Class A Power Amplifier

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Power amplifiers are large-signal amplifiers.

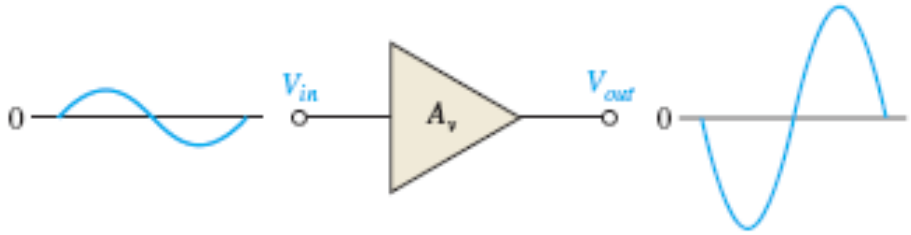
This generally means that a much larger portion of the load line is used during signal operation than in a small-signal amplifier.

Power amplifiers are those amplifiers that have the objective of delivering power to a load.

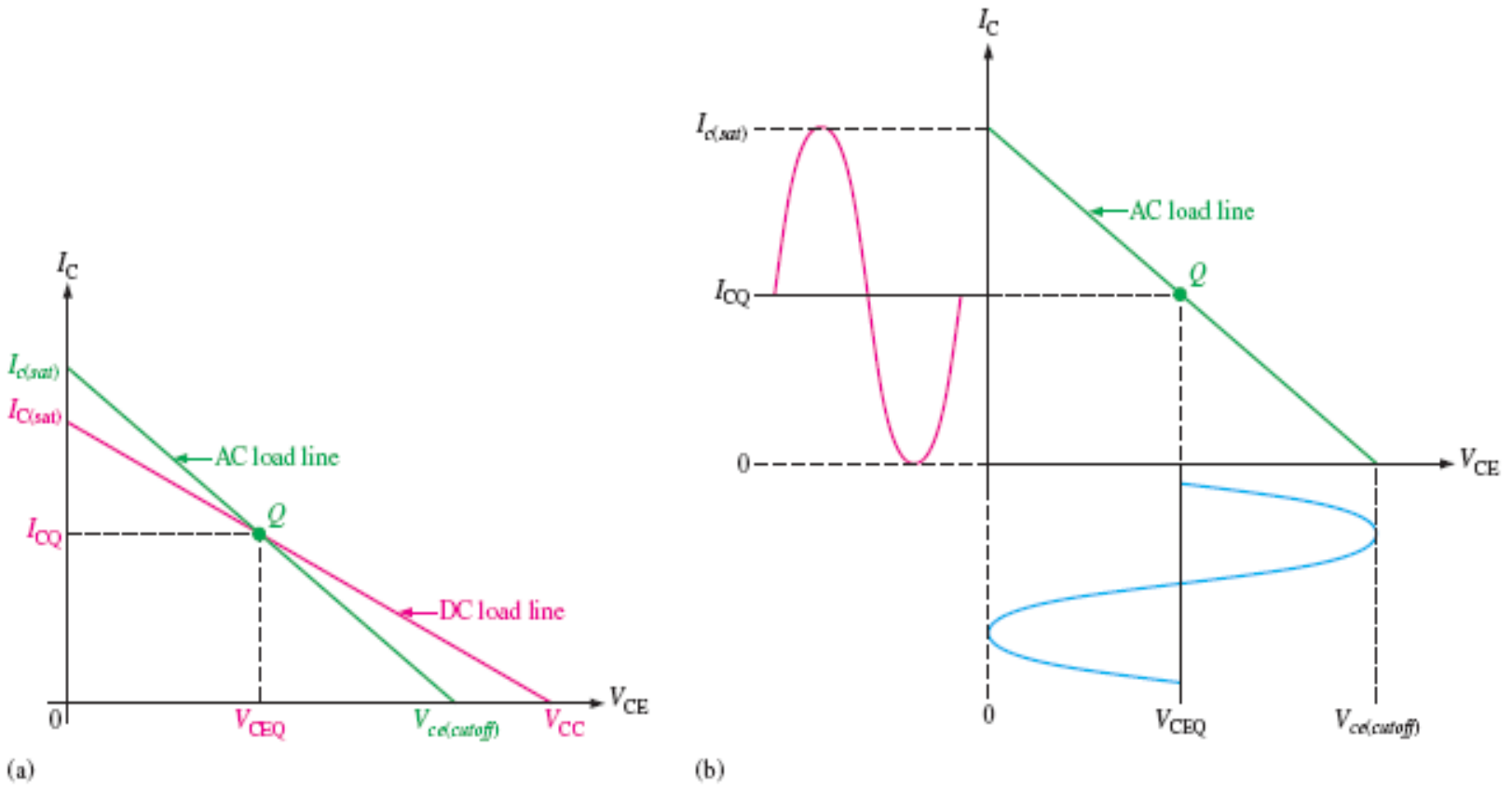
Power amplifiers are normally used as the final stage of a communications receiver or transmitter to provide signal power to speakers or to a transmitting antenna.

Class A Power Amplifier

When an amplifier is biased such that it always operates in the linear region where the output signal is an amplified replica of the input signal, it is a **class A amplifier.**



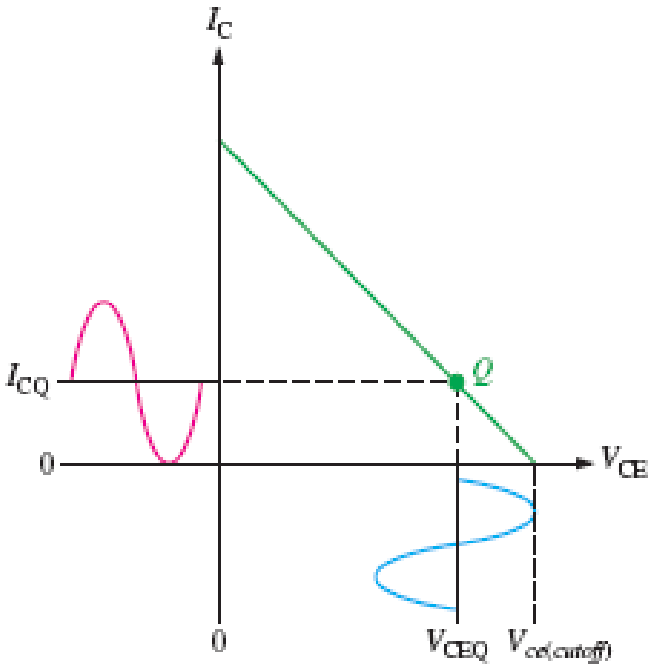
Centered Q-Point



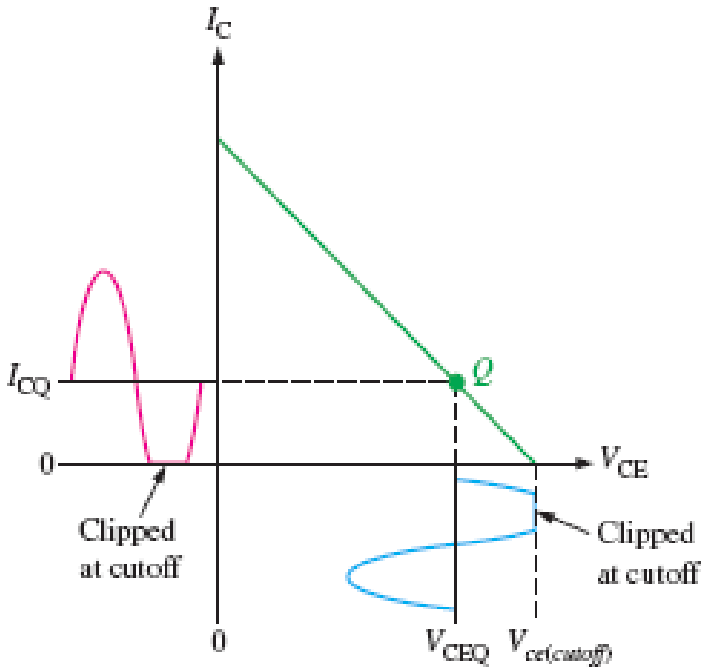
▲ FIGURE 7–2

Maximum class A output occurs when the Q-point is centered on the ac load line.

If the Q-point is not centered on the ac load line, the output signal is limited. Figure shows an ac load line with the Q-point moved away from center toward cutoff. The output variation is limited by cutoff in this case.



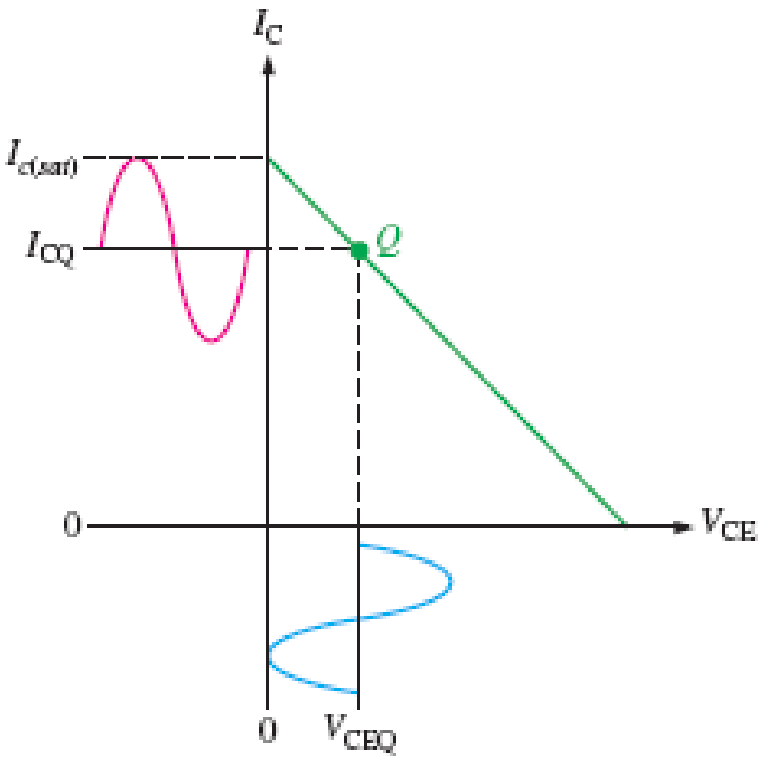
(a) Amplitude of V_{ce} and I_c limited by cutoff



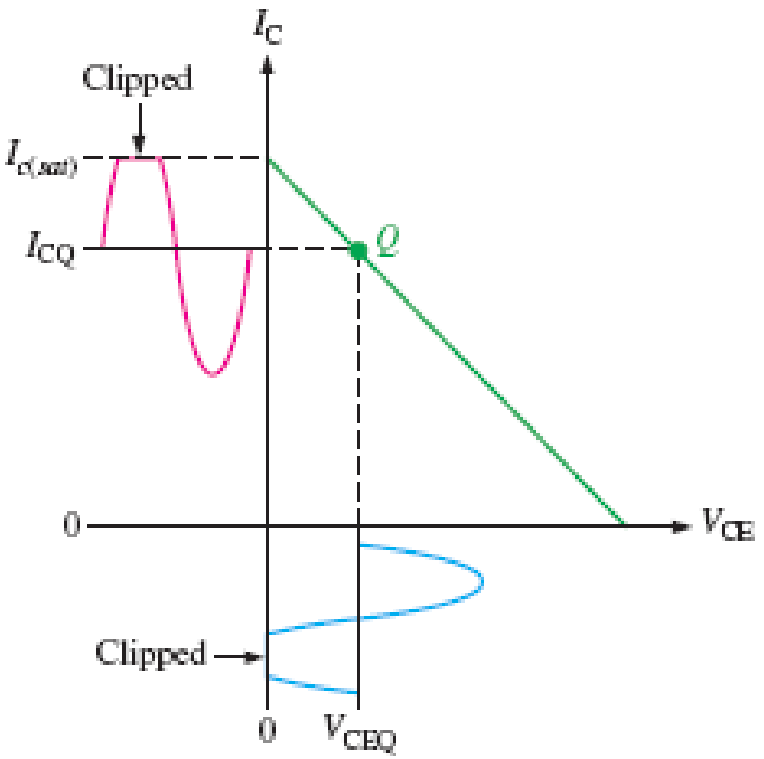
(b) Transistor driven into cutoff by a further increase in input amplitude

Figure shows an ac load line with the Q-point moved away from center toward saturation.

In this case, the output variation is limited by saturation. The collector current can only swing up to near saturation and an equal amount below $I_{CQ.}$



(a) Amplitude of V_{ce} and I_c limited by saturation



(b) Transistor driven into saturation by a further increase in input amplitude

Power Gain

A power amplifier delivers power to a load. The **power gain** of an amplifier is the ratio of the output power (power delivered to the load) to the input power. In general, power gain is

$$A_p = \frac{P_L}{P_{in}}$$

where A_p is the power gain, P_L is signal power delivered to the load, and P_{in} is signal power delivered to the amplifier.

The power gain can be computed by any of several formulas, depending on what is known. Frequently, the easiest way to obtain power gain is from input resistance, load resistance, and voltage gain. To see how this is done, recall that power can be expressed in terms of voltage and resistance as

$$P = \frac{V^2}{R}$$

For ac power, the voltage is expressed as rms. The output power delivered to the load is

$$P_L = \frac{V_L^2}{R_L}$$

The input power delivered to the amplifier is

$$P_{in} = \frac{V_{in}^2}{R_{in}}$$

By substituting into Equation 7–1, the following useful relationship is produced:

$$A_p = \frac{V_L^2}{V_{in}^2}\left(\frac{R_{in}}{R_L}\right)$$

Since $V_L/V_{in} = A_v$,

$$A_p = A_v^2\left(\frac{R_{in}}{R_L}\right)$$

Recall from Chapter 6 that for a voltage-divider biased amplifier,

$$R_{in(tot)} = R_1 \parallel R_2 \parallel R_{in(base)}$$

and that for a CE or CC amplifier,

$$R_{in(base)} = \beta_{ac} R_e$$

DC Quiescent Power

The power dissipation of a transistor with no signal input is the product of its Q-point current and voltage.

$$P_{DQ} = I_{CQ}V_{CEQ}$$

The only way a class A power amplifier can supply power to a load is to maintain a quiescent current that is at least as large as the peak current requirement for the load current.

A signal will not increase the power dissipated by the transistor but actually causes less total power to be dissipated.

The **dc quiescent power, given in above Equation, is the maximum** power that a class A amplifier must handle. The transistor's power rating must exceed this value.

Output Power

In general, the output signal power is the product of the rms load current and the rms load voltage.

The maximum unclipped ac signal occurs when the Q-point is centered on the ac load line.

For a CE amplifier with a centered Q-point, the maximum peak voltage swing is

$$V_{c(max)} = I_{CQ}R_c$$

The rms value is $0.707V_{c(max)}$.

The maximum peak current swing is,

$$I_{c(max)} = \frac{V_{CEQ}}{R_c}$$

The rms value is $0.707I_{c(max)}$.

To find the maximum signal power output, use the rms values of maximum current and voltage. The maximum power out from a class A amplifier is,

$$P_{out(max)} = (0.707I_c)(0.707V_c)$$

$$\mathbf{P_{out(max)} = 0.5I_{CQ}V_{CEQ}}$$

Efficiency

The efficiency of any amplifier is the ratio of the output signal power supplied to a load to the total power from the dc supply.

$$P_{DC} = I_{CC}V_{CC} = 2I_{CQ}V_{CEQ}$$

The maximum efficiency, of a capacitively coupled class A amplifier is,

$$\eta_{max} = \frac{P_{out}}{P_{DC}} = \frac{0.5I_{CQ}V_{CEQ}}{2I_{CQ}V_{CEQ}} = 0.25$$

The maximum efficiency of a capacitively coupled class A amplifier cannot be higher than **0.25, or 25%**, and, in practice, is usually considerably less (**about 10%**).