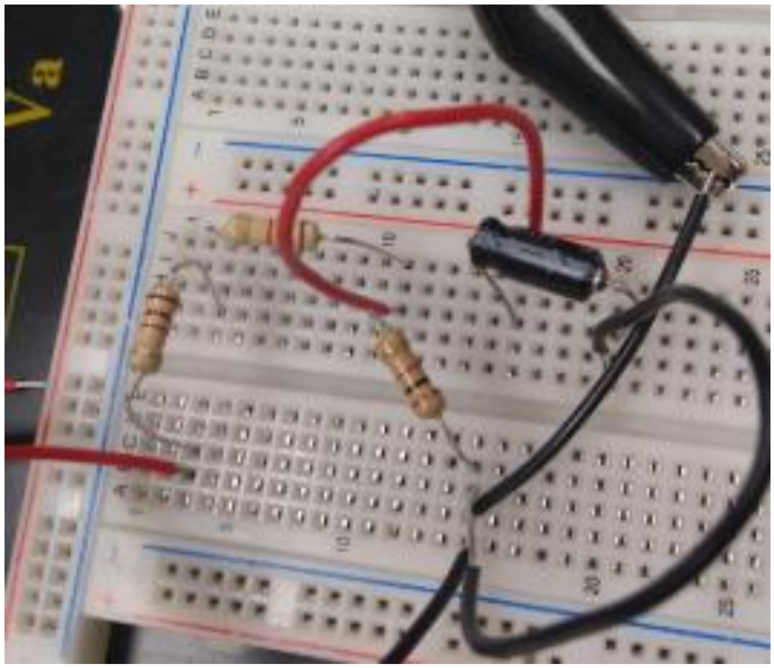
Experiment 44 - Capacitors: Coupling and Bypass; Level V



Rebecca Ashmore
Kayleigh Labrecque
Hannah Limanek

03/5/2019 - 03/8/2019

Objectives:

Upon completion of this lab, we will learn:

- Understand a sinusoidal wave that has reference voltage, that is not zero
- Observe the effects of coupling and bypass capacitors

Materials:

We used the following materials:

- Dual-variable power supply
- DMM
- Oscilloscope
- Function generator
- Voltmeter
- 1.1k (2), 1.8k, 2k, 2.7k, 3.3k, 4.7k resistors
- 10 µF capacitor (2)
- Multisim
- Excel
- Probes and Test Leads

Procedures:

1). To begin this experiment, we constructed the circuit shown in figure 44-1.

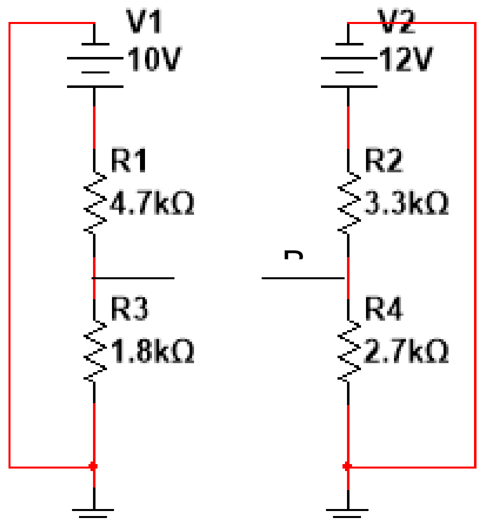


Figure 44-1

2).We used a voltmeter to measure points A and B, the results are shown in table 44-1.

Point	*Measure Voltage (V)*	*Multisim Voltage (V)*
A	2.76	2.77
B	4.55	5.39

Table 44-1

3). We then place a jumper wire across points A and B.
4). Then, we measured the voltage at both points. These results are shown in table 44-2.

Point	*Measure Voltage (V)*	*Multisim Voltage (V)*
A	3.66	3.98
B	3.66	3.98

Table 44-2

We found that both of the voltages are the same. They had increased

5). Then we removed the jumper wire and replaced it with a 10 μF capacitor.
6). We also measured the voltage at points A and B and the voltage of the capacitor. The results are recorded in Table 44-3.

Point	*Measure Voltage (V)*	*Multisim Voltage (V)*
A	2.76	2.77
B	4.55	5.39
Capacitor	1.79	2.63

Table 44-3

The voltage at points A and B shown in Table 44-1 and 44-3 were the same. But compared the to the voltages shown in table 44-2, the voltages shown in table 44-3 had decreased.

7).Next we connected a function generator set to 1 kHz and added a 10 μF capacitor, as shown in Figure 44-2.

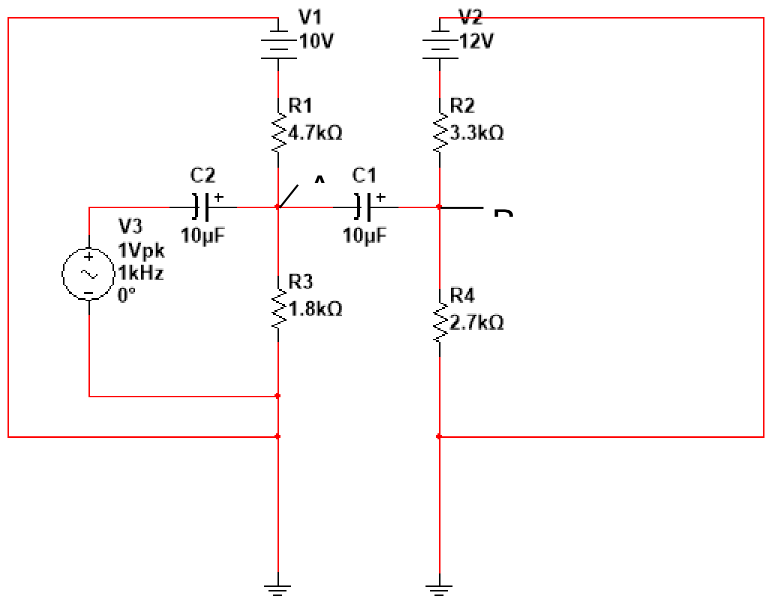


Figure 44-2

8).We used channel one on an oscilloscope to measure at point A. These values are shown in table 44-4

9). The diagram shown in figure 44-3, shows the waves that are produced from circuit shown in figure 44-2. The top wave shows the values measured from channel 2 and the bottom wave shows the values measured for channel 1.

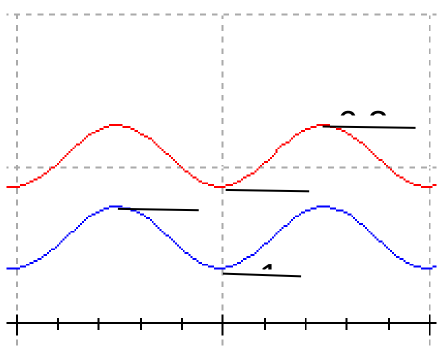


Figure 44-3

10). Next, we used the dual function on the oscilloscope and measured point B with channel two. Values are shown in Table 44-4.

11). We kept both channels in the same place and used the add function on the oscilloscope. We inverted channel two in order to subtract the voltages. This was just the capacitor voltage, which was 1.8Vpk

	Point A Measured(Vpk)	Point A Multisim (Vpk)	Point B Measured (Vpk)	Point B Multisim (Vpk)
High Peak	3.68	3.76	6.25	6.39
Lower Peak	1.81	1.78	4.43	4.41

Table 44-4

12).Next, we constructed the circuit shown in Figure 44-4.

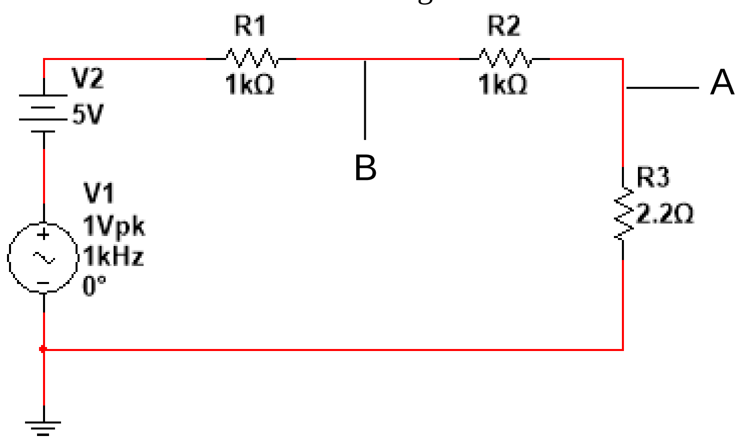


Figure 44-4

13).We used a DMM to measure the voltage across each resistor. The results are shown in Table 44-5.

Point	***Measure Voltage (V)***	***Multisim Voltage (V)***
V_{R_1}	1.34	1.199
V_{R_2}	1.34	1.199
V_{R_3}	2.44	2.619

Table 44-5

14).Using an oscilloscope, measured the voltage at points A and B. The results are shown in Table 44-6.

Point	*Measure Voltage (Vpk)*	*Multisim Voltage (Vpk)*
A	2.89	3.14
B	4.53	4.56

Table 44-6

15).Next, we drew another sinusoidal wave diagram. The diagram shows the peak voltages and the reference voltage. The diagram is shown in figure 44-5

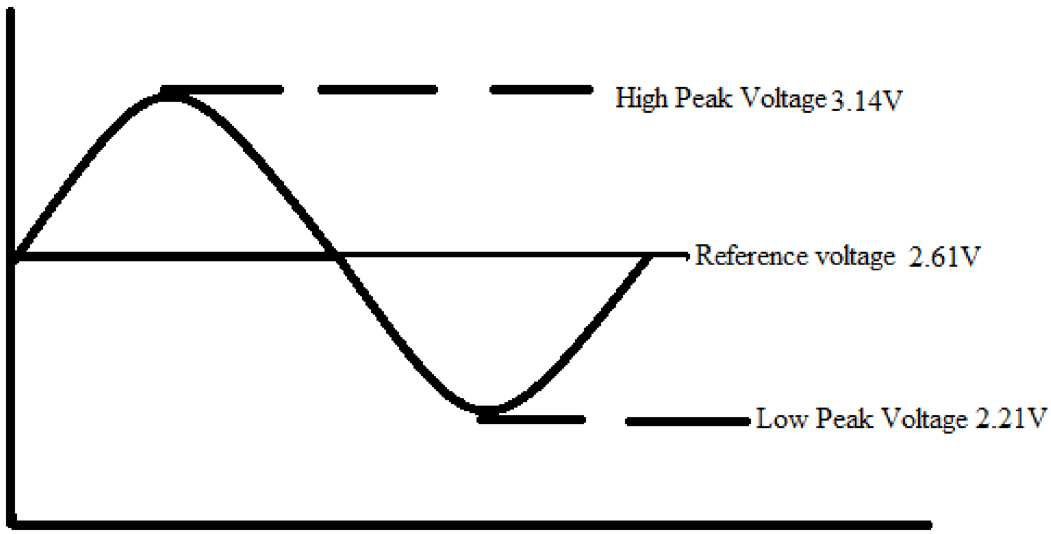


Figure 44-5

16).We then added a 10 µF capacitor parallel to the 2.2k Ω resistor to the circuit, shown in Figure 44-6.

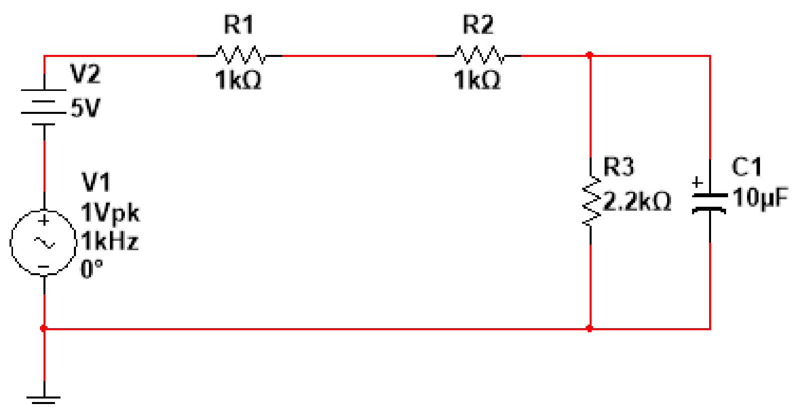


Figure 44-6

17).We repeated the same process to measure across each resistor, the results are shown in Table 44-7 below.

Point	***Measure Voltage (V)***	***Multisim Voltage (V)***
V_{R_1}	1.34	1.34
V_{R_2}	1.34	1.34
V_{R_3}	2.44	2.44

Table 44-7

The values of the resistors has increased from table 44-6. This is because the capacitor that was added was a bypass capacitor.

18). We also measured points A and B using an oscilloscope like before. The results are shown in Table 44-8 below.

Point	***Measure Voltage (Vpk)***	***Multisim Voltage (Vpk)***
A	2.4	2.5
B	4.2	4.3

Table 44-8

19).We used an oscilloscope (ac) to measure the peak voltage across the dc power supply. The measured voltage was 0Vpk and the multisim voltage was 0Vpk. The dc power supply does not have an ac signal. When we measured the the dc power supply with an oscilloscope to find ac voltage pk, already we knew that the value were going to be zero.

20). We used a DMM to measure the dc voltage across the ac function generator. The measured voltage was 0V and the multisim voltage was 0V. Similar to dc voltage, the ac function generator does not have a dc signal, meaning that the values are zero.

Observations:

1. The dc voltages did not change when the capacitor was inserted into the circuit.(Step 6)

2. The difference in multisim dc voltage was 2.62 volts which was about the capacitors voltage. The difference in the measured dc voltages was 1.79 which was the capacitors voltage. (Step 6)
3. The measured dc voltages in Table 44-3 were the same as the dc voltages indicates on the reference waveform. The voltage reference is the dc voltage is always the reference voltage in a sinusoidal wave.
4. The ac voltage was across the capacitor was -2.61 Vpk shown in table 44-4 (step 11)
5. Frequency is inversely proportional to capacitive reactance. The capacitive reactance in terms of the ac voltage source would only be 16 ohms. Since, voltage is directly proportional to impedance. The ac voltage drop across the capacitor would be much smaller than the voltage drops across the resistors which have ohm values in the thousands. Meaning that there is ac voltage, just a small amount.
6. If the capacitor between points A and B was made smaller there would be a higher ac voltage across the capacitor.
7. Both the value of the capacitor and the value of frequency are important when creating the coupling capacitor. This is because the reactance of the capacitor should be low for the impedance to be low. In order to have low reactance both the value of the capacitor and value of frequency have an impact.
8. In step 3 the capacitor was shorted
9. If the capacitor between points A and B was opened, the ac voltage at point A would be 1Vpk and the ac voltage at point B would be 0Vpk.
10. The peak to peak voltage at point A is 1.98Vpk-pk. The diagram shown in figure 44-3 Point A is the bottom wave.
11. The peak to peak voltage at point B is 1.98Vpk-pk. The diagram shown in figure 44-3 Point B is the top wave.
12. The Coupling capacitor did not drop any ac or dc voltage in figure 44-2.
13. When the capacitor was placed into the circuit, the dc resistance does not change. The capacitive reactance formula states $Xc=1/2\pi fc$, and the frequency of dc is zero. Xc is infinity, which does not have an impact on the circuit whatsoever.
14. The impedance of the circuit before the capacitor was inserted, was 4.2kΩ. The capacitive reactance is about 16Ω. When vectored together the impedance increased to 4.4kΩ.
15. The ac voltage across the 2.2kΩ resistor in figure 44-4 (no capacitor) is about 3.1Vpk. The ac voltage of the same resistor, but in figure 44-6 (with the bypass capacitor) is about 2.6Vpk.
16. The ac voltage across R1 changed from 1.47Vpk Figure 44-4 to 1.69Vpk Figure 44-6. Which was an increase
17. The capacitor shorted the ac voltage of R3 which increased the total circuit current resulting in a higher ac voltage drop across R1.

18. If the bypass capacitor value decreased then the capacitive reactance would increase because capacitive reactance is inversely proportional to capacitance, shown in the equation for capacitive reactance $X_c=1/2\pi fc$. Having the reactance increase make the impedance increase as well because impedance is directly proportional to the reactance. Since, voltage is directly proportional to impedance, the voltage would increase.
19. If the bypass capacitor opened, then the dc voltage across R3 would be 1.34V (table 44-7). The ac voltage would be .75Vpk because there is no bypass capacitor to short out the ac voltage.
20. If the bypass capacitor was shorted, then both the dc and ac voltages would be 0V because the short would short R3 as well.

Discussion

The only problem that we ran into was when setting up the first circuit in multisim, before doing it out on the benches. For some reason, none of us could remember which way to place the dc voltage source. We placed it having the positive side connected to ground. At first this small detail went unnoticed until we actually measured the values. We found that our values were negative when they should have been positive. Once figured out why our values were the opposite of all of the groups, we were disappointed in ourselves. After this mistake, our experiment went smoothly.

Conclusion

A sinusoidal wave is like a sine wave, but does not have a reference voltage of zero. The diagram shown in figure 44-5 of step 15 is what the wave actually looks like. As shown in that figure the reference voltage is 2.61 volts, which is not zero. The reference voltage of the sinusoidal wave is the dc voltage of the signal that is trying to be shown. In the case of this example, the dc voltage is the measured dc voltage of the 2.2k resistor. The peaks of the wave are the ac voltage peaks.

A coupling capacitor is a capacitor that is used to couple or link together one ungrounded point to another ungrounded point of the circuit. The capacitor allows a dc isolation between two dc points. In the first circuit (figure 44-1), there are two parts of a circuit. When the two parts were completely separate, the voltages are shown in table 44-1. When a jumper wire is place to connect the parts, it affects the voltages being measured. The voltages of the two points being measured increased to the same voltage, shown in table 44-2 which was about 3 volts. When the capacitor was placed in the same location, the voltages went back to the same values in table 44-1.

A bypass capacitor is a capacitor that shorts out the ac signal, without affecting the dc signal. This means at a certain point in the circuit where there is a dc voltage and an ac signal, the capacitor placed parallel to the component would short the ac signal and only the ac signal. In the circuit shown in figure 44-4, the voltage across 2.2k resistor is about 2.5 volts dc and about 3 volts peak. When the capacitor was placed parallel to the 2.2k resistor, the dc voltage had stayed the same, but the ac voltage went from about a 3 volt peak to a 2.5 volt straight line, meaning it is the same as the reference. This shows that the bypass capacitor did its job and shorted the ac signal of the resistor.