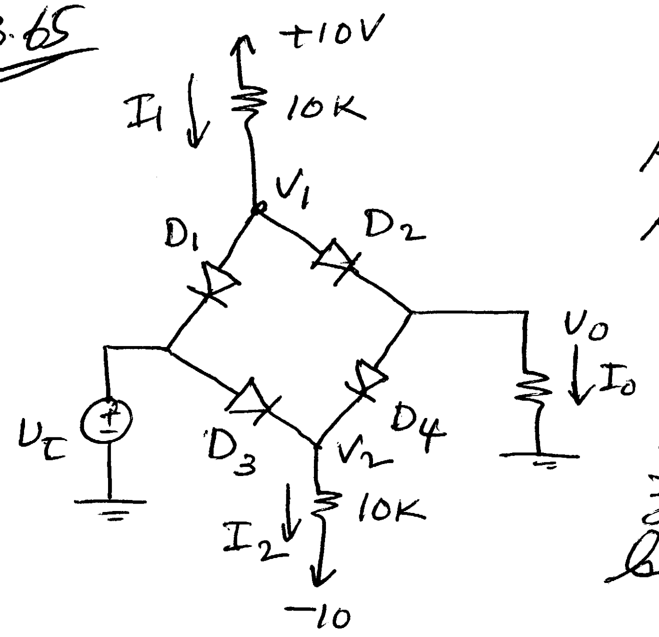
Assignment #2

EE 341

3.65



Consider first $v_I > 0$

Assume $v_i \leq 4.65\,V$

All the diodes will conduct.

$V_1 = v_i + 0.7$

$V_o = V_1 - 0.7 = V_o$

Note: as v_i increases from zero, I_1 will decrease but both I_o & I_2 will increase.

when $v_i = 4.65\,V$, $V_1 = 4.65 + 0.7 = 5.35\,V$

$\therefore I_1 = \frac{10 - 5.35}{10K} = 0.465\,mA$

Since $V_o = V_i$ $I_o = \frac{4.65}{10K} = 0.465\,mA$

Thus all the current I_1 will be diverted toward the output. Beyond that D_1 & D_4 will turn off. & v_o will remain fixed at 4.65V.

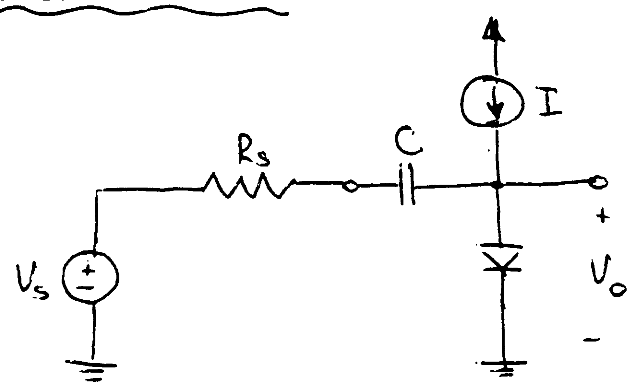
Since the circuit is symmetrical, the same argument can be used to show that when $v_i < 0$ $v_o = v_i$ as long as $v_i > -4.65\,V$. If $v_i < -4.65$, D_2 & D_3 will be off & v_o will remain fixed as $-4.65\,V$

3.77 $V_Z = V_{Z0} + I_Z r_Z \;\therefore\; V_{Z0} = V_Z - r_Z I_Z = 9.1 - 0.005 \times 28 = 8.96$

$V_Z(I_Z = 10\,mA) = V_{Z0} + I_Z r_Z = 9.01$ ✓

$V_Z(I_Z = 100\,mA) = V_{Z0} + I_Z r_Z = 9.46\,V$

Problem P 3.70



Small signal model requires that @ the operating point $I - V_D$, where diode is conducting,

$$V_S \ll V_D, \quad V_S \ll nV_T,$$

a small change in a signal V_S gives rise to a change in V_o

Let $V_o = \tilde{V}_{o(const\, I)} + V_o'(signal)$

Using the voltage-divider rule for a small signal

$$\frac{V_o'}{V_S} = \frac{r_D}{R + r_D} \qquad r_D = \frac{nV_T}{I}. \qquad \text{Substituting, } \frac{V_o'}{V_S} = \frac{\frac{nV_T}{I}}{R + \frac{nV_T}{I}}$$

It follows that $V_o' = V_S \cdot \dfrac{nV_T}{RI + nV_T}$

Now $R_S = 1k\Omega$, $n = 2$, $V_S = 10\,mV$

a) $I = 1mA$ $\qquad V_o' = 10mV \dfrac{2 \cdot 0.025V}{1k\Omega \cdot 1mA + 2 \cdot 0.025V} = 0.0476 \cdot 10mV = \underline{\underline{0.476\,mV}}$

b) $I = 0.1mA$ $\qquad V_o' = 10mV \dfrac{2 \cdot 0.025V}{1k\Omega \cdot 0.1mA + 2 \cdot 0.025V} = 0.333 \cdot 10mV = \underline{\underline{3.33\,mV}}$

c) $I = 1\mu A$ $\qquad V_o' = 10mV \dfrac{2 \cdot 0.025V}{1k\Omega \cdot 0.001mA + 2 \cdot 0.025V} = 0.98 \cdot 10mV = \underline{\underline{9.8\,mV}}$

Even for the case c) $V_o' = 9.8\,mV \ll nV_T = 50\,mV$, but it's close to the limit where a small-signal model is valid.

$$V_o' = \frac{1}{2}V_S \Rightarrow \left(RI + nV_T\right)\frac{1}{2} = nV_T \Rightarrow RI = nV_T \Rightarrow I = \frac{nV_T}{R}$$

$$I = \frac{2 \cdot 0.025V}{1k\Omega} = \underline{\underline{0.05\,mA}}$$