17/10/23

UNIT-II

DIODE APPLICATIONS

Power Supply

- Linear mode power supply (LMPS)
- Switch mode power supply (SMPS)

- ac to dc (converter)
- dc - dc (converter), dc - ac (inverter)

- A transformer is a device that transfers electrical energy from one circuit to another

Transformer (Based on voltage levels)

Step up Transformer
- Used b/w power generator and power grid
- The secondary output voltage is higher than the input voltage.

Step-down Transformer
- Used to convert high voltage primary supply to low-voltage secondary output.

- Basic Building block of Linear Mode power Supply.

i/p → Step down T.F → Rectifier → Filter (R, L, C) → Regulator (Zener) → Desired o/p V

- 230 V, 50 HZ

Rectifier

- Converting ac voltage into dc voltage

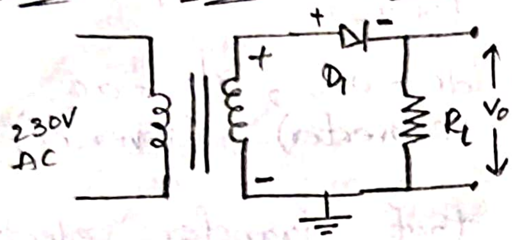
Half-wave Rectifier
- that allows one-half of the AC voltage signal & blocks the other half and converts AC Vol to DC Vol

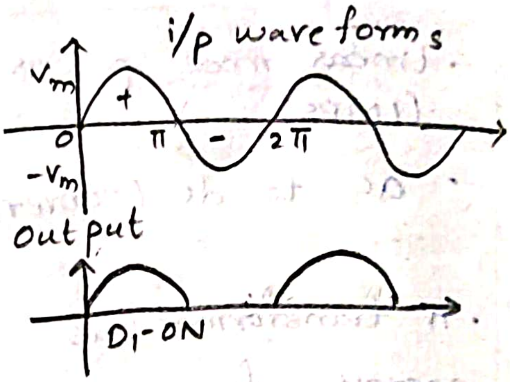
Full-wave Rectifier
- that converts the complete cycle of alternating current into pulsating DC.
  - Center tapped
  - Bridge rectifier

Filters

- Inductive filter (L)
- Capacitor filter (C)
- LC filter
- CLC filter

* **Half wave Retifier :-**





In a half wave rectifier a single diode is used. The a.c from the secondary of the transformer is applied to the diode and a load resistance R_L in series. During the positive half cycle, the diode is forward biased and current flows through the diode and the load resistance. During the negative half cycle, the diode is reverse biased and current does not flow through the diode. Thus current flows during the positive half cycle only. The output across the load resistance contains rectified voltage which is a variable DC.

⇒ Efficiency of half - wave rectifier

$$= \frac{\text{DC power Output}}{\text{AC power input}} = \frac{0.406\, R_L}{R_L + r_f}$$

⇒ $\eta_{max} = 0.406$

Maximum efficiency of half wave rectifier is 40.6%.

→ Half wave rectifier Ratings :

1. Ripple factor
2. Efficiency
3. Transformer utiliser factor (TUF)
4. Form factor.
5. Peak factor
6. (PIV) Peak inverse Voltage.

1. Ripple factor (Γ): It is the ratio of rms value of AC components to give DC value of a component.

$$\Gamma = \frac{V_{r\,rms}}{V_{dc}}$$

$$V_{r\,rms} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$\Gamma = \frac{\sqrt{V^2_{rms} - V^2_{dc}}}{V_{dc}}$$

$$\Gamma = \sqrt{\left(\frac{V^2_{rms}}{V^2_{dc}} - 1\right)}$$

$V_{dc} = ?$, $V_{rms} = ?$

$$\Rightarrow V_{avg} = V_{dc} = \frac{1}{2\pi}\int_0^{\pi} V_m \sin(\omega t)\, d(\omega t) + \int_{\pi}^{2\pi} 0 \cdot d(\omega t)$$

$$= \frac{1}{2\pi}(V_m)\int_0^{\pi} \sin(\omega t)\, d\omega t$$

$$= \frac{V_m}{2\pi}(-\cos\omega t)_0^{\pi}$$

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

$$= \frac{V_m}{2\pi}\left[(-)(-1-1)\right]$$

$$V_{dc} = \frac{V_m}{\cancel{2}\pi}(\cancel{2}) \Rightarrow \frac{V_m}{\pi}$$

$\Rightarrow V = IR \rightarrow I = \frac{V}{R}$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{V_m}{\pi \cdot R_L}$$

$$I_{dc} = \frac{I_m}{\pi} \quad \because \frac{V_m}{R_L} = I_m$$

If r_f & r_s can be taken

r_f → Forward resistance of diode

r_s → Secondary winding resistance.

$$V_{dc} = \frac{V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$I_{dc} = \frac{V_{dc}}{r_s + r_f + R_L} = \frac{V_m}{\pi(r_s + r_f + R_L)}$$

1. Ripple factor (Γ) : It is the ratio of rms value of AC components to give DC value of a component.

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If r_f & r_s can be taken

r_f → Forward resistance of diode ; r_s → Secondary winding resistance.

$$V_{dc} = \frac{V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} v^2{}_m \sin^2\omega t \, d\omega t}$$

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

$$= V_m \sqrt{\frac{1}{4\pi}\int_0^{\pi} 1 \cdot d\omega t - \int_0^{\pi}\cos 2\omega t \, d\omega t}$$

$$= V_m \sqrt{\frac{1}{4\pi}\left[\omega t\right]_0^{\pi} - \underbrace{\left[\frac{\sin 2\omega t}{2}\right]_0^{\pi}}_{0}}$$

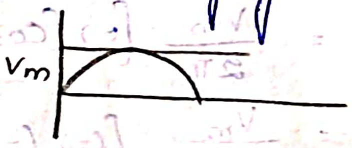
$$V_{rms} = V_m \sqrt{\frac{1}{4\cancel{\pi}}(\cancel{\pi})} = \frac{V_m}{2}$$

$$\Gamma = \sqrt{\frac{\left(\frac{V_m}{2}\right)^2}{\left(\frac{V_m}{\pi}\right)^2} - 1} \Rightarrow \sqrt{\frac{\pi^2}{4} - 1}$$

$$\Gamma = 1.21\ \% \Rightarrow 121\%$$

2. Peak inverse voltage : It is defined as the maximum reverse voltage, that a diode can with stand without destroying the junction.

$$PIV = V_m$$



3. TUF : It is defined as the dc power delivered to the load to the ac rating of the transformer secondary.

$$TUF = \frac{P_{dc}}{P_{ac,\ rated}}.$$

4. Efficiency : It is the ratio of dc output power to ac input power.

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$\left\{\begin{array}{l} P = V \cdot I \\ P = I^2 R \\ P = \frac{V^2}{R} \end{array}\right\}$$

$$\rightarrow P_{dc} = \frac{V_{dc}^2}{R_L} \Rightarrow \frac{V_m^2}{\pi^2 R_L}$$

$$\rightarrow P_{ac} = \frac{V_{rms}^2}{R_L} = \frac{V_m^2}{4R_L}$$

$$\eta = \frac{\frac{V_m^2}{\pi^2 R_L}}{\frac{V_m^2}{4R_L}} = \frac{4}{\pi^2} = 0.405$$

$\Rightarrow 40.5\%$

- For half wave rectifier the secondary voltage is $\frac{V_m}{\sqrt{2}}$ & current is $\frac{I_m}{2}$

$$P_{dc} = I^2_{dc} \cdot R_L \; ; \; P_{ac} = \frac{V_m}{\sqrt{2}} , \frac{I_m}{2}$$

$$\Rightarrow \frac{I_m^2}{\pi^2} \cdot R_L$$

$$TUF = \frac{\frac{I_m^2}{\pi^2} R_L}{\frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2}} \Rightarrow \frac{\frac{V_m^2}{\pi^2 \cdot R_L^2} \cdot R_L}{\frac{V_m}{\sqrt{2}} \cdot 2\frac{V_m}{R_L}}$$

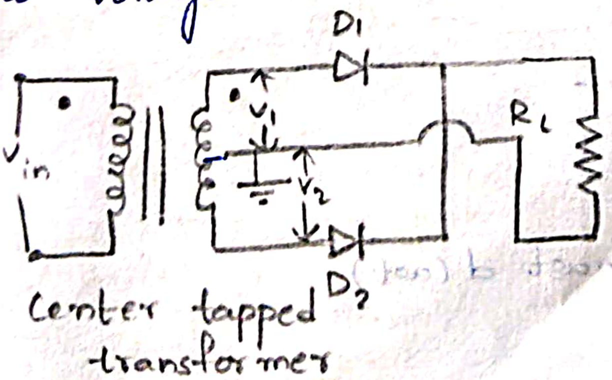
$$= \frac{2\sqrt{2}}{\pi^2} = 0.286$$

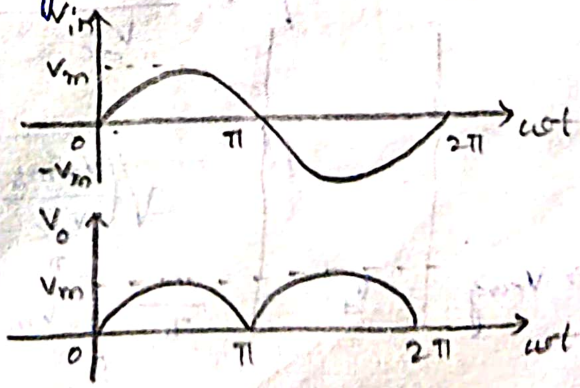
- form factor $= \frac{\text{rms value}}{\text{average value}} = \frac{V_m/2}{V_m/\pi} = \frac{\pi}{2} = 1.57$

- Peak factor $= \frac{\text{Peak value}}{\text{rms value}} = \frac{V_m}{V_m/2} = 2$

* Full - wave Rectifier :-

It converts an ac voltage into a pulsating dc voltage using both half cycles of the applied ac voltage.





It uses two diode's of which one conducts during one half - cycle while the other diode conducts during the other half - cycle of the applied ac voltage. There are two types of full wave rectifiers

i) center tapped   ii) bridge rectifier

In figure, shows the basic circuit and wave forms of center tapped transformer full-wave rectifier.

During positive half of the input signal, anode of diode D_1 becomes positive and at the same time the anode of diode D_2 becomes negative. Hence D_1 conducts and D_2 does not conduct. The load current flows through D_1 and the voltage drop across R_L will be equal to input voltage.

During negative half-cycle of the input, the anode of D_1 becomes negative and the anode of D_2 becomes positive. Hence, D_1 does not conduct and D_2 conducts. The load current flows through D_2 and the voltage drop across R_L will be equal to the input voltage.

Full-wave rectifier Ratings

1. Ripple factor:

$$\Gamma = \frac{V_{rrms}}{V_{dc}}$$

$$\Gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

$$\rightarrow V_{avg} = V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \sin\omega t \, d(\omega t)$$

$$= \frac{1}{\pi} V_m \int_0^{\pi} \sin\omega t \, d(\omega t)$$

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

$$= \frac{V_m}{\pi}(1+1) = \frac{2V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} \Rightarrow \frac{2I_m}{\pi} \quad \& \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$\rightarrow V_{dc} = \frac{2V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$I_{dc} = \frac{V_{dc}}{(r_s + r_f) + R_L} \Rightarrow \frac{2V_m}{\pi(r_s + r_f + R_L)}$$

$$\rightarrow V_{rms} = \sqrt{\left(\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2\omega t \, d(\omega t)\right)} = \cancel{V_{m/4}}$$

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

$$= V_m \sqrt{\frac{1}{2\pi}\int_0^{\pi} 1 \cdot d\omega t - \int_0^{\pi}\cos 2\omega t \, d\omega t}$$

$$= V_m \sqrt{\frac{1}{2\pi}[\omega]_0^{\pi} - \underbrace{\left[\frac{\sin 2\omega t}{2}\right]_0^{\pi}}_{0}}$$

$$V_{rms} = V_m \sqrt{\frac{1}{2\cancel{\pi}}(\cancel{\pi})} \Rightarrow \frac{V_m}{\sqrt{2}}$$

$$\Gamma = \sqrt{\left(\frac{(V_m/\sqrt{2})^2}{2V_m/\pi}\right)^2 - 1} \Rightarrow \sqrt{\frac{V_m^2/2}{2V_m^2/\pi}}$$

$$= \sqrt{\frac{\pi^2}{8} - 1} = 0.482.$$

2. Efficiency (η) : $\eta = \dfrac{\text{dc output power}}{\text{ac input power}} = \dfrac{P_{dc}}{P_{ac}}$

$$\Rightarrow \frac{(V_{dc})^2/R_L}{(V_{rms})^2/R_L} = \frac{\left(\frac{2V_m}{\pi}\right)^2}{\left(\frac{V_m}{\sqrt{2}}\right)^2} = \frac{8}{\pi^2} = 0.812$$

$$= 81.2\ \%$$

3. Transformer utilisation factor (TUF) :- The average TUF in a full wave rectifying circuit is determined by considering the primary secondary winding separately

and it gives a value of 0.693.

Form factor : $\dfrac{\text{rms value of output voltage}}{\text{average value of output voltage}}$

$$\Rightarrow \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}} = 1.11$$

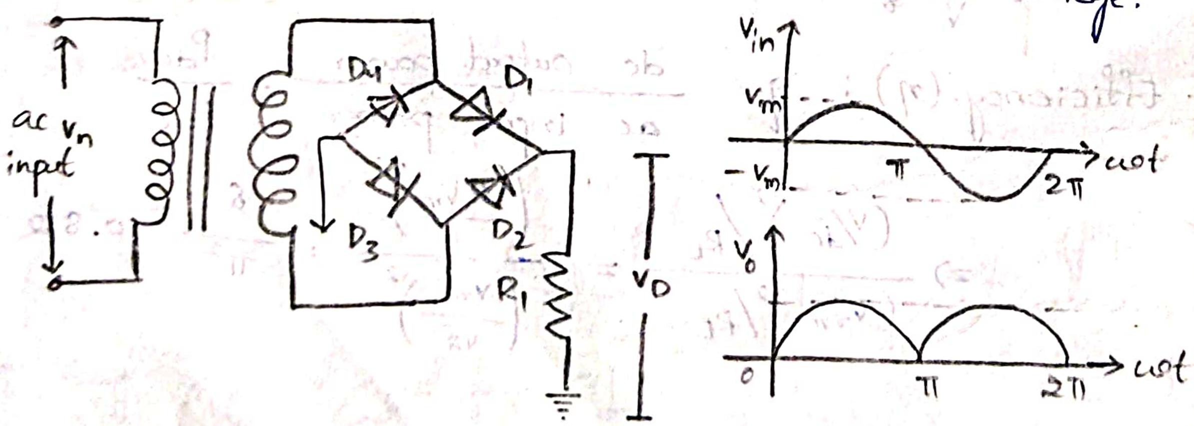
Peak factor : $\dfrac{\text{Peak value of output voltage}}{\text{rms value of out voltage}}$

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

- Peak inverse voltage for full wave rectifier is $2V_m$ because the entire secondary voltage appears accross the non-conducting diode.

→ Bridge Rectifier

The need for a center tapped transformer in a full-wave rectifier is eliminated in the bridge rectifier. The bridge rectifier has four diodes connected to form a bridge. The ac input voltage is applied to diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.



→ For positive half cycle of the input ac voltage, diodes D_1 and D_3 conduct, whereas diodes D_2 and D_4 do not conduct. The conducting diodes will be in series through load resistance R_L. So the load current flow through R_L.

• During the negative half-cycle of the input ac voltage diode D_2 & D_4 Conduct, where as D_1 & D_3 does not conduct. The current flows through R_L in the Same direction as in the previous half cycle. Thus a bidirectional wave is converted into an unidirectional one.

→ The average values of output voltage and load Current for bridge rectifier are same as for a center-tapped full wave rectifier

$$V_{dc} = \frac{2V_m}{\pi} \quad \text{and} \quad I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi}$$

→ r_s, r_f Consideration :-

$$V_{dc} = \frac{2V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$I_{dc} = \frac{2V_m}{\pi} = \frac{2V_m}{\pi(r_s + r_f + R_L)}$$

The maximum efficiency = 81.2%

ripple factor = 0.48

The PIV = V_m

* **Advantages of bridge rectifier :**

→ The bulky center tapped transformer is not required

→ TUF is high, since the current flowing in the transformer secondary is purely alternating, the TUF increases to 0.812 which is main reason for the popularity of a bridge rectifier.

→ If stepping up or stepping down of voltage is not needed, we may even do away without transformer.

→ The transformer secondary voltage of CT rectifier is $2V_m$, where as in bridge the transformer secondary must have a peak voltage of V_m. That is the transformer secondary of CT rectifier must have double the number of turns.

Disadvantages :

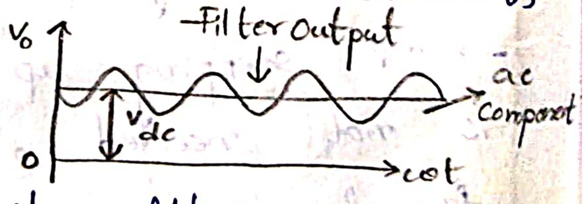
1. Requires 4 diodes
2. Internal resistance voltage drop is twice than that of Centre Tap Circuit.

3. * Comparison of Rectifiers

Particulars	Type of rectifier		
	Half-wave	Full-wave	Bridge
No. of diodes	1	2	4
Maximum efficiency	40.6%	81.2%	81.2%
V_{dc} (no load)	V_m/π	$2V_m/\pi$	$2V_m/\pi$
Average current/diode	I_{dc}	$I_{dc}/2$	$I_{dc}/2$
Ripple factor	1.21	0.48	0.48
Peak inverse voltage	V_m	$2V_m$	V_m
output frequency	f	2f	2f
Transformer utilisation factor	0.287	0.693	0.813
Form factor	1.57	1.11	1.11
Peak factor	2	$\sqrt{2}$	$\sqrt{2}$

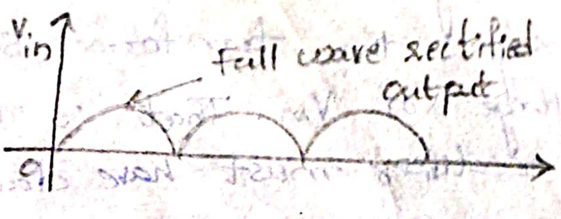
* Filters :- The devices which converts the pulsating DC in to pure DC is called filter.

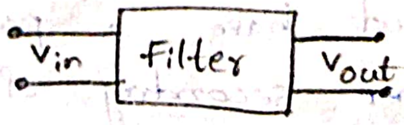
- To remove substances such as dust (or) dirt, (or) electronic signals.



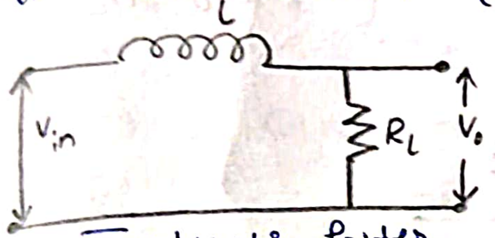
Some important filters are

a) Inductor filter
b) Capacitor filter
c) LC (or) L-section filter
d) CLC (or) π type filter.

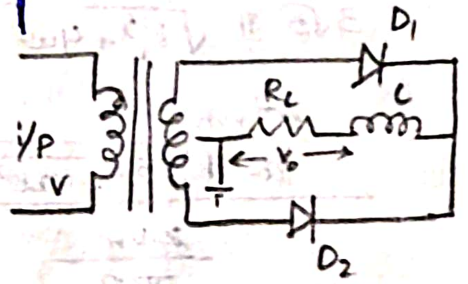




1) ~~Inductor~~ filter :- When the output of the rectifier passes through an inductor, it blocks the ac component and allows only the dc component to the load. (~~Magnetic field~~)



Inductor filter



FWR with Inductor filter

→ Ripple factor :- (∵ Inductor filter is more effective only when the load current is high).

$$\Gamma = \frac{I_{r\,rms}}{I_{dc}} \quad (or) \quad \frac{V_{r\,rms}}{V_{dc}}$$

Analysis By using Fourier series representation of O/P FWR in the filter

$$V_o = \frac{2V_m}{\pi} - \frac{4V_m}{\pi} \sum_{\substack{K=even \\ K\neq 0}} \frac{\cos(K\omega t)}{(K+1)(K-1)} \longrightarrow (FWR)$$

$$V_o = \frac{2V_m}{\pi} - \frac{4V_m}{\pi}\left[\frac{\cos 2\omega t}{3} + \frac{\cos 4\omega t}{15} + \cdots\right]$$

$$I_o = \frac{2I_m}{\pi} - \frac{4I_m}{\pi}\left[\frac{\cos 2\omega t}{3}\right] \text{ —— ①}$$

By neglecting higher order ~~Comparison~~ Terms

$$I_{dc} = \frac{2I_m}{\pi} = \frac{2V_m}{\pi \cdot R_L}$$

$$I_{rrms} = \frac{I_m}{\sqrt{2}}$$

Impedance of L & R_L at 2ω is

$Z = R_L + j2\omega L$

$\therefore |Z| = \sqrt{R_L^2 + (2\omega L)^2}$

$\phi = \tan^{-1}\left(\frac{2\omega L}{R_L}\right)$

∴ Assume r_s, r_c, r_f ≈ 0 when compared to R_L

For a.c component

$$I_m = \frac{V_m}{|R_L + j2\omega L|}$$

$$= \frac{V_m}{\sqrt{R_L^2 + 4\omega^2 L^2}}$$

$$\Rightarrow \frac{V_m}{\sqrt{R_L^2 + 4\omega^2 L^2}}$$

$$I_o = \frac{2V_m}{\pi R_L} - \frac{4V_m}{3\pi\sqrt{R_L^2+4\omega^2L^2}}\cos(2\omega t-\phi)$$

$$\phi = \tan^{-1}\left(\frac{2\omega L}{R_L}\right)$$

$$I_{r\,rms} = \frac{4V_m}{3\sqrt{2}\,\pi\sqrt{R_L^2+4\omega^2L^2}} \qquad \left(\because I_{r,rms} = \frac{I_m}{\sqrt{2}}\right)$$

$$\Gamma = \frac{\dfrac{\cancel{4}^2 V_m}{3\sqrt{2}\cdot\cancel{\pi}\sqrt{R_L^2+4\omega^2L^2}}}{\dfrac{\cancel{2}V_m}{\cancel{\pi}R_L}}$$

$$= \frac{2\cancel{R_L}}{3\sqrt{2}\,\cancel{R_L}\sqrt{1+\frac{4\omega^2L^2}{R^2}}}$$

$$= \frac{2}{3\sqrt{2}}\cdot\frac{1}{\sqrt{1+\frac{4\omega^2L^2}{R_L^2}}}$$

when $\frac{4\omega^2L^2}{R_L^2} >> 1$ then

$$\Gamma = \frac{2}{3\sqrt{2}}\cdot\frac{1}{\sqrt{\frac{4\omega^2L^2}{R_L^2}}}$$

$$\Rightarrow \frac{\cancel{2}}{3\sqrt{2}}\cdot\frac{R_L}{\cancel{2}\omega L} = \frac{R_L}{3\sqrt{2}\,\omega L}$$

In case, the load resistance is infinity, i.e the output is an open circuit, then the ripple factor is

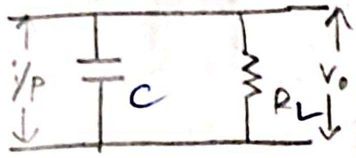
$$\Gamma = \frac{2}{3\sqrt{2}} = 0.471$$

2) Capacitor filter :- An inexpensive filter for light loads is found in the capacitor filter which is connected directly across the load.

→ The property of a capacitor is that allows ac component and blocks the dc component.

→ During the positive half-cycle, the capacitor charges up to the peak value of the transformer secondary voltage V_m and will try to maintain this value as the full wave input drops to zero.

→ The capacitor will discharge through R_L slowly until the transformer secondary voltage again increases to a value greater than the capacitor voltage.



(a) Capacitor filter

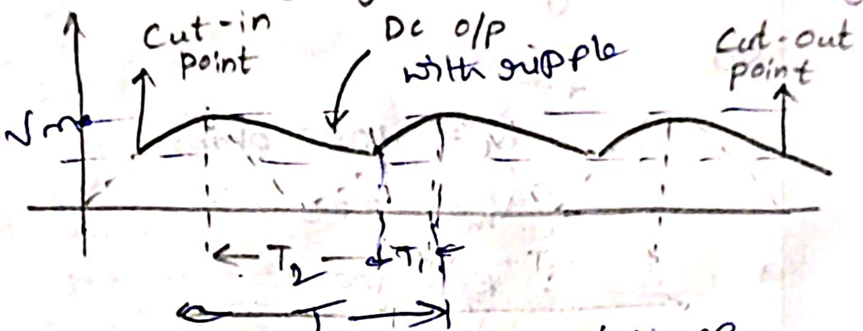


fig Ripple Voltage Triangular waveform

$V_s > V_r \xrightarrow{\text{diode}}$ Conducting

$V_s < V_r \longrightarrow$ Blocks

The charge it has acquired $= V_{r,\,p-p} \times C$

The charge it has lost $= I_{dc} \times T_2$

Therefore, $V_{r,\,p-p} \times C = I_{dc} \times T_2$ —— ①

(if C is large (or) R_L is large) $T_2 = \frac{T}{2} = \frac{1}{2f}$

$$V_{r,\,p-p} \times C = I_{dc} \cdot \frac{1}{2f}$$

$$V_{r,\,p-p} = \frac{I_{dc}}{2fC}$$

$$\because I_{dc} = \frac{V_{dc}}{R_L}$$

$$V_{r,p-p} = \frac{V_{dc}}{2fCR_L}$$

→ with assumptions made above ripple wave form is triangular

$$\therefore \boxed{V_{r,\,rms} = \frac{V_{r,\,p-p}}{2\sqrt{3}}}$$

$$V_{r,\,rms} = \frac{V_{dc}}{4\sqrt{3}\,fCR_L}$$

$$\Gamma = \frac{V_{r,\,rms}}{V_{dc}} = \frac{\frac{V_{dc}}{4\sqrt{3}\,fCR_L}}{V_{dc}} = \frac{1}{4\sqrt{3}\,fCR_L}$$

The ripple may be decreased by increasing C (or) R_L with a resulting increase in dc output voltage.

i) A half wave rectifier having a resistive load of 1000 ohms. Rectifiers an alternating voltage of 325V peak value & the diode has a forward resistance of 100 ohms. i) Calculate P, average and rms value of current.

ii) DC power output

iii) AC input power

iv) Effiency of the rectifier

Sol Given:-

$R_L = 1000$ ohms

$V_m = 325$ V

$R_f = 100\,\Omega$

i) → Peak value of Current $I_m = \frac{V_m}{R_L + R_f}$

$= \frac{325}{100+1000} = \frac{325}{1100} = 295.45$ mA

→ avg value of Current $I_{dc} = \frac{I_m}{\pi} = \frac{295.45}{\pi}$

$= 94.046$ mA

→ rms value of Current $I_{rms} = \frac{I_m}{2} = \frac{295.45}{2}$

$= 147.725$ mA

iii) a.c power i/p $(P_{a.c}) = I^2(R_L + R_f)$

$= (147.725 \times 10^{-3})^2 (1100)$

$= 24$ W

ii) d.c power o/p $= I^2_{dc} \times R_L$

$= (94.046 \times 10^{-3})^2 \times 1000 = 8.845$ W

iv) $\eta = \frac{P_{dc}}{P_{ac}} = \frac{8.845}{24} = 0.3685$

$= 36.85\%$

2) FWR delivers 50 watts to a load of 200Ω. If the ripple factor is 1%. calculate the a.c ripple voltage across the load.

Sol Given:-

$R_L = 200\Omega$

$P_{dc} = 50$ watts

$\Gamma = 1\% = \frac{1}{100} = 0.01$

$P_{dc} = \frac{V_{dc}^2}{R_L}$

$50 = \frac{V_{dc}^2}{200}$

$V_{dc} = \sqrt{50 \times 200}$

$V_{dc} = 100V$

$\Gamma = \frac{V_{ac}}{V_{dc}}$

$0.01 = \frac{V_{ac}}{100}$

$V_{ac} = 100 \times 0.01$

$V_{ac} = 1V$

3) A 230V, 50Hz voltage is applied to the prim. ary of 4:1 step down transformer bridge rectifier having load resistance of 600Ω. Assuming the diodes to be ideal i) Determine dc output voltage ii) dc power deliver to the load, iii) PIV iv) Output frequency. (where $V_m = \sqrt{2} \times V_{rms}$)

Sol Given:-

$V_i = 230V$, $f = 50Hz$

$R_L = 600\Omega$

$N_1 : N_2 = 4 : 1$

4) o/p $f = 2f \Rightarrow 2 \times 50$

3) $PIV = 2V_m = 162.634V$

$= 2 \cdot V_m$ Secondary voltage of T.F

$V_m = \sqrt{2}\ V_{rms} = 81.317V$

$V_{rms} = V_i \times \frac{N_2}{N_1} = \frac{230}{4} = 57.5\ V$

1) d.c o/p voltag

$V_{dc} = \frac{2V_m}{\pi} = \frac{2.(81317)}{\pi}$

$= 51.768\ V$

2) $P_{d.c} = \frac{V^2_{dc}}{R_L} = \frac{(51.7)^2}{600\Omega} = 4.45\ W$

Non linear wave shaping - clippers & clampers.

* Clippers :-

Clippers are used to remove the undesired part (or) some part of the signal (or) and trasmitt the remaining part of the signal without changing it. (Non-linear)

→ Applications :

• These are used in Amplitude selecters (or) voltage limiters (or) current limiters

* Clampers :

Clamping means shifting of the signal with referance level

* Classification of clippers.

* Application of clippers

• To generate and shape the waveforms, clippers are used.

• Power supply units consist of clippling circuits

• FM transmitters to remove the excess amount of ripples clipping circuits are used

- To protect the transistors from the transients the diodes are connected in a parallel manner with the load that is inductive by nature.

* Applications of clampers

- To remove the distortions and to identify the polarity of circuits the clampers are used.
- To improve the 'Reverse Recovery Time' clamping circuits are used.
- To mold the waveforms to the desired shape and the ranges clampers are used.
- SONAR (Sound Navigation & Ranging) systems and testing equipment consists of clamping circuits.

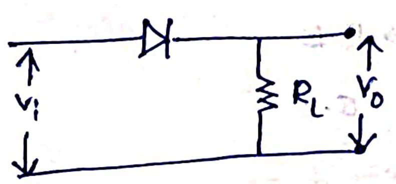
* Classification of clippers

- Clippers
  - Single level
    - Series
      - +ve
        - with VR
        - w/o VR
      - -ve
        - w
        - V_0
    - Shunt / parallel
      - +ve
      - - ve
  - Two level

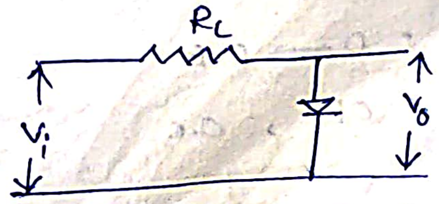
* Classification of clamper

- clamper
  - Positive clampler
    - Positive Reference voltage
    - Negative Reference voltage
  - negative clamper
    - +ve
    - -ve

Series clippers

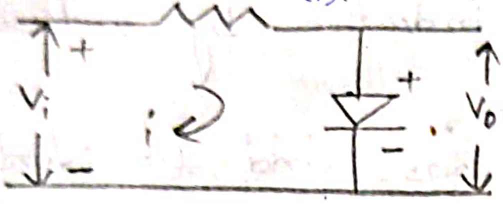


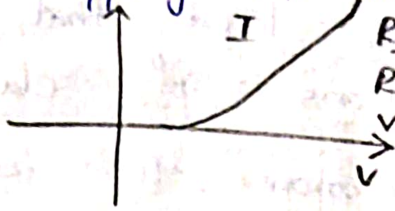
Parallel clipper

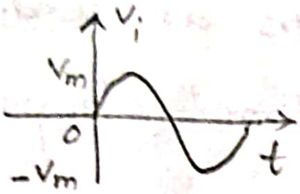


* Shunt clippers (Positive clipping with zero reference voltage)

(i) Positive peak clippling w/o reference voltage

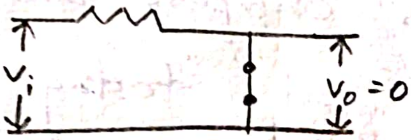




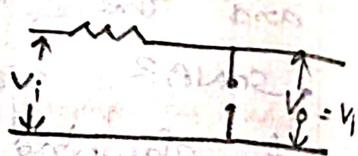


* +ve shunt clipper without V_R

- +ve half cycle
  $V_i > 0$
  $D \rightarrow$ F.B
  ON, S.C



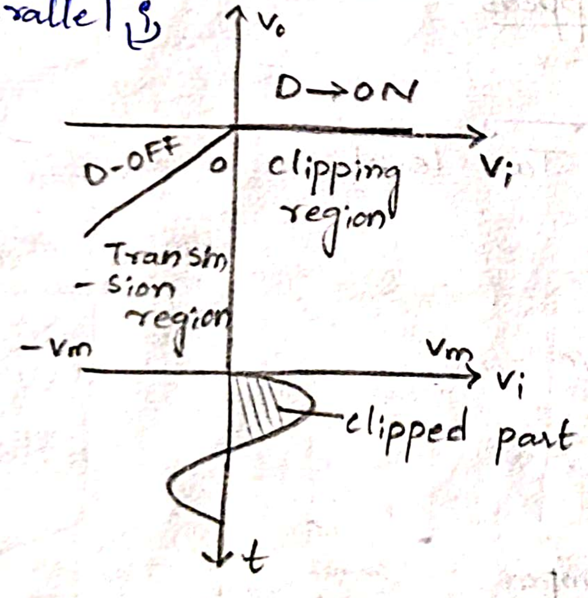
- −ve half cycle
  $V_i < 0$
  $D \rightarrow$ R.B
  OFF, O.C

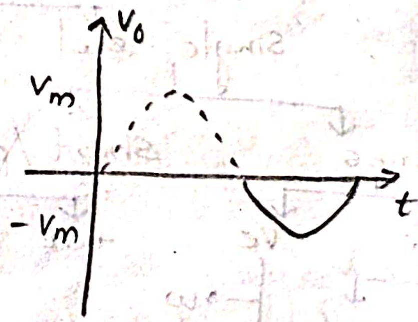


* Transfer characterstics

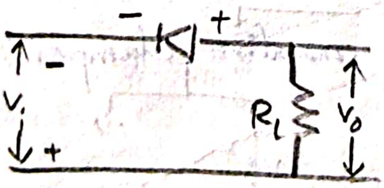
- Parallel

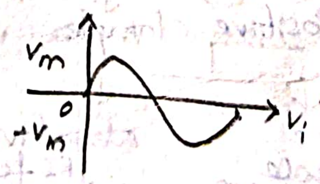
$$\left[\begin{array}{l} D\text{-ON} :- V_i > V_r \\ D\text{-OFF} : V_i < V_r \end{array}\right]$$



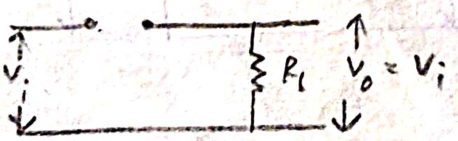


- Series clipper

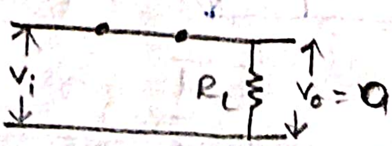


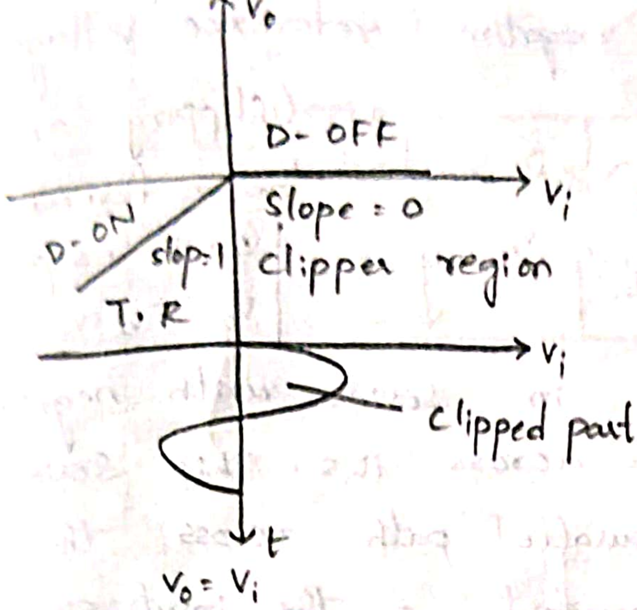


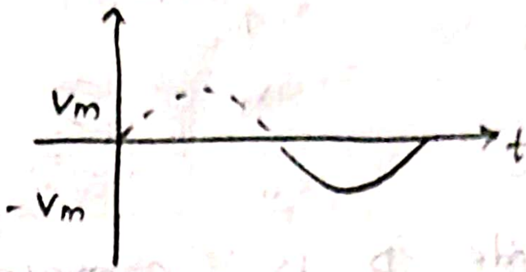
- +ve half cycle
- $V_i > 0$
- $D \rightarrow$ R.B
- OFF, O.C



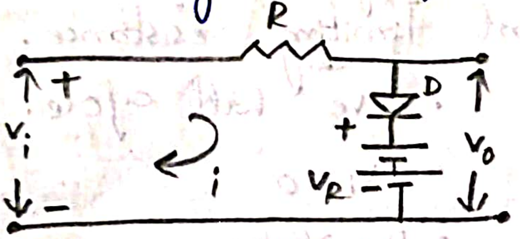
- −ve half cycle
- $V_i < 0$
- $D \rightarrow$ F.B
- ON, S.C







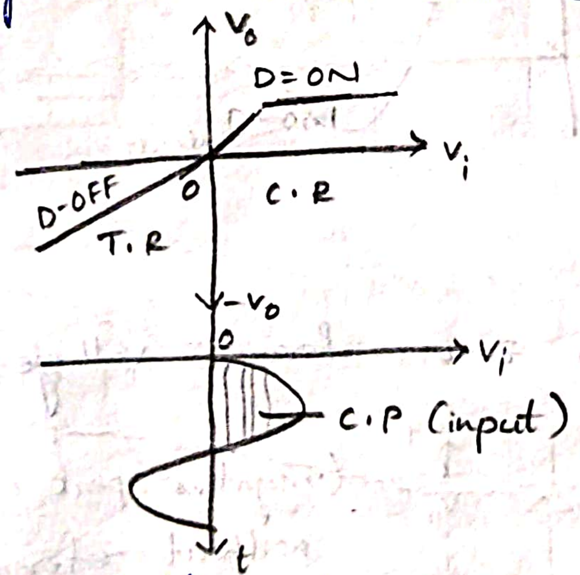
iii) Positive Clipping with positive reference voltage

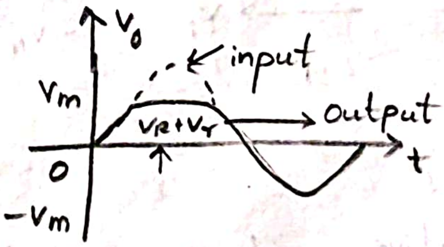


(Positive peak clipping above reference level)

$$\begin{bmatrix} V_o = V_i \,;\ \text{slope} = 1 \\ V_o = (V_R + V_r) \,;\ \text{slope} = 0 \end{bmatrix}$$

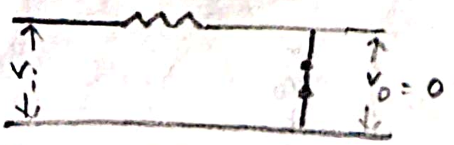
A diode D is connected in series with DC reference voltage V_R & this series combination forms a parallel path across the output. A resistor R is connected at the input side which controls the current flowing through the diode and called current limiting resistance

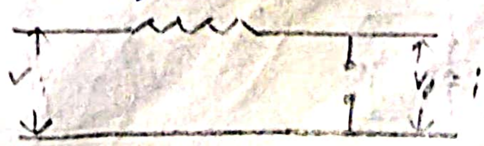




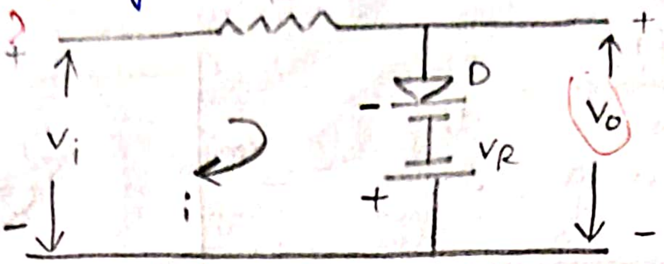
- +ve half cycle
- $V_i > 0$
- D → F.B
- ON , S.C

- −ve half cycle
- $V_i < 0$
- D → R.B
- OFF , O.C





iii) Positive clipping with negative reference voltage



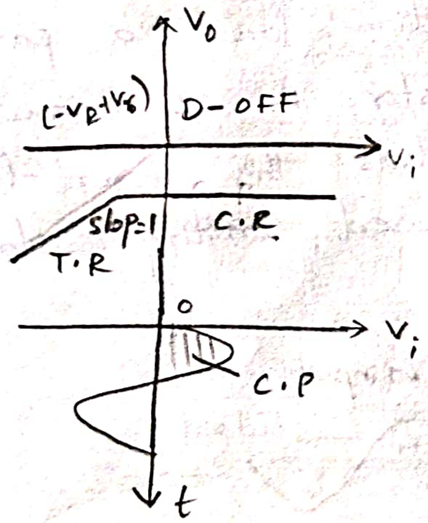
(clipping above the reference level)

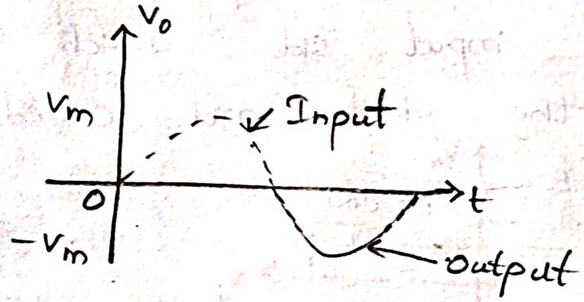
$\left[\begin{array}{l} V_o = V_i \ , \text{ Slope} = 1 \\ V_o = (-V_R + V_\gamma) ; \text{ Slope} = 0 \end{array}\right]$

Diode D is connected in Series with negative dc reference voltage V_R across its. This Series Combination forms a parallel path across the o/p. A resistor R is connected at the input side with controls the current flowing through the diode & it is called Current limiting resistance.

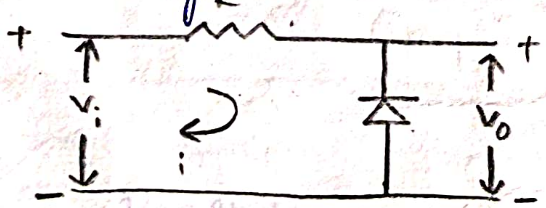
- +ve half cycle
- $V_i > 0$
- $D \longrightarrow$ F.B
- ON , S.C

- −ve half cycle.
- $V_i < 0$
- $D \rightarrow$ R.B.
- OFF , O.C





iv) Negative clipping with zero reference voltage

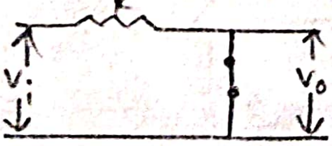


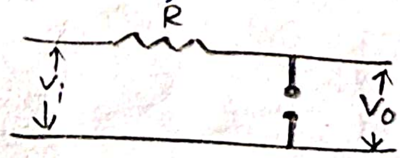
(negative peak clipping without reference voltage)

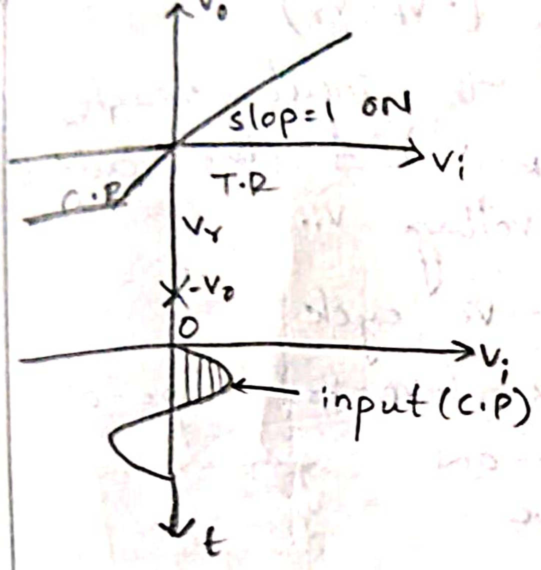
- +ve cycle
- $V_i \geq 0$
- OFF , S.C

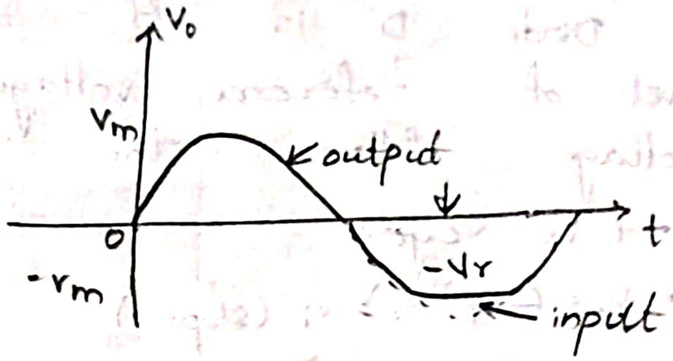
- −ve cycle
- $V_i \leq 0$
- OFF , O.C

$\left[\begin{array}{l} D - ON : V_i < V_\gamma \\ D - OFF : V_i > -V_\gamma \end{array}\right]$

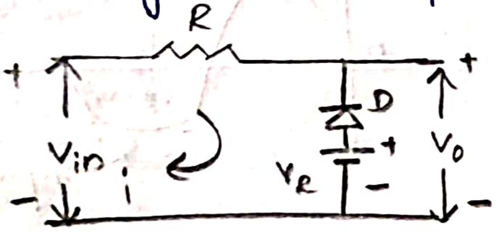








v) Negative clipping with positive reference voltage

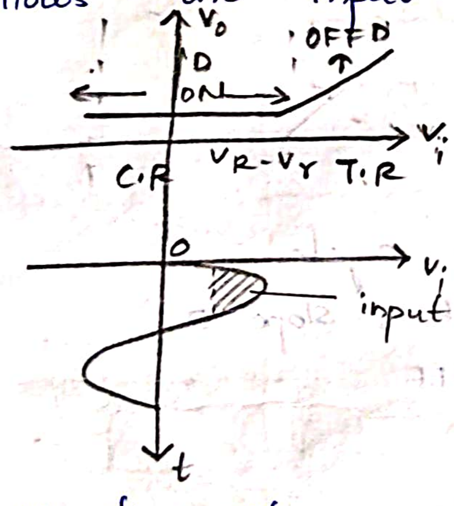


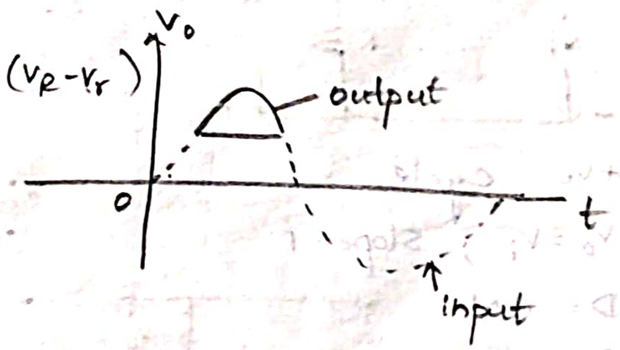
(positive bias clipping)

$\begin{bmatrix} V_i < (V_R - V_\gamma) \; ; \; \text{slope} = 0 \\ V_i > (V_R - V_\gamma) \; ; \; \text{slope} = 1 \end{bmatrix}$

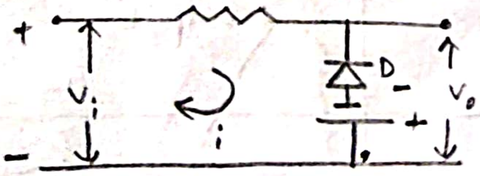
The diode D conducts only when the input potential is less than the reference voltage $(V_R - V_\gamma)$ & the output voltage is equal to $(V_R - V_\gamma)$

The diode D is OFF when the input reaches the level of reference voltage and the output voltage follows the input voltage.





vi) Negative clipping with negative reference voltage

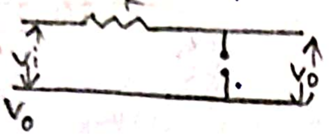


(below reference level)

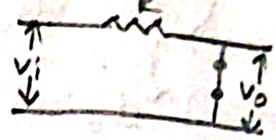
Diode D conducts only when the input potential is less than negative reference voltage and the output voltage is equal to $(+V_R - V_\gamma)$

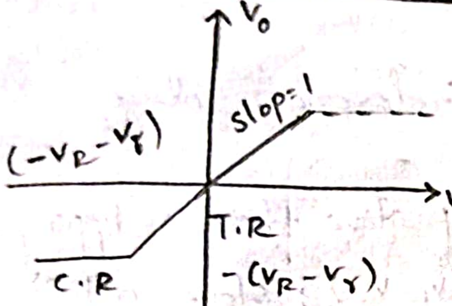
Diode D is off when the input reaches the level of reference voltage $(-V_R - V_\gamma)$ & the output voltage follows the input voltage V_i.

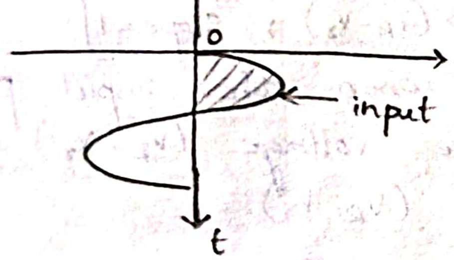
- +ve cycle
- $V_0 = \cancel{(-V_R - V_\gamma)}\ V_i$ (slope = 1)
- D = OFF
- O.C

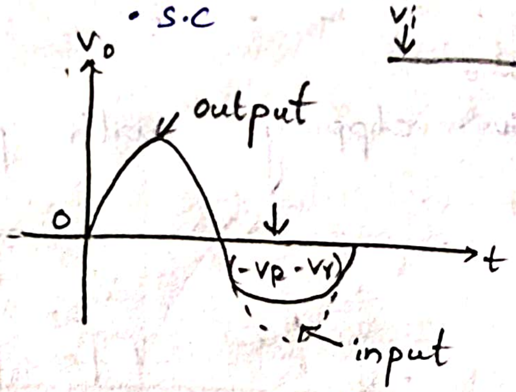


- −ve cycle
- $V_0 = (-V_R - V_\gamma)$ (slope = 0)
- D = ON
- S.C





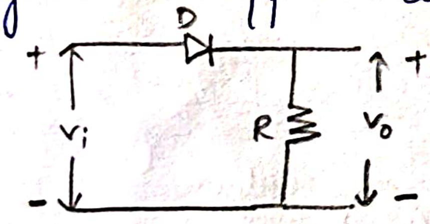




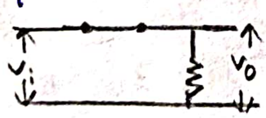
** Series clippers

i) Negative Clipper with zero reference

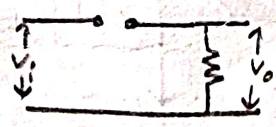
ii)

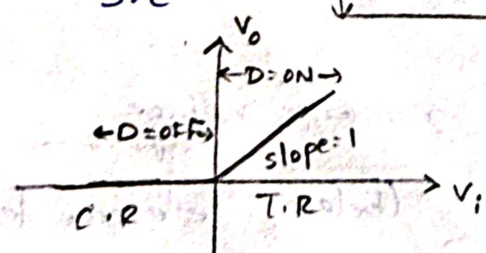


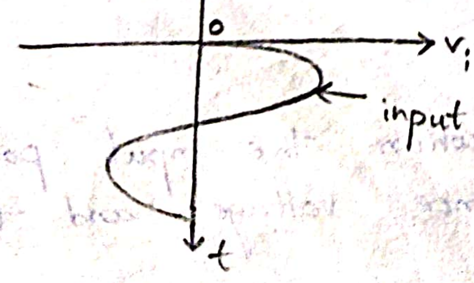
- +ve cycle
- $V_0 = V_i$; slope = 1
- D = ON
- S.C

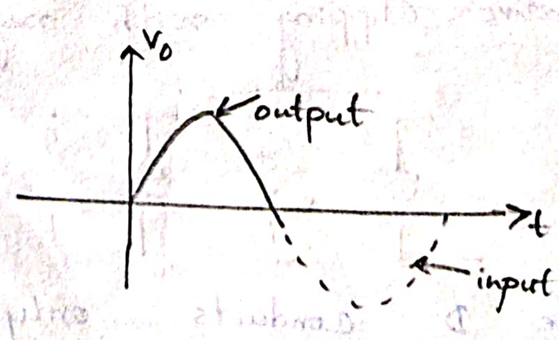


- −ve cycle
- $V_0 = 0$; slope = 0
- D = OFF
- O.C

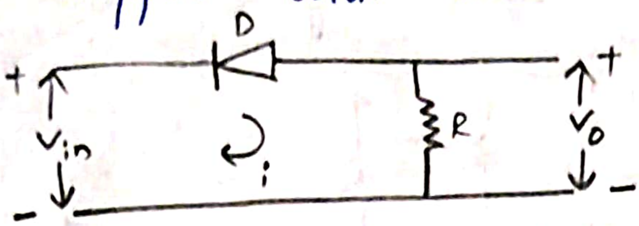






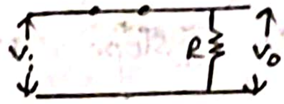


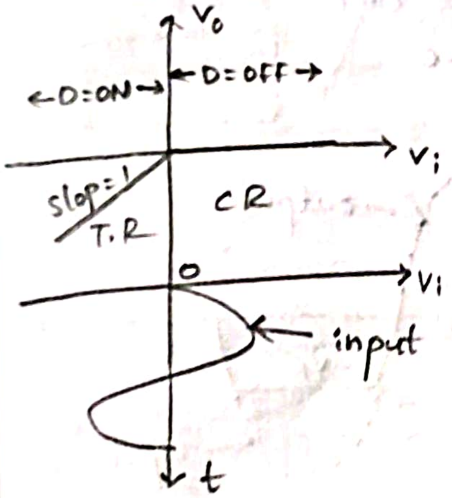
ii) Positive Clipper with zero reference.

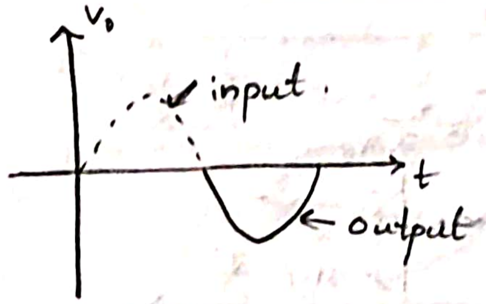


- +ve cycle ($V_p > -V_\gamma$)
- $V_o = 0$; slope = 0
- D = OFF
- O.C

- -ve cycle ($V_i < -V_\gamma$)
- $V_o = V_i + V_\gamma \Rightarrow V_o = V_i$; Slope = 1
- D = ON
- S.C

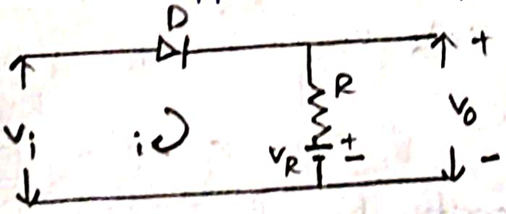




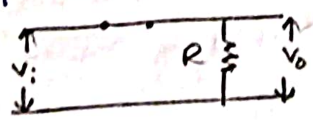


$\therefore V_o = V_R$.

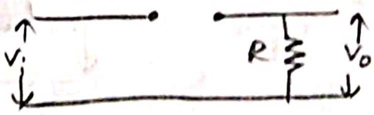
iii) Negative clipper with positive reference.
(below reference level)

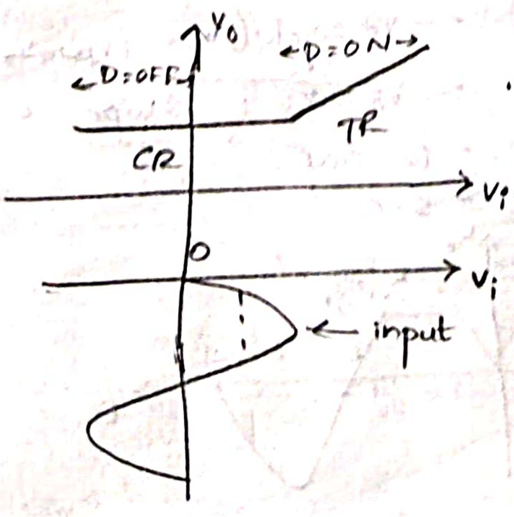


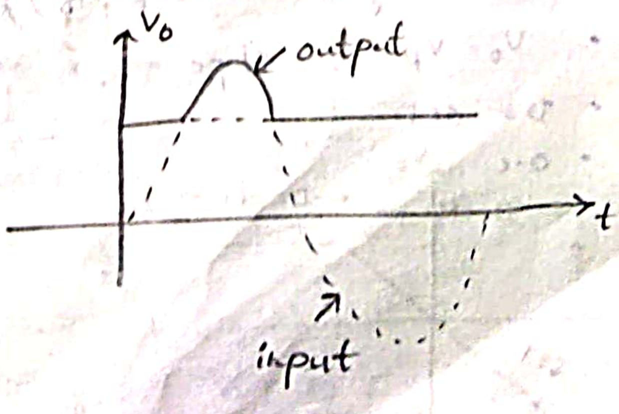
- +ve cycle
- $V_o = V_i$; slope = 1
- D = ON
- S.C



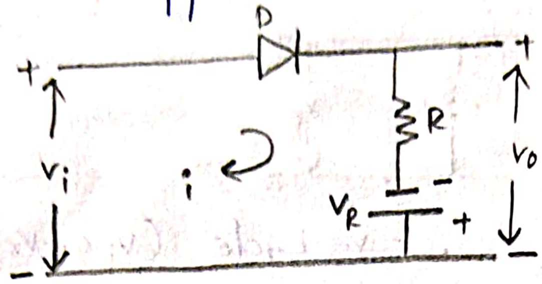
- -ve cycle
- $V_o = V_R$, slope = 0
- D = OFF
- O.C





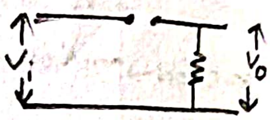


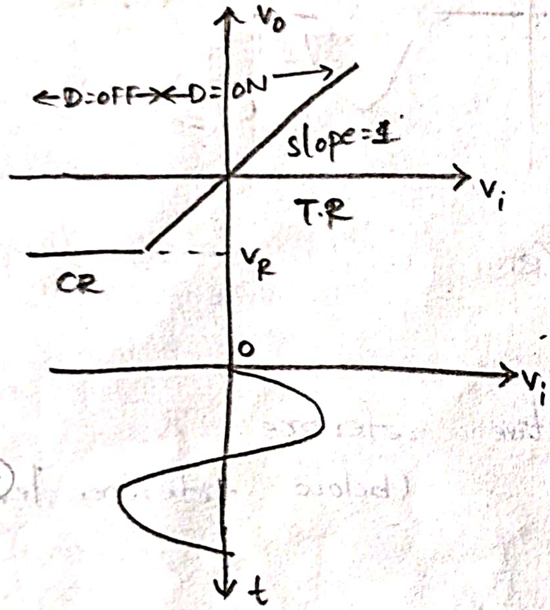
iv) Negative clipper with Negative reference.

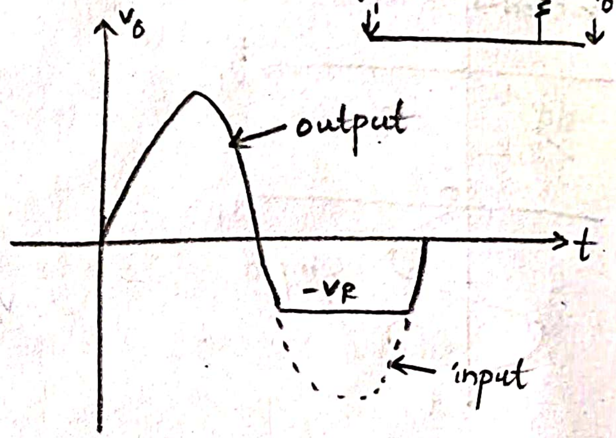


- +ve cycle ($v_i > (-V_R + V_\gamma)$)
- $V_o = V_i$, slope = 1
- D = ON
- S.C

- -ve cycle ($v_i < (-V_R + V_\gamma)$)
- $V_o = -V_R$, slope = 0
- D = OFF
- O.C





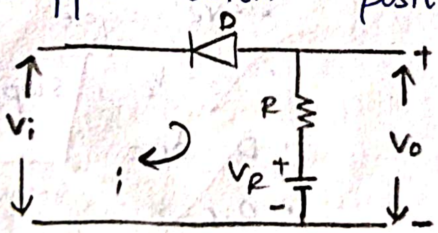


(6)

∴ $V_o = V_i$

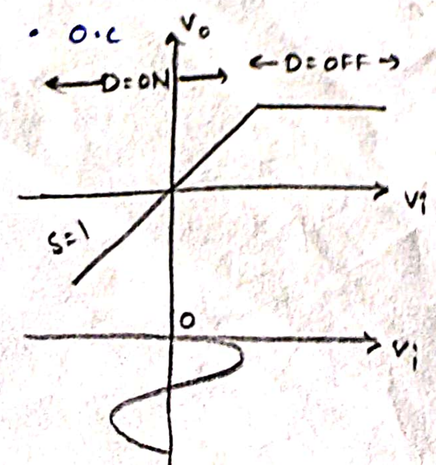
v) Positive clipper with positive reference.

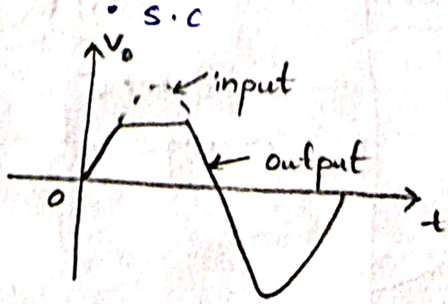
(3)



- +ve cycle ($v_i > (v_R - V_\gamma)$)
- $V_o = V_R$; slope = 0
- D = OFF
- O.C

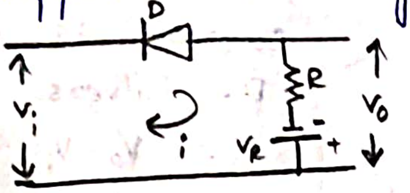
- -ve cycle ($v_i < (v_R - V_\gamma)$)
- $V_o = V_i$; slope = 1
- D = ON
- S.C





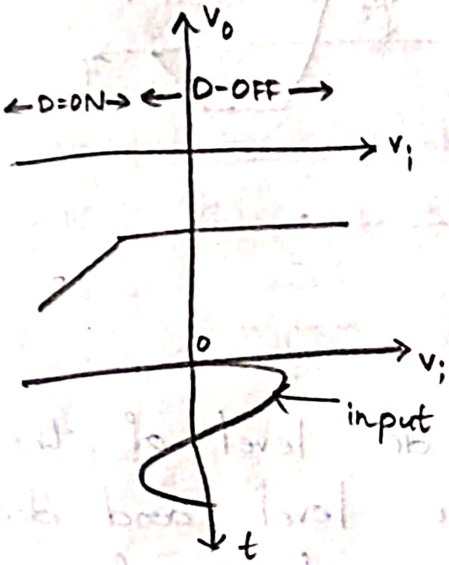
v) Positive Clipper with Negative Reference.

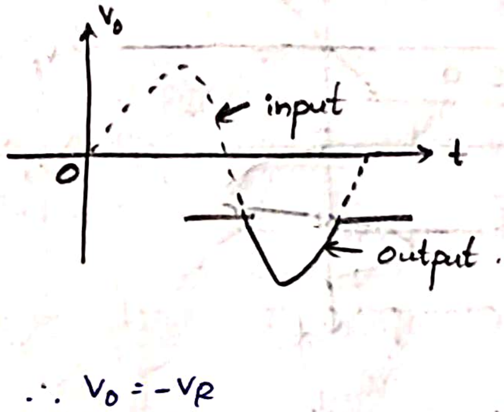
(4)



- +ve cycle $(v_i > (-V_R - V_\gamma))$
- $V_0 = -V_R$; slope = 0
- D = OFF
- O.C

- −ve cycle $(v_i < (-V_R - V_\gamma))$
- $V_0 = +V_R$; slope = 0
- D = ON
- S.C

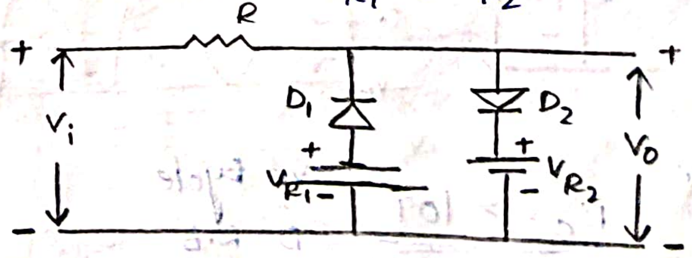




$\therefore V_0 = -V_R$

* Clipping at two independent levels.

- Diode clippers may be used in pairs to perform double ended clipping at independent levels.
- A parallel, a series, (OR a series-parallel arrangement may be used.
- A parallel arrangement is showbelow where $V_{R_2} > V_{R_1}$
- This circuit is also called as slicer b/w the o/p contains a slice of the input b/w the two reference levels V_{R_1} & V_{R_2}



i) $V_i \le V_{R_1}$; D_1 = ON, D_2 = OFF ; $V_0 = V_{R_1}$

ii) $V_{R_2} < V_i < V_{R_1}$; D_1 = OFF, D_2 = OFF ; $V_0 = V_i$

iii) $V_i \ge V_{R_2}$; D1 = OFF, D_2 = ON ; $V_0 = V_{R_2}$

a) when $V_i > V_{R}$

current is positive

D_2 = forward biased

$\therefore V_0 = V_{R_2}$

b) when $V_i < V_{R_2}$

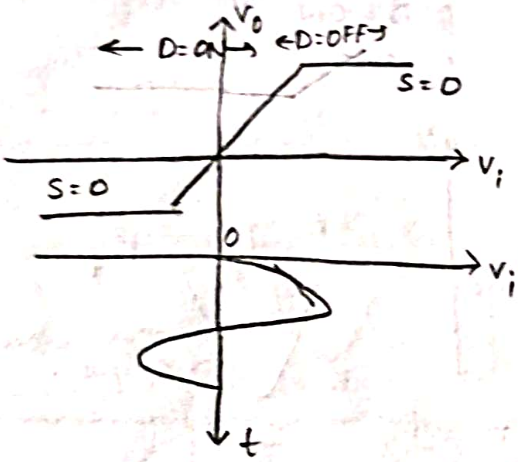
current is negative

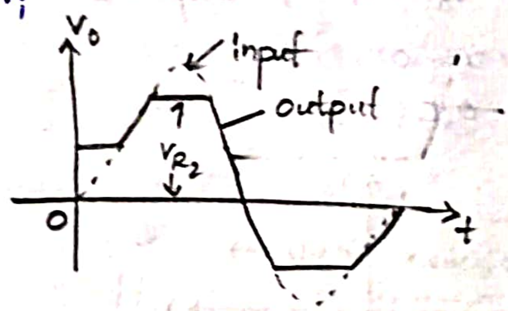
D – Reverse biased

$\therefore V_0 = V_i$

D_1 = ON , D_2 = OFF

$V_0 = V_{R_1}$, $V_0 = V_i$

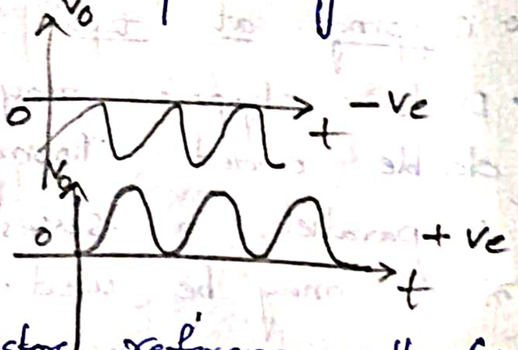




clamping It changes the dc level of the input signal with reference level and doesn't effect the shape of the input signal.

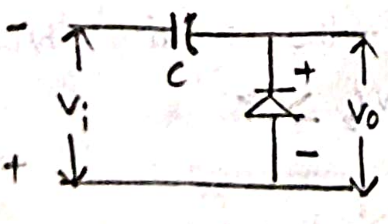
They are of two types

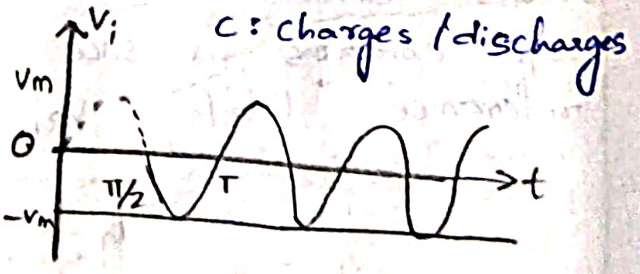
1) Positive clamper circuit
2) Negative clamper circuit.
3) Clamper with bias



(capacitors, diodes, resistors, reference voltage(V_R))

→ Positive clamper circuit.





C: charges / discharges

+Ve cycle

D = F.B

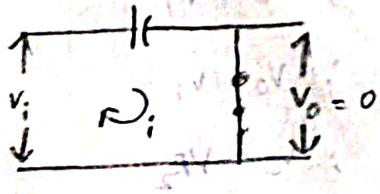
D = ON , S.C

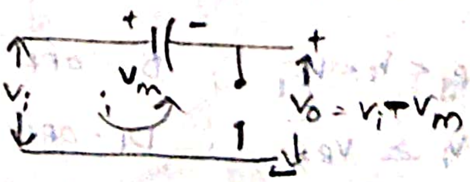
$R_C >> 10T$

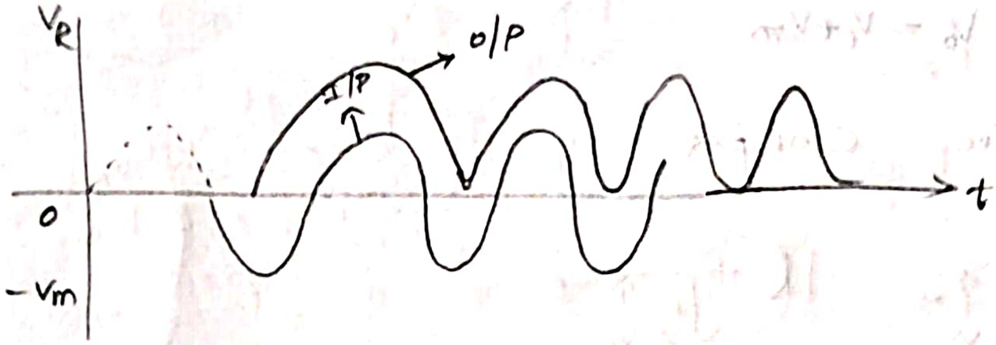
–Ve cycle

D = R.B

D = OFF , O C







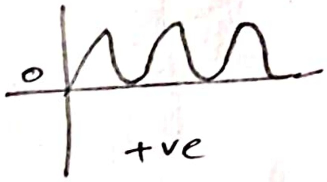
Cases :- $V_i = V_m$ $\quad V_o = 2V_m$

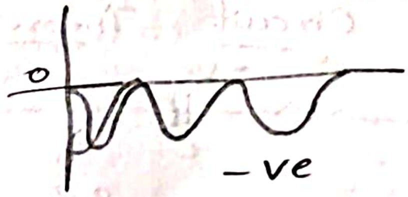
$V_i = 0$ $\quad V_o = V_m$

$V_i = -V_m$ $\quad V_o = 0$.

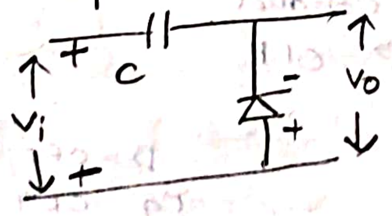
+ve : Negative Peak clamper $\rightarrow V_o = V_i + V_m$

-ve : Positive peak clamper

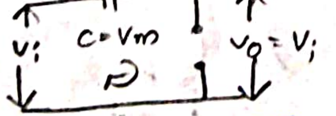




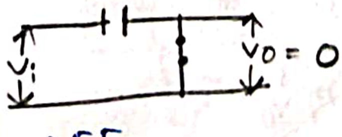
• Positive clamper



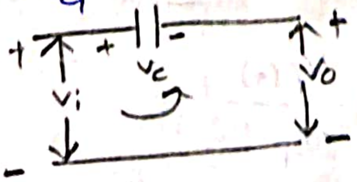
+ve half



-ve half



⇒ After $= \frac{3\pi}{4}$, D = OFF



$+V_o + V_c - V_i = 0$

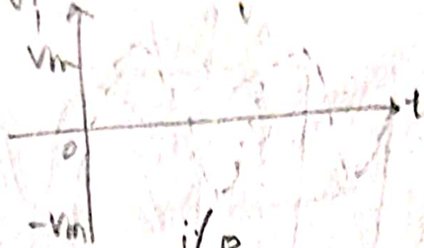
$V_o = V_i - V_c$

$V_o = V_i - V_m$

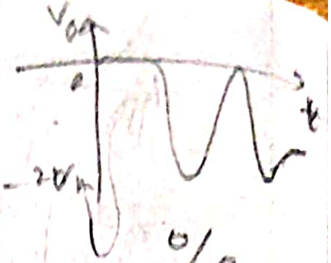
$= V_i - (-V_m)$

$V_0 = V_i + V_m$

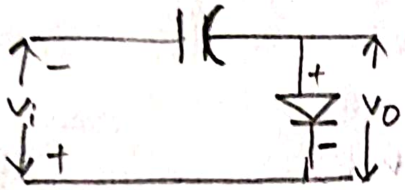
• Negative Clamper



i/p



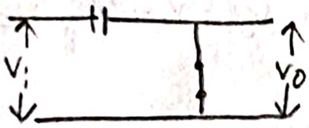
o/p



→ The signal source has negligible output impedence & that the diode is ideal.

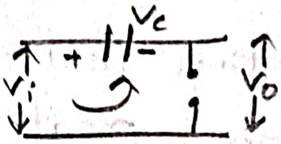
+ve half cycle

D = ON



- ve half cycle

D = OFF

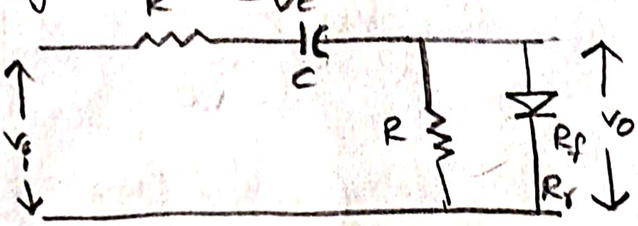


→ It is termed as positive peak clamper since the circuit clamps +ve peak of signal to zero level.

$V_0 = V_i + V_C$

$V_i - V_m \longrightarrow V_0$

* Clamping Circuit Theorem

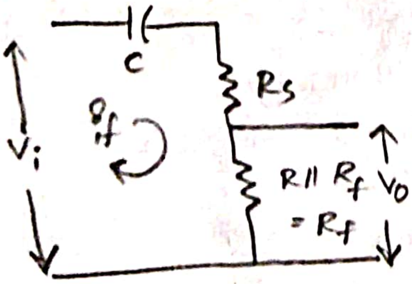


D → Rf → conduct

D → Rr → OFF

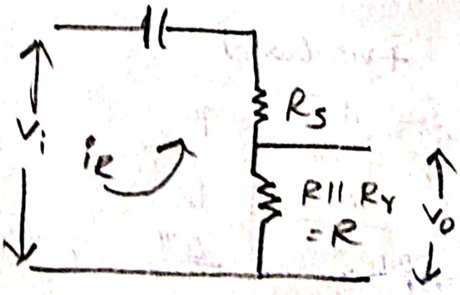
D = ON

eq ckt



D = OFF

eq CKT



$Q/q = \int_0^{T_1} i_f(t)\,dt \qquad i_f(t) = \frac{V_f(t)}{R_f}$

$= \int_0^{T_1} \frac{V_f(t)}{R_f}\,dt = \frac{1}{R_f}\int_0^{T} V_f(t)\,dt = \frac{A_f}{R_f}$

$T_1 \longrightarrow T_1 + T_2 : Q_R \qquad \int_{T_1}^{T_1+T_2} i_R(t)\,dt \qquad i_R(t) = \frac{V_R(t)}{R}$

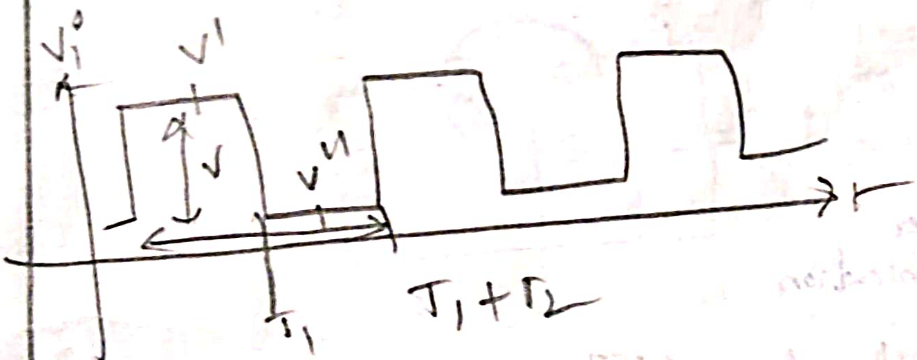
$$= \int_{T_1} \frac{v_R(t)}{R}\, dt$$

$$= \frac{1}{R} \int_{T_1}^{T_1+T_2} v_R(t)\, dt$$

→ For any Input waveform under steady state conditions, the ratio of the area A_f under the output curve in the forward direction ~~to that~~ off reverse direction A_R is equal to the ratio $\frac{R_f}{R}$

$$\therefore \frac{A_f}{A_R} = \frac{R_f}{R}$$

$\int i_f(t)\, dt$ $\qquad$ $i_f(t) = \frac{v_f(t)}{R_f}$



Square wave i/p signal