AY-2025-2026
ODD SEM

Department of ECE

ANALOG ELECTRONIC CIRCUIT DESIGN

24EC2104

Topic:

BJT Q-POINT

Session - 03

SESSION CONTENT

- Open circuit voltage
- Short circuit current
- Load line
- Operating point

AIM OF THE SESSION

To demonstrate operating point of BJT

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Demonstrate open circuit voltage
2. Demonstrate circuit current
3. Demonstrate Load line of BJT.
4. Identify operating point of BJT for changing current gains.

LEARNING OUTCOMES

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

1. Plot open circuit voltage
2. Plot short circuit current
3. Determine Load line of BJT.
4. Identify operating point of BJT for changing current gains.

BJT PLACED IN A CIRCUIT

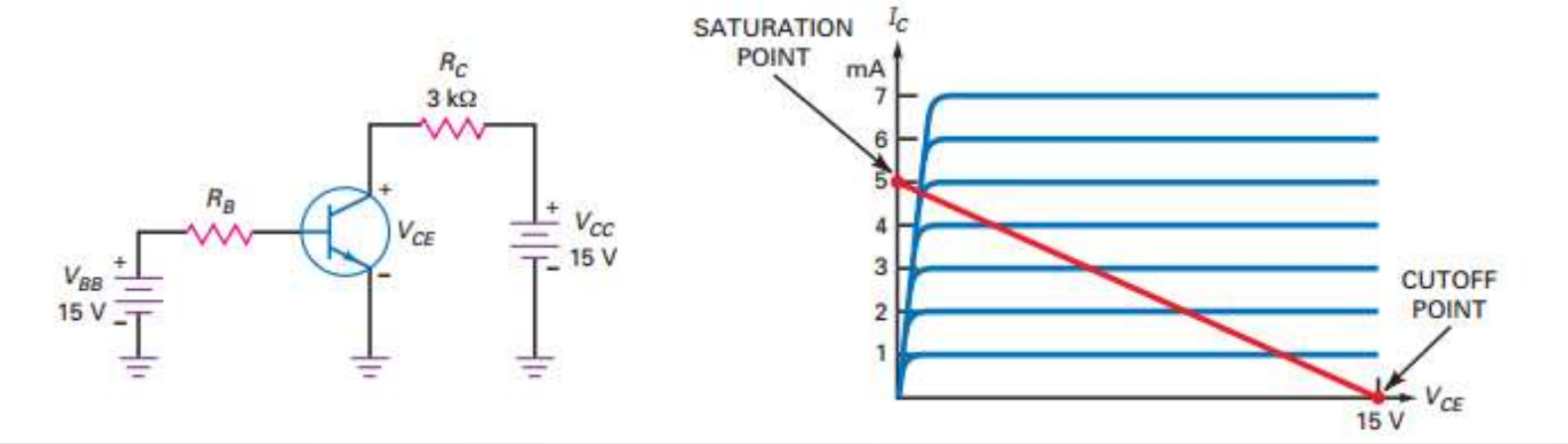


Fig. 3.1. BJT placed in a circuit with fixed conditions, identifying circuit conditions and operating characteristics

- **In order for a transistor to function as an amplifier or a switch, it must first have its dc circuit conditions set properly. This is referred to as properly biasing the transistor.**
- **Fig. 3.1. depicts a situation where BJT with given output characteristics is placed in a circuit with given voltages and resistors.**
- **Further step is to determine which are the worst case voltage and current that BJT shall carry in the given circuit.**
- **Finally to obtain a common point which satisfy the operating characteristics and circuit conditions.**

OPEN CIRCUIT VOLTAGE

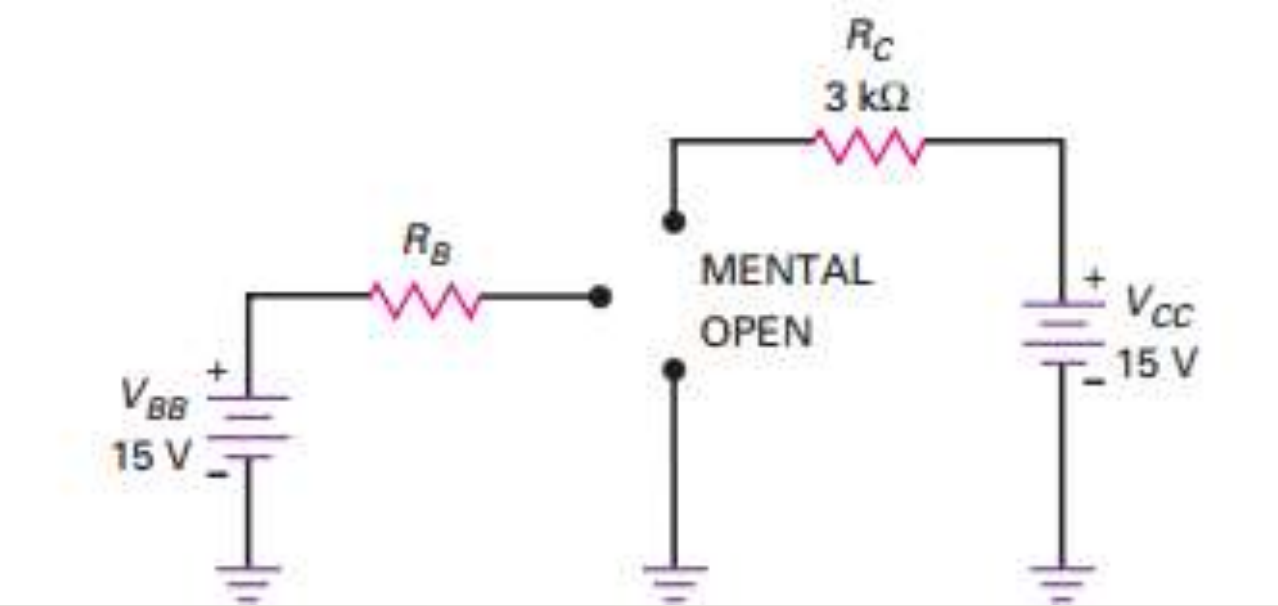


Fig. 3.2. BJT placed in a circuit with fixed conditions, identifying open circuit voltage

- To determine which are the worst case voltage and current that BJT shall carry in the given circuit.
- First, open circuit the BJT terminals and find the voltage across collector-emitter terminals
- For the given circuit conditions, the open circuit voltage across C-E terminals $V_{CEcutoff}$ = 15 V

SHORT CIRCUIT CURRENT

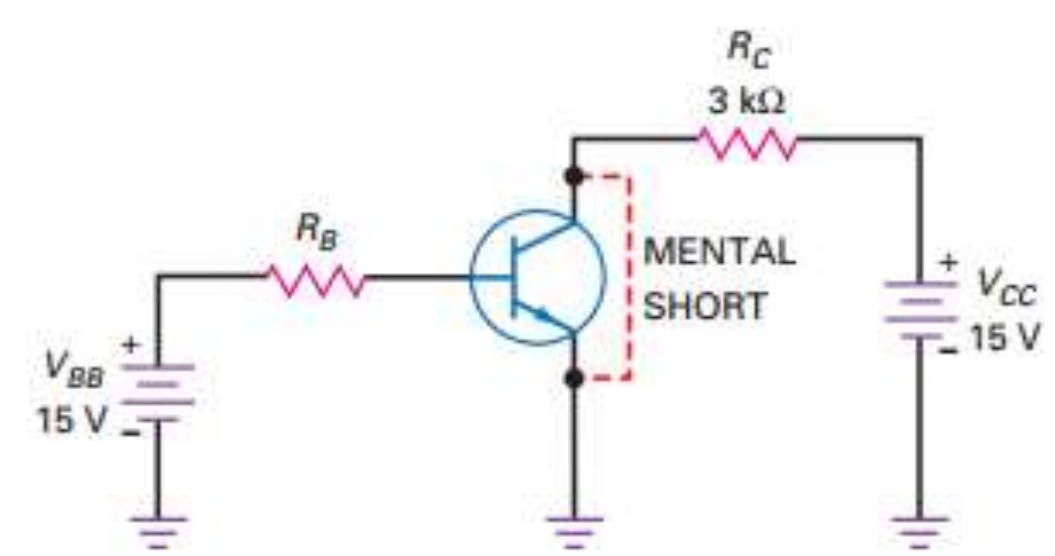
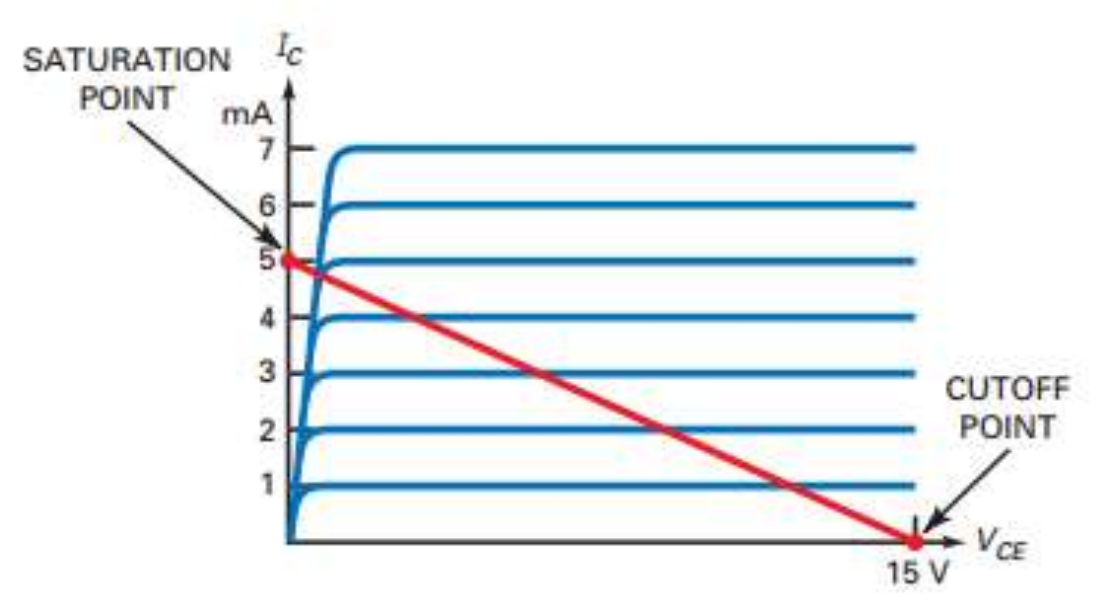


Fig. 3.3. BJT placed in a circuit with fixed conditions, identifying short circuit current

- **To determine which are the worst case voltage and current that BJT shall carry in the given circuit.**
- **Next, short circuit the BJT C-E terminals and find the current through the short circuit.**
- **For the given circuit conditions, the short circuit current through C-E terminals I_{Csat} = 15V/3 kΩ = 9mA**

LOAD LINE



- **Now, the voltage across C-E terminals and current through C-E terminals can take the values only on the line joining the $V_{CEcutoff}$ and I_{Csat} , owing to the given output circuit.**
- **This line joining these two parameters is termed as Load line**

Fig. 3.4. BJT placed in a circuit with fixed conditions, identifying circuit conditions and operating characteristics

OPERATING POINT (Q-POINT)

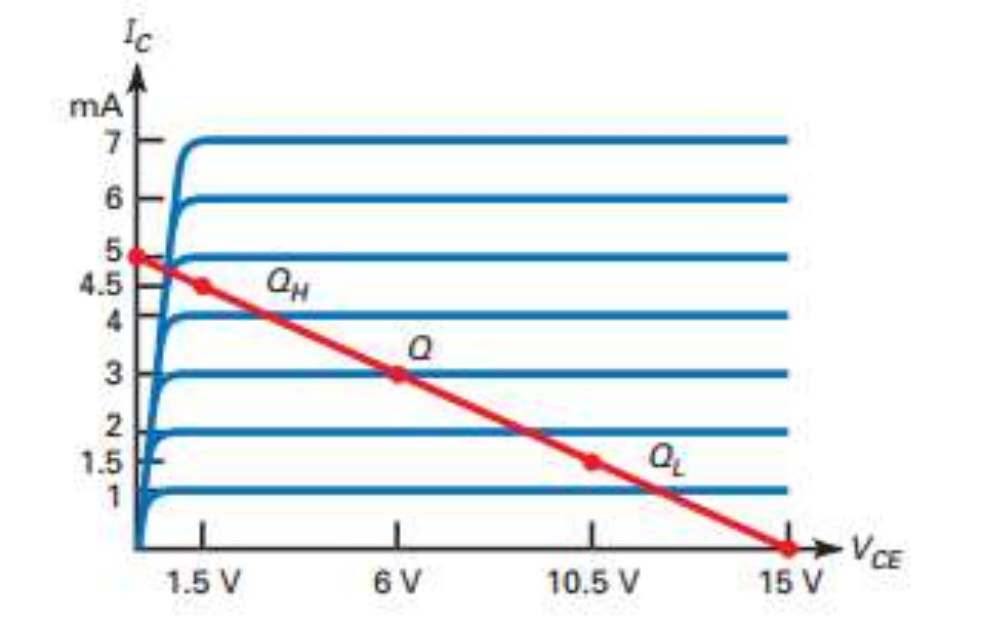


Fig. 3.5. BJT placed in a circuit with fixed conditions, identifying operating point

- The voltage across C-E terminals and current through C-E terminals can take the values only on the line joining the $V_{CEcutoff}$ and I_{Csat} , owing to the given output circuit.
- This line joining these two parameters is termed as Load line.
- Output characteristics are controlled by current gain and input current.
- The intersection of load line and output characteristics is the only points where both device operation and circuit operation are feasible.
- This is termed as operating point or Q-point

Example Problems

3.1 Draw the load lines for circuits shown in Fig. 3.6.

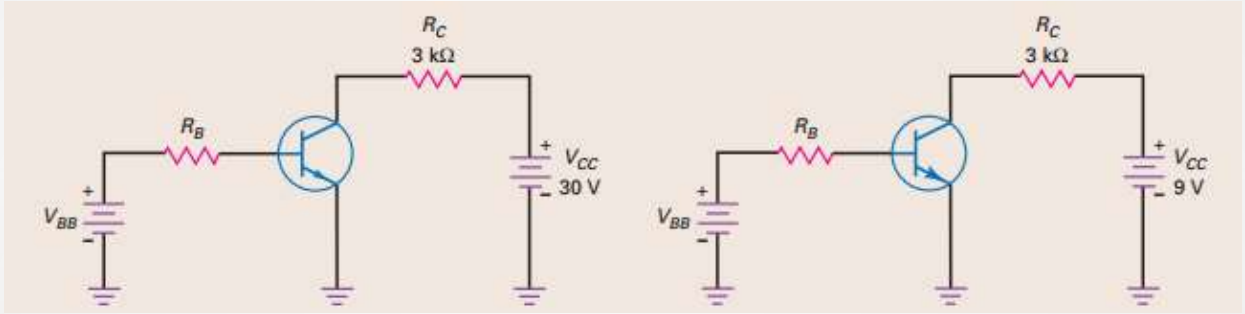


Fig. 3.6. BJT placed in circuits with voltage and current limiter resistances

SOLUTION Visualize a short between the collector and emitter. Then:

$$I_{C(sat)} = \frac{30\text{ V}}{3\text{ k}\Omega} = 10\text{ mA}$$

Next, visualize the collector-emitter terminals open. In this case:

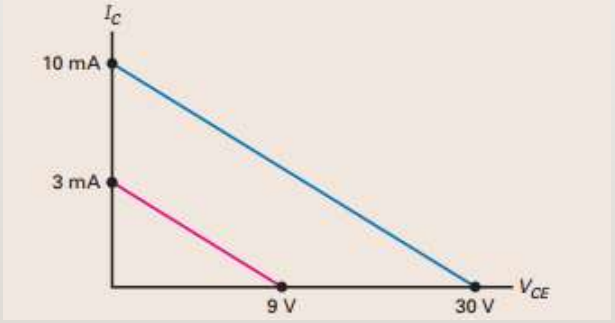
$$V_{CE(cutoff)} = 30\text{ V}$$

SOLUTION With a mental short between the collector and emitter:

$$I_{C(sat)} = \frac{9\text{ V}}{3\text{ k}\Omega} = 3\text{ mA}$$

A mental open between the collector and emitter gives:

$$V_{CE(cutoff)} = 9\text{ V}$$



Example Problems

3.2 For the ideal BJT shown in Fig. 3.7 having β_{DC} of 100, determine Q-point and if base resistance changes to 1 MΩ determine the new Q-Point.

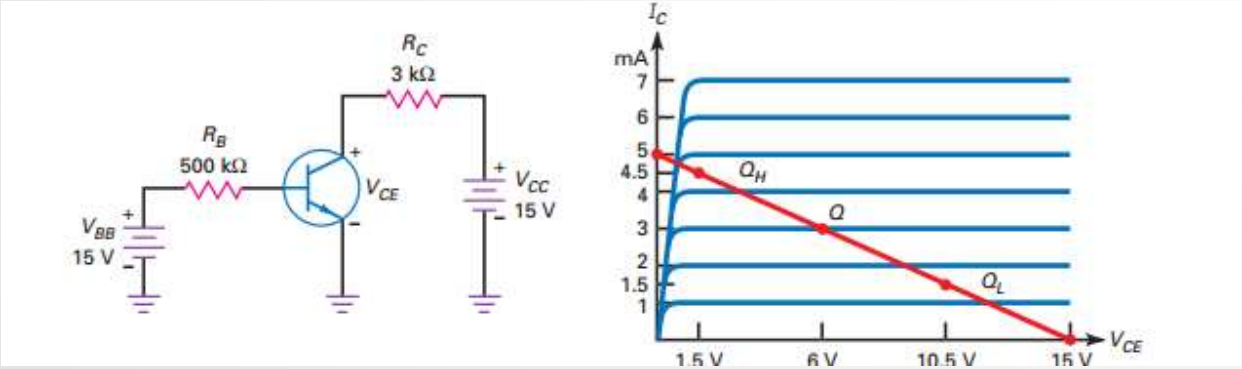


Fig. 3.7. CE Configured BJT biased with external voltages

Solution:

SOLUTION Ideally, the base current would decrease to 15 μA, the collector current would decrease to 1.5 mA, and the collector-emitter voltage would increaseto:

$$V_{CE} = 15 - (1.5\text{ mA})(3\text{ k}\Omega) = 10.5\text{ V}$$

To a second approximation, the base current would decrease to 14.3 μA, and the collector current would decrease to 1.43 mA. The collector-emitter voltage would increase to:

$$V_{CE} = 15 - (1.43\text{ mA})(3\text{ k}\Omega) = 10.7\text{ V}$$

SELF-ASSESSMENT QUESTIONS

1. Load line is drawn between

(a) V_{OC} and I_{SC}
(b) I_{OC} and V_{SC}
(c) V_{SC} and V_{OC}
(d) I_{SC} and I_{OC}

2. What is the Quiescent collector current I_C for BJT in active region

(a) βI_B
(b) $< \beta I_B$
(c) Zero

SELF-ASSESSMENT QUESTIONS

3. Which mode does BJT Q-point to be biased for amplification

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

4. Operating point is the intersection of load line and device characteristics.

(a) False
(b) True

ANSWERS

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

TERMINAL QUESTIONS

1. Describe open circuit voltage across a circuit element at load terminals.
2. Discuss short circuit current in a circuit element
3. Draw the load line of BJT for given circuit.
4. Draw output characteristics of BJT for various input base current values.
5. Draw the load lines for varying resistance in output loop of BJT.
6. Identify the Q-point of BJT for given circuit.

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

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