

Last Name, First Name

Student No.

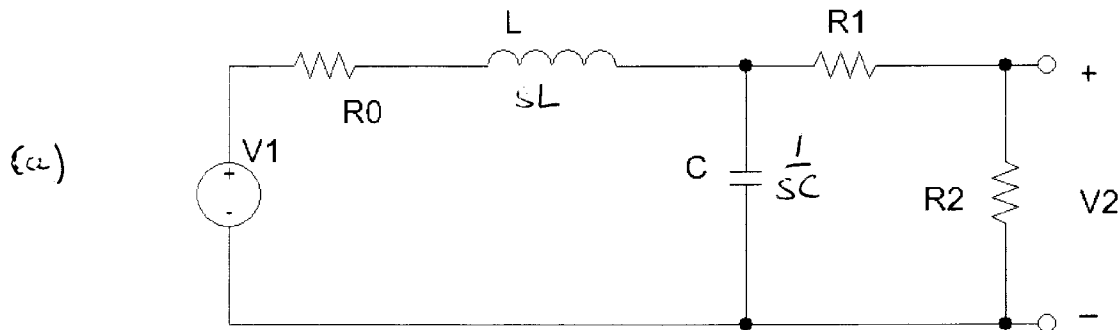
Check your tutorial section (REQUIRED!):

TUT0101	TUT0102	TUT0103	TUT0104	TUT0105	TUT0106	TUT0107	TUT0108
Thu. 9 am	Thu. 9 am	Thu. 9 am	Thu. 9 am	Mon. 10am	Mon. 10am	Mon. 3 pm	Mon. 3 pm
BA2165	BA2155	BA2145	BA2195	BA2145	BA2165	BA2145	HA410
Claudia	Ahmadreza	Hugo	Isaac	Shuo	Ashwin	Shuo	Farid

University of Toronto
Department of Electrical & Computer Engineering
ECE212F – Circuit Theory
Quiz 3 – November 21, 2002, 10:00-11:00 AM

Instructions: Non-programmable calculators allowed. No other aids. Answer in the space provided on these sheets. The back sides of these sheets can be used as well. For full marks (25) you must show methods, state UNITS and compute numerical answers when requested. *Please write in pen, NOT IN PENCIL! Quizzes written in pencil can not be considered for mark revision.*

1. **Network Functions.** In the circuit below $R_0=10\text{k}\Omega$, $R_1=R_2=5\text{k}\Omega$, $L=0.1\text{mH}$, and $C=1\mu\text{F}$.
- Transform the circuit into the s-domain. (1 mark)
 - Find the driving-point impedance $Z(s)$ and the transfer function $T(s)=V_2(s)/V_1(s)$. (6 marks)
 - Find all poles and zeroes of $T(s)$ and $Z(s)$. (3 marks)
 - For $v_1(t)=10\cos(100t)$ find $v_2(t)$. (3 marks)



$$\begin{aligned} (b) \quad Z(s) &= R_0 + sL + \frac{1}{sC + \frac{1}{R_1 + R_2}} \\ &= L \frac{s^2 + s \left(\frac{R_0}{L} + \frac{1}{C(R_1 + R_2)} \right) + \frac{R_0}{LC(R_1 + R_2)} + \frac{1}{LC}}{s + \frac{1}{C(R_1 + R_2)}} \\ &= 10^{-4} \frac{(s + 200,000.2)(s + 0.9999 \cdot 10^8)}{s + 100} \end{aligned}$$

$$T(s) = \frac{R_2}{R_2 + R_1} \left(\frac{\frac{1}{sC + \frac{1}{R_1 + R_2}}}{\frac{1}{sC + \frac{1}{R_1 + R_2}} + R_0 + sL} \right)$$

$$= \frac{R_2}{R_2 + R_1} \frac{1}{LC \left(s + \frac{R_0}{L} \right) \left(s + \frac{1}{C(R_1 + R_2)} \right) + 1}$$

$$= \frac{5 \cdot 10^7}{(s + 0.9999 \cdot 10^8)(s + 200.0002)}$$

(c) $T(s)$: poles: $-0.9999 \cdot 10^8, -200.0002$

zeros: none

$Z(s)$: poles: $s = -100$

zeros: $-0.9999 \cdot 10^8, -200.0002$

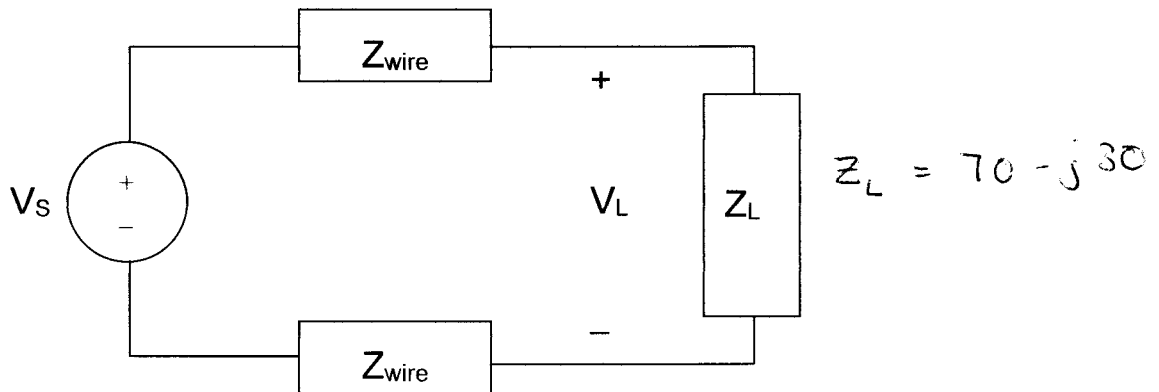
(d) $T(j \cdot 100) = 0.19998 - j 0.1000$

$|T(j\omega)| = 0.2236 \quad \Theta(\omega) = -26.57^\circ$

$v_2(t) = 2.236 \cos(100t - 26.57^\circ)$

2. Power in the sinusoidal steady state. The load in the circuit below consists of a 70Ω resistor in series with a capacitor that has a reactance of 30Ω . The wires have an impedance of $Z_{\text{wire}} = 1 + j10\Omega$. The load draws 1.5 A (rms) at 60 Hz .

- (a) Find the rms source voltage. (2 marks)
 (b) Find the complex, average, reactive, and apparent power absorbed by the load, and the power factor. (4 marks)
 (c) Find the complex power supplied by the source. (2 marks)
 (d) Calculate the transmission efficiency. (2 marks)
 (e) Which reactive component would have to be added to the load to produce an overall power factor of 0.95? (2 marks)



$$(a) V_s^{\text{rms}} = |I_{\text{rms}} (Z_L + 2Z_{\text{wire}})| = |1.5 (70 - j30 + 2(1 + j10))| = |1.5 (72 - j10)| = 109.04 \text{ [V]}$$

$$(b) S_L = Z_L \cdot I_{\text{rms}}^2 = 157.5 - j67.5$$

\uparrow average power \uparrow reactive power

$$|S_L| = 171.355 \text{ [VA]} \rightarrow \text{pf} = 0.9192, \text{ leading}$$

$$(c) S_s = V_s \bar{I}^* = 162 - j13.50$$

$$(d) \eta = \frac{\text{Re}(S_L)}{\text{Re}(S_s)} \cdot 100 = 97.22\%$$

$$(e) Q_{\text{total}} = Q_L + Q_x = \frac{P_L \sqrt{1 - 0.95^2}}{0.95} = 51.77 = X_{\text{total}} \cdot \bar{I}_{\text{rms}}^2$$

$$X_{\text{total}} = \pm 23.008 = -30 + X$$

$$\Rightarrow X = 53.009, 6.99$$

$$\Rightarrow L = 0.141 \text{ H, } 18.5 \text{ mH}$$

lagging leading