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Assignment 3 – Diode Applications

Question 1:

(a) Thermal voltage VT at 25°C

The thermal voltage is calculated by the formula:

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

where

- $k = 1.38 \times 10^{-23}$ J/K(Boltzmann constant)
- $q = 1.6 \times 10^{-19}$ C(electron charge)
- T is the temperature in Kelvin

Step 1: Convert temperature to Kelvin

$$T = 25 + 273 = 298\,K$$

Step 2: Substitute values

$$V_T = \frac{1.38 \times 10^{-23} \times 298}{1.6 \times 10^{-19}}$$
$$V_T \approx 0.0257\,V$$

(b) Diode current ID

Given:

- $I_S = 40\,nA$
- $n = 2$
- $V_D = 0.5\,V$

The diode current equation is:

$$I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

Step 1: Calculate nV_T

$$nV_T = 2 \times 0.0257 = 0.0514\,V$$

Step 2: Calculate the exponent

$$\frac{V_D}{nV_T} = \frac{0.5}{0.0514} \approx 9.73$$

Step 3: Calculate the current

$$I_D = 40 \times 10^{-9}(e^{9.73} - 1)$$
$$I_D \approx 6.70 \times 10^{-4}\, A$$

Question 2: Chapter 2 – Problem 4 (Boylestad)

- Supply voltage $E = 30\, V$

- Resistor $R = 1.5\, k\Omega$

- Silicon diode

(a) Approximate diode model

For a silicon diode, the forward voltage is assumed to be:

$$V_D \approx 0.7\, V$$

Step 1: Apply KVL

$$E = V_D + V_R$$
$$V_R = 30 - 0.7 = 29.3\, V$$

Step 2: Calculate diode current

$$I_D = \frac{V_R}{R} = \frac{29.3}{1500}$$
$$I_D \approx 19.53\, mA$$

(b) Ideal diode model

For an ideal diode, the forward voltage drop is:

$$V_D = 0\, V$$

Step 1: Voltage across resistor

$$V_R = 30\, V$$

Step 2: Diode current

$$I_D = \frac{30}{1500} = 20\,mA$$

(c) Comparison

The current using the approximate model is 19.53 mA,
and using the ideal model is 20 mA.

The difference is small (about 2.35%), so the ideal model gives a reasonable result when the supply voltage is much larger than the diode voltage drop.

Question 3: Chapter 2 – Problem 5 (Boylestad)

Assume silicon diodes with forward voltage:

$$V_D \approx 0.7\,V$$

(a)

The diode is reverse biased, so it does not conduct.

I = 0

(b)

Both diodes are forward biased and conduct.

Step 1: Voltage after diode

$$V = -20 + 0.7 = -19.3\,V$$

Step 2: Current through each resistor

For 10Ω:

$$I_{10} = \frac{0 - (-19.3)}{10} = 1.93\,A$$

For 20Ω:

$$I_{20} = \frac{0 - (-19.3)}{20} = 0.965\,A$$

Step 3: Total current

$$I = I_{10} + I_{20} = 2.895\,A$$

(c)

The middle branch has two opposite diodes, so no current flows in that branch.

Only the 10Ωresistor conducts.

$$I = \frac{10}{10} = 1\,A$$

Question 4: Chapter 2 – Problem 11 (Boylestad)

(a)

Step 1: Output voltage

$$V_o = 1 - 0.7 = 0.3\,V$$

Step 2: Current

$$I = \frac{0.3}{1000} = 0.3\,mA$$

(b)

Step 1: Total supply voltage

$$V = 16 - (-4) = 20\,V$$

Step 2: Voltage across resistor

$$V_R = 20 - 1.4 = 18.6\,V$$

Step 3: Current

$$I = \frac{18.6}{4700} \approx 3.96\,mA$$

Step 4: Output voltage

$$V_o = -4 + 18.6 = 14.6\,V$$