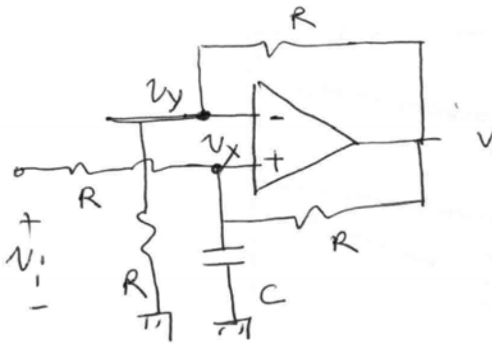
Non inverting integrator



$$\cancel{v_x = v_i \frac{1/sC}{R+1/sC} = v_i \frac{1}{1+sCR}}$$

At v_x node:

$$-\frac{v_i - v_x}{R} + v_x \cdot sC + \frac{v_x - v_o}{R} = 0$$

$$\frac{v_i}{R} + \frac{v_o}{R} = v_x \left(\frac{1}{R} + sC + \frac{1}{R}\right) = v_x \left(\frac{2}{R} + sC\right)$$

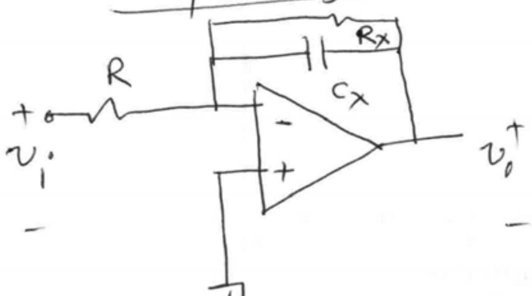
But $v_y = v_x$ (ideal OP-AMP)

$$= \frac{v_o}{2}$$

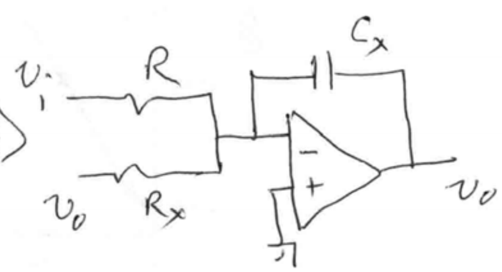
So $$\frac{v_i}{R} + \frac{v_o}{R} = \frac{v_o}{2}\left(\frac{2}{R} + sC\right) = \frac{v_o}{R} + \frac{v_o}{2} sC$$

$$v_i = \frac{v_o}{2} RSC \quad ; \quad \boxed{\frac{v_o}{v_i} = \frac{2}{sCR}}$$

Lossy Integrator:



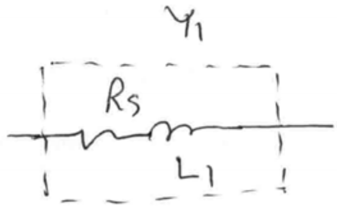
$\Rightarrow$



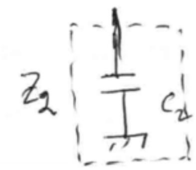
$$v_o = -v_i \frac{1}{sC_xR} - v_o \frac{1}{sC_xR_x}$$

$$v_o \left[1 + \frac{1}{sC_xR_x}\right] = -v_i \frac{1}{sC_xR}$$

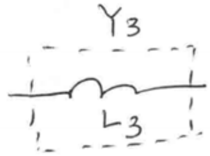
$$\frac{v_o}{v_i} = -\frac{1}{sC_xR} \cdot \frac{sC_xR_x}{1+sC_xR_x} = -\frac{R_x}{R} \cdot \frac{1}{1+sC_xR_x} = -\frac{1/RC_x}{s+1/C_xR_x}$$



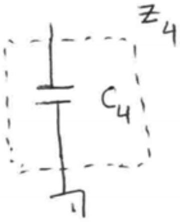
; $Y_1 = \dfrac{1/L_1}{s + R_S/L_1} \rightarrow T_1(s)$



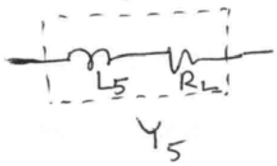
; $-Z_2 = -\dfrac{1}{sC_2} \rightarrow T_2(s)$



; $Y_3 = \dfrac{1}{sL_3} \rightarrow T_3(s)$



; $-Z_4 = -\dfrac{1}{sC_4} \rightarrow T_4(s)$



; $Y_5 = \dfrac{1/L_5}{s + R_L/L_5} \rightarrow T_5(s)$

$T_1(s) \rightarrow$ a VTF, unitless. So convert ~~Z_1~~ Y_1, an admittance to unitless by multiplying with $-R$.

So $T_1(s) = RY_1 = \dfrac{R/L_1}{s + R_S/L_1}$ → like a lossy integ. except for a -ve sign.

~~But~~ So to bring this -ve sign, we put a simple inverter. Thus

$T_1(s) \rightarrow$

$\underbrace{\qquad}_{\dfrac{-1/RC_x}{s + 1/R_xC_x}}$

$$\frac{V_{out}}{V_{in}} = T_1(s) = \frac{+1/RC_x}{s + 1/R_xC_x}$$

Now compare $Y_1 \to T_1 = \dfrac{R/L_1}{s + R_s/L_1}$

& try to obtain $\dfrac{1/C_x R}{s + 1/C_x R_x} = T_1$.

Comparing $\dfrac{R}{L_1} = \dfrac{1}{C_x R}$

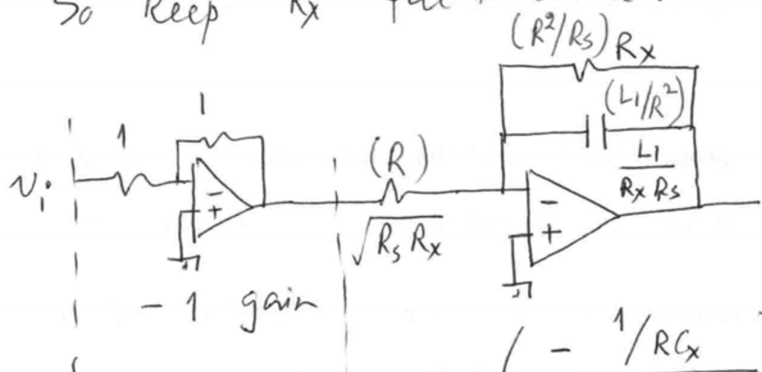
ie $R^2 = \dfrac{L_1}{C_x}$; But $\dfrac{R_s}{L_1} = \dfrac{1}{C_x R_x}$; $\dfrac{1}{C_x} = \dfrac{R_x R_s}{L_1}$

So $R^2 = \dfrac{L_1}{C_x} \cdot \dfrac{R_x R_s}{L_1} = R_x R_s$ $\boxed{\text{OR } R = \sqrt{R_x R_s}}$

choose, R_s given

Again $\dfrac{R_s}{L_1} = \dfrac{1}{C_x R_x}$; $C_x = \dfrac{L_1}{R_x R_s}$ decides $R_x = \dfrac{R^2}{R_s}$

So keep R_x free to choose:



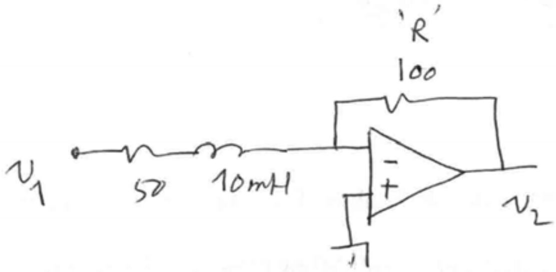
$$\left(\frac{-\,1/RC_x}{s + 1/C_x R_x} \right) \equiv \frac{-R/L_1}{s + R_s/L_1}$$

in terms of the components:

$$\frac{-\,\dfrac{1}{\sqrt{R_s R_x}} \cdot \dfrac{L_1}{R_x R_s}}{s + \dfrac{1}{R_x} \cdot \dfrac{L_1}{R_x R_s}} = \frac{-\sqrt{R_s R_x}/L_1}{s + \dfrac{R_s}{L_1}}$$

$$\because R = \sqrt{R_x R_s} \qquad = \frac{-R/L_1}{s + \dfrac{R_s}{L_1}}$$

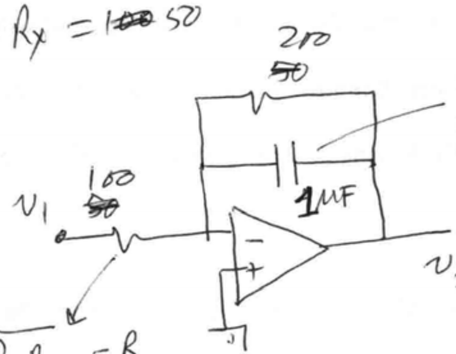
Prof:



$$\frac{v_2}{v_1} = - \frac{100 / 10mH}{s + 50/10mH}$$

$$\boxed{= \frac{-10^4}{s + 5000}}$$

Let $R_x = \cancel{100}\ 50$



$$\frac{L_1}{R_x R_s} = \frac{10mH}{\cancel{50\times 50}\ 200\times 50}$$

$$= \frac{10^{-2}}{2500} = 0.000004$$

$$= \frac{10^{-2}}{10^4} = 10^{-6} = 1\,\mu F$$

We must get $\boxed{\frac{v_2'}{v_1} = \frac{-10^4}{s+5000}}$

$\sqrt{R_s R_x} = R$

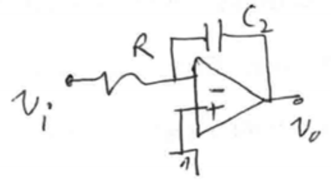
$= \sqrt{50 \times \cancel{100}\ 50}$

$= 50$

$R_s R_x = R^2 = 10^4$

$R_x = \frac{10^4}{50} = 2 \times 10^2 = 200$

Similarly , $T_2(s) = -\frac{Z_2}{R} = -\frac{1}{sC_2R}$



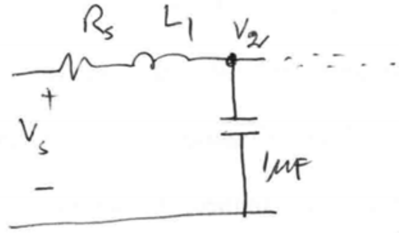
$$\frac{v_o}{v_i} = T_2(s) = -\frac{1}{sC_2R}$$

How we organize T_1 & T_2 here?

Consider : $V_1' = (V_1 - V_2)\, Y_1 R = (V_1 - V_2)\, T_1$

& $-V_2 = (V_1' - V_3')\left(-\frac{Z_2}{R}\right) = (V_1' - V_3')\, T_2$

& $V_1 = V_s$ now

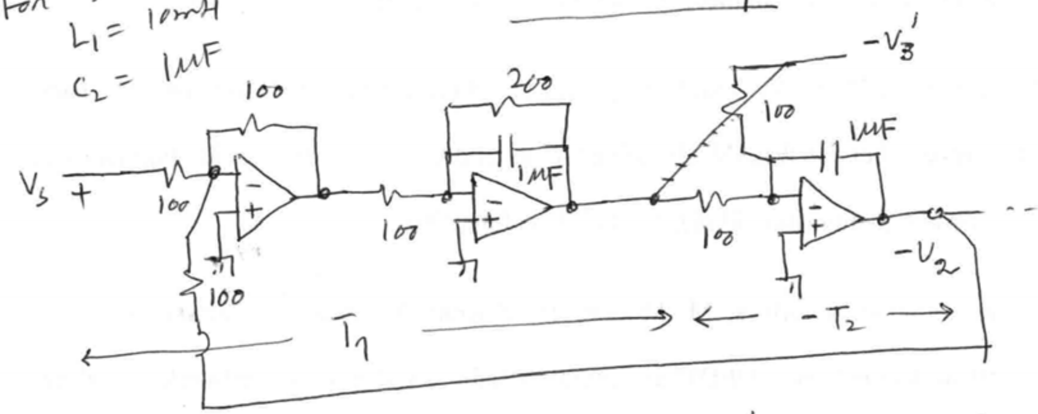


$R = 100\Omega$ (assumed)

For $R_s = 50$

$L_1 = 10mH$

$C_2 = 1\mu F$



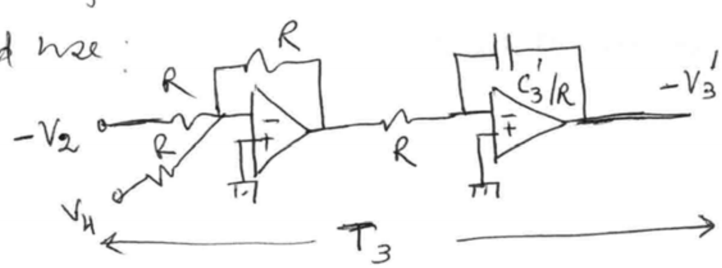
$\frac{1}{R.C_3'}$

About $-V_3'$? Recall $-V_3' = (-V_2 + V_4)\, Y_3 R$

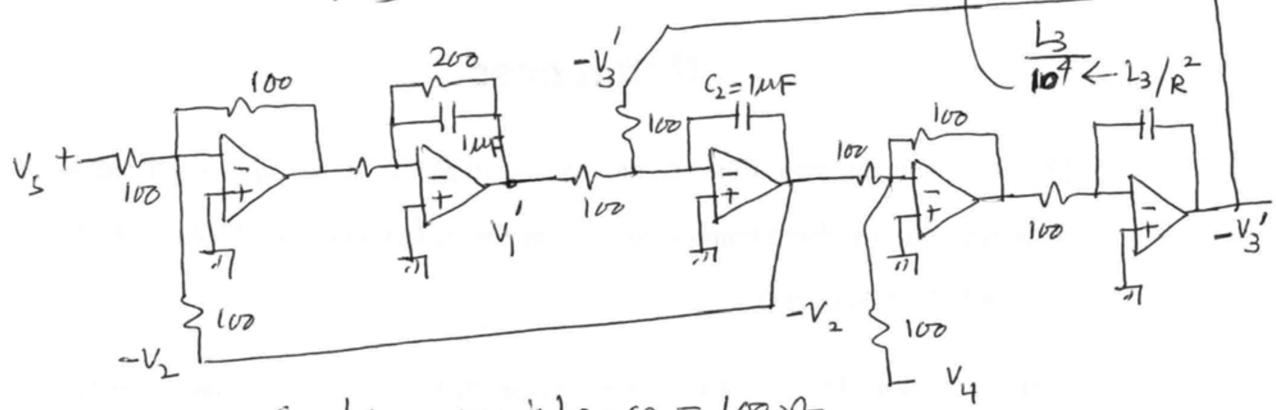
where $T_3 = Y_3 R = \frac{R}{sL_3} = \frac{1}{s(L_3/R)} = \frac{1}{sC_3'}$

$C_3' = L_3/R$, A non inverting ~~amp~~ integrator

We could use:

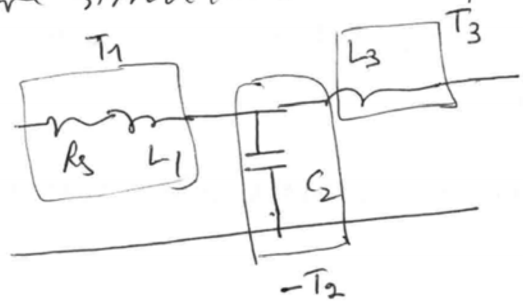


So $T_1, -T_2, T_3$ together now:



Scaling resistance = 100 Ω

We have simulated the operation of



& continue this way