$$R = \frac{E_i - E_o}{I_z + I_{L\,max}}$$

chapter-1

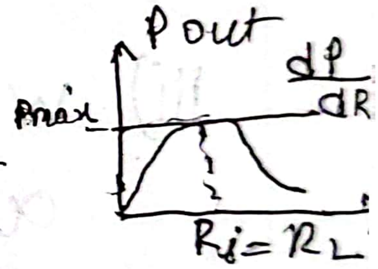
~~Ex-1.1~~

Maximum power transfer theorem

Maximum power is transferred from a source to a load when the load resistance is made equal to the internal resistance of source

$$I = \frac{V_{th}}{R_{th} + R_L}$$

$$P = I^2 R_L$$



$$P = \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 R_L$$

$$\frac{dP}{dR_L} = 0$$

$$\Rightarrow \frac{d}{dR_L}\left(\frac{V_{th}^2}{(R_{th}+R_L)^2} \times R_L\right) = 0 \Rightarrow V_{th}^2 \frac{d}{dR_L}\left(\frac{R_L}{(R_{th}+R_L)^2}\right)$$

$$\Rightarrow V_{th}^2 \left[\frac{(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L)}{(R_{th}+R_L)^4}\right] = 0$$

$$(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L) = 0$$

$$\Rightarrow (R_{th}+R_L)^2 = 2R_L(R_{th}+R_L)$$

$$\Rightarrow R_{th}+R_L = 2R_L$$

$$\Rightarrow R_{th} = R_L$$

Load resistance = internal resistance

Ex-1.5

TOPIC NAME : DAY : TIME : DATE : / /

Questionsolve 20-21

1 a) The electrons in the outermost orbit of an atom are known as valance electrons. one the basis of electron conductivity material are genarall classified conductor insulator semiconductors

Conductor

When the number of valence electron less than 4 the matirial is usally a Metal and a conductor

Ex: sodiam, magnesium.

Insulator

when the number of valence electron of an atom is more than 4, the material is usally a non-metal and an insulator.

Ex. nitrozen, salphar

Semiconductor

When the number of valence electron of an atom is 4, the material has both metal

TOPIC NAME : DAY : TIME : DATE : / /

and non-metal properties and is usually a semiconductor. Examples are carbon, silicon, germanium

~~b) A direct voltage source is a device that pro~~

b) There are two type of voltage source

i) Direct voltage source

ii). Alternative voltage source

i) Direct Voltage source

A direct voltage source is provide a constant voltage output with a fixed polarity meaning the positive and negative terminals remain Fixed. ~~Ex~~

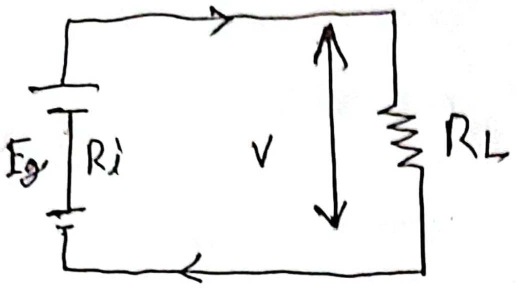
Example: battery cells, dc genaratorrs.

When a load resistance connected a direct current flow from the positive terminal to the negetive terminal throug the load

GOOD LUCK

TOPIC NAME : DAY : TIME : DATE : / /

Figure



equation

Load current, $I = \frac{E_g}{R_L + R_i}$

Terminal voltage $V = E_g - IR_i$ or IR_L

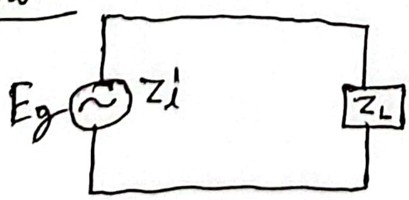
ii) Alterchating ~~current~~ voltage source

A device which prodces alternating voltage output continuously is know as alternating voltage sorce. ~~An~~

Ex. ac genarator.

An the important charactoristics of altornating Voltage source is that is priodicly reverse polarity of the output voltage.

Figure:



equation:

Load current $I_{(r.m.s)} = \frac{E_g}{Z_i + Z_L}$

Terminal voltage, $V = (E_g - IZ)$ or IZ_L

TOPIC NAME : DAY : TIME : DATE : / /

c) book ex- 1.1

$E_g = 24V$

$r_i = 0.01\Omega$

Power = 100 watts

$P = E_g \times I$

$I = \frac{\cancel{24}\,100}{\cancel{100}\,24} = 4.17 A$

(i) voltage drop internal resistance $= 4.17 \times 0.01$

$\cancel{= 0.017V}$

$= 0.0417V$

(ii) Terminal voltage drop $= 24 - 0.0417V$

$= 23.96V$

1. **The electrons of outer most is known as valance electron. How these electrons determine the electrical properties of a material? (20-21)**

Answer:

Valence electrons, the electrons in the outermost shell of an atom, play a crucial role in determining the electrical properties of a material. Here's how:

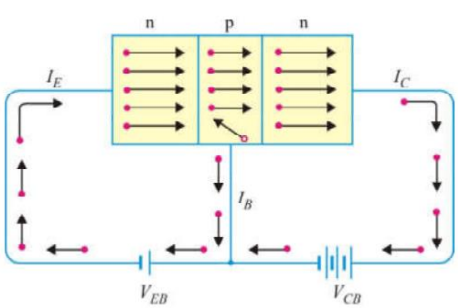
- **Conductors**: In conductive materials, like metals, valence electrons are loosely bound to their atoms and can move freely through the material. These free-moving electrons allow electric current to flow easily when an electric field is applied, making metals good conductors.
- **Insulators**: In insulating materials, such as rubber or glass, valence electrons are tightly bound to their atoms and cannot move freely. This lack of free electrons means there is little to no current flow, making these materials resist electric currents.
- **Semiconductors**: Materials like silicon and germanium have valence electrons that are not as free as in conductors, but also not as restricted as in insulators. Semiconductors' electrical properties can change when they gain or lose electrons through doping, allowing them to conduct electricity under certain conditions. This property is crucial for creating electronic components like diodes, transistors, and integrated circuits.

2. **Explain the working principle of npn transistor.(20-21)**

Answer:

The working principle of npn transistor is given below:

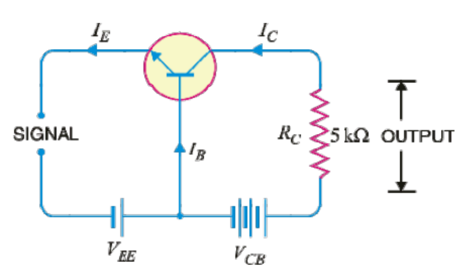
An **npn** transistor operates by using a small base current to control a larger collector current, effectively acting as a current amplifier. When the **emitter-base junction** is forward biased, electrons from the **n-type emitter** flow towards the **p-type base**, creating the **emitter current (I_E)**. As these electrons pass through the base, only a small fraction (less than 5%) combine with holes due to the base being very thin and lightly doped. This small recombination forms the **base current (I_B)**, while the majority of electrons (more than 95%) continue across the reverse-biased **collector-base junction** to the **collector**, forming the **collector current (I_C)**. The total emitter current thus equals the sum of the collector and base currents, expressed as $I_E = I_B + I_C$. This process allows the **npn** transistor to control and amplify currents effectively.



Basic connection of *npn* transistor

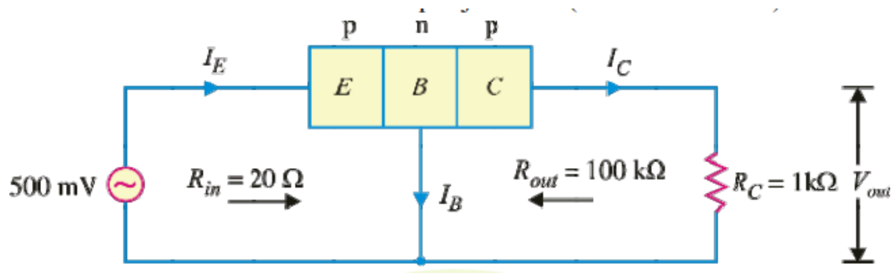
3. **How transistor can be used as an amplifier? With an appropriate diagram.(20-21)**

Answer:



A transistor acts as an amplifier by using a small input signal at the base to control a much larger current between the collector and emitter. In a common-emitter configuration, the base-emitter junction is forward biased, and the collector-base junction is reverse biased. When a small current or voltage is applied to the base, it results in a proportionally larger collector current due to the transistor's current gain (β\betaβ). This means that small changes in the base current produce amplified changes in the collector current, creating a larger output signal across the load connected to the collector.

4. A common base transistor amplifier has an input resistance of 20 ohm and output resistance of 100 kilo ohm. The collector load is 1 kilo ohm. If a signal of 500 mV is applied between emitter and base, find the voltage amplification. Assume α_{ac} to be nearly one. (20-21)



Answer:

Note that output resistance is very high as compared to input resistance. This is not surprising because input junction (base to emitter) of the transistor is forward biased while the output junction (base to collector) is reverse biased. (Transfer + Resistor = Transistor.)

Input current, $I_E = \dfrac{\text{Signal}}{R_{in}} = \dfrac{500\ \text{mV}}{20\ \Omega} = 25\ \text{mA}$. Since α_{ac} is nearly 1, output current, $I_C = I_E = 25\ \text{mA}$.

$$\text{Output voltage, } V_{out} = I_C R_C = 25\ \text{mA} \times 1\ \text{k}\Omega = 25\ \text{V}$$

$$\therefore \quad \text{Voltage amplification, } A_v = \frac{V_{out}}{\text{signal}} = \frac{25\ V}{500\ mV} = 50$$

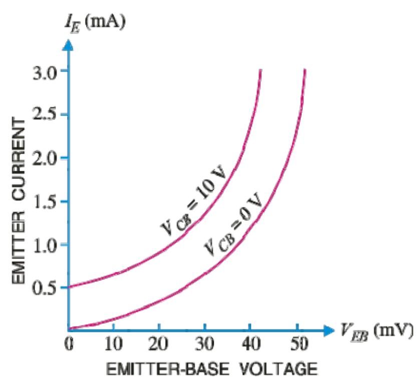
5. Explain the characteristics of Common Base Connection with diagram and equations. (20-21)

Answer:

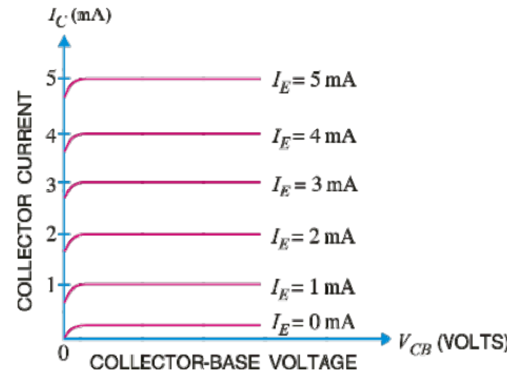
In a **Common Base (CB) connection** of a transistor, the base terminal is shared by both the input and output circuits. Here are its main characteristics:

Input Characteristics:

- ❖ The input is applied between the **emitter** and **base**, while the output is taken between the **collector** and **base**.
- ❖ The **input characteristics** show how the input current (emitter current, I_E) changes with the input voltage (emitter-base voltage, V_{EB}), while the output voltage (collector-base voltage, V_{CB}) is kept constant.
- ❖ As V_{EB} increases, IE also increases, similar to how current flows in a diode.



Output Characteristics:



- ❖ The output characteristics show how the **output current** (collector current, I_C) depends on the **output voltage** (collector-base voltage, V_{CB}), for different values of **input current** (emitter current, IE).
- ❖ Beyond a certain V_{CB} value, I_C remains mostly constant, meaning the collector current doesn't change much with the output voltage, which is useful for amplification.

Current Gain (α):
The current gain in CB mode is defined as the ratio of collector current (I_C) to emitter current (I_E):

$\alpha = I_C / I_E$ (**α** is close to 1, so most of the emitter current flows to the collector.)

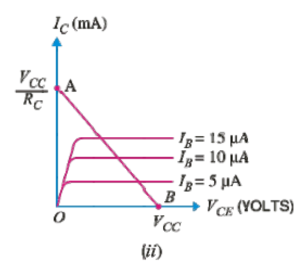
Input Resistance:
The input resistance in a CB connection is low, meaning a small input voltage change causes a large change in emitter current.

Voltage Gain:
The voltage gain in a common-base amplifier is high, making this setup suitable for amplifying small signals.

6. How would you determine the load line and operating point of a transistor? (20-21)

Answer:

The load line represents all possible combinations of collector current (I_C) and collector-emitter voltage (V_{CE}) in a transistor circuit, limited by the external supply voltage and load resistor.



Determining the Load Line:
Use the equation derived from Kirchhoff's Voltage Law:

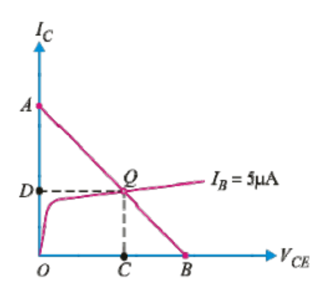
$V_{CE} = V_{CC} - I_C R_C$

To plot it on the IC-VCE graph:

- ❖ **When V_{CE} = 0V**, $I_C = V_{CC} / R_C$, representing the maximum collector current.
- ❖ **When I_C = 0**, $V_{CE} = V_{CC}$, representing the maximum collector-emitter voltage.

Connect these points to draw a straight line, called the load line, which represents the limits of operation for the transistor in the circuit.

The **operating point** or **Q-point** is the specific point on the load line where the transistor functions under steady-state conditions, defined by a specific collector current and collector-emitter voltage.



Determining the Operating Point:

- ❖ Identify the base current I_B based on the input biasing circuit.
- ❖ Find the transistor's characteristic curve for this I_B.
- ❖ The intersection of this curve with the load line gives the Q-point, showing the actual I_C and V_{CE} values where the transistor will operate.

7. Establish the relation between β and α.(20-21)

Answer:

Current amplification factor (α) and Base current amplification factor (β) i.e.

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{--- (i)}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{--- (ii)}$$

Relation between β and α is given below:

We know,

$$I_E = I_B + I_C$$

$$\Rightarrow \Delta I_E = \Delta I_B + \Delta I_C$$

$$\Rightarrow \Delta I_B = \Delta I_E - \Delta I_C$$

Substituting ΔI_B in exp (ii) we get,

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

$$\Rightarrow \beta = \frac{\frac{\Delta I_C}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} \quad \left[\text{Dividing numerator and denominator by } \Delta I_E\right]$$

$$\Rightarrow \beta = \frac{\alpha}{1 - \alpha} \quad \left[\because \alpha = \frac{\Delta I_C}{\Delta I_E}\right]$$

$\therefore \beta = \frac{\alpha}{1-\alpha}$, This is the required relationship.

8. Breakdown voltage and knee voltage is important concept for pn junction. Why?(20-21)

Answer:

The importance of breakdown voltage and knee voltage for pn junction is given below:

Breakdown Voltage is the reverse voltage at which a p-n junction starts to let a large current flow. If this voltage is exceeded, it can damage the device. Knowing this helps protect circuits from too much reverse voltage.

Knee Voltage is the forward voltage needed to start allowing current through the p-n junction (about 0.7V for silicon, 0.3V for germanium). This voltage is important to set the junction to work correctly.

9. Explain the construction and biasing of a transistor. (19-20)

Answer:

Construction of a Transistor:

A transistor has three layers: emitter, base, and collector.

- **Emitter:** Heavily doped to inject charge carriers (electrons in NPN, holes in PNP).
- **Base:** Thin and lightly doped to allow most carriers to pass through.
- **Collector:** Moderately doped, larger to dissipate heat, collects charge carriers from the base.

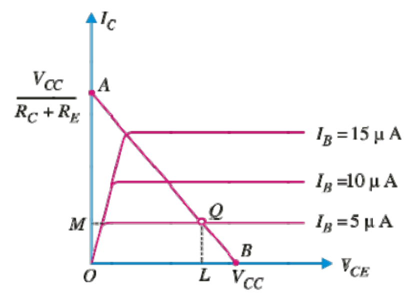
Transistor Biasing involves applying external voltages to control the transistor's operation:

1. **NPN Transistor**:
   - **Emitter-Base Junction**: Forward-biased (base positive relative to emitter) for electron flow from emitter to base.
   - **Collector-Base Junction**: Reverse-biased (collector positive relative to base) to pull electrons into the collector.
2. **PNP Transistor**:
   - **Emitter-Base Junction**: Forward-biased (emitter positive relative to base) for hole flow from emitter to base.
   - **Collector-Base Junction**: Reverse-biased (base positive relative to collector) to pull holes into the collector.

10. Discuss d.c and a.c load lines with the help of the output characteristics of a transistor. (19-20)

Answer:

d.c. load line: It is the line on the output characteristics of a transistor circuit which gives
the values of I_C and V_{CE} corresponding to zero signal or d.c. conditions. **Kirchhoff's Voltage Law** is used in the collector-emitter circuit to find the equation of the d.c. load line:



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

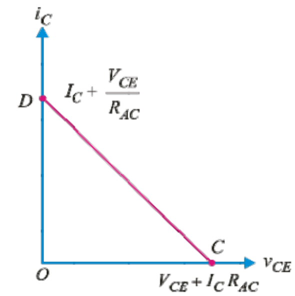
$$V_{CE} = V_{CC} - I_C (R_C + R_E) \qquad [\because I_E \sim I_C]$$

Here V_{CC} and $(R_C + R_E)$ are constant, therefore, it is a first degree *equation and can be represented by a straight line on the output characteristics. This is known as d.c. load line and determines the load of V_{CE} and I_C points in the zero signal conditions.

The value of V_{CE} will be maximum when $I_C = 0$; Max $V_{CE} = V_{CC}$

And the value of Ic will be maximum when $V_{CE} = 0$; Max $I_c = V_{CC} / (R_c + R_E)$

a.c. load line: This is the line on the output characteristics of a transistor circuit which gives the values of I_C and V_{CE} when signal is applied.



When we add a.c. load line to the output characteristics, we get two end points, one maximum collector-emitter voltage point and the other maximum collector current point.

Max. collector-emitter voltage = $V_{CE} + I_C R_{AC}$

And Maximum collector current = $I_C + (V_{CE} / R_{AC})$

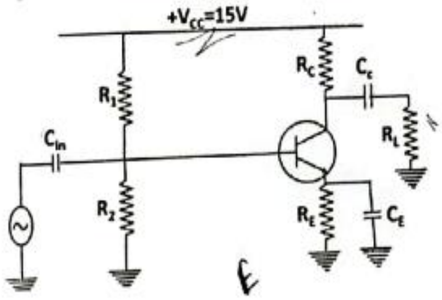
where

$R_{AC} = R_C \parallel R_L = R_C R_L / (R_C + R_L)$

11. The Transistor amplifier shown in figure $R_1 = 10K\Omega$, $R_2 = 5K\Omega$, $R_C = 1K\Omega$, $R_E = 2K\Omega$, $R_L = 1K\Omega$. (19-20)

(i) Draw d.c. load line and

(ii) Determine the operating point.



Answer:

***(i)* d.c. load line :**

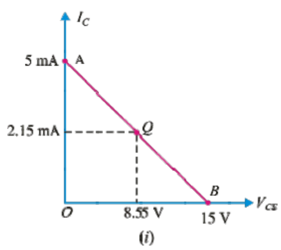
To draw d.c. load line, we require two end points *viz* maximum *VCE* point and maximum *IC* point.

$$\text{Maximum } V_{CE} = V_{CC} = 15\text{ V [See Art. 10.8]}$$

This locates the point *B* (*OB*=15 V) of the d.c. load line.

$$\text{Maximum } I_C = \frac{V_{CC}}{R_C + R_E} = \frac{15\,V}{(1+2)\,\text{k}\Omega} = 5\text{ mA} \quad \text{[See Art. 10.8]}$$

This locates the point *A* (*OA* = 5 mA) of the d.c. load line. Fig. 10.16 (*i*) shows the d.c. load line *AB*.



(*ii*) Operating point Q. The voltage across R_2 (= 5 kΩ) is *5 V *i.e.* V_2 = 5 V.

$$\text{Now} \quad V_2 = V_{BE} + I_E R_E$$

$$\therefore \quad I_E = \frac{V_2 - V_{BE}}{R_E} = \frac{(5-0.7)\,V}{2\text{ k}\Omega} = 2.15\text{ mA}$$

$$\therefore \quad I_C = I_E = 2.15\text{ mA}$$

$$\text{Now} \quad V_{CE} = V_{CC} - I_C(R_C + R_E) = 15 - 2.15\text{ mA} \times 3\text{ k}\Omega = 8.55\text{ V}$$

∴ Operating point *Q* is **8.55 V, 2.15 mA.** This is shown on the d.c. load line.

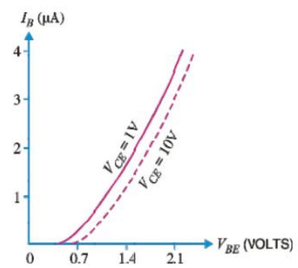
12. Explain input and output characteristics of a common emitter transistor connection. (19-20)

Answer:

The Input and Output Characteristics of a Common Emitter (CE) Transistor Connection is given below,

Input Characteristics:

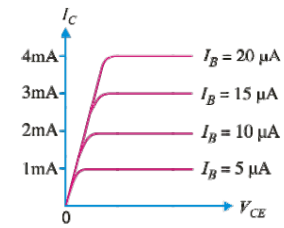
- Input characteristics show the relationship between **base current (I_B)** and **base-emitter voltage (V_{BE})**.
- With the **collector-emitter voltage (V_{CE})** kept constant, as **V_{BE}** increases, **I_B** increases.
- The input curve resembles a **diode curve**, showing exponential growth after a threshold.



Input Resistance(R_i) is calculated as:

$$R_i = \Delta V_{BE} / \Delta I_B \quad \text{,where } V_{CE} \text{ is constant}$$

Output Characteristics:



- Output characteristics show the relationship between **collector current (I_C)** and **collector-emitter voltage (V_{CE})** for different base currents (I_B).
- For a constant I_B, I_C increases with V_{CE} initially but levels off, indicating **saturation** and **active regions**.
- At higher V_{CE}, I_C is almost constant, showing **high output impedance**.

Output Resistance (R_O) is calculated as:

$R_O = \Delta V_{CE} / \Delta I_C$, where I_B is constant.

13. A transistor is connected in a common emitter configuration in which the collector supply is 8V and the voltage drop across resistance Re connected in the collector circuit is 0.5V. The value of Re=8002 if a=0.96 determines (i) VCE and (ii) IB Answer: (19-20)

Example 8.12. *A transistor is connected in common emitter (CE) configuration in which collector supply is 8V and the voltage drop across resistance R_C connected in the collector circuit is 0.5 V. The value of $R_C = 800\ \Omega$. If $\alpha = 0.96$, determine :*

(i) collector-emitter voltage

(ii) base current

Solution. Fig. 8.22 shows the required common emitter connection with various values.

(i) Collector-emitter voltage,

$$V_{CE} = V_{CC} - 0.5 = 8 - 0.5 = 7.5\ \text{V}$$

(ii) The voltage drop across $R_C (= 800\ \Omega)$ is 0.5 V.

$$\therefore \quad I_C = \frac{0.5\ \text{V}}{800\ \Omega} = \frac{5}{8}\ \text{mA} = 0.625\ \text{mA}$$

$$\text{Now} \quad \beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$$

$$\therefore \quad \text{Base current,} \quad I_B = \frac{I_C}{\beta} = \frac{0.625}{24} = 0.026\ \text{mA}$$

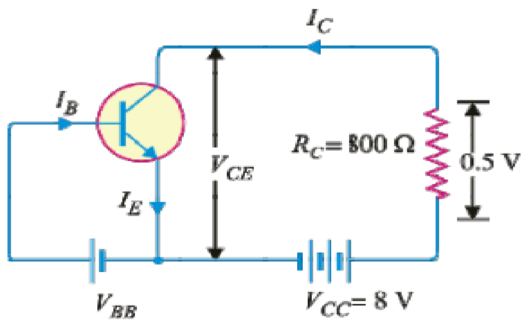


Fig. 8.22

14. Among CB, CE and CC connection which is most popular. Why?(18-19)

Answer:

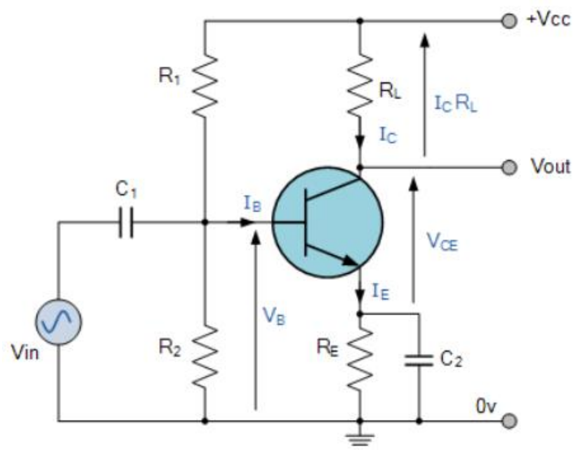
The **common emitter (CE)** connection is the most popular among CB, CE, and CC connections. This is because:

- **High Voltage and Power Gain**: The CE configuration provides good voltage gain and high power gain, making it suitable for amplifiers.
- **Phase Inversion**: It produces a 180° phase shift, useful in many applications.
- **Moderate Input and Output Resistance**: It has a balance of input and output resistance, making it versatile for various circuits.

15. Draw the circuit diagram of the common emitter amplifier and hence show that the output voltage of a single-stage common emitter transistor amplifier is 180º out of phase with the input voltage. (19-20)

Answer:

The most common amplifier configuration for an NPN transistor is that of the Common Emitter Amplifier circuit.



Baki ongser excat ans. Pai na

For mid 1

Chapter 5

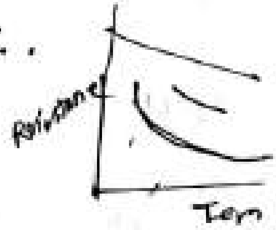
s[i] --= 1

s[i] = s[i] -1

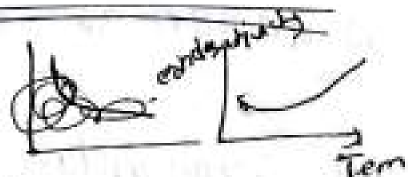
Semiconductor:- A semiconductor is a substance which has resistivity (10^{-4} to 0.5 Ωm) in between conductor and insulator. For example germenium, silicon, carbon.

Properties of semiconductor:-

i. The resistivity of semiconductor is less than an an insulator but more than a conductor.



ii. Semiconductors have negative temparature co-efficient of resistance.

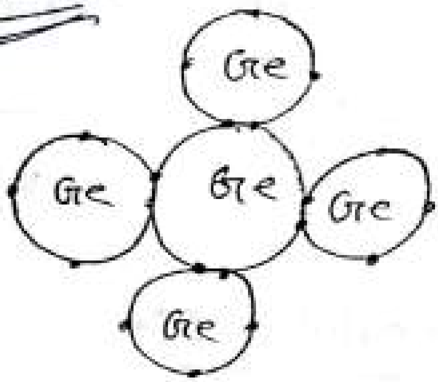


The resistance of a semiconductor decress with the increase in temperature and vice-versa.

iii. When a suitable metallic impurity (arsenic, gallium) is added to a semiconductor. its current conducting properties change appreciably

Bonds in semiconductor :-

In semiconductors bonds are formed by sharing of valence electrons. Such bonds are called co-valent bonds.



covalent bond

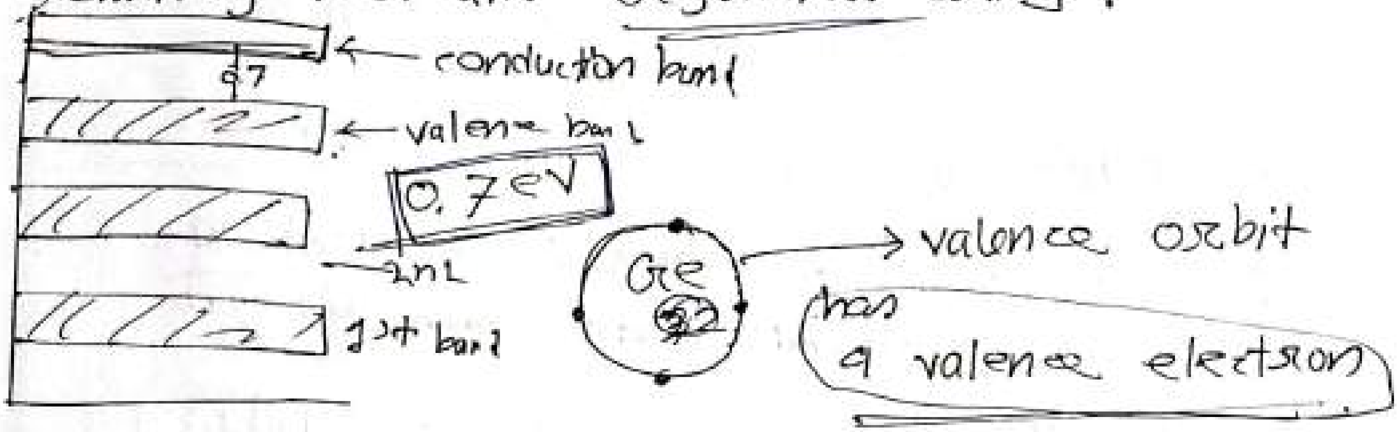
crystals :- is A substance in which the atoms or molecules are arranged in an orderly pattern is known as a crystal.

All semiconductors have crystalline structure.

The crystalline structure leads to well defined energy bands and predictable electrical behaviour.

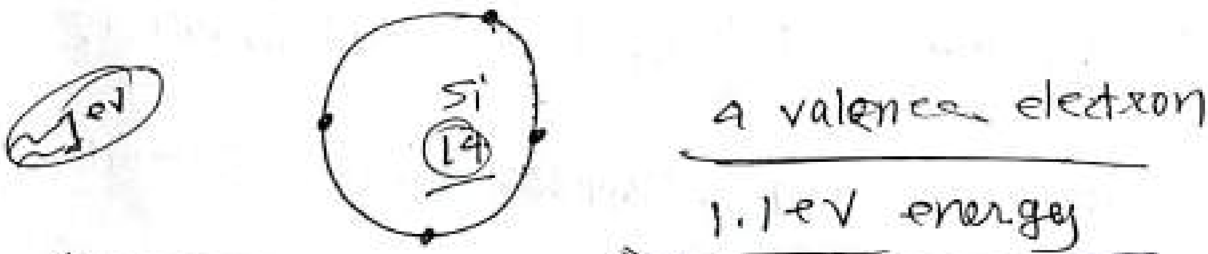
Germanium

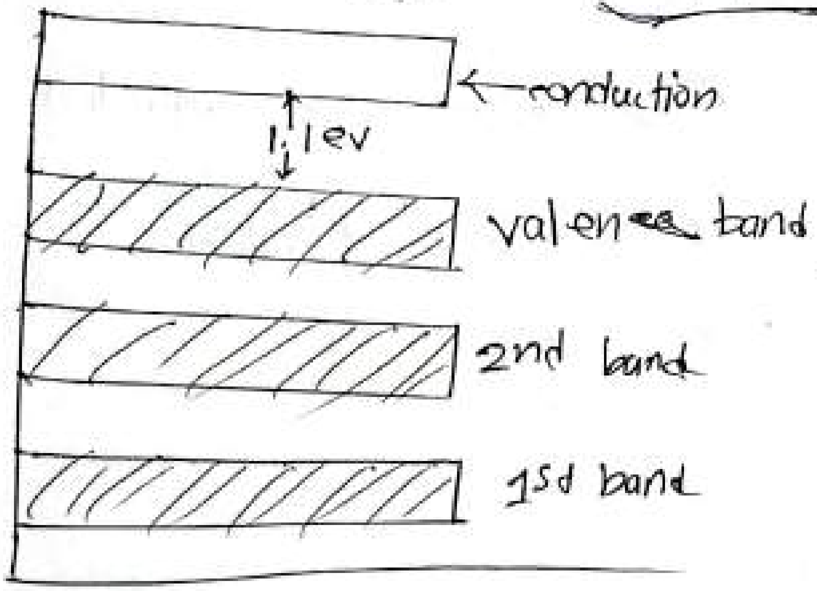
The main reason being that it can be purified relatively well and crystallized easily.



Silicon

The silicon compounds are chemically reduced to silicon which is 100% pure for use as a semiconductor





silicon

Effect of temperature on semiconductor:-

(i) At absolute zero temperature the semiconductor behaves the crystal as a perfect insulators.

insulator

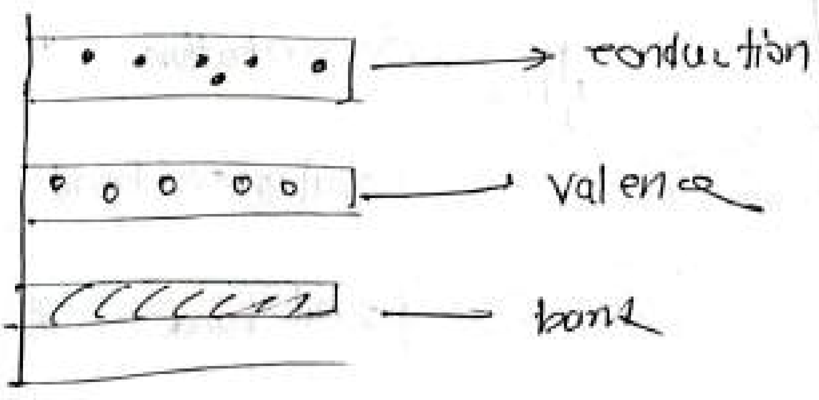
At this temperature, the co-valent bond are very strong and have not any free electrons.

valance band complete conduction band empty

(ii) Above absolute zero temperature: when the temperature raised some of the covalent bond break due to thermal energy. This result few free electrons exist in the semiconductor.

increased

These free electron supplied the current

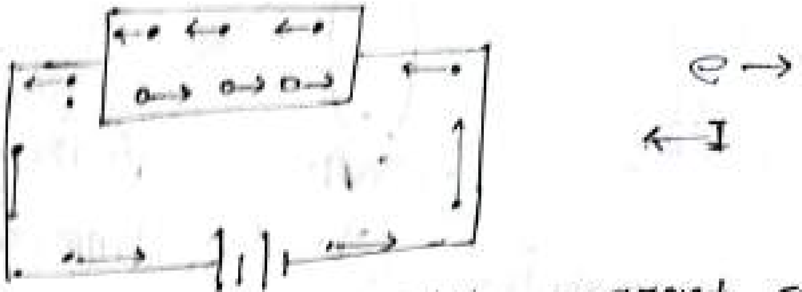


Hole current :- Hole current is a movement of positive charge carriers (holes) in a semiconductor, which occurs when electron shift to fill empty position in the valence band, creating the effect of a positive charge flo

Intrinsic semiconductor

A semiconductor in an extremely pure form is known as an intrinsic semiconductor.

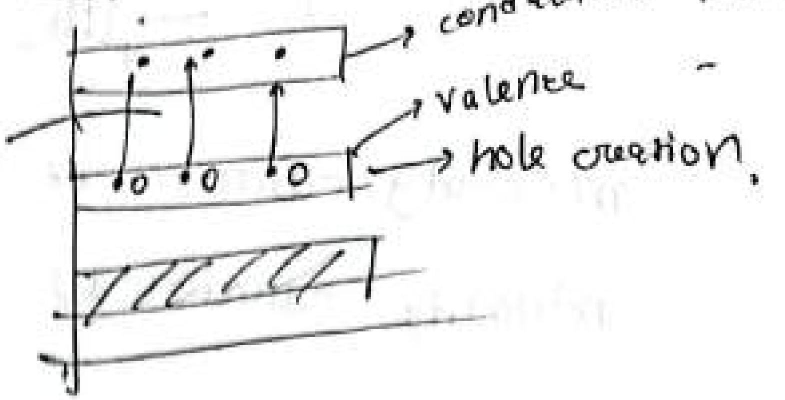
Ex: Ge, Si, Sn.



The intrinsic semiconductor has little current conduction capability in room temperature.

Extrinsic semiconductors are semiconductors that are doped with specific impurities.

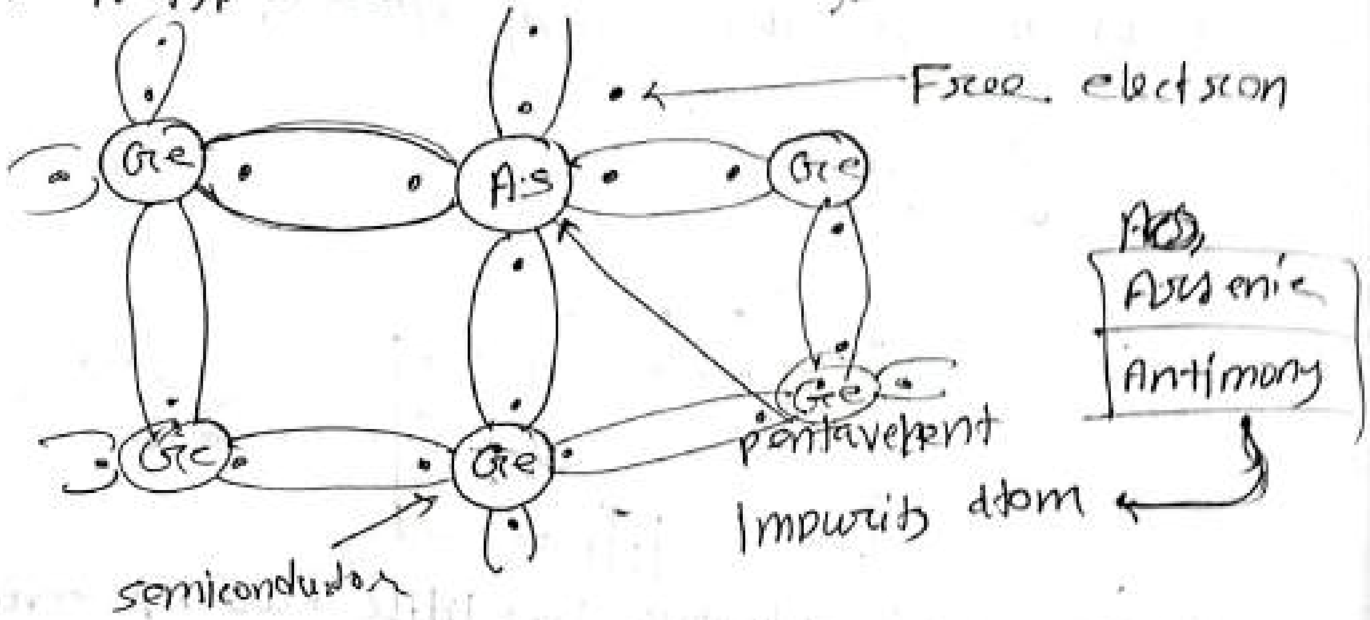
p type and n type.

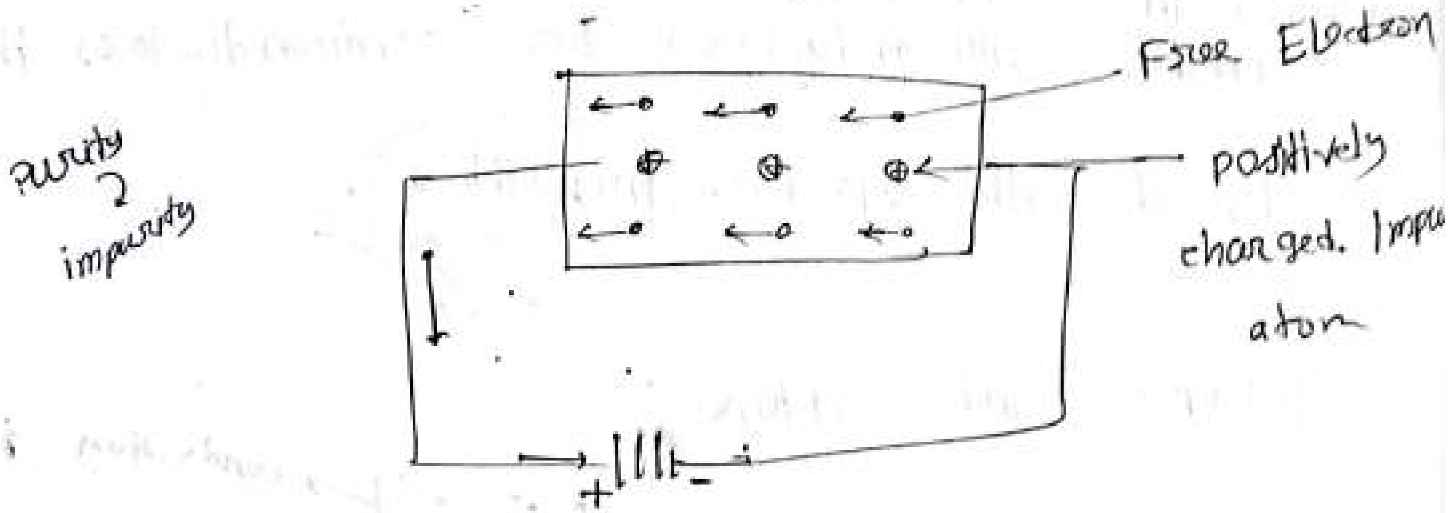


n-type semiconductor

when a small ammount of pentavalent impuri[ty] is added to a pure semiconductor, it is known as n-type semiconductor

Ge + As



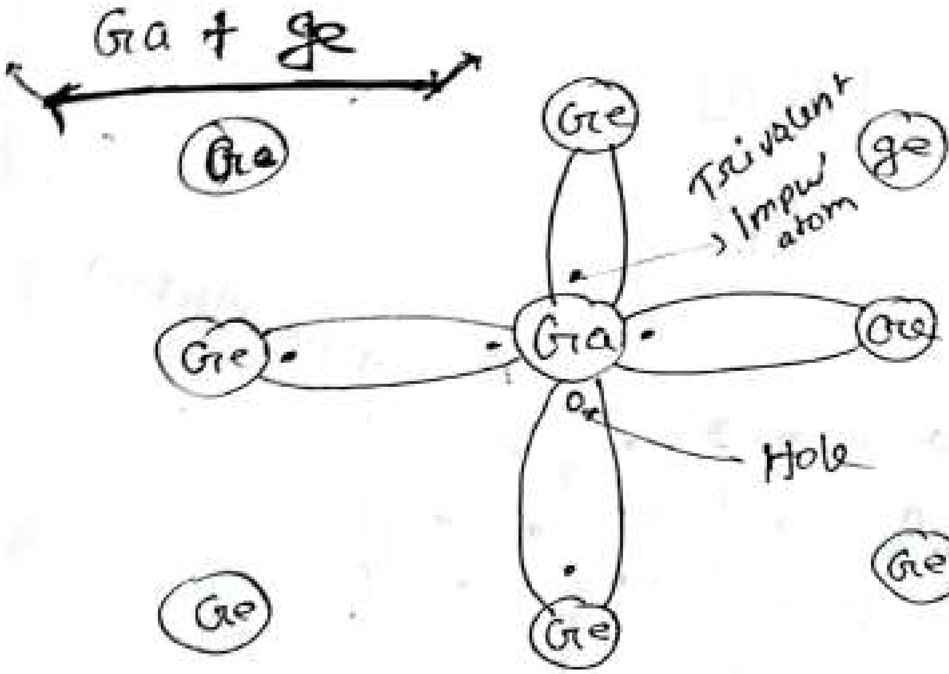


majority carrier is electron

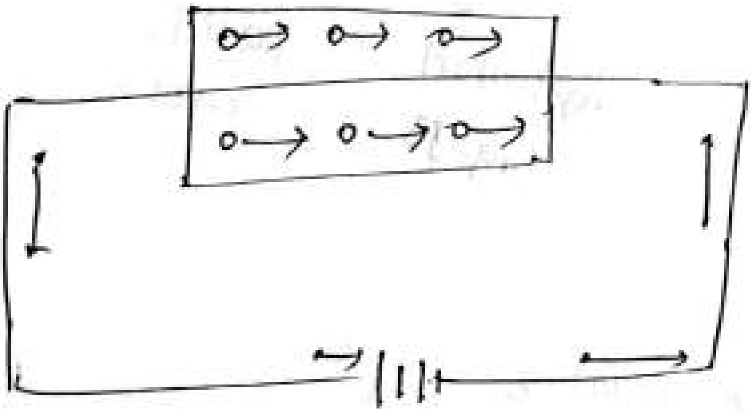
minority carrier is hole

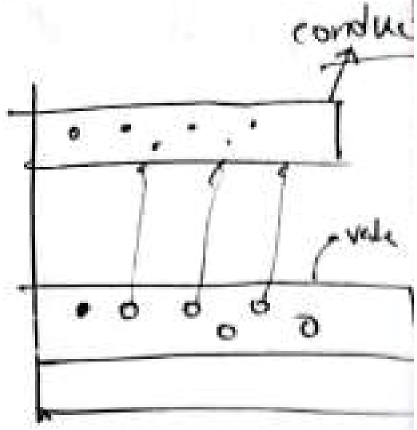
P-type semiconductor

When a small ammount of trivalent impurity is added to a pure semiconductor id is called p-type semicon...



gallium, indium → Acceptar impurities



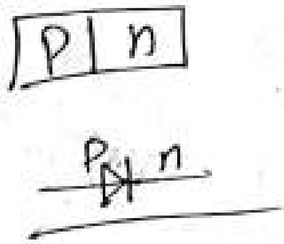


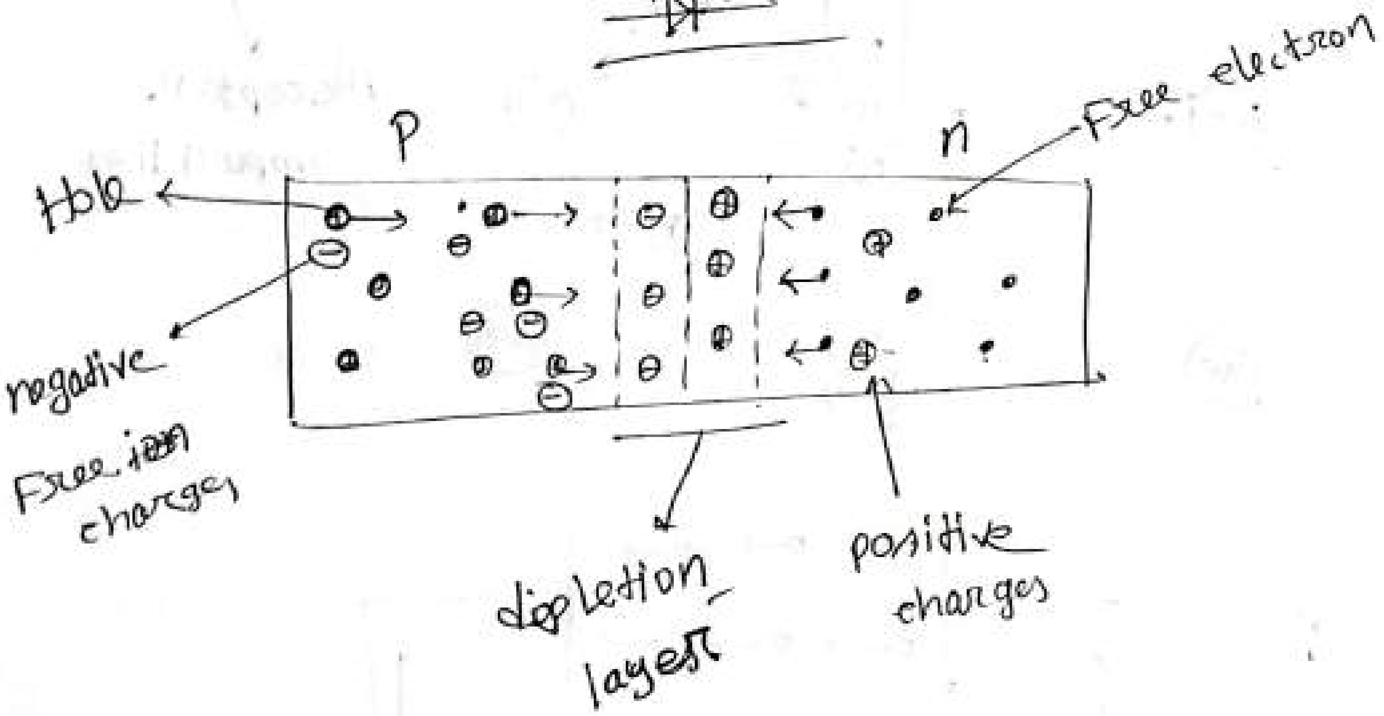
majority carrier is hole

minority " is electron

p-n junction

when a p-type semiconductor is suitably join to n-type semiconductor, the contact surface is called pn junction





barrier potential V_0

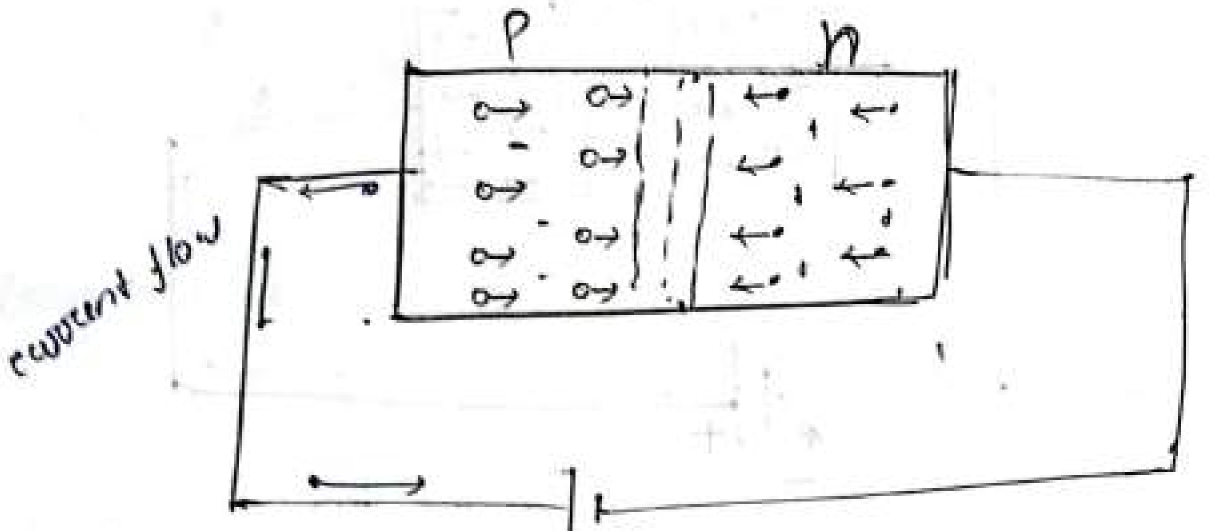
for silicon $V_0 = 0.7\,V$

for germ- $V_0 = 0.3\,V$

Forward biasing

- Forward bias meaning is that the current flows in the forward direction due to the voltage applied in the forward direction.

- In forward bias, the p-type (anode) of the semiconductor is connected to the positive end, and the n type (cathod) is connected to the negative end of the battery.



properties

I. The anode voltage is greater than the cathod voltage

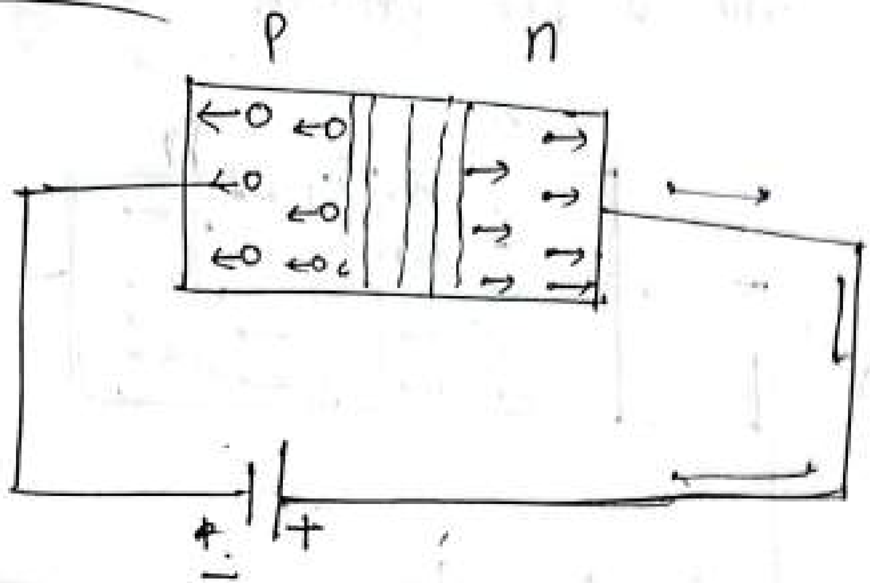
II. The current level depends on the forward voltage

III. depletion ~~to~~ layer is thinner

IV. in forward biyas layer can be decrease instan

V. Forward voltage (0.1 to 0.3 v)

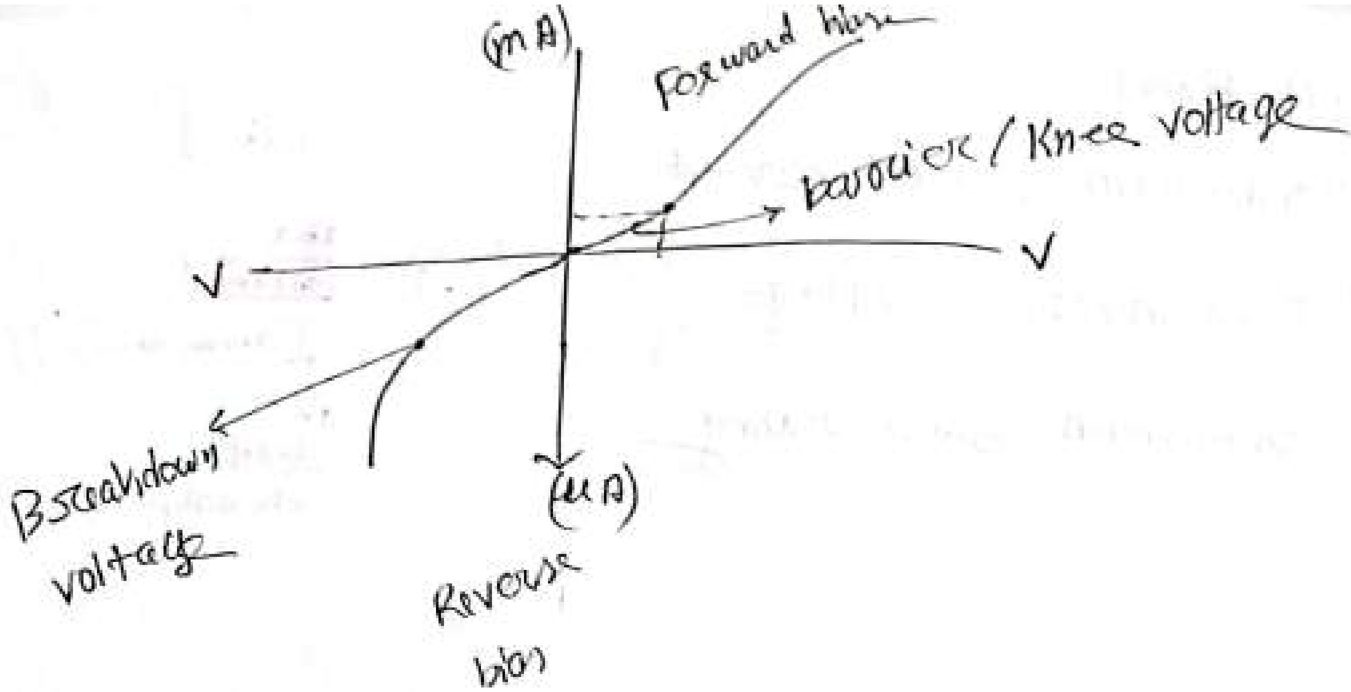
Reverse bias



I. In reverse bias, the anode voltage is less than its cathod

II. passing the current is minimal

III. diode's ~~increase~~ resistance increase instan



barrier / knee voltage :-

It is the forward voltage at which the current through the junction starts to increase rapidly.

Si = 0.7V
Ge = 0.3V
⟶ knee voltage.

Breakdown voltage :- It is the minimum reverse voltage at which pn junction breaks down with sudden rise in reverse current

Lim,
(i)
(ii)
(iii)

Properties of pn junction.

1. Depletion Region; Forms as electrons diffus from the n-region to the p region, creating positive and negative charge layers

2. The depletion layers prevents the movemen of charge carriers

3. The barrier potential of Ge is 0.3 and Si

4. The depletion layer is thin compared to the p and n regions.

Limitations of pn Junction:

1. maximum forward current :- The highest current the junction can conduct without damage. Exceeding this can cause overheating and destruction.

II. peak inverse voltage :- The highest reverse voltage the junction can handle without damage

III. ~~The hi~~ maximum power rating:-

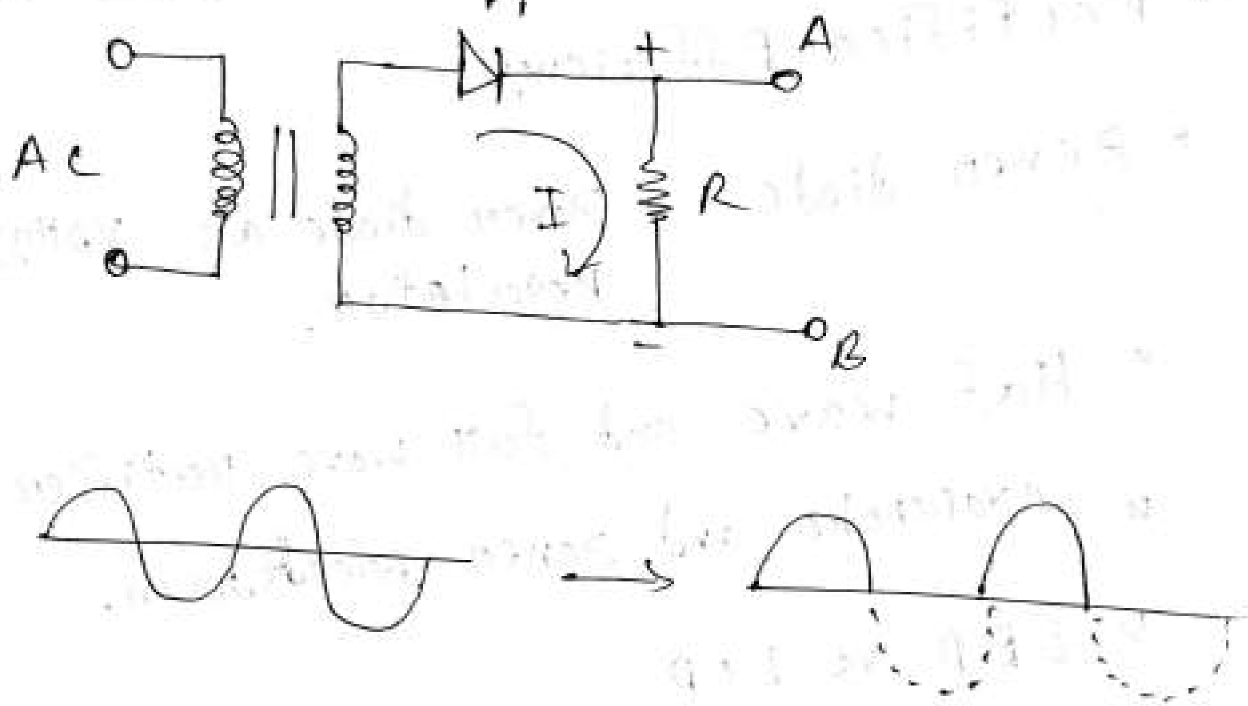
The highest power the junction can dissipate without overheating damage

6,7 Topics

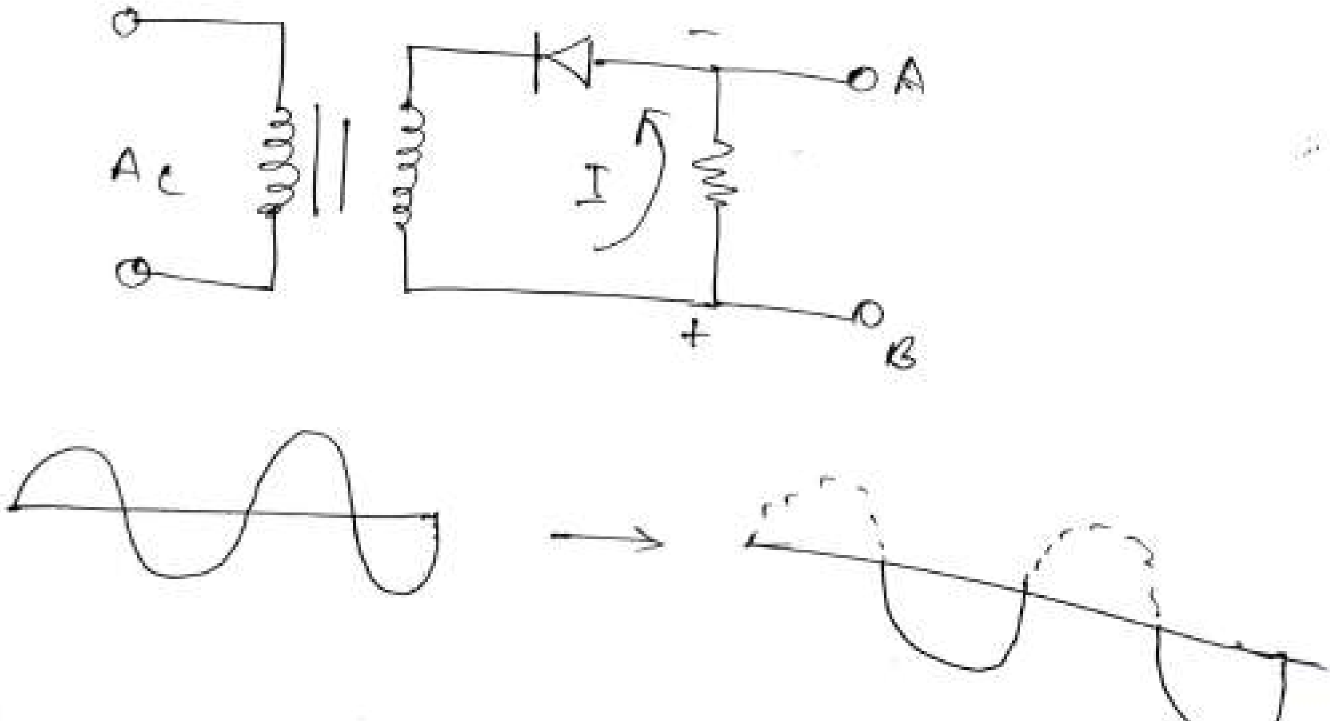
* Rectifier * crystal diode
* Rectifier Efficiency
* Zener diode * Zener diode as voltage Regulator.
* Haf wave and full wave rectifier.
* avalanche and zener breakdown.
* LED vs LCD

Half wave Rectifiers

Positive



Negative



$\boxed{\text{Equation}} \rightarrow \dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

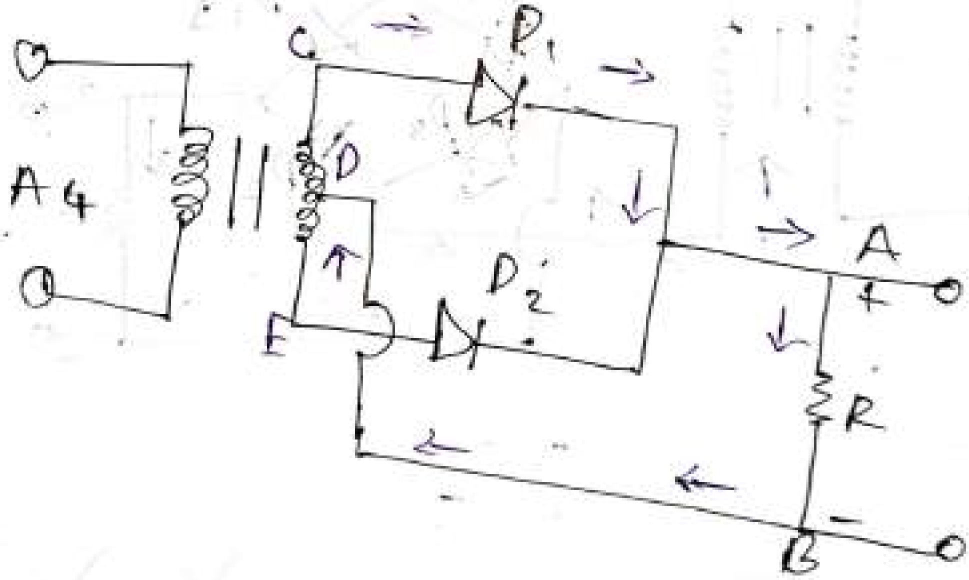
here, $V_s = V_{s\,rms}$ [V_{rms} = root mean square voltage]

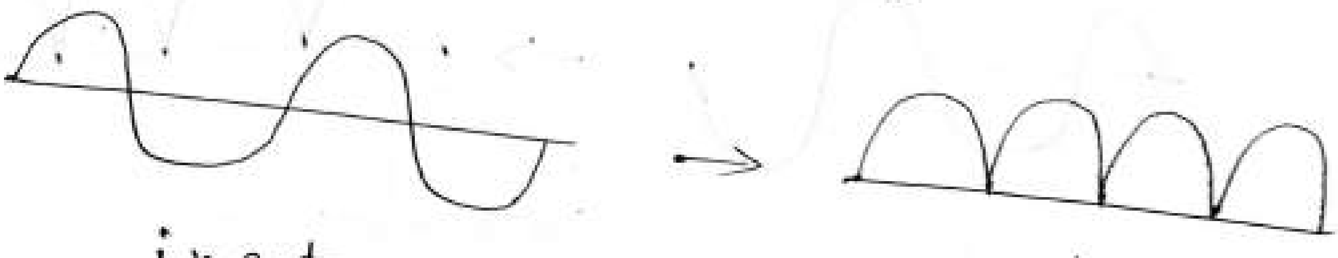
Also, $V_{s\,peak} = V_{s\,rms} \times \sqrt{2}$

For halfwave,

[average] $V_{avg} = \dfrac{V_{peak}}{\pi}$

Full-wave





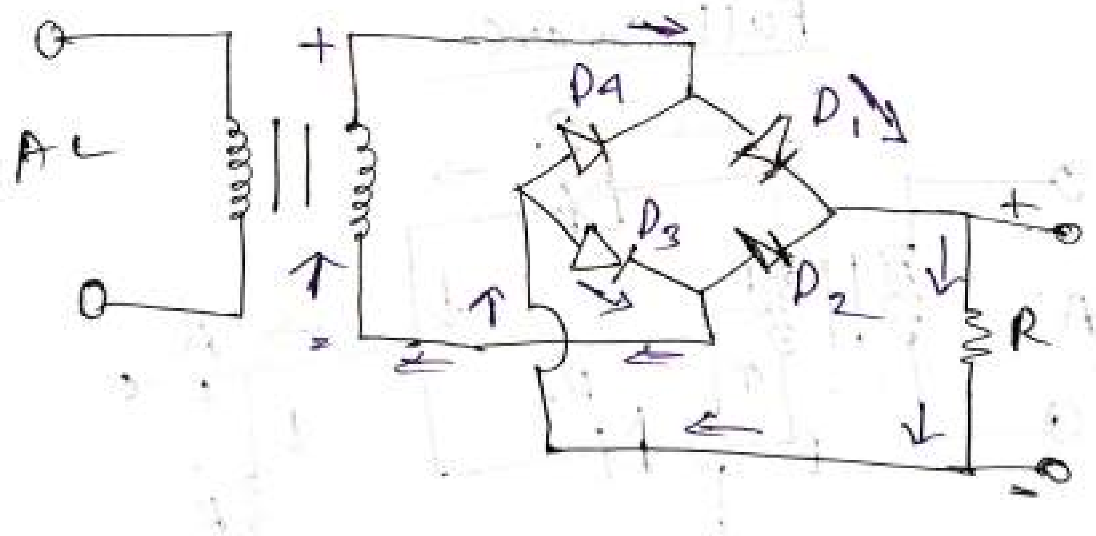
For full wave,

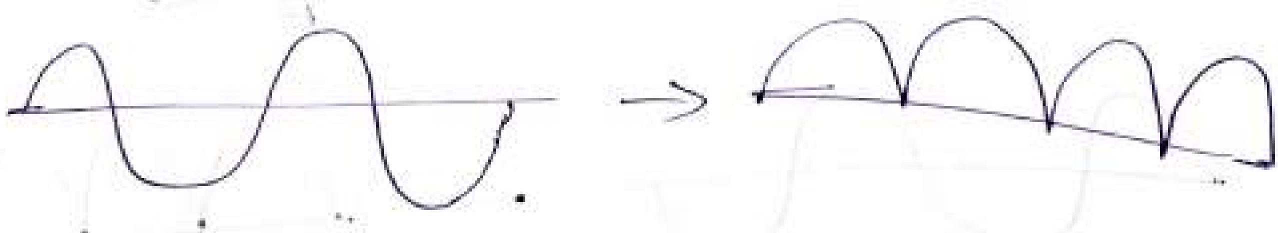
$$V_{CE} = V_S \qquad V_{PK} = V_{DC}\sqrt{2}$$

$$\therefore V_{DC} = \frac{V_S}{2}$$

$$V_{avg} = \frac{2 V_{PK}}{\pi}$$

Full-Bridge Rectifier





Half wave rectifier efficiency

$$\eta = \frac{P_{Load}}{P_{in}} \times 100\%$$

$$= \frac{I_{dc}^2 R}{I_{rms}^2 R} \times 100\% \quad \Bigg| \quad I_{dc} = \frac{I_m}{\pi}; \quad I_{rms} = \frac{I_m}{2}$$

peak current

$$= \frac{I_m^2/\pi^2}{I_m^2/4} \times 100\%$$

$$= \frac{4}{\pi^2} \times 100\% = 40.56\%$$

Full wave Rectifier efficiency

$$\eta = \frac{P_{Load}}{P_{in}} \times 100\%$$

$$= \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\% \quad \Bigg| \quad I_{dc} = \frac{2 I_m}{\pi}; \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$= \frac{4 I_m^2/\pi^2}{I_m^2/2} \times 100\%$$

$$= \frac{8}{\pi^2} \times 100\% = 81.13\%$$

20-21

3(c)

A rectifier is an electrical device that converts Alternating current (AC), into direct current (DC).

A crystal diode is commonly used for rectification due to its ability to allow current to flow in only one direction (forward bias) and block current in the opposite direction (reverse bias)

Rectification process:

i) In a half-wave rectifier, a single crystal diode is used to allow only the positive half cycles of AC to pass, blocking the negative half-cycles.

ii) In a full wave rectifier, two or more diodes are used in a bridge configuration to convert both half of the AC signal into DC.

— : —

3(d)

here, Applied voltage, $V = 10\,V$.

D_1 and D_3 diodes are forward biased and they are in series with the $48\,\Omega$ load resistance.

thus, total resistance, $R = (1 + 1 + 48)\,\Omega$
$= 50\,\Omega$

∴ current through $48\,\Omega$,

$$I = \frac{V}{R} = \frac{10}{50}\,A$$
$$= 0.2\,A$$

— : —

4(a)

Forward current is the current that flows through a diode when it is forward-biased.

Peak Inverse voltage is the maximum reverse voltage a diode can withstand without breaking down.

Leakage current is the current that flows through a diode when it is reverse biased.

Importance in diode operation:

Forward current defines the conduction capacity of the diode, crucial for its role in circuits like Rectifiers, Peak inverse voltage ensures the diode operates reliably in reverse-bias condition without breakdown. Leakage current impacts efficiency and power dissipation in circuits.

— o —

4(b)

Rectifier efficiency, $\eta = \dfrac{\text{d.c Power output}}{\text{Input a.c. Power}}$

Let, r_f = Diode resistance

R_L = load resistance

$v = V_m \sin\theta$

d.c Power:

$$I_{av} = \frac{1}{2\pi}\int_0^{\pi} i \, d\theta$$

$$= \frac{1}{2\pi}\int_0^{\pi} \frac{V_m \sin\theta}{r_f + R_L} \, d\theta$$

$$= \frac{V_m}{2\pi(r_f+R_L)} \int_0^{\pi} \sin\theta \, d\theta$$

$$= \frac{V_m}{2\pi(r_f+R_L)} \cdot \left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{V_m}{\cancel{2}\pi(r_f+R_L)} \times \cancel{2}$$

$$= \frac{V_m}{r_f+R_L} \times \frac{1}{\pi}$$

$$= I_m \times \frac{1}{\pi}$$

$$\therefore P_{dc} = I_{dc}^2 \times R_L = \left(\frac{I_m}{\pi}\right)^2 \times R_L$$

<u>a.c power:</u>

$$P_{ac} = I_{rms}^2 \times (r_f+R_L)$$

$$= \left(\frac{I_m}{2}\right)^2 \times (r_f+R_L)$$

$$I_{rms} = \frac{I_m}{2}$$

∴ Rectifier efficiency

$$= \frac{\text{d.c. output power}}{\text{a.c input power}}$$

$$= \frac{\left(\frac{I_m}{\pi}\right)^2 \times R_L}{\left(\frac{I_m}{2}\right)^2 (r_f + R_L)}$$

$$= \frac{0.406 R_L}{r_f + R_L}$$

The efficiency will be max if r_f is negligible

$= 40.6\%$

— c —

4(c)

here, $V_{S(RMS)} = ?$

$V_{P(RMS)} = 230V$

$$\frac{N_P}{N_S} = \frac{10}{1}$$

$$\therefore \frac{V_{S(RMS)}}{V_{P(RMS)}} = \frac{N_S}{N_P} \quad \therefore V_{S(RMS)} = \frac{230}{10} = 23V$$

Peak voltage on the secondary,

$$V_{S(m)} = \sqrt{2}\, V_{RMS}$$

$$= \sqrt{2} \cdot 23 = 32.52 \text{ V}$$

$\therefore$ i) Output DC voltage,

$$V_{DC} = \frac{V_m}{\pi} = \frac{32.52}{\pi}$$

$$= 10.35 \text{ V}$$

ii) The peak inverse voltage for a half-wave rectifier is equal to the maximum voltage the diode must block when it is reverse biased.

$$PIV = V_{S(m)} = 32.52 \text{ V}$$

19-20

2(a)

A zener diode is a special type of Diode designed to allow current to flow in the reverse direction when the voltage across it exceeds a certain value, known as the zener breakdown voltage.

A zener diode is commonly used to maintain a constant output voltage across a load, even if the input voltage is much higher.

Zener diode used as voltage Regulator:

The zener diode is connected in reverse bias parallel to the load resistor. A series resistor is connected to limit the input current.

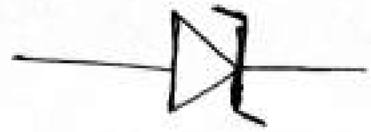
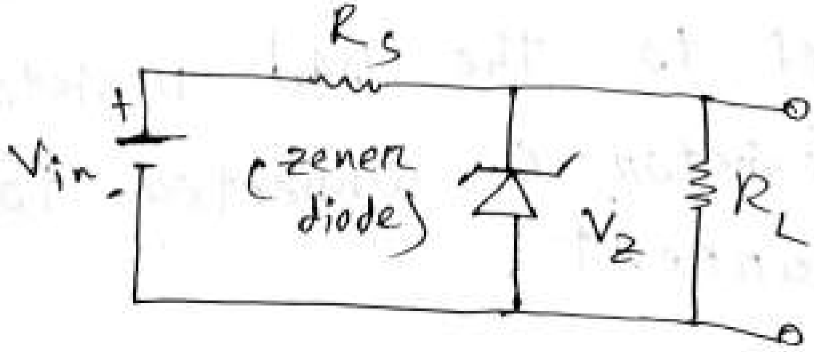


fig: Zener diode symbol.

When the input voltage (V_{in}) exceeds the zener breakdown voltage (V_Z) the zener diode starts conducting.

To maintain constant voltage the zener diode clamps the voltage across the load to its breakdown voltage (V_Z). This way the load receives a stable voltage.

If V_{in} is less than V_Z, the zener diode does not conduct.



2(b)

A half-wave rectifier is a circuit that converts Ac into Dc using a single diode. It allows only one half cycle of the input Ac signal to pass through while blocking the other half.

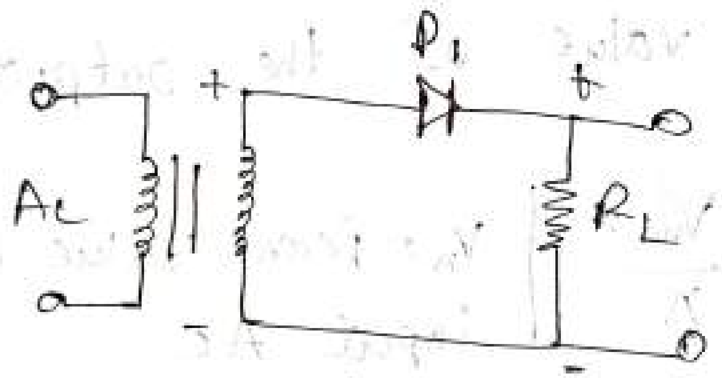


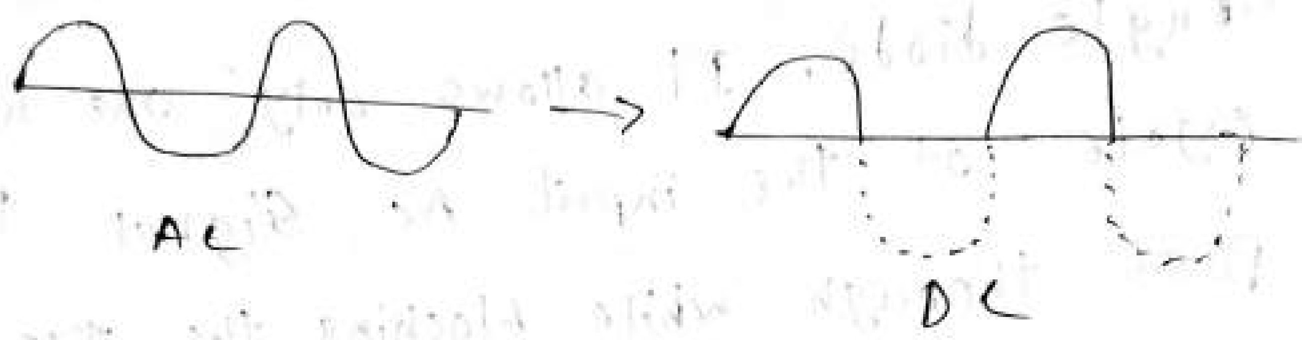
fig: ~~Half~~ Half-wave Rectifier.

Operation:

i) During the positive half cycle of the Ac input, the diode is forward biased and conducts current.

ii) During the negative half cycle of the Ac input, the diode is reverse-biased and does not conduct.

Thus, input AC is converted to DC signal.



The average value of the output voltage,

$$V_{DC} = \frac{V_m}{\pi}$$ | V_m = peak value of input AC

The average current through the load resistor (R_L),

$$I_{DC} = \frac{V_{DC}}{R_L} = \frac{V_m}{\pi R_L}$$

The ripple factor is a measure of the AC fluctuations in the output relative to the DC output.

For a half wave rectifier,

$RF = 1.21$.

Efficiency of a half-wave rectifier, $\eta = \frac{P_{DC}}{P_{AC}} \times 100$

$= \frac{40.6}{100} \approx 40.6\%$

This shows that a half wave rectifier is not very efficient due to significant power loss in the blocked half-cycles.

18-19

2 (a)

ii) A Full wave rectifier is a circuit that converts Ac into Dc using two diodes. It converts both positive and negative half cycles of an Ac signal.

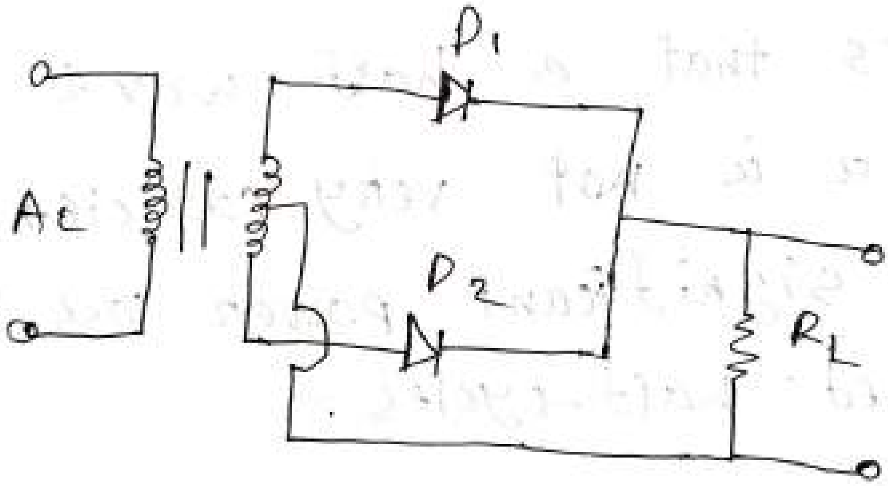


fig: full wave rectifier,

Operation:

i) During the positive half of the Ac input, one diode conducts and current flows through the load.

ii) During the negative half of the Ac input, the other diode conducts, and current flows through the load in the same direction.

thus converting Ac into Dc.

2(b)

voltage regulation refers to the ability of the circuit to maintain a constant output voltage regardless of variations in input voltage or load current.

4.(a)

Both the general-purpose diode and the LED (Light emitting Diode) are formed by joining P-type and N-type semiconductors. But the difference lies in the type of material used and the energy conversion mechanism.

1) P-N Junction Diode:

When a P-N Junction diode is forward biased, electrons from N-region move to the P-region and fill the empty spaces, they release energy. It is mostly heat energy. This occurs because materials used (silicon, germanium) do not emit photons efficiently.

2) LED:

these are made from gallium arsenide or gallium phosphide. when electrons and holes recombine in an LED, the energy released is emitted as photons due to the materials direct bandgap property.

4(b)

Avalanche: Occurs in ordinary diodes at high reverse voltages. When the reverse voltage is high enough, free electrons in the depletion region gain sufficient energy to knock other electrons from their atoms, creating an avalanche of charge carriers.

Result: A sudden, large reverse current flows through the diode.

Zener breakdown occurs in a zener diode when it is operated in reverse bias and the reverse voltage exceeds a specific zener voltage (V_Z). This zener breakdown typically occurs at lower reverse voltages.

When the reverse voltage increases and reaches the zener breakdown voltage, the electric field across the depletion region becomes strong enough to pull electrons from their atomic bonds, causing a sharp increase in current.

— x —

17-18

2 (a)

Breakdown voltage refers to the minimum voltage required to make an insulating material conduct electricity. It is the voltage at which an insulating material becomes conductor. when the material's resistance collapses, a large current can pass through.

Example:

In air, this happens as a spark or lightning when the breakdown voltage is exceeded.

— c —

2(b)

LED (Light emitting Diode)	LCD (Liquid crystal Display)
i) Produces light through electroluminescence when current passes through.	i) Blocks or allows light from a backlight using Liquid crystals.
ii) No backlight required.	ii) Requires a backlight.
iii) Brighter and more vibrant.	iii) Less bright compared to LEDs.
iv) energy efficient.	iv) consumes more energy.

2(d)

Given, $R_f = 20\Omega$

$V_{rms} = 50V$

$R_L = 980\Omega$

Peak voltage, $V_m = \sqrt{2}\, V_{rms}$

$= \sqrt{2} \times 50 = 70.71V$

Total resistance, $R = R_L + R_f$. [only one diode conducts at any given time]

$= 980 + 20$

$= 1000\Omega$

$\therefore$ Peak load current, $I_m = \frac{V_m}{R_{total}} = \frac{70.71}{1000}$

$= 70.71mA$

$\therefore$ mean " ", $I_{mean} = \frac{2I_m}{\pi} = \frac{2 \times 70.71}{\pi}$

$= 45.03mA$

— c —

3(a)

The ripple factor is a measure of the effectiveness of a rectifier in converting AC to DC. It is defined as the ratio of the RMS value of the AC component in the rectified output to the DC component in the output.

$$\text{Ripple Factor}(\gamma) = \frac{\text{RMS value of AC}}{\text{DC value.}}$$

Ripple factor of,

half wave Rectifier; 1.21

Full " " "; 0.48

3(c)

here, Transformer turn ratio = 10 : 1

Input AC voltag = 230 V

$$V_{secondary} = \frac{230}{10} = 23V$$

Peak voltage, $V_{peak} = (\sqrt{2} \cdot 23)$

$= 32.52 V$

$\therefore$ Dc output,

$$V_{DC} = \frac{V_{peak}}{\pi} = \frac{32.52}{\pi}$$

$= 10.35 V$

20-21

1(c)

The diode equation, also known as the Shockley diode equation is;

$$I = I_s \left(e^{\frac{qv}{KT}} - 1 \right)$$

here,

I = current flowing through Diode.

I_s = The saturation current, a very small current that flows through the diode when it is reverse biased.

q = the charge of an electron, 1.6×10^{-19} coulombs.

v = the voltage across diode.

K = boltzmann's constant $= 1.38 \times 10^{-23}$ J/K.

T = Temperature in Kelvins.

e = base of the natural log. $= 2.718$

(15) Explain the terms: FET and JFET

A Field-Effect Transistor (FET) is a type of transistor that controls the flow of current using an electric field. FETs have high input impedance and are used for amplification and switching applications. They can be classified into different types, including JFETs, MOSFETS, and others.

Junction Field-Effect Transistor (JFET):

A JFET has three terminals: Drain (D)

(16) what is meant by multistage transistor amplifier?

A multistage transistor amplifier is a configuration that uses two or more transistor stages to amplify a signal. Each stage provides additional gain, improving overall amplification, bandwidth, and input/output impedance characteristic. This design enchances performance for various applications, such as audio and radio frequency amplification.

(17) Describe the construction and operation of MOSFET.

construction of MOSFET.

i) Body: made of p-type semiconductor.

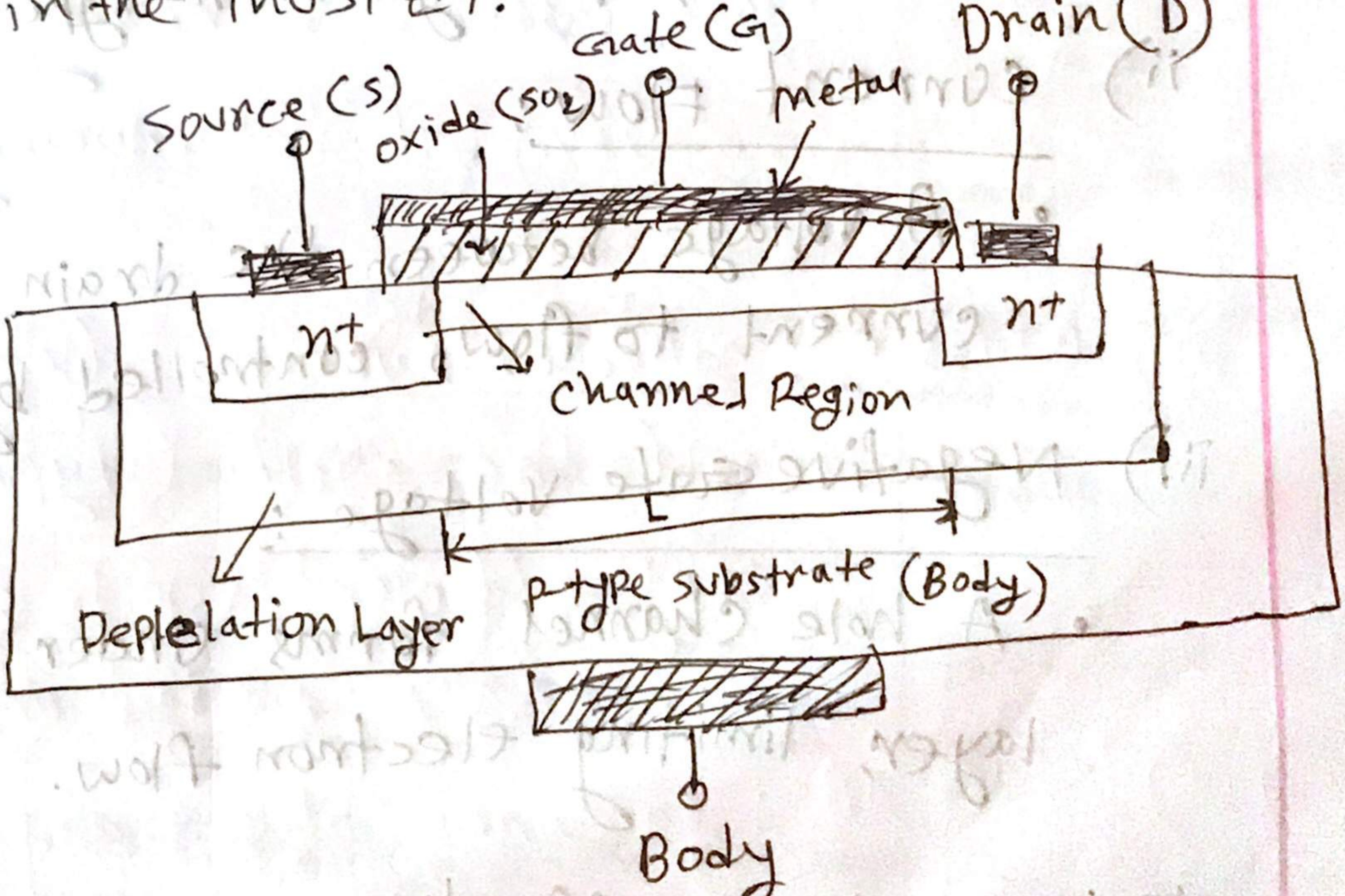
ii) Source and Drain: Heavily doped n-type regions (n+) on either side of the body.

iii) Isolation and Layer: Silicon dioxide (SiO_2) is deposited for electrical isolation

iv) Gate: A thin metallic layer is added on the SiO_2, patterned to form the gate terminal.

v) circuit connection: A voltage source connects the source and drain to form a DC circuit.

This structure enables effective control and current flow in the MOSFET.



MOSFET circuit Diagram

MOSFET working operation:

The operation of a MOSFET relies on the MOS capacitor principle, where the semiconductor surface beneath the oxide layer can be inverted.

i) positive Gate voltage:

- Holes are repelled, creating a depletion region filled with negative charges.
- Electrons from the n^+ source and drain are attracted, forming an n-type channel.

ii) Current Flow:

- A voltage between the drain and source allows current to flow, controlled by the gate voltage.

iii) Negative Gate Voltage:

- A hole channel forms under the oxide layer, limiting electron flow.

This enables effective control of current in circuits.

(23) write short note on:-

i) MOSFET

ii) TRIAC

iii) DIAC

iv) UJT

v) CMOS

vi) IC fabrication process.

(i) MOSFET:

Definition: A MOSFET (Metal oxide semiconductor FET) is a type of field-effect transistor that can operate in enhancement mode, increasing channel conductivity.

Key points: • Operation modes: can operate in enhancement mode (increasing channel width), unlike JFETs, which only use depletion mode (decreasing channel width)

Advantage: • High input impedance: Requires minimal gate current.

• Low production cost: More economical to manufacture.

Applications: widely used in amplification and switching circuits due to flexibility and efficiency.

circuit হলো 17 নং MOSFET এর circuit.

Summary: MOSFETs provide enchanced performance and versatility in electronic applications compared to JFETs.

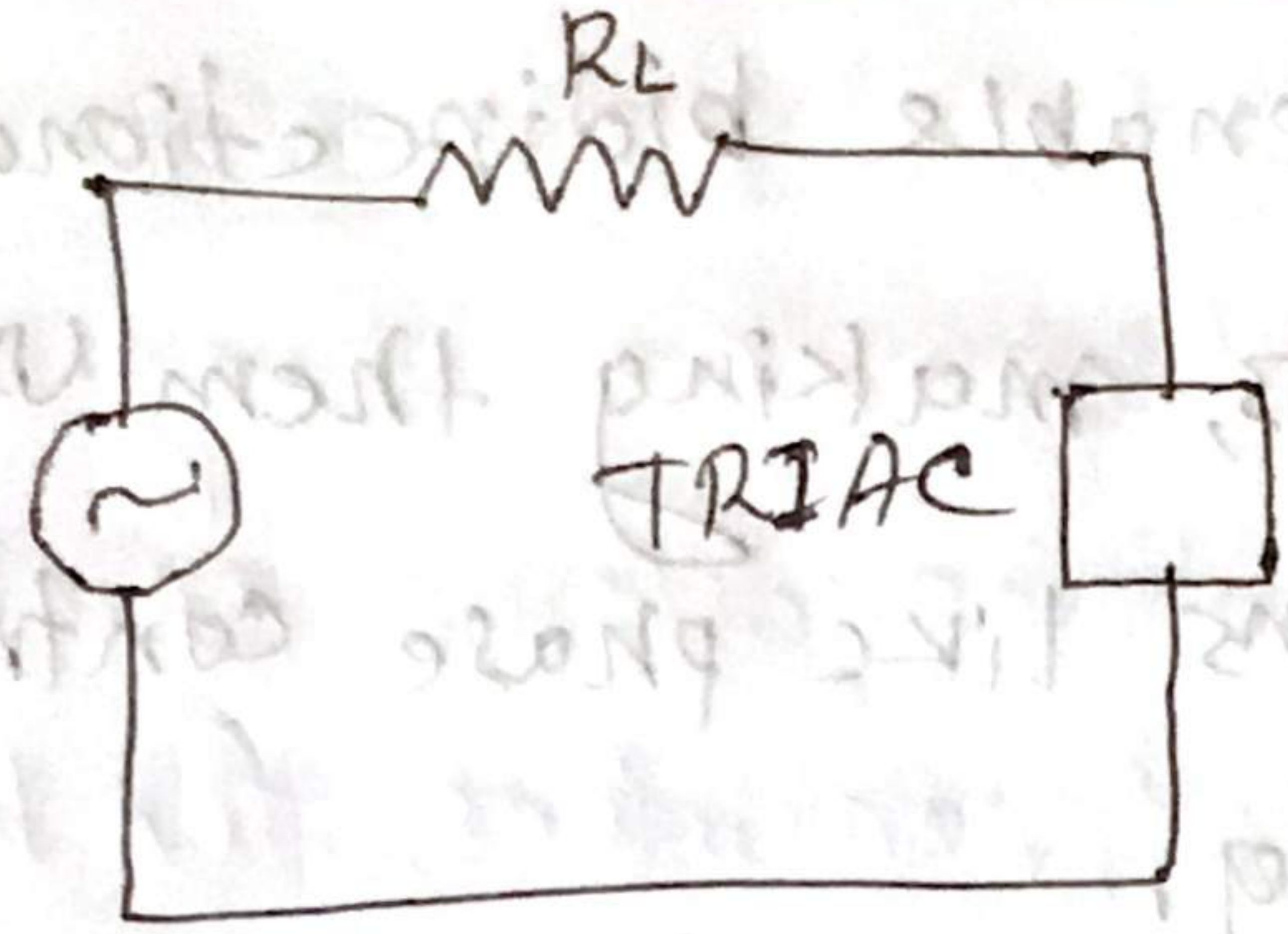
(ii) TRIAC :

Definition ; A Triac (Triode AC switch) is a three-terminal semiconductor device that controls alternating current (AC) in both directions.

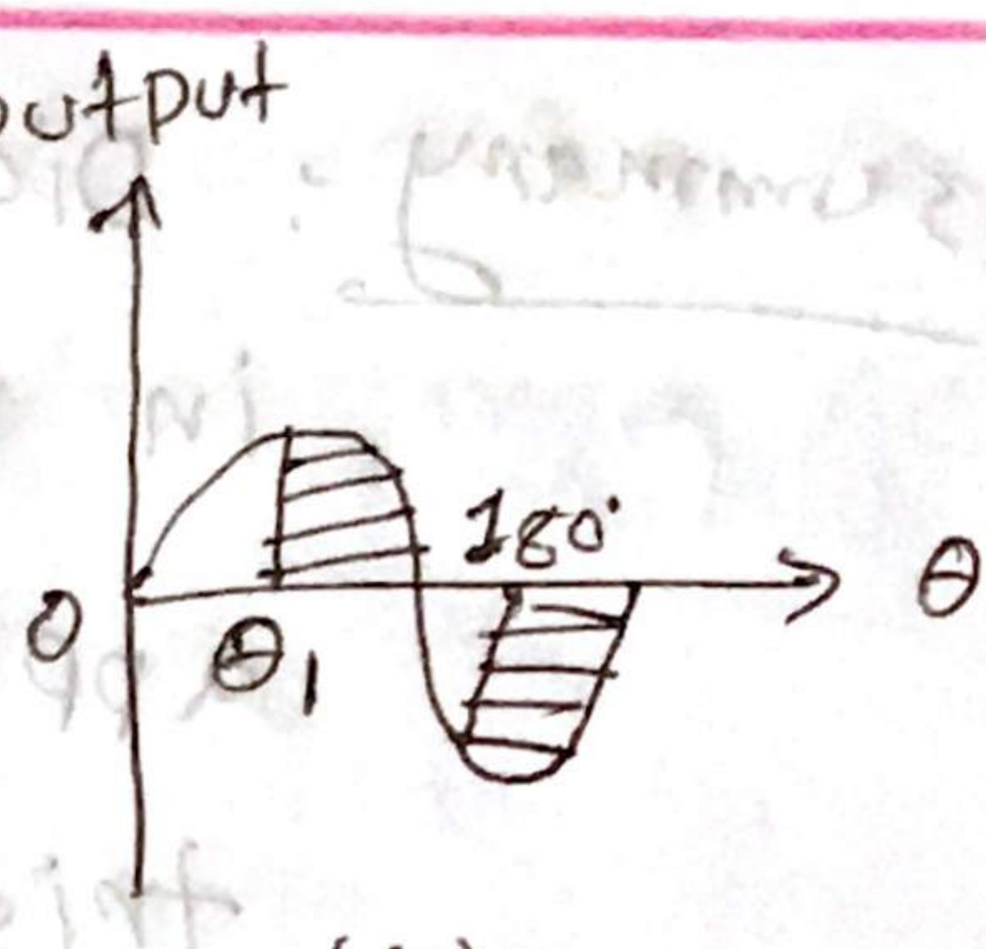
Key points :

- **Functionality :** controls both positive and negative half-cycles of AC, unlike SCRs.
- **Operation :** Adjustable control circuit allows passing specific portions of the AC waveform.
- **Applications :** Commonly used in light dimmers, motor controls, and other AC power applications.

Summary : Triacs provide effective bidirectional control of AC power, setting them apart from unidirectional devices like SCRs.



(i)



(ii)

(iii) DiAC:

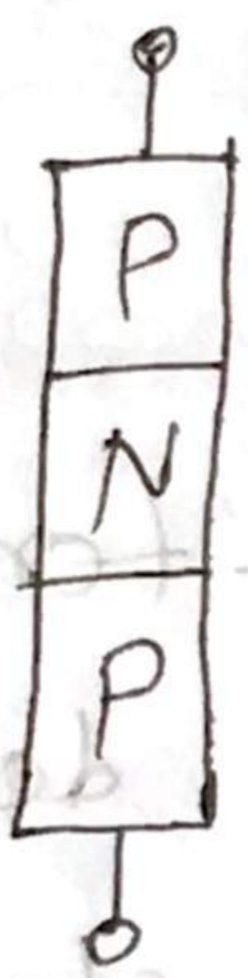
Definition: A Diac is a two-terminal, three-layer bidirectional device that switches from OFF to ON state for both polarities of applied voltage.

Key points: • **construction**: can be in either npn or pnp form, consisting of two p-regions separated by an n-region.

• **structure**: Similar to a transistor but with no base terminal and symmetrical regions.

• **properties**: Identical doping concentrations in all regions, providing symmetrical characteristics.

Summary : Diacs enable bidirectional switching in circuits, making them useful in applications like phase control and triggering.



DIAC Basic construction

DIAC symbol

(iv) UJT (Unijunction Transistor)

Definition : A UJT is a three-terminal silicon device with one PN junction (base-1, base-2, and emitter).

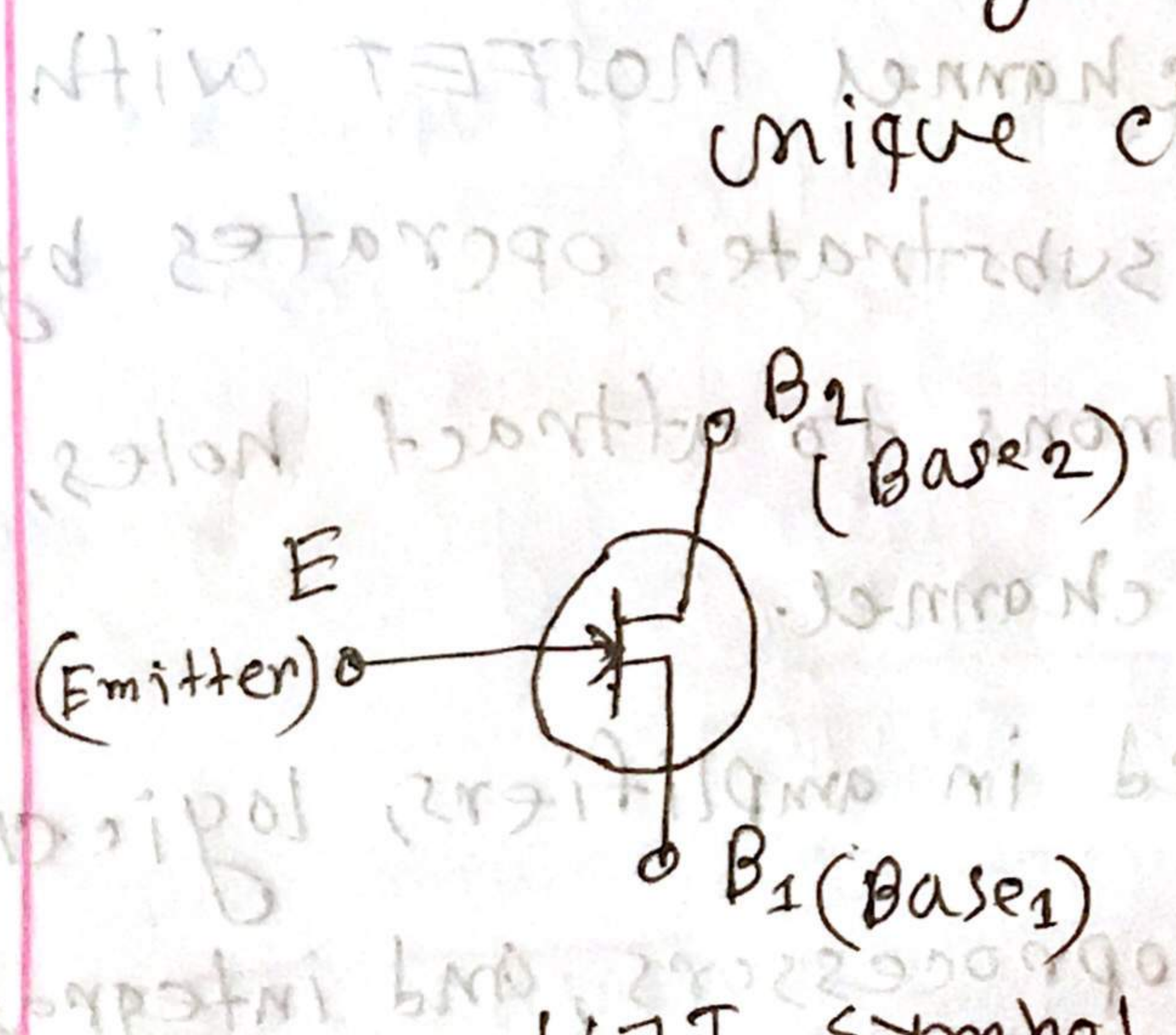
Key points : • Terminals : UJTs have three terminals, unlike ordinary diodes (two terminals).

- power control: They don't amplify like FETs but can control large AC power with small signals.

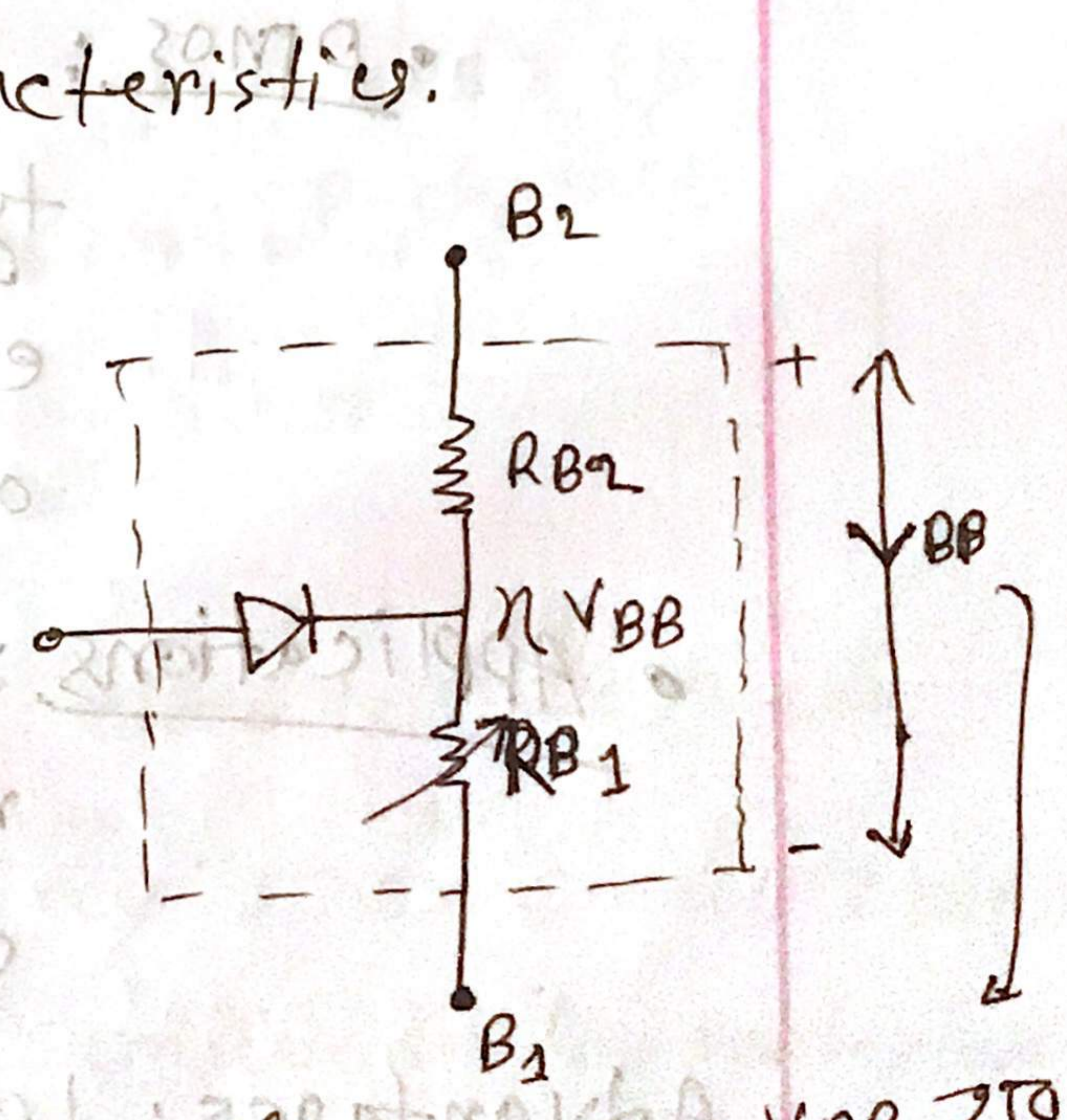
- operation: Emitter junction is forward-biased

- Negative Resistance: UJTs exhibit negative resistance, suitable for oscillators.

Summary: UJTs effectively control AC power and generate oscillations due to their unique characteristics.



UJT Symbol



simplified equivalent circuit

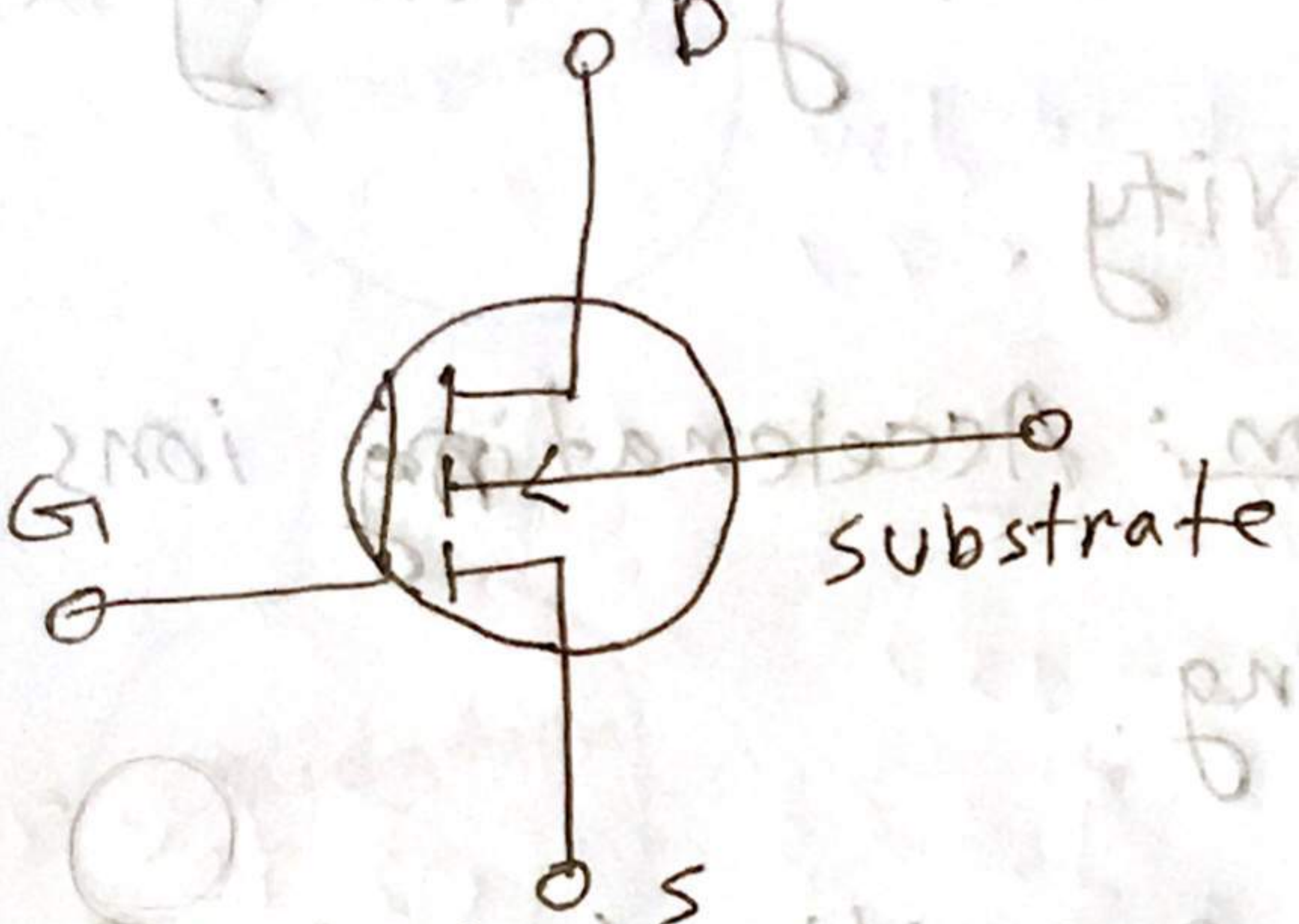
(v) CMOS

Definition: CMOS (complementary metal-oxide-semiconductor) combines NMOS and PMOS transistors for low-power and high-density logic circuits.

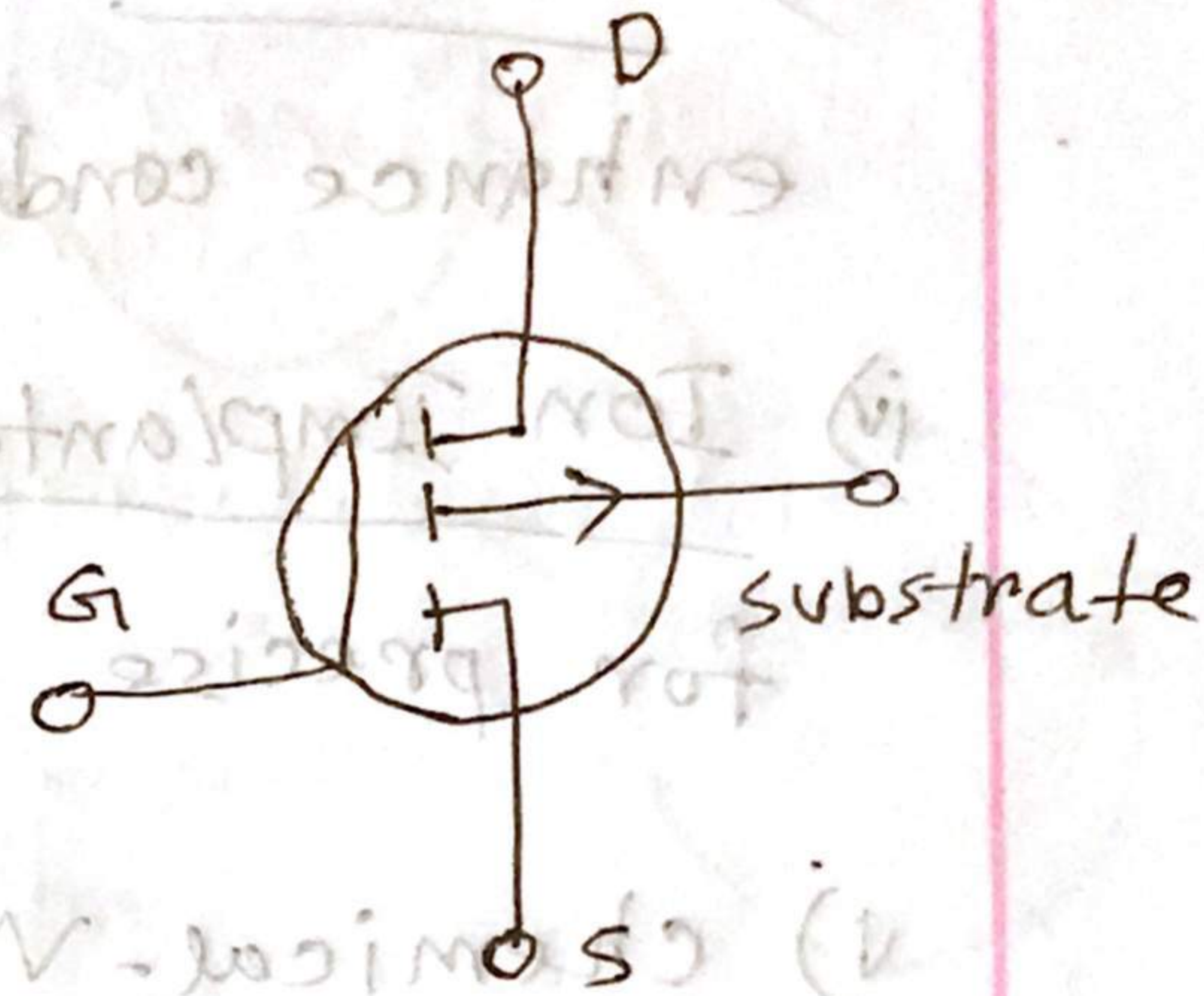
Key points:
- **Transistor Types:**
  - **NMOS:** N-channel MOSFET with a p-type substrate; faster due to electron mobility.
  - **PMOS:** P-channel MOSFET with an n-type substrate; operates by repelling electrons to attract holes, forming a p-channel.
- **Applications:** used in amplifiers, logic circuits, microprocessors, and integrated circuit chips.

Advantages: Low power dissipation, fewer manufacturing steps compared to bipoler Junction transistors.

Summary: CMOS technology is essential in semiconductor design due to its efficiency and performance, leveraging the strengths of both NMOS and PMOS transistors.



N-channel
NMOS



P-channel
PMOS

(vi) IC Fabrication process:

Definition: Integrated circuits (ICs) are electronic circuits on small chips made from semiconductor materials like silicon and germanium.

Key steps in IC fabrication:

i) Wafer preparation: cutting and polishing high-purity silicon wafers.

ii) Oxidation: forming Silicon dioxide for insulation and protection.

iii) Diffusion: Introducing impurity atoms to enhance conductivity.

iv) Ion Implantation: Accelerating ions into silicon for precise doping.

v) Chemical-Vapor Deposition (CVD): Depositing thin films for protective layers.

vi) photolithography: using light to pattern photoresist on the wafer.

vii) Metallization: Applying metal layers for electrical connections.

viii) Packaging: Testing, separating, and sealing finished chips.

Summary: The IC fabrication process combines various techniques to produce complex electronic circuits, vital for modern technology.