L-SECTION FILTER (OR) LC FILTER

FWR with LC filter :

Properties of Inductor - blocks AC

- allows DC

Properties of Capacitor - blocks DC

- allows AC

In inductor filter ripple factor is directly proportional to load resistance

$$\gamma = \frac{R_L}{3\sqrt{2}\omega L}$$

In capacitor filter ripple factor is inversely proportional to load resistance

$$\gamma = \frac{R_L}{4\sqrt{3}\, fCR_L}$$

$\therefore$ These two filters are combined to form LC filter so that ripple factor is independent of load resistance.

Any ripple current that has passed through 'L' is bi-passed through 'C' and pure form of dc appears through load.

Here, the choke 'L' is in series with parallel combination of R & C. The reactance of the choke must be large in comparison with parallel combination of R and X_C. This parallel impedance is making smaller by taking smaller value of capacitive reactance.

Therefore we can assume that entire ac passes through capacitor and none of ac component passes through R_L.

$$X_L >> X_C$$
$$R_L >> X_C$$

Impedance is mainly due to choke

$$X_L = 2\omega L \qquad \text{(reactance of inductor at 2}^{\text{nd}}\text{ harmonic)}$$

From Fourier series.

$$V0 = \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t$$

Dc component $= \dfrac{2V_m}{\pi} = V_{dc}$

Magnitude of ripple voltage $= \dfrac{4V_m}{3\pi}$

Magnitude of ripple current $, I' = \dfrac{\frac{4V_m}{3\pi}}{X_L}$

Rms value of ripple current $= \dfrac{4V_m}{3\sqrt{2}\pi}\dfrac{1}{X_L}$

$$= \frac{2\sqrt{2}V_m}{3\pi X_L}$$

$$= \frac{\sqrt{2}}{3}\frac{2V_m}{\pi}\frac{1}{X_L}$$

Ac ripple voltage across the load resistance is same as that across the capacitor filter.

$$V'_{rms} = I'_{rms} X_C$$

$$= \frac{\sqrt{2}}{3}\frac{2V_m}{\pi}\frac{1}{X_L} X_C$$

X_C is reactance of capacitor at 2nd harmonic

$$X_C = \frac{1}{2\omega C}$$

X_L is reactance of inductor at 2nd harmonic

$$X_L = 2\omega L$$

Ripple factor, $\gamma = \frac{V'_{rms}}{V_{dc}} = \frac{\sqrt{2}}{3}\frac{X_C}{X_L}$

$$= \frac{\sqrt{2}}{3}\frac{1}{2\omega L}\left(\frac{1}{2\omega C}\right)$$

$$\gamma = \frac{\sqrt{2}}{3}\frac{1}{4\omega^2 LC}$$

Here ripple factor expression is independent of R_L

$$\gamma = \frac{1}{6\sqrt{2}\omega^2 LC}$$

If $f = 50Hz$. C in μF, L in henrys

$$\gamma = \frac{1}{6\sqrt{2}(2\pi\times 50)^2 \times 10^{-6}\times C\times L}$$

$$= \frac{10^2}{6\sqrt{2}\pi^2 LC}$$

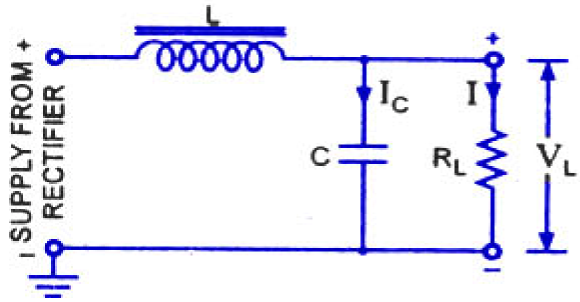
$$= \frac{1.194}{LC}$$

HWR with LC filter :

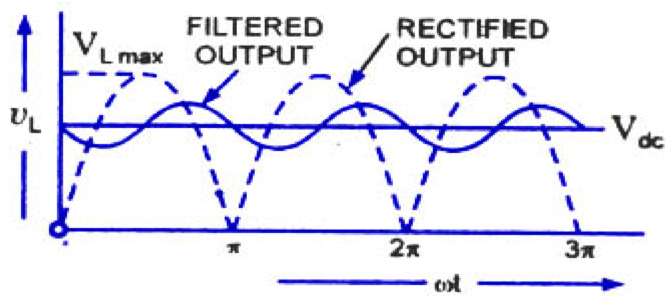
Critical inductance :

It is assumed that current flows through circuit in all times. In absence of inductor (small), the current flows in diode circuit for small portion of cycle (short period in each half cycle). When small inductance is included, then current flow through the diode for longer time. When value of inductance is further increased, a value is reached for which diode supplies current to load continuously. The value of inductance is called critical inductance (L_C).

The critical inductance is the value of inductance at which current doesn't falls to zero (continuously) to calculate critical inductance the following conditions are to be satisfied.



Circuit Diagram



Rectified and Filtered Output Voltage Waveform
Full-wave Rectifier With Choke-Input Filter

$I_{dc} \geq$ negative peak value of ac component

d.c. component, $I_{dc} = \dfrac{V_{dc}}{R_C}$

a.c. component peak value $= \dfrac{4V_m}{3\pi X_L}$

$$I_{dc} \geq \frac{4V_m}{3\pi X_L}$$

$$\frac{V_{dc}}{X_L} \geq \frac{4V_m}{3\pi X_L}$$

$$V_{dc} = \frac{2V_m}{\pi} \Rightarrow V_m = \frac{\pi}{2}V_{dc}$$
$$\frac{V_{dc}}{R_L} \geq \frac{4}{3\pi X_L}\frac{\pi}{2}V_{dc}$$
$$\frac{V_{dc}}{R_L} \geq \frac{2}{3}\frac{V_{dc}}{X_L}$$
$$\frac{V_{dc}}{R_L} \geq \sqrt{2}I'_{rms}$$

$$X_L \geq \frac{2}{3}R_L \qquad where\ X_L = 2\omega l$$
$$2\omega L_C \geq \frac{2}{3}R_L$$

$$\boxed{L_C \geq \frac{R_L}{3\omega}}$$

The above condition is not satisfied for all load requirements. For no load condition $R_L \to \infty$ the value of L_C also tends to ∞. To overcome this problem a resistor R_B called bleeder resistor is connected in // with C. A minimum current always be present for optimum working of inductor. A bleeder resistor also provides a safety by acting as discharging path for capacitor. It improves the voltage regulation of supply

Multiple LC filter :

Better filtering can be achieved by using two or more L-section filters.

For I stage L-section filter

$$r = \frac{\sqrt{2}}{3}\frac{X_C}{X_L}$$

In a similar manner r.f. of II stage LC filter.

$$r = \frac{\sqrt{2}}{3}\frac{X_{C_1}}{X_{L_1}}\frac{X_{C_2}}{X_{L_2}}$$

$$X_{C_1} = \frac{1}{2\omega C_1} \quad X_{L_1} = 2\omega L_1$$

$$X_{C_2} = \frac{1}{2\omega C_2} \quad X_{L_2} = 2\omega L_2$$

$$r = \frac{\sqrt{2}}{3}\frac{1}{4\omega^2 L_1 C_1}\frac{1}{4\omega^2 L_2 C_2}$$

$$= \frac{\sqrt{2}}{3}\frac{1}{16\omega^4 L_1 C_1 L_2 C_2}$$

$$\omega = 2\pi f$$

$$= \frac{\sqrt{2}}{3}\frac{1}{16 \cdot 16\pi^4 f^4 L_1 L_2 C_1 C_2}$$

$$r = \frac{\sqrt{2}}{3}\frac{1}{\left(16 \cdot 16\pi^2 f^2\right)^2 L_1 L_2 C_1 C_2}$$

This is the value of r.f. for II stage L-section filter.