Physical Experiments I

Pre-lab Assignment

The Wheatstone Bridge and the Prototype of Electric Balance

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Score

Answers to Questions (20 points)

(1) What is the formula for V_g in terms of voltage and resistance in the following circuit (see Fig.P3.12-1)?

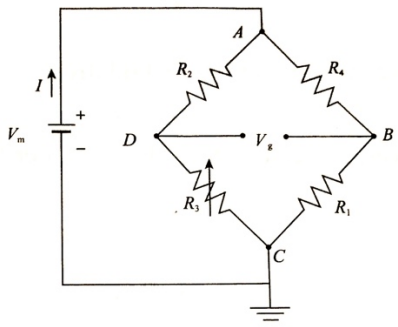

Fig. P3.12-1 An wheatstone bridge

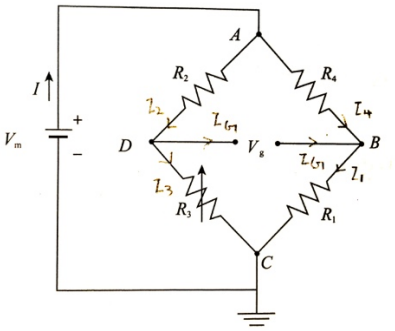

Fig. P3.12-1 An wheatstone bridge

First Second

For the graph given by the book, I just given the notation of some current in the second graph.

Then, I calculate as follows:

First, by using the Kirchhoff's current law:

$$I_4 + I_G - I_1 = 0$$

$$I_2 - I_G - I_3 = 0$$

$$I_4 \cdot R_4 + I_G \cdot R_G - I_1 \cdot R_1 = 0$$

$$I_2 \cdot R_2 - I_G \cdot R_G - I_3 \cdot R_3 = 0$$

When the bridge is balanced:

$$I_G = 0$$

$$I_4 = I_1$$

$$I_3 = I_2$$

$$I_4 \cdot R_4 = I_2 \cdot R_2$$

$$I_1 \cdot R_1 = I_3 \cdot R_3$$

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

(The aboving result can help to solve the next qusetion)

$$V_G = 0$$

Even if the bridge is not balanced, we can also apply the following formulas to get:

$$V_G = \left(\frac{R_3}{R_4 + R_1} - \frac{R_1}{R_2 + R_3}\right) V_m$$

where V_G is the voltage of node D relative to node B.

(2) In Fig. P3.12-2, an unbalanced wheatstone bridge is constructed. Calculated the output voltage across points C and D and the value of resistor R_4 required to balance the bridge circuit.

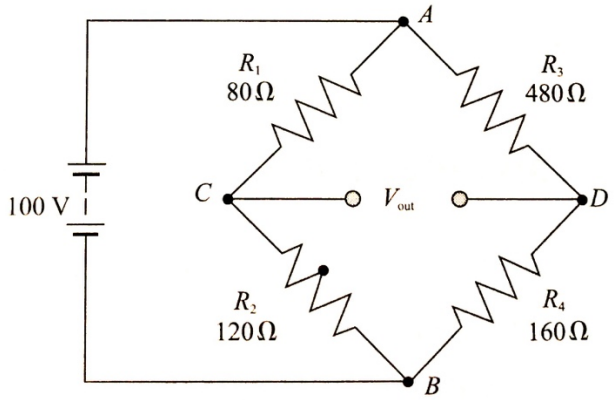

Fig. P3.12-2 An unbalanced wheatstone bridge

From the result got from the last question, we can get:

$$V_G = \left(\frac{R_4}{R_3 + R_4} - \frac{R_2}{R_1 + R_2}\right) V_m = \left(\frac{120\Omega}{80\Omega + 120\Omega} - \frac{160\Omega}{480\Omega + 160\Omega}\right) 100V = -35V$$

Where V_G is the voltage of node C relative to node D.

If we want to balance the bridge, we need also apply the result we got from the last question:

$$R_4 = \frac{R_3 R_2}{R_1} = \frac{120\Omega \times 480\Omega}{80\Omega} = 720\Omega$$

So, if the $R_4 = 240\Omega$, there will have $I_G = 0$ which means that there is no current across the bridge and the bridge is balanced.