BIAS DC TRANSISTOR BIPOLAR

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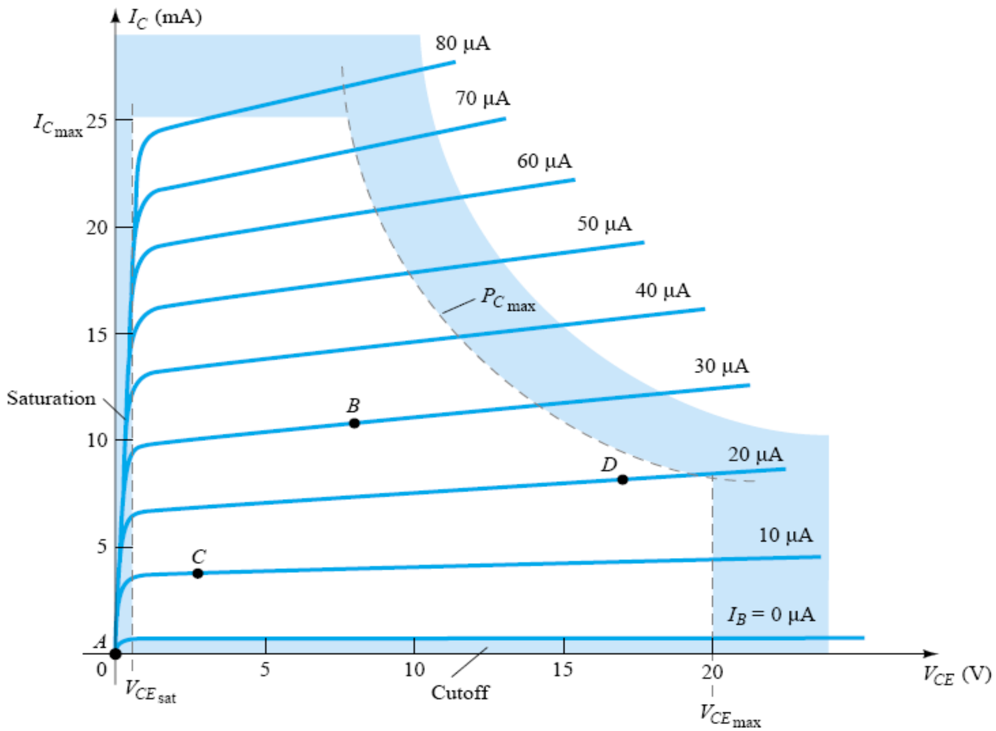
TITIK KERJA TRANSISTOR



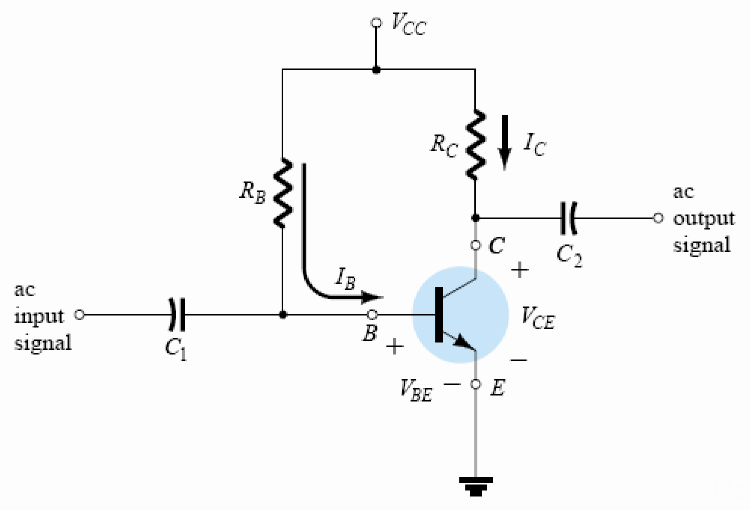
$$V_{BE} = 0.7\ \text{V}$$

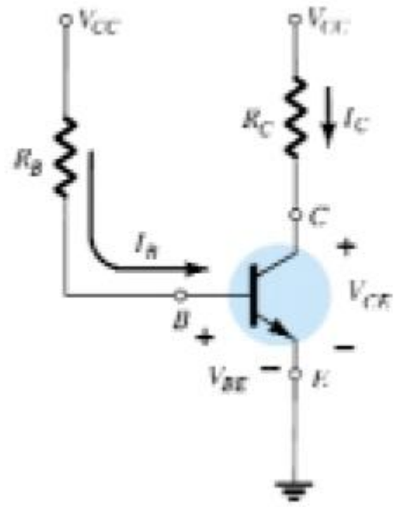
$$I_E = (\beta + 1)I_B \cong I_C$$

$$I_C = \beta I_B$$

- Dalam penguat transistor level tegangan dan arus yang tetap tersebut akan menempatkan suatu titik kerja pada kurva karakteristik sehingga menentukan daerah kerja transistor.

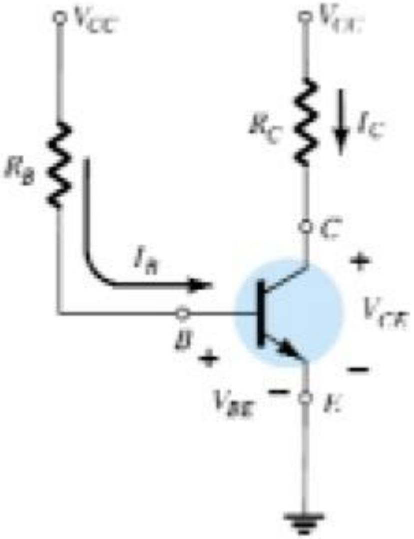
FIXED-BIAS CIRCUIT

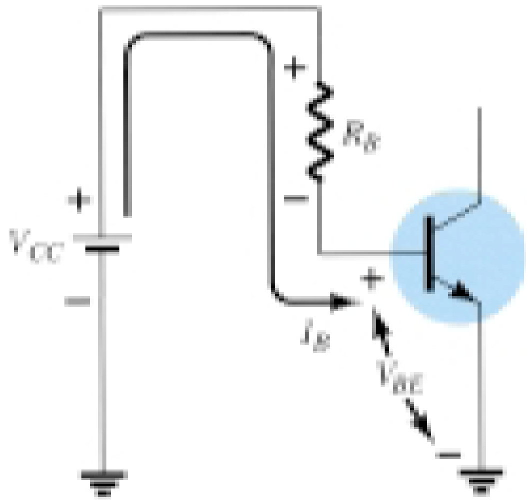




- Rangkaian bias ini terdiri atas dua resistor R_B dan R_C.
- Kapasitor C1 dan C2 merupakan kapasitor kopling yang berfungsi mengisolasi tegangan dc dari transistor ke tingkat sebelum dan sesudahnya, namun tetap menyalurkan sinyal ac-nya.

FBC → FORWARD BIAS OF BASE–EMITTER

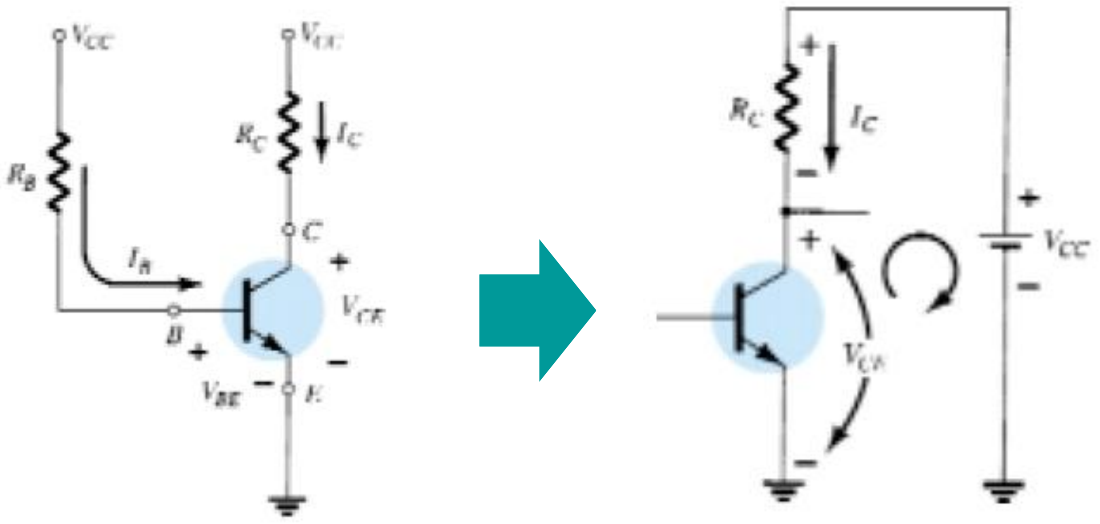




$$+V_{CC} - I_B R_B - V_{BE} = 0$$

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

FBC→COLLECTOR-EMITTER LOOP



$$I_C = \beta I_B$$

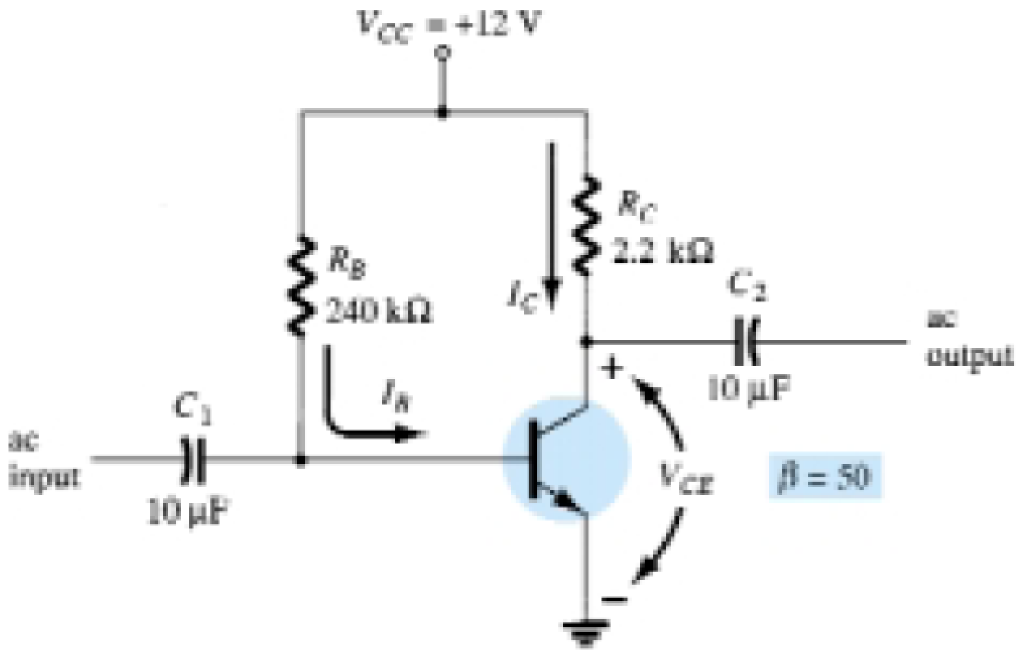
$$V_{CE} + I_C R_C - V_{CC} = 0$$

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

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

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

CONTOH



Determine the following for the fixed-bias configuration

(a) I_{B_Q} and I_{C_Q}.

(b) V_{CE_Q}.

(c) V_B and V_C.

(d) V_{BC}.

CONTOH

$$I_{B_Q} = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12\text{ V} - 0.7\text{ V}}{240\text{ k}\Omega} = \mathbf{47.08\ \mu A}$$

$$I_{C_Q} = \beta I_{B_Q} = (50)(47.08\ \mu\text{A}) = \mathbf{2.35\ mA}$$

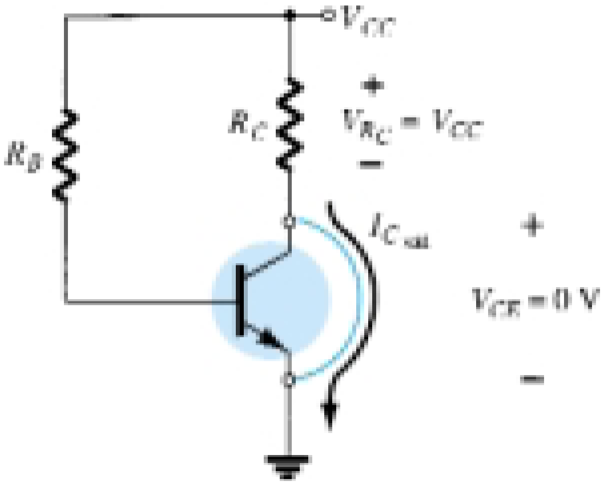
$$\begin{aligned} V_{CE_Q} &= V_{CC} - I_C R_C \\ &= 12\text{ V} - (2.35\text{ mA})(2.2\text{ k}\Omega) \\ &= \mathbf{6.83\ V} \end{aligned}$$

$$V_B = V_{BE} = \mathbf{0.7\ V}$$

$$V_C = V_{CE} = \mathbf{6.83\ V}$$

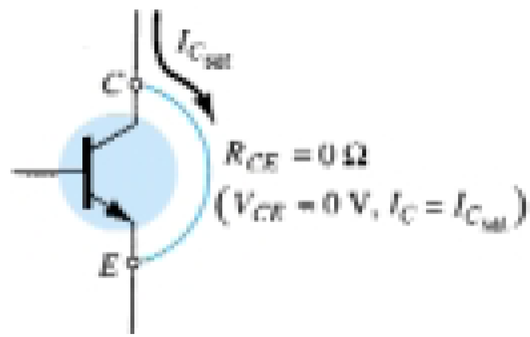
$$\begin{aligned} V_{BC} &= V_B - V_C = 0.7\text{ V} - 6.83\text{ V} \\ &= \mathbf{-6.13\ V} \end{aligned}$$

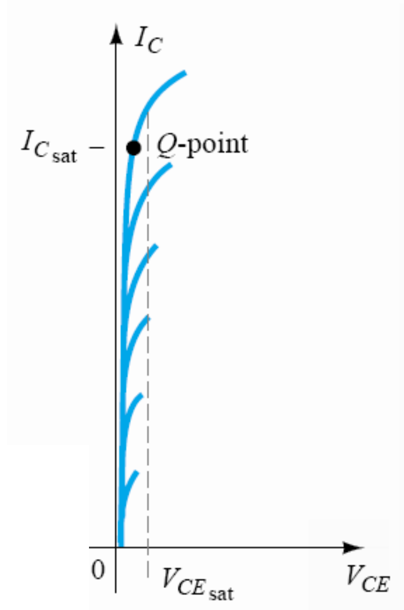
TRANSISTOR SATURATION

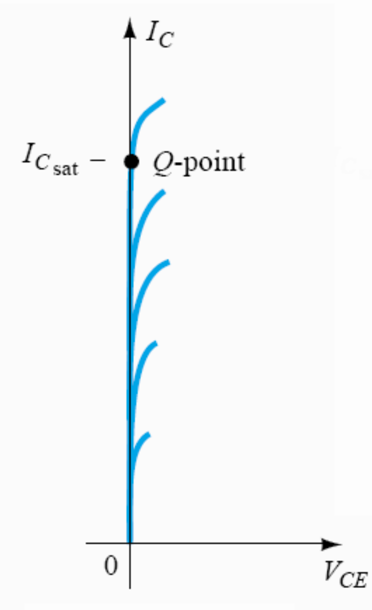


$$R_{CE} = \frac{V_{CE}}{I_C} = \frac{0\ \text{V}}{I_{C_{sat}}} = 0\ \Omega$$

$$\boxed{I_{C_{sat}} = \frac{V_{CC}}{R_C}}$$

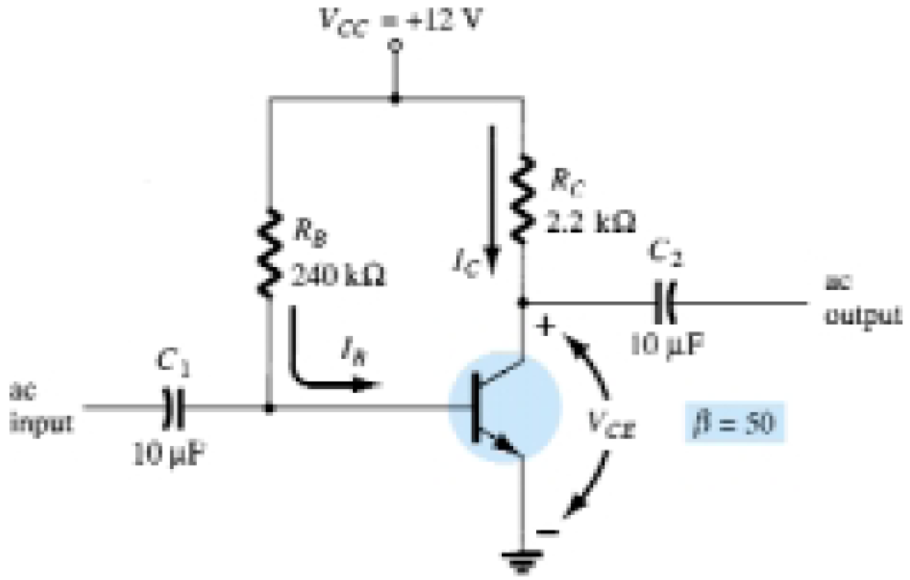






- Transistor berada pada kondisi saturasi bila titik kerja transistor berada pada daerah saturasi yaitu saat I_C maksimum dan V_{CE} =0.

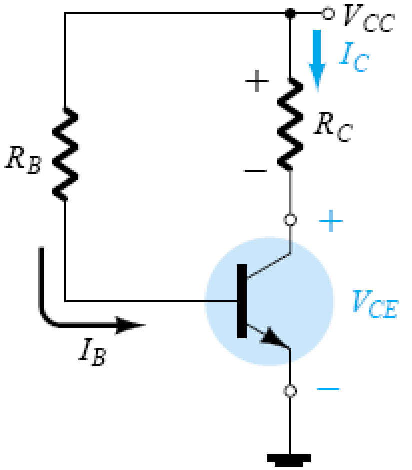
CONTOH

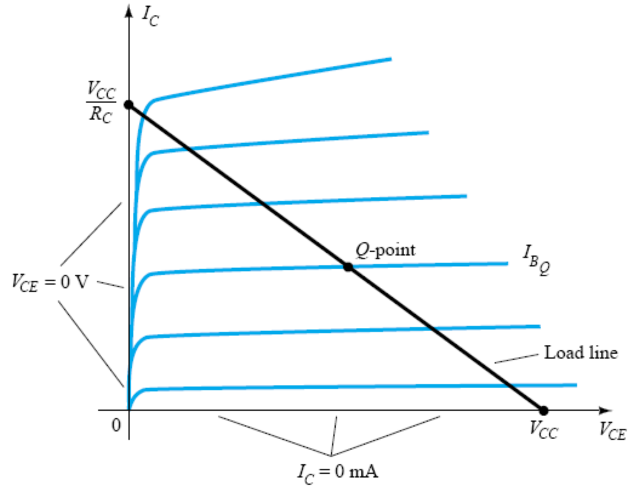


- Berapa besar I_C pada saat transistor saturasi?

$$I_{C_{sat}} = \frac{V_{CC}}{R_C} = \frac{12\text{ V}}{2.2\text{ k}\Omega} = \mathbf{5.45\ mA}$$

ANALISA GARIS BEBAN TRANSISTOR

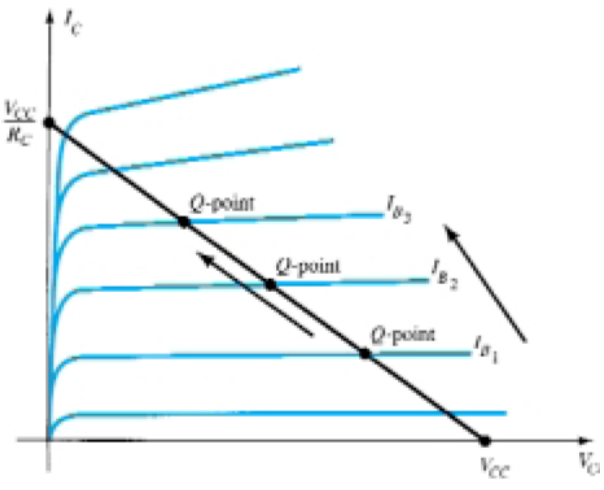




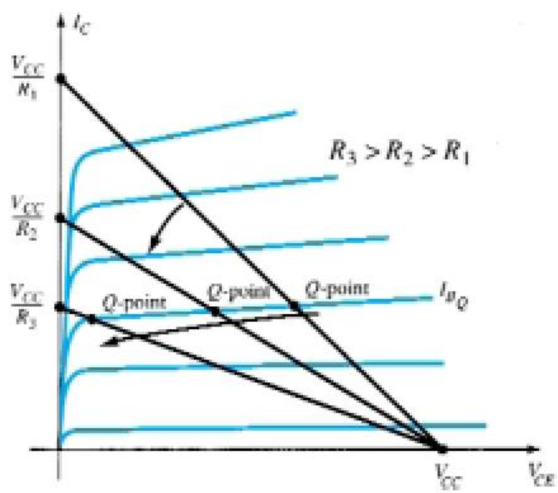
$$V_{CE} = V_{CC} - I_C R_C$$

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

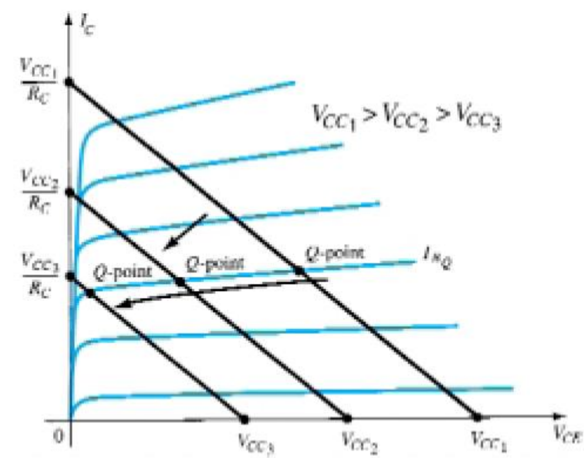
$$I_C = \frac{V_{CC}}{R_C}\bigg|_{V_{CE} = 0\ \text{V}}$$



Q - Point berubah karena perubahan IB

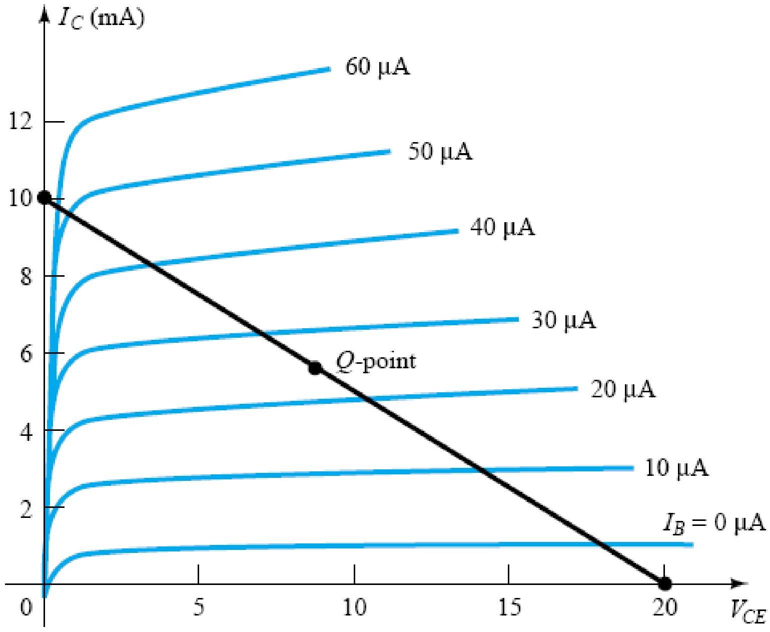


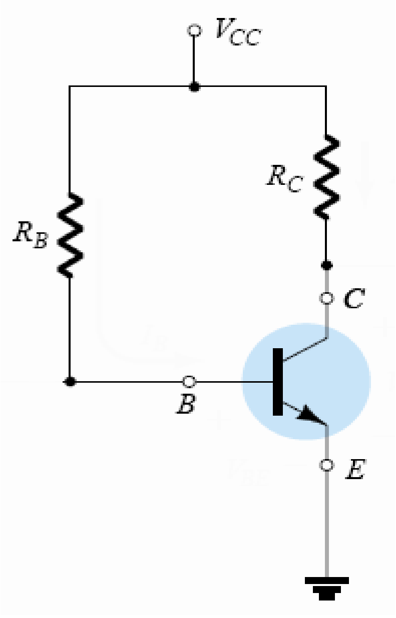
Garis beban berubah karena perubahan RC



Perubahan karena perubahan VCC

CONTOH


I_C (mA)
60 µA
50 µA
40 µA
30 µA
20 µA
10 µA
I_B = 0 µA
Q-point
12
10
8
6
4
2
0
5
10
15
20
V_{CE}


V_{CC}
R_C
R_B
C
B
E

CONTOH

$$V_{CE} = V_{CC} = \mathbf{20\ V} \text{ at } I_C = 0 \text{ mA}$$

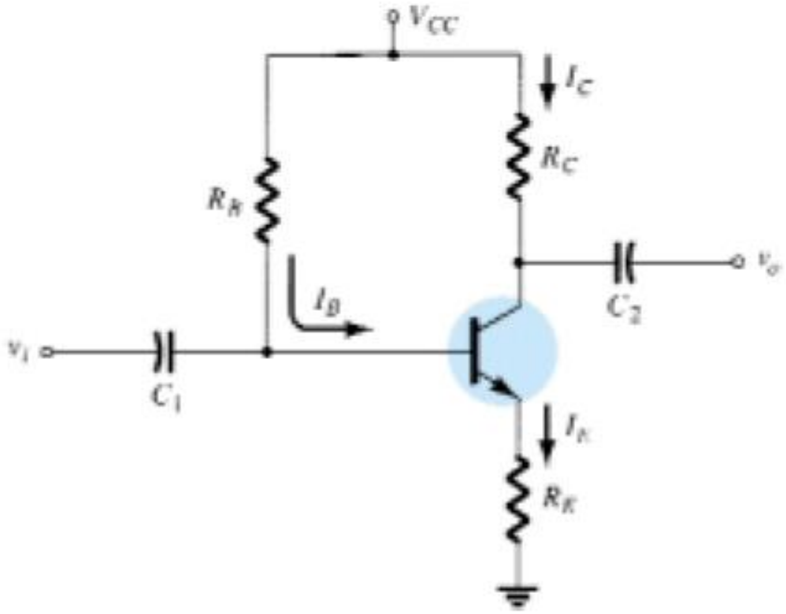
$$I_C = \frac{V_{CC}}{R_C} \text{ at } V_{CE} = 0 \text{ V}$$

$$R_C = \frac{V_{CC}}{I_C} = \frac{20 \text{ V}}{10 \text{ mA}} = \mathbf{2\ k\Omega}$$

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

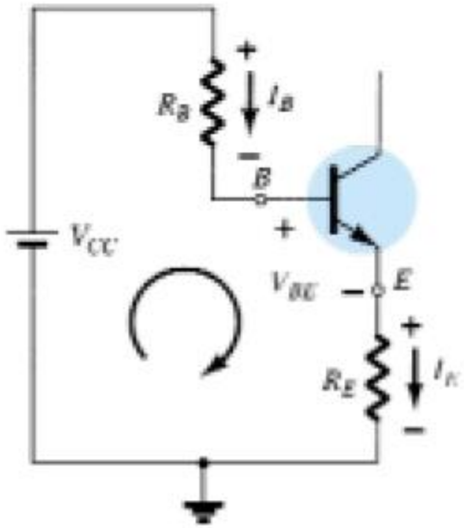
$$R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{20 \text{ V} - 0.7 \text{ V}}{25\ \mu\text{A}} = \mathbf{772\ k\Omega}$$

EMITTER-STABILIZED BIAS CIRCUIT



- Titik kerja dari rangkaian bias tetap sangat dipengaruhi oleh harga β.
- Karena β sangat peka terhadap perubahan temperatur, maka stabilitas kerja dari rangkaian bias tetap kurang baik.
- Untuk memperbaiki stabilitas terhadap variasi β, maka diberikan resistor pada kaki emitor (RE)

ESBC ➔ BASE–EMITTER LOOP



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

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

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

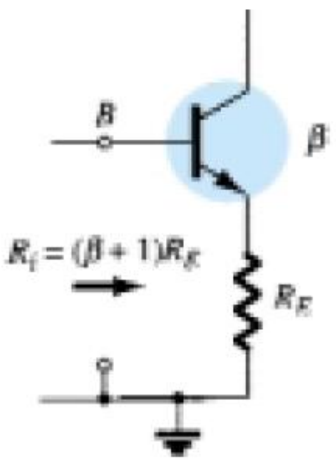
$$-I_B(R_B + (\beta + 1)R_E) + V_{CC} - V_{BE} = 0$$

x -1

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

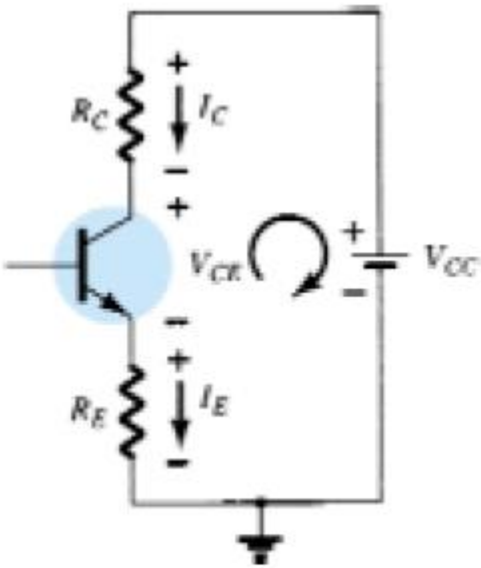
$$I_B(R_B + (\beta + 1)R_E) = V_{CC} - V_{BE}$$

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



$$\boxed{R_i = (\beta + 1)R_E}$$

ESBC → COLLECTOR–EMITTER LOOP



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

$$I_E \cong I_C$$

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

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

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

→

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

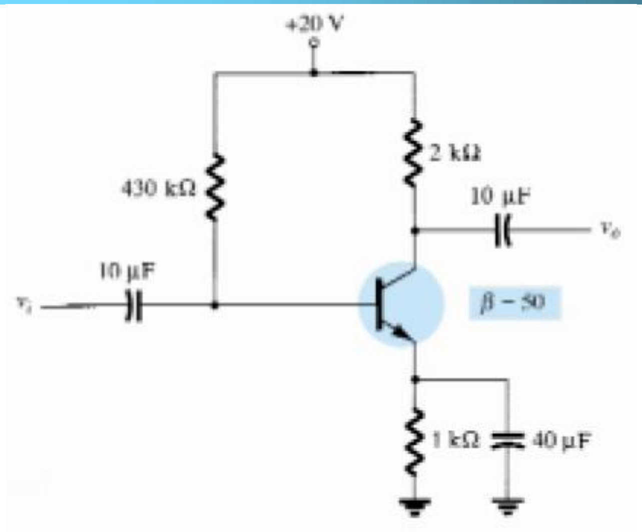
$$\boxed{V_C = V_{CE} + V_E}$$

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

$$\boxed{V_B = V_{CC} - I_B R_B}$$

$$\boxed{V_B = V_{BE} + V_E}$$

CONTOH



For the emitter bias network

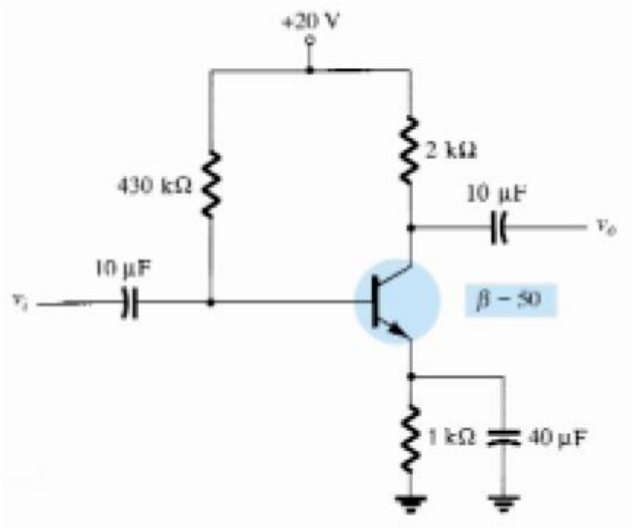
(a) I_B.
(b) I_C.
(c) V_{CE}.
(d) V_C.
(e) V_E.
(f) V_B.
(g) V_{BC}.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E} = \frac{20\text{ V} - 0.7\text{ V}}{430\text{ k}\Omega + (51)(1\text{ k}\Omega)}$$
$$= \frac{19.3\text{ V}}{481\text{ k}\Omega} = \mathbf{40.1\ \mu A}$$

$$I_C = \beta I_B$$
$$= (50)(40.1\ \mu\text{A})$$
$$\cong \mathbf{2.01\ mA}$$

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$
$$= 20\text{ V} - (2.01\text{ mA})(2\text{ k}\Omega + 1\text{ k}\Omega) = 20\text{ V} - 6.03\text{ V}$$
$$= \mathbf{13.97\ V}$$

CONTOH



$$V_C = V_{CC} - I_C R_C$$
$$= 20\text{ V} - (2.01\text{ mA})(2\text{ k}\Omega) = 20\text{ V} - 4.02\text{ V}$$
$$= \mathbf{15.98\ V}$$

$$V_E = V_C - V_{CE}$$
$$= 15.98\text{ V} - 13.97\text{ V}$$
$$= \mathbf{2.01\ V}$$

$$V_E = I_E R_E \cong I_C R_E$$
$$= (2.01\text{ mA})(1\text{ k}\Omega)$$
$$= \mathbf{2.01\ V}$$

$$V_B = V_{BE} + V_E$$
$$= 0.7\text{ V} + 2.01\text{ V}$$
$$= \mathbf{2.71\ V}$$

$$V_{BC} = V_B - V_C$$
$$= 2.71\text{ V} - 15.98\text{ V}$$
$$= \mathbf{-13.27\ V}$$

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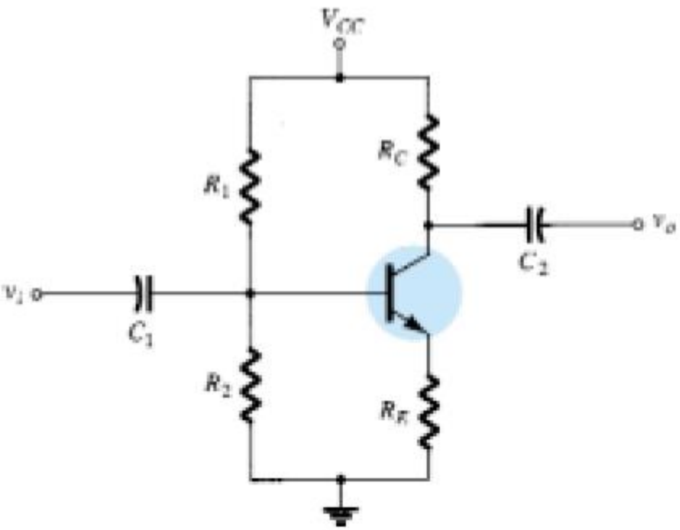
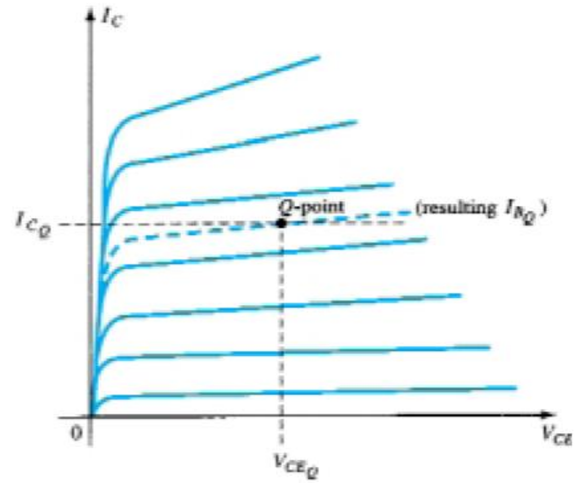
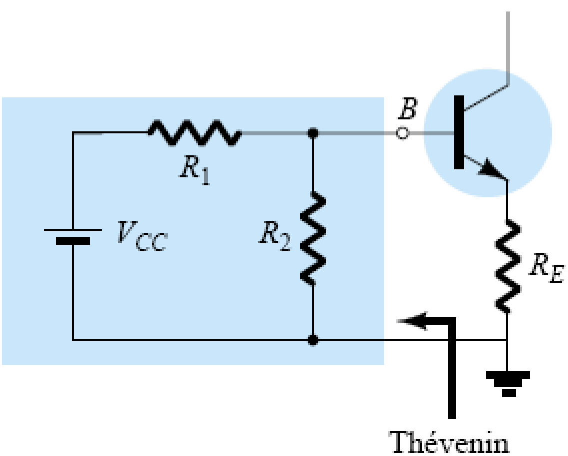
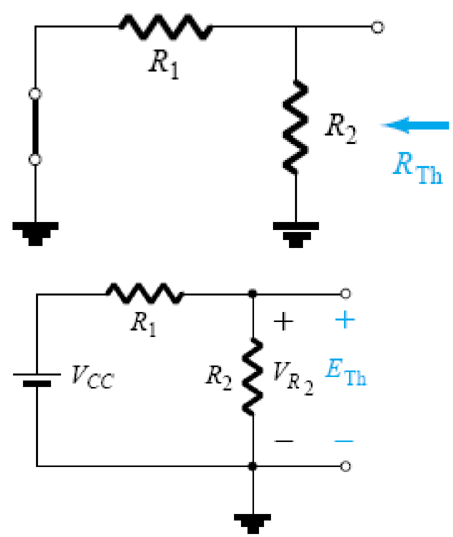
ESBC → VOLTAGE DEVIDER BIAS





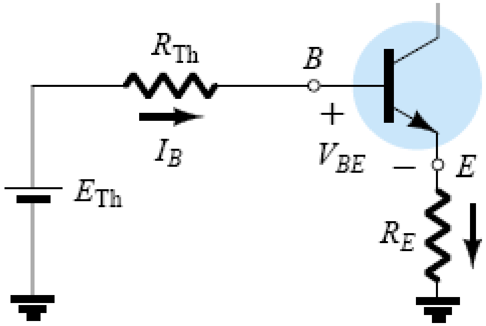




$$R_{Th} = R_1 \| R_2$$

$$E_{Th} = V_{R_2} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

ESBC ➔ VOLTAGE DEVIDER BIAS



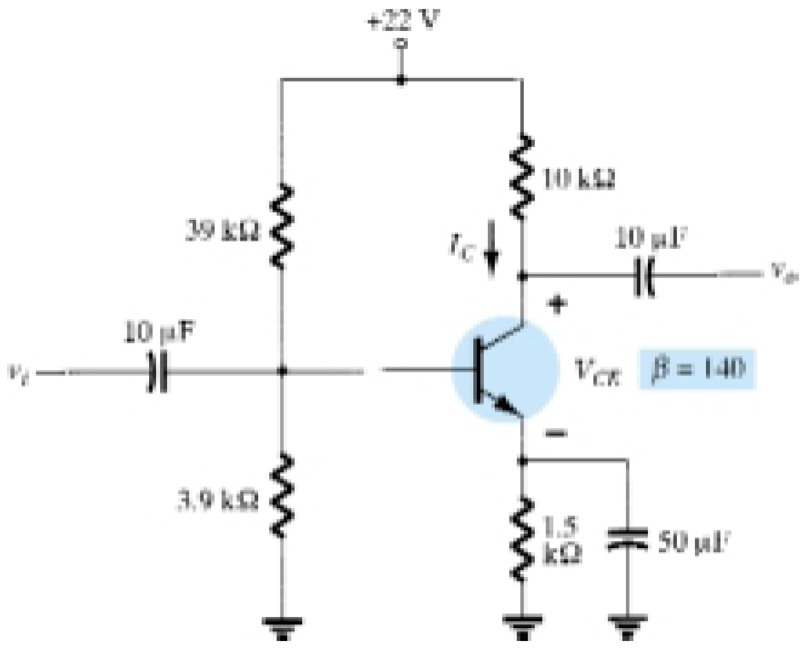
$$E_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$$

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

$$\boxed{I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1) R_E}}$$

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

CONTOH



Determine the dc bias voltage V_{CE} and the current I_C

$$R_{Th} = R_1 \| R_2$$

$$= \frac{(39\text{ k}\Omega)(3.9\text{ k}\Omega)}{39\text{ k}\Omega + 3.9\text{ k}\Omega} = 3.55\text{ k}\Omega$$

$$E_{Th} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

$$= \frac{(3.9\text{ k}\Omega)(22\text{ V})}{39\text{ k}\Omega + 3.9\text{ k}\Omega} = 2\ V$$

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$$

$$= \frac{2\text{ V} - 0.7\text{ V}}{3.55\text{ k}\Omega + (141)(1.5\text{ k}\Omega)} = \frac{1.3\text{ V}}{3.55\text{ k}\Omega + 211.5\text{ k}\Omega}$$

$$= 6.05\ \mu A$$

$$I_C = \beta I_B$$

$$= (140)(6.05\ \mu\text{A})$$

$$= \mathbf{0.85\ mA}$$

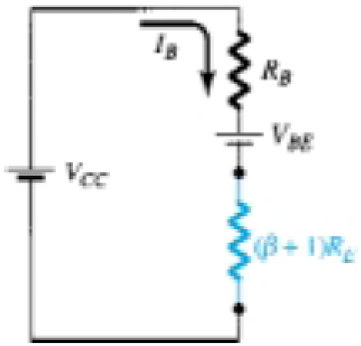
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

$$= 22\text{ V} - (0.85\text{ mA})(10\text{ k}\Omega + 1.5\text{ k}\Omega)$$

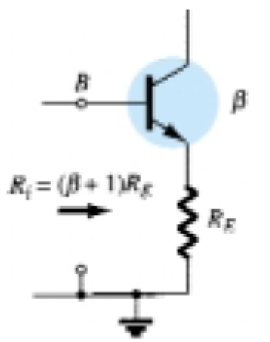
$$= 22\text{ V} - 9.78\text{ V}$$

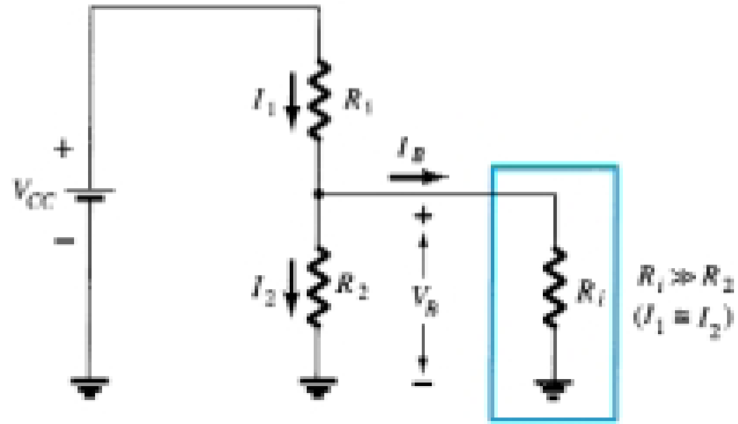
$$= \mathbf{12.22\ V}$$

ESBC ➔ VOLTAGE DEVIDER BIAS



$$R_i = (\beta + 1)R_E$$





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

$$R_i = (\beta + 1)R_E \cong \beta R_E$$

$$\beta R_E \geq 10R_2$$

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

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

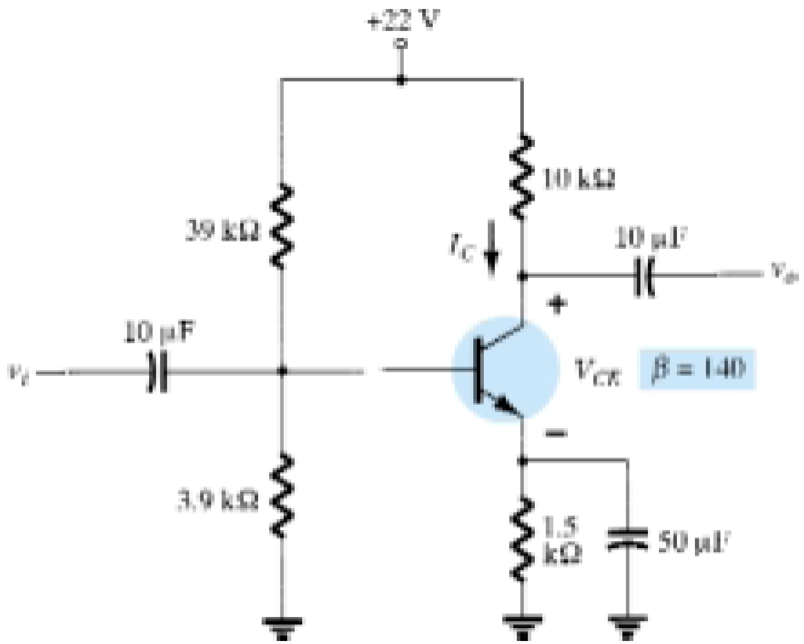
$$I_{C_Q} \cong I_E$$

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

$$I_E \cong I_C,$$

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

CONTOH



$$\beta R_E \geq 10R_2$$

$$(140)(1.5\ \text{k}\Omega) \geq 10(3.9\ \text{k}\Omega)$$

$$210\ \text{k}\Omega \geq 39\ \text{k}\Omega\ (\textit{satisfied})$$

$$\text{Eq. (4.32):}\quad V_B = \frac{R_2 V_{CC}}{R_1 + R_2}$$

$$= \frac{(3.9\ \text{k}\Omega)(22\ \text{V})}{39\ \text{k}\Omega + 3.9\ \text{k}\Omega}$$

$$= 2\ \text{V}$$

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

$$= 2\ \text{V} - 0.7\ \text{V}$$

$$= 1.3\ \text{V}$$

$$I_{CQ} \cong I_E = \frac{V_E}{R_E} = \frac{1.3\ \text{V}}{1.5\ \text{k}\Omega} = \mathbf{0.867\ mA}$$

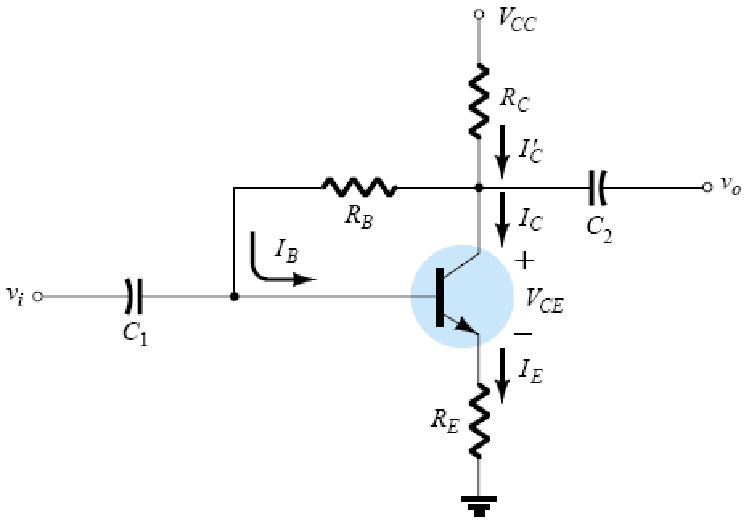
$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E)$$

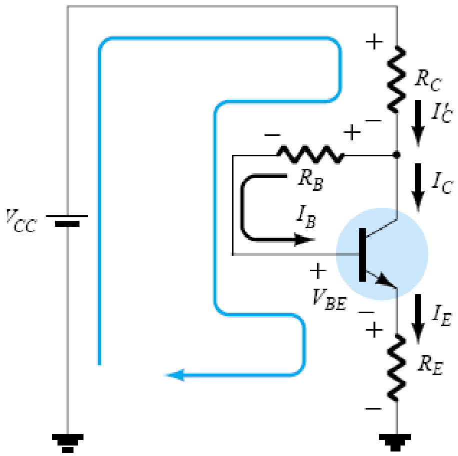
$$= 22\ \text{V} - (0.867\ \text{mA})(10\ \text{kV} + 1.5\ \text{k}\Omega)$$

$$= 22\ \text{V} - 9.97\ \text{V}$$

$$= \mathbf{12.03\ V}$$

DC BIAS WITH VOLTAGE FEEDBACK





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

$I_C' = I_C + I_B$ $\qquad$ $I'_C \cong I_C = \beta I_B$

$$I_E \cong I_C$$

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

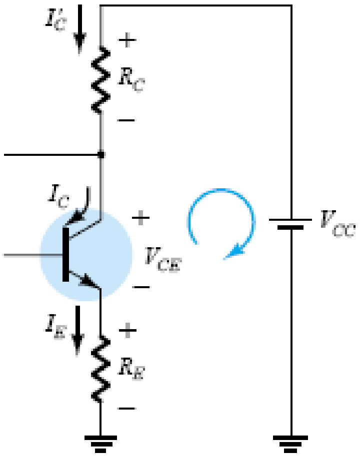
$$V_{CC} - V_{BE} - \beta I_B (R_C + R_E) - I_B R_B = 0$$

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

$I_B = \dfrac{V'}{R_B + \beta R'}$ $\qquad$ $R' = R_C + R_E$ $\qquad$ $I_C = \beta I_B,$

$$I_{C_Q} = \frac{\beta V'}{R_B + \beta R'}$$

DC BIAS WITH VOLTAGE FEEDBACK

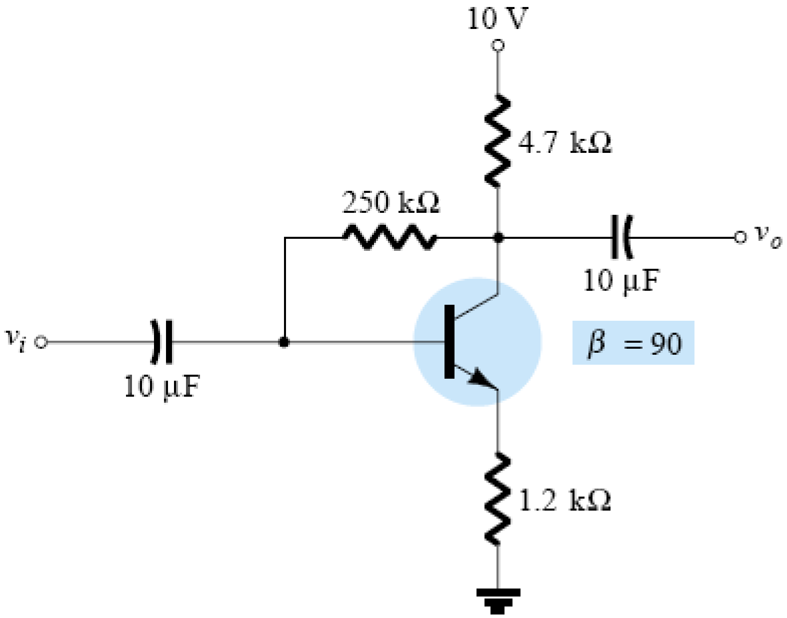


$$I_E R_E + V_{CE} + I'_C R_C - V_{CC} = 0 \qquad I'_C \cong I_C \qquad I_E \cong I_C,$$

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

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

CONTOH



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

$$= \frac{10\text{ V} - 0.7\text{ V}}{250\text{ k}\Omega + (90)(4.7\text{ k}\Omega + 1.2\text{ k}\Omega)}$$

$$= \frac{9.3\text{ V}}{250\text{ k}\Omega + 531\text{ k}\Omega} = \frac{9.3\text{ V}}{781\text{ k}\Omega}$$

$$= 11.91\ \mu\text{A}$$

$$I_{C_Q} = \beta I_B = (90)(11.91\ \mu\text{A})$$

$$= \mathbf{1.07\ mA}$$

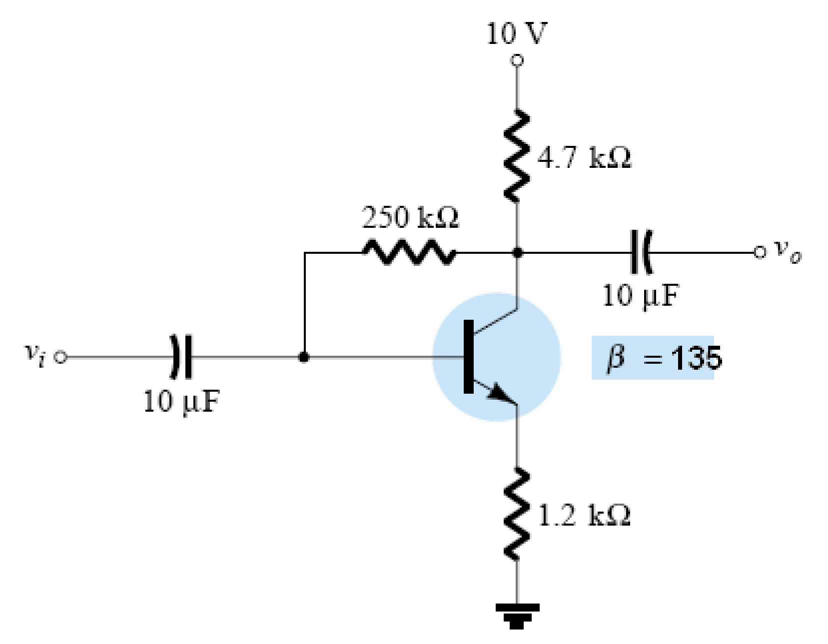
$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E)$$

$$= 10\text{ V} - (1.07\text{ mA})(4.7\text{ k}\Omega + 1.2\text{ k}\Omega)$$

$$= 10\text{ V} - 6.31\text{ V}$$

$$= \mathbf{3.69\ V}$$

CONTOH



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

$$\frac{10\text{ V} - 0.7\text{ V}}{250\text{ k}\Omega + (135)(4.7\text{ k}\Omega + 1.2\text{ k}\Omega)}$$

$$= \frac{9.3\text{ V}}{250\text{ k}\Omega + 796.5\text{ k}\Omega} = \frac{9.3\text{ V}}{1046.5\text{ k}\Omega}$$

$$= 8.89\ \mu\text{A}$$

$$I_{C_Q} = \beta I_B$$

$$= (135)(8.89\ \mu\text{A})$$

$$= \mathbf{1.2\ mA}$$

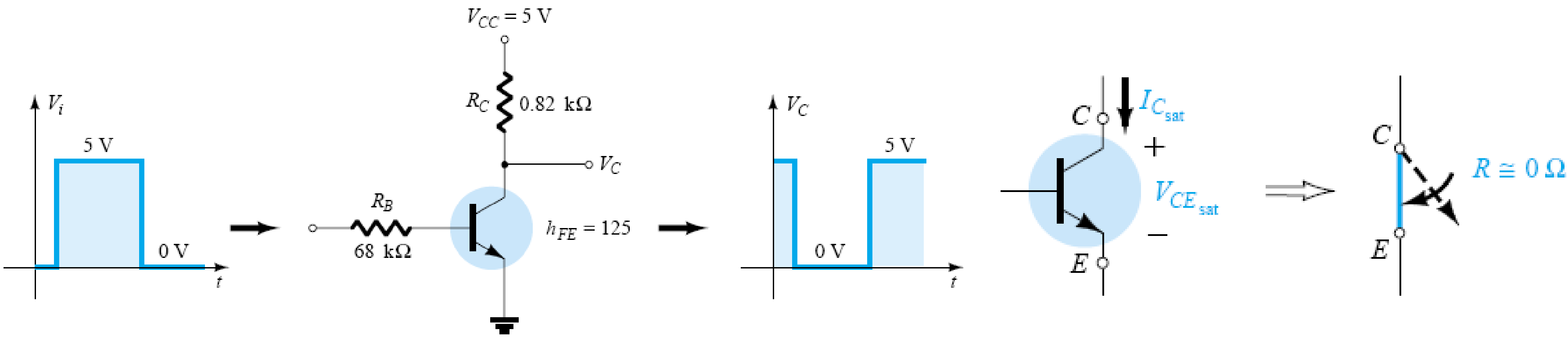
$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E)$$

$$= 10\text{ V} - (1.2\text{ mA})(4.7\text{ k}\Omega + 1.2\text{ k}\Omega)$$

$$= 10\text{ V} - 7.08\text{ V}$$

$$= \mathbf{2.92\ V}$$

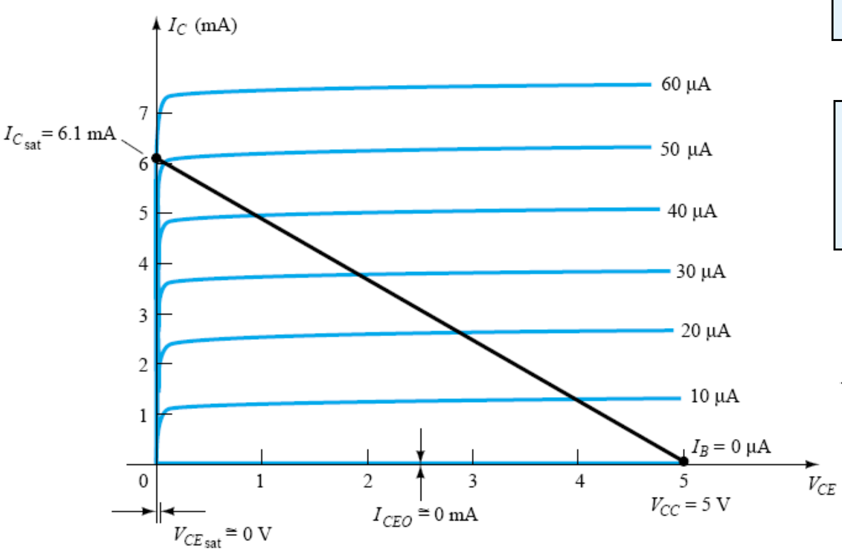
TRANSISTOR SWITCH

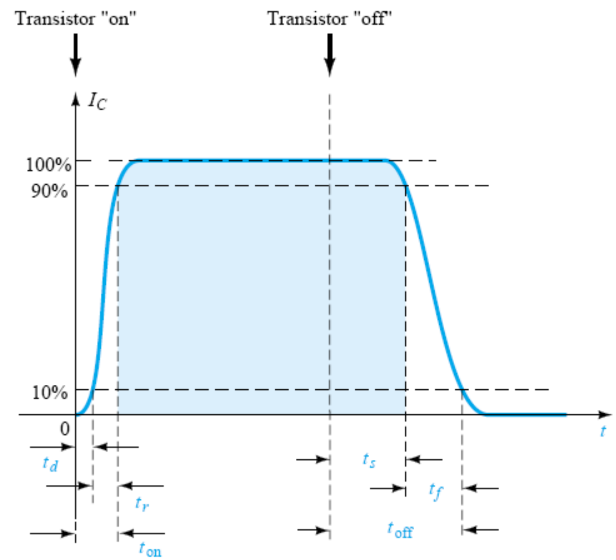


$$I_{C_{sat}} = \frac{V_{CC}}{R_C}$$

$$I_B > \frac{I_{C_{sat}}}{\beta_{dc}}$$

$$R_{sat} = \frac{V_{CE_{sat}}}{I_{C_{sat}}}$$





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