

5. Filter Circuits

5.1 Introduction

A power supply must provide ripple free source of power from an A.C. line. But the output of a rectifier circuit contains ripple components in addition to a D.C. term. It is necessary to include a filter between the rectifier and the loads in order to eliminate these ripple components. Ripple components are high frequency A.C. Signals in the D.C output of the rectifier. These are not desirable, so they must be filtered. So filter circuits are used.

Many types of passive filters are in use such as.

- Shunt capacitor filter
- Series inductor filter
- Chock input (LC) filter
- Pi(π) section filter or CLC filter or capacitor input filter .

5.2 Shunt capacitor filter

This type of filter consists of large value of capacitor connected across the load resistor R_L as shown in figure 5.1. This capacitor offers a low reactance to the a.c. components and very high impedance to d.c. so that the a.c. components in the rectifier output find low reactance path through capacitor and only a small part flows through R_L , producing small ripple at the output as shown in figure.

Here $X_c (=1/2\pi fC)$, the impedance of capacitor) should be smaller than R_L . Because, current should pass through C and C should get charged. If C value is very small, X_c will be large and hence current flows through R_L only and no filtering action takes place.

The capacitor C gets charged when the diode (in the rectifier) is conducting and gets discharged (when the diode is not conducting) through R_L . When the input voltage $v = V_m \sin \omega t$ is greater than the capacitor voltage, C gets charged. When the input voltage is less than that of the capacitor voltage, C will discharge through R_L . The stored energy in the capacitor maintains the load voltage at a high value for a long period. The diode conducts only for a short interval of high current. The waveforms are as shown in figure 5.2. Capacitor opposes sudden fluctuations in voltage across it. So the ripple voltage is minimized.

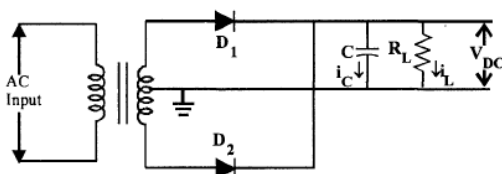


Fig 5.1 CT FWR with shunt Capacitor filter

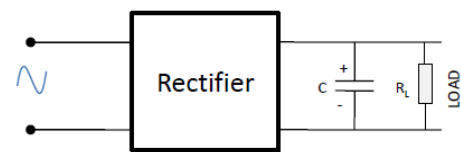


Fig 5.3 Rectifier with shunt Capacitor filter

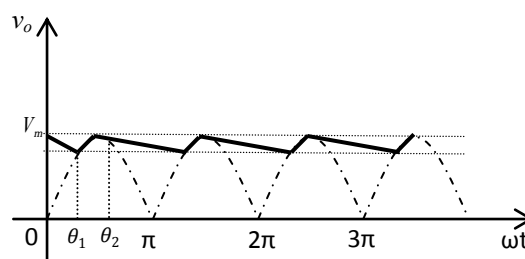


Fig 5.2 Filter output waveform

The discharging of the capacitor depends upon the time constant $C.R_L$. Hence the smoothness and the magnitude of output voltage depend upon the value of capacitor C and R_L . As the value of C increases the smoothness of the output also increases. But the maximum value of the capacitor is limited by the current rating of the diode. Also decrease in the value of R_L increases the load current and makes the time constant smaller. These types of filters are used in circuits with small load current like transistor radio receivers, calculators, etc. The ripple factor in capacitor filter is given by $\gamma = 1/4\sqrt{3}fCR_Ly$.

Advantages

- Low cost
- Small size and weight
- Good characteristics
- Can be connected for both HW and FW rectifiers
- Improved d.c. output

Disadvantages

- Capacitor draws more current

5.3 Series inductor filter

The working of series inductor filter depends on the inherent property of the inductor to oppose any variation in current intended to take place. Fig 5.4 shows a series inductor filter connected at the output of a FWR. Here the reactance of the inductor is more for ac components and it offers more opposition to them. At the same time it provides no impedance for d.c. component. Therefore the inductor blocks a.c. components in the output of the rectifier and allows only d.c. component to flow through R_L .

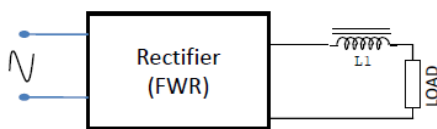


Fig 5.5 Rectifier with series inductor filter

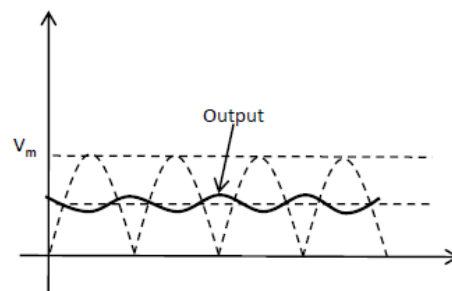


Fig 5.5 Filter output waveform

The action of an inductor depends upon the current through it and it requires current to flow at all time. Therefore filter circuits consisting inductors can only be used together with full wave rectifiers.

In inductor filter an increase in load current will improve the filtering action and results in reduced ripple. Series inductor filters are used in equipments of high load currents. The ripple factor in series inductor filter $\gamma = R_L/3\sqrt{2}\omega L$

Advantages

- Sudden changes in current is smoothen out
- Improved filtering action at high load currents

Disadvantages

- Reduced output voltage due to the drop across the inductor.
- Bulky and large in size
- Not suitable for HWR

5.4 LC filter

It is a combination of inductor and capacitor filter. Here an inductor is connected in series and a capacitor is connected in parallel to the load as shown in fig 5.6. As discussed earlier, a series inductor filter will reduce the ripple, when increasing the load current. But in case of a capacitor filter it is reverse that when increasing current the ripple also increases. So a combination of these two filters would make ripple independent of load current. The ripple factor of a chock input filter is given by $\gamma = 1.194/LC$ (by taking $f=50\text{Hz}$)

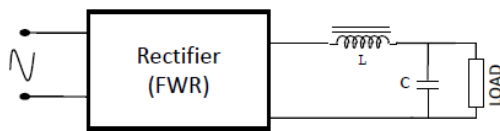


Fig 5.6 Rectifier with LC filter

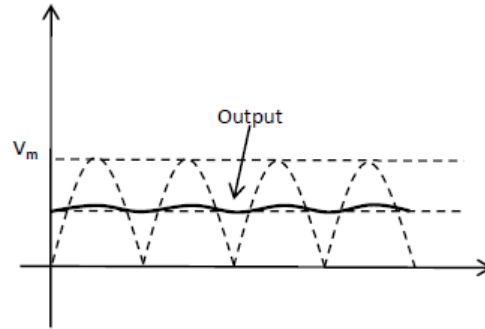


Fig 5.7 output waveform of Rectifier with LC filter

Since the d.c. resistance of the inductor is very low it allows d.c. current to flow easily through it. The capacitor appears open for d.c. and so all d.c. component passes through it. The capacitor appears open for d.c. and so all d.c. components passes through the load resistor R_L .

5.4.1 Bleeder resistor

For optimum functioning, the inductor requires a minimum current to flow through, at all time. When the current falls below this rat, the output will increase sharply and hence the regulation become poor. To keep up the circuit current above this minimum value, a resistor is permanently connected across the filtering capacitor and is called **bleeder resistor**. This resistor always draws a minimum current even if the external load is removed. It also provides a path for the capacitor to discharge when power supply is turned off.

Advantages

- Reduced ripples at the output
- Action is independent of load current

Disadvantages

- Low output voltage
- Bulky and large in size
- Not suit to connect with HWR.

5.5 π – filter (Capacitor input filter) or CLC filter

This filter is basically a capacitor filter followed by an LC filter as shown in fig 5.8. Since its shape (C-L-C) is like the letter π it is called π – filter. It is also called capacitor input filter because the rectifier feeds directly into the capacitor C_1 . Here the first capacitor C_1 offers a low reactance to a.c. component of rectifier output but provide more reactance to d.c. components. Therefore most of the a.c. components will bypass through C_1 and the d.c. component flows through chock L. The chock offers very high reactance to the a.c. component. Thus it blocks a.c. components while pass the d.c. The capacitor C_2 bypasses any other a.c. component appears across the load and we get study d.c. output as shown below.

The ripple factor in a π -section filter is given by $\gamma = \sqrt{2} X_{C1} X_{C2} / X_L R_L$

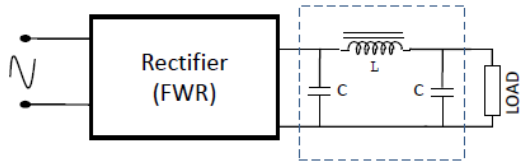


Fig 5.8 Rectifier with CLC filter

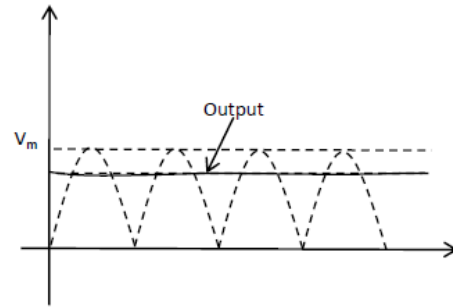


Fig 5.9 output waveform of Rectifier with CLC filter

Advantages

- More output voltage
- Ripple less output
- Suitable to be used with both HWR and FWR

Disadvantages

- Large in size and weight
- High cost