Multimeter Lab: Week 1

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Objective:

The objective of this week is to first design voltmeter, ammeter, and ohmmeter circuits. We will then breadboard and test the circuit, we will design the enclosure, and we will build the circuit in Ultiboard then

Procedure:

The first thing our group did to approach the ohmeter project was to draw up schematics for the ammeter, the voltmeter, and the ohmmeter.

Creating Schematic 1 (Ohmmeter):

First, we created the schematic for the ohmmeter: we determined our three settings, which are 500 Ohms, 5k Ohms, and 50k Ohms. Next, we determined the values of the shunts. To find the shunt values, we first determined the total current at each setting, as shown in **Equation 1**. Next we determined the amount of current that needed to be diverted at each point, and knowing the voltage is the same in parallel, we had the data needed to find the resistance at each point. The equations used to find the resistors are shown in **Equation 2**. The final shunt values are shown in **Schematic 1**.

Next, we needed to the determine the values of the multipliers. To solve this, we first determined the voltage values at each point, by taking the 9 volt source and subtracting the voltage of the analog meter. Since the 9v is theoretically constant, we determined that the voltage at each multiplier is the same. Using the currents found in Equation 1, we then knew he current at each branch, and then continued to find the value of each resistor. We then needed to find the value of the variable resistor, to zero out the multimeter. We determined that 5k Ohms was the best option because it allows us to use a 43k ohm resistor for our last multiplier, and bare wire for the other two settings, because both are relatively close to 5k ohms. The final schematic is shown in **Schematic 1**.

Creating Schematic 2 (Voltmeter):

Next, we began to create the schematic for the voltmeter, using the settings of 1V, 10V, and 25V. We first needed to determine the values of the multipliers. Using the source voltage, we determined the amount of voltage that had to be diverted, by subtracting the source voltage, by the voltage limit of the meter. Next, we knew that current is the same in a series circuit, so the current of each multiplier was equivalent to the meter's current, which is 100uA. Using the current and the voltage of each resistor, we solved for the resistance of the multipliers, as shown in **Equation 4** and **Schematic 2**.

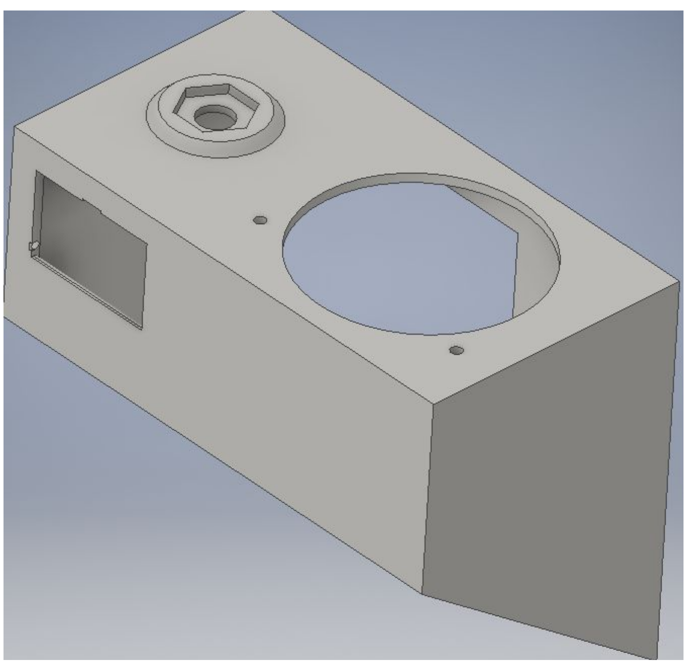
Creating Schematic 3 (Ammeter):

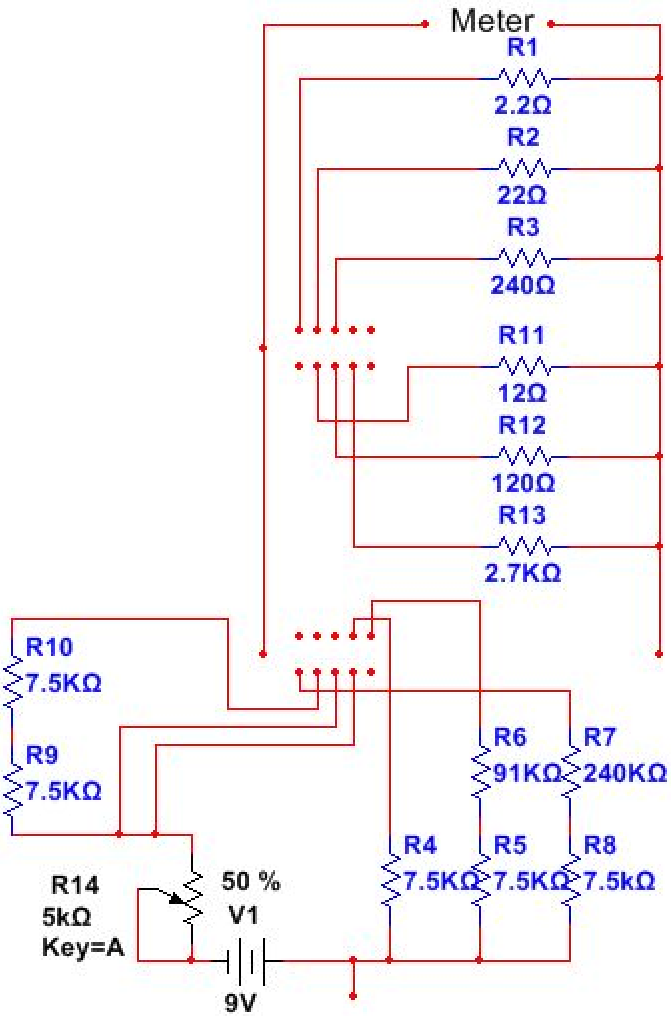
In order to create our ammeter we chose the ranges of .1 amp, .01 amps and .001 amps. After creating our range we needed to calculate each shunt's value. Knowing the voltage is the same in a parallel circuit, we only needed to find the current, by subtracting the current of the meter by the source current. We then solved for the resistance as shown in **Ammeter equations 5-7** then rounding for the closest resistor we could use. After figuring out the shunt values we built the ammeter shown in **schematic 3** putting the shunts in parallel with the meter.

Creating Enclosure:

While we were creating the circuits for the multimeter we also had to create a 3D printed container to hold and protect the circuitry of the multimeter shown as **Picture 1**. First we took the measurements of the meter and made three holes in the top of the container and decided that the meter was going to screw into the top of the board and have detachable wires going from the meter to the circuit board. We also added a fourth hole on the top of the box for the rotary switch, we also added a hexagon shaped indent so we can put a hex-nut in and screw the rotary switch into the hex-nut so the rotary switch stays in place.We also added two rectangular holes on the container, one in the front and one in the back, the hole in the front is for the banana plugs and it's smaller than the hole in the back. The larger hole in the back is for access to the circuit board and the battery for the ohmmeter.

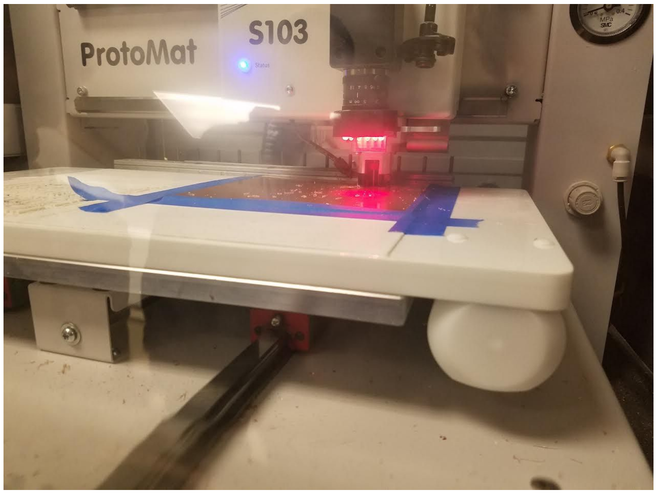
Picture 1





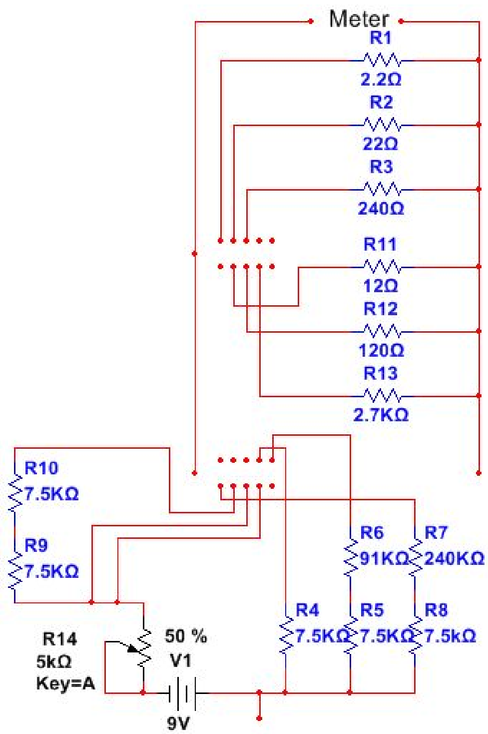
Meter
R1
2.2Ω
R2
22Ω
R3
240Ω
R11
12Ω
R12
120Ω
R13
2.7KΩ
R10
7.5KΩ
R9
7.5KΩ
R6
91KΩ
R7
240KΩ
R4
7.5KΩ
R5
7.5KΩ
R8
7.5kΩ
R14
5kΩ
Key=A
50 %
V1
9V

Making the board:

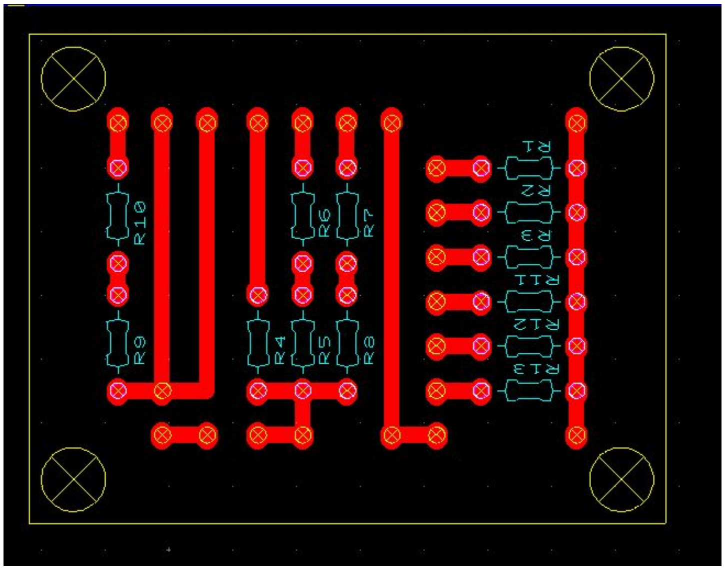


Picture 2

After working on the enclosure we decided to port our completed multisim (**Schematic 4**) into ultiboard (**Picture 3**) and then we drew the copper traces in between each resistor. After connecting the copper traces together we sent the file to the proto mat to make the board shown in **picture 2**.



Schematic 4



Picture 3

Equation 1:
$R_T = 500\ \Omega$
$9V/500\Omega = 18mA$

Equation 2:
$R_T = 5k\Omega$
$9/5000 = 1.8mA$

Equation 3:
$R_T = 50k\Omega$
$9/50000 = 180uA$

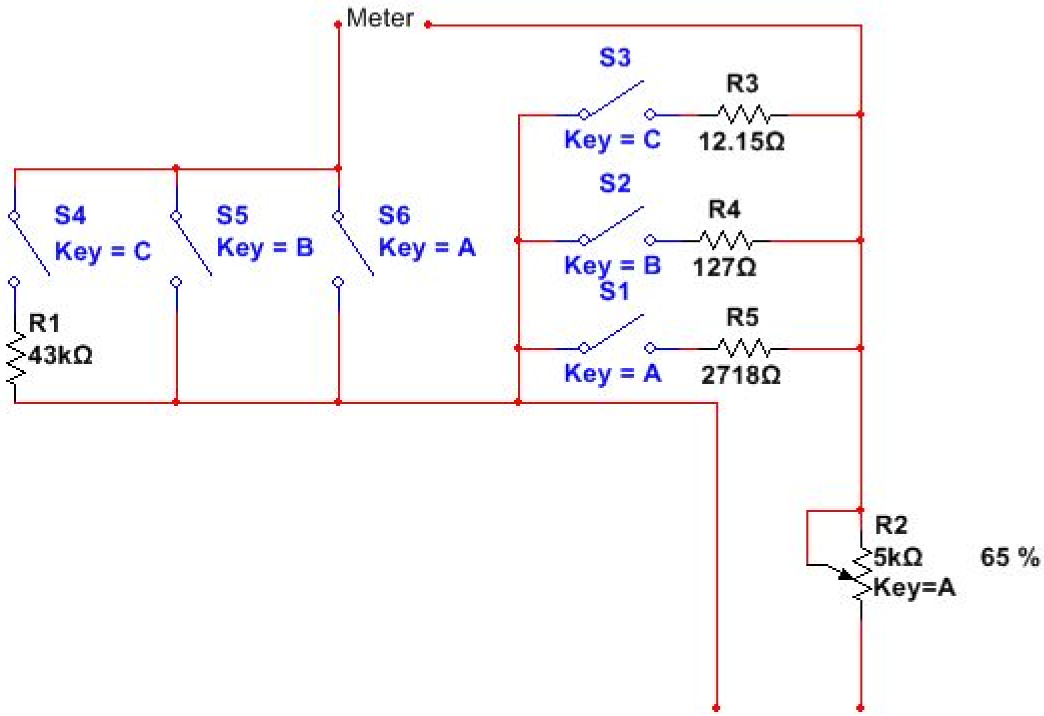
Equation 4:
For R_1:
$R=V/I = .7825V/.0001A = 7825\Omega$
For R_2:
$R=V/I = 9.7825V/.0001A = 97825\Omega$
For R_3:
$R=V/I = 24.78V/.0001A = 247825\Omega$

Equation 5:
$.2175$ Volts/ $.0999$ amps= $2.2\ \Omega$

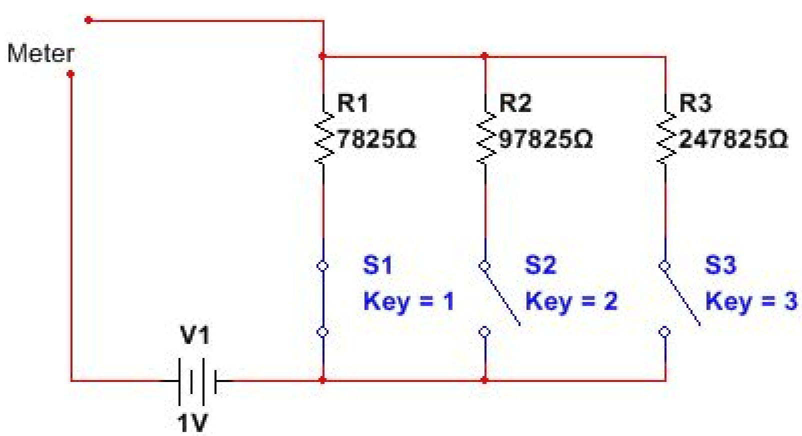
Equation 6:
$.2175$ Volts/$.00999$ amps=$22\ \Omega$

Equation 7:

.2175 Volts/.000999 amps=240 Ω

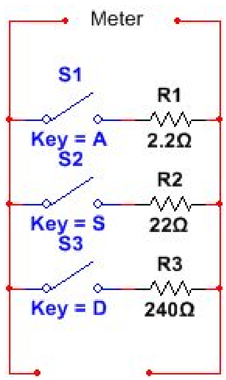


Schematic 1



Schematic 2

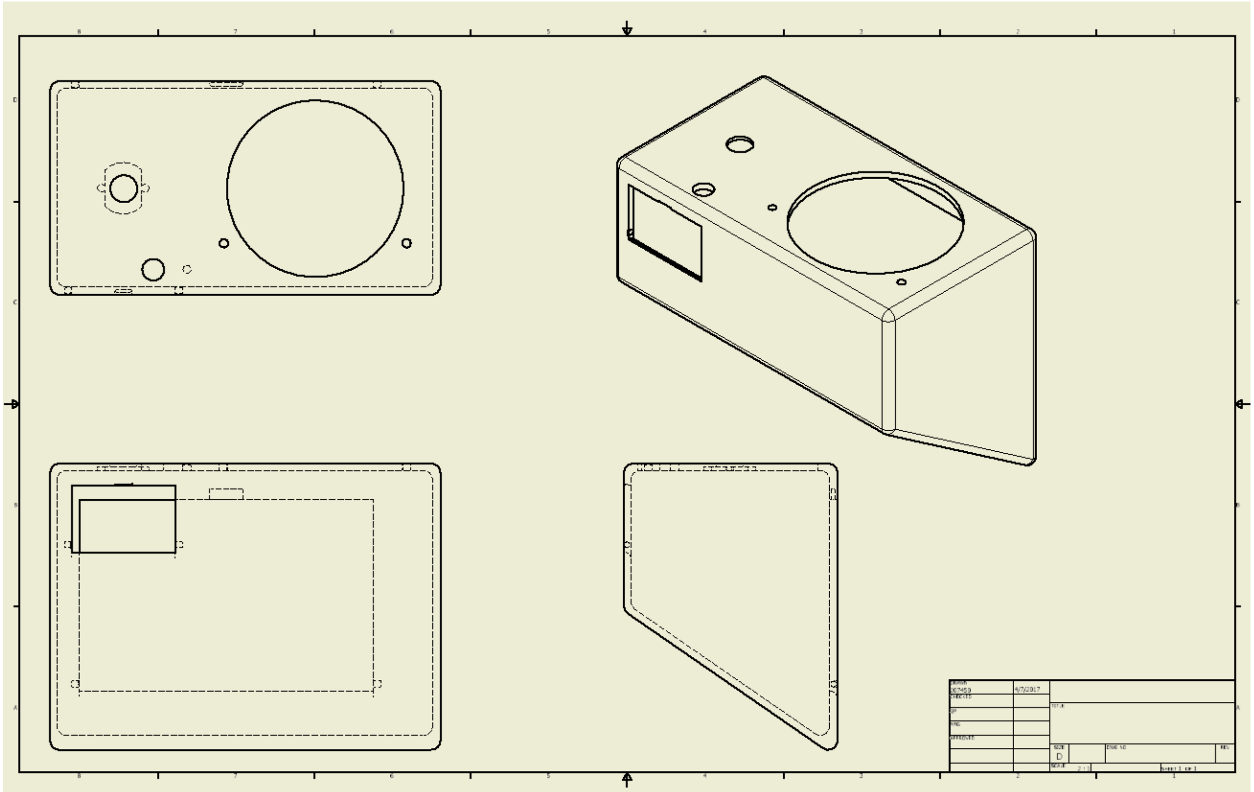
Schematic 3



Dissusion:

When we first started to do calculations for the shunts and multipliers we didn't know that their were specific values we had to use so we ended up having to redo our whole calculation.

Conclusion: In order to design our three circuits first had to calculate our resistor values as shown in **equations 1-7** then to create our schematics we put the shunts in parallel for the ammeter as shown in **schematic 3,** for the voltmeter we put the multipliers in series **schematic 2,** and the ohmmeter was a combination of multipliers,shunts, and a potentiometer shown in **schematic 1**. A potentiometer is used in an ohm meter to zero the meter because of changes in the voltage source.



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SHEET 1 OF 1