Networks and Wheatstone Bridge

A circuit to determine the resistance of an unknown resistor accurately has been devised by Wheatstone. It is called the Wheatstone bridge and is shown below .

OBJECT: To measure the resistance of an unknown resistor using the slide-wire Wheatstone bridge and verify the resistance law for two resistors connected in series and parallel.

APPARATUS: Slide-wire Wheatstone bridge, BK Precision Power Supply/Battery Eliminator 3.3/4.5/6/7.5/9/12,1 A Model # 1513(set to 3.3 Volts), digital voltmeter (DVM), standard decade resistance box (set to 10K Ohms), unknown resistance board (use resistor numbers 2, 7, and 9), and connecting wires.

THEORY: A Wheatstone bridge is a circuit consisting of four resistors as shown in Fig. 4.1. The value of one unknown resistance can be computed from the remaining three resistances which are known.
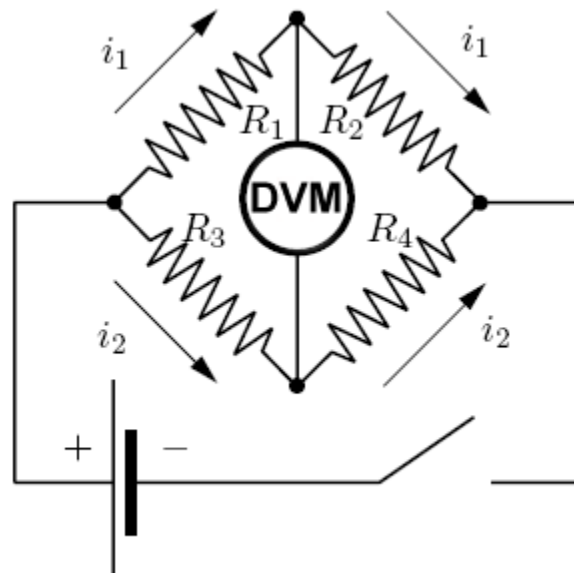

Figure 4.1: Wheatstone Bridge.

When the bridge is balanced, the digital voltmeter reads zero.

Also, the potential drop across $R1$ is equal to that across $R3$, so that

$$i_1 R_1 = i_2 R_3 \tag{1}$$

Similarly, the potential drop across R_2 is equal to that across R_4 and:

$$i_1 R_2 = i_2 R_4, \tag{2}$$

using Eq. (1).

Dividing Eq. (2) by Eq. (3) yields the final relation:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \tag{3}$$

Therefore, if any three of the resistances in Fig. 4.1 are known, the fourth one may be calculated by using Eq. (4).

In the slide-wire form of the bridge, as shown in Fig. 4.2, the resistances $R3$ and $R4$ are replaced by the lengths AB and CB, respectively, of a uniform wire AB with a sliding contact key at C. Since the wire is uniform, the resistances of the two portions are proportional to their lengths. Hence, the ratio of resistances $R3/R4$ is equal to the ratio of lengths AC/CB. If $R1$ is represented by the unknown resistance X, and $R2$, by the known resistance R, Eq. (3) becomes:

$$\frac{X}{R} = \frac{AC}{CB}, \quad \text{or} \quad X = \frac{AC}{CB} R, \tag{4}$$

from which the value of the unknown resistance, X, may be calculated.

PROCEDURE:

1. Connect the circuit as shown in Fig. 4.2, with connecting wires as short as possible. A standard resistance box is used for R. Have the circuit checked out by the instructor.

2. Contact is made to the wire at C.

3. Adjust R to 10,000 Ohms. Turn on the power supply and find the null point by shifting the contact until zero voltage is observed on the digital voltmeter (set the voltmeter on the 2000mv or 2v range).

4. Record the resistance R and lengths AC and CB.

5. Calculate the unknown resistance X (let X_1= #9 on the resistance board, X_2= #7 on the resistance board, X_3= #2 on the resistance board):

$$X = \frac{AC}{CB} R. \tag{5}$$

6. Select two more unknown resistors and determine their resistances. Connect the resistances, x_1 and x_2, x_2 and x_3, x_1 and x_3 in series and parallel and determine the total resistance of each combination. Compare the results obtained from the series and parallel combinations with the calculated values.
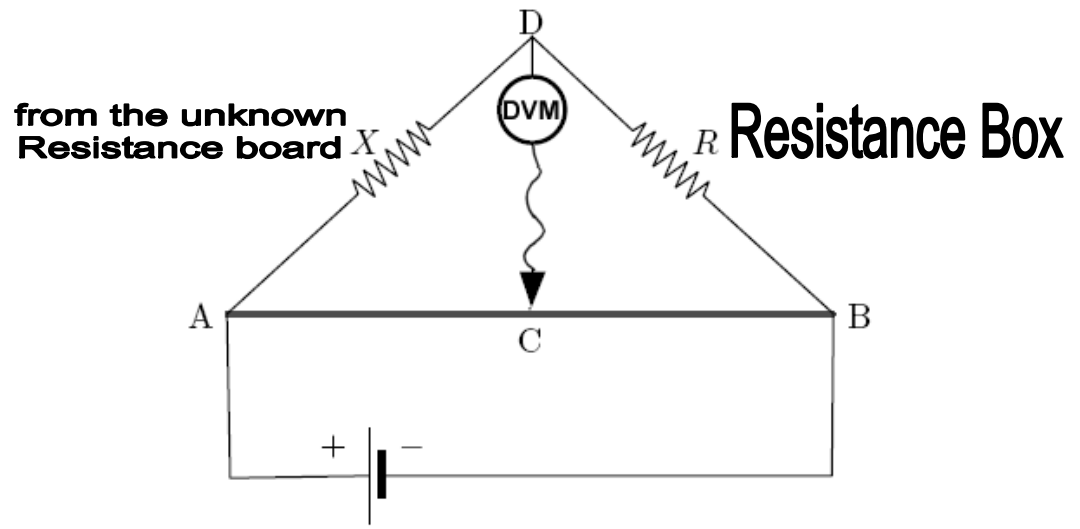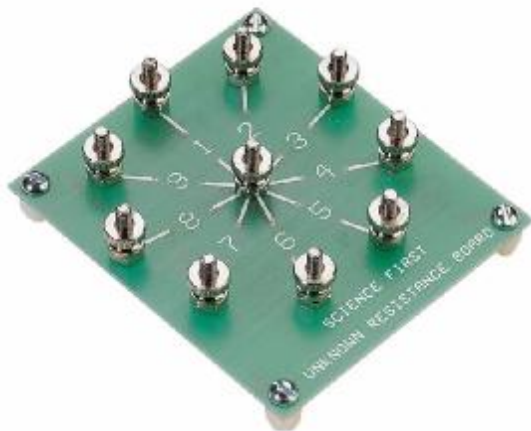
Figure 4.2: Experimental Setup.

Figure 4.3   Unknown Resistance Board