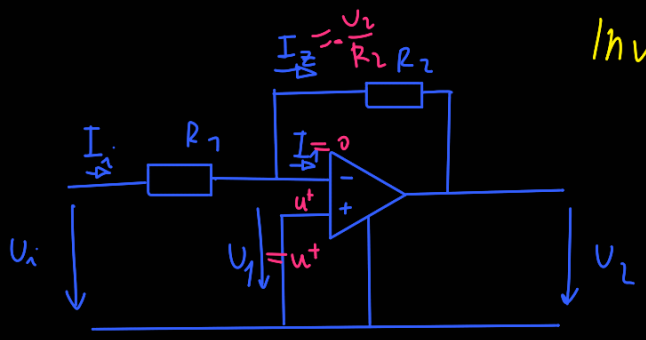
Invertující zesilovač



$$I_1 = \frac{U_i}{R_1} = \frac{U_2}{R_2}$$

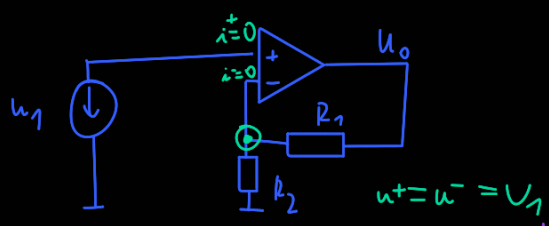
$$U_2 = -U_i \frac{R_2}{R_1}$$

$u^+ = u^-$

$i^+ = i^- = 0$

$$P = \frac{U_2}{U_i}$$

Neinvertující



$u^+ = u^- = U_1$

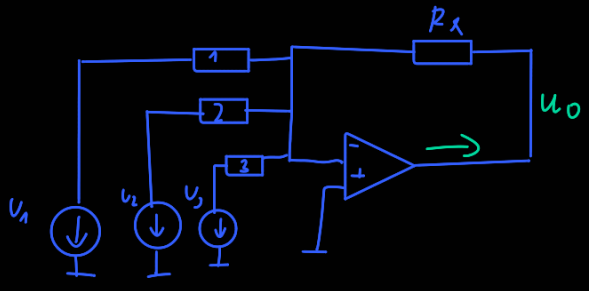
MUN:

$$\frac{u^-}{R_2} + \frac{u^- - u_0}{R_1} = 0$$

$$\frac{R_1 u^-}{R_2} + u^- - u_0 = 0$$

$$u_0 = \left(\frac{R_1}{R_2} + 1\right) U_1$$

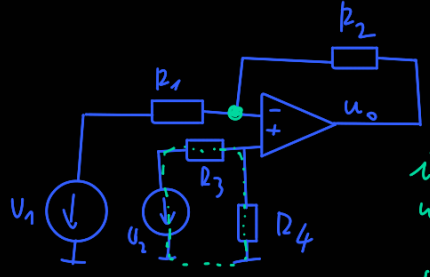
Sumační zesilovač



$$\frac{U_1}{R_1} + \frac{U_2}{R_2} + \frac{U_3}{R_3} = -\frac{U_0}{R_x}$$

$$U_0 = R_x \sum_{i=0}^{n} \frac{U_i}{R_i}$$

Rozdílový zesilovač



$i^- = i^+ = 0$

$u^- = u^+$

$$u^+ = U_2 \frac{R_4}{R_3 + R_4}$$

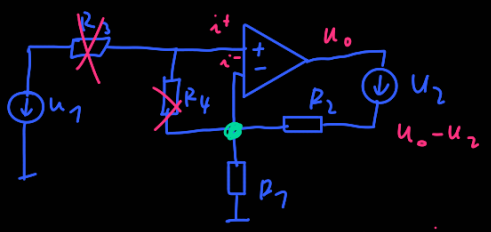
MUN:

$$\frac{u^- - u_0}{R_2} + \frac{u^- - U_1}{R_1} = 0$$

$$u_0 = u^- + (u^- - U_1)\frac{R_2}{R_1}$$

$$u_0 = u^-\left(1 + \frac{R_2}{R_1}\right) - u_1 \frac{R_2}{R_1}$$

$$u_0 = U_2 \frac{R_4}{R_3 + R_4}\left(1 + \frac{R_2}{R_1}\right) - u_1 \frac{R_2}{R_1}$$



$i^+ = i^- = 0$

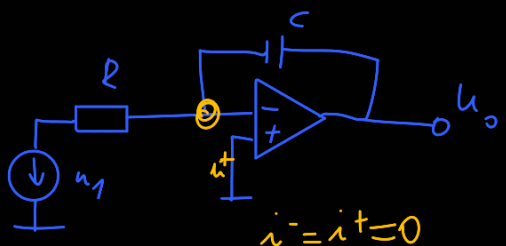
$u^+ = u^- = u_1$

$$\frac{u^- - (u_0 - u_2)}{R_2} + \frac{u^-}{R_1} = 0$$

$$\frac{u_1 - u_0 + u_2}{R_2} + \frac{u_1}{R_1} = 0$$

$$R_2\left(\frac{u_1}{R_2} + \frac{u_1}{R_1} + \frac{u_2}{R_2}\right) = u_0$$

$$u_1 + u_2 + u_1\frac{R_2}{R_1} = u_0$$



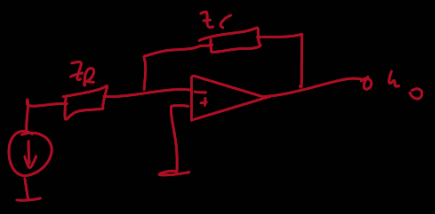
$i^- = i^+ = 0$

$u^- = u^+ = 0$

$$C\frac{d(0-u_0)}{dt} + \frac{0-u_1}{R} = 0$$

$$-C\frac{du_0}{dt} - \frac{u_1}{R} = 0$$

$$u_0 = -\int_0^t \frac{u_1}{CR}\,dt$$

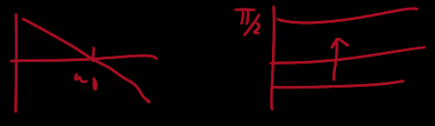


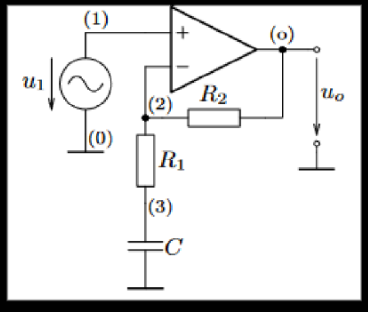
$$\frac{0-u_1}{Z_R} + \frac{0-u_0}{Z_C} = 0$$

$$u_0 = -\frac{Z_C u_1}{Z_R}$$

$$u_0 = -\frac{u_1}{j\omega CR}$$

$$\hat{P} = \frac{u_0}{u_1} = -\frac{1}{j\omega CR} \qquad u_0 = \frac{1}{CR}$$





$u^+ = u^- = u_1$

$i^- = i^+ = 0$

$$\frac{u_1 - u_0}{Z_2} + \frac{u_1 - 0}{Z_1 + Z_C} = 0$$

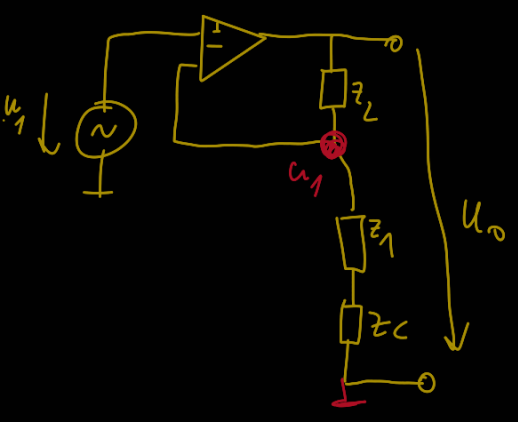
$$u_0 = u_1 + \frac{Z_2 u_1}{Z_1 + Z_C}$$

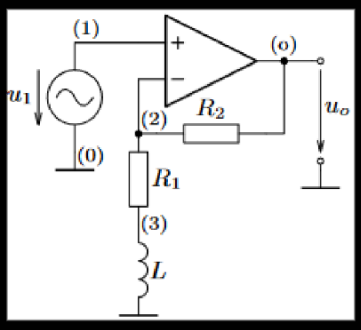
$$u_0 = u_1 + \frac{R_2 u_1}{R_1 + \frac{1}{j\omega C}}$$

$$u_0 = u_1 + \frac{j\omega C R_2 u_1}{j\omega C R_1 + 1}$$

$$\hat{P} = 1 + \frac{j\omega C R_2}{j\omega C R_1 + 1}$$

$$\hat{P} = \frac{j\omega C(R_1 + R_2) + 1}{j\omega C R_1 + 1}$$





$i^- = i^+ = 0$

$u^+ = u^- = u_1$

MUN: $\frac{u_1}{z_{R_1} + z_L} + \frac{u_1 - u_o}{z_{R_2}} = 0$

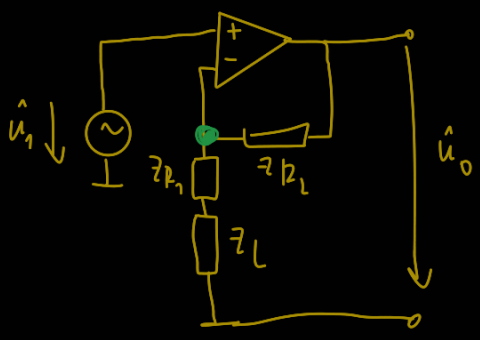
$u_o = u_1 + \frac{z_{R_2} u_1}{z_{R_1} + z_L}$

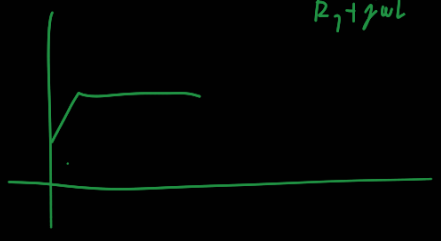
$u_o = u_1 + \frac{R_2 u_1}{R_1 + j\omega L}$

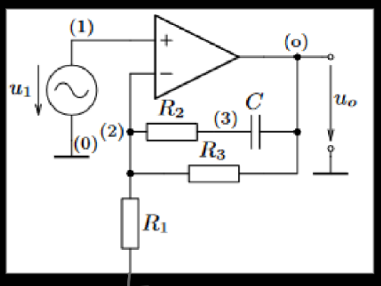
$\hat{p} = 1 + \frac{R_2}{R_1 + j\omega L}$

$\hat{p} = \frac{R_1 + j\omega L + R_2}{R_1 + j\omega L}$

$\hat{p} = \frac{R_1 + R_2}{R_1} \cdot \frac{1 + j\omega \frac{L}{(R_1 + R_2)}}{1 + j\omega \frac{L}{R_1}}$







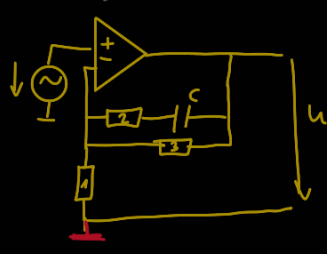
$i^- = i^+ = 0$

$u^- = u^+ = u_1$

$\frac{u_1}{z_{R_1}} + \frac{u_1 - u_o}{(z_{R_2} + z_C) \| z_{R_3}} = 0$

$\frac{u_1}{R_1} + \frac{u_1 - u_o}{\frac{(R_2 + \frac{1}{j\omega C}) \cdot R_3}{R_2 + \frac{1}{j\omega C} + R_3}} = 0$

$P = 1 + \frac{R_3 (j\omega C R_2 + 1)}{R_1 (j\omega C (R_2 + R_3) + 1)}$



$\frac{u_1}{R_1} + \frac{u_1 - u_o}{\frac{j\omega C R_3 + 1}{j\omega C} R_3} = 0$

$\frac{u_1}{R_1} + \frac{(u_1 - u_o)(j\omega C (R_2 + R_3) + 1)}{(j\omega R_2 + 1) R_3} = 0$

$P = \frac{R_1 [j\omega C (R_2 + R_3) + 1] + R_3 [j\omega C R_2 + 1]}{R_1 [j\omega C (R_2 + R_3) + 1]}$

$P = \frac{j\omega C (R_2 + R_3) R_1 + R_1 + j\omega C R_2 R_3 + R_3}{(j\omega C (R_2 + R_3) + 1) R_1}$

$u_o = \frac{R_3 u_1 (j\omega C (R_2 + R_3) + 1)}{R_1 (j\omega C (R_2 + R_3) + 1)} + u_1$

$P = \frac{j\omega C R_1 (R_2 + 2R_3) + R_1 + R_3}{R_1 [j\omega C (R_2 + R_3) + 1]}$

$P = \frac{R_2 + R_3}{R_1} \cdot \frac{j\omega C \frac{R_1 (R_2 + 2R_3)}{R_2 + R_3} + 1}{j\omega C (R_2 + R_3) + 1}$