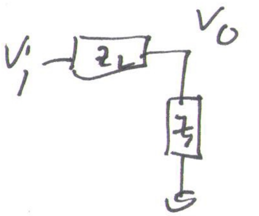
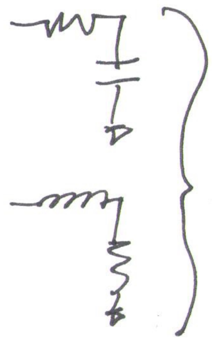
16B 18SP W3L2 3B

Bode Plots

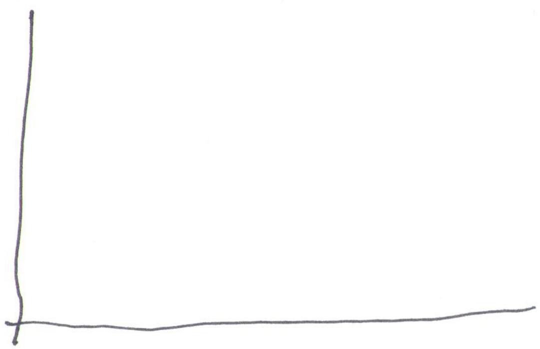
Filters

LC

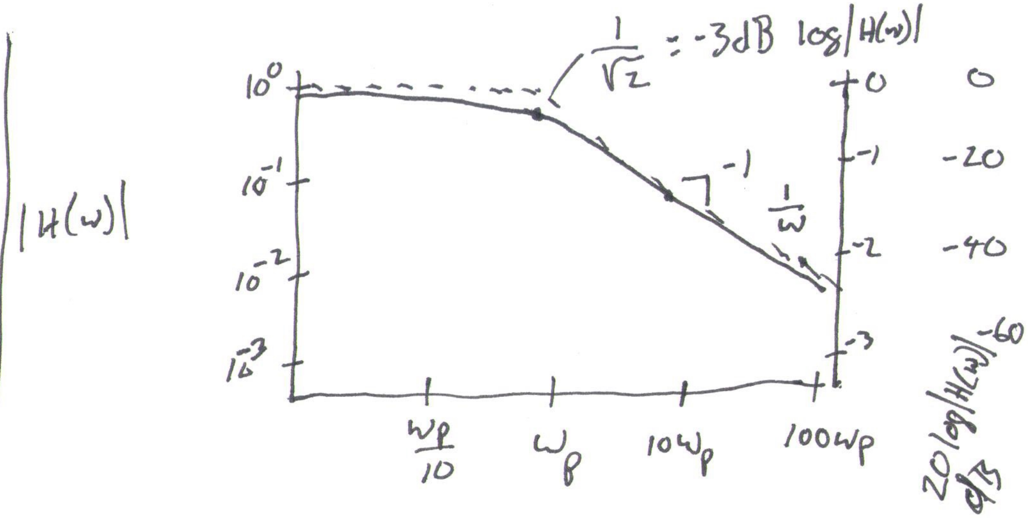


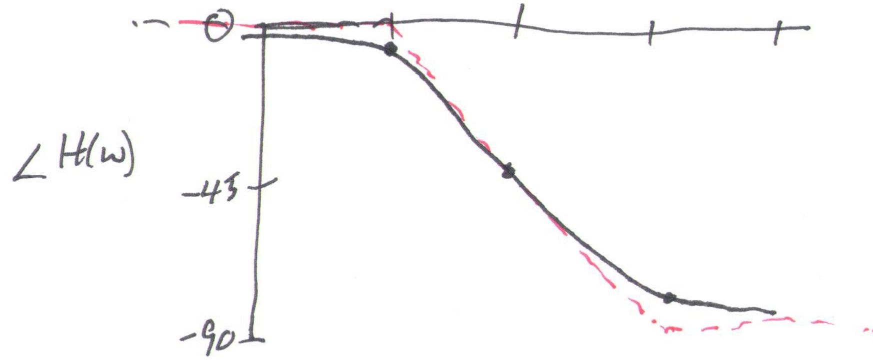


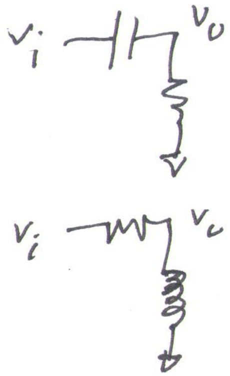
$$H(\omega) = \frac{1}{\left(1 + j\omega/\omega_p\right)}$$



$$H(\omega) \approx \begin{cases} 1 & \omega << \omega_p \\ \frac{1}{1+j} & \omega == \omega_p \\ \frac{\omega_p}{j\omega} & \omega >> \omega_p \end{cases}$$

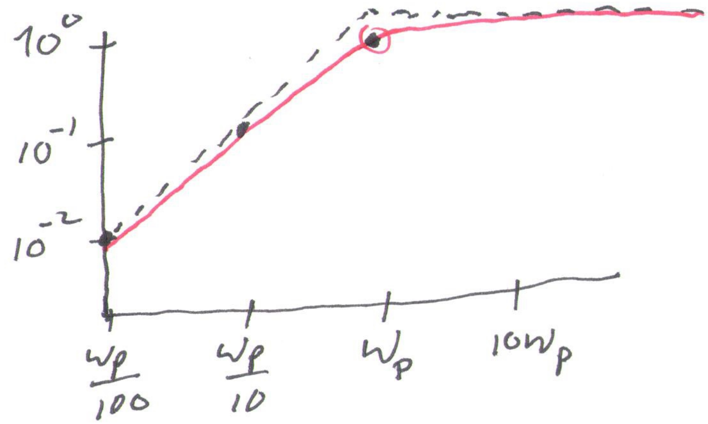


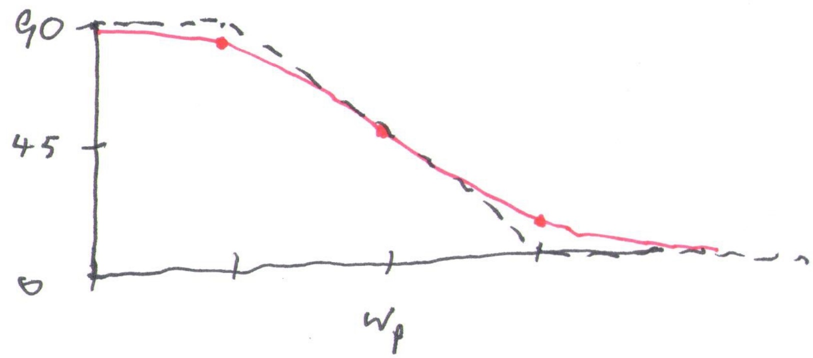




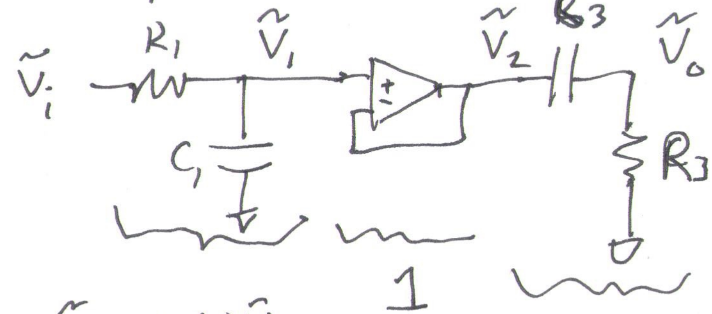
$$H(\omega) = \frac{j\omega/\omega_p}{1 + j\omega/\omega_p}$$

$$H(\omega) = \begin{cases} \dfrac{j\omega}{\omega_p} & \omega \ll \omega_p \\ \dfrac{j}{1+j} & \omega == \omega_p \\ 1 & \omega \gg \omega_p \end{cases}$$





Composing filters



$$\tilde{V}_1 = H_1(\omega)\tilde{V}_i$$

$$\tilde{V}_2 = 1\,\tilde{V}_1$$

$$\tilde{V}_o = H_2(\omega)\tilde{V}_2$$
$$= H_2\tilde{V}_1$$
$$= H_2 H_1 \tilde{V}_i$$
$$= H V_i$$

$$H(\omega) = \frac{\tilde{V}_o}{\tilde{V}_i} = H_1 H_2$$

$$|H(\omega)| = |H_1 H_2|$$
$$= |H_1(\omega)|\ |H_2(\omega)|$$

$$\angle H(\omega) = \angle H_1 H_2 = \angle\left(|H_1|e^{j\angle H_1}\,|H_2|e^{j\angle H_2}\right)$$
$$= \angle H_1 + \angle H_2$$

$R_1 = 1\,K\Omega \quad C_1 = 0.1\,\mu f \quad \tau_1 = R_1 C_1$

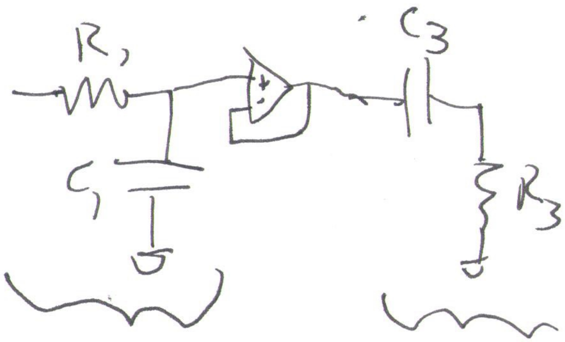
$= 10^3\, 10^{-7} = 10^{-4}\, s$

$R_3 = 200\,\Omega \quad C_3 = 1\mu$

$\tau_3 = R_3 C_3 = (200)\,10^{-6} = 2\times 10^{-4}\, s$

$\omega_{p1} = \frac{1}{\tau_1} = 10^4 \frac{rad}{s}$

$\omega_{p3} = \frac{1}{\tau_3} = \frac{1}{2\times 10^{-4}} = 5\times 10^3 \frac{rad}{s}$

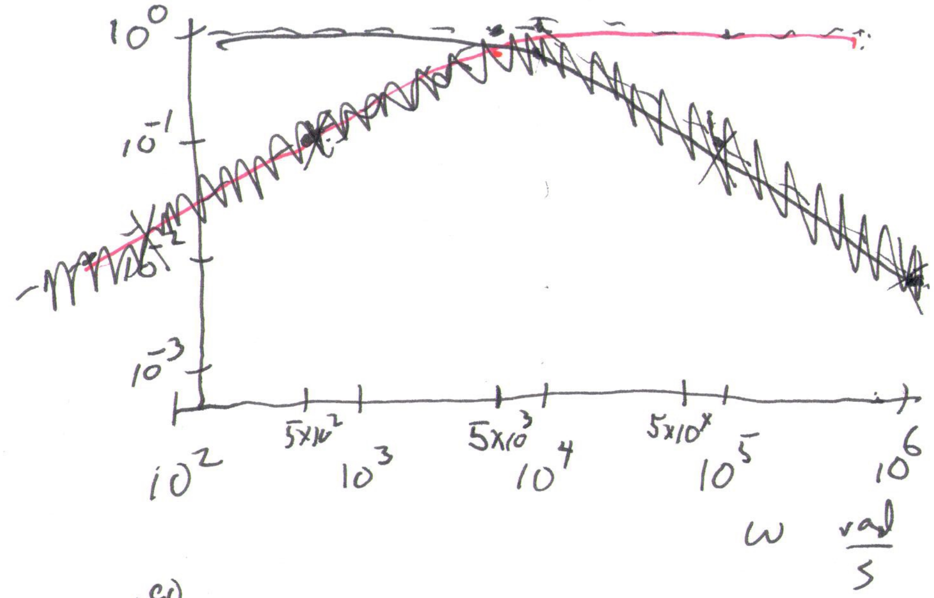


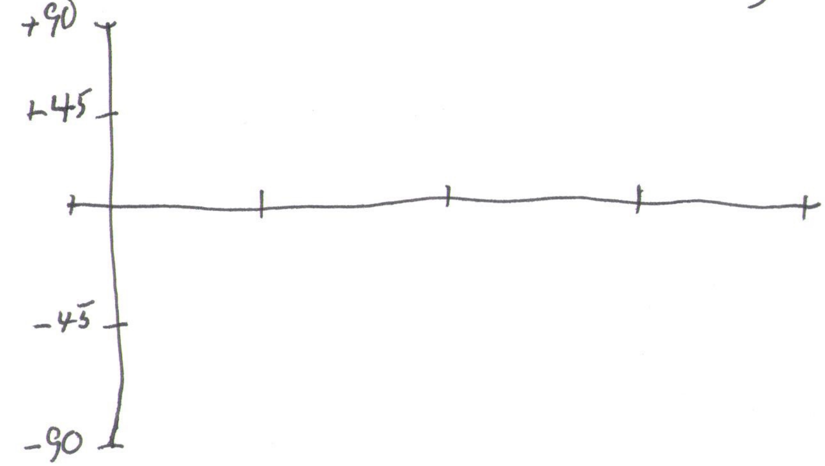
LPF

$\omega_{p1} = 10^4 \frac{rad}{s}$

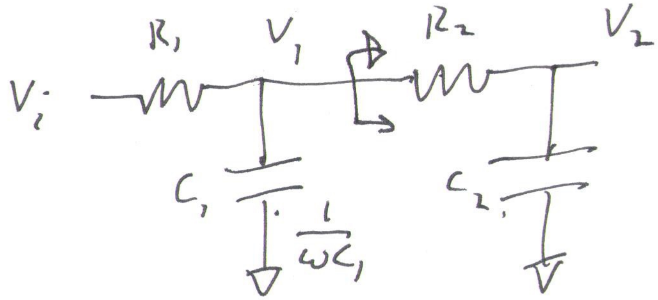
HPF

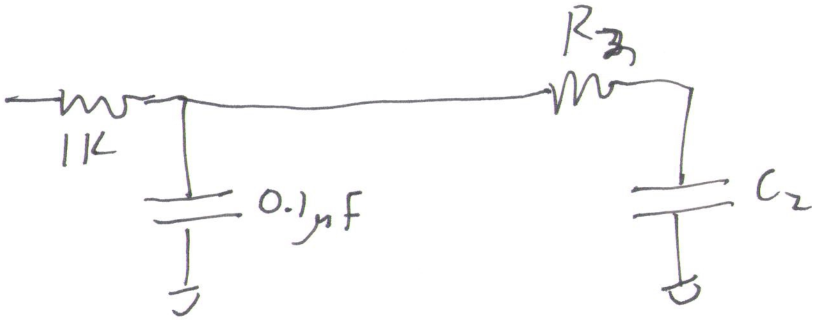
$\omega_{p3} = 5\times 10^3\, rad$





Buffers?





~~$R_1 \gg R_2$~~

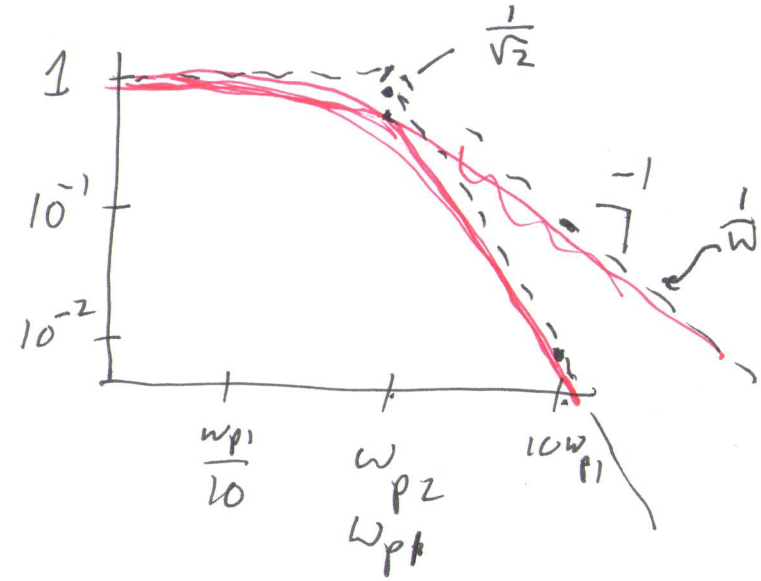
$$\left|R_2 + \frac{1}{\omega C_2}\right| \gg \frac{1}{\omega C_1}$$

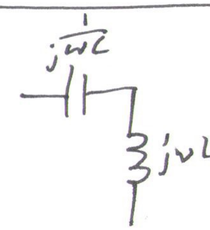
$$C_2 = \frac{C_1}{100}$$

want $\omega_{p1} = \omega_{p2}$

$$R_1 C_1 = R_2 C_2$$

$$R_2 = 100 R_1$$





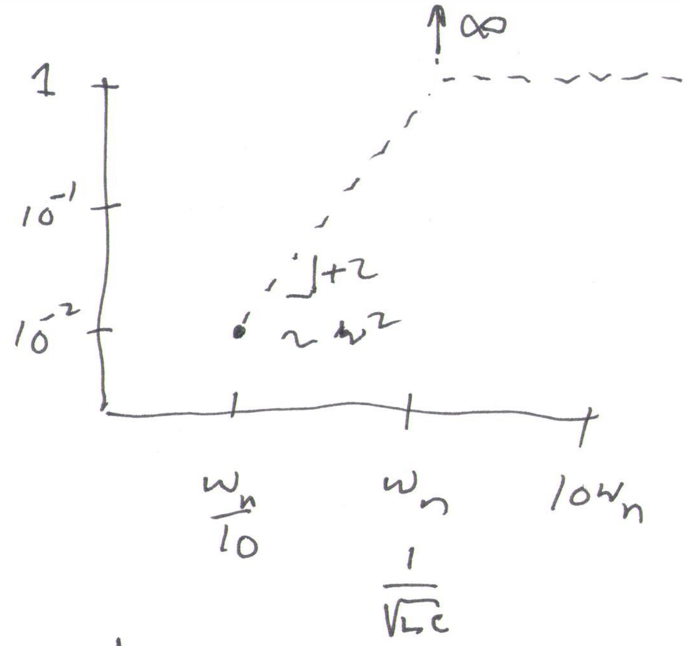
$$H(\omega) = \frac{j\omega L}{j\omega L + \frac{1}{j\omega C}}$$

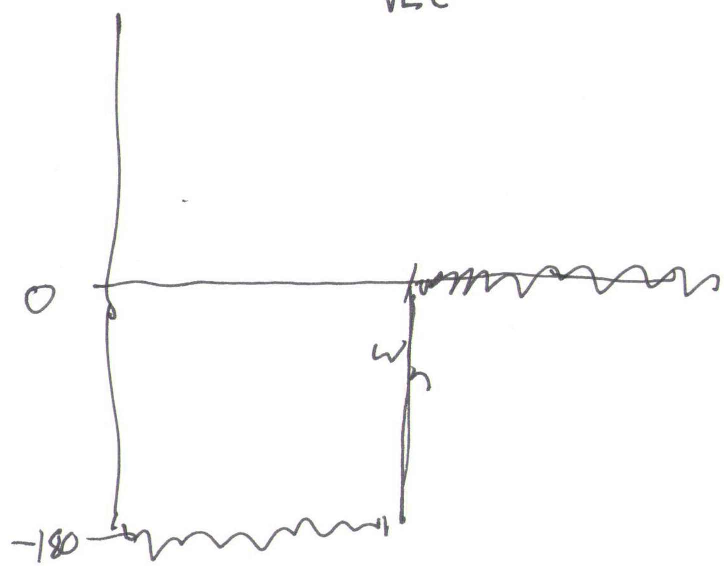
$$= \frac{(j\omega L)(j\omega C)}{(j\omega L)(j\omega C) + 1}$$

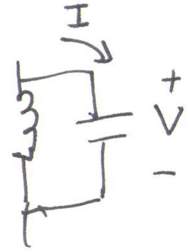
$$= \frac{-\omega^2 LC}{1 - \omega^2 LC}$$

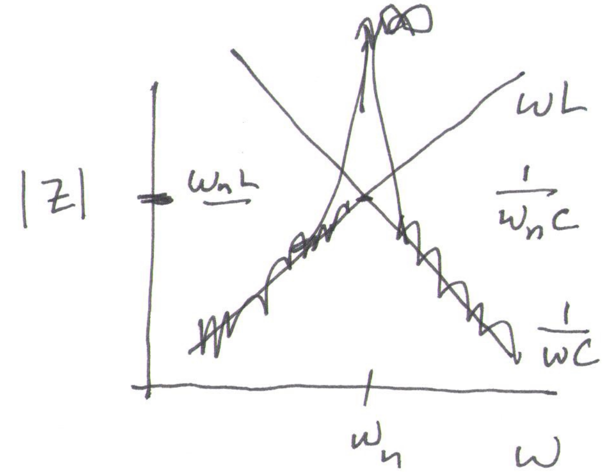
$$\omega_n = \frac{1}{\sqrt{LC}}$$

$$H(\omega) = \begin{cases} -\omega^2 LC = -\frac{\omega^2}{\omega_n^2} & \omega \ll \omega_n \\ \infty & \omega = \omega_n \\ 1 & \omega \gg \omega_n \end{cases}$$









$$Z = \frac{j\omega L \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C}}$$

$$= \frac{j\omega L}{(j\omega L)(j\omega C)+1}$$

$$Z\left(\omega_n = \frac{1}{\sqrt{LC}}\right) = \infty$$

$$I = C\frac{dV}{dt}$$

$$V = L\frac{d}{dt} I_L$$

$$I_L = -I$$

$$V = L\frac{d}{dt}\left(-C\frac{dV}{dt}\right)$$

$$= -LC\frac{d^2V}{dt^2}$$

$$LC\frac{d^2V}{dt^2} + V = 0$$

$$V(t) = V_0 \cos(\omega t + \phi)$$

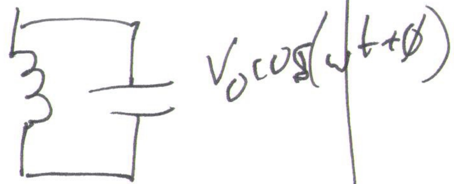
$$\frac{dV}{dt} = -\omega V_0 \sin(\omega t + \phi)$$

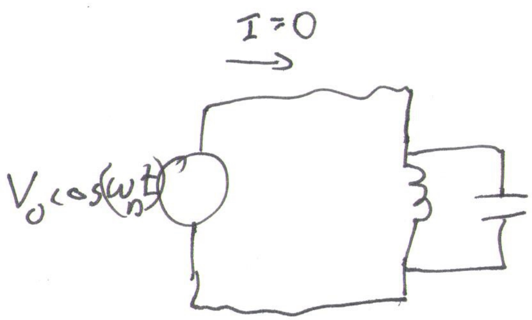
$$\frac{d^2V}{dt^2} = -\omega^2 V_0 \cos(\omega t + \phi)$$

$$LC\left(-\omega^2 V_0 \cos(\omega t + \phi)\right) + V_0 \cos(\omega t + \phi) = 0$$

$$-LC\omega^2 + 1 = 0$$

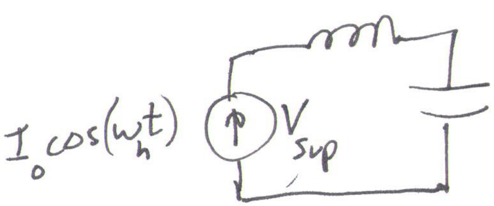
$$\omega_n = \frac{1}{\sqrt{LC}}$$





$$\omega_n = \frac{1}{\sqrt{LC}}$$

$$Z_{par} = \frac{\tilde{V}_0}{\tilde{I}} = \infty$$



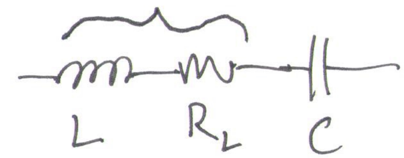
$I_0\cos(\omega t)$

$$\omega_n = \frac{1}{\sqrt{LC}}$$

$$V_{sup} = 0$$

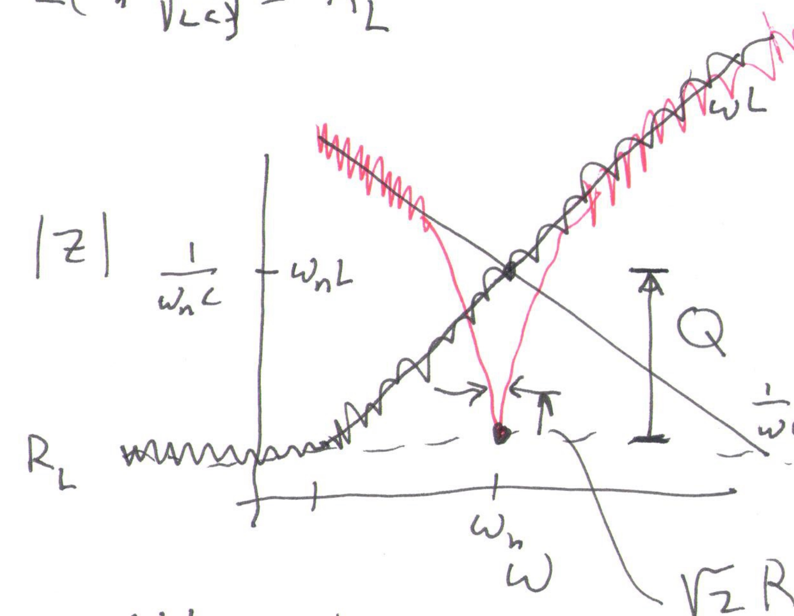
$$Z_{series} = \frac{\hat{V}_{sup}}{\bar{I}_0} = 0$$

Real inductors



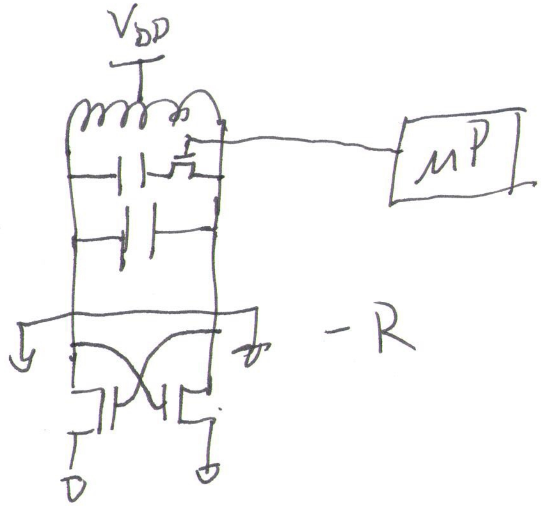
$$Z = j\omega L + R_L + \frac{1}{j\omega C}$$

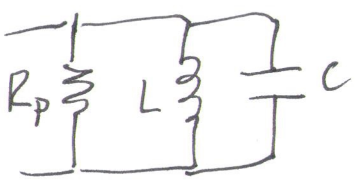
$$Z\left(\omega_n = \frac{1}{\sqrt{LC}}\right) = R_L$$



$$Q = \frac{\omega_n L}{R_L} = \frac{1}{\omega_n RC}$$

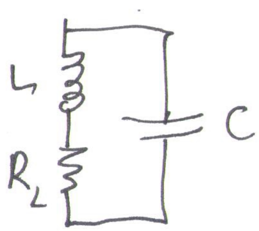
$$B = \frac{\omega_n}{Q}$$





$$Z = R_p \,\|\, \boxed{LC \text{ tank}}$$

$$Z\left(\omega_n = \frac{1}{\sqrt{LC}}\right) = R_p$$



$$j\omega L + R_L \,\|\, \frac{1}{j\omega C}$$

$$Z_{eq} = \frac{(j\omega L + R_L)}{j\omega C} \cdot \frac{1}{j\omega L + R_L + \frac{1}{j\omega C}}$$