Prob. Set 6 Solutions from Instructor's Manual for Fund. of EE by Bobrow

6.8 Si has 5×10^{28} atoms/m^3. $n_i = 1.5\times10^{16}\ m^{-3}$ $T = 300K$

$\mu_n = 0.13\ m^2/V\text{-}s$ $\mu_p = 0.05\ m^2/V\text{-}s$

For p-type semiconductor:

$$\sigma \approx p\mu_p q \Rightarrow p = \frac{\sigma}{\mu_p q} = \frac{20.8}{(0.05)(1.6\times10^{-19})} = 2.6\times10^{21}\ m^{-3}$$

Also

$$N_A \approx p = \underline{\underline{2.6\times10^{21}\ m^{-3}}} >> n \approx \frac{n_i^2}{N_A} = \frac{(2.5\times10^{19})^2}{2.6\times10^{21}} = 2.4\times10^{17}\ m^{-3}$$

$$N_A = 5\times10^{28}\left(\frac{x}{10^8}\right) = 2.6\times10^{21} \Rightarrow x = \frac{2.6\times10^{21}}{5\times10^{20}} = \underline{\underline{5.2 \text{ parts per } 10^8}}$$

6.16 Find $V_0 = V_T \ln \frac{N_A N_D}{n_i^2}$.

Ge: $\sigma_p = 50\ \mho/m$, $\sigma_n = 100\ \mho/m$

$T = 300\ K$, $n_i = 2.5\times10^{19}\ m^{-3}$

$\mu_p = 0.18\ m^2/V\text{·}s$, $\mu_n = 0.38\ m^2/V\text{·}s$

For p-type semiconductor, $p \approx N_A$

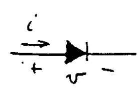
$$\sigma_p \approx p\mu_p q = N_A \mu_p q$$

$$N_A \approx \sigma_p/(\mu_p q) = \frac{50\ \mho/m}{0.18\ m^2/V\text{·}s \times 1.6\times10^{-19}C} = \underline{\underline{1.74\times10^{21}\ m^{-3}}}$$

Similarly, $$N_D \approx \frac{\sigma_n}{\mu_n q} = \frac{100\ \mho/m}{0.38\ m^2/V s\times 1.6\times10^{-19}C} = \underline{\underline{1.64\times10^{21}\ m^{-3}}}$$

$$V_0 = 26\ mV \times \ln \frac{1.74\times10^{21}\times1.64\times10^{21}}{(2.5\times10^{19})^2} = \underline{\underline{0.22V}}$$

6.21 Si diode



$i = 20\ mA$, $v = 0.8\ V$

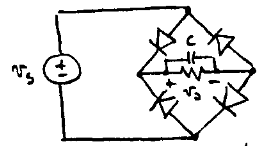
$\eta = 2$ $T = 300\ K$

$i = I_s(e^{v/\eta V_T} - 1)$ $V_T = \frac{T}{11{,}586}$

$$I_s = \frac{i}{e^{v/\eta V_T} - 1}$$

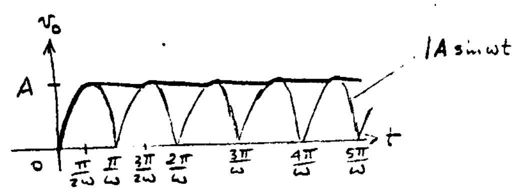
(a) $T = 300K \Rightarrow$ $$I_s = \frac{20m}{e^{0.8/\frac{2(300)}{11{,}586}} - 1} = \underline{\underline{3.91\ nA}}$$

6.73



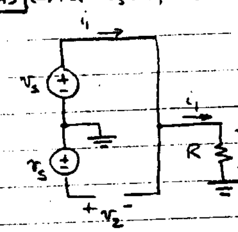
$v_s = A \sin\omega t\, u(t)\ V$

The first time that v_s goes to A volts, the capacitor will charge to $v_o = A$ volts. Since $RC >> T = 2\pi/\omega$, the capacitor will remain charged at approximately A volts as shown below:



6.74 Same solution as Problem 6.73.

6.45 (a) For $v_s > 0$, assume that D_1 ON, D_2 OFF. Then



By KVL, $\underline{v_o = v_s}$

Since $v_s > 0$, then

$i_1 = \frac{v_o}{R} = \frac{v_s}{R} > 0 \Rightarrow D_1$ indeed ON

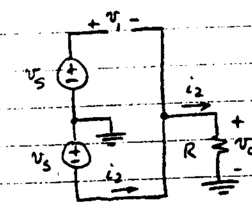
By KVL, $v_2 = -v_s - v_s = -2v_s$

Since $v_s > 0$, then $-v_s < 0$

$\therefore v_2 = -2v_s < 0 \Rightarrow D_2$ indeed OFF

(b)

For $v_s < 0$, assume that D_1 OFF, D_2 ON. Then



By KVL, $\underline{v_o = -v_s}$

Since $v_s < 0$, then $-v_s > 0$

$i_2 = \frac{v_o}{R} = \frac{-v_s}{R} > 0 \Rightarrow D_2$ indeed ON

By KVL, $v_1 = v_s + v_s = 2v_s$

Since $v_s < 0$, then $2v_s < 0$

$\therefore v_1 = 2v_s < 0 \Rightarrow D_1$ indeed OFF

In summary,

$$v_o = \begin{cases} v_s & \text{for } v_s > 0\ V \\ -v_s & \text{for } v_s < 0\ V \end{cases}$$