

Experiment 1: Electrical Resistance and the Resistor

Introduction

Ohm's law is the most fundamental equation in electric circuit analysis. It states that the amount of electric current flowing in a circuit is directly proportional to the voltage applied to the circuit, and inversely proportional to its resistance.

$$I = \frac{V}{R}$$

I is current in amperes, V is potential difference in volts, and R is resistance in ohms.

Resistors are used in electric circuits to control the flow of current. Resistors are commercially available which have a specific amount of resistance and power dissipation ability. The amount of resistance is usually marked on the resistor using a color code. The power dissipation is determined by the physical size of the resistor.

An "ohmmeter" is used to measure resistance. Most ohmmeters are part of an instrument that is also capable of measuring other electrical quantities, such as voltage and current. These are typically called "multi-meters", and since they usually have a digital display, they are called "digital multi-meters" or "DMMs" for short. To use the DMM you need to know how to set it to make the desired measurement (function), and how to set it for best accuracy (range).

Objectives

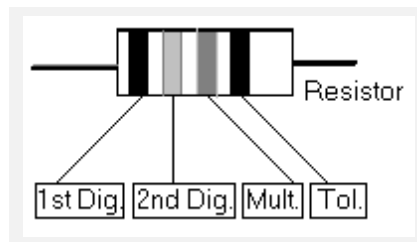
The purpose of this lab exercise is to learn how to measure resistance with the DMM. An error analysis will compare the measured resistor values to the labeled resistor values using a spreadsheet. In addition, you will measure the resistance of series and parallel combinations of resistors, and compare the results to theoretical calculations based on equations provided.

Series and parallel connections will be made using a solder-less breadboard. The object of this part of the exercise is to learn to use the breadboard. *Theoretical knowledge of series and parallel resistor connections is not expected.*

Resistance values are read using the color code given below.

Standard Resistor Color Code

Color	Value	Color	Value
Black	0	Blue	6
Brown	1	Violet	7
Red	2	Gray	8
Orange	3	White	9
Yellow	4	Gold	0.1 / 5%
Green	5	Silver	0.01 / 10%



This color code is for "standard" resistors with an accuracy rating, or "tolerance", of $\pm 5\%$ or $\pm 10\%$. That is, their value is guaranteed to be within $\pm 5\%$ or $\pm 10\%$ of their labeled value.

Their colors are read from left to right. The first two color bands represent the first two significant digits of the resistor value. The color of the third band represents a multiplier of 10^N , where N is the value represented by the color.

The fourth band is always gold or silver, which indicates a tolerance of $\pm 5\%$ or $\pm 10\%$. The first band is never gold or silver. *So to read a resistor's value correctly, the gold or silver band must be on the right.*

For example, a resistor whose first band is red, second band is yellow, third band is orange, and fourth band is gold, has a value of 24,000 ohms (24×10^3), and a tolerance of 5%.

Resistance Measurement

A digital multi-meter (DMM) will be used for measuring the resistance values. The instructor may explain the operation of the instrument before you use it for the first time. You may also check to see if an instruction manual is available for the instrument. The DMM may have buttons and/or switches to its function and range.

Set the function to "OHMS". Some meters are capable of automatically setting the range to get the most accurate reading, which is related to the number of significant digits displayed. You should be able to get at least three significant digits of accuracy. Experiment with the range settings when making the measurements specified in the procedure below.

The power rating of each resistor is determined by its physical size. Smaller dimensions represent a smaller power handling capability. A sample of several different size resistors should be available in the lab. A very common power rating is $\frac{1}{4}$ watt. If a $\frac{1}{4}$ watt resistor dissipates more than $\frac{1}{4}$ watt it will get excessively hot and may burn out.

Procedure

Equipment and Parts

DMM and Breadboard.

Resistors: 1K, 4.7K, 10K, $\frac{1}{4}$ watt, 5% or 10% tolerance.

Part A: Measurements and the Spreadsheet

Do not touch the metal tips of the DMM probes when making measurements.

1. Use the resistor color code to select the 1K, 4.7K, and 10K resistors. Determine their tolerance. Measure the values of the resistors with the DMM to at least three significant digits.
2. Enter the results into a spreadsheet. Calculate the deviation of each resistor's measured value compared to its labeled value. Calculate the percent deviation of each resistor's measured value from its labeled value. Refer to the example on the next page. Note that starting a spreadsheet's cell with an equal sign indicates the cell contains a formula.

Use the spreadsheet layout shown below to do the calculations.

	A	B	C	D	E	F
1	Resistor	Labeled Val.	Measured Val.	Deviation	Labeled %	Measured %
2	1	1000				
3	2	4700				
4	3	10000				
5						
6						

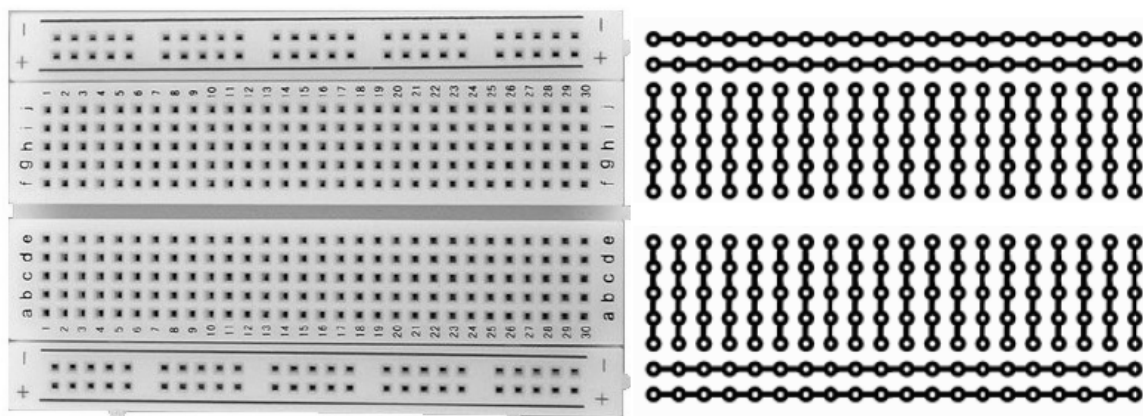
Deviation: =C2-B2 Percent deviation: =(D2/B2)*100

Enter the expression for deviation into cell D2 and percent deviation into cell E2. Use the “fill down” feature of the spreadsheet to calculate rows 3 and 4.

Part B: Series and Parallel Connections

Before starting this exercise (and the other exercises in this manual) you need to have a way of connecting electronic parts together into a circuit. An easy and very common method to quickly connect parts together is to use the “solder-less breadboard”, also called a “prototyping board” or “protoboard”. The board has holes 0.1 inches apart into which component leads can be inserted.

Solder-less breadboards are available from a variety of manufacturers and sources, in a variety of sizes, but they all have the same arrangement of the holes and connections



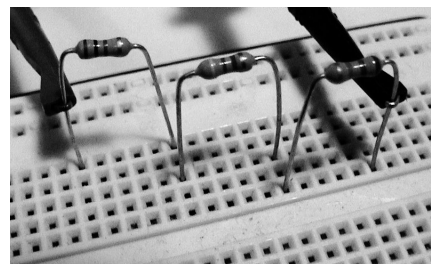
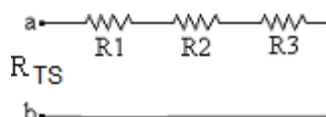
The picture above on the left shows a typical breadboard. Components such as resistors, capacitors, transistors, integrated circuits, and wires can be plugged into it. The picture above on the right shows how the holes are connected. You should memorize these connections.

Components such as resistors can be connected in series, parallel, and in a combination of series and parallel. The following exercises show how to connect resistors in series and parallel, and how to measure the resistance of the series and parallel combinations.

The measurements will be compared to the theoretically expected values using the equations provided. If a measurement does not agree with the calculation, check the breadboard connections and the labeled values of the resistors.

1. Connect your 1K, 4.7K and 10K resistors in series. Measure the resistance, R_{TS} , of the combination as shown in the circuit's schematic diagram below. A connection example is shown on the right.

Ohmmeter leads connect between points a and b.



$R_{TS} =$ _____ (measured total series resistance)

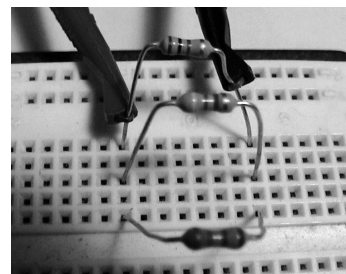
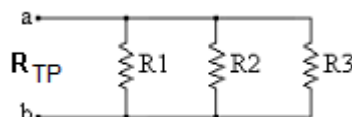
2. Calculate the theoretical resistance of this series combination as given the equation:

$$R_{TS} = R1 + R2 + R3.$$

Use the measured values of the resistors from part A. Enter the equation into your spreadsheet and have the spreadsheet do the calculation. Also enter the measured value into the spreadsheet as shown in the example spreadsheet on the next page.

3. Connect the 1K, 4.7K and 10K resistors in parallel as shown in the diagram below and picture on the right. Measure the resistance, R_{TP} , of the parallel combination.

Ohmmeter leads are connected between points a and b.



$R_{TP} =$ _____ (measured total parallel resistance)

4. Calculate the resistance of this parallel combination using the equation below.

$$\frac{1}{R_{TP}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \quad \text{so that} \quad R_{TP} = \frac{1}{\left(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\right)}$$

Use the measured values of the resistors from part A. Enter the equation into your spreadsheet and have the spreadsheet do the calculation. Also enter the measured value of the series resistance and the measured value of parallel resistance into the spreadsheet as shown in the example spreadsheet below.

	A	B	C	D	E	F
1	Resistor	Labeled Val.	Measured Val.	Deviation	Labeled %	Measured %
2	1	1000	996	-4	0.05	-0.4
3	2	4700	4760	60	0.05	1.276595745
4	3	10000	9720	-280	0.05	-2.8
5						
6						
7		Calculated Val.	Measured Val.	Deviation	% Deviation	
8	Series	15476	15390	-86	-0.555699147	
9	Parallel	759.3125376	762.2	2.8874624	0.380273246	

Equation in B8: =C2+C3+C4

Equation in B9: =1/(1/C2+1/C3+1/C4)

LAB REPORT

1. Open a word processor document and save it as: "Experiment 1 Report". Use the following format:

Student name and lab partner name (if applicable).

Course number: Lab experiment number and name.

Example:

George Jones and Sally Smith

EET111: EXPERIMENT 1: Electrical Resistance and the Resistor

2. Copy your spreadsheet results and paste them into the document.

The instructor will specify how to turn in the report. You may just need to show the resulting document on the lab computer, or the instructor may also ask for additional analysis, including a more comprehensive lab report.

History Note:

Georg Simon Ohm (17 March 1789 – 6 July 1854) was a German physicist. As a high school teacher, Ohm began his research with the recently invented electrochemical cell, invented by Italian Count Alessandro Volta. Using equipment of his own creation, Ohm determined that there is a direct proportionality between the potential difference (voltage) applied across a conductor and the resultant electric current. This relationship is now known as Ohm's law.

[From Wikipedia, the free encyclopedia](#)

