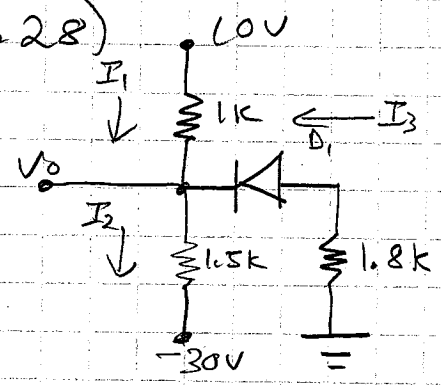
Anthony Mancuso
ECE 321
HW-2
30-Aug-2012

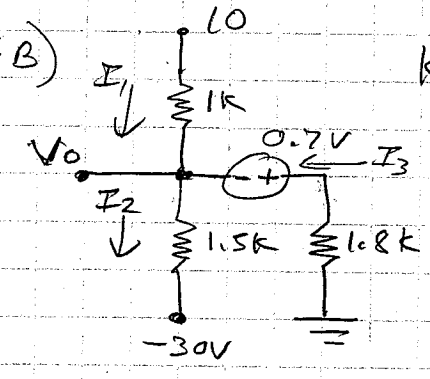
(1.28)



$V_\gamma = 0.7V$

Suppose D_1 is forward biased:

(FB)



KCL: $-\left(\frac{10-V_o}{1k}\right) + \frac{V_o-(-30)}{1.5k} - \left(\frac{0-(V_o+0.7)}{1.8k}\right) = 0$

$$\frac{V_o-10}{1k} + \frac{V_o+30}{1.5k} + \frac{V_o+0.7}{1.8k} = 0$$

$$9V_o - 90 + 6V_o + 180 + 5V_o + 3.5 = 0$$

$$20V_o = -93.5 \Rightarrow V_o = -4.675V$$

$$I_3 = \frac{0-(-4.675+0.7)}{1.8k} = 2.21mA$$

I_3 is positive $\therefore$ D_1 is forward biased

$$V_o = \boxed{-4.675V}$$

$$I_1 = \frac{10-(-4.675)}{1k} = \boxed{14.675mA}$$

$$I_2 = \frac{-4.675-(-30)}{1.5k} = \boxed{16.883mA}$$

$$I_3 = \boxed{2.21mA}$$

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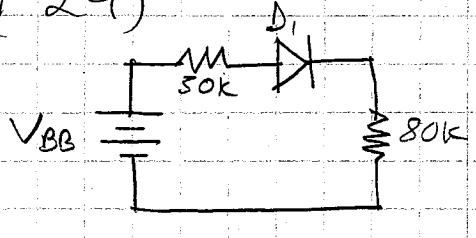
(1-29)



$I_S = 10nA$

(a) $V_{BB} = 1V$. Suppose D_1 is forward biased:

KVL: $-1V + 50k I_D + V_{D1} + 80k I_D = 0$

$$(130k) I_D + 26mV \ln\left(\frac{I_D}{10nA} + 1\right) = 1$$

$$I_D = \boxed{6.3997\mu A}$$

$$V_D = 26mV \ln\left(\frac{6.3997\mu A}{10nA} + 1\right)$$

$$V_D = \boxed{168mV}$$

(b) $V_{BB} = 10V$. Suppose D_1 is forward-biased:

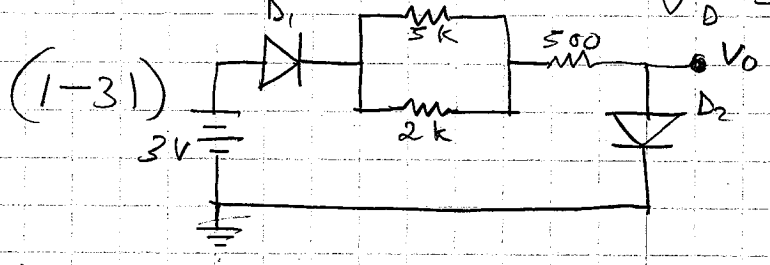
KVL: $(130k) I_D + 26mV \ln\left(\frac{I_D}{10nA} + 1\right) = 10$

$$I_D = \boxed{75.14\mu A}$$

$$V_D = 26mV \ln\left(\frac{75.14\mu A}{10nA} + 1\right)$$

$$V_D = \boxed{232mV}$$

(1-31)



$I_{SD1} = 1nA$

$I_{SD2} = 4nA$

$I_{D1} = I_{D2} = I_D$

Assume D_1 and D_2 are forward biased:

KVL: $-3V + V_{D1} + (5k//2k) I_D + 500 I_D + V_{D2} = 0$

$$26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 5k//2k\, I_D + 500 I_D + 26mV\left(\frac{I_D}{4nA} + 1\right) = 3 \Rightarrow I_D = \boxed{1.197mA}$$

$\therefore$ D_1 and D_2 are forward-biased

$$V_{D2} = 26mV \ln\left(\frac{1.197mA}{4nA} + 1\right) = 328mV$$

$$V_o = V_{D2} = \boxed{328mV}$$

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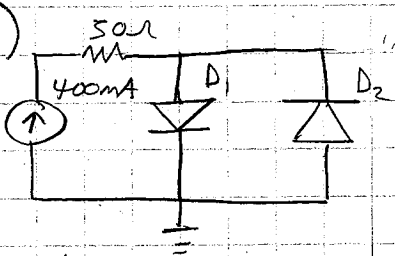
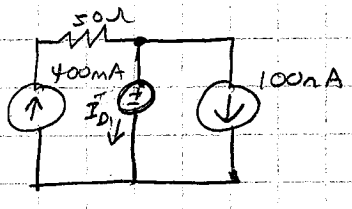
(1.32)



$I_{SD1} = 175nA$
$I_{SD2} = 100nA$

Assume D_1 forward biased and D_2 reverse biased



KCL: $-400mA + I_{D1} + 100nA = 0$

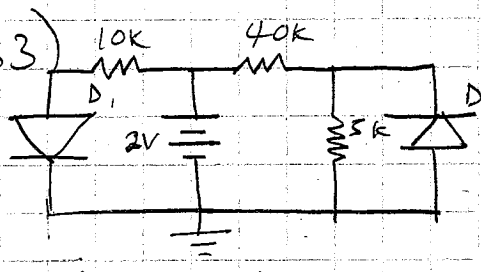
$I_{D1} = 400mA - 100nA \approx 400mA$

$I_{D1} \approx 400mA = 175nA\left(e^{\frac{V_D}{26mV}} - 1\right)$

$V_{D1} = 26mV \ln\left(\frac{400mA}{175nA} + 1\right) = \boxed{381mV} = V_c$

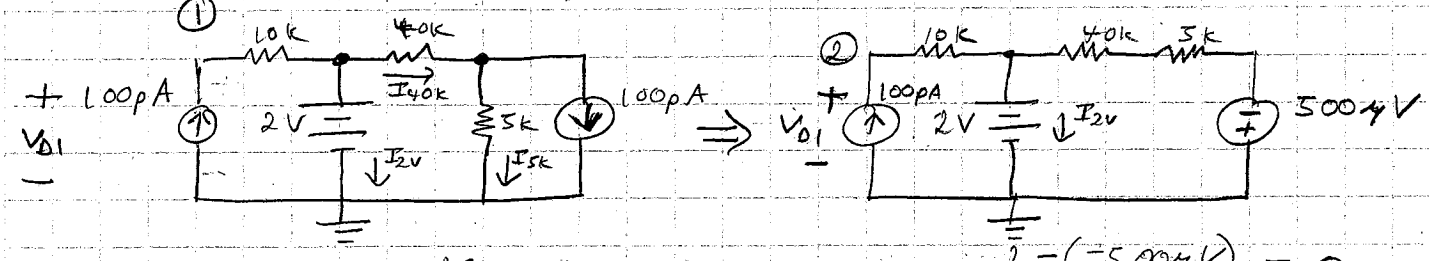
∴ Biasing assumption is correct
D_1 is forward biased, D_2 is reverse-biased

(1.33)



$I_{SD1} = I_{SD2} = 100pA$

Assume D_1 reverse biased and D_2 reverse biased.



KCL ②: $-100pA + I_{2V} + \frac{2 - (-500\mu V)}{45k} = 0$

$I_{2V} = 100pA + 44.44\mu A = 44.4\ \mu A$

$I_{40K} = 44.44\mu A$

KCL ①: $-44.45\mu A + I_{5K} + 100pA = 0 \Rightarrow I_{5K} = \boxed{44.44\mu A}$

$I_{D1} = -I_{SD1} = 100pA$ (reverse current), $V_{D1} = 2V - (100pA)(10K)$

$V_{D1} = 2.000001V$
$= 2V$ (continued next page)

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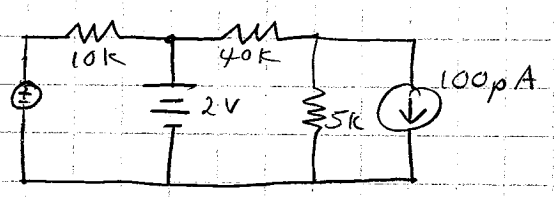
(1.33) (continued)

$V_{D1} = 2V$

$\therefore$ D_1 is not reverse biased

Let D_1 be forward biased and D_2 reverse-biased



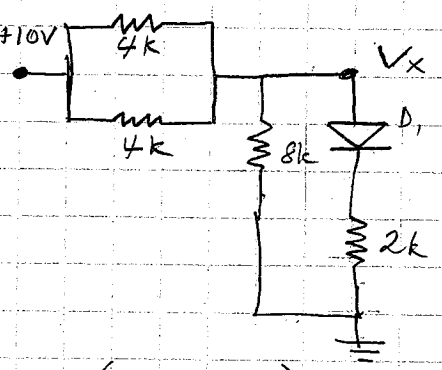
KVL: $-2 + I_{D1}(10k) + 26mV \ln\left(\frac{I_D}{100\mu A} + 1\right) = 0$

$I_{D1} = \boxed{162.8\,\mu A}$

$V_{D1} = \boxed{371.88\,mV}$ $\therefore$ D_1 is forward-biased and D_2 is reverse-biased.

$I_{5k} \approx \boxed{44.44\,\mu A}$

(1.34)



$I_S = 1nA$

Assume D_1 is forward biased

KCL: $-\left(\frac{10 - V_x}{2k}\right) + \frac{V_x}{8k} + I_D = 0$

$V_x = V_{D1} + 2k\,I_D = 26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 2k\,I_D$

$$\frac{-10 + 26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 2k\,I_D}{2k} + \frac{26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 2k\,I_D}{8k} + I_D = 0$$

$$-40 + (4)26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 8k\,I_D + 26mV \ln\left(\frac{I_D}{1nA} + 1\right) + 2k + 8k\,I_D = 0$$

$I_D = \boxed{2.12\,mA}$

$V_D = 26mV \ln\left(\frac{2.12mA}{1nA} + 1\right) = \boxed{371.9\,mV}$

$\therefore$ D_1 is forward-biased.

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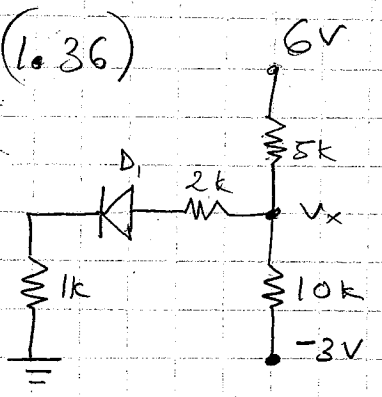

$I_s = 2\mu A$

Assume D_1 is forward-biased

$$\frac{-(6-V_x)}{5k} + I_{D1} + \frac{V_x-(-3)}{10k} = 0$$

$$V_x = 3k I_{D1} + V_{D1} = 3k I_D + 26mV \ln\left(\frac{I_D}{2\mu A}+1\right)$$

$$-12 + 2V_x + 10k I_{D1} + V_x + 3 = 0$$

$$-12 + 2\left[3k I_D + 26mV \ln\left(\frac{I_D}{2\mu A}+1\right)\right] + 10k I_{D1} + 3k I_{D1} + 26mV \ln\left(\frac{I_D}{2\mu A}+1\right) = 0$$

$$19k I_D + 78mV \ln\left(\frac{I_D}{2\mu A}+1\right) = 9$$

$$I_{D1} = \boxed{451.4\mu A}$$

$$V_{D1} = 26mV \ln\left(\frac{451.4\mu A}{2\mu A}+1\right) = \boxed{141.02mV}$$

$\therefore$ D_1 is Forward-biased