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BEC Final Prep →

Ch: Intro to Electronics

Q What is semiconductor?

⇒ A solid substance that has a conductivity between that of an insulator & a conductor either due to the addition of an impurity or because of temperature effects is called semiconductor. Ex: Silicon.

Q Diff b/w intrinsic & extrinsic semiconductors.

⇒

Intrinsic semiconductors →	Extrinsic semiconductors →
① Intrinsic semiconductors are pure forms of semiconductors.	① Extrinsic semiconductors are made by adding some impurity to pure form of semiconductors.
② They exhibit poor electrical conductivity.	② They exhibit significantly high conductivity.
③ The number of free electrons is equal to the number of holes.	③ The number of free electrons is not equal to the number of holes.
④ The electrical conductivity of intrinsic semiconductor depends only on the temperature.	④ The electrical conductivity depends on the temperature as well as the amount of doped impurity.
⑤ Ex Si	⑤ Ex Si with As.

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Q What is doping?

=> Doping is the process of adding certain chemical elements to a semiconductor in order to change its electric conductivity. These elements are tiny impurities. There are two types of doping :-

(i) n-type doping -> In this, the element with five valence electrons are added as impurity (pentavalent or donor impurity) in the semiconductor. Semiconductor has four valence electrons, when it is doped with pentavalent impurity, the four valence electron makes covalent bond & the remaining one is more free to move, this is how n-type doping increases conductivity of the semiconductor. Due to excess of electron it generates an overall negative charge & thus the name n-type semiconductor.

(ii) p-type doping -> In this, the element with three valence electron are added as impurity (trivalent impurity or acceptor impurity) in the semiconductor. The three electron in the semiconductor bonds with the three electrons of the dopant. The one electron would not make bond & thus the vacant space where electron should be there is created. This vacant space is known as holes. Electron from another atom jumps in these hole to fill it & a hole is created there, & the same thing continues. Thus by this way conductivity is increased in p-type doping.

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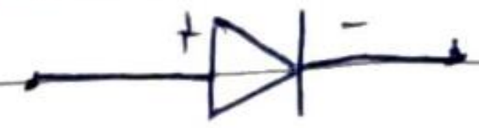
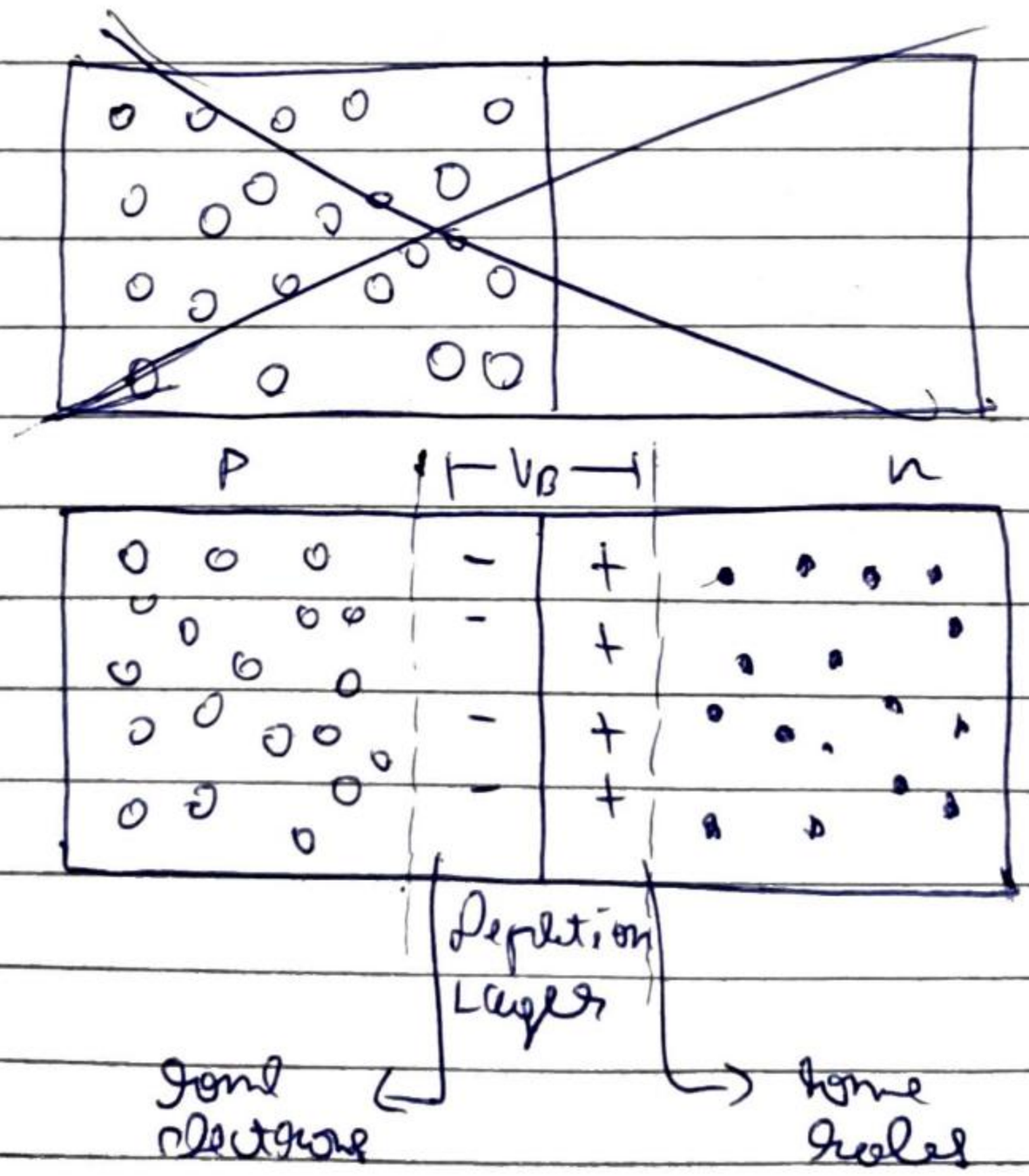
Q- What is pn junction diode?



=>. When a p-type semiconductor is joined to n-type semiconductor, the contact surface of the semiconductors is called as p-n junction diode.

- The p-type semiconductor has holes & the n-type semiconductor has free electrons as majority charge carriers. At the junction, the free electrons from the n-side diffuse over to p-side & the holes from the p-side to the n-side. Due to this movement, a barrier is set up against the movement of charge carriers across the junction. This is called potential barrier (V_B).



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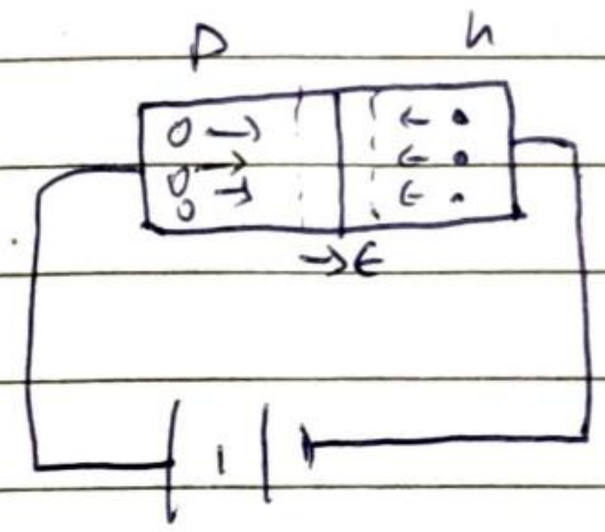
Biasing of pn junction?

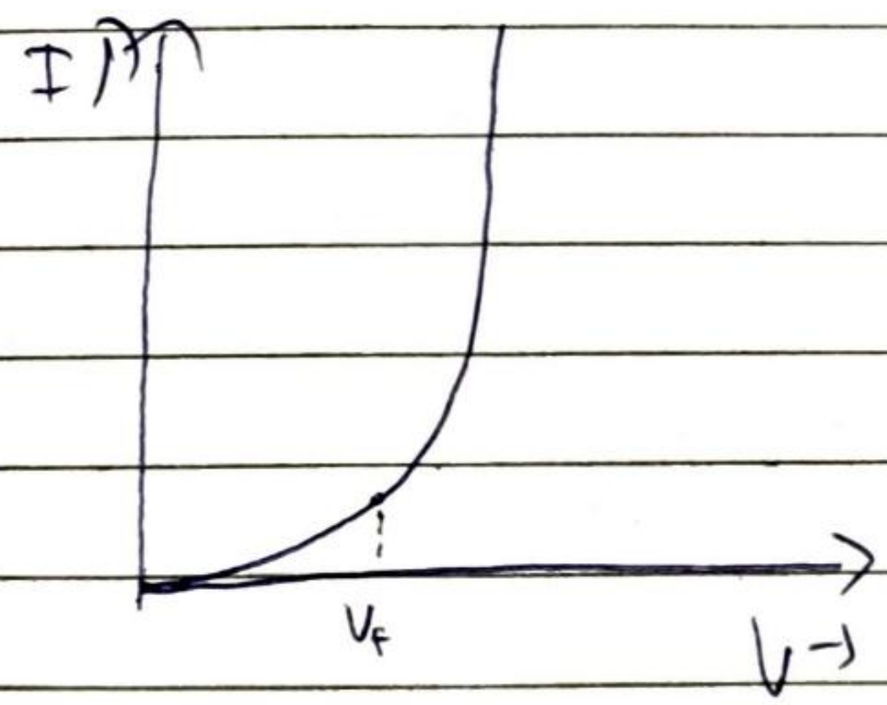
Q

=>. Biasing means presence of external voltage source (mainly via battery).

- The biasing conditions for a pn junction are of two types ->
  - Forward bias
  - Reverse bias

- <u>Forward Bias</u> ->





- To make a pn junction forward bias, the p type is connected to the positive terminal of the battery & n-type to the negative terminal.

- When forward biased, the potential barrier is cancelled, thus permitting the current flow.

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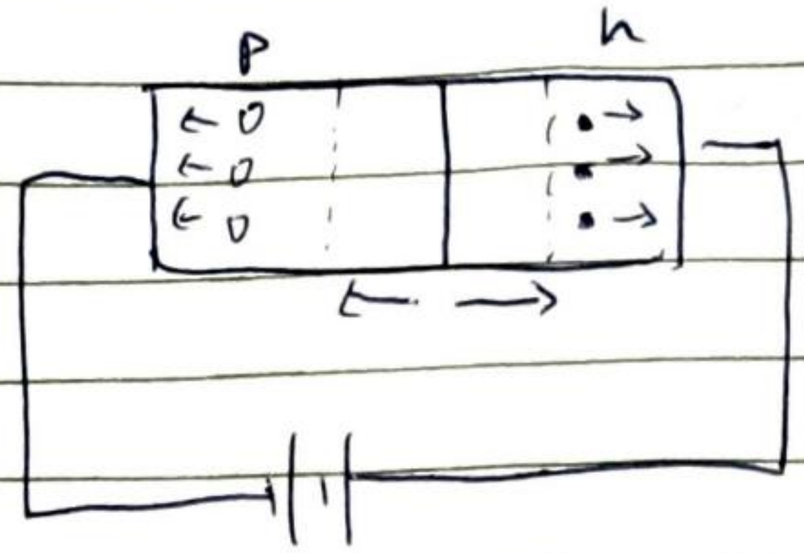
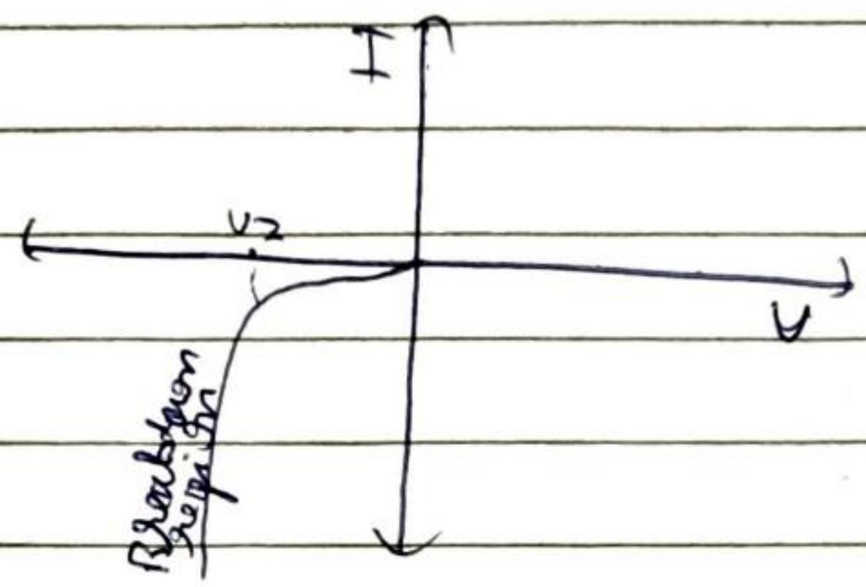
- Reverse Bias →





- To make a pn junction reverse bias, the p-type is connected to the negative terminal of the battery & n-type to positive terminal.

- When reversed bias, the potential barrier is increased, thus resisting the current flow.

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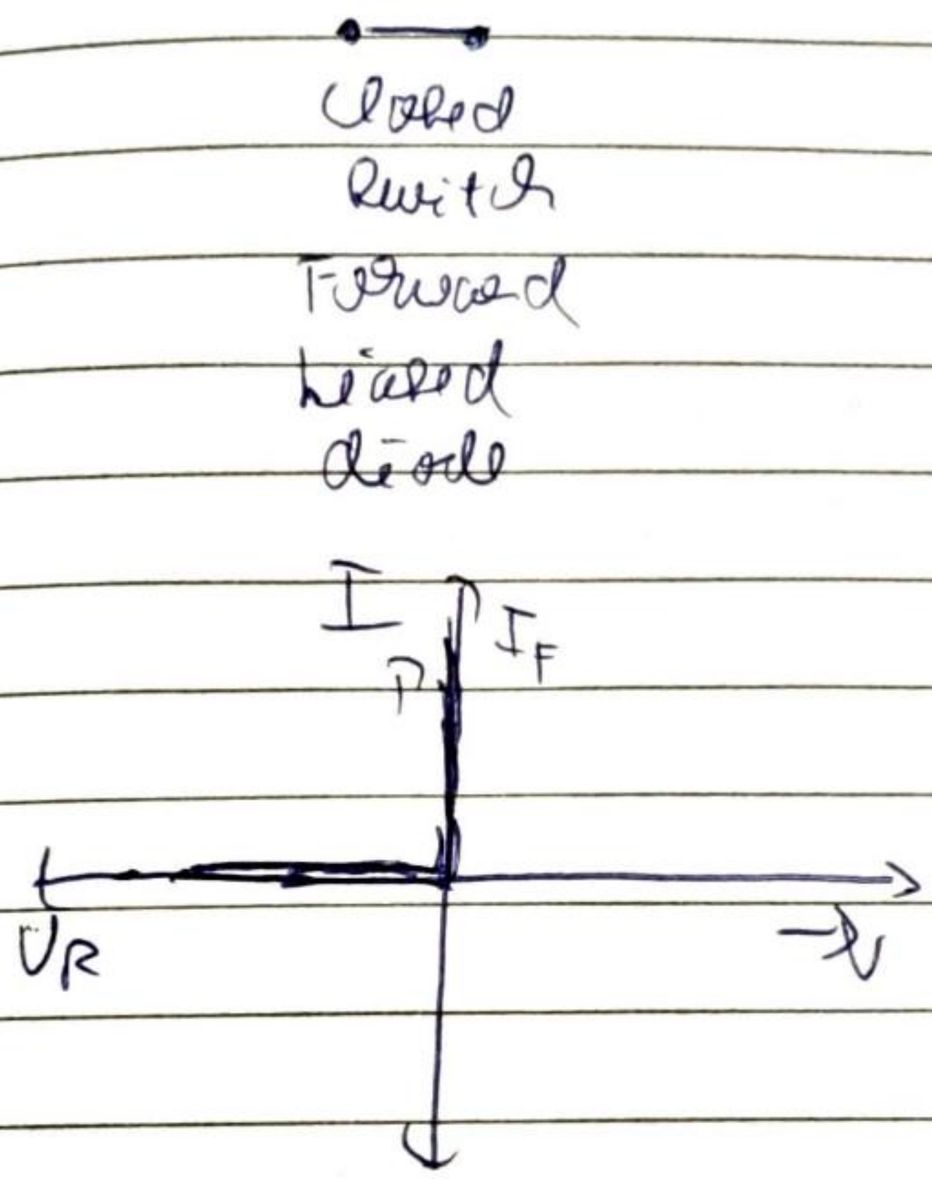
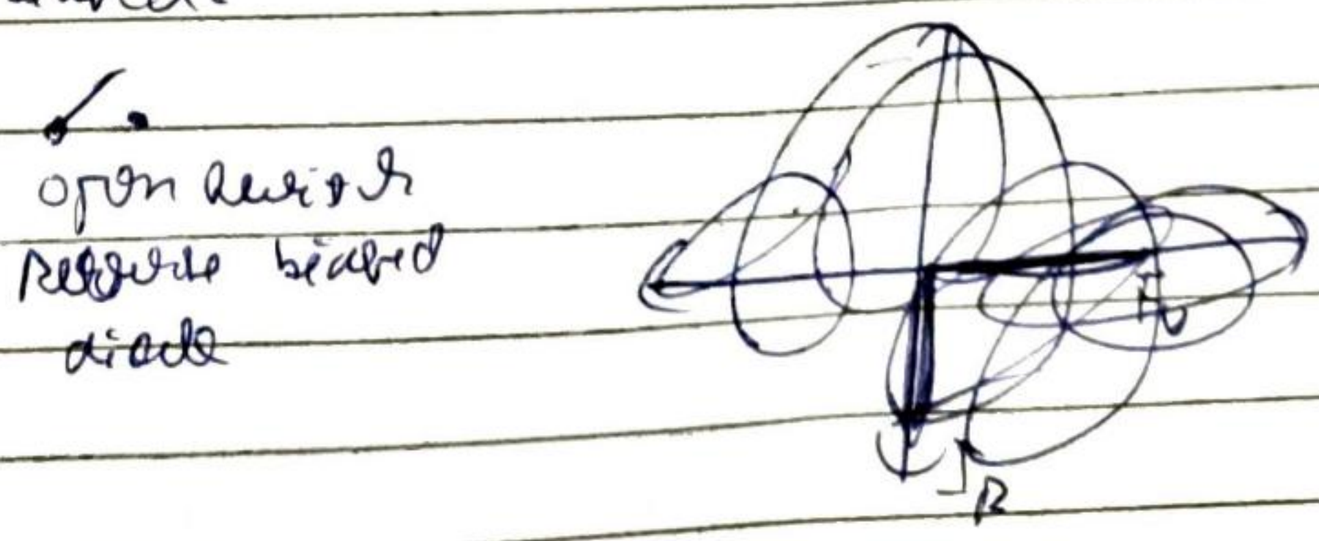
Q what is ideal diode?

=>. An ideal diode does not offer any resistance to the flow of current through it when it is in forward biased mode. This means that the ideal diode will be a perfect conductor when forward biased.



• An ideal diode is expected to fully ~~[illegible]~~ resist the flow of current through it under reverse biased condition. It works as perfect insulator when reversed biased.



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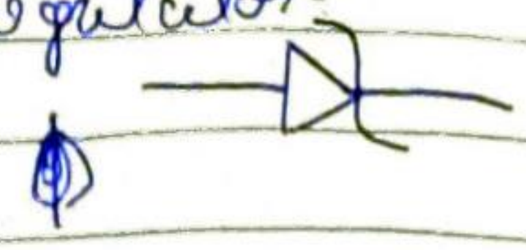
Q What is zener diode as voltage regulator?



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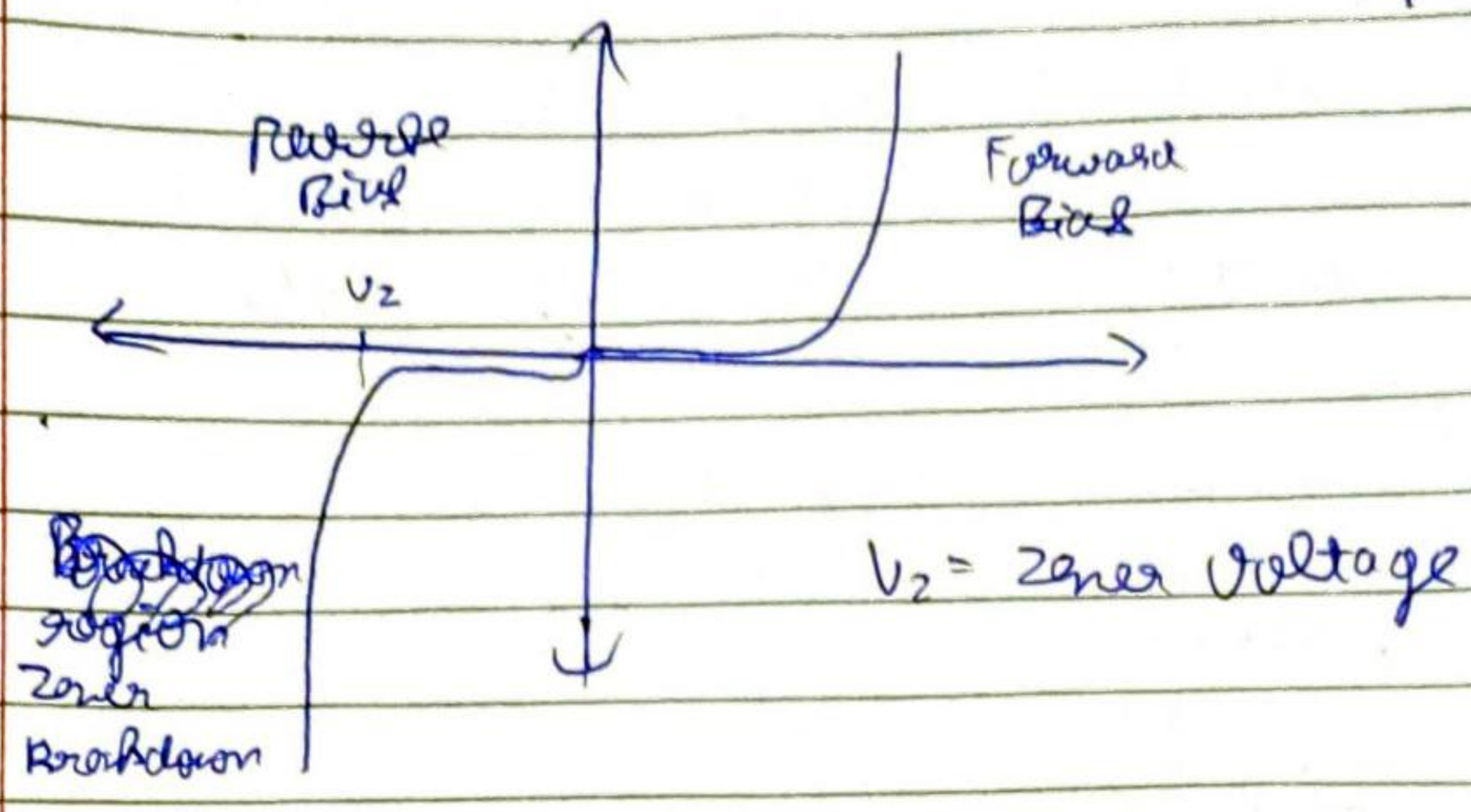
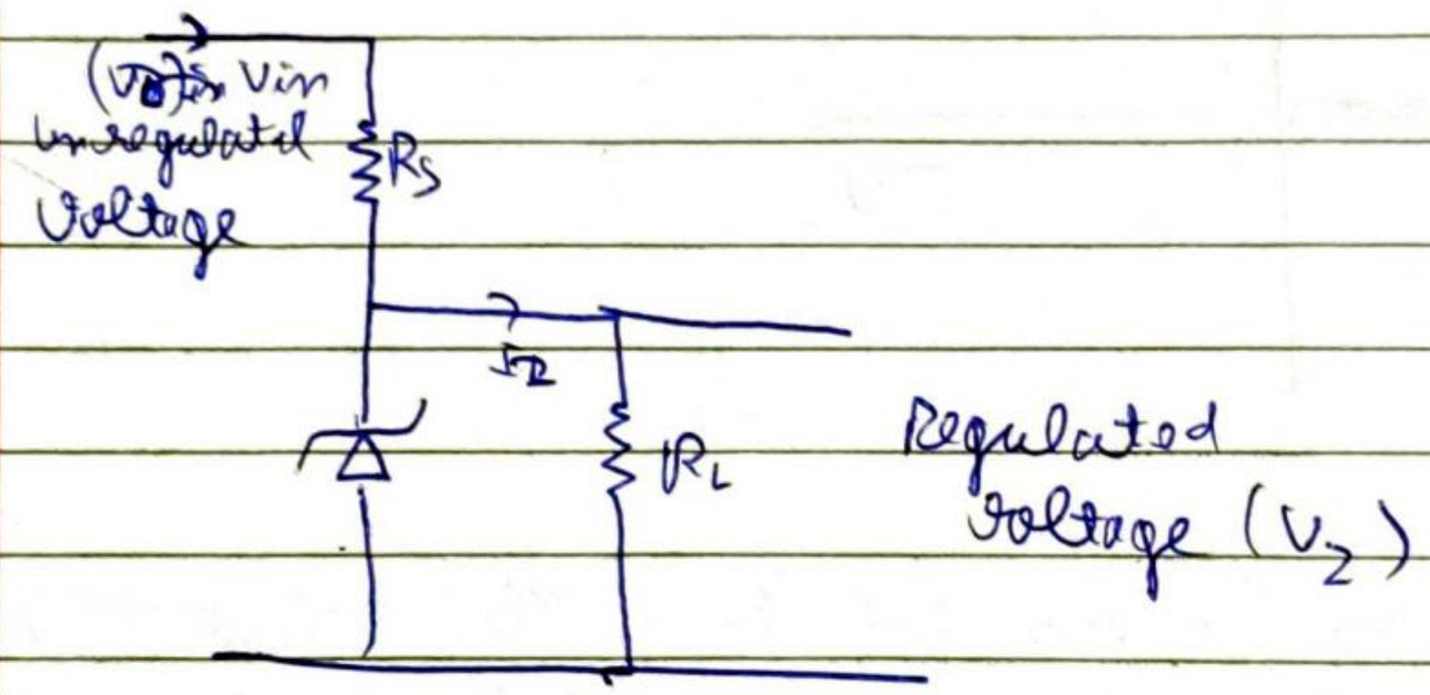


- Zener diode is a heavily doped semiconductor device that is designed to operate in the reverse direction.



- Let a variable voltage V_{in} be applied across load R_L

(i) When $V_{in} < V_Z$, no current flows through zener diode & the same voltage appears across the load.

(ii) When $V_{in} > V_Z$, this will cause the zener diode to conduct a large current I_Z. Consequently more current flows through series resistor R which increases the voltage drop across it. Thus overall voltage

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is absorbed by the series resistor. Hence a constant voltage is maintained across load R_L.

Q What is LED?

=>

Q Two types of breakdown in zener diode?

=> • There are two types of breakdown in zener diode →
- Avalanche Breakdown
- Zener breakdown.

• Avalanche Breakdown →

Avalanche breakdown occurs at high reverse voltage. When a high value of reverse voltage is applied to the pn junction, the free electrons gain sufficient energy & accelerate at high velocities. These free electrons moving at high velocity collide with other atoms & knock off more electrons. Due to this continuous collision, a large no. of free electrons are generated as a result of electric current in the diode increases. Zener diode is designed to operate under avalanche breakdown & can sustain the sudden spike of current. Avalanche breakdown occurs in with zener voltage (V_Z) greater than 6V.

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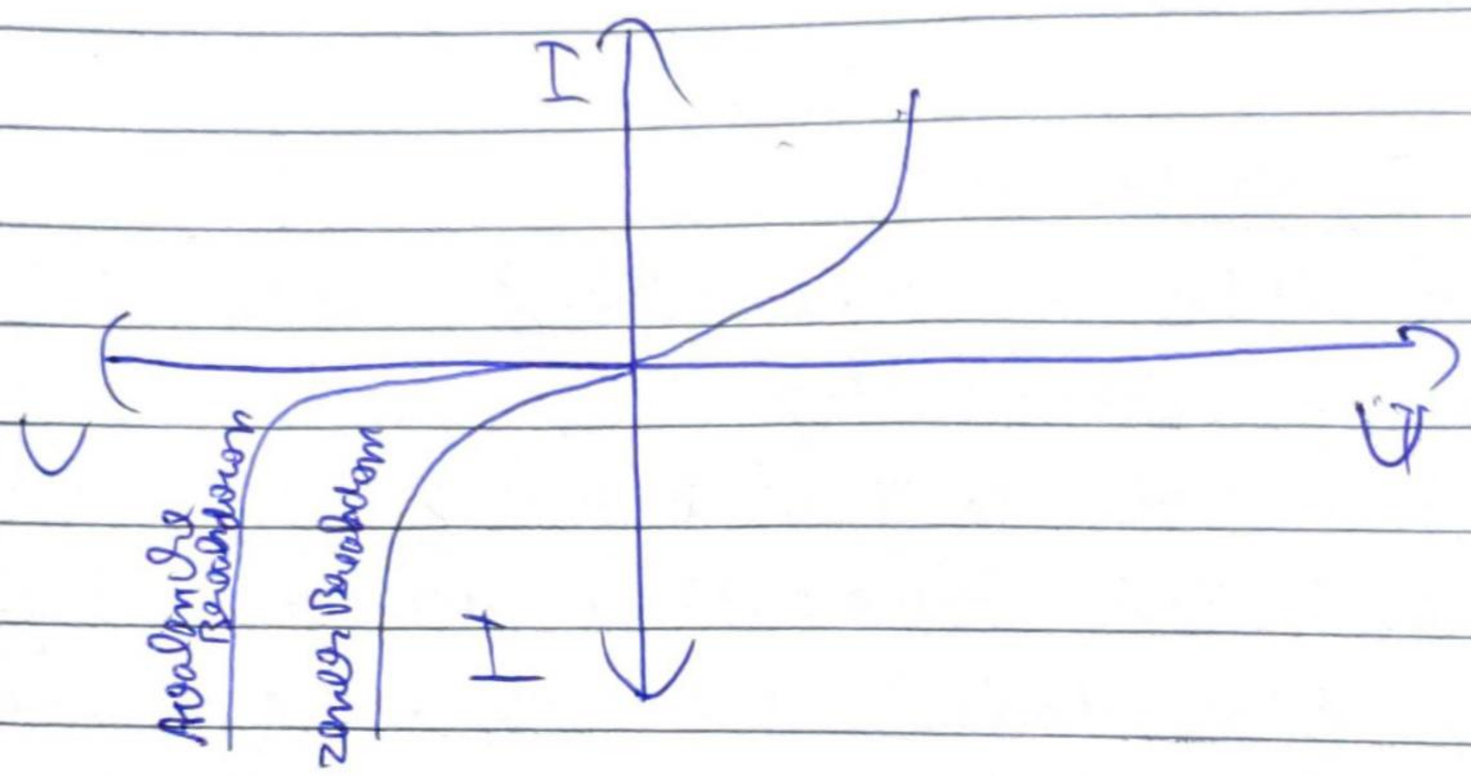
- Zener breakdown:

When the applied reverse bias voltage reaches close to the zener voltage, the electric field in the depletion region gets strong enough to pull electrons from their valence band. The valence electrons that gain sufficient energy from the strong electric field of the depletion region break free from the parent atom. At the zener breakdown region, a small increase in the voltage results in the rapid increase of the electric current. This happens when $-4V \leq V_Z \leq 6V$



→ Gallium Arsenide is used in its construction.

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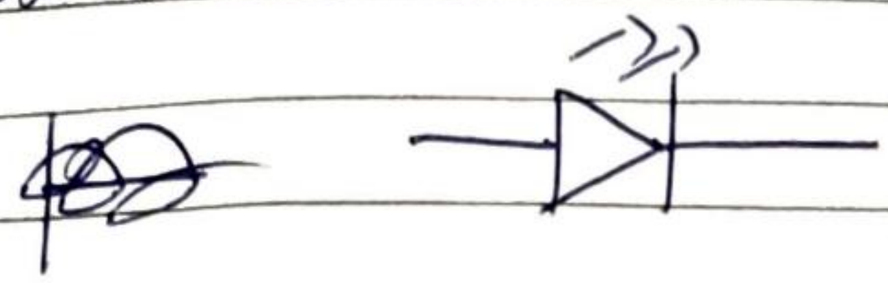
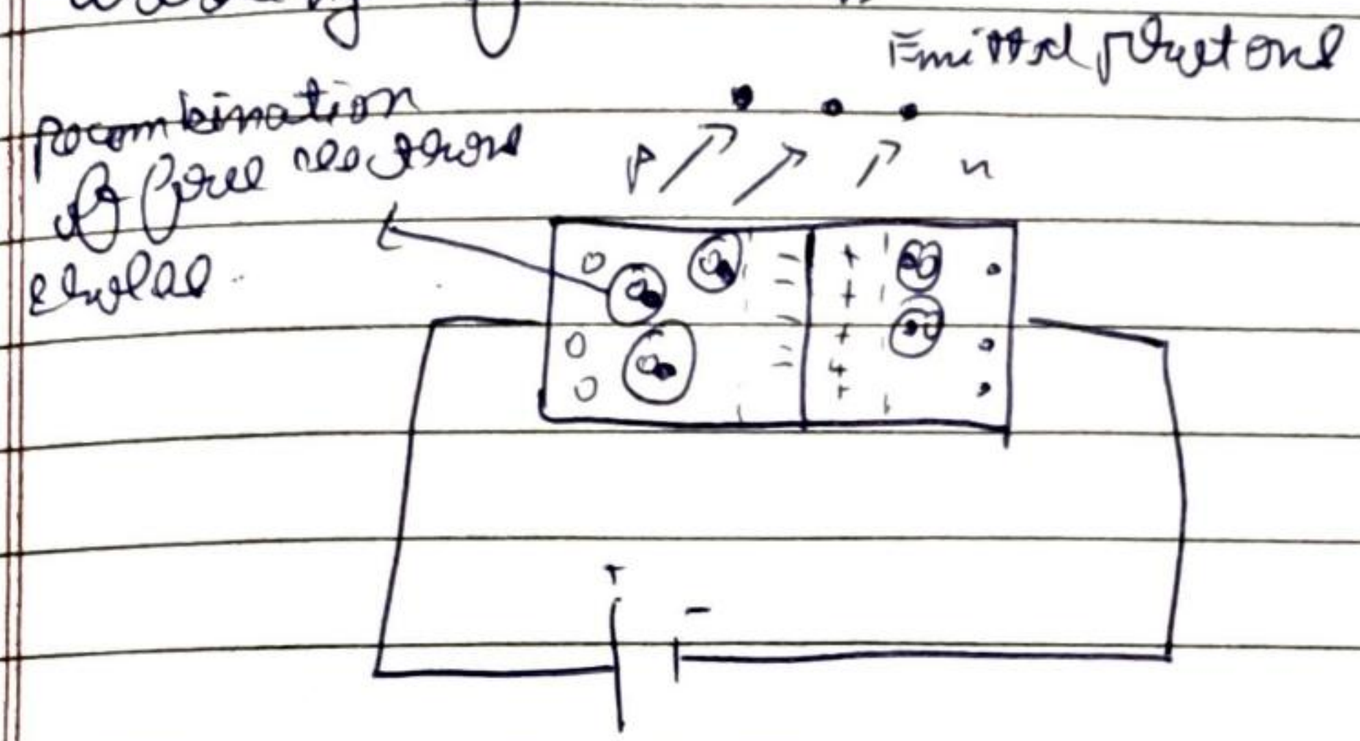
Q What is LED ? Working ?

⇒ • Light Emitting Diode is more widely used semiconductor which emit either visible or invisible infrared light when forward biased.



• Working of LED →



LED works only in forward biased condition. The recombination of free electrons & holes takes place in depletion region as well as in p-type & n-type semiconductor. The free electrons in conduction band release energy in the form of light before they recombine with holes.
When external voltage is applied to valence electrons, the valence electrons which breaks bonding with parent atom are called free electrons & that empty space is called a hole. Since energy of free electrons is always more than the energy of valence electrons or holes, so it need to loose energy in order to recombine with holes. Hence such recombination of charge emits energy in the form of light.

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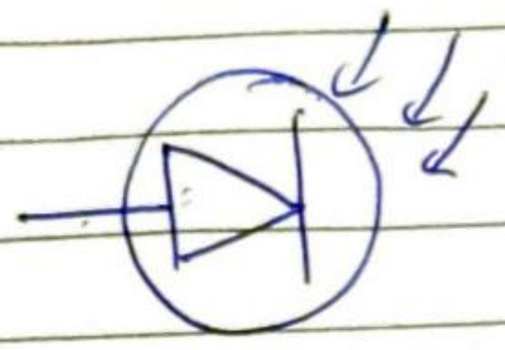
Q What is photodiode?

⇒ A photodiode is a pn junction diode that will conduct current when exposed to light. This diode is actually designed to operate in the reverse bias mode.



Ch. 2 Transistors & its applications

Q What is a transistor?

⇒ A transistor is a three terminal semiconductor device that regulates current or voltage flow & acts as a switch or gate for signals.

Q Constructional Details of Transistor?

⇒ There are two types of BJT →

~~(i) pnp , (ii) npn~~

(i) npn , (ii) pnp

The three terminals indicate Emitter, Base & Collector.

- Emitter →
  - This has a moderate size & is heavily doped as its main function is to supply a number of majority carriers i.e. electrons or holes

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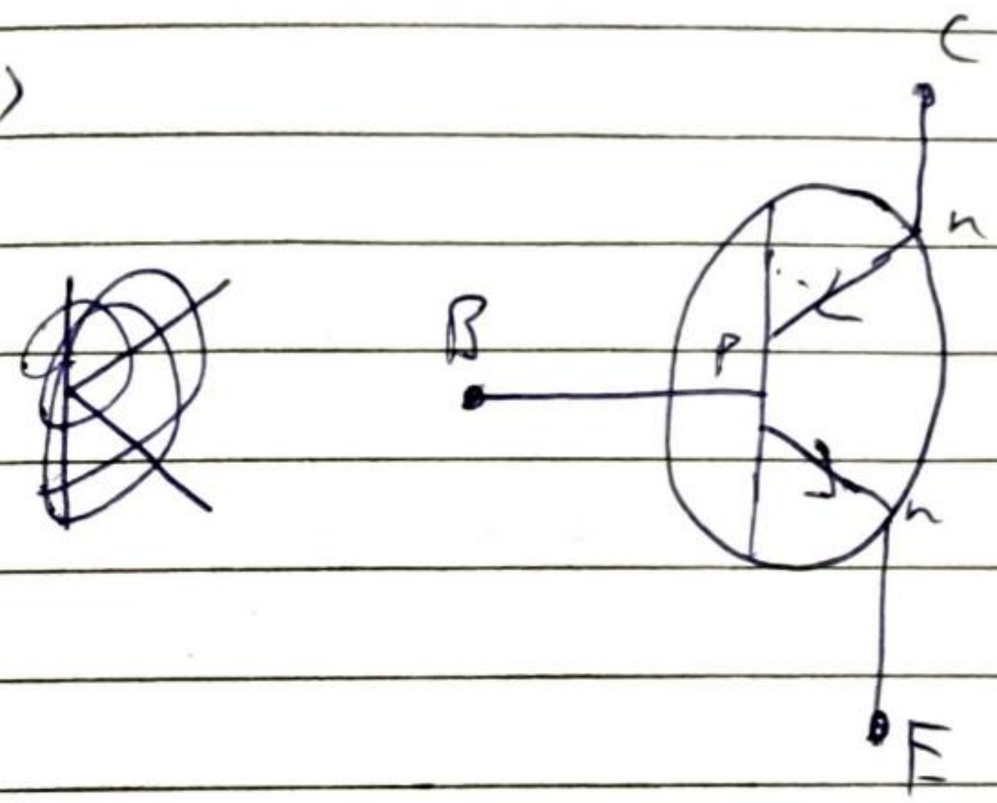
- Base →
  - It is thin & lightly doped.
  - Its main function is to pass the majority carriers from the emitter to the collector.

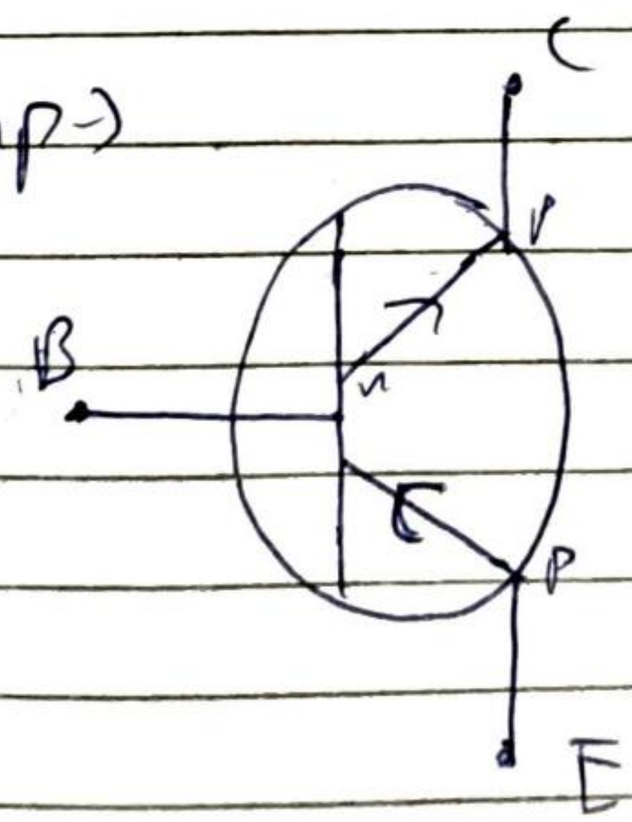
- Collector →
  - This is a bit larger in size than emitter & base. It is moderately doped.
  - Its function is to collect the carriers.

- The symbols of npn & pnp

npn →



pnp →



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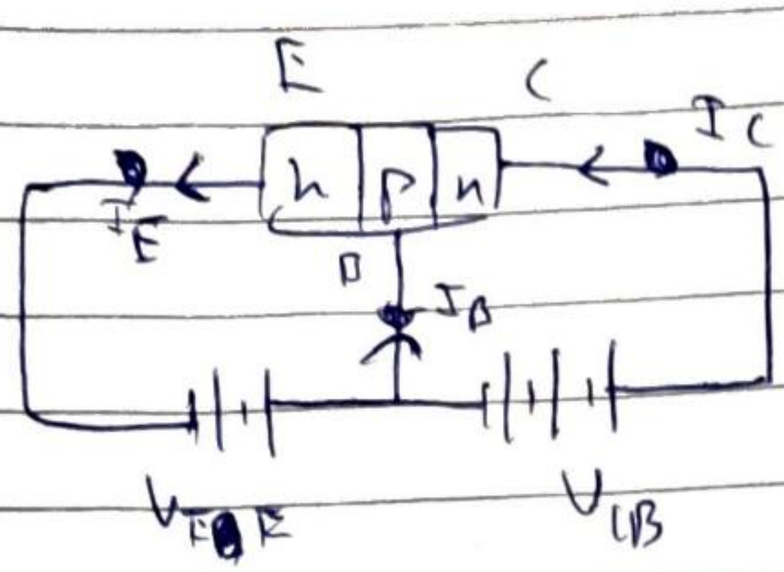
Q Working of npn transistor?

⇒



$$I_E = I_B + I_C$$

- The voltage V_{EE} provides a negative potential at the emitter which repels the electrons in the n-type material & these electrons cross the emitter base junction to reach the base region. There, a very low percent of electrons recombine with free holes of p-region. This provides very low current which constitutes the base current I_B. The remaining holes cross the collector base junction to constitute the collector current I_C.

- As an electron reaches out of the collector terminal, & enters the positive terminal of the battery, an electron from negative terminal of the battery V_{EB} enters the emitter region. This flow slowly increases & the electron current flows through the transistor.

Q What is an amplifier?

⇒ An amplifier is an electronic device that increases the voltage, current or power of the signal.

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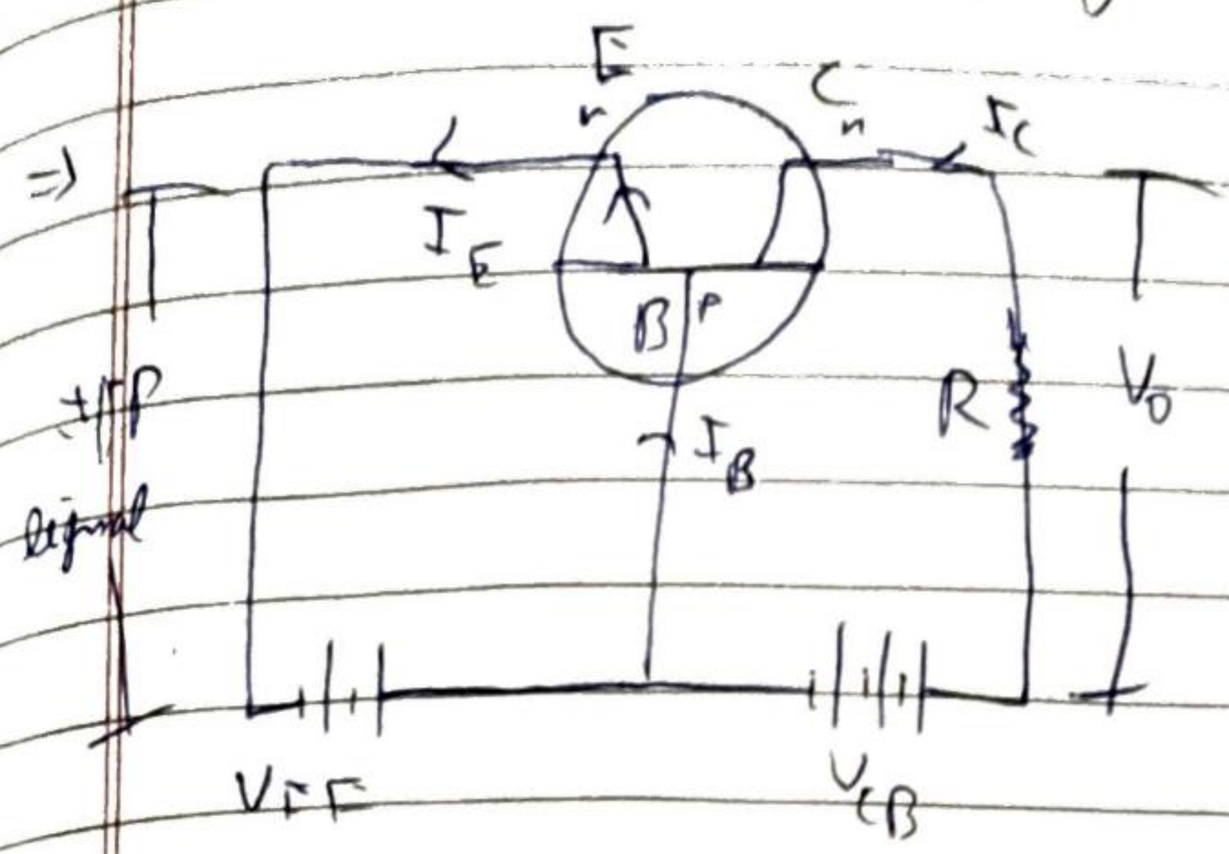
Q Transistor as an amplifier?

=>

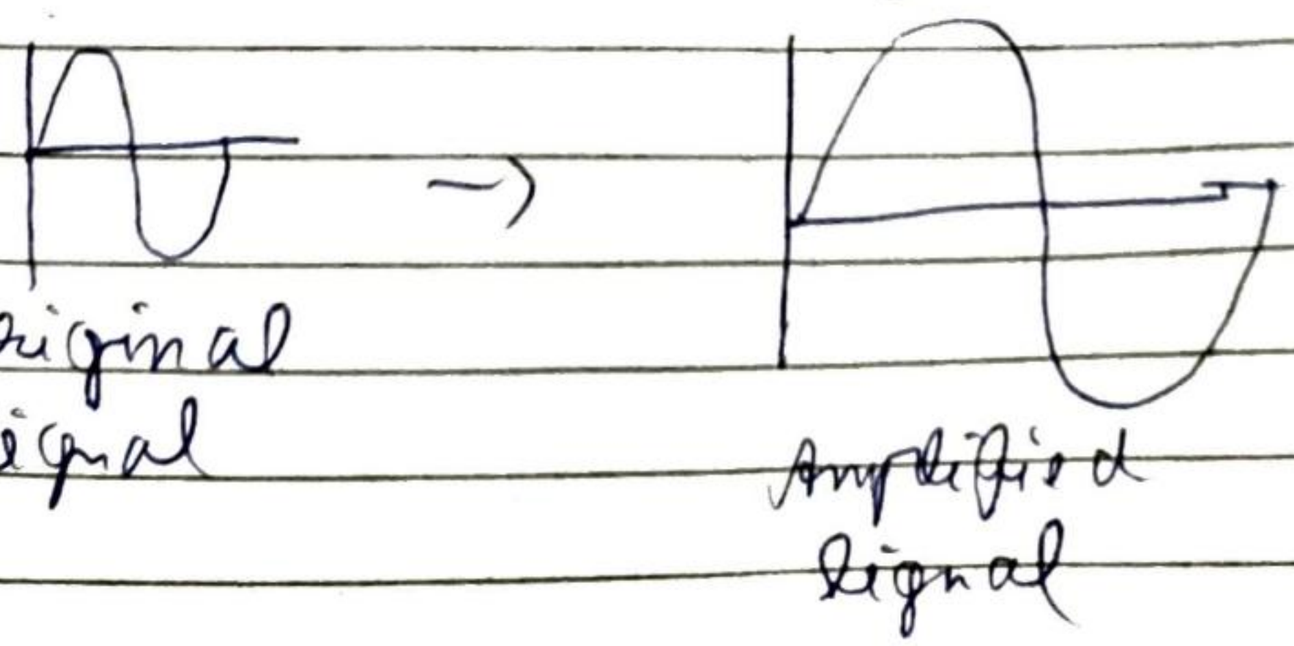


- A transistor is a device which raises the strength of a weak signal & thus acts as an amplifier.

- The input (weak signal) is applied across emitter base & the output (amplified signal) is obtained across load resistance R connected in collector circuit.

- When a weak signal is applied at the input, a small change in signal voltage causes an appreciable change in emitter current.

- In the collector circuit, a load resistance R of high value is connected. When collector current flows through such a high resistance, it produces a large voltage drop. This results in amplified signal.



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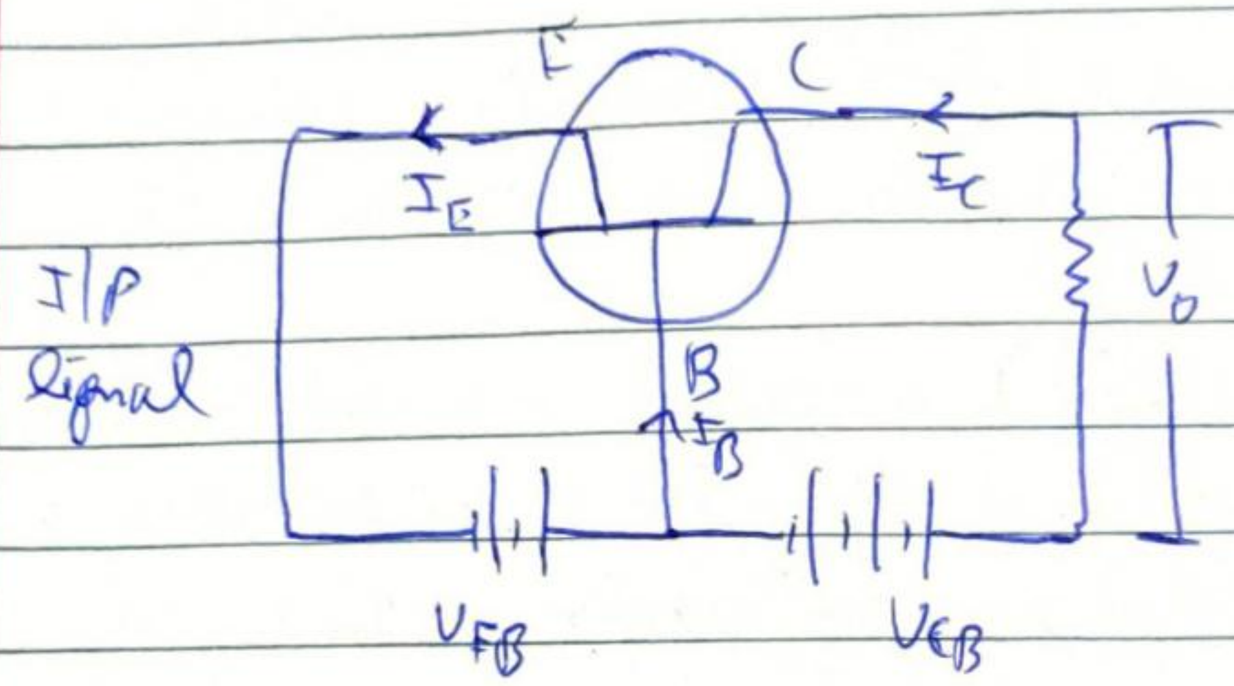
Q Configurations of a transistor.

=> There are 3 basic configurations in which transistor works :-

Common Base (CB)
Common Emitter (CE)
Common Collector (CC)

Q Common Base ~~Emitter~~ ?

=>



~~Current amplification factor (α)~~

In CB configuration the base terminal of transistor is common between input & output terminals.

Current amplification factor (α) : The ratio of output current to input current is known as current amplification factor.

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

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$$I_E = I_B + I_C$$

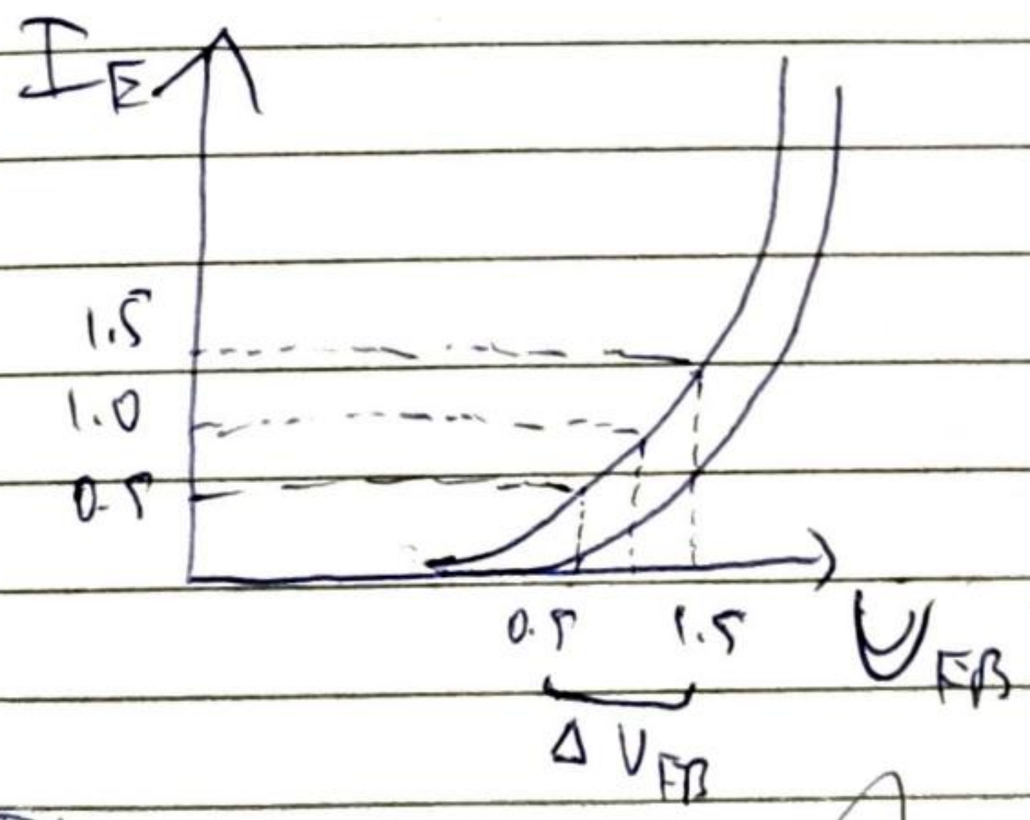
$$\Delta I_E = \Delta I_B + \Delta I_C$$

$$\frac{\Delta I_E}{\Delta I_E} = \frac{\Delta I_B}{\Delta I_E} + \frac{\Delta I_C}{\Delta I_E}$$

$$1 = \alpha + \frac{\Delta I_B}{\Delta I_E}$$

$$\boxed{\alpha = 1 - \frac{\Delta I_B}{\Delta I_E}}$$ for C.B.

· Input Characteristics



· The curve plot b/w Emitter current I_E & Emitter voltage V_{EB}

· For a particular value of V_{CB}, the curve is just like diode characteristic in the forward region.

· When V_{CEB} is increased, the value of I_E increases.

$$\boxed{R_i = \frac{\Delta V_{EB}}{\Delta I_E}}$$

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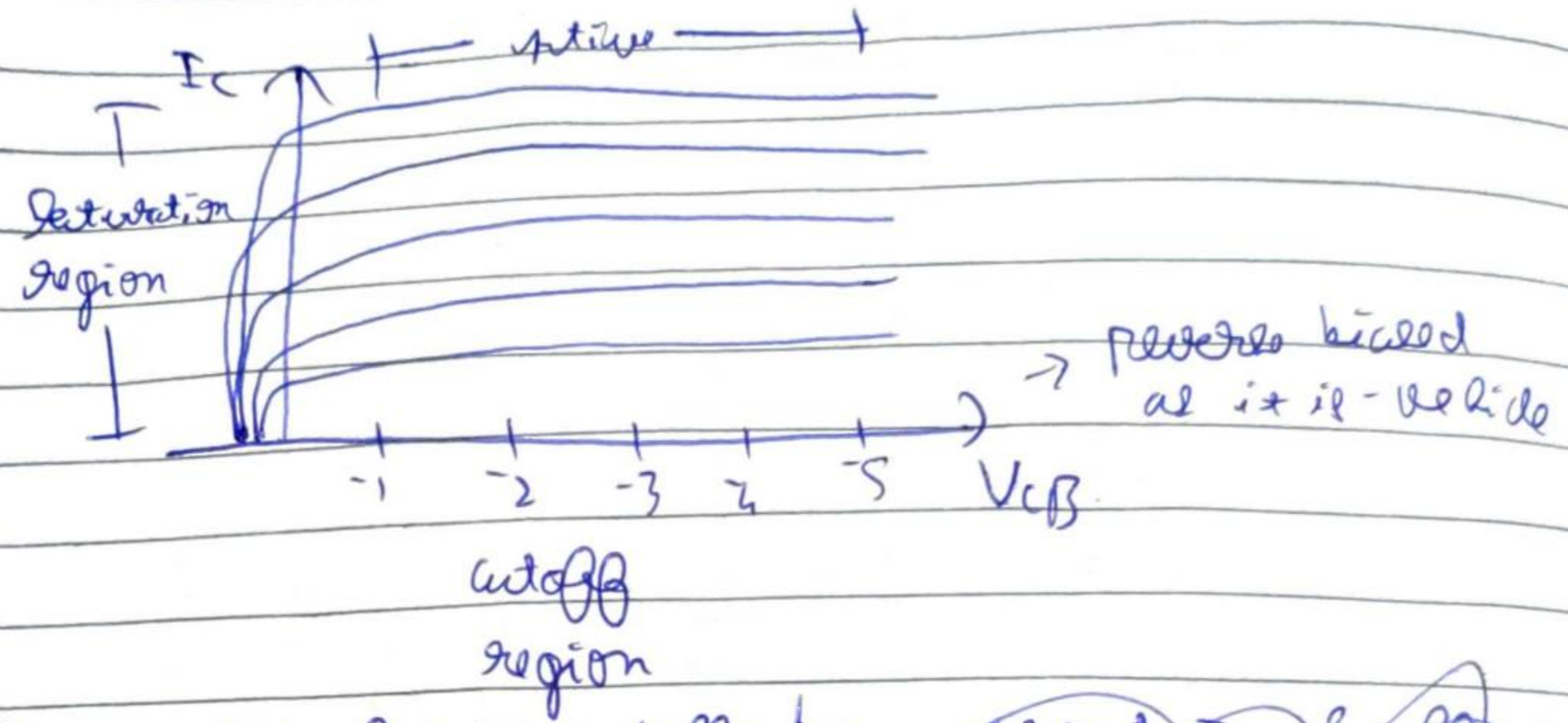
- Output characteristics →



~~The curve plot b/w collector current I_C & collector voltage V_{CB}~~

~~In the active region where collector base junction is reverse biased, the collector current I_C is almost equal to emitter current I_E~~

~~When V_{CB} becomes positive i.e. B junction is forward biased the collector current I_C decreases, this region is known as saturation region.~~

~~When $I_E = 0$, collector current $I_C \neq 0$~~

$$\boxed{r_o = \frac{\Delta V_{CB}}{\Delta I_C}}$$

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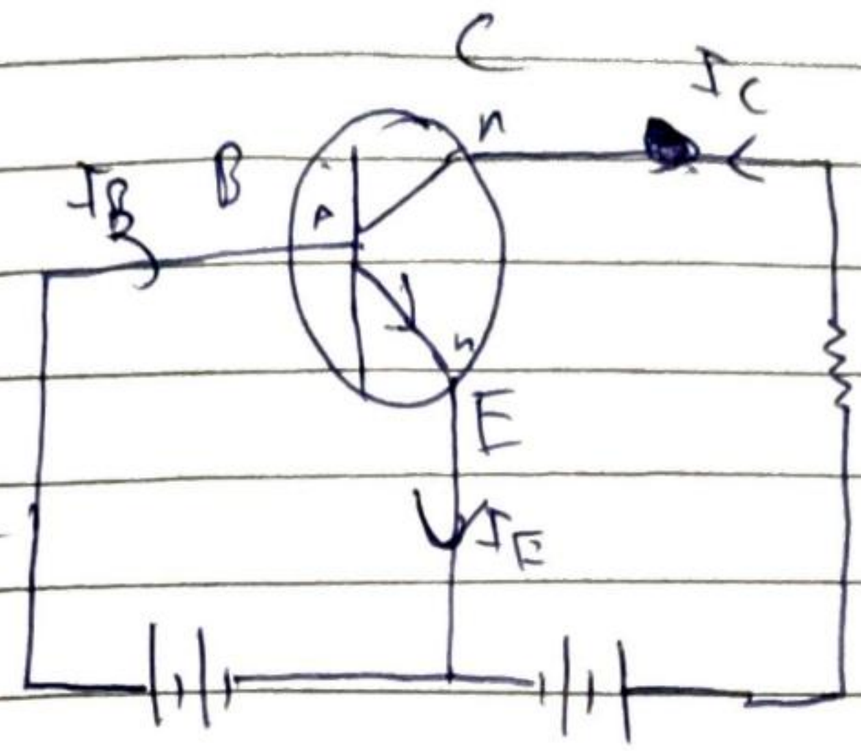
Q Common Emitter ?

=>



$I_E = I_B + I_C$

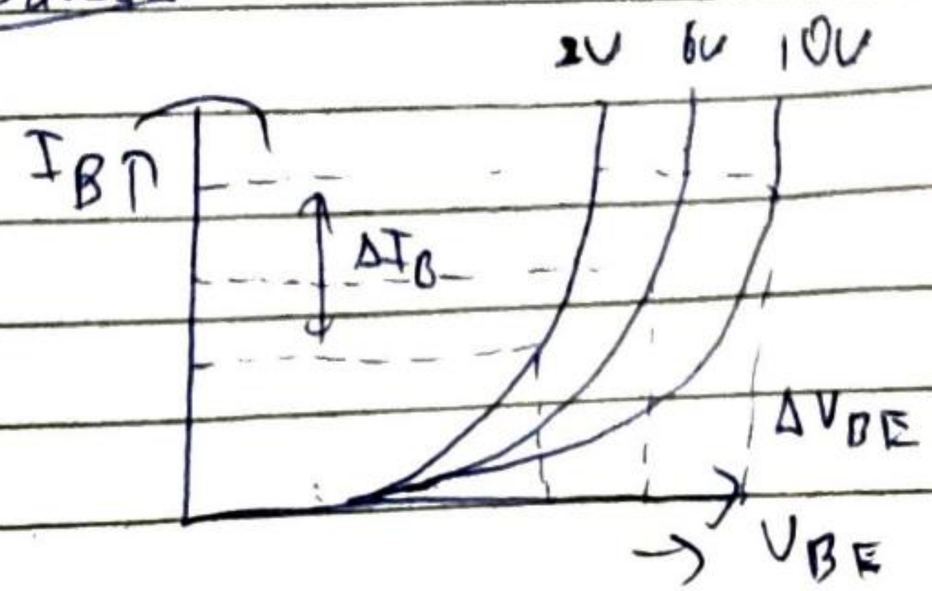
In CE, the Emitter terminal of transistor will be connected common to both input & output terminal.

<u>Base current amplification factor (β)</u> : The ratio of change in collector current to the change in base current is known as base current amplification factor.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

- <u>Input characteristics</u> ->



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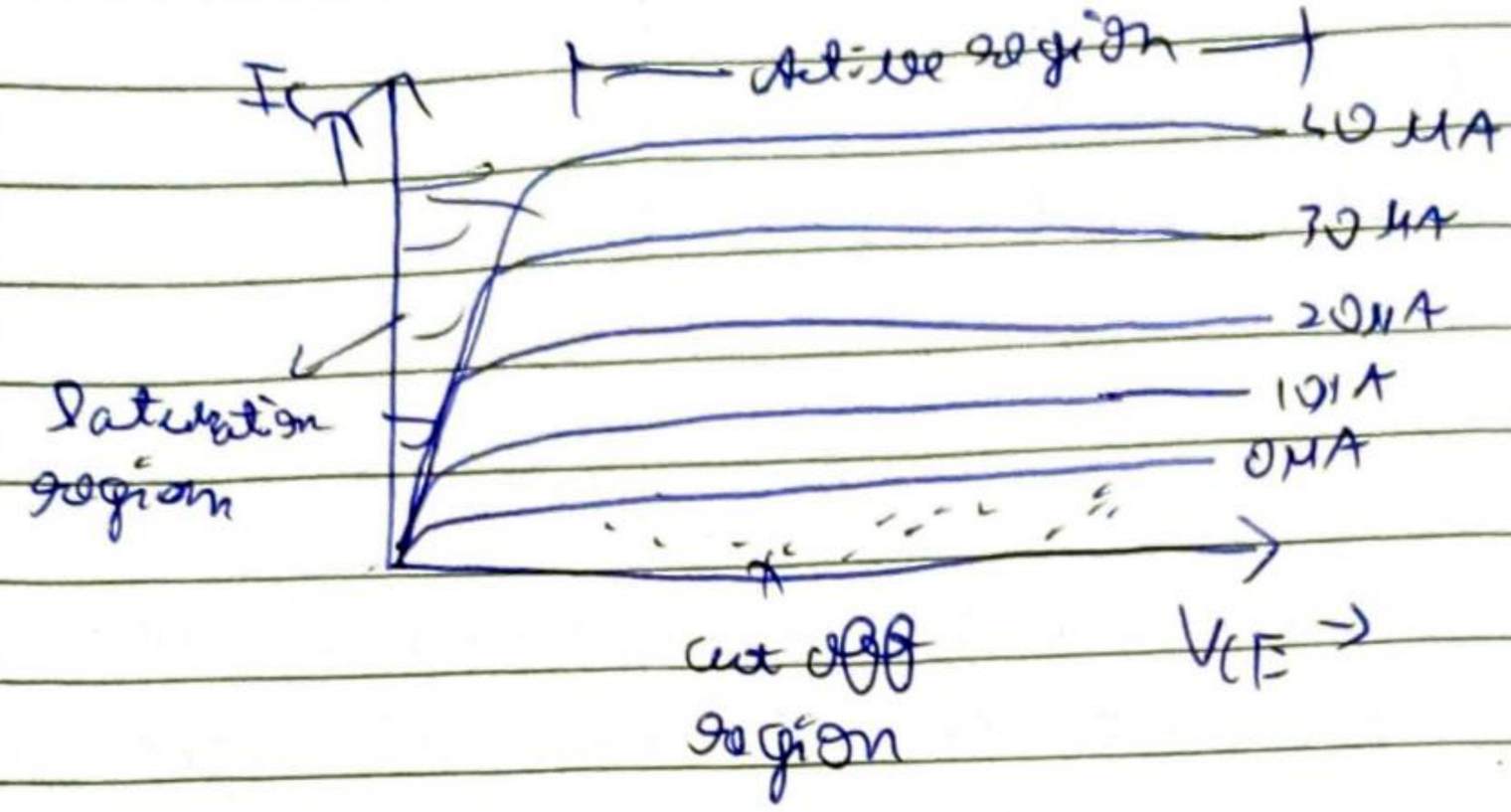
Input resistance $r_i = \dfrac{\Delta V_{BE}}{\Delta I_B}$

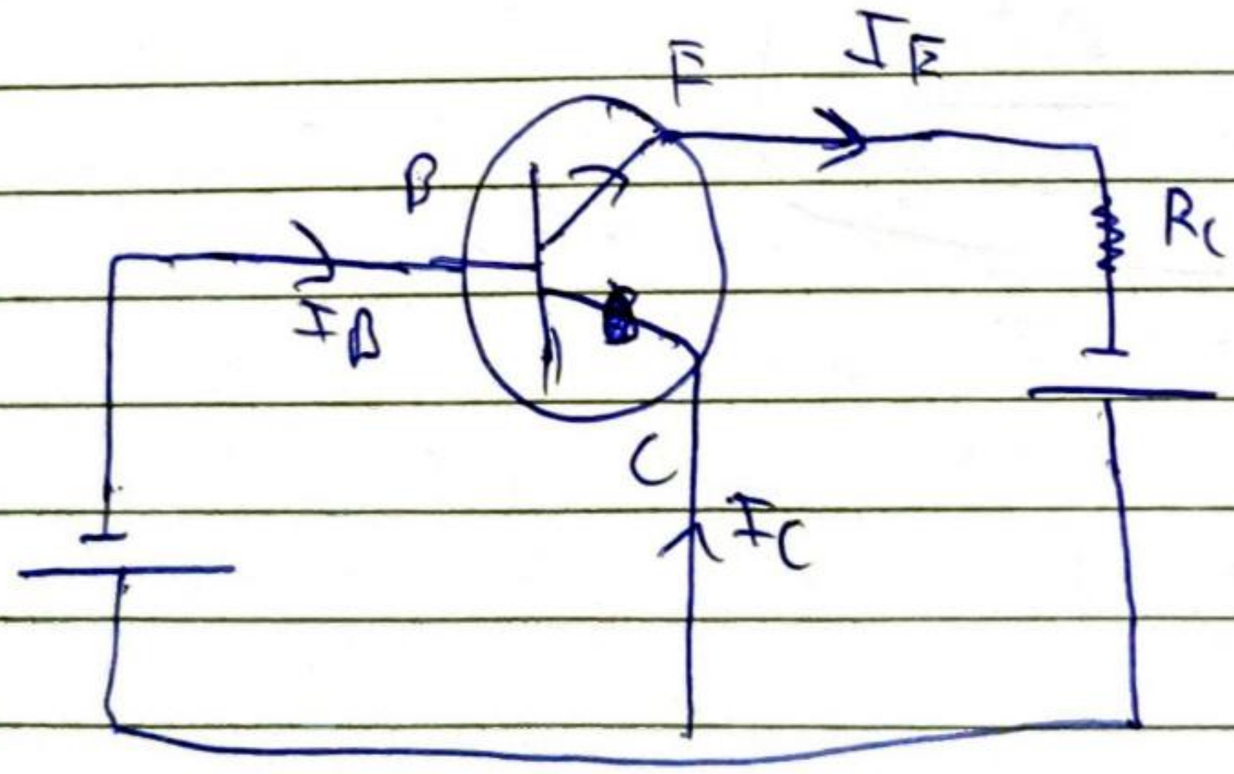
· Output characteristic →



Output resistance $r_o = \dfrac{\Delta V_{CE}}{\Delta I_C}$

Q Common collector ?

⇒



$$\boxed{\gamma = \frac{\Delta I_E}{\Delta I_B}}$$

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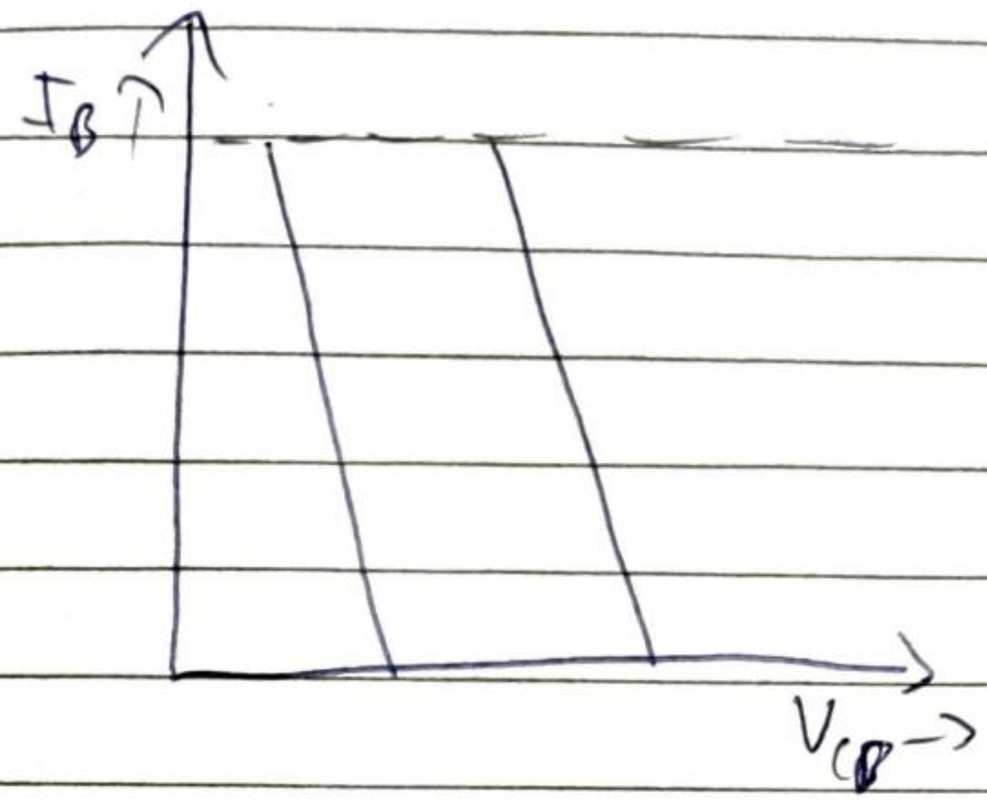
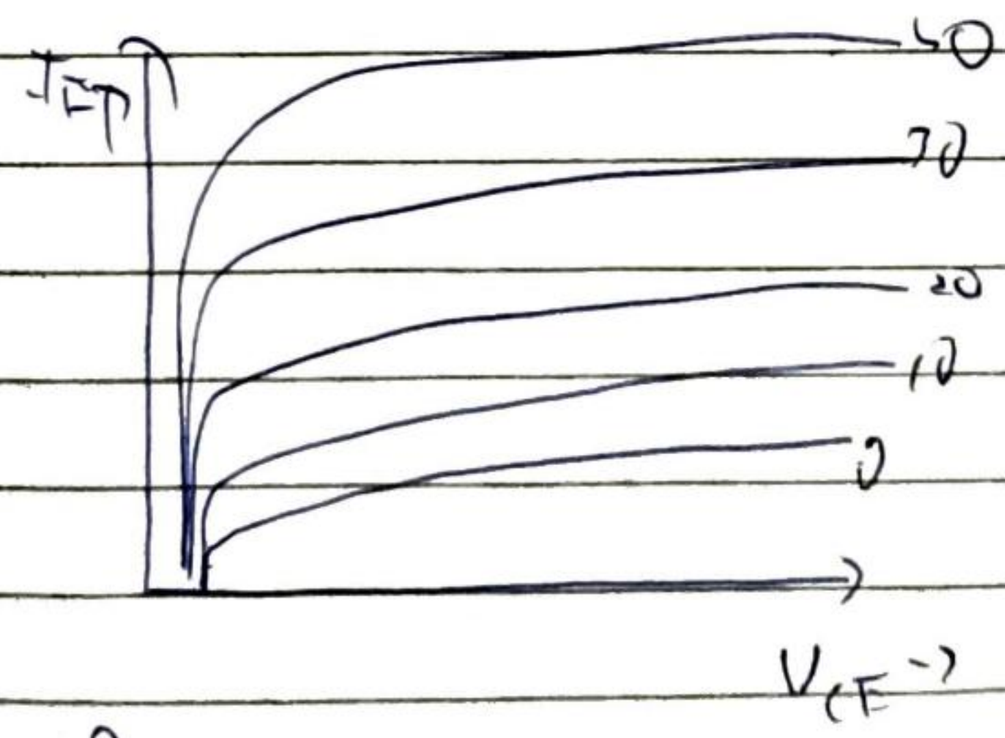
$$\boxed{\gamma = \frac{1}{1-\alpha}}$$

· Input characteristic →



Input resistance $r_i = \dfrac{\Delta V_{CB}}{\Delta I_B}$

· Output characteristic →



Output resistance $r_o = \dfrac{\Delta V_{CE}}{\Delta I_E}$

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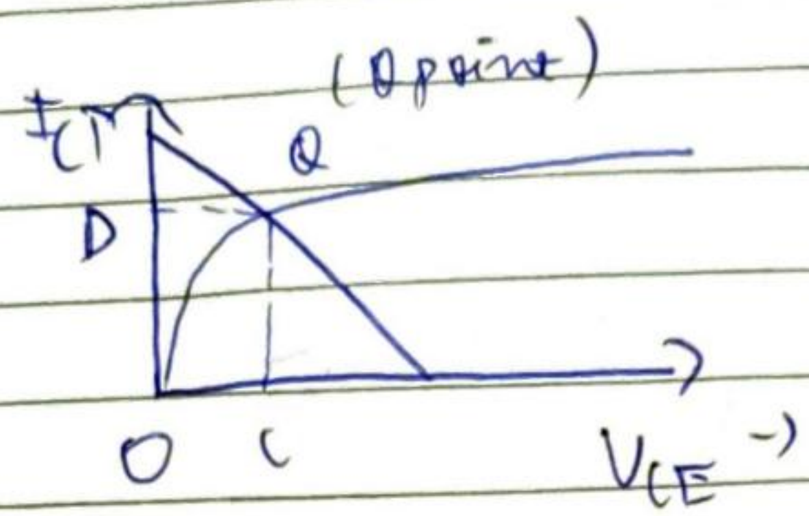
Q What is operating point?

→ The point obtained by the value of I_C & V_{CE} when no signal is applied at the input is known as operating point.



It is called an operating point since variation of I_C & V_{CE} takes place at this point. This point is also called Q point / silent point bcoz it is a point on $I_C - V_{CE}$ characteristics when the transistor is silent i.e. no signal is applied at the input.

Q Need of biasing in transistor?

→ If a signal of very small voltage is given to the input of BJT, it cannot be amplified. Because for a BJT to amplify a signal, two conditions have to be met.

- The input voltage should exceed cut in voltage.
- The BJT should be in active region to be operated as an amplifier.

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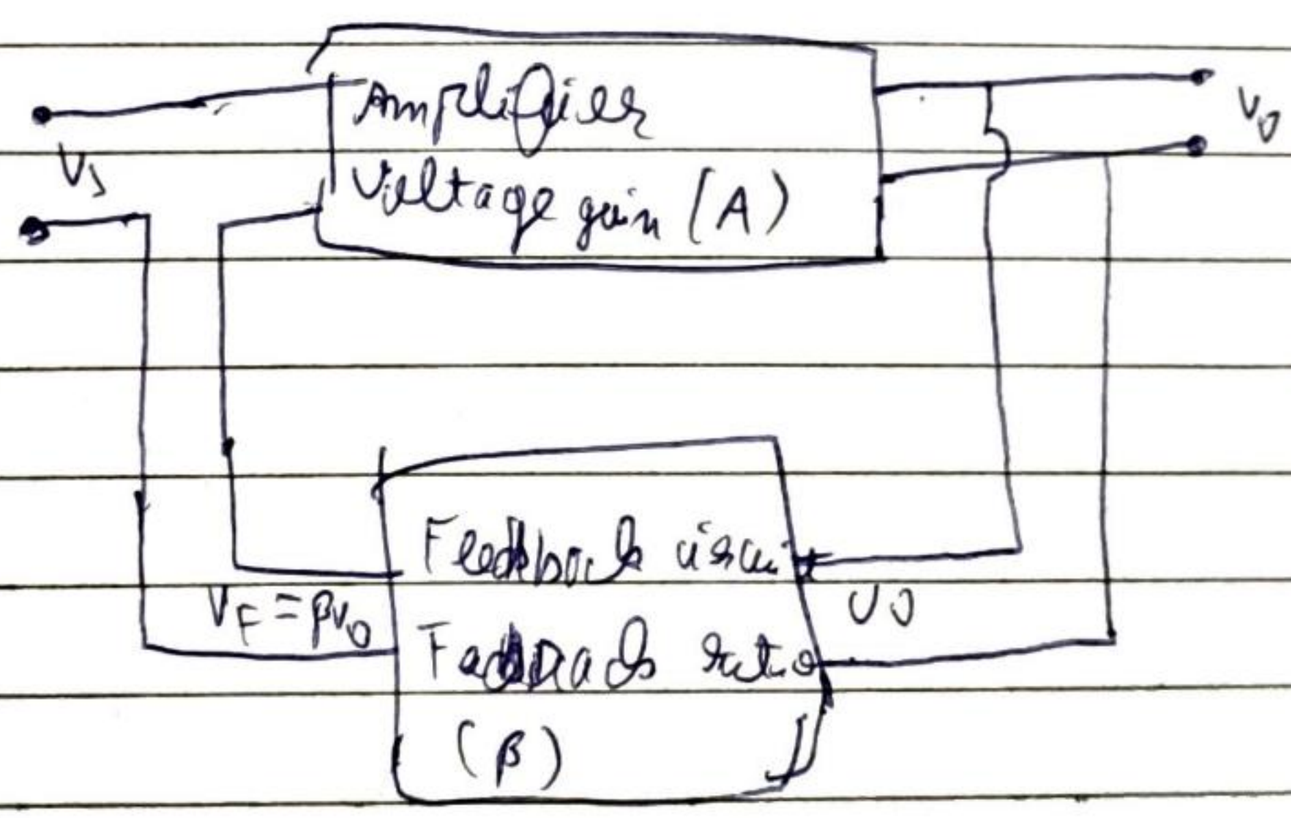
Q-3 Oscillators

Q- What is feedback in amplifier?

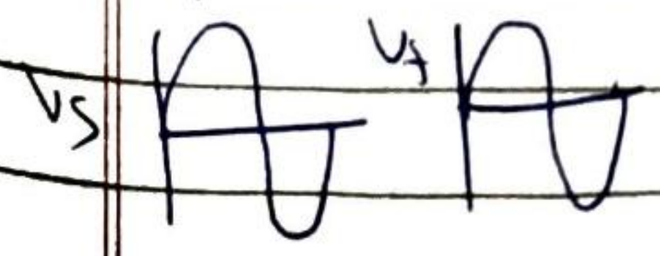
⇒ • When a fraction of the output of an amplifier is fed back to the input, this process is called feedback & the amplifier is called feedback amplifier.

• Due to feedback the input of the amplifier becomes slightly dependent on output & it helps to control the output. A feedback amplifier consists of 2 parts: one is amplifier & other is feedback circuit

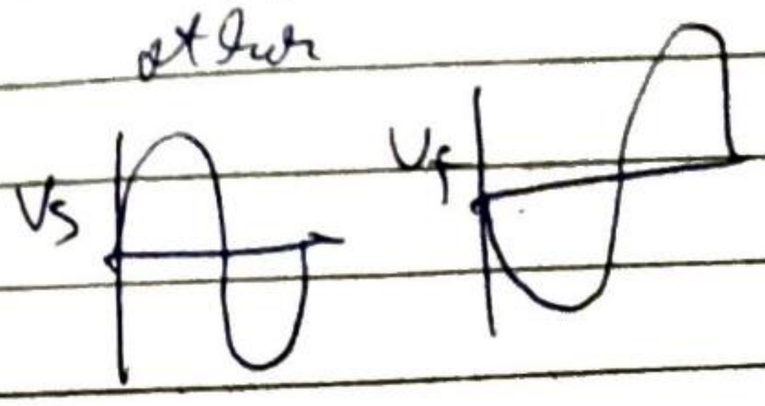


• Feedback of two types +ve & -ve.

+ve →
Source & feedback signal are in same phase



-ve →
Source & feedback are out of phase with each other



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Q What is oscillator?

⇒ Oscillator are the feedback circuits which generates periodic waveform output without any input. In the feedback amplifier gain with feedback is given by →

$$\boxed{A_f = \frac{A}{1-A\beta}}$$

A_f → the feedback gain

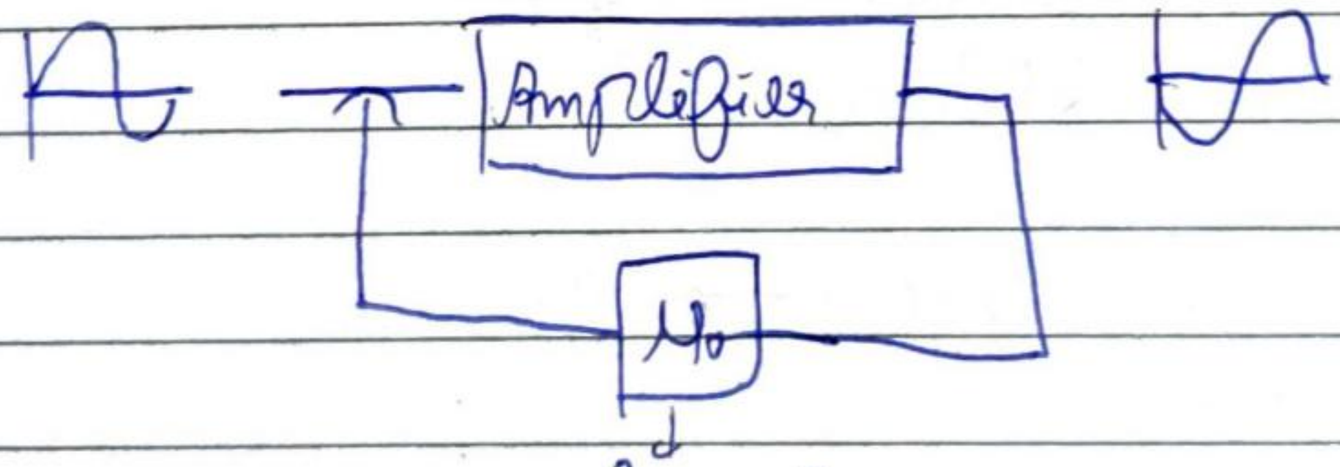
A → gain of amplifier

β → gain of feedback circuit

Q Barkhausen criteria?

⇒ It states that →

(i) Total phase shift in the loop from input to amplifier, feedback network & back to the input must be an integral multiple of 360°.



$$\boxed{\phi = n\,360^\circ}$$

(ii) The magnitude of product of amplifier gain & gain of feedback network must be equal to 1

$$\boxed{|A\beta| = 1}$$

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Q Sinusoidal Oscillators?

⇒ Sinusoidal oscillators are divided into 2 types on basis of frequency of O/P generated.

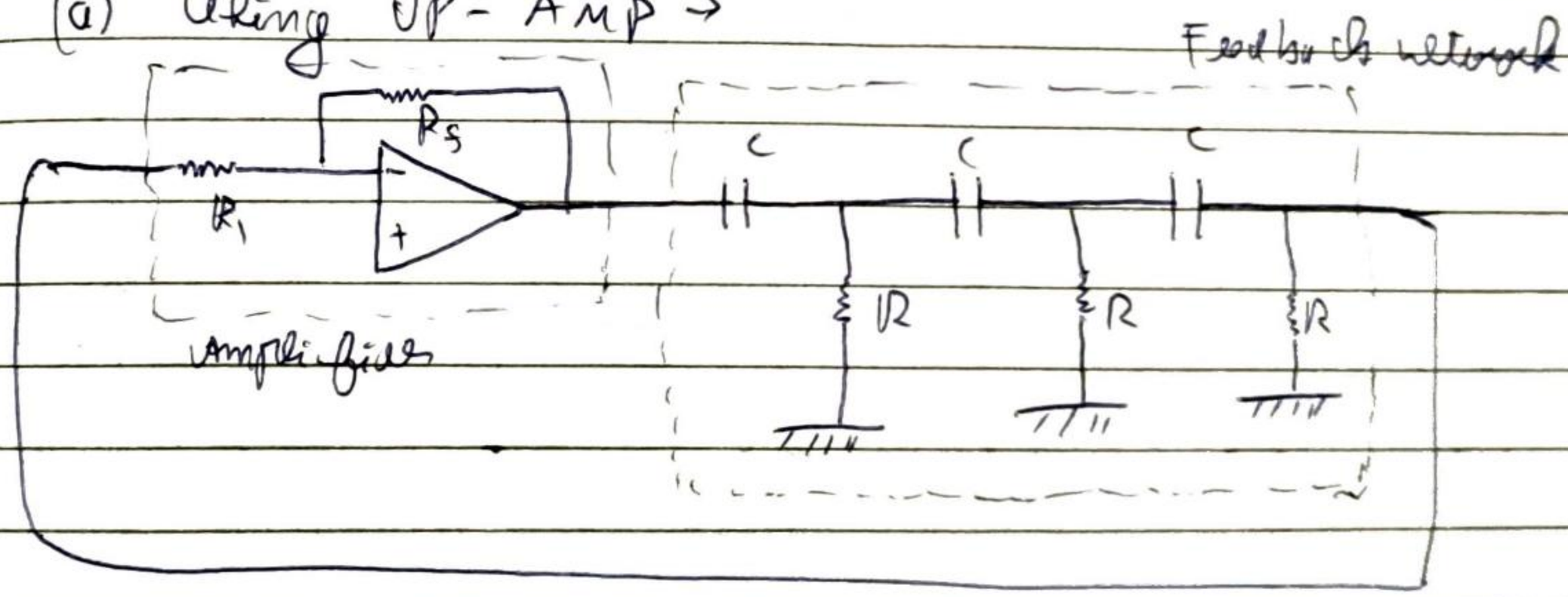
① RC oscillators →
These oscillators generate audio frequency O/P.

② LC oscillators →
These generate O/P of radio frequencies.

① RC Oscillators →

① RC phase shift oscillators →

(a) Using OP-AMP →



- In RC phase shift oscillator 3 RC networks are used in feedback. Each RC network in feedback circuit is adjusted so that each RC network provides phase shift of 60°, hence total phase shift by 180°.

- To satisfy Barkhausen's criteria the total phase shift around loop should be 360° hence the amplifier (OP-AMP) is operated in inverting mode so that it provides

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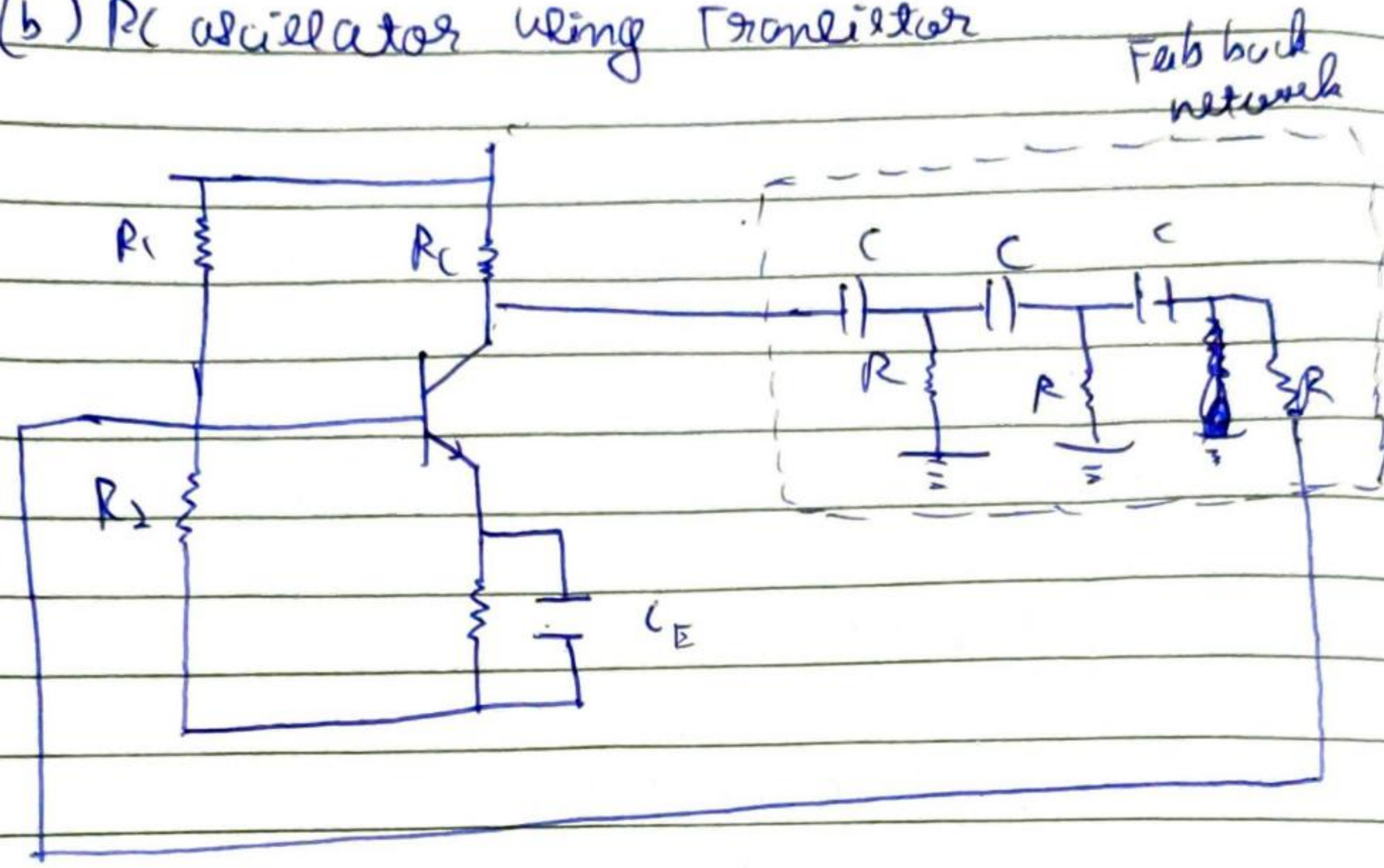
a phase shift of 180°, so total phase shift he comes 360°.

(b) RC oscillator using transistor



It is a fixed frequency oscillator because to change the frequency of oscillations we need to change all the three RC networks in order to adjust total phase shift of 360°

$$\boxed{f = \frac{1}{2\pi\sqrt{6RC}}}$$

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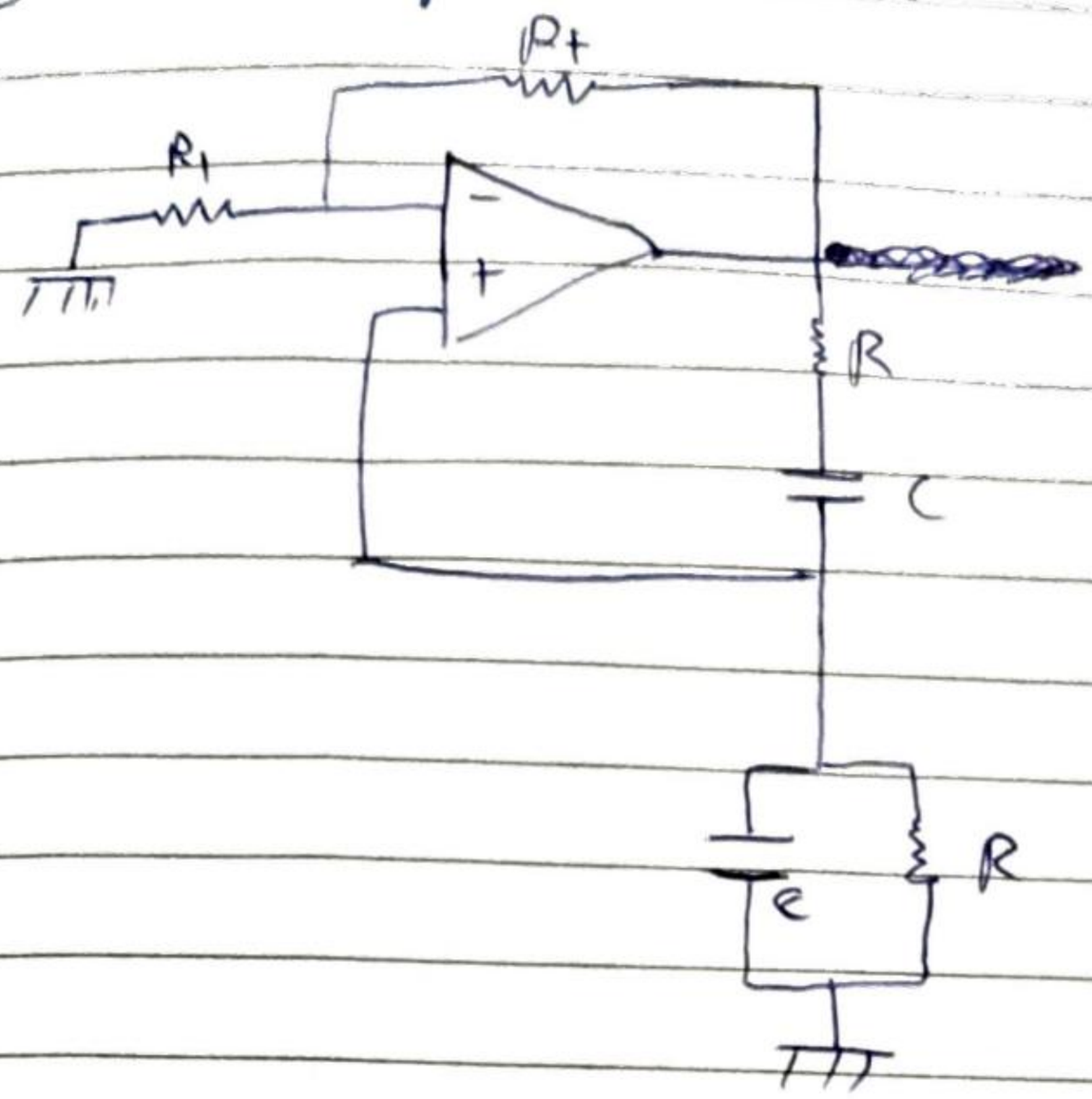
(2) Wein bridge oscillator



- A basic wein bridge oscillator consist of a series & a parallel RC combination one in +ve feedback network.

- In wein bridge oscillator the feedback network provide 0° phase shift, hence the OP-AMP is operated in non inverting mode

$$\boxed{f = \frac{1}{2\pi\sqrt{RC}}}$$

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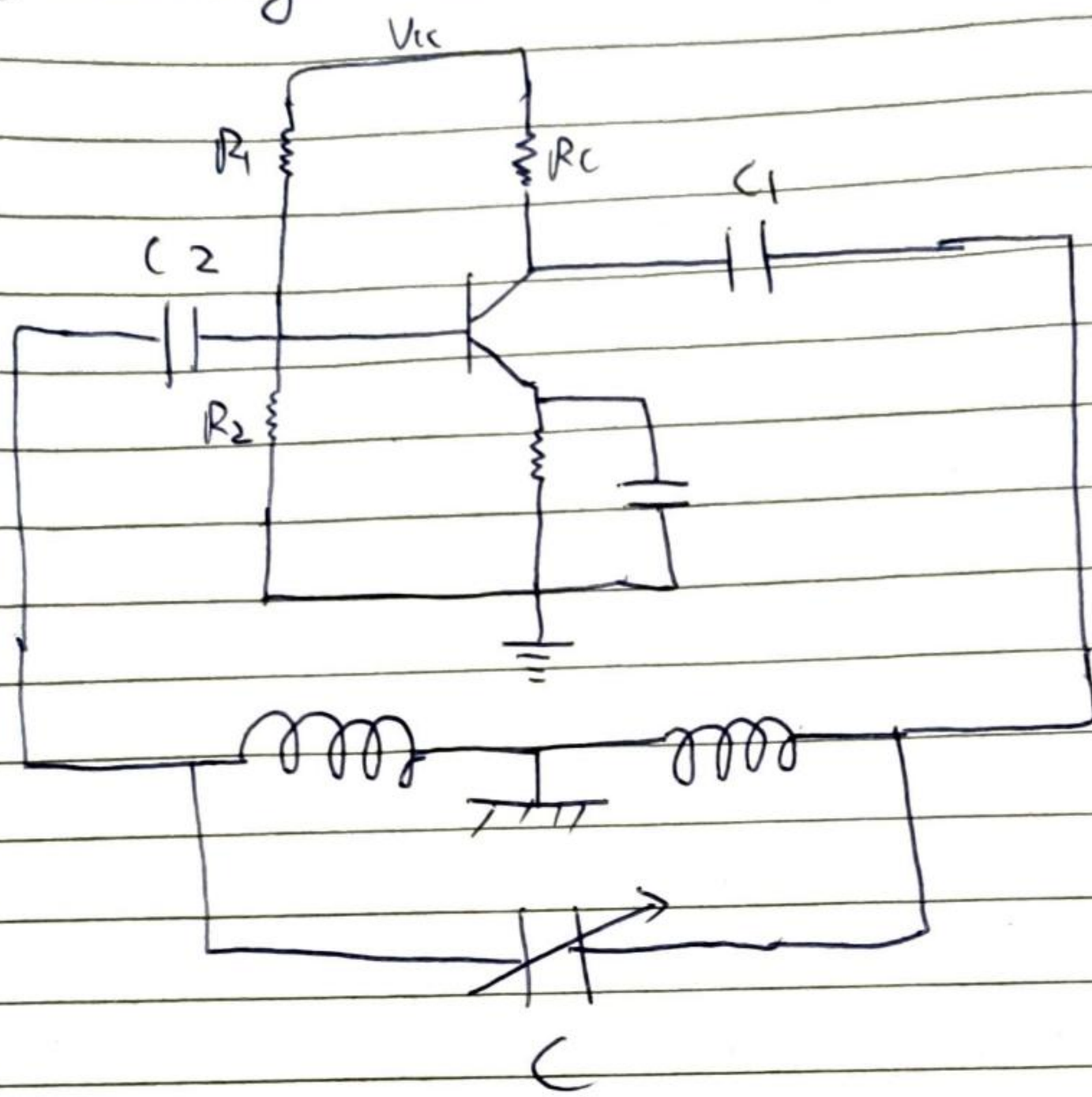
(2) LC Oscillators →

(1) Hartley Oscillators

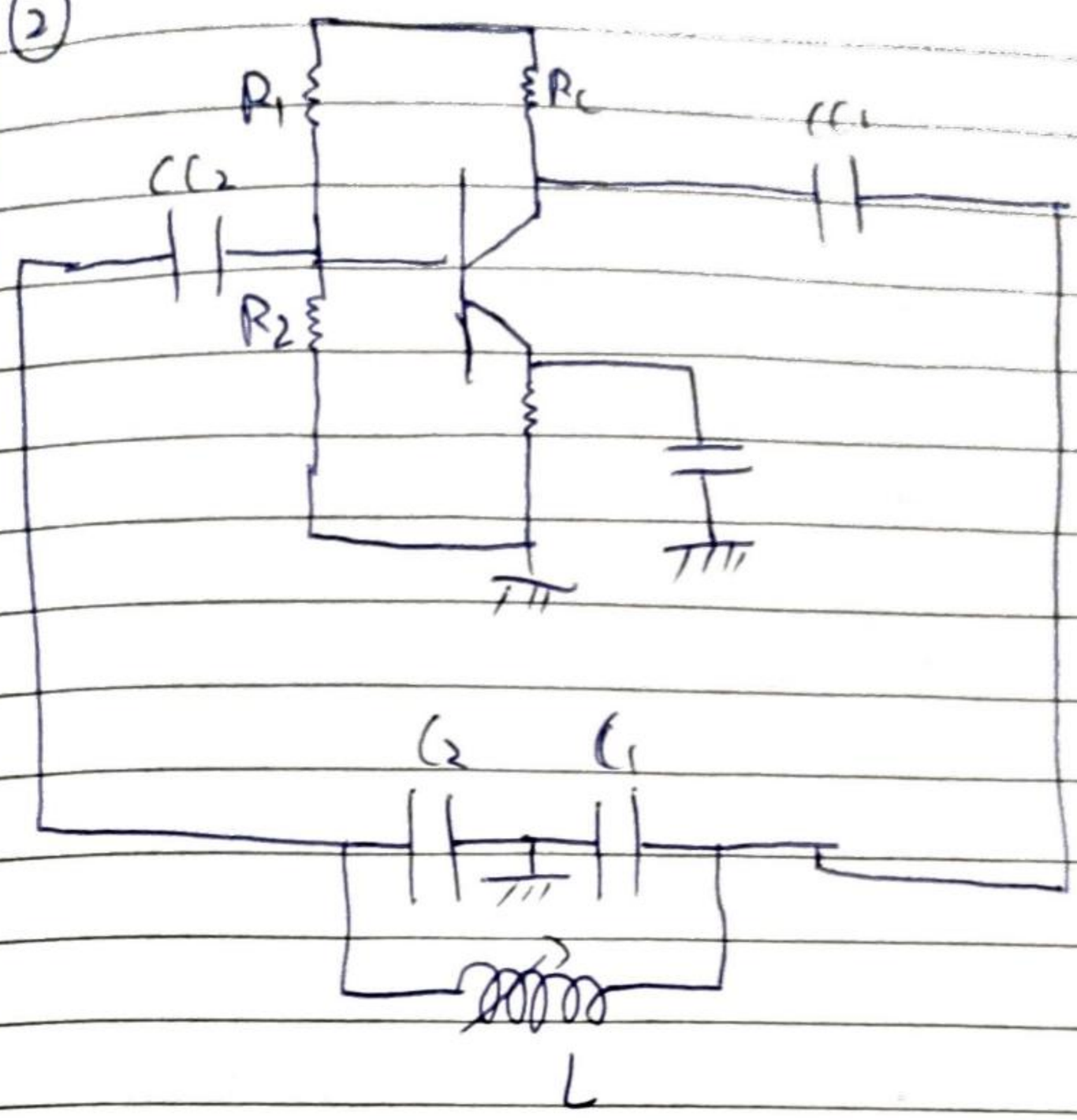


A Hartley Oscillator uses LC Tank circuit in the feedback network consisting of center tapped inductor in parallel with capacitor. The principle of operation is parallel resonance. The feedback network provides phase shift of 180° & remaining 180° phase shift is provided by transistor.

$$f = \frac{1}{2\pi\sqrt{(L_1+L_2)C}}$$

Colpitt Oscillator

(2)



$$f = \frac{1}{2\pi\sqrt{L C_{eq}}}$$

where $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

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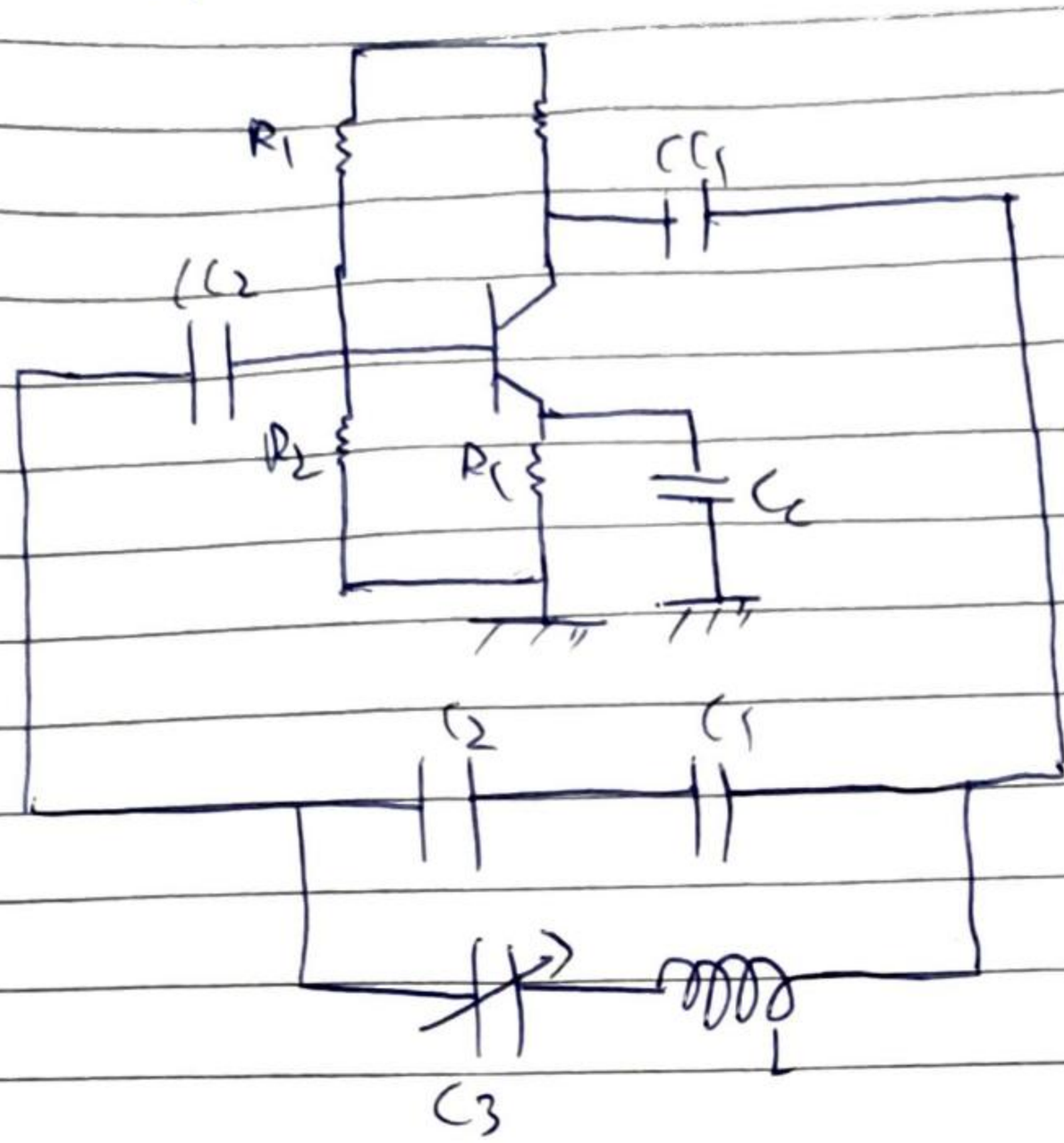
③ Clapp Oscillator



$$f = \frac{1}{2\pi\sqrt{LC_3}}$$

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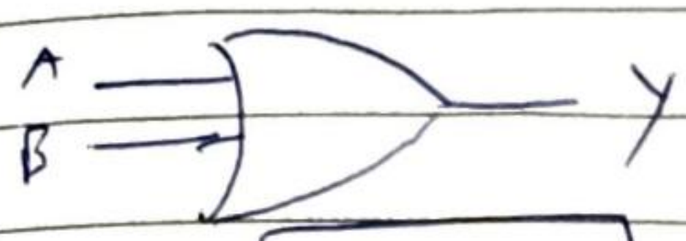
Ch 4 Fundamentals of Digital Electronics

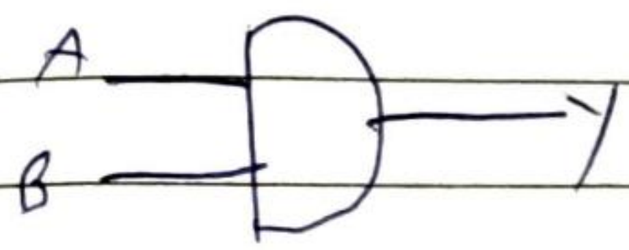
- NAND, NOR → Universal gates
  AND, OR, NOT → Basic gates

- 

OR gate

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

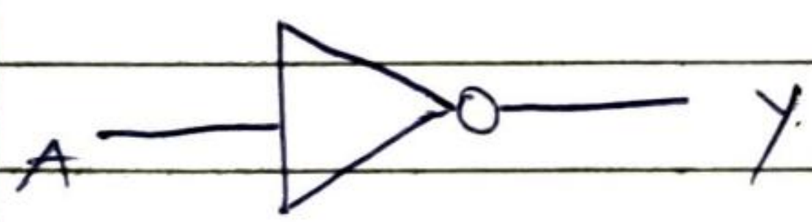
$Y = A + B$

- 

AND gate

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

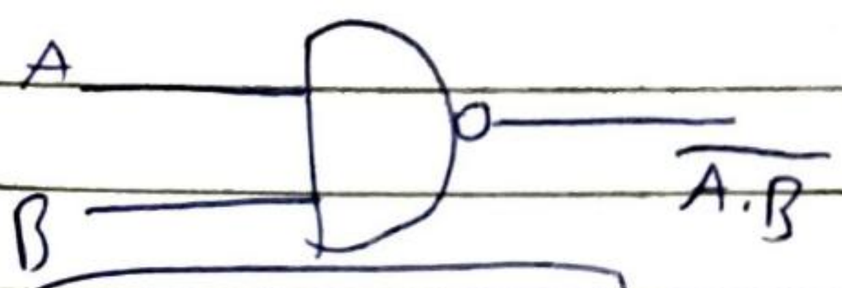
$Y = A.B$

- 

$Y = \bar{A}$

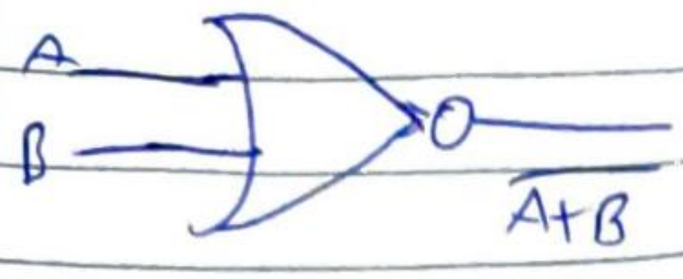
A	Y
0	1
1	0

NOT gate

- 

NAND gate

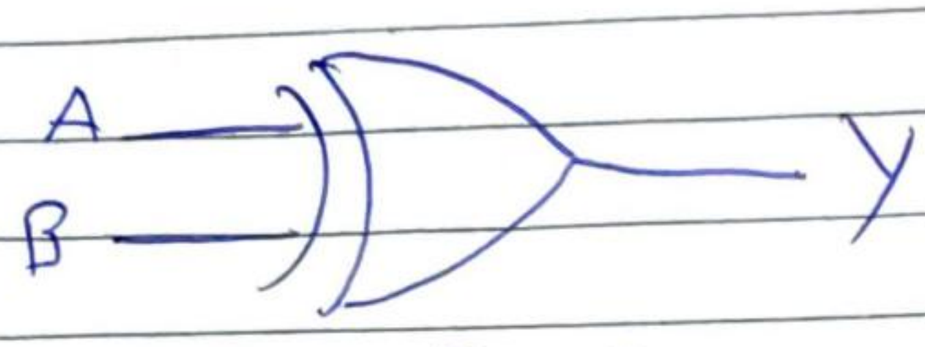
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

- 

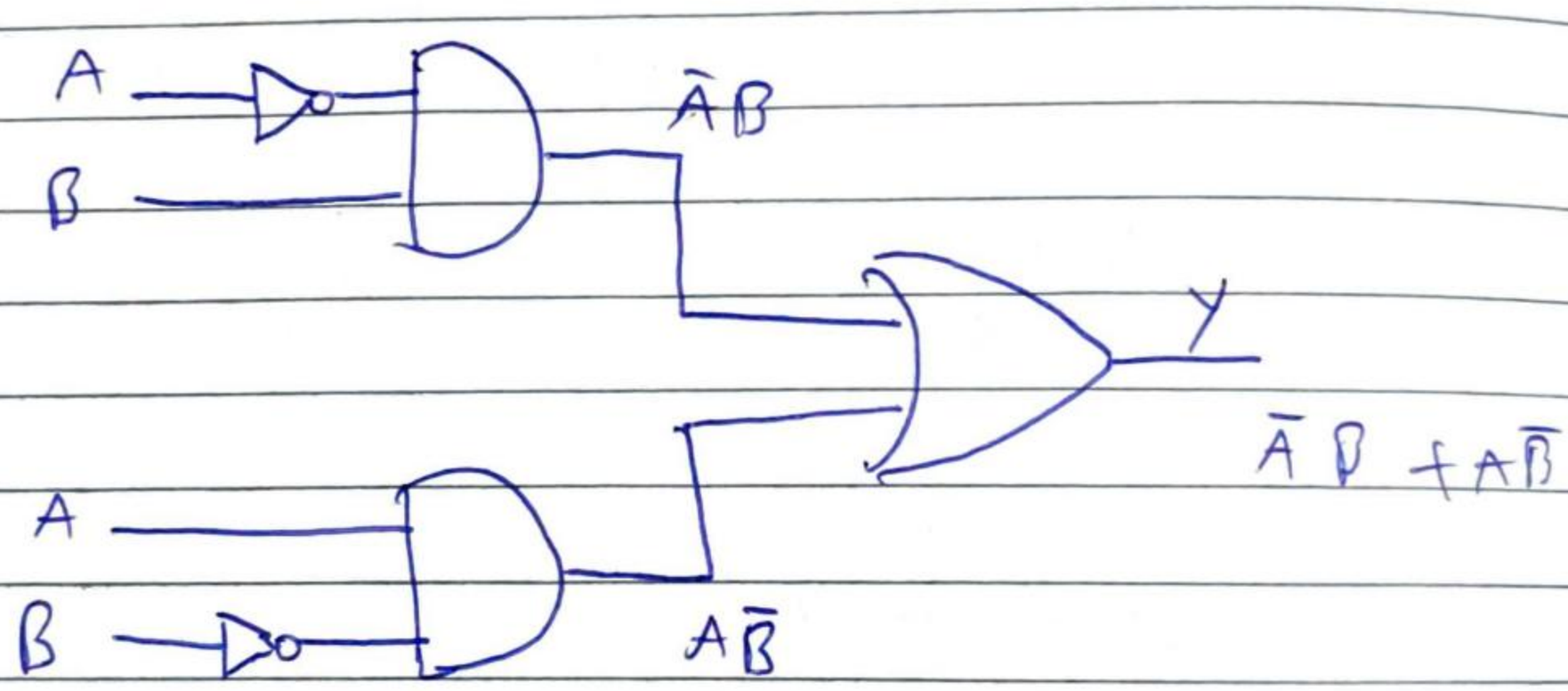
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

NOR gate

- Exclusive OR (EXOR / XOR) →



$Y = A\bar{B} + \bar{A}B$



A	B	$\bar{A}$	$\bar{B}$	$\bar{A}B$	$A\bar{B}$	$Y = \bar{A}B + A\bar{B}$
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

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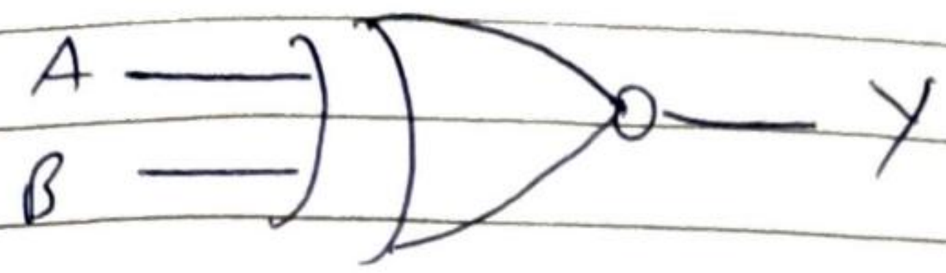
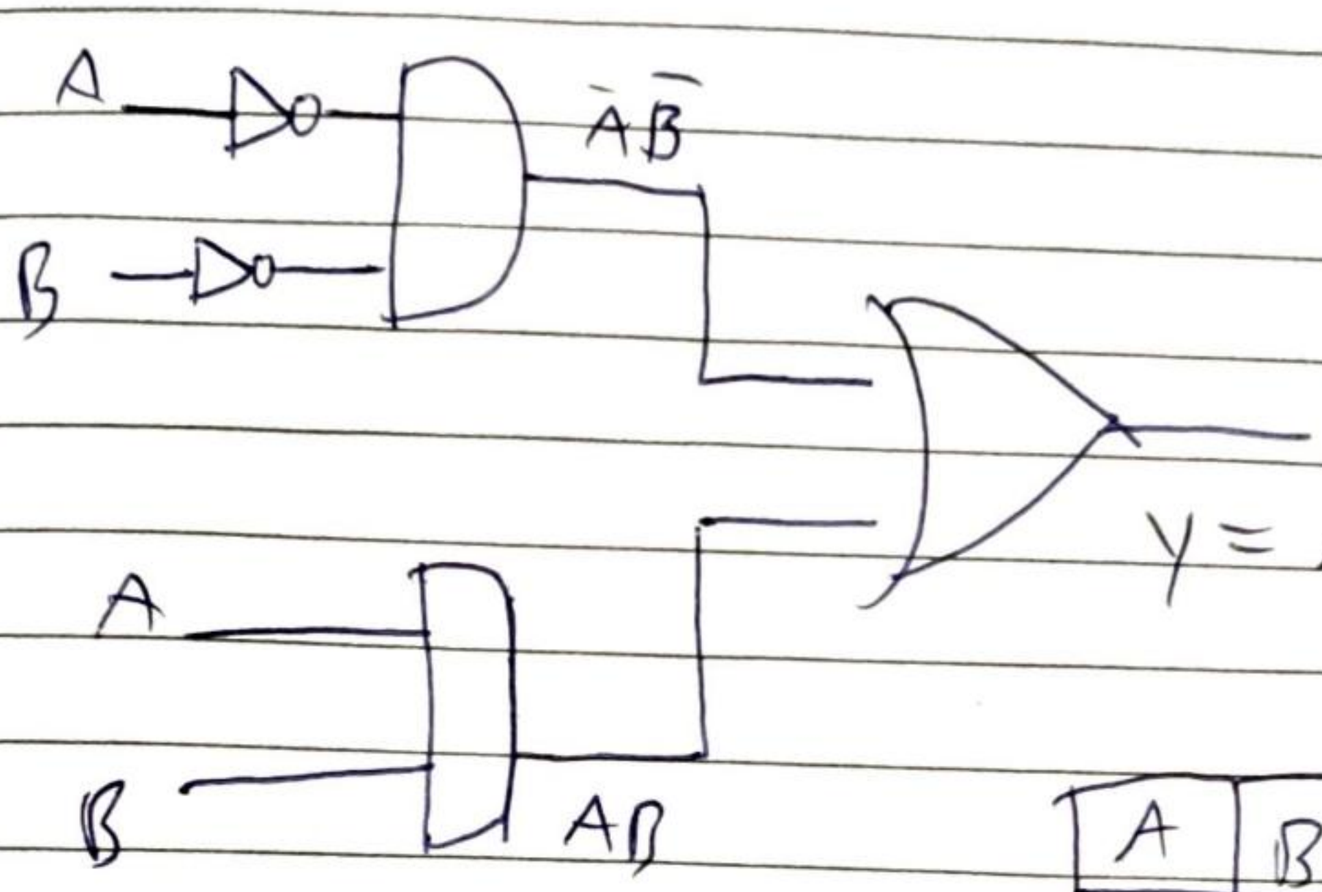
- Exclusive NOR (XNOR) →



$$Y = \bar{A}\bar{B} + AB$$



$$Y = \bar{A}\bar{B} + AB$$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Convert Decimal to any other →

- $(19.35)_{10} \rightarrow (\ )_2$

$\div 2$ ← 19 ; 35 → $\times 2$

$\Rightarrow (10011.0101)_2$

2	19	1
2	9	1
2	4	0
2	2	0
2	1	0

10011

.35 x 2

.70	0
×2	
1.40	1
.40×2	
.80	0
.80×2	
1.60	1

0101

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Same for $()_8$ & $()_{16}$

Convert other base to decimal →

- $(1101.01)_2 \rightarrow (\ )_{10}$

$1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 \cdot 0\times2^{-1} + 1\times2^{-2}$

$8 + 4 + 0 + 1 \cdot 0 + \frac{1}{4}$

$(13.25)_{10}$ Ans

Same for $()_8$ & $()_{16}$

Conversion b/w any base of power 2 →

Binary , Octal , Hexa
2^1 2^3 2^4

- ~~$(11011.110)_2 \rightarrow (\ )_8 \Rightarrow (33.6)$~~

add 0 011

~~Since octal has 3 bit pairs (000, 001 .... 111)~~
~~∴ divide in group of 3~~

First convert to decimal, then decimal to desired

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~~# Subtraction using 1's complement ->~~

~~(i)~~

1's complement ->

1011010 → 0100101
(Inverse the digits)

2's complement

110110

001001
+ 1

001010 → 2's complement

OR

10100 ← (Jab tak pehla 1 nhi milta, write as it is, after that change)
2's → 01100

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- Subtraction using 1's complement ->

X-Y

(i) Take 1's complement of Y
(ii) Add 1's complement of Y to X
(iii) If addition results in output carry, remove carry & add it to the result.
(iv) Here, if the signbit is 0, then the result is +ve, If signbit is 1, the result is 1's complement of step 3.

Q $(111001)_2 - (110001)_2$

$Y = 110001$
$Y' = 001110$

$X + Y' =$

```
  111001
  001110
  ------
1 000111
        +1
  ------
  001000
  ------
```

signbit Ans

Q- $(01010)_2 - (00011)_2$

$Y = 00011$
$Y' = 11100$
$X + Y' =$

```
  01010
  11100
  -----
1 00110
        1
  -----
  00111 Ans
```

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Q $(100101)_2 - (110110)_2$

$Y = 110110$
$Y' = 001001$
$X + Y' =$

$$\begin{array}{r} 100101 \\ 001001 \\ \hline 101110 \end{array}$$

↓
Signbit

1's complement
⇒ -010001 Ans

Sub. using 1's complement →

(i) Take 2's complement of Y
(ii) Add 2's of Y to X.
(iii) If the addition result in output carry then discard this carry.
(iv) If the answer obtained in step 3 has its signbit 0, then it is desired the answer, If signbit 1, then result is 2's complement of step 3 & -ve.

Q $(111001)_2 - (110001)_2$

$Y = 110001$
2's of Y = 001111
X + 2's of Y =

$$\begin{array}{r} 111001 \\ 001111 \\ \hline 1\,001000 \\ \hline \end{array}$$

Ignore

$\boxed{001000}$ Ans

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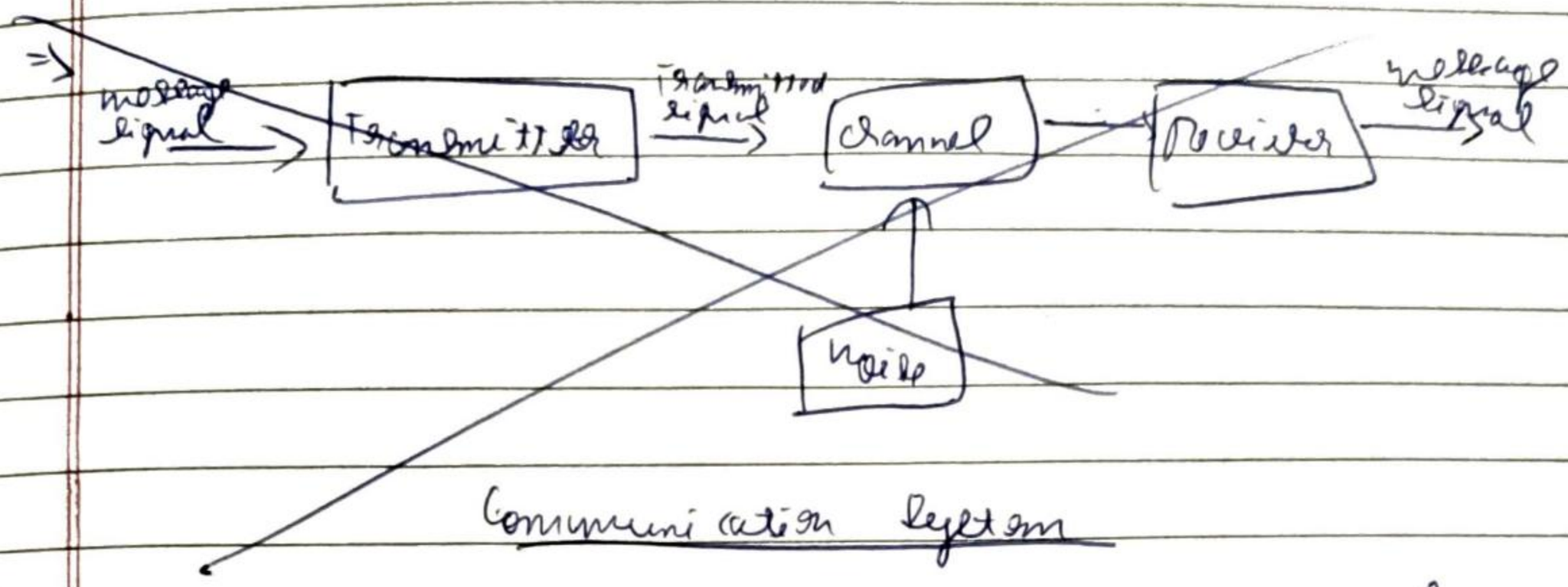
Q5 Analog communication →

Q Elements of a communication system.

⇒



Communication system

⇒ Sender → Transducer → Transmitter → Channel → Receiver → Output Transducer → O/P signal

- Transmitter →
The transmitter consists of a transducer, modulator, amplifier & transmitting antenna in radio transmitter.

- Communication Channel →
The duty of communication channel is to carry the modulated signal from transmitter to receiver. The communication channel is also called a transmission link or medium

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Receiver:-

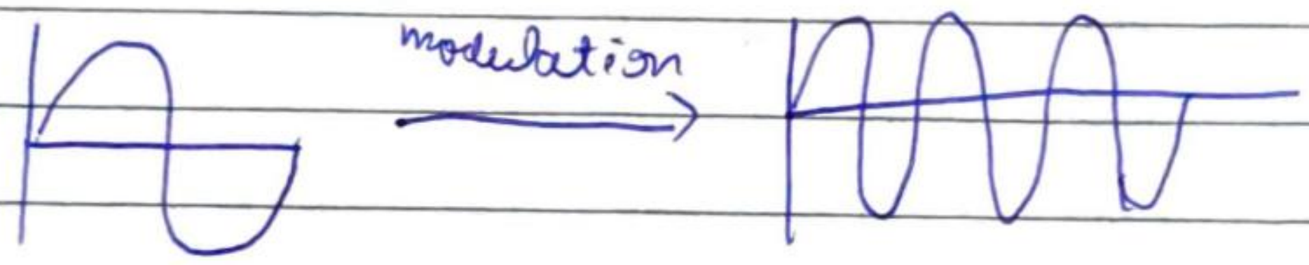
The receiver consists of

- Pickup antenna - To pick the signal
- Demodulator - To separate the audio signal from the modulated signal
- Amplifier - To boost up the weak audio signal
- Transducer - converts back audio signal in the form of electrical pulse into sound waves.

Q What is modulation & demodulation?

=) Modulation -

- It is the process of modulating the base signal over some carrier signal over some distance.



carrier signal
+
Base signal

Demodulation -

- Demodulation is getting the original form back a modulated carrier wave.

- To recover the data from a modulated carrier wave, a demodulator circuit comes in use.

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Q need of modulation ?

=> ① To remove interface problem :

modulation allocates a separate frequency band to different message signal transmissions, many stations can transmit their message signals simultaneously without any interference.

Audio Signal → 20 Hz - 20 kHz

② Practical height of the antenna →

The transmitting & receiving antennas must have lengths comparable to a quarter wavelength ($\lambda/4$) of the freq. used for transmission.

Height of antenna $= \frac{\lambda}{4}$

$(c = \lambda f)$

$\Rightarrow \lambda = \frac{c}{f}$

$= \frac{c}{f}\left(\frac{1}{4}\right)$

(c = speed of light)

Antenna height $\propto \frac{1}{f}$

as $f \uparrow$, antenna height $\downarrow$

After modulation as the freq. incr, it results in decreased height of antenna

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Ex

audio signal → 4 kHz

$$l = \frac{\lambda}{4} \Rightarrow \frac{c}{f}\left(\frac{1}{4}\right)$$

$$= \frac{3 \times 10^8}{4 \times 10^3 \times 4}$$

$$= 0.187 \times 10^5 \text{ m}$$

$$= 18.7 \text{ km}$$ (Pratically impossible)

③ Possibility of multiplexing →

multiplexing can be defined as a process by which two or more signals can be transmitted simultaneously over the same communication channel. modulation helps in multiplexing by using carrier waves of different frequencies

④ Long distance communication →

~~High frequency signals attenuate less as compared to low freq signals.~~

modulation is used for long distance communication. In modulation we use high frequency carrier wave for transmission of the message signal. High frequency signals attenuate less as compared to low frequency signals. Therefore modulation is beneficial for long distance communication.

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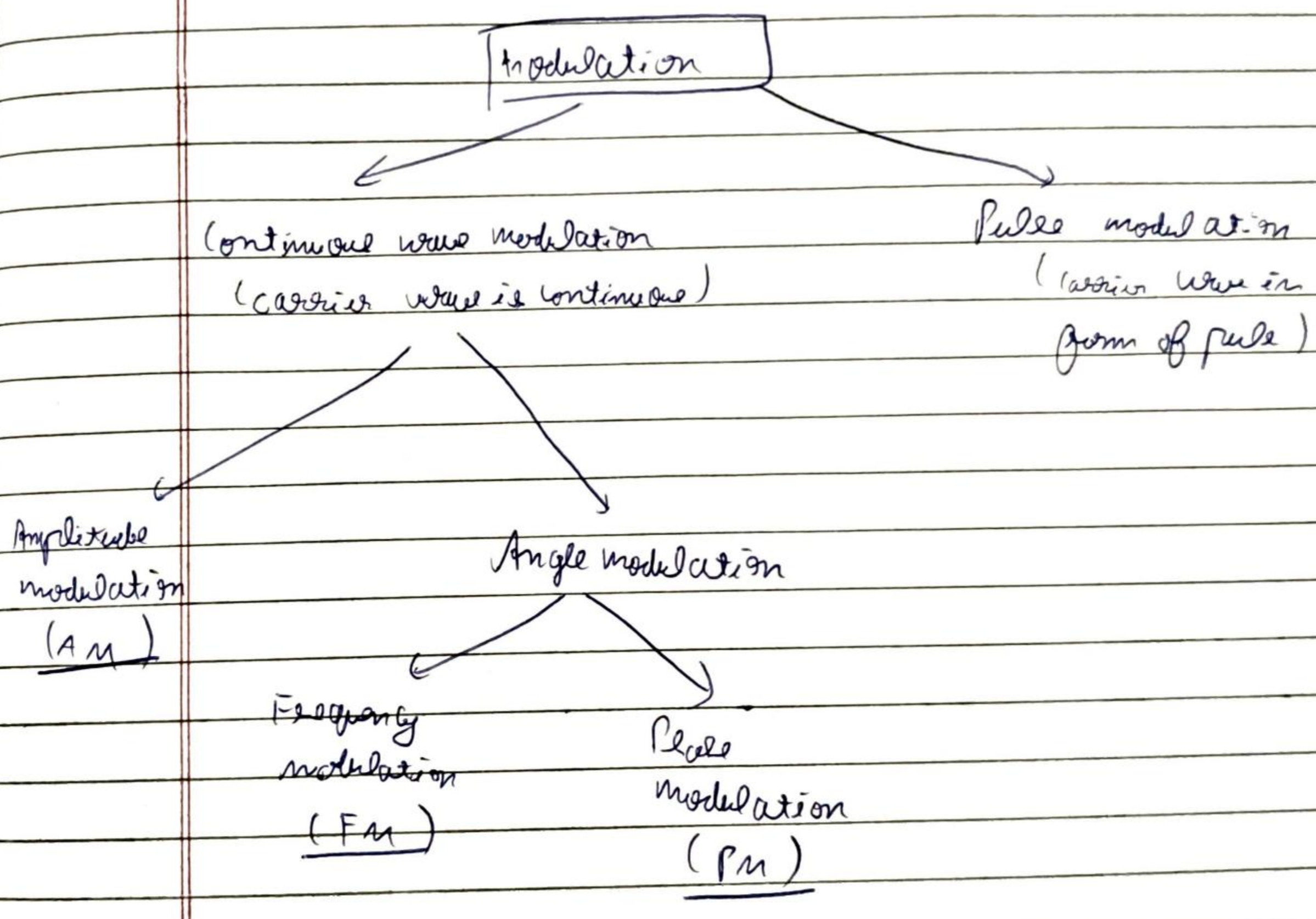
(5) Improved signal quality at the receiver.

Some techniques of modulation like FM have the capability to improve quality of signal received at the receiving end. So it helps in reducing the noise level in signal, which is a ~~bad~~ big advantage of modulation.

Q Types of modulation?



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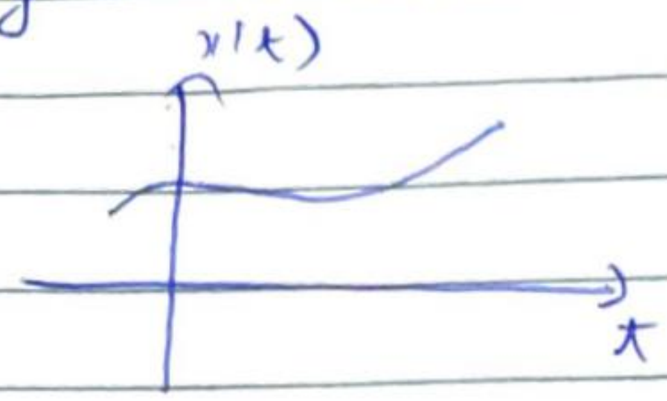
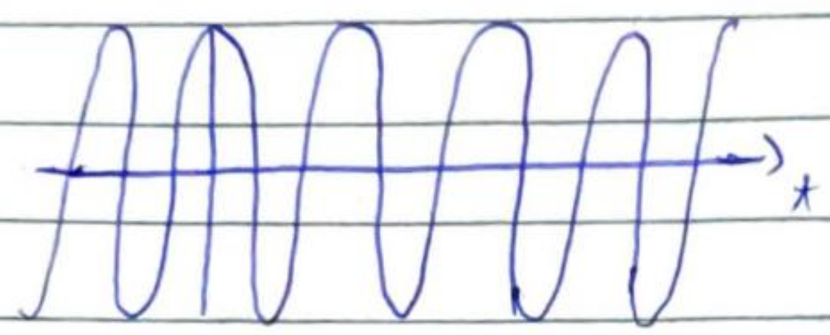
Q What is Amplitude modulation (AM) ?

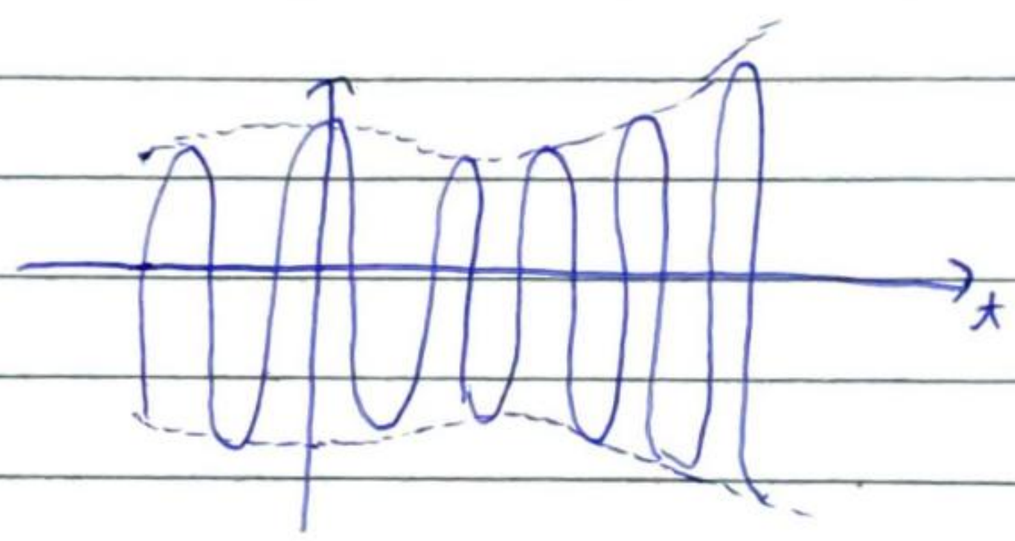
=> The amplitude modulation is the type of modulation, where the maximum amplitude of the carrier wave varies according to the instantaneous value of the message signal.



message signal



carrier wave



modulated wave

~~Fig~~ 4

mathematical Analysis →

Fig $x(t)$ → modulating signal
(message signal)

$A \cos \omega_c t$ → carrier wave
(const. amp. & const. high freq.)

modulated signal

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$$s(t) = [A + x(t)] \cos \omega_c t \quad -(1)$$

$$s(t) = x(t) \cos \omega_c t + A \cos \omega_c t \quad -(2)$$

The unique property of AM is that the envelope of the modulated carrier has the same shape as the message signal or base band signal

$$s(t) = \boxed{[A + x(t)]} \cos \omega_c t$$

↳ Envelop of the AM wave $[E(t)]$

$$E(t) = A + x(t)$$

$$\Rightarrow \boxed{s(t) = E(t) \cos \omega_c t}$$

Q Modulation Index of AM wave?

⇒ <u>Modulation Index (m_a)</u> →

Modulation index in amplitude modulation system is defined as the measure of extent of amplitude variation about an unmodulated maximum carrier.

$$\text{Modulation Index } (m_a) = \frac{|x(t)|_{max}}{\text{max}^m \text{ carrier amplitude}}$$

$$= \frac{|x(t)|_{max}}{A}$$

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Here $|x(t)|_{max}$ = max^m amplitude of modulating (message) signal.

A = max^m amplitude of carrier signal

<u>Percentage modulation</u> →

If modulation index (m_a) is multiplied by 100 i.e.

$m_a \times 100$ ⇒ Percentage modulation

~~To prove~~

$$\because \; m_a = \frac{|x(t)|_{max}}{A}$$

To preserve the modulating signal (message signal) in the envelope of AM signal, it is required

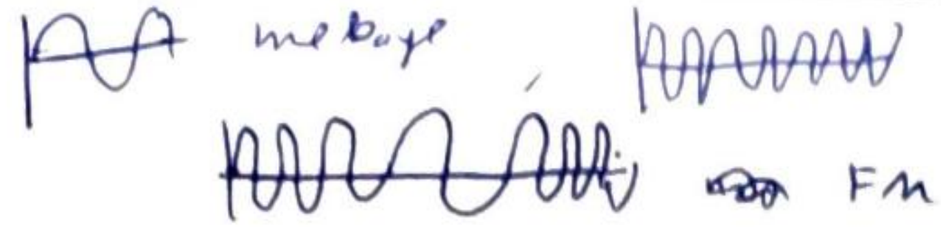
$$\boxed{|x(t)|_{max} \leq A} \quad \text{or} \quad \boxed{m_a \leq 1}$$

But if $|x(t)|_{max} > A$ i.e. $m_a > 1$

The message signal (modulating signal) is not preserved in the envelope.

If $m_a > 1$, then the message signal received from the envelope would be distorted. This kind of distortion is called as Envelope Distortion.

The amplitude modulated signal with $m_a > 1$ is known as "overmodulated signal".



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Q What is Frequency modulation?

=) It is that angle of modulation in which the instantaneous frequency ω_i is varied linearly with a message or baseband signal about an unmodulated carrier frequency ω_c

mathematically, $\omega_i = \omega_c + k_f \cdot x(t)$ — (1)

where k_f = proportionality constant

Let the expression for unmodulated carrier signal

$$c(t) = A\cos(\omega_c t + \theta_0) \quad -(2)$$

or

$$c(t) = A\cos\phi \quad -(3)$$

$$\phi = \omega_c t + \theta_0 \quad -(4)$$

ϕ = total phase angle of unmodulated carrier

By frequency modulation →

$$s(t) = A\cos\phi_i \quad -(5)$$

from (4)

$$\phi = \omega_c t + \theta_0$$

$$\frac{d\theta}{dt} = \omega_c$$

Integrate

$$\phi = \int \omega_c \, dt$$

$$\Rightarrow \phi_i = \int \omega_i \, dt \quad -(6)$$

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From ①

$$\phi_i = \int (\omega_c + k_f \cdot x(t))\, dt$$

$$\phi_i = (\omega_c t + k_f \int x(t)\, dt)$$

Put in ⑤

$$\boxed{s(t) = A\cos[(\omega_c t + k_f \int x(t)\, dt]}$$

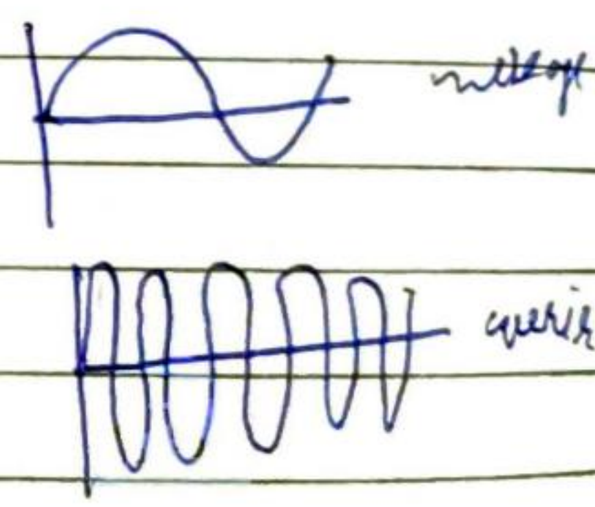
Q What is Phase modulation?

⇒ It is that type of angular modulation in which phase angle ϕ is varried linearly with baseband or modulating signal. ($x(t)$ & the modulated phase angle i.e. $(\omega_c t + \theta_0)$).
If the unmodulated carrier signal is represented as

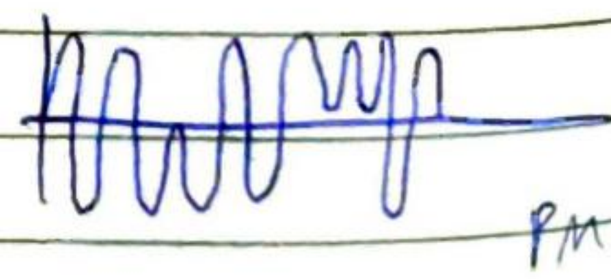
$$c(t) = A\cos(\omega_c t + \theta_0)$$

$$c(t) = A\cos\phi$$

$\therefore \phi$ varies linearly with baseband signal $x(t)$



ϕ_i = inst. value of phase angle



$$\phi_i = \omega_c t + k_p\, x(t)$$

k_p = prop constant

$$\boxed{s(t) = A\cos[\omega_c t + k_p \cdot x(t)]}$$

$\Downarrow$
modulated signal

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Ch 6 Digital communication →

Q Advantages of digital communication?

⇒ • Digital communication system are simple & cheaper compared to analog communication system because of the advancements made in circuit.

• In digital communication, it is possible to use multiplexing to merge speech, video & other forms of data for transmission over a common channel

• High level of privacy can be obtained in digital communication using data encryption technique. This privacy provides the facility to allow the transmitted signals to be received only by the permitted receivers.

• In digital, it is easy to detect & correct error. This is possible due to the use of channel coding.

• In digital channel encoding is used. Because of this encoding, there is less accumulation of noise from repeater to repeater, in case of long distance communication.

Q What is Digital modulation?

⇒ It is a special kind of modulation, where the message signal (modulating signal) is of digital in nature (Binary or M-ary encoded version), & the carrier wave to be modulated is of usually sinusoidal (analog) nature.

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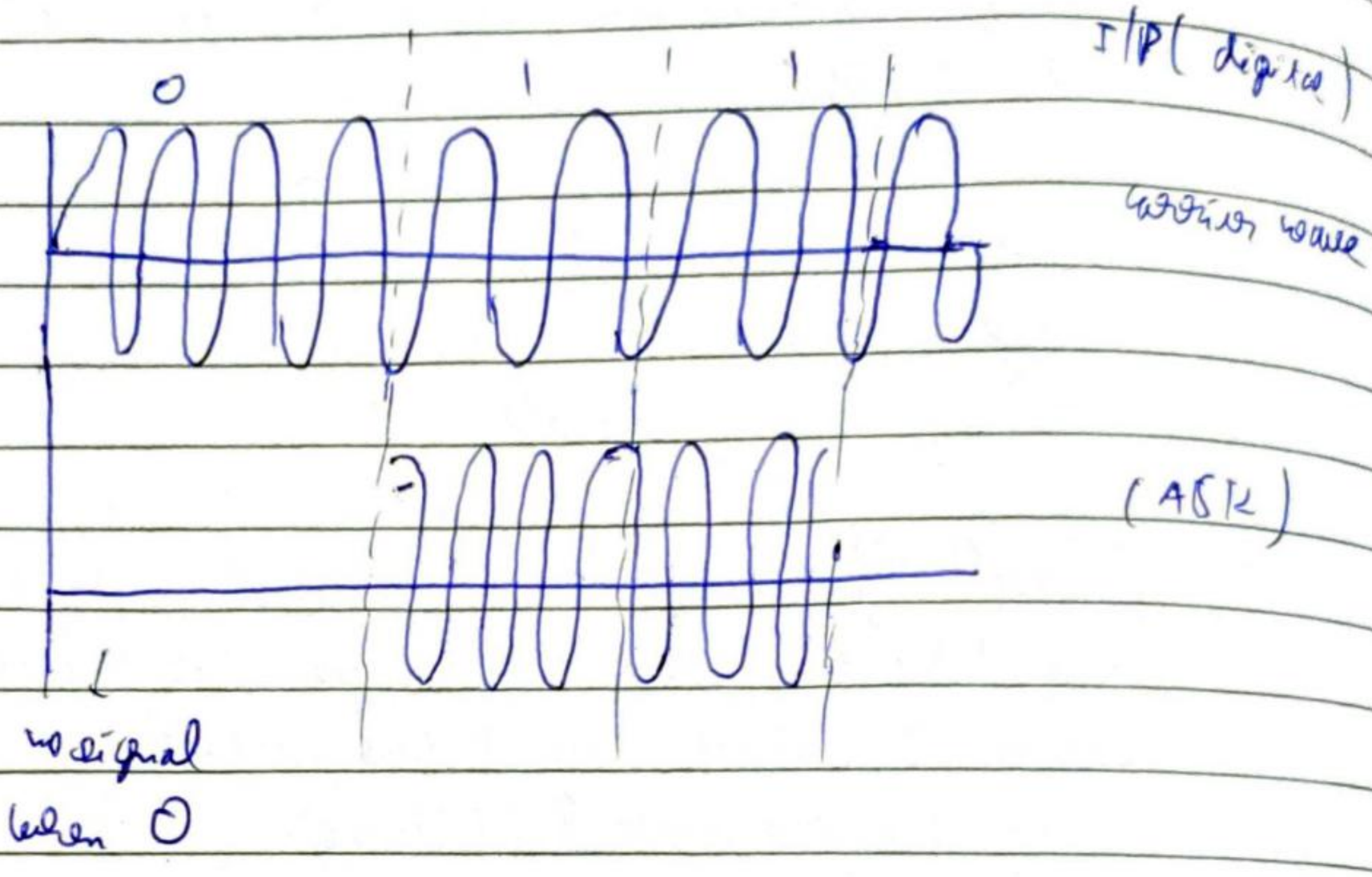
Q What is Amplitude Shift Keying?

=> It is also known as on-off key. In this method, there is only one unit energy carrier & it is switched on or off depending upon the input binary sequence.



$s(t) = \sqrt{2P_s} \cos(2\pi f_c t)$ to transmit '1'

$s(t) = 0$ to transmit '0'

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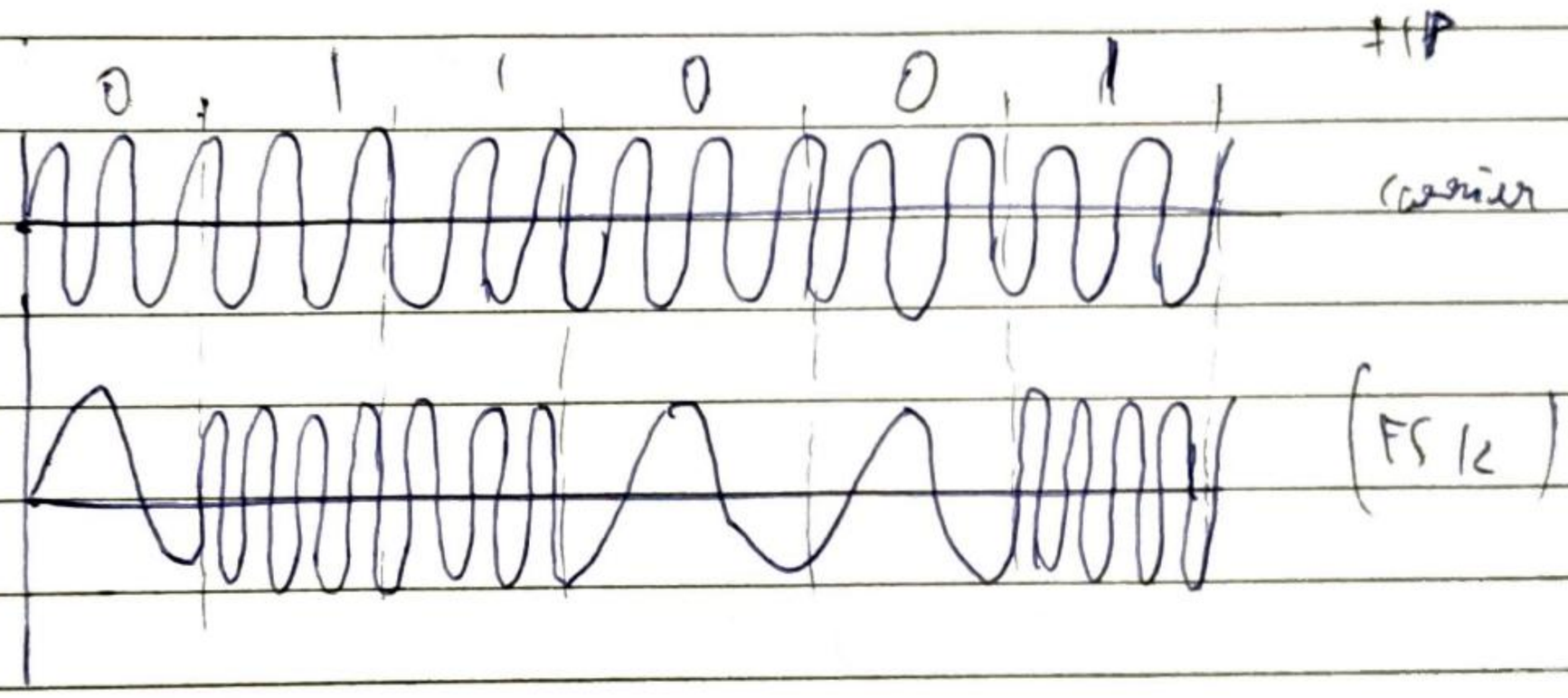
Q What is Frequency Shift Keying?

=> It is a type of digital modulation binary FSK i.e. BFSK

- Binary FSK is a form of constant amplitude angle modulation similar to conventional frequency modulation except that the modulating signal is a binary signal that varies between 2 discrete voltage levels rather than continuously changing.

$$V_{FSK}(t) = V_c \cos[2\pi(f_c + V_m(t)\Delta f)t]$$



Q What is Phase Shift Keying?

=> It is also known as BPSK

- PSK is similar to conventional phase modulation except that with PSK the input signal is binary digital signal & a limited no of output phases are possible.

- logic 0 = 0°
  logic 1 = 180°

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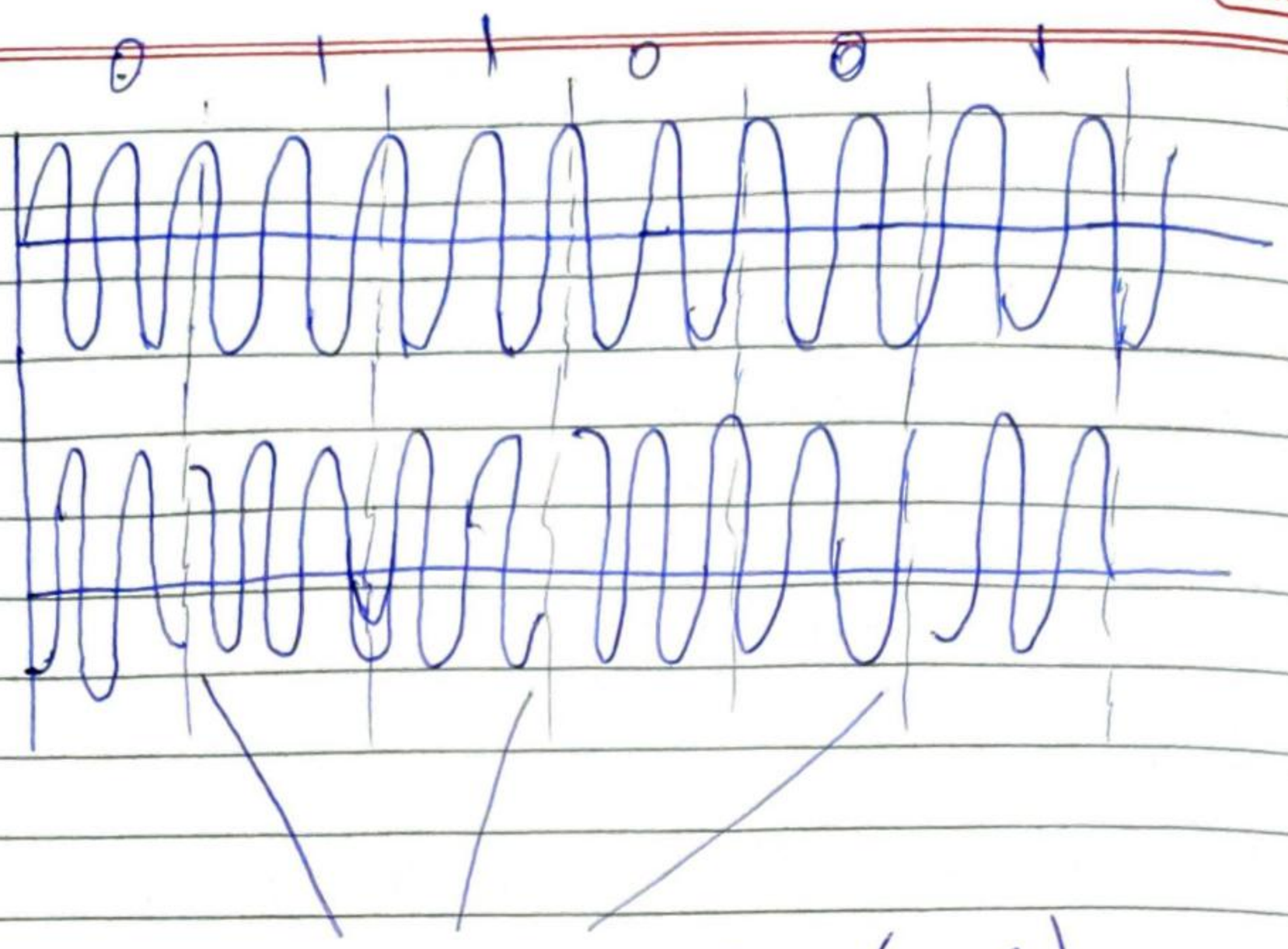
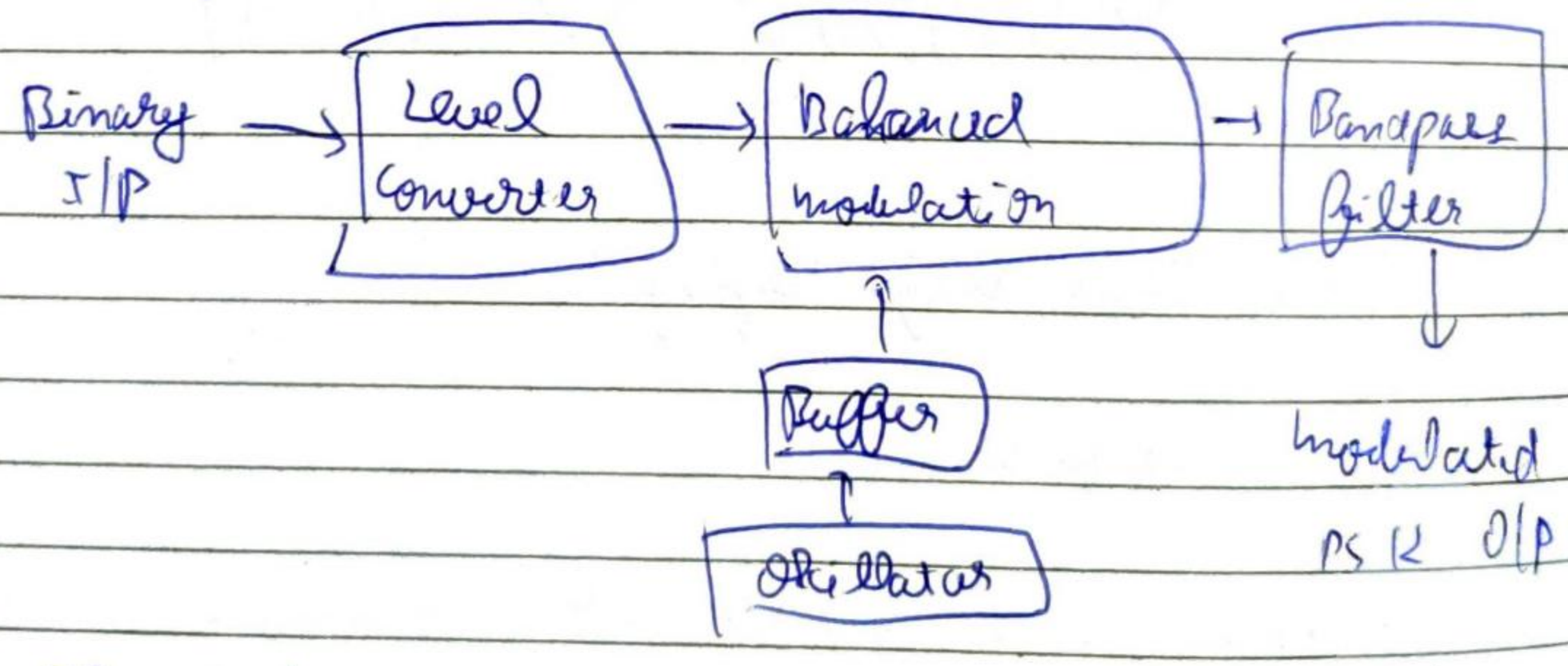


- It is also called phase reversal key

- Block diagram →



- The Balanced modulator acts as phase reversing switch depending on the logic condition of digital I/P, the carrier is transferred to O/P either in phase 0 or 180°.

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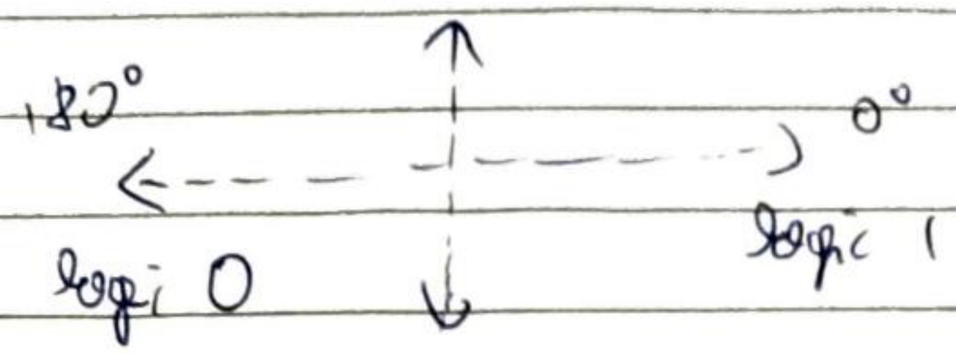
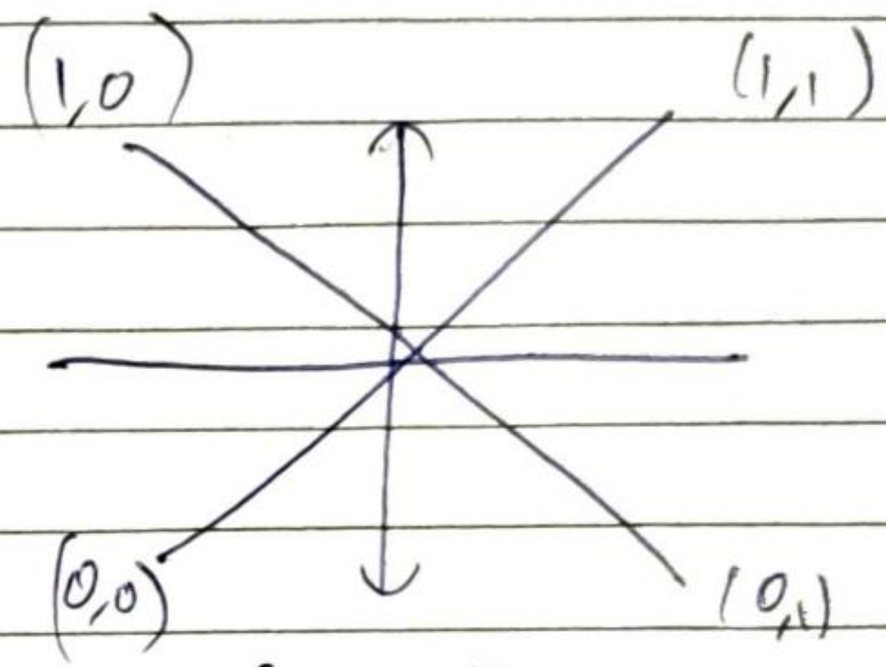


Truth table →

a	I	o/p phase
0	0	-135°
0	1	-45°
1	0	+135°
1	1	+45°



phase diagram

Q What is M-ary encoding?

→ This is the type of digital modulation technique used for data transmission in which instead of one bit, two or more bits are transmitted at a time.

$$N = \log_2 M$$

$N \rightarrow$ no. of bits encoded

$$2^n = m$$

Q PSK is a M-ary encoding technique where $m = 4$. with QPSK 4 output phases are possible for a single carrier frequency. ∴ 4 diff input conditions will be used.