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① Problem 3.1'

From the graph below

when $i_D = 10\,mA$, $V_D = 0.8V$

when $i_D = 1\,mA$, $V_D = 0.7V$

$$Slop = \frac{10-1}{0.8-0.7} = 90\ mA/V$$

$$r_D = \frac{1}{slope} = \frac{1}{90\times10^{-3}} = 11.11\,\Omega$$

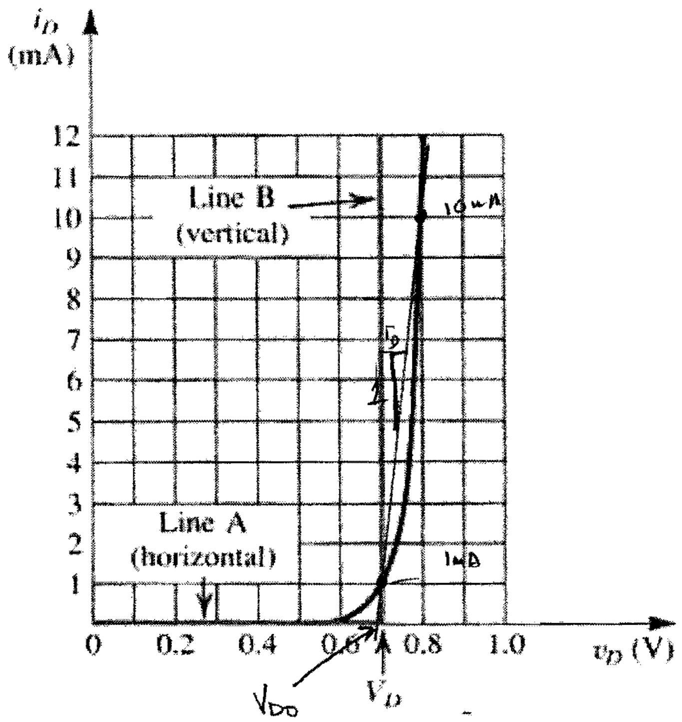
$$i_D = \frac{V_D - V_{DD}}{r_D} \Rightarrow V_{DD} = V_D - r_D \cdot i_D$$

$$V_{DD} = 0.8 - (11.11)(10\times10^{-3}) = 0.6889\,V$$

$v_D = V_{D0} + i_D r_D$

$\Rightarrow V_{D0} = v_D - i_D r_D$

✓ close to plot



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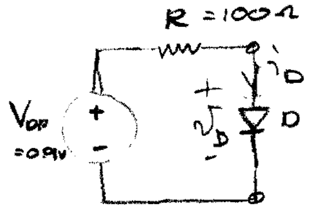
② Problem 3.2'

From Fig.1 on Lecture 3 note, draw the load line corresponding to an external circuit consisting of a 0.9V Voltage Source and a 100Ω Resistor. Calculate the diode Voltage and the loop current, Using

ⓐ the actual diode characteristics

Finding the intersection between the lode line and the exponential curve.



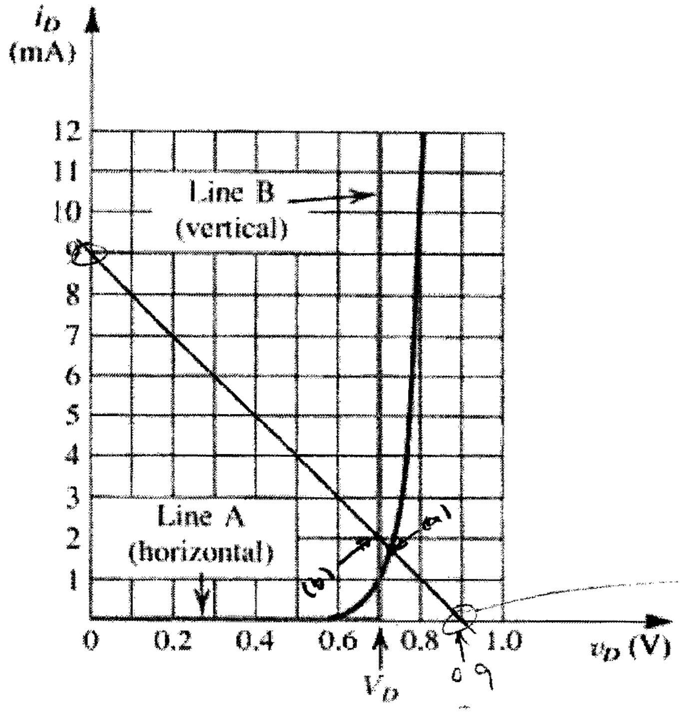
KVL:
$V_{DD} = i_D R + v_D$

$$Slope = \frac{1}{100\Omega}, \quad \text{load line}: i_D = v_D\left(\frac{1}{R}\right) + \frac{V_{DD}}{R}, \quad i_D\big|_{(v_D=0)} = \frac{V_{DD}}{R} = \frac{0.9}{100} = 9\,mA$$

$V_D \approx 0.73$ $\quad$ $I_D \approx 1.7\,mA$

ⓑ the two-segment model shown

Finding the intersection between the load line and Vertical line



$V_D \approx 0.7\,V$

$i_D = 2.0\,mA$

$V_{DD} = i_D R + v_D$

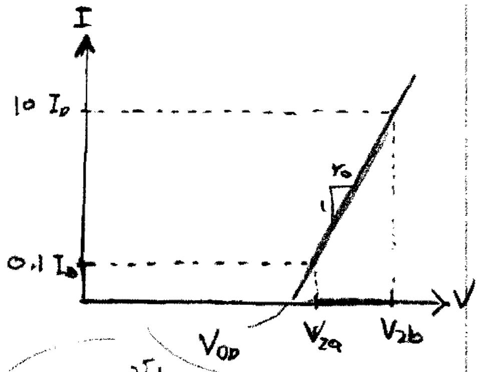
When $i_D = 0 \Rightarrow$

$v_D = V_{DD} = 0.9V$

③ PROBLEM 3.3'

Calculate r_D and V_{D0} the elements of the battery plus - resistor model for which the straight line inrersects the diode exponential characteristic at 0.1 x and 10 x the specified diode current :

given : the straight line intesecte the diode exponential curve at 0.1 x and 10 x the specified diode current.



x Using (4.5)

$$V_2 - V_1 = 2.3 \times n\, V_T \log_{10}\left(\frac{I_2}{I_1}\right)$$

$$V_2 = 2.3\, n\, V_T \log_{10}\left(\frac{I_2}{I_1}\right) + V_1$$

$$i_d = I_S e^{\frac{v_d}{nV_T}}$$

$$\frac{I_1}{I_2} = e^{\frac{V_1 - V_2}{nV_T}} \Rightarrow \ln\left(\frac{I_1}{I_2}\right) = \frac{V_1 - V_2}{nV_T}$$

$$V_1 - V_2 = nV_T \ln\left(\frac{I_1}{I_2}\right)$$

$$V_2 = V_1 + nV_T \ln\left(\frac{I_2}{I_1}\right)$$

For 0.1 X

$I_D = 0.1\, I_D$, $I_1 = I_D$, $I_2 = i_D$, $V_1 = 0.7$ v

$$V_{2a} = 2.3\,(0.025)\log\left(\frac{0.1 I_D}{I_D}\right) + 0.7 = \underline{0.6425\text{V}}$$

For 10 x

$I_D = 10\, I_D$, $I_1 = I_D$, $I_2 = i_D$, $V_1 = 0.7$ v

$$V_{2b} = 2.3\,(0.025)\log\left(\frac{10 I_D}{I_D}\right) + 0.7 = \underline{0.7575\text{V}}$$

Since

(i) V_{2a} and V_{2b} are independent of I_D

(ii) $V_D = 0.7$ and $n = 1$ in Part a, b, and c

(iii) the same relation (0.1 x and 10 x) are needed for part a, b, and c.

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③ Cont. Problem 3.3'

$$r_D = \left[\frac{I_D(10-0.1)}{V_{2b} - V_{2a}}\right]^{-1} = \frac{0.115}{9.9}\left(\frac{1}{I_D}\right)$$

$$r_D = \frac{0.01162}{I_D}$$

$$V_{D0} = V_D - i_D r_D = V_{2a} - 0.1\, I_D \left(\frac{0.01162}{I_D}\right)$$

$$= 0.6425 - 0.1(0.01162)$$

$$= 0.6413\ V$$

V_{D0} independent of I_D so it will be the same for part a, b and c.

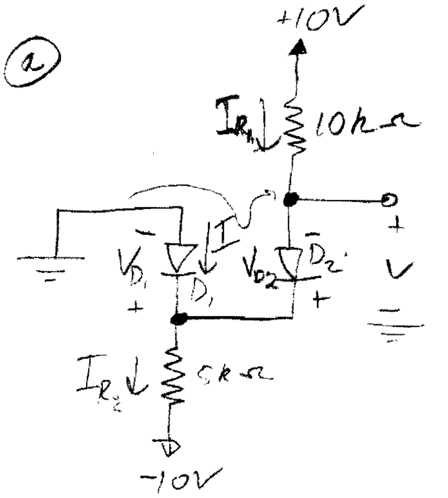
ⓐ $r_D = \frac{0.01162}{0.001} = 11.62\ \Omega$

ⓑ $r_D = \frac{0.01162}{1} = 0.01162\ \Omega$

ⓒ $r_D = \frac{0.01162}{10 \times 10^{-6}} = 1.162\ k\Omega$

4) Problem 4.40

(a)



Refer to Example 4.2

Find the value of I and V in the circuits
Assume $V_D = 0.65V$

If both D_1 and D_2 are conducting

$$I_{R_1} = \frac{10 - V}{10K} = \frac{10 - (+0.65 - 0.65)}{10K} = \underline{1mA}$$

$\underline{V = 0V}$

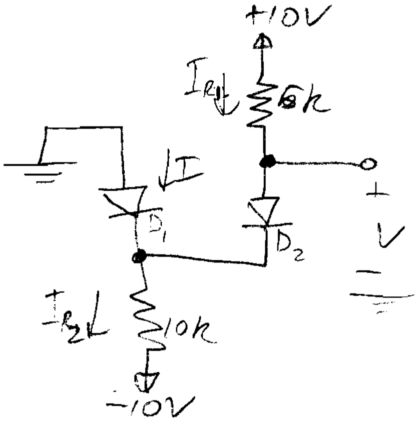
$\underline{V_{D_1} = V_{D_2} = -0.65V}$

$$\underline{I_{R_2}}_{5k} = \frac{-0.65 - (-10)}{5k} = \underline{1.87mA}$$

$\underline{I} = 1.87 - 1 = \underline{0.87mA}$

4) cont. problem 4.40

(b) Now, interchange the two resistors and reanalyze:



Both D_1 and D_2 conducting

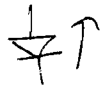
$V = 0V$

$I_{R_1} = \frac{10-0}{5k} = 2mA$

$V_{D_1} = V_{D_2} = -0.65V$

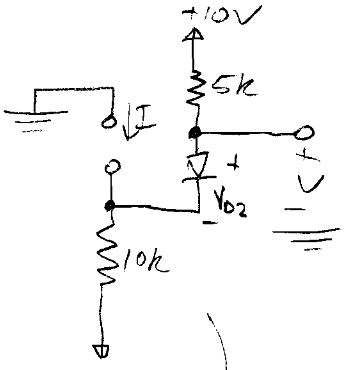
$I_{R_2} = \frac{-0.65+10}{10k} = 0.935mA$

$I = I_{R_2} - I_{R_1} = -1.065mA$



not correct assumption, current needs to be positive

Assume D_1 cutoff D_2 conducting

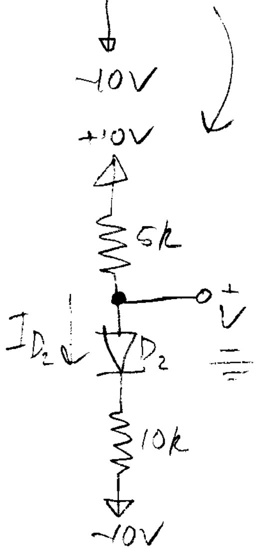


$\underline{\underline{I = 0V}}$

$V_{D2} = 0.65V$

$I_{D_2} = \frac{10-(0.65)-(-10)}{10k+5k} = \underline{1.29mA}$

$\underline{\underline{V}} = -10 + 1.29(10) + 0.65 = \underline{\underline{3.55V}}$



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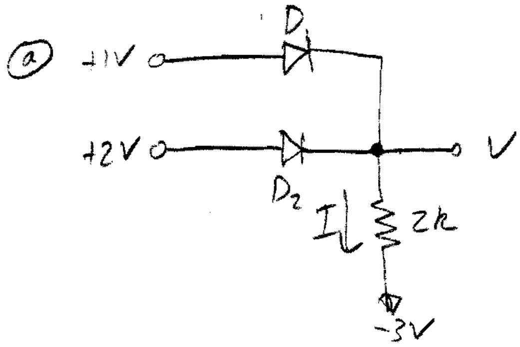
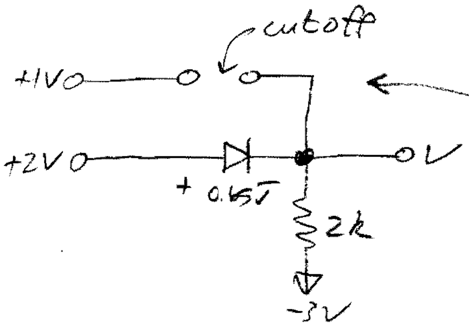
5) Problem 4.42

ⓐ



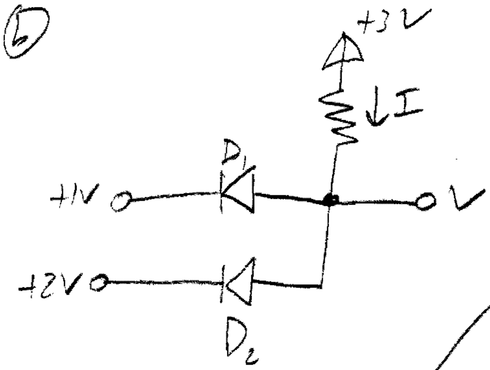


reverse biases D1 ✓

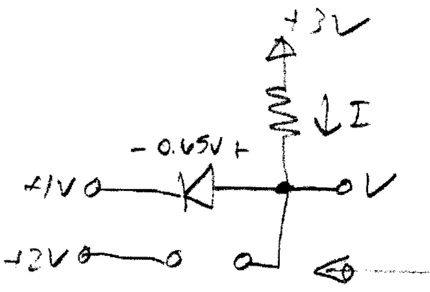
$V = 2 - 0.65 = \underline{\underline{1.35V}}$

$I = \frac{1.35-(-3)}{2k} = \underline{\underline{2.175mA}}$

ⓑ



Assume D1 is conducting



D2 is reversed biased ✓

$\underline{\underline{V}} = 1 + 0.65V = \underline{\underline{1.65V}}$

$\underline{\underline{I}} = \frac{3-1.65}{2k} = \underline{\underline{0.675mA}}$

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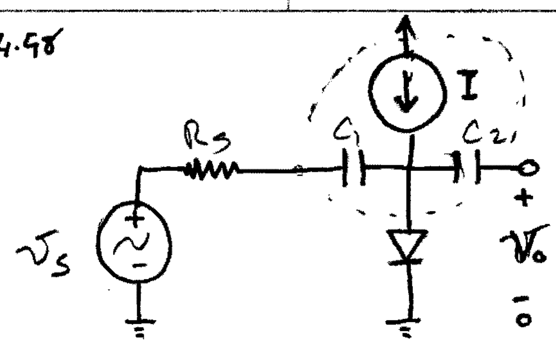
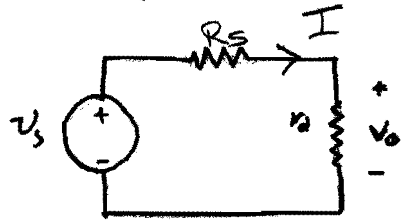
⑥ Problem 4.98



block the dc current from flowing into the Signal Source or the load.

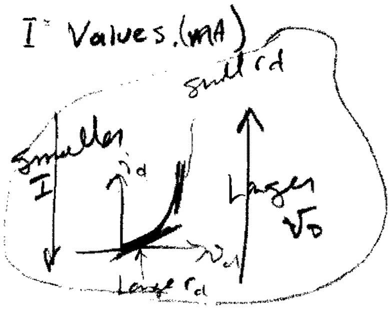
Small-signal equivalent CKT ($Z_{C1}, Z_{C2} \to 0$)



$$r_d = \frac{nV_T}{I_D}$$

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

w/ $n = 1$ $\quad v_o : 10\text{ mV} \times \frac{25\text{mV}}{25\text{mV} + I \times 10^3}$ — Solve V_o, by using given I values (mA)



Signal attenuator controlled by I_{DC}.

$I = 1\text{ mA}$, $V_o = 0.24\text{ mV}$

$I = 0.1\text{ mA}$, $V_o = 2.0\text{ mV}$

$I = 1\ \mu\text{A}$, $V_o = 9.6\text{ mV}$

when $V_o = \frac{1}{2} V_s = V_s \times \frac{0.025}{0.025 + I \times 10^3}$ $\quad$ V_s Cancel, Solve for I.

$$\Longrightarrow I = \underline{25\ \mu A}$$

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(7) Problem 4.59

From Fig. 4.19 $V_{ZK} \approx V_{Z0}$ and I_{ZK} is very small

$$V_Z = V_{Z0} + I_Z r_Z$$

(c) $r_Z = 2\Omega$, $V_Z = 6.8V$, $V_{ZK} = 6.6V$. **Find I_{ZT}**

$6.8 = 6.6 + I_{ZT} \times 2$

$I_{ZT} = 0.1A$ → For power rating, chose $I = 2 \cdot I_{Zt}$ $= 2mA$

then, $V_Z = 6.6 + 0.2 \times 2 = 7V$

$P = 7 \times 0.2 = 1.4W$

(d) $V_Z = 18V$, $I_{ZT} = 5mA$, $V_{ZK} = 17.6V$. **Find r_Z**

$r_Z = \frac{V_Z - V_{Z0}}{I_{ZT}} = \frac{18 - 17.6}{5mA} = 80\Omega$

For power rating at $I = 2 I_{Zt}$

$I_Z = 2 \times I_{ZT} = 0.01A$

new $V_Z = 17.6 + 0.01 \times 80 = 18.4V$

$P = 18.4 \times 0.01 = 184 \text{ mW}$

(e) Given $I_{ZT} = 200 mA$, $V_Z = 7.5V$, $r_Z = 1.5\Omega$ **Find V_{Z0}**

$7.5 = V_{Z0} + 0.2 \times 1.5$

$V_{Z0} = 7.2V$

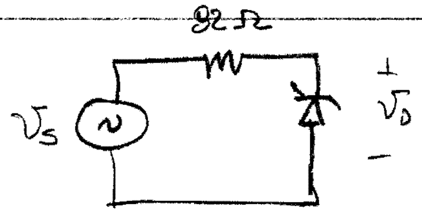
For power rating at $I = 2I_{ZT}$ $= 2 \cdot 0.2$ $= 0.4A$

$I_Z = 2 \times I_{ZT} = 0.4A$

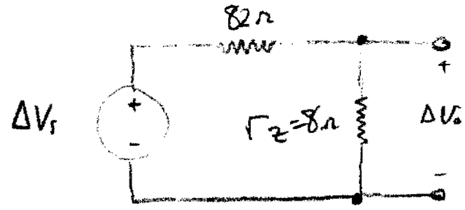
$V_Z = 7.2 + 0.4 \times 1.5 = 7.8V$

$P = 7.8 \times 0.4 = 3.12W$

① PROBLEM 4.61



$r_Z = 8\,\Omega$, $\Delta v_S = 1.0\,V$



$$\frac{\Delta V_o}{\Delta V_s} = \frac{8}{8+82} = \frac{8}{90}$$

$\Delta V_s = 1.0\,V \longrightarrow \Delta V_o = \frac{8}{90} \times \Delta V_s = \underline{0.0\overline{88}}\ V$