Lab 1 Progress

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1 Introduction

In this lab, we familiarized ourselves with the Analog Discovery 2 and a Mastech multimeter and measured the internal resistances of the voltmeters in the Analog Discovery 2 and the multimeter's voltmeter as well as the internal resistance of the multimeter's ammeter. We also analyzed the I-V curves of diodes and LEDs.

2 Active Discovery 2 Calibration

First, we used the built-in calibration in the "Waveforms" program to calibrate the waveform generator, oscilloscope, and positive and negative supplies of the Active Discovery 2 by following this guide from Diligent https://digilent.com/reference/instrumentation/guides/waveforms-calibration.

3 Voltmeter Internal Resistance

We next measured the internal resistance of the voltmeter portion of the Mastech multimeter. To begin with we measured the resistance of five resistors because the reported resistance may not be accurate. Next, we created a circuit with the voltmeter in series with one of the measured resistors as shown in Figure 1. Once the circuit was set up, we recorded the voltage measured by the voltmeter for each of the previously measured resistors. Next, we followed the same procedure with the Analog Discovery 2 using five different resistors because, while we recorded the resistances, we did not physically separate the ones that we used for the Mastech voltmeter, so it would be much more effort than it is worth to find the exact ones that were used before. The internal resistances were calculated using the formula $R_{int} = \frac{V_m}{5V - V_m} R$, which was derived by us, where V_m is the voltage measured by the voltmeter and R is the measured value of the resistor.

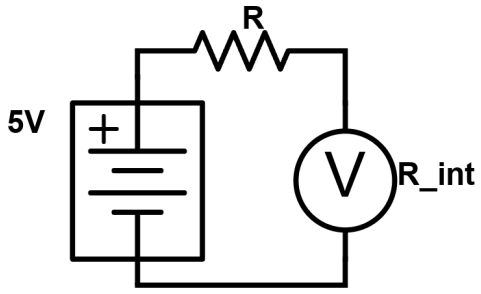

Figure 1: Internal Resistance of a Voltmeter

R (Ω)	V_m (V)	R_{int} (MΩ)
1.19	5.00	N/A
10.5	5.00	N/A
1.51×10^8	4.93	10.61
4.61×10^8	4.78	10.02
8.29×10^9	2.86	11.08
Average		10.57

Table 1: Mastech Voltmeter Internal Resistance

R (Ω)	V_m (V)	R_{int} (MΩ)
1.51×10^8	4.366	1.04
2.20×10^8	4.128	1.04
3.30×10^8	3.794	1.04
5.71×10^9	0.768	1.04
9.95×10^9	0.470	1.03
Average		1.04

Table 2: Analog Discovery 2 Oscilliscope Internal Resistance

The first two resistors had resistances that were too small compared to the internal resistances of the voltmeter, so the voltage drop across that resistor did not affect the reading of the voltmeter. The internal resistance of the Mastech voltmeter was measured to be 10.57 MΩ. The internal resistance of the Active Discovery 2 oscilloscope was measured to be 1.04 MΩ. The first two resistors had resistances that were too small compared to the internal resistances of the voltmeter, so the voltage drop across that resistor did not affect the reading of the voltmeter.

4 Ammeter Internal Resistance

After measuring the internal resistance of the two voltmeters we measured the internal resistance of the ammeter portion of the Mastech multimeter. Two resistors, R_0 and R_1 were connected in series and the ammeter was connected in parallel to R_1. One resistor, R_0 was chosen such that it was resistant enough to limit the overall current and prevent the resistors from being burnt out. The value of R_0 was measured to be 220.5 Ω. Next, the current through the circuit was measured with five different resistors in the place of R_1. The resistance of each of these resistors was measured and recorded before being used in the circuit. The internal resistance was found by solving the system of equations

$$\begin{aligned} I_1 + I_2 &= I_0 \\ 5V - I_0 \cdot R_0 - I_1 \cdot R_1 &= 0 \\ I_2 \cdot R_{int} - I_1 \cdot R_1 &= 0 \end{aligned}$$

for R_{int}. This was done using row reduction on a matrix created from the known values.

R_1 (Ω)	I_2 (mA)	R_{int} (Ω)
1.41	2.68	11.85
2.63	5.04	21.99
5.24	9.31	12.47
7.38	10.75	15.95
10.69	13.10	17.65
Average		15.97

Table 3: Mastech Ammeter Internal Resistance

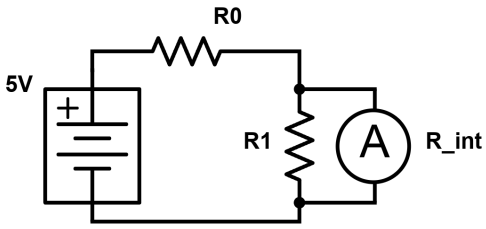

Figure 2: Internal Resistance of an Ammeter

In conclusion, the internal resistance of the Mastech ammeter was measured to be 15.97 Ω. This seems reasonable because the ammeter should have a low internal resistance but it cannot be zero.

5 I-V Curves of Electrical Components

In the second part of the lab, we measured the I-V curves of LED lights, diodes, and a resistor, which are shown in Figure 3. The circuit was set up with an oscilloscope measuring the voltage drop across a 1 kΩresistor and another measuring the voltage drop across a diode, as in Figure 4.

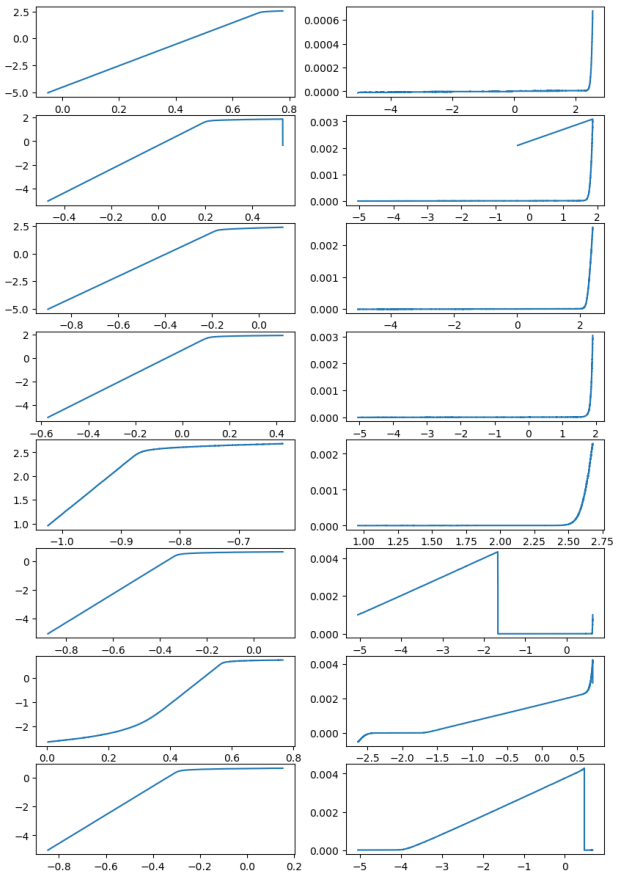

Figure 3: I-V Curves

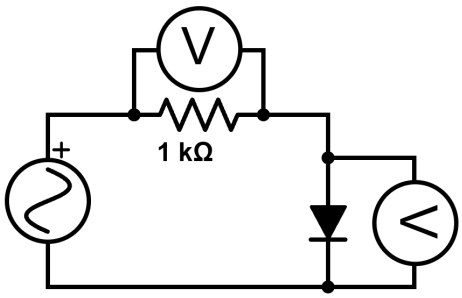

Figure 4: Measuring the I-V Curve of a Diode

6 Things I Learned

- I had used a breadboard before but not very extensively, so I learned ways of keeping the circuit organized and how to make them easy to adjust in ways I know they will need to be adjusted. For example, placing a resistor in an easily accessible location because I know it will need to be swapped out.
- I learned how to navigate and use the Waveforms software.
- This lab also helped develop my intuition about how circuits work in general and the different effects that components in series or parallel can have.
- I helped Audrey and Ryan on the bench behind mine with troubleshooting their circuits and also with using the Waveforms software.