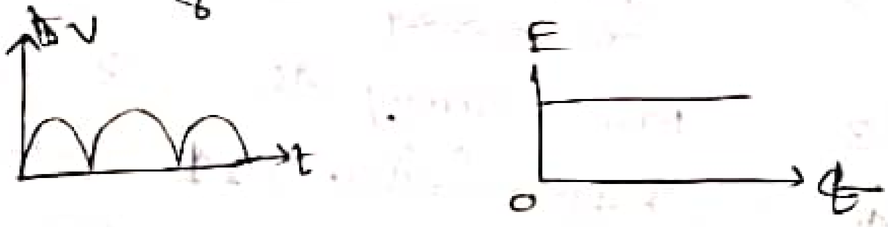
Filter

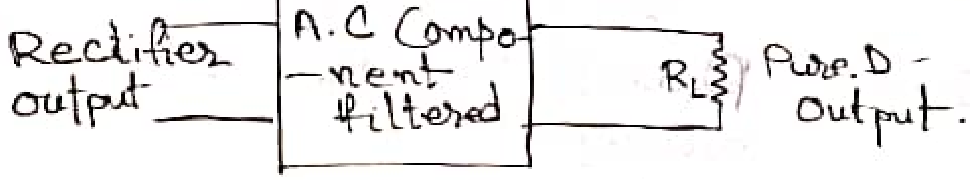
(i) The output of a rectifier is pulsating to nature i.e It contains dc and ac components.

(ii) A filter circuit is a device which removes for ripples components (for ac components) of rectifier output but allows the dc component to reach the load.

(iii) Obviously a filter circuit should be installed between the rectifier and the load as shown as fig.

(iv) A filter circuit is generally a combination of Inductors (L) and capacitors (C) that converts pulsating output of a rectifier into a steady dc Voltage





Filter Circuit

Types of Filter Circuits:-

The most commonly used filter circuits are:

(a) Shunt Capacitor Filter

(b) series Inductor filter.

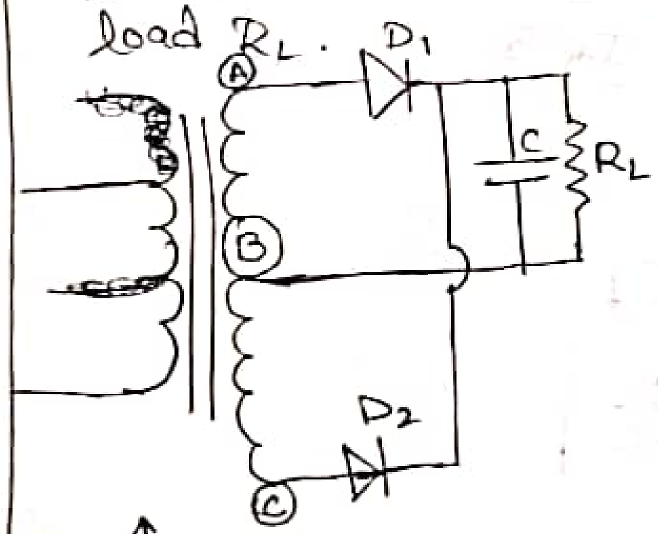
(c) Choke Input or L-Type filter.

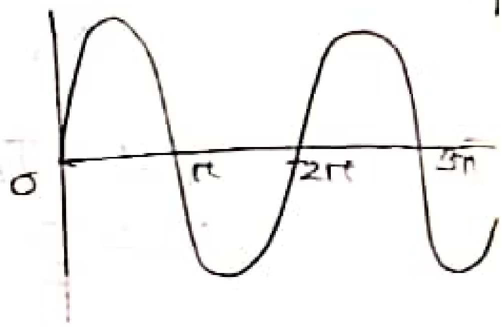
(d) Capacitor Input or π-filter.

Shunt Capacitor Filter:-

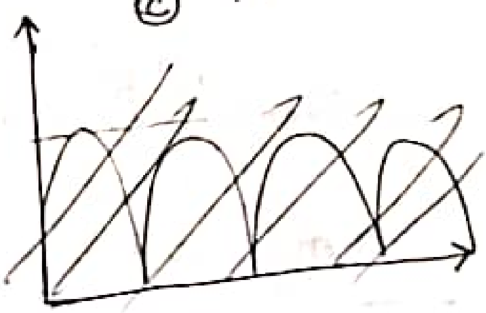
1) Filtering is frequently done by shunting the load with a capacitor called Shunt Capacitor Filter.

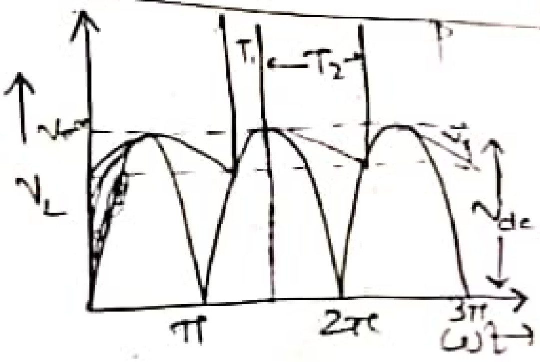
2) This ~~a for~~ is the most simplest from of the filter circuit and in this arr-angement a capacitor C put across the rectifier output in parallel with load R_L.





$$V_{dc} = V_{Lmax} - \frac{V_r}{2}$$





Calculation of Ripple factor for full wave rectifier with Shunt Capacitor:-

Charge lost by the capacitor during interval T_2

$$(q)_{discharge} = I_{dc} T_2 \quad \text{— (i)}$$

[Capacitor discharge during Interval T_2]

During Interval T_1, when the capacitor volt changes by an amount = peak to peak value of ripple voltage, charge gain by ~~$V_{dc} = V_{max} - \frac{V_r}{2}$~~ the capacitor during time T_1.

$$(q)_{charge} = V_r \times C \quad \text{— (ii)}$$

Steady state,

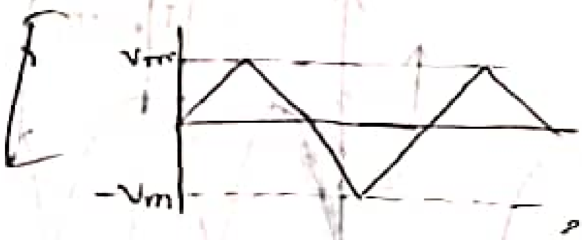
$$V_r C = I_{dc} T_2$$

$$\Rightarrow V_r = \frac{I_{dc} T_2}{C} \quad \text{— (iii)}$$

$$T_1 << T_2$$

$$T_2 \simeq \frac{T}{2} = \frac{1}{2f} \quad \text{— (iv)}$$

$$\boxed{V_r = \frac{I_{dc}}{2fC}} \quad \text{— (v)}$$



$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi/2} (I_m \sin\omega t)\, d\omega t}$$

$$= \sqrt{\frac{1}{2\pi}\int^{\pi/2} I_m \sin\omega t}$$

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

$$V_{rms} = \sqrt{\frac{1}{\pi/2}\int_0^{\pi/2}\left(\frac{V_m}{\pi/2}\theta\right)^2 d\theta}$$

$$= \sqrt{\frac{1}{\pi/2}\times\frac{V_m^2}{(\pi/2)^2}\int_0^{\pi/2}\theta^2 d\theta}$$

θ^2

$= \frac{\theta^3}{3}$

$$= \sqrt{\frac{1}{\pi/2}\times\left(\frac{V_m}{\pi/2}\right)^2\left[\frac{\theta^3}{3}\right]_0^{\pi/2} d\theta}$$

$$= \sqrt{\frac{1}{\pi/2}\times\frac{V_m^2}{\pi^2}\left(\frac{\pi}{2}\right)^3\frac{1}{3}}$$

$$= V_m^2\times\frac{1}{\pi/2}\times\frac{1}{\pi}\times\frac{\pi}{2}\times\pi\times\frac{1}{3}$$

$$= \boxed{\frac{V_m}{\sqrt{3}}}$$

$\therefore \gamma = V_m/\sqrt{3}$

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

$$V_r(rms) = \frac{V_r}{2\sqrt{3}} = \frac{I_{dc}}{4\sqrt{3}fC} \quad \text{——(vi)}$$

$$V_{rms} = \frac{I_{dc}}{4\sqrt{3}fCR_L} \quad \text{——(vii)}$$

$$V_{r\,rms} = \frac{V_{dc}}{4\sqrt{3}fCR_L} \quad \text{——(viii)}$$

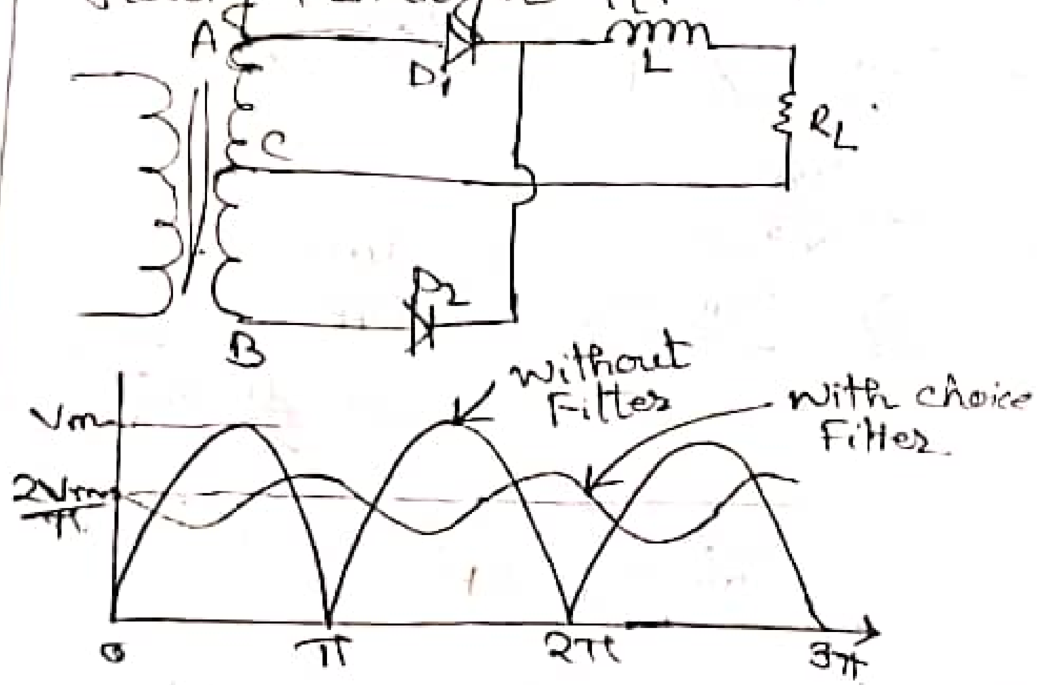
$$\boxed{\gamma = \frac{1}{4\sqrt{3}fCR_L}}$$

Ripple factor decrease by increasing either load resistance or capacitor

Series Inductor Fielter

1) In series Inductor filter the inductor is connected in series with the rectifier element of the load resistr. Thus, it called series Inductor filter.

2) The filtering action of an inductor filter depends upon its property of opposing and a change of current flowing through it.



The filtering action of an inductor filter depends upon its properties of opposing many change in current flowing through it. Does by placing a choke coil or an inductor in series with the rectifier element and the load Resistance R_L. Sudden change in any current that may have occured in the circuit in the absence of an inductor es filtered out by the presence of an conductor

Calculation of Ripple factor for full wave rectifier with series inductor field

The fourier series for the load current of full wave rectified sine wave

$$i_L = \frac{2I_m}{\pi} - \frac{4I_m}{3\pi}\cos 2\omega t - \frac{4I_m}{15\pi}\cos 4\omega t \quad \text{--- (1)}$$

[Note: Fourier series for full wave rectified sine wave $f(t) = \frac{2A}{\pi} - \frac{4A}{\pi}\sum_{n=1}^{\infty}\frac{\cos 2n\omega t}{4n^2-1}$]

The reactance of inductor increases with increase in frequency. There is a better ~~field~~ filtering action for higher order.

So the effect of 3^{rd} and higher order harmonic can be neglected.

$$i_L = \underbrace{\frac{2I_m}{\pi}}_{DC} - \underbrace{\frac{4I_m}{3\pi}\cos 2\omega t}_{AC} \quad \text{--- (ii)}$$

Neglecting forward resistance of diode; The DC component of current is given by.

$$\frac{2I_m}{\pi} = \frac{2V_m}{\pi R_L} \quad \text{--- (iii)}$$

AC component of current is given by,

$$I_m = \frac{V_m}{Z} \quad \text{--- (iv)}$$

$$Z = R_L + j2X_L \quad \text{--- (v)}$$

The ripple present in the ~~[illegible]~~ 2nd harmonic components

$$|z| = \sqrt{R_L^2 + 4(\omega L)^2} \angle\phi$$

$$= \cancel{\tan^{-1}\frac{2X_L}{R_\omega}}$$

$$= \tan^{-1}\frac{2X_L}{R_L} = \tan^{-1}\frac{2\omega L}{R_L}$$

for equation (iv),

$$I_m = \frac{V_m}{\sqrt{R_L^2 + (4\omega)^2}}$$

$$= \frac{V_m}{\sqrt{R_L + \omega^2 L^2}} \quad \text{— (vi)}$$

Then eq - (ii),

$$i_L = \frac{2V_m}{\pi R_L} - \frac{4V_m}{3\pi\sqrt{R^2 + \omega^2 L^2 4}} \cdot \cos(2\omega t - \phi) \quad \rightarrow \text{(vii)}$$

$$I_m = \frac{V_m}{\sqrt{R^2 + 4\omega^2 L^2}} \quad \text{— (viii)}$$

Ripple factor: $\gamma = \frac{I_{n(rms)}}{I_{dc}}$

$$\cancel{I_{rms} = \frac{V_m}{\sqrt{2}\sqrt{R^2 + 4\omega^2 L^2}}}$$

$$I_{n(rms)} = \frac{4V_m}{3\sqrt{2}\pi\sqrt{R^2 + 4\omega^2 L^2}}$$

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

$$\gamma = \frac{\dfrac{4V_m}{\pi 3\sqrt{2}\sqrt{R^2 + \omega^2 L^2 4}}}{\dfrac{2V_m}{\pi R_L}} \Rightarrow \gamma = \frac{2}{3\sqrt{2}} \frac{R_L}{\sqrt{R_L^2 + 4\omega^2 L^2}}$$

$$= \frac{2}{3\sqrt{2}} \frac{1}{\sqrt{1 + \frac{4\omega^2 L^2}{R^2}}} \quad \text{— (ix)}$$

$$\boxed{\gamma = \frac{2}{3\sqrt{2}} \frac{1}{\sqrt{1+\frac{4\omega^2L^2}{R_L^2}}}} \longrightarrow (x_0)$$

If $\frac{4\omega^2L^2}{R_L^2} >> 1$.

$$\gamma = \frac{2}{3\sqrt{2}} \frac{1}{\frac{2\omega L}{R_L}} = \frac{R_L}{3\sqrt{2}\omega L} \quad —— (x_1)$$

[Small load resistance & high Current → More efficient]

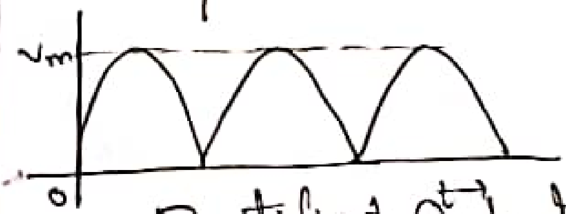
If $R_L = \infty$
$\gamma = \frac{2}{3\sqrt{2}}$
$= 0.471$.

→ Here, No filtering action takes place.
This filter not apply for all loads

→ By using combination of inductors and capacitors ripple factor can be toward.

→ Ripple current can be restricted.

→ Simultaneously ~~and~~ can be made independent of R_L.

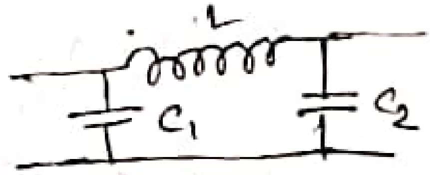


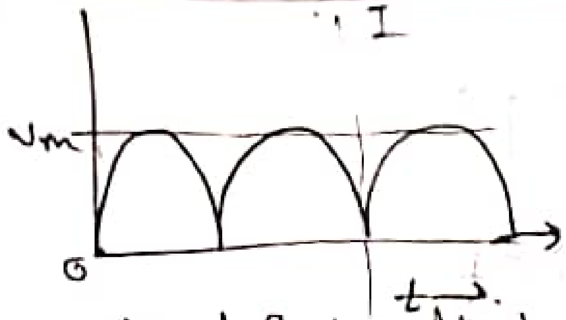
Rectified Output

Circuit
Before full wave Rectifier

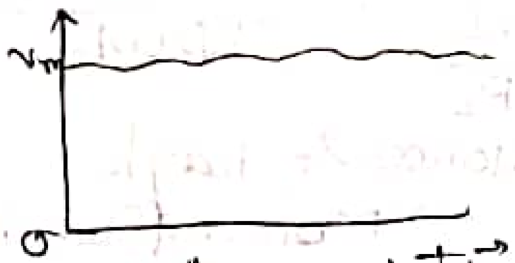
Filter output

Full wave rectifier with choke input or L-type filter.





Rectified output



Filtered output.

Full wave rectifier with capacitor input or π-type filter.

~~the same~~