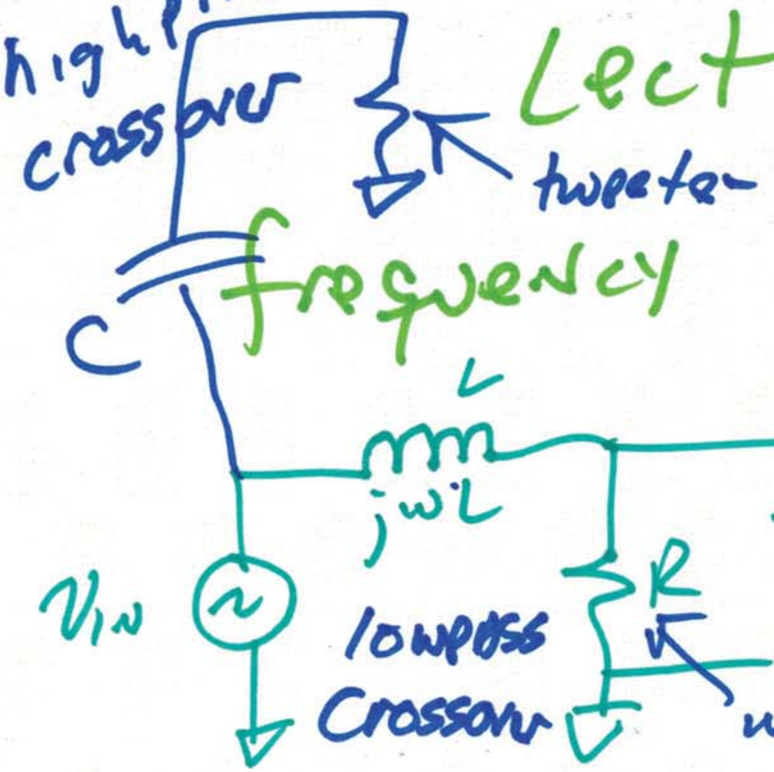
EE 221 circuits II

MARCH 6, 2019

Lecture 12

frequency response examples



$$v_{OUT} = v_{IN} \cdot \frac{R}{R + j\omega L}$$

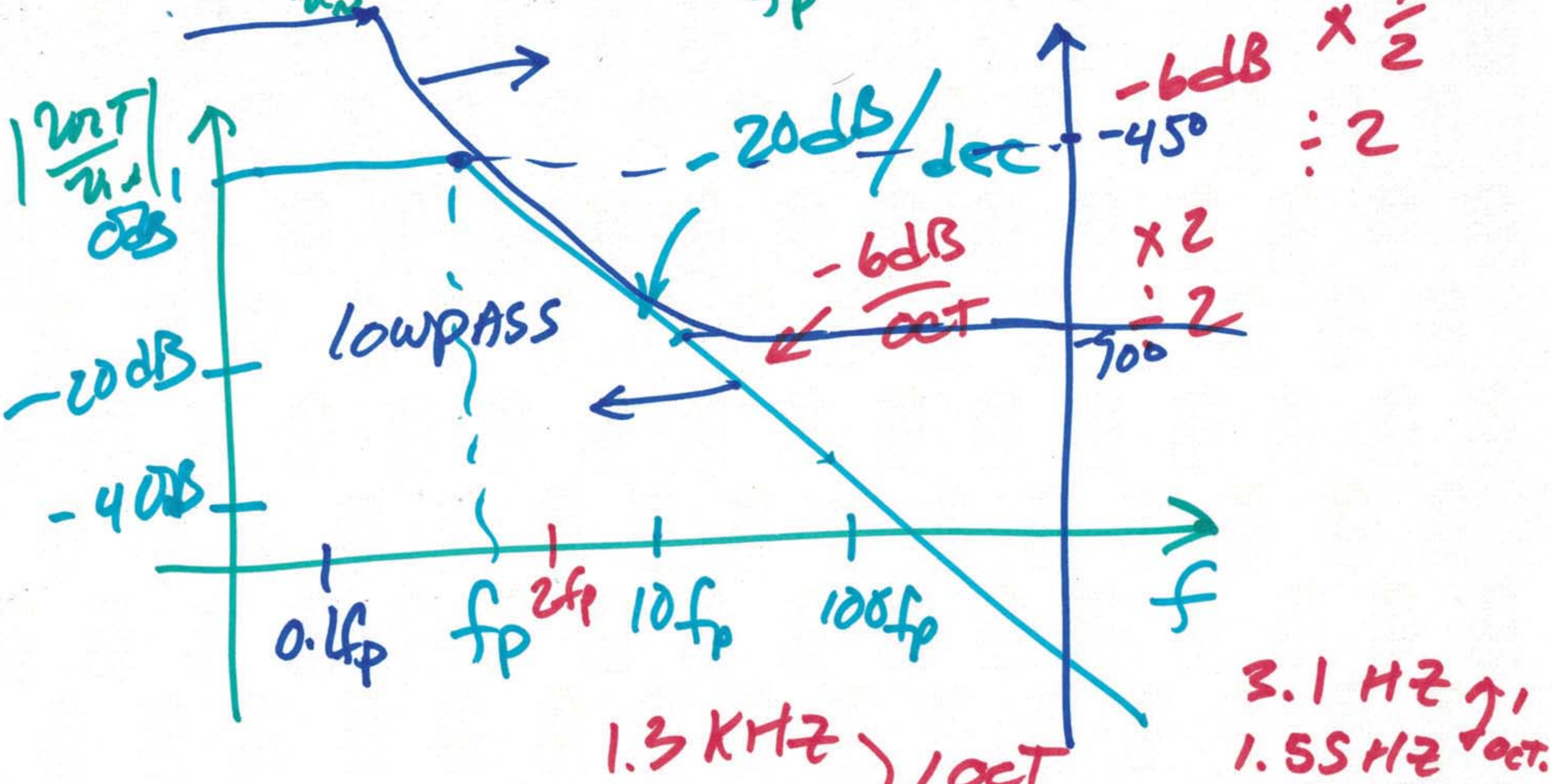
$$\frac{v_{OUT}}{v_{IN}} = \frac{1}{1 + j\omega \frac{L}{R}}$$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{1}{\sqrt{1 (2\pi f \cdot L/R)^2}} = \frac{1}{\sqrt{1 + \left(\frac{f}{f_p}\right)^2}} \quad f_p = \frac{1}{2\pi L/R}$$

1) $\angle \frac{v_{OUT}}{v_{IN}} = -\tan^{-1} \frac{f}{f_p}$

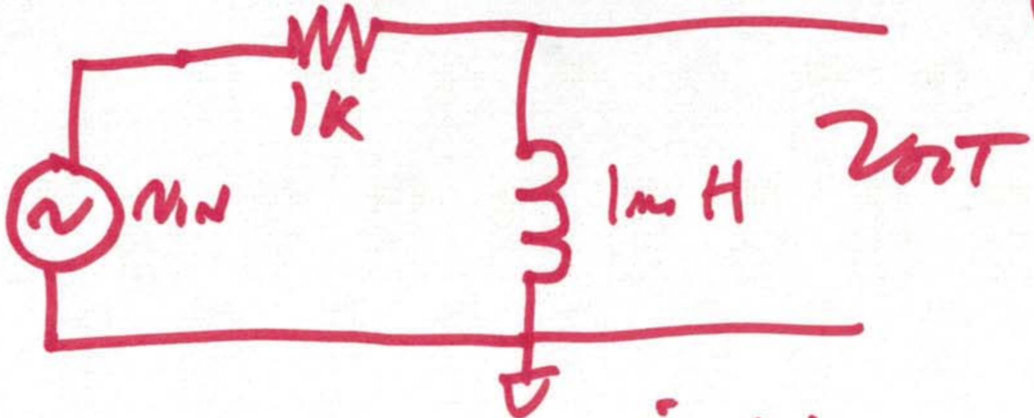
$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_p}\right)^2}} \qquad f_p = \frac{1}{2\pi L/R}$$

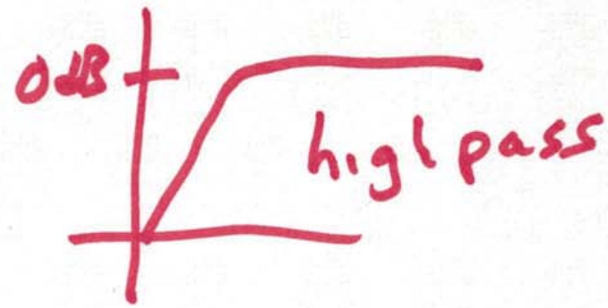
$$\angle \frac{v_{out}}{v_{in}} = -\tan^{-1}\frac{f}{f_p}$$



2.6 KHZ

plot Bode responses





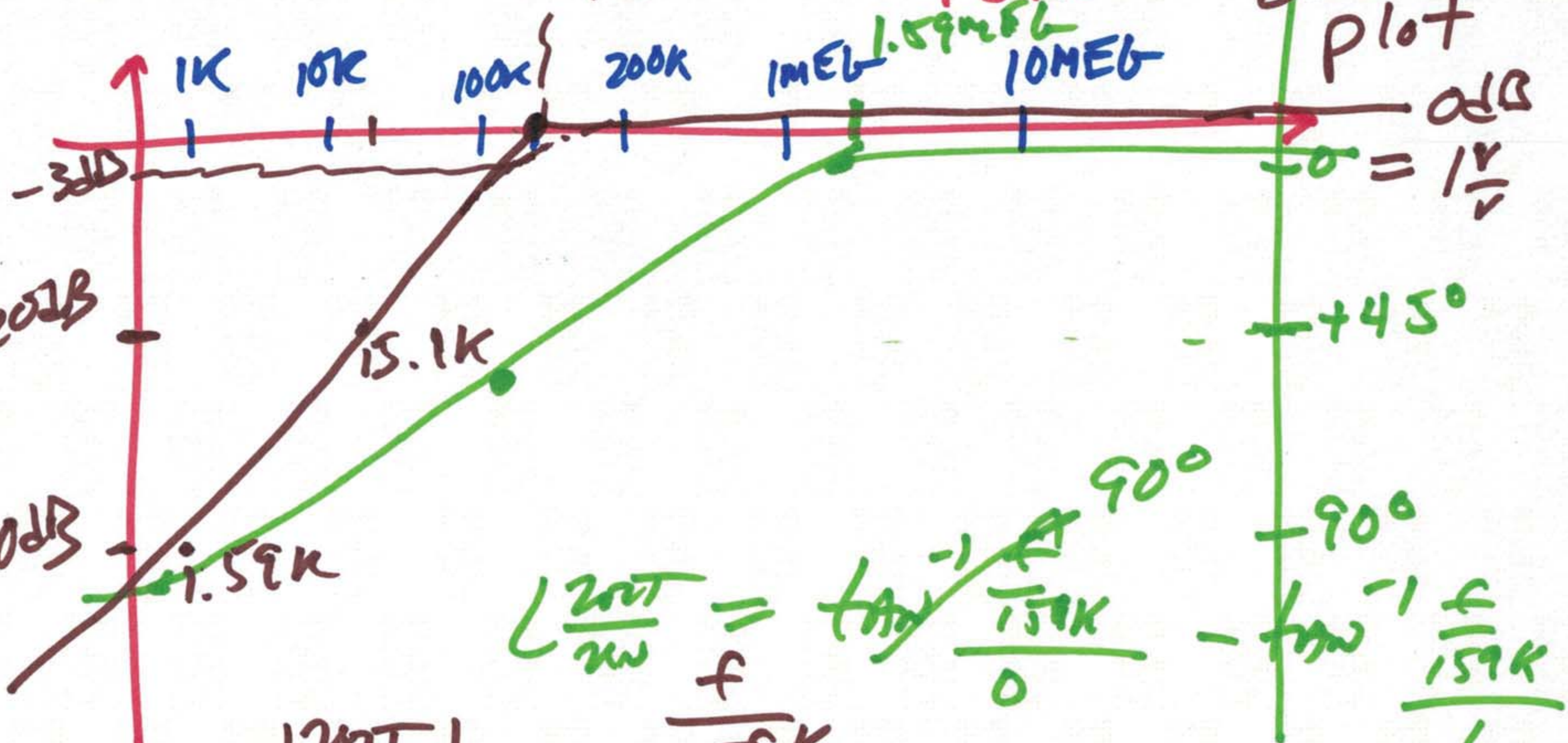
$$v_{out} = v_{in} \cdot \frac{j\omega L}{j\omega L + R}$$

$$\frac{v_{out}}{v_{in}} = \frac{j \cdot 2\pi \cdot f \cdot 10^{-3}}{j \cdot 2\pi \cdot f \cdot 10^{-3} + 10^{3}}$$

$$\frac{v_{out}}{v_{in}} = \frac{0 + j \cdot f \cdot 2\pi \cdot 10^{-6}}{1 + j \cdot f \cdot 2\pi \cdot 10^{-6}}$$

$$\frac{v_{OUT}}{v_{IN}} = \frac{0 + j\frac{f}{159K}}{1 + j\frac{f}{159K}}$$

Bode plot



$$\angle\frac{v_{OUT}}{v_{IN}} = \tan^{-1}\frac{\frac{f}{159K}}{0} \rightarrow 90^\circ - \tan^{-1}\frac{\frac{f}{159K}}{1}$$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{\frac{f}{159K}}{\sqrt{1 + \left(\frac{f}{159K}\right)^2}}$$

4)

$v_{IN} = 3(\sin 2\pi \cdot 40k \cdot t)$

$f = 40\ \text{KHz}$

$\left|\frac{v_{OUT}}{v_{IN}}\right| = -12\ \text{dB}$

$\angle \frac{v_{OUT}}{v_{IN}} = +75°$

$-12\,\text{dB} = 20 \log\left|\frac{v_{OUT}}{v_{IN}}\right|$

$\frac{v_{OUT}}{v_{IN}} = 10^{-12/20} = \frac{1}{4}$

$v_{OUT} = \frac{3}{4} \sin(2\pi \cdot 40k \cdot t + 75°)$

$-20\,\text{dB} = \frac{1}{10}$

$-14\,\text{dB} = \frac{1}{5}$

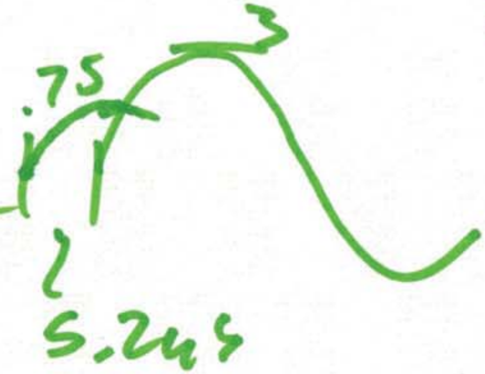
$-12 = \frac{1}{4}$

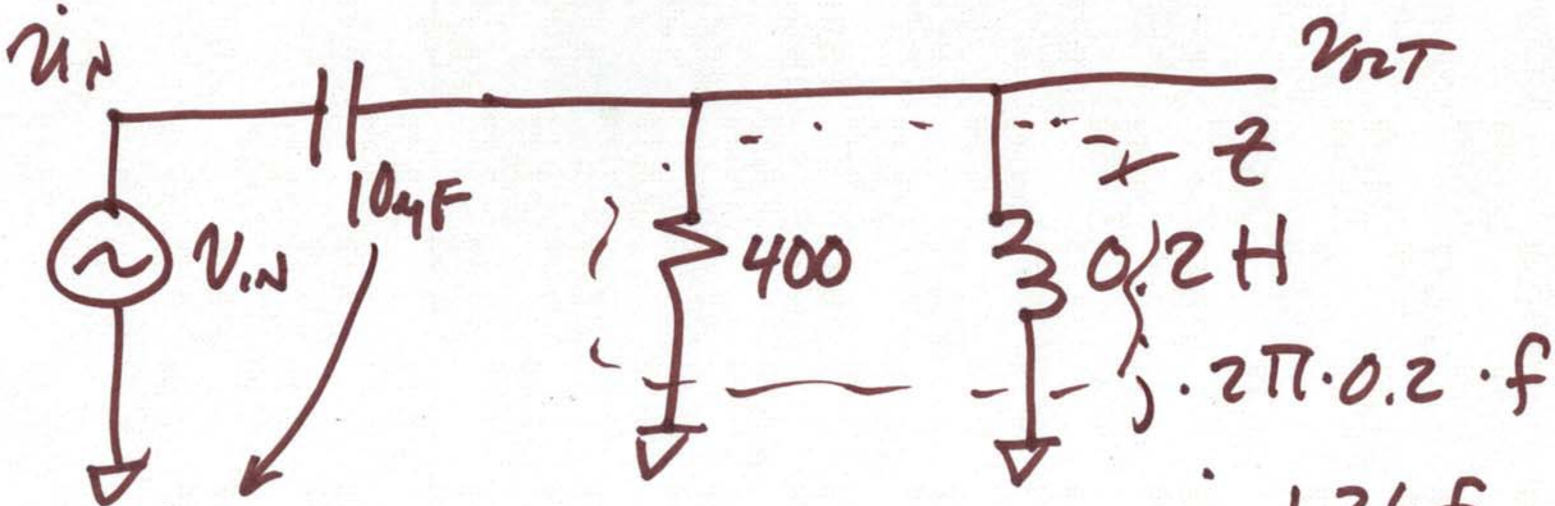
$-6 = \frac{1}{2}$

$-3 = \frac{1}{\sqrt{2}} = 0.707 \approx \frac{\sqrt{2}}{2}$

$75 = \frac{t_d}{T} \cdot 360 = t_d \cdot 360 \cdot 40k$

$t_d = \frac{75}{360 \cdot 40k} = \underline{\underline{5.2\,\mu s}}$





$$\frac{-j}{2\pi\cdot 10^{-5}\cdot f} \qquad -j\,\frac{15.9k}{f}$$

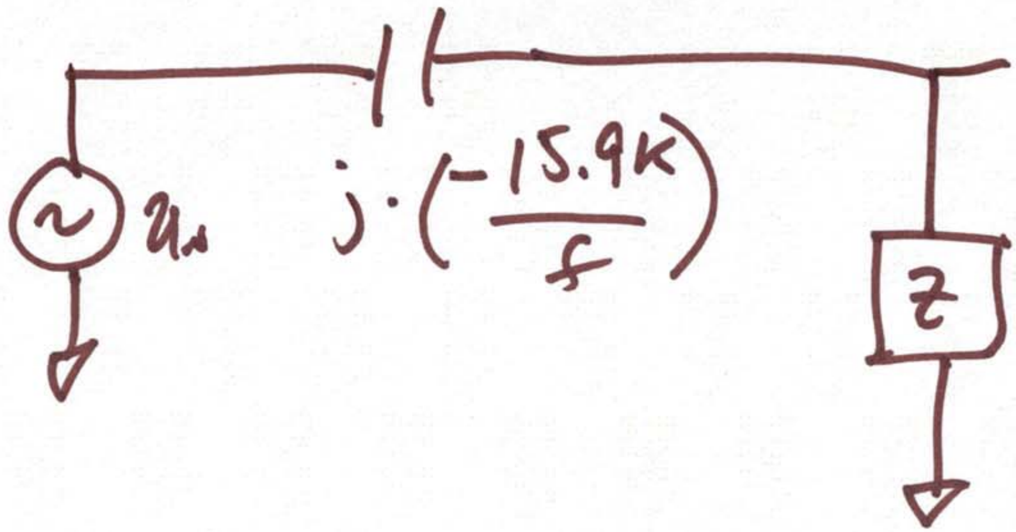
$$j\cdot 1.26f$$

$$Z = \frac{400\cdot j\cdot 1.26f}{400 + j\cdot 1.26f}$$

$$= \frac{400\angle 0^\circ \cdot 1.26f\angle 90^\circ}{400 + j1.26f}$$

$$\frac{502.4\overset{0}{\cos 90} + j\,502.4f\overset{1}{\sin 90^\circ}}{400 + j1.26f} = \frac{502.4f\angle 90^\circ}{400 + j1.26f}$$

$$(400+j0)(0+j1.26f)$$



$$\frac{j\cdot 502.4f}{400+j\,1.26f}$$

$$\frac{v_{OUT}}{v_{IN}} = \frac{\dfrac{j\cdot 502.4f}{\cancel{400+j1.26f}}}{\dfrac{j\,502.4f}{\cancel{400+j1.26f}} + j\left(\dfrac{15.9K}{\cancel{f}}\right)\cdot(400+j1.26f)}$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{j\,502.4f}{j\,502.4f + j\,\frac{6.36\cdot 10^6}{f} - 20k}$$

$$j\,\frac{15.9k}{f}\cdot\left(400 + j\,1.26f\right) \quad ? \quad \sqrt{(20k)^2 + \frac{(6.36\cdot 10^6)^2}{f^2}}$$

$$\frac{1.59k}{f}\angle 90^\circ \cdot \sqrt{(400)^2 + (1.26f)^2}\cdot\angle \tan^{-1}\frac{1.26f}{400}$$

$$\frac{1.59k}{f}\cdot\sqrt{(400)^2 + (1.26f)^2}\;\angle 90 + \tan^{-1}\frac{1.26f}{400}$$

4×10^{11}

$\cancel{637k}$

$$\sqrt{\frac{160k\,(1.59k)^2}{f^2} + \frac{(1.26)^2}{(1.59k)^2}}$$

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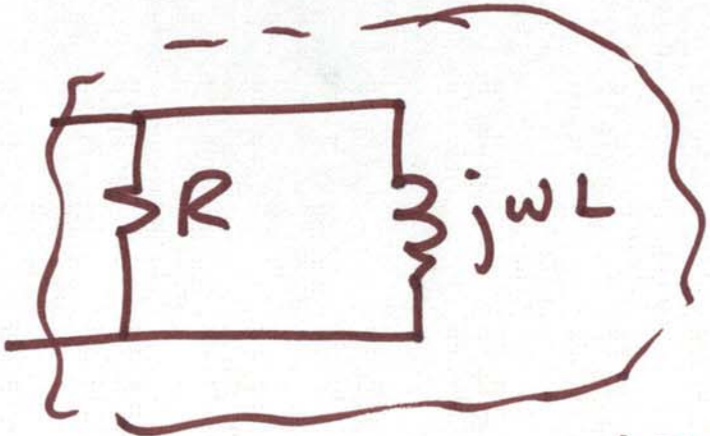
8)



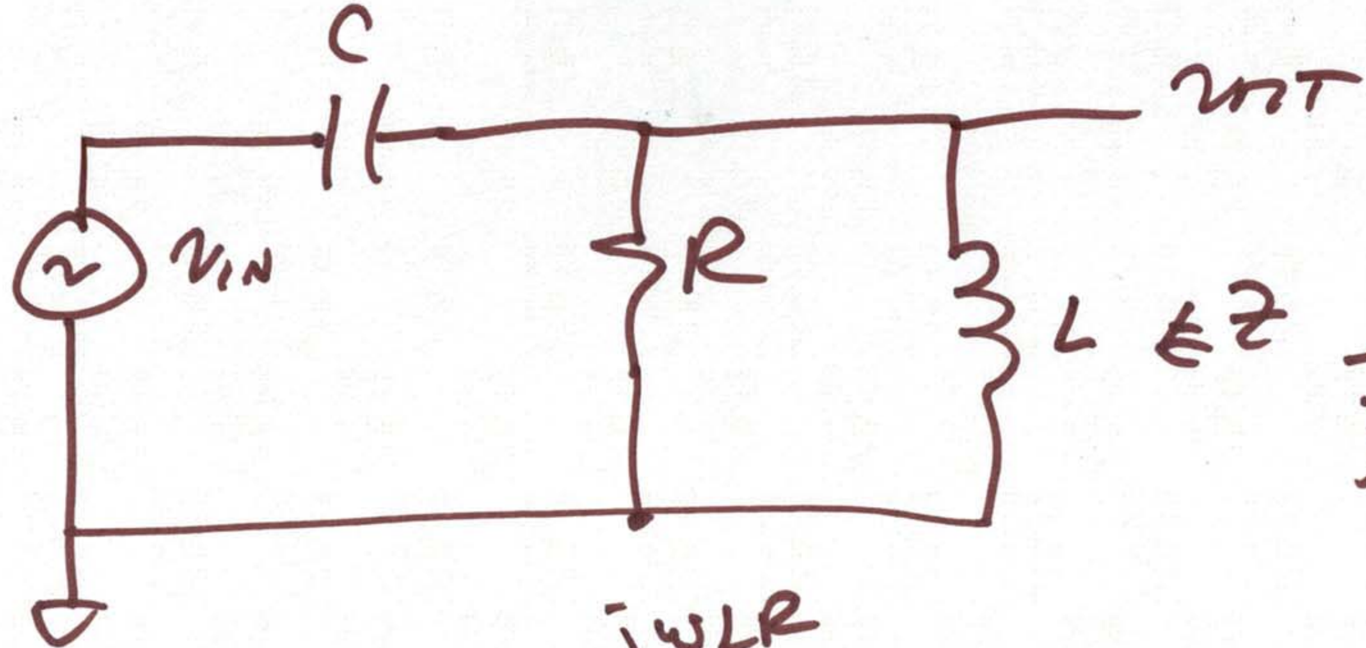
$$Z = \frac{j\omega L \cdot R}{R + j\omega LR}$$

$$|Z| = \frac{\omega L \cdot R}{\sqrt{R^2 + (\omega LR)^2}}$$

$$\frac{\omega LR \angle 90^\circ}{\sqrt{R^2 + (\omega LR)^2} \angle \tan^{-1} \frac{\omega L\cancel{R}}{\cancel{R}}}$$

$$\angle Z = 90 - \tan^{-1} \frac{\omega LR}{\cancel{R}}$$

yes!



$\Leftarrow Z \quad \dfrac{j\omega LR}{j\omega L + R}$

$$\frac{v_{OUT}}{v_{IN}} = \frac{\dfrac{j\omega LR}{j\omega L + R}}{\dfrac{j\omega LR}{j\omega LR + R} + \dfrac{1}{j\omega C}} = \frac{j\omega LR}{j\omega LR + \dfrac{j\omega LR + R}{j\omega C}}$$

$$\frac{v_{OUT}}{v_{IN}} = \frac{-\omega^2 LRC}{j\omega LR + R + \cancel{s}(-\omega^2 LRC)}$$

$$\frac{v_{OUT}}{v_{IN}} = \frac{-\omega^2 LRC + j0}{(R - \omega^2 LRC) + j\omega LR}$$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{\sqrt{(\omega^2 LRC)^2 + 0^2}}{\sqrt{(R-\omega^2 LRC)^2 + (\omega LR)^2}}$$

$$\angle\frac{v_{OUT}}{v_{IN}} = 180^\circ - \tan^{-1}\frac{\omega LR}{R-\omega^2 LRC}$$

$L = 0.2$ $\quad \omega LR = f \cdot 2\pi \cdot 400 = 2512 f$

$C = 10\mu$ $\quad \omega^2 LRC = f^2 \cdot (2\pi)^2 \cdot 400 \cdot 10\mu = 0.158 f^2$

$R = 400$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{f \cdot 0.4}{}$$