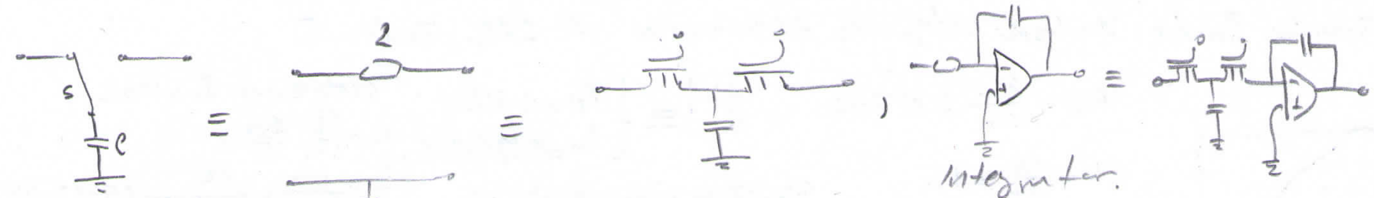
SC filtri

$\omega_0 = \frac{1}{RC} \Rightarrow 2\pi f_0 = \frac{1}{RC}$

- preklapanje kapaciteta kontrolnim prekidačima (sklopkama) te se mogu izvesti otpornici različitih vrijednosti

- princip rada



Zadatak Design of analog filters. Passive, Active RC, and Switched Capacitor [DESIGN OF ANALOG FILTERS] - knjiga Rolf Schaumann, Mohammed S. Ghausi, Kenneth R. Laker

Pokažite ovisnost vremenske konstante SC integratora o frekv. otipkavanja te realizirajte SC filter pomoću integriranog kruga MF10.

a) RC integrator

- poč. uvjeti $=0$

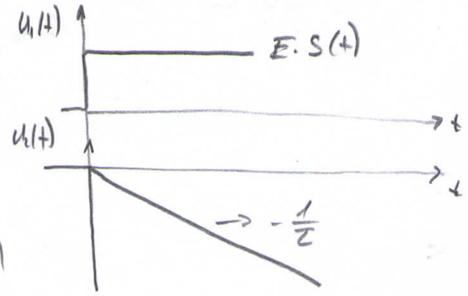
$U_C(0) = U_2(0) = 0$

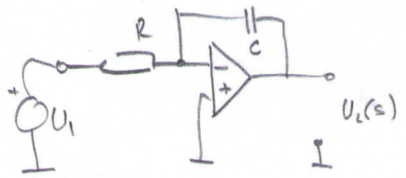
$I_1(s) = \frac{U_1(s)}{R}$

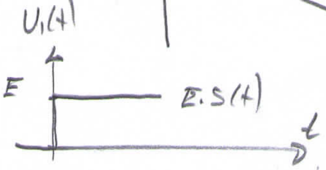
$U_2(s) = -I(s)\cdot\frac{1}{sC} = -\frac{U_1(s)}{R}\cdot\frac{1}{sC}$

$H(s) = \frac{U_2(s)}{U_1(s)} = -\frac{1}{sRC} = -\frac{1}{\tau}\cdot\frac{1}{s}$

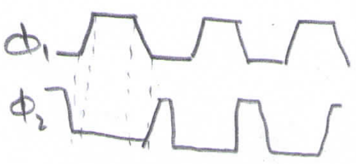
$\tau = RC$



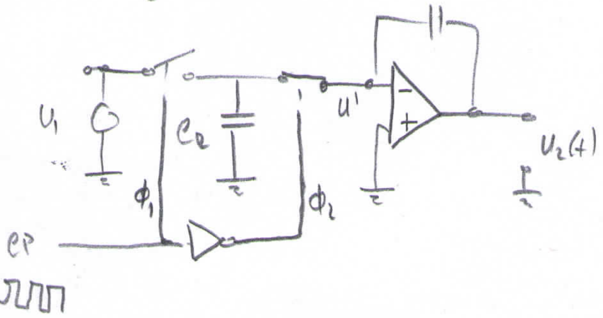




b) SC integrator



Pazi da se ne preklapaju



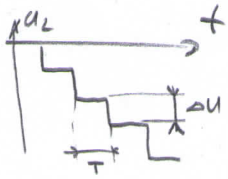
$\Delta Q = E\cdot C_R$

$\Delta U = \frac{\Delta Q}{C_2} = E\frac{C_R}{C_2}$

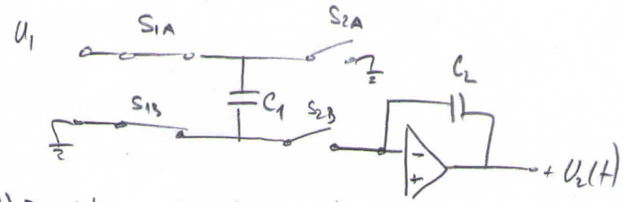
$i = \frac{\Delta Q}{\Delta} = \frac{E\cdot C_R}{T} = E C_R \cdot f_{CLK}$

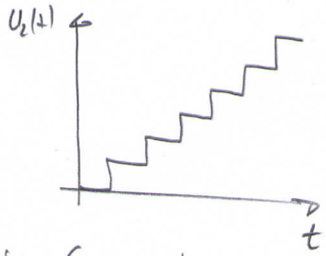
$R = \frac{E}{i} = \frac{E}{E C_R f_{CLK}} = \frac{1}{C_R f_{CLK}}$

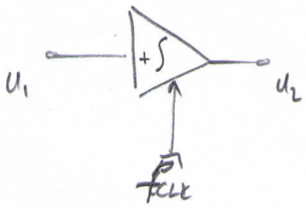
$\tau = RC_2 = \frac{C_2}{C_R f_{CLK}}$



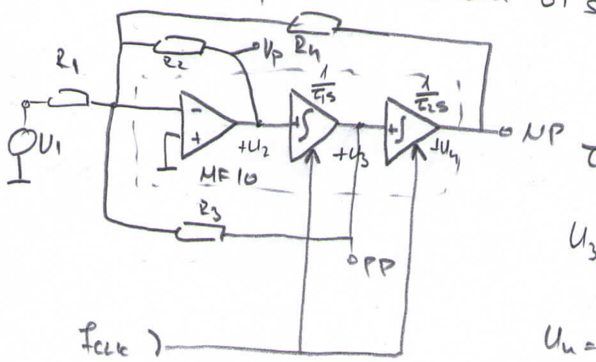
c) pozitivni integrator u MF10







d) Direktna realizacija sustava 2. reda GP sekcija (general purpose)



$\tau_1 = \frac{C_2}{C_1 f_{CLK}}$

$\tau_2 = \frac{C_4}{C_3 f_{CLK}}$

$U_2 = -R_2\left[\frac{U_1}{R_1} + \frac{U_3}{R_3} + \frac{U_4}{R_4}\right]$

$\frac{U_4}{U_1} = \frac{-\frac{R_4}{R_1}}{s^2\left(\frac{R_4}{R_2}\tau_1\tau_2\right) + s\left(\frac{R_4}{R_3}\tau_1\tau_2\right) + 1} = \frac{K}{\frac{s^2}{\omega_0^2} + \frac{s}{\omega_0 Q} + 1}$

$U_3 = \frac{1}{\tau_1 s}U_2$

$U_4 = \frac{1}{\tau_2 s}U_3$

$\omega_0 = \sqrt{\frac{R_2}{R_4}}\sqrt{\frac{C_1C_3}{C_2C_4}}\cdot f_{CLK}$ $\quad Q = \sqrt{\frac{R_2}{R_4}}\cdot\frac{R_3}{R_2}\sqrt{\frac{C_2C_3}{C_1C_4}}$

$\omega_0 = \sqrt{\frac{R_2}{R_4}}\frac{1}{\sqrt{\tau_1\tau_2}}$ $\quad Q = \sqrt{\frac{R_2}{R_1}}\frac{R_3}{R_2}\sqrt{\frac{\tau_1}{\tau_2}}$

Planarnom tehnologijom na Si moguće je postići vrlo precizno omjer kapaciteta. Proizvođač čipa MF10 je odabrao slijedeći omjer kapaciteta $C_2:C_1 = C_4:C_3 = 50:1$ i tako vrijede slijedeće formule koje se daju u kataloškim podacima za opis navedenog integriranog kruga.

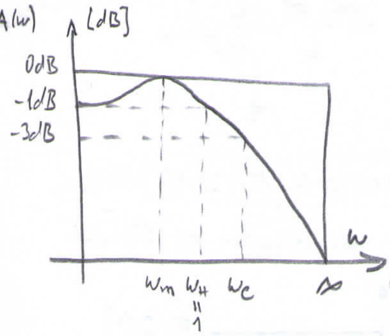
- za LP(NP):

$\omega_0 = \sqrt{\frac{R_2}{R_4}}\frac{f_{CLK}}{50}$, $K_{LP} = -\frac{R_4}{R_1}$

$Q = \sqrt{\frac{R_2}{R_4}}\cdot\frac{R_3}{R_2}$

Zadatak: Realizirati pomoću integriranog kruga MF10 Čebiševljev NP filtar 2. reda sa max. valovitosti u području propuštanja 1dB i sa graničnom frekv. 10kHz ako je frekv. otipkavanja $f_{CLK}=500kHz$. U realizaciji ćemo koristiti jednu bikvadratnu sekciju. (za matlab cheby, cheby apt, butter...)

Tablice: Tomislav Brodić "Analogna integrirana Elektronika" str. 276., Tablica 5.



$$\omega_m = \frac{\omega_m}{\omega_H} = 0.707$$

$$\omega_H = \frac{\omega_H}{\omega_H} = 1$$

$$\omega_c = \frac{\omega_c}{\omega_H} = 1.308$$

$$\omega_0 = \frac{\omega_0}{\omega_H} = 1.05000$$

$$Q = 0.95652$$

$$\left.\begin{matrix}\omega_0 \\ Q\end{matrix}\right\} \equiv \left\{\begin{matrix} Re = 0.5490 \\ Im = 0.8953206\end{matrix}\right.$$

$$\omega_H = 2\pi \cdot 10 \cdot 10^3 Hz = 2\pi \cdot 10^4 \, rad/s$$

$$\omega_0 = 1.05 \cdot 2\pi \cdot 10^4 = 65973{,}44 \, rad/s$$

$$Q = 0.95652$$

$$K_{LP} = -1 = -\frac{R_4}{R_1} \Rightarrow R_1 = 10k\Omega$$

Odabiremo $R_4 = 10k\Omega$

$$\omega_0 = \sqrt{\frac{R_2}{R_4}} \cdot \frac{f_{CLK}}{50}$$

$$\sqrt{\frac{R_2}{R_4}} = \frac{50}{f_{CLK}}\omega_0 = \frac{50}{500 \cdot 10^3} 65973{,}44$$

$$= 6{,}597344$$

$$R_2 = \left(\sqrt{\frac{R_2}{R_4}}\right)^2 R_4 = 6.597344^2 \cdot 10^4 = 435k\Omega$$

$$Q = \sqrt{\frac{R_2}{R_4}}\,\frac{R_3}{R_2} \Rightarrow R_3 = R_2 \frac{Q}{\sqrt{\frac{R_2}{R_4}}} = 435k \frac{0.95652}{6{,}597344}$$

$$= 63k\Omega$$