13.2 POWER CIRCUITS WITH DIODES

A major use for diodes is in the *rectification* of AC signals, specifically in power supplies in which the conversion from AC to DC is required. Small-signal diodes can be used as rectifiers in non-power or low-power applications. Larger diodes with higher power ratings are employed when constructing power supply circuits meant to provide more power. An AC power signal is a sine wave of arbitrary amplitude that is centered about 0 V. Its voltage peaks are of equal magnitude above and below 0 V. A digital circuit requires a steady DC power supply. The first step in creating a steady DC power supply is to rectify the AC input such that the negative AC sine wave excursions are blocked. Figure 13.5 shows a single diode performing this function. The rectified output is reduced in voltage by the diode's forward voltage. This circuit is called a *half-wave* rectifier, because it passes only half of the incoming power signal. Once rectified, capacitors and inductors can smooth out (lowpass filter) the rectified AC signal to create a steady DC output.

The single-diode half-wave rectifier does the job, but does not take advantage of the negative portion of the AC input. Four diodes can be assembled into a *full-wave bridge rectifier* that passes the positive portion of the sine wave and inverts the negative portion relative to the DC ground. This circuit is shown in Fig. 13.6. The bridge rectifier works by providing a current conduction path through the resistor to ground regardless of the polarity of the incoming AC signal. When the AC input is positive with respect to the polarity markings shown in the diagram, diodes D1 and D3 are forward biased, conducting current from D1 through the resistor, then through D3 to the negative AC input wire. When the AC input is negative during the next half of the sinusoid, D2 and D4 are forward biased and allow current to flow in the same direction through the resistor. The result is that a positive voltage is always developed across the load with respect to ground. Note that, because of the two diodes in series with the load, the rectified output voltage is reduced by twice the diodes' forward voltage.

Power rectifier circuits are generally found in systems wherein a high-voltage input (e.g., 120 VAC) must be converted into a low-voltage output such as +5 VDC to power a digital logic circuit. Transformers are used in conjunction with bridge rectifiers to step down the high-voltage AC input to a more appropriate intermediate level that is much closer to the final voltage level required by the system. A power filter circuit can then be used to smooth the heavily rippled rectified signal into a more stable DC input. Finally, a voltage regulator performs the final adjustments to convert the

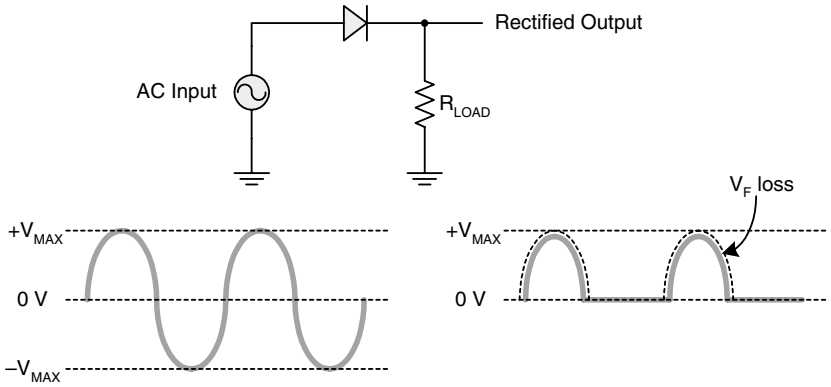

FIGURE 13.5 Half-wave rectifier circuit.

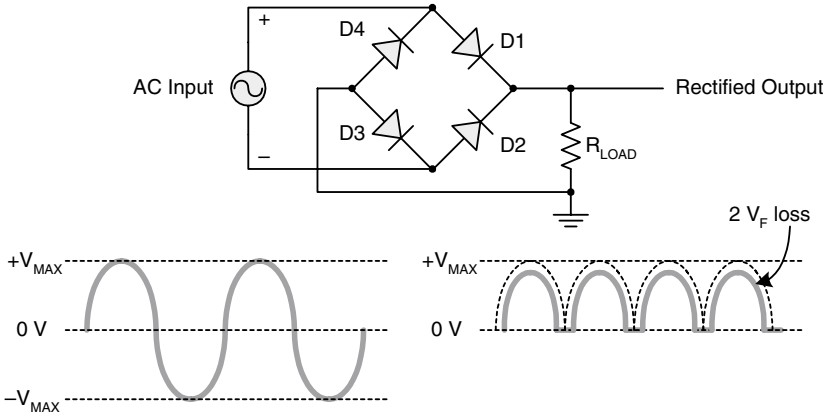

FIGURE 13.6 Bridge rectifier circuit.

intermediate voltage into a more accurate digital supply voltage. This common AC-to-DC power supply configuration is illustrated in Fig. 13.7.

Another power application of diodes is in combining multiple power supplies to feed a single component or group of components while ensuring that the failure or disappearance of one supply does not cause that component to lose power and cease operation. This concept relies on the fact that a standard diode will not conduct under normal reverse-bias conditions. As shown in Fig. 13.8, each power supply is isolated by a diode whose cathodes form a common voltage supply node for a circuit. Under normal operating conditions, each diode is forward biased, because the respective power supplies are functioning. When one supply fails, its associated diode becomes reverse biased, thereby preventing the failing supply from pulling power from the functioning supply and causing the system to fail. These diodes are often called *OR-ing diodes,* because they perform a logical OR function on the power supplies.

Diode OR-ing circuits are also seen in battery-backup applications in which it is desired to keep a low-power static RAM chip powered by a battery when the main power supply is turned off. A typical scenario is a higher-voltage operating supply (e.g., +5 V) and a lower-voltage data-retention bat-

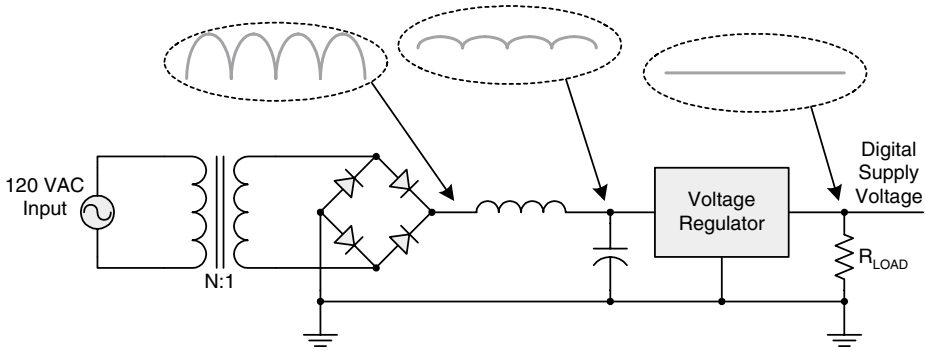

FIGURE 13.7 AC-to-DC power supply.