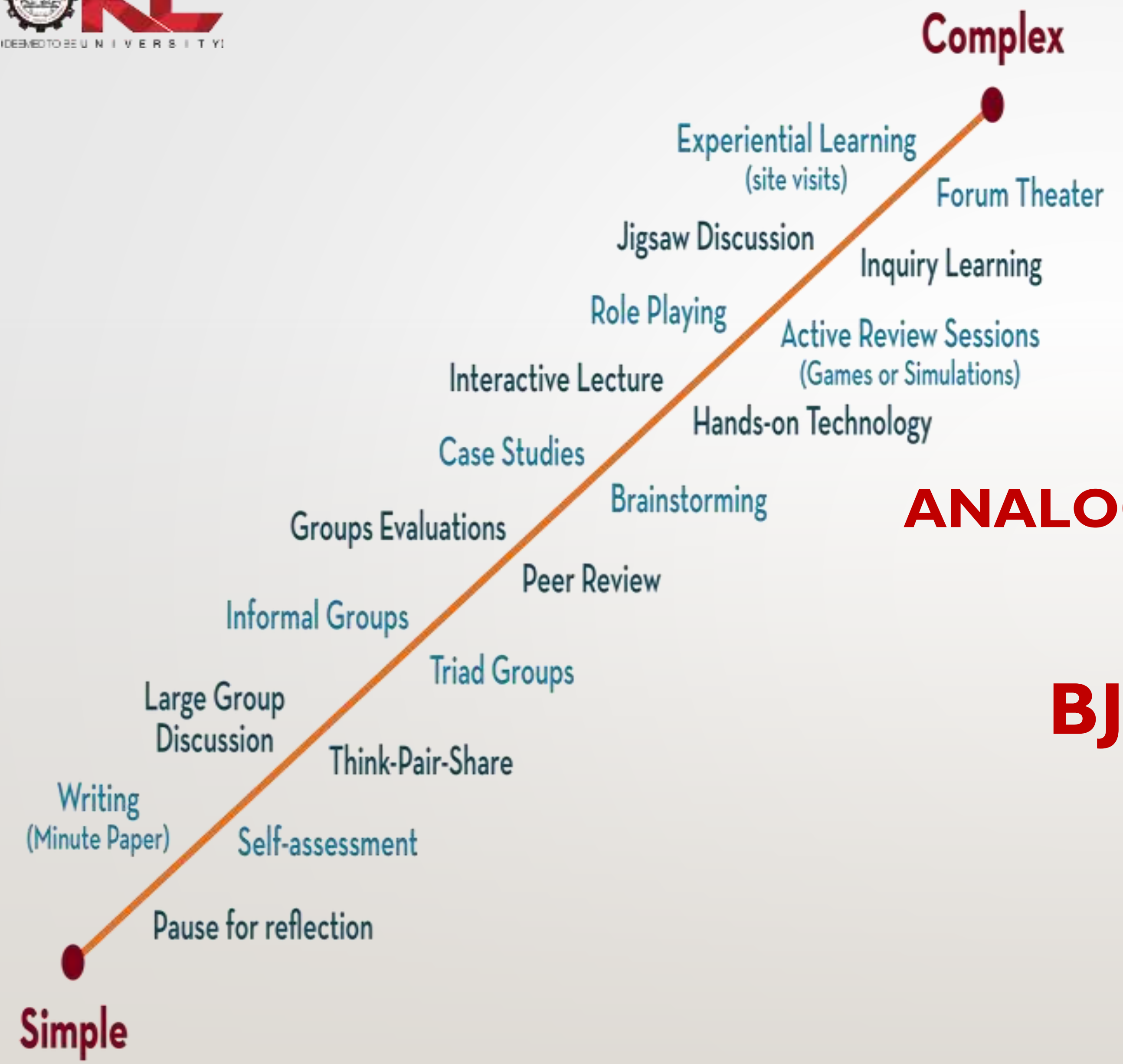


AY-2025-2026
ODD SEM

Department of ECE

ANALOG ELECTRONIC CIRCUIT DESIGN
24EC2104

Topic:

BJT BIASING CIRCUITS

Session - 04

SESSION CONTENT

- General Biasing Circuits
- Fixed Bias
- Emitter Feedback Bias
- Collector Feedback Bias

AIM OF THE SESSION

To demonstrate Biasing of BJT to desired Q-point

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Demonstrate BJT biasing circuits
2. Describe BJT desired operating point

LEARNING OUTCOMES

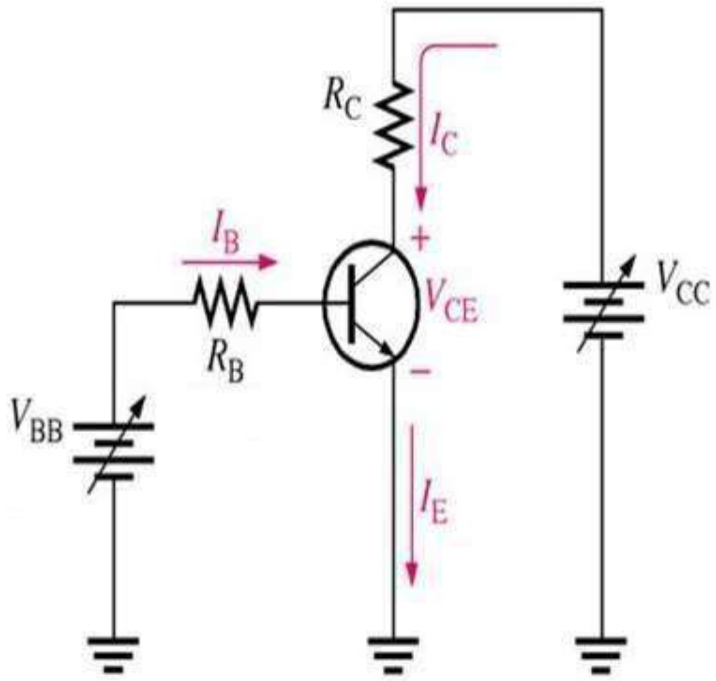
At the end of this session, you should be able to:

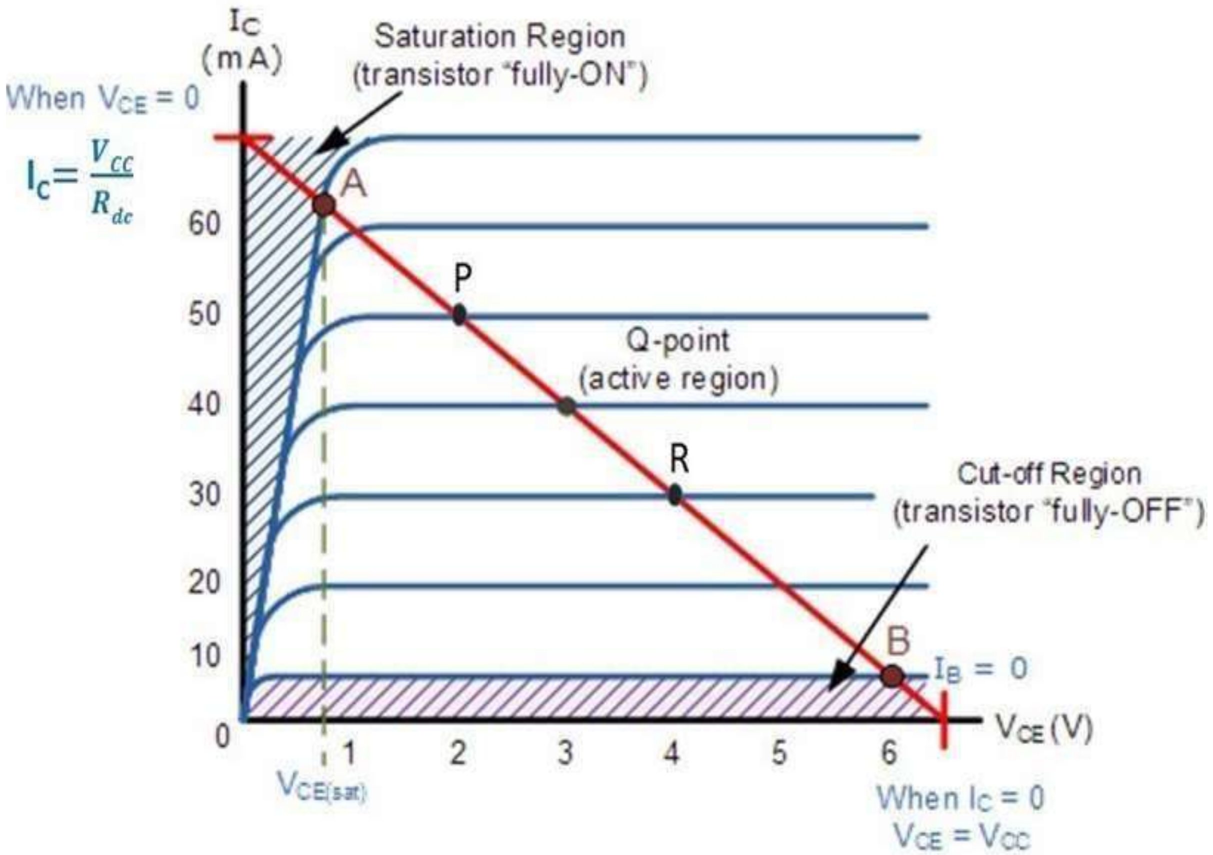
1. Describe BJT biasing circuits
2. Select biasing circuit for given application

Biasing in BJT Amplifier Circuits

- Fixed Bias(Base Bias)
- Self Bias/Voltage Divider Bias Circuits
- **Biasing Using a Collector-to-Base Feedback Resistor**
- Biasing using a Constant-Current Source

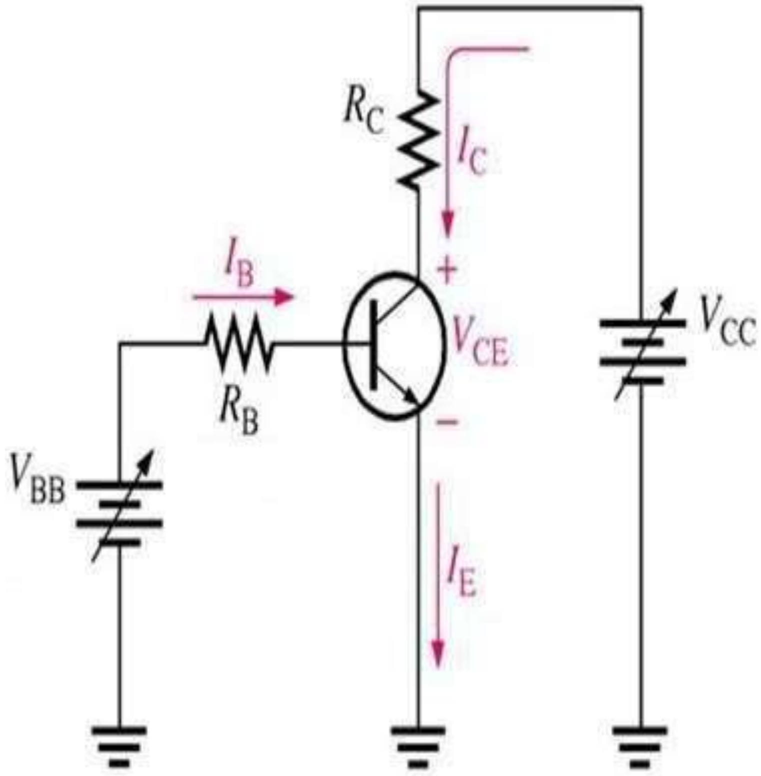
Biasing in BJT Amplifier Circuits

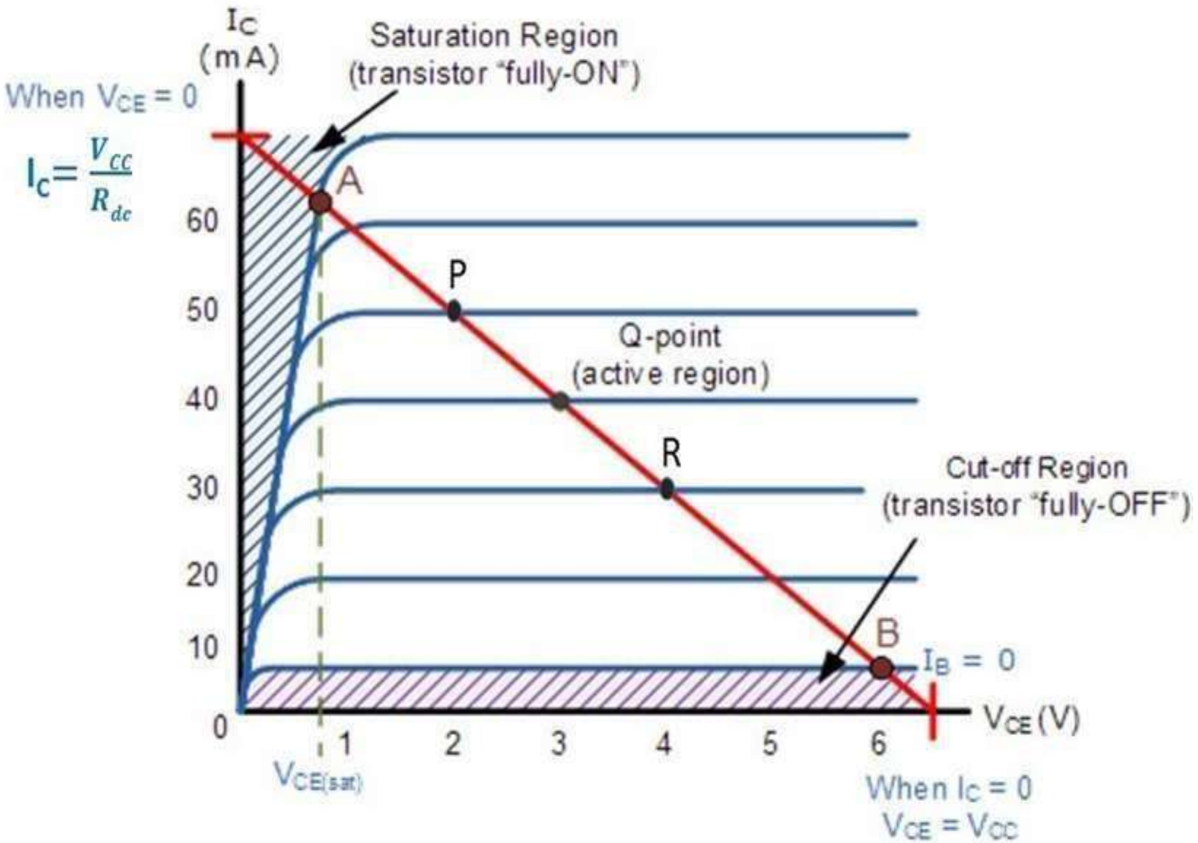




❖ The biasing problem is that of establishing a **constant dc current** in the collector of the BJT.

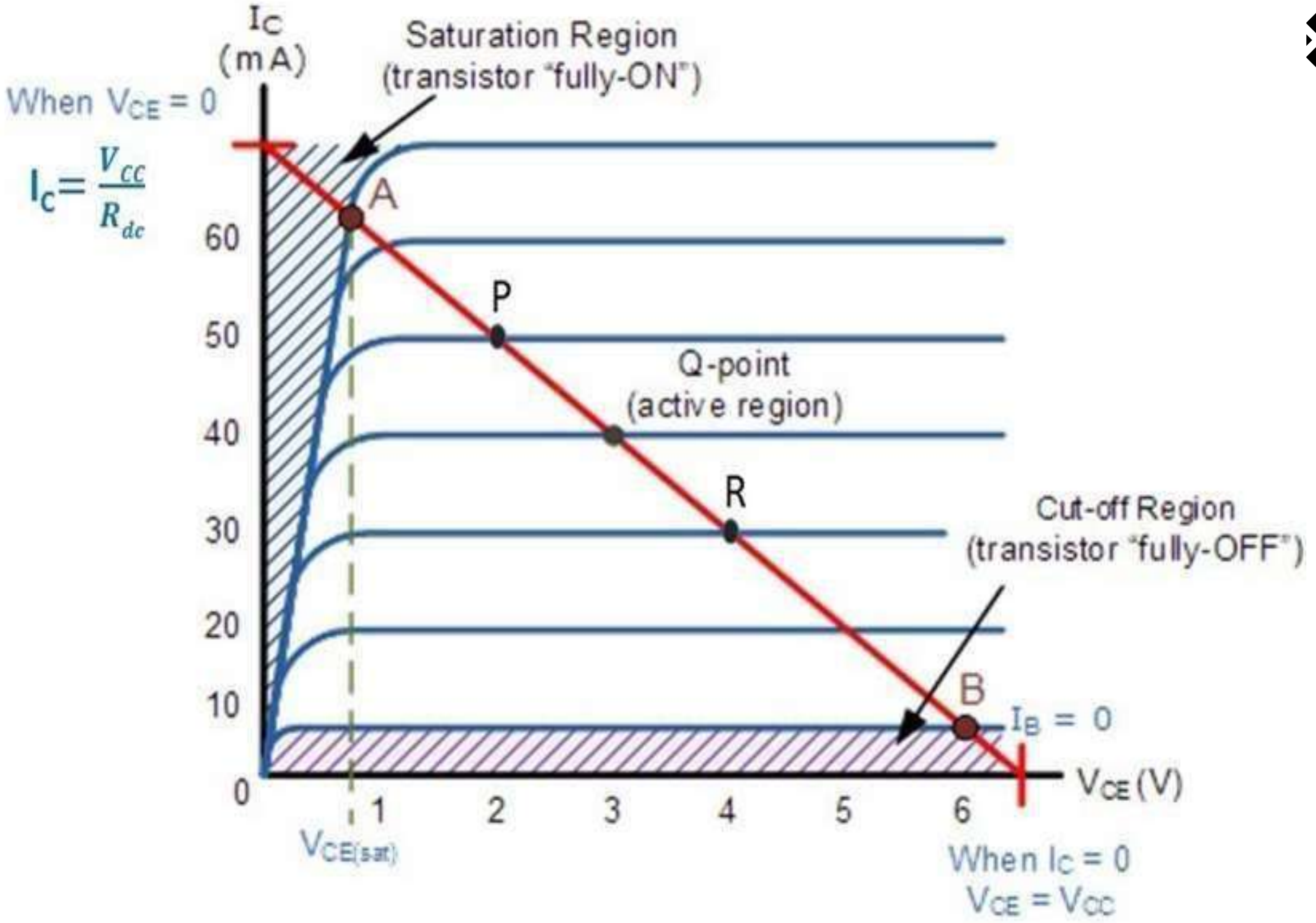
Biasing in BJT Amplifier Circuits





❖ This current has to be **calculable, predictable, and insensitive** to variations in temperature and to the large variations in the value of β encountered among transistors of the same type.

Biasing in BJT Amplifier Circuits



❖Another important consideration in bias design is **locating the dc bias point** in **the *iC–vCE*** *plane to allow for maximum* output signal swing.

Fixed Bias/Base Bias

$$I_C = \beta I_B$$

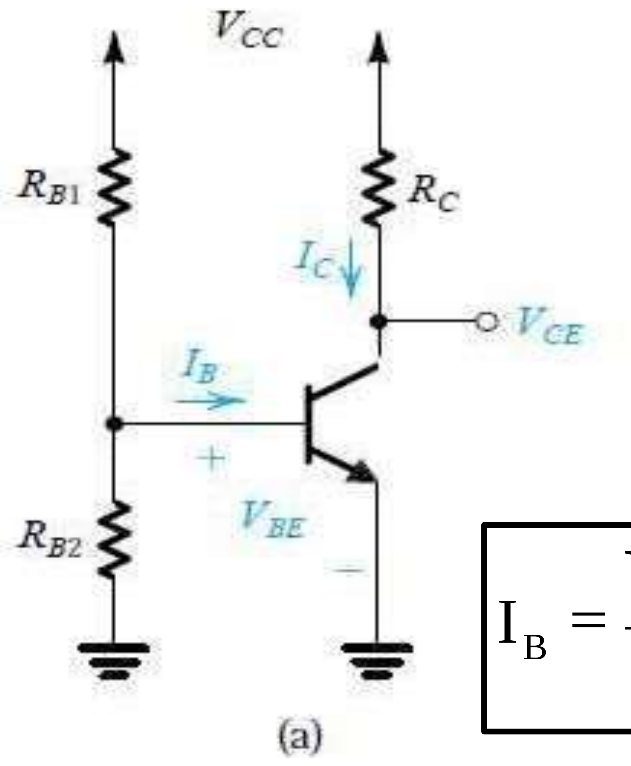
$$I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

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

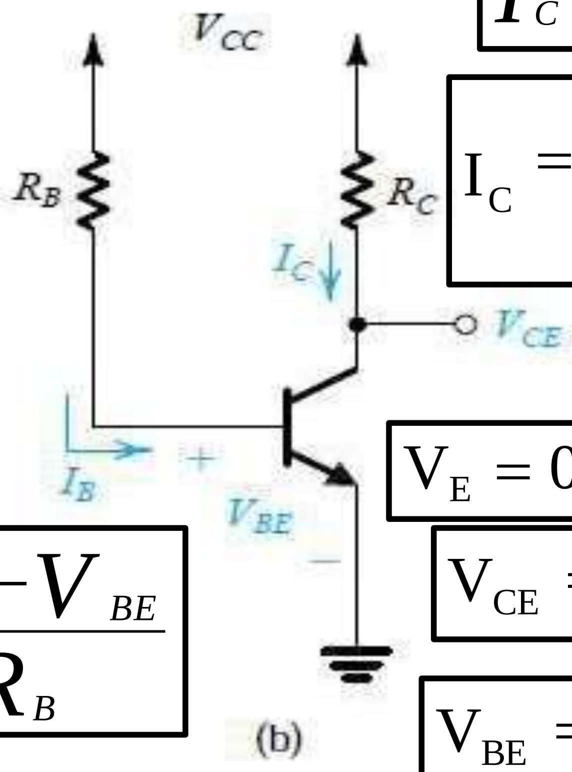
$$V_E = 0$$

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

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



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



Two obvious schemes for biasing the BJT: **(a) by fixing *VBE; (b) by fixing IB. Both result*** in wide variations in *IC and hence in VCE and therefore are considered to be “bad.” Neither scheme is* recommended.

GENERAL BIASING CIRCUITS

Base bias	$I_B = \frac{V_{BB} - 0.7\text{ V}}{R_B}$ $I_C = \beta I_B$ $V_{CE} = V_{CC} - I_C R_C$	Few parts; β dependent; fixed base current	Switch; digital

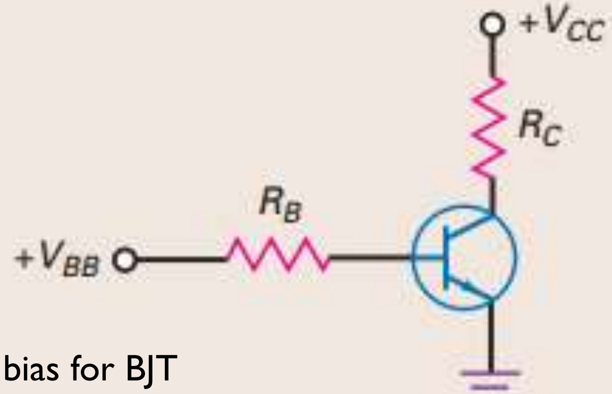


Fig. 4.1. Base bias for BJT

Fixed Bias/Base Bias

- **First, attempting to bias the BJT by fixing the voltage *VBE by, for* instance, using a voltage divider across the power supply *VCC, is not* a viable approach:**
- The very sharp exponential relationship ***iC–vBE*** *means that any small and* inevitable differences in *VBE from the desired value will result in large differences in IC and* in *VCE.*
- *Second, biasing the BJT by establishing a constant current in the base,*where is also not a recommended approach.
- Here the typically large variations in the value of β among units of the same device type will result in correspondingly **large variations** in *IC and hence in VCE.*

Fixed Bias/Base Bias

ADVANTAGES OF FIXED BIAS CIRCUIT

1. Simple circuit as it uses few components.

2. It provides max flexibility, because the biasing conditions are easily set by changing the value of R_B.

DISADVANTAGES OF FIXED BIAS CIRCUIT

Poor stability

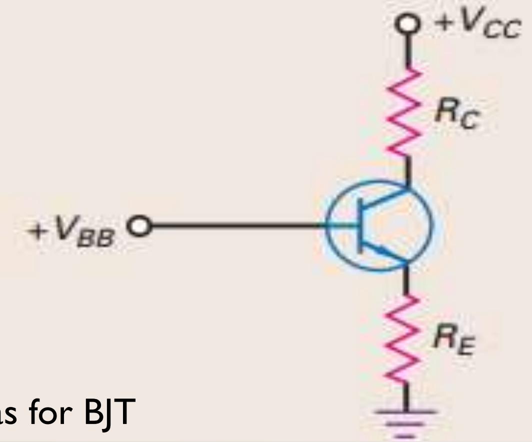
1. There is no means to stop self increase of I_C due to increase in temperature.

   So, thermal stability is not provided.

2. If β increases due to transistor replacement then, Ic also increases by factor β

Therefore there is a chance of thermal runaway $I_C = \beta I_B$

GENERAL BIASING CIRCUITS

Emitter bias  Fig. 4.2. Emitter bias for BJT	$V_E = V_{BB} - 0.7\text{ V}$ $I_E = \frac{V_E}{R_E}$ $V_C = V_C - I_C R_C$ $V_{CE} = V_C - V_E$	Fixed emitter current; β independent	I_C driver; amplifier

GENERAL BIASING CIRCUITS

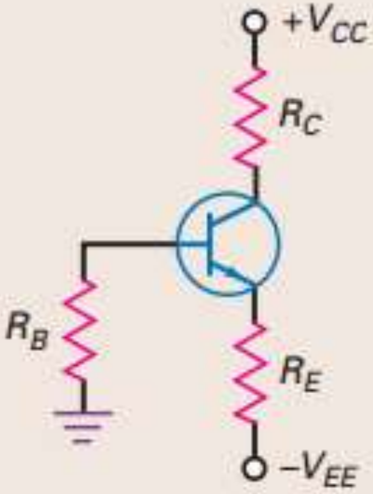
Two-supply emitter bias 	$V_B \approx 0\text{ V}$ $V_E = V_B - 0.7\text{ V}$ $V_{RE} = V_{EE} - 0.7\text{ V}$ $I_E = \frac{V_{RE}}{R_E}$ $V_C = V_{CC} - I_C R_C$ $V_{CE} = V_C - V_E$	Needs positive and negative power supplies; β independent	Amplifier

Fig. 4.3. Two supply emitter bias for BJT

FIXED BIAS AND EMITTER FEED BACK BIAS

Fixed Bias

Emitter Feedback Bias

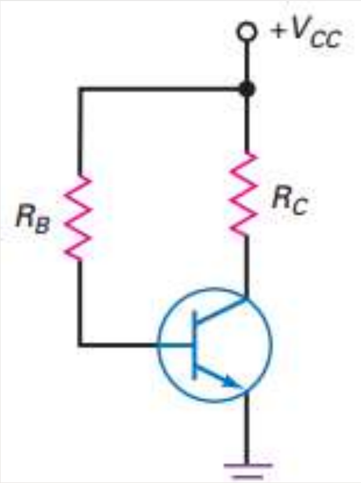


Fig. 4.4. Fixed Bias

- No Q-point Stabilization

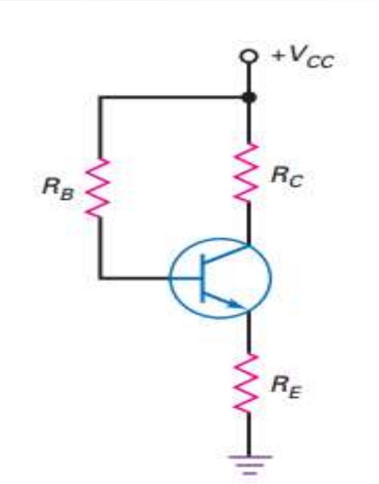


Fig. 4.5. Emitter Feedback Bias

- First attempt for Q-Point stabilization using Emitter resistance

Circuit Equations

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

$$V_E = I_E R_E$$

$$V_B = V_E + 0.7\ \text{V}$$

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

- Design

Large R_E value to swap out variations in β_{dc}

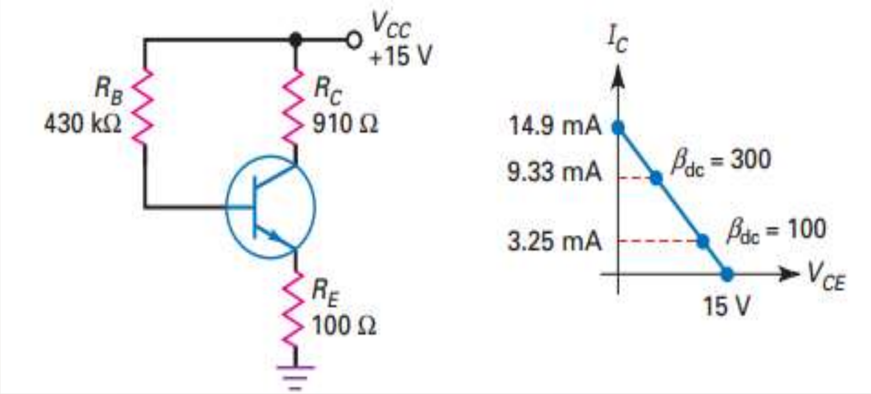
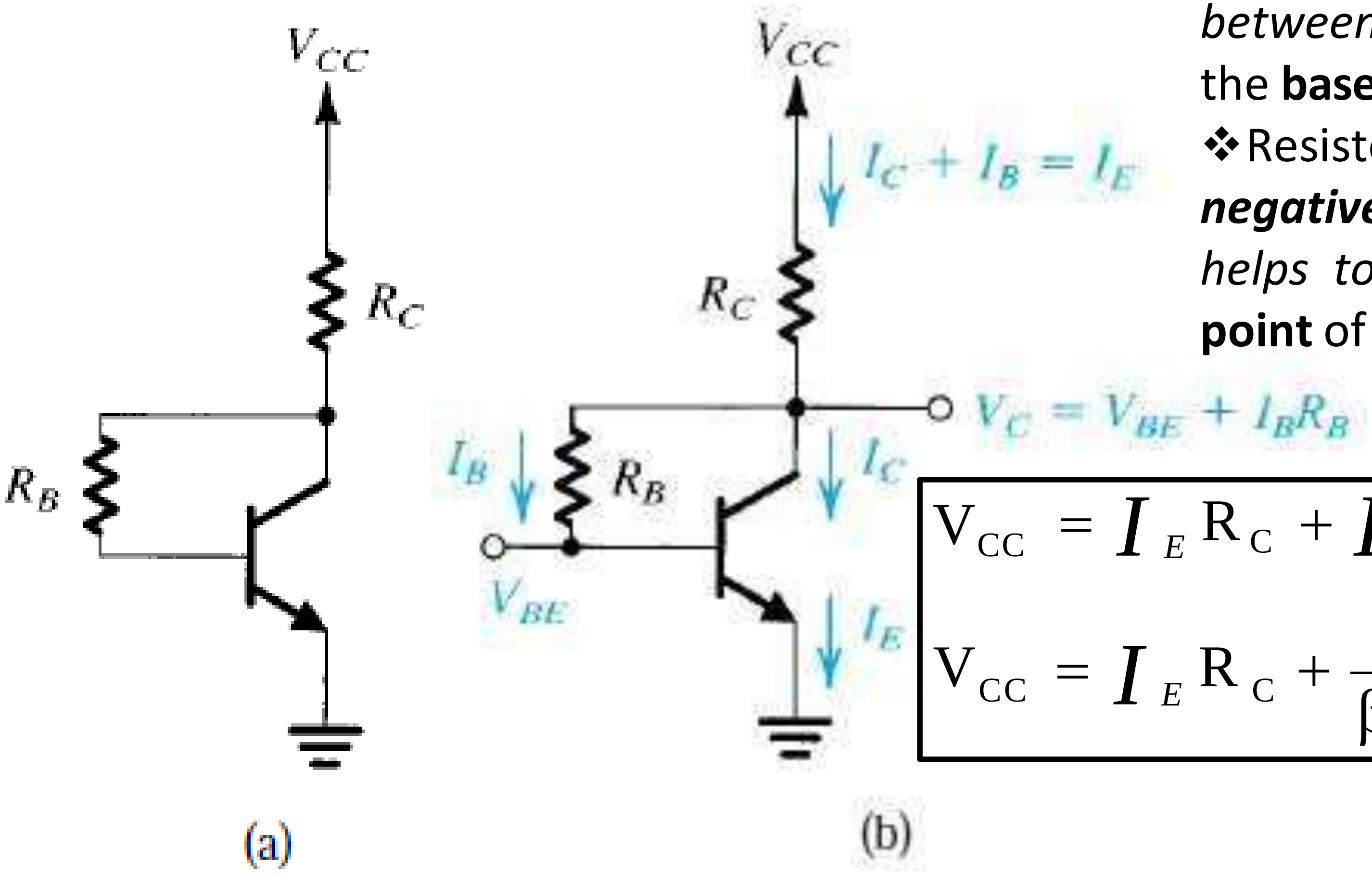


Fig. 4.6. Depicting Limitations of Emitter Feedback Bias – Variation in Q-point for change in β_{DC}

- Large change in collector current for 3:1 change in current gain

Biasing Using a Collector-to-Base Feedback Resistor

- The circuit employs a **resistor** ***RB*** *connected between the* ***collector*** and the **base**.
- Resistor *RB provides* ***negative feedback****, which helps to* ***stabilize*** *the* ***bias point*** of the BJT.

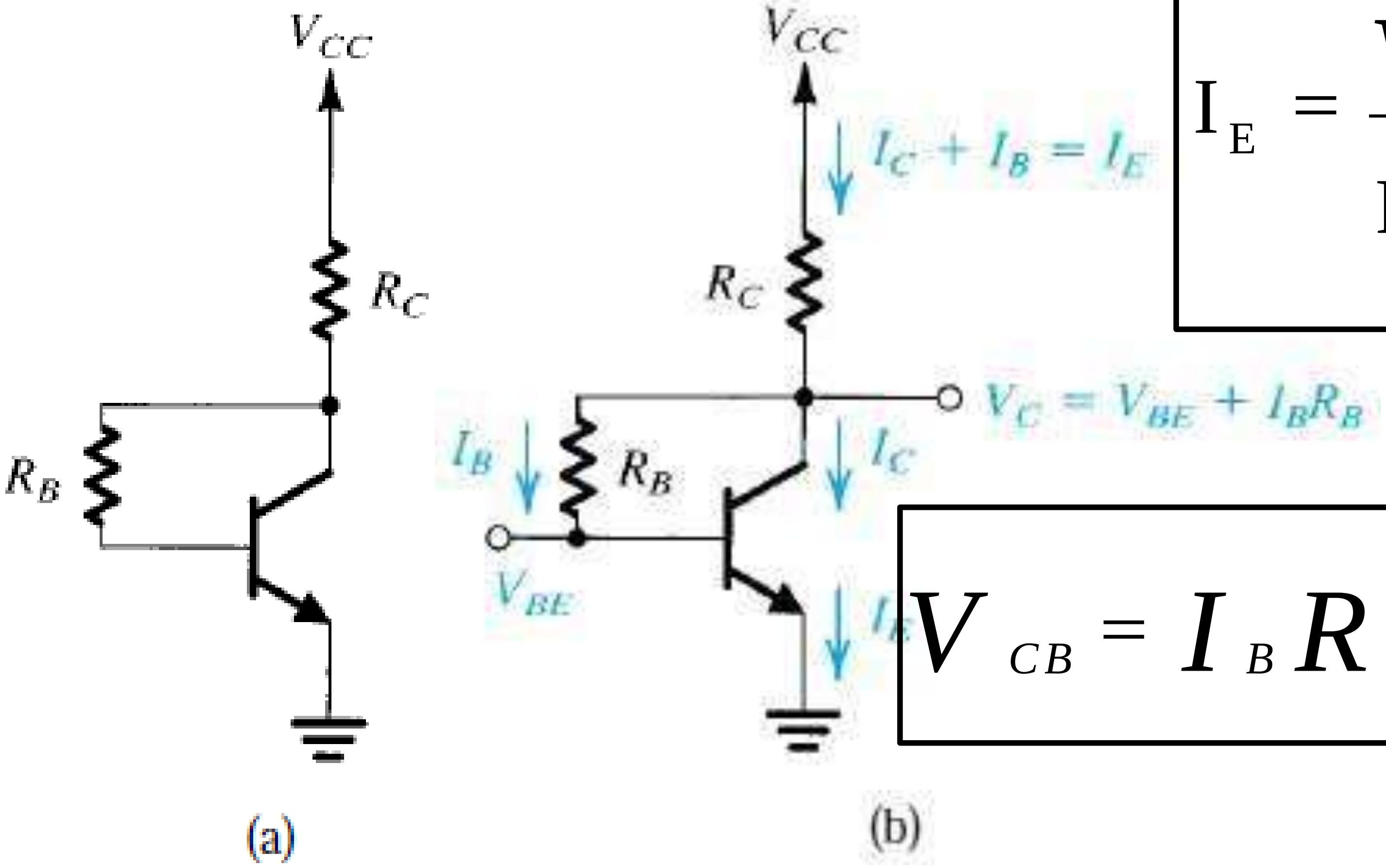


$$V_{CC} = I_E R_C + I_B R_B + V_{BE}$$

$$V_{CC} = I_E R_C + \frac{I_E}{\beta + 1} R_B + V_{BE}$$

(a) A CE transistor amplifier biased by a feedback resistor *RB.*
(b) Analysis of the circuit in **(a).**

Biasing Using a Collector-to-Base Feedback Resistor

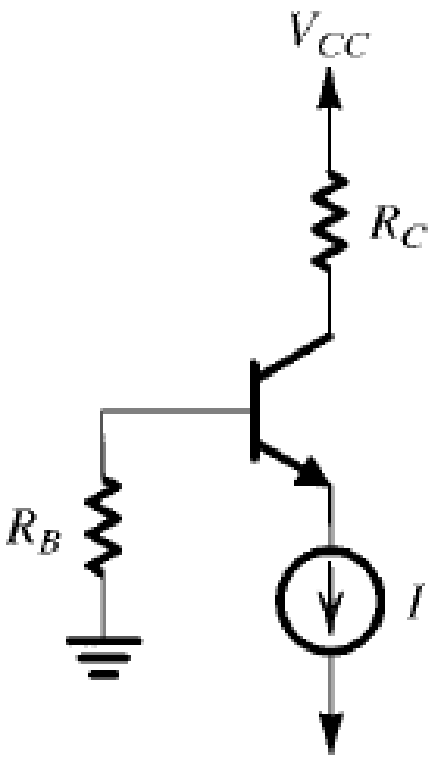


$$I_E = \frac{V_{CC} - V_{BE}}{R_{CE} + \frac{R_B}{\beta + 1}}$$

$$V_{CB} = I_B R_B = I_E \frac{R_B}{\beta + 1}$$

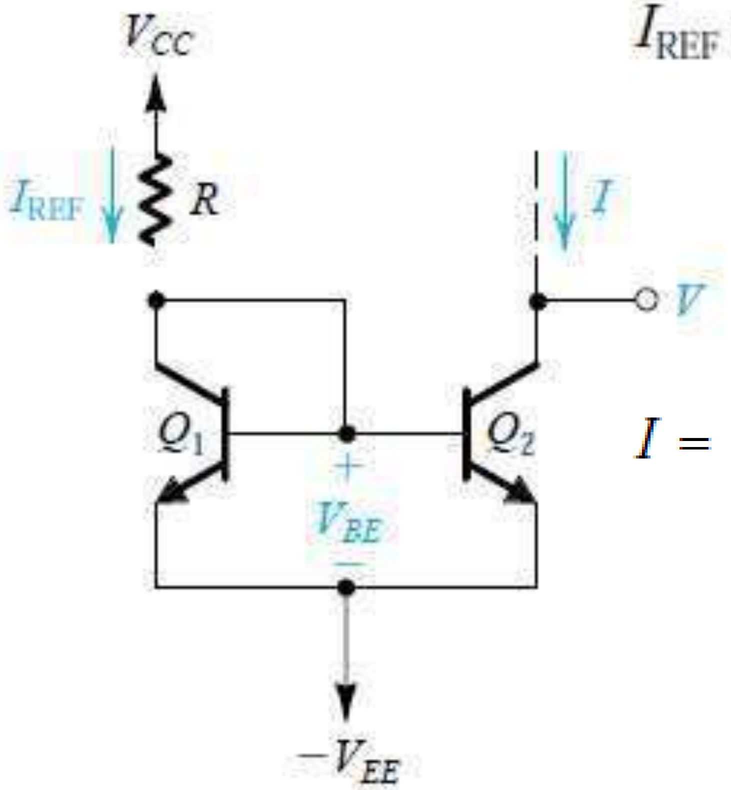
(a) A CE transistor amplifier biased by a feedback resistor *RB*.
(b) Analysis of the circuit in **(a).**

Biasing Using a Constant-Current Source



(a)

Current Mirror



(b)

$$I_{REF} = \frac{V_{CC} - (-V_{EE}) - V_{BE}}{R}$$

$$I = I_{REF} = \frac{V_{CC} + V_{EE} - V_{BE}}{R}$$

COLLECTOR FEED BACK BIAS

Collector Feedback Bias

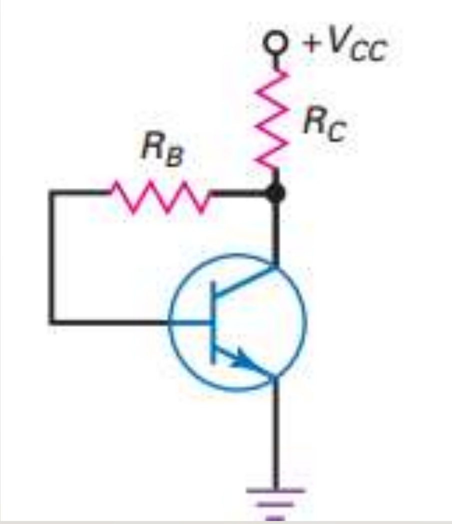


Fig. 4.7. Collector Feedback Bias

Circuit Equations

$$I_E = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta_{dc}}$$

$$V_B = 0.7\ \text{V}$$

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

- Design

$$R_B = \beta_{dc} R_C$$

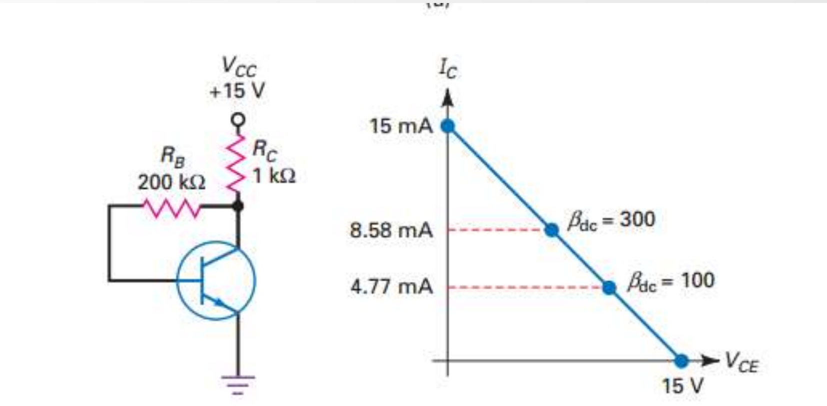


Fig. 4.8. Q-point for change in β_{DC}

- Better Q-Point stabilization using Collector feedback resistance

- Q point is less sensitive to changes in current gain

Example Problems

4.1 Calculate the Emitter resistance for Emitter bias as shown in Fig. 4.9 which could drive an LED of 21 mA Fig. 4.9.

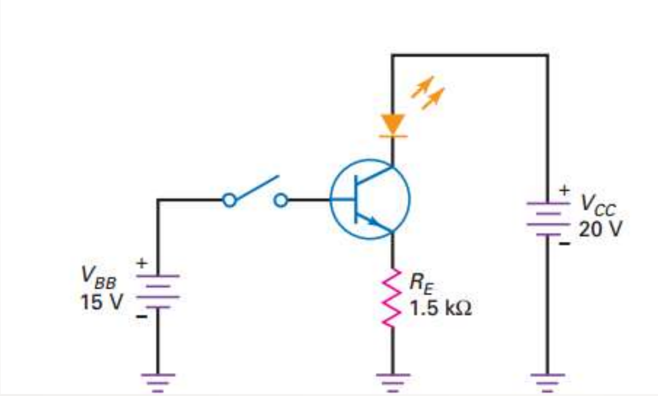


Fig. 4.9. Emitter bias for LED driving

Solution: Considering $I_E \sim I_C$

$I_E = 21$ mA

KVL in input loop gives

$V_{BB} = V_{BE} + I_E R_E$

Now, $R_E = (15-0.7)/(21 \text{ mA}) = 680\ \Omega$

Example Problems

4.2. Identify the application of the Base Biased BJT circuit shown in Fig. 4.10.

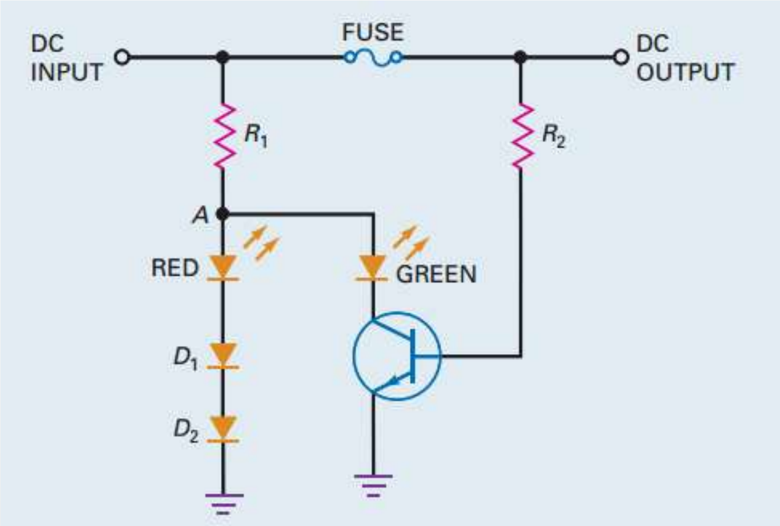


Fig. 4.10. Base bias for BJT

SOLUTION This is a blown-fuse indicator for a dc power supply. When the fuse is intact, the transistor is base-biased into saturation. This turns on the green LED to indicate that all is OK. The voltage between point A and ground is approximately 2 V. This voltage is not enough to turn on the red LED. The two series diodes (D_1 and D_2) prevent the red LED from turning on because they require a drop of 1.4 V to conduct.

SELF-ASSESSMENT QUESTIONS

1. Which Bias is suitable for Digital circuits?

(a) Emitter Bias
(b) Base Bias
(c) Collector feedback Bias
(d) Emitter feedback Bias

2. Which of the following bias is less effected by Beta variation?

(a) Emitter feedback bias
(b) Collector feedback bias

SELF-ASSESSMENT QUESTIONS

3. Which of the following biasing is suitable for IC driver application?

(a) Emitter Bias
(b) Base Bias
(c) Collector feedback Bias
(d) Emitter feedback Bias

4. Operating point of the BJT does not depend on temperature

(a) False
(b) True

ANSWERS

1. B
2. B
3. A
4. A

TERMINAL QUESTIONS

1. Describe the operation of Base bias. Sketch circuit obtain operating point.
2. Describe the operation of Emitter bias. Sketch circuit obtain operating point.
3. Describe the operation of two-supply bias. Sketch circuit obtain operating point.
4. Describe the operation of Fixed bias. Sketch circuit obtain operating point.
5. Describe the operation of Collector feedback bias. Sketch circuit obtain operating point.

REFERENCES FOR FURTHER LEARNING OF THE SESSION

Reference Books:

1. Albert Malvino, David Bate, "Electronic Principles"
2. Robert L. Boylestad and Louis Nashelsky - "Electronic Devices and Circuit Theory"

THANK YOU

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