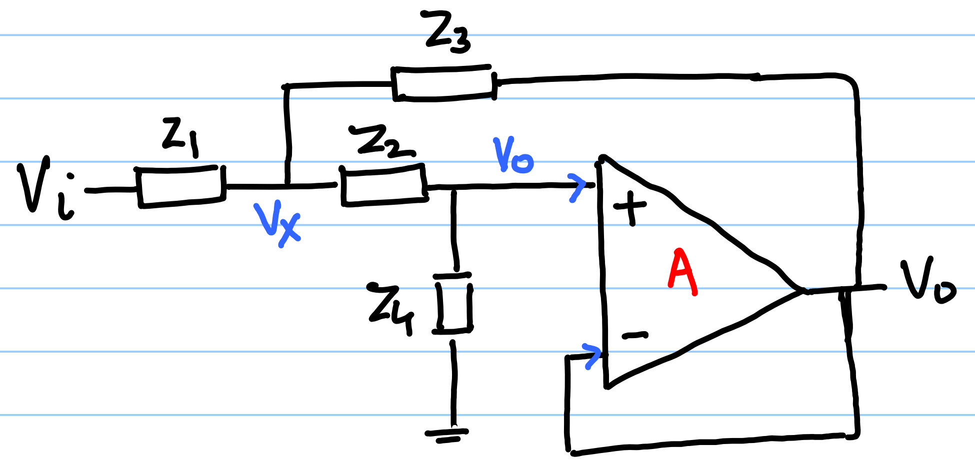
Note Title 31-03-2022

lecture # 34

Sallen-Key Filter.



$$\frac{V_x - V_o}{Z_2} = \frac{V_o}{Z_4}$$

$$\Rightarrow V_x = V_o\left(1 + \frac{Z_2}{Z_4}\right) \qquad -(1)$$

$$\frac{V_x - V_i}{Z_1} + \frac{V_x - V_o}{Z_2} + \frac{V_x - V_o}{Z_3} = 0$$

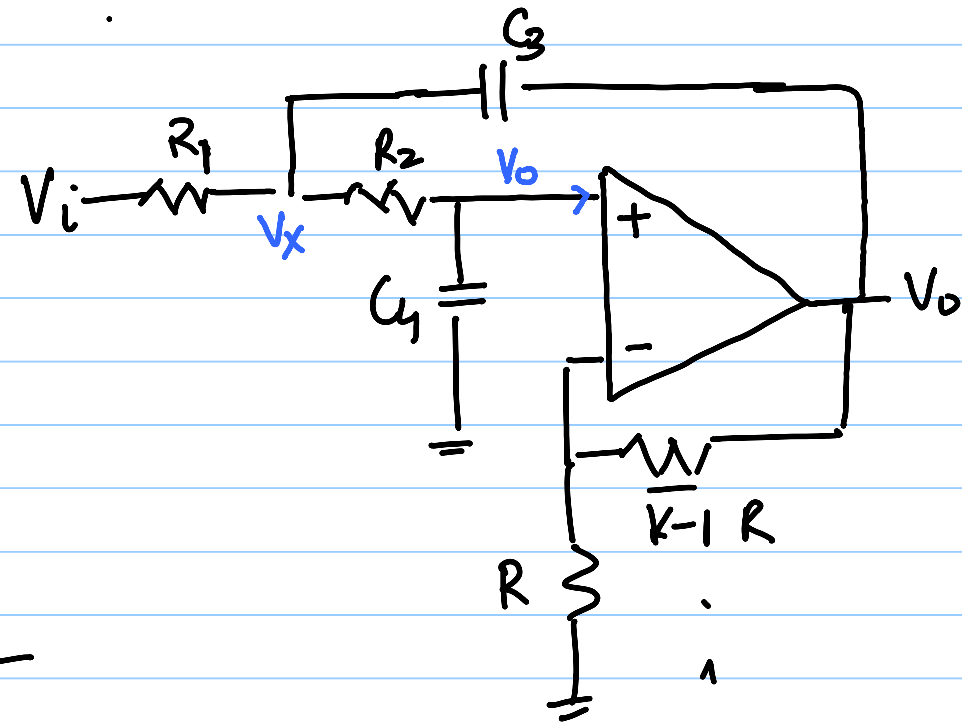
$$V_x\left(\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}\right) = V_o\left(\frac{1}{Z_2} + \frac{1}{Z_3}\right) + \frac{V_i}{Z_1} \qquad -(2)$$

$$V_o\left(1 + \frac{Z_2}{Z_4}\right)\left(\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}\right) = V_o\left(\frac{1}{Z_2} + \frac{1}{Z_3}\right) + \frac{V_i}{Z_1}$$

$$\frac{V_o}{V_i} = \frac{Z_3Z_4}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3 + Z_3Z_4} = \frac{1}{\frac{s^2}{\omega_p^2} + \frac{s}{\omega_p Q_p} + 1}$$

$$= \frac{Y_1Y_2}{Y_3Y_4 + Y_2Y_4 + Y_1Y_4 + Y_1Y_2}$$

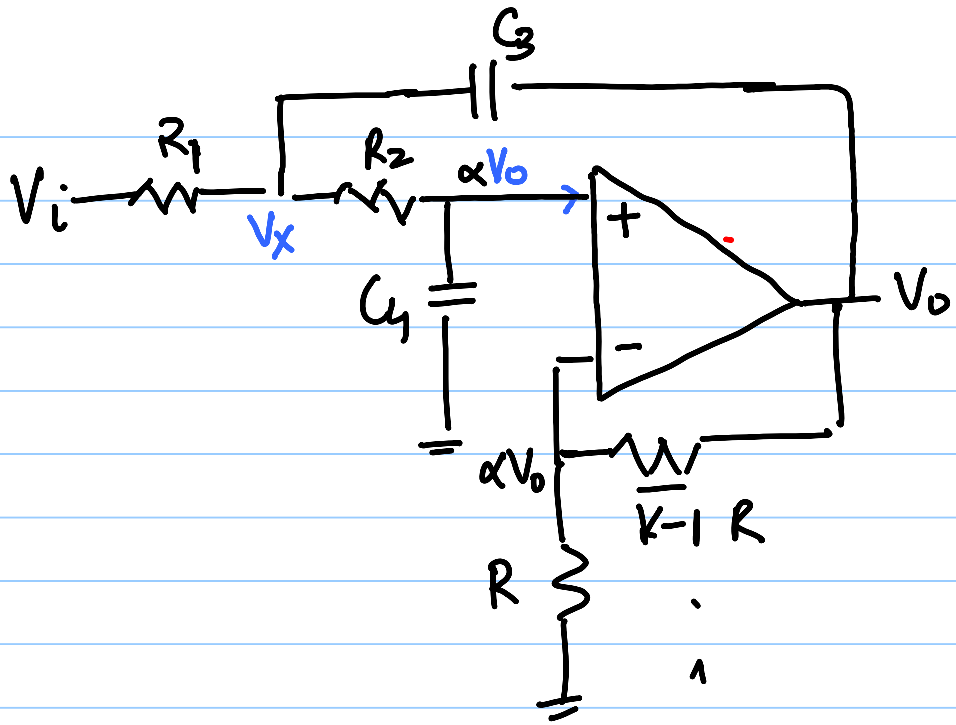
Y_1	Y_2	Y_3	Y_4
G_1	G_2	sC_3	sC_4



$$\frac{V_o'}{V_i} = \frac{G_1G_2}{s^2C_3C_4 + sC_4(G_1+G_2) + G_1G_2}$$

$$= \frac{1}{s^2 R_1R_2C_3C_4 + sC_4(R_1+R_2) + 1}$$

1



$$\alpha V_o = \frac{1/sC_4}{R_2 + \frac{1}{sC_4}} V_x = \frac{1}{1+sC_4R_2} V_x$$

$$\frac{V_x - V_i}{R_1} + \frac{V_x - \alpha V_o}{R_2} + \frac{V_x - V_o}{1/sC_3} = 0 \checkmark$$

$$V_x\left(\frac{1}{R_1} + \frac{1}{R_2} + sC_3\right) = V_o\left(\frac{\alpha}{R_2} + sC_3\right) + \frac{V_i}{R_1}$$

$\alpha = \frac{1}{K}$

$$\alpha V_o (1+sC_4R_2)\left(\frac{R_1+R_2+sC_3R_1R_2}{R_1R_2}\right) = V_o\left(\frac{\alpha + sC_3R_2}{R_2}\right) + \frac{V_i}{R_1}$$

$$V_o\left\{\frac{\alpha}{\alpha}(1+sC_4R_2)(R_1+R_2+sC_3R_1R_2) - \frac{\alpha}{\alpha}R_1 - \frac{s}{\alpha}C_3R_1R_2\right\} = V_i \cdot R_2/\alpha$$

$$\frac{V_o}{V_i} = \frac{1 / \alpha}{s^2 C_3 C_4 R_1 R_2^{\cancel{2}} + \cancel{s}\left(C_4 R_1 \cancel{R_2} + C_4 R_2^{\cancel{2}} + C_3 R_1 \cancel{R_2}\right) - s\frac{C_3}{\alpha} R_1 \cancel{R_2} + \frac{\cancel{R_1} + R_2}{R_2}}$$

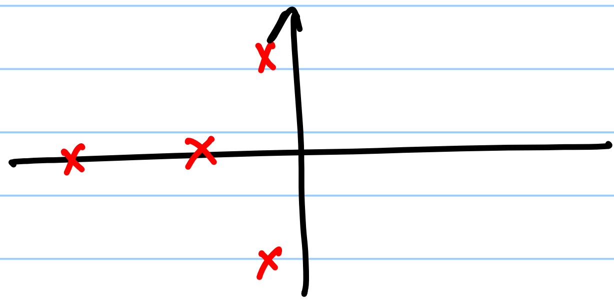
$$= \frac{K}{\underbrace{s^2 C_3 C_4 R_1 R_2} + s\left(\underbrace{C_4 R_1 + C_4 R_2} + \overbrace{C_3 R_1 - K C_3 R_1}^{(1-K) C_3 R_1}\right) + 1}$$

$$a x^2 + bx + c = 0$$

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$$x_1 + x_2 = \frac{-b}{2a} < 0$$

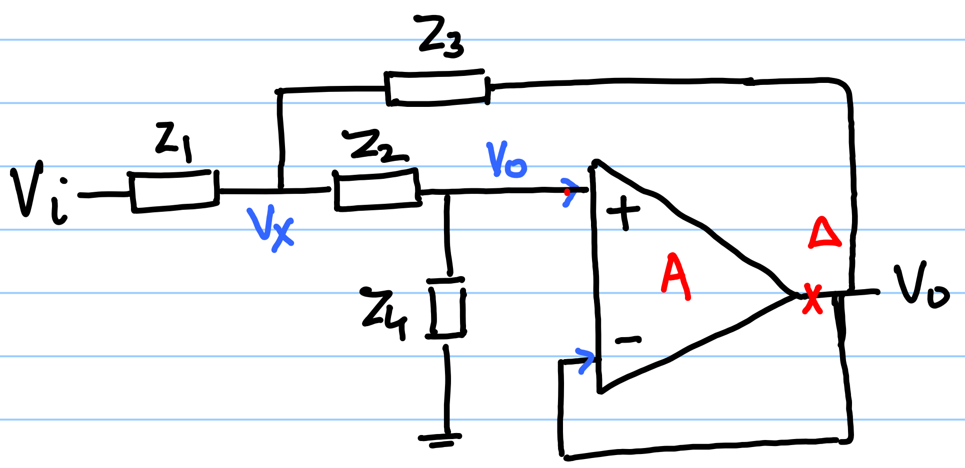
$$b > 0$$



$$C_4 R_1 + C_4 R_2 + \underbrace{C_3} R_1 (1 - K) > 0$$

$$\frac{C_4}{C_3} + \frac{C_4}{C_3}\frac{R_2}{R_1} + 1 - K > 0$$

$$K < 1 + \frac{C_4}{C_3} + \frac{C_4}{C_3}\frac{R_2}{R_1}$$



Ln

$$\frac{V_o}{V_i} = \frac{Z_3 Z_4}{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3 + Z_3 Z_4} = \frac{s^2/\omega_p^2}{\frac{s^2}{\omega_p^2} + \frac{s}{\omega_p Q_p} + 1}$$

$$= \frac{Y_1 Y_2}{Y_3 Y_4 + Y_2 Y_4 + Y_1 Y_4 + Y_1 Y_2} \quad = \frac{s/\omega_p Q_p}{\frac{s^2}{\omega_p^2} + \frac{s}{\omega_p Q_p} + 1}$$

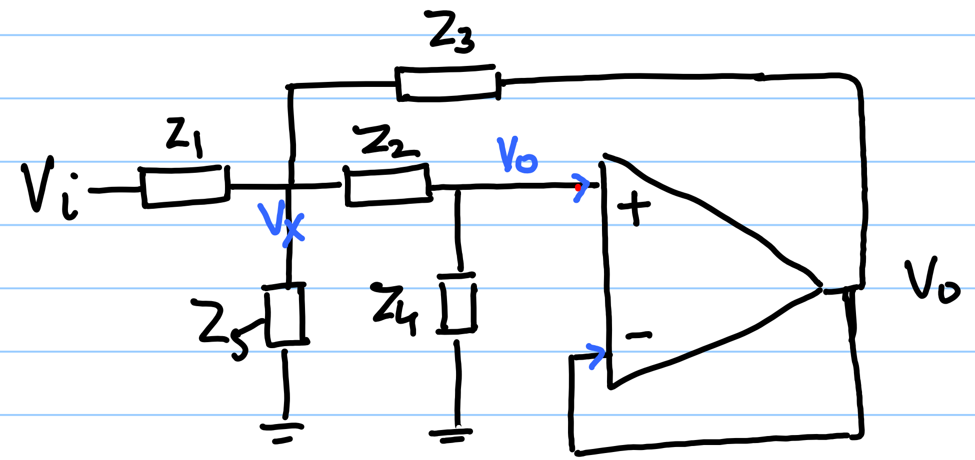
Y_1	Y_2	Y_3	Y_4
sC_1	sC_2	$\frac{1}{R_3}$	$\frac{1}{R_4}$

(High Pass Filter)

Y_1	Y_2	Y_3	Y_4
sC_1	$\frac{1}{R_2}$	$\frac{1}{sL_3}$	sC_4
		sC_3	$\frac{1}{R_4}$

$$H(s) = \frac{sC_1/R_2}{s^2 C_1 C_4 + s\frac{C_1}{R_2} + s\frac{C_4}{R_2} + \frac{sC_4}{sL_3}}$$

$$= \frac{sC_1 L_3 / C_4 R_2}{\frac{s^2 C_1 L_3}{1} + s\frac{C_1 L_3}{C_4 R_2} + \frac{sL_3}{R_2} + 1}$$



$$\frac{V_o}{V_i} = \frac{Y_1Y_2}{Y_2Y_5 + Y_2Y_4 + Y_4Y_5 + Y_3Y_4 + Y_1Y_2 + Y_1Y_4}$$

Y_1	Y_2	Y_3	Y_4	Y_5
sC_1	$\frac{1}{R_2}$	$\frac{1}{R_3}$	sC_4	$\frac{1}{R_5}$

"Rauch Filter"