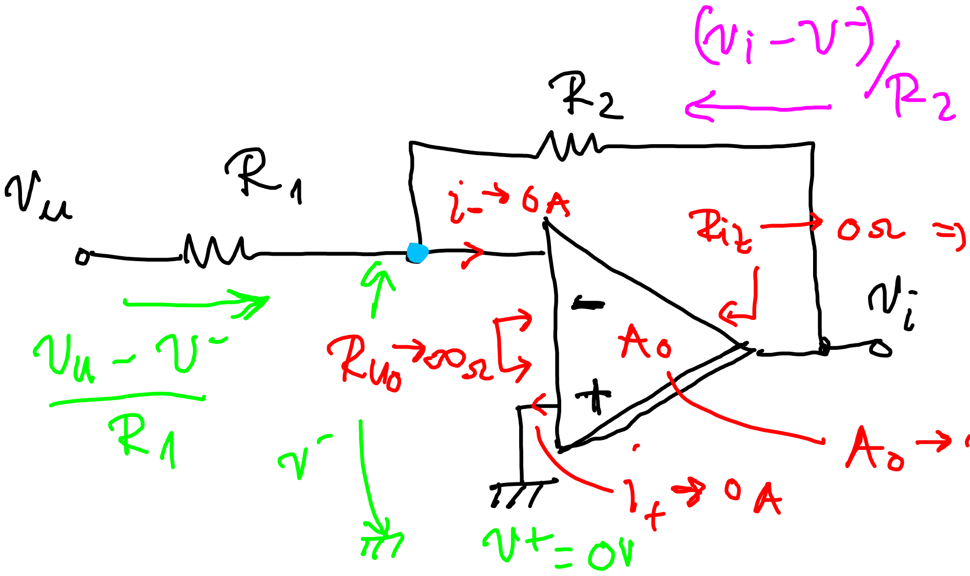
* INVERTUJUĆI POJAČAVAČ

$$A_u \triangleq \frac{V_i}{V_u}$$



$\Rightarrow$ NIKADA NE PISATI I K.Z ZA IZLAZNI ČVOR IDEALNOG OPAMPA !

$A_0 \to \infty \Rightarrow V^+ - V^- = \frac{V_i}{A_0} \to 0V \Rightarrow V^+ \approx V^-$ (KONAČNO)

ZA REŠAVANJE ZADATAKA SA IDEALNIM OPAMPOM DOVOLJNO JE PISATI I K Z SAMO ZA ULAZNE PRIKLJUČKE (V^+, V^-)

$$\frac{V_u - V^-}{R_1} + \frac{V_i - V^-}{R_2} = i^- \Rightarrow \frac{V_u}{R_1} + \frac{V_i}{R_2} = 0 \Rightarrow \boxed{\frac{V_i}{V_u} = -\frac{R_2}{R_1}}$$

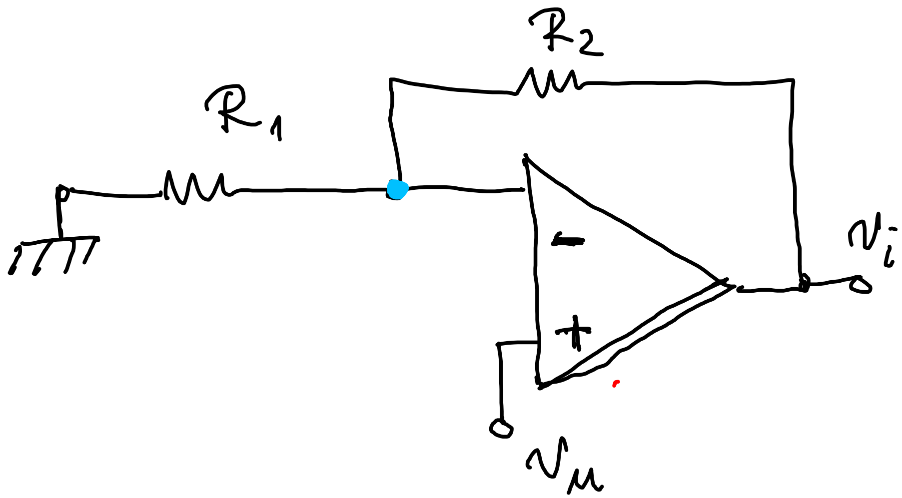
$A_0 \to \infty \Rightarrow V^- \approx V^+ = 0\ V$

$i^- = i^+ = 0A$

INVERTUJE ULAZNI NAPON

$V_i = A_u \cdot V_u, \quad A_u = -\frac{R_2}{R_1} < 0$

* NEINVERTUJUĆI POJAČAVAČ



$$A_0 \to \infty \Rightarrow v^- \approx v^+ = v_u$$

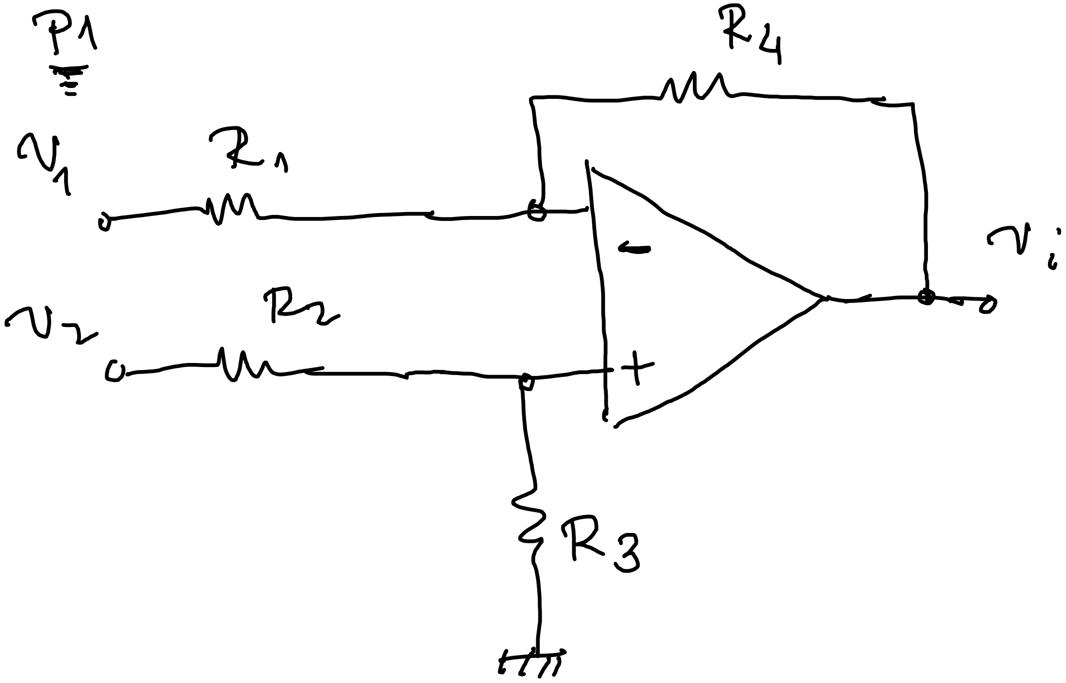
$$\frac{v_i - v_u}{R_2} = \frac{v_u}{R_1}$$

$$\boxed{\frac{v_i}{v_u} = 1 + \frac{R_2}{R_1}}$$

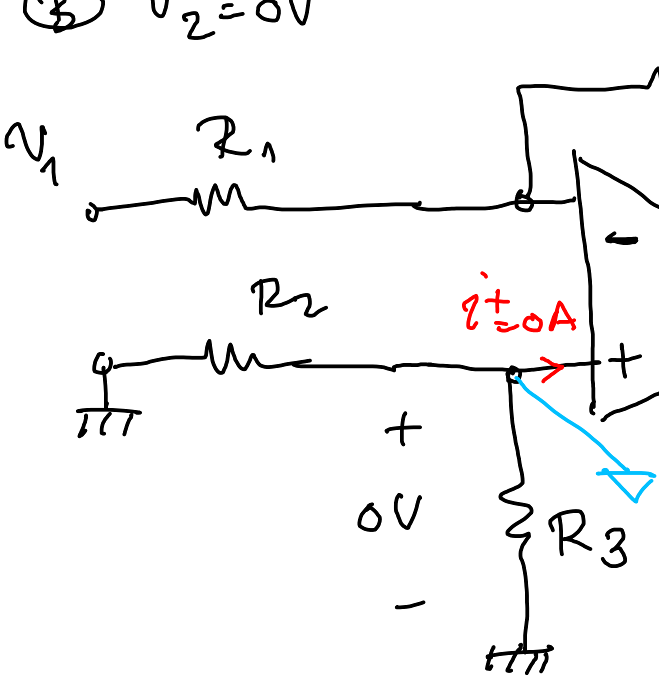
NE INVERTUJE ULAZNI NAPON

$$v_i = A_u \cdot v_u \;, \quad A_u = 1 + \frac{R_2}{R_1} > 1$$

P1

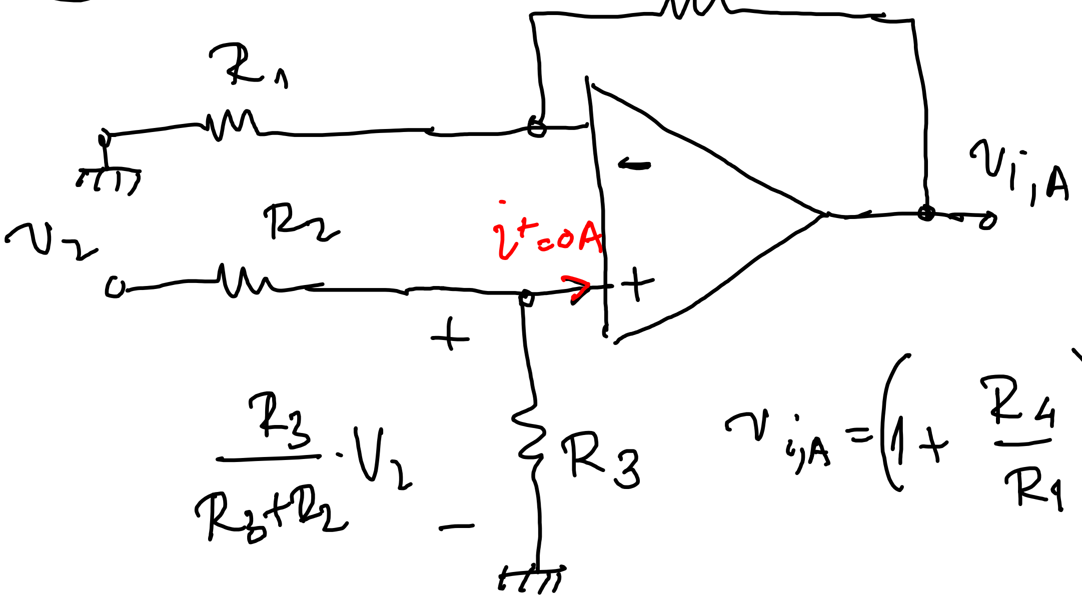


(B) $v_2 = 0V$



$$v_{i,B} = -\frac{R_4}{R_1} \cdot v_1$$

(A) $v_1 = 0V$

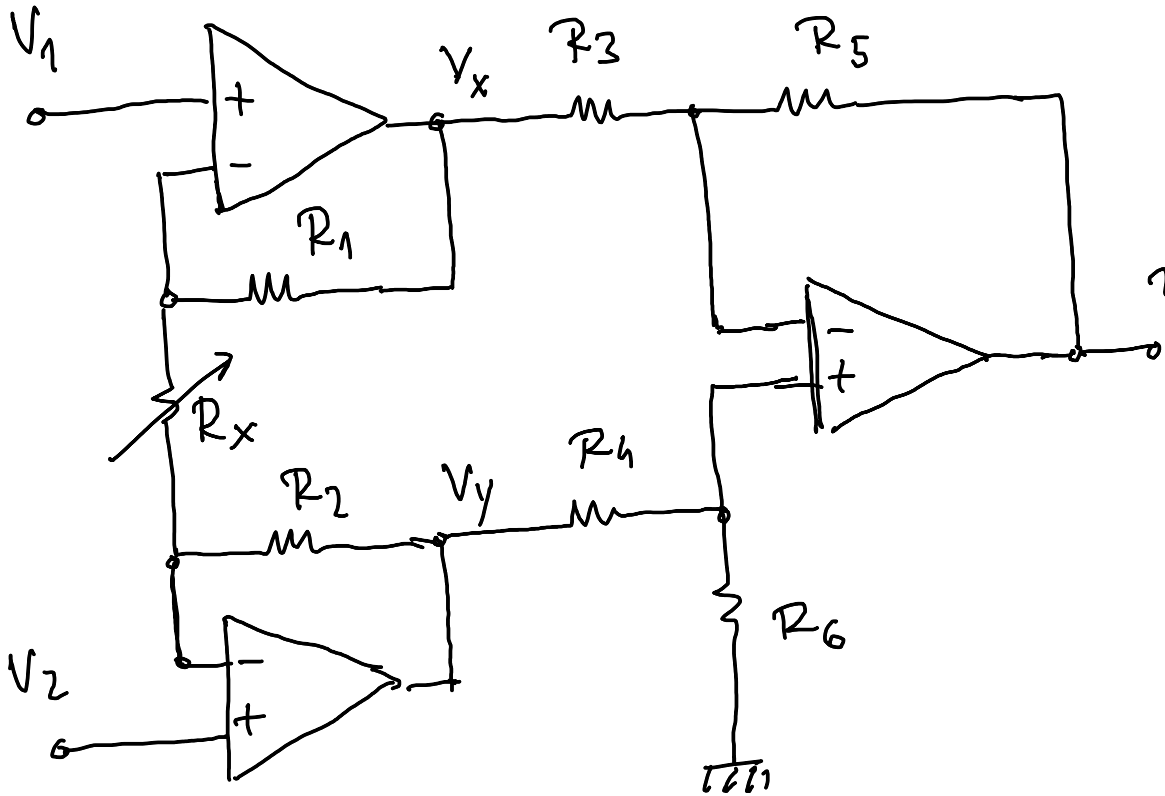


$$v_{i,A} = \left(1 + \frac{R_4}{R_1}\right) \frac{R_3}{R_3+R_2} \cdot v_2$$

$$v_i = v_{i,A} + v_{i,B}$$

$$\boxed{v_i = \left(1 + \frac{R_4}{R_1}\right) \frac{R_3}{R_3+R_2} \cdot v_2 - \frac{R_4}{R_1} \cdot v_1}$$

P 2

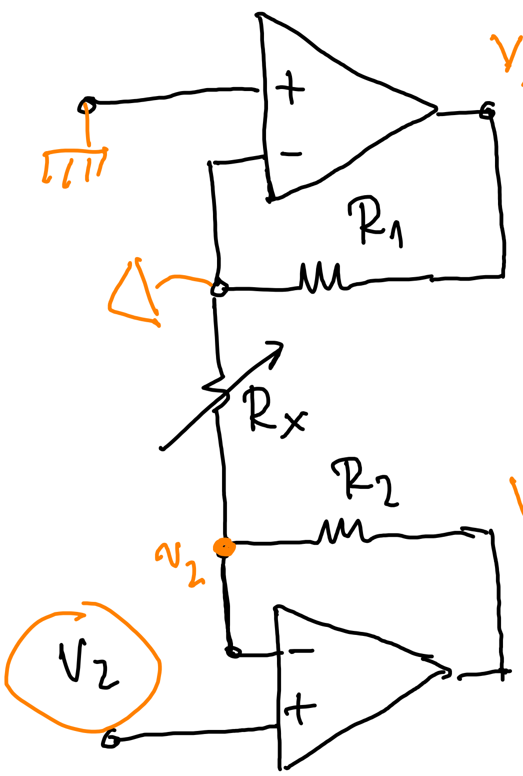


$$v_i = \frac{R_6}{R_6+R_4} \cdot \left(1+\frac{R_5}{R_3}\right) V_y - \frac{R_5}{R_3} \cdot V_x$$

$$v_x = v_{x,A} + v_{x,B} = -\frac{R_1}{R_x} v_2 + \left(1+\frac{R_1}{R_x}\right) \cdot v_1$$

$$v_y = v_{y,A} + v_{y,B} = \left(1+\frac{R_2}{R_x}\right) v_2 - \frac{R_1}{R_x} \cdot v_1$$

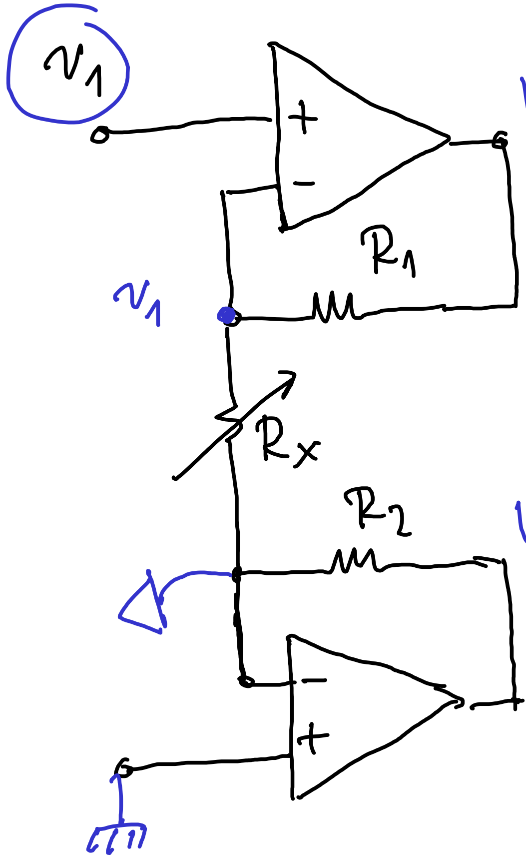
A $V_1 = 0\,V$



$V_{x,A} = -\frac{R_1}{R_x} v_2$

$V_{y,A} = \left(1+\frac{R_2}{R_x}\right) V_2$

B $V_2 = 0\,V$



$V_{x,B} = \left(1+\frac{R_1}{R_x}\right) V_1$

$V_{y,B} = -\frac{R_2}{R_x}\cdot v_1$

$$v_i = \frac{R_6}{R_6+R_4}\cdot\left(1+\frac{R_5}{R_3}\right)\left(\left(1+\frac{R_2}{R_x}\right)v_2 - \frac{R_1}{R_x}\cdot v_1\right)$$

$$-\frac{R_5}{R_3}\left(-\frac{R_1}{R_x}v_2 + \left(1+\frac{R_1}{R_x}\right)\cdot v_1\right)$$

$$V_i = \left(\frac{R_6}{R_6+R_4} \cdot \left(1+\frac{R_5}{R_3}\right)\left(1+\frac{R_2}{R_x}\right) + \frac{R_5}{R_3}\frac{R_1}{R_x} \right) V_2$$

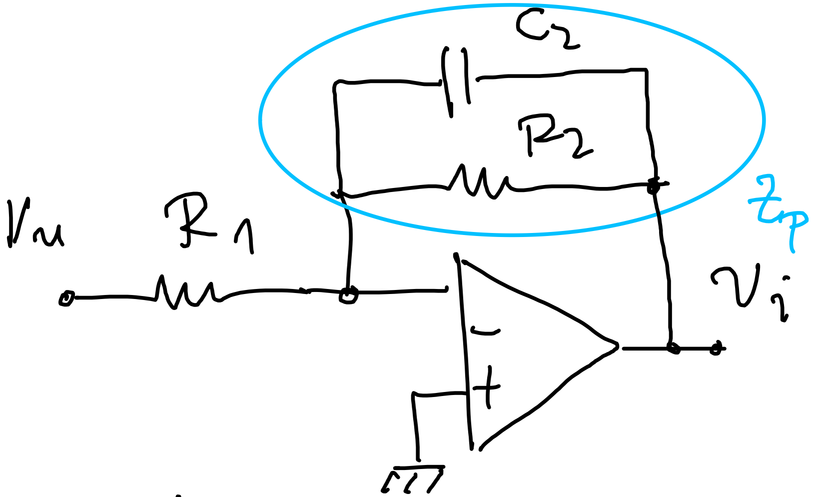
$$- \left(\frac{R_6}{R_6+R_4} \cdot \left(1+\frac{R_5}{R_3}\right)\frac{R_1}{R_x} \cdot + \frac{R_5}{R_3}\left(1+\frac{R_1}{R_x}\right) \cdot \right) V_1$$

$R_i = R_{i+1} = R$; $i = 1, 2, \dots, 5$; $R_x \neq R$

$$V_i = \left(\frac{1}{\cancel{2}} \cdot \cancel{2} \cdot \left(1+\frac{R}{R_x}\right) + \frac{R}{R_x} \right) V_2 - \left(\frac{1}{\cancel{2}} \cdot \cancel{2} \cdot \frac{R}{R_x} + 1 \cdot \left(1+\frac{R}{R_x}\right) \right) V_1$$

$$V_i = \left(1+\frac{2R}{R_x}\right) \cdot (V_2 - V_1) \Rightarrow \boxed{A_{n,inst} = \frac{V_i}{V_2 - V_1} = 1 + \frac{2R}{R_x}}$$

* INTEGRATOR SA OPAMPOM



$$A_u = \frac{V_i}{V_u} = -\frac{Z_p}{R_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + sC_2R_2}$$

$$Z_p = \frac{R_2}{1 + sC_2R_2}$$

LPF

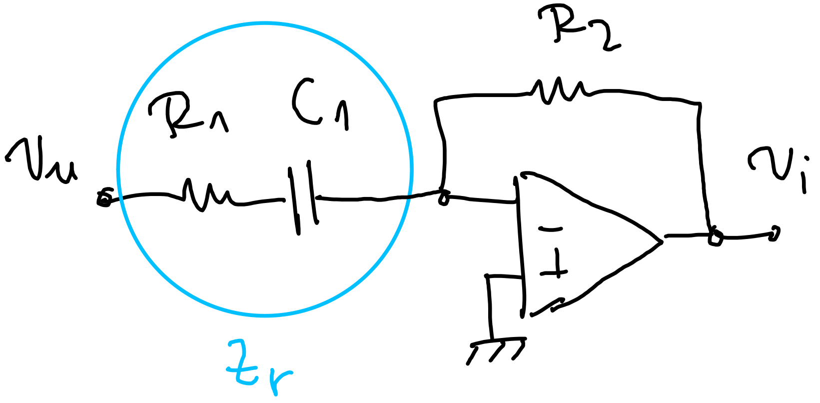
$$A_u = \frac{A_0}{1 + s/\omega_0} \quad ; \quad A_0 = -\frac{R_2}{R_1}$$

$$\omega_0 = \frac{1}{C_2R_2}$$

$$i_c = C\frac{dV_i}{dt} \Rightarrow V_i = \frac{1}{C}\int i_c(V_u) \cdot dt$$

---

* DIFERENCIJATOR



$$A_u = -\frac{R_2}{Z_r} = -\frac{sC_1R_2}{1 + sC_1R_1} = -\frac{R_2}{R_1} \cdot \frac{sC_1R_1}{1 + sC_1R_1}$$

$$A_u = \frac{s/\omega_0}{1 + s/\omega_0} \;, \quad A_0 = -\frac{R_2}{R_1}$$

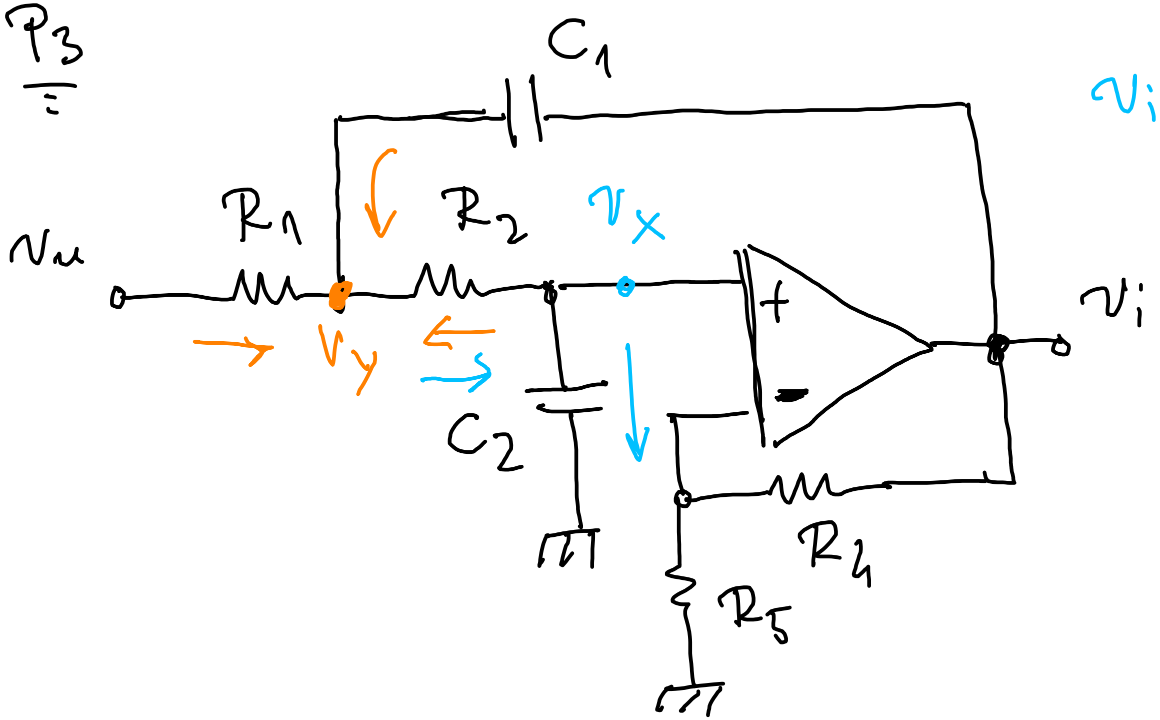
HPF

$$\omega_0 = \frac{1}{C_1R_1}$$

$$Z_r = \frac{1 + sC_1R_1}{sC_1}$$

$$i_c(V_i) = C\frac{dV_c(V_u)}{dt}$$

P3



$$v_i = \left(1 + \frac{R_4}{R_5}\right) V_x = K \cdot V_x$$

$$K = 1 + \frac{R_4}{R_5}$$

$$\boxed{V_x = V_i / K}$$

$$\frac{V_u - V_y}{R_1} + (V_i - V_y)\cdot sC_1 + \frac{V_i/K - V_y}{R_2} = 0$$

$$\frac{V_y - V_i/K}{R_2} = \frac{V_i}{K}\cdot sC_2 \Rightarrow V_y = \frac{V_i}{K}(1 + sC_2R_2)$$

$$\frac{V_u}{R_1} = \left(\frac{1}{R_1} + \frac{1}{R_2} + sC_1\right)\underbrace{\frac{V_i}{K}(1 + sC_2R_2)}_{V_y} - sC_1 V_i - \frac{V_i/K}{R_2} \Big) R_1 \cdot K$$

$$K V_u = \left[\left(1 + \frac{R_1}{R_2} + sC_1R_1\right)\left(1 + sC_2R_2\right) - sC_1R_1 \cdot K \cdot - \frac{R_1}{R_2}\right] V_i$$

$$A_u \equiv H = \frac{V_i}{V_u} = \frac{K}{1 + s\left(\left(1 + \frac{R_1}{R_2}\right)C_2R_2 + C_1R_1(1-K)\right) + s^2 C_1R_1C_2R_2}$$

LPF

$R_1 = R_2 = R$; $C_1 = C_2 = C$

$$H = \frac{K}{1 + s(3-K)\cdot C \cdot R + s^2 (CR)^2} \quad ; \quad K = 1 + \frac{R_4}{R_5}$$

$$H_0 = K = 1 + R_4/R_5$$

$$A_u \equiv H(s) = \frac{H_0}{1 + a_1 \cdot s + a_2 \cdot s^2} \Rightarrow$$

$$a_1 = (3-K)CR$$

$$a_2 = (CR)^2$$