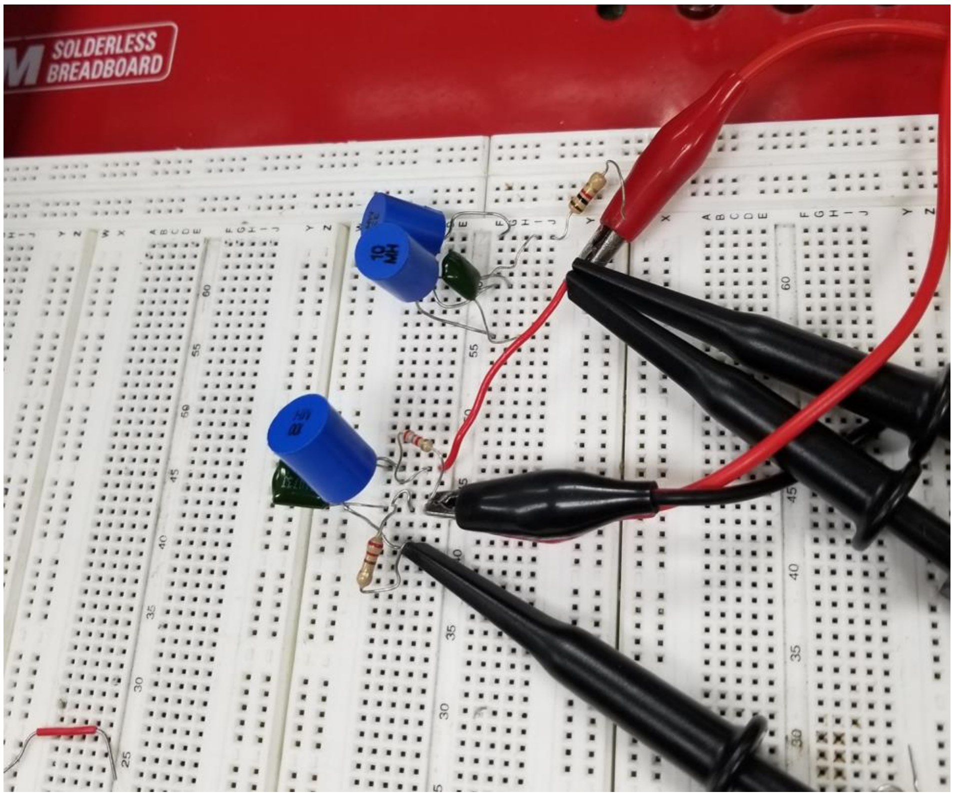
Experiments 51: Parallel RLC Circuits Level 1



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Objectives:

- Observe the following characteristics of a parallel RLC circuit:
    - Phase angle of total circuit current versus applied voltage.
    - Phase angle of the current through each reactive component versus the voltage across that component.
    - The effect changing frequency has on the phase angle of the total circuit versus the applied voltage.
    - The effect changing components has on the phase angle of the total circuit versus the applied voltage.
- Understand how to use the oscilloscope external trigger to measure phase angles.

Procedure:

Phase angle of current versus applied voltage in a parallel RLC circuit:

1. The circuit shown in Figure 51-1 was constructed on the multisim then on a protoboard with the installed wires shown.

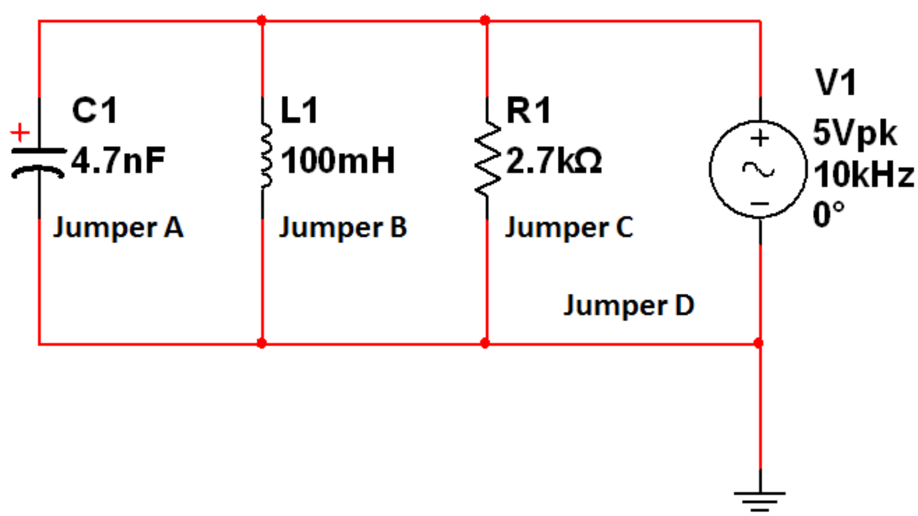

Figure 51-1

2. The oscilloscope external trigger and Channel 2 were connected across the function generator to measure the applied voltage.
3. Jumper wire A was replaced with a 220-Ω resistor to measure the voltage across the resistor to represent the capacitor current since the resistor voltage is in-phase with current.
4. The oscilloscope was set to dual mode and Channel 1 was connected between the capacitor and the 220-Ω resistor. The phase shift between the applied voltage and the resistor was recorded in table 51-1.

5. The 220-Ω resistor was replaced with Jumper A and Jumper B was replaced with the 220-Ω resistor to measure the voltage across the resistor to represent the inductor current since the resistor voltage is in-phase with current.
6. Channel 1 was connected between the capacitor and the 220-Ω resistor. The phase shift between the applied voltage and the resistor was recorded in table 51-1.
7. The 220-Ω resistor was replaced with Jumper B and Jumper C was replaced with the 220-Ω resistor to measure the voltage across the resistor to represent the resistor current since the resistor voltage is in-phase with current.
8. Channel 1 was connected between the capacitor and the 220-Ω resistor. The phase shift between the applied voltage and the resistor was recorded in table 51-1.
9. The 220-Ω resistor was replaced with Jumper C and Jumper D was replaced with the 220-Ω resistor.
10. Channel 1 was connected between the capacitor and the 220-Ω resistor. The 220-Ω resistor is in-phase with the total circuit current. Using the resistor voltage to represent the total circuit current, the phase shift between the total circuit current and applied voltage was measured then recorded in table 51-1.

Position of resistor	Multisim Applied Voltage vs Total Circuit Current Current Phase Angle (°)	Protoboard Applied Voltage vs Total Circuit Current Phase Angle (°)
Jumper A (Capacitor)	69.85	75.60
Jumper B (Inductor)	-110.15	-104.40
Jumper C (Resistor)	-20.15	-21.60
Jumper D (Total Current)	-18.2	-18.00

Table 51-1

11. Channel 2 was set to measure the applied voltage and Channel 1 was connected across the 220-Ω resistor.
12. The frequency was adjusted down to 4 kHz. The phase angle between the applied voltage and total circuit current was measured then recorded in table 51-2.

Frequency (kHz)	Multisim Applied Voltage vs Current Phase Angle (°)	Protoboard Applied Voltage vs Current Phase Angle (°)
10	20.15	21.60
9	13.47	14.40
8	5.72	7.20
7	-3.22	-3.60
6	-13.41	-14.4
5	-24.77	-25.2
4	-37.09	-39.6

Table 51-2

13. The circuit shown in Figure 51-2 was constructed on the multisim then on a protoboard with the installed wire shown.

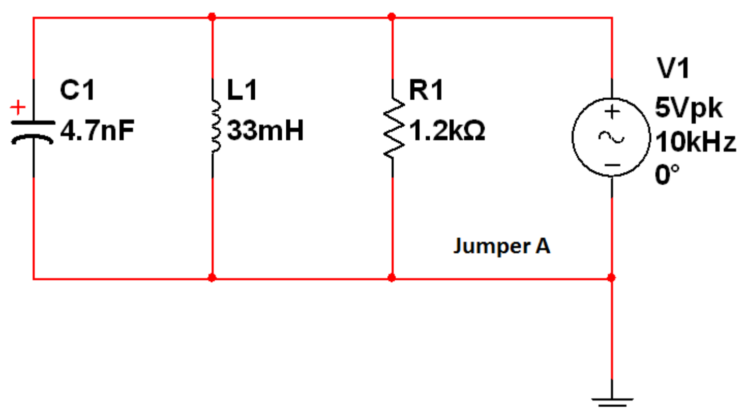

Figure 51-2

14. Jumper A was replaced with a 220-Ω resistor to measure the voltage across the resistor to represent the phase angle of current since they are in phase.
15. The phase shift between the total circuit current and applied voltage was measured then recorded in table 51-3 and 51-5 to serve as a reference.

Multisim Applied Voltage vs Total Circuit Current Phase Angle (°)	Measured Applied Voltage vs Total Circuit Current Phase Angle (°)
-12.67	-10.8

Table 51-3

16. The values in table 51-3 were used to create a phasor diagram as shown in figure 52-3.

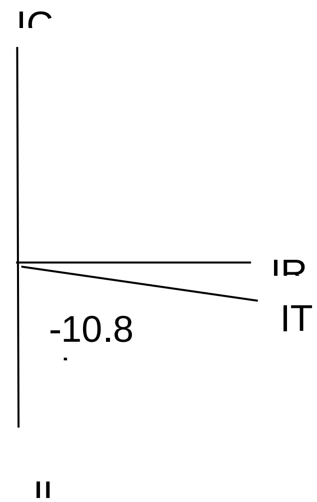

Figure 51-3

17. The frequency was adjusted up to 15 kHz with intervals of 1 kHz. The phase angle between the applied voltage and total circuit current was measured then recorded in table 51-4.

Frequency (kHz)	Multisim Applied Voltage vs Total Circuit Current Phase Angle (°)	Protoboard Applied Voltage vs Total Circuit Current Phase Angle (°)
10	-12.67	-10.80
11	-7.79	-7.20

12	-3.29	-3.60
13	0.86	0.00
14	4.70	3.60
15	8.27	7.2

Table 51-4

18. The function generator was set to 10 kHz.
19. The 0.0047-µF was replaced with the 0.001-µF.
20. The phase shift between the total circuit current and applied voltage was measured then recorded in table 51-5.
21. The 1.2-kΩ resistor was removed from the circuit.
22. The phase shift between the total circuit current was measured then recorded in table 51-5.
23. The 120-Ω resistor was placed in the gap from the 1.2k-kΩ resistor.
24. The phase shift between the total circuit current was measured then recorded in table 51-5.

Change in Circuit Components	Multisim Applied Voltage vs Total Circuit Current Phase Angle (°)	Measured Applied Voltage vs Total Circuit Current Phase Angle (°)
Original Circuit	-12.67	-10.80
Switching from the 0.0047-µF capacitor to the 0.001-µF capacitor	-26.73	-25.20

Removing the 1.2-kΩ resistor	-89.6	-90.00
Placing in the 120-Ω resistor	-2.88	-3.60

Table 51-5

Discussion:

When setting up for the lab, we had trouble finding a working oscilloscope. To fix this we tested each oscilloscope by connecting the probe to the calibrate connection to see if the oscilloscope would read a 0.5V square wave.

Conclusion:

Jumper D is connected in series to the applied voltage and since the 220-Ω resistor is in-phase with the current, it represents the phase angle between the total circuit current and applied voltage. Based on table 51-1, the total circuit current is lagging the applied voltage by 20.15°.

The other jumper wires, where the 220-Ω resistor was placed, represent the branches of current going through each component. Based on table 51-1, the phase angle between the applied voltage and capacitor current is 69.85° which is the difference between the phase angle of the applied voltage to total circuit current and 90°, the phase angle between the capacitor voltage and current. The phase angle between the applied voltage and capacitor current is -110.15° which is the difference between the phase angle of the applied voltage to total circuit current and -90°, the phase angle between the inductor voltage and current. The phase angle between the applied voltage and the resistor is the same as the total circuit current, 20.15°. This is because the resistor voltage and current are in-phase with each other.

Based on table 51-2, as the frequency decreases, the phase shift between the applied voltage and the total circuit current also decreases. This is because frequency is directly proportional to the reactance of the inductor so as frequency decreases, the circuit is more inductive. Based on table 51-4, as the frequency increases, the phase shift between the applied voltage and the total circuit current also increases. This is because frequency is inversely proportional to the reactance of the capacitor so as frequency decreases, the circuit is more capacitive. Based on these two conclusions, it can verified that the phase shift between the applied voltage and total circuit current directly proportional to frequency.

Based on table 51-5, switching out the capacitor with one with a lower capacitance value, decreases the phase shift between the applied voltage and total circuit current. This is because capacitance is inversely proportional to reactance so decreases the capacitance increases the reactance thus less current goes through that branch. Removing the 1.2-kΩ creates an open in the resistive branch. Since, the reactance of the capacitive branch was significantly increases as from swapping out the capacitor, most of the current goes to the inductor, making the phase shift between the applied voltage and total circuit current close to -90°. Placing in the 120-Ω resistor makes most of the current in the circuit go down the resistive branch making the circuit mostly ressitive. This makes the phase shift between the applied voltage and total circuit current close to 0°.

Based on all the tables shown in the lab, placing the external trigger of the oscilloscope across the applied voltage sets it as the reference or 0° for phase angles. This allowed Channel 2, which was also placed across the applied voltage, to display a reference wave. Since, oscilloscopes can’t measure current, the 220-Ω resistor was placed for each branch when it came to measuring in order find the phase shift between the resistor voltage, which represents the current of that branch, and the applied voltage.