Digital Electronics Spring 2019 Midterm Exam 05/03/2019

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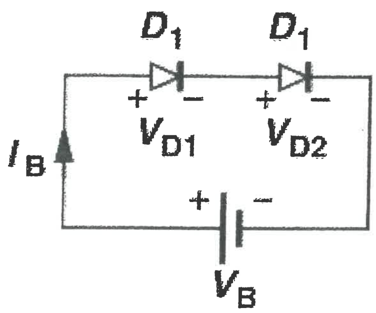
$\mu_n C_{ox} = 200\ \mu A/V^2$, $\mu_p C_{ox} = 100\ \mu A/V^2$, NMOS $V_{TH} = 0.4$ V, PMOS $V_{TH} = -0.4$ V,

Saturation current $I_D = (1/2)\mu_n C_{ox}(W/L)(V_{GS} - V_{TH})^2$; $g_m = [2\mu_n C_{ox}(W/L)I_D]^{1/2}$; $r_o = [1/(\lambda I_D)]$

10

1. (10%) Two diodes with reverse saturation currents of I_{S1} and I_{S2} placed series. Calculate I_B, V_{D1}, and V_{D2} in terms of V_B, I_{S1}, and I_{S2}. $I_D = I_S \exp(V_D/V_T)$ $V_T = 26$mV



$V_B = V_{D1} + V_{D2}$

$I_B = I_{D1} = I_{D2}$

$I_{D1} = I_{S1} e^{\frac{V_{D1}}{V_T}}$

$I_{D2} = I_{S2} e^{\frac{V_{D2}}{V_T}}$

$V_B = V_T \left(\ln \frac{I_{D1} I_{D2}}{I_{S1} I_{S2}} \right)$

$\Rightarrow \frac{I_B^2}{\cancel{I_{S1} I_{S2}}} = e^{\frac{V_B}{V_T}} \cdot I_{S1} I_{S2}$

$\Rightarrow I_B = \sqrt{I_{S1} I_{S2} e^{\frac{V_B}{V_T}}}$ ※

$V_{D1} = \ln \frac{I_{D1}}{I_{S1}} \cdot V_T$

$V_{D2} = \ln \frac{I_{D2}}{I_{S2}} \cdot V_T$

$V_{D1} = V_T \cdot \ln \frac{I_B}{I_{S1}}$

$= V_T \cdot \ln \frac{\sqrt{I_{S1} I_{S2} e^{\frac{V_B}{V_T}}}}{\sqrt{I_{S1}^2}} = V_T \left(\ln \sqrt{\frac{I_{S2}}{I_{S1}}} + \frac{V_B}{2V_T} \right)$

$V_{D1} = V_T \cdot \ln \sqrt{\frac{I_{S2}}{I_{S1}}} + \frac{V_B}{2}$ ※

$V_{D2} = V_T \cdot \ln \sqrt{\frac{I_{S1}}{I_{S2}}} + \frac{V_B}{2}$ ※

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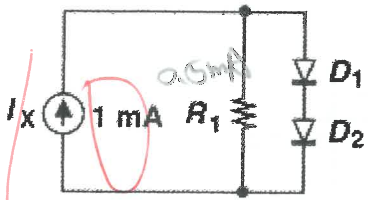
2. (10%) Determine the value of R_1 such that R_1 carries 0.5mA. Assume $I_S = 5\times10^{-16}$ A for each diode.



Ans:

$V_{R1} = V_{D1} + V_{D2}$

$I_{D1} = I_{D2} = 0.5$ mA

$I_{D1} = I_S e^{\frac{V_{D1}}{V_T}} = I_{D2} = I_S e^{\frac{V_{D2}}{V_T}}$

$\Rightarrow V_{D1} = V_{D2}$

$0.5\times10^{-3} = 5\times10^{-16} \cdot e^{\frac{V_D}{0.026}}$

$10^{12} = e^{\frac{V_D}{0.026}}$

$V_D = \ln 10^{12} \times 0.026$

$= 0.7184 \approx 0.718$

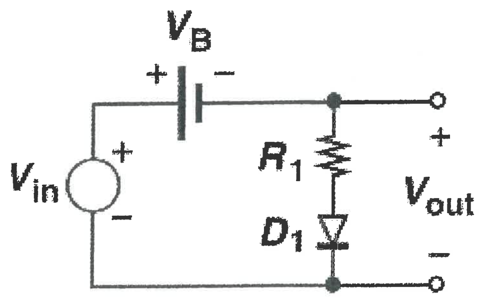
$V_{R1} = 2V_D$

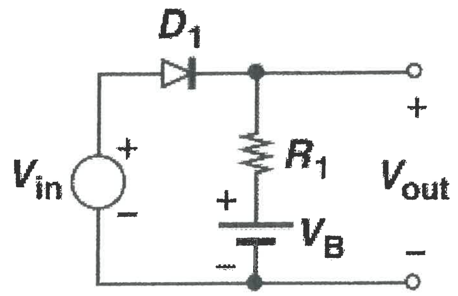
$= 2\times0.718$

$= 1.436$ V

$R_1 = \frac{1.436}{0.5\times10^{-3}} \approx 2.87\ k\Omega$ ※

3. (10%) Plot the input/output characteristics of the circuit shown below using an ideal model for the diode. (Assume V_B =2V).



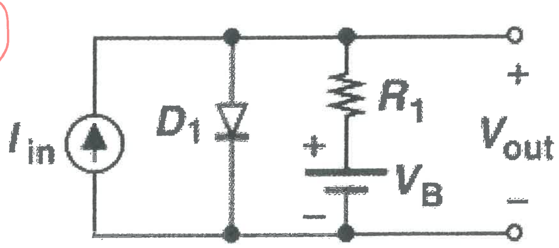


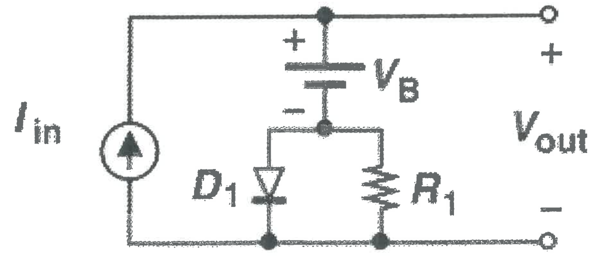
Ans:

(a)

(b)

4. (20%) Assume constant voltage diode model, plot $\cancel{V_{out}}$ I_{R1} as a function of I_{in} for the circuits shown below. (Assume V_B =2V).





Ans:

(a)

(b)

5. (20%) Plot the input/output characteristics of the circuit illustrated in Fig. 3.76 assuming a constant voltage model and V_B =2 V.

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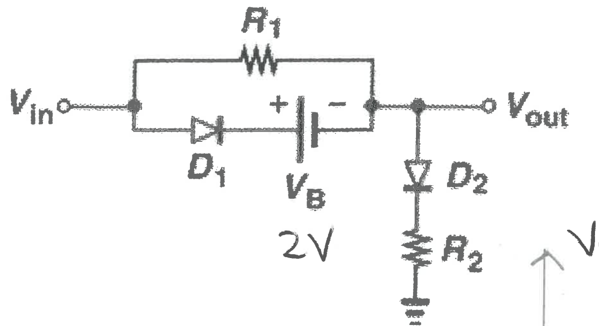
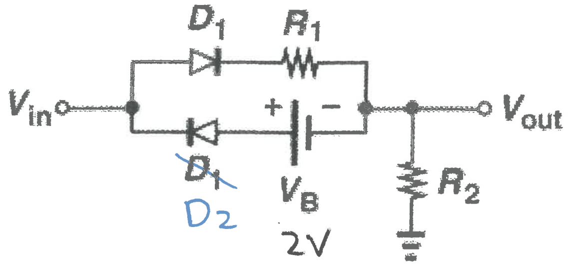




$V_{in} = I(R_1+R_2)$

$V_{out} = IR_2$

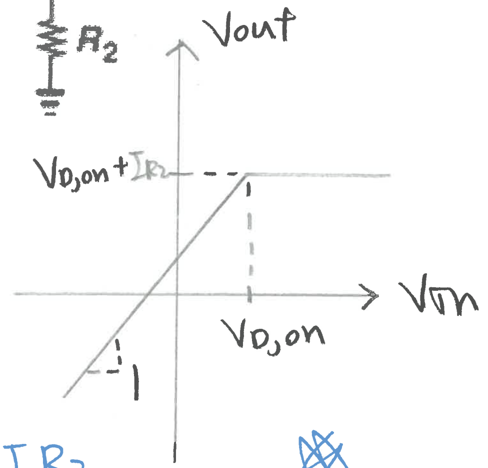
Ans:

$V_{in} < V_{D,on}$

$V_{in} = V_{out}$

$V_{in} > V_{D,on}$

$V_{out} = V_{D,on} + IR_2$



6. (10%) Suppose the diodes carry a current of 5 mA and the load, a current of 20 mA. If the load current increases to 21 mA, what is the change in the total voltage across the three diodes? Assume R_1 is much greater than $3r_d$. $r_d = V_T / I_D$, $V_T = 26\text{mV}$

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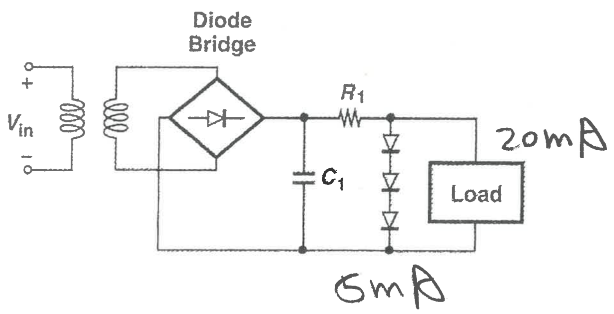


$3r_d = 3 \times \frac{26}{5} = 15.6\ \Omega$

$15.6 \times \cancel{5} = \cancel{20}\ 4 \times x$

$x = 3.9\ \Omega$

$3.9 \times 21 \times 10^{-3}$

$= 0.0819\ V$

$\approx 82\ mV$

7. (10%) Assuming a constant V_{DS}, a graph of $g_m r_o$ verse $(V_{GS} - V_{TH})$ of a NMOS gives a slope of 50 V^{-1}. Find the W/L ratio if $\lambda = 0.1\ V^{-1}$ and $I_D = 0.5$ mA, $g_m = \mu_n C_{ox}(W/L)(V_{GS}-V_{TH})$, $r_o=[1/(\lambda I_D)]$

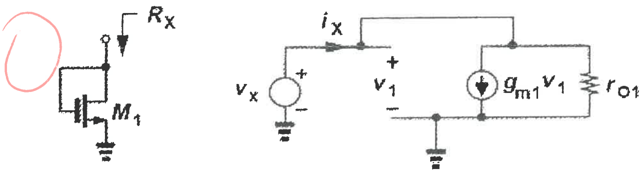
$$\frac{g_m r_o}{(V_{GS}-V_{TH})} = 50V^{-1} = \frac{\mu_n C_{ox}\left(\frac{W}{L}\right)\cancel{(V_{GS}-V_{TH})}\cdot\frac{1}{(\lambda I_D)}}{\cancel{(V_{GS}-V_{TH})}}$$

10

$$= \frac{200\ uA/V^2 \times \frac{W}{L}}{0.1\,V^{-1} \times 0.5\,mA} \Rightarrow 50 = \frac{200\times10^{-6}\times\left(\frac{W}{L}\right)}{0.1\times0.5\times10^{-3}}$$

$$\Rightarrow \frac{W}{L} = 12.5$$ #

8. (10%) Find R_X of the following circuit.



Ans:

9. (10%) If the circuit in the following figure represents a source and load with v_s=90V, and i_1=6mA, then **what are the values of i_3 and R_3?**

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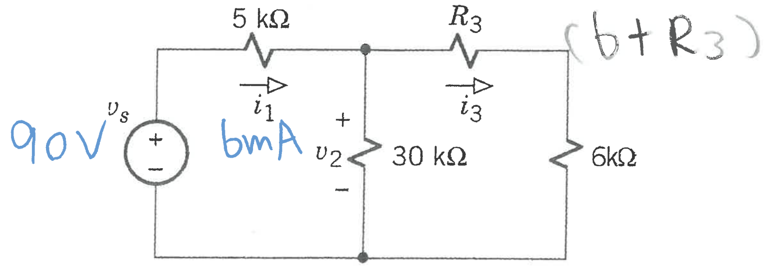

Ans:

$$R = \frac{90V}{6mA} = 15k\Omega$$

$$15 = 5 + \frac{1}{\frac{1}{6+R_3} + \frac{1}{30}}$$

V_2 V_2

$30k\Omega$ $15k\Omega$

A 1 : 2

2mA 4mA

$\Rightarrow i_3 = 4mA$ ※

$$\frac{1}{6+R_3} + \frac{\cancel{1}}{\cancel{30}} = \frac{\cancel{1}}{\cancel{10}} \frac{\cancel{2}}{\cancel{30}} \frac{1}{15} \Rightarrow R_3 = 9k\Omega$$ ※

10. (10%)In Fig. 6.42, what is the current when $V_{GS} = 2V_{TH}$ and W/L=10/0.14? Find the region in which the device operates. [$V_{DS} > V_{GS} - V_{TH} \rightarrow$Saturation, $V_{DS} < V_{GS} - V_{TH} \rightarrow$Triode]

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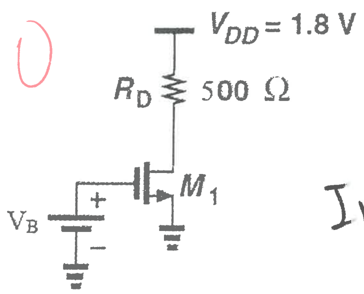

Fig 6.42

ANS:

Assume Saturation

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS}-V_{TH})^2$$

$$= \frac{1}{2} \times 200 \times 10^{-6} \times \frac{10}{0.14} \times (0.4)^2$$

$$= 1.14285\cdots \times 10^{-3} A$$

$$\approx 1.143 mA$$

$$V_{DS} = V_{DD} - R_D I_D = 1.8V - 1.143mA \times 500\Omega$$

$$= 1.2285V$$

$\because$ $1.2285 > 0.4$ $\therefore$ 假設成立 ※

$V_{DS} > V_{GS} - V_{TH}$ $\Rightarrow$ Saturation

Digital Electronics Spring 2017 Midterm Exam 04/21/2017

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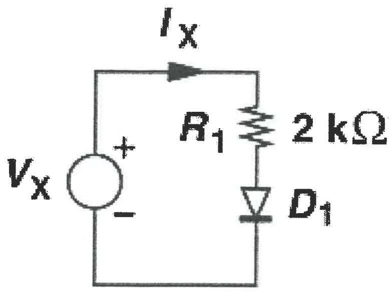
1. (15%) For what value of V_X in following Figure, does R_1 sustain a voltage equal to $V_X/2$? Assume $I_S = 2 \times 10^{-16}$ A. $I_D = I_S \exp(V_D/V_T)$ $V_T = 26\text{mV}$



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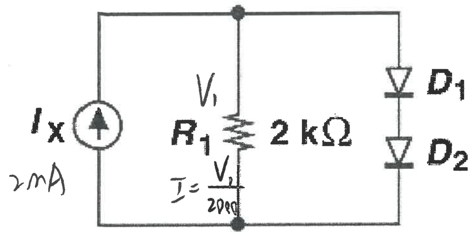
$V_D = V_T \ln \frac{I_D}{I_S}$

$I_X = \frac{\frac{V_X}{2}}{2000} = \frac{V_X}{4000}$

$\frac{V_X}{2} = 0.026 \ln \frac{V_X}{8\times10^{-13}}$

$V_X = 0.052 \ln \frac{V_X}{8\times10^{-13}}$ #

2. (15%) In the following Figure, employs two identical diodes with $I_S = 5\times10^{-16}$ A. Calculate the voltage across R_1 for I_X=2 mA



-13

$V_1 = 2V_D = 2V_T \ln\frac{I_D}{I_S}$

$= 0.052\ln\frac{I_D}{I_S}$

$\frac{0.052\ln\frac{I_D}{I_S}}{2000} + I_D = 2mA$

$0.052\ln\frac{I_D}{I_S} + 2000 I_D = 2A$

$I_D \fallingdotseq 0$

$I_1 \fallingdotseq 2mA$

$V_1 = 2000 \times 2m = 4$ #

3. (5%) Consider a *pn* junctions in forward bias. Initially a current of 5 mA flows through it, and the current increases by 8 times hen the forward voltage is increased by 1.5 times. Determine the initial bias applied and reverse saturation current. ($V_T = 26\text{mV}$) $I_D = I_S \exp(V_F/V_T)$

-4

$$\begin{cases} 5mA = I_s \cdot e^{\frac{V_F}{V_T}} \\ 40mA = I_s \cdot e^{\frac{1.5V_F}{V_T}} \end{cases}$$

+1

$$8 = e^{\frac{0.5V_F}{0.026}}$$

$$\frac{0.5V_F}{0.026} = \ln 8$$

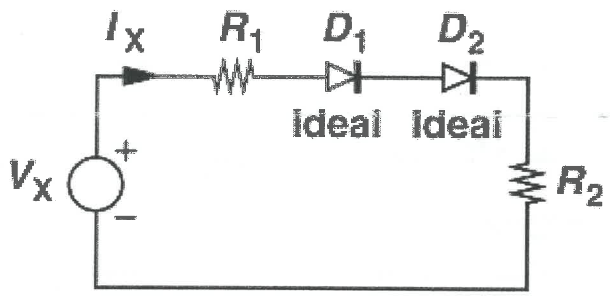
$$V_F = 2\ln 8 \cdot V_T$$

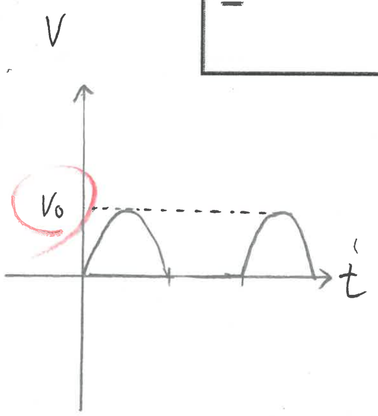
$$5\times10^{-3} = I_s \cdot e^{2\ln 8}$$

$$I_s = 5\times10^{-3} \div (8\times8) = 3.125\times10^{-4} \ \#$$

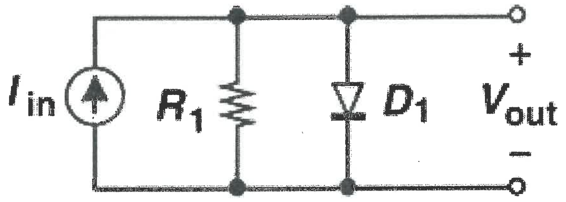
4. (5%) If the input in following Figure is expressed as $V_X = V_0 \sin\omega t$, plot the current through the circuit as a function of time.

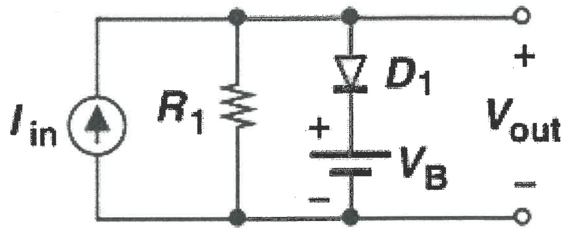
-2



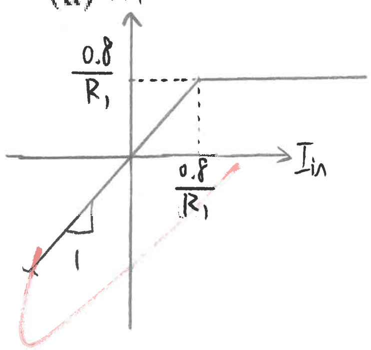


5. (10%) In the circuit plot the current flowing through R_1 as a function of I_{in}. Assume a constant voltage diode model (Assume $V_B = 2$ V, $V_{D,ON} = 800$ mV).

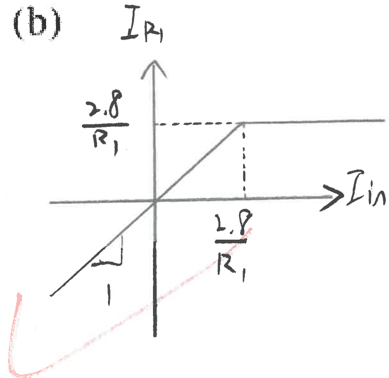




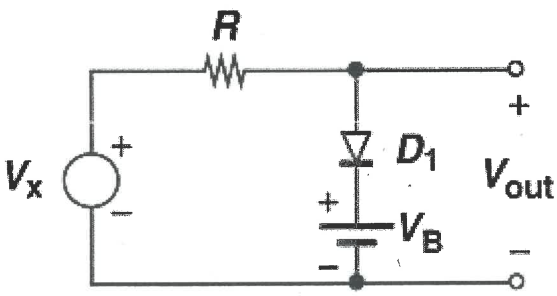
(a)

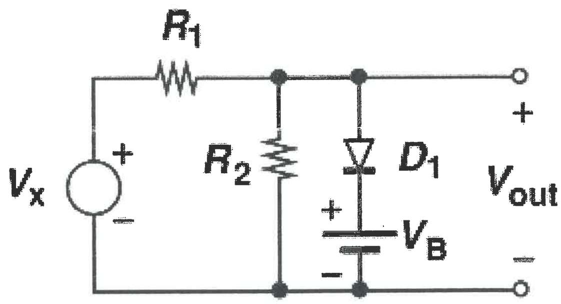


(b)



6. (10%) Plot the input voltage / output votlage characteristics of the circuit below. Assuming a constant voltage diode model.



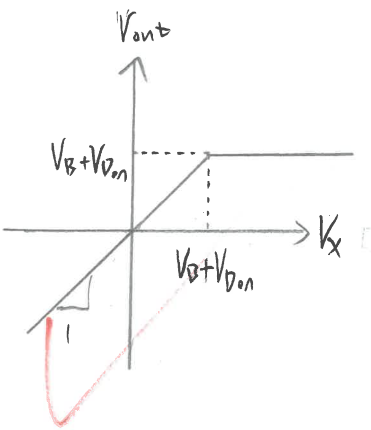


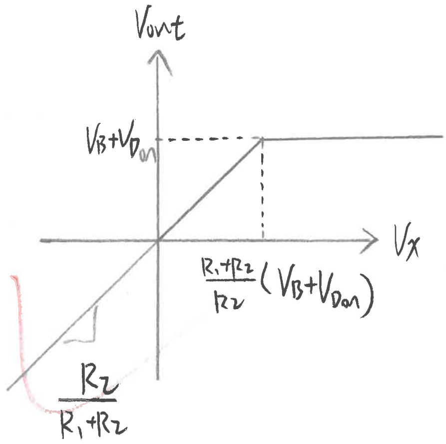
$V_x - V_B = V_D$

$V_x = V_B + V_D$

(a)

(b)

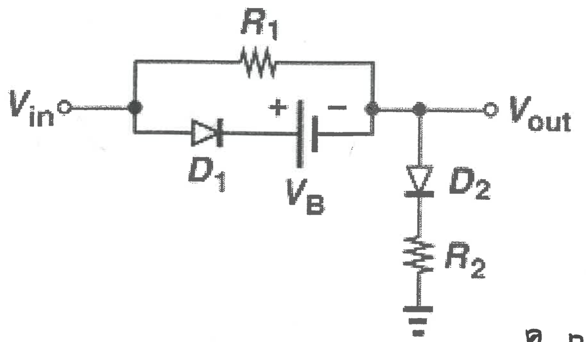


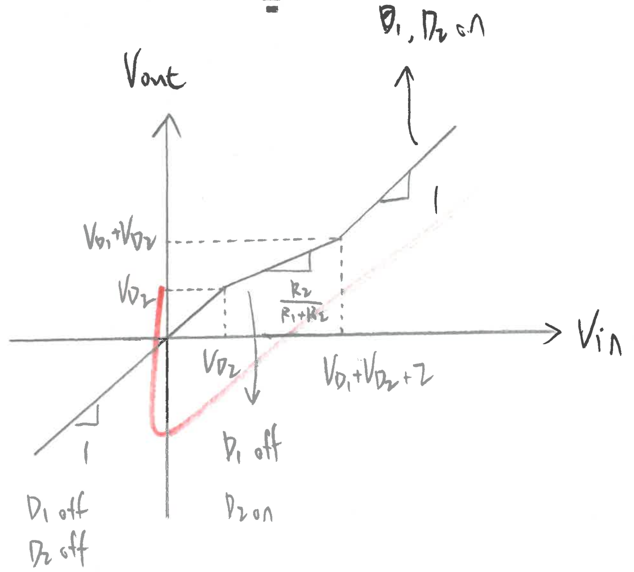


$V_{out} = \frac{R_2}{R_1+R_2} V_x$

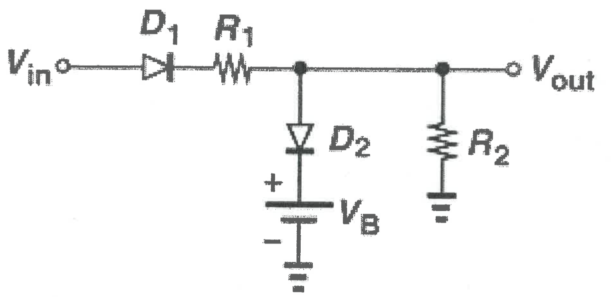
$V_x = \frac{R_1+R_2}{R_2} V_{out}$

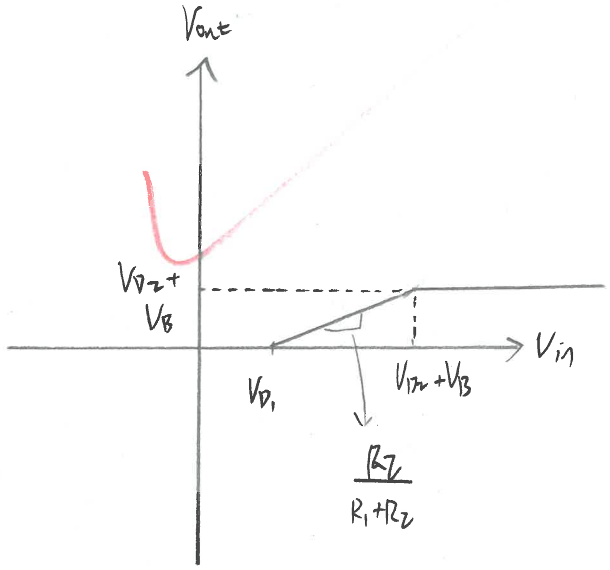
7. (10%) Plot the input/output characteristics of the following circuit assuming a constant voltage model and V_B =2 V.





8. (10%) Plot the input/output characteristic of the following circuit using the constant voltage model.





9. (10%) A cellphone incorporates a 2.4GHz oscillator whose frequency is defined by the resonance frequency of an LC tank If the tank capacitance is realized as the pn junction of Example 2.15, calculate the change in the oscillation frequency while the reverse voltage goes from 0 to 1.5 V. Assume the circuit operates at 2.4 GHz at a reverse voltage of 0 V, and the junction area is 2500 μm^2.

$$f_{res} = \frac{1}{2\pi}\frac{1}{\sqrt{LC}},\ C_j = 0.265 fF/\mu m^2,\ C_{j,tot} = \frac{C_{j0}}{\sqrt{1+\frac{V_R}{V_0}}},\ V_0 = 0.73V$$

$$C_{t_1} = 0.265f \times 2500 = 662.5f$$

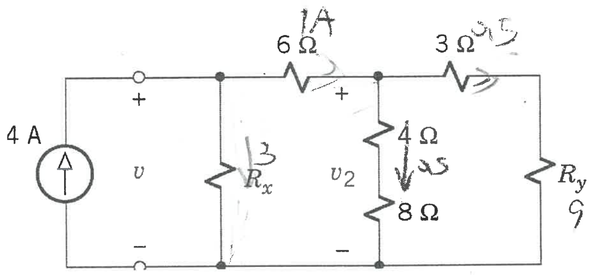
$$L = \frac{C}{(2\pi f)^2} = 6.6\times10^{-9}$$

$$C_{t_2} = \frac{0.625\,f}{\sqrt{1+\frac{1.5}{0.73}}} \times 2500 = \frac{662.5f}{1.7464} = 379.35f$$

$$\sqrt{3.05} = 1.7464$$

$$f = \frac{1}{2\pi}\cdot\frac{1}{\sqrt{6.6\times379.35\times10^{-24}}} = \frac{10^{12}}{2\pi}\times\frac{1}{50} \fallingdotseq 3.18\,GHz$$ #

10.(10%) **Find the R_{eq}** for the ladder network shown below when $R_x = 4\Omega$, $R_y = 9\Omega$. Then **calculate v_2?**



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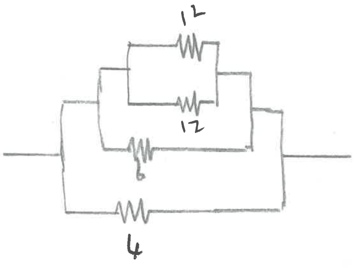

$$\frac{1}{\frac{1}{12}+\frac{1}{12}} = 6$$

$$\frac{1}{\frac{1}{6}+\frac{1}{6}} = 3$$

$$\frac{1}{\frac{1}{3}+\frac{1}{4}} = \frac{12}{7}$$

$$V = \frac{48}{7}$$ #

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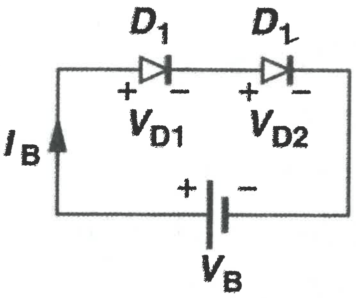
1. (15%) Two diodes with reverse saturation currents of I_{S1} and I_{S2} placed series. Calculate I_B , V_{D1} , and V_{D2} in terms of V_B , I_{S1} , and I_{S2} . $\boldsymbol{I_D = I_S \exp(V_D / V_T)}$ $\boldsymbol{V_T = 26\text{mV}}$



$I_{D1}=I_{D2}=I_B$

$V_B=V_{D1}+V_{D2}=V_T\ln\frac{I_B}{I_{S1}}+V_T\ln\frac{I_B}{I_{S2}}=V_T\ln\frac{I_B^2}{I_{S1}I_{S2}}$

8/

$\Rightarrow I_B=\sqrt{I_{S1}I_{S2}\,e^{\frac{V_B}{26\times10^{-3}}}}$ #

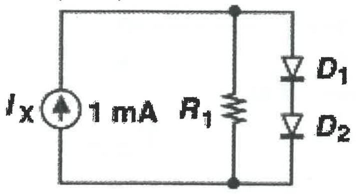
$V_{D1}=V_T\ln\frac{I_B}{I_{S1}}=V_T\ln\sqrt{\frac{I_{S2}}{I_{S1}}e^{\frac{V_B}{V_T}}}=V_T(\ln\sqrt{\frac{I_{S2}}{I_{S1}}}+\ln e^{\frac{V_B}{2V_T}})$

$=26\times10^{-3}\times\sqrt{\frac{I_{S2}}{I_{S1}}}+\frac{V_B}{2}$ #

$V_{D2}=V_T\ln\frac{I_B}{I_{S2}}=26\times10^{-3}\times\sqrt{\frac{I_{S1}}{I_{S2}}}+\frac{V_B}{2}$ #

+15

2. (15%) Determine the value of R_1 such that R_1 carries 0.5mA. Assume $I_S = 5\times10^{-16}$ A for each diode.



$I_{D1}=I_{D2}=0.5mA$, $V_R=V_{D1}+V_{D2}$

$V_{D1}=V_{D2}=26\times10^{-3}\times\ln\frac{0.5\times10^{-3}}{5\times10^{-16}}\approx0.718V$

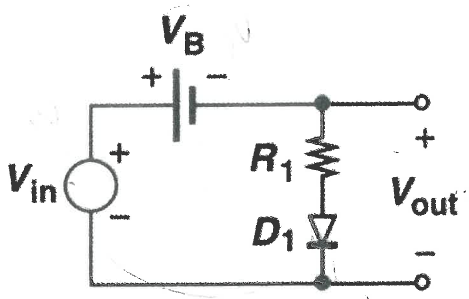
$V_R=0.718+0.718=1.436V$

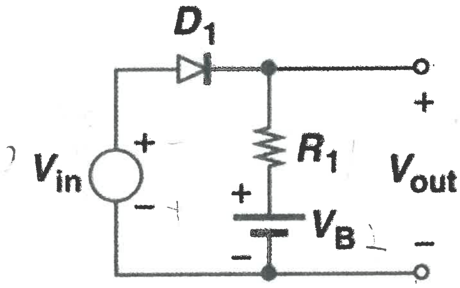
$R_1=\frac{1.436}{0.5\times10^{-3}}=2872\,\Omega$ #

+15

3. (10%) Plot the input/output characteristics of the circuit shown below using an ideal model for the diode. (Assume V_B =2V).

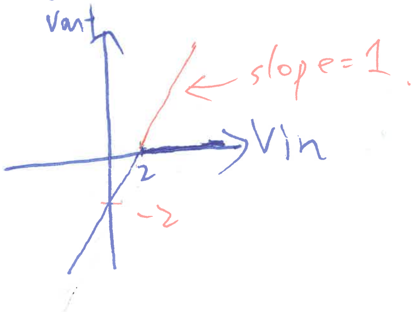
+7





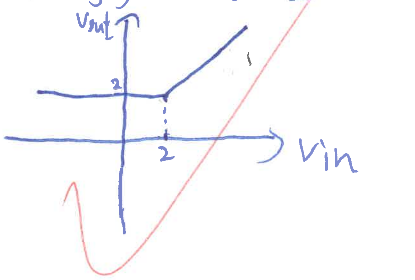
$V_{in} > V_B \Rightarrow V_{out} = 0$

$V_{in} < V_B \Rightarrow V_{out} = V_{in} - 2$



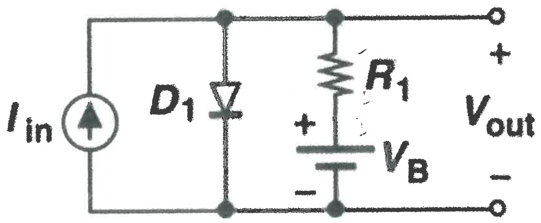
$V_{in} > V_B \Rightarrow V_{out} = V_{in}$

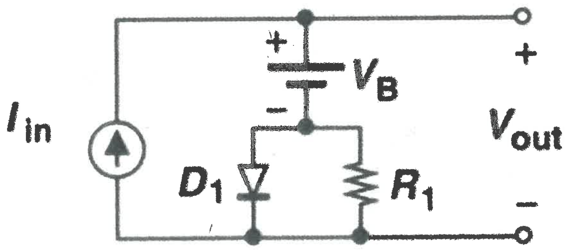
$V_{in} < V_B \Rightarrow V_{out} = 2$



4. (10%) Assume constant voltage diode model, plot I_{R1} as a function of I_{in} for the circuits shown below. (Assume V_B =2V).

+0.

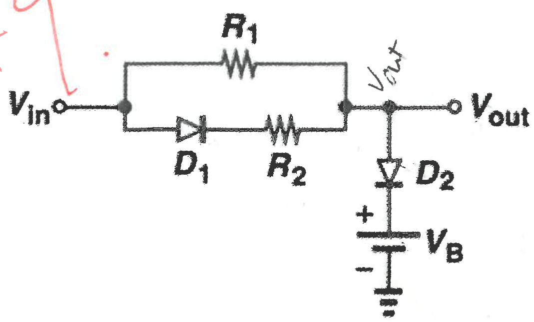




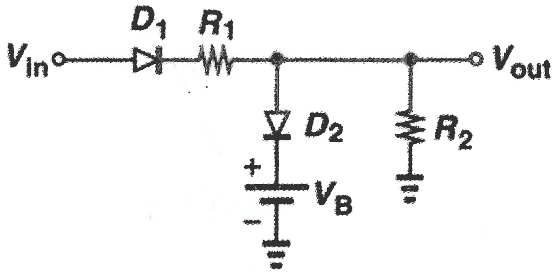
5. (15%) Plot the input/output characteristics of the circuit illustrated in Fig. 3.76 assuming a constant voltage model and V_B =2 V.

+9

(a)

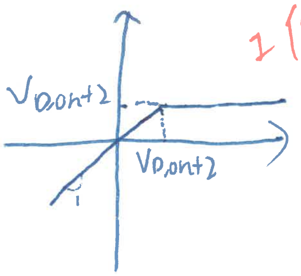


(b)



$V_{in} > V_{D,on} + V_B \Rightarrow V_{out} = V_{D,on} + 2$

$V_{in} \le V_{D,on} + V_B \Rightarrow V_{out} = V_{in}$

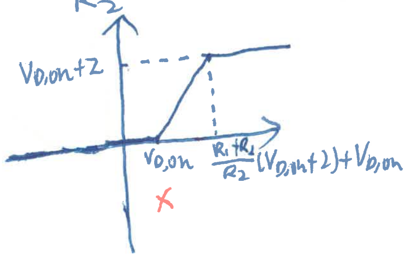


$V_{in} < V_{D,on} \Rightarrow V_{out} = 0$

$V_{in} > V_{D,on} + I(R_1+R_2) \Rightarrow V_{out} = V_{D,on} + 2$

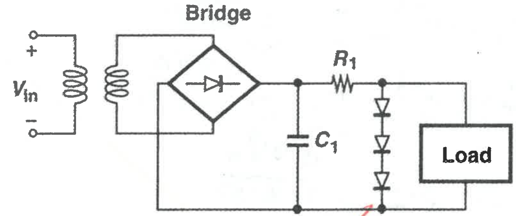
$V_{in} = V_{D,on} + I(R_1+R_2)$

$I = \frac{V_B + V_{D,on}}{R_2} \Rightarrow V_{in} = \frac{R_1+R_2}{R_2}(V_{D,on}+2) + V_{D,on}$



6. (15%) Suppose the diodes carry a current of 5 mA and the load, a current of 20 mA. If the load current increases to 21 mA, what is the change in the total voltage across the three diodes? Assume R_1 is much greater than $3r_d$. **$r_d = V_T / I_D$, V_T = 26mV**

+15.



$r_d = \frac{26 \times 10^{-3}}{5 \times 10^{-3}} = 5.2\,\Omega$

$\Delta V = (-1) \times (3 \times 5.2) = -15.6\ mV_{\#}$

$\frac{26 \times 10^{-3}}{5 \times 10^{-3}}$

$r_d = \frac{26\,mV}{5\,mA} = 5.2(\Omega) \times 3$

$r_d = \frac{26\,mV}{4\,mA} = 6.5(\Omega) \times 3$

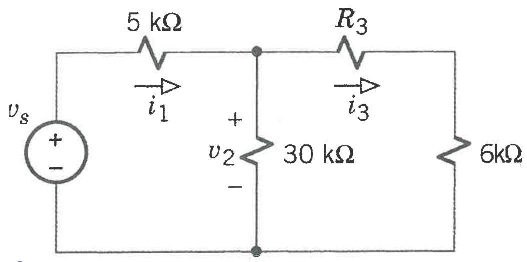
$\frac{26 \times 10^{-3}}{4 \times 10^{-3}} \times 3$

Ω

$= 15.6\,\Omega \times 0.5m = 0.078$

$= 19.5\,\Omega \times 4m =$

7. (10%) If the circuit in the following figure represents a source and load with v_s=90V, and i_1=6mA, then **what are the values of i_3 and R_3?**



+10

$R_{total} = \frac{90}{6} = 15 = 5 + \frac{1}{\frac{1}{30} + \frac{1}{R_3+6}}$

$\frac{1}{30} + \frac{1}{R_3+6} = \frac{1}{10} \Rightarrow \frac{1}{R_3+6} = \frac{1}{15}$

$\therefore R_3 = 9\,k\Omega$ #

$i_3 = i_1 \times \frac{30}{30+15} = 4mA$ #

8. (10%) Consider a *pn* junctions in forward bias. Initially a current of 5 mA flows through it, and the current increases by 8 times hen the forward voltage is increased by 1.5 times. Determine the initial bias applied and reverse saturation current. (V_T = 26mV) $\boldsymbol{I_D = I_S \exp(V_D/V_T)}$ $\boldsymbol{V_T = 26}$**mV**

$5\times10^{-3} = I_S \cdot e^{\frac{V_D}{26\times10^{-3}}}$

$40\times10^{-3} = I_S \cdot e^{\frac{1.5V_D}{26\times10^{-3}}}$

$\Rightarrow 8 = e^{\frac{0.5V_D}{26\times10^{-3}}}$

+10

$\Rightarrow V_D = \frac{26\times10^{-3} \times \ln 8}{0.5} \approx 0.108\,V$ #

$I_S = \frac{5\times10^{-3}}{e^{\frac{0.108}{26\times10^{-3}}}} = 7.8\times10^{-5}\,A$ #

$5\times10^{-3} = I_S \times e^{\frac{V_D}{V_T}}$

$40\times10^{-3} = I_S \times e^{\frac{1.5V_D}{V_T}}$

$8 = e^{\frac{0.5V_D}{26mV}}$

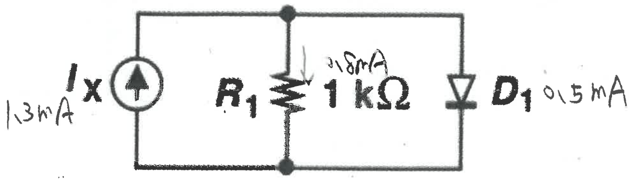
$\ln 8 = \frac{0.5V_D}{26mV}$

$5\times10^{-3} \times e^{\frac{-V_D}{26\times10^{-3}}} = I_S$

Digital Electronics Spring 2021 Midterm Exam 04/26/2021

Name: 張碩文 ID# B093040007

1. (15%) The the circuit shown below, we wish D_1 to carry a current of 0.5mA for I_x = 1.3mA. Determine the required I_s. $I_D = I_S \exp(V_D/V_T)$ $V_T = 26\text{mV}$



Ans:

$$V_{R_1} = V_{D_1} = (0.8\,mA)\times(1\,k\Omega) = 0.8V$$

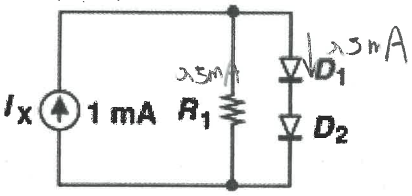
$$\therefore\ 0.5\times10^{-3} = I_S \times e^{\frac{0.8}{26\times10^{-3}}}$$

$$0.5\times10^{-3}\times e^{-\frac{0.8\times1000}{26}} = I_S$$

$$\therefore\ I_S = 2.168017926\times10^{-17}\ (A)$$

+15

2. (15%) Determine the value of R_1 such that R_1 carries 0.5mA. Assume $I_S = 5\times10^{-16}$ A for each diode.



$$I_D = I_S \times e^{\frac{V_D}{V_T}}$$

$$0.5\times10^{-3} = 5\times10^{-16}\times e^{\frac{V_{D1}}{V_T}}$$

$$0.5\times10^{-3} = 5\times10^{-16}\times e^{\frac{V_{D2}}{V_T}}$$

Ans:

$$V_X = V_{R_1} = V_{D_1} + V_{D_2}$$

$$\cancel{25}\times10^{-2}\times10^{-6} = \cancel{25}\times10^{-32}\times e^{\frac{V_X}{V_T}}$$

$$10^{20} = e^{\frac{V_X}{V_T}} = e^{\frac{V_X}{26\times10^{-3}}}$$

24

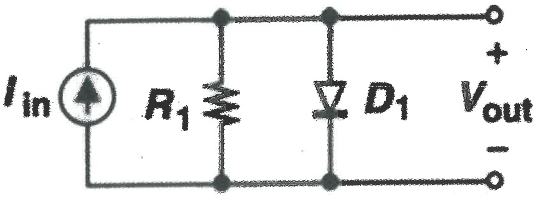
+10

$$26\times10^{-3}\cdot 20\ln 10 = V_X = 1.197\ (V)$$

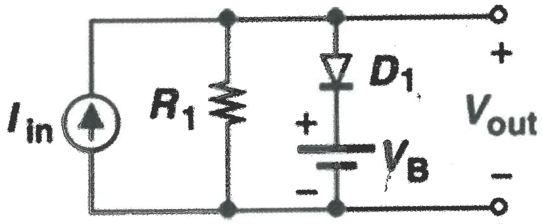
$$\therefore\ R_1 = \frac{1.197\ (V)}{0.5\ (mA)} = 2394\ (\Omega)$$

3. (10%) plot the current flowing through $\mathbf{R_1}$ as a function of I_{in} Assume a constant voltage diode model (Assume $V_B = 2$ V, $V_{D,ON} = 800$ mV).

+10

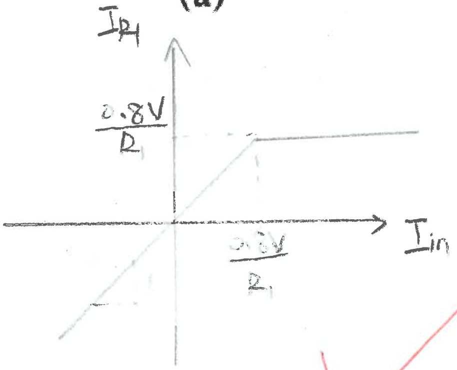


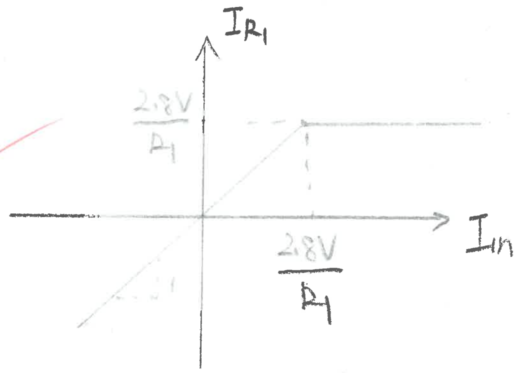
(a)



(b)

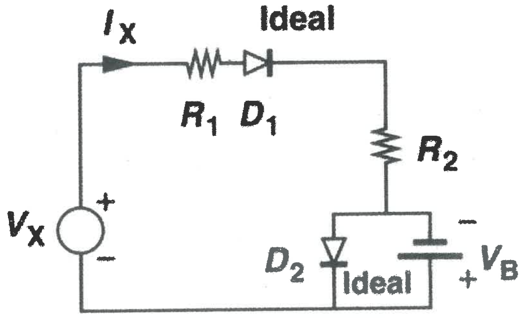
Ans:





4. (10%) For the circuit shown below, plot I_X and I_{R1} as a function of V_X .

+3



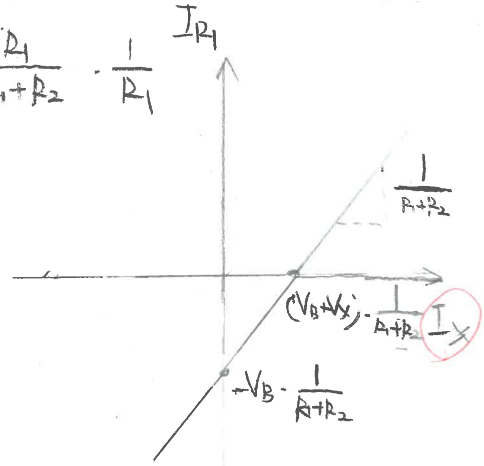
Ans: if $V_X > 0$ $\quad I_X = I_{R_1} = (V_X + V_B) \cdot \frac{R_1}{R_1+R_2} \cdot \frac{1}{R_1}$

if $V_X < 0$ 且 $|V_X| < |V_B|$

$$I_{R_1} = (V_X - V_B) \cdot \frac{R_1}{R_1+R_2} \cdot \frac{1}{R_1}$$

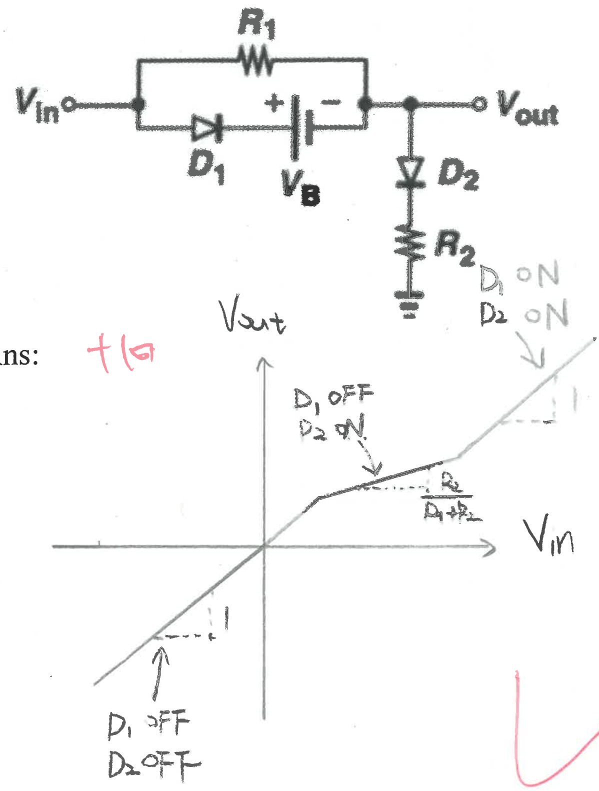
if $V_X < 0$ 且 $|V_X| > |V_B|$

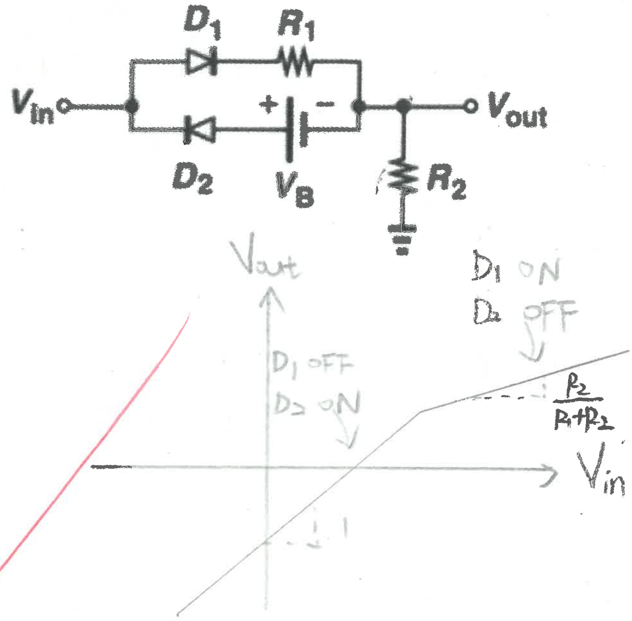
$$I_X = I_{R_1} = (V_X - V_B) \cdot \frac{R_1}{R_1+R_2} \cdot \frac{1}{R_1}$$



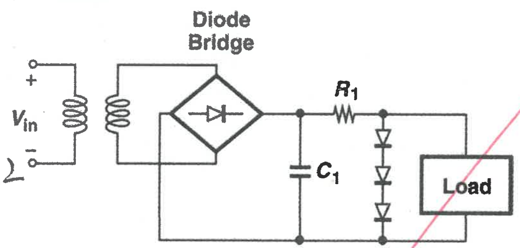
5. (10%) Plot the input/output characteristics of the circuit illustrated in Fig. 3.76 assuming a constant voltage model and V_B =2 V.

Ans: +10





6. (15%) Suppose the diodes carry a current of 5 mA and the load, a current of 20 mA. If the load current increases to 21 mA, what is the change in the total voltage across the three diodes? Assume R_1 is much greater than $3r_d$. $r_d = V_T / I_D$, $V_T = 26mV$

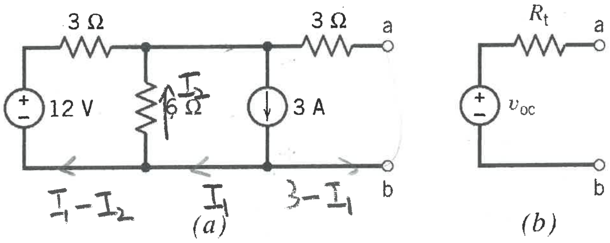


+15

$3r_d = 3 \times \frac{26}{5} = 3 \times 5.2$

$\Delta V = (-1) \times (15.6) = -15.6$ (mV)

7. (15%) Determine the value of R_t and v_{oc} that cause the circuit shown below (b) to be the Thévenin equivalent circuit of (a).



(a) (b)

Ans:

$-2I_1 + I_2 = -1$

8. (10%) Consider a *pn* junctions in forward bias. Initially a current of 5 mA flows through it, and the current increases by 8 times hen the forward voltage is increased by 1.5 times. Determine the initial bias applied and reverse saturation current. (V_T = 26mV) $I_D = I_S \exp(V_D / V_T)$ $V_T = 26\text{mV}$

Ans:

$$5 \times 10^{-3} = I_S \times e^{\frac{V_D}{V_T}}$$

$$40 \times 10^{-3} = I_S \times e^{\frac{1.5V_D}{V_T}}$$

+8

$$8 = e^{\frac{0.5V_D}{26(mV)}} = e^{\frac{V_D}{52\times10^{-3}}}$$

$$\ln 8 \cdot 52 \times 10^{-3} = V_D \fallingdotseq 0.108 \checkmark$$

$$I_s = 5 \times 10^{-3} \times e^{\frac{-0.108\times10^{3}}{26}} = 7.851950283 \times 10^{-5} \text{ (A)}$$