3.12.2 DEPLETION CAPACITANCE

Depletion capacitance (alias transition, barrier, or space-charge capacitance) has to do with the charge stored in immobile ions in the depletion region. The basic idea was illustrated in Fig. 3.18 for zero, positive, and negative applied voltages. Because the amount of bound charge in the depletion region changes with voltage, it is no surprise that there is a capacitive effect. A straightforward derivation (see the text by Mattson in the references listed at the end of the chapter) shows that the depletion charge, Q_{dep}, varies with diode voltage as in Fig. 3.62a. Depletion capacitance dominates the dynamic behavior of the diode when the junction is reverse biased. While less important than diffusion capacitance for the forward-biased diode, depletion capacitance still contributes to switching delays during transitions between points such as *a* and *b*.

For nonlinear capacitors, a second definition, *small-signal* or *incremental capacitance*, is widely used. Incremental capacitance is *defined at a point* on the Q versus V curve as the slope of the curve at that point; that is,

$$C = \frac{dQ}{dV}$$

This definition prompts us to use the tangent to the curve to estimate the change in stored charge dQ required for a small change dV in voltage. (Figure 3.59 shows that incremental capacitance and "capacitance" are the same for the linear capacitor.) The incremental depletion capacitance of the pn junction is especially interesting and useful. Computing dQ_{dep}/dv_D from the theoretical expression for Fig. 3.62a gives the result