EECS 311 PS2 Solutions

P2.1

11.38) $A_v = -6\ V/V$

a) $Z_{in} = 20\,k\Omega$

$Z_{out} = 0\,\Omega$

b) $A_v = 1 + \frac{R_F}{R_i} = 1 + 8 = 9\ V/V$

$Z_{in} = 75\,k\Omega$

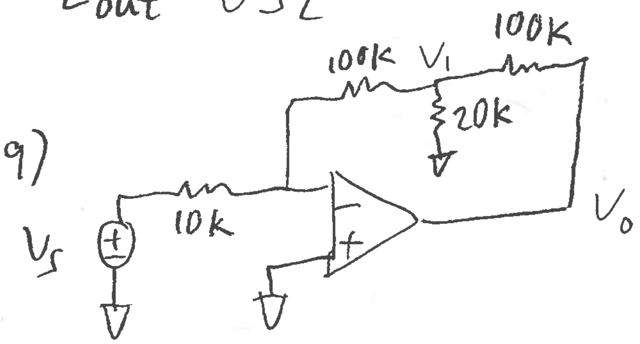
$Z_{out} = 0$

c) $A_v = 0\ V/V$

$Z_{in} = 160\,k\Omega$

$Z_{out} = 0\,\Omega$

11.39)



$Z_{in} = 10\,k\Omega$

$Z_{out} = 0\,\Omega$

$$\frac{V_s}{10k} = \frac{-V_1}{100k}$$

$$\frac{-V_1}{100k} = \frac{V_1}{20k} + \frac{V_1 - V_0}{100k}$$

$$\frac{V_1}{50k} + \frac{V_1}{20k} = \frac{V_0}{100k} \Rightarrow \frac{7V_1}{100k} = \frac{V_0}{100k}$$

$$7V_1 = V_0$$

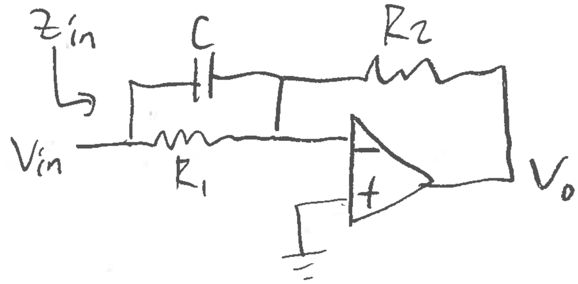
$$\therefore 10\,V_s = -\frac{V_0}{7}$$

$$\frac{V_0}{V_s} = -70\ V/V$$

EECS 311 - fall 08, HW2 solutions

P2.2

a)



$$Z_{in} = R_1 // \frac{1}{sC} = \frac{R_1}{1+sR_1C}$$

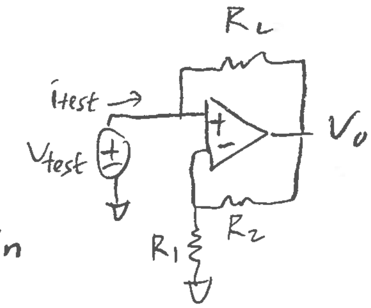
$$\frac{V_o}{V_{in}} = -\frac{Z_f}{Z_i} = -\frac{R_2}{R_1 // \frac{1}{sC}} = -\frac{R_2}{\frac{R_1}{1+sR_1C}} = -\frac{R_2}{R_1}(1+sR_1C)$$

b) $$\frac{V_o}{V_{in}} = -\frac{Z_f}{Z_i} = -\frac{1/sC}{R} = -\frac{1}{sRC}$$ $\quad Z_{in} = R$

c) $\frac{V_o}{V_{in}} = 1 \qquad Z_{in} = \infty$

d) $V- = \frac{R_1}{R_1+R_2} V_o = V+ = V_{in}$

$$\frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$



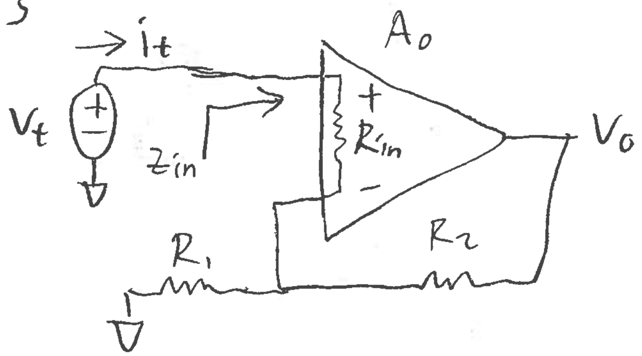
Z_{in}: $V_o = \left(1+\frac{R_2}{R_1}\right)V_{in}$

$$i_{test} = \frac{V_{test} - \left(1+\frac{R_2}{R_1}\right)V_{test}}{R_L}$$

$$= V_{test}\left(-\frac{R_2}{R_1 R_L}\right) \qquad Z_{in} = -\frac{R_1 R_L}{R_2}$$

< 0 only possible w/ active elements such a[s] an op-amp.

P2.3



$$V_0 = A_0(V_+ - V_-)$$

$$i_t + \frac{V_0 - V_-}{R_2} = \frac{V_-}{R_1} \quad (2)$$

$$i_t R_{in} = V_+ - V_-$$

$$V_0 = A_0 i_t R_{in} \quad (1)$$

$$V_t = V_+$$

$$V_- = V_t - i_t R_{in} \quad (3)$$

(1) & (3) into (2):

$$i_t + \frac{A_0 i_t R_{in} - (V_t - i_t R_{in})}{R_2} = \frac{V_t - i_t R_{in}}{R_1}$$

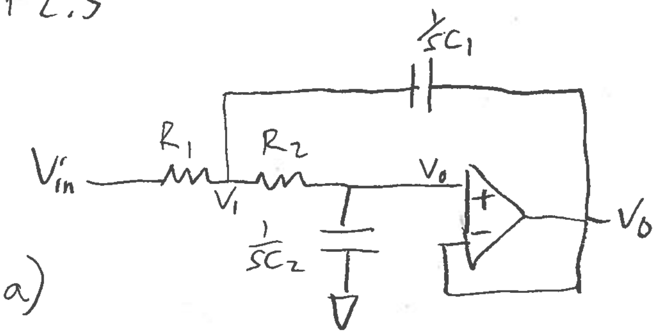
$$i_t\left(1 + \frac{A_0 R_{in}}{R_2} + \frac{R_{in}}{R_2} + \frac{R_{in}}{R_1}\right) = V_t\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$i_t \frac{R_1R_2 + A_0R_1R_{in} + R_1R_{in} + R_2R_{in}}{R_1R_2} = V_t \frac{R_1 + R_2}{R_1R_2}$$

$$Z_{in} = \frac{R_1R_2 + R_1R_{in} + R_2R_{in} + A_0R_1R_{in}}{R_1 + R_2}$$ assuming $R_{in} \gg R_1, R_2$

$$Z_{in} \approx \frac{R_{in}(R_1 + R_2 + A_0R_1)}{R_1 + R_2} \approx R_{in}\left(1 + \frac{A_0R_1}{R_1 + R_2}\right)$$

P2.5



$$\frac{V_{in}-V_1}{R_1} + sC_1(V_o - V_1) = \frac{V_1 - V_o}{R_2} \quad ①$$

$$\frac{V_1 - V_o}{R_2} = sC_2 V_o$$

$$V_1 = V_o(sR_2C_2 + 1) \quad ②$$

a)

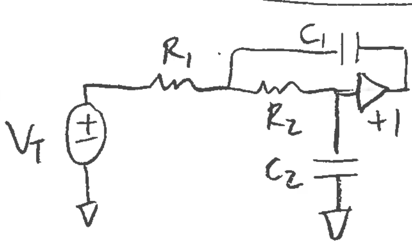
plug ② into ①:

$$\frac{V_{in} - V_o(1+sR_2C_2)}{R_1} + sC_1V_o(-sR_2C_2) = \frac{V_o\, s\cancel{R_2}C_2}{\cancel{R_2}}$$

$$V_{in} - V_o(1+sR_2C_2) = V_o(sR_1C_2 + s^2R_1R_2C_1C_2)$$

$$V_{in} = V_o(sC_2(R_1+R_2) + s^2R_1R_2C_1C_2 + 1)$$

$$\frac{V_o}{V_{in}} = \frac{1}{s^2R_1R_2C_1C_2 + sC_2(R_1+R_2) + 1}$$



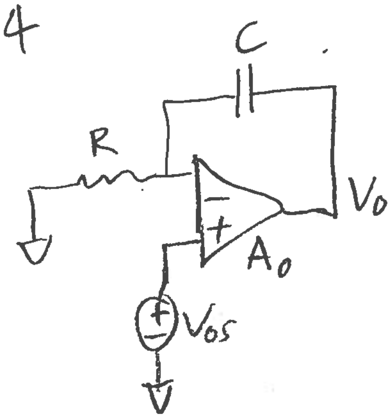
$$\Rightarrow \quad Z_{in} = R_1 + \frac{1}{sC_2}\left(\frac{1+sR_2C_2}{1+sR_2C_1}\right)$$

b) $$A_v = \frac{1}{\left(\frac{s}{\omega_n}\right)^2 + \frac{s}{\omega_n}\,\frac{C_2(R_1+R_2)}{\sqrt{R_1R_2C_1C_2}} + 1}$$

$$d = \frac{C_2(R_1+R_2)}{\sqrt{R_1R_2C_1C_2}}$$

P2,4

a)



$$V_o = A_o(V_{os} - V_-) \Rightarrow V_- = V_{os} - \frac{V_o}{A_o}$$

$$\frac{V_o - V_-}{\frac{1}{sC}} = \frac{V_-}{R} \Rightarrow V_-\left(\frac{1}{R} + sC\right) = sC V_o$$

$$\left(V_{os} - \frac{V_o}{A_o}\right)\left(\frac{1+sRC}{R}\right) = sC V_o$$

$$V_{os} - \frac{V_o}{A_o} = \frac{sRC}{1+sRC} V_o$$

$$V_{os} = V_o\left(\frac{sRC}{1+sRC} + \frac{1}{A_o}\right) = V_o\left(\frac{sRCA_o + 1 + sRC}{A_o(1+sRC)}\right)$$

$$\frac{V_o}{V_{os}} = \frac{A_o(1+sRC)}{1+sRC+sRCA_o} = \frac{A_o(1+sRC)}{1+sRC(1+A_o)}$$

b) at DC, $\frac{V_o}{V_{os}} = \frac{A_o}{1} = A_o$

$\therefore$ s.s. $V_o = A_o V_{os}$