Lab Final Part 1

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Introduction

The project given, is to design a circuit that will act as a DC power supply. The circuit needs the ability to switch between two different voltage references. The circuit will also need to include a transient, since the project will not tolerate instant changes in reference. The voltage supply of the circuit (Vs) will be the 15V supply given. The first voltage reference (V1) will need to be in between 9V and 10V. The second voltage reference (V2) needs to be in between 4V and 5V. To accomplish this, you will need 3 resistors (R1, R2, R3) and one capacitor (C). All 3 resistors need to be in between 4.7KOhm and 30KOhm, and the Capacitor is the one given 0.1uF. Also, find Tau for the switch being open and closed, both must be in between 1ms and 4ms.

The circuit layout given is a transient circuit. A transient circuit is a circuit with a disturbed state. The circuit then needs to go from that disturbed state to a steady state. Transients are things such as a capacitor or inductor. A capacitor is a voltage transient (delays the instant change in voltage) and an inductor is a current transient (delays the instant change in current). These circuits are used in products that cannot handle immediate changes in voltage or current.

Methods

I will first design this graph, then proceed to test is using MultiSim, and construct the model with provided lab equipment. However, first I must find what values I will use for R1, R2, R3, and C. I will do these methods first for the circuit in which the switch is open, then I will run all design and tests again in the switch is closed. The way I will find these answers is using a Voltage Divider, but in reverse. It is also important to note since C is also in the circuit, that when evaluating these values, C will act as an open part of the circuit, thus all that remains is the source, and resistors.

V1: Since I am given the value V1 needs to be, I can use it to set V1 equal to the voltage divider and find the resistor values. However, I am faced with two resistors that currently have no values. Since I cannot form two equations from what is given, I will assume the first resistor (R1) to be a value in the given constraints. I currently have limited resistors, so I will make R1 equal to 10KOhm. This makes R1 a plausible answer since it is within 4.7KOhm and 30KOhm. Using the V1 reference, Vs, and R1, I can use the voltage divider equation to find R2.

After finding R2 = 17.272KOhm, I decided since I have an 18KOhm resistor, to use that as the value for R2. Since R2 is between 4.7KOhm and 30KOhm, this is a plausible answer. This gives me the values for all resistors in the circuit, which means I can now solve for tau. Tau will be equal to Rth*C, in which Rth is the equivalent resistance seen by the circuit, and C is the capacitance. Rth = 10KOhm + 18KOhm gives 28KOhm. C was a given as 0.1uF. This gives tau = 2.80ms. Which is good as tau must be in between 1ms and 4ms.

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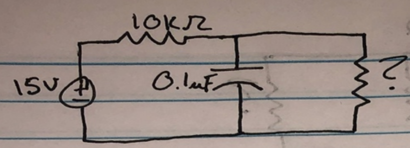

Use Voltage Divider and assume $R_i = 10K$

$$V_{Ref} = 15 \cdot \left(\frac{R_2}{10K + R_2}\right)$$

* Since $V_{Ref} = 9 \le x \le 10$, set $V_{Ref} = 9.5$

$$9.5 = 15 \cdot \left(\frac{R_2}{10{,}000 + R_2}\right) \Rightarrow R_2 = 17.272\,K\Omega$$

* Using our resistors, set $\underline{R_2 = 18K\Omega}$

$$\tau = R_{th} \cdot C$$

$$\Rightarrow (10K + 18K) \cdot 0.1uF$$

$$\underline{\tau = 2.80ms}$$

(1)

V2: Since I have found plausible answers for the first circuit, we can now move on to the second reference voltage when the switch is closed. We will once again use the voltage divider equation in reverse to solve for R3, since we know all values except for R3. So we set R1 = 10KOhm, R2 = 18KOhm, V2 = 4V < 5V, and Vs = 15V.

This gives me R3 = 5.625KOhm, however, since I have limited resistors, I will set R3 = 5.5KOhm. This gives me the values for all resistors in the circuit, which means I can now solve for tau. Tau will be equal to Rth*C, in which Rth is the equivalent resistance seen by the circuit, and C is the capacitance. Rth = 10KOhm + (18KOhm||5.5KOhm) gives 14.21KOhm. C was a given as 0.1uF. This gives tau = 1.421ms. Which is good as tau must be in between 1ms and 4ms.

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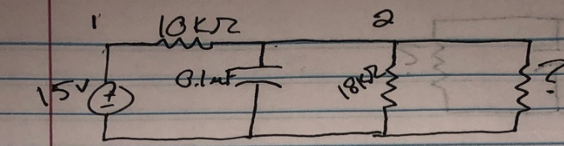


Use Voltage Divider.
Assume $R_1 = 10K\Omega$ & $R_2 = 18K\Omega$

* Notice 2 Nodes
  Since $V_{Ref} = 4 \le x \le 5$, set $V_{Ref} = 4.5V$

* I found using divider on opposite node made it work out better on my calculator.

* If Node 2 = 4.5v, then Node 1 = 10.5v

Use equation => $10.5 = 15 \cdot \left(\frac{10K}{10K + \left(\frac{18K \cdot x}{18K + x}\right)}\right)$

$x = R_3 = \underline{5.625K\Omega}$

* Using my resistors I will make
  $\underline{R_3 = 5.5K\Omega}$

$\tau = R_{th} \cdot C$ $\quad R_{th} = 10K + (18K \| 5.5K)$
$R_{th} = 14.21 K\Omega$
$\Rightarrow 14.21K \cdot 0.1\mu F \Rightarrow \tau = \underline{1.421 ms}$

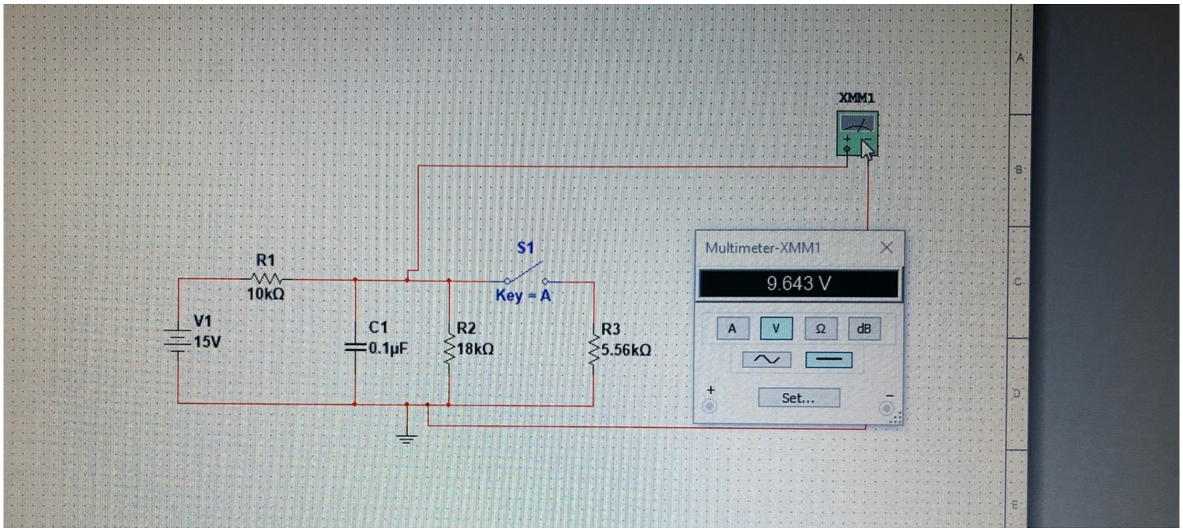
(2)

Results

	Switch Open (V1)	Switch Closed (V2)
Vs	15V	15V
R1	10KOhm	10KOhm
R2	18KOhm	18KOhm
R3	--	5.5KOhm
C	0.1uF	0.1uF
Tau	2.80ms	1.421ms
Vref	9.5V	4.5V

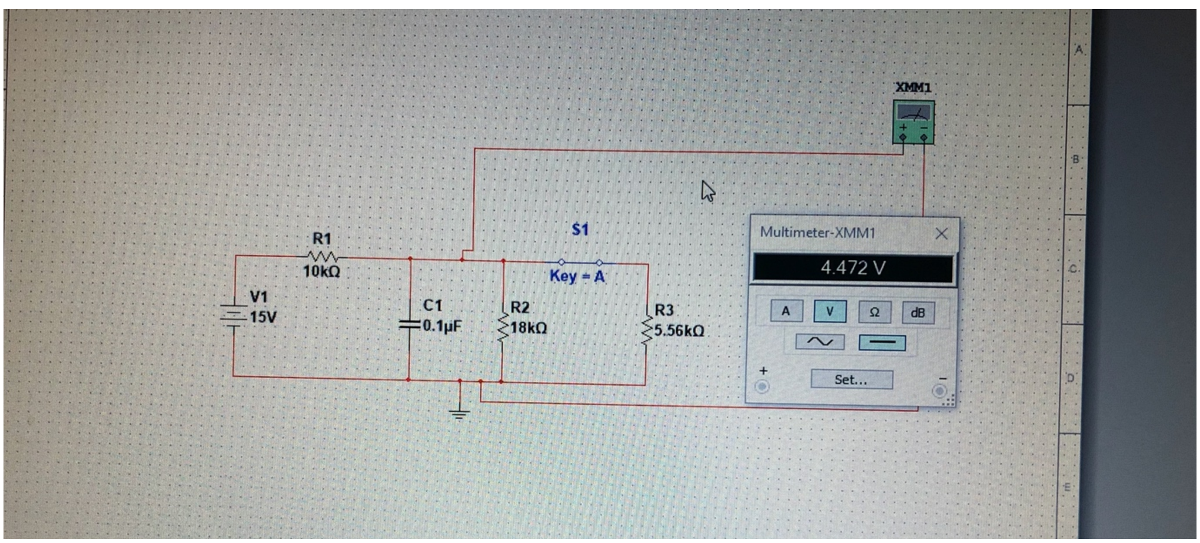
Design/Testing

Now that we have found all of our answers and have all fit the criteria given, we will now test these answers. We will use MultiSim to build the circuit using the values we have found, and then using a virtual multimeter, measure the Vref for when the switch is open and closed. First we will look for Vref when the circuit is open.



(3)

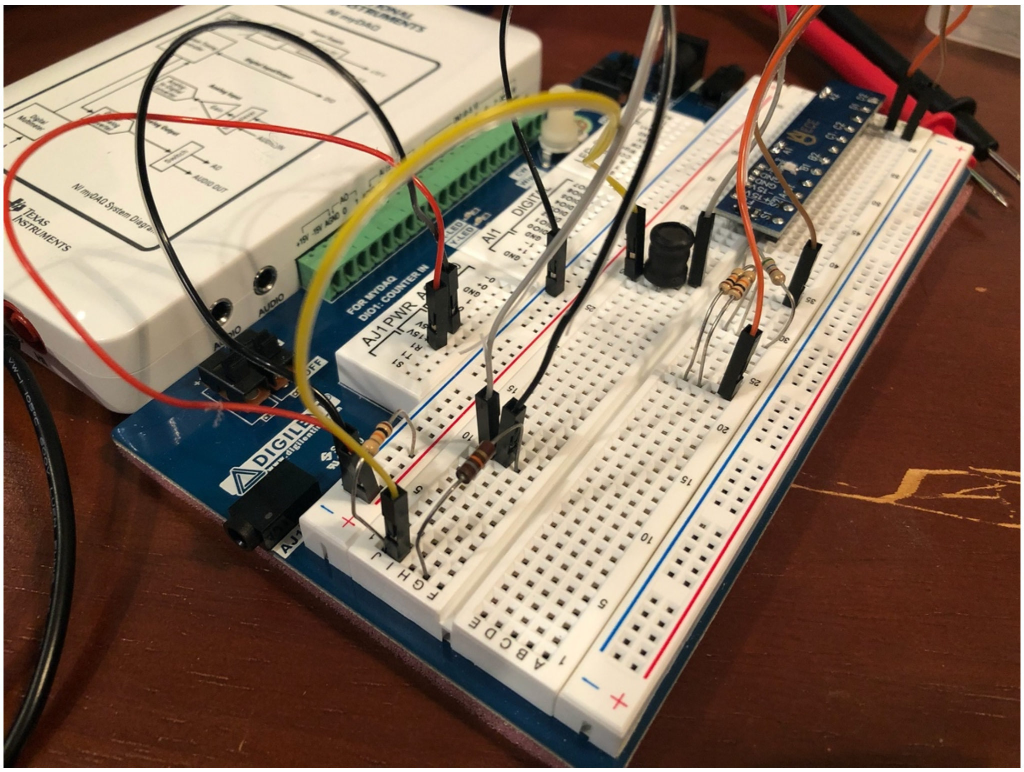
This shows that the value of V1 is within the constraints of 9V and 10V. This means according to MultiSim, our values are correct in getting the correct Vreference when the switch is open. Now let's look at when the switch is closed.



(4)

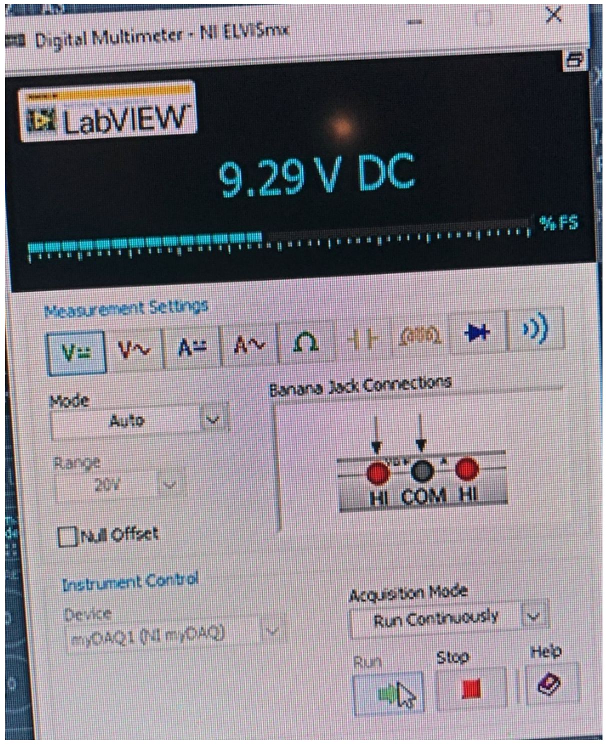
This shows that the value of V2 is within the constraints of 4V and 5V. This means according to MultiSim, our values are correct in getting the correct Vreference when the switch is closed.

Physical Testing: To further test my values for the circuit, I will also build the circuit physically on a breadboard and test the voltages for V1 and V2 using a multimeter. I will use the 15V source on the breadboard for Vs, a 10KOhm resistor for R1, an 18KOhm resistor for R2, two 10KOhm resistors in parallel with one 560Ohm in series to make a 5.5KOhm resistor for R3 [560Ohm + (10KOhm || 10KOhm) = 5.5Kohm], and a 0.1uF capacitor.



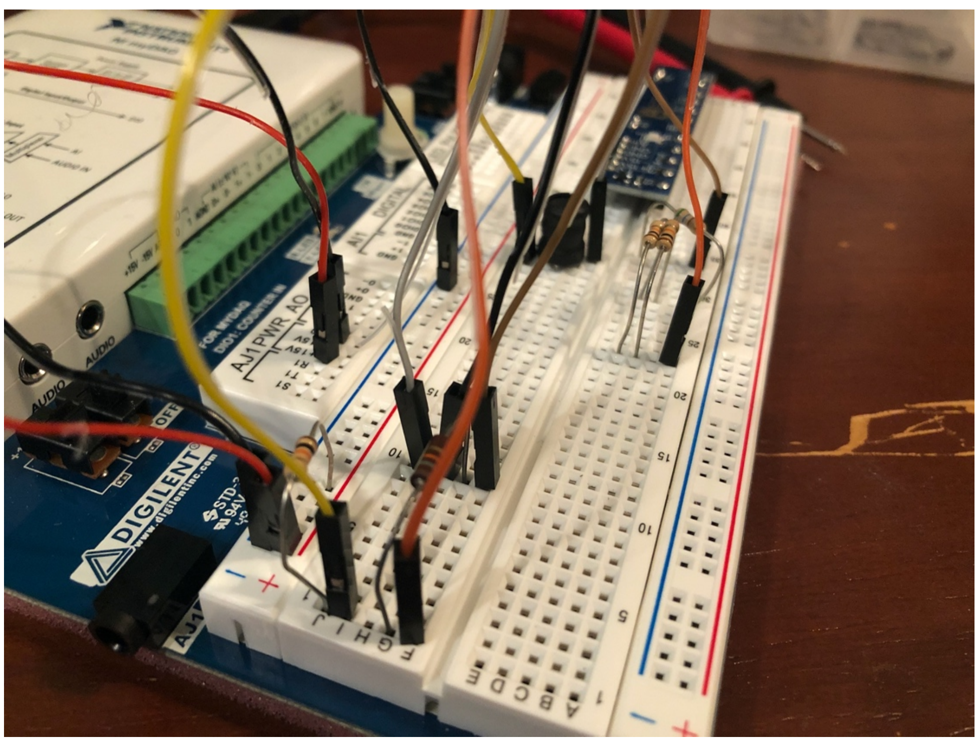
(5)

This shows the physical build of the circuit with the switch open. After building the circuit use the myDAQ to measure the voltages at Vref.



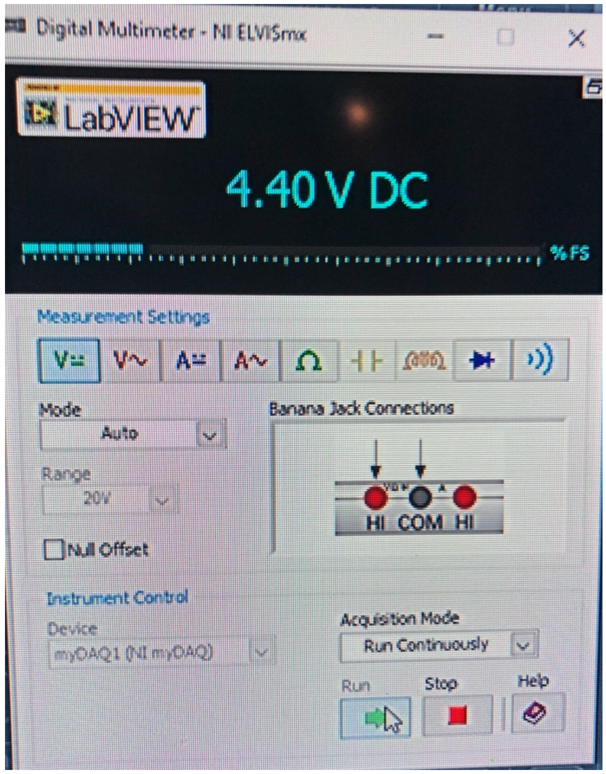
(6)

This shows the Voltage reference 1 (V1) on the physical build of the circuit with the switch open. Now build the circuit again but this time with the switch closed.



(7)

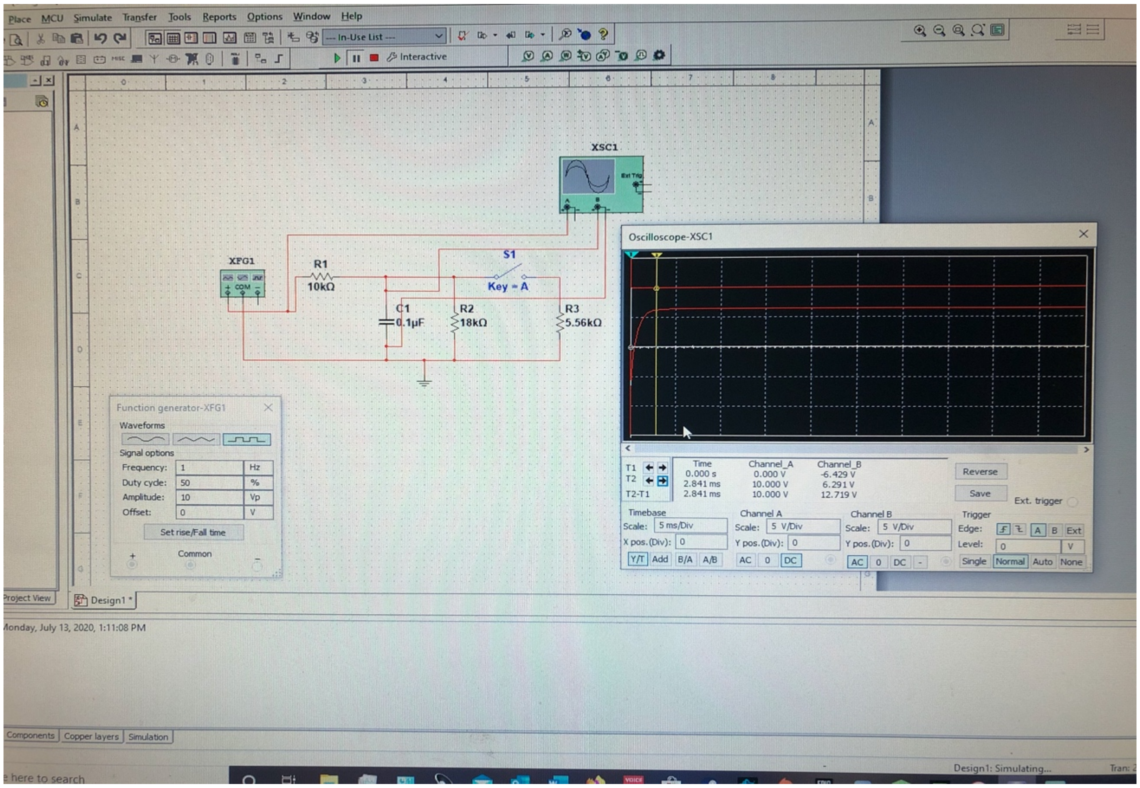
This shows the physical build of the circuit with the switch closed. After building the circuit use the myDAQ to measure the voltages at Vref.



(8)

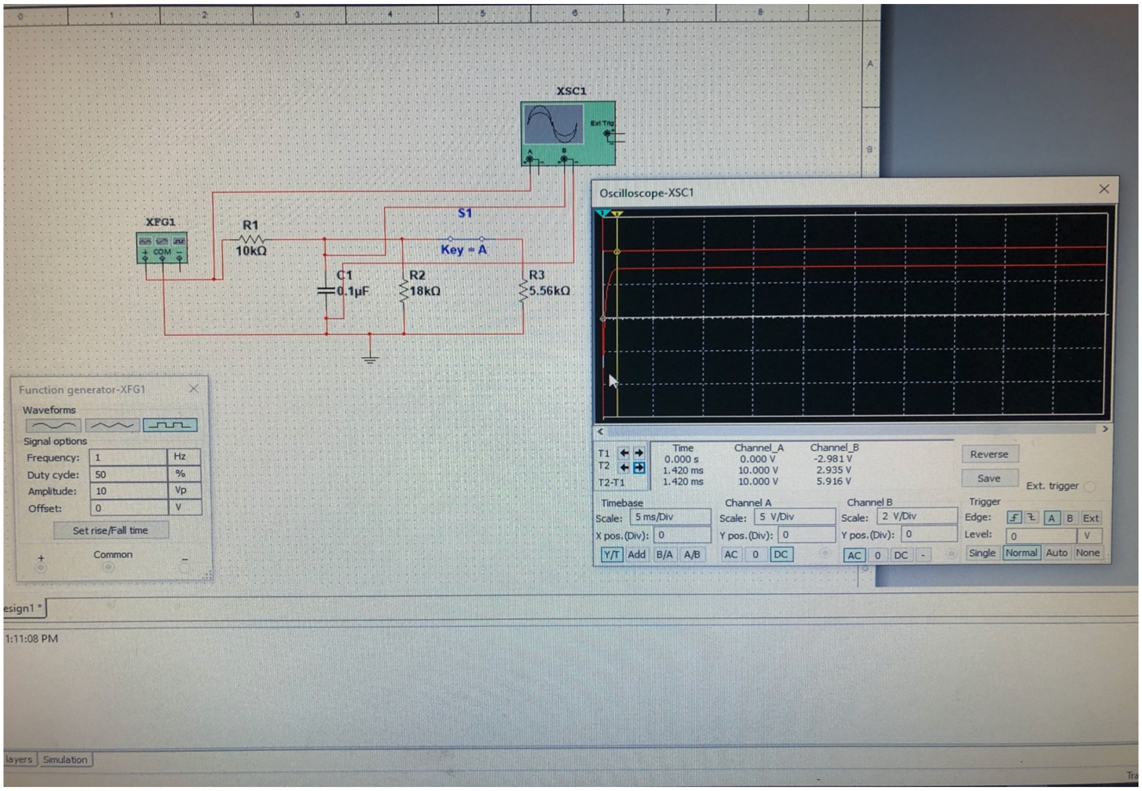
This shows the voltage of V2 when the switch is closed. While both voltages are a little smaller than the values given by the virtual circuit in MultiSim, this is expected since physical resistors are not perfect and do not equal exact values, and because the source does not equal exactly 15V. However, even with small flaws, when the switch is opened or closed the circuit still performs correctly. Since V1 is between 9V and 10V, and V2 is between 4V and 5V, the physical build also shows our circuit is correct. This proves our values are good since the virtual and physical models of the circuit have given correct values.

Testing Tau: Testing what we found for tau will be a little different than what we previously have done. Now, instead of using multimeters and breadboards, we will use MultiSim's function generator and Oscilloscope, to verify our tau value. First, we create the circuit in MultiSim just as we did before, but this time instead of using the DC voltage, we plug in our function generator. Using a square wave with a frequency of 1 (for better viewing) we can plug the virtual Oscope into the circuit.



(9)

When looking at the wave, we can compare the square wave to the transient wave and easily distinguish the two. The transient wave has a slight curve, and then begins to enter what is called "steady state". Tau is the value of time it takes to go from 0 to "steady state". Here you can see that it takes 2.841ms to enter steady state. This value is the same value we found earlier in our calculations, and also is between 1ms and 4ms which makes it a plausible value.



(10)

Here you can see that it takes 1.420ms to enter steady state. This value is the same value we found earlier in our calculations, and also is between 1ms and 4ms which makes it a plausible value.

Results

After running a series of tests (virtual and physical) we can see that the values found for all resistors, and capacitor fit the requirements given for the project. The final values for all components are:

	Switch Open (V1)	Switch Closed (V2)
Vs	15V	15V
R1	10KOhm	10KOhm
R2	18KOhm	18KOhm
R3	--	5.5KOhm
C	0.1uF	0.1uF
Tau	2.80ms	1.421ms
Vref	9.5V	4.5V

Analysis

This was a complete success for the project. While some values for V1 and V2 varied, it was very minor, and due to physical error, that cannot be accounted for. For instance, the value of resistors is not perfect, but the value given to resistors in MultiSim is. The numbers I found in formulas before starting the testing, looked much closer to the values found in MultiSim, since that is the same thing MultiSim uses. The physical testing was slightly lower due to resistors and the source not being perfect but were still quite close. Even with the small error, the circuit still passed the project qualifications. Overall, it was a complete success.

Conclusion

This project was given to find a DC power supply that could be changed with a switch, but also needed non-immediate change (which means using a transient of some kind). I first used known equations to solve for what I could find, which then led to giving me all the values I needed to create the circuit. This then prompted me to begin testing, which started with virtual circuits, and then started using physical circuits. Lastly, I used an Oscope to verify my value for tau, since it cannot be done using a multimeter. All values added up perfectly, and even made the small percent error given my physical imperfections, still work according to the project specifications. In the future, I would like to keep going on this project, and make even larger circuits. If this was the case, I might would have to use formulas inside another, or possibly have to start with testing first and move into further testing. Overall, this project was a complete success.

References

1. This image shows handwritten equations for finding the values to use in the circuit with an open switch. In these equations I use a voltage divider which can be found in class notes, or in the book. I then also used the equation for tau which I found in the class notes, and also in the previous lab (Lab 8).
2. This image shows handwritten equations for finding the values to use in the circuit with a closed switch. In these equations I use a voltage divider which can be found in class notes, or in the book. I then also used the equation for tau which I found in the class notes, and also in the previous lab (Lab 8).
3. This image shows the constructed circuit with open switch in MultiSim, which I used to test my values previously found. I used Lab 1 to remember how to use MultiSim in building circuits and using the virtual multimeter.
4. This image shows the constructed circuit with closed switch in MultiSim, which I used to test my values previously found. I used Lab 1 to remember how to use MultiSim in building circuits and using the virtual multimeter.
5. This shows the physical board for the circuit given with the switch open. I used previous labs (Lab 2 and 3) to remind myself how to use the myDAQ and breadboard.
6. This shows the reading of the multimeter that was reading V1 with the switch open. I used previous labs (Lab 2 and 3) to remind myself how to use the myDAQ and breadboard.
7. This shows the physical board for the circuit given with the switch closed. I used previous labs (Lab 2 and 3) to remind myself how to use the myDAQ and breadboard.
8. This shows the reading of the multimeter that was reading V2 with the switch open. I used previous labs (Lab 2 and 3) to remind myself how to use the myDAQ and breadboard.
9. This shows MultiSim testing of Tau with the switch open, using a virtual function generator and Oscope. I used the previous lab (Lab 8) to see how to setup the function generator and Oscope for a better reading.
10. This shows MultiSim testing of Tau with the switch closed, using a virtual function generator and Oscope. I used the previous lab (Lab 8) to see how to setup the function generator and Oscope for a better reading.