Analog Electronics Circuit

Course Code	**BEEE3021**

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Analog Electronics Circuit

BJT Biasing Circuits and Stabilization

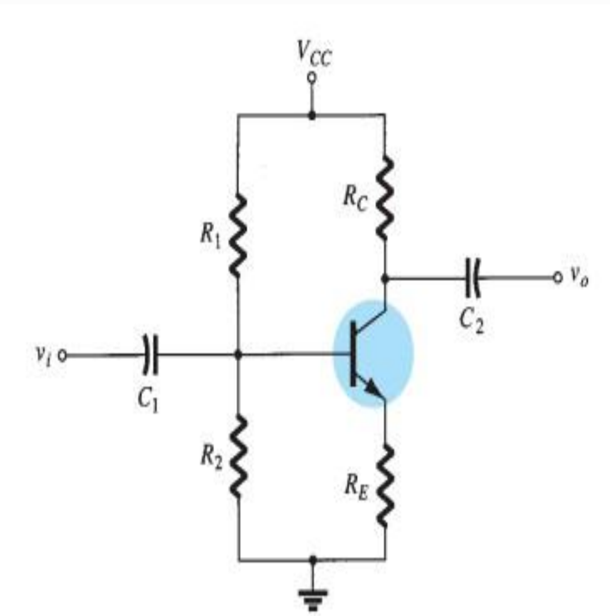
Source & References:
The materials presented in this lecture has been taken from various books and internet websites. This instruction materials is for instructional purposes only.
Referred book: R. Boylestad, Electronic Devices and Circuit Theory, 11th edition, Prentice Hall.

Contents:

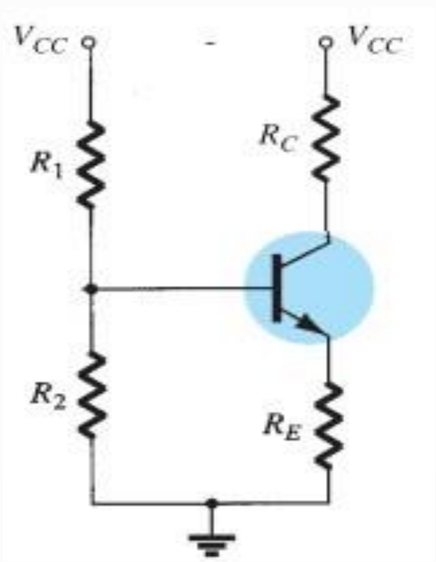
- Voltage-Divider bias configuration
- Collector Feedback bias Configuration
- Emitter-Follower bias configuration
- Common-Base Configuratio
- Miscellaneous bias configuration
- Bias Stabilization

Voltage-Divider Configuration

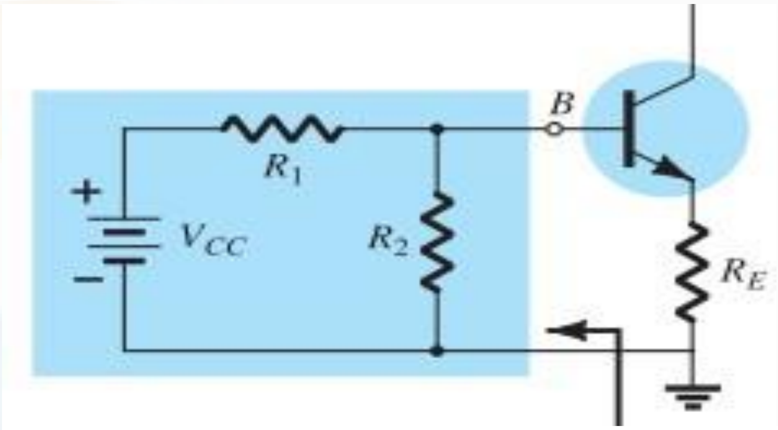
•Voltage-divider bias configuration.

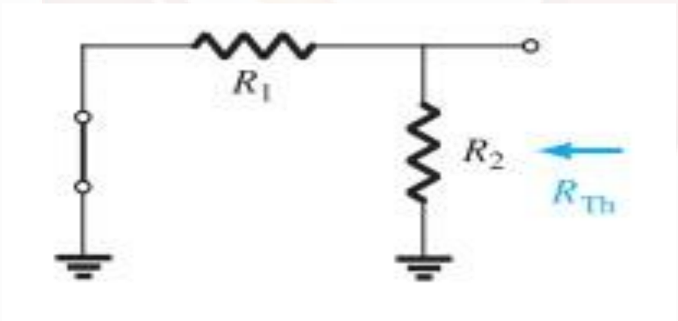


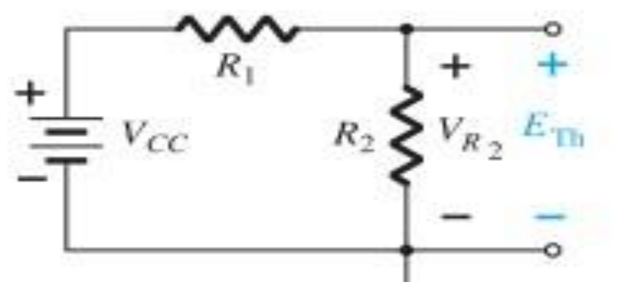
- DC components of the voltage-divider configuration.



- Exact Analysis

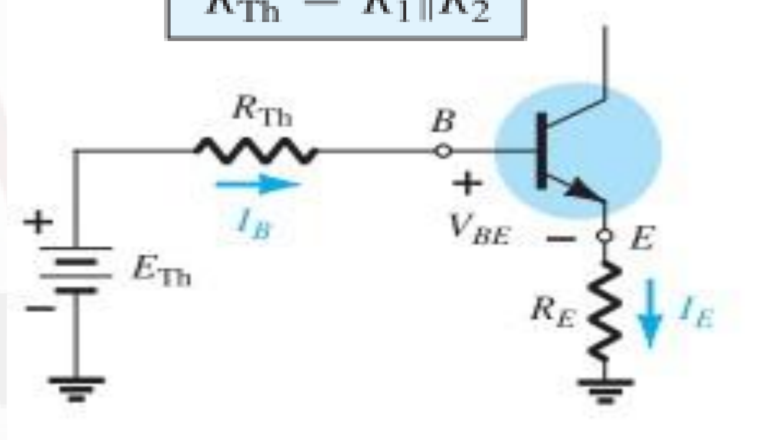






$$E_{Th} = V_{R_2} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

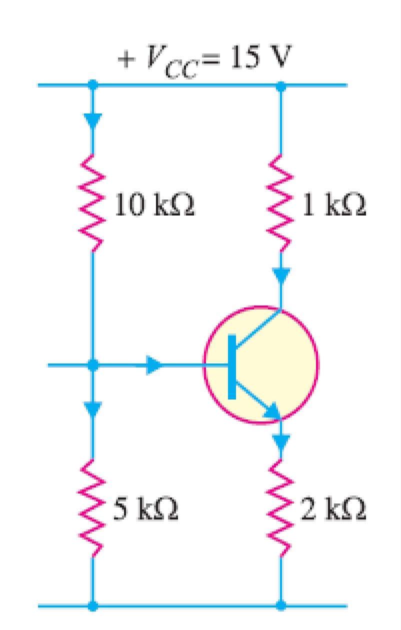
$$R_{Th} = R_1 \| R_2$$

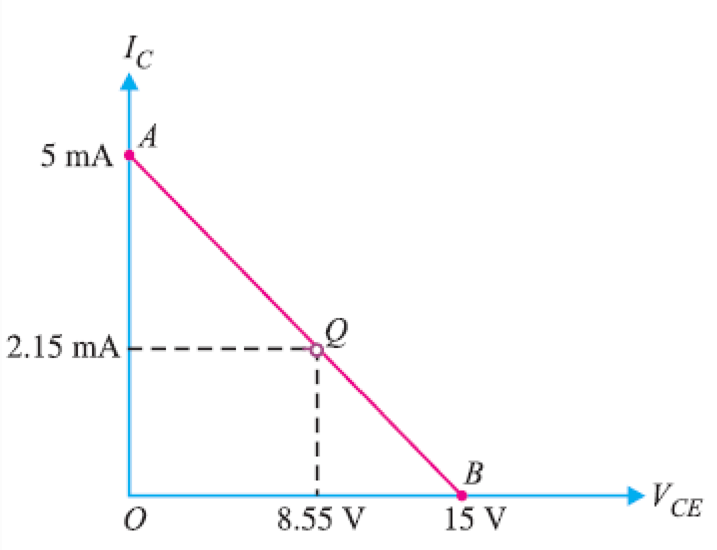


$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$$

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

Fig. 1 shows the voltage divider bias method. Draw the d.c. load line and determine the operating point. Assume the transistor to be of silicon.





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

When $I_C = 0$, $V_{CE} = V_{CC} = 15$V. This locates the first point *B* (*OB* = 15V) of the load line on the collector-emitter voltage axis.

When $V_{CE} = 0$, $I_C = \dfrac{V_{CC}}{R_C + R_E} = \dfrac{15\text{ V}}{(1+2)\text{ k}\Omega} = 5\text{ mA}$

Voltage across 5 kΩ is

$$V_2 = \frac{V_{CC}}{10+5} \times 5 = \frac{15 \times 5}{10+5} = 5 \text{ V}$$

∴ Emitter current, $I_E = \frac{V_2 - V_{BE}}{R_E} = \frac{5 - 0.7}{2 \text{ k}\Omega} = \frac{4.3 \text{ V}}{2 \text{ k}\Omega} = 2.15 \text{ mA}$

∴ Collector current is

$$I_C \simeq I_E = 2.15 \text{ mA}$$

Collector-emitter voltage, $V_{CE} = V_{CC} - I_C (R_C + R_E)$

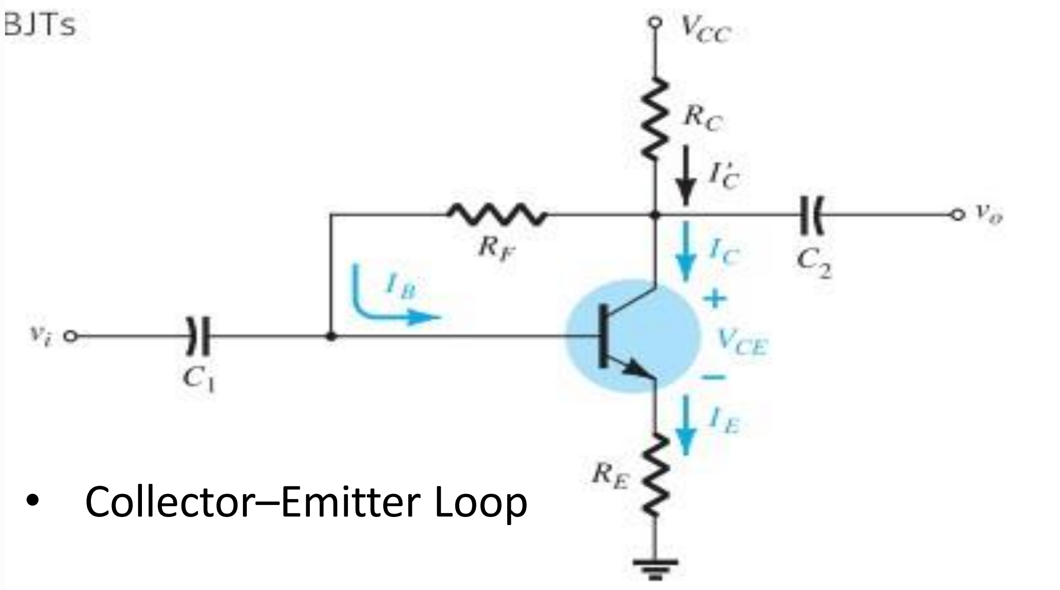
$$= 15 - 2.15 \text{ mA} \times 3 \text{ k}\Omega = 15 - 6.45 = 8.55 \text{ V}$$

∴ Operating point is **8.55 V, 2.15 mA.**

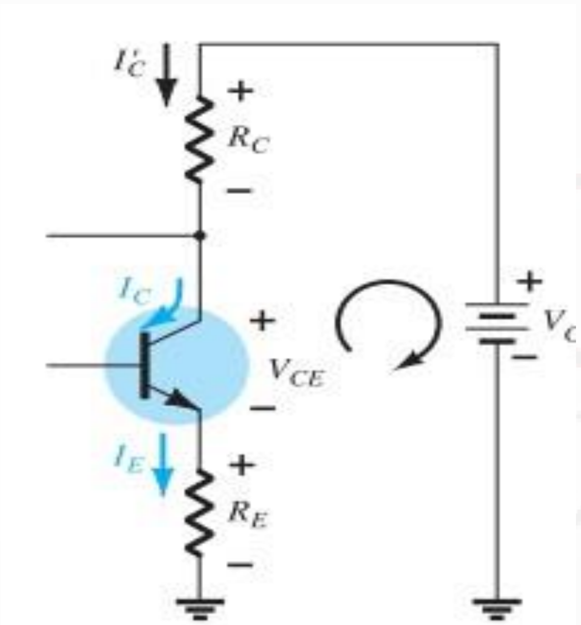
the operating point Q on the load line has co-ordinates are I_C = 2.15 mA, V_{CE} = 8.55 V.

Collector Feedback Configuration

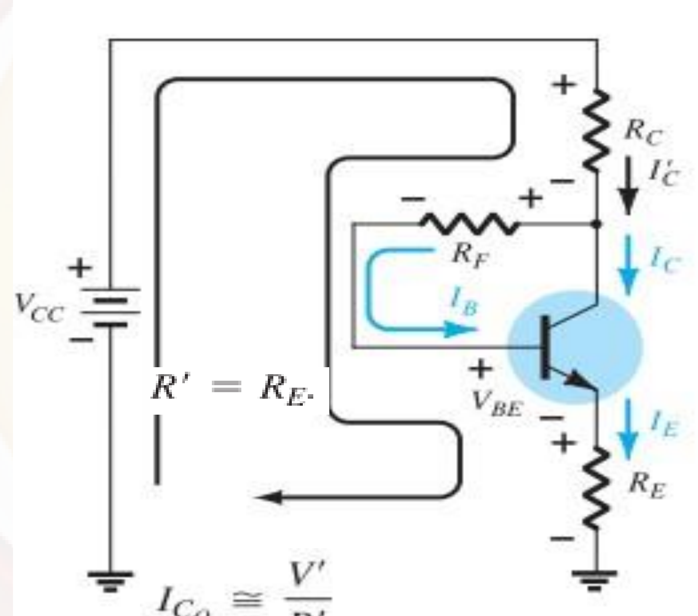
- DC bias circuit with voltage feedback.



- Collector–Emitter Loop



- Base–Emitter Loop



$$I_{C_Q} \cong \frac{V'}{R'}$$

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

$$I_B = \frac{V'}{R_F + \beta R'}$$

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

$$I_E R_E + V_{CE} + I'_C R_C - V_{CC} = 0$$

Because $I'_C \cong I_C$ and $I_E \cong I_C$, we have

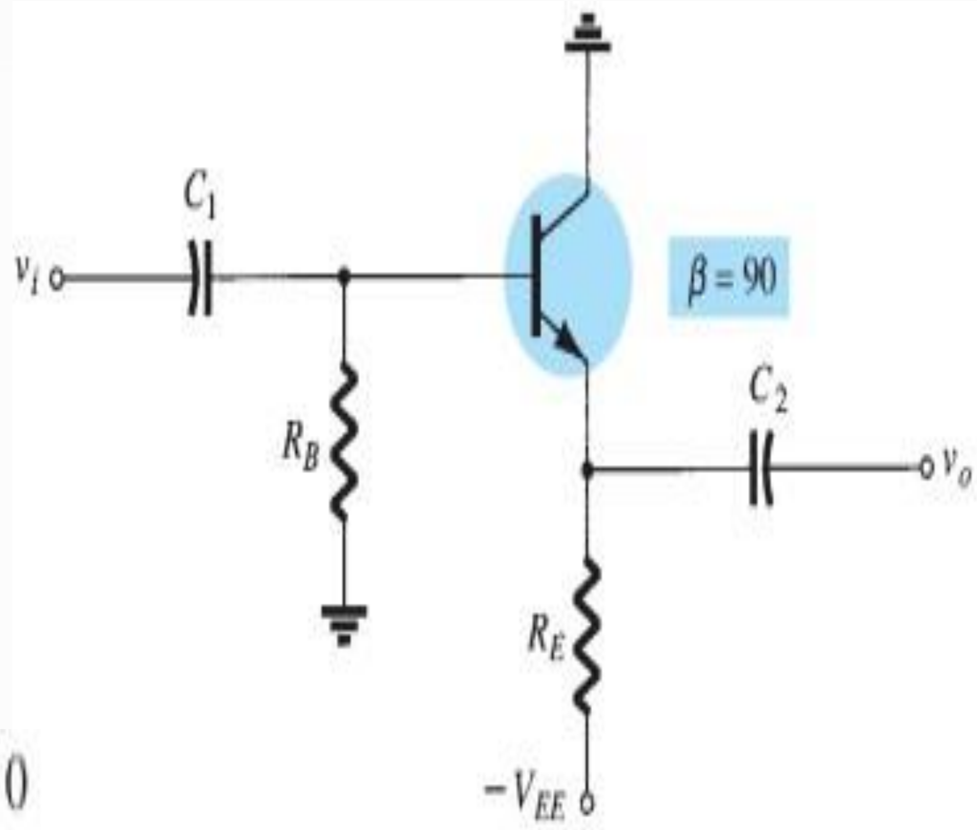
$$I_C(R_C + R_E) + V_{CE} - V_{CC} = 0$$

and

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

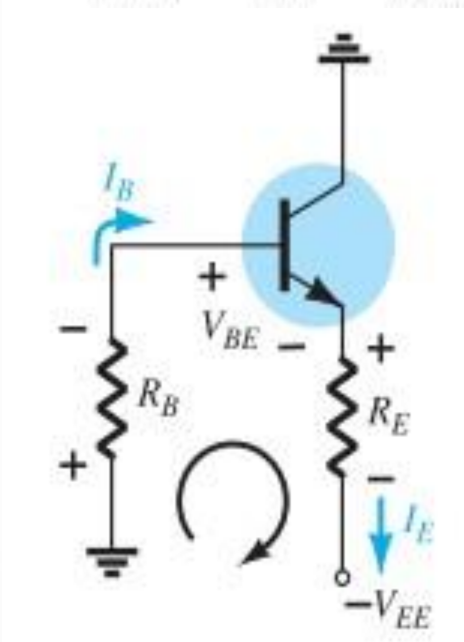
Emitter-Follower Configuration

- Common-collecter (emitter-follower) configuration.



- dc equivalent circuit
- Input circuit

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



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

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

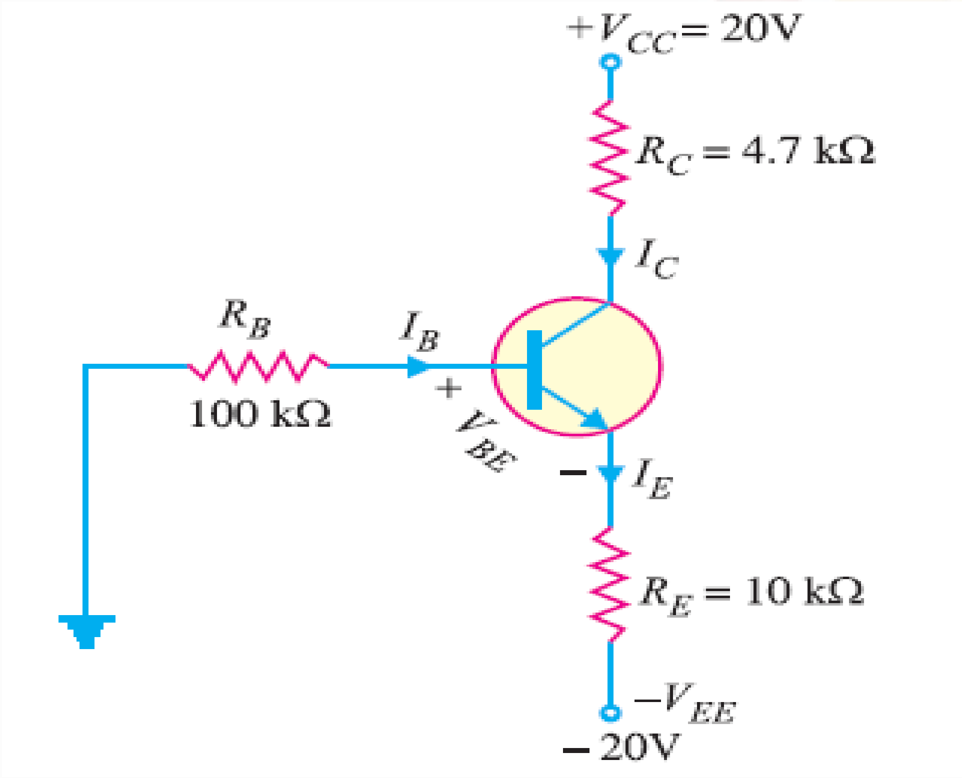
o/p ct

$$-V_{CE} - I_E R_E + V_{EE} = 0$$

$$\boxed{V_{CE} = V_{EE} - I_E R_E}$$

Emitter-Follower Configuration

Problem: For the emitter bias circuit shown in Fig. 10, find I_E, I_C, VC and V_C and V_{CE} for β= 85 and V_{BE} = 0.7V.



Emitter-Follower Configuration

$$I_C \simeq I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{20\text{V} - 0.7\text{V}}{10\text{ k}\Omega + 100\text{ k}\Omega/85} = 1.73\text{ mA}$$

$$V_C = V_{CC} - I_C R_C = 20\text{V} - (1.73\text{ mA})(4.7\text{ k}\Omega) = 11.9\text{V}$$

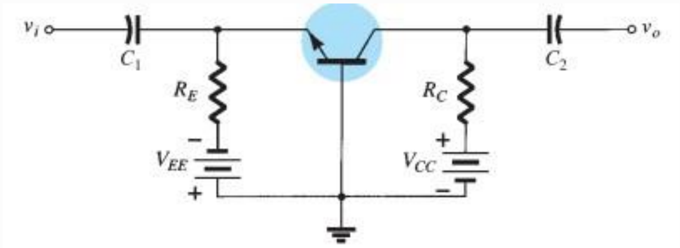
$$V_E = -V_{EE} + I_E R_E = -20\text{V} + (1.73\text{ mA})(10\text{ k}\Omega) = -2.7\text{V}$$

$$\therefore \quad V_{CE} = V_C - V_E = 11.9 - (-2.7\text{V}) = 14.6\text{V}$$

Note that operating point (or Q – point) of the circuit is 14.6V, 1.73 mA.

Common-Base Configuration

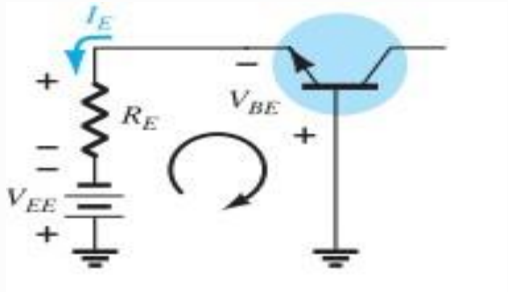
- Common-base configuration



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

$$\boxed{I_E = \frac{V_{EE} - V_{BE}}{R_E}}$$

  - i/p ct



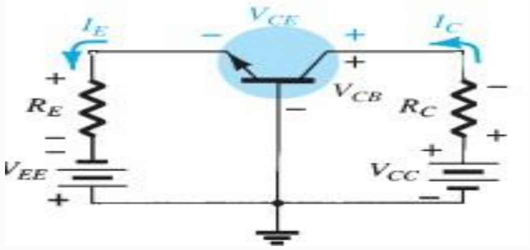
$$-V_{EE} + I_E R_E + V_{CE} + I_C R_C - V_{CC} = 0$$

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

$$I_E \cong I_C$$

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

- Determining V_{CB} & V_{CE}



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

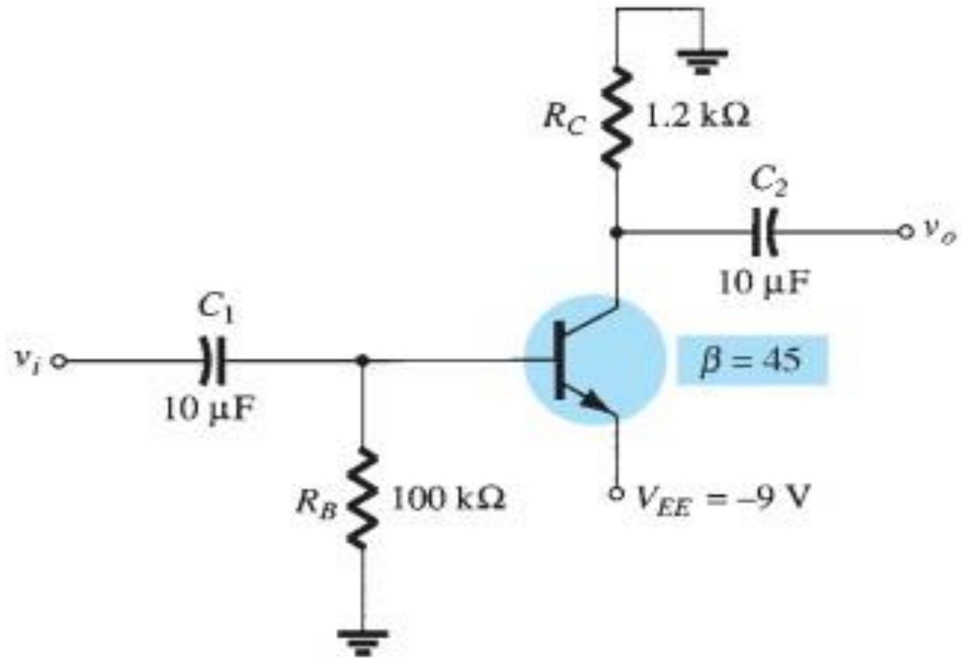
$$V_{CB} = V_{CC} - I_C R_C$$

$$I_C \cong I_E$$

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

Common-Base Configuration

EXAMPLE 4.19 Determine V_C and V_B for the network of Fig. 4.54.



Solution: Applying Kirchhoff's voltage law in the clockwise direction for the base–emitter loop results in

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

and

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

Substitution yields

$$I_B = \frac{9\text{ V} - 0.7\text{ V}}{100\text{ k}\Omega} = \frac{8.3\text{ V}}{100\text{ k}\Omega} = 83\ \mu\text{A}$$

$$I_C = \beta I_B = (45)(83\ \mu\text{A}) = 3.735\text{ mA}$$

$$V_C = -I_C R_C = -(3.735\text{ mA})(1.2\text{ k}\Omega) = \mathbf{-4.48\ V}$$

$$V_B = -I_B R_B = -(83\ \mu\text{A})(100\text{ k}\Omega) = \mathbf{-8.3\ V}$$

Thank You