Electrical, Electronic and Digital Principles (EEDP)

Lecture 3

Other BJT Biasing Techniques

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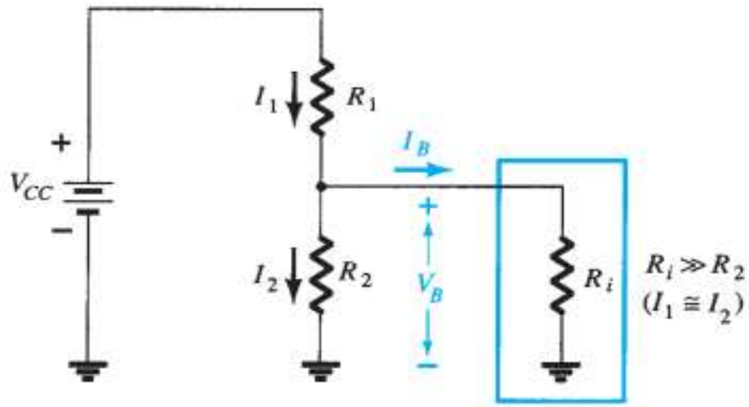
Voltage-divider Bias

Approximate Analysis



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

Ri = is the equivalent resistance between base and ground

$$\beta R_E \geq 10R_2$$

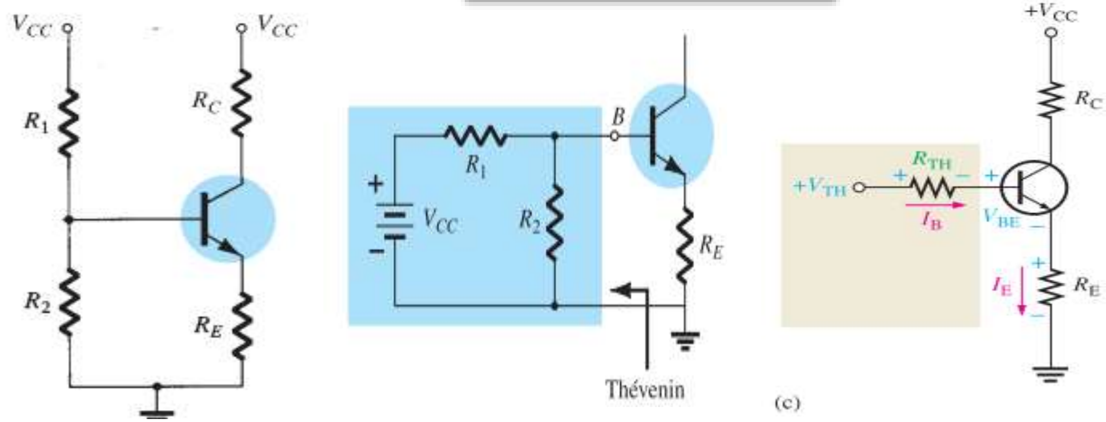
$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2}$$

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

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

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

Exact Analysis



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

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

$$V_{TH} = I_B R_{TH} + V_{BE} + I_E R_E$$

Substituting I_E/β_{DC} for I_B,

$$V_{TH} = I_E(R_E + R_{TH}/\beta_{DC}) + V_{BE}$$

Then solving for I_E,

$$I_E = \frac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}}$$

Substituting $I_E = (\beta + 1)I_B$ and solving for I_B yields

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

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

Approximate Analysis | **Voltage-divider Bias** | Exact Analysis

EXAMPLE 4.8 Determine the dc bias voltage V_{CE} and the current I_C for the voltage-divider configuration of Fig. 4.35.

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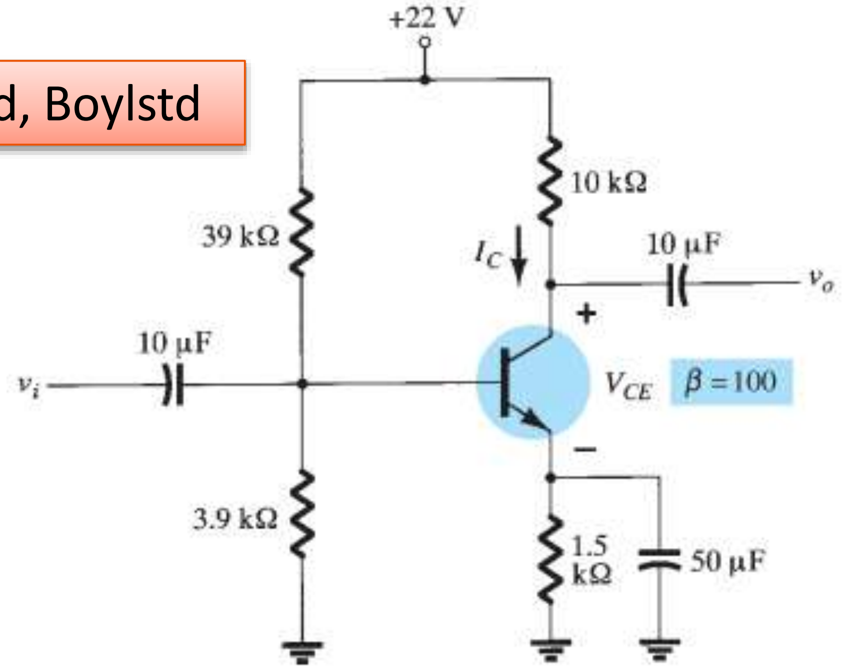


$$R_{Th} = R_1 \| R_2 = \frac{(39\ \text{k}\Omega)(3.9\ \text{k}\Omega)}{39\ \text{k}\Omega + 3.9\ \text{k}\Omega} = 3.55\ \text{k}\Omega$$

$$E_{Th} = \frac{R_2 V_{CC}}{R_1 + R_2} = \frac{(3.9\ \text{k}\Omega)(22\ \text{V})}{39\ \text{k}\Omega + 3.9\ \text{k}\Omega} = 2\ \text{V}$$

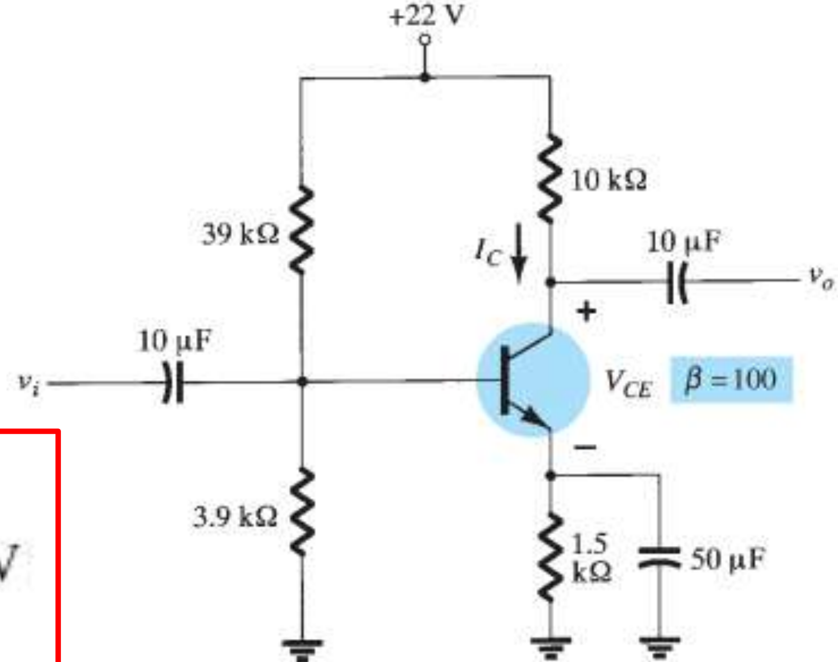
$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E} = \frac{2\ \text{V} - 0.7\ \text{V}}{3.55\ \text{k}\Omega + (101)(1.5\ \text{k}\Omega)} = \frac{1.3\ \text{V}}{3.55\ \text{k}\Omega + 151.5\ \text{k}\Omega} = 8.38\ \mu\text{A}$$

$$I_C = \beta I_B = (100)(8.38\ \mu\text{A}) = \mathbf{0.84\ mA}$$

$$V_{CE} = V_{CC} - I_C(R_C + R_E) = 22\ \text{V} - (0.84\ \text{mA})(10\ \text{k}\Omega + 1.5\ \text{k}\Omega) = 22\ \text{V} - 9.66\ \text{V} = \mathbf{12.34\ V}$$

Approximate Analysis | **Voltage-divider Bias** | Exact Analysis

EXAMPLE 4.9 Repeat the analysis of Fig. 4.35 using the approximate technique, and compare solutions for I_{C_Q} and V_{CE_Q}.



Solution: Testing:

$$\beta R_E \geq 10R_2$$

$$(100)(1.5\text{ k}\Omega) \geq 10(3.9\text{ k}\Omega)$$

$$150\text{ k}\Omega \geq 39\text{ k}\Omega \ (\textit{satisfied})$$

$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2} = \frac{(3.9\text{ k}\Omega)(22\text{ V})}{39\text{ k}\Omega + 3.9\text{ k}\Omega} = 2\text{ V}$$

$$V_E = V_B - V_{BE} = 2\text{ V} - 0.7\text{ V} = 1.3\text{ V}$$

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

$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E) = 22\text{ V} - (0.867\text{ mA})(10\text{ kV} + 1.5\text{ k}\Omega) = 22\text{ V} - 9.97\text{ V} = \mathbf{12.03\text{ V}}$$

The results for I_{C_Q} and V_{CE_Q} are certainly close,

The larger the level of Ri compared to R2 , the closer is the approximate to the exact

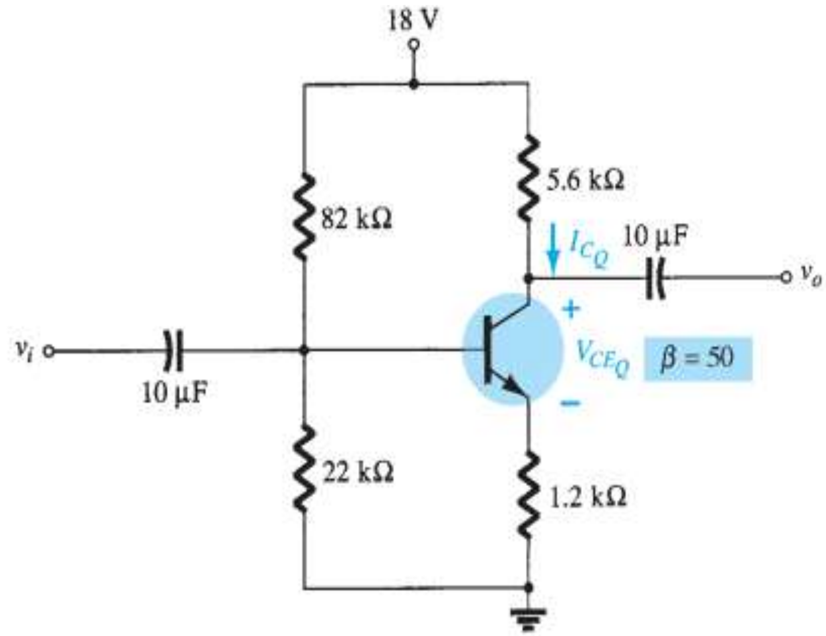
Approximate Analysis | **Voltage-divider Bias** | Exact Analysis

The larger the level of Ri compared to R2 ,
the closer is the approximate to the exact

$$\beta R_E \geq 10R_2$$
$$(50)(1.2\text{ k}\Omega) \geq 10(22\text{ k}\Omega)$$
$$60\text{ k}\Omega \ngeq 220\text{ k}\Omega\ (\textit{not satisfied})$$

Comparing the exact and approximate approaches.

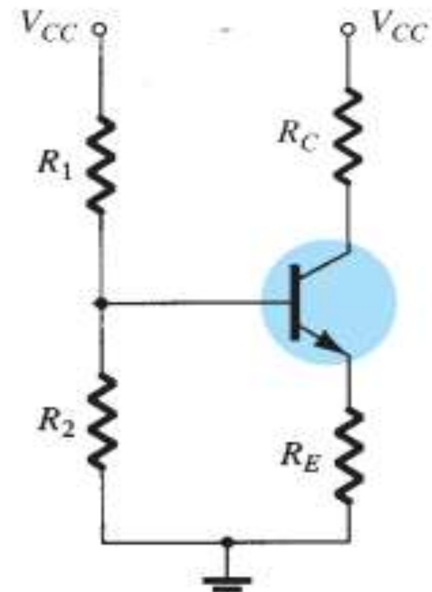
	I_{C_Q} (mA)	V_{CE_Q} (V)
Exact	1.98	4.54
Approximate	2.59	3.88



- ✓ The results reveal the difference between exact and approximate solutions.
- ✓ ICQ is about 30% greater with the approximate solution,
- ✓ VCEQ is about 10% less.

Voltage-divider Bias

Load-Line Analysis



- From the collector–emitter loop appears in Fig.

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

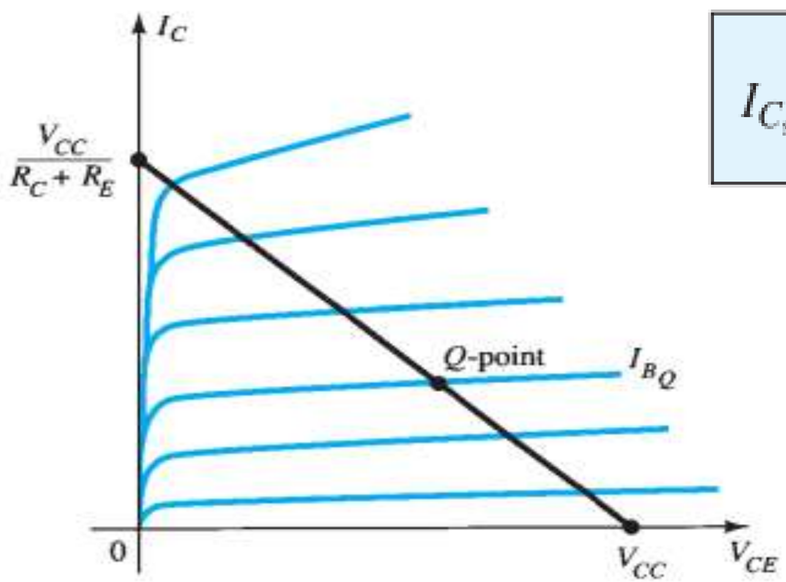
Substituting $I_E \cong I_C$ and grouping terms gives

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

and

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

- The addition of the emitter resistor reduces the collector saturation level



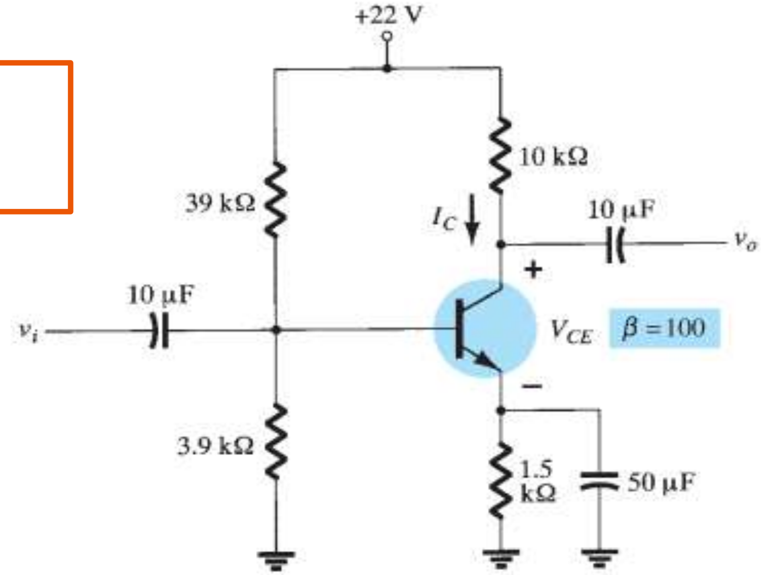
$$I_{C_{sat}} = \frac{V_{CC}}{R_C + R_E}$$

Voltage-divider Bias

β_{DC} effect (Stability)

EXAMPLE 4.10 Repeat the exact analysis of Example 4.8 if β is reduced to 50, and compare solutions for I_{C_Q} and V_{CE_Q}.

This example is for testing how much the Q-point will move if the level of β_{DC} is cut in half



$R_{Th} = 3.55\ k\Omega, \qquad E_{Th} = 2\ V$

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E} = \frac{2\ V - 0.7\ V}{3.55\ k\Omega + (51)(1.5\ k\Omega)} = \frac{1.3\ V}{3.55\ k\Omega + 76.5\ k\Omega} = 16.24\ \mu A$$

$$I_{C_Q} = \beta I_B = (50)(16.24\ \mu A) = \mathbf{0.81\ mA}$$

$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E) = 22\ V - (0.81\ mA)(10\ k\Omega + 1.5\ k\Omega) = \mathbf{12.69\ V}$$

Effect of β variation on the response of the voltage-divider configuration of Fig. 4.35.

β	I_{C_Q} (mA)	V_{CE_Q} (V)
100	0.84 mA	12.34 V
50	0.81 mA	12.69 V

- The results show the relative insensitivity of the circuit to the change in β_{DC} .
- Even though β_{DC} is drastically cut in half, the levels of I_{CQ} and V_{CEQ} are essentially the same.

5–3 OTHER BIAS METHODS

- four additional methods for dc biasing a transistor circuit are discussed.
- These methods are not as common as voltage-divider because of the stability

- The more stable a configuration, the less its response will change due to undesireable changes in temperature and parameter variations

- If the Q-point is highly dependent on BDC of the transistor, the configuration is not stable.
- BDC is temperature sensitive, especially for silicon transistors, and its actual value is usually not well-defined,

1. Base Bias
2. Emitter-Feedback Bias
3. Emitter Bias
4. Collector-Feedback Bias

- Common Assumptions that could be used for simplification (if needed):

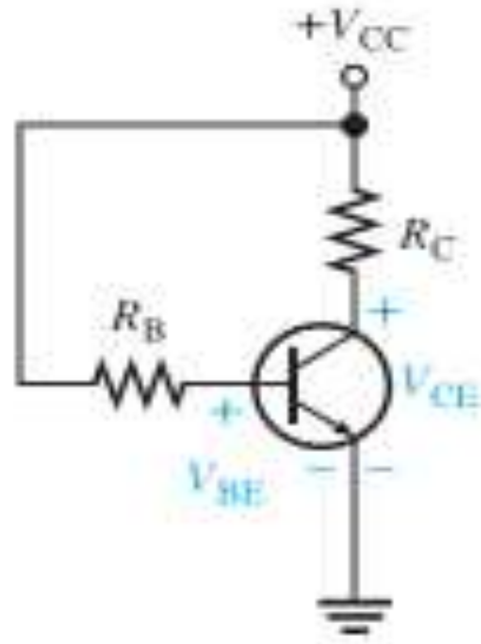
$$V_{BE} \cong 0.7\text{ V}$$

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

$$I_C = \beta I_B$$

5–3 OTHER BIAS METHODS

1. Base Bias (Fixed Bias)



- This method of biasing is common in switching circuits.
- The analysis of this circuit for the linear region shows that it is directly dependent on B_{DC}

➢ The Kirchhoff's voltage law around the base circuit:

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

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

Then solving for I_B,

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

➢ The Kirchhoff's voltage law around the collector circuit:

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

Substituting the expression for I_B into the formula $I_C = \beta_{DC} I_B$ yields

$$I_C = \beta_{DC}\left(\frac{V_{CC} - V_{BE}}{R_B}\right)$$

Solving for V_{CE},

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

5–3 Other Bias Methods

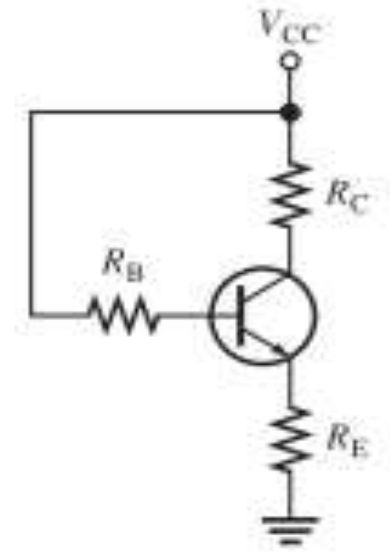
1. Base Bias

Q-Point Stability of Base Bias

- ✓ Since I_C is dependent on B_{DC}
- ✓ That a variation in B_{DC} causes I_C and, V_{CE} to change, thus changing the Q-point of the transistor.
- ✓ This makes the base bias circuit extremely beta-dependent and unpredictable.

- ❖ B_{DC} varies with temperature and from one transistor to another of the same type due to manufacturing variations.
- ❖ For these reasons, base bias is rarely used in linear circuits

2. Emitter-Feedback Bias



- ✓ If an emitter resistor is added to the base-bias, the result is emitter-feedback bias
- ✓ The idea is to help make base bias more predictable with **negative feedback** (negates any attempted change in collector current with an opposing change in base voltage).

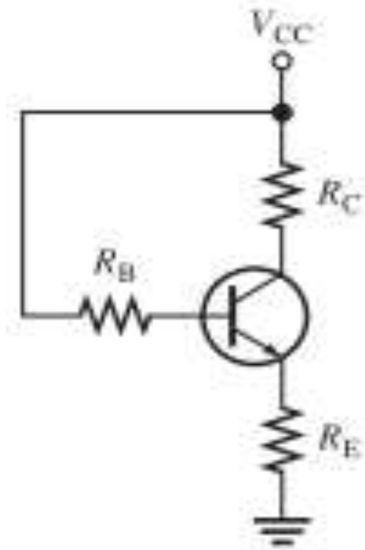
- ❖ If the I_C tries to increase, V_E increases, causing an increase in V_B because:

$$V_B = V_E + V_{BE}.$$

- ❖ This increase in V_B reduces the voltage across R_B, thus reducing I_B and keeping I_C from increasing.
- ❖ A similar action occurs if the collector current tries to decrease.

While this is better for linear circuits than base bias, it is still dependent on B_{DC} and is not as predictable as voltage-divider bias.

2. Emitter-Feedback Bias



- ✓ Calculating the emitter current:

write Kirchhoff's voltage law (KVL) around the base circuit.

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

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

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

Grouping terms then provides the following:

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

solving for I_B gives

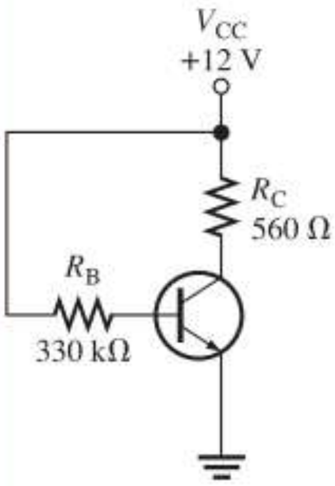
$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E}$$

- ✓ The emitter current can be approximated by : $I_E = B\ I_B$

$$I_E = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{DC}}$$

Stability Comparison between Emitter-Feedback Bias and Base Bias

EXAMPLE 5–8 Determine how much the Q-point (I_C, V_{CE}) for the circuit in Figure 5–20 will change over a temperature range where β_{DC} increases from 100 to 200.



For $\beta_{DC} = 100$,

$$I_{C(1)} = \beta_{DC}\left(\frac{V_{CC} - V_{BE}}{R_B}\right) = 100\left(\frac{12\text{ V} - 0.7\text{ V}}{330\text{ k}\Omega}\right) = 3.42\text{ mA}$$

$$V_{CE(1)} = V_{CC} - I_{C(1)}R_C = 12\text{ V} - (3.42\text{ mA})(560\ \Omega) = 10.1\text{ V}$$

For $\beta_{DC} = 200$,

$$I_{C(2)} = \beta_{DC}\left(\frac{V_{CC} - V_{BE}}{R_B}\right) = 200\left(\frac{12\text{ V} - 0.7\text{ V}}{330\text{ k}\Omega}\right) = 6.84\text{ mA}$$

$$V_{CE(2)} = V_{CC} - I_{C(2)}R_C = 12\text{ V} - (6.84\text{ mA})(560\ \Omega) = 8.17\text{ V}$$

The percent change in I_C as β_{DC} changes from 100 to 200 is

$$\%\Delta I_C = \left(\frac{I_{C(2)} - I_{C(1)}}{I_{C(1)}}\right)100\%$$

$$= \left(\frac{6.84\text{ mA} - 3.42\text{ mA}}{3.42\text{ mA}}\right)100\% = \mathbf{100\%}\text{ (an increase)}$$

The percent change in V_{CE} is

$$\%\Delta V_{CE} = \left(\frac{V_{CE(2)} - V_{CE(1)}}{V_{CE(1)}}\right)100\%$$

$$= \left(\frac{8.17\text{ V} - 10.1\text{ V}}{10.1\text{ V}}\right)100\% = \mathbf{-19.1\%}\text{ (a decrease)}$$

Stability Comparison between Emitter-Feedback Bias and Base Bias

- As you can see, the Q-point is very dependent on in this (very unreliable).
- The base bias is not normally used if linear operation is required.
- However, it can be used in switching applications.

EXAMPLE 5–9

Determine how **much the Q-point will change** if the same circuit is used but converted to emitter-feedback bias with R_E = 1000 ohms

For $\beta_{DC} = 100$,

$$I_{C(1)} = I_E = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{DC}} = \frac{12\text{ V} - 0.7\text{ V}}{1\text{ k}\Omega + 330\text{ k}\Omega/100} = 2.63\text{ mA}$$

$$V_{CE(1)} = V_{CC} - I_{C(1)}(R_C + R_E) = 12\text{ V} - (2.63\text{ mA})(560\ \Omega + 1\text{ k}\Omega) = 7.90\text{ V}$$

For $\beta_{DC} = 200$,

$$I_{C(2)} = I_E = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{DC}} = \frac{12\text{ V} - 0.7\text{ V}}{1\text{ k}\Omega + 330\text{ k}\Omega/200} = 4.26\text{ mA}$$

$$V_{CE(2)} = V_{CC} - I_{C(2)}(R_C + R_E) = 12\text{ V} - (4.26\text{ mA})(560\ \Omega + 1\text{ k}\Omega) = 5.35\text{ V}$$

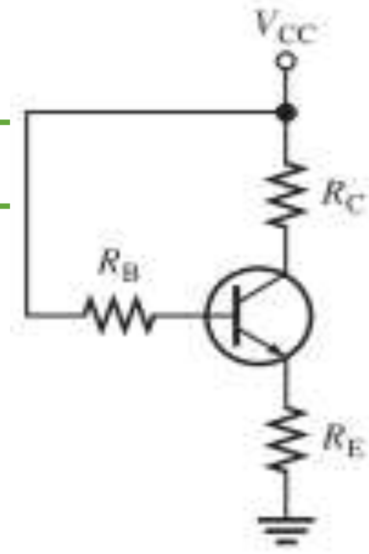
The percent change in I_C is

$$\%\Delta I_C = \left(\frac{I_{C(2)} - I_{C(1)}}{I_{C(1)}}\right)100\% = \left(\frac{4.26\text{ mA} - 2.63\text{ mA}}{2.63\text{ mA}}\right)100\% = \mathbf{62.0\%}$$

$$\%\Delta V_{CE} = \left(\frac{V_{CE(2)} - V_{CE(1)}}{V_{CE(1)}}\right)100\% = \left(\frac{7.90\text{ V} - 5.35\text{ V}}{7.90\text{ V}}\right)100\% = \mathbf{-32.3\%}$$

- **Although it significantly improved the stability of the bias for a change in B_{DC} compared to base bias, it still does not provide a reliable Q-point.**

2. Emitter-Feedback Bias



✓ Load Line equation: (Output loop similar to voltage-divider bias)

➢ From the collector–emitter loop appears in Fig.

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

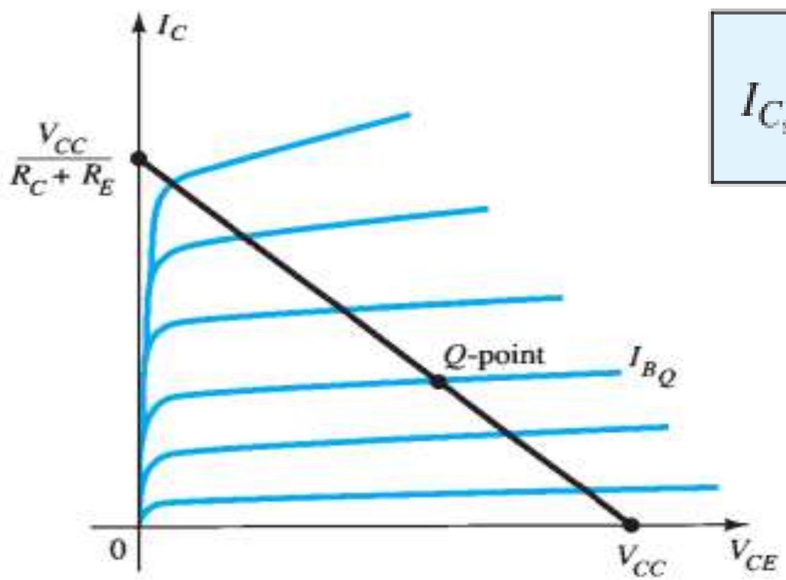
Substituting $I_E \cong I_C$ and grouping terms gives

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

and

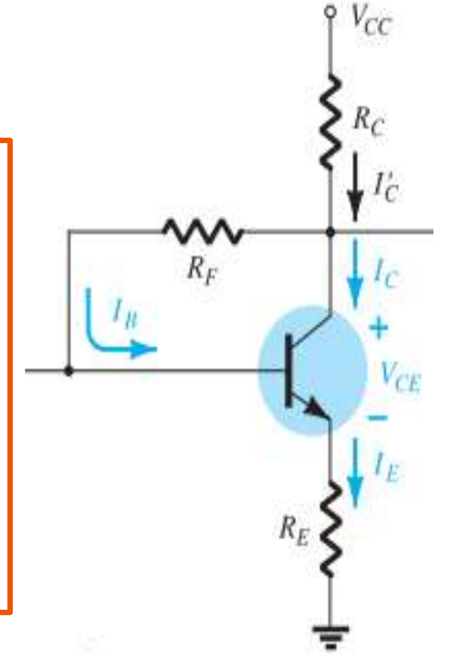
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

➢ The addition of the emitter resistor reduces the collector saturation level



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

3. Collector-Feedback Bias



- ✓ The collector voltage provides the bias for the B-E junction.
- ✓ The negative feedback creates an "offsetting" effect that tends to keep the Q-point stable.
- ✓ Although the Q -point is not totally independent of beta (even under approximate conditions), the sensitivity to changes in beta or temperature variations is normally less than encountered in other three types

➢ Base–Emitter Loop

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

$$I'_C = I_C + I_B$$

However, the level of Ic and Ic′ far exceeds the usual level of IB

$$I'_C \cong I_C$$

Substituting $I'_C \cong I_C = \beta I_B$ $\qquad I_E \cong I_C$

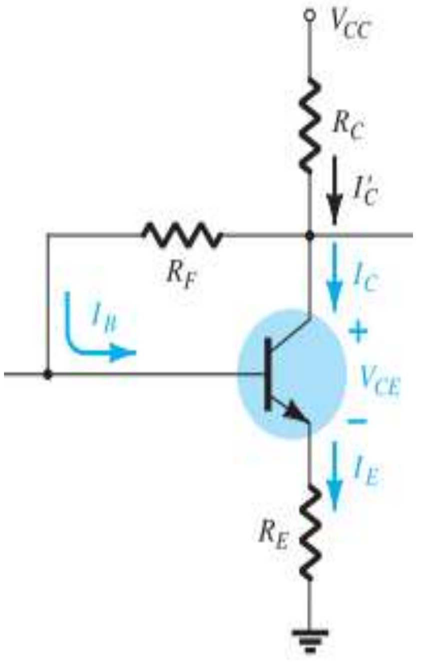
The new equation is : $V_{CC} - \beta I_B R_C - I_B R_F - V_{BE} - \beta I_B R_E = 0$

Gathering terms, we have $V_{CC} - V_{BE} - \beta I_B (R_C + R_E) - I_B R_F = 0$

and solving for I_B yields

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

3. Collector-Feedback Bias



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

This can be written as:

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

Because $I_C = \beta I_B$,

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

In general, the larger R' is compared with $\frac{R_F}{\beta}$, the more accurate the approximation that

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

- ✓ The result is an equation absent of BDC, which would be very stable for variations in BDC.

3. Collector-Feedback Bias

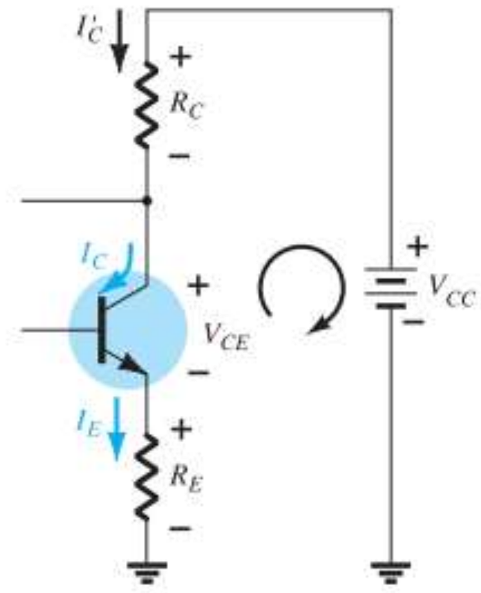
Output Loop Equation

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

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

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

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



Other Biasing :

EMITTER-FOLLOWER CONFIGURATION

COMMON-BASE CONFIGURATION

4.11 DESIGN OPERATIONS

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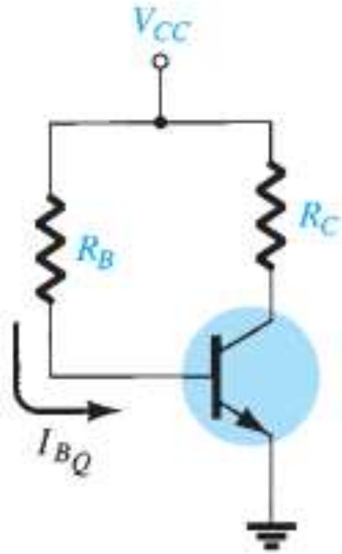
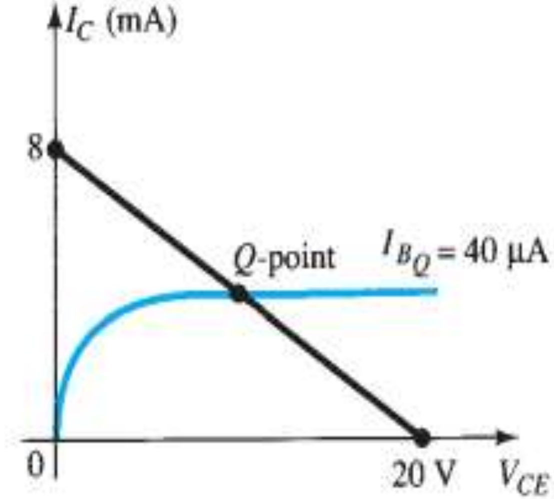
- The design process is one where a current and/or voltage may be specified and the elements required to establish the designated levels must be determined.
- The path toward a solution is less defined and in fact may require a number of basic assumptions that do not have to be made when simply analyzing a network.

- ✓ If the transistor and supplies are specified, the design process will simply determine the required resistors for a particular design.
- ✓ Once the theoretical values of the resistors are determined, the nearest standard commercial values are normally chosen and any variations due to not using the exact resistance values are accepted as part of the design.
- ✓ This is certainly a valid approximation considering the tolerances normally associated with resistive elements and the transistor parameters.

EXAMPLE 4.21 Given the device characteristics of Fig. 4.59a, determine V_{CC}, R_B, and R_C for the fixed-bias configuration of Fig. 4.59b.

Base Bias (Fixed Bias)





Solution: From the load line

$$V_{CC} = \mathbf{20\ V}$$

$$I_C = \left.\frac{V_{CC}}{R_C}\right|_{V_{CE}=0\,V}$$

$$R_C = \frac{V_{CC}}{I_C} = \frac{20\ V}{8\ mA} = \mathbf{2.5\ k\Omega}$$

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

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

$$= \frac{20\ V - 0.7\ V}{40\ \mu A} = \frac{19.3\ V}{40\ \mu A}$$

$$= \mathbf{482.5\ k\Omega}$$

Standard resistor values are

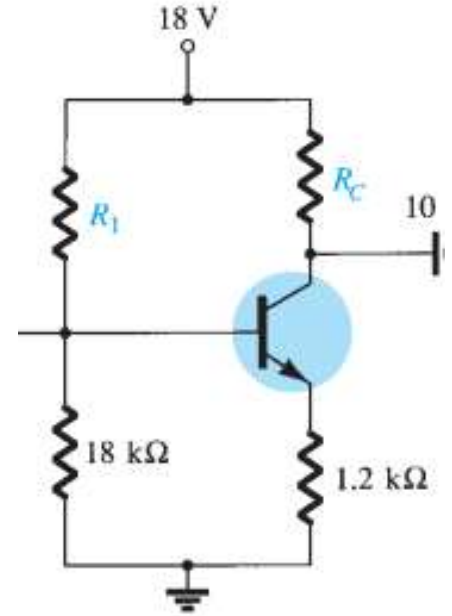
$$R_C = 2.4\ k\Omega$$
$$R_B = 470\ k\Omega$$

Using standard resistor values gives

$$I_B = 41.1\ \mu A$$

which is well within 5% of the value specified.

EXAMPLE 4.22 Given that $I_{C_Q} = 2\text{ mA}$ and $V_{CE_Q} = 10\text{ V}$, determine R_1 and R_C for the network of Fig. 4.60.



Solution:

$$V_E = I_E R_E \cong I_C R_E$$
$$= (2\text{ mA})(1.2\text{ k}\Omega) = 2.4\text{ V}$$
$$V_B = V_{BE} + V_E = 0.7\text{ V} + 2.4\text{ V} = 3.1\text{ V}$$
$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2} = 3.1\text{ V}$$
$$\frac{(18\text{ k}\Omega)(18\text{ V})}{R_1 + 18\text{ k}\Omega} = 3.1\text{ V}$$
$$324\text{ k}\Omega = 3.1R_1 + 55.8\text{ k}\Omega$$
$$3.1R_1 = 268.2\text{ k}\Omega$$
$$R_1 = \frac{268.2\text{ k}\Omega}{3.1} = \mathbf{86.52\text{ k}\Omega}$$
$$R_C = \frac{V_{R_C}}{I_C} = \frac{V_{CC} - V_C}{I_C}$$
$$V_C = V_{CE} + V_E = 10\text{ V} + 2.4\text{ V} = 12.4\text{ V}$$

$$R_C = \frac{18\text{ V} - 12.4\text{ V}}{2\text{ mA}} = \mathbf{2.8\text{ k}\Omega}$$

- The nearest standard commercial values to R1 are 82 k and 91 k .
- However, using the series combination of standard values of 82 k and 4.7 k = 86.7 k would result in a value very close to the design level.

Design Technique to obtain a given specification (operating point)

1. The **supply voltage** and **operating point** were selected from the manufacturer's information on the transistor used in the amplifier.

- ✓ The selection of collector and emitter resistors cannot proceed directly from the information just specified (two unknown quantities (R_C and R_E)]
- ✓ R_E cannot be unreasonably large because the voltage across it limits the range of swing of the voltage V_{CE}
- ✓ The examples examined in this chapter reveal that the voltage from emitter to ground is typically around (1/4) to (1/10) of the supply voltage.

2. Selecting the conservative case (1/10)

emitter-bias

$$V_E = \frac{1}{10}V_{CC} = \frac{1}{10}(20\text{ V}) = 2\text{ V}$$

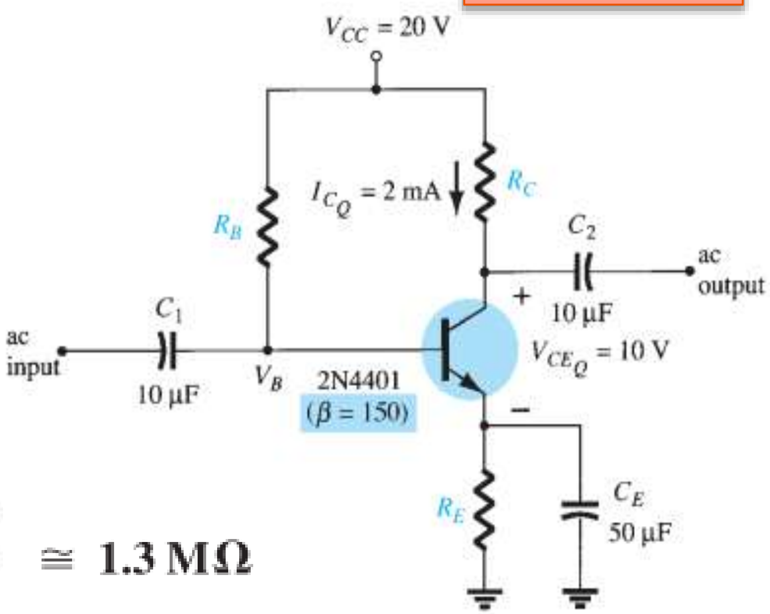
$$R_E = \frac{V_E}{I_E} \cong \frac{V_E}{I_C} = \frac{2\text{ V}}{2\text{ mA}} = 1\text{ k}\Omega$$

$$R_C = \frac{V_{R_C}}{I_C} = \frac{V_{CC} - V_{CE} - V_E}{I_C} = \frac{20\text{ V} - 10\text{ V} - 2\text{ V}}{2\text{ mA}} = \frac{8\text{ V}}{2\text{ mA}}$$

$$= 4\text{ k}\Omega$$

$$I_B = \frac{I_C}{\beta} = \frac{2\text{ mA}}{150} = 13.33\ \mu\text{A}$$

$$R_B = \frac{V_{R_B}}{I_B} = \frac{V_{CC} - V_{BE} - V_E}{I_B} = \frac{20\text{ V} - 0.7\text{ V} - 2\text{ V}}{13.33\ \mu\text{A}} \cong 1.3\text{ M}\Omega$$



Design Technique to obtain a specified operating point

Use the technique for voltage-divider bias

Design of a Current-Gain-Stabilized (Beta-Independent) Circuit

EXAMPLE 4.25 Determine the levels of R_C, R_E, R_1, and R_2 for the network of Fig. 4.63 for the operating point indicated.

$$V_E = \tfrac{1}{10}V_{CC} = \tfrac{1}{10}(20\text{ V}) = 2\text{ V}$$

$$R_E = \frac{V_E}{I_E} \cong \frac{V_E}{I_C} = \frac{2\text{ V}}{10\text{ mA}} = \mathbf{200\ \Omega}$$

$$R_C = \frac{V_{R_C}}{I_C} = \frac{V_{CC} - V_{CE} - V_E}{I_C} = \frac{20\text{ V} - 8\text{ V} - 2\text{ V}}{10\text{ mA}} = \frac{10\text{ V}}{10\text{ mA}} = \mathbf{1\ k\Omega}$$

$$V_B = V_{BE} + V_E = 0.7\text{ V} + 2\text{ V} = 2.7\text{ V}$$

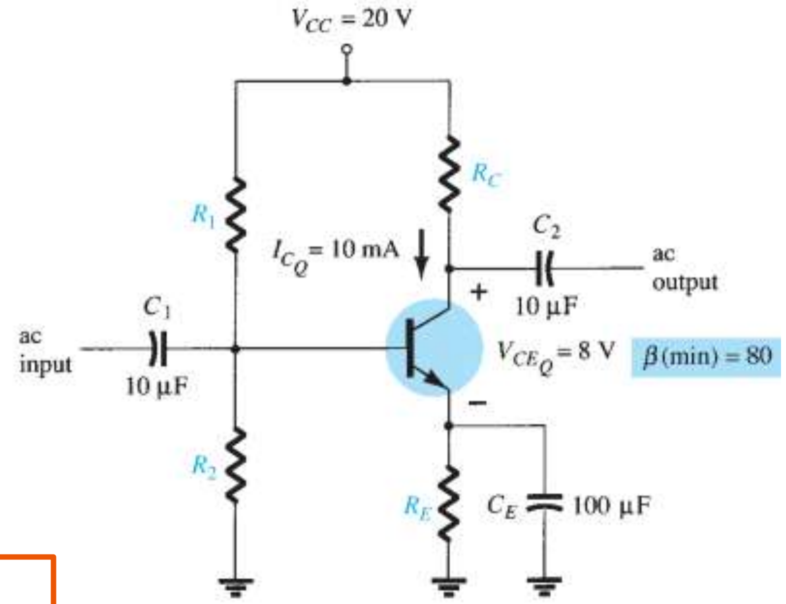


FIG. 4.63
Current-gain-stabilized circuit for design considerations.

- ✓ Assume that the current through R1 and R2 should be approximately equal to and much larger than the base current (at least 10:1).

$$R_2 \le \tfrac{1}{10}\beta R_E$$

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

$$R_2 \le \tfrac{1}{10}(80)(0.2\text{ k}\Omega) = \mathbf{1.6\ k\Omega}$$

$$V_B = 2.7\text{ V} = \frac{(1.6\text{ k}\Omega)(20\text{ V})}{R_1 + 1.6\text{ k}\Omega}$$

$$2.7R_1 + 4.32\text{ k}\Omega = 32\text{ k}\Omega$$

$$2.7R_1 = 27.68\text{ k}\Omega$$

$$R_1 = \mathbf{10.25\ k\Omega} \quad (\text{use } 10\text{ k}\Omega)$$