

First name

Date

Last name

Degree program name

Exercise 140: Ohm's law

Table I: Determination of resistance

	<u>Designated resistance</u> [Ω]		
<u>Resistor 1</u>		<u>Calculated resistance</u> [Ω]	<u>Percentage difference</u> [%]
<u>Resistor 2</u>			
<u>Series connection</u>			
<u>Parallel conection</u>			

Table II: Filament resistance of the bulb

	Resistance at frequency 0,3 Hz	
	Minimum	Maximum
Resistance at frequency 60 Hz	$U = \dots\dots\dots$ V	$U = \dots\dots\dots$ V
	$I = \dots\dots\dots$ A	$I = \dots\dots\dots$ A
$R = \dots\dots\dots$ Ω	$R_{\min} = \dots\dots\dots$ Ω	$R_{\max} = \dots\dots\dots$ Ω

Exercise 140: Ohm's law

PURPOSE

The primary objective of this experiment is to investigate the current-voltage relationship in materials that either adhere to or deviate from Ohm's law.

THEORY

The graphical representation of the current passing through a metallic conductor as a function of the applied voltage typically exhibits a linear pattern. This implies that the resistance of the conductor, defined as the ratio of voltage to current, remains constant irrespective of the voltage magnitude.

$$R = \frac{U}{I} = \text{const.}$$

This principle, applicable exclusively to metallic conductors, is known as Ohm's law. We assume that the temperature of the conductor remains constant throughout the measurements. Consequently, Ohm's law holds true only for low current intensities that do not induce significant heating in the conductor, typically caused by the generation of Joule heat. In such cases, minimal heat dissipates into the surroundings, leading to only slight fluctuations in the conductor's temperature.

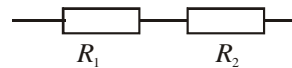
As the current intensity increases, the conductor absorbs more heat, and it can no longer dissipate all of it into the surroundings. Consequently, the conductor's temperature rises, resulting in a change in resistance.

It is worth noting that the resistance of a metallic conductor is also influenced by temperature. This phenomenon can be demonstrated by measuring the resistance of a light bulb. At high frequencies of alternating current supplied to the bulb, the filament maintains an almost constant temperature because current variations occur too rapidly to affect the temperature. Consequently, the resistance of the bulb remains stable. Conversely, at low frequencies, typically below 1 Hz, the temperature of the bulb filament fluctuates during each current cycle, leading to variations in resistance. In general, the resistance of a metallic conductor increases as the temperature rises.

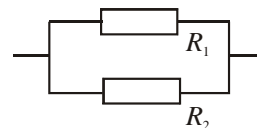
Furthermore, resistors, which are components characterized by specific resistance values, can be integrated into more complex configurations. The most basic of these connections are series and parallel connections.

In accordance with Kirchhoff's laws, the total resistance of two resistors, denoted as R_1 and R_2 , connected in series is equal to the sum of their individual resistances. Conversely, in a parallel connection, the reciprocal of the total resistance is equal to the sum of the reciprocals of the component resistances.

Series connection: $R = R_1 + R_2$.



Parallel connection: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$.



SPARKvue programme



1. **Axis Lock**
Click to lock or unlock axis scaling.
2. **Measurement Selector**
Click to change the displayed measurement or units.
3. **Axis**
Click and drag to scale each axis individually.
4. **Plot Area**
Click and drag to move the plot area.
5. **Legend**
Select a run to analyze by clicking the run in the legend. Right-click the run symbol to change the run color and other data set properties.
6. **Tools Drawer**
Click to show or hide the Graph tools.
7. **Scale to Fit**
Automatically scale the axes to fit all data from the selected run within the plot area.
8. **Cursor Mode**
Click to toggle the function of the cursor.
 - Switch to **Move Mode** to use the cursor to move the plot area.
 - Switch to **Select Mode** to highlight an area on the plot for data analysis.
9. SPARKvue provides two types of coordinates tools:
 - **Coordinates Tool**
Use to determine the coordinates of a single data point. Use the delta tool to determine the difference between two points of data.
 - **Multi-Coordinates Tool**
Use to compare coordinates across multiple runs or measurements.
10. **Slope Tool**
The slope tool provides the slope of a line tangent to a curve at a single point.
11. **Statistics**
 11. **Statistics**
Use the statistics tool to find the minimum, maximum, mean, and standard deviation of a range of data.
12. SPARKvue provides two curve fit tools:
 - **Linear Fit**
Use the linear fit tool to fit a line to data and determine the slope and y-intercept of the trend line.
 - **Curve Fit Tool**
Use the curve fit tool to fit a curve to data and obtain values about the trend line parameters.
13. **Annotation Tool**
Use the annotation tool to label a data point with a brief note.
14. Use these tools to display multiple y-axes:
 - **Add y-axis**
Display multiple measurements on the same plot area by adding additional y-axes to a line graph.
 - **Align Origins**
When displaying more than one y-axis, select to align the origins and scales of each axis.
 - **Add Plot Area**
Display an additional measurement in a line graph on separate plot area located below the current plot area.
15. **Prediction Tool**
Before collecting data, draw a prediction of the results directly on the graph.
16. **Properties**
Change the visibility of data points, symbols, and lines connecting data points in a line graph.

Figure 1) Overview and Description of the SPARKvue Program Window (Description Sourced from: <https://help.pasco.com/sparkvue>).

PASCO 550 Universal Interface

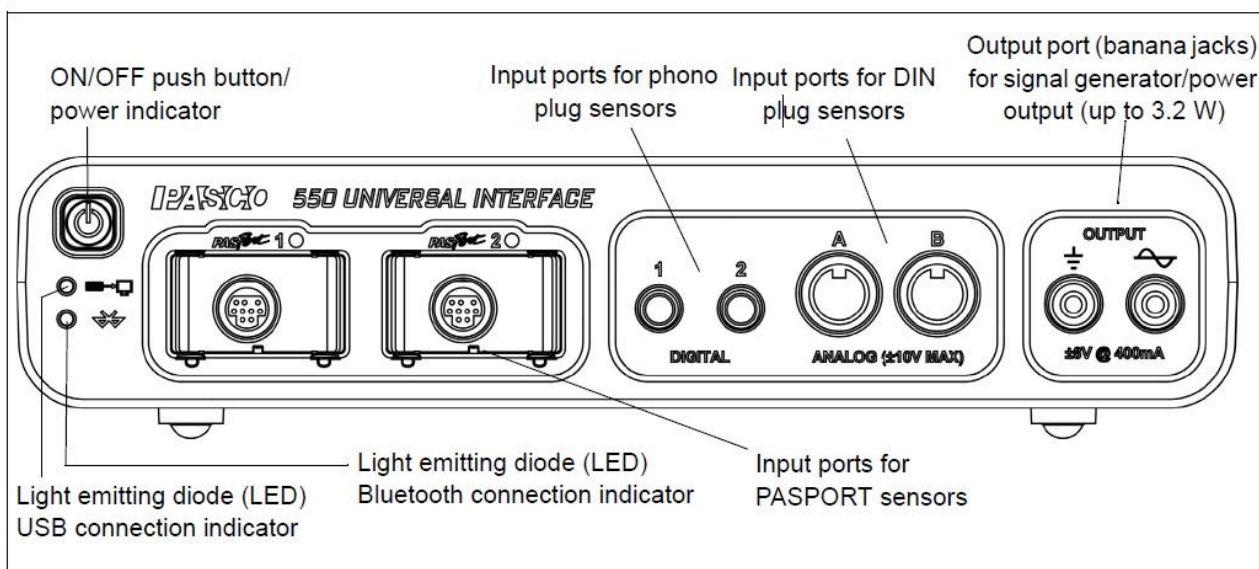


Figure 2: Depicts the PASCO interface, available at <https://www.pasco.com/products/>. This figure showcases its appearance and provides a schematic representation.

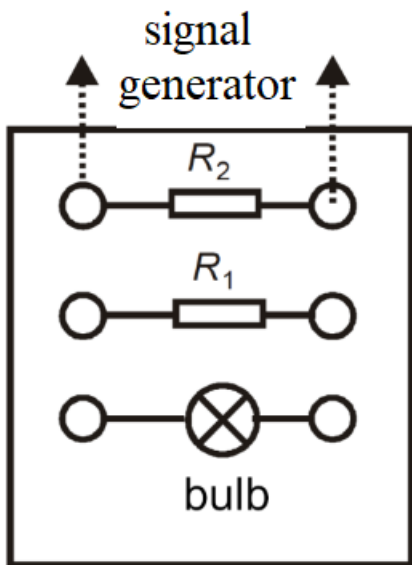


Figure 3: Illustrates a diagram featuring a box containing resistors and a bulb.

PART I A: Measuring Arrangement - Resistance of a Metallic Conductor

The resistors and the bulb are enclosed within the box illustrated in Figure 3.

1. Connect the signal generator to one of the resistors on the base using wires.

PART II A: Preparing the Computer

2. Turn on the power for the table (located on the table dashboard, to your left when sitting in front of the computer). Rotate the red "knob" in the direction of the arrows until it pops out, turn the key similarly to starting a car, and release it. Initiate the PASCO interface first, followed by starting the computer. Log in with the username "140."
3. Once the Windows operating system has fully booted up, click on the 140 application on the desktop. This action will reveal the oscilloscope main window on the right and the generator settings window on the left.
4. Configure the signal generator to produce a triangular alternating voltage with an amplitude of 2.97 V and a frequency of 60 Hz. Ensure that the "Auto" option is selected, which allows measurements to commence automatically upon pressing the "Start" button and cease after 5 seconds.

PART III A: Running and Recording Measurements – Resistor

1. Click the "Start" button in the window.
2. After 5 seconds, the measurement will conclude, and the oscilloscope window will display the voltage variation curve corresponding to the current passing through the resistor in question.

PART IV A: Data Analysis

1. Beneath the graph, locate and click on the "Tools drawer - Fig.1. no. 6" icon, then select the "Linear fit - Fig.1. no. 12" tool from the list (tool descriptions are available when you hover your mouse over them). Upon clicking this tool, the computer will automatically fit a straight line to the recorded data and display the fitting parameters.
2. Retrieve the resistance value R_1 as the slope of the fitted straight line $y = a_1 + a_2x$. As you may know, the relationship $U = R \cdot I$ is linear, and the slope of the straight line directly signifies the resistance value 'R.'
3. Perform identical measurements for the second resistance - R_2 , and for the resistors tested in series - R_2 , and in parallel - R_p .
4. Calculate the resultant resistance values as per the formulas provided in the theory section.
5. Compare the measured values with the calculated ones. Determine the percentage difference between the resultant resistance value R obtained from the graph and the calculated value

$$B_p = \frac{|R - R_o|}{R_o} \cdot 100\% .$$

PART I B: Measuring System - Filament Lamp Resistance**Measure the resistance of an incandescent light bulb filament subjected to a 60 Hz current.**

Connect the incandescent light bulb fixed within the measuring box (Figure 3) to the signal generator. Do not alter the computer settings. To measure the resistance, repeat all the steps outlined in Parts III A and IV A.

Measure the resistance of the filament in the light bulb under a 0.3 Hz current.***PART II B: Setting up the Computer***

In this segment of the exercise, adjust the amplitude and frequency of the voltage within the signal generator window.

1. Set the amplitude value to 2.5 V.
2. Set the frequency value to 0.30 Hz.

PART III B: Running and Recording Measurements - Filament of a Light Bulb

Repeat all the procedures described in Part III A.

Part IV B: Data Analysis

1. Analyze the resistance variation of the filament using the current-voltage diagram.
2. Estimate the minimum and maximum values of the resistance by reading the voltage and current values from the graph section where experimental points align along the straight line with the smallest and largest slope relative to the current axis. Utilize the "Coordinates tool" (Figure 1, No. 9) to read and record the coordinates of these points as illustrated in Figure 4. Then, input these values into the table and perform the necessary calculations.

The measurement taken on our bench still displays an initial curve (refer to Figure 5), which can be attributed to the lower 'starting' temperature of the bulb. However, it's important to note that this curve is not considered in our analysis.

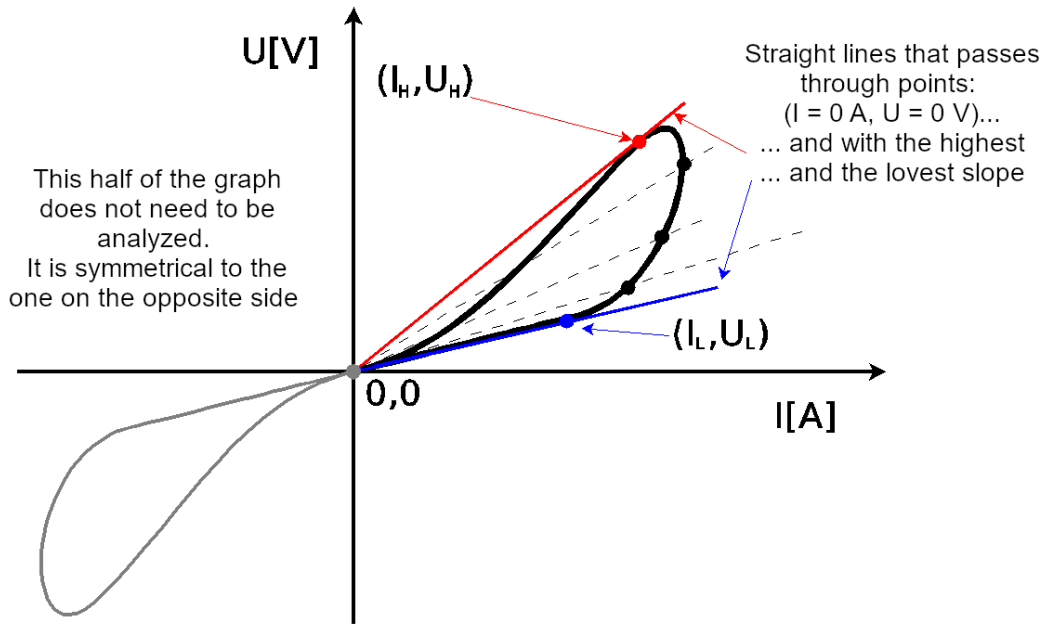


Figure 4) This graph illustrates the process of point searching to determine both the minimum and maximum resistance values of the light bulb at a flashing frequency of 0.3 Hz

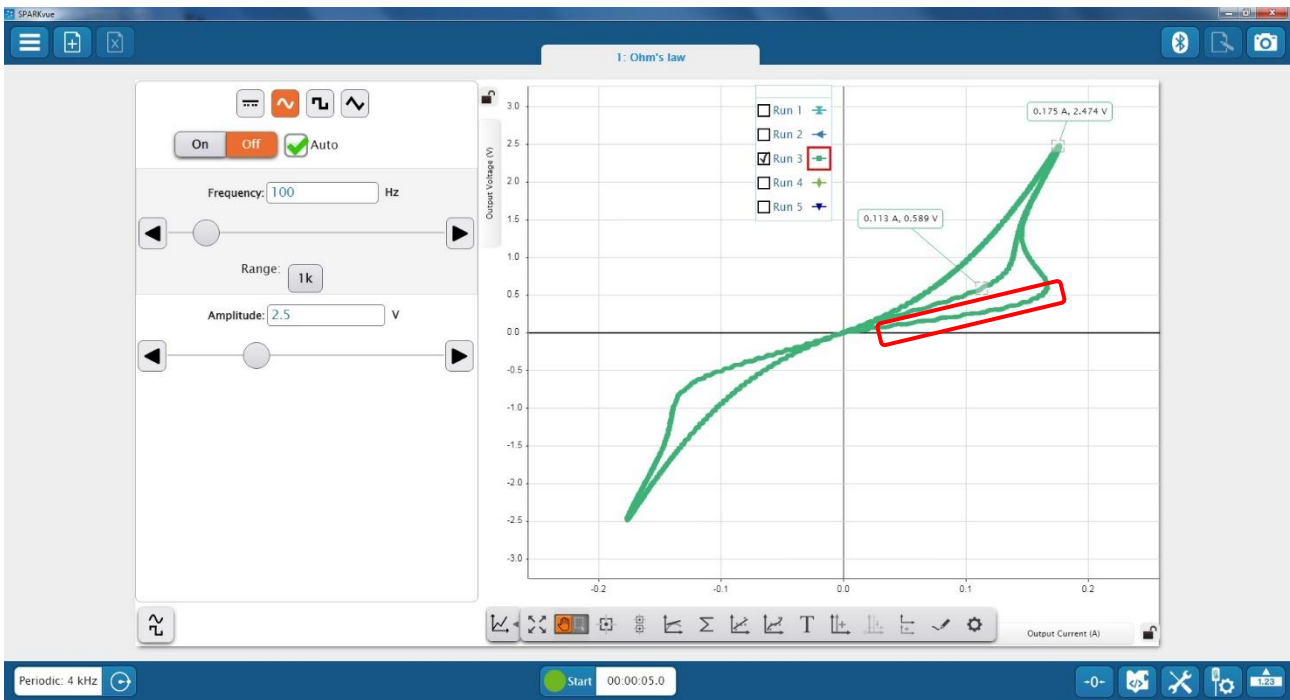


Figure 5) This figure showcases the program window, providing an example of the waveform recording from the bulb. It's worth emphasizing that the curve highlighted in red within the graph should be excluded from the analysis.

The following questions will be addressed in the conclusion section of the report

Analysis of Three Measured Resistances for the Light Bulb:

Why were three distinct resistance values measured?

What is the explanation behind these variations?

Ohmmeter Measurement of the Light Bulb:

When using an ohmmeter to measure the light bulb's resistance, what value is obtained?

Adherence to Ohm's Law:

Does the behavior of the light bulb conform to Ohm's law?