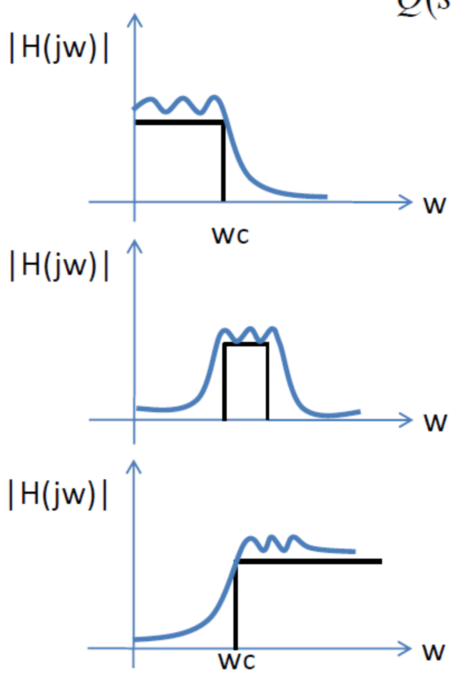
FILTROS ACTIVOS COMO APLICACIÓN LINEAL

- Circuitos de primer orden:
- Circuitos de segundo orden:

Sallen-Key

Un filtro es un sistema lineal que elimina partes del espectro

$$H(s)=\frac{P(s)}{Q(s)}=\frac{s^{M}a_{M-1}s^{M-1}\ldots a_{1}s+a_{0}}{s^{N}+b_{N-1}s^{N-1}\ldots b_{1}s+b_{0}}$$



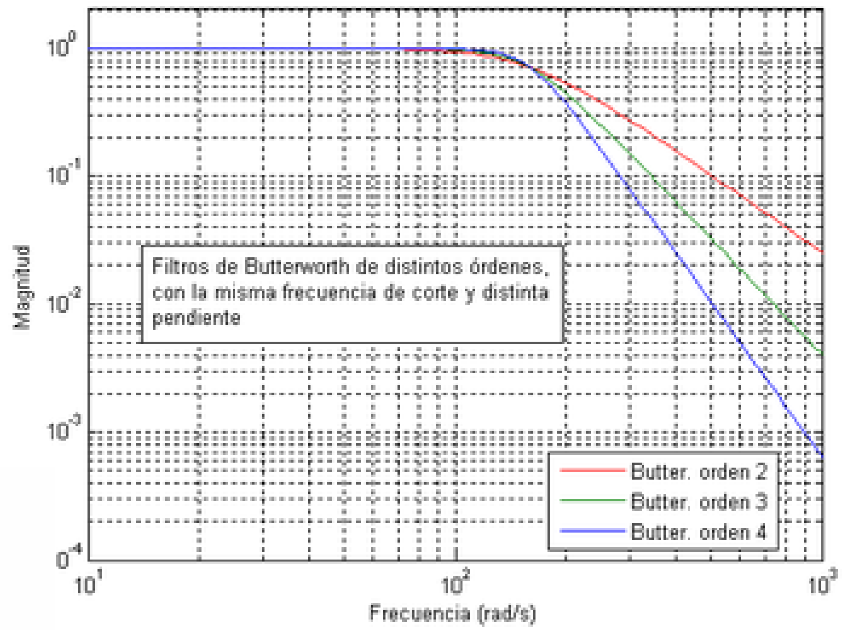
Filtro ideal/real paso bajo

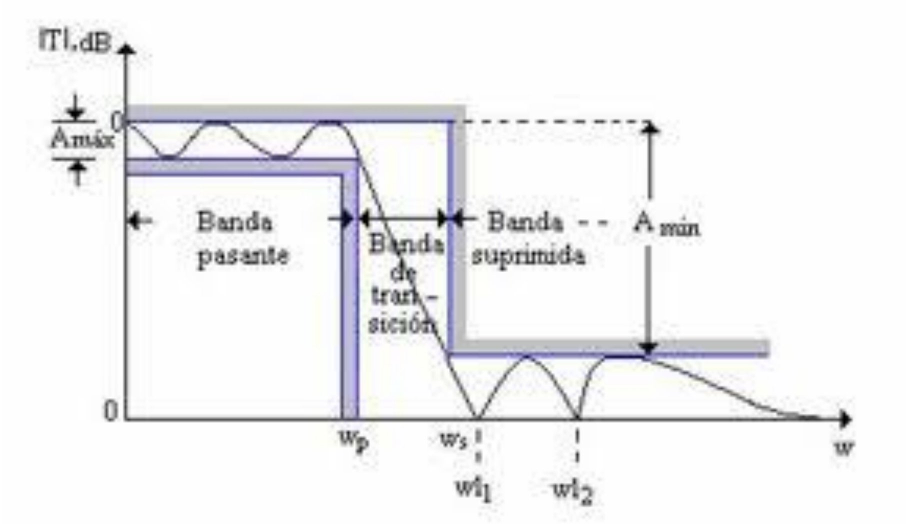
Filtro ideal/real paso banda

Filtro ideal/real paso alto

Teoría de aproximación de filtros

$$|H(\Omega)|^2 = \frac{1}{1 + (\Omega/\Omega_c)^{2N}}$$





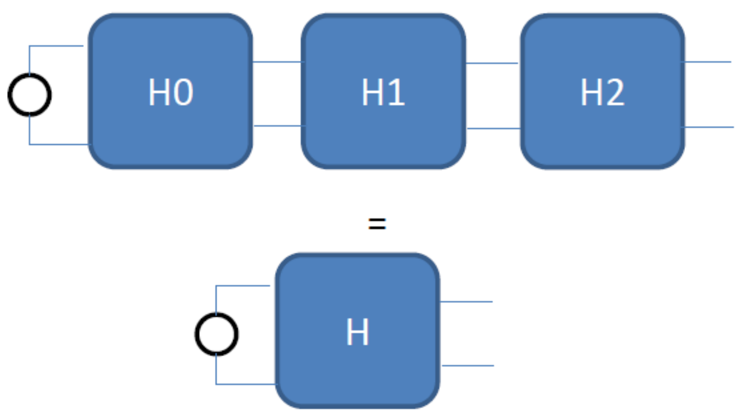
Aproximación de magnitud pasa baja
Aproximación maximalmente plana
- Butterworth
- Chebyshev inversa

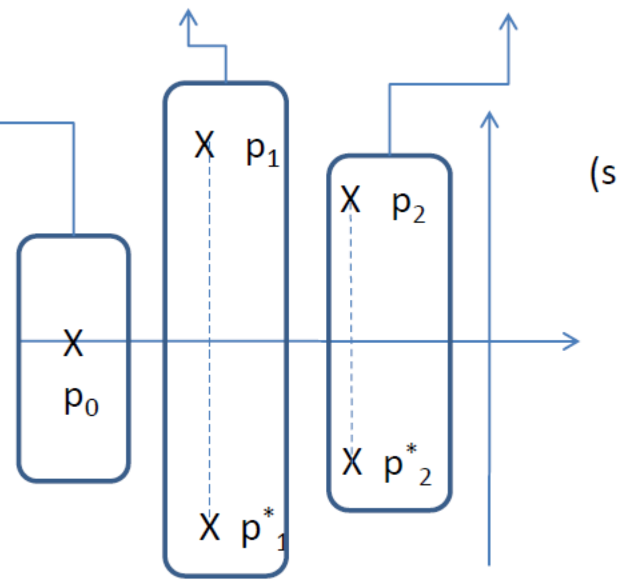
Aproximación de igual rizado
- Chebyshev
- Elíptica

Aproximación Bessel

Síntesis de filtros en cascada

$$H(s)=\frac{P(s)}{Q(s)}=\frac{K}{s^N+b_{N-1}s^{N-1}\ldots b_1 s+b_0}=\frac{k_0}{s+p_0}\cdot\frac{k_1}{(s-p_1)\cdot(s-p_1^*)}\cdot\frac{k_2}{(s-p_2)\cdot(s-p_2^*)}\cdots$$

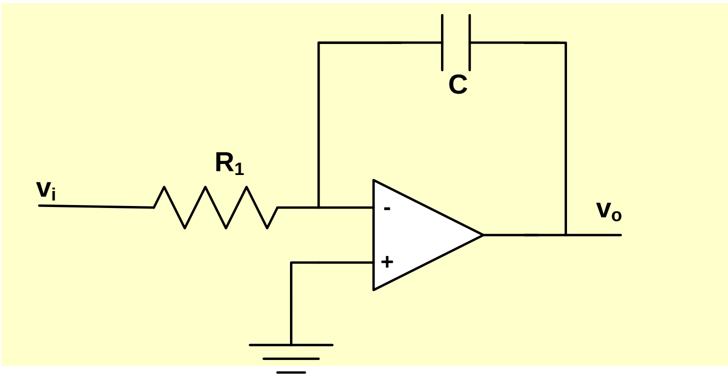




- Circuitos de primer orden

Integrador

IDEAL



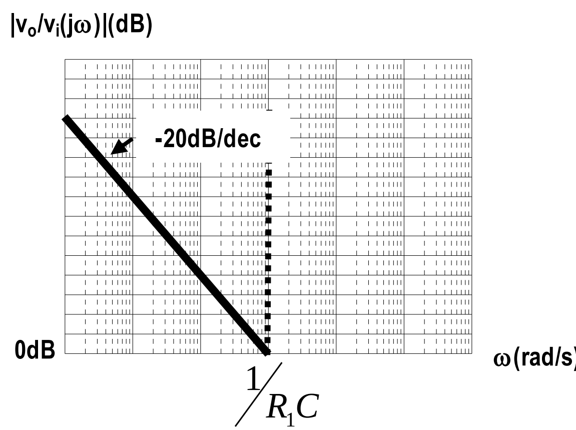
$$\frac{V_o}{V_i}(s) = -\frac{1}{sR_1C}$$

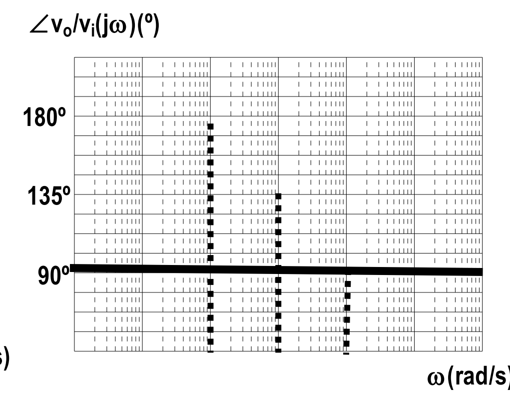
- Polo s = 0

$$\frac{V_o}{V_i}(j\omega) = -\frac{1}{j\omega R_1C}$$

- Cortocircuito virtual:v+=v-
- $i(R_1)=i(C)$

$$v_o(t) = -\frac{1}{R_1C}\cdot\int v_i(t) + v_o(0)$$



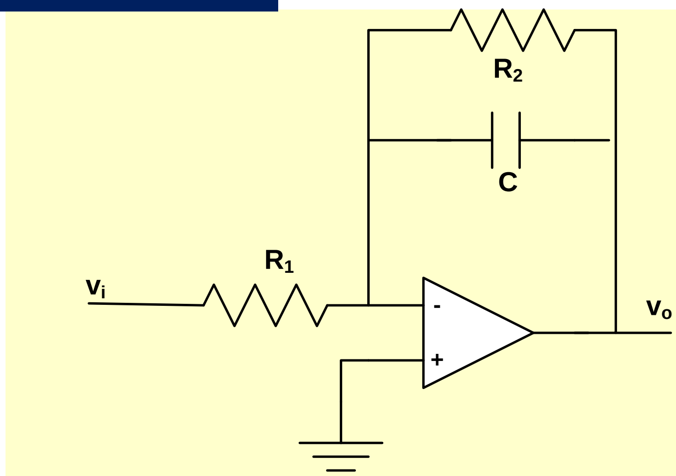


- Integra $\forall\ \omega$

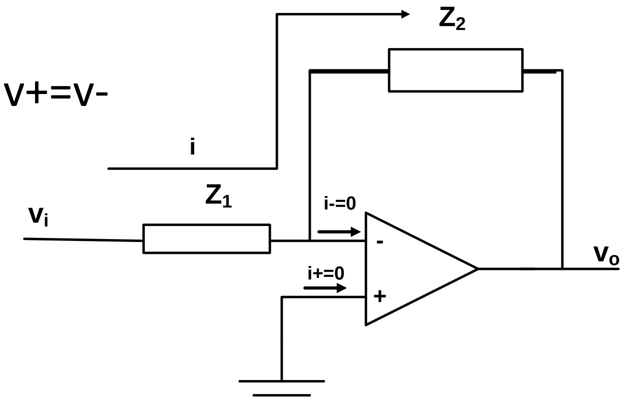
- $\left.\frac{v_o}{v_i}\right|_{DC} \to \infty$

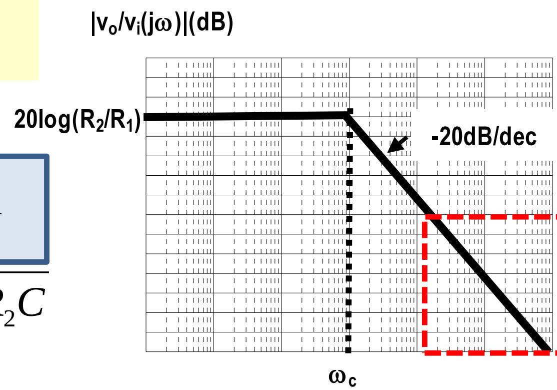
Integrador

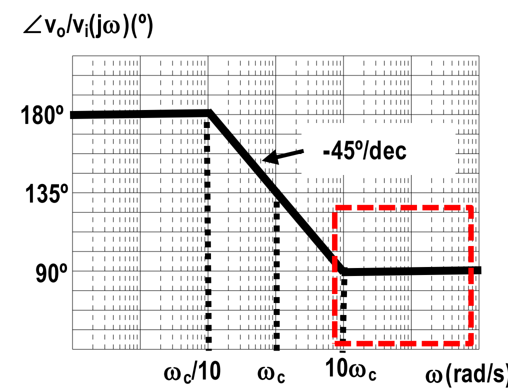
REAL



- Cortocircuito virtual:v+=v-
- $i(Z_1)=i(Z_2)=i$







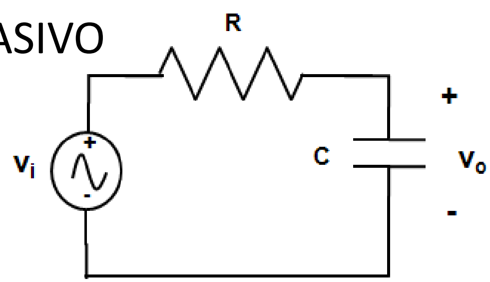
$$\frac{V_o}{V_i}(j\omega)=-\frac{Z_2}{Z_1}=-\frac{\dfrac{R_2}{1+j\omega R_2C}}{R_1}=\frac{-\dfrac{R_2}{R_1}}{1+j\omega R_2C}$$

Polo: $\omega_c=\dfrac{1}{R_2C}$

Integra si $\omega \gg 1/R_2C$

$$\left.\frac{v_o}{v_i}\right|_{BF}\rightarrow -\frac{R_1}{R_2}$$

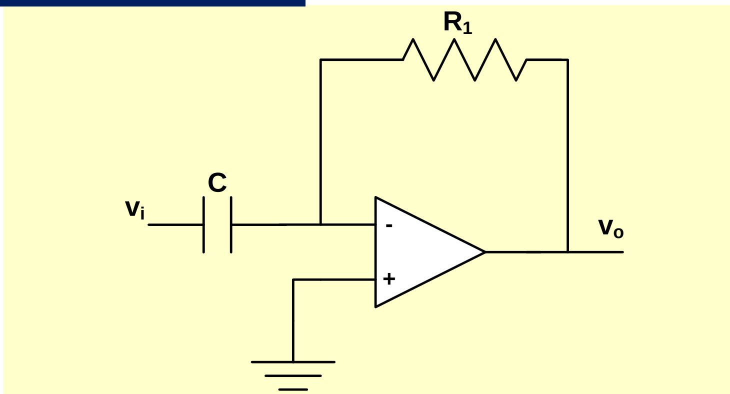
PASIVO



$$\frac{V_o}{V_i}(j\omega)=\frac{1}{1+j\omega RC}$$

IDEAL

Derivador



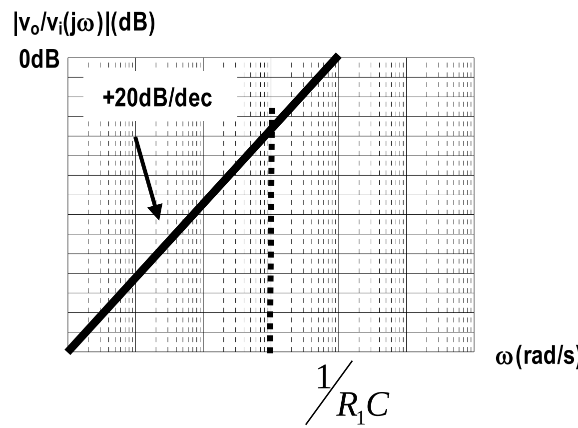
$$\frac{V_o}{V_i}(s) = -sR_1C$$

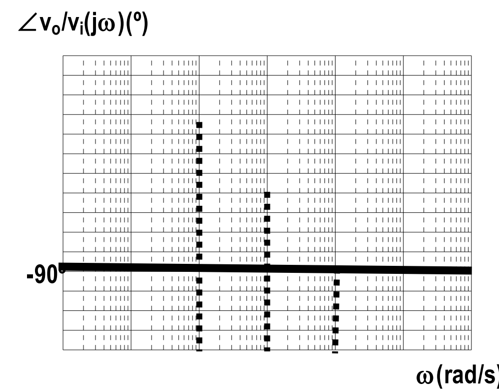
- Polo s $\rightarrow \infty$

$$\frac{V_o}{V_i}(j\omega) = -j\omega R_1 C$$

- Cortocircuito virtual: v+=v-
- $i(R_1) = i(C)$

$$v_o(t) = -R_1C\cdot\frac{dv_i(t)}{dt}$$

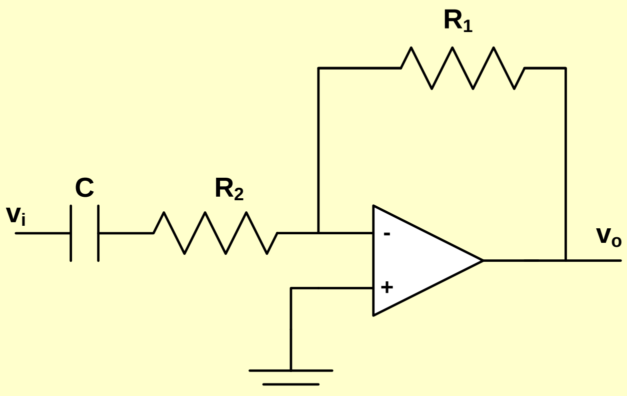




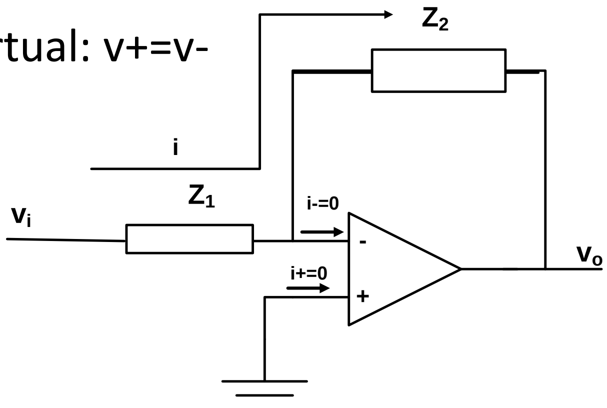
- Deriva $\forall\ \omega$
- $\left.\frac{v_o}{v_i}\right|_{HF} \rightarrow \infty$

Derivador

REAL

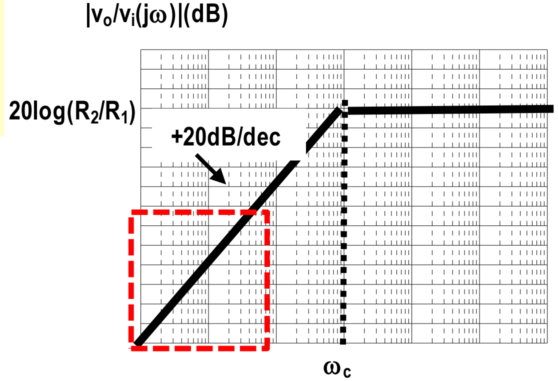


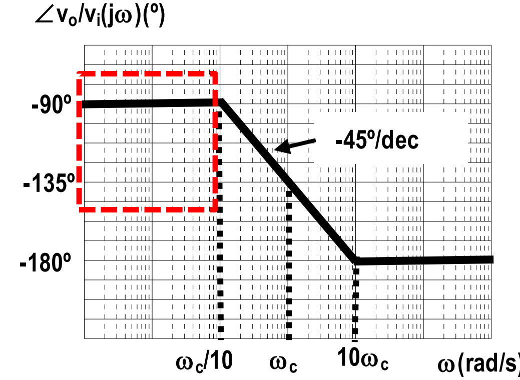
- Cortocircuito virtual: v+=v-
- $i(Z_1)=i(Z_2)=i$



$$\frac{V_o}{V_i}(j\omega) = -\frac{Z_2}{Z_1} == \frac{-j\omega \cdot R_1 \cdot C}{1 + j\omega R_2 C}$$

Polo: $\omega_c = \dfrac{1}{R_2 C}$

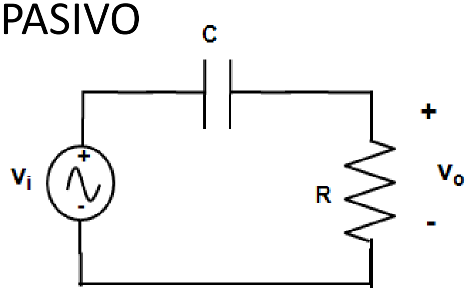




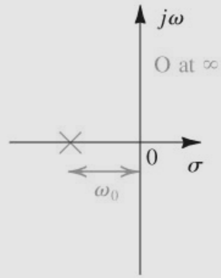
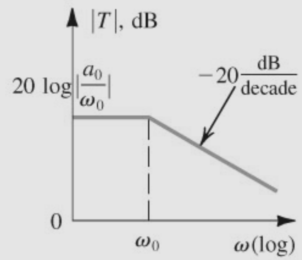
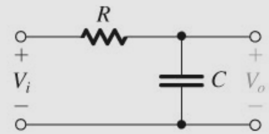
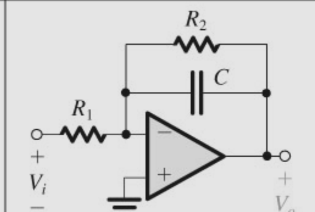
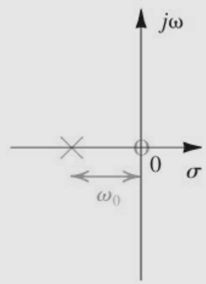
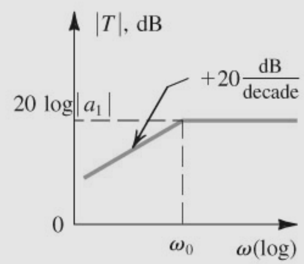
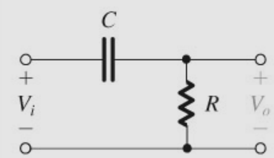
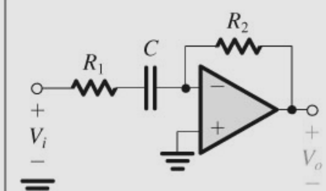
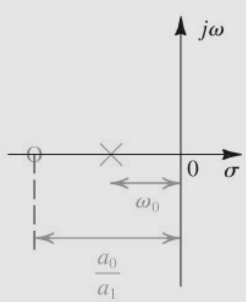
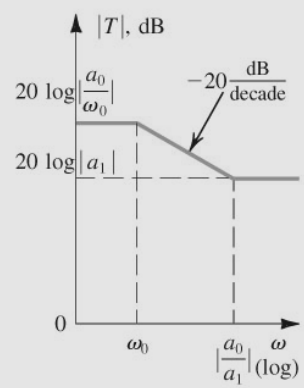
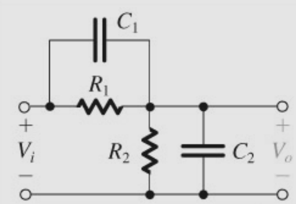
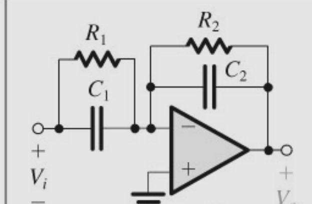
Deriva si $\omega \ll 1/R_2C$

$$\left.\frac{v_o}{v_i}\right|_{HF} \rightarrow -\frac{R_1}{R_2}$$

PASIVO

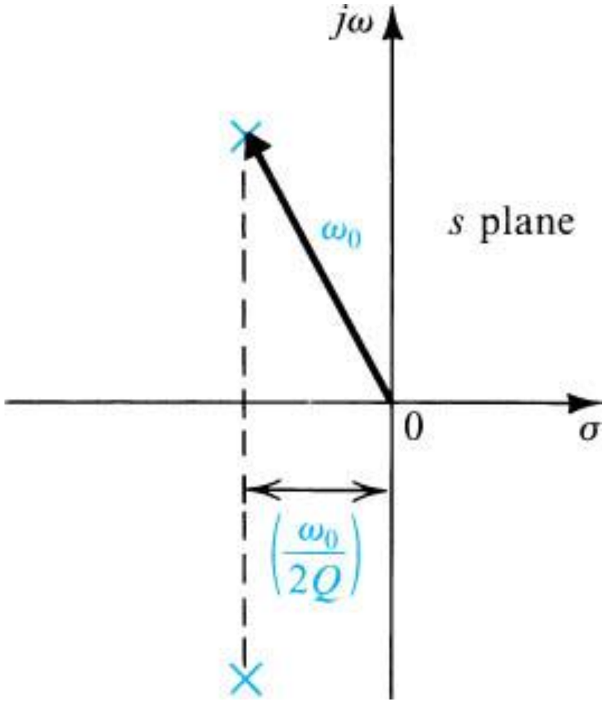


$$\frac{V_o}{V_i} = \frac{j\omega RC}{1 + j\omega RC}$$

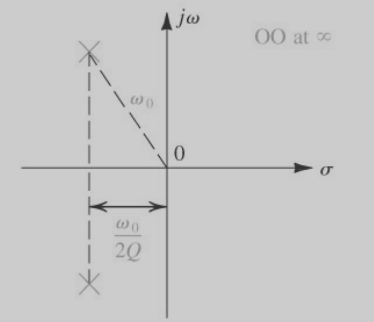
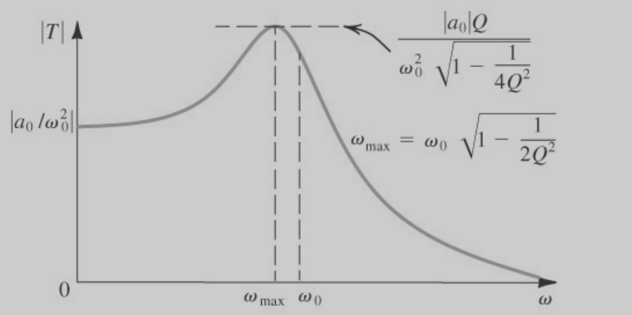
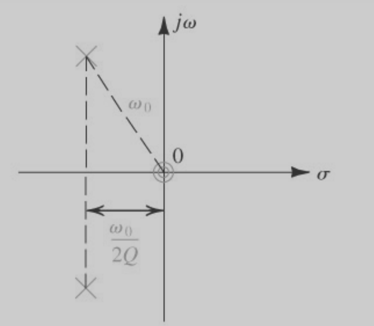
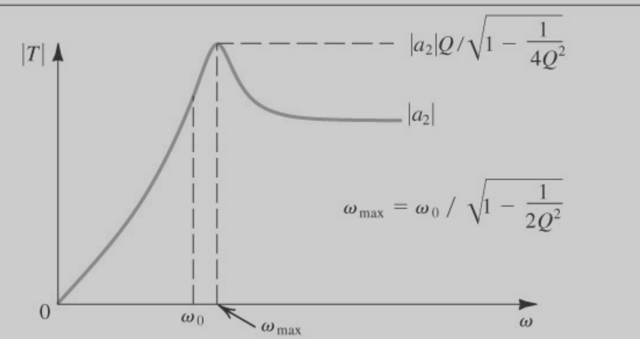
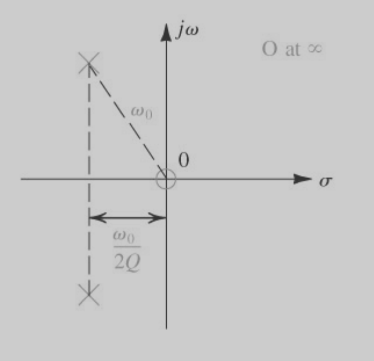
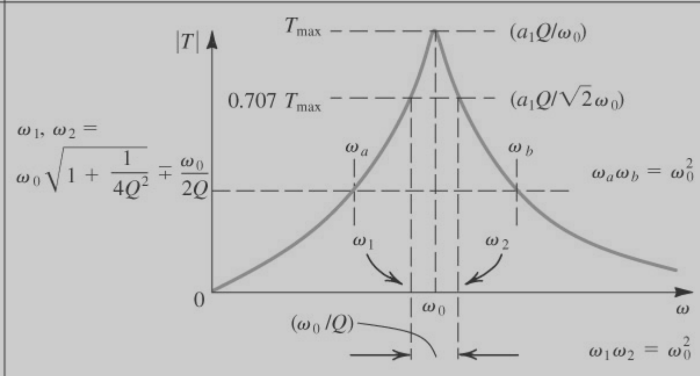
Filter Type and $T(s)$	s-Plane Singularities	Bode Plot for $\lvert T\rvert$	Passive Realization	Op Amp–RC Realization
(a) Low pass (LP) $T(s) = \frac{a_0}{s+\omega_0}$			 $CR = \frac{1}{\omega_0}$ DC gain = 1	 $CR_2 = \frac{1}{\omega_0}$ DC gain $= -\frac{R_2}{R_1}$
(b) High pass (HP) $T(s) = \frac{a_1 s}{s+\omega_0}$			 $CR = \frac{1}{\omega_0}$ High-frequency gain = 1	 $CR_1 = \frac{1}{\omega_0}$ High-frequency gain $= -\frac{R_2}{R_1}$
(c) General $T(s) = \frac{a_1 s + a_0}{s+\omega_0}$			 $(C_1 + C_2)(R_1 /\!/ R_2) = \frac{1}{\omega_0}$ $C_1R_1 = \frac{a_1}{a_0}$ DC gain $= \frac{R_2}{R_1 + R_2}$ HF gain $= \frac{C_1}{C_1 + C_2}$	 $C_2R_2 = \frac{1}{\omega_0}$ $C_1R_1 = \frac{a_1}{a_0}$ DC gain $= -\frac{R_2}{R_1}$ HF gain $= -\frac{C_1}{C_2}$

•Circuitos de segundo orden: Sallen-Key

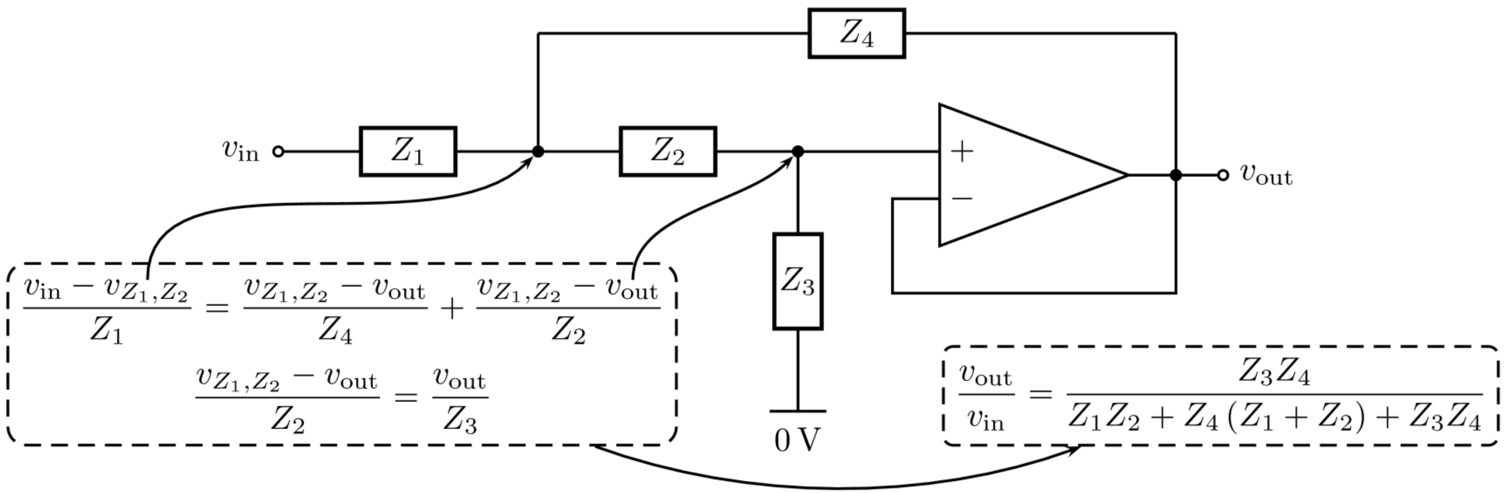
$$H(s) = \frac{P(s)}{Q(s)} = \frac{A_2 s^2 + A_1 s + A_0}{s^2 + \frac{w_o}{Q} s + w_o^{\;2}} = \frac{A_2 s^2 + A_1 s + A_0}{(s - p_1)\cdot\left(s - p_1^{\;*}\right)}$$



A_2, A_1, A_0 determinan el tipo de filtro

Filter Type and *T(s)*	***s*-Plane Singularities**	**|*T*|**
(a) Low pass (LP) $T(s) = \frac{a_0}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$ DC gain $= \frac{a_0}{\omega_0^2}$		
(b) High pass (HP) $T(s) = \frac{a_2 s^2}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$ High-frequency gain $= a_2$		
(c) Bandpass (BP) $T(s) = \frac{a_1 s}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$ Center-frequency gain $= \frac{a_1 Q}{\omega_0}$		

Sallen-Key



http://focus.ti.com.cn/cn/lit/an/sloa024b/sloa024b.pdf

Sallen Key paso bajo

Filtro de Sallen-Key

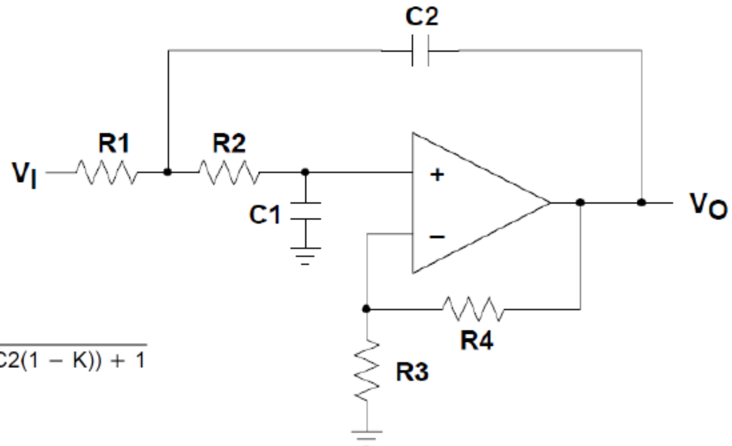


Figure 5. Low-Pass Sallen-Key Circuit

$$\frac{Vo}{Vi}(lp) = \frac{K}{s^2(R1R2C1C2) + s(R1C1 + R2C1 + R1C2(1 - K)) + 1}$$

$$fc = \frac{1}{2\pi\sqrt{R1R2C1C2}}, \quad \text{and } Q = \frac{\sqrt{R1R2C1C2}}{R1C1 + R2C1 + R1C2(1 - K)}$$

Sallen Key paso bajo de ganancia intensificada

Si R1=R2=R, C=C1=C2

$$fc = \frac{1}{2\pi RC} \quad Q = \frac{1}{3-K}$$