VE311 Electronic Circuits

Homework 03

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The course homework is intended for the students to learn and to think rather that just copy and paste. This is why, me and my TAs team are confident that you're going to learn.

- Diodes and Rectifiers
  1. A diode is doped with $N_A = 10^{19}$ /cm^3 on the p-type side and $N_D = 10^{18}$/cm^3 on the n-type side. (a) What is the depletion-layer width w_{do} ? (b) What are the values of x_p and x_n? (c) What is the value of the built-in potential of the junction? (d) What is the value of E_{MAX}? Use Eq. (3.3) and Fig. 3.5.
  2. A diode has $w_{do} = 0.4$ μm and $\phi_j = 0.85$ V. (a) What reverse bias is required to triple the depletion-layer width? (b) What is the depletion region width if a reverse bias of 7 V is applied to the diode?
  3. Suppose a drift current density of 5000 A/cm^2 exists in the neutral region on the p-type side of a diode that has a resistivity of 2.5 Ω·cm. What is the electric field needed to support this drift current density?
  4. Suppose that $N_A(x) = N_o \exp(-x/L)$ in a region of silicon extending from x = 0 to x = 12 μm, where N_o is a constant. Assume that $p(x) = N_A(x)$. Assuming that j_p must be zero in thermal equilibrium, show that a built-in electric field must exist and find its value for L = 1 μm and $N_o = 10^{18}$/cm^3
  5. A diode has n=1.05 at T =320 K. What is the value of $n \cdot V_T$? What temperature would give the same value of $n \cdot V_T$ if n=1.00?
  6. A diode has $I_S = 10^{-17}$A and n = 1.07. (a) What is the diode voltage if the diode current is 70 μA? (b) What is the diode voltage if the diode current is 5 μA? (c) What is the diode current for v_D = 0 V? (d) What is the diode current for v_D = -0.075 V? (e) What is the diode current for v_D = -5 V?
  7. The saturation current for diodes with the same part number may vary widely. Suppose it is known that 10^{-14} A $\leq I_S \leq 10^{-12}$ A. What is the range of forward voltages that may be exhibited by the diode if it is biased with i_D=1mA?
  8. A diode with $I_S = 2.5\times10^{-16}$A at 30°C is biased at a current of 1 mA. (a) What is the diode voltage? (b) If the diode voltage temperature coefficient is -2 mV/K, what will be the diode voltage at 50°C?

9. A diode has a doping of $N_D = 10^{20}/\text{cm}^3$ on the n-type side and $N_A = 10^{18}/\text{cm}^3$ on the p-type side. What are the values of w_{do} and ϕ_j? What is the value of w_d at a reverse bias of 5 V? At 25 V?

10. (a) Plot the load line and find the Q-point for the diode circuit in Fig.P3.57 if V =10 V and R = 5 kΩ . Use the $i - v$ characteristic in Fig. P3.42. (b) Repeat for V = -10 V and R = 5 kΩ . (c) Repeat for V = -2 V and R = 2 kΩ

11. Use the $i - v$ characteristic in Fig.1a. (a) Plot the load line and find the Q-point for the diode circuit in Fig. 1 if V = 6V and R = 4kΩ. (b) For V = -6 V and R = 3 kΩ.(c) For V = -3 V and R = 3 kΩ. (d) For V = 12 V and R = 8 kΩ. (e) For V = -25 V and R = 10kΩ

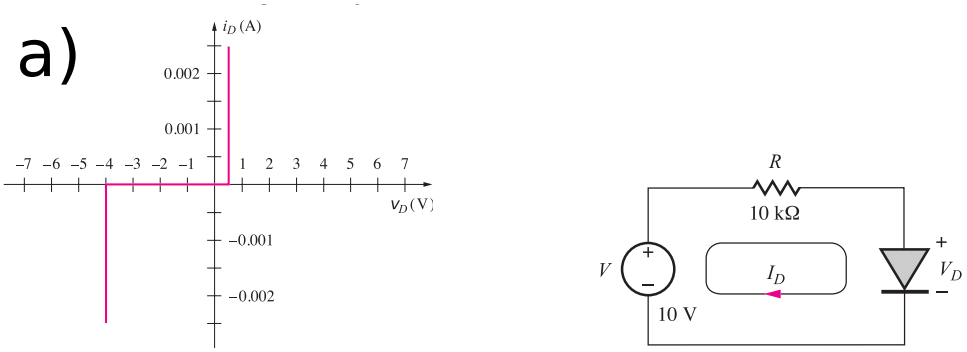

Figure 1: $i - v$ diode characteristics and schematic diagram for the diode...

12. Simulate the behavior of the half-wave rectifier in Fig.2 for $v_I = 10 \sin 120\pi t$, R = 0.025 Ω and C = 0.5 F. (Use $I_S = 10^{-10}$ A, R_S=0 and RELTOL = 10^{-6}.) Compare the simulated values of dc output voltage, ripple voltage, and peak diode current to hand calculations. Repeat simulation with R_S =0.02Ω.

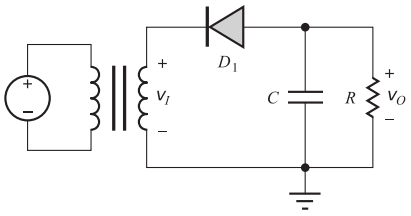

Figure 2: Half-wave rectifier

13. What are the dc output voltages V_1 and V_2 for the rectifier circuit in Fig. 3 if $v_I = 40 \sin 377t$ and C = 20 000 μF?

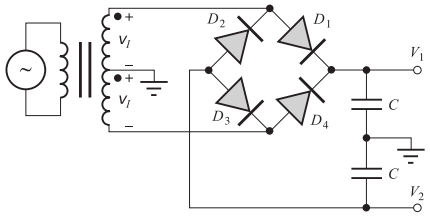

Figure 3: Full-wave rectifier