EE 2101 - EXPERIMENT 4
WHEATSTONE BRIDGE

INTRODUCTION

A bridge is a special class of circuits that can be used for measuring resistance, capacitance, or inductance. A resistance bridge is especially useful when a very accurate measurement of a resistance is required. The Wheatstone bridge or four arm bridge, invented by C. Wheatstone in 1843, is the most widely used resistance bridge for measuring resistance values above 1 Ω. Commercial Wheatstone bridges are accurate to about 0.1 percent, making the values of resistance obtained far more accurate than values obtained from many types of meters. For resistances below 1 Ω, a Kelvin Bridge can used [1].

A Wheatstone bridge consists of a voltage source and two parallel voltage dividers, as shown in Figure 1. The bridge is said to be *balanced* when $v_{12} = 0$. For the balanced condition, the voltage v_3 is divided in the path containing resistors R_a and R_b in the same ratio as in the path containing resistors R_c and R_x, which allows the unknown resistance R_x to be determined in terms of R_a, R_b and R_c.

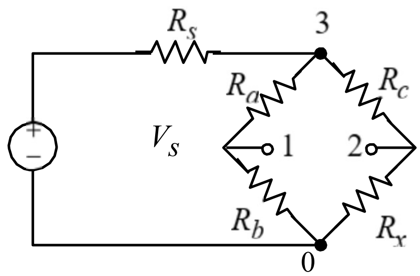

Figure 1: Wheatstone Bridge Circuit.

We can find R_x in terms of R_a, R_b and R_c as follows. Using the voltage divider relation,

$$v_1 = \frac{R_b}{R_b + R_a} v_3, \qquad v_2 = \frac{R_x}{R_x + R_c} v_3$$

For the balanced condition, $v_{12} = 0$, or $v_1 = v_2$. Equating the above expressions for v_1 and v_2 gives

$$\frac{R_b}{R_b + R_a} = \frac{R_x}{R_x + R_c}$$

Multiplying both sides by $(R_x + R_c)$ and $(R_b + R_a)$ gives $R_b(R_x + R_c) = R_x(R_b + R_a)$. Subtracting $R_b R_x$ from both sides and solving for R_x gives

$$R_x = \frac{R_b R_c}{R_a}.$$

In order to achieve balance for a specific unknown resistance R_x, let R_a and R_c have fixed, known values, and let R_b be a calibrated (adjustable) resistor. The procedure is to adjust R_b until $v_{12} = 0$, and then use the expression derived above to determine R_x.

Lab Work

1. Construct the Wheatstone bridge shown in Figure 1. Use resistor values $R_a = 1$ kΩ, $R_c = 10$ kΩ, and $R_s = 10$ kΩ Use a decade resistance box for R_b and a DC power supply adjusted to 5 volts.

2. Measure the value of an "unknown" resistance supplied by your lab GTA $1 \text{ k}\Omega \leq R_x \leq 10 \text{ k}\Omega$. In adjusting R_b using the decade resistance box, start with the coarsest scale and work toward the finest scale, while monitoring v_{12} with the DMM.

3. Calculate the unknown resistance.

Next, perform one (or both, if time permits) of the following exercises (your choice):

4. Measure the resistance of a photo-resistor under various lighting conditions.

5. Measure the resistance of ten different 1 kΩ resistors and plot their values in terms of percent deviation from the nominal value. A bar graph is a convenient form for this plot.

[1] Wolf, Stanley, *Guide to Electronic Measurements and Laboratory Practice*. Prentice-Hall, Englewood Cliffs, New Jersey, 1973.