Chapter 12
Power Amplifiers

Definitions

In small-signal amplifiers the main factors are:

- **Amplification**
- **Linearity**
- **Gain**

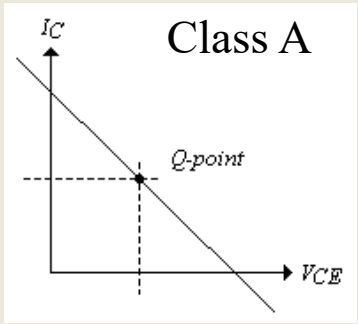
Since large-signal, or power, amplifiers handle relatively large voltage signals and current levels, the main factors are:

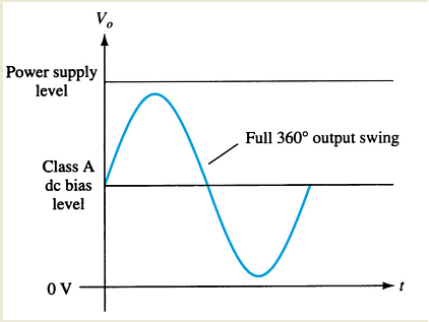
- **Efficiency**
- **Maximum power capability**
- **Impedance matching to the output device**

Amplifier Types

Class A

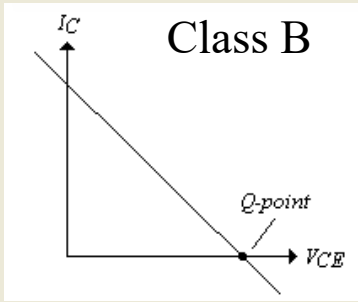
The amplifier conducts through the full 360° of the input. The Q-point is set near the middle of the load line.

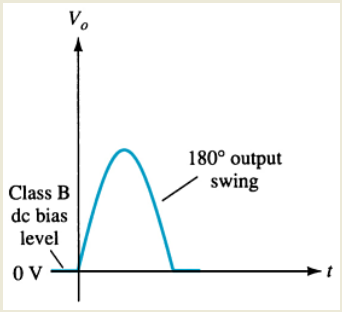




Class B

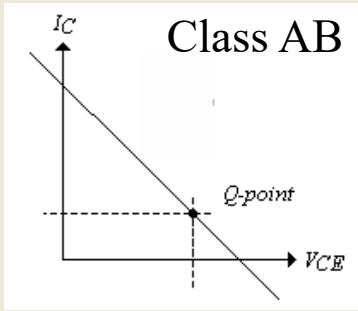
The amplifier conducts through 180° of the input. The Q-point is set at the cutoff point.





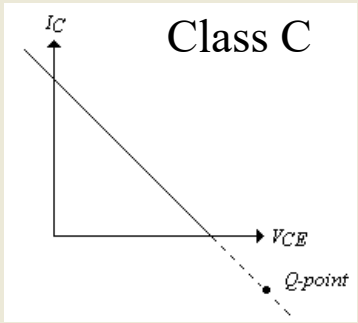
Class AB

This is a compromise between the class A and B amplifiers. The amplifier conducts somewhere between 180° and 360° . The Q-point is located between the mid-point and cutoff.



Class C

The amplifier conducts less than 180 of the input. The Q-point is located below the cutoff level.



Class D

This is an amplifier that is biased especially for digital signals.

Amplifier Efficiency

Comparison of Amplifier Classes					
	A	*AB*	Class *B*	*C**	*D*
Operating cycle	360°	180° to 360°	180°	Less than 180°	Pulse operation
Power efficiency	25% to 50%	Between 25% (50%) and 78.5%	78.5%		Typically over 90%

**Class C is usually not used for delivering large amounts of power, thus the efficiency is not given here.*

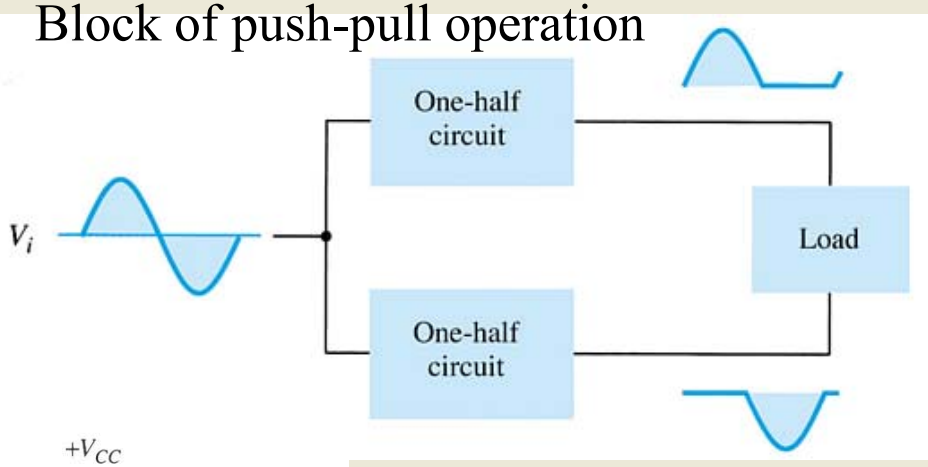
***Efficiency* refers to the ratio of output to input power. The lower the amount of conduction of the amplifier the higher the efficiency.**

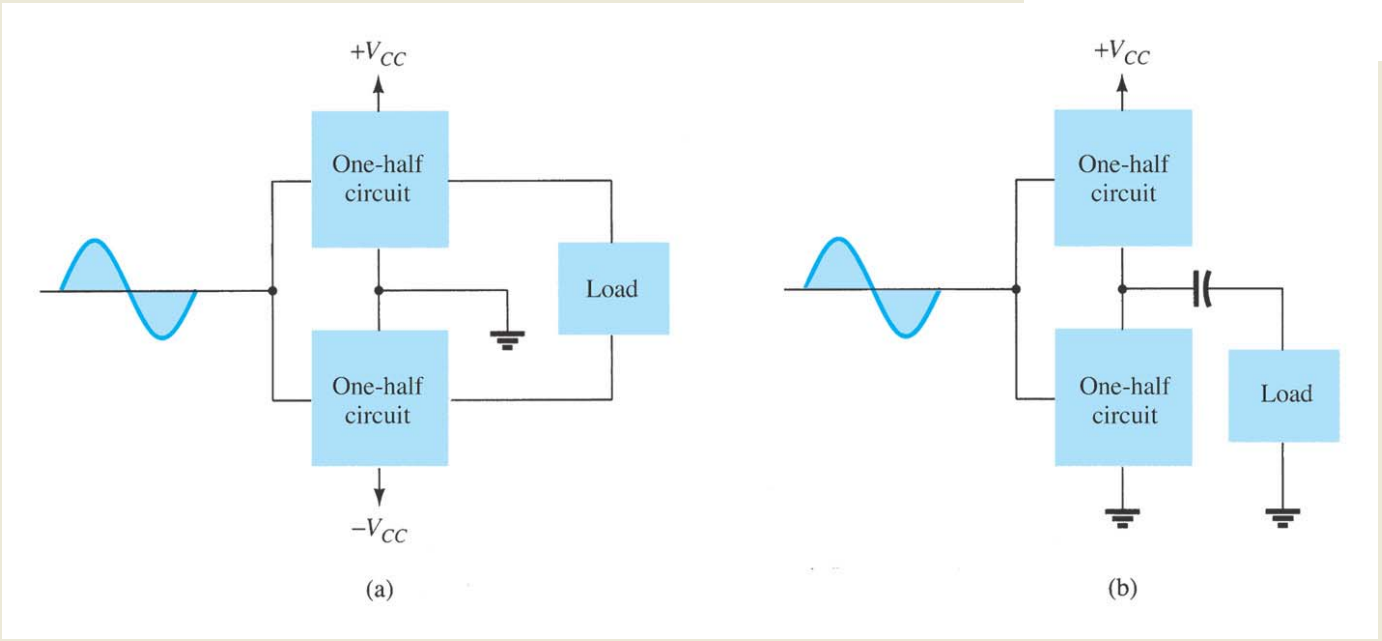
12.4 Class B Amplifier Operation

In class B, the dc bias leaves the transistor biased just off. The AC signal turns the transistor on. The transistor only conducts when it is turned on by one-half of the AC cycle.

In order to get a full AC cycle out of a class B amplifier, you need two transistors.

Block of push-pull operation





$$\text{maximum } P_{i(dc)} = V_{CC}(\text{maximum } I_{dc}) = V_{CC}\left(\frac{2V_{CC}}{\pi R_L}\right) = \frac{2V^2_{CC}}{\pi R_L}$$

$$\text{maximum } P_{o(ac)} = \frac{V^2_{CC}}{2R_L}$$

For maximum power, $V_L = V_{cc}$

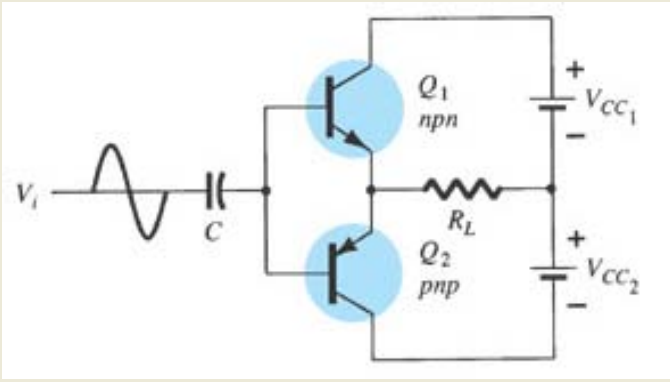
The maximum efficiency of a class B amplifier is 78.5%.

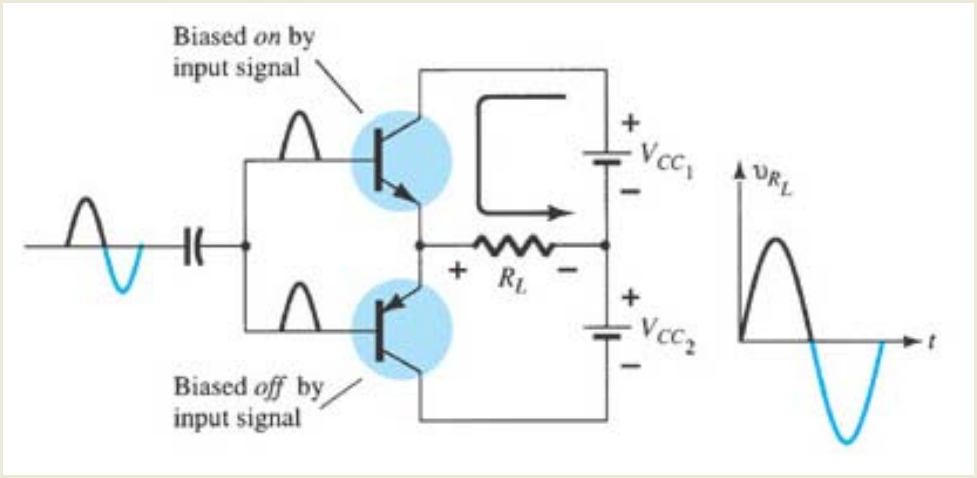
$$\%\eta = \frac{P_{o(ac)}}{P_{i(dc)}} \times 100 = \frac{\pi}{4} \times 100 \cong 78.5\%$$

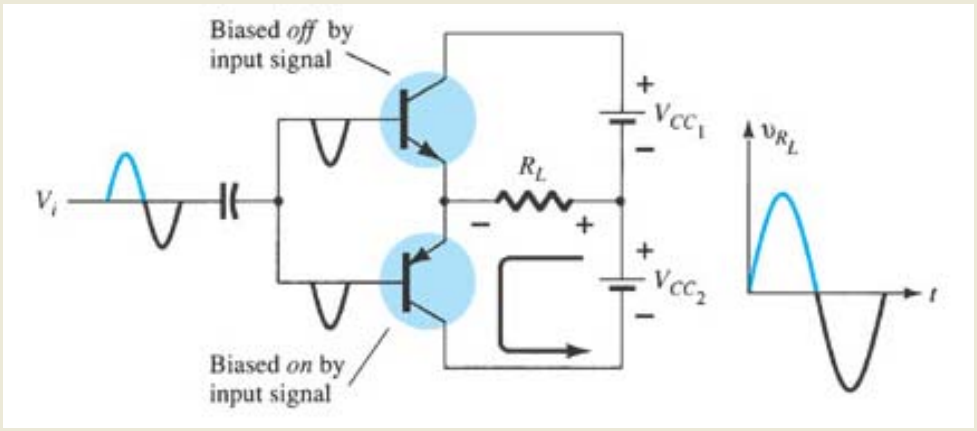
12.5 Class B Amplifier Circuits

Complementary-symmetry Push-Pull circuit

- During the positive half of the AC input cycle, transistor Q_1 (*npn*) is conducting and Q_2 (*pnp*) is off.
- During the negative half of the AC input cycle, transistor Q_2 (*pnp*) is conducting and Q_1 (*npn*) is off.



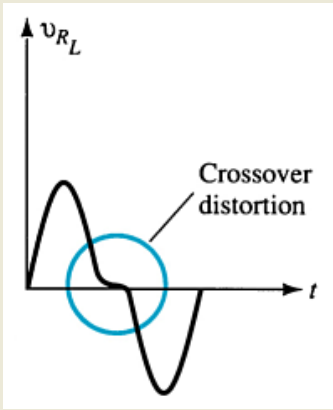




Important quantities:

- ✓ input power, maximum input power
- ✓ output power, maximum output power and the input voltage at which it occurred
- ✓ power dissipation, maximum power dissipation and the input voltage at which it occurred
- ✓ power efficiency

Class B Amplifier Circuits: Crossover Distortion

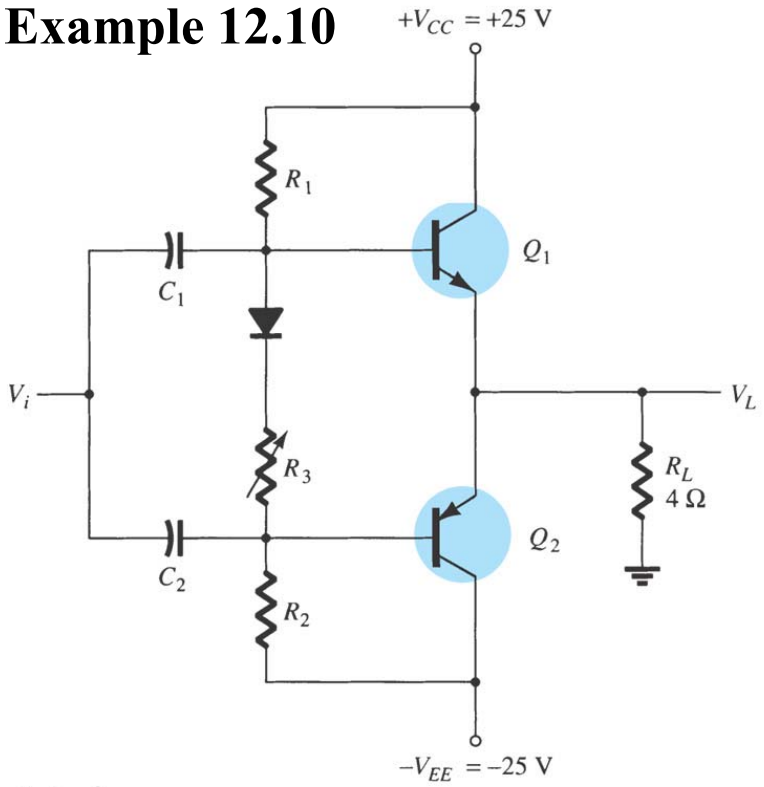


If the transistors Q_1 and Q_2 do not turn on and off at exactly the same time, then there is a gap in the output voltage.

Class AB, Complementary-symmetric Push-Pull Amplifier

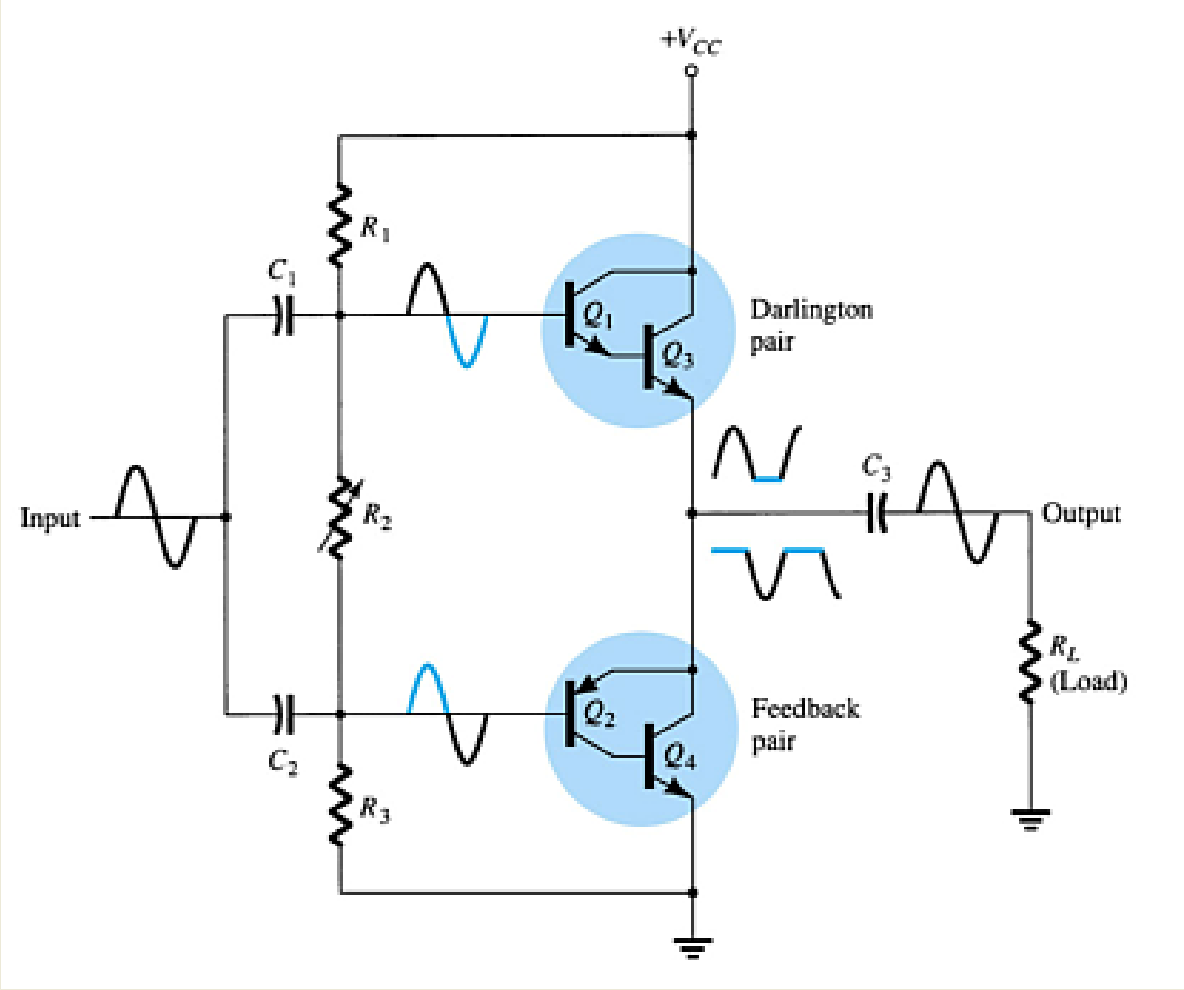
To overcome crossover distortion: Biasing the transistors in class AB improves push-pull operation by biasing both transistors to be on for more than half a cycle.

Example 12.10



Quasi-Complementary Push-Pull Amplifier

A Darlington pair and a feedback pair combination perform the push-pull operation. This increases the output power capability.



Summary of Chapter 12

- **Concepts of power amplifiers**
  - **Amplifier types: according to Q-point (DC biasing) and the conduction angle**
  - **Efficiency : application related**
- **Power amplifier circuits**
  - **Complementary push-pull amplifier**
    - **Class B: Crossover distortion**
    - **Class AB: to overcome crossover distortion**
  - **Quasi-complementary push-pull amplifier**
- **Be able to calculate important quantities of a power amplifier**
  - **input power, maximum input power**
  - **output power, maximum output power and the input voltage at which it occurred**
  - **power dissipation, maximum power dissipation and the input voltage at which it occurred**
  - **power efficiency**