

Wheatstone Bridge and the Diode

1 Object

To better understand resistance and circuits by studying the Wheatstone Bridge circuit; also to see a *non-linear* device, the diode.

2 Apparatus

A Wheatstone Bridge apparatus, wires, power supply, galvanometer, diode, ammeter, and digital meter.

3 Theory

3.1 Wheatstone Bridge

Most physics books have a section on the Wheatstone Bridge, so the student is referred there for a detailed discussion. The results of that are presented here. The derived equation for the unknown resistance in the bridge circuit is:

$$R_? = R_{std} \frac{R_2}{R_1} \quad (1)$$

where $R_?$ is the unknown resistance to be found, R_{std} is a standard resistance of known value, and R_1 and R_2 are two other resistors. The device labeled G is the galvanometer, which is to be adjusted to read zero by varying R_1 and R_2 . This is shown in figure 1. On the apparatus, R_1 and

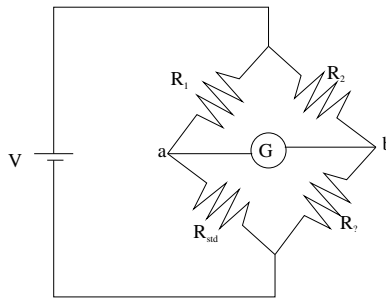


Figure 1: Wheatstone Bridge circuit.

R_2 are two ends of the same wire which is contacted by a metallic knife edge which electrically splits the wire at the point of contact. The knife edge can be moved along the wire and the contact is pressed down by the user. This contact point then causes R_1 to be the length of wire on one side, and R_2 to be the length of wire on the other. Since resistance is given by

$$R = \frac{\rho L}{A} \quad (2)$$

then the resistance of each side of wire is proportional to the length of each side. Since R_1 and R_2 are a ratio in equation 1, the equation may be re-written as

$$R_? = R_{std} \frac{L_2}{L_1} \quad (3)$$

These lengths can be measured directly from the apparatus, and, with a known R_{std} , $R?$ can be found.

4 Procedure

4.1 Wheatstone Bridge

1. Assemble the circuit in figure 1. The standard resistor is the grey one in the envelope, and its value is printed on the front of the envelope. There are also four other resistors in the envelope. Put one of these into the circuit and check to see that you have correctly wired everything.
2. Set the power supply to a small voltage (barely turn the knob on the front panel). Start with the sliding knife edge near the middle of the wire and press the knife edge down momentarily onto the wire. See what the needle does on the galvanometer, then adjust the position of the knife edge so that when depressed the needle no longer deflects.
3. The bridge is balanced now, so record the values for L_1 and L_2 into your data table.
4. Repeat these steps for the other individual resistors.
5. Measure the actual values for your four resistors with the DMM and treat these values as the theoretical values.
6. Now connect the four resistors without the masking tape in series as the unknown, balance the bridge, and record the L 's.
7. Connect the four resistors in parallel, balance, and record L 's.
8. Connect two of the resistors in series and two in parallel and use this combination as your unknown. Make sure you sketch which resistor is what correctly and include this in your lab write-up.
9. Lastly, create your own resistor combination as the unknown, balance, and record the L 's. Sketch as well.

4.2 Diode

Wire in series with the resistor in a circuit a *diode*. A diode is a circuit element similar to a resistor, but made from semiconductors. The symbol for a diode is shown below in figure 2. Often, a band on the actual diode corresponds to the line in the schematic – diodes have a direction. First insert the diode in one direction and vary the voltage for six values and record the voltage across the diode and the corresponding currents. Next, change the direction of the diode and repeat for the same values of voltage.

5 Calculations

5.1 Wheatstone Bridge

1. Determine the resistance of each of your unknowns from equation 3.
2. Compare these values to the theoretical values you measured.

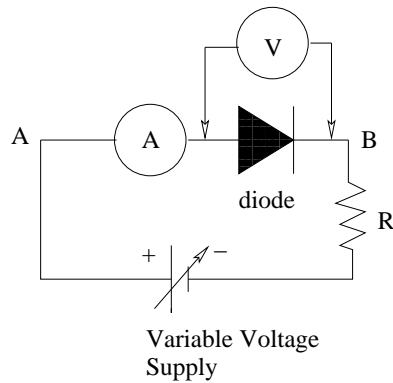


Figure 2: The diode circuit.

3. Determine the resistance of the resistor combinations. Compare the experimental value to what you get by adding the resistors properly using the values you determined above. What is the percent difference between these values?

5.2 Diode

Plot the voltage across the diode versus the current through the diode. For the diode in the direction as shown in figure 2, call these voltages and currents positive. Call the voltages and currents with the diode reversed negative, so that all data can be put on one graph. That is, put all of your currents in one column (with proper sign) followed by voltages (with proper sign) in the next column. Print out the resulting graph.

6 Questions

1. With the Wheatstone Bridge apparatus you used and the known resistance you were given, over what range of resistance can you experimentally determine the resistance of and unknown? Justify your answer with calculations and detailed explanations.
2. What effect does the resistance of the galvanometer have in the circuit?
3. What can you say about the diode's behavior? Is it linear? What might be a use for such a device?

7 Data

7.1 Wheatstone Bridge

Resistor	L_1	L_2
Units		
R_1		
R_2		
R_3		
R_4		
Combo 1		
Combo 2		
Combo 3		
Combo 4		

7.2 Diode

$V(+)$	$I(+)$	$V(-)$	$I(-)$