DIODE APPLICATIONS

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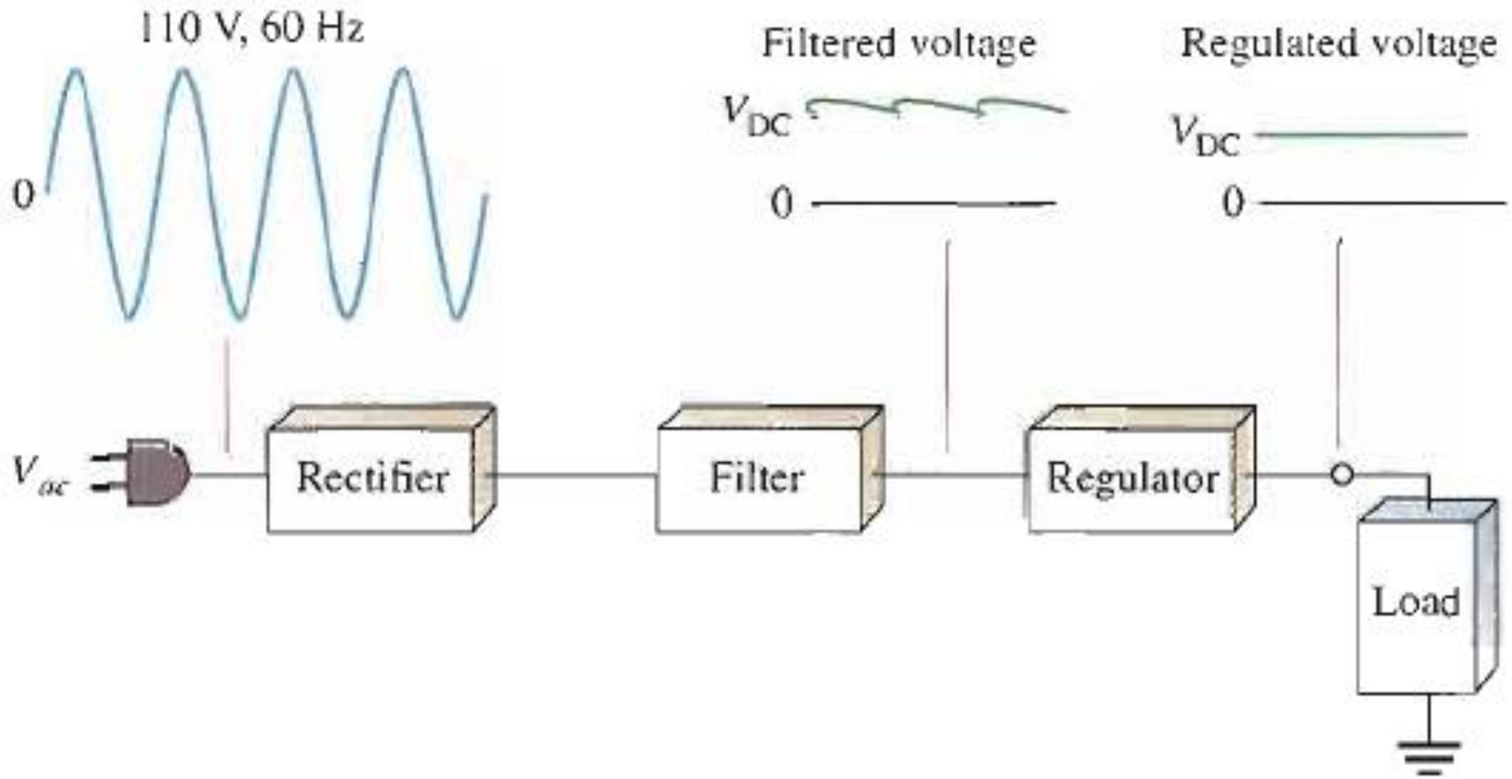
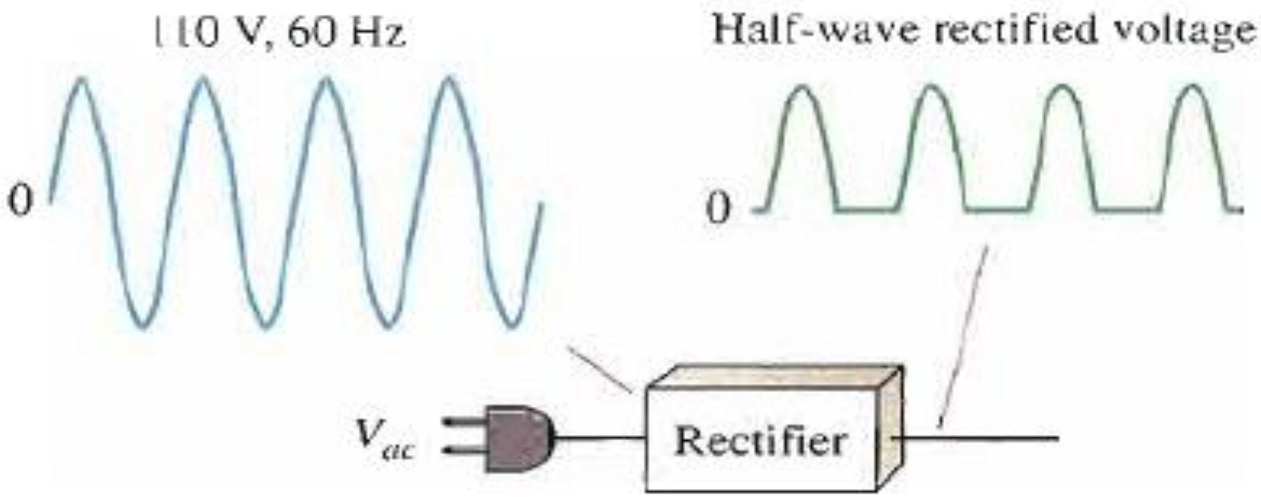
The Basic DC Power Supply



Block Diagram of DC Power supply

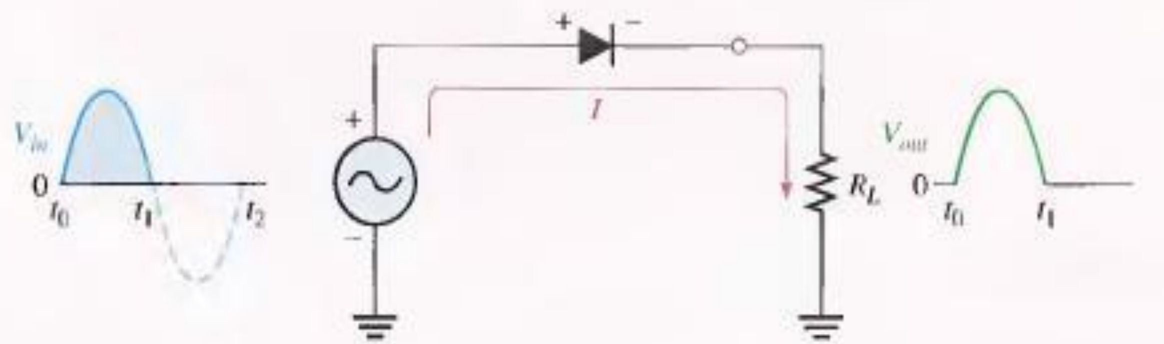
DIODE RECTIFICATION:



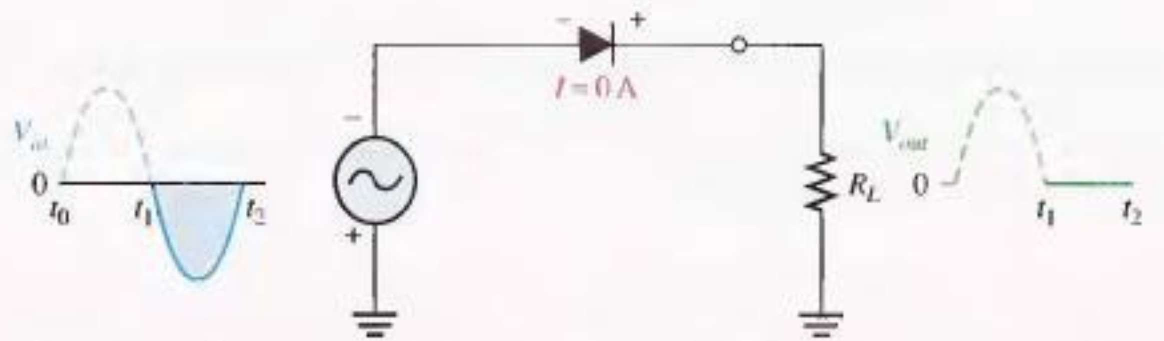
- Diodes are used in circuits called Rectifiers that converts **AC voltage into DC voltage**.

- They are based on the principle that diodes have the ability to conduct current in one direction and block current in the other direction.

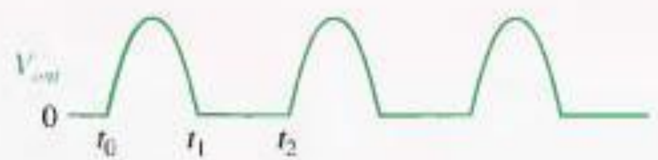
Half-Wave rectifier:



(a) During the positive alternation of the 60 Hz input voltage, the output voltage looks like the positive half of the input voltage. The current path is through ground back to the source.



(b) During the negative alternation of the input voltage, the current is 0, so the output voltage is also 0.



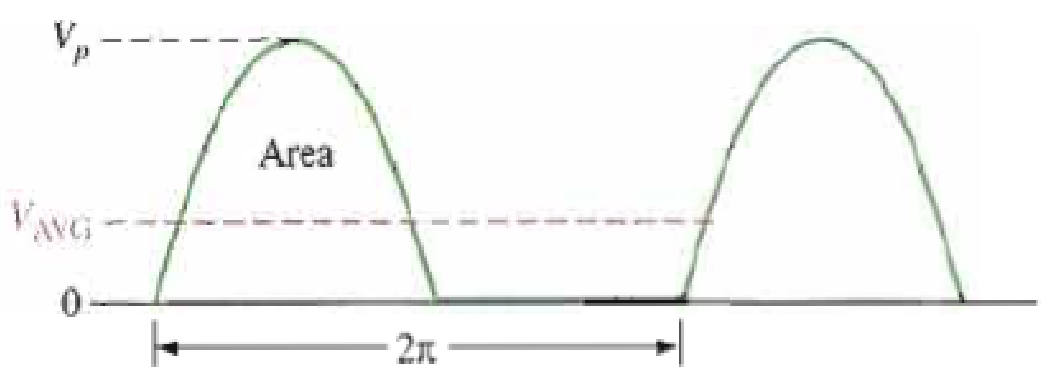
(c) 60 Hz half-wave output voltage for three input cycles

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 dc voltmeter. Mathematically, it is determined by finding the area under the curve over a full cycle, as illustrated in Figure 2–3, and then dividing by 2π, the number of radians in a full cycle. The result of this is expressed in Equation 2–1, where V_p is the peak value of the voltage. This equation shows that V_{AVG} is approximately 31.8% of V_p for a half-wave rectified voltage. See Appendix B for a detailed derivation.

$$V_{AVG} = \frac{V_p}{\pi}$$

FIGURE 2–3

Average value of the half-wave rectified signal.



Example

What is the average value of the half-wave rectified voltage in Figure 2–4?

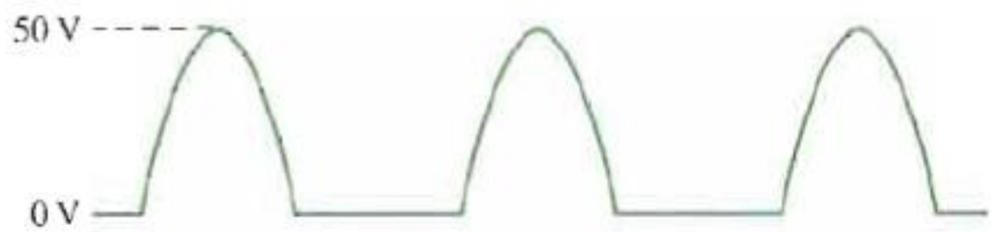


FIGURE 2–4

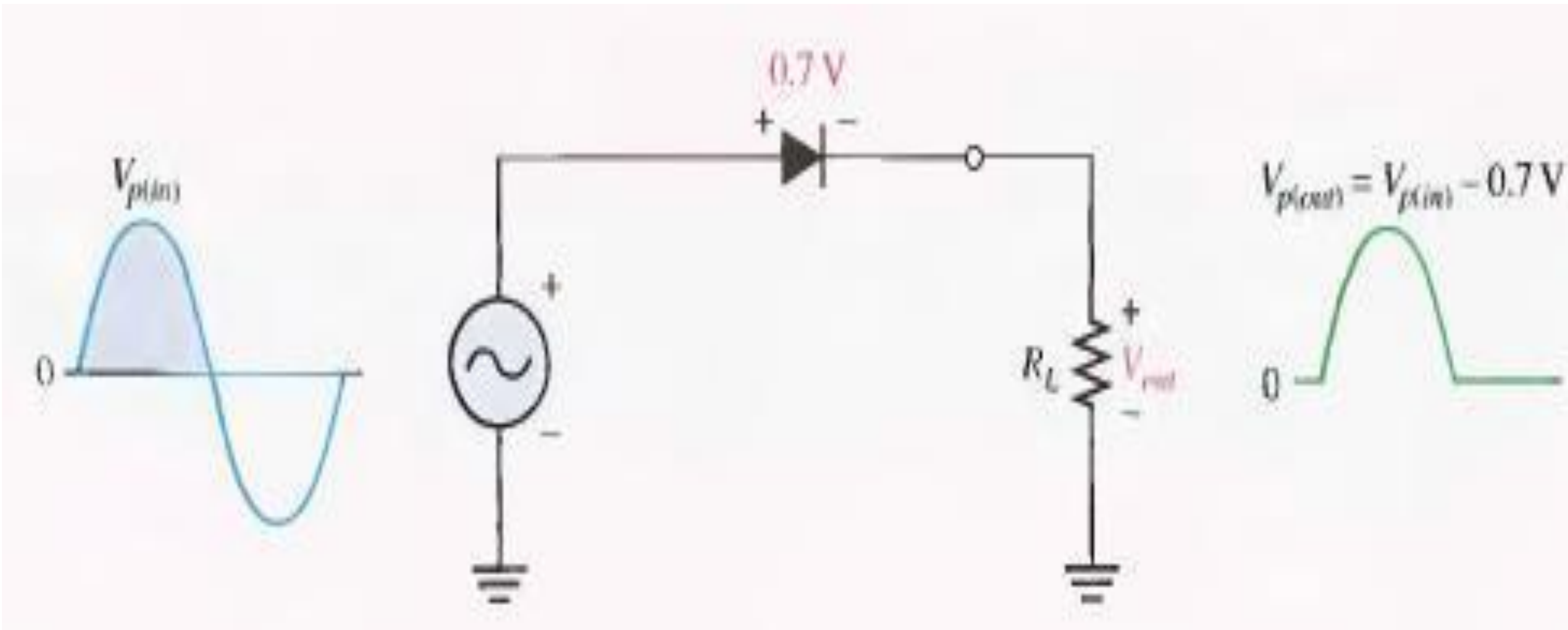
Solution

$$V_{AVG} = \frac{V_p}{\pi} = \frac{50\text{ V}}{\pi} = \mathbf{15.9\ V}$$

Notice that V_{AVG} is 31.8% of V_p.

Related Problem* Determine the average value of the half-wave voltage if its peak amplitude is 12 V.

Effect of the barrier potential on the Half-Wave Rectifier Output:



0.7 V less than the peak value of the input, as shown in Figure 2–5. The expression for the peak output voltage is

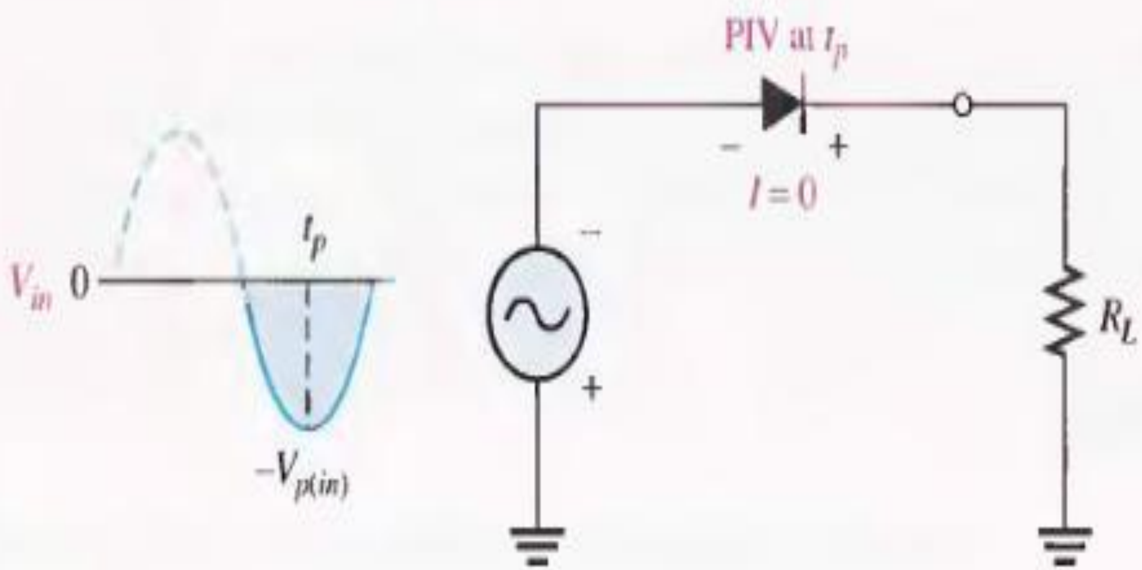
$$V_{p(out)} = V_{p(in)} - 0.7\text{ V}$$

Muhammad Adeel

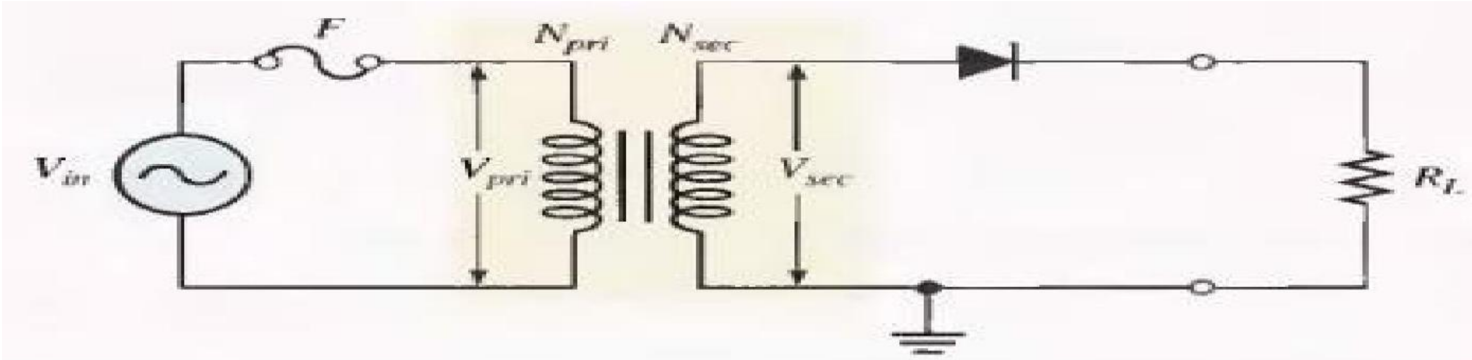
Peak Inverse Voltage (PIV)

The **peak inverse voltage (PIV)** equals the peak value of the input voltage, and the diode must be capable of withstanding this amount of repetitive reverse voltage. For the diode in Figure 2–8, the maximum value of reverse voltage, designated as PIV, occurs at the peak of each negative alternation of the input voltage when the diode is reverse-biased.

$$\text{PIV} = V_{p(in)}$$



Half-Wave Rectifier With Transformer-Coupled Input Voltage:



From your study of basic ac circuits recall that the secondary voltage of a transformer equals the turns ratio, n, times the primary voltage, as expressed in Equation 2–4. We will define the turns ratio as the ratio of secondary turns, N_{sec}, to the primary turns, N_{pri}: $n = N_{sec}/N_{pri}$.

$$V_{sec} = nV_{pri}$$

If $n > 1$, the secondary voltage is greater than the primary voltage. If $n < 1$, the secondary voltage is less than the primary voltage. If $n = 1$, then $V_{sec} = V_{pri}$.

The peak secondary voltage, $V_{p(sec)}$, in a transformer-coupled half-wave rectifier is the same as $V_{p(in)}$ in Equation 2–2. Therefore, Equation 2–2 written in terms of $V_{p(sec)}$ is

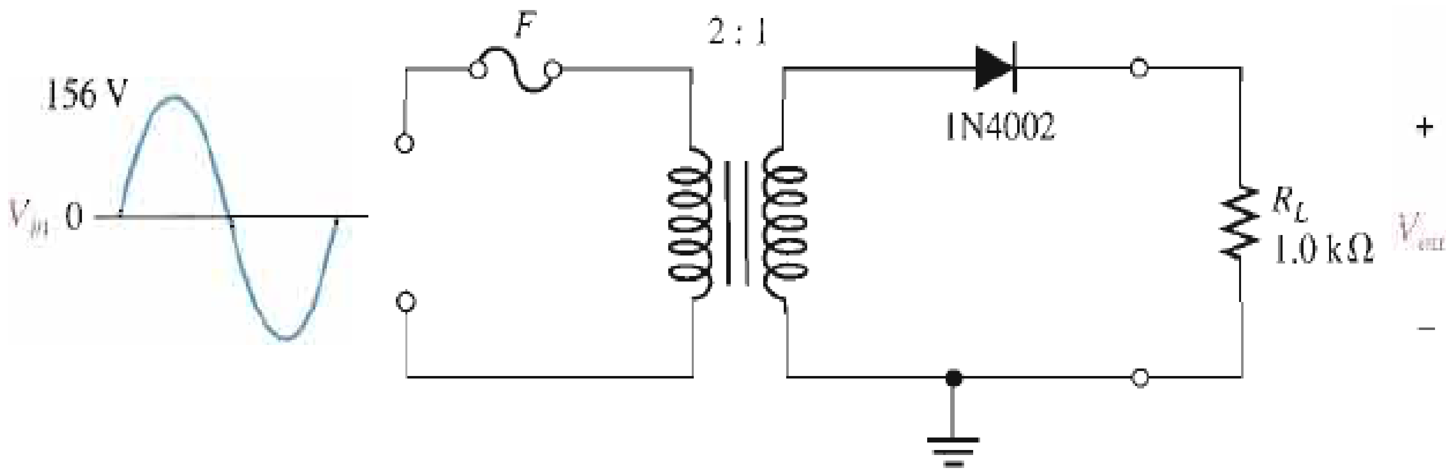
$$V_{p(out)} = V_{p(sec)} - 0.7\text{ V}$$

and Equation 2–3 in terms of $V_{p(sec)}$ is

$$\text{PIV} = V_{p(sec)}$$

Example

Determine the peak value of the output voltage for the figure below if the turns ratio is 0.5.



Solution

$$V_{p(pri)} = V_{p(in)} = 156\text{ V}$$

The peak secondary voltage is

$$V_{p(sec)} = nV_{p(pri)} = 0.5(156\text{ V}) = 78\text{ V}$$

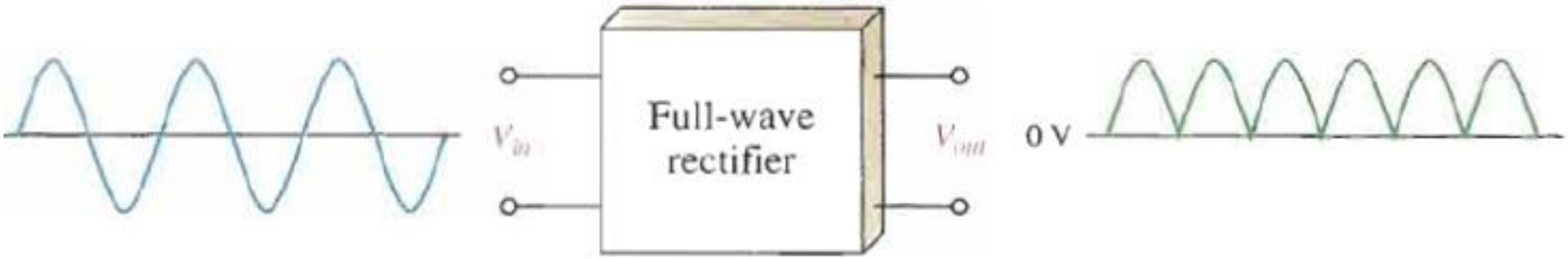
The rectified peak output voltage is

$$V_{p(out)} = V_{p(sec)} - 0.7\text{ V} = 78\text{ V} - 0.7\text{ V} = \mathbf{77.3\text{ V}}$$

where $V_{p(sec)}$ is the input to the rectifier.

Full-Wave Rectifiers:

A **full-wave rectifier** allows unidirectional (one-way) current through the load during the entire 360° of the input cycle, whereas a half-wave rectifier allows current through the load only during one-half of the cycle. The result of full-wave rectification is an output voltage with a frequency twice the input frequency that pulsates every half-cycle of the input, as shown in Figure 2–11.



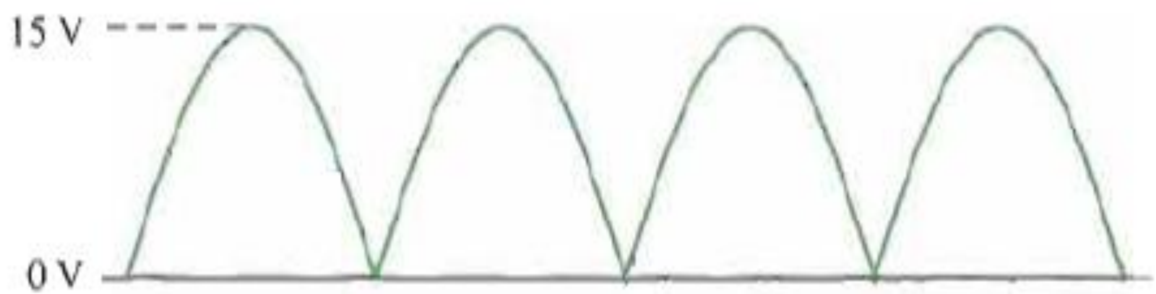
The number of positive alternations that make up the full-wave rectified voltage is twice that of the half-wave voltage for the same time interval. The average value, which is the value measured on a dc voltmeter, for a full-wave rectified sinusoidal voltage is twice that of the half-wave, as shown in the following formula:

$$V_{AVG} = \frac{2V_p}{\pi}$$

V_{AVG} is approximately 63.7% of V_p for a full-wave rectified voltage.

Example

Find the average value of the full-wave rectified voltage in Figure 2–12.

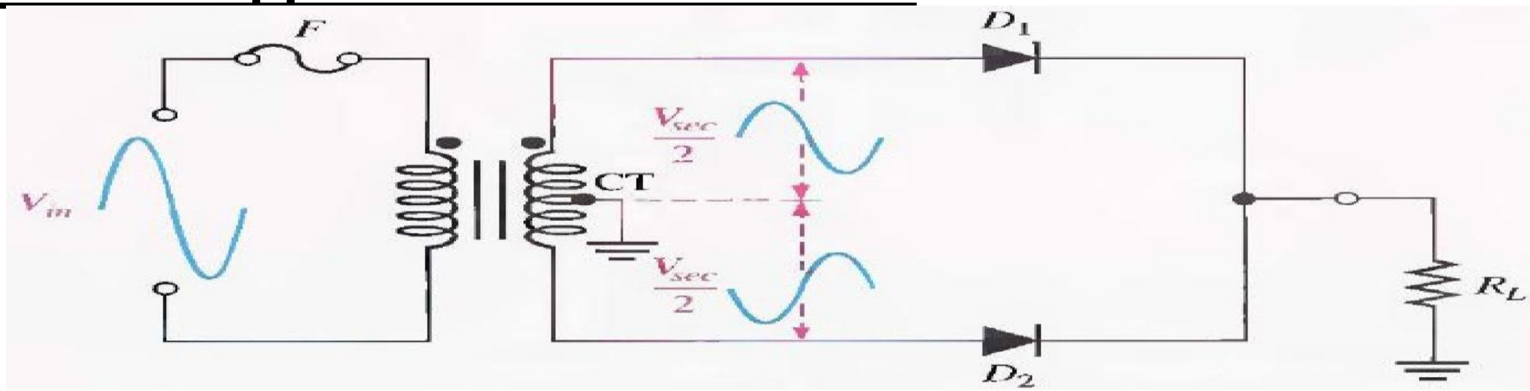


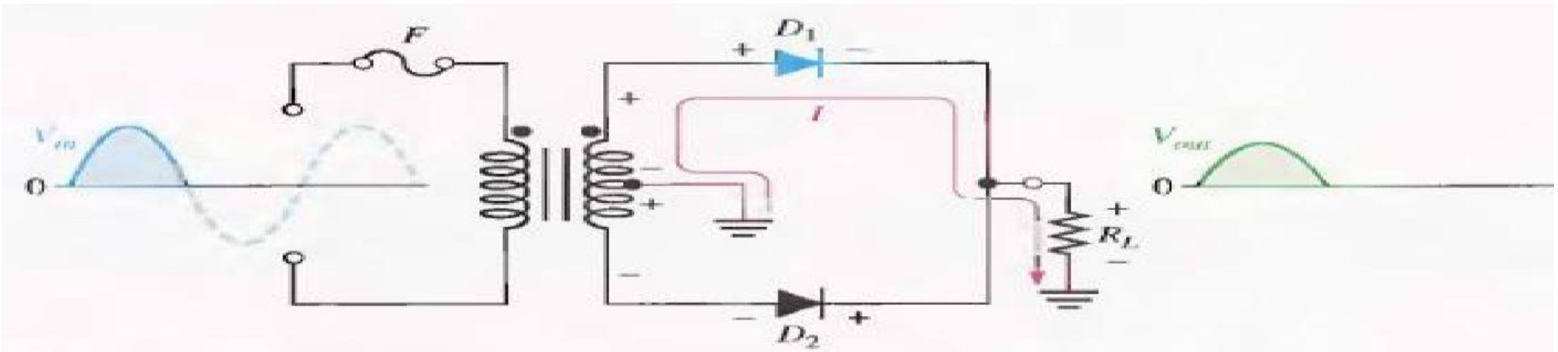
Solution

$$V_{AVG} = \frac{2V_p}{\pi} = \frac{2(15\text{ V})}{\pi} = \mathbf{9.55\ V}$$

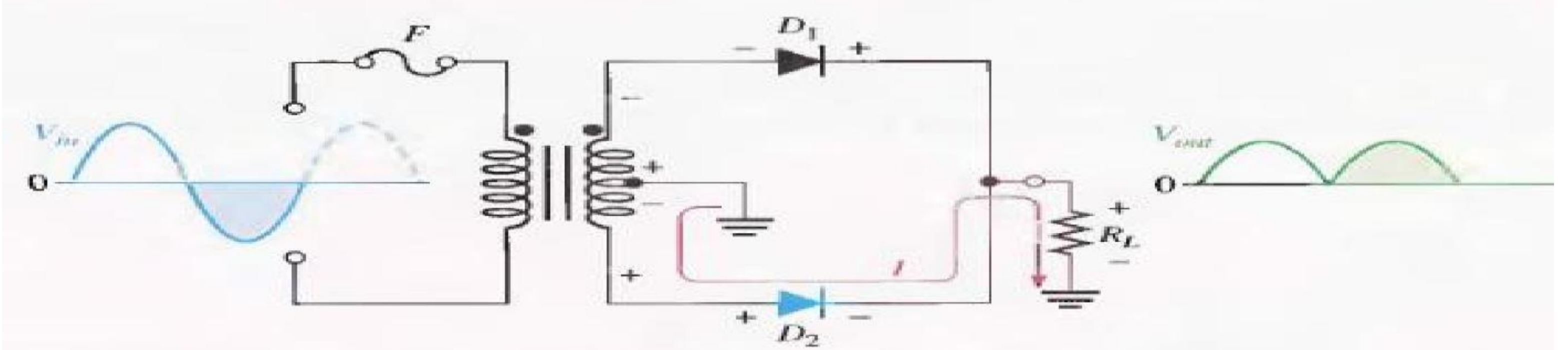
V_{AVG} is 63.7% of V_p.

The Center-Tapped Full-Wave Rectifier:





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



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