

1.3.1: Resistors and Ohms Law – Resistance Variations

Overview:

In this lab, we will experimentally explore the characteristics of resistors. Resistance is measured using an ohmmeter; this measured resistance is compared to a voltage-current characteristic curve measured for the resistor. Some basic statistical data analysis methods are introduced briefly in this lab assignment. MATLAB commands used to perform basic statistical analysis of data are provided in the background material related to this lab assignment.

Before beginning this lab, you should be able to:

- State Ohm's law from memory
- Use a digital multimeter to measure resistance and voltage (Labs 1.1, 1.2.1)
- Use color codes on resistors to determine the resistor's nominal resistance

After completing this lab, you should be able to:

- Calculate the mean, median, and standard deviation values of a set of data

This lab exercise requires:

- Digilent Analog Parts Kit
- Digital multimeter (DMM)

Symbol Key:

DEMO	Demonstrate circuit operation to teaching assistant; teaching assistant should initial lab notebook and grade sheet, indicating that circuit operation is acceptable.
ANALYSIS	Analysis; include principle results of analysis in laboratory report.
SIM	Numerical simulation (using PSPICE or MATLAB as indicated); include results of MATLAB numerical analysis and/or simulation in laboratory report.
DATA	Record data in your lab notebook.

General Discussion:

Fixed resistors are fabricated with a nominal resistance value. Individual resistors will, in general, not have exactly this resistance – their actual resistance will vary from this nominal value to some extent. In this portion of the lab assignment, we will measure the resistance of several resistors which all have the same nominal resistance, in order to determine the actual resistor-to-resistor resistance variations. These variations will be compared with the manufacturer's specified tolerances.

Important Note:

Since the resistance of individual resistors will vary from the value specified by the manufacturer, it is generally important, when incorporating a resistor in a circuit, to measure the resistor's actual resistance and record that value in your laboratory notebook when you are constructing a circuit. It is possible that the variations in resistance can affect your experimental results.

We will use *statistical analyses* to in this section to examine variations in resistors' resistances. Statistics are a way to quantify variations in results which are due to random effects such as variations in manufacturing, uncertainty in measured quantities, and measurement noise.

Related information:

Some basic information relative to common statistical quantities used to characterize data is provided in Appendix A of this experiment. Basic MATLAB commands which can be used to perform these statistical analyses are also provided in this Appendix.

Pre-lab: None

Lab Procedures:

DATA

1. Pick five (5) 2.2K Ω resistors from your analog parts kit. Using an ohmmeter, measure the resistance of each of the resistors and record the values in your lab notebook. Calculate the mean, median, and standard deviation of the resistance values and record these quantities in your lab notebook. Convert these values to percentages of the nominal resistance, and record these results in your lab notebook. Determine the manufacturer's tolerance on the resistance values of the resistance and comment on whether your resistors lie within the specified tolerance.

DATA

2. Repeat procedure 1 above with five (5) 47K Ω resistors.

Appendix A – Basic Statistics

In this appendix, we briefly present some common statistical values used to characterize data which have some random component. We will also present MATLAB commands which can be used to determine these values.

Mean value:

If we have N sample values, $\{y_1, y_2, \dots, y_N\}$, we can determine the mean of the values by the following expression:

$$\bar{y} = \frac{1}{N} (y_1 + y_2 + y_3 + \dots + y_N) = \frac{1}{N} \sum_{i=1}^N y_i \quad (1)$$

Thus, the mean can be determined by summing all the sample values and dividing by the total number values. It is essentially what we do when we determine an *average* of a series of values.

Median value:

The median value of a set of N sample values $\{y_1, y_2, \dots, y_N\}$ is the value which has the same number of samples above the value as there are below the value. This definition, however, does not necessarily uniquely determine the median value of a set of numbers. We will, therefore, refine our definition as follows:

- If N is an odd number, sort the data so that they are ordered from smallest to largest. The median value is then the middle data value.
- If N is an even number, again sort the data so that they are ordered from smallest to largest. There is no value exactly at the middle of the resulting sequence, so we choose the median value as the mean of the middle two numbers.

Standard deviation:

The standard deviation of a set of values $\{y_1, y_2, \dots, y_N\}$ can be thought of as the amount of “spread” that the numbers have from their mean value. Thus, the standard deviation provides an indication as to how closely grouped the values are around their mean. The definition of standard deviation that we will use is:

$$s = \frac{1}{N-1} \sqrt{\sum_{i=1}^N (y_i - \bar{y})^2} \quad (2)$$

where s is the standard deviation and $\bar{y}$ is the mean of the values, as defined above. The positive square root is used in the calculation, so that s is always represented as a positive number. Some textbooks use an alternate version of the standard deviation; we will exclusively use equation (2). When using a software package to perform statistical analyses, always check the definition of standard deviation that is used.

MATLAB syntax:

If the variable **y** has been defined as a vector of numbers in the workspace, the following MATLAB syntax will calculate the mean, median, and standard deviation of the numbers.

- Mean: **mean(y)**
- Median: **median(y)**
- Standard Deviation: **std(y)**