

forward voltage, V_F . A diode conducts very little current below V_F , measured in micro- or nanoamps. The relationship between a diode's current and voltage is exponential and therefore increases rapidly around V_F . Above V_F , the diode presents very low impedance and appears almost like a short circuit, or a piece of wire. A typical silicon diode's I-V characteristic is shown in Fig. 13.2 with V_F of approximately 0.7 V. For many applications, especially those in digital systems, a diode's I-V characteristic can be simplified to a step function from zero to infinite current at the forward voltage. Real diodes also have a reverse breakdown voltage, called the Zener voltage, V_Z , at which point they will conduct under reverse-biased conditions. Normal diodes are usually not subjected to reverse-bias voltages sufficient to achieve significant conduction. Special-purpose Zener diodes are designed specifically to operate under reverse-bias conditions and are commonly used in voltage reference and regulation applications.

Saying that a diode conducts "infinite" current beyond V_F really means that its impedance becomes so low that it no longer becomes the limiting factor in a circuit. If a typical diode is connected directly to a battery such that it is forward biased, the diode will form nearly a short circuit, which will cause a large current flow. Fairly soon afterward, the diode will likely fail due to thermal overload. Diodes are specified with maximum forward currents, I_F . Exceeding I_F causes the diode to dissipate more power than it is designed for, usually with destructive consequences.

When a diode is used in an application wherein it may be forward biased and driven with excessive current, a current-limiting resistor is inserted into the circuit to keep the diode within its specified operating limits. Diodes are useful for providing a fixed voltage reference regardless of a circuit's operating voltage. The circuit shown in Fig. 13.3 takes advantage of a diode's relatively static forward voltage with respect to current. A loosely regulated 12-V supply may have a tolerance of ± 20 percent—a range of 9.6 to 14.4 V. If a resistor divider is used to generate a reference voltage, its accuracy could be no better than that of the 12-V supply. Some applications require a more accurate voltage reference with which to sense an incoming signal. A 1N4148 exhibits $V_F = 0.7$ V at

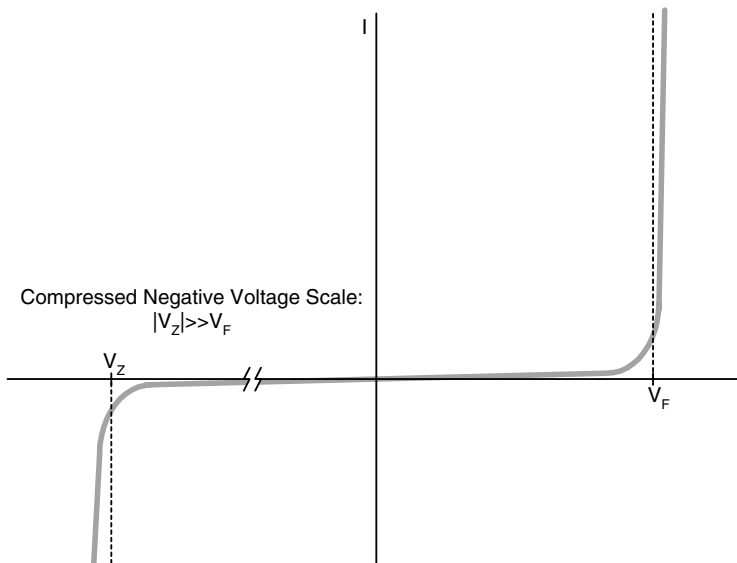


FIGURE 13.2 Silicon diode I-V characteristic.

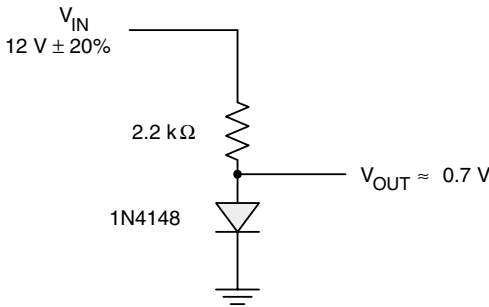


FIGURE 13.3 Diode-based voltage reference.

5 mA under typical conditions.* The 2.2-k Ω resistor limits the current through the diode to approximately 5 mA when $V_{IN} = 12$ V. If the input changes by 20 percent and causes a corresponding change in the current, the diode voltage changes by a small fraction. Using a basic small signal diode in this manner is an effective scheme for many applications. If tighter tolerance is desired, more stable voltage reference diodes are available. Thermal overload is not a problem for this diode, because its power dissipation is relatively constant at 0.7 V \times 5 mA = 3.5 mW.

Diodes are available with a broad spectrum of characteristics. Aside from silicon diodes, there are *Schottky* diodes that exhibit lower forward voltages of under 0.5 V. Lower forward voltages provide benefits for high-power applications in which heat and power dissipation are prime concerns. Reduced V_F means reduced power. Diodes are manufactured in a variety of packages according to the amount of power that they are designed to handle. Small-signal diodes are not intended to handle much power and are available in small, surface mount packages. At the other extreme, diodes can be as large as hockey pucks for very high-power applications. Small-signal diodes are manufactured with varying response times to changes in voltage. A diode can be used to *clip* a signal to prevent it from exceeding a certain absolute voltage, as shown in Fig. 13.4. As the signal's edge rate increases, a slower diode may not respond fast enough to be effective. If a single diode's forward voltage is insufficient, multiple diodes can be placed in series to increase the clipping threshold. Some of the more common small-signal diodes used in digital circuits include the leaded 1N914 and 1N4148 devices, and their surface mount equivalents, the SOT-23 MMBD914 and MMBD4148.

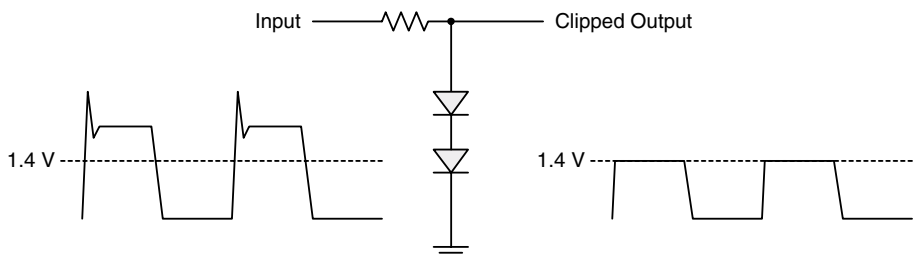


FIGURE 13.4 Clipping a signal with a diode.

* 1N4148, Fairchild Semiconductor Corporation, 2002, p. 2.