ECE 3144: Circuit Analysis I

Experiment 3

Title: **BRIDGE CIRCUITS/WHEATSTONE BRIDGE**

OBJECTIVE: To become acquainted with principles of the bridge/comparison circuit.

DISCUSSION: A great many systems require that a signal be extracted from a background that is not necessarily friendly. For example, the select frequency corresponding to a favorite radio station is immersed in an ocean of other signals, some of which are other stations, some of which are ambient. The only way that we are able to extract this signal is by means of a comparison, in this case to the carrier frequency. By determination of the null, we can identify and extract the information carried by the broadcast frequency.

It is the comparison that is key. A large category of circuits fall in the category of comparison circuits.

And many of these are the category of bridge circuits. You will find these under a large variety of names and applications. The better known ones are (1) Wheatstone bridge (DC circuits), Wein bridge (AC circuits), crystal bridge (high frequency), and power bridge (power amplifiers). For this exercise we will concentrate on Wheatstone bridge circuits.

The classical Wheatstone bridge circuit is shown by figure 3-1. One side is the reference side and the other side is the evaluation side, with one of the elements an unknown resistance. Usually the tests are made upon an item that is either a very large resistance or a very small resistance, and outside the range of our normal lab instrumentation. In this case, since we are as interested in the characteristics of the bridge circuit, the test item (a resistance) will be also measurable by other means.

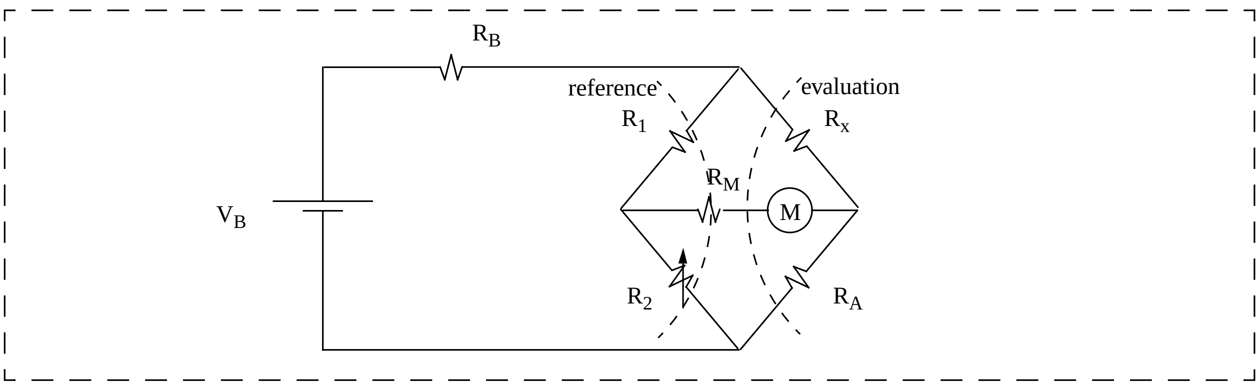

Figure 3-1: Wheatstone bridge:

Operation of the Wheatstone bridge requires that R_2 be adjusted until the meter reaches a null reading. At this point the unknown resistance (labelled as Rx) can be determined by:

$$R_X = \frac{R_1}{R_2} R_A$$

For best range and sensitivity of measurement, the comparison resistance R_A must be of the same order of magnitude as R_X.

Your mission, should you choose to accept it, is to assess the Wheatstone bridge for best performance characteristics under measurement requirements of different magnitudes.

PROCEDURE:

I. Bridge response

A. Construct the circuit as shown by figure I-A.1on your prototyping motherboard. Check values of resistances with the DMM (before assembling circuit). Note that R_2 is a resistance box. Let the reference resistance R_A = 15kΩ and the "unknown" resistance R_x be 10kΩ. Adjust R_2 from 10kΩ to 90kΩ in steps of 5 kΩ and measure and record I_M vs R_2. (see experiment 2 for technique of using ammeter in the prototyping board environment).

B. At what value of R_2 is $I_M = 0$? You may have to adjust R_2 in much smaller steps. How precise is your measurement? (i.e. what is $\Delta R_2/R_2$?)

C. Replace R_A with a resistance of value 200 Ω and repeat steps A and B. How precise is your measurement?

D. Replace R_A with a resistance of value 1.5 kΩ and repeat steps A and B. How precise is your measurement?

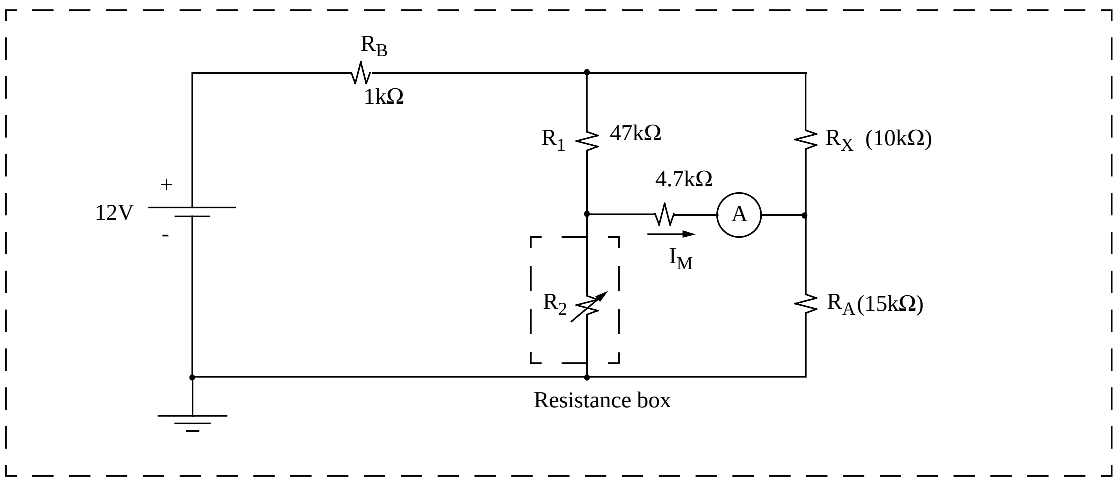

Figure I-A.1: Wheatstone bridge setup

II. Application:

A. Your instructor will furnish you with an unknown resistance which you will substitute in place of R_X. You are expected to measure this resistance to as high precision as you are able to measure R_A (the reference resistance), which should be to within .01%. Note that you will need to make an appropriate choice of R_A in order to accomplish this goal.

B. Measure the unknown resistance R_X with your DMM and compare results.

ANALYSIS:

A. Plot I_M vs R_2 for each case of part I and determine the slope at the null value.

B. Why is the current variation not symmetrical about the balance (null) condition? Identify the limiting factors on the use of a Wheatstone bridge for measurement of a resistance.

C. What if your kindly instructor handed you a 3 ft piece of 14-gauge Romex (house wiring) and asked you to measure its resistance? What if he handed you a 3 ft strip of wet paper towel (twisted into a "wire")?