RLC circuit, $R = 75\Omega$, $L = 20mH$, $f_0 = 4kHz$, $\omega_0 = 2\pi f_0$

(a) what is the capacitance?

$$\omega_0 = \frac{1}{\sqrt{LC}} \Rightarrow \omega_0^2 = \frac{1}{LC} \Rightarrow C = \frac{1}{L\omega_0^2} = \frac{1}{20mH\,(2\pi \times 4\times10^3\,rad/s)^2}$$

$$= \boxed{79nF}$$

(b) what is the impedance @ $\omega = \omega_0$?

$$Z = \sqrt{(75\Omega)^2 + \underbrace{\left((2\pi\times4\times10^3\,rad/s)\,20mH - \frac{1}{(2\pi\times4\times10^3\,rad/s)\,79nF}\right)^2}_{0\ (@\ \omega=\omega_0,\ X_L - X_C = 0)}}$$

$$= \boxed{75\Omega}$$

(c) what is the impedance @ $f = 3kHz$?

Same as above w/ $2\pi \times 4\times10^3\,rad/s \rightarrow 2\pi\times3\times10^3\,rad/s$

$Z = \boxed{303\Omega}$

#48 $Z(\omega_d) = \sqrt{R^2 + \left(\omega_d L - \frac{1}{\omega_d C}\right)^2}$, $\omega_0 = \frac{1}{\sqrt{LC}}$ ← what we want to get

$$Z(\omega_d) = \sqrt{R^2 + \omega_d^2 L^2 (1 - \omega_0^2/\omega_d^2)^2}$$ ← Starting with what we are given...

$$= \sqrt{R^2 + \omega_d^2 L^2 \left(1 - \frac{1}{LC\omega_d^2}\right)^2}$$ Substituting $\omega_0 = \frac{1}{\sqrt{LC}}$...

$$= \sqrt{R^2 + \left(\omega_d L - \frac{1}{\omega_d C}\right)^2}$$ ← rearrange, and they are equal!

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Note that for an RLC circuit $I_P = \frac{V_P}{Z}$ and at

resonance $I_{res} = \frac{V_P}{R}$, where I_{res} is the current in

the resistor. Therefore $\frac{I_P}{I_{res}} = \frac{R}{Z} = \frac{1}{\sqrt{1+\frac{(X_L-X_C)^2}{R^2}}}$

$$= \left(1 + \frac{L}{R^2C}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2\right)^{-1/2}$$

Since changing ω to $\frac{1}{\omega}$ in this equation does not change the result, then $\omega = \frac{1}{2}\omega_0$ and $\omega = 2\omega_0$ will give the same current, as stated.

(b) you were not asked to learn phasors
If I have time I will cover it in the review.

#53

Eqn 33-17 $P_{av} = V_{rms} I_{rms} \cos(\varphi) = 120V \times 4.6A \cos(25°) = \boxed{500W}$

#59

Transformers were not covered in lecture. Again, if there is time and interest, I will mention something in the review.

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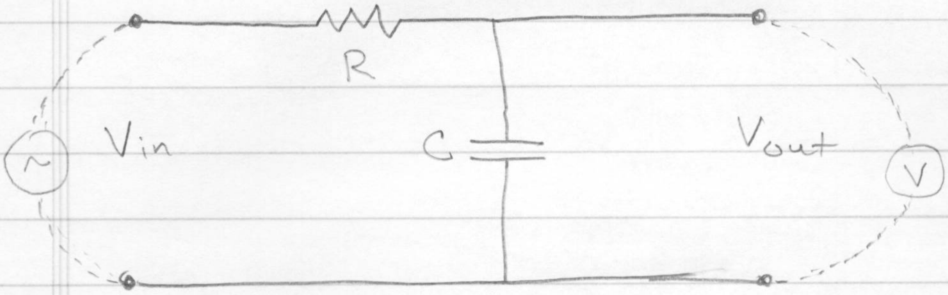
low pass filter



(a) Show that $V_{out} = \dfrac{V_{in}}{\sqrt{1+(RC\omega)^2}}$

By looking at what I have sketched into the diagram you can see that we are dealing with a series RC circuit. We can use our analysis of RLC circuits with $L=0$. Note also that $V_{out} = V_{capacitor}$.

$$I_P = \frac{V_P}{Z} = \frac{V_P}{\sqrt{R^2+(-X_C)^2}} \text{ , note } V_P = V_{in}$$

$$V_{out} = I_P X_C = \frac{V_{in}X_C}{\sqrt{R^2+X_C^2}} = \frac{V_{in}}{\sqrt{\frac{R^2}{X_C^2}+1}} = \boxed{\frac{V_{in}}{\sqrt{(R^2C^2\omega^2)+1}}}$$

(b) $$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{(R^2C^2\omega^2)+1}} \Rightarrow R^2C^2\omega^2 = 1 \Rightarrow \boxed{\omega = \frac{1}{RC}}$$