Design & Simulate 6 Ex1.9

ECE2204 CRN:82929

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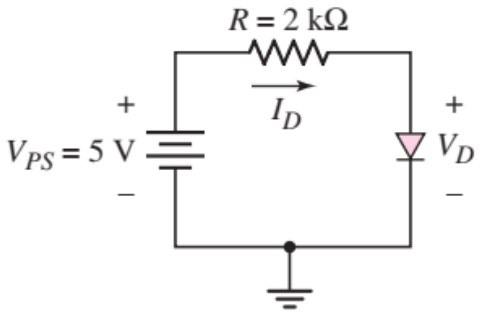
Problem 6.9.a.1:

Design

Assume that in the pictured circuit that the diode is actually two identical diodes in series D_1 and D_2 with D_1 being closest to the resistor. Determine the mode, diode voltage V_{D1}, V_{D2}, current I_{D1}, I_{D2}, and power dissipated by the diode P_{D1}, P_{D2} in the circuit below. When determining the mode, assume all diodes are off. Assume piecewise linear diode parameters for both diodes are $V_\gamma = 0.6V$ and $r_f = 10\Omega$.



$$V_{D1} = V_{PS} = 5V \implies V_{D1} > V_\gamma \implies \text{Diode 1 is on.} \tag{1}$$

$$V_{D2} = V_{D1} - V_\gamma = 4.4V \implies V_{D2} > V_\gamma \implies \text{Diode 2 is on.} \tag{2}$$

$$I_{D1} = I_{D2} = I_D = \frac{V_{PS} - V_{\Sigma\gamma}}{R + r_{\Sigma f}} = \frac{5V - (0.6V + 0.6V)}{2k\Omega + (10\Omega + 10\Omega)} = 1.881mA \tag{3}$$

$$V_D = V_\gamma + I_D r_f \tag{4}$$

$$V_{D1} = V_{D2} = V_\gamma + I_D r_f = 0.6V + 1.881mA \times 10\Omega = 0.619V \tag{5}$$

$$V_{\Sigma D} = V_{D1} + V_{D2} = 2 \times 0.619V = 1.238V \tag{6}$$

$$P_D = I_D \times V_D \tag{7}$$

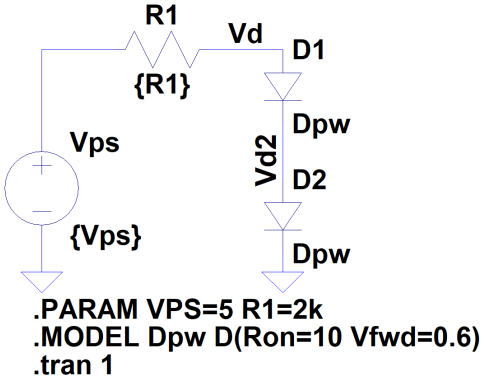
$$P_{D1} = P_{D2} = 1.881mA \times 0.619V = 1.164mW \tag{8}$$

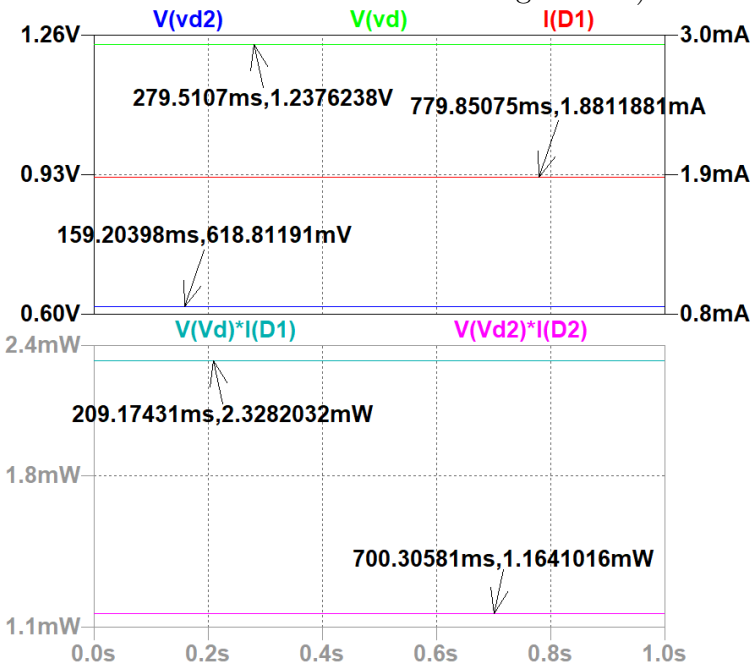
$$P_{\Sigma D} = I_D \times V_{\Sigma D} = 1.881mA \times 1.238V = 2.329mW \tag{9}$$

The voltage, current, and power are the same for Diodes 1 and 2. They are $V_D = 0.619V$, $I_D = 1.881mA$, and $P_D = 1.164mW$. The voltage, current, and power for the diode series are as follows. $V_{\Sigma D} = 1.238V$, $I_{\Sigma D} = I_D = 1.881mA$, and $P_{\Sigma D} = 2.329mW$.

Validation

LTSpice Implementation (accurate with $< 1\%$ deviation from design result)





$$Err_{VD} = \frac{|619-618|}{619} = 0.0016 = 0.16\% \qquad Err_{ID} = \frac{|1.881-1.881|}{1.881} = 0.00 = 0.00\%$$

$$Err_{PD} = \frac{|1.164-1.164|}{1.164} = 0.00 = 0.00\% \qquad Err_{V\Sigma D} = \frac{|1.238-1.237|}{1.238} = 0.0008 = 0.08\%$$

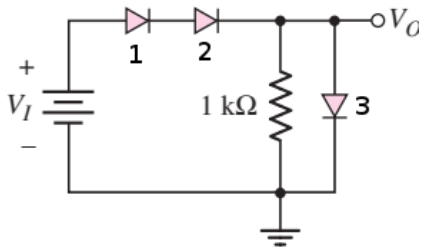
$$Err_{P\Sigma D} = \frac{|2.329-2.328|}{2.329} = 0.0004 = 0.04\% \qquad Err_{Avg} = \frac{0.0016+0+0+0.0008+0.0004}{5} = 0.056\%$$

Problem 6.9.b.1:

Derived by merging the problem 1.44 and the circuit for 1.42 and changing the values.

Design

Consider the circuit shown below. Determine the diode currents I_{D1-D3} and voltages V_{D1-D3}. The following are the piecewise linear diode parameters for these diodes. $V_\gamma = 0.7V$ and $r_f = 6\Omega$. Assume $V_1 = V_{PS} = 10V$.



$$V_{D3} = V_R \implies V_{PS} = V_{D1} + V_{D2} + V_{D3} = V_{D1} + V_{D2} + V_R \tag{10}$$

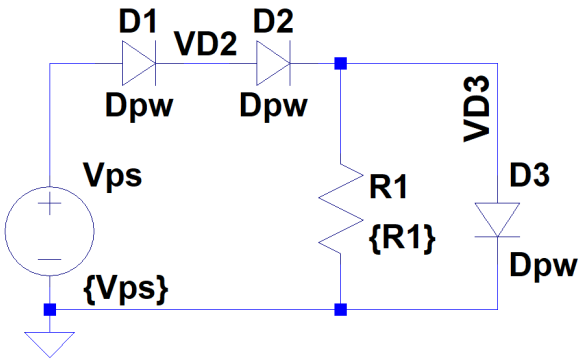
$$I_{D1} = I_{D2} = I_{D3} = \frac{V_{PS} - 3\times V_\gamma}{R + 3\times r_f} = \frac{10V - 3\times 0.7V}{0 + 3\times 6\Omega} = 438.9mA \tag{11}$$

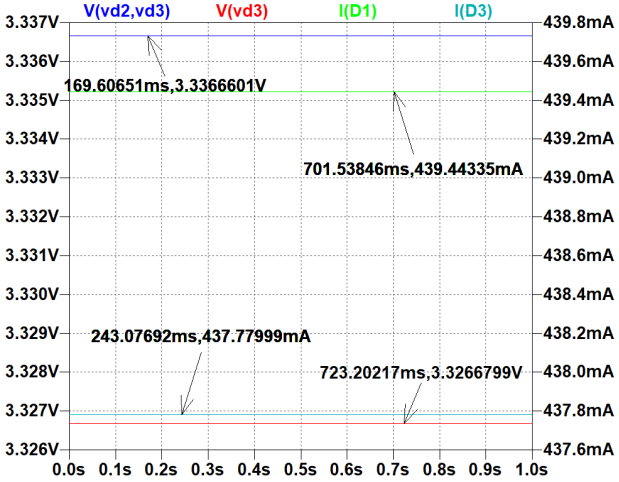
$$V_D = V_\gamma + I_D r_f \tag{12}$$

$$V_{D1} = V_{D2} = V_{D3} = V_\gamma + I_{D1} r_f = 0.7V + 438.9mA \times 6\Omega = 3.333V \tag{13}$$

Validation

LTSpice Implementation (accurate with $< 1\%$ deviation from design result)





$$Err_{VD1\&VD2} = \frac{|3.333-3.336|}{3.333} = 0.0009 = 0.09\% \qquad Err_{VD3} = \frac{|3.333-3.326|}{3.333} = 0.002 = 0.20\%$$

$$Err_{IDI\&ID2} = \frac{|438.9-439.4|}{438.9} = 0.0011 = 0.11\% \qquad Err_{ID3} = \frac{|438.9-438.7|}{438.9} = 0.0004 = 0.04\%$$

$$Err_{Avg} = \frac{0.09+0.20+0.11+0.04}{4} = 0.11\%$$

This assignment demonstrates a basic understanding of approximating diode circuits using piecewise linear analysis.

I have neither given nor received unauthorized assistance on this assignment.