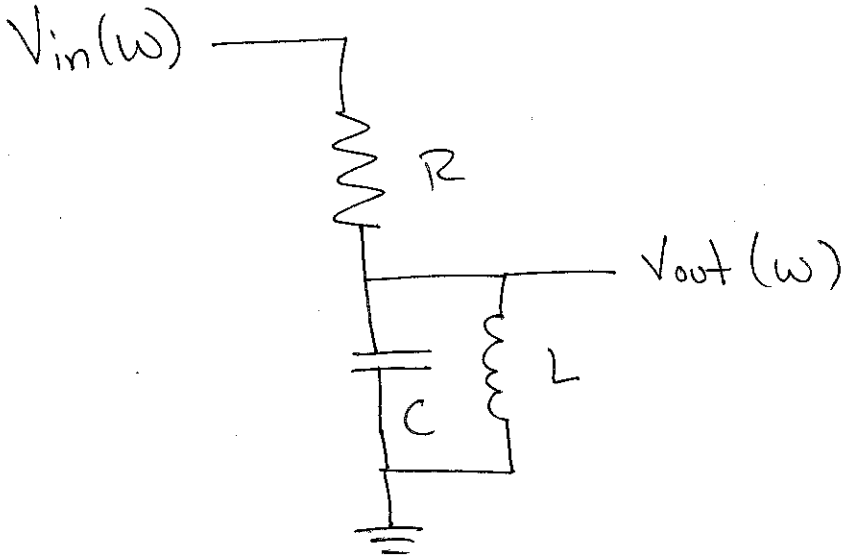
3-4



$$V_{out} = \frac{Z_2}{Z_1 + Z_2} V_{in}$$

$$Z_1 = R$$

$$Z_2 = Z_C \parallel Z_L$$

$$= \frac{Z_C Z_L}{Z_C + Z_L} \quad \text{where } Z_C = \frac{1}{i\omega C}$$

$$Z_L = i\omega L$$

$$Z_2 = \frac{\left(\frac{i\omega L}{i\omega C}\right)}{\frac{i}{i}\cdot\frac{1}{i\omega C} + i\omega L} = \frac{(L/C)}{i(\omega L - 1/\omega C)}$$

$$V_{out} = V_{in}\left(\frac{\frac{L/C}{i(\omega L - 1/\omega C)}}{R + \frac{L/C}{i(\omega L - 1/\omega C)}}\right) \cdot \frac{i(\omega L - 1/\omega C)}{i(\omega L - 1/\omega C)}$$

$$= \frac{LC^{-1}}{LC^{-1} + i(\omega L - 1/\omega C)R} \cdot \frac{LC^{-1} - i(\omega L - 1/\omega C)R}{LC^{-1} - i(\omega L - 1/\omega C)R}$$

$$V_{out} = V_{in} \frac{(LC^{-1})^2 - i(\omega L - 1/\omega C) LC^{-1} R}{(LC^{-1})^2 + (\omega L - 1/\omega C)^2 R^2}$$

$$= a + ib$$

$$|V_{out}| = \sqrt{a^2 + b^2} = \frac{\left[(LC^{-1})^4 + (\omega L - 1/\omega C)^2 (LC^{-1} R)^2\right]^{1/2}}{(LC^{-1})^2 + (\omega L - 1/\omega C)^2 R^2}$$

$$\tan\phi = b/a$$

$$\phi = \tan^{-1}\left(\frac{-(\omega L - 1/\omega C) LC^{-1} R}{(LC^{-1})^2} \right)$$

$$= \tan^{-1}\left(\frac{-(\omega L - 1/\omega C) R}{LC^{-1}} \right)$$

$$\phi = \tan^{-1}\left(\frac{RC(1/\omega C - \omega L)}{L} \right)$$

$L = 10\,\mu H$

$C = 1\,\mu F$

$R = 1\,K\Omega$

$R := 1000:$

$C := 10^{-6}:$

$L := 10 \cdot 10^{-6}:$

$evalf\left(\omega_0 = (L \cdot C)^{-\frac{1}{2}}\right);$

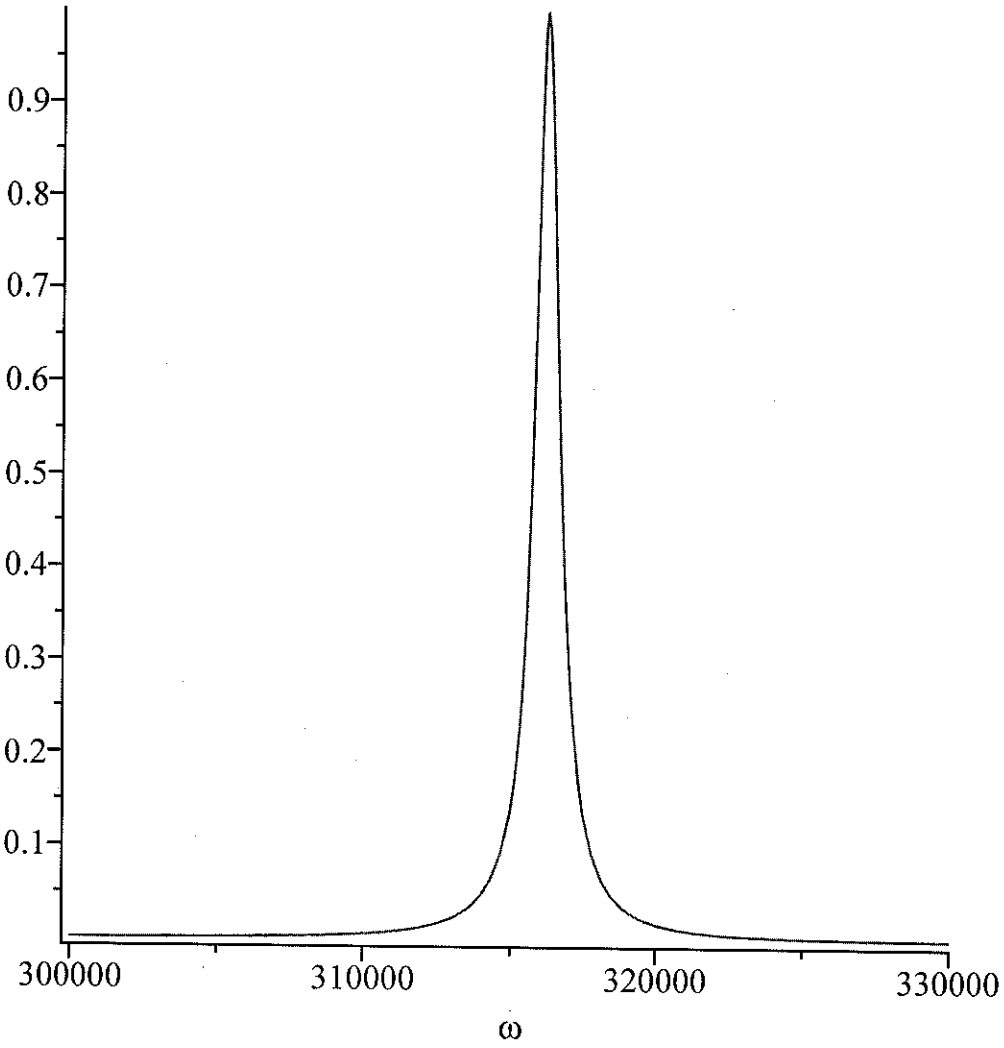
$$\omega_0 = 3.162277660\ 10^5 \tag{1}$$

$$Vout := \frac{\left(\left(\frac{L}{C}\right)^4 + \left(\omega \cdot L - \frac{1}{\omega \cdot C}\right)^2 \left(\frac{L \cdot R}{C}\right)^2\right)^{\frac{1}{2}}}{\left(\frac{L}{C}\right)^2 + \left(\omega \cdot L - \frac{1}{\omega \cdot C}\right)^2 R^2}:$$

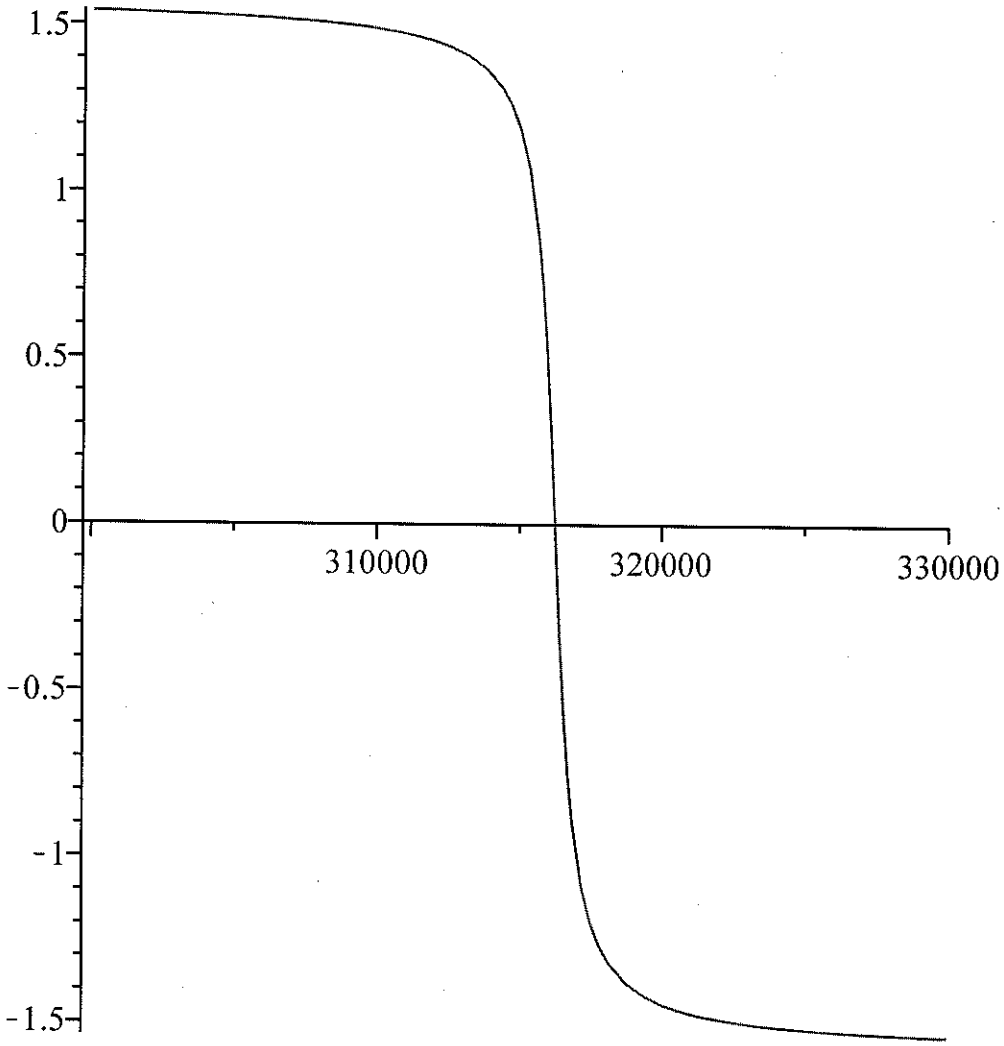
$$phase := \arctan\left(\frac{R \cdot C \cdot \left(\frac{1}{\omega \cdot C} - \omega \cdot L\right)}{L}\right):$$

$with(plots):$

$plot([Vout], \omega = 300000..330000);$



$plot(phase, \omega = 300000..330000);$


1.5
1
0.5
0
-0.5
-1
-1.5
310000
320000
330000