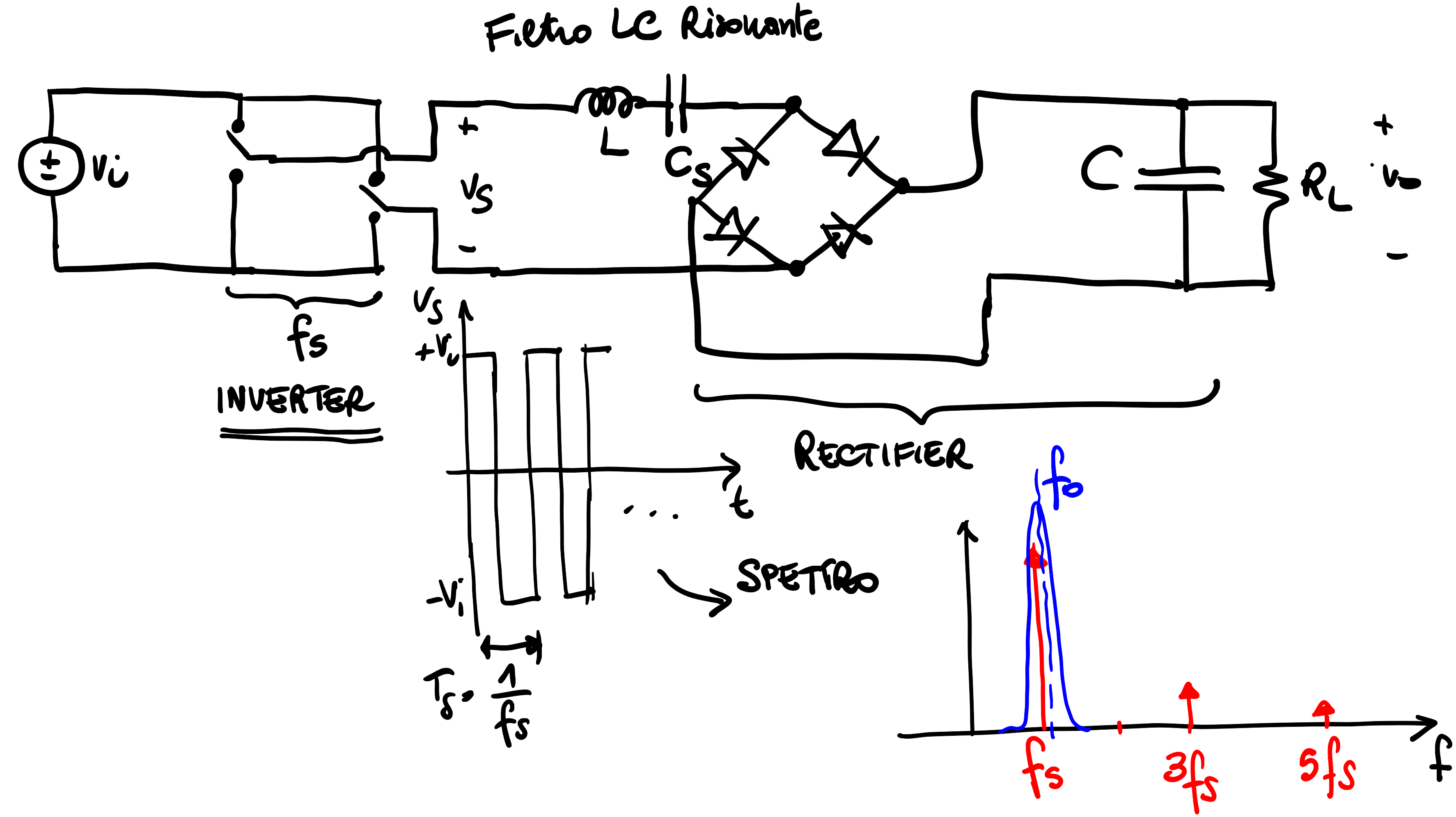
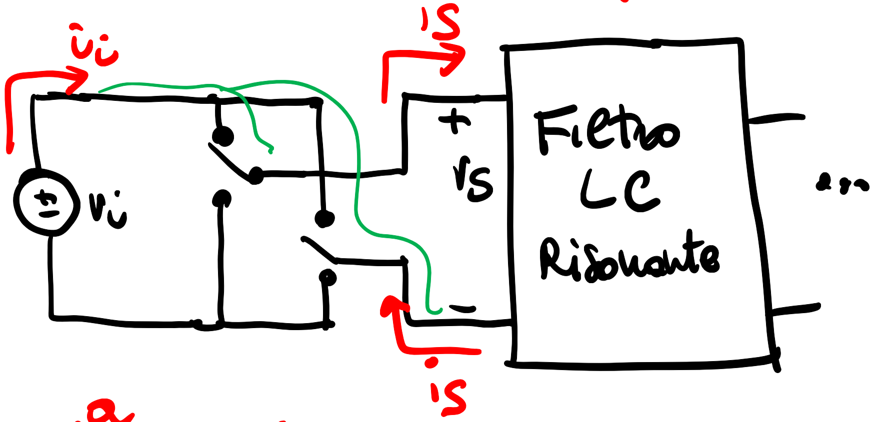
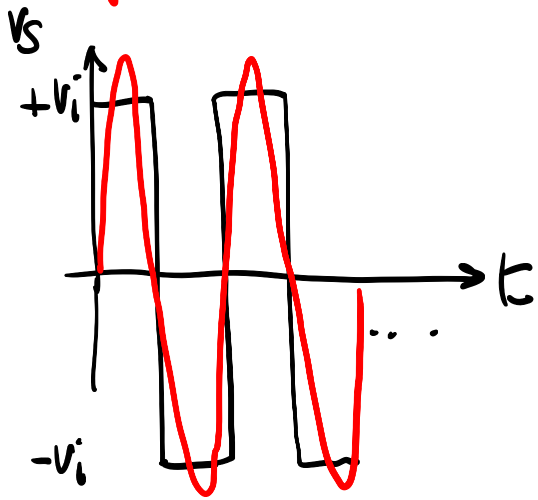
Convertitori RISONANTI (DC-DC)



Analisi con approssimazione sinusoidale (1^a armonica)

si può fare se $f_s \sim f_0$ e Q del filtro LC <u>alto</u>



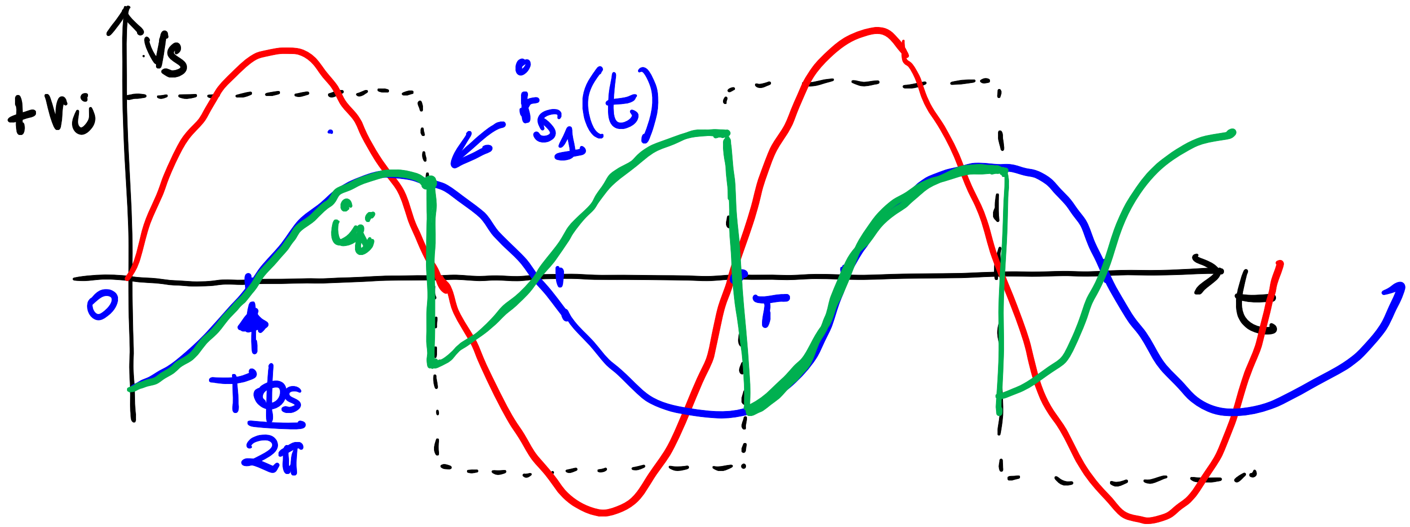


1^a armonica

$$v_{s_1}(t) = \frac{4}{\pi} V_i \sin(\omega_s t)$$

$$i_{s_1}(t) = I_{s_1} \sin(\omega_s t - \phi_s)$$

[se $v_s = v_i$ allora $i_s = i_i$
se $v_s = -v_i$ allora $i_s = -i_i$]



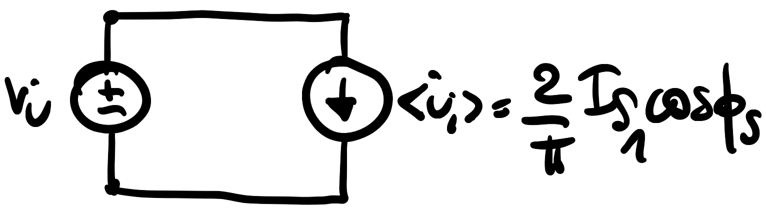
$$\langle i_i \rangle = \frac{1}{T/2}\int_0^{T/2} i_{s_1}(t)\,dt = \frac{1}{T/2}\int_0^{T/2} I_{s_1}\sin(\omega_s t - \phi_s)\,dt =$$

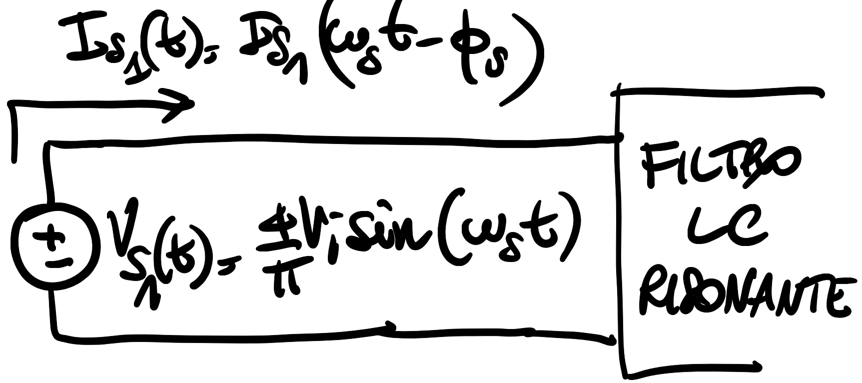
$$= \frac{-1}{T/2}\left.\frac{I_{s_1}\cos(\omega_s t - \phi_s)}{\omega_s}\right|_0^{T/2} = \frac{-2}{T\omega_s} I_{s_1}\left[\cos\left(\frac{\omega_s T}{2} - \phi_s\right) - \cos(-\phi_s)\right]$$

$$\frac{\omega_s T}{2} = \frac{\cancel{2}\pi \cancel{f_s}}{\cancel{2}}\frac{1}{\cancel{f_s}} = \pi$$

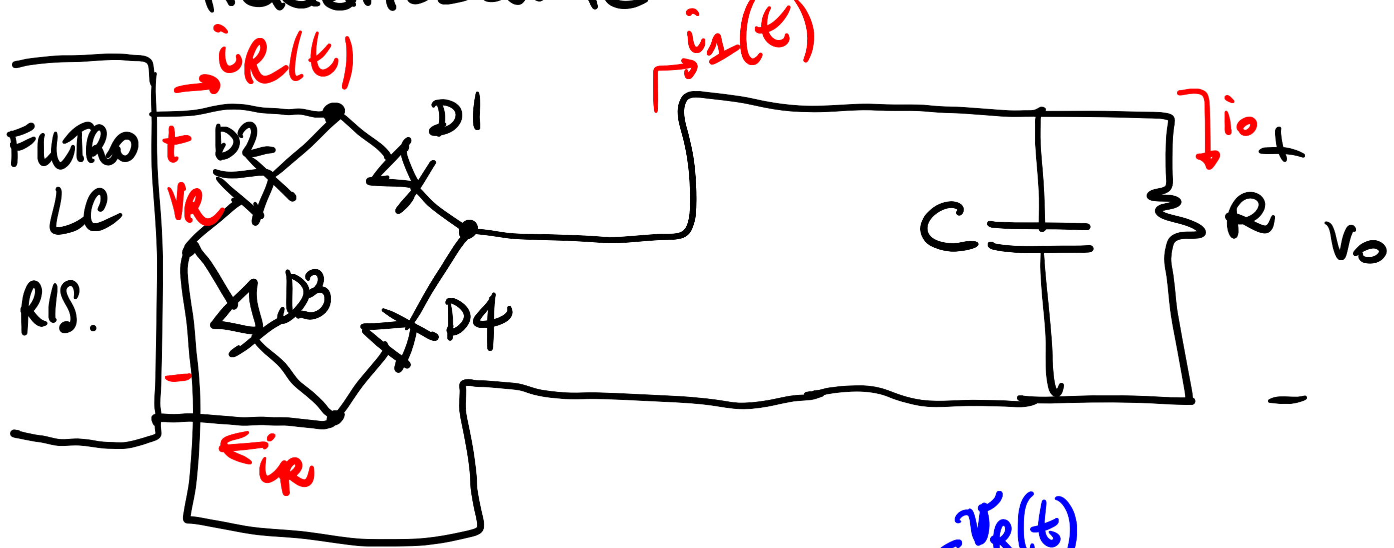
$$\boxed{\langle i_i \rangle = +\frac{2}{\pi} I_{s_1}\cos\phi_s}$$

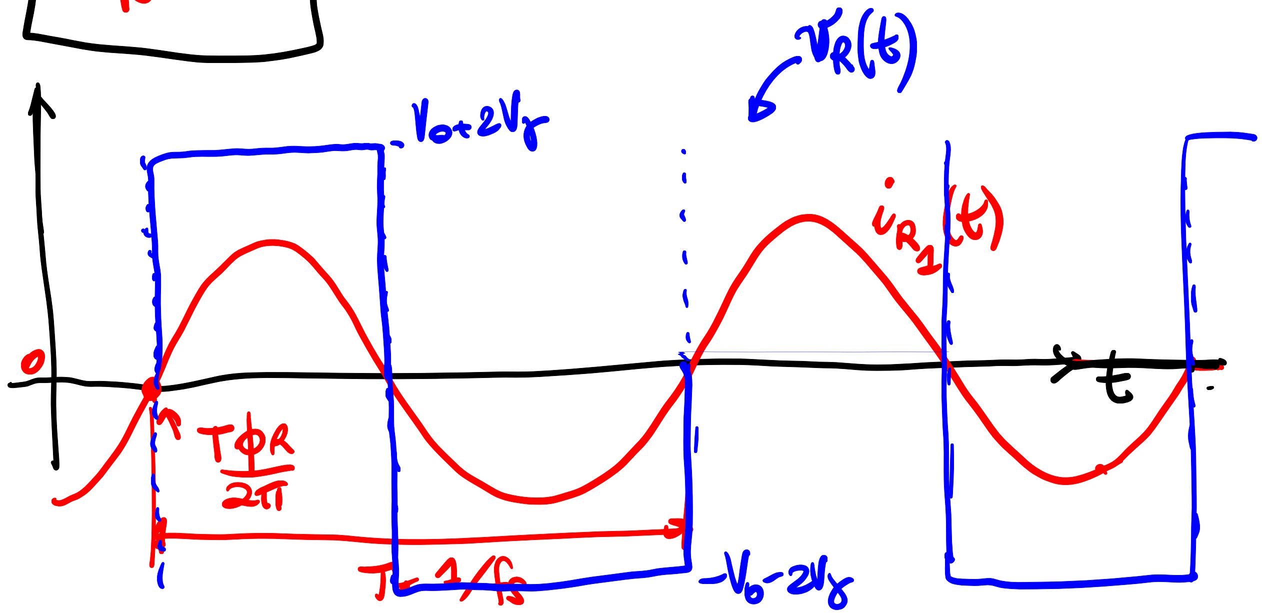
CIRCUITO EQUIVALENTE:





Raddrizzatore





se $\underline{\underline{i_R>0}}$

D1, D3 ON
D2, D4 OFF $\Rightarrow V_o = V_R - 2V_\gamma$

$\underline{\underline{V_R = V_o + 2V_\gamma}}$

se $\underline{\underline{i_R<0}}$

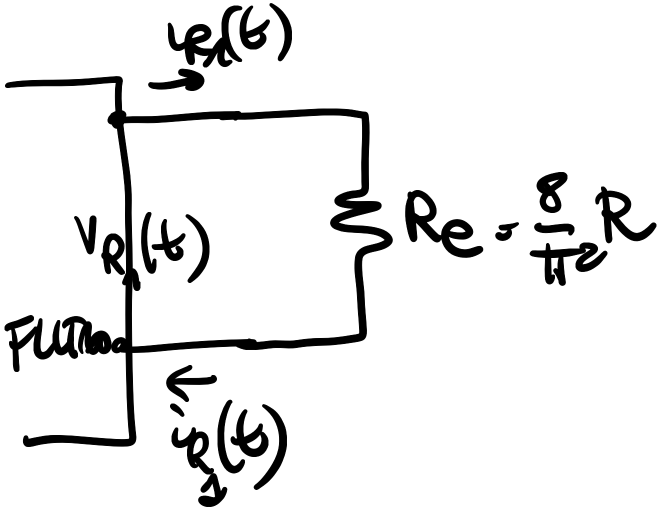
D1, D3 OFF
D2 D4 ON $\Rightarrow V_o = -V_R - 2V_\gamma$

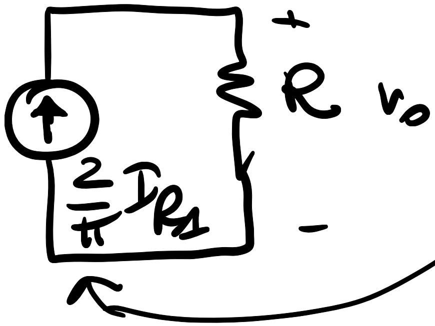
$\underline{\underline{V_R = -V_o - 2V_\gamma}}$

$$i_{R_1}(t) = \underline{\underline{I_{R_1}}} \sin(\omega_s t - \phi_R)$$

$$v_{R_1}(t) = \underbrace{\frac{4}{\pi}(V_o+2V_\gamma)}_{V_{R_1}} \sin(\omega_s(t) - \phi_R$$

CIRCUITO equivalente (1ª armonica)





$i_1(t) = |i_R(t)|$

$\langle i_o \rangle = \langle i_1(t) \rangle = \langle |i_R(t)| \rangle$

$$\boxed{\langle i_o \rangle = \frac{2}{\pi} I_{R_1}}$$

$V_o = \langle i_o \rangle R = \frac{2}{\pi} I_{R_1} R$

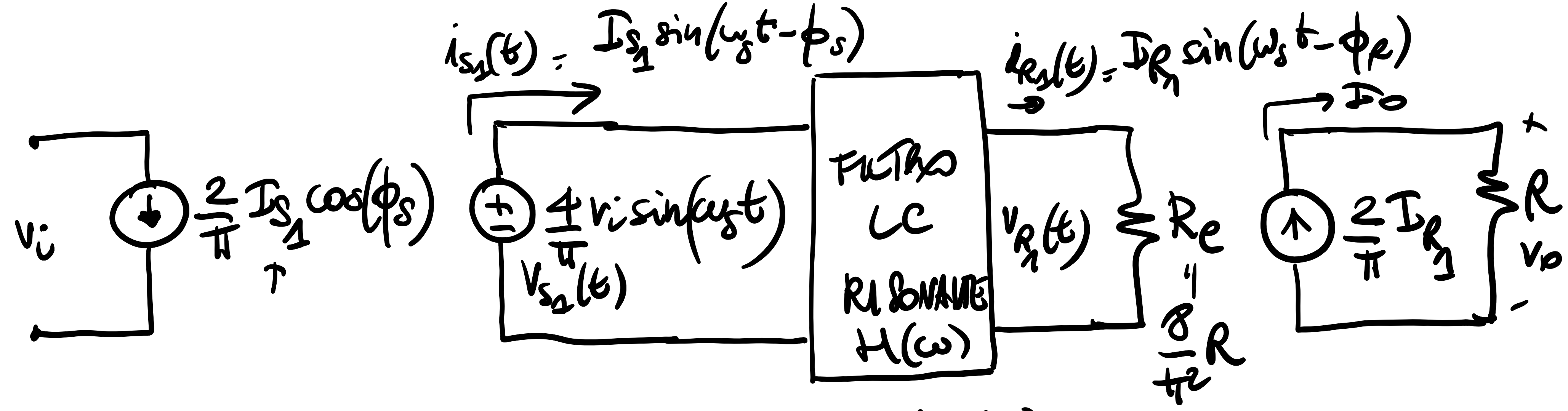
$V_{R_1} = \frac{4}{\pi}(V_o + 2V_\gamma) = \frac{4}{\pi}\left(\frac{2}{\pi} I_{R_1} R + 2V_\gamma\right)$

se trascuro $2V_\gamma$

$V_{R_1} = \frac{8}{\pi^2} R\, I_{R_1}$

$$\boxed{\frac{V_{R_1}}{I_{R_1}} = \frac{8R}{\pi^2} = R_e}$$ ← Resistenza equivalente per la 1ª armonica

CIRCUITO EQUIVALENTE PER LA 1ª armonica

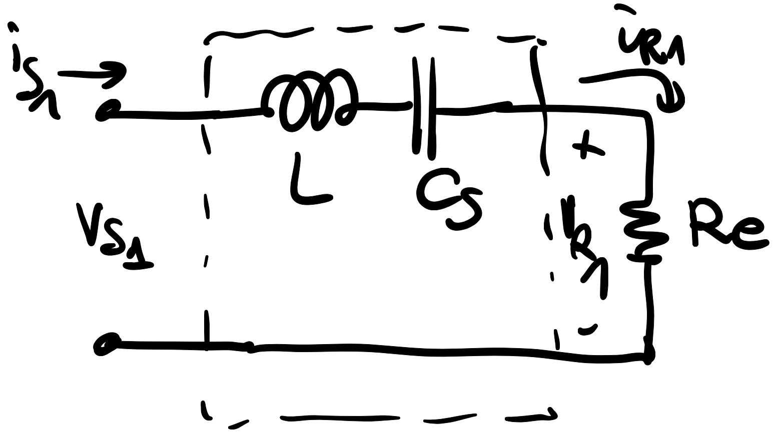


$$H(\omega) = \frac{V_{R_1}(\omega)}{V_{S_1}(\omega)} \quad \text{con carico } \underline{\underline{R_e}}$$

$$VCR = \frac{V_o}{V_i} = \frac{V_o}{I_o} \cdot \frac{I_o}{\underset{\omega_s}{I_{R_1}}} \cdot \frac{\overset{\omega_s}{I_{R_1}}}{\underset{\omega_s}{V_{R_1}}} \cdot \frac{\overset{\omega_s}{V_{R_1}}}{V_{S_1}} \cdot \frac{V_{S_1}}{V_i} =$$

$$= R \cdot \frac{2}{\pi} \frac{1}{R_e} \left|H(\omega_s)\right| \cdot \frac{4}{\pi} = \underbrace{\frac{8}{\pi^2}\frac{R}{R_e}}_{1} \left|H(\omega_s)\right| = \left|H(\omega_s)\right|$$

FILTRO LC RISONANTE SERIE



$$H(s) = \frac{R_e}{R_e + Ls + \frac{1}{C_s s}} =$$

$$H(s) = \frac{R_e C_s s}{L C_s s^2 + R_e C_s s + 1}$$

$$H(s) = \frac{\frac{s}{Q\omega_0}}{\frac{s^2}{\omega_0^2} + \frac{s}{Q\omega_0} + 1}$$

$$\omega_0 = \frac{1}{\sqrt{L C_s}}$$

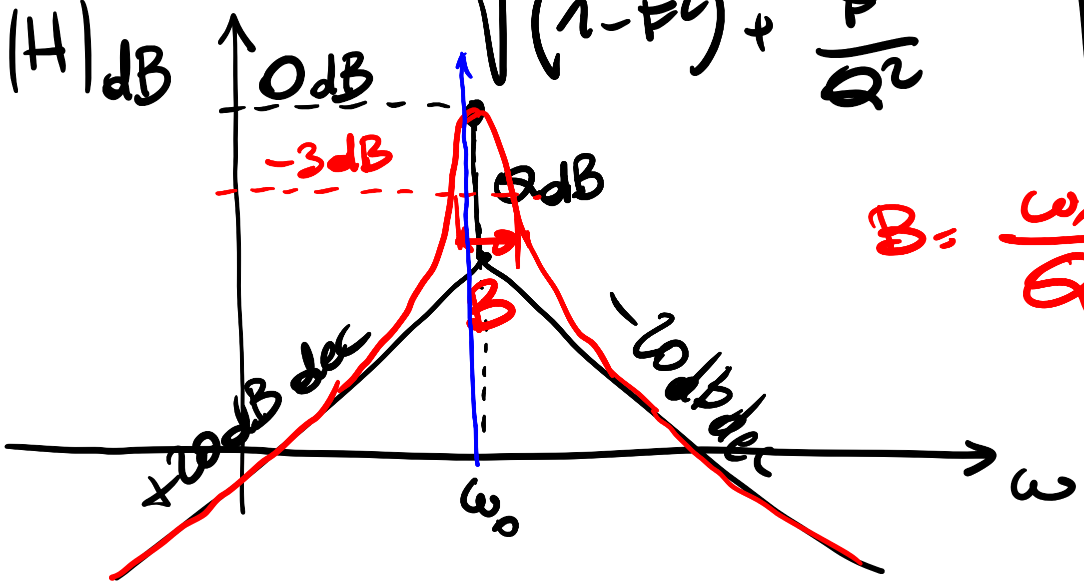
$$\frac{1}{Q\omega_0} = R_e C_s \rightarrow Q = \frac{1}{\omega_0 R_e C_s} = \frac{1}{R_e}\sqrt{\frac{L}{C_s}}$$

$\gg 1$

$$|H(j\omega_s)| = \frac{\left|\frac{j\omega_s}{Q\omega_0}\right|}{\left|-\frac{\omega_s^2}{\omega_0^2} + \frac{j\omega_s}{Q\omega_0} + 1\right|} = \frac{\frac{\omega_s}{Q\omega_0}}{\sqrt{\left(1-\frac{\omega_s^2}{\omega_0^2}\right)^2 + \frac{\omega_s^2}{Q^2\omega_0^2}}}$$

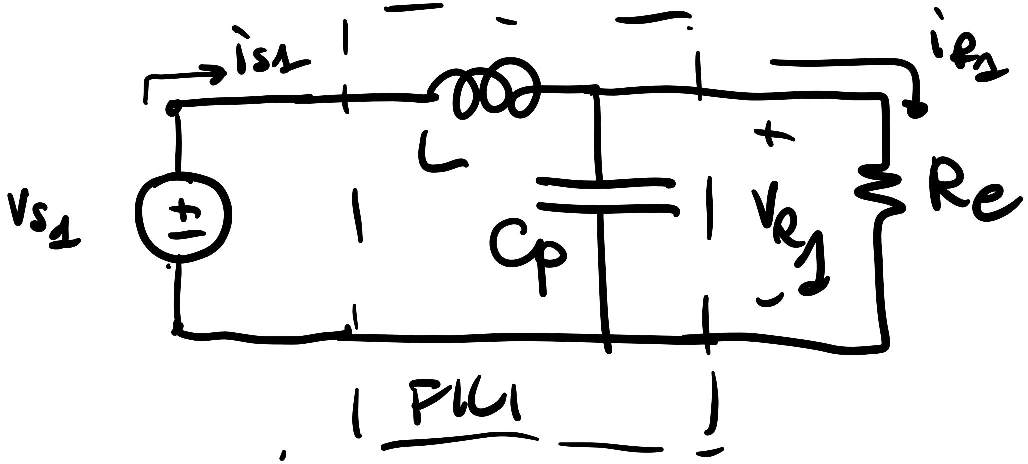
se $F = \frac{\omega_s}{\omega_0}$

$$|H(j\omega_s)| = \frac{F/Q}{\sqrt{(1-F^2)^2 + \frac{F^2}{Q^2}}} = \frac{1}{\sqrt{1 + \frac{(1-F^2)^2 Q^2}{F^2}}}$$



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

FILTRO LC RISONANTE PARALLELO (STEP UP)



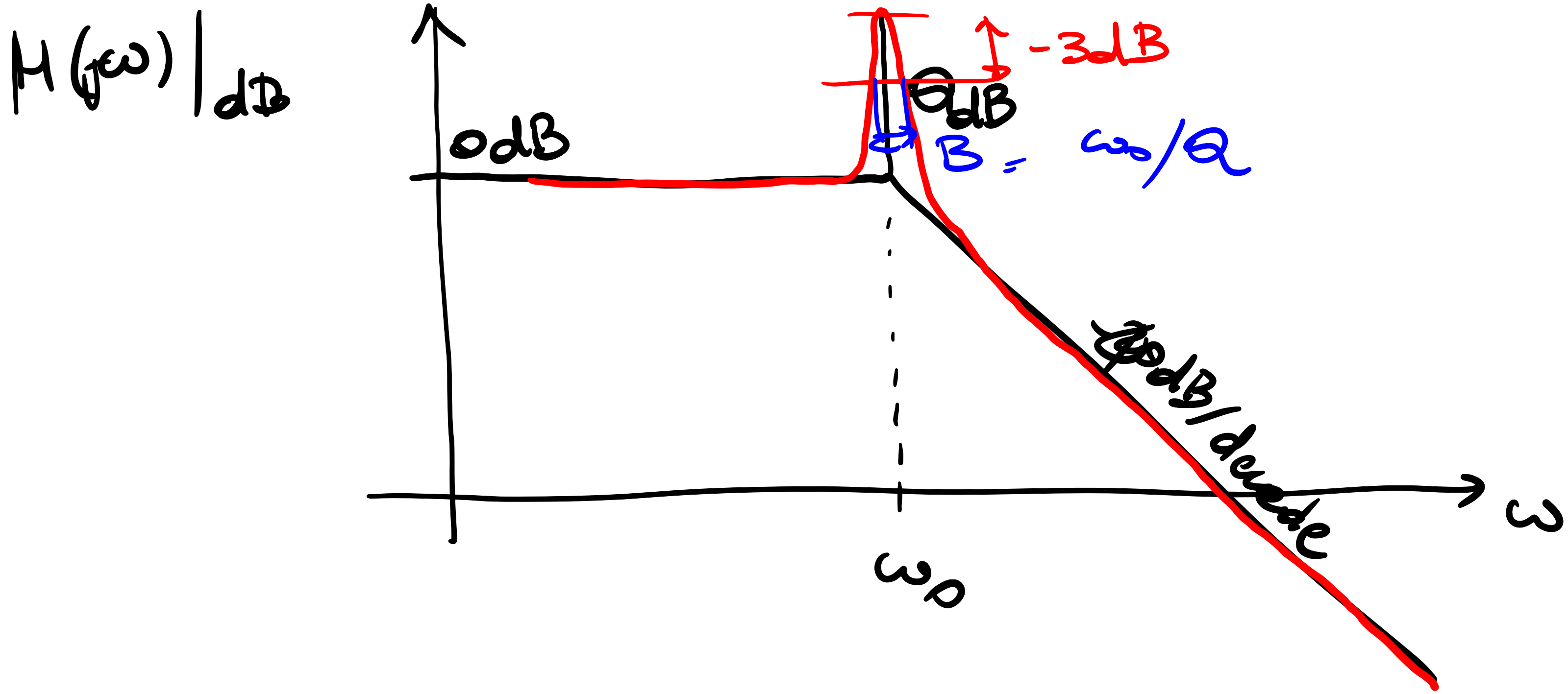
$$H(s) = \frac{V_{R1}(s)}{V_{s1}(s)} = \frac{R_e /\!/ \frac{1}{C_p s}}{R_e /\!/ \frac{1}{C_p s} + Ls}$$

$$H(s) = \frac{\frac{R_e}{1+R_eC_ps}}{\frac{R_e}{1+R_eC_ps} + Ls} = \frac{R_e}{LC_pR_es^2 + Ls + R_e}$$

$$\boxed{H(s) = \frac{1}{LC_ps^2 + \frac{L}{R_e}s + 1}}$$

$$H(s) = \frac{1}{\frac{s^2}{\omega_0^2} + \frac{s}{Q\omega_0} + 1} \rightarrow \omega_0 = \frac{1}{\sqrt{LC_p}}$$

$$Q = \frac{R_e}{L\omega_0} = R_e\sqrt{\frac{C_p}{L}}$$



|H(jω)|dB
0dB
-3dB
QdB
B = ω0/Q
-40dB/decade
ω0
ω