

Assignment #4

2-1. A Silicon diode has a reverse saturation current of 0.1 nA and an empirical scaling constant, $\eta = 2$. Assume operation at room temperature.

- At what diode voltage will the reverse current attain 99% of the saturation value?
- At what diode voltage will the forward current attain the same magnitude?
- Calculate the forward currents at diode voltages of 0.5V to 0.8 V in 0.1V increments.

Solution:

#2-1

$$I_s := 0.1 \cdot 10^{-9} \quad \eta := 2 \quad V_t := 0.026$$

(a) $I := -0.99 I_s$

Solve for the diode voltage, V, for I using solve block.

Guess

$$V := 0.1$$

Given

$$I = I_s \cdot \left(e^{\frac{V}{\eta \cdot V_t}} - 1 \right)$$

$$\text{Find}(V) = -0.239$$

The diode voltage required for $I = -0.99 I_s$ is $V = -0.239$ V.

(b) $I := 0.99 I_s$

Solve for the diode voltage, V, for I using solve block.

Guess

$$V := 0.05$$

Given

$$I = I_s \cdot \left(e^{\frac{V}{\eta \cdot V_t}} - 1 \right)$$

$$\text{Find}(V) = 0.036$$

The diode voltage required for $I = 0.99 I_s$ is $V = 0.036$ V.

(c) $i := 0..3$

$$V_i := 0.5 + 0.1 \cdot i$$

$$I_i := I_s \cdot \left(e^{\frac{V_i}{\eta \cdot V_t}} - 1 \right)$$

$$I_i =$$

The diode currents are:

V	I
0.5 V	1.5 μ A
0.6 V	10.3 μ A
0.7 V	70.2 μ A
0.8 V	480.2 μ A

2-10. Let the reverse saturation current of a diode equal 15 nA and $\eta V_t = 25.6$ mV.

If $I_D = 5$ mA, find

- a) V_d ,
- b) V_d/I_D ,
- c) r_d .

If I_D varies over the range $4.8 \text{ mA} \leq I_D \leq 5.2 \text{ mA}$, what is the range of

- d) V_d and
- e) r_d ?

Solution: MathCAD

#2-10

$$I_s := 15 \cdot 10^{-9} \quad \eta V_t := .0256$$

Let $I_D := 0.005$

(a) $V_d := \eta V_t \ln \left[\left(\frac{I_D}{I_s} \right) + 1 \right]$ **So the diode voltage is: $V_d = \blacksquare$**

(b) $\frac{V_d}{I_D} = \blacksquare$ **$V_d/I_D = 65.111 \Omega$**

(c) **The dynamic resistance is: 65.111Ω**

I_D varies between $4.8 \text{ mA} \leq I_D \leq 5.2 \text{ mA}$

(d) $I_D := 0.0048, 0.005, 0.0052$

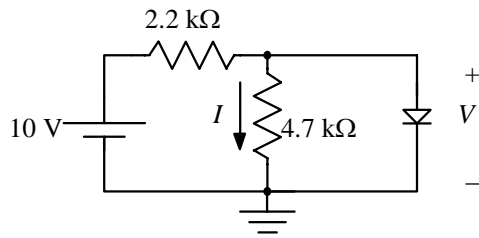
$$V_d(I_D) := \eta V_t \ln \left[\left(\frac{I_D}{I_s} \right) + 1 \right] \quad V_d(I_D) = \blacksquare$$

Therefore the range is $0.325 \text{ V} \leq V_d \leq 0.327 \text{ V}$

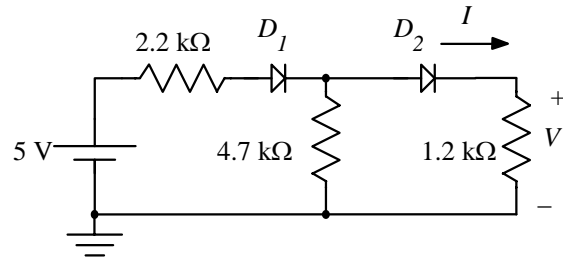
(e) $\frac{V_d(I_D)}{I_D} = \blacksquare$

The Dynamic resistance r_d varies from $62.80 \Omega \leq r_d \leq 67.61 \Omega$

2-14. Find the values of I and V for the circuits shown below. Assume that the diodes are ideal.



(a)



(b)

Solution:

Because the diodes are ideal, the characteristics are: short ckt when $V_d=0$ and open ckt when $V_d < 0$.

(a) The anode of the diode will not be negative since a positive voltage source is used.

Therefore, the ideal diode acts as a short ckt causing the diode voltage $V = 0V$ and $I = 0A$.

(b) Similarly, the voltage of the anodes of diodes D_1 and D_2 are never negative. Therefore, they can be treated as short ckts. By ckt theory,

$$V = 5 \frac{1.2k \parallel 4.7k}{1.2k \parallel 4.7k + 2.2k} = \mathbf{1.52V} \quad \text{and} \quad \mathbf{I = 1.52/1200 = 1.26mA.}$$