1.3 RECTIFIERS

Rectifiers are classified according to the period ofconduction. They are

- Half Wave Rectifier
- Full Wave Rectifier

Half Wave Rectifier:

The half wave rectifier is a type of rectifier that rectifies only half cycle of the waveform. This describes the half wave rectifier circuit working. 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:

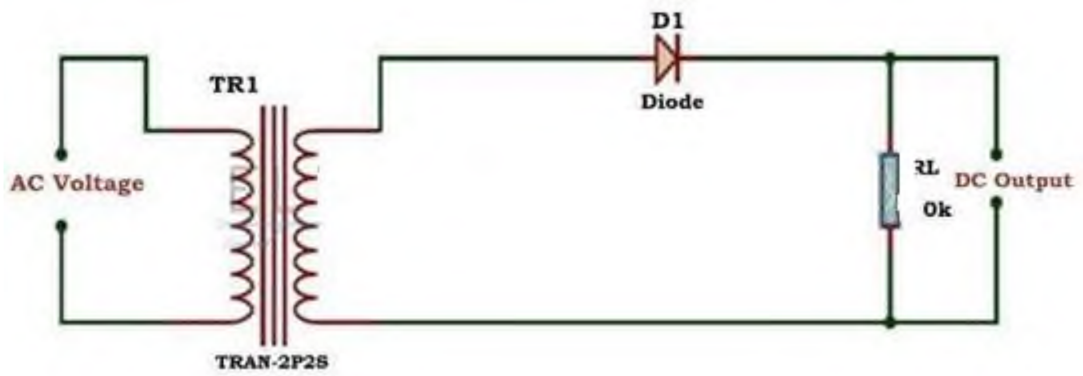

Figure: 1.3.1 Half wave Rectifier

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 252]

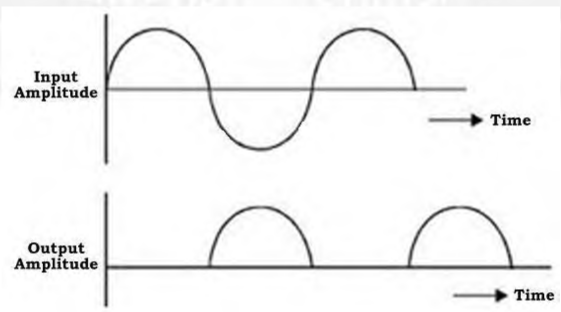

Figure: 1.3.2 Half wave Rectifier Wave Form

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 253]

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 RL.

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 thesecondary 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 DCvoltage to the load resistance RL. We can get the pulsating DC at the Load resistance.

Negative Half Cycle:

- In the negative half cycle the current will flow in the anti-clockwise directionand the diode will go in to the reverse bias. In the reverse bias the diode will not conduct so, no current in flown from anode to cathode, and we cannot getany power at the load resistance.
- Only small amount of reverse current is flown from the diode but this current is almost negligible. And voltage across the load resistance is also zero.

Characteristics of Half Wave Rectifier:

There are some characteristics to the half wave rectifier they are

- **Efficiency:** The efficiency is defined as the ratio of input AC to the output DC. Efficiency, Ƞ = P dc / Pac
- DC power delivered to the load, $P_{dc} = I^2_{dc} R_L = (I_{max/pi})^2 R_L$

AC power input to the transformer, P_{ac} = Power dissipated in junction of diode + Power

Dissipated in load resistance RL= $I^2_{rms} R_F + I^2_{rms} R_L = \{I^2_{MAX}/4\} [R_F + R_L]$

Rectification Efficiency, Ƞ = $P_{dc} / P_{ac} = \{4/ ^2\} [RL/ (R_F + R_L)] = 0.406/\{1+ R_{F/RL} \}$

If RF is neglected, the efficiency of half wave rectifier is 40.6%.

- **Ripple factor:** It is defined as the amount of AC content in the output DC. It nothingbut amount of AC noise in the output DC. Less the ripple factor, performance of the rectifier is more. The ripple factor of half wave rectifier is about 1.21 (full wave rectifier has about0.48). It can be calculated as follows:
- The effective value of the load current I is given as sum of the rms values of harmonic currents I1, I2, I3, I4 and DC current Idc.
- $I^2 = I^2dc + I^21 + I^22 + I^24 = I^2dc + I^2ac$
- Ripple factor, is given as $\gamma = I_{ac} / I_{dc} = (I^2 - I^2_{dc}) / I_{dc} = \{(I_{rms} / I_{dc}^2) - 1\} = K_f^2 - 1)$ Where Kf is the form factor of the input voltage. Form factor is given as

  $K_f = I_{rms} / I_{avg} = (I_{max}/_2) / (I_{max}/pi) = pi/2 = 1.57$

  So, ripple factor, $\gamma = (1.57^2 - 1) = 1.21$

- **Peak Inverse Voltage:** It is defined as the maximum voltage that a diode can with standin reverse bias. During the reverse bias as the diode do not conduct total voltage drops across the diode. Thus peak inverse voltage is equal to the input voltage Vs.

- **Transformer Utilization Factor (TUF):** The TUF is defined as the ratio of DC poweris delivered to the load and the AC rating of the transformer secondary. Half wave rectifier has around 0.287 and full wave rectifier has around 0.693.
- Half wave rectifier is mainly used in the low power circuits. It has very low performance when it is compared with the other rectifiers.

1.4 FULL WAVE RECTIFIER

Full wave rectifier rectifies the full cycle in the waveform i.e. it rectifies both the positive and negative cycles in the waveform. We have already seen the characteristics and working of Half Wave Rectifier. This Full wave rectifier has an advantage over the half wave i.e. it has average output higher than that of half wave rectifier. The number of AC components in the output is less than that of the input.

The full wave rectifier can be further divided mainly into following types.

- Center Tapped Full Wave Rectifier
- Full Wave Bridge Rectifier

Centre-Tap Full Wave Rectifier

We have already discussed the Full Wave Bridge Rectifier, which uses four diodes, arranged as a bridge, to convert the input alternating current (AC) in both half cycles to direct current (DC).

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.

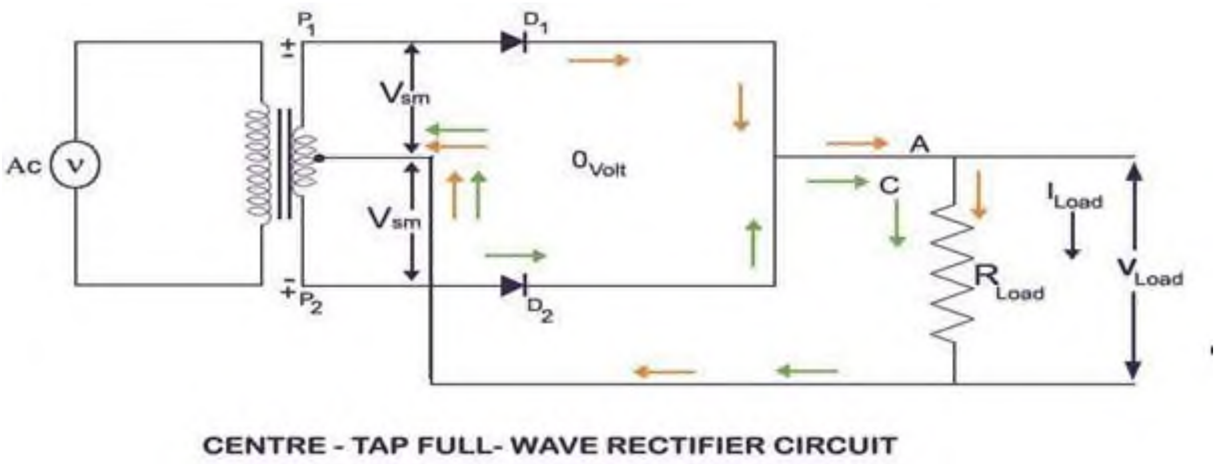

Figure: 1.4.1 Centre Tap Full Wave Rectifier Circuit

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 268]

Working of Centre-Tap Full Wave Rectifier

As shown in the figure, an ac input is applied to the primary coils of the transformer. This input makes the secondary ends P1 and P2 become positive and negative alternately.

For the positive half of the ac signal, the secondary point D1 is positive, GND point will have zero volt and P2 will be negative.

At this instant diode D1 will be forward biased and diode D2 will be reverse biased.

As explained in the Theory behind P-N Junction and Characteristics of P-N JunctionDiode, the diode D1 will conduct and D2 will not conduct during the positive half cycle. Thus the current flow will be in the direction P1-D1-C-A-B-GND. Thus, the positive half cycle appears across the load resistance RLOAD.

During the negative half cycle, the secondary ends P1 becomes negative and P2 becomes positive. At this instant, the diode D1 will be negative and D2 will be positive with the zero reference point being the ground, GND. Thus, the diode D2 will be forward biased and D1 will be reverse biased. The diode D2 will conduct and D1 will not conduct during the negative half cycle. The current flow will be in the directionP2-D2-C-A-B-GND.

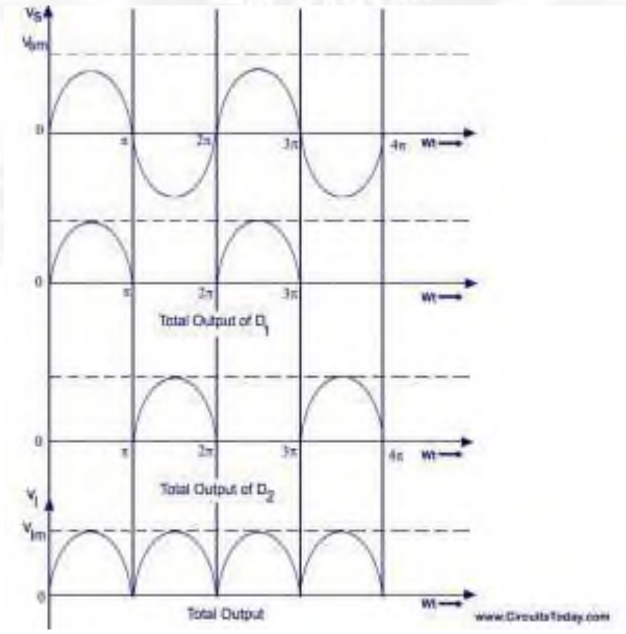

Figure: 1.4.2 Centre-tap Full-wave Rectifier-Waveform

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 268]

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 RLOAD). 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.

Peak Inverse Voltage (PIV) of Centre-Tap Full Wave Rectifier

PIV is the maximum possible voltage across a diode during its reverse biased period. Let us analyze the PIV of the Centre-tapped rectifier from the circuit diagram. During the first half or the positive half of the input ac supply, the diode D1 is positive and thus conducts and provided no resistance at all. Thus, the whole of voltage Vs developed in the upper-half of the ac supply is provided to the load resistance RLOAD. Similar is the case of diode D2 for the lower half of the transformer secondary.

Therefore,

PIV of D2 = Vm +Vm =

2VmPIV of D1 = 2Vm

- **Peak Current**

The instantaneous value of the voltage applied to the rectifier can be written as

Vs = Vsm Sinwt

Assuming that the diode has a forward resistance of RFWD ohms and a reverse resistance equal to infinity, the current flowing through the load resistance RLOAD isgiven as

Im = Vsm / (RF + RLoad)

- **Output Current**

Since the current is the same through the load resistance RL in the two halves of the ac cycle, magnitude of dc current Idc, which is equal to the average value of ac current, can be obtained by integrating the current i1 between 0 and pi or current i2 between pi

$$\mathbf{Idc} = \mathbf{1/\pi}\int_0^{\pi} \boldsymbol{i1\ d(wt)} = \mathbf{1/\pi}\int_0^{\pi} \boldsymbol{Imax\ \sin wt\ d(wt)} = \boldsymbol{2Im/\ \pi}$$

Output current of Centre Tap rectifier

- **DC Output Voltage**

Average or dc value of voltage across the load is given as

$$\mathbf{Idc = 1/\pi \int_0^{\pi} i1\ d(wt) = 1/\pi \int_0^{\pi} Imax\ wt\ d(wt) = 2Im/\pi}$$

DC Output Voltage of center Tap Rectifier

- **Root Mean Square (RMS) Value of Current**

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

$$\mathbf{I^2rms = 1/\pi \int_0^{\pi} i\ d(\ wt) = I^2\ m/2\ or\ I_{rms} = I_m/\sqrt{2}}$$