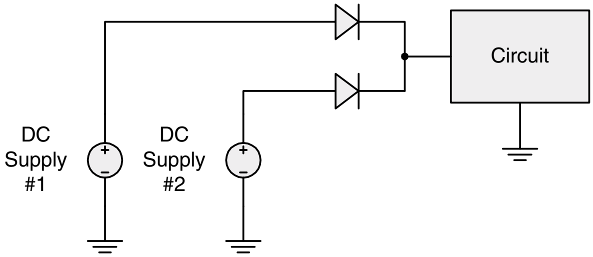

FIGURE 13.8 Power supply OR-ing diodes.

tery (e.g., +3 V) are each connected to an SRAM via independent OR-ing diodes. Under normal operation, the operating supply forces the battery's diode into reverse bias, preventing the battery from supplying power to the SRAM, thereby extending the battery's life. When power is turned off, the battery's diode becomes forward biased and maintains power to the SRAM so that its data are not lost. Schemes like this are commonly employed in certain PCs and other platforms that benefit from storing configuration information in nonvolatile SRAM.

13.3 DIODES IN DIGITAL APPLICATIONS

Not only can diode logic functions be implemented for power supply sharing or backup, they are equally applicable to implementing certain simple logic tasks on a circuit board. Diodes can implement both simple OR and AND functions and are useful when either a standard logic gate is unavailable or when the amplitude of the incoming signals violates the minimum or maximum input voltages of other components. Figure 13.9 shows diodes implementing two-input OR and AND functions. Pull-down and pull-up resistors are necessary for the OR and AND functions, respectively, because the diodes conduct only when forward biased. When both diodes are reverse biased, the circuit must be pulled to a valid logic state. The value of the resistors depends on the input current of the circuit being driven but ranges from 1 to 10 kΩ are common.

The pull-down resistor in the OR circuit maintains a default logic level of 0 when both inputs are also at logic 0. Both inputs must remain below V_F = 0.7 V for the circuit to generate a valid logic 0-V level. When the input signals transition to logic 1, they must stabilize at a higher voltage

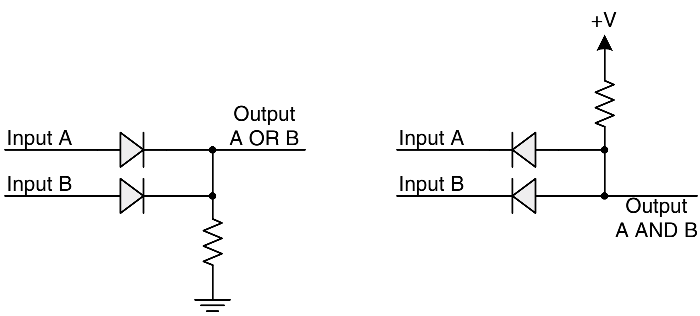

FIGURE 13.9 Diode OR and AND functions.

that is sufficient to meet the minimum logic-1 input voltage of the driven circuit. The value of the pull-down resistor should be high enough to limit the power consumption of the circuit but low enough to create a voltage that is comfortably below the driven circuit's logic-0 threshold. A CMOS input has a much lower input current specification than a TTL input. A typical TTL input has a low-level input current of under 0.5 mA, and it should be kept well below 0.8 V for adequate margin. A 1-kΩ pull-down resistor would create less than a 0.5-V drop under these conditions. This may be adequate for some designs, or a more conservative approach could be taken by using a smaller resistance, perhaps 470 Ω. When either input rises to its logic-1 voltage, this will be reflected in the circuit's output minus a diode drop. This places a restriction on the input voltages: they cannot exceed the maximum input voltage of the driven circuit by more than a diode drop. However, the input voltages can violate the minimum input voltage specification, because the diodes will be reverse biased under these conditions and thereby prevent the circuit's output voltage from dropping below 0 V, or ground.

Similarly, the AND circuit emits a logic-1 voltage when both diodes are reverse biased, because of the pull-up resistor. The diodes are reverse biased whenever the input voltages are near or above the logic supply voltage, +V. This enables the circuit to perform the AND function for input signals that would otherwise violate the maximum input voltage of the driven circuit. When either input transitions to a logic 0, that input's diode becomes forward biased and drags the output voltage down to the input level plus a diode drop, driving a logic-0 out. For the AND circuit to function reliably, a guarantee must be made of meeting the maximum logic-0 input voltage for the driven circuit. Using a normal silicon diode with V_F = 0.7 V may make this impossible if the input voltage is not guaranteed to go below 0 V. Therefore, a low-V_F Schottky diode such as a BAT54 may be required that exhibits V_F < 0.4 V at low currents. Just as the OR-circuit provides input voltage protection at logic 0 but not logic 1, the AND-circuit provides input voltage protection at logic 1 but not logic 0. The input voltage must not fall below the driven circuit's minimum input voltage by more than a diode drop.

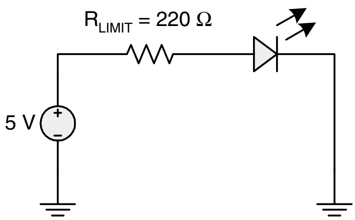

FIGURE 13.10 LED circuit.

Finally, perhaps the most visible types of diodes are *light emitting diodes* (LEDs). LEDs are constructed from various semiconductors and metals that emit visible or invisible light when forward biased. An LED is graphically distinguished from a normal diode by drawing representations of light or photons next to the diode symbol as shown in Fig. 13.10. LEDs exhibit forward voltages that are substantially higher than normal diodes, typically in the range of 2 to 3 V. Whether an LED is wired to the power supply to provide a "power on" indicator, or it is connected to the output pin of an IC, it should be *current limited* using a series resistor. Each LED has its own specifications for V_F and I_F. The current-limiting resistor should be chosen to provide the required current given the supply voltage and V_F.

In Fig. 13.10, the diode is assumed to have V_F = 2 V, and the supply voltage is 5 V. The resistor therefore drops 3 V and allows 13.6 mA of current to flow through the circuit. Allowing more current to flow through the LED will make it glow brighter but will also cause it to dissipate more heat. Most small LEDs emit sufficient light at currents ranging from 10 to 30 mA. In situations where power savings are critical, less current may be possible, depending on the desired light intensity.

LEDs are available in a wide range of colors. At first, only shades of green, red, and yellow were commonly found. Blue LEDs became widely available in the late 1990s, allowing full-color red-green-blue (RGB) displays. Common household remote control units rely on infrared LEDs. Ultraviolet LEDs are available as well for special applications.