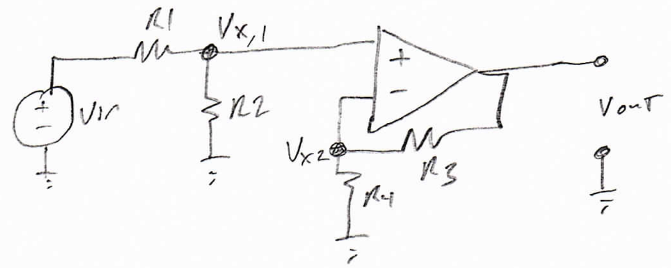
Midterm Solutions – ENGR 210

1 Model:



a) Find Av:

$$V_{x1} = \frac{R_2}{R_1+R_2}\cdot V_{in} \quad ; \quad V_{x2} = \frac{R_4}{R_3+R_4}\cdot V_{out}$$

$$V_{x1} = V_{x2} = \left(\frac{R_2}{R_1+R_2}\right)V_{in} = \frac{R_4}{R_3+R_4}V_{out} \Rightarrow \boxed{\frac{V_{out}}{V_{in}} = \frac{R_2(R_3+R_4)}{R_4(R_1+R_2)}}$$

b) Find Rin:

$$\frac{V_{in}}{I_{in}} = R_{in} \Rightarrow I_{in} = \frac{V_{in}}{R_1+R_2} \Rightarrow \boxed{R_{in} = R_1+R_2}$$

c) Find Rout:

$$\frac{V_{test}}{I_{test}} = R_{out} \Rightarrow \frac{V_{test}}{\infty} = R_{out} \Rightarrow \boxed{R_{out} = 0\,\Omega}$$

d) Find R_1, R_2, R_3, R_4; $V_{DD}/V_{SS} = +/-5V$; $V_{in} = +/-2.5V$; Max Av, $R_{in} = 10K$

$R_1 = R_2 = 5K \Rightarrow [R_1+R_2 = 10K]$

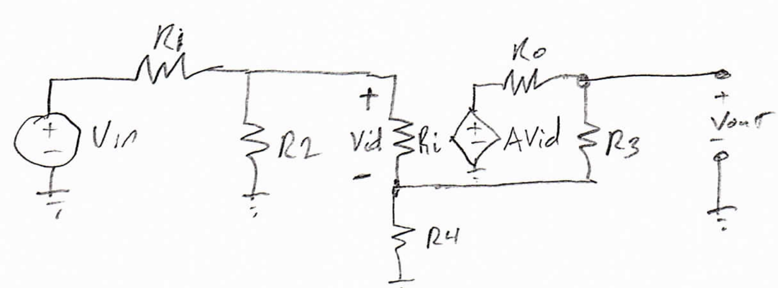
$$\frac{V_{out}}{I_{out}} = R_3+R_4 \Rightarrow \frac{5}{10mA} = [500\,\Omega = R_3+R_4]$$

Gain: $V_{in} = 2.5$, $V_{out} = 5V \Rightarrow A_v = 2$

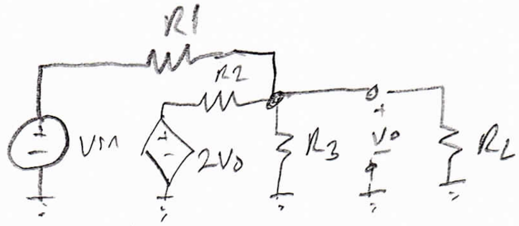
$$A_v = \frac{R_2(R_3+R_4)}{R_4(R_1+R_2)} = 2 \Rightarrow \frac{R_2(500)}{R_4(10K)} = 2 \Rightarrow \left[\frac{R_2}{R_4} = 40\right]$$

Since $R_2 = 5K$, then $\boxed{R_4 = 125\,\Omega \text{ and } R_3 = 375\,\Omega}$

e) Draw non-ideal amp



2 Model;



a) Find Norton "I_N" & "R_N"

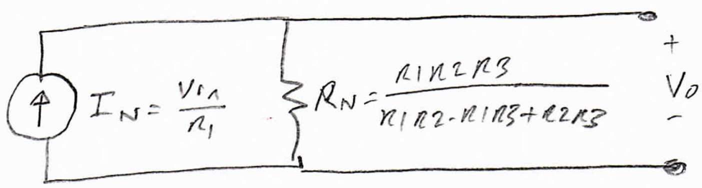
$$I_N \Rightarrow R_L = 0 \Rightarrow \frac{V_{in}-0}{R_1} + \frac{0-0}{R2} - \frac{0}{R3} - I_N = 0 \Rightarrow \boxed{I_N = \frac{V_{in}}{R_1}}$$

$$R_N \Rightarrow \frac{V_{test}}{I_{test}} \Rightarrow I_{test} = \frac{V_{test}}{R3} + \frac{V_{test} - 2V_{test}}{R2} + \frac{V_{test}}{R_1}$$

$$\Rightarrow I_{test} = V_{test}\left(\frac{1}{R3} - \frac{1}{R2} + \frac{1}{R1}\right) = V_{test}\left(\frac{R1R2 - R1R3 + R2R3}{R1R2R3}\right)$$

$$\Rightarrow \boxed{R_N = \frac{R1R2R3}{R1R2 - R1R3 + R2R3}}$$

b) Draw Equivalent Model



c) Determine "R_L"

$$\boxed{R_L = R_N = \frac{R1R2R3}{R1R2 - R1R3 + R2R3}}$$

d) Find "P_L"

$$P_L = I_L^2 R_L = \left(\frac{I_N}{2}\right)^2 R_L = \frac{V_{in}^2}{4R_1^2} \cdot \frac{R1R2R3}{R1R2 - R1R3 + R2R3} = \frac{V_{in}^2 R2R3}{4R_1(R1R2 - R1R3 + R2R3)}$$

e) Find "A_V"

$$\frac{V_{in} - V_{out}}{R_1} + \frac{2V_{out} - V_{out}}{R2} - \frac{V_{out}}{R3} - \frac{V_{out}}{R_L} = 0$$

$$\frac{V_{in}}{R_1} = V_{out}\left(\frac{1}{R1} - \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R_L}\right) = 0$$

$$\boxed{A_V = \left(1 - \frac{R_1}{R2} + \frac{R_1}{R3} + \frac{R_1}{R_L}\right)^{-1}}$$