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Development of Virtual Resistance Meters using LabVIEW

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ABSTRACT

This paper presents the development of three virtual resistance meters using LabVIEW. The unknown resistance is measured in terms of a known resistance of high accuracy by employing (a) a real dc voltage source, (b) a real dc current source, and (c) a virtual dc voltage source. In each case, ratio of two voltage signals is acquired by a single-ADC based multichannel data acquisition card. Therefore error of the ADC gets cancelled, when ratio of two voltages is used in the final calculation of the value of unknown resistance. The first two VRMs use a real excitation source and are thus semi-virtual instruments, whereas the third one is fully-virtual as the excitation source is also implemented in the LabVIEW software along with DAC section of the data acquisition card. The three virtual resistance meters have been successfully implemented. The principle of ratio-metric measurement used makes the accuracy (uncertainty) of final measurement free from the uncertainties of the ADC, the DAC and the excitation source. Standard deviations of the readings taken with the three VRMs have been evaluated and compared. It is concluded that the fully-virtual instrument has the lowest and excellent value of standard deviation.

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1. INTRODUCTION

Virtual instruments (VIs) are gaining popularity over physical instruments very fast in the fields of measurement, control, testing and education. The major advantages offered by VIs is flexibility (as all critical functions are implemernted in software), short development time (as off-the-shelf hardware is used and only software developnt is required) and low cost (specially, if an instrument with some special functionalities is needed). A control system for a pneumatic measuring instrument through a serial port was designed and developed by Jiang Chao et al using the graphical language LabVIEW [1]. The major role of the VI software in this work is to transmit control commands to the pneumatic instrument and receive data from it, both through a serial port. In addition, the software does some data processind and ouputs alarm signals. In 2013, Zhongbao Ji published an interesting paper on how the VIs can be used effectively in electronics education [2]. His approach lies in replacing a number of physical instruments needed for testing the performance of an electronic circuit or system by a VI system based on LabVIEW. The VI carries out basically three functions: acquisition of signal, data processing/analysis and presentation of results. Design and construction of a virtual ohm meter is described in Reference [3]. However, it is only a simulation of ohmmeter suitable for educational purposes. Reference [4] reports the development of an impedance meter using a voltage/current pulse excitation. The instrument is semi-virtual as the excitation source is a real one.

The present paper reports the development of three virtual resistance meters (VRMs) using LabVIEW software and a data acquisition card. The first two VRMs are semi-virtual as they use a real dc voltage or current source. The third VRM uses a virtual dc source and is, therefore, a fully-virtual instrument. Their basic principle is a cmparison of the unknown resistance with a known resistance of high accuracy. In each case, values of two voltage signals are acquired using a multi-channel data acquisition card and a driver software. All the three implementations of VRM have been successfully tested and the results along with their analysis are presented here.

2. PRINCIPLE OF RESISTANCE MEASUREMENT

The two principles of resistance measurement used here to develop VRMs are described below:

2.1. Resistance Measurement using Voltage Source

A dc voltage source is used to excite a series circuit of the unknown resistance (R) and a known resistance (r), as shown in Figure 1. The voltages across the series combination (V1) and that across the known resistance (V2) are measured by the same voltage measuring device. So, the unknown resistance (R) is given by

$$R = (V1/V2-V1)*r \qquad (1)$$

As Equation (1) involves ratio of two voltages measured by the same device, the systemic error of the measuring device and variation in the source voltage do not affect the accuracy of measurement of R. The equation also shows that the error of measurement of R comes directly from the error in r. For example, if r has an accuracy of 1%, the accuracy of measurement of R would also be 1%, except for random errors of the measurement.

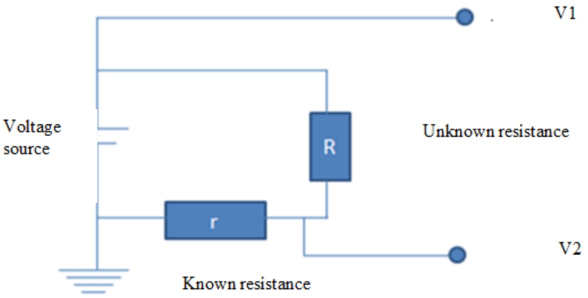


Figure 1. Principle of resistance measurement using a voltage source

2.2. Resistance Measurement using Current Source

In this approach, a dc current source is used to excite the series circuit of R and r, as shown in Figure 2, and voltage drops V1 and V2 are measured as in the first approach. The value of the resistance R is therefore given again by Equation (1). In this approach too, the systemic error of the measuring device and variation in the source current do not affect the accuracy of measurement of R.

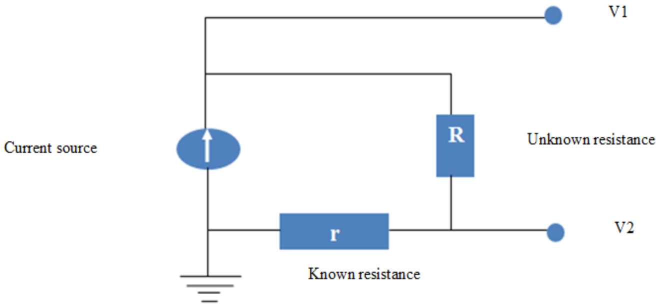


Figure 2. Principle of resistance measurement using a current source

3. REAL VOLTAGE SOURCE BASED VRM

3.1. Hardware Setup

In addition to the PC, on which LabVIEW based VI software is implemented, the hardware involves a dc voltage source (regulated dc power supply), a USB compatible data acquisition card (DAQ) of NI make and breadboard on which resistances are placed and connected, as shown in Figure 3.The known resistance is a carbon resistance of 200Ω value and ±1% tolerance (accuracy) and the unknown resistance is a similar resistance of 100Ω. The DAQ Card, NI-USB-6008, has 8 analog-input and two analog-output channels, a maximum sampling rate of 10 kHz and input range of 0-10V [5].

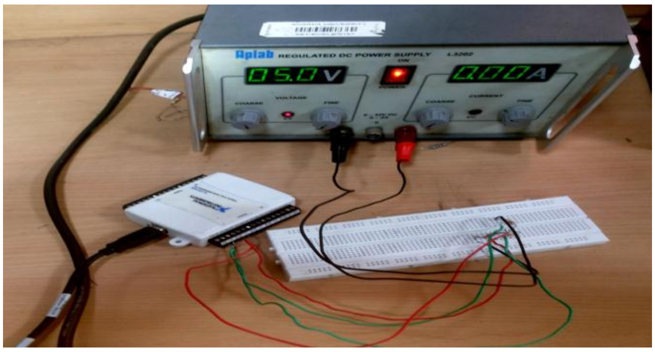


Figure 3. Hardware setup of VRM using real voltage source (regulated dc power supply)

3.2. VRM Software

The VI software of the VRM has been developed on LabVIEW version 13.0 [6-8]. The block diagram and the front panel of the instrument are shown in Figure 4 and Figure 5, respectively. As seen in Figure 4, the value of the known resistance is a constant data of the value 200 (ohms).

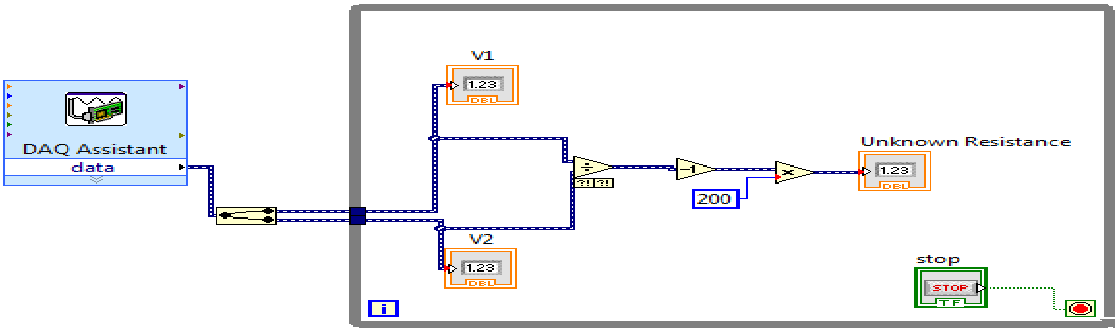
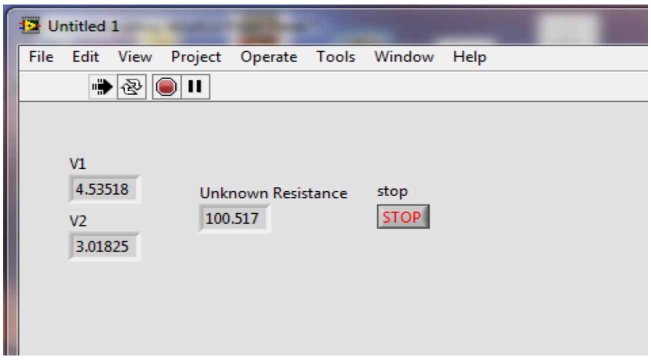


Figure 4. Block diagram of real voltage source based VRM



V1
4.53518
V2
3.01825
Unknown Resistance
100.517
stop
STOP

Figure 5. Front panel of real voltage source based VRM

4. RESULTS AND ANALYSIS

Table 1 shows the results of seven measurements carried out with real voltage source based VRM. For each measurement a different voltage is applied. The average measured value of the unknown resistance is 100.573Ω, while the standard deviation is 0.284Ω, or 0.284%.

Table1. Results of resistance measurement with real voltage source based VRM

Serial Number	Applied Voltage	V1	V2	Measured Value (R)
1.	2.5V	2.580V	1.715V	100.908 Ω
2.	3V	3.079V	2.046V	101.010 Ω
3.	3.5V	3.583V	2.382V	100.868 Ω
4.	4V	4.021V	2.677V	100.393 Ω
5.	4.5V	4.535V	3.018V	100.517 Ω
6.	5V	5.532V	3.349V	100.619 Ω
7.	5.5V	5.532V	3.679V	100.702 Ω
			Average value of R	100.573 Ω
			Standard deviation	0.284Ω

4. REAL CURRENT SOURCE BASED VRM

4.1. Hardware Setup

The hardware setup of this VRM is shown Figure 6. The only difference between this hardware setup and that shown in Figure 3 is that of the excitation source a variable dc current source is shown in Figure 6.

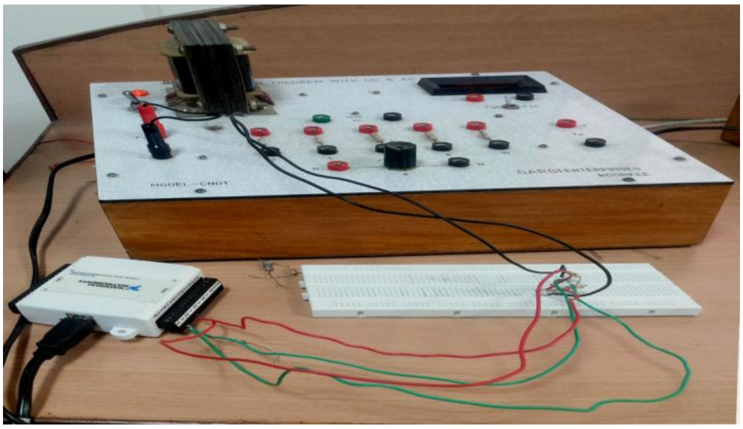


Figure 6. Hardware setup of VRM using dc current source

4.2. VRM software

The software of this VRM is identical to that of the real voltage source based VRM.

4.3. Results

Results of the seven measurements is carried out with this VRM using different values of the applied current are given in Table 2. The average measured value of R is found to be 100.607Ω and the standard deviation is 0.170Ω.

Table 2. Results of resistance measurement with real current source based VRM

Serial Number	Applied Current	V1	V2	Measured Value (R)
1.	5mA	1.39V	0.924V	100.861 Ω
2.	10mA	2.627V	1.749V	100.400 Ω
3.	15mA	3.717V	2.472V	100.728 Ω
4.	25mA	8.045V	5.502V	100.642 Ω
5.	40mA	12.295V	8.188V	100.317 Ω
6.	45mA	13.303V	8.850V	100.632 Ω
7.	50mA	14.82V	9.858V	100.669 Ω
			Average value of R	100.607Ω
			Standard deviation	0.170 Ω

5. VIRTUAL VOLTAGE SOURCE BASED VRM: FULLY-VIRTUAL RM

Finally, a fully-virtual resistance meter was developed, wherein the excitation is provided by a virtual dc voltage source of adjustable voltage magnitude.

5.1. Hardware Schematic

Figure 7 shows the hardware and connections used for realizing the fully-virtual resistance meter. At the heart of the instrument is a personal computer (PC) loaded with the LabVIEW software. The DAC section of the NI-USB-6008 DAQ card was configured to convert the digital voltage signal generated by LabVIEW into analog voltage at its output terminal AO0. This analog dc voltage output was used for exciting the series circuit of the unknown resistance (R) and the known resistance (r). Two analog input channels, AI0 and AI1, of the ADC section of the DAQ card were used for acquiring the analog voltage signals V1 and V2, respectively, as shown in the figure.

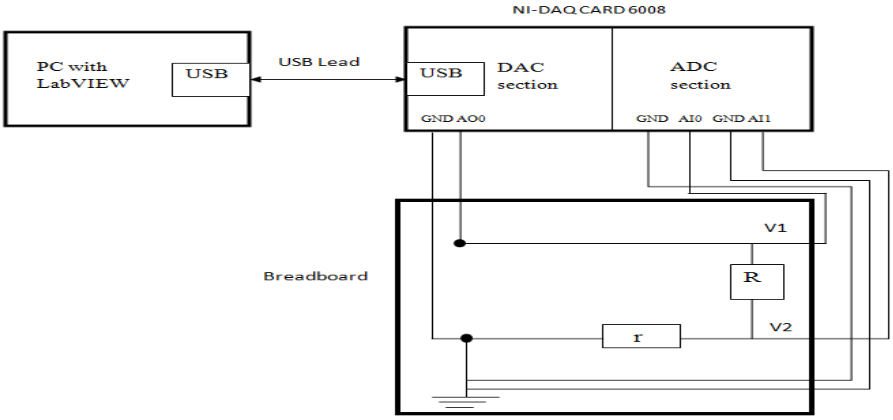


Figure 7. Hardware schematic of fully-virtual resistance meter

5.2. VRM Software

The block diagram of the fully-virtual RM is shown in Figure 8. Voltage to be generated by DAQ Assistant1 is applied as input data to the DAC. DAQ Assistant2 has been programmed for acquisition of V1 and V2 and their conversion into digital data, which is used for computing the value of unknown resistance in terms of known resistance. The value of known resistance in the block diagram is taken as 200 (meaning, 200Ω). The front panel of the fully virtual RM is shown in Figure 9. In addition to displaying the values of V1, V2 and R, the front panel displays the value of the voltage applied from the virtual voltage source.

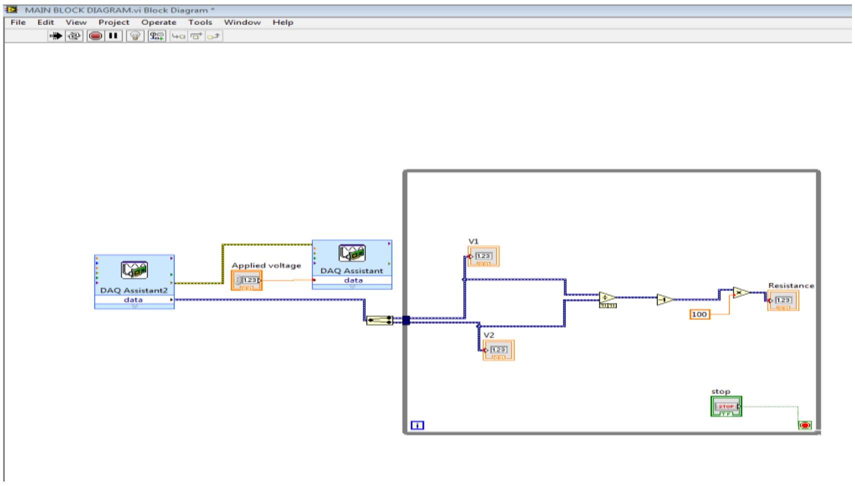
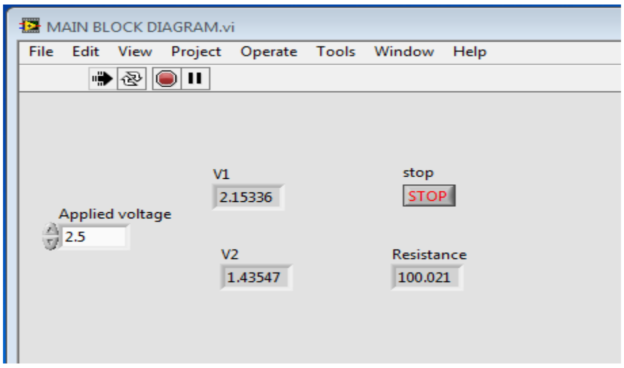


Figure 8. Block diagram of fully-virtual RM



Applied voltage 2.5

V1 2.15336

V2 1.43547

stop

Resistance 100.021

Figure 9. Front panel of fully-virtual RM

5.3. Results

The measurements carried out with this fully virtual instrument with different values of the applied voltage, are given in Table 3. The results, as expected, are similar to those obtained in real voltage and current source based VRMs. Because of the differences in the random errors, the average measured value of R is 100.677Ω and the standard deviation is 0.076Ω.

Table 3. Results of resistance measurement with fully-virtual resistance meter

Serial no.	Applied Voltage	V1	V2	Resistance
1.	1.8V	1.720V	1.145V	100.436 Ω
2.	2.2V	2.156V	1.435V	100.487 Ω
3.	2.6V	2.585V	1.720V	100.581 Ω
4.	3.1V	3.013V	2.005V	100.548 Ω
5.	3.5V	3.446V	2.290V	100.960 Ω
6.	3.9V	3.873V	2.275V	100.815 Ω
7.	4.1V	4.097V	2.723V	100.918 Ω
		Average Value of R Standard deviation		100.677 Ω 0.76 Ω

6. CONCLUSION

Development of two partially virtual-resistance meters and a fully-virtual resistance meter has been carried out successfully using the LabVIEW software and a USB compatible data acquisition card. The DAC section of the card has been utilized for realizing a virtual dc voltage source in the fully-virtual resistance meter. The obvious advantage of the fully-virtual instrument over the two partially-virtual instruments is that the former does not require any real excitation source. Only a PC along with a data acquisition card and LabVIEW software are needed to implement a fully-virtual resistance meter.

The ratio-metric principle of measurement employed in these VRMs has a significant advantage that the final accuracy (uncertainty) of measurement of unknown resistance is free from errors or uncertainties of the excitation source, the ADC and the DAC. In fact, it depends only on the accuracy (uncertainty) of the known resistance, which in any case is unavoidable. The random errors of measurement do affect the final result, as reflected in the standard deviation. The standard deviations calculated for the measurements carried out with the three VRMs are 0.284%, 0.170% and 0.076%, respectively. The first and second values, which are for the VRMs using real dc voltage/current source, are higher than the third value, which is for the VRM using virtual voltage source. This difference is due to the presence of 100-Hz ripples in the real dc voltage and current sources working on 240-V 50-Hz power supply. There is no such ripple or fluctuation present in the virtual dc voltage source. The standard deviation of the readings taken with the fully-virtual VRM, that is 0.076%, is excellent (very low). To underline the contribution made by this research paper, it may be pointed out that none of the papers reviewed under 'Introduction' made any attempt to evaluate or assesss uncertainty or accuracy of the developed virtual instrument, or the standard deviation.

REFERENCES

[1] Jiang Chao, *et al*, "Design of Instrument Control System Based on LabVIEW," *TELKOMNIKA (Telecommunication Computing Electronics and Control)*," vol.11, no.6, pp.3427-3432, June 2013.

[2] Zhongbao Ji, "Application of Virtual Instrument in Electronic Education, " *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, vol.11, no.9, pp. 5433-5460, Sept. 2013.

[3] "Design and construction of virtual ohm meter," at www.wpi.edu

[4] Abraham Mejía-Aguilar and Ramon Pallàs-Areny, "Electrical impedance measurement using voltage/current pulse excitation," *XIX IMEKO World Congres , vols 1-4,* pp. 591-597, 2009.

[5] "User guide for NI-USB 6008 DAQ card", National Instruments.

[6] "LabVIEW Tutorial- Creating application", National Instruments.

[7] "Building a stand-alone application", National Instruments.

[8] "Using the LabVIEW Run-Time Engine", National Instruments.

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