Review: Chapter 14

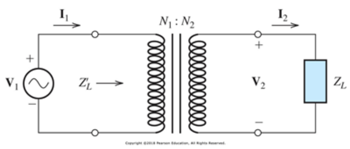


Figure 14.25 The impedance seen looking into the primary is $Z'_L = (N_1 / N_2)2 \times Z_L$.

$$v_2(t) = \frac{N_2}{N_1} v_1(t) \qquad i_2(t) = \frac{N_1}{N_2} i_1(t)$$

$$p_2(t) = p_1(t)$$

Chapter 9 Diodes

1. Diode operation principle.
2. Voltage regulator
3. Rectifier
4. Wave shaping circuits

Basic diode concept

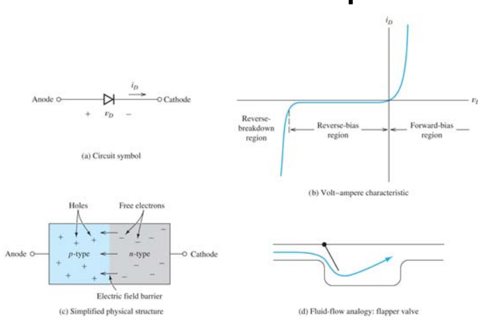


Figure 9.1 Semiconductor diode.

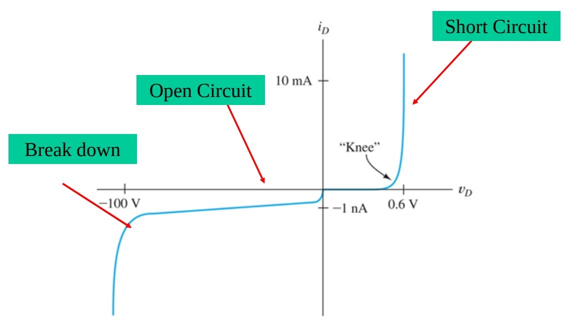


Figure 9.2 Volt–ampere characteristic for a typical small-signal silicon diode at a temperature of 300 K. Notice the change of scale for negative current and voltage.

Shockley Equation

$$i_D = I_s\left[\exp\left(\frac{v_D}{nV_T}\right) - 1\right]$$

$$I_s : Saturation\ \ current$$

$$n : Emission\ \ coefficient$$

$$V_T = \frac{kT}{q}$$

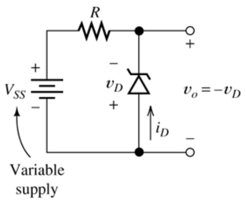
k = 1.38 × 10^{-23} J/K: Boltzmann's constant
q = 1.60 × 10^{-19} C: the electrical charge of an electron.
At a temperature of 300 K, we have $V_T \cong 26\,\mathrm{mV}$

Zener Diodes

Diodes that are intended to operate in the breakdown region are called **Zener diodes**.

Zener-diode voltage-regulator circuits

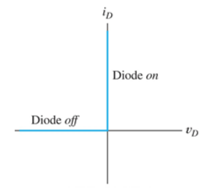
A voltage regulator circuit provides a nearly constant voltage to a load from a variable source.



$$V_{SS} + Ri_D + v_D = 0$$

Ideal-diode model

The ideal diode acts as a short circuit for forward currents and as an open circuit with reverse voltage applied.



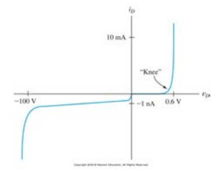


Figure 9.15 Ideal-diode volt–ampere characteristic. **Figure 9.2** diode volt–ampere characteristic.

Diode circuit analysis

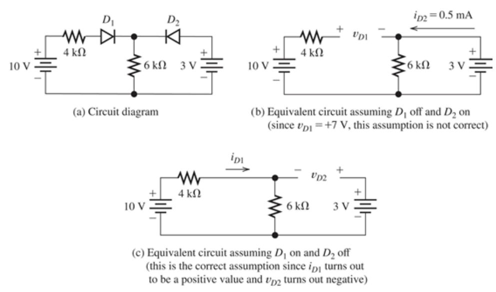


Figure 9.16 Analysis of a diode circuit, using the ideal-diode model. See Example 9.5.

Exercise 9.8
Find the diode states

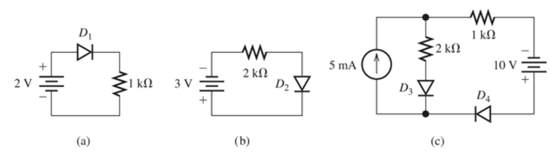


Figure 9.17 Circuits for Exercise 9.8.

Simple diode model

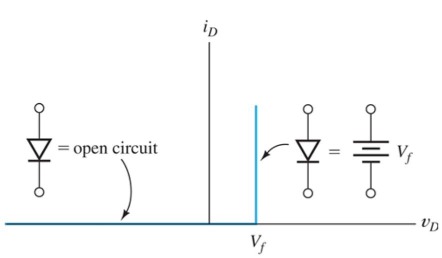


Figure 9.23 Simple piecewise-linear equivalent for the diode.

Application: Half-wave rectifier

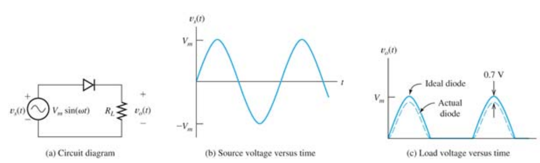


Figure 9.24 Half-wave rectifier with resistive load.

Application: Battery charge circuit

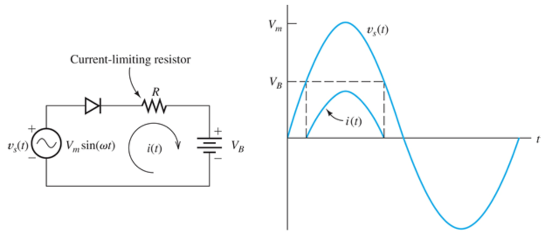


Figure 9.25 Half-wave rectifier used to charge a battery.

Half-wave rectifier with smoothing capacitor

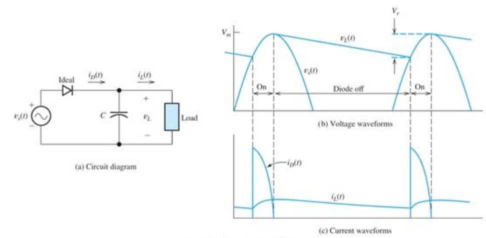


Figure 9.26 Half-wave rectifier with smoothing capacitor.

$$C = \frac{I_L T}{V_r} \qquad V_L \cong V_m - \frac{V_r}{2}$$

Full-wave rectifier

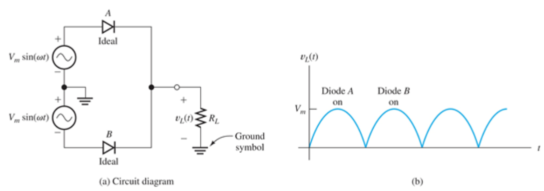


Figure 9.27 Full-wave rectifier.

Full-wave rectifier

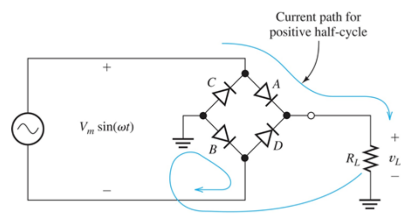


Figure 9.28 Diode-bridge full-wave rectifier.

Peak Inverse Voltage

An important aspect of rectifier circuits is the **peak inverse voltage** (PIV) across the diodes.

Smoothing capacitor:
The capacitance required for a full-wave rectifier is given by:

$$C = \frac{I_L T}{2V_r}$$

Application: Clipper circuits

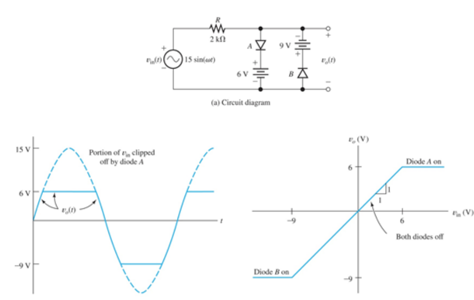
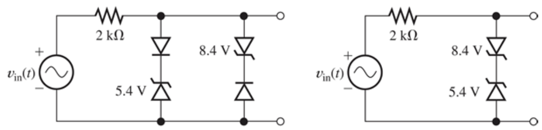


Figure 9.29 Clipper circuit.

Clipper circuits



(a) Circuit of Figure 9.29 with batteries replaced by Zener diodes and allowance made for a 0.6-V forward diode drop

(b) Simpler circuit

Figure 9.30 Circuits with nearly the same performance as the circuit of Figure 9.29.

Exercise 9.15

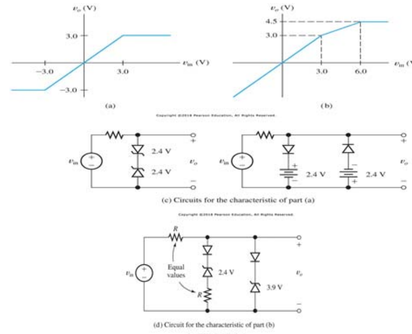


Figure 9.32 See Exercise 9.15.