Class B Power Amplifier

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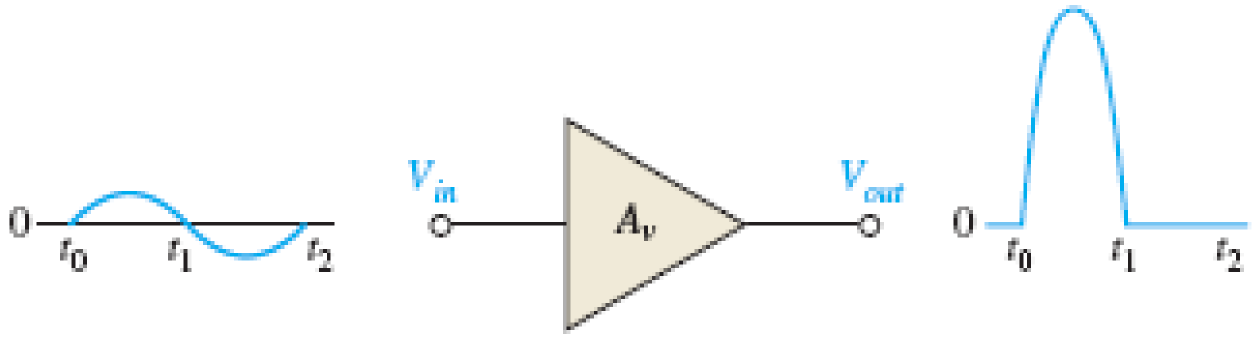
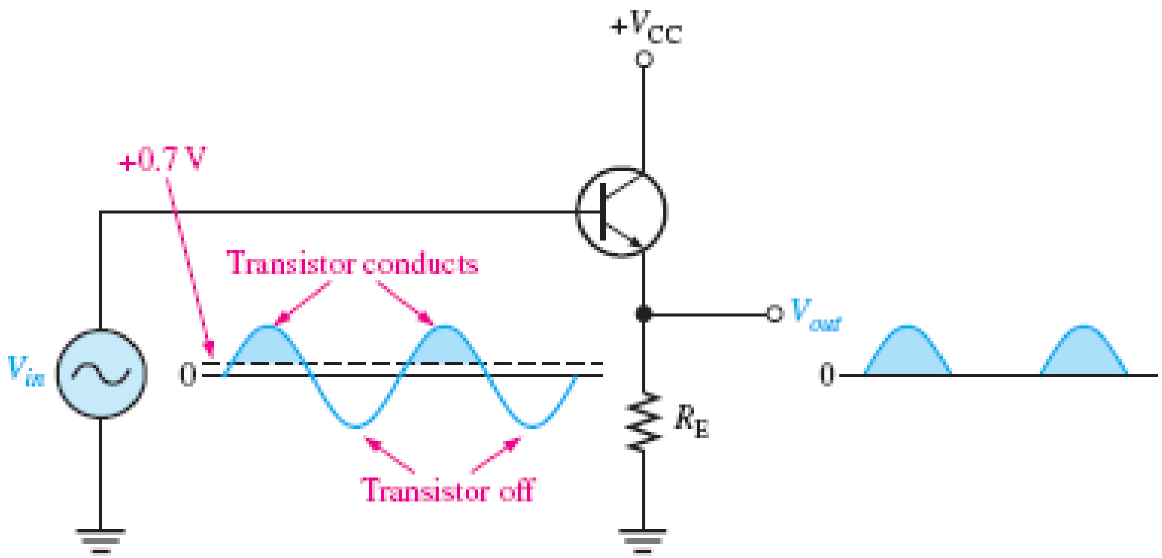
When an amplifier is biased at cutoff so that it operates in the linear region for of the input cycle and is in cutoff for it is a **class B amplifier.**



The Q-Point is at Cutoff

The class B amplifier is biased at the cutoff point so that $I_{CQ} = 0$ and $V_{CEQ} = V_{CE(cutoff)}$.

It is brought out of cutoff and operates in its linear region when the input signal drives the transistor into conduction.



Class B Push Pull Amplifier

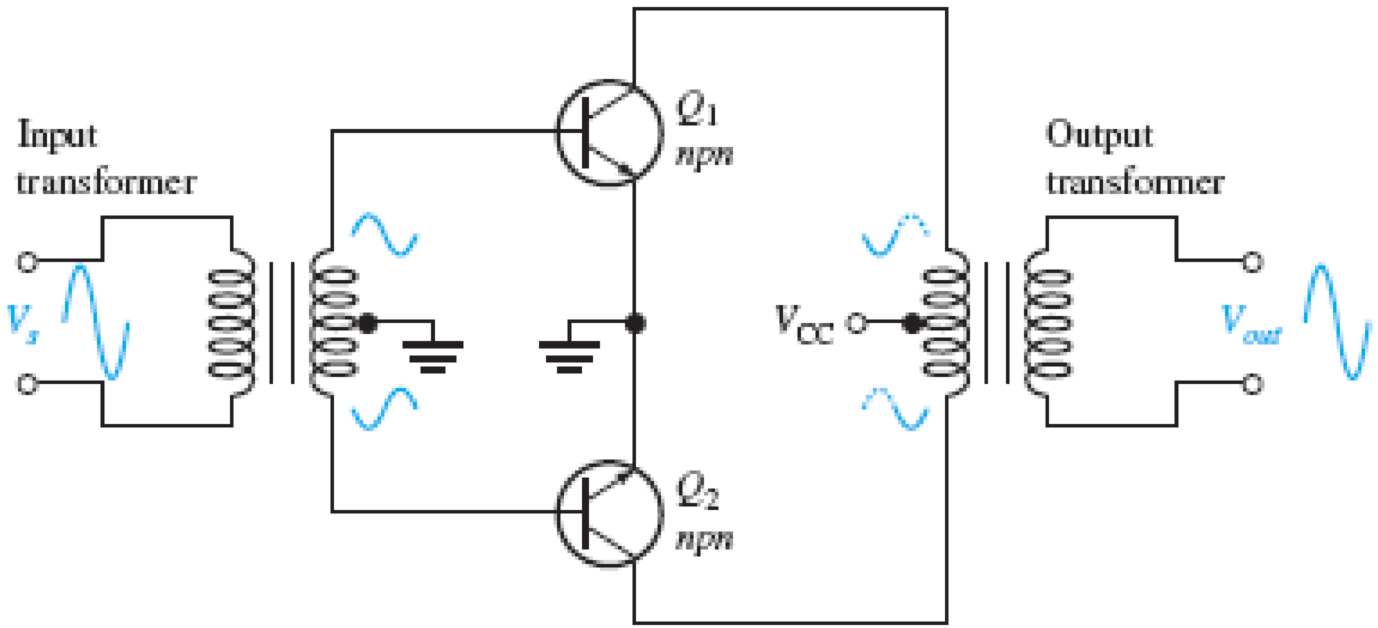
To amplify the entire cycle, it is necessary to add a second class B amplifier that operates on the negative half of the cycle.

The combination of two class B amplifiers working together is called **push-pull operation.**

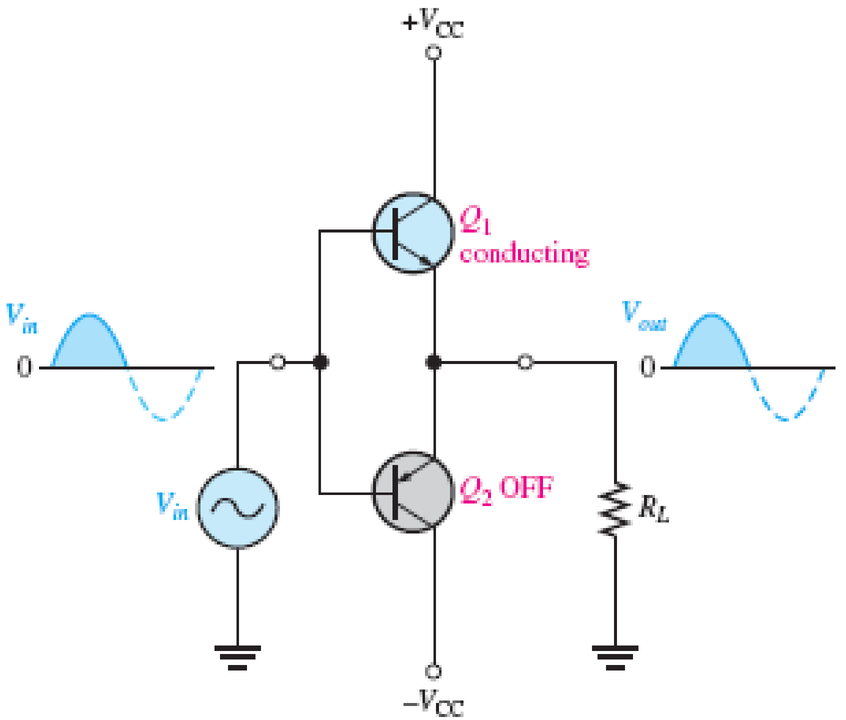
There are two common approaches for using push-pull amplifiers to reproduce the entire waveform. The first approach uses transformer coupling.

The second uses two **complementary symmetry transistors; these are a matching pair of *npn/pnp BJT***

Transformer Coupling



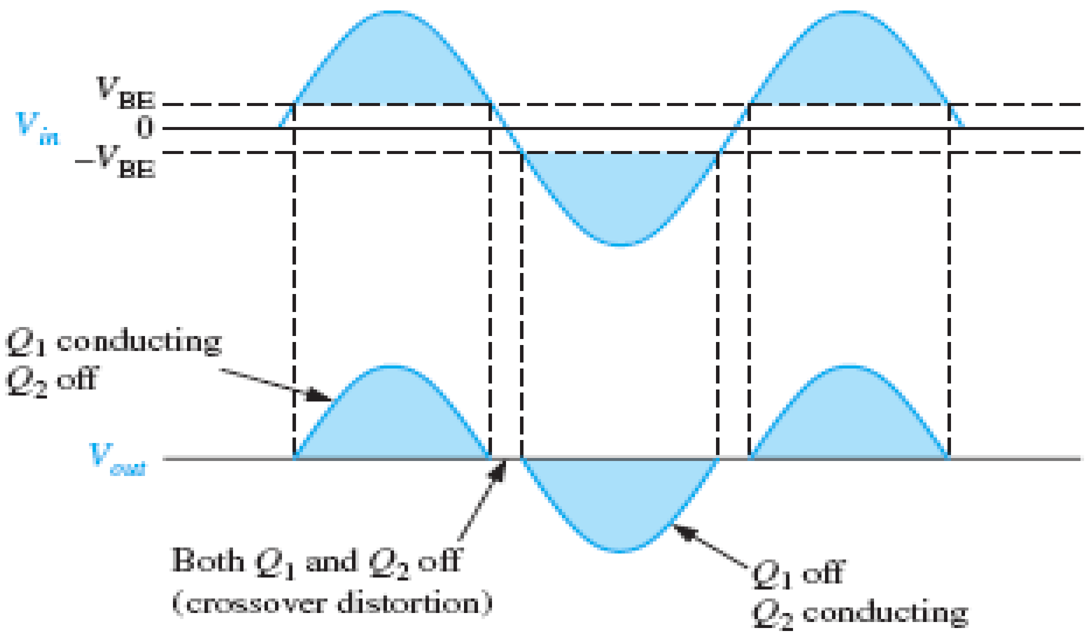
Complementary Symmetry Transistors



(a) During a positive half-cycle

(b) During a negative half-cycle

Crossover Distortion

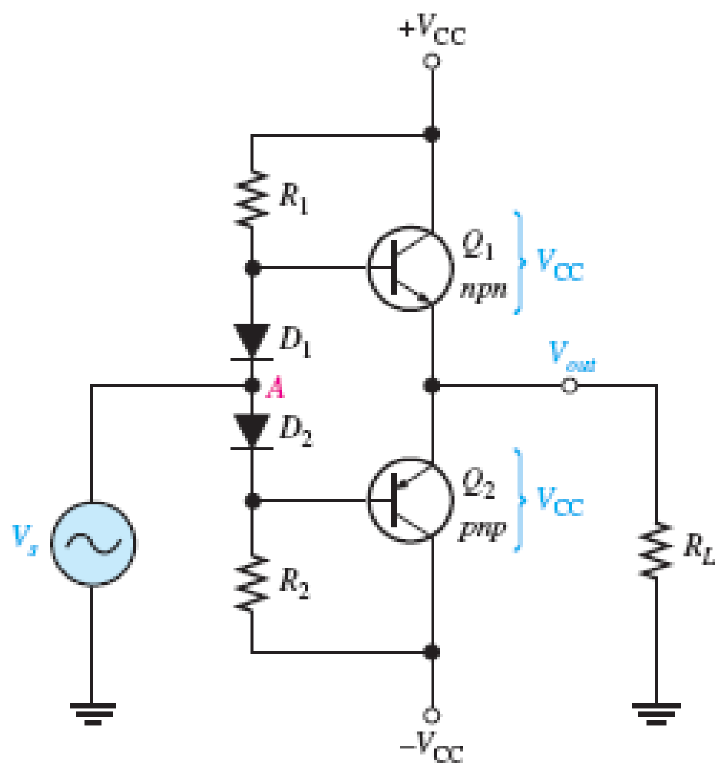


When the dc base voltage is zero, both transistors are off and the input signal voltage must exceed *VBE before a transistor conducts.*
Because of this, there is a time interval between the positive and negative alternations of the input when neither transistor is conducting, as shown in Figure.
The resulting distortion in the output waveform is called **crossover distortion.**

Method to Eliminate Crossover Distortion

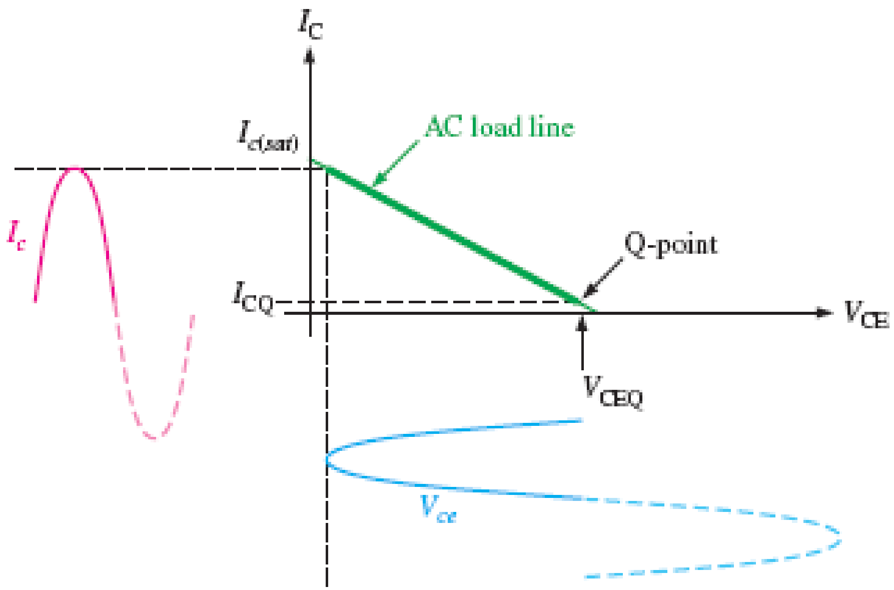
To overcome crossover distortion, the biasing is adjusted to just overcome the ***V_{BE}*** *of the* transistors; this results in a modified form of operation called **class AB. In class AB operation,** the push-pull stages are biased into slight conduction, even when no input signal is present.

This can be done with a voltage-divider and diode arrangement,

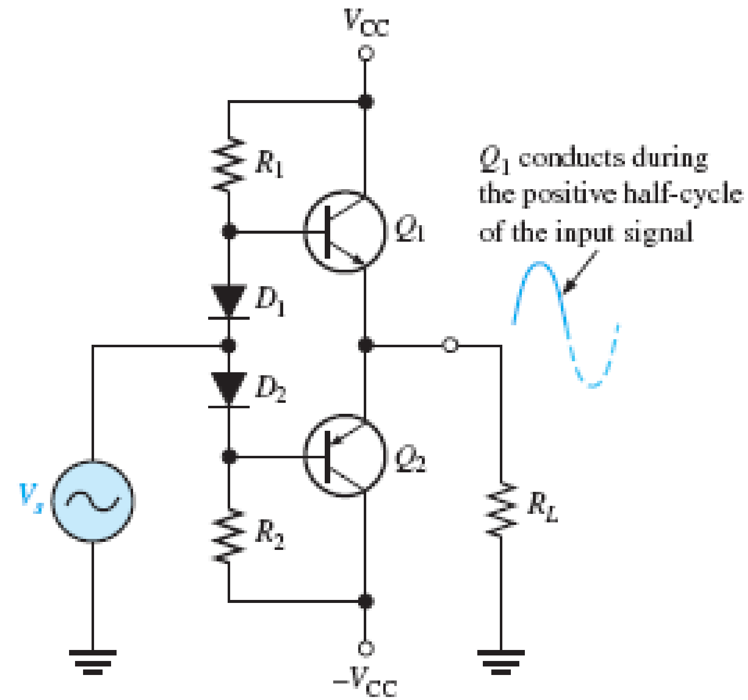


$$I_{CQ} = \frac{V_{CC} - 0.7\text{ V}}{R_1}$$

$$I_{c(sat)} = \frac{V_{CC}}{R_L}$$



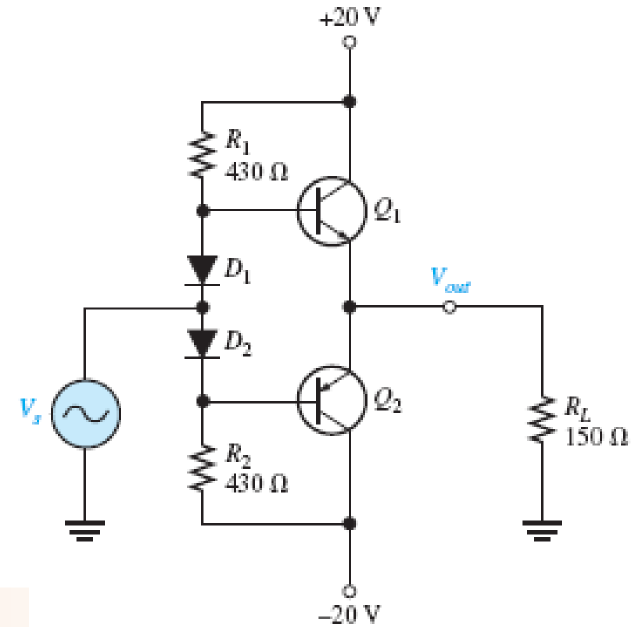
(a) AC load line for Q_1



(b) Circuit

Example

Determine the ideal maximum peak output voltage and current for the circuit shown in Figure.



The ideal maximum peak output voltage is

$$V_{out(peak)} \cong V_{CEQ} \cong V_{CC} = \mathbf{20\ V}$$

The ideal maximum peak current is

$$I_{out(peak)} \cong I_{c(sat)} \cong \frac{V_{CC}}{R_L} = \frac{20\text{ V}}{150\ \Omega} = \mathbf{133\ mA}$$

The actual maximum values of voltage and current are slightly smaller.

Class B/AB Power

Maximum Output Power You have seen that the ideal maximum peak output current for both dual-supply and single-supply push-pull amplifiers is approximately $I_{c(sat)}$, and the maximum peak output voltage is approximately V_{CEQ}. Ideally, the maximum *average* output power is, therefore,

$$P_{out} = I_{out(rms)}V_{out(rms)}$$

Since

$$I_{out(rms)} = 0.707I_{out(peak)} = 0.707I_{c(sat)}$$

and

$$V_{out(rms)} = 0.707V_{out(peak)} = 0.707V_{CEQ}$$

then

$$P_{out} = 0.5I_{c(sat)}V_{CEQ}$$

Substituting $V_{CC}/2$ for V_{CEQ}, the maximum average output power is

$$\mathbf{P_{out} = 0.25I_{c(sat)}V_{CC}}$$

DC Input Power The dc input power comes from the V_{CC} supply and is

$$P_{DC} = I_{CC}V_{CC}$$

Since each transistor draws current for a half-cycle, the current is a half-wave signal with an average value of

$$I_{CC} = \frac{I_{c(sat)}}{\pi}$$

So,

$$P_{DC} = \frac{I_{c(sat)}V_{CC}}{\pi}$$

Efficiency An advantage of push-pull class B and class AB amplifiers over class A is a much higher efficiency. This advantage usually overrides the difficulty of biasing the class AB push-pull amplifier to eliminate crossover distortion. Recall that efficiency, η is defined as the ratio of ac output power to dc input power.

$$\eta = \frac{P_{out}}{P_{DC}}$$

The maximum efficiency, η_{max}, for a class B amplifier (class AB is slightly less) is developed as follows, starting with Equation 7–6.

$$P_{out} = 0.25 I_{c(sat)} V_{CC}$$

$$\eta_{max} = \frac{P_{out}}{P_{DC}} = \frac{0.25 I_{c(sat)} V_{CC}}{I_{c(sat)} V_{CC}/\pi} = 0.25\pi$$

$$\boldsymbol{\eta_{max} = 0.79}$$

or, as a percentage,

$$\eta_{max} = 79\%$$

Recall that the maximum efficiency for class A is 0.25 (25 percent).

Input Resistance

The complementary push-pull configuration used in class B/class AB amplifiers is, in effect, two emitter-followers. The input resistance for the emitter-follower, where R_1 and R_2 are the bias resistors, is

$$R_{in} = \beta_{ac}(r'_e + R_E) \| R_1 \| R_2$$

Since $R_E = R_L$, the formula is

$$R_{in} = \beta_{ac}(r'_e + R_L) \| R_1 \| R_2$$