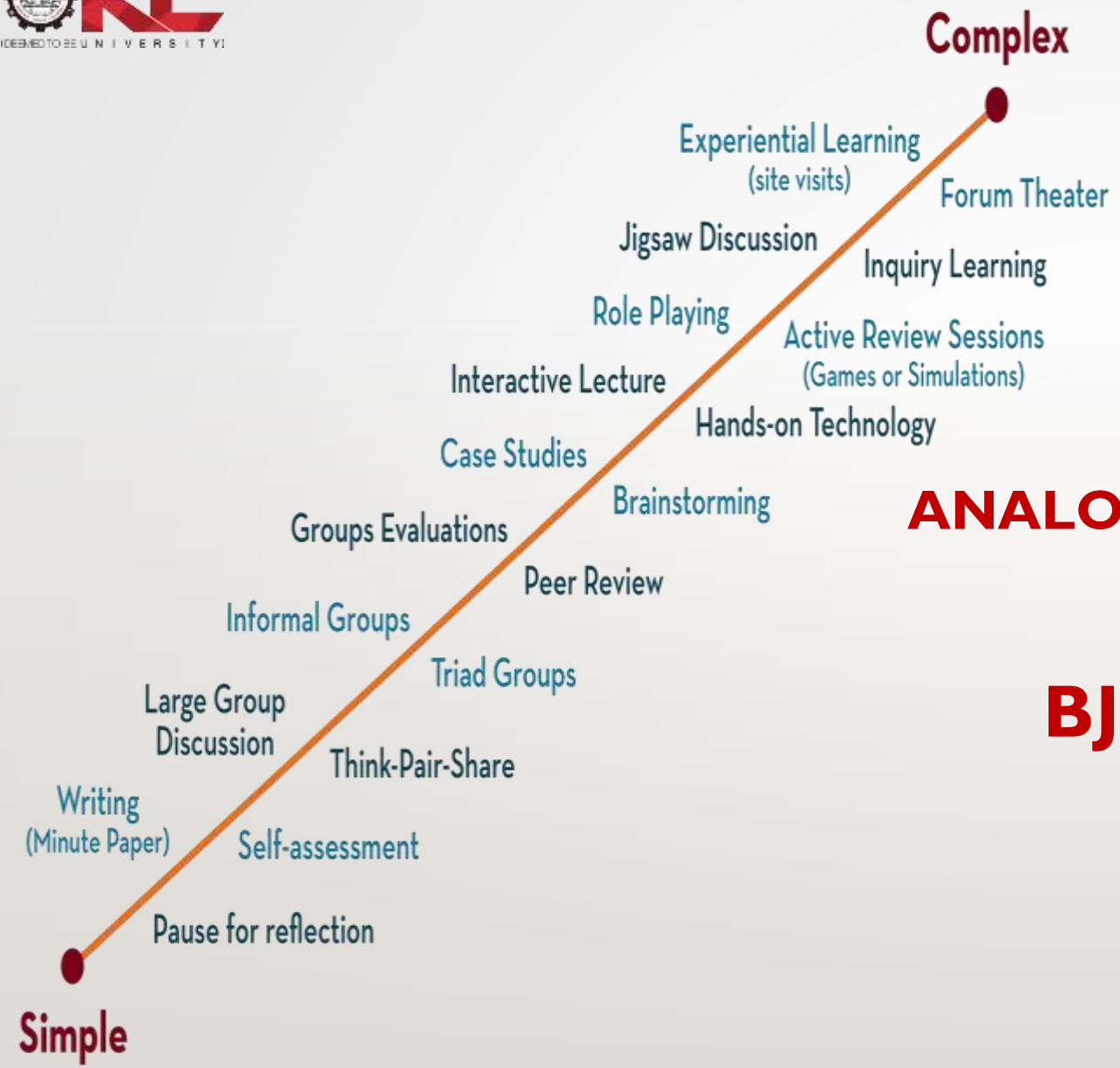


AY-2025-2026
ODD SEM

Department of ECE

ANALOG ELECTRONIC CIRCUIT DESIGN

23EC2104

Topic:

BJT CHARACTERISTICS

Session - 02

SESSION CONTENT

- CE CONFIGURATION
- INPUT CHARACTERISTICS
- OUTPUT CHARACTERISTICS
- REGIONS OF BJT OPERATION

AIM OF THE SESSION

To demonstrate characteristics of BJT

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Plot input characteristics of BJT
2. Plot output characteristics of BJT
3. Understand operating modes of BJT

LEARNING OUTCOMES

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

1. Demonstrate input characteristics
2. Demonstrate input characteristics
3. Identify various modes of operation of BJT

COMMON EMITTER CONFIGURATION

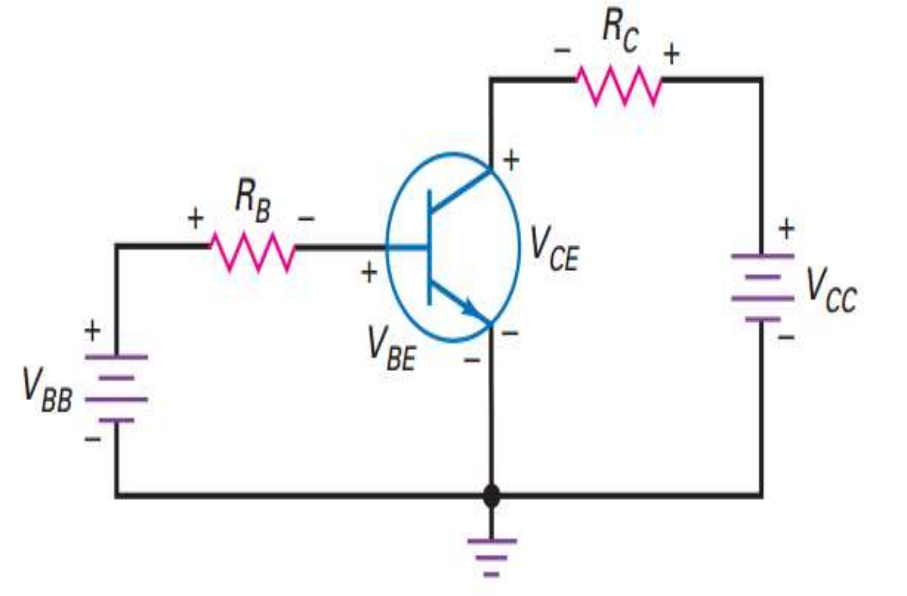


Fig. 2.1. CE configured BJT supplied with variable external voltages

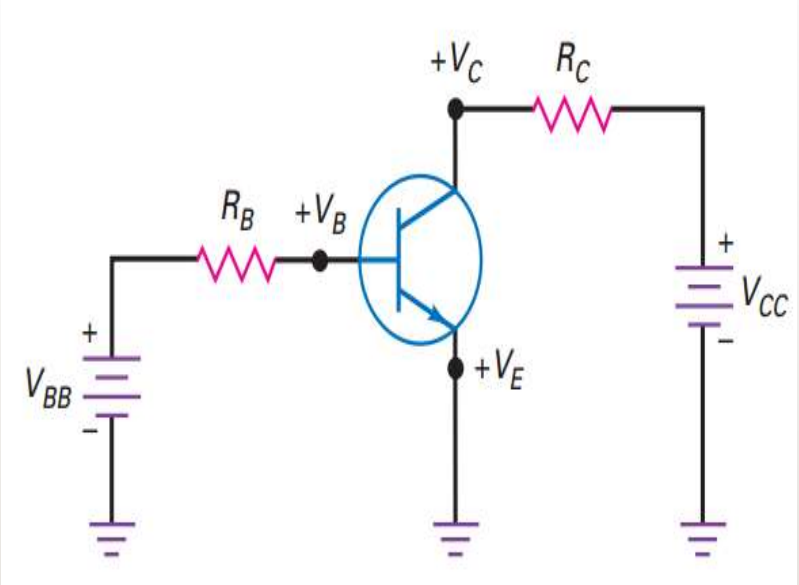


Fig. 2.2. separation of ground terminal for ease of identification of input and output loops

- **Fig. 2.1. depict the BJT configured for common emitter mode operation**
- **Input voltage is applied across B-E junction with limiter resistance R_B.**
- **Output loop consists of variable voltage V_{CC}, current limiter R_C and output voltage of the BJT across collector and emitter, V_{CE} For easiness to identify input loop and output loop the ground terminal is separated as shown in Fig. 2.2.**

THE BASE CURVE / INPUT CHARACTERISTICS

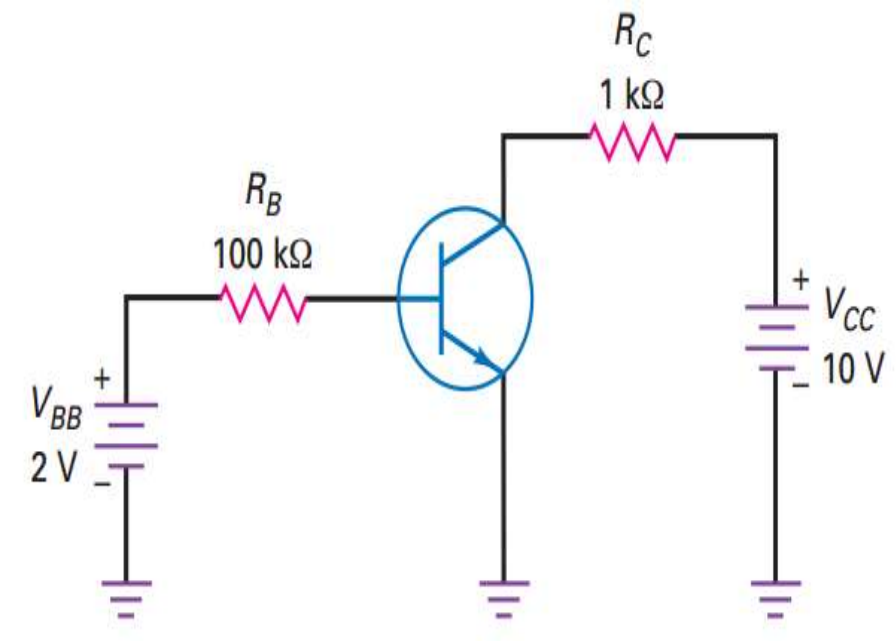


Fig. 2.3. Circuit operation to plot input characteristics

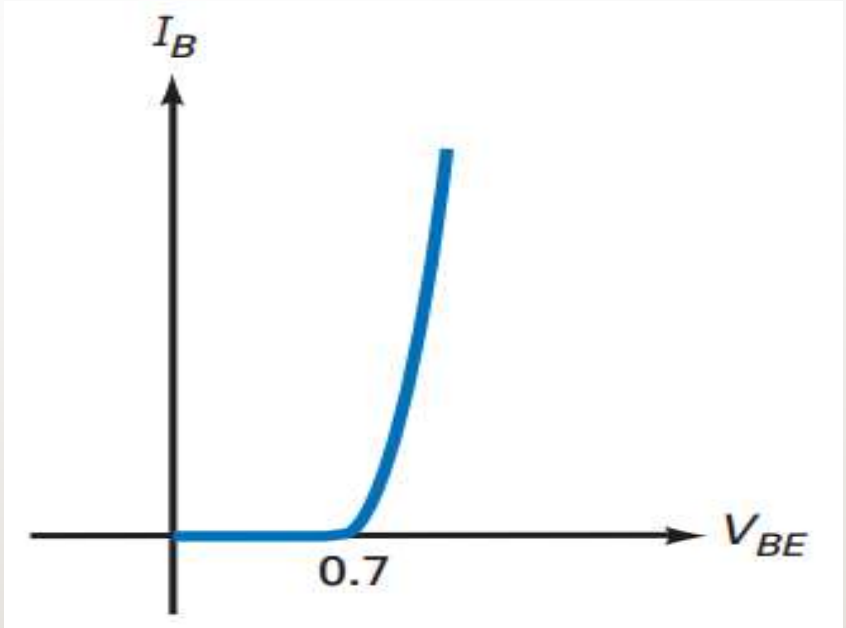


Fig. 2.4. Input characteristics of CE configured BJT

- Graph I_B versus V_{BE}
- Like ordinary diode
- Ohm's law to Base loop

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

- Ideal diode V_{BE} = 0 and second app. V_{BE} = 0.7 V

COLLECTOR CURVE / OUTPUT CHARACTERISTICS

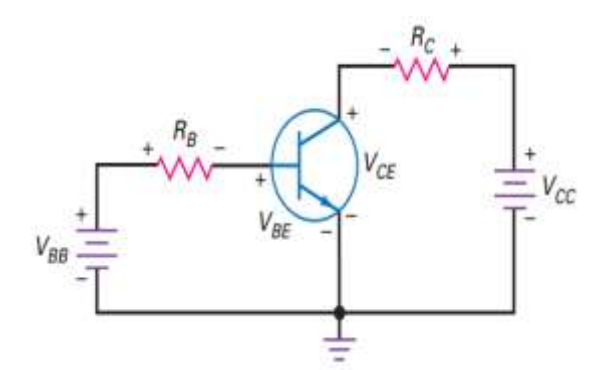


Fig. 2.5. Circuit operation to plot output characteristics

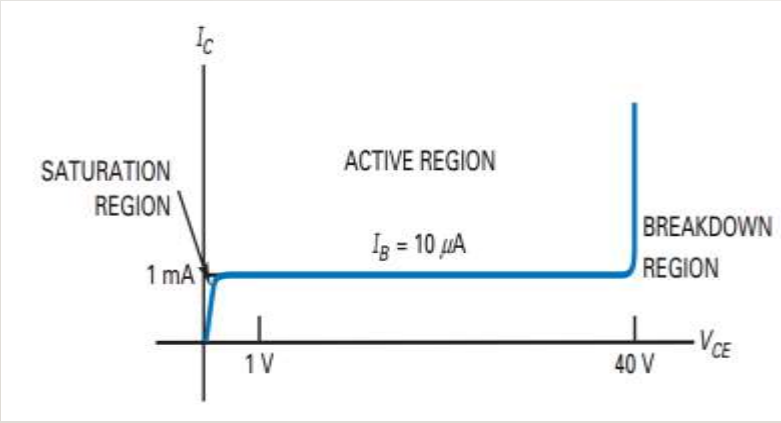


Fig. 2.6. Output characteristics of CE configured BJT for fixed base current

Fig. 2.7. Output characteristics of CE configured BJT for
Various values of input base current

- Graph I_C versus V_{CE}
- Ohm's low to Collector loop

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

- Fixed value of based current, vary V_{CC} and measure I_C and V_{CE}

Analogy with Transistor in Active Region: Fluid-jet operated Valve

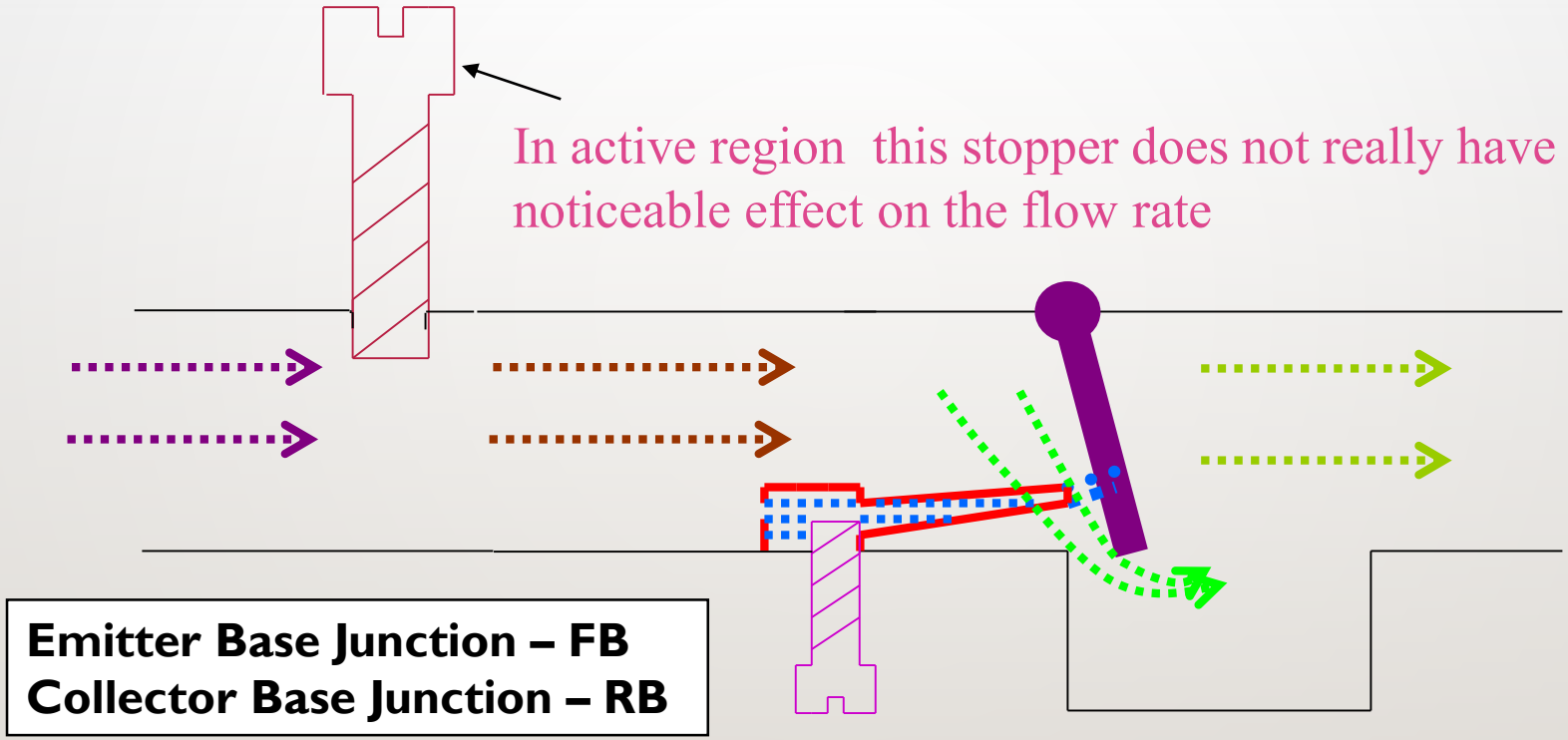


Fig. 2.8. Analogy of fluid jet operation to active region of BJT

Analogy with Transistor Cutoff
Fluid-jet operated Valve

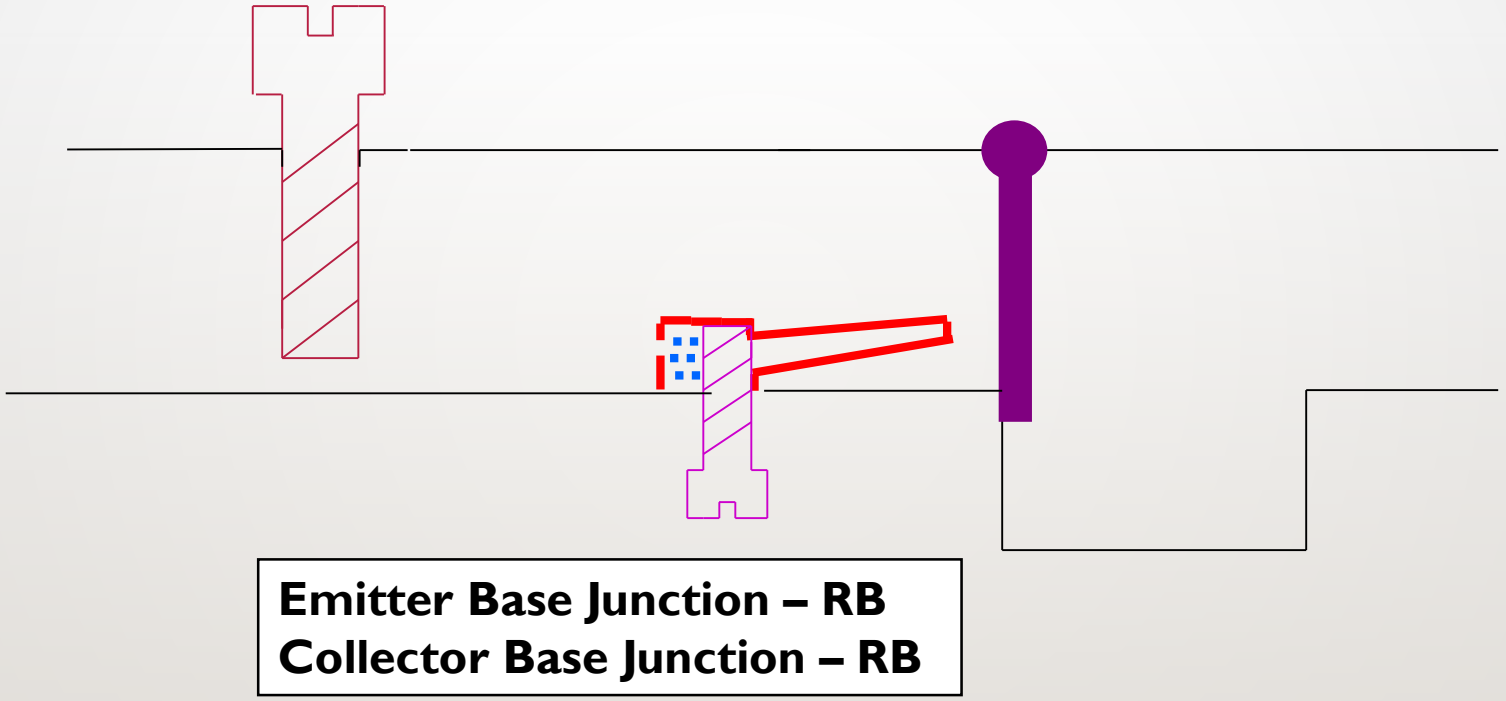
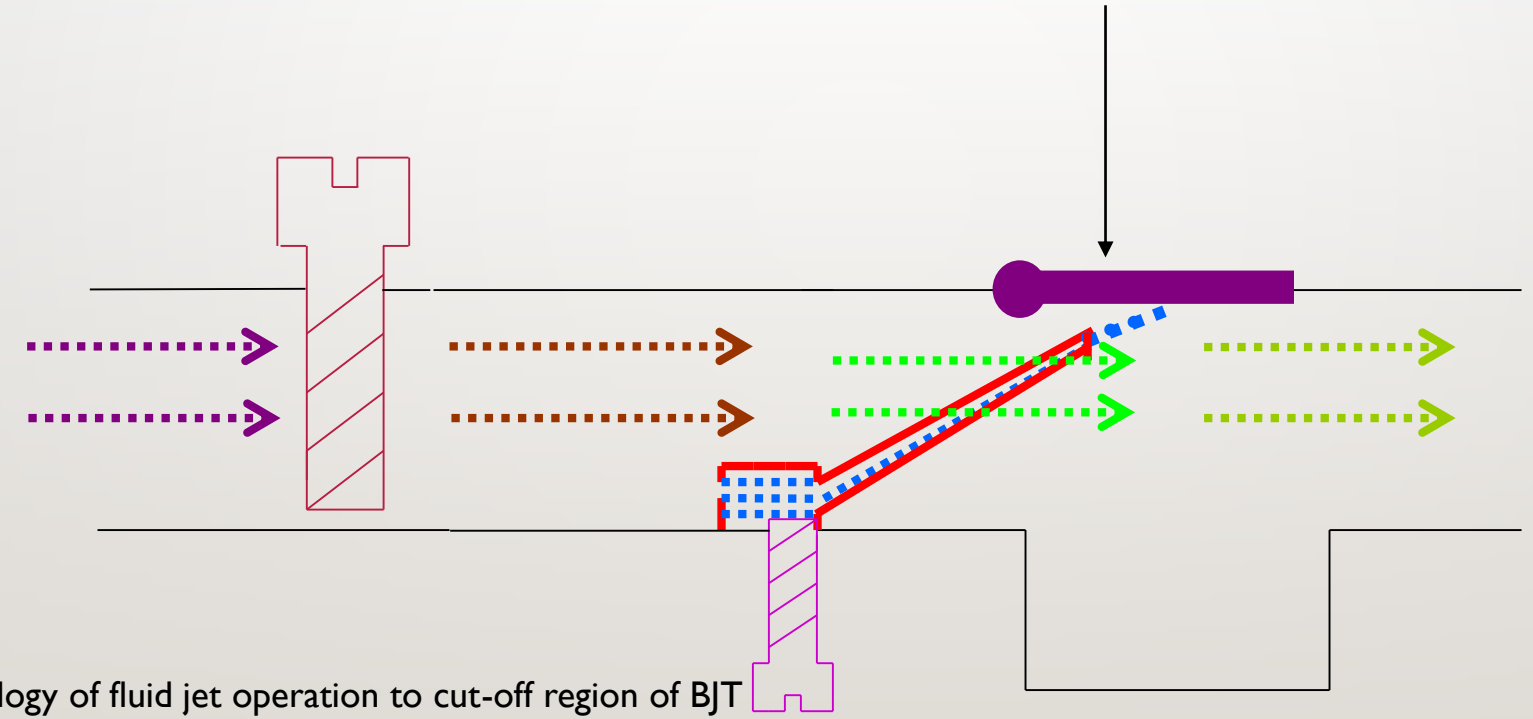


Fig. 2.9. Analogy of fluid jet operation to saturation region of BJT

Analogy with Transistor Saturation
Fluid-jet operated Valve

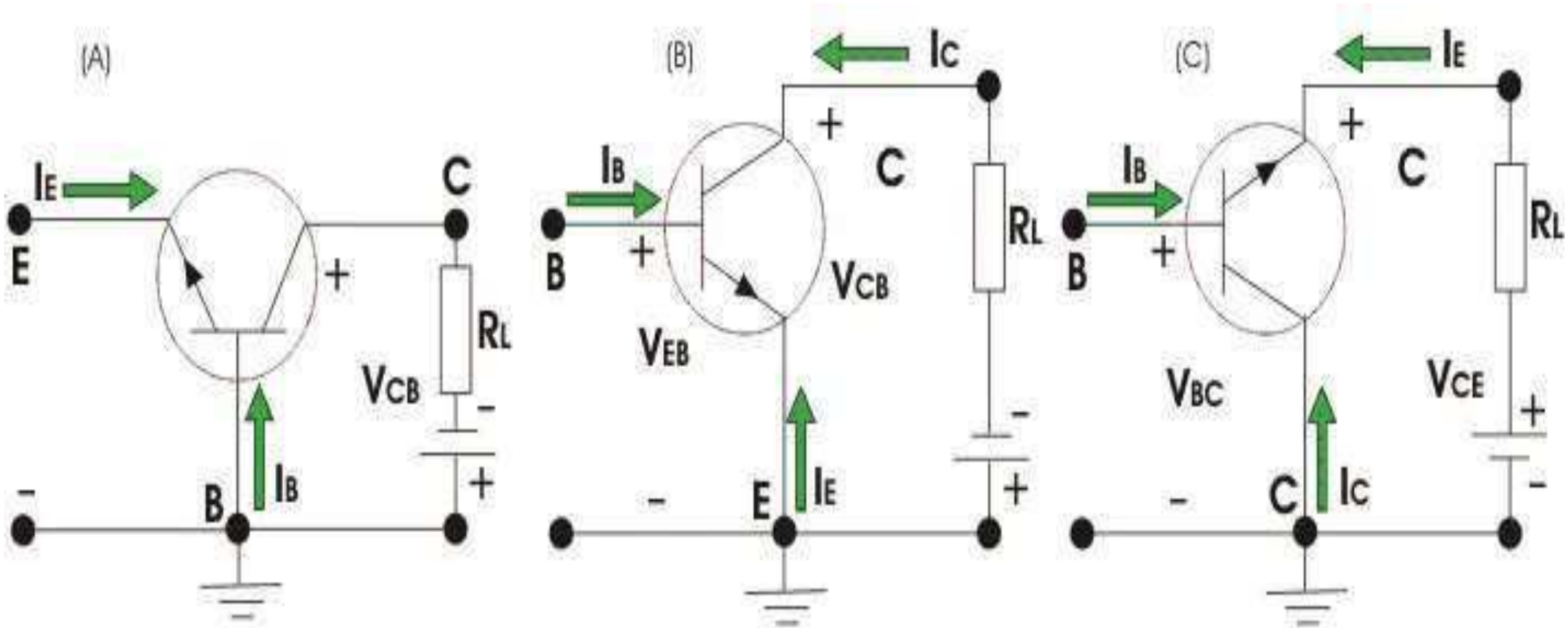
The valve is wide open; changing valve position a little bit does not have much influence on the flow rate.



E-B Junction – FB
C-B Junction – FB

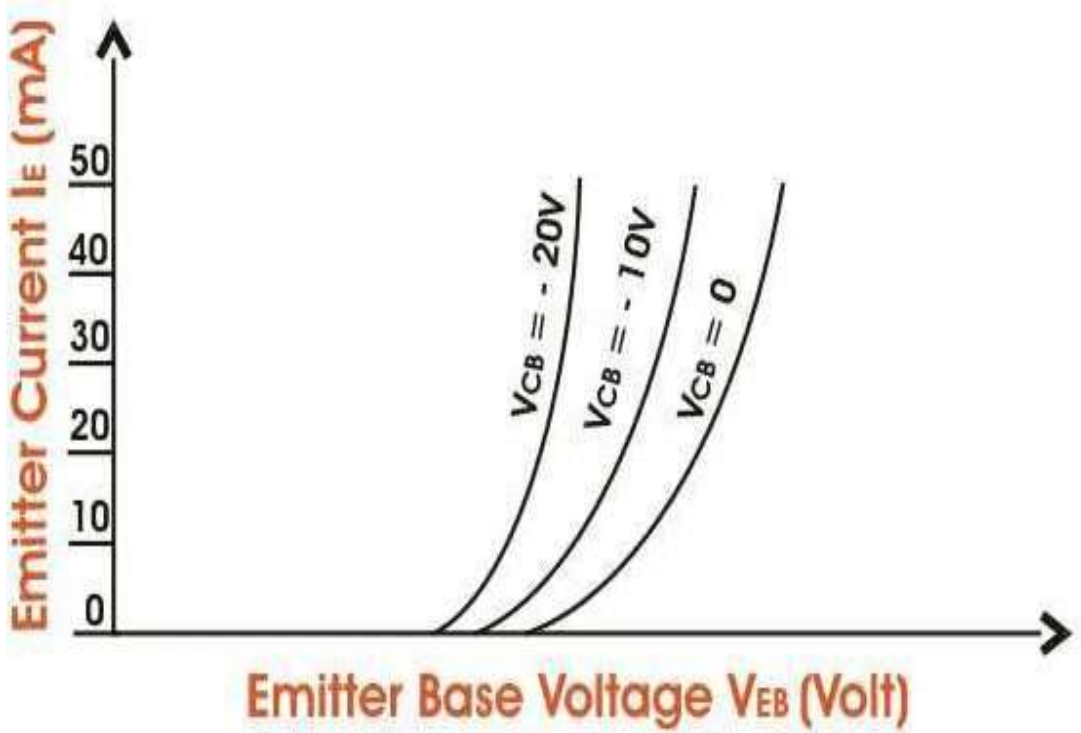
Fig. 2.10. Analogy of fluid jet operation to cut-off region of BJT

BJT

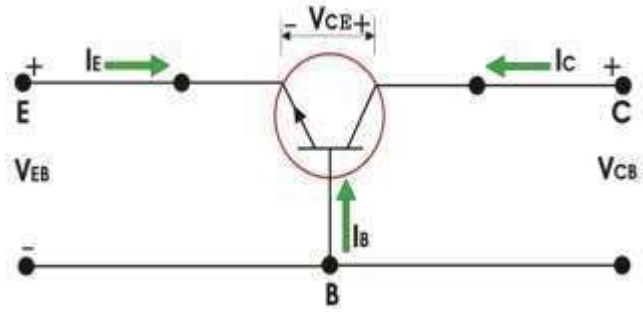


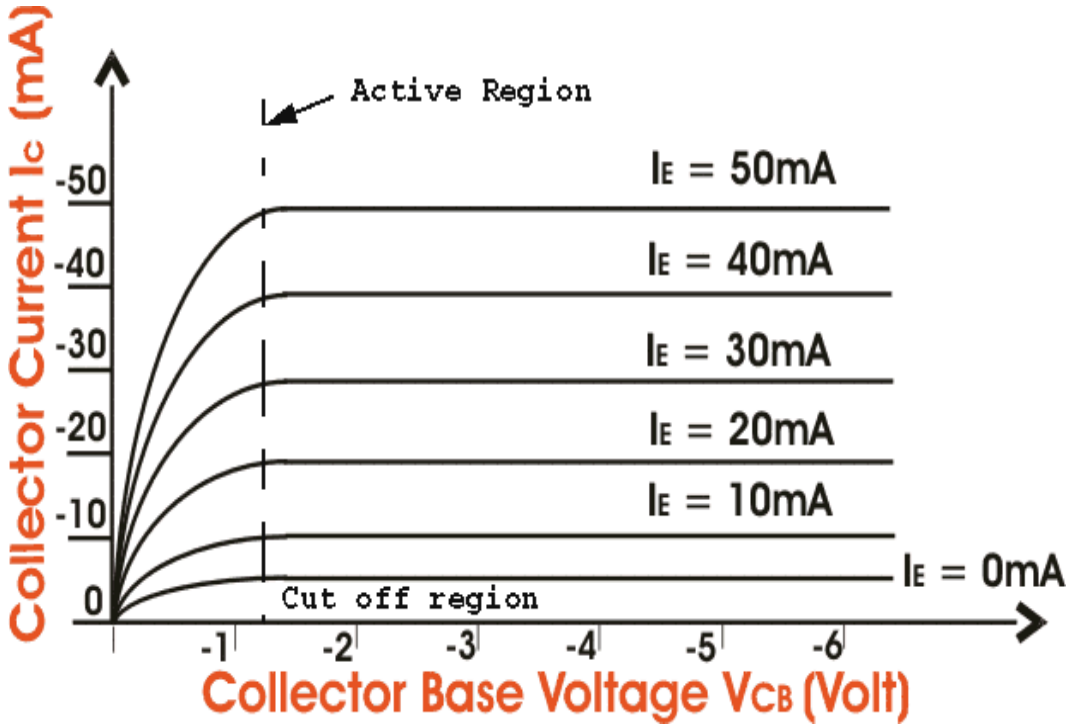
BJT

Common Base Characteristics
Input Characteristics



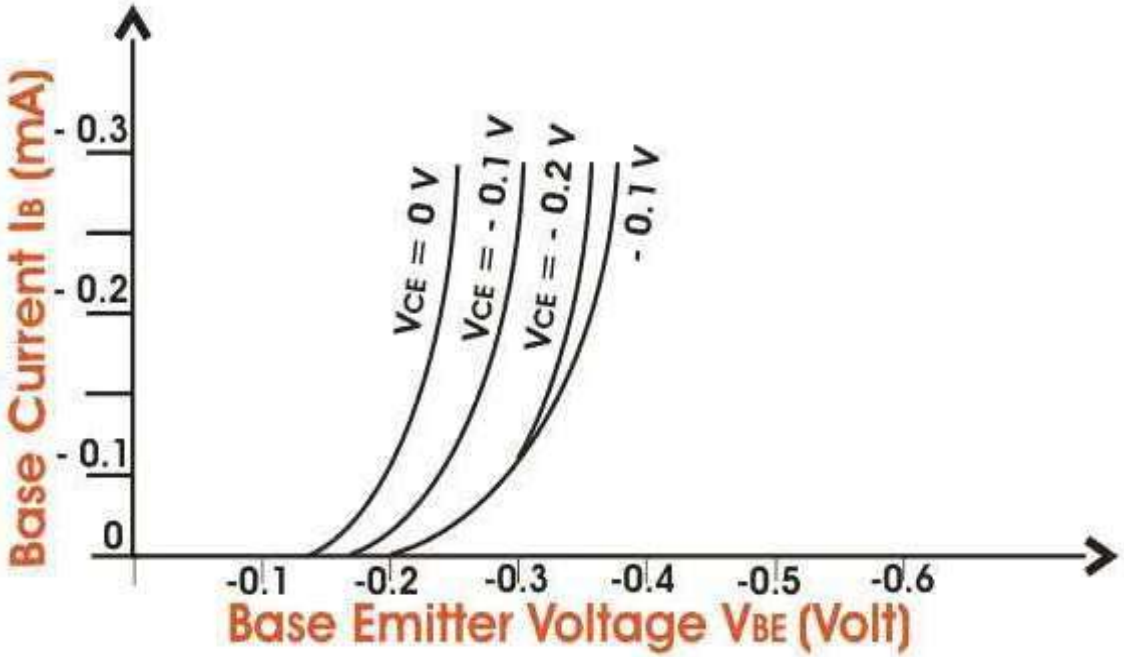
Output Characteristics



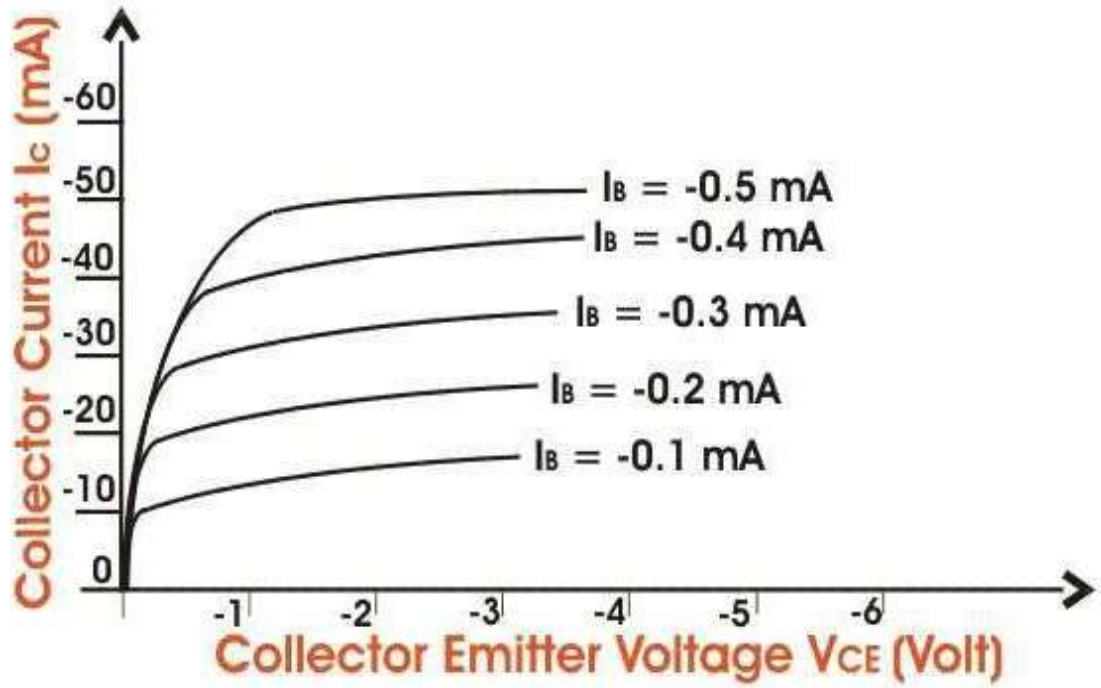


BJT

Common Emitter Characteristics
Input Characteristics



Output Characteristics

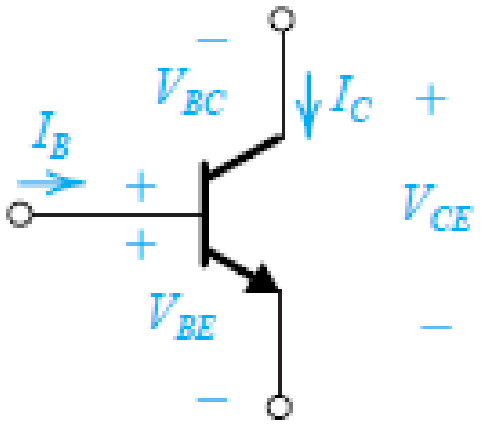


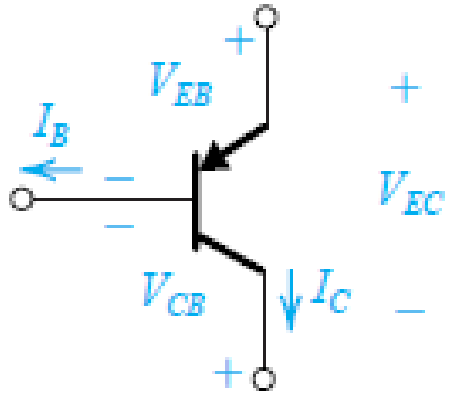
BJT Circuits at DC

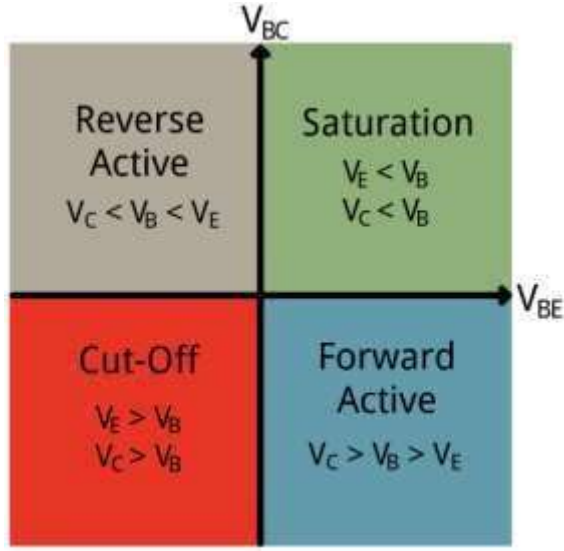
- Only DC Voltages are applied
- Vbe=0.7 V and Vce=0.2 V

Conditions and Models for the Operation of the BJT in Various Modes

npn	*pnp*



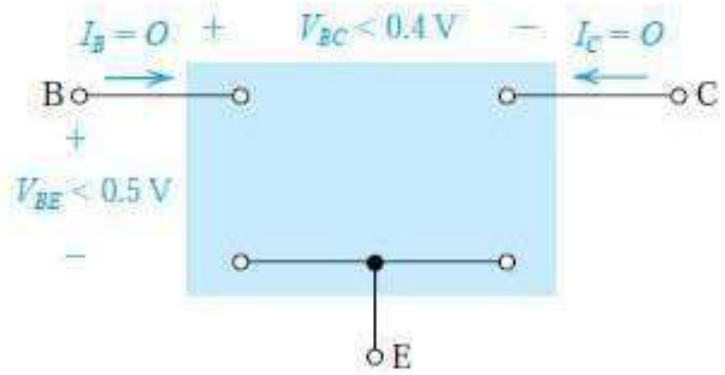


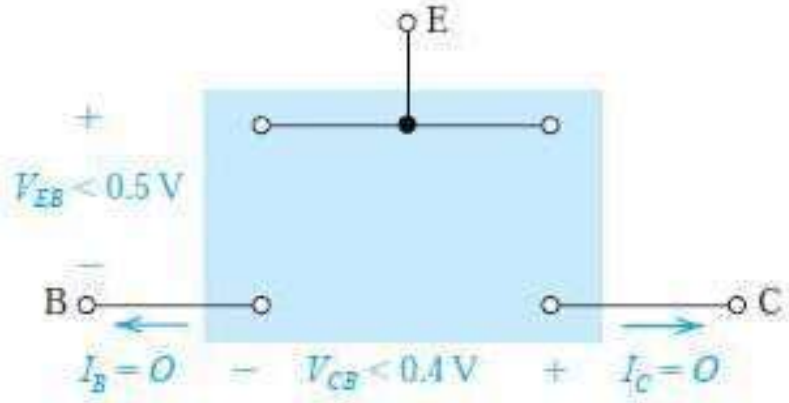


Cutoff

EJB: Reverse Biased

CBJ: Reverse Biased





BJT Circuits at DC

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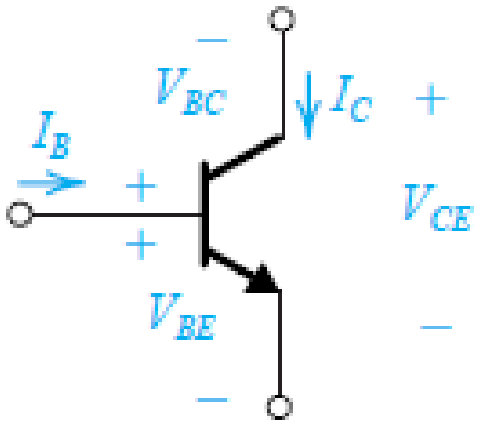
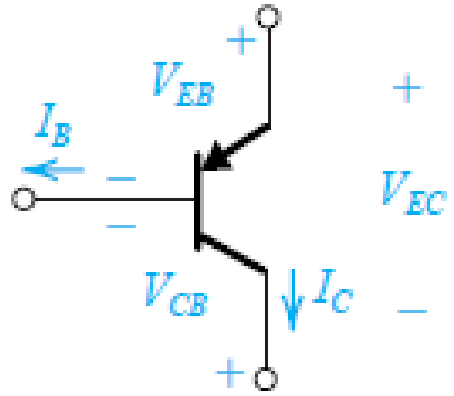
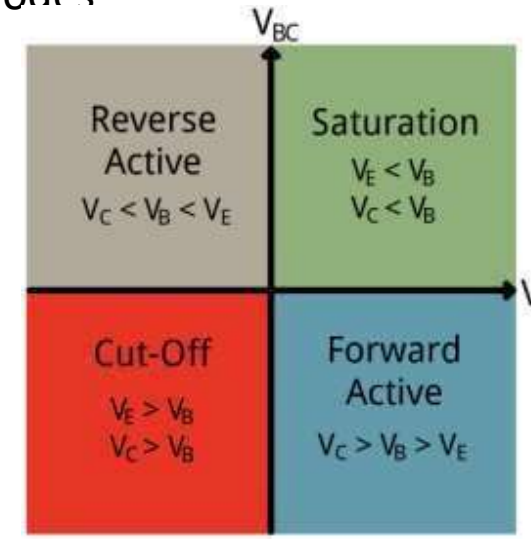
Conditions and Models for the Operation of the BJT in Various Modes

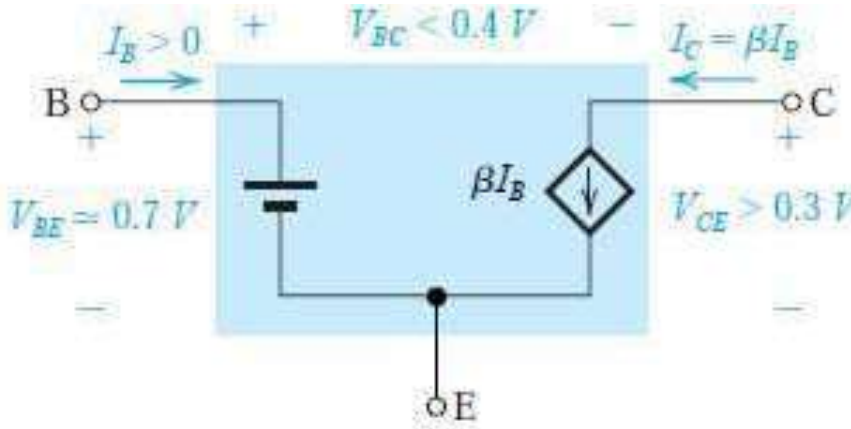
npn	*pnp*

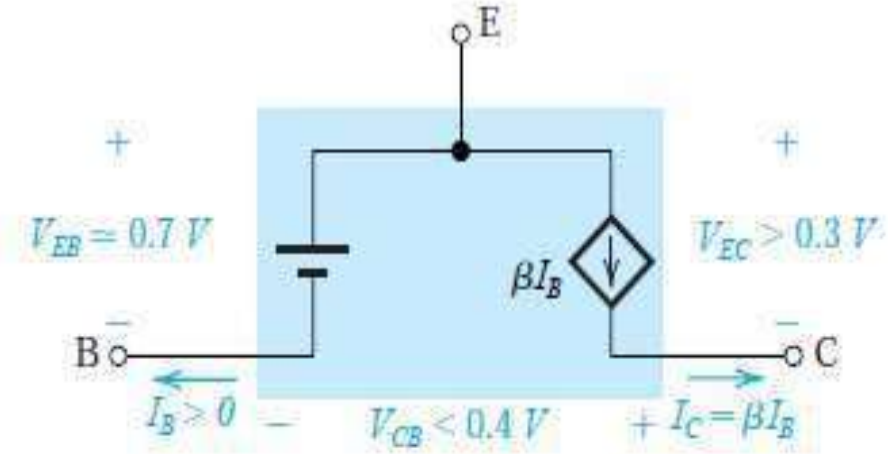






Active
EBJ: Forward Biased
CBJ: Reverse Biased

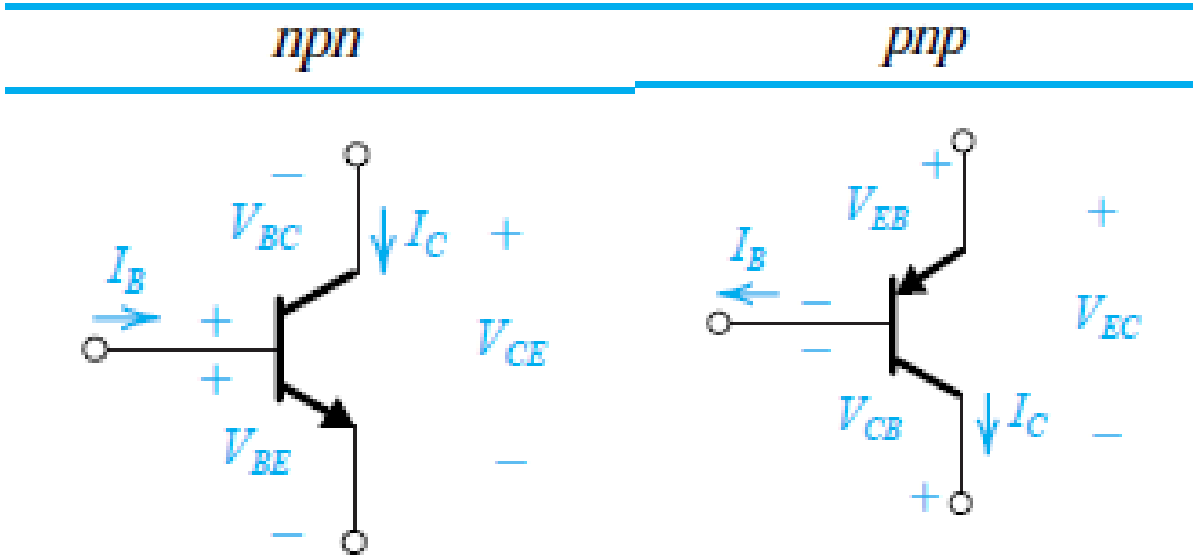


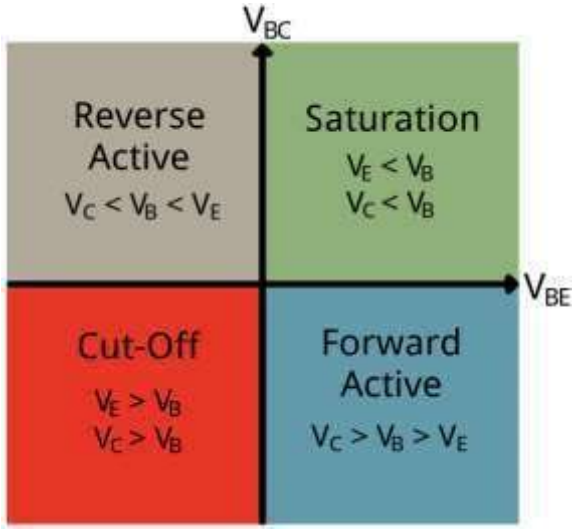


BJT Circuits at DC

Conditions and Models for the Operation of the BJT in Various Modes

- Only DC Voltages are applied
- Vbe=0.7 V and Vce=0.2 V

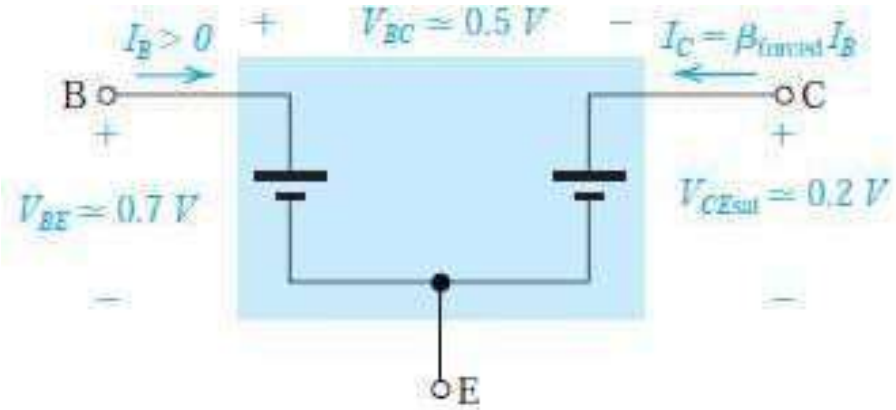


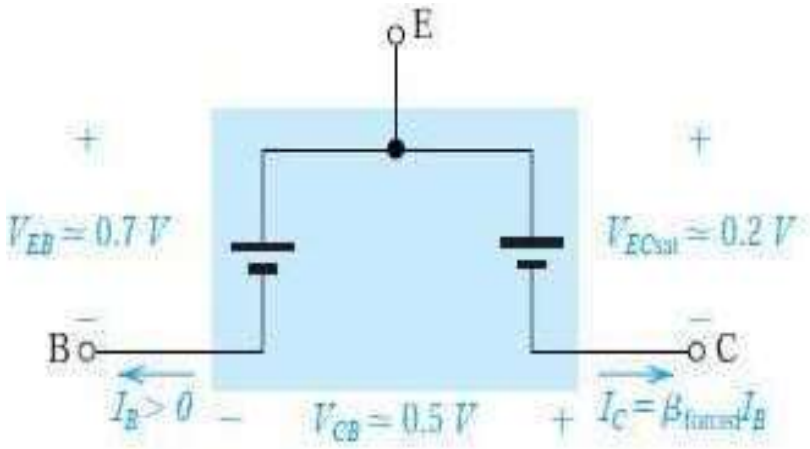


Saturation

EBJ: Forward Biased

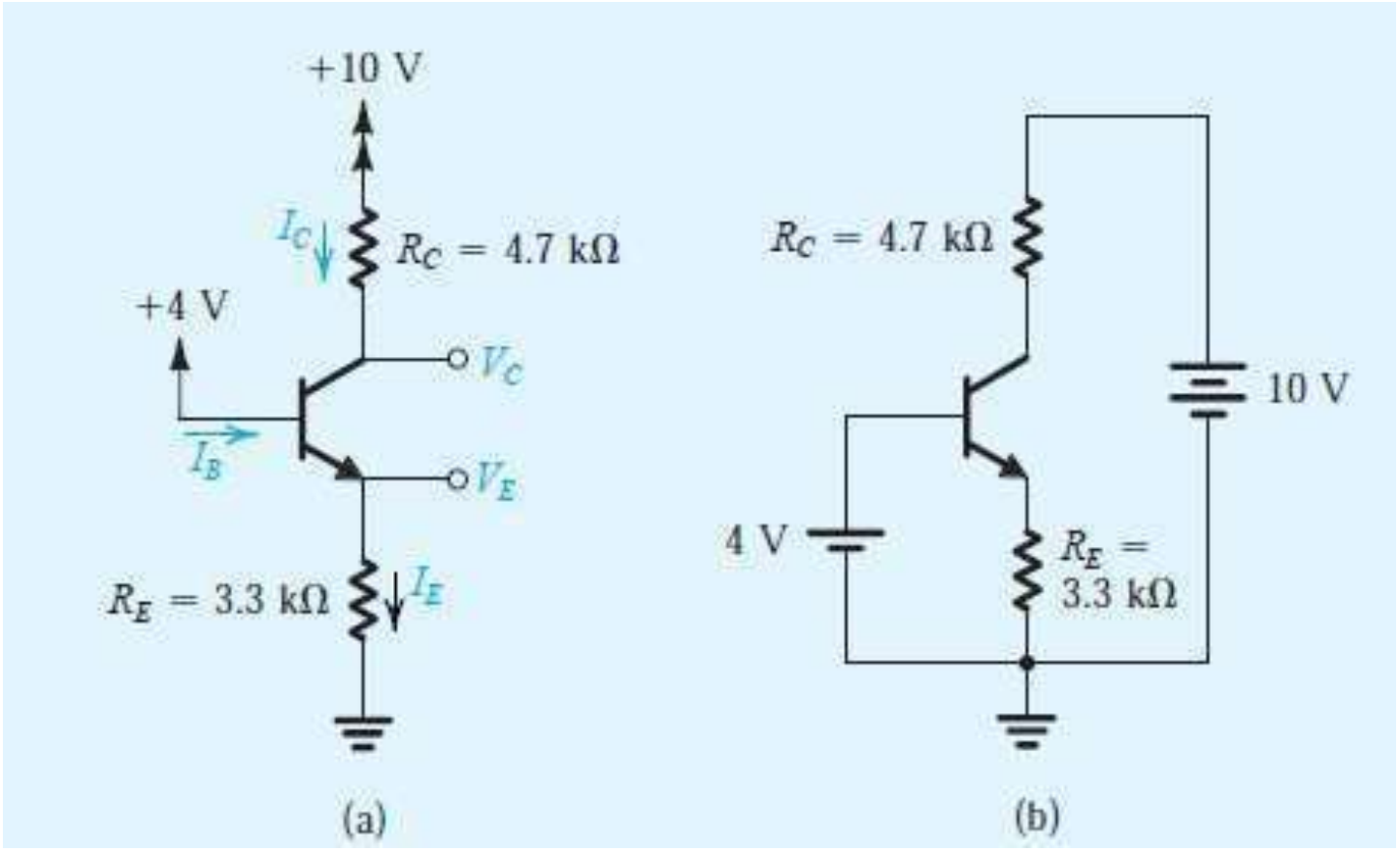
CBJ: Forward Biased

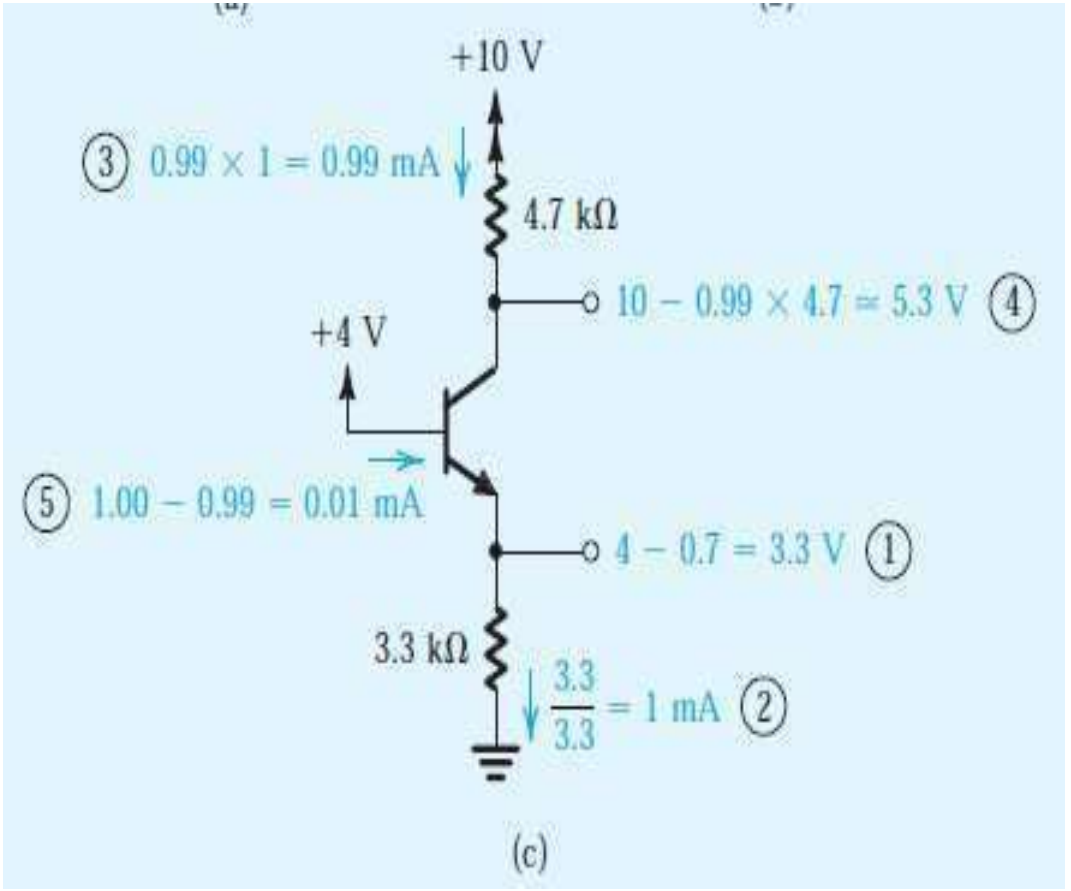




BJT Circuits at DC-Active Mode(Problems)

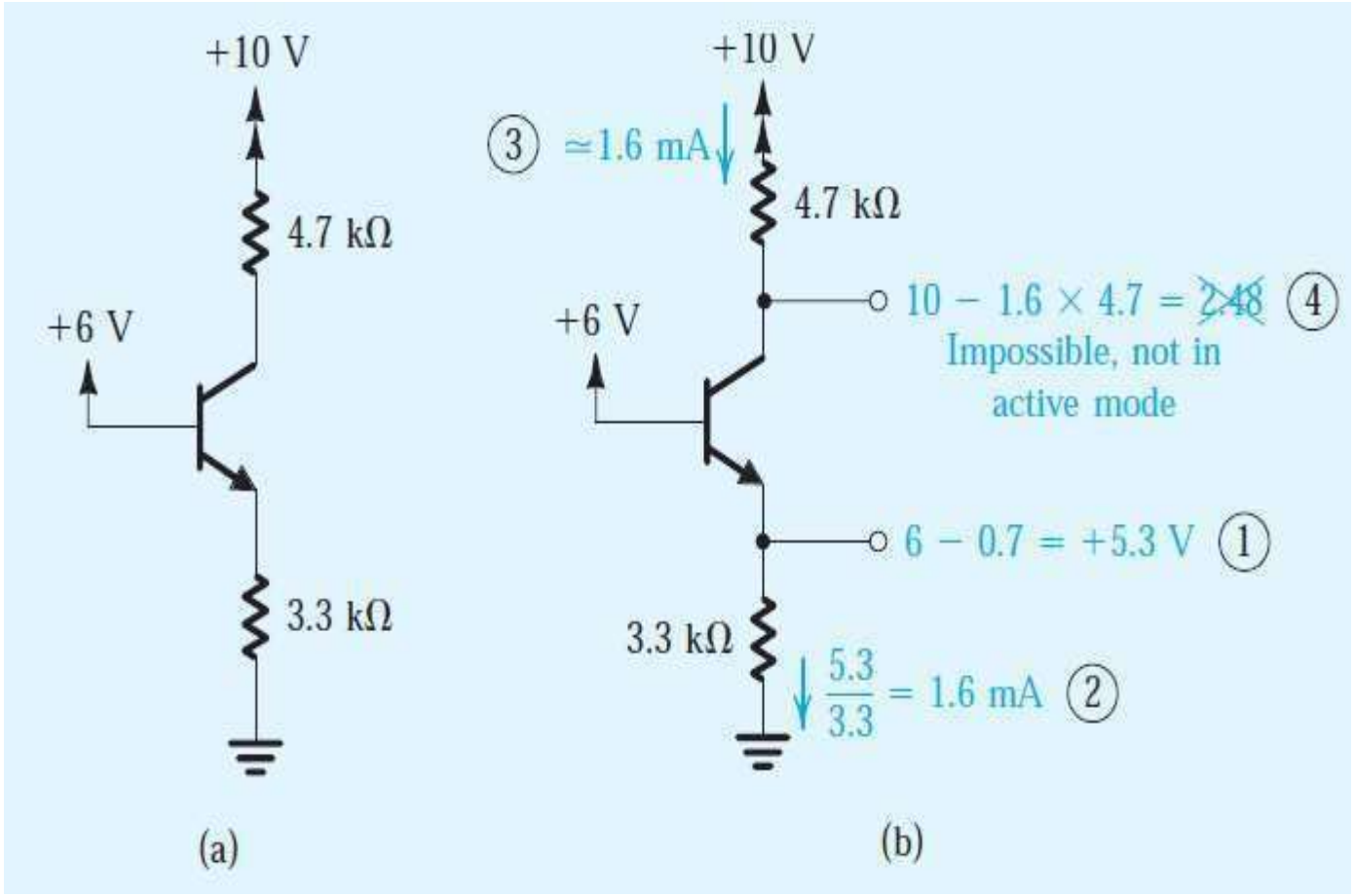
Example, β is specified to be 100.

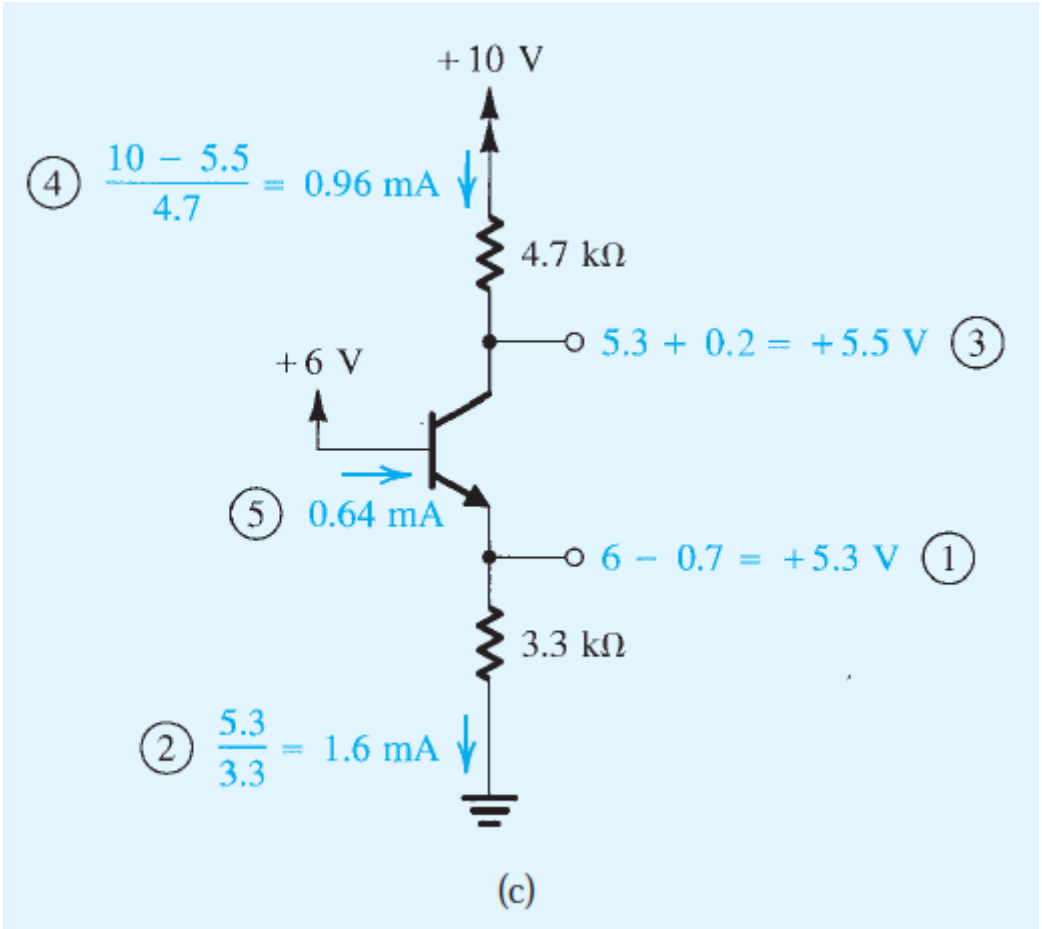




BJT Circuits at DC-Saturation Mode(Problems)

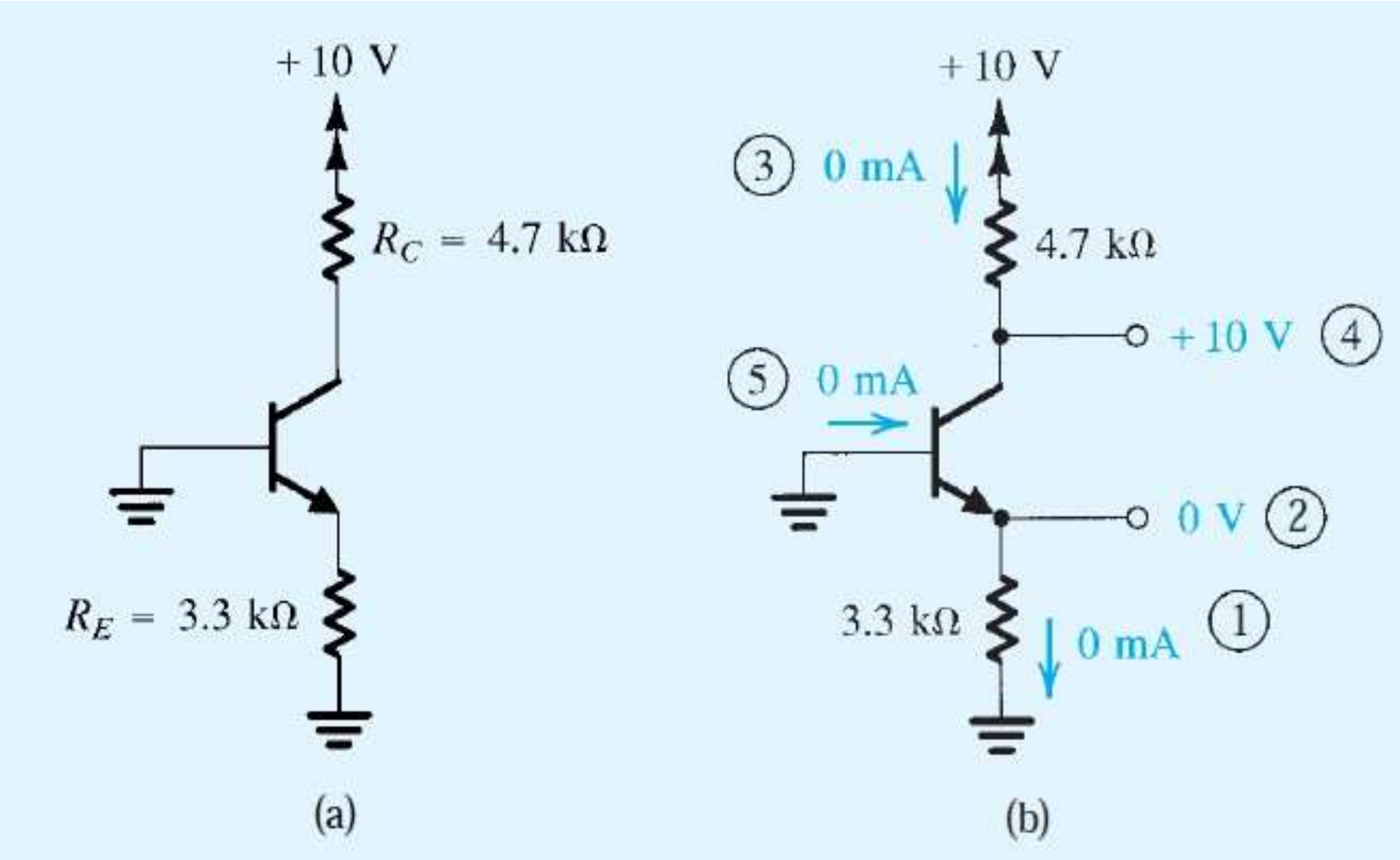
Example, β is specified to be ATLEAST OF 50.





BJT Circuits at DC-Cutoff Mode(Problems)

Example



BJT OPERATING REGIONS

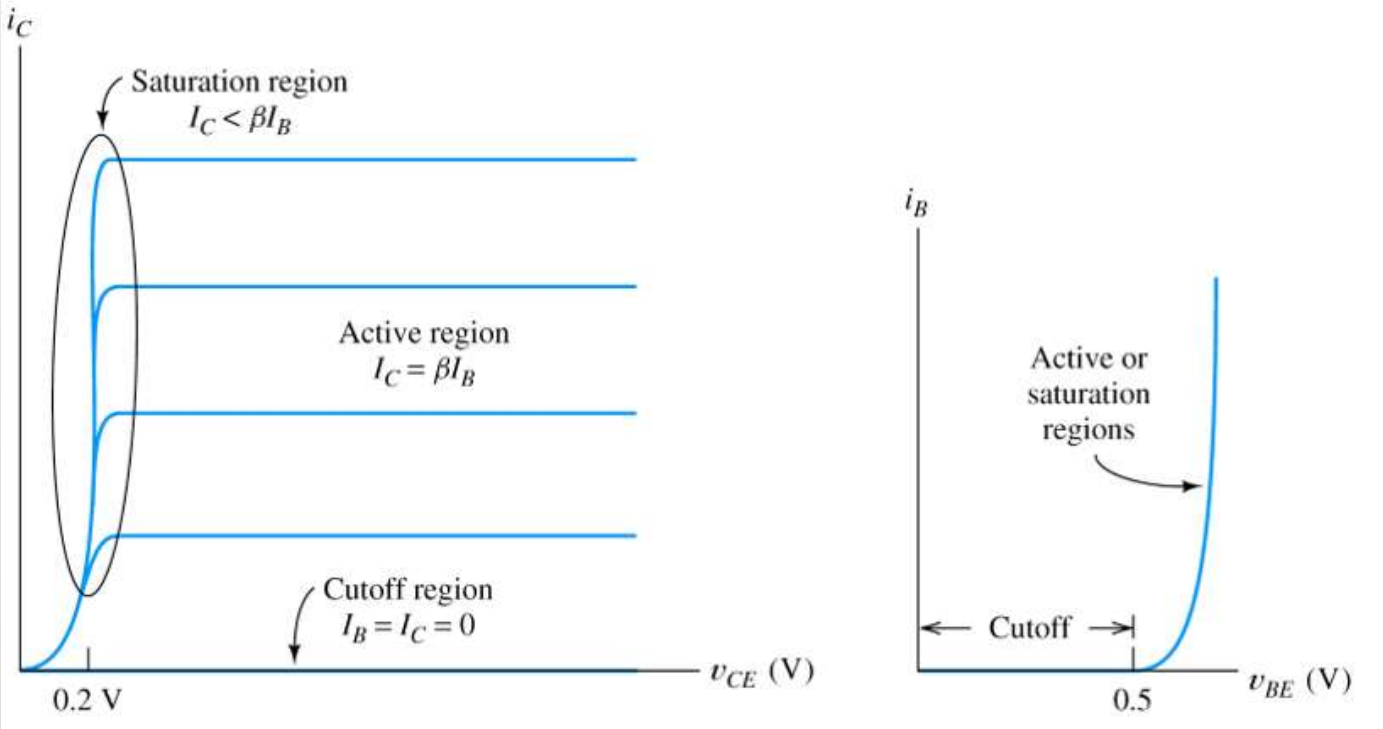
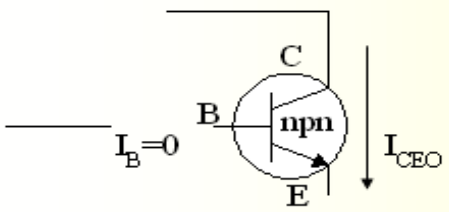


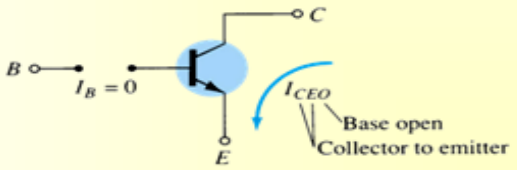
Fig. 2.11. Output and input characteristics of CE configured depicting possible operating regions of BJT (active, saturation, cutoff)

- **With the analogy discussed, the operation of BJT is driven in to any of the three regions with base current value.**
- **For this reason, BJT is termed as current controlled current source.**
- **BJT acts as controlled switch when continuously operated in cut off and saturation regions**
- **BJT acts as an amplifier when driven in to active region**

SUMMARY

Active region	Saturation region	Cut-off region
• B-E junction is forward bias • C-B junction is reverse bias • can be employed for voltage, current and power amplification	• B-E and C-B junction is forward bias, thus the values of I_B and I_C is too big. • The value of V_{CE} is so small. • Suitable region when the transistor as a logic switch. • NOT and avoid this region when the transistor as an amplifier.	• region below $I_B=0\mu A$ is to be avoided if an undistorted o/p signal is required • B-E junction and C-B junction is reverse bias • $I_B=0$, I_C not zero, during this condition $I_C=I_{CEO}$ where is this current flow when B-E is reverse bias.





Example Problems

2.1 BJT shown in Fig. 2.12 has β_{DC} of 300. Calculate I_B, I_C, V_{CE} and P_D.

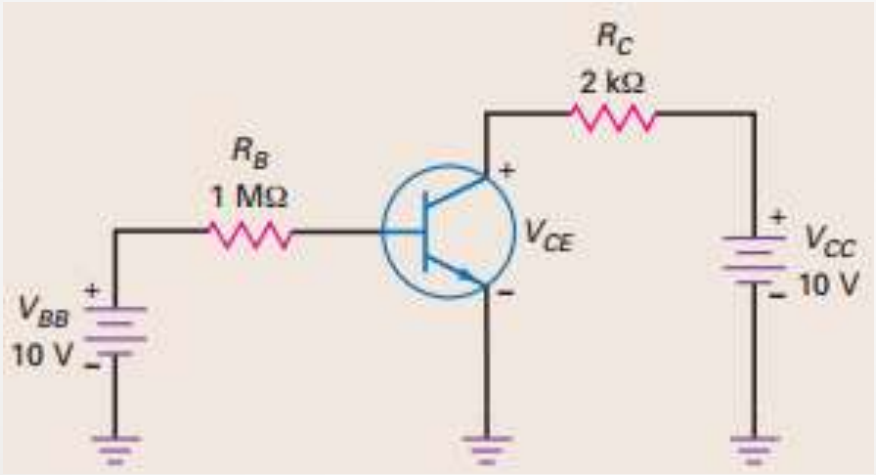


Fig. 2.12. CE Configured BJT biased with external voltages

Solution:

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{10\text{ V} - 0.7\text{ V}}{1\text{ M}\Omega} = 9.3\ \mu\text{A}$$

The collector current is:

$$I_C = \beta_{dc} I_B = (300)(9.3\ \mu\text{A}) = 2.79\text{ mA}$$

and the collector-emitter voltage is:

$$V_{CE} = V_{CC} - I_C R_C = 10\text{ V} - (2.79\text{ mA})(2\text{ k}\Omega) = 4.42\text{ V}$$

The collector power dissipation is:

$$P_D = V_{CE} I_C = (4.42\text{ V})(2.79\text{ mA}) = 12.3\text{ mW}$$

Example Problems

2.2 For the ideal BJT shown in Fig. 2.13 has β_{DC} of 100. Determine V_{CE}

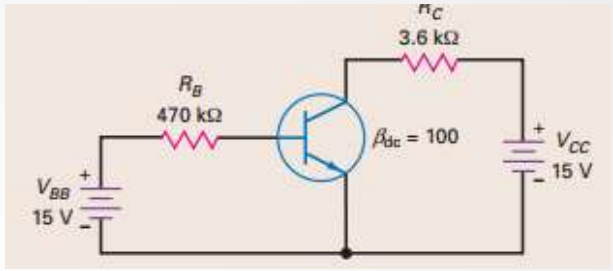


Fig. 2.13. CE Configured BJT biased with external voltages

Solution:

$$V_{BE} = 0$$

Therefore, the total voltage across R_B is 15 V. Ohm's law tells us that:

$$I_B = \frac{15\text{ V}}{470\text{ k}\Omega} = 31.9\ \mu\text{A}$$

The collector current equals the current gain times the base current:

$$I_C = 100(31.9\ \mu\text{A}) = 3.19\text{ mA}$$

Next, we calculate the collector-emitter voltage. It equals the collector supply voltage minus the voltage drop across the collector resistor:

$$V_{CE} = 15\text{ V} - (3.19\text{ mA})(3.6\text{ k}\Omega) = 3.52\text{ V}$$

In a circuit like Fig. 6-14, knowing the value of the emitter current is not important, so most people would not calculate this quantity. But since this is an example, we will calculate the emitter current. It equals the sum of the collector current and the base current:

$$I_E = 3.19\text{ mA} + 31.9\ \mu\text{A} = 3.22\text{ mA}$$

This value is extremely close to the value of the collector current, which is another reason for not bothering to calculate it. Most people would say that the emitter current is approximately 3.19 mA, the value of the collector current.

SELF-ASSESSMENT QUESTIONS

1. BJT is modelled as

(a) Voltage controlled voltage source
(b) Current controlled voltage source
(c) Current controlled current source
(d) Voltage controlled current source

2. What is the current in BJT in cut-off region

(a) βI_B
(b) $< \beta I_B$
(c) Zero

SELF-ASSESSMENT QUESTIONS

3. Which mode does BJT operate if B-E and B-C junctions are forward biased?

(a) Saturation
(b) Active
(c) Cut-off

4. Which parameter shall be constant to plot input characteristics?

(a) V_{CE}
(b) V_{BE}
(c) I_C
(d) I_B

ANSWERS

1. C
2. C
3. A
4. A

TERMINAL QUESTIONS

1. Describe how to configure BJT in common emitter mode operation.
2. Discuss the input characteristics of BJT.
3. Discuss the output characteristics of BJT.
4. Draw output characteristics of BJT for various input base current values.
5. Derive the analogy between electron flow in BJT and jet flow in valve operated tube.
6. Identify the regions of operation of BJT

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

(DEEMED TO BE UNIVERSITY)

Team – ANALOG ELECTRONIC CIRCUIT DESIGN

Prepared by – Mr. S. Ravi Teja