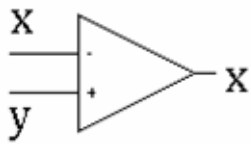


OPERACIJE

Operacijski ojačevalec – najpomembnejši element

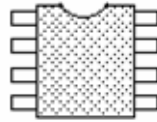


$$A \neq \infty$$

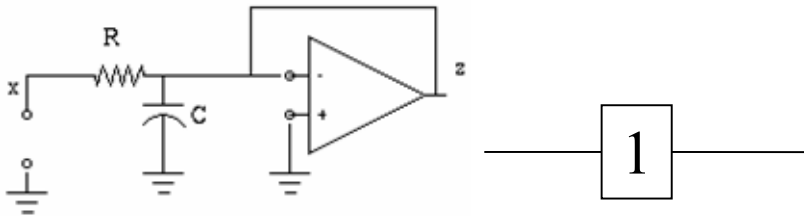
$$I_{bias} \neq 0$$

$$U_{off} \neq 0$$

$$slew\ rate \neq \infty$$

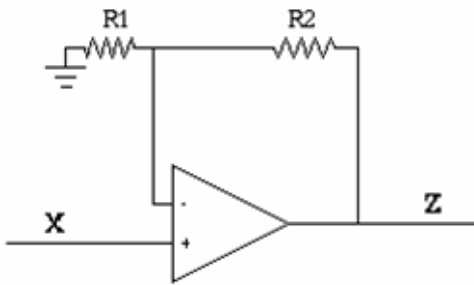


- Primer uporabe RC člen:



vezava z OP omogoča nizko izhodno impendanco (gre za množenje s faktorjem 1).

- Primer uporabe: ojačevalec , neidealn OP-AMP



$$\frac{0 - \eta}{R_1} + \frac{z - \eta}{R_2} + I_{bias} = 0$$

$$A(x - \eta + Off) = z \Rightarrow \eta = -\frac{z}{A} + Off + x$$

$$\frac{(-x + \frac{z}{A} - Off)}{R_1} + \frac{(z + \frac{z}{A} - Off - x)}{R_2} + I_{bias} = 0$$

$$z \left[\frac{1}{R_2} + \frac{1}{AR_1} + \frac{1}{AR_2} \right] - x \left[\frac{1}{R_1} + \frac{1}{R_2} \right] - Off \left[\frac{1}{R_1} + \frac{1}{R_2} \right] + I_{bias} = 0$$

$$z = \frac{\left[\frac{1}{R_1} + \frac{1}{R_2} \right]}{\left[\frac{1}{AR_1} + \frac{1}{AR_2} + \frac{1}{R_2} \right]} x + Off \frac{\left[\frac{1}{R_1} + \frac{1}{R_2} \right]}{\left[\frac{1}{AR_1} + \frac{1}{AR_2} + \frac{1}{R_2} \right]} - \frac{I_{bias}}{\left[\frac{1}{AR_1} + \frac{1}{AR_2} + \frac{1}{R_2} \right]}$$

$$z = \frac{\frac{R_2}{R_1} + 1}{1 + \frac{1}{A} + \frac{R_2}{AR_1}} x + Off \frac{\frac{R_2}{R_1} + 1}{1 + \frac{1}{A} + \frac{R_2}{AR_1}} - I_{bias} R_2 \frac{1}{1 + \frac{1}{A} + \frac{R_2}{AR_1}}$$

PRIMERI

1.) $A \rightarrow \infty$

$$z = \left[\frac{R_2}{R_1} + 1 \right] x + Off \left[\frac{R_2}{R_1} + 1 \right] - R_2 I_{bias}$$

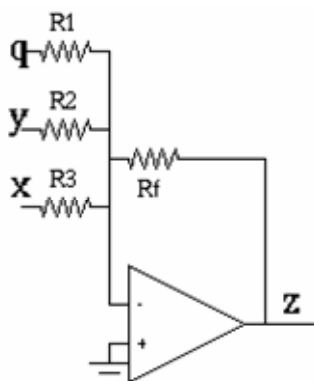
2.) $Off \rightarrow 0$, $Off \in [\mu V - mV]$

$$z = \left[\frac{R_2}{R_1} + 1 \right] x - R_2 I_{bias}$$

3.) $I_{bias} \rightarrow 0$

$$z = \left[\frac{R_2}{R_1} + 1 \right] x$$

- Seštevalnik (DA konverter)



$$A \rightarrow \infty, \text{Off} = 0, I_{bias} = 0$$

$$\frac{q}{R_1} + \frac{y}{R_2} + \frac{x}{R_3} + \frac{z}{R_f} = 0$$

$$z = -R_f \left[\frac{q}{R_1} + \frac{y}{R_2} + \frac{x}{R_3} \right] = - \left[\frac{R_f}{R_1} q + \frac{R_f}{R_2} y + \frac{R_f}{R_3} x \right]$$

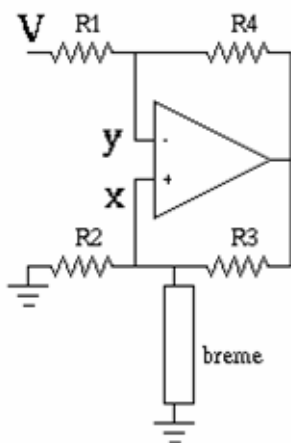
PRIMERI

$$1.) R_f = R_1 = R_2 = R_3 \rightarrow z = -(x + y + q)$$

$$2.) \frac{R_f}{R_1} = 1, \frac{R_f}{R_2} = 2, \frac{R_f}{R_3} = 4$$

V 2.) smo dobili 3 bitni DAC pretvornik, ki pa ni najboljša rešitev. To bomo spoznali kasneje.

- Tokovni izvor



$$A \rightarrow \infty, \text{Off} = 0, I_{bias} = 0$$

$$\frac{z - x}{R_3} + \frac{-x}{R_L} + \frac{-x}{R_2} = 0$$

$$\frac{z - y}{R_4} + \frac{V - y}{R_1} = 0$$

$$A(x - y) = z$$

$$z - R_3 I_L - x \left[1 + \frac{R_3}{R_2} \right] = 0$$

$$z - x \left[1 + \frac{R_4}{R_1} \right] + \frac{VR_4}{R_1} = 0$$

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

$$z - (z - R_3 I_L) + \frac{VR_4}{R_1} = 0$$

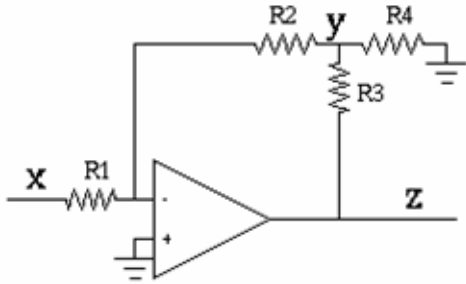
$$R_3 I_L = - \frac{VR_4}{R_1} \Rightarrow I_L = - \frac{V}{R_2}$$

To vezje ne deluje najboljše ker:

- o mora biti R2 majhen in hitro dosežemo limito izhodnega toka.
- o Pri visokih frekvencah pa pade A.

- Natančna razmerja uporov.

- Kaj dela to vezje?



$$\frac{x}{R_1} + \frac{y}{R_2} + I_{bias} = 0$$

$$\frac{z - y}{R_3} + \frac{-y}{R_4} + \frac{-y}{R_2} = 0$$

$$z + \frac{R_2}{R_1}x + I_{bias}R_2 + \frac{\frac{R_2}{R_1}x + I_{bias}R_2}{R_4} + \frac{\frac{R_2}{R_1}x + I_{bias}R_2}{R_2} = 0$$

$$z \frac{1}{R_3} + x \left[\frac{R_2}{R_1 R_3} + \frac{R_2}{R_1 R_4} + \frac{R_2}{R_1 R_2} \right] + I_{bias} \left[1 + \frac{R_2}{R_4} + \frac{R_2}{R_3} \right] = 0$$

$$z = - \left[\frac{R_2}{R_1} + \frac{R_2 R_3}{R_1 R_4} + \frac{R_3}{R_1} \right] x + R_3 I_{bias} \left[1 + \frac{R_2}{R_4} + \frac{R_2}{R_3} \right]$$