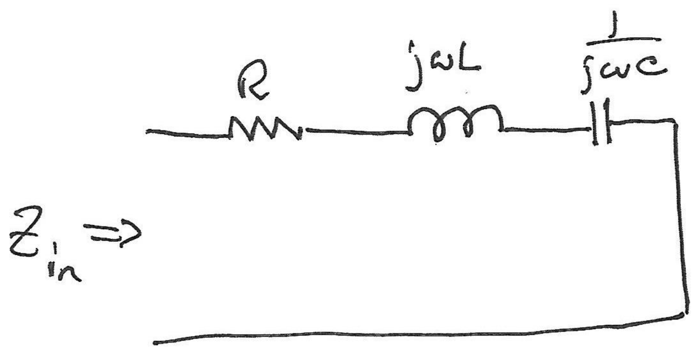
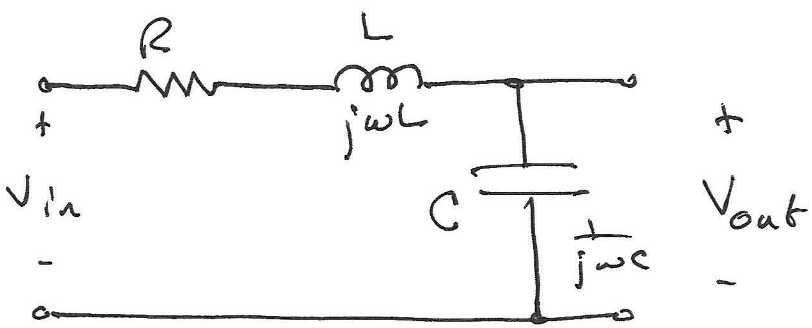


Assume sinusoidal signals.

$$Z_{in} = R + j\omega L + \frac{1}{j\omega C} = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

If $\omega L = \frac{1}{\omega C}$ then $Z_{in} = R$ is real



Assume sinusoidal signals.

$$\left.\begin{matrix} H(j\omega) \\ H(\omega) \end{matrix}\right\} = \frac{\frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}} \cdot \frac{j\omega C}{j\omega C}$$

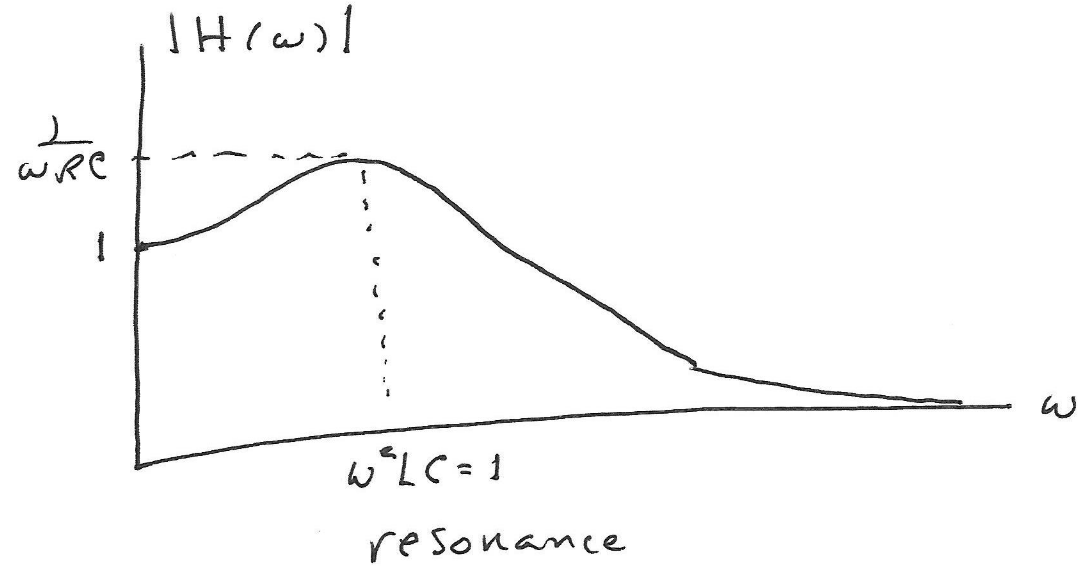
$$= \frac{1}{(1 - \omega^2 LC) + j\omega RC}$$

$$H(\omega) \rightarrow \frac{1}{j\omega RC} \quad \text{as} \quad \omega^2 LC \rightarrow 1$$

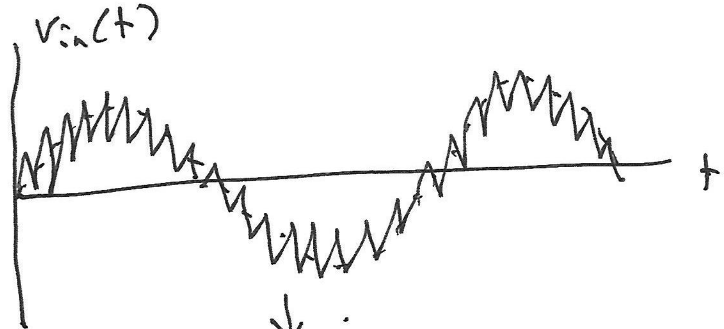
$$H(\omega) = \frac{1}{(1-\omega^2 LC) + j\omega RC}$$

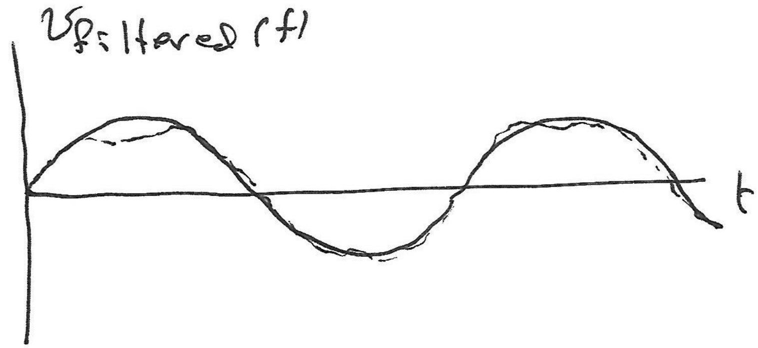
$$|H(\omega)| = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + (\omega RC)^2}}$$

$$\longrightarrow \quad \frac{1}{\omega RC} \quad \text{as} \quad \omega LC \to 1$$

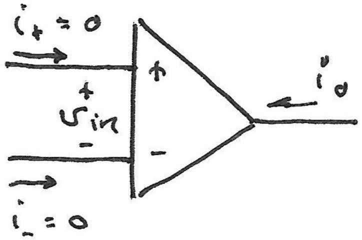


$$v_{in}(t) = A_1 \sin 5t + A_2 \sin(100t) + A_3 \sin(1000t)$$





Operational Amplifier (OpAmp)



Ideal:

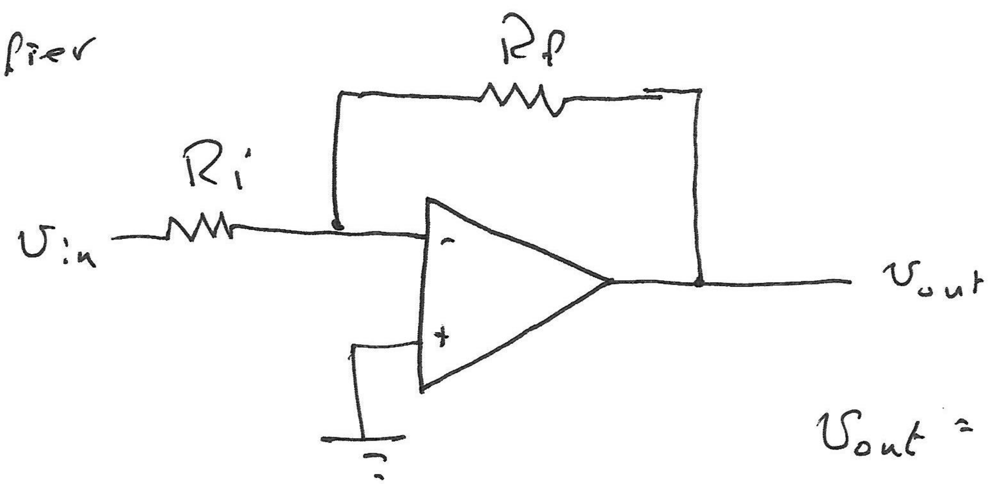
$v_{in} \approx 0$

$i_+ \approx 0$

$i_- \approx 0$

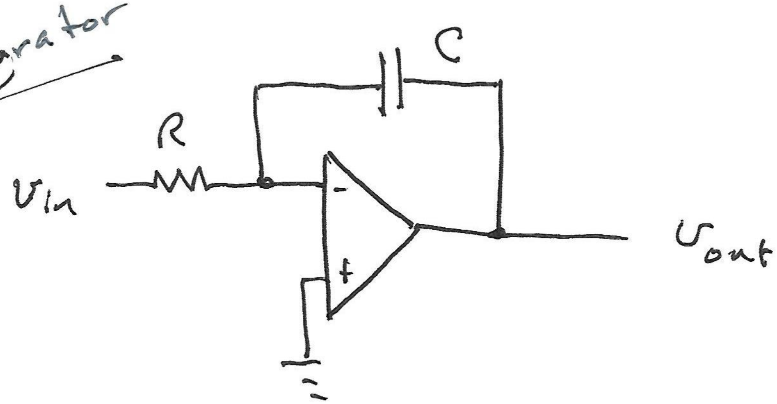
$i_o = ?$ (determined by the rest of the circuit.)

Inverting Amplifier



$$v_{out} = -\frac{R_f}{R_i} v_{in}$$

Integrator

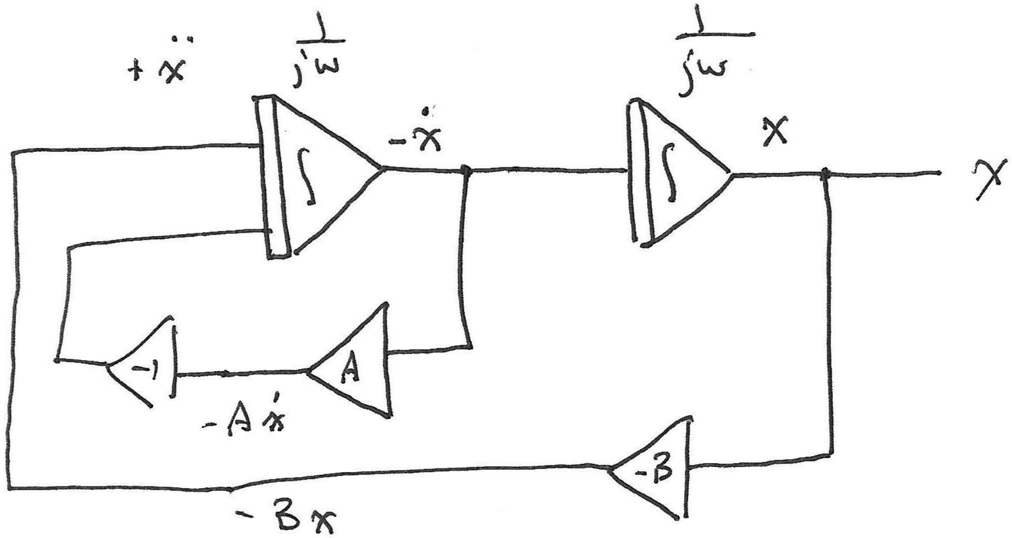


$$v_{out} = -\frac{1}{RC}\int_{-\infty}^{t} v_{in}\,dt$$

$$V_{out} = -\frac{1}{j\omega RC} V_{in}$$

$$\ddot{x} + A\dot{x} + Bx = 0$$

$$\ddot{x} = -A\dot{x} - Bx$$



Complex Numbers

$A \angle \theta$

polar

$Ae^{\pm j\theta}$

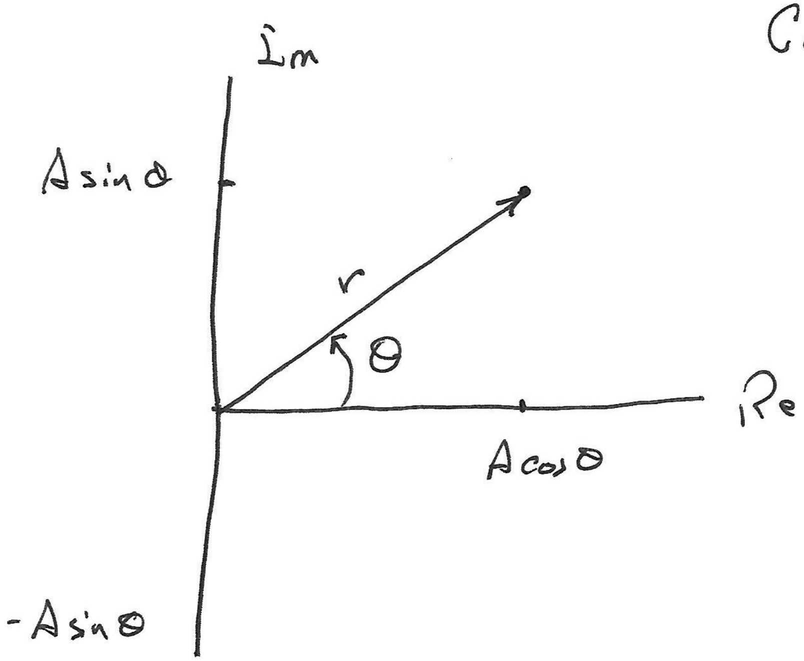
exponentrial

$\downarrow$ Euler's Identity

$A(\cos\theta \pm j\sin\theta)$

$= A\cos\theta \pm jA\sin\theta$

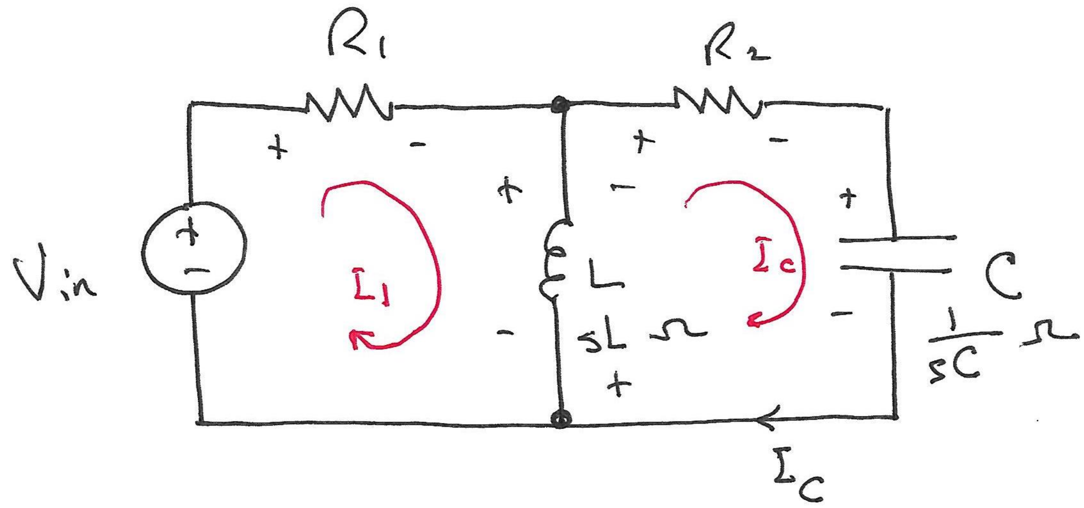
rectangular or Cartesian form



$$r = \sqrt{(A\cos\theta)^2 + (A\sin\theta)^2}$$

$$\theta = \tan^{-1}\frac{A\sin\theta}{A\cos\theta}$$

$$= \tan^{-1}\frac{\sin\theta}{\cos\theta}$$

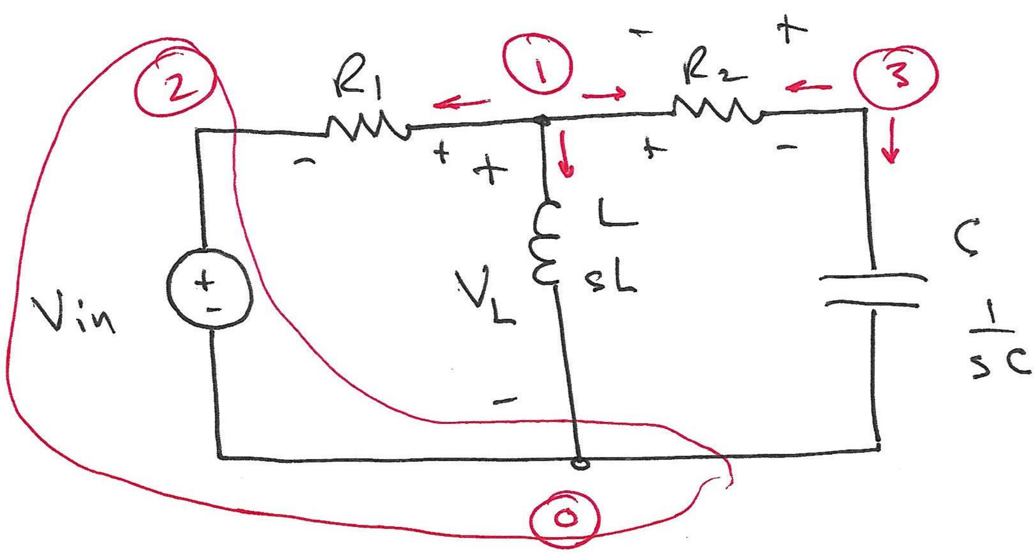


Determine I_c.

$$R_1 I_1 + sL(I_1 - I_c) = V_{in} \qquad \text{KVL for mesh } I_1$$

$$sL(I_c - I_1) + R_2 I_c + \frac{1}{sC} I_c = 0 \qquad \text{KVL for mesh } I_c$$

$$\begin{bmatrix} R + sL & -sL \\ -sL & sL + R_2 + \frac{1}{sC} \end{bmatrix} \begin{bmatrix} I_1 \\ I_c \end{bmatrix} = \begin{bmatrix} V_{in} \\ 0 \end{bmatrix}$$



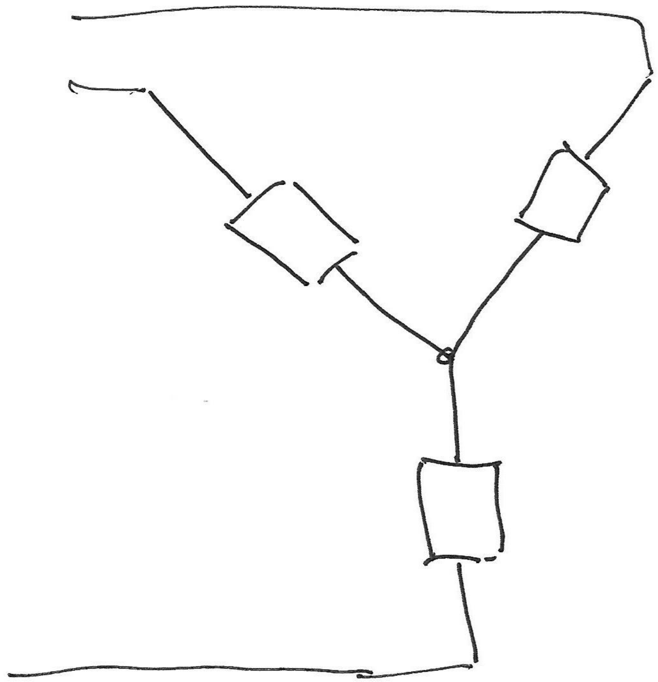
$$V_2 = V_{in}$$ Source constraint

$$\frac{V_1 - V_2}{R_1} + \frac{V_1}{sL} + \frac{V_1 - V_3}{R_2} = 0$$ KCL for node 1

$$\frac{V_3 - V_1}{R_2} + \underbrace{\frac{V_3}{\left(\frac{1}{sC}\right)}}_{= sC\,V_3} = 0$$ KCL at node 2

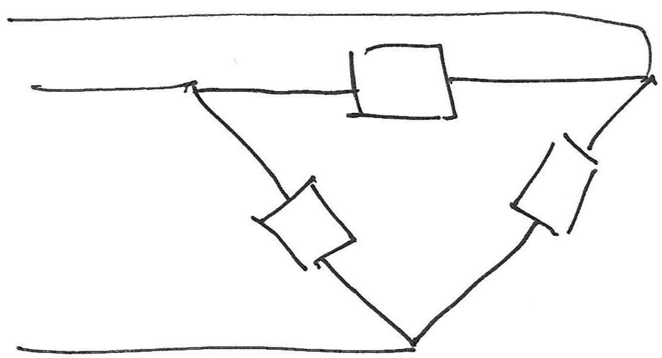
$$\begin{bmatrix} 0 & 1 & 0 \\ \frac{1}{R_1} + \frac{1}{sL} + \frac{1}{R_2} & -\frac{1}{R_1} & -\frac{1}{R_2} \\ -\frac{1}{R_2} & 0 & \frac{1}{R_2} + sC \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} V_{in} \\ 0 \\ 0 \end{bmatrix}$$

Solve. Then $V_L = V_1$.



wye

star



delta