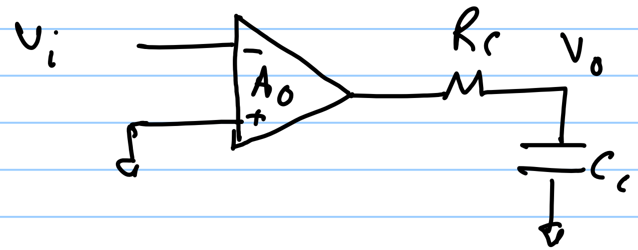
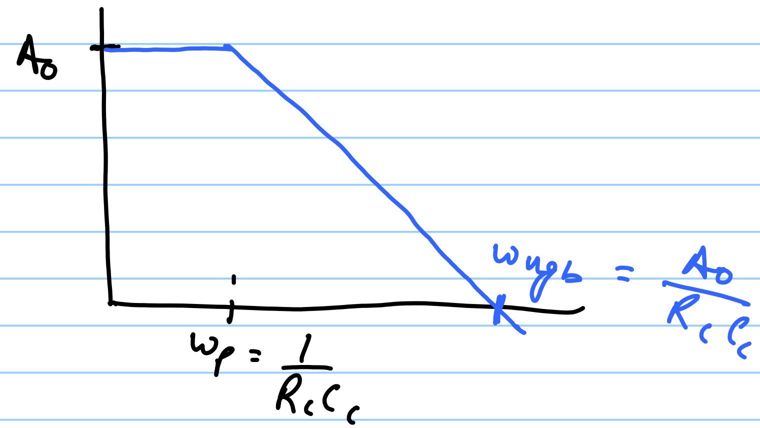
EE2019 Analog systems & Lab

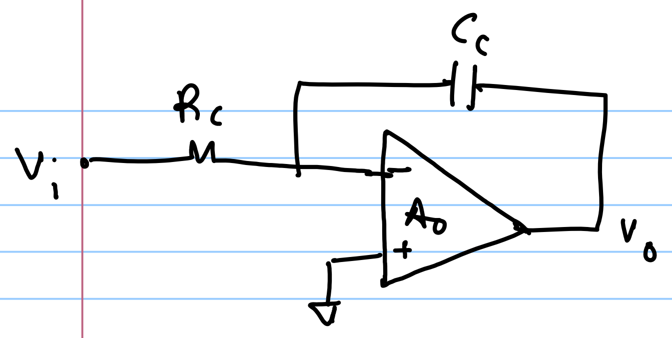
Note Title 3/11/2020

Miller compensation

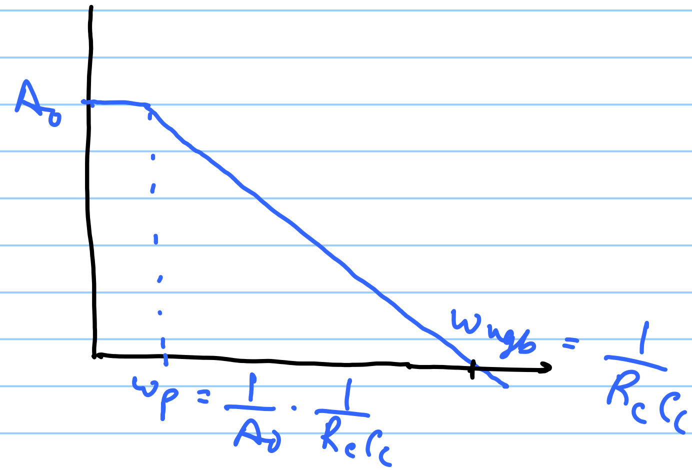


$\Rightarrow$





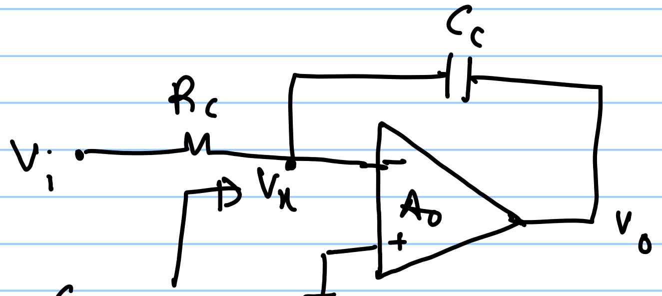
$\Rightarrow$



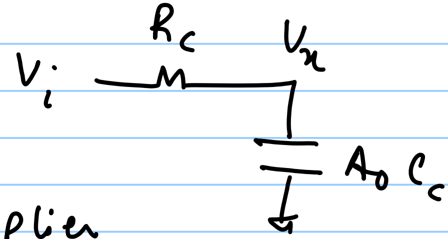
$$C_c = \frac{370\,nF}{A_0}$$

if $A_0 = 1000$

$$C_c = 370\,pF$$



$\Rightarrow$

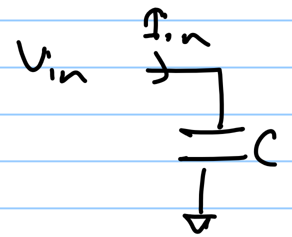


$C_{eff} = A_0 C_c \longrightarrow$ Capacitor multiplier

$\Downarrow$

Miller effect

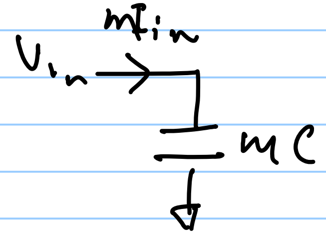
$$\frac{V_x}{V_i} = \frac{1}{1 + A_0 R_c C_c s}$$

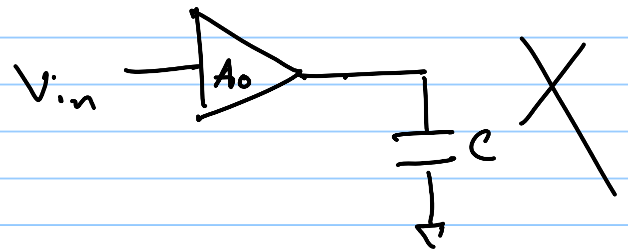


$Z_{in} = \frac{1}{sC}$

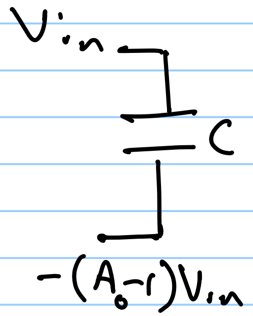
if Z_{in} is reduced to $\frac{1}{m}$ times

for same V_{in} $I_{in} = m\,X$ $\Rightarrow$



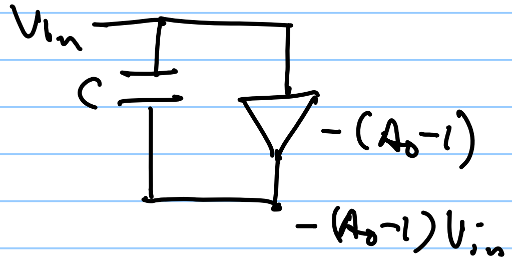


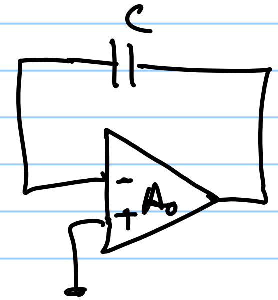
no change in impedance



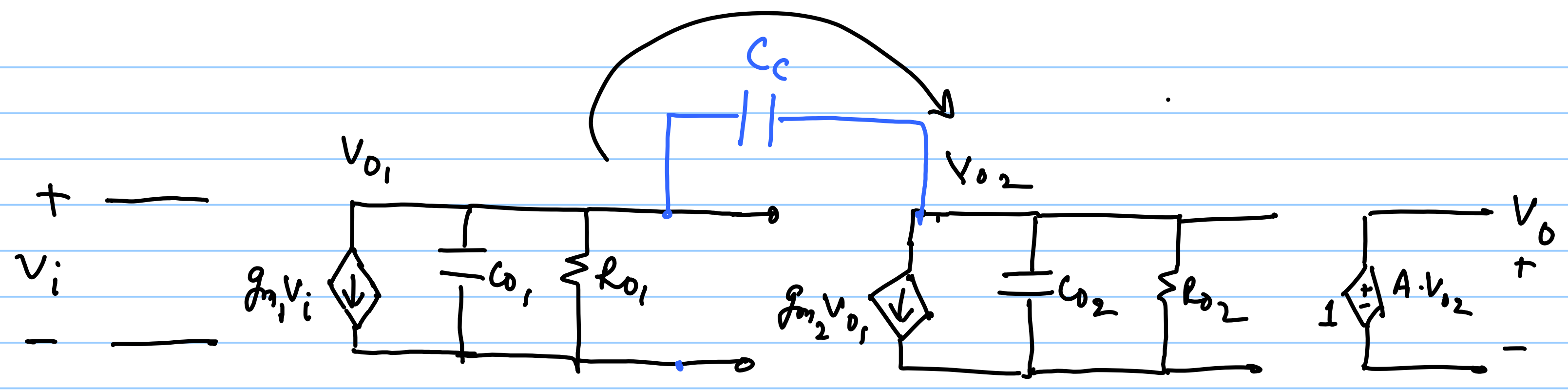
$\Rightarrow$

$I_{in} = A_0 V_{in} \times sC \Rightarrow$ C is multiplied by A_0





$C_{in} = (1+A_0)C$



Apply KCL at V_{o_1}

$$g_{m_1}V_i + V_{o_1}C_{o_1}s + V_{o_1}G_{o_1} + (V_{o_1} - V_{o_2})sC_c \qquad \left(G_{o_1} = \frac{1}{R_{o_1}}\right)$$

$$g_{m_1}V_i + \underline{V_{o_1}C_{o_1}s} + \underline{V_{o_1}G_{o_1}} + \underline{V_{o_1}C_c s} - V_{o_2}C_c s$$

$$\Rightarrow V_{o_1}\left[G_{o_1} + (C_{o_1} + C_c)s\right] = V_{o_2}C_c s - g_{m_1}V_i$$

$$V_{o1} = \frac{V_{o2} C_c s - g_{m1} V_i}{G_{o1} + (C_{o1} + C_c) s} \quad \text{— (1)}$$

Apply KCL at V_{o2}

$$g_{m2} V_{o1} + G_{o2} V_{o2} + V_{o2} C_{o2} s + (V_{o2} - V_{o1}) C_c s = 0$$

$$V_{o1} (g_{m2} - C_c s) \quad + \quad V_{o2} \left(G_{o2} + (C_{o2} + C_c) s \right] = 0$$

substitute V_{o1} from — (1)

$$\frac{(V_{o2} C_c s - g_{m1} V_i)}{G_{o1} + (C_{o1} + C_c) s} (g_{m2} - C_c s) + V_{o2} \left(G_{o2} + (C_{o2} + C_c) s \right) = 0$$

$$V_{o2}\left(G_{o2} + (C_{o2} + C_c)s\right)\left(G_{o1} + (C_{o1} + C_c)s\right) = \left(V_i\, g_{m1} - V_{o2} C_c s\right)\left(g_{m2} - C_c s\right)$$

$$V_{o2}\left(G_{o2} + (C_{o2} + C_c)s\right)\left(G_{o1} + (C_{o1} + C_c)s\right) = g_{m1}(g_{m2} - C_c s)\, v_i - \underline{V_{o2} C_c s (g_{m2} - C_c s)}$$

$$V_{o2}\left(G_{o2} + C_{o2}s + C_c s\right)\left(G_{o1} + C_{o1}s + C_c s\right) + V_{o2}\left(\underline{g_{m2} C_c s - C_c^2 s^2}\right) = g_{m1}(g_{m2} - C_c s)\, v_i$$

$$V_{o2}\Big(G_{o2} G_{o1} + \underline{G_{o2} C_{o1} s} + \underline{G_{o2} C_c s} + \underline{C_{o2} G_{o1} s} + \underline{C_{o1} C_{o2} s^2} + \underline{C_{o2} C_c s^2}$$
$$+ \underline{G_{o1} C_c s} + \underline{C_c C_{o1} s^2} + \cancel{C_c^2 s^2} + \underline{g_{m2} C_c s} - \cancel{C_c^2 s^2}\Big) = g_{m1}(g_{m2} - C_c s)\, v_i$$

$$V_{o2}\Big[\left(C_{o1}C_{o2} + C_{o2}C_c + C_c C_{o1}\right)s^2 + \left(G_{o2}C_{o1} + G_{o2}C_c + G_{o1}C_{o2} + G_{o1}C_c + g_{m2}C_c\right)s + G_{o1}G_{o2}\Big] = g_{m1}\left(g_{m2} - C_c s\right)V_i$$