Implementarea filtrelor active de ordinul doi cu AOI

Schema cea mai utilizata este prezentată in figura 7.1(schema cu reacție multiplă)

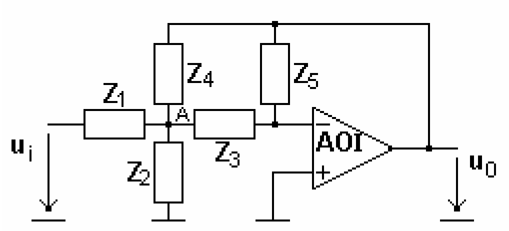


Figura 7.1

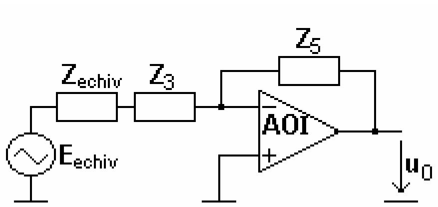
Notând cu: E_{echiv}-generatorul echivalent in pct A

Z_{echiv}-impedanța generatorului echivalent in pct A

se scrie legea Kirchoff I la borna neinversoare a amplificatorului:

$$E_{echiv} = \frac{\frac{u_i}{Z_i} + \frac{u_0}{Z_4}}{\frac{1}{Z_{echiv}}}$$

$$\frac{1}{Z_{echiv}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_4}$$



$$\frac{E_{echiv}}{Z_3 + Z_{echiv}} + \frac{u_0}{Z_5} = 0$$

Notite

$$\left(\frac{u_i z_{echiv}}{z_1}+\frac{u_0 z_{echiv}}{z_4}\right)z_5=-u_0(z_3+z_{echiv})$$

$$H(s)=\frac{u_0(s)}{u_i(s)}=-\frac{\frac{z_5}{z_1}z_{echiv}}{\frac{z_5}{z_4}z_{echiv}+z_3+z_{echiv}}=-\frac{\frac{1}{z_1z_3}}{\frac{1}{z_3z_4}+\frac{1}{z_3z_5}+\frac{1}{z_5z_{echiv}}}$$

$$H(s)=-\frac{Y_1Y_3}{Y_5(Y_1+Y_2+Y_3+Y_4)+Y_3Y_4}$$

Observatie: Demonstratia decurge mai simplu daca se calculeaza cu admitante, formula finala fiind aceeasi.

$$Y_{echiv}=Y_1+Y_2+Y_4$$

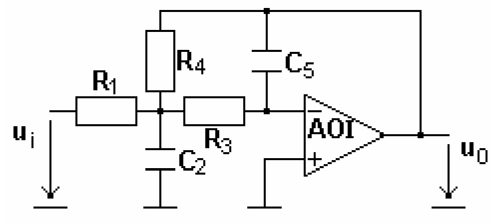
$$E_{echiv}=\frac{u_iY_1+u_0Y_4}{Y_1+Y_2+Y_4}$$

$$\frac{E_{echiv}}{\frac{1}{Y_3}+\frac{1}{Y_{echiv}}}=-u_0Y_5$$

Alegând convenabil admitanțele Y_1-Y_5 se pot obține următoarele tipuri de filtre:

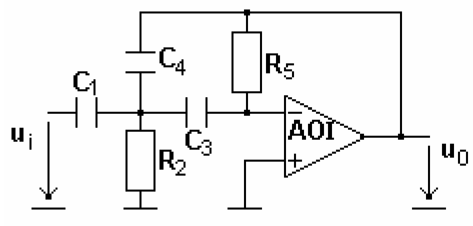
FTJ :

$$H(s)=-\frac{\frac{1}{R_1}\frac{1}{R_3}}{sC_5\left[\left(\frac{1}{R_1}+\frac{1}{R_3}+\frac{1}{R_4}\right)+sC_2\right]+\frac{1}{R_3}\frac{1}{R_4}}$$



FTS:

$$H(s)=-\frac{s^2C_1C_3}{\frac{1}{R_5}\left[\frac{1}{R_2}+s(C_1+C_3+C_4)\right]+s^2C_3C_4}$$

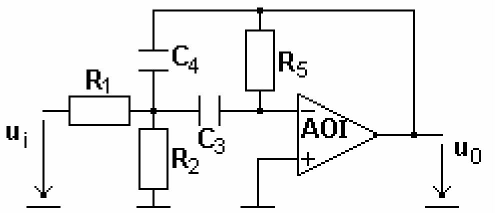


FTB:

a)

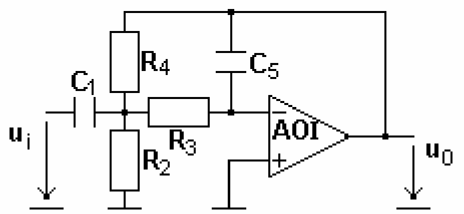
Notite

$$H(s) = -\frac{\frac{1}{R_1}C_3 s}{\frac{1}{R_5}\left[\left(\frac{1}{R_1}+\frac{1}{R_2}\right)+s(C_3+C_4)\right]+s^2C_3C_4}$$

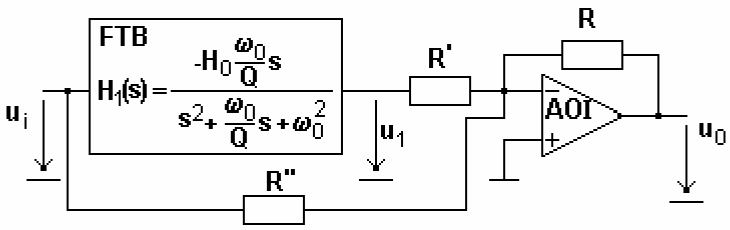


b)

$$H(s) = \frac{-sC_1\frac{1}{R_3}}{sC_5\left[\left(\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}\right)+sC_1\right]+\frac{1}{R_3R_4}}$$



FRB: Implementarea poate fi facuta utilizant un FTB si un AO in configuratie de sumator



$u_1(s) = H_1(s)u_i(s)$

$u_0(s) = -u_1\frac{R}{R'} - u_i\frac{R}{R''} = -u_i(s)(H_1(s)\frac{R}{R'} + \frac{R}{R''})$

$$H_2(s) = \frac{\frac{R}{R'}(s^2+\frac{\omega_0}{Q}s+\omega_0{}^2) - \frac{R}{R''}H_0\frac{\omega_0}{Q}s}{s^2+\frac{\omega_0}{Q}s+\omega_0^2} = \frac{\frac{R}{R'}(s^2+\omega_0{}^2) + \frac{sR\omega_0}{R'Q}(1-\frac{R'}{R''}H_0)}{s^2+\frac{\omega_0}{Q}s+\omega_0^2}$$

Pentru ca schema sa fie un filtru rejector de bandă (FRB) trebuiesc indeplinite urmatoarele condiții:

$$1 = \frac{R'H_0}{R''} \Rightarrow H_0 = \frac{R''}{R'}$$

Amplificarea noului filtru H_0' va fi R/R’

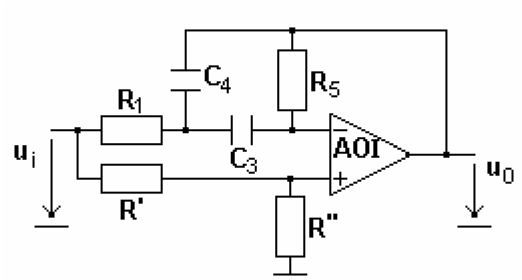
Notite

FTT: Pentru ca schema prezentata anterior sa fie un filtru rejector de bandă (FTT) trebuie indeplinita urmatoarea condiție:

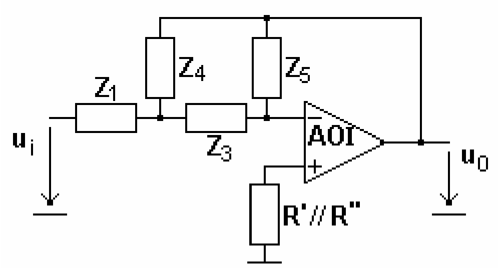
$$-1 = 1 - \frac{R' H_0}{R''} \Rightarrow H_0 = \frac{2R''}{R'}$$

Implementarea filtrelor cu amplificator cu reactii multiple modificat

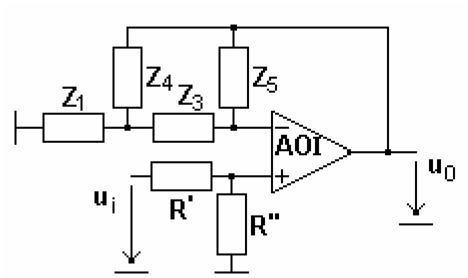
O alta posibilitate de implementare a filtrelor, cu un singurAO, este utilizarea unui filtru cu reactii multiple modificat (Z_2->∞) folosit in conexiune de amplificator difrential.



Pentru a calcula acesta schema utilizam rezultatele de la amplificatorul diferential (calculand cu teorema superpozitiei) si de la filtrul general cu reactii multiple, in cazul particular precizat.(Z_2=>∞).



$$u_0'(s) = -\frac{Y_1Y_3}{Y_5(Y_1+Y_3+Y_4)+Y_3Y_4} u_i(s) \text{ si}$$



$$u_0''(s) = \frac{R''}{R'+R''}\left(1+\frac{Y_1Y_3}{Y_5(Y_1+Y_3+Y_4)+Y_3Y_4}\right)u_i(s)$$

$$u_0 = u_0' + u_0'' \text{(conform teoremei superpozitiei)}$$

utilizand notatia $K = \frac{R''}{R'+R''}$ se obtine expresia generala a functiei de transfer:

$$H(s) = \frac{Y_1Y_3(K-1)+KY_5(Y_1+Y_3+Y_4)+KY_3Y_4}{Y_5(Y_1+Y_3+Y_4)+Y_3Y_4}$$

In cazul particular analizat obtinem expresia:

Notite

$$H(s)=\frac{\frac{1}{R_1}sC_3(k-1)+k\frac{1}{R_5}(\frac{1}{R_1}+sC_3+sC_4)+ks^2C_3C_4}{\frac{1}{R_5}(\frac{1}{R_1}+sC_3+sC_4)+s^2C_3C_4}$$

Functia de transfer este un biquad deci poate fi folosita si pentru implementarea unui **FTT**. Pentru a fi un filtru rejector de banda (**FBR**) trebuie ca coeficientul variabilei s sa fie zero, adica trebuie indeplinita conditia:

$$\frac{1}{R_1}C_3(k-1)+\frac{C_3+C_4}{R_5}k=0$$

Daca se alege $C_3=C_4=C$ conditia devine :

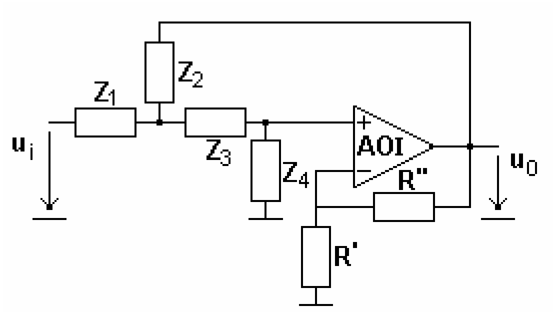
$0=(k-1)/R_1+2k/R_5 \Rightarrow k=R_5/(R_5+2R_1)$

Implementarea filtrelor cu AO cu câştig scăzut

Aceste filtre utilizează AO caracterizate prin urmatorii parametrii:

($Z_{int}\to\infty$, $Z_{ies}\to 0$ $A<20dB$)

Această caracterizare corespunde unui generator de tensiune ideal şi de aceea aceste filtre se mai intalnesc, in literatura de specialitate, sub numele de filtre cu generator de tensiune comandat. Una dintre cele mai utilizate structuri este descrisă in figura urmatoare:



Pentru deducerea funcţiei de transfer se observa ca amplificarea amplificatorului neinversor este data de relatia:

$A_u=k=1+\frac{R''}{R'}$ in pct. A

Deducerea formulei finale este mai uşoară dacă se utilizează admitanţele:

$$E_{echiv}=\frac{u_iY_1+u_0Y_2}{Y_1+Y_2}$$

$$Y_{echiv}=Y_1+Y_2$$

$$U_0=E_{echiv}k\frac{1}{1+\frac{Y_4}{Y_3}+\frac{Y_4}{Y_{echiv}}}=\frac{kY_3(u_iY_1+u_0Y_2)}{(Y_3+Y_4)(Y_1+Y_2)+Y_3Y_4}$$

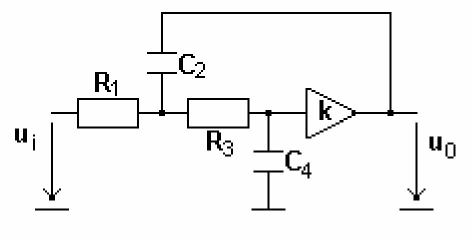
de unde:

$$H(s)=\frac{u_0(s)}{u_i(s)}=\frac{kY_1Y_3}{(Y_3+Y_4)(Y_1+Y_2)+Y_3Y_4-kY_2Y_3}$$

Notite

Cu această structură se pot obține următoarele tipuri de filtre:

FTJ:



$$H(s)=\frac{\frac{k}{R_1R_3}}{\left(\frac{1}{R_1}+sC_2\right)\left(\frac{1}{R_3}+sC_4\right)+\frac{1}{R_3}sC_4-\frac{k}{R_3}sC_2}$$

$$H(s)=\frac{\frac{k}{R_1R_3}}{s^2(C_2C_4)+s(\frac{C_4}{R_1}+\frac{C_2}{R_3}+\frac{C_4}{R_3}-\frac{kC_2}{R_3})+\frac{1}{R_1R_3}}$$

$$H(s)=\frac{k\frac{1}{R_1R_3C_2C_4}}{s^2+s\left(\frac{1}{R_1C_2}+\frac{1}{R_3C_4}+\frac{1}{R_3C_2}-\frac{k}{C_4R_3}\right)+\frac{1}{R_1R_3C_2C_4}}$$

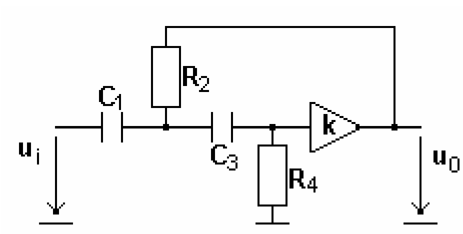
unde

$$\alpha=\frac{\omega_0}{Q}=\frac{R_3C_4+R_1C_2+R_1C_4-kR_1C_2}{R_1R_3C_2C_4}$$

$$H_0=k \text{ si } \omega_0^2=\frac{1}{R_1R_3C_2C_4}$$

Observatie: Pentru urmatoarele exemple se vor pune in evidenta parametrii filtrelor

FTS:

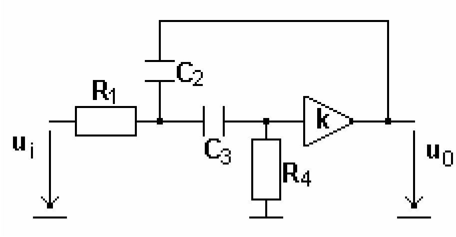


$$H(s)=\frac{s^2C_1C_3k}{(sC_1+\frac{1}{R_2})(sC_3+\frac{1}{R_4})+sC_3\frac{1}{R_4}-\frac{1}{R_2}sC_3k}$$

Notite

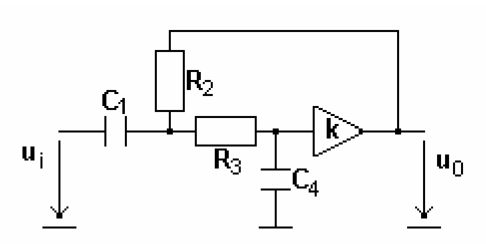
FTB:

a)



$$H(s)=\frac{ksC_3\frac{1}{R_1}}{\left(\frac{1}{R_1}+sC_2\right)\left(sC_3+\frac{1}{R_4}\right)+sC_3\frac{1}{R_4}-ks^2C_2C_3}$$

b)



$$H(s)=\frac{ksC_1\frac{1}{R_2}}{\left(sC_1+\frac{1}{R_2}\right)\left(\frac{1}{R_3}+sC_4\right)+sC_4\frac{1}{R_3}-k\frac{1}{R_2R_3}}$$

Continuarea este scanata curs8.2