APPLICATIONS OF PN JUNCTION DIODE

Rectification

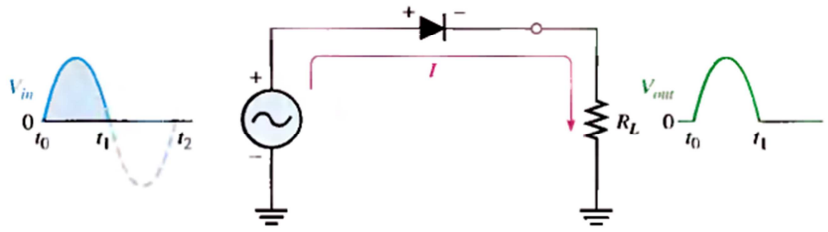
The conversion of alternating current into direct current is known as rectification. A PN-junction diode can conduct current only when it is forward biased and a very weak current flow across PN-junction when it is reversed biased. This action of junction enables us to use it as a rectifier. Rectifiers may be placed into following two categories:

i) Half wave rectification

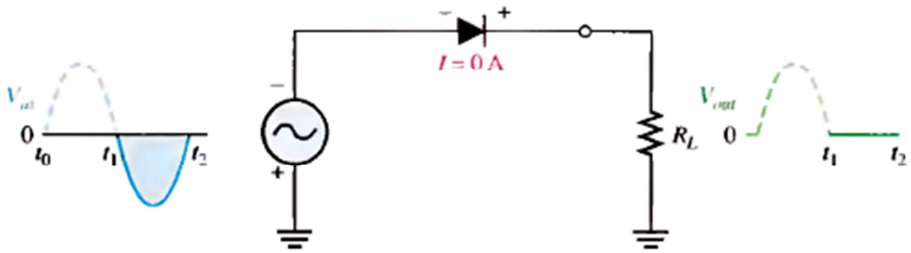
ii) Full wave rectification

Half Wave Rectification

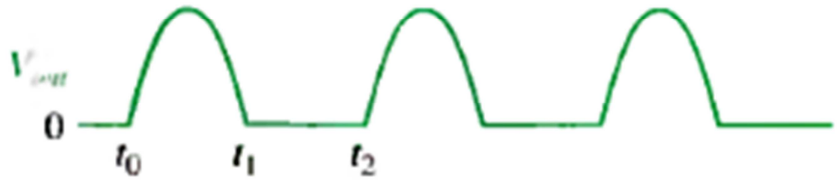
A half-wave rectifier allow current through the load only during one-half of the cycle. A diode is connected to an ac source and to a load resistor R_L forming a half-wave rectifier. When the sinusoidal input voltage (V_{in}) goes positive, the diode is forward-biased and conducts current through the load resistor. The current produces an output voltage across the load R_L which has the same shape as the positive half-cycle of the input voltage as shown in figure below:



When the input voltage goes negative during the second half of its cycle, the diode is reverse-biased. There is no current, so the voltage across the load resistor is 0 V, as shown in figure below:

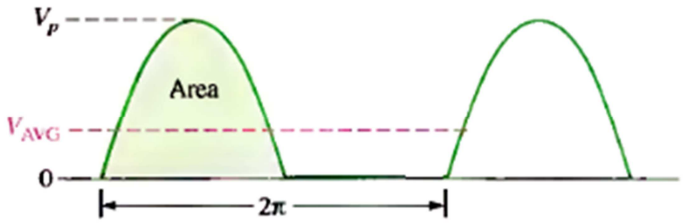


The net result is that only the positive ha]f-cycles of the ac input voltage appear across the load. Since the output does not change polarity, it is a pulsating dc voltage with a certain frequency as shown in the figure below:



Average Value of the Half-Wave Output Voltage

The average value of the half-wave rectified output voltage is the value you would measure on a de voltmeter. Mathematically, it is determined by finding the area under the curve over a full cycle, as illustrated in the figure below, then dividing by 2π, the number of radians in a full cycle.



$$V_{dc} = \frac{1}{2\pi}\int_0^{\pi} V_m \sin\theta \, d\theta = \frac{V_m}{2\pi} \, |-\cos\theta|_0^{\pi}$$

$$V_{dc} = \frac{V_m}{2\pi}\,[1 - (-1)] = \frac{V_m}{2\pi}\,[2]$$

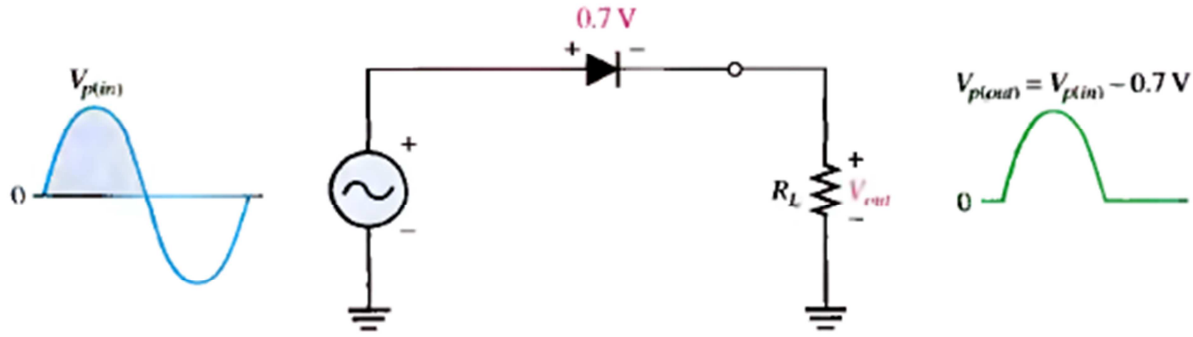
$$V_{dc} = \frac{V_m}{\pi} = 0.318\, V_m$$

Note that $V_m \sin\theta$ is the instantaneous AC voltage.

Effect of the Barrier Potential on the Half-Wave Rectifier Output

In the previous discussion, the diode was considered ideal. When the practical diode model is used with the barrier potential of 0.7 V taken into account, this is what happens. During the positive half-cycle, the input voltage must overcome the barrier potential before the diode becomes forward-biased. This results in a half-wave output with a peak value that is

0.7 V less than the peak value of the input, as shown in figure below:



The expression for the peak output voltage is

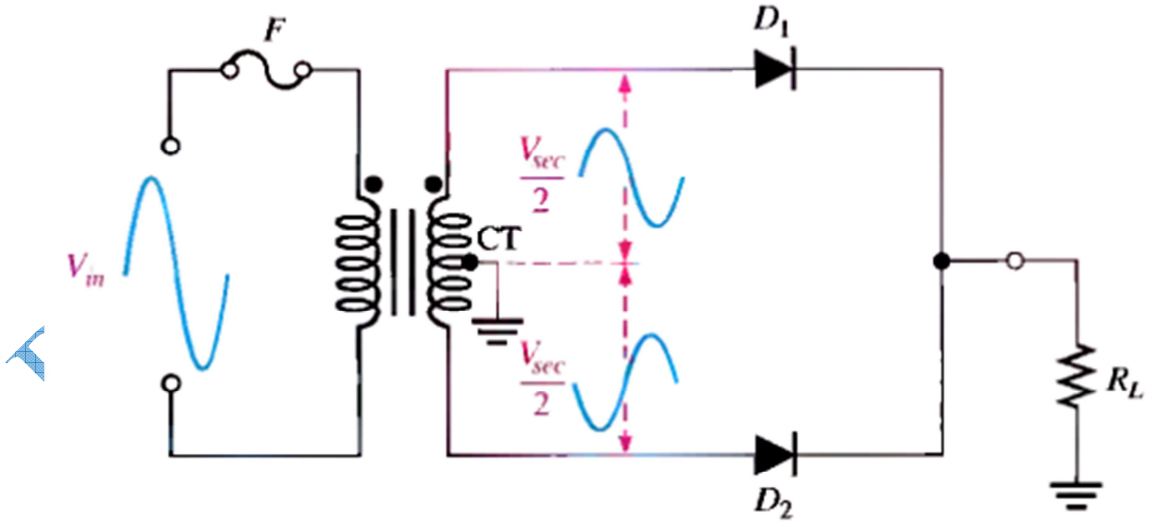
$$V_{p(out)} = V_{p(in)} - 0.7\,V$$

Full-Wave Rectifiers

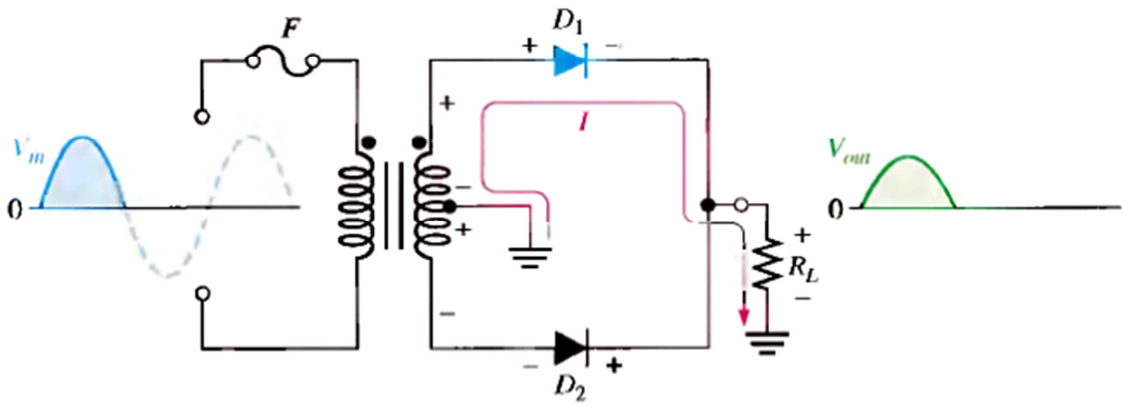
A full-wave rectifier allows unidirectional (one-way) current through the load during the entire 360˚ of the input cycle.

The Center-Tapped Full-Wave Rectifier

A center-tapped rectifier is a type of full-wave rectifier that uses two diodes connected to the secondary of a center-tapped transformer, as shown in figure below. The input voltage is coupled through the transformer to the center-tapped secondary. Half of the total secondary voltage appears between the center tap and each end of the secondary winding as shown.

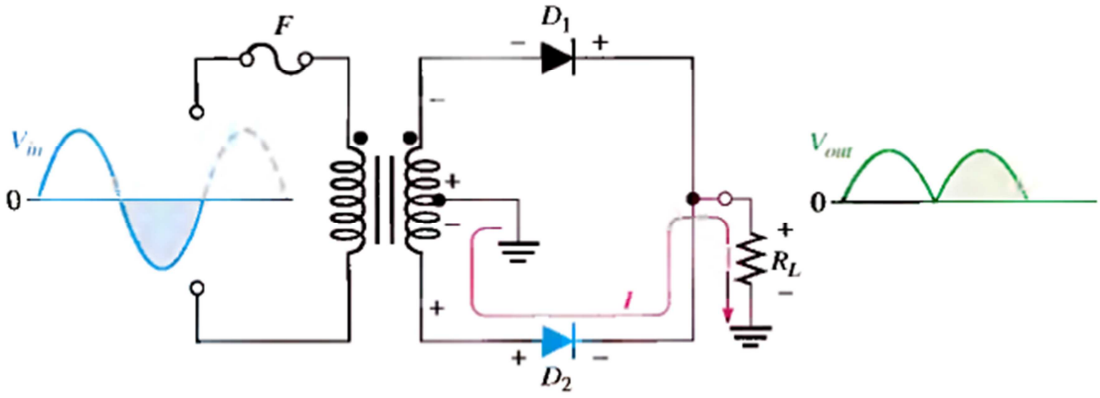


For a positive half-cycle of the input voltage, the polarities of the secondary voltages are as shown in Figure (a). This condition forward-biases diode D_1 and reverse-biases diode D_2. The current path is through D_1 and the load resistor R_L.



(a) During positive half-cycles, D_1 is forward-biased and D_2 is reverse-biased.

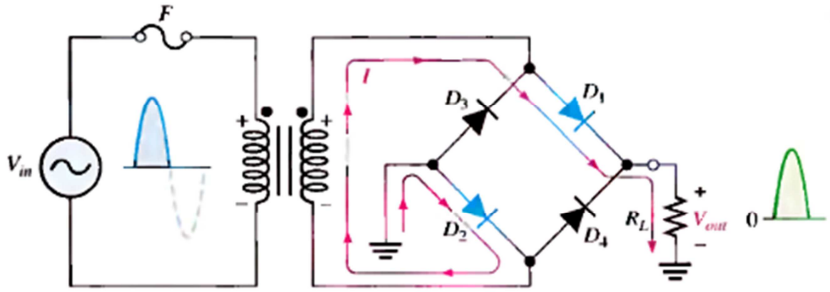
For a negative half-cycle of the input voltage, the voltage polarities on the secondary are as shown in Figure (b). This condition reverse-biases D_1 and forward-biases D_2. The current path is through D_2 and R_L as indicated. Because the output current during both the positive and negative portions of the input cycle is in the same direction through the load, the output voltage developed across the load resistor is a full-wave rectified dc voltage.



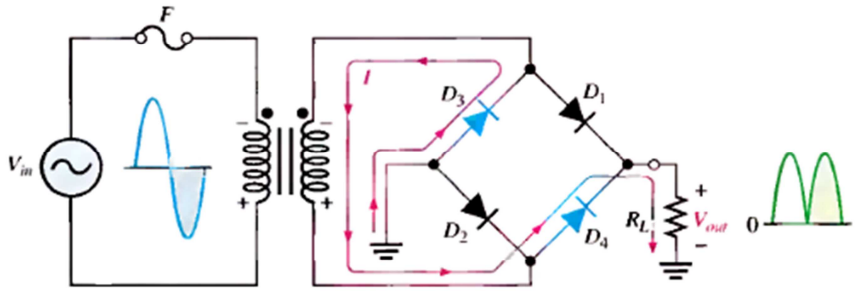
(b) During negative half-cycles. D_2 is forward-biased and D_1 is reverse-biased.

The Bridge Full-Wave Rectifier

The bridge rectifier uses four diodes connected as shown in Figure 2-20_ When the input cycle is positive as in part (a), diodes D_l and D_2 are forward-biased and conduct current in the direction shown. A voltage is developed across R_L that looks like the positive half of the input cycle. During this time, diodes D_3 and D_4 are reverse-biased.



(a) During the positive half-cycle of the input, D_1 and D_2 are forward-biased and conduct current. D_3 and D_4 are reverse-biased.



(b) During the negative half-cycle of the input, D_3 and D_4 are forward-biased and conduct current. D_1 and D_2 are reverse-biased.

When the input cycle is negative as in Figure (b), diodes D_3 and D_4 are forward-biased and conduct current in the same direction through R_L as during the positive half-cycle. During the negative half-cycle, D_1 and D_2 are reverse-biased. A full-wave rectified output voltage appears across R_L as a result of this action.