EEE-2103: Electronic Devices and Circuits

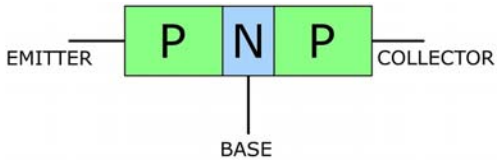
Dept. of Computer Science and Engineering
University of Dhaka

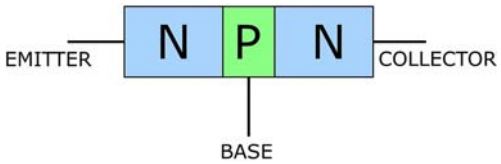
Prof. Sazzad M.S. Imran, PhD
Dept. of Electrical and Electronic Engineering
sazzadmsi.webnode.com

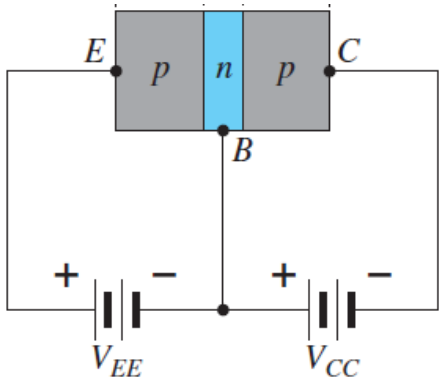
Transistor Construction

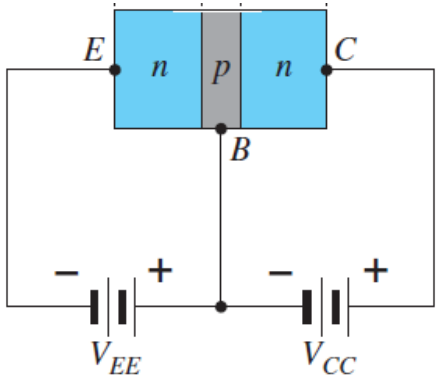
Transistor →

three-layer semiconductor device
pnp = two *p* - and one *n* -type layers
npn = two *n* - and one *p* -type layers
E = emitter, *C* = collector, *B* = base





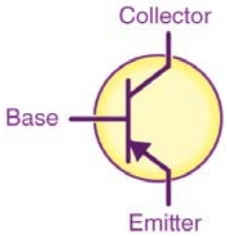


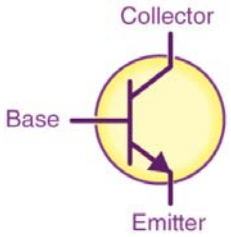


emitter layer is heavily doped,
base and collector are lightly doped

total width : center layer = 150:1
sandwiched layer doping : outer layers doping <= 1:10

BJT = bipolar junction transistor
bipolar = both holes and electrons participate in injection process





Transistor Operation

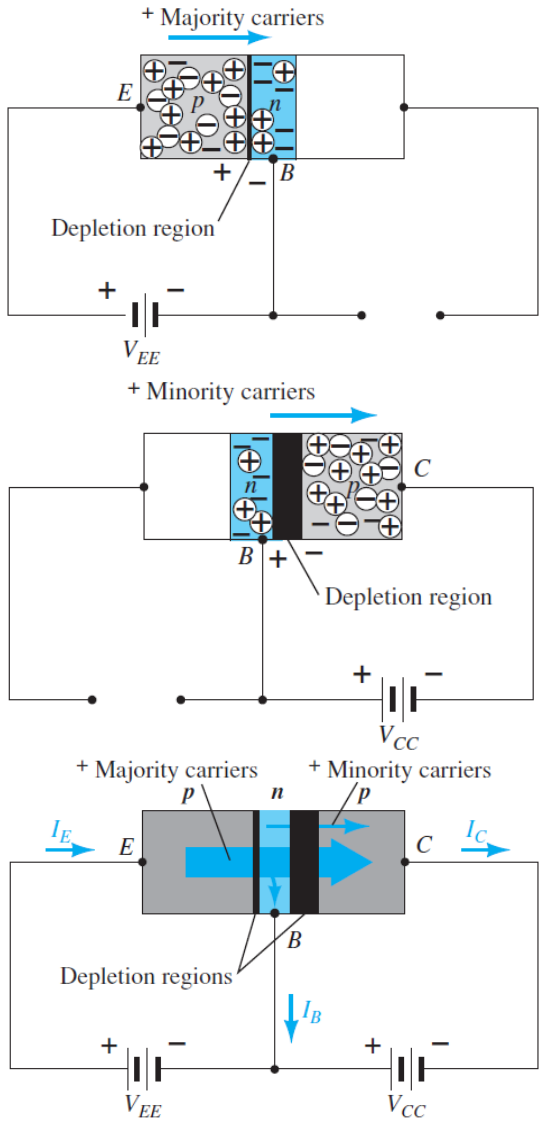
One *p*-*n* junction is reverse-biased
Another *p*-*n* junction is forward-biased.

Large number of majority carriers diffuse across
forward biased *p*-*n* junction into *n*-type material.

Sandwiched *n*-type material is very thin and has low conductivity.
very small number of majority carriers → base terminal.

For reverse-biased junction →
injected majority carriers = minority carriers in *n*-type base region.
Larger number of majority carriers +
all minority carriers in depletion region →
diffuse across reverse-biased junction into *p*-type.

$I_B \approx$ microamperes,
$I_E \approx$ milliamperes.



Transistor Operation

Applying Kirchhoff's current law

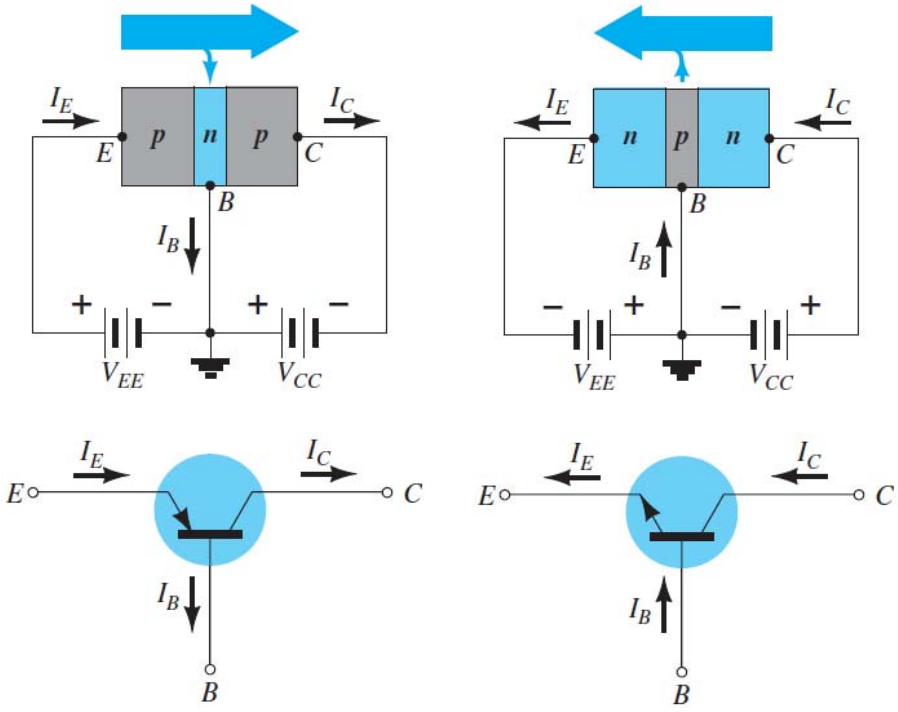
$$I_E = I_C + I_B$$

Collector current = majority + minority carriers
Minority-current component = I_{CO} = leakage current
$I_{CO} = I_C$ current with emitter terminal *O*pen

$I_C = I_{C\text{majority}} + I_{CO\text{minority}}$

$I_C \approx$ milliamperes
$I_{CO} \approx$ microamperes or nanoamperes

$I_B \approx$ microamperes,
$I_E \approx$ milliamperes.



Common-Base Configuration

Common-base terminology →

base is common to both input and output

base is closest to, or at, ground potential.

$I_E = I_C + I_B$

biasing voltage sources establish current such that

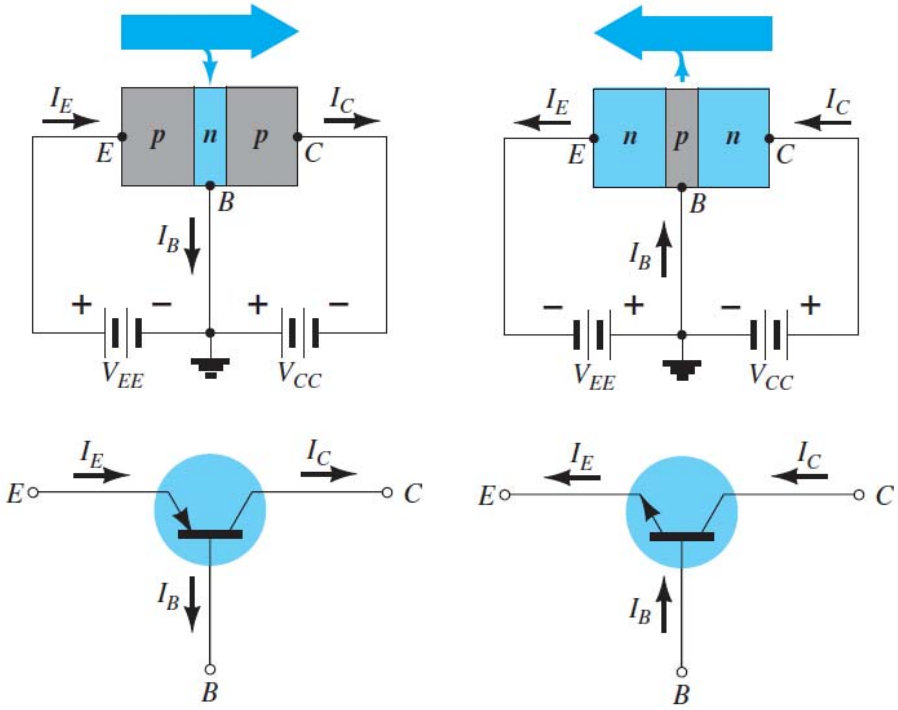
V_{EE} → direction of I_E

V_{CC} → direction of I_C

Two sets of characteristics →

i) driving point or input parameters

ii) output side.

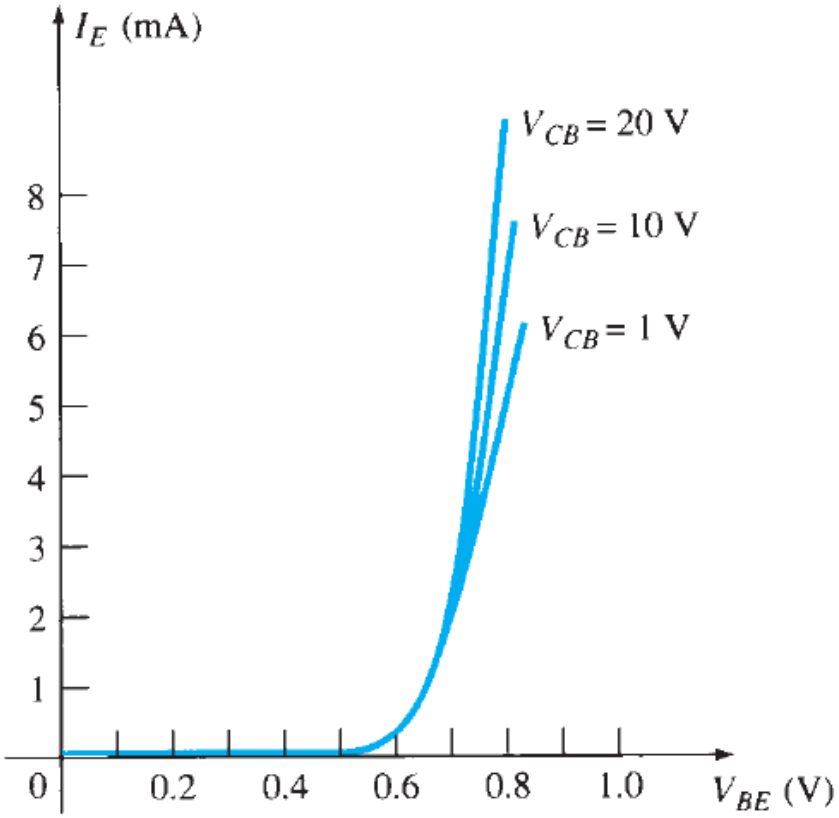


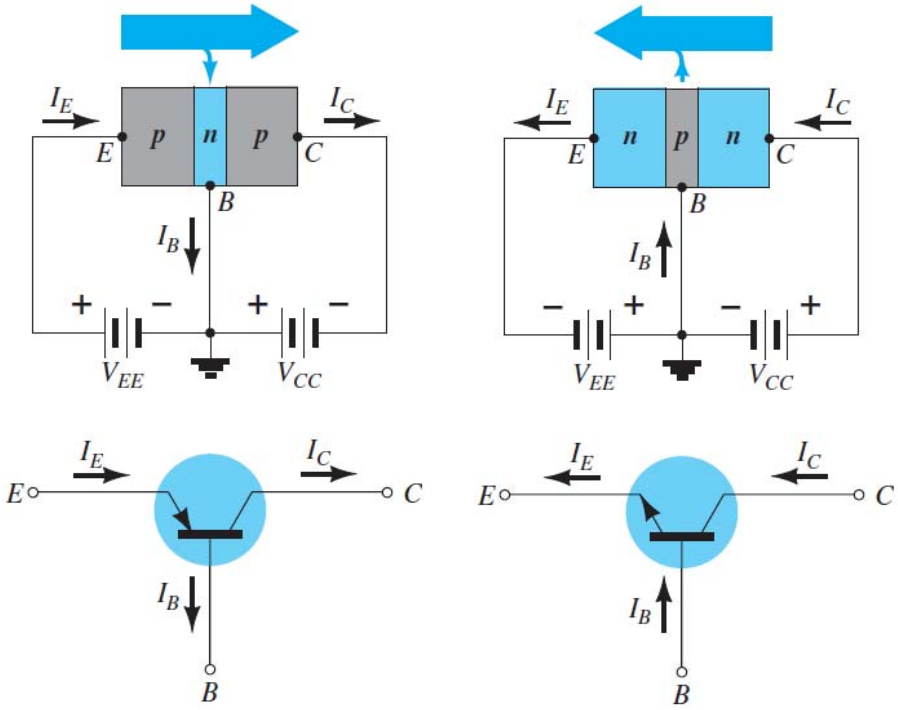
Common-Base Configuration

Input set for CB configuration →

input current (I_E) to input voltage (V_{BE})

various levels of output voltage (V_{CB})





Common-Base Configuration

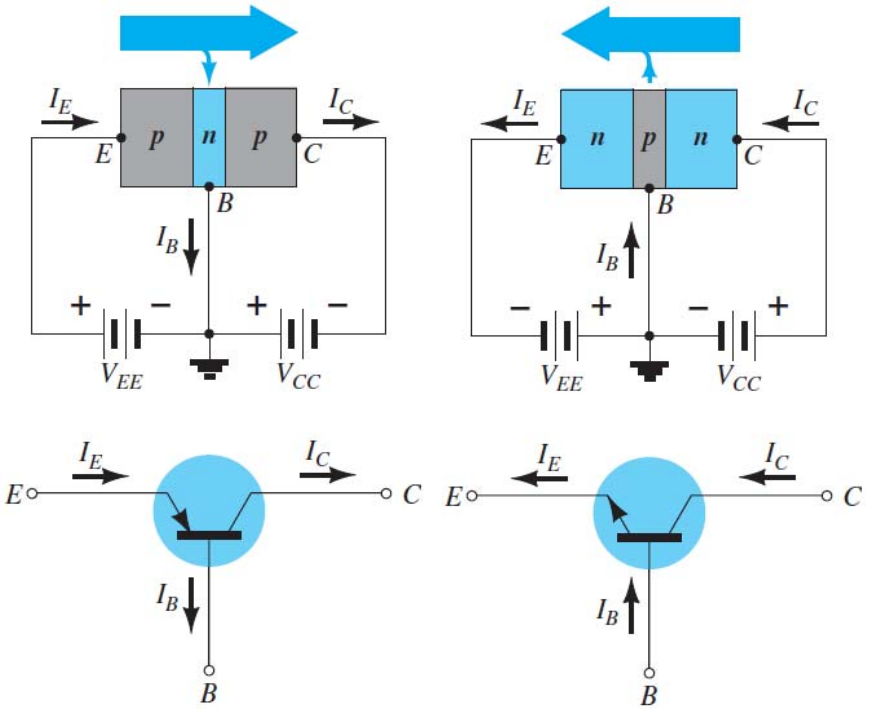
Output set for CB configuration →

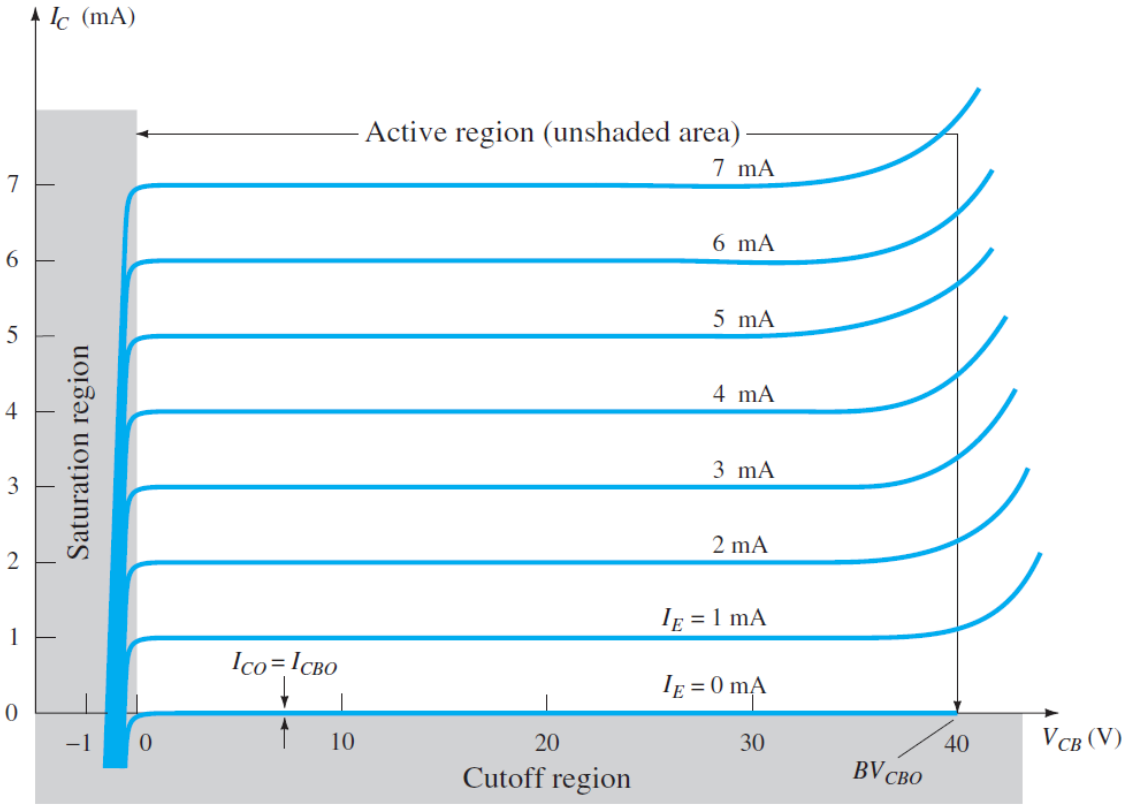
output current (I_C) to output voltage (V_{CB})

various levels of input current (I_E)

Three basic regions of interest →

active, cutoff, and saturation

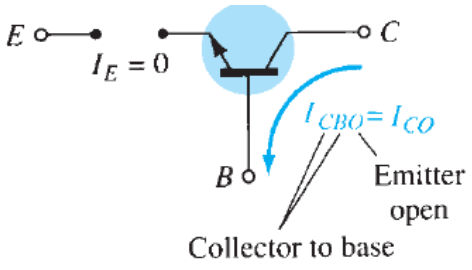


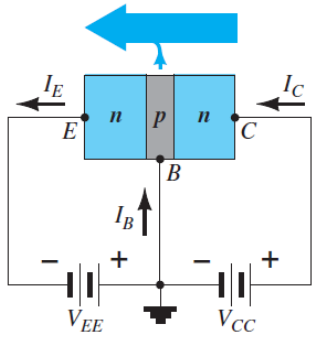


Common-Base Configuration

Active region →

base-emitter junction is forward-biased
collector-base junction is reverse-biased.





Lower end of active region →

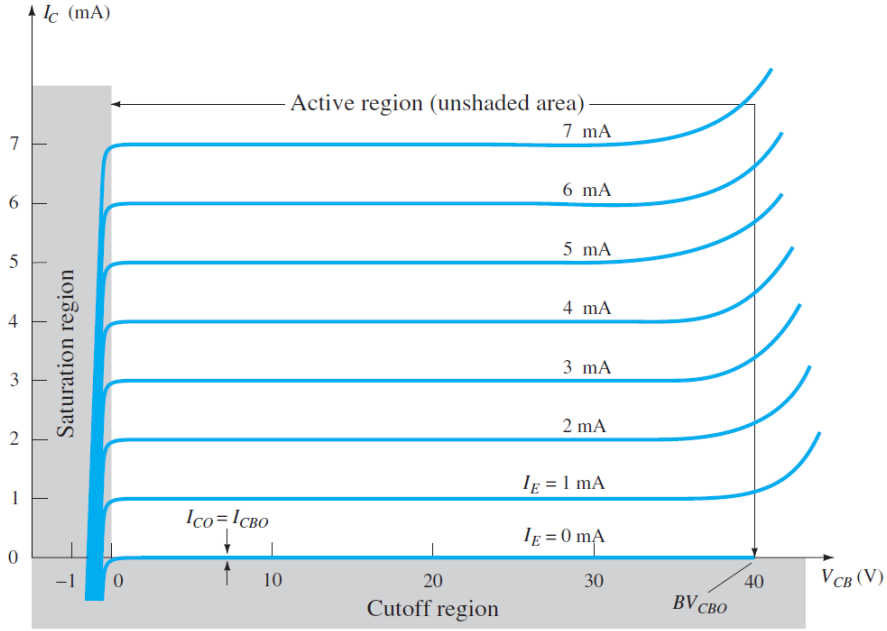
I_E = 0, $I_C = I_{CO}$ = microamperes

$I_{CO} = I_{CBO}$ = collector-to-base current emitter leg open

I_E increases above zero →

$I_C \approx I_E$

effect of V_{CB} is negligible.



Common-Base Configuration

Cutoff region →

base-emitter and collector-base junctions are both reverse-biased.

$I_C = 0$

Saturation region →

base-emitter and collector-base junctions are forward-biased.