Development of Virtual Resistance Meter using LabVIEW

Puja Kumari[1], Priyam Singh[2], Prof. H.K Verma[3] and Mrs. Suman Lata[4]

[1]*M.tech (EEE), School of Engineering and Technology, Sharda University*
[2]*M.tech (ECE) Shri Ram College of Engineering & Management, Palwal priyam.sng@gmail.com*
[3]*(Distinguished Professor) Department of Electrical and Electronics*
[4]*Assistant Professor, Department of Electrical and Electronics*
E-mail: [1]puja.kumari.196@gmail.com

Abstract—*This paper presents the development of three virtual resistance meters using LabVIEW. The unknown resistance is measured in terms of a known resistance by employing (i) a real dc voltage source, (ii) a real dc current source and (iii) a virtual dc voltage source. In each case, ratio of two voltage signals is acquired by a single-ADC based multichannel data acquisition card employing a single ADC. 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 VRMs have been successfully implemented. The principle of ratio-metric measurement used makes the accuracy (uncertainty) of final measurement free from the uncertainties of ADC, DAC and the excitation source.*

Keywords*: Voltage source, current source, DAQ card, ratio-metric measurement, virtual voltage source.*

1. INTRODUCTION

Low accuracy measurement of unknown resistance is usually done by using a low cost instrument like analog or digital multimeter. These instruments either pass a known current through the unknown resistance and measuring the voltage drop across it, or amplifying a known voltage across the resistance and measuring the current flowing through it. For higher accuracy, unknown resistance is measured by comparison with a known resistance using a potentiometeric circuit or Wheatstone bridge. The design and construction of a virtual ohm meter described in [1], in effect of a simulation of ohmmeter for laboratory demonstration and training. Reference [2] reports the development of an impedance meter using a voltage/ current pulse excitation. The instrument is semi-virtual as the excitation source is real one.

This 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. All the three implementation 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:

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 fig.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

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

As, equation (1) involves ratio of two voltages measured by the same device, the systemic error of the instrument does 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.
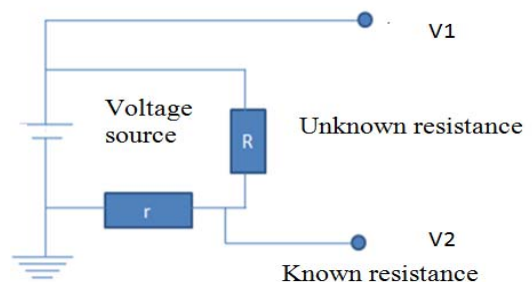

Fig. 1: Principle of resistance measurement using a voltage source

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 fig.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). This approach has the same advantages as does the first approach.
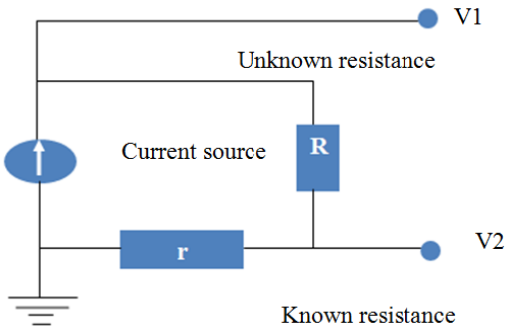

Fig. 2: Principle of resistance measurement using a current source

Real Voltage Source Based VRM

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 of NI make and breadboard on which resistances are placed and connected, as shown in fig.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 10V.
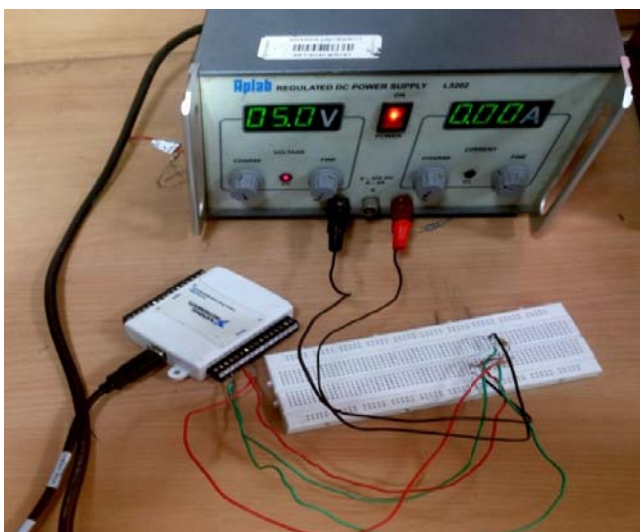

Fig.3 Hardware setup of VRM using real voltage source (regulated dc power supply)

VRM software

The VI software of the VRM has been developed on LabVIEW version 13.0. The   block diagram and the front panel of the instrument are shown in figures 4 and 5, respectively. As seen in Fig.4, the value of the known resistance is a constant data of the value 200.
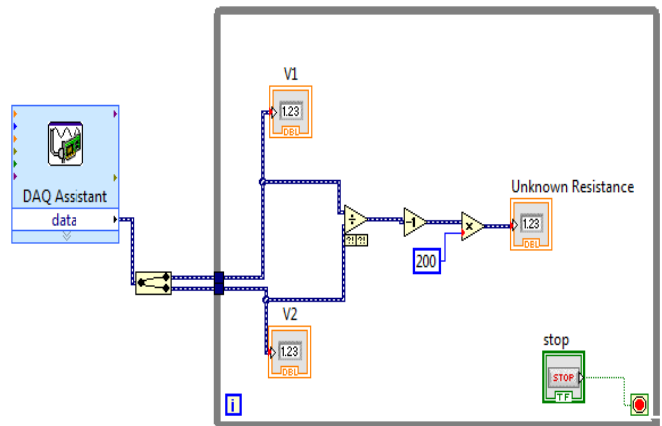

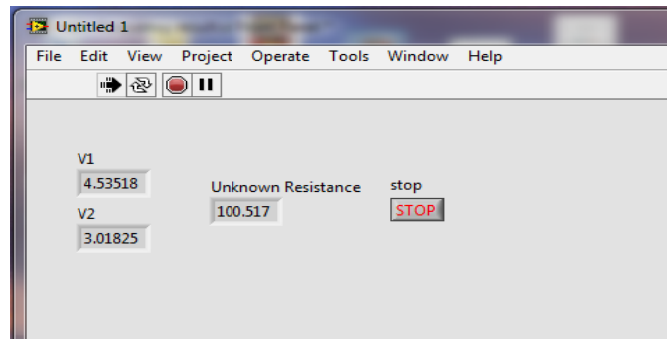**Fig. 4 Block diagram of real voltage source based VRM**

Fig. 5 Front panel real of voltage source based VRM

Results

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 is 100.573Ω with the standard deviation is 0.284Ω.

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	100.908Ω
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(Unknown Resistance)				100.573Ω
Standard deviation				0.284Ω

Real Current Source Based VRM

Hardware Setup

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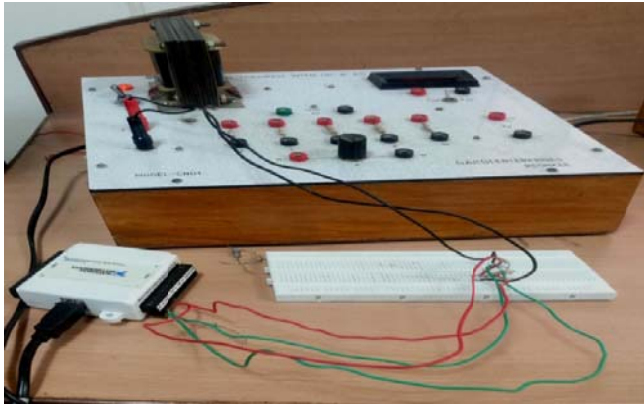
Fig.6 Hardware setup of VRM using dc current source

VRM software

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

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 of is 0.17Ω.

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

Serial number	Applied Voltage	V1	V2	Measured Value (R)
1.	5mA	1.39V	0.924V	100.861Ω
2.	10mA	2.627V	1.749V	100.400Ω
3.	15mA	3.717V	2.472V	100.728Ω
4.	25mA	8.045V	5.502V	100.642 Ω
5.	40mA	12.295V	8.188V	100.317Ω
6.	45mA	13.303V	8.850V	100.632Ω
7.	5.5V	5.532V	3.679V	100.702 Ω
Average Value of R(Unknown Resistance)				100.573Ω
Standard deviation				
Standard deviation				
				0.284Ω

Virtual Voltage Source Based VRM: Fully-Virtual Resistance Meter

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

Hardware Schematic

Fig.7 shows the hardware and connections used for realizing the fully- virtual RM. 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 serves to convert the digital voltage signal into analog voltage at its output terminal AO0, meant 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 are used for acquiring the analog voltage signals V1 and V2, respectively as shown in the figure.
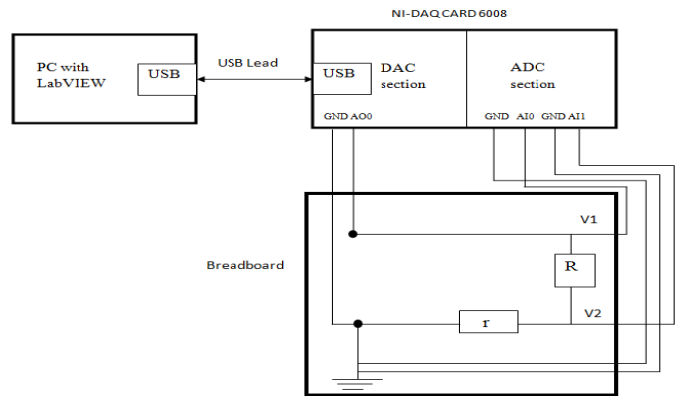
Fig. 7 Hardware schematic of fully virtual resistance meter

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 convert them 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 resistance (meaning, 200Ω). The front panel of the fully virtual RM is shown in Fig.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.
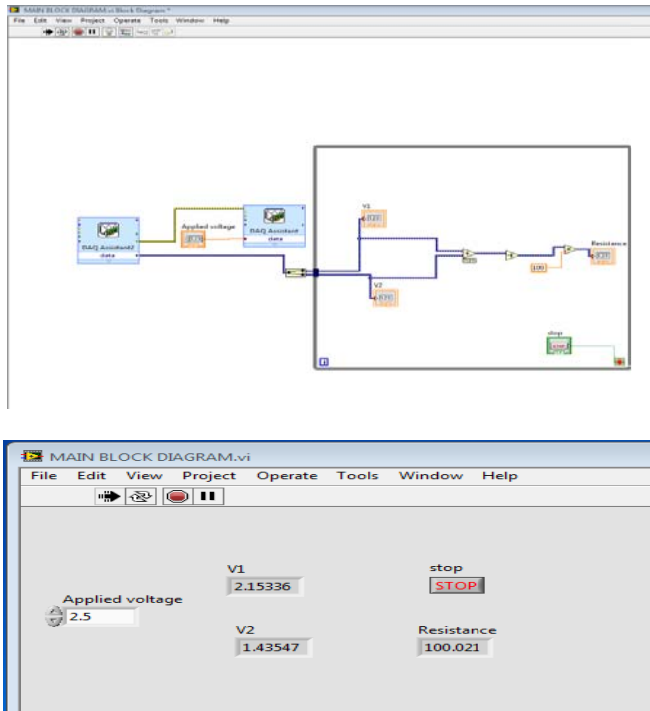
Fig.9 Front panel of fully virtual RM

Results

The measurements carried out with this fully virtual instrument with different values of the applied voltage, are given in Table3. 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 fully virtual RM

Serial no.	Applied voltage	V1	V2	Resistance
1.	1.8V	1.720V	1.145V	100.436Ω
2.	2.2V	2.156V	1.435V	100.487Ω
3.	2.6V	2.585V	1.720V	100.581Ω
4.	3.1V	3.013V	2.005V	100.548Ω
5.	3.5V	3.446V	2.290V	100.960Ω
6.	3.9V	3.873V	2.275V	100.815Ω
7.	4.1V	4.097V	2.723V	100.918Ω
Average Value of R				100.677Ω
Standard deviation				0.076Ω

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 instrument. The obvious advantage of the fully virtual instrument over the two partially virtual instruments is that it does not require any real source excitation.

The ratio-metric principle of measurement employed in the 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, ADC and DAC. In fact, it depends only on the accuracy (uncertainty) of the known resistance and the random errors of measurement, as reflected in the standard deviation. For each VRM, the standard deviation is approximately 0.03Ω, or 0.03%.

References

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