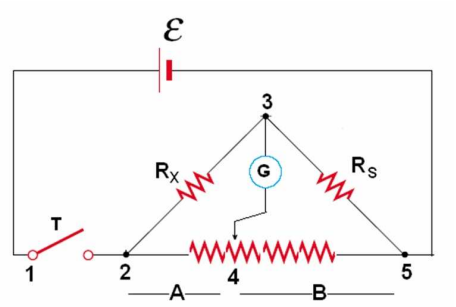
The Wheatstone Bridge

Objects: To learn how (and why) resistance can be measured by the use of Wheatstone Bridge both for single resistors and for combinations of resistors. Also, to contast the potential drop relations in an open circuit with those in a closed circuit.



Theory: Figure represents a typical circuit for a slidewire form of the Wheatstone Bridge. Runnung from point 2 to point 5 is a smooth, straight piece of nichrome wire. R_x is a resistance whose value is to be determined. $R_S$is a resistance of known value. A galvanometer is connected between point 3 and sliding contact, point 4. The source of potential is a 1.5 Volt flashlight battery, connected across points 2 and 5 by means of a tap key, T. In making a resistance measurement, the slide contact (point 4) is shifted along the wire until a position is found such that the galvanometer shows no deflection. At such a balance point, the potential difference between points 3 and 4 would be zero. With points 3 and 4 at the same potential, there would be equal values of potential drop between points 2 and 3 and between points 2 and 4. That is,

$$V_{23} = V_{24}. \tag{1}$$

Also,

$$V_{35} = V_{45}. \tag{2}$$

By Ohm's law, we would have

$$R_x I_3 = R_A I_4 \tag{3}$$

and

$$R_S I_3 = R_B I_4. \tag{4}$$

Dividing eqn.3 by eqn.4, we get

$$\frac{R_x}{R_S} = \frac{R_A}{R_B}. \tag{5}$$

But because of the constant cross section of the slidewire, the ratio $\frac{R_A}{R_B}$ may be given as a ration of length. Thus,

$$\frac{R_A}{R_B} = \frac{A}{B}, \tag{6}$$

or

$$R_x = \frac{A}{B} R_S. \tag{7}$$

Procedure:

1. Set up the circuit shown in Figure. For S, use the standard resistance board and the value recommended by the instructor. Have the instructor inspect and approve your circuit.

2. Using the coarse setting of the galvanometer, try various positions of the slide contact (point 4) until the galvanometer shows approximately no deflection.

3. Then change to a more sensitive setting of the galvanometer and make a refined approach to zero deflection. Note the reading of the meter stick under the slide wire and record this value, in centimerets, as the value of A. Subtract A from 100 cm to get B.

4. Use equation 5 to compute R_x, the value of unknown resistance.

5. Remove the first unknown resistor R_1 and insert the second unknown, R_2, in position X. Starting again with the galvanometer in its coarse setting, and finally in its sensitive setting, feel out a new balance point and compute the value R_2. *Note:* Whenever possible, use an R_S value such that you achieve balance in the region near the midpoint of the sidewire. If A and B are noteably different, the resistance of the leads and connections becomes appreciable, and rather significant errors may develop.

6. Measure R_3, the resistance of the third unknown resistor.

7. Now make a series connection of R_1, and R_2, and place the combination in position X. (use alligator clip connectors to join the resistors, rather than simply twisting the ends together.) Measure R_{12-ser} the resistance of R_1, and R_2 when used in series.

8. Measure $R_{123-ser}$ the equivalent resistance of the three resistors in series.

9. Make a parallel connection of R_1, and R_2 and proceed to measure R_{12-par} the equivalent resistance of R_1, and R_2 when used in parallel.

10. Measure $R_{123-par}$ the equivalent resistance of the three resistors in parallel.

11. Now connect R_1, and R_2 in parallel and let this parallel element to be followed by R_3 in series. Measure $R_{12-par-3-ser}$, the equivalent resistance of the combination.

12. In appropriate spaces of the data sheet, make computations of B, R_{x-comp}, and % difference.

13. Remove the galvanometer from the circuit. Also remove all resistors from positions X and S. This should leave the remaining series circuit consisting of the battery, the tap switch, and the slidewire. Connect a voltmeter between points 1 and 5. With the switch open, measure the potential between these points:

    $V_{15-open}$= _____

14. Place the voltmeter across points 1 and 2 and measure the potential with the switch still open:

    $V_{12-open}$= _____

15. Close the switch and again measure the potential between points 1 and 5 and then between points 1 and 2:

$V_{15-close}$= ————————

$V_{12-close}$= ————————

16. Make a generalized description of what you have observed in procedures 13,14, and 15.

17. Explain (both in words and by use of equations) why things turned out as they did in procedures 13,14, and 15.

Resistor Configuration	Slidewire Reading	A	B	Measured R_{x-exp}	Computed R_{x-exp}	% difference
R_1					N/A	N/A
R_2					N/A	N/A
R_3					N/A	N/A
R_{12-ser}						
$R_{123-ser}$						
R_{12-par}						
$R_{123-par}$						
$R_{12-par-3-ser}$						