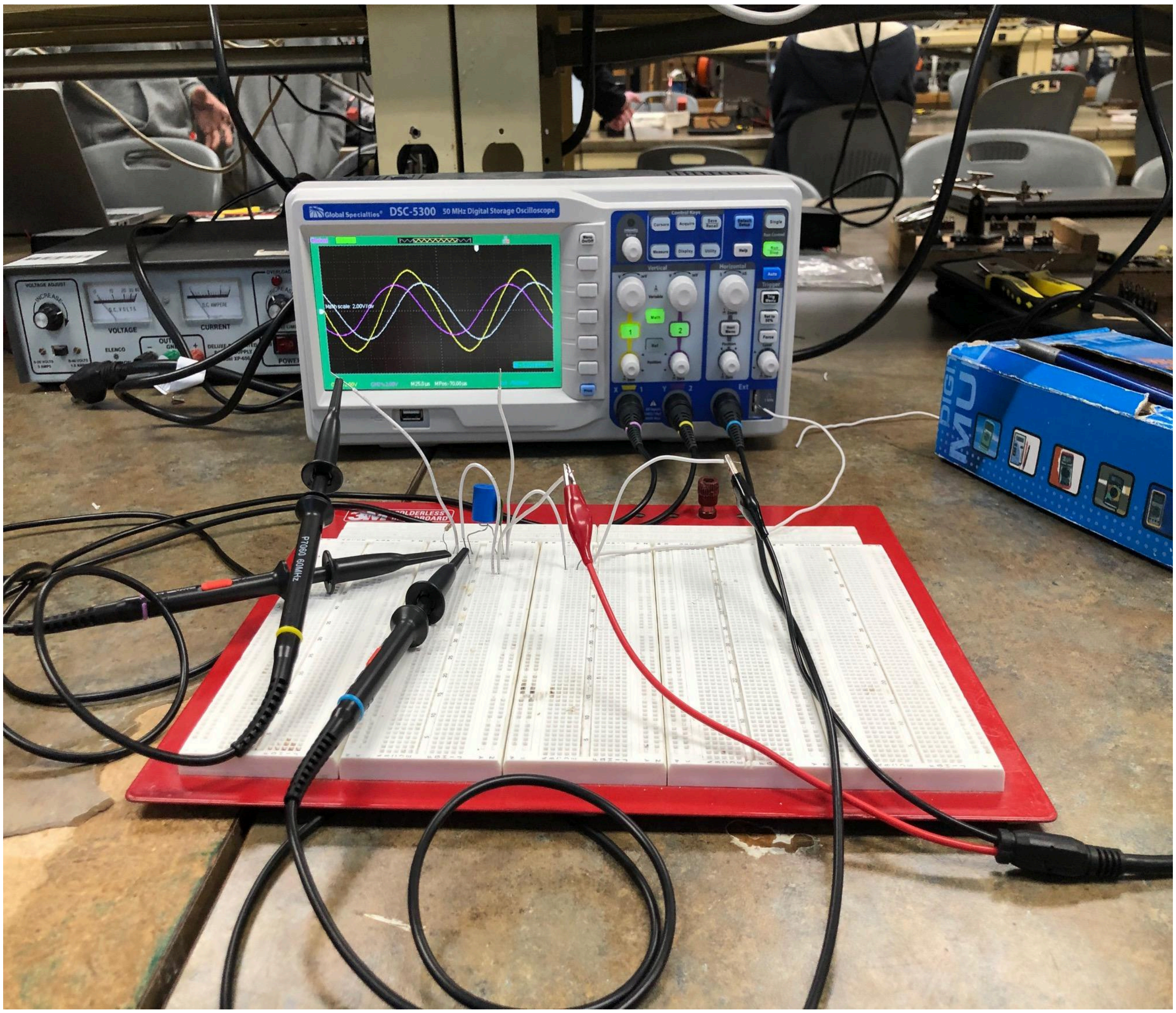
Experiment 49 - AC RLC Series Circuits Level 1



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Objectives:

1. Observe the characteristics of a series AC RLC circuit operating at frequencies that will cause the circuit to act capacitively or cause the circuit to act inductively
2. Determine by experimentation, the phase angle between the circuit current and applied voltage, the individual voltage drops, and the value of circuit current
3. Observe changes in the characteristics as variations are made to circuit components or frequency

Procedure:

1. The required materials that we used were:
    a. Function generator
    b. Dual trace oscilloscope
    c. 100mH inductor
    d. 33mH inductor
    e. .022 uF capacitor
    f. 1.8 kOhm resistor
    g. 390 Ohm resistor
    h. Linear graph paper
    i. Various test leads
    j. Multisim
    k. Google Spreadsheets
2. We measured the actual resistances of the resistors we needed
    a. 390 Ohm = 387 Ohm
    b. 1.8 kOhm = 1.785 kOhm
3. We constructed figure 49-1 on a breadboard and in Multisim

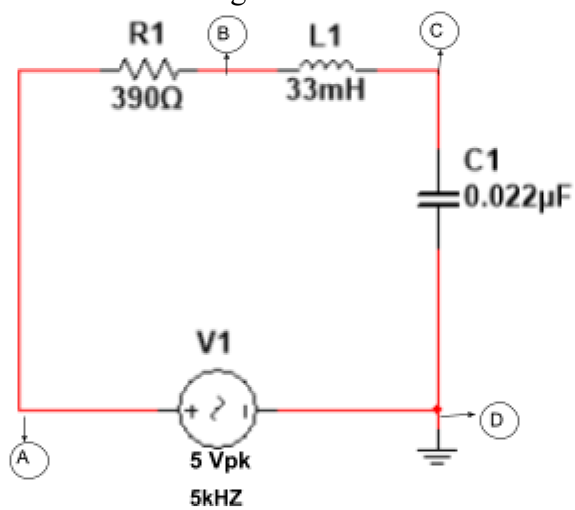


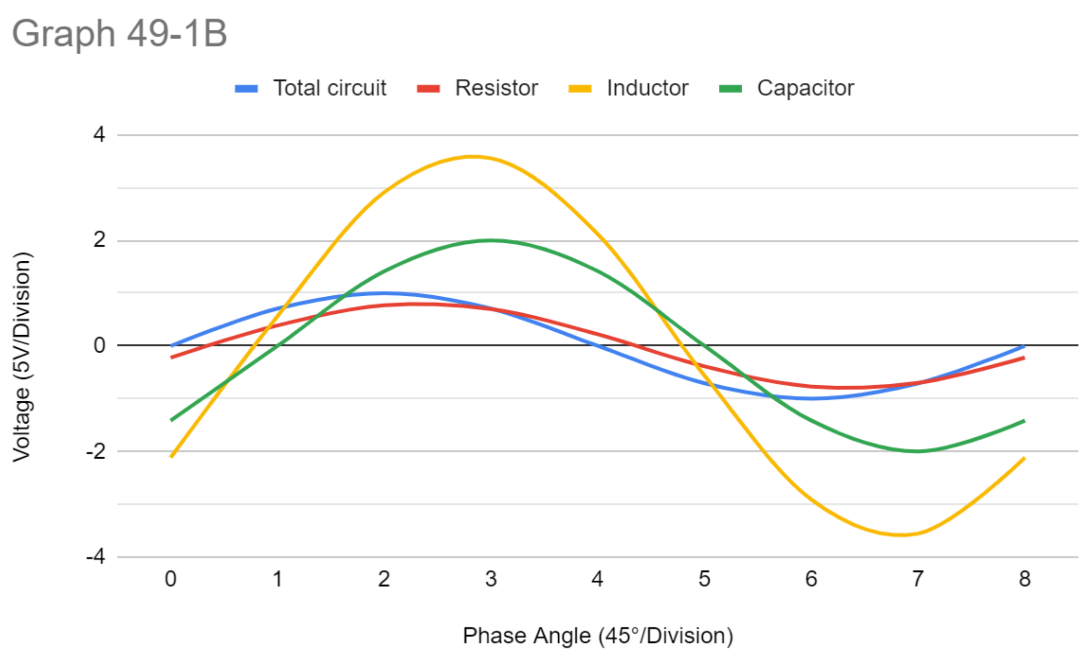
Figure 49-1

4. We connected the external trigger of the oscilloscope to point A in the circuit and switched the triggering source of the oscilloscope to EXT.
5. We connected channel 2 of the oscilloscope to point A as well and adjusted the oscilloscope display until the waveform was in standard position
6. We set up the oscilloscope for the subtract function to be used, channel one was inverted and will be used like a ground lead for a voltmeter and channel two will be the test lead

7. In table 49-1 we measured the voltage drop and phase angle across the resistor, inductor, and the capacitor in multisim and on a breadboard for figure 49-1

Component	Volt Peak (V) Breadboard	Phase angle (°) Breadboard	Volt Peak (V) Multisim	Phase angle (°) Multisim
Capacitor	10	-45	9.6	-45
Inductor	18	-36	18.035	-36
Resistor	4	-16	3.99	-16

8. Using standard position as a reference point and the information gained in table 49-1 we used google spreadsheets to create a graph of the voltage waveforms across each component in real life and in Multisim (Graph 49-1B)



9. If the frequency of the applied voltage is increased but not above 6 kHz what will happen to the following: (increase, decrease, or stay the same)
    a. Net reactance: **decreases**
    b. Phase shift between current and applied voltage: **decreases**
    c. Current: **increases**
    d. Resistance voltage: **increases**
10. We then increased the frequency of the circuit and confirmed that our suspicions were true
11. If the frequency of the applied voltage is decreased, what will happen to the following: (increase, decrease, or stay the same)
    a. Net reactance: **increases**
    b. Phase shift between current and applied voltage: **increases**
    c. Current: **decreases**

d. Resistance voltage: **decreases**

12. We then decreased the frequency of the circuit and confirmed that our suspicions were true
13. Next, we constructed figure 49-2 on a breadboard and in Multisim

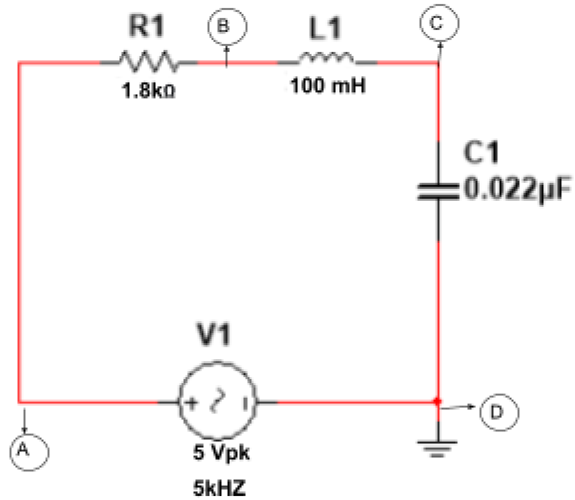
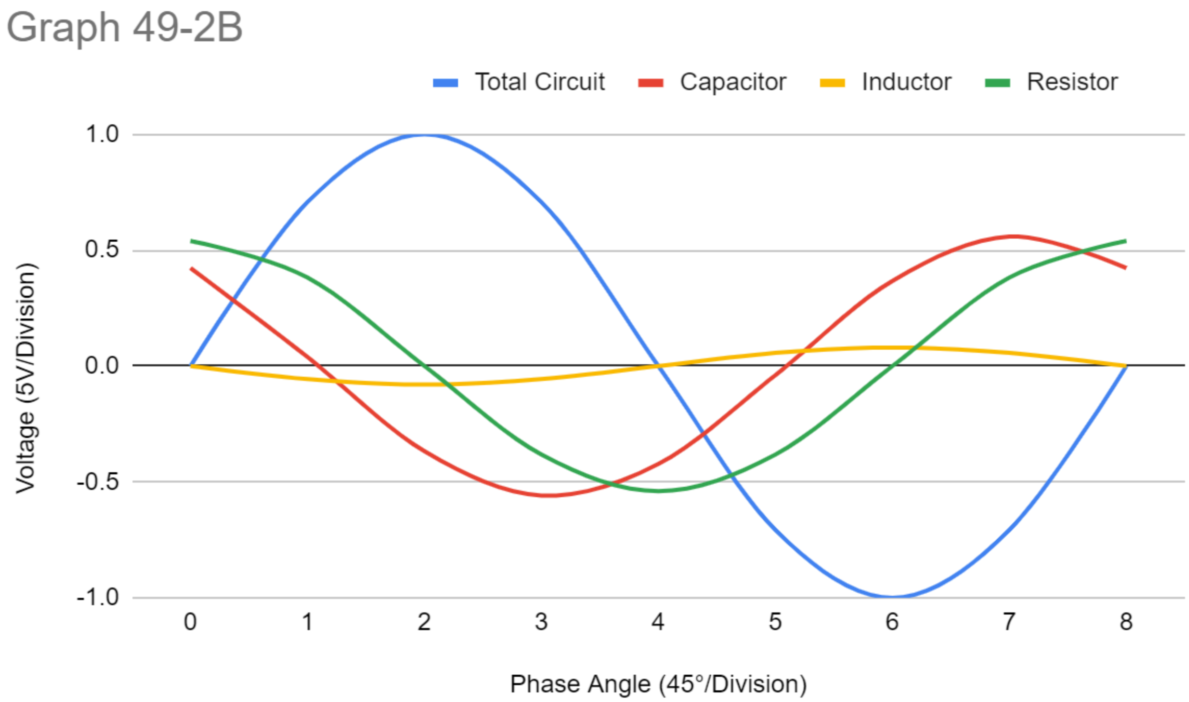


Figure 49-2

14. We recorded values for the voltage drops across each component and the phase shift across each component in Multisim and in real life in table 49-2

Component	Volt Peak (V) Breadboard	Phase angle (°) Breadboard	Volt Peak (V) Multisim	Phase angle (°) Multisim
Capacitor	2.8	135	2.9	131
Inductor	.4	180	.5	180
Resistor	2.7	90	2.67	90

15. This table shows that the larger the resistor value the smaller voltage drop and this is shown because the resistor value changed to be higher and now its resisting more voltage then table 49-1.
16. Using standard position as a reference point and the information gained in table 49-2 we used google spreadsheets to create a graph of the voltage waveforms across each component in real life and in Multisim (Graph 49-2B)



<u>Observation Questions:</u>

Answer the following questions using table 49-1 and the graphs

1. Is the circuit acting capacitively or inductively?
    a. The circuit was acting capacitively due to its phase angle being negative, and the smallest voltage differences were between the capacitor and the resistor.
2. In a series circuit, which reactive component will determine the phase angle between the current and applied voltage (the component with the smallest or largest reactance?)
    a. In a series circuit, the component with the largest reactance will determine the phase angle between the current and applied voltage.
3. Determine the circuit current value
    a. The total circuit current value is 5V/566Ω **= 8.8 mA**
4. Determine the value of the inductive reactance and the capacitive reactance
    a. The value for inductive reactance was 2(pi)(0.033H)(5000Hz) = **1036.7Ω** and the capacitive reactance was 1/(2(pi)(.000000022F)(5000Hz)) = **1446.9Ω.**
5. Determine the net reactance
    a. The net reactance would be 1036.7-1446.9 = **-410.2Ω**
6. Using the net reactance, determine the voltage that should be measured across the inductor and the capacitor
    a. The voltage across the the inductor and capacitor together should be 0.0088A*410.2Ω **= 3.6 Volts**

Answer the following questions using the information given in table 49-2 and the graphs

1. Is the circuit acting capacitive or inductive?
    a. The circuit was acting inductively due to its phase angle being positive.
2. Explain the previous answer

   a. The circuit is acting this way due to its phase angle being positive and the inductive reactance was higher.
3. Determine the circuit current value
   a. The total circuit current would be 5V/2472.2Ω = **2 mA**.
4. Determine the value of the inductive reactance and the capacitive reactance
   a. The value of inductive reactance would be 2(pi)(0.1H)(5000Hz) = **3141.5Ω** and the capacitive reactance would be 1/(2(pi)(.000000022F)(5000Hz)) = **1446.8Ω**.
5. Determine the net reactance
   a. The net reactance would be 3141.5-1446.8 = **1694.7Ω**.
6. Using the net reactance, determine the voltage that should be measured across the inductor and the capacitor
   a. The voltage across the inductor and capacitor together should be 0.002A*1694.7Ω **= 3.4 Volts**.
7. If the frequency of the applied voltage is decreased but not below 3 kHz what will happen to the following: (increase, decrease, or stay the same)
   a. Net reactance: **decreases**
   b. Phase shift between current and applied voltage: **decreases**
   c. Current: **increases**
   d. Resistance voltage: **increases**
8. If the frequency of the applied voltage is increased, what will happen to the following: (increase, decrease, or stay the same)
   a. Net reactance: **increases**
   b. Phase shift between current and applied voltage: **increases**
   c. Current: **decreases**
   d. Resistance voltage: **decreases**

Discussion:

Problem: The multisim oscilloscope was more difficult to control because it was not exactly like our bench oscilloscope and the controls were varied.

Troubleshooting: We looked up tutorials on how to read the oscilloscope on multisim so that we could get a better understanding for this lab and future labs

Solution: we determined that there were controls and markers on the multisim oscilloscope to easily measure time and degrees of phase shift between different waves.

Conclusion:

1. We determined that when the capacitive reactance was higher and the phase angle was negative, the circuit acted more capacitively like in figure 49-1 where the circuit phase angle was -46.4 degrees. However when the inductive reactance was higher and when the phase angle was positive, the circuit acted more inductively like in figure 49-2 where the total circuit phase angle was 43.3 degrees. However, in each circuit we were asked to observe what would happen if the frequency was changed but we were only allowed to change it to a point because if we went past that point the circuit would be close to resonance and if we did go past resonance then the circuit would act inductively if it was previously acting capacitively and vice versa.
2. We determined the phase angle of the total circuit by using the equation arctan((XL-XC)/R) then we found the phase angle of individual voltage drops by finding the total amount of graticules for one waveform to complete and dividing 360 by the number of counted graticules to find the degrees per graticule on the reference wave.

Then by starting at 180 degrees of the reference point or the total circuit current and then count the graticules until reaching the 180 degree point of the voltage drop being measured. Multiply the number of graticules counted by the degrees per graticule to find the phase difference. Step 14 details this where when figuring out the phase shift from the total circuit phase to the capacitor, we counted 15 graticules and multiplied it by nine to find a phase shift of 135 degrees.

3. We determined that when frequency increases in a circuit that has mainly capacitive characteristics, net reactance and phase shift between current and applied voltage decrease. When frequency increases current and resistance voltage increase. Shown in step 11 where we measured the total circuit current after frequency was increased from 5kHz to 5.5kHz originally the net reactance would have been 1036.7-1446.9= **-410.2 Ohms** but at 5.5kHz the net reactance would be 1140.4-1315.3= -**174.9 Ohms.** If net reactance decreases when frequency increases then total phase angle would also decrease. At 5kHz the phase angle would have been Arctan(-410.2/390)= **-46.4 degrees** but when at 5.5kHz the total phase angle would have been Arctan(-174.9/390)= **-24.2 degrees** which means that when frequency increased the circuit became much more resistive. When the frequency increases so does the current in the circuit. At 5kHz the current in the circuit was 5/566= **8.8 mA** when at 5.5kHz the total circuit current would be 5/427.4= **11.7 mA.** Resistor voltage increases when frequency increases because at 5kHz resistance voltage is 0.0088*390= **3.43 Volts** but at 5.5kHz resistance voltage is 0.0117*390= **4.56 Volts** but in a circuit with mainly inductive characteristics the opposite would be true

Impedance