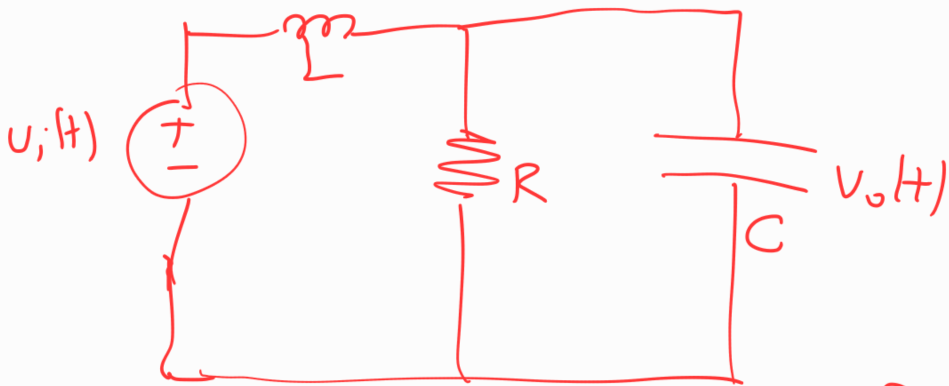
Example 14.10:



What type of filter
cutoff freq?

$R = 2k\Omega \qquad L = 2H \qquad C = 2\mu F$

$$\begin{cases} \omega \to 0 & v_o \to j\omega L \to 0, \ \frac{1}{j\omega C} \to \infty & v_o \to v_i \text{ geçirir} \\ \omega \to \infty & v_o \to j\omega L \to \infty, \ \frac{1}{j\omega C} \to 0 & v_o \to 0 \text{ geçirmez} \end{cases}$$

Low pass filter olabilir.

$$V_o = V_i \frac{R \parallel \frac{1}{j\omega C}}{j\omega L + \left(R \parallel \frac{1}{j\omega C}\right)}$$

$$\frac{V_o}{V_i} = H(\omega) = \frac{R \parallel \frac{1}{j\omega C}}{j\omega L + \left(R \parallel \frac{1}{j\omega C}\right)} = \frac{\frac{\frac{R}{j\omega C}}{R + \frac{1}{j\omega C}}}{j\omega L + \frac{\frac{R}{j\omega C}}{R + \frac{1}{j\omega C}}}$$

$$H(\omega) = \frac{\frac{R}{1 + j\omega RC}}{j\omega L + \frac{R}{1 + j\omega RC}}$$

$$= \frac{\frac{R}{\cancel{1 + j\omega RC}}}{\frac{j\omega L - \omega^2 RLC + R}{\cancel{1 + j\omega RC}}} = \frac{R}{j\omega L + (R - \omega^2 RLC)}$$

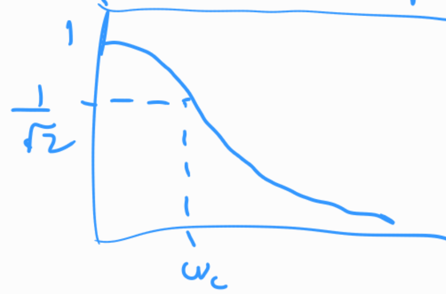
$$\boxed{|H| = \frac{R}{\sqrt{\omega^2 L^2 + (R - \omega^2 RLC)^2}}}$$

$$|H| = \frac{2000}{\sqrt{4w^2 + \left(2000 - w^2\, 2000 \times 2 \times 2 \times 10^{-6}\right)^2}}$$

$$\left.\begin{array}{l} \lim\limits_{w \to 0} |H(w)| = 1 \\ \lim\limits_{w \to \infty} |H(w)| = 0 \end{array}\right\} \text{LPF } \checkmark$$

Bir tek w_c var

$$\boxed{|H(w_c)| = \frac{1}{\sqrt{2}}}$$



$$\frac{1}{\sqrt{2}} = \frac{2000}{\sqrt{4w^2 + \left(2000 - w^2\, 8 \times 10^{-3}\right)^2}}$$

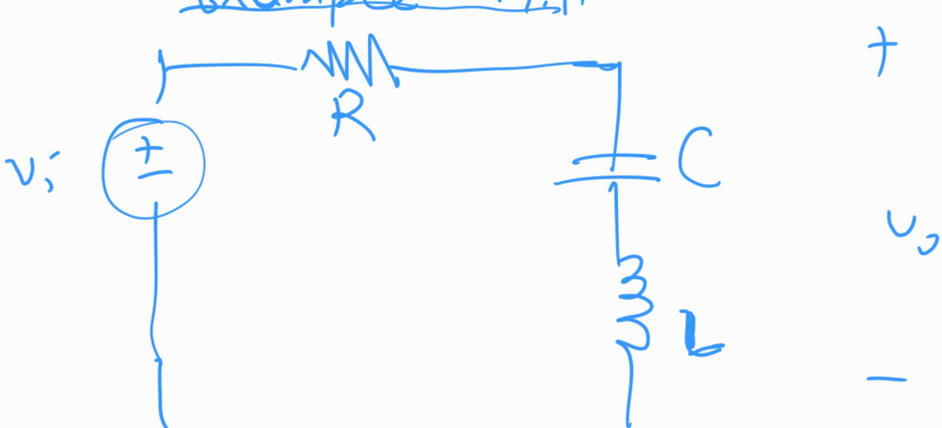
$$4w^2 + \left(2000 - w^2\, 8 \times 10^{-3}\right)^2 = 8 \times 10^6$$

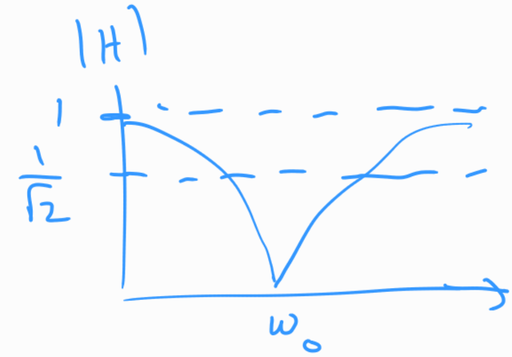
$$4w^2 + 4 \times 10^6 - 32w^2 + w^4\, 64 \times 10^{-6} = 8 \times 10^6$$

$$\boxed{w^4\, 64 \times 10^{-6} - 28w^2 - 4 \times 10^6 = 0} \qquad w^2 = A$$

$$w_c = 742 \text{ rad/sn}$$

Example 14.11





$f_o = 200$ Hz olması için

L ve C ?

$R = 150\,\Omega$ ve $B = 100$ Hz olsun

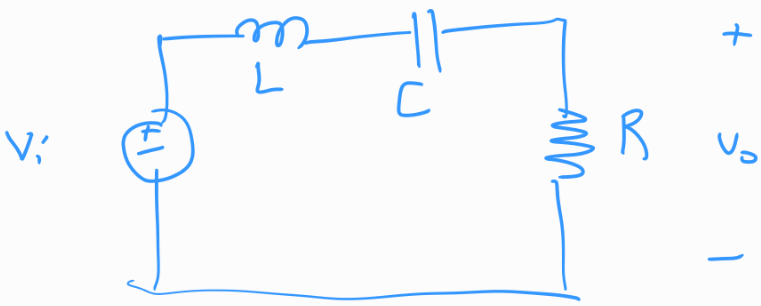
$w_0 = 2\pi \times 200 = 400\pi$ rad/sn $= \dfrac{1}{\sqrt{LC}}$ (1)

(2) $B = \dfrac{\overset{150}{R}}{L} = 2\pi \times 100 \Rightarrow L = \dfrac{150}{200\pi} = 0.2387$ H

(1) $= 400\pi = \dfrac{1}{\sqrt{0.2387 \times C}} \Rightarrow C = \dfrac{1}{0.2387 \times 160000\pi^2}$

$= 2.65\mu F$ ✓

Problem 14.11



$w \to 0 \Rightarrow V_o \to 0$

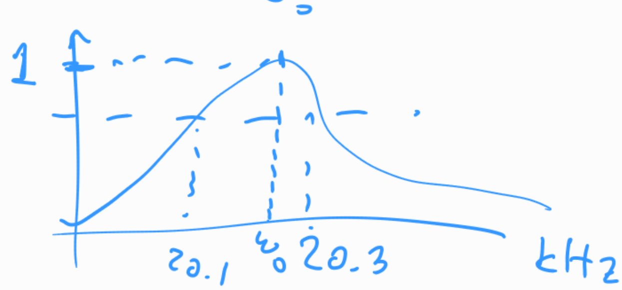
$w \to \infty \Rightarrow V_o \to 0$

$\underbrace{w = w_0 \Rightarrow V_o = V_{in}}_{j w_0 L - \frac{j}{w_0 C} = 0 \text{ olur.}}$

$w_{c_1} = 20.1$ kHz

$w_{c_2} = 20.3$ kHz

$R = 30k\Omega$



$B = w_{c_2} - w_{c_1} = 200 \text{ Hz} \times 2\pi$

$= 4\pi \times 10^2 = \dfrac{R}{L} = \dfrac{30000}{L}$

$L = \dfrac{300\cancel{00}}{4\cancel{00}\pi} = \dfrac{300}{4\pi} = 23.87$ H ✓

$w_0 \neq 20.2$

$\boxed{w_0 = \sqrt{w_{c_1} w_{c_2}}} = \sqrt{20.1 \times 20.3}$ kHz $= \dfrac{1}{\sqrt{LC}}$

$$20000 = \frac{1}{\sqrt{LC}} \Rightarrow C = 0.102\ nF$$
$$= 102.67\ pF$$

keskin filtre yapmak gerekiyorsa aktif filtre kullanılmalı.

14.8 AKTİF FİLTRELER

R, C ve OPAMP (L yok)

Avantajlar:

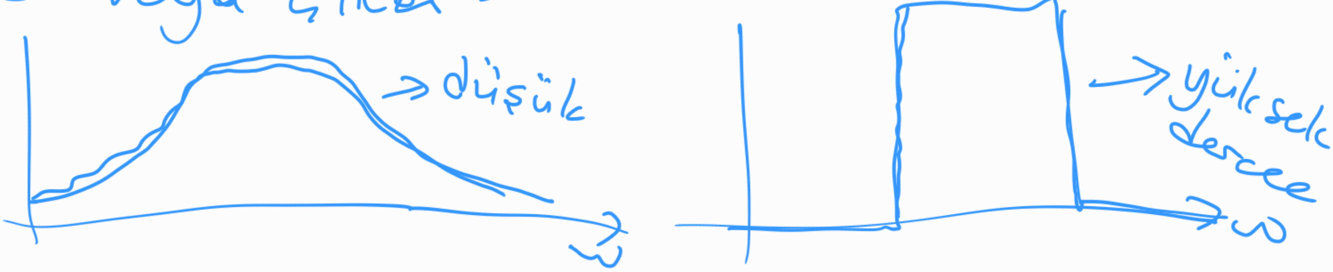
1) Kaskat yapılara izin verir. (Cascade)
2) Kazanç sağlayabilir.

Filtre derecesi: Transfer fonksiyonundan, paydadaki polinomun derecesi.

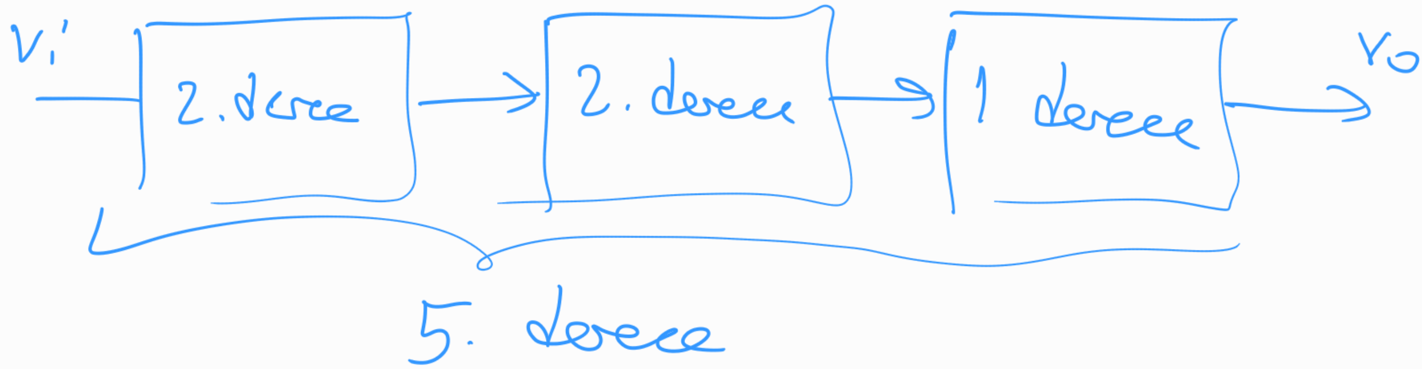
$$\frac{1}{s^2+2s+1} \rightarrow 2.\ \text{derece}$$

$$\frac{1}{s^4+3s^2+2s+1} \rightarrow 4.\ \text{derece}$$

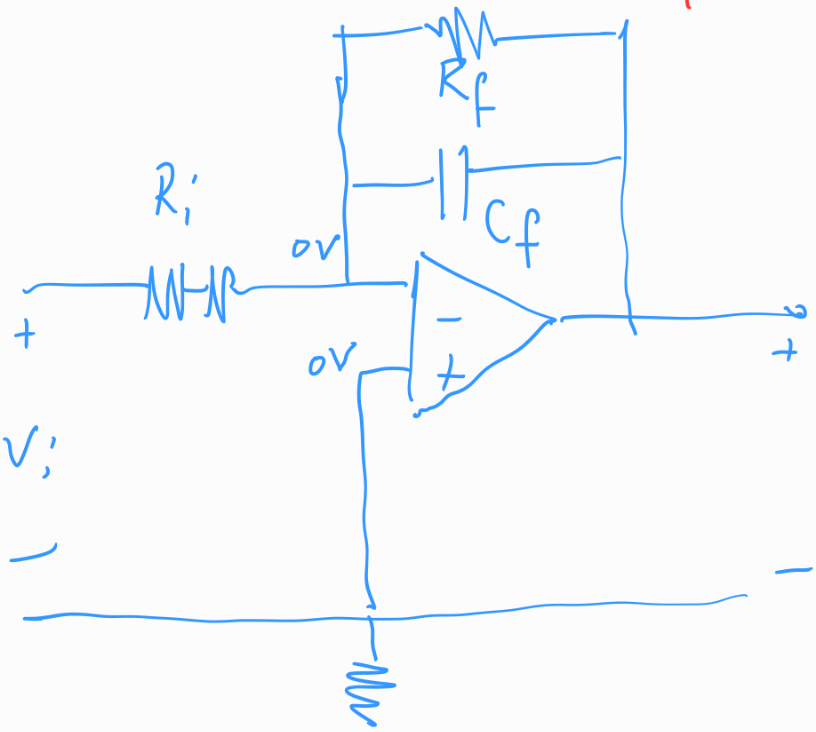
Derece ne kadar fazla olursa, transfer fonksiyonu kırılma noktalarından sonra, o kadar hızlı iner veya çıkar.



Elimizde 1. derece ve 2. derece temel aktif filtre yapıları (hem LPF, hem de HPF) olacak. Sonradan..



Birinci Derece Düşük Geçirgen Filtre



Aktif 1. derece alçak-geçirgen filtre

$\omega \to 0$: $\dfrac{R_f}{R_i}$ kazanç

$\omega \to \infty$ $\quad V_o = 0$

$\Downarrow$

LPF

$$\frac{V_i}{R_i} = \frac{-V_o}{R_f \parallel \frac{1}{j\omega C_f}}$$

$$H = \frac{V_o}{V_i} = -\frac{R_f \parallel \frac{1}{j\omega C_f}}{R_i} = -\frac{\frac{R_f}{j\omega C_f}}{\left(R_f + \frac{1}{j\omega C_f}\right) R_i}$$

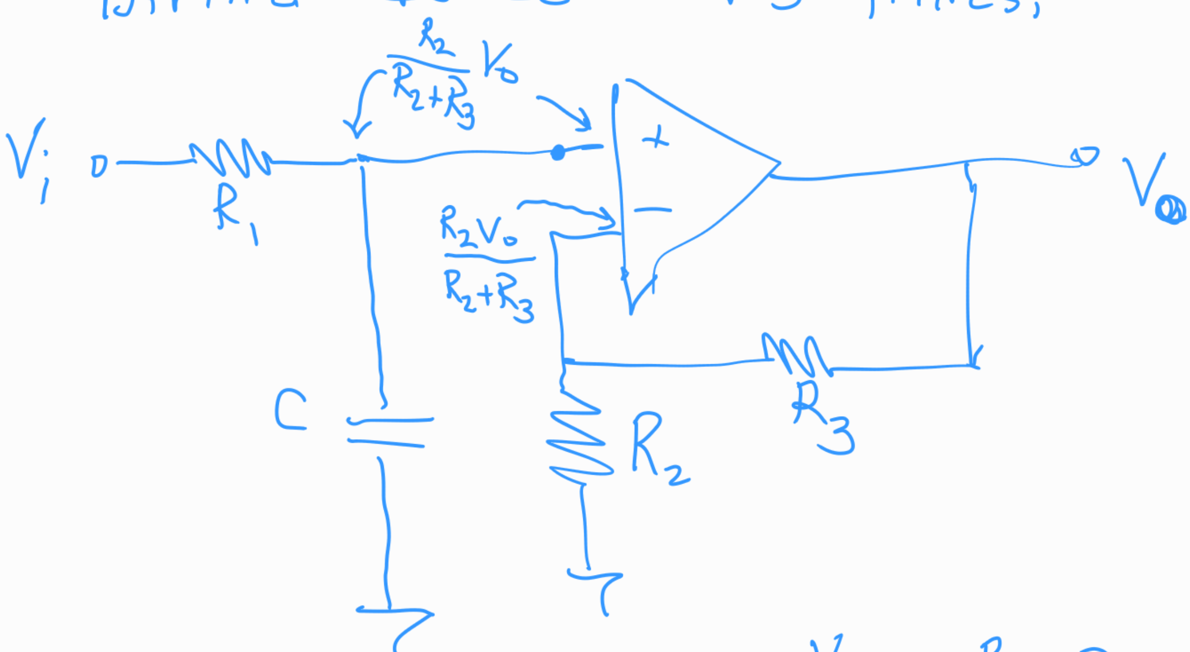
$$H(\omega) = -\frac{R_f}{(1 + j\omega C_f R_f) R_i} = -\underbrace{\frac{R_f}{R_i}}_{\text{kazanç}} \underbrace{\frac{1}{1 + j\omega C_f R_f}}_{\text{filtre}}$$

Birinci derece filtrelerin genel formu:

$$H = \frac{K b \omega_c}{s + b\omega_c}$$

$$H(s) = -\frac{R_f}{R_i} \frac{\frac{1}{C_f R_f}}{s + \frac{1}{C_f R_f}} \Rightarrow \boxed{K = -\frac{R_f}{R_i}} \quad \boxed{b = 1} \quad \boxed{\omega_c = \frac{1}{C_f R_f}}$$

Birinci derece VCVS filtresi:



$\omega \to 0 \Rightarrow \frac{1}{j\omega C} = \infty$

$\omega \to \infty \Rightarrow \frac{1}{j\omega C} \Rightarrow 0$

$V_o = \frac{R_3 + R_2}{R_2} V_i$ geçirir

$V_o = 0$

$\boxed{\text{LPF}}$

$$\frac{V_i}{R_1+\frac{1}{jwC}}\,\frac{1}{jwC} = \frac{R_2}{R_2+R_3}\,V_o$$

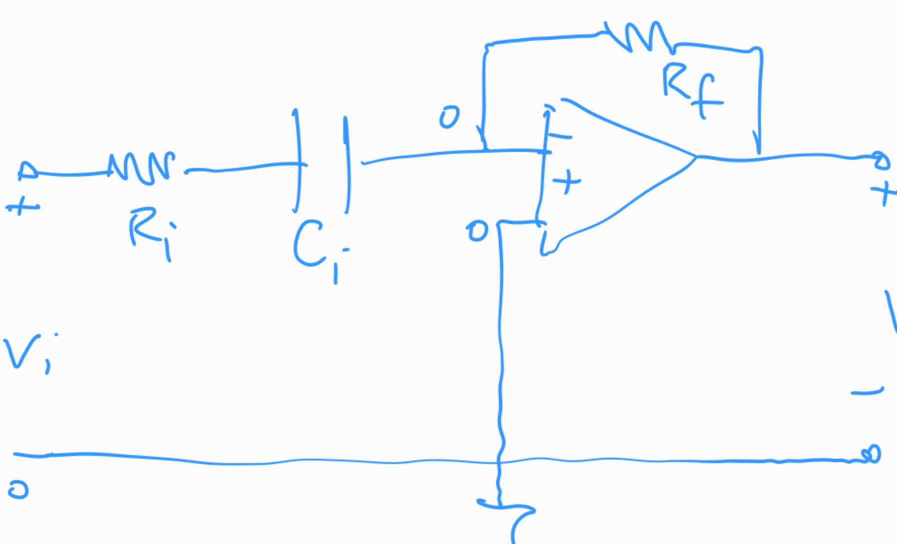
$$V_i\,\frac{1}{1+jwR_1C} = V_o\,\frac{R_2}{R_2+R_3}$$

$$\frac{V_o}{V_i} = \frac{R_2+R_3}{R_2}\,\frac{1}{1+jwR_1C} = \frac{R_2+R_3}{R_2}\,\frac{\frac{1}{R_1C}}{jw+\frac{1}{R_1C}}$$

$$H(s) = \left(1+\frac{R_3}{R_2}\right)\frac{\frac{1}{R_1C}}{s+\frac{1}{R_1C}}$$

$$\boxed{K = 1+\frac{R_3}{R_2} \qquad b=1 \qquad w_c = \frac{1}{R_1C}}$$

Birinci Derece Yüksek Geçirgen Filtre



$w \to 0$: $V_o = 0$

$w \to \infty$: C_i kısa devre

$$\boxed{V_o = -V_i\,\frac{R_f}{R_i}}$$ geçirir

HPF

$$\frac{V_i}{R_i + \frac{1}{j\omega C_i}} = \frac{-V_o}{R_f} \Rightarrow H(\omega) = \frac{V_o}{V_i} = -\frac{R_f}{R_i + \frac{1}{j\omega C_i}}$$

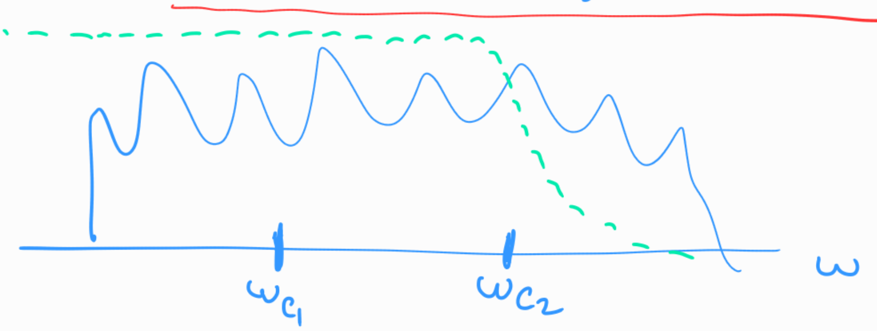
$$\frac{V_o}{V_i} = H(\omega) = -\frac{R_f}{R_i} \frac{1}{1 + \frac{1}{j\omega C_i R_i}}$$

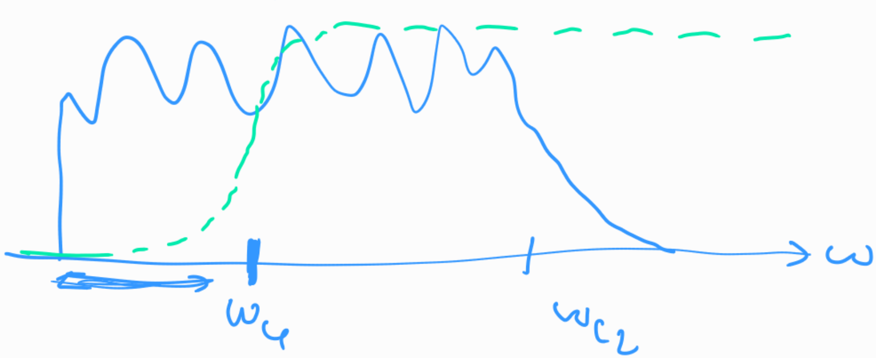
$$H(\omega) = -\frac{R_f}{R_i} \cdot \frac{j\omega}{j\omega + \frac{1}{C_i R_i}}$$

Genel form: $H(s) = K \dfrac{s}{s + b\omega_c}$

burada $\boxed{K = -\dfrac{R_f}{R_i} \qquad b = 1 \qquad \omega_c = \dfrac{1}{C_i R_i}}$

Bant Geçiren Filtreler:

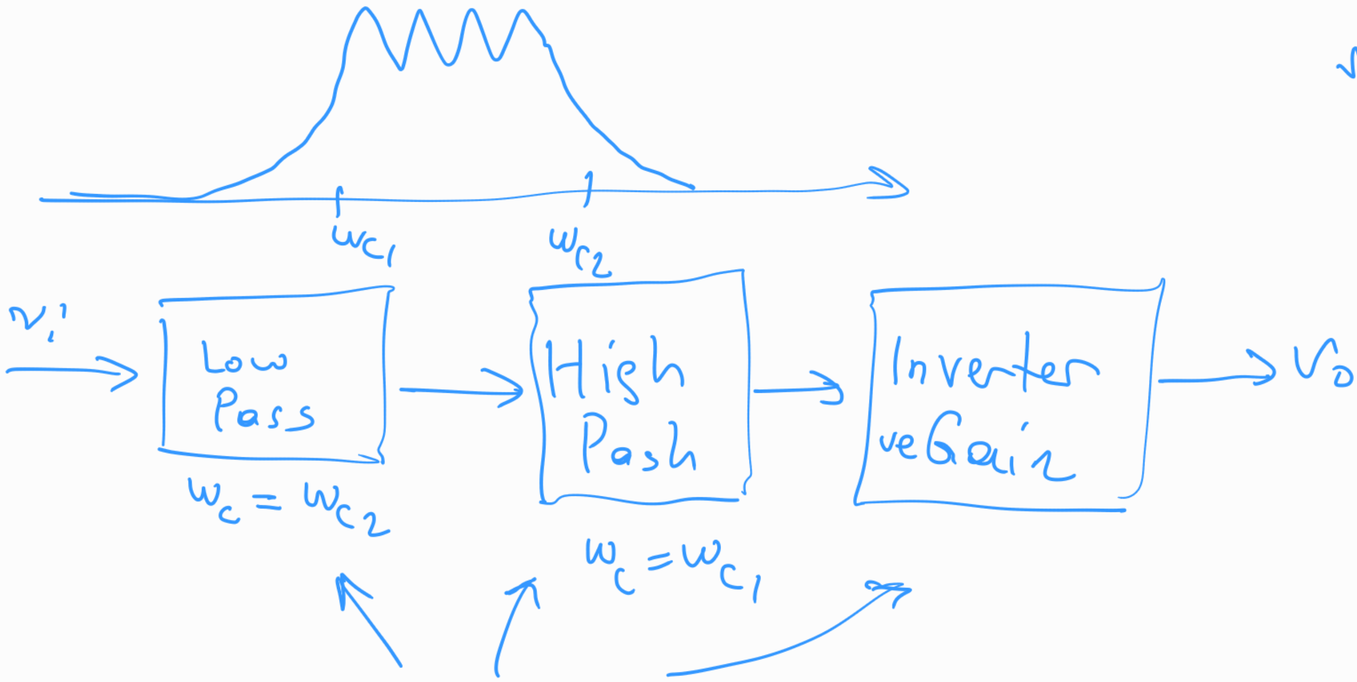




$B = \omega_{c_2} - \omega_{c_1}$

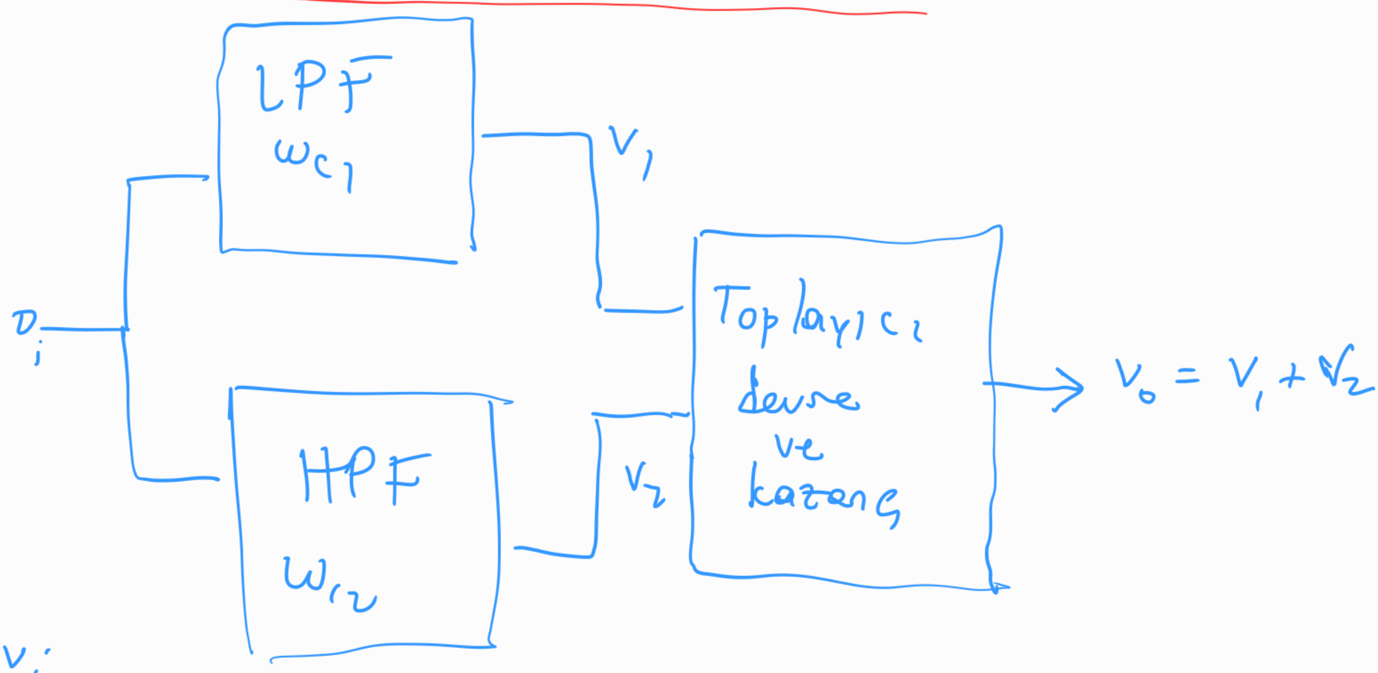
$\omega_0 = \sqrt{\omega_{c_1} \omega_{c_2}}$

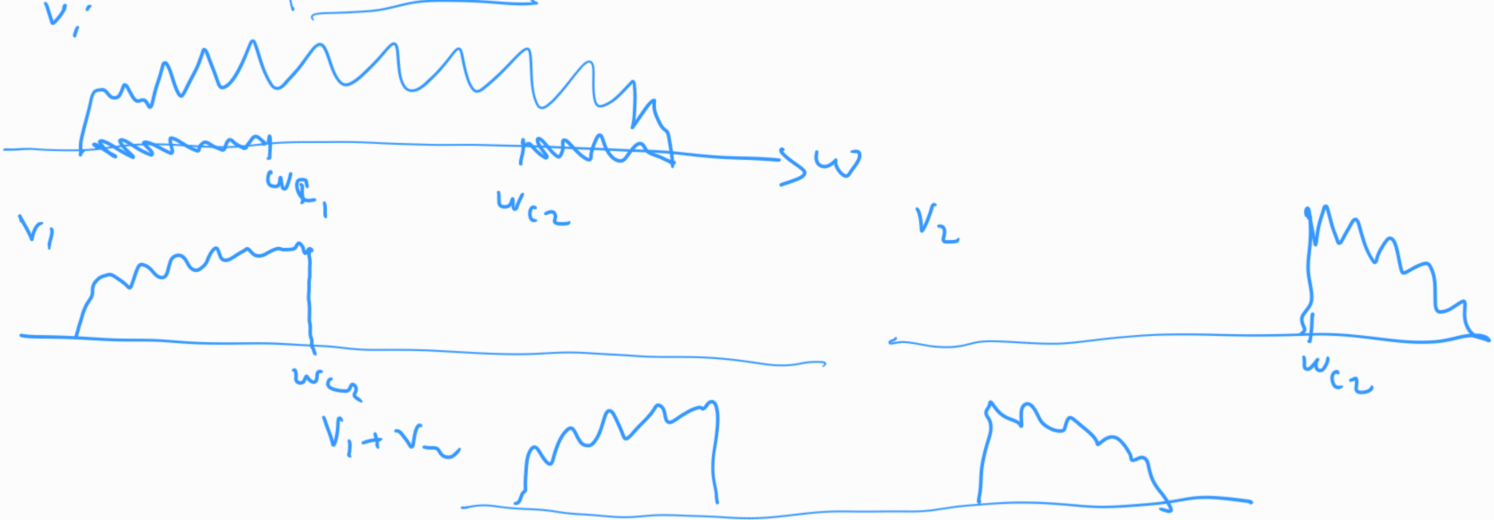
$Q = \dfrac{\omega_0}{B}$



sıra değişebilir, farketmez

Bant Durduran Filtre:





Example 14.12

LPF active

gain = 4

$f_c = 500\,Hz$

$$\frac{R_f}{R_i} = 4 \qquad \frac{1}{C_f R_f} = 1000\pi$$

$R_i = 1k\Omega$ olsun. O zaman $R_f = 4k\Omega$ olur.

$$C_f = \frac{1}{1000\pi \times 4000} = \frac{1}{4\times10^6\pi}\,F$$

Problem 14.12

Active HPF

kazanç 5

f_c ~~ω_c~~ $= 2\,kHz$

$C = 50\,nF$ olsun.

$$\frac{R_f}{R_i} = 5 \qquad \frac{1}{R_i C_i} = 4000\pi$$

C_i → 50nF olsun

$$R_i = \frac{1}{4000\pi \times 5\times10^{-8}} = \frac{10^5}{20\pi} = \frac{5000}{\pi} \cong 1600\,\Omega$$

$$\boxed{R_f = 5\times R_i = 8\,k\Omega}$$

Example 14.13

Active BPF

$f_{c_1} = 250\,Hz$

$f_{c_2} = 3000\,Hz$

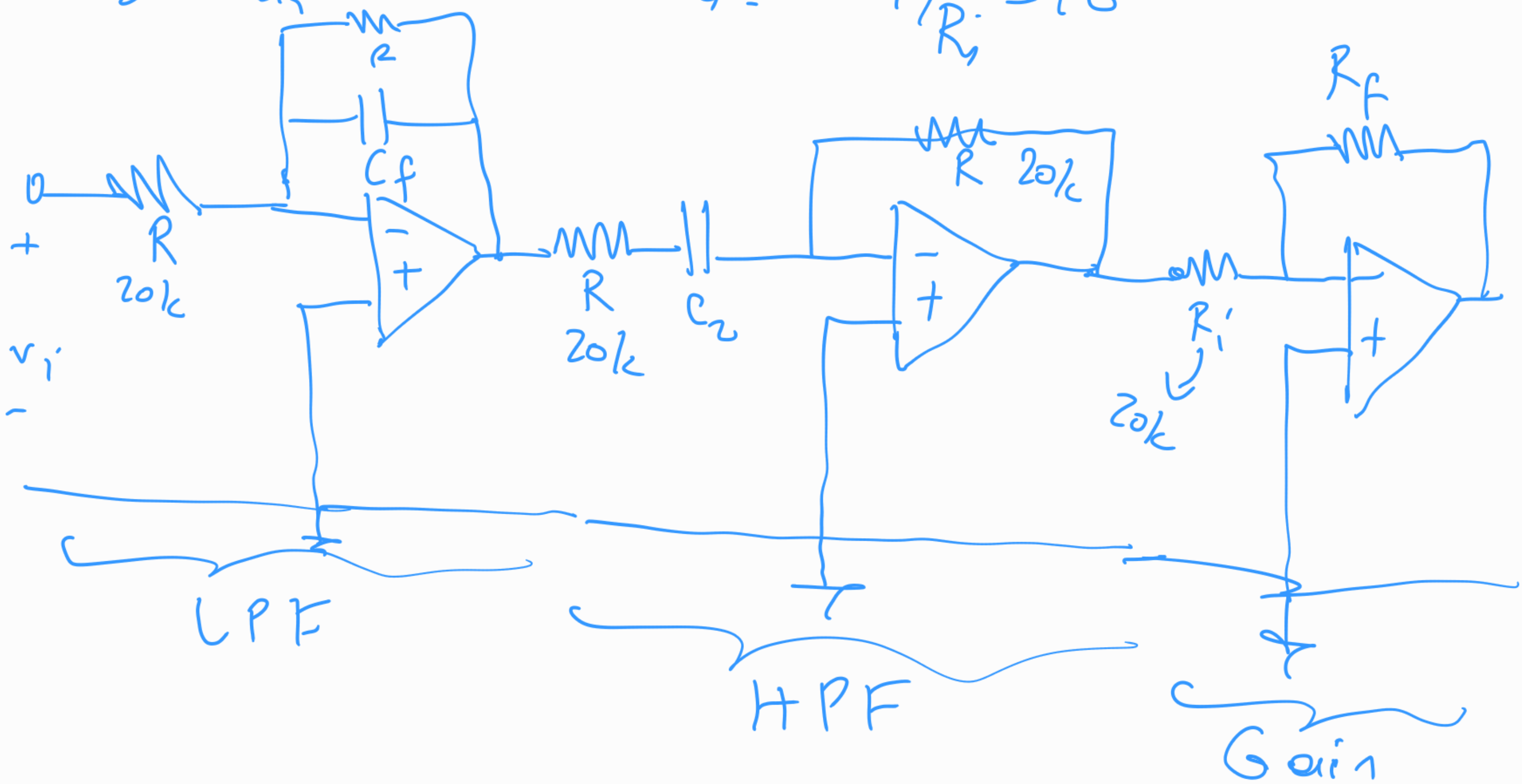
$K = 10$

$R = 20k\Omega$ olsun.

LPF $\rightarrow$ $\omega_c = 6000\pi$ rad/sn

HPF $\rightarrow$ $\omega_c = 500\pi$ rad/sn

son aşama kazanç: $R_f / R_i = 10$



$$6000\pi = \frac{1}{20000 \times C_f} \Rightarrow C_f = 2.65\,nF$$

$$500\pi = \frac{1}{20000\, C_i} = 31.83\,nF$$

$R_i = 20k$ olursa

$R_f = 200k$ olur.