國立臺灣科技大學答案卷

National Taiwan University of Science and Technology Answer Sheet

評分 Score	教師簽章 Signature of Lecturer

姓名/Name 張恆豪 學號/Student ID B11002110 班級/Class 四電子二乙

科目/Course title 電子學 日期/Date 111.10.18

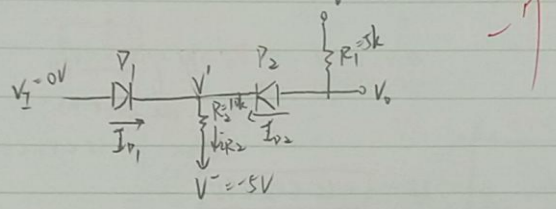
記分欄

從此處開始寫起。試卷用紙務須節用，非經主試認可不得續用其他紙張作答。/Please write from here.

1.

When $V_I=0V$, $V_O=?$ 1.9V, $I_{D_1}=?$ 0A, $I_{D_2}=0.62mA$

$V_I=4V$, $V_O=?$ ~~4.2V~~ $I_{D_1}=0.95mA$, $I_{D_2}=0.12mA$

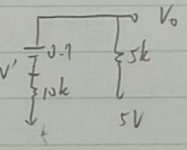


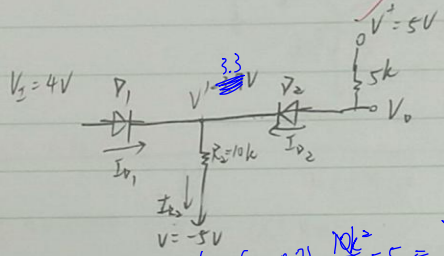
D_2 ON:

$$V_O=\frac{\frac{-0.3}{10k}+\frac{5}{5k}}{\frac{1}{10k}+\frac{1}{5k}}=\frac{-4.3+10}{3}=\frac{5.7}{3}>0\Rightarrow D_1 \text{ OFF}$$

$$\Rightarrow I_{D_1}=0A$$

$$I_{D_2}=\frac{\frac{5.7}{30}-0.7+5}{10k}=0.62mA$$





D_2 ON: $V'=(10-0.7)\cdot\frac{10k}{10k+5k}-5=\frac{6.2}{18.6}-5=1.2V$

$V'=\frac{57}{30}-0.7=1.2$

$4-1.2>0.7\Rightarrow D_1$ ON

$\Rightarrow V'=3.3V$

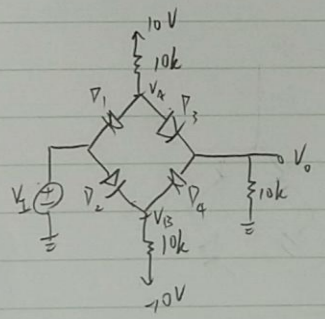
$\Rightarrow I_{D_2}=\frac{5-3.3}{5k}-0.7=\frac{1}{5k}=0.2mA$

$\Rightarrow V_O=5-I_{D_2}\cdot 5k=4V$

$\Rightarrow I_{R_2}=\frac{3.3}{10k}+5=0.83mA$

$\Rightarrow I_{D_1}=0.83-0.2=0.81mA$

2.

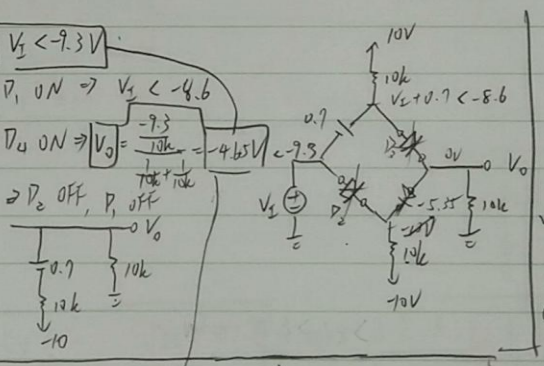


When $V_I<-9.3V$:

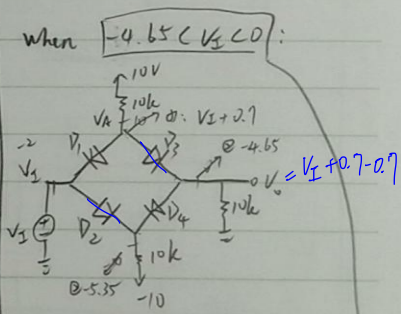
① D_1 ON $\Rightarrow V_I<-8.6$

② D_4 ON $\Rightarrow V_O=\frac{-9.3}{10k}\cdot 10k=-4.65V$

$\Rightarrow D_2$ OFF, D_3 OFF



When $-4.65<V_I<0$:



① D_1 ON: $V_A=V_I+0.7V$

② D_4 ON: $V_O=-4.65-0.7=-5.35V$

③ D_3 跨壓: $V_I+0.7-(-4.65)=V_I+5.35$

D_2 跨壓: $V_I+5.35$

$I=\frac{20-1.4}{20k}=0.93mA$

$V_B=-0.7V$, $V_A=0.7V$

$\Rightarrow D_2$, D_3 ON

$\Rightarrow V_O=V_I$

$V_O=V_I+0.7-0.7$

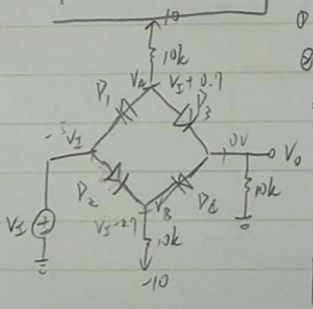
When $-9.3<V_I<-4.65$:

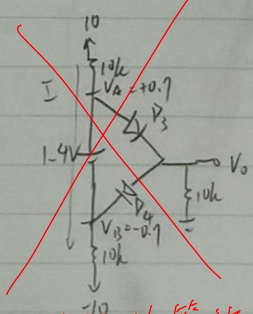
① D_1 ON $\Rightarrow V_A=V_I+0.7$

② D_4 ON $\Rightarrow V_O=-4.65V$, $V_B=-5.35V$

$\Rightarrow D_2$, D_3 OFF

the same as when $V_I<-9.3$





不能把 Vx 等效掉

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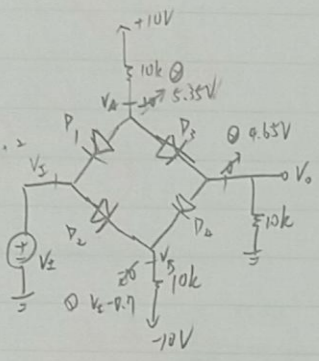
When $0 < V_I < 7.3V$



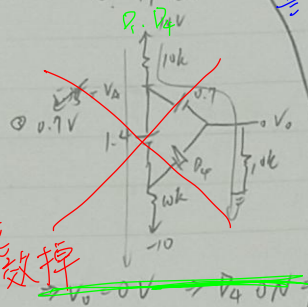
① D_2 ON → $V_B = V_I - 0.7$

② D_3 ON:

$V_o = \frac{10-0.7}{20k} \cdot 10k = 4.65V$

If $0 < V_I < 4.65$

① D_1 ON



不能把V_I等效掉

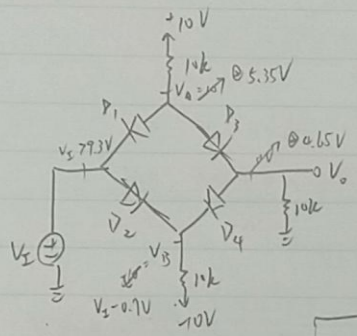
$V_o = 0V \Rightarrow D_4$ ON $\Rightarrow V_o = V_I$

(the same as when $-4.65 < V_I < 0V$)

If $4.65 < V_I < 9V$

D_1, D_4 OFF $\Rightarrow$ $V_o = 4.65V$

When $V_I > 7.3V$



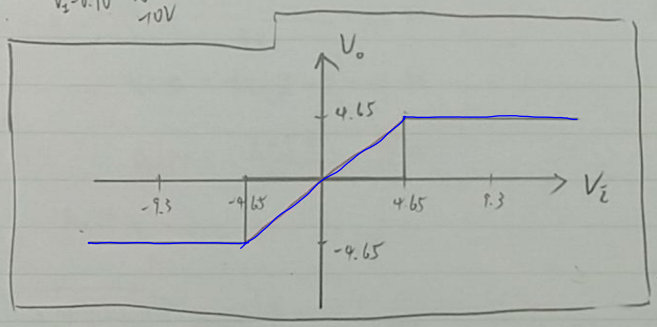
① D_2 ON $\Rightarrow V_B = V_I - 0.7V$

② D_3 ON

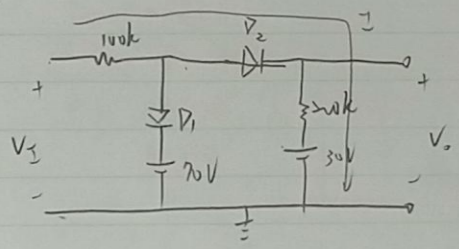
$V_o = 4.65V$

D_1, D_4 OFF $\Rightarrow$ $V_o = 4.65V$

So:



※2



When $V_I < 30V$:

D_1, D_2 OFF $\Rightarrow V_o = 3V$

~~When $3V < V_I < 7V$:~~

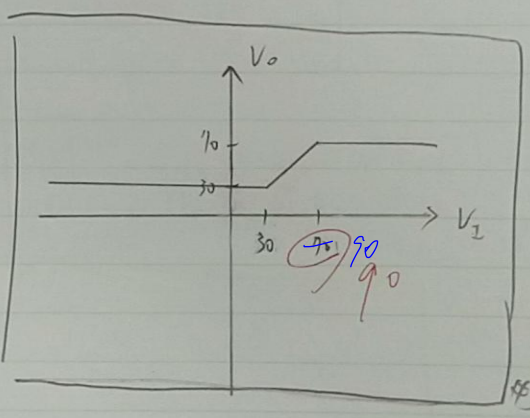
~~D_2 ON~~

~~$\frac{V_I - 3}{100} = \frac{}{30k}$~~

~~When $V_I > 7V$:~~

~~D_1, D_2 ON $\Rightarrow V_o = 7V$~~

So:



※3

-10

~~7~~

when $V_I \geq 30V$:

$$V_o = \frac{\frac{V_I}{100} + \frac{3}{30}}{\frac{1}{30} + \frac{1}{100}} = \frac{2V_I + 30}{3} = \frac{2}{3}V_I + 10$$

If $\frac{2}{3}V_I + 10 \geq 70V \Rightarrow V_I \geq 60 \cdot \frac{3}{2} \Rightarrow V_I \geq 90V$: $V_o = 70V$

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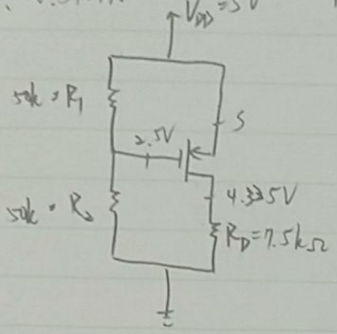
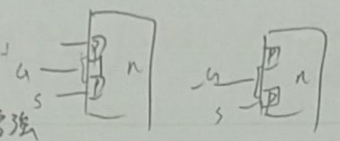
4. $I_D = ?$ 0.516mA





PMOS增強

$V_t = -0.8V$

$k_p = 0.2 mA/V^2$

設在飽和區：

$I_D = k_p (V_{SG}+V_t)^2 \Rightarrow I_D = 0.2m(2.5-0.8)^2 = 0.578mA$

$V_G = 2.5V \Rightarrow V_{GS} = -2.5V$

check：

$V_D = I_D R_D = 4.335V \Rightarrow V_{DS} = -0.665$

$V_{GS} - V_{DS} = [-2.5 - (-0.665)] = -1.835 < -0.8$ (X)

在非飽和區：

$I_D = k_p[2(V_{SG}+V_t)V_{SD} - V_{SD}^2]$

$I_D = 0.2m[(2.5+0.8)\cdot V_{SD} - V_{SD}^2]$

$I_D = \frac{5-V_{SD}}{7.5k}$

$\Rightarrow 5 - V_{SD} = 1.5[3.4V_{SD} - V_{SD}^2] = 5.1V_{SD} - 1.5V_{SD}^2$

$\Rightarrow -1.5V_{SD}^2 + 6.1V_{SD} - 5 = 0 \Rightarrow V_{SD} = 2.93$ or 1.13 (不合)

$V_{GS}-V_{DS} = 0.43 > 0.8$

$V_{GS}-V_{DS} = -1.37 < 0.8$

$\Rightarrow \boxed{I_D = \frac{5-1.13}{7.5k} = 0.516mA}$ ※4

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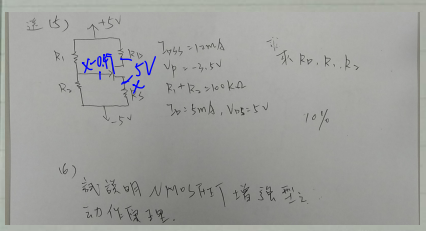

設在飽和區：

$I_D = 5m = 12m\left(1-\frac{V_{GS}}{-3.5}\right)^2 \Rightarrow \frac{5}{12} = 1 - \frac{V_{GS}^2}{3.5^2} \Rightarrow V_{GS} = \pm\frac{7}{12}\cdot(3.5)^2 \fallingdotseq \pm 7.15V$ (正不合) (負不合)

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設在非飽和區：

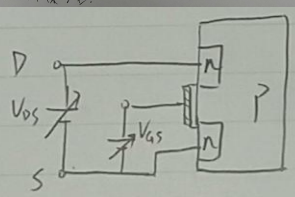
$I_D = 5m = 12m\left(2\left(1-\frac{V_{GS}}{-3.5}\right)\cdot\frac{5}{3.5} - \left(\frac{5}{3.5}\right)^2\right) \Rightarrow \frac{5}{12} = \left[2+\frac{2V_{GS}}{3.5}\right]\cdot\frac{10}{7} - \frac{100}{49} \Rightarrow V_{GS} = -0.49V$

$\Rightarrow V_{GD} = V_{DS} - V_{GS} = 5.49V$

當 $V_G > V_S$，S極中的電子受到正電吸引，如果 $V_{GS} > V_T$，將吸引足夠多的電子形成通道，反之則無法吸引足夠多的電子形成通道，無法導通

如果 $V_{GS} > V_T$，但 $V_G - V_D < V_T$，D,G 接面處將夾止，造成電流不會無限隨著 V_{DS} 上升而增加 ⇒ 這代表什麼？

此時 E-NMOS 導進入飽和區



$\frac{X+5}{R_S} = 5m = \frac{5-X-5}{R_D}$

沒給 R_S，會算不出來 ⇒ 送

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