EE-202 Electronics-I-

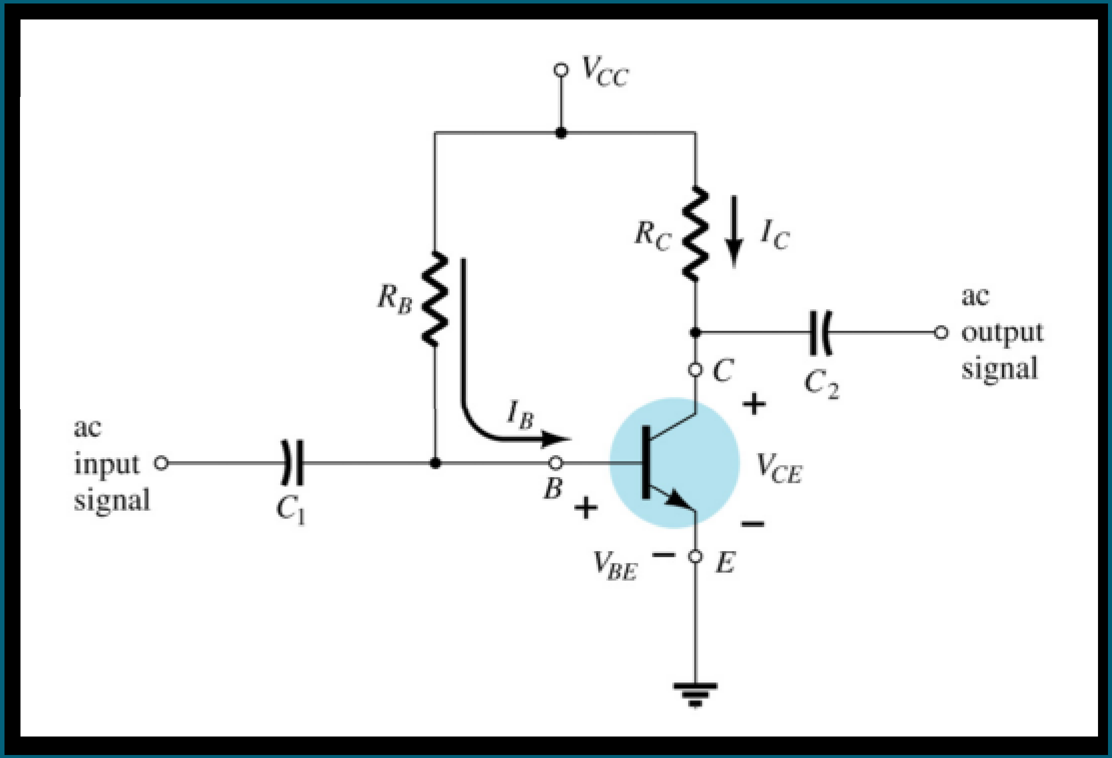
Chapter 8:

BJT DC Biasing Circuits

DC Biasing Circuits

- **Fixed-bias circuit**
- **Emitter-stabilized bias circuit**
- **Collector-emitter loop**
- **Voltage divider bias circuit**
- **DC bias with voltage feedback**

Fixed Bias Circuit



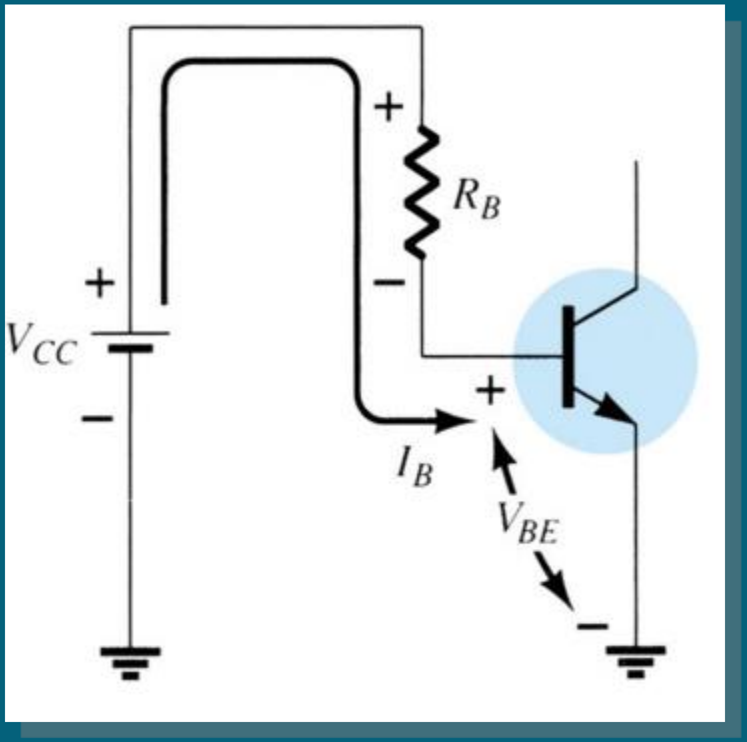
Base-Emitter Loop

From Kirchhoff's voltage law:

$$+V_{CC} - I_B R_B - V_{BE} = 0$$

Solving for the base current:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$



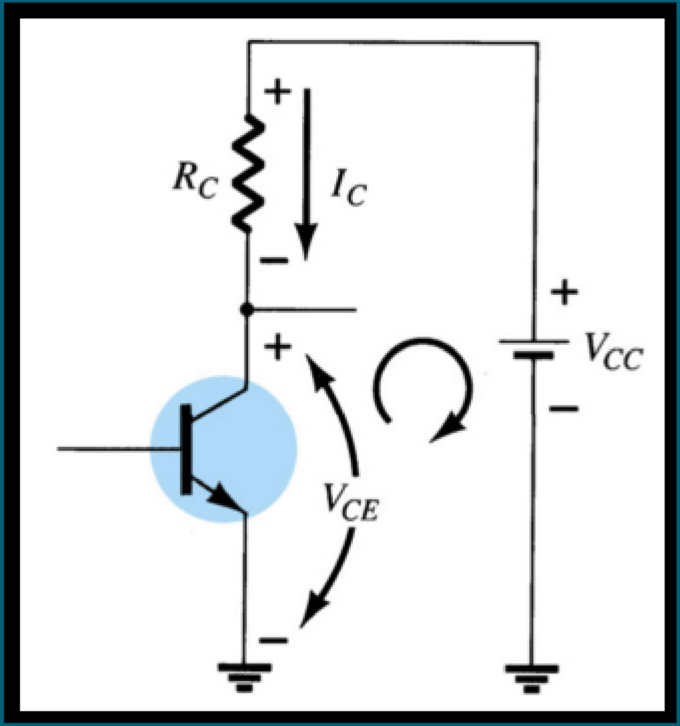
Collector-Emitter Loop

The collector current is given by:

$$I_C = \beta I_B$$

From Kirchhoff's voltage law:

$$V_{CE} = V_{CC} - I_C R_C$$



Transistor Saturation Level

maximum current **flow through the transistor.**

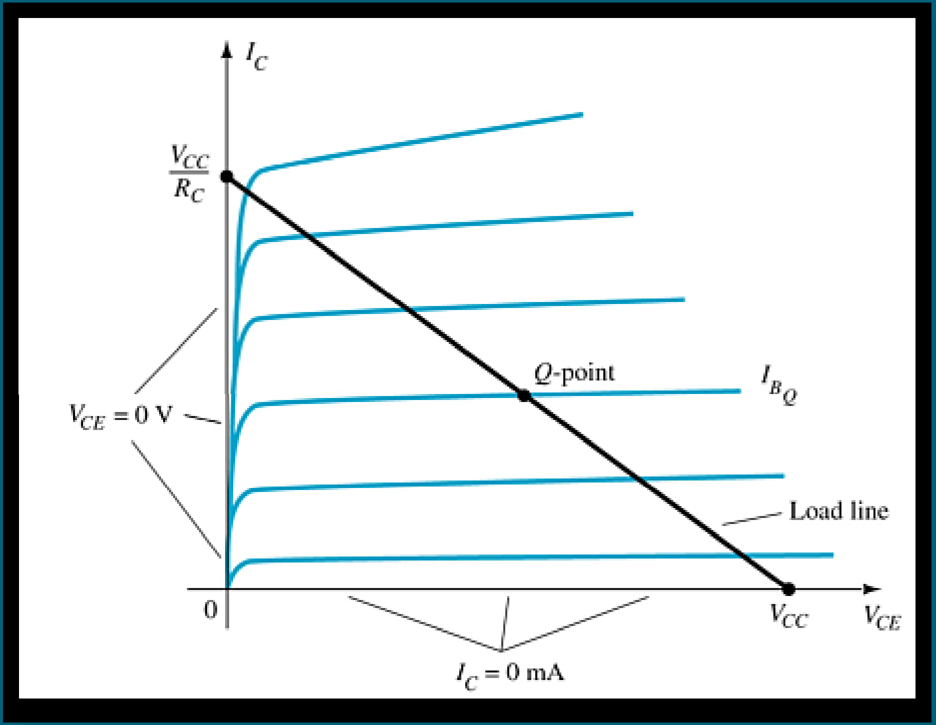
$$I_{Csat} = \frac{V_{CC}}{R_C}$$

$$V_{CE} \cong 0\,V$$

Load Line

The end points of the load line are:

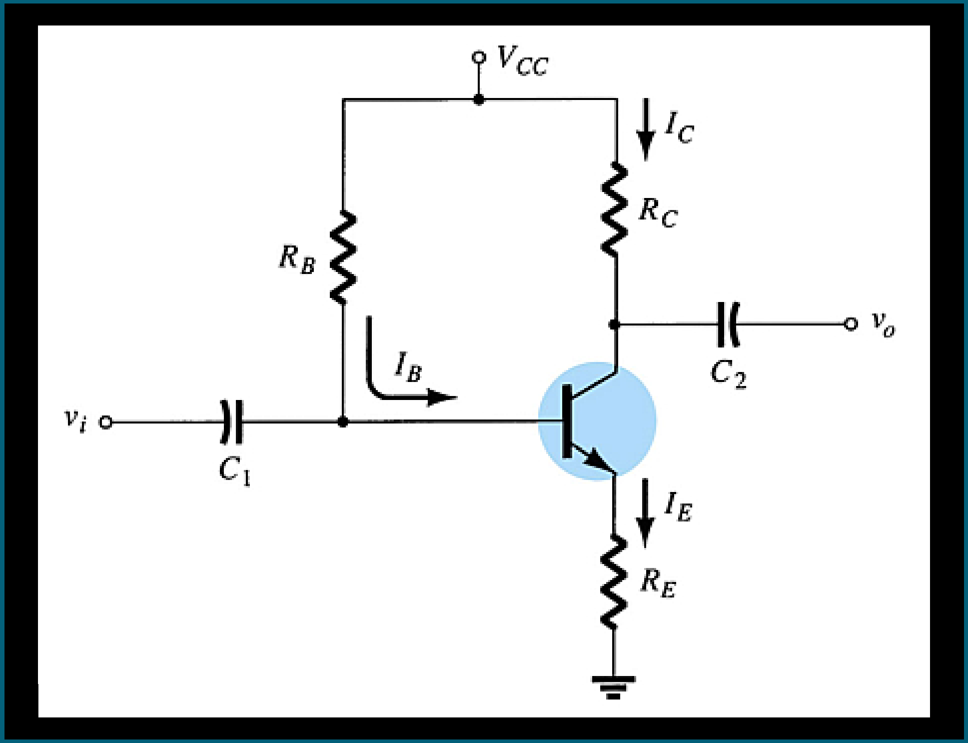
- I_{Csat}
  - $I_C = V_{CC} / R_C$
  - $V_{CE} = 0$ V
- $V_{CEcutoff}$
  - $V_{CE} = V_{CC}$
  - $I_C = 0$ mA



The Q-point is the particular operating point:

Emitter-Stabilzed Bias Circuit

Adding a resistor (R_E) to the emitter circuit stabilizes the bias circuit.



Base-Emitter Loop

From Kirchhoff's voltage law :

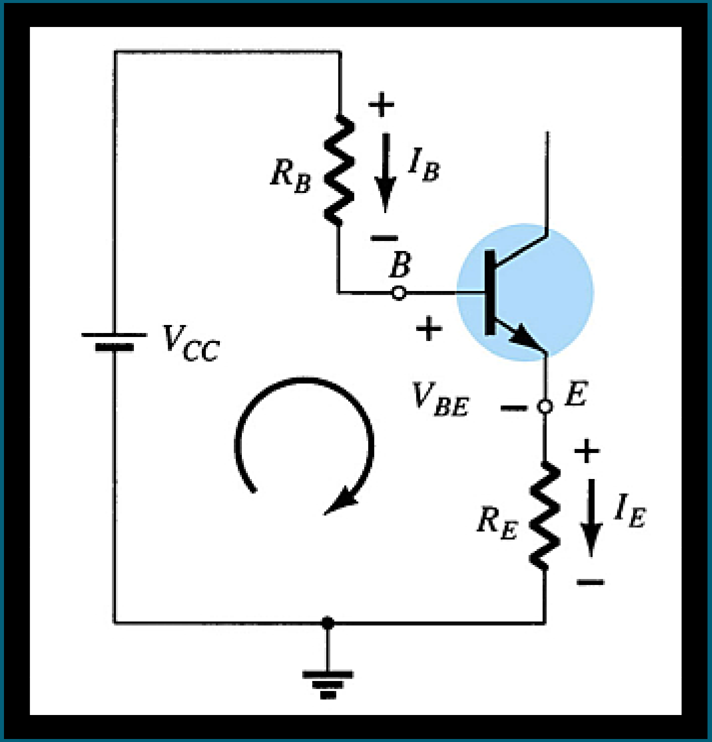
$$+V_{CC} - I_E R_E - V_{BE} - I_E R_E = 0$$

Since $I_E = (\beta + 1)I_B$:

$$V_{CC} - I_B R_B - (\beta + 1) I_B R_E = 0$$

Then I_B:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1) R_E}$$



Collector-Emitter Loop

From Kirchhoff's voltage law :

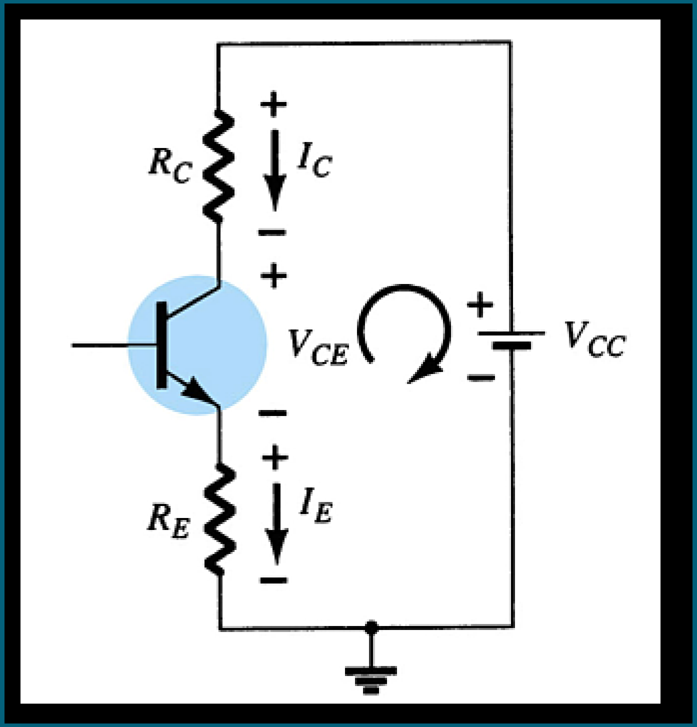
$$+I_E R_E + V_{CE} + I_C R_C - V_{CC} = 0$$

Since $I_E \cong I_C$:

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

Also:

$$V_E = I_E R_E$$
$$V_C = V_{CE} + V_E = V_{CC} - I_C R_C$$
$$V_B = V_{CC} - I_R R_B = V_{BE} + V_E$$



Voltage Divider

A very stable bias circuit.
Currents and voltages are independent from β variations.

Transistor Saturation Level

$$I_{Csat} = I_{Cmax} = \frac{V_{CC}}{R_C + R_E}$$

For $I_B << I_1$ and I_2 and $I_1 \cong I_2$:

$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2}$$

For $\beta R_E > 10R_2$:

$$I_E = \frac{V_E}{R_E}$$

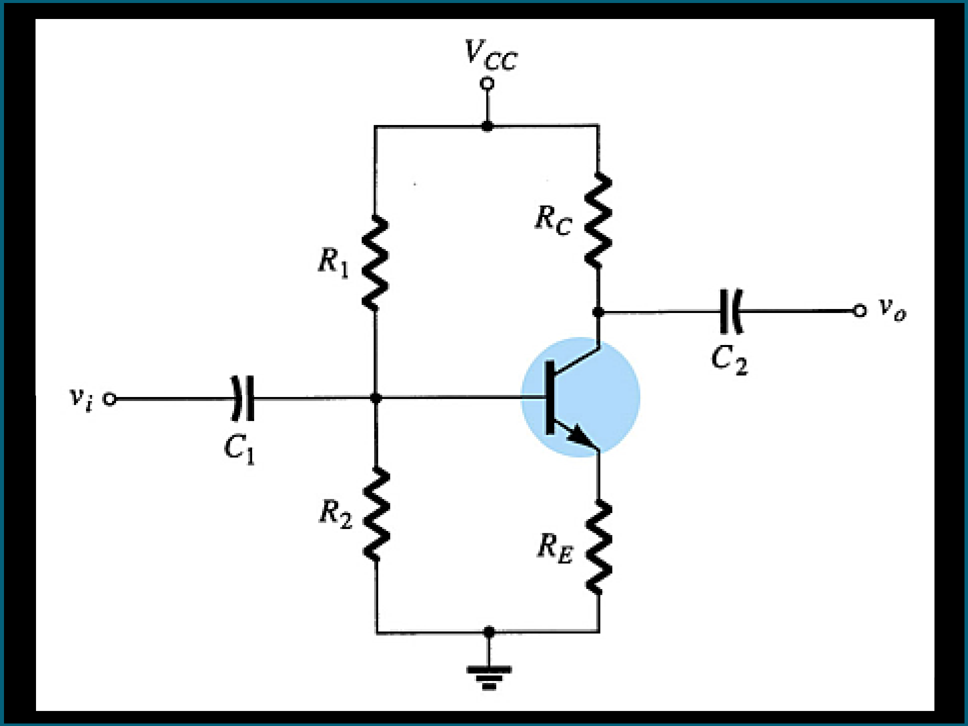
$$V_E = V_B - V_{BE}$$

From Kirchhoff's voltage law:

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$I_E \cong I_C$$

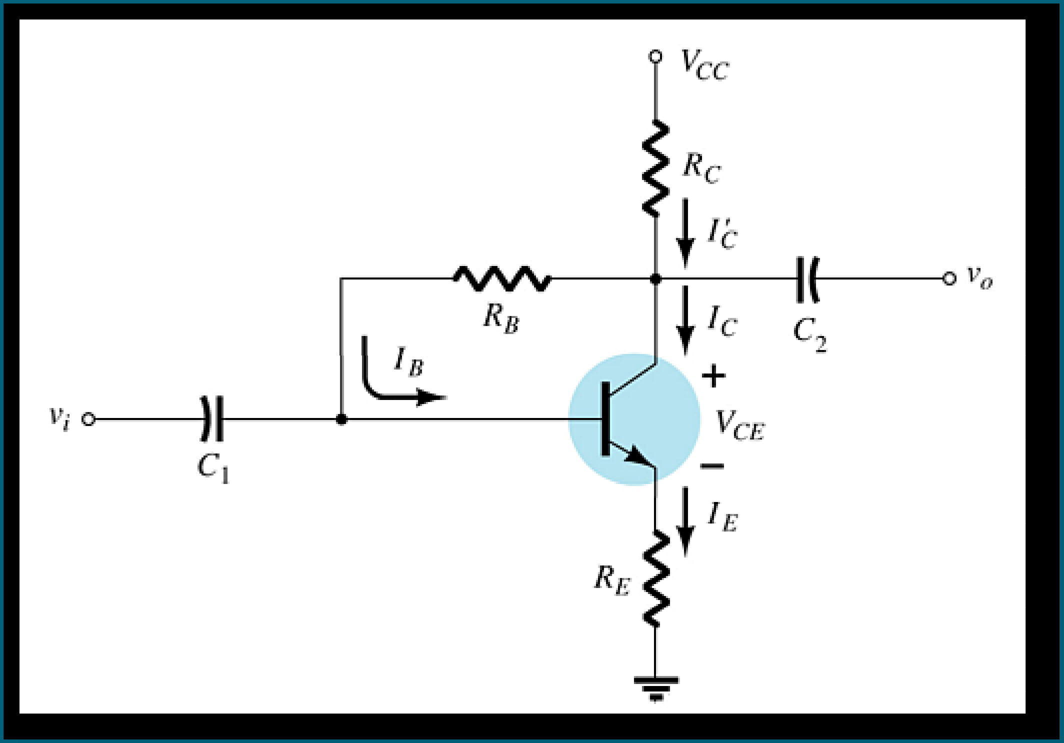
$$V_{CE} = V_{CC} - I_C (R_C + R_E)$$



DC Bias with Voltage Feedback

A bias circuit for improving the stability.

Q-point is only slightly dependent on the transistor β value.



Base-Emitter Loop

From Kirchhoff's voltage law:

$$V_{CC} - I'_C R_C - I_B R_B - V_{BE} - I_E R_E = 0$$

For $I_B << I_C$:

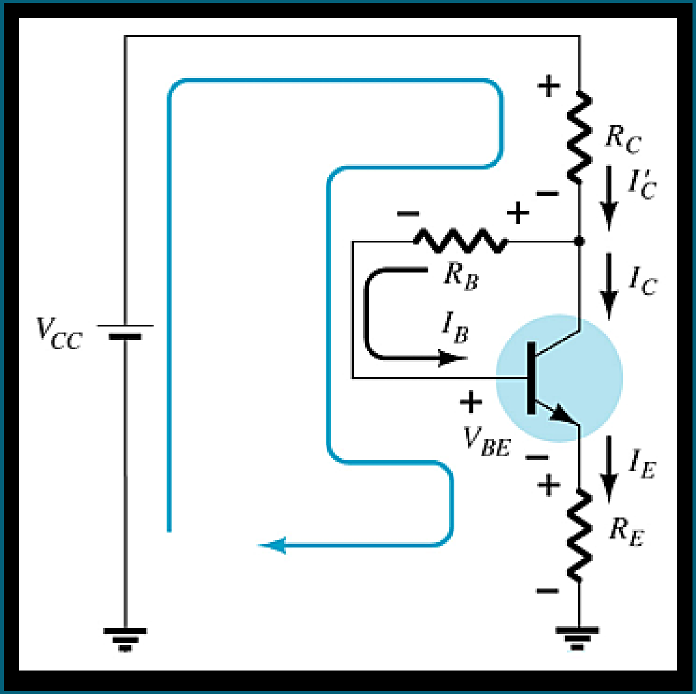
$$I'_C = I_C + I_B = I_C$$

For $I_C = \beta I_B$ and $I_E \cong I_C$, the equation:

$$V_{CC} - \beta I_B R_C - I_B R_B - V_{BE} - \beta I_B R_E = 0$$

Solving for I_B:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta(R_C + R_E)}$$



Collector-Emitter Loop

Applying Kirchoff's voltage law:

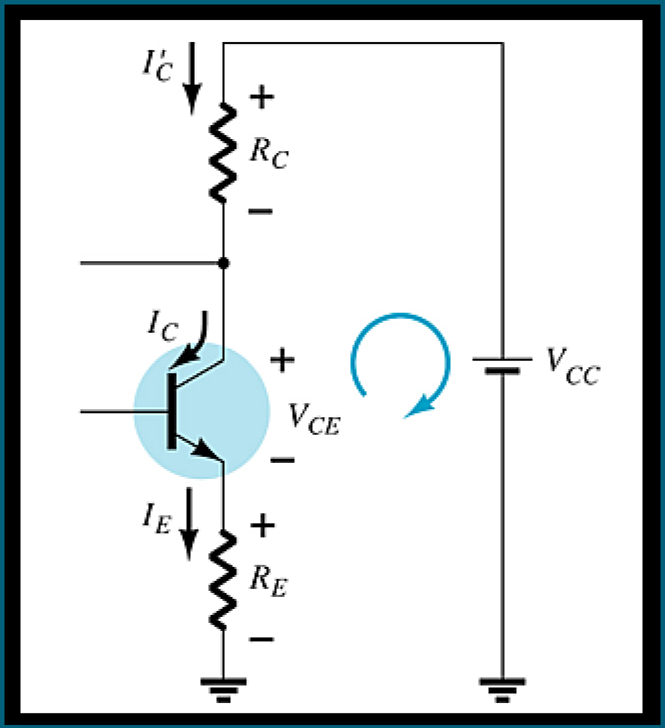
$$I_E + V_{CE} + I_C{}'R_C - V_{CC} = 0$$

Since $I_C{}' \cong I_C$ and $I_C = \beta I_B$:

$$I_C(R_C + {}_{RE}) + V_{CE} - V_{CC} = 0$$

Solving for V_{CE}:

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$



Base-Emitter Bias Analysis

Transistor Saturation Level

$$I_{Csat} = I_{Cmax} = \frac{V_{CC}}{R_C + R_E}$$

Load Line Analysis

Cutoff

$$V_{CE} = V_{CC}$$
$$I_C = 0mA$$

Saturation

$$I_C = \frac{V_{CC}}{R_C + R_E}$$
$$V_{CE} = 0V$$