Full Wave & Bridge Rectifier Circuit

Manoj Kr. Das

Associate Professor

Department of Physics

J N College, Boko

Single Phase Full Wave Rectifier :

In case of full wave rectifier circuit, two diodes D_1 and D_2 are connected.

It is assumed that the two diodes are identical and the dynamical forward resistance of each is R_f.

Under the action of sinusoidal AC voltage of frequency ($\omega/2\pi$) applied to the primary of the transformer, the AC voltage across S_1 and S_2 are given by

$$V_1 = V_m sin\omega t$$

$$V_2 = V_m sin(\omega t - \pi)$$

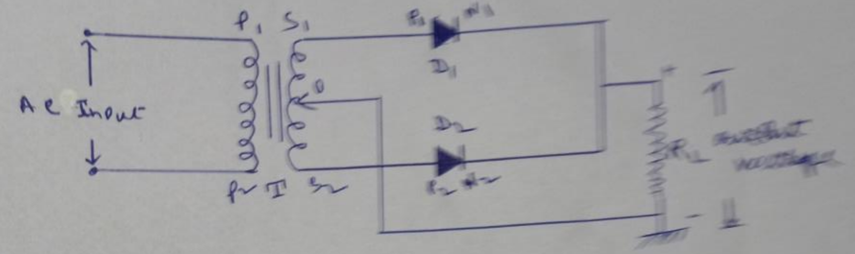


Fig (v) - Full wave Rectifier Circuit

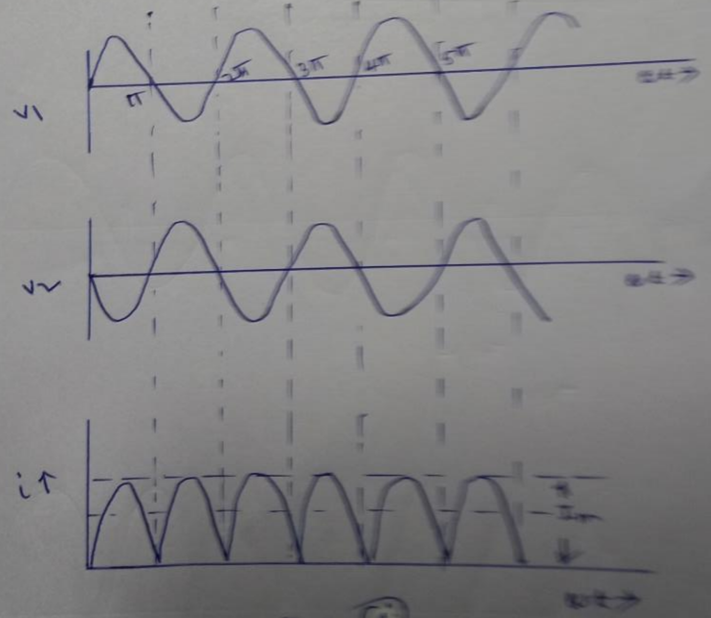


Fig (vi)

Where V_m is the maximum value of voltage from either end of the secondary to the centre tape.

These voltages are simultaneously applied across the diodes through the load R_L.

During the half cycle of the AC input voltage when the diode D_1 is forward biased a current i_1 flows in the circuit in the direction $P_1N_1R_LOS_1P_1$. During the time the diode D_2 is reverse biased, therefore no current flows through it.

During the next half cycle the diode D_2 is forward biased. Consequently the current i_2 flows in the circuit in the direction of $P_2N_2R_LOS_2P_2$. During this time D_1 is reverse biased, there is no current flows through it.

Consequently the current through R_L is unidirectional and it flows in the form of half sine waves without separation.

When $0 \leq \omega t \leq \pi$

$$i_1 = \frac{V_m}{R_L + R_f} sin\omega t$$

$$= I_m \, sin\omega t$$

and $$i_2 = 0$$

When $\pi \leq \omega t \leq 2\pi$

$$i_2 = \frac{V_m}{R_L + R_f} sin\omega t$$

$$= I_m \, sin\omega t$$

and $$i_1 = 0$$

The corresponding voltage across R_L is also in the form of half sine waves in phase with the current pulses. Since in one cycle of the AC input voltages two current pules is two times of the frequency of input voltage.

Average DC current through R_L:

It is given by

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

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

RMS value of the current:

The rms value of the total current is given by

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

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

Power supplied to the circuit:

The Power supplied to the circuit from the source is given by

$$P_i = I_{rms}{}^2(R_L + R_f)$$

$$P_i = \frac{I_m{}^2}{2}(R_L + R_f)$$

Average Power supplied to the load:

The average power supplied to the load (R_L):

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

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

Efficiency of the Rectifier:

The efficiency of the full wave rectifier is given by

$$\eta = \frac{P_{dc}}{P_i} \times 100\%$$

$$\eta = \frac{\frac{4I_m^2}{\pi^2} R_L \times 100}{\frac{I_m^2}{2}(R_L + Rf)} \%$$

$$\eta = \frac{8 \times 100}{\pi^2\left(1 + \frac{R_f}{R_L}\right)} \%$$

$$\eta = \frac{81.2}{1+\frac{R_f}{R_L}}\,\%$$

When $R_f \leq R_L$, then the theoretical maximum value for the full wave rectifier circuit is 81.2 % which is twice the value for the half wave rectifier.

Ripple Factor:

For the full wave rectifier we have

$$\frac{I_{rms}}{I_{dc}} = \frac{I_m}{\sqrt{2}} \cdot \frac{\pi}{2I_m} = \frac{\pi}{2\sqrt{2}} = 1.11$$

Therefore Ripple Factor (γ)

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

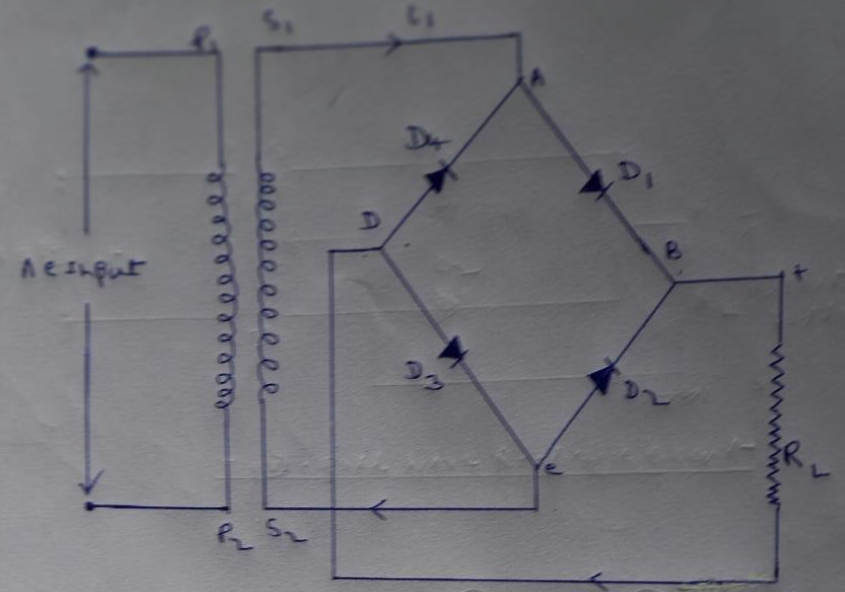
So DC output voltage of the full wave rectifier has smaller ripple factor.

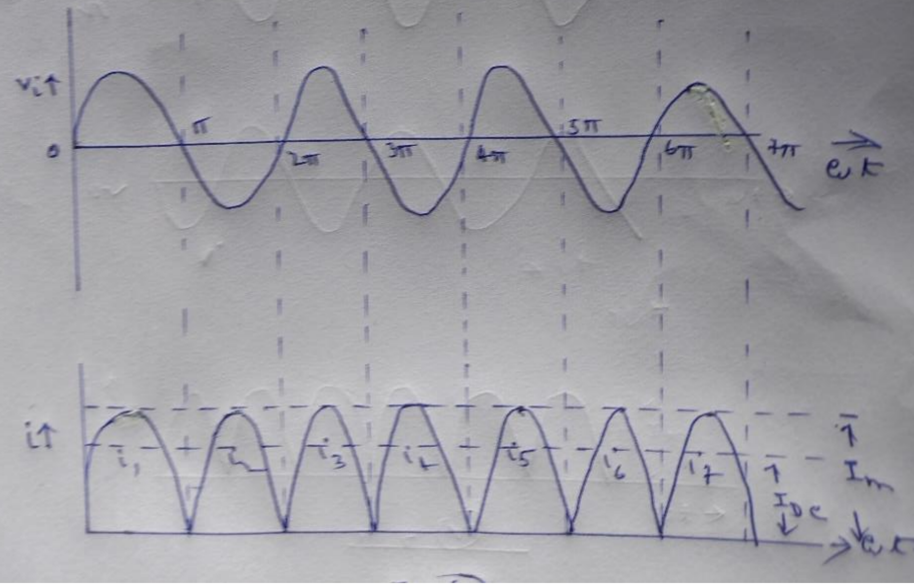
Single Phase Bridge Rectifier:

In this circuit four diodes D_1, D_2, D_3 and D_4 are connected to form a network.

As shown in Fig (ii),two opposite ends A and C of the network are connected to the ends S_1 and S_2 of the secondary of the power transformer T and the other two opposite ends B and D are connected to the load resistance R_L .

In case of Bridge Rectifier, it does not require centre-tap in the secondary of the transformer.


AC input
P1
P2
S1
S2
A
B
C
D
D1
D2
D3
D4
+
-
RL


vi
0
π
2π
3π
4π
5π
6π
7π
ωt
i
i1
i2
i3
i4
i5
i6
i7
Im
IDC
ωt

Under the action of sinusoidal AC voltage applied to the primary of the transformer, the AC voltage across the secondary, which is applied to the point A and C of the network is given by

$$V_i = V_m sin\omega t$$

Where V_m is the maximum secondary voltage

During the half cycle of AC input voltage when the point A is positive with respect to the point C, the diodes D_1 and D_3 are forward biased. Consequently a current i_1 flows through $ABR_LDCS_2S_1A$. During this time the diodes D_2 and D_4 are reversed biased.

Hence a current i_2 flows in the direction $CBR_LDAS_1S_2C$. During this time D_1 and D_3 are reversed biased and so they are not conduct. In subsequent half cycles of the AC input voltage the same process is repeated. Hence the current flows through R_L in one direction only i.e. it is unidirectional.

It is evident that the diodes conduct in pairs and at instant the current flows through two diodes, the load resistance and the secondary of the transformer.

The current pulses are represented by

When $0 \leq \omega t \leq \pi$

$$i_1 = \frac{V_m}{R_L + 2R_f} sin\omega t$$

And

$$i_2 = 0$$

When $\pi \leq \omega t \leq 2\pi$

$$i_2 = \frac{V_m}{R_L + 2R_f} sin\omega t$$

And

$$i_1 = 0$$

Where R_f is the dynamic forward resistance of each diode.

For the Bridge Rectifier, the maximum current is given by

$$I_m = \frac{V_m}{R_L + 2R_f}$$

The average DC current, RMS value of current and the Ripple factor are given by the same expression as for the full wave rectifier.

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

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

$$\gamma = 0.482$$

The efficiency is

$$\eta = \frac{81.2}{1+\frac{2R_f}{R_L}}\%$$

The peak inverse voltage across each diode is the maximum voltage V_m across the secondary of the transformer and not $2V_m$ as in the case of full wave rectifier.

Advantage of Bridge Rectifier:

1) Centre tape on the secondary of the transformer is not necessary

2) Smaller transformer can be used

The peak Inverse Voltage per diode is V_m which is one half of the value for each diode in a full wave rectifier.

Disadvantage of Bridge Rectifier:

1) Two extra diodes are used

2) The voltage regulation is poor