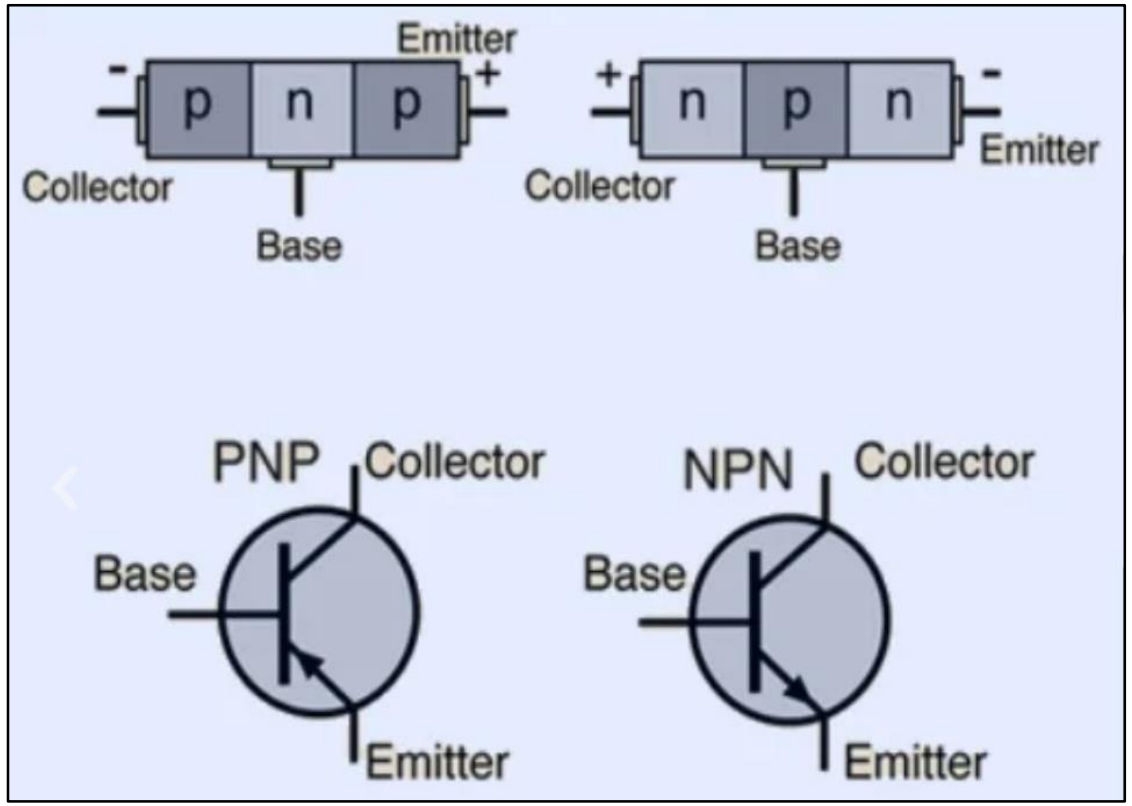
Lecture 3B: BJT Circuits

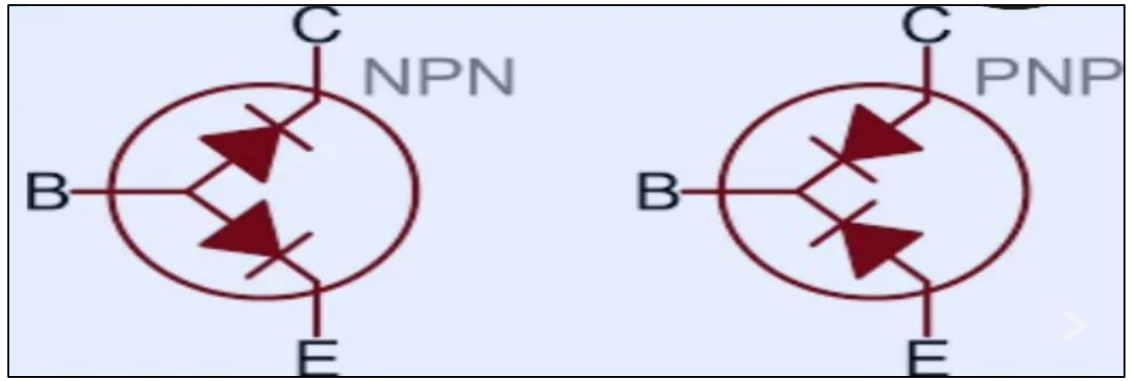
EE 103

2023-24/I (Autumn)

Joseph John (j.john@iitb.ac.in, jjohn@ee.iitb.ac.in)

Bipolar Junction Transistor (BJT)





Parameter	BJT
Types	Based on the construction, BJTs are classified into two types: NPN and PNP
Terminals	BJT has three terminals viz. emitter, base and collector.
Controlling quantity	BJT is a current controlled device Base current ($\mathbf{I_B}$) controls the Collector Current ($\mathbf{I_C}$)
Applications	BJT is used in Following applications 1. Amplifiers 2. Oscillators 3. **Switches** 4. Buffers

Modes of Operation

- BJT has Three terminals, Two junctions:
  - Base-Emitter Junction and Base Collector Junction
- Base-Emitter is the main controlling junction
- Three main modes of operation:
  - Cut-off: Both Base-Emitter and Base-Collector junctions reverse-biased
  - Active : Base-Emitter junction is forward-biased, Base-Collector junction reverse biased.
  - Saturation: Both Base-Emitter and Base-Collector junctions are forward-biased

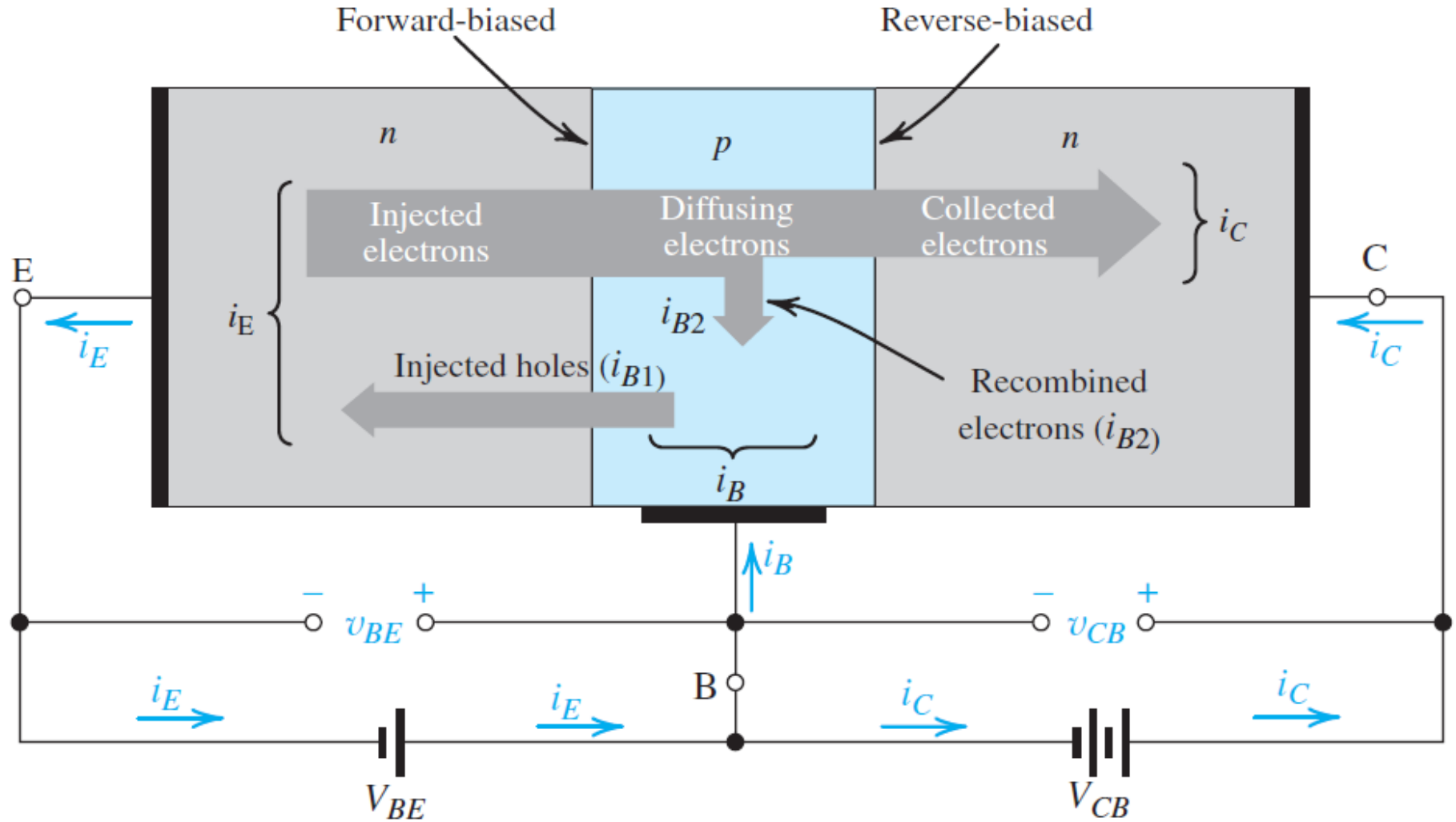


Figure 6.3 Current flow in an *npn* transistor biased to operate in the active mode. (Reverse current components due to drift of thermally generated minority carriers are not shown.)

Basic Equations

- $I_E = I_B + I_C$ (KCL) – always true
- $\beta = I_C/I_B$ (Current gain in the Common-Emitter mode)
  - $\beta >> 1$
  - Common Emitter: Input applied between Base and Emitter, Output between Collector and Emitter. Emitter is common to both input and output.
- $\alpha = I_C/I_E$ (Current gain in the Common-Base mode)
  - $\alpha < 1$
  - Common Base: Input applied between Emitter and Base, Output between Collector and Base. Base is common to both input and output.
- $\beta = \alpha/(1- \alpha)$; $\alpha = \beta/(\beta+1)$

BJT Inverter Circuit

BJT Inverter

- **Case-1** $V_{IN} < V_{BE}$ (Less than PN Junction Conduction Voltage)

  $I_B = 0, I_C = 0. \rightarrow V_{out} = V_{CE} = V_{CC}$ (BJT is said to be Cut-off)

- **Case-2** $V_{IN} > V_{BE}$ BJT Conducts, with $I_B > 0$

  $I_B = (V_{IN} - V_{BE})/ R_B$ and $I_C = \beta I_B \rightarrow V_{OUT} = V_{CE} = V_{CC} - I_C R_C$

  $V_{CEmin} = V_{CE\ Sat} = 0.2$ V $I_{CMax} = (V_{CC} - V_{CESat})/ R_C = \beta I_{BSat}$

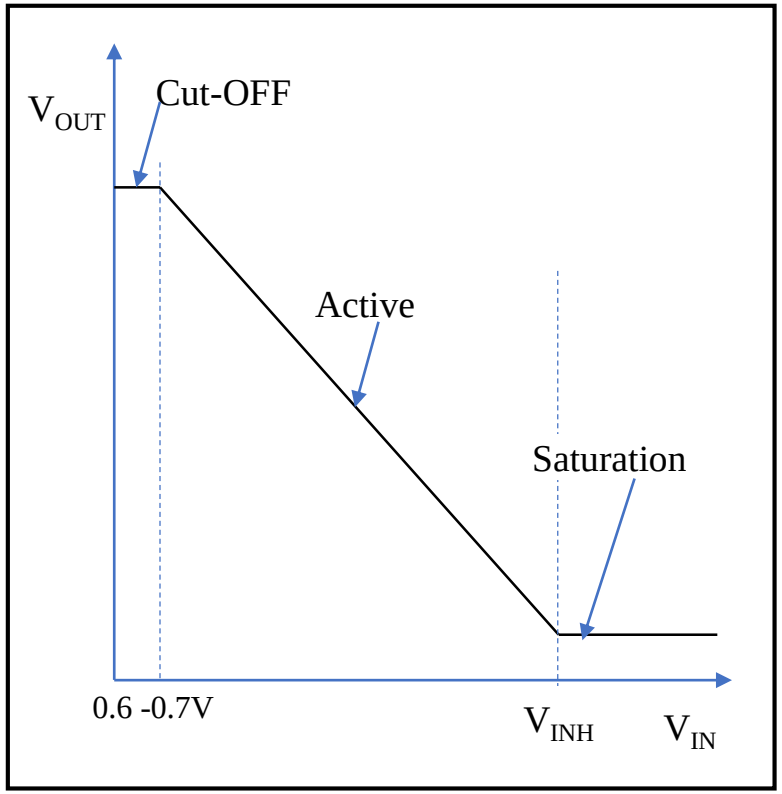
  At that point $V_{BE} = 0.7$ V and Corresponding $V_{INH} = I_{BSat} R_B + V_{BE}$

  (Active/ Linear Region)

- **Case-3** $V_{IN} > V_{INH}$

  $I_B = (V_{IN} - V_{BESat})/ R_B$ and $I_C = I_{CMax}$ But $\mathbf{I_B \beta > I_{CMax}}$

  (BJT is said to be in Saturation)



Conditions on (Vin)➔	$V_{IN} < V_{BE}$ (=V_{IL})	$V_{IN} > V_{INH}$
	BJT: OFF	**(BJT: Saturation)**

BJT DC Circuits