Common Emitter Amplifiers

Objectives:

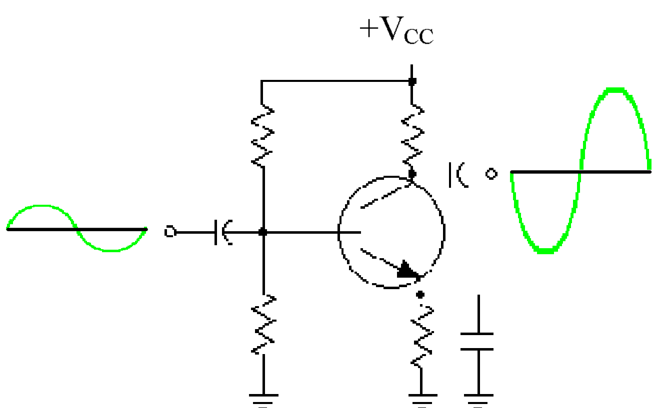
Describe the operating characteristics of a common emitter amplifier.

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

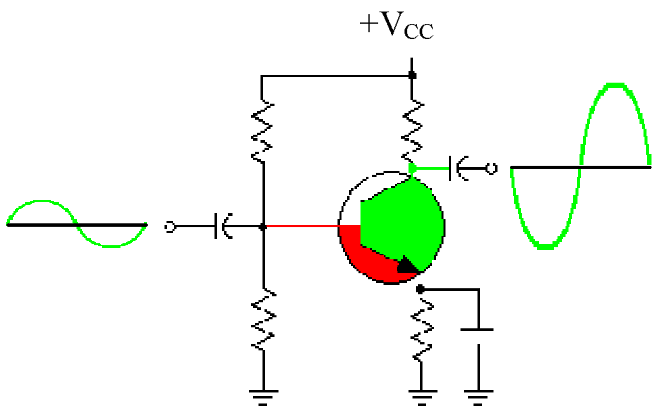
Describe methods to determine class of operation.

Describe methods to determine voltage gain.

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



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

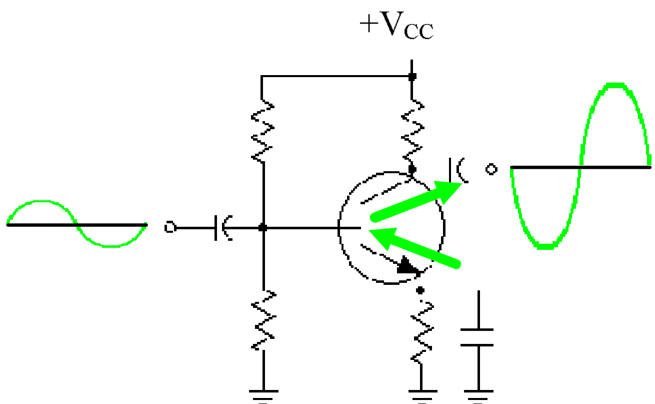


Notice the emitter is common in both parts.
This means that a change on the input side affects the output side.

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

When the input signal increases, the bias voltage increases.

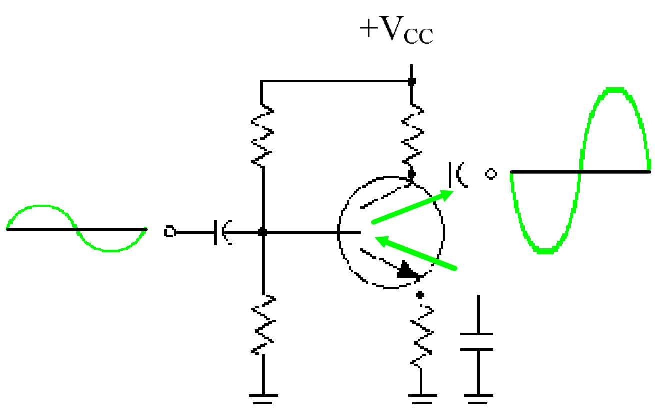
An increase in bias voltage affects current flow in the emitter collector circuit.
Current increases.



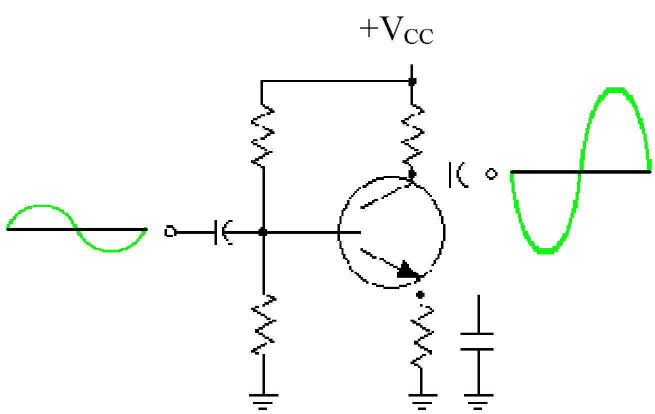
When the input signal decreases, the bias voltage decreases.

A decrease in bias voltage affects current flow in the emitter collector circuit. Current decreases.

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



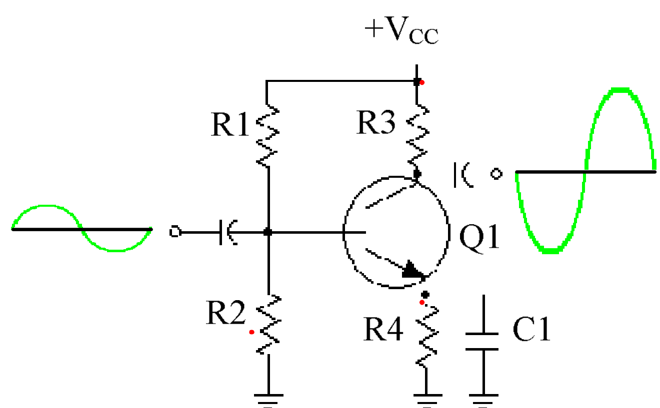
Note, an increasing input signal produces a decreasing output signal.
A decreasing input signal produces an increasing output signal.
A small input signal controls a large output signal.



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

When an input signal is applied to the base of Q1, it's combined with the fixed bias voltage established by R1 and R2.

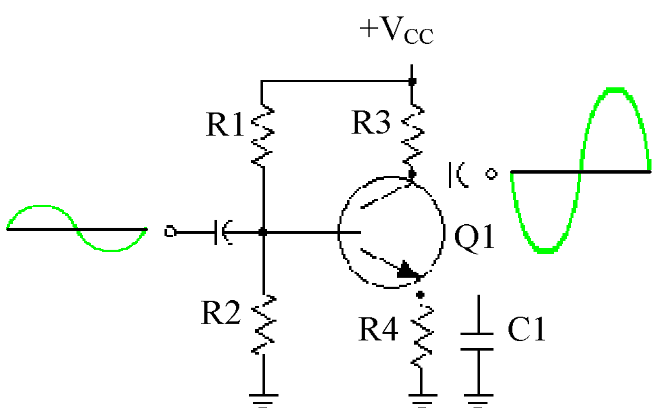
R1 and R2 form a voltage divider that is operated by $+V_{CC}$. A fixed DC voltage is always present on the base of Q1.



Any change in the fixed bias of Q1 produces a predicted change at the output.

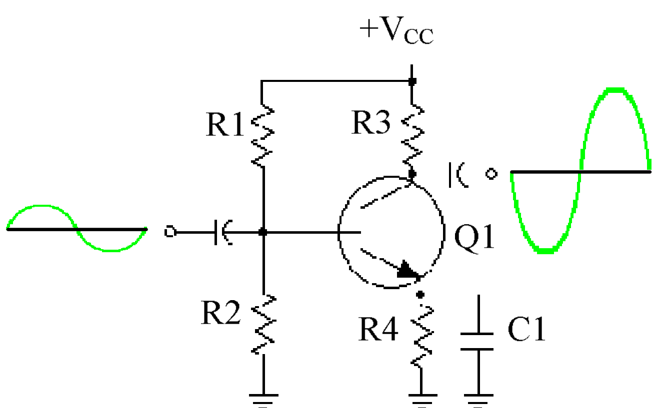
Resistor R4 and bypass capacitor C1 provide self biasing for the emitter and stability for the circuit.

Normal operation of the amplifier produces heat. Heat causes an unpredictable change at the output.



R4 provides temperature stability by decreasing emitter current when current increases due to heat.

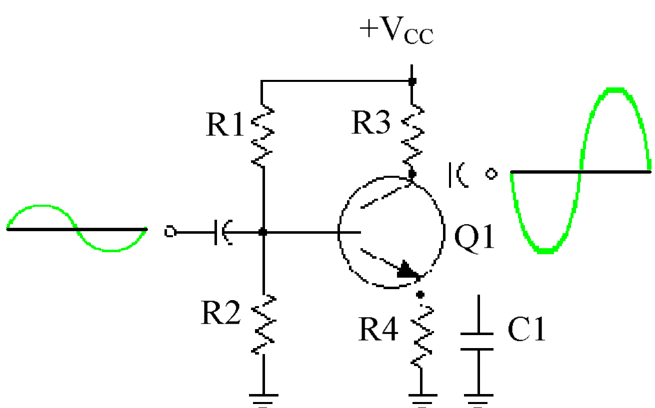
C1 provides a path for any unwanted AC that is produced. This insures that the output signal is not affected.



The output signal is determined by collector load resistor R3.

When the emitter to collector current increases, more voltage drops across R3 and the output signal decreases.

When current decreases, less voltage is dropped across R3 and the output signal increases.

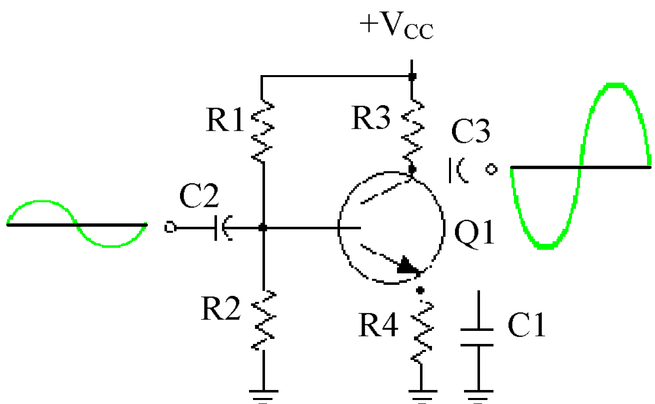


The result is a signal on the output that is a replica of the input signal except it is amplified and inverted.

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.

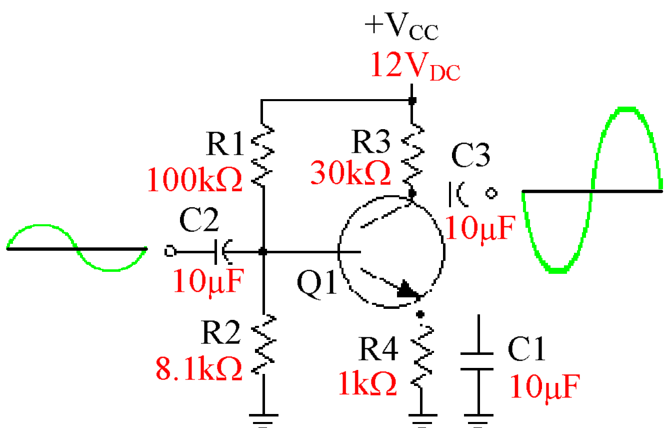


The coupling capacitors do not effect the bias voltages on Q1.

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.

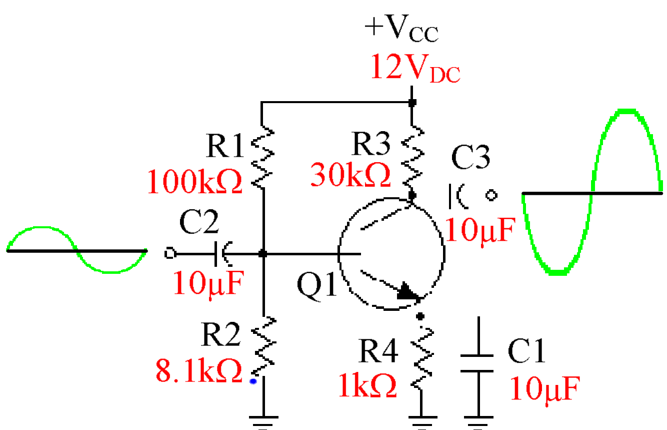
The gain is determined by emitter resistor R4 and collector resistor R3.



If class of operation and voltage gain are unknown, normal operation is determined by comparing input and output signals.

If the output signal shows a full 360 ° cycle, it is a class A amplifier.

Also, the base voltage must be greater than .6 volts and the input signal cannot drive the transistor into cutoff.



If the transistor is cutoff at any point on the input signal and the base voltage is greater than .6 volts, the class of operation is AB.

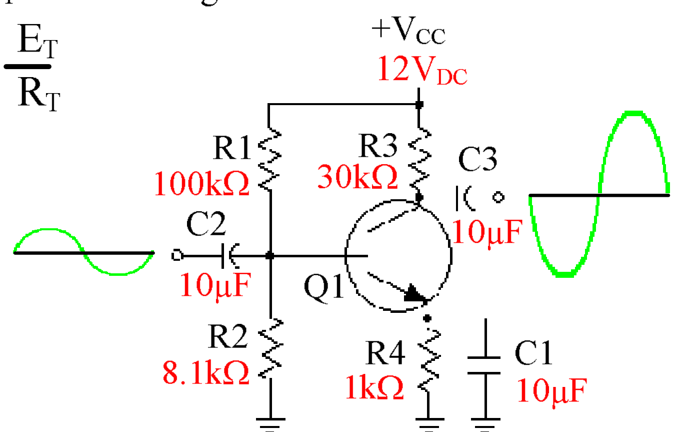
The base bias voltage can be calculated by finding the voltage across of R2 because R2 is between the base and ground.

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.

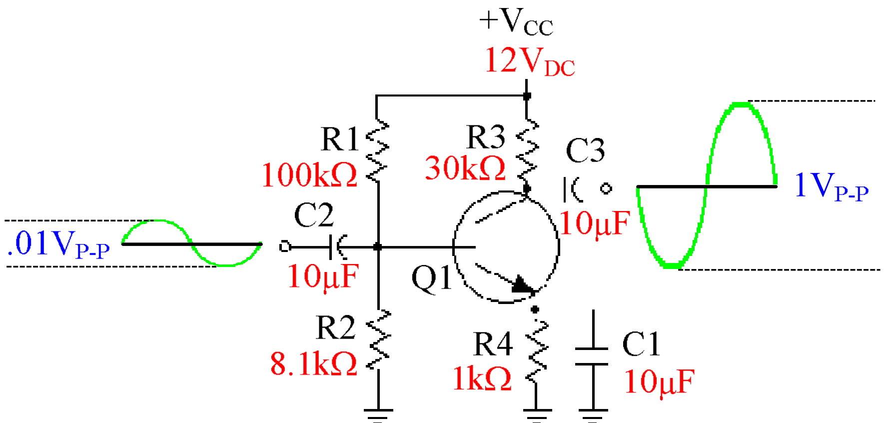
$$E_{R2} = I_T \bullet R2$$

$$E_B = E_{R2}$$

If class of operation and voltage gain are unknown, normal operation is determined by comparing input and output signals.

If the output signal shows a full 360 ° cycle, it is a class A amplifier.

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.

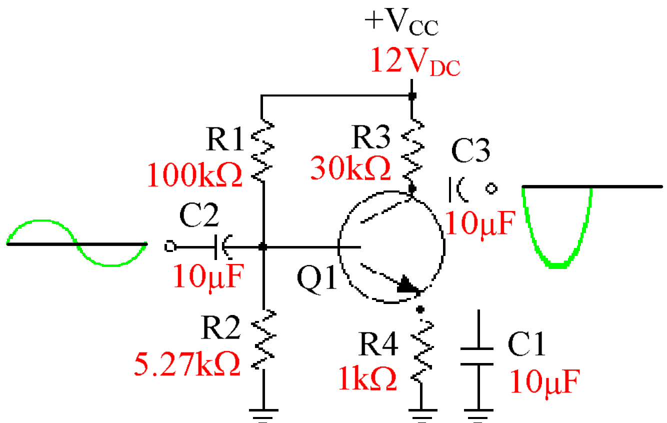


$$Av = \frac{E_{out}}{E_{in}}$$

If the 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 negative half cycle of the input signal; therefore, the transistor only reproduces half of the signal on the output.



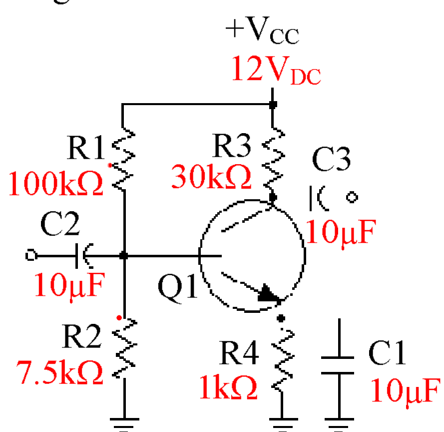
The actual component values determine the class of operation and voltage gain.
Calculate the base bias on Q1 to determine class of operation.

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.

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

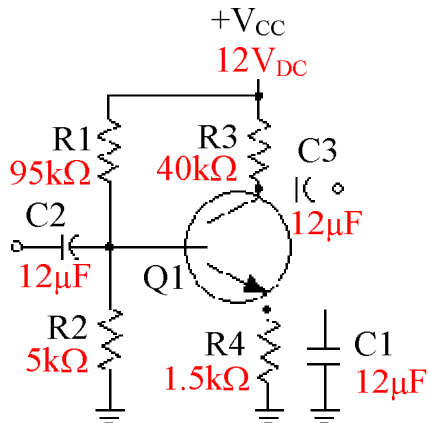


Step 3. Find voltage of R2.

$E_{R2} = I_T \bullet R2$

$E_B = E_{R2}$

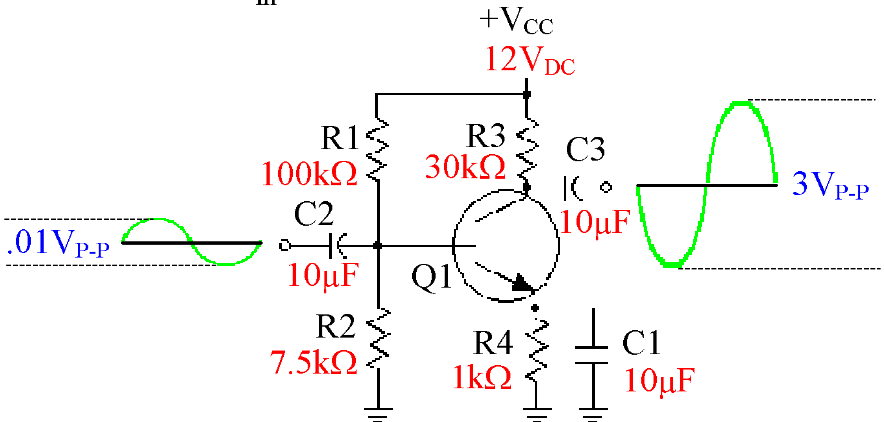
Determine class of operation for this common emitter circuit.



Once the class of operation is determined, the gain (Av) is found by comparing the input and output signals.

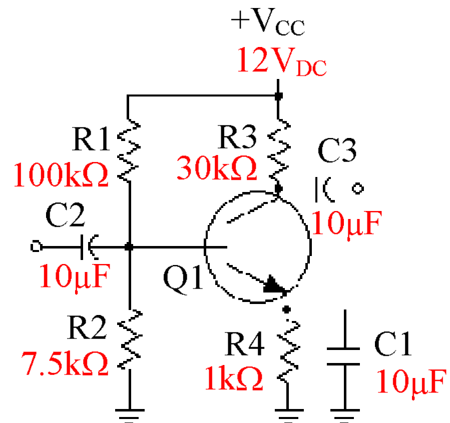
Gain (Av) is calculated using the following formula:

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



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.

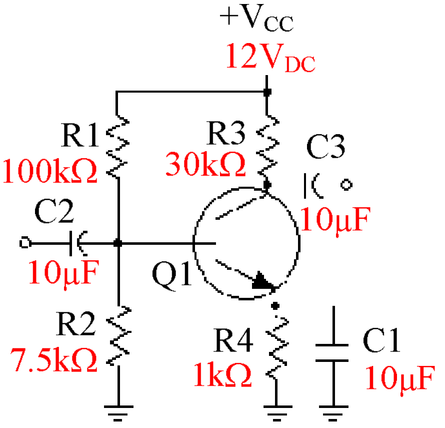
Finding I_E will take a few calculations. First, we must find the base voltage (E_B).

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.

$E_{R2} = I_T \bullet R2$

$E_B = E_{R2}$

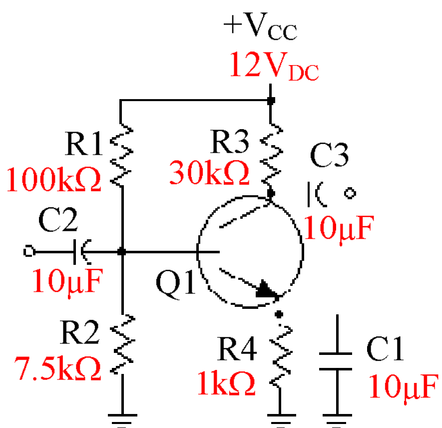
Next, find the emitter voltage(E_E), and finally the emitter current (I_E).

Step 4. Find E_E.

$$E_E = E_B - .6V$$

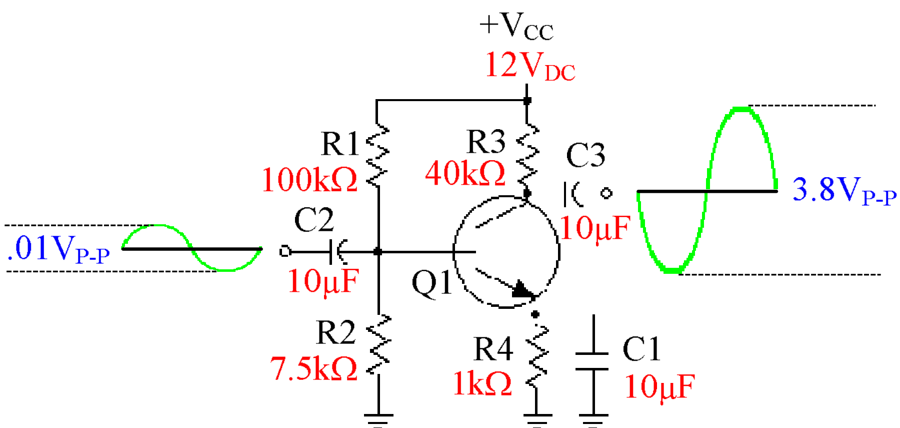
Step 5. Find I_E.

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



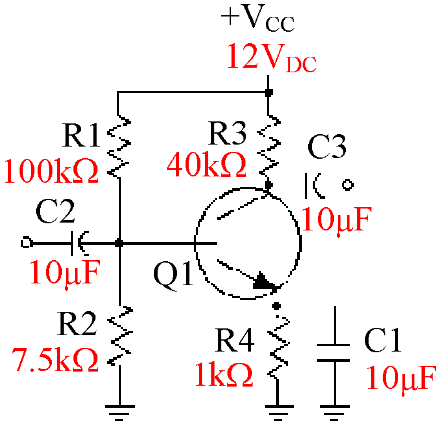
$$Av = \frac{R_C}{.025 \div I_E}$$

What is the measured Av of this circuit?



What is the calculated Av of this circuit?

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



What is the calculated Av of this circuit?

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