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BEC
Unit 1
Introduction to Semiconductors

Semiconductor : whose conductivity lies b/w a conductor and an insulator.

Conductors
↓
metals
resistance ↓
free flow of e^-

Insulator
↓
wood, rubber

SK Sendey

Semiconductor eg - Si, Ge

There are 2 types of semiconductors -

Intrinsic
- sc in its pure form
- its valence band is completely filled & conduction band is completely empty.
- when some heat energy is supplied to it, some of the valence electrons are shifted to valence band leaving behind holes in the valence band.

Extrinsic

Impurity called dopant is added either as trivalent or penta-valent impurity to ↑ conductivity that's why we add dopant.

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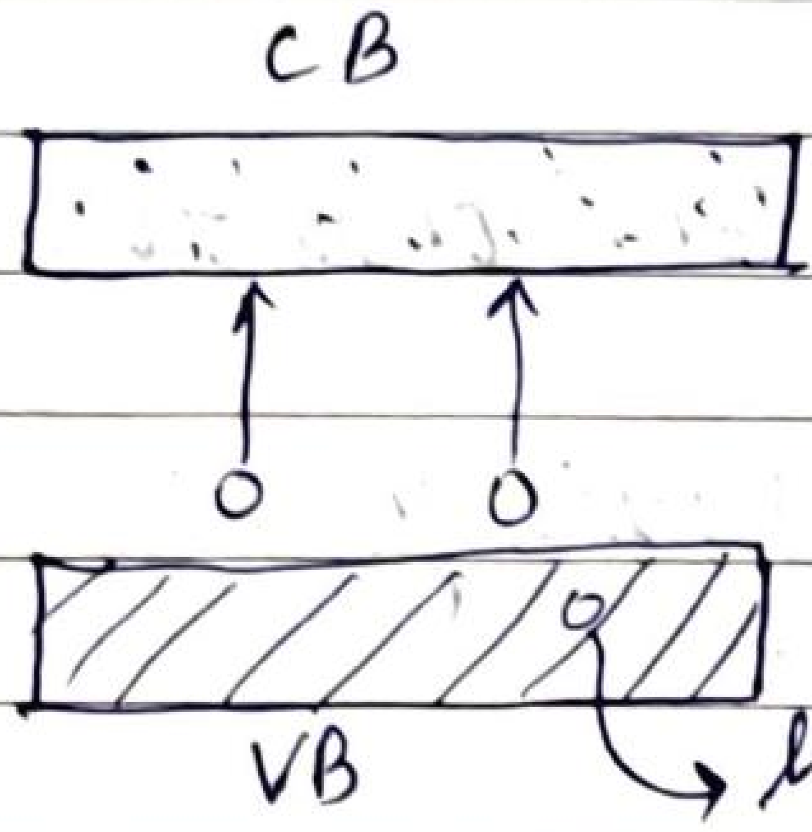
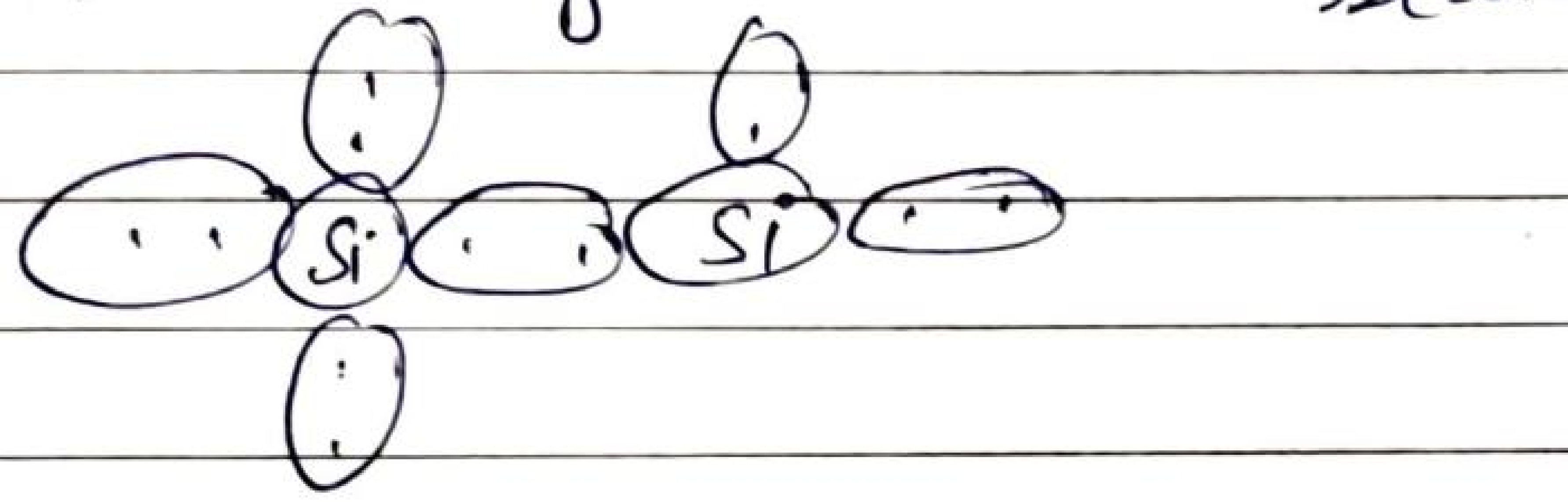


e-s free to move ie electricity is produced.

holes in VB after e-s move to CB.

-ve coefficient of resistivity. ↑ temp ↓ resistivity or become like conductor.



→ Doping: The process by which an impurity is added to a semiconductor is called doping.

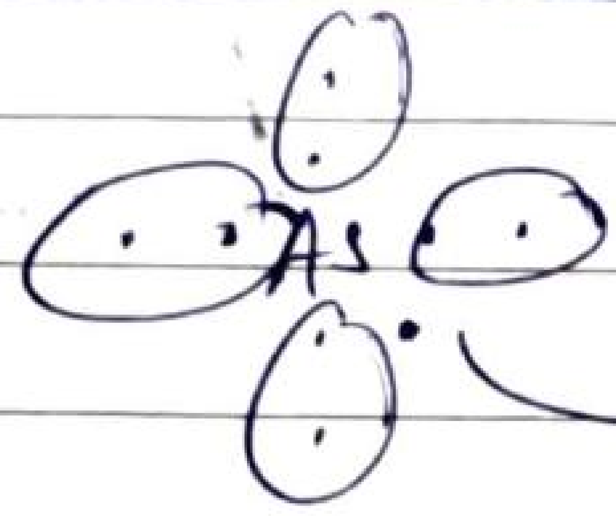
Depending on the type of impurity added, extrinsic semiconductor are classified as -

n-type p-type

- If a pentavalent impurity is added to a pure semiconductor, a large no. of free electrons will exist. This will result in n-type semi-conductor.

If a trivalent impurity is added to a pure semiconductor large no of holes will exist in semiconductor, resulting in p-type Sc.

→ Pentavalent impurity: Arsenic (33)
(2, 8, 18, 5)
↓
pentavalent



→ free e⁻
(n-type semiconductor)

→ Trivalent impurity: Gallium (31)
(2, 8, 18, 3)

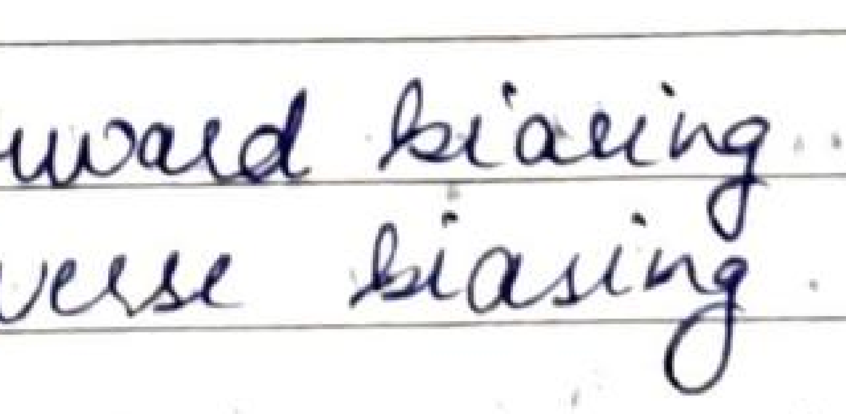
p-type semiconductor.

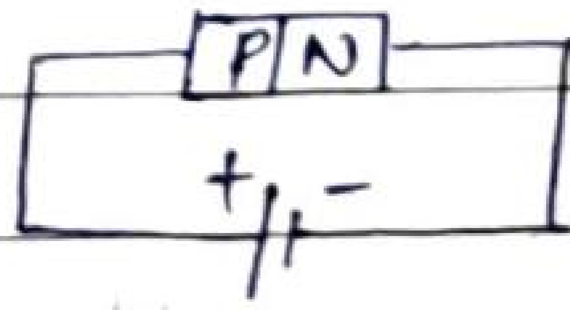
↓
junction
↳ doesn't move e⁻s from p to n or n to p. Its because of high resistance and widened distance between them.

(n type to −ve end
p type to +ve end)

Biasing → forward
→ reverse

(providing voltage from outside)





→ Diode conduct
Biasing → forward biasing
→ reverse biasing

It conducts only in forward biasing not as much as in reverse biasing.

forward ↓

p type + of battery
n type with − ve battery

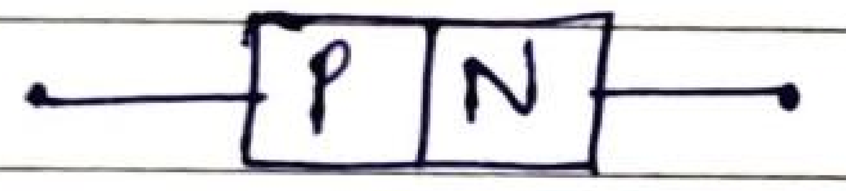
reverse

p → −
n → +

- Diode conduct when forward biased.
  p → n junction diode.

⇒ Semiconductor Diode −

Diode has 2 terminal and 1 junction.

 2 terminals.

transitor : has 3 terminal, 2 junction
pnp npn

smartwatches − all made up of diode, transistor

- basic diode is pn junction.
  p → majority e^- minority holes
  n → majority holes minority e^-

At room temp., holes will try to merge in e^- and e^- to merge in holes and after diffusion they create a potential barrier. But at some time only they can recombine so due to potential barrier now not able to recombine.

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potential barrier

potential barrier : is voltage

So we give extra source of voltage so that they can recombine and extra source of voltage is called biasing.

forward biasing

$0.3\,V \rightarrow Ge$
$0.7\,V \rightarrow Si$

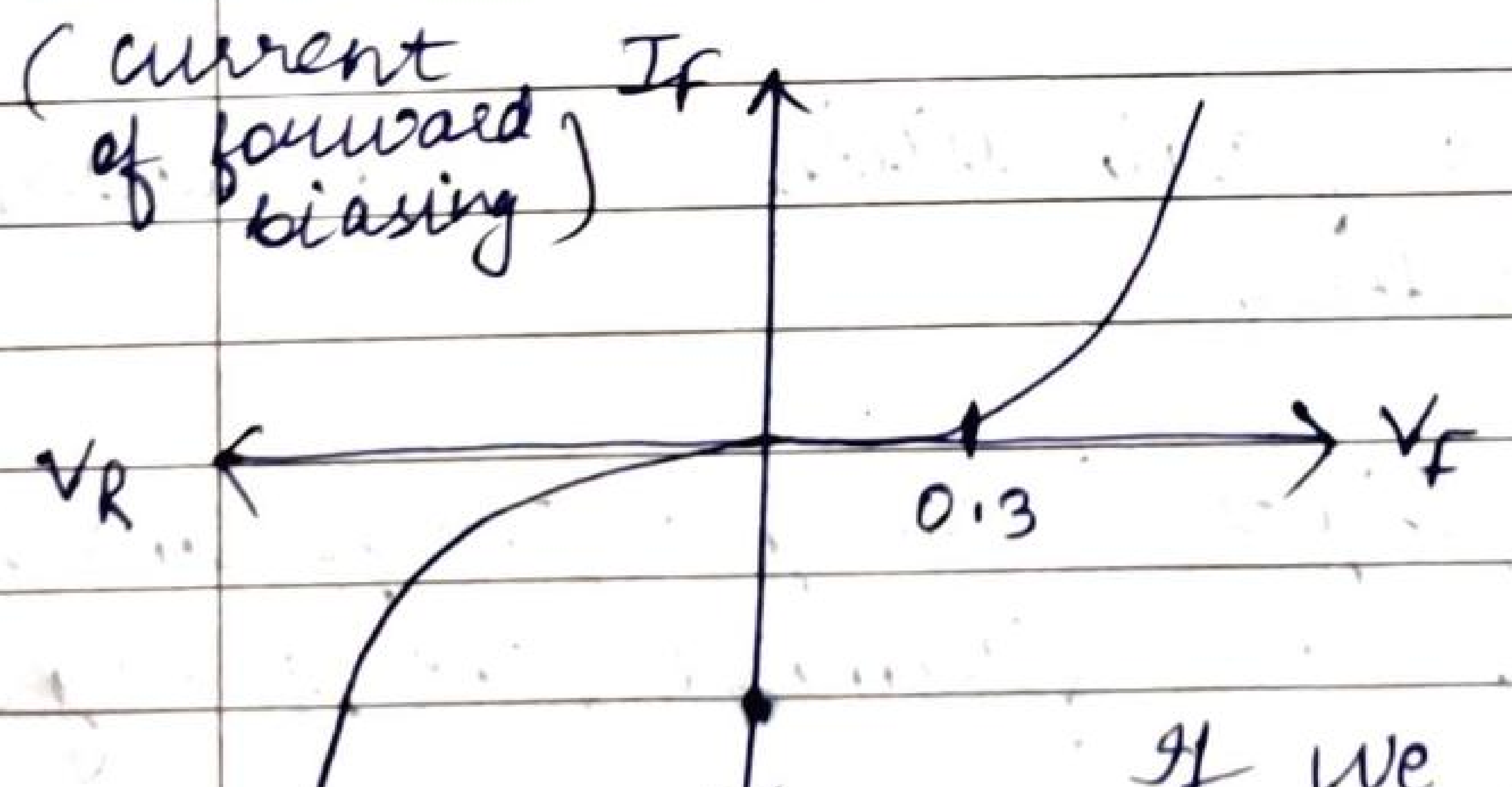
So due to forward biasing, potential difference will be there and there will be a change of electrons

reverse biasing

$P \rightarrow -$
$N \rightarrow +$

We need 0.3 on Ge then 0.3 V to cross the voltage is potential barrier.

In this potential barrier will be more wide and no current flow.



V-I characteristic of forward biasing

If we give max voltage to diode up to its breakdown potential, it will lead to breakdown voltage.

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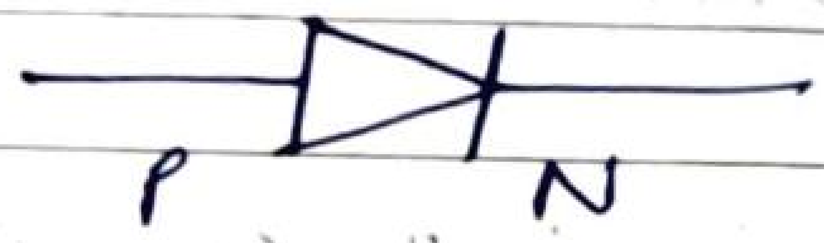
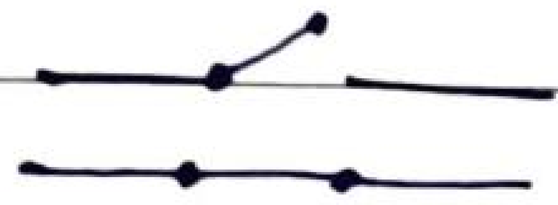
Symbol of diode -

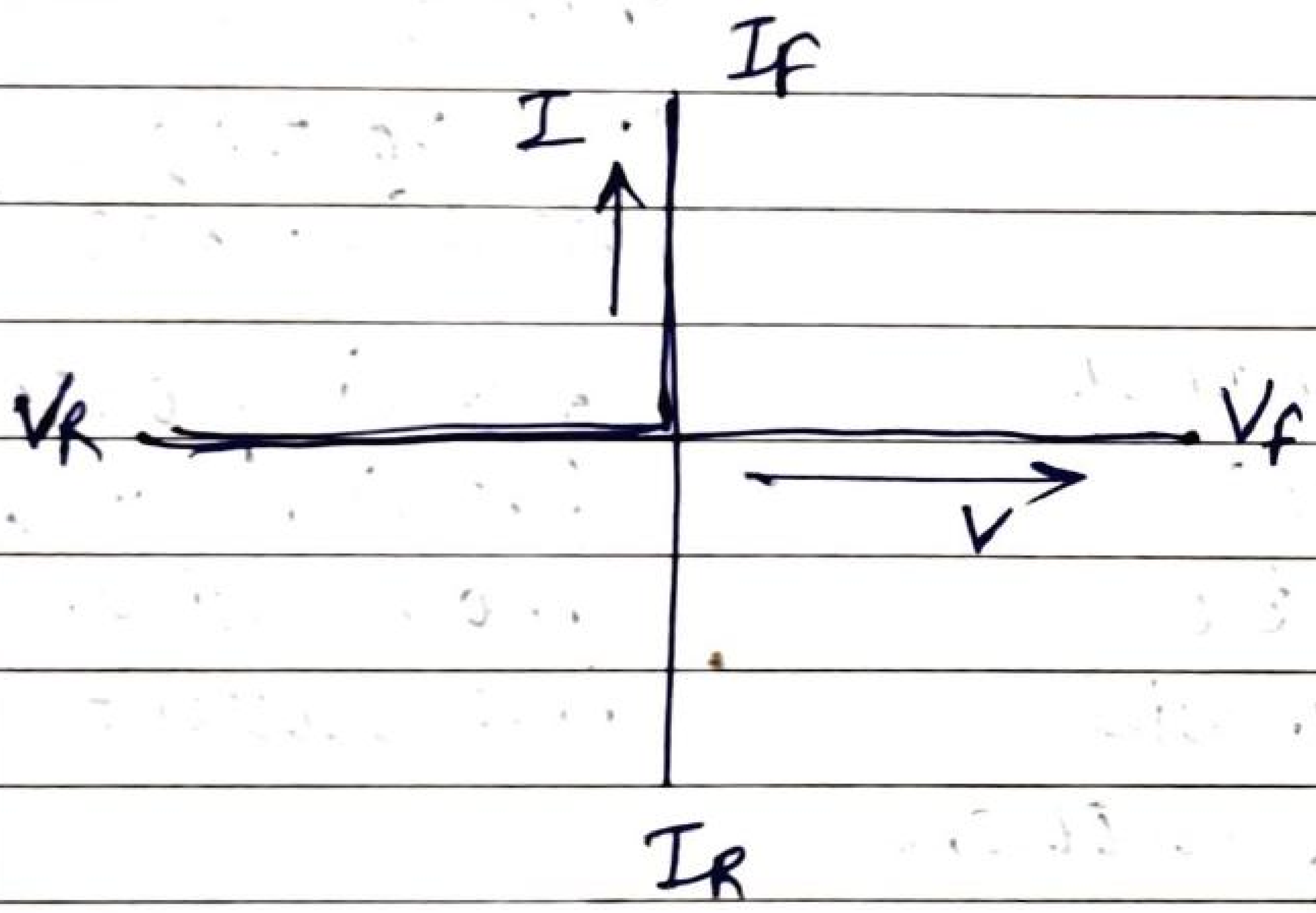


→ Ideal diode : means if forward bias so work as close switch means no current should go in reverse biasing.
Ideal diode to work as close or open switch.



open switch
closed switch

Charactoristic



value of current in reverse should be 0 ie. 0 reverse current means with very low voltage current shootup.

→ Diode also called crystal diode as semiconductor have crystal structure.

Merits : compact, light in weight, very small, occupy less space, no filament, very high efficiency.

Demerits : can't stand with very high P-V. cannot be operated at very high temp.

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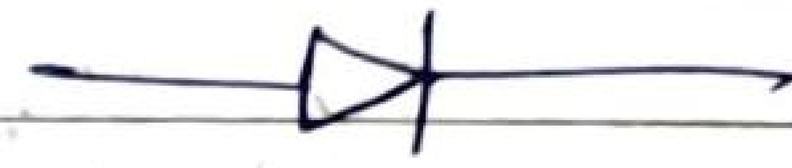
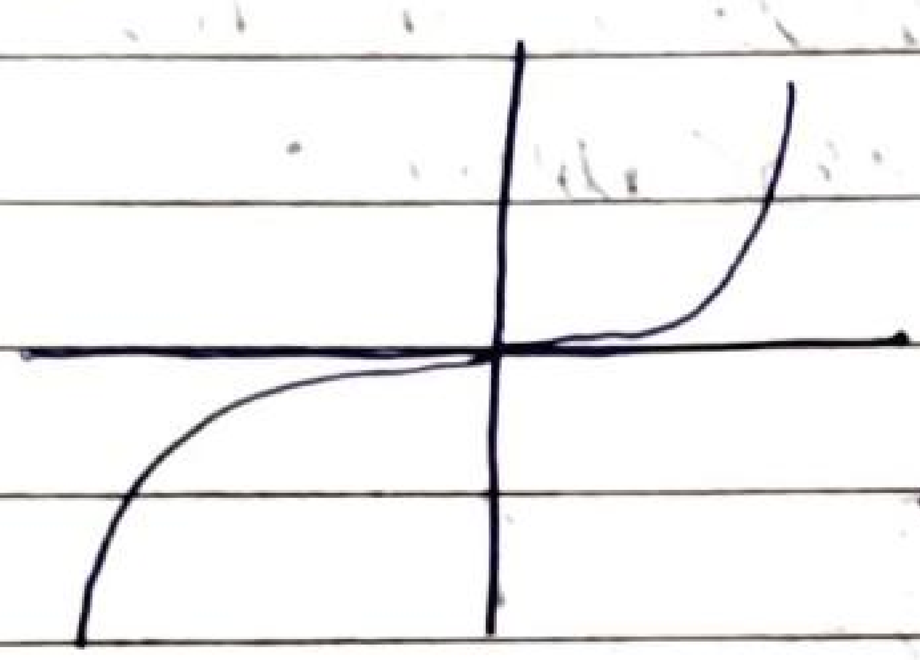
Zener Diode : (special diode)

LED diode, photodiode.

Works in reverse breakdown feature (also in zero, forward bias).
It has sharp breakdown region construction in such way that sharp breakdown in reverse region.

symbol :- 



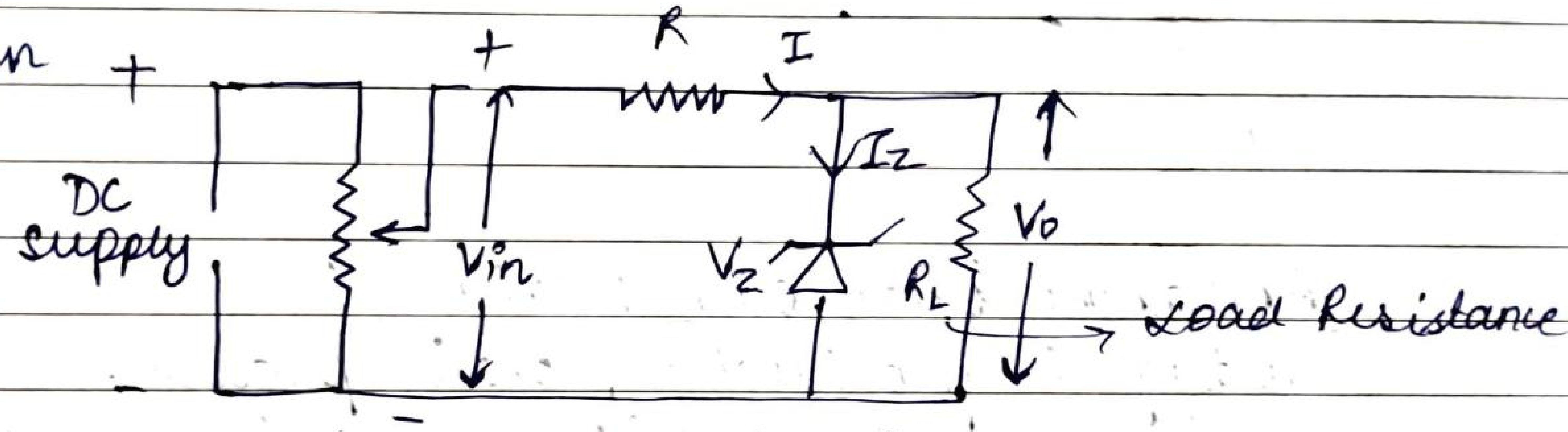
Avalanche breakdown : Thicker junction when voltage is provided. , chain process.
• minority add up with more minority carrier and shoot up.
For thicker junctions the breakdown mechanism is by the process of avalanche breakdown when the electric field existing in the depletion layer is sufficiently high. The velocity of carrier crossing the depletion layer ↑. These carrier collide with crystal atoms. some collision are so violent that e⁻ are ~~known~~ knocked off the crystal.

Creating e⁻ hole pairs. These pair attain high velocities to cause further pair generation through more collisions. This is a cummulative process and as the breakdown voltage approaches the field becomes so large that the chain of collisions can give rise to almost ∞ current. This is known as avalanche breakdown.

Zener breakdown: Takes place in a thin junction when the electric field becomes high in the depletion layer with only a small applied reverse biased voltage. Therefore some electrons jump across the barrier from valence band in p-material to unfilled conduction band in n-material. This is known as zener breakdown.

Imp.

Application of zener diode



zener diode as Voltage Regulator

$$\underbrace{V_{in} - V_Z}_{\text{voltage drop accross } R} = R$$

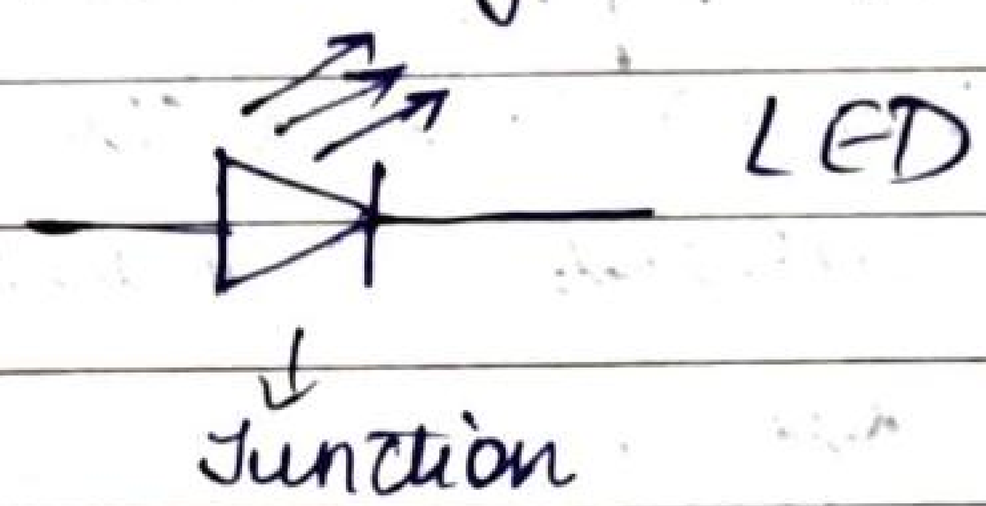
This is also known as voltage stabalisation

Let a variable Voltage V_{in} be applied across load R_L ~~when the~~.

(i) when $V_{in} < V_Z$, no current flows through it and the same voltage appears across the load.

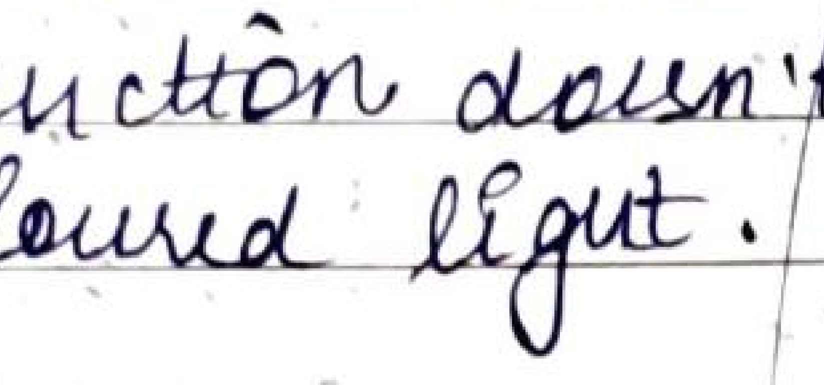
(ii) When $V_{in} > V_Z$, this will cause the zener diode to conduct a large current I_Z consequently more current flows through series resister R which $\uparrow$es the voltage drop across it. Thus, Vin excess of V_Z ie $V_{in} - V_Z$ is absorbed by the series resister. Hence, a constant voltage V_o ($= V_Z$) is maintained across load R_L.

⇒ LED (Light Emitting Diode): Special purpose diode because it emits light as normal p-n junction doesn't emit light. It emits different coloured light.

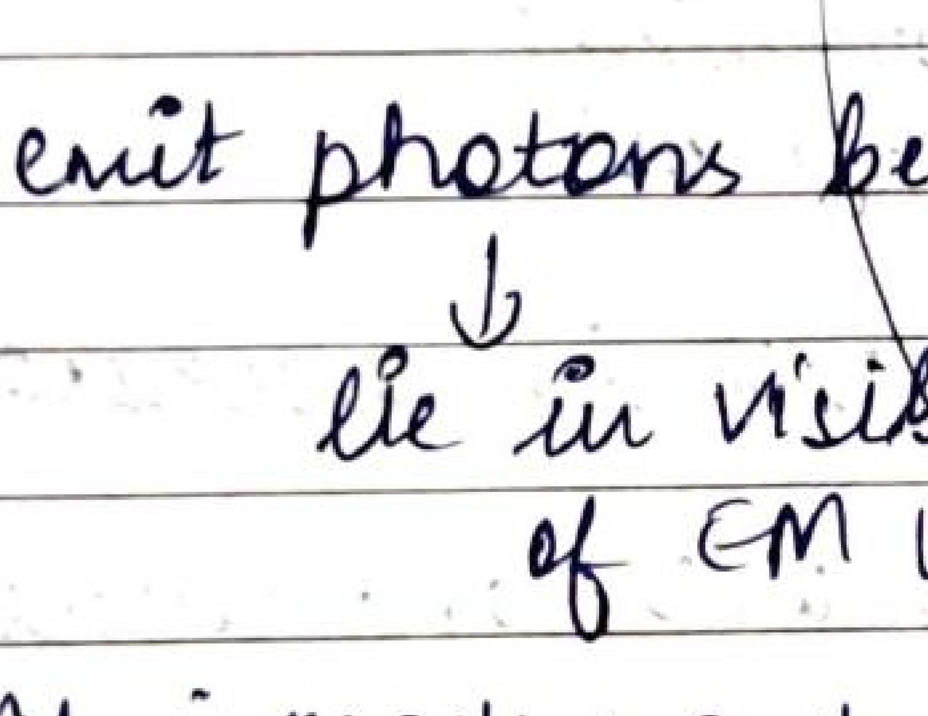


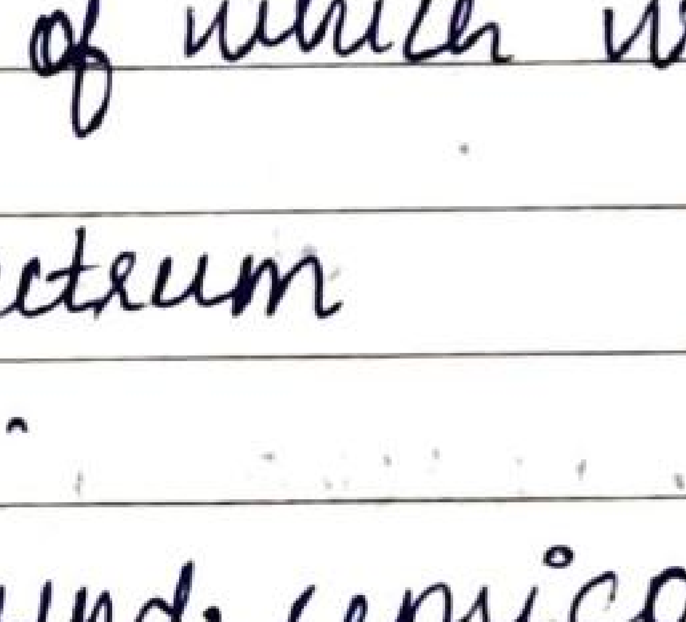
- emit photons because of which we can see light.
  ↓
  lie in visible spectrum of EM waves.

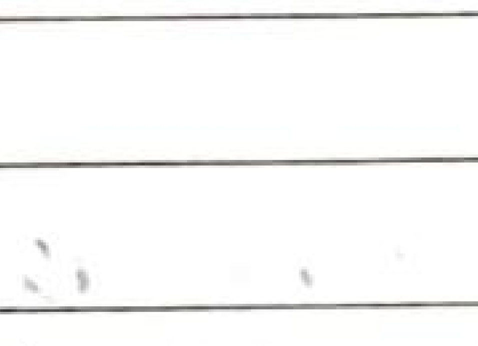
It is made up of compound semiconductor due to which it emits light.



~~lower~~ higher energy to lower energy thats why releases energy and emits light.







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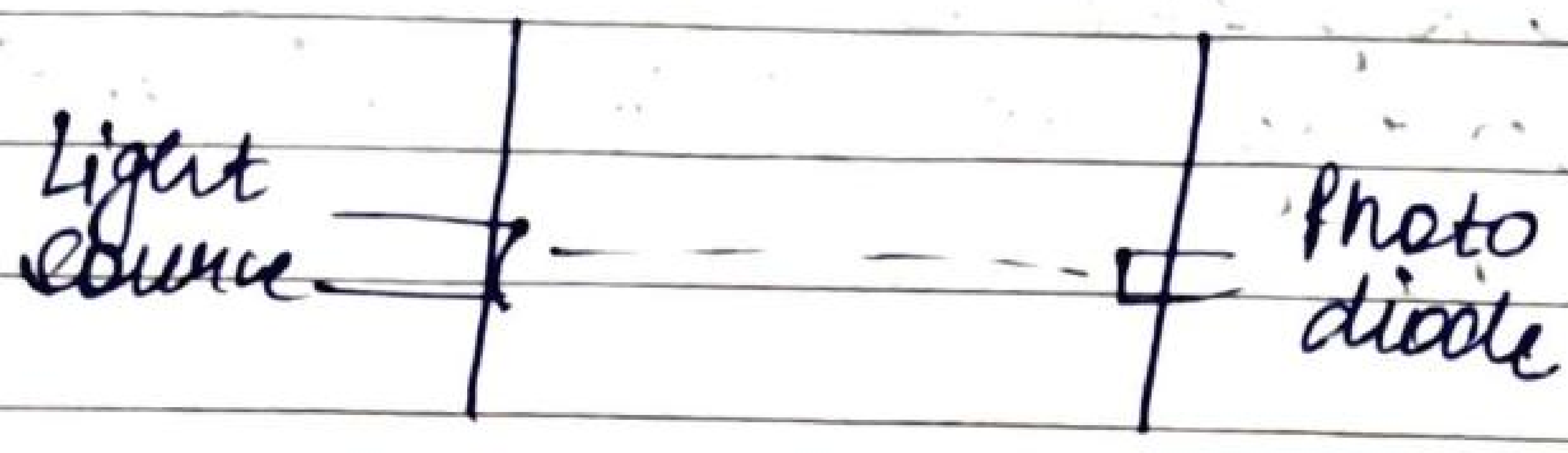
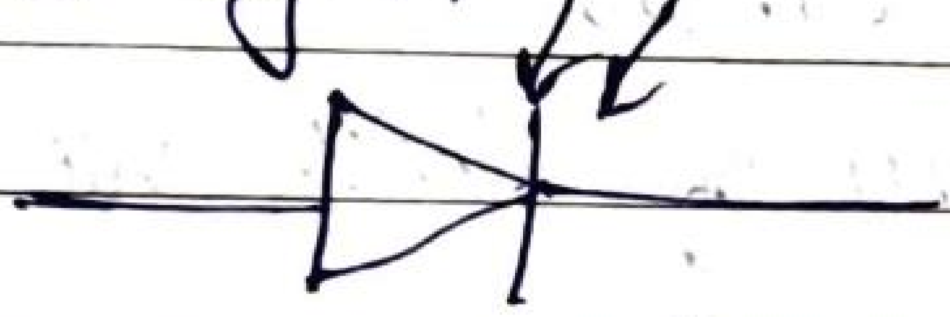
⇒ Photodiode : used for object identification and home security system.



By less no. of minority carrier when current is generated it is called as dark current.

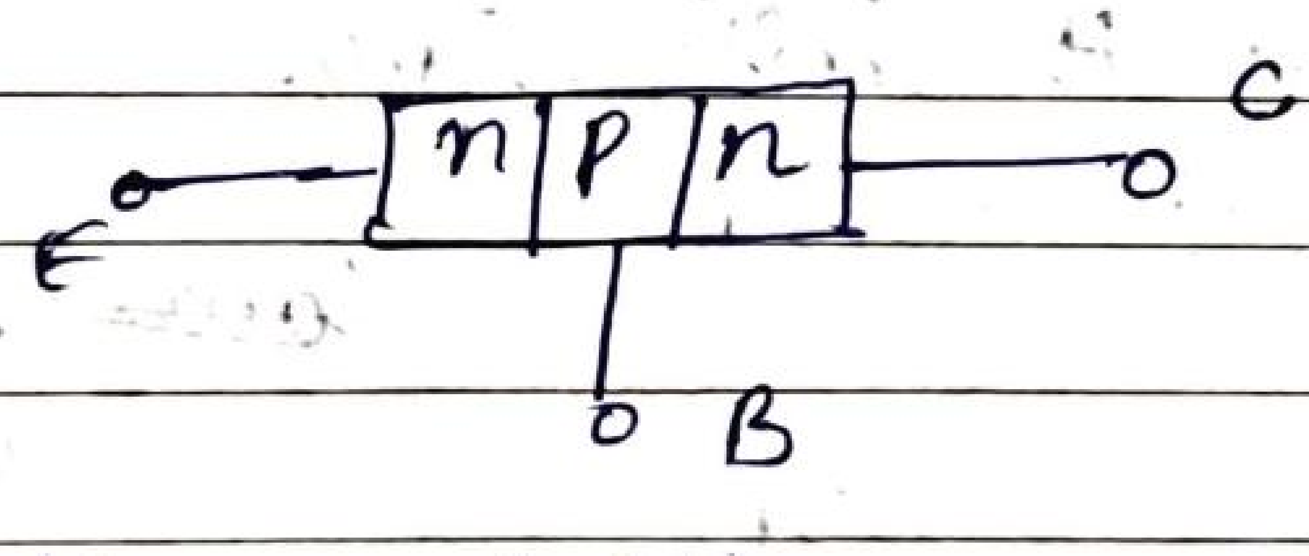
In malls when we enter we see footfall & they have count of person. There photodiode is used. We have broken the flow of current & count increases by 1.



It is connected in reversed biased.

The dark current always works on reverse biasing.

⇒ Transistors



npn
pnp

3 terminals → Emitter
→ Base (thin)
→ Collector

BJT – Bipolar junction transistor

Emitter : Base → forward biased
Base : Collector → reverse biased.

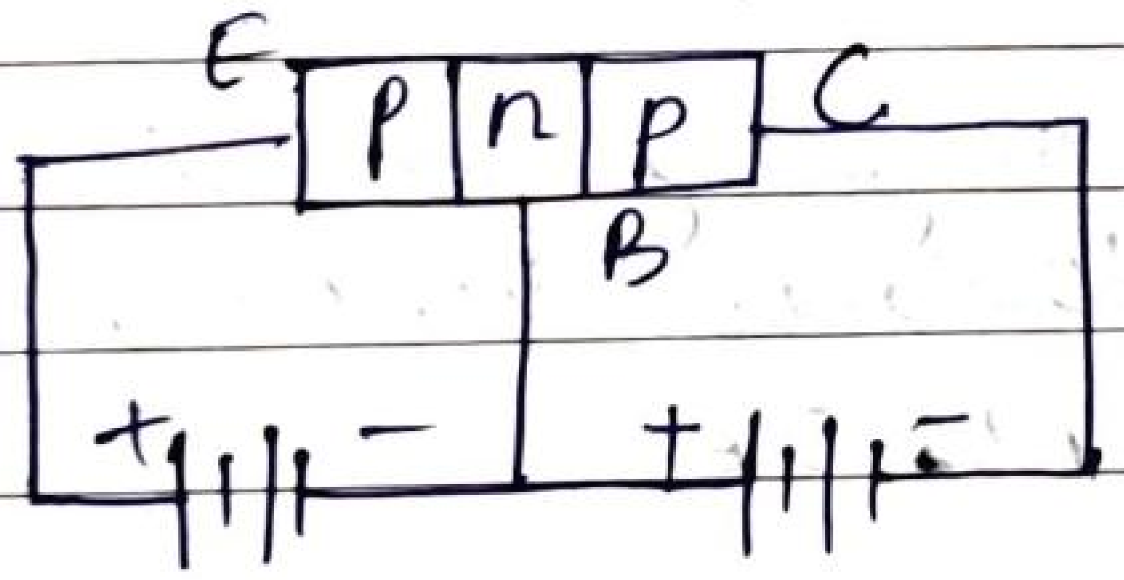
⇒ Emitter : Supplies large no. of majority carriers.

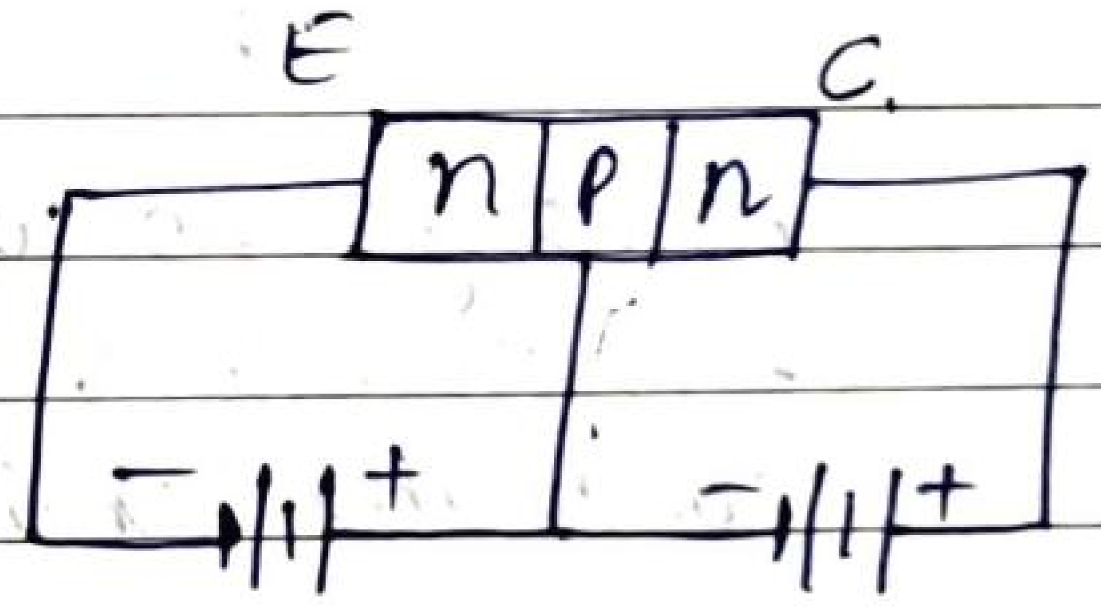
- It is always forward biased w.r.t base so as to supply large no. of majority carrier to its junction with the base.
- It is heavily doped but moderate in size.

⇒ Collector : It collects the major portion of the majority carriers supplied by the emitter.

- Collector base junction is reverse biased.
- It is moderately doped but larger in size so that it can collect most of the majority carrier ~~select by~~ supplied by emitter.

⇒ Base : The middle part is base. Base forms two circuits.





The base emitter junction is forward biased providing low resistance and base collector junction is reversed biased offering high resistance path.

The base is lightly doped and very thin so that it can pass on most of the majority carriers supplied by emitter to the collector.

Configuration –

common base

common emitter

Common collector

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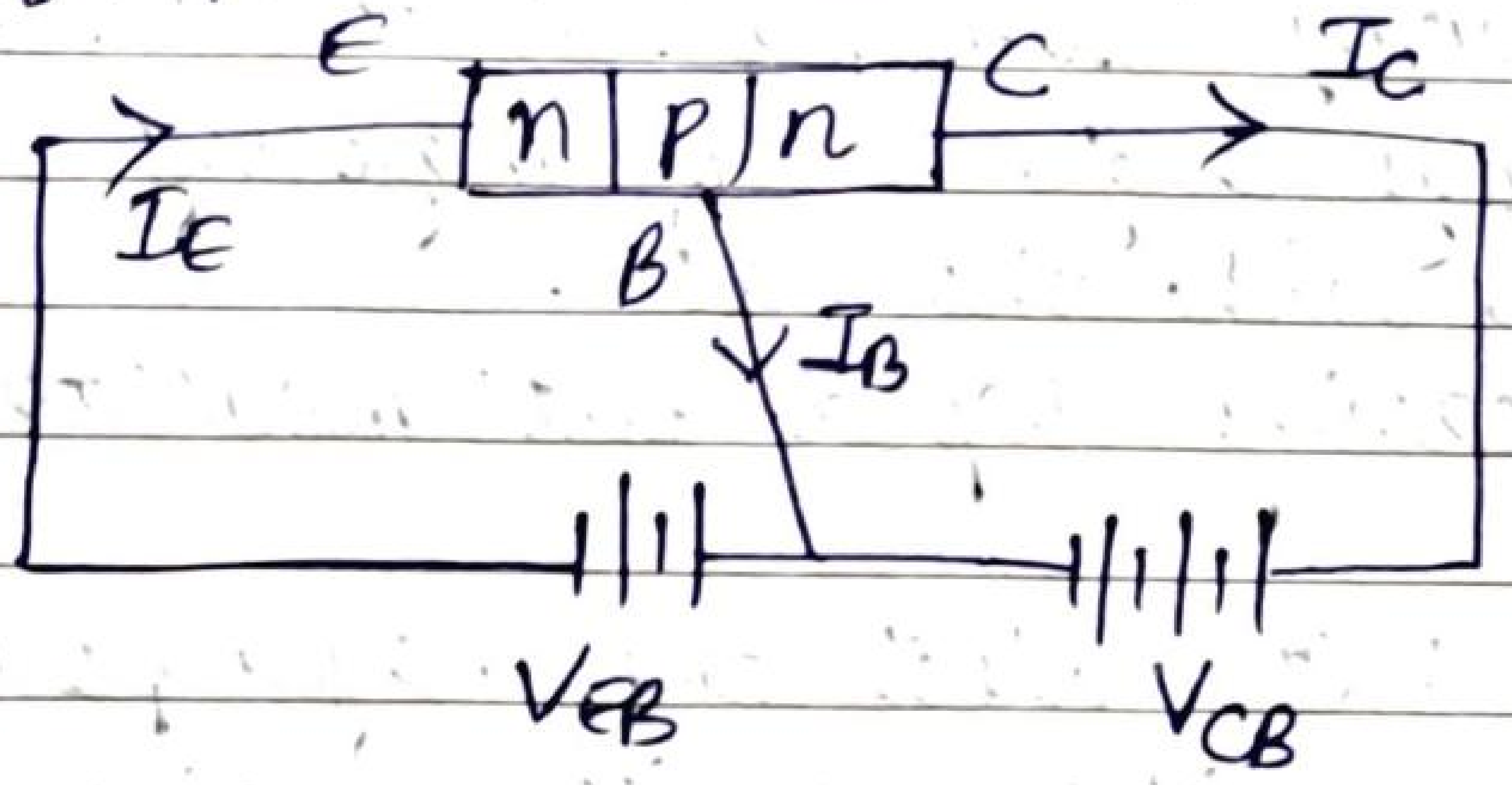
Working of npn transistor –



I_E inwards then
I_C and I_B outwards

$\boxed{I_E = I_B + I_C}$

The emitter base junction is forward biased. The voltage V_{EB} is quite small and reverse biased voltage V_{CB} is considerably high because of E.B junction is forward biased

A large no. of e⁻s (majority carriers) in the emitter are pushed towards the base. This constitutes emitter current I_E.

When these e⁻s enter the base region, they combine with the holes. Since the base is lightly doped and is thin. Only a few e⁻s (less than 5%) combine with the holes and constitute base current I_E, the remaining e⁻s diffuse across the thin base region and reach under the collector, comes under the influence of +vely biased n-region. Therefore, they are attracted towards the collector and constitute collector current I_C.

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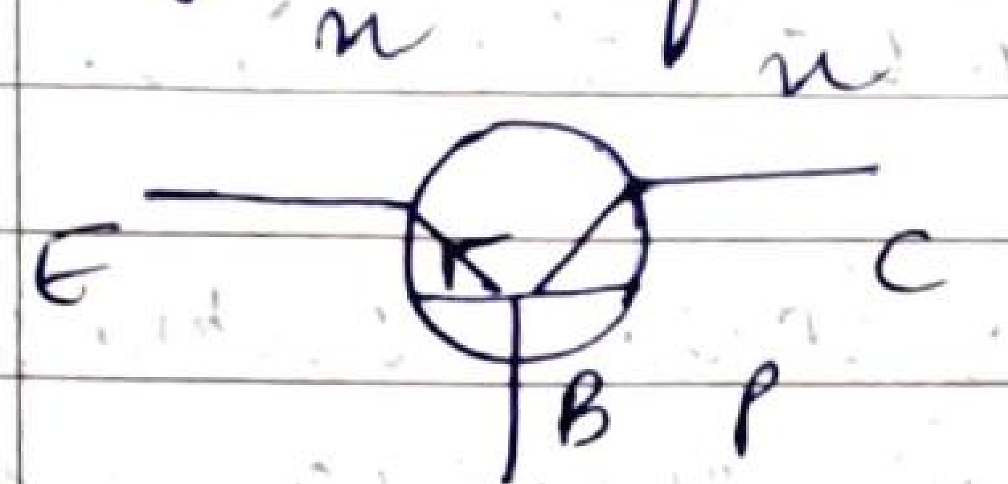
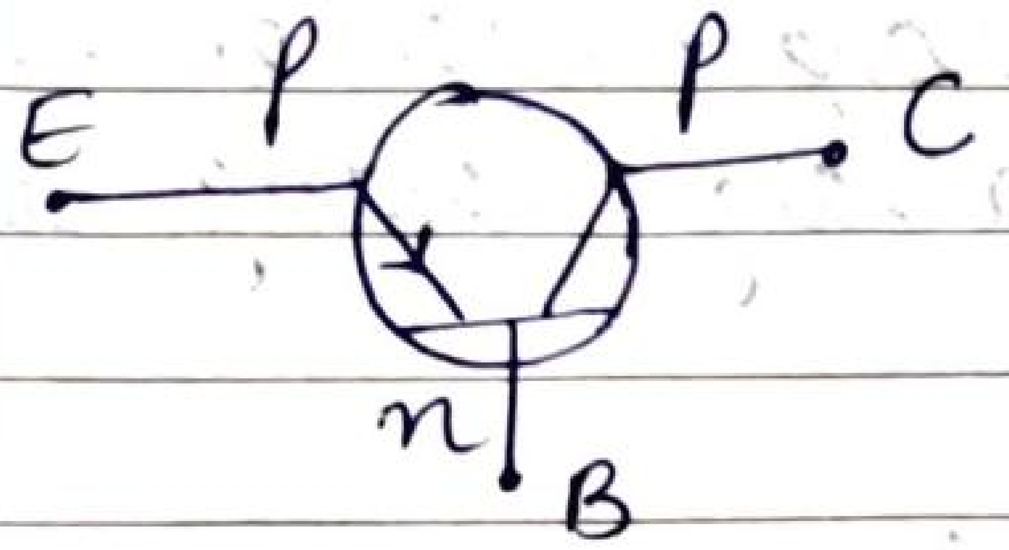
⇒ Symbols of transistors -

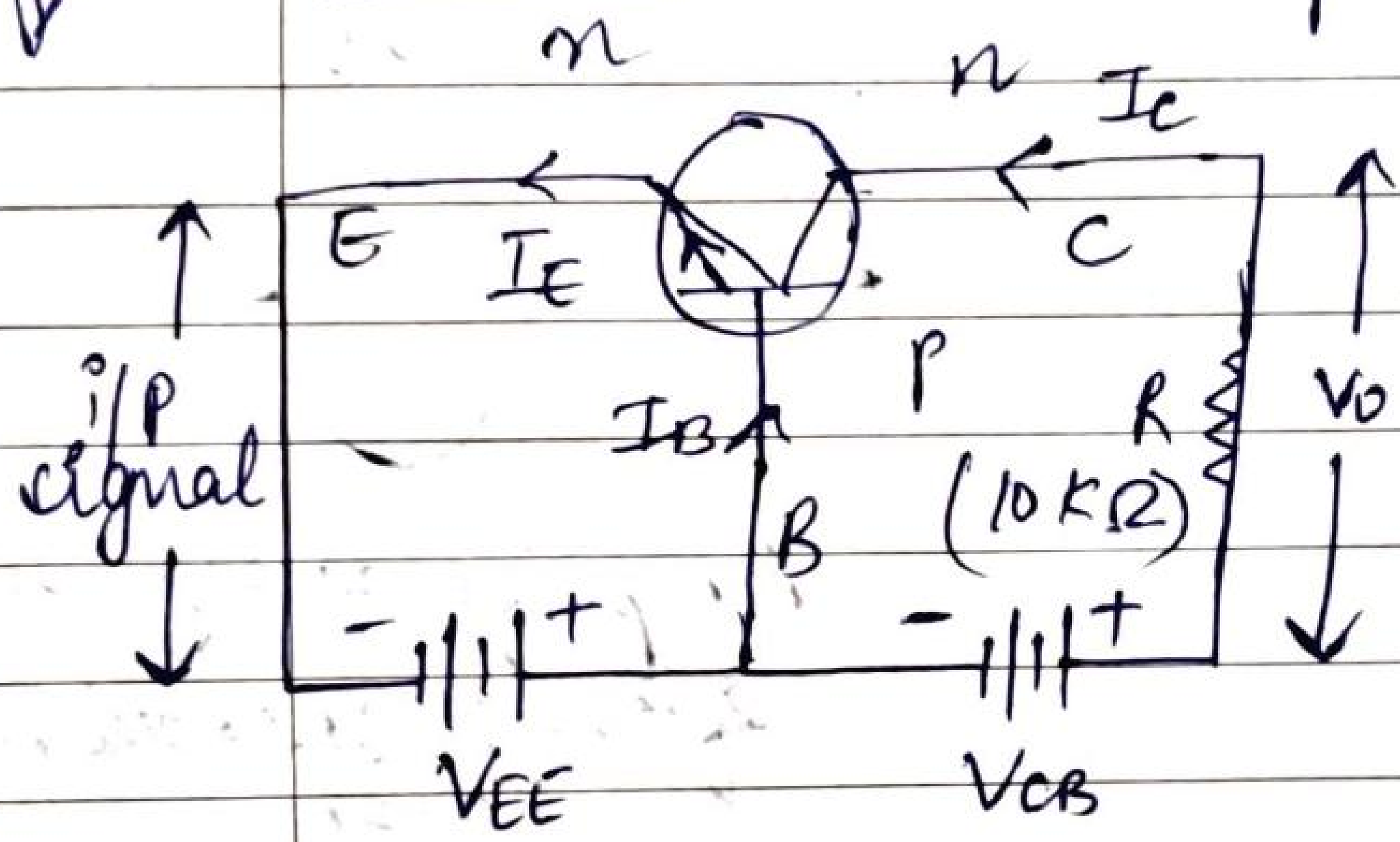


→ npn transistor



→ pnp transistor

Imp ⇒ Transistor as an amplifier -

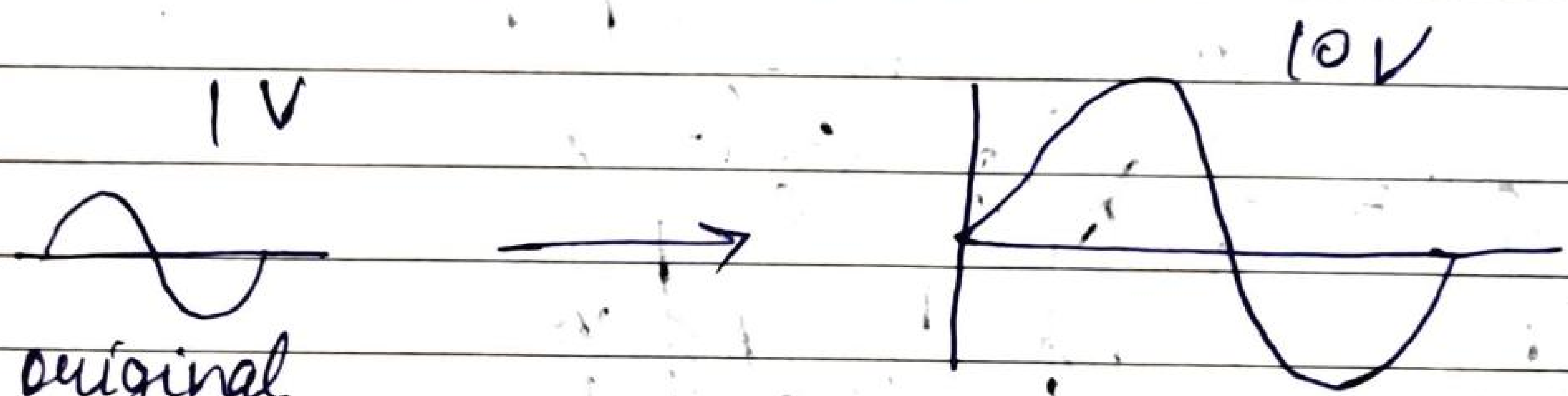


- ~~We~~ A transistor is a device which raises the strength of a weak signal and thus acts as an amplifier.
- The input (weak signal) is applied across emitter base and the output (amplified signal) is obtained across load resistance R connected in the collector circuit.
- When a weak signal is applied at the input, a small change in signal voltage causes an appreciable change in emitter current.

Eg - A change of 0.1 V in signal voltage causes a change of 1 mA in ammeter current as the input circuit has very low resistance. This causes almost the same change in collector current.

- In the collector circuit, a load resistance R of high value say 10 KΩ is connected when collector current flows through such a high resistance, it produces a large voltage drop

$$V = IR$$
$$V_0 = 10\,K\Omega \times 1mA$$
$$V_0 = 10\,V$$



original signal.

Amplified signal after transaction action

v. imp

⇒ <u>Configurations of a transistor</u> -

There are 3 basic configurations in which a transistor can work ie -

Common base (CB)
Common emitter (CE)
Common collector (CC)

(In actual we have 4 terminals but to make it 3 we take any one as common)

CE is most used for amplification.

- <u>~~CB~~</u>:

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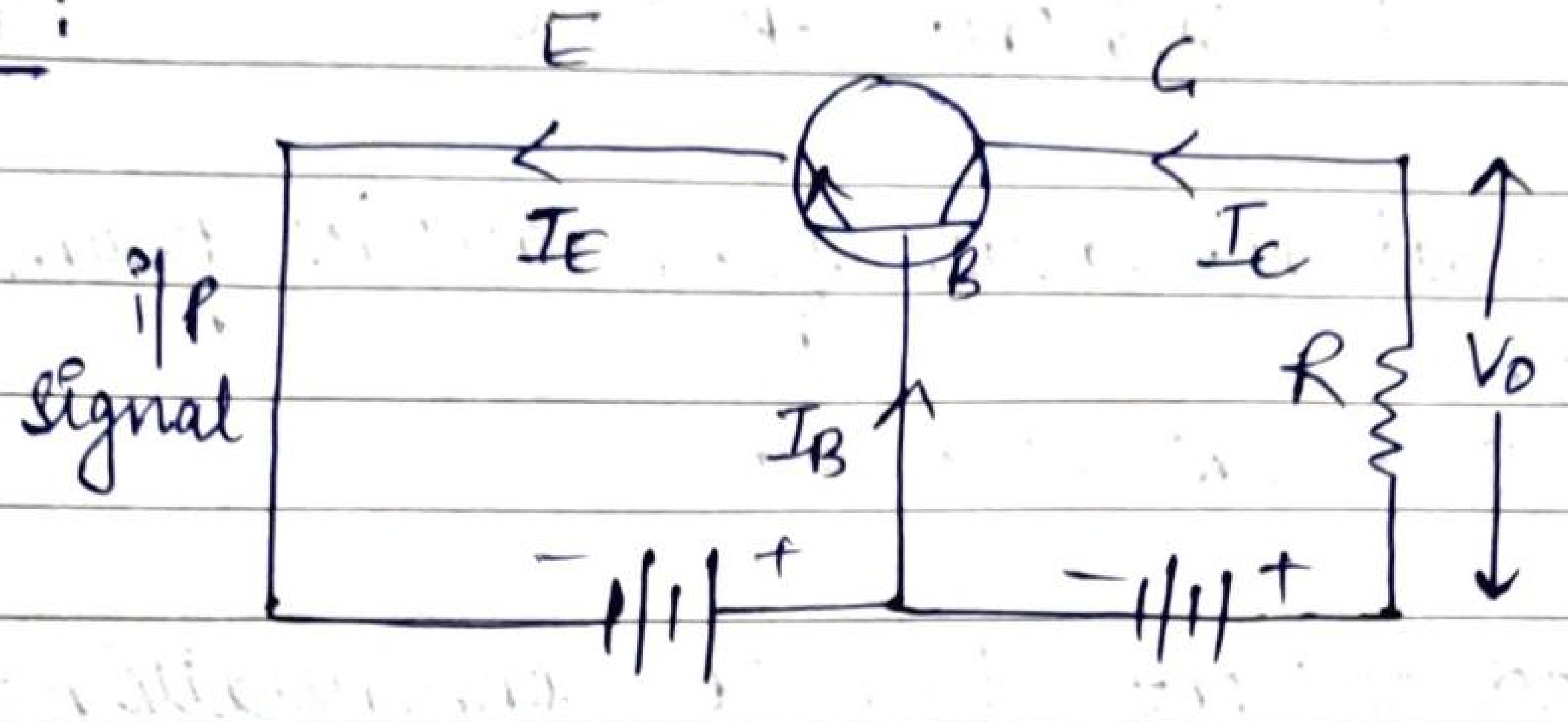
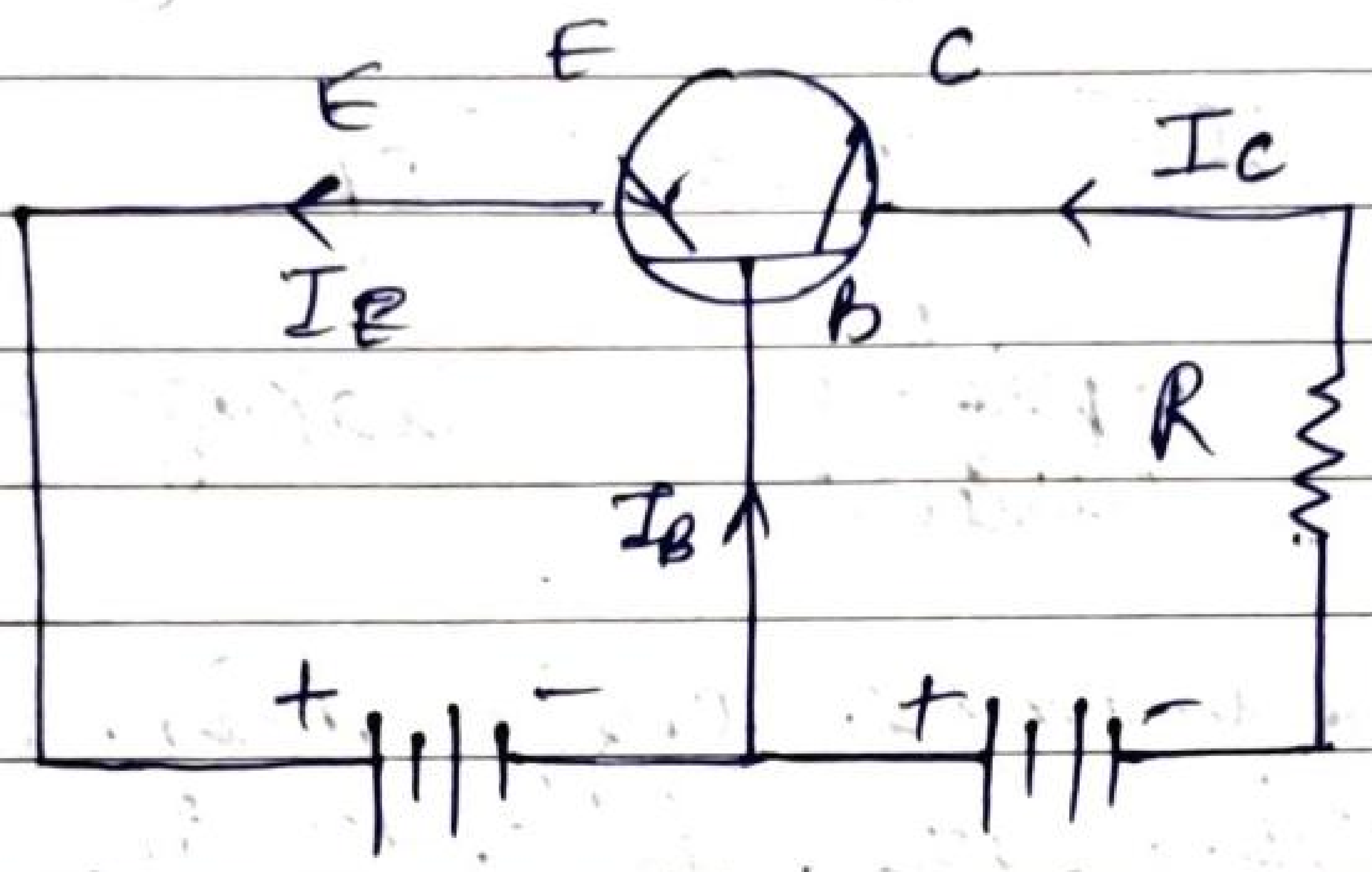
- **CB :**



npn



pnp

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

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

$$\cancel{= \frac{\Delta I_C}{\Delta I_B + \Delta I_C}} \qquad (\because I_E = I_B + I_C)$$

$$I_E = I_B + I_C$$

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

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

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

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

$\Rightarrow \alpha < 1$; The value of α is less than 1.

$\alpha = 1$ when $I_B = 0$

The practical value of α varies from 0.95 to 0.99.

$$0.95 < \alpha < 0.99$$

<u>Collector current for CB configuration</u> -

$$I_C = \underbrace{\alpha I_E}_{\text{amplified current}} + \underbrace{I_{CBO}}_{\text{leakage current}}$$

Q - In a common base configuration, the current amplification factor is 0.97 if the emitter current is 1 mA. Determine the value of base current.

$$\alpha = 0.97$$
$$I_E = 1 mA$$

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

$$0.97 = 1 - \Delta I_B$$

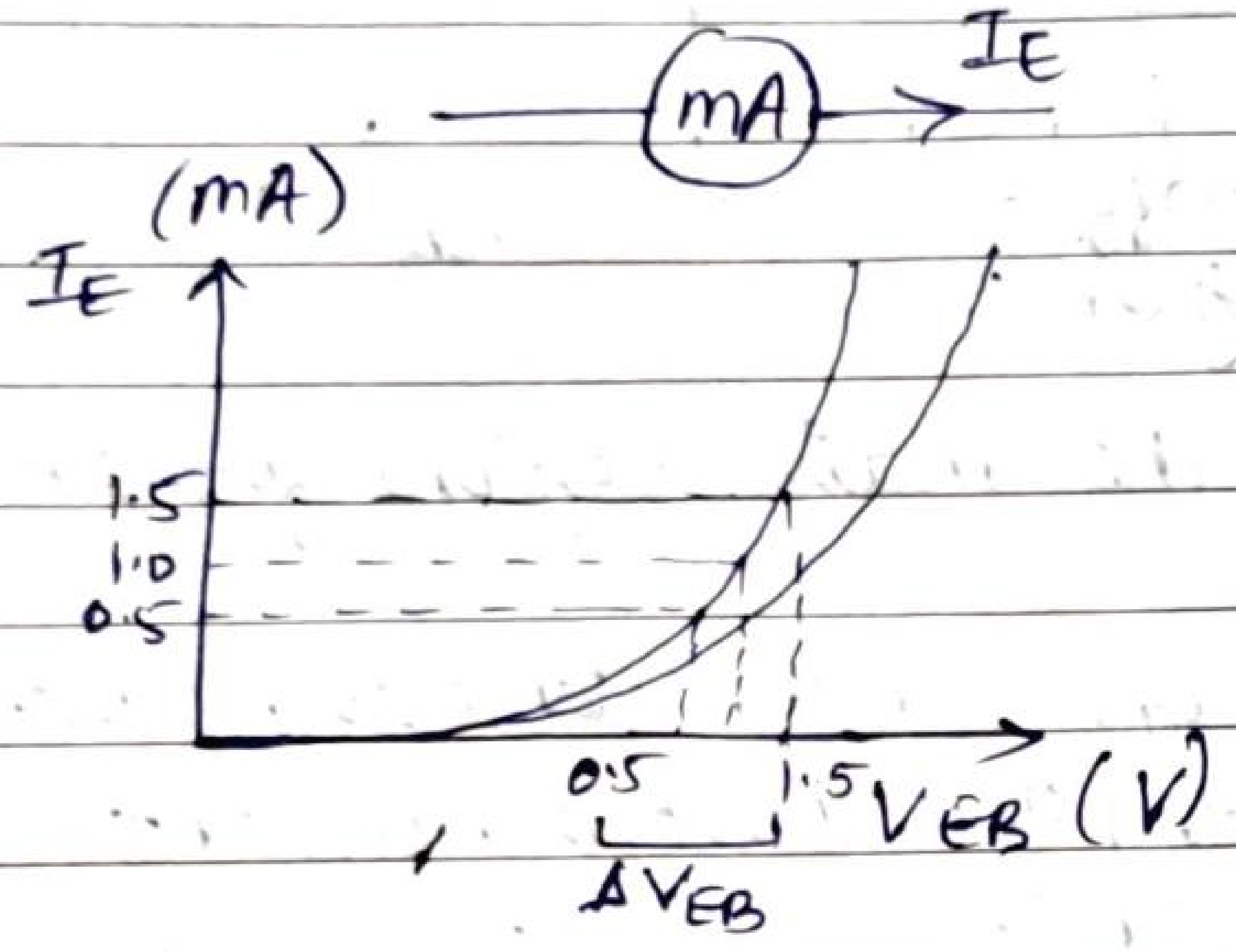
$$\Delta I_B = 1 - 0.97$$
$$\Delta I_B = 0.03 \text{ mA}$$

→ ~~CB Configuration~~ -

→ CB configuration

Input characteristics

Input : Emitter
Output : Collector



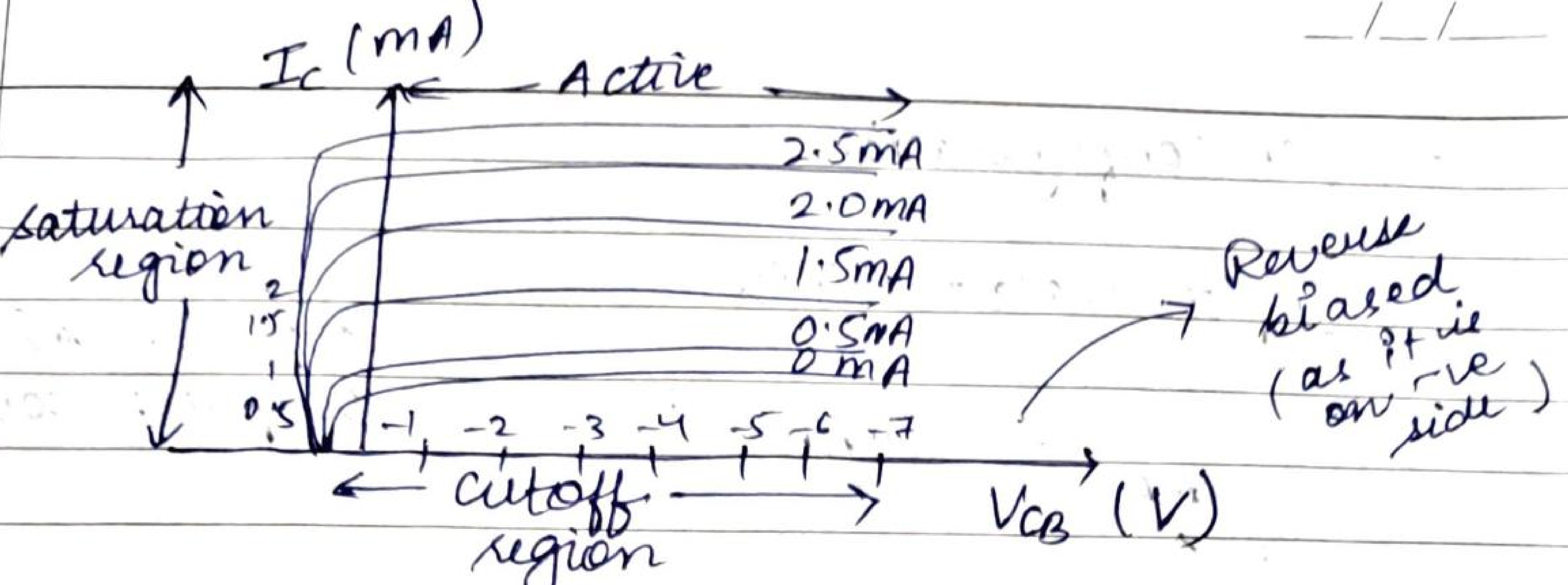
In CB configuration, the curve plotted between emitter current I_E and Emitter base voltage V_{EB} ~~and~~ at constant collector base voltage V_{CB} is called input characteristics.

- For a particular value of V_{CB}, the curve is just like diode characteristic in the forward region.
- When V_{CB} is increased, the value I_E increases slightly for the given value of V_{EB}. Hence, the junction becomes better diode.

Input resistance $\boxed{r_i = \dfrac{\Delta V_{EB}}{\Delta I_E}}$ at constant V_{CB}.

Output characteristics

In CB configuration, the curve plotted between ~~charact~~ collector current I_C and collector base voltage V_{CB} at constant emitter current I_E is called output characteristics.

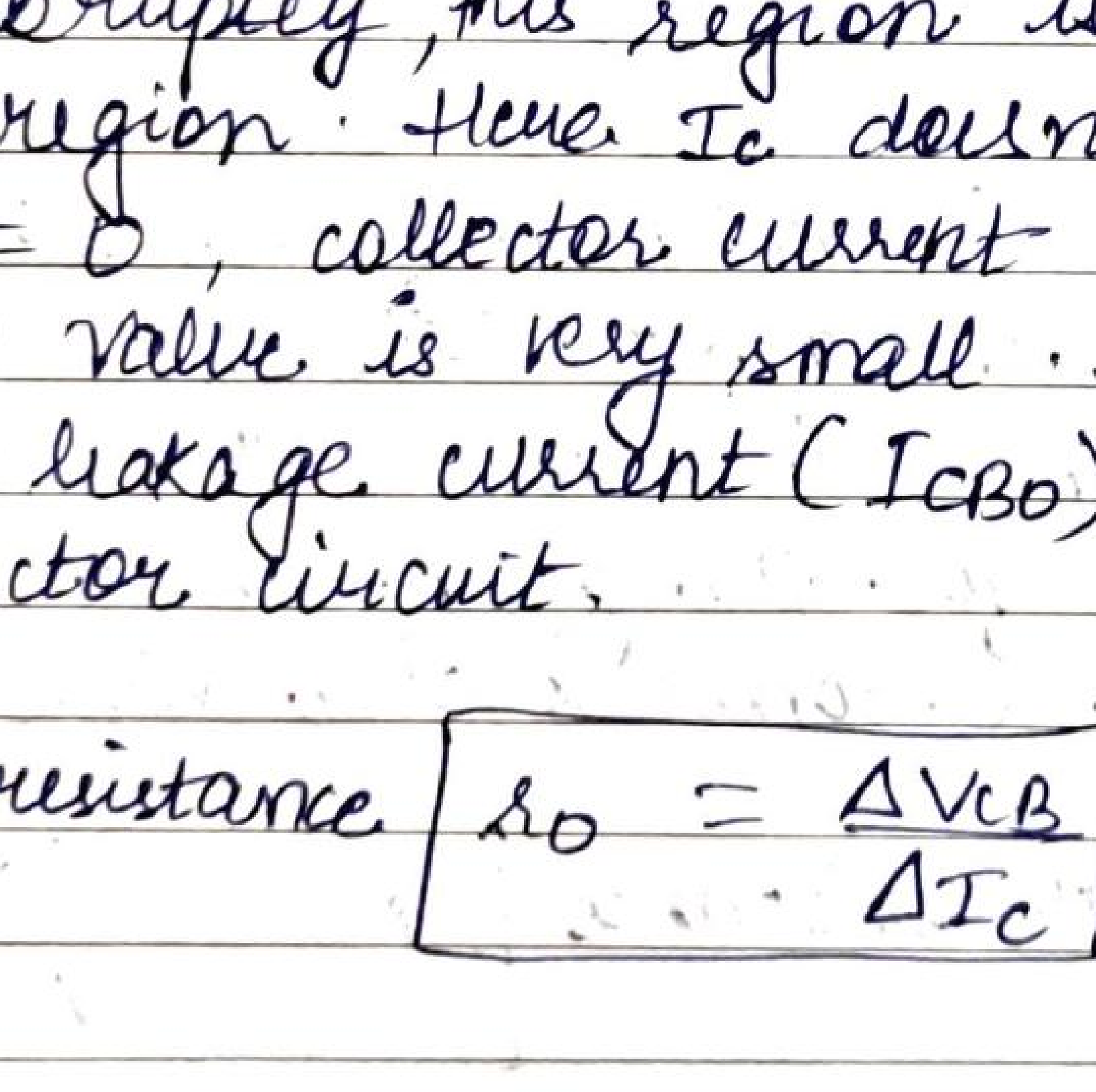


Active region is the main region for transistors.

- In the active region where collector base junc. is reverse biased, the collector current I_C is almost equal to emitter current I_E and the transistor is always operated in this region.
- When V_{CB} becomes positive i.e. C B junction is forward biased the collector current I_C decreases abruptly, this region is known as saturation region. Here I_C does not depend on I_E.
- When $I_E = 0$, collector current $I_C \neq 0$. Although its value is very small. Infact this is the reverse leakage current (I_{CBO}) that flows in the collector circuit.

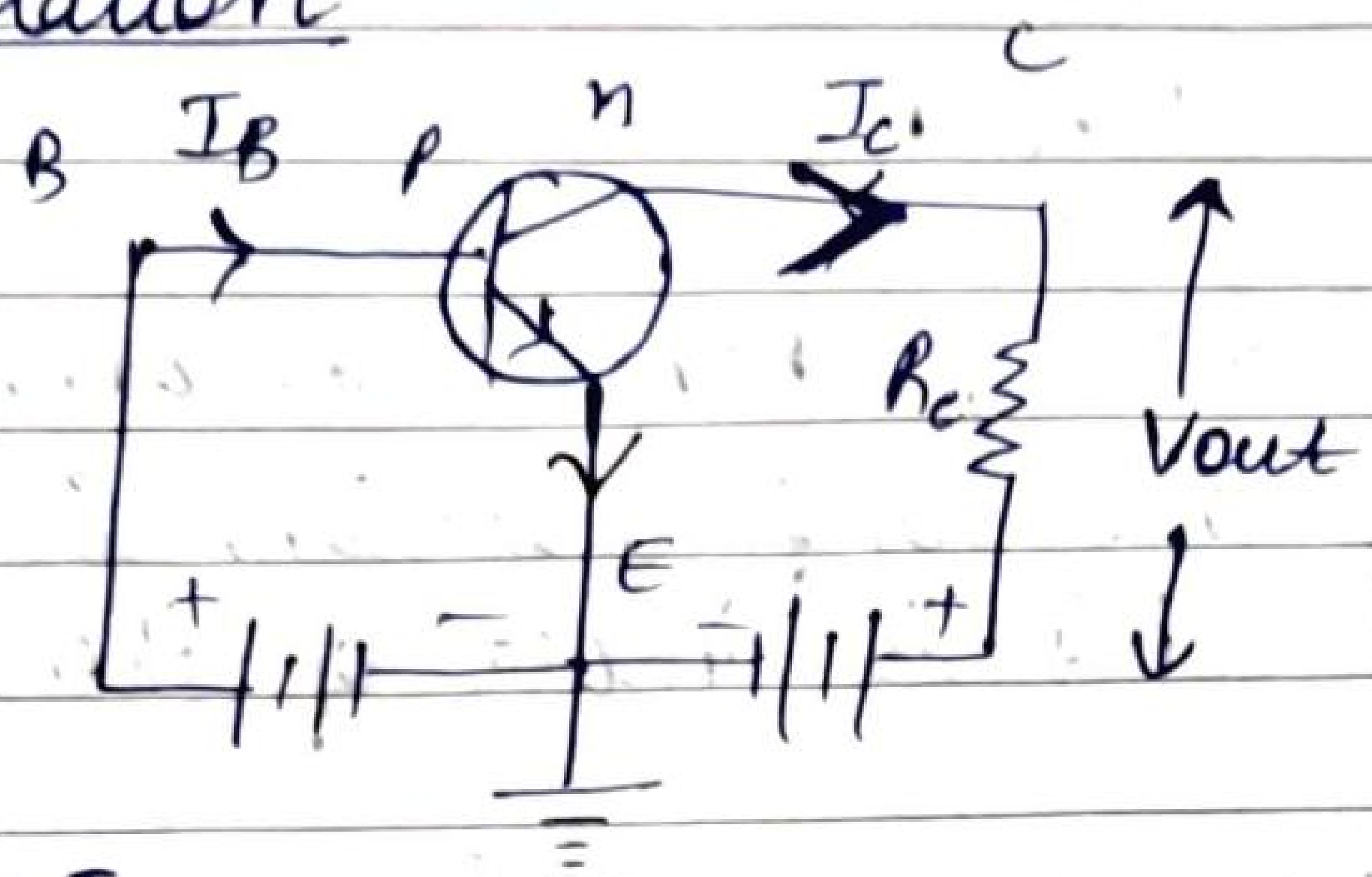
Output resistance $\boxed{r_O = \dfrac{\Delta V_{CB}}{\Delta I_C}}$ at constant I_E

→ CE configuration



most Imp.

→ CE Configuration –



$I_E = I_B + I_C$

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

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

Relation b/w α and β –

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{— (ii)} \qquad \beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{— (i)}$$

$$I_E = I_B + I_C$$

$$\Delta I_E = \Delta I_B + \Delta I_C \quad \text{— (iii)}$$

$$\Delta I_B = \Delta I_E - \Delta I_C \quad \longrightarrow \text{Substituting in eq (i)}$$

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C} \quad \text{— (iv)}$$

Dividing (iv) by ΔI_E

$$\beta = \frac{\Delta I_C / \Delta I_E}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} \quad \text{(from eq. (ii))}$$

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

If $\alpha \to 1$, then, β becomes infinite so, gain of this configuration is high thats why we use this in most of the configurations.

Q- Find the value of β if $\alpha = 0.9$, $\alpha = 0.94$, $\alpha = 0.98$

$$\beta = \frac{0.9}{1-0.9} = \frac{0.9}{0.1} = 9$$

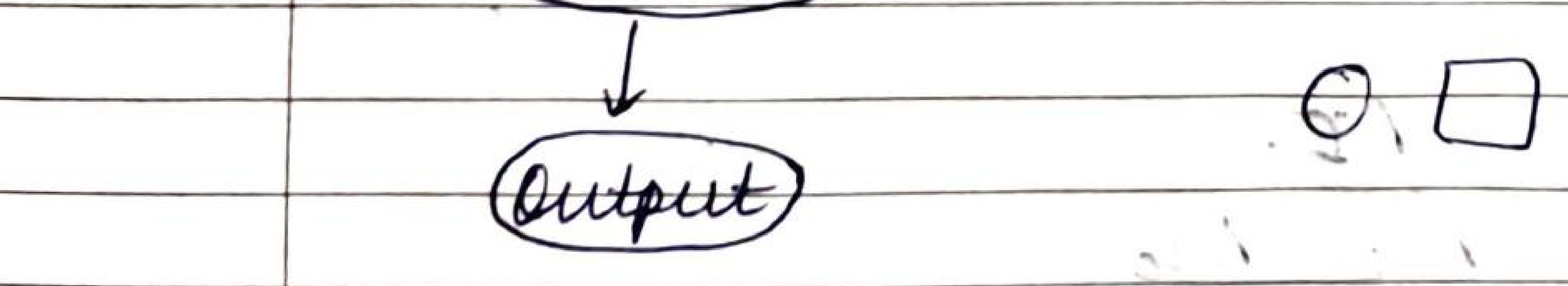
$$\beta = \frac{0.94}{1-0.94} = \frac{0.94}{0.06}$$

$$= \frac{94}{6} = \frac{47}{3} = 15.66$$

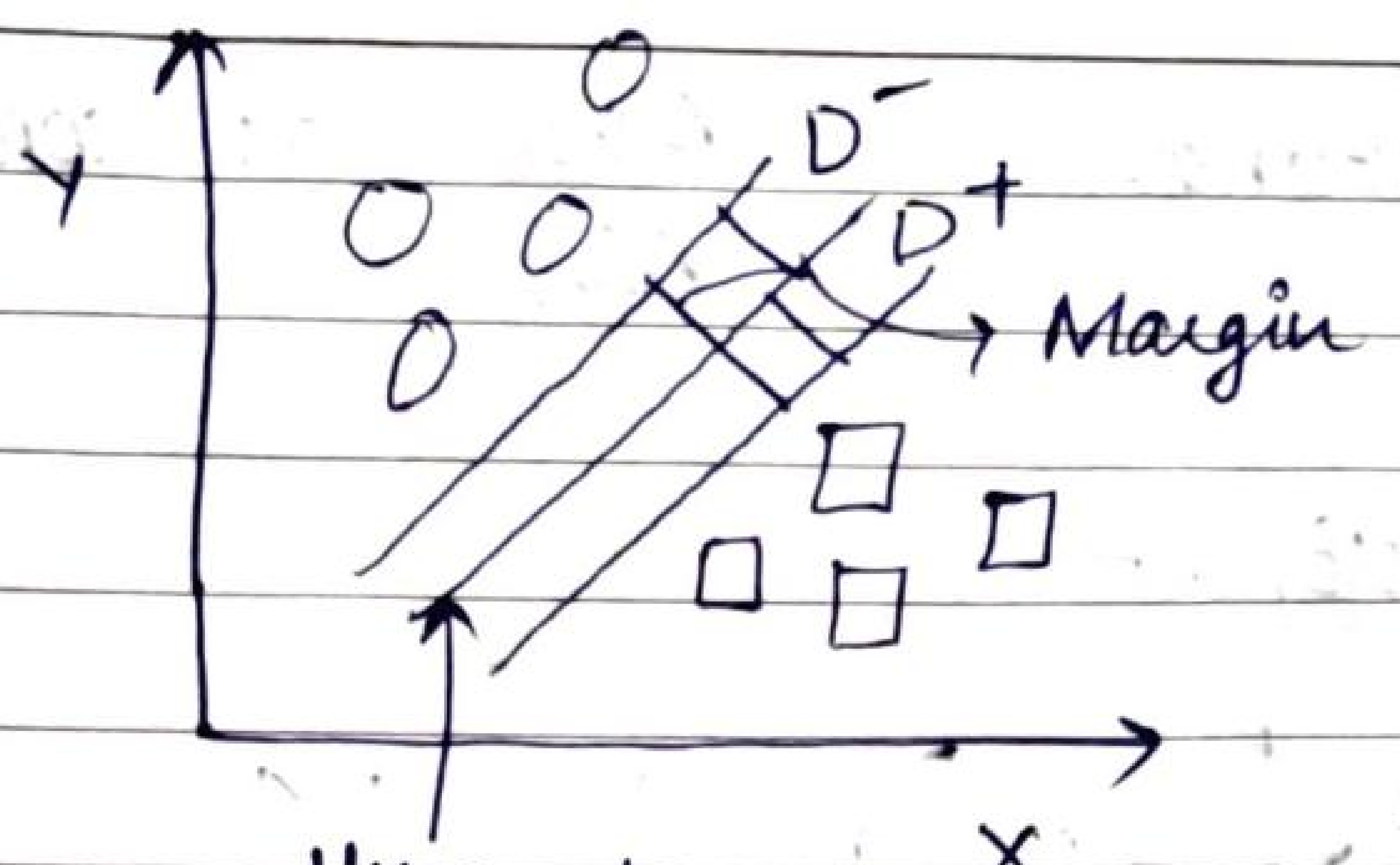
$$\begin{array}{r} 1.\cancel{0}0 \\ -0.94 \\ \hline 06 \end{array}$$

$$\beta = \frac{0.98}{1-0.98} = \frac{0.98}{0.02} = 49$$

→ Support Vector Regression (SVR)



Jason Brownly

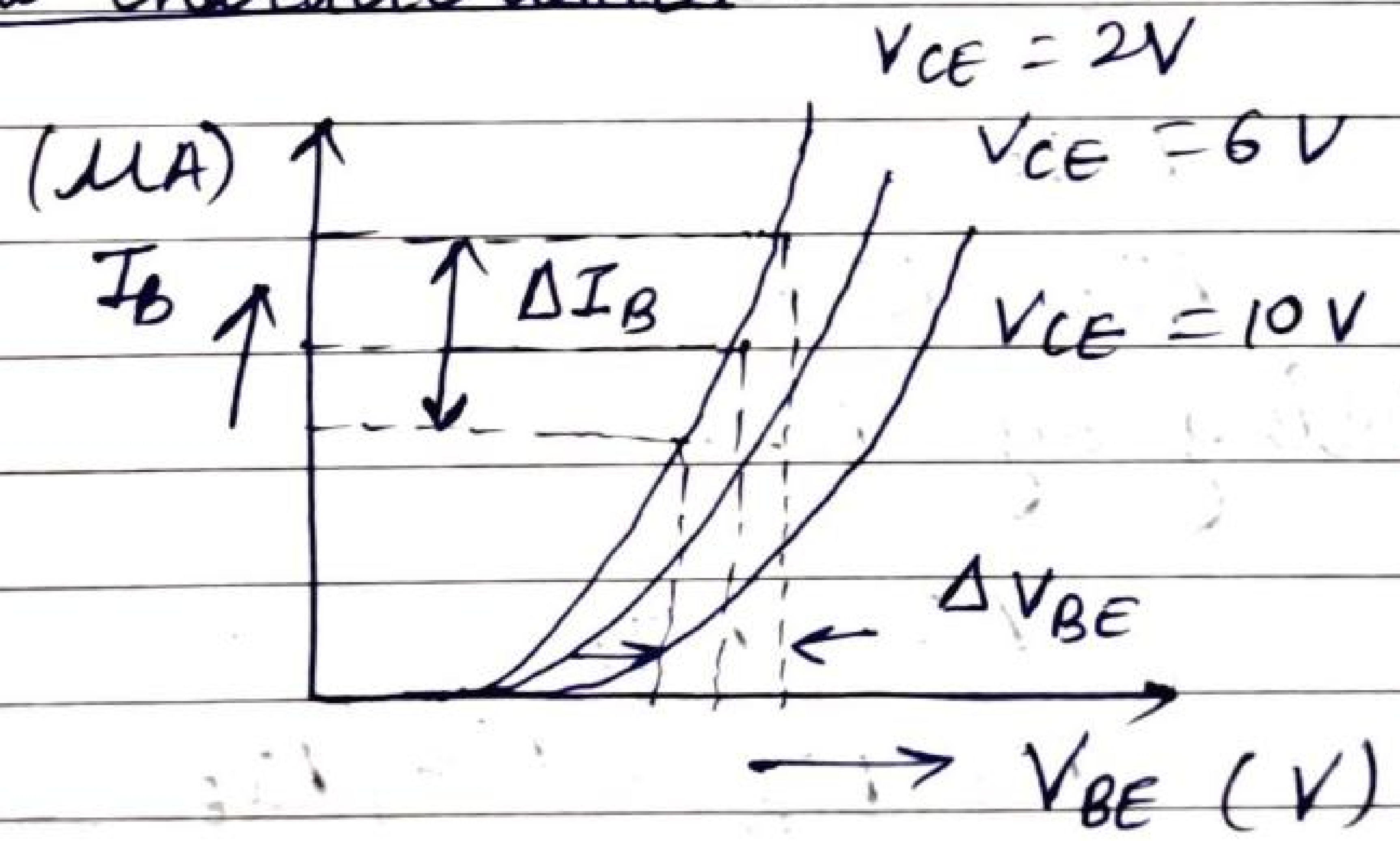


Hyperplane :
(It acts as 2-D plane)

Distance b/w line touching circle and hyperplane is D^-.
Distance b/w line touching square and hyperplane is D^+.

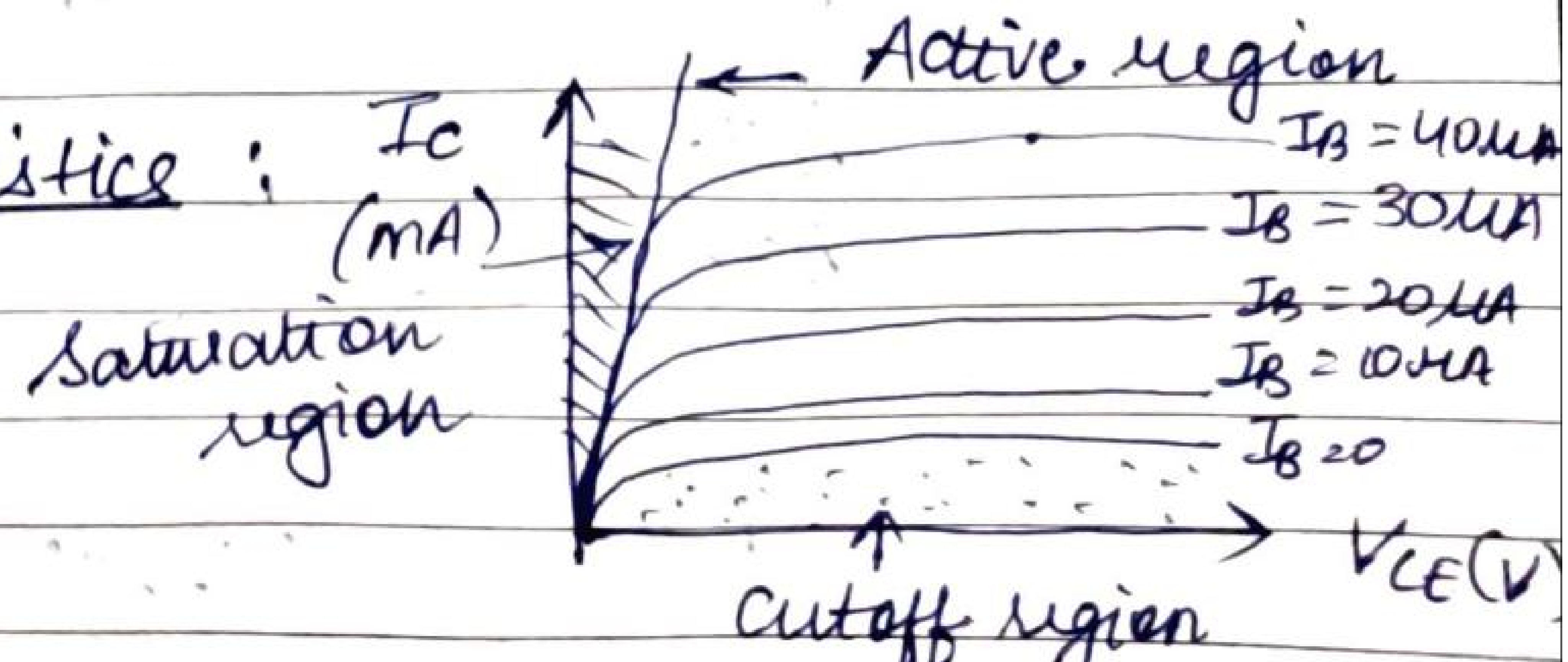
→ CE configuration -

- Input characteristics :



Input resistance $r_i = \frac{\Delta V_{BE}}{\Delta I_B}$ at constant V_{CE}

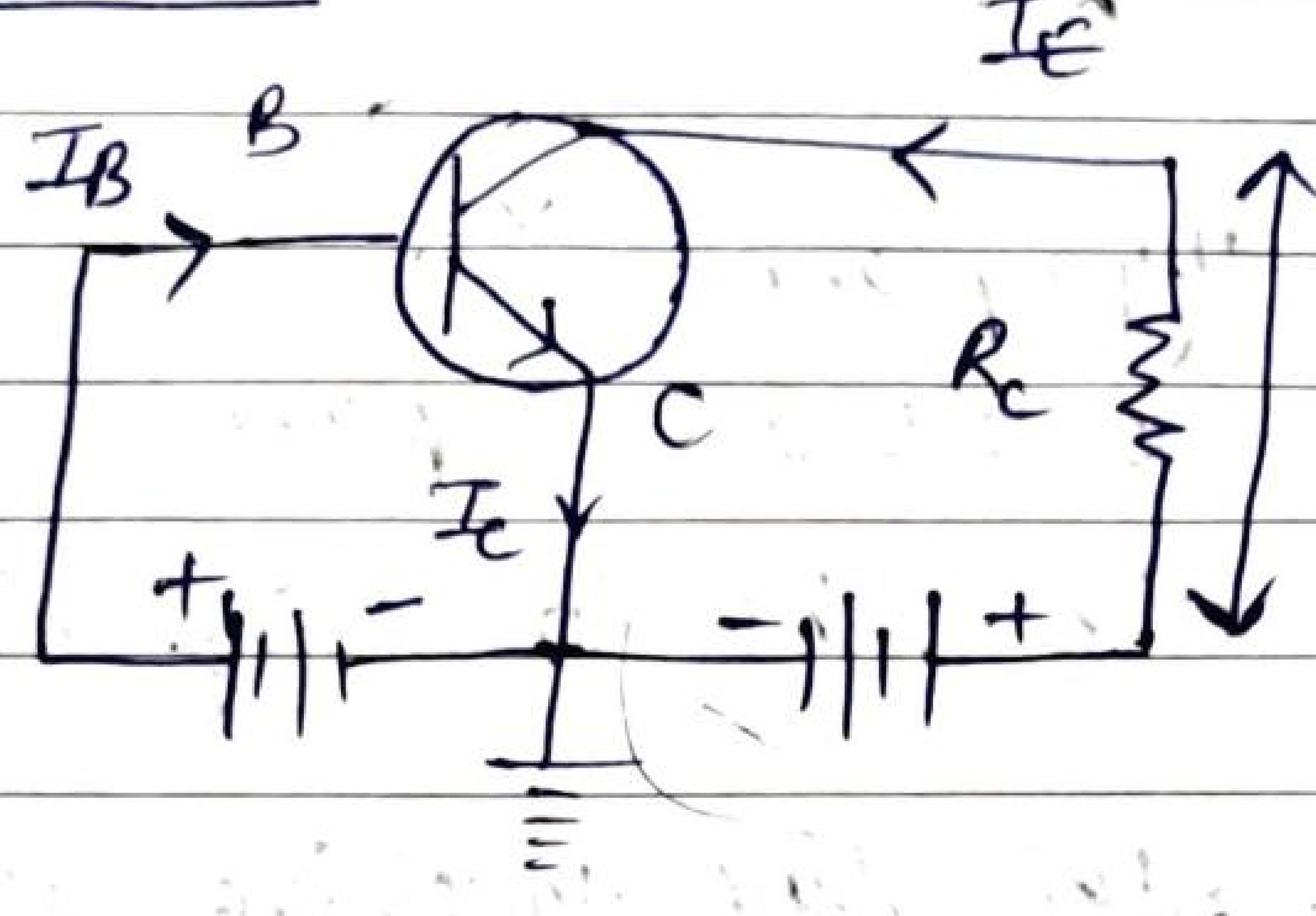
- Output characteristics :



current is always in p to n direction

Output resistance $r_o = \frac{\Delta V_{CE}}{\Delta I_C}$ at constant I_B.

CC configuration -



$\gamma = \frac{\Delta I_E}{\Delta I_B}$ — (i) $\qquad \alpha = \frac{\Delta I_C}{\Delta I_E}$ — (ii)

$I_E = I_C + I_B$

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

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

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

Dividing by ΔI_E

$$\gamma = \frac{\Delta I_E / \Delta I_E}{\Delta I_E/\Delta I_E - \Delta I_C/\Delta I_E}$$

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

$\alpha = \frac{\Delta I_C}{\Delta I_E}$ $\qquad \beta = \frac{\alpha}{1-\alpha}$ — (1) $\qquad \gamma = \frac{1}{1-\alpha}$ — (2)

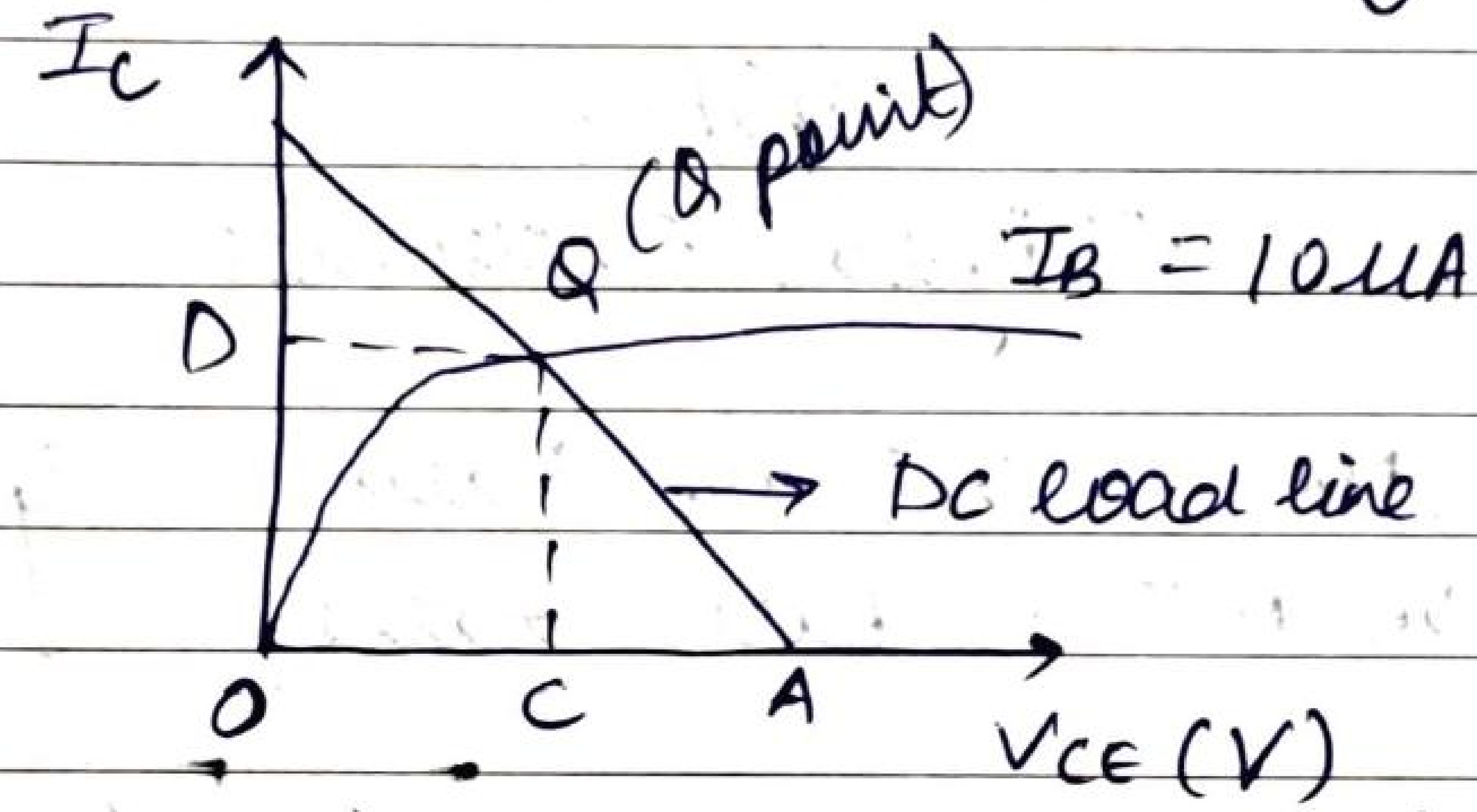
(1) × (2)

$$\beta\gamma = \frac{\alpha}{(1-\alpha)^2}$$

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

$$\boxed{\beta = \alpha\gamma}$$

→ <u>Operating point</u>: The point obtained by the value of I_C and 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 and V_{CE} takes place at this point then signal is applied at the input. This point is also called Quiscent point / Q point / silent point because it is a point on $I_C - V_{CE}$ characteristics when the transistor is silent ie no signal is applied at the input. The Q point can be determined by DC load line where

$$OA = V_{CC} = V_{CE}$$

$$OB = I_C = \frac{V_{CC}}{R_E}$$

is drawn on the output characteristics. The point Q where DC load line intersect the output characteristics of $I_B = 10\mu A$ is the operating point.

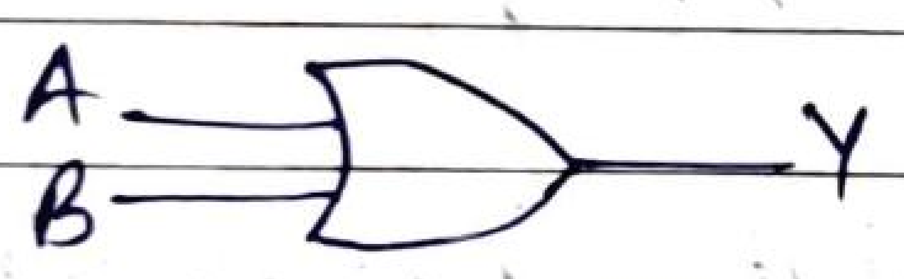
MST 1 : Ch-1, 2 Part A
Ch-3 Part B

→ Assignment (next friday)

1) How can zener diode be used for regulation of voltage?
(b) Can photodiode work as photovoltaic and photoconductive device? Write applications.
2) Explain common emitter configuration in detail and highlight the applications of transistors. Also compare the 3 configurations of transistors.

Unit-3
Digital Electronics

NAND, NOR → Universal Gates
AND, OR, NOT → Basic Gates
} Logic Gates

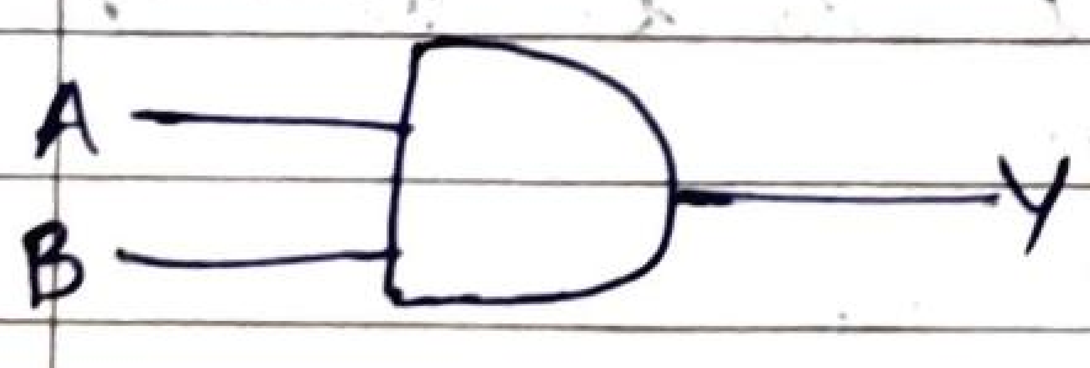


OR Gate

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

For n inputs, we have 2^n outputs

$Y = A + B$

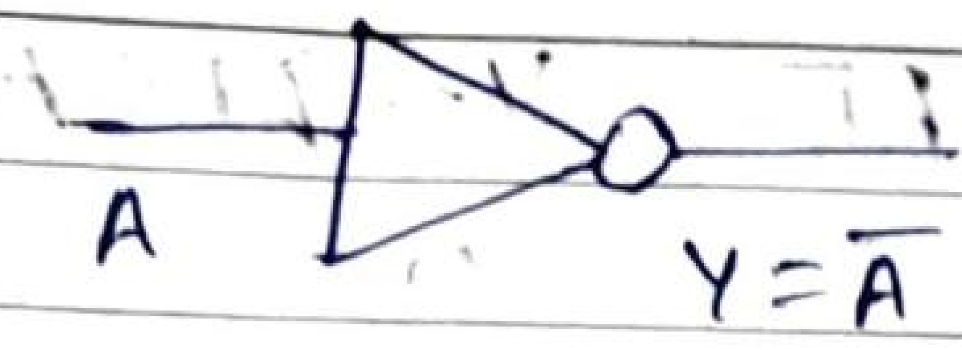


$Y = A \cdot B$

AND Gate

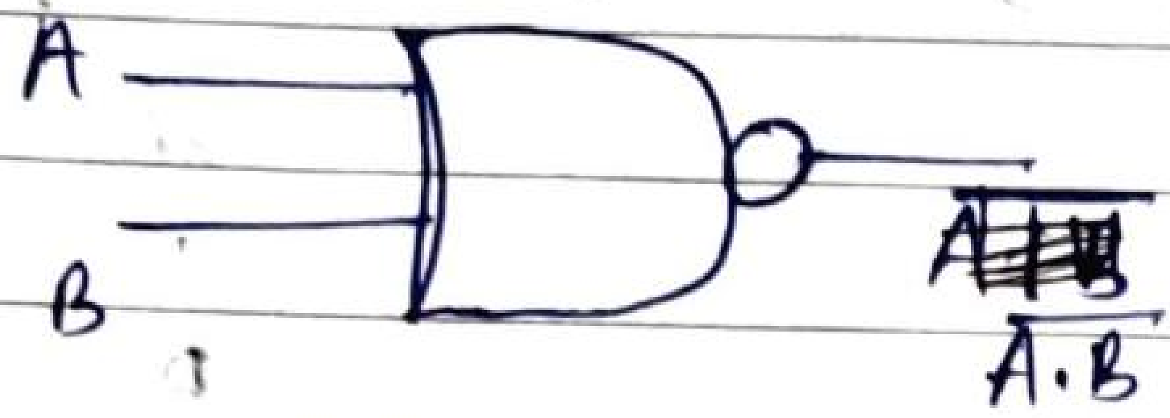
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

$Y = A \cdot B$



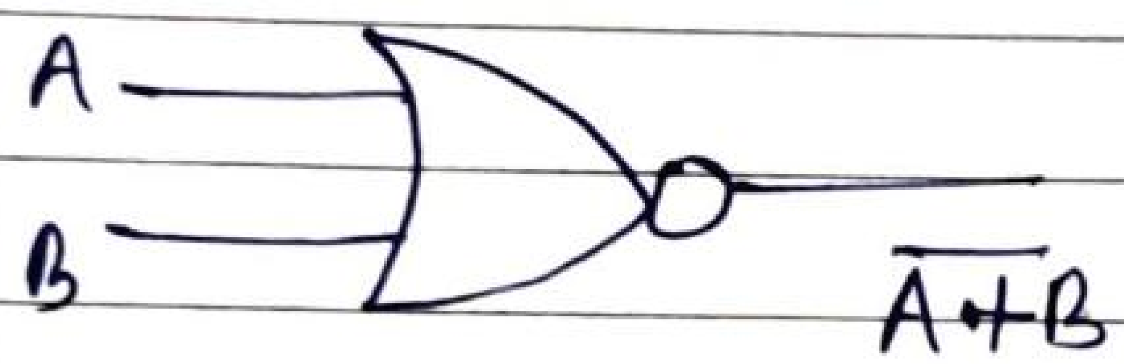
$\boxed{\text{NOT}}$

A	$Y = \overline{A}$
0	1
1	0



$\boxed{\text{NAND}}$

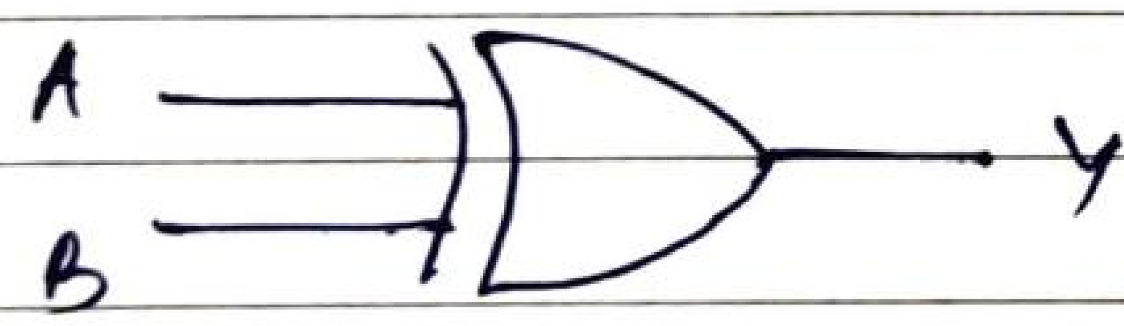
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0



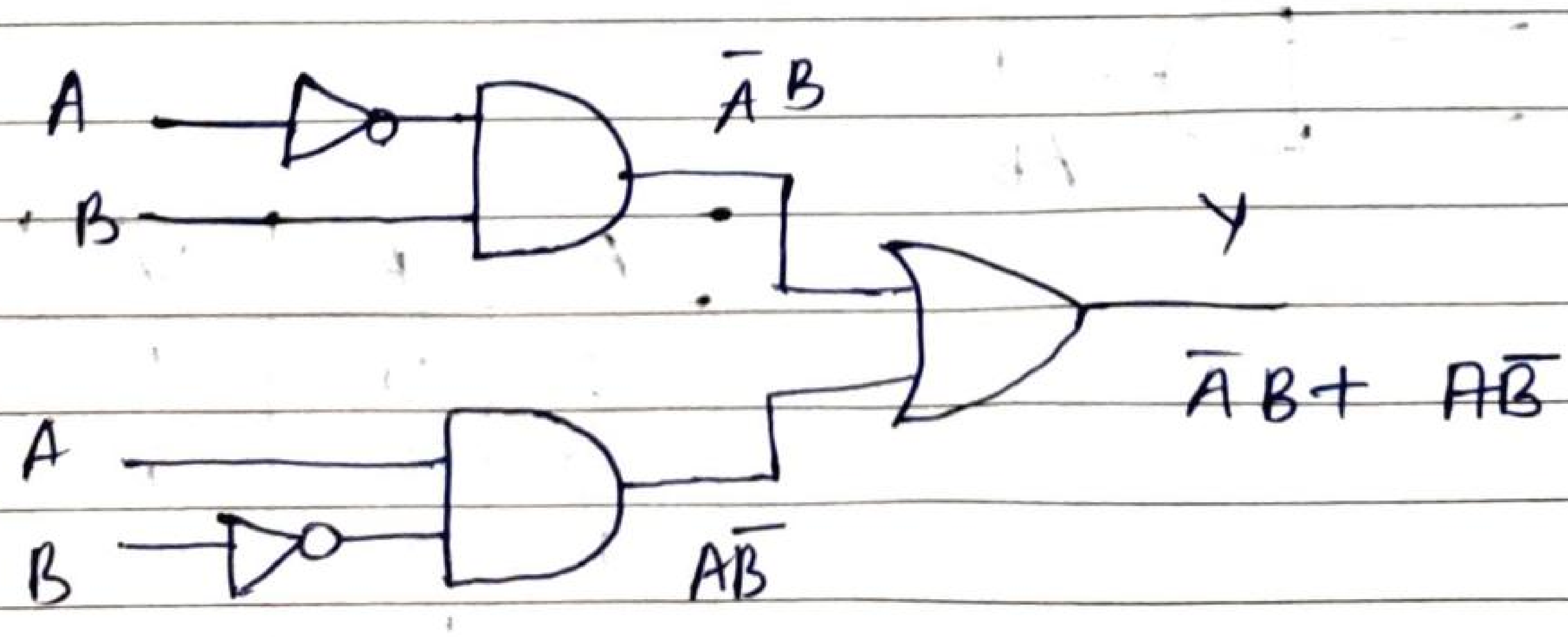
$\boxed{\text{NOR}}$

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

→ <u>Exclusive-OR</u> (EXOR / XOR)



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



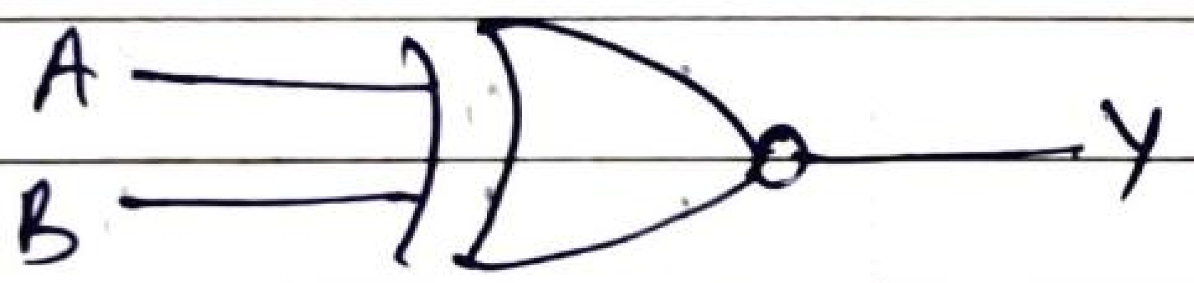
A	B	$\bar{A}$	$\bar{B}$	$\bar{A}B$	$A\bar{B}$	$Y = \bar{A}B + A\bar{B}$
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

$\Downarrow$

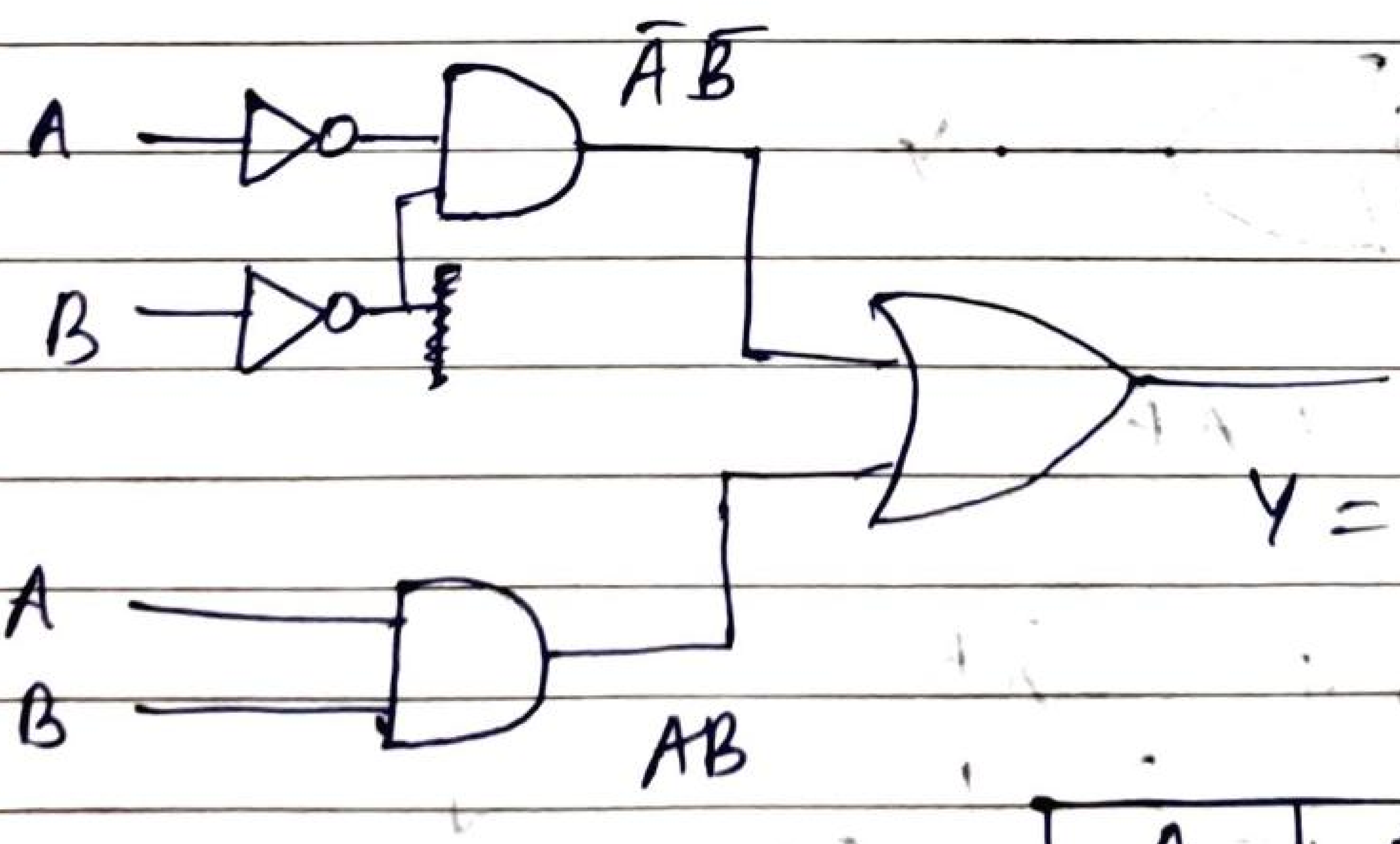
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

$\bar{A}\bar{B}$	AB
1	0
0	0
0	0
0	1

→ <u>Exclusive-NOR</u> (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

→ Boolean Postulates / Algebra :

For minimisation, we use boolean algebra.

(i) $0 \cdot 0 = 0$
(ii) $1 \cdot 1 = 1$
(iii) $1 \cdot 0 = 0$
(iv) $\overline{1} = 0$
(v) $1 + 1 = 1$
(vi) $0 + 0 = 0$
(vii) $0 + 1 = 1$
(viii) $\overline{0} = 1$

0	00
1	01
2	10
3	11
4	100

→ Boolean Theorems :

(i) $0 \cdot x = 0$
(ii) $1 \cdot x = x$
(iii) $x \cdot x = x$
(iv) $x \cdot \overline{x} = 0$

AND

(i) $1 + x = 1$
(ii) $0 + x = x$
(iii) $x + x = x$
(iv) $x + \overline{x} = 1$

OR

→ Prove the expression -

(i) $XY + \overline{X}Z + YX = XY + \overline{X}Z$

$L \cdot H \cdot S = XY + \overline{X}Z + YX$

(ii) $(x+y)(\bar{x}+z)(y+z) = (x+y)(\bar{x}+z)$

Number system

Q- convert $(101101)_2$ to decimal.

$= 2^5\times1 + 2^4\times0 + 2^3\times1 + 2^2\times1 + 2^1\times0 + 2^0\times1$
$= 32+8+4+1 = (45)_{10}$

Q- $(1011.0111)_2$ to decimal.

$= 2^3\times1 + 2^2\times0 + 2^1\times1 + 2^0\times1$ $\quad 0\times2^{-1} + 1\times2^{-2} + 1\times2^{-3} + 1\times2^{-4}$
$= 8+2+1 = 11$ $\quad 0 + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}$
$= (11.437)_{10}$

Q- $(143)_{10}$ to binary $\quad (101)_{10}$ to binary
$(10001111)_2$

Q- $(0.4375)_{10}$ to binary $\quad (25.375)_{10}$

Q- $(754)_8 \rightarrow (\ )_{10}$

$7\times8^2 + 5\times8^1 + 4\times8^0$
$7\times64 + 40 + 4$
$448 + 40 + 4 = (492)_{10}$

$64 \times 7 = 448$

$0.375 \times 2 = 0.750 \quad 0$
$0.750 \times 2 = 1.500 \quad 1$
$0.500 \times 2 = 1.000 \quad 1$

2	25
2	12 − 1
2	6 − 0
2	3 − 0
2	1 − 1
	0 − 1

$(11001.011)_2$

Q- $(321.32)_8 \rightarrow (\ )_{10}$

$8^2\times3 + 8^1\times2 + 8^0\times1 + 8^{-1}\times3 + 8^{-2}\times2$
$64\times3 + 8\times2 + 1\times1 + \frac{3}{8} + \frac{\cancel{2}}{\cancel{64}}\ \frac{1}{32}$
$= 192 + 16 + 1 + \quad = (209.40625)_{10}$

__/__/__

Q- $(175)_{10} \rightarrow (\ )_8$ $(257)_8$

$$\begin{array}{r|l} 8 & 175 \\ \hline 8 & 21 - 7 \\ \hline 8 & 2 - 5 \\ \hline & 0 - 2 \end{array}$$

Q- $(0.40625)_{10} \rightarrow ()_8$ $(0.32)_8$

→ <u>Octal to binary</u> -

Q- $(305)_8 \rightarrow ()_2$ $(011\ 000101)_2$

→ <u>Binary to Octal</u> -

Q- $(101011011.011010111)_2$
$= 5332.07$

Q- $(305.7)_8 \longrightarrow$ decimal through binary

$\hookrightarrow (011000101\ .\ 111) \longrightarrow (197.875)_{10}$

→ <u>Hexadecimal</u> (0 - 15) (16 numbers in total)

0 - 9
10 - A
11 - B
12 - C
13 - D
14 - E
15 - F

Hexadecimal to decimal

(1) $(\overset{3}{7}\overset{2}{5}\overset{1}{B}\overset{0}{F})_{16} \longrightarrow (\ )_{10}$

$= 15 \times 16^0 + 11 \times 16^1 + 5 \times 16^2 + 7 \times 16^3$

$= 15 + 176 + 1280 + 28672 = (30143)_{10}$

(2) $(5245)_{10} \rightarrow (\quad)_{16}$

$= (147D)_{16}$

$$\begin{array}{r|l}
16 & 5245 \\
16 & 327 - 13 \\
16 & 20 - 7 \\
16 & 1 - 4 \\
16 & 0 - 1
\end{array}$$

(3) $(85E7)_{16} \rightarrow (\quad)_2$

$(1000\ 0101\ 1110\ 0111)_2$

(4) $(10100111.01011101)_2$

$(A7.5D)_{16}$

(5) $(1AF)_{16} \rightarrow (\quad)_8$

$(0001\ 1010\ 1111)_2$

$= (110101111)$

$= (657)_8$

$1 \times 2^0 + 1 \times 2^1 + 1 \times 2^2$

$1 + 2 + 4$

$= 7$

→ 1's complement

1011010 → 0100101 1's

+1 2's

0100110

Q- Find 2's complement of 110110

1's 001001

+1

001010 → 2's complement

→ **Binary Addition**

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 10

Q –
$$\begin{array}{r} 101 \\ +\,110 \\ \hline 1011 \end{array}$$

→ **Binary Subtraction**

0 − 0 = 0
1 − 1 = 0
1 − 0 = 1
0 − 1 = 1

Q –
$$\begin{array}{r} 1101 \\ -\,1001 \\ \hline 100 \end{array}$$

Q –
$$\begin{array}{r} {\scriptstyle 10} \\ 1\cancel{0}11 \\ -\,101 \\ \hline 110 \end{array}$$

Q –
$$\begin{array}{r} {\scriptstyle 1\;10} \\ 1\cancel{0}\cancel{0}1 \\ -\,111 \\ \hline 0010 \end{array}$$

Imp

→ Subtraction using 1's complement -

$X - Y$

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

0 → +ve
1 → 1's complement of step 3 and -ve

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

$Y = 110001$
$Y' = 001110$

$$
\begin{array}{rl}
X + Y' = & 111001 \\
& + 001110 \\
\hline
& 1\,000111 \\
& +1 \\
\hline
& \boxed{0}01000
\end{array}
$$

↓
signbit (0) ∴ The result is +ve

Q- Perform the following subtraction using 1's complement.

$(01010)_2 - (00011)_2$

$Y = 00011$
$Y' = 11100$

$$
\begin{array}{rr}
X + Y' = & \overset{1}{0}1010 \\
 & 11100 \\
\hline
 & (1)00110 \\
 & +1 \\
\hline
 & 00111
\end{array}
$$

Q- $(\overset{37}{100101})_2 - (\overset{54}{110110})_2$

$Y = 110110$
$Y' = 001001$

$$
\begin{array}{rr}
X + Y' = & 100101 \\
 & 001001 \\
\hline
 & 101110
\end{array}
$$

1's $\rightarrow$ -010001

$= -17.$

$1\times2^0 + 0\times2^1 + 1\times2^2 + 0\times2^3 + 0\times2^4 + 1\times2^5$
$= 1+4+32$
$= 37$

$$
\begin{array}{r}
\overset{1}{3}7 \\
17 \\
\hline
54
\end{array}
$$

→ <u>Subtraction using 2's complement</u> - $(X-Y)$

(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

$2^1\ 2^0$
$1\ 1$ 100

most significiant bit 0, then it is the desired result and result is +ve.
If MSB is 1, then desired result is 2's c of step3 and result is -ve.

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

$Y = 110001$

2's of Y =
$$\begin{array}{r} 001110 \\ +\ 1 \\ \hline 001111 \end{array}$$

X + 2's of Y =
$$\begin{array}{r} 111001 \\ 001111 \\ \hline 1001000 \end{array}$$

Ignore carry

$\boxed{001000}$ final ans

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

2's of Y =
$$\begin{array}{r} 001001 \\ +1 \\ \hline 001010 \end{array}$$

X + 2's of Y =
$$\begin{array}{r} 100101 \\ +\ 001010 \\ \hline 101111 \end{array}$$

010001

2's

step 4 $+2^2\times1 + 2^1\times1 + 2^0\times1$
$2^3\times$

$$\begin{array}{r} 010000 \\ +1 \\ \hline 010001 \end{array}$$

final answer.

$2^4\times1 + 1\times2^0$
$16+1$

$= -17$

$2^5 \quad 2^3 \quad 2^2$

101111

$2^4 \quad 2^1 \quad 2^0$

__/__/__

2 bit

0	00
1	01
2	10
3	11

3 bit

0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

4 bit

0 - 0000	8 -	1000	
1 - 0001	9 -	1001	
2 - 0010	10 -	1010	(A)
3 - 0011	11 -	1011	(B)
4 - 0100	12 -	1100	(C)
5 - 0101	13 -	1101	(D)
6 - 0110	14 -	1110	(E)
7 - 0111	15 -	1111	(F)

Q - $(143)_{10} \rightarrow (\ )_2$

2	143
2	71 - 1
2	35 - 1
2	17 - 1
2	8 - 1
2	4 - 0
2	2 - 0
2	1 - 0
	0 - 1

$(10001111)_2$

Unit-4

Analog Communication

Communication means establishing a link b/w sender & reciever.
- sender
- transmitter
- reciever

medium → wired | wireless

wired ↓ small distance

wireless ↓ large distance

→ **Elements of communication system -**

Sender (i/p) (text, speech, image, video) → Transducer (i/p) → Transmitter → (channel) → Reciever → output Transducer → O/P signal

We have to convert it into electrical ~~equipment~~ equivalent whether its wired or wireless.

Transmitter : → modulation (main function)
If wired then wired modulation after transmitter (guidant medicines), In wireless (antennas, broadband).

Generally, weak signal, ↑ its frequency in order to transmit at very large signal.

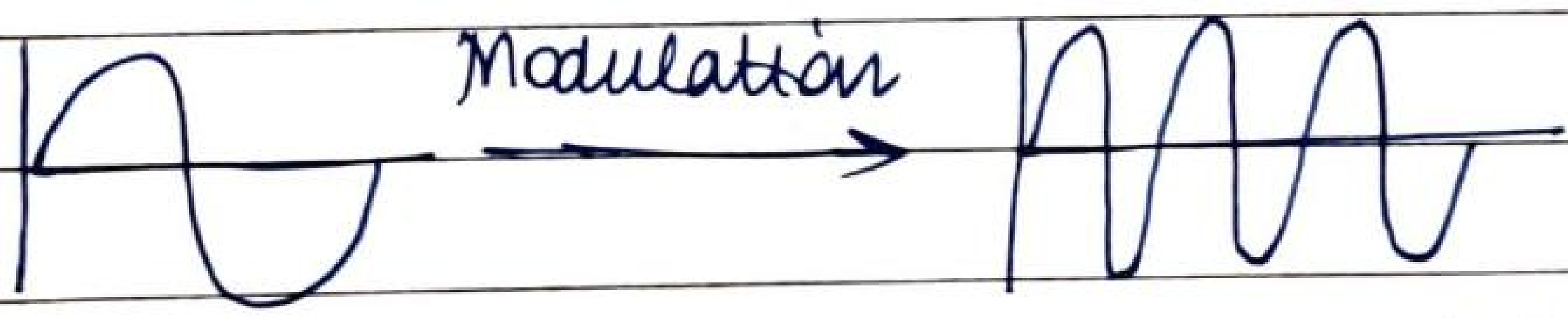
__/__/__

Modulation → input signal (baseband signal)
Carrier signal → Higher frequency signal because it has to carry information.

Channel : always give noise while transferring information. There are some systems to reduce this noise.

Reciever : It will recieve the signal. This recieve will get demodulated signal and hence we get the required output.

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



Carrier signal
+
Base signal

characteristic change according to the input signal.

- Continous wave modulation : carrier signal is continous
- Pulsed wave modulation : carrier signal is the form of pulse.

→ Length of antenna : Wavelength's 1/4

$= \frac{\lambda}{4}$

Q- Frequency 5 khz. Length of antenna to transmit this frequency?

$$f = 5hz$$
$$f = \frac{1}{\lambda}$$

$$L = \frac{c}{4f} = \frac{3 \times 10^{\cancel{8}\,5}}{4 \times 5 \times \cancel{10^3}} = \frac{3 \times 1\cancel{0} \times 10^4}{2\cancel{0}}$$
$$= 1.5 \times 10^4$$
$$= 15000\,m$$
$$= 15\,Km$$

Q- Frequency 3 mhz. Length of antenna?

$$L = \frac{\cancel{3} \times 10^{\cancel{8}\,2}}{4 \times \cancel{3} \times \cancel{10^6}} = 25\,m$$

~~Nee~~ Need of modulation.

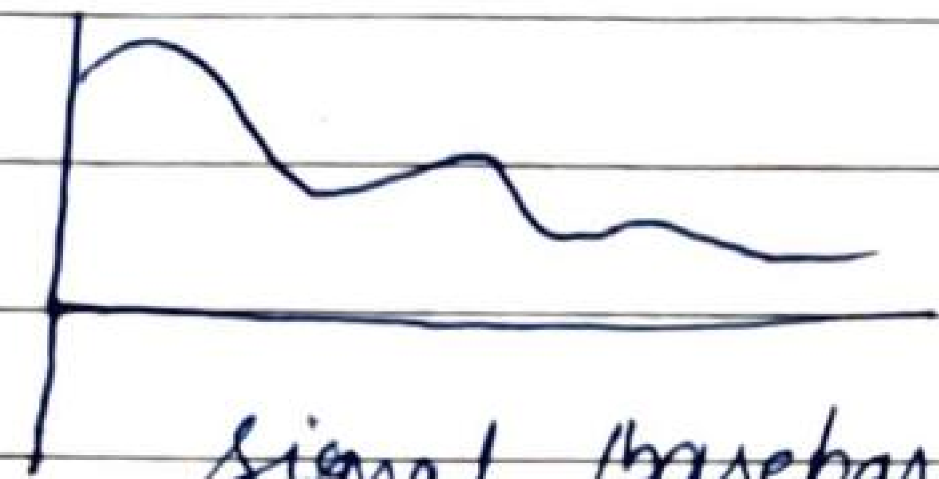
1.) Practicalability of Antenna (Explain above example)
2.) To remove interference -
audio signal : 20 Hz - 20 khz

3.) Reduction of noise

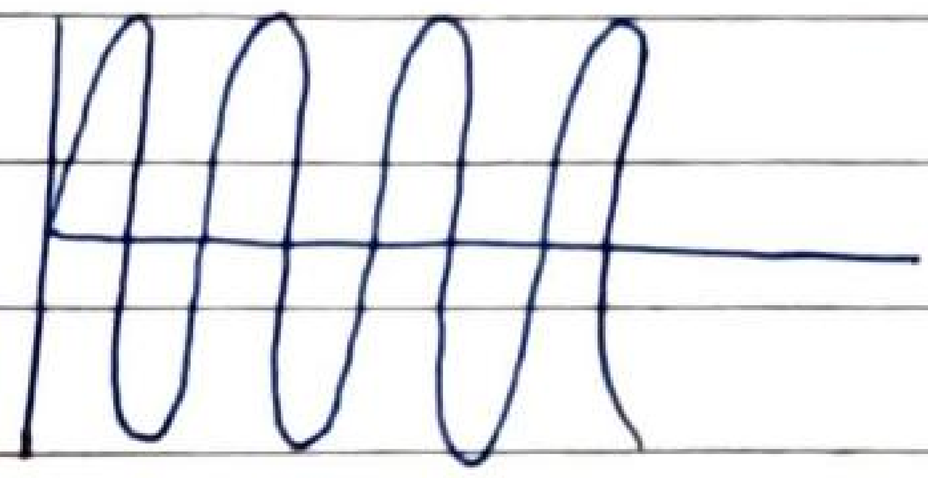
⇒ Demodulation: When we separate carrier information from the input signal.

Modulating signal + Carrier signal ⟶ Modulated signal

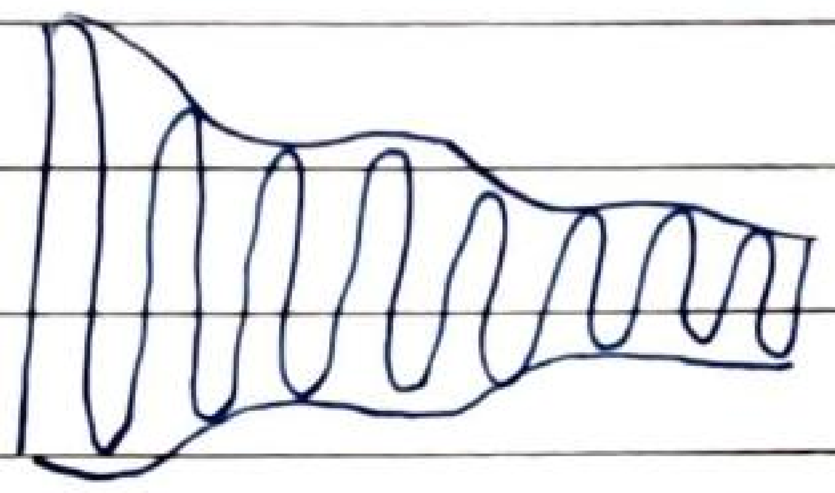
→ <u>Amplitude Modulation (AM)</u> : In this carrier's amplitude is changed wrt base signal.



signal (baseband)



Carrier



← Modulated Signal.

It is defined as a system in which the maximum amplitude of the carrier wave is made proportional to the instantaneous value of modulating or baseband signal.

<u>Example</u>- Let us consider a sinosuidal carrier wave —

$$\underset{\text{Amplitude}}{A}\cos \underbrace{\omega_c t}_{\text{frequency (angular)}} \quad \text{— (1)}$$

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

$c(t)$ = carrier wave

Let $x(t)$ denotes the modulating signal.

∴ Acc. to Amplitude modulation, the max. amplitude of 'A' carrier will have to be made proportional to the instanteous amplitude of modulating signal $x(t)$.

∴ The standard eqn. for AM can be expressed as —

$$s(t) = x(t) \cos \omega_c t + A \cos \omega_c t \quad \text{— (2)}$$

__/__/__

$$s(t) = [x(t) + A] \cos \omega_c t \qquad -③$$

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

$(x(t) + A) \rightarrow$ showing the envelope

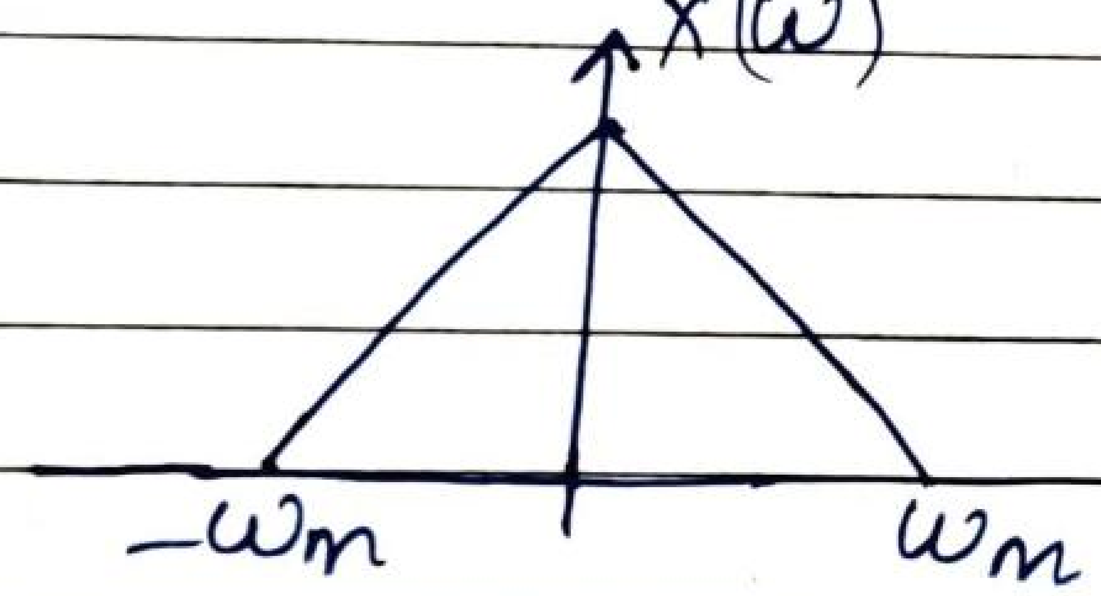
$\Downarrow$

E

$$s(t) = E(t) \cos \omega_c t$$

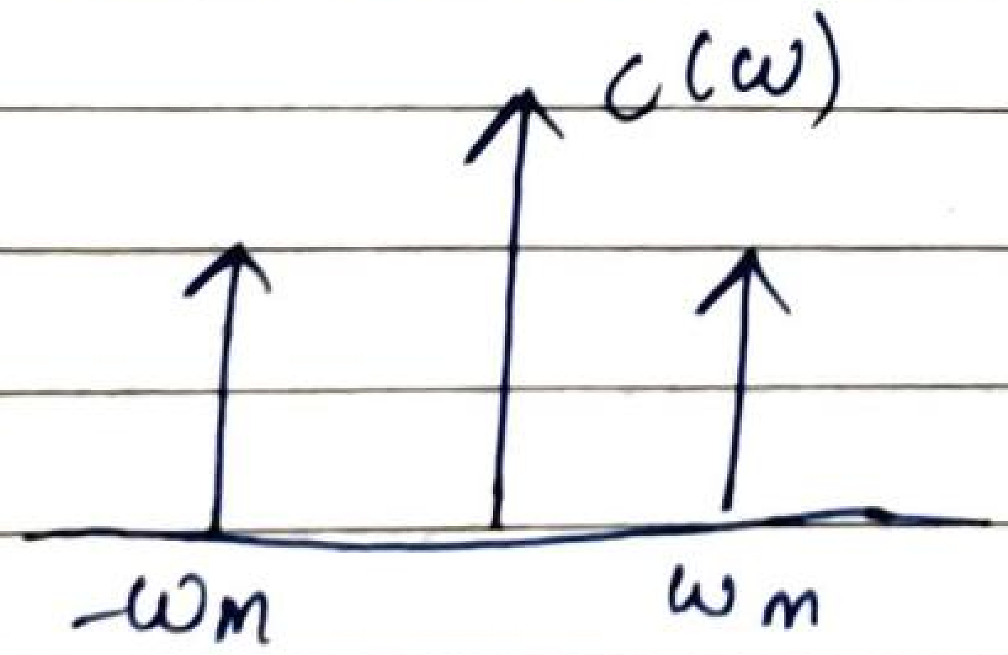
$$\boxed{E(t) = x(t) + A}$$

- The modulating signal has frequency ranges from $-\omega_m$ to ω_m which means it includes -ve frequencies.



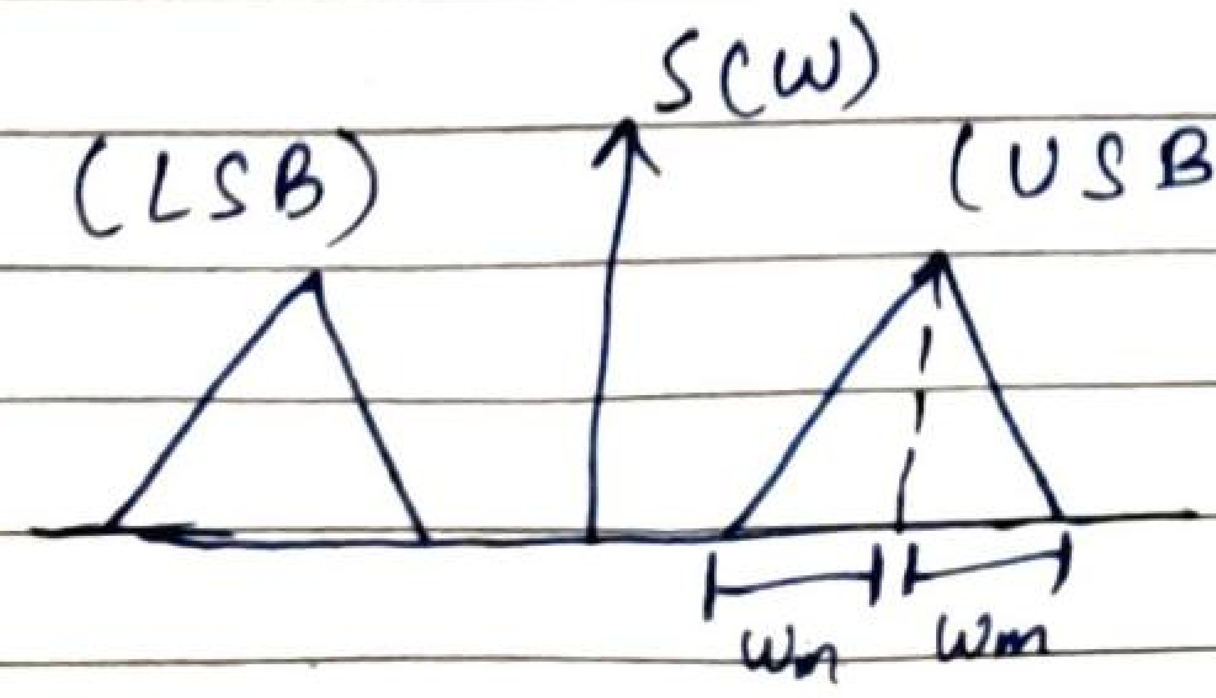
→ In case of modulating signal

-ve frequencies have no practical meaning but is used for mathematical convenience.



→ In case of carrier, as it has one frequency only.

LSB – Lower side band



→ In case of modulated signal.

- The difference b/w two extreme frequencies is equal to the bandwidth of the AM wave.

Bandwidth is the distance b/w the lower freq. and upper frequency.

Lower freq $\rightarrow$ $-\omega_c$
Upper freq $\rightarrow$ ω_c.
} carrier signal. $-\omega_m$, ω_m in case of MS.

$$\text{Bandwidth} = (\omega_c + \omega_m) - (\omega_c - \omega_m)$$

$$\boxed{B = 2\omega_m}$$

$\Rightarrow$ Modulation Index : The ~~index~~ extent to which carrier amplitude is changing wrt baseband signal.

It is defined as the measure of extent of amplitude variation about an unmodulated maximum carrier.

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

To find %, $m_a = \frac{|x(t)_{max}|}{A} \times 100$

- The modulating signal will be preserved in the envelop when $m_a \leq 1$

$$\Rightarrow |x(t)_{max}| \leq A$$

- $m_a \leq 1$ but if $m_a > 1$, the baseband signal is not preserved and the signal will not be recovered back from the envelop. This type of distortion is known as envelop distortion and the signal with $m_a > 1$ is known as overmodulated signal.

In case AM to happen, m_a should be less than equal to 1 or 100%.

→ Power content in AM wave –

$$P_c = \frac{A^2}{2}$$

The total power = Carrier power + Sideband power.

$$P_t = P_c\left(1 + \frac{m_a^2}{2}\right)$$

Q– A 400W carrier is modulated to a depth of 75%. Find the total power in AM wave assume modulating signal to be sinosuidal.

$$P_t = 400\left(1 + \frac{m_a^2}{2}\right)$$

$$m_a = 75\% = \frac{75}{100} = \frac{3}{4}$$

$$P_t = 400\left(1 + \frac{\left(\frac{3}{4}\right)^2}{2}\right)$$

$$= 400\left(1 + \frac{9}{32}\right)$$

Angular Modulation

Phase — Frequency

$$= 400 \left(\frac{32+9}{32}\right)$$

$$= 512.5\ W$$

⇒ Phase Modulation (PM) : It is that type of angular modulation in which phase angle ϕ is varried linearly with baseband or modulating signal ($x(t)$ and the modulated phase angle ie $(\omega_c t + \theta_0)$. If the unwanted carrier signal is expressed as -

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

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

$\phi = \omega_c t + \theta_0$

∴ ϕ varies linearly with baseband signal $x(t)$.

If we ignore θ_0

$$\boxed{\phi = \omega_c t}$$

Let the instantaneous value of phase angle be denoted by ϕ_i, then -

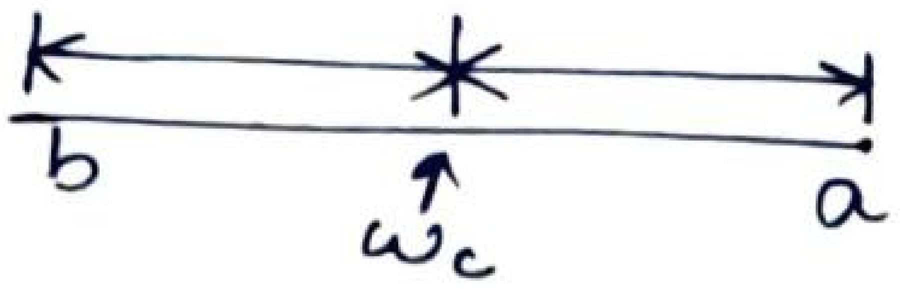
$$\phi_i = \omega_c t + k_p . x(t)$$

where k_p = proportionality constant and is known as phase sensitivity of the modulator.

$$s(t) = A \cos[\omega_c t + k_p . x(t)]$$

⇓

modulated signal

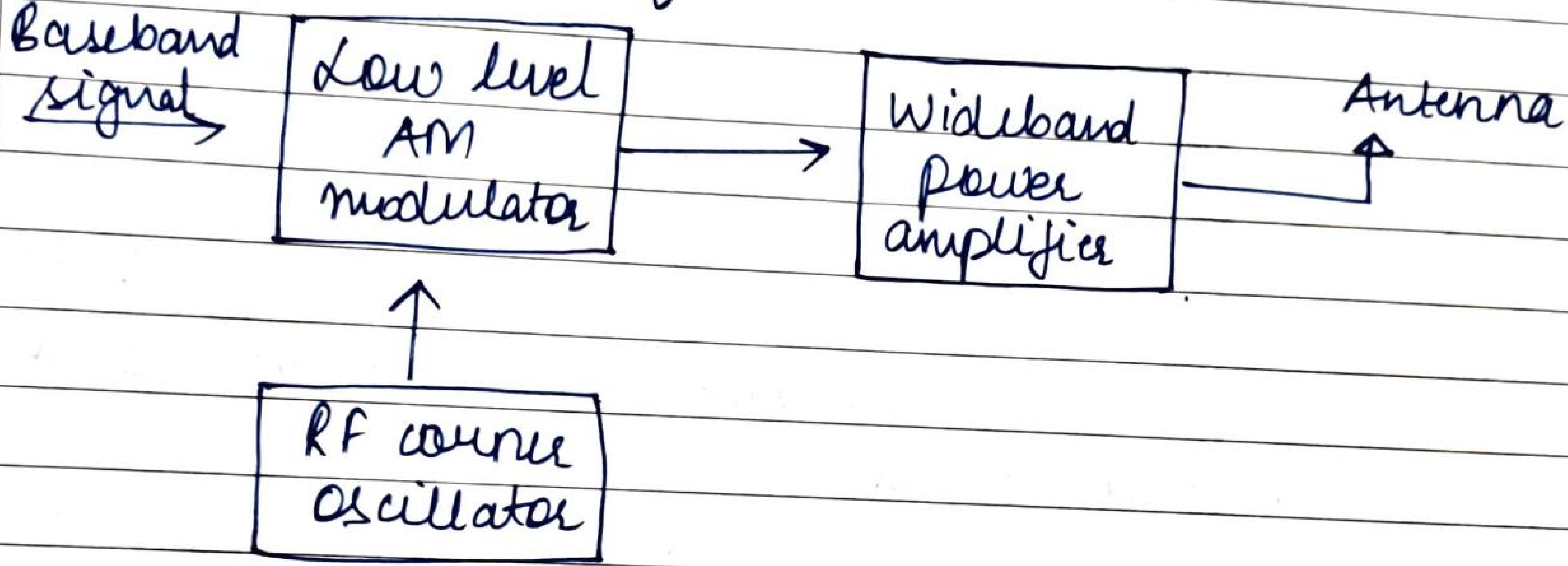


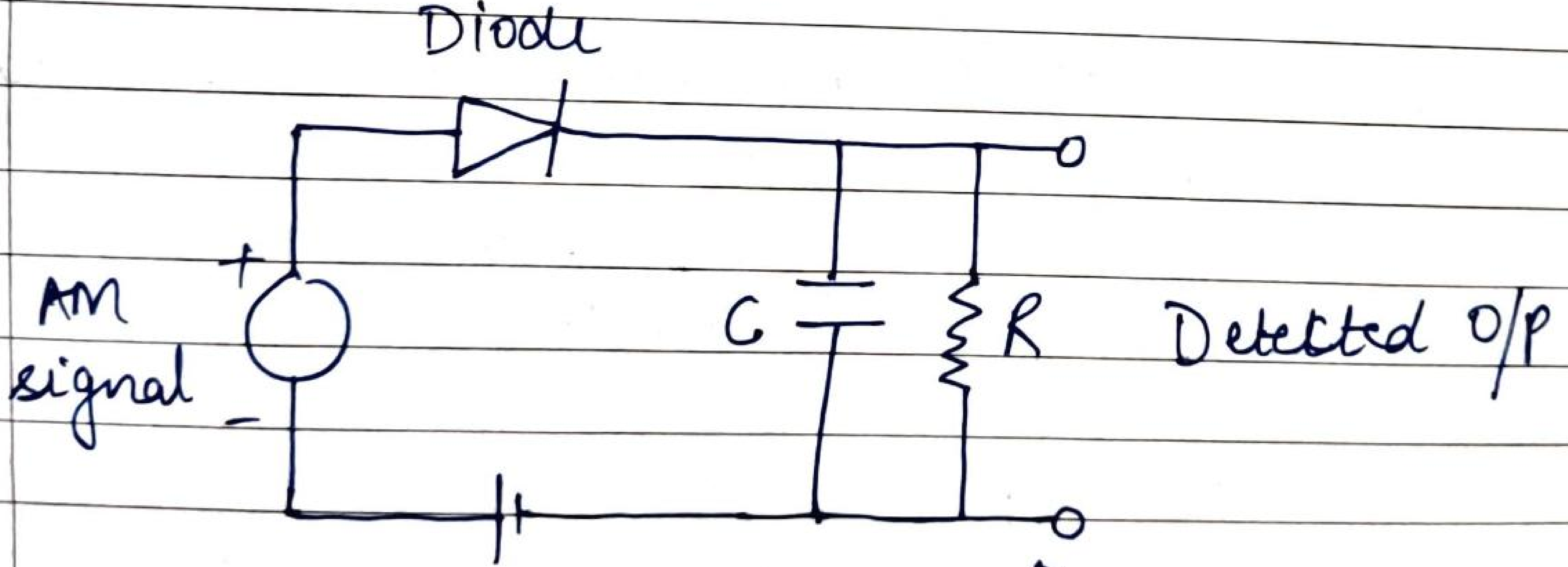
→ Frequency deviation –

The max. change in instantaneous frequency from the average frequency ω_c is called frequency deviation.

This maximum change depends upon the magnitude and sign of $k f x(t)$ and is represented by $\Delta\omega$.

$$\Delta\omega = |k f x(t)|$$





Diode Detector

Analog communication

→ Advantages of digital communication –

1) Digital communication system are simpler and cheaper compared to analog communication system because of the advances made in

Integrated circuits

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IC's technology.

2) In DC, the speech, video and other data may be merged and transmitted over a common channel using multiplexing.
3) Using data encryption, only permitted receivers may be allowed to detect the transmitted data.
4) Since the transmission is digital and chanel encoding is used. Therefore, the noise doesnot accumulate from repeater to repeater in long distance communication.
5) Since the transmitted signal is digital in nature a large amount of noise interferes may be tolerated.
6) As chanel coding is used, therefore the errors may be detected and corrected in the recievers.
7) DC is adapted to other advanced branches of data processing such as digital signal processing, image processing, data compression etc.

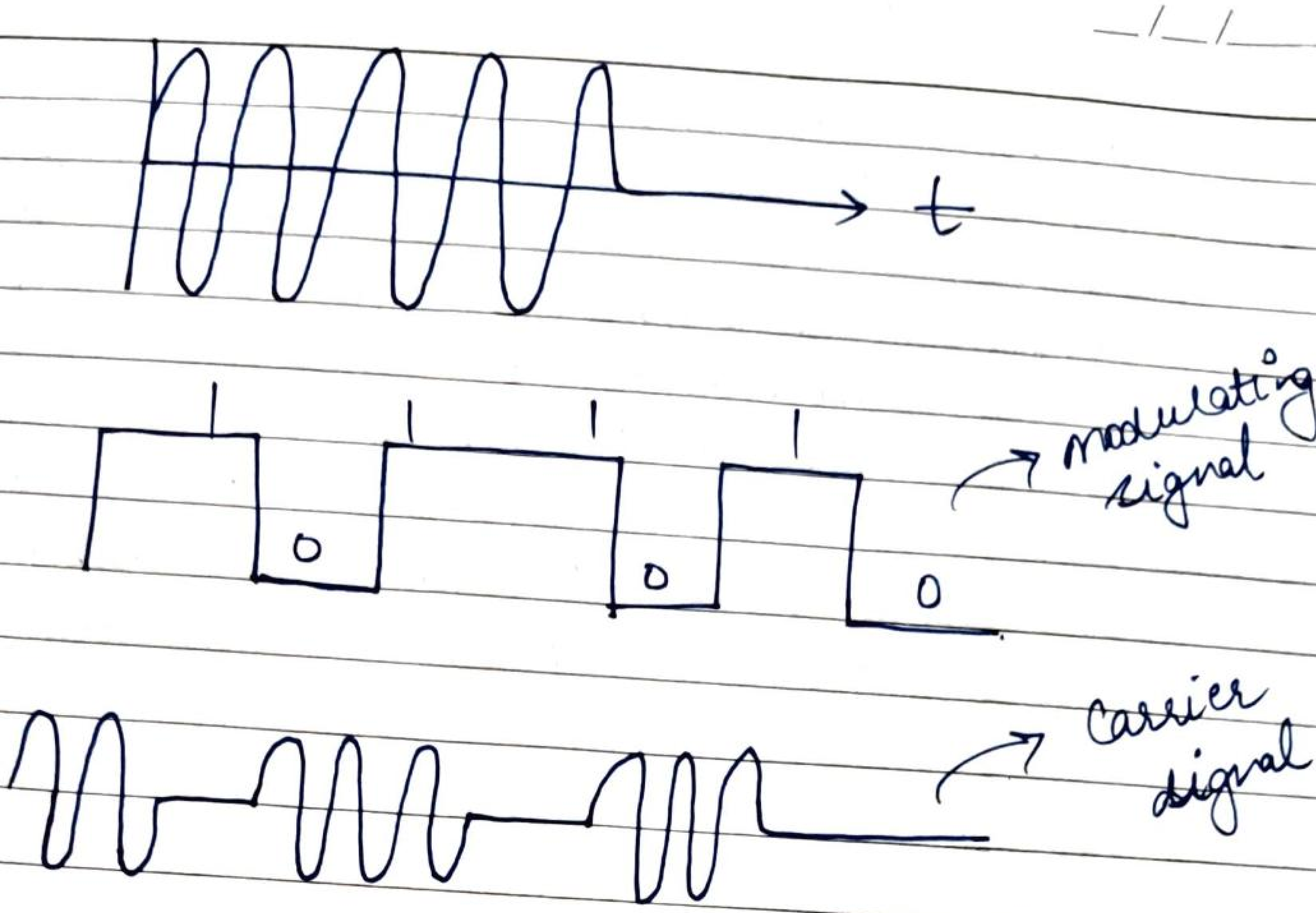
⇒ <u>Modulation techniques in digital communication</u> –

ASK (Amplitude shift keying)
FSK (Frequency " ")
PSK (Phase " ")
] Digital

1.) <u>ASK</u>: It is also known as On-off key (OOK). In this method, there is only one unit energy carrier and it is switched on or off depending upon the input binary sequence

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

$$s(t) = 0 \quad \text{to transmit '0'}$$



Signal space diagram of ASK:

$$s(t) = \sqrt{P_s T_b}\,\sqrt{2/T_b}\,\cos(2\pi f_c t)$$

$$= \sqrt{P_s T_b}\,\phi_1(t)$$

There is only one carrier function $\phi_1(t)$ and signal space diagram will have 2 points on $\phi_1(t)$

symbol '0'   symbol '1'

$\longrightarrow \phi_1(t)$

$\sqrt{P_s T_b}$

The distance b/w 2 signal points is –

$$d = \sqrt{P_s T_b} = \sqrt{P_s T_b} - 0$$

$$\boxed{d = \sqrt{E_b}}$$

_/_/_

→ Frequency Modulation : It is that angle of modulation in which the instantaneous frequency ω_i is varied linearly with a message or baseband signals about an unmodulated carrier frequency ω_c.
Mathematically, $\omega_i = \omega_c + k_f \cdot x(t)$ — ①

where k_f = proportionality constant and is known as frequency sensitivity of the modulator.

Now, 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 the unmodulated carrier.
Let ϕ_i be the instantaneous phase angle of the modulated signal.
From eq. ③ on frequency modulation.
All frequency modulation amplitude 'A' must remain constant only angle ϕ with change. Hence expression for frequency modulated wave is -

$$s(t) = A\cos\phi_i \quad — ⑤$$

from eq. ④ -

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

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

Integrate -

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

__/__/__

∴ We write instantaneous value of ϕ as ϕ_i

Integration is $\phi_i = \int \omega_i \, dt$ — (6)

where ω_i = Instantaneous frequency of frequency modulated wave

Now, putting the value of ω_i –

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

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

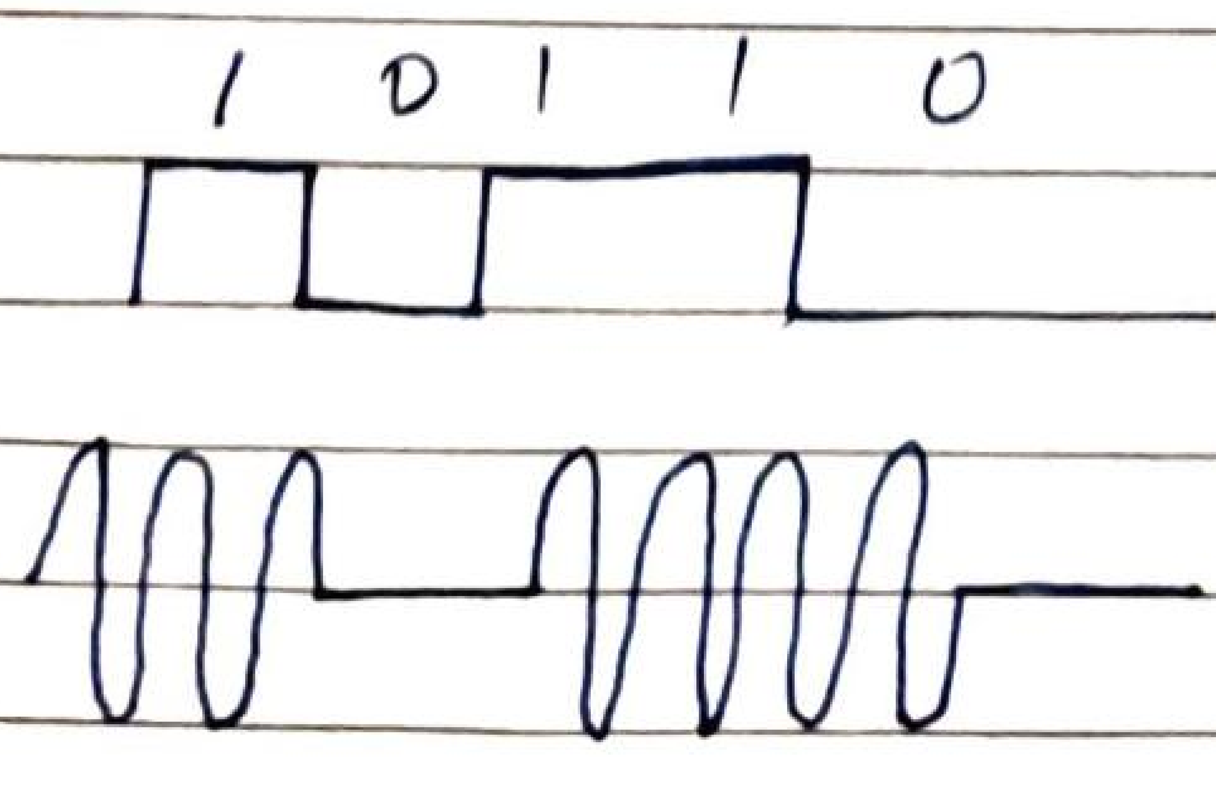
Put the value of ϕ_i in eq. (5) –

$$s(t) = A \cos [(\omega_c t + k_f \int x(t)) \cdot dt]$$

⇒ Assignment – 2

1.) (i) Discuss 7 segment LCD display
(ii) Perform conversions from hexadecimal to all the number systems.

2) (i) What do you understand by modulation index in case of frequency modulation. Analyse fm and pm mathematically.
Discuss demodulation of both. Discuss difference –
(ii) ~~Discuss~~ Highlight the application of modulation in engineering.



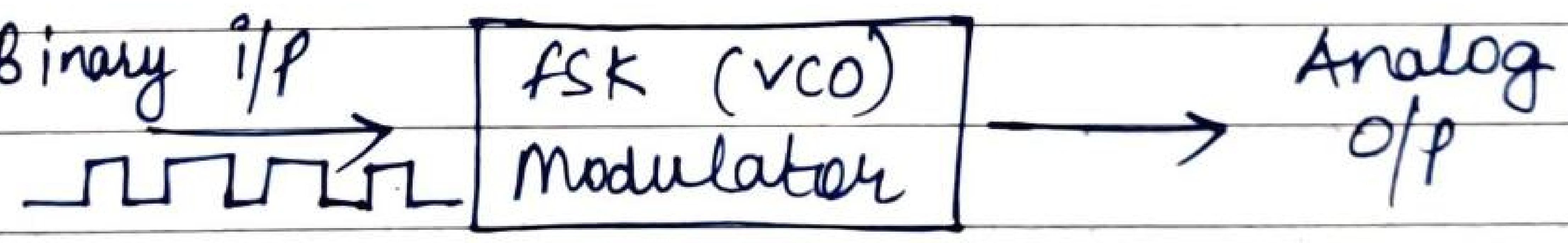
2.) FSK : (Frequency shift keying) It is a type of digital modulation binary FSK ie BFSK)

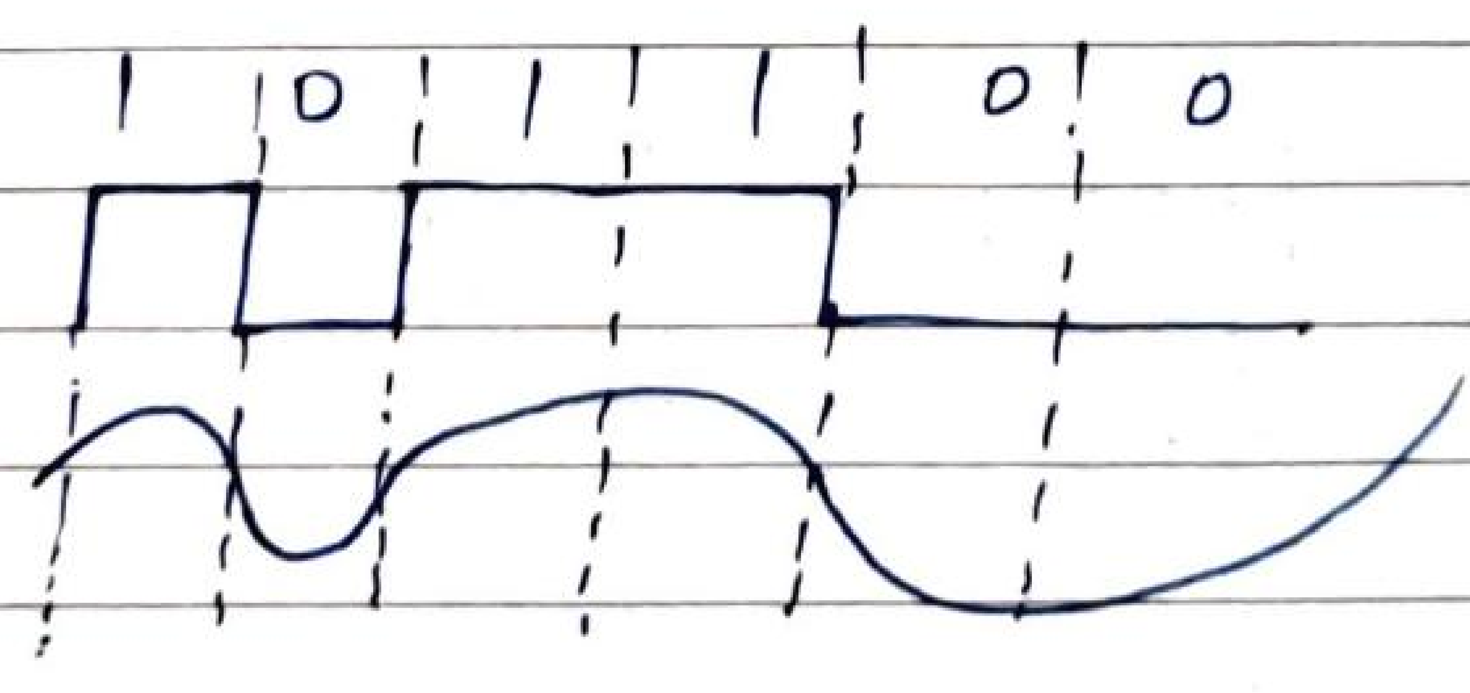
Binary FSK is a form of constant amplitude angle modulation similar to conventional frequency modulation except that the modulating signal is a binary signal that varies between 2 discrete voltage levels rather than continously changing analog wave form. The general expression for binary FSK is -

$$V_{fsk}(t) = V_c \cos[2\pi[f_c + V_m(t)\Delta f]t \quad \text{—(1)}$$

where V_{fsk} = binary FSK
V_c = peak amplitude of carrier
f_c = carrier / center frequency
Δf = change in frequency / freq. deviation
V_m = modulating signal

FSK modulator :





Δf in eq. (1) is proportional to amplitude and polarity of binary Input signal and modulating signal $V_m(t)$ can take

Electronic Communication System
By - Tomasi

2 values ie +1 for logic 1
-1 for logic 0

For logic 1 -

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

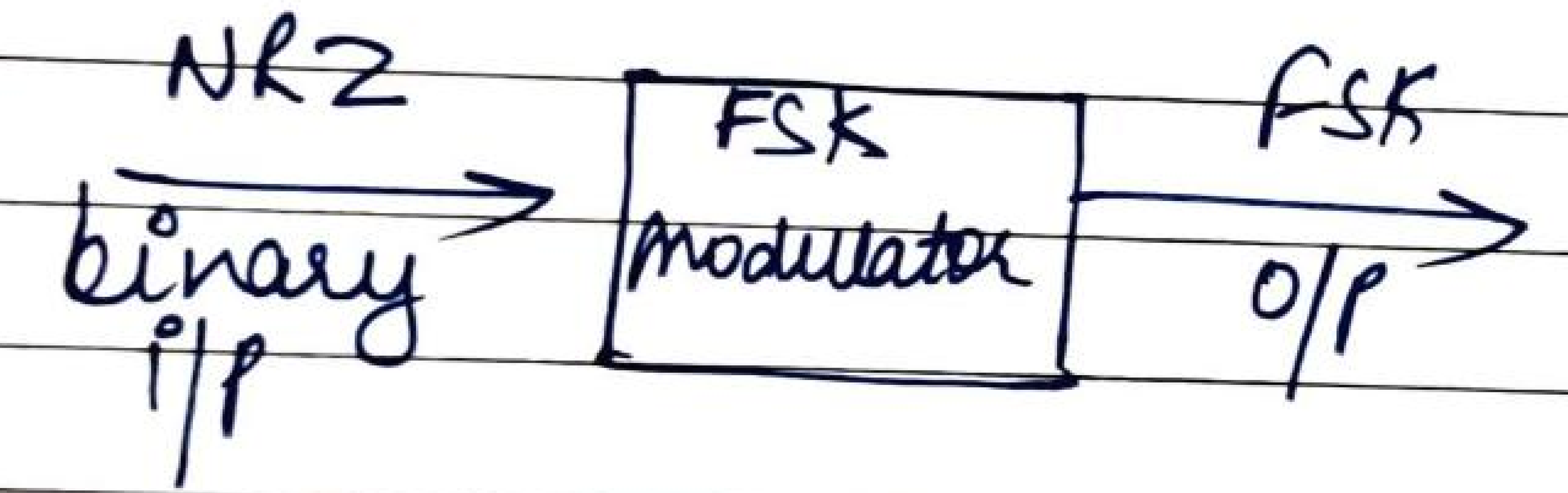
For logic 0 -

$$V_{fsk}(t) = V_c \cos[2\pi[f_c - \Delta f]t]$$

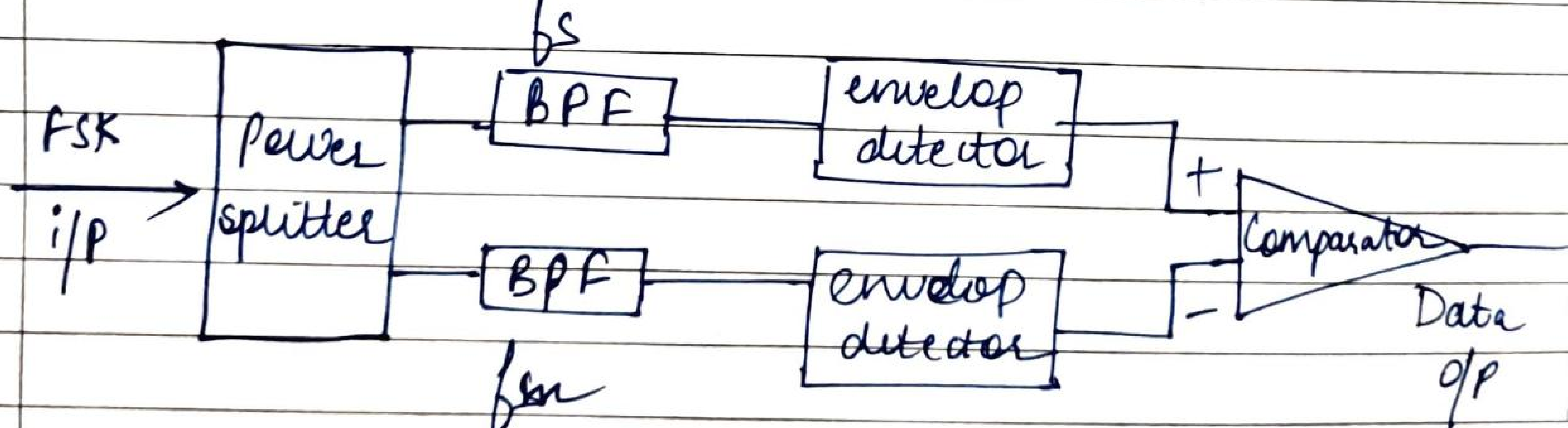
Two ranges in which signal lies -
$f_c + \Delta f$ $f_c - \Delta f$

<u>FSK transmitter</u> : It will take input of NRZ and give output of analog.

NRZ waveform → not return to zero.



RZ waveform → return to zero

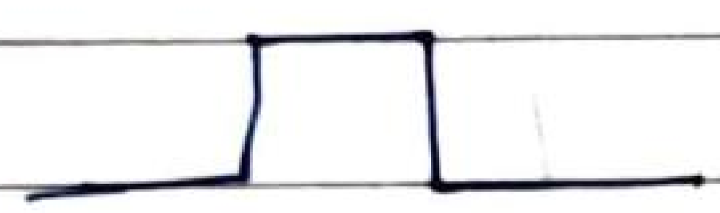


3.) <u>PSK</u>: (Phase shift keying) It starts from BPSK
↓
M-ary { no. of phases acc. to no. of signals }

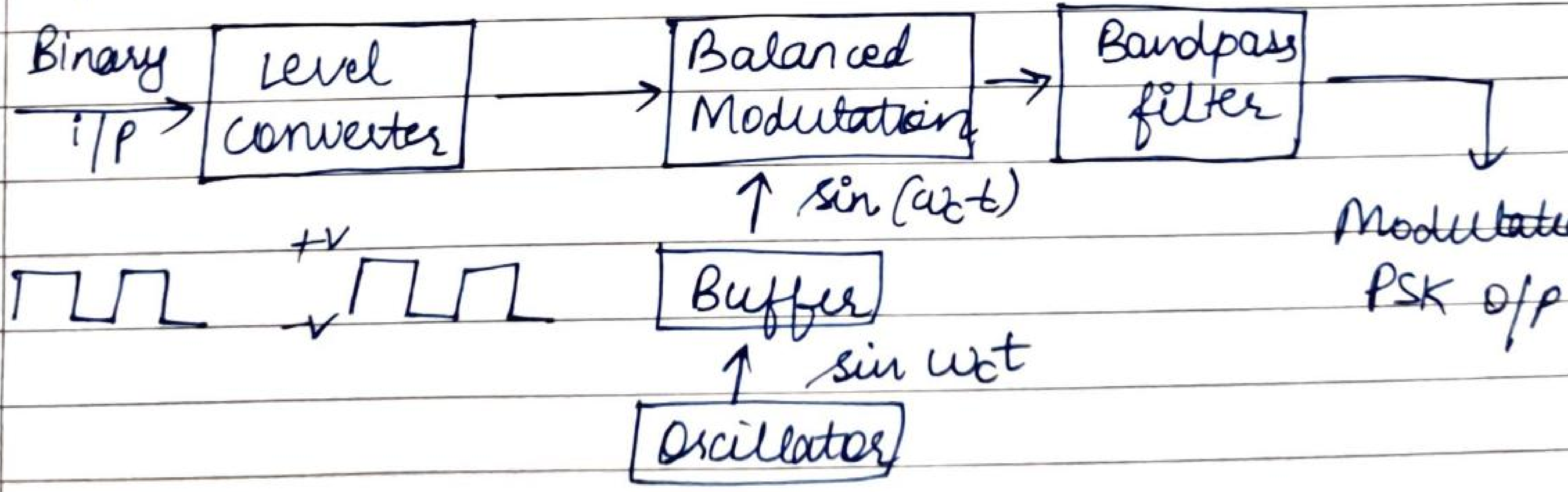
PSK is similar to conventional phase modulation except that with PSK the input signal is binary digital signal and a limited no. of output phases are possible

- BPSK

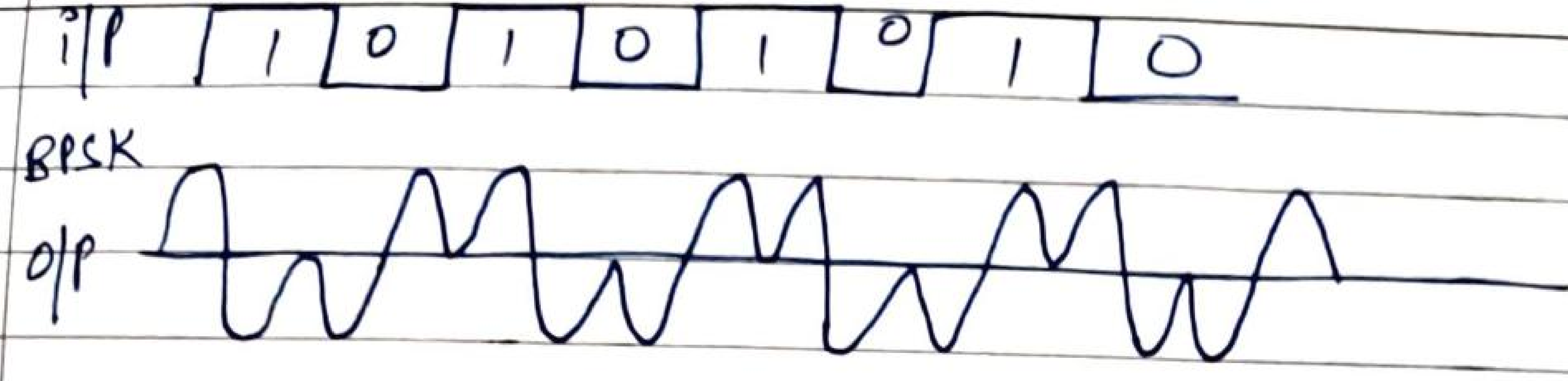
logic 0 = 0°
logic 1 = 180°



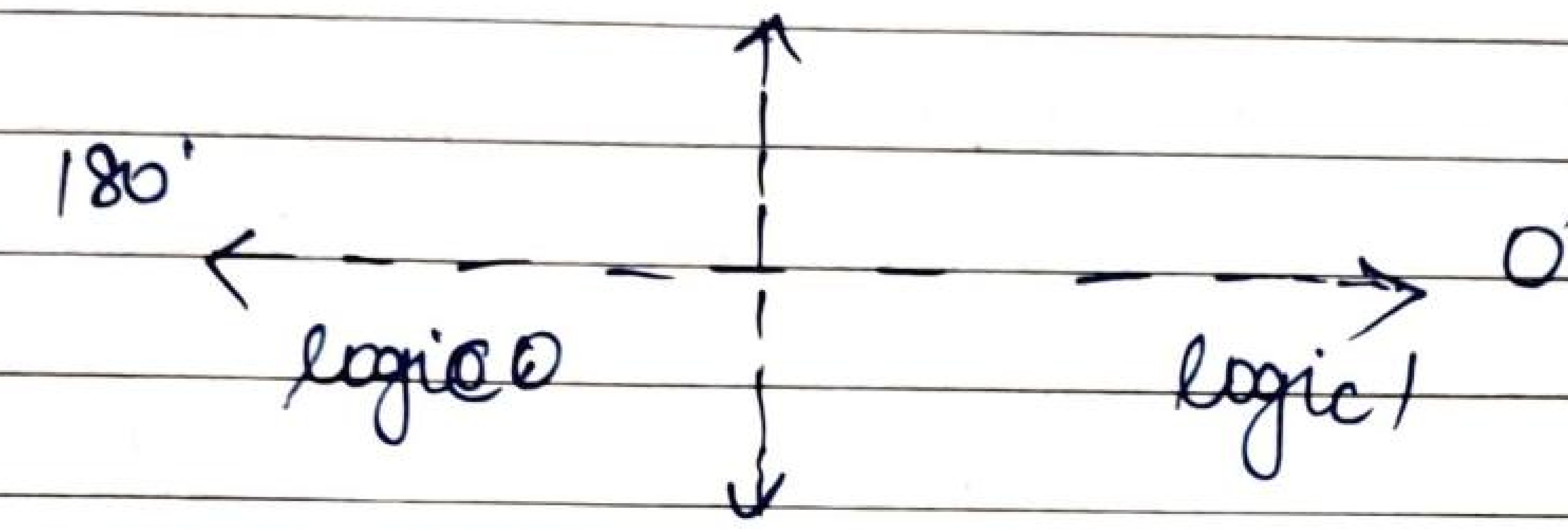
- With BPSK, two output phases are possible for a signal carrier frequency. One o/p phase represents logic 1 and other logic 0.
- As input digital signal changes state, the phase of the output carrier shifts between 2 angles i.e 180° out of phase.
- Other name of BPSK are - phase reversal key or biphase modulation



In the block diagram, the balanced modulator acts as phase reversing switch depending on the logic condition of digital i/p, the carrier is transferred to the o/p either in phase or 180° out off phase with the reference carrier oscillator.

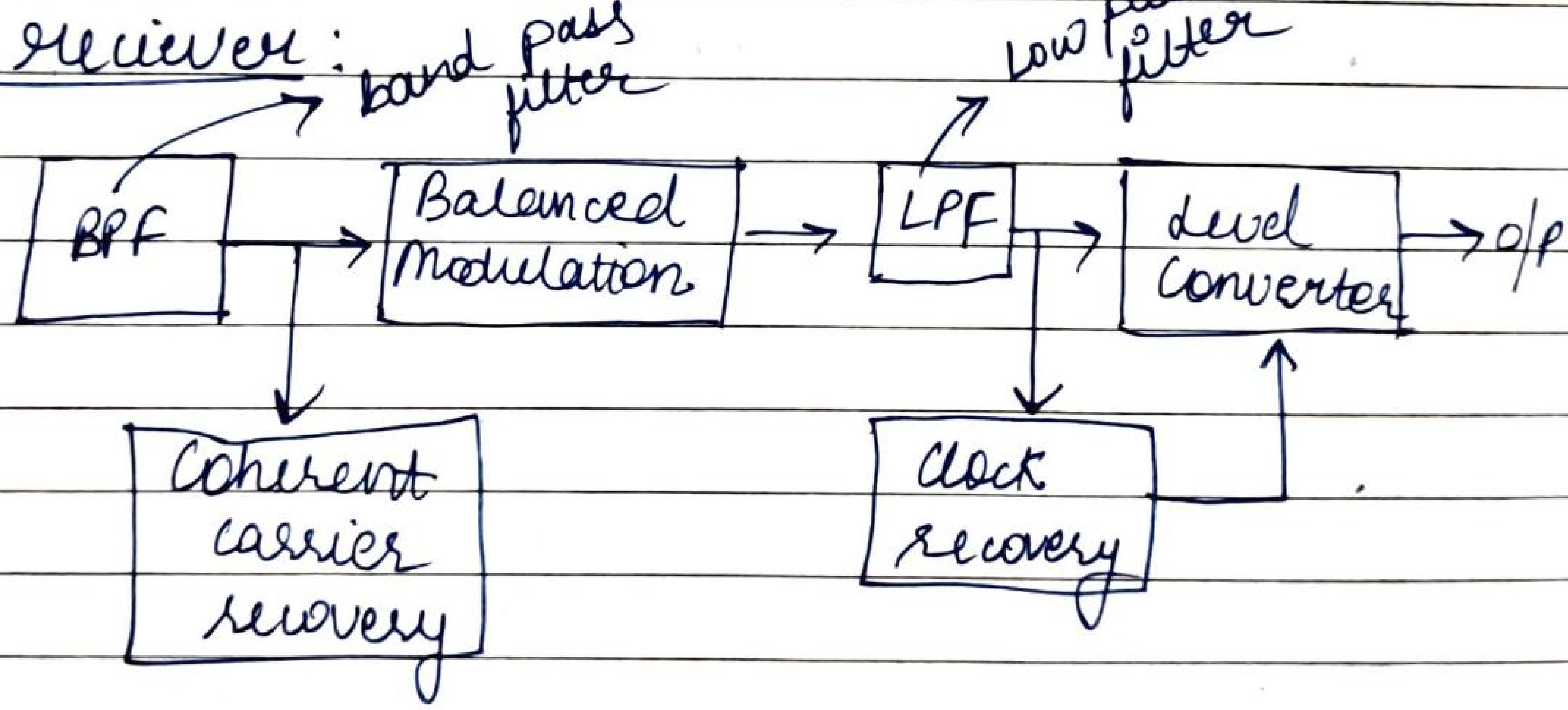


Binary i/p	o/p phase
logic 0	180'
logic 1	0'



constellation Diagram

- BPSK reciever:



→ M-ary Encoding -

Advantages: can send more no. of information bit in less time.

$N = \log_2 M$ ⟷ M → no. of output conditions possible

N → no. of bits encoded

$2^n = m$

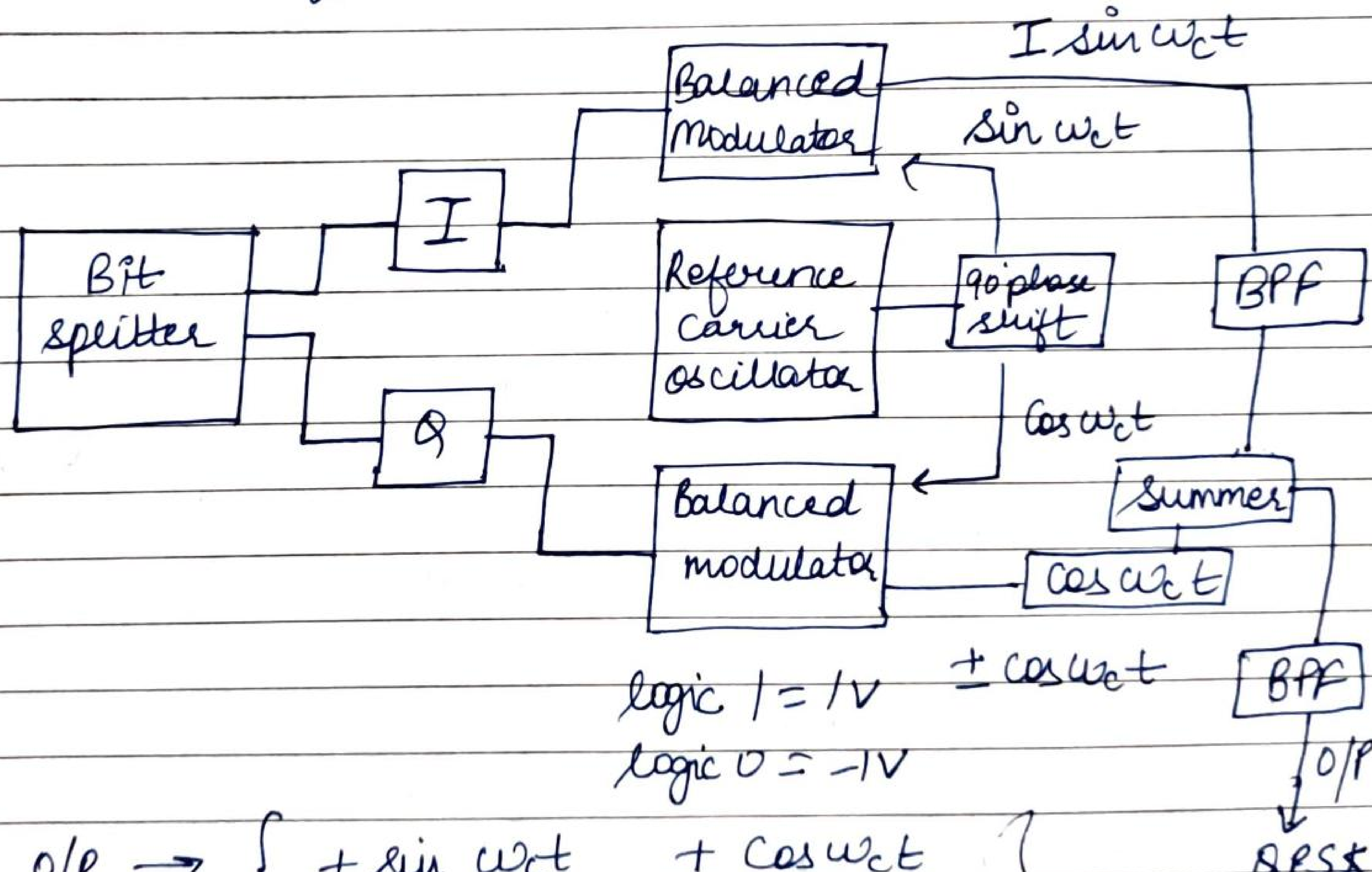
__/__/__

QPSK → Quaternary phase shift keying

$\pm \sin \omega_c t$, $\pm \cos \omega_c t$

modulated on basis of logic 0 & logic 1.

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



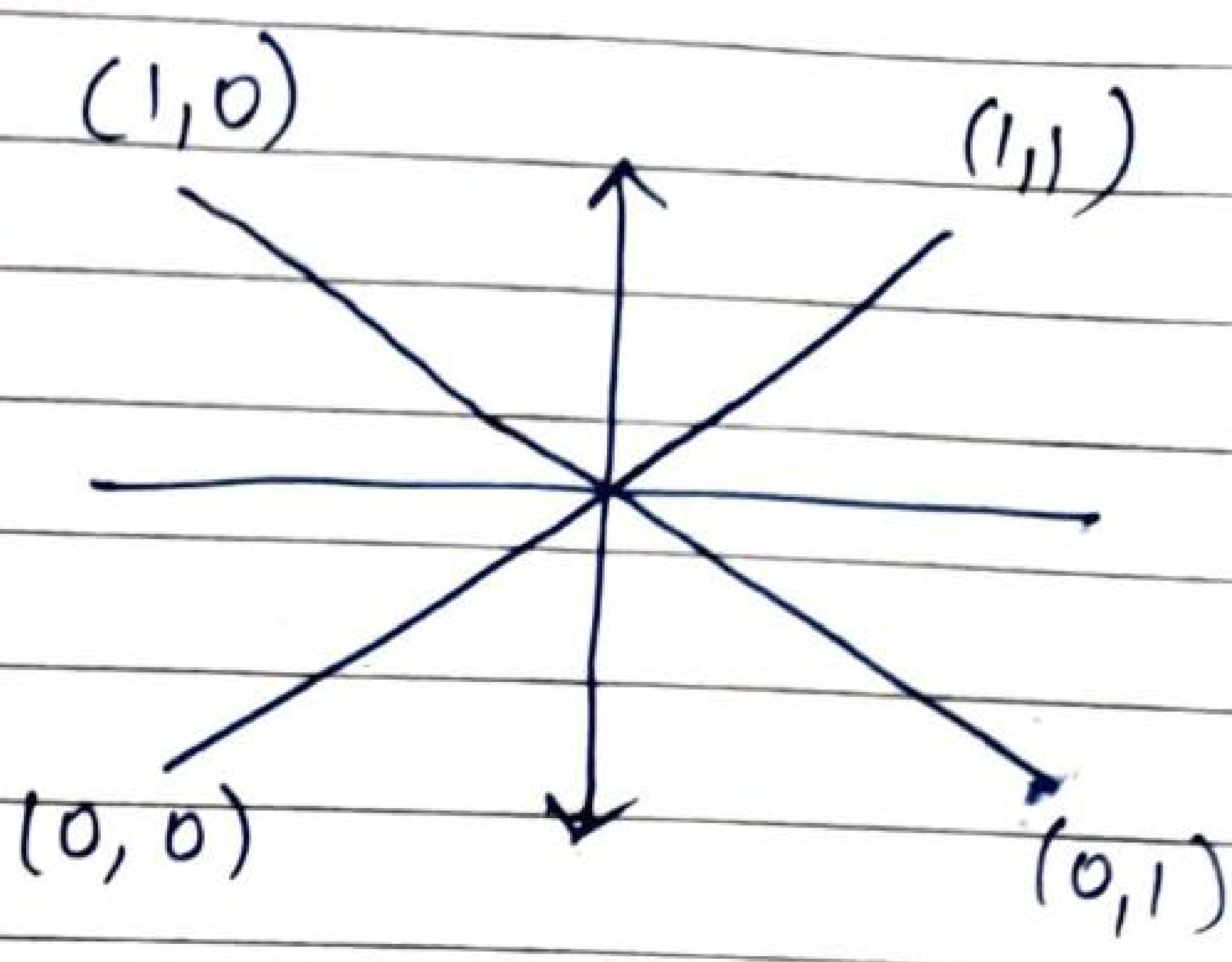
logic 1 = 1V
logic 0 = −1V

$$\text{O/P} \rightarrow \left\{ \begin{array}{ll} +\sin \omega_c t & +\cos \omega_c t \\ +\sin \omega_c t & -\cos \omega_c t \\ -\sin \omega_c t & +\cos \omega_c t \\ -\sin \omega_c t & -\cos \omega_c t \end{array} \right\}$$

QPSK Transmitter

Truth table

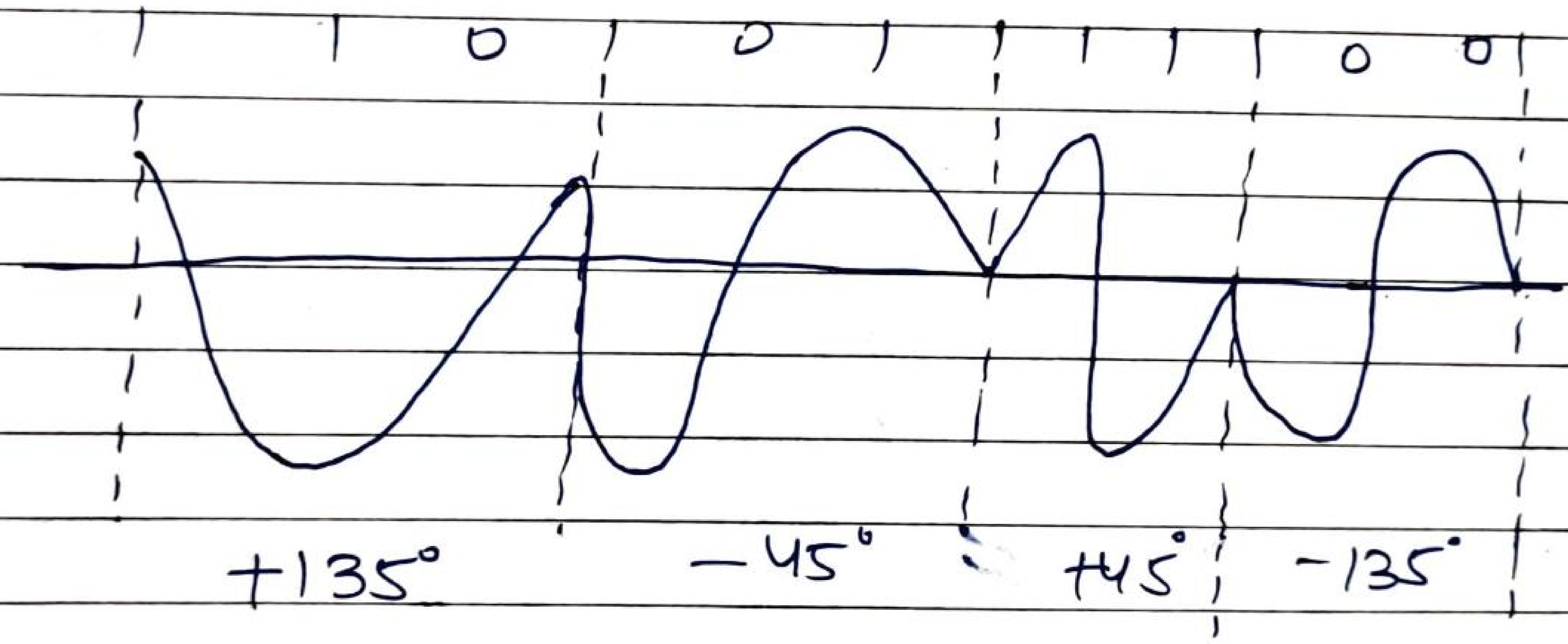
Q	I	O/P phase
0	0	−135°
0	1	−45°
1	0	+135°
1	1	+45°



phase diagram

→ <u>constellation diagram</u>

Output phase :



<u>QPSK Reciever</u> -

The power splitter for the reciever directs the input QPSK signal to I and Q detectors and carrier recovery circuit. To reproduce the original transmit carrier oscillator signal. The QPSK signal is demodulated in I and Q products detector which generates the original IQ databits. The O/P of the detectors are fed to the bit combining circuit where they are

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converted from parallel I & Q data channels to a single binary output datastream.

Ch - Oscillators

Oscillators: when you give feedback to your circuits, it becomes a loop, then the oscillations start.

Barkhausen Criteria

→ Oscillators: Oscilators are +ve feedback circuits which generates a periodic waveform output without any input.

In +ve feedback amplifier gain with feedback is given by:-

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

A → gain of amplifier

β → gain of feedback circuit.

+ve feedback gain

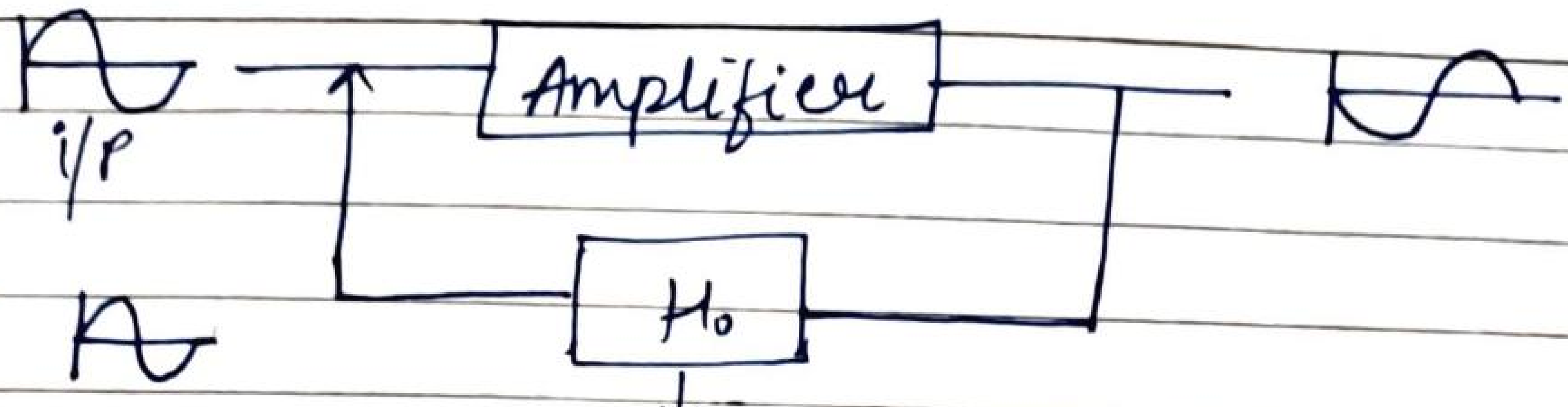
→ $\boxed{|A\beta| = 1}$ → Condition for amplifier converting to oscillator.

→ To convert an amplifier into an oscillator, the magnitude of $A\beta$ should be 1.

→ Barkhausen Criteria: It states that through

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

R → Resistor
C → Capacitor
L → Inductor



↓
feedback circuit

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

↓
integer

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

→ Types of Senisodial Oscillator - (depending upon frequencies produced)

LC Oscillator

RC Oscillator
(produces audio frequency)
20 hz - 20 khz

→ Senisodial Oscillator - It is divided into 2 types on the basis of frequency of output generated by the oscillators.

(i) RC Oscillators : These oscillators generates audio frequency outputs (20 hz—20khz)

(ii) LC Oscillators : These generates output of radio frequency range.

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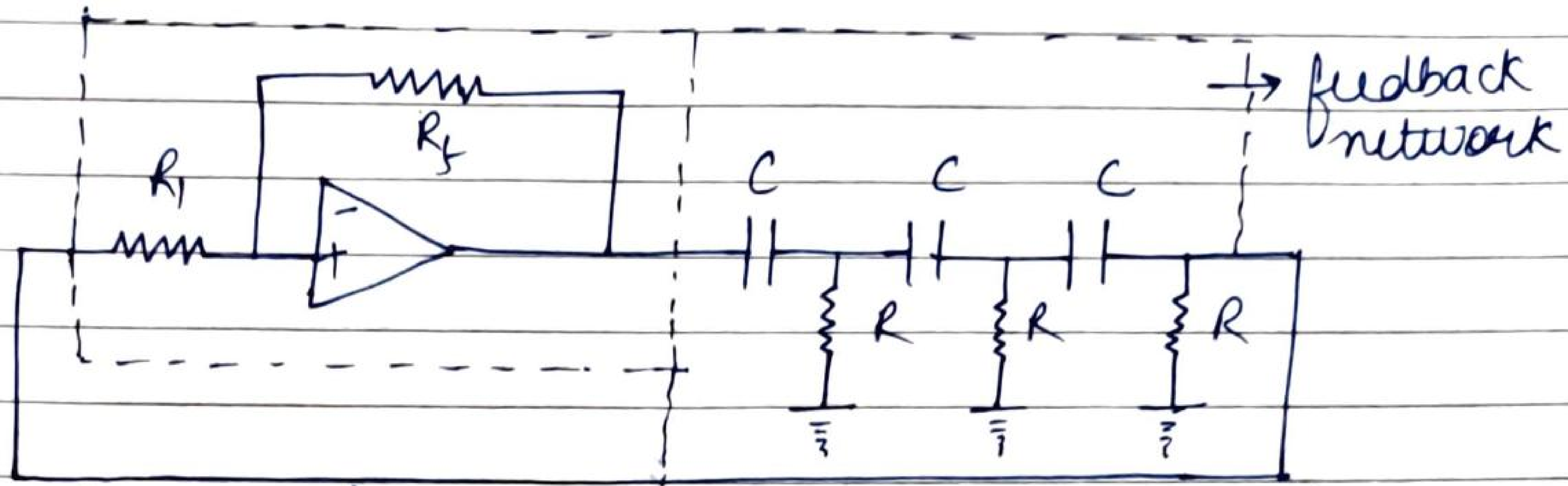
(i) RC phase shift oscillator:



(op. amp)
↓
also produces phase shift of 180°

each RC produces 60° phase shift, Total phase shift is by 180°

Total phase shift (180° + 180° = 360°)
After that it will become oscillator by satisfying Barkhausen criteria.

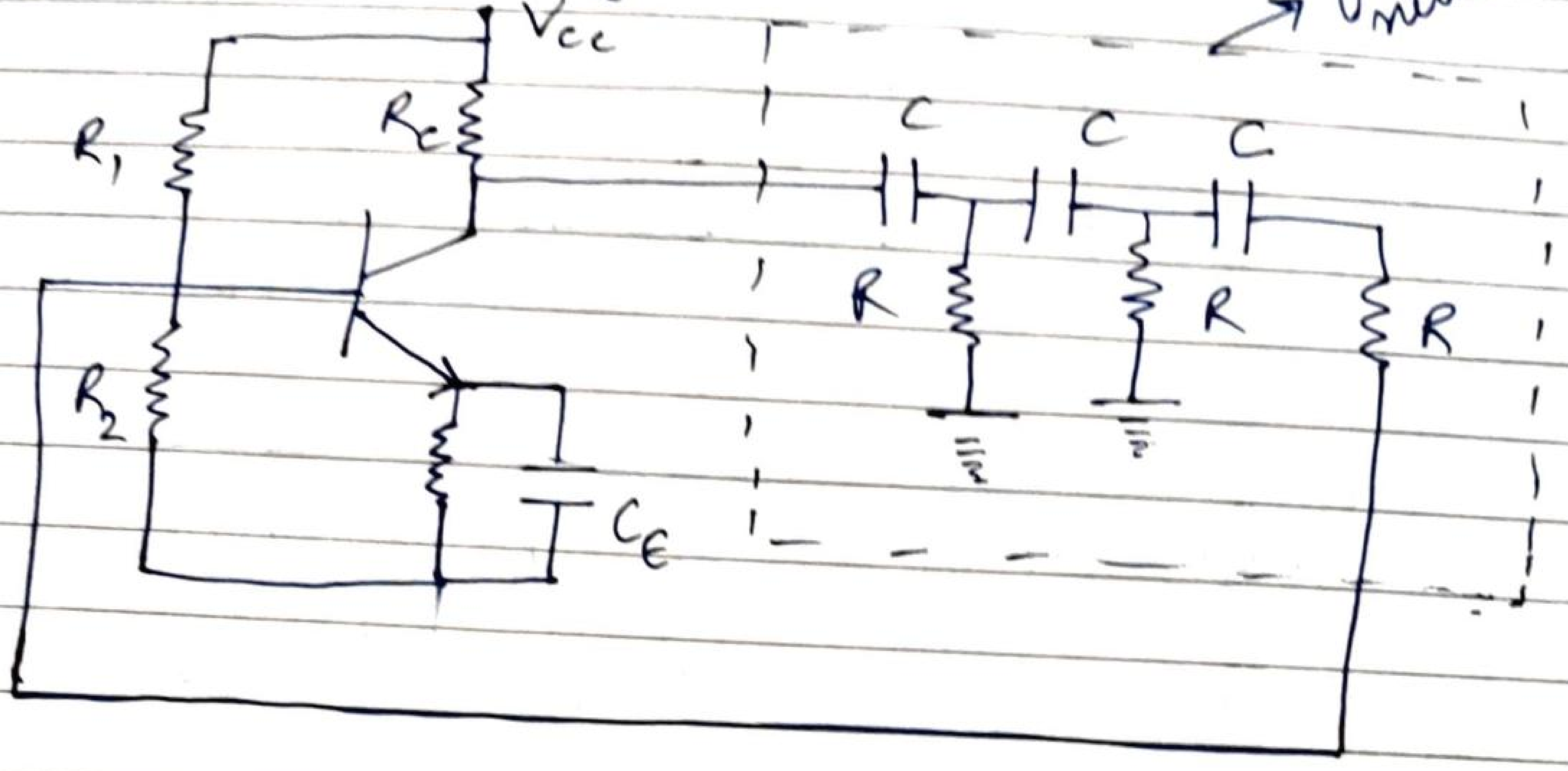
In RC phase shift ~~criteria~~ oscillator, 3 RC networks are used in feedback and these each RC network in circuit is adjusted so that each RC network provides phase shift of 60°
Hence, total phase shift provided by overall feedback network is 180°

To satisfy Barkhausen criteria, the total phase shift around loop should be 360°.
Hence, the operational amplifier is operated in inverting mode so that it provides a phase shift of 180°. So, the total phase shift becomes 360.

2 terminals → inverting (+ve) and non-inverting (-ve)

360° ← phase shift → 180°

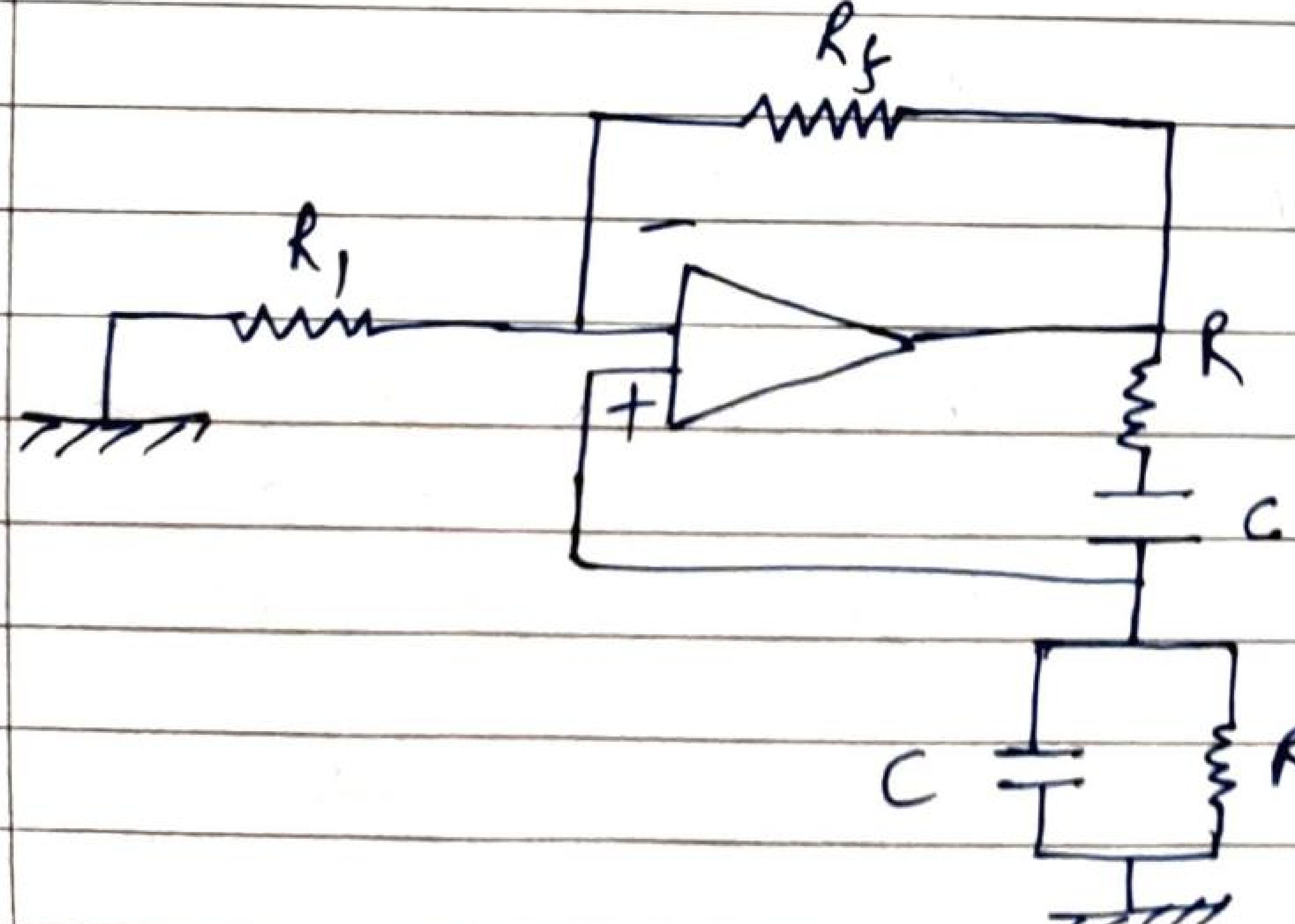
→ RC oscillator using transistor -



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'

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

Weinbridge oscillator -



This feedback network doesnot provide any phase shift to signal. This is a combination of series and parallel combination of R & C

- A basic Weinbridge oscillator consist of a series and a parallel RC combinations in the feedback network.
- In Weinbridge oscillator, the feedback network provides 0° phaseshift. Hence, the operational amplifier is operated in non-inverting mode and frequency of oscillation is given by -

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

- To sustain the oscillation, we have -

$$|\beta| = \frac{1}{3}$$

$$|A\beta| = 1$$

$$|A| = 3$$

- As the amplifier is operated in non-inverting mode. Therefore, $A = 1 + \frac{R_f}{R_1}$

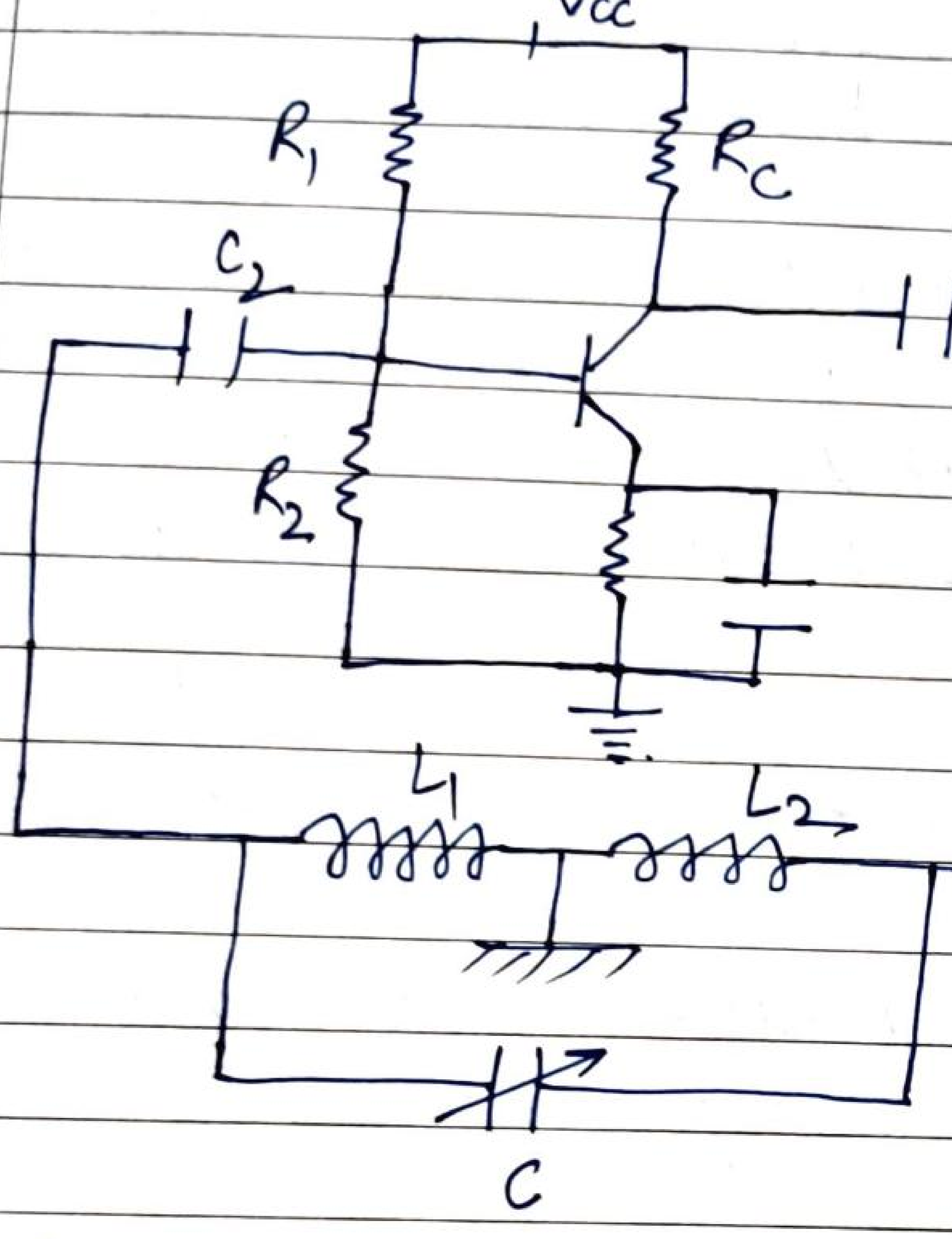
$$3 = 1 + \frac{R_f}{R_1}$$

$$\boxed{\frac{R_f}{R_1} = 2}$$

$$\Rightarrow \boxed{R_f = 2R_1}$$

→ LC Oscillators

(a) Hartley Oscillator



→ Principle is parallel resonance.

A Hartley Oscillator uses LC Tank circuit in the feedback network consisting of center tant tagged inductor in parallel with capacitor. The principle of operation is parallel resonance. The feedback network provides phase shift of 180° and remaining 180° phase shift is provided by transistor.
The frequency of oscillations produced is given by —

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

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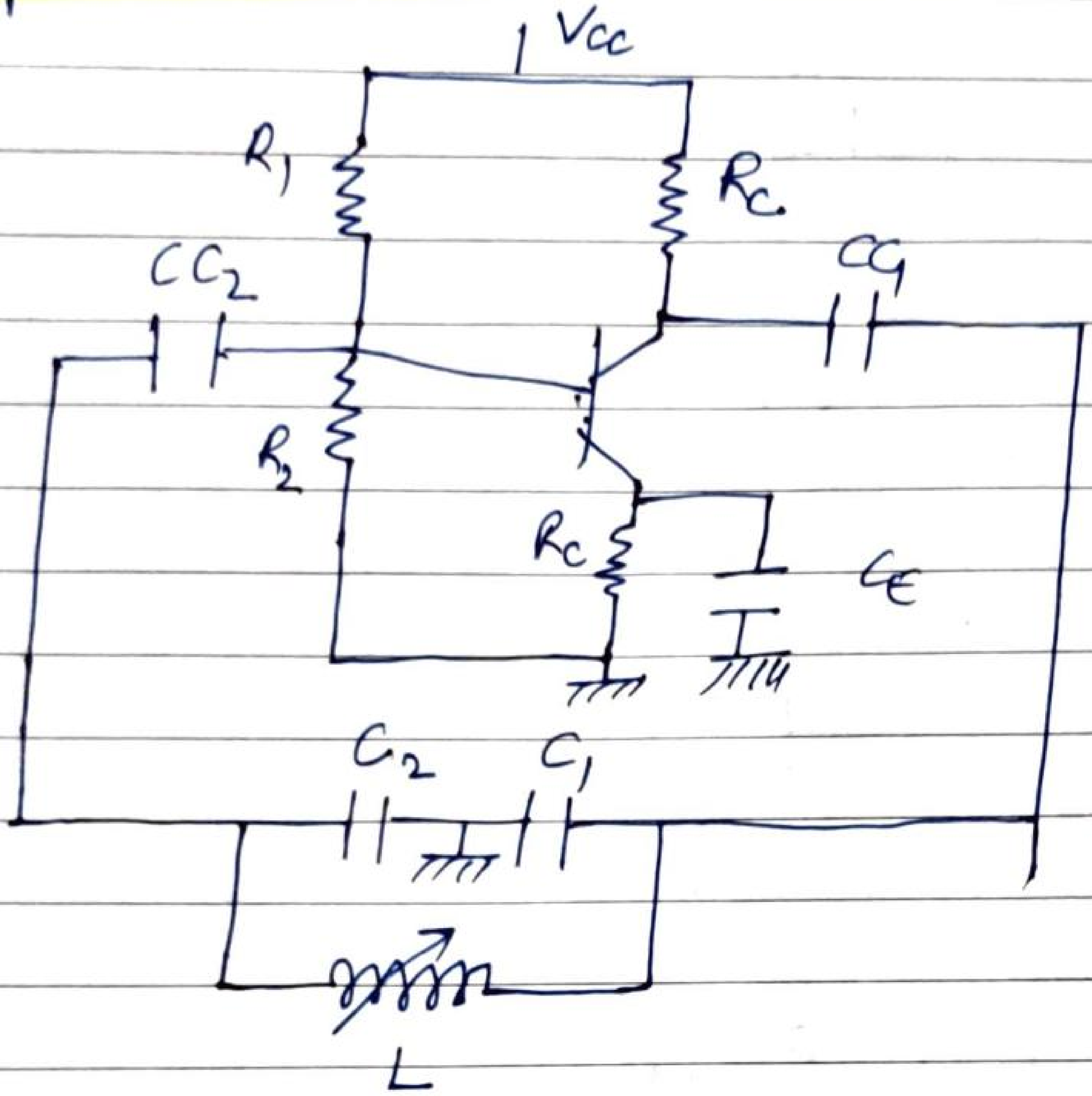
(5) Colpet Oscillator

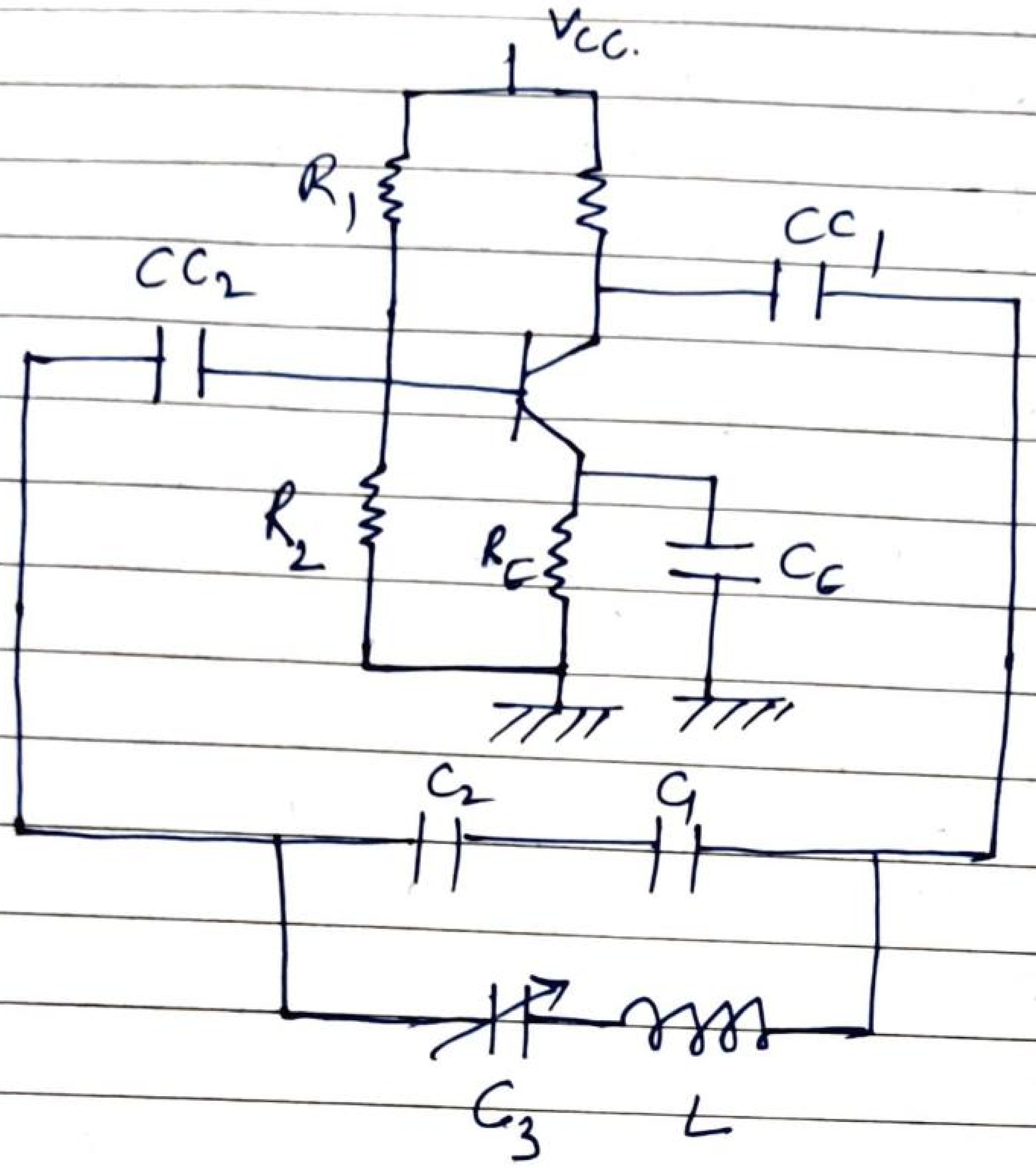


A colpet oscillator uses a tank circuit consisting of 2 capacitors with the ground b/w them in parallel with an inductor. The principle of operation is parallel resonance.
The disadvantage of this circuit is inductive tuning. The frequency of oscillation is given by -

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

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

(c) **Clapps Oscillator**:



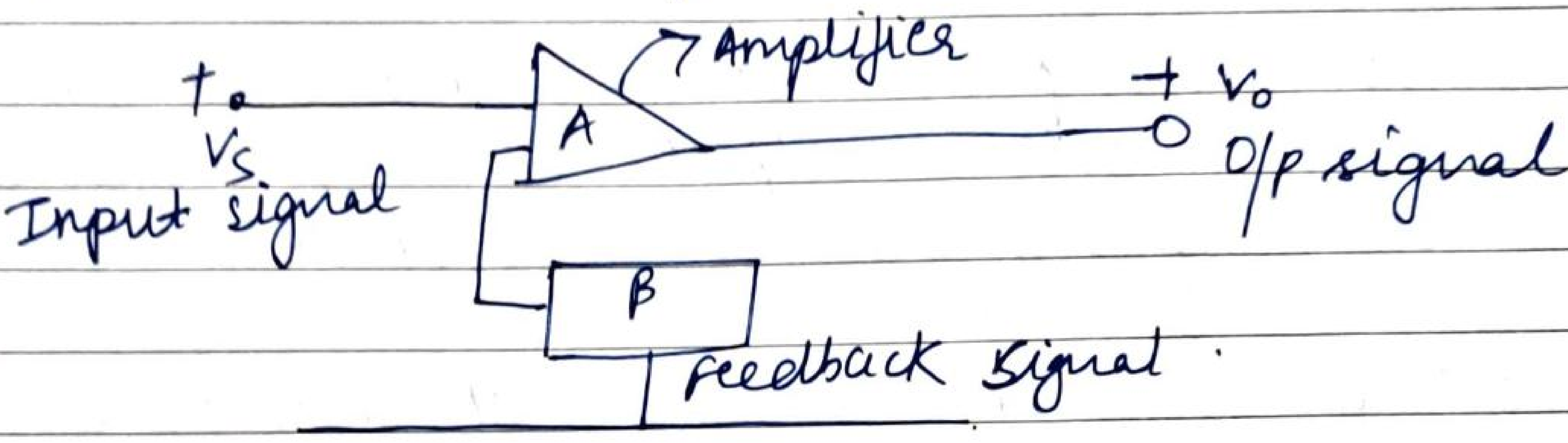
The clapps oscillator removes the disadvantage of colpet oscillator. The clapps oscillator is tuned by verifying capacitor C_3.

The frequency of oscillation is given by -

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

Feedback in Amplifier

Feedback Amplifier is a device that is based on the principle of feedback. The process by which some fraction of output is combined with the input is known as feedback.

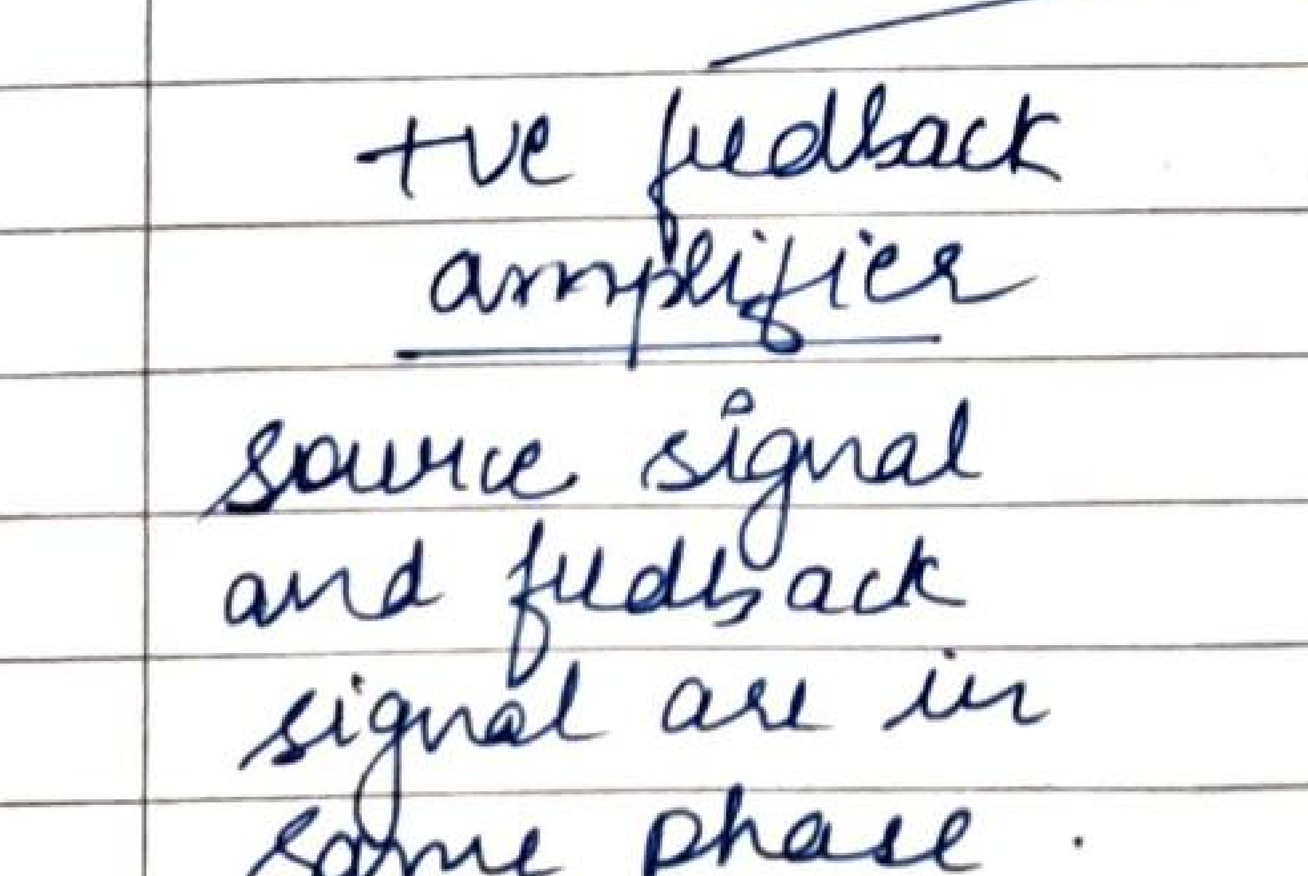


We know, for an ideal amplifier, there exists imp. characteristics like voltage gain, input impedence, output impedence, bandwidth etc. To control these parameters, feedback network is employed. Thus, a feedback network is employed in an amplifier so as to control the gain and other factors of the device.

2 types

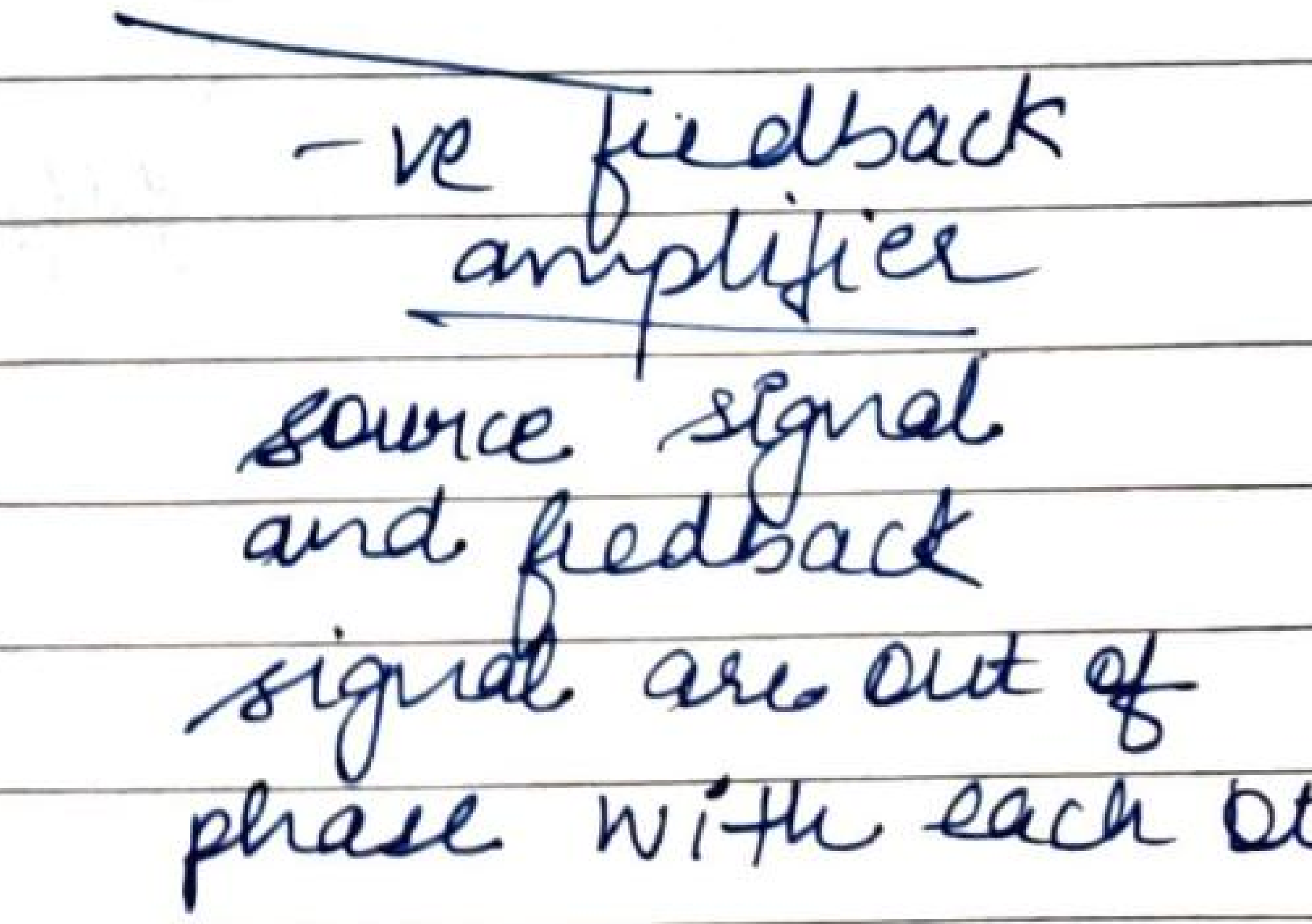
+ve feedback amplifier

source signal and feedback signal are in same phase.



-ve feedback amplifier

source signal and feedback signal are out of phase with each other



increases the strength of a signal.

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Types of amplifier –

1.) Current Amplifier : An amplifier that makes the given input current higher. It is characterisd by low input inpldence and high o/p impedance.

2.) Voltage Amplifier : It amplifies given voltage for a larger voltage output. It is characterisd by high input impedence and low o/p impedance.

3.) Transconductance Amplifier : It changes output current according to changing input voltage.

4.) Transresistance Amplifier : It changes output voltage according to changing input current. It is also known as current to voltage converter.

→ Reverse of transconductance amplifier.

Apart from the above basic amplifiers, there are several other types of amplifiers such as power amplifiers, operational amplifiers, transistor amplifiers etc.