Common Base Amplifiers

Objectives:

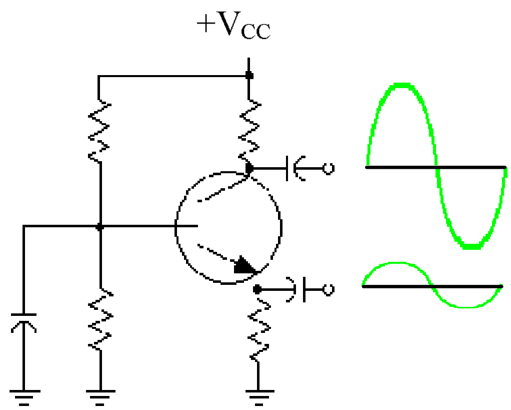
Describe the operating characteristics of a common base amplifier.

Describe the purpose of individual components in a base emitter amplifier.

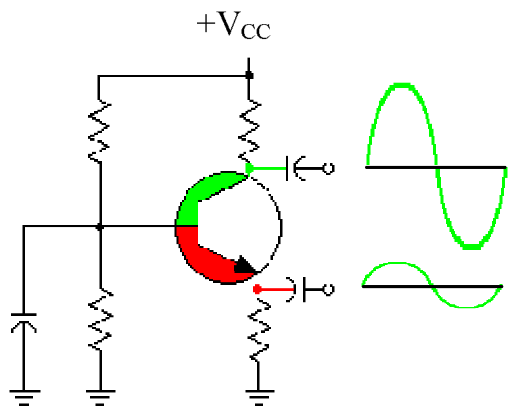
Describe methods to determine class of operation.

Describe methods to determine voltage gain.

This is a typical common base amplifier circuit.
The amplifiers output is controlled by a small input signal.
The output signal is an amplified replica of the input signal.



There are two parts to this amplifier circuit:
Input - Emitter-to-Base
Output - Base-to-Collector

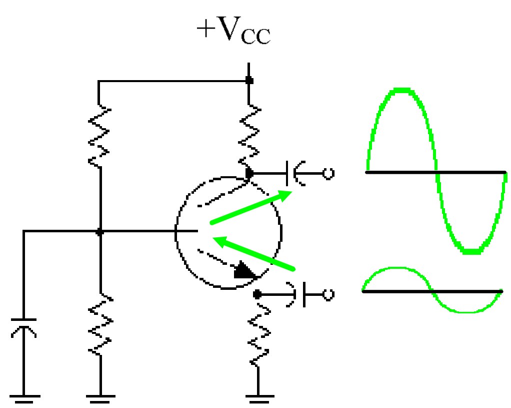


Notice the base is common in both parts.
This means that a change on the input side affects the output side.

A changing input signal changes the bias voltage on the emitter of the transistor.

When the input signal increases, the emitter voltage increases, decreasing the forward bias on the base-to-emitter PN junction.

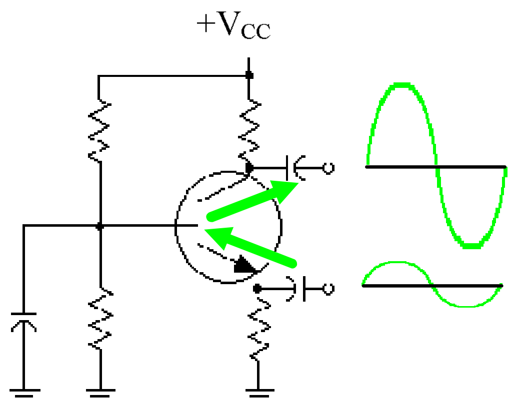
A decreases forward bias decreases emitter to collector current.



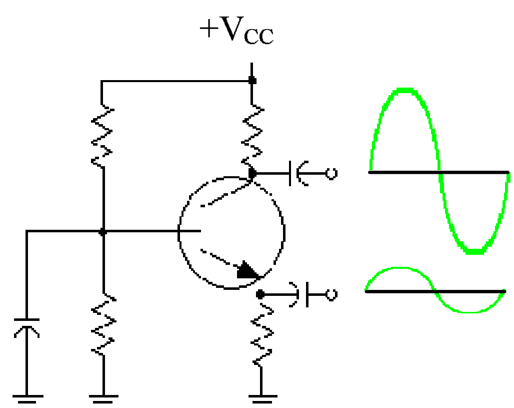
When the input signal decreases, the voltage on the emitter decreases, increasing forward bias on the base-to-emitter PN junction.

An increased forward bias increases emitter to collector current.

The effects of a changing input signal are seen in a changing output signal.



Note, an increasing input signal produces an increasing output signal.
A decreasing input signal produces a decreasing output signal.
A small input signal controls a large output signal.

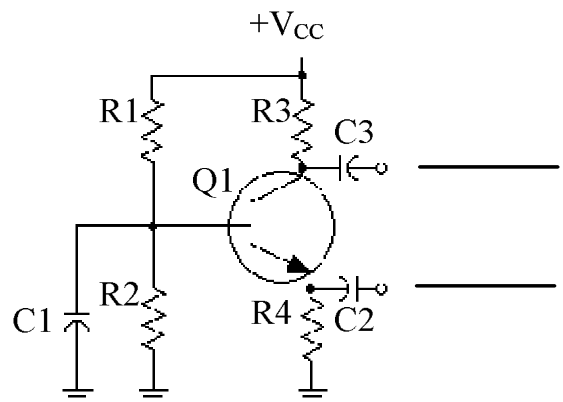


Transistor bias is determined by R1, R2, R3, R4, and C1.

R1 and R2 develop the base bias of Q1 and establish the operating point.

R1 and R2 form a voltage divider that is operated by $+V_{CC}$. A fixed DC voltage is always present on the base of Q1.

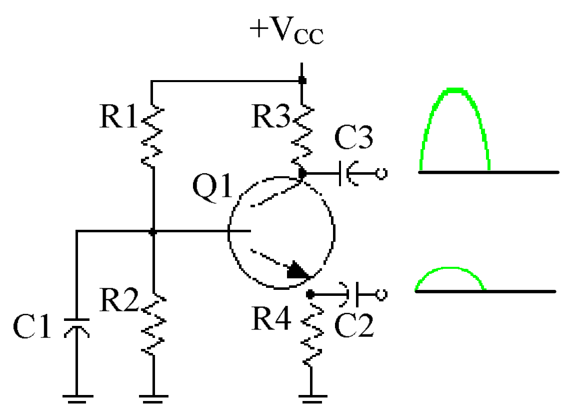
C1 grounds any AC voltage that develops on the base.



Resistor R4 establishes emitter bias. Any change in the emitter voltage produces a predictable change at the output.

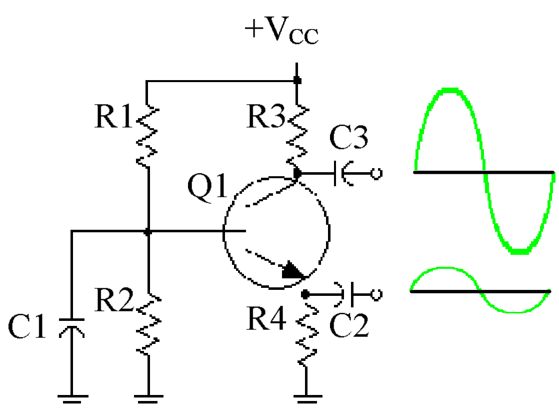
The output signal is determined by collector load resistor R3.

An increasing input signal decreases the emitter to collector current. Less voltage drops across R3 and the output signal increases.



A decreasing input signal increases current. More voltage drops across R3 and the output signal decreases.

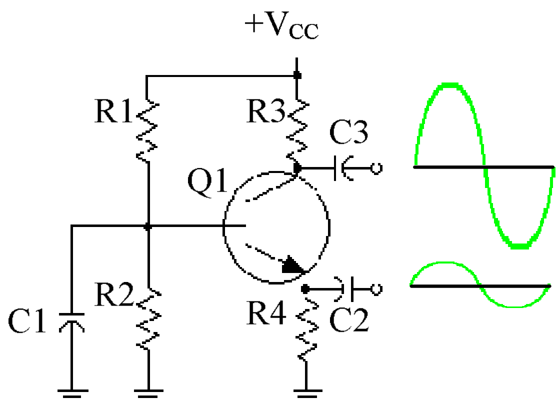
The result is an output signal that is an amplified replica of the input signal.



Two more important components to the amplifier circuit are C2 and C3.

C2 is an input coupling capacitor that stops any DC voltage from reaching the base of the transistor.

C3 is an output coupling capacitor that prevents the DC bias on the collector from reaching the output.

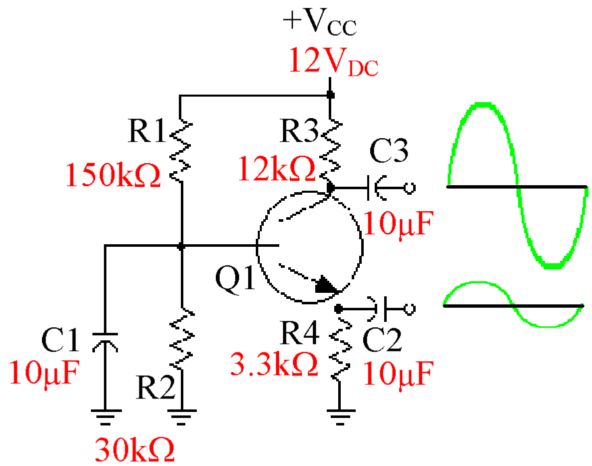


The coupling capacitors do not effect the bias voltages on Q1.

The class of operation and the voltage gain (Av) are needed to identify normal operation of a common emitter amplifier.

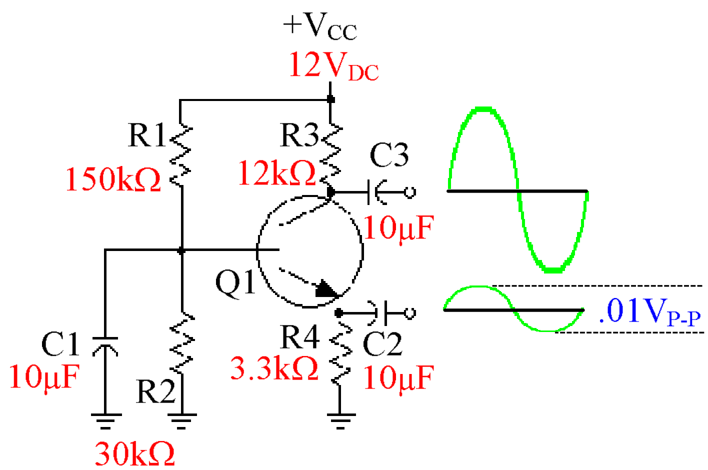
The class of operation is determined by the bias placed on the base of Q1 by R1 and R2.

The gain is determined by emitter resistor R4 and collector resistor R3.



If class of operation and voltage gain are known, comparison of input and output signals determine if the amplifier is operating normally.

Common base amplifiers are normally biased Class A for good fidelity with low distortion.



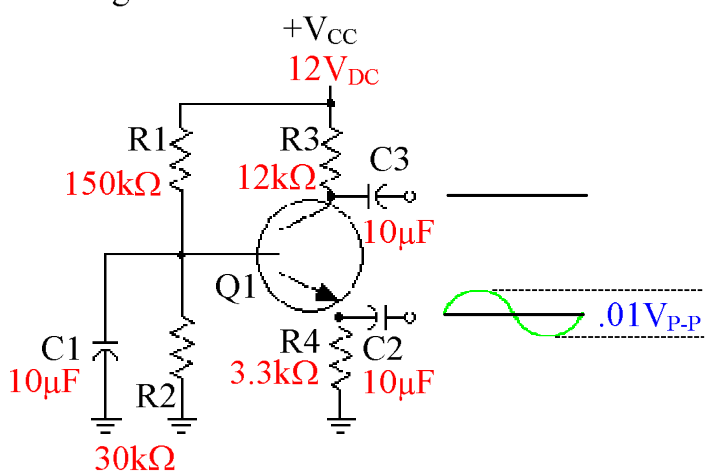
Find the class of operation by calculating the base voltage. It must be above .6 volts and the input signal cannot place the transistor into cutoff for class A.

Step 1. Find R_T for the voltage divider on the base.

$R_T = R1 + R2$

Step 2. Find I_T for the voltage divider.

$$I_T = \frac{E_T}{R_T}$$



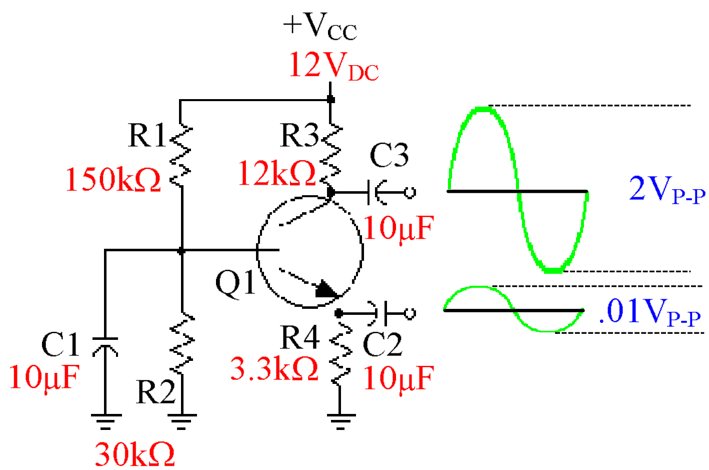
Step 3. Find voltage of R2.

$E_{R2} = I_T \bullet R2$

$E_B = E_{R2}$

This is a class A because the base voltage is above .6 volts and the input signal never drives the transistor into cutoff.

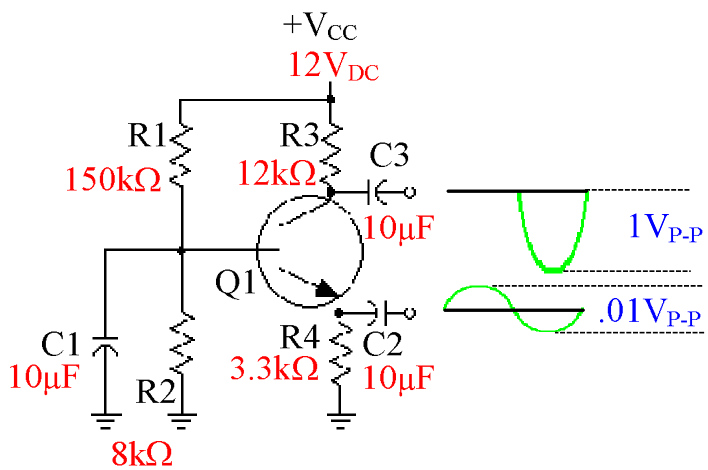
If the output signal voltage and input signal voltage is known, gain (Av) can be calculated by dividing the output signal voltage by the input signal voltage.



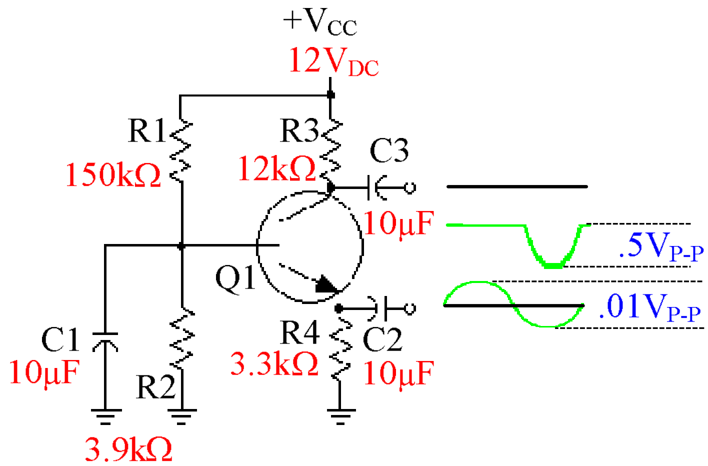
$$Av = \frac{E_{out}}{E_{in}}$$

If the base bias on Q1 is equal to .6 V, the class of operation becomes class B. The output signal shows only 180 °.

The transistor is driven into cutoff during the positive half cycle of the input signal; therefore, the transistor only reproduces half of the signal on the output.



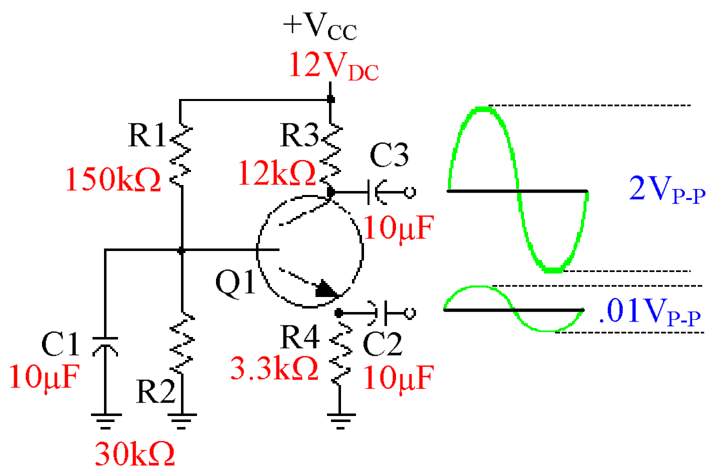
If the base bias on Q1 is less than .6 V, the class of operation becomes class C.
The output signal shows less than 180 °.
The transistor is driven into cutoff during the positive half cycle of the input signal and some of the negative half cycle.
Therefore, the transistor reproduces less than half of signal on the output.



This is a class A common base with a gain of 200. The input to output comparison shows normal operation.

If the output signal voltage and input signal voltage are known, gain (Av) can be calculated by dividing the output signal voltage by the input signal voltage.

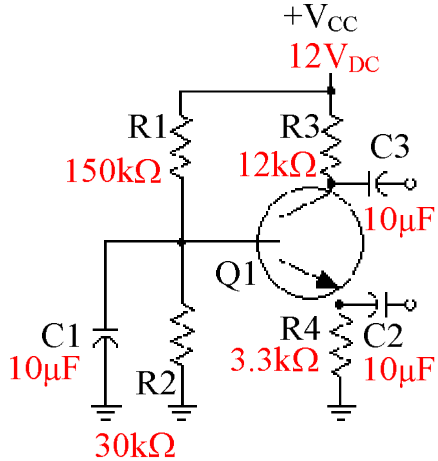
The actual component values determine the class of operation and voltage gain.



$$Av = \frac{E_{out}}{E_{in}}$$

However, if the input and output signal voltage are unknown, gain can be calculated using the component values and the following formula.

$$Av = \frac{R_C}{.025 \div I_E}$$



The collector load resistor (R_C) is the resistor between the collector of Q1 and V_{CC}. In this circuit, R_C is R3.

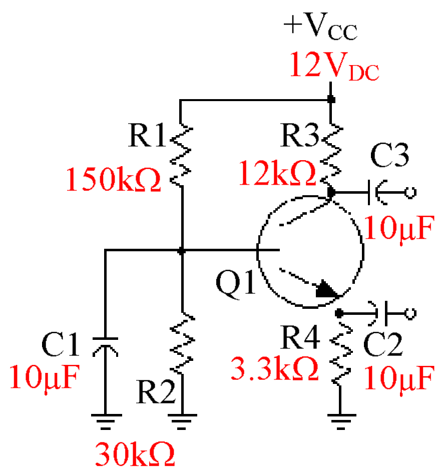
Finding I_E will take a few calculations. First, we must find the base voltage (E_B).

Step 1. Find R_T for the voltage divider on the base.

$$R_T = R1 + R2$$

Step 2. Find I_T for the voltage divider.

$$I_T = \frac{E_T}{R_T}$$



$$Av = \frac{R_C}{.025 \div I_E}$$

Step 3. Find voltage of R2.

$$E_{R2} = I_T \bullet R2$$

$$E_B = E_{R2}$$

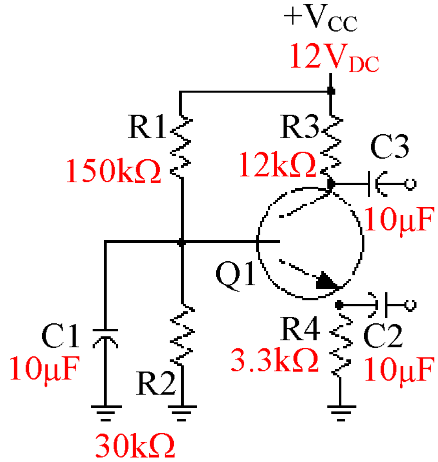
Next, find the emitter voltage(E_E), and finally the emitter current (I_E).

Step 4. Find E_E.

$$E_E = E_B - .6V$$

Step 5. Find I_E.

$$I_E = \frac{E_E}{R4}$$



$$Av = \frac{R_C}{.025 \div I_E}$$