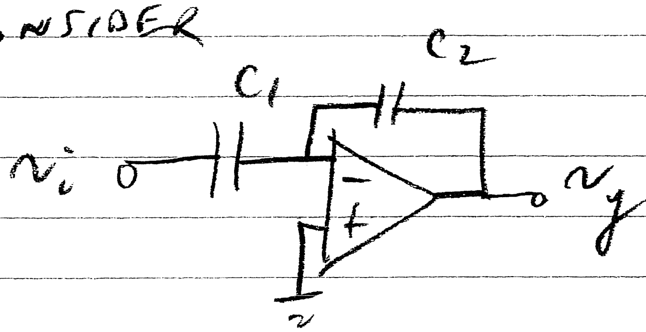
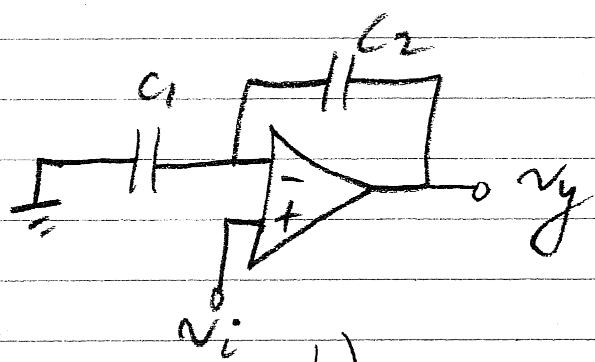
FEEDBACK RE-VISITED

CONSIDER

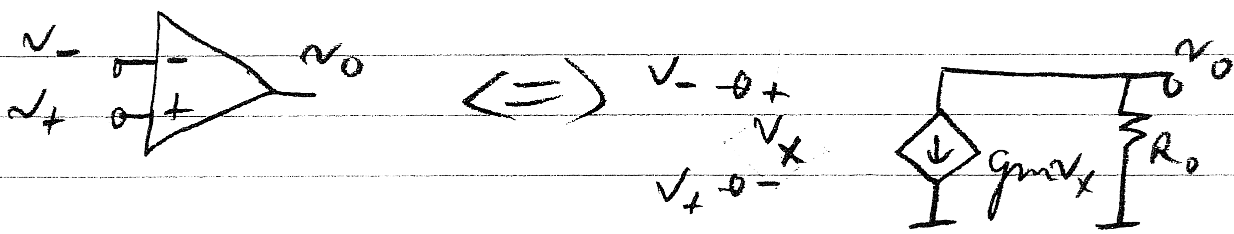


a)



b)

WHERE OPAMP MODEL IS



(1A)

WANT TO USE FEEDBACK

ANALYSIS TO FIND $A(s)$, $\beta(s)$

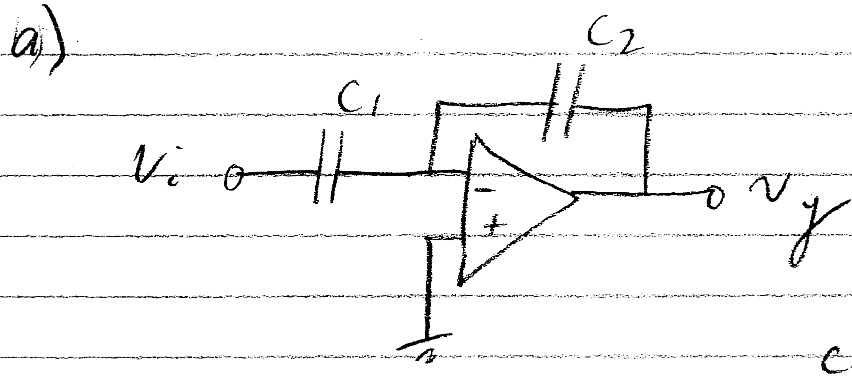
FOR a) & b)

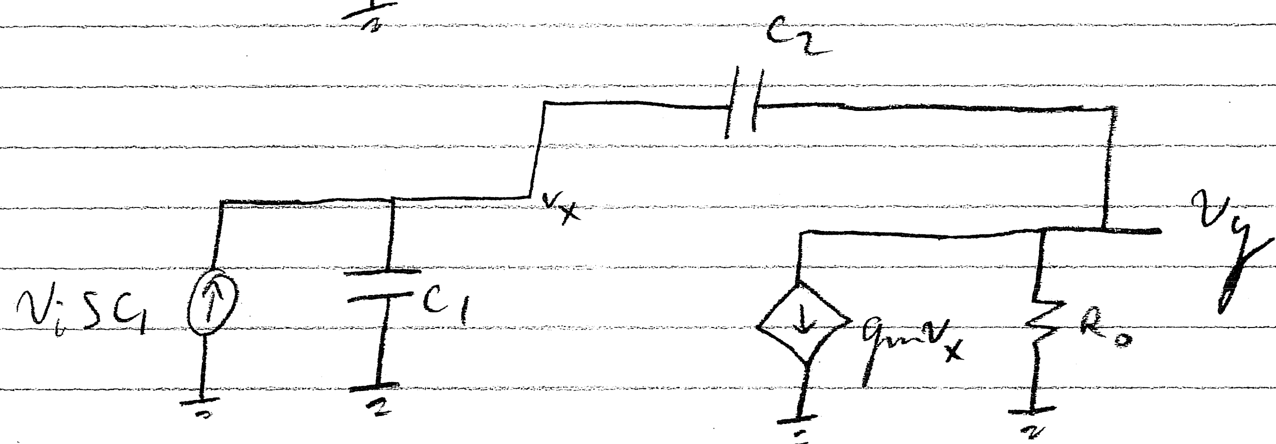
AND FIND POLE FOR BOTH

CASES WHEN $g_m R_o >> 1$

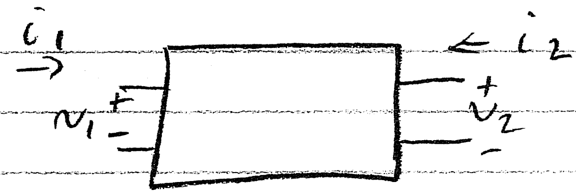
$C_2 >> C_1$

a)





RECALL



$y \Rightarrow$ ADMITTANCES

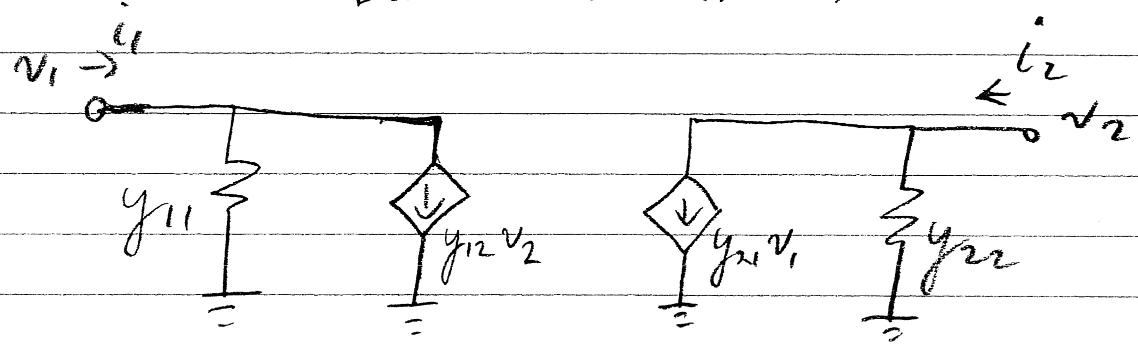
$$i_1 = y_{11} v_1 + y_{12} v_2$$

$$i_2 = y_{21} v_1 + y_{22} v_2$$

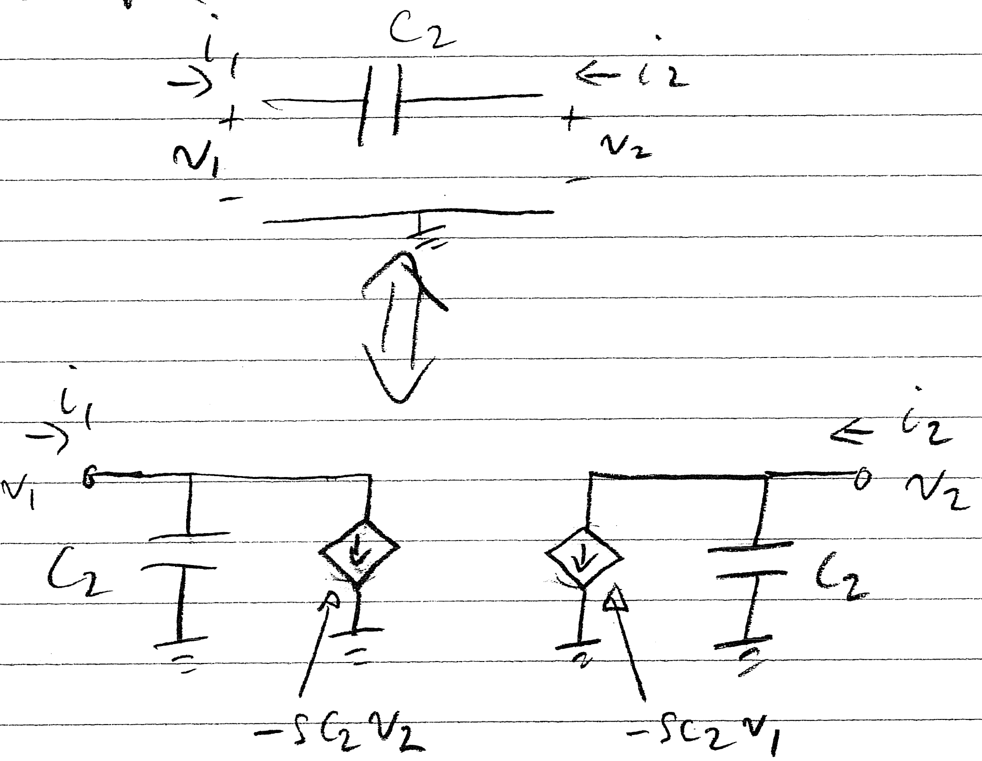
$$y_{11} = \left.\frac{i_1}{v_1}\right|_{v_2=0} \qquad y_{12} = \left.\frac{i_1}{v_2}\right|_{v_1=0}$$

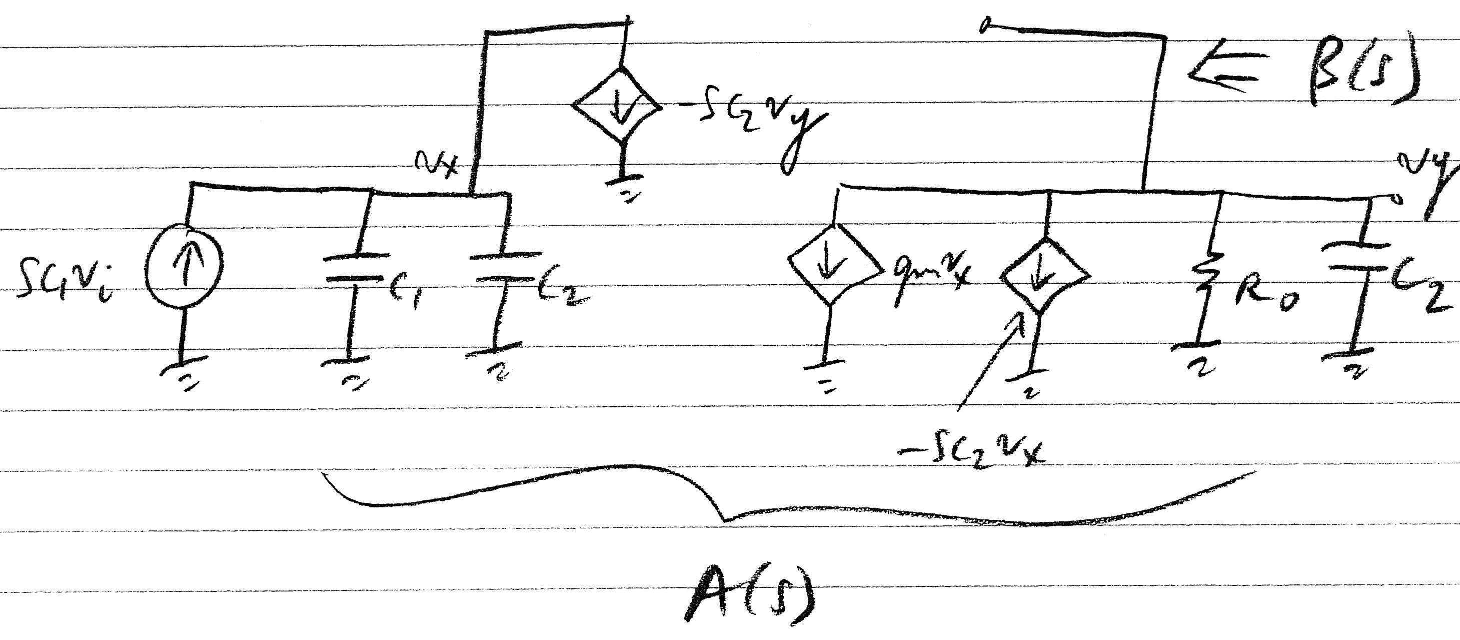
$$y_{21} = \left.\frac{i_2}{v_1}\right|_{v_2=0} \qquad y_{22} = \left.\frac{i_2}{v_2}\right|_{v_1=0}$$

EQUIVALENT CIRCUIT

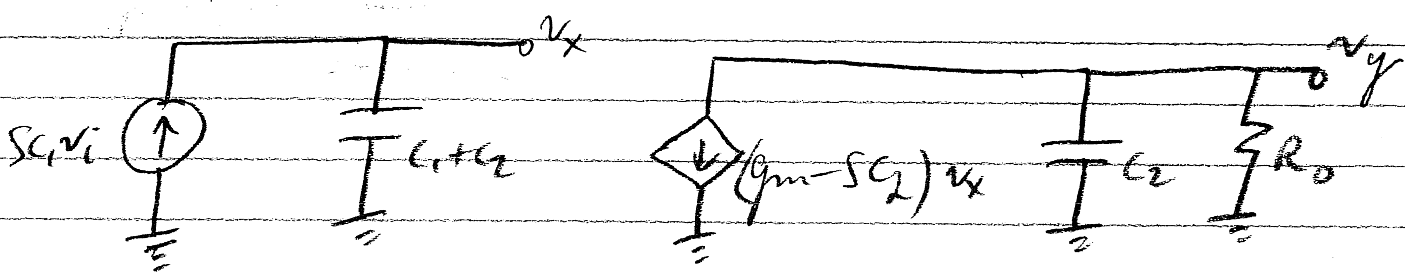


SO FOR


i_1
C_2
i_2
v_1
v_2
i_1
i_2
v_1
v_2
C_2
C_2
$-sC_2v_2$
$-sC_2v_1$

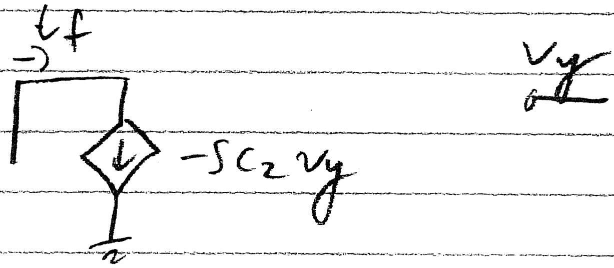

$\beta(s)$
$-sC_2v_y$
v_x
v_y
sC_1v_i
C_1
C_2
g_mv_x
R_o
C_2
$-sC_2v_x$
$A(s)$

$\underline{A(s)}$



$$A(s) = \frac{v_y}{sC_1 v_i} = \frac{-1}{s(C_1+C_2)}(g_m - sC_2)\left(R_o \parallel \frac{1}{sC_2}\right)$$

$\underline{\beta(s)}$



$$\beta(s) = \frac{i_f}{v_y} = -sC_2$$

CLOSED LOOP GAIN

$$A_{CL} = \frac{A(s)}{1 + A(s)\beta(s)} = \frac{v_y}{sC_1 v_i}$$

$$\frac{v_y}{v_i} = \frac{sC_1 A(s)}{1 + A(s)\beta(s)}$$

$$\frac{v_y}{v_i} = \frac{sC_1 (sC_2 - g_m)(R_o \| \frac{1}{sC_2})}{s(C_1 + C_2) + sC_2 (g_m - sC_2)(R_o \| \frac{1}{sC_2})}$$

$$= \frac{C_1 (sC_2 - g_m) R_o}{C_1 + C_2 + sC_1 C_2 R_o + g_m C_2 R_o} = \frac{N(s)}{D(s)}$$

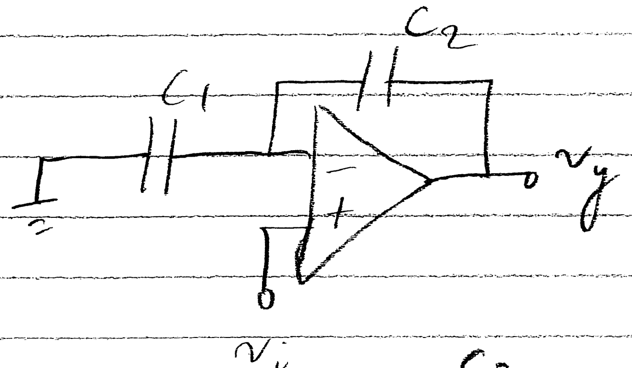
POLE AT $D(s) = 0$

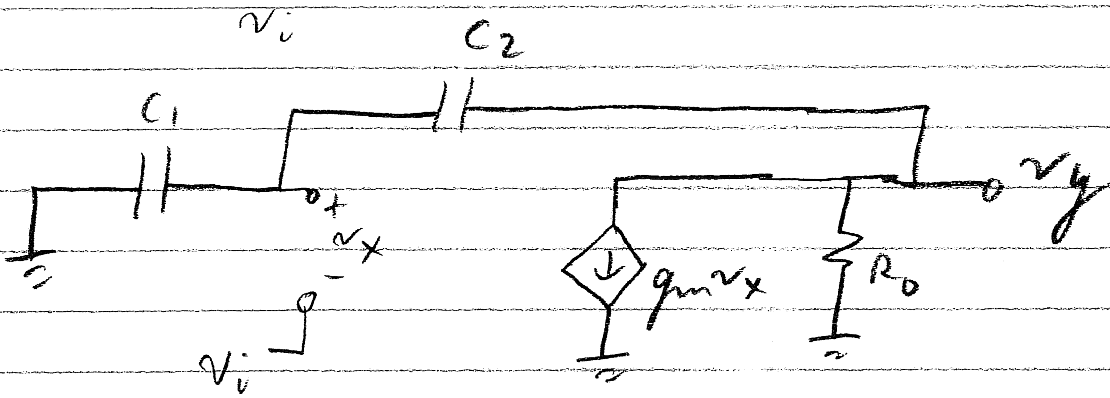
$$\Rightarrow s = \frac{-(g_m R_o C_2 + C_1 + C_2)}{C_1 C_2 R_o}$$

FOR $g_m R_o \gg 1$ & $C_2 \gg C_1$

POLE $s \approx -\frac{g_m}{C_1}$

b)





$$A(s) = +g_m\left(R_o \,||\, \left(\frac{1}{sC_1} + \frac{1}{sC_2}\right)\right)$$

$$\beta(s) = \frac{C_2}{C_1+C_2}$$

$$A_{CL} = \frac{A(s)}{1+A(s)\beta(s)}$$

$$A(s) = +g_m\left(\frac{R_o(C_1+C_2)}{C_1+C_2+sC_1C_2R_o}\right)$$

$$A_{CL} = \frac{g_m R_o (C_1 + C_2)}{C_1 + C_2 + sC_1C_2R_o + g_m R_o C_2} = \frac{N(s)}{D(s)}$$

POLES AT $D(s) = 0$

$$s = \frac{-(g_m R_o C_2 + C_1 + C_2)}{C_1 C_2 R_o}$$

SAME AS a)

SO FOR $g_m R_o \gg 1$ & $C_2 \gg C_1$

$$s \simeq -\frac{g_m}{C_1}$$

NOTE HOWEVER THAT $A(s)$ & $\beta(s)$

DIFFERENT FOR CASES a) & b)

IN GENERAL, LOOP GAIN $L(s)$

$$L(s) \equiv A(s)\,\beta(s)$$

& POLES OCCUR AT $1 + L(s) = 0$

HOWEVER WRITE

$$L(s) = \frac{N_L(s)}{D_L(s)}$$

$$\therefore \quad 1 + L(s) = 0$$

$$D_L(s) + N_L(s) = 0$$

ARBITRARY $D_2(s)$

IF $\quad L_2(s) = \dfrac{N_L(s) - D_2(s)}{D_L(s) + D_2(s)}$

POLES ASSOCIATED WITH LOOP GAIN $L_2(s)$

$$1 + L_2(s) = 0 \Rightarrow 1 + \frac{N_L(s) - D_2(s)}{D_L(s) + D_2(s)} = 0$$

$$D_L(s) + D_2(s) + N_L(s) - D_2(s) = 0$$

$$D_L(s) + N_L(s) = 0$$

SAME POLES AS $L(s)$!

FOR A GIVEN SET OF CLOSED LOOP POLES THERE ARE MULTIPLE LOOP GAINS GIVING SAME POLES. EACH LOOP GAIN MAY HAVE DIFFERENT PHASE + GAIN MARGINS !!