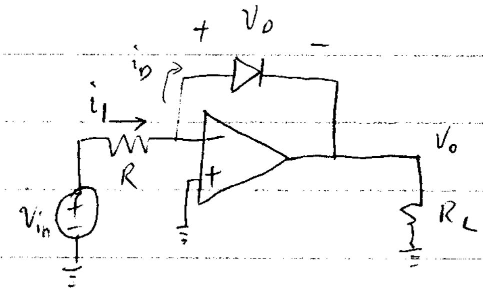
HW 8 Solution

2



$$i_1 = i_D$$

$$\frac{V_{in}}{R} = i_D \qquad \text{since } V_- = V_+ = 0$$

$$\frac{V_{in}}{R} = K V_D^2$$

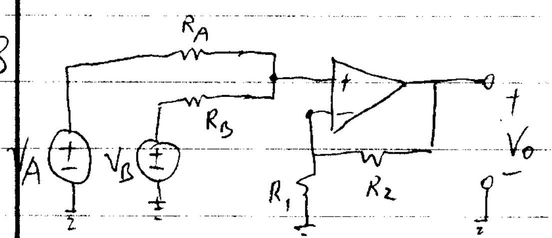
$$\frac{V_{in}}{R} = K(0 - V_0)^2 \qquad \text{since } V_D = V_- - V_0$$

$$\frac{V_{in}}{R} = K(-V_0)^2$$

$$\boxed{V_0 = -\sqrt{\frac{V_{in}}{RK}}}$$

This is an inverting amplifier

3



KCL for node + : $\frac{V_A - V_+}{R_A} + \frac{V_B - V_+}{R_B} = 0$

KCL for node − : $\frac{V_0 - V_-}{R_2} + \frac{0 - V_-}{R_1} = 0$

$$V_- = \frac{R_1}{R_1 + R_2} V_0 = V_+$$

substitute V_+ : $\frac{V_A - \frac{R_1}{R_1+R_2} V_0}{R_A} + \frac{V_B - \frac{R_1}{R_1+R_2} V_0}{R_B} = 0$

$$\boxed{V_0 = \left(\frac{R_1 + R_2}{R_1}\right) \frac{V_A R_B + V_B R_A}{R_A + R_B}}$$

4 KCL for node $-$: $\frac{V_{in}(t) - V_-}{10K} = \frac{V_o - V_-}{R_2}$ $\quad V_- = V_+ = 1V$

$$V_o = -\frac{R_2}{10K} V_{in}(t) + \left(1 + \frac{R_2}{10K}\right)$$

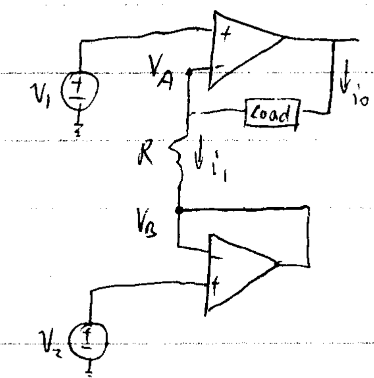
$$V_o = -\frac{R_2}{10K}\left(2 + 3\cos(2000\pi t)\right) + \left(1 + \frac{R_2}{10K}\right)$$

set dc component of V_o to 0 :

$$0 = -\frac{2R_2}{10K} + \left(1 + \frac{R_2}{10K}\right)$$

$$\boxed{R_2 = 10K}$$

5 a

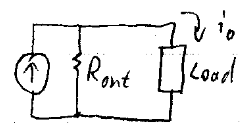


$i_o = i_1$

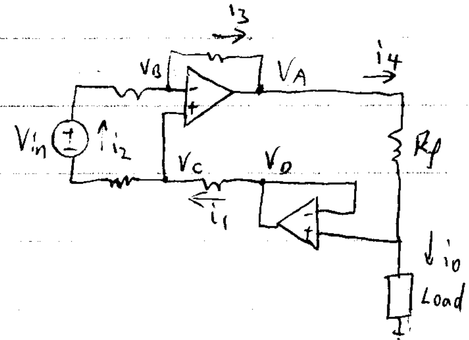
$i_o = \frac{V_A - V_B}{R}$ $\quad V_B = V_2 \quad V_A = V_1$

$i_o = \frac{V_1 - V_2}{R}$

Output impedance is ∞, because i_o is not depended on the Load impedance. Imaging:



b



Note $i_1 = i_2 = i_3 \qquad i_4 = i_o$

$$V_A = V_D + i_4 R_f = i_1 R + V_D + i_3 R$$

$$i_4 = \frac{2 i_1 R}{R_f}$$

$$i_1 = \frac{V_D - V_C}{R}$$

$$V_B - V_C = i_1 R + V_{in} + i_1 R = 0$$

$$i_1 = -\frac{V_{in}}{2R}$$

$$\boxed{i_o = i_4 = -\frac{V_{in}}{R_f}}$$

Out impedance is ∞, same argument.

6a KCL for V_o : $\dfrac{A_{OL} V_i - V_o}{R_o} = \dfrac{V_o - V_s}{R_{in}}$ $\quad V_i = V_s - V_o$

$$V_o = \left(\frac{A_{OL}(V_s - V_o)}{R_o} + \frac{V_s}{R_{in}}\right) \cdot \left(\frac{R_o R_{in}}{R_o + R_{in}}\right)$$

$$V_o/V_s = \frac{A_{OL} R_{in} + R_o}{R_o + R_{in} + A_{OL} R_{in}}$$

substitude values : $\boxed{\dfrac{V_o}{V_s} = 0.99999}$ (not 1)

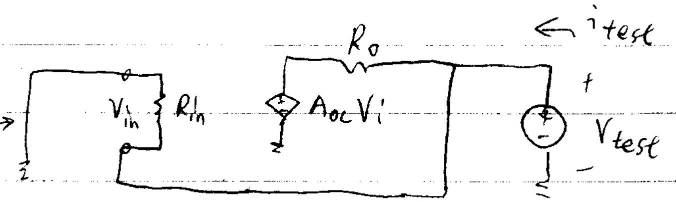
b $\quad i_s = \dfrac{V_s - V_o}{R_{in}}$ $\qquad V_o = A_{OL}(i_s R_{in}) + i_s R_o$

$$i_s = \frac{V_s - A_{OL} R_{in} i_s + R_o i_s}{R_{in}}$$

$$i_s = V_s / (R_{in} + R_o + A_{OL} R_{in}) \rightarrow Z_{in} = V_s / i_s = R_{in} + R_o + A_{OL} R_{in}$$

$Z_{in} = 10^{11}\,\Omega$ (not ∞)

c note $V_s = 0$



$V_i = -V_{test}$

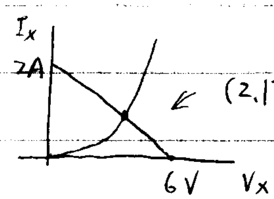
$$i_{test} = \frac{V_{test}}{R_{in}} + \frac{V_{test} - A_{OL} V_i}{R_o}$$

$$Z_o = \frac{V_{test}}{i_{test}} = \frac{1}{\frac{1}{R_{in}} + \frac{1 + A_{OL}}{R_o}} = 2.5 \times 10^{-4}\,\Omega \quad \text{(not 0)}$$

7 using Loadline analysis: $6V = 3\Omega \cdot I_x + V_x$

plot $6 = 3 I_x + V_x$

$i_x = V_x^3 / 8$



(2.17 V, 1.28 A)

8 As the load resistance becomes smaller, the reverse current through the zener diode becomes smaller in magnitude. The smallest load for which the load voltage remains at 10 V corresponds to zero diode current. The the load current is equal to the current through the 100 Ω resistor which is $i_L = 15-10/_{100} = 50mA$.
$\therefore$ the minimum load is $R_L = V_o/i_L = 200\Omega$

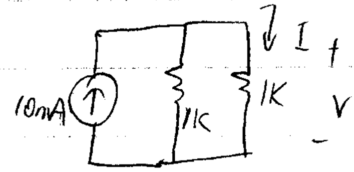
9 a The diode is on, $V = 0$ since voltage across ideal diode is 0,

$$I = \frac{10-0}{2.7K} = 3.7\ mA$$

b The diode is off, $I = 0$ $\therefore V = 10V$

c The diode is on, $V = 0$ $I = \frac{0-0}{2.7K} = 0$

d The diode is on, equivalent ckt



$$I = 10mA \cdot \frac{1}{2} = 5mA$$

$$V = 5mA \cdot 1K\Omega = 5V$$