VE311 HW2.

Question 1.

$i_1 = \frac{V_i}{2000} = i_2$

$V_o = 0 - 5V_i = -5V_i$

voltage gain $= \frac{V_o}{V_i} = -5$

$i_2 + i_o = i_L \Rightarrow \frac{V_i}{2000} + 0.001A = \frac{V_1}{5000}$

$\frac{-V_o}{10000} = \frac{V_o}{5000} - 0.001A$

$\Rightarrow V_o = 3.33V. \Rightarrow i_1 = i_2 = 0.33mA$

$V_i = -0.67V. \quad i_L = 0.66mA.$

$\frac{i_L}{i_1} = 2$. (current gain)

power gain: $\frac{V_o \cdot i_o}{V_i \cdot i_1} = 10$.

Question 2.

$i_1 = -\frac{V_i}{4000}$

$V_o = V_i - i_1 \cdot 12k\Omega = V_i + 3V_i = 4V_i$

$A = \frac{V_o}{V_i} = 4.$

$i_2 + i_o = i_L \Rightarrow \frac{V_i - V_o}{12k\Omega} + 1mA = \frac{V_o}{7k\Omega}$

$\frac{-\frac{3V_o}{4}}{12k\Omega} + 1mA = \frac{V_o}{7k\Omega}$

$\Rightarrow V_o = 4.87V. \quad i_1 = i_2 = 0.30mA$

$V_i = 1.22V. \quad i_L = 0.696mA$

Question 3

a) if R_G disconnected:

$V_o = V_{2d} + \frac{V}{R_2}(2R_1 + R_2) - (\frac{V}{R_2} + \frac{V_{1d}}{2R_1})(2R_1 + R_2)$

$= -\frac{R_2 V_{2d}}{2R_1}$

$\frac{V_o}{V_{2d}} = -\frac{R_2}{2R_1}$

b) $\begin{cases} \frac{V_A - V_{1x}}{R_1} = \frac{V_B - V_o}{R_2} \\ \frac{V_{1B} - V_x}{R_1} = \frac{V_x}{R_2} \end{cases} \Rightarrow \begin{cases} \frac{V_2 - V_B}{R_1} = \frac{V_o R_1}{R_2 R_G} + \frac{V_x}{R_2} \\ \frac{V_1 - V_A}{R_1} + \frac{V_o R_1}{R_2 R_G} = \frac{V_x - V_o}{R_2} \end{cases}$

Voltage over R_G: $\frac{R_1}{R_2} \cdot V_o$.

$V_{1D} = V_1 - V_2 = (V_B + \frac{V_o R_1^2}{R_2 R_G} + \frac{R_1 V_x}{R_2}) + (V_A + \frac{R_1 V_x - R_1 V_o}{R_2} - \frac{R_1^2 V_o}{R_2 R_G})$

$= -\frac{R_1}{R_2} V_o - \frac{2 V_o R_1^2}{R_2 R_G} - \frac{R_1 V_o}{R_2}$

$A = \frac{V_o}{V_{1D}} = -\frac{R_2 R_G}{2(R_1 R_G + R_1^2)}$

Question 4.

$V_{21} = \frac{3}{5}V_i$, $V_{22} = \frac{2}{3}V_i$

$V_{2d} = V_{22} - V_{21} = \frac{1}{15}V_i$

$A_d = -\frac{500k\Omega}{25k\Omega}\left(1 + \frac{10k\Omega}{1k\Omega}\right) = -22$

$\Rightarrow V_o = \frac{220}{15}V_i = \frac{44}{3}V_i$

or

$$\begin{cases} V_{i2} + I \cdot 10k = V_i \\ V_{i1} - I \cdot 10k = \frac{4}{15}V_i \end{cases}$$

also, $\frac{\frac{4}{15}V_i - V_k}{25} = \frac{V_k - V_o}{500}$

$\Rightarrow V_o = \frac{44}{3}V_i$

$A = \frac{V_o}{V_i} = \frac{44}{3}$.

Question 5

(a) $V_o = 0 - i_2 R_f$.

$R_m = \frac{V_o}{i_2} = -R_f$.

$R_i = \frac{V_i}{i_2} = 0$.

(b) $V_i = -\frac{V_o}{A}$ & $V_i - i_i R_f = V_o$

$\Rightarrow R_{mo} = \frac{V_o}{i_i} = -\frac{AR_f}{A+1}$

$R_i = \frac{V_i}{i_i} = \frac{R_f}{A+1}$

(c)

$V_i = -\frac{V_o}{A}$.

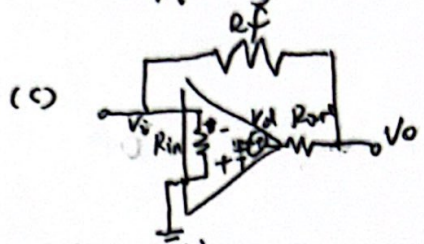
$V_o = V_i - i_i R_f = V + i_i R_{out}$.

$R_m = \frac{V_o}{i_i} = \frac{AV_i}{i_i V_i} = \frac{V}{\frac{V}{R_f} R_{out}}$.

$V = -AV_i - \frac{V}{R_f} R_{out}$.

$\left(1 + \frac{R_{out}}{R_f}\right) V = -AV_i$.

(c)

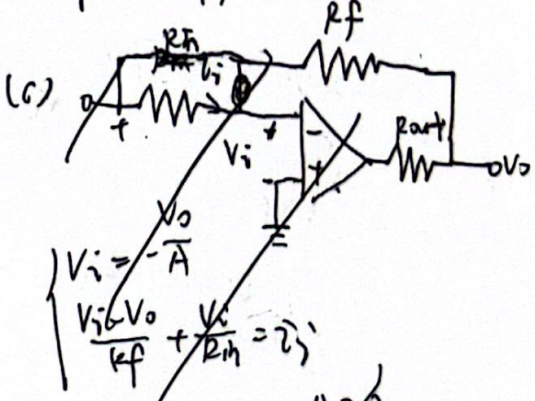


$V_d = -AV_i$.

$$\begin{cases} \frac{V_i - V_o}{R_f} + \frac{V_i}{R_{in}} = i_i \\ V_o = V_d + R_{out} \cdot \frac{V_i + V_o}{R_{in}(R_{out} + R_f)} \end{cases} \Rightarrow V_i = V_d + (R_{out} + R_f) \cdot \frac{V_i - V_o}{R_f}.$$

$$\Rightarrow \begin{cases} R_i = \frac{R_{in}(R_{out} + R_f)}{(1+A)R_{in} + R_{out} + R_f} \\ R_m = \frac{R_{out} - AR_f}{R_f + R_{out}} \cdot \frac{R_{in}(R_{out} + R_f)}{(1+A)R_{in} + R_{out} + R_f} \end{cases}$$

(c)



$$\begin{cases} V_i = -\frac{V_o}{A} \\ V_i - V_o \\ \hline R_f \end{cases} + \frac{V_i}{R_{in}} = i_i$$

$$\Rightarrow \begin{cases} R_m = -\frac{AR_f R_{in}}{R_{in} + AR_{in} + R_f} \\ R_i = \frac{R_f R_{in}}{R_{in} + AR_{in} + R_f} \end{cases}$$