Study of Half and Full Wave Rectifier

Object. To study the half wave and full wave rectifier.

Apparatus. Step down transformer, condensers, inductor, resistors, input supply, connecting wires, diodes.

Theory. A power supply is a unit to get DC power from AC power. The AC is necessary for power transmission from one place to other, while DC is necessary for use in most of the domestic and technical appliances and instruments. In order to study a power supply, let it be represented as:

AC power from a power transformer is converted into DC power by the process known as rectification. The diodes are used to rectify AC to DC due to their unidirectional current flow for forward bias only. The output of rectifier has pulsating DC. This pulsating DC is applied at the input of filter to smooth it.

The components of a filter circuit are L, C and R. The pulsating DC is made smooth by using a capacitor of large capacitance. Usually, electrolytic capacitors are used for this purpose. The capacitor charges to peak voltage V_0 instantaneously during increasing pulsating voltage. It discharges slowly through load resistance R in accordance with relation:

$$V = V_0(1-e^{-t/RC})$$

The fast-charging rate and slow discharging rate of C fills the gaps between peaks of the pulsating DC. This process smoothens the DC at the output of filter. However, this process leaves small AC ripple voltage V_r, superposed on relatively large DC output voltage. This ripple voltage is reduced by an inductance coil of large value of L. Note that the basic property of C is to oppose variation in voltage, while that of L is to oppose variation in current.

On this basic following type of filter circuits are in use;

(1) Capacitor input filter.

(2) Inductor input filter.

(3) L-section filter.

(4) π-section filter.

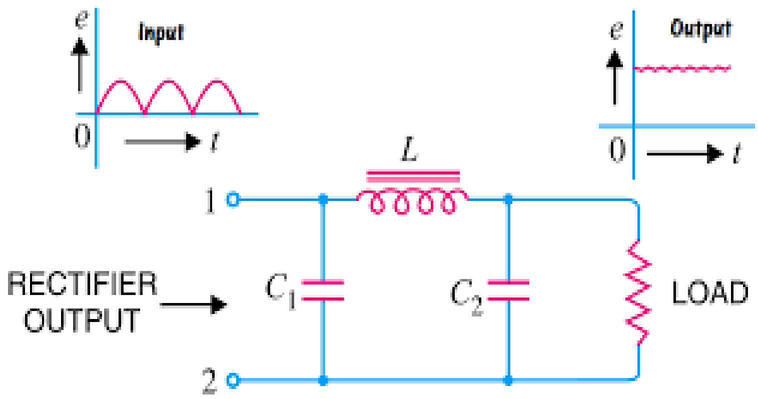

Fig. 1 Action of π filter

Out of these filters, the π filter is the best because it uses two capacitors. Hence one capacitor is at input and the other at the output of the filter circuit. The π filter is shown in fig. 1.

The capacitor C_1 acts as reservoir capacitor and it is supported by C_2 to minimize voltage variation at the output of filter. The L minimizes ripple voltage V_r. Most of the V_r, drops across L in accordance with relation:

Inductive Reactance = ωL,

where ω for ripples is the same as a frequency for half wave and its value is 2ω for full wave rectifiers.

Half wave rectification uses only one diode as shown in fig. 2(a) whereas, the full wave rectification either uses two diodes with CTT (Centre Tapped Transformer) as shown in fig. 2(b) or four diodes in bridge configuration without CTT.

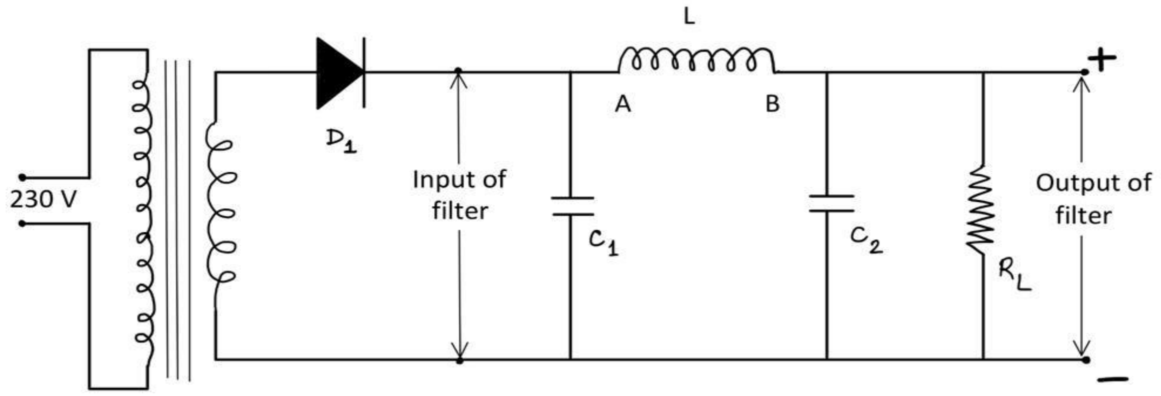

Fig. 2 (a) Half Wave Rectifier

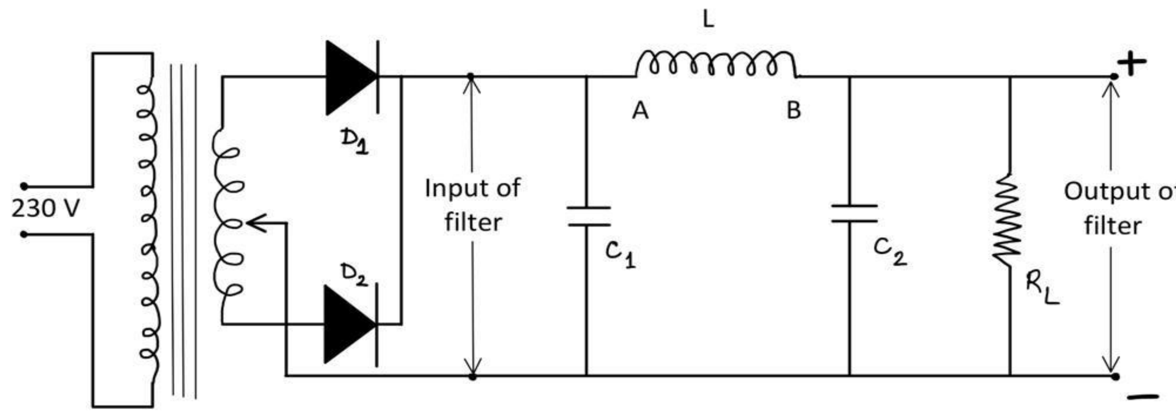

Fig. 2 (b) Full Wave Rectifier

The parameters of interest are % voltage regulation (%VR) and % Ripple (% r). These are defined and given by following relations:

$$\% VR = \left(\frac{V_0 - V_L}{V_L} \right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where V_0 is open load DC output voltage and V_L is the value at load R_L.

$$\% r = \frac{V_r}{V_L} * 100 = \frac{AC\ ripple\ voltage\ at\ output}{DC\ \ voltage\ at\ output} * 100 \ldots\ldots\ldots\ldots (2)$$

The ripple factor $\gamma = 1.21$ for half wave rectification and $\gamma = 0.48$ for full wave rectification. It shows that $V_r > V_{dc}$ in case of half wave rectification and a little less than half the value of V_{dc} in case of full wave rectification. The CRO patterns of half and full wave pulsating DC voltage show these facts visually.

The reservoir capacitor at the input of the filter circuit reduces the value of V_r considerably by the charging - discharging action. Thus $V_r << V_{dc}$ for half and full wave rectification followed by a filter. Of course, V_r halves for full wave as compared to that for half wave. In π filter, even this small value V_r drops across L to about 90% of V_r. The π combination therefore acts as a complex potential divider with most of the V_{dc} across capacitors and V_r across L. Note that V_{dc} across C_1 is greater than that across C_2 because some DC voltage drops across ohmic resistance of the L coil due to load current I_L.

Procedure. (Not to be written in copy)

Proceed to conduct the experiment in following steps:

(a) Without filter

(b) With π filter

The following has to be determined and evaluated:

(i) % Voltage regulation (% VR).

(ii) % Ripple (%r).

(iii) Evaluation of Ripple Factor γ.

(a) Half wave rectifier without filter.

(1) Switch on the power supply.

(2) Keep rotary switch at mark V_{rms}. Now read the rms value of input AC voltage across line 1 and centre tap (CT) and record it as V_{rms} volt.

(3) Connect terminals 1-1, 3-3 & A-B.

(4) Rotate the rotary switch at mark V_{dc}. Do not connect load resistance R_L. Now note the output voltage as V_0 volt (using multimeter), the voltage at open load. Now connect R_L to terminals 6 & 7. Note the DC output voltage at load as V_L volt.

Calculate % voltage regulation by relation:

$$\% VR = \left(\frac{V_0 - V_L}{V_L}\right) * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

(5) Knowing V_{rms}, calculate the value of i_{rms} by relation:

$$i_{rms} = \frac{V_{rms}}{R_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Calculate the value of I_{dc} by relation:

$$I_{dc} = \frac{2}{\pi} * \frac{V_{rms}}{R_L} = 0.636 * \frac{V_{rms}}{R_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Now calculate the value of ripple factor γ by substituting the values of i_{rms} and I_{dc} in the following relation:

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

(b) Half wave rectifier with π filter.

Remove all the connections made in case of without filter.

(1) Switch on the power supply.

(2) Keep rotary switch at mark V_{rms}. Now read the rms value of input AC voltage across line 1 and centre tap (CT) and record it as V_{rms} volt.

(3) Connect terminals 1-1, 3-3, 4-C_1, A-A_L, B-B_L, & 5-C_2.

(4) Rotate the rotary switch at mark V_{dc}. Do not connect load resistance R_L. Now note the output voltage as V_0 volt (using multimeter), the voltage at open load.

Now connect R_L to terminals 6 & 7. Note the DC output voltage at load as V_L volt.

Calculate % voltage regulation by relation:

$$\% VR = \left(\frac{V_0 - V_L}{V_L}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(5) **Ripple voltage**. Rotate rotary switch at mark $V_{r(p\text{-}p)}$ at C_1. Read the peak- to-peak value of ripple voltage across input capacitor C_1. Note it as $V_{r(p\text{-}p)}$ at C_1.

Now rotate rotary switch at mark $V_{r(p\text{-}p)}$ at C_2. Read the peak-to-peak value of ripple voltage across the output capacitor. Note this value as $V_{r(p\text{-}p)}$ at C_2. Calculate % r by following relation:

$$\% r = \frac{Vr(p-p)\ at\ C_2}{V_L} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Note: Most of the ac ripple voltage drops across the inductor L and only a fraction remains in the output.

(6) Knowing V_{rms}, calculate the value of i_{rms} by relation:

$$i_{rms} = \frac{V_{rms}}{R_L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Calculate the value of I_{dc} by relation:

$$I_{dc} = \frac{2}{\pi} * \frac{V_{rms}}{R_L} = 0.636 * \frac{V_{rms}}{R_L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Now calculate the value of ripple factor γ by substituting the values of i_{rms} and I_{dc} in the following relation:

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

(c) Full wave rectifier without filter.

Remove all the connections made in case of half wave rectifier.

(1) Switch on the power supply.

(2) Keep rotary switch at mark V_{rms}. Now read the rms value of input AC voltage across line 1 and centre tap (CT) and record it as V_{rms} volt.

(3) Connect terminals 1-1, 2-2, 3-3 & A-B.

(4) Rotate the rotary switch at mark V_{dc}. Do not connect load resistance R_L. Now note the output voltage as V_0 volt (using multimeter), the voltage at open load. Now connect R_L to terminals 6 & 7. Note the DC output voltage at load as V_L volt.

Calculate % voltage regulation by relation:

$$\%\ VR = \left(\frac{V_0 - V_L}{V_L}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(5) Knowing V_{rms}, calculate the value of i_{rms} by relation:

$$i_{rms} = \frac{V_{rms}}{R_L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Calculate the value of I_{dc} by relation:

$$I_{dc} = \frac{2\sqrt{2}}{\pi} * \frac{V_{rms}}{R_L} = 0.9 * \frac{V_{rms}}{R_L} \quad \text{………………….. (3)}$$

Now calculate the value of ripple factor γ by substituting the values of i_{rms} and I_{dc} in the following relation:

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} \quad \text{………………..….. (4)}$$

(d) Full wave rectifier with *π* filter.

Remove all the connections made in case of without filter.

(1) Switch on the power supply.

(2) Keep rotary switch at mark V_{rms}. Now read the rms value of input AC voltage across line 1 and centre tap (CT) and record it as V_{rms} volt.

(3) Connect terminals 1-1, 2-2, 3-3, 4-C_1, A-A_L, B-B_L, & 5-C_2.

(4) Rotate the rotary switch at mark V_{dc}. Do not connect load resistance R_L. Now note the output voltage as V_0 volt (using multimeter), the voltage at open load. Now connect R_L to terminals 6 & 7. Note the DC output voltage at load as V_L volt.

Calculate % voltage regulation by relation:

$$\% \ VR = \left(\frac{V_0 - V_L}{V_L}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(5) **Ripple voltage**. Rotate rotary switch at mark $V_{r(p-p)}$ at C_1. Read the peak- to-peak value of ripple voltage across input capacitor C_1. Note it as $V_{r(p-p)}$ at C_1.

Now rotate rotary switch at mark $V_{r(p-p)}$ at C_2. Read the peak-to-peak value of ripple voltage across the output capacitor. Note this value as $V_{r(p-p)}$ at C_2. Calculate % r by following relation:

$$\% \ r = \frac{Vr(p-p) \ at \ C_2}{V_L} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

<u>Note:</u> Most of the ac ripple voltage drops across the inductor L and only a fraction remains in the output.

(6) Knowing V_{rms}, calculate the value of i_{rms} by relation:

$$i_{rms} = \frac{V_{rms}}{R_L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Calculate the value of I_{dc} by relation:

$$I_{dc} = \frac{2\sqrt{2}}{\pi} * \frac{V_{rms}}{R_L} = 0.9 * \frac{V_{rms}}{R_L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Now calculate the value of ripple factor γ by substituting the values of i_{rms} and I_{dc} in the following relation:

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Observations.

Least count of Voltmeter = ……………………

Use and set multimeter to DC to record the readings for V_0 and V_L.

Half Wave Rectifier

(i) Without filter.

S. No.	R_L (kΩ)	V_{rms} (V)	i_{rms} (mA)	I_{dc} (mA)	V_0 (V)	V_L (V)	% VR	γ

(ii) With π filter.

S. No.	R_L (kΩ)	V_{rms} (V)	i_{rms} (mA)	I_{dc} (mA)	V_0 (V)	V_L (V)	Ripple Voltage		% VR	% r	γ
							$V_{r(p-p)}$ at C_1	$V_{r(p-p)}$ at C_2			

Full Wave Rectifier

(i) Without filter.

S. No.	R_L (kΩ)	V_{rms} (V)	i_{rms} (mA)	I_{dc} (mA)	V_0 (V)	V_L (V)	% VR	γ

(ii) With π filter.

S. No.	R_L (kΩ)	V_{rms} (V)	i_{rms} (mA)	I_{dc} (mA)	V_0 (V)	V_L (V)	Ripple Voltage		% VR	% r	γ
							$V_{r(p-p)}$ at C_1	$V_{r(p-p)}$ at C_2			

Results.

1. The value of $R_L >> r_d$, the dynamic resistance of the diode.
2. The ripple factor γ = ……………. for half wave rectifier.
3. The ripple factor γ = ……………. for full wave rectifier.

Precautions.

1. The terminals of transformer should not be touched by hands.

2. V.T.V.M. should be adjusted in proper range and its zero adjustment must be made before using it.
3. While measuring the D.C. current and D.C. voltage, the + ve marked terminal of multimeter and V.T.V.M. should be connected towards the cathode of diode.

Viva-Voce

Q. What is your experiment?

Ans. To study the half wave and full wave rectifiers and to determine the voltage regulation and ripple factor of the half wave and full wave rectifier.

Q. How does a diode rectify the alternating current?

Ans. During one half cycle of AC, the plate of diode valve is positive (or the junction diode is in forward bias), so it conducts, while in the remaining half cycle, the plate of the diode valve is negative (or the junction diode is in reverse bias) so it offers infinite resistance and does not conduct

Q. How does a full wave rectifier differ from a half wave rectifier?

Ans. In a half wave rectifier, only one diode is used and so output voltage is obtained only for half cycle of input AC voltage. But in a full wave rectifier, two diodes are used, out of which one diode conducts for half cycle of input AC voltage while the other diode conducts for its remaining half cycle and so output is obtained for the complete cycle of AC input voltage.

Q. How is a full wave rectifier better than a half wave rectifier?

Ans. (i) The efficiency of full wave rectifier is twice that of a half wave rectifier.

(ii) In a full wave rectifier, output is obtained over the complete cycle while in a half wave rectifier, output is obtained only for the half cycle.

(iii) The ripple factor in a full wave rectifier is reduced to 0.48 from 1.21 which is in a half wave rectifier.

(iv) The voltage regulation of a full wave rectifier is better than that of a half wave rectifier.

Q. What do you mean by the term 'ripple factor'?

Ans. It is the factor which tells us how much alternating component present in the output of power supply as compared to its DC component. i.e.,

Ripple factor $\gamma = \frac{Output\ AC\ voltage}{Output\ DC\ voltage}$

Q. What do you mean by voltage regulation?

Ans. Voltage regulation is the quantity which represents the ability to maintain the output voltage of the power supply constant when load resistance is changed.

i.e., Voltage regulation R= $\frac{V_0 - V_L}{V_L}$

Q. What is the reason for the voltage regulation of a rectifier to be poor?

Ans. The output voltage falls due to voltage drop across the different resistive components (such as external resistance in circuit, resistance of primary and secondary coils of transformer etc.) present in the circuit of rectifier. As a result, the output voltage does not remain constant.

Q. How is the ripple factor of a rectifier reduced?

Ans. By using filter circuits with it.

Q. What kind of filter circuit do you suggest for use in your rectifier?

Ans. π section filter

Q. What is a π section filter? Explain its working.

Ans. In this filter, a circuit is made by joining an inductance L in between the two condensers C_1 and C_2. The AC component of voltage (or current) obtained from the rectifier charges the condenser C_1 in the first half cycle. The charged condenser in the next half cycle discharges through the inductance and the load. Thus, there is a very little voltage drop in the output voltage obtained from the π section filter and the value of output pulsating voltage remains nearly equal to the peak input voltage in the filter. The output voltage obtained from the π section filter is much smooth than the output voltage of L section filter (in which only one condenser is used with an inductance) because in π section filter, the ripples which pass through the inductance passed through the condenser C_2.

Q. How do you obtain the voltage regulation?

Ans. By using the Zener diode in reverse bias at Zener breakdown. By this, the output voltage almost remains unaffected by the change in load resistance (or load current).