ELECTRONIC DEVICES AND CIRCUIT THEORY

TENTH EDITION

BOYLESTAD

PEARSON

Chapter 4
DC Biasing–BJTs

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Biasing

Biasing: **The DC voltages applied to a transistor in order to turn it on so that it can amplify the AC signal.**

Recall the following basic relationships for a transistor:

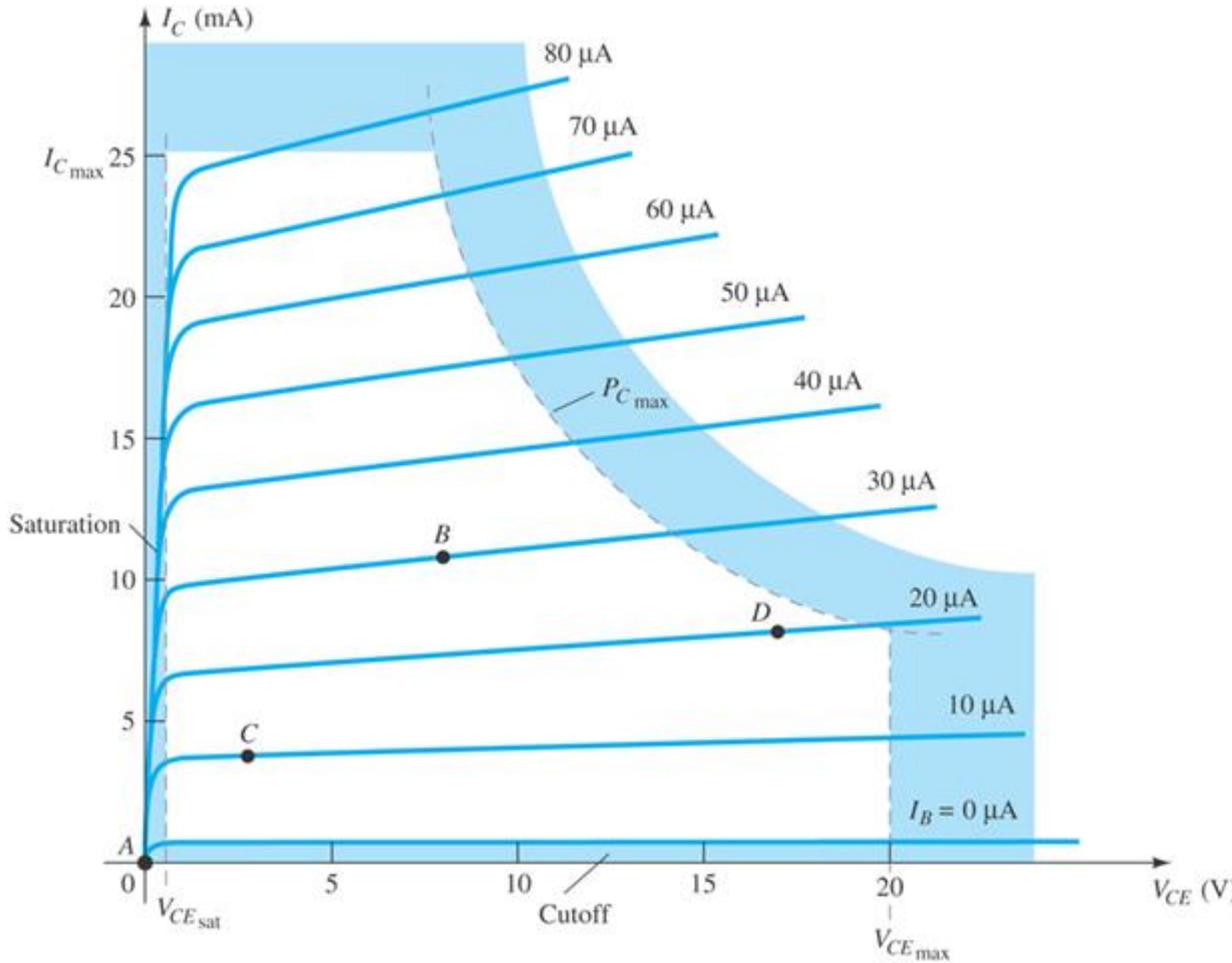
$$V_{BE} = 0.7\ \text{V}$$

$$I_E = (\beta + 1) I_\beta$$

$$I_C = \beta I_\beta$$

Operating Point

The DC input establishes an operating or ***quiescent point*** called the ***Q-point***.



Various operating points within the limits of operation of a transistor.

The Three States of Operation

- **Active or Linear Region Operation**

  Base–Emitter junction is forward biased

  Base–Collector junction is reverse biased

- **Cutoff Region Operation**

  Base–Emitter junction is reverse biased

- **Saturation Region Operation**

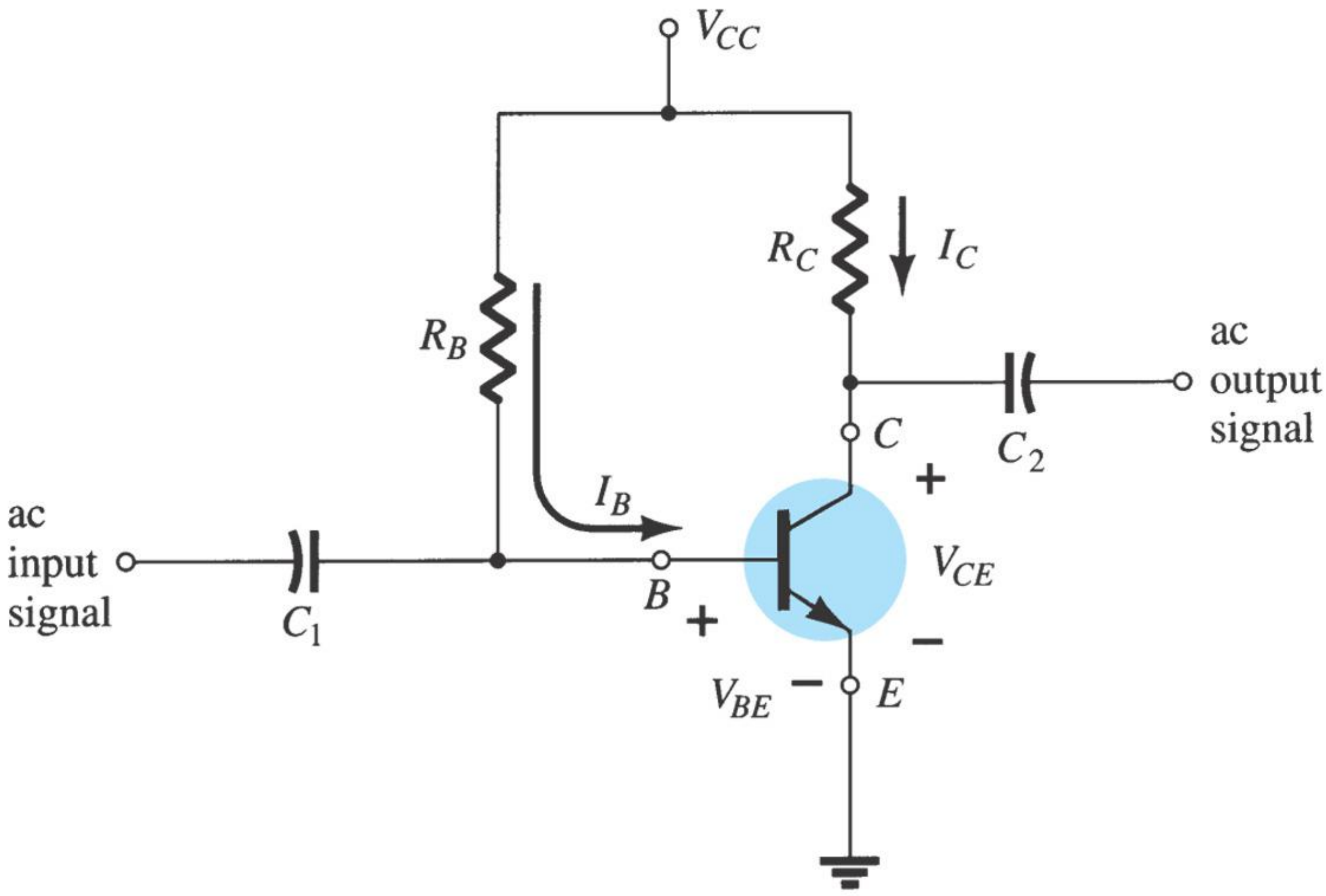
  Base–Emitter junction is forward biased

  Base–Collector junction is forward biased

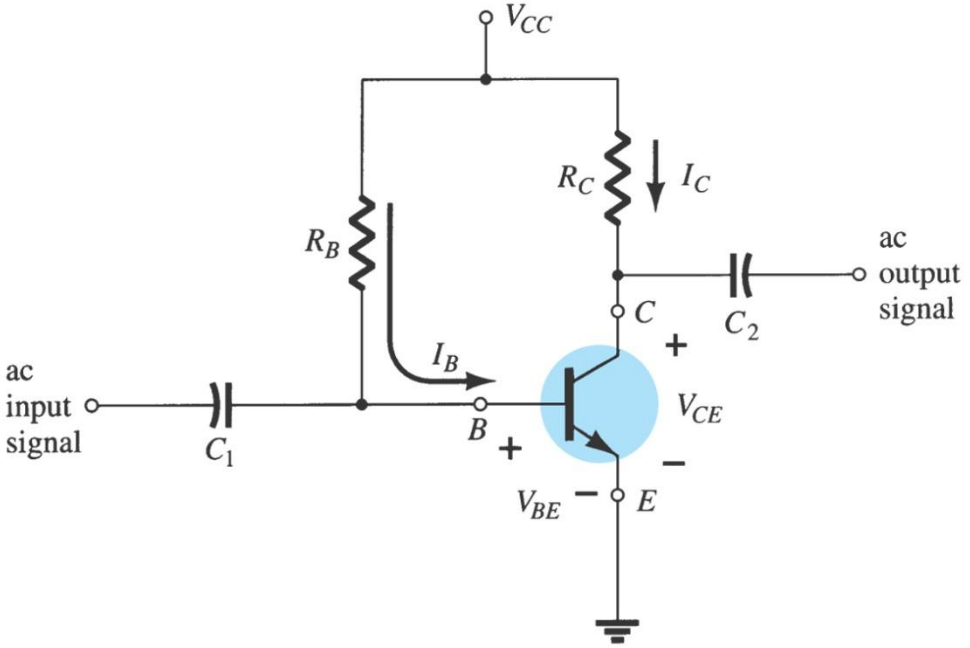
DC Biasing Circuits

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

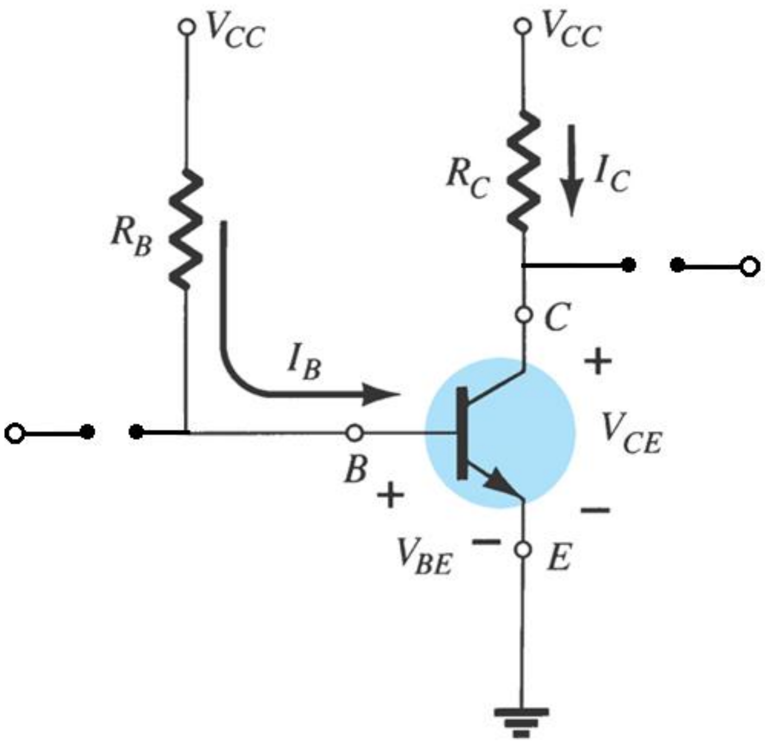
Fixed Bias configuration



Fixed Bias configuration



Fixed bias circuit



DC equivalent

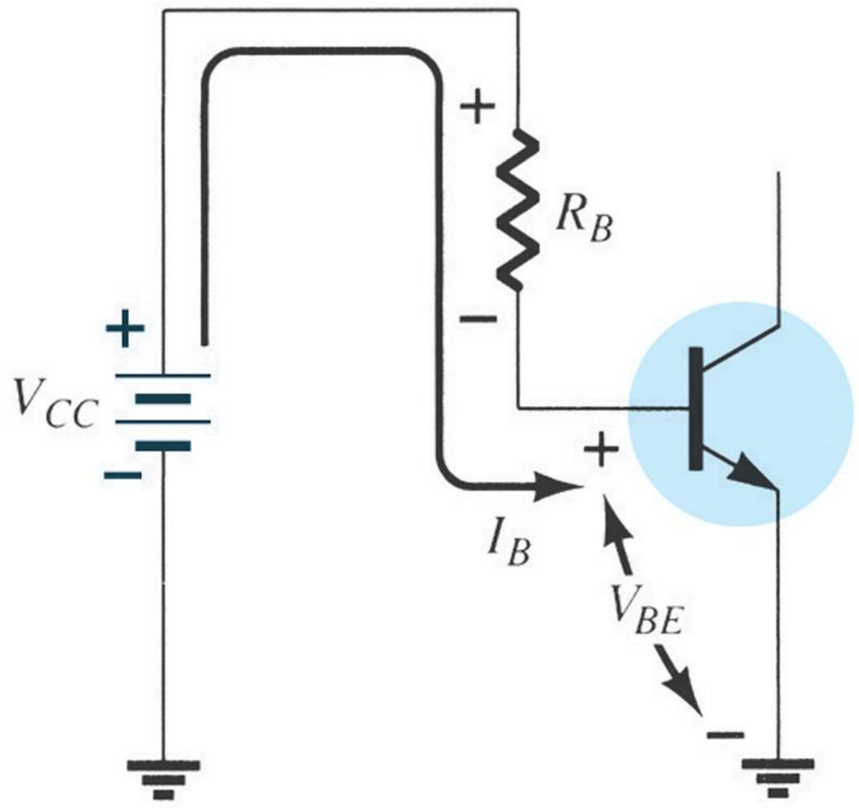
The Base-Emitter Loop

From Kirchhoff's voltage law:

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

Solving for base current:

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



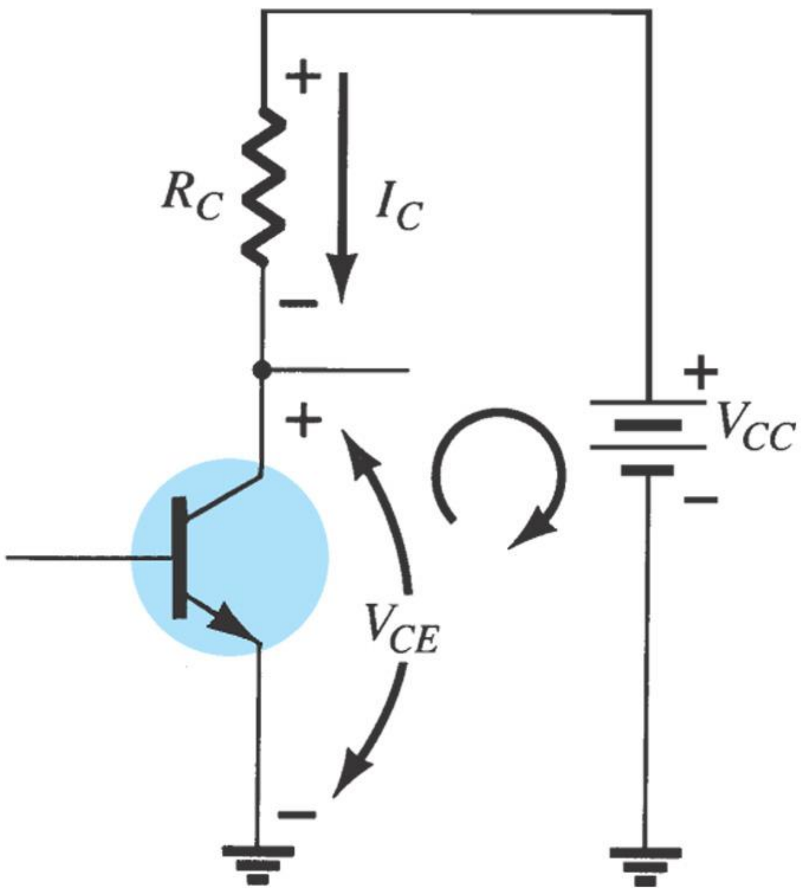
Collector-Emitter Loop

Collector current:

$$I_C = \beta I_B$$

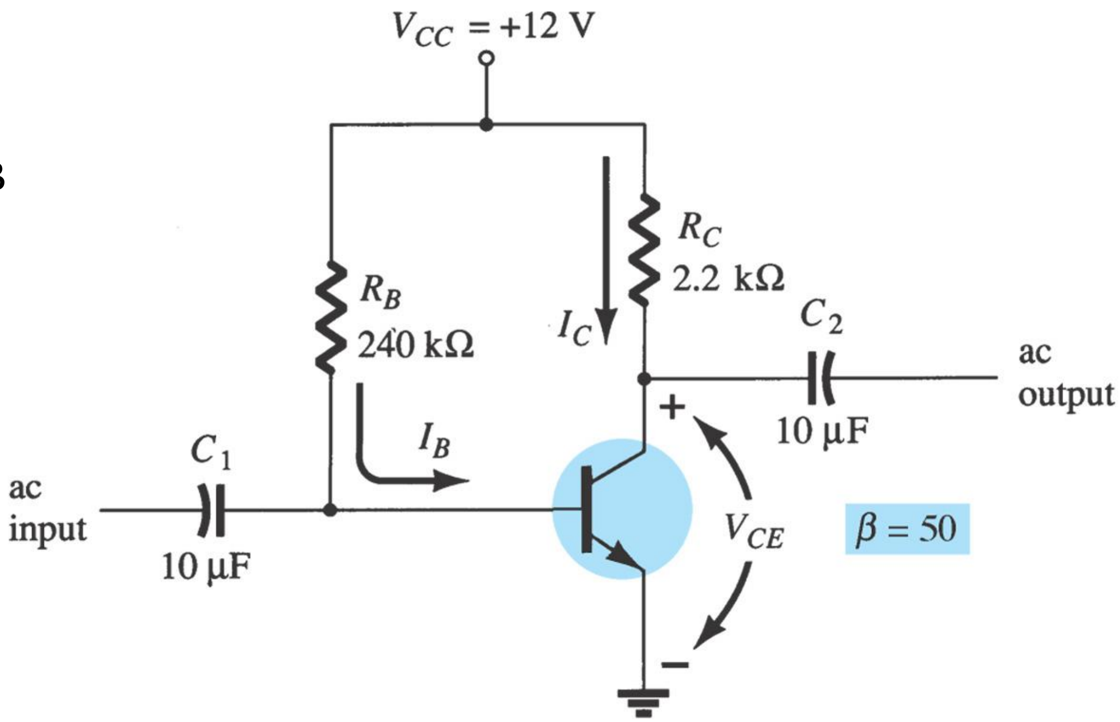
From Kirchhoff's voltage law:

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

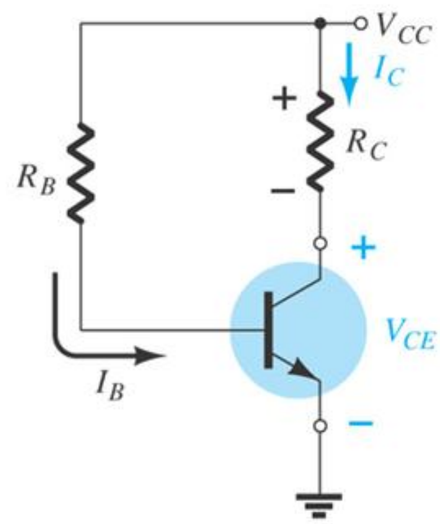


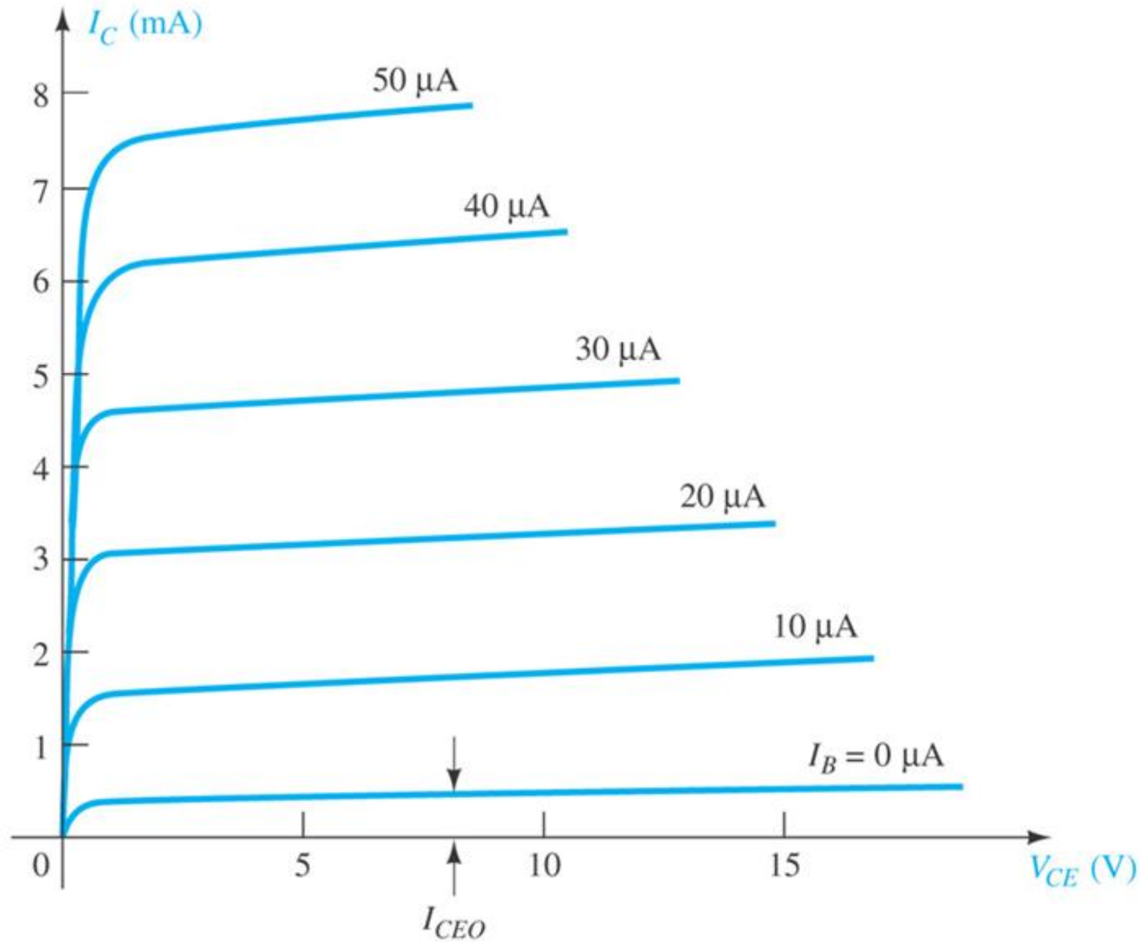
Example 4.1

Find I_{BQ} , I_{CQ} , V_{CEQ} , V_B , V_C , V_{BC}.



Load Line Analysis





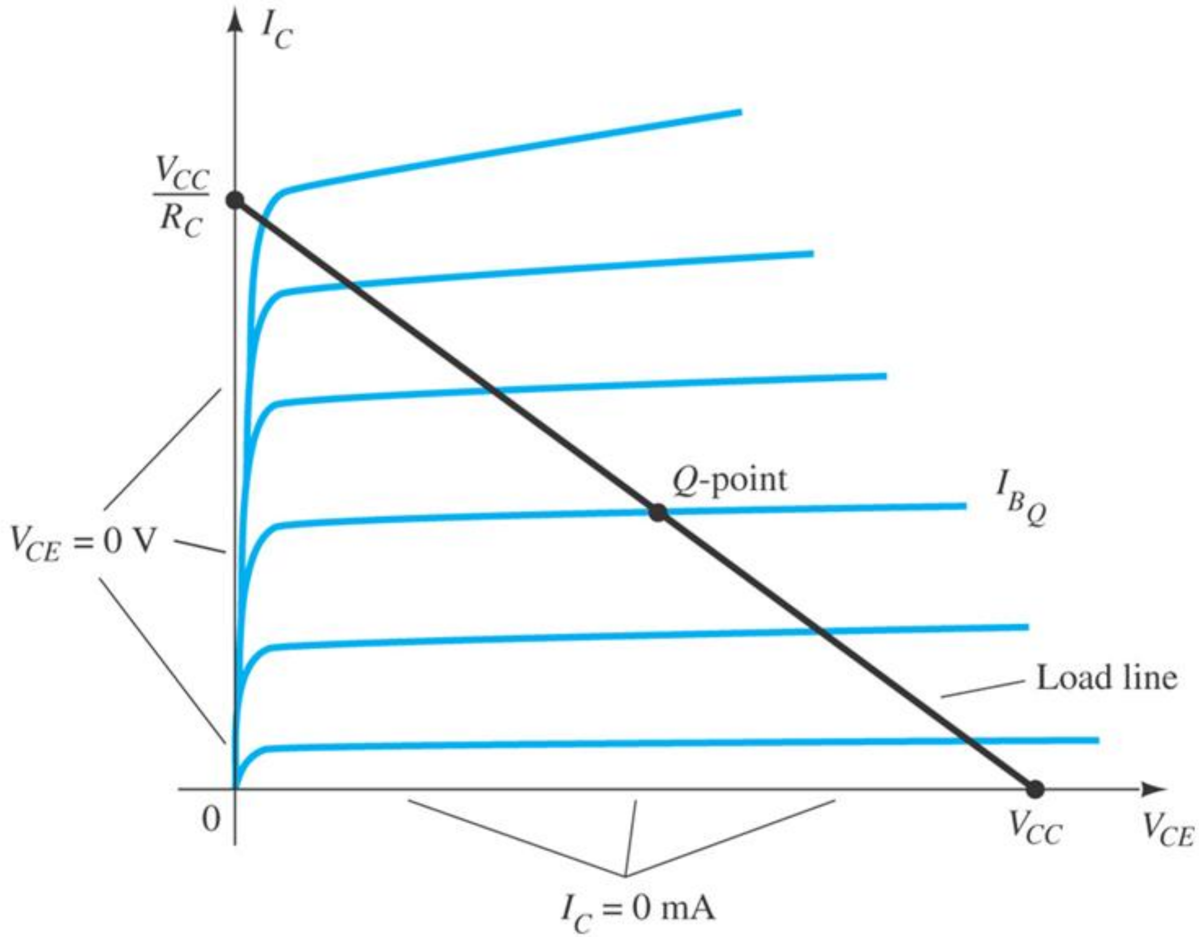
$$V_{CE} = V_{CC} - I_C R_C$$

Load Line Analysis

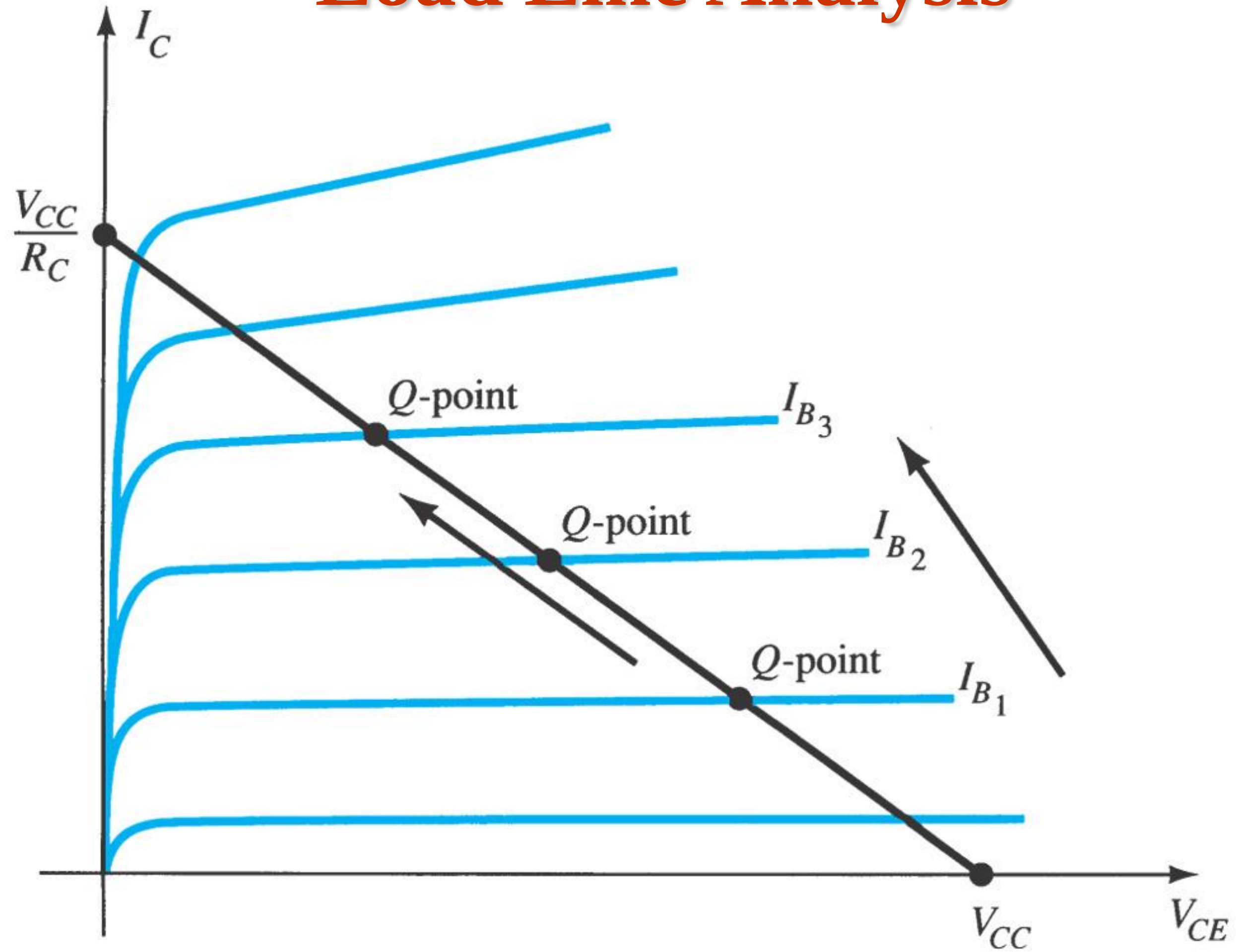
$$V_{CE} = V_{CC} - I_C R_C$$

$$V_{CE} = V_{CC}\big|_{I_C = 0mA}$$

$$I_C = \frac{V_{CC}}{R_C}\bigg|_{V_{CE} = 0V}$$



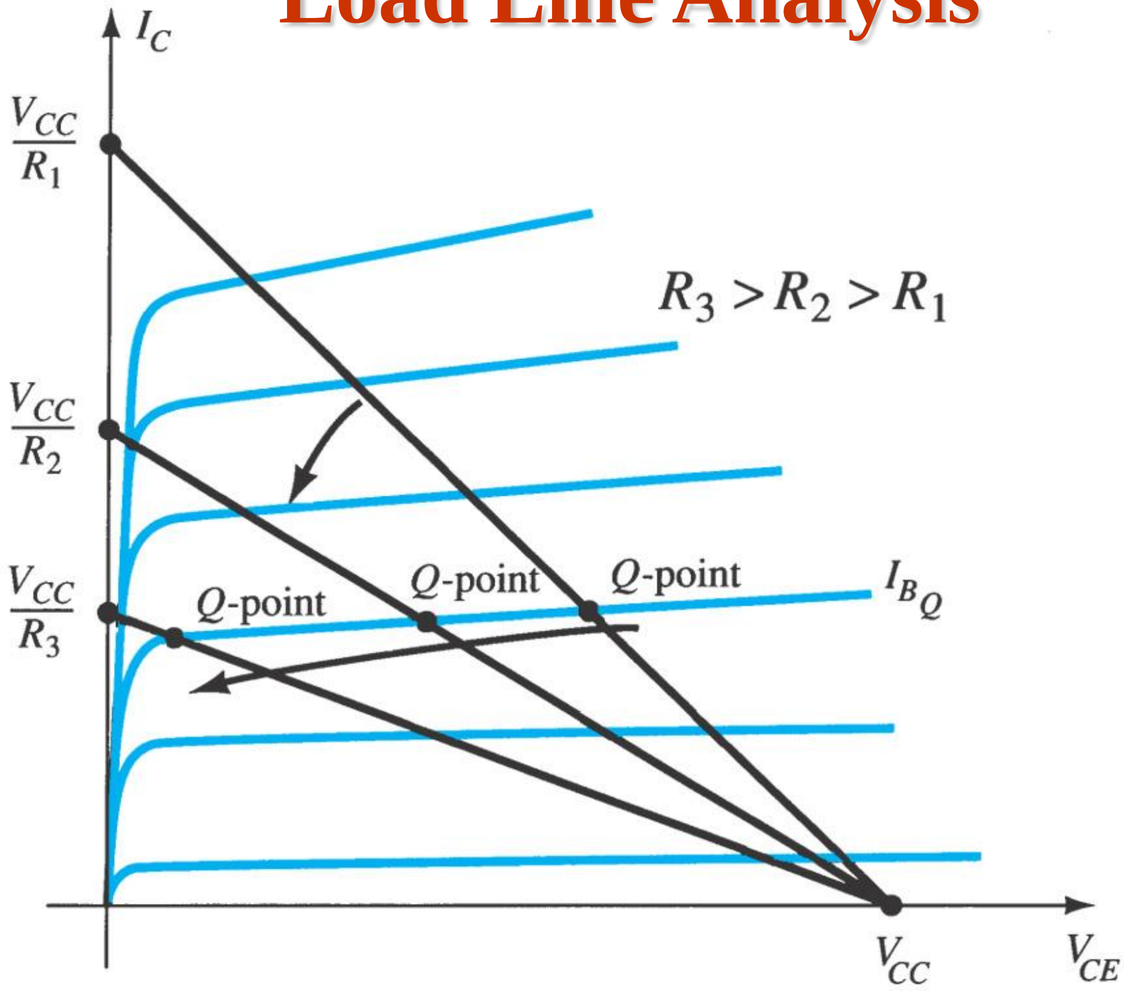
Load Line Analysis



Movement of the *Q*-point with increasing level of I_B.

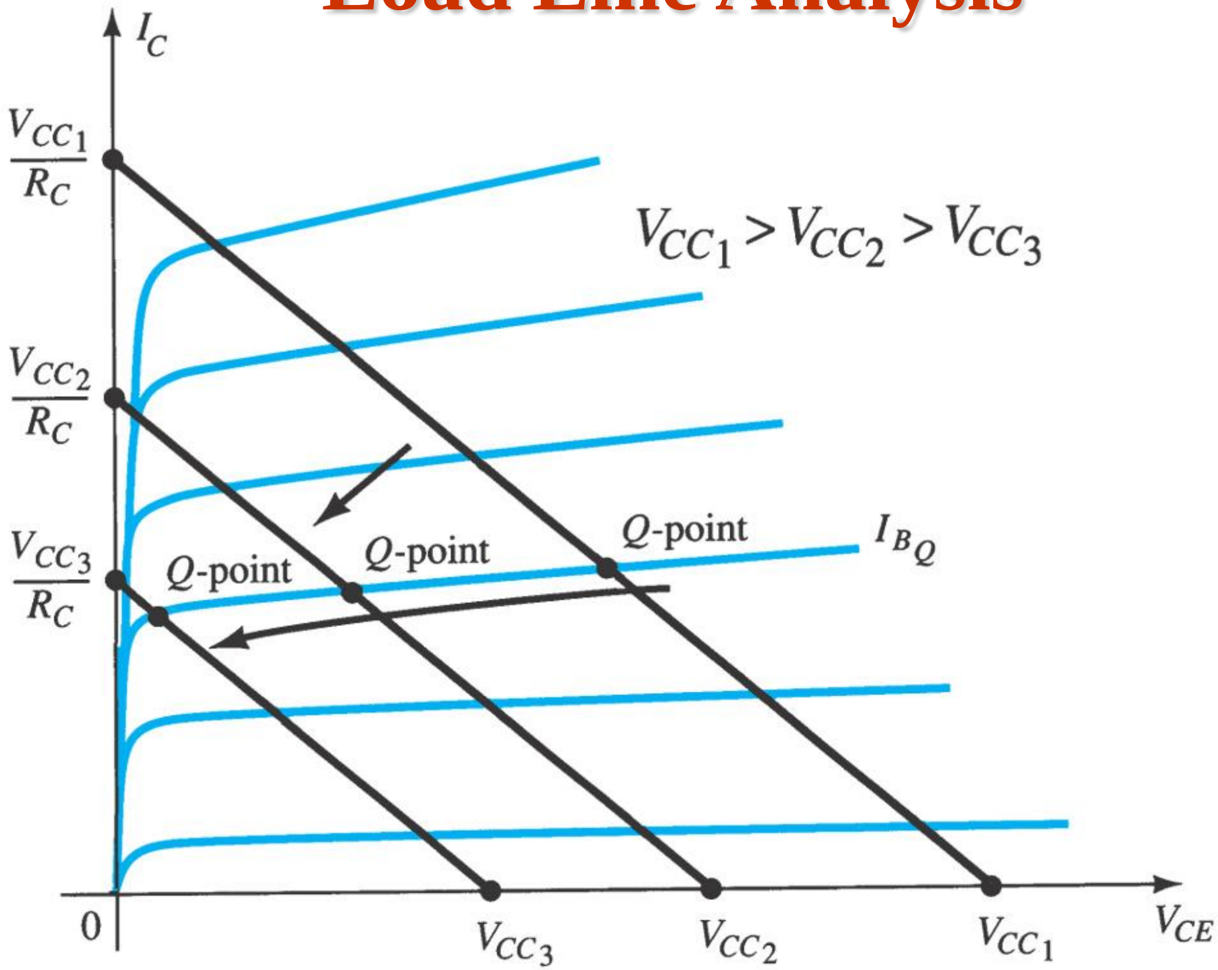
(The level of I_B is changed by varying the value of R_B)

Load Line Analysis



Effect of an increasing level of R_C on the load line and the *Q*-point. (V_{CC} fixed)

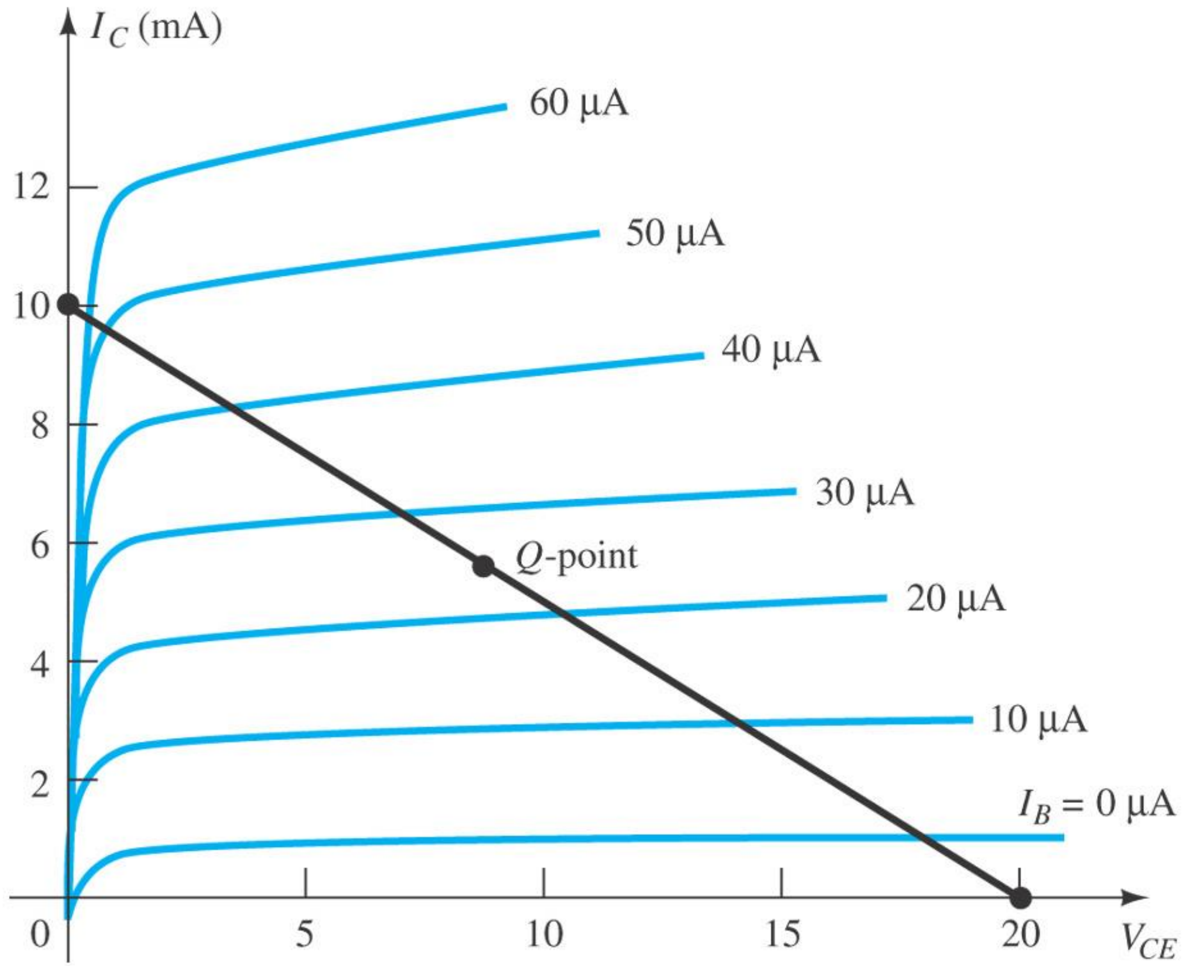
Load Line Analysis



Effect of lower values of V_{CC} on the load line and the *Q*-point.

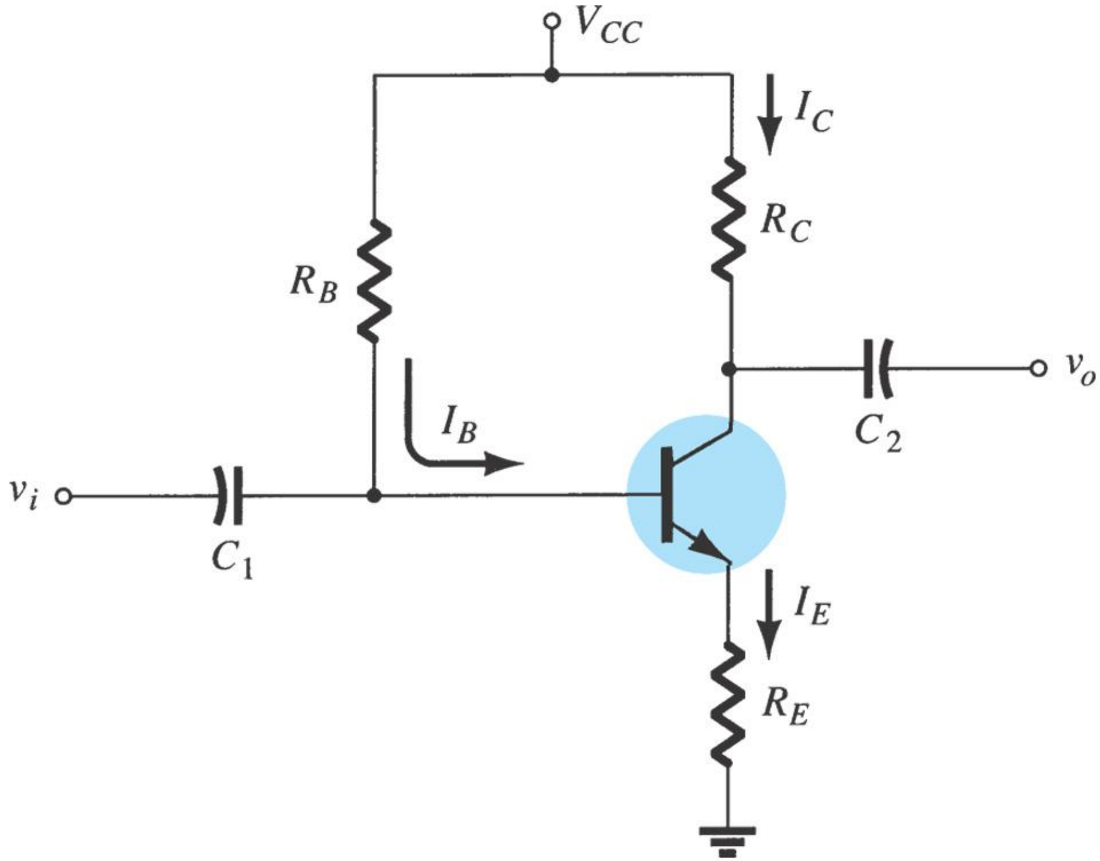
Example 4.3

Find V_{CC} , R_C , R_B for the fixed biasing configuration

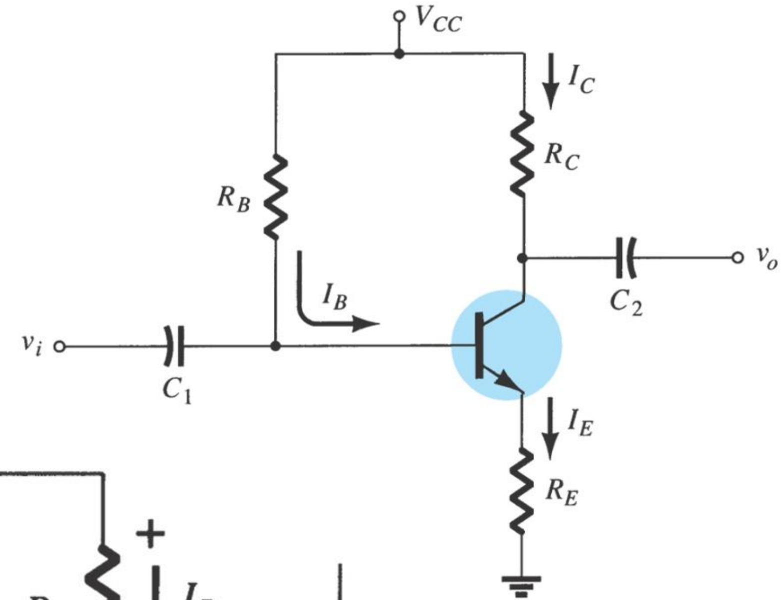


Emitter-Stabilized Bias Circuit

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



Base-Emitter Loop



From Kirchhoff's voltage law:

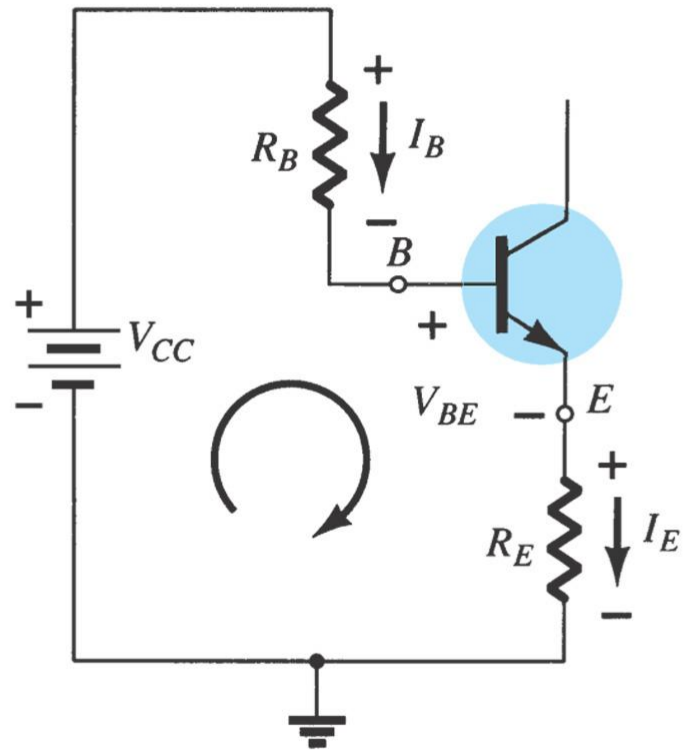
$$+V_{CC} - I_E R_E - V_{BE} - I_E R_E = 0$$

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

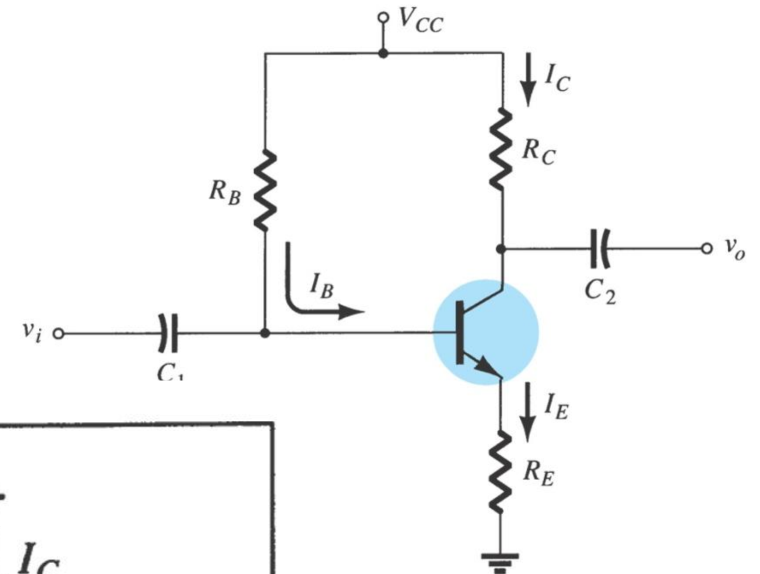
$$V_{CC} - I_B R_B - (\beta + 1) I_B R_E = 0$$

Solving for I_B:

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



Collector-Emitter Loop



From Kirchhoff's voltage law:

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

Since $I_E \cong I_C$:

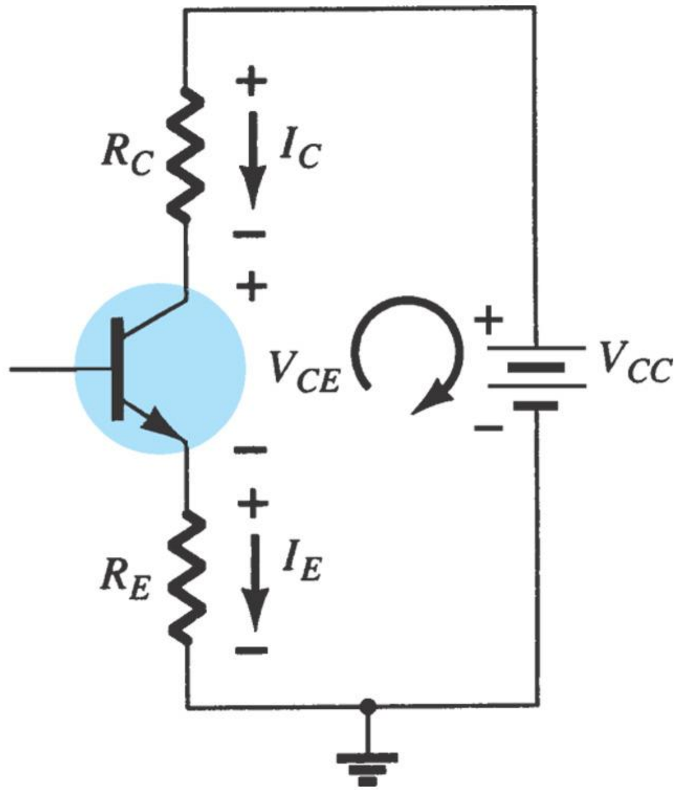
$$\mathbf{V_{CE} = V_{CC} - I_C (R_C + R_E)}$$

Also:

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

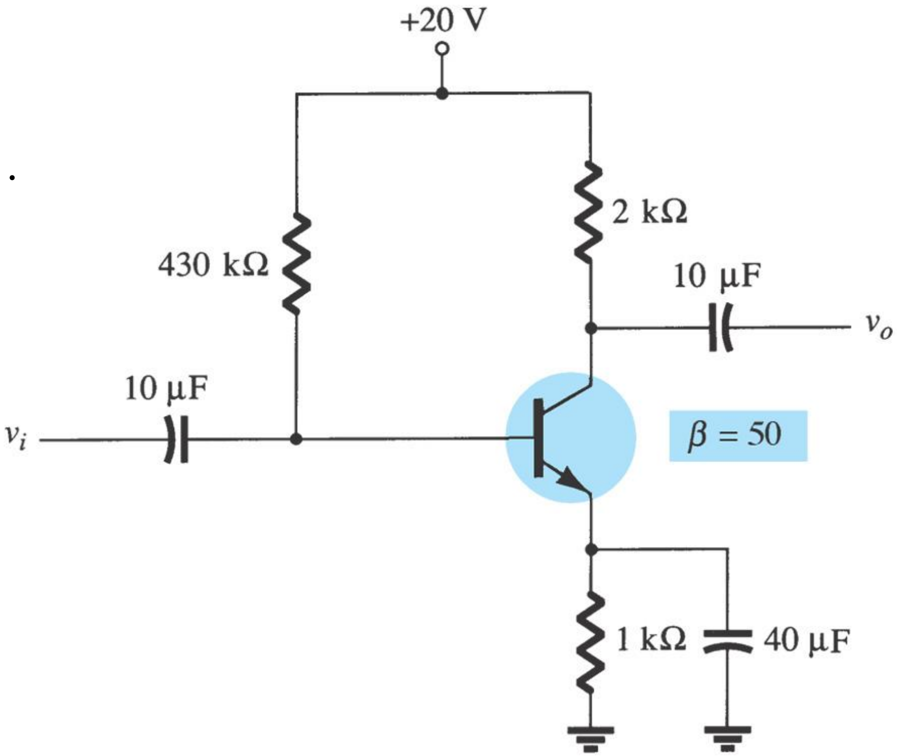
$$\mathbf{V_C = V_{CE} + V_E = V_{CC} - I_C R_C}$$

$$\mathbf{V_B = V_{CC} - I_R R_B = V_{BE} + V_E}$$



Example 4.4

Find I_B, I_C, V_{CE}, V_C, V_E, V_B, V_{BC}.

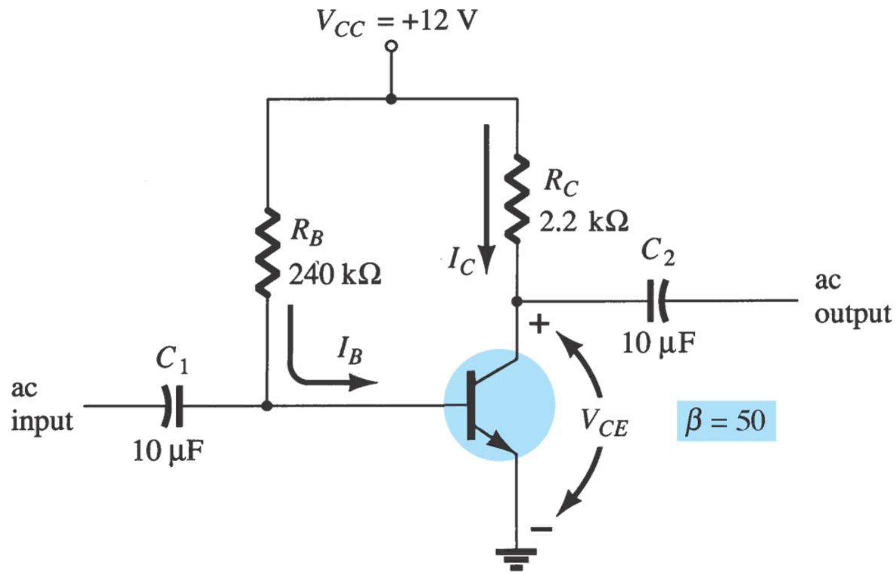


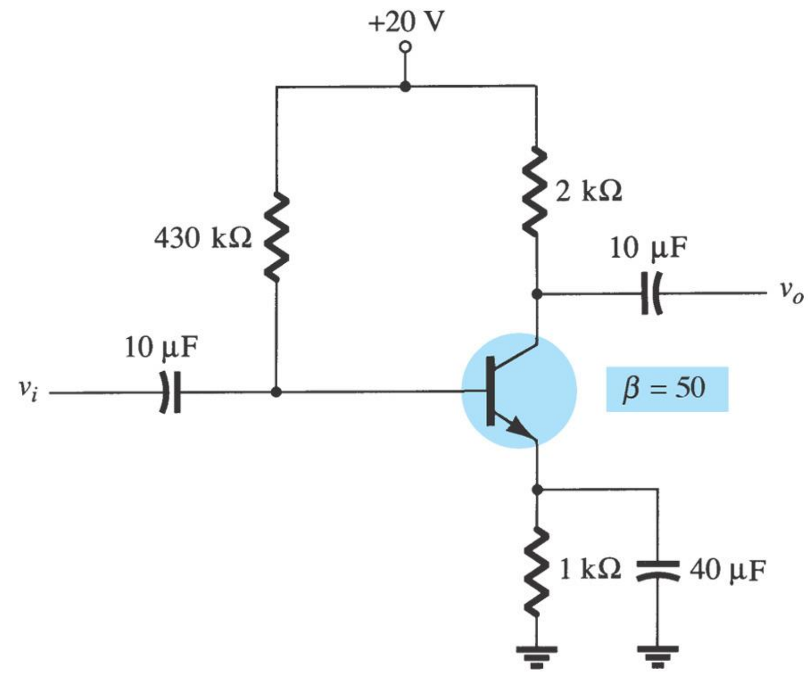
Improved Biased Stability

Stability refers to a circuit condition in which the currents and voltages will remain fairly constant over a wide range of temperatures and transistor Beta (β) values.

Adding R_E to the emitter improves the stability of a transistor.

Improved Biased Stability



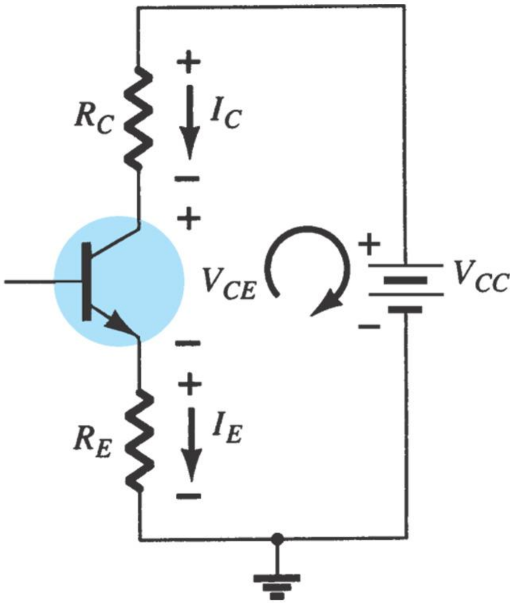


β	I_B (µA)	I_C (mA)	V_{CE} (V)
50	47.08	2.35	6.83
100	47.08	4.71	1.64

β	I_B (µA)	I_C (mA)	V_{CE} (V)
50	40.1	2.01	13.97
100	36.3	3.63	9.11

Load Line Analysis

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



$$V_{CE} = V_{CC} \Big|_{I_C = 0mA}$$

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