University of Portland
EE 271 Electrical Circuits Laboratory

Experiment: Ohm's Law

I. Objective

The objectives of this experiment are to learn how to read a resistor's color code, measure current, and measure the relationship between voltage and current for a resistor.

II. List of Components

The following components will be used in this experiment:

- One 1 kΩ resistor
- One 10 kΩ resistor

III. Background: Resistor Color Codes

Standard resistors are labeled with a color code which indicates their resistance values (see Figure 1).

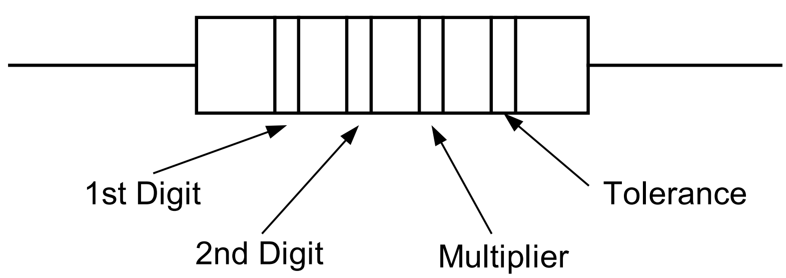


Figure 1. Resistor with 4 color bands.

The value indicated by each color band is listed in Tables 1, 2, and 3, and the resistor's value can be computed by the following equation:

$$R = \left[\left(\text{1st Digit}\right) \times 10 + \left(\text{2nd Digit}\right)\right] \times \left(\text{Multiplier}\right)$$

Table 1. 1st and 2nd bands

Color	Value
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Table 2. Multiplier band

Color	Value
Silver	0.01
Gold	0.1
Black	1
Brown	10
Red	100
Orange	1 k
Yellow	10 k
Green	100 k
Blue	1 M
Violet	10 M
Gray	100 M

Table 3. Tolerance band

Color	Tolerance
Red	2%
Gold	5%
Silver	10%
none	20%

Consider, for example, a resistor that has the following color bands: brown, green, orange, and silver. We first recognize that the silver band must be the tolerance band since the 1st Digit cannot be silver (see Tables 1 and 3). So the brown band must be the 1st band, which indicates that the value of the 1st Digit equals 1 (see Table 1). The second band, then, is green, which indicates that the value of the 2nd Digit equals 5 (see Table 1). The multiplier band is orange which indicates a value of 1 k (see Table 2). So the value of this resistor is $R = \left[(1)\times 10 + (5)\right]\times 1\text{k} = 15 \ \text{k}\Omega$. Furthermore, the silver tolerance band indicates that the actual value of the resistance might deviate by $\pm 10\%$ (see Table 3).

A resistor with the bands red, violet, red, gold, would have a value of $R = \left[(2)\times 10 + (7)\right]\times 100 = 2700 \ \Omega \ = \ 2.7 \ \text{k}\Omega$ with a tolerance of $\pm 5\%$.

A resistor with the bands orange, orange, brown, gold, would have a value of $R = \left[(3)\times 10 + (3)\right]\times 10 = 330 \ \Omega$ with a tolerance of $\pm 5\%$.

You might think that a 5000 Ω resistor with a tolerance of $\pm 5\%$ could have the bands black, green, orange, gold because R = [(0)x10 + (5)]x1000 = 5000 Ω, but <u>the first band will never be black</u>, so a 5000 Ω resistor with a tolerance of $\pm 5\%$ would actually have the bands green, black, red, gold because R = [(5)x10 + (0)]x100 = 5000 Ω.

IV. Prelab Assignment

1. Determine the color bands for a 1 kΩ and 10 kΩ, resistor with 5% tolerance.

Table 4. Color codes for the 1 kΩ and 10 kΩ resistors.

R (kΩ)	First	Second	Third	Fourth
1				
10				

2. Read the Analog Discovery Tutorial – Part 1. Download and install the software.

V. Procedure

Part 1: Set up the Analog Discovery Power Supply

Connect the Analog Discovery's V+ Power Supply and Ground to the breadboard as shown in Figure 2 (see Analog Discovery tutorial). Launch the WaveForms software and set the power supply to 1V. Measure the power supply voltage with your DMM.

Measured power supply voltage: ____________

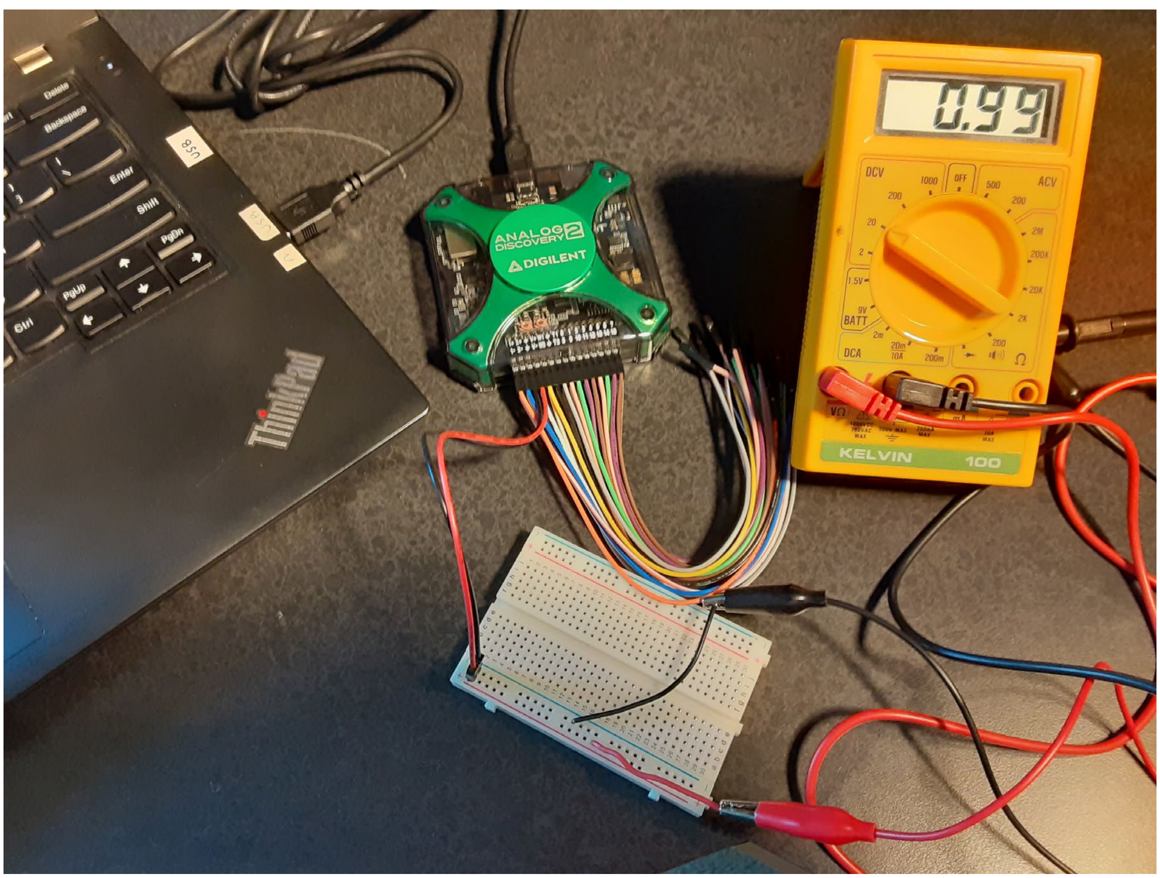


Figure 2: Using Analog Discovery's Power Supply

Part 2: Measure the Current through a 1 kΩ Resistor

Before we use a resistor, it is good practice to measure its value. It is very easy to misread the color code, and measuring the value of each resistor is an easy way to check to make sure that you have the correct value. Also, resistance cannot be measured properly once the resistor is connected in a circuit, so checking the resistor values after building the circuit is inconvenient.

Use the DMM to measure the resistance of the 1 kΩ resistor: _______________

Compute the $\% \, error = \frac{Theoretical - Measured}{Theoretical} x100$ = ______________

Is the absolute value of the % error less than the 5% tolerance? _________

Next we will construct the circuit in Figure 3 to measure the current through a resistor where R = 1 kΩ and V = 1V. It is good practice to turn off the power supply while you construct or modify circuits.

In order to measure current, the DMM must be placed in series with the resistor (see DMM tutorial). When the DMM is used to measure current, it behaves like a short circuit, so be careful NOT to short out the power supply by connecting the DMM directly across the power supply. Doing so may burn out a fuse in your DMM. If your DMM always displays close to 0A when you measure current, the fuse may be burned out or it may be connected improperly.

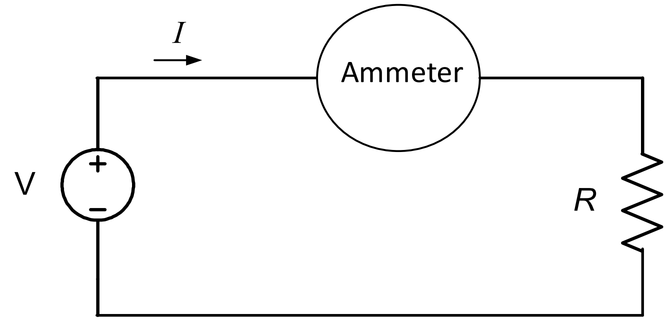


Figure 3: Circuit to Measure I and V

Your circuit should look something like Figure 4. For this particular circuit, it is a good idea to have your instructor check your circuit BEFORE turning on the power supply.

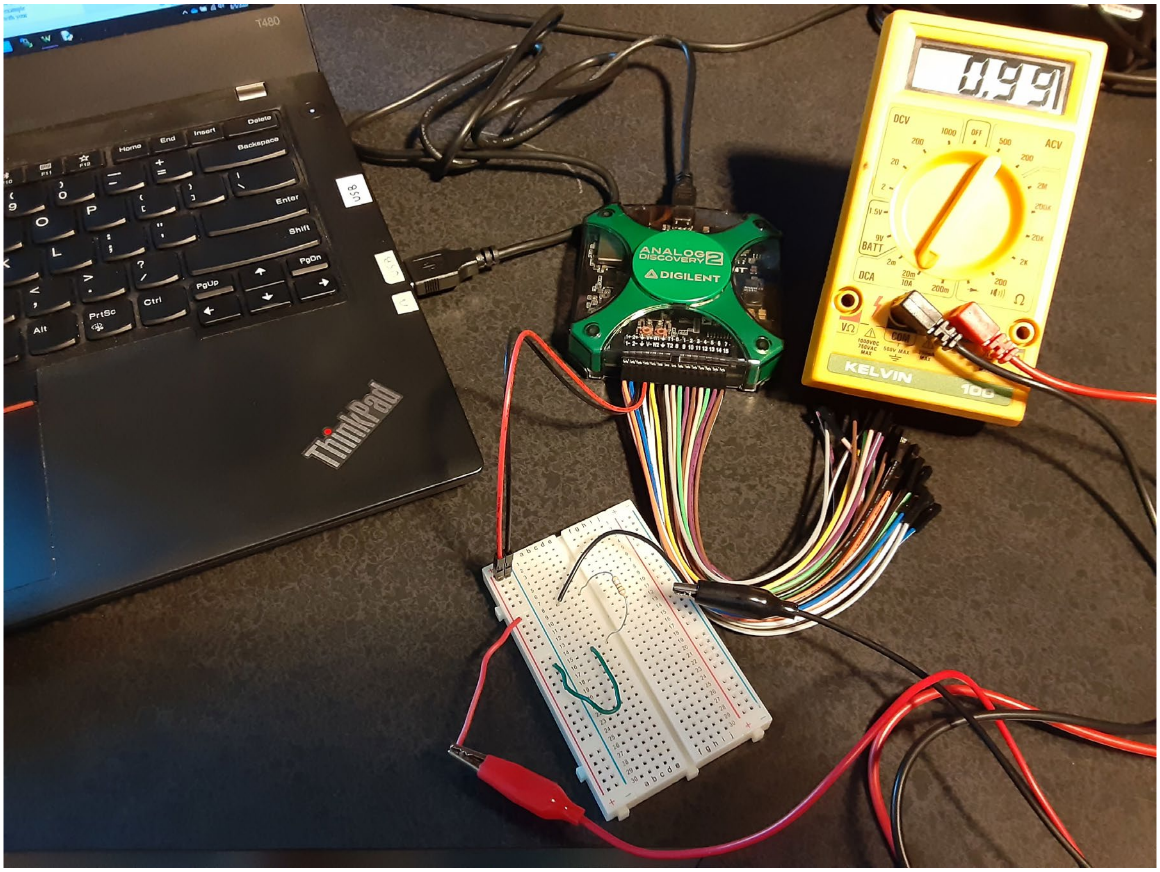


Figure 4: Measuring Current through a Resistor

Once you are convinced that the circuit is connected properly, turn on the power supply, adjust the voltage to 1V, and measure the current I.

Measured Current: _________

Compute the $\%\ error = \frac{Theoretical - Measured}{Theoretical} x100$ = ______________

Part 3: Measure the Relationship Between Voltage and Current in a Resistor

Using the circuit from Figure 3, change the power supply voltage to several values between 0 and 5V and record the resulting current I for each voltage (you will need at least 6 or so values for a decent graph).

V (Volts)	I (Amps)

Use MATLAB (or your favorite software) to graph your measured voltages (on the vertical axis) versus current (on the horizontal axis) and the best fit line. An example using MATLAB is shown below (replace the values of voltage and current with your measured values).

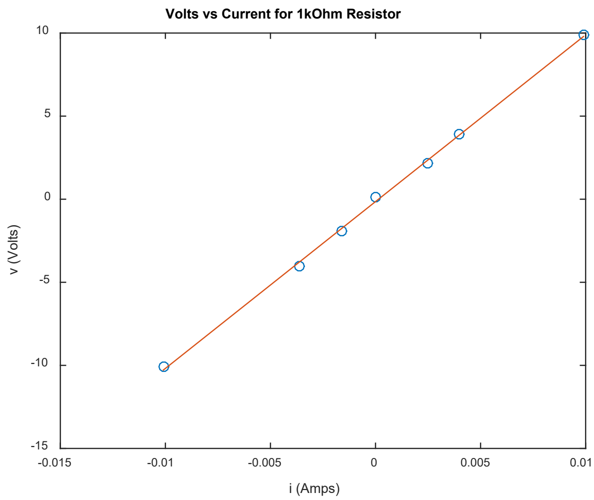
```
% Measured voltage(V) (replace with your values)
v = [-10.1 -4.0 -1.9 0.1 2.2 3.9 9.9];

% Measured current(A) (replace with your values)
i = [-0.0101 -0.0036 -0.0016 0.00 0.0025 0.0040
0.0099];

% Compute 1st degree polynomial fit
c = polyfit(i,v,1)

% Compute best fit line
% c(1) is the slope for example data
% c(2) is the intercept for example data
vfit = c(1)*i + c(2);

% Plot measured values with circles
% and plot best fit line
plot(i,v,'o',i,vfit)
```



Write the equation for the best fit line that you found for the 1 kΩ resistor: __________

Write the slope that you found for the 1 kΩ resistor: ______________

How is the resistance related to the slope of the best fit line? __________________

Part 4: Series Resistances

Resistors are manufactured in a variety of standard values, but sometimes we need a resistance that is not a standard value. In this case, we can often combine two or more resistors in series (or parallel) to achieve the desired value.

Use the DMM to measure the resistance of the 10 kΩ resistor: _______________

Compute the $\% \; error = \frac{Theoretical - Measured}{Theoretical} x100$ = ______________

Is the absolute value of the % error less than the 5% tolerance? _________

Connect the 1 kΩ resistor in series with the 10 kΩ resistor and measure the resistance of the series combination (see Figure 5). Compare the resistance of the series combination to the measured values of each resistor.

How does connecting resistors in series affect the resistance? _____________________

Does connecting two (or more) resistors in series increase or decrease the resistance? ___

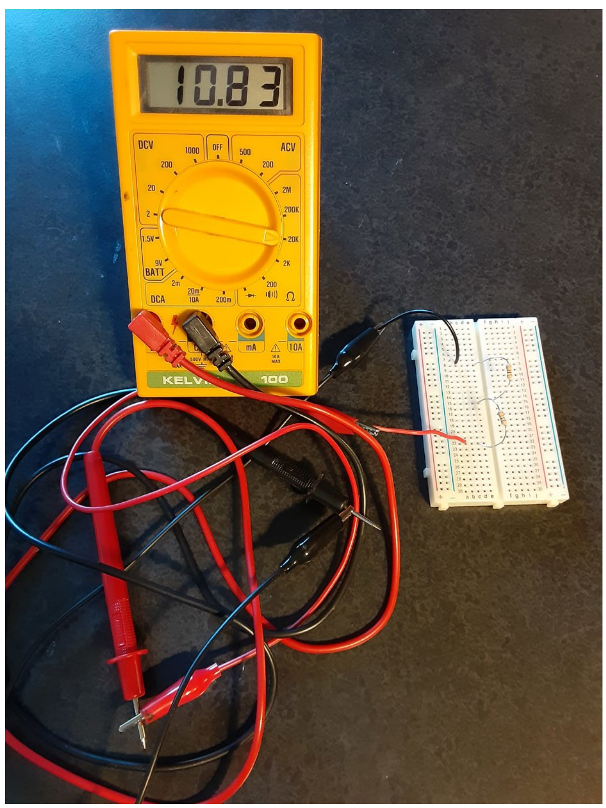


Figure 5: Measuring Series Resistors

Part 5: Parallel Resistances

Connect the 1 kΩ resistor in parallel with the 10 kΩ resistor and measure the resistance of the parallel combination (see Figure 6). Compare the resistance of the parallel combination to the measured values of each resistor.

How does connecting resistors in parallel affect the resistance? ______________________

Does connecting two (or more) resistors in parallel increase or decrease the resistance?

____

Figure 6: Measuring Parallel Resistors

VI. Conclusion

Write a paragraph that summarizes what you have learned in this lab. Describe the relationship between voltage and current in a resistor (which is called Ohm's Law) and how the resistance is related to the graph of voltage versus current. Describe how the resistance of series and parallel resistors can be computed.