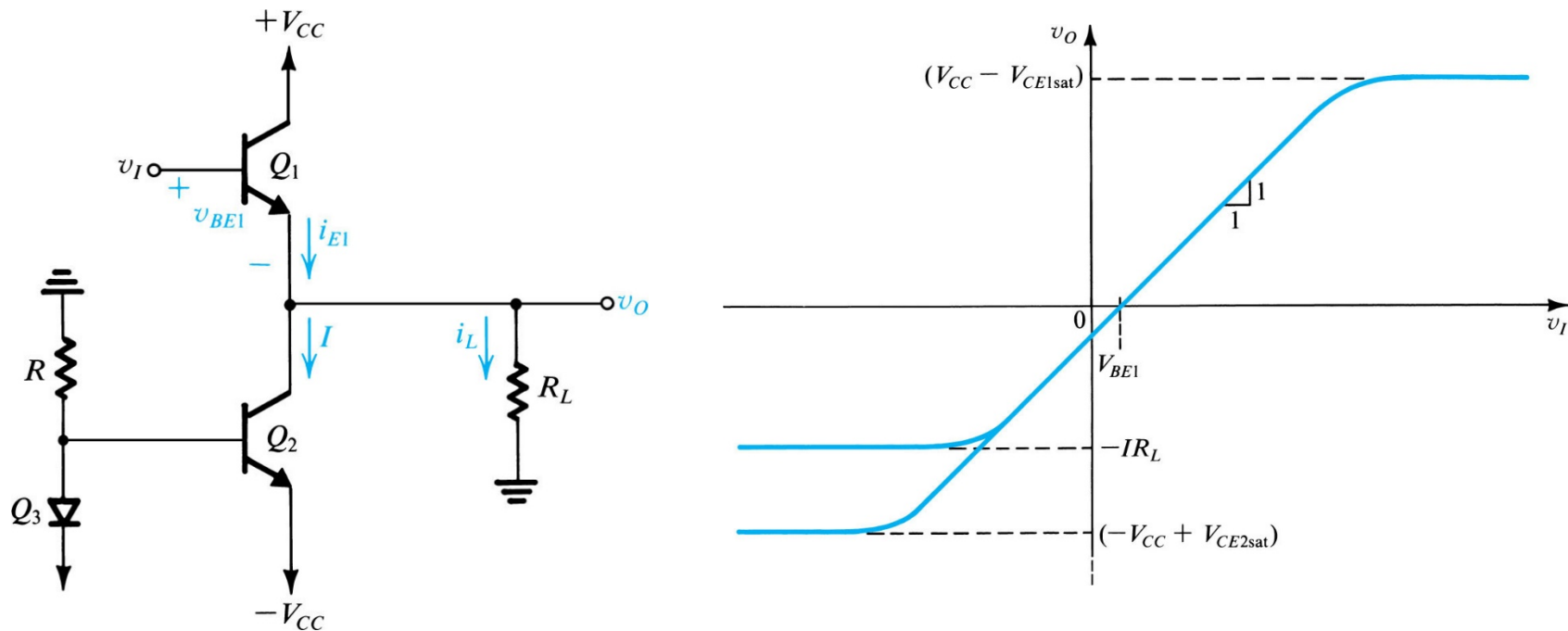
Class AB Power Amplifier



Class C Power Amplifier



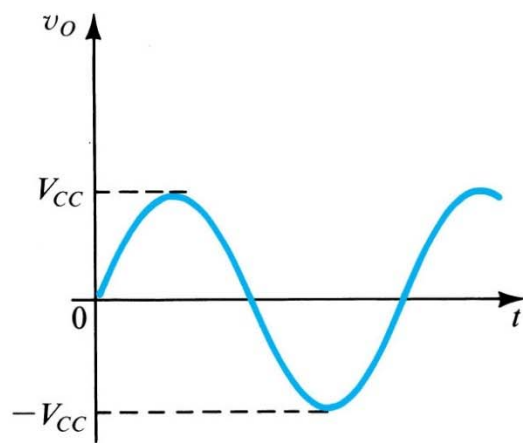
Class A Power Amplifier



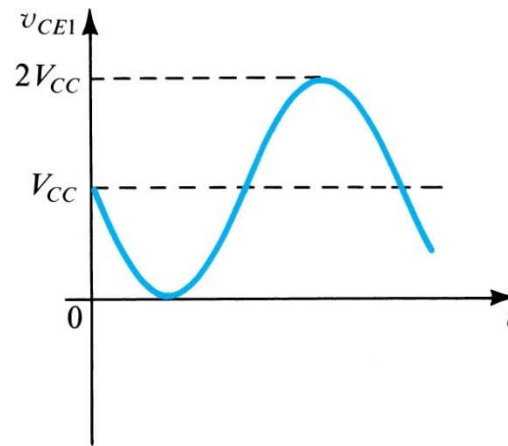
$$V_{o(Max)} = V_{CC} - V_{BE1}$$

$$V_{o(Min)} = -IR_L$$

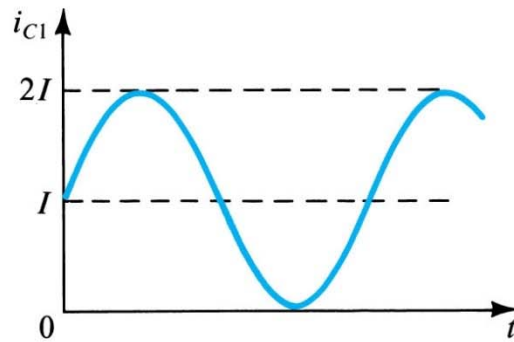
Class A Power Amplifier



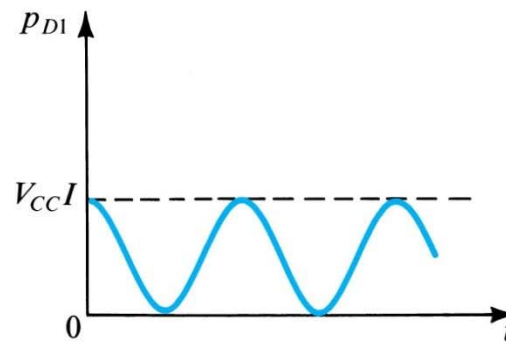
(a)



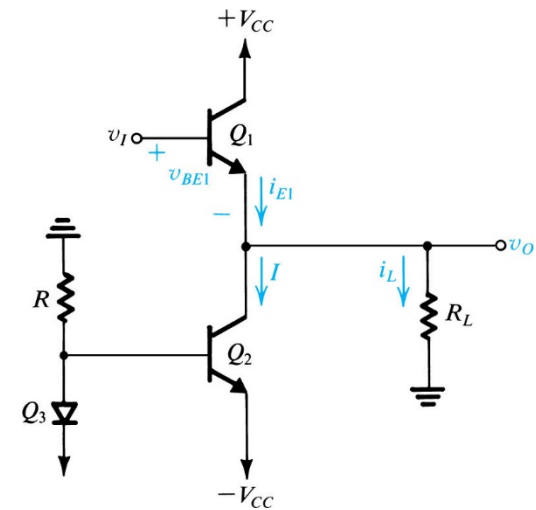
(b)



(c)



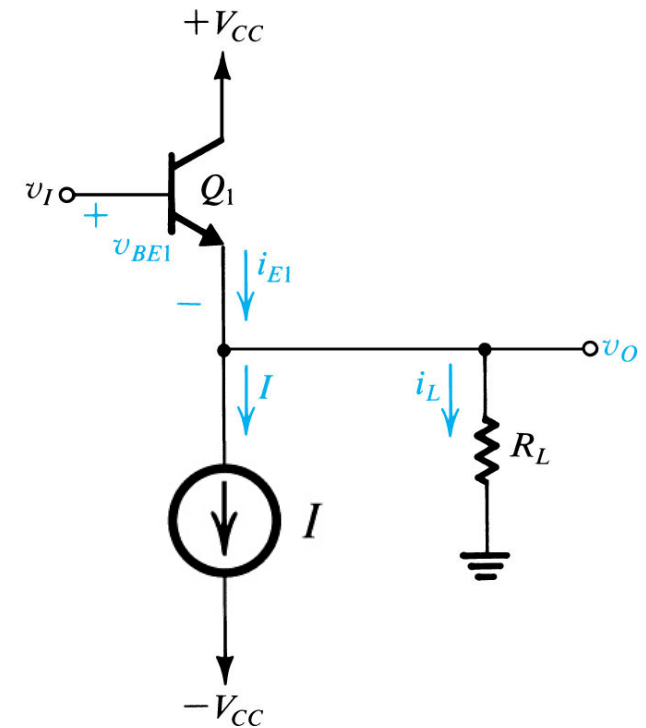
(d)



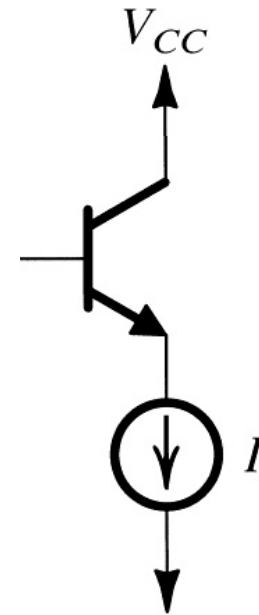
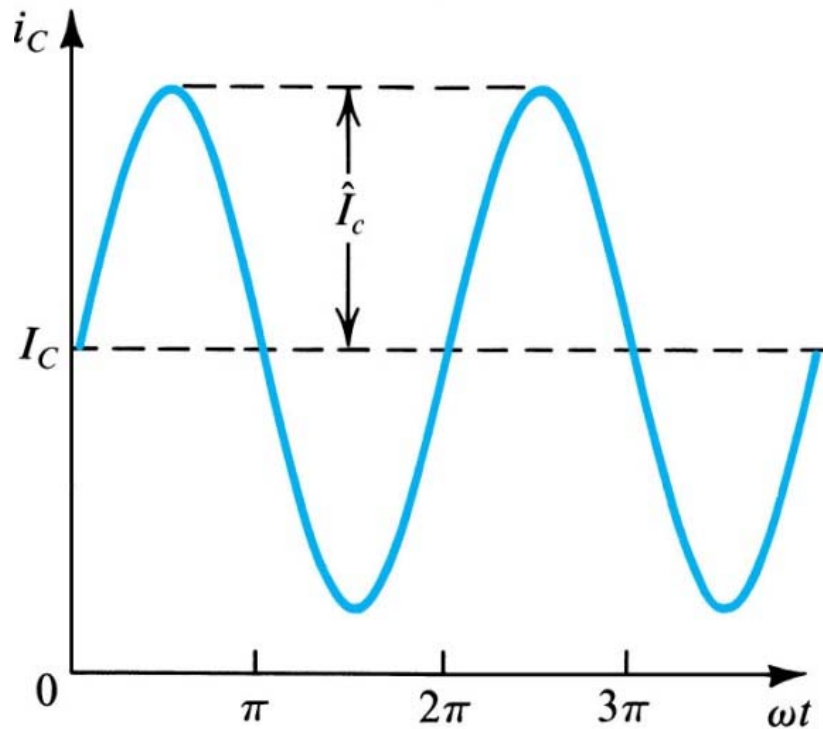
Example: Class A Power Amplifier

If $V_{CC}=10V$, and $R_L=100\ \Omega$, then determine:

- 1) Current source I
- 2) P_{D1} and P_{D2} in quiescent mode
- 3) P_{D1} and P_{D2} when maximum swing
- 4) Efficiency when maximum swing
- 5) Efficiency when swing is 8V Peak
- 6) Output resistance
- 7) Input resistance

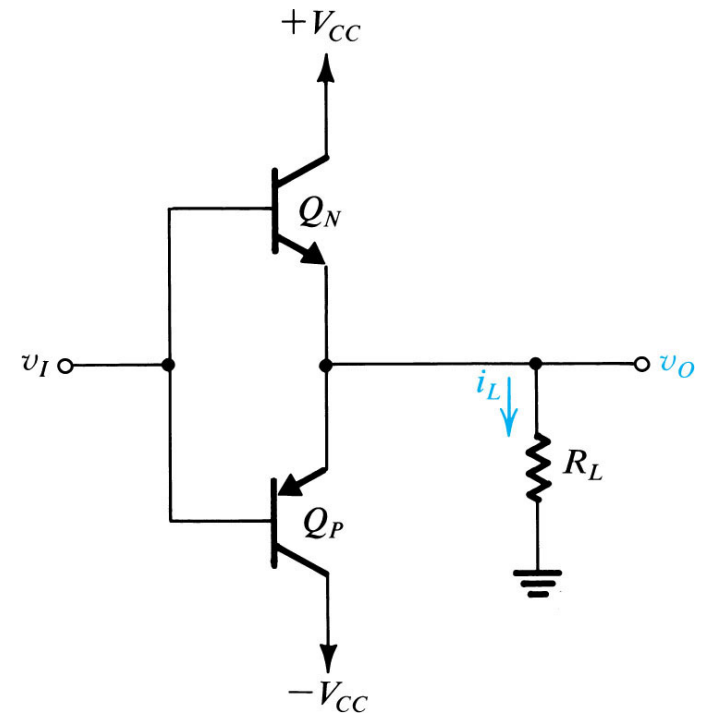
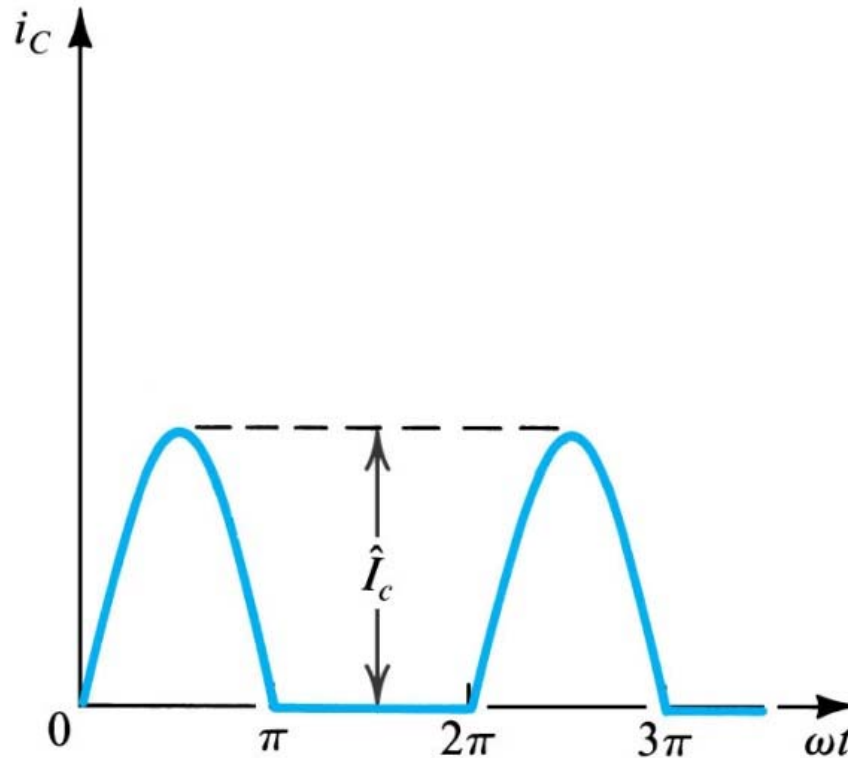


Class A Power Amplifier



$$P_S = 2IV_{CC}$$
$$P_L = \frac{\hat{V}_O^2}{2R_L}$$
$$\eta = \frac{P_L}{P_S} = \frac{\hat{V}_O^2}{4R_L IV_{CC}} = \frac{1}{4} \left(\frac{\hat{V}_O}{V_{CC}} \right)^2$$

Class B Power Amplifier



$$P_S = 2I_{av}V_{CC} = 2\frac{\hat{V}_O}{\pi R_L}V_{CC}$$

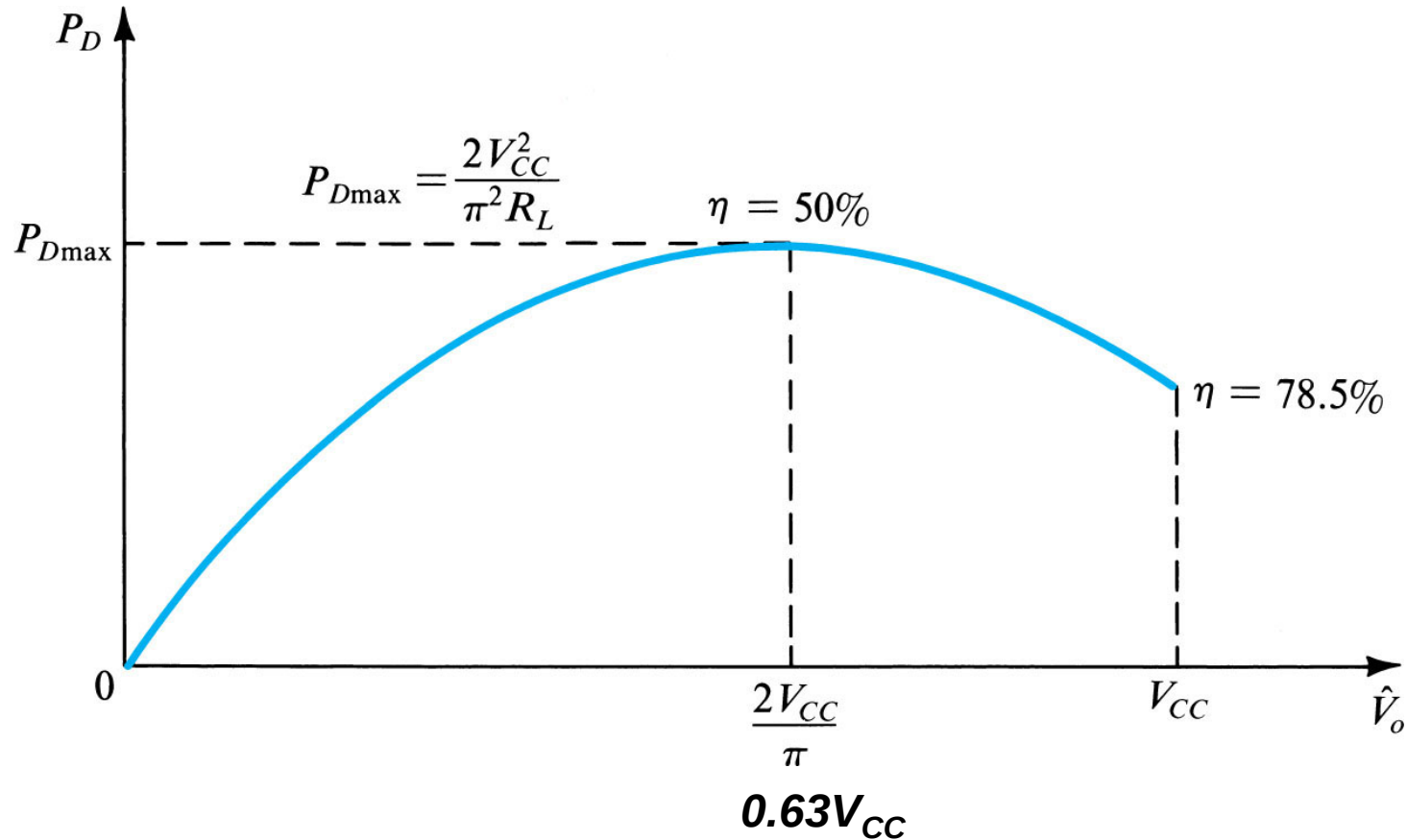
$$P_L = \frac{\hat{V}_O^2}{2R_L}$$



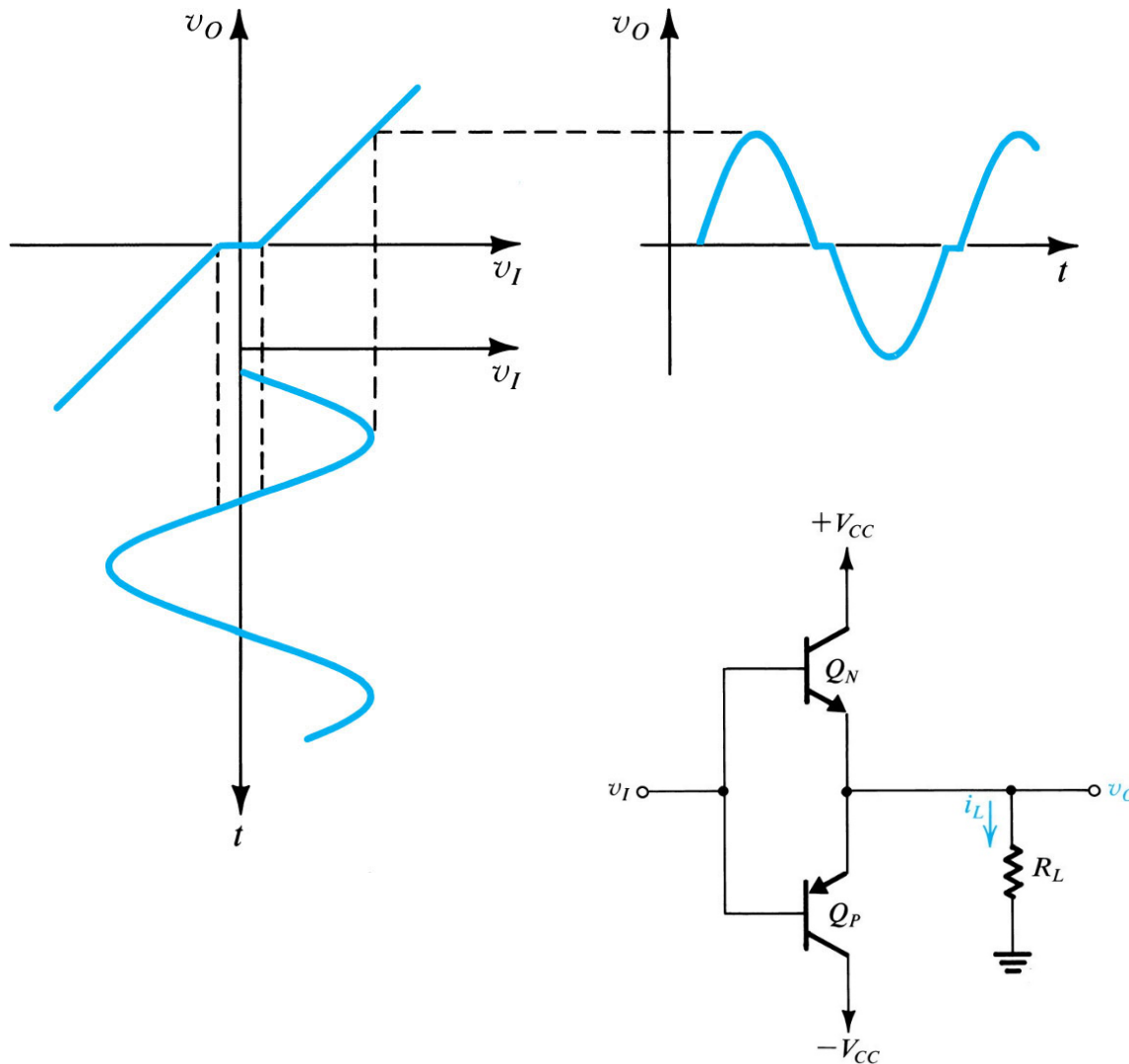
$$\eta = \frac{P_L}{P_S} = \frac{\pi}{4} \left(\frac{\hat{V}_O}{V_{CC}} \right)$$

Device Peak Power Dissipation

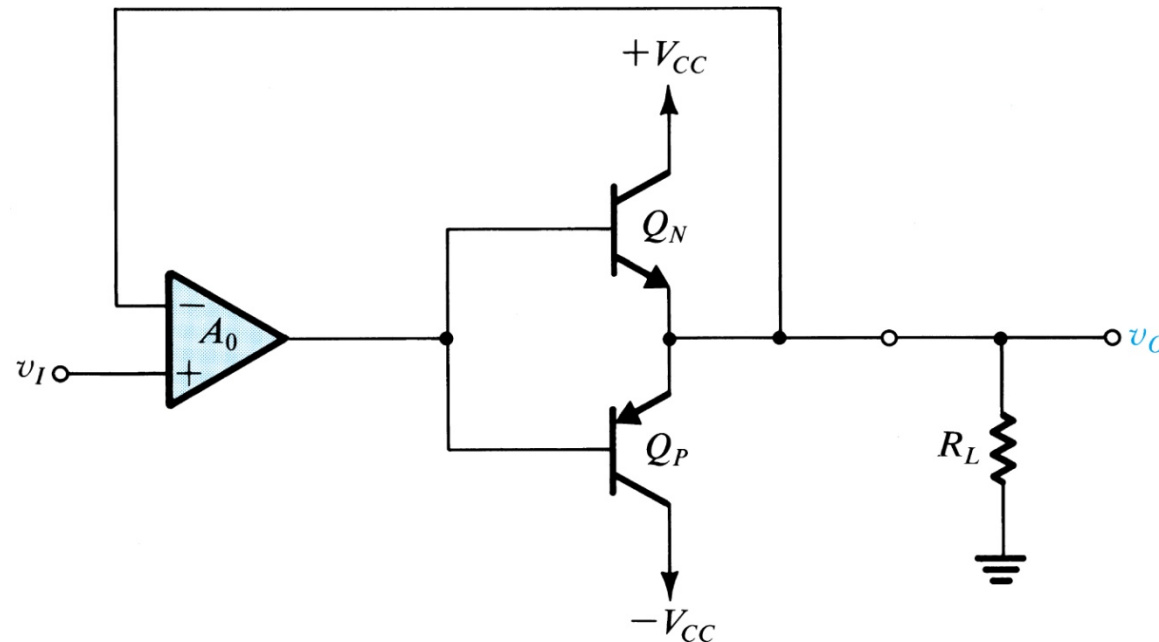
$$P_D = P_S - P_L$$



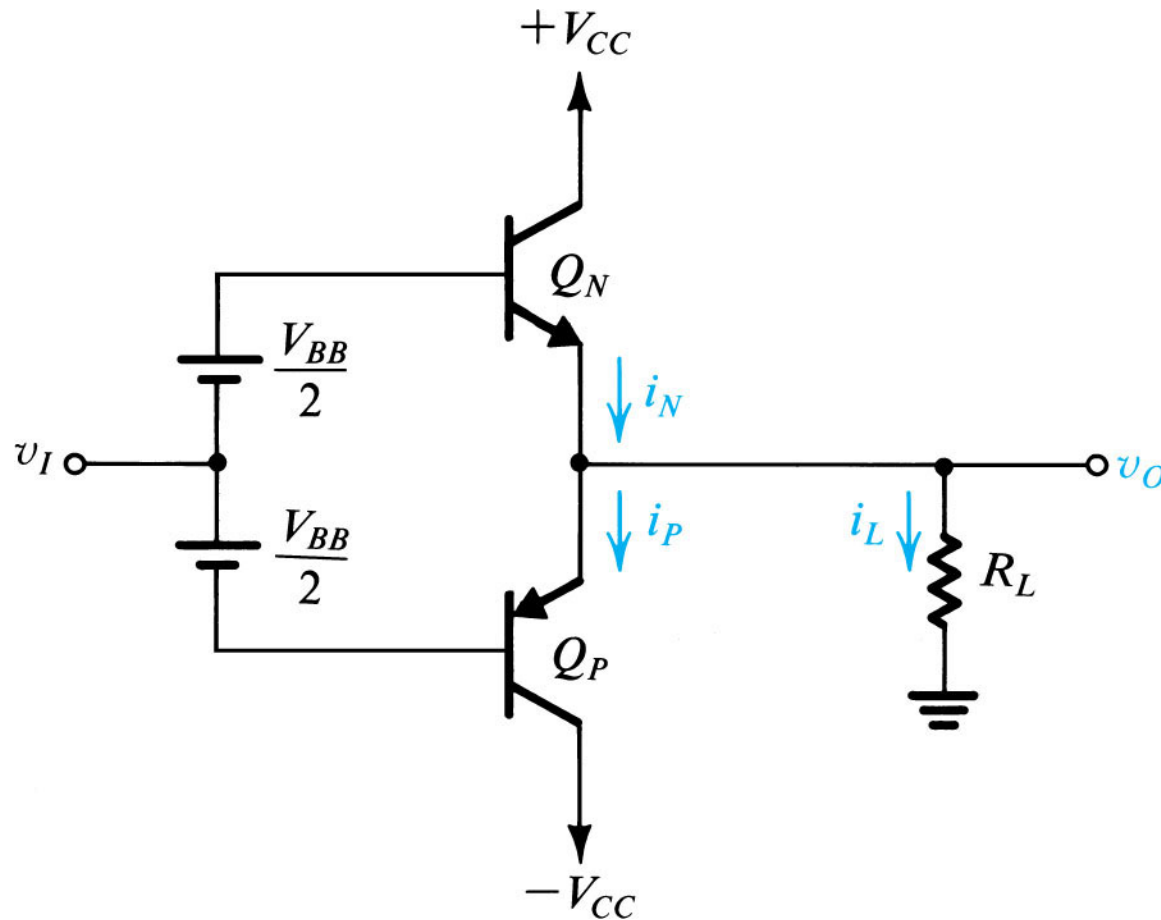
Crossover Distortion



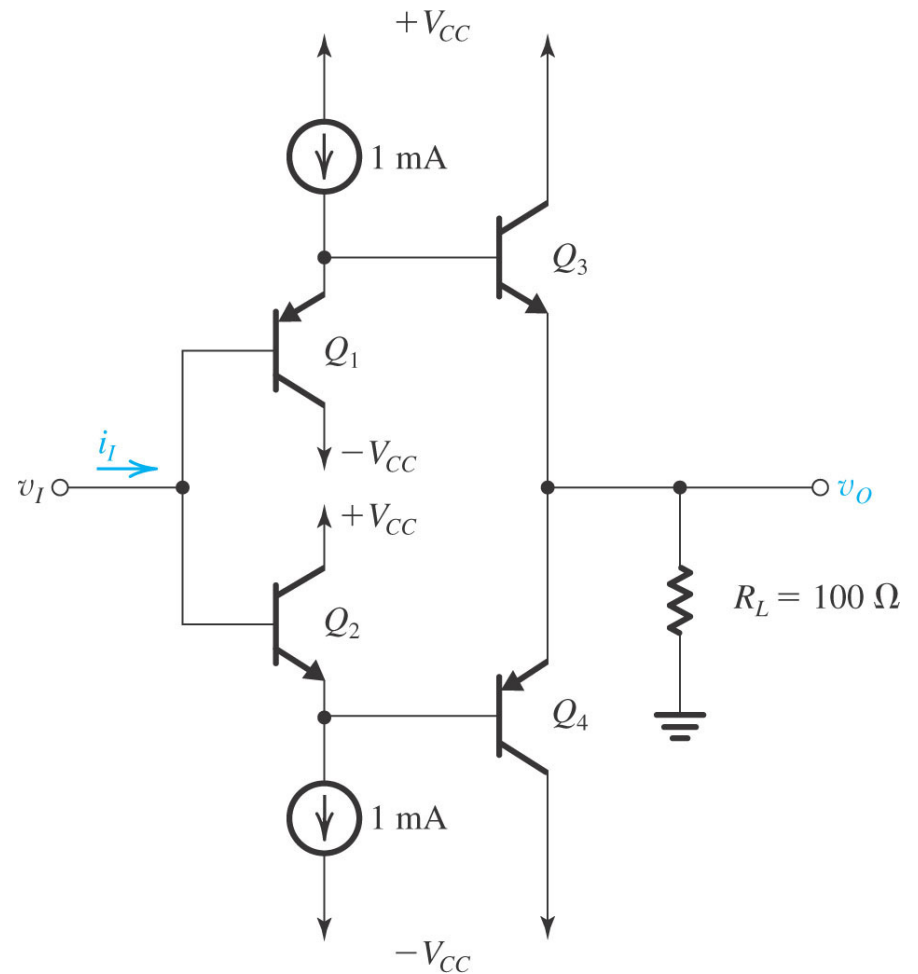
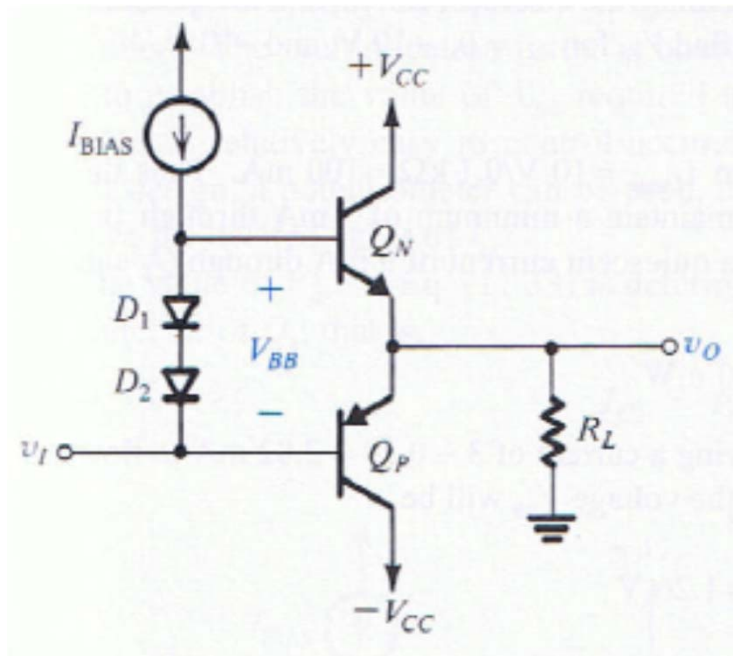
Reducing Crossover Distortion: Feedback



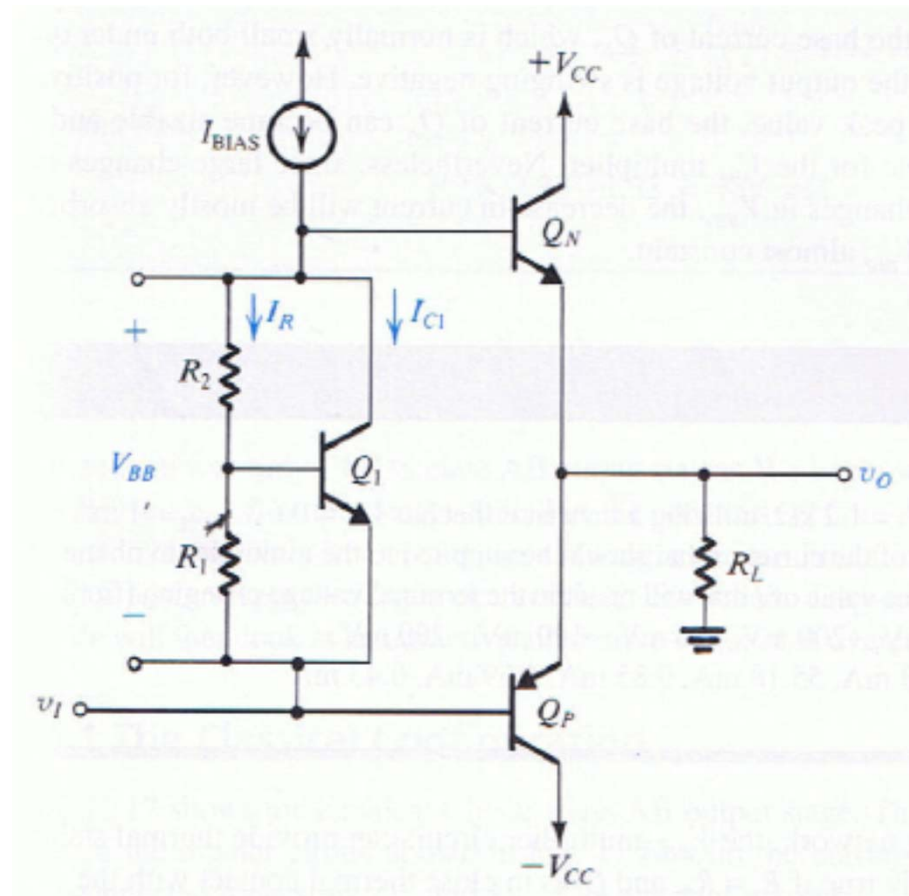
Reducing Crossover Distortion: Class AB



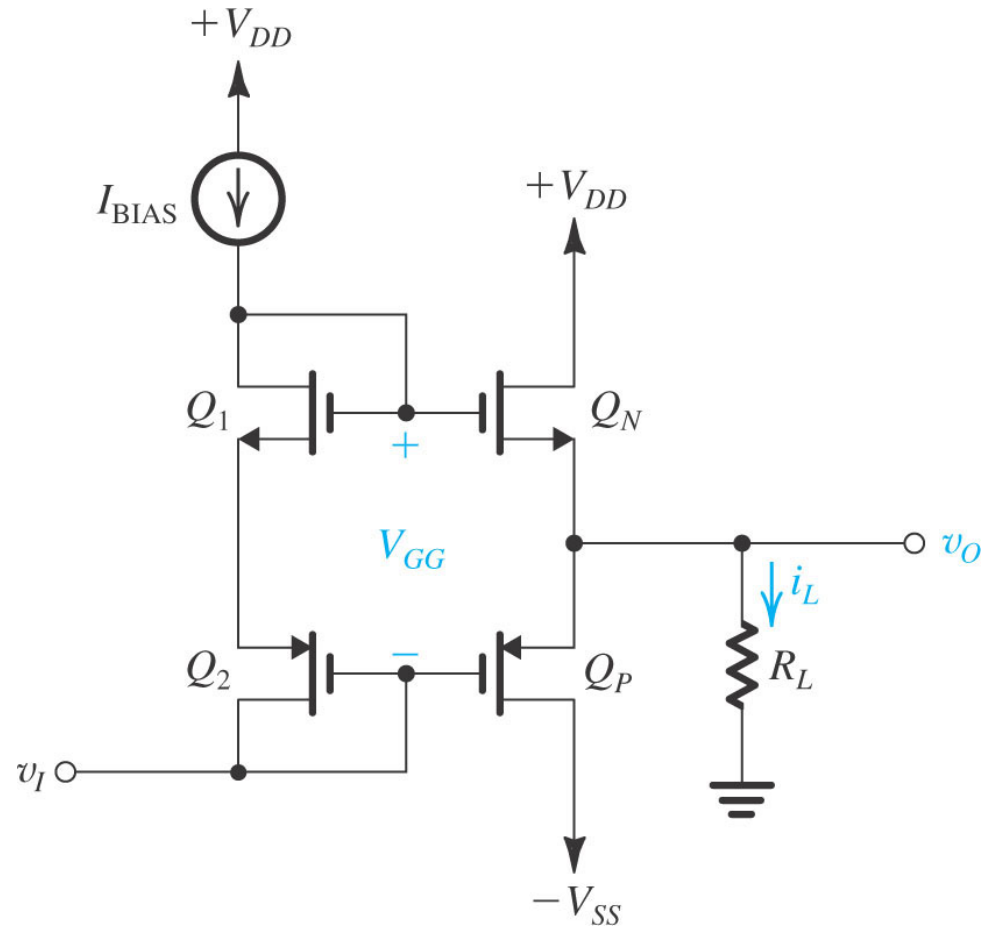
Practical Implementation of Class AB



Class AB using V_{BE} Multiplier



CMOS Class AB



CMOS Class AB using Common Source

