EEC311
Electronics (2)
Lec. 1: Amplifier Characteristics and BJT Configurations

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Outline

- Course Information
- Course Contents
- Basic Concepts of Amplifiers
- BJT as an Amplifier
- BJT Biasing Circuits

Course Information

Instructor:	**Dr. Maher Abdelrasoul**
Lectures:	Sunday : 3:00-5:00
Office Hours:	Wednesday : 12:00-2:00
Teaching Assistant:	Eng. Mahmoud Badr
Credit:	100 Marks
Grading:	• Final Exam (40 Marks) • Mid Term Exam1 (30 Marks) • Mid Term Exam2 (20 Marks) • Activities (10 Marks)

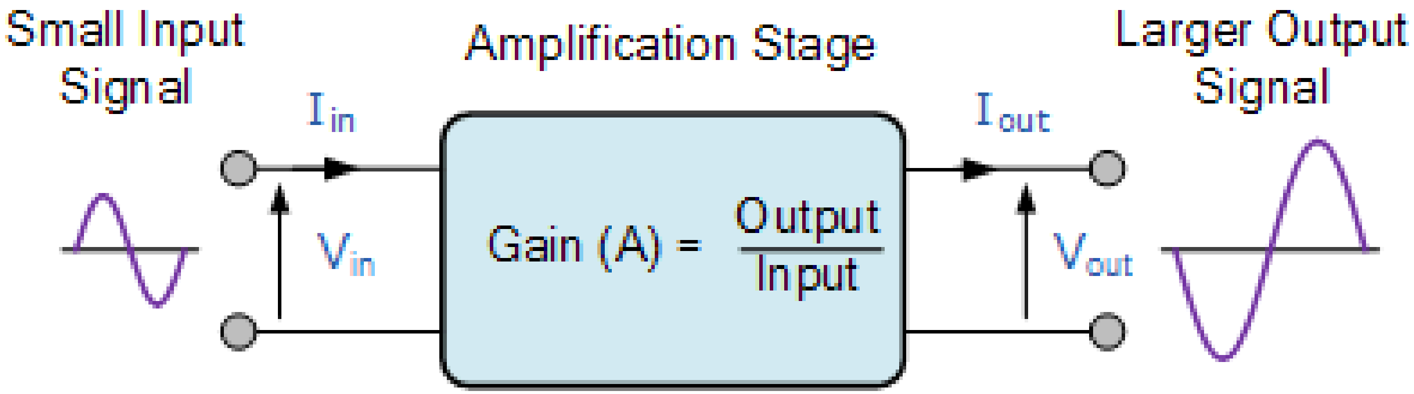
Course Content

- Electronic Amplifier Theory
- Power Amplifiers
- Differential Amplifiers
- Operational Amplifiers
- Filters and Oscillators

Basic Concepts of Amplifiers

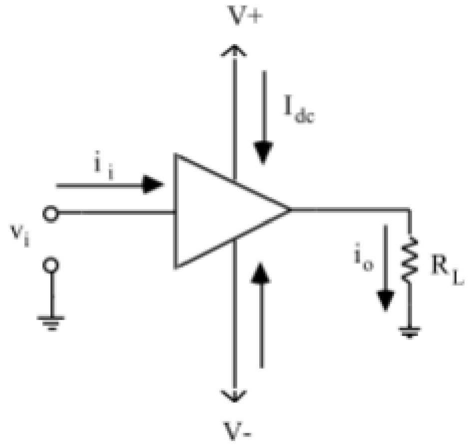
Amplifier

- An amplifier is an electronic device that can increase the power of a signal.
- The amount of amplification provided by an amplifier is measured by its gain: the ratio of output to input.



Amplifier Power Supply

- An amplifier uses electric power from a power supply to increase the amplitude of a signal.
- Most analog amplifiers use two power supply voltages or “rails”.



- Some amplifiers use only one power supply, but some times they internally split that signal voltage into two rails by making an artificial ground voltage half way from the real ground to the supply voltage

Important Characteristics of an Amplifier

- The quality of an amplifier is measured by a series of specifications called figures of merit. They are as follows:

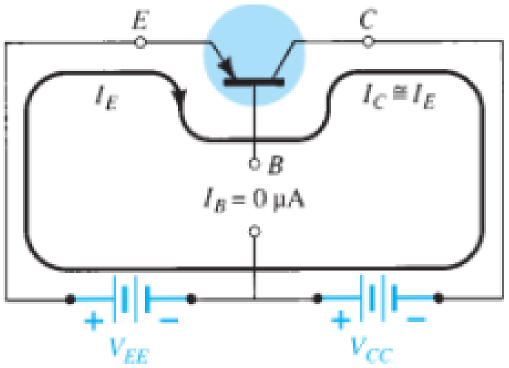
1. **Gain:** The ratio between the magnitudes of input and output signals.
2. **Input/output Impedance :** The impedance between the input/output terminals.
3. **Bandwidth:** The frequency range at which the amplifier can operate.
4. **Stability:** The ability to provide constant and reliable output.
5. **Linearity**: The degree of proportionality between input and output signals.
6. **Efficiency:** The ratio between the output power and power consumed.

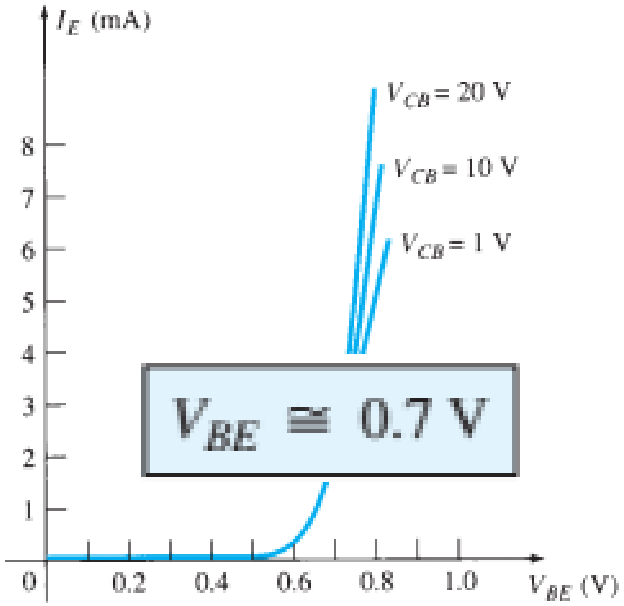
BJT as an Amplifier

Transistor Configurations

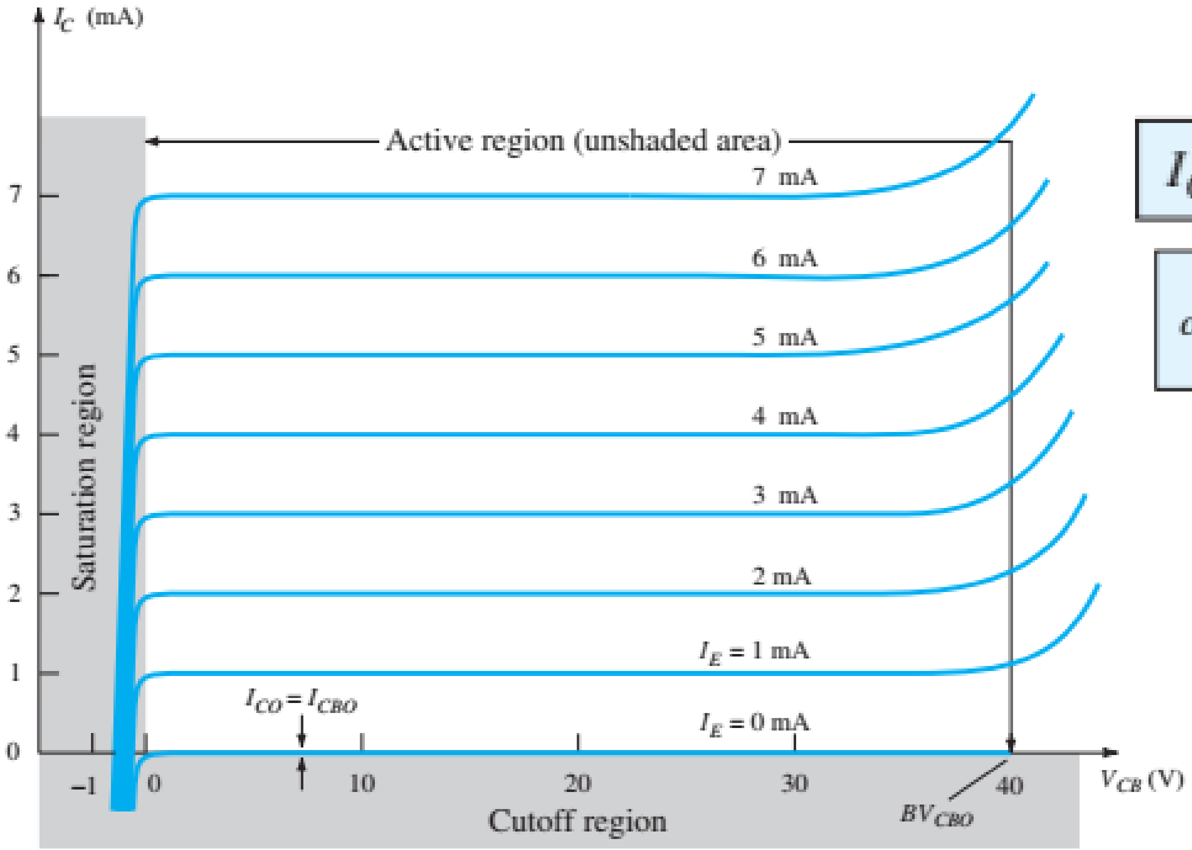
- Common-Base Configuration
- Common-Emitter Configuration
- Common-Collector Configuration

1. Common-Base Configuration





Input or driving point characteristics for a common-base silicon transistor amplifier.



Output or collector characteristics for a common-base transistor amplifier.

$$I_C = \alpha I_E + I_{CBO}$$

$$I_C \cong I_E$$

α = 0.90:0.998

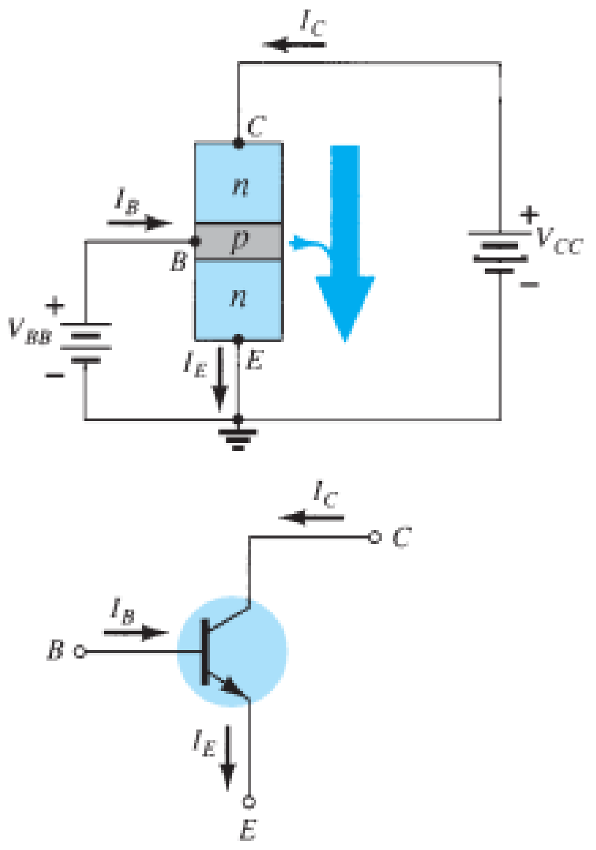
$$\alpha_{dc} = \frac{I_C}{I_E}$$

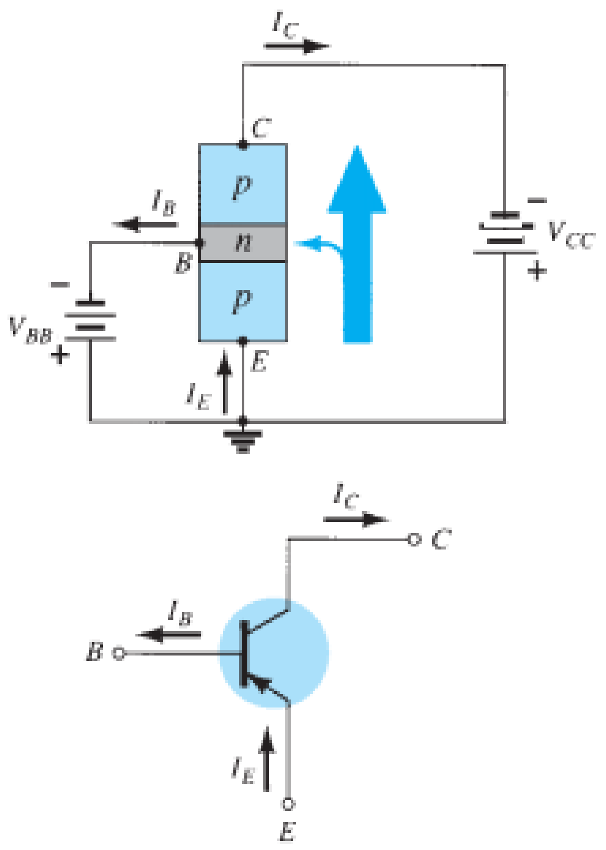
$$\alpha_{ac} = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB}=\text{constant}}$$

In the active region the base–emitter junction is forward-biased, whereas the collector–base junction is reverse-biased.

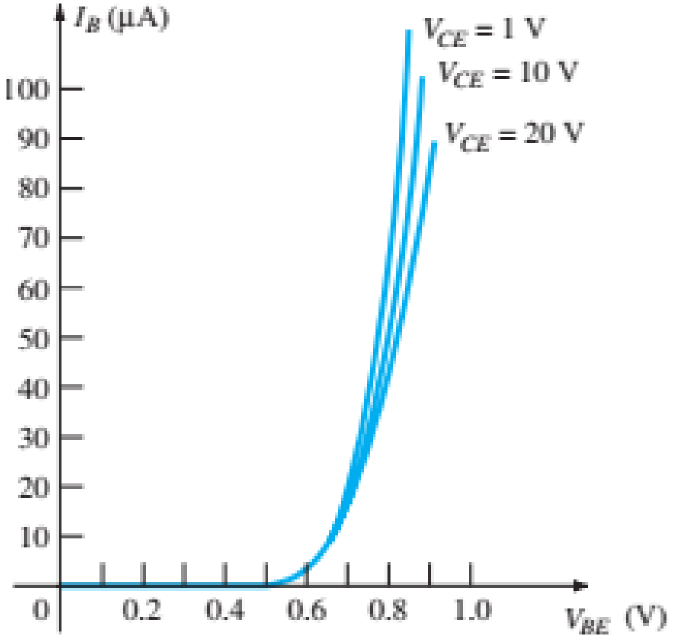
2. Common-Emitter Configuration (1)

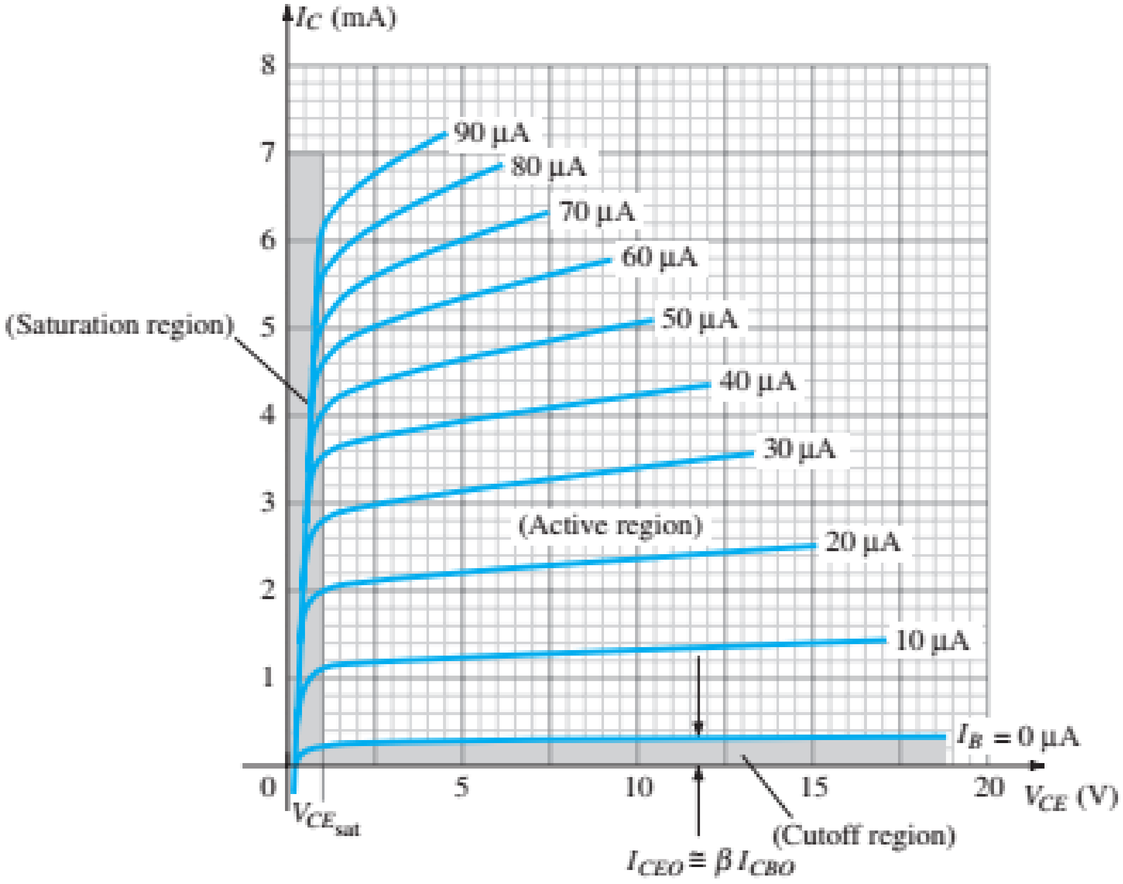
- It is called the *common-emitter configuration* because the emitter is common to bth the input and output terminals (in this case common to both the base and
  collector terminals).

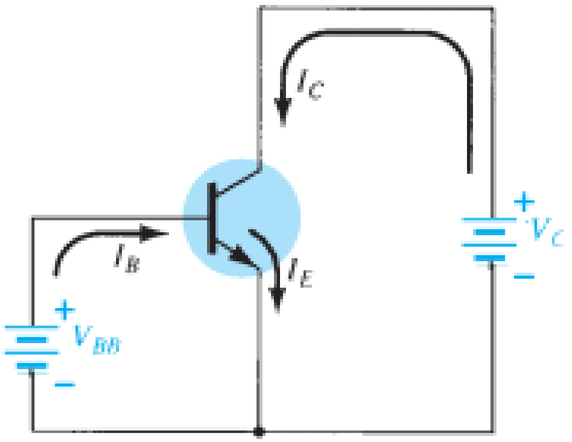




2. Common-Emitter Configuration







$$\beta_{dc} = \frac{I_C}{I_B}$$

β=50:400

$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{constant}}$$

$$\alpha = \frac{\beta}{\beta + 1}$$

$$\beta = \frac{\alpha}{1 - \alpha}$$

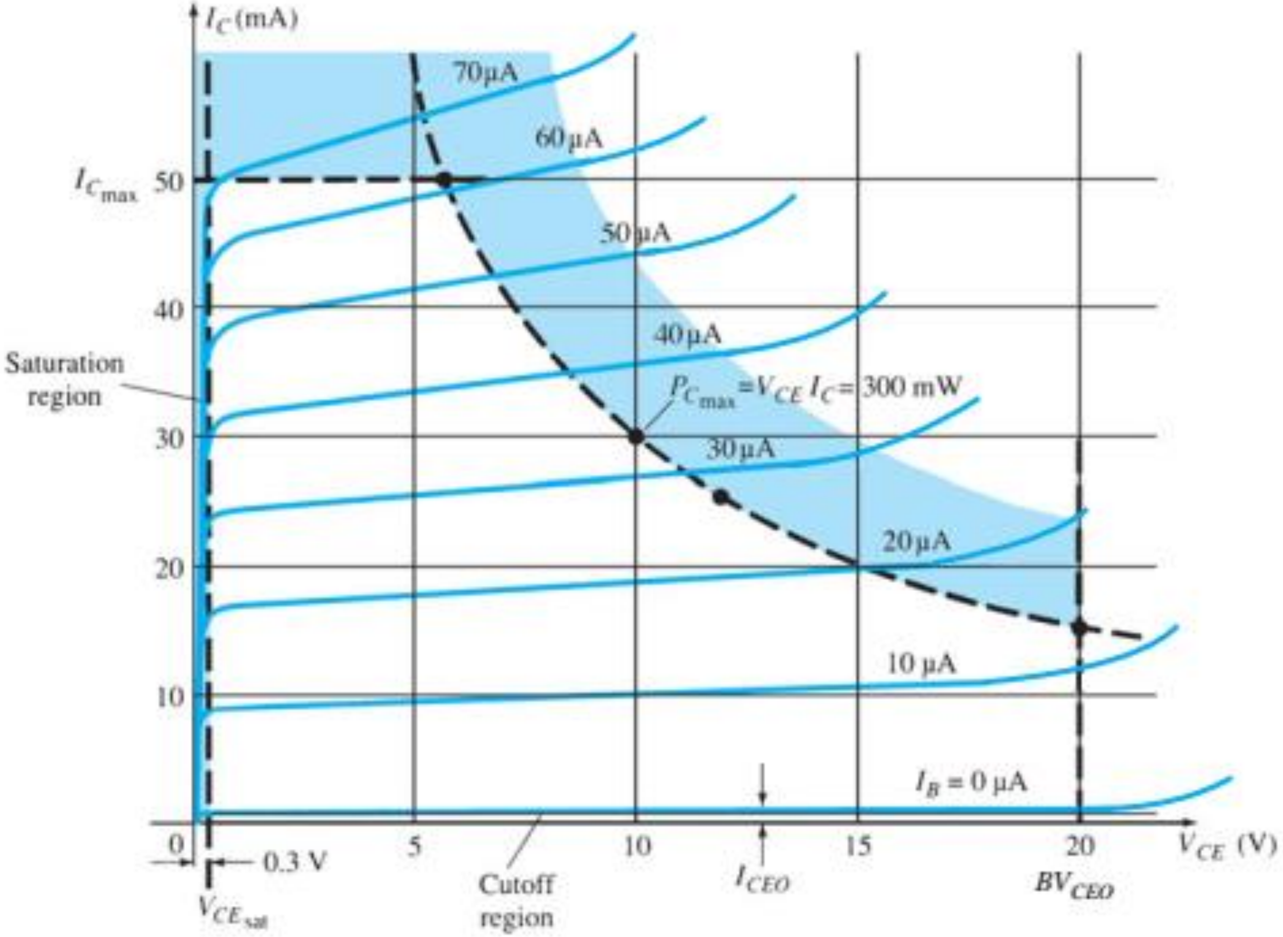
$$I_C = \beta I_B$$

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

3. Common-Collector Configuration

- Limits of operation

Defining the linear (undistorted) region of operation for a transistor



The output characteristics of the common-collector configuration are the same as for the common-emitter configuration ($I_c \approx I_E$).

$$P_{C_{max}} = V_{CE} I_C$$

$$I_{CEO} \leq I_C \leq I_{C_{max}}$$
$$V_{CE_{sat}} \leq V_{CE} \leq V_{CE_{max}}$$
$$V_{CE} I_C \leq P_{C_{max}}$$

Transistor Configuration Sheet

- Since the specification sheet is the communication link between the manufacturer and user, it is particularly important that the information provided be recognized and correctly understood.

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	30		Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40		Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	50 25	150 –	–
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	0.95	Vdc

Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	200	–

FAIRCHILD
SEMICONDUCTOR ™

2N4123

General Purpose Transistor NPN Silicon

MAXIMUM RATINGS

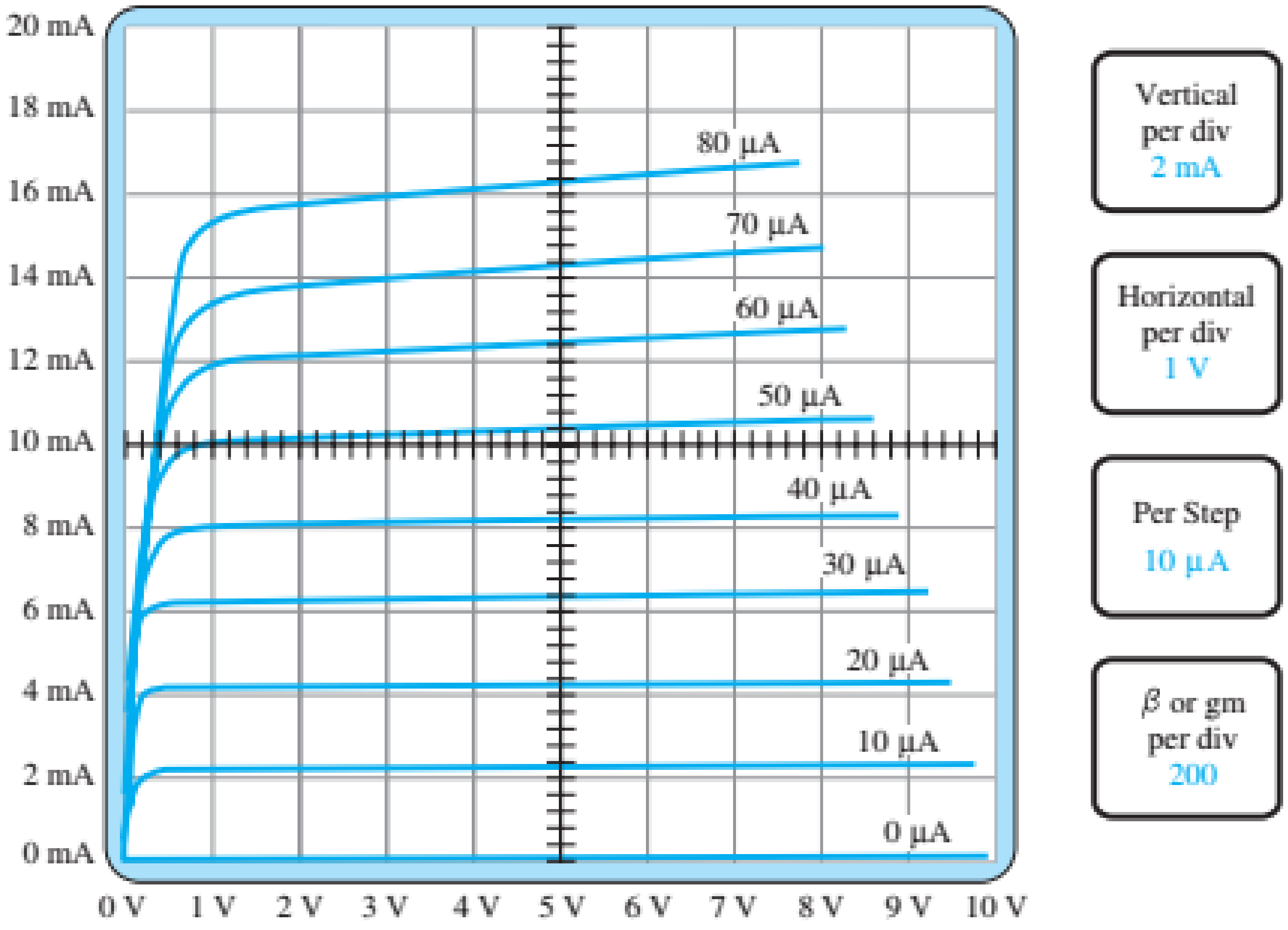
Rating	Symbol	2N4123	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_j, T_{stg}	−55 to +150	°C

Limits of Operation

$$7.5\ \mu A \leqq I_C \leqq 200\ mA$$
$$0.3\ V \leqq V_{CE} \leqq 30\ V$$
$$V_{CE} I_C \leqq 650\ mW$$

Transistor Testing

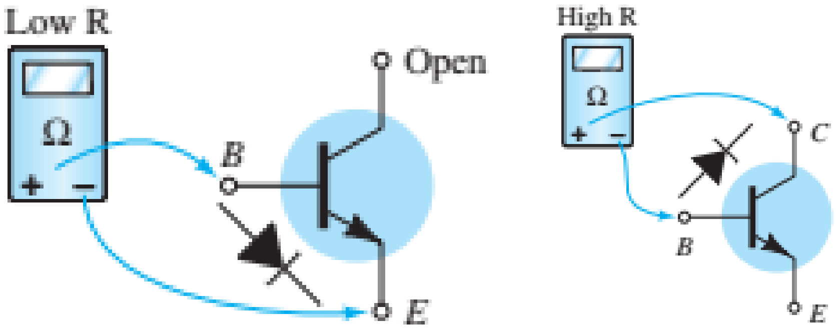
1. Curve Tracer



Curve tracer response to 2N3904 npn transistor.

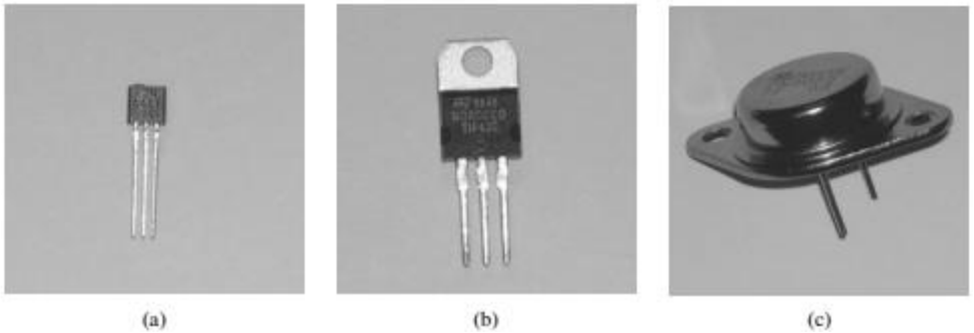
2. Transistor Testers

3. Ohmmeter



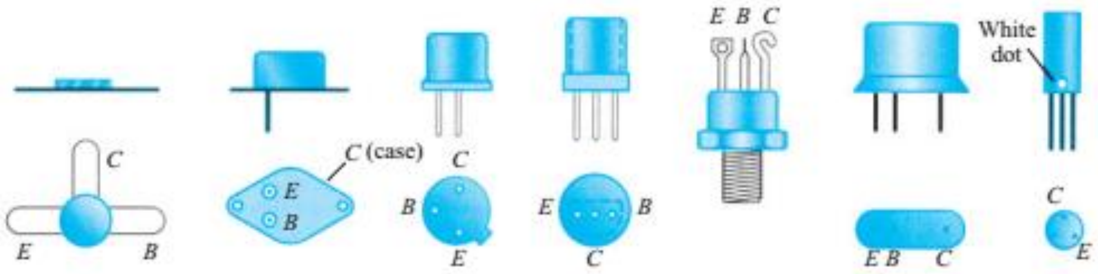
Transistor Casing and Terminal Identification

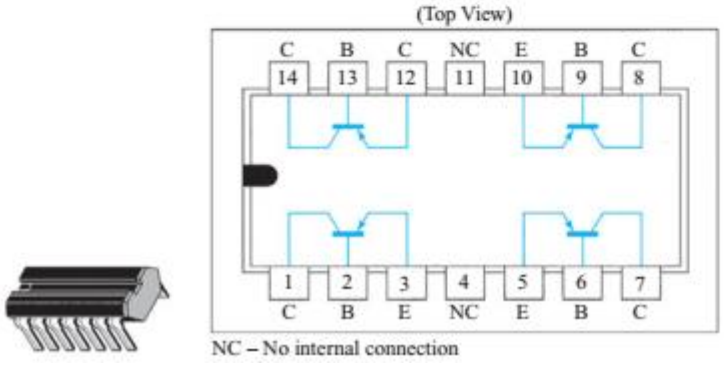
- Casing



Various types of general-purpose or switching transistors:
(a) low power; (b) medium power; (c) medium to high power.

- Terminal Identification





Type Q2T2905 Texas Instruments quad pnp silicon transistor

BJT Biasing Circuits

BJT Biasing

- Any increase in ac voltage, current, or power is the result of a transfer of energy from the applied dc supplies.
- Therefore, the analysis or design of any electronic amplifier has two components: dc and ac.
- Basic Relationships/formulas for a transistor:

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

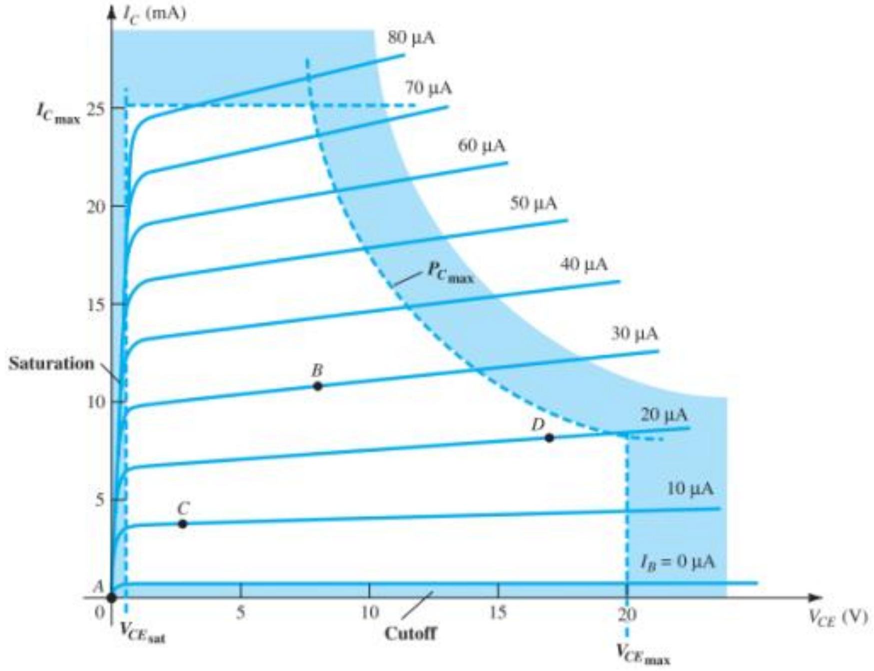
$$I_E = (\beta + 1)I_B \cong I_C$$

$$I_C = \beta I_B$$

- ***Biasing*** means applying of dc voltages to establish a fixed level of current and voltage. >>> Q-Point

Operating Point

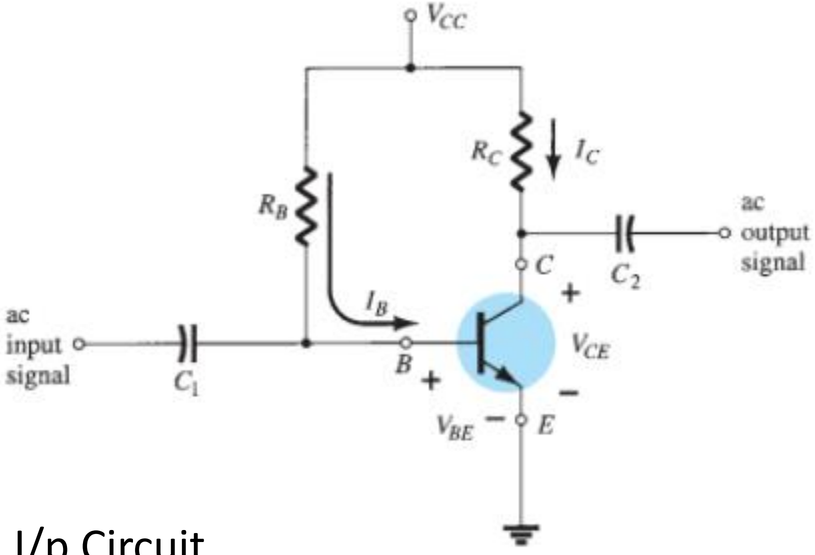
- For transistor amplifiers the resulting dc current and voltage establish an operating point on the characteristics that define the region that will be employed for amplification of the applied signal.
- Because the operating point is a fixed point on the characteristics, it is also called the quiescent point (abbreviated Q-point).
- Transistor Regions Operation:
  1. Linear-region operation:
     Base–emitter junction forward-biased
     Base–collector junction reverse-biased
  2. Cutoff-region operation:
     Base–emitter junction reverse-biased
     Base–collector junction reverse-biased
  3. Saturation-region operation:
     Base–emitter junction forward-biased
     Base–collector junction forward-biased



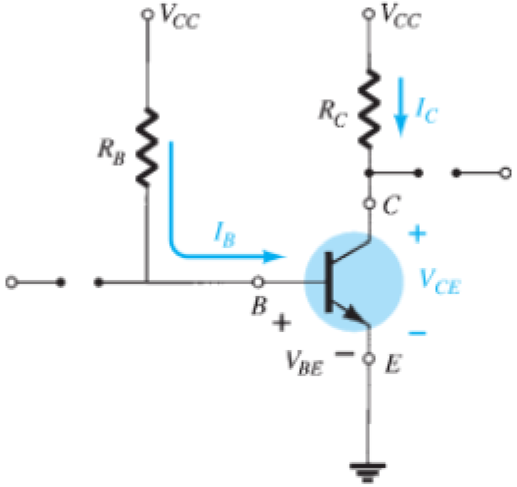
Transistor DC Bias Configurations

- Common-Collector Configurations
  - Fixed-Bias Configuration
  - Emitter-Bias Configuration
  - Voltage-Divider Bias Configuration
  - Collector Feedback Configuration
- Emitter-Follower Configuration
- Common-Base Configuration
- Miscellaneous Bias Configurations

Fixed-Bias Configuration (1 of 3)

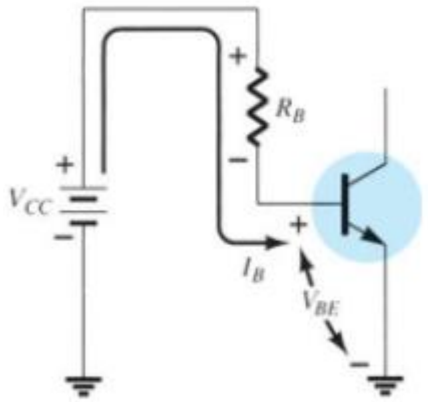


DC equivalent



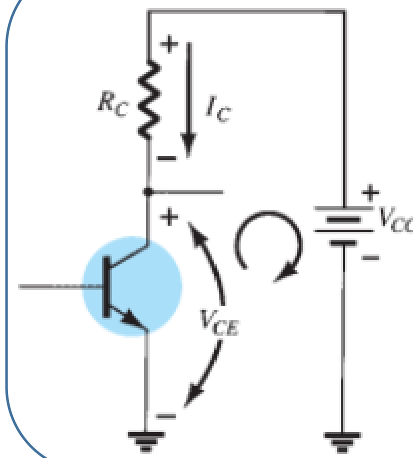
I/p Circuit

O/p Circuit



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

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



$$I_C = \beta I_B$$

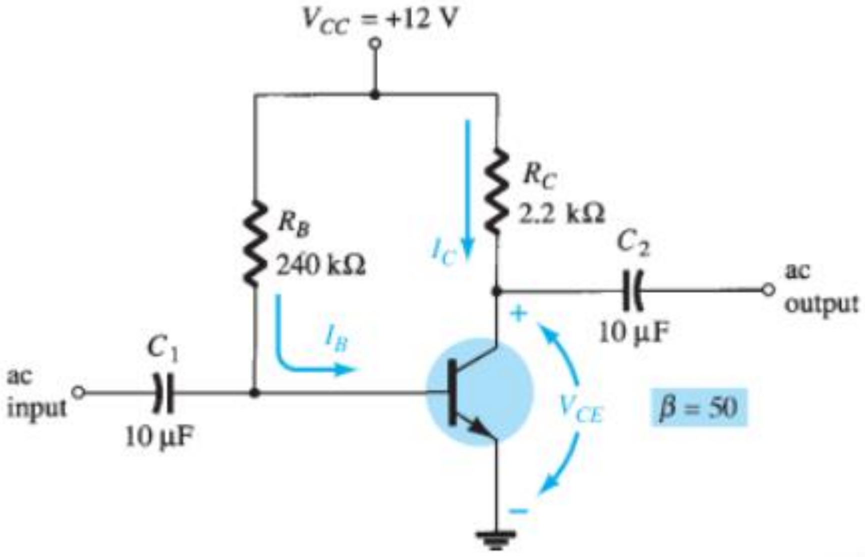
$$V_{CE} + I_C R_C - V_{CC} = 0$$

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

Fixed-Bias Configuration (2 of 3)

EXAMPLE 4.1 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}.



Solution:

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

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

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

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

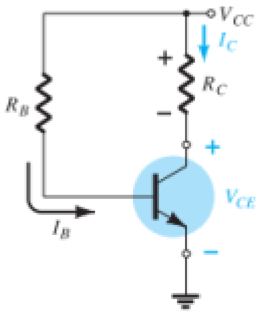
Using double-subscript notation yields

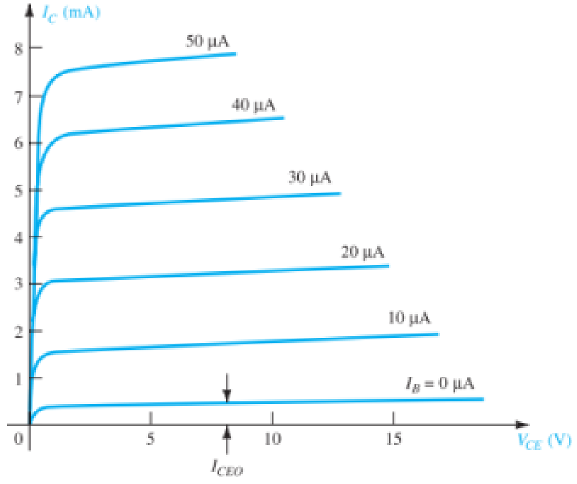
$$\begin{aligned} V_{BC} &= V_B - V_C = 0.7\text{ V} - 6.83\text{ V} \\ &= \mathbf{-6.13\ V} \end{aligned}$$

with the negative sign revealing that the junction is reversed-biased, as it should be for linear amplification.

Fixed-Bias Configuration (3 of 3)

- **Load Line Analysis**

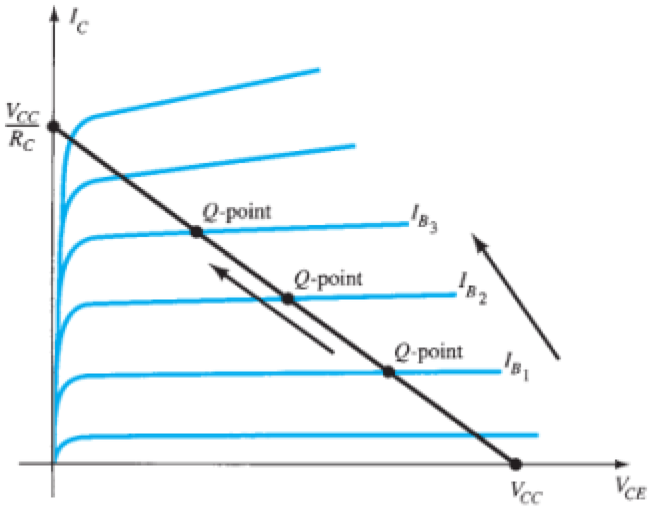




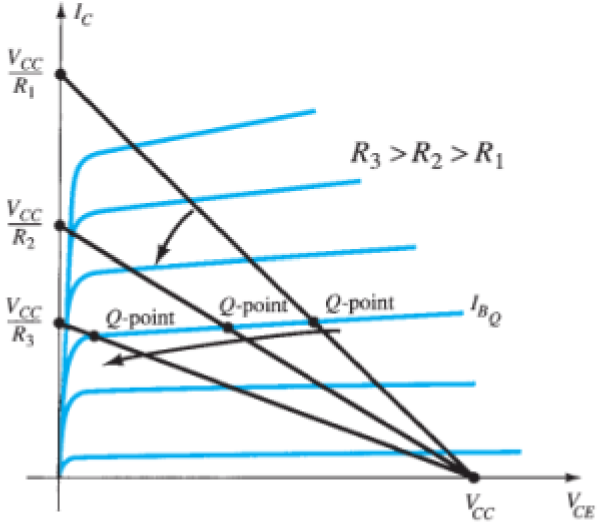
$$V_{CE} = V_{CC} - I_C R_C$$

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

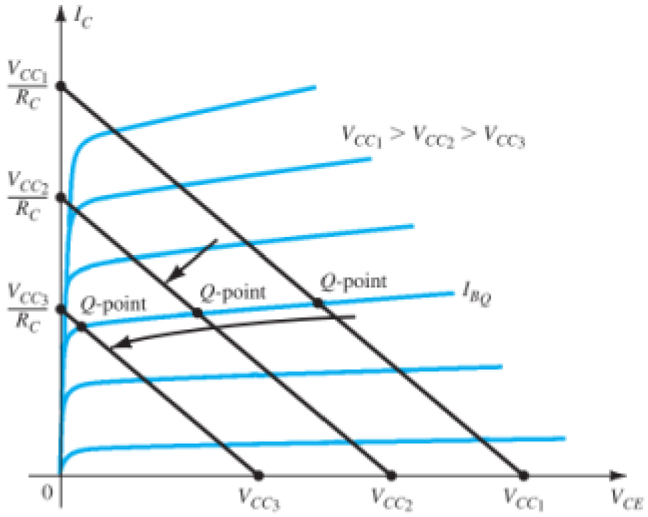
$$I_C = \frac{V_{CC}}{R_C}\bigg|_{V_{CE} = 0\,\text{V}}$$



Movement of the Q-point with increasing level of I_B.

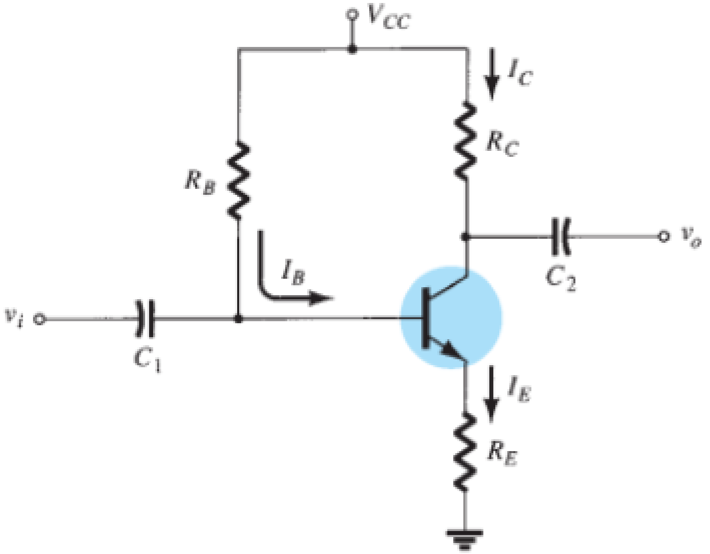


Effect of an increasing level of R_C on the load line and the Q-point.

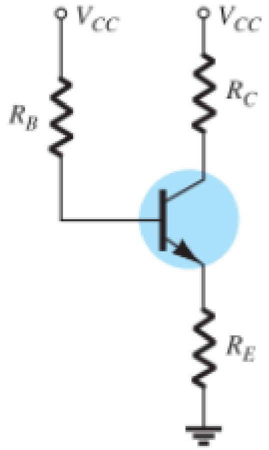


Effect of lower values of V_{CC} on the load line and the Q-point.

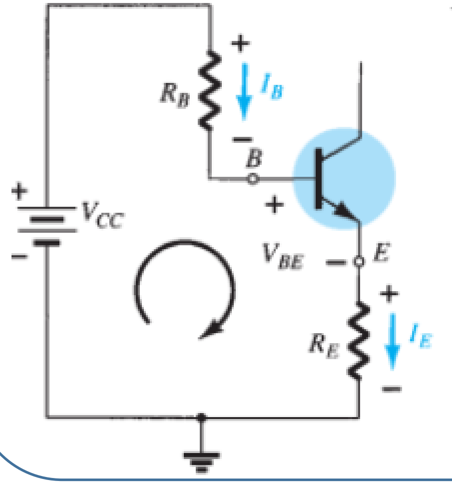
Emitter-Bias Configuration (1 of 3)



DC equivalent



I/p Circuit



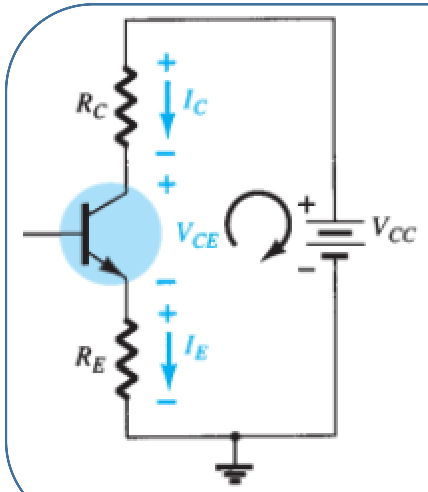
$$+V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0$$

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

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

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

O/p Circuit



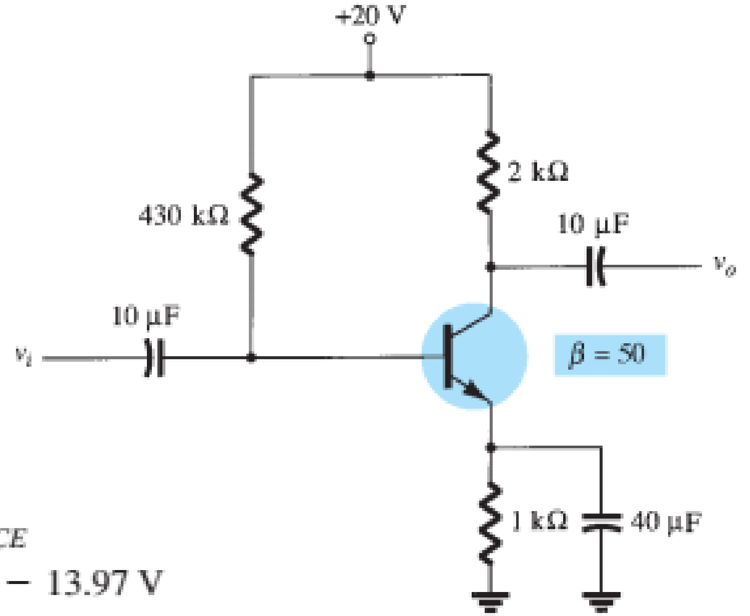
$$+I_E R_E + V_{CE} + I_C R_C - V_{CC} = 0$$

$$I_E \cong I_C$$

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

$$V_E = I_E R_E$$

Emitter-Bias Configuration (2 of 3)



EXAMPLE 4.4 For the emitter-bias network of Fig. 4.23, determine:

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

Solution:

a. Eq. (4.17): $$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E} = \frac{20\text{ V} - 0.7\text{ V}}{430\text{ k}\Omega + (51)(1\text{ k}\Omega)} = \frac{19.3\text{ V}}{481\text{ k}\Omega} = \mathbf{40.1\ \mu A}$$

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

c. Eq. (4.19): $$V_{CE} = V_{CC} - I_C(R_C + R_E) = 20\text{ V} - (2.01\text{ mA})(2\text{ k}\Omega + 1\text{ k}\Omega) = 20\text{ V} - 6.03\text{ V} = \mathbf{13.97\ V}$$

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

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

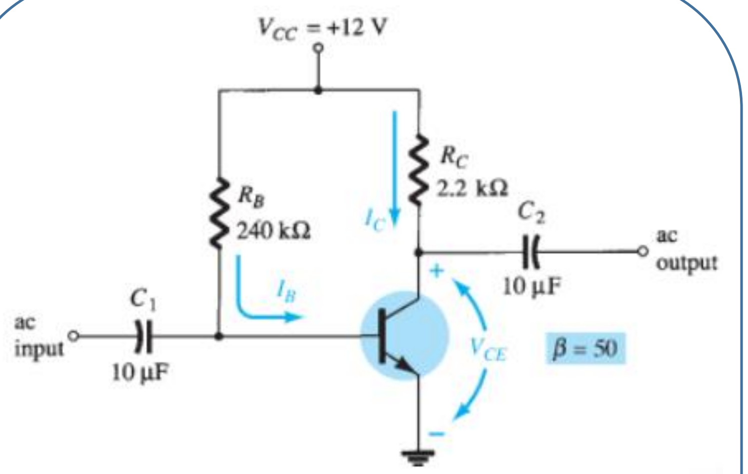
or $$V_E = I_E R_E \cong I_C R_E = (2.01\text{ mA})(1\text{ k}\Omega) = \mathbf{2.01\ V}$$

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

g. $$V_{BC} = V_B - V_C = 2.71\text{ V} - 15.98\text{ V} = \mathbf{-13.27\ V}$$ (reverse-biased as required)

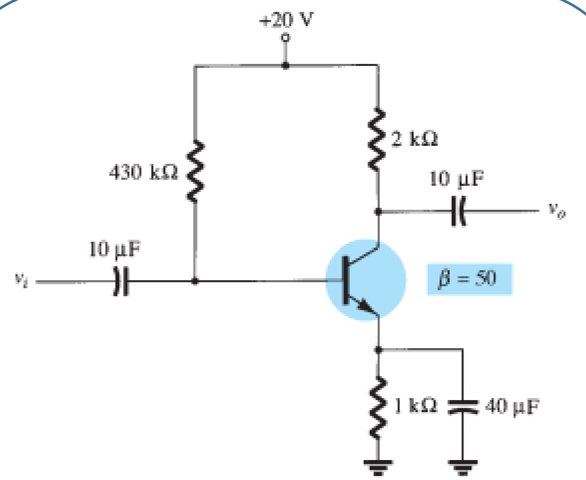
Emitter-Bias Configuration (3 of 3)

- Improved Bias Stability
  The addition of the emitter resistor to the dc bias of the BJT provides improved stability, that is, the dc bias currents and voltages remain closer to where they were set by the circuit when outside conditions, such as temperature and transistor beta, change.



Effect of β variation on the response of the fixed-bias configuration of Fig. 4.7.

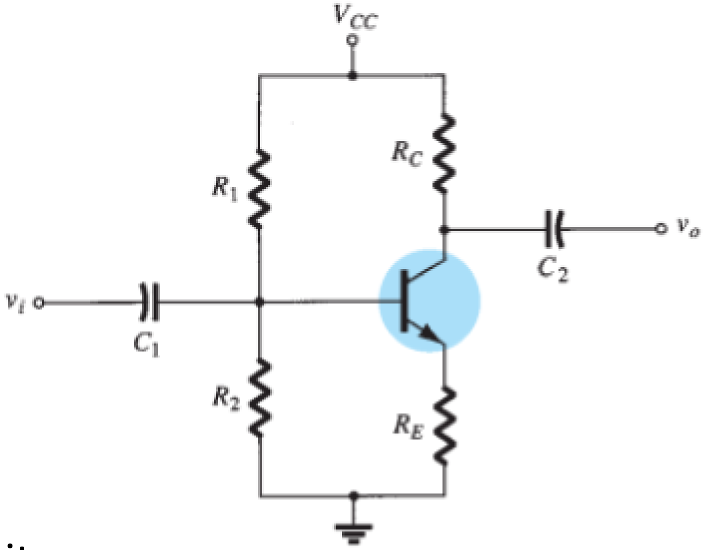
β	I_B (μA)	I_C (mA)	V_{CE} (V)
50	47.08	2.35	6.83
100	47.08	4.71	1.64



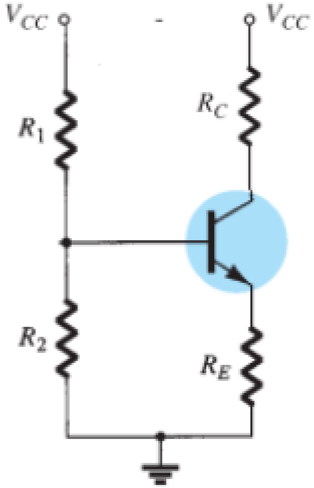
Effect of β variation on the response of the emitter-bias configuration of Fig. 4.23.

β	I_B (μA)	I_C (mA)	V_{CE} (V)
50	40.1	2.01	13.97
100	36.3	3.63	9.11

Voltage-Divider Configuration (1 of 2)



DC equivalent

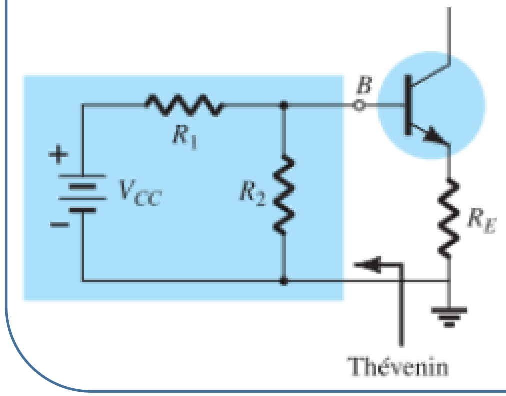


O/p Circuit

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

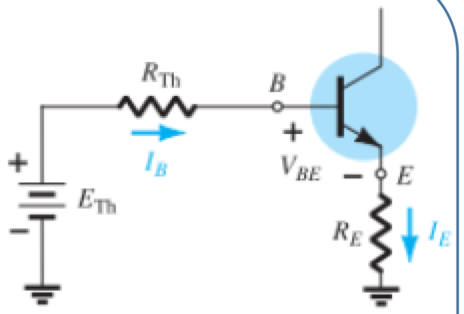
I/p Circuit

Exact Analysis



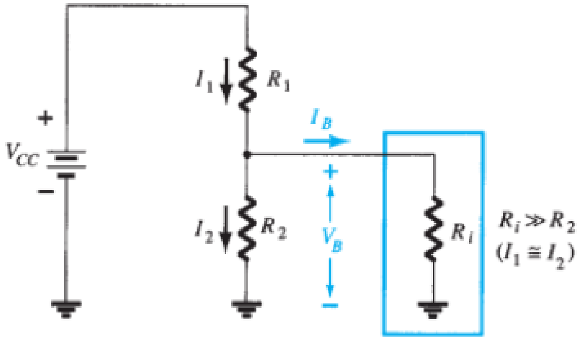
$$R_{Th} = R_1 \| R_2$$

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



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

Approximate Analysis



$$\beta R_E \geq 10R_2$$

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

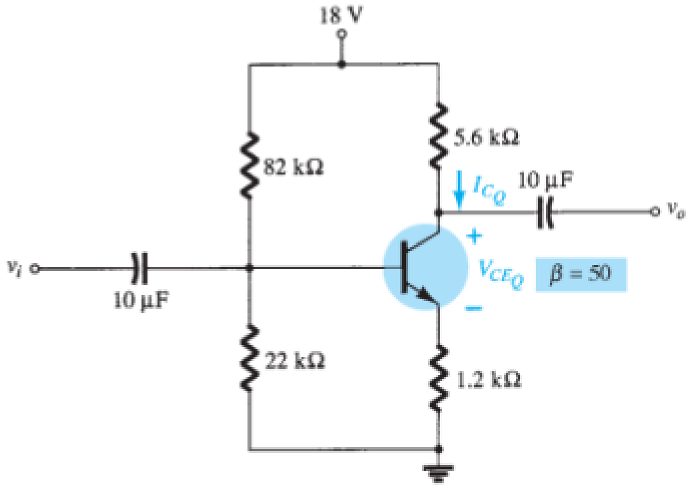
$$R_i = (\beta + 1)R_E \cong \beta R_E$$

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

$$I_{C_Q} \cong I_E$$

Voltage-Divider Configuration (2 of 2)

EXAMPLE 4.11 Determine the levels of I_{C_Q} and V_{CE_Q} for the voltage-divider configuration of Fig. 4.37 using the exact and approximate techniques and compare solutions. In this case, the conditions of Eq. (4.33) *will not be satisfied* and the results will reveal the difference in solution if the criterion of Eq. (4.33) is ignored.



Solution: Exact analysis:

Eq. (4.33):

$$\beta R_E \geq 10R_2$$

$$(50)(1.2\text{ k}\Omega) \geq 10(22\text{ k}\Omega)$$

$$60\text{ k}\Omega \ngeq 220\text{ k}\Omega \text{ (not satisfied)}$$

$$R_{Th} = R_1 \| R_2 = 82\text{ k}\Omega \| 22\text{ k}\Omega = 17.35\text{ k}\Omega$$

$$E_{Th} = \frac{R_2 V_{CC}}{R_1 + R_2} = \frac{22\text{ k}\Omega(18\text{ V})}{82\text{ k}\Omega + 22\text{ k}\Omega} = 3.81\text{ V}$$

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E} = \frac{3.81\text{ V} - 0.7\text{ V}}{17.35\text{ k}\Omega + (51)(1.2\text{ k}\Omega)} = \frac{3.11\text{ V}}{78.55\text{ k}\Omega} = 39.6\,\mu\text{A}$$

$$I_{C_Q} = \beta I_B = (50)(39.6\,\mu\text{A}) = \mathbf{1.98\text{ mA}}$$

$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E)$$
$$= 18\text{ V} - (1.98\text{ mA})(5.6\text{ k}\Omega + 1.2\text{ k}\Omega)$$
$$= \mathbf{4.54\text{ V}}$$

Approximate analysis:

$$V_B = E_{Th} = 3.81\text{ V}$$

$$V_E = V_B - V_{BE} = 3.81\text{ V} - 0.7\text{ V} = 3.11\text{ V}$$

$$I_{C_Q} \cong I_E = \frac{V_E}{R_E} = \frac{3.11\text{ V}}{1.2\text{ k}\Omega} = \mathbf{2.59\text{ mA}}$$

$$V_{CE_Q} = V_{CC} - I_C(R_C + R_E)$$
$$= 18\text{ V} - (2.59\text{ mA})(5.6\text{ k}\Omega + 1.2\text{ k}\Omega)$$
$$= \mathbf{3.88\text{ V}}$$

Comparing the exact and approximate approaches.

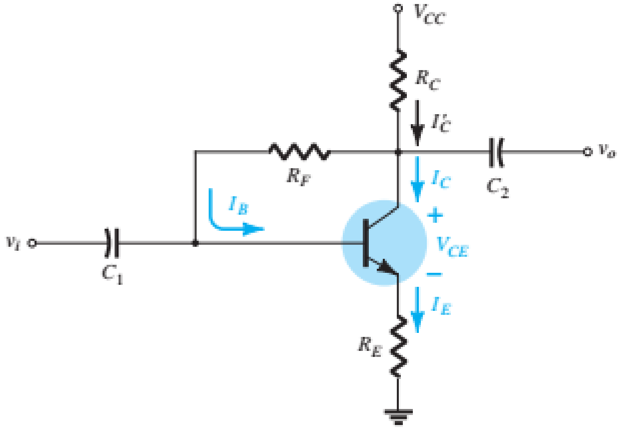
	I_{C_Q} *(mA)*	V_{CE_Q} *(V)*
Exact	1.98	4.54
Approximate	2.59	3.88

To ensure a close similarity between exact and approximate solutions.

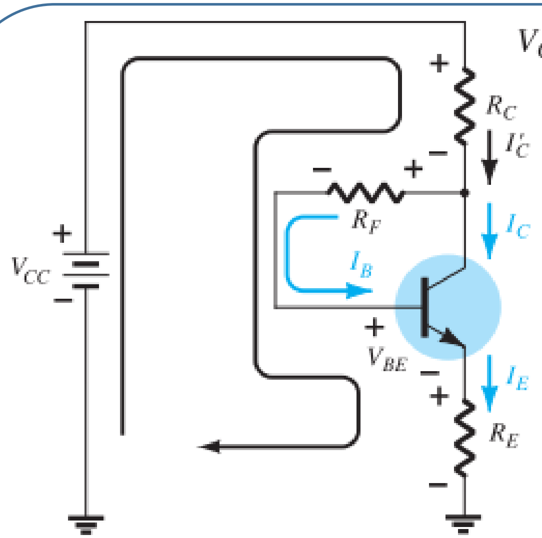
$$\beta R_E \geq 10R_2$$

Collector Feedback Configuration

- DC bias circuit with voltage feedback.



I/p Circuit



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

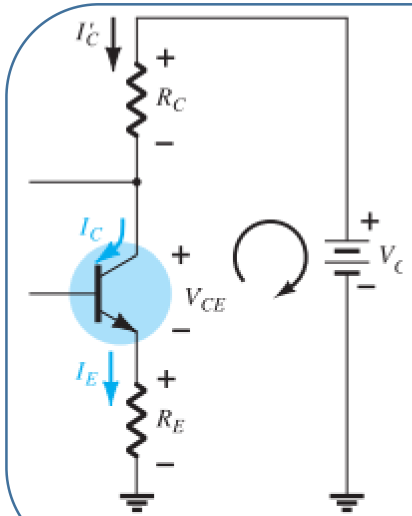
$$I_B = \frac{V_{CC} - V_{BE}}{R_F + \beta(R_C + R_E)}$$

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

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

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

O/p Circuit



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

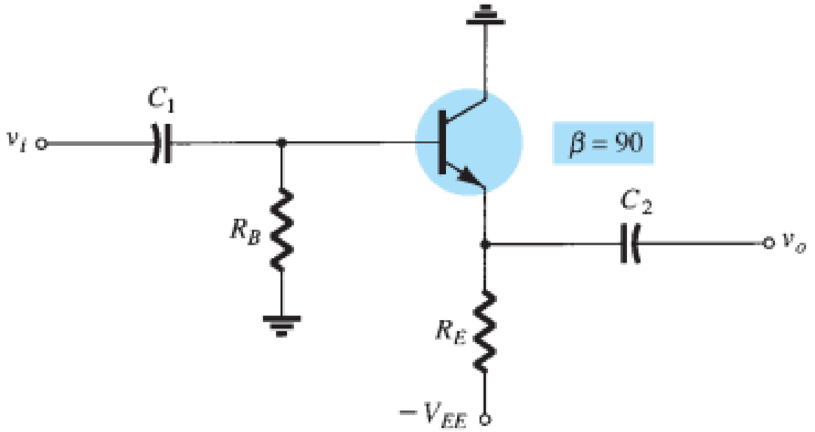
Because $I'_C \cong I_C$ and $I_E \cong I_C$, we have

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

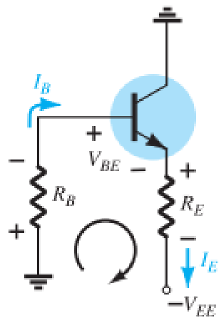
and

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

Emitter-Follower Configuration



DC equivalent →



I/p Circuit

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

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

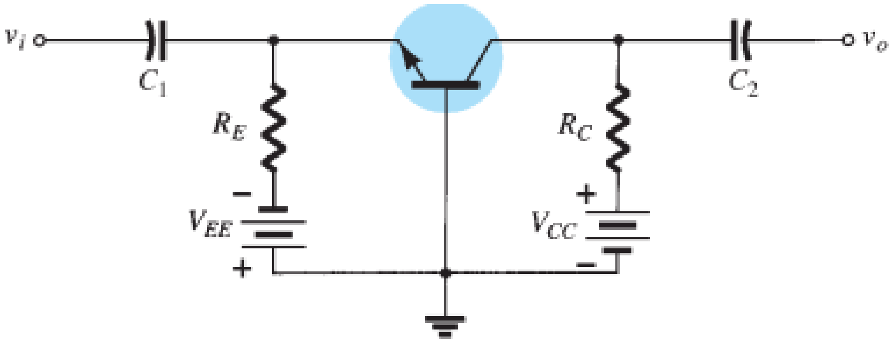
$$I_B = \frac{V_{EE} - V_{BE}}{R_B + (\beta + 1) R_E}$$

O/p Circuit

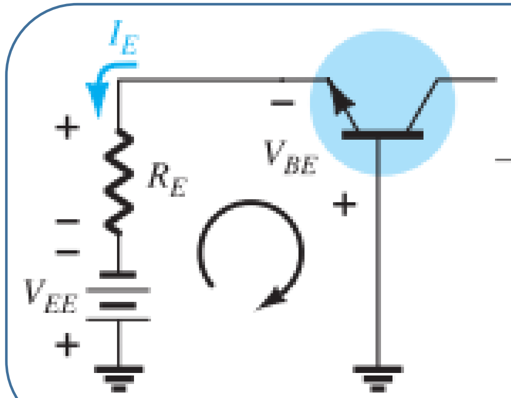
$$-V_{CE} - I_E R_E + V_{EE} = 0$$

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

Common-Base Configuration



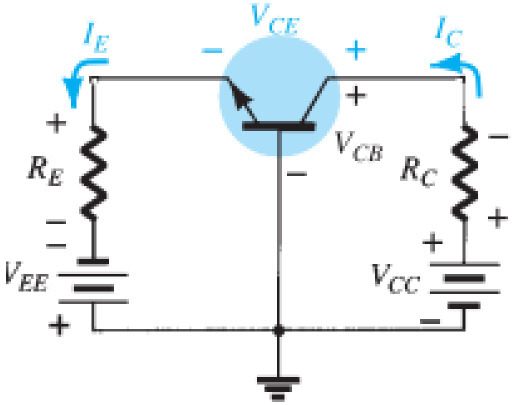
I/p Circuit



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

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

O/p Circuit



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

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

$$I_E \cong I_C$$

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

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

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

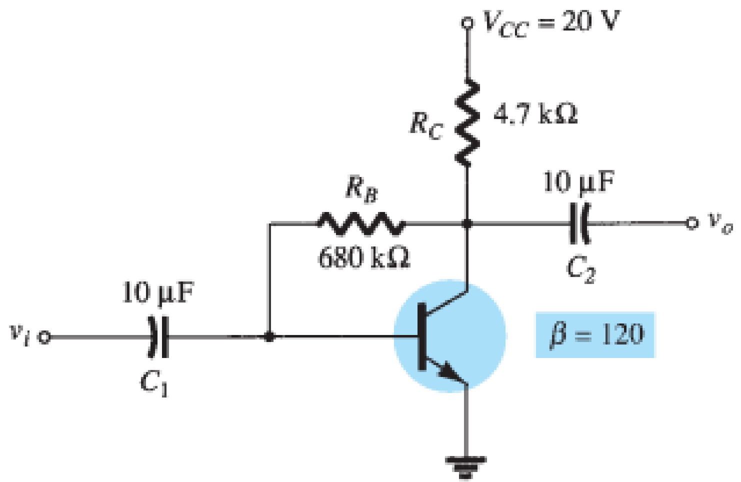
$$I_C \cong I_E$$

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

Miscellaneous Bias Configurations

EXAMPLE 4.18 For the network of Fig. 4.53:

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



Solution:

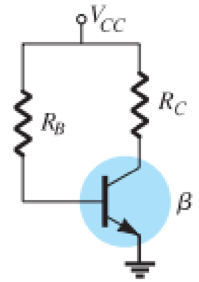
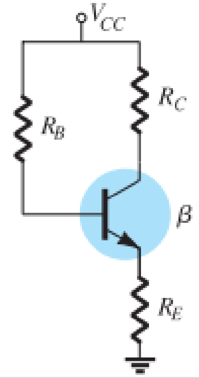
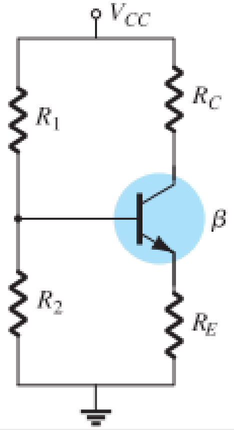
a. The absence of R_E reduces the reflection of resistive levels to simply that of R_C, and the equation for I_B reduces to

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

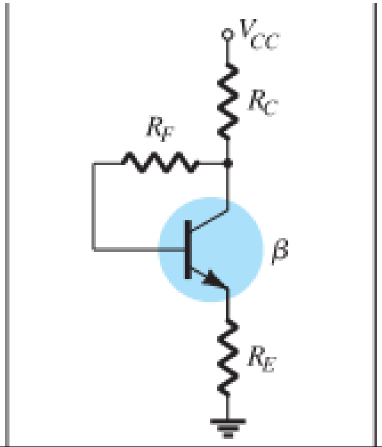
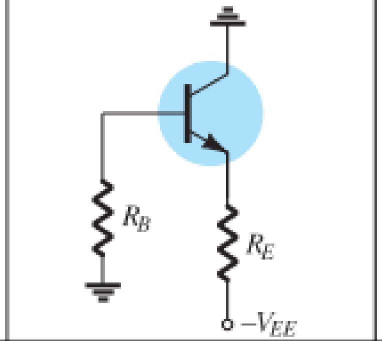
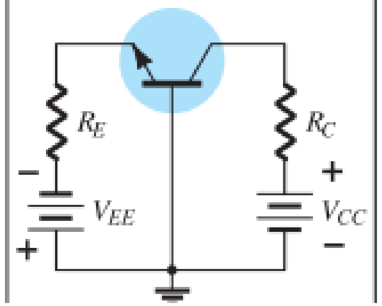
b.
$$V_B = V_{BE} = \mathbf{0.7\ V}$$
$$V_C = V_{CE} = \mathbf{11.26\ V}$$
$$V_E = \mathbf{0\ V}$$
$$V_{BC} = V_B - V_C = 0.7\text{ V} - 11.26\text{ V}$$
$$= \mathbf{-10.56\ V}$$

Summary Table

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: $\beta R_E \geq 10R_2$ $V_B = \dfrac{R_2 V_{CC}}{R_1 + R_2}, V_E = V_B - V_{BE}$ $I_E = \dfrac{V_E}{R_E}, I_B = \dfrac{I_E}{\beta + 1}$ $V_{CE} = V_{CC} - I_C(R_C + R_E)$

Summary Table..

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		$I_B = \dfrac{V_{EE} - V_{BE}}{R_B + (\beta + 1)R_E}$ $I_C = \beta I_B, I_E = (\beta + 1)I_B$ $V_{CE} = V_{EE} - I_E\,R_E$
Common-base		$I_E = \dfrac{V_{EE} - V_{BE}}{R_E}$ $I_B = \dfrac{I_E}{\beta + 1}, I_C = \beta I_B$ $V_{CE} = V_{EE} + V_{CC} - I_E(R_C + R_E)$ $V_{CB} = V_{CC} - I_C R_C$

Design Operations

- Discussions thus far have focused on the analysis of existing networks. All the elements are in place, and it is simply a matter of solving for the current and voltage levels of the configuration.

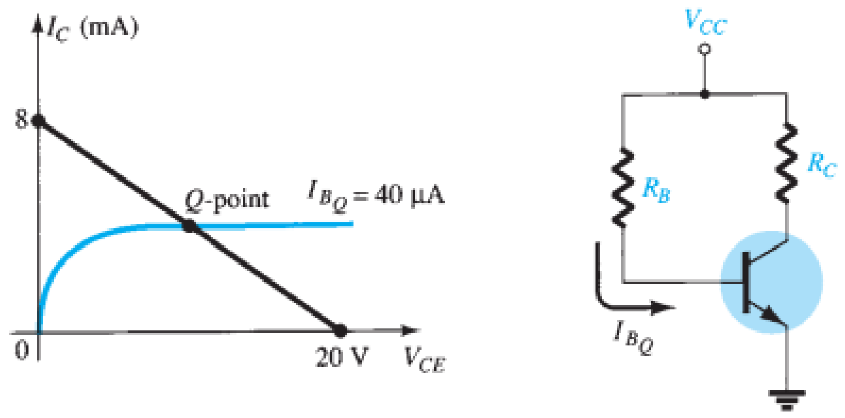
- The design process is one where a current and/or voltage may be specified and the elements required to establish the designated levels must be determined.

- The design sequence is obviously sensitive to the components that are already specified and the elements to be determined. 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.

Design Operations Example

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.



(a) (b)

Solution: From the load line

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

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

and

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

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

with

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

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

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

Standard resistor values are

$$R_C = 2.4\text{ k}\Omega$$

$$R_B = 470\text{ k}\Omega$$

Using standard resistor values gives

$$I_B = 41.1\ \mu\text{A}$$

which is well within 5% of the value specified.


Thank You!