Electronics

CTE 207

Lecture 16

- DC Biasing of BJT -

(2023 - 2024)

Dr. Zaidoon AL-Shammari

Lecturer / Researcher

zaidoon.waleed@mustaqbal-college.edu.iq

Fixed Bias Circuit

- The fixed-bias circuit of Figure below provides a relatively straight forward and simple introduction to transistor DC bias analysis.

- Even though the network employs an NPN transistor, the equations and calculations apply equally well to a PNP transistor configuration merely by changing all current directions and voltage polarities.

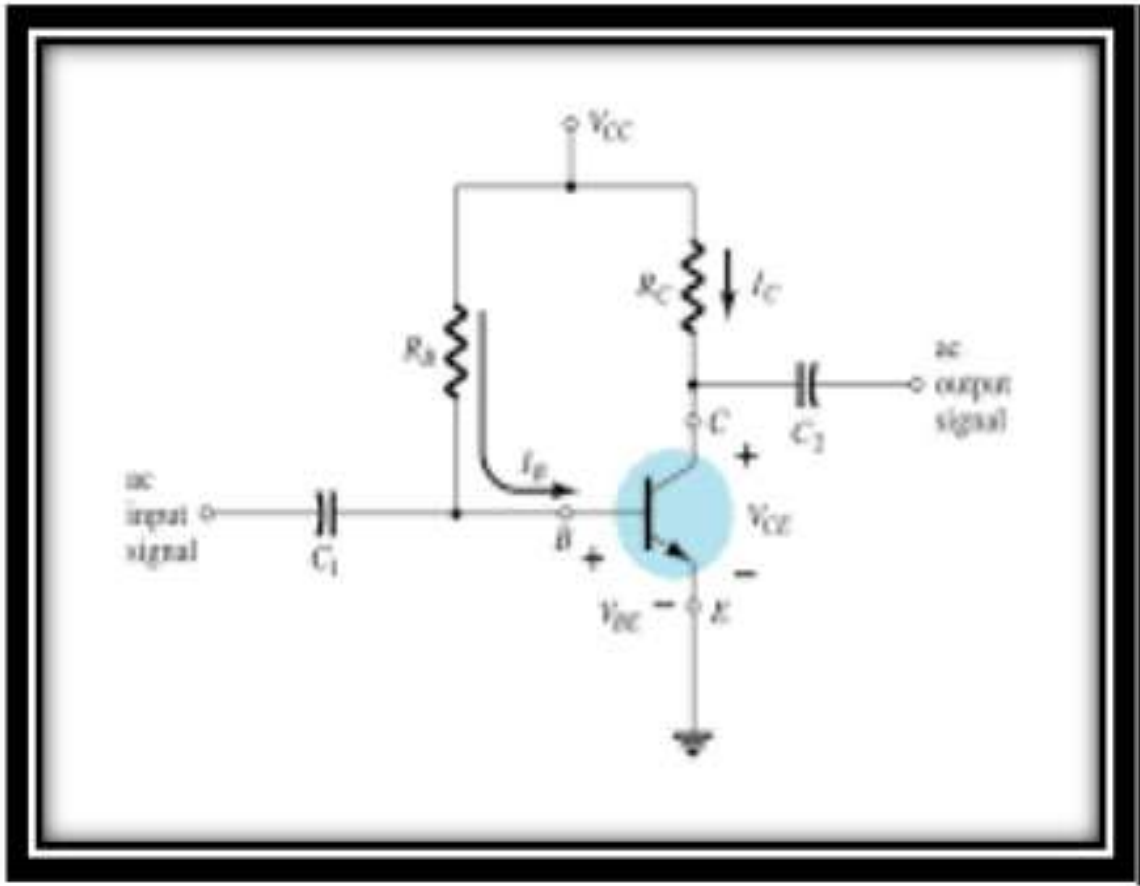
Fixed Bias Circuit

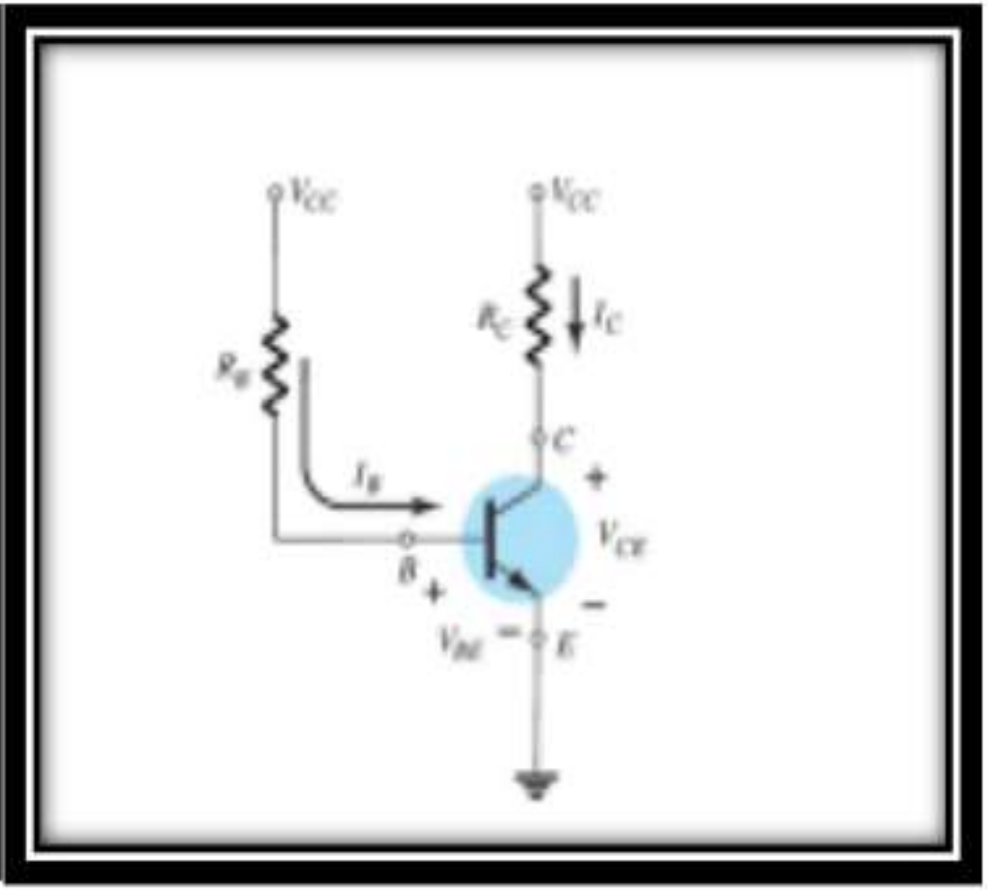
- For the DC analysis the network can be isolated from the indicated AC levels by replacing the capacitors with an open circuit equivalent.

- In addition, the DC supply VCC can be separated into two supplies (for analysis purposes only) as shown in Figure below.

- The separation is valid, as we note in Figure below that VCC is connected directly to RB and RC just as in Figure below.

Fixed Bias Circuit





DC Biasing of BJT

- The analysis or design of a transistor amplifier requires a knowledge of both the DC and AC response of the system.

- The analysis or design of any electronic amplifier therefore has two components: the DC portion and the AC portion.

- Fortunately, the superposition theorem is applicable and the investigation of the DC conditions can be separated from the AC response.

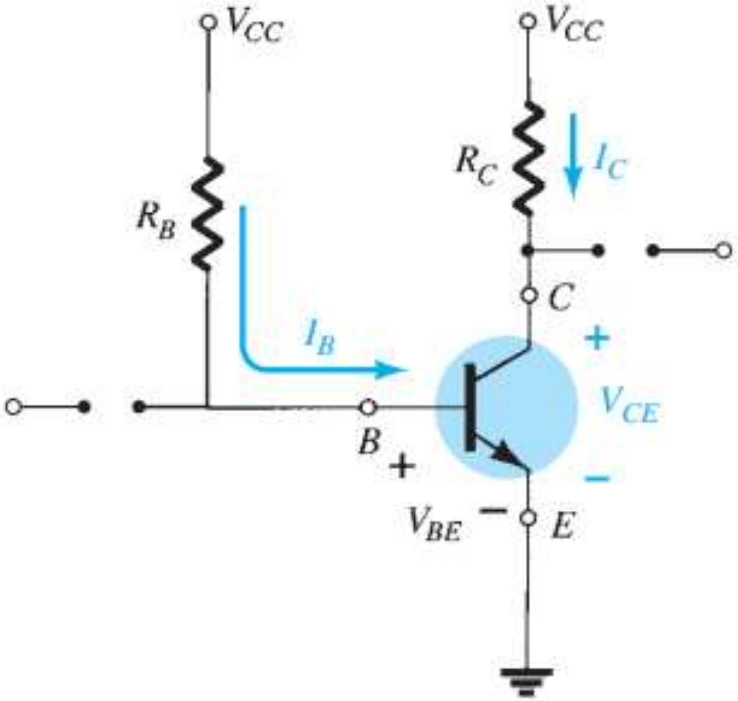
- To analysis any network in following these rules are true:

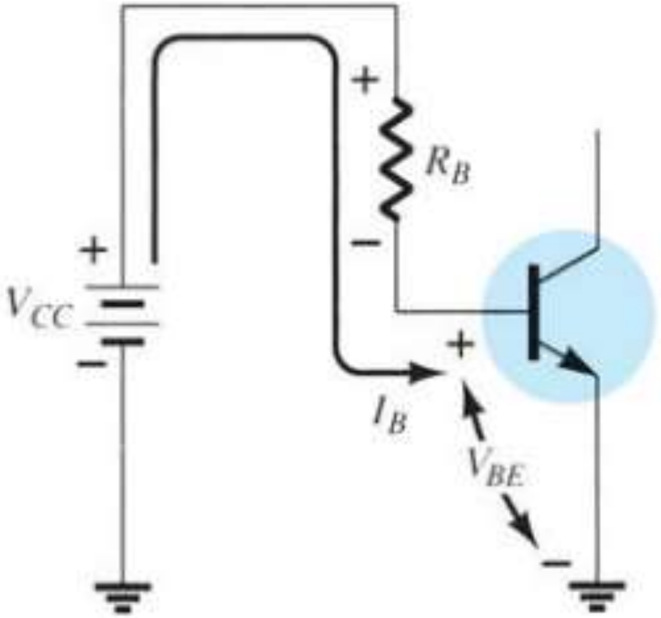
$$V_{BE} \cong 0.7\ \text{V}$$

$$I_E = (\beta + 1)I_B \cong I_C$$

$$I_C = \beta I_B$$

Base - Emitter loop





Base - Emitter loop

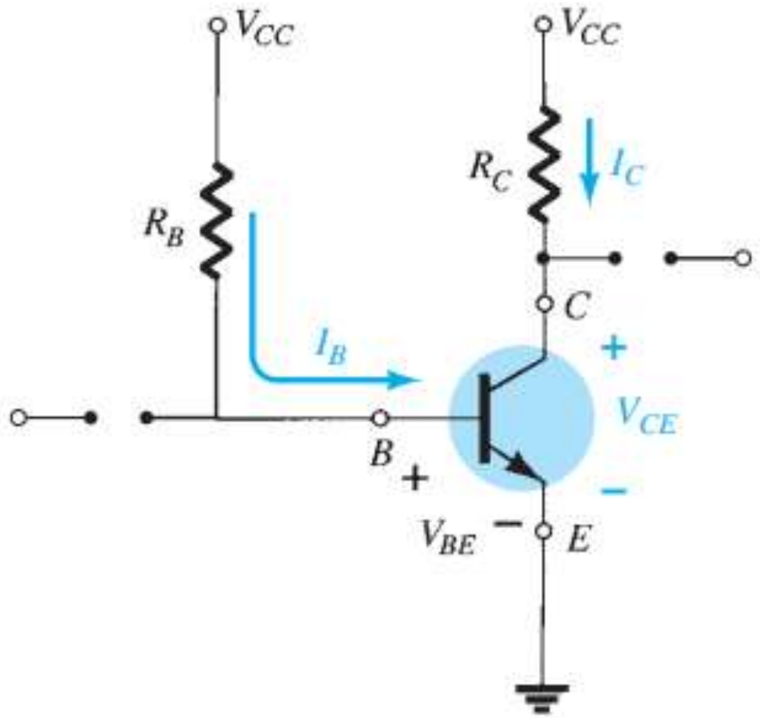
Consider first the base–emitter circuit loop of Fig. 4.4. Writing Kirchhoff's voltage equation in the clockwise direction for the loop, we obtain

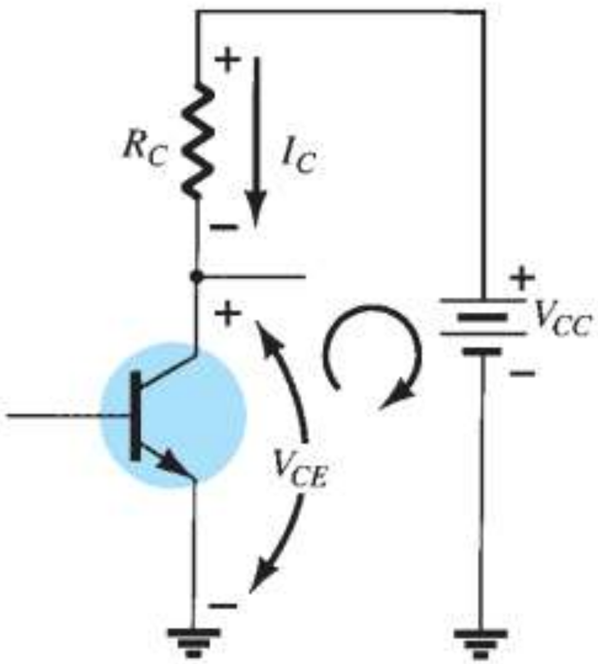
$$+V_{CC} - I_B R_B - V_{BE} = 0$$

Note the polarity of the voltage drop across R_B as established by the indicated direction of I_B. Solving the equation for the current I_B results in the following:

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

Collector - Emitter Loop





Collector - Emitter Loop

The collector–emitter section of the network appears in Fig. 4.5 with the indicated direction of current I_C and the resulting polarity across R_C. The magnitude of the collector current is related directly to I_B through

$$I_C = \beta I_B$$

It is interesting to note that because the base current is controlled by the level of R_B and I_C is related to I_B by a constant β, the magnitude of I_C is not a function of the resistance R_C. Changing R_C to any level will not affect the level of I_B or I_C as long as we remain in the active region of the device. However, as we shall see, the level of R_C will determine the magnitude of V_{CE}, which is an important parameter.

Collector - Emitter Loop

Applying Kirchhoff's voltage law in the clockwise direction around the indicated closed loop of Fig. 4.5 results in the following:

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

and

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

which states that the voltage across the collector–emitter region of a transistor in the fixed-bias configuration is the supply voltage less the drop across R_C.

As a brief review of single- and double-subscript notation recall that

$$\boxed{V_{CE} = V_C - V_E}$$

Collector - Emitter Loop

where V_{CE} is the voltage from collector to emitter and V_C and V_E are the voltages from collector and emitter to ground, respectively. *In this case,* since $V_E = 0$ V, we have

$$V_{CE} = V_C$$

In addition, because

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

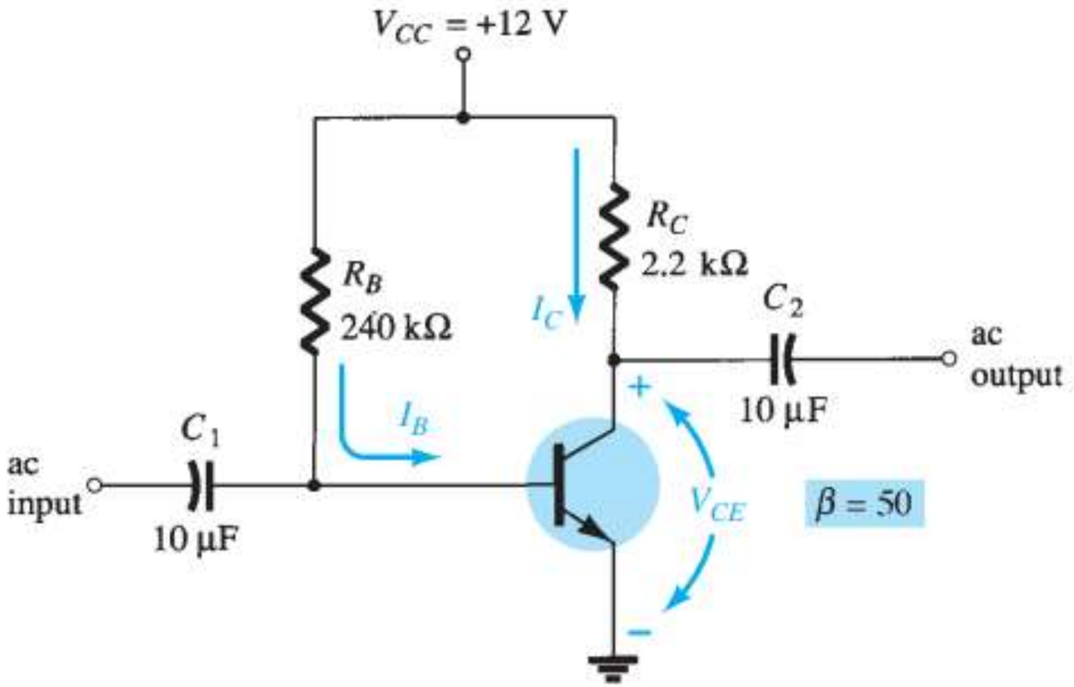
and $V_E = 0$ V, then

$$V_{BE} = V_B$$

Example

Determine the following for the fixed-bias configuration of Figure below

a. I_{B_Q} and I_{C_Q}.
b. V_{CE_Q}.
c. V_B and V_C.
d. V_{BC}.



Sol

a. Eq. (4.4): $$I_{B_Q} = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12\text{ V} - 0.7\text{ V}}{240\text{ k}\Omega} = \mathbf{47.08\ \mu A}$$

Eq. (4.5): $$I_{C_Q} = \beta I_{BQ} = (50)(47.08\ \mu\text{A}) = \mathbf{2.35\ mA}$$

b. Eq. (4.6): $$\begin{aligned} V_{CE_Q} &= V_{CC} - I_C R_C \\ &= 12\text{ V} - (2.35\text{ mA})(2.2\text{ k}\Omega) \\ &= \mathbf{6.83\ V} \end{aligned}$$

c. $V_B = V_{BE} = \mathbf{0.7\ V}$
$V_C = V_{CE} = \mathbf{6.83\ V}$

d. Using double-subscript notation yields

$$\begin{aligned} V_{BC} &= V_B - V_C = 0.7\text{ V} - 6.83\text{ V} \\ &= \mathbf{-6.13\ V} \end{aligned}$$