EEE 1231

Date: 08.07.24

Lecture-1

Semi-conductor (~~অর্ধ~~ অর্ধপরিবাহী)

insulator - অপরিবাহী
conductor - পরিবাহী

$\Big\}\rightarrow$ এদের মাঝে semi-conductor

single crystal

negative temperature co-efficient - (inverse)

doping use করে semi-conductor এর conductivity বাড়ানো বা কমানো যায়।

most used semiconductor metarial - Silicon, Germanium

Energy Level: (imp) v.v.

conduction level: current flow শুরু হয়,

পরমশূন্য তাপমাত্রায় semi-conductor insulator হয়ে যায়। (ইলেকট্রনের মুক্ত মুভমেন্ট হয়না, energy level দিয়ে explain)

~~#~~ movement বন্ধ হলে নিচের ব্যান্ড থেকে উপরের ব্যান্ডে যেতে পারে না।

room temparature - 25°c

0 kelvin / -273.15° এ silicon crystal এর মধ্যে
e^- pass করাতে room temp. -এ নিতে হয়।

energy gain
↓
breaking covalent band (সমযোজী বন্ধন)
↓
Free electron
↓
moveable electron

☐ pentavalent - যেসব বস্তুসমূহ পাঁচটি ইলেকট্রন -
পাঁচযোজী (N-type)

trivalent - ত্রিযোজী (p-type)

Valence Band, Conduction Band, Forbidden Energy Gap.

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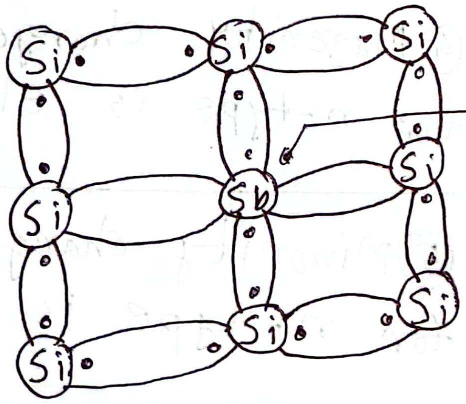
Lecture - 2
14.7.2024

Doping: The process of adding impurities to intrinsic semiconductor knows as semiconductor.

Semi-conductor

- Intrinsic
  pure Si, pure Ge
- Extrinsic
  - n type (penta valent) impurity
    P, As, sb
    P → (phosphorus)
    As → (Arsenic)
    sb → (Antimony)
  - p-type (Trivalent) Impurity
    Al, Ga, B
    Al → Almi.
    Ga → Gallium
    B → Boron

N-type:

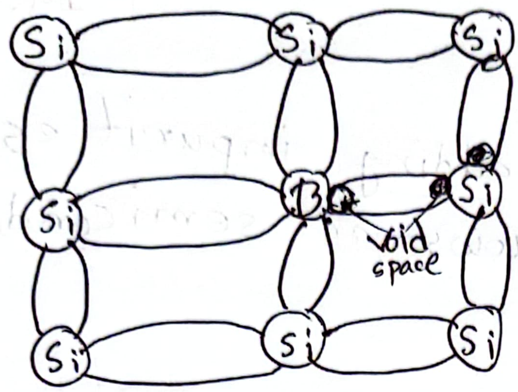


Free electron

pentavelent

N-type semiconductor

P-type



AL

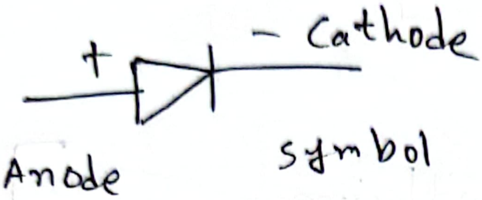
Hole (str)

$$\Sigma \text{ +charge} = \Sigma \text{ -charge}$$

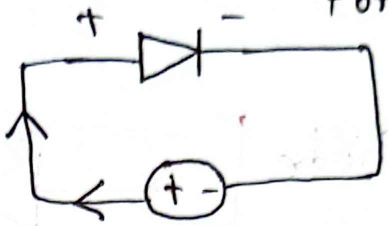
Differen betn p-type and n-type semiconductor

p-type	n-type
① trivalent impurity is added	① pentavalent impurity is added.
② Free e^- is formed	② Hole is formed
③ B - acceptor Atom	③ Sb - Donar Atom
④ Majority change carieer for ~~N~~ P-type is Hole	④ Majority change carrier for n-type is electron
⑤ Minority charge carrier for p-type is electron	⑤ Minority charge carrier for n-type is Hole.

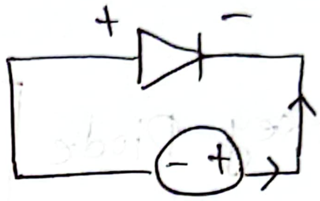
Diode: Diode is a two terminal device that allows current to flow in only one direction and blocks current coming from opposite direction.



Forward Bias



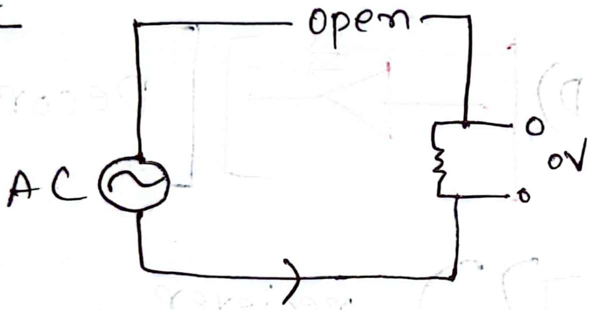
Diode on/Active



Reverse Bias

Diode ~~of~~ off/Inactive

Rectifier:



Lecture - 3,4

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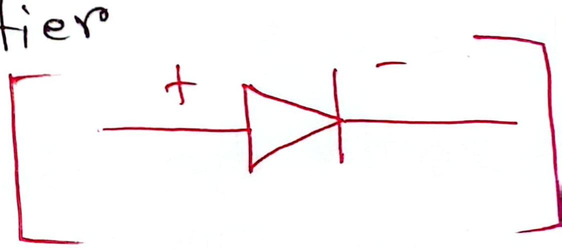
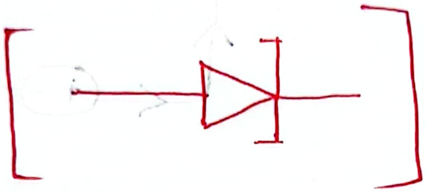
25.08.2024
15.07.2024

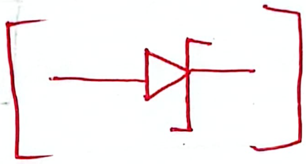
Types of Diode

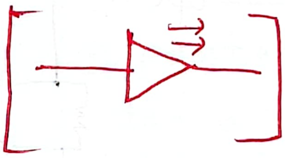
1. p-n Junction diode/rectifier

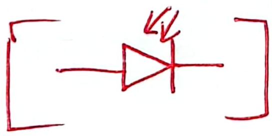


2. Zener Diode [stablizer এ voltage regulator হিসেবে ব্যবহৃত হয়]

3. Tunnel Diode  [~~swithcing~~ switching in PC]

4. ~~Scho~~ Schottkey Diode  [High frequency and high speed operation]

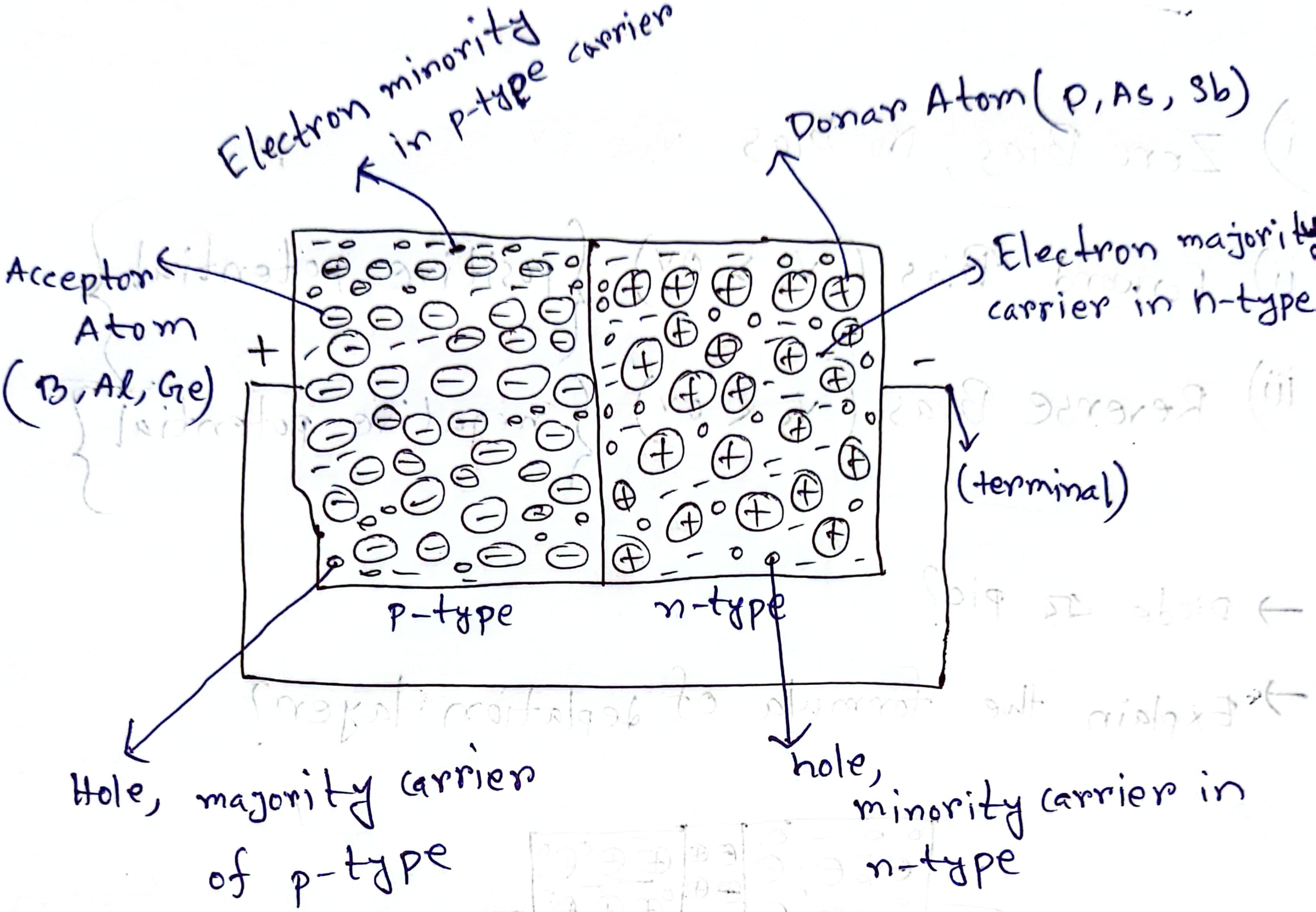
5. Light Emitting Diode (LED)  [Decoration]

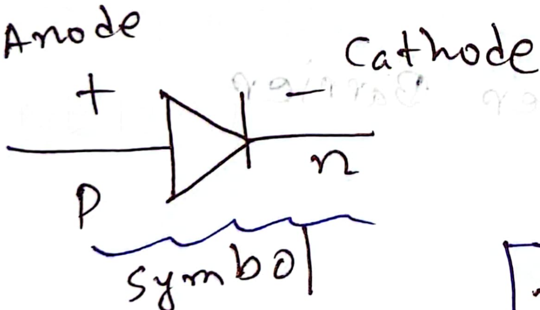
6. photo Diode  → reciever

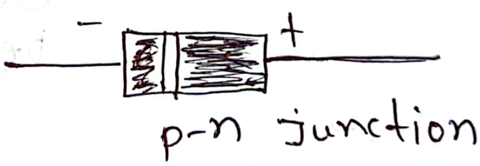
→ used as a pair in pulse oximeter

7. IR Diode  → transmetter

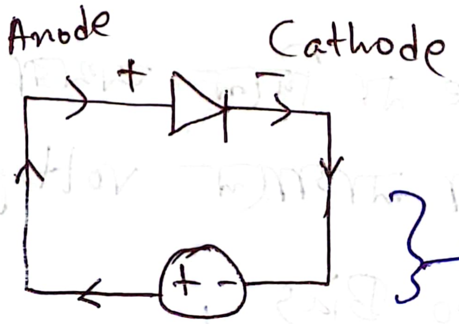
Internal Structure of Diode







কাজ : তড়িৎপ্রবাহকে একমুখীকরণ



বাইরে থেকে voltage দেওয়া হয়।

Biasing in Diode

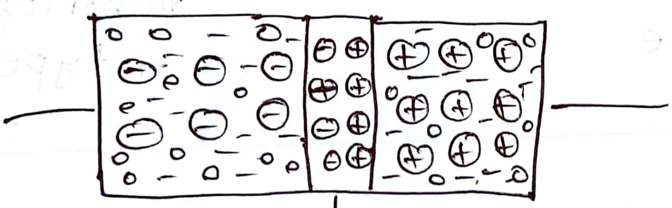
i) Zero Bias, No Bias $V_s = 0V$

ii) Forward Bias ($V_s > 0V$) {positive potential}

iii) Reverse Bias ($V_s < 0V$) {negative potential}

→ Diode এর pic?

→ Explain the formula of deplation layer?



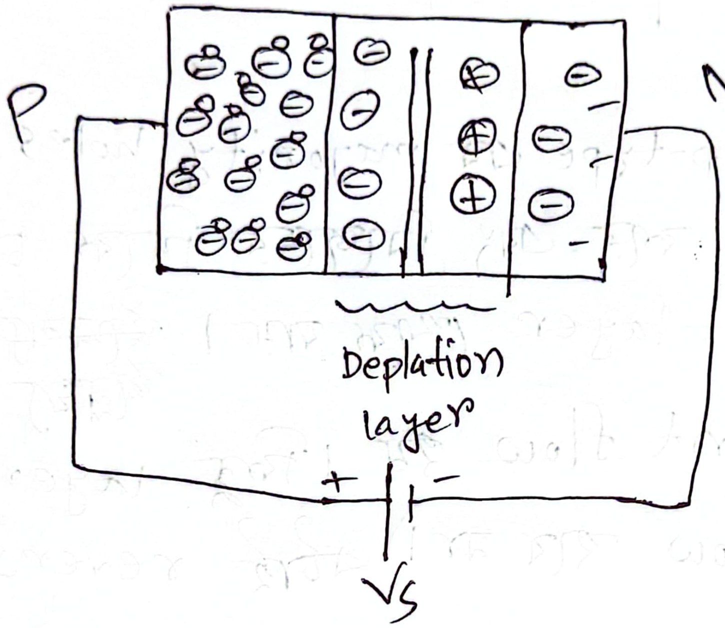
Depletion layer Barrier

i) Zero Bias

Diode এ ~~যদি~~ voltage না দিলে অথবা দুইদিকের তারের মধ্যে একসাথে জোড়া লাগালে voltage 0 এবং current 0 হয়। এটাই Zero Bias।

ii) Forward Bias:

Diode -এর (+) প্রান্তের সাথে ব্যাটারির (+) প্রান্ত ও Diode এর (-) প্রান্তের সাথে ব্যাটারির (-) প্রান্ত যুক্ত থাকে।



here,

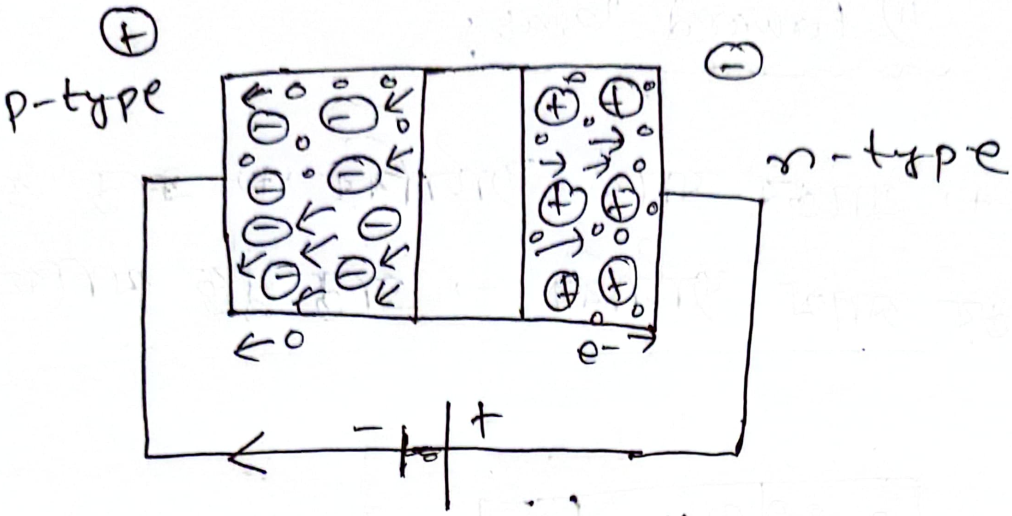
$V_s > 0V$

positive potential

- Deplation layer সরে গেলে current flow হবে।
- p-n junction -এ forward Bias -এ শুধু current flow হবে

iii) Reverse Bias

এখানে, $V_s < 0V$



ব্যাটারির '+' চার্জ /– p-type এর majority holes গুলোর (+) একে অপরকে আকর্ষণ করে এবং নিজেদের দিকে চার্জ টেনে নেয়। ফলে deplation layer বেড়ে যায়। ~~ইলেকট্রন~~ deplation layer কমলে current flow হয়। কিন্তু layer বাড়ার কারণে current flow হবে না। এটাই reverse bias.

p-n junction শুধু forward bias-এ কাজ করে।

Graph

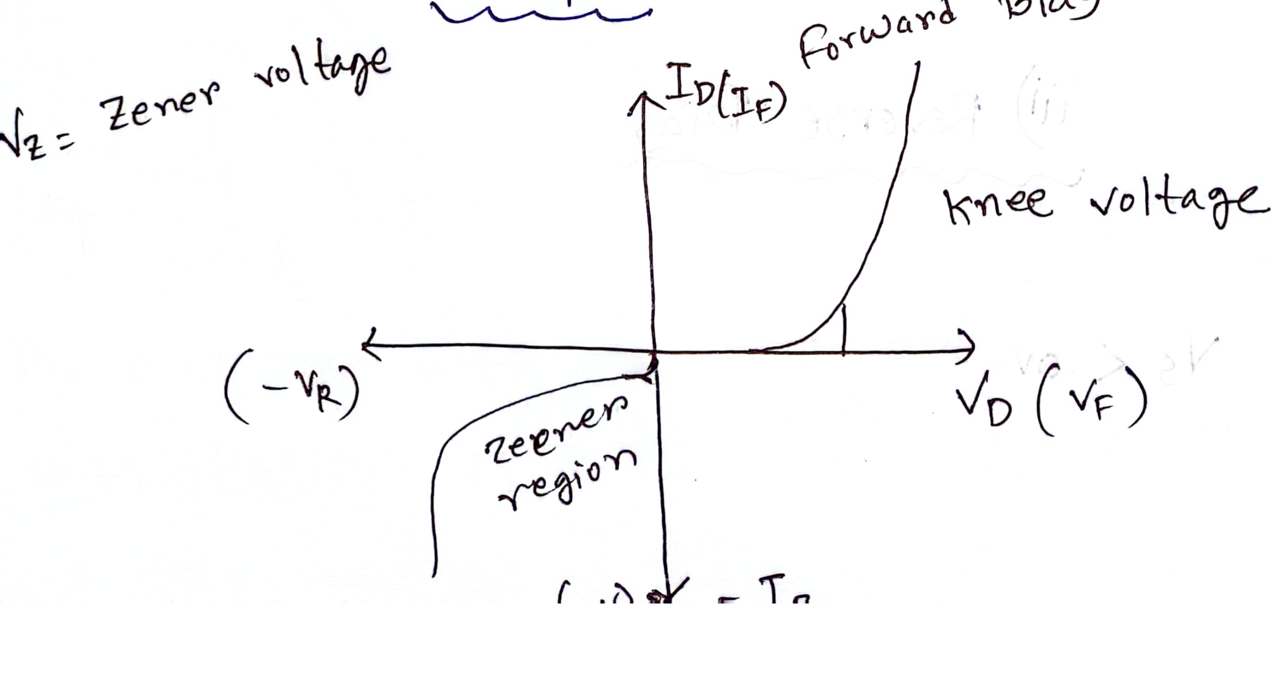


Fig: VI characteristic carve of a p-n junction

knee voltage. The minimum amount of voltage for which current through a diode starts rising rapidly.

minority charge carrier depends on temparature. that's why through reverse bias, minority current does flow.

Zener reverse diode g কাজ করে।

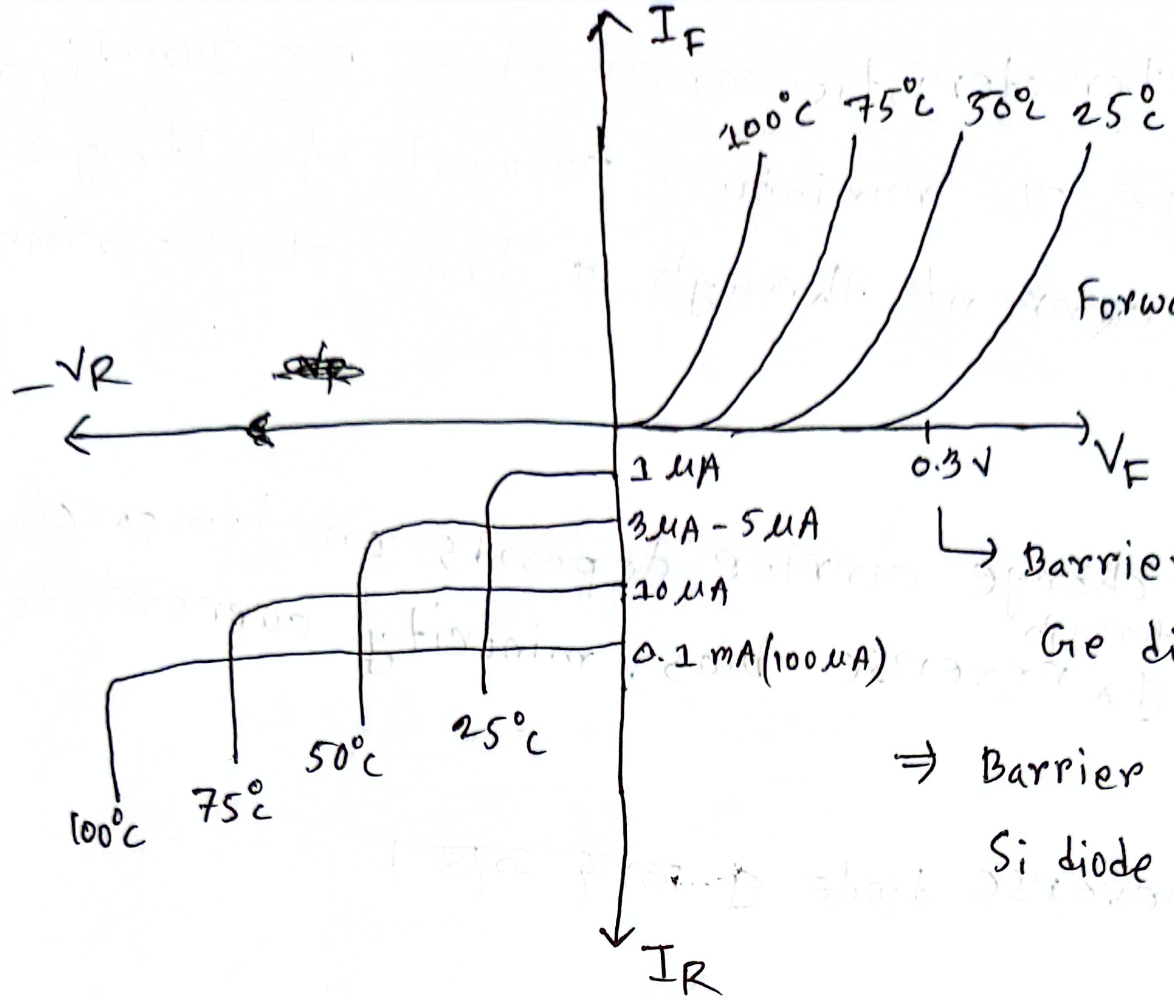
EEE 1231 Semiconductor Lecture-5
1.7.2024

Effect of temparature on Ge Diode

1. { 200°c ⟶ Si (p-n)
 100°c ⟶ Ge (zener)

2. { Breakdown voltage Si = 1000V
 " " Ge = 400V

3. { Silicon is more available and cheap than Ge



↳ Barrier voltage for Ge diode

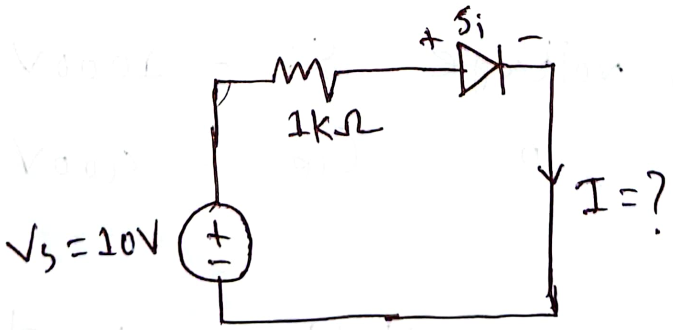
⇒ Barrier voltage for Si diode is 0.7 V

Fig: 1.24 (Book)

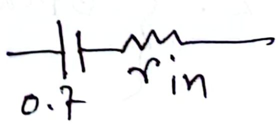
With the increase of temparature forward ~~bias~~ characterstics ~~for~~ of a Ge diode becomes more ideal

Math Part

Q 1/Type-1



equivalent cir



Two condition:

1. Supply voltage, $V_s > 0.7$?
2. Diode এর direction forward কিনা?

method-1:

$$I = \frac{10 - 0.7}{1\,k\Omega} = 9.3\,mA$$

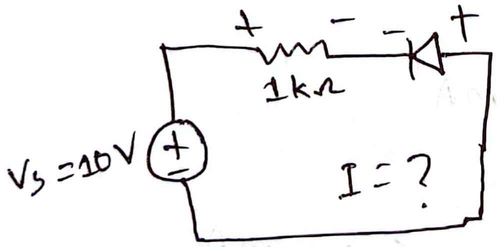
method: 2: Applying KVL,

$$-10V + V_R + 0.7 = 0$$

$$\text{or, } -10 + I \times 1 + 0.7 = 0$$

$$\therefore I = \frac{10 - 0.7}{1\,k\Omega} = 9.3\,mA$$

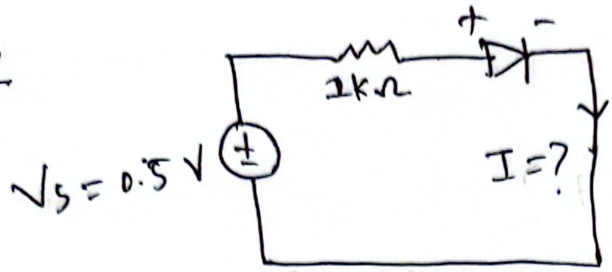
Type: 2



Hence diode is attached in oposite direction with V_s, that's why it is a open circuit.

$$\therefore I = 0$$

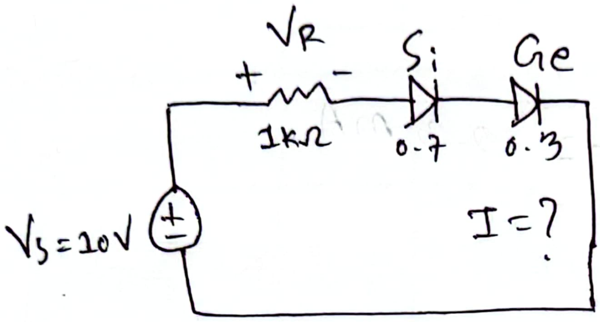
Type-3



$V_s < 0.7$

So.... diode will not active, Hence $V_s < 0.7$

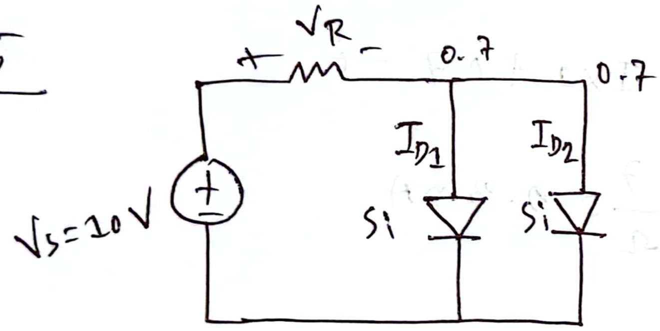
Type-4



$$\therefore I = \frac{10 - 0.7 - 0.3}{1k\Omega}$$

$$= 9 \text{ mA}$$

Type-5

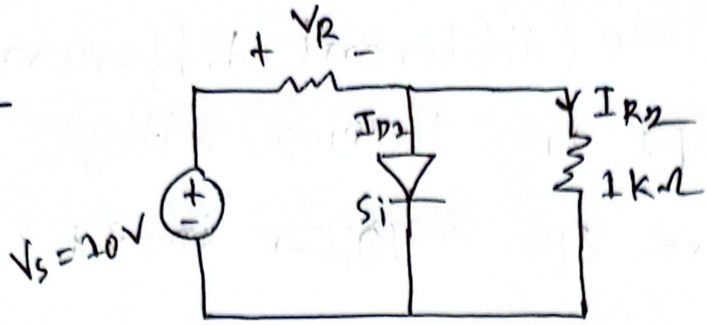


Calculate I, I_{D1}, I_{D2}?

Here, $I = \frac{10 - 0.7}{1k\Omega} = 9.3 \text{ mA}$

Now, $I_{D1} = I_{D2} = \frac{I}{2} = 4.65 \text{ mA}$

Type-6



I, I_{D1}, I_{R2}?

Here, $I = \frac{10-0.7}{1} = 9.3 \, mA$

$V = IR$

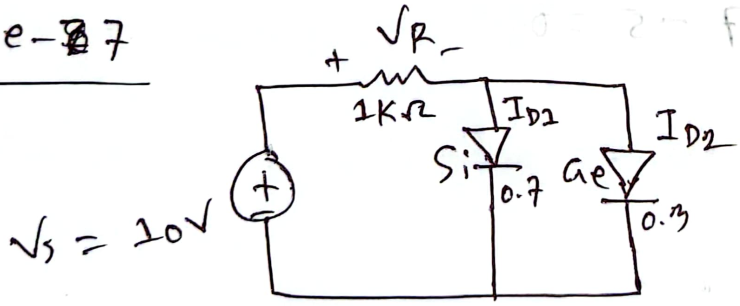
$I_{R2} = \frac{V}{R} = \frac{0.7}{1} = 0.7 \, mA$

Applying, KCL, $I = I_{D1} + I_{R2}$

or, $I_{D1} = (9.3 - 0.7) \, mA$

$= 8.6 \, mA$

Type-7



I_1, I_{D1}, I_{D2}?

এখানে, Ge এর voltage 0.3 হওয়ায় Ge যুক্ত Diode প্রথমে active হবে, $I = I_{D2} = \frac{10-0.3}{1} = 9.7 \, mA$

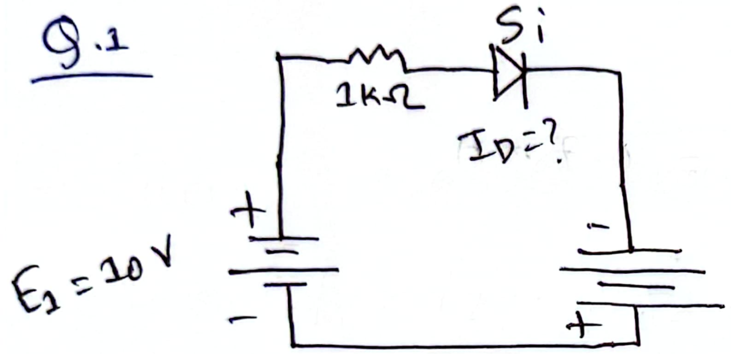
$I_{D1} = 0$ $\therefore I_{D2} = 9.7 \, mA$

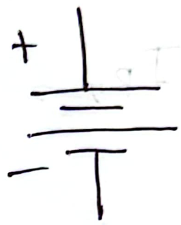
যখন অনেকগুলো Diode (different different) সমান্তরালে বসানো থাকলে যার barrier voltage সবচেয়ে কম সেটি আগে Active হয় অন্যগুলো বন্ধ ই থাকবে

EEE 1231 — **Math Part** — **Lecture-6**

02.09.2024

Q.1





হলে −5V হবে

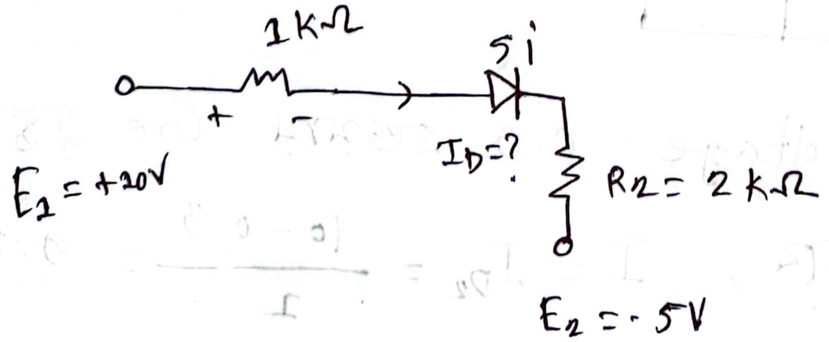
$$I = \frac{10 + 5 - 0.7}{1} = 14.3\,mA$$

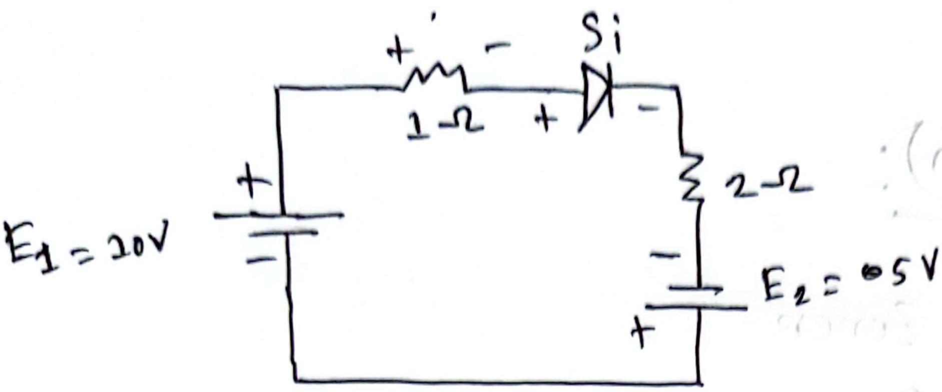
Applying KVL,

$$-10 + I \times 1 + 0.7 - 5 = 0$$

$$\therefore I = 14.3\,mA$$

Q.2





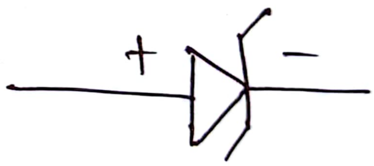
Applying KVL,

$$-10 + I\times 1 + 0.7 + 2\times I - 5 = 0$$

or, $I + 2I = 14.3$

$\therefore I = 4.767$ mA

Zener Diode



symbol

⇒ heavily doped

⇒ Thin depletion layer

⇒ (1.8 – 100)V doping এর উপর নির্ভর

⇒ 5.5V (ল্যাবে যেটা ব্যবহৃত হয়)

যদি doping বাড়ানো তখন charge carrier বাড়বে। এর ফলে Deplation layer পাতলা হয়ে যাবে। এবং

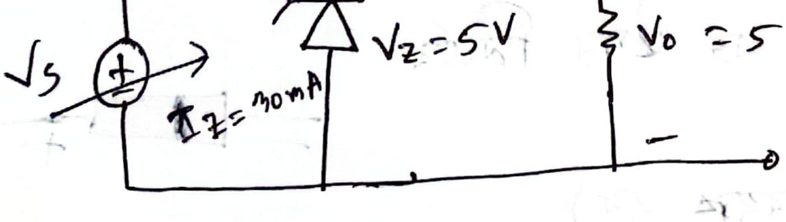
Breakdown voltage করবে।

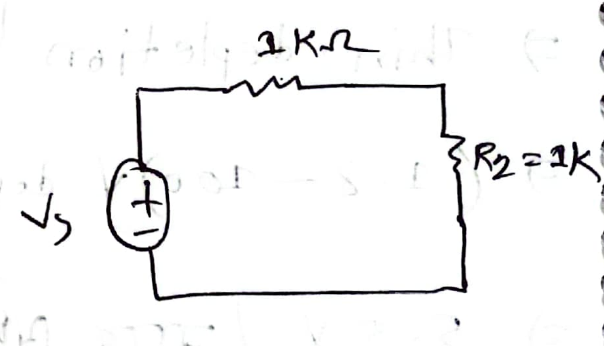
operation (3 region):

① In forward bias Zener diode behave as a forward p-n diode

② During reverse Bias $V_Z = 5V$,
when, $V_D < V_Z$; diode will be open circuited

③ During Reverse Bias
when $V_D > V_Z$, diode will work as a voltage regulator.



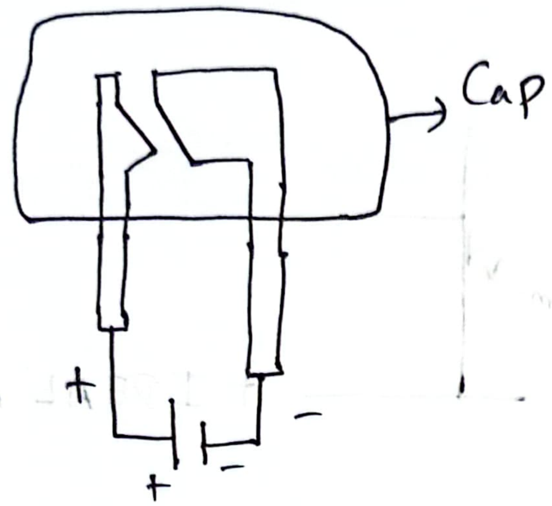


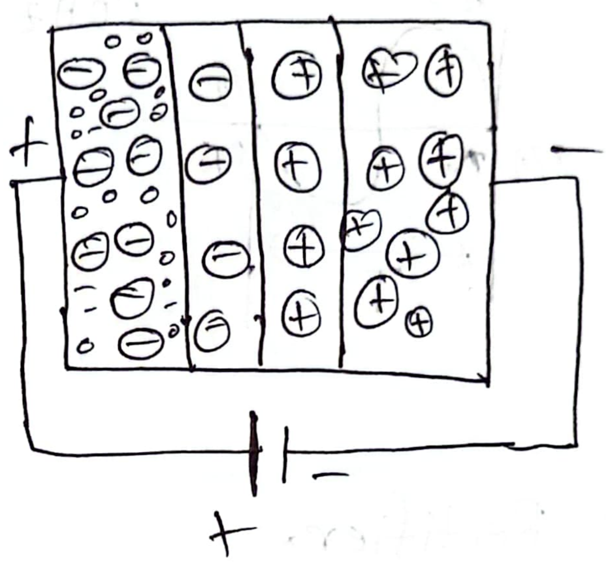
$$1V = V_{R_2} = \frac{1}{1+1} = \frac{1}{2}$$

$0.5 < V_Z$ Circuit open থাকবে

LED (Light Emitting Diod)

⇒ ~~LP~~ Emits light when energised.





$$E_g = \frac{hc}{\lambda} \longrightarrow 400 - 700 \text{ (nm)}$$

Materials → GaAsP, GaP

⇒ Define Electroluminencence ?

EEE 1231 Lecture-8

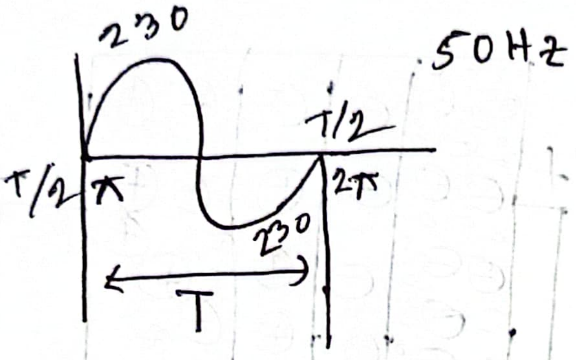
Application of Diode 07.07.2024

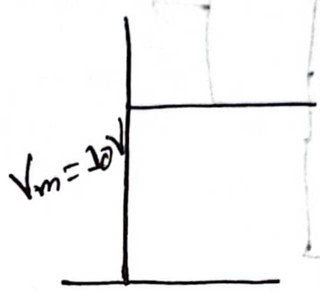
1. Rectifier circuit
2. Clipper
3. Clamper

Clipper and Clamper → wave shaping circuit

Rectifier

\# A device that converts AC into DC.

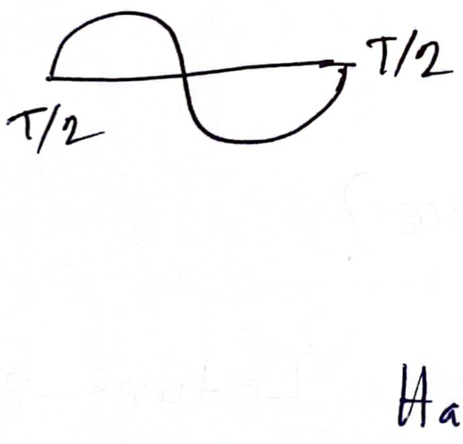




+ IDEAL AC

Types of Rectifier:

1. Half Wave Rectifier

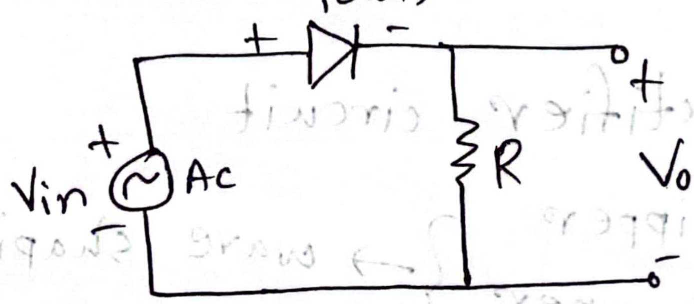


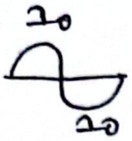
2. Full Wave Rectifier

Half Wave Rectifier

প্রথম diode positive,

ideal; drop = 0

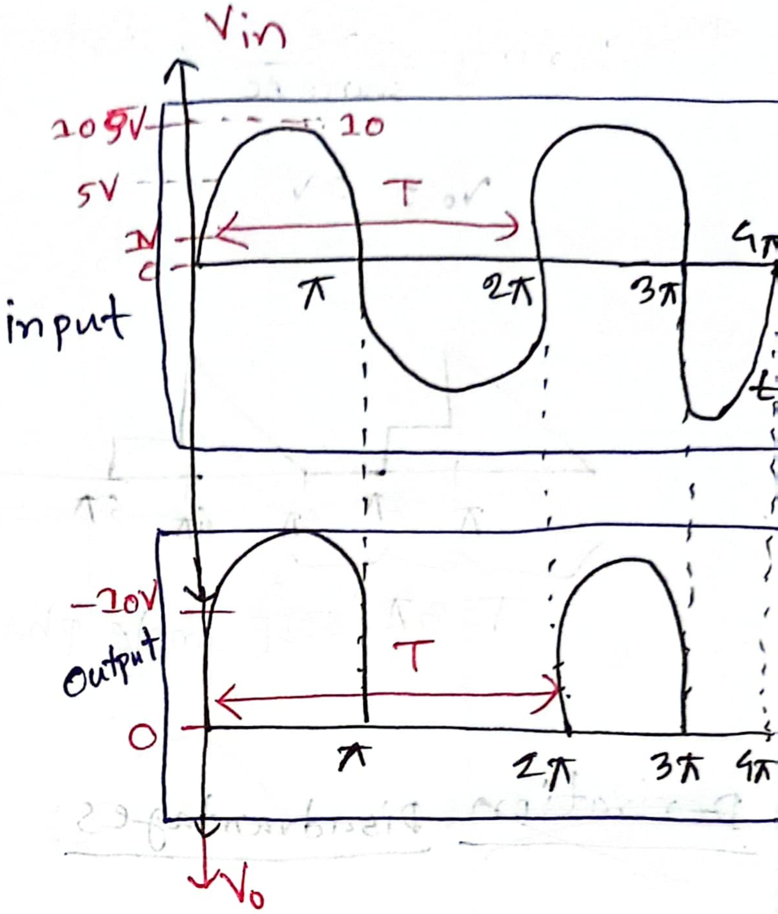




, During $\underset{\text{source AC}}{\underline{(+)\text{ve}}}$ half,

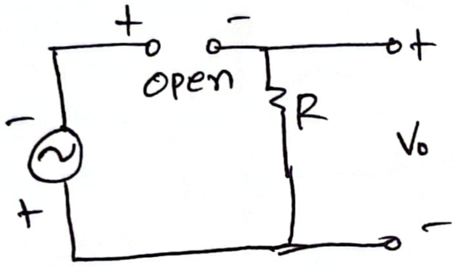
Diode is active,

$$\boxed{\therefore V_o = V_{in}}$$

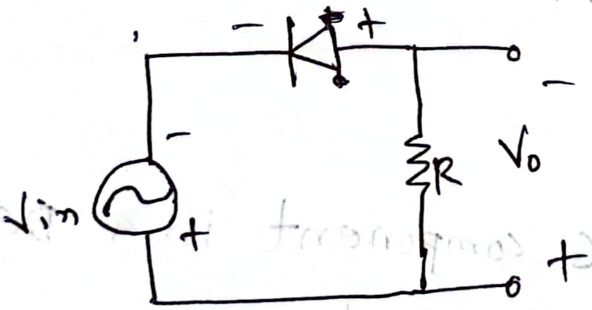


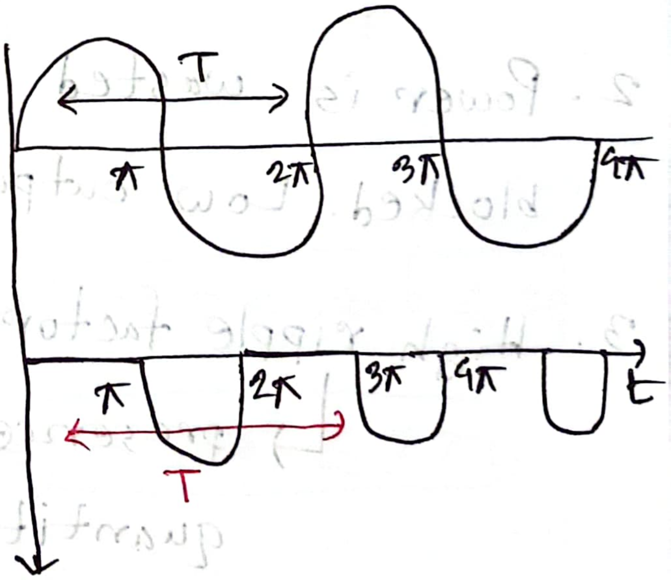
During $\underset{\text{Source AC}}{\underline{(-)\text{ve}}}$ half, diode is open

$\therefore V_o = 0V$



যখন diode negative,



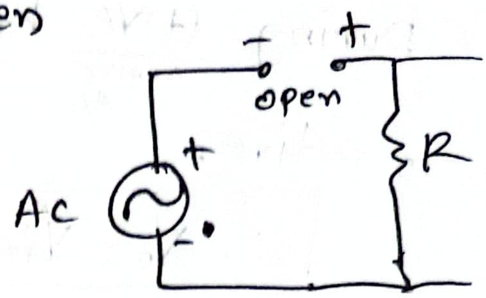


During $\underset{\text{source AC}}{\underline{(-)\text{ve}}}$ diode is active

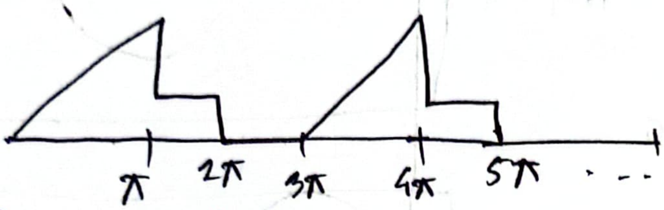
$\therefore V_{in} = V_o$

$T = 2\pi$

and, During $\frac{(+)ve}{\text{source AC}}$, diode is open



$V_o = 0V$



$\rightarrow$ $T = 3\pi$

$T = 3\pi$ (একটি single phase)

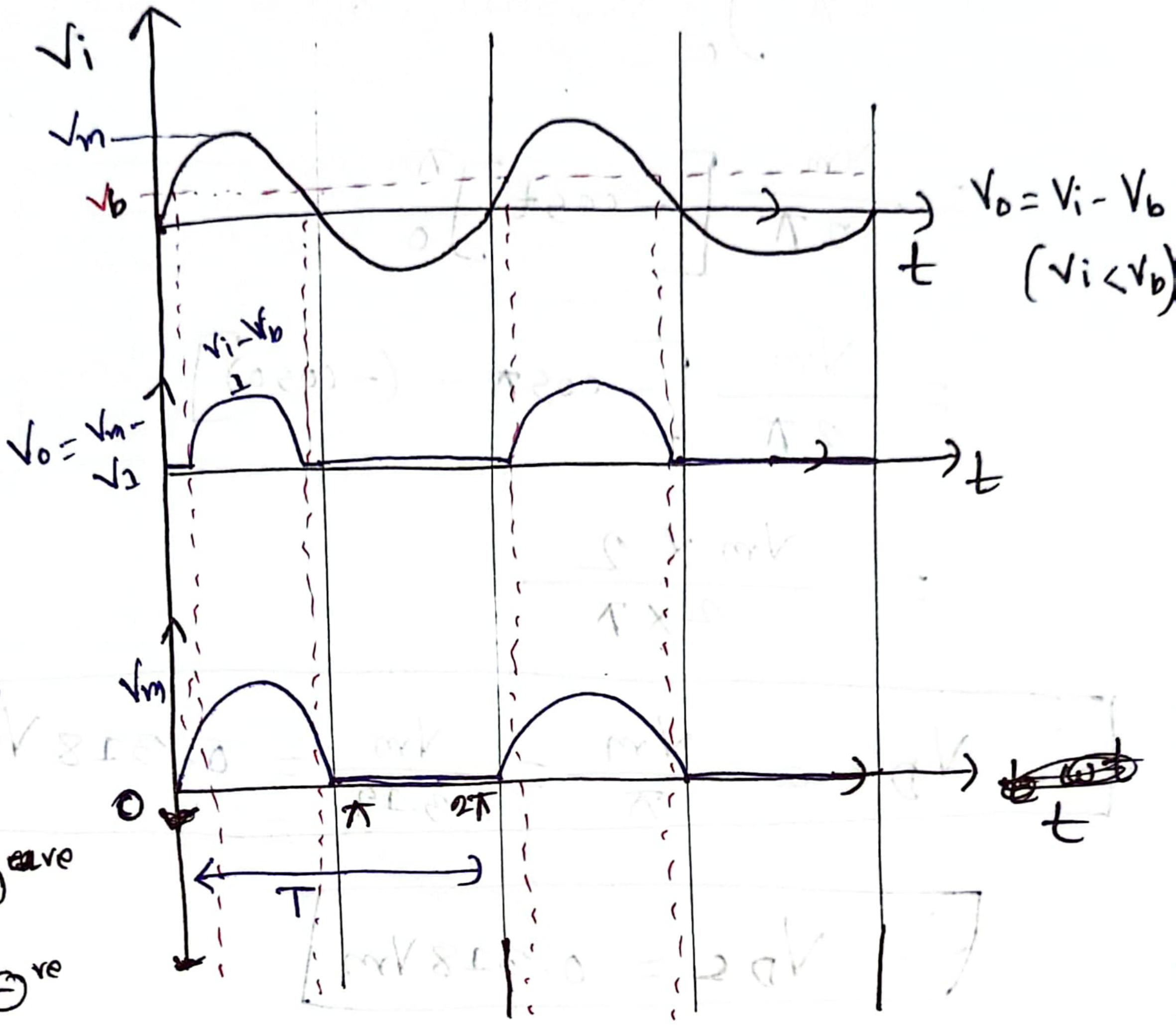
~~Derivation~~ Disadvantages:

1. Low output voltage

2. Power is wasted as one of the half cycle is blocked. Low output power.

3. High ripple factor
   ↳ presence of AC component in a DC quantity is called ripple.

Derivation:



Ideal diode, V_o

$V_b = 0$

$V_o = V_i \to \oplus$ ve

$V_o = 0 \to \ominus$ ve

Output Voltage: (V_{DC})

$$V_o = V_m \sin t \to \boxed{0 \le t < \pi}$$

$$V_o = 0 \to \boxed{\pi \le t \le 2\pi}$$

$$\therefore V_{DC} = \int_0^T V_o \, dt \Big/ T - 0 \qquad [T = 2\pi]$$

$$= \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin t \, dt + \int_{\pi}^{2\pi} 0 \cdot dt\right]$$

$$= \frac{1}{2\pi}\int_0^{\pi} V_m \sin t \,.\, dt$$

$$= \frac{V_m}{2\pi}\left[-\cos t\right]_0^{\pi}$$

$$= \frac{V_m}{2\pi}\left[-\cos\pi - (-\cos 0)\right]$$

$$= \frac{V_m \times 2}{2 \times \pi}$$

$$\boxed{\therefore V_{DC} = \frac{V_m}{\pi} = \frac{V_m}{3.14} = 0.318\, V_m}$$

$$\boxed{\therefore V_{DC} = 0.318\, V_m}$$

again. for, $V_{rms} = \sqrt{\frac{1}{T}\int_0^T V_o^2\, dt}$

$$= \sqrt{\frac{1}{2\pi}\left[\int_0^{\pi} V_m^2 \sin^2 t(dt) + \int_{\pi}^{2\pi} 0.\, dt\right]}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\int_0^{\pi} \sin^2 t(dt)}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \int_0^{\pi} \frac{1}{2}(1 - \cos t) \cdot dt}$$

$$= \sqrt{\frac{V_m^2}{4\pi} \left[t - \frac{\sin^2 t}{2} \right]_0^{\pi}}$$

$$= \sqrt{\frac{V_m^2}{4\pi} \times (\pi - 0)}$$

$$= \frac{V_m}{2}$$

$$\boxed{\therefore V_{rms} = V_{AC} = \frac{V_m}{2}}$$

extra

$$I_{DC} = \frac{V_{DC}}{R} = \frac{V_m/\pi}{R} = \frac{V_m}{R\pi} = \frac{I_m \times R}{R \times \pi}$$

$$\boxed{\therefore I_{DC} = \frac{I_m}{\pi}}$$

Similarly,

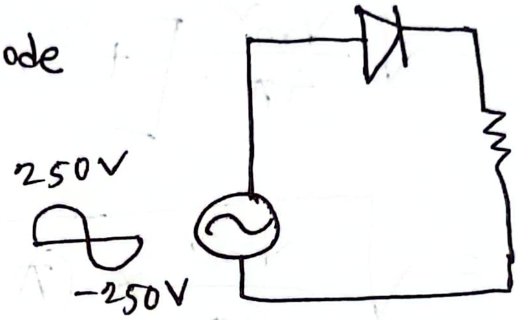
$$I_{AC} = \frac{V_{AC}}{R} = \frac{V_m/2}{R} = \frac{V_m}{2R} = \frac{I_m \times R}{2 \times R}$$

$$\boxed{\therefore I_{AC} = \frac{I_m}{2}}$$

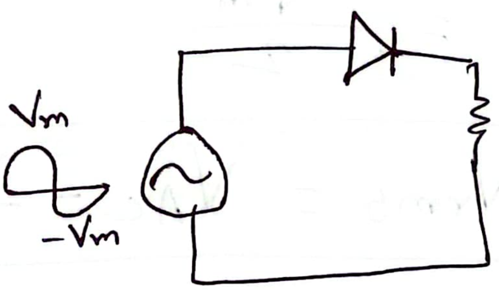
PIV rating for Half Wave Rectifier

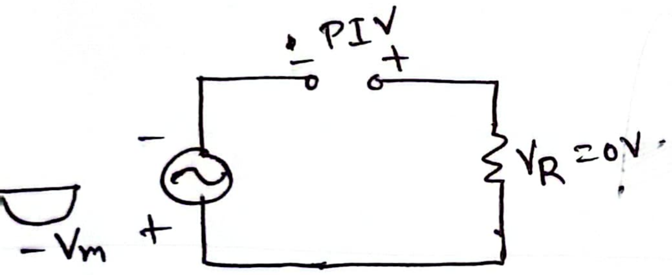
Lecture - 9
15.09.2024

সর্বোচ্চ যত voltage দিলে Diode নষ্ট হবে না তাই PIV rating



During $(-)^{ve}$ half diode is open

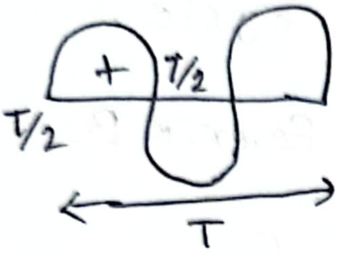




Applying KVL, $+V_m - PIV = 0$

$\Rightarrow PIV = V_m \rightarrow$ এমন Diode use করতে হবে হবে যা $PIV \geq V_m$ হবে

Full Wave Rectifier

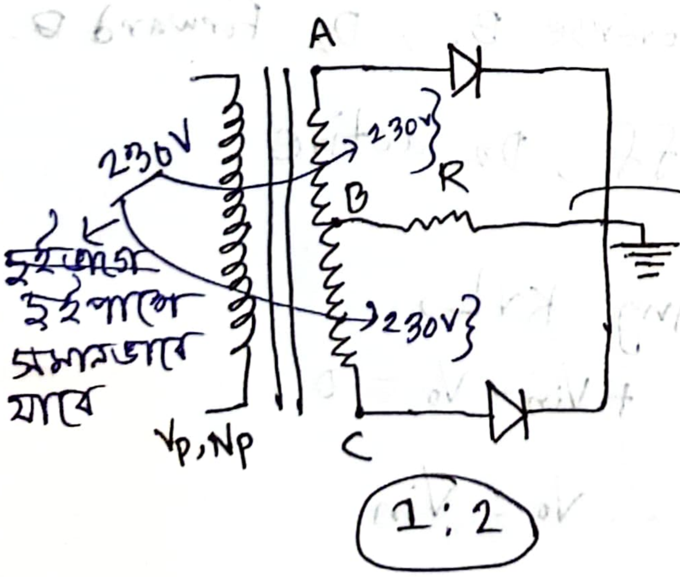


Types:

(2টা diode লাগে)

1. Full wave rectifier with centre tapped transformer
2. Bridge rectifier [4 diode] {এ ক্ষেত্রে একটা ব্রিজ তৈরি হয়}

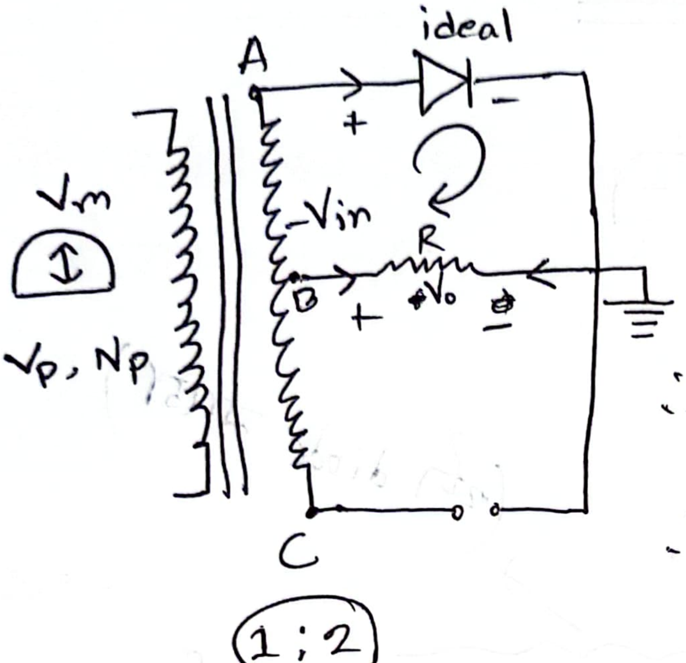
Full Wave Rec with Centre....



$N_{AB} = N_{BC}$ | $\frac{V_p}{N_s} = \frac{N_p}{N_s}$; $V_p \propto N_p$

→ মাঝ থেকে wire বের করে ground-এ কানেক্ট। ফলে AB, BC দুই ভাগে ভাগ হয়েছে

For Positive half cycle



During $(+)^{ve}$ half cycle,

D_1 Forwar B. , D_2 Reverse B.

$\therefore$ D_1 active , D_2 off

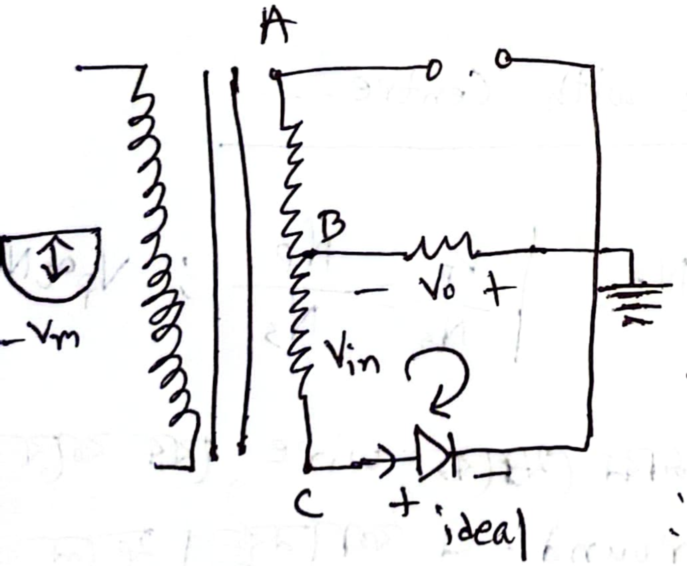
$\therefore$ $V_o = V_{in}$

applying KVL,

$-V_{in} + V_o = 0$

$\therefore V_o = V_{in}$

For Negative half cycle



During $(-)^{ve}$ half cycle

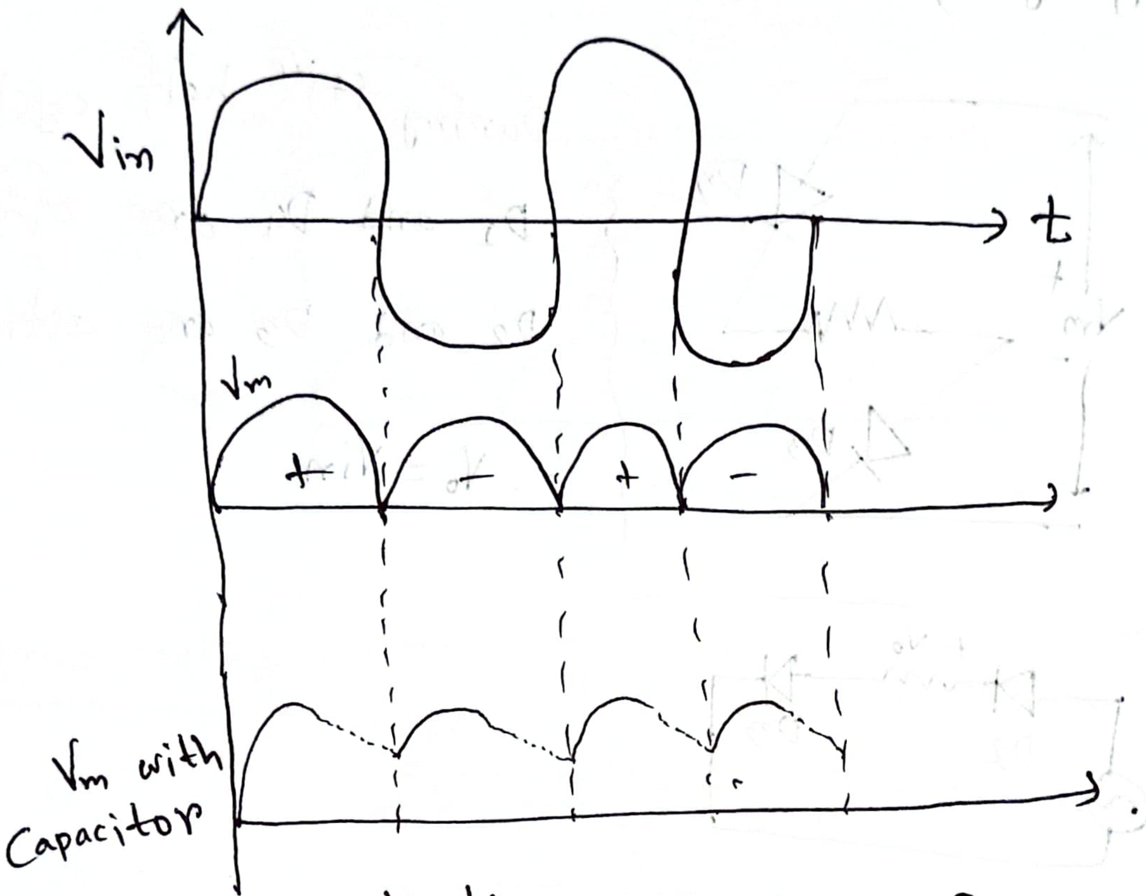
D_1 Reverse B. , D_2 Forward B.

$\therefore$ D_1 off , D_2 active

$\therefore$ Applying KVL,

$+V_{in} - V_o = 0$

$\therefore V_o = V_{in}$

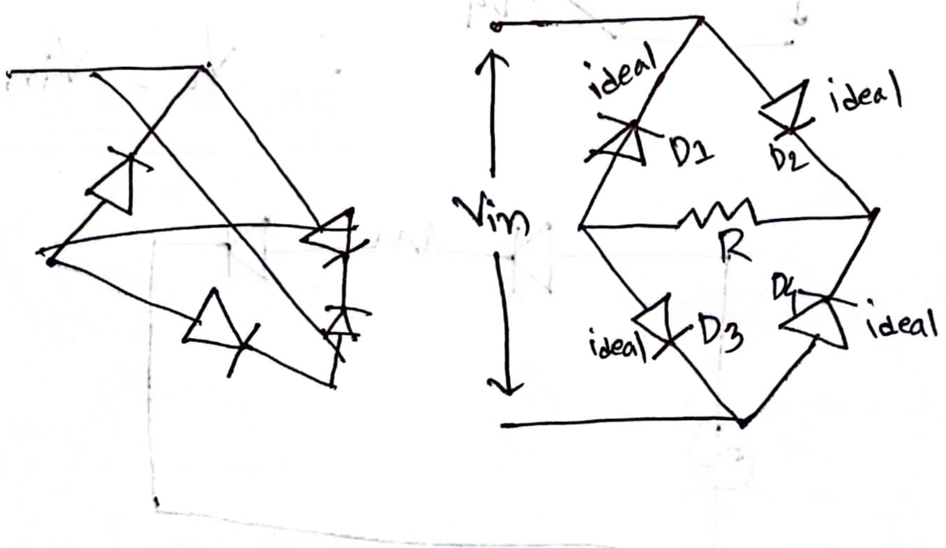


pulsating DC = AC+DC } ripple factor

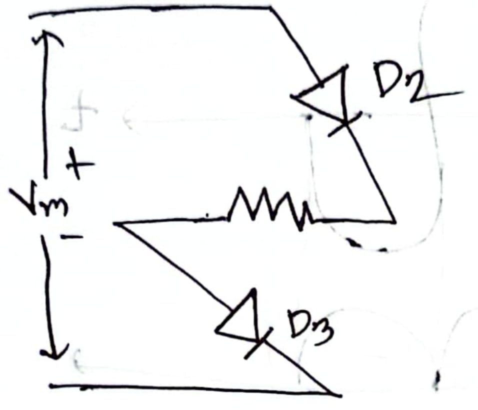
EEE 1231

Lecture - 10
22.09.2024

*** Bridge Rectifier

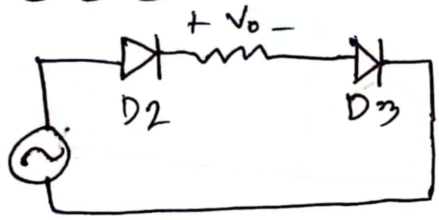


positive half cycle;

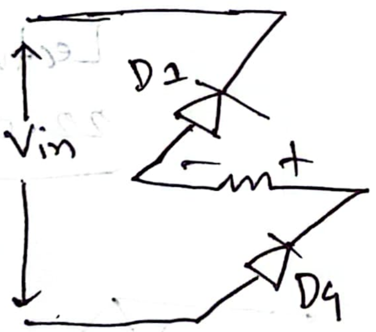


During $(+)^{ve}$ half cycle D_1 and D_4 are off. D_2 and D_3 are active

$\therefore V_o = V_{in}$

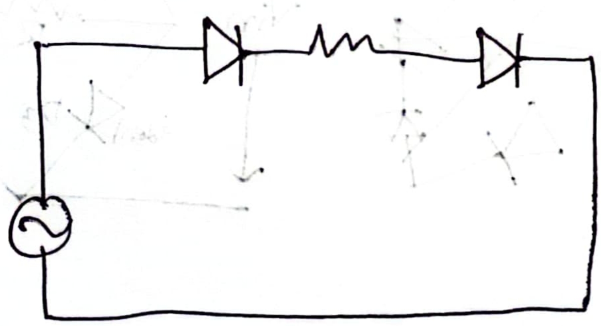


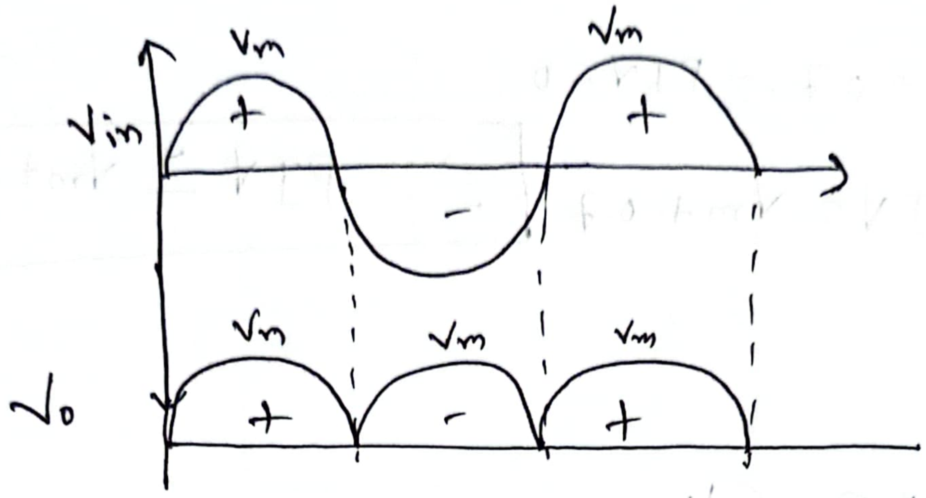
negative half cycle,



During $(-)^{ve}$ half cycle D_2 and D_3 are off. D_1 and D_4 are active

$\therefore V_o = V_{in}$.





Output voltage: $\boxed{V_{DC} = \frac{2V_m}{\pi}}$ $\rightarrow$ both bridge and centre tapped

$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$

centre tapped : $\rightarrow$ $V_{DC} = \frac{2V_m - \overset{Si}{0.7}/\overset{Ge}{0.3}}{\pi}$

bridge tapped : $\rightarrow$ $V_{DC} = \frac{2V_m - 2\times \overset{Si}{0.7}/\overset{Ge}{0.3}}{\pi}$

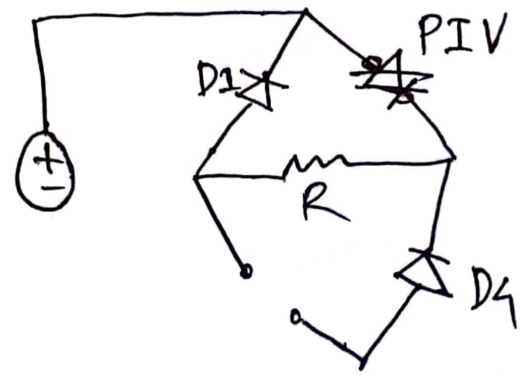
PIV rating

when ideal diode,,,

$+V_o - \cancel{0}.\ PIV = 0$

$\Rightarrow PIV = V_o(max)$

$\therefore PIV = V_m \mid PIV \geq V_m$



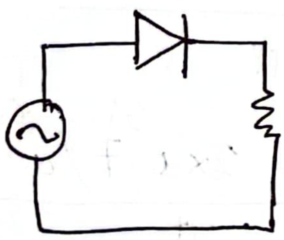
when Si diode,

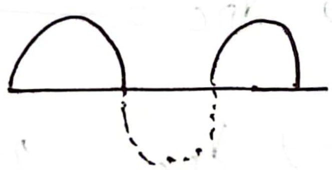
$$+V_o + 0.7 - PIV = 0$$

$$\therefore PIV = V_m + 0.7 \quad \boxed{\therefore PIV \geq V_m + 0.7}$$

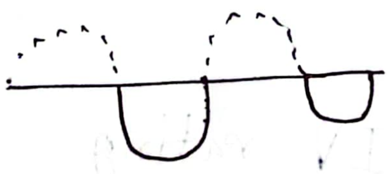
* 2. Clipper

Clipper: Clipper is a device that clips of a portion of the input waveform without distorting the remaining part.



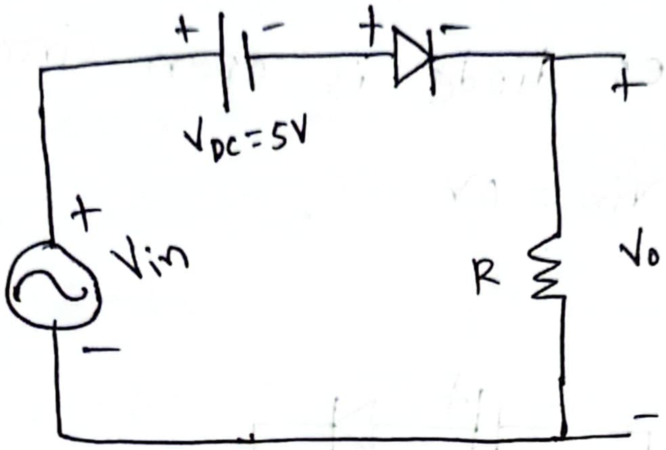


negative Clipper



positive clipper

Type-1



During (+)ve half cycle,

when $V_{in} < V_{DC}$

D_1 is off, So,

$V_o = 0\,V$

when $V_{in} > V_{DC}$

Applying KVL,

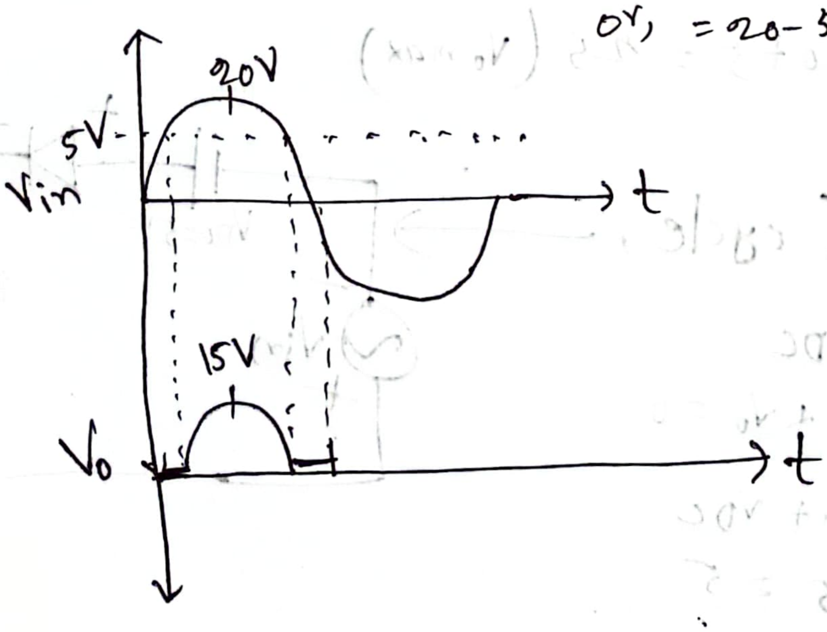
$-V_{in} + V_{DC} + V_o = 0$

$\Rightarrow V_o = V_{in} - V_{DC}$

or, $= 5 - 5 = 0V$

or, $= 7 - 5 = 2V$

or, $= 20 - 5 = 15$

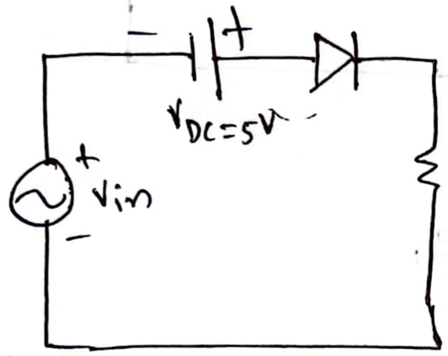


and During $(-)^{ve}$ half cycle,

for both sources diode is open circuited,

$$V_{in} = 0V$$

Type-2



During $(+)^{ve}$ half cycle ; both source diode is active

$$-V_{in} - V_{DC} + V_o = 0$$

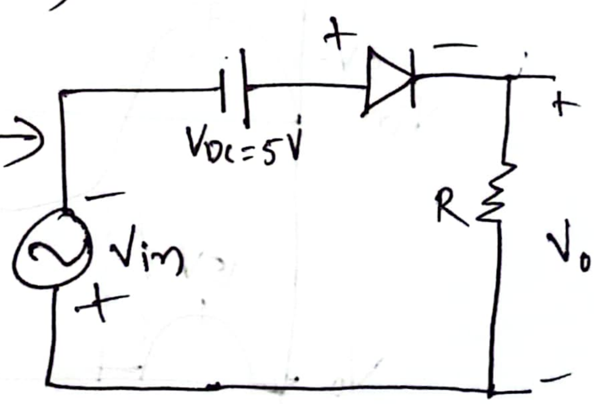
$$\therefore V_o = V_{in} + V_{DC}$$

$$= 0 + 5 = 5V \; (V_o \, min)$$

$$= 20 + 5 = 25 \; (V_o \, max)$$

During $(-)^{ve}$ half cycle,

when $V_{in} < V_{DC}$



$$+V_{in} - V_{DC} + V_o = 0$$

$$\therefore V_o = -V_{in} + V_{DC}$$

$$= 0 + 5 = 5$$

$$= -5 + 5 = 0$$

when $V_{in} > V_{DC}$, ~~Do~~ D_1 (diode) is open.

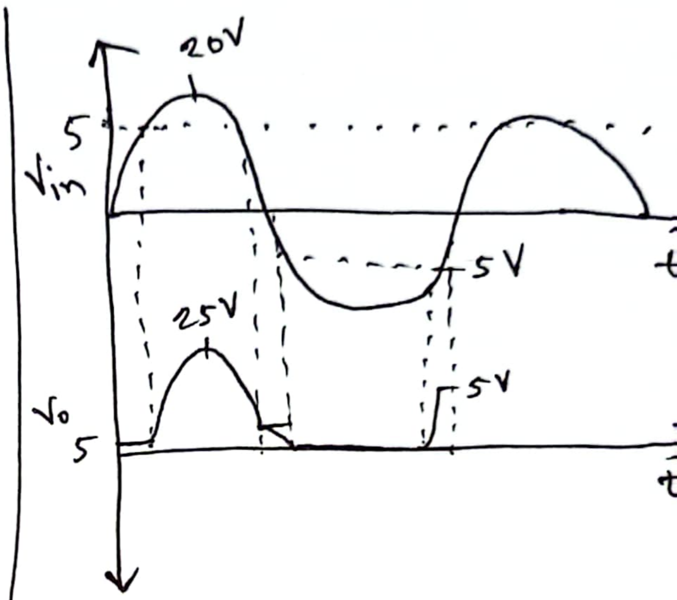
$\therefore V_o = 0V$

$= -(5+5)V = 0V$

or, $= (-4+5)V = 1V$

or, $= (-2+5)V = 3V$

or, $= (0+5) = 5V$

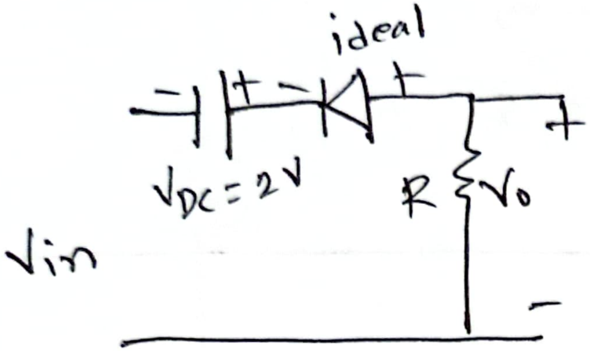


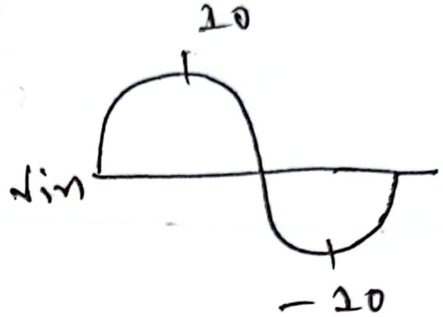
$\boxed{\text{Book}} \rightarrow$ Biased series clipper.

EEE 1231

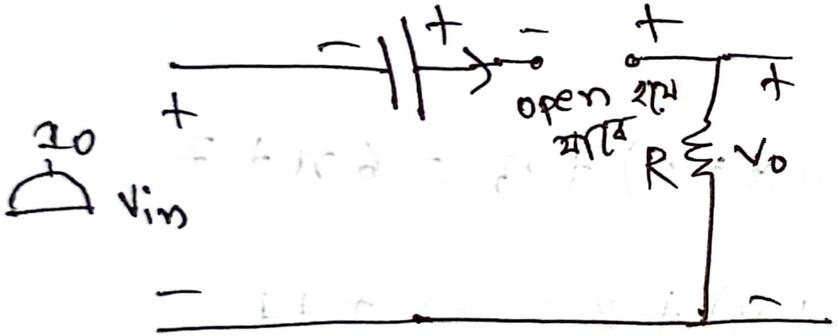
Clipper Math

lecture- 11
23.07.2024





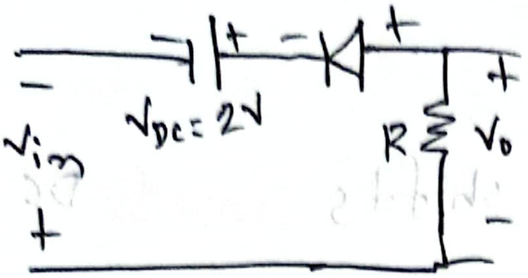
During $(+)^{ve}$ half cycle,



for both sources diode is open,

$V_o = 0V$

During $(-)^{ve}$ half cycle



when $V_{in} < V_{DC}$,

diode open circuited

$V_o = 0V$

and, when $V_{in} > V_{DC}$

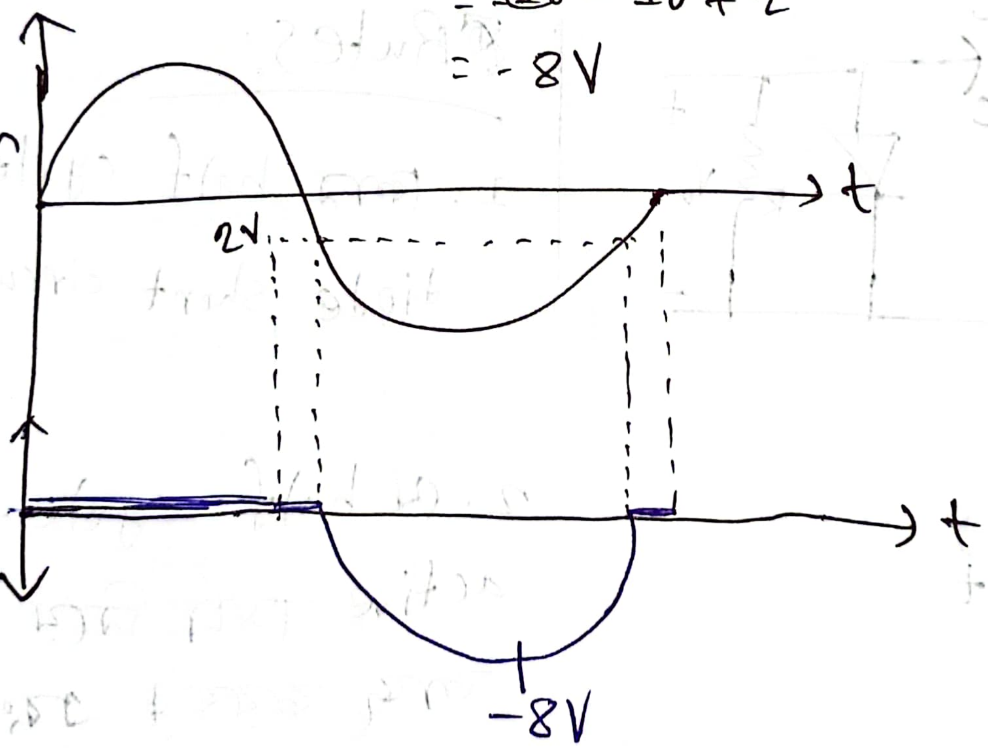
KVL,

$+V_{in} - V_{DC} + V_o = 0$

$\therefore V_o = -\cancel{V_o}V_{in} + V_{DC}$

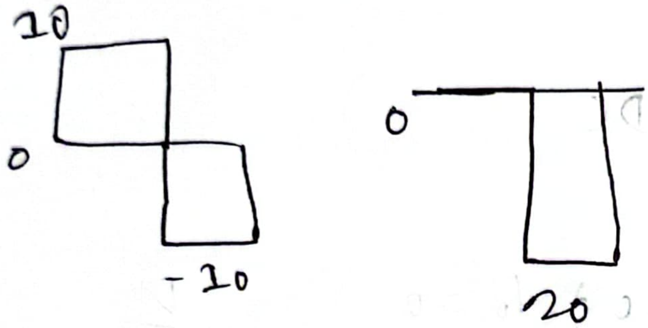
$= -10 + 2$

$= -8V$

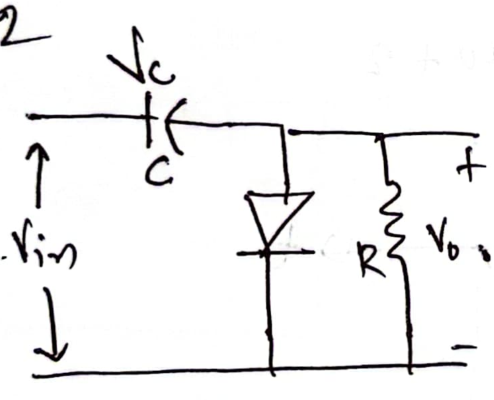


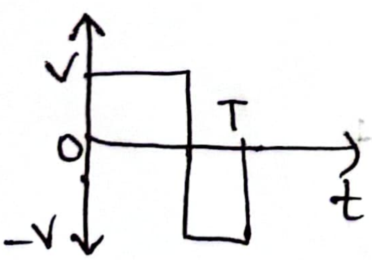
Clamper

⇒ Clamper is a circuit that shifts input DC level into another DC level.



Math-2





Rules:

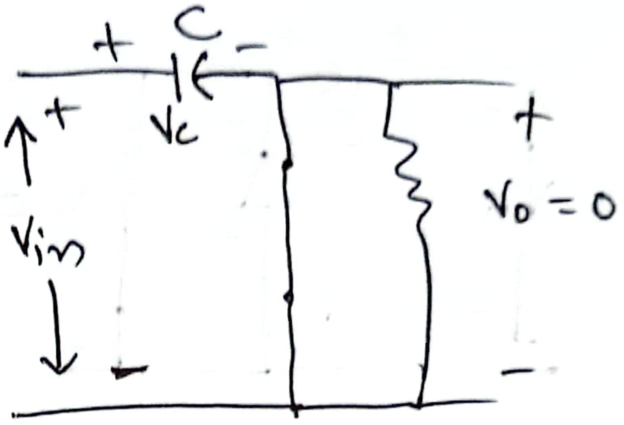
1. কোন half cycle -এ diode short circuited/active

2. যে half cycle -এ diode active সেটা নিয়ে আগে কাজ করব এবং V_c বের করব (capacitor V)

3. Finally other half cycle এর জন্য V_o বের করবো

for $(+)^{ve}$ half ~~ha~~ cycle,

diode is active



$V_o = 0V$

$\therefore -V_{in} + V_c = 0$

$\therefore V_c = V_{in}$

$= 10V$

এই half cycle-এ diode short হয়ে যায় এই half-cycle -এ capacitor charge হয়।

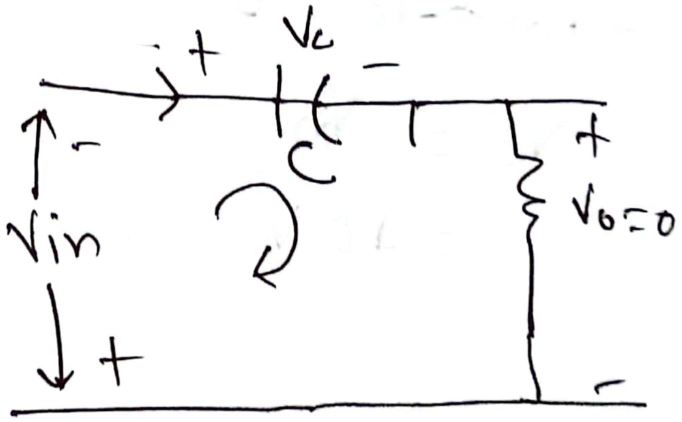
For $(-)^{ve}$ half cycle,

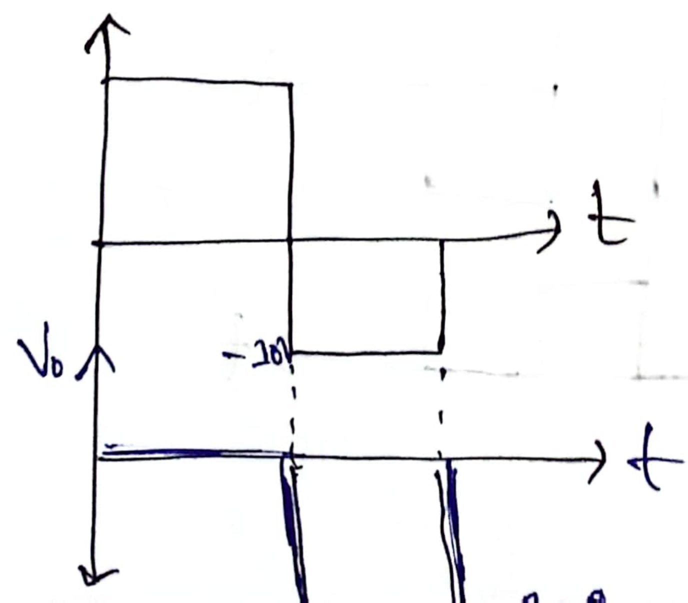
$+V_{in} + V_c + V_o = 0$

$\therefore V_o = -V_{in} - V_c$

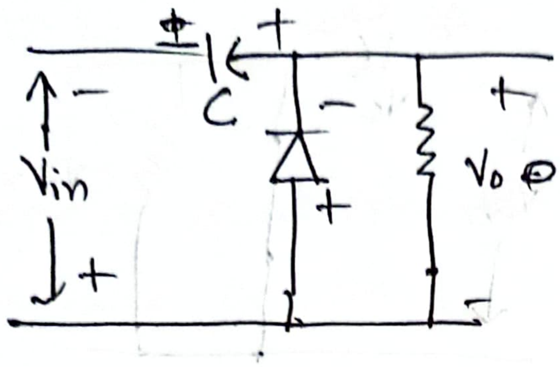
$= -10 - 10$

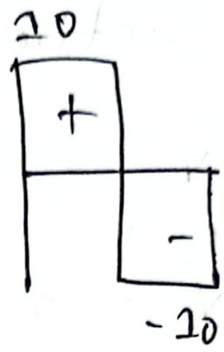
$= -20V$





Math-3





for $(-)^{ve}$ half cycle, diode is active,

$\therefore V_o = 0$

$+V_{in} - V_c = 0$

$\therefore V_c = V_{in}$

$= 10\,V$

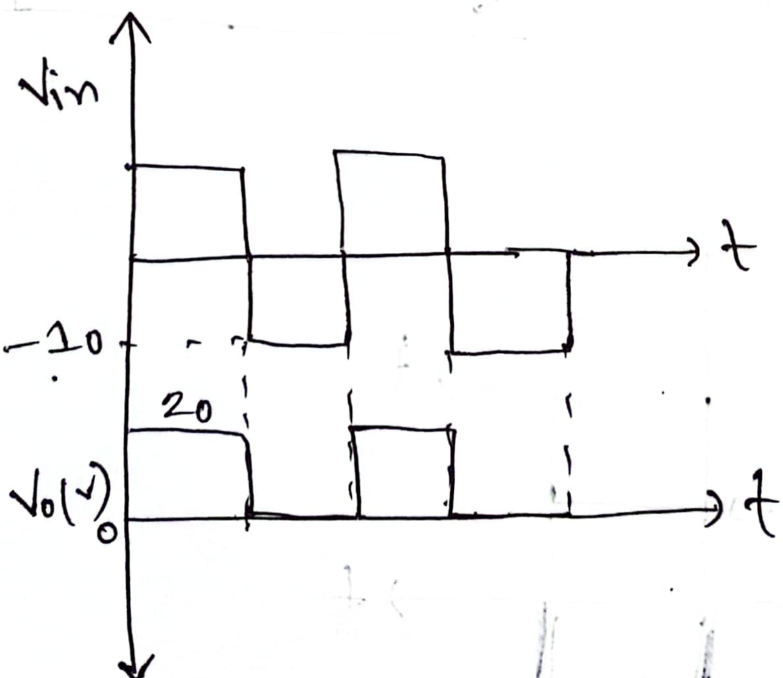
for $(+)^{ve}$ half cycle,

$-V_{in} - V_c + V_o = 0$

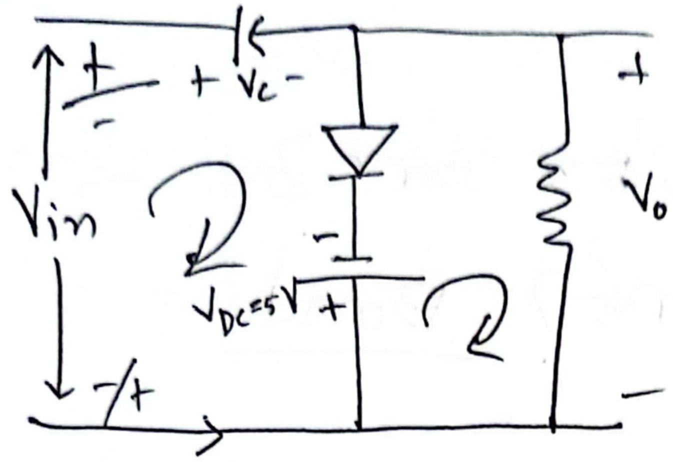
or, $V_o = V_c + V_{in}$

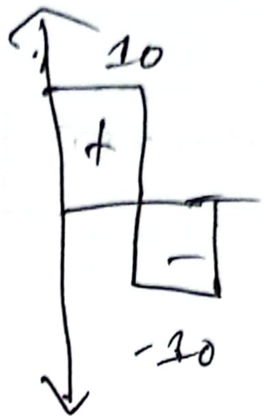
$= 10 + 10$

$= 20\,V$



math - 4





During $(+)^{ve}$ half,

diode is active (short circuited)

$V_o = -5V$

$-V_{in} + V_c - V_{DC} = 0$

$V_c = 5 + \underset{10V}{V_{in}} = 15\ V$

During $(-)^{ve}$ half,

$+V_{in} + V_c + V_o = 0$

$V_o = -V_{in} - V_c$

$= -10 - 15$

$= -25\ V$