NEPAL ENGINEERING COUNCIL

Concept of Basic Electrical and Electronics Engineering

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Contents

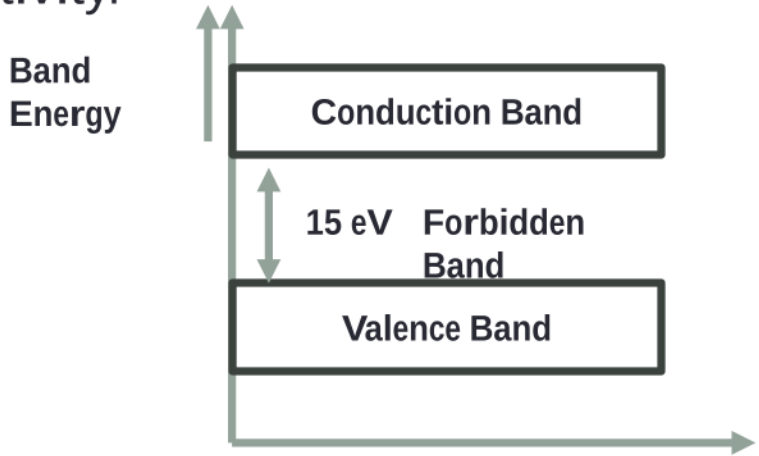
1.4 Semiconductor devices: Semiconductor diode and its characteristics, BJT Configuration and biasing, small and large signal model, working principle and application of MOSFET and CMOS.

Energy Band Diagram

i. **Insulator**

- Valence band is full, conduction band is empty.
- Energy gap ≈15 eV (Very large)
- Very large electric field is required to push valence electron to conduction electron thus almost nil electrical conductivity.
- AC peak value is responsible for

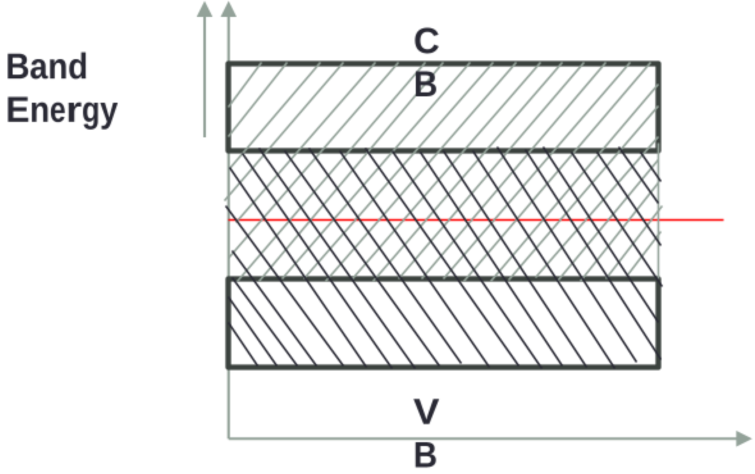
Insulator breakdown



eV = Electron Volt: the energy gained by an electron when it has been accelerated by a potential difference of 1 volt

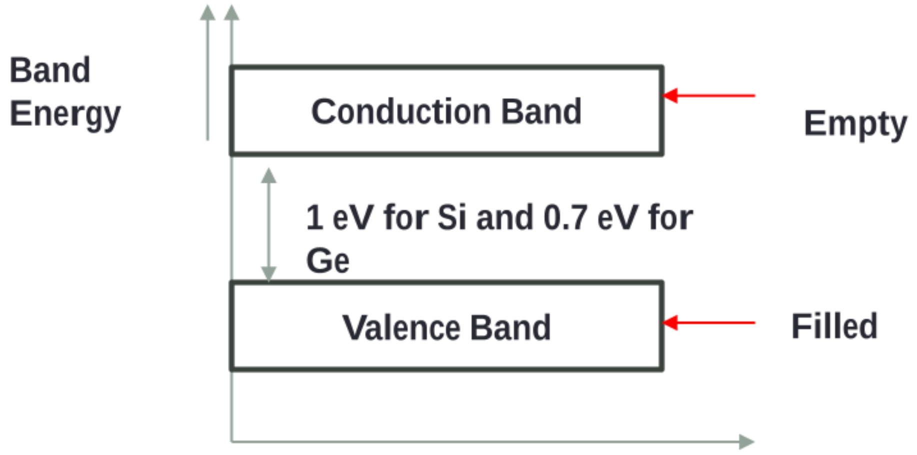
ii. **Conductors**

- Very large number of free electrons are available
- VB and CB overlap each overlap each other.
- Hence, slight potential difference across it causes free electrons to constitute current.
- As T↑ R↑ (+ Ve temperature coefficient of R)



iii. Semiconductors

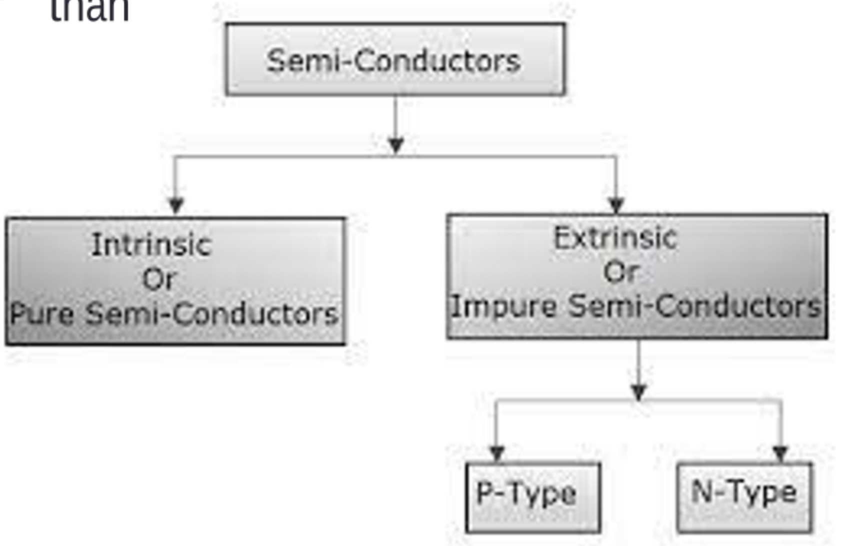
- Conductivity lies between conductor and insulator
- Valance Band is almost full
- Conduction is almost empty
- Very small energy gap $(\approx 1\ \text{eV for Si and } 0.7\text{eV for Ge})$
- Comparatively small electric field is required to push electron from VB to CB).



Semiconductor Devices

Semiconductor devices are made up of materials that are neither good conductors nor good insulators.

- Higer Resistance than metals and lower than insulators.
- Negative temperature coefficient
- Si, Ge

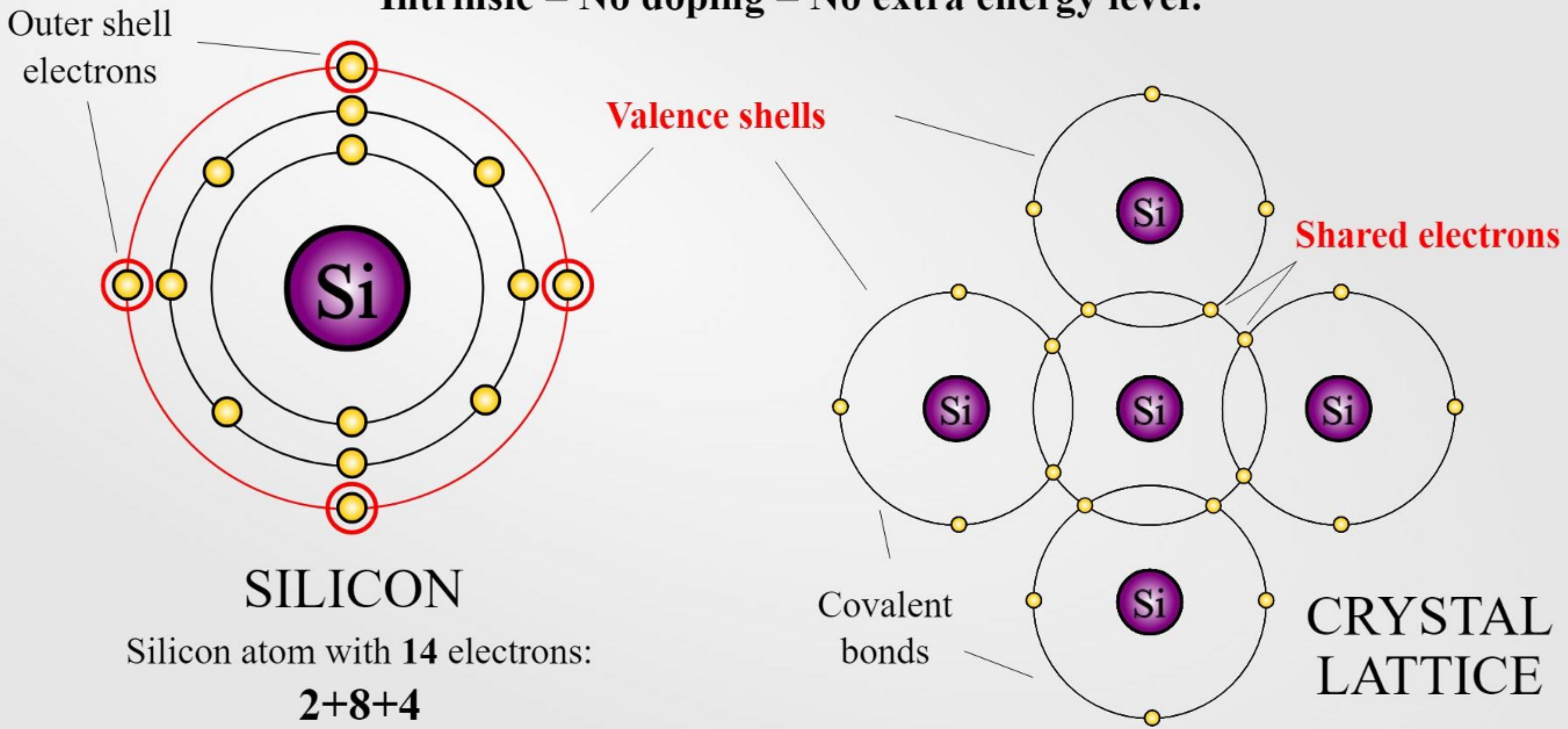


Types of Semiconductor

S.NO	Intrinsic Semiconductor	Extrinsic Semiconductor
1	It is in pure form.	It is formed by adding trivalent or pentavalent impurity to a pure semiconductor.
2	Holes and electrons are equal.	No. of free holes are more in p-type and no. of free electrons are more in n-type.
3	Fermi level lies in between valence and conduction Bands.	Fermi level lies near valence band in p-type and near conduction band in n-type.
4	Ratio of majority and minority carriers is unity.	Ratio of majority and minority carriers is not unity.

Intrinsic Semiconductor

Intrinsic = No doping = No extra energy level!



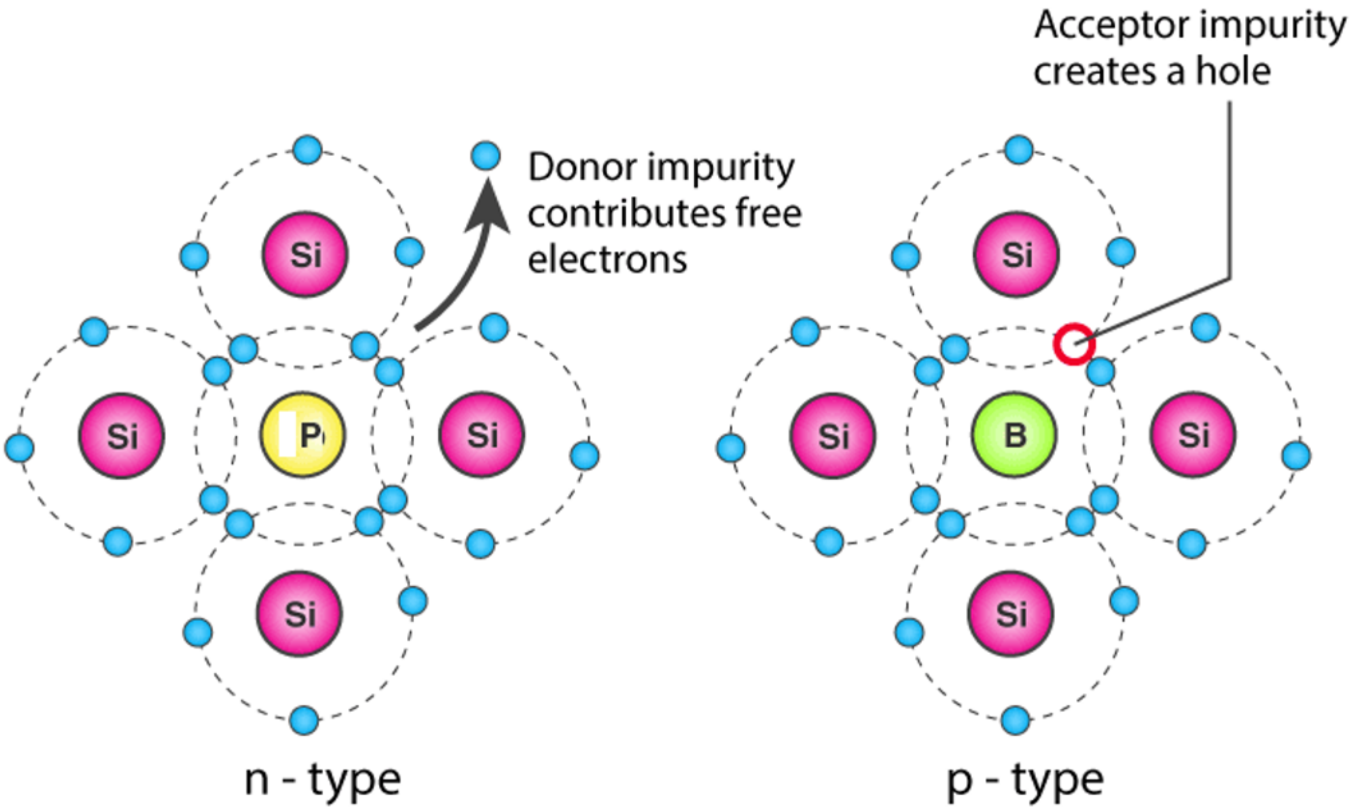
Extrinsic semiconductors

N type:

- Doped with Pentavalent atom (Phosphorus, Arsenic, Antimony)
- Has excess electron

P type:

- Dopant are triavalent atom (Boron, Aluminium, Gallium)
- Has excess hole



Which one of the following statement is FALSE?

a. Pure Si doped with trivalent impurities gives a p-type semiconductor.
b. Majority carriers in a n-type semiconductor are holes
c. Minority carriers in a p-type semiconductor are electrons
d. The resistance of intrinsic semiconductor decreases with increase of temperature

Answer A

In a pure semiconductor crystal, if current flows due to breakage of crystal bonds, then what is the semiconductor is called?
a) Acceptor
b) Donor
c) Intrinsic semiconductor
d) Extrinsic semiconductor

Answer C

Which of the following, when added as an impurity, into the silicon, produces n-type semiconductor?

a) Phosphorous
b) Aluminum
c) Magnesium
d) Sulfur

Answer a

In n-type semiconductors, which one is the minority charge carriers?

a) Holes
b) Protons
c) Neutrons
d) Electrons

Answer a

A small impurity is added to germanium to get a p-type semiconductor. Identify the impurity?

a) Bivalent substance
b) Trivalent substance
c) Pentavalent substance
d) Monovalent substance

Answer b

The dominant contribution to current comes from holes in case of which of the following?

a) Metals
b) Intrinsic semiconductors
c) p-type extrinsic semiconductors
d) n-type extrinsic semiconductors

Answer c

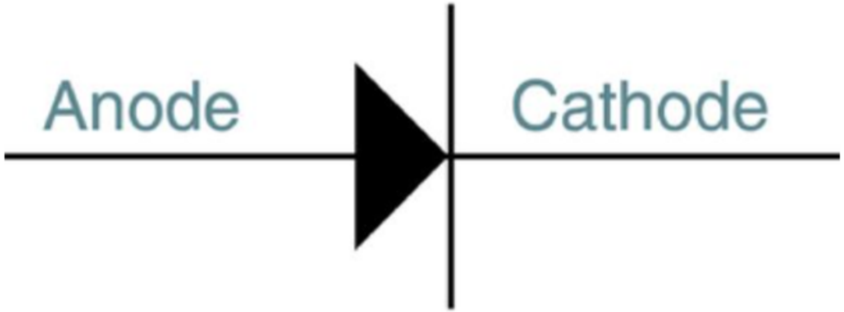
In a p-type semiconductor, germanium is doped with which of the following?

a) Gallium
b) Copper
c) Phosphorous
d) Nitrogen

Answer a

Diode

- Diodes let current flow one way, but not the other
- Current flows from anode to cathode

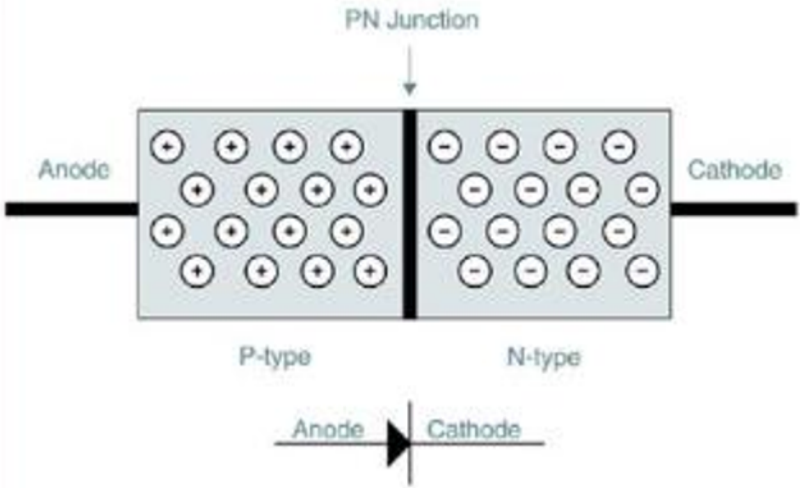


Types of Diodes

1. Light Emitting Diode
2. Laser diode
3. Avalanche diode
4. Zener diode
5. Schottky diode
6. Photodiode
7. PN junction diode

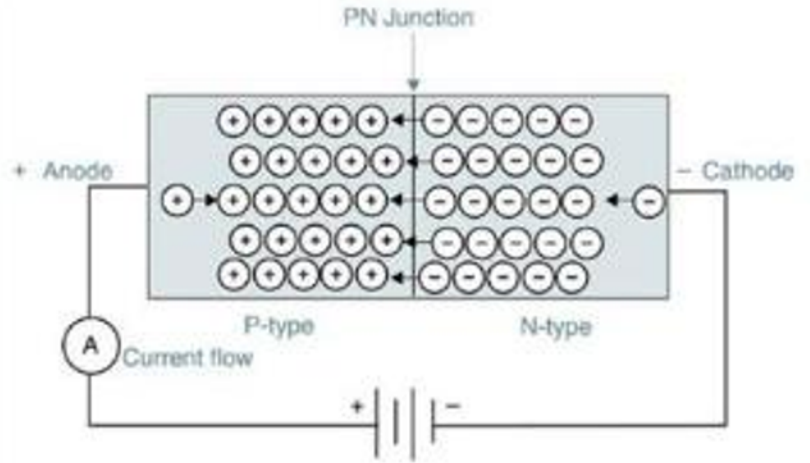
PN Junction diode

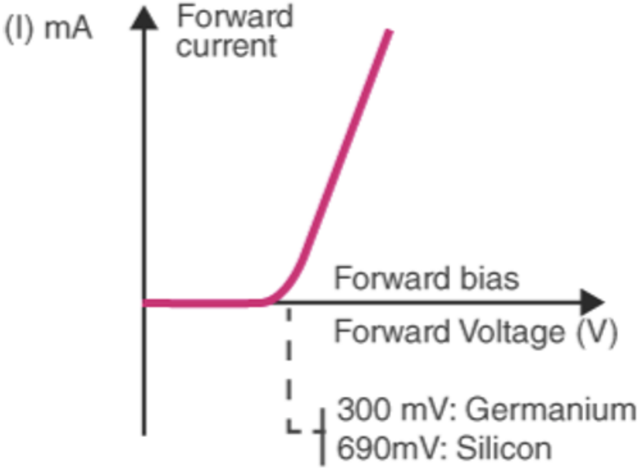
- The P-N junction diode includes two layers of semiconductors.
- One layer of the semiconductor material is doped with P-type material and the other layer with N-type material.
- The combination of these both P and N-type layers form a junction known as the P-N junction. Hence, the name P-N junction diode.
- P-N junction diode allows the current to flow in the forward direction and blocks the flow of current in the reverse direction.



Forward Biasing

Forward bias
Positive terminal of battery is connected to *p*-type and negative terminal to *n*-type semiconductor.
Depletion layer is very thin.
p-n junction offers very low resistance.
An ideal diode have zero resistance.

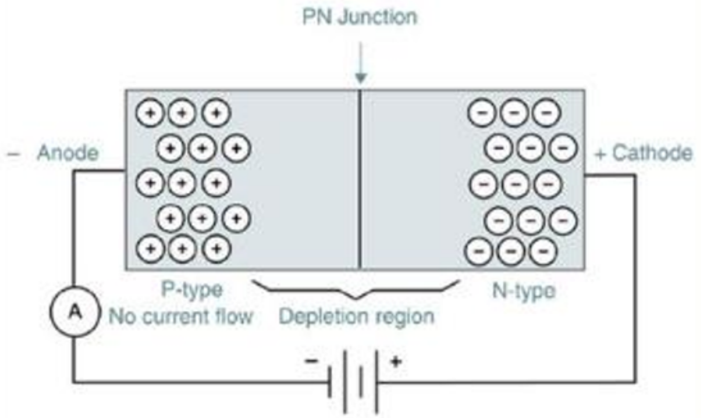


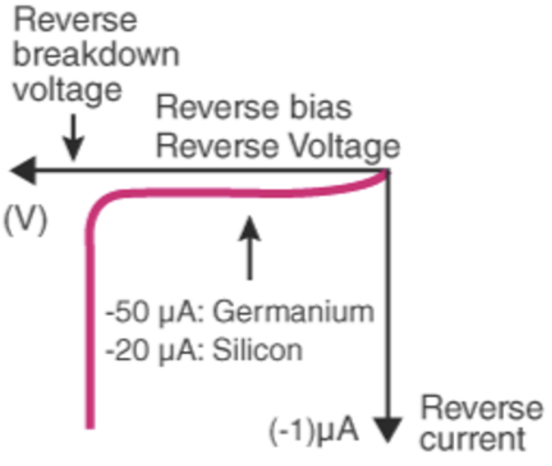


Forward-biased diode

Reverse Biasing

Reverse bias
Positive terminal of battery connected to *n*-type and negative terminal to *p*-type semiconductor.
Depletion layer is thick.
p-*n* junction offers very high resistance.
An ideal diode have infinite resistance.

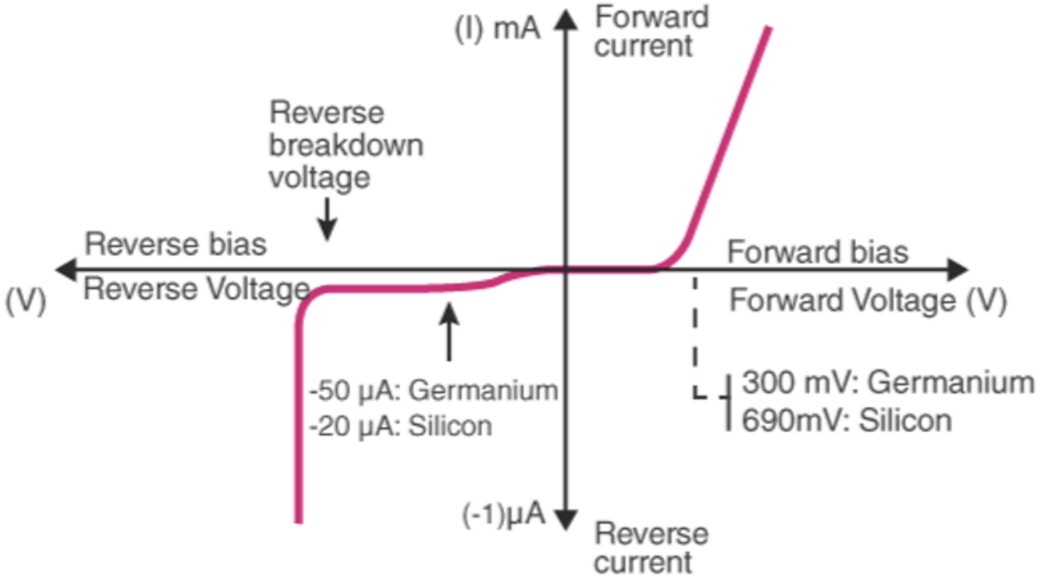




Reverse-biased diode

Characteristics of Diode

Operation of diode can be summarized in form of I-V **diode characteristics** graph.



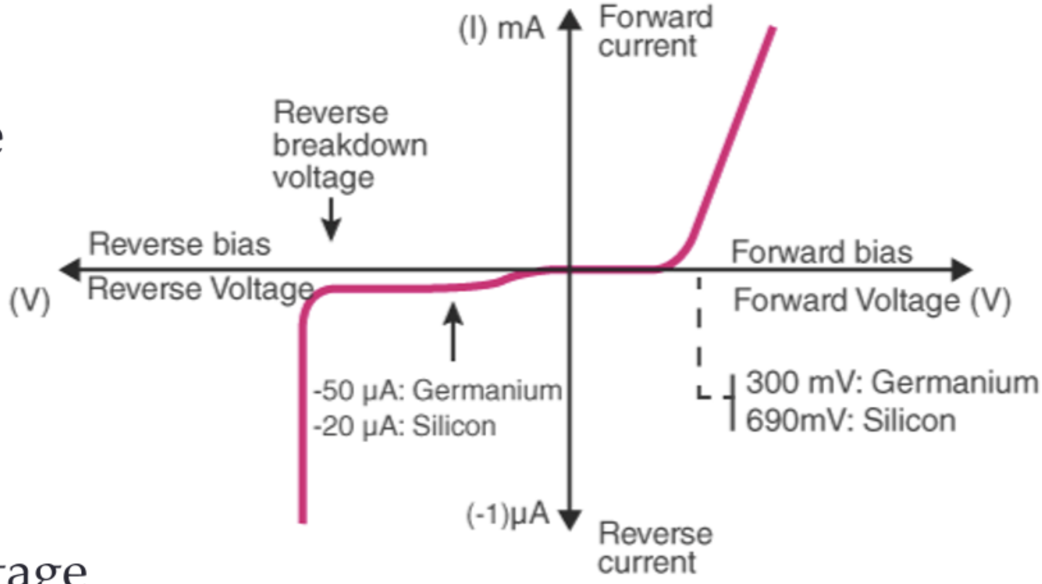
VI characteristics of Diode

Characteristics of Diode

Operation of diode can be summarized in form of I-V **diode characteristics** graph.

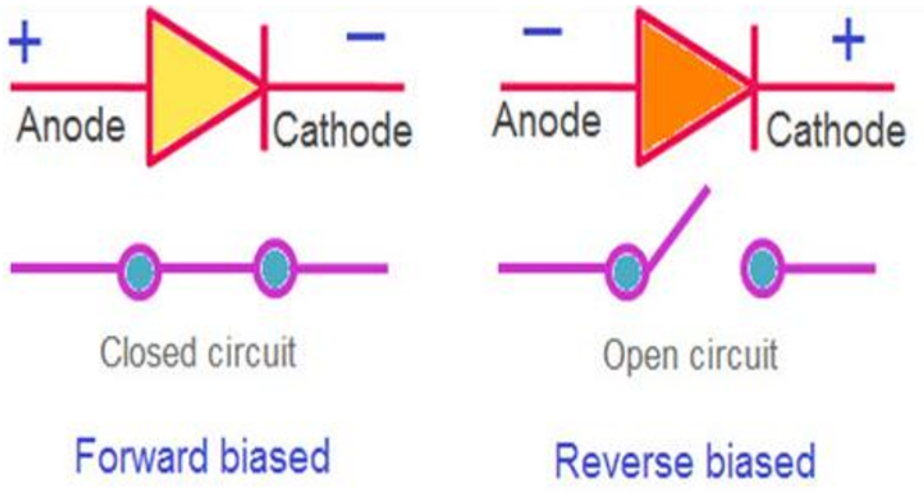
Knee Voltage: Forward Voltage (0.3/0.7 for Ge/Si)

Breakdown Voltage: Reverse Voltage



VI characteristics of Diode

Ideal Diode



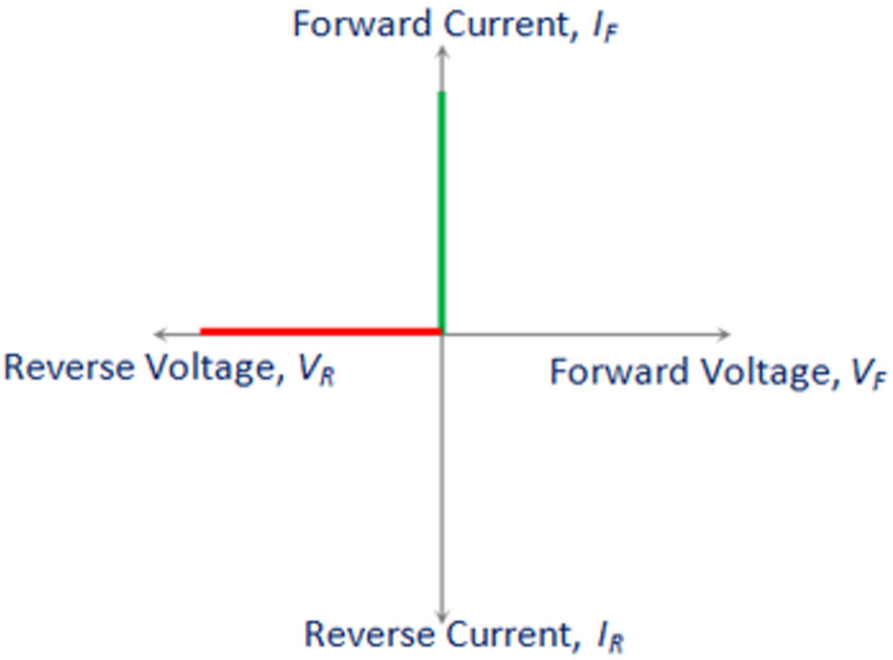


Figure 1 I-V Characteristics of an Ideal Diode

How ideal diode responds to forward voltages?

a. Perfect conductor
b. Perfect insulator
c. Semiconductor
d. Insulator

Ans: a, Ideally, the resistance offered for applied forward voltages by the diode is 0. These are known as Perfect conductors.

How diode circuit behaves in forward mode ideally?

a. Resistive
b. Short-circuit
c. Open circuit
d. Series

Ans: b

How ideal diode responds to reverse voltages?

a. Perfect conductor
b. Perfect insulator
c. Semiconductor
d. Insulator

Ans: b, In an ideal situation, the diode doesn't allow any current to flow and its resistance is infinite.

Reverse saturation current for a diode …….. for every 10 degree C rise in temperature

a. Double
b. Half
c. Remain same
d. Triple

Answer a, when temp increases more electron hole pair gets generates and Is increases

The potential barrier at a P-n junction is due to the charges on either side of the junction. These charges are

a. Fixed ions
b. Majority carriers
c. Both majority and minority carriers
d. Minority carriers

Answer: A

The barrier voltage for germanium is

a. 0.1V
b. 0.3V
c. 0.5V
d. 0.7V

Ans: b, For Si-0.7 and for Ge-0.3V (Barrier voltage/cut in voltage/knee voltage is the minimum voltage required for practical diode to conduct)

In a p-n junction, there exist a concentration difference of charge carriers in the given junctions. A covalent bond is formed when an electron from n-section diffuses into the p-section in a process called electron hole recombination. Accumulation of electric charges of opposite polarities creates a potential barrier between the two sections of the junction. This electric field setting up a potential barrier in the junction which opposes further diffusion is due to the fixed acceptor and donor ions on either side of the junction.

What are the units used in the measurement of forward current & Reverse currents in diode ?

A. Micro Amperes, Micro Amperes
B. Micro Amperes, milli Amperes
C. milli Amperes, Micro Amperes
D. milli Amperes, milli Amperes

Ans: C

Condition in which diode never intentionally operate is

A) reverse biased

B) forward biased

C) floating biased

D) neutral biased

Answer: A

Point in a characteristics curve at which barrier potential is overcome and current increases drastically is termed as

A) knee of characteristics curve

B) base of characteristics curve

C) core of characteristics curve

D) saturation of characteristics curve

Answer A

Multiplication of conduction electrons in reverse breakdown condition is called

A) avalanche

B) burning

C) break over

D) Knee

Answer: A

Ideal Diode Equation

$$I_D = I_s(e^{\frac{V_D}{\eta V_T}} - 1)$$

Where,

I_D is diode current

I_s is reverse saturation current

V_D is Diode terminal voltage

V_T=kT/q=thermal voltage= 25mV at room temperature

T _ absolute temperature of p-n junction, K

k _ Boltzmann's constant 1.38x 10^{-23} J/K)

q _ electron charge 1.6x10^{-19} C

η = empirical constant, 1 for Ge and 2 for Si

Q) A Germanium diode is used in a rectifier and is operating at 25 degree C with a reverse saturation current of 1000 μA. The value of forward current, iuf it is forward biased by 0.22V.

a. 4.638
b. 6.633
c. 0.633
d. 0.468

$$I_D = I_s(e^{\frac{V_D}{\eta V_T}} - 1)$$

n=1 for Ge
Is given
V_D given
V_T=KT/q
T= 273+25 Kelvin

Calculate the thermal voltage when the temperature is 25°C.
a) 0V
b) 0.02V
c) 0.026V
d) 0.25V

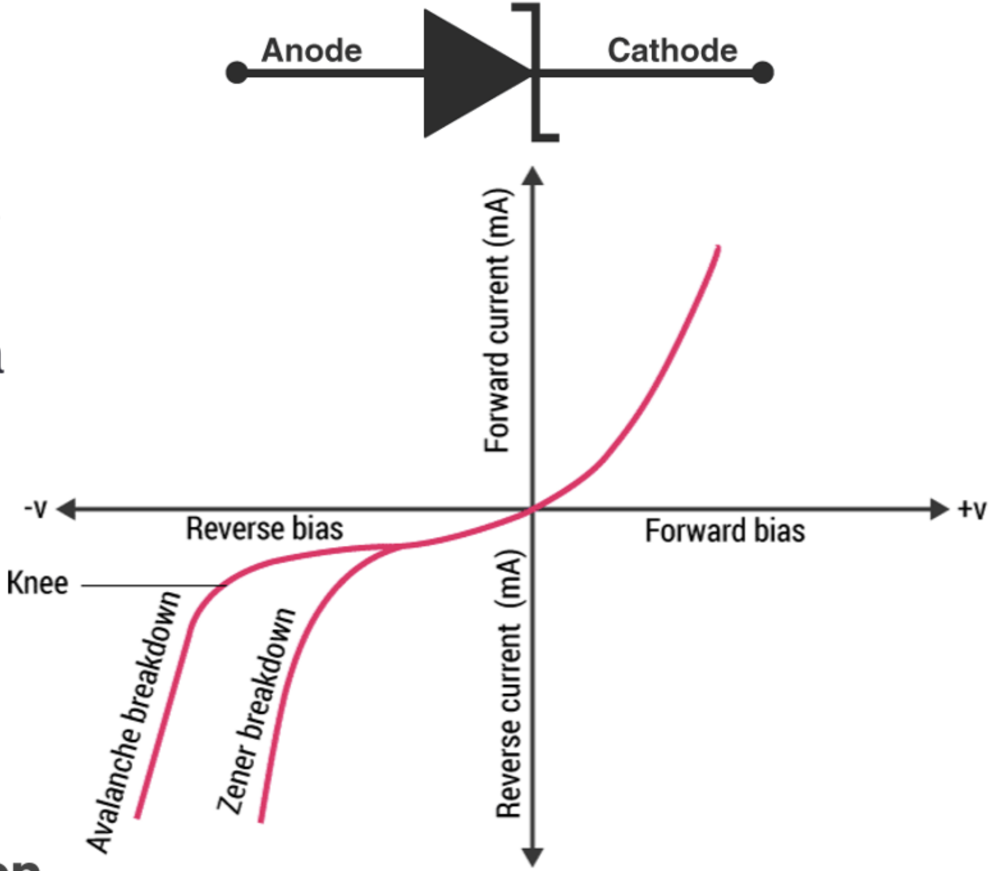
Answer: C
Thermal voltage V_T is given by k T/q
Where k is the Boltzmann constant and q is the charge of electron. This can be reduced to
V_T = T/11600
Therefore, V_T = 298/11600 = 0.0257V.

Calculate the forward bias current of a Si diode when forward bias voltage of 0.4V is applied, the reverse saturation current is 1.17×10^{-9}A and the thermal voltage is 25.2mV.
a) 9.156mA
b) 8.23mA
c) 1.256mA
d) 5.689mA

Answer: a
$I=I_0\times(e^{(V/\eta V_T)}-1)$
$I_0 = 1.17 \times 10^{-9}$A, $V_T = 0.0252$V, $\eta = 1$, V = 0.4V
Therefore, $I = 1.17\times10^{-9} \times e^{0.4/0.025} -1$ = 9.156mA.

Zener Diode

- A Zener diode functions similarly to regular diode when forward-biased.
- However, in reverse-biased mode, a small leakage current flows through the diode. As the reverse voltage increases and reaches the predetermined breakdown voltage (Vz), current begins to flow through the diode.



Zener diode as a voltage regulator

Zener diode in over-voltage protection

Zener diode in clipping circuits

Modelling of Diode (Piecewise linear model)

$$i_D = \frac{v_D - V_{D0}}{r_D} \quad ; v_D \geq V_{D0}$$

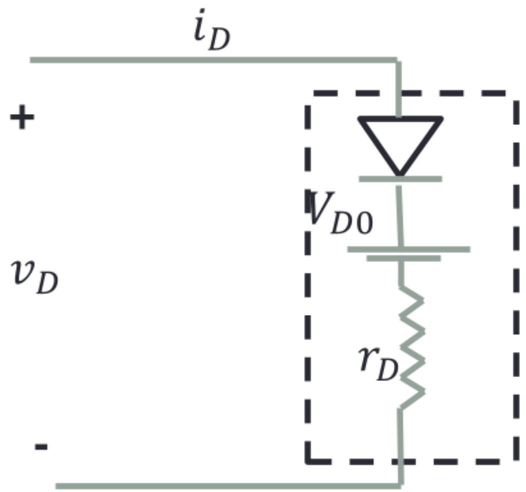
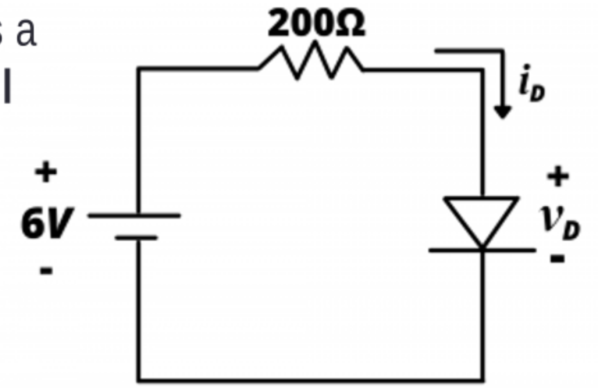
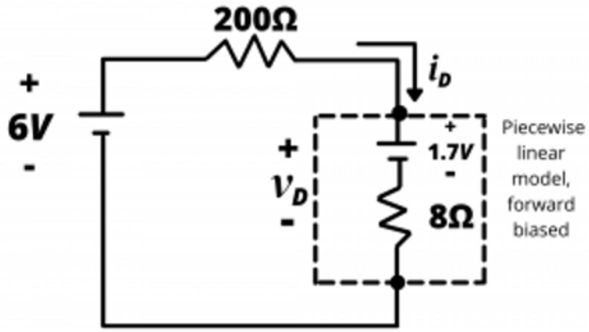


Fig: equivalent circuit representation

Determine the current in the circuit shown if the diode has a turn-on voltage V_D=1.7V. Consider piecewise linear model with r_D=8 ohm.

a) 30mA
b) 40 mA
c) 36mA
d) 21mA





$$i_D = \frac{6-1.7}{200+8} = 0.021A = 21mA.$$

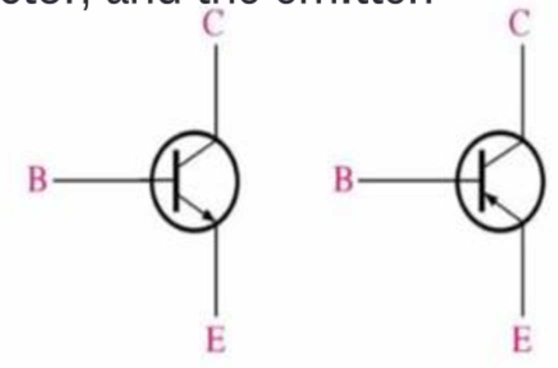
MCQs

- Separate file

Bipolar Junction Transistor

- A bipolar junction transistor is a three-terminal semiconductor device that consists of **two p-n junctions** which are able to amplify and switching a signal. The device is called "bipolar junction transistor" because current is due to motion of two types of charge carriers — **free electrons & holes**
- It is a current controlled device.
- The three terminals of the BJT are the base, the collector, and the emitter.

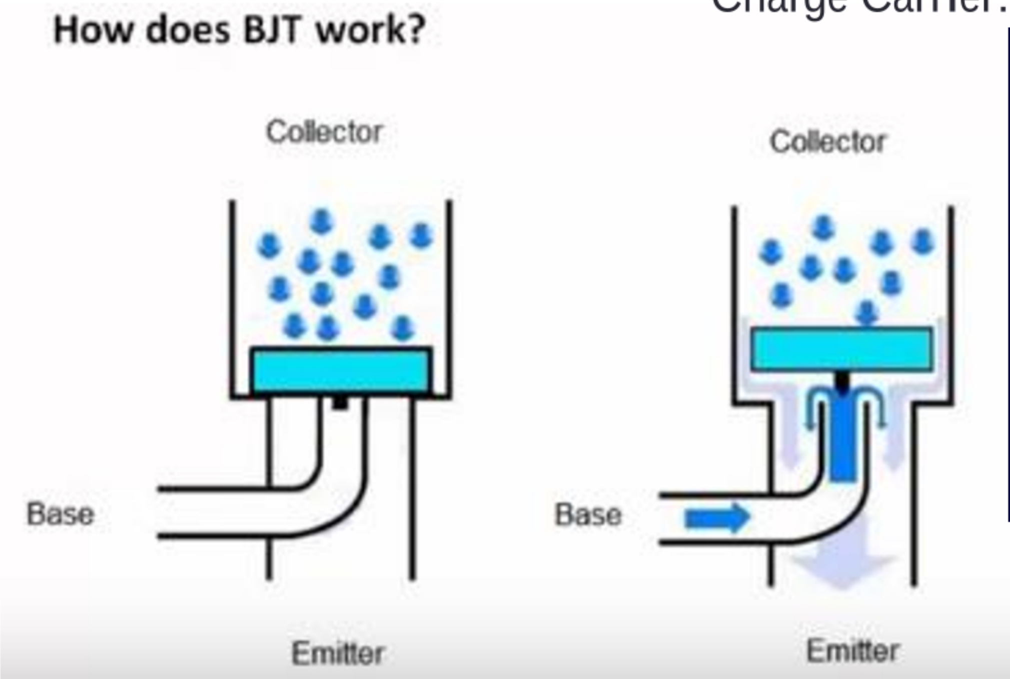
Base is very **thin** compared to the other two layers.
Base is **lightly doped.**
Emitter is **heavily doped**.
Collector is **moderately doped and thick**

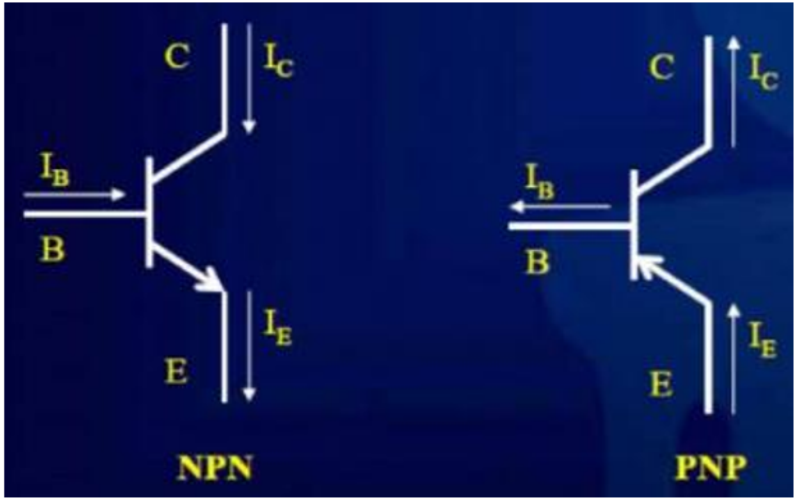


(a) *npn* (b) *pnp*

BJT

Charge Carrier: Electron Hole





$$I_E = I_C + I_B$$

Operating Mode/ Biasing

- Transistor consists of two pn-junctions:
  - emitter-base junction (EBJ)
  - collector-base junction (CBJ)
- Operating mode depends on biasing.
- **active mode** – used for **amplification**
- **cutoff and saturation modes** – used for **switching**.

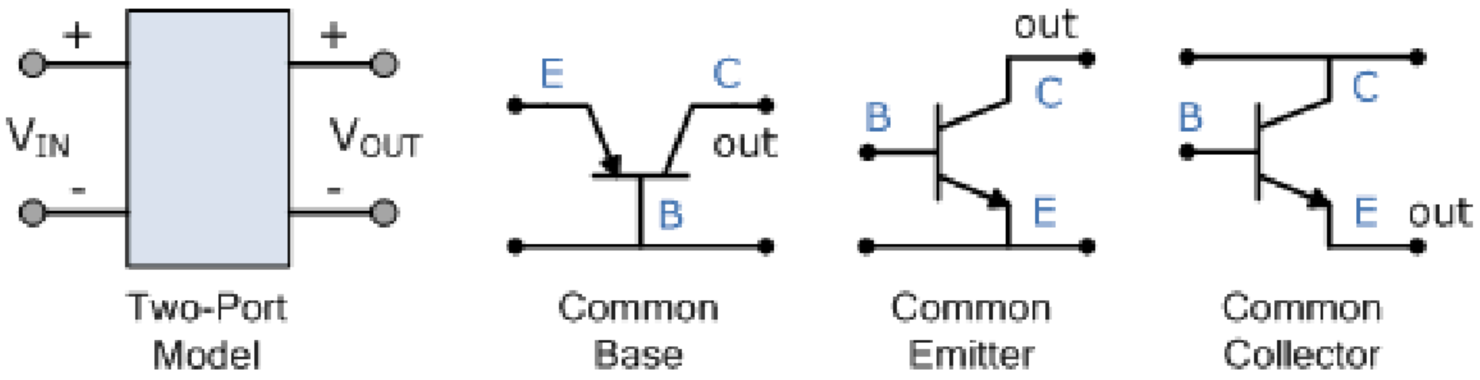
BJT Modes of Operation		
Mode	EBJ	CBJ
Cutoff	Reverse	Reverse
Active	Forward	Reverse
Saturation	Forward	Forward

MCQs

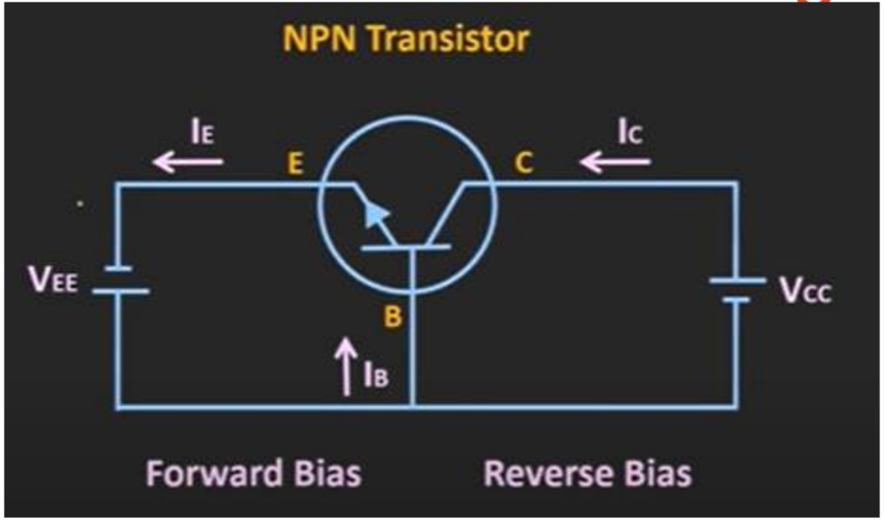
- Separate file

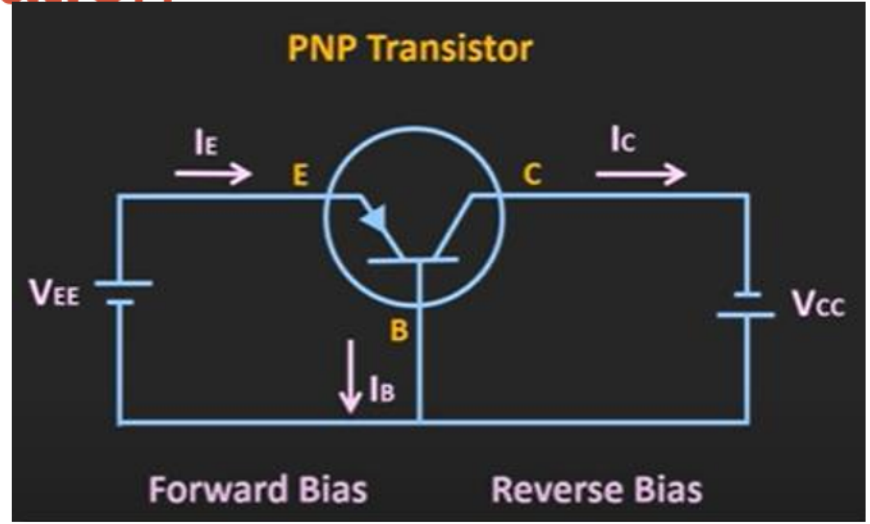
BJT configuration

- Since a Bipolar Junction Transistor is a three-terminal device, there are three ways to connect it within an electric circuit while one terminal is the same for both output and input.
- Every method of connection responds differently to the input signals within a circuit.



Common Base Configuration





(Resistors are not shown here for simplicity)

Base is common between input and output

– Input voltage: $V_{EB} = V_{EE}$ Input current: I_E

– Output voltage: $V_{CB} = V_{CC}$ Output current: I_C

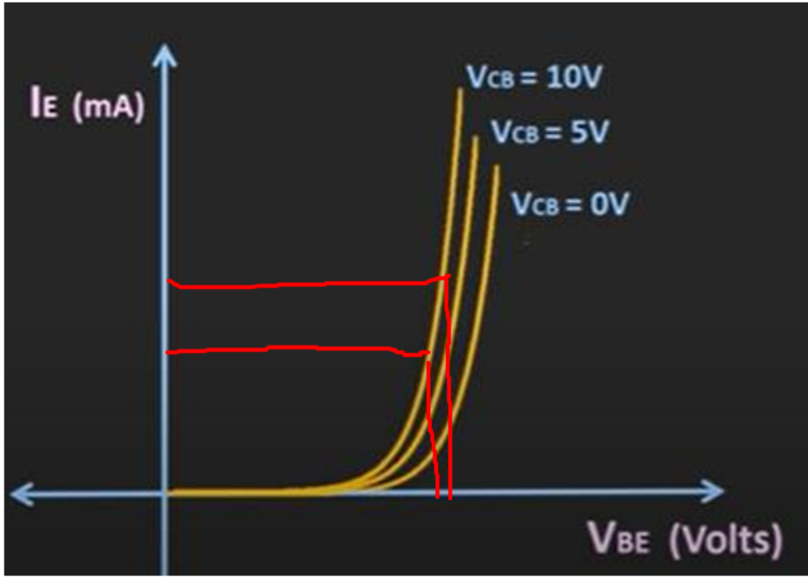
CB input Characteristics

Base is common between input and output

– Input voltage: $V_{EB} = V_{EE}$ Input current: I_E

– Output voltage: $V_{CB} = V_{cc}$ Output current: I_C

- A plot of IE versus VEB for various values of VCB
- It is similar to forward biased diode characteristics
- As VCB is increased, IE increases only slightly
- Input impendence $= \frac{\Delta VBE}{\Delta IE}$ = low



CB Output Characteristics

Base is common between input and output

– Input voltage: $V_{EB} = V_{EE}$ Input current: I_E

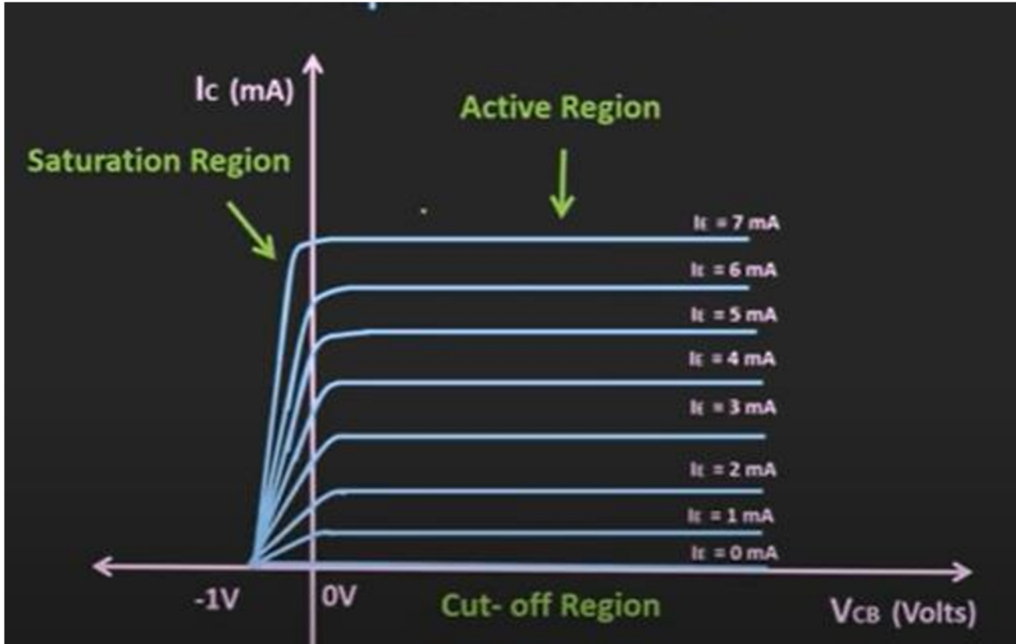
– Output voltage: $V_{CB} = V_{cc}$ Output current: I_C

- A plot of IC versus VCB for various values of IE
- Output Impedance $=\frac{\Delta VCB}{\Delta IC}=$ Very high
- Three regions are identified:

Active Region

Saturation region, and

Cut off Region



Current and Voltage Gain

Gain= $= \frac{Output}{Input}$

Current Gain=$\alpha = \frac{Output\ Current}{Input\ Current} = \frac{Ic}{I_E} < 1$ (Can be observed from Output characteristics)

Voltage Gain=Av $= \frac{Output\ Voltage}{Input\ Voltage} = \frac{VcB}{V_{EB}}$ is high (Can be observed from input characteristics)

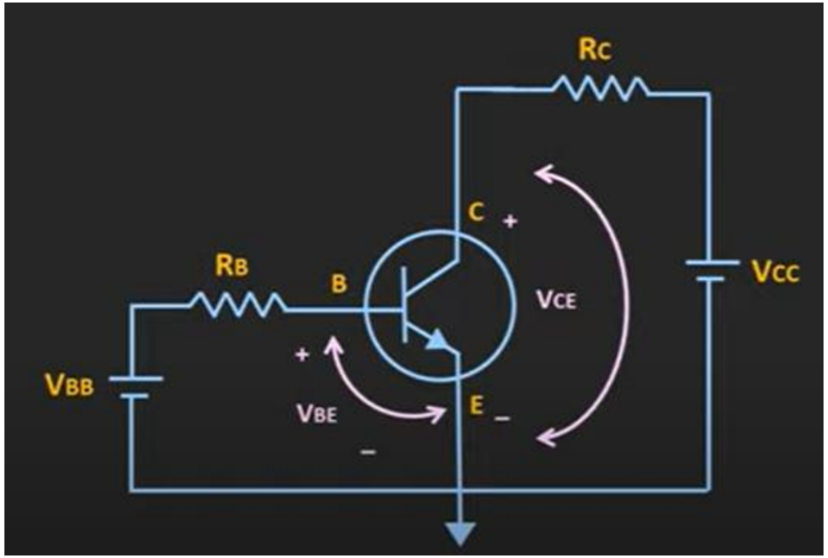
Base is common between input and output

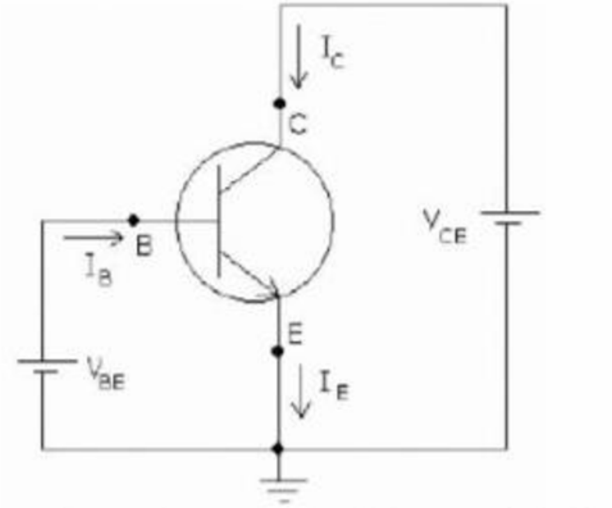
– Input voltage: $V_{EB} = V_{EE}$ Input current: I_E

– Output voltage: $V_{CB} = V_{CC}$ Output current: I_C

Common Emitter Configuration

- Most widely used





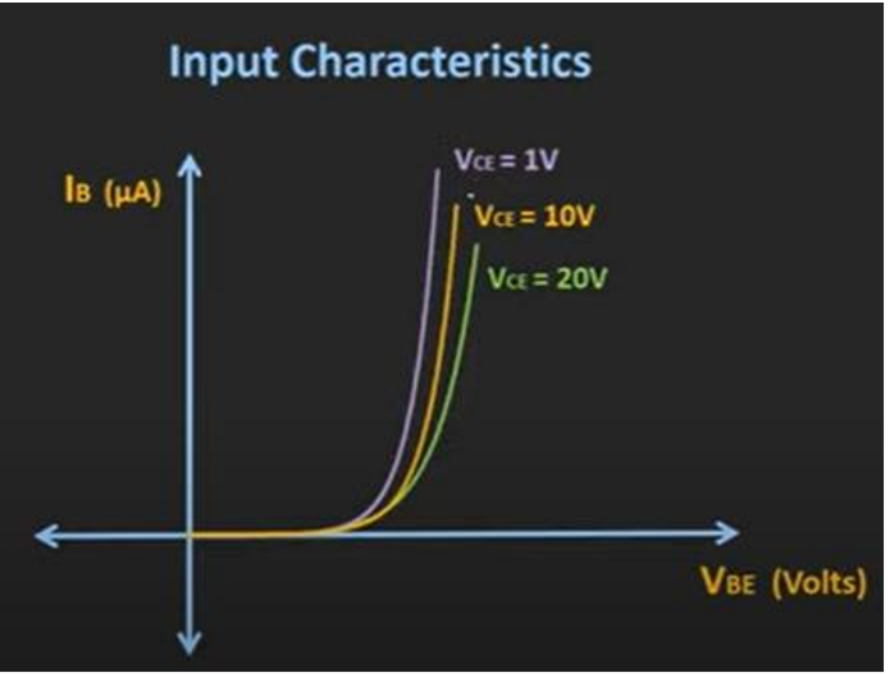
(Resistors are omitted for simplicity)

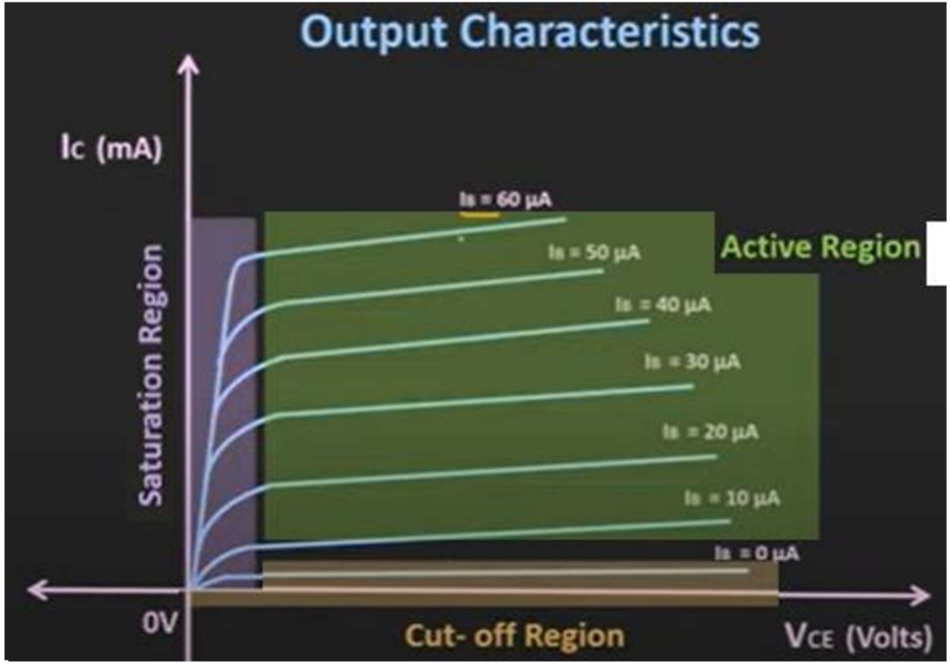
Emitter is common between input and output

– Input voltage: *V_{BE} ;* *Input current: I_B*

– Output voltage: *V_{CE};* *Output current: I_C*

Input and Output Characteristics





Conclusion

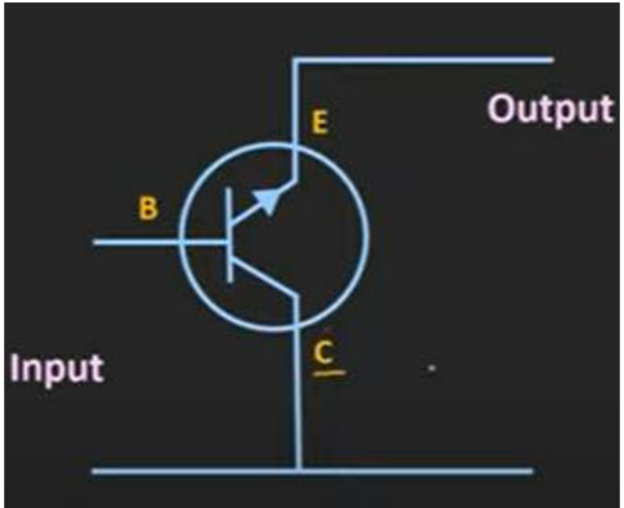
Current Gain=β $= \frac{Output\ Current}{Input\ Current} = \frac{I_C}{I_B}$ >100 (Can be observed from Output characteristics)

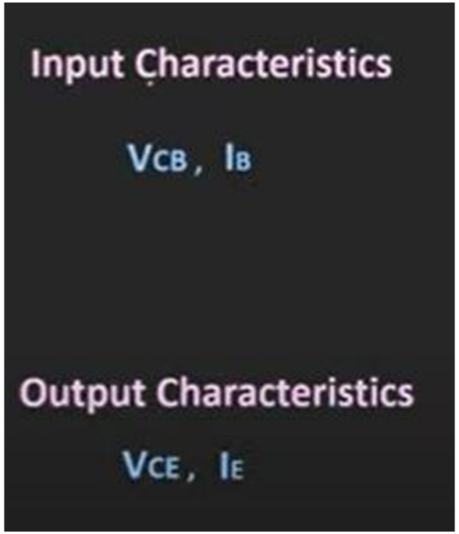
Voltage Gain=Av $=\frac{Output\ Voltage}{Input\ Voltage} = \frac{VcE}{V_{EB}}$ is high (Can be observed from input characteristics)

- Input impendence $=\frac{\Delta VBE}{\Delta IB}$= Medium
- Output Impedance $=\frac{\Delta VCB}{\Delta IC}$= high

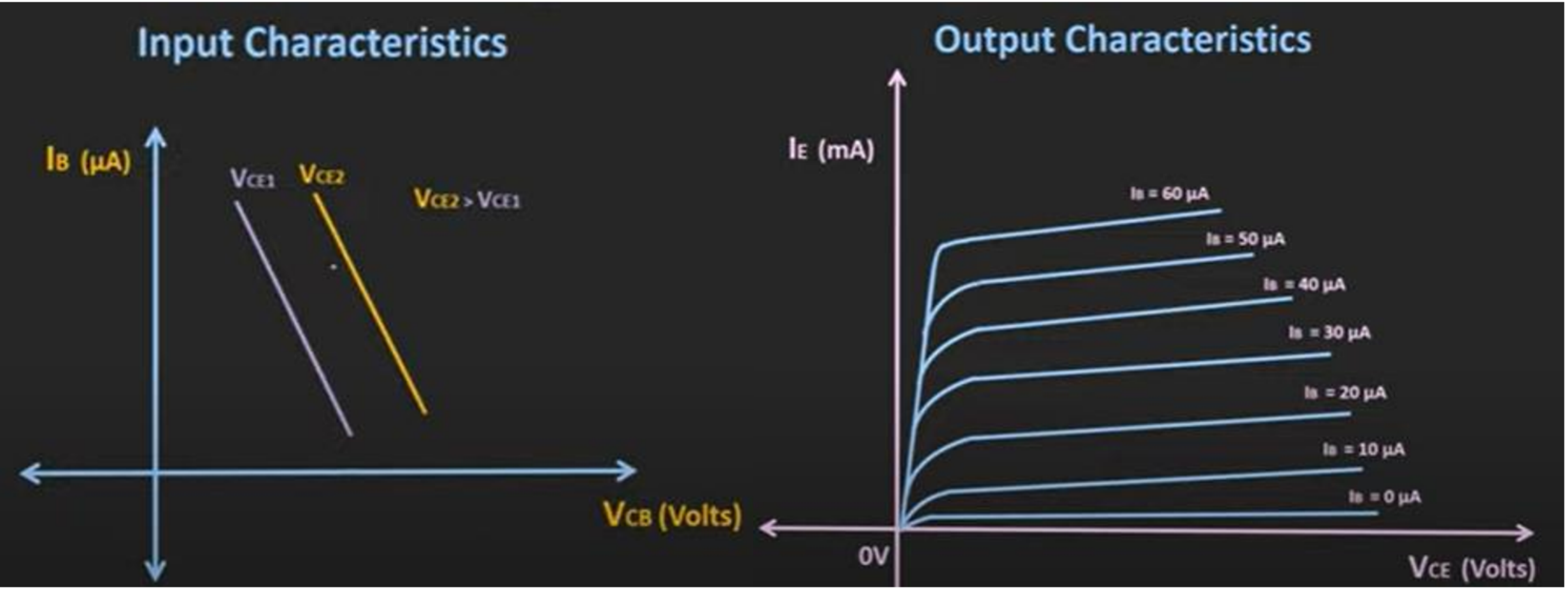
Common Collector Configuration

- Collector is common between input and output,
- Input: V_{BC} and I_B
- Output: V_{CE} and I_E





Input and Output Characteristics



Current Gain

$$\text{Alpha}, (\alpha) = \frac{I_C}{I_E} \quad \text{and} \quad \text{Beta}, (\beta) = \frac{I_C}{I_B}$$

$$\therefore I_C = \alpha . I_E = \beta . I_B$$

$$\text{as:} \quad \alpha = \frac{\beta}{\beta + 1} \qquad \beta = \frac{\alpha}{1 - \alpha}$$

$$I_E = I_C + I_B$$

$$I_E = \frac{I_C}{\alpha} = I_B (1 + \beta)$$

$$I_C = \beta . I_B = \alpha . I_E$$

$$I_B = \frac{I_C}{\beta} = \frac{I_E}{1 + \beta} = I_E (1 - \alpha)$$

Note: Value of α will always be less than unity

Characteristic	Common Base	Common Emitter	Common Collector
Input Impedance	Low	Medium	High
Output Impedance	Very High	High	Low
Phase Shift	0^0	180^0	0^0
Voltage Gain	High	Medium	Low
Current Gain	Low	Medium	High
Power Gain	Low	Very High	Medium

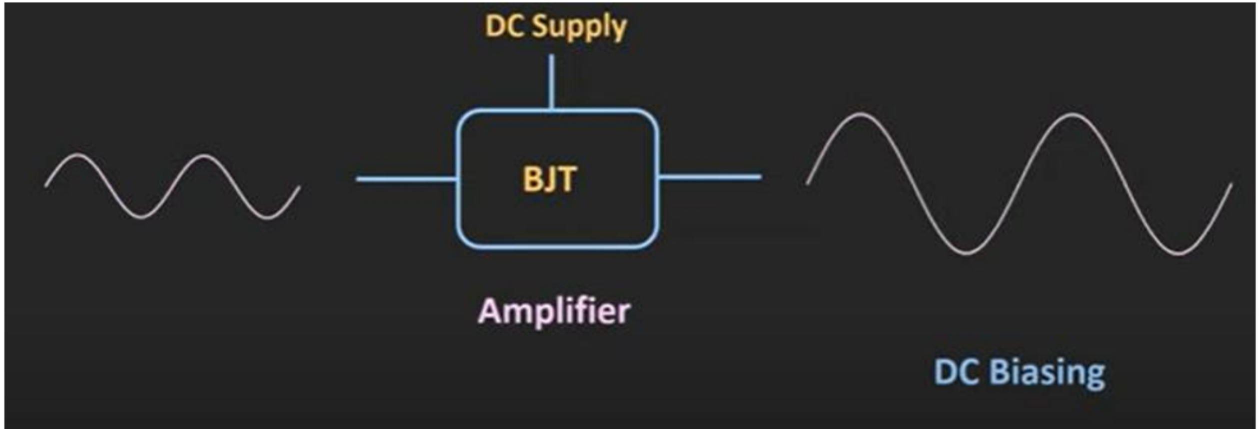
MCQs

- Separate file

BJT Biasing

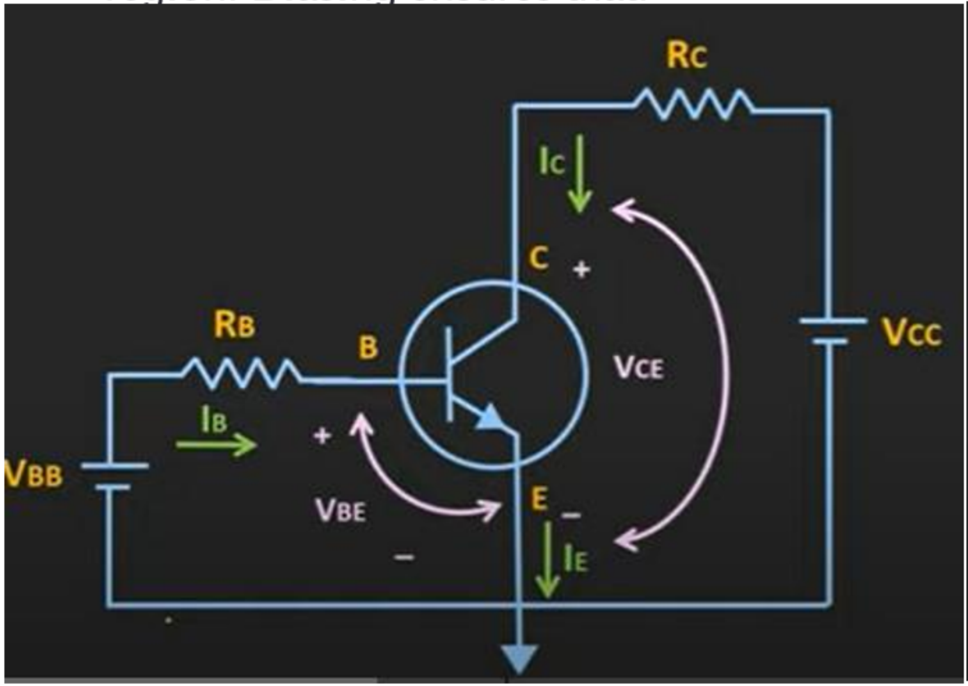
- Applying external dc voltages to ensure that transistor operates in the desired region .
- Which is the desired region?
  - For amplifier application, transistor should operate in active region
  - For switch application, it should operate in cut-off and saturatation

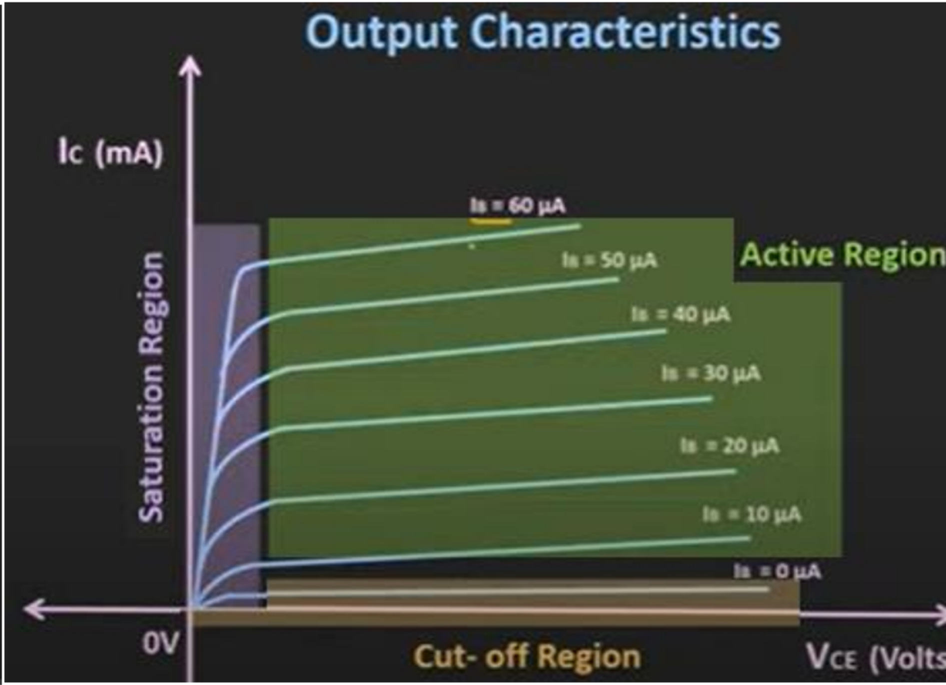
E.G During amplification of AC, separate DC should be given to BJT. This DC supply is biasing of BJT



Biasing

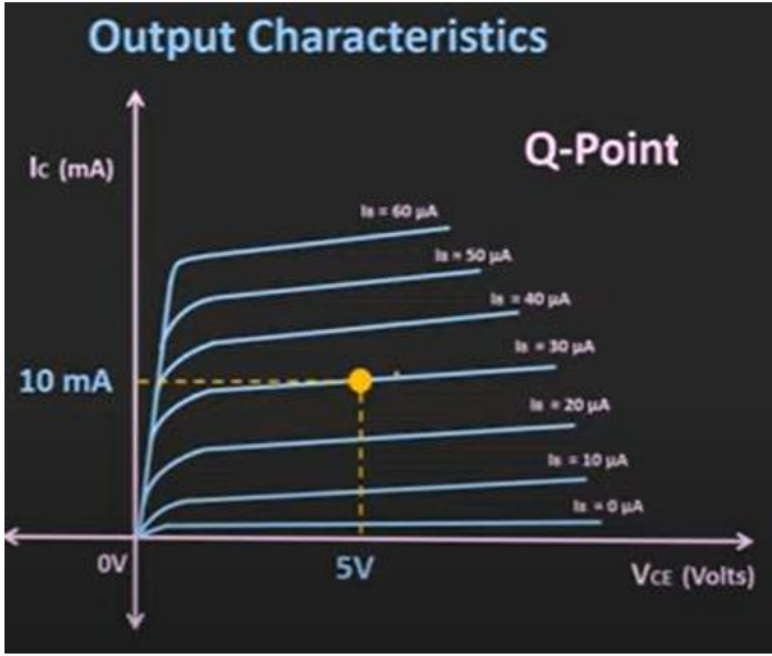
Let CE configuration. If this configuration is used as amplifier, it must work on active region. Biasing ensures that.



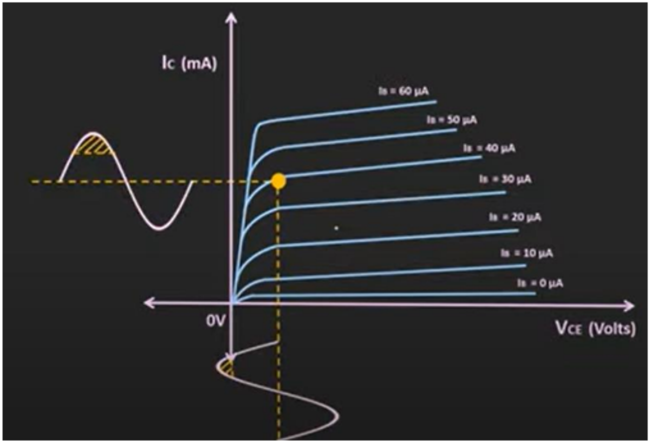


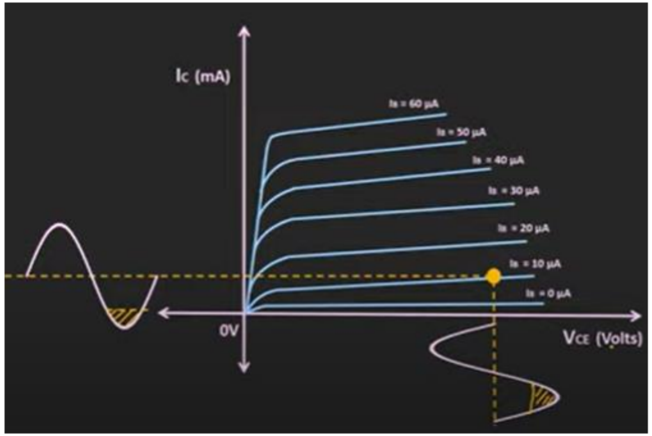
Operating Point / Q Point

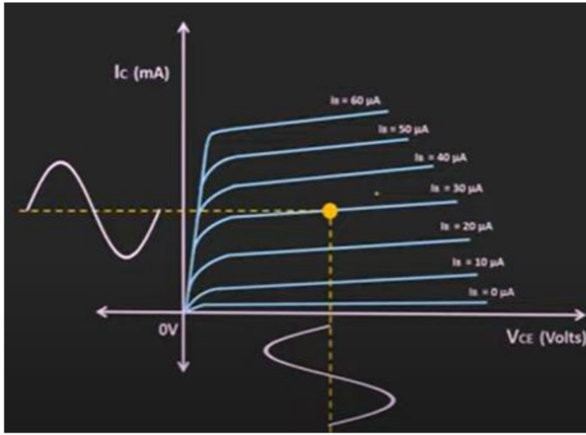
- Example: Yellow dot shows that, BJT is operated at 5V and 10mA at I_B =30 microampere.
- But it could be anywhere in active region.



- For CE output is 180 out of phase
- If Q point is near to other region, and AC is given input output AC signal of the amplifier can be distorted. Fig 1 and 2. so Q point should be as fig 3







Types of Biasing

- **Fixed Biasing**
- Emitter feedback DC biasing
- Collector Feedback DC biasing
- **Voltage divider biasing**/ Self biasing :Most stable biasing and Needs 2 large resistance so not suitable for IC

Fixed Biasing

Fig1:Amplifier as a CE configuration

AC input and amplified AC output and DC Biasing as shown

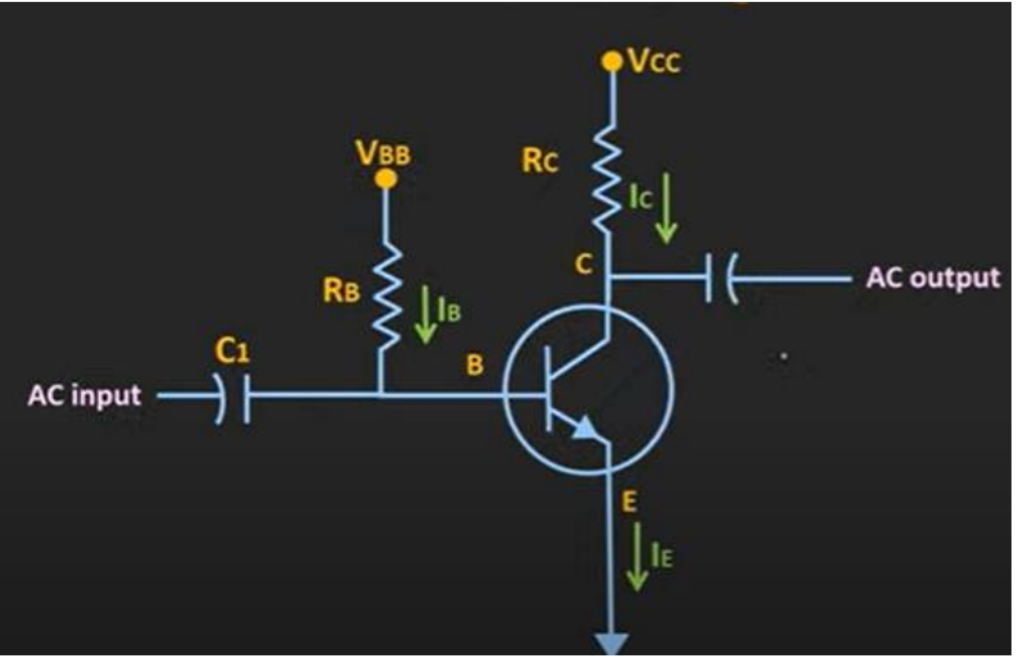
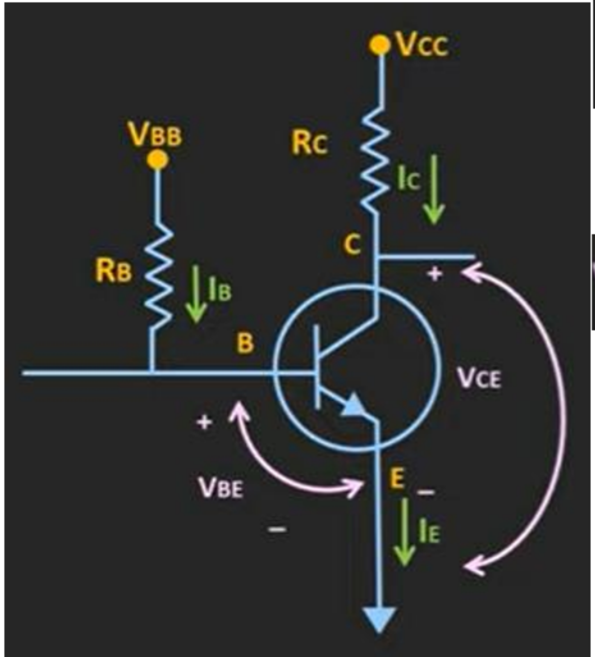


Fig2:Only DC Biasing as shown

Some relations are can be derived as:



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

$$I_C = \beta I_B$$

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

Load Line

- We know

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

Then

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

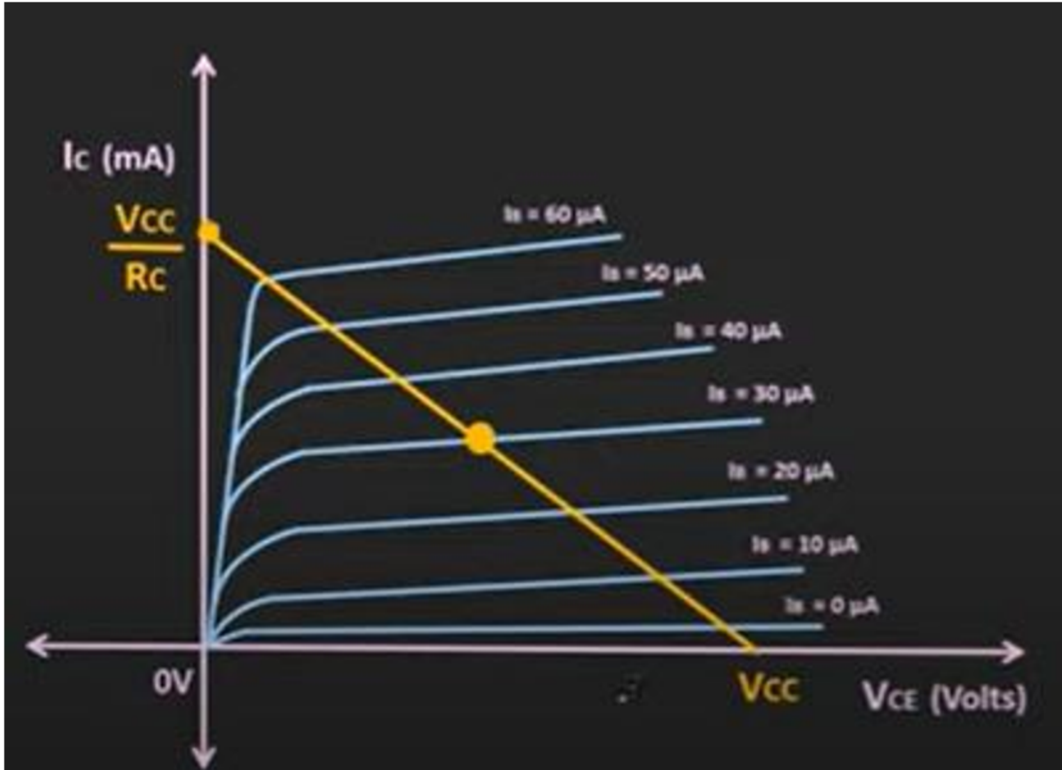
For Max Ic, VcE should be 0.

$$I_{C(max)} = \frac{V_{CC}}{R_C}$$

ALSO,

$$V_{CE(max)} = V_{CC}$$

If we point Vcc and Vcc/Rc in the output characteristics curve, and join the two point with a line, as show: this is load line(Defined by R_C). And it gives the possible Q point for required I_B

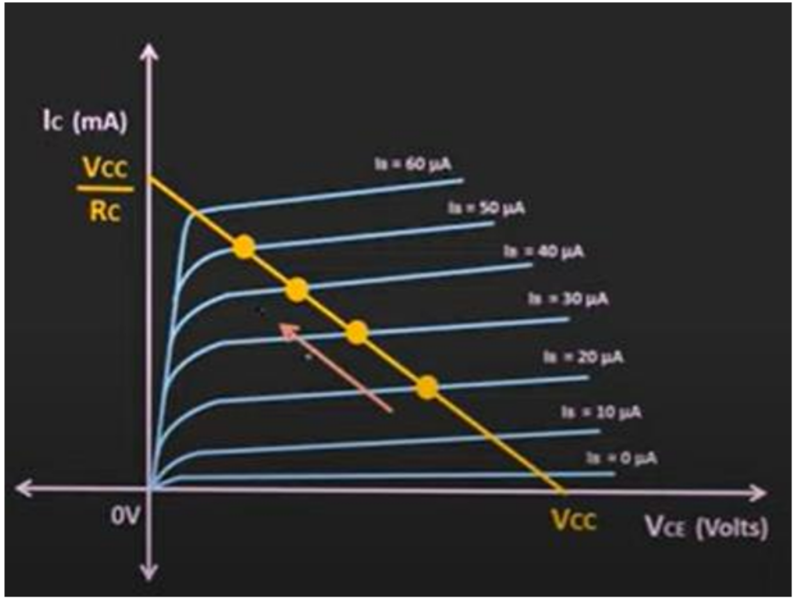


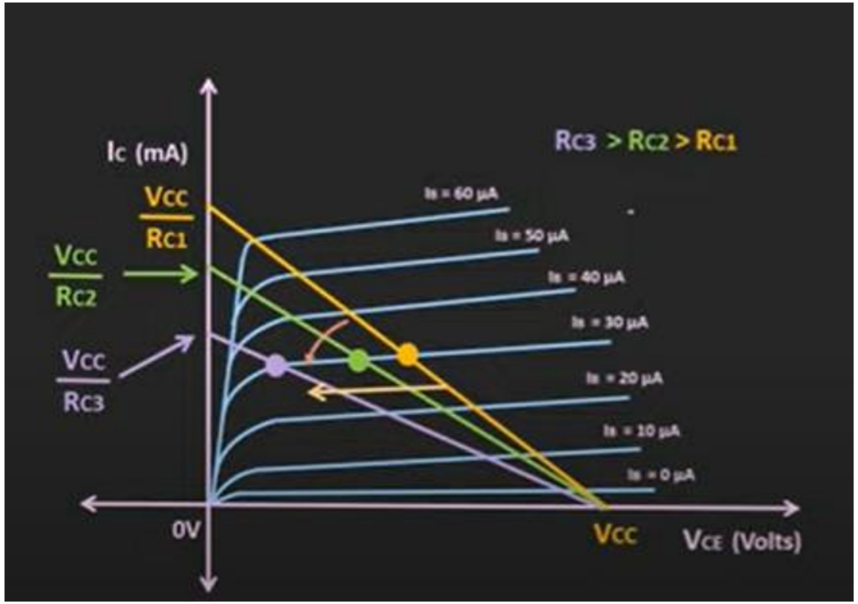
Variation of Load Line due to R_B and R_C

If Ib is changed by varying Rb, then Q points also changes

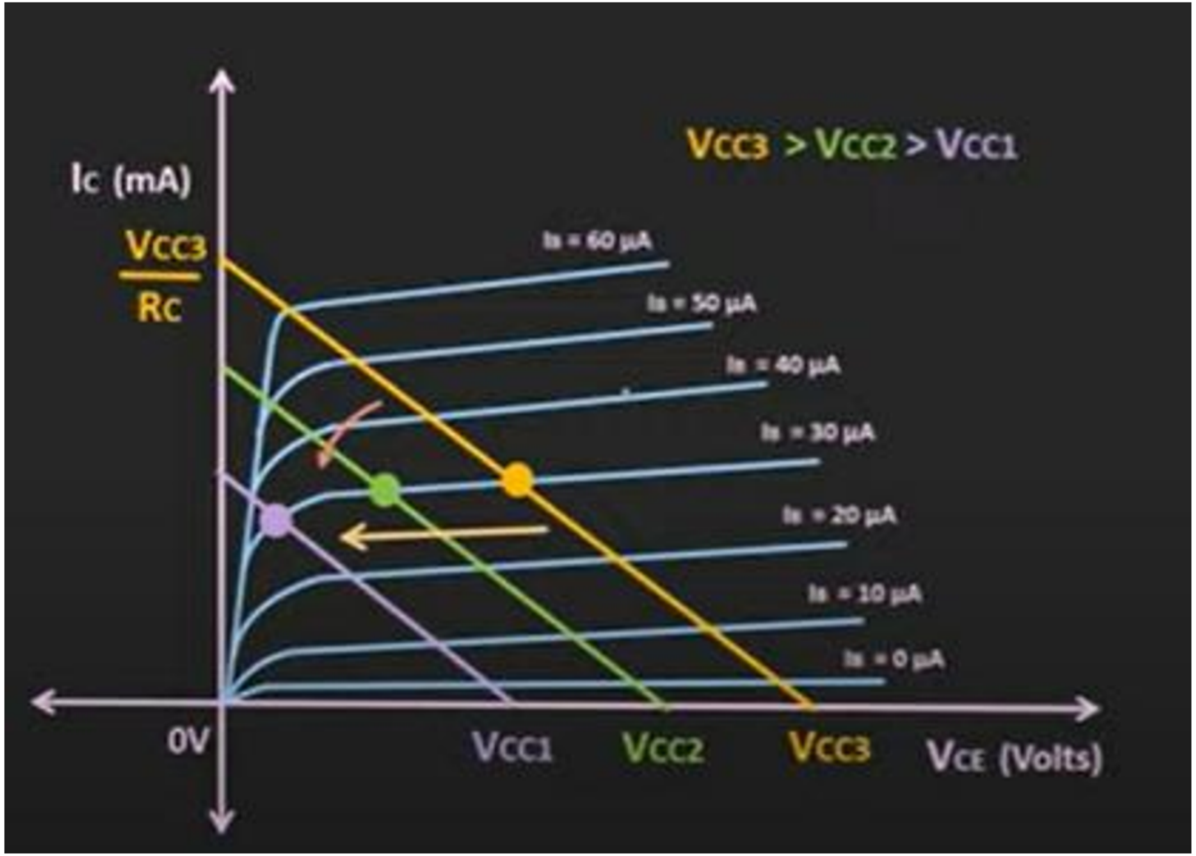
$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

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





Load Line change with Vcc (Rc constant)



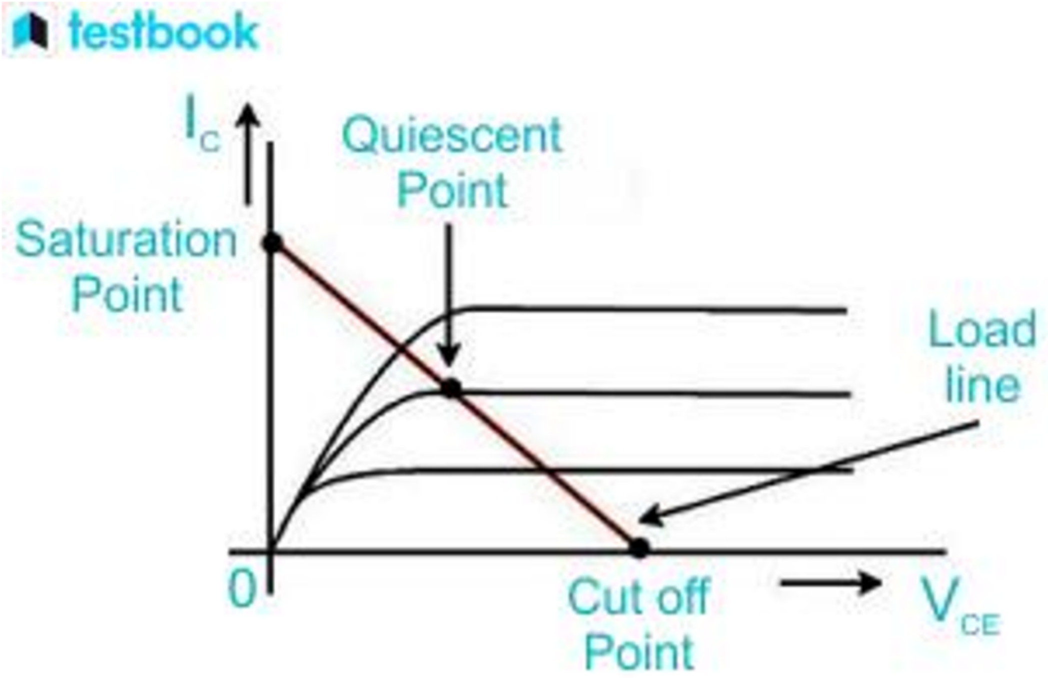
Three different Q points are shown on a dc load line. The upper Q point represents the ………….

A. Minimum current gain

B. Quiescent point (Q point)

C. Saturation point

D. Cutoff point



What is the operating point of a transistor as an amplifier known as?

1. Quiescent Point
2. Cutoff Point
3. Saturation Point
4. Flood In Point

If biasing is not done in an amplifier circuit, it results in

1. a decrease in the base current
2. Excessive collector bias
3. Unfaithful amplification
4. High power loss

Which of the following method of biasing provides the best operating point stability?

1. Two battery bias
2. Collector-to-base bias
3. Fixed bias
4. Self bias

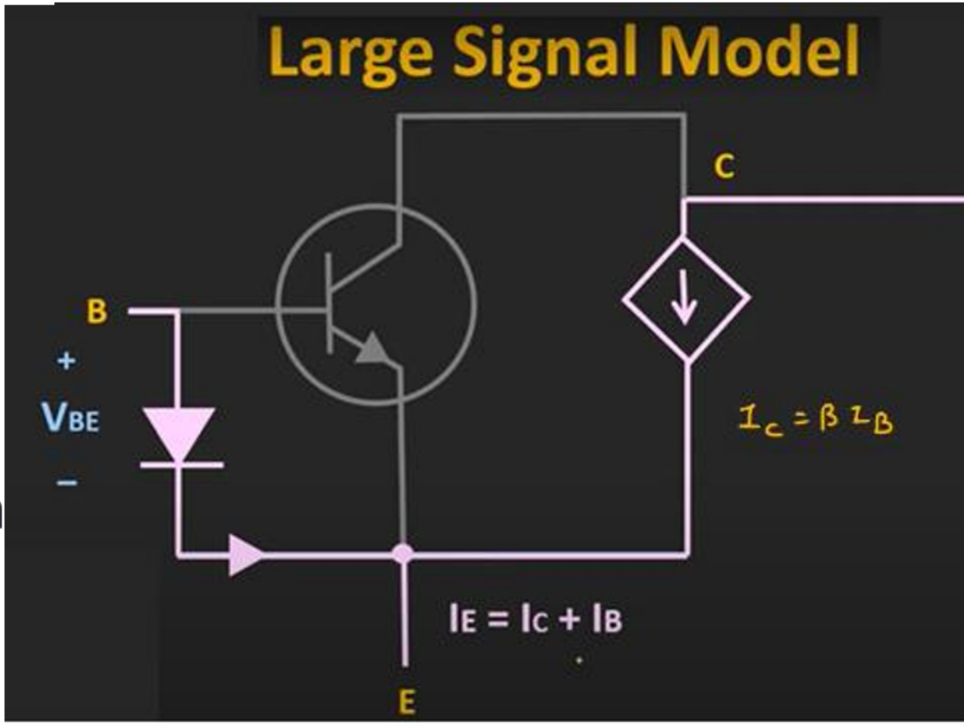
Voltage divider bias or self-bias provides a highly stable operating point compared to all the other biasing circuits.

The ends of a load line drawn on a family of curves determine ……

1. saturation and cutoff
2. the operating point
3. the power curve
4. the amplification factor

Large Signal Model

Transistor model where all ac signal are removed and observe the effect of DC.



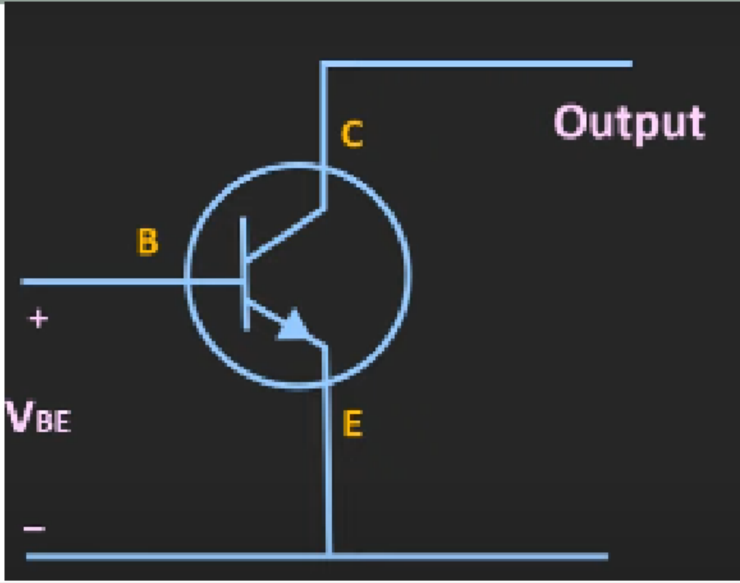
For CE configuration,

V_{BE} acts as forward biased diode .

And flow of Ic is dependent to base curren

Small signal model

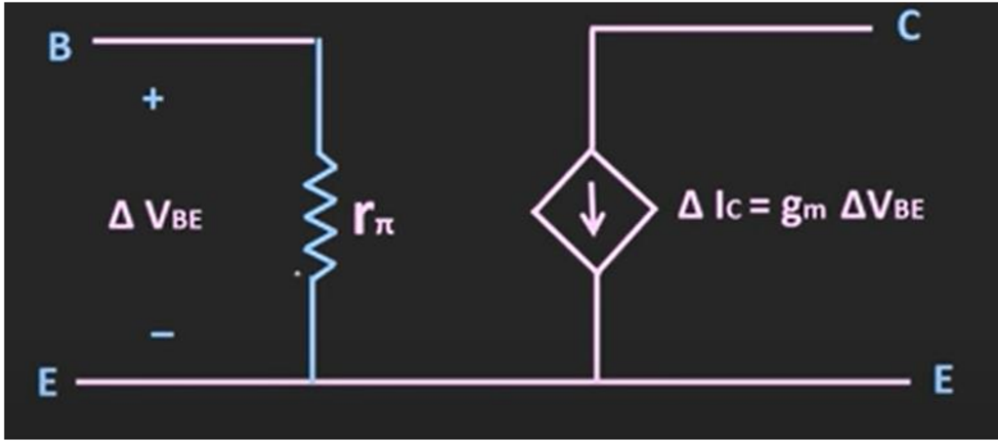
Transistor model where all DC signal are removed and observe the effect of AC.



For CE configuration,

V_{BE} can be modelled as a resistor as shown.

And flow of Ic is dependent to base emmitor voltage with transconductance gm



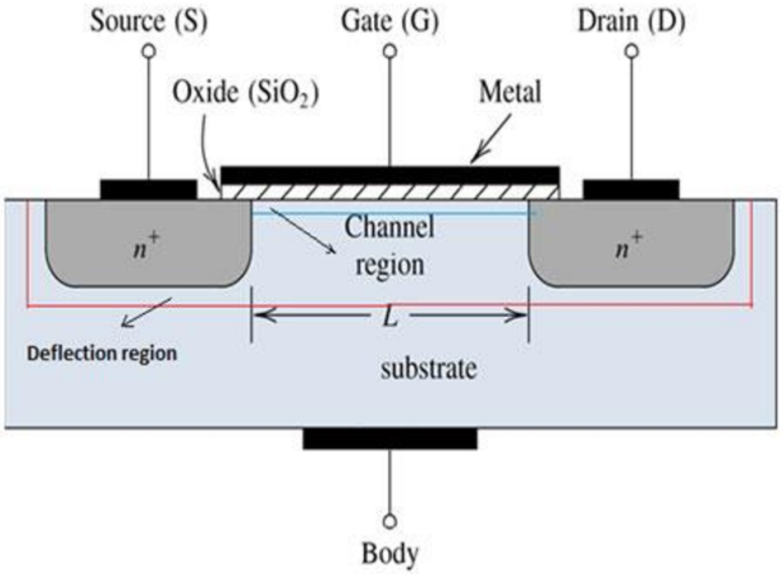
MOSFET

- Metal Oxide Silicon Field Effect Transistors commonly known as MOSFETs are electronic devices used to switch or amplify voltages in circuits.
- It is a voltage controlled device and is constructed by three terminals.
- The **three terminals** (4 parts) of MOSFET are named as follows:
  - **Source**
  - **Gate**
  - **Drain**
  - Body/Substrate

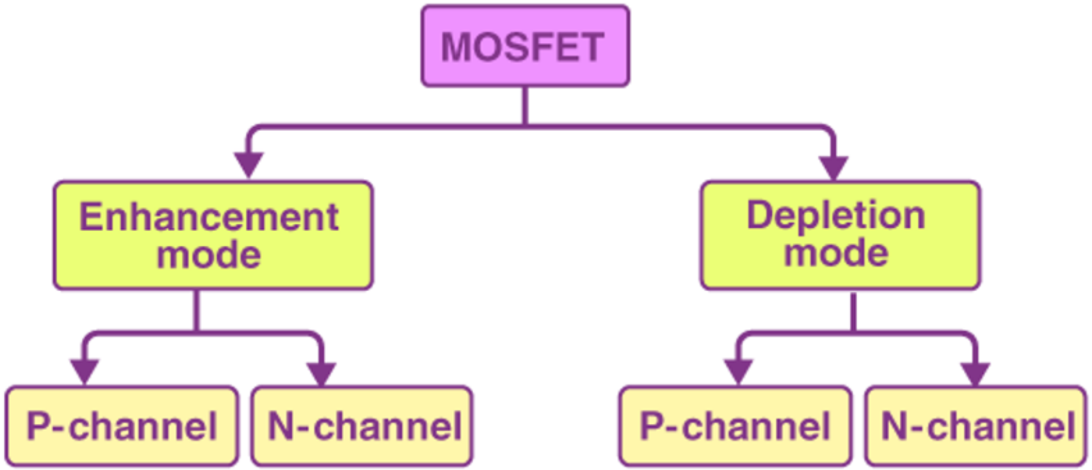
Construction of MOSFET

The material depends upon type of mosfet

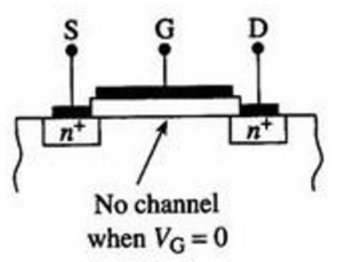
- Source:
- Drain:
- Gate: Voltage is applied here to control conduction between drain and source
- Substrate
- Metal Oxide/SiO2 acts as insulator and doesn't let the gate voltage apply directly to semiconductor, instead act as capacitor (one plate with gate voltage, other plate with attracted voltage from substrate



Types



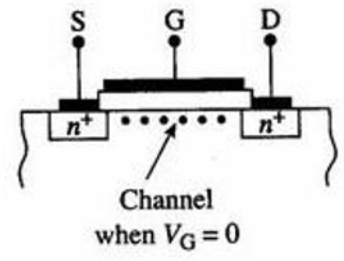
Enhancement Mode



Initially off
If Vg applied, on

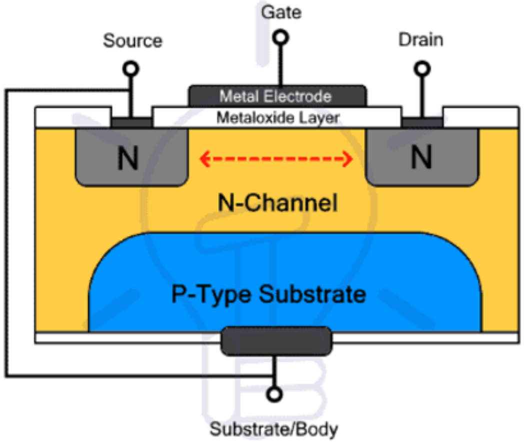
Conduction between source and drain regions is *enhanced* by applying a gate voltage

Depletion Mode

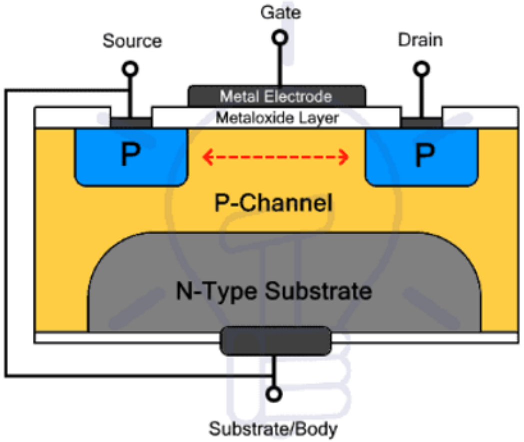


Initially ON
If Vg applied, off

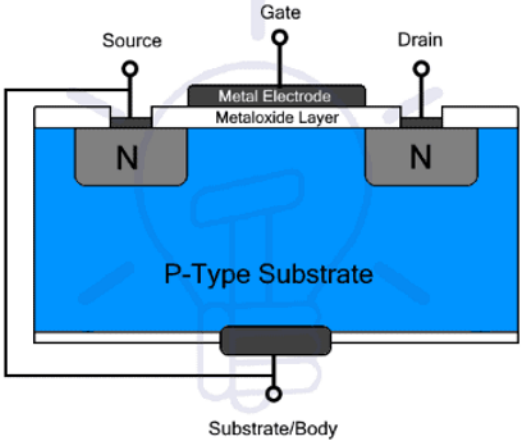
A gate voltage must be applied to *deplete* the channel region in order to turn off the transistor



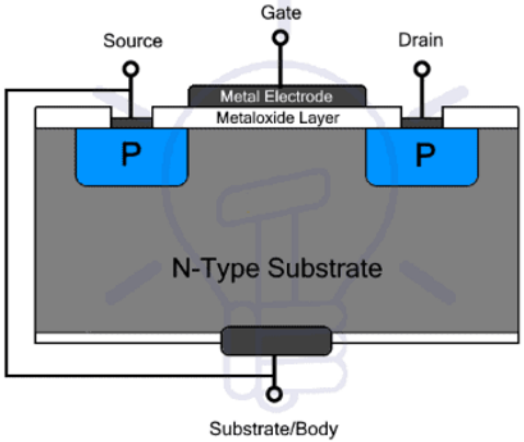
N-Channel D-MOSFET



P-Channel D-MOSFET

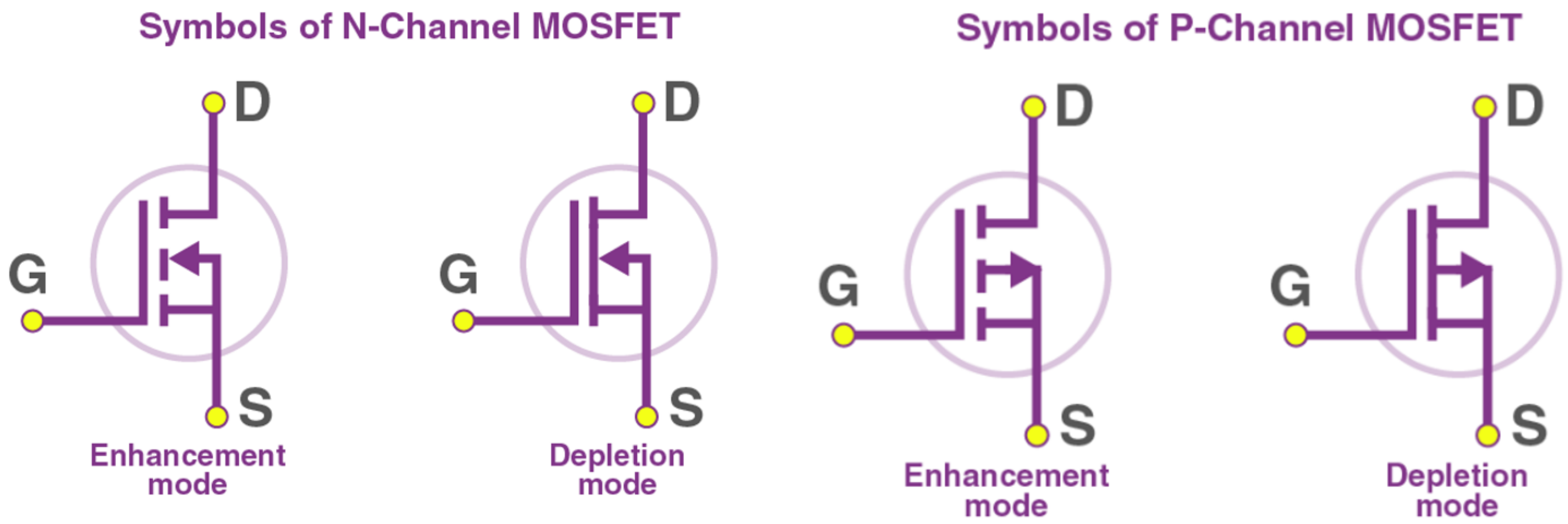


N-Channel E-MOSFET



P-Channel E-MOSFET

Symbols



- Arrow: Direction of flow of electron, Towards G => N and Outward G=>P
- Line : Continuous for Depletion type and dotted for enhancement type

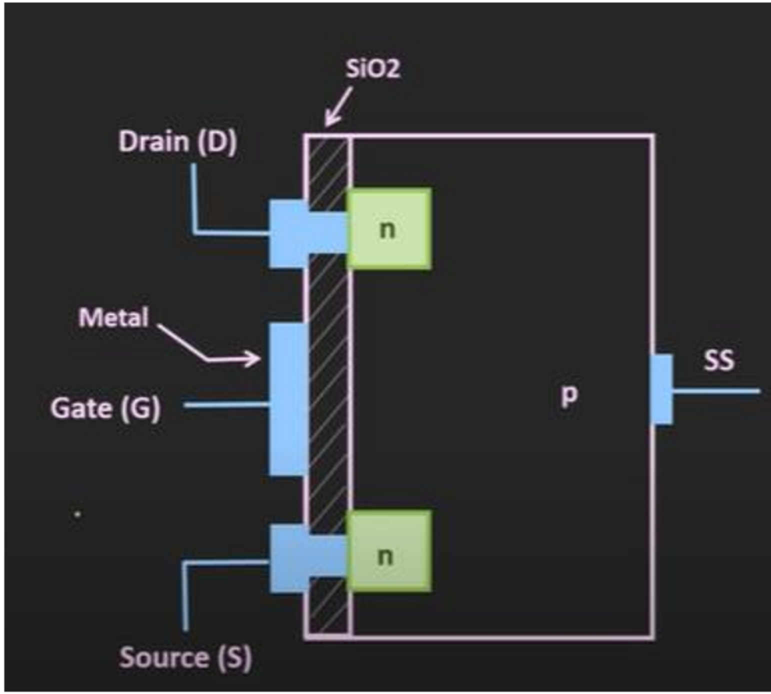
E type MOSFET Working

Initially off

If Vg applied, on

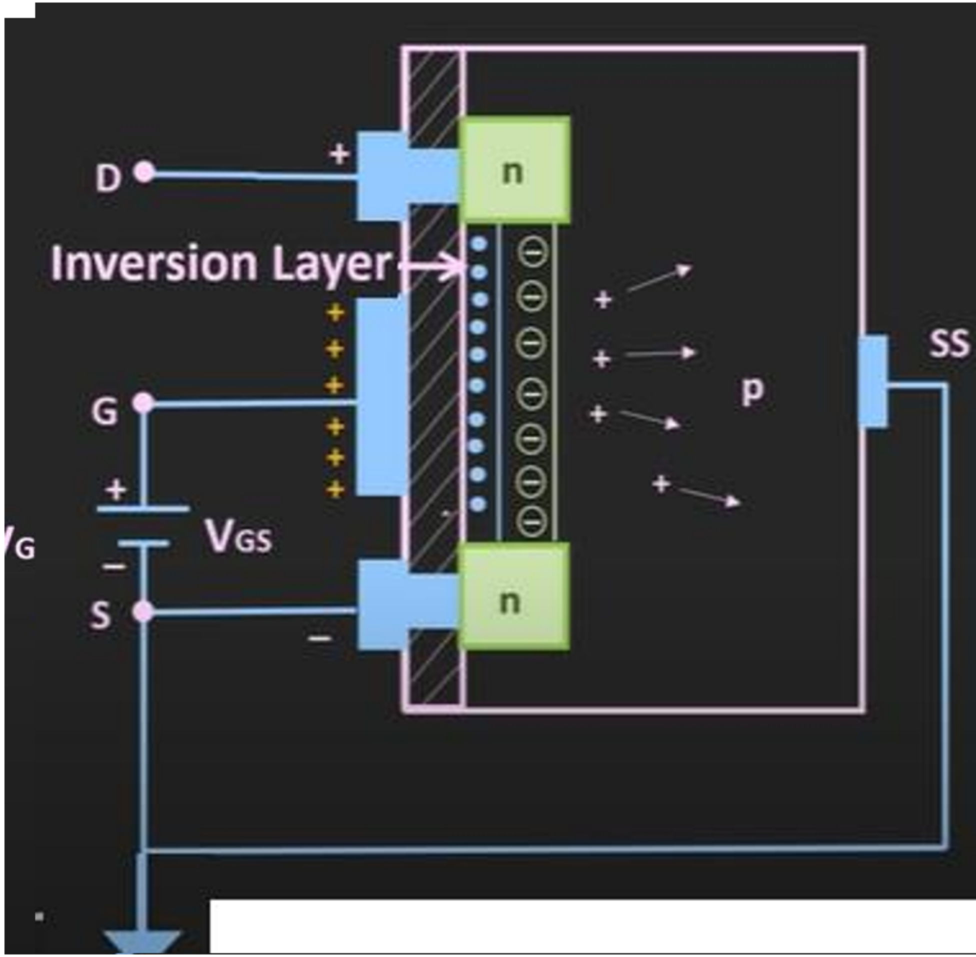
i. When operated at no gate voltage

- MOSFET don’t have channel to conduct.
- So OFF initially

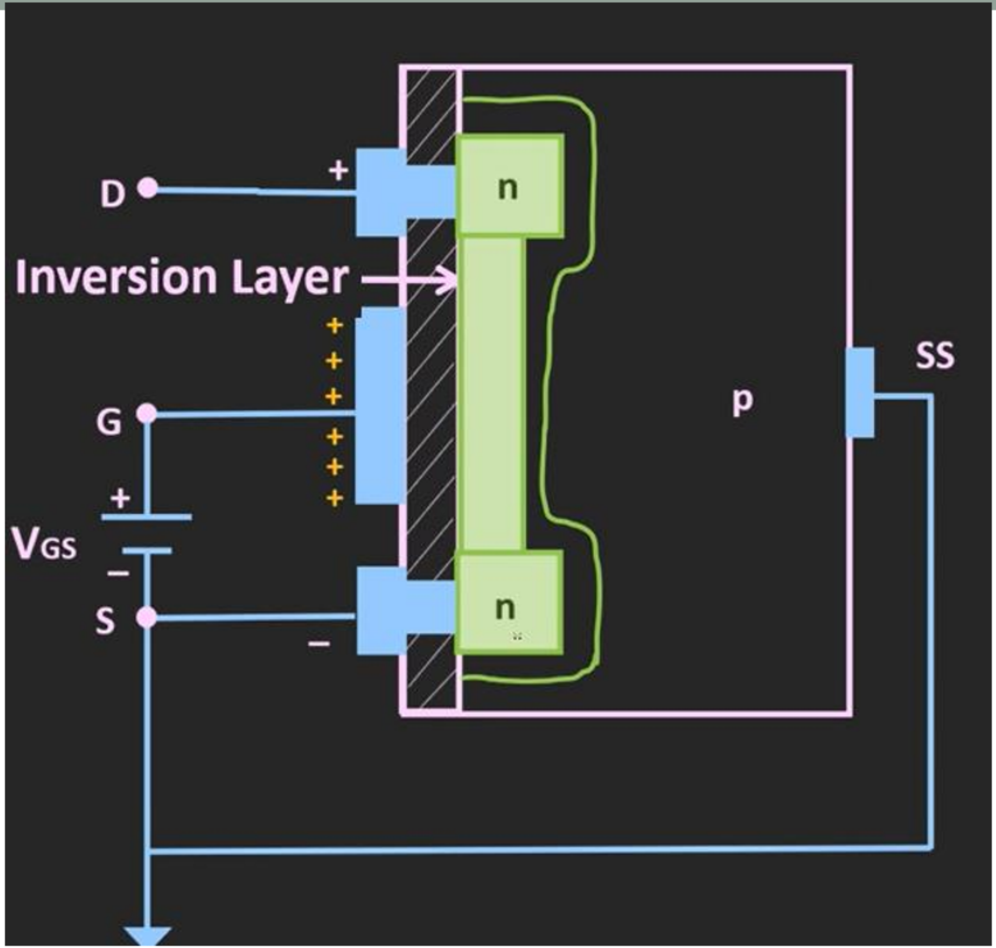


ii. When operated at small +Ve gate voltage (+V_{GS}) only, no V_{DS}

- MOSFET have small electron channel to conduct.
- If more gate voltage is applied, more electrons will be accumulated near gate terminal and formed **inversion layer**.
- The gate voltage at which inversion layer is created is called **threshold voltage (Vt)**
- **If V_{GS}>Vt only mosfet is ON.**

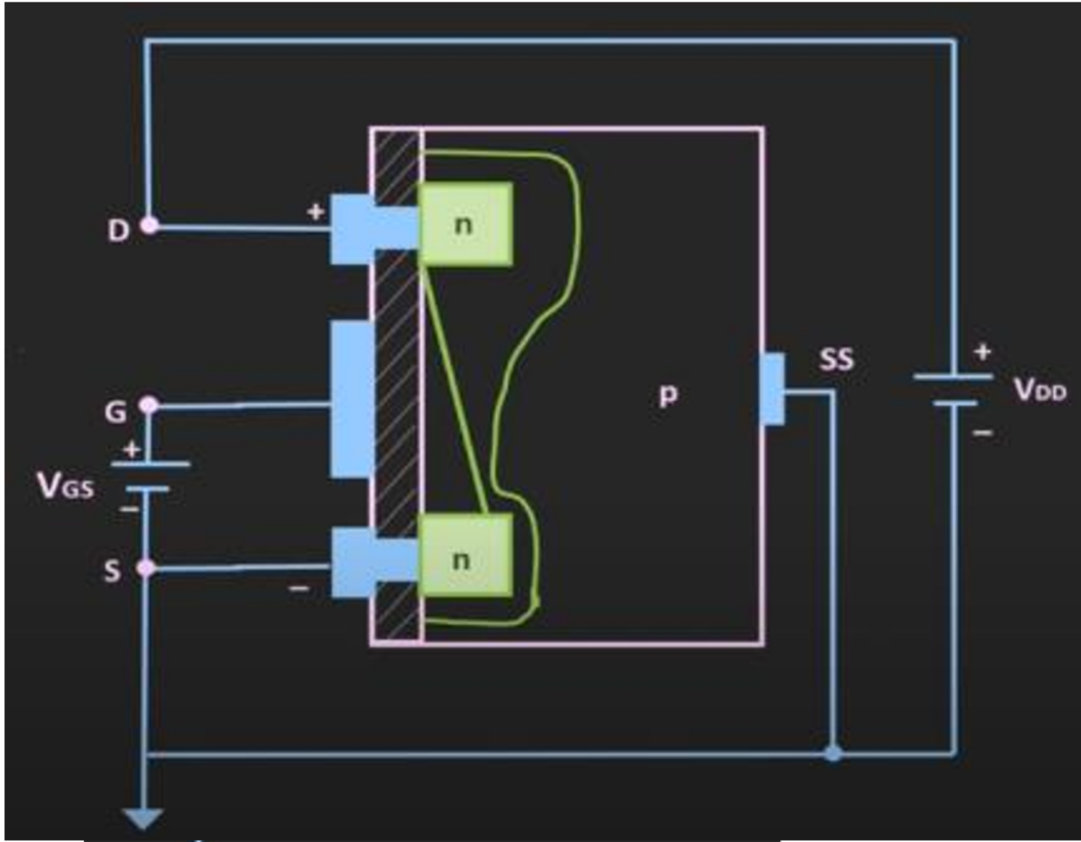


- Here two PN junction Drain - Substrate and Source-substrate are formed with depletion layer as shown by green line.
- Both are reversed biased when V_{DS} is supplied.

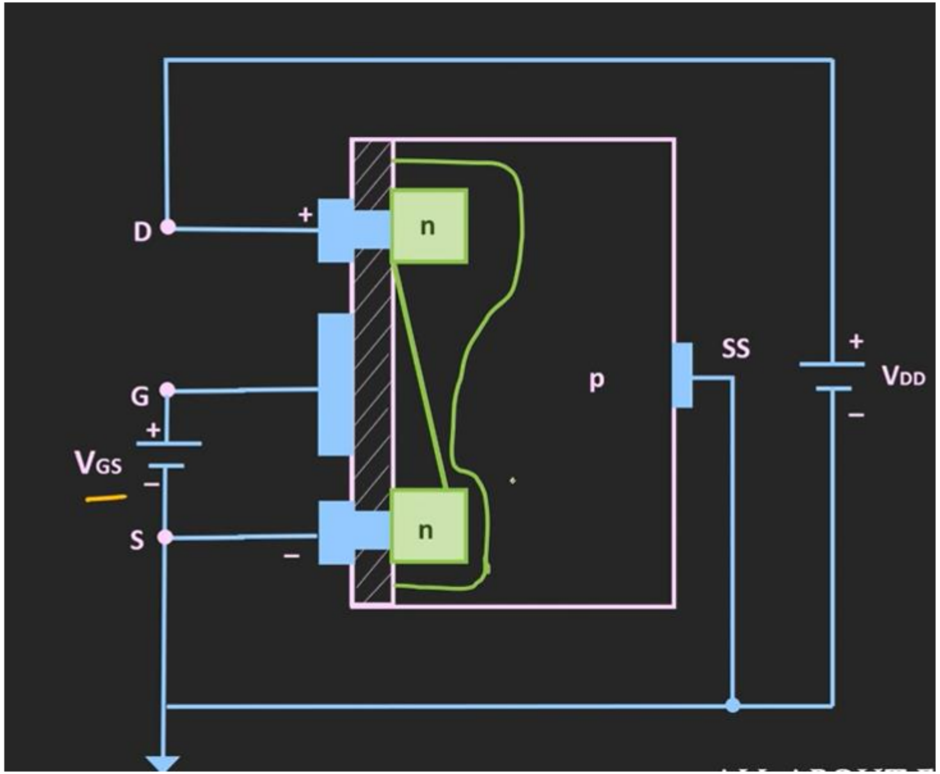


iii. When V_{GS}>Vt and V_{DS} is also applied

- Current will flow from drain to source.
- The electron accumulated channel become narrower at drain side. It is because, when V_{DS} is increased, in comparison to gate voltage, voltage near drain become less positive than near to gate voltage so attract few electron near to drain.
- If further V_{DS} is increased, the channel width will be pinched off as shown.
- That particular V_{DS} is **Pinched off voltage**



If Vds is increased above pinched off voltage, the channel will be further pinched off, but mosfet still conduct by passing electron from depletion layer due to high electric field. And this current is known as saturation current.



Depletion type MOSFET

The characteristics of D-MOSFET are similar to that of E MOSFET except that D-MOSFET can operate in both the enhancement mode and depletion mode.

When v_{GS} is positive, D- MOSFET operates in enhancement mode and when v_{GS} is negative, D-MOSFET operates in depletion mode.

The only difference is that the threshold voltage V_t of D MOSFET is negative.

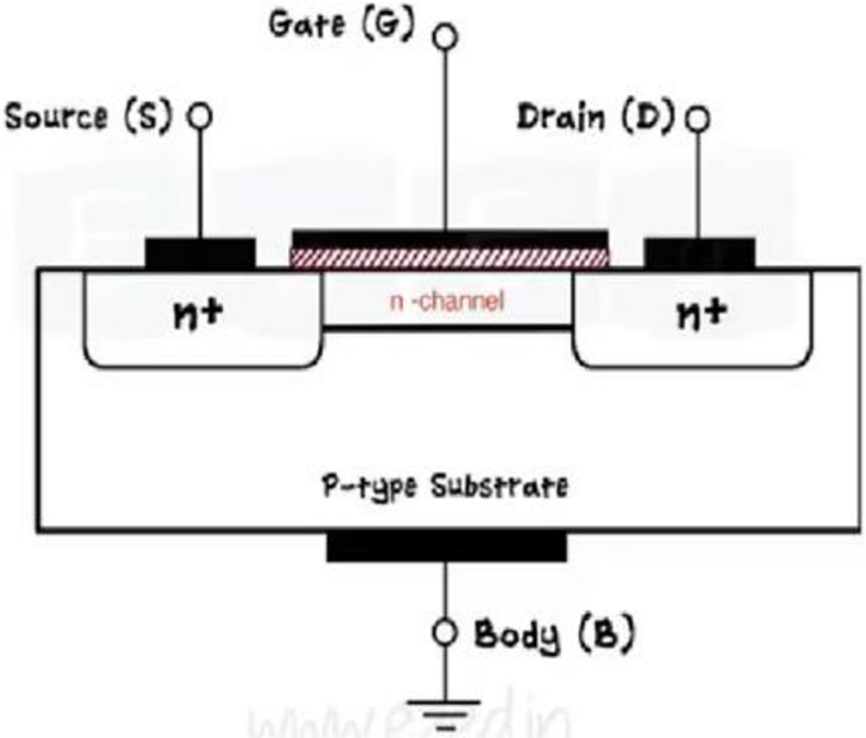


Fig: n channel Depletion mosfet

Application of MOSFET

- Radiofrequency applications use MOSFET amplifiers extensively.
- Power MOSFETs can be used to regulate DC motors.
- MOSFETs are used in the design of the chopper circuit.
- E type used in MoS digital ic

Tips

MOSFET:

- **MOSFET is a voltage-driven/controlled device.**
- The current through the two terminals is controlled by a voltage at the third terminal (gate)
- It is a unipolar device (current conduction is only due to one type of majority carrier either electron or hole)
- It has a high input impedance.
- Fast switching action than BJT as no recombination occurs here

BJT:

- **BJT's are current-driven devices.**
- The current through the two terminals is controlled by a current at the third terminal (base).
- It is a bipolar device (current conduction by both types of carriers, i.e. majority and minority electrons and holes)
- It has a low input impedance.

Which one of the following is not a basic MOSFET device type?

1. Enhancement P-channel MOSFET
2. Depletion N-channel MOSFET
3. Narrow P-channel MOSFET
4. Enhancement N-channel MOSFET

Option 3 :

Which type of the MOSFETs is exclusively used by MOS digital ICs?

1. Enhancement MOSFET
2. Depletion MOSFET
3. Either enhancement or depletion MOSFET
4. None of these

Option 1

Which of the following is the fastest switching device?

1. JFET
2. BJT
3. MOSFET
4. Triode

Option 3 :

Which of the following terminals does not belong to the MOSFET?
a) Drain
b) Gate
c) Base
d) Source

Answer: c
Explanation: MOSFET is a three terminal device D, G & S.

Choose the correct statement
a) MOSFET is a unipolar, voltage controlled, two terminal device
b) MOSFET is a bipolar, current controlled, three terminal device
c) MOSFET is a unipolar, voltage controlled, three terminal device
d) MOSFET is a bipolar, current controlled, two terminal device

Answer: c
Explanation: MOSFET is a three terminal device, Gate, source & drain. It is voltage controlled unlike the BJT & only electron current flows.

The arrow on the symbol of MOSFET indicates
a) that it is a N-channel MOSFET
b) the direction of electrons
c) the direction of conventional current flow
d) that it is a P-channel MOSFET
Answer: b
Explanation: The arrow is to indicate the direction of electrons (opposite to the direction of conventional current flow).

The controlling parameter in MOSFET is
a) Vds
b) Ig
c) Vgs
d) Is

Answer: C
Explanation: The gate to source voltage is the controlling parameter in a MOSFET.

What are the main terminals that carry current?

a. Source
b. Drain
c. Source & Drain
d. Gate

Answer C

Which transistor is preferred for applications of High power?

a) BJT
b) UJT
c) MOSFET
d) JFET

What is required to switch OFF the MOSFET (Depletion type)?

a) VGS
b) VDS
c) VGD
d) Either VDS or VGD

Answer: a

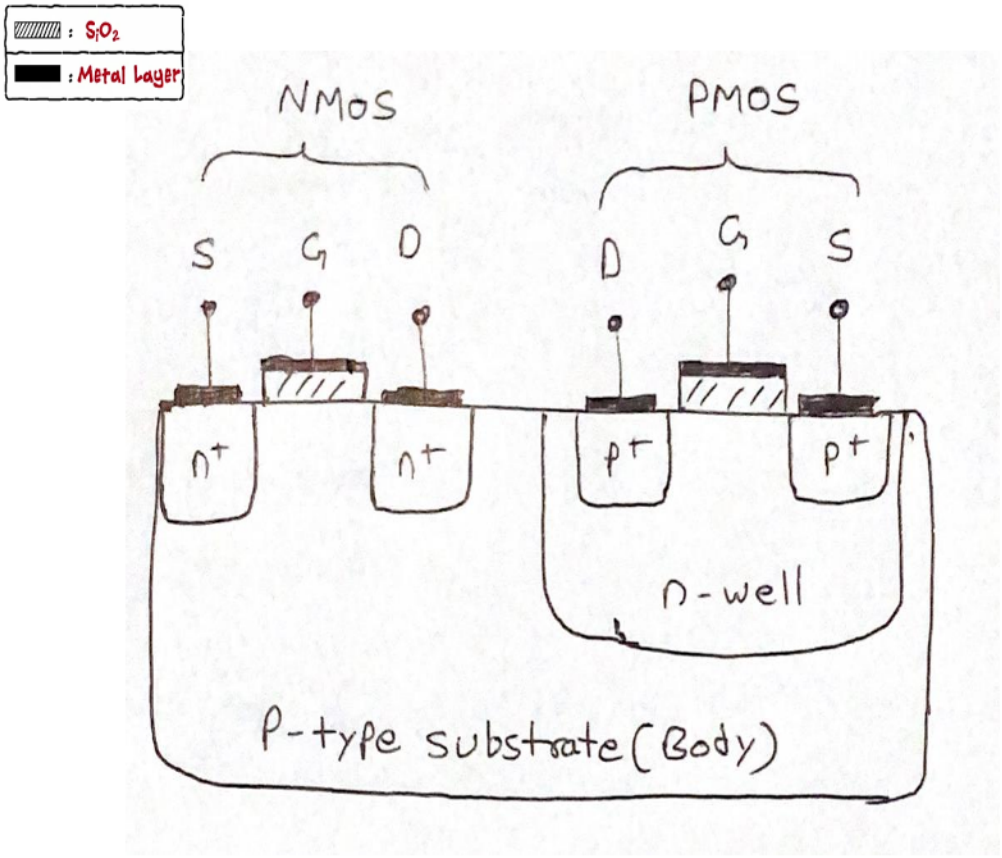
What condition makes MOSFET a Transconductance device?

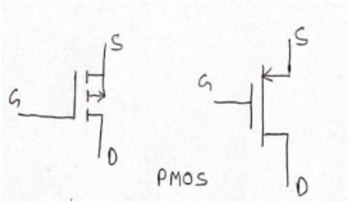
a) VGS> VTH
b) VGS<VTH
c) VGS=VTH
d) VGS= 0

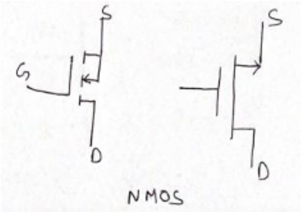
CMOS

- A very effective logic circuit can be made by constructing a **p-channel n-channel MOSFET on the same substrate** as shown in figure.
- This configuration is referred to as complementary MOSFET (CMOS) arrangement.
- It has extensive application in computer logic design.
- PMOS and NMOS are fabricated in the same substrate.
- N-MOS is fabricated directly on the p-type substrate while the P-MOS is fabricated in a specially created n region known as “n well”.
- Less power consumption

Cross section of CMOS IC







1. The full form of CMOS is ___________
A. Capacitive metal oxide semiconductor
B. Capacitive metallic oxide semiconductor
C. Complementary metal oxide semiconductor
D. Complemented metal oxide semiconductor

Answer: C

. CMOS technology is used in ___________
A. Inverter
B. Microprocessor
C. Digital logic
D. Both microprocessor and digital logic

Answer: D
Clarification: CMOS technology is used in Microprocessor, Microcontroller, static RAM and other digital logic circuits. CMOS technology is also used for several analog circuits such as image sensors (CMOS sensor), data converters and highly integrated transceivers for many types of communication.

CMOS behaves as a/an ____________

A. Adder

B. Subtractor

C. Inverter

D. Comparator

Answer: C

Clarification: Since, the outputs of the PMOS and NMOS transistors are complementary such that when the input is low, the output is high and when the input is high, the output is low. Because of this behaviour of input and output, the CMOS circuit's output is the inverse of the input. Whereas, adders and subtractors are combinational circuits.

. CMOS logic dissipates _______ power than NMOS logic circuits.

A. More

B. Less

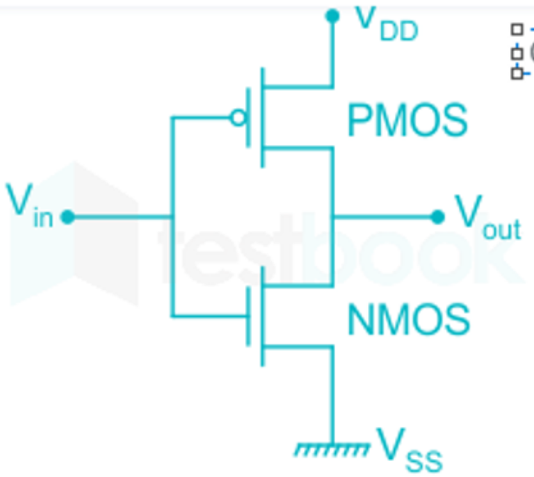
C. Equal

D. Very High

Answer: B

Clarification: CMOS logic dissipates less power than NMOS logic circuits because CMOS dissipates power only when switching ("dynamic power"). Thus, CMOS has less power consumption and is more efficient.

CMOS



CMOS

- The two important characteristics of CMOS devices are **high noise immunity and low power dissipation.**
- CMOS devices dissipate less power than NMOS devices because the CMOS dissipates power only when switching ("dynamic power), whereas N channel MOSFET dissipates power whenever the transistor is on because there is a current path from V_{dd} to V_{ss}.
- In a CMOS, only one MOSFET is switched on at a time. Thus, there is no path from voltage source to ground so that a current can flow. Current flows in a MOSFET only during switching.
- Thus, compared to N-channel MOSFET has the advantage of lower drain current from the power supply, thereby causing less power dissipation.