Questions:

Circuit Analysis: Phasor Math

What is admittance?

How do bridge circuits behave with complex impedances?

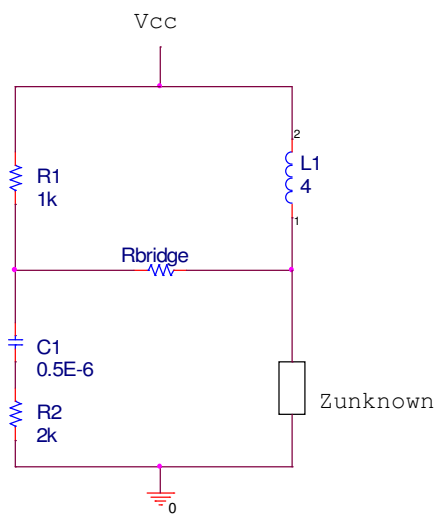
How does the total impedance of a series RLC circuit behave with frequency?

How does the total impedance of a parallel RLC circuit behave with frequency?

Complex Power

a. What is instantaneous power?
b. What is real power?
c. What is reactive power?
d. What is total power?
e. What is rms voltage? rms current?
f. How do we determine total power produced by a source?
g. What is the power factor?
h. What does it mean if the power factor is 'leading'? 'lagging'?

1) Bridge circuits



a) What value of Zunknown balances the bridge (no current through R3) when ω=1000 rad/s?

$C_1 := 0.5 \cdot 10^{-6} F \qquad R_1 := 1k\Omega \qquad R_2 := 2k\Omega \qquad L_1 := 4H$

$\omega_1 := 1000 \frac{rad}{s}$

$$Z_u = \frac{(Z_{C1} + Z_{R2}) \cdot Z_{L1}}{Z_{R1}}$$

$$\frac{\left(\frac{1}{j\omega C_1} + R2\right) \cdot j\omega L_1}{R_1}$$

$$\left(\omega_1 \cdot C_1\right)^{-1} = 2 \times 10^3\,\Omega \qquad \omega_1 \cdot L_1 = 4 \times 10^3\,\Omega$$

$$\frac{\left(-2j \cdot 10^3 + 2 \cdot 10^3\right) \cdot 4j \cdot 10^3}{1 \times 10^3} = 8 \times 10^3 + 8i \times 10^3 \qquad 8k + 8kj$$

b) What component combination would balance the bridge?

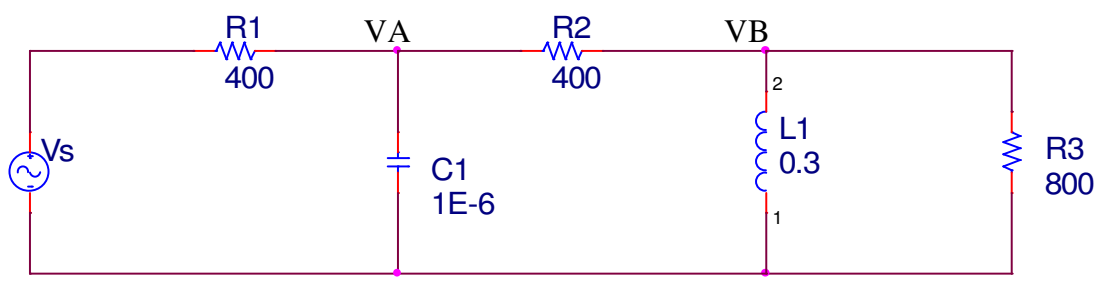
An 8k resistor and 8 H inductor

2) Phasor KCL/KVL

The source in the above circuit is 20cos(2000t)

$$Z2_{R1} := 400\Omega \qquad Z2_{R2} := 400\Omega \qquad Z2_{R3} := 800\Omega \qquad Z2_{C1} := -500j\Omega \qquad Z_{L1} := 600j\Omega$$

$$Z2_{C1} = \frac{-j}{2000 \cdot 1 \cdot 10^{-6}} \qquad Z_{L1} = j \cdot 2000 \cdot 0.3$$



a. Determine the voltage across the capacitor using node analysis.

Find VA

At VA:

$$\frac{V_A - V_s}{Z2_{R1}} + \frac{V_A}{Z2_{C1}} + \frac{V_A - V_B}{Z2_{R2}} = 0$$

$$\frac{V_A}{400} + \frac{V_A}{-500j} + \frac{V_A}{400} - \frac{V_B}{400} = \frac{20}{400}$$

(1) $$V_A\left(\frac{1}{400}+\frac{1}{-j\cdot 500}+\frac{1}{400}\right)+V_B\left(\frac{-1}{400}\right)=\frac{20}{400}$$

At VB:

$$\frac{V_B-V_A}{Z2_{R2}}+\frac{V_B}{Z2_{L1}}+\frac{V_B}{Z2_{R3}}=0$$

(2) $$V_A\left(\frac{-1}{400}\right)+V_B\left(\frac{1}{400}+\frac{1}{j600}+\frac{1}{800}\right)=0$$

$$M:=\begin{bmatrix}\left(\frac{1}{400}+\frac{-1}{500j}+\frac{1}{400}\right) & \left(\frac{-1}{400}\right)\\ \left(\frac{-1}{400}\right) & \left(\frac{1}{400}+\frac{1}{600j}+\frac{1}{800}\right)\end{bmatrix}$$

$$C_2:=\begin{pmatrix}\frac{20}{400}\\ 0\end{pmatrix}$$

$$M^{-1}\cdot C_2=\begin{pmatrix}12.086-4.627i\\ 7.873+0.414i\end{pmatrix}$$

$$V_A=12.086-4.627j$$

$$\sqrt{12.086^2+(-4.627)^2}=12.941$$

$$\operatorname{atan}\left(\frac{-4.627}{12.086}\right)=-20.949\cdot deg$$

$$V_A=12.94<-20.95deg$$

b. Determine the voltage across the capacitor using mesh analysis.

Loop 1: $$Z2_{R1}\cdot i_1+Z2_{C1}\cdot(i_1-i_2)-V_S=0$$

$$(400-500j)\cdot i_1+500j\cdot i_2=20$$

Loop 2: $$Z2_{R2}\cdot i_2+Z2_{L1}\cdot(i_2-i_3)+Z2_{C1}\cdot(i_2-i_1)=0$$

$$500j\cdot i_1+[400+(600j-500j)]\cdot i_2-600j\cdot i_3=0$$

Loop 3: $$Z2_{R3}\cdot i_3+Z2_{L1}\cdot(i_3-i_2)=0$$

$$-600j \cdot i_2 + (800 + 600j) \cdot i_3 = 0$$

$$M_2 := \begin{bmatrix} 400 - 500j & 500j & 0 \\ 500j & 400 + 100j & -600j \\ 0 & -600j & (800 + 600j) \end{bmatrix}$$

$$C_3 := \begin{pmatrix} 20 \\ 0 \\ 0 \end{pmatrix}$$

$$M_2^{-1} \cdot C_3 = \begin{pmatrix} 0.0198 + 0.0116i \\ 0.0105 - 0.0126i \\ 0.0098 + 0.0005i \end{pmatrix}$$

$$i_1 := 0.0198 + 0.0116i$$

$$i_2 := 0.0105 - 0.0126i$$

$$V_{C1} := Z2_{C1} \cdot (i_1 - i_2)$$

$$V_{C1} = (12.1 - 4.65i)\,\Omega$$

$$\sqrt{(12.1)^2 + (-4.65)^2} = 12.963$$

$$\operatorname{atan}\left(\frac{-4.65}{12.1}\right) = -21.022 \cdot \text{deg}$$