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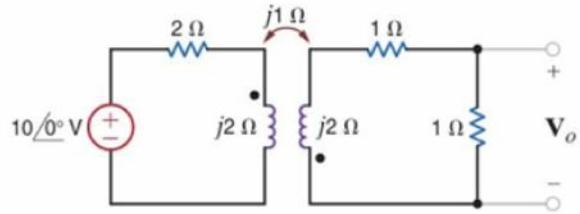
ECE 2322
04/06/2013

Reworked Exam 3

1. Find V_o in polar form (magnitude and phase).



In order to solve the current circuit, loop currents were defined in each mesh. Figure 1.1 shows the defined currents.

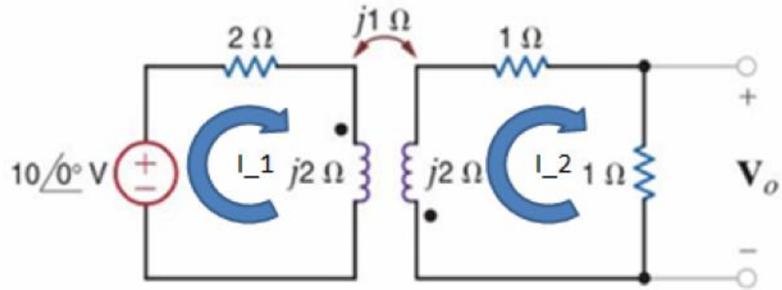


Figure 1.1

Applying KVL across the first mesh, the following expression is obtained:

$$-10 + 2I_1 + j2I_1 + j1I_2 = 0$$

This equation can be simplified as follows:

$$(2 + j2)I_1 + j1I_2 = 10$$

Solving for I_1,

$I_1 = \frac{10 - j1I_2}{2 + j2}$……………………………………………………………………………….(1)

Applying KVL around the second mesh, the following expression can be obtained:

$$j2I_2 + 2I_2 + j1I_1 = 0$$

Or $(2 + j2)I_2 + j1I_1 = 0$…………………………………………………………………(2)

By substituting equation (1) into equation (2), it can be said that:

$$(2 + j2)I_2 + j1\frac{(10 - j1I_2)}{2 + j2} = 0$$

Then, I_2 can be factored out and solved. Then, I_2 would be:

$I_2 = 1.24 < -172.87^{\circ}\text{A}$

The output voltage can then be calculated with Ohm's Law as follows:

$$V_o = IR$$

$$V_o = 1.24 < -172.87^{\circ} A(1\Omega) \text{ or}$$

$$V_o = 1.24 < -172.87V$$

The obtained solution was confirmed by simulating the circuit in Multisim and doing a single frequency AC analysis. Figure 1.2 shows the circuit build in Multisim, while Figure 1.3 shows the result for the Analysis.

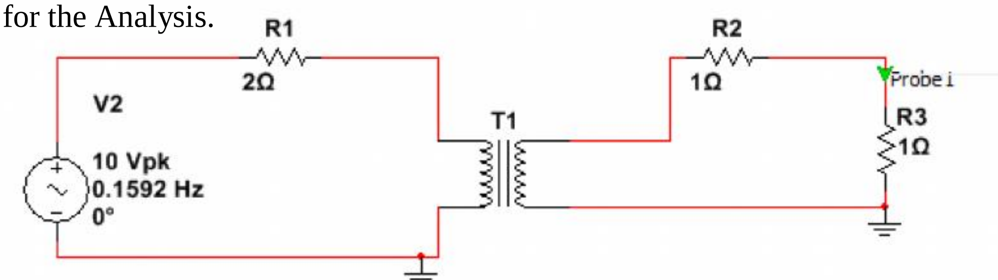


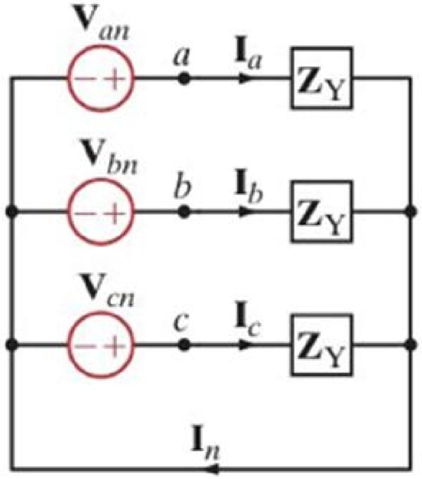
Figure 1.2

Design1
Single Frequency AC Analysis @ 0.1592 Hz

	AC Frequency Analysis	Magnitude	Phase (deg)
1	V(Probe1)	1.24039	7.11104

Figure 1.3

2. In a balanced three-phase wye–wye system, the total power loss in the lines is 400 W. V_{AN} = 105.28/31.56° V rms (the magnitude is 105.28; the angle is 31.56°) and the power factor of the load is 0.77 lagging. If the line impedance is 2 + j1 Ω, determine the load impedance. (A balanced wye-wye connection is shown to the right. The line impedance appears in series between the three-phase sources, V_{an}, V_{bn} and V_{cn}, and each of the loads.)



In order to solve the problem, the per-phase circuit diagram was drawn. Figure 2 shows the mentioned diagram.

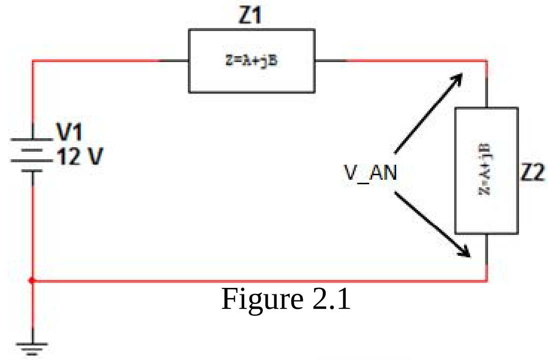


Figure 2.1

The power loss in the line is 400W, then since the power dissipated in given by $I^2R = P$, the power current in each phase can be calculated by $I^2R = \frac{P}{3}$. By substituting the value of the line impedance into the equation, it can be said that:

$I = \sqrt{\frac{400}{6}}$ or $I = 8.16$ A.

With the current and the value of the V_{AN}, the real value of the load impedance can be easily calculated.

$Z_L = \frac{V_{AN}}{I}$ or $Z_L = \frac{105.28V}{8.16A}$, then the real value of the impedance is $Z_L = 12.90\Omega$. The value of the angle for the load can then be calculated with the power factor as follows:

$\cos^{-1} pf = \theta$ or $\cos^{-1} 0.77 = \theta$, which gives an angle of θ = 39.64˚.

To prove that the found impedance was correct, the circuit was simulated in Multisim and the power factor of the line was measured. Figure 2.2 shows the Multisim simulation of the circuit, while figure 2.3 shows the measurement of the wattmeter showing that the power factor, also known as the angle of the impedance, is in fact 0.77.

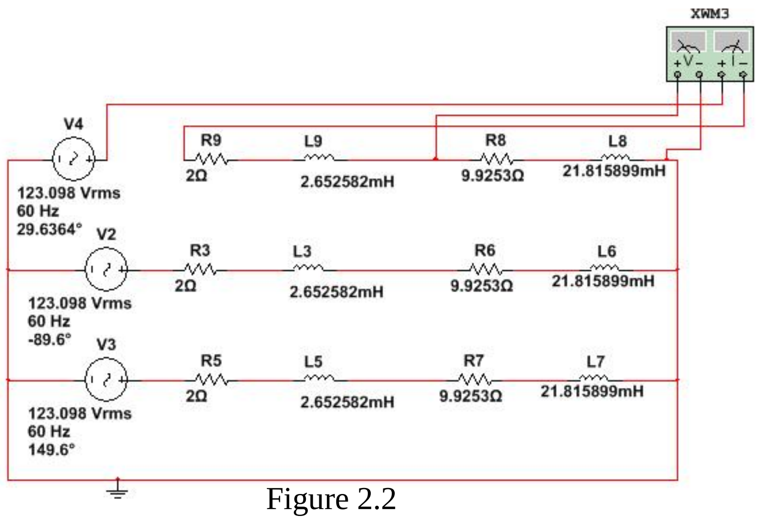


Figure 2.2

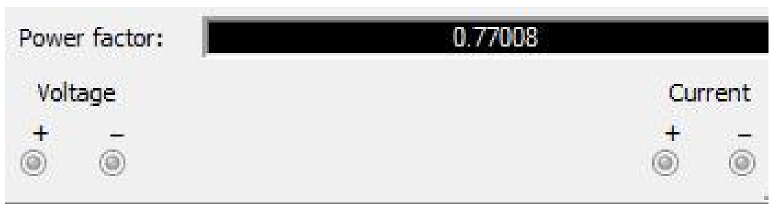
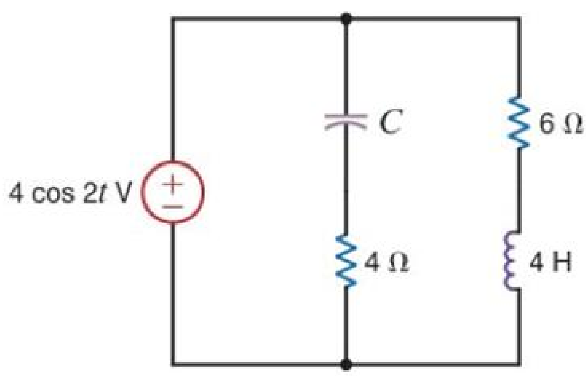


Figure 2.3

3. Determine the value of C in the network shown for the circuit to be in resonance.



In order to solve the present problem it is important to understand that the impedance and the admittance of the system are purely real. Since the impedances are connected in parallel, it would be easier to work with admittances instead of impedances. In this sense, the admittance of the system seen from the source is given by:

$$Y(j\omega) = \frac{j\omega C}{1 + j\omega C4} + \frac{1}{6 + j\omega 4}$$

The expression can be simplified as follows:

$$\frac{C\omega}{1 + 16\omega^2 C^2} - \frac{4\omega}{36 + 16\omega^2} = Y(j\omega)$$

The frequency at which the admittance is purely real is when

$$\frac{C\omega}{1 + 16\omega^2 C^2} - \frac{4\omega}{36 + 16\omega^2} = 0$$

Then, by simplifying the expression and substituting ω by 2, as it is specified in the circuit, the following expression is obtained:

$\frac{C}{1+64C^2} = \frac{4}{100}$ or $256C^2 - 100C + 4 = 0$ by solving for C in the equation, it can be determined that for the circuit to be at resonance, the Capacitor should be

$$C = 0.3453F$$

The given circuit was simulated in Multisim to determine if the value found for the capacitor was accurate. In this sense, Figure 1.3 shows the circuit built in Multisim with the value found for the capacitor.

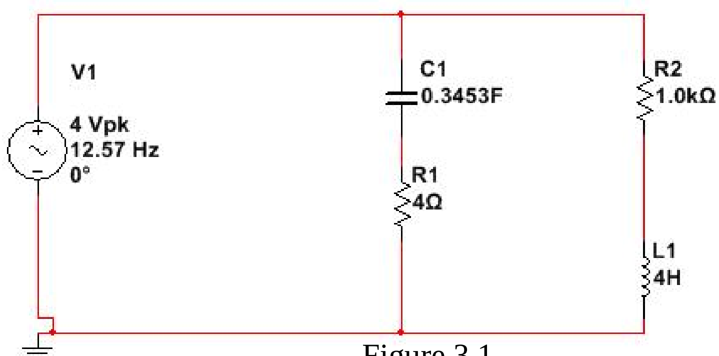


Figure 3.1

In order to test the result, an impedance meter was placed where the source is, and the impedance at frequencies at a range of 0-15Hz were measured. The given circuit was determined to be at a frequency of 12.57. Figure 3.2 shows the results for the frequency sweep with variable impedances.

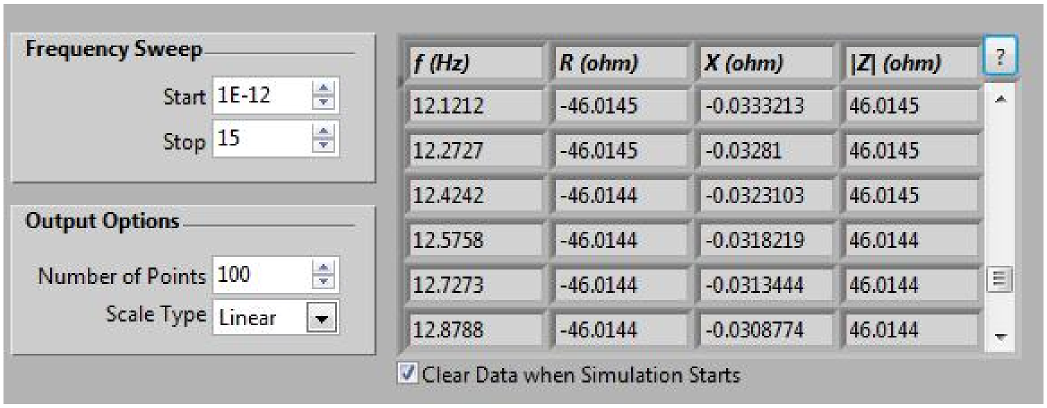


Figure 3.2

It can be seen that the imaginary impedance approaches 0, as the frequency sweep approaches 12.57 Hz which means that at that given frequency, the impedance is almost purely real and therefore, the circuit is in resonance.