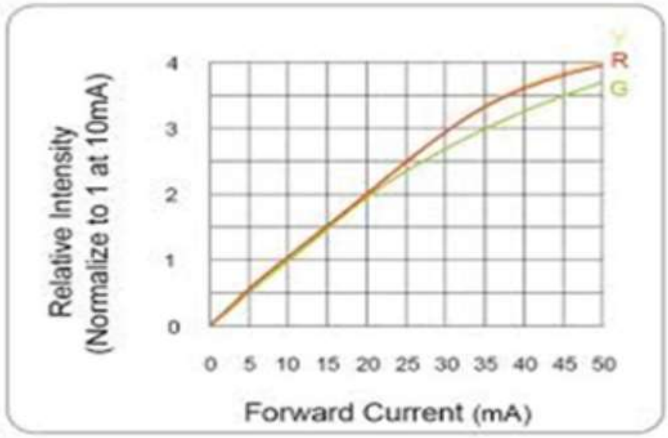
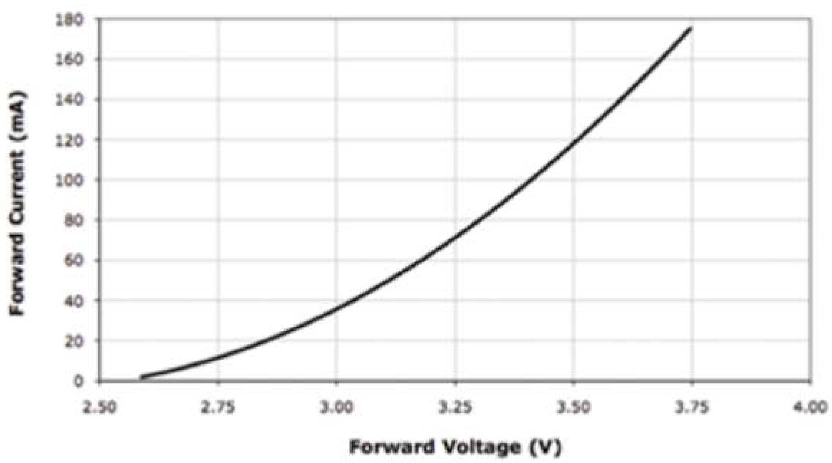




Procedure

Forward Bias-Si Diode

1. Set DC voltage to 0.2 V .
2. Select the diode.
3. Set the resistor.
4. Voltmeter is placed parallel to LED and ammeter series with resistor.
5. The positive side of battery to the P side(anode) and the negative of battery to the N side(cathode) of the diode.
6. Now vary the voltage upto 5V and note the Voltmeter and Ammeter reading for particular DC voltage .
7. Take the readings and note Voltmeter reading across LED and Ammeter reading.
8. Plot the V-I graph and observe the change.

EXPERIMENT-4

Objective: To study half-wave, full-wave rectifier and evaluate their efficiency.

Apparatus required

Power supply

Lab trainer kit

Jumper wires

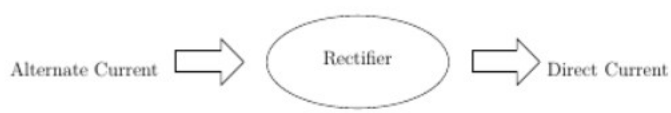
Oscilloscope

Waveform generator

Multimeter

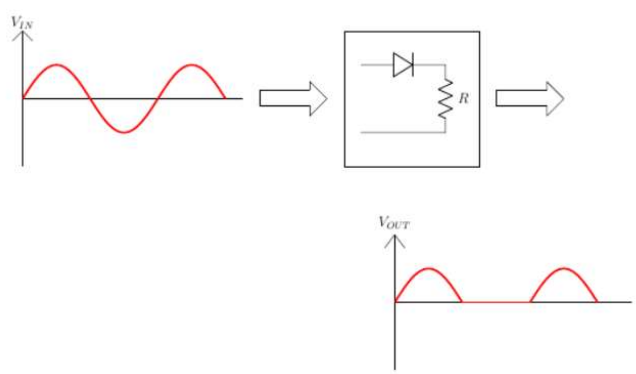
Theory

A rectifier is a device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers are essentially of two types – a half wave rectifier and a full wave rectifier.



Half Wave Rectification

On the positive cycle the diode is forward biased and on the negative cycle the diode is reverse biased. By using a diode we have converted an AC source into a pulsating DC source. In summary we have 'rectified' the AC signal.



The simplest kind of rectifier circuit is the half-wave rectifier.The half-wave rectifier is a circuit that allows only part of an input signal to pass. The circuit is simply the combination of a single diode in series with a resistor, where the resistor is acting as a load. The output DC voltage of a half wave rectifier can be calculated with the following two ideal equations.

$$V_{peak} = V_{rms} \times \sqrt{2}$$

$$V_{dc} = \frac{V_{peak}}{\mathit{\Pi}}$$

<u>Average output voltage</u>

$$V_O = V_m \times \sin wt \quad for \quad 0 \leq wt \leq \pi$$

$$V_O = 0 \quad for \quad \pi \leq wt \leq 2\pi$$

$$V_{av} = \frac{V_m}{\pi} = 0.318V_m$$

RMS load voltage

$$V_{rms} = I_{rms} \times R = \frac{V_m}{2}$$

Average load current

$$I_{av} = \frac{V_{av}}{R} = \frac{\frac{V_m}{\pi}}{R}$$

$$I_{av} = \frac{V_m}{\pi \times R} = \frac{I_m}{\pi}$$

RMS load current

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

Form factor: It is defined as the ratio of rms load voltage and average load voltage.

$$F.F = \frac{V_{rms}}{V_{av}}$$

$$F.F = \frac{\frac{V_m}{2}}{\frac{V_{av}}{2}} = \frac{\pi}{2} = 1.57$$

$$F.F \geq 1$$

$$rms \geq av$$

<u>Ripple Factor</u>

$$\gamma = \sqrt{(F.F^2 - 1)} \times 100\%$$

$$\gamma = \sqrt{(1.57^2 - 1)} \times 100\% = 1.21\%$$

Efficiency: It is defined as ratio of dc power available at the load to the input ac power.

$$n\% = \frac{P_{load}}{P_{in}} \times 100\%$$

$$n\% = \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\%$$

$$n\% = \frac{\frac{I_m^2}{\pi^2}}{\frac{I_m^2}{4}} \times 100\% = \frac{4}{\pi^2} \times 100\% = 40.56\%$$

Peak Inverse Volatge

For rectifier applications, peak inverse voltage (PIV) or peak reverse voltage (PRV) is the maximum value of reverse voltage which occurs at the peak of the input cycle when the diode is reverse-biased.The portion of the sinusoidal waveform which repeats or duplicates itself is known as the cycle. The part of the cycle above the horizontal axis is called the positive half-cycle, the part of the cycle below the horizontal axis is called the negative half cycle. With reference to the amplitude of the cycle, the peak inverse voltage is specified as the maximum negative value of the sine-wave within a cycle's negative half cycle.

$$PIV = V$$

$$-V_m + V = 0 \Rightarrow V = V_m$$

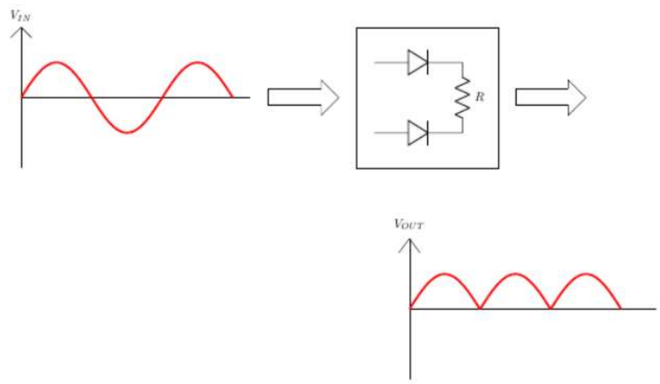
$$PIV \geq V_m$$

Procedure

1. Set the resistor RL.
2. Click on 'ON' button to start the experiment.
3. Click on 'Sine Wave' button to generate input waveform
4. Click on 'Oscilloscope' button to get the rectified output.
5. Vary the Amplitude, Frequency, volt/div using the controllers.
6. Click on "Dual" button to observe both the waveform.
7. Channel 1 shows the input sine waveform, Channel 2 shows the output rectified waveform.
8. Calculate the Ripple Factor.Theoretical Ripple Factor= 1.21.

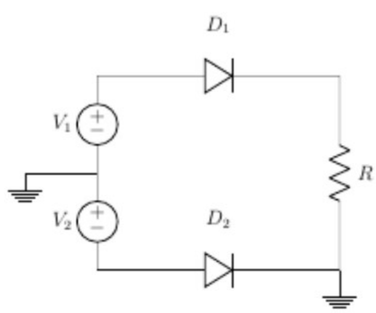
Full Wave Rectifier

A full-wave rectifier is exactly the same as the half-wave, but allows unidirectional current through the load during the entire sinusoidal cycle (as opposed to only half the cycle in the half-wave). A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Let us see our half wave rectifier example and deduce the circuit.



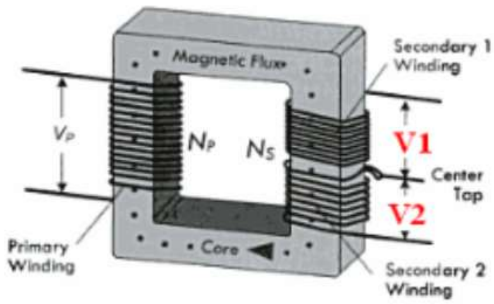
Full Wave Rectifier - Circuit

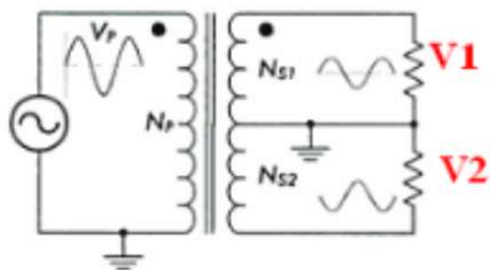
So, we have seen that this rectifier circuit consists of two sources which have a phase difference along with two diodes. When V_1 is positive, V_2 is negative. Hence the top diode(D_1) will be a short and the bottom diode(D_2) will be an open. On the other hand, when V_1 is negative, V_2 is positive. Hence the bottom diode(D_2) will be on and the top diode(D_1) will be an open circuit. This configuration is rarely used because sometimes it may be impractical to obtain two voltage sources and it is difficult to SYNC the sources. Let us see how a single source can be used.



Full Wave Rectifier – Center Tapped Transformer

A Full-Wave Rectifier can be constructed using Center-Tapped transformer – which give us two shifted sinusoids so that exactly one of the waveforms is positive at one time and two diodes. As compared to the half wave rectifier we use two diodes instead of one, one of the two diodes remains in conduction in both of the halfcycles. At any point in time, only one of the diodes is forward biased. This allows for continuous conduction through load.



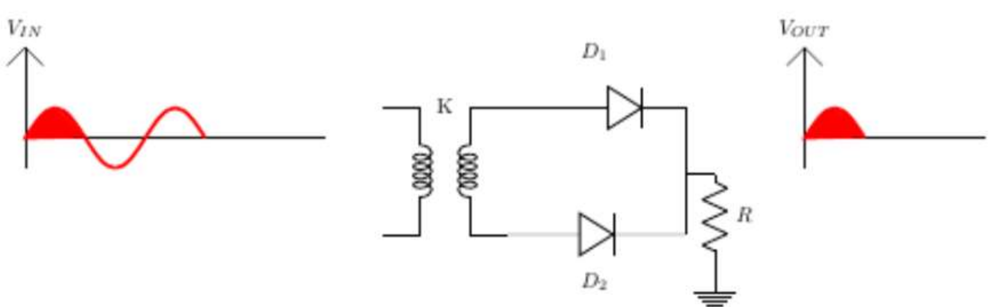


Secondary voltages are 180° out of phase with each other.

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{1}{2}$$

$$V_S = 2V_I$$

<u>Center Tapped Transformer – Positive cycle</u>

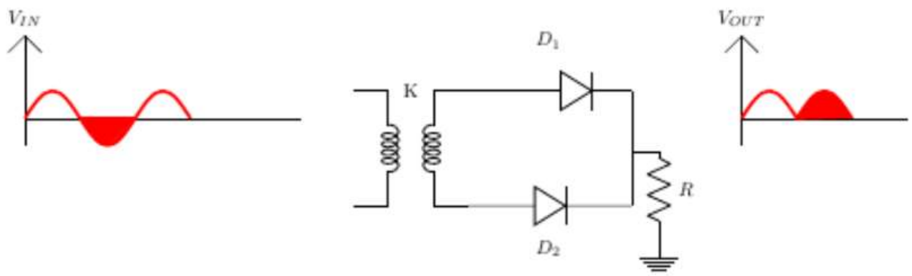


For Positive Cycle D_1 is Forward Biased and D_2 is Reverse Biased

$$V_I - V_O = 0$$

$$\Rightarrow V_O = V_I$$

Center Tapped Transformer– Negative cycle



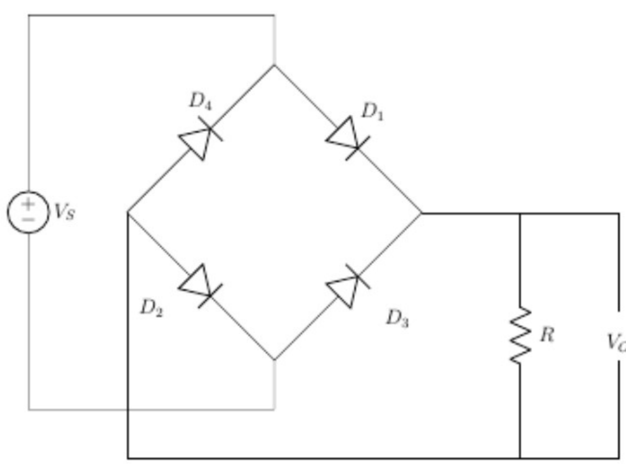
For Negative Cycle D1 is Reversed Biased and D2 is Forward Biased

$$V_I - V_O = 0$$

$$\Rightarrow V_O = V_I$$

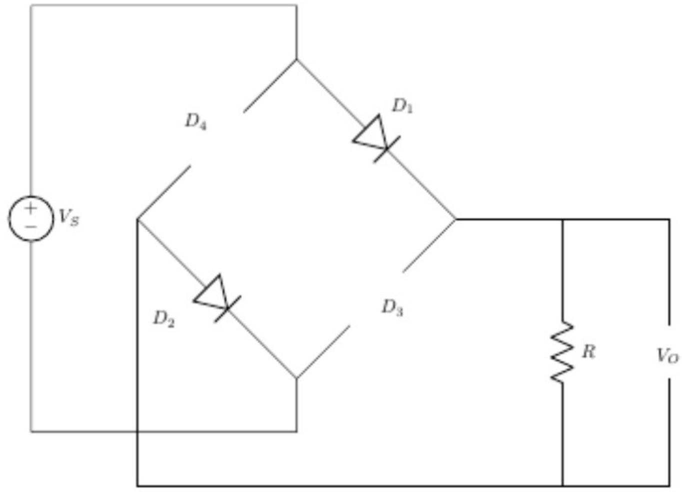
Bridge Rectifier

Bridge rectifier uses 4 rectifying diodes connected in a "bridged" configuration to produce the desired output but does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.



Bridge Rectifier – Positive Half Cycle

During the positive half cycle of the supply diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased (ideally they can be replaced with open circuits) and the current flows through the load as shown below.



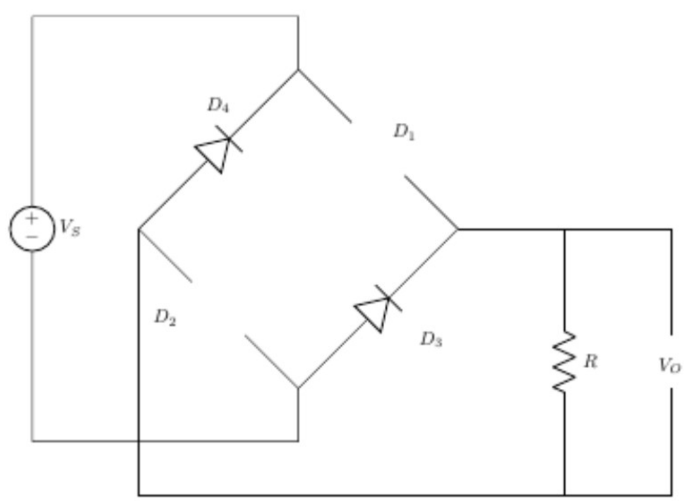
For Positive Half Cycle D1 and D2 is Forward Biased and D3 and D4 is Reverse Biased.

$$V_I - V_O = 0$$
$$\Rightarrow V_O = V_I$$
$$V_O = V_I - 2\times V_b$$
$$V_O = V_I - 2\times V_b - 2\times I_{rd}$$

where, V_I is the input voltage, V_b is barrier potential, r_d is diode resistance.

<u>Bridge Rectifier – Negative Half Cycle</u>

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch of as they are now reverse biased. The current flowing through the load is the same direction as before.



For Negative Half Cycle D1 and D2 is Reverse Biased and D3 and D4 is Forward Biased.

$$V_I - V_O = 0$$

$$\Rightarrow V_O = V_I$$

Average DC Load Voltage

$$V_O = V_m \times sinwt$$

$$0 \leq wt \leq \pi$$

$$V_{av} = V_{dc} = \frac{2V_m}{\pi}$$

Average Load Current

$$I_{av} = \frac{V_{av}}{R} = \frac{2 \times V_m}{\pi \times R}$$

$$I_{av} = \frac{2 \times I_m}{R}$$

RMS Load Current

$$I = I_m \times sinwt$$

$$0 \leq wt \leq \pi$$

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

RMS Load Voltage

$$V_{rms} = I_{rms} \times R = \frac{I_m}{\sqrt{2}} \times R$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

Form factor: It is defined as the ratio of rms load voltage and average load voltage.

$$F.F = \frac{V_{rms}}{V_{av}}$$

$$F.F = \frac{\frac{V_m}{\sqrt{2}}}{\frac{(2\times V_m)}{\pi}} = \frac{\pi}{2\sqrt{2}} = 1.11$$

$$F.F \geq 1$$

Ripple Factor

$$\gamma = \sqrt{(F.F^2 - 1)} \times 100\%$$

$$\gamma = \sqrt{(1.11^2 - 1)} \times 100\% = 48.1\%$$

Efficiency: It is defined as ratio of dc power available at the load to the input ac power.

$$n\% = \frac{(I_{dc}^2 \times R)}{(I_{rms}^2 \times R)} \times 100\%$$

$$n\% = \frac{\frac{4\times I_m^2}{\pi^2}}{\frac{I_m^2}{2}} \times 100\% = \frac{8}{\pi^2} \times 100\% = 81.13$$

Peak Inverse Volatge

For rectifier applications, peak inverse voltage (PIV) or peak reverse voltage (PRV) is the maximum value of reverse voltage which occurs at the peak of the input cycle when the diode is reverse-biased. The portion of the sinusoidal waveform which repeats or duplicates itself is known as the cycle. The part of the cycle above the horizontal axis is called the positive half-cycle, the part of the cycle below the horizontal axis is called the negative half cycle. With reference to the amplitude of the cycle, the peak inverse voltage is specified as the maximum negative value of the sine-wave within a cycle's negative half cycle.

For Bridge Rectifier, D1 and D2 is Forward Biased D3 and D4 is Reverse Biased

$$V_m - V_O = 0$$

$$\Rightarrow V_O = V_m$$

$$V_O + PIV = 0$$

$$PIV = V_m$$

$$PIV \geq V_m$$

For Center Tapped Rectifier, D2 is Forward Biased, PIV at D1,