SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Course Name: 23BMB101-Electron Devices and Circuits

I Year : II Semester

Unit II –Transistors

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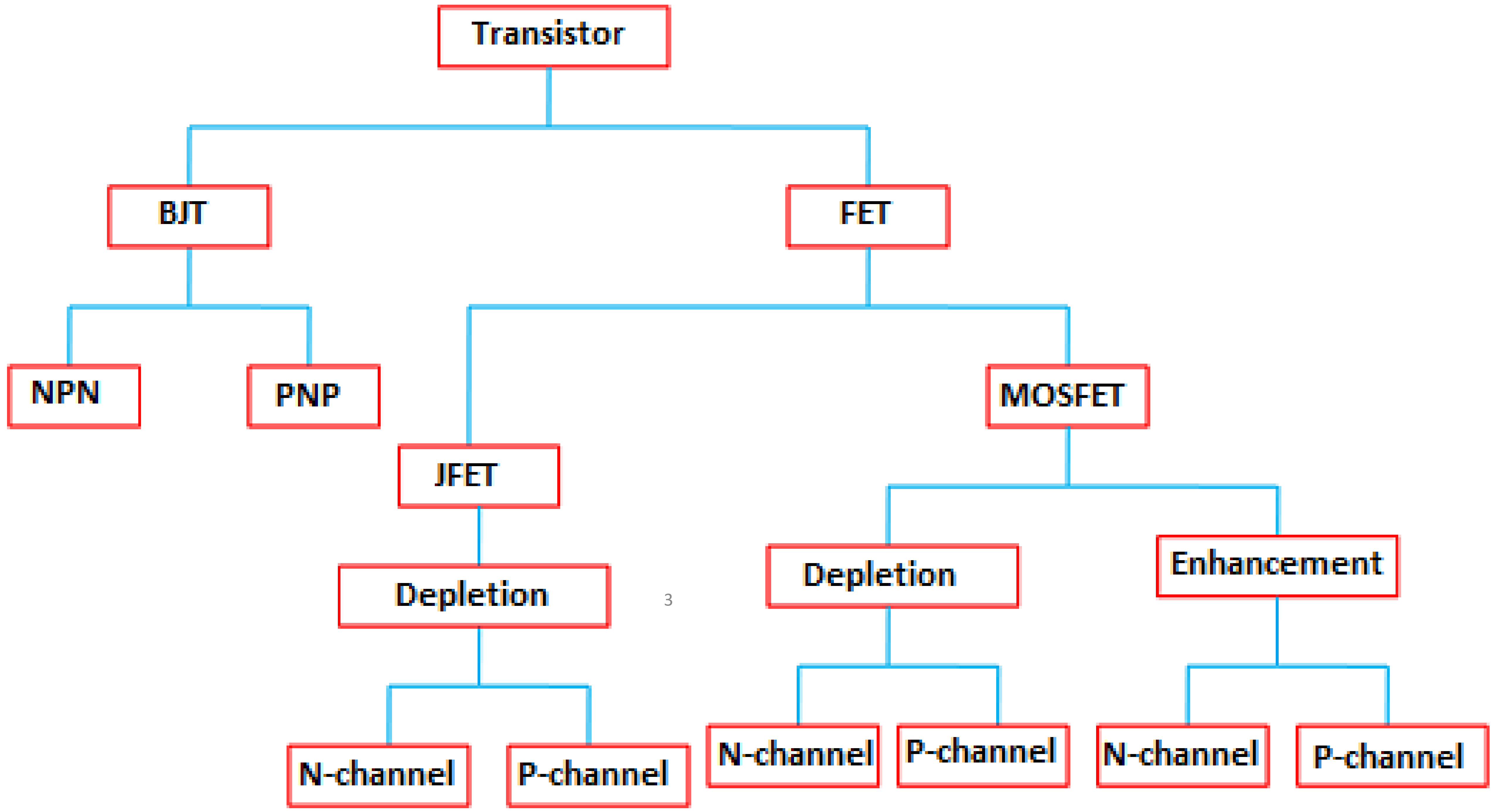
Topic : Bipolar Junction Transistor

INTRODUCTION

- When a p-type semiconductor is joined with the n-type semiconductor, a p-n junction is formed between them. This p-n junction forms a most popular device known as a semiconductor diode.
- An addition of another layer to a p-n junction diode forms a three terminal device called a transistor that amplifies the electronic signals. The term transistor normally refers to a Bipolar Junction Transistor (BJT).
- The transistor that is made up of one p-type and two n-type semiconductor layers is known as n-p-n transistor whereas the transistor that is made up of one n-type and two p-type semiconductor layers is known as p-n-p transistor.

Classification of Transistors



Classification of transistors

Bipolar Junction Transistor

- A bipolar junction transistor or BJT is a three terminal electronic device that amplifies the flow of current.
- It is a current controlled device. In bipolar junction transistor, electric current is conducted by both free electrons and holes.
- Bipolar junction transistors are classified into two types based on their construction: They are
    - ✓ NPN transistor
    - ✓ PNP transistor

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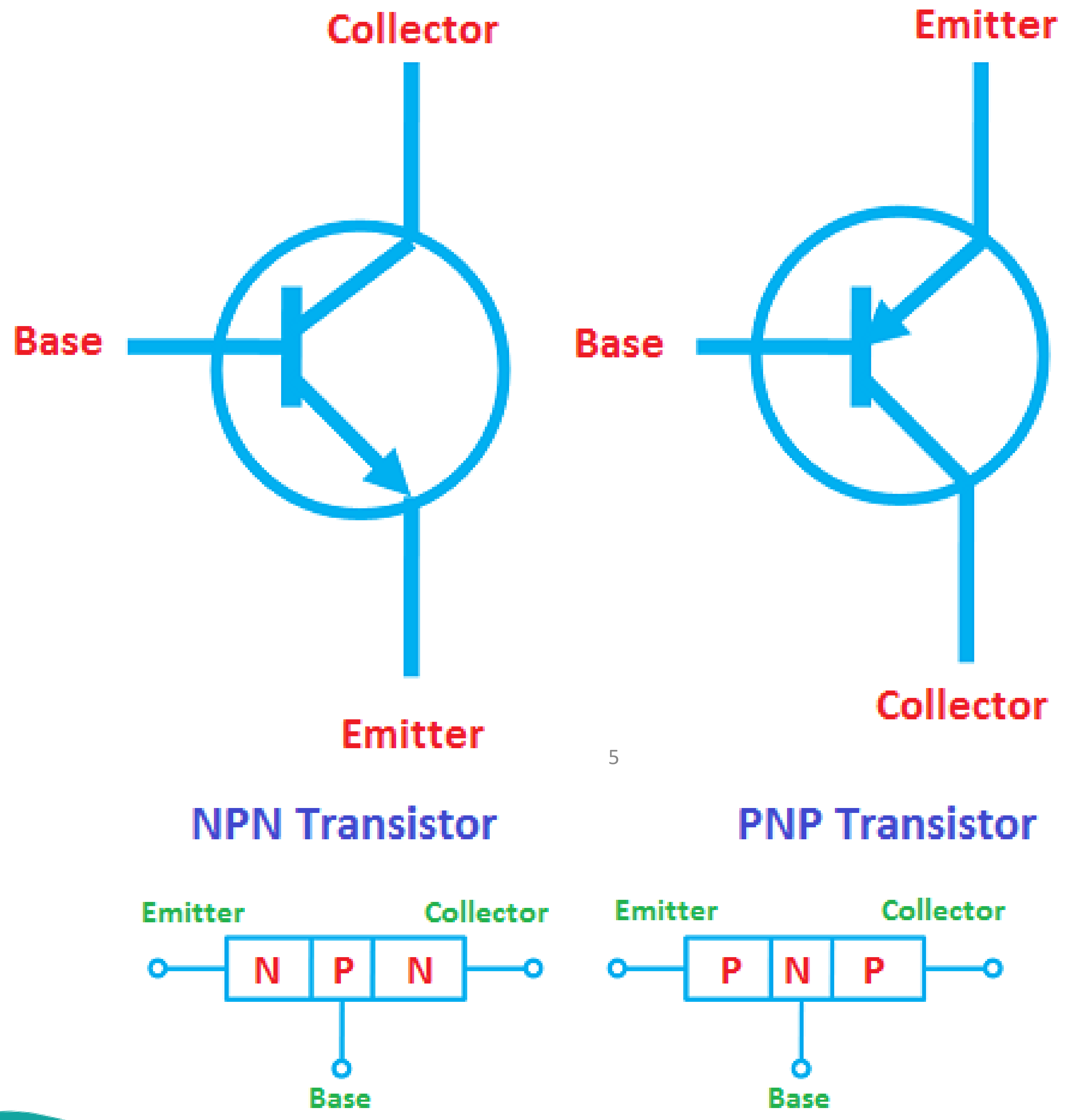
Bipolar Junction Transistor



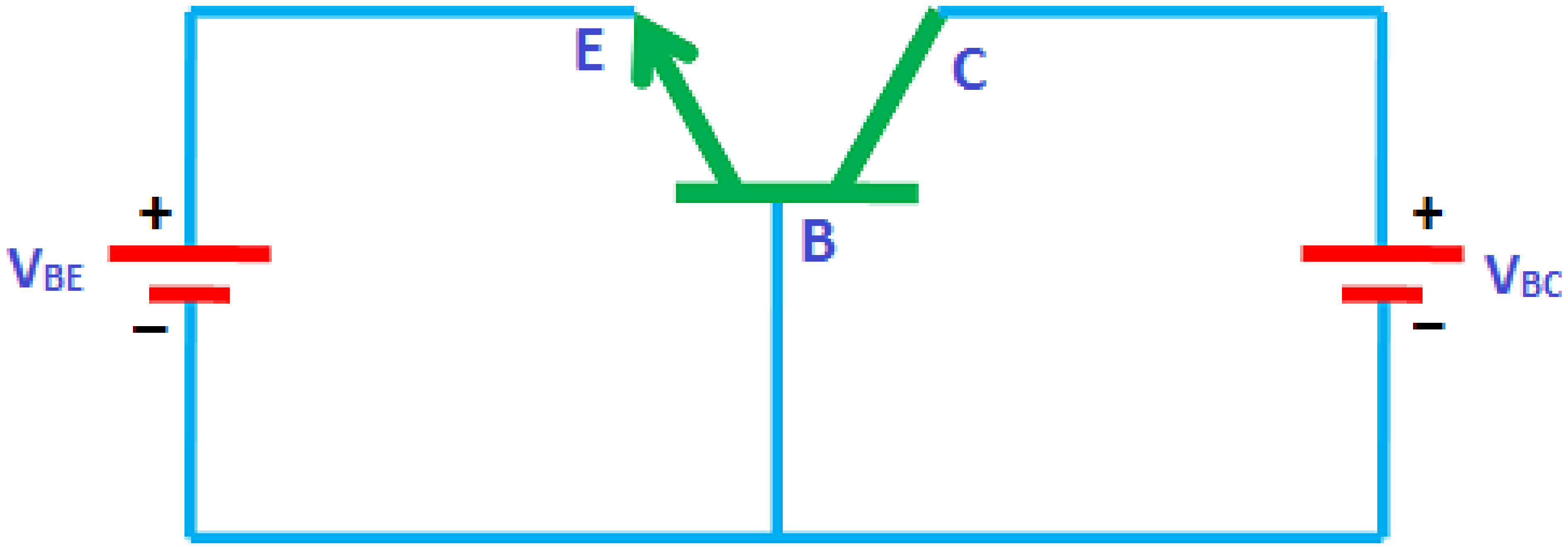
Bipolar Junction Transistor

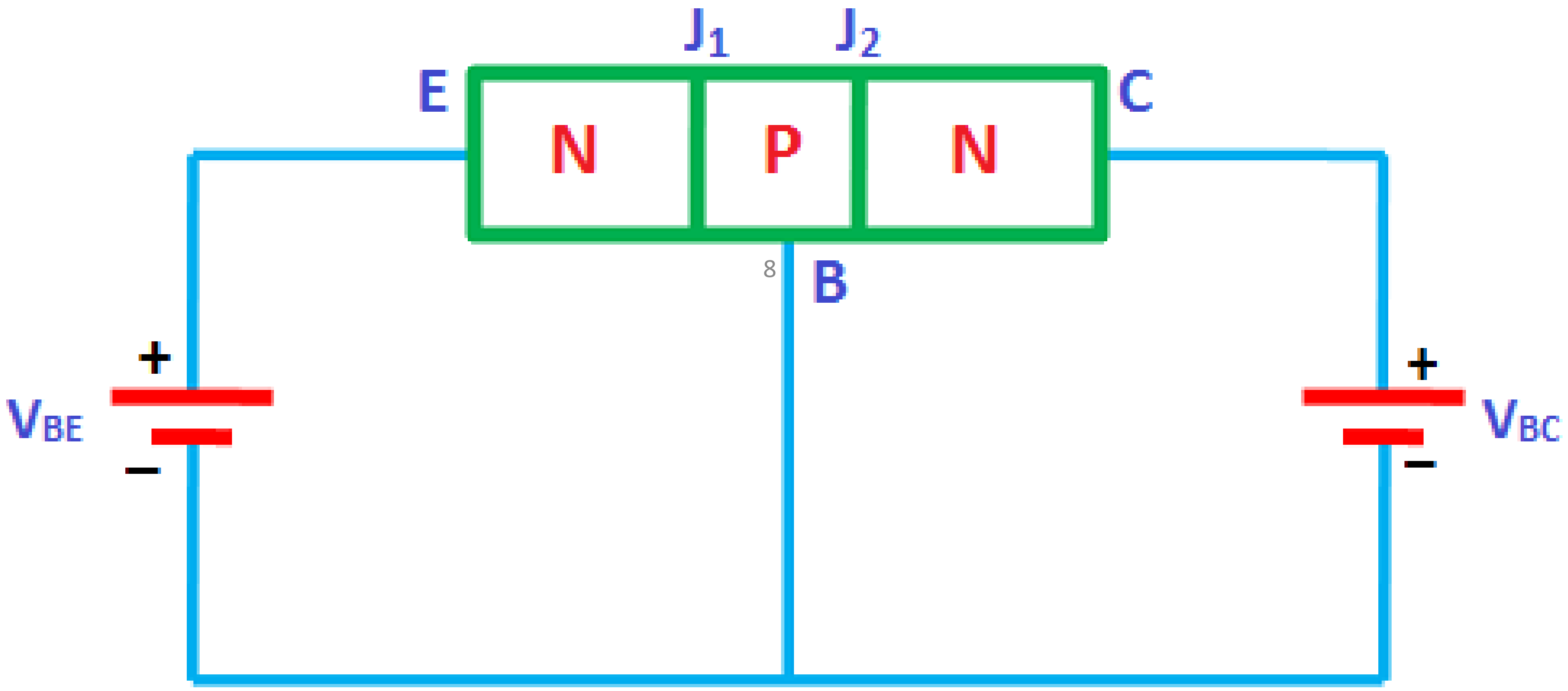
- **Emitter:** As the name suggests, the emitter section supplies the charge carriers. The emitter section is heavily doped so that it can inject a large number of charge carriers into the base. The size of the emitter is always greater than the base.
- **Base:** The middle layer is called base. The base of the transistor is very thin as compared to emitter and collector. It is very lightly doped.
- **Collector:** The function of the collector is to collect charge carriers. It is moderately doped. The size of the collector is always greater than emitter and base.

BJT operation modes

- **The transistor can be operated in three modes:**
  - ✓ **Cut-off mode**
  - ✓ **Saturation mode**
  - ✓ **Active mode**
- Applying dc voltage to the transistor is nothing but the biasing of transistor.
- In order to operate transistor in one of these regions, we have to supply dc voltage to the npn or pnp transistor.
- Based on the polarity of the applied dc voltage, the transistor operates in any one of these regions.

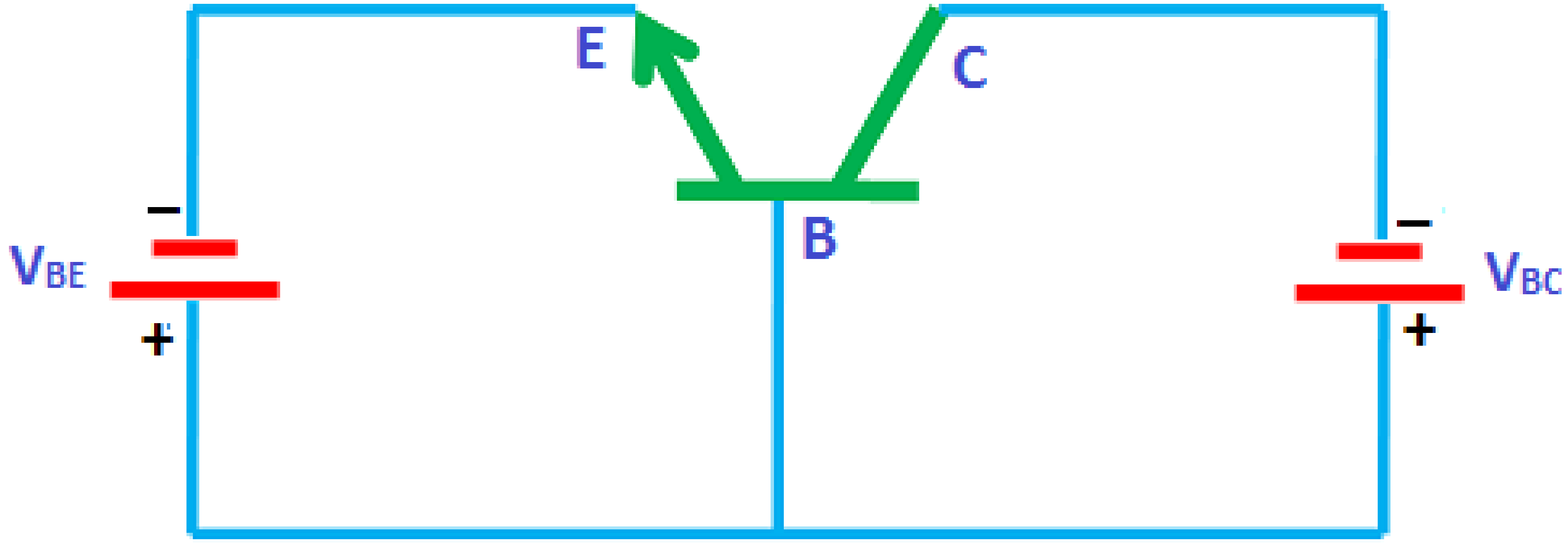
Cut-off mode

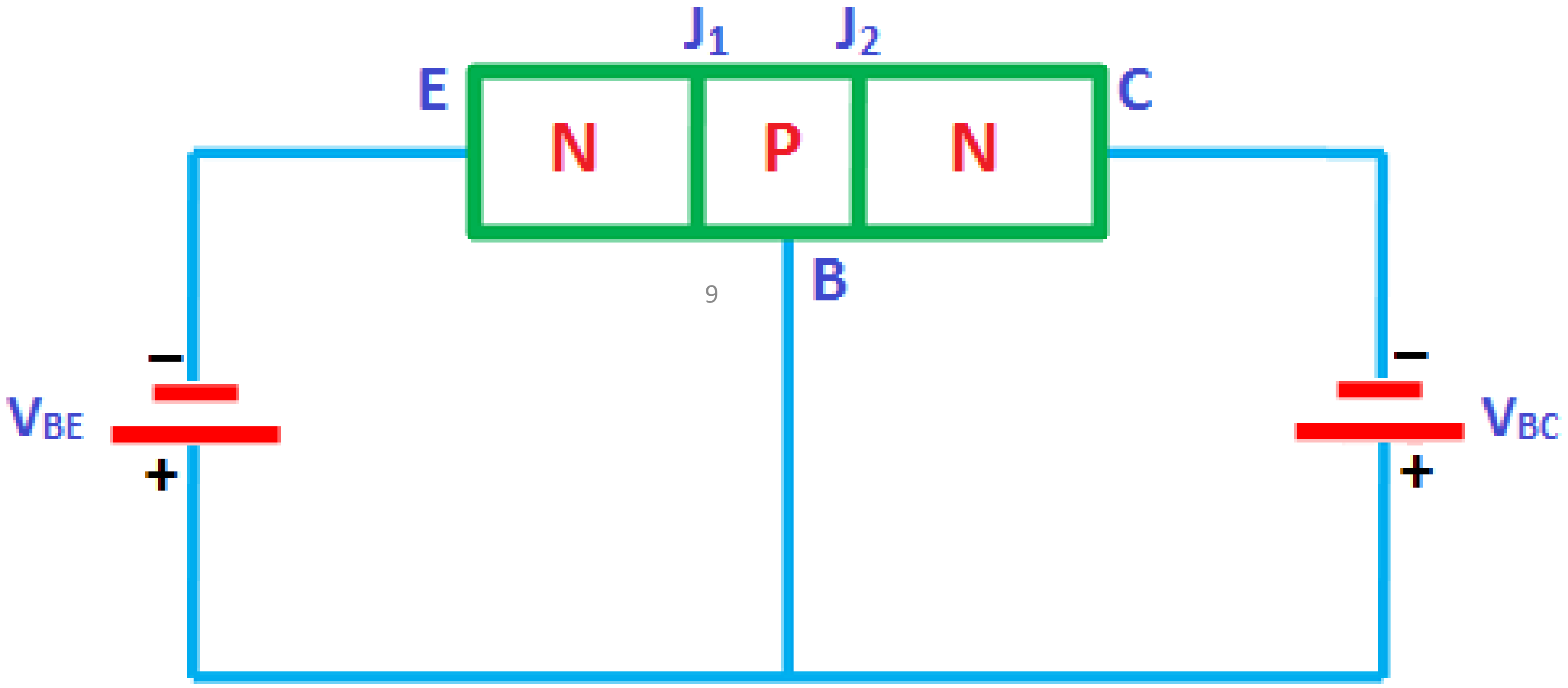




Cutoff mode

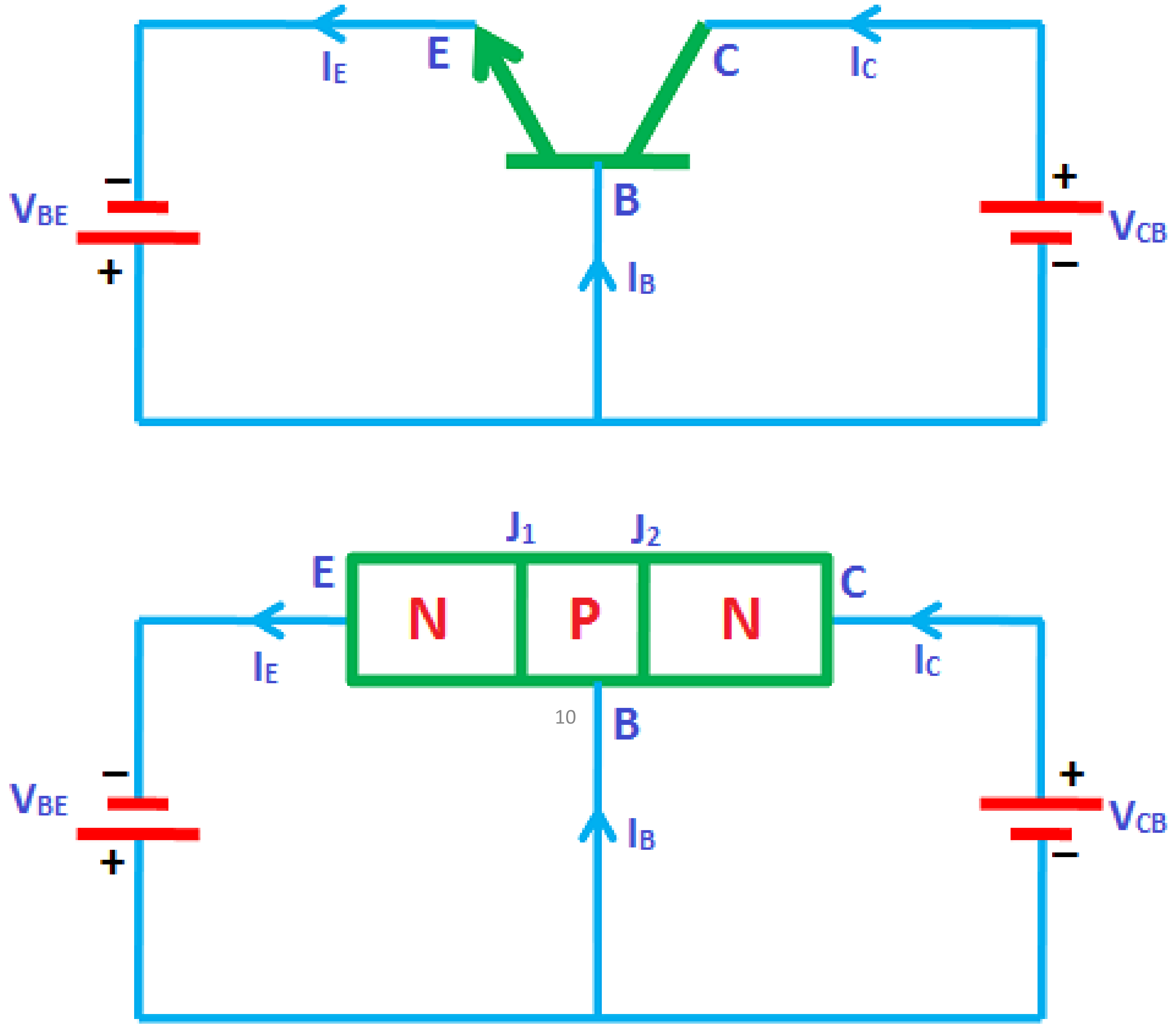
Saturation mode





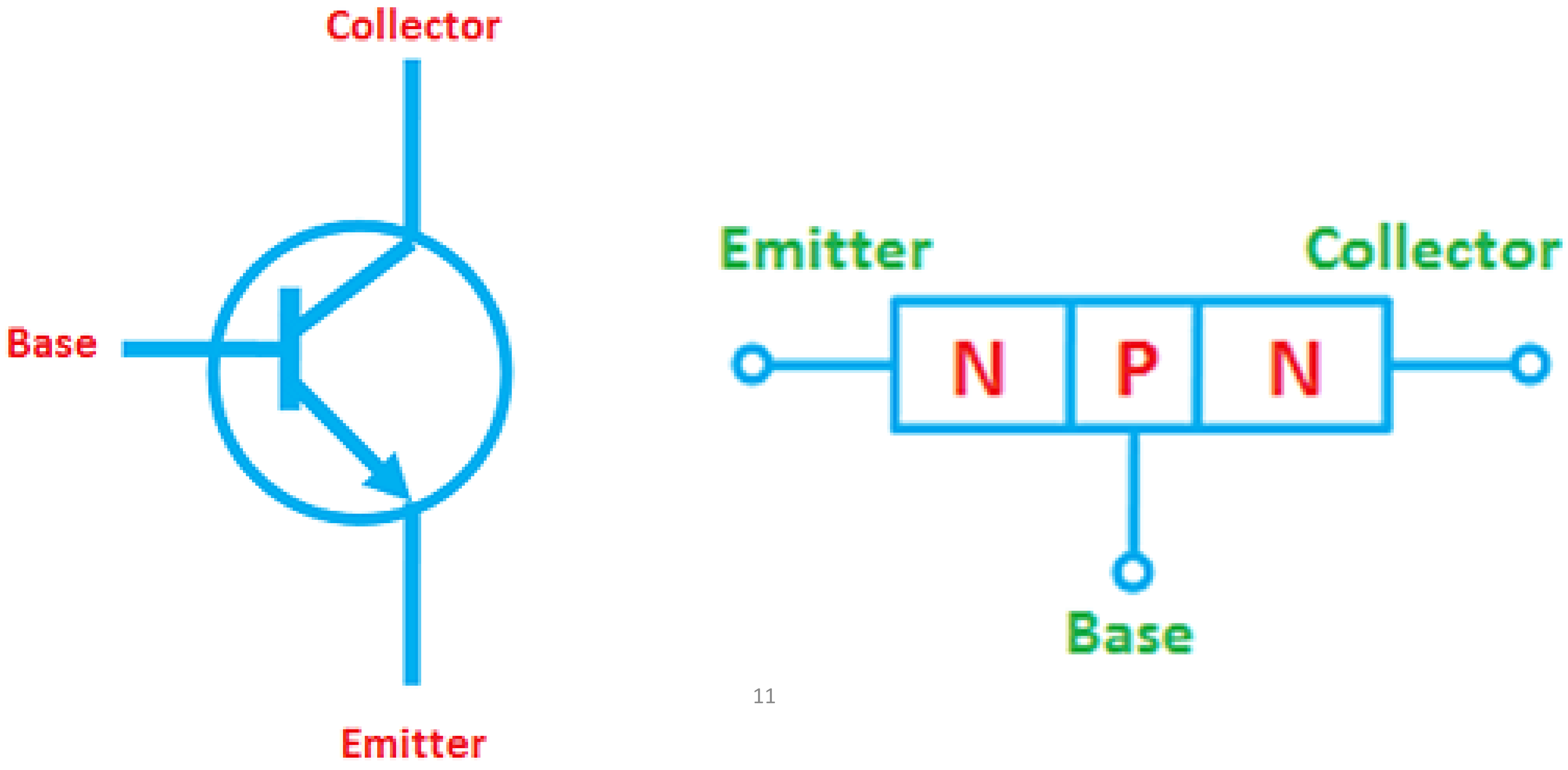
Saturation mode

Active mode



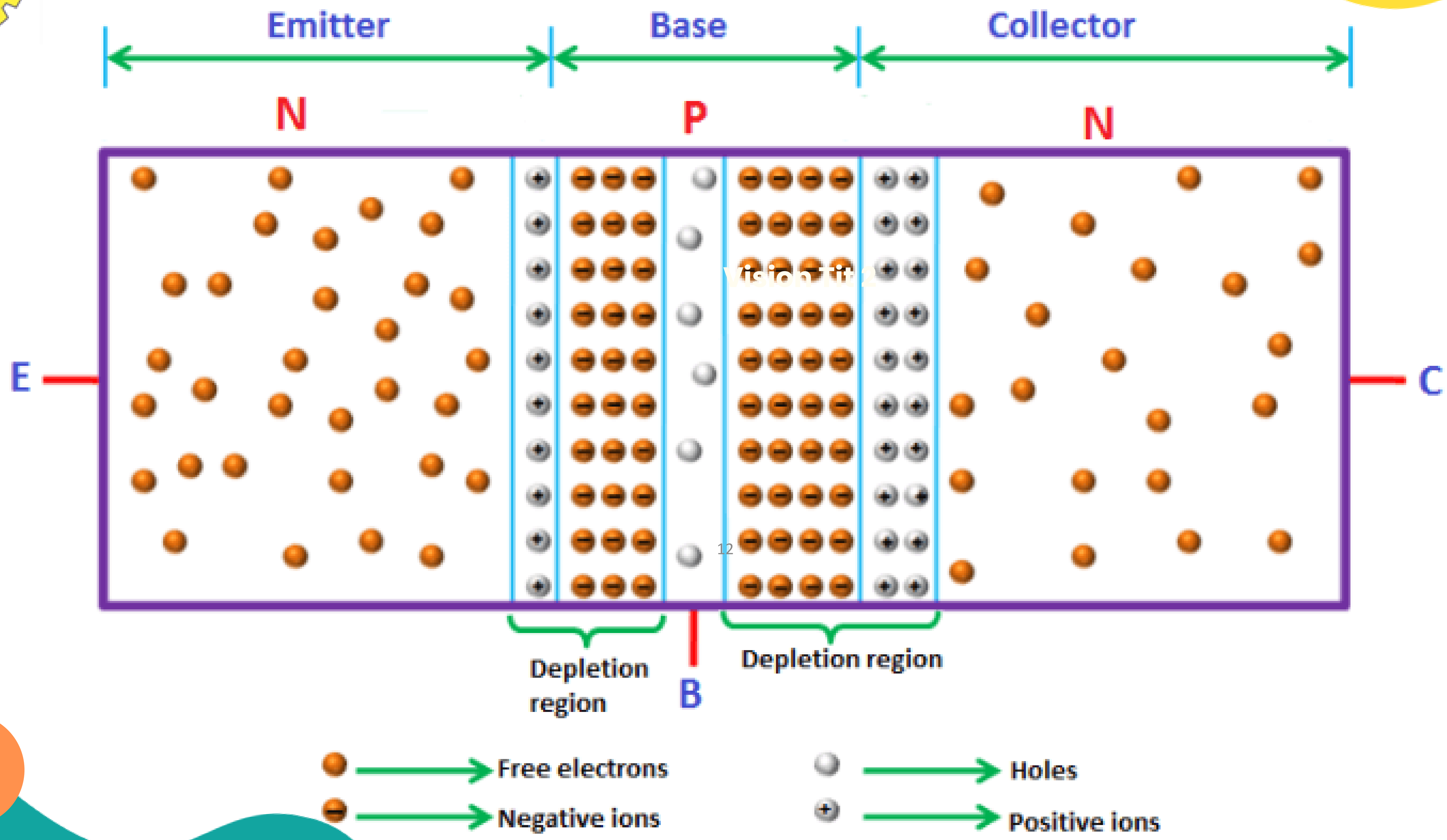
Active mode

NPN transistor

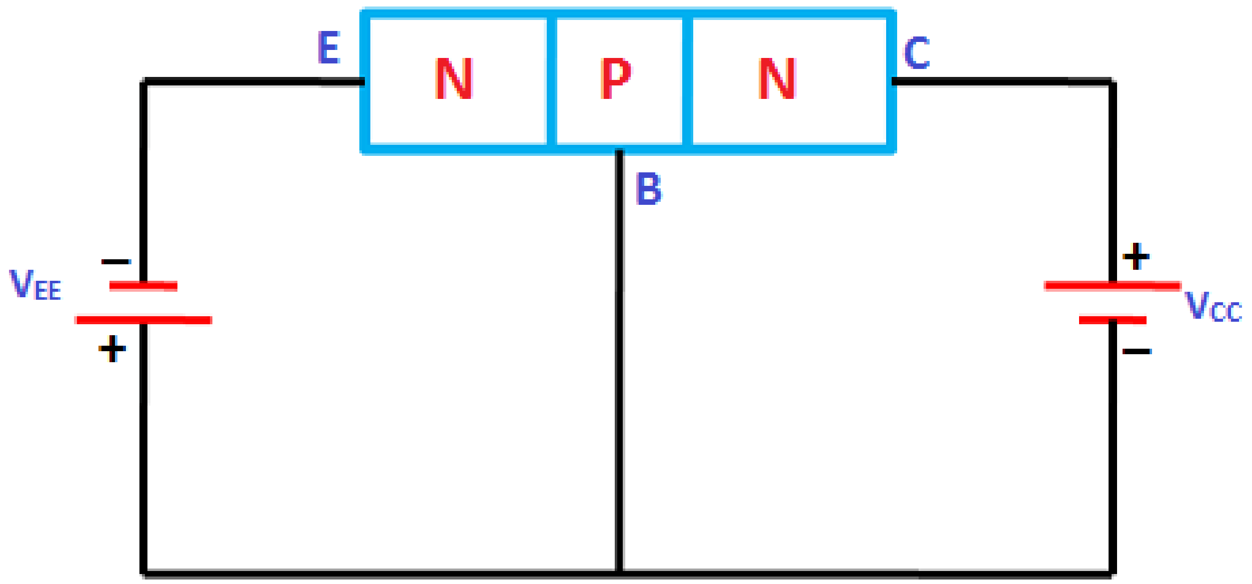


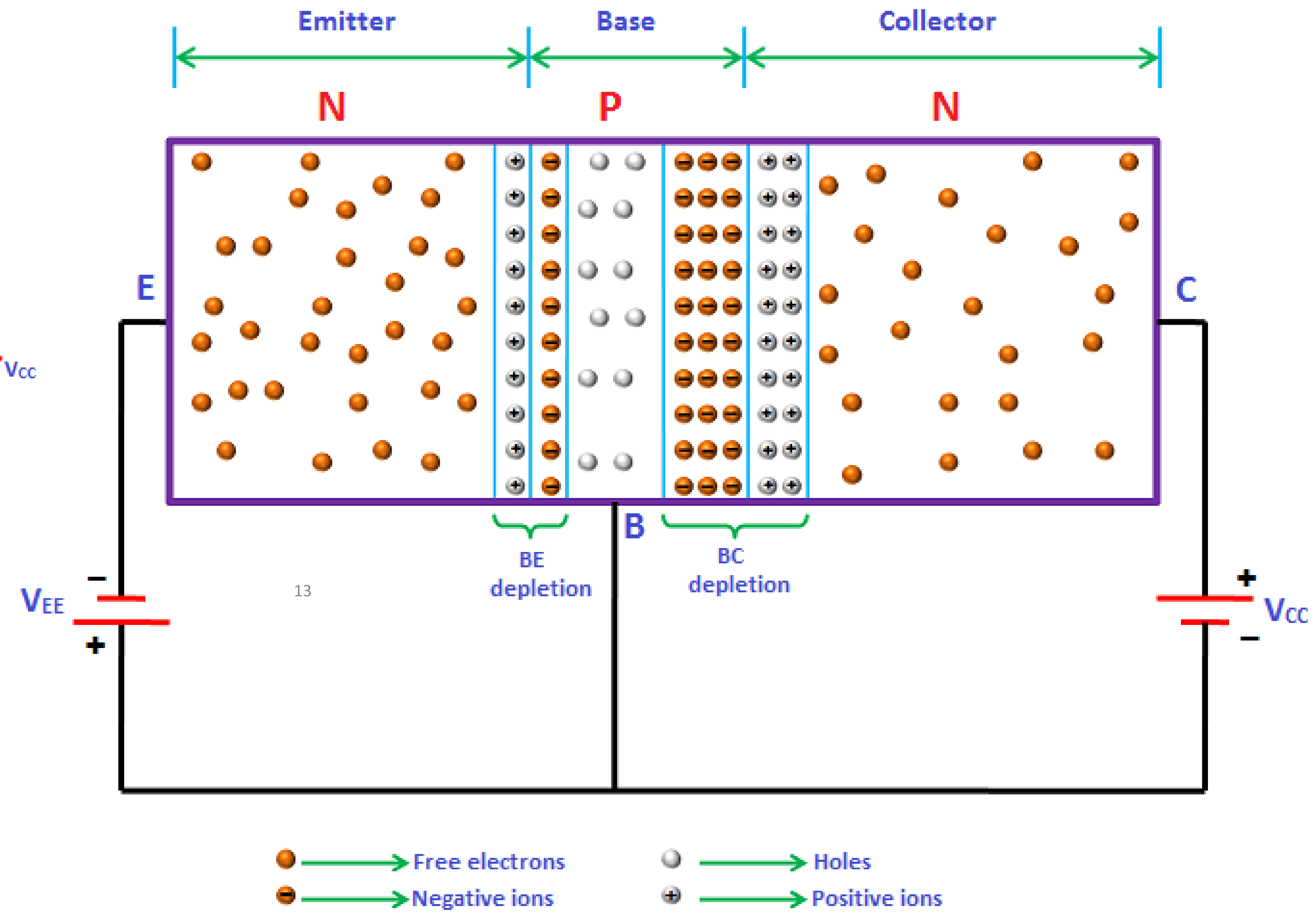
NPN transistor symbol

Working of NPN transistor- Unbiased



Working of NPN transistor- Biased





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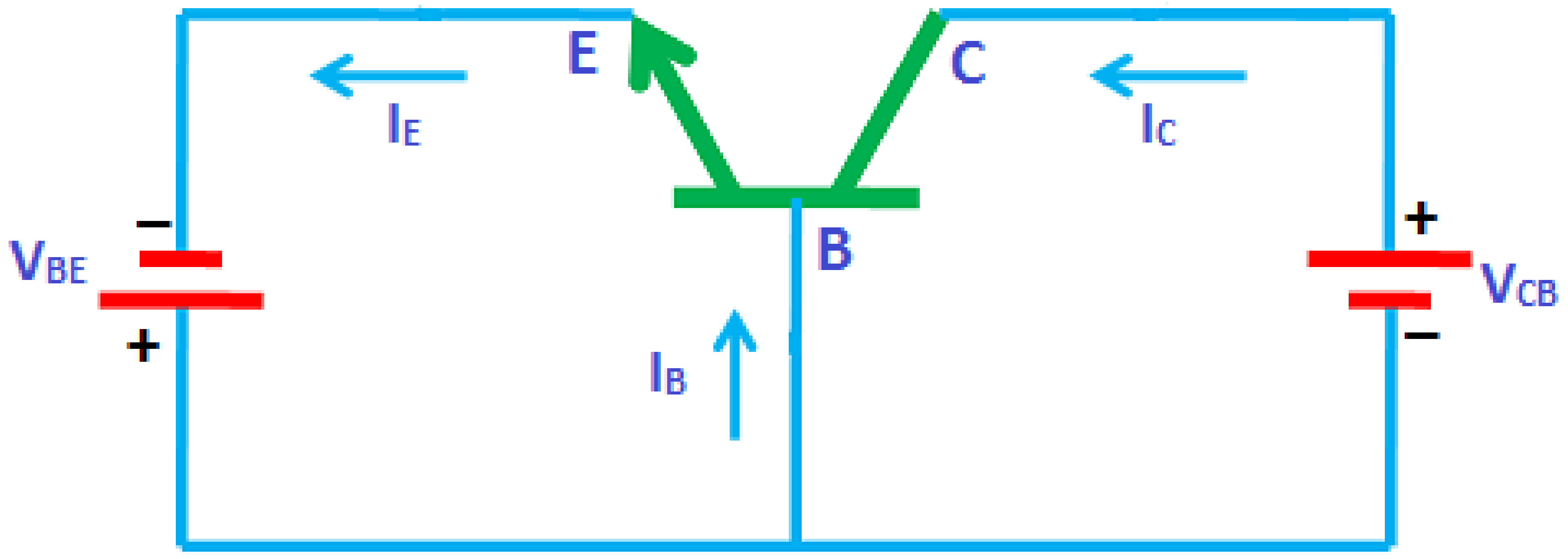
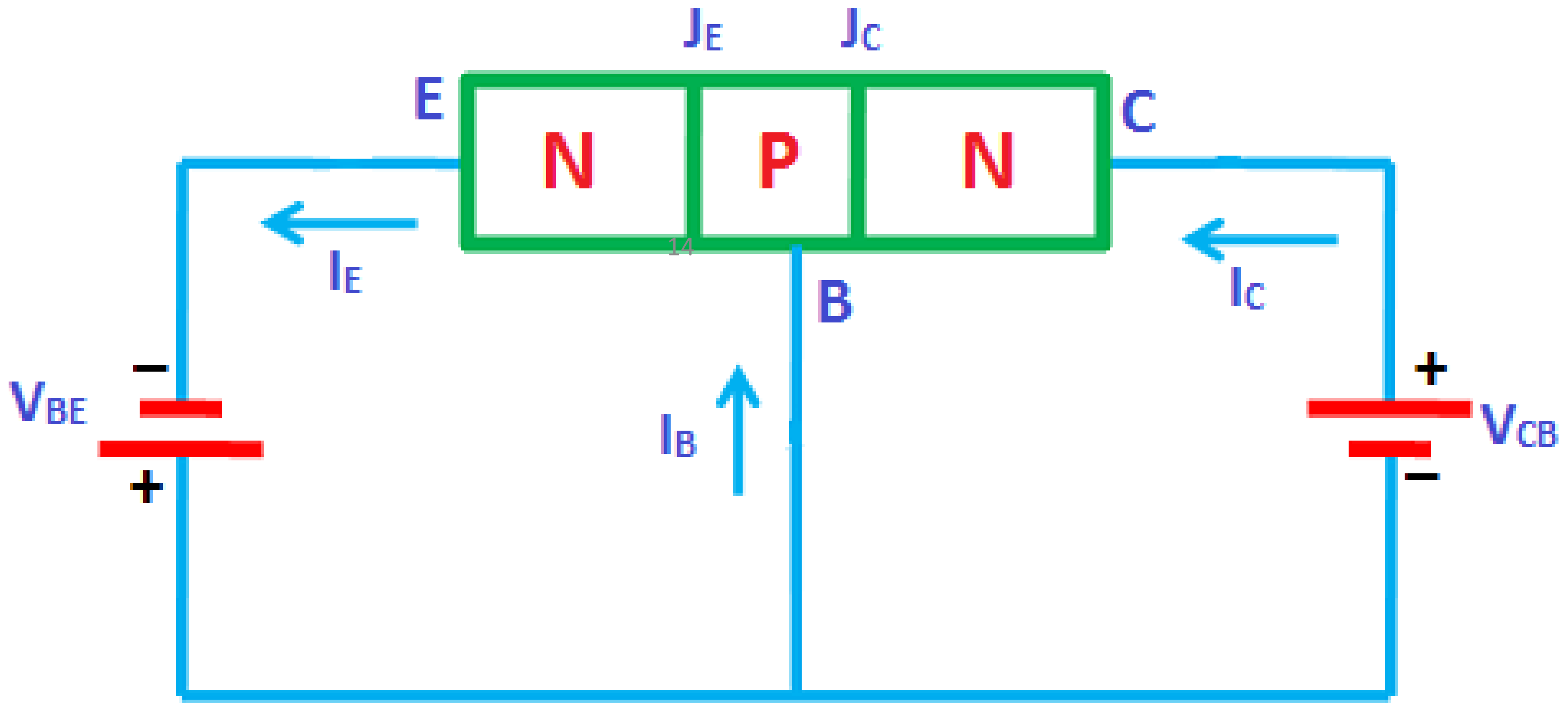
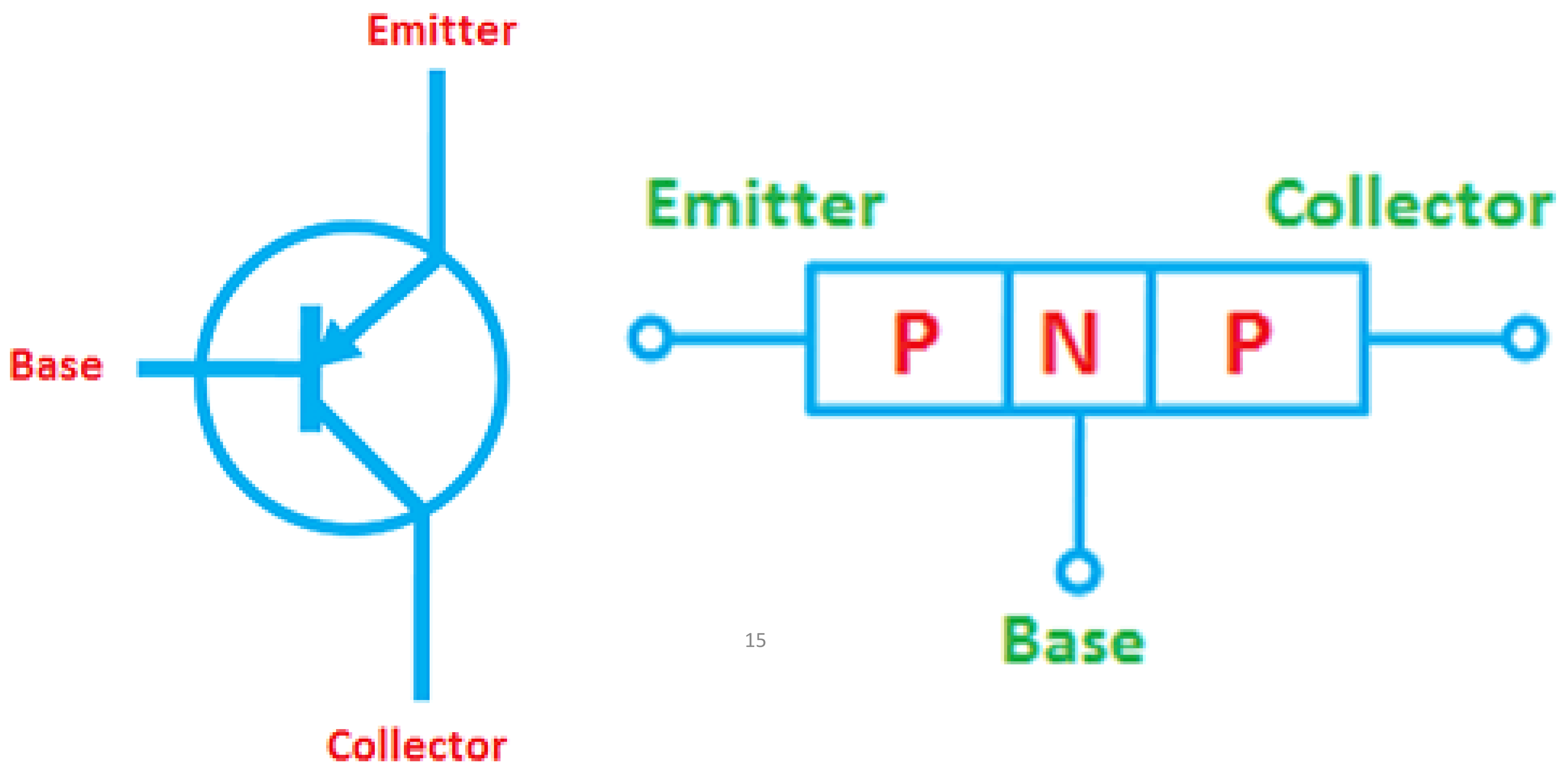
Current direction in NPN transistor



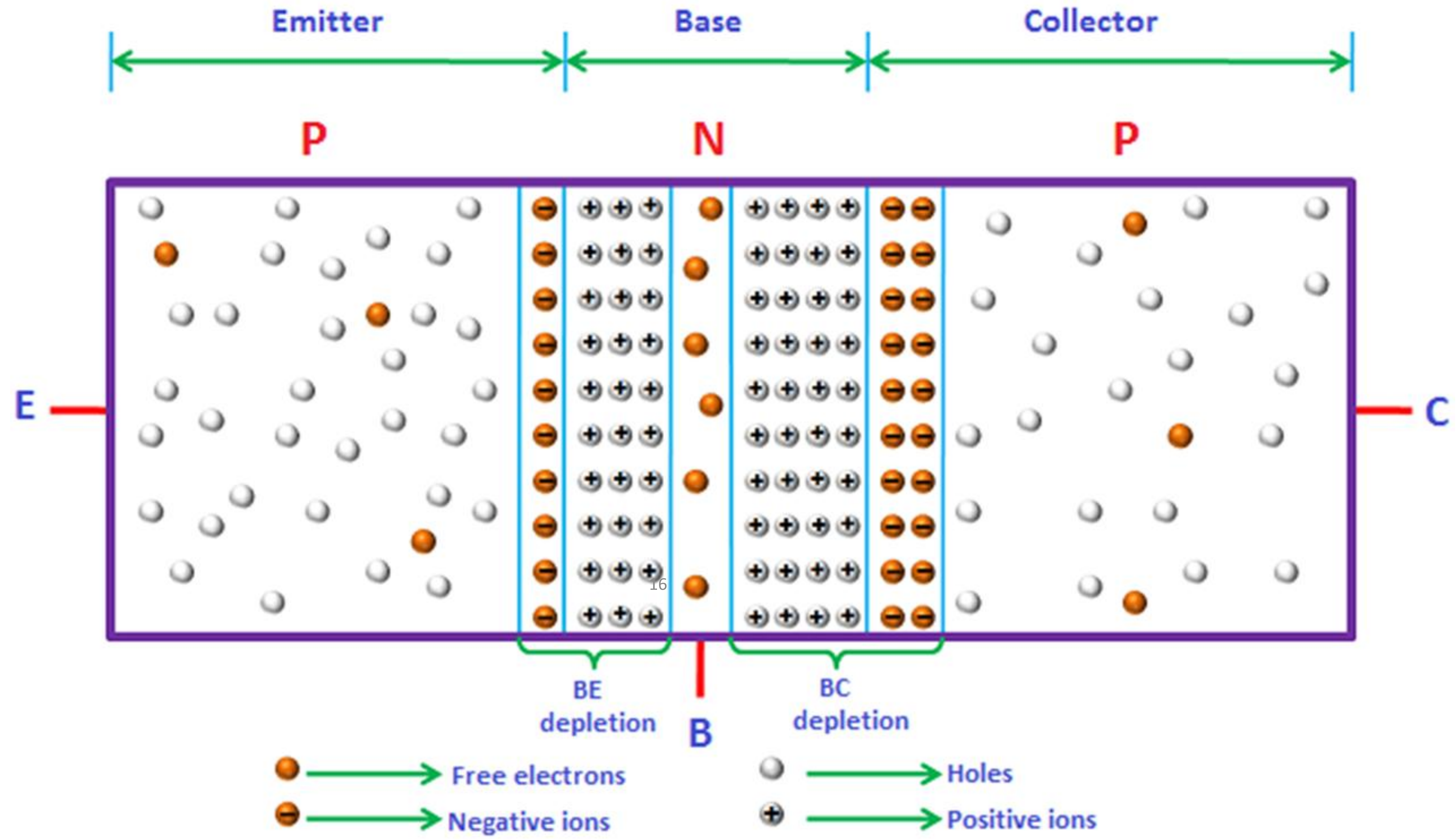


PNP Transistor

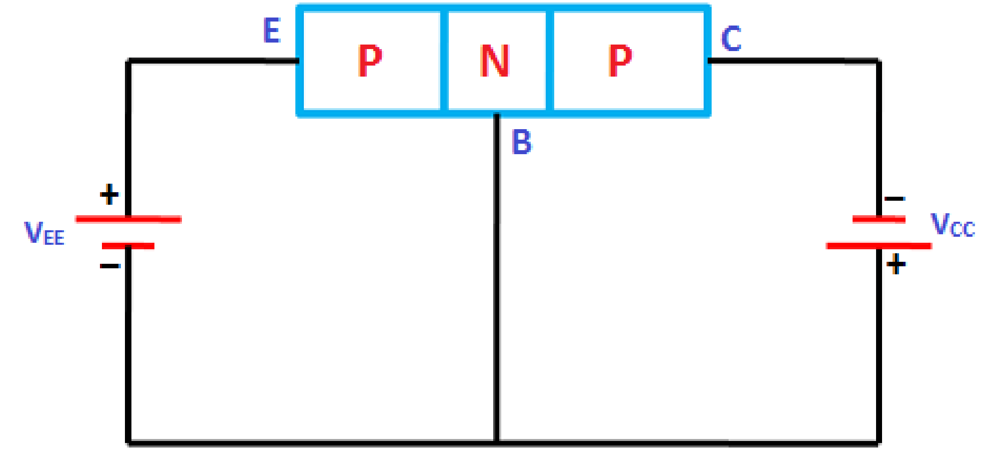


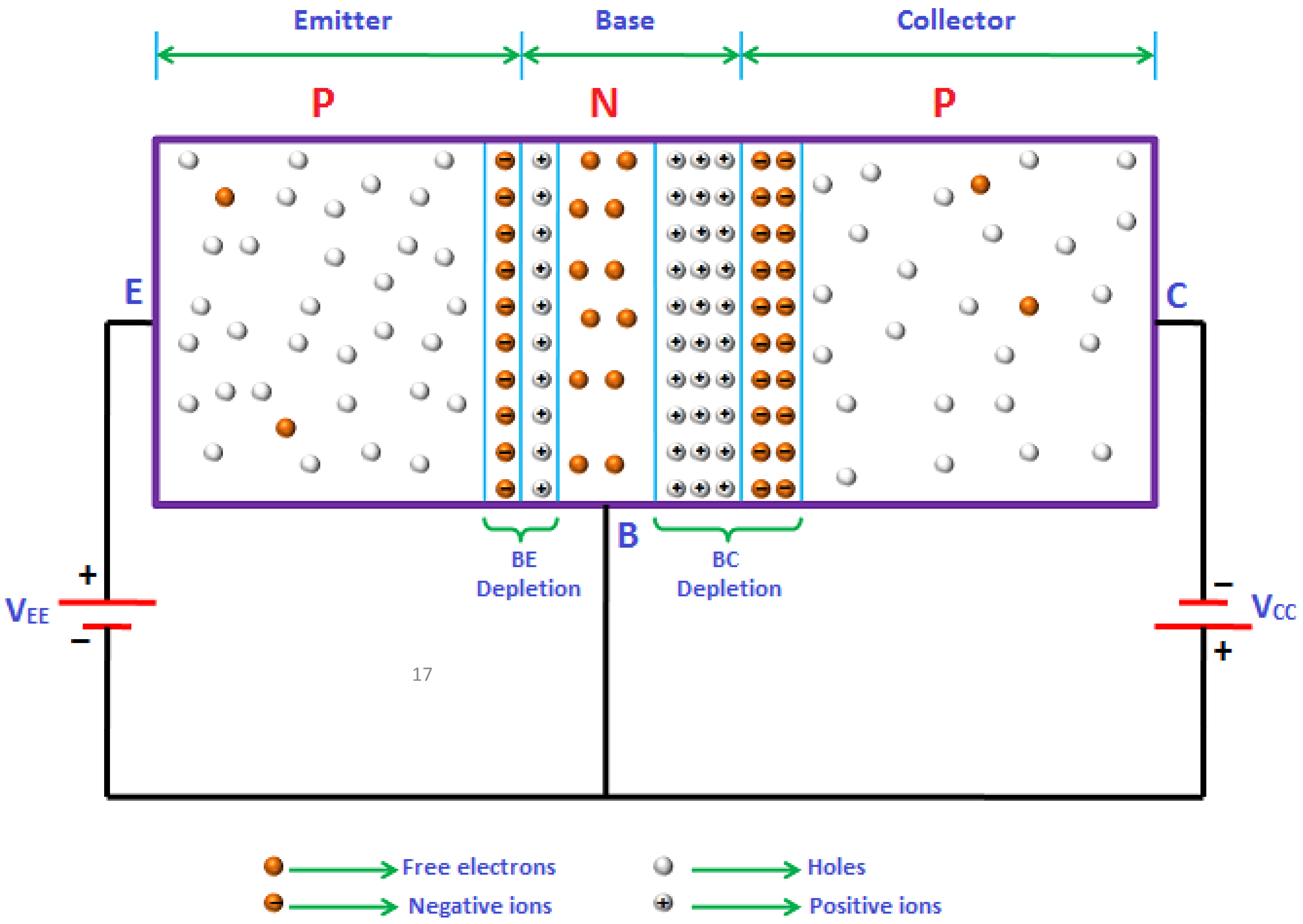
PNP transistor symbol

Working of NPN transistor- Unbiased

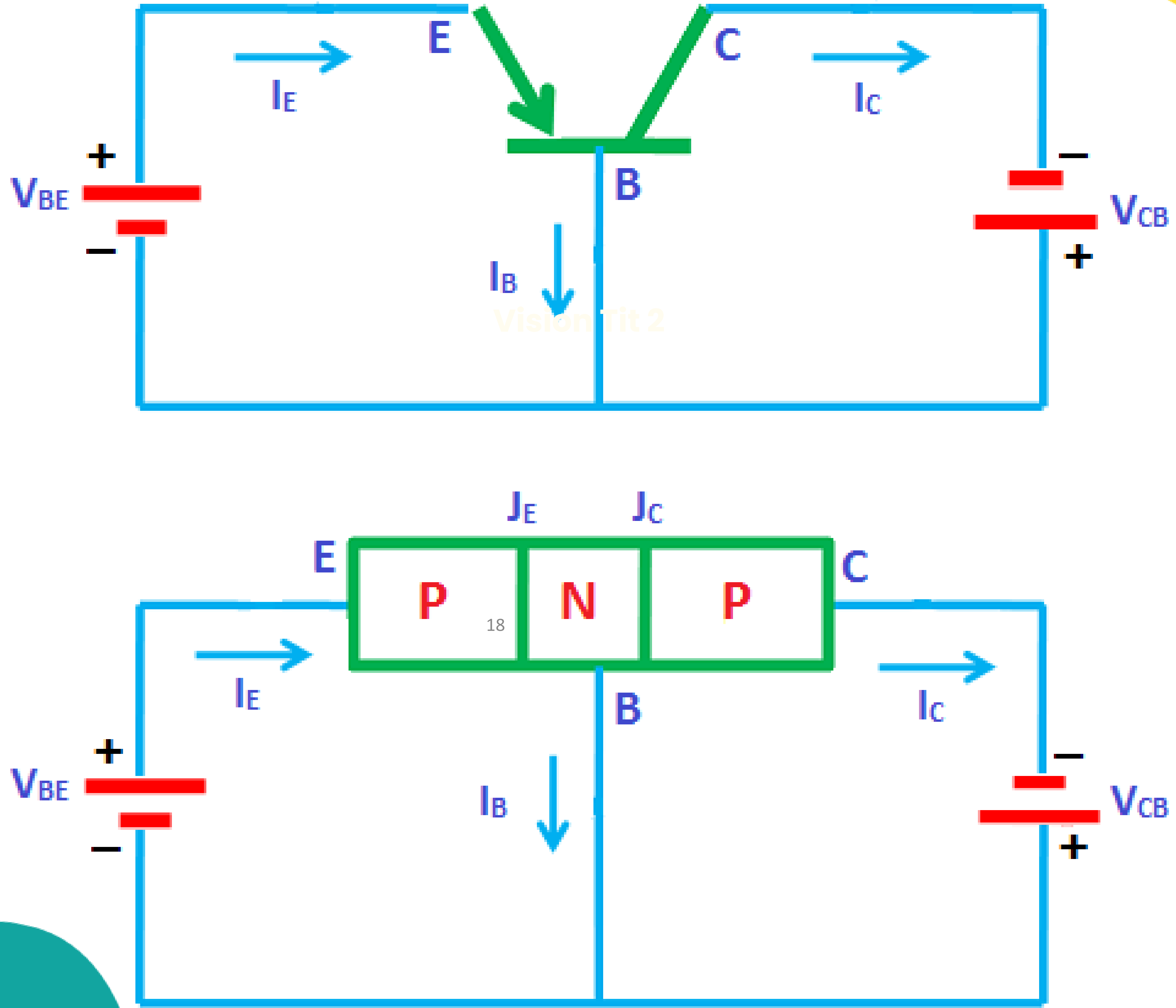


Working of NPN transistor- Biased





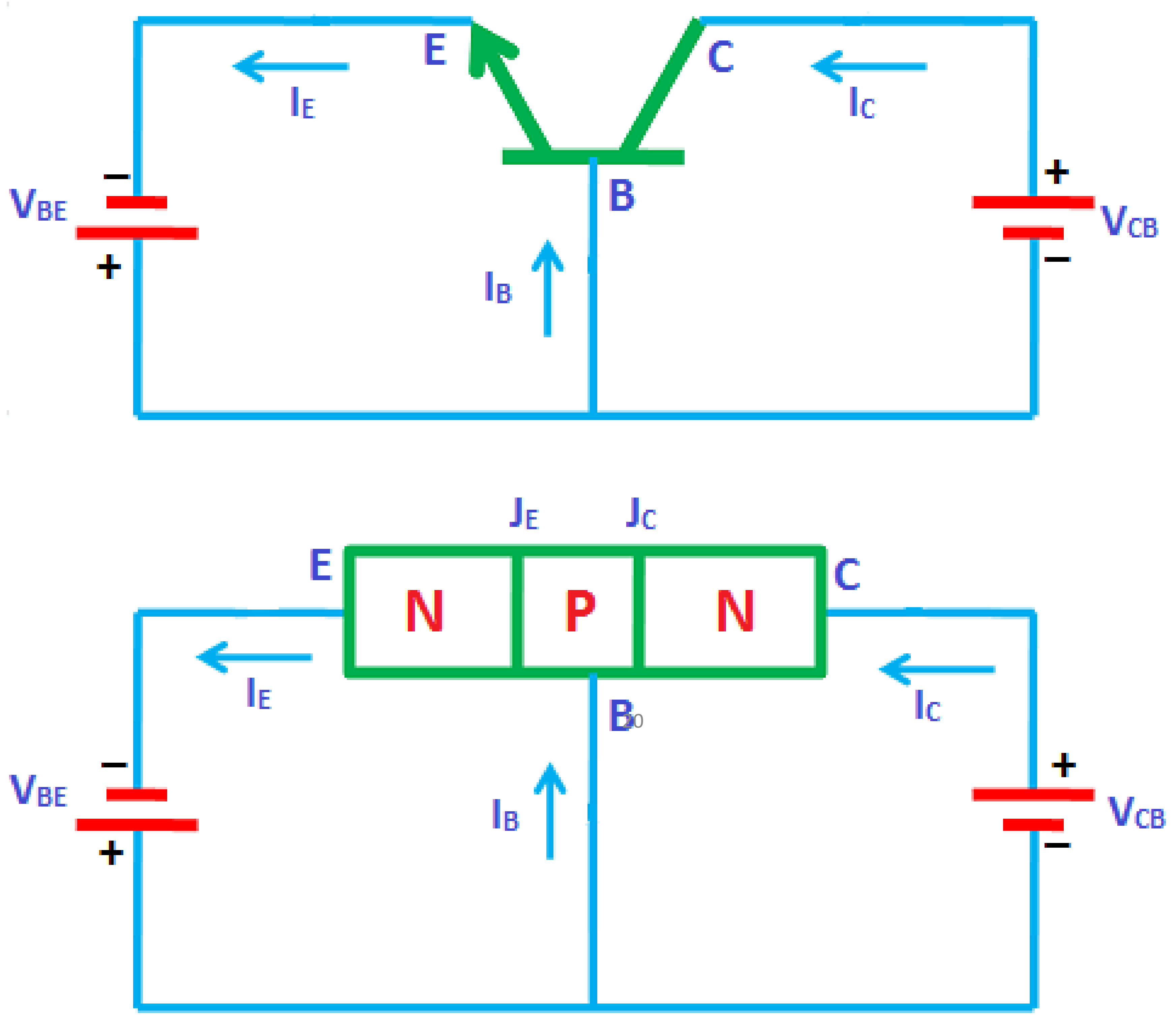
Current direction in PNP transistor



Types of Transistor Configuration

- We know that transistor has three terminals namely emitter (E), base (B), and collector (C). But to connect a transistor in the circuit, we need four terminals: two terminals for input and other two terminals for output.
- When a transistor is to be connected in a circuit, one terminal is used as the input terminal, the other terminal is used as the output terminal and the third terminal is common to the input and output.
- Depending upon the terminal which is used as a common terminal to the input and output terminals, the transistor can be connected in the following three configurations. They are:
  - ✓ **Common base (CB) configuration**
  - ✓ **Common emitter (CE) configuration**
  - ✓ **Common collector (CC) configuration**

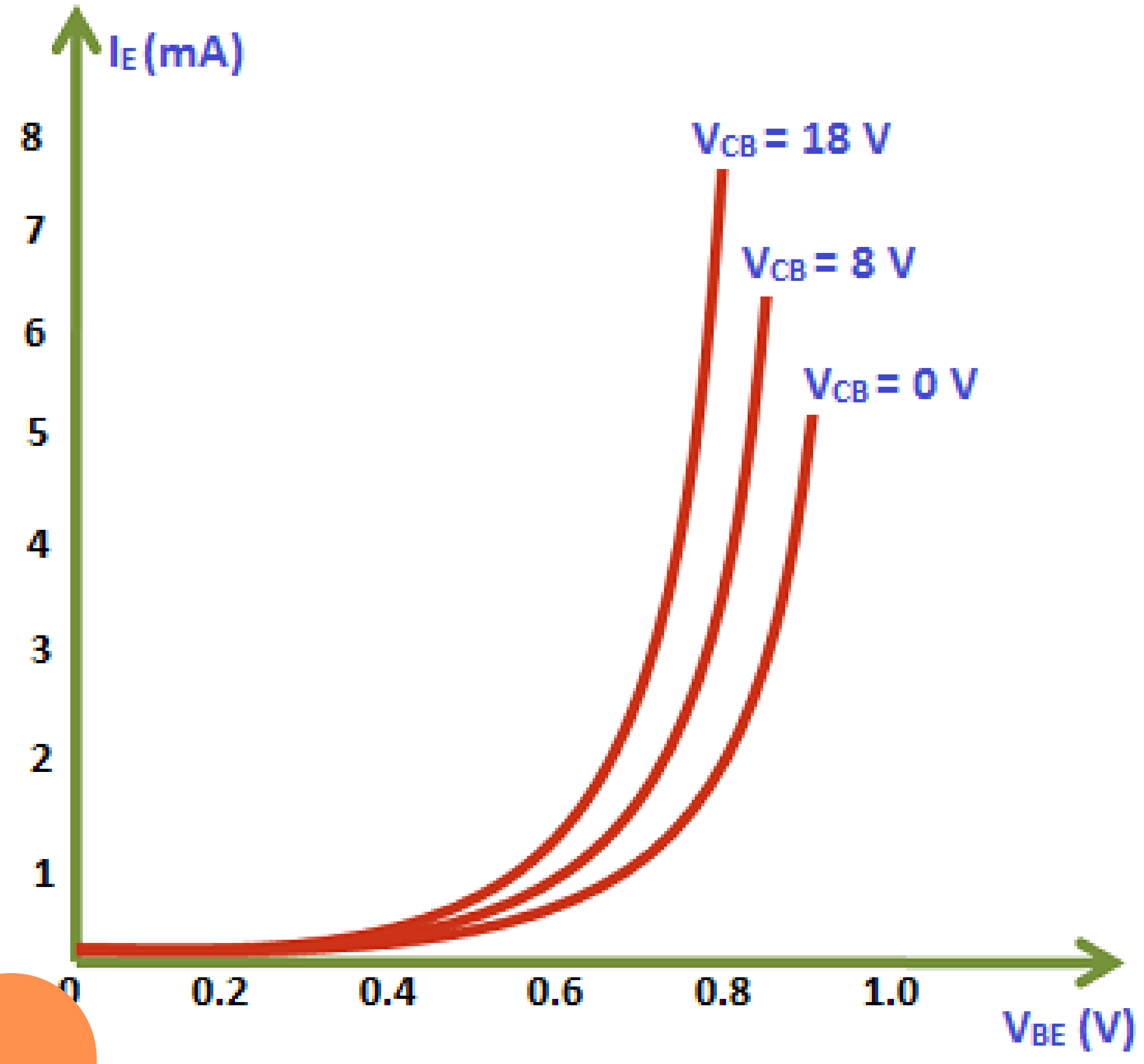
Common base (CB) configuration



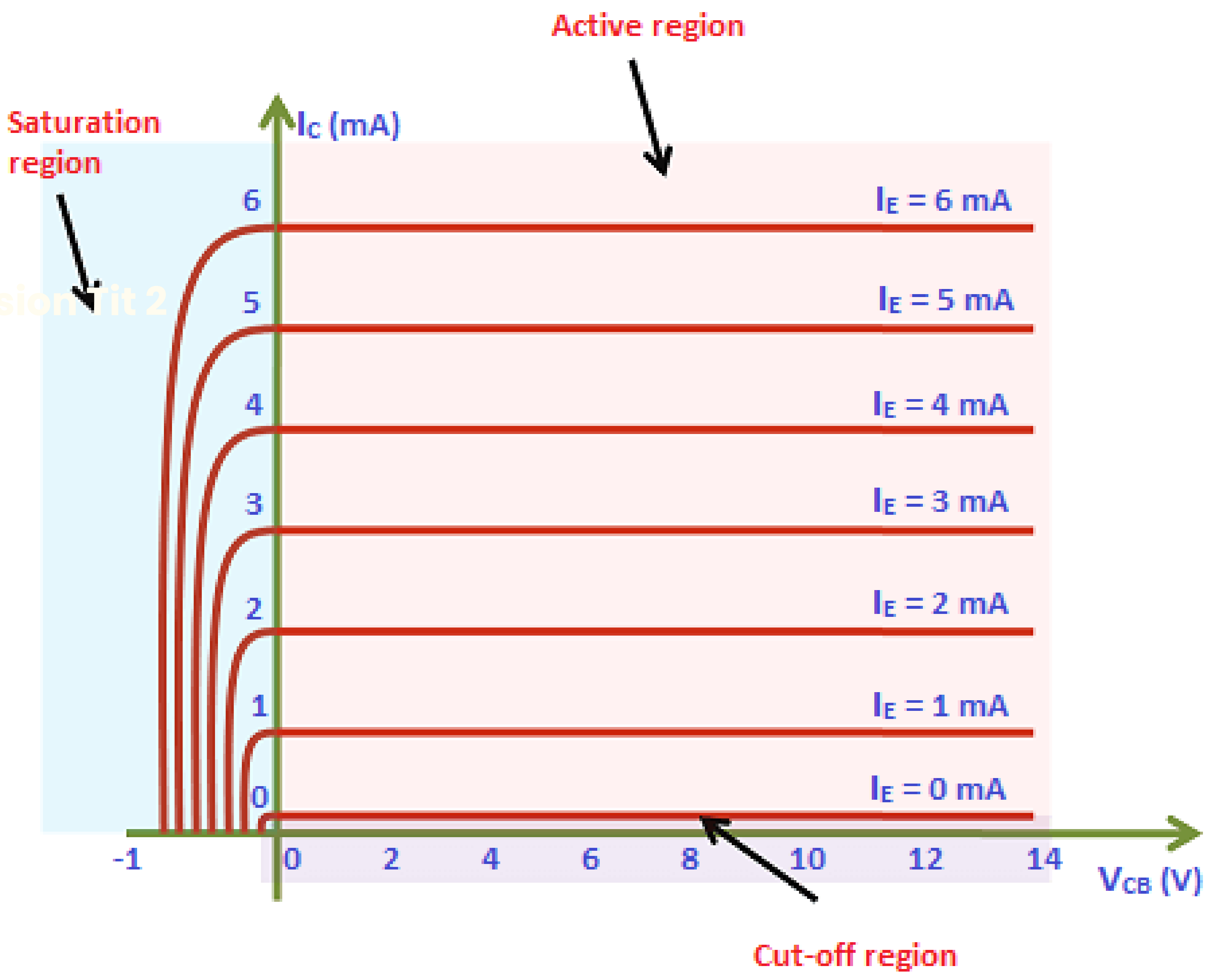
$$I_E = I_B + I_C$$

Common base configuration

Transistor Characteristics



I/p characteristics CB configuration

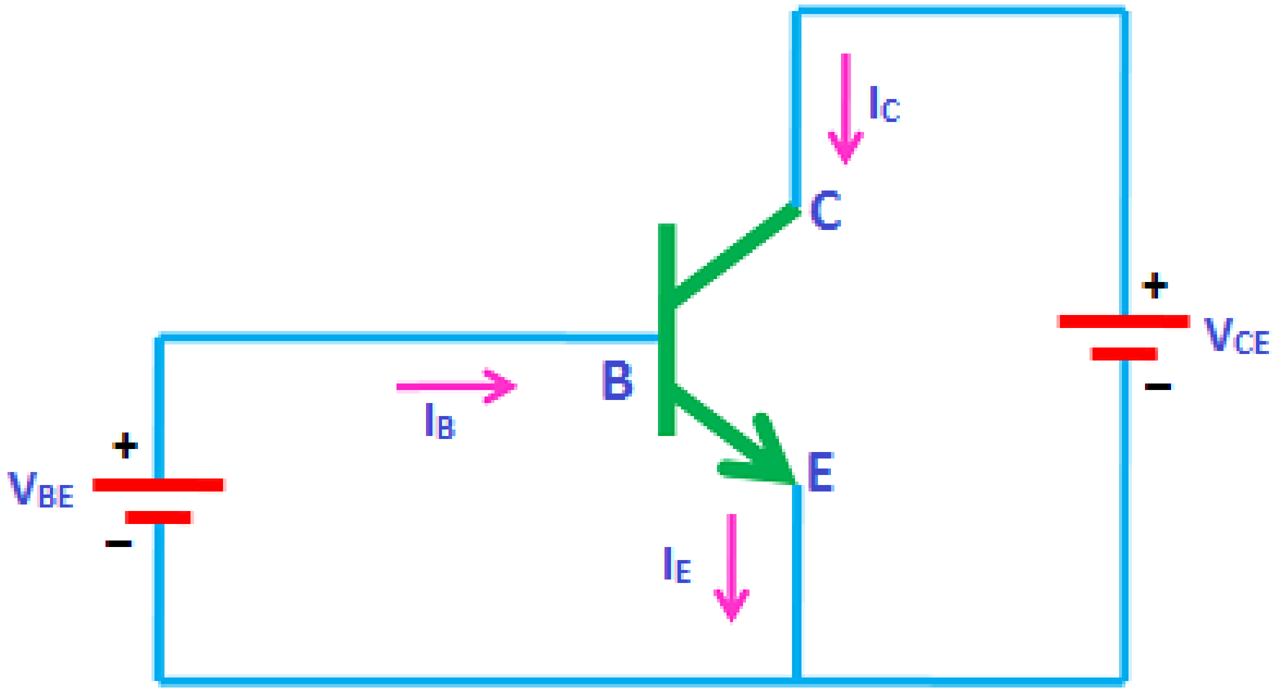


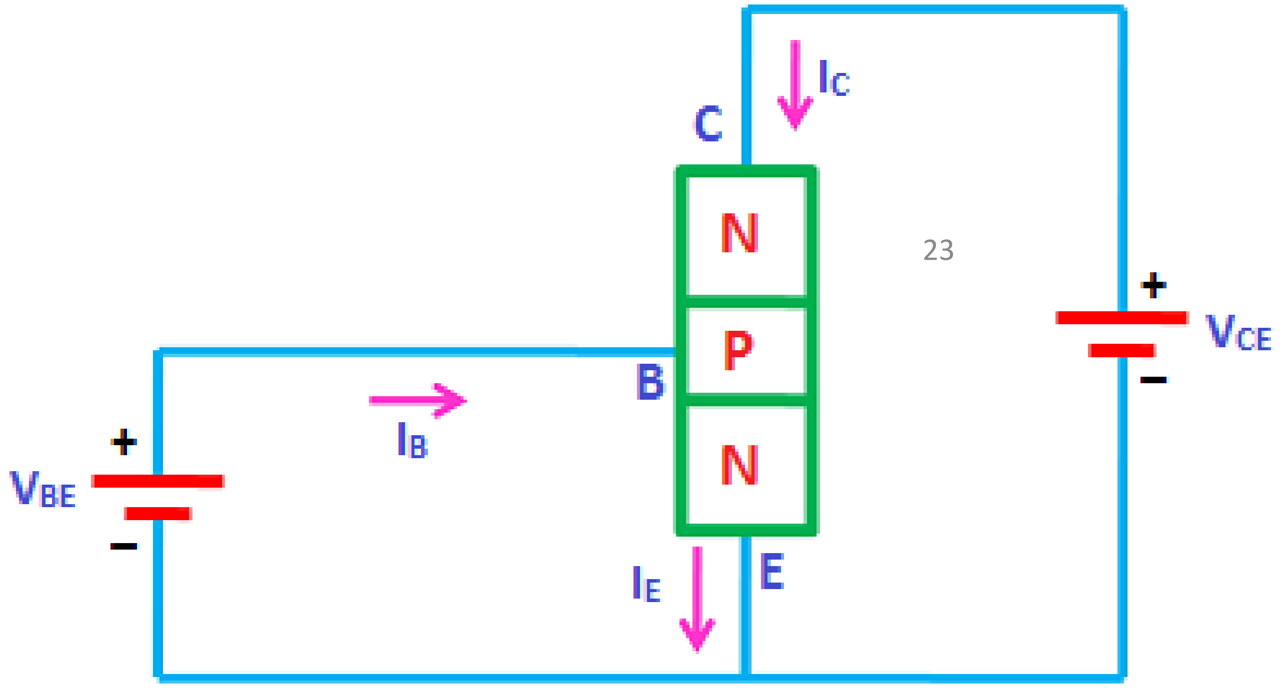
O/P characteristics CB configuration

Transistor Parameters

Dynamic input resistance (r_i)	Dynamic output resistance (r_o)	Current gain (α)
Dynamic input resistance is defined as the ratio of change in input voltage or emitter voltage (V_{BE}) to the corresponding change in input current or emitter current (I_E), with the output voltage or collector voltage (V_{CB}) kept at constant.	Dynamic output resistance is defined as the ratio of change in output voltage or collector voltage (V_{CB}) to the corresponding change in output current or collector current (I_C), with the input current or emitter current (I_E) kept at constant.	The current gain of a transistor in CB configuration is defined as the ratio of output current or collector current (I_C) to the input current or emitter current (I_E).
$r_i = \frac{\Delta V_{BE}}{\Delta I_E}$, $V_{CB} = Constant$	$r_o = \frac{\Delta V_{CB}}{\Delta I_C}$, $I_E = Constant$	$\alpha = \frac{I_C}{I_E}$

Common Emitter Configuration

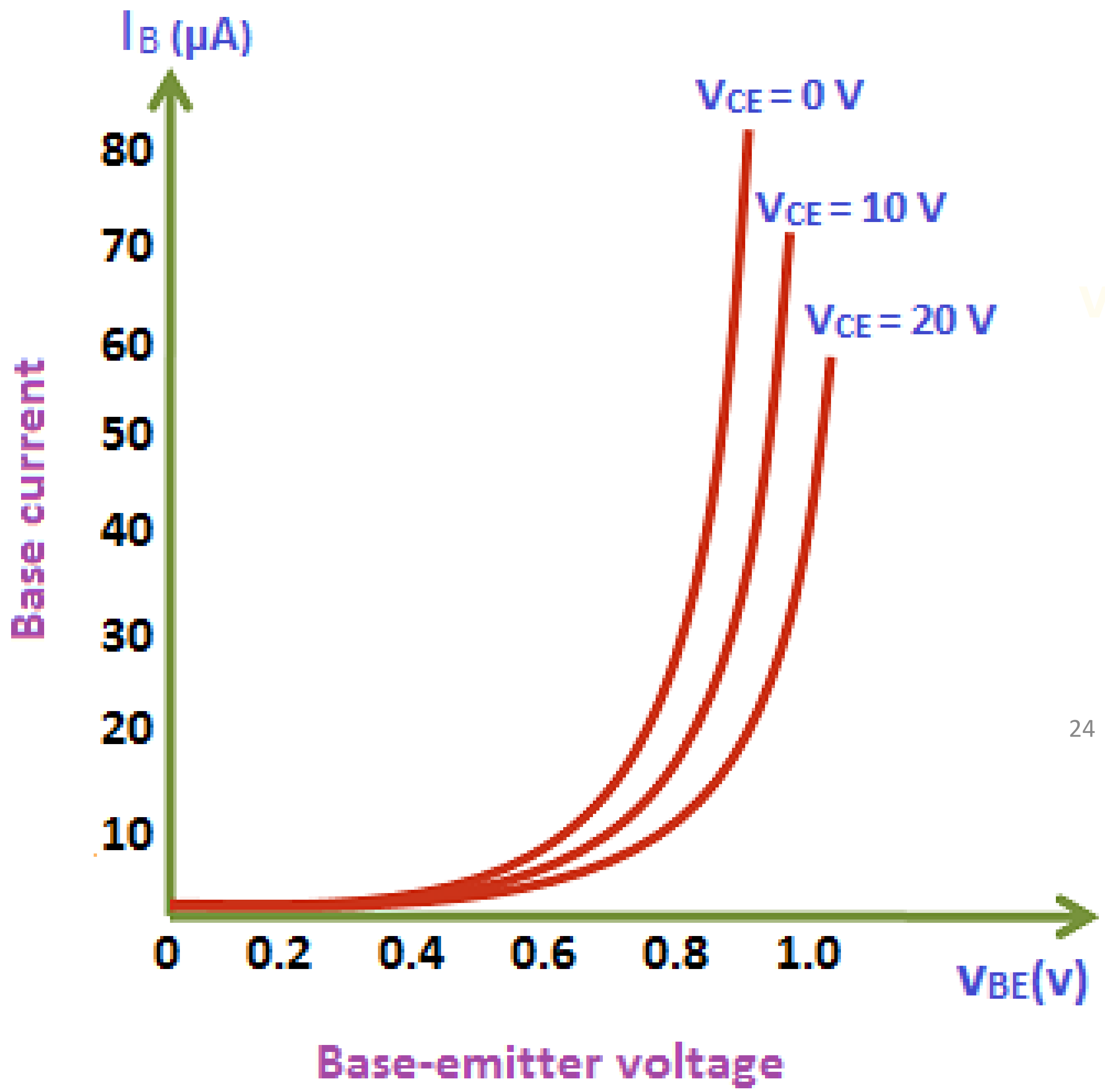




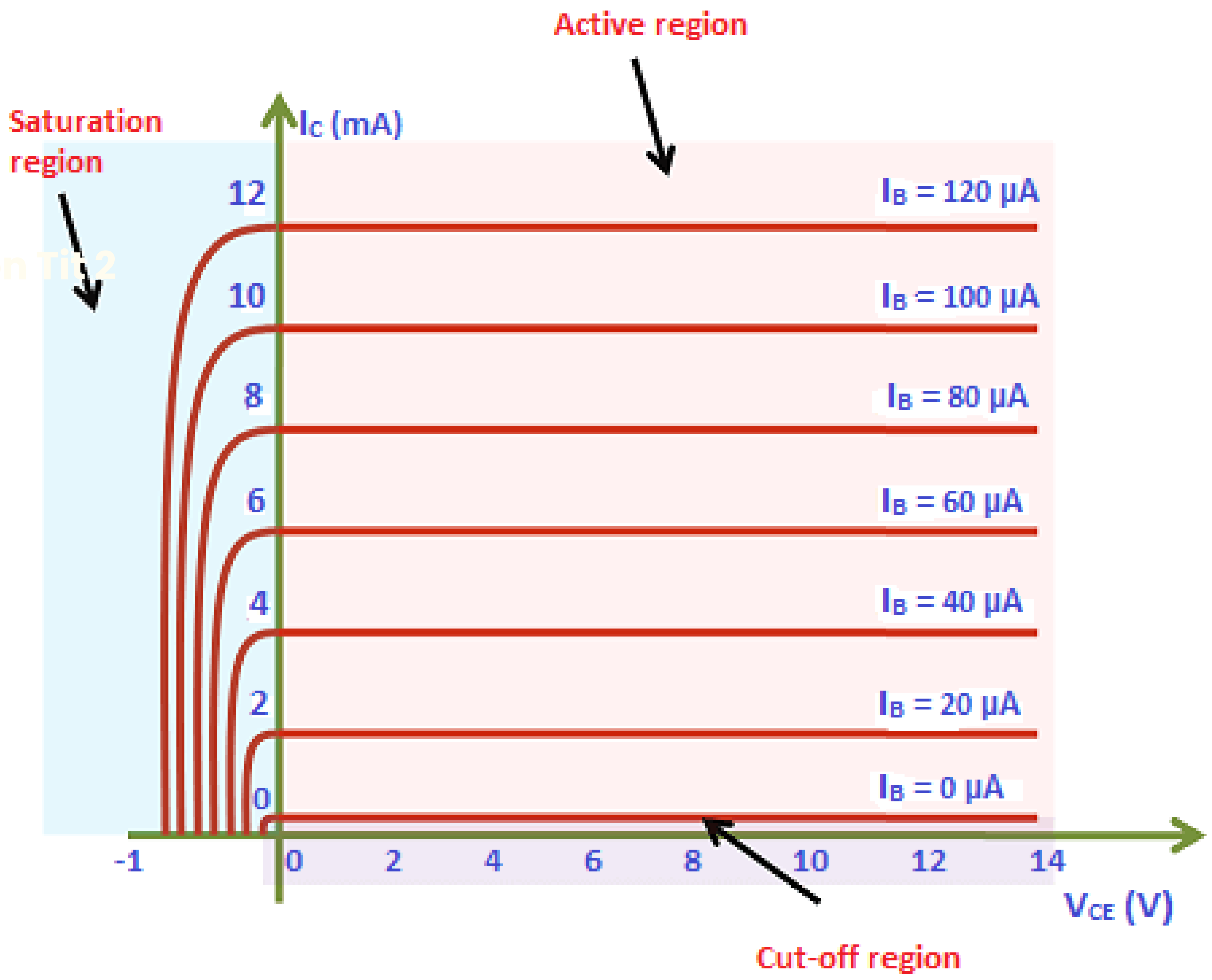
Common emitter configuration

$$I_E = I_B + I_C$$

Transistor Characteristics



I/P cl ristics CE configuration

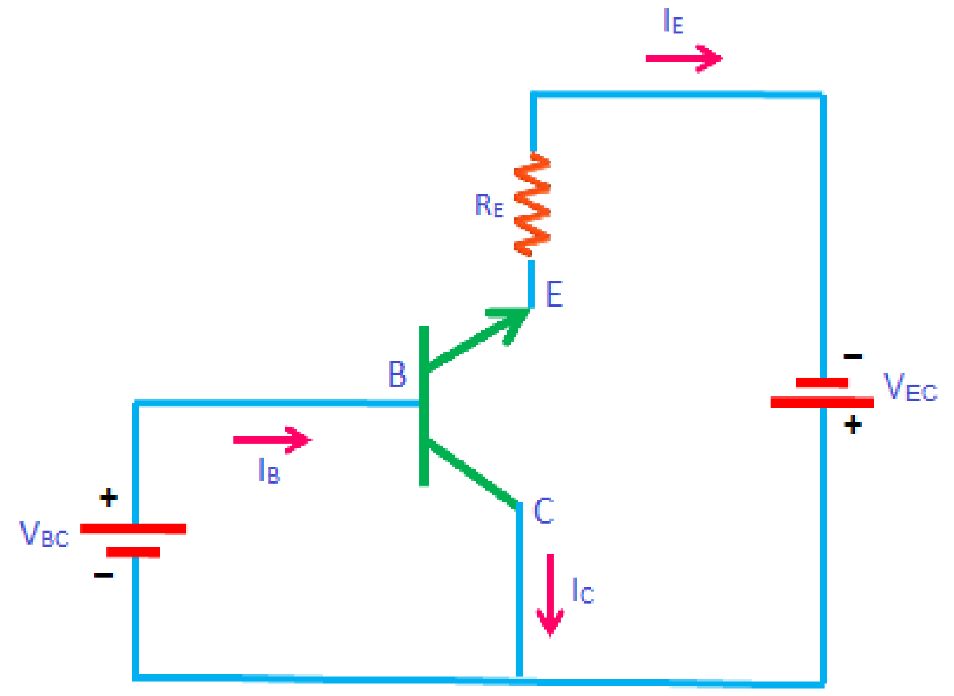


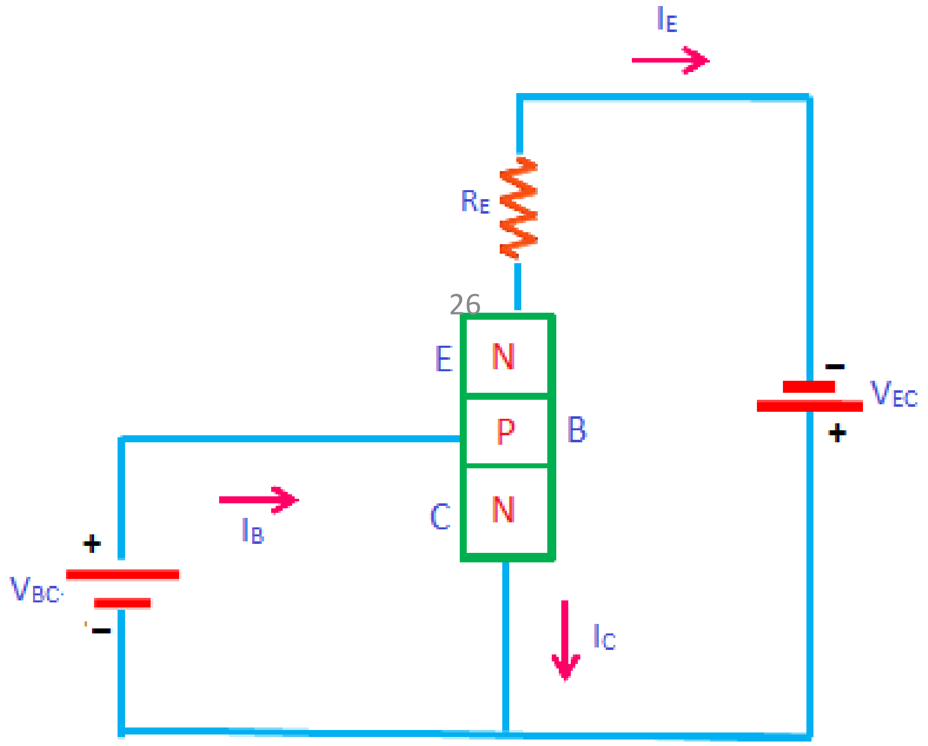
O/P Characteristics CE Configuration

Transistor Parameters

Dynamic input resistance (r_i)	Dynamic output resistance (r_o)	Current gain (α)
Dynamic input resistance is defined as the ratio of change in input voltage or base voltage (VBE) to the corresponding change in input current or base current (IB), with the output voltage or collector voltage (VCE) kept at constant. $r_i = \frac{\Delta V_{BE}}{\Delta I_B},$ $V_{CE} = Constant$	Dynamic output resistance is defined as the ratio of change in output voltage or collector voltage (VCE) to the corresponding change in output current or collector current (IC), with the input current or base current (IB) kept at constant. $r_o = \frac{\Delta V_{CE}}{\Delta I_C},$ $I_B = Constant$	The current gain of a transistor in CE configuration is defined as the ratio of output current or collector current (IC) to the input current or base current (IB). $\alpha = \frac{I_C}{I_B}$

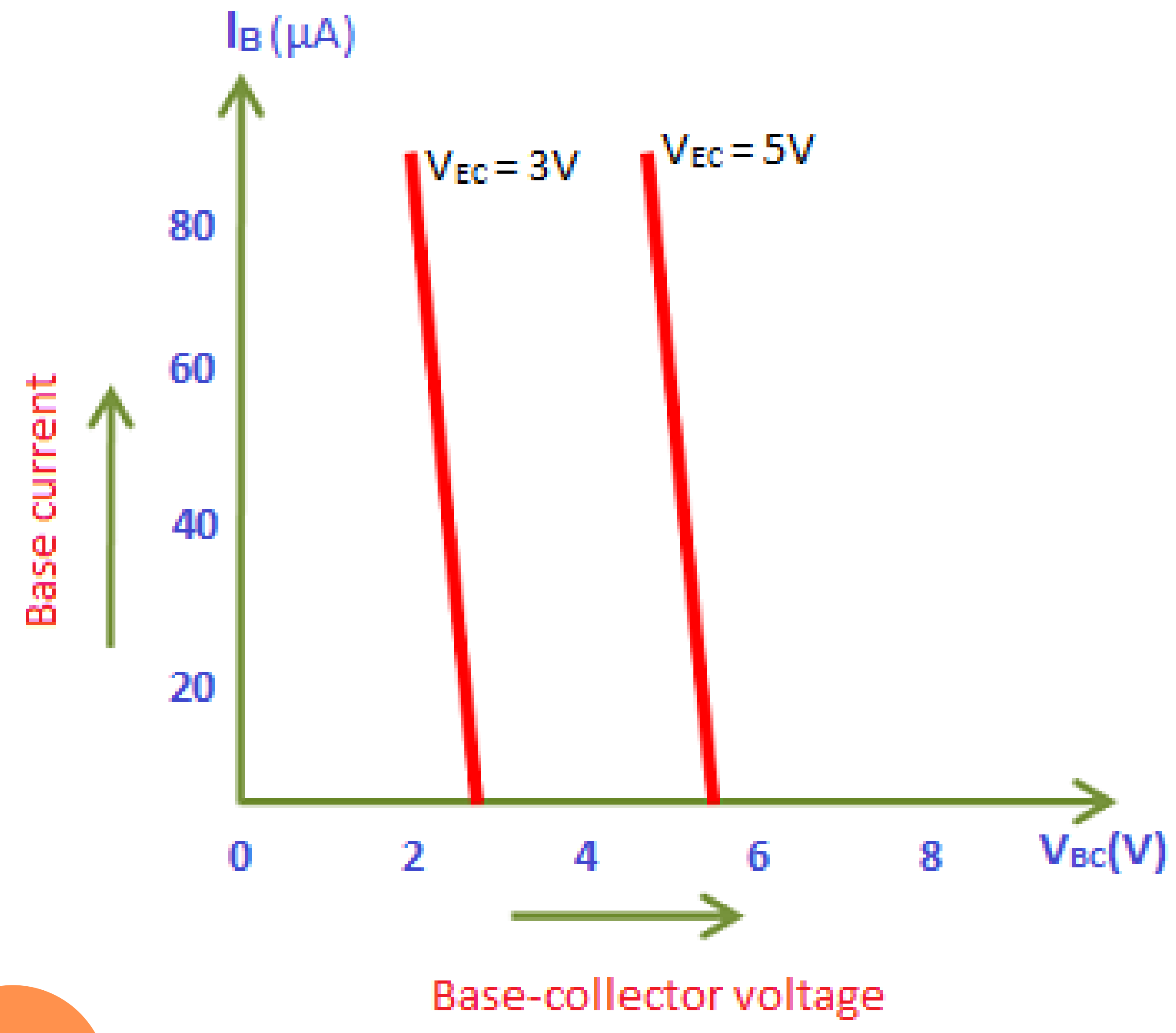
Common Collector Configuration





Common collector configuration

Transistor Characteristics



Input characteristics

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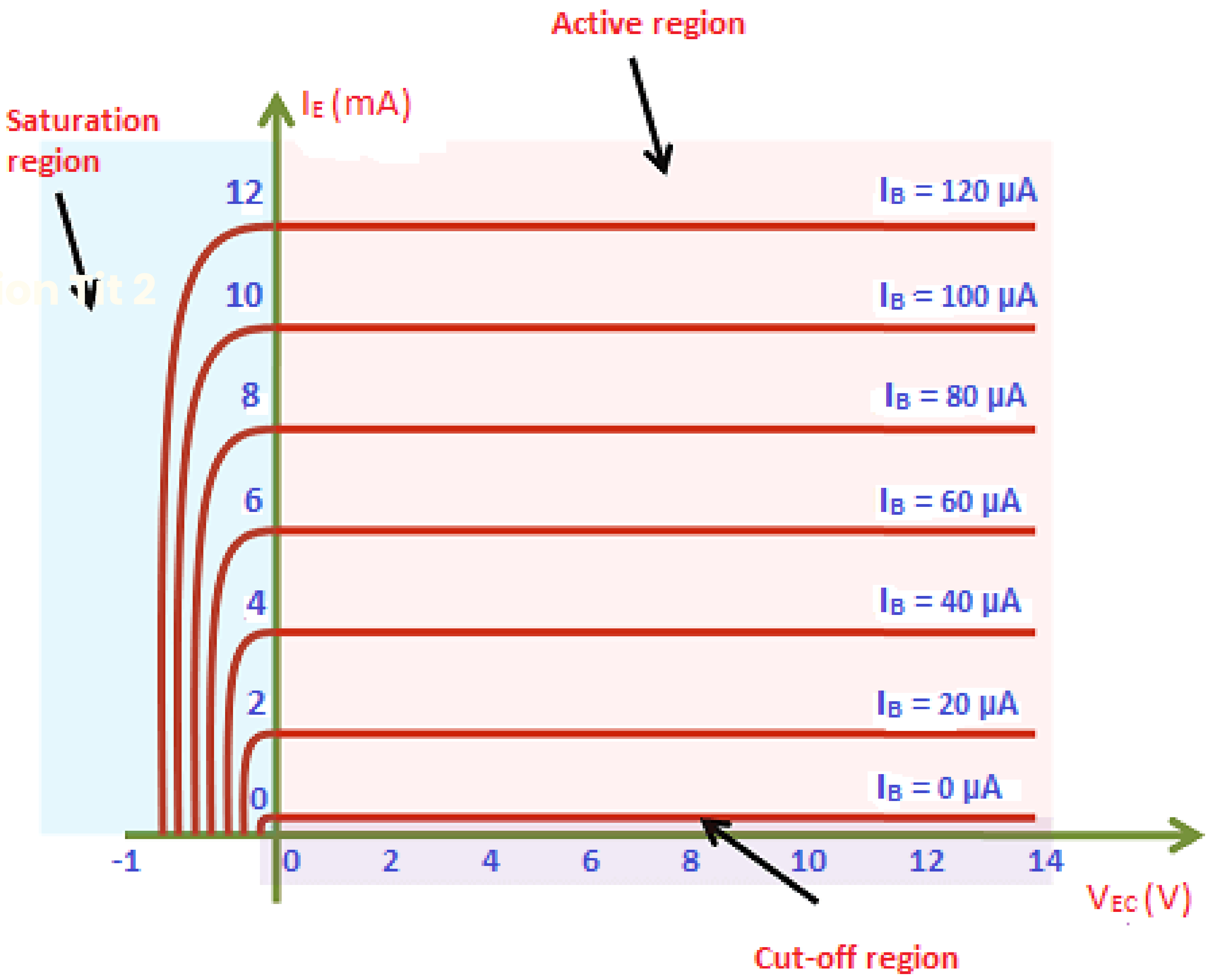

Output characteristics

Transistor Parameters

Dynamic input resistance (r_i)	Dynamic output resistance (r_o)	Current gain (α)
Dynamic input resistance is defined as the ratio of change in input voltage or base voltage (V_{BC}) to the corresponding change in input current or base current (IB), with the output voltage or emitter voltage (V_{EC}) kept at constant. $r_i = \frac{\Delta V_{BC}}{\Delta I_B}$, $V_{CE} = Constant$	Dynamic output resistance is defined as the ratio of change in output voltage or emitter voltage (V_{EC}) to the corresponding change in output current or emitter current (I_E), with the input current or base current (IB) kept at constant. 28 $r_o = \frac{\Delta V_{CE}}{\Delta I_E}$, $I_B = Constant$	The current gain of a transistor in CE configuration is defined as the ratio of output current or collector current (IC) to the input current or base current (IB). $\gamma = \frac{\Delta I_E}{\Delta I_B}$