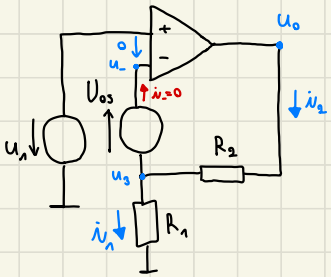



$u_3 = U_{os} + u_1$

$u_- = u_1$

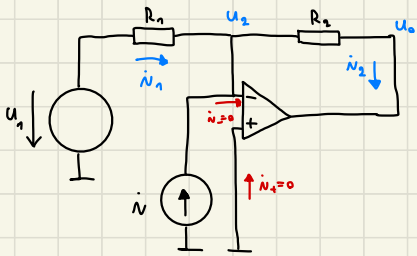
$i_- = 0 \rightarrow i_2 = i_1$

MUN (pro $u_3$ uzel):

$i_1 = (U_{os} + u_1) \cdot \frac{1}{R_1}$

$u_0 = i_2 \cdot R_2 + u_3 = i_1 \cdot R_2 + u_3 = (U_{os} + u_1) \cdot \frac{R_2}{R_1} + (U_{os} + u_1) = (U_{os} + u_1)\left(\frac{R_2}{R_1} + 1\right) = (U_{os} + u_1)\left(\frac{R_1 + R_2}{R_1}\right)$

√

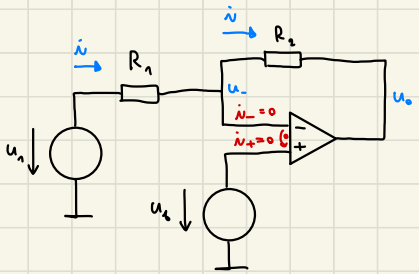



$u_+ = u_- = u_2 = 0$

MUN: $\frac{0-u_1}{R_1} - i_1 + \frac{0-u_0}{R_2} = 0$

$-i_1 - \frac{u_1}{R_1} = \frac{u_0}{R_2} \rightarrow u_0 = R_2\left(-i_1 - \frac{u_1}{R_1}\right)$

$i_2 = \frac{u_2 - u_0}{R_2} = i + \frac{u_1}{R_1}$

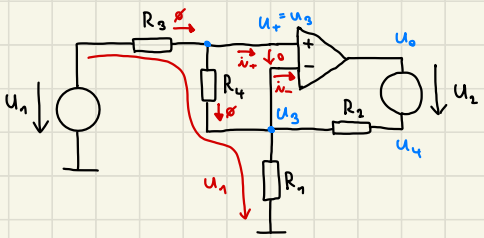



$$u_- = u_+$$

$$\dot{\imath} = \frac{u_1 - u_+}{R_1} = \frac{u_+ - u_0}{R_2}$$

$$\rightarrow u_0 = \frac{R_2 u_1 - R_2 u_+ - R_1 u_+}{R_1} \cdot (-1)$$

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




1) MUN: $\frac{U_1 - U_3}{R_3} + \frac{U_3 - U_0}{0} + 0 = 0$

$U_1 - U_3 = 0$

$U_1 = U_3 = U_+$

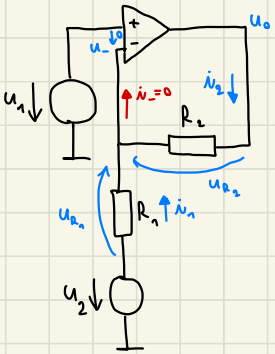
2) $0 + 0 + \frac{U_4 - U_1}{R_2} + \frac{-U_1}{R_1} = 0$

$\frac{U_4}{R_2} = U_1\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = U_1\left(\frac{R_1 + R_2}{R_1 R_2}\right)$

$U_4 = U_1\left(\frac{R_1 + R_2}{R_1}\right)$

$U_0 = U_2 + U_4$

$U_0 = U_2 + U_4 = U_2 + U_1\left(\frac{R_1 + R_2}{R_1}\right) = \frac{U_2 R_1 + U_1 R_1 + U_1 R_2}{R_1}$



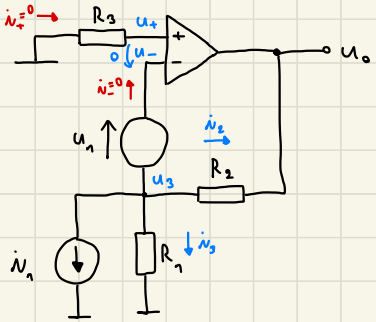

$$u_- = u_1$$

$$u_{R_1} = u_2 - u_1$$

$$i_1 = \frac{u_{R_1}}{R_1} = (u_2 - u_1) \cdot \frac{1}{R_1}$$

$$i_{R_2} = -i_1 = (u_1 - u_2) \cdot \frac{1}{R_1}$$

$$u_0 = u_{R_2} - u_{R_1} + u_2 = i_{R_2} R_2 + u_1 - u_2 + u_2 = (u_1 - u_2)\frac{R_2}{R_1} + u_1 = \frac{R_2 u_1 - R_2 u_2 + R_1 u_1}{R_1}$$




$u_- = u_+ = 0$

$u_3 = u_1$

$u_0 = 0$

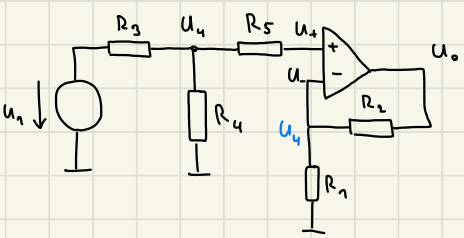
MUN: $0 + i_1 + \frac{u_1 - 0}{R_1} + \frac{u_1 - u_0}{R_2} = 0$

$R_1 R_2 i_1 + R_2 u_1 + R_1 u_1 = R_1 u_0$

$u_0 = u_1 + R_2 i_1 + \frac{R_2}{R_1} u_1$

$i_2 = \frac{u_1 - u_0}{R_2} = -i_1 - \frac{u_1}{R_1}$

$i_3 = \frac{u_1}{R_1}$



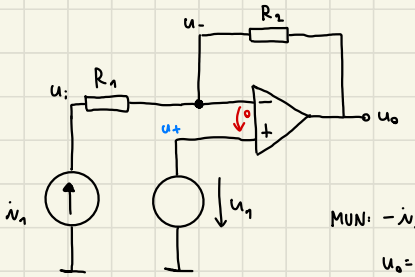

$$U_4 = U_1 \cdot \frac{R_4}{R_4 + R_5}$$

$$\frac{U_4 - U_+}{R_5} = 0 \rightarrow U_+ = U_- = U_4$$

$$\frac{U_4}{R_1} + \frac{U_4 - U_0}{R_2} = 0 \rightarrow \frac{U_0}{R_2} = U_4 \left( \frac{1}{R_1} + \frac{1}{R_2} \right)$$

$$U_0 = U_4 \left( 1 + \frac{R_2}{R_1} \right)$$

$$U_0 = U_1 \cdot \frac{R_4}{R_4 + R_5} \left( \frac{R_1 + R_2}{R_1} \right)$$



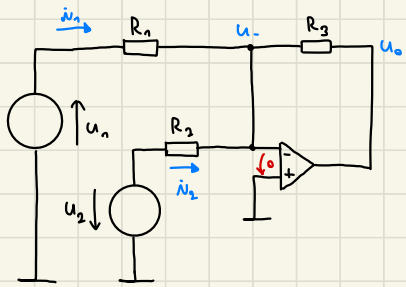

$u_+ = u_- = u_1$

$i_{R_1} = \frac{u_1 - u_1}{R_1}$

$u_1 = u_1 + R_1 i_{R_1}$

MUN: $-i_1 + 0 + \frac{u_1 - u_0}{R_2} = 0$

$u_0 = u_1 - i_1 R_2$



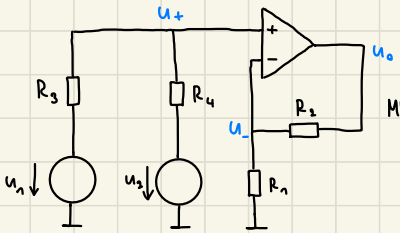

$u_- = u_+ = 0$

MUN: $\frac{0-(-u_1)}{R_1} + \frac{0-u_o}{R_3} + \frac{0-u_2}{R_2} = 0$

$u_o = \frac{R_3}{R_1} u_1 - \frac{R_3}{R_2} u_2$

$i_1 = \frac{-u_1-0}{R_1} = -\frac{u_1}{R_1}$

$i_2 = \frac{u_2}{R_2}$




$u_+ = u_- = u_3$

MUN: 1) $\frac{u_3 - u_1}{R_3} + \frac{u_3 - u_2}{R_4} = 0$

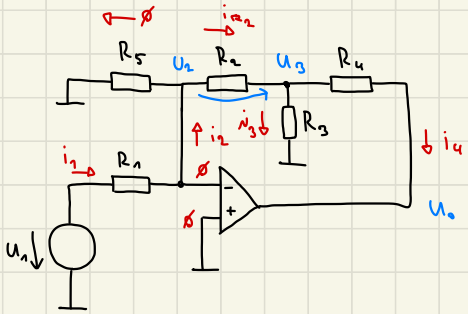
$u_3\left(\frac{1}{R_3} + \frac{1}{R_4}\right) = \frac{u_1}{R_3} + \frac{u_2}{R_4}$

$u_3\left(\frac{R_3 + R_4}{R_3 R_4}\right) = \frac{R_4 u_1 + R_3 u_2}{R_3 R_4} \quad / \left(\frac{R_3 R_4}{R_3 + R_4}\right)$

$u_3 = \frac{R_4 u_1 + R_3 u_2}{R_3 \cdot R_4} = u_- = u_+$

2) $\frac{u_3}{R_1} + \frac{u_3 - u_0}{R_2} = 0$

$u_0 = u_3\left(1 + \frac{R_2}{R_1}\right) = \frac{R_4 u_1 + R_3 u_2}{R_3 \cdot R_4} \cdot \left(\frac{R_1 + R_2}{R_1}\right) = \frac{R_1 R_4 u_1 + R_1 R_3 u_2 + R_2 R_4 u_1 + R_2 R_3 u_2}{R_1 R_3 R_4}$




$i_1 = i_2 = \frac{U_1}{R_1}$

$U_2 = U_- = U_+ = 0$

$i_2 = i_{R_2}$

$U_{R_2} = i_2 \cdot R_2 = U_1 \frac{R_2}{R_1}$

$U_3 = -U_{R_2} = -U_1 \frac{R_2}{R_1}$

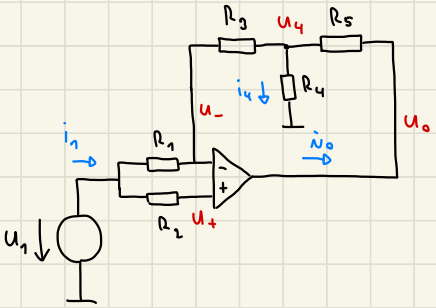
$i_3 = \frac{U_3}{R_3} = -U_1 \frac{R_2}{R_1 R_3}$

$\frac{U_3}{R_2} + \frac{U_3}{R_3} + \frac{U_3 - U_0}{R_4} = 0 \rightarrow U_0 = U_3 \cdot \left(1 + \frac{R_4}{R_2} + \frac{R_4}{R_3}\right)$

$\frac{R_2R_3 + R_3R_4 + R_2R_4}{R_2R_3}$

$U_0 = -U_1 \cdot \frac{R_2}{R_1} \left( \frac{R_2R_3 + R_3R_4 + R_2R_4}{R_2R_3} \right) = -U_1 \frac{R_2R_3 + R_3R_4 + R_2R_4}{R_1R_3}$

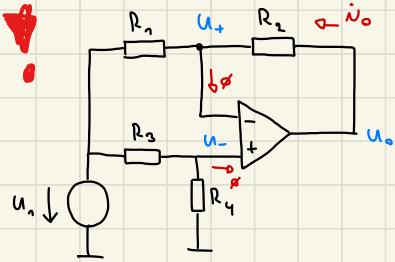
$i_4 = i_2 - i_3 = U_1 \left( \frac{1}{R_1} + \frac{R_2}{R_1R_3} \right) = U_1 \left( \frac{R_2 + R_3}{R_1R_3} \right)$




$i_{R_2} = 0 \rightarrow u_+ = u_- = u_1 \rightarrow i_1 = 0$

$u_4 = u_1 \rightarrow i_4 = \frac{u_1}{R_4} \rightarrow i_4 = i_0$

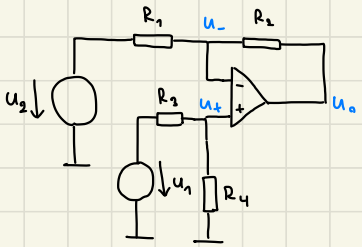
$u_0 = i_0 R_5 + u_4 = u_1 \frac{R_5}{R_4} + u_1 = u_1 \left( \frac{R_4 + R_5}{R_4} \right)$




$$U_+ = U_- = U_1 \frac{R_4}{R_3 + R_4}$$

$$i_0 = \frac{U_+ - U_1}{R_1} = U_1 \left( \frac{R_4}{R_1(R_3+R_4)} - \frac{1}{R_1} \right) = -U_1 \left( \frac{R_3}{R_1(R_3+R_4)} \right)$$

$$U_0 = i_0 \cdot R_2 + U_+ = U_1 \left( \frac{R_4}{R_3+R_4} - \frac{R_2 R_3}{R_1(R_3+R_4)} \right) = U_1 \left( \frac{R_1 R_4 - R_2 R_3}{R_1(R_3+R_4)} \right)$$



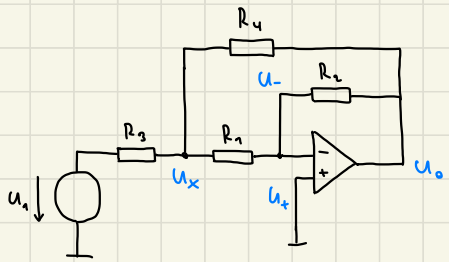

$$u_+ = u_- = u_1 \cdot \frac{R_4}{R_3+R_4}$$

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

$$u_0 = u_+\left(1 + \frac{R_2}{R_1}\right) - u_2\frac{R_2}{R_1}$$

$$u_0 = u_1 \cdot \frac{R_4}{R_3+R_4} \cdot \left(\frac{R_1+R_2}{R_1}\right) - u_2\frac{R_2}{R_1}$$

$$u_0 = u_1\left(\frac{R_4(R_1+R_2)}{R_1(R_3+R_4)}\right) - u_2\left(\frac{R_2}{R_1}\right)$$




$$U_+ = U_- = 0$$

$$\frac{U_x - U_1}{R_3} + \frac{U_x}{R_1} + \frac{U_x - U_0}{R_4} = 0$$

$$\frac{U_x}{R_1} + \frac{U_0}{R_2} = 0 \rightarrow U_x = -U_0 \frac{R_1}{R_2}$$

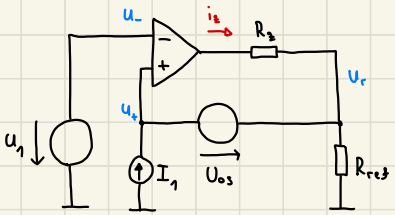
$$-U_0 \frac{R_1}{R_2 R_3} - \frac{U_1}{R_3} - U_0 \frac{1}{R_2} - U_0 \frac{R_1}{R_2 R_4} - U_0 \frac{1}{R_4} = 0$$

$$-U_0 \left( \frac{R_1}{R_2 R_3} + \frac{1}{R_2} + \frac{R_1}{R_2 R_4} + \frac{1}{R_4} \right) = U_1 \frac{1}{R_3}$$

$$\frac{R_1 R_4 + R_3 R_4 + R_1 R_3 + R_2 R_3}{R_2 R_3 R_4}$$

$$U_0 = -U_1 \frac{R_2 R_4}{R_1 R_4 + R_3 R_4 + R_1 R_3 + R_2 R_3}$$

$$U_x = U_1 \frac{R_1 R_4}{R_1 R_4 + R_3 R_4 + R_1 R_3 + R_2 R_3}$$



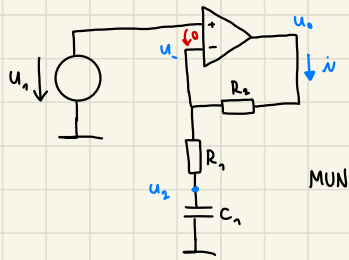

$$u_- = u_+ = u_1$$

$$u_r = u_1 - U_{os}$$

$$i_z' = -I_1$$

$$i_z'' = \frac{u_r}{R_{ref}} = \frac{u_1 - U_{os}}{R_{ref}}$$

$$\left.\begin{array}{l} i_z' = -I_1 \\ i_z'' = \frac{u_r}{R_{ref}} = \frac{u_1 - U_{os}}{R_{ref}} \end{array}\right\} \; i_z = -I_1 + \frac{u_1 - U_{os}}{R_{ref}}$$




$u_- = u_+ = u_1$

$\hat{Z}_c = \frac{1}{sC}$

$u_2 = u_1 \cdot \frac{\hat{Z}_c}{R_1 + \hat{Z}_c} = u_1 \cdot \frac{\frac{1}{sC}}{\frac{R_1 sC + 1}{sC}} = \frac{u_1}{1 + sR_1C}$

MUN: $\frac{u_1 - u_o}{R_2} + \frac{u_1 - u_2}{R_1} = 0$

$u_o = u_1 + \frac{R_2}{R_1}(u_1 - u_2)$

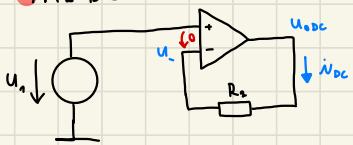
$= u_1 + \frac{R_2}{R_1} u_1 \left(1 - \frac{1}{1+sR_1C}\right) = u_1\left(1 + \left(\frac{R_2}{R_1}\left(1 - \frac{1}{1+sR_1C}\right)\right)\right)$

$= u_1\left(1 + \left(\frac{R_2}{R_1} \cdot \frac{sR_1C}{1+sR_1C}\right)\right) = u_1\left(1 + \frac{sR_1R_2C}{R_1 + sR_1^2C}\right) = u_1\left(\frac{R_1 + sR_1^2C + sR_1R_2C}{R_1 + sR_1^2C}\right)$

$u_o = u_1 \cdot \left(\frac{R_1 + sR_1C(R_1 + R_2)}{R_1 + sR_1^2C}\right) = u_1 \cdot \frac{1 + sC(R_1 + R_2)}{1 + sR_1C}$

$= |\hat{Z}_c| = \frac{1}{\omega C}$

**1) Pro DC:**

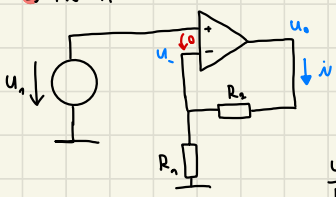



$u_+ = u_- = u_1$

$\frac{u_1 - u_{oDC}}{R_2} = 0$

$u_1 = u_{oDC}$

**2) Pro AC**

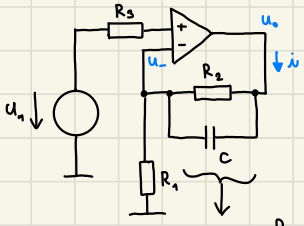



$\left(\frac{1}{\omega C} \rightarrow$ zadané $\omega$ a $C \Rightarrow 0 < x < 1\right)$

↳ nepřejdi se

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

$u_o = u_1\left(1 + \frac{R_2}{R_1}\right)$




$\hat{Z}_c = \frac{1}{j\omega C}$

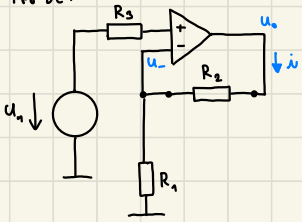
$i_+ = i_{R_3} = 0 \rightarrow u_- = u_+ = u_1$

MUN: $\frac{u_1}{R_1} + \frac{u_1 - u_0}{\hat{Z}} = 0$

$u_0 = u_1\left(1 + \frac{\hat{Z}}{R_1}\right) = u_1\left(\frac{R_1 + \hat{Z}}{R_1}\right) = u_1\left(\frac{R_1 + R_2 + j\omega R_1 R_2 C}{R_1(1 + j\omega R_2 C)}\right)$

$\hat{Z} = R_2 \| \hat{Z}_c = \frac{R_2}{1 + j\omega R_2 C}$

Pro DC:

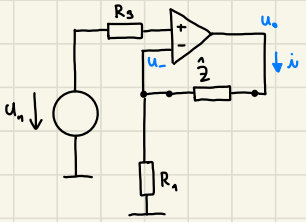



$u_- = u_+ = u_1$

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

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

Pro AC:

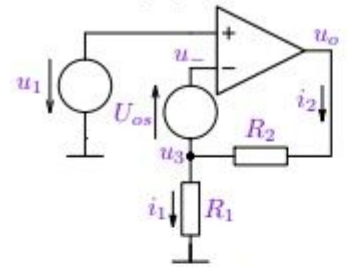



$\hat{Z} = \frac{R_2 \hat{Z}_c}{R_2 + \hat{Z}_c} = \frac{\frac{R_2}{j\omega C}}{\frac{1 + j\omega R_2 C}{j\omega C}} = \frac{R_2}{1 + j\omega R_2 C}$

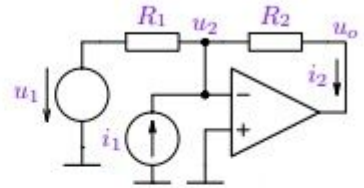
$\frac{u_1}{R_1} + \frac{u_1 - u_0}{\hat{Z}} = 0$

$u_0 = u_1\left(1 + \frac{\hat{Z}}{R_1}\right) = u_1\left(\frac{R_1 + \hat{Z}}{R_1}\right) = u_1\left(\frac{R_1 + R_2 + j\omega R_1 R_2 C}{R_1(1 + j\omega R_2 C)}\right)$

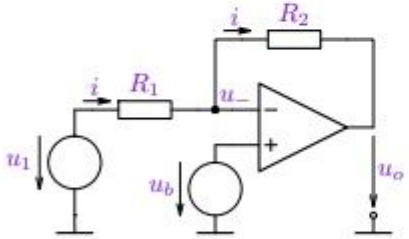
Zapojení 1



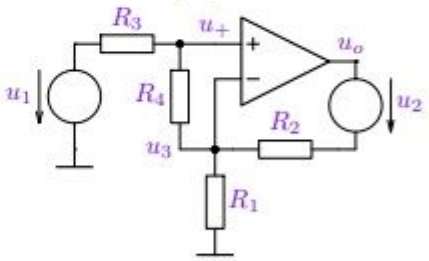

Zapojení 2



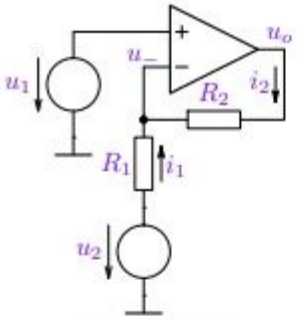

Zapojení 3



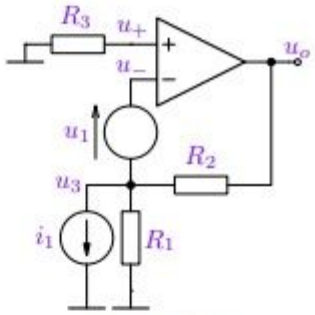

Zapojení 4



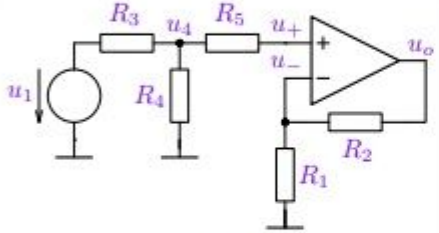

Zapojení 5



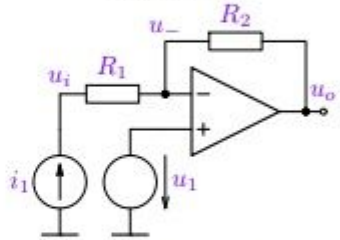

Zapojení 6



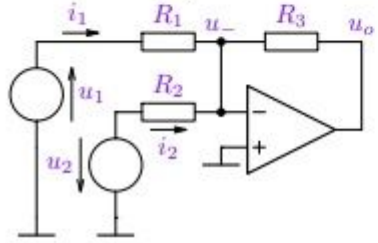

Zapojení 7




Zapojení 8




Zapojení 9

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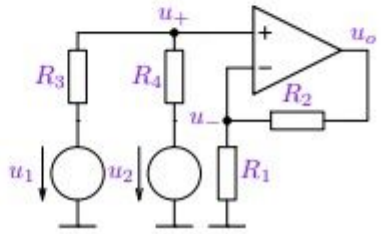
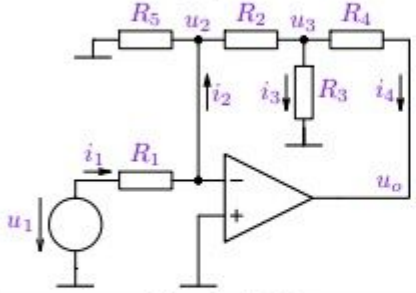
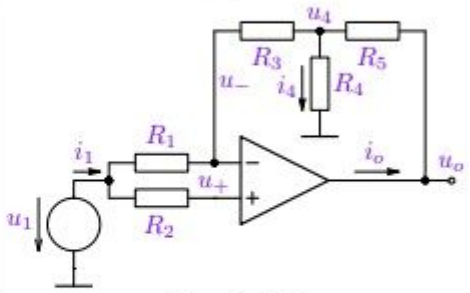


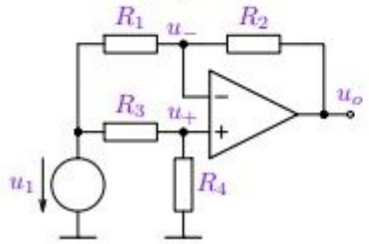

Zapojení 11



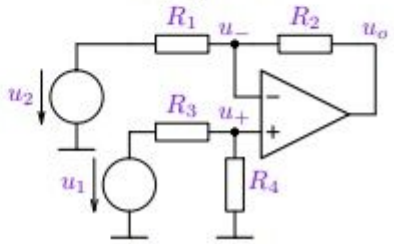

Zapojení 12



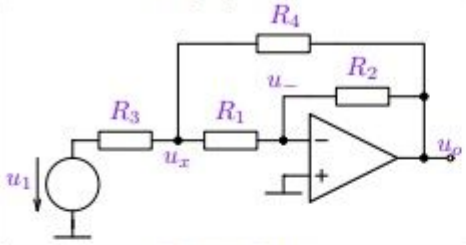

Zapojení 13



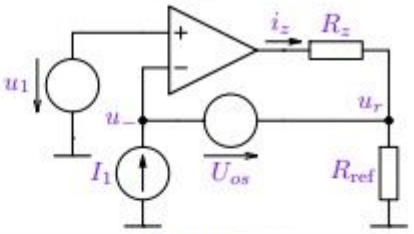

Zapojení 14



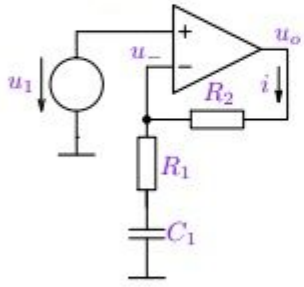

Zapojení 15




Zapojení 16




Zapojení 17




Zapojení 18