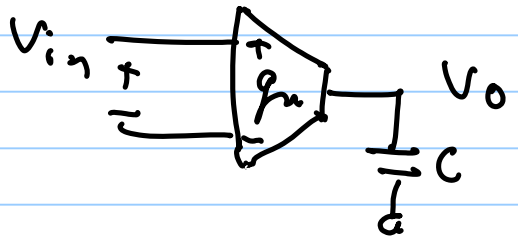
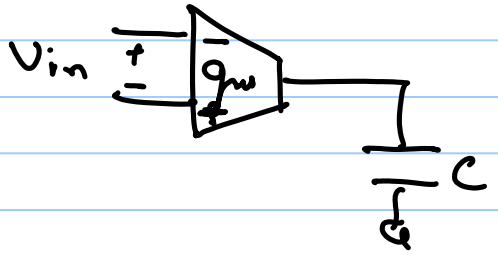
EE2019

Note Title 3/26/2019

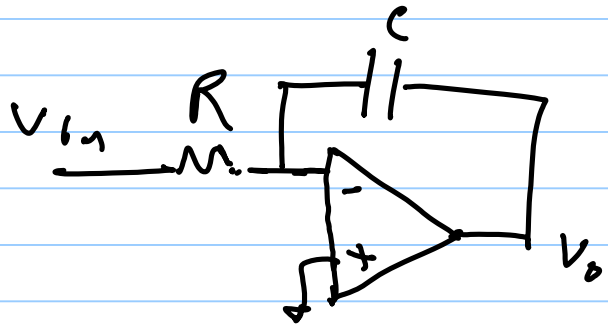
Gm - C Filters



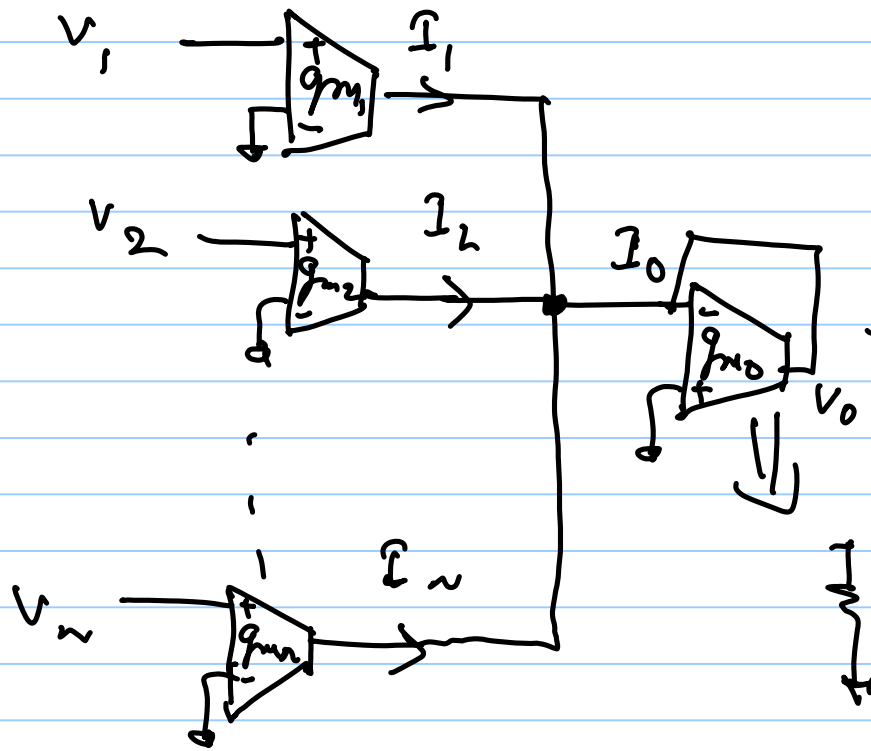
$$V_o = \frac{g_m}{Cs} V_{in}$$



$$V_o = -\frac{g_m}{Cs} V_{in} \Rightarrow$$



Adder



$$I_0 = I_1 + I_2 + \cdots I_n$$

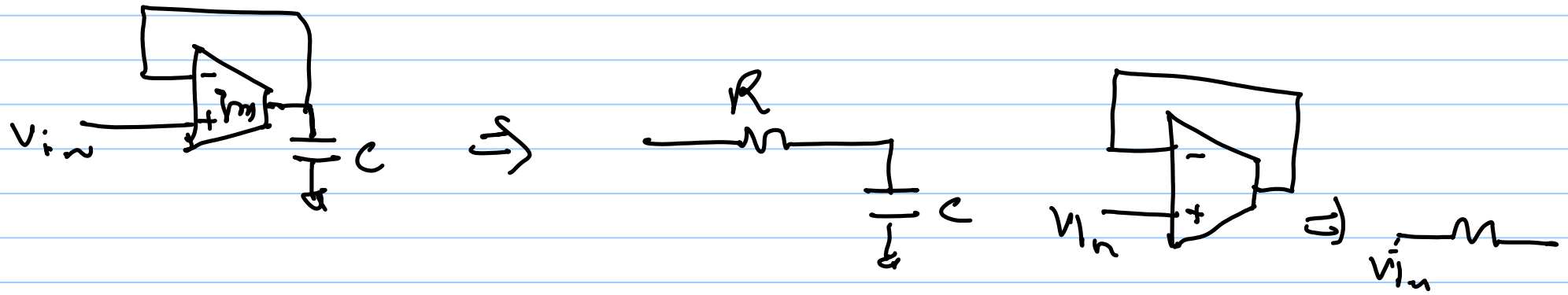
$$I_0 = V_1 g_{m_1} + V_2 g_{m_2} + \cdots V_n g_{m_n}$$

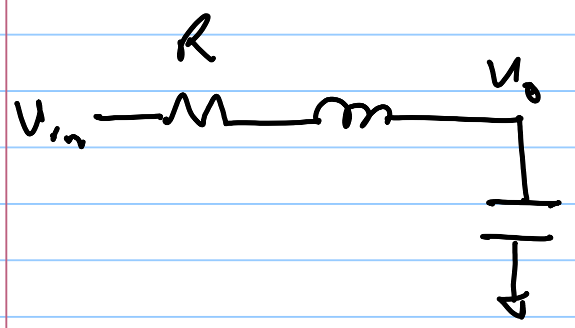
$$R = \frac{1}{g_{m_0}}$$

$$V_0 = \frac{1}{g_{m_0}} \left(V_1 g_{m_1} + V_2 g_{m_2} + \cdots V_n g_{m_n} \right)$$

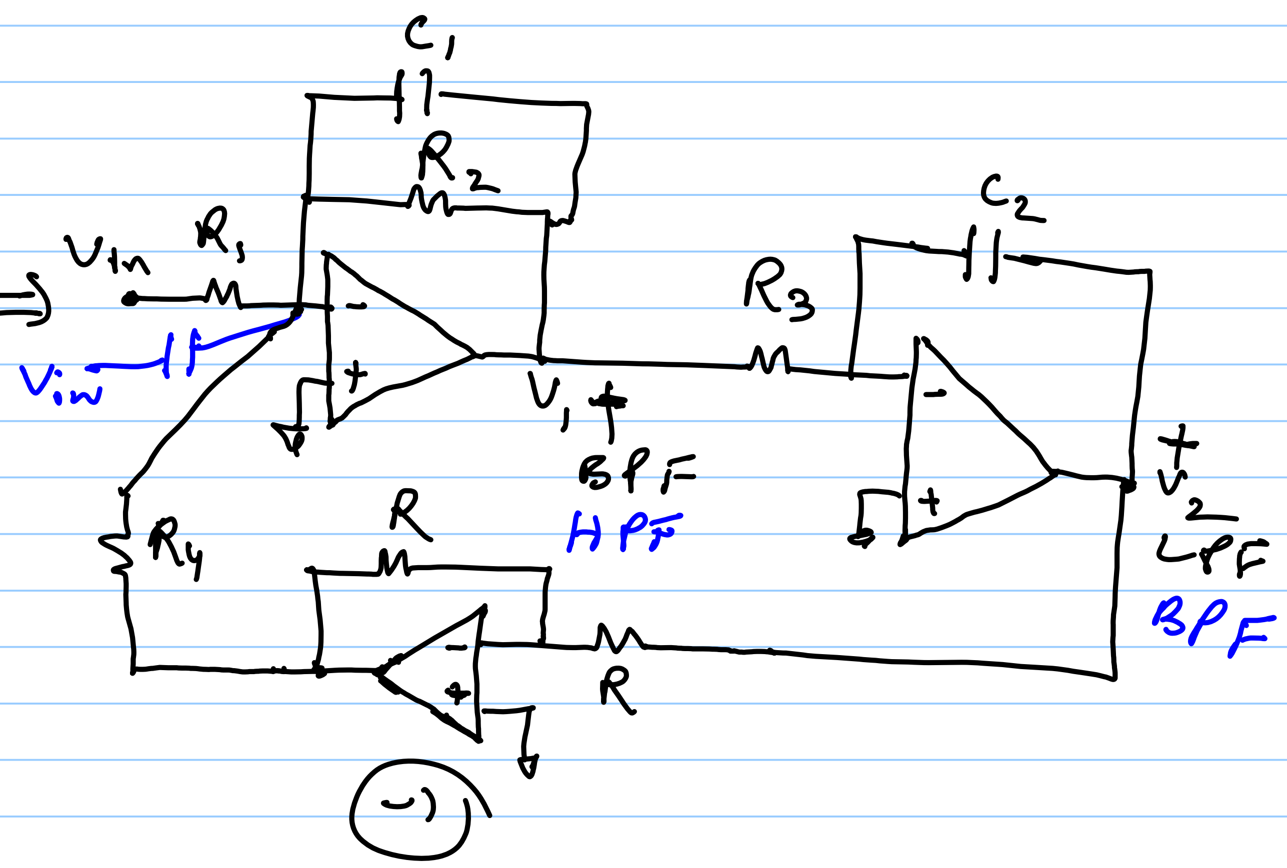
$$g_{m_0} = g_{m_1} = g_{m_2} = \cdots g_{m_N}$$

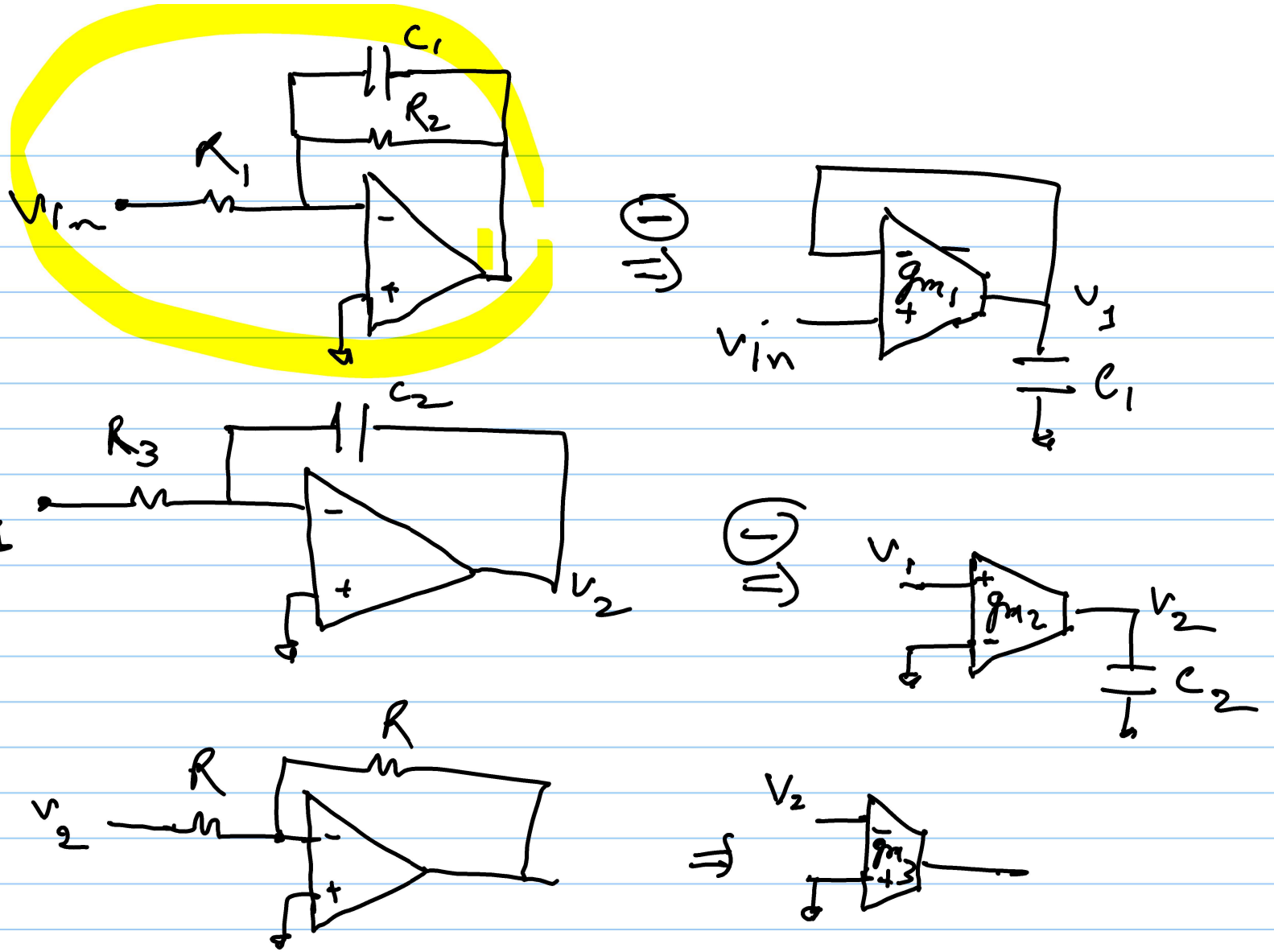
$$V_o = V_1 + V_2 + \cdots V_N$$

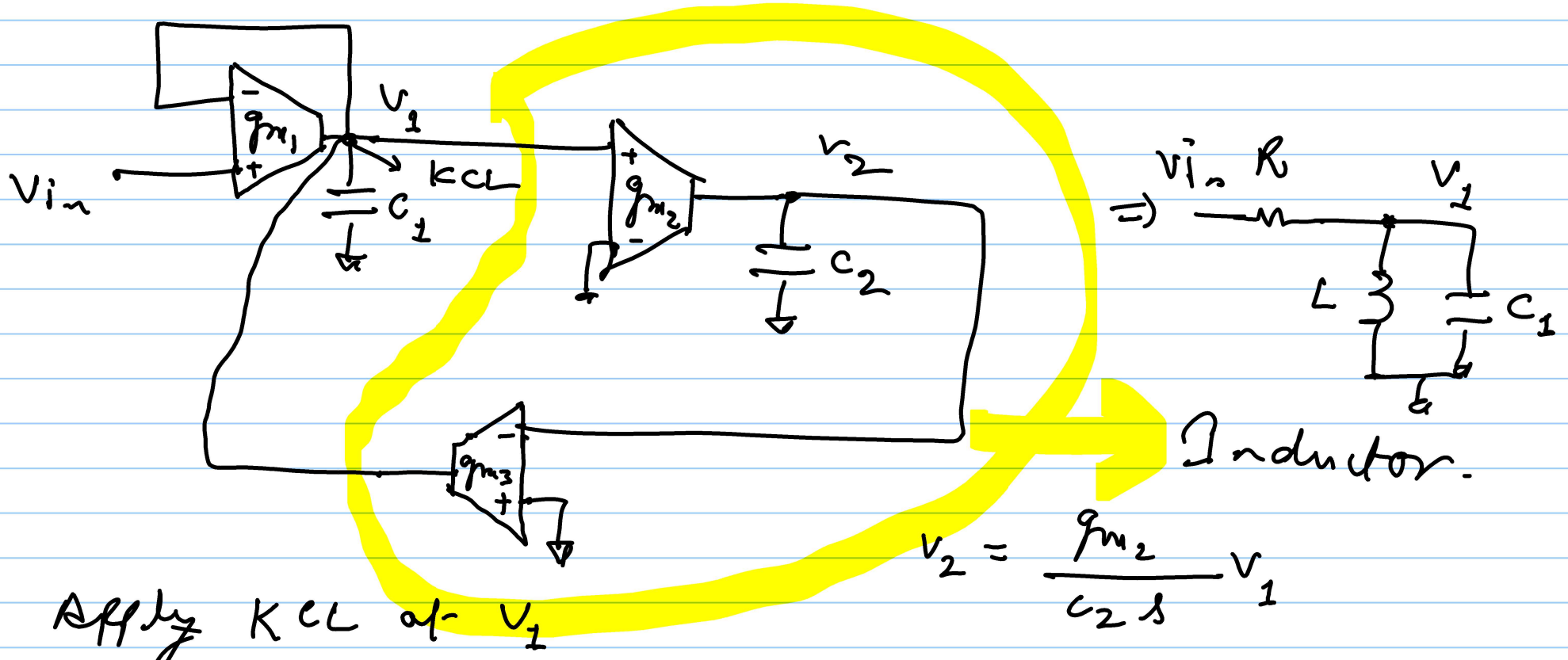



V_{in}
R
V_0

⇒


V_{in}
R_1
C_1
R_2
V_{in}
V_1 +
BPF
HPF
R_3
C_2
+
V_2
LPF
BPF
R
R_4
R


C1
R2
R1
Vin
gm1
V1
Vin
C1
C2
R3
V1
V2
gm2
V1
V2
C2
R
R
V2
V2
gm3



$$V_2 = \frac{g_{m2}}{C_2 s} V_1$$

Apply KCL at V_1

$$(V_{in} - V_1) g_{m1} + (-V_2 g_{m3}) + (-V_1 C_1 s) = 0$$

$$V_{in} g_{m_1} - V_1 g_{m_1} - V_2 g_{m_3} - V_1 C_1 s = 0$$

$$V_2 = \frac{g_{m_2}}{C_2 s} V_1$$

$$V_{in} g_{m_1} - V_1 g_{m_1} - \frac{g_{m_2} g_{m_3}}{C_2 s} V_1 - V_1 C_1 s = 0$$

$$V_{in} g_{m_1} = V_1 \left[g_{m_1} + \frac{g_{m_2} g_{m_3}}{C_2 s} + C_1 s \right]$$

$$V_{in} g_{m_1} C_2 s = V_1 \left[g_{m_1} C_2 s + g_{m_2} g_{m_3} + C_1 C_2 s^2 \right]$$

$$\frac{V_1}{V_{in}} = \frac{g_{m_1} C_2 s}{C_1 C_2 s^2 + g_{m_1} C_2 s + g_{m_2} g_{m_3}}$$

$$= \frac{\frac{g_{m_1} C_2}{g_{m_2} g_{m_3}} s}{\frac{C_1 C_2}{g_{m_2} g_{m_3}} s^2 + \frac{g_{m_1}}{g_{m_2} g_{m_3}} C_2 s + 1}$$

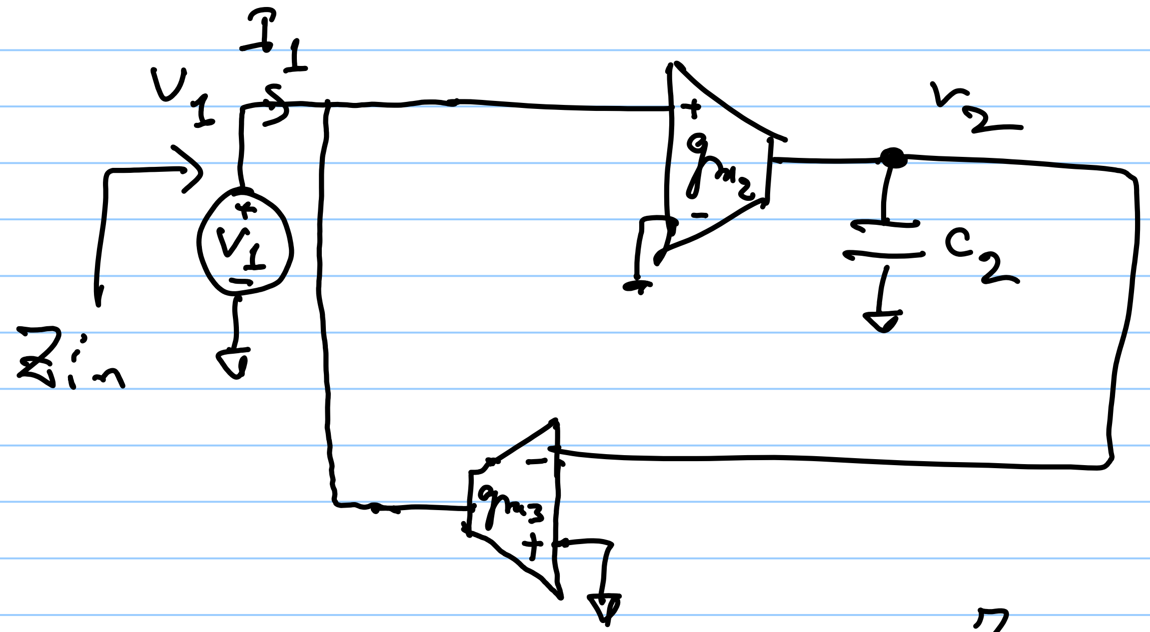
B.P.F.

$\downarrow$

LC

$$LC = \frac{C_1 C_2}{g_{m_2} g_{m_3}}$$

$$L = \frac{C_2}{g_{m_2} g_{m_3}}$$



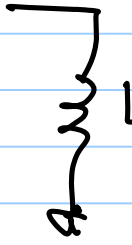
at-

$$Z_{in} = \frac{V_1}{I_1}$$

$$V_2 s C_2 = V_1 g_{m2} \Rightarrow V_2 = \frac{g_{m2}}{sC_2} V_1$$

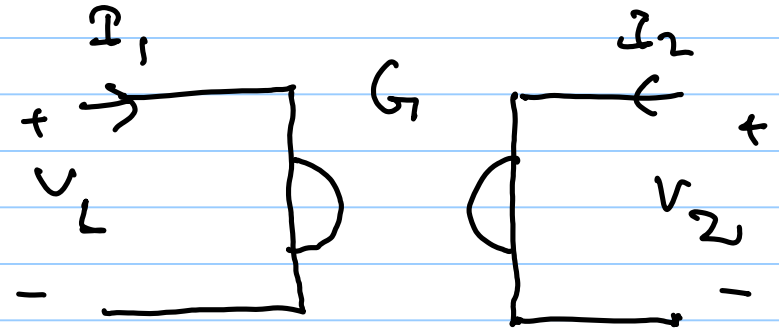
$$I_1 = V_2 \cdot g_{m3} = \frac{g_{m2} g_{m3}}{sC_2} V_1$$

$$\frac{V_1}{I_1} = \frac{C_2}{g_{m_2} g_{m_3}} s \Rightarrow Ls$$



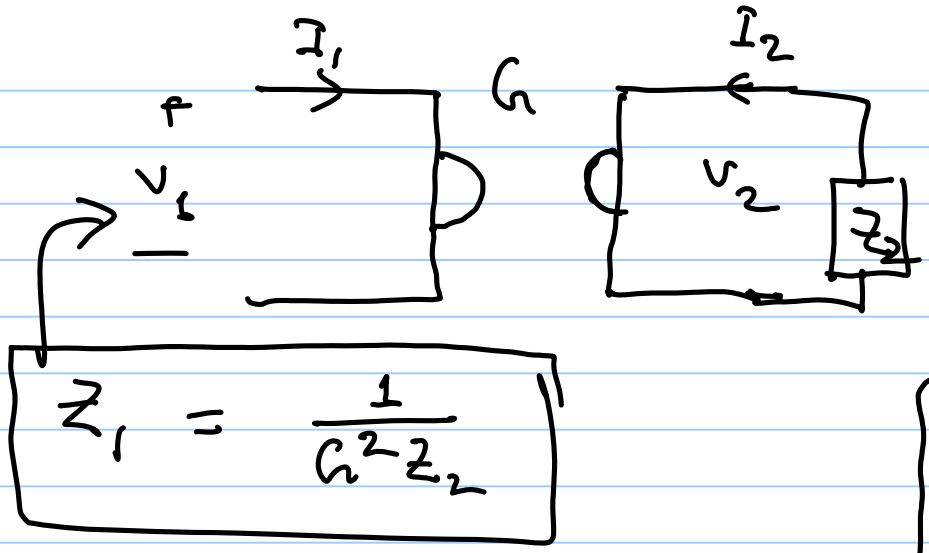
$$L = \frac{C_2}{g_{m_2} g_{m_3}}$$

This is called Gyrator or Impedance Inverter.



$$I_1 = G V_2$$

$$I_2 = -G V_1$$

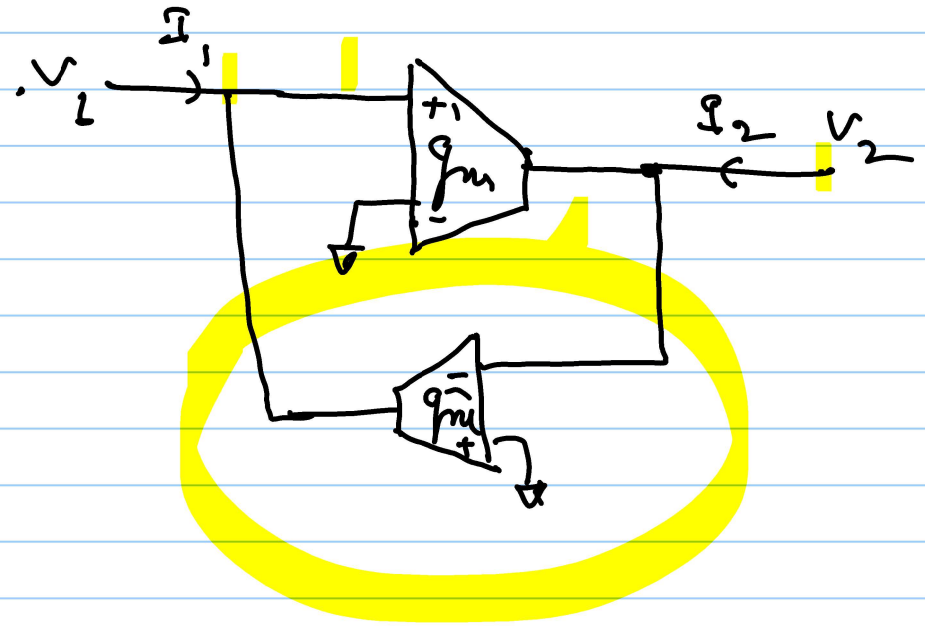


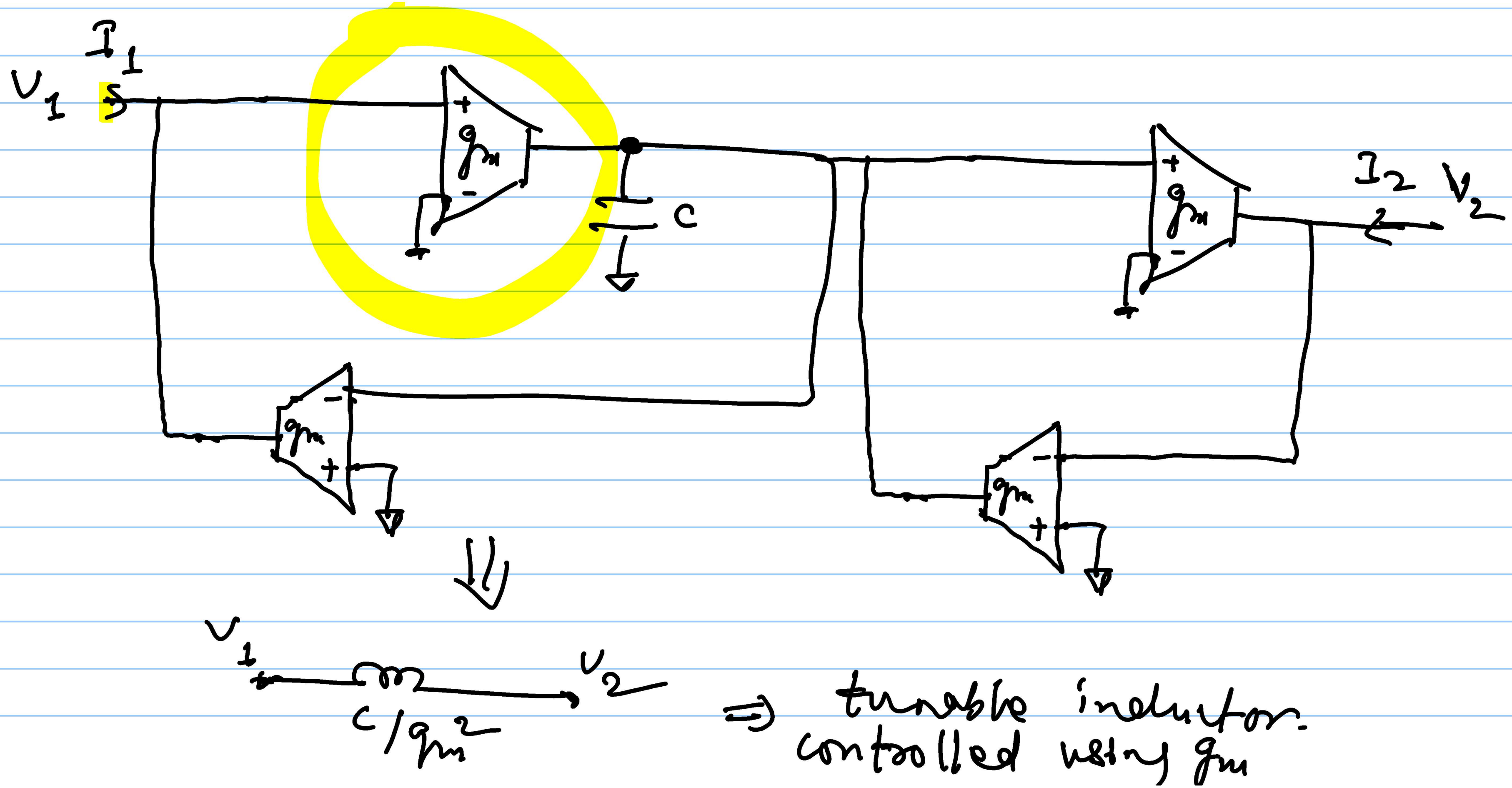
$$Z_1 = \frac{1}{G^2 Z_2}$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 0 & G \\ -G & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$I_1 = G V_2$$

$$I_2 = -G V_1$$





$\Rightarrow$ tunable inductor controlled using g_m