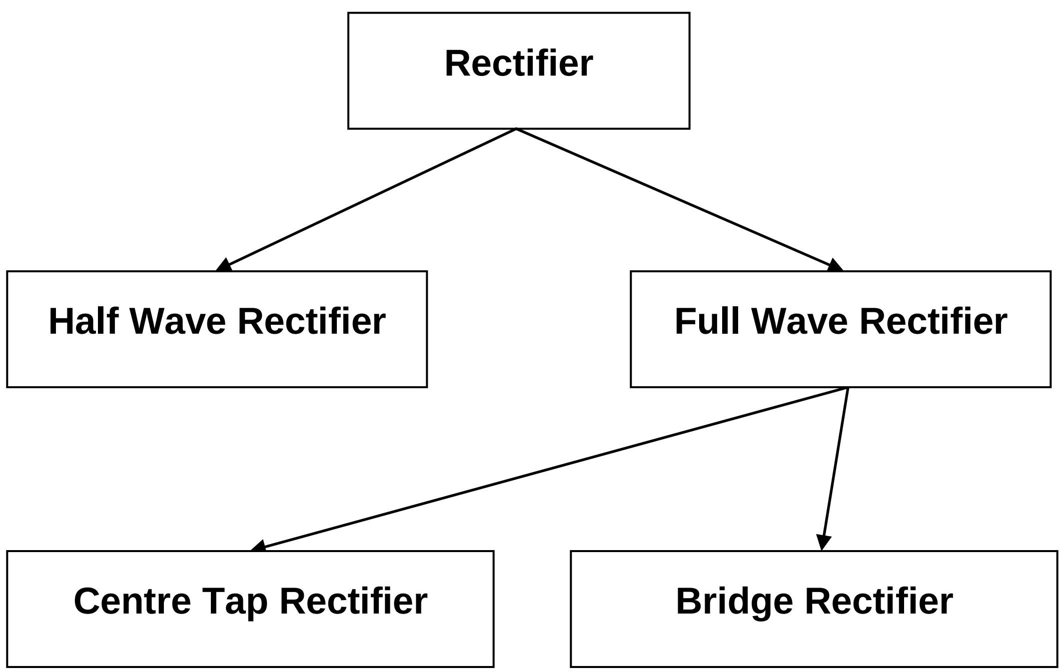
Rectifiers

A diode is used to pass current in a single direction. Alternating current is a current which flows in both directions. In some applications we need dc (direct current) power supply. A method to obtain dc supply is by using batteries. But it is not economical at all times. It is possible to obtain dc from ac supply .That process is known as rectification. Rectification is of two types:

1. Half wave rectification
2. Full wave rectification

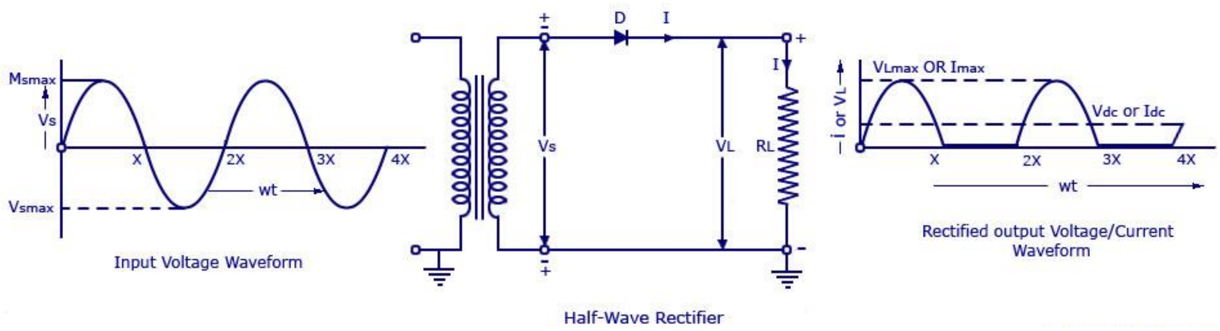
In a half wave rectifier only one half cycle of ac voltage is used. Unlike a half wave rectifier, a full wave rectifier conducts in both half cycles of ac voltage. A full wave rectifier can be implemented in two ways

1. Full wave centre tap rectifier
2. Full wave bridge rectifier



Half Wave Rectifier

The half rectifier consist a step down transformer, a diode connected to the transformer and a load resistance connected to the cathode end of the diode. The circuit diagram of half wave transformer is shown below:



The main supply voltage is given to the transformer which will increase or decrease the voltage and give to the diode. In most of the cases we will decrease the supply voltage by using the step down transformer here also the output of the step down transformer will be in AC. This decreased AC voltage is given to the diode which is connected serial to the secondary winding of the transformer, diode is electronic component which will allow only the forward bias current and will not allow the reverse bias current. From the diode we will get the pulsating DC and give to the load resistance R_L.

Working of Half Wave Rectifier

The input given to the rectifier will have both positive and negative cycles. The half rectifier will allow only the positive half cycles and omit the negative half cycles. So first we will see how half wave rectifier works in the positive half cycles.

Positive Half Cycle

- In the positive half cycles when the input AC power is given to the primary winding of the step down transformer, we will get the decreased voltage at the secondary winding which is given to the diode.

- The diode will allow current flowing in clock wise direction from anode to cathode in the forward bias (diode conduction will take place in forward bias) which will generate only the positive half cycle of the AC.
- The diode will eliminate the variations in the supply and give the pulsating DC voltage to the load resistance R_L. We can get the pulsating DC at the Load resistance.

Negative Half Cycle

- In the negative half cycle diode will go in to the reverse bias. In the reverse bias the diode will not conduct so, no current flow through diode from anode to cathode, and we cannot get any power at the load resistance.

Half Wave Rectifier Circuit Analysis

1. Peak Inverse Voltage (PIV)

Peak Inverse Voltage (PIV) rating of a diode is important in its design stages. It is the maximum voltage that the rectifying diode has to withstand, during the reverse biased period.

When the diode is reverse biased, during the negative half cycle, there will be no current flow through the load resistor R_L. Hence, there will be no voltage drop through the load resistance R_L which causes the entire input voltage to appear across the diode. Thus V_{SMAX}, the peak secondary voltage, appears across the diode. Therefore,

$$PIV = V_{Smax}$$

2. Average and Peak Currents in the diode

By assuming that the voltage across the transformer secondary be sinusoidal of peak values V_{SMAX}, instantaneous value of the voltage given to the rectifier can be written as

$$V_S = V_{Smax} \sin \omega t$$

For Instantaneous value of voltage applied to Half Wave Rectifier, assuming that the diode has a forward resistance of R_F ohms and infinite reverse resistance value, the current flowing through the output load resistance R_L is

$$i = I_{max} \sin \omega t \qquad for\ 0 \leq \omega t \leq \pi$$

$$i = 0 \qquad for\ \pi \leq \omega t \leq 2\pi$$

Maximum current flowing through the diode

$$I_{max} = \frac{V_{Smax}}{(R_F + R_L)}$$

3. DC Output Current

The dc output current is given as

$$I_{dc} = \frac{1}{2\pi} \int_0^{2\pi} i\ d(\omega t)$$

$$I_{dc} = \frac{1}{2\pi} \left[\int_0^{\pi} i\ d(\omega t) + \int_{\pi}^{2\pi} i\ d(\omega t) \right]$$

$$I_{dc} = \frac{1}{2\pi} \left[\int_0^{\pi} i\ d(\omega t) + 0 \right]$$

$$I_{dc} = \frac{1}{2\pi} \int_0^{2\pi} I_{max} \sin \omega t\ \ d(\omega t)$$

$$I_{dc} = \frac{I_{max}}{2\pi} \int_0^{2\pi} \sin \omega t\ \ d(\omega t)$$

$$I_{dc} = \frac{I_{max}}{2\pi} [-(-1-1)]$$

$$I_{dc} = \frac{I_{max}}{\pi}$$

$$I_{dc} = 0.318 I_{max}$$

Substituting the value of I_{MAX} for the equation $I_{MAX} = V_{SMAX}/(R_F + R_L)$, we have

$$I_{dc} = \frac{V_{Smax}}{(R_F + R_L)\pi}$$

if $R_L >> R_F$ $$I_{dc} = \frac{V_{Smax}}{\pi R_L}$$

4. DC Output Voltage

Dc value of voltage across the load is given by

$$V_{dc} = I_{dc} R_L$$

$$V_{dc} = \frac{V_{Smax}}{(R_F + R_L)\pi} R_L$$

$$V_{dc} = \frac{V_{Smax}}{R_L\left(\frac{R_F}{R_L}+1\right)\pi} R_L$$

$$V_{dc} = \frac{V_{Smax}}{\left(\frac{R_F}{R_L}+1\right)\pi}$$

if $R_L >> R_F$

$$V_{dc} = \frac{V_{Smax}}{\pi}$$

5. Root Mean Square (RMS) Value of Current

RMS value of current flowing through the diode is given as

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 \, d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\left[\int_0^{\pi} i^2 \, d(\omega t) + \int_{\pi}^{2\pi} i^2 \, d(\omega t)\right]}$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\left[\int_0^{\pi} i^2 \, d(\omega t) + 0\right]}$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_{max}^2 \, \sin^2 \omega t \; d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{2\pi}\int_0^{\pi} \sin^2 \omega t \; d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{2\pi}\int_0^{\pi} \left(\frac{1-\cos 2\omega t}{2}\right) d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{4\pi}\left[\int_0^{\pi} 1 \, d(\omega t) - \int_0^{\pi} \cos 2\omega t \; d(\omega t)\right]}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{4\pi}[\pi - 0]}$$

$$I_{rms} = \sqrt{\left(\frac{I_{max}}{2}\right)^2}$$

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

Substituting the value of I_{max}

$$I_{rms} = \frac{V_{Smax}}{2(R_F + R_L)}$$

6. Root Mean Square (RMS) Value of Output Voltage

RMS value of voltage across the load is given as

$$V_{Lrms} = I_{rms} R_L$$

$$V_{Lrms} = \frac{V_{Smax}}{2(R_F + R_L)} R_L$$

$$V_{Lrms} = \frac{V_{Smax}}{2\left(\frac{R_F}{R_L} + 1\right) R_L} R_L$$

if $R_L >> R_F$

$$V_{Lrms} = \frac{V_{Smax}}{2}$$

7. Rectification Efficiency

Rectification efficiency is defined as the ratio between the output power to the ac input power.

$$\eta = \frac{\text{DC power delivered to the load}}{\text{AC input power from the transformer}} = \frac{P_{dc}}{P_{ac}}$$

DC power delivered to the load,

$$P_{dc} = I_{dc}^2 R_L$$

$$P_{dc} = \left[\frac{I_{max}}{\pi}\right]^2 R_L$$

AC power input to the transformer,

P_{ac} = Power dissipated in diode junction + Power dissipated in load resistance (R_L)

$$P_{ac} = I_{rms}^2 R_F + I_{rms}^2 R_L$$

$$P_{ac} = \left(\frac{I_{max}}{2}\right)^2 R_F + \left(\frac{I_{max}}{2}\right)^2 R_L$$

$$P_{ac} = \frac{I_{max}^2}{4}(R_F + R_L)$$

So, Rectification Efficiency,

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$\eta = \frac{\frac{I_{max}^2}{\pi^2} R_L}{\frac{I_{max}^2}{4}(R_F + R_L)}$$

$$\eta = \frac{4}{\pi^2} \frac{R_L}{(R_F + R_L)}$$

$$\eta = \frac{0.406}{\left(1 + \frac{R_F}{R_L}\right)}$$

if $R_L >> R_F$

$$\eta = 0.406$$

$$\eta = 40.6\%$$

The maximum efficiency that can be obtained by the half wave rectifier is 40.6%. This is obtained if R_F is neglected.

8. Ripple Factor

Ripple factor is a measure of the remaining alternating components in a filtered rectifier output. It is the ratio of the effective value of the ac components of voltage (or current) present in the output from the rectifier to the dc component in output voltage (or current).

The effective value of the load current is given as

$$I^2 = I_{dc}^2 + I_1^2 + I_2^2 + I_4^2 + \cdots = I_{dc}^2 + I_{ac}^2$$

Where, I_1, I_2, I_4 and so on are the rms values of fundamental, second, fourth and so on harmonics and I^2_{ac} is the sum of the squares if the rms values of the ac components.

So, ripple factor,

$$\gamma = \frac{I_{ac}}{I_{dc}} = \frac{\sqrt{I^2_{rms} - I^2_{dc}}}{I_{dc}}$$

$$\gamma = \sqrt{\frac{I^2_{rms} - I^2_{dc}}{I^2_{dc}}} = \sqrt{\frac{I^2_{rms}}{I^2_{dc}} - 1}$$

$$\gamma = \sqrt{K_f^2 - 1}$$

Where K_f is the form factor of the input voltage. For half wave rectifier, form factor is given as

$$K_f = \frac{I_{rms}}{I_{dc}} = \frac{I_{max}/2}{I_{max}/\pi} = \frac{\pi}{2} = 1.57$$

So, ripple factor,

$$\gamma = \sqrt{K_f^2 - 1} = \sqrt{1.57^2 - 1} = 1.21$$

$$\gamma = 1.21$$

Disadvantages of Half wave rectifier

1. The output current in the load contains, in addition to dc component, ac components of basic frequency equal to that of the input voltage frequency. Ripple factor is high and an elaborate filtering is, therefore, required to give steady dc output.

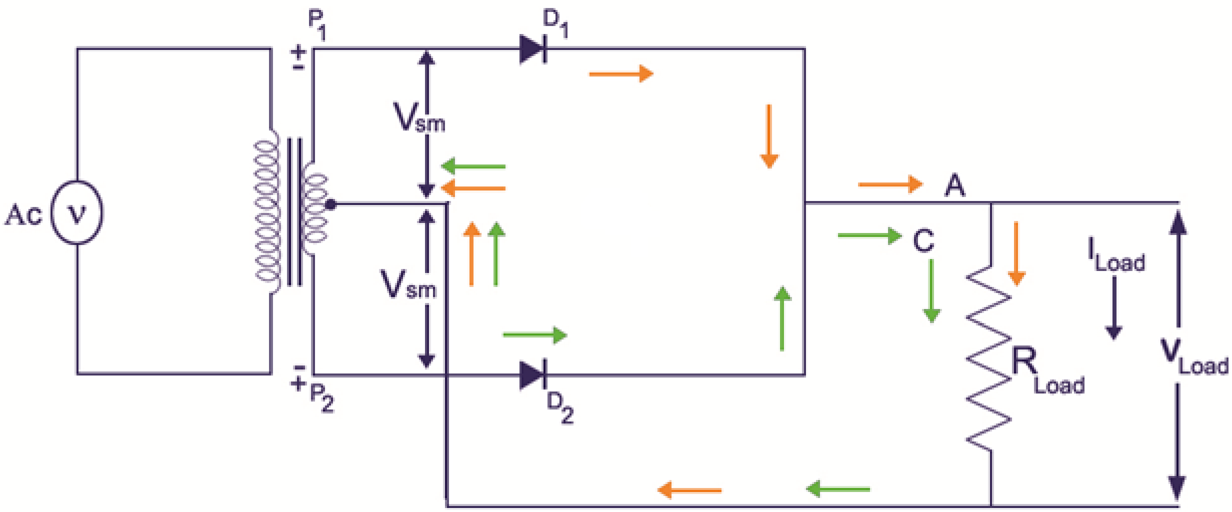
2. The power output and, therefore, rectification efficiency is quite low. This is due to the fact that power is delivered only during one half cycle of the input alternating voltage.

3. Transformer utilization factor is low.

4. DC saturation of transformer core resulting in magnetizing current and hysteresis losses and generation of harmonics.

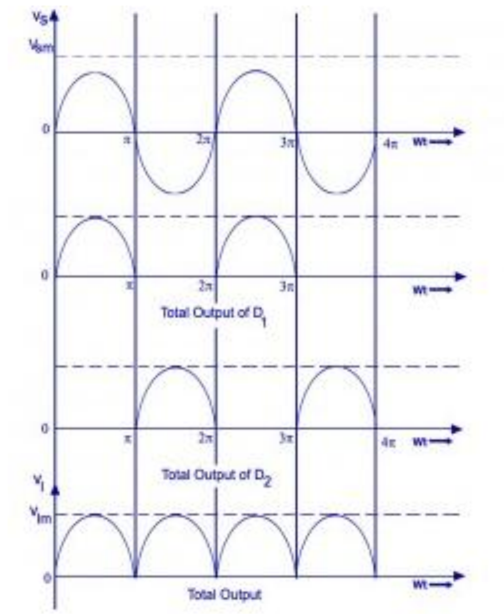
Centre-Tap Full Wave Rectifier

In the case of centre-tap full wave rectifier, only two diodes are used, and are connected to the opposite ends of a centre-tapped secondary transformer as shown in the figure below. The centre-tap is usually considered as the ground point or the zero voltage reference point.



As shown in the figure, an ac input is applied to the primary coils of the transformer. This input makes the secondary ends P_1 and P_2 become positive and negative alternately. For the positive half of the ac signal, the secondary point D_1 is positive, GND point will have zero volt and P_2 will be negative. At this instant diode D_1 will be forward biased and diode D_2 will be reverse biased. As explained in the Theory of P-N Junction and Characteristics of P-N Junction Diode, the diode D_1 will conduct and D_2 will not conduct during the positive half cycle. Thus the current flow will be in the direction P_1-D_1-C-A-B-GND. Thus, the positive half cycle appears across the load resistance R_{LOAD}.

During the negative half cycle, the secondary ends P_1 becomes negative and P_2 becomes positive. At this instant, the diode D_1 will be negative and D_2 will be positive with the zero reference point being the ground, GND. Thus, the diode D_2 will be forward biased and D_1 will be reverse biased. The diode D_2 will conduct and D_1 will not conduct during the negative half cycle. The current flow will be in the direction P_2-D_2-C-A-B-GND.



Centre-tap Full-wave Rectifier-Waveform

When comparing the current flow in the positive and negative half cycles, we can conclude that the direction of the current flow is the same (through load resistance R_{LOAD}). When compared to the Half-Wave Rectifier, both the half cycles are used to produce the corresponding output. The frequency of the rectified output voltage is twice the input frequency. The output that is rectified consists of a dc component and a lot of ac components of minute amplitudes.

1. Peak Inverse Voltage (PIV)

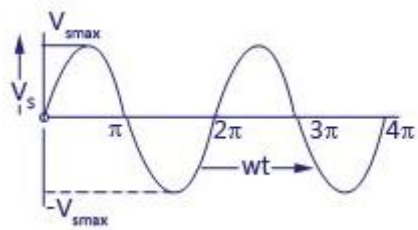
Peak Inverse Voltage (PIV) rating of a diode is important in its design stages. It is the maximum voltage that the rectifying diode has to withstand, during the reverse biased period. At any instant when the transformer secondary voltage attains positive peak value V_{Smax}, diodes D_1 will be forward biased (conducting) and the diodes D_2 will be reverse biased (non conducting). If we consider ideal diodes, the forward biased diodes D_1 will have zero resistance. This means voltage drop across the conducting diode will be zero. This will result in the entire transformer secondary voltage being developed across diode D_2. Thus PIV of a centre-tap rectifier is

$$PIV = 2V_{Smax}$$

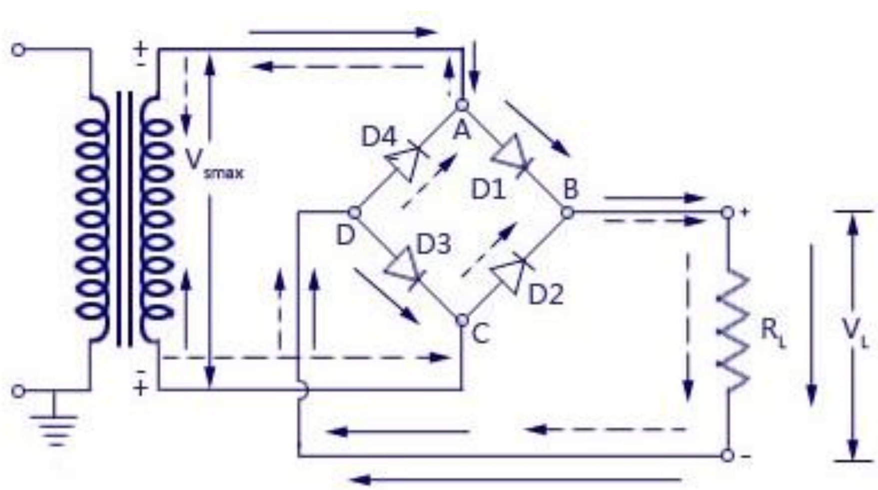
Full Wave Bridge Rectifier

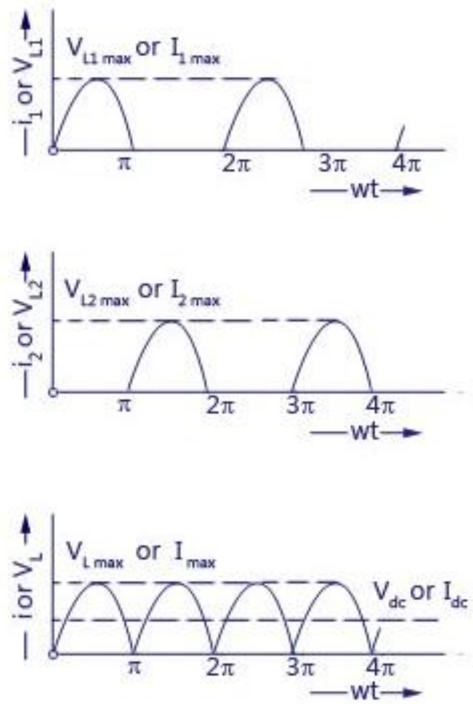
A Full wave rectifier is a circuit arrangement which makes use of both half cycles of input alternating current (AC) and converts them to direct current (DC). A half wave rectifier makes use of only one half cycle of the input alternating current. Thus a full wave rectifier is much more efficient than a half wave rectifier. This process of converting both half cycles of the input supply (alternating current) to direct current (DC) is termed full wave rectification.

The working & operation of a full wave bridge rectifier is pretty simple. The circuit diagrams and wave forms we have given below will help you understand the operation of a bridge rectifier perfectly. In the circuit diagram, 4 diodes are arranged in the form of a bridge. The transformer secondary is connected to two diametrically opposite points of the bridge at points A & C. The load resistance R_L is connected to bridge through points B and D.



Input Voltage Waveform





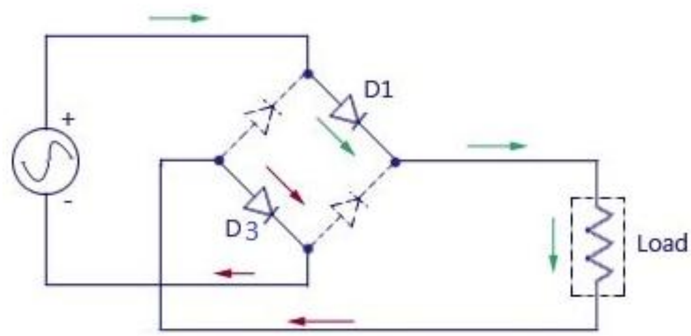
Rectified Output Voltage/Current Waveforms

During the first half cycle

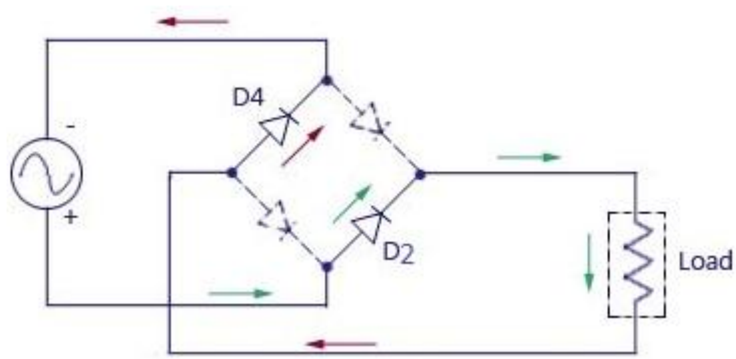
During first half cycle of the input voltage, the upper end of the transformer secondary winding is positive with respect to the lower end. Thus during the first half cycle diodes D_1 and D_3 are forward biased and current flows through arm AB, enters the load resistance R_L, and returns back flowing through arm DC. During this half of each input cycle, the diodes D_2 and D_4 are reverse biased and current is not allowed to flow in arms AD and BC. The flow of current is indicated by solid arrows in the figure above. We have developed another diagram below to help you understand the current flow quickly. See the diagram below – the green arrows indicate beginning of current flow from source (transformer secondary) to the load resistance. The red arrows indicate return path of current from load resistance to the source, thus completing the circuit.

During the second half cycle

During second half cycle of the input voltage, the lower end of the transformer secondary winding is positive with respect to the upper end. Thus diodes D_2 and D_4 become forward biased and current flows through arm CB, enters the load resistance R_L, and returns back to the source flowing through arm DA. Flow of current has been shown by dotted arrows in the figure. Thus the direction of flow of current through the load resistance R_L remains the same during both half cycles of the input supply voltage. See the diagram below – the green arrows indicate beginning of current flow from source (transformer secondary) to the load resistance. The red arrows indicate return path of current from load resistance to the source, thus completing the circuit.



Path of current in I^{st} Half Cycle



Path of current in 2^{nd} Half Cycle

The only difference in the analysis between full wave and centre tap rectifier is that

- In a bridge rectifier circuit two diodes conduct during each half cycle and the forward resistance becomes double ($2R_F$).
- In a bridge rectifier circuit V_{smax} is the maximum voltage across the transformer secondary winding whereas in a centre tap rectifier V_{smax} represents that maximum voltage across each half of the secondary winding.

Full Wave Rectifier Circuit Analysis

1. Peak Inverse Voltage (PIV)

Peak Inverse Voltage (PIV) rating of a diode is important in its design stages. It is the maximum voltage that the rectifying diode has to withstand, during the reverse biased period. At any instant when the transformer secondary voltage attains positive peak value V_{Smax}, diodes D_1 and D_3 will be forward biased (conducting) and the diodes D_2 and D_4 will be reverse biased (non conducting). If we consider ideal diodes in bridge, the forward biased diodes D_1 and D_3 will have zero resistance. This means voltage drop across the conducting diodes will be zero. This will result in the entire transformer secondary voltage being developed across load resistance R_L. Thus PIV of a bridge rectifier is

$$PIV = V_{Smax}$$

2. Average and Peak Currents in the diode

By assuming that the voltage across the transformer secondary be sinusoidal of peak values V_{SMAX}, instantaneous value of the voltage given to the rectifier can be written as

$$V_S = V_{Smax}\sin\omega t$$

For Instantaneous value of voltage applied to full wave bridge rectifier, assuming that the diode has a forward resistance of R_F ohms and infinite reverse resistance value, the current flowing through the output load resistance R_L is

$$i_1 = I_{max}\sin\omega t \qquad for\ 0 \le \omega t \le \pi$$

$$i_2 = 0 \qquad for\ 0 \le \omega t \le \pi$$

and

$$i_1 = 0 \qquad for\ \pi \le \omega t \le 2\pi$$

$$i_2 = I_{max}\sin\omega t \qquad for\ \pi \le \omega t \le 2\pi$$

The total current flowing through the load resistance R_L, being the sum of currents i_1 and i_2 is given as

$$i = i_1 + i_2$$

$$i = I_{max} \sin \omega t$$

Maximum current flowing through the diode

$$I_{max} = \frac{V_{Smax}}{(R_F + R_L)} \qquad \text{for centre-tap rectifier}$$

$$I_{max} = \frac{V_{Smax}}{(2R_F + R_L)} \qquad \text{for bridge rectifier}$$

3. DC Output Current

The dc output current is given as

$$I_{dc} = \frac{1}{\pi} \int_0^{\pi} i \; d(\omega t)$$

$$I_{dc} = \frac{1}{\pi} \int_0^{\pi} I_{max} \sin \omega t \; d(\omega t)$$

$$I_{dc} = \frac{I_{max}}{\pi} \int_0^{\pi} \sin \omega t \; d(\omega t)$$

$$I_{dc} = \frac{I_{max}}{\pi} [-(-1 - 1)]$$

$$I_{dc} = \frac{2I_{max}}{\pi}$$

4. DC Output Voltage

The dc value of voltage across the load is given by

$$V_{dc} = I_{dc} R_L$$

$$V_{dc} = \frac{2}{\pi} I_{max} R_L$$

5. Root Mean Square (RMS) Value of Current

The rms or effective value of current flowing through the load resistance R_L is given as

$$I_{rms} = \sqrt{\frac{1}{\pi} \int_0^{\pi} i^2 \; d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{1}{\pi} \int_0^{\pi} I_{max}^2 \sin^2 \omega t \; d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{\pi}\int_0^{\pi} \sin^2 \omega t \ d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{\pi}\int_0^{\pi} \left(\frac{1-\cos 2\omega t}{2}\right) d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{2\pi}\left[\int_0^{\pi} 1 \, d(\omega t) - \int_0^{\pi} \cos 2\omega t \ d(\omega t)\right]}$$

$$I_{rms} = \sqrt{\frac{I_{max}^2}{2\pi}[\pi - 0]}$$

$$I_{rms} = \sqrt{\left(\frac{I_{max}}{\sqrt{2}}\right)^2}$$

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

6. Root Mean Square (RMS) Value of Output Voltage

The rms value of voltage across the load is given as

$$V_{Lrms} = I_{rms} R_L$$

$$V_{Lrms} = \frac{I_{max}}{\sqrt{2}} R_L$$

Rectification efficiency is defined as the ratio between the output power to the ac input power.

$$\eta = \frac{\text{DC power delivered to the load}}{\text{AC input power from the transformer}} = \frac{P_{dc}}{P_{ac}}$$

DC power delivered to the load

$$P_{dc} = I_{dc}^2 R_L$$

$$P_{dc} = \left[\frac{2}{\pi} I_{max}\right]^2 R_L$$

$$P_{dc} = \frac{4}{\pi^2} I_{max}^2 R_L$$

AC power input to the transformer

P_{ac} = Power dissipated in diode junction + Power dissipated in load resistance (R_L)

$$P_{ac} = I_{rms}^2 R_F + I_{rms}^2 R_L$$

$$P_{ac} = \left(\frac{I_{max}}{\sqrt{2}}\right)^2 R_F + \left(\frac{I_{max}}{\sqrt{2}}\right)^2 R_L$$

$$P_{ac} = \frac{I_{max}^2}{2}(R_F + R_L)$$

So, Rectification Efficiency

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$\eta = \frac{\frac{4}{\pi^2} I_{max}^2 R_L}{\frac{I_{max}^2}{2}(R_F + R_L)}$$

$$\eta = \frac{8}{\pi^2} \frac{R_L}{(R_F + R_L)}$$

$$\eta = \frac{0.812}{\left(1 + \frac{R_F}{R_L}\right)}$$ for centre-tap rectifier

$$\eta = \frac{0.812}{\left(1 + \frac{2R_F}{R_L}\right)}$$ for bridge rectifier

if $R_L >> R_F$

$$\eta = 0.812$$

$$\eta = 81.2\%$$

The maximum efficiency that can be obtained by the full wave rectifier is 81.2%. This is obtained if R_F is neglected.

8. Ripple Factor

Ripple factor is a measure of the remaining alternating components in a filtered rectifier output. It is the ratio of the effective value of the ac components of voltage (or current) present in the output from the rectifier to the dc component in output voltage (or current).

The effective value of the load current is given as

$$I^2 = I_{dc}^2 + I_1^2 + I_2^2 + I_4^2 + \cdots = I_{dc}^2 + I_{ac}^2$$

Where, I_1,I_2, I_4 and so on are the rms values of fundamental, second, fourth and so on harmonics and I^2_{ac} is the sum of the squares.

So, ripple factor,

$$\gamma = \frac{I_{ac}}{I_{dc}} = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}}$$

$$\gamma = \sqrt{\frac{I_{rms}^2 - I_{dc}^2}{I_{dc}^2}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}$$

$$\gamma = \sqrt{K_f^2 - 1}$$

Where K_f is the form factor of the input voltage. For half wave rectifier, form factor is given as

$$K_f = \frac{I_{rms}}{I_{dc}} = \frac{I_{max}/\sqrt{2}}{2I_{max}/\pi} = \frac{\pi}{2\sqrt{2}} = 1.11$$

So, ripple factor,

$$\gamma = \sqrt{K_f^2 - 1} = \sqrt{1.11^2 - 1} = 0.482$$

$$\gamma = 0.482$$

Merits and Demerits of Full-wave Rectifier over Half-Wave Rectifier

Merits

- Efficiency is double for a full wave bridge rectifier. The reason is that, a half wave rectifier makes use of only one half of the input signal. A bridge rectifier makes use of both halves and hence doubles efficiency.

- The residual ac ripples (before filtering) is very low in the output of a bridge rectifier. The same ripple percentage is very high in half wave rectifier. A simple filter is enough to get a constant dc voltage from bridge rectifier.
- The efficiency of full wave bridge is double than half wave rectifier. This means higher output voltage, Higher transformer utilization factor (TUF) and higher output power.

Demerit

- Full-wave rectifier needs more circuit elements and is costlier.

Merits and Demerits of Bridge Rectifier over Center-Tap Rectifier

Merits

- A center tap rectifier is always difficult one to implement because of the special transformer involved. A center tapped transformer is costly as well.
- A bridge rectifier can be constructed with or without a transformer.
- If a transformer is involved, any ordinary step down/step up transformer can be used.
- Bridge rectifier is suited for high voltage applications. The reason is the high peak inverse voltage (PIV) of bridge rectifier, when compared to the PIV of a center tap rectifier.
- Transformer utilization factor (TUF) is higher for bridge rectifier.

Demerits

- The significant disadvantage of a bridge rectifier over center tap is the involvement of 4 diodes in the construction of bridge rectifier.
- In a bridge rectifier, 2 diodes conduct simultaneously on a half cycle of input. A center tap rectifier has only 1 diode conducting on one half cycle. This increases the net voltage drop across diodes in a bridge rectifier (it is double to the value of center tap).