To implement resistance measurement techniques using DC bridge circuits (Wheatstone and Kelvin double bridge) on National Instruments ELVIS-II workstation

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Abstract- Resistors plays a vital role in electrical and electronic circuits. A particular circuit works behaves well if it has required value of resistance, capacitance and inductance are connected in a proper fashion. There are various methods to find out the unknown values of passive components like resistors, capacitors and inductance. If we take the case of resistors then unknown resistance can be measured by using multimeter, using color coding of resistors and various bridge circuits. In this paper we are going to measure the value of unknown resistance using Educational laboratory virtual instrumentation suite-II (ELVIS –II) workstation. ELVIS workstation is designed by National instruments. Using ELVIS kit we can easily measure the resistance in more accurate way.

Keywords:NI-ELVIS, Wheatstone bridge, Kelvin double bridge, virtual instrument

I. Introduction

Educational Laboratory Virtual Instrumentation Suite (ELVIS) is a hands-on design and prototyping platform which integrates the most commonly used instruments in instrumentation laboratories–including oscilloscope, digital millimeter, function generator, bode analyzer etc into a compact form for the labs. It connects to our PC through USB connection, provides quick and easy acquisition and display of measurements. With commonly used bench top instruments available in a single platform, NI ELVIS reduces the need to purchase multiple instruments for single application.

Fig.1. NI-ELVIS-II workstation top view

- **Resistance Measurement using Wheat Stone Bridge**

The basic bridge circuit called Wheatstone bridge is suitable to measure medium range resistance. A DC voltage source and DC meter may be used in this case, since the impedances to be used are real.

The battery and galvanometer connections to the Wl1eatstonc bridge may be interchanged without affecting the condition of balance of the bridge [1]

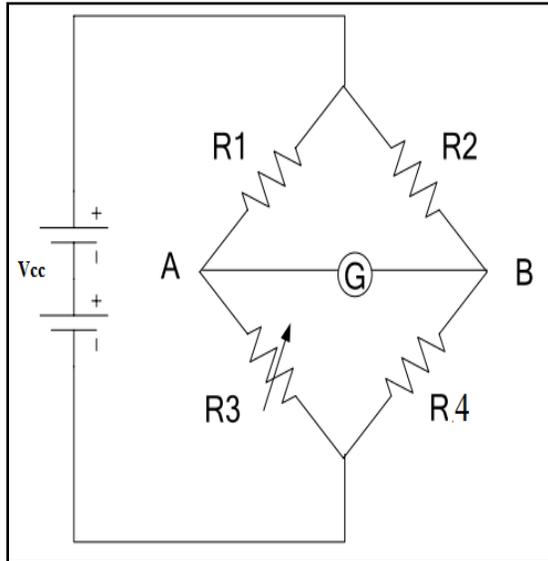At the point of balance $\frac{R1}{R2} = \frac{R3}{R4}$

Fig.2. Wheat Stone Bridge

- **Resistance Measurement using Kelvin Double Bridge**

The Kelvin Double Bridge is a modification of the Wheatstone bridge and provides greatly increased accuracy in the measurement of low-value resistances, generally below 1Ω.
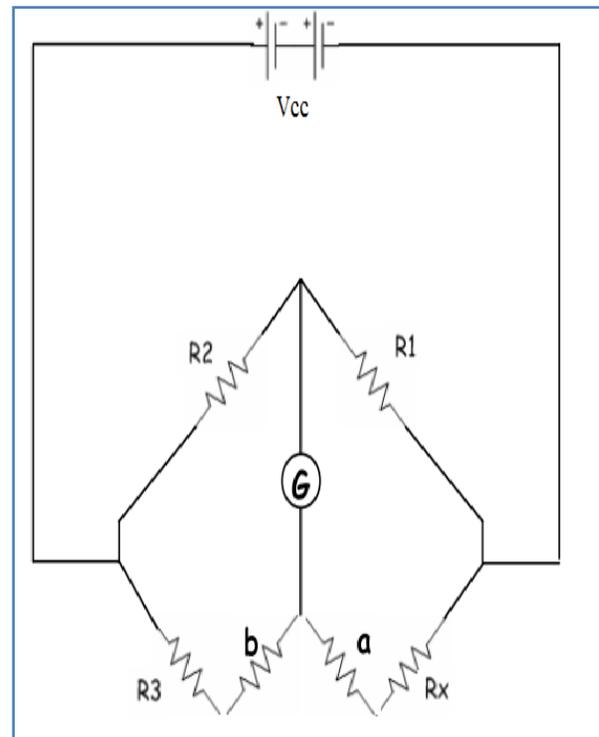

Fig. 3. Kelvin Double Bridge

The term double bridge is used because the circuit contains a second set of ratio arms.The unknown resistance Rx can be calculated as follows:

$$R_x = \frac{R_1 R_3}{R_2} + \frac{b R_y}{(a + b + R_y)}\left(\frac{R_1}{R_2} - \frac{a}{b}\right)$$

Where Ry is the yoke resistance measured between the node connecting R3 and b and the node connecting Rx and a.

Procedure- Steps **to design the circuit on ELVIS-II prototyping board:**

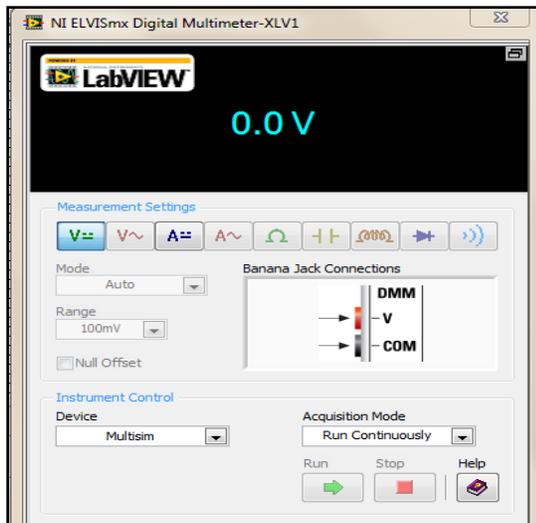1. Launch NI ELVIS, select Digital Multimeter and click on the Ohms button.

Fig.4. DMM SFP

2. Using 2K resistances, make the bridge circuit on the prototyping board and use connecting wires to make connect supply voltage Vcc(5V) and ground (GND).

3. Open the DMM SFP; select Voltage and using banana probes, measure the voltages across the resistances.

4. Also check the difference voltages for zero difference i.e zero galvanometer deflection for the bridge to be balanced.

II. Steps for creating VI (Virtual Instrument)

Wheatstone bridge

1. Open a new VI.

2. Start by taking numeric controls on the front panel; 4 for the resistances and 1 for the value of supply voltage ie Vcc = 5. Use decorations in control palette to draw the circuit of Wheat Stone Bridge.

3. On the block diagram, using the addition, subtraction, division and multiplication functions, create the following formulae for the currents and the voltages across the resistances [2]

$$Total\ Resistance\ (R) = \frac{(R1 + R2) * (R3 + R4)}{(R1 + R2) + (R3 + R4)}$$

$$Total\ Current\ (I) = \frac{Vcc}{R}$$

$$I(1 - 2) = \frac{Vcc}{(R1 + R2)}$$

$$I(3 - 4) = \frac{Vcc}{(R3 + R4)}$$

$$V_{R1} = I(1 - 2) * R1$$

$$V_{R2} = I(1 - 2) * R2$$
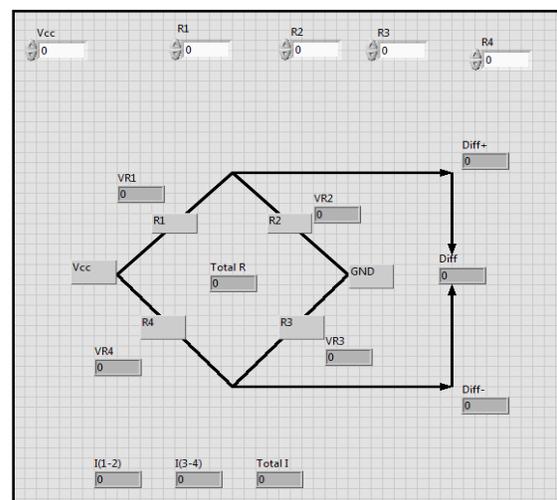
$$V_{R3} = I(3 - 4) * R3$$

$$V_{R4} = I(3 - 4) * R4$$

Fig 5. Front Panel
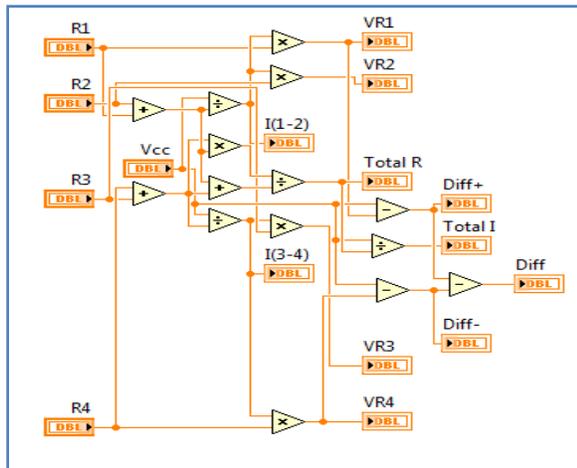
Fig. 6. Block Diagram

Kelvin Double Bridge

1. Open a new VI.

2. On front panel, use decorations in control palette to draw the circuit of Kelvin Double Bridge. On block diagram, using addition, subtraction, multiplication and division, generate the following formula [3]

$$R_x = \frac{R_1 R_3}{R_2} + \frac{bR_y}{(a+b+R_y)}\left(\frac{R_1}{R_2} - \frac{a}{b}\right)$$

3. Set R1, R2, R3, a, b =1KΩ. Calculate the value of unknown resistance.

III. Results & Discussion

From the VI, calculated the value of voltages across resistances and also the difference voltage. From the circuit on prototyping board and using DMM SFP, verified the voltages.

As seen the deflection in galvanometer is zero when same value of resistances were used in the bridge circuit of wheat stone bridge. Also when the Kelvin Double Bridge is balanced, value of unknown resistance can be calculated.

IV. Conclusion

It is a very accurate and precise method to measure the value of unknown resistance.Measurement of resistance was achieved using NI ELVIS-II workstation and using Wheatstone and Kelvin double bridge methods. Also virtual instruments depicting Wheatstone bridge and Kelvin double bridge were designed on Lab VIEW software.

V. References

(1) F. Ralph Kotter, "Location of the Galvanometer Branch for Maximum Sensitivity of the Wheatstone Bridge", Journal of Research, May 1948,pp. 401-404

(2) Jeffrey T. LabVIEW for everyone. - M .: DMK Press; PriborKomplekt, 2005. 544 p.

(3) S.Muruganandhan, G.Jayabaskaran, P.Bharathi, "LabVIEW-NI ELVIS II based Speed Control of DC Motor", International Journal of Engineering Trends and Technology (IJETT), Volume4Issue4- April 2013,pp. 811-814

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