Mario Palacios and Andrew Peterson

California State University: Sacramento

Lab 2: Calculation of Internal Resistance of Voltmeter, Ammeter, and Scope

EEE 117 Lab – Section 04: Tuesday, 4:30pm – 7:10pm

Abstract:

The objective of this lab is to study the internal resistance of the Voltmeter, Ammeter, and Probes. We do this by designing a circuit with resistors of our choice, in which we would apply KVL, KCL, and Voltage Division; to measure the internal resistance of the various meters. The instruments are not considered ideal and have an internal impedance which may have an impact on the signal and measurements of the circuit. As a result we must perform circuit analysis to see if the measurements taken are within the expected range of values.

Introduction:

When recording measurements from a circuit design the values recorded are passed through an internal resistance that would give you the current or voltage passing through a circuit. It is important to know how much internal resistance the various instruments being used have. In order to measure the internal resistance of the Voltmeter, Ammeter, and Oscilloscope Probes; a circuit created by the student needs to be created. The circuit can be in series or parallel but must have some loading. The load resistor should be higher than the internal resistance of the supply circuit. The meter circuit should be connected to the output port of the circuit whose measurements are to be made.

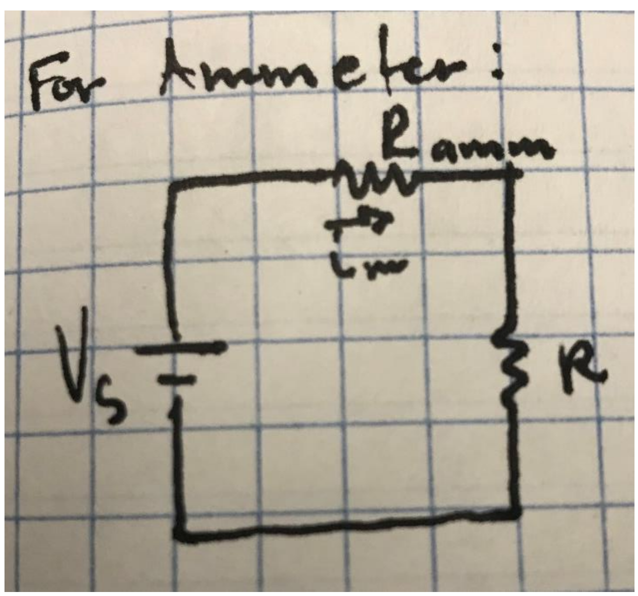

Figure 1. Circuit Design for Ammeter

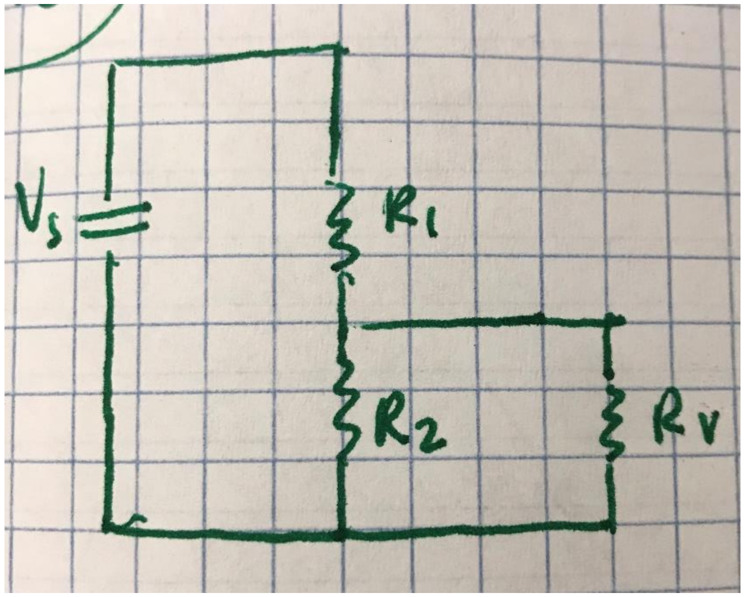

Figure 2. Circuit Diagram with Resistance Load

Simulations and Data Collection:

In order to get the measurements, a circuit of the students' choice needs to be created. It may have a source and its internal resistance in series or parallel with some loading. KCL, KVL, and Voltage Division should be applicable to the circuit. The model should include the Voltmeter, Ammeter, and Oscilloscope Probe, and the analysis done will calculate the value of internal resistance. To measure the voltage across the Ammeter, the circuit design should incorporate the Ammeter in series with a resistor, refer to Figure 1. We chose to use a DC voltage source of 1V and a 10 Ω resistor for the circuit.

	Theoretical	Measured	Percent Error
Resistor (Ω)	10 Ω	10.112 Ω	1.12%
Current (A)	0.0989 A	0.06415	35.14%
Resistance (Ammeter)	1 – 10 Ω	5.476 Ω	---

Table 1. Measurements of Ammeter from Figure 1

The steps taken to record the values from the ammeter will be repeated but instead of using circuit diagram found on Figure 1, we will be using the one found on Figure 2. The circuit diagram will be used for the remainder of the lab, to collect measurements on the Voltmeter, X1 probe, X10 probe. The DC voltage source of 1v will remain the same. The value of both resistors were 910k Ω. For this part we also used Voltage Division to measure the internal resistance of the Voltmeter and Oscilloscope Probes. The resistors will be connected in series and the load resistor will be connected in parallel with the second resistor.

	Theoretical	Measured	Percent Error
Resistor 1 (Ω)	910k Ω	903.6k Ω	0.7%
Resistor 2 (Ω)	910k Ω	904k Ω	0.66%
Voltmeter Resistance (Ω)	10M Ω	10.15M Ω	0.92%
Vs_Voltmeter (V)	1 V	1 V	0%
Vr_Voltmeter (V)	0.5001 V	0.4788 V	4.26%

Table 2. Measurements of Voltmeter

	Theoretical	Measured	Percent Error
Resistor 1 (Ω)	910k Ω	903.6k Ω	0.7%
Resistor 2 (Ω)	910k Ω	904k Ω	0.66%
X1 Resistance (Ω)	1M Ω	1.005M Ω	0.51%
Vs_X1 (V)	1 V	1 V	0%
Vr_x1 (V)	0.5001 V	0.345 V	31.01%

Table 3. Measurements of X1 Oscilloscope Probe

	Theoretical	Measured	Percent Error
Resistor 1 (Ω)	910k Ω	903.6 Ω	0.7%
Resistor 2 (Ω)	910k Ω	904 Ω	0.66%
X10 Resistance (Ω)	10M Ω	10.785M Ω	7.86%
Vs_X10 (V)	1 V	1 V	0%
Vr_X10 (V)	0.5001 V	0.48 V	4.02%

Table 4. Measurements of X10 Oscilloscope Probe

Results and Calculations:

When looking at what the internal resistance for the Ammeter, the circuit diagram used can be found in Figure 1. The resistor used was 10 Ω, the internal resistance is in the range of $1\Omega \leq R_{amm} \leq 10\Omega$. Using ohms law we predicted that the current passing through the system is 0.0989 Amps. The measurements we collected we found out that the internal resistance of the Ammeter was 5.746 Ω, falling within the range given to us. The calculations can be found below (Figure 3).

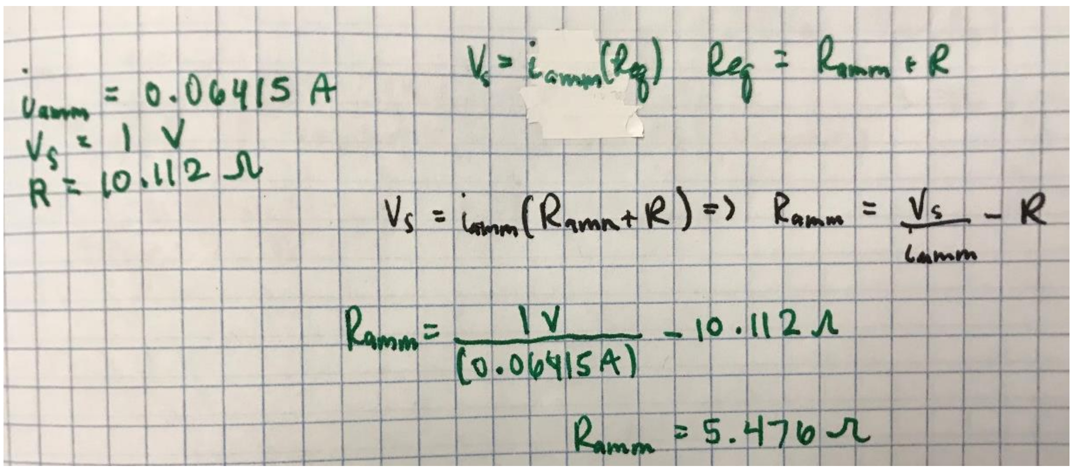

Figure 3. Calculation of Internal Resistance of Ammeter

For the remainder of the lab, the circuit diagram used can be found on Figure 2. The results for the Voltmeter can be found in Table 2. After some calculations, which can be seen in Figure 4, we can see how to find the internal resistance using the circuit diagram on Figure 2. For the Voltmeter, which has a 10M Ω internal resistance, we calculated an internal resistance of 10.15M Ω, giving us a percent error of 0.92%. The results for the X1 Oscilloscope Probe can be found in Table 3. The internal resistance for this instrument is 1M Ω, however with our measurements we got an internal resistance of 1.005M Ω, giving us a percent error of 0.51%. This was strange for me because the voltage across the X1 probe had a high percent error (31.01%). The results for the X10 Oscilloscope Probe can be found in Table 4. The internal resistance is supposed to be 10M Ω, but we got a measurement of 10.785M Ω, with a percent error of 7.86%.

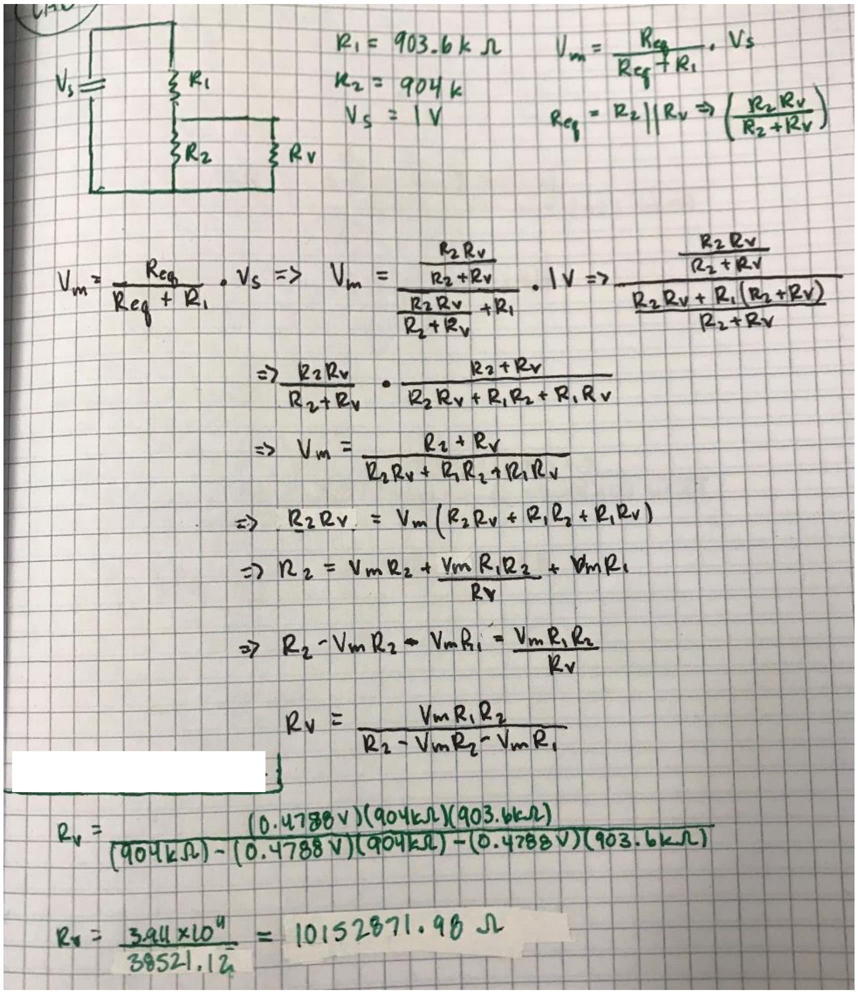

Figure 4. Calculation for Internal Resistance for Voltmeter, X1 probe, and X10 Probe

Conclusion:

In this lab we can see that when circuit analysis and voltage division is be being calculated the internal resistance of the instruments we use record are not taken into consideration. In an ideal world this is the case, however in reality the internal resistance impact the results. We confirmed that Voltage Division is a proper way to calculate the internal resistance of a measuring instrument. The high percent error found in Table 3 can be explained by the fact that our load resistance was not higher than our or internal resistance. Which impacted our value for the voltage across the X1 probe.