Homework II

1. $R_1 = R_3$
   $R_2 = R_4$

   $R_{id} = 2R_1$
   $10 = 2R_1$
   $\Rightarrow R_1 = 5k\Omega = R_3$

(a) $1\ V/V$

$$A_d = \frac{R_2}{R_1}$$

$$1 = \frac{R_2}{5} \Rightarrow R_2 = 5k$$

$\therefore R_1 = R_3 = 5k\Omega$
$R_2 = R_4 = 5k\Omega$ #

(b) $5\ V/V$

$$A_d = \frac{R_2}{R_1}$$

$$5 = \frac{R_2}{5} \Rightarrow R_2 = 25k$$

$\therefore R_1 = R_3 = 5k\Omega$
$R_2 = R_4 = 25k\Omega$ #

(c) $10\ V/V$

$$A_d = \frac{R_2}{R_1}$$

$$10 = \frac{R_2}{5} \Rightarrow R_2 = 50k$$

$\therefore R_1 = R_3 = 5k\Omega$
$R_2 = R_4 = 50k\Omega$ #

(d) $25\ V/V$

$$A_d = \frac{R_2}{R_1}$$

$$25 = \frac{R_2}{5} \Rightarrow R_2 = 125$$

$\therefore R_1 = R_3 = 5k$
$R_2 = R_4 = 125k$ #

2. $V_0 = -V_1$

① $V_0 = \frac{R}{R+R}\left(1+\frac{R}{R}\right)V_2 = V_2$

$\Rightarrow V_0 = V_2 - V_1$

$R_{i1} = \frac{dV_1}{di_1}$

$V_1 = \frac{V_2}{2} + i_1 R$

$\Rightarrow R_{i1} = R$ #

② $R_{i2} = 2R$

$V_2 - V_1 = V$

$\Rightarrow R_{id} = \frac{dV}{di}$

$V = V_0$

$V - V_1 = V_2 \Rightarrow V = V_2 - V_1$

$V_2 = 2Ri$

$R_i = 2R$ #

③
$$\begin{cases} 2I_x R - V_x + 2I_x R = V_0 \\ V_0 = V_2 - V_1 = V_x \end{cases}$$

$\Rightarrow 4I_x R = 2V_x$

$\Rightarrow R_i = \frac{V_x}{I_x} = 2R$ #

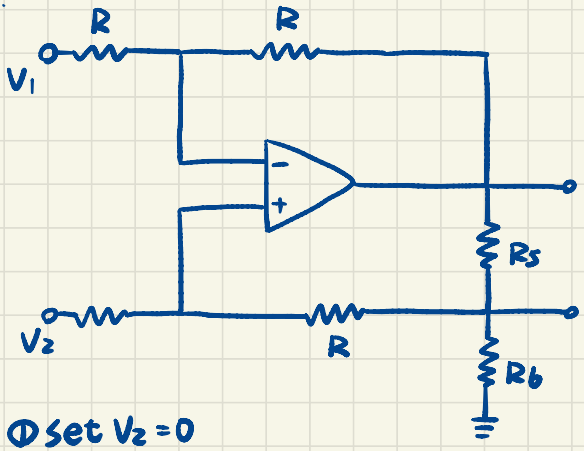
④ $V^+ = \frac{R_4}{R_3+R_4}V_x = 0.5V_x = V^-$

$i_1 = \frac{\Delta V}{R} = \frac{0.5V_x}{R} = \frac{V_x}{2R} = i_2$

$I_x = i_1 + i_2 = \frac{V_x}{R}$

$\Rightarrow R_i = \frac{V_x}{I_x} = R$ #

3.



① Set $V_2 = 0$

$$\frac{V^+ - V_2}{R} + \frac{V^+ - \beta V_{02}}{R} = 0 \Rightarrow 2V^+ = \beta V_{01}$$

$$\frac{V^- - V_1}{R} + \frac{V^- - V_{01}}{R} = 0 \Rightarrow 2V^- = V_1 + V_{01}$$

$$\because V^+ = V^- \Rightarrow \beta V_{01} = V_1 + V_{01} \Rightarrow V_{01} = \frac{V_1}{\beta - 1}$$

② Set $V_1 = 0$

$$\frac{V^+ - V_2}{R} + \frac{V^+ - \beta V_{02}}{R} = 0 \Rightarrow 2V^+ = V_2 + \beta V_{02}$$

$$V^- = V_{02} \cdot \frac{R}{R+R} = \frac{V_{02}}{2} \Rightarrow 2V^- = V_{02}$$

$$\because V^+ = V^- \Rightarrow V_{02} = V_2 + \beta V_{02} \Rightarrow V_{02} = \frac{V_2}{1-\beta}$$

$$\Rightarrow V_0 = V_{01} + V_{02} = \frac{V_1}{\beta - 1} + \frac{V_2}{1-\beta} = \frac{V_{Id}}{1-\beta}$$

$$\Rightarrow A_d = \frac{V_0}{V_{Id}} = \frac{1}{1-\beta} \#$$

$$R_{id} = 2R = 2M\Omega \Rightarrow R = 1M\Omega \#$$

$$A_d = \frac{1}{1-\beta} = 10 \Rightarrow \beta = 0.9 = \frac{R_6}{R_5 + R_6} \Rightarrow R_5 = \frac{1}{9} R_6$$

$$\Rightarrow R_5 + R_6 \le \frac{R}{100} = 10k\Omega \Rightarrow R_6 \le 9k\Omega \Rightarrow R_6 = 9k\Omega,\ R_5 = 1k\Omega \#$$

4. $n_i = BT^{3/2} e^{-Eg/2kT}$

① hole

$N_A = 5\times10^{18}/cm^3$ #

② electron concentration

$$n_i = (1.3\times10^{15} cm^{-3}K^{-3/2})(300K)^{\frac{3}{2}} \cdot e^{\frac{-1.12eV}{2\cdot8.62\times10^{-5}eV/k\cdot300k}}$$

$\fallingdotseq 1.5\times10^{10}$

$$\Rightarrow n = \frac{n_i^2}{P} = \frac{(1.5\times10^{10})^2}{5\times10^{18}} \fallingdotseq 45/cm^3 \#$$

5. $I_S = n_i^2$

$n_i = BT^{3/2} e^{-Eg/2kT}$

① 300K

$n_i = (1.3\times10^{15} cm^{-3}K^{-3/2})\cdot(300K)^{3/2} \cdot e^{-1.12eV/(2\cdot(8.62\times10^{-5}eV/K)\cdot300K)}$

$= 1.49\times10^{10}$

② 305k

$n_i = (1.3\times10^{15} cm^{-3}K^{-3/2})\cdot(305k)^{3/2} \cdot e^{-1.12eV/(2\cdot(8.62\times10^{-5}eV/K)\cdot305K)}$

$= 2.16\times10^{10}$

$$\frac{②^2}{①^2} = \frac{(2.16\times10^{10})^2}{(1.49\times10^{10})^2} \fallingdotseq 2.1 \#$$

6. $I_S = A q n_i^2 \left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A} \right)$

$= (100 \times 10^{-8} cm^2) \times (1.6 \times 10^{-19} C) \times (1.5 \times 10^{10} cm^{-3})^2$

$\times \left[\frac{10 cm^2/s}{(5 \times 10^{-4} cm \times 10^{16}/cm^3)} + \frac{18 cm^2/s}{(10 \times 10^{-4} cm \times 10^{17}/cm^3)} \right]$

$= 7.85 \times 10^{-17} A$ *

$I_{tot} = I_S (e^{V/V_T} - 1)$

$= 7.85 \times 10^{-17} A (e^{750mV/25.9mV} - 1)$

$\approx 2.96 \times 10^{-4} A$ *