Tikrit university

Collage of Engineering Shirqat

Department of Electrical Engineering

Second Class

Electronic I

Chapter 4

DC Biasing—BJTs

Prepared by

Lec 5

Asst Lecturer. Ahmed Saad Names

8.4 Common-Base Configuration

The common-base configuration is unique in that the applied signal is connected to the emitter terminal and the base is at, or just above, ground potential. It is a fairly popular configuration because in the ac domain it has a very low input impedance, high output impedance, and good gain.

A typical common-base configuration appears in Fig. 49. Note that two supplies are used in this configuration and the base is the common terminal between the input emitter terminal and output collector terminal. The dc equivalent of the input side of Fig. 49 appears in Fig.50.

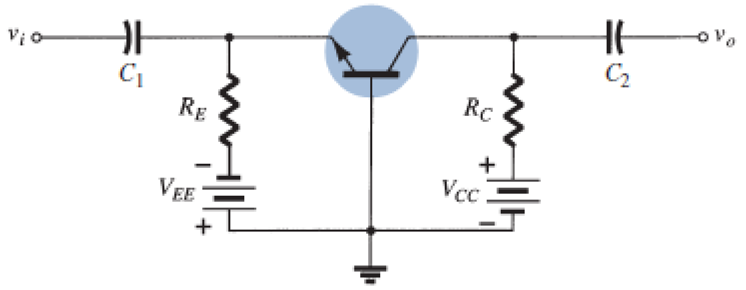


FIG. 49
Common-base configuration.

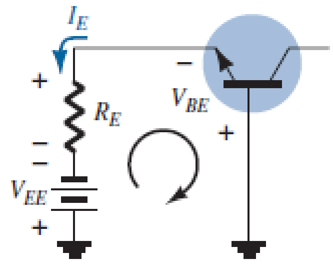


FIG. 50
Input dc equivalent of Fig. 49.

Applying Kirchhoff's voltage law will result in

-*VEE* + *IERE* + *VBE* = 0

$$\boxed{I_E = \frac{V_{EE} - V_{BE}}{R_E}} \qquad (46)$$

Applying Kirchhoff's voltage law to the entire outside perimeter of the network of Fig. 51 will result in

-VEE + IERE + VCE + ICRC - VCC = 0

and solving for VCE: VCE = VEE + VCC - IERE - ICRC

Because IE ≈ IC

$$\boxed{V_{CE} = V_{EE} + V_{CC} - I_E(R_C + R_E)} \qquad (47)$$

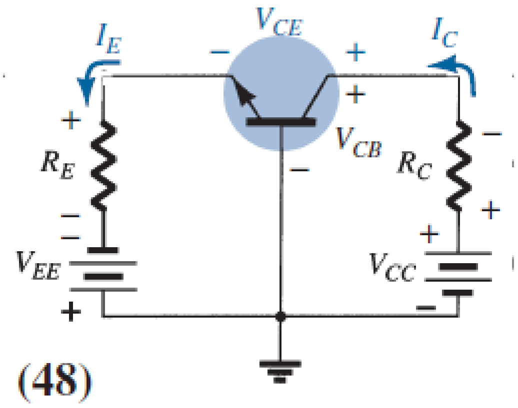
The voltage *VCB* of Fig. 51 can be found by applying Kirchhoff's voltage law to the output loop of Fig 51 to obtain:

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

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

Using $I_C \approx I_E$

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



(48)

FIG. 51
Determining V_{CE} and V_{CB}.

EXAMPLE 17 Determine the currents I_E and I_B and the voltages V_{CE} and V_{CB} for the common-base configuration of Fig. 52.

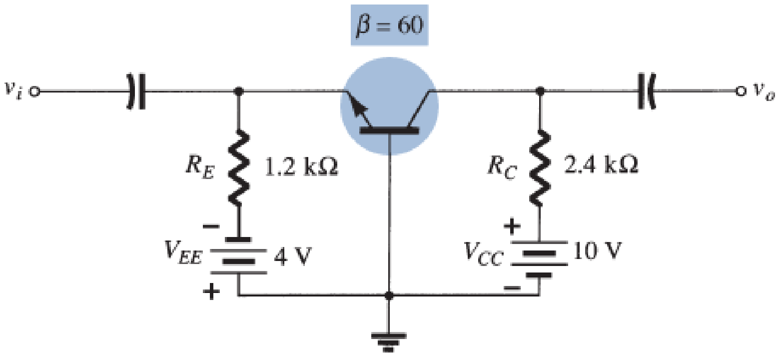


FIG. 52
Example 17.

Solution: Eq. 46:

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

$$= \frac{4\text{ V} - 0.7\text{ V}}{1.2\text{ k}\Omega} = \mathbf{2.75\text{ mA}}$$

$$I_B = \frac{I_E}{\beta + 1} = \frac{2.75\text{ mA}}{60 + 1} = \frac{2.75\text{ mA}}{61}$$

$$= \mathbf{45.08\ \mu A}$$

Eq. 47:

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

$$= 4\text{ V} + 10\text{ V} - (2.75\text{ mA})(2.4\text{ k}\Omega + 1.2\text{ k}\Omega)$$

$$= 14\text{ V} - (2.75\text{ mA})(3.6\text{ k}\Omega)$$

$$= 14\text{ V} - 9.9\text{ V}$$

$$= \mathbf{4.1\text{ V}}$$

Eq. 48:

$$V_{CB} = V_{CC} - I_C R_C = V_{CC} - \beta I_B R_C$$

$$= 10\text{ V} - (60)(45.08\ \mu\text{A})(24\text{ k}\Omega)$$

$$= 10\text{ V} - 6.49\text{ V}$$

$$= \mathbf{3.51\text{ V}}$$

9 Miscellaneous Bias Configurations

There are a number of BJT bias configurations that do not match the basic mold of those analysed in the previous sections. In fact, there are variations in design that would require many more pages than is possible in a single publication. However, the primary purpose here is to emphasize those characteristics of the device that permit a dc analysis of the configuration and to establish a general procedure toward the desired solution. For each configuration discussed thus far, the first step has been the derivation of an expression for the base current. Once the base current is known, the collector current and voltage levels of the output circuit can be determined quite directly. This is not to imply that all solutions will take this path, but it does suggest a possible route to follow if a new configuration is encountered. The first example is simply one where the emitter resistor has been dropped from the voltage-feedback configuration of Fig. 38. The analysis is quite similar, but does require dropping *RE* from the applied equation.

EXAMPLE 18 For the network of Fig. 53:

a. Determine I_{C_Q} and V_{CE_Q}.
b. Find V_B, V_C, V_E, and V_{BC}.

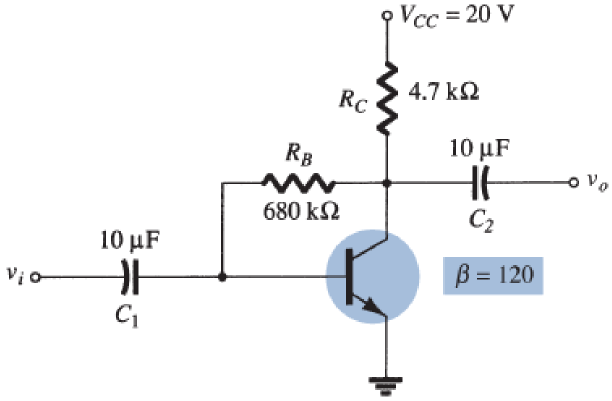


FIG. 53
Collector feedback with $R_E = 0\ \Omega$.

Solution:

a. The absence of R_E reduces the reflection of resistive levels to simply that of R_C, and the equation for I_B reduces to

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta R_C}$$
$$= \frac{20\text{ V} - 0.7\text{ V}}{680\text{ k}\Omega + (120)(4.7\text{ k}\Omega)} = \frac{19.3\text{ V}}{1.244\text{ M}\Omega}$$
$$= \mathbf{15.51\ \mu A}$$
$$I_{C_Q} = \beta I_B = (120)(15.51\ \mu\text{A})$$
$$= \mathbf{1.86\ mA}$$
$$V_{CE_Q} = V_{CC} - I_C R_C$$
$$= 20\text{ V} - (1.86\text{ mA})(4.7\text{ k}\Omega)$$
$$= \mathbf{11.26\ V}$$

b.
$$V_B = V_{BE} = \mathbf{0.7\ V}$$
$$V_C = V_{CE} = \mathbf{11.26\ V}$$
$$V_E = \mathbf{0\ V}$$
$$V_{BC} = V_B - V_C = 0.7\text{ V} - 11.26\text{ V}$$
$$= \mathbf{-10.56\ V}$$

EXAMPLE 19 Determine V_C and V_B for the network of Fig. 54.

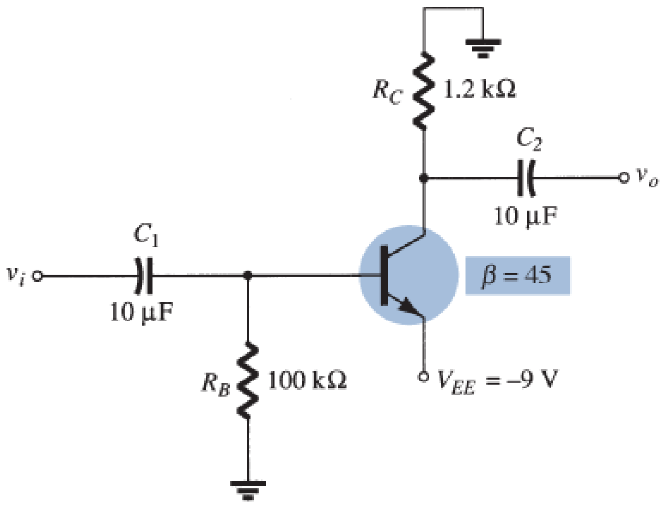


FIG. 54
Example 19.

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

$$-I_BR_B - V_{BE} + V_{EE} = 0$$

and

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

Substitution yields

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

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

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

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

EXAMPLE 20 Determine V_C and V_B for the network of Fig. 55.

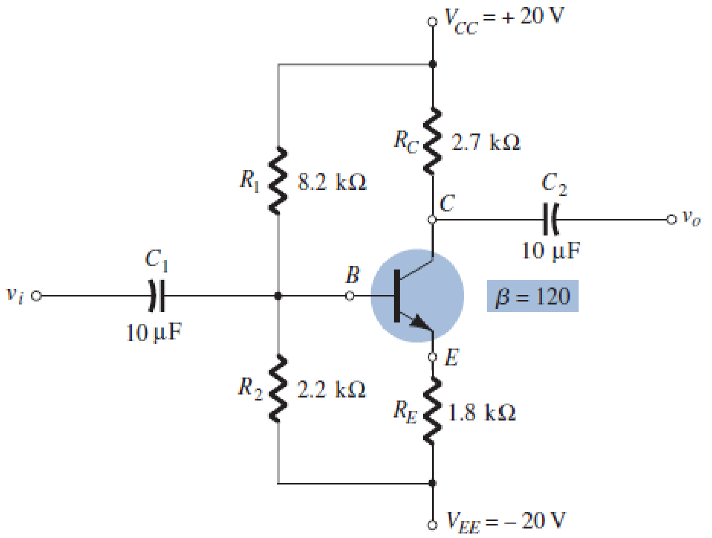


FIG. 55
Example 20.

Solution: The Thévenin resistance and voltage are determined for the network to the left of the base terminal as shown in Figs. 56 and 57.

R_{Th}

$$R_{Th} = 8.2\ \text{k}\Omega \,\|\, 2.2\ \text{k}\Omega = 1.73\ \text{k}\Omega$$

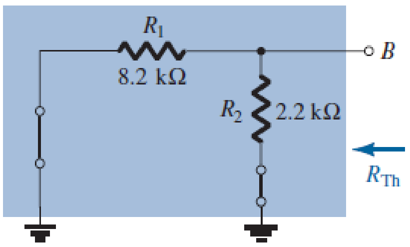


FIG. 56
Determining R_{Th}.

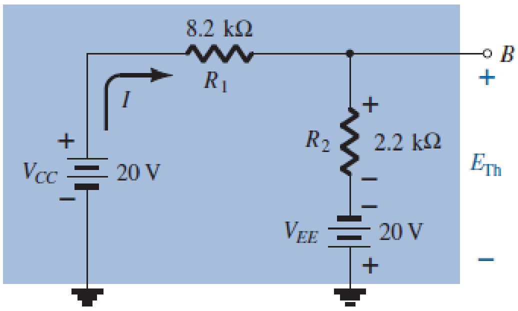


FIG. 57
Determining E_{Th}.

E_{Th}

$$I = \frac{V_{CC} + V_{EE}}{R_1 + R_2} = \frac{20\text{ V} + 20\text{ V}}{8.2\text{ k}\Omega + 2.2\text{ k}\Omega} = \frac{40\text{ V}}{10.4\text{ k}\Omega}$$
$$= 3.85\text{ mA}$$
$$E_{Th} = IR_2 - V_{EE}$$
$$= (3.85\text{ mA})(2.2\text{ k}\Omega) - 20\text{ V}$$
$$= -11.53\text{ V}$$

The network can then be redrawn as shown in Fig. 58, where the application of Kirchhoff's voltage law results in

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

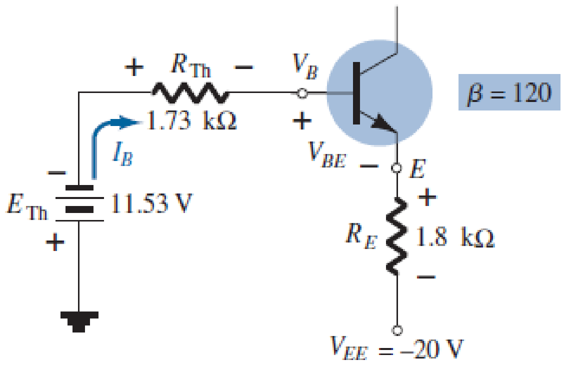


FIG. 58
Substituting the Thévenin equivalent circuit.

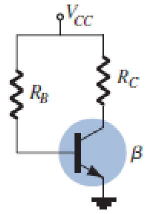
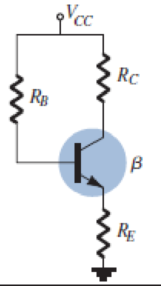
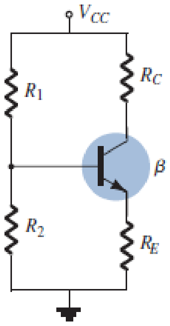
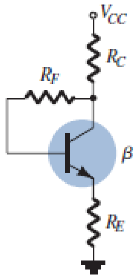
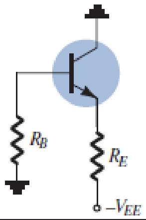
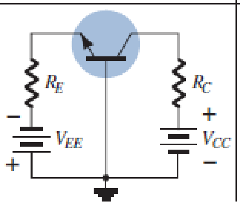
Substituting $I_E = (\beta + 1)I_B$ gives

$$V_{EE} - E_{Th} - V_{BE} - (\beta + 1)I_B R_E - I_B R_{Th} = 0$$

and

$$I_B = \frac{V_{EE} - E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$$
$$= \frac{20\text{ V} - 11.53\text{ V} - 0.7\text{ V}}{1.73\text{ k}\Omega + (121)(1.8\text{ k}\Omega)}$$
$$= \frac{7.77\text{ V}}{219.53\text{ k}\Omega}$$
$$= 35.39\ \mu\text{A}$$
$$I_C = \beta I_B$$
$$= (120)(35.39\ \mu\text{A})$$
$$= 4.25\text{ mA}$$
$$V_C = V_{CC} - I_C R_C$$
$$= 20\text{ V} - (4.25\text{ mA})(2.7\text{ k}\Omega)$$
$$= \mathbf{8.53\text{ V}}$$
$$V_B = -E_{Th} - I_B R_{Th}$$
$$= -(11.53\text{ V}) - (35.39\ \mu\text{A})(1.73\text{ k}\Omega)$$
$$= \mathbf{-11.59\text{ V}}$$

TABLE 1
BJT Bias Configurations

Type	Configuration	Pertinent Equations
Fixed-bias		$I_B = \dfrac{V_{CC} - V_{BE}}{R_B}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $V_{CE} = V_{CC} - I_C R_C$
Emitter-bias		$I_B = \dfrac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $R_i = (\beta + 1)R_E$ $V_{CE} = V_{CC} - I_C(R_C + R_E)$
Voltage-divider bias		EXACT: $R_{Th} = R_1 \| R_2, E_{Th} = \dfrac{R_2 V_{CC}}{R_1 + R_2}$ $I_B = \dfrac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $V_{CE} = V_{CC} - I_C(R_C + R_E)$ APPROXIMATE: $\beta R_E \geq 10R_2$ $V_B = \dfrac{R_2 V_{CC}}{R_1 + R_2}, V_E = V_B - V_{BE}$ $I_E = \dfrac{V_E}{R_E}, I_B = \dfrac{I_E}{\beta + 1}$ $V_{CE} = V_{CC} - I_C(R_C + R_E)$
Collector-feedback		$I_B = \dfrac{V_{CC} - V_{BE}}{R_F + \beta(R_C + R_E)}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $V_{CE} = V_{CC} - I_C(R_C + R_E)$
Emitter-follower		$I_B = \dfrac{V_{EE} - V_{BE}}{R_B + (\beta + 1)}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $V_{CE} = V_{EE} - I_E R_E$
Common-base		$I_E = \dfrac{V_{EE} - V_{BE}}{R_E}$ $I_B = \dfrac{I_E}{\beta + 1}, I_C = \beta I_B$ $V_{CE} = V_{EE} + V_{CC} - I_E(R_C + R_E)$ $V_{CB} = V_{CC} - I_C R_C$