UNIT-1

ONE SHOT : Revision

Today's Target

All Important Topics

As per
New Syllabus
2022-23

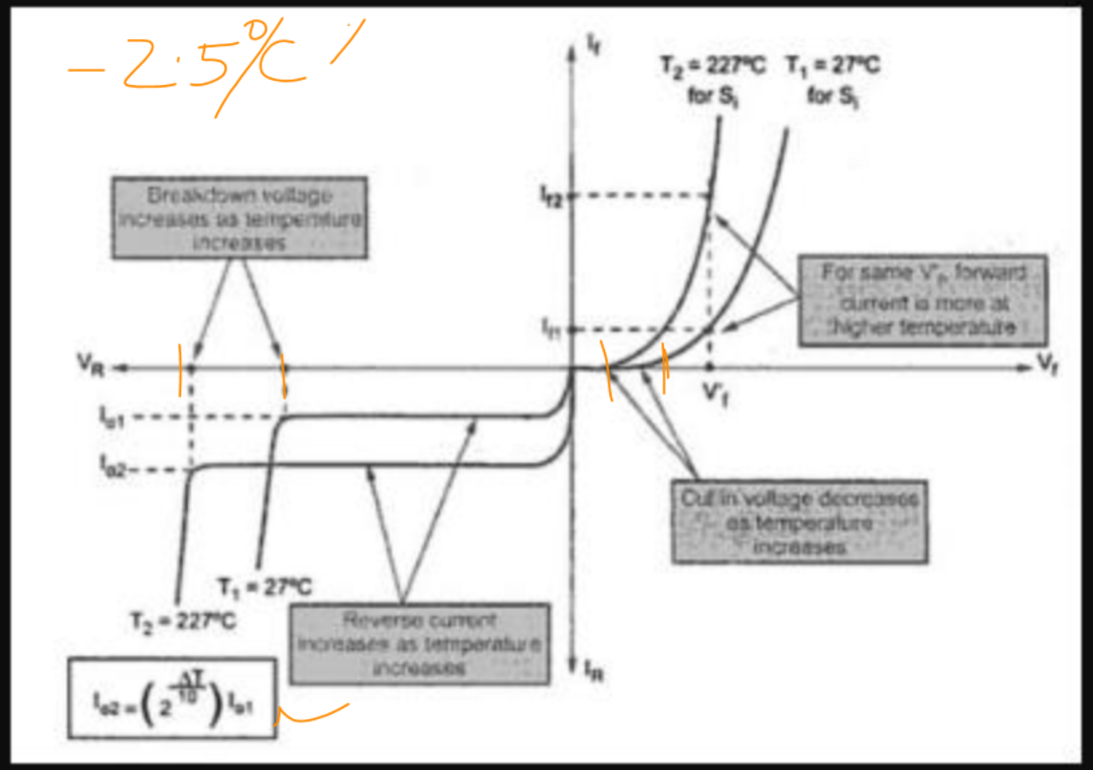
Temperature Dependence of V-I Characteristic

From experimental data it is found that reverse saturation current I0 increases 7 per cent per °C for both silicon and germanium. Since (1.07)10 ≈2.0, the reverse saturation current approximately doubles for every 10°C rise in temperature.

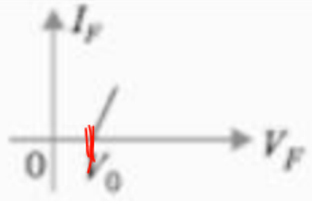
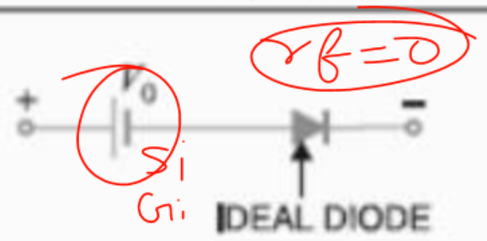
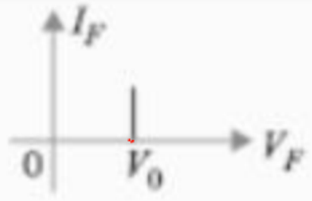
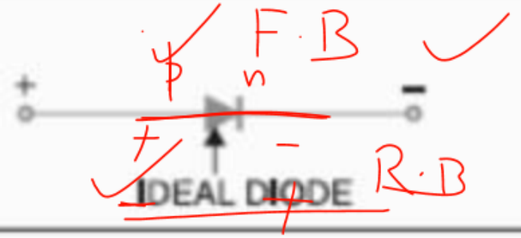
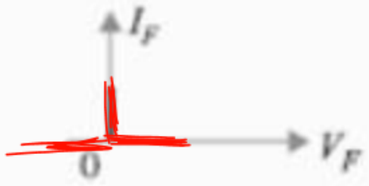
Germanium is more temperature dependent than silicon because its reverse saturation current is approximately 1,000 times larger.

In case of forward bias region the characteristics of diode shift to left side at rate of 2.5mv/C rise in temperature.

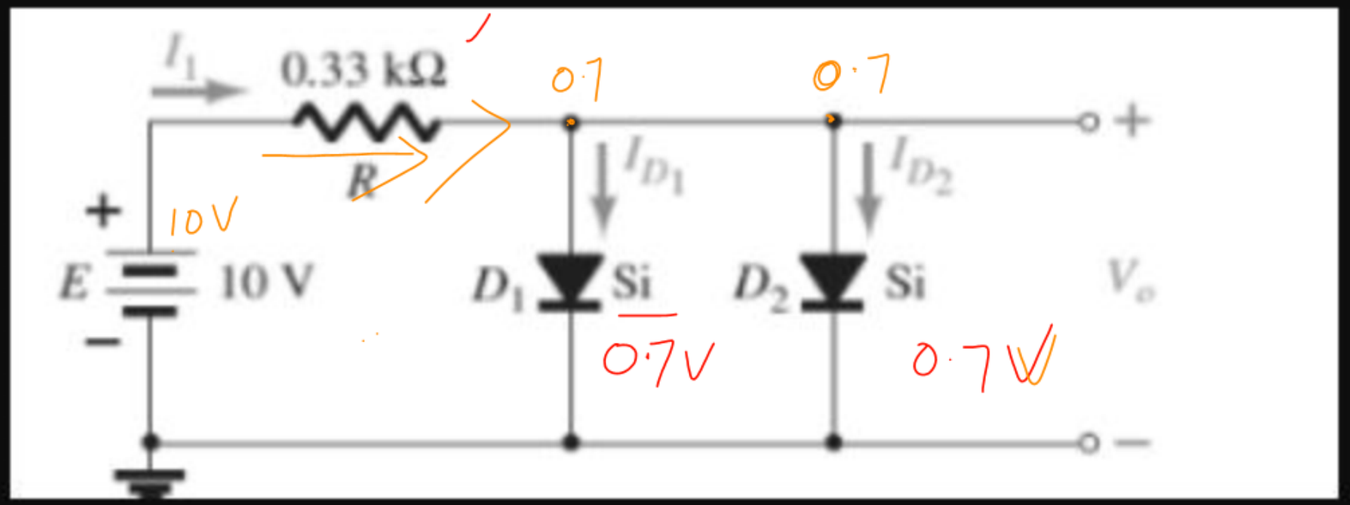
−2.5%/C



Equivalent circuits of diode

S.No.	Type	Model	Characteristic
1.	Approximate model		
2.	Simplified model		
3.	Ideal Model		

Determine Vo, I_1, I_{D1} and I_{D2} for the parallel diode configuration shown in fig.



$V = IR$

$I = \frac{V}{R}$

$= \frac{10 - 0.7}{0.33K}$

$I_1 = 28.18\,mA$

$V_o = 0.7V$

$I_{d_1} = I_{d_2} = \frac{I_1}{2} = \frac{28.18\,mA}{2} = 14.09\,mA$

A Ge diode carries a current of 1 mA at room temperature when a forward bias of 0.15 V is applied. Estimate the reverse saturation current at room temperature.

$$I_d = I_0\left(e^{V_A/\eta V_T} - 1\right)$$

Ge $\eta = 1$

$$1\,mA = I_0\left(e^{\frac{0.15}{0.025}} - 1\right)$$

$I_d = 1\,mA$

$V_A = 0.15\,V$

$V_T = 25\,mV$

$I_0 = ?$

$$1\times10^{-3} = I_0\left(403.428 - 1\right)$$

$$\boxed{I_0 = 2.48\,\mu A}$$

Ans = 250 & 1.25K

$$I_R = I_{Z_{max}} + I_L$$

$$\frac{50-10}{1K} = 32mA + \frac{10}{R_{L_{max}}}$$

$$\frac{40}{1000} = 32m + \frac{10}{R_{L_{max}}}$$

$$40 = 32 + \frac{10}{R_{L_{max}}}$$

$$40 - 32 = \frac{10}{R_{L_{max}}}$$

$$8 = \frac{10}{R_{L_{max}}}$$

$$\boxed{R_{L_{max}} = \frac{10}{8} = 1.25K}$$

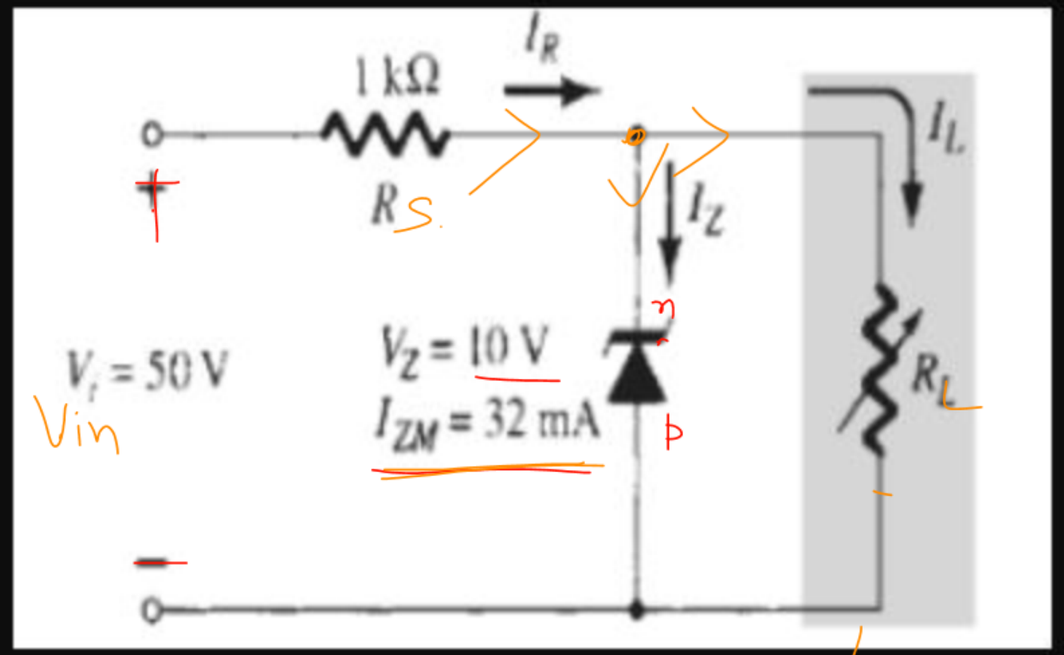
$$V_{R_L} = \frac{V_{in} R_L}{R_s + R_L} = V_Z$$

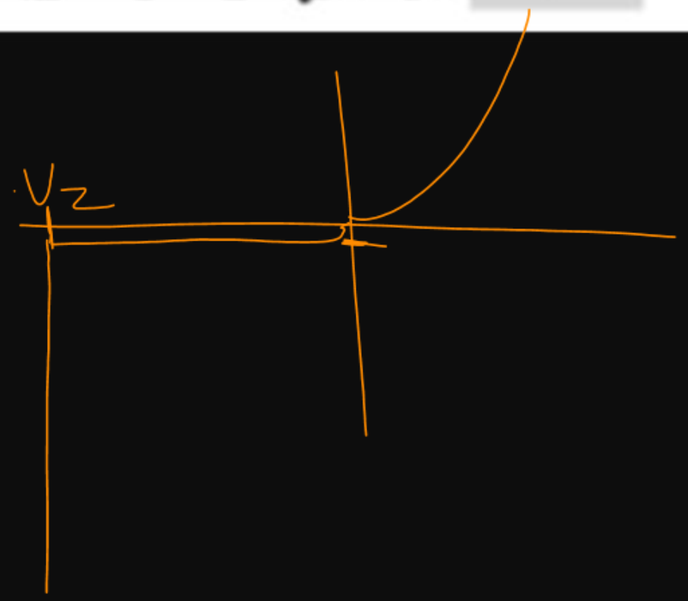
$$\frac{50 R_{L_{min}}}{1K + R_{L_{min}}} = 10V$$

$$50 R_{L_{min}} = 10K + 10 R_{L_{min}}$$

$$40 R_{L_{min}} = 10K$$

$$\boxed{R_{L_{min}} = \frac{10K}{40} = 250\Omega}$$





Over what range of input voltage will the zener circuit shown in Fig. 8 maintain 30 V across 2000 Ω load, assuming that series resistance R = 200 Ω and zener current rating is 25 mA ?

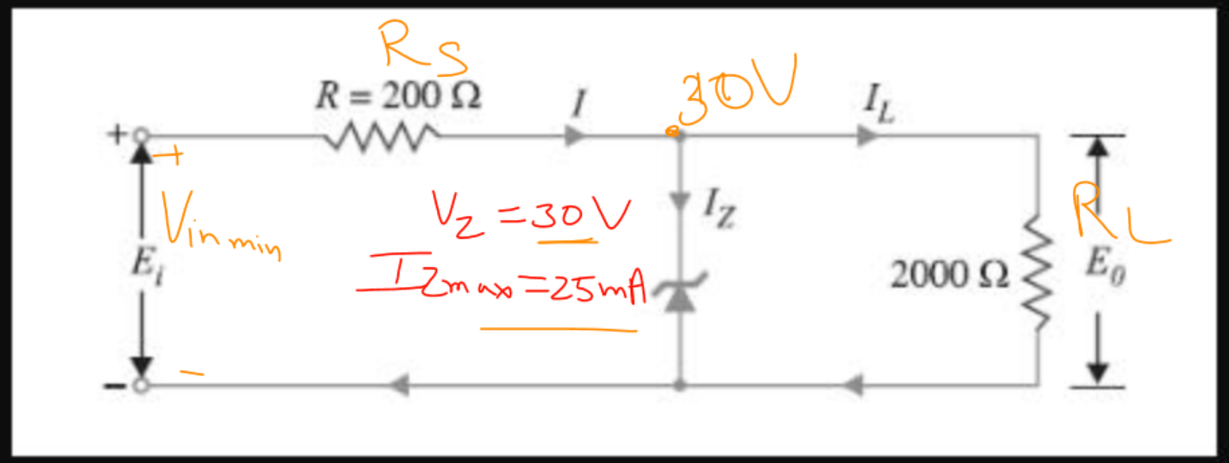
Ans=33-38v

$$V_{RL} = \frac{V_{in_{min}} R_L}{R_L + R_S} = V_Z$$

$$\frac{V_{in_{min}} \times 2K}{2K + 200} = 30V$$

$$V_{in_{min}} = \frac{30(2200)}{2000}$$

$$\boxed{V_{in_{min}} = 33V}$$



$$I = I_{Z_{max}} + I_L$$

$$\frac{V_{in_{max}} - 30}{200} = 25mA + \frac{30}{2000}$$

$$= 0.025 + 0.015$$

$$= 0.04$$

$$V_{in_{max}} = (200 \times 0.04) + 30$$

$$\boxed{V_{in_{max}} = 38V}$$

During +ve half cycle

A → +ve → n
B → −ve → p

① $V_{in} < 4V$

$V_n < V_p$

F.B

$V_o = 4V$

② $V_{in} > 4V$

$V_n > V_p$

R.B

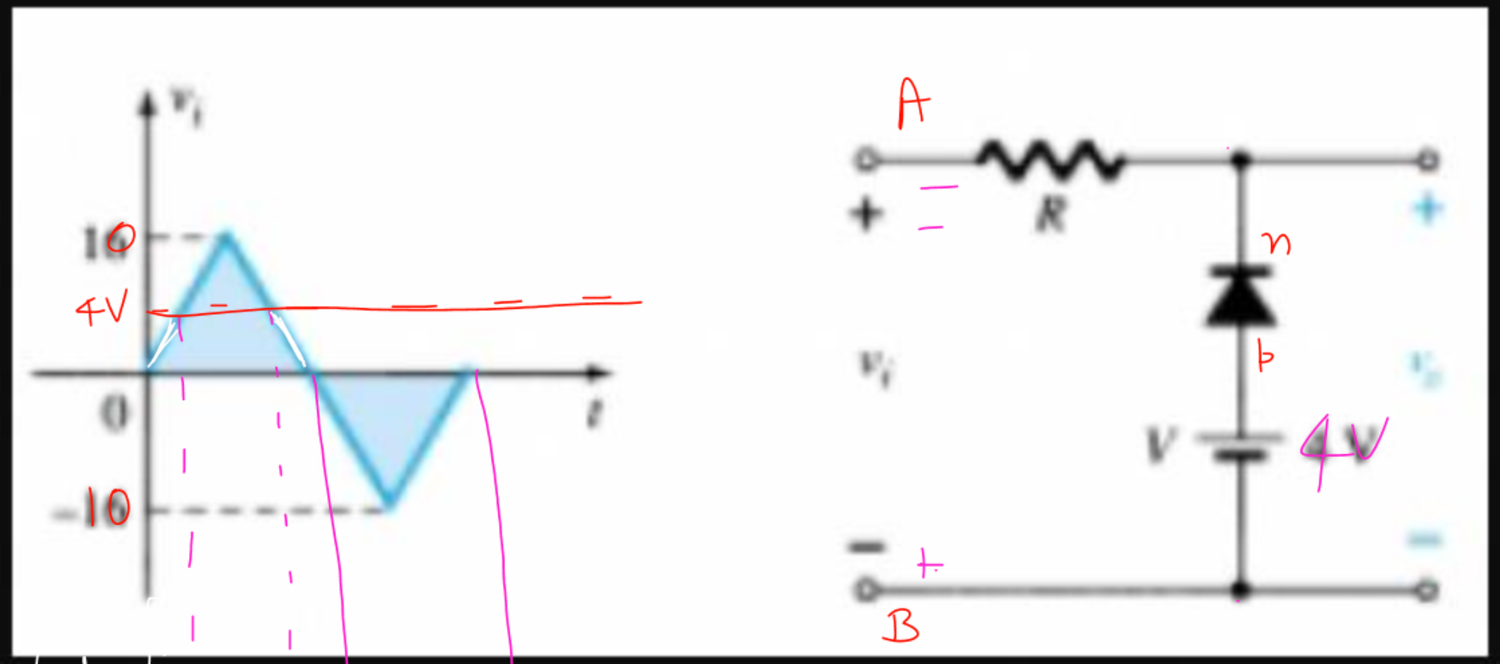
$V_o = V_{in}$

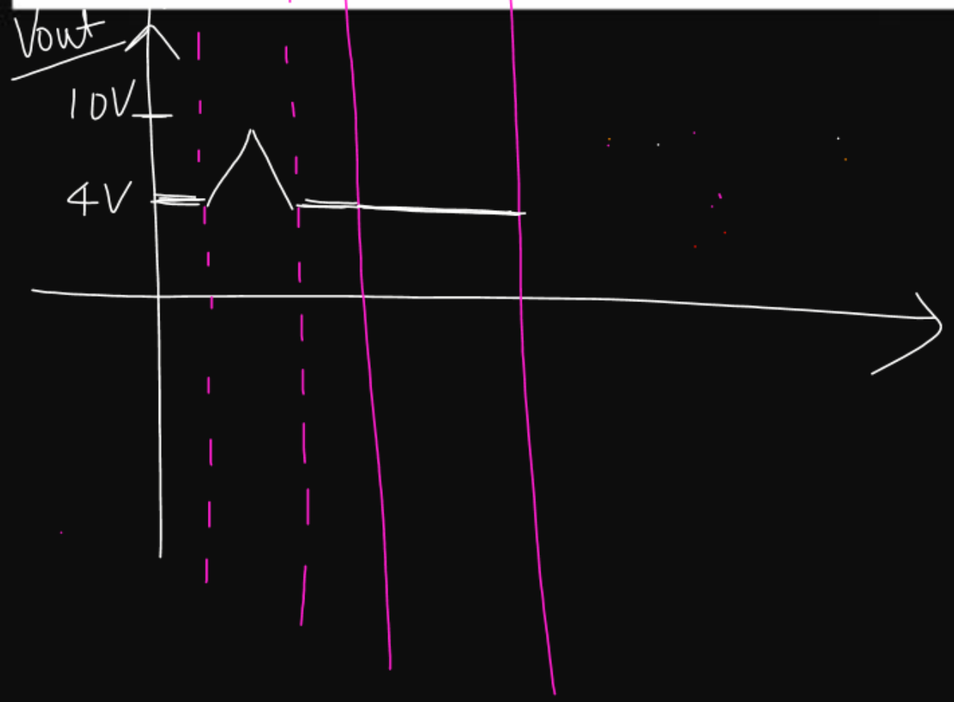
During −ve half cycle

A → −ve → n
B → +ve → p

Diode F.B

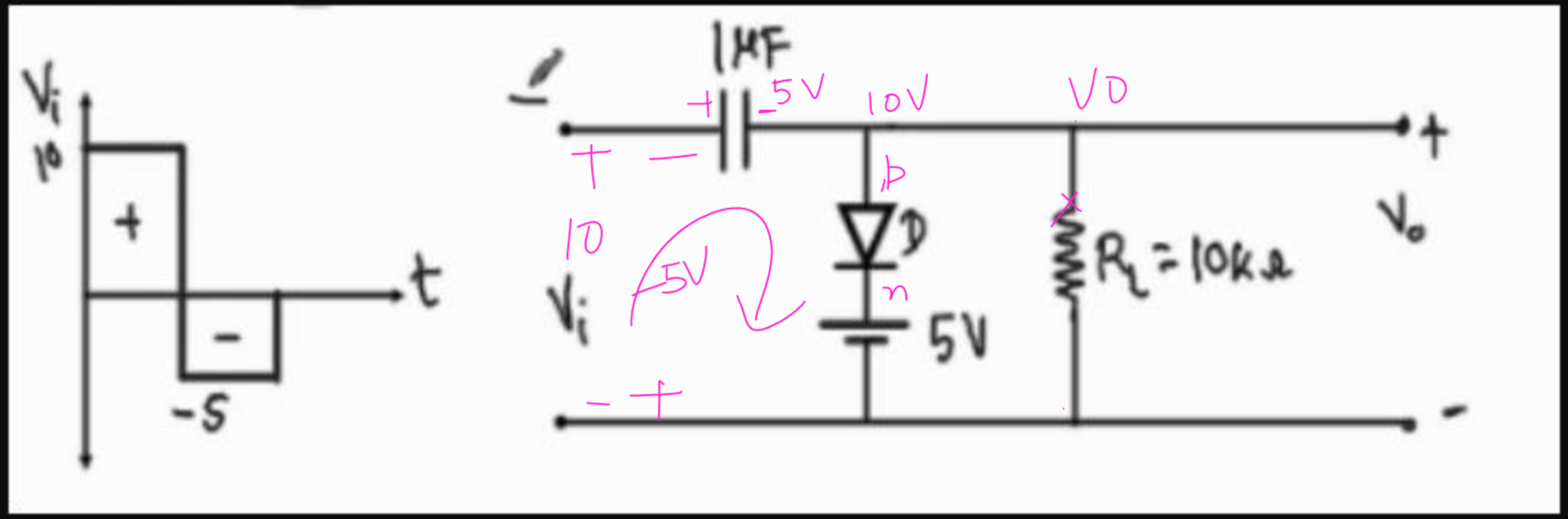
$V_o = 4V$





$V_p > V_n$ F.B

$V_p < V_n$ R.B



During +ve half cycle

$\boxed{V_o = 5V}$

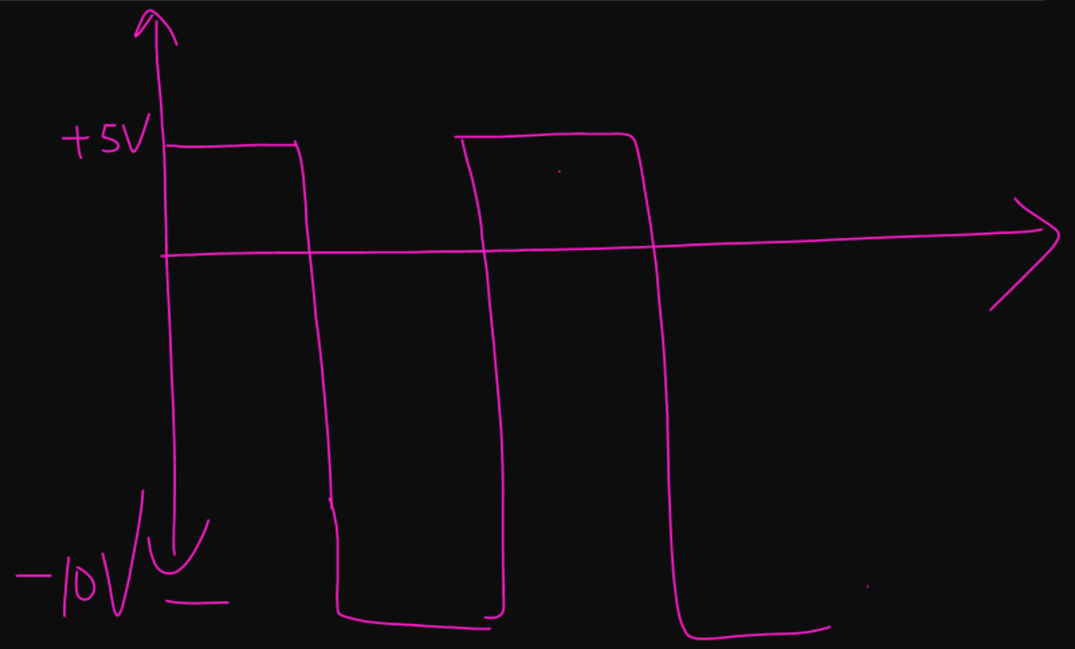
$10 - V_c - 5 = 0$

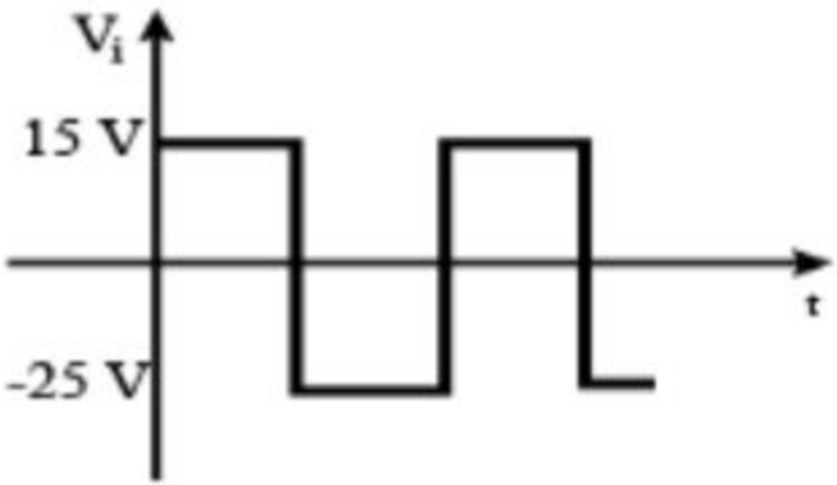
$\boxed{V_c = 5V}$

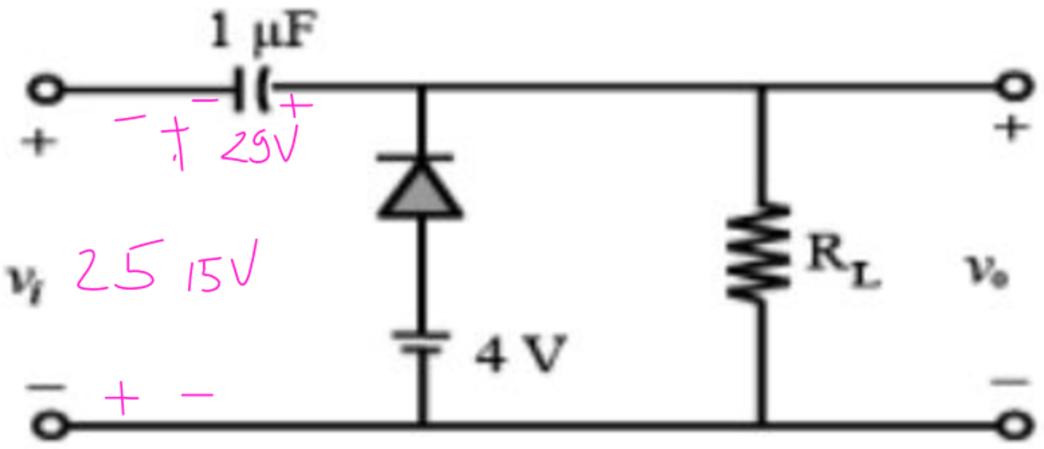
During -ve half cycle

Diode OFF

$\boxed{V_o = -10V}$







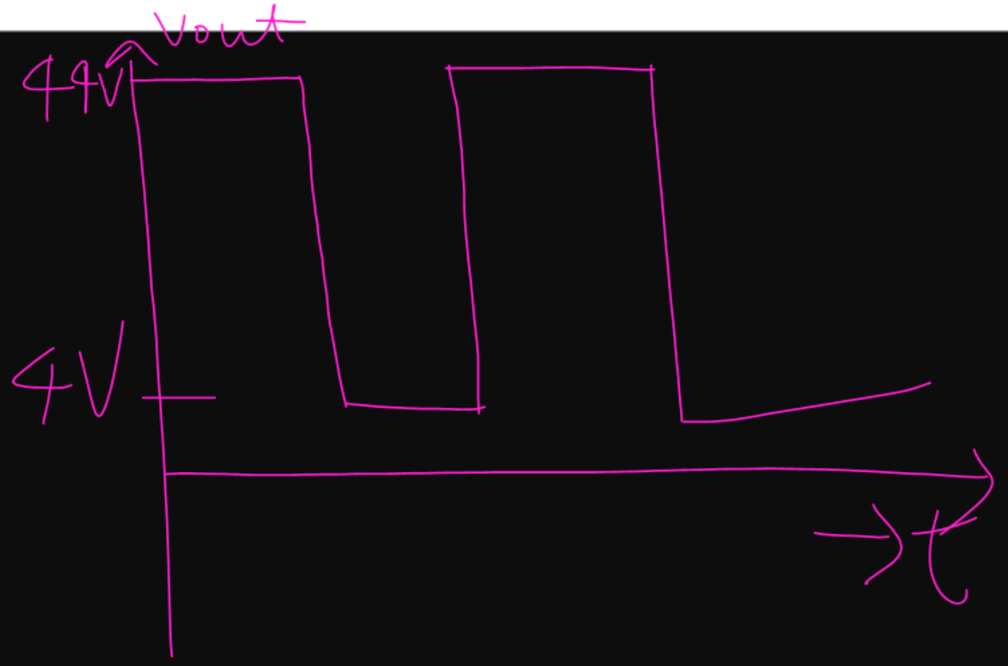
① During −ve half

$V_o = 4\,V$

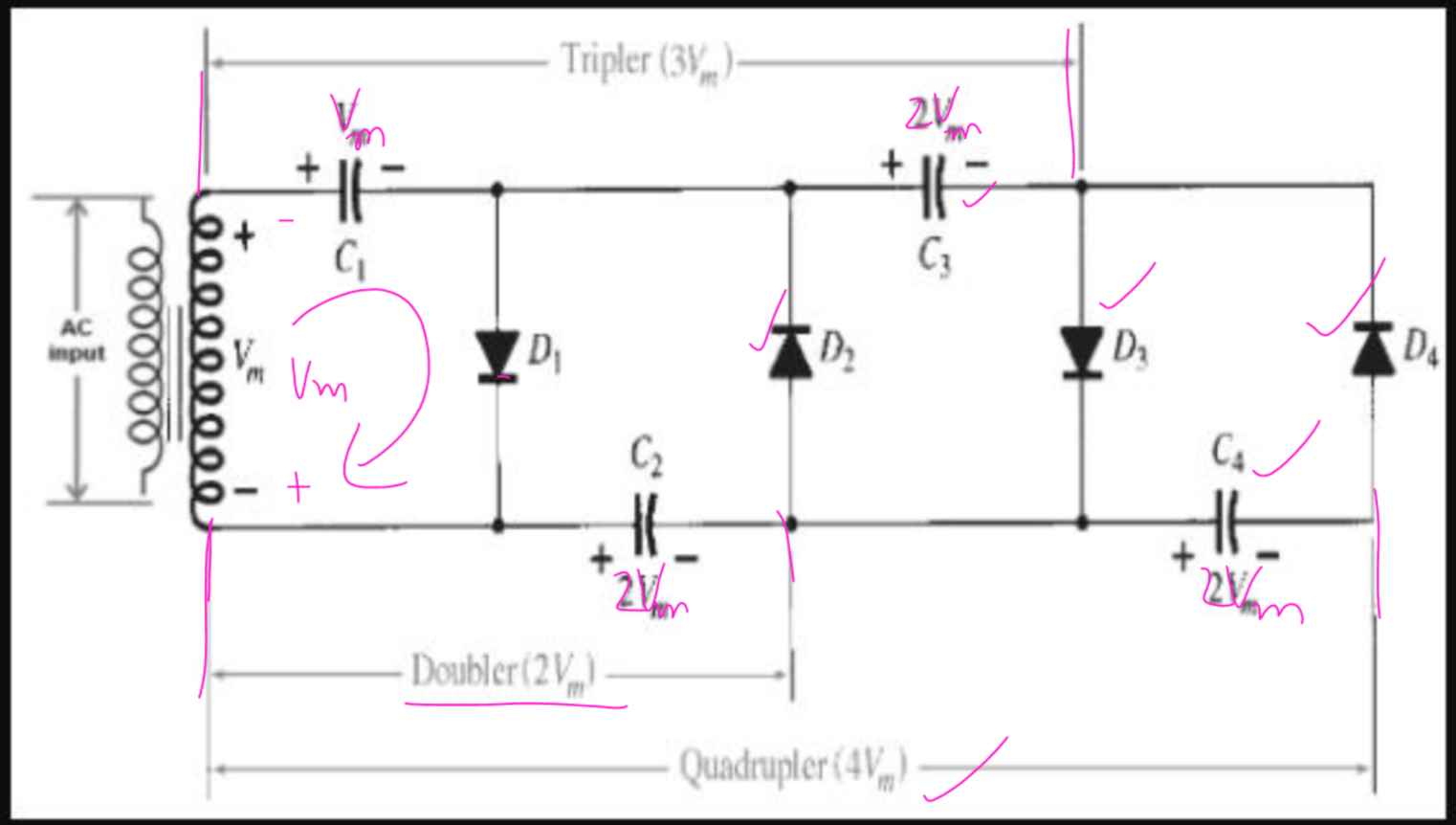
$\boxed{V_c = 29V}$

② During +ve half

$\boxed{V_o = 44V}$



Half Wave Doubler, Tripler, Quadrupler Circuit



① During ① +ve half

$D_1 \rightarrow ON$ $C_1 = V_m$

② During ① -ve half

$D_2 \rightarrow ON$ $C_2 = 2V_m$

③ During ② +ve half

$D_3 \rightarrow ON$ $C_3 = 2V_m$

④ During ② -ve half

$D_4 \rightarrow ON$ $C_4 = 2V_m$

Varactor Diodes

If reverse voltage is increased then width of depletion layer will increase. So, C will decrease. If reverse voltage is decreased then width of depletion layer will decrease. So, C will increase.

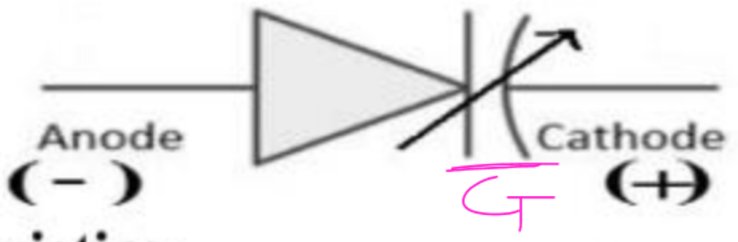
$C_T = \frac{\varepsilon_0 A}{d}$

$\uparrow d \uparrow$

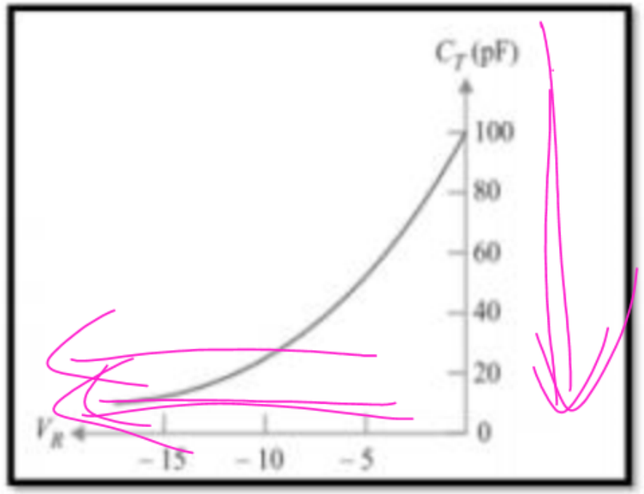
Application:

- FM modulator
- Tuning circuit
- In TV receiver
- In Radio receiver

Symbol:



Characteristics:



Tunnel Diodes

Tunnel diode is very highly doped diode.

The doping of Tunnel diode is 1000 times greater than simple diode.

So, depletion layer is very narrow and is of the order of 10 nm.

Working principle:

In p-n junction a potential barrier exists. According to classical mechanics an electron can pass the barrier if it has an energy equal or greater than energy of potential barrier.

If doping is very high then according to quantum mechanics a electron with energy less than barrier energy can penetrate the barrier or cross the barrier, This effect is called tunneling effect and such diode are called Tunnel diode.

V-I characteristics of Tunnel diode

Point A to B: Current increases till point B at very low voltage due to tunnelling effect.

Point B to C: Current decreases till point C. At point C current is minimum and diode shows negative resistance.

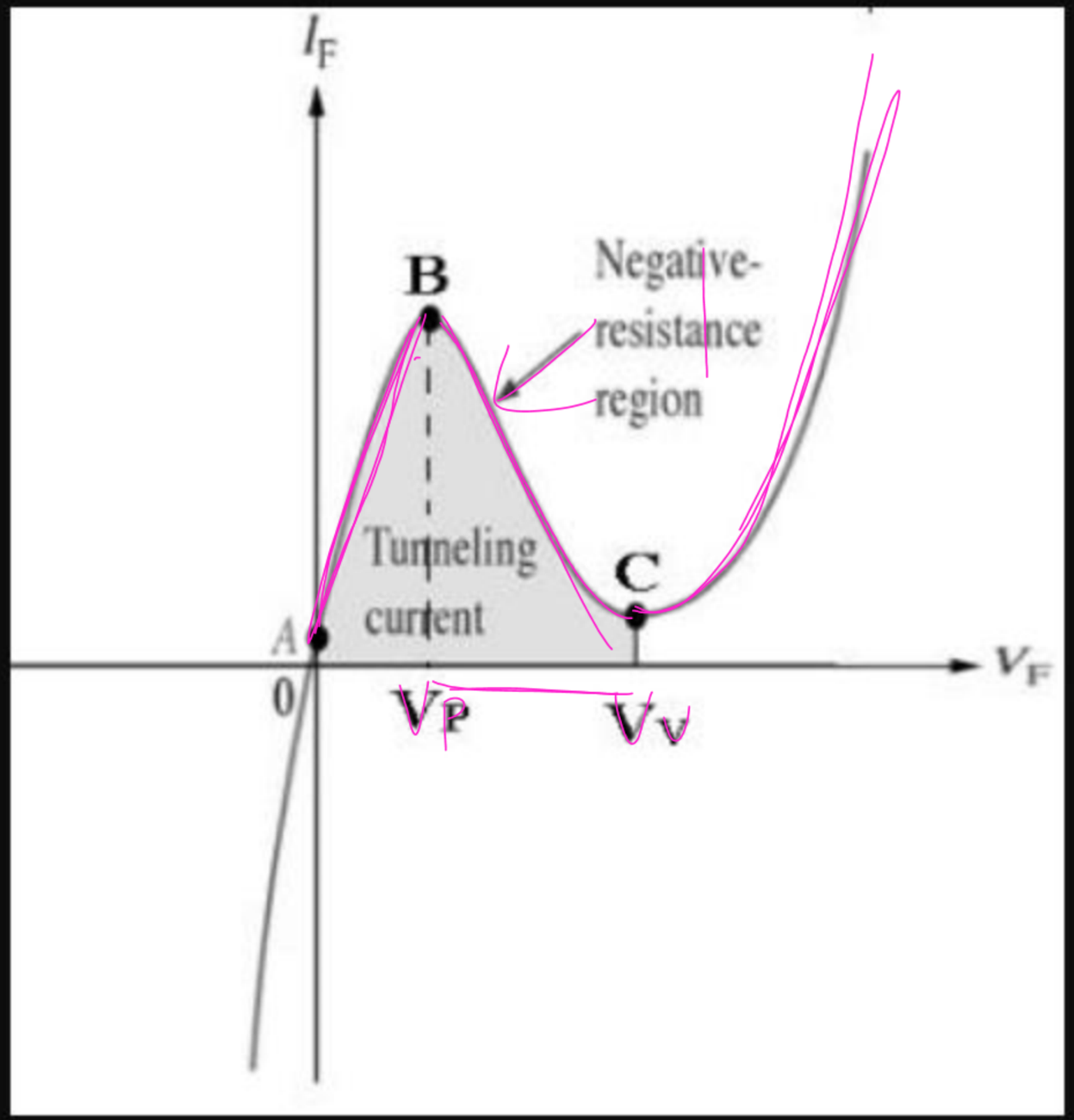
After point C: Tunnel diode woks as normal diode.

Application:

Microwave application

Microwave oscillation

Binary memory.



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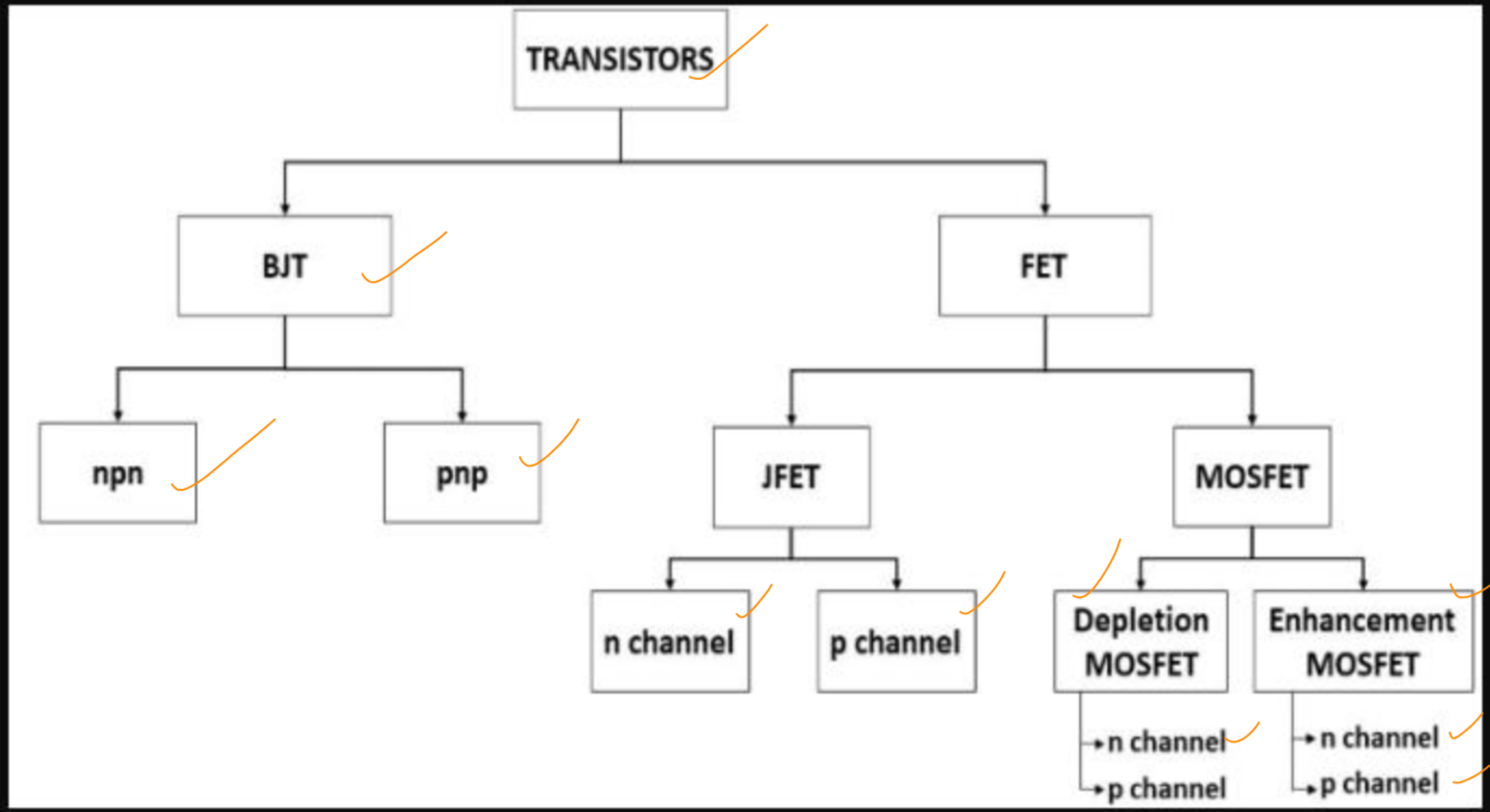
UNIT-2
ONE SHOT Revision

As per
New Syllabus
2022-23

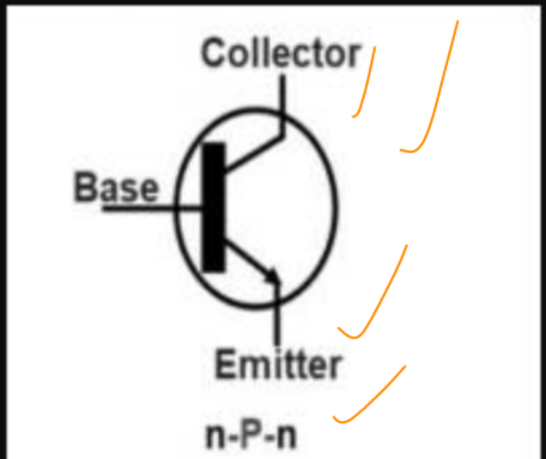
Today's Target

- ✓ Complete Revision Unit-2

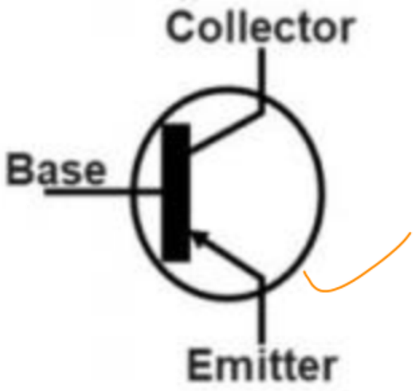
Classification of Transistor



Construction of Transistor



n-P-n



P-n-P

Emitter: It is the highest doping region in the transistor. It supplies (emits) carrier to the base. It supplies electron to the base in n-p-n and holes in p-n-p.

Base: The middle part of transistor is called base. It is very thin and lightly doped . So most of the carrier coming from emitter passes to collector.

Collector: Collector collect the carriers which are coming from base. Doping of collector is heavier than base but less than emitter.

$$I_E = I_C + I_B$$

Area profile: C > E > B

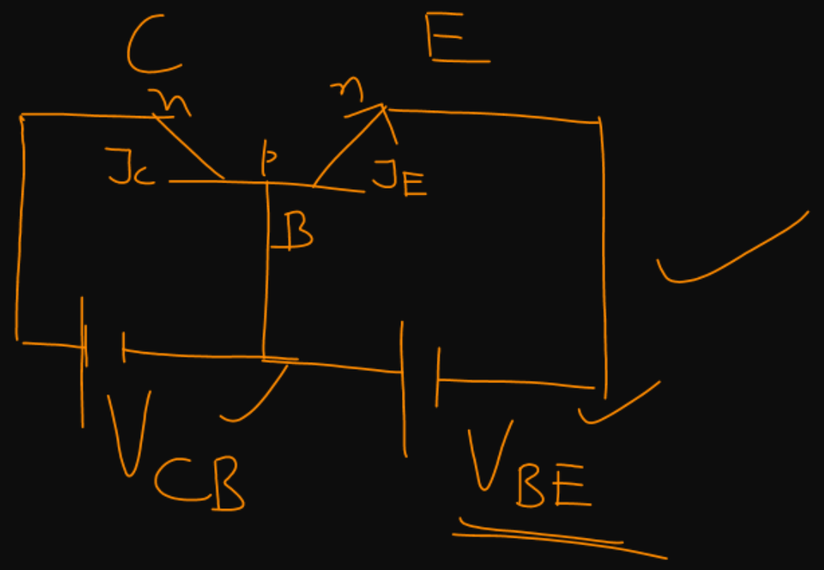
Doping profile: E > C > B

Mode or Working Regions of Transistor

Transistor operates in three modes

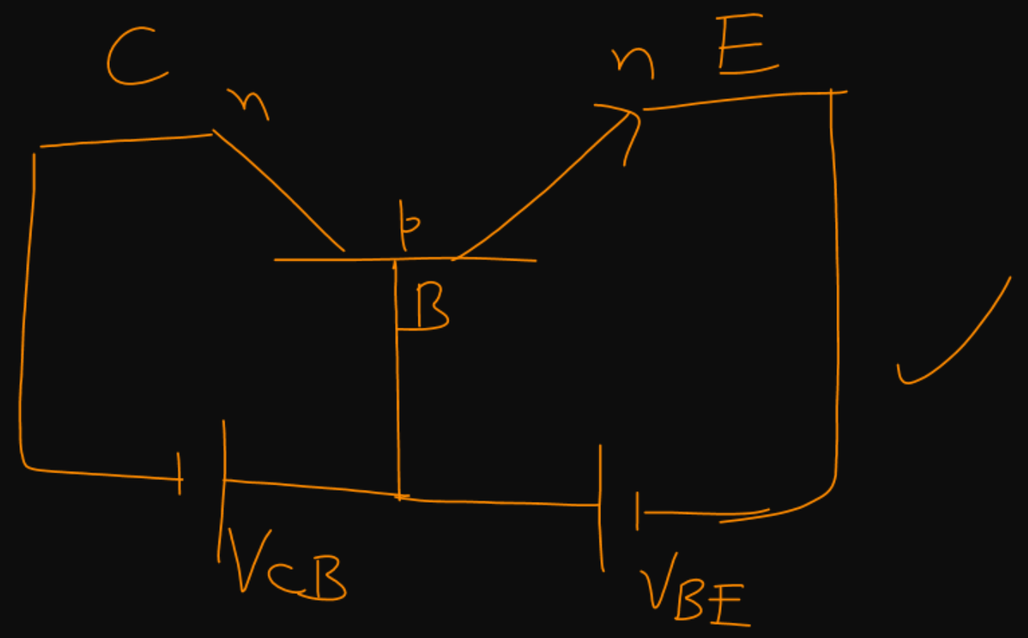
i) Active region:

In active region emitter-base junction (JE) is forward biased and collector -base junction (JC) is reverse biased. In this region transistor works as an amplifier.



ii) Saturation region:

In this region emitter-base junction (JE) and collector –base junction (JC) are forward biased. In this region transistor works as a closed switch.



iii) Cut-off region:

In this region emitter-base junction (JE) and collector -base junction (JC) are reverse biased. In this region transistor works as a open switch.

Common base configuration (CB)

Input is applied between emitter and base

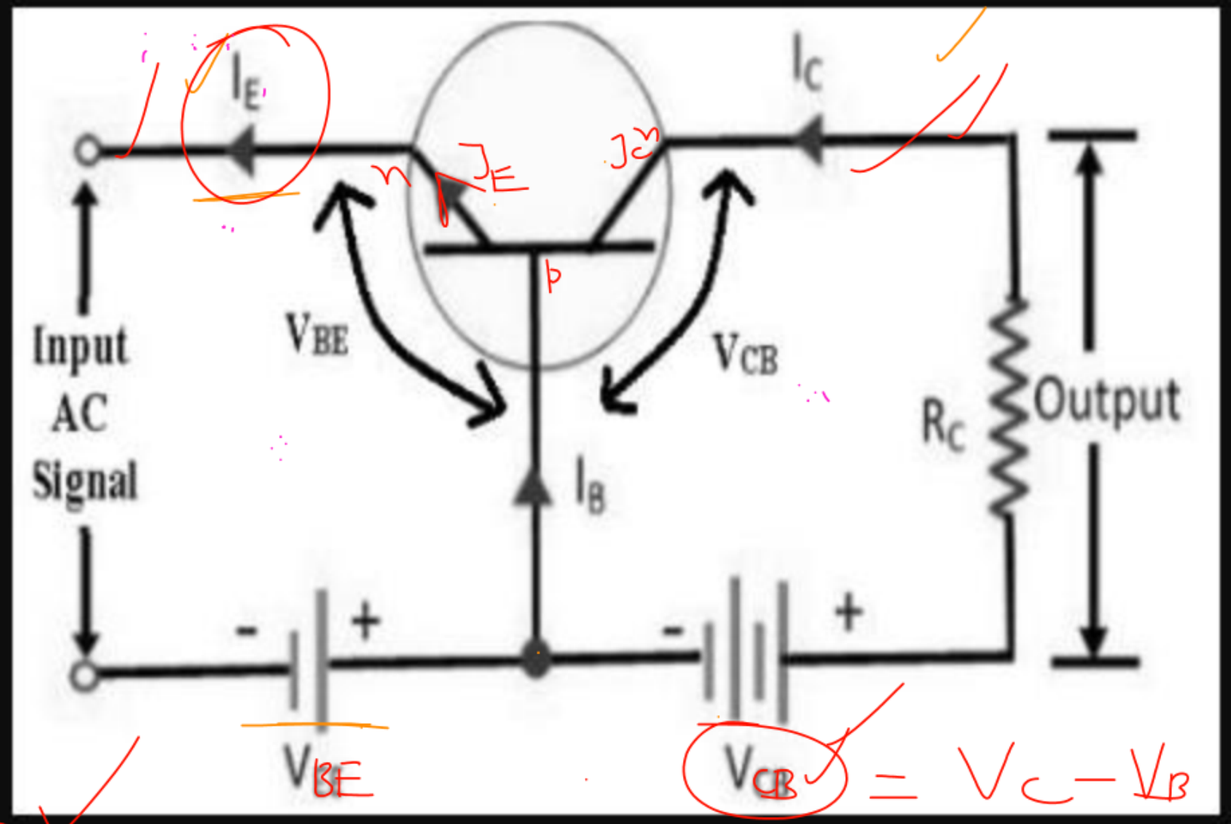
Output is taken out from collector and base

Base is common between input and output.

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

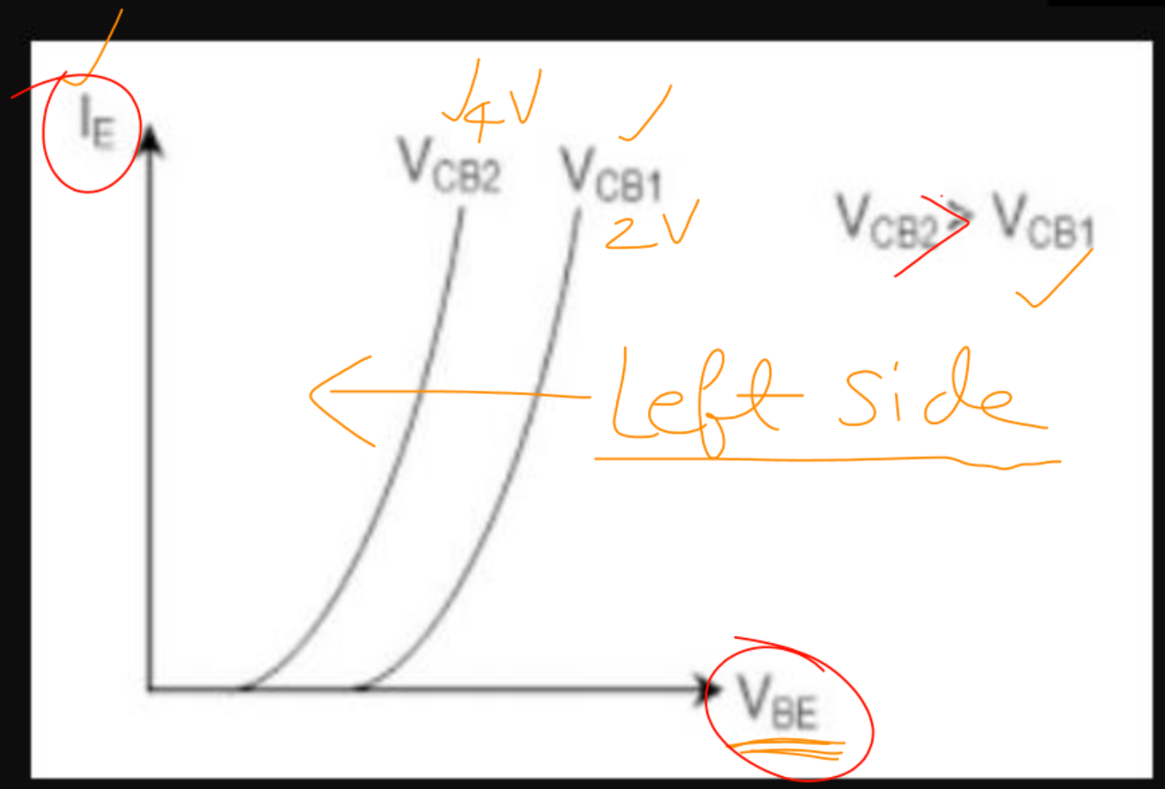
$$I_E = I_C + I_B$$

$$I_C = \alpha I_E + I_{CBO}$$



Input V/I Characteristics of CB Configuration

By keeping constant V_{CB}, when forward bias at emitter base junction is increased then graph between I_B and V_{EB} is similar to forward characteristics of pn junction diode. If this graph is again drawn for some higher value of V_{CB} a similar graph is obtained with reduced knee voltage.



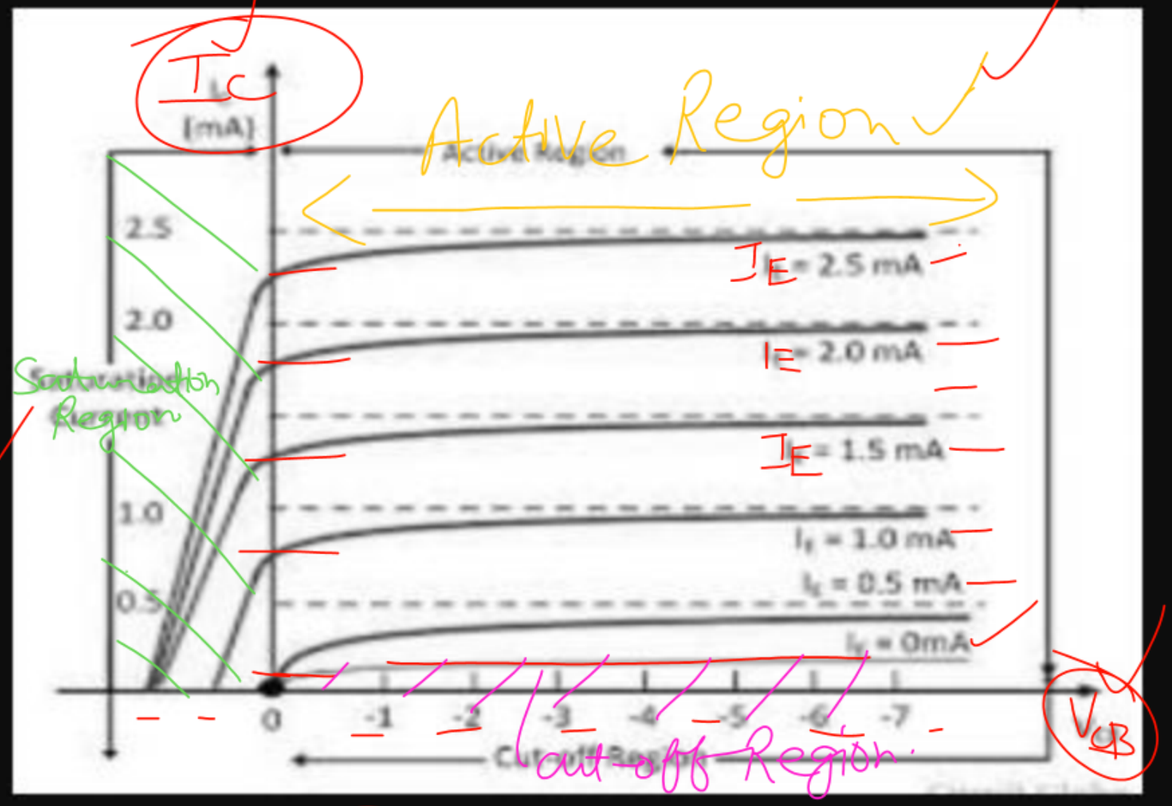
Input V/I Characteristics of CB Configuration

It is graph between output current IC and output voltage V_{CE} at constant input current I_E. This graph is drawn for all three operating regions of BJT.

Active Region: For given α and I_E, I_C is dependent only on I_0 which is slightly dependent on V_{CB}. So, graph of active region is almost independent of V_{CB}.

Saturation Region: When the transistor is switched from active to saturation region, a large change in collector current for very small forward bias voltage at collector to base junction is obtained in negative direction.

Cut-Off Region: When both the junctions are reverse biased, a very small collector current is obtained which is close to horizontal axis.



$I_E = I_C + I_B$

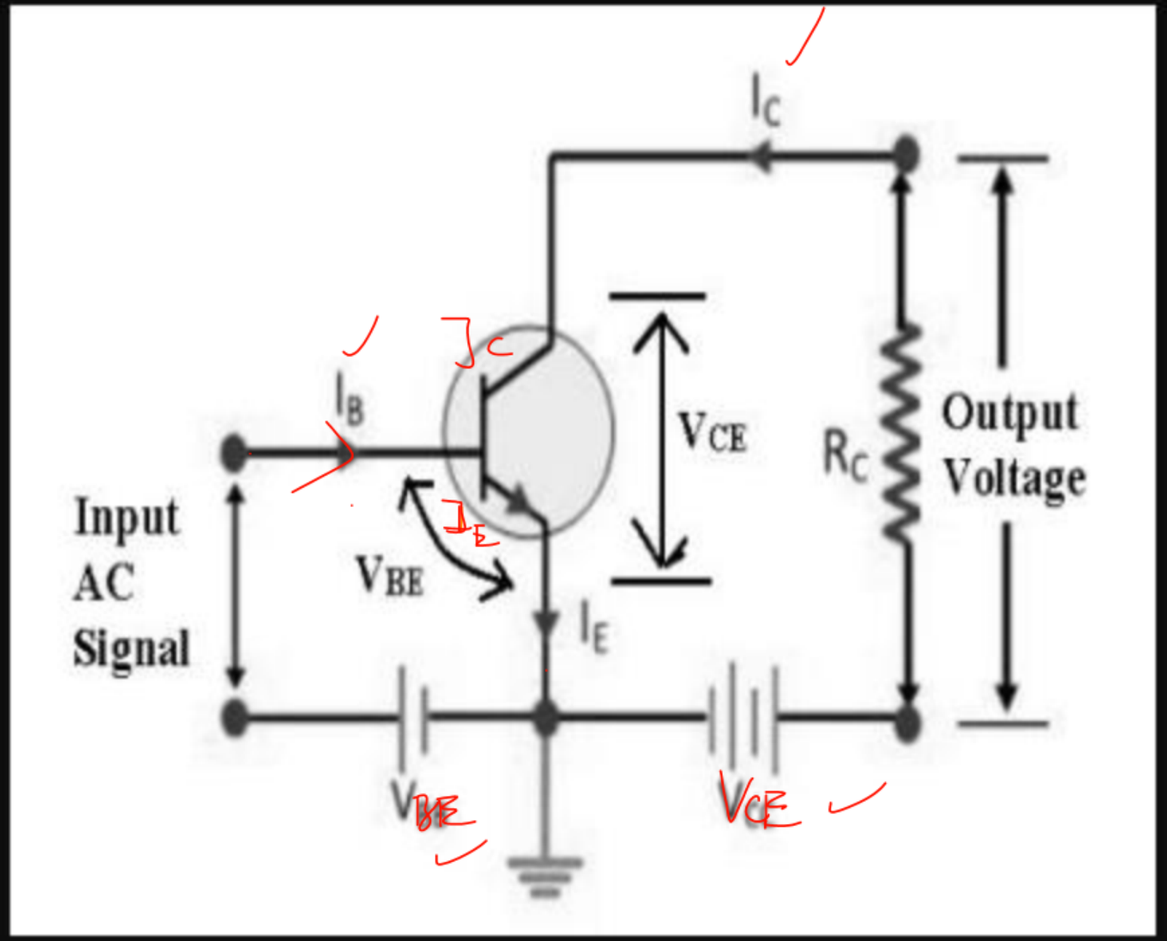
Common Emitter Configuration (CE)

In this configuration input is applied between base and emitter while output is taken out from collector and emitter. So, emitter of transistor is common to both input and output.

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

$$I_C = \beta I_B + I_{CEO}$$

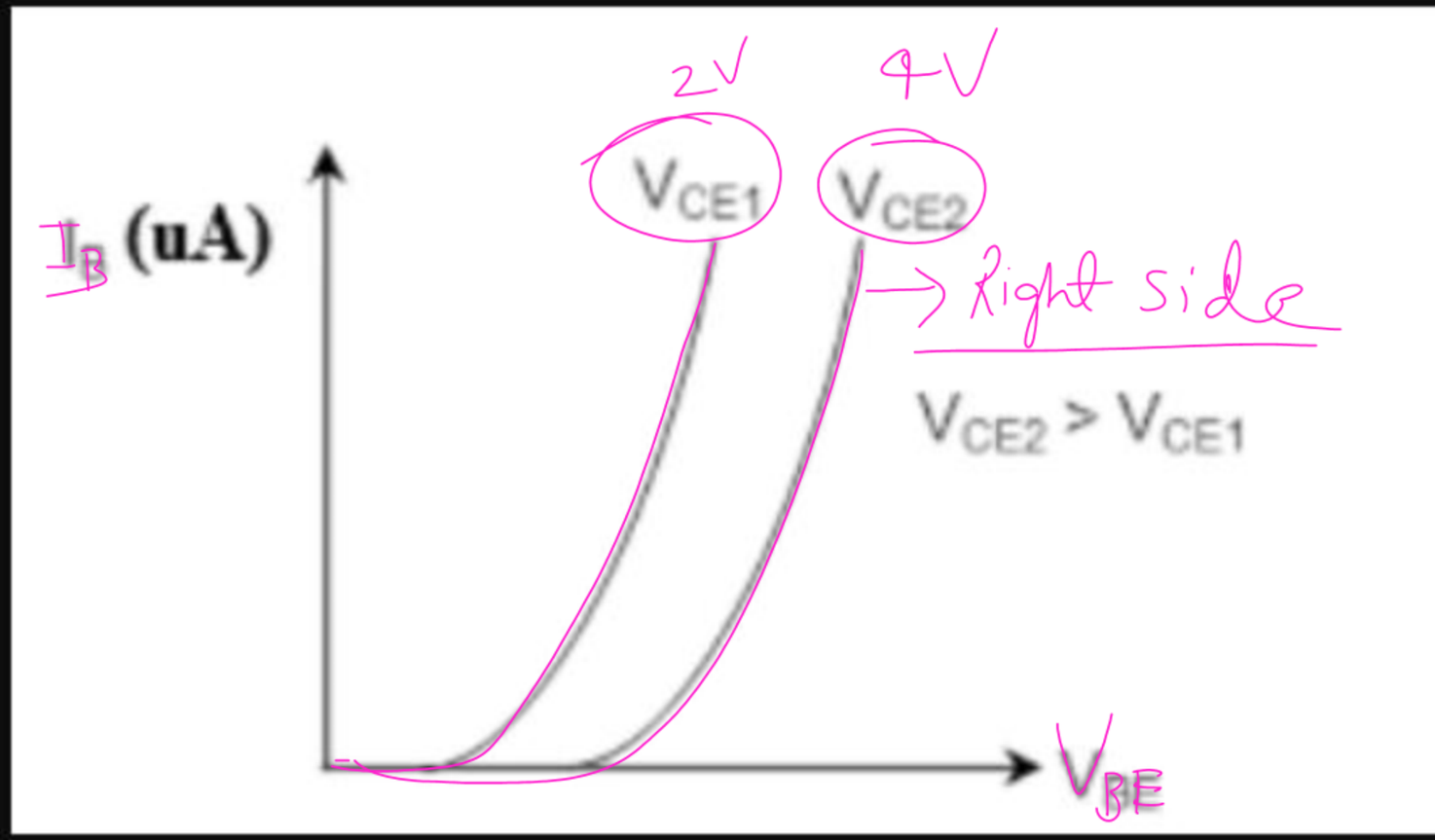
$$I_{CEO} = \frac{I_{CBO}}{1-\alpha}$$



Input V/I Characteristics of CE Configuration

It is graph between input current (I_B) and input voltage (VBE) at constant output voltage (V_{CE}).
This graph is drawn for active region of BJT.

By keeping constant V_{CE}, when forward bias at emitter base junction is increased then graph between I_E and V_{BE} is similar to forward characteristics of pn junction diode.

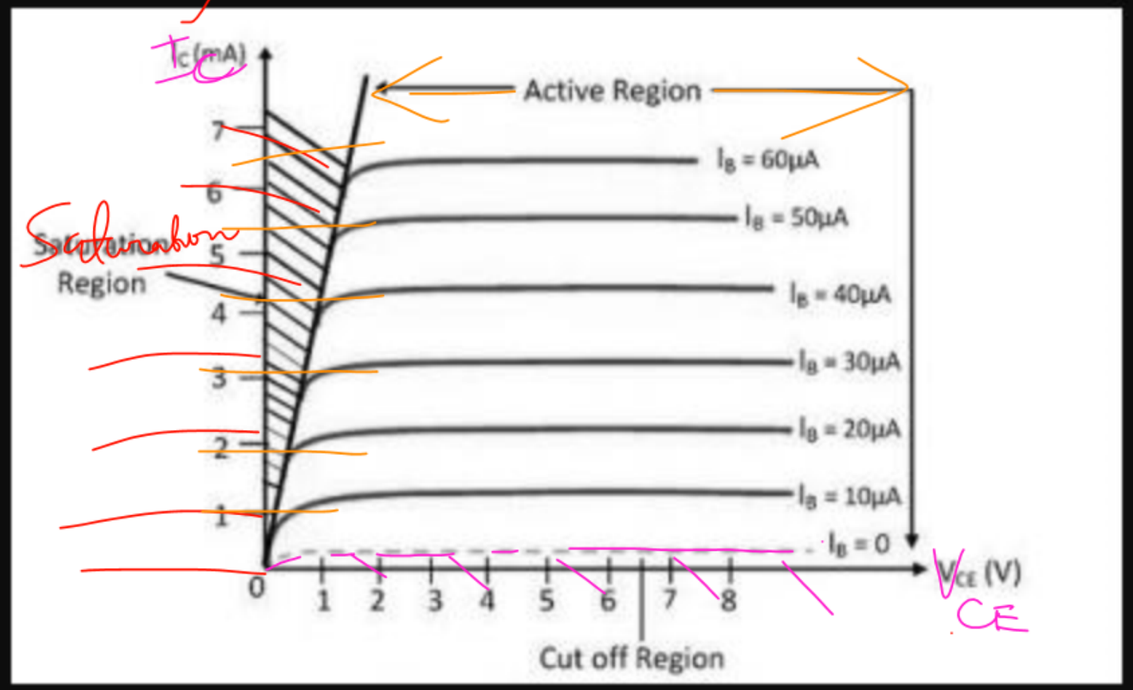


Output V/I Characteristics of CE Configuration

Active Region: For given β and I_B, I_C is dependent on $(\beta + 1)I_0$ which is more dependent on V_{CE} than in case of CB configuration. So, graph of active region has some slope showing change in I_C on changing V_{CE}.

Saturation region: When the transistor is switched from active to saturation region, a large change in collector current for very small change in collector voltage is obtained in negative direction.

Cut-Off Region: When both the junctions are reverse biased, a very small collector current is obtained which is close to horizontal axis.



$I_E = I_C + I_B$

$I_C = I_E - I_B$

Expression for Output Current

Numerical Problem : In a common base connection, the emitter current is 1mA. If the emitter circuit is open, the collector current is 50 μA. Find the total collector current. Given that α = 0.92

Answer= 0.97mA

$I_E = 1mA$

$I_{CBO} = 50\mu A$

$\alpha = 0.92$

$I_C = \alpha I_E + I_{CBO}$

$= (0.92)\, 1\times10^{-3} + 50\mu$

$= 0.97mA$

$I_C = \beta I_B + I_{CEO}$

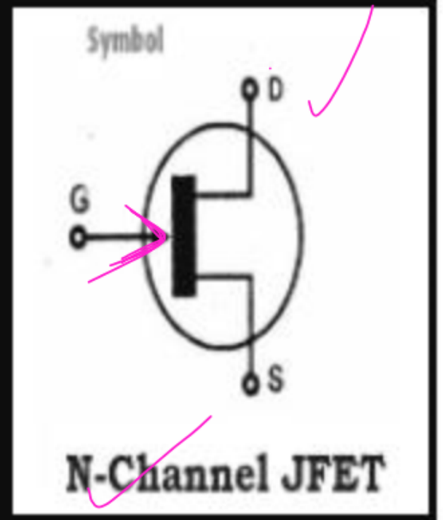
$I_{CEO} = \frac{I_{CBO}}{1-\alpha}$

N- Channel JFET(Junction Field Effect Transistor)

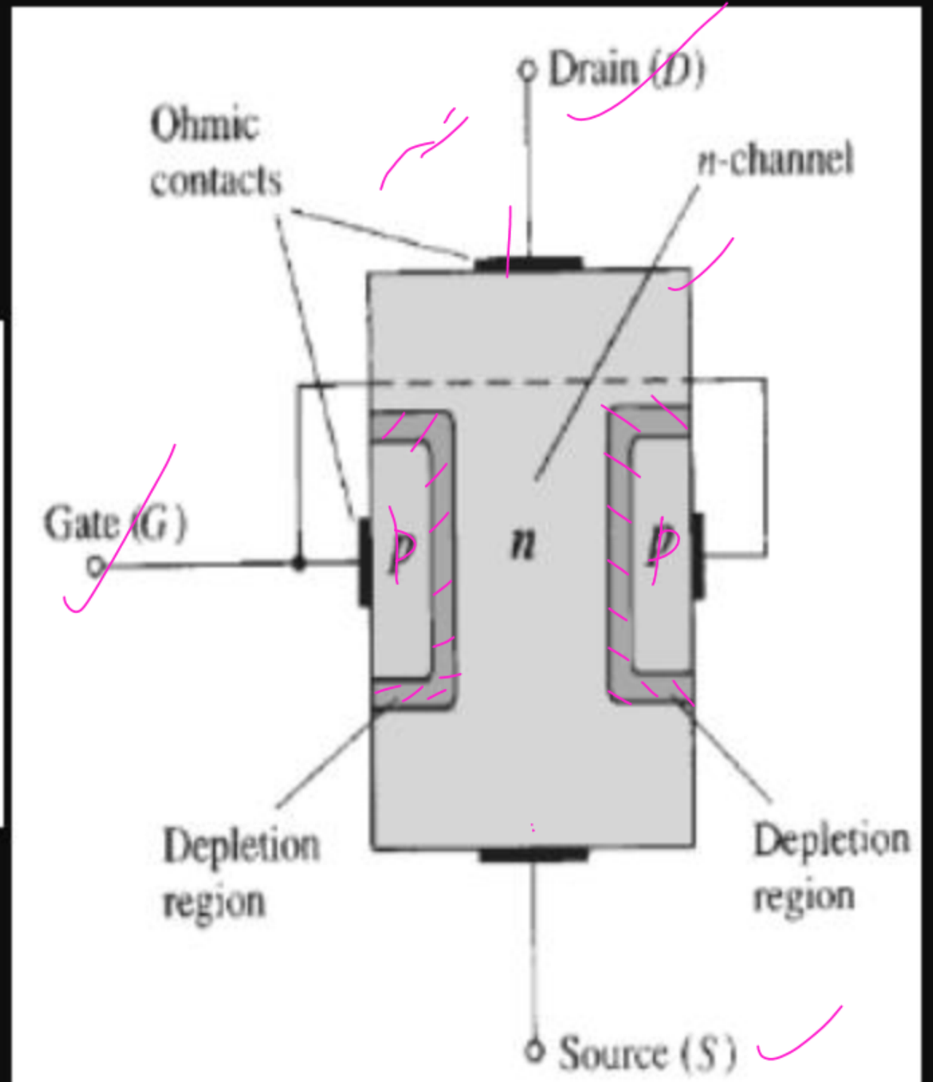
A n-channel JFET have n type base.

On both side of base two heavily doped p regions are formed.

So two p-n junction is formed which are internally connected by a gate terminal. Other two terminal are drain and source.



N-Channel JFET



Junction field-effect transistor (JFET).

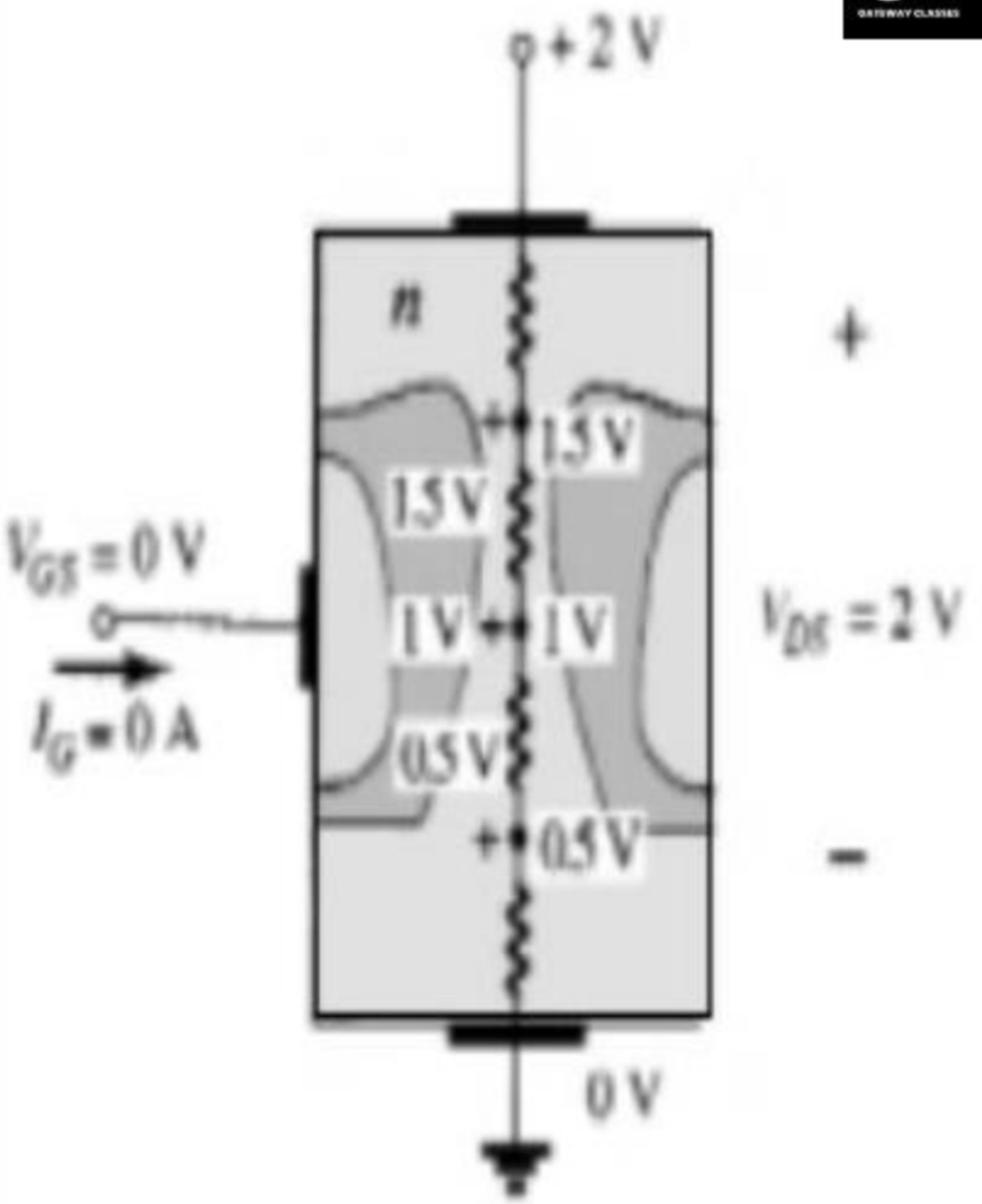
In JFET structure, the channel is uniformly doped and it can be modeled as series combination of equal resistances.

If current is flowing from drain to source, the voltage at upper part of the channel is higher than the lower part.

So if we apply VDs > 0 and VGS 0, both pn junctions are reverse biased and very high input impedance is achieved.

This reverse bias voltage is not uniform and decreases as we move downwards.

So, a non uniform depletion region is formed at junctions which is wider in upper part than the lower part of the channel.



Working of n Channel JFET

Its working is divided in two parts:

(1) When $V_{DS} > 0$ and $V_{GS} = 0$

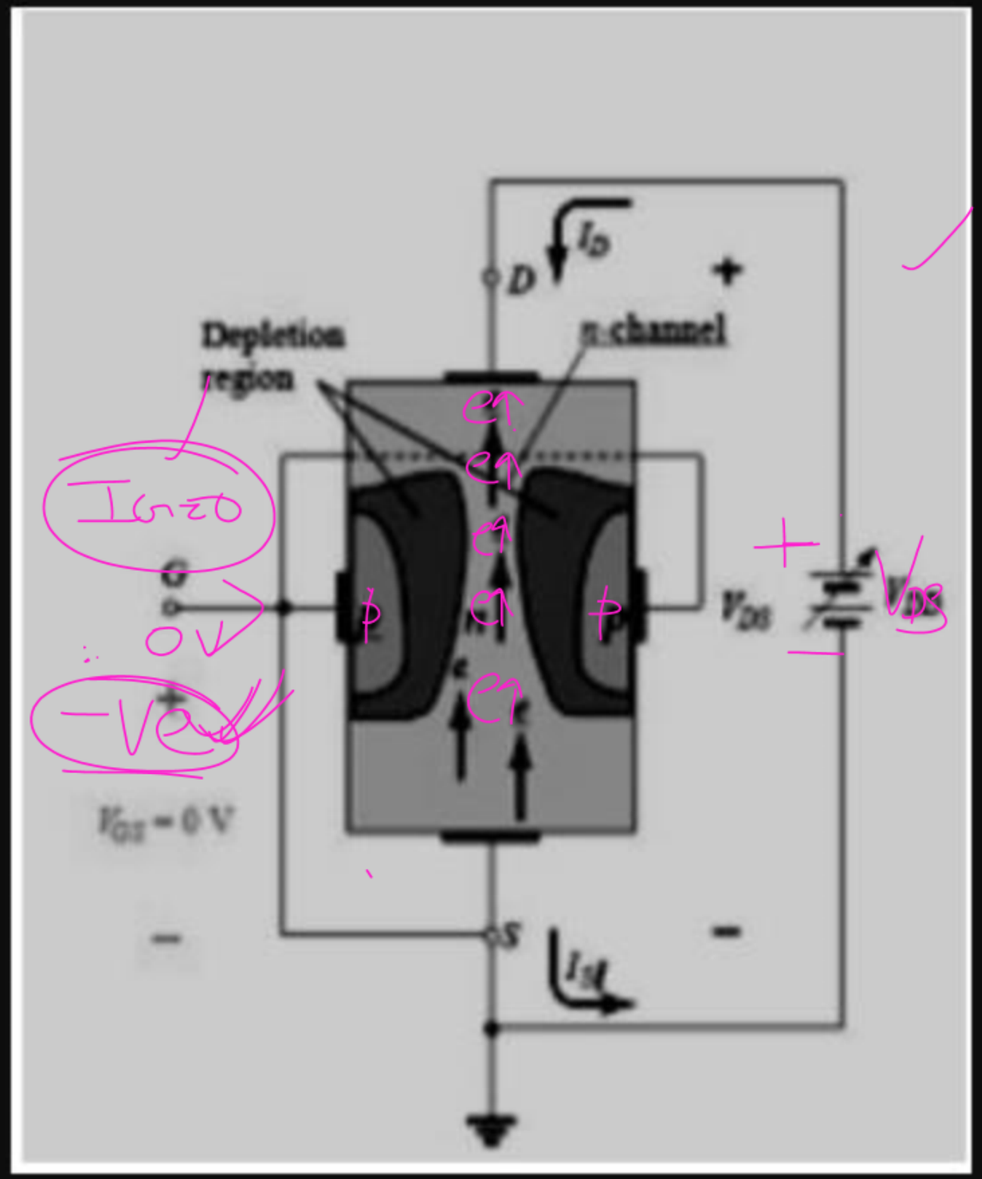
(2) When $V_{DS} > 0$ and $V_{GS} < 0$

1. When $V_{DS} > 0$ and $V_{GS} = 0$:

Two pn junctions are reverse biased and biasing voltage is decreasing from top to bottom. So depletion is more on upper part of the structure than lower part.

Electrons in channel move towards drain (positive terminal), so a current I_D from drain to source us obtained

On increasing V_{DS}, I_D as well as reverse bias both increases.



At certain value of V_{DS}, width of depletion layer become maximum and drain current become constant. It is called pinch off condition

V_{DS} corresponding to pinch-off condition is called pinch off voltage (P) and constant drain current is denoted as I_{DSS}.

After $V_{DS} = V_P$, on increasing V_{DS}, I_D remains constant until reverse breakdown.

This condition is shown in graph of ID vs VDS at VGS=0V.

(2) When $V_{DS} > 0$ and $V_{GS} < 0$

Now pinch off condition arrives at lower values of VDS

The magnitude of saturation current is also smaller than the magnitude at $V_{GS} = 0$ V.

This condition is shown graphically for different negative values
of V_{GS}

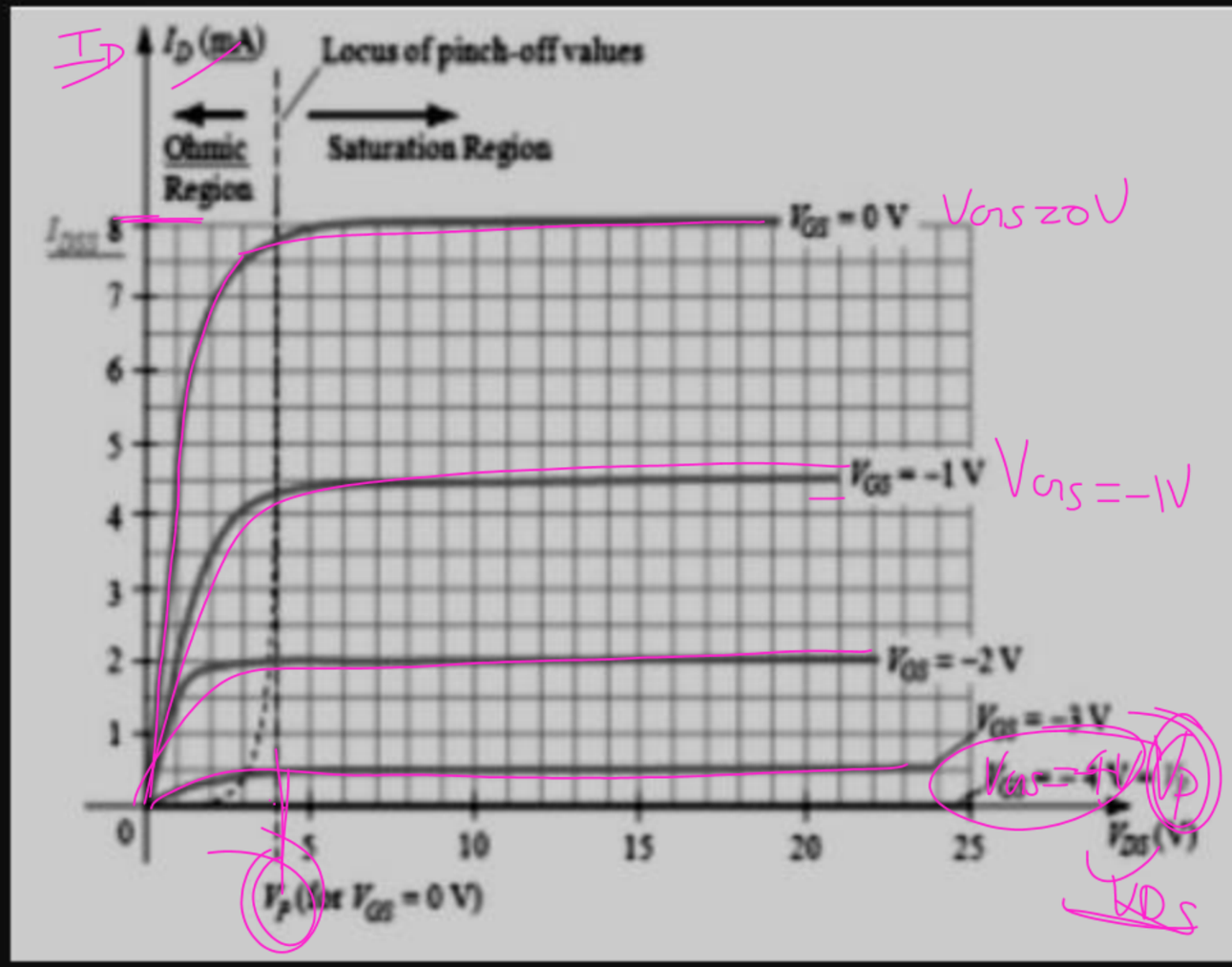
Drain Characteristics / output

It is graph between output current I_D and output voltage V_{DS} at constant V_{GS}. It can be explained from working of the structure discussed above.

For smaller values of V_{DS}, I_D V_D. So this region of the graph is called ohmic or linear region.

In ohmic region the slope of the graph is dependent on V_{GS}. So FET can be used as voltage controlled resistance.

After pinch off condition the drain current become constant and this region of the graph is called saturation region.



Transfer Characteristics

It is graph between output current ID and input voltage V_{GS}.

The relation between I_D and V_{GS} can be given as:

Above equation is also known as Shockley's equation.

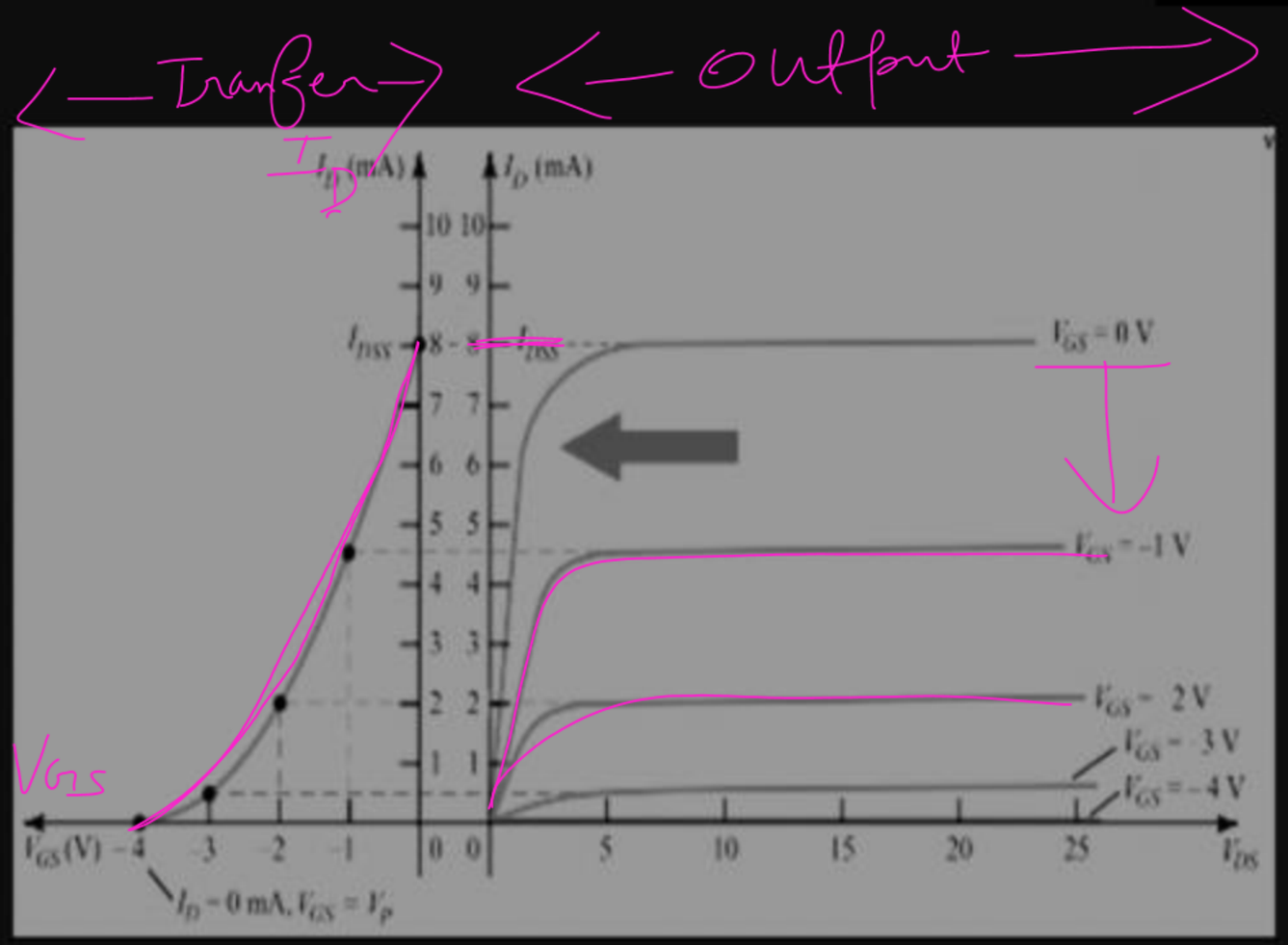
The transfer curve can be obtained using Shockley's equation or from the output characteristics.

Here two graphs are provided, with the vertical scaling in
milliamperes for each graph. One is a plot of ID versus VDS , while the other is ID versus VGS .

Using the drain characteristics on the right of the “y” axis, a horizontal line can be drawn from the saturation region of the curve denoted VGS =0 V to the ID axis. The resulting current level for both graphs is IDSS.

In a similar way for different values of VGS we can note constant values of ID from output curve.

By joining all these points curve obtained is called transfer curve.

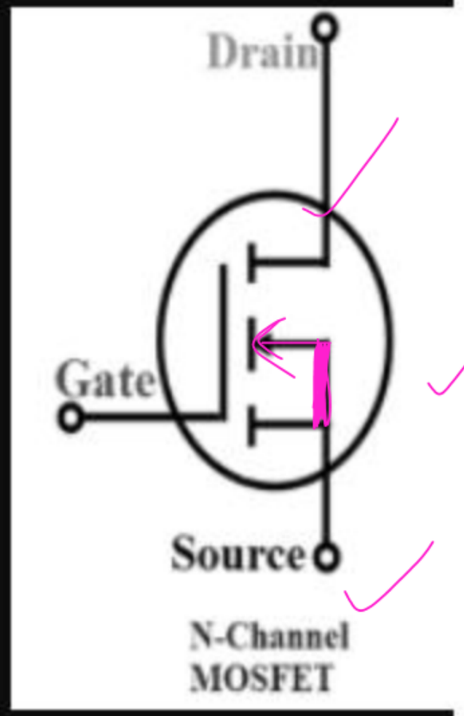


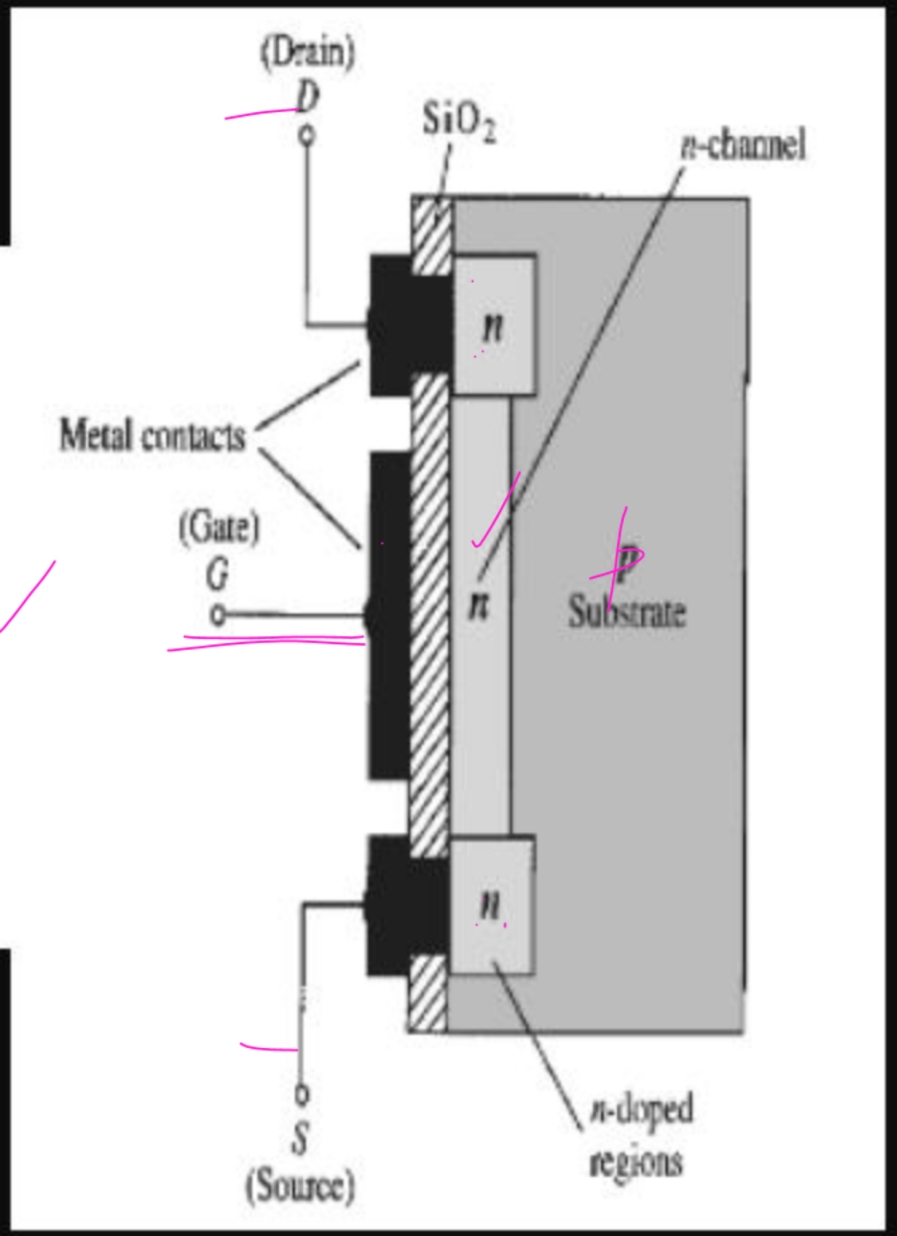
N-Channel Depletion Type MOSFET

n-channel depletion type MOSFET have p-type base(substrate). Then two n region are formed.

A thin layer of Sio2 (Silicon di oxide) is deposited. Drain and source are connected with metallic contact.

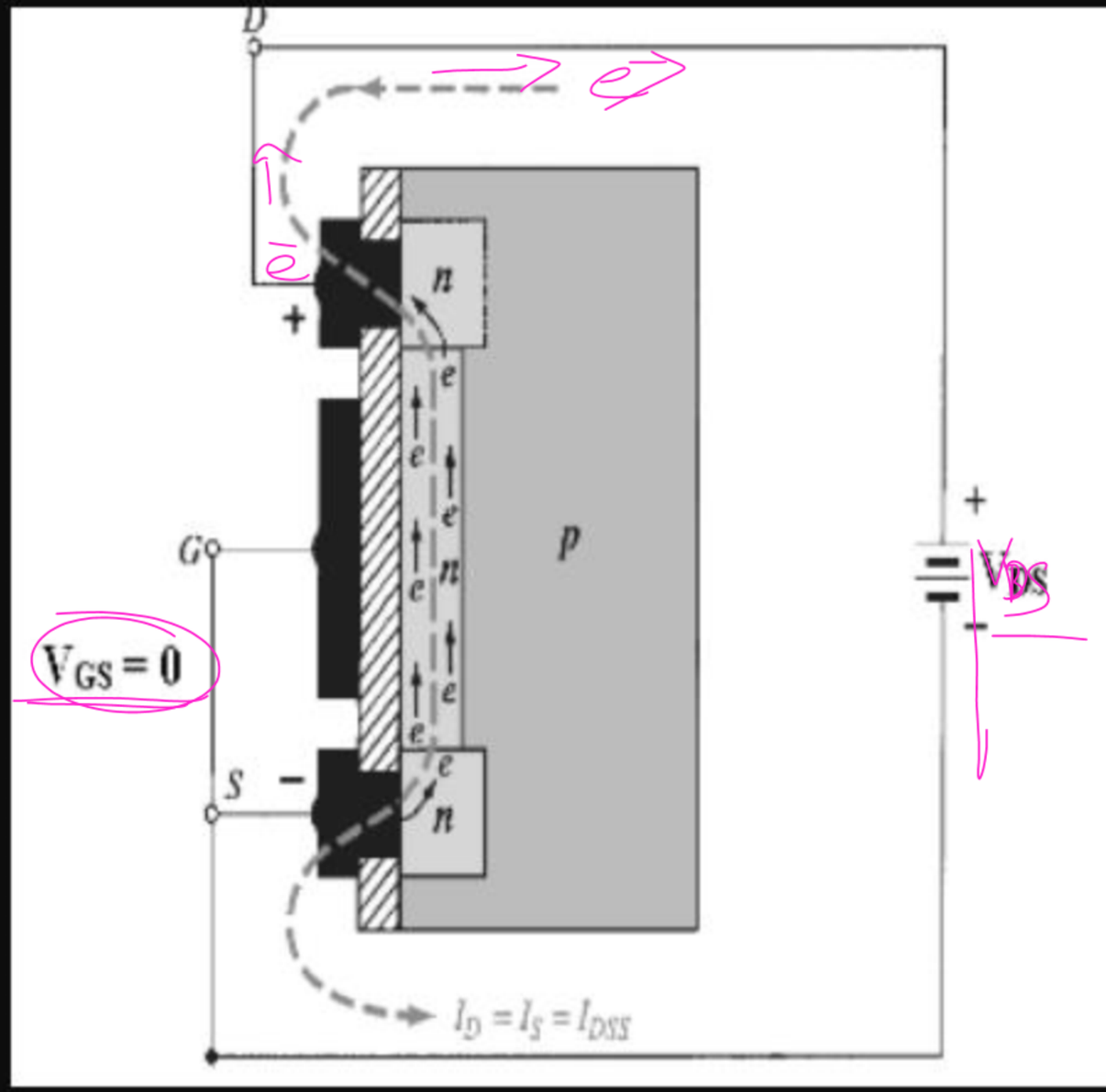
A n channel is formed between two n regions. Gate is insulated from n-channel by Sio2 layer. So, IG is zero.





When V_{DS} is increased more and more electrons move from source to drain. So current increases. A condition comes when current becomes constant.

This condition is called pinch-off condition. The value of V_{DS} which established this condition is called pinch-off voltage (V_P). After pinch-off current becomes constant.



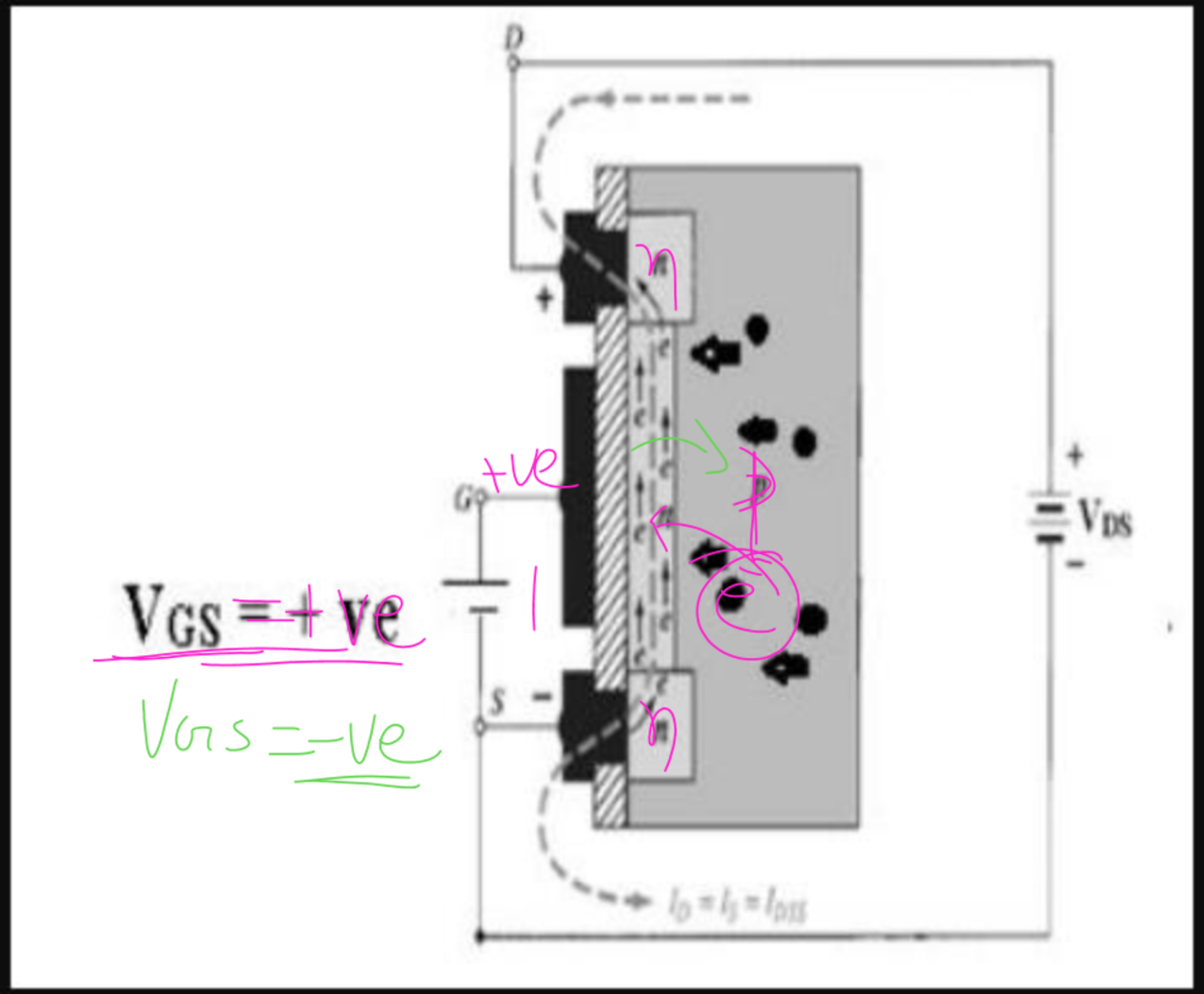
V_{DS} = +ve and V_{GS} = -ve

If V_{GS} is increased then holes in p-type substrate moves towards the channel.

So, recombination process occurs in channel. So, pinch-off condition comes earlier and pinch-off voltage decreases in parabolic manner. This is called depletion mode.

V_{DS} = + ve and VGS = + ve

If positive voltage is applied at gate then electrons in p-type substrate move towards the channel. So, number of electrons in channel increases. This is called enhancement mode.



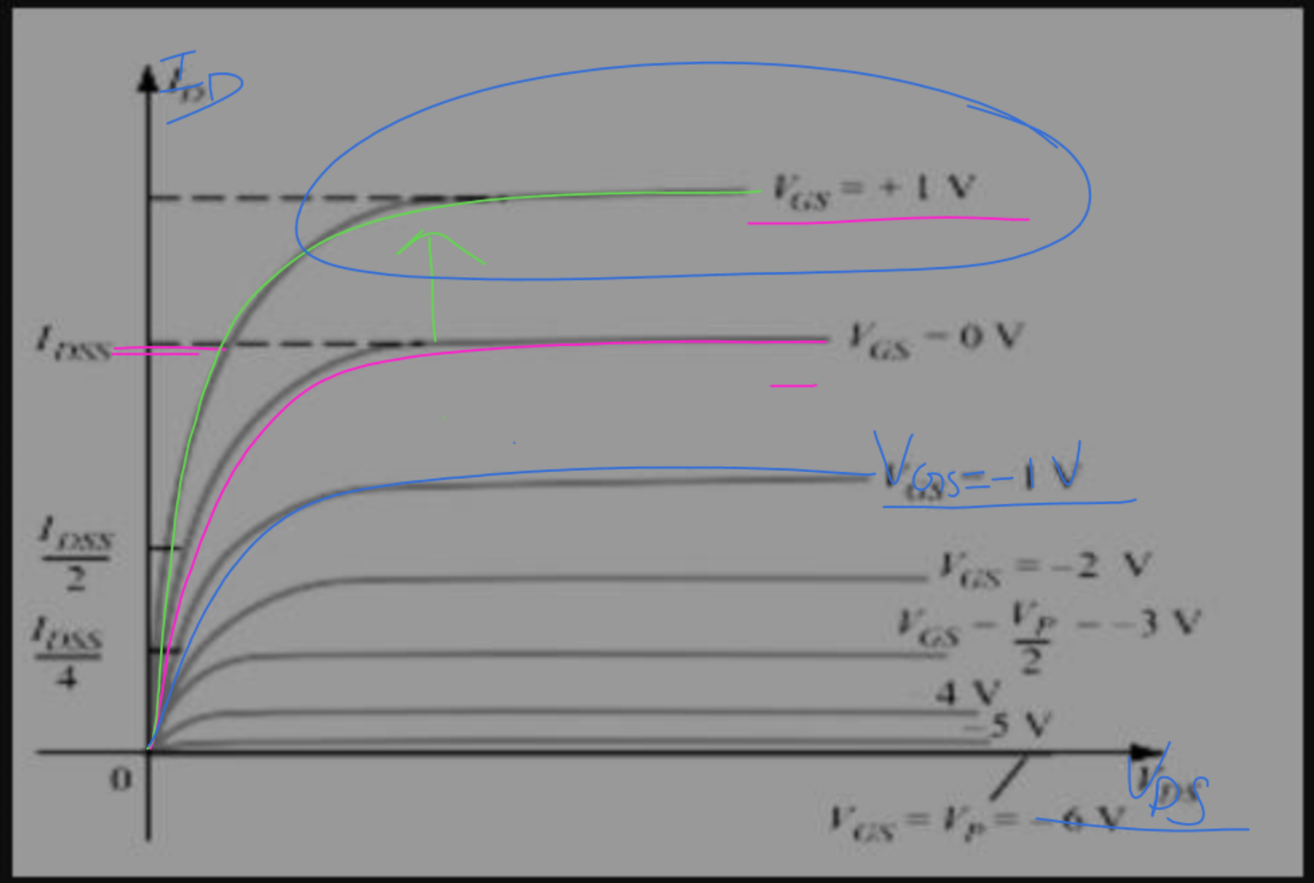
Drain Characteristics

It is graph between output current I_D and output voltage V_{DS} at constant V_{GS}. It can be explained from working of the structure discussed above.

For smaller values of V_{DS}, $I_D V_D$. So this region of the graph is called ohmic or linear region.

In ohmic region the slope of the graph is dependent on V_{GS}. So MOSFET can be used as voltage controlled resistance.

After pinch off condition the drain current become constant and this region of the graph is called saturation region.



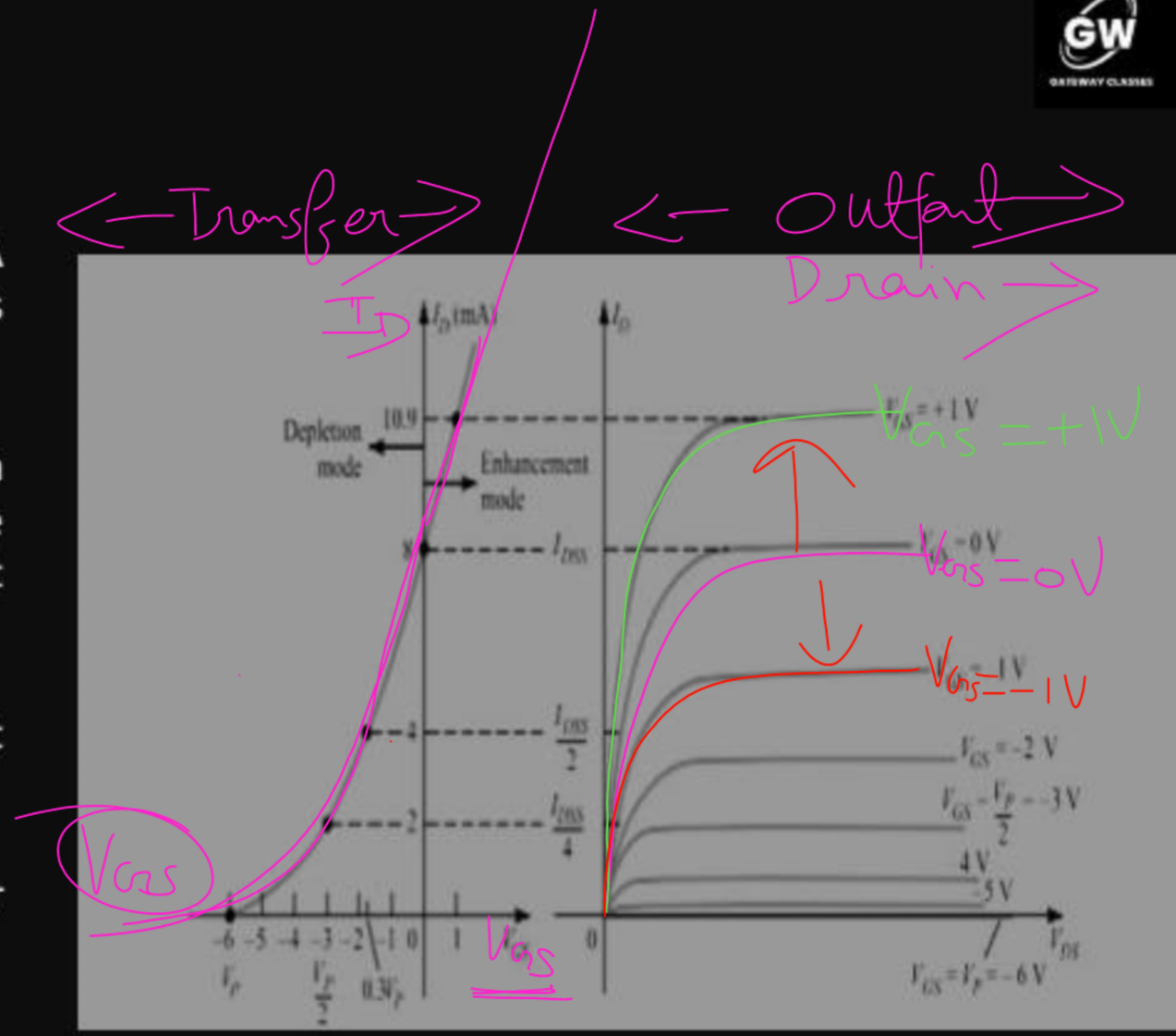
Transfer Characteristics

Here two graphs are provided, with the vertical scaling in mA for each graph. One is a plot of I_D versus V_{DS} , while the other is I_D versus V_{GS} .

Using the drain characteristics on the right of the "y" axis, a horizontal line can be drawn from the saturation region of the curve denoted V_{GS} = 0 V to the I_D axis. The resulting current level for both graphs is I_{DSS}.

In a similar way for different values of V_{GS} we can note constant values of I_D from output curve.

By joining all these points curve obtained is called transfer curve.

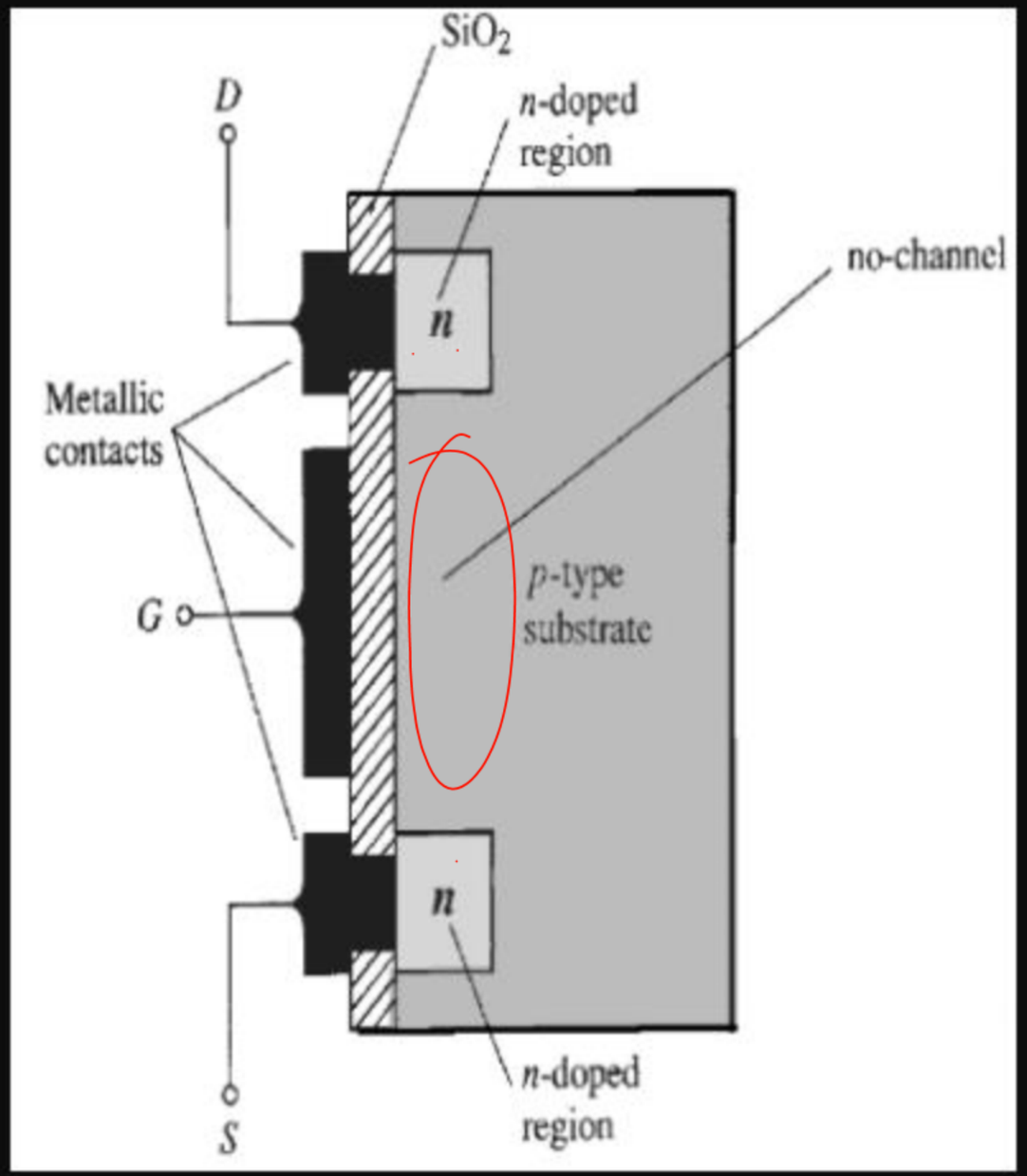


N-Channel Enhancement Type MOSFET

n-channel Enhancement type MOSFET has p type substrate.

Then two n regions are formed, A thin layer of Sio2 (Silicon die oxide) is deposited.

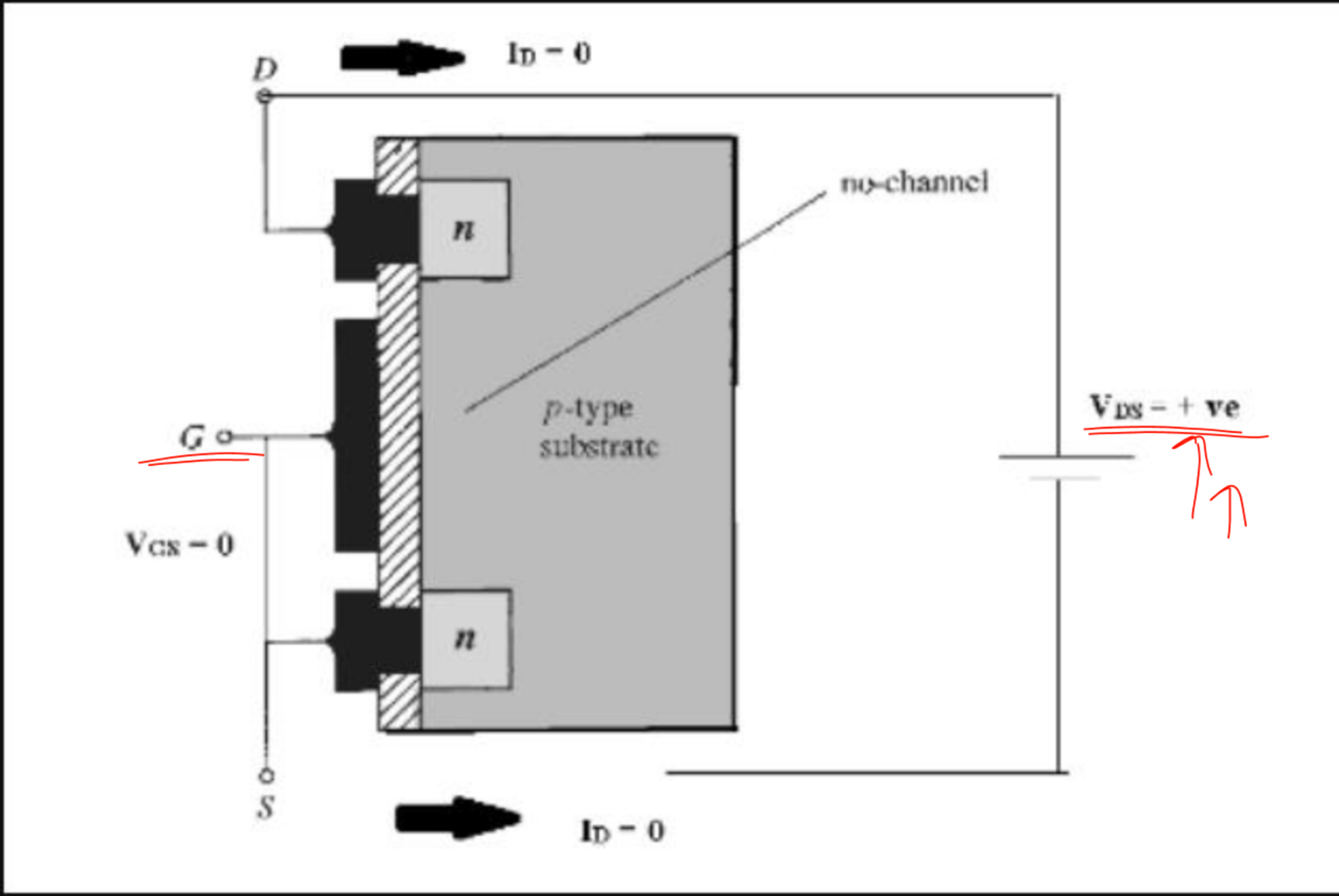
Drain and source are connected with the help of metallic contact. There is no channel between two n regions.



Operation:

V_{DS} = + ve, V_{GS} = 0

If VDS is increased then no current will flow because the is no channel i.e. ID = 0

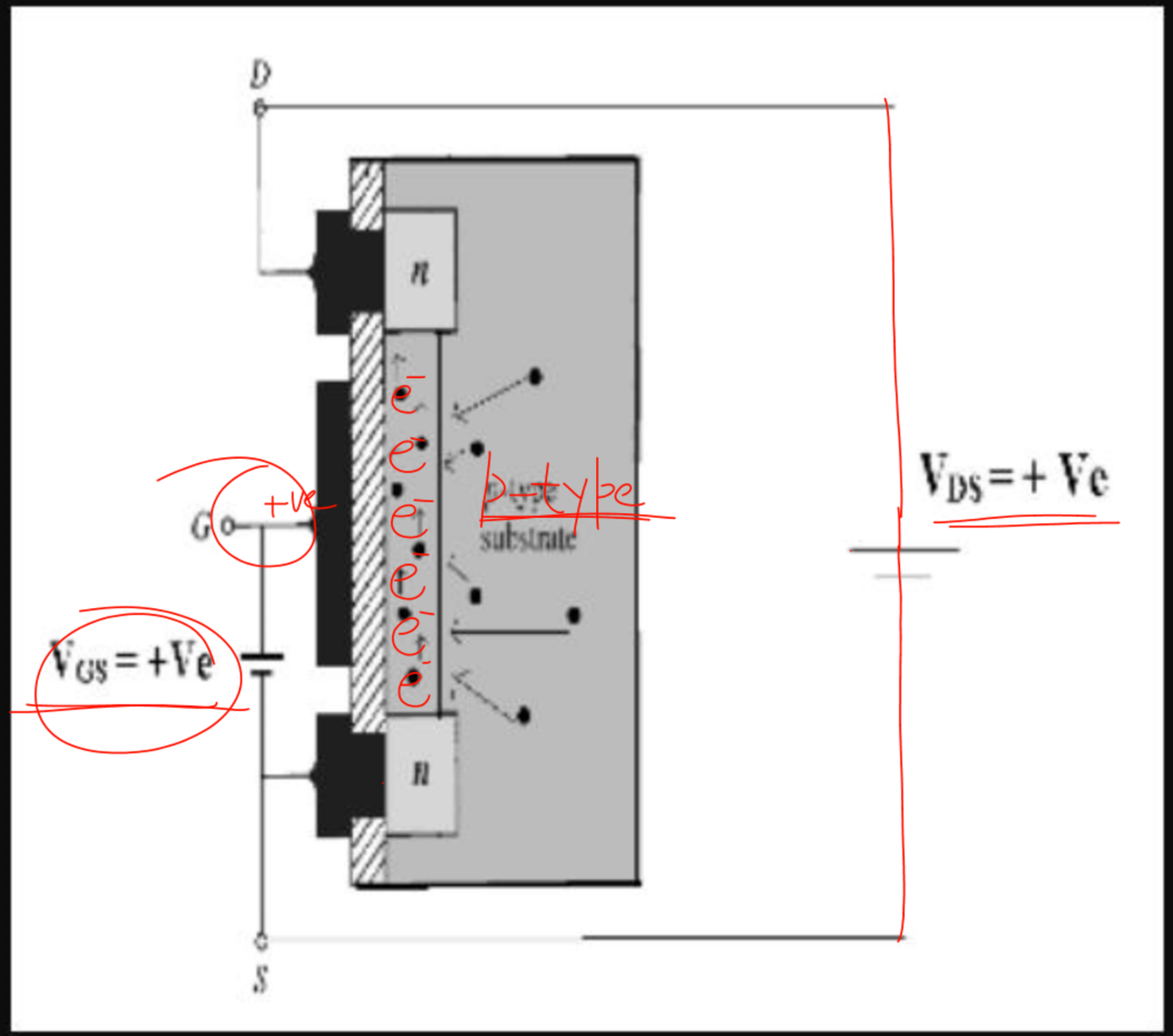


ii) VDS = + Ve , VGS = +Ve

If positive voltage is applied at gate then electron in p type moves towards the gate and holes moves away from the gate.

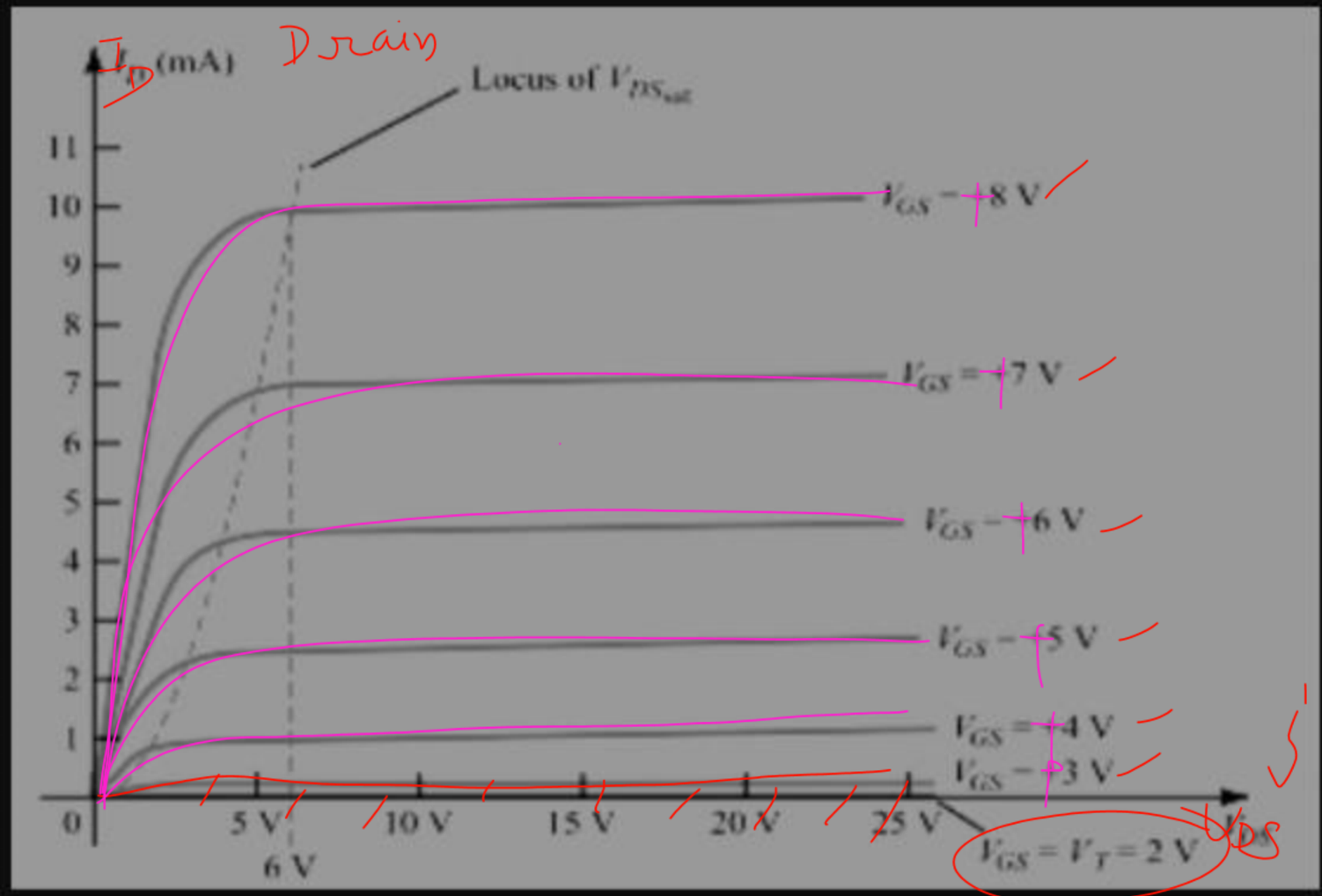
Till 2V no channel is formed. But after 2V channel is formed. This 2V is called threshold voltage (VT).

If V_{GS} is further increased then I_D continuously increases. This is called enhancement MOSFET.



Drain or output characteristics:

It is the curve between drain current (I_D) and drain to source voltage (V_{DS}), while gate to source voltage (V_{GS}) should be constant.



Transfer Characteristics

It is graph between output current I_D and input voltage V_{GS}.

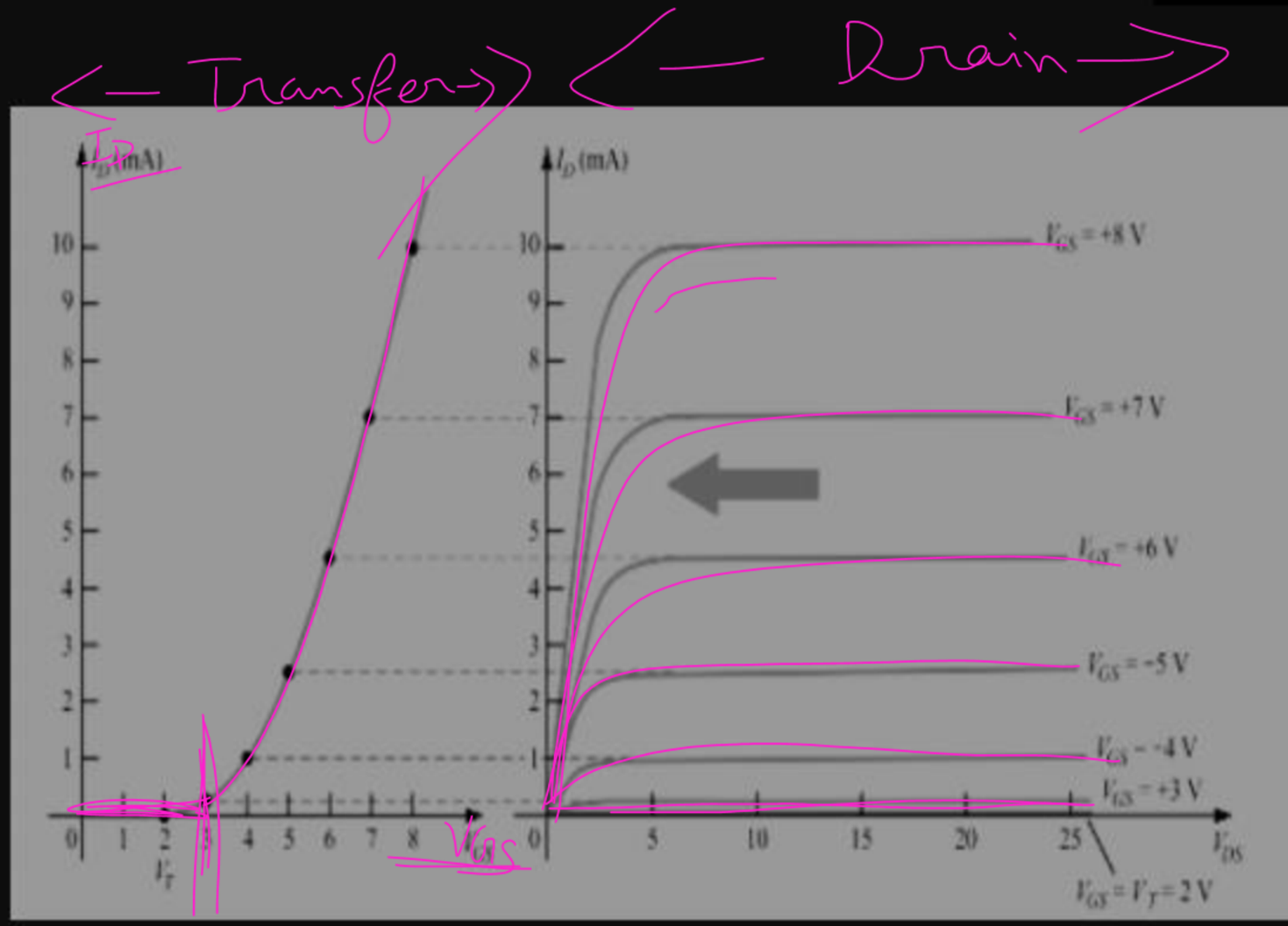
The relation between I_D and V_{GS} can be given as:

$$I_D = k(V_{GS} - V_T)2$$

Here k is a constant dependent on the construction of device.

The transfer curve can be obtained using above equation or from the output characteristics.

Here V_T is called threshold voltage. It is minimum positive voltage required for n channel EMOSFET to start conduction through n channel.



Comparison between bjt, jfet and mosfet

Input impedance ↑
Output impedance ↓
Gain ↑
Noise ↓

Types	BJT	JFET	MOSFET
Device	Current controlled device	Voltage controlled	Voltage controlled
Flow of current	Bipolar	Unipolar	Unipolar
Mode of Operation	No Modes	Only Depletion	Both Depeltion and Enhancement Mode
Input Impedance	Low	High	Very High
Noise level	High	Low	Low
Thermal durability	Low	Better than BJT	High

For more Subject/pdf Notes
Download Gateway Classes Application
From Google Play store

Link in Description

Thank You

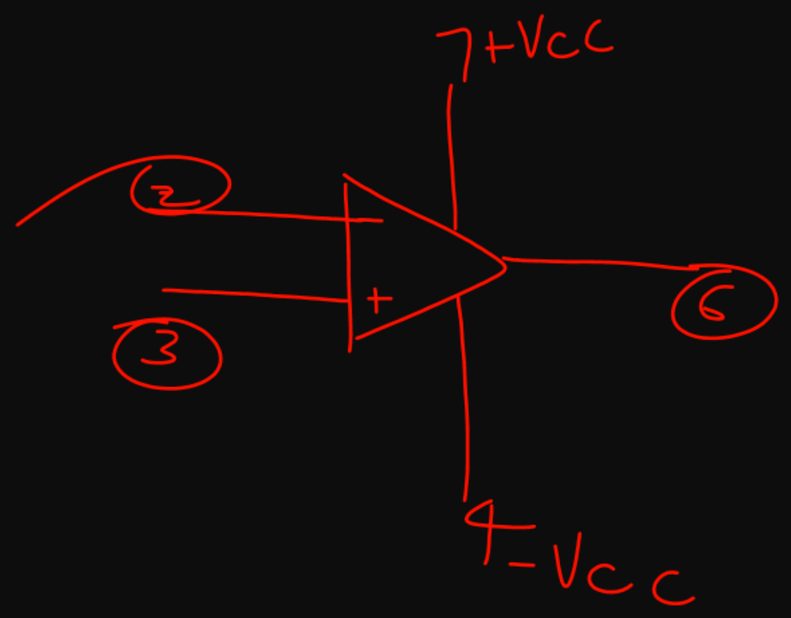
UNIT-3
ONE SHOT

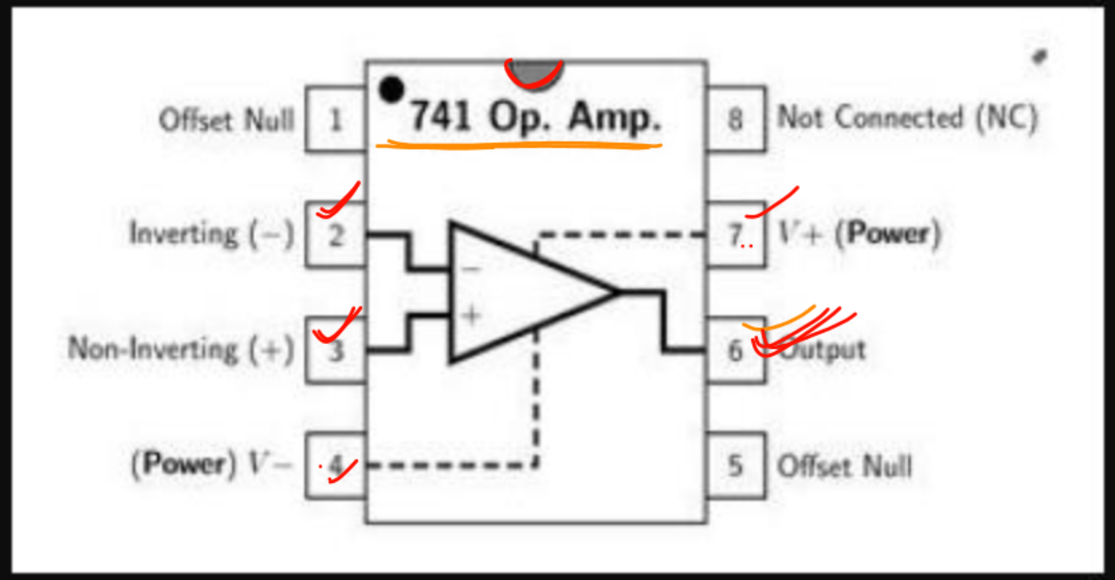
As per
New Syllabus
2022-23

Today's Target

- ✓ Complete Revision

741 IC Pin diagram





Ideal Characteristics of Op-amp

$$\text{Gain} = \frac{V_o}{V_{in}}$$

Infinite Open Loop gain ∞

Infinite input impedance ∞

Zero output impedance 0

Infinitely fast (infinite bandwidth) ∞

Infinite CMRR $= \frac{A_d}{A_c = 0} \infty$

Infinite Slew Rate $S.R = \frac{dV_{out}}{dt} = \infty$

Zero input offset voltage $= 0$

Zero Input offset Current $= 0$

Zero Input Bias Current

Virtual Ground Concept

$$V_o = A(V_d)$$

$$= A(V_2 - V_1)$$

$$A = \frac{V_o}{V_2 - V_1} = \infty$$

$$\boxed{V_2 - V_1 = 0} \Rightarrow V_1 = V_2$$

Summing Amplifier

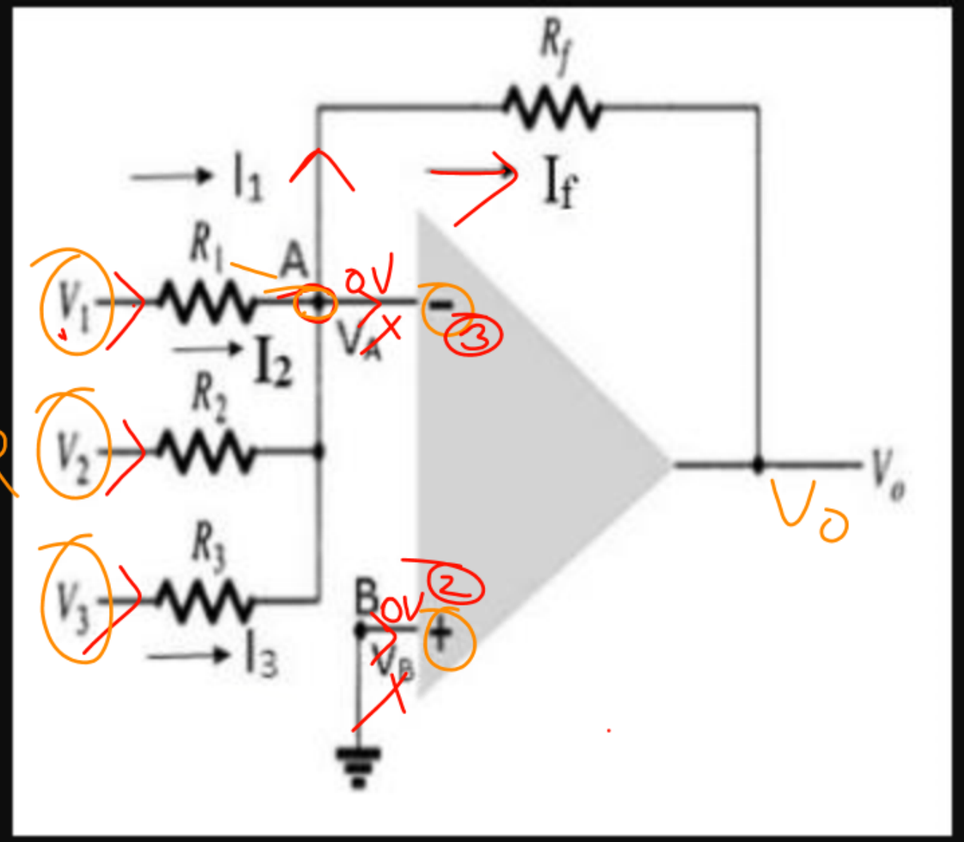
A → KCL

$$I_1 + I_2 + I_3 = I_f$$

$$\frac{V_1 - 0}{R_1} + \frac{V_2 - 0}{R_2} + \frac{V_3 - 0}{R_3} = \frac{0 - V_0}{R_f}$$

$$V_0 = -R_f\left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right] \quad R_1 = R_2 = R_3 = R$$

$$V_0 = -\frac{R_f}{R}\left[V_1 + V_2 + V_3\right]$$



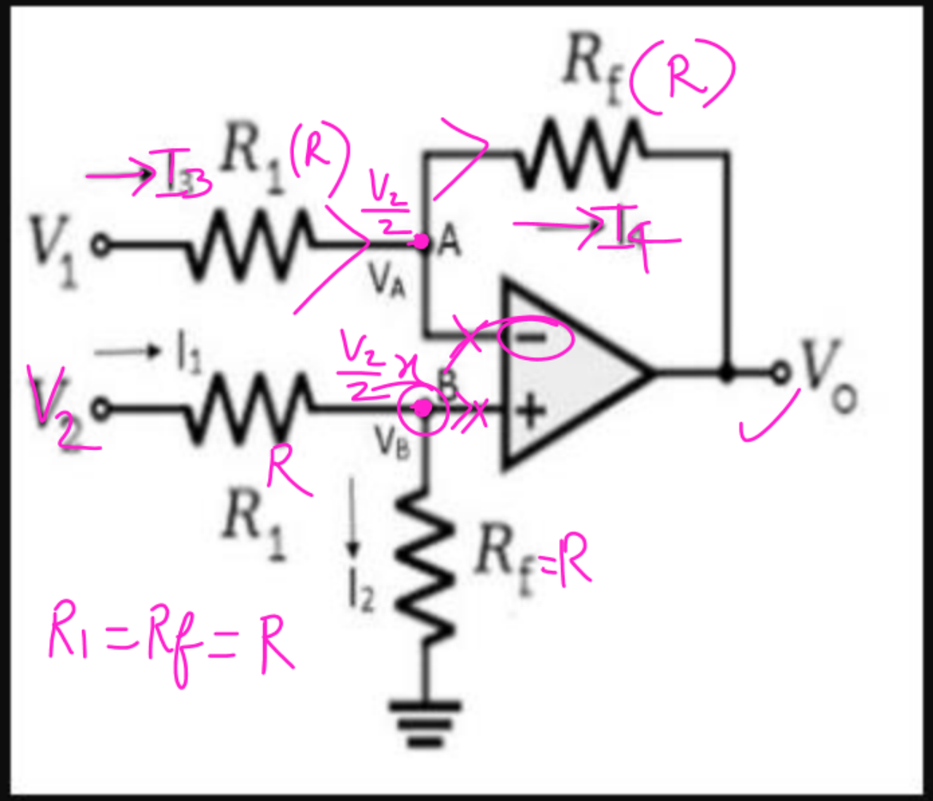
Difference Amplifier

$$V_A = \frac{V_2}{2}$$

$$I_3 = I_4$$

$$\frac{V_1 - \frac{V_2}{2}}{R} = \frac{\frac{V_2}{2} - V_0}{R}$$

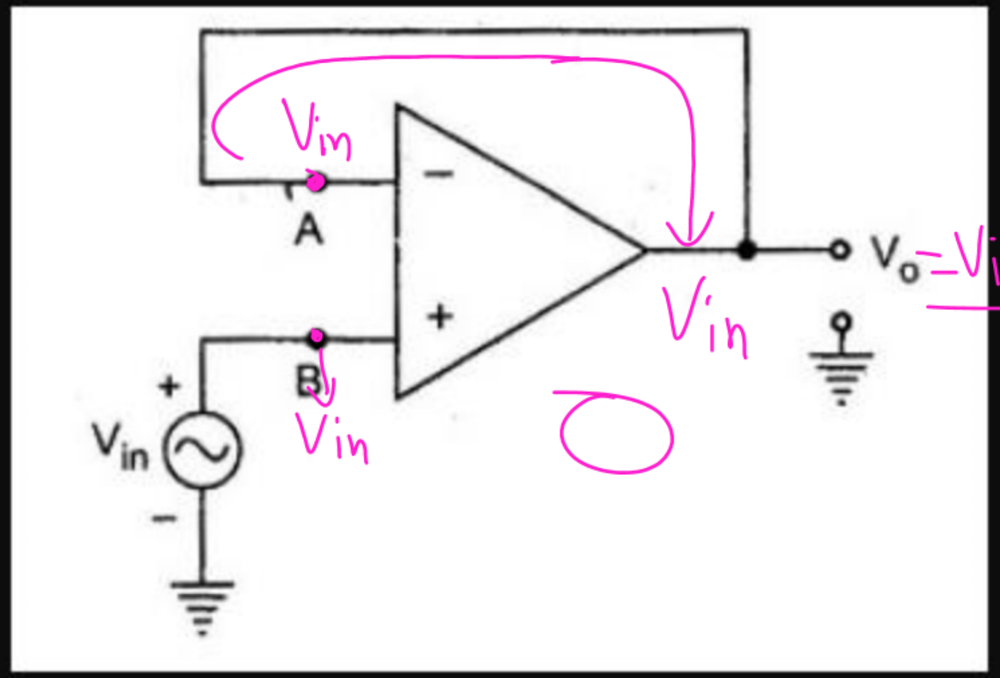
$$\boxed{V_0 = V_2 - V_1}$$



Unit Follower

$$V_o = V_{in}$$

$$\text{Gain} = \frac{V_o}{V_{in}} = \frac{V_{in}}{V_{in}} = 1$$



Calculate the output voltage if V1 = –0.2 V and V2 = 0 V.

Answer = 2v

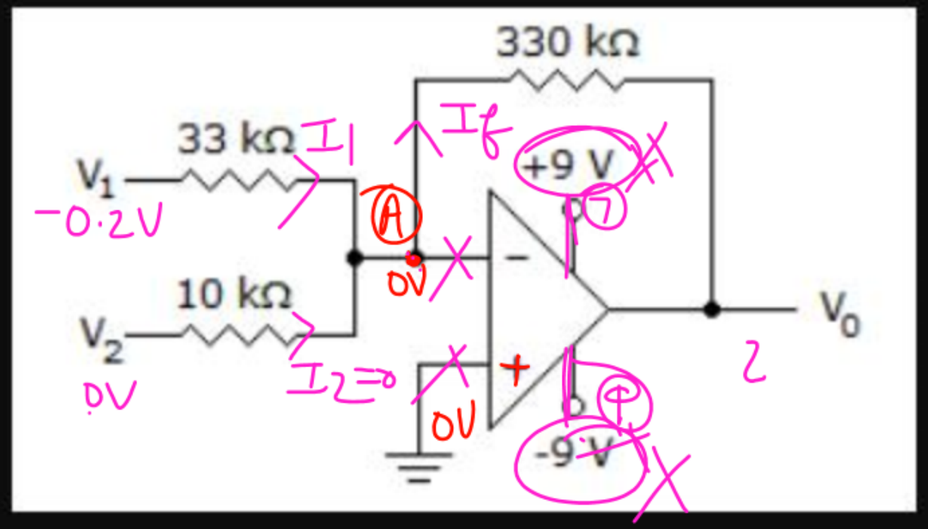
KCL at A.

$I_1 + I_2 = I_f$

$\frac{-0.2-0}{33K} + 0 = \frac{0 - V_0}{330K}$

$-2 = -V_0$

$V_0 = 2V$



Determine the output voltage for this circuit with a sinusoidal input of 2.5 mV.

Answer= –0.125 V

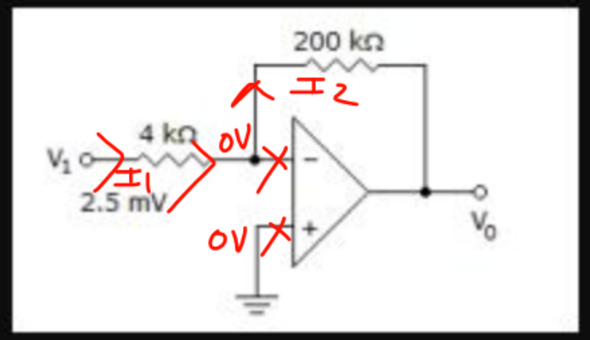
$I_1 = I_2$

$$\frac{2.5mV - 0}{4K} = \frac{0 - V_0}{200K}$$

50

$V_0 = -(50 \times 2.5\ mV)$

$V_0 = -0.125V$



# Determine the output voltage when V1 = V2 = 1 V.
Answer=0v

$$\frac{1-x}{20K} = \frac{x-0}{20K}$$

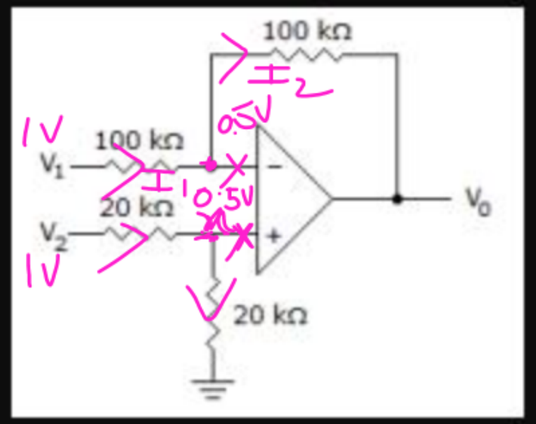
$$1 = 2x$$

$$x = 0.5V$$

$$I_1 = I_2$$

$$\frac{1-0.5}{100K} = \frac{0.5-V_0}{100K}$$

$$V_0 = 0V$$



Calculate the output of the first-stage op-amp when V1 = 25 mV

~~Answer=0.075 V~~

$I_1 = I_2$

$\frac{0-25m}{5K} = \frac{25mV - V_A}{10K}$ 2

$-50m = 25mV - V_A$

$V_A = 75mV$

$I_3 = I_4$

$\frac{75m-0}{5K} = \frac{0-V_B}{5K}$

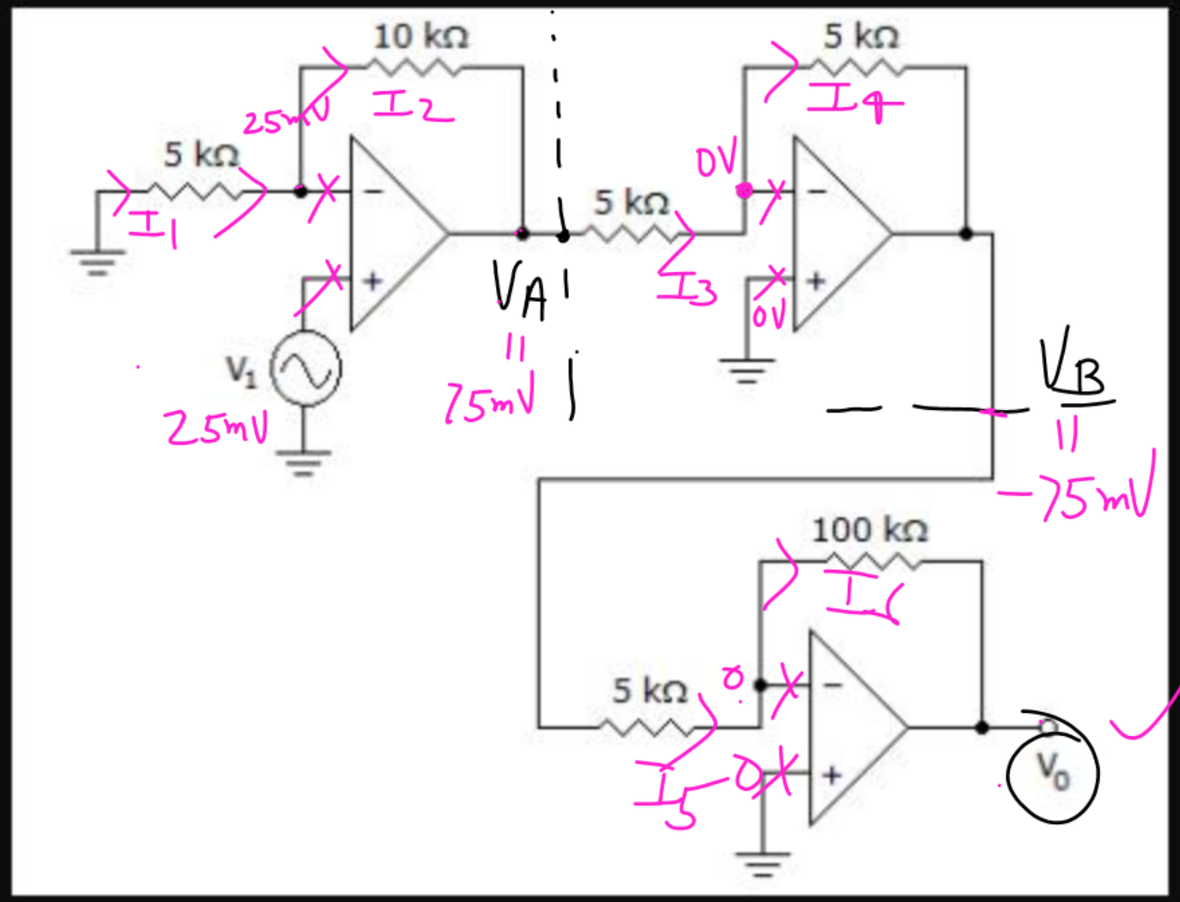
$V_B = -75mV$

$I_5 = I_6$

$\frac{-75m-0}{5K} = \frac{0-V_o}{100K}$ 20

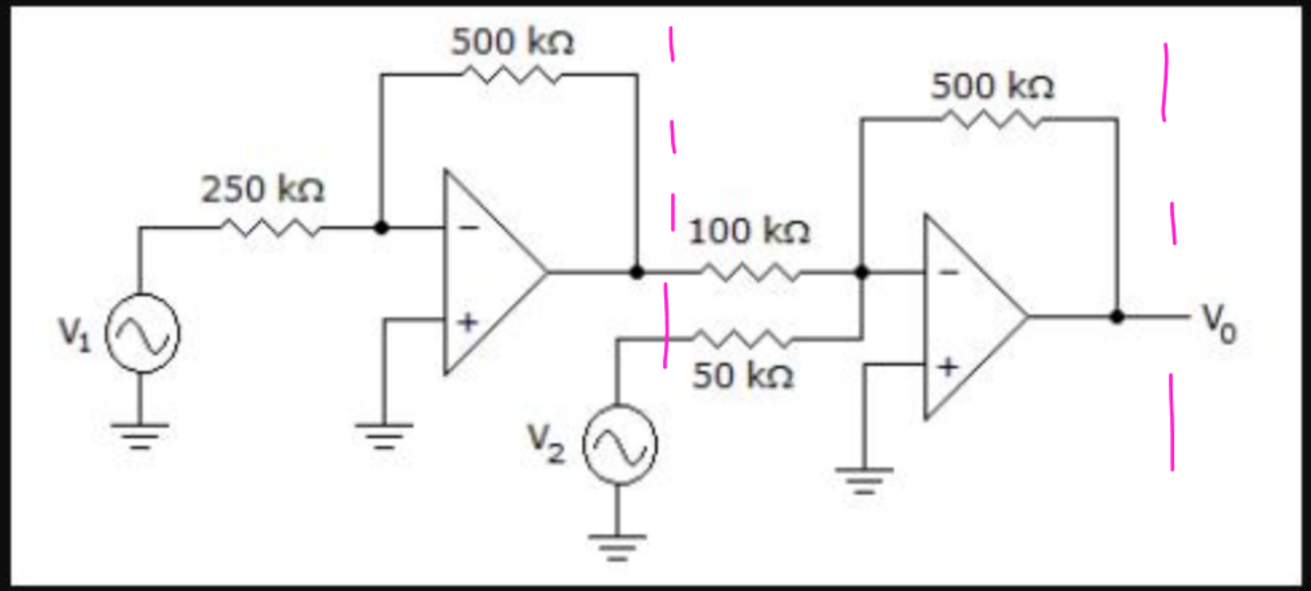
$V_o = (20 \times 75)mV$

$= 1.5V$

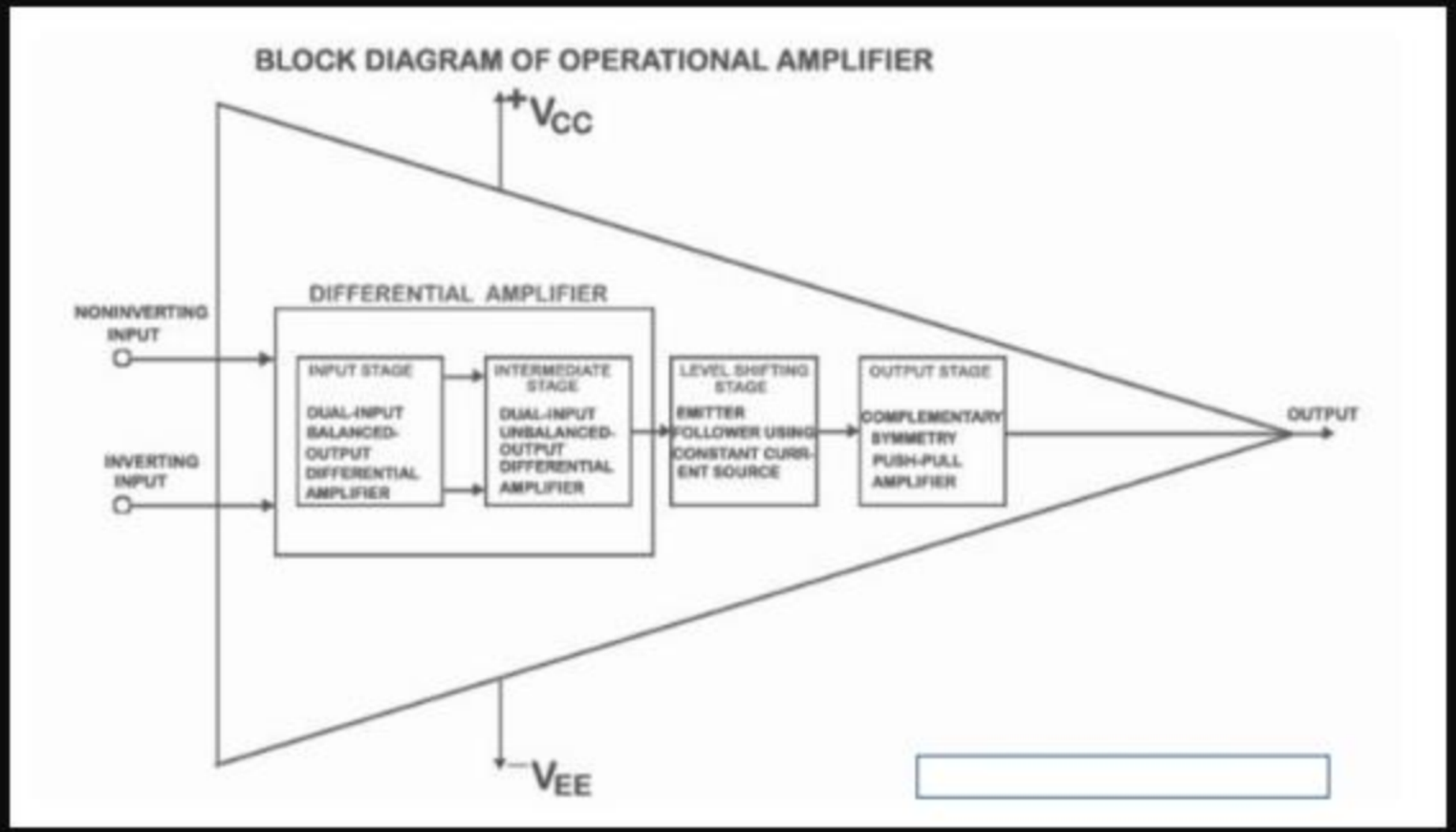


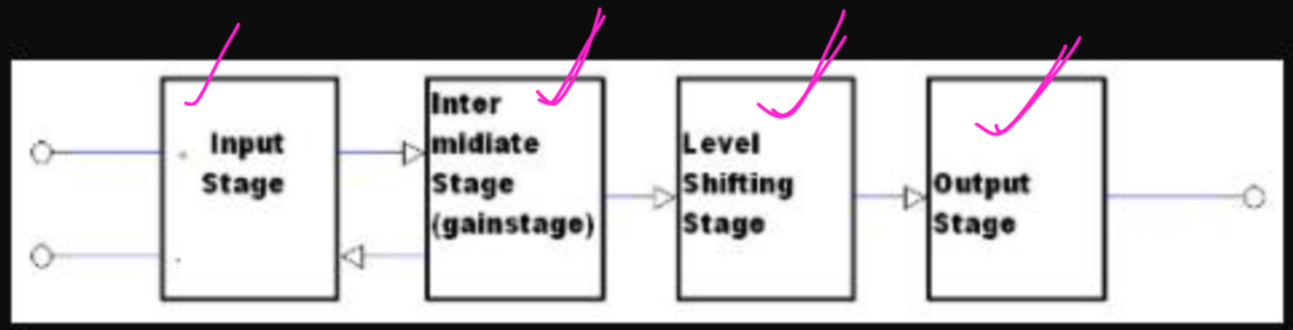
Calculate the output voltage if V1 = 300 mV and V2 = 700 mV.

Answer= –4 V



Block diagram of Op-amp





- Input Stage: - It consists of a dual input, balanced output differential amplifier. Its function is to amplify the difference between the two input signals. It provides high differential gain, high input impedance and low output impedance.
- Intermediate stage:- It consists of another differential amplifier with dual input, and unbalanced (single ended) output. The overall gain requirement of an Op-Amp is very high. Since the input stage alone cannot provide such a high gain. Intermediate stage is used to provide the required additional voltage gain.
- Level shifting stage:- The level shifting stage is used after the intermediate stage to shift the DC level at the output of the intermediate stage downward to zero volts with respect to ground when no signal is applied at the input terminals.
- Output stage:- It consists of a push-pull complementary amplifier. The output stage increases the output voltage swing, and the current supplying capabilities of the opamp, output stage also provides the low output resistance.

Integrator circuit Using Op-amp

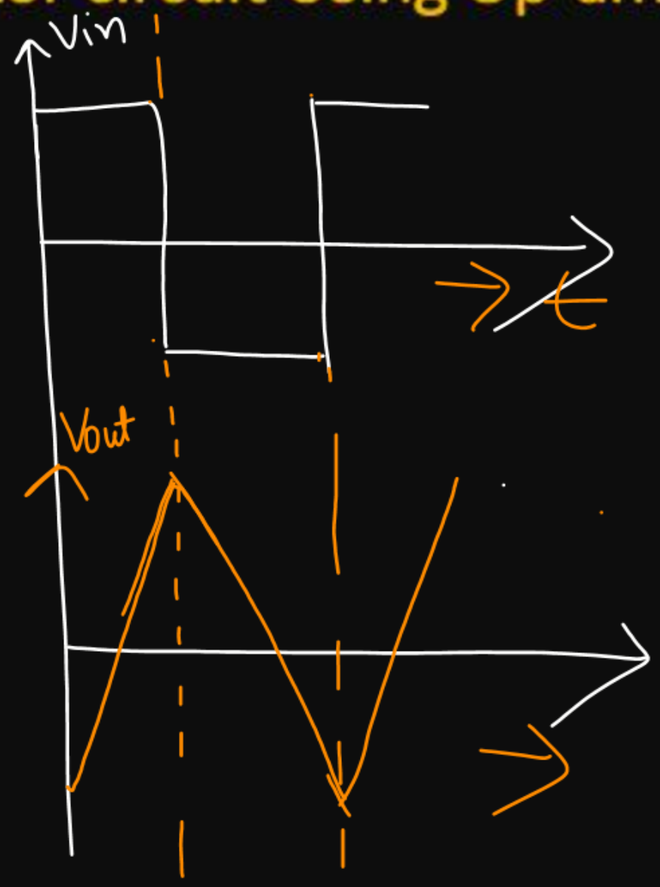
$$I_1 = I_C$$

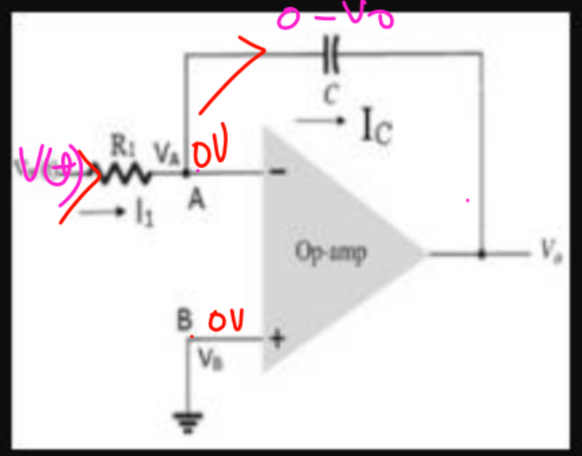
$$\frac{V_{in} - 0}{R_1} = \frac{C\, d(0 - V_0)}{dt}$$

$$\frac{V_{in}}{R_1} = -\frac{C\, dv_0}{dt}$$

$$\int dv_0 = -\int \frac{1}{R_1 C} V_{in}\, dt$$

$$\boxed{V_0 = -\frac{1}{R_1 C} \int V_{in}\, dt}$$





$$C = \frac{Q}{V}$$

$$Q = C\,V(t)$$

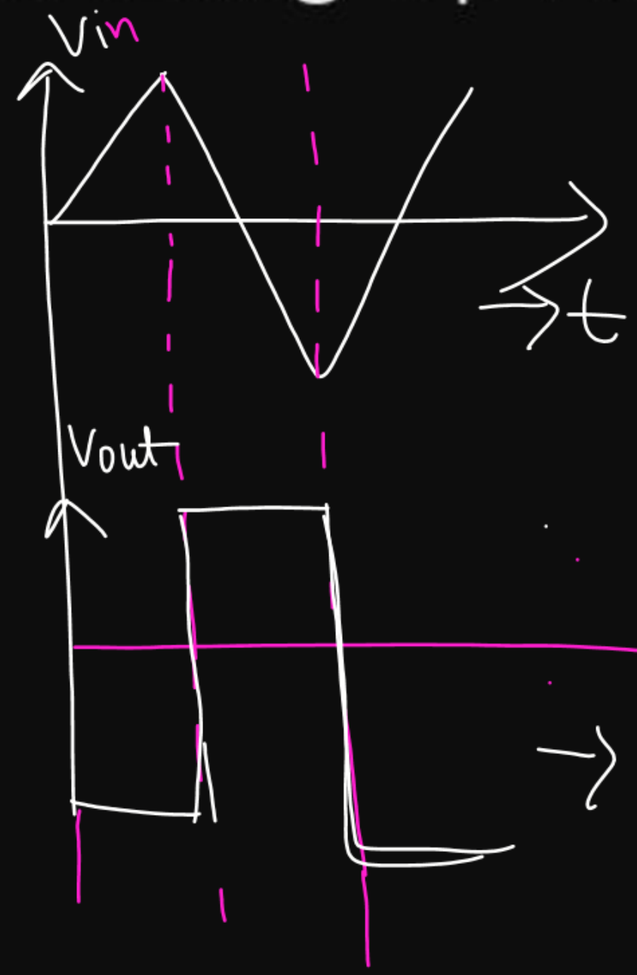
$$\boxed{I_C = \frac{dQ}{dt} = C\frac{dV_{in}(t)}{dt}}$$

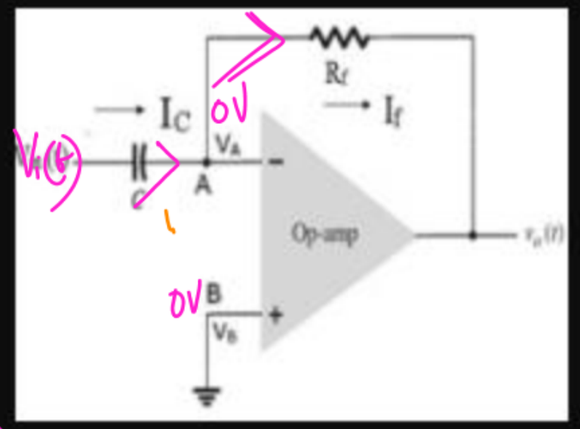
Differentiator Circuit Using Op-Amp

$$I_C = I_f$$

$$C\frac{d(V_{in}-0)}{dt} = \frac{0-V_o}{R_f}$$

$$\boxed{V_o = -R_f C\frac{dV_{in}}{dt}}$$





$$C = \frac{Q}{V}$$

$$Q = CV$$

$$i_c = C\frac{dV(t)}{dt}$$

Comparator

- Comparator is a circuit which compare signal voltage applied at one
- input terminal of op-amp with reference voltage applied at other
- terminal.

- Comparator produce High (+Vsat) or low (-Vsat) output demanding
- which input is higher

- Comparator are of two types.

- Inverting Comparator

- Non-inverting Comparator

Inverting comparator

Input is applied at inverting terminal.

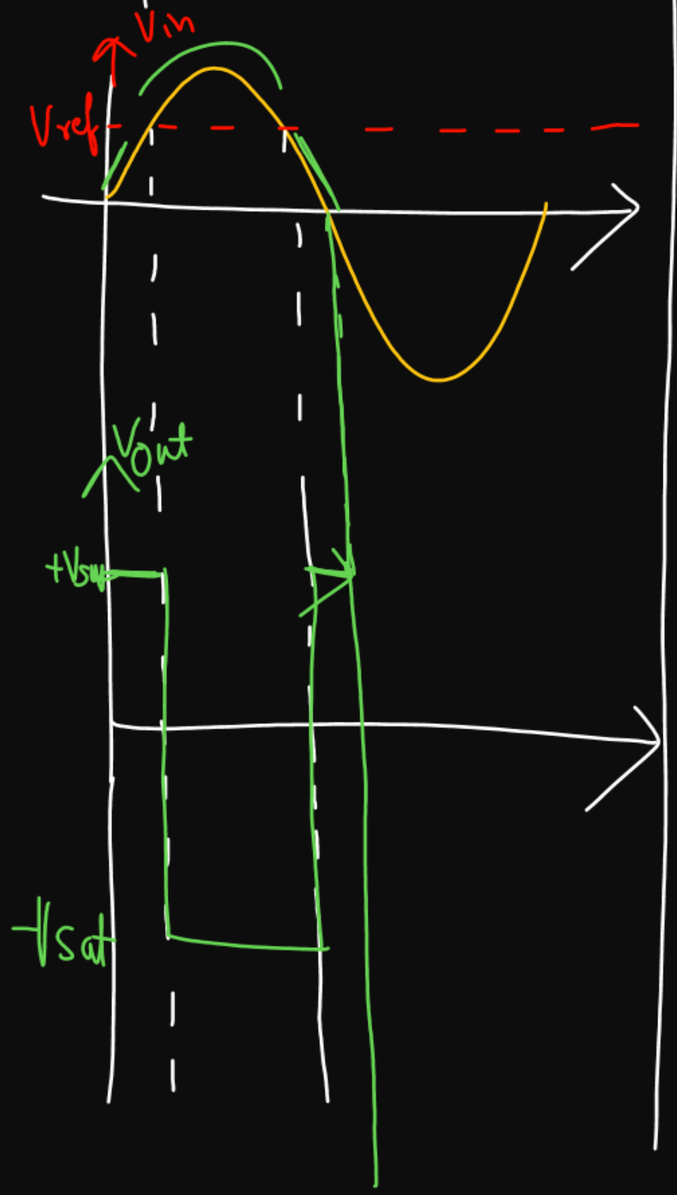
Reference voltage is applied at non-inverting terminal.

Inverting comparators can be classified into two categories.

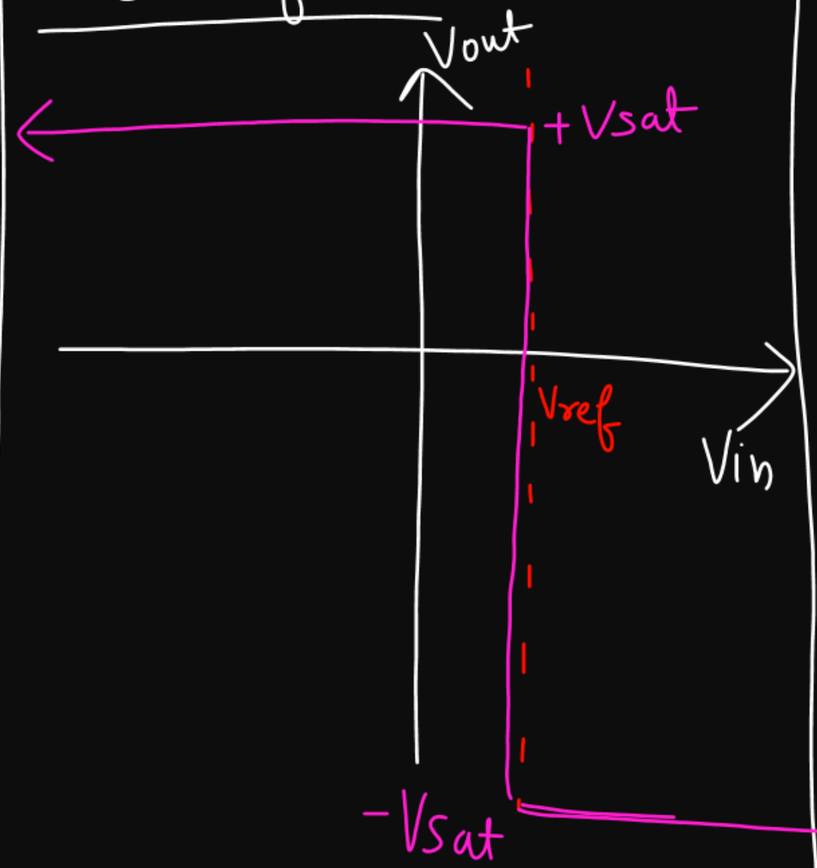
Inverting Comparator with Zero Reference Voltage or Zero Crossing
Detector

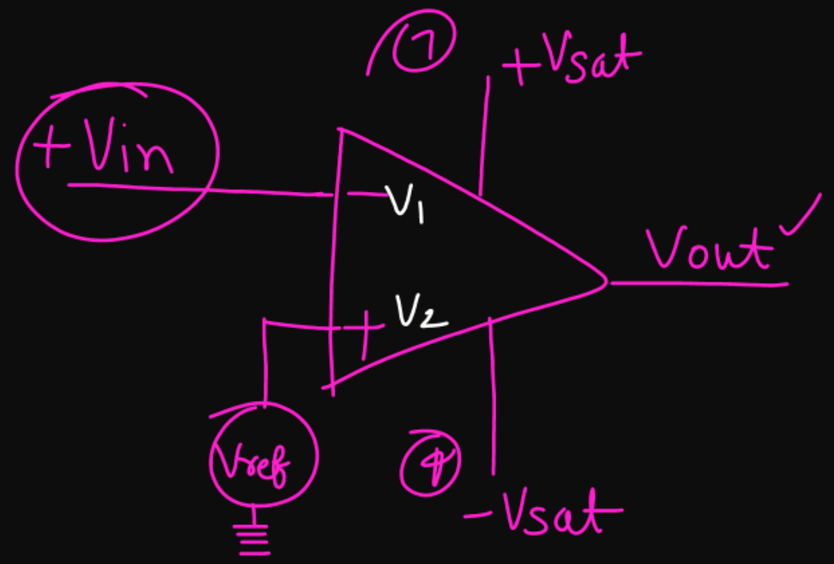
Inverting Comparator with Non-Zero Reference Voltage

Input-output



Transfer





$V_o = A(V_d)$

$V_o = A(V_2 - V_1)$

$V_o = A(V_{ref} - V_{in})$

① $V_{in} < V_{ref}$ $\boxed{V_o = +V_{sat}}$

② $V_{in} > V_{ref}$ $\boxed{V_o = -V_{sat}}$

Non inverting comparator

Input is applied at Non-inverting terminal.

Reference voltage is applied at inverting terminal.

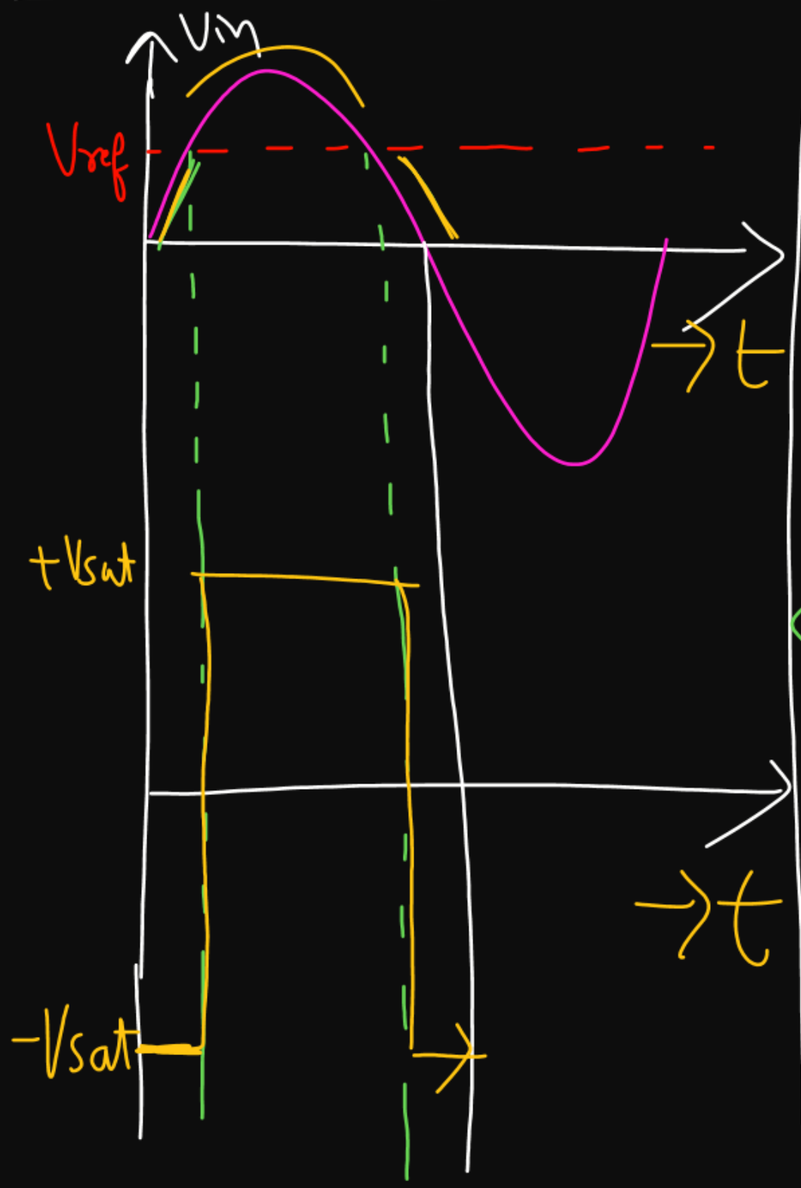
Non-inverting comparators can be classified into two categories.

Non-inverting Comparator with Zero Reference Voltage or Zero

Detector

Non-inverting Comparator with Non-Zero Reference Voltage

Input-output



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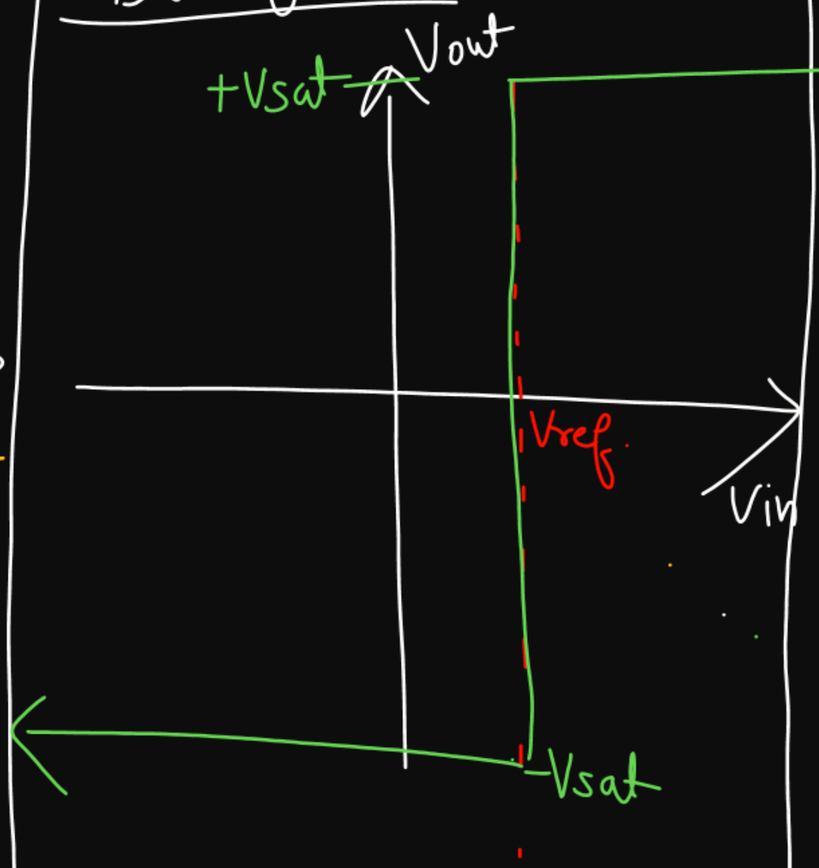
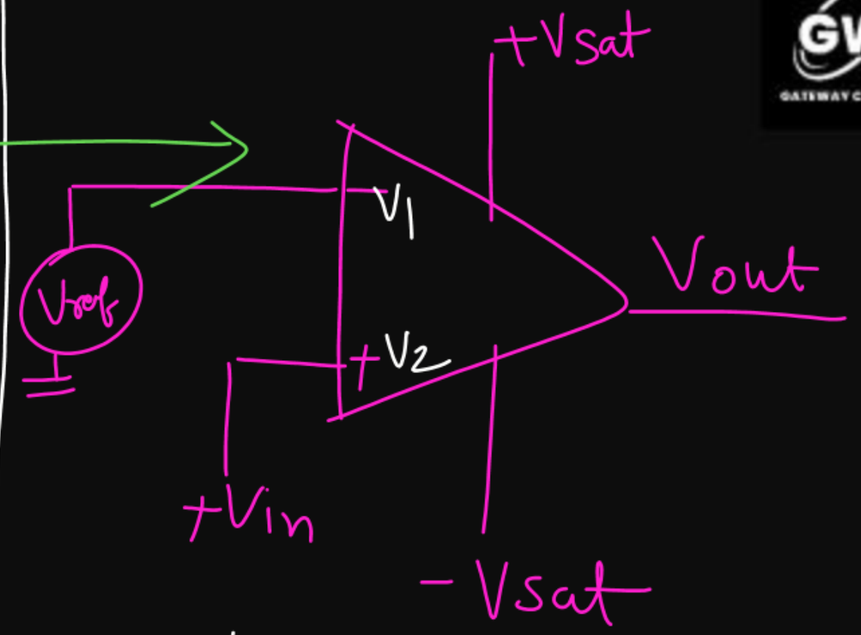




$$V_0 = A\,V_d$$

$$V_0 = A\,(V_2 - V_1)$$

$$= A(V_{in} - V_{ref})$$

① $V_{in} < V_{ref}$

$$\boxed{V_0 = -V_{sat}}$$

② $V_{in} > V_{ref}$

$$\boxed{V_0 = +V_{sat}}$$

For more Subject/pdf Notes
Download Gateway Classes Application
From Google Play store

Link in Description

Thank You

Digital Electronics

Today's Target

- ✓ Number System
- ✓ Number Conversion

Gateway Classes

Unit 4

Digital Electronics: Number system & representation, Binary arithmetic, Introduction of Basic and Universal Gates, using Boolean algebra simplification of Boolean function. K Map Minimization upto 6 Variables.

Gateway Classes

Number system

0, 1, 2, ... 9

$(79)_{10}$

0, 1

- A number system defines how a number can be represented using distinct digits or symbols.
- A number can be represented differently in different systems. For example, the two numbers $(2A)_{16}$ and $(52)_8$ both refer to the same quantity, $(42)_{10}$, but their representations are different.
- Number systems include decimal, binary, octal and hexadecimal

$(0+115)_2$

Number System	Base	Symbol
Binary	Base 2	B
Octal	Base 8	O
Decimal	Base 10	D
Hexadecimal	Base 16	H

Gateway Classes

Decimal Number System

Digits → 10 → Numbers

↳ Base – 10

$(0, 1, 2, 3, 4, 5, 6, 7, 8, 9)_{10}$

$(0 - 9)_{10}$

Gateway Classes

Binary Number System

Digits = 2 → Numbers

↳ Base → 2

$(0, 1)_2$

$(0 - 1)_2$

GatewayClasses

Octal Number System

→ Numbers/digits → 8

→ Base - 8

$(0, 1, 2, 3, 4, 5, 6, 7)_8$

$(0 - 7)_8$

Gateway Classes

Hexa-Decimal Number System

→ Numbers / digits → 16

→ Base – 16

(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F)$_{16}$

$(0-F)_{16} \rightarrow (0-15)_{16}$

10 – A

11 – B

12 – C

13 – D

14 – E

15 – F

Gateway Classes

NUMBER CONVERSIONS

Decimal to Binary -

① $(259)_{10} = (?)_2$

2	259	
2	129	1
2	64	1
2	32	0
2	16	0
2	8	0
2	4	0
2	2	0
	1	0

$(100000011)_2$ Ans

② $(178)_{10} = (?)_2$ → H.W.

③ $(78.25)_{10} = (?)_2$

2	78	
2	39	0
2	19	1
2	9	1
2	4	1
2	2	0
	1	0

$.25 \times 2 = 0.50$

$0.50 \times 2 = 1.00$

$(1001110.01)_2$ Ans

Gateway Classes

NUMBER CONVERSIONS

Decimal to Octal -

$(259)_{10} = (?)_8$

$(403)_8$

8	259	
8	32	3
	4	0

$(178)_{10} = (?)_8$

Gateway Classes

NUMBER CONVERSIONS

Decimal to Hexadecimal -

$(259)_{10} = (?)_{16}$

16	259	
16	16	3
	1	0

$= (103)_{16}$

$(178)_{10} = (?)_{16}$

Gateway Classes

NUMBER CONVERSIONS

Binary to Decimal -

$(100000011)_2 = (?)_{10}$ — 259

$0\times2^6+0\times2^5+0\times2^4+0\times2^3+0\times2^2+1\times2^1+1\times2^0$
$+0\times2^7+1\times2^8$

$256+0+0+0+0+0+0+2+1$

$=(259)_{10}$ Ans

$2^3\ 2^2\ 2^1\ 2^0$
$8\ 4\ 2\ 1$

Q $(1011011)_2 = (?)_{10}$ → H.W

Q $(1001110.01)_2 = (?)_{10}$

$1\times2^6+0\times2^5+0\times2^4+1\times2^3+1\times2^2+1\times2^1+0\times2^0$
$+0\times2^{-1}+1\times2^{-2}$

$64+0+0+8+4+2+0+0+\frac{1}{4}$

$78+0.25$

$(78.25)_{10}$ Ans

Gateway Classes

NUMBER CONVERSIONS

Binary to Octal -

$$(10000011)_2 = (?)_8$$

$$\underbrace{100}_{4}\ \underbrace{000}_{0}\ \underbrace{011}_{3}$$

$$(4\ 0\ 3)_8$$

$2^3 = 8$

2^3	2^2	2^1	2^0
8	4	2	1
0	1	1	→ 3
0	0	0	→ 0
1	0	0	→ 4

Gateway Classes

$$(100000011)_2 = (?)_8$$

$$1\times 2^8 + 0\times 2^7 + 0\times 2^6 + 0\times 2^5 + 0\times 2^4 + 0\times 2^3 + 0\times 2^2 + 1\times 2^1 + 1\times 2^0$$

$$256 + 2 + 1 \Rightarrow (259)_{10}$$

Now

8	259	
8	32	3
	4	0

$$(403)_8$$ Ans

Gateway Classes

NUMBER CONVERSIONS

Binary to Hexadecimal-

Q $(100000011)_2 = (?)_{16}$

$000 \; 1 \; 0000 \; 0011$

$\downarrow \quad \downarrow \quad \downarrow$

$1 \quad 0 \quad 3$

$(103)_{16}$ Ans

$2^3 \; 2^2 \; 2^1 \; 2^0$ $\qquad 2^4 = 16$

$8 \; 4 \; 2 \; 1$

$0 \; 0 \; 1 \; 1 = 3$

$0 \; 0 \; 0 \; 0 = 0$

$0 \; 0 \; 0 \; 1 = 1$

$(100000011)_2 = (?)_{16}$

$\Downarrow$

$(259)_{10} \Rightarrow (103)_{16}$ Ans

Gateway Classes

NUMBER CONVERSIONS

Octal to Decimal -

$$(403)_8 = (?)_{10}$$

$$4 \times 8^2 + 0 \times 8^1 + 3 \times 8^0$$

$$256 + 0 + 3$$

$$= (259)_{10}$$

Gateway Classes

NUMBER CONVERSIONS

Octal to Binary -

$(403)_8 = (?)_2$

4	0	3
↓	↓	↓
100	000	011

$(100000011)_2$ Ans

2^2	2^1	2^0
4	2	1
0	1	1
1	0	0

$(403)_8 = (?)_2$

↳ $(259)_{10}$

↳ $(100000011)_2$

Gateway Classes

NUMBER CONVERSIONS

Octal to Hexadecimal -

$(403)_8 = (?)_{16}$

$\Downarrow$

$(259)_{10}$

$\Downarrow$

$(103)_{16}$ Ans

$(403)_8 = (?)_{16}$

$\Downarrow$

$(100000011)_2$

$\Downarrow$

$(103)_{16}$ Ans

$(403)_8 = (?)_{16}$

$\Downarrow$

$(100000011)_2$

$\Downarrow$

$(259)_{10}$

$\Downarrow$

$(103)_{16}$ Ans

Gateway Classes

NUMBER CONVERSIONS

Hexadecimal to Decimal -

$$(103)_{16} = (?)_{10}$$

$$1 \times 16^2 + 0 \times 16^1 + 3 \times 16^0$$

$$256 + 0 + 3$$

$$(259)_{10}$$ Ans

Gateway Classes

NUMBER CONVERSIONS

Hexadecimal to Binary -

$(103)_{16} = (?)_2$

1 0 3

$(\boxed{000}\ 100000011)_2$

A

8	4	2	1
0	0	0	1
0	0	1	1

$(103)_{16} = (?)_2$

$\Downarrow$

$(259)_{10}$

$\Downarrow$

$(100000011)_2$

Gateway Classes

NUMBER CONVERSIONS

Hexadecimal to Octal-

$(103)_{16} = (?)_8$

$\Downarrow$

$(259)_{10}$

$\Downarrow$

$(403)_8$ Ans

$103 = (?)_8$

$\Downarrow$

$(000100000011)_2$

$\Downarrow$

$(0403)_8 = (403)_8$ Ans

Gateway Classes

$$(1A2)_{16} = (?)_2$$

$$\begin{array}{ccc} 1 & A & 2 \\ \downarrow & \downarrow & \\ (0001 & 1010 & 0010)_2 \end{array}$$

2^3	2^2	2^1	2^0
8	4	2	1

0001 = 1

1010 = 10

0010 = 2

Gateway Classes

Introduction of Boolean Algebra

Today's Target

- ✓ Introduction of Boolean Algebra
- ✓ Boolean Laws
- ✓ Examples On Boolean Laws

Gateway Classes

Introduction of Boolean Algebra

High → 1 ← A B C D E F

Low → 0 ← $\bar{A}$ $\bar{B}$ $\bar{C}$ $\bar{D}$

A' B' C' D'

A = 1

A' = 0

A → 0

$\bar{A}$ = 1

Gateway Classes

Boolean Laws

- There are Eight types of Boolean Laws.

$A + B = B + A$
$A \cdot B = B \cdot A$

1) Commutative law

Any binary operation which satisfies the following expression is referred to as commutative operation.

(i) $A.B = B.A$ (ii) $A + B = B + A$

Commutative law states that changing the sequence of the variables does not have any effect on the output of a logic circuit.

2) Associative law

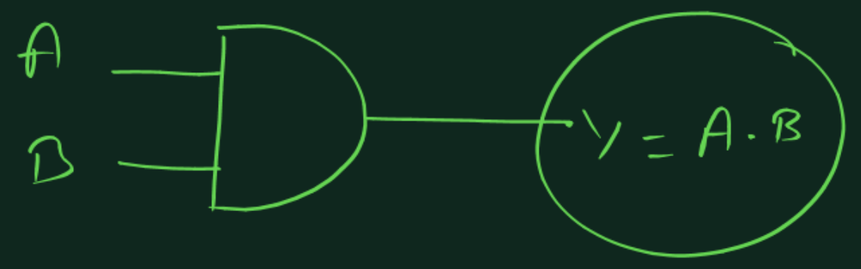
This law states that the order in which the logic operations are performed is irrelevant as their effect is the same.

(i) $(A.B).C = A.(B.C)$ (ii) $(A+B)+C = A+(B+C)$

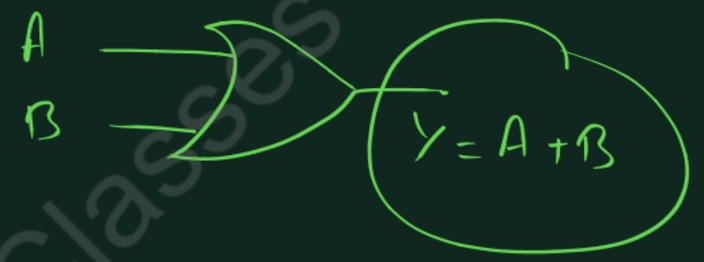
$A \cdot (B \cdot C) = (A \cdot B) \cdot C$
$A + (B + C) = (A + B) + C$

Gateway Classes

AND Gate



OR Gate



NOT Gate

Gateway Classes

Boolean Laws

3) Distributive law

Distributive law states the following condition.

$$A.(B+C) = A.B + A.C$$

$A \cdot (B + C) = A \cdot B + A \cdot C$

4) AND law

These laws use the AND operation. Therefore they are called as AND laws.

(i) $A.0 = 0$ (ii) $A.1 = A$

(iii) $A.A = A$ (iv) $A.\overline{A} = 0$

$A \cdot 0 = 0$, $A \cdot 1 = A$, $A \cdot A = A$

$A \cdot \overline{A} = 0$

5) OR law

These laws use the OR operation. Therefore they are called as OR laws.

(i) $A + 0 = A$ (ii) $A + 1 = 1$

(iii) $A + A = A$ (iv) $A + \overline{A} = 1$

$A + 0 = A$, $A + 1 = 1$, $A + A = A$

$A + \overline{A} = 1$

Gateway Classes

	1		
	0	1	0
0	0	1	0
1	1	0	1

$Y = A + B$

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

Gateway Classes

Boolean Laws

6) Inversion law

This law uses the NOT operation. The inversion law states that double inversion of a variable results in the original variable itself.

$$\overline{\overline{A}} = A$$

$A = 1$

$\overline{A} = 0$

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

$A = \overline{\overline{A}}$

7) Absorption law

This law enables a reduction in a complicated expression to a simpler one by absorbing like terms.

$A(A+B) = A$

$A + AB = A$

$A(A+B) = A$

$A + AB = A$

Gateway Classes

Boolean Laws

8) De Morgan's Law

$\overline{A+B} = \bar{A} \cdot \bar{B}$

$\overline{A \cdot B} = \bar{A} + \bar{B}$

There are two "de Morgan´s" rules or theorems,

(1) Two separate terms NOR´ed together is the same as the two terms inverted (Complement) and AND´ed for example:

$$(A+B)' = A' . B'$$

(2) Two separate terms ~~N~~AND´ed together is the same as the two terms inverted (Complement) and OR´ed for example:

$$(A.B)' = A' + B'$$

Gateway Classes

Examples On Boolean Laws

Example No1: simplify the following expression: $(A+B)(A+C)$

Soln.

$$(A+B)(A+C)$$

$$A\cdot A + A\cdot C + B\cdot A + B\cdot C$$

$$A + A\cdot C + B\cdot A + B\cdot C \quad \{\text{By AND operation } A\cdot A = A\}$$

$$A(1+C) + B\cdot A + B\cdot C$$

$$A + B\cdot A + B\cdot C \quad \{\text{By OR operation } 1+C = 1\}$$

$$\boxed{A + BC} \quad \{\because \text{By Absorption Law } A + AB = A\}$$

Ans

Gateway Classes

Examples On Boolean Laws

Example No2: simplify the following expression: **C + (BC)'**

$\overline{B \cdot C} = \overline{B} + \overline{C}$

Solⁿ.

$= C + (BC)'$

$= C + (B' + C')$ {By D' Morgan theorem}

$= C + C' + B'$

$= 1 + B'$ {By OR operation $C + C' = 1$}

$= 1$ {By OR operation $1 + B' = 1$}

Gateway Classes

Examples On Boolean Laws

Example No3: simplify the following expression: **(AB)'(A' + B)(B' + B)**

Soln

$(AB)'(A'+B)(B'+B)$

$(A'+B')(A'+B)(B'+B)$ (By De morgan theorem)

$(A'+B')(A'+B)\,1$ {By OR operation $B+B'=1$}

$A'\cdot A'+A'B+A'B'+BB'$

$A'+A'B+A'B'+0$ {By AND operation $A'\cdot A'=A$, $B\cdot B'=0$}

$A'+A'(B+B')$

$A'+A'\,1$ (OR operation $B+B'=1$)

$A'+A' \Rightarrow A'$ {By OR operation}

Gateway Classes

Examples On Boolean Laws

Example No4: simplify the following expression: **AB + BC(B + C)**

Sol^n:

$$AB + BC(B+C)$$
$$= AB + BBC + BCC$$
$$= AB + \underline{BC} + \underline{BC}$$ { By AND Law $B \cdot B = B$, $C \cdot C = C$
$$= AB + BC$$
$$= B(A+C)$$ { By OR Law $BC + BC = BC$ }

Gateway Classes

Examples On Boolean Laws

Example No5: simplify the following expression: **A + B(A + C) + AC**

Soln.

$A + B(A+C) + AC$

$= A + AB + BC + AC$

$= A + AC + BC$ (By Absorption law $A + AB = A$

or $= A + BC$ (By Absorption Law $A + AC = A$)

$A(1+B) + BC + AC$

$A + AC + BC$

$A(1+C) + BC$

$A + BC$

Gateway Classes

Gates

Today's Target

- ✓ Digital Logic Gates
- ✓ Universal Gates

Gateway Classes

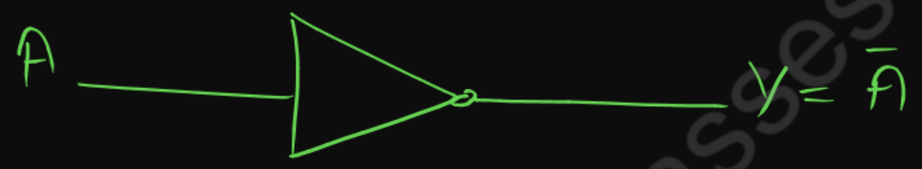
Digital Logic Gates

- Boolean functions may be practically implemented by using electronic gates.
- Electronic gates require a power supply.
- Gate **INPUTS** are driven by voltages having two nominal values, e.g. 0V and 5V representing logic 0 and logic 1 respectively.
- The **OUTPUT** of a gate provides two nominal values of voltage only, e.g. 0V and 5V representing logic 0 and logic 1 respectively. In general, there is only one output to a logic gate except in some special cases.
- These gates are the AND, OR, NOT, NAND, NOR, EXOR and EXNOR gates.

Gateway Classes

NOT Gate

- The NOT gate produces an inverted version of the input at its output.
- It is also known as an *inverter*.
- Symbol:



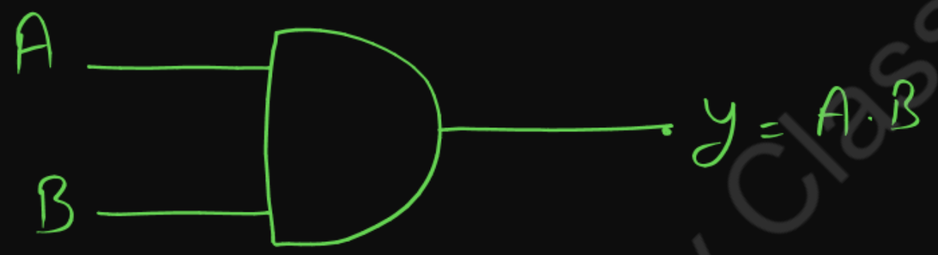
- Truth Table:

Input A	Output $Y = \bar{A}$
0	1
1	0

Gateway Classes

AND Gate

- The AND gate is an electronic circuit that gives a **high** output (1) only if **all** its inputs are high.
- A dot (.) is used to show the AND operation i.e. A.B. Or AB
- Symbol:



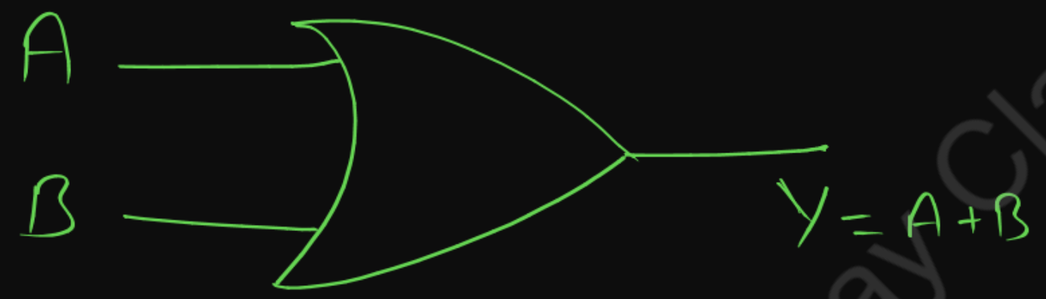
- Truth Table:

Inputs		Output
A	B	Y = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Gateway Classes

OR Gate

- The OR gate is an electronic circuit that gives a high output (1) if **one or more** of its inputs are high.
- A plus (+) is used to show the OR operation.
- Symbol:



- Truth Table:

Inputs		Output
A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Gateway Classes

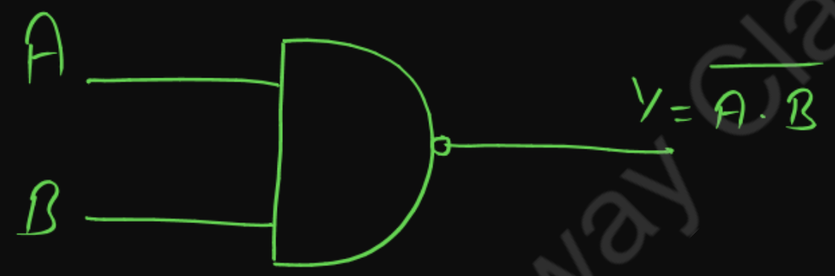
NAND Gate

$\overline{A \cdot B}$

$\overline{0 \cdot 0} = \overline{0} = 1$

N AND
↳ NOT

- This is a NOT-AND gate
- The outputs of all NAND gates are high if **any** of the inputs are low.
- The small circle represents inversion.
- Symbol:



- Truth Table:

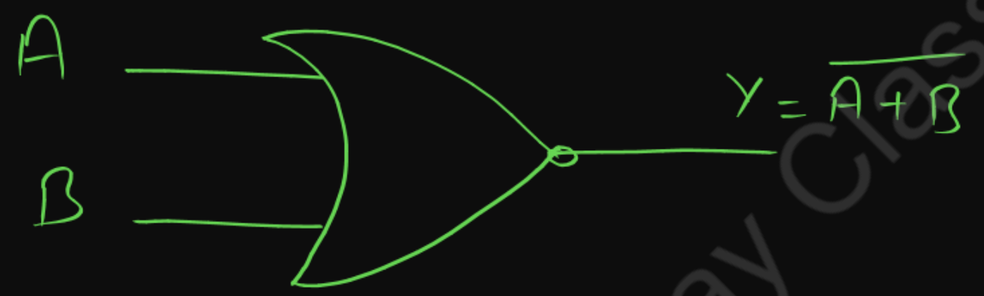
Inputs		Output
A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

Gateway Classes

NOR Gate

N - OR
↳ NOT

- This is a NOT-OR gate
- The outputs of all NOR gates are low if **any** of the inputs are high.
- Symbol:



- Truth Table:

Inputs		output
A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Gateway Classes

EXOR Gate

- The '**Exclusive-OR**' gate is a circuit which will give a high output if **either, but not both**, of its two inputs are high.
- An encircled plus sign ⊕ is used to show the ExOR operation.
- Symbol:

$Y = A \oplus B$

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

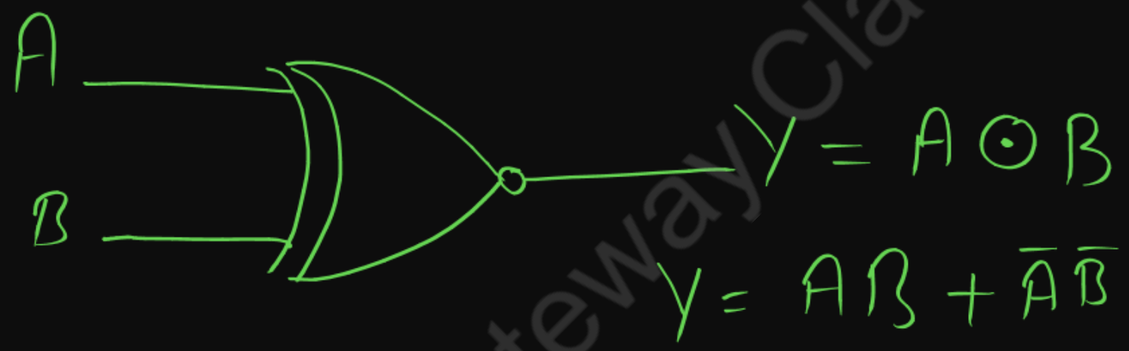
- Truth Table:

Inputs		Output
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Gateway Classes

EX-NOR Gate

- The '**Exclusive-NOR**' gate circuit does the opposite to the EX-OR gate.
- It will give a low output if **either, but not both**, of its two inputs are high.
- The symbol is an EXOR gate with a small circle on the output.
- Symbol:



- Truth Table:

Inputs		Output
A	B	Y = A ⊙ B
0	0	1
0	1	0
1	0	0
1	1	1

GatewayClasses

Universal Gates

- A universal gate is a gate which can implement any Boolean function without need to use any other gate type.

- The NAND and NOR gates are universal gates.

- This is advantageous since NAND and NOR gates are economical and easier to fabricate and are the basic gates used in all IC digital logic families.

Gateway Classes

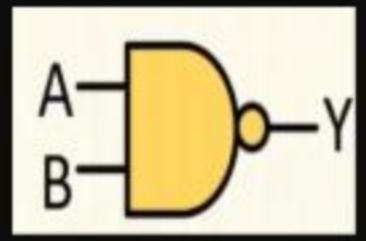
Logic Gates Using Only NAND Gates

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

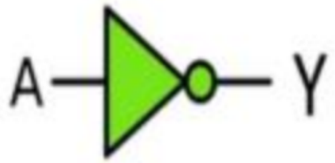
$Y = \overline{\overline{A}} \cdot \quad \overline{A}$

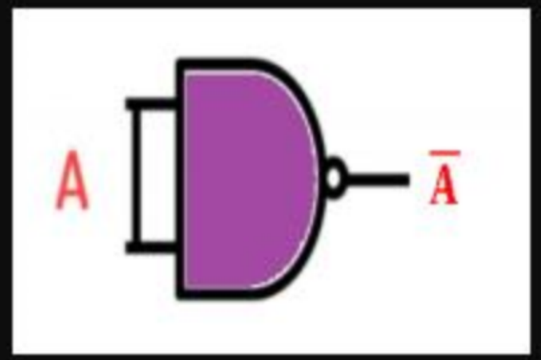
NAND AS NOT GATE

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



$Y = \overline{A}$





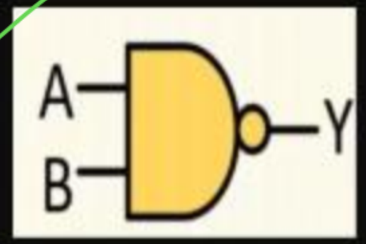
$\overline{\overline{A} \cdot \overline{B}}$

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

$A + B$

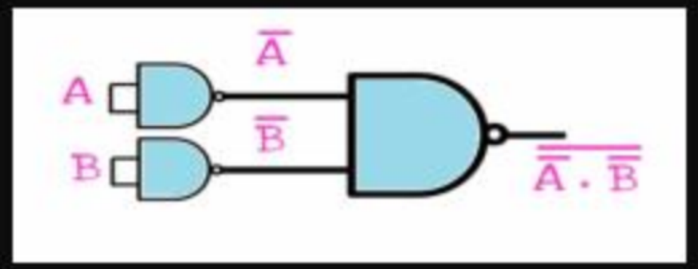
NAND AS OR GATE

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



$Y = A + B$

Y=A+B

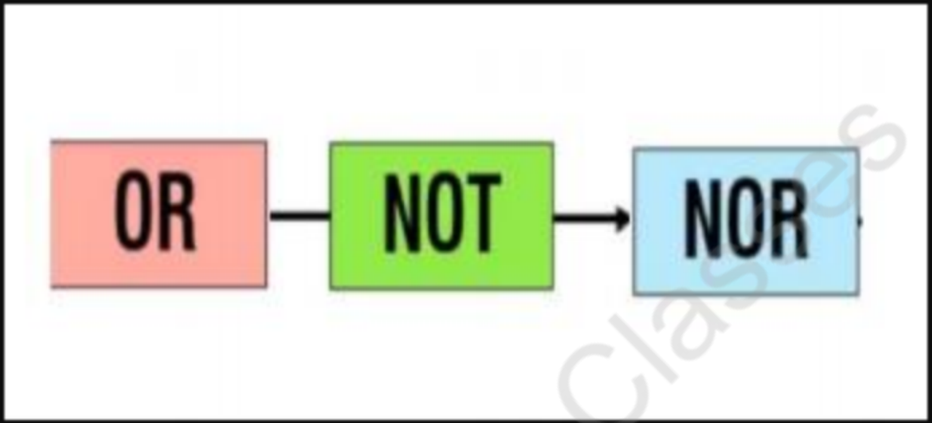


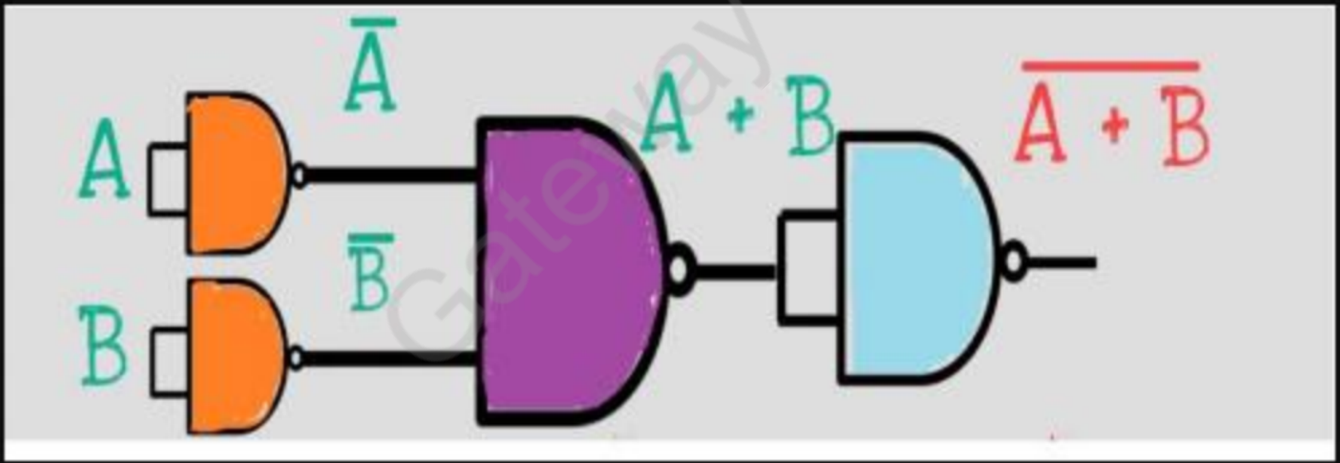
$Y = \overline{\overline{A + B}}$

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

Gateway Classes

NAND AS NOR



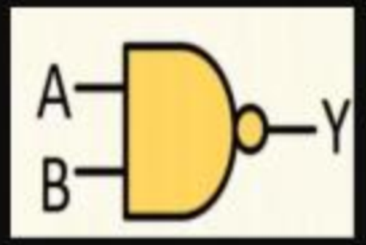


Gateway Classes

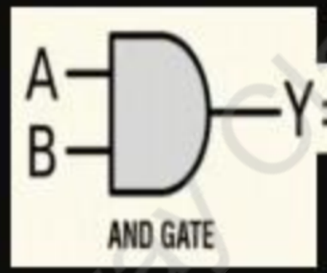
NAND AS AND GATE

NOT + AND

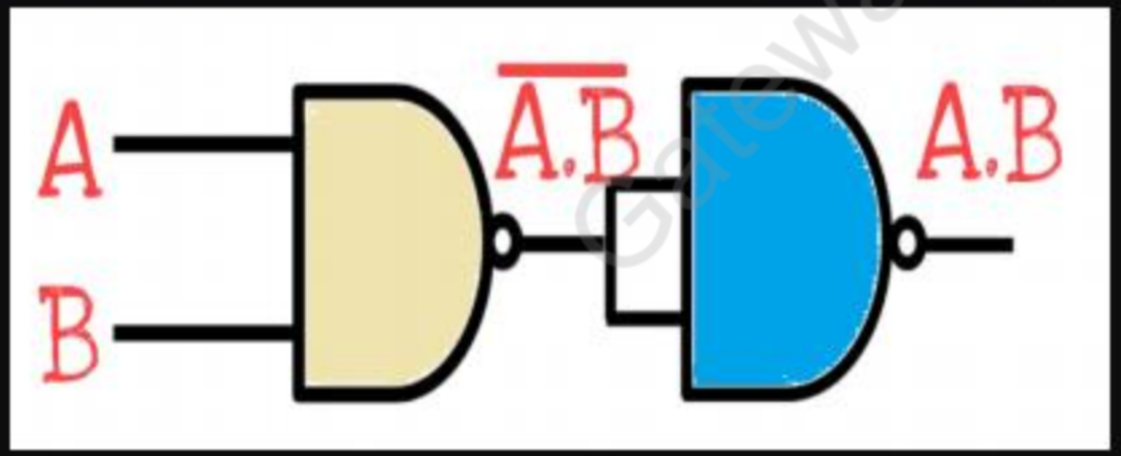
NAND + NOT → AND



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



$Y = A \cdot B$



Gateway Classes

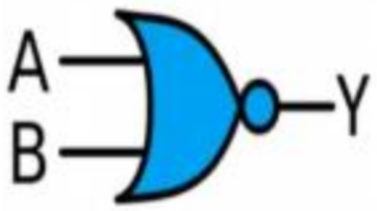
Logic Gates Using Only NOR Gates

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

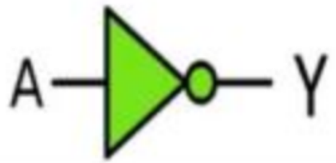
$Y = \overline{A}$ $\quad \overline{A}$

NOR AS NOT GATE

$Y = \overline{A+B}$



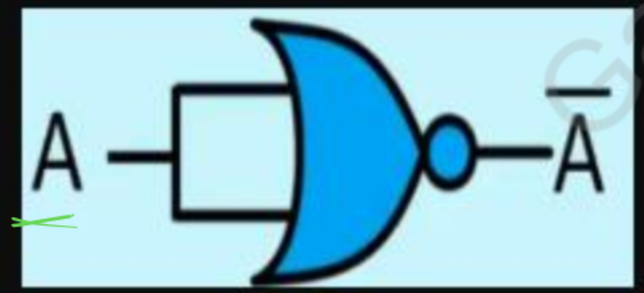
$Y = \overline{A}$



$Y = \overline{A+B}$

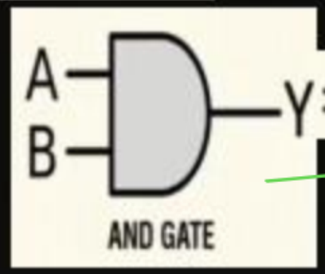
$Y = \overline{A+A}$

$Y = \overline{A}$



NOR AS AND GATE

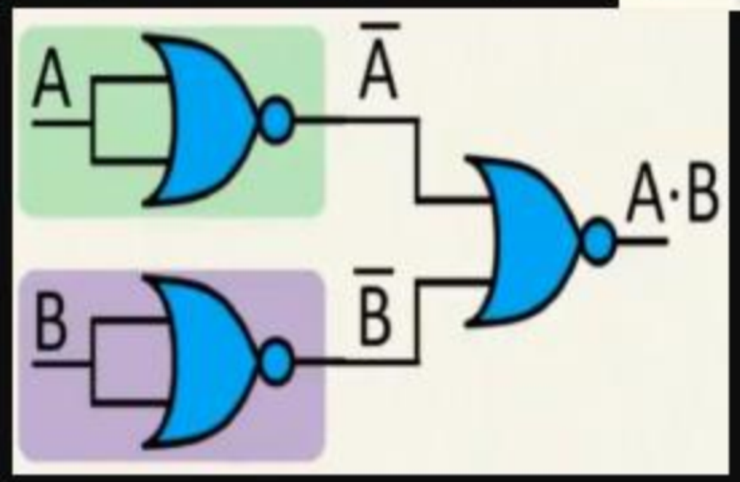
$Y = \overline{A+B}$



$Y = A \cdot B$

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

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



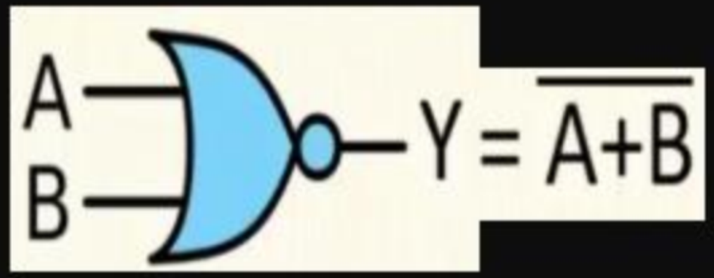
$\overline{\overline{A}+\overline{B}}$

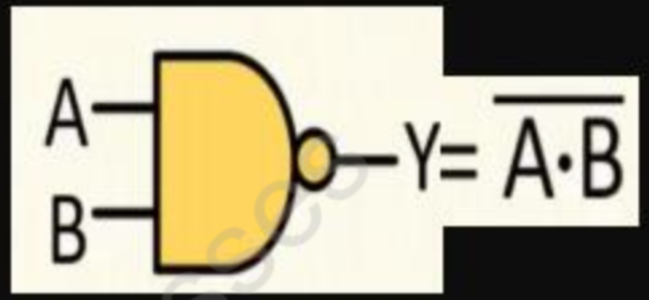
$\overline{\overline{A \cdot B}}$

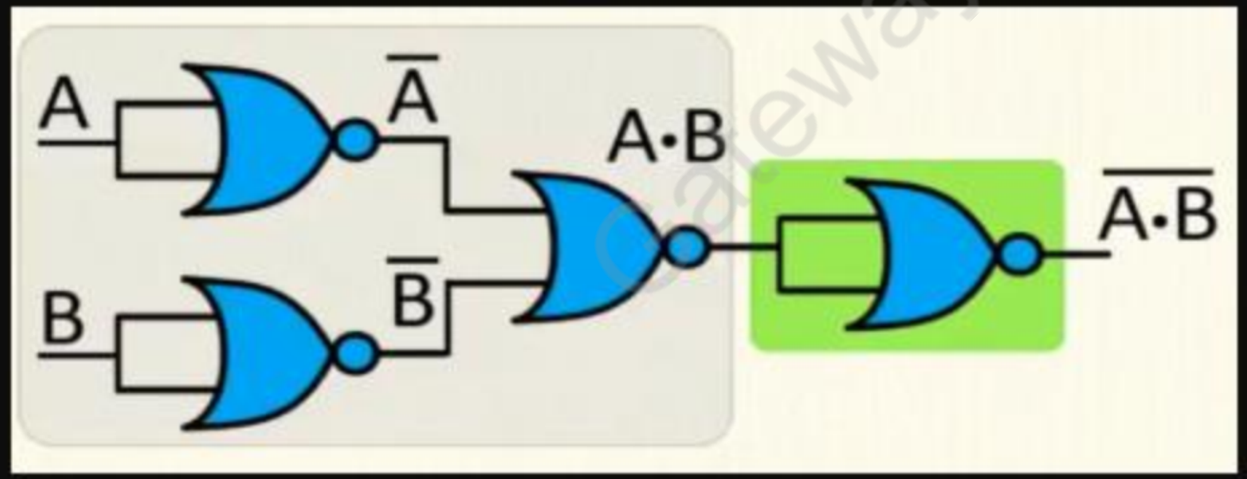
$\overline{A} \cdot \overline{B}$

Gateway Classes

NOR AS NAND GATE

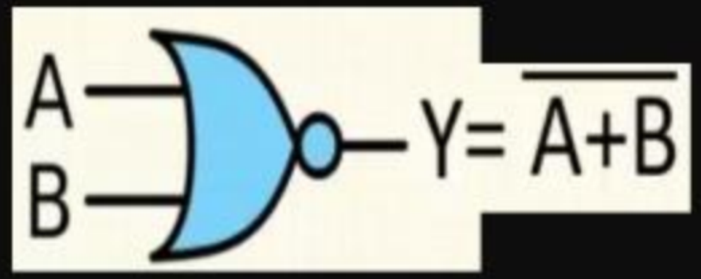


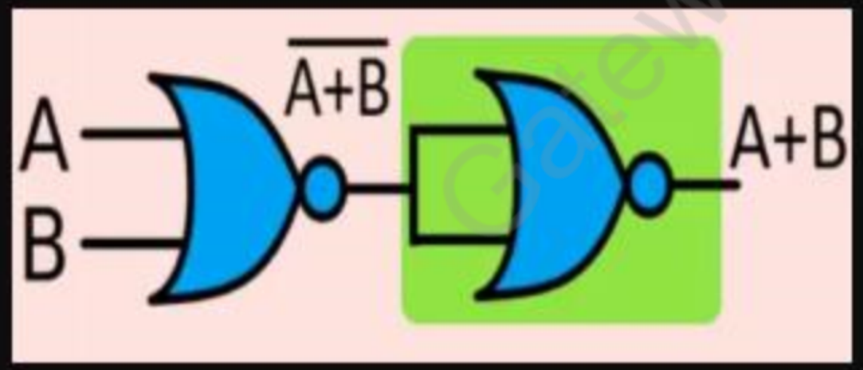




Gateway Classes

NOR AS OR GATE





NOR

$\overline{\text{NOT + OR}}$

NOT

OR

Gateway Classes

KARNAUGH MAP (K-Map)

Today's Target

- ✓ Two Variable K-Map
- ✓ Three Variable K-Map

Gateway Classes

KARNAUGH MAP (K-Map)

$2^3\ 2^2\ 2^1\ 2^0$
$8\ \ 4\ \ 2\ \ 1$

2-Variable

$AB \rightarrow 2^2 = 4$

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

AB
0 0
0 1
1 0
1 1

A \ B	$\bar{B}$ 0	B 1
$\bar{A}$ 0	0 0 $\bar{A}\bar{B}$ 0	0 1 $\bar{A}B$ 1
A 1	1 0 $A\bar{B}$ 2	1 1 AB 3

3-Variable

$2^3 = 8$

ABC	
0 0 0	0
0 0 1	1
0 1 0	2
0 1 1	3
1 0 0	4
1 0 1	5
1 1 0	6
1 1 1	7

A \ BC	00	01	11	10
0	000 $\bar{A}\bar{B}\bar{C}$ 0	001 $\bar{A}\bar{B}C$ 1	011 $\bar{A}BC$ 3	010 $\bar{A}B\bar{C}$ 2
1	100 $A\bar{B}\bar{C}$ 4	101 $A\bar{B}C$ 5	111 ABC 7	110 $AB\bar{C}$ 6

Gateway Classes

SOP → Sum of Product

$AB\bar{C} + \bar{A}DC$

$+$

POS → Product of Sum

$(A + B + \bar{C})(\bar{A} + D + C)$

Gateway Classes

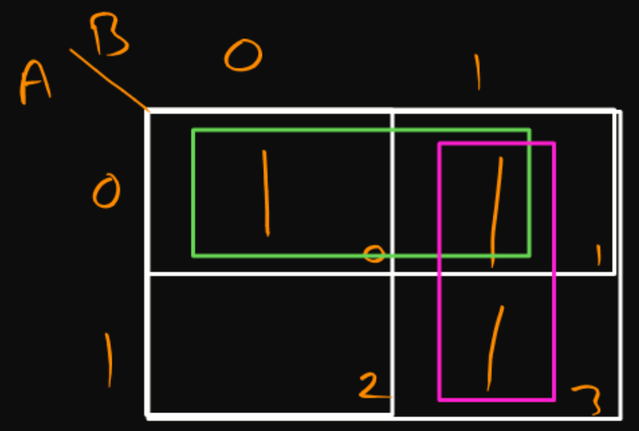
Steps to solve expression using K-map

- Select K-map according to the number of variables.
- Identify minterm or maxterms as given in problem.
- For SOP put 1's in blocks of K-map respective to the minterms.
- For POS put 0's in blocks of K-map respective to the maxterms.
- Make rectangular groups containing total terms in power of two like 2,4,8 ..(except 1) and try to cover as many elements as you can in one group.
- From the groups made in step 5 find the product terms and sum them up for SOP form.

Gateway Classes

Two Variable K-Map

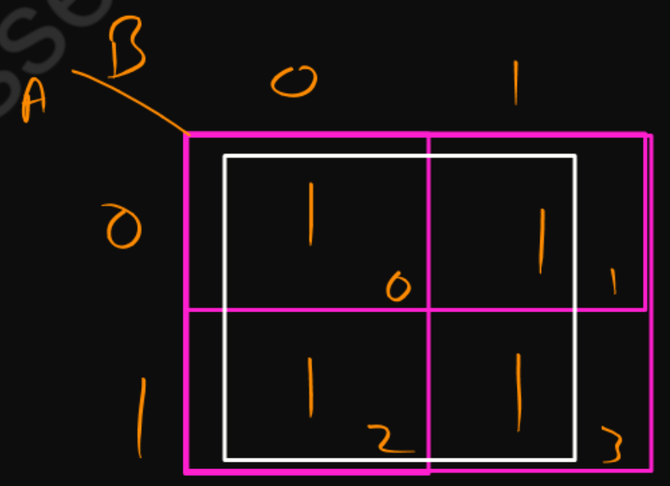
Example- $f(A,B) = \sum m(0,1,3)$



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

Ans

Example- $f(A,B) = \sum m(0,1,2,3)$



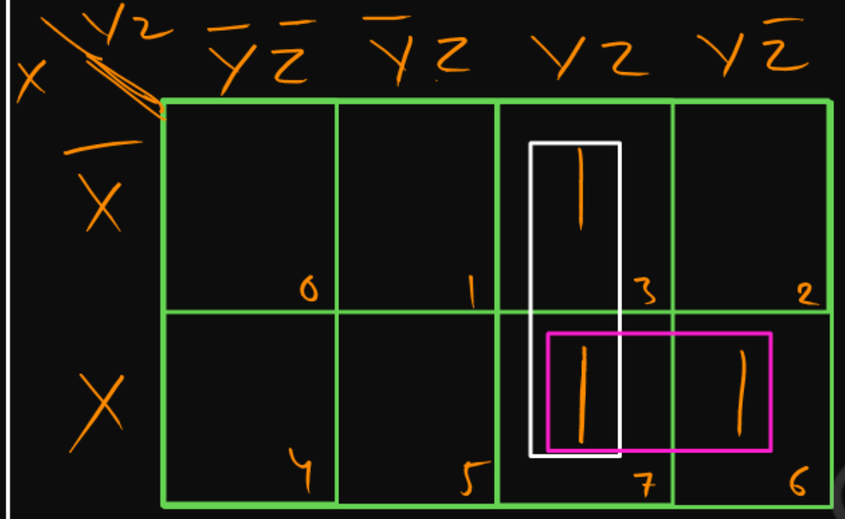
$$F = 1$$

Ans

Gateway Classes

Three Variable K-Map

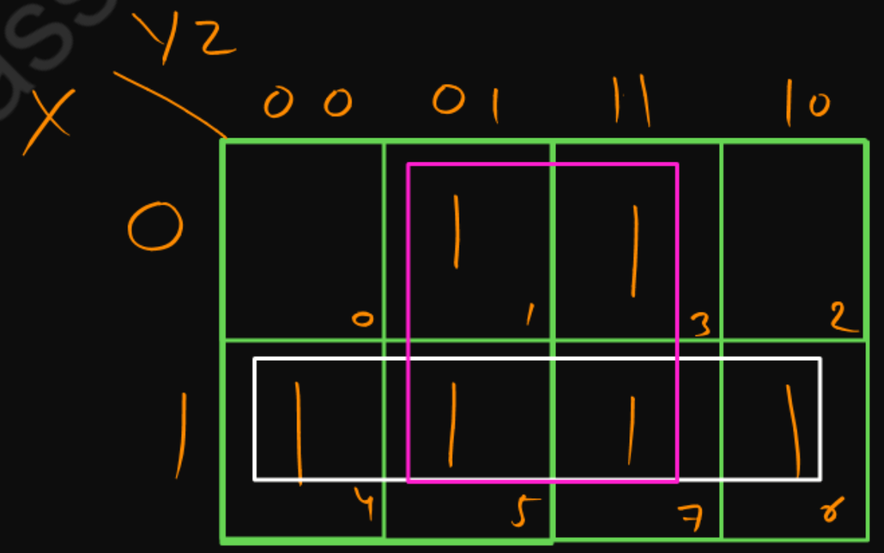
Example- F = XYZ'+XYZ+X'YZ



$$F = YZ + XY$$
$$= Y(X+Z)$$

Ans

Example- F(X,Y,Z) = (1,3,4,5,6,7)



$$F = X + Z$$

Ans

Gateway Classes

KARNAUGH MAP (K-Map)

Today's Target

- ✓ Four Variable K-Map
- ✓ Don't Care (Incompletely Specified) Conditions

Gateway Classes

Four Variable K-Map

Example:1

$F = \sum m(0,2,5,7,8,10,13,15)$

$2^4 = 16$

F	CD $\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
AB / $\bar{A}\bar{B}$ 00	1 (0)	(1)	(3)	1 (2)
$\bar{A}B$ 01	(4)	1 (5)	1 (7)	(6)
AB 11	(12)	1 (13)	1 (15)	(14)
$A\bar{B}$ 10	1 (8)	(9)	(11)	1 (10)

$$\boxed{F = BD + \bar{B}\bar{D}} = B \odot D$$

Example:2

$F = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}C\bar{D} + A\bar{B}\bar{C}\bar{D} + A\bar{B}C\bar{D}$

0000 0010 1000 1010

F	CD $\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
AB / $\bar{A}\bar{B}$ 00	1 (0)	(1)	(3)	1 (2)
$\bar{A}B$ 01	(4)	(5)	(7)	(6)
AB 11	(12)	(13)	(15)	(14)
$A\bar{B}$ 10	1 (8)	(9)	(11)	1 (10)

$$\boxed{F = \bar{B}\bar{D}}$$

Gateway Classes

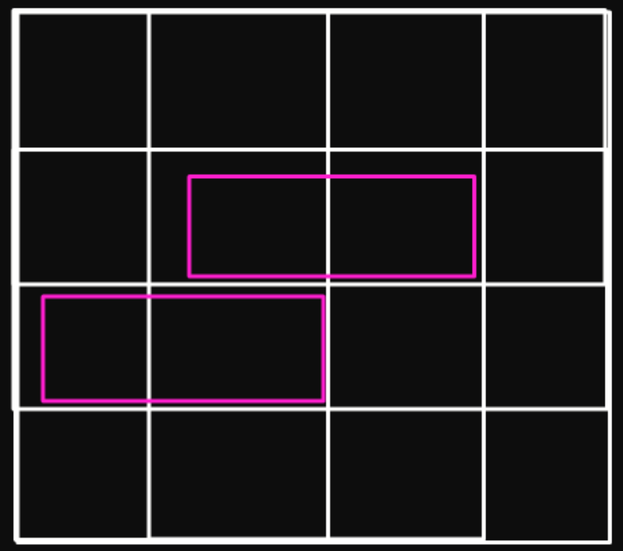
Four Variable K-Map

Example:

Obtain POS expression
F(W,X,Y,Z) = ΠM(5,7,12,13)

Redundant Group

WX \ YZ	[00] Y+Z	[01] Y+Z'	[11] Y'+Z'	[10] Y'+Z
[00] W+X	1 (0)	1 (1)	1 (3)	1 (2)
[01] W+X'	1 (4)	0 (5)	0 (7)	1 (6)
[11] W'+X'	0 (12)	0 (13)	1 (15)	1 (14)
[10] W'+X	1 (8)	1 (9)	1 (11)	1 (10)



F = (W+X'+Z') (W'+X'+Y)

Gateway Classes

F	wx $(w+x)$	$(w+\bar{x})$	$(\bar{w}+\bar{x})$	$(\bar{w}+x)$
yz	00	01	11	10
$(y+z)$ 00	0	4	12	8
$(y+\bar{z})$ 01	1	5	13	9
$(\bar{y}+\bar{z})$ 11	3	7	15	11
$(\bar{y}+z)$ 10	2	6	14	10

$$\boxed{F = (w+\bar{x}+\bar{z})(\bar{w}+\bar{x}+y)}$$

Gateway Classes

Don't Care (Incompletely Specified) Conditions

$F=\sum m(3,6,7)+d(2)$

A \ BC	$\bar{B}\bar{C}$ (00)	$\bar{B}C$ (01)	BC (11)	$B\bar{C}$ (10)
(0) $\bar{A}$	0	1	1 (3)	X (2)
(1) A	4	5	1 (7)	1 (6)

$$\boxed{F = B}$$

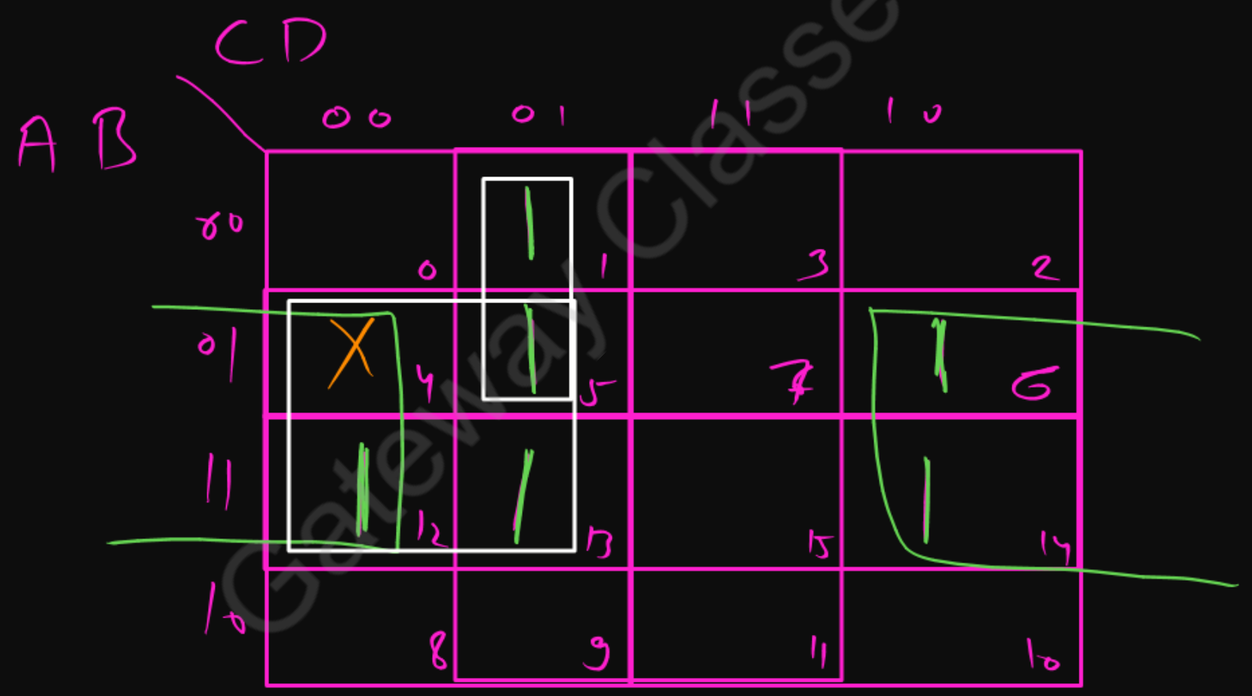
Ans

Gateway Classes

Don't Care (Incompletely Specified) Conditions

Minimise the following function in SOP minimal form using K-Maps:
F(A, B, C, D) = m(1, 5, 6, 12, 13, 14) + d(4)

$$F = B\bar{C} + B\bar{D} + \bar{A}\,\bar{C}D$$



Gateway Classes

Don't Care (Incompletely Specified) Conditions

Minimise the following function in SOP minimal form using K-Maps:

F(A, B, C, D) = M(6, 7, 8, 9) + d(10, 11, 12, 13, 14, 15)

$$F = A + BC$$

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	1 7	1 6
11	X 12	X 13	X 15	X 14
10	1 8	1 9	X 11	X 10

Gateway Classes

KARNAUGH MAP (K-Map)

Today's Target

- ✓ 5 Variable K-Map
- ✓ 6 Variable K-Map

Gateway Classes

5 Variable K-Map

(A, B, C, D, E)

$2^5 = 32$

$2^6 = 64$

$\bar{A}$

BC \ DE	00	01	11	10
00	m_0 0	m_1 1	m_3 3	m_2 2
01	m_4 4	m_5 5	m_7 7	m_6 6
11	m_{12} 12	m_{13} 13	m_{15} 15	m_{14} 14
10	m_8 8	m_9 9	m_{11} 11	m_{10} 10

A

BC \ DE	00	01	11	10
00	m_{16} 16	m_{17} 17	m_{19} 19	m_{18} 18
01	m_{20} 20	m_{21} 21	m_{23} 23	m_{22} 22
11	m_{28} 28	m_{29} 29	m_{31} 31	m_{30} 30
10	m_{24} 24	m_{25} 25	m_{27} 27	m_{26} 26

00
01
10
11

Gateway Classes

5 Variable K-Map

$F(A,B,C,D,E) = \sum (m_0, m_2, m_5, m_7, m_8, m_{10}, m_{16}, m_{21}, m_{23}, m_{24}, m_{27}, m_{31})$

$\bar{A}$

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	1 (0)	(1)	(3)	1 (2)
$\bar{B}C$	(4)	1 (5)	1 (7)	(6)
BC	(12)	(13)	(15)	(14)
$B\bar{C}$	1 (8)	(9)	(11)	1 (10)

A

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	1 (16)	(17)	(19)	(18)
$\bar{B}C$	(20)	1 (21)	1 (23)	(22)
BC	(28)	(29)	1 (31)	(30)
$B\bar{C}$	1 (24)	(25)	1 (27)	(26)

$F = \bar{A}\bar{C}\bar{E} + \bar{B}CE + ABDE + \bar{C}\bar{D}\bar{E}$

Gateway Classes

6 Variable K-Map

ABCDEF

$\bar{B}$ B

$2^6 = 64$

$\bar{A}$

CD \ EF	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

CD \ EF	00	01	11	10
00	16	17	19	18
01	20	21	23	22
11	28	29	31	30
10	24	25	27	26

A

CD \ EF	00	01	11	10
00	32	33	35	34
01	36	37	39	38
11	44	45	47	46
10	40	41	43	42

CD \ EF	00	01	11	10
00	48	49	51	50
01	52	53	55	54
11	60	61	63	62
10	56	57	59	58

Gateway Classes

6 Variable K-Map

$F = \sum (m_0, m_2, m_8, m_9, m_{10}, m_{12}, m_{13}, m_{16}, m_{18}, m_{24}, m_{25}, m_{26}, m_{29}, m_{31}, m_{32}, m_{34}, m_{35}, m_{39}, m_{40}, m_{42}, m_{43}, m_{47}, m_{48}, m_{50}, m_{56}, m_{58}, m_{61}, m_{63})$

$\bar{B}$ B

$\bar{A}$

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1 (0)	(1)	(3)	1 (2)
$\bar{C}D$	(4)	(5)	(7)	(6)
CD	1 (12)	1 (13)	(15)	(14)
$C\bar{D}$	1 (8)	1 (9)	(11)	1 (10)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	(16)	(17)	(19)	1 (18)
$\bar{C}D$	(20)	(21)	(23)	(22)
CD	(28)	1 (29)	1 (31)	(30)
$C\bar{D}$	1 (24)	1 (25)	(27)	1 (26)

A

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1 (32)	(33)	1 (35)	1 (34)
$\bar{C}D$	(36)	(37)	1 (39)	(38)
CD	(44)	(45)	1 (47)	(46)
$C\bar{D}$	1 (40)	(41)	1 (43)	1 (42)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1 (48)	(49)	(51)	1 (50)
CD	(52)	(53)	(55)	(54)
CD	(60)	1 (61)	1 (63)	(62)
$C\bar{D}$	1 (56)	(57)	(59)	1 (58)

$$F = \bar{D}\bar{F} + \bar{A}\bar{B}C\bar{E} + BCDF + \bar{A}C\bar{E}F + A\bar{B}EF$$

Gateway Classes

For more subjects
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Link in Description

GW
GATEWAY CLASSES

Thank You

Gateway Classes

Fundamentals of Communication Engineering:

Today's Target

- ✓ Block Diagram of Communication System

Unit 5

Fundamentals of Communication Engineering: Basics of signal representation and analysis, Electromagnetic spectrum, Elements of a Communication System, Need of modulation and typical applications, Fundamentals of amplitude modulation and demodulation techniques.

Introduction to Wireless Communication: Overview of wireless communication, cellular communication, different generations and standards in cellular communication systems, Fundamentals of Satellite & Radar Communication.

Block Diagram of Communication System

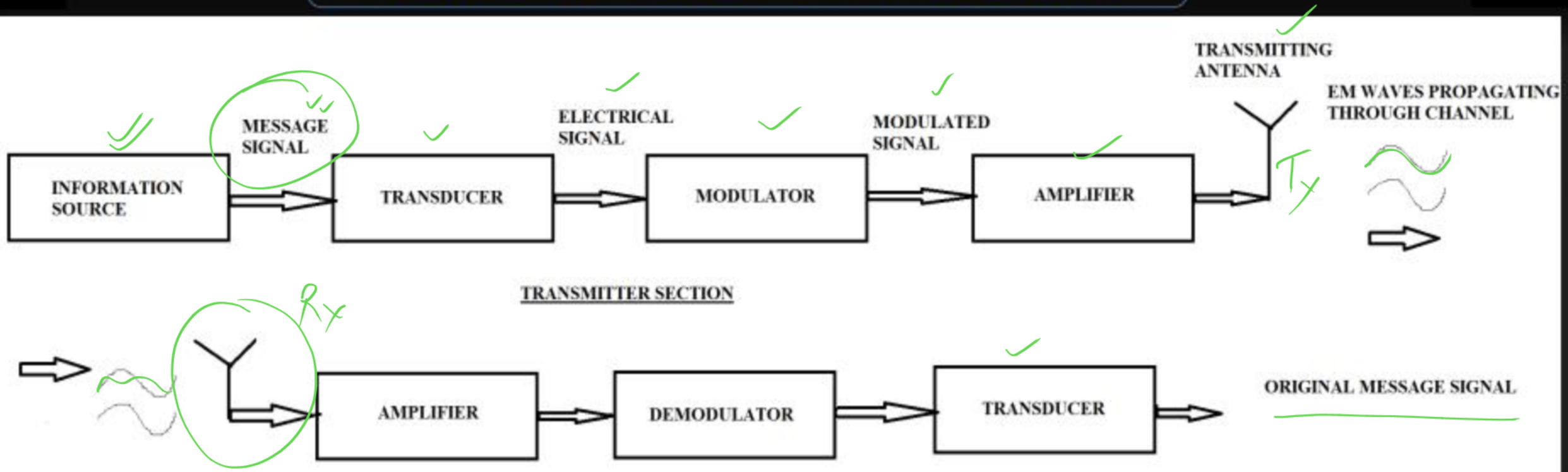
- Communication is the transfer of information from point A to point B using electricity or magnetism.
- Communication system can be divided into three parts:

(i) Transmitter

(ii) Channel(Medium)

(iii) Receiver

Block Diagram of Communication System



Block Diagram of Communication System

- **Transmitter Section**

The **transmitter section** consists of:

(i) **Information Source:** It is used to generate message signal which may be in the form of audio, video or data.

(ii) **Transducer:** It is a device which converts one form of energy into different form.

(iii) **Modulator:** Here message signal is superimposed on a high frequency carrier wave so that it can cover long distance.

(iv) **Amplifier:** This block is used to enhance the strength of the signal before transmission.

(v) **Transmitting Antenna:** It is used to convert electrical signal into electromagnetic waves which can travel in the atmosphere.

Block Diagram of Communication System

- **Channel Section**

The output of transmitter section travels through a path or medium to reach receiver. This path or medium is called channel.

There are several types of channel such as:

(i) Wired Channel : medium is physical i.e. optical fibre, co-axial cable etc.

(ii) Wireless Channel : medium is air.

Block Diagram of Communication System

- **Receiver Section**

The receiver section consists of:

(i) **Receiving Antenna:** It is used to convert desired electromagnetic waves in the atmosphere into the electrical signal.

(ii) **Amplifier:** The signal at the receiver suffered various types of losses and become weak. So, an amplifier is used to increase its strength.

(iii) **Demodulator:** Here carrier wave is separated from the message signal.

(iv) **Transducer:** To convert electrical signal into original message signal.

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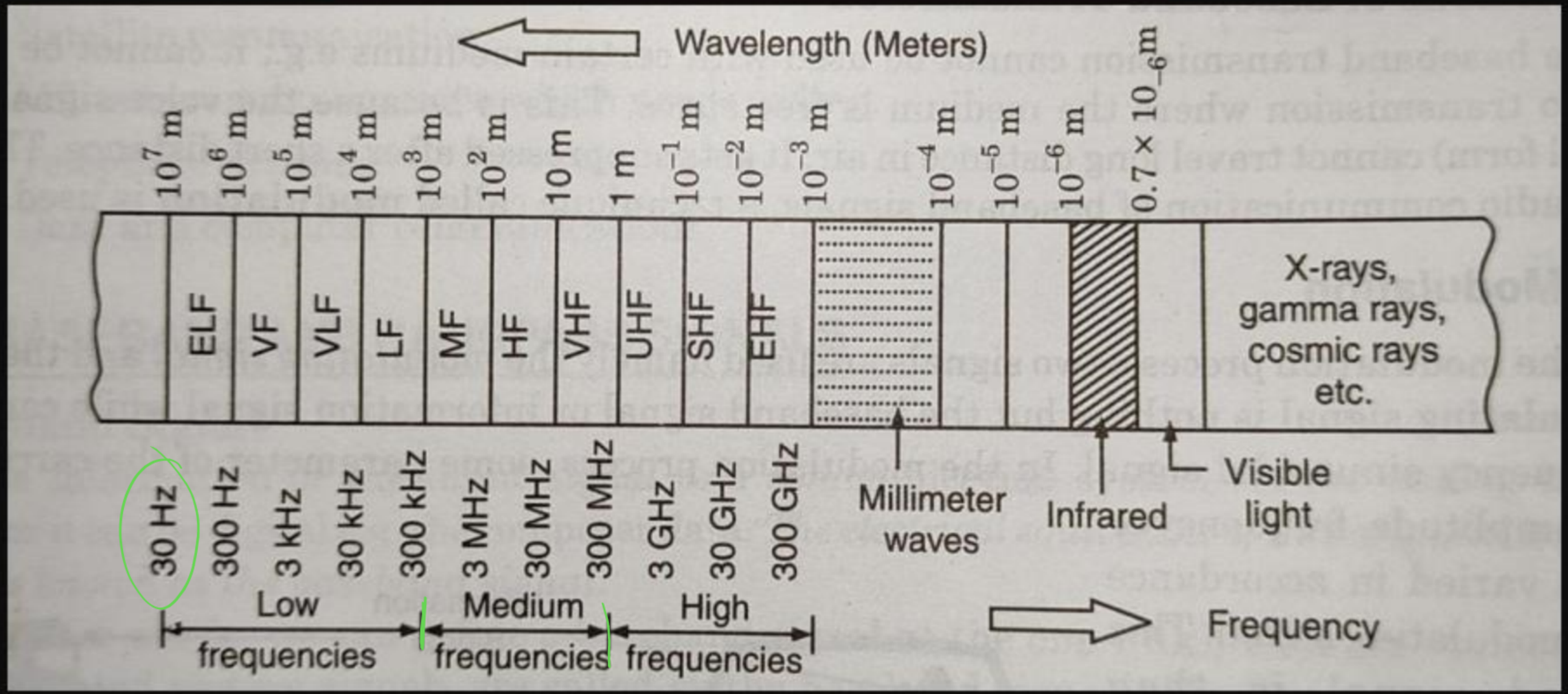
Thank You

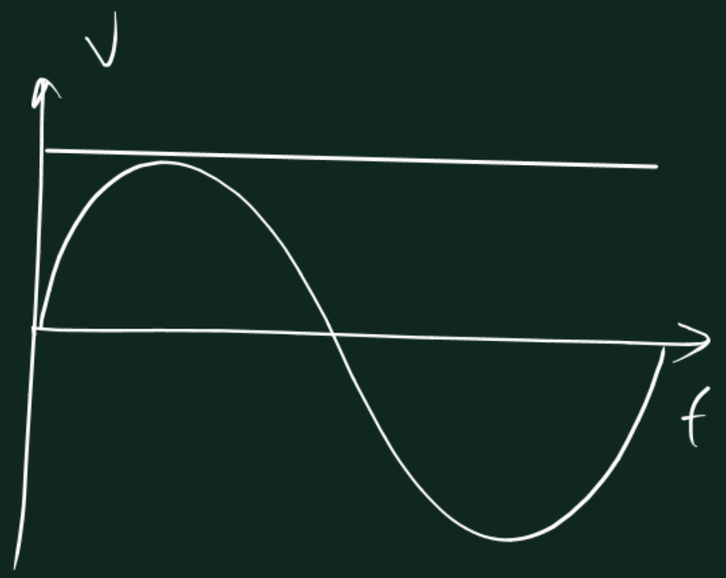
Modulation

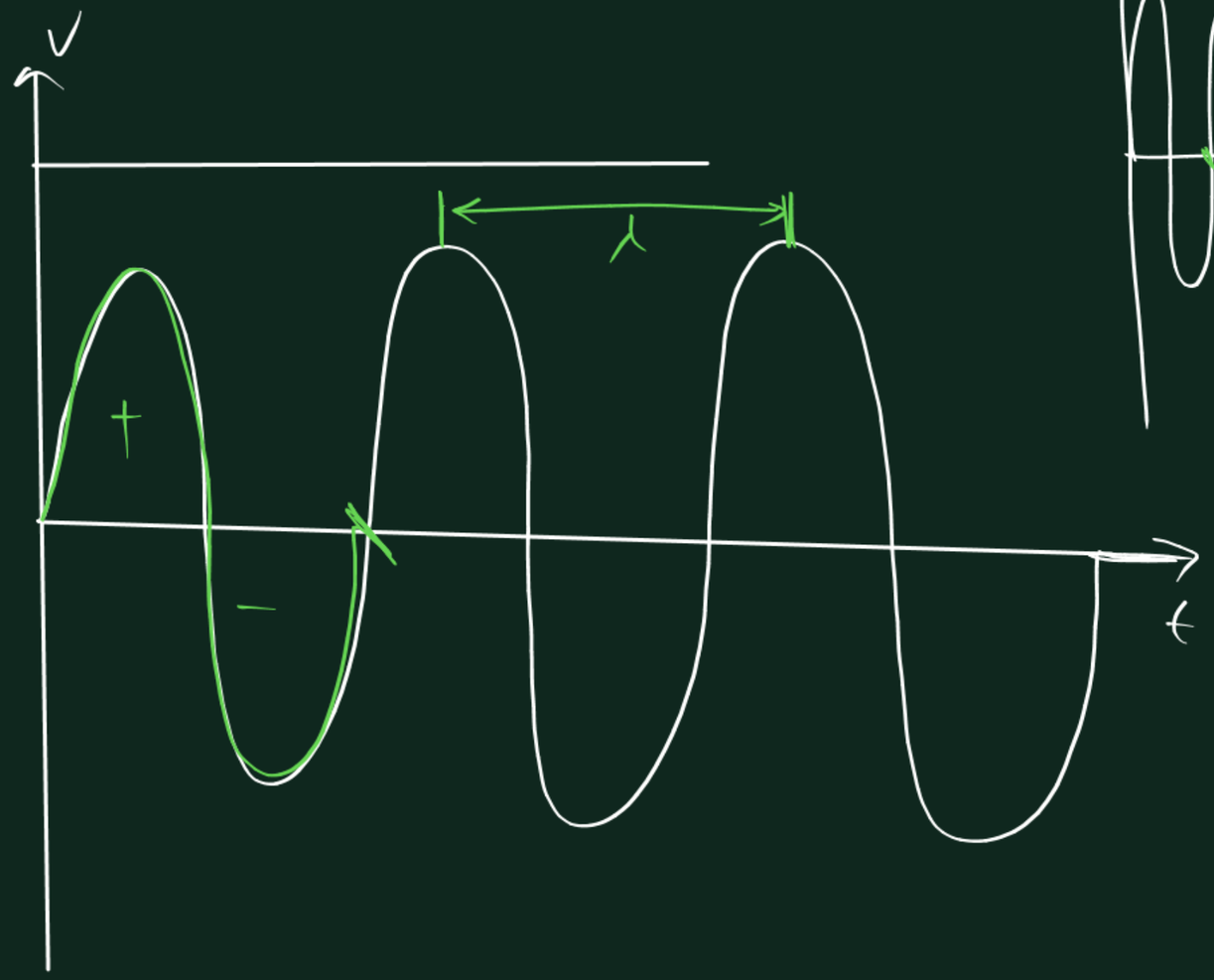
Today's Target

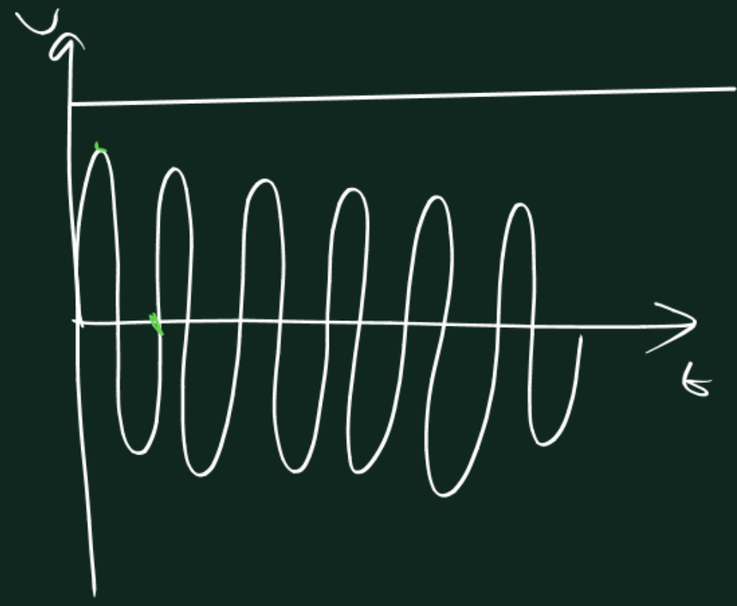
- ✓ Electromagnetic Spectrum
- ✓ Modulation
- ✓ Need of Modulation
- ✓ Amplitude Modulation (AM)
- ✓ AM Demodulator
- ✓ Advantages and Disadvantages of Amplitude Modulation

Electromagnetic Spectrum









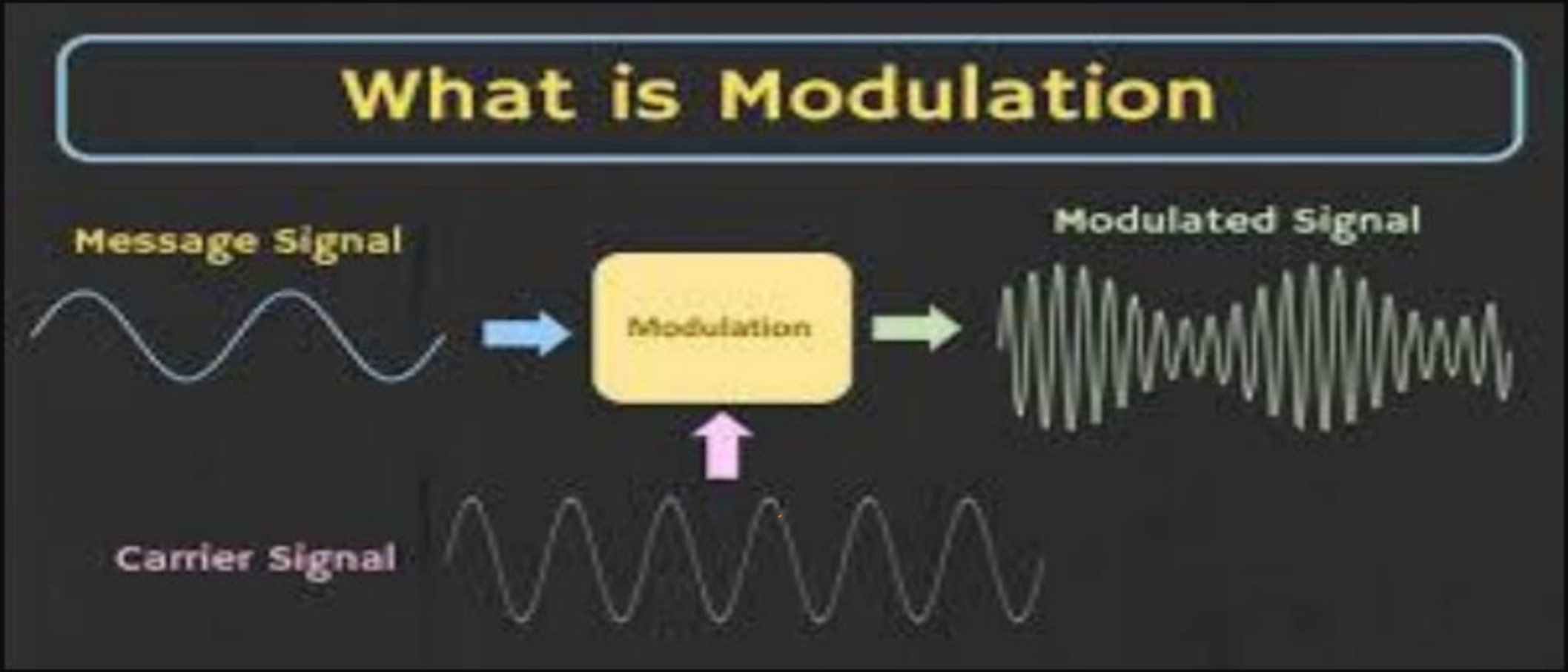
$$f \propto \frac{1}{\lambda}$$

Electromagnetic Spectrum

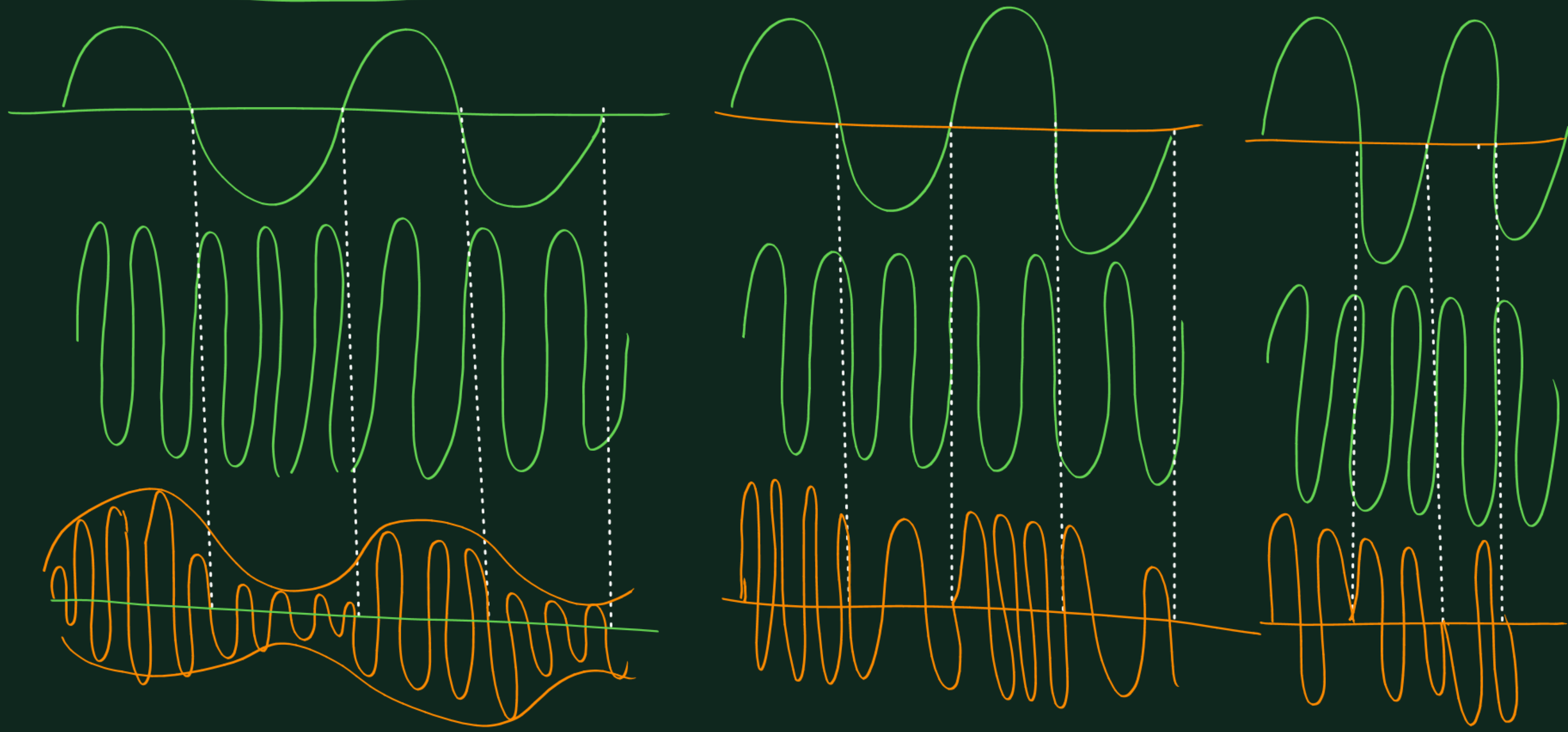
S.No.	Name	Frequency	Wavelength
1.	Extremely low frequency (ELF)	30-300 Hz	10^7 to 10^6 m
2.	Voice frequecies (VF)	300-3000 Hz	10^6 to 10^5 m
3.	Very low frequencies (VLF)	3-30 kHz	10^5 to 10^4 m
4.	Low frequencies (LF)	30-300 kHz	10^4 to 10^3 m
5.	Medium frequencies (MF)	300 kHz-3 MHz	10^3 to 10^2 m
6.	High frequencies (HF)	3-30 MHz	10^2 to 10 m
7.	Very high frequencies (VHF)	30-300 MHz	10 to 1 m
8.	Ultra high frequencies (UHF)	300 MHz-3GHz	1 to 10^{-1} m
9.	Super high frequencies (SHF)	3-30 GHz	10^{-1} to 10^{-2} m
10.	Extremely high frequencies (EHF)	30-300 GHz	10^{-2} to 10^{-3} m
11.	Infrared	—	0.7 to 10 μm
12.	Visible light	—	0.4 μm to 0..8 μm

Modulation

It is a process in which low frequency message signal is superimposed on the high frequency carrier wave. In this process one of the parameters of the carrier varies according to the message signal.



⇒ Modulation → AM, FM, PM



Modulation

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

Wavelength

- **Need of Modulation**

- There are several factors due to which modulation is needed in communication:-

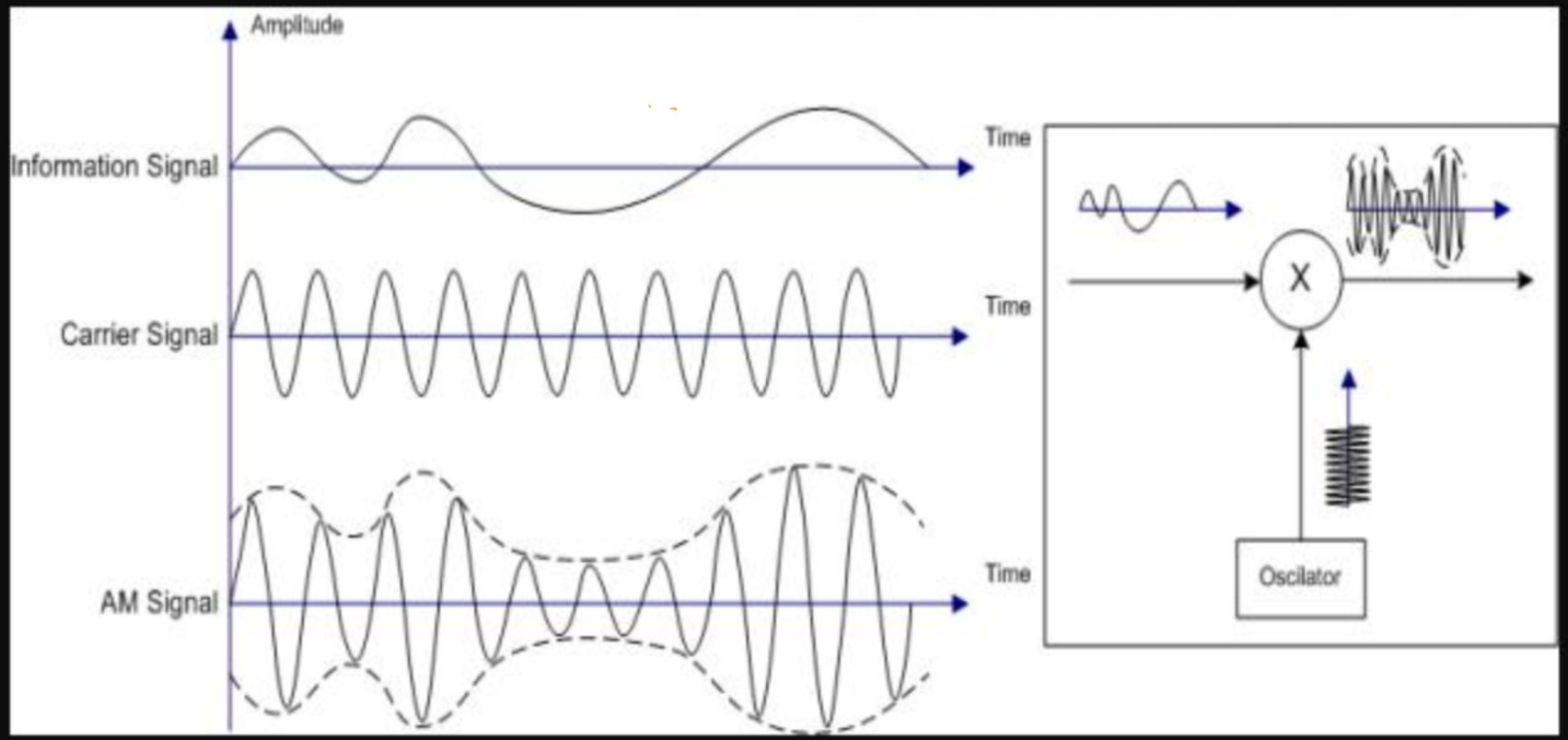
(i) **Interference or Mixing Problem:** As message signals are generally low frequency signals there is large probability of mixing with other signals of the same frequency range already present in the atmosphere. So, low frequency message signals are sent through high frequency carrier wave (modulation) to avoid such problems.

(ii) **Height of Antenna:** Practical height of transmitting or receiving antenna = $\lambda/4$, where λ is the wavelength of the signal being used. If we use low frequency message signal without modulation the height of antenna is of the order of kilometres. Therefore to reduce the height of antenna modulation is needed.

(iii) **Power Dissipation:** When an electromagnetic wave is travelling through atmosphere it suffers from various losses which are inversely proportional to the frequency of the signal. Thus low frequency signals are more prone to atmospheric losses and therefore modulation is used to reduce these losses.

Modulation

- **Amplitude Modulation (AM)**
- In amplitude modulation the amplitude of the carrier signal is modulated according to the instantaneous amplitude of the message signal.



Modulation

gmP

- **Mathematical Analysis**

$$e_m(t) = E_m \cos \omega_m t \quad \text{—— (1)}$$

$$e_c(t) = E_c \cos \omega_c t \quad \text{—— (2)}$$

$$e_{AM}(t) = \underline{A} \cos \omega_c t \quad \text{—— (3)}$$

$$A = E_c + e_m(t)$$

$$A = E_c + E_m \cos \omega_m t$$

$$= E_c\left(1 + \boxed{\frac{E_m}{E_c}} \cos \omega_m t\right)$$

modulation index 'm'

$$A = E_c(1 + m \cos \omega_m t)$$

Put the value of A in eqn (3)

$$e_{AM}(t) = E_c(1 + m \cos \omega_m t) \cos \omega_c t$$

$$e_{AM}(t) = E_c \cos \omega_c t + m E_c \cos \omega_m t \cdot \cos \omega_c t$$

$$= E_c \cos \omega_c t + \frac{m E_c}{2}\left[2 \cos \omega_m t \cos \omega_c t\right]$$

$$= E_c \cos \omega_c t + \frac{m E_c}{2}\left[\cos(\omega_m + \omega_c)t + \cos(\omega_m - \omega_c)t\right]$$

$$\boxed{e_{AM}(t) = E_c \cos \omega_c t + \frac{m E_c}{2} \cos(\omega_m + \omega_c)t + \frac{m E_c}{2} \cos(\omega_m - \omega_c)t}$$

Carrier signal

Upper side band

Lower side band

Carrier signal – $E_c \cos \omega_c t$

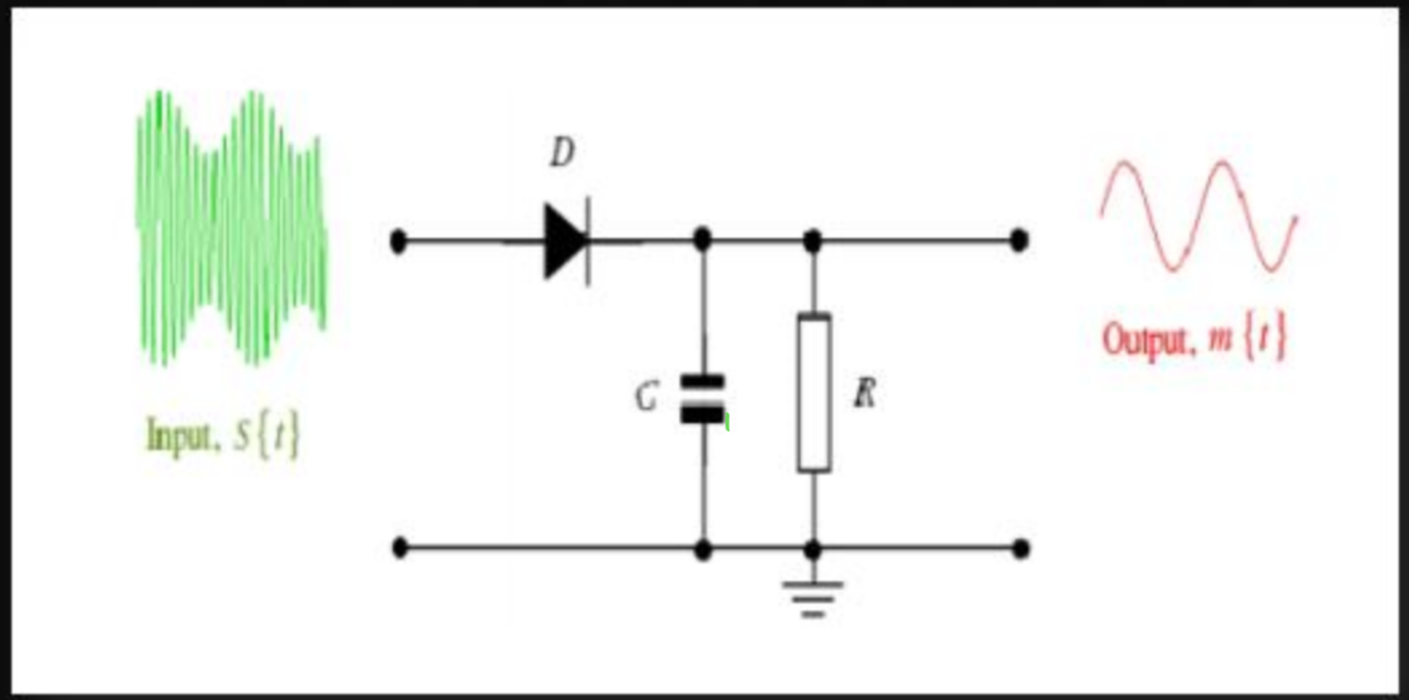
Upper sideband – $\frac{mE_c}{2} \cos(\omega_m + \omega_c)t$

Lower sideband – $\frac{mE_c}{2} \cos(\omega_m - \omega_c)t$

Modulation

- **AM Demodulator**

Linear Diode Detector or Envelope Detector:



Modulation

- **AM Demodulator**
- Here, diode is the main detecting device so it sometimes also called as Diode detector.
- In the positive half cycle diode conducts and capacitor charges to it peak value.
- During other half of the cycle diode gets reverse biased and capacitor discharge through a resistor R.
- Hence the output voltage across capacitor C is a spiky envelope of the AM wave, which is same as the amplitude variation of the modulating signal.

Modulation

- **Advantages and Disadvantages of Amplitude Modulation**

Advantages	Disadvantages
Amplitude Modulation is easier to implement.	When it comes to power usage it is not efficient.
Demodulation can be done using few components and a circuit.	It requires a very high bandwidth.
The receiver used for AM is very cheap.	Noise interference is highly noticeable.

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Thank You

Wireless Communication

Today's Target

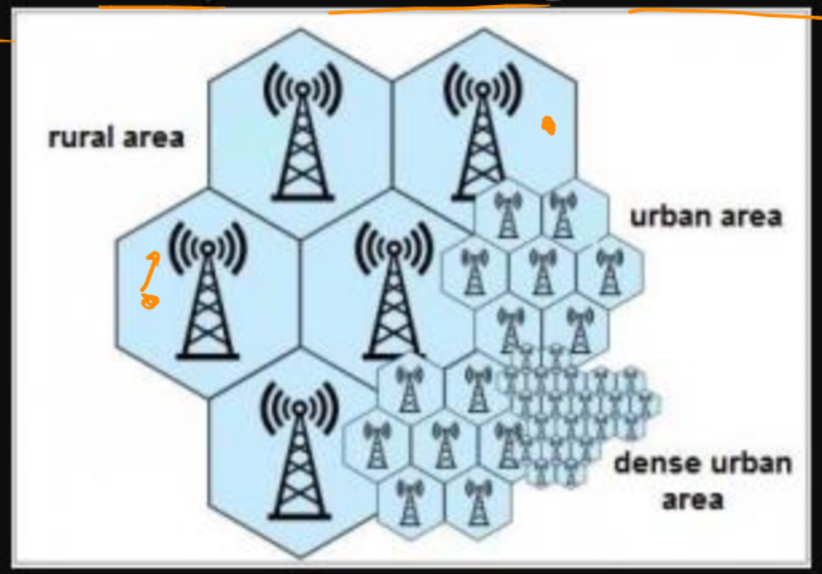
- ✓ Wireless Communication - Overview
- ✓ Cellular communication - Overview
- ✓ Evolution of Mobile Communication

Wireless Communication - Overview

- Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.
- Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

Cellular communication - Overview

- **Cellular communication** is a form of communication technology that enables the use of **mobile phones**.
- A mobile phone is a bidirectional radio that enables simultaneous transmission and reception.
- Cellular communication is based on the geographic division of the communication coverage area into cells, and within cells.
- Each cell is allocated a given number of frequencies (or channels) that allow a large number of subscribers to conduct conversations simultaneously.



APPLICATIONS OF NETWORKS

Some of the network applications in different fields are the following:-

(i) Marketing and sales

(ii) Financial services

(iii) Information services

(iv) Cellular telephone

(v) Cable television

(vi) Teleconferencing

(vii) E-mail etc.

(viii) Communication facilities

EVOLUTION OF MOBILE COMMUNICATION

- Over recent years, the evolution of mobile wireless communication in the world has become more important after arrival of 5G technology.
- This evolution journey consists of several generations start with 1G followed by 2G, 2.5G,3G, 4G, and under research future generations 5G is still going on.

EVOLUTION OF MOBILE COMMUNICATION

FIRST GENERATION (1G)

- It uses analog radio signal which has frequency 150 MHz, only voice transmission call is done.
- This generation is unreliable.
- It speeds up to 2.4Kbps.

EVOLUTION OF MOBILE COMMUNICATION

SECOND GENERATION (2G)

- The next generation of mobile networks, 2G uses **GSM technology** (Global System for Mobile Communication).
- It used digital signal for transmission rather than analog.
- Data speed up to 64Kbps.

EVOLUTION OF MOBILE COMMUNICATION

3G

- 3G is the third generation of mobile phone standards and technology,
- 3G uses **CDMA technique** for data transmission.
- 3G transmits data up to 2 Mbps.

EVOLUTION OF MOBILE COMMUNICATION

Vo LTE LTE

4G

- This generation provide wider bandwidth, high security and high speed internet access. This generation based on Long Term Evolution (LTE).
- The 4G is offering improved multimedia, video gushing, worldwide access, and around the world transportability through a wide range of gadgets.
- 4G transmits data up to 100 Mbps.

EVOLUTION OF MOBILE COMMUNICATION

5G

- 5G networks are cellular networks, in which the service area is divided into small geographical areas called *cells*.
- The main advantage of the new networks is that they will have greater bandwidth, giving higher download speeds.
- 5G transmits data up to 10 gigabits per second (Gbit/s).

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Wireless Communication

Today's Target

- ✓ Radar Communication
- ✓ Satellite Communication

RADAR COMMUNICATION

- **Radar** is a detection system that uses radio waves to determine the range, angle, or velocity of objects.
- It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain.
- Radio waves are electromagnetic waves of frequency between 10 hertz (Hz) and 30000 megahertz (MHz).

Elements of Radar Communication system:-

(i) Transmitter:- For transmitting signal.

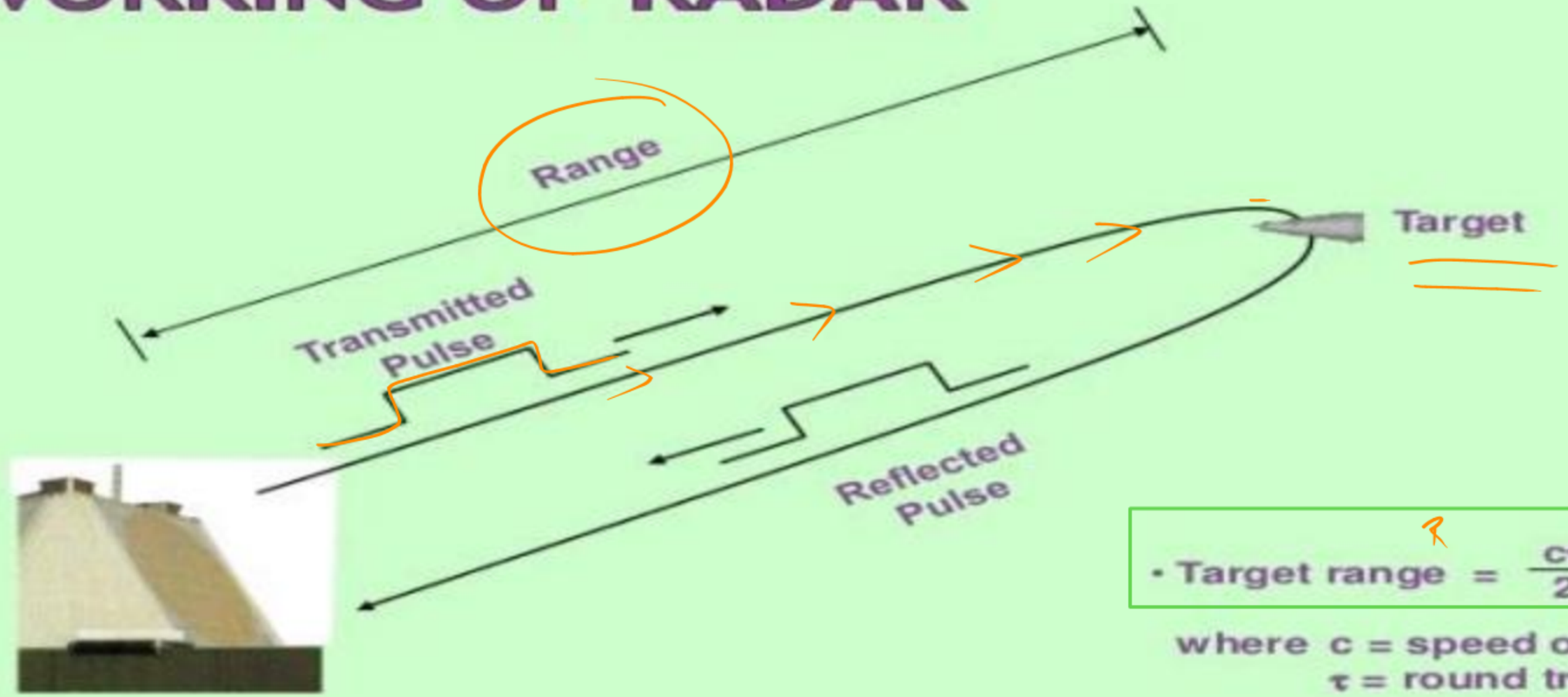
(ii) Antenna:- used to transmit or receive signal

(iii) Receiver :- used to receive signal

(iv) Power supply:- used to provide power.

RADAR COMMUNICATION

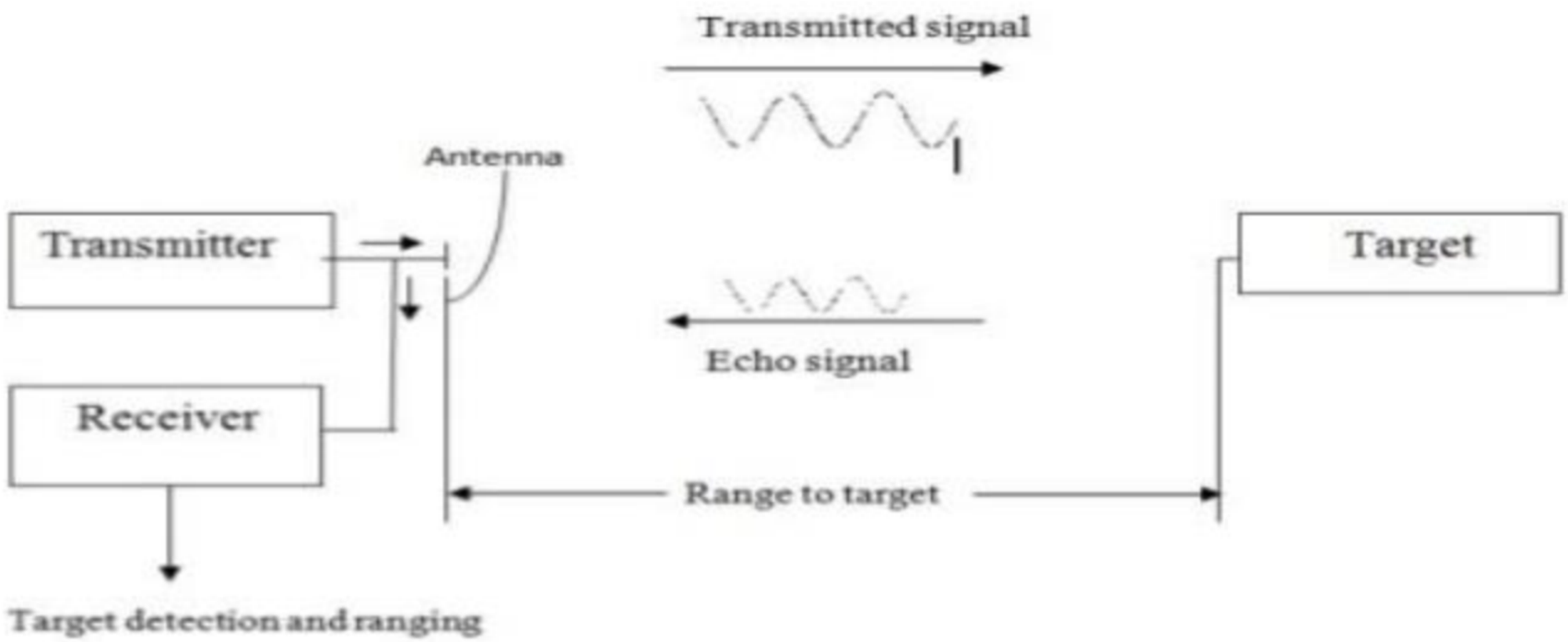
WORKING OF RADAR



- Target range $= \frac{c\tau}{2}$

where c = speed of light
τ = round trip time

Principle of Working



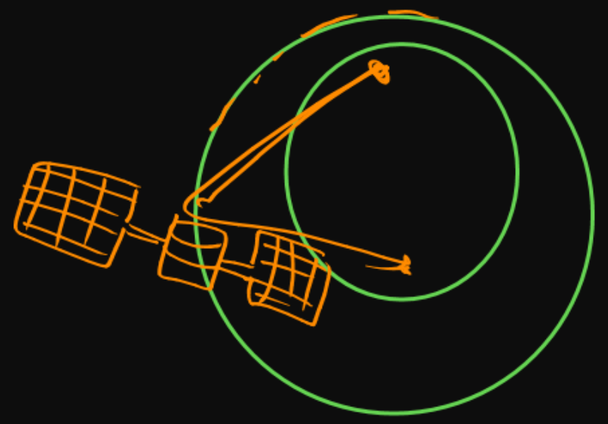
RADAR COMMUNICATION

- **WORKING**

- A radar system has a transmitter that emits radio waves known as *radar signals* in predetermined directions.
- When these signals contact an object they are usually reflected in many directions.
- Radar signals are reflected by materials of considerable electrical conductivity—such as most metals, seawater, and wet ground.
- The radar signals that are reflected back towards the radar receiver are the desirable ones that make radar detection work.
- If the object is *moving* either toward or away from the transmitter, there will be a slight change in the frequency of the radio waves due to the Doppler effect.

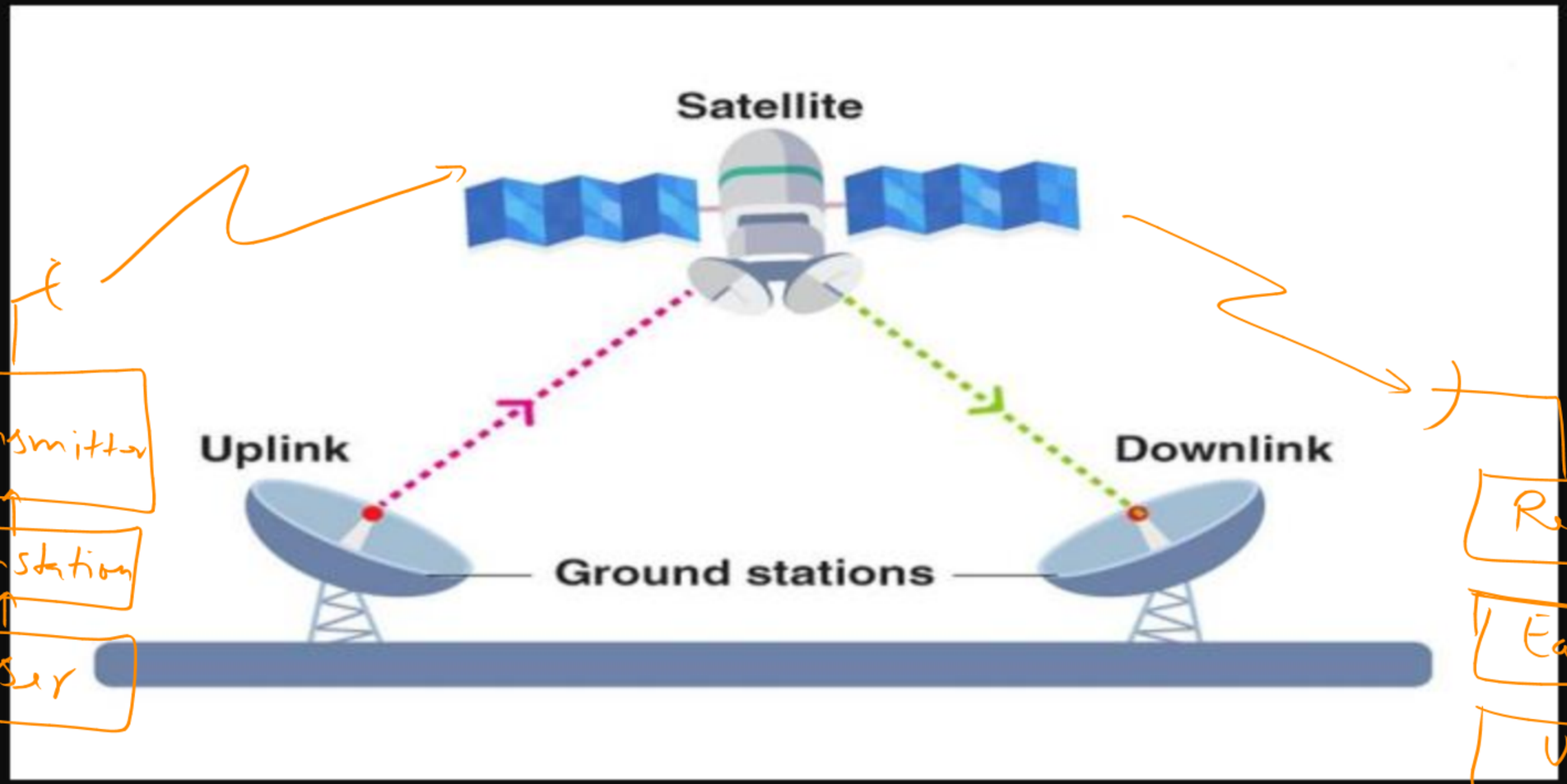
SATELLITE COMMUNICATION

- A **Satellite** is a smaller object that revolves around a larger object in space. For example, moon is a natural satellite of earth.
- **Communication** refers to the exchange (sharing) of information between two or more entities, through any medium or channel.
- Communication takes place between any two earth stations through a satellite, then it is called as **satellite communication**.
- In this communication, electromagnetic waves are used as carrier signals. These signals carry the information such as voice, audio, video or any other data between ground and space and vice-versa.



SATELLITE COMMUNICATION

6/4



Transmitter
Earth station
User

Receiver
Earth station
User

SATELLITE COMMUNICATION

Basic Elements of Satellite Communication:

- User
- Satellite
- Earth Station(Ground Station)

(i) The user generates a signal which is transmitted to a satellite at the earth station.

(ii) The satellite consists of a large number of repeaters in the space that perform the reception of high frequency carrier from all the earth station.

(iii) Repeaters retransmits back to the Earth Station in the down link frequency spectrum.

(iv) In order to avoid the interference downlinks frequency spectrum should be different from uplink frequency spectrum.

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Fundamentals of Electronics Engineering [BEC101/202]

Unit:-1 :- SEMICONDUCTOR DIODE (18 Marks)

- Explain the working of P-n junction diode and draw its V-I characteristics? — 7
- Diff^n Zener breakdown and Avalanche Breakdown — 2
- Half Wave Rectifier
  Full Wave Rectifier } 100% + Working + I/O waveform

  and also Calculate expression PIV, DC Voltage and DC current, RMS value of current, Ripple factor, Rectification Efficiency + Numerial — 07

- Clippers
  Clampers } Numerical (100%) — 07
- Zener diode as shunt Regulator → Numerical (07)
- Voltage-Multiplier Circuits
  ↳ working (Tripler, doubler, quadrupler)
  } → (50%)
- LED
  Photodiodes } 07
- Varactor diode — 02
- Explain Principle of operation and construction of tunnel diode. Draw its V-I characteristics — 07
- Depletion layer — 02
- Doping — 02

Unit :-2 (BJT and FET) (16 Marks)

- Explain CB/CE/CC N-p-n transistor with its Input and output characteristics (100%)
- $\alpha = \frac{\beta}{1+\beta}$, $\beta = \frac{\alpha}{1-\alpha}$, $\gamma = 1+\beta$, 02 Numberical (100%)
- Explain the n-channel JFET and draw its transfer characteristics.
- MOSFET (Depletion and Enchancement) — (101%) Imp.

  Depletion → n-channel; Enchancement → p-channel.

  and drain and transfer characteristics.
-

Unit-3 (Operational Amplifier) (18 Marks)

- Define op-Amp with the help of block diagram. Also draw its equivalent circuit. List the ideal characteristics of op-Amp (100%)
- Inverting op-Amp / Non-Inverting Amp → Theory Question
- Inverting Summer (Numerial 100%)
- Integrator, Differentiator → Numerial
- Voltage Followers Circuit (Unity Gain) — Imp 07
- CMRR, Slew Rate → 02 (100% Imp)

  On characteristics of op-Amp.

Unit:- 4 Digital Electronics (16 Marks)

* Determine 2's Complement of $(1010.110)_2$
  Convert $(25.125)_{10}$ into Hexadecimal number
  Add binary number $(1011)_2$ and $(1111)_2$
  State De-Morgen Law
  Define minterm and Maxterm
  Substract 10's Complement using :- $(9754)_{10} - (364)_{10}$
  Substract using 1's complement: $(10111)_2 - (110011)_2$

V. Imp

07+10

(9) Mark

* Gates - (07+02) Imp

- K-Map (100%) - M. Imp

Unit:- 5 Fundamental of Communication Engineering (16 Marks)

- Need of Modulation.
- Explain with the help of block diagram the elements of Communication System.
- Define amplitude modulation. Derive the expression for AM modulated waveform. Define Modullation Index of AM
  + Numerical (100%)
- Describe briefly Radar | satellite Communication (100%)