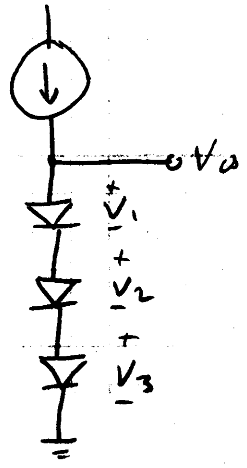
EE 321

Fall 2002

Homework #5

Solutions

3.22



$n = 1 \quad I_S = 10^{-14} A$

Want $V_O = 2V$. Because the diodes are identical, $V_1 = V_2 = V_3 = V_O/3$

$I_1 = I_S e^{\left(\frac{V_1}{nV_T}\right)} = 10^{-14} e^{\left(\frac{2/3 V}{1 \times 25 mV}\right)}$

$\boxed{I = 3.8 mA}$

If 1 mA drawn away by a load,

$I = 3.8mA - 1mA = 2.8mA$

$V = 3V_1 = 3 nV_T \ln(I/I_S) = 1.977V$

$\boxed{\Delta V = 2.000 V - 1.977V = 23.1 mV}$

Note: I used $V_T = 25 mV$. You will get slightly different answers if you use a different value for V_T.

3.24

$V_1 = 0.650 V, \quad I_1 = 0.2 mA$

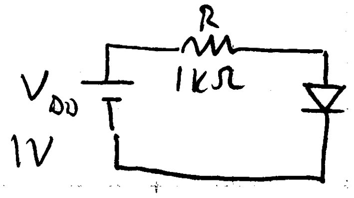
$V_2 = 0.750V, \quad I_2 = 10mA$

$$\frac{I_1}{I_2} = \frac{I_S e^{V_1/nV_T}}{I_S e^{V_2/nV_T}} = e^{(V_1 - V_2)/nV_T}$$

$$\frac{V_1 - V_2}{nV_T} = \ln \frac{I_1}{I_2} \Rightarrow n = \frac{V_1 - V_2}{V_T \ln(I_1/I_2)} = 1.0225$$

$$I_S = I_1 e^{-V_1/nV_T} = 1.81 \times 10^{-15} A$$

3.48



$I_S = 10^{-15}A$ $\quad V_T = 25mV$

$n = 1$

Assume $V_{D_1} = 0.7V$

$$I_{D2} = \frac{V_R}{R} = \frac{V_{DD} - V_{D_1}}{R} = 0.300\,mA$$

$$V_{D2} = nV_T \ln(I_{D2}/I_s) = 0.6607V$$

$$I_{D3} = \frac{V_{DD} - V_{D2}}{R} = 0.339\,mA$$

$$V_{D3} = nV_T \ln(I_{D3}/I_s) = 0.6638V$$

$$I_{D4} = \frac{V_{DD} - V_{D3}}{R} = 0.336\,mA$$

$$V_{D4} = nV_T \ln(I_{D4}/I_s) = 0.6635V$$

$$I_{D5} = \frac{V_{DD} - V_{D4}}{R} = 0.336\,mA$$

$$V_{D5} = nV_T \ln(I_{D5}/I_s) = 0.6635V$$

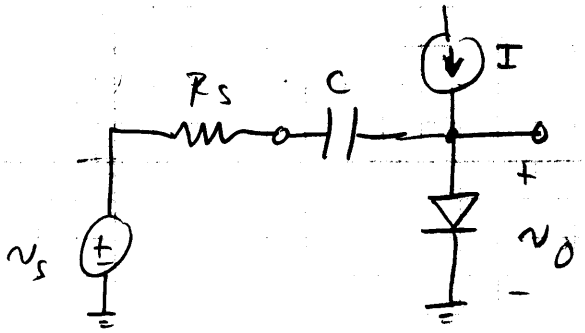
$\boxed{V_D = 0.6635V}$ $\quad\boxed{I_D = 0.336\,mA}$

or

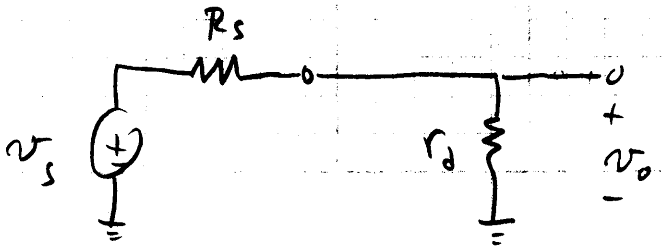
$$V_D = V_{DD} - nV_T\, W\left(\frac{I_s R e^{(V_{DD}/nV_T)}}{nV_T}\right)$$

$= 0.6635V$ (from MATLAB)

3.70



Small-signal model: C is a short, I is an open,
Diode is a resistor ($r_d = \frac{nV_T}{I}$)



$$v_o = \frac{r_d}{r_d + R_s} v_s = \frac{\frac{nV_T}{I}}{\frac{nV_T}{I} + R_s} v_s = \frac{nV_T}{nV_T + IR_s} v_s$$

Let $v_s = 10\,mV$, $R_s = 1k\Omega$, $n = 2$, $V_T = 25\,mV$

I	v_o
1 mA	0.476 mV
0.1 mA	3.333 mV
1 μA	9.804 mV

$$\frac{v_o}{v_s} = \frac{nV_T}{nV_T + IR_s} \Rightarrow I = \frac{\frac{nV_T}{(v_o/v_s)} - nV_T}{R_s}$$

For $\frac{v_o}{v_s} = \frac{1}{2}$, $I = \frac{nV_T}{R_s} = 50\,\mu V$

3.77

$V_Z = V_{Z0} + r_Z I_Z$ (eqn 3.56)

$V_{Z0} = V_{ZT} - r_Z I_{ZT} = 9.1\,V - (5\,\Omega)(28\,mA) =$

$V_Z = V_{Z0} + r_Z I_Z = 8.96\,V$

I_Z	V_Z
10 mA	9.01 V
100 mA	9.46 V