/ L-1 / 20.07.2023 /

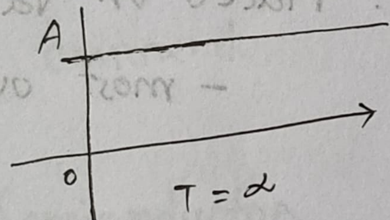
Analog~~ue~~ Electronics

Analog Signal ⇒ Infinite amplitude

Digital Signal ⇒ Finite amplitude

$$\text{Level} = 2^n$$

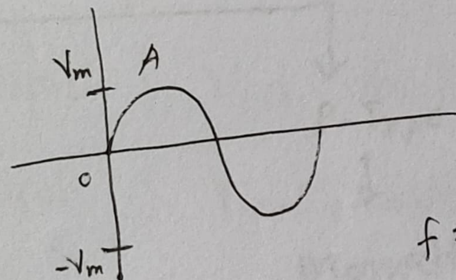
DC Signal ⇒



$T = \infty$

$f = 0$

AC Signal ⇒

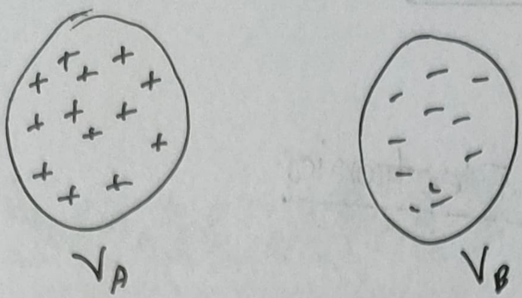


$f = \frac{1}{T}$

$T = ?$ finite

Passive Components ⇒ consume power only

Active Components ⇒ consume power and ~~amp~~ amplify power.



$$V = V_A - V_B$$

$$I = \frac{dQ}{dt}$$ (changes of current)

Valance Electron : Placed on Valance shell

- most outer shell

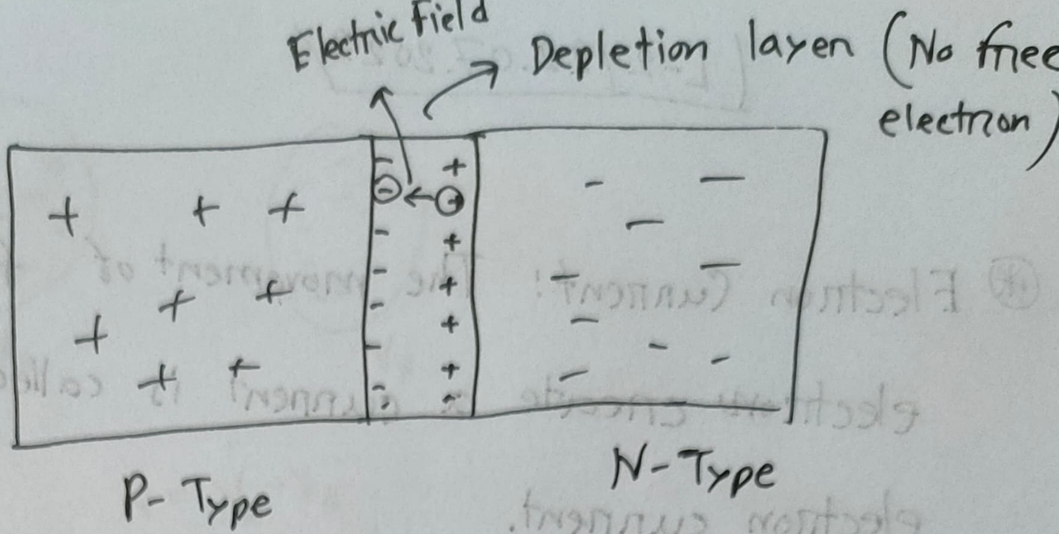
L-2 / 22.07.2023

⊛ Electron Current: The movement of free electrons create a current is called electron current.

⊛ Hole current: The hole has moved from one place to another in the crystal structure it is called hole current.

Semiconductor

- N-Type
  - Majority area electron
  - minor- holes
    - donor atom
- P-Type
  - Majority - holes
  - minor - electron



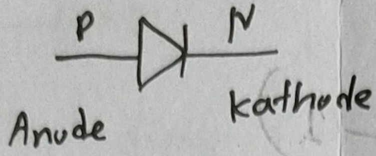
P-N Junction

(*) Construction of Diode : (How?)

⇒ A diode can be made by a silicon or a germanium semiconductor material.

For a diode half is doped as a p region and another half is doped as an n region. In a pn junction a depletion region exist in between p and n type materials.

⊛ Representation of Diode :



Diode Operating Condition

No bias ⇒ All normal and no external voltage

Forward bias ⇒ ~~EP~~ External voltage given in

$\overset{(+)}{P}-\overset{(-)}{N}$; external voltage greater than barrier potential.

$$I_D = I_{maj} - \underbrace{I_s}_{\to 0}$$

Reverse bias ⇒ External voltage connected as

$\overset{(-)}{P}-\overset{(+)}{N}$

$$I_D = \underbrace{I_{maj}}_{\to 0} - I_s$$

Diode Equation:

$$I_D = I_s \left(e^{V_D/nV_T} - 1 \right)$$

$$V_T = \frac{kT_k}{q} (v)$$

V_D = applied forwan biw voltage

I_s = reverse current

n = identity factor (1)

V_T = thermal voltage

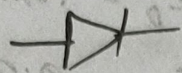
$k = 1.38 \times 10^{-23}$ J/k

T_k = absolute temperature in kelvins

q = magnitude of electron charge $= 1.6 \times 10^{-19}$ C

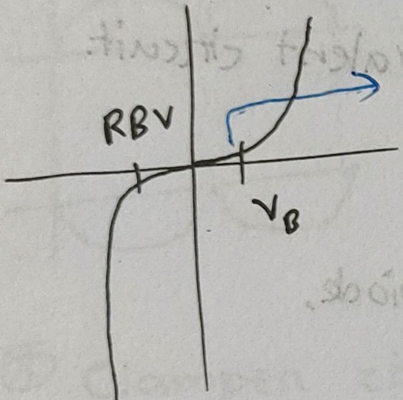
Lecture - 2 - Page - 12

/ L-3 / 27.07.2023 /

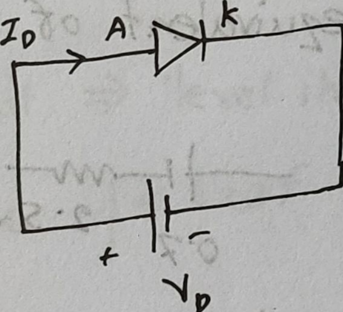


⇒ That is diode

⇒ Biasing → Forward, Reverse

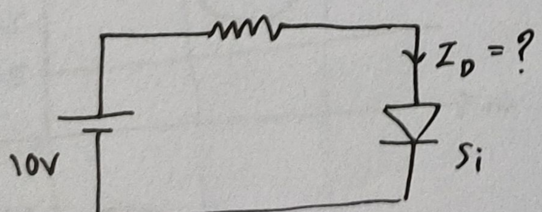


Thermal effect (I_s = minority current)

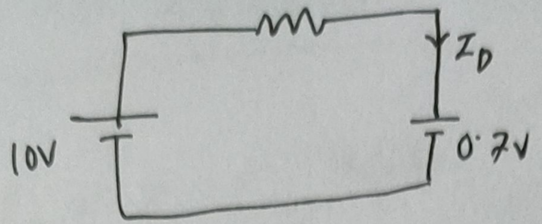


$V_D > 0$

⊛ Reverse Break down Voltage

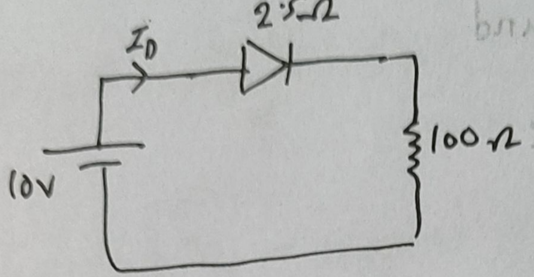


⊛ Ideal case, remove the diode and calculate.



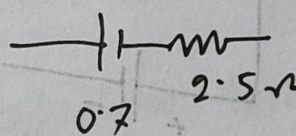
$I_D = 10mA$

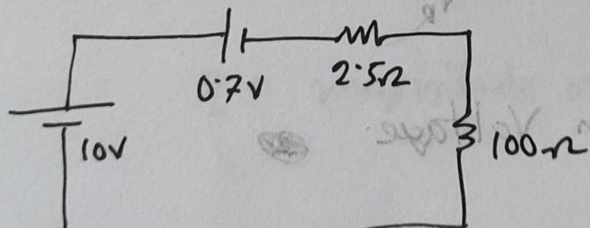
$I_D = 9.3mA$



Find I_D using piece-wise equivalent circuit.

Forward Bias equivalent of Diode.





Now solve it

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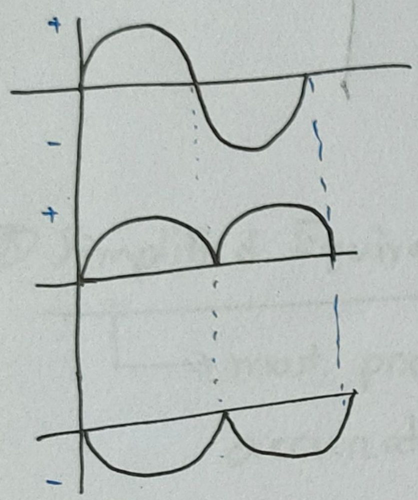
⊛ Semiconductor Diode Application

⊛ Rectifier (AC to DC)



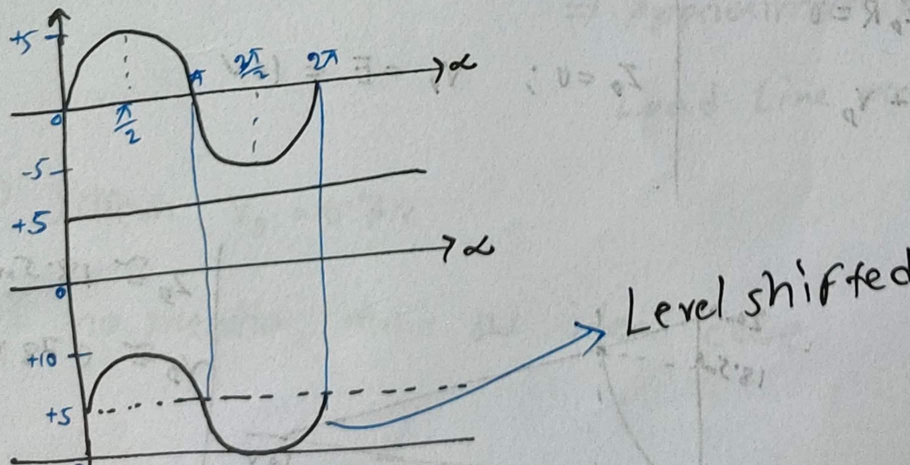
⊛ Clipper circuit

⇒ cut out voltage without changing ~~vo~~ waveform.

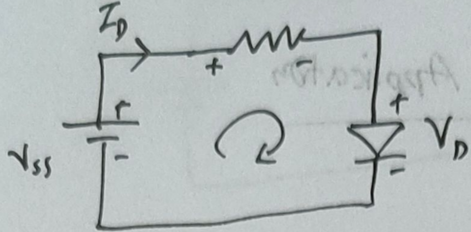
⊛ Clamper circuit ⇒ level shift

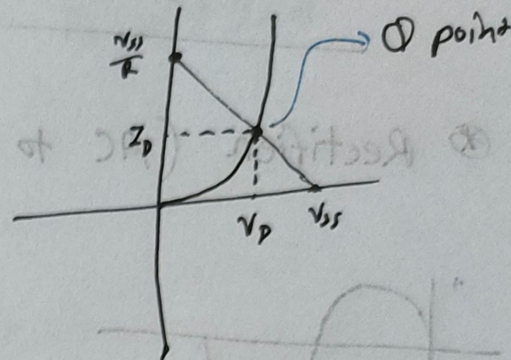
$v = 5 + 5\sin\alpha$ | $\alpha = \omega t$

DC AC



Load Line analysis:





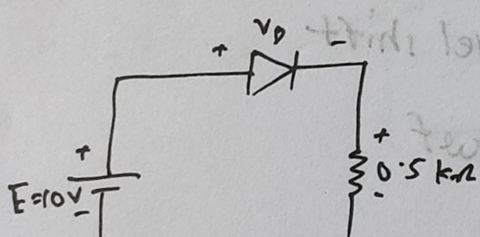
$V_{SS} - I_D R - V_D = 0$

$V_{SS} = I_D R + V_D$

→ $V_D = 0$; $I_D = \frac{V_{SS}}{R} =$

→ $I_D = 0$; $V_D = V_{SS} =$

Load Line analysis:

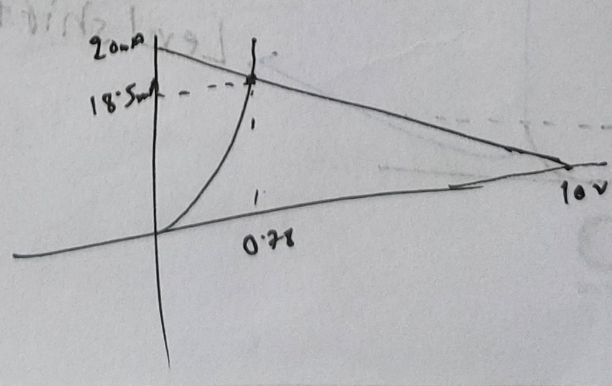


$E - V_D - I_D R = 0$

$E = I_D R + V_D$

$V_D = 0$; $I_D = \frac{E}{R} = \frac{10}{0.5\ k\Omega} = 20\ mA$

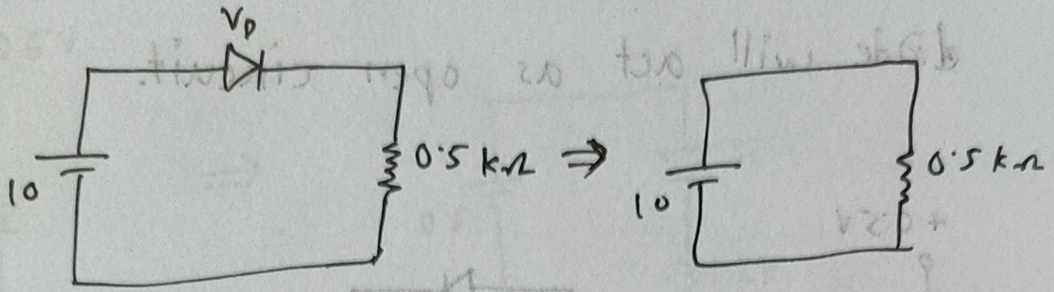
$I_D = 0$; $V_D = E = 10V$



$I_D \cong 18.5\ mA$

$V_D \cong 0.78\ V$

⊛ Ideal Equivalent Circuit:

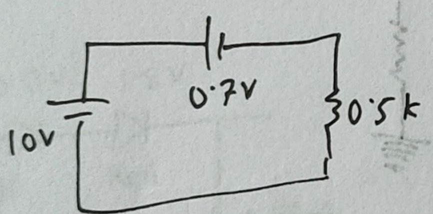


$I_D = 20\,mA$

Ideal value, no drop, no barrier.

⊛ Simplified Equivalent Circuit:

→ most preferable esy calculation and almost accurate result for complex circuit.



$V_D = 0.7V$

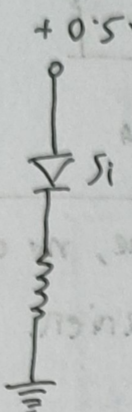
$I_D = \left(\frac{10-0.7}{0.5k}\right) = 18.6\,mA$

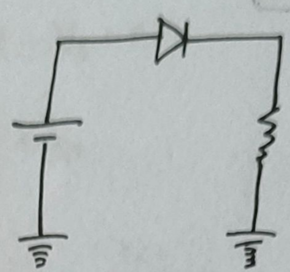
⇒ Approximately same as Load Line analysis.

⊛ Silicon, $V_D = 0.7V$

if no mention, take as ideal case.

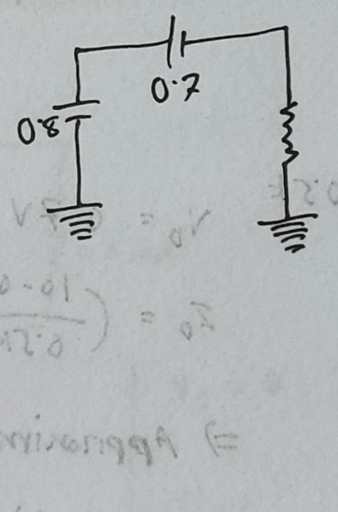
* Applied voltage less than barrier voltage, the diode will act as open circuit.



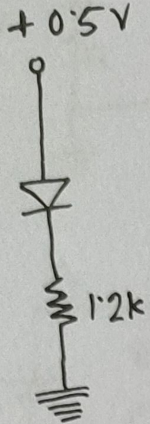


$I_D = 0V$

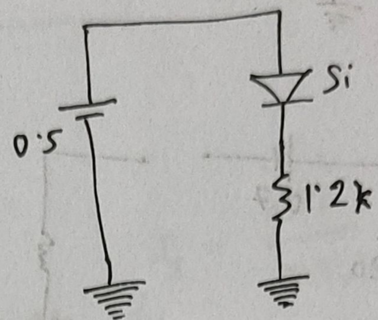
if, $V = 0.8V$ → forward bias replace



L-5/05.08.2023/

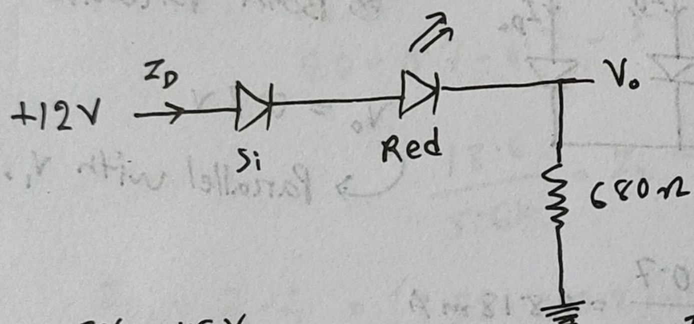


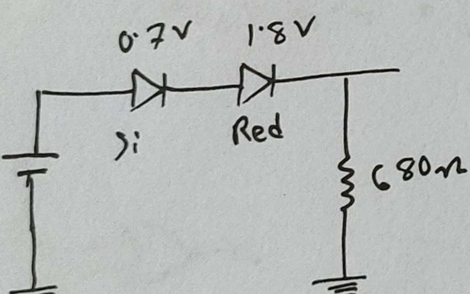
⇒



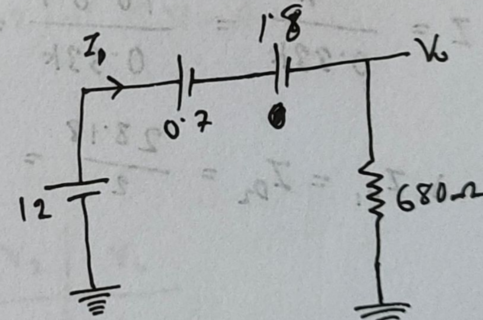
$0.5 < Si = 0.7$

∴ No current

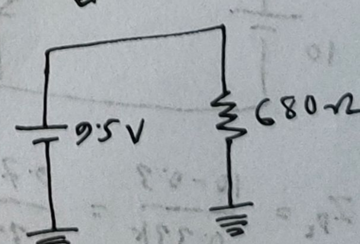




⇒



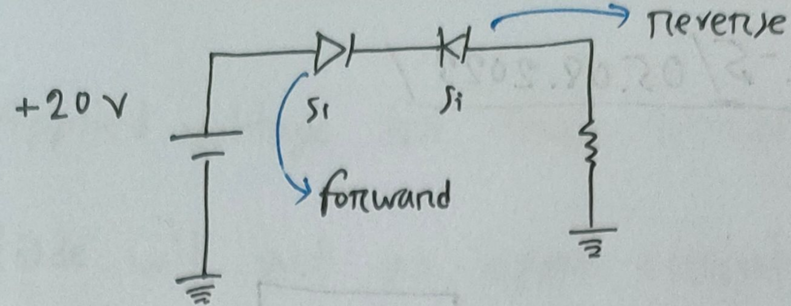
⇓

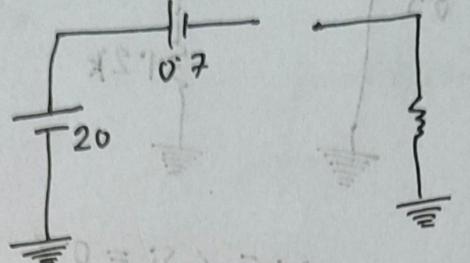


⇐

$V_D = 9.5\ V$

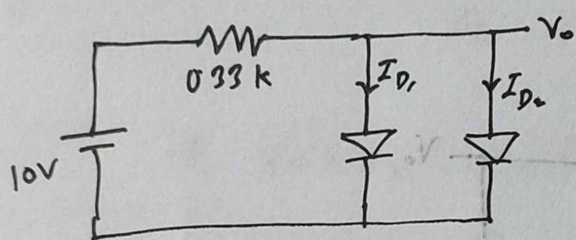
$I_D = \frac{9.5}{0.68}\ mA$





$I_D = 0$

$V_{D_2} = 20V$



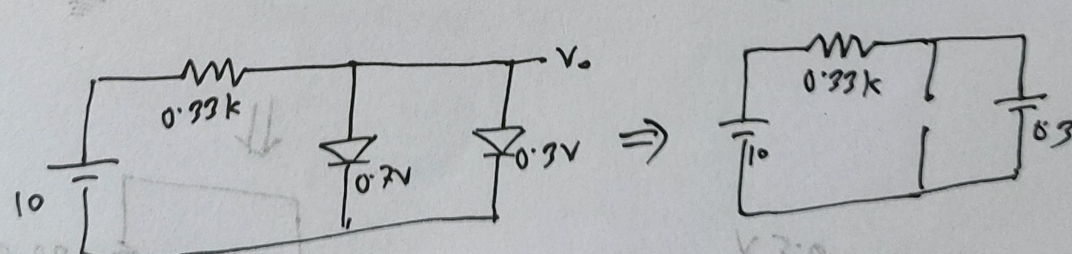
⊛ Both forward

$V_o = 0.7V$

↪ Parallel with V_1, V_2

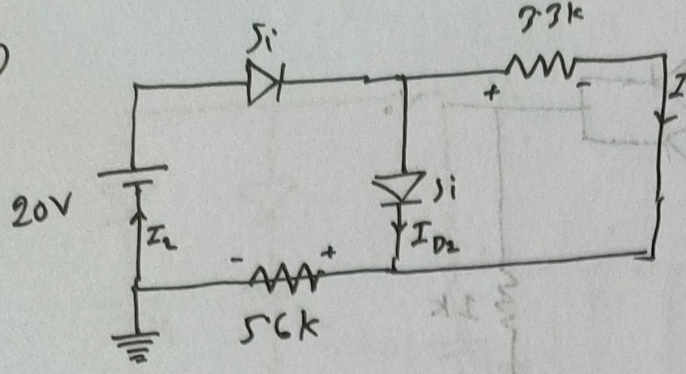
$$I = \frac{V_R}{0.33k} = \frac{10-0.7}{0.33k} = 28.18 \, mA$$

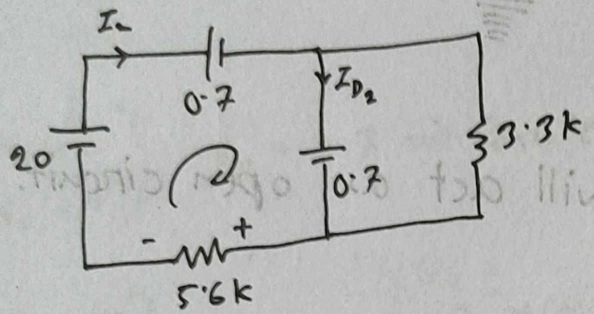
$$\rightarrow I_{D_1} = I_{D_2} = \frac{28.18}{2} = 14.09 \, mA$$



$$I_{D_2} = \frac{10-0.3}{0.33k} = \frac{9.7}{0.33k} mA$$

⊛ Current will follow the shortest and easyest path.





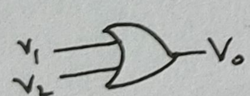
$I_1 = \frac{0.7}{3.3k} = 0.212\ mA$

Parallel with D_2

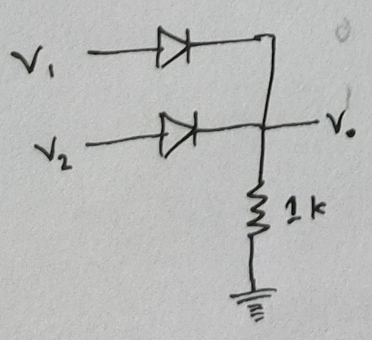
$20 - 0.7 - 0.7 - 5.6k \cdot I_2 = 0$

$\frac{18.6}{5.6k} = I_2 = 3.32\ mA$

$I_{D_2} = I_2 - I_1 = (3.32 - 0.212) = 3.11\ mA$

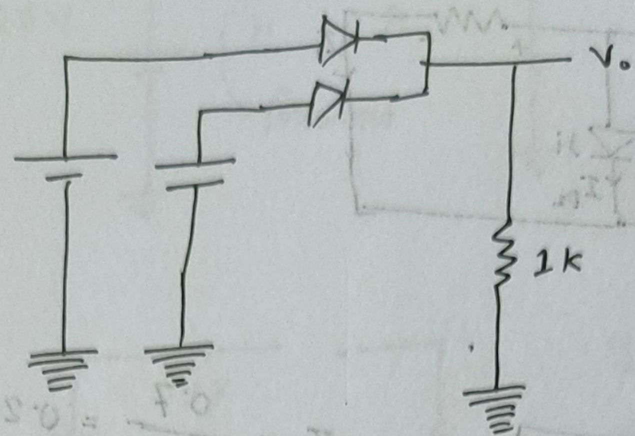


V_1	V_2	V_o
0	0	0
0	1	1
1	0	1
1	1	1



Seacal-D
Calcium Carbonate (From Coral Source) and Vitamin D3 (Colecalciferol)

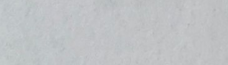
Seacal-DX
Calcium Carbonate (From Coral Source) and Vitamin D3 (Colecalciferol)



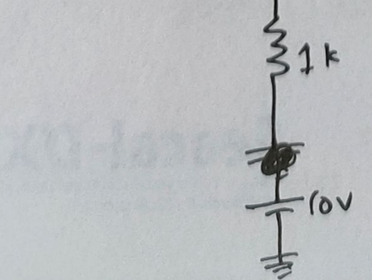
$\Rightarrow$ $V_1 = 0$, $V_2 = 0$ } Diode will act as open circuit.

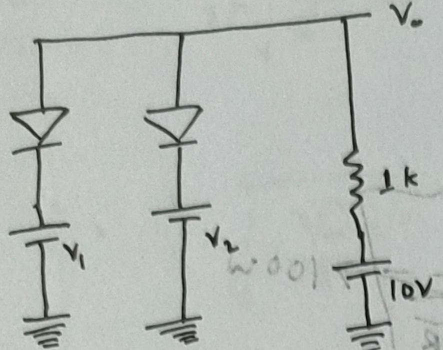
$V_1 = 0$, $V_2 = 5$ } D_1 = Open, $D_2 = 0.7$ (forward) $\Rightarrow V_o = 5 - 0.7 = 4.3V$

$V_1 = 5$, $V_2 = 5$ } $D_1 = 0.7$, $D_2 = 0.7$ } Both forward $\Rightarrow V_o = 4.3V$



V_1	V_2	V_o
0	0	0
0	1	0
1	0	0
1	1	1



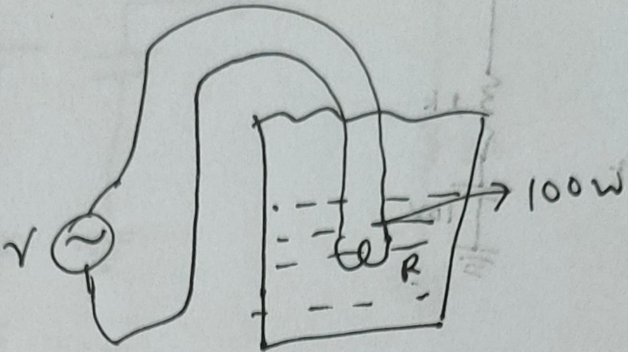


$\left.\begin{aligned} V_1 &= 0 \\ V_2 &= 0 \end{aligned}\right\}$ $V_o = 0.7 \Rightarrow$ Parallel with V_1, V_2

$\left.\begin{aligned} V_1 &= 10 \\ V_2 &= 0 \end{aligned}\right\}$ $V_o = 0.7 \Rightarrow V_1 =$ Open

$\left.\begin{aligned} V_1 &= 10 \\ V_2 &= 10 \end{aligned}\right\}$ $V_o = 10V \Rightarrow V_1 = V_2 =$ Open

L-6/10.08.2023/



Power factor

P.F. ≅ 1
is most effecient

$$P_{DC} = \frac{v^2}{R}$$

$$P_{AC} = \frac{v^2}{R} = \frac{V_m^2 \, 2\sin^2\omega t}{2R}$$

$$= \frac{V_m^2}{2R}(1-\cos 2\omega t)$$

$P = VI\cos\theta$

P.f.

$$P_{avg} = \frac{V_m^2}{4\pi R}\int_0^{2\pi}(1-\cos 2\omega t)\, d\omega t$$

$$= \frac{V_m^2}{4\pi R}\cdot 2\pi$$

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

RMS

Root

Mean

Square

$$P_{DC} = P_{avg}(AC)$$

$$\frac{v^2}{R} = \frac{V_m^2}{2R} \quad \therefore \quad V_{effective} = \frac{V_m}{\sqrt{2}} = 0.707\, V_m$$

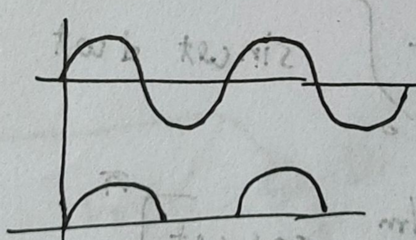
$$V_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V_m^2 \sin^2\omega t \, d\omega t}$$

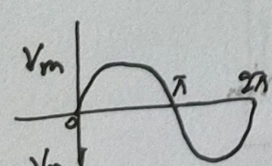
$$= \sqrt{\frac{V_m^2}{2}}$$

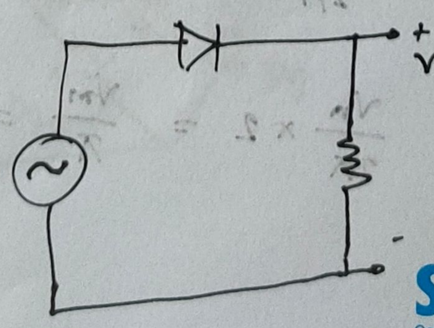
$$= \frac{V_m}{\sqrt{2}} = V_{effective}$$

Rectifier
- Half Wave
- Full Wave
  - Bridge
  -

Half Wave

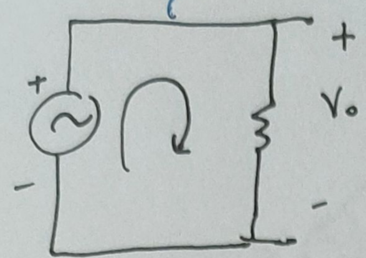






For positive parts

forward (short)

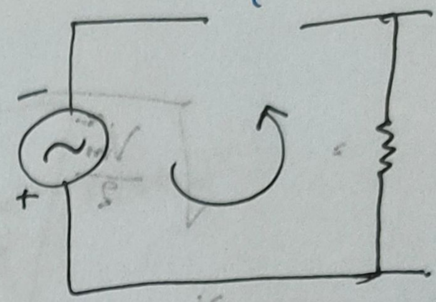


$V_m - V_o = 0$

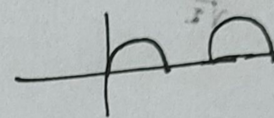
$V_m = V_o$

For negative parts

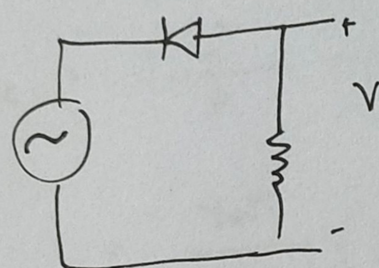
Reverse(open)



$V_o = 0$

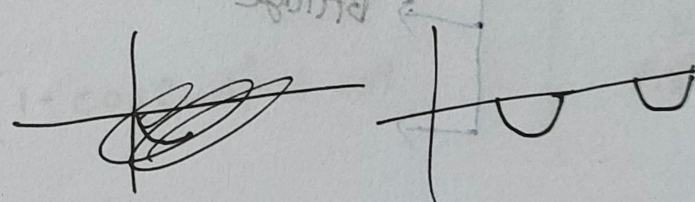


㊉



For positive ⇒ reverse (open)

For negative ⇒ forward (short)



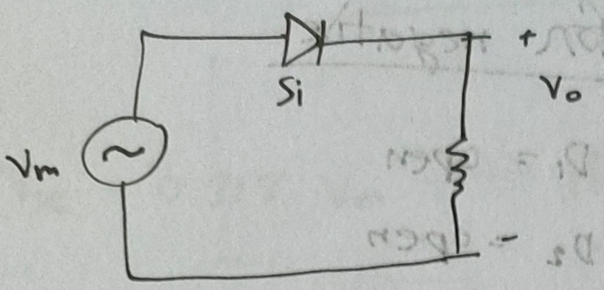
㊉

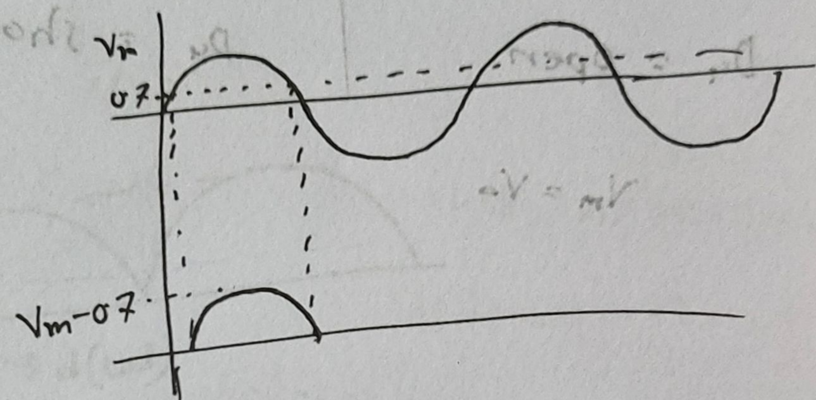
$$V_{avg} = \frac{V_m}{2\pi} \int_0^{\pi} \sin \omega t \; d\omega t$$

$$= -\frac{V_m}{2\pi} \cos \omega t \Big]_0^{\pi}$$

$$= \frac{V_m}{2\pi} \times 2 = \frac{V_m}{\pi} = 0.318 \, V_m$$

*

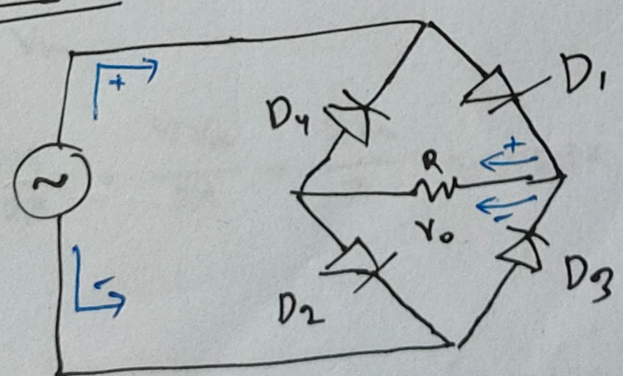




$$V_{avg} = 0.318\, V_m$$
$$= 0.318\,(V_m - 0.7)$$

* Diode Rating

* Full Wave:



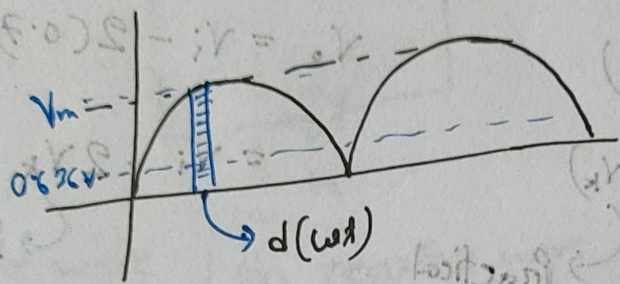
for positive	for negative
D_1 = short	D_1 = open
D_2 = short	D_2 = open
D_3 = open	D_3 = short
D_4 = open	D_4 = short

$V_m = V_o$

L-7/12-08.2023

* $V_{DC} = 0.318\ V_m \longrightarrow$ Half Wave Rectifier

$V_{DC} = 0.636\ V_m \longrightarrow$ Full Wave Rectifier



* $\int_0^{2\pi} V_m \sin\omega t \, d\omega t$

$= V_m \left[\left\{ \int_0^{\pi} \sin\omega t \, d\omega t + \int_{\pi}^{2\pi} \sin\omega t \, d\omega t \right\} \right.$

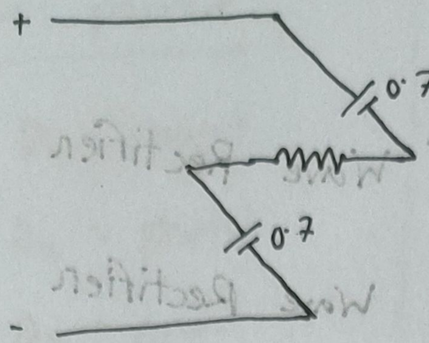
$= -V_m \left\{ \left[\cos\omega t\right]_0^{\pi} + \left[\cos\omega t\right]_{\pi}^{2\pi} \right\}$

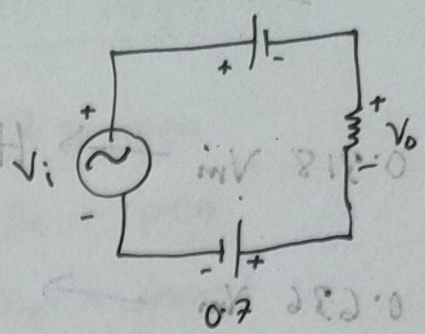
$= -V_m \left\{ (-1-1) + (-1-1) \right\}$

$= 4\ V_m$

$\therefore V_{DC} = \frac{A}{2\pi} = \frac{4V_m}{2\pi} = \frac{2V_m}{\pi} = 0.636\ V_m$

⊛





$$\Rightarrow V_i - 0.7 - V_o - 0.7 = 0$$

$$V_o = V_i - 2(0.7)$$

$$= V_i - 2V_k$$

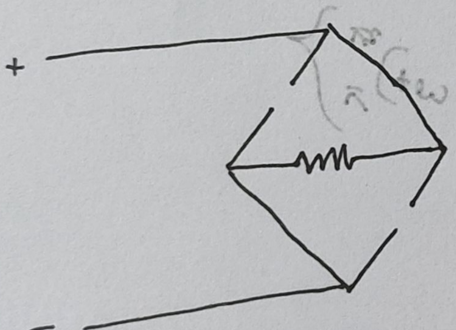
knee voltage

$\therefore V_{AC} = 0.636\, V_m$ (ideal)

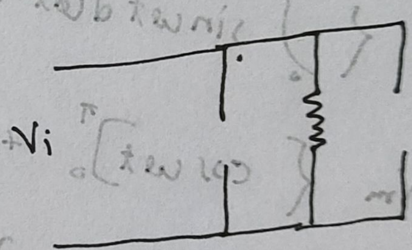
$V_{DC} = 0.636\,(V_m - 2V_k)$

Practical

⊛ Diode Rating

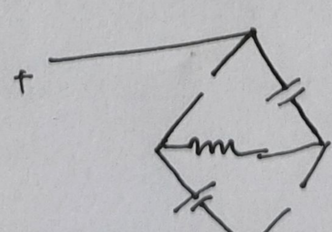


ideal case



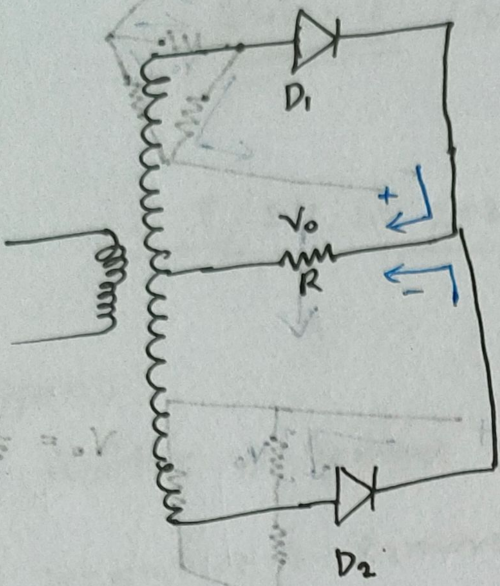
$$V_{PIV} \geq V_m$$

* ⇒ Practical Case



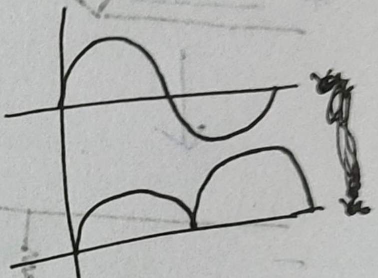
then, $V_{PIV} \geq (V_m - V_k)$

⊛ Center tapped transformer



⊛ its costly, used on low power source and for effeciency.

for positive wave	for negative wave
D_1 = short	D_1 = open
D_2 = open	D_2 = short



⊛ Question Pattern: Real Diode effect with output graph. it will reduce by V_K.

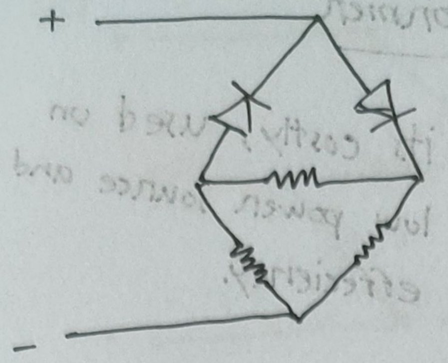
⊛ PIV → V.V.I

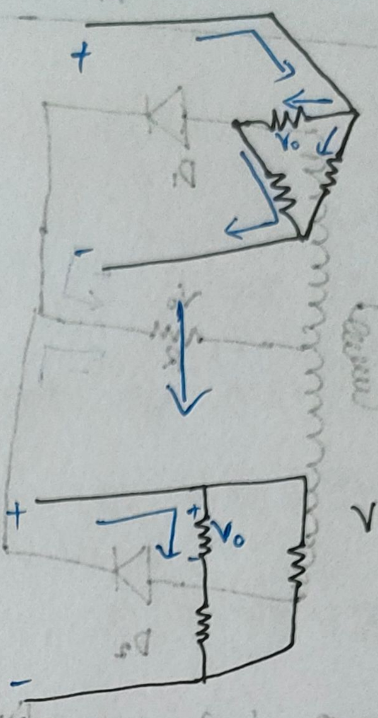
for negative,

in D_1 position

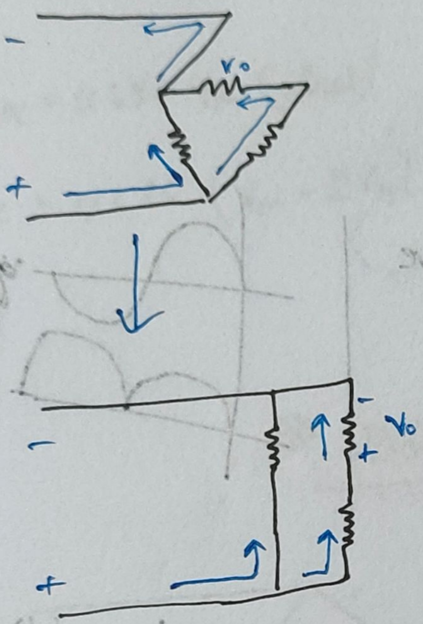
$$-V_i + V_{PIV} - V_o = 0$$

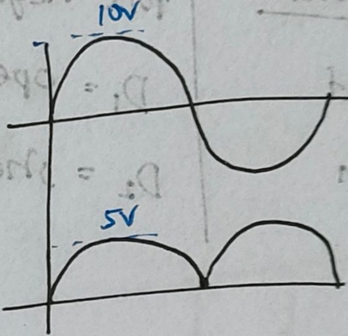
$$V_{PIV} = V_i + V_o = V_i + V_i = 2V_m$$



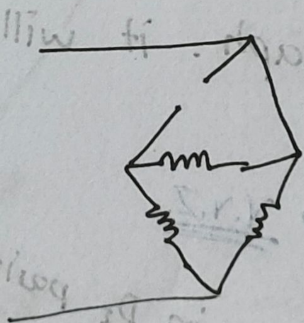


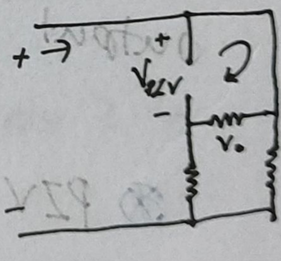
$V_o = \frac{1}{2} V_i$





$V_o = \frac{1}{2} V_i$





$V_o = V_{PIV}$

$V_{PIV} = \frac{1}{2} V_m = 5V$

Quiz-1
Next ~~Sunday~~ Saturday
L 1-4

Practical Application

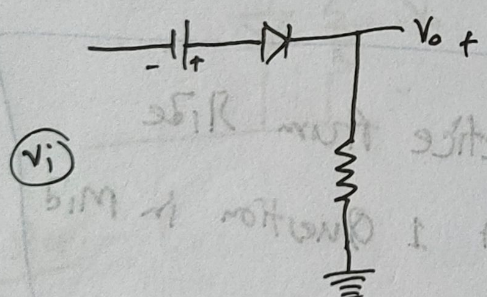
L-8 / 19.08.2023 /

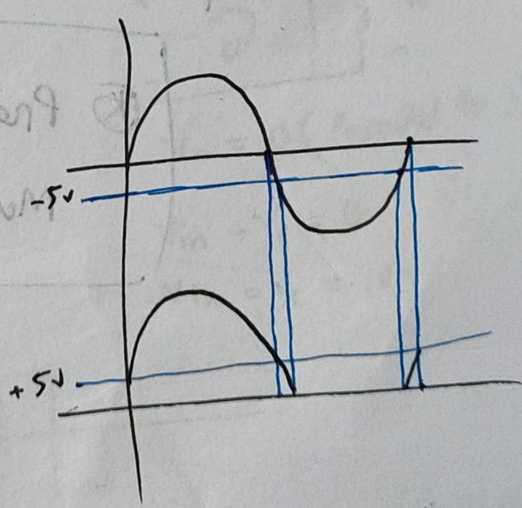
Quiz-1 / No Class

L-9 / 24.08.2023 /

Clippers
- Positive ⇒ Remove positive half cycle
- Negative ⇒ Remove negative
- Biased
- Combinational

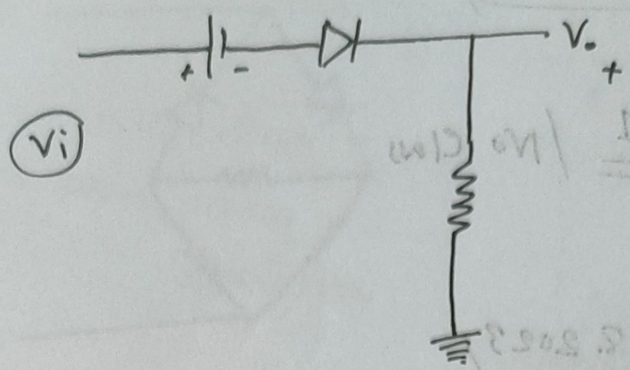
Biased





$V_{in} + 5 - V_o = 0$

$V_o = 5 + V_{in}$

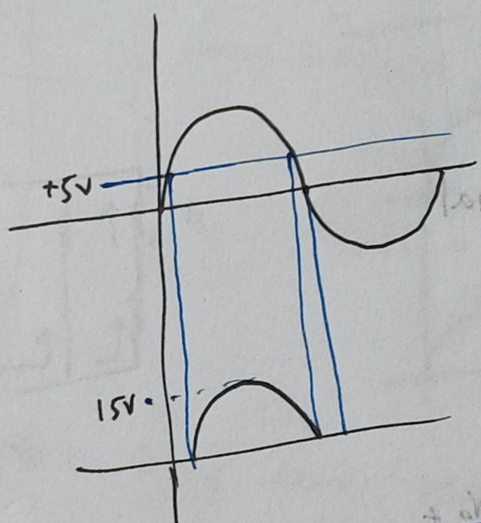


$V_{in} - 5 - V_o = 0$

$V_o = V_{in} - 5$

$-V_{in} - 5 - V_o = 0$

$V_o = -5in - 5$



(*) Practice from Slide
Must 1 Question in Mid

L-10/26.08.2023/

Clamper Circuit

⊛ Solving Step:

1st Step:

⇒ Forward Cycle indetification

⇒ Calculate V_o

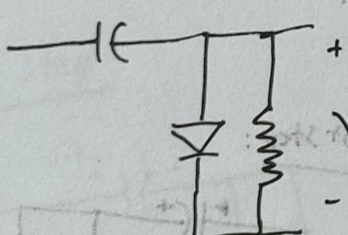
⇒ Calculate V_c

2nd Step:

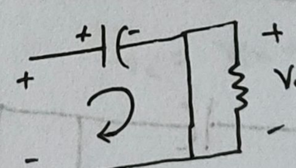
⇒ Reverse Cycle identification

⇒ Calculate V_o

⊛



1st Step

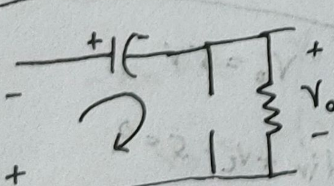


$V_o = 0$ (Parallel to short)

$V_{in} - V_c = 0$

$V_{in} = V_c = 10V$

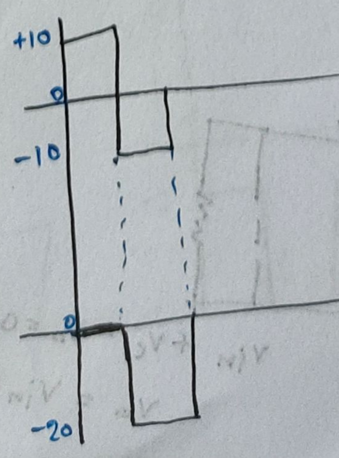
2nd Step:



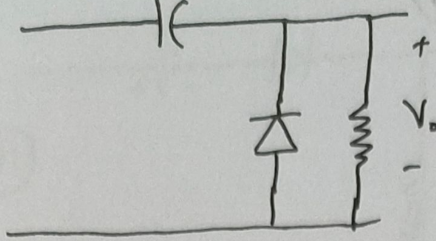
$-V_{in} - V_c - V_o = 0$

$V_o = -(V_{in} + V_c)$

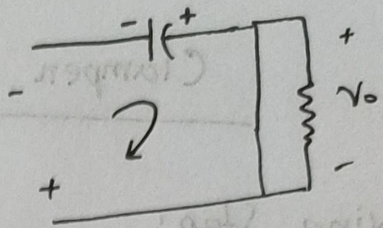
$= -20V$



⊛



1st Step

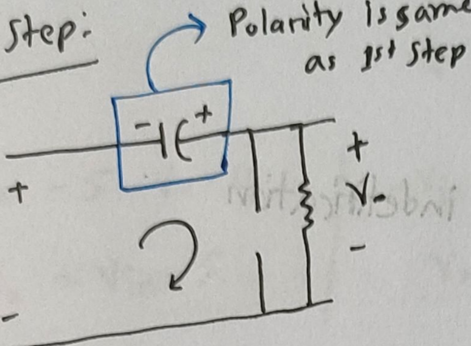


$V_o = 0$

$-V_{in} + V_c = 0$

$V_c = V_{in} = 10V$

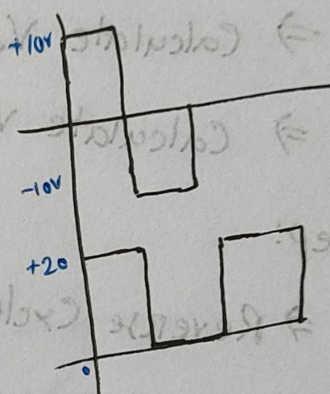
2nd Step:



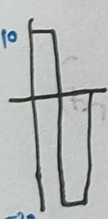
$V_{in} + V_c - V_o = 0$

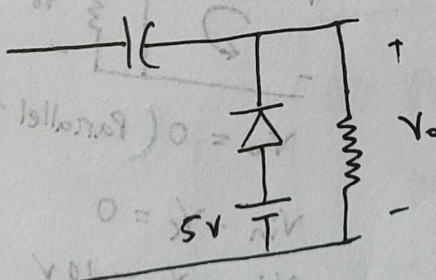
$V_o = V_{in} + V_c$

$= 20V$

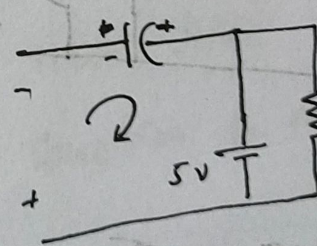


⊛ Biased Clamper Circuit:





1st Step:



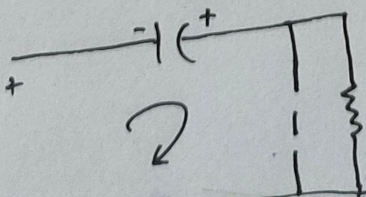
$V_o = 5V$

$-V_{in} + V_c - 5 = 0$

$V_c = V_{in} + 5$

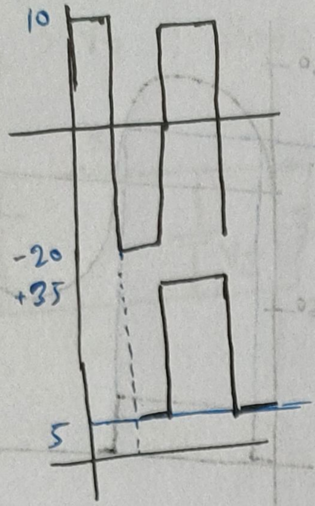
$= 25$

2nd Step



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

$V_o = V_{in} + V_c = 10 + 25 = 35$



Practice more from Slide

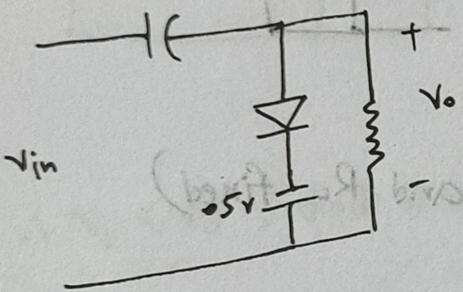
Swing

$10+20=30$

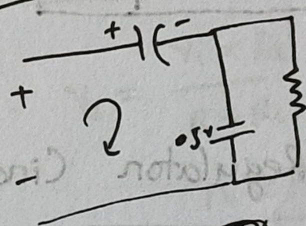
$35-5=30$

Authentication Successful

From Slide



1^{st} Step

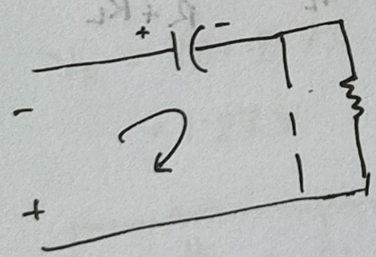


$V_o = -5V$

$V_{in} - V_c + 5 = 0$

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

2^{nd} Step

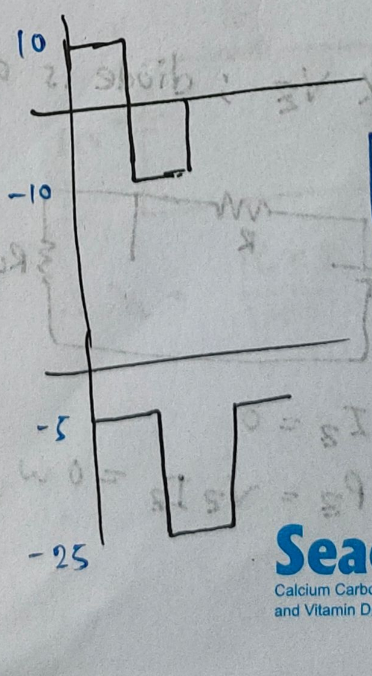


$-V_{in} - V_c - V_o = 0$

$V_o = -(V_{in} + V_c)$

$= -(10+15)$

$= -25V$



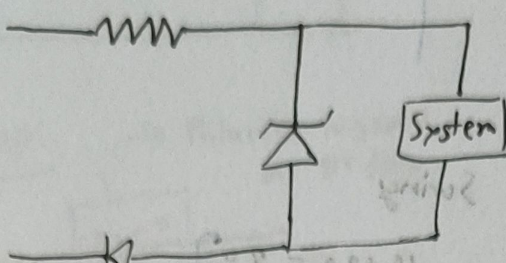
2^{nd} Week Quiz-2

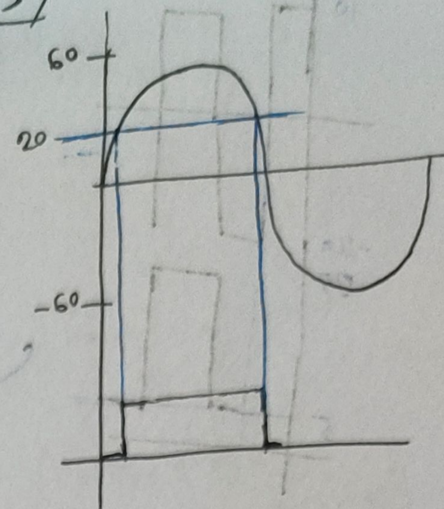
Swing

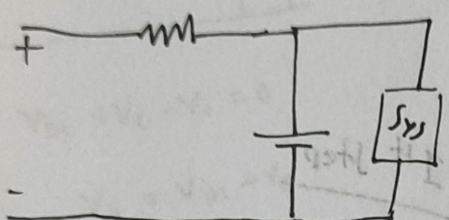
$10+10=20$

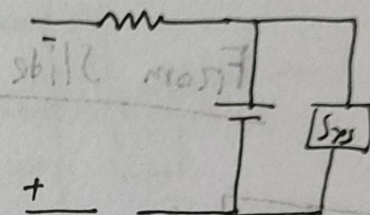
$-5+25=20$

L-11/31.08.2023/

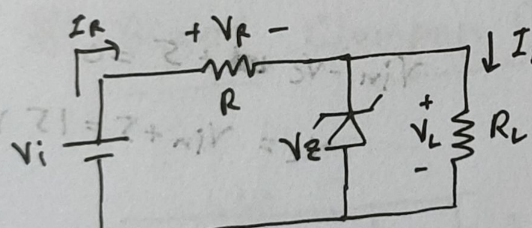






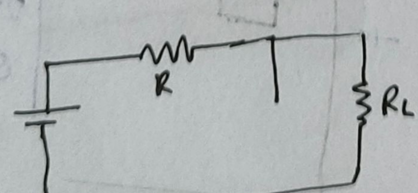


⊛ Voltage Regulator Circuit (V_i and R_L fixed)



$$V_L = \frac{V_i \times R_L}{R + R_L}$$

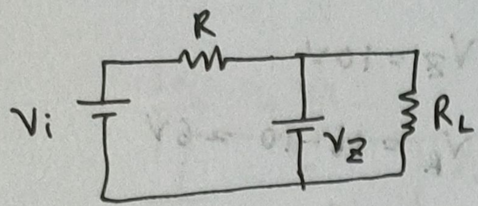
(i) $V_L < V_Z$; diode is off



$I_Z = 0$

$P_Z = V_Z I_Z = 0\ W$

(ii) $V_L > V_Z$; diode is On



$$I_R = \frac{V_R}{R} = \frac{V_i - V_Z}{R}$$

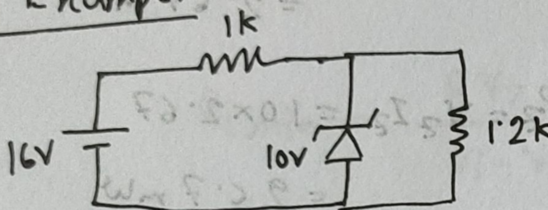
$$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L}$$

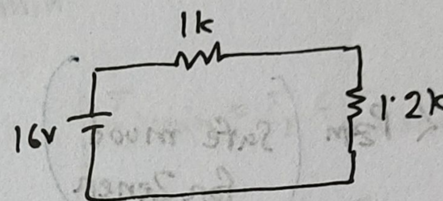
$$I_R = I_Z + I_L$$

$$I_Z = I_R - I_L$$

$$P_Z = V_Z I_Z$$

Example:





$$\therefore V_L = \frac{V_i \times R_L}{R + R_L}$$

$$= \frac{16 \times 1{\cdot}2}{1 + 1{\cdot}2}$$

$$= 8{\cdot}73\,V$$

$\therefore V_L < V_Z$; diode is off

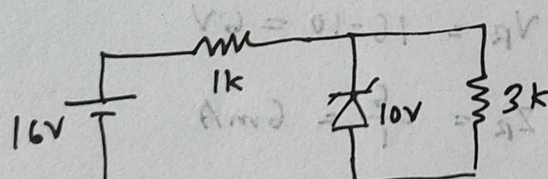
$\therefore I_Z = 0$

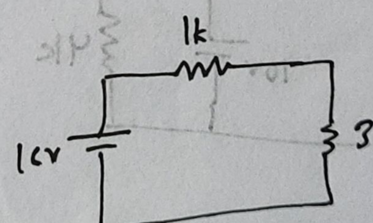
$P_Z = 0\,W$

$V_R = 10 - 8{\cdot}73$

$= 1{\cdot}27\,V$

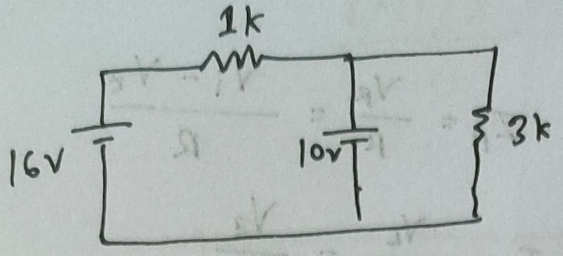
✱





$$\therefore V_L = \frac{16 \times 3}{1+3} = 12V$$

$\therefore V_L > V_Z$; diode is On.



$V_L = 12V$

$V_Z = 10V$

$V_R = 16 - 10 = 6V$

$I_R = \frac{6}{1} = 6mA$

$I_L = \frac{V_L}{R_L} = \frac{10}{3} = 3.33mA$

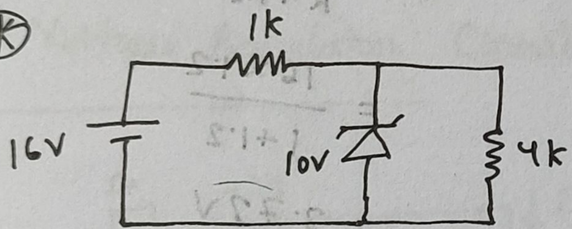
$I_Z = I_R - I_L = 6 - 3.33$

$= 2.67 mA$

$P_Z = V_Z I_Z = 10 \times 2.67$

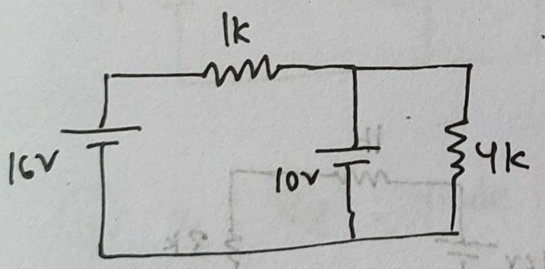
$= 26.7 mW$

$\therefore P_Z < P_{ZM}$ (Safe mood for Zener)



$V_L = \frac{16 \times 4}{1+4} = 12.8V$

$\therefore$ Diode is on



$\therefore V_L = 12.8V$

$V_R = 16 - 10 = 6V$

$I_R = \frac{6}{1} = 6mA$

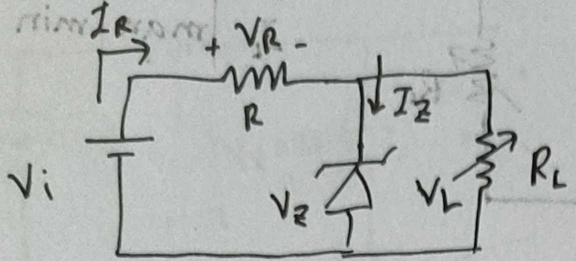
$I_L = \frac{V_L}{R_L} = \frac{10}{4} = 2.5mA$

$I_Z = I_R - I_L = 6 - 2.5 = 3.5mA$

$P_Z = V_Z I_Z = 10 \times 3.5 = 35 mW$

$\therefore P_Z > P_{ZM}$ (Not safe, Zener diode will be damage)

⊛ Voltage Regulator (V_i fixed & R_L variable)



$$V_Z = V_L = \frac{V_i \times R_{L\,min}}{R + R_{L\,min}}$$

$$R_{L\,min} = \frac{R V_Z}{V_i - V_Z}$$

$$I_{L\,min} = I_R - I_{Z\,max}$$

$$P_{ZM} = V_Z I_{Z\,max}$$

$$I_{L\,max} = \frac{V}{R_{L\,max}}$$

$$R_{L\,max} = \frac{V_L}{I_{L\,min}}$$

$$I_{Z\,min} = I_R - I_{L\,max}$$