

- 1a. $\omega \rightarrow 0: L \rightarrow \text{short}$ so gain=1. $\omega \rightarrow \infty: C \rightarrow \text{short}$ so gain=1. Passes low & high freqs.
 $0 < \omega < \infty: L||C$ can only get larger, so gain < 1. Gain has a minimum somewhere.
- 1b. Let $Z = j\omega L || \frac{1}{j\omega C} = \frac{(j\omega L)/(j\omega C)}{j\omega L + 1/(j\omega C)} = \frac{j\omega L}{1 - \omega^2 LC}$.
- $$H(j\omega) = \frac{V_O}{V_I} = \frac{R}{R+Z} = \frac{R(1-\omega^2 LC)}{R(1-\omega^2 LC) + j\omega L} = \frac{(j\omega)^2 + \frac{1}{LC}}{(j\omega)^2 + j\omega \frac{1}{RC} + \frac{1}{LC}}$$
- 1c. $|H(j\omega)| = 0$ (can't get smaller than that) at $\omega_o = 1/\sqrt{LC}$ (same as series RLC).
- 1d. $|H(j0)| = |H(j\infty)| = 1$ so $|H(j\omega)| = 1/\sqrt{2}$ at cutoff frequencies ω_{c1}, ω_{c2} .
 $|H(j\omega)| = 1/\sqrt{2}$ when $\pm \omega \frac{1}{RC} = \frac{1}{LC} - \omega^2 \rightarrow \omega_{c1}, \omega_{c2} = \pm \frac{1}{2RC} + \sqrt{\frac{1}{(2RC)^2} + \frac{1}{LC}}$.
- 1e. Bandwidth = $\omega_{c2} - \omega_{c1} = \frac{1}{RC}$. As before, $\omega_{c1} \approx \omega_o - \frac{1}{2RC}$; $\omega_{c2} \approx \omega_o + \frac{1}{2RC}$.
- 1f. $Q = \frac{\text{resonant freq}}{\text{bandwidth}} = \omega_o RC$ (same as parallel RLC circuit).

2a. $2\pi(50kHz) = \frac{1}{\sqrt{LC}} \rightarrow L = 1/[(100,000\pi)^2(0.1 \times 10^{-6})] = 101.3\mu H$.

2a. $8 = Q = \omega_o RC = 100,000\pi(0.1 \times 10^{-6})R \rightarrow R = \frac{800}{\pi} = 254.6\Omega$.

2c. $Q = \frac{\text{resonant freq}}{\text{bandwidth}} \rightarrow \text{Bandwidth} = \frac{50kHz}{8} = 6.25kHz$.

2b. $f_{c1} = 50 - \frac{6.25}{2} = 46.9kHz$. $f_{c2} = 50 + \frac{6.25}{2} = 53.1kHz$.

These differ from the exact answers using the square root by only 0.1kHz.

3a. $\frac{V_O}{V_I} = -\frac{Z_F}{Z_I}$ where $Z_I = R_1 + \frac{1}{j\omega C_1} = \frac{j\omega R_1 C_1 + 1}{j\omega C_1}$ and $Z_F = R_2 || \frac{1}{j\omega C_2} = \frac{R_2}{j\omega R_2 C_2 + 1}$.

3a. $H(j\omega) = -\frac{j\omega/(R_1 C_2)}{(j\omega + \frac{1}{R_1 C_1})(j\omega + \frac{1}{R_2 C_2})}$. Zero: origin. Poles: $\frac{1}{R_2 C_2}$; $\frac{1}{R_1 C_1}$.

3b. $H(j0) = 0$. Makes sense: $C_2 \rightarrow \text{open}$ vanishes; $C_1 \rightarrow \text{open} \rightarrow \text{gain}=0$.

3c. $H(j\infty) = 0$. Makes sense: $C_1 \rightarrow \text{short}$ vanishes; $C_2 \rightarrow \text{short} \rightarrow \text{gain}=0$.

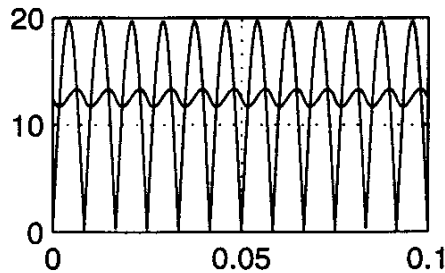
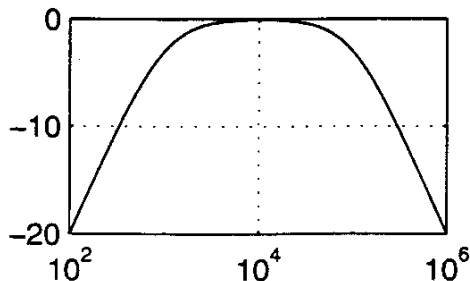
Bode: Zero: origin. Poles: $\frac{1}{R_2 C_2} = 10^3$; $\frac{1}{R_1 C_1} = 10^5$. $\omega \rightarrow 0: |H(j\omega)| \simeq |\frac{-10^5 j\omega}{10^3 10^5}| = \frac{\omega}{10^3}$.

4. $Q = \frac{\text{resonant freq}}{\text{bandwidth}} = \frac{100kr/s}{4r/s} = 25 = \frac{(100kr/s)L}{1000\Omega} \rightarrow L = 0.25H$
 $100,000 = \frac{1}{\sqrt{LC}} \rightarrow C = 10^{-10}/0.25 = 400pF$. At resonance, impedance=R=1000 Ω

5a. $V_I(t) = 12.54 - 25.08 \sum_{n=1}^{\infty} \frac{\cos(754nt)}{4n^2-1}$ where $\frac{2(19.7)}{\pi} = 12.54$ (from inside back cover).

5b. Pole: $\frac{1}{RC} = \frac{1}{2(0.00663)} = 75.4 \frac{\text{rad}}{\text{sec}} = 12Hz$. Gain = $\frac{1}{\sqrt{1+(\frac{f}{12})^2}}$. Phase = $-\tan^{-1} \frac{f}{12}$.

5c. $V_O(t) = 12.54 - 25.08 \sum_{n=1}^{\infty} \frac{\cos[754nt - \tan^{-1}(10n)]}{(4n^2-1)\sqrt{1+100n^2}}$ using $f = 120n \rightarrow \omega RC = \frac{120n}{12} = 10n$.



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W=logspace(2,6,1000); M=1:1000;
H(M)=20*log10(abs(W*100000./(j*W+1000).(j*W+100000)));
subplot(4,3,1),semilogx(W,H),grid on; T=linspace(0,0.1,1000);
VI(1:1000)=12.54*ones(1,1000); VO(1:1000)=12.54*ones(1,1000);
for N=1:100; VI=VI-25.08*cos(754*N*T)/(4*N*N-1);
VO=VO-25.08*cos(754*N*T)/(4*N*N-1)/sqrt(1+100*N*N);
end

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