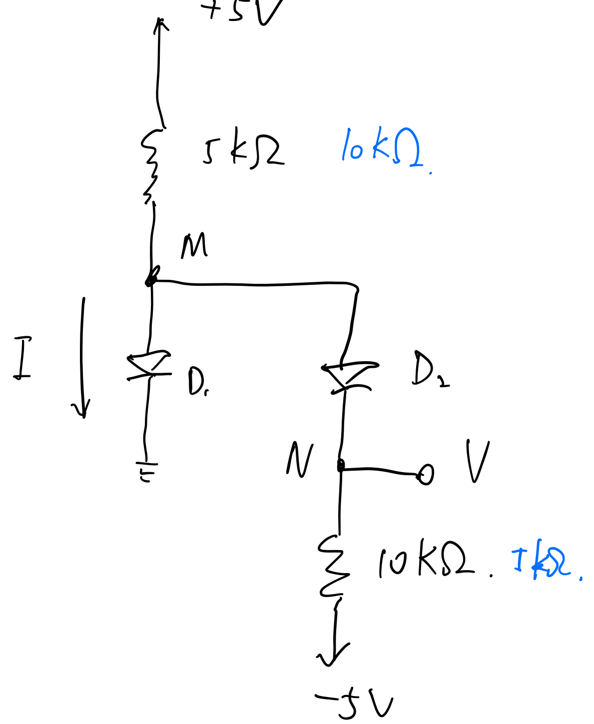
3.9



1° D_1、D_2 都导通.

$V_M = 0V$. $I_1 = \frac{V_0 - V_M}{R_1} = 1mA$

$V_N = V_M = 0V$. $I_2 = \frac{V_N - V_2}{R_2} = 0.5mA$

$I_2 < I_1$

故假设成立, $V = 0V$

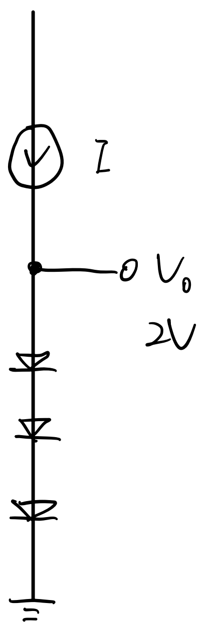
(b) 1° D_1 D_2 都导通

$V_M = 0V$. $I_1 = \frac{V_0 - V_M}{R_1} = 0.5mA$

$V_N = V = V_m = 0V$.

$I_2 = \frac{V_N - V_2}{R_2} = 0.5mA$

3.23



衡量二极管与理想模型偏差

$n=1$, $I_s = 10^{-14}A$ $\qquad i = I_s(e^{\frac{V}{nV_T}} - 1)$

$V_T = 25mV$ $\qquad \approx I_s e^{\frac{V}{nV_T}}$

∵ 流过每个二极管电流相同

∴ $V_0 = V_{D1} + V_{D2} + V_{D3} = 3V_D = 2V \Rightarrow V_D = \frac{2}{3}V$

$I = I_D = 10^{-14} \cdot e^{\frac{V_D}{nV_T}} \approx 3.82mA$

故初始电流为 3.82mA

$I_D' = I_s e^{\frac{V_D'}{V_T}} \Rightarrow V_T \ln\left(\frac{I_D'}{I_s}\right) = V_D'$

$V_D' = 0.025 \ln\left(\frac{2.82 \times 10^{-3}}{10^{-14}}\right) \approx 0.659V$

$V_0' = 3V_D' \approx 1.977V$ 故 $\Delta V = -0.023V$

3.75

$V_o = 0.7V$, $I = 1\,mA$

$V_o = 0.1V$ $I = 1\times 10^{-6}\,mA$

$V_o = 0.5V$, $I = 10^{-2}\,mA$

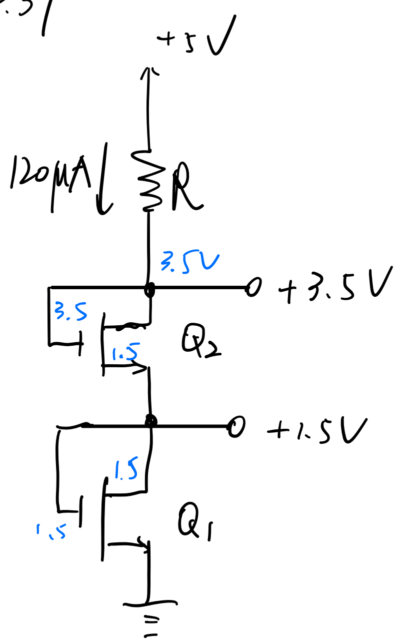
$V_o = 1V$, $I = 10^{3}\,mA$

$V_o = 2V$, $I = 10^{13}\,mA$

$V_o = 5V$. $I = 10^{43}\,mA$

$V_o = 10V$. $I = 10^{93}\,mA$

4.37



$V_t = 1V \quad \mu_n C_{ox} = 120\mu A/V^2$

$\lambda = 0. \quad L_1 = L_2 = 1\mu m$

$$R = \frac{5V - 3.5V}{120\mu A} = 12.5k\Omega.$$

对 1.

$V_{GS} = 2V,\ V_{DS} = 2.5V.\quad V_{DS} > V_{GS} - V_t$

$\rightarrow$ 在饱和区

对 2. $V_{GS} = 1.5V \quad V_{DS} > V_{GS} - V_t$

$\rightarrow$ 在饱和区.

$$I_{D_1} = \frac{1}{2} k_n' \frac{W_1}{L} (V_{GS_1} - V_t)^2$$

$$= 60 W_1 \quad = 120\mu A ?$$

$$I_{D_2} = \frac{1}{2} k_n' \frac{W_2}{L} (V_{GS_2} - V_t)^2.$$

$$= 15 W_2. \quad = 120\mu A ?$$

$W_1 = 2\ \mu m \qquad W_2 = 8\ \mu m$

4.42.

(a). $V_G = 0V$ $V_S = -10V$.

1° 在饱和区: $I_D = \frac{1}{2}k'W/L(V_{GS} - V_t)^2 = I_S$

$\Rightarrow V_{GS} = 4V$. $V_2 = 10V - 4kV \cdot 2mA = 2V$.

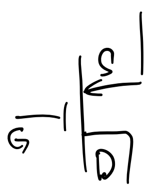
$V_1 = -4V$. $\Rightarrow V_{DS} = 6V$ $V_{DS} > V_{GS}$ $\Rightarrow$ 假设成立

(b) $V_G = V_D = V_3$. $V_S = 0$

1° 在饱和区 $I_D = \frac{1}{2}k'W/L(V_{GS} - V_t)^2 = 1mA$

$V_{GS} = 3.41V. = V_3$.

(c) $I_D = 2mA = \frac{1}{2}k'W/L(V_{GS} - V_t)^2$



$\Rightarrow V_{GS} = -4V$ $\Rightarrow V_4 = V_S = 4V$

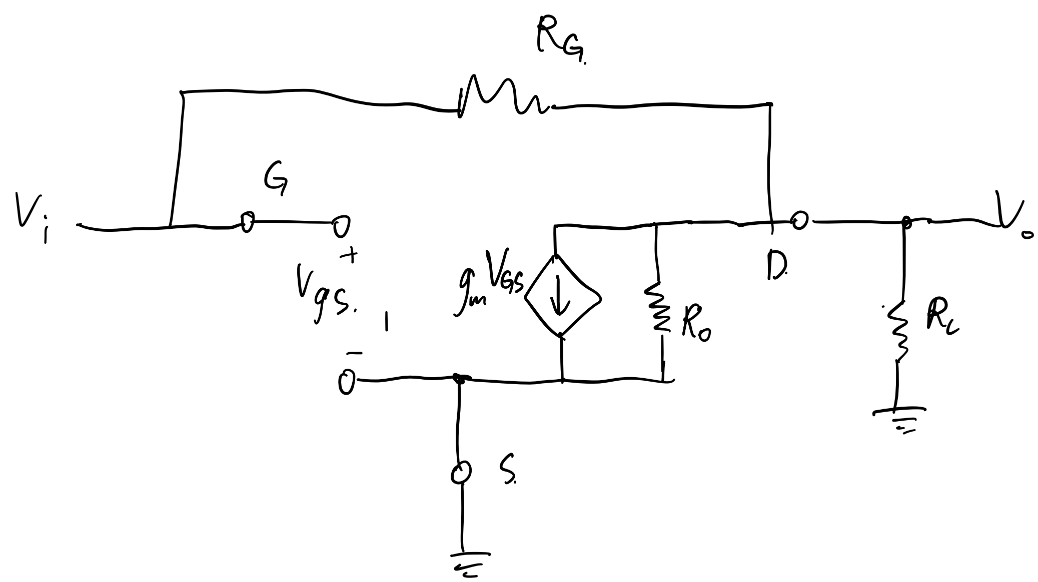
$V_5 = -10V + 2.5k\Omega \cdot 2mA = -5V$

$V_{DS} = -9V$. $V_{DS} < V_{GS}$?

(d) $I_D = 2mA$ $\Rightarrow V_{GS} = -4V$ $\Rightarrow V_6 = 6V$.

$V_7 = V_6 - 4V = 2V$

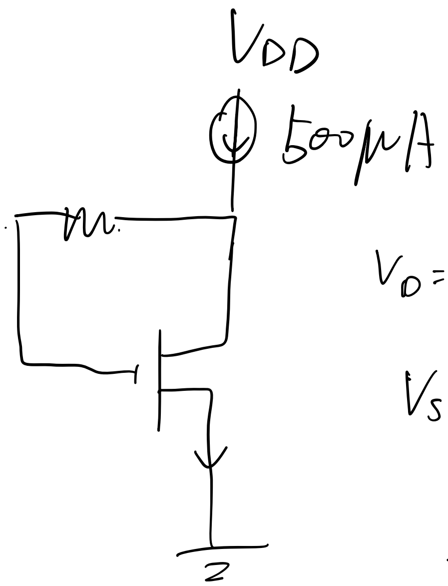
4.75 $|V_t| = 0.9V$, $V_A = 50V$. $V_D = 2V$,



$R_o = \frac{V_A}{I_D} = 100k\Omega$. $g_m = k_n' \frac{W}{L}(V_{GS} - V_t)$

$= \frac{2 I_D}{V_{GS} - V_t} = \frac{2 \cdot 0.5}{2 - 0.9} = 0.91 mA/V$

$$\frac{V_o}{V_i} = \frac{-g_m V_{gs}(R_o // R_L)}{V_{gs}} = -g_m (R_o // R_L) = -8.3$$



$V_O = 2V$. $I_D = 500\mu A = 0.5\,mA$

$V_S = 0$ $\quad V_{DS1} = 2V = V_{GS1}$

$$I_{D1} = \frac{1}{2} k_n' \frac{W}{L} (V_{GS1} - V_t)^2 = 0.5\,mA$$

$$I_{D2} = 1\,mA$$

$$\frac{I_{D2}}{I_{D1}} = \frac{2}{1} = \frac{(V_{GS2} - V_t)^2}{(V_{GS1} - V_t)^2}$$

$$V_{GS2} = 0.9 + \sqrt{2}(2 - 0.9) = 2.5\,V$$

$$V_O = 2.5\,V$$

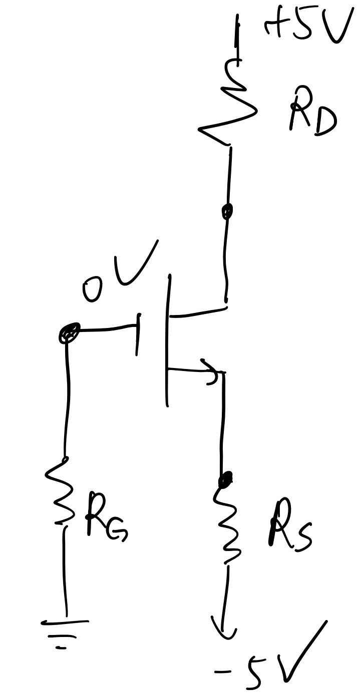
修改后：

$$g_{m2} = 1.3\,mA/V$$

$$r_{o2} = \frac{V_A}{I_D} = 50\,k\Omega$$

$$A = -g_{m2}(r_{o2} \| R_L) = -10.8$$

4.87 $V_t = 1V$. $k_n' W/L = 0.8\, mA/V^2$ $V_A = 40V$



(a) $I_D = 0.1\, mA$

$$= \frac{1}{2} \cdot 0.8 \cdot (V_{GS} - V_t)^2$$

$\Rightarrow V_{GS} = 1.5V$. $V_G = 0V$

$V_S = -5V + I_D R_S = -1.5V$

$R_S = 35k\Omega$

$V_G = (V_{GS} - V_t) + V_t + V_S$

$= 0V$

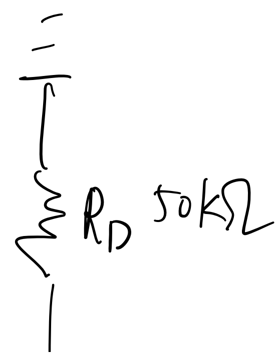
$R_D = \frac{5-0}{0.1} = 50k\Omega$

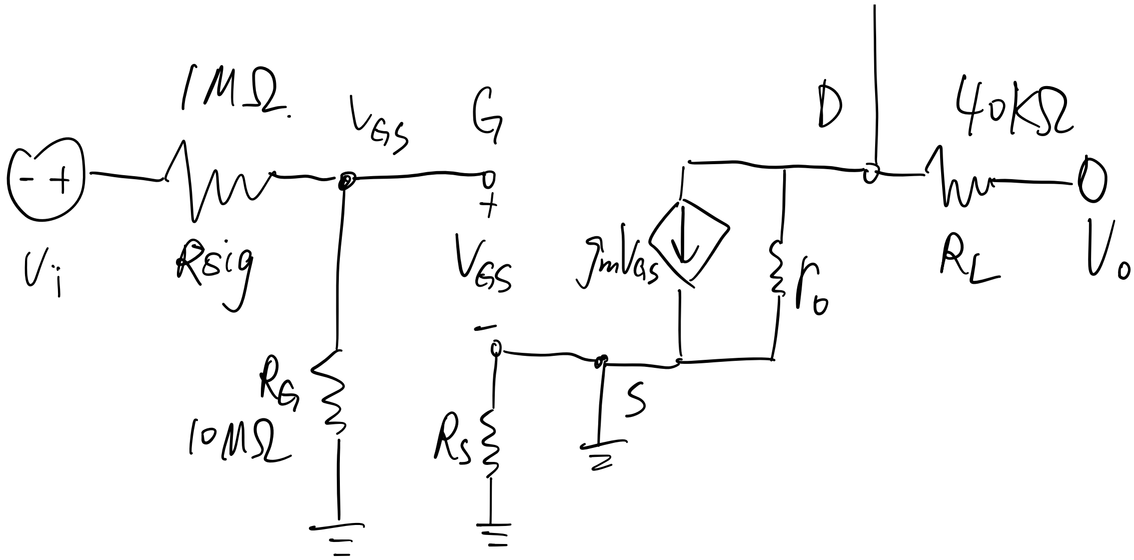
$R_G = 10M\Omega$

(b) $g_m = \frac{2I_D}{V_{GS} - V_t} = 0.4\, mA/V$

$r_o = \frac{V_A}{I_D} = 400k\Omega$

(c)





$$V_o = -g_m V_{GS}\left((r_o \| R_D) + 40\right)$$

$$V_i = \frac{V_{GS}}{R_G}\left(R_G + R_{sig}\right)$$

$$\frac{V_o}{V_i} =$$

(d) t模型

$$CD:\ A_{vo} = \frac{r_o \| R_S}{\frac{1}{g_m} + (r_o \| R_S)} = 0.93$$

$$R_{out} = \frac{1}{g_m} \parallel r_o \parallel R_S = 2.3k\Omega$$

(e) $R_{in} = \frac{1}{g_m} \parallel R_S = 2.33k\Omega$.

$$i_i = i_{sig} \frac{R_{sig}}{R_{sig} \parallel R_{in}} = 9.77\mu A$$

$$i = \frac{R_S}{R_S + \frac{1}{g_m}} i_i = 9.12\mu A$$

$$V_y = R_D \cdot i = 0.46V$$

5.80

(a) $I_E = 2mA \quad I_B = \frac{1}{\beta+1} I_E = 0.0198mA$

$$I_C = \frac{\beta}{\beta+1} I_E = 1.98mA.$$

$$V_B = -I_B \cdot R_B \quad V_1 = V_B - V_{BE} = -1.136V$$

$$V_2 = 5V - I_C R_C = 1.832V$$

(b) $V_B = 0V$. $V_E = -0.7V$ $I_4 = \frac{V_E - (-5V)}{2.2k\Omega}$

$= 1.955mA$

$I_C = \frac{\beta}{\beta+1} I_4 \Rightarrow V_3 = 5 - 1.6 \cdot \frac{100}{101} I_4$

$= 1.904V$

(c)

$$0 - \frac{I_E}{1+\beta} \cdot 22 - 0.7 - 2.2 I_E = -5$$

$\Rightarrow I_E = 1.778mA$

$V_7 = 5 - \frac{\beta}{1+\beta} I_E \times 1.6 = 2.183V$

$V_5 = -5 + 2.2 I_E = -1.087V$

$V_6 = V_5 + 0.7 = -0.387V$

(d) $5 - 3.3 I_E - 0.7 - \frac{1}{\beta+1} I_E \cdot 56 = 1.2$

$\Rightarrow I_E = 0.8147\,mA$

$V_8 = 5 - 3.3 I_E = 2.3114V$

$V_9 = -5V + 5.1 \cdot \frac{\beta}{\beta+1} \cdot I_E$

$= -0.8862V$

(e) $V_{BB} = -5 + \frac{150}{150+91} \cdot (5+5) = 1.224V$

$R_{BB} = (150 // 91) = 56.64k\Omega$

$5 - 3.3 I_E - 0.7 - \frac{I_E}{\beta+1} R_{BB} = 1.224V$

$\Rightarrow I_E = 0.7967\,mA$

$V_{11} = 5 - 3.3 I_E = 2.371V$

$$V_{12} = \frac{B}{\beta+1} I_E \cancel{\cdot} 5.1 - 5 = 0.977V$$

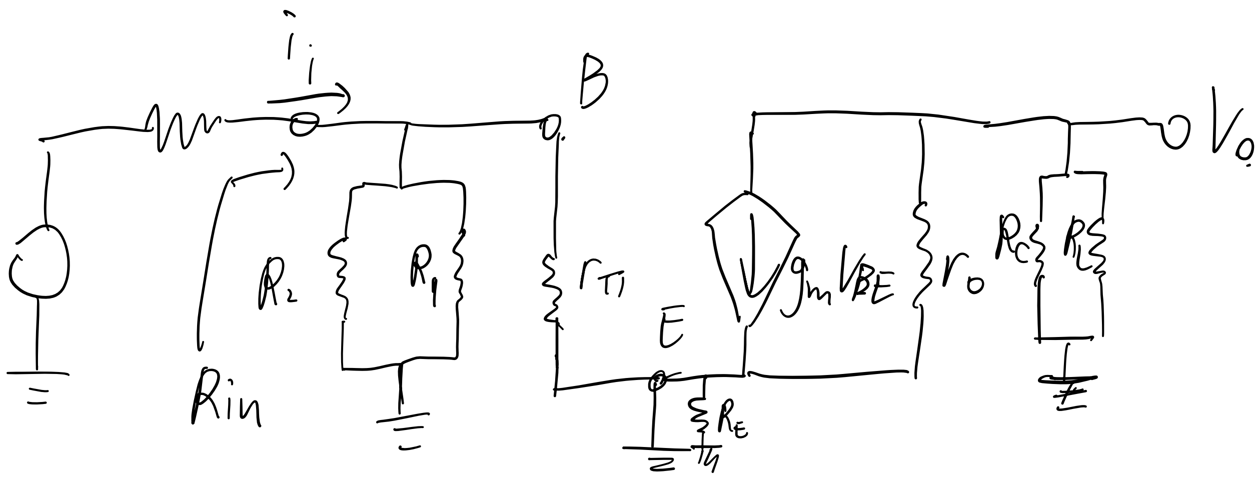
$$V_{10} = V_{11} - 0.7V$$

5.130.

$$V_{BB} = V_{CC} \cdot \frac{R_2}{R_1+R_2} \qquad R_B = (R_1 // R_2) = 9.64k\Omega$$

$$V_{BB} - \frac{1}{\beta+1} I_E R_B - 0.7 - I_E R_E = 0$$

$$\Rightarrow I_E = 1.94mA$$



$$V_o = - g_m V_\pi (R_c // R_L)$$

$$i_i = \frac{V_\pi}{(R_1 // R_2 // R_\pi)}$$

$$V_{sig} = V_\pi + i_i R_{sig}$$

$$= \left(1 + \frac{R_{sig}}{R_1 // R_2 // R_\pi}\right) V_\pi$$

$$\frac{V_o}{V_{sig}} = \frac{-g_m (R_C // R_L)}{1 + \frac{R_{sig}}{(R_1 // R_2 // R_\pi)}} = -8.13$$

$$i_o = \frac{V_o}{R_C} = -g_m V_\pi \frac{(R_c // R_L)}{R_L}$$

$$\frac{i_o}{i_i} = \frac{-g_m \frac{(R_c // R_L)}{R_L}}{(R_1 // R_2 // R_\pi)} =$$

$$-45.3$$

$g_m = I_C / V_T \quad r_\pi = \beta / g_m \quad r_o = \frac{V_A}{I_C}$

5.136.

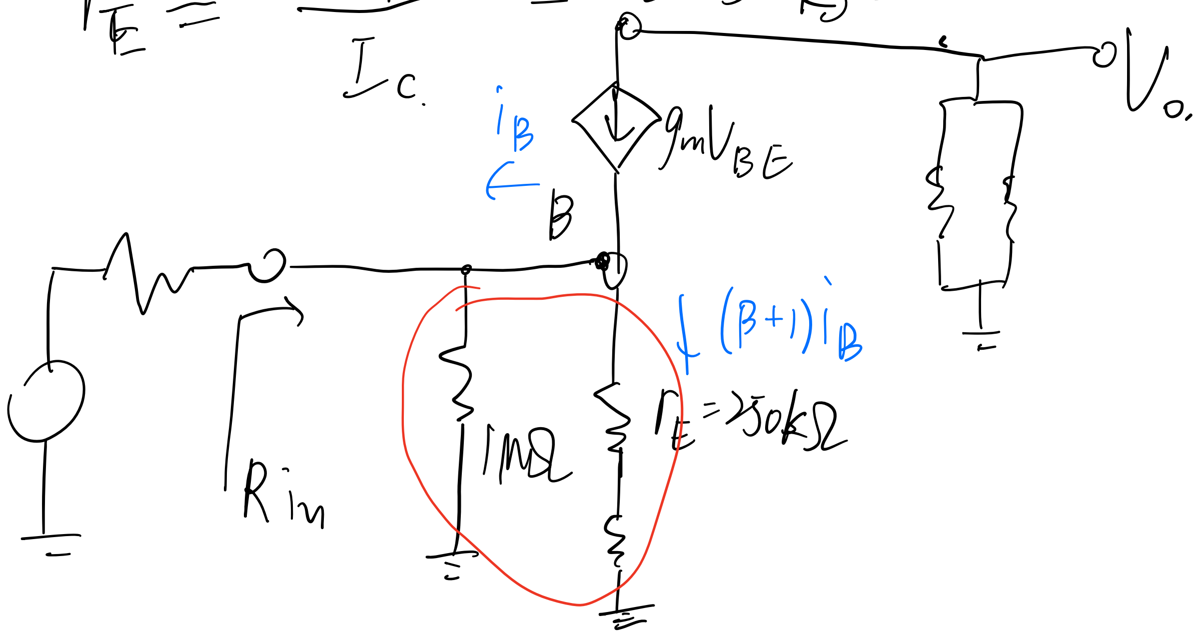
$I_E = 0.1\,mA. \quad I_B = \frac{1}{\beta+1} I_E$

$= 9.9 \times 10^{-4}\,mA$

$I_C = 9.9 \times 10^{-2}\,mA$

$g_m = I_C / V_T = 1.41 \times 10^{-3}\,mA/V$

$r_E = \frac{\frac{\beta}{1+\beta}}{I_C} = 250\,k\Omega$



$R_{in} = 50.5k\Omega$

$$\frac{U_b}{U_s} = \frac{R_{in}}{R_s + R_{in}} = 0.72$$

$$\frac{U_o}{U_b} = \frac{-2(20//20)}{(r_e + R_E)} = -19.8$$

$U_{be} = 5mv$, $V_e = 5mV$

$U_b = 10mV$ $U_s = 13.88mV$

$U_o = 13.88 \times 14.2$

$= 197.2mV$

5.147

(a).

$V_{BB} = 4.5V$. $R_{BB} = 10k\Omega$.

$$4.5 - \frac{1}{\beta+1} I_E (10+10) - 0.7 - 2 I_E = 0.$$

$\Rightarrow I_E = 1.73 \ mA$

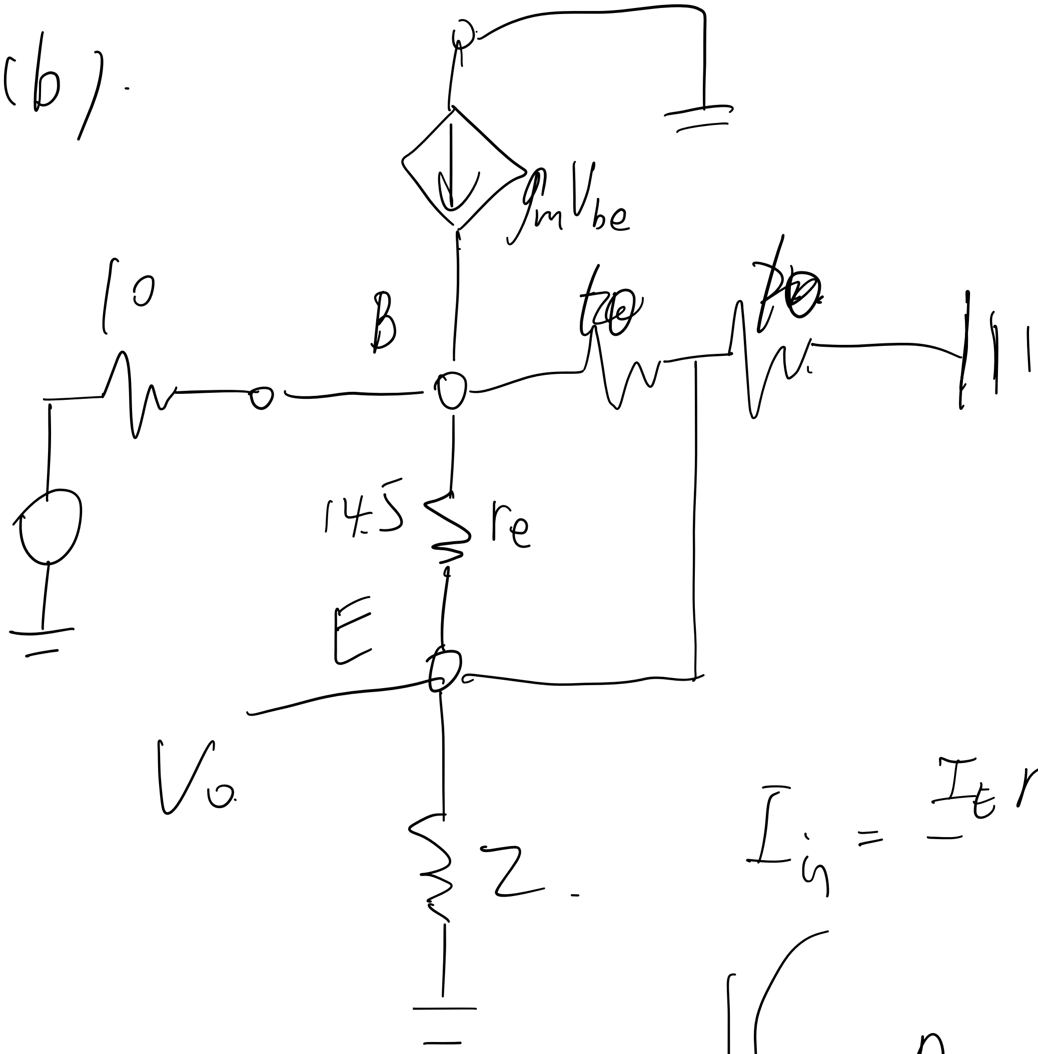
$I_C = 1.71 mA$.

$$g_m = \frac{I_C}{V_T} = 68.5 \ mA/V$$

$$r_e = \frac{\frac{\beta}{\beta+1}}{g_m} = 14.5k\Omega$$

$$r_\pi = \frac{\beta}{g_m} = 1.46k\Omega.$$

(b).



$$I_{in} = \frac{I_t}{r_e}\left(\frac{1}{r_e} + \frac{1}{20}\right)$$

$$R_i = \frac{V_b}{I_{in}} = 120\ k\Omega$$

$$V_o = (Z \parallel 10) \cdot I_E$$

$$\frac{V_o}{V_{sig}} = \frac{V_b}{V_{sig}} \cdot \frac{V_o}{V_b} =$$

$$\frac{R_i}{R_i + R_s} \quad \frac{114.48}{115.48} = 0.92.$$

6.34. $\beta = \infty \Leftrightarrow i_B = 0.\ i_E = i_C.$

6.34 Find the voltages at all nodes and the currents through all branches in the circuit of Fig. P6.34. Assume $|V_{BE}| = 0.7$ V and $\beta = \infty$.

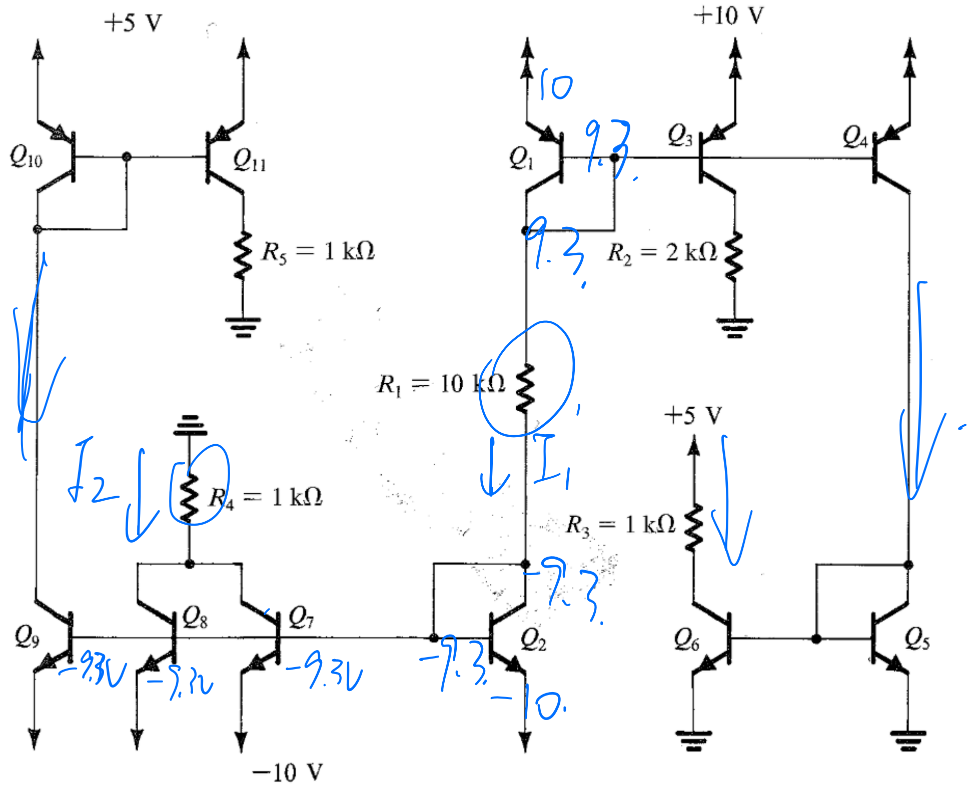


FIGURE P6.34

$$I_1 = \frac{2 \times 9.3}{R_1} = 1.86\,mA$$

$$I_{E1} = I_{C2} = \ldots = I_{C6} =$$

$$\ldots = I_{C11} = 1.86\,mA.$$

$V_{C3} = 3.72\,V$

$V_{C6} = 3.14\,V$

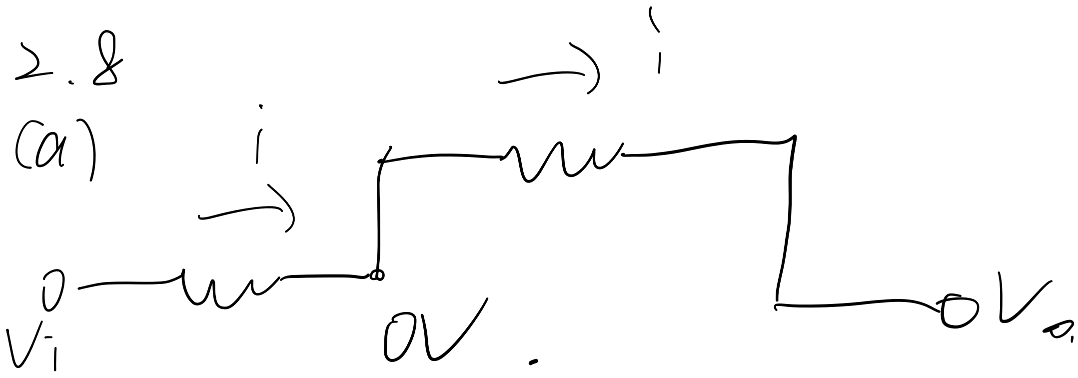
$V_{C11} = 1.86\,V$

$V_{C5} = 0.7\,V.$

$V_{C7} = -3.72\,V$

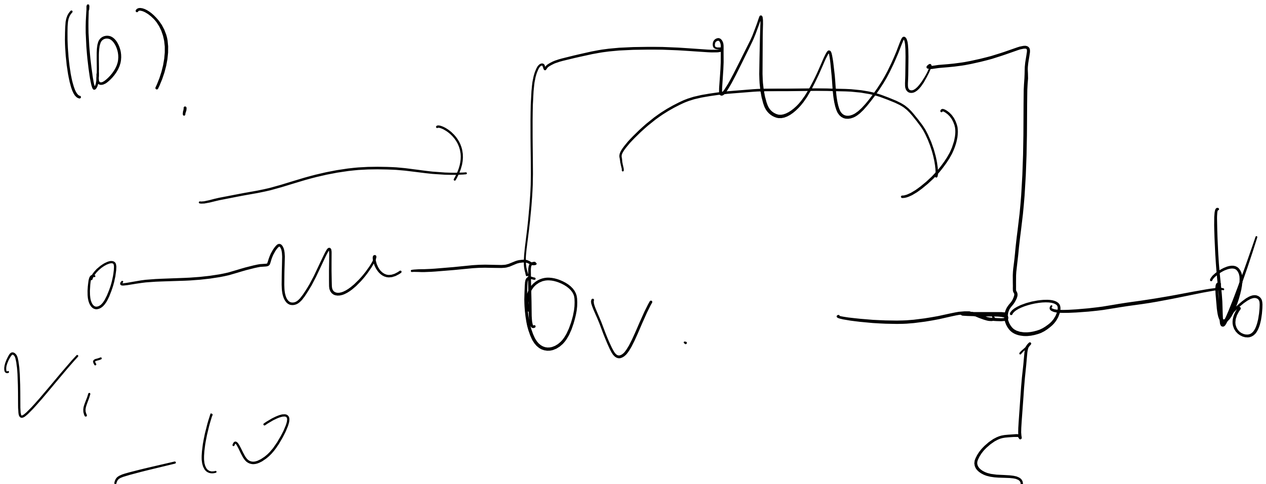
2.8

(a)



$$\frac{V_o}{V_i} = \frac{100}{-10} = -10. \quad R_{in} = 10k\Omega.$$

(b)



$$\frac{V_o}{V_i} = \frac{100}{-10} = -10.$$

$R_{in} = 10k\Omega.$

(c) $\frac{u_o}{u_i} = -10$. $R_{in} = 10$

(d) $\frac{u_o}{u_i} = -10$ $R_{in} = 10$

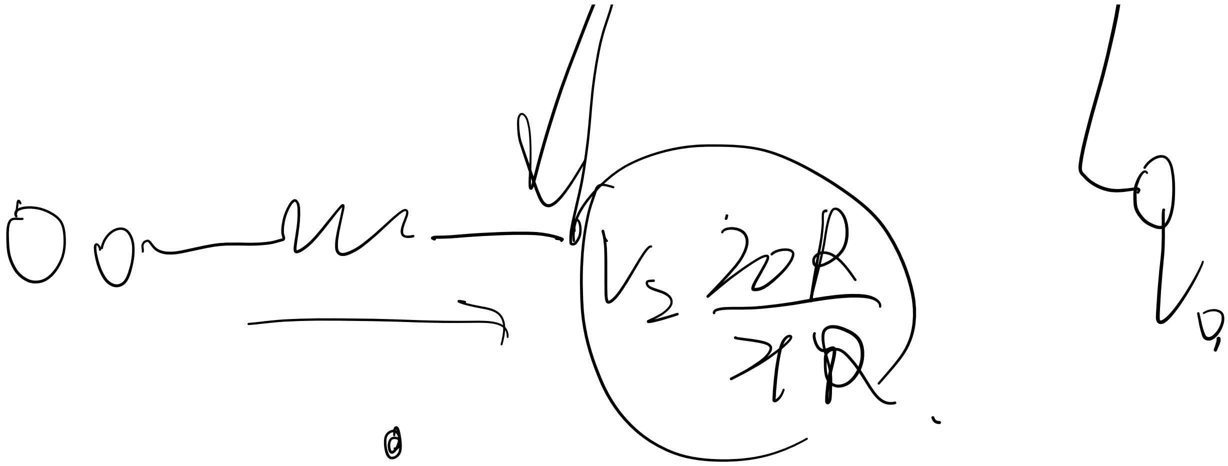
2.50.

叠加原理

$V_{o1} = -20V_1$

$V_{o2} = V_2\left(\frac{20R}{21R}\right)$

$0 \leftarrow 0$



$$V_{o2} = V_2\left(\frac{21R}{R}\right)\left(\frac{20R}{21R}\right)$$

$$= 20V_2$$

$$V_o = V_{o1} + V_{o2}$$

$$= 4\sin(2\pi \times 1000t)$$

2. b2.

V_1 only: $R_I = \frac{U_1}{I} = R$.

V_2 only: $R_I = \cancel{2}R$.

?! between 2 terminals:

$R_I = \frac{U}{I} = 2R$.

$V_+ = V_- = 0$.

?? V_s connected ~~to~~ both V_1 and V_2.

$R_I = \frac{U}{I} = R$. $V_+ = U_- = \frac{U_s}{2}$

13.26.

13.26 For the circuit in Fig. P13.26, sketch and label the transfer characteristic v_O–v_I. The diodes are assumed to have a constant 0.7-V drop when conducting, and the op amp saturates at ±12 V. What is the maximum diode current?

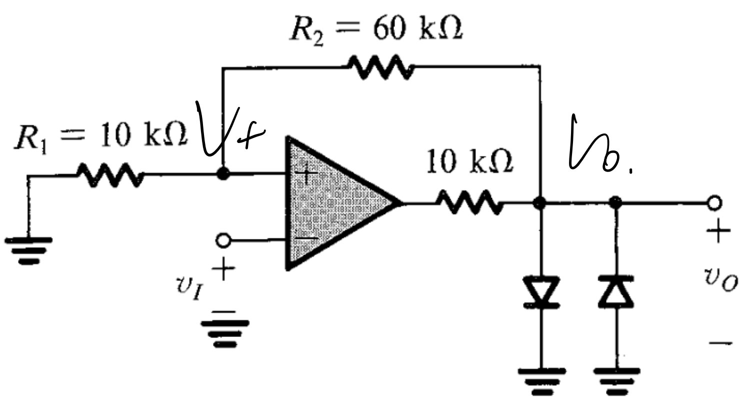
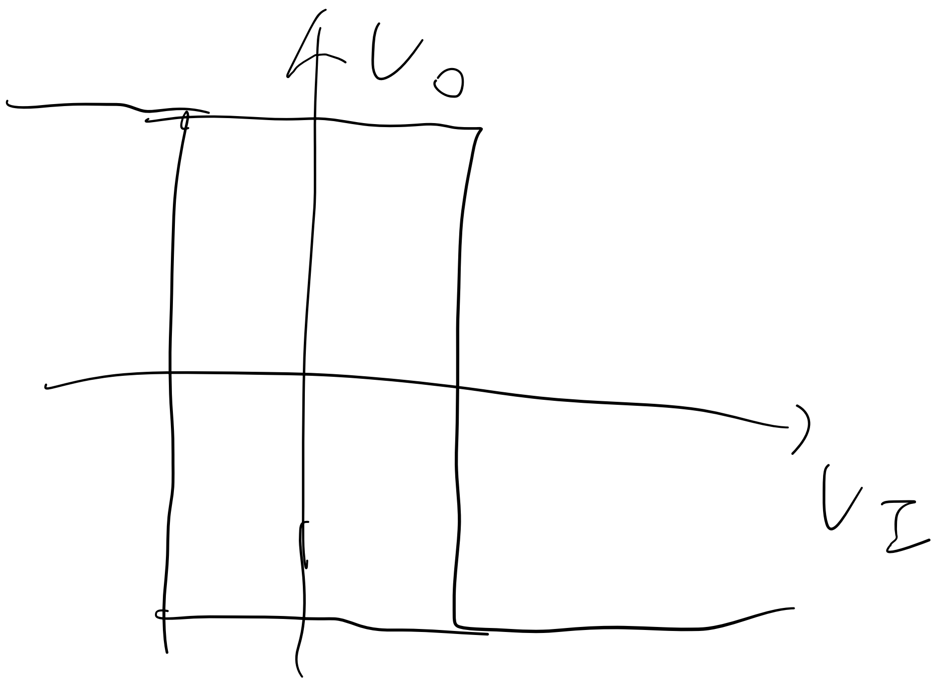


FIGURE P13.26

$$V_+ = \frac{1}{7} V_o$$

$$V_o = 0.7V / -0.7V.$$

$$V_+ = 0.1V / -0.1V$$


v_O
v_I