DC Power Supply

DC power supply is required for the operation of most of the electronic devices & circuits. Nowadays, almost all electronic devices includes a ckt that converts ac supply into a DC supply. The part of the equipment that converts the ac into DC is called DC power supply.

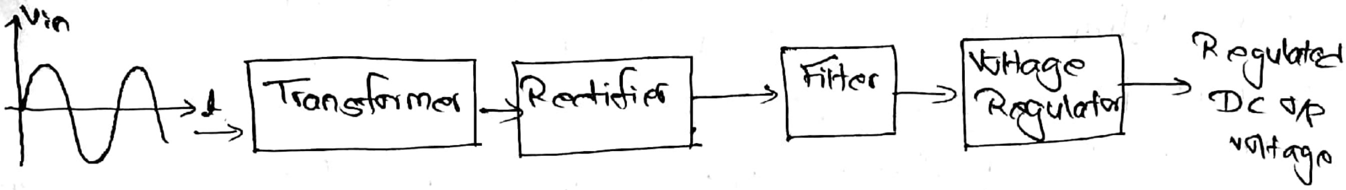


Fig: Block diagram of DC power supply.

Rectifier

The electronic ckt which converts ac signal into pulsating DC signal is called a rectifier. & the process of converting sinusoidal ac signal into a pulsating DC signal is called rectification.

There are 2 types of rectifiers

1) Half wave rectifier
2) Full wave rectifier

Rectifier parameters

i) Efficiency (η)

The ratio of dc o/p power to ac i/p power of rectifier is called efficiency.

i.e. $$\eta = \frac{\text{o/p dc power}}{\text{i/p ac power}} = \frac{P_{dc}}{P_{ac}}$$

ii) Ripple factor

The pulsating o/p voltage contains dc & ac components. The ac components are called ripples. The ripple should be minimum for dc power supply.

Ripple factor is the ratio of ac component to dc component at the o/p of rectifier.

i.e., $$r = \frac{\text{ac component}}{\text{dc component}} = \frac{I_{ac}}{I_{dc}}$$

Since, $I_{rms}^2 = I_{ac}^2 + I_{dc}^2$

$\Rightarrow I_{ac} = \sqrt{I_{rms}^2 - I_{dc}^2}$

Thus, $r = \frac{I_{ac}}{I_{dc}} = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

$$\therefore\ r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

iii) Peak Inverse Voltage (PIV)

The maximum voltage drop across a reverse-biased diode in a rectifier ckt is called peak inverse voltage.

1) Half Wave Rectifier

The rectifier ckts which converts any of half cycle (either +ve half cycle or -ve half cycle) of i/p ac signal to pulsating DC signal is called half wave rectifier.

It consist of step-down transformer & diode connected across a load R_L as shown in figure below:

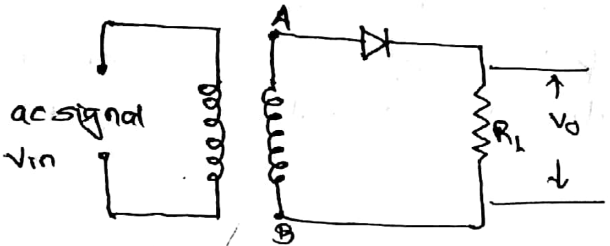


Fig: Half wave rectifier

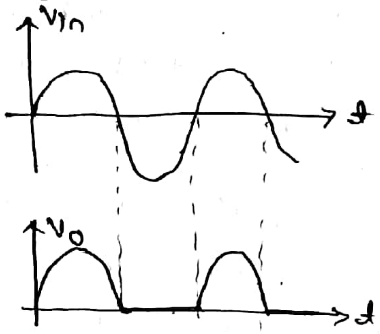
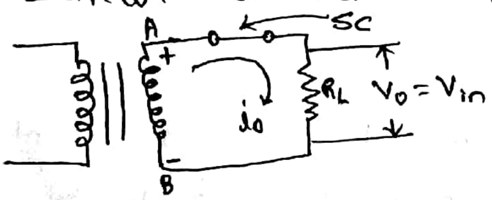


Fig: I/O waveform

Operation:

i) For +ve Half cycle of Input

During +ve half cycle of i/p ac signal, the end A of secondary winding of transformer becomes +ve & end B becomes -ve. The diode is forward biased, & ideally it behaves as a short circuit so that current i_o flows through the load R_L.



Here, $V_o = V_{in}$

ii) For -ve half cycle of Input

During -ve half cycle of ac i/p signal, the end A of secondary winding of transformer becomes -ve & end B becomes +ve. The diode is reverse-biased (open ckt) & thus it doesn't conduct current through load resistance R_L.

Here, $V_o = 0$

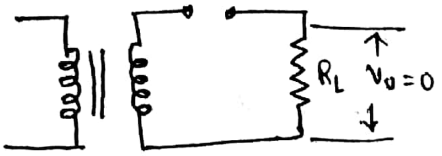


Fig: Reverse-biased ckt.

Thus diode conducts the current during +ve half cycle only & resultant o/p voltage waveform is as shown below.

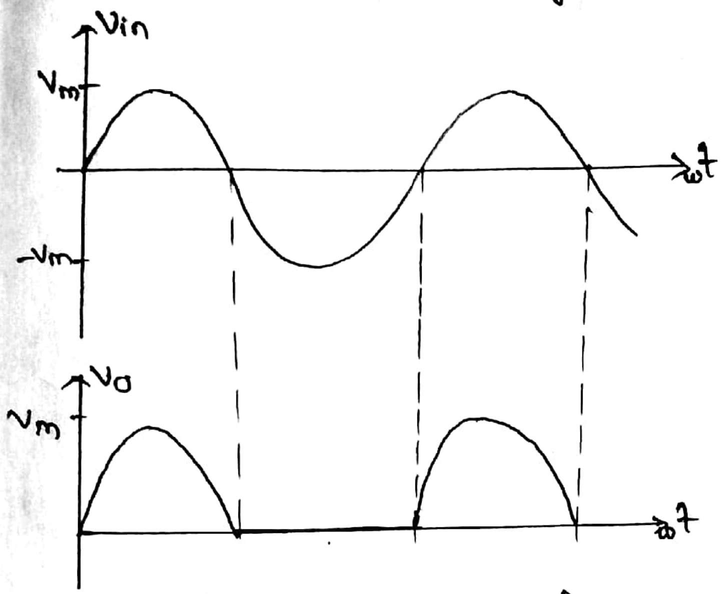


Fig: I/p & O/p voltage waveform

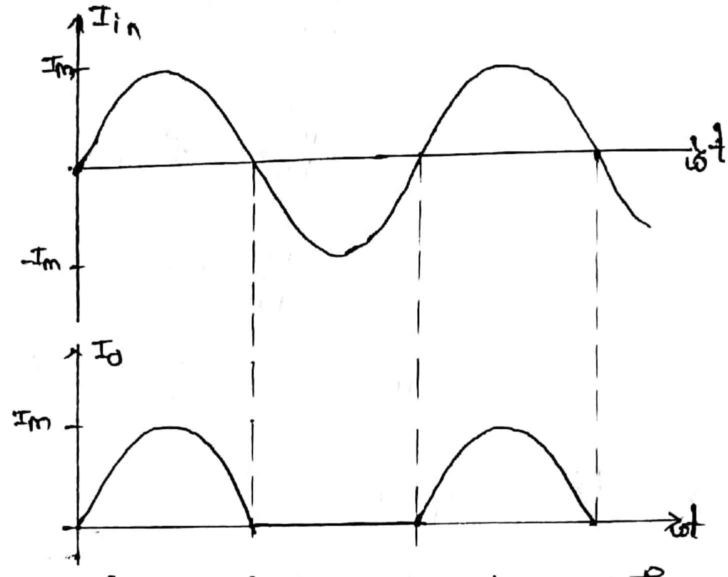


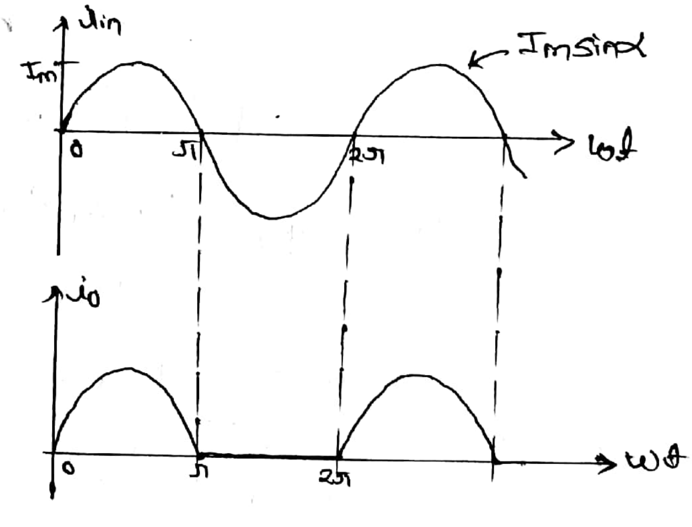
Fig: I/p & O/p current waveform

Efficiency, Ripple factor & PIV of Half wave Rectifier

Consider a sinusoidal ac i/p current to the half wave rectifier circuit,

$$i_{in} = I_m \sin\alpha \quad \text{for } 0 < \alpha < 2\pi$$

where $\alpha = \omega t$



Then, the o/p current of half-wave rectifier is,

$$i_0 = \begin{cases} I_m \sin\alpha & \text{for } 0 < \alpha < \pi \\ 0 & \text{for } \pi < \alpha < 2\pi \end{cases}$$

Now, a) DC average value of o/p current is,

$$I_{avg} = I_{dc} = \frac{1}{2\pi}\int_0^{\pi} I_m \sin\alpha \, d\alpha \Leftarrow \frac{1}{2\pi}\int_0^{\pi} i_0 \, d\alpha$$

$$= \frac{I_m}{2\pi}\left[-\cos\alpha\right]_0^{\pi} = \frac{I_m}{2\pi}\left(-\cos\pi + \cos 0\right)$$

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

$$\therefore I_{avg} = I_{dc} = \frac{I_m}{\pi}$$

b) Rms value of o/p current

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} i_o^2\, d\alpha} = \sqrt{\frac{1}{2\pi}\int_0^{\pi}(I_m \sin\alpha)^2\, d\alpha}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\int_0^{\pi}\frac{1-\cos 2\alpha}{2}\, d\alpha}$$

$$= \sqrt{\frac{I_m^2}{4\pi}\int_0^{\pi}(1-\cos 2\alpha)\, d\alpha} \quad \left[= \sqrt{\frac{I_m^2}{4\pi}\left[\alpha - \cancel{\frac{\sin 2\alpha}{2}}^{\,0}\right]_0^{\pi}}\ \right]$$

$$= \sqrt{\frac{I_m^2}{4\pi}[\alpha]_0^{\pi}}$$

$$= \sqrt{\frac{I_m^2}{4\pi}\times\pi}$$

$$\therefore I_{rms} = \frac{I_m}{2}$$

c) Efficiency (η)

$$\eta = \frac{\text{dc o/p power}}{\text{ac o/p power}} = \frac{P_{dc}}{P_{ac}}$$

where, $P_{dc} = I_{dc}^2 \cdot R_L = \left(\frac{I_m}{\pi}\right)^2 R_L$

& $P_{ac} = I_{rms}^2 (R_L + r_D)$, where r_D = diode resistance

$$= \left(\frac{I_m}{2}\right)^2 (R_L + r_D)$$

Thus, $$\eta = \frac{(I_m/\pi)^2 R_L}{(I_m/2)^2 (R_L + r_D)}$$

For max^m efficiency, $R_L + r_D \simeq R_L$ $(\because r_d << R_L)$

So, $$\eta_{max} = \frac{1/\pi^2 \times R_L}{1/4 \times R_L} = \frac{4}{\pi^2} = 0.4053$$

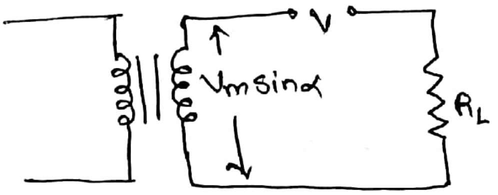
$\therefore \eta_{max} = 40.53\%$. This is the maximum possible efficiency.

d) Ripple factor (r)

$$r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\frac{(I_m/2)^2}{(I_m/\pi)^2} - 1} = \sqrt{\frac{\pi^2}{4} - 1}$$

$$\therefore r = \sqrt{1.4674} = 1.21$$

c) Peak inverse voltage (PIV)



Here, $V = V_m \sin\alpha$, when diode is reverse biased.

For maxm value, $\sin\alpha = 1$

so that $V = V_m$

$\therefore PIV = V_m$

2) Full Wave Rectifier

The rectifier circuit which converts both +ve & -ve cycle of ac i/p signal to dc o/p signal is called full-wave rectifier.

There are two types of full wave rectifier

i) Center-Tap Full wave Rectifier

ii) Bridge Full wave Rectifier

i) Center Tap Full wave Rectifier

The center-Tap full wave rectifier consists of a center-tap step down transformer & two diodes D_1 & D_2 connected across secondary winding of transformer & connected to load resistance R_L as shown in fig below.

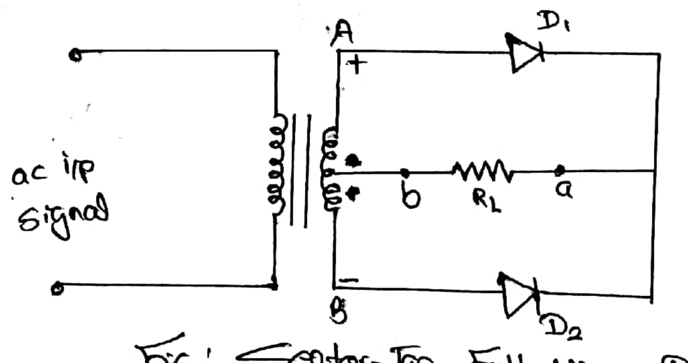


Fig: Center-Tap Full wave Rectifier

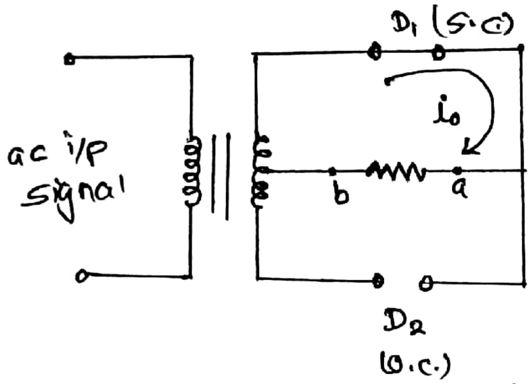
Operation:

a) For +ve half cycle of Input

During +ve half cycle of i/p, end A of secondary winding of transformer becomes +ve & end B becomes -ve.

Diode D_1 becomes forward biased & D_2 is reverse biased.

The forward biased diode D_1 conducts current through the load resistor R_L from end 'a' & end 'b' as shown in figure below.

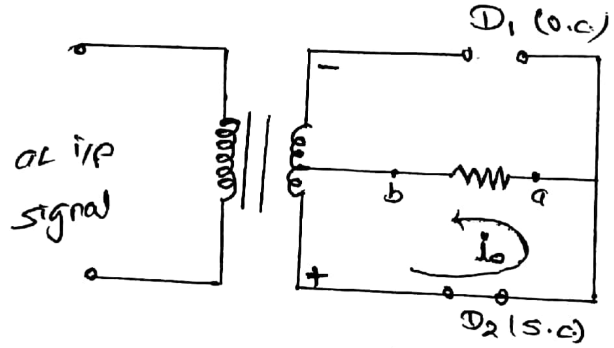


$D_1 \rightarrow$ Forward Biased $\rightarrow$ Short circuit

$D_2 \rightarrow$ Reverse Biased $\rightarrow$ open ckt

b) For -ve Half cycle of Input

During -ve half cycle of i/p, end A of secondary winding of transformer becomes -ve & B becomes +ve. So that diode D_1 is reverse biased & D_2 is forward biased.
Thus diode D_2 conducts current through load resistor R_L from end 'a' to 'b' as shown in fig below.



$D_1 \Rightarrow$ reverse bias $\rightarrow$ O.C

$D_2 \Rightarrow$ forward-bias $\Rightarrow$ S.C.

Since, in both +ve & -ve half cycles of i/p, diode conducts current in same direction through load resistance R_L. Then dc o/p is obtained across R_L. & the resultant o/p voltage & current waveform is,

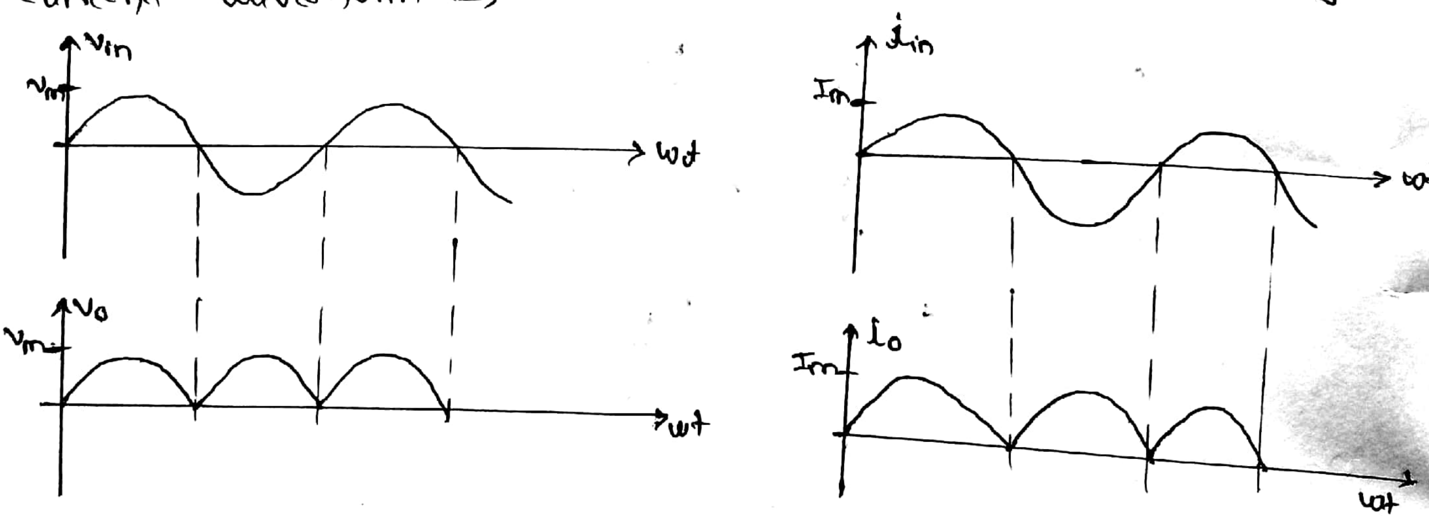


Fig: I/p & o/p waveform of voltage & current in Center Tap Full wave Rectifier.

(ii) Bridge Full Wave Rectifier

Bridge full wave rectifier consists of a diode bridge circuit with four diodes D_1, D_2, D_3, D_4 along with a load resistor connected as shown in figure below. (& a step down transformer).

The secondary winding of the transformer is connected to one diagonally opposite end of diode bridge ckt & load R_L is connected to the next diagonally opposite ends.

Operation:

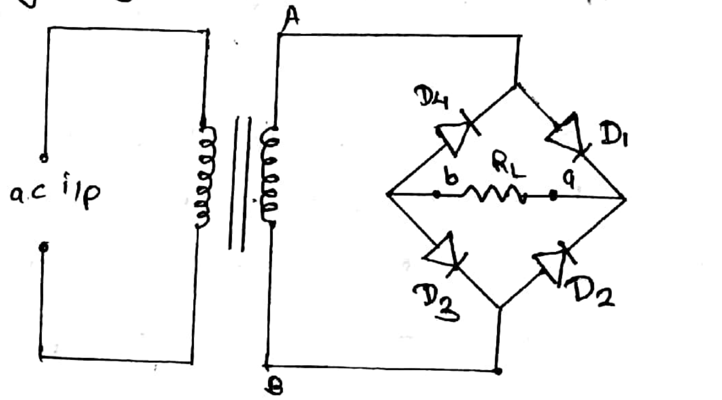


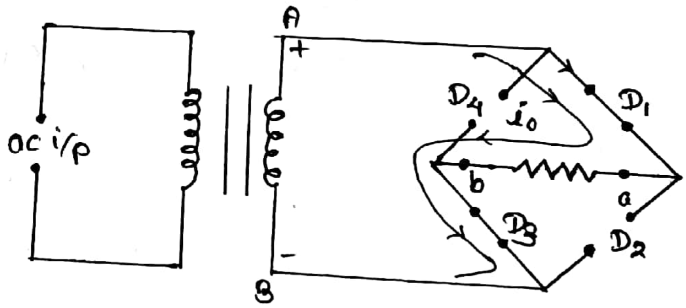
Fig: Bridge Full Wave Rectifier

a) For +ve half cycle of I/p

During +ve cycle of i/p, end A of 2ndary winding of transformer becomes +ve & end B becomes -ve. Here diodes D_1 & D_3 are forward biased and diode D_2 & D_4 are reverse-biased. So that diodes D_1 & D_3 conducts current through load resistance R_L from end 'a' to end 'b' as shown in figure below.

Here, $D_1, D_3 \Rightarrow$ F.B $\Rightarrow$ S.C.

$D_2, D_4 \Rightarrow$ RB $\Rightarrow$ O.C.

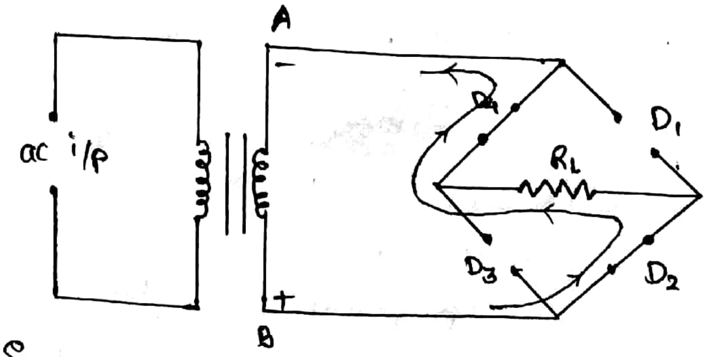


b) For -ve half cycle of I/p

During -ve half cycle of I/p, end A of 2ndary winding of transformer becomes -ve & end B becomes +ve. Here Diodes D_2 & D_4 forward biased and diodes D_1 & D_3 are reverse biased. Thus diodes D_2 & D_4 conducts current through the load R_L from end 'a' to end 'b' as shown in figure below.

Here, $D_2, D_4 \Rightarrow$ F.B. $\Rightarrow$ S.C.

$D_1, D_3 \Rightarrow$ R.B. $\Rightarrow$ O.C.



As current flows in same direction in load resistor R_L for both +ve & -ve half cycle of i/p, the resultant o/p waveform is as shown below;

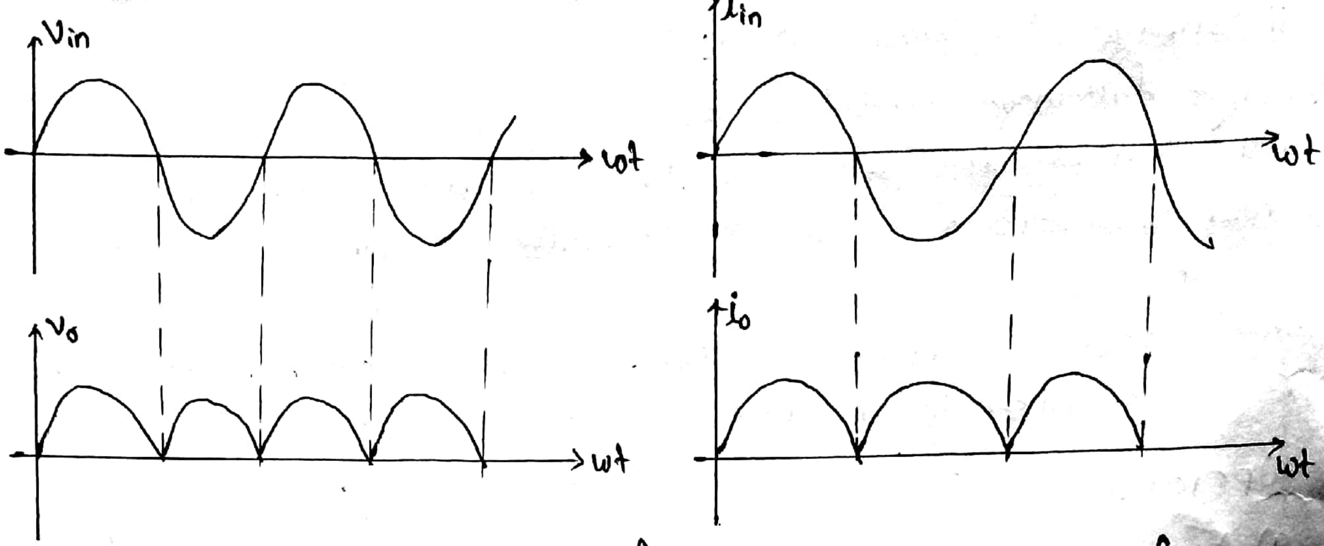


fig: I/P & O/P waveform for voltage & current for Bridge Full Wave Rectifier circuit.

Efficiency, Ripple factor & PIV of Full Wave Rectifier

Consider a sinusoidal ac i/p current supplied to full wave rectifier,

$$I_{in} = I_m \sin\alpha \quad \text{for } 0 < \alpha < 2\pi$$
where $\alpha = \omega t$

Then the o/p current of fullwave rectifier is given by

$$i_o = I_m \sin\alpha \quad \text{for } 0 < \alpha < \pi$$

Now, a) DC average o/p value of o/p current is

$$I_{avg} = I_{dc} = \frac{1}{\pi}\int_0^{\pi} i_o\, d\alpha = \frac{1}{\pi}\int_0^{\pi} I_m \sin\alpha\, d\alpha = \frac{I_m}{\pi}\left[-\cos\alpha\right]_0^{\pi}$$

$$\therefore I_{avg} = \frac{I_m}{\pi}(1+1) = \frac{2I_m}{\pi}$$

b) RMS value of o/p current

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} i_o^2\, d\alpha} = \sqrt{\frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2\alpha\, d\alpha}$$

$$= \sqrt{\frac{I_m^2}{\pi}\int_0^{\pi} \frac{1-\cos 2\alpha}{2}\, d\alpha} = \sqrt{\frac{I_m^2}{2\pi}\left[\alpha\right]_0^{\pi}} = \sqrt{\frac{I_m^2}{2}}$$

$$\therefore I_{rms} = \frac{I_m}{\sqrt{2}}$$

c) Efficiency (η)

$$\eta = \frac{\text{dc o/p power}}{\text{ac i/p power}} = \frac{P_{dc}}{P_{ac}}$$

Where, $P_{dc} = I_{dc}^2 R_L = \left(\frac{2I_m}{\pi}\right)^2 . R_L$

& $P_{ac} = I_{rms}^2 (R_L + r_D')$

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 (R_L + r_D')$$

Here $r_D' = r_D$ for Center-tap full wave rectifier
& $r_D' = 2r_D$ for Bridge Full wave rectifier.

$$\therefore \eta = \frac{(2I_m/\pi)^2 \cdot R_L}{(I_m/\sqrt{2})^2 (R_L + r_D')}$$

For maximum efficiency $R_L + r_D' \simeq R_L$ (i.e. neglect r_D').

So,
$$\eta_{max} = \frac{(2I_m/\pi)^2 \cdot R_L}{(I_m/\sqrt{2})^2 \cdot R_L} = \frac{2^2 \times (\sqrt{2})^2}{\pi^2} = \frac{8}{\pi^2} = 0.8105$$

$$\therefore \eta_{max} = 81.05\%$$

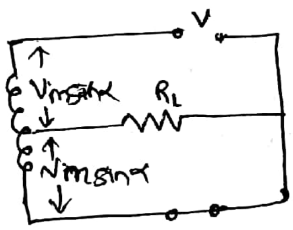
d) Ripple Factor (r)

$$r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1} = \sqrt{\frac{\pi^2}{8} - 1} = 0.48$$

$\therefore r = 0.48$

e) Peak Inverse Voltage (PIV)

i) Center-Tap FW Rectifier



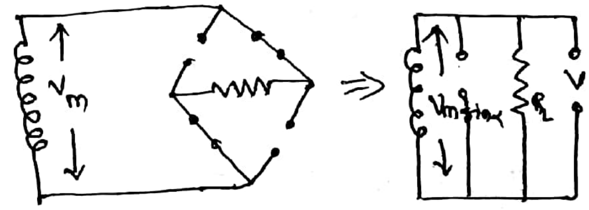
Here,

$V = V_m \sin\alpha + V_m \sin\alpha$
$= 2V_m \sin\alpha$

For maxm value,
$\sin\alpha = 1$

$\therefore$ PIV $= 2V_m$

ii) Bridge FW Rectifier



Here, $V = V_m \sin\alpha$

For maxm value $\sin\alpha = 1$

$\therefore$ PIV $= V_m$

Filter Circuits:

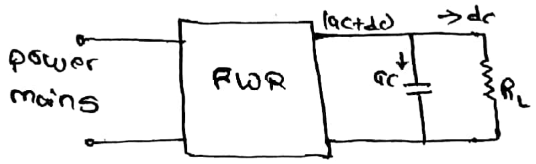
The o/p of rectifier ckt contains both dc & ac components. The ac components are undesirable & must removed from rectified o/p voltage.

A filter ckt is a device which removes the ac components of rectifier o/p & allows the dc components to flow through load.

There are various types of filter circuits,

1) Capacitor Filter,
2) Inductor Filter,
3) LC filter &
4) π-filter

1) Capacitor Filter / Shunt Capacitor Filter



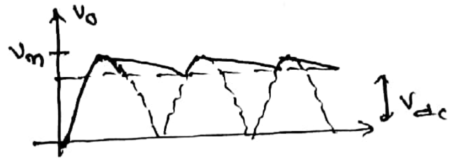


Fig: Shunt capacitor filter & its o/p waveform

The o/p obtained from rectifier gives pulsating dc o/p voltage containing both ac & dc components. When capacitor is shunt to o/p (load) resistance, it allows the ac components to pass & block the dc components. So that o/p contains a small portion of ac components & large dc components.

Here, it still contains some ripples. It can further minimized using higher values of capacitance or using an LC or π-filter.

[C allows ac signal to pass → pass through C & grounded
block dc " → so remains → pass through R_L ⇒ o/p]

2) Series Inductor Filter

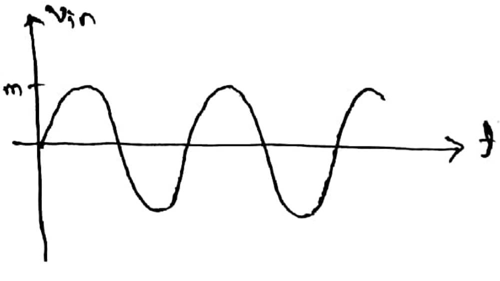


Fig: Series inductor filter

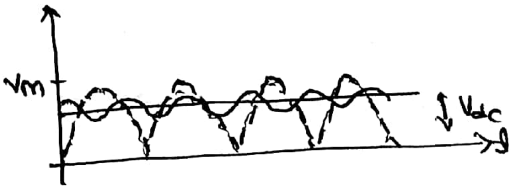


Fig: O/P waveform.

Series inductor filter consists of inductor & load resistor connected in series to op of a rectifier.

Inductor is normally connected in series with rectifier hence it is called series inductor filter.
Inductor passes dc signal & block ac signal. Hence we get pure dc signal at the o/p of filter.

3) LC Filter

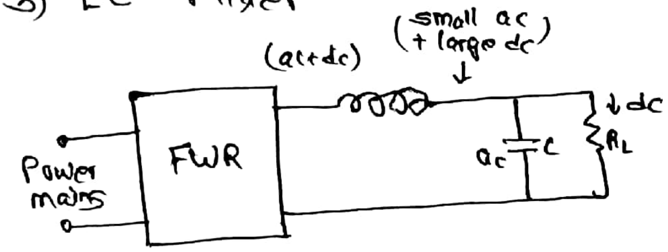
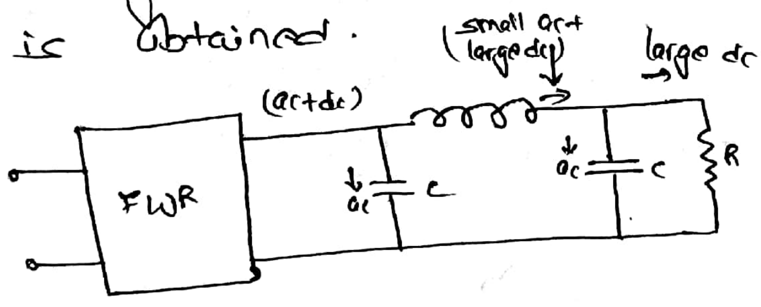


Fig: LC filter & I/p o/p waveform.

The LC filter contains series inductor & shunt capacitor. The inductor allows the dc components to pass & block ac components (i.e. small ac + large dc). And capacitor blocks dc components while allows only ac components to pass. Thus there will be large dc components & only small components of ac as an O/p.

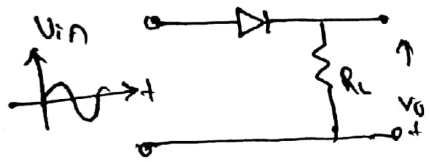
4) π Filter (CLC Filter / Capacitor Input filter)

The π-filter or CLC filter consists of 2 capacitors that are separated by inductor as shown in fig below. Capacitor blocks dc component & so dc component & small ac components pass towards inductor, which blocks ac components & only pass dc component. If small ac components are present after the inductor, it is passed through shunt capacitor. Thus, more smooth dc o/p voltage is obtained.

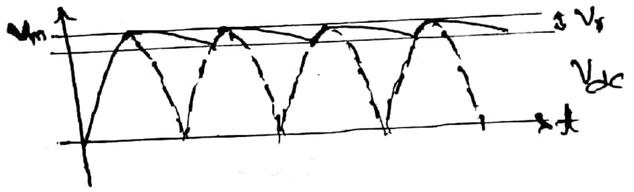


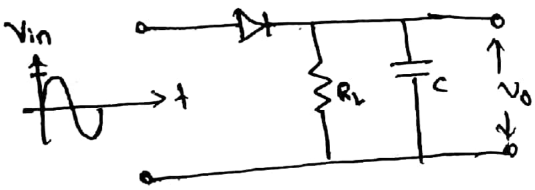
* Half Wave Rectifier with shunt capacitor filter

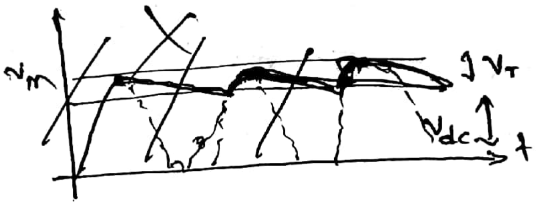
In halfwave rectifier diode conducts current during +ve half cycle since it is forward-biased & it doesn't conduct (opened) current during -ve half cycle as it is reverse biased, as shown in figure below.



The halfwave rectifier with shunt capacitor filter is as shown in figure below.







In +ve half cycle, i.e. from point 'o' to 'a', diode is forward biased & current flows through the diode & capacitor ~~is~~ charges upto V_m. As the V_{in} falls down from a point 'a' i.e. $|V_{in}| < V_m$, then the diode turn OFF, as it is reverse biased. Then capacitor discharges through R_L and voltage across the capacitor is also reduced. Also as soon as $|V_{in}| > |V_c|$ in next +ve half cycle, then diode turns ON & capacitor charges again. By this process, almost constant (with minimum ripples), o/p voltage is obtained across R_L & filtered o/p. waveform is obtained as shown in above figure.

Here, DC, average value, $V_{dc} = V_m - \frac{V_r}{2}$

The total charge lost during discharge time T_2 through the load is given by,

$$Q_{discharge} = I_{dc} T_2$$

This charge is stored during time interval T_1 in which voltage across the capacitor increases by V_r volts. Thus charge gained by capacitor is,

$$Q_{charge} = C V_r$$

Since $Q_{charge} = Q_{discharge}$

or, $C V_r = I_{dc} T_2$

or, $V_r = \frac{I_{dc} T_2}{C}$

Let $T_2 >> T_1$ & $T_2 = T = 1/f$

Then, $V_r = \frac{I_{dc} \times 1/f}{C} = \frac{I_{dc}}{fC}$

$\therefore V_{dc} = V_m - \frac{V_r}{2} = V_m - \frac{I_{dc}}{2fC}$

Ripple factor,

The rms value is given by,

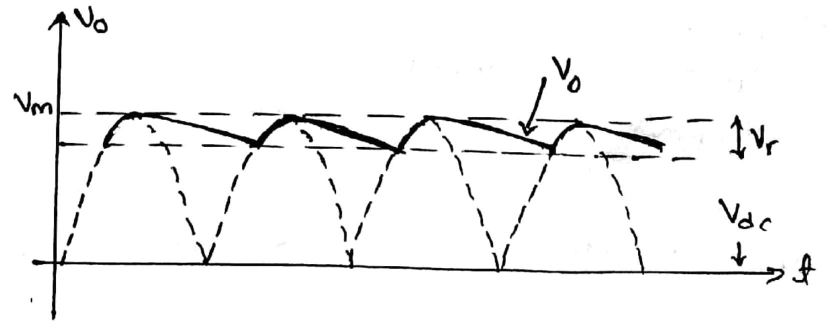
$$V_{ac,rms} = \frac{V_r}{2\sqrt{3}}$$

So, ripple factor, $r = \frac{V_{ac,rms}}{V_{dc}} = \frac{V_r}{2\sqrt{3}} \times \frac{1}{I_{dc} R_L}$

$$= \frac{I_{dc}}{2\sqrt{3} fC} \times \frac{1}{I_{dc} R_L} = \frac{1}{2\sqrt{3} fCR_L}$$

* Full wave Rectifier with shunt capacitor filter

The filtered o/p waveform for full wave rectifier with shunt capacitor filter is as shown



In this case, non conduction period has reduced because both diodes conduct. The ripple voltage V_r reduces & the average dc voltage increases.

Scanned by CamScanner

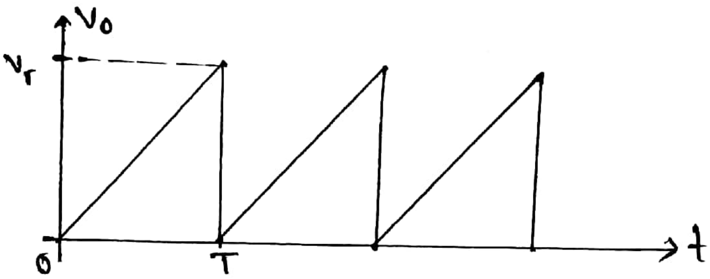
Here, $V_r = \frac{I_{dc}}{2f_c}$ and, $V_{dc} = V_m - \frac{V_r}{2} = V_m - \frac{I_{dc}}{4f_c}$

Again, $V_{ac\,rms} = \frac{V_r}{2\sqrt{3}}$

Now, ripple factor, $r = \frac{V_{ac\,rms}}{V_{dc}} = \frac{V_r}{2\sqrt{3}} \times \frac{1}{I_{dc} R_L}$

$$= \frac{I_{dc}}{2f_c} \times \frac{1}{2\sqrt{3}} \times \frac{1}{I_{dc} R_L}$$

$$\therefore r = \frac{1}{4\sqrt{3} f_c R_L}$$



The rms value for the triangular waveform as shown above is,

$$V_{rms}^2 = \frac{1}{T} \int_0^T V_o^2(t)\, dt$$

$$= \frac{1}{T} \int_0^T \left(\frac{V_m}{T} t\right)^2 dt = \frac{1}{T} \int_0^T \frac{V_m^2}{T^2} t^2 dt$$

$$= \frac{1}{T} \frac{V_m^2}{T^2} \left[\frac{t^3}{3}\right]_0^T = \frac{V_m^2}{T^3} \left(\frac{T^3 - 0}{3}\right) = \frac{V_m^2}{3}$$

$$\therefore V_{rms} = \frac{V_m}{\sqrt{3}}$$

Clipper (Clipping Circuits)

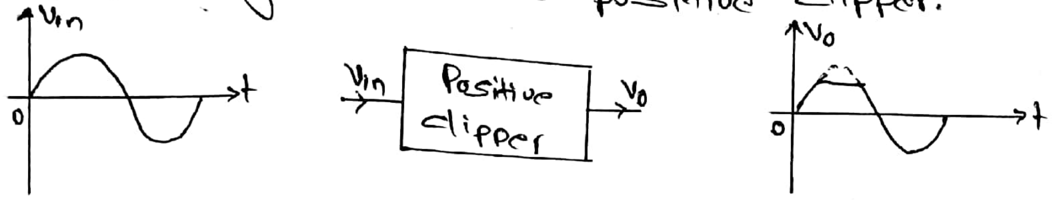
A diode ~~ckt~~ which is used to clipp-off or remove certain portion of i/p ac signal (above or below some reference level) are called clipper.

There are 3 types of clippers.

1) Positive clipper
2) Negative "
3) Dual clipper (Positive Negative clipper)

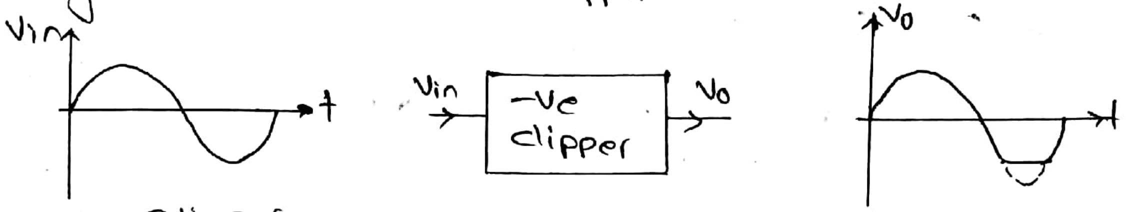
1) Positive Clipper

The diode ckts which are used to remove certain positive portion of ac signal are called positive clipper.



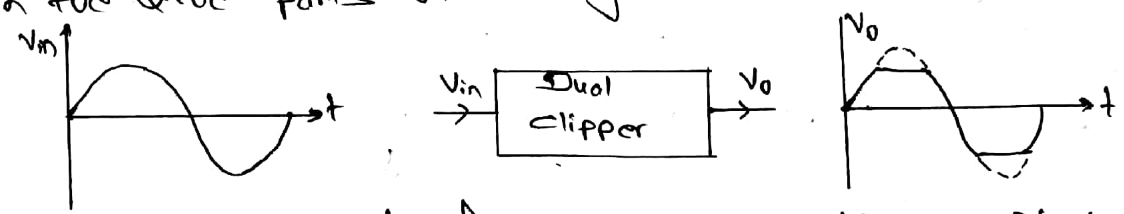
2) Negative Clipper

The diode ckts which are used to remove certain -ve portion of ac signal is called -ve clipper.

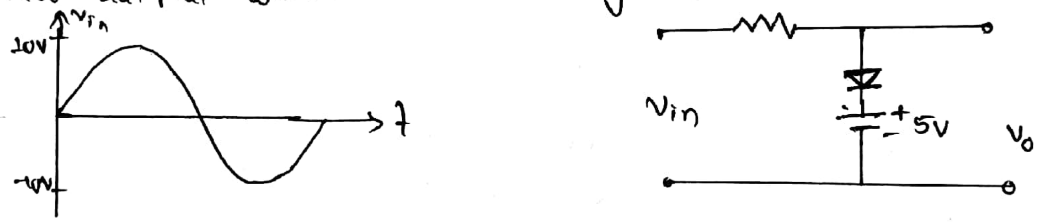


3) Dual Clipper

The diode ckts which are used to remove certain portion of both +ve & -ve parts of ac signal are called dual clippers.



Draw output waveform for following i/p & ckt. (Assume ideal diode)



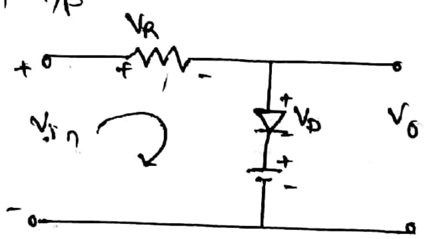
Soln: Consider a +ve cycle of i/p

Applying KVL,

$V_{in} - V_R - V_D - 5 = 0$

On neglecting V_R,

$V_D = V_{in} - 5$



Condition for diode to be ON

$V_D > 0$

or, $V_{in} - 5 > 0$

$\therefore V_{in} > 5V$

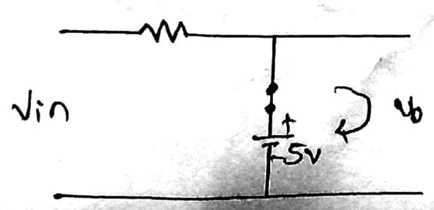
<u>If diode is ON:</u>

replace diode by short ckt.

Applying KVL,

$5 - V_0 = 0$

$\Rightarrow V_0 = 5V$

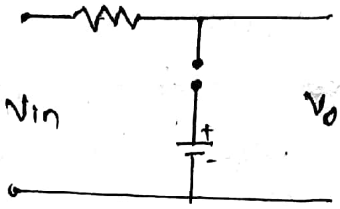


Scanned by CamScanner

If diode is OFF,

→ replace it by open ckt,

Here, $V_o = V_{in}$



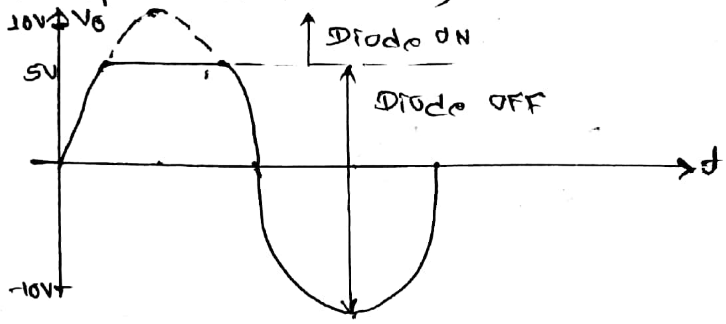
Now,

Condition is, $V_{in} > 5V$

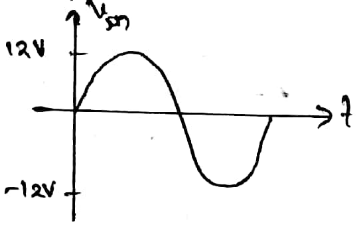
Diode ON, $V_0 = 5V$

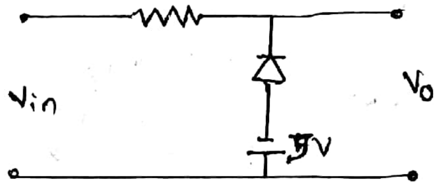
Diode OFF, $V_0 = V_{in}$

Thus, the o/p waveform is,



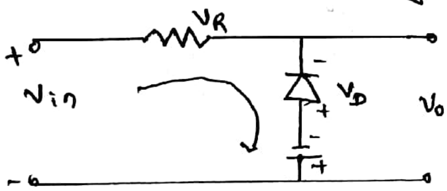
Draw o/p waveform. (Assume ideal diode)





Soln:

Consider +ve cycle of i/p



Applying KVL, we get,

$V_{in} + V_D + 5 = 0$

$V_D = -V_{in} - 5$

Condition for diode to be on ~~diode~~

* If diode ON,

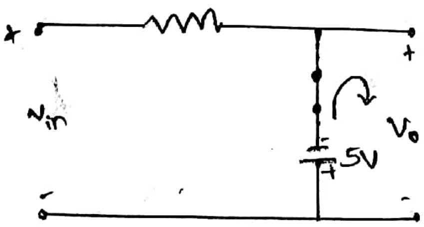
Here, $V_o = -5V$

$V_D > 0$

or, $-V_{in} - 5 > 0$

or, $-V_{in} > 5$

∴ $V_{in} < -5$



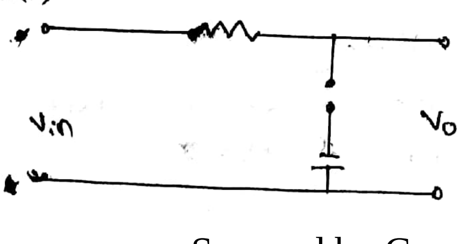
$-5 - V_o = 0$

$\Rightarrow V_o = -5V$

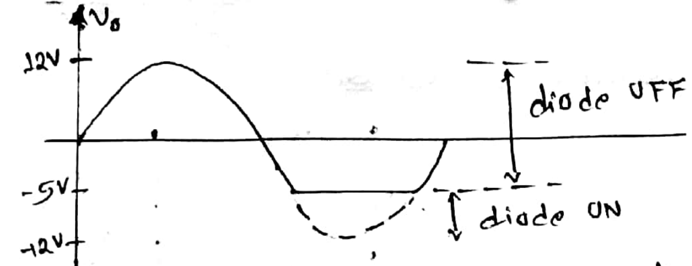
* If diode is OFF,

→ diode is replaced by open ckt,

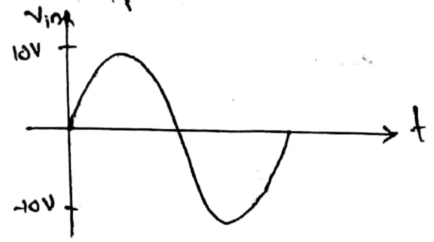
$V_o = V_{in}$

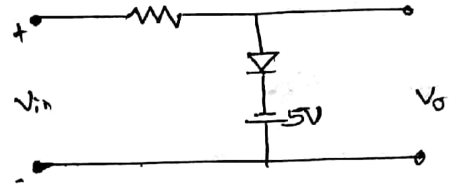


Scanned by CamScanner



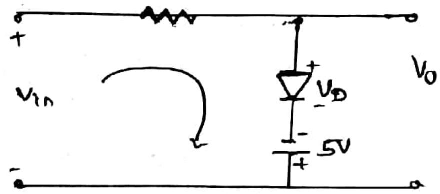
Draw o/p waveform. (assume ideal diode)





Soln:

Consider two cycle of i/p,



Applying KVL,

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

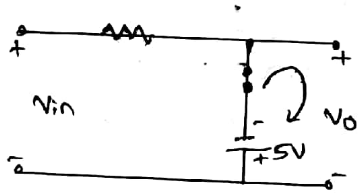
or, $V_D = V_{in} + 5$ —— (i)

Condition for diode to be ON,

$V_D > 0$

$V_{in} + 5 > 0$

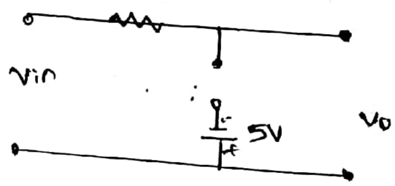
$\Rightarrow V_{in} > -5$



If diode is ON,

$-5 - V_o = 0$

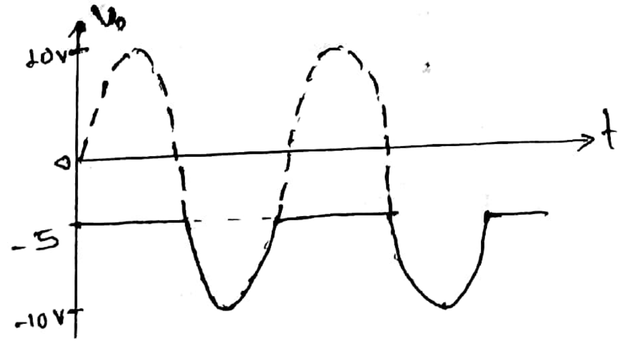
$\Rightarrow V_o = -5$



If diode is OFF,

Here, $V_o = V_{in}$

Now, the o/p waveform is,



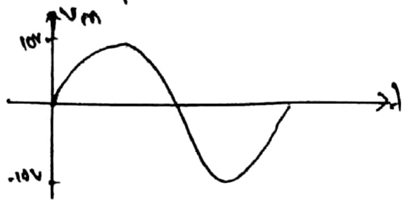
$V_{in} > -5 \Rightarrow$ ON

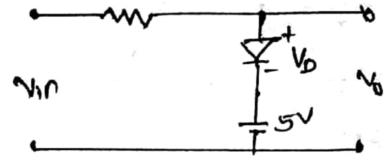
~~Same o/p~~

$V_{in} = -5 \Rightarrow$ ON
constant o/p

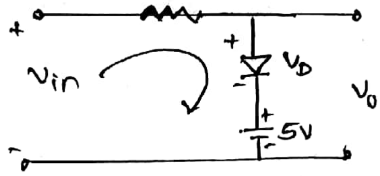
$V_{in} < -5 \Rightarrow$ OFF
$V_o = V_{in}$
Same as i/p

Draw o/p waveform (assume Si diode)





Soln: Consider +ve cycle of i/p



Applying KVL,

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

$\therefore V_D = V_{in} - 5$

Condition for diode to be ON,

$V_D > 0.7$

$V_{in} - 5 > 0.7$

$V_{in} > 5.7$

→ If diode is ON
replace diode by 0.7V source

$-V_0 + 5 + 0.7 = 0$

$\Rightarrow V_0 = 5.7V$

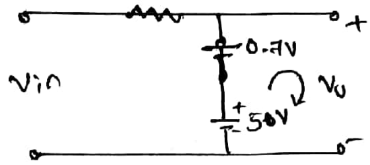


Fig: If diode is ON

If diode is OFF

→ replace diode by open ckt

$\therefore V_0 = V_{in}$

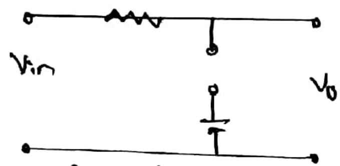
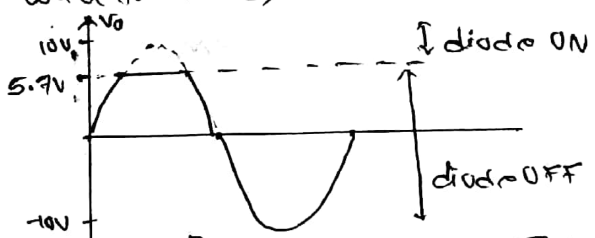
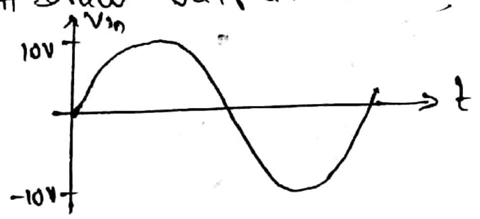


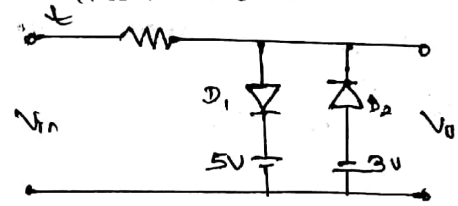
Fig: If diode is OFF

Now, o/p waveform is,

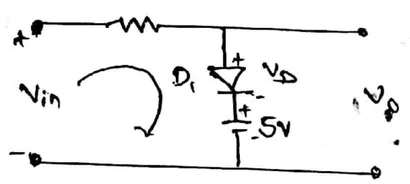


Draw output waveform (assume Silicon diode)





Soln: Consider diode D_1 only,



Applying KVL

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

$\Rightarrow V_D = V_{in} - 5$

Condition for diode to be ON,

$V_D > 0.7$

$V_{in} - 5 > 0.7$

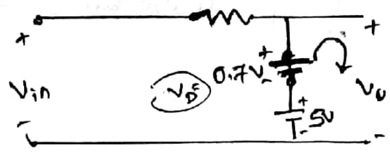
$V_{in} > 5.7$

If diode is ON

Applying KVL,

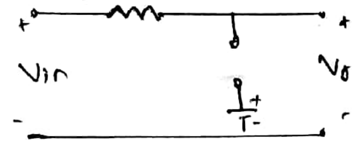
$5 + 0.7 - V_0 = 0$

$\therefore V_0 = 5.7V$

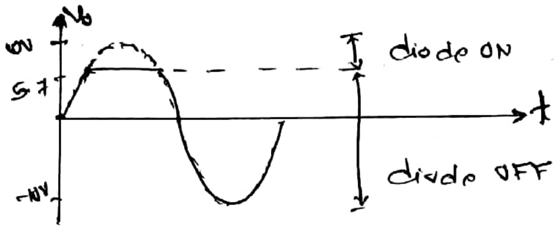


If diode is OFF

Here, $V_0 = V_{in}$



Now, o/p waveform is,

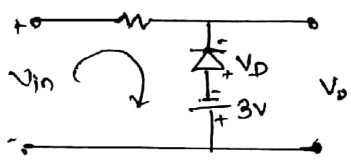


Consider diode D_2 only,

Applying KVL,

$V_{in} + V_D + 3 = 0$

$\Rightarrow V_D = -V_{in} - 3$



Condition for diode to be ON,

$V_D > 0.7$

or, $-V_{in} - 3 > 0.7$, or, $-V_{in} > 3.7$

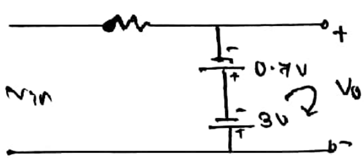
$\Rightarrow V_{in} < -3.7V$

If diode is ON

Applying KVL,

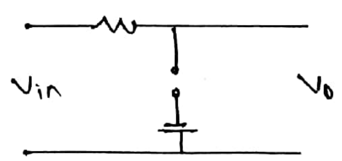
$-3 - 0.7 - V_0 = 0$

$\Rightarrow V_0 = -3.7V$

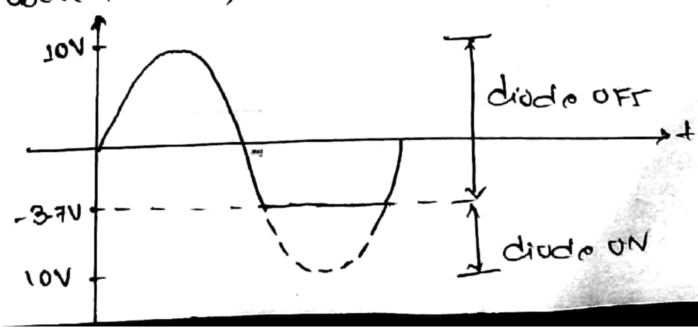


If diode is OFF,

$V_0 = V_{in}$



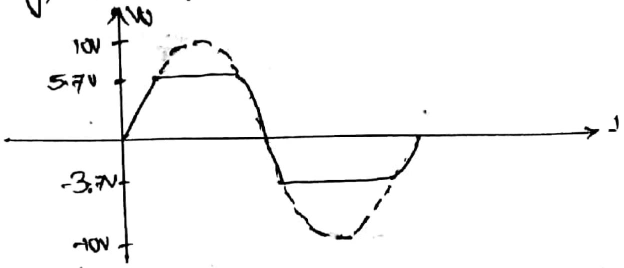
Now, o/p waveform is,



$V_{in} < -3.7V$

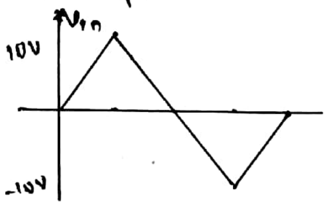
$\Rightarrow$ ON for $-3.7V$, $-4V$, $-5V$ & $-\infty$ on

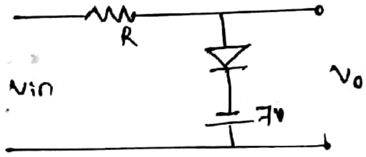
On combining, the o/p waveform is,



~~Clampers (Clamping Circuits)~~

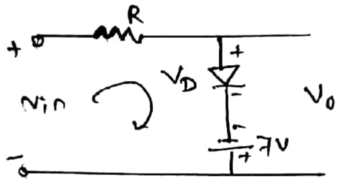
Draw o/p waveform (assume ideal diode)





Soln:

Consider +ve (half) cycle,



Applying KVL,

$V_{in} - V_D + 7 = 0$

$\Rightarrow V_D = V_{in} + 7$

Condition for diode to be ON

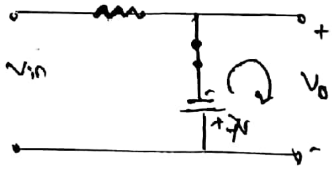
$V_D > 0$

or, $V_{in} + 7 > 0$

$\Rightarrow V_{in} \geq -7$

If diode is ON,

→ replace diode by short ckt,



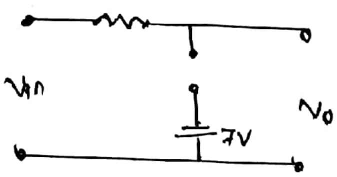
$-7 - V_0 = 0$

$\Rightarrow V_0 = -7V$

If diode is OFF

→ replace diode by open ckt

Here, $V_0 = V_{in}$

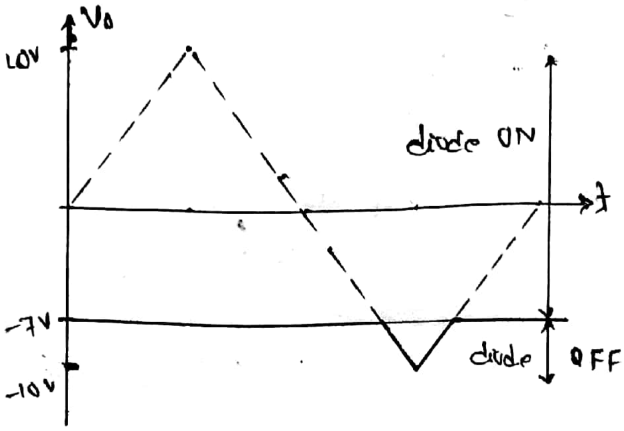


Now,

Condition: $V_{in} \geq -7$

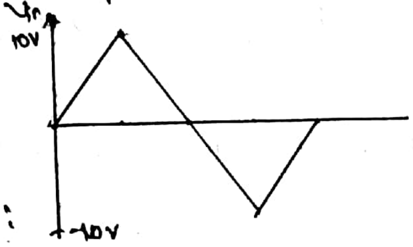
ON & , $V_0 = -7$

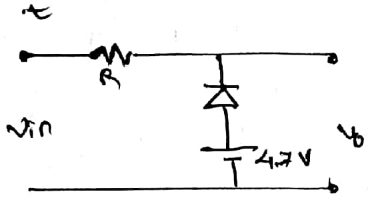
OFF , $V_0 = V_{in}$



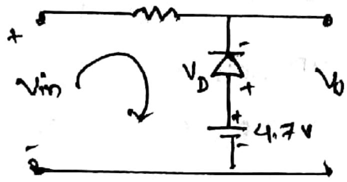
[$V_{in} \geq -7 \Rightarrow -5V, 0, 5, 10V$]

Draw output waveform. (Assume practical diode)





Soln:



Applying KVL

$V_{in} + V_D - 4.7 = 0$

$\Rightarrow V_D = 4.7 - V_{in}$

For diode to be ON,

$V_D > 0.7$

$4.7 - V_{in} > 0.7$

or, $4 > V_{in}$

$\Rightarrow V_{in} < 4$

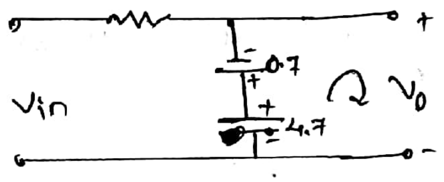
If diode is ON,

$\Rightarrow$ replace diode by 0.7V,

using KVL,

$4.7 - 0.7 - V_0 = 0$

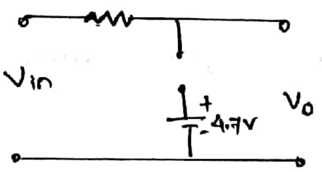
$\Rightarrow V_0 = 4V$



If diode is OFF

$\Rightarrow$ replace diode by open ckt,

Here, $V_0 = V_{in}$

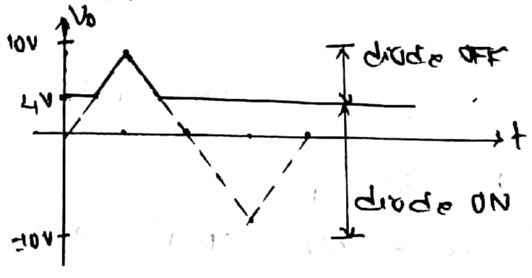


Now,

$V_{in} < 4V$

ON: $V_0 = 4V$

OFF: $V_0 = V_{in}$



Scanned by CamScanner

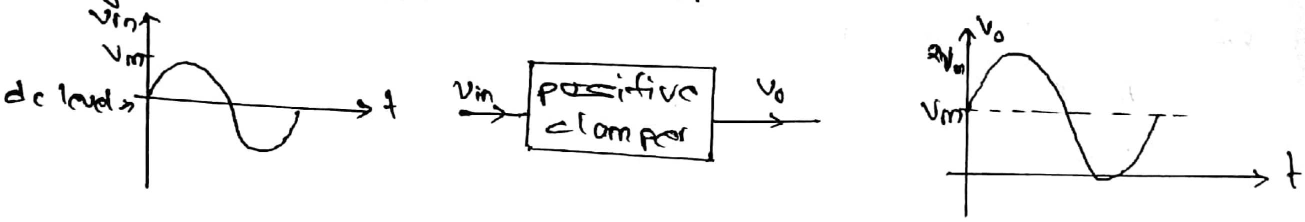
Clampers (Clamping Circuits)

The diode ckts which are used to shift the dc level of an ac waveform are called clampers.
It can also be defined as the diode ckts that are used to add a dc signal to an ac signal.

There are 2 types of clampers

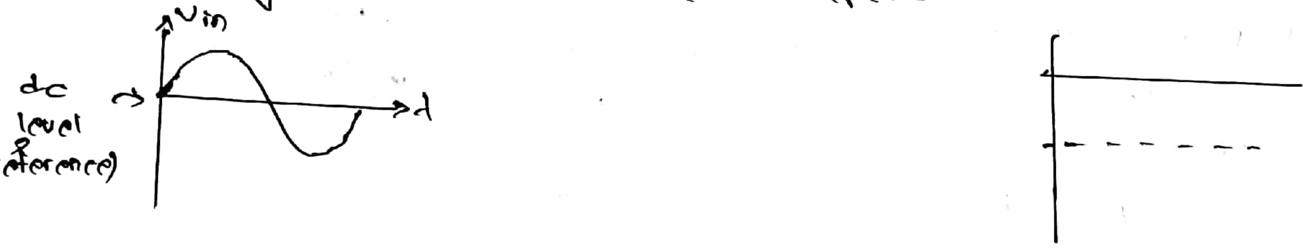
1) Positive Clamper

The diode ckts which are used to add +ve dc voltage to an ac signal are called +ve clampers.

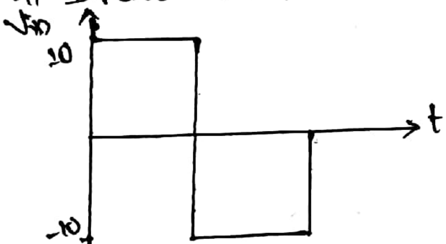


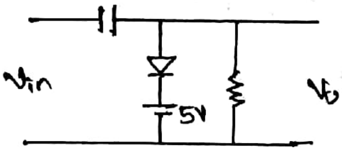
2) Negative Clamper

The diode ckt which are used to add a -ve dc voltage to a ac signal are called -ve clampers.

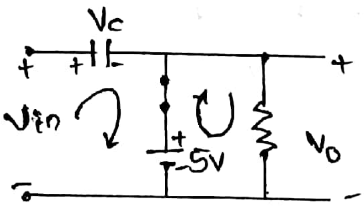


Draw output waveform. (Assume ideal diode)





Soln: Here, diode is forward biased for +ve cycle of i/p.



i) For +ve cycle of i/p
⇒ replace diode by short circuit.

Applying KVL at i/p loop

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

or, $V_c = V_{in} - 5 = 10 - 5$

$\therefore V_c = 5V$

Applying KVL at o/p loop,

$5 - V_0 = 0$

$\Rightarrow V_0 = 5V$

ii) For -ve cycle of i/p

⇒ replace diode by open ckt.

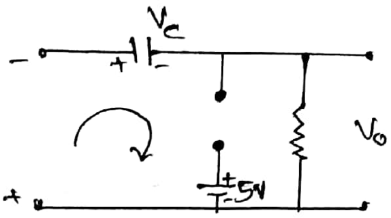
Applying KVL,

$-V_{in} - V_c - V_0 = 0$

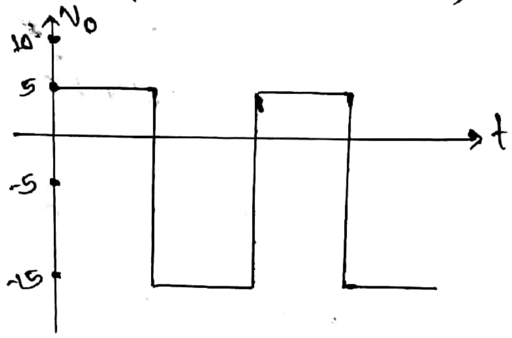
or, $V_0 = -V_{in} - V_c$

or, $V_0 = -10 - 5$

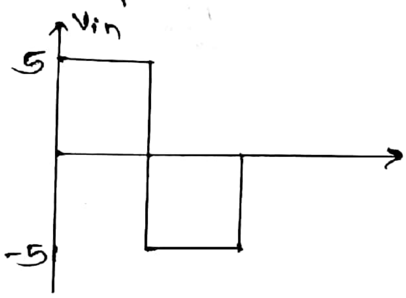
$\Rightarrow V_0 = -15V$

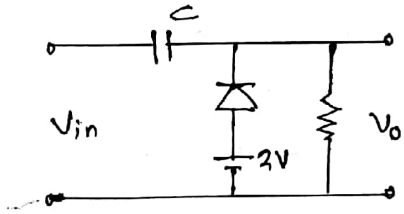


Now, the o/p waveform is,



Draw o/p waveform (Assume ideal diode)





Soln: Here, diode is forward biased for -ve cycle of i/p.

i) For -ve cycle of i/p

→ replace diode by short ckt,

Applying KVL on i/p loop,

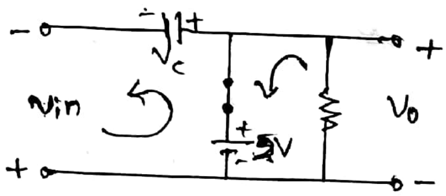
$V_{in} + 2 - V_c = 0$

$\Rightarrow V_c = V_{in} + 2 = 5 + 2 = 7V$

Applying KVL in O/p loop,

$V_0 - 2 = 0$

$\Rightarrow V_0 = 2V$



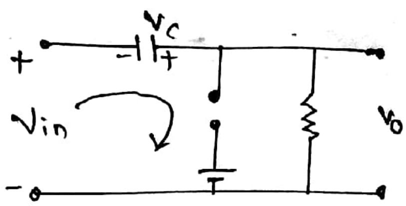
ii) For +ve cycle of i/p

diode is reverse biased, replace diode by open ckt,

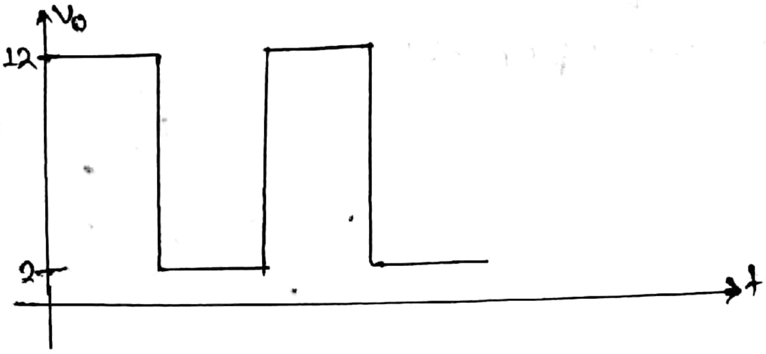
Applying KVL, $V_{in} + V_c - V_0 = 0$

$\Rightarrow V_0 = V_{in} + V_c = 5 + 7$

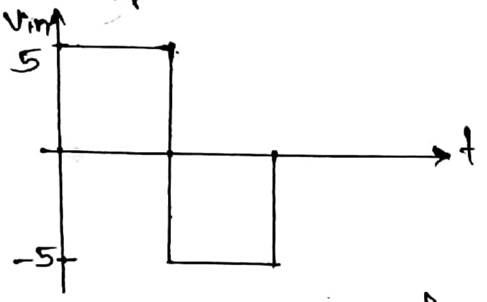
$= 12V$

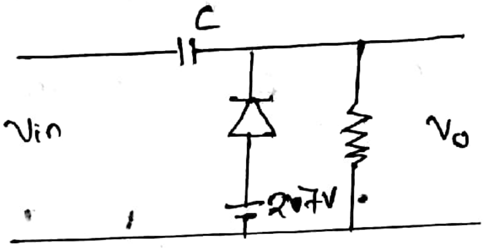


Now, o/p waveform is,



Draw o/p waveform. (Assume Si diode).



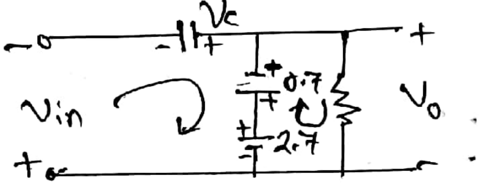


Soln: Here, diode is forward biased for -ve cycle of i/p.

i) For -ve cycle of i/p

→ replace diode by 0.7V voltage source,

Applying KVL at i/p loop,



$-V_{in} + V_c + 0.7 - 2.7 = 0$

$\Rightarrow V_c = V_{in} + 2 = 5 + 2 = 7V$

Applying KVL at o/p loop,

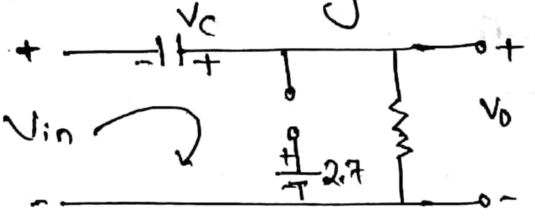
$2.7 - 0.7 - V_o = 0.$

$\Rightarrow V_o = 2V$

ii) For +ve cycle of i/p

→ diode is reverse-biased, replace diode by open ckt,

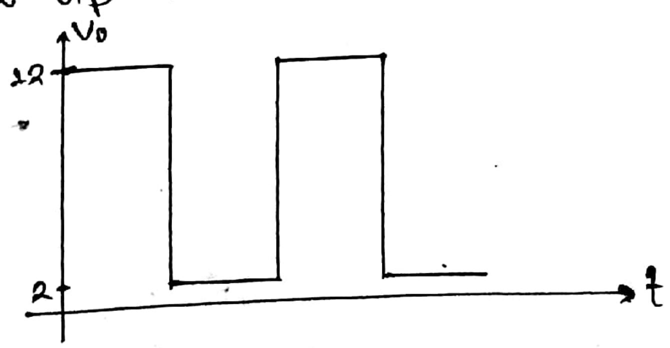
Applying KVL,



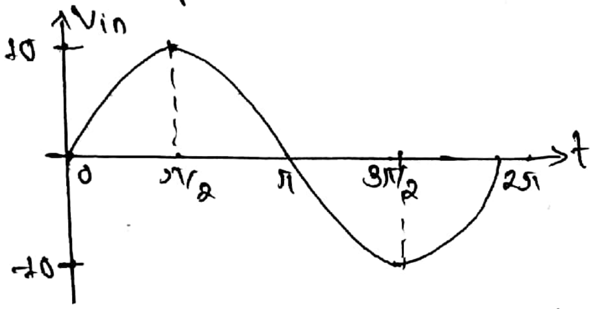
$V_{in} + V_c - V_o = 0$

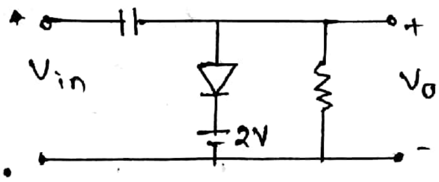
$\Rightarrow V_o = V_{in} + V_c = 5 + 7 = 12V$

Now o/p waveform is,



Draw o/p waveform. (Assume ideal diode).



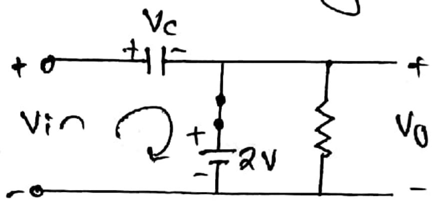


Soln: Here, diode is forward biased for +ve cycle of i/p.

i) For +ve cycle of i/p.

→ replaced diode by short ckt.

Applying KVL at i/p loop,



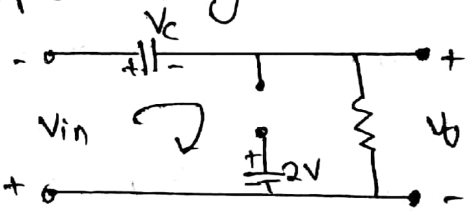
$V_{in} - V_c - 2 = 0$

$\Rightarrow V_c = V_{in} - 2 = 10 - 2 = 8V$

ii) For -ve cycle of i/p

→ diode is reverse biased & replace it by open ckt.

Applying KVL,



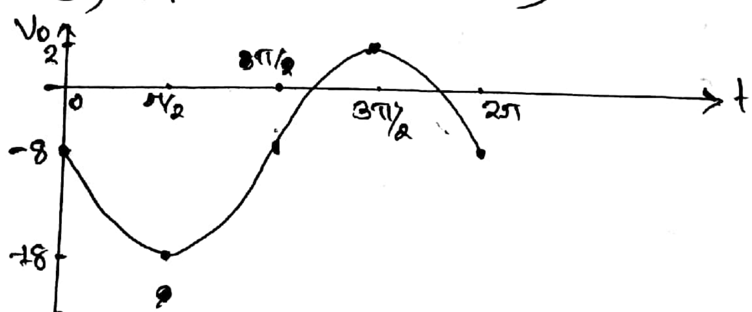
$-V_{in} - V_c - V_o = 0$

$\Rightarrow V_o = -V_{in} - V_c = -V_{in} - 8$

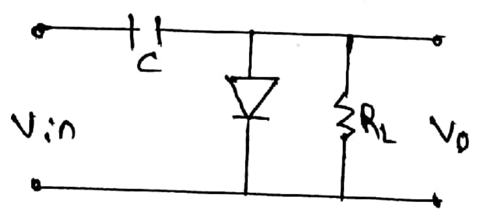
Now,

ωt	0	$\pi/2$	π	$3\pi/2$	2π
V_{in}	0	10	0	-10	0
V_o	-8	-18	-8	2	-8

Thus, o/p waveform is,

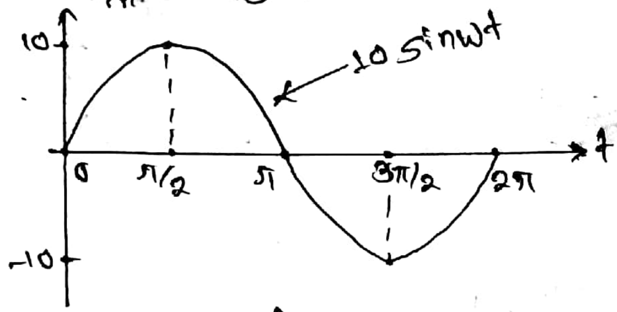


Draw o/p waveform for the i/p signal, $V_{in} = 10\sin\omega t$. (Assume Silicon diode).



Soln: The i/p waveform is,

$V_{in} = 10\sin\omega t$

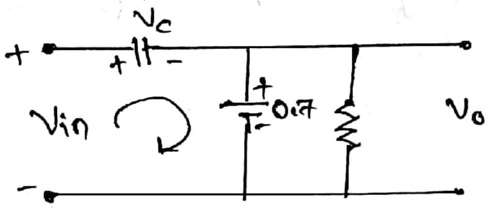


Here, diode is forward biased for +ve cycle of i/p.

i) For +ve cycle of i/p

⇒ replace diode by voltage source of 0.7V.

Applying KVL at i/p loop,



$V_{in} - V_c - 0.7 = 0$

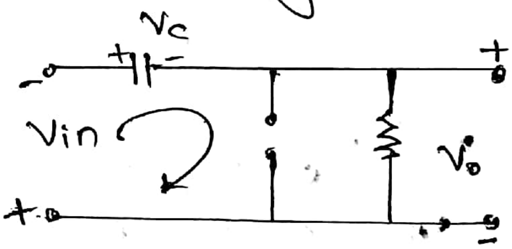
$\Rightarrow V_c = V_{in} - 0.7 = 10 - 0.7$

or $V_c = 9.3V$

ii) For -ve cycle of i/p

⇒ diode is reverse biased, replace it by open ckt.

Applying KVL at i/p loop,



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

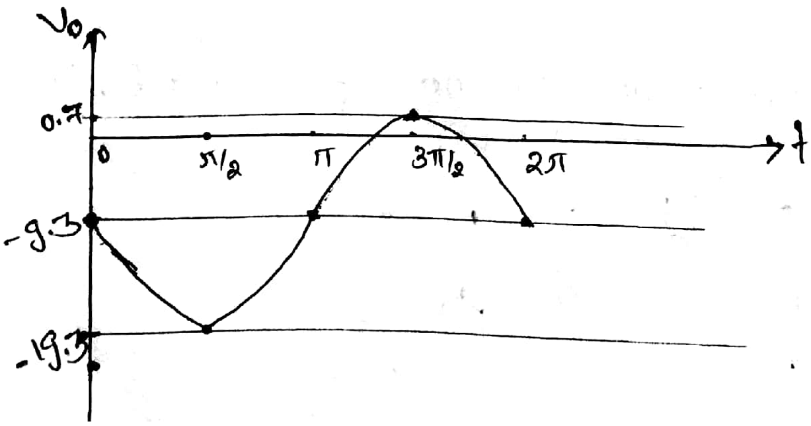
$\Rightarrow V_o = -V_{in} - V_c$

or, $V_o = -V_{in} - 9.3V$

Now,

ωt	0	π/2	π	3π/2	2π
Vin	0	10	0	-10	0
Vo	-9.3	-19.3	-9.3	0.7	-9.3

Thus, o/p waveform is,



Scanned by CamScanner

Regulated & Unregulated Power Supplies

Unregulated Power Supply

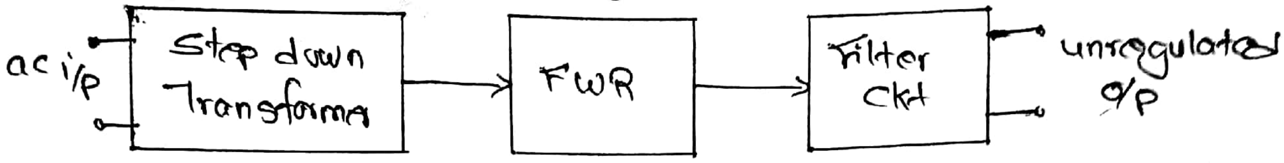


Fig: Block diagram of unregulated power supply.

Regulated Power Supply

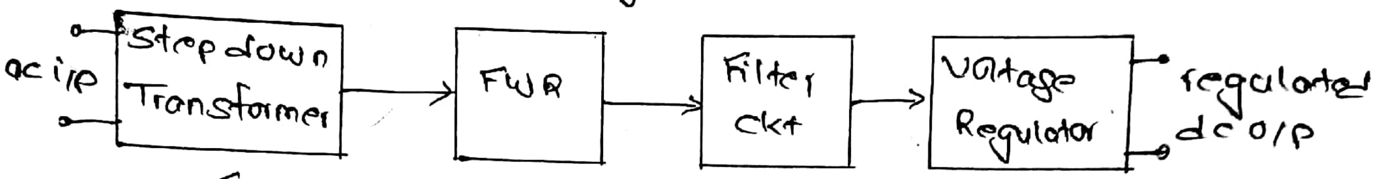


Fig: Block diagram of regulated Power supply.