



## Virtual Wheatstone bridge based on LabVIEW software for remote laboratory works

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### Keywords

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### Abstract

Nowadays, Virtual Instruments are becoming an important part of solving engineering problems in particular in the area of Automatic Control of Industrial Processes and Education. Due to the continuously increasing performance and flexibility of PC combined with their cost reduction, virtual instruments are successfully concurring the traditional instruments. During the pandemic, covid-19 as a result of adapting the emergent solution in education students and teachers should work from home. Except for lessons and seminars, doing laboratory work faced difficulties to be performed because students should be in the laboratory, which was not possible. In this work we have built a virtual instrument for electrical resistance measurement which imitates in detail the Wheatstone Bridge in our Electrical Measurement Laboratory and tested remotely to measure resistance by interacting with a virtual instrument like with the real instrument.

### Introduction

Development of the technology rises the opportunities to facilitate the teaching aspect as well as the acquisition of knowledge by students. However, the speed of change in technology in various fields of science creates some problems for academic institutions, particularly engineering disciplines. This requires a constant updating and extension of teaching materials, which represents the greatest difficulty in engineering fields, where experimental support is required.

The main problem remains the same: To provide students valuable practice experience, being limited in laboratory equipment and infrastructure. One solution to this problem would be: to make use of techniques based on computers so that the students interface with the real world. This manner allows further, sophistication and flexibility because the main part of the application is created on the computer and so it can be modified without the need for additional physical devices [1-2].

From the teaching point of view, to build the applications in the laboratory, all engineering problems deal with some physical quantities such as potential difference, electric current, temperature, pressure, speed, position, mechanical torque, moisture level, etc. We can see these quantities by using a computer coupled with conditioning circuits, data acquisition, transducers, and software. Moreover, these data can be processed, and stored, and even we can publish them on the Internet. "Figure 1" illustrates an experimental test bed supported by the computer in real-time.

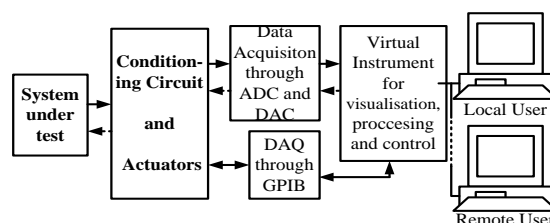


Figure 1. Block diagram of a laboratory test bench based on PC

At the Automation Department of Electrical Engineering Faculty in Tirana the Electrical Measurements subject includes 4 laboratory works. One of them deals with measuring and error calculation with the Wheatstone and Thomson Bridge.



**Figure 2.** MTV Thomson-Wheatstone Bridge in the Electrical Measurements Laboratory

In this work have built a virtual instrument for electrical resistance measurement which imitates in detail the Wheatstone bridge in our Electrical Measurement Laboratory “Fig. 2” and tested remotely to measure resistance by interacting with a virtual instrument like with the real instrument.

### Material and Method

To build the Wheatstone Bridge Virtual Instrument we relied on [3-4] for instrument programming.

For the Wheatstone bridge formulas and theory, there is plenty of literature which can be found on the internet. However, we are referring to literature in Albanian [5] for the equation of the current flowing in the galvanometer  $I_G$  that is:

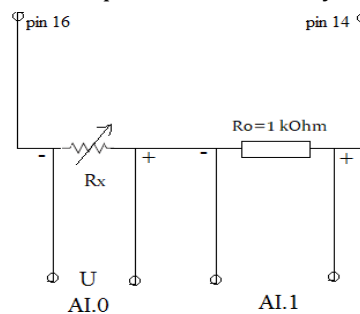
$$I_G = U \frac{R_1 R_4 - R_2 R_3}{R_G (R_1 + R_2)(R_3 + R_4) + R_1 R_2 (R_3 + R_4) + R_3 R_4 (R_1 + R_2)} \quad (1)$$

Where U- is the voltage that feeds the bridge and  $R_1, R_2, R_3$  and  $R_4$ - are the resistors of the branches of the Wheatstone bridge.

To acquire electrical quantities in order to measure the resistance through the “**Virtual Wheatstone Bridge**” we have used the NI 6008 USB DAQ from National Instruments [6].

We measure the voltage drop and the current across the unknown resistor through two **analog inputs** of the NI 6008 DAQ card. Since this card doesn’t support **analog current** inputs we used an external known resistor with a value of 1kΩ and measure the voltage drop across it. Then since analog inputs have a very high impedance we assume that the current calculation for the external resistor is equal to the current passing to the unknown resistor since the resistors are connected in series. After this, dividing the voltage across the resistor with the current calculated we obtain the resistance value in the virtual instrument.

We use the NI 6008 USB DAQ card also for feeding the interface (conditioning circuit) through one of its **analog outputs** and by changing the voltage of this output from the virtual instrument “**Sensitivity knob**” we can change the current passing through the interface and improve the sensitivity. The interface is shown in Figure 3.



**Figure 3.** Interface of the virtual instrument for resistance measurement

After calculation, the unknown resistance value is not shown in the virtual instrument front panel. It is processed again by the Wheatstone bridge formula, which requires resistances  $R_2, R_3$  and  $R_4$  inputs calculation variables for the **galvanometer** current  $I_G$ .

$R_2$  is composed as the sum of  $10 \times (1000 + 100 + 10 + 1 + 0.1) \Omega$ ;  $R_3$  and  $R_4$  have a discrete value of (10, 100, 1000, 10000)  $\Omega$ . Combining them in the Wheatstone bridge formula we get the unknown resistance value  $R_x$  when  $I_G=0$ , because  $R_x=R_2 \cdot R_3 / R_4$ .

$I_G$  current is displayed on the virtual instrument **front panel** in a “**Meter indicator**” called Galvanometri. This value is first added with a value of 0 to 1000 to imitate the series resistor  $R_s$  which is usually present in the Wheatstone bridge to limit the Galvanometer current during equilibration. Students are warned to try not to push the galvanometer indicator to the limit of its scale during interacting with the Wheatstone bridge to find the unknown resistance values.

Last, using LabVIEW G Web Server we can publish the virtual instrument online so the students can interact and perform remote laboratory work.

The Wheatstone Bridge Virtual Instrument front panel is shown in Figure 4 during  $R_x = 506.12 \Omega$  value measurement (left) and its graphical code (right).

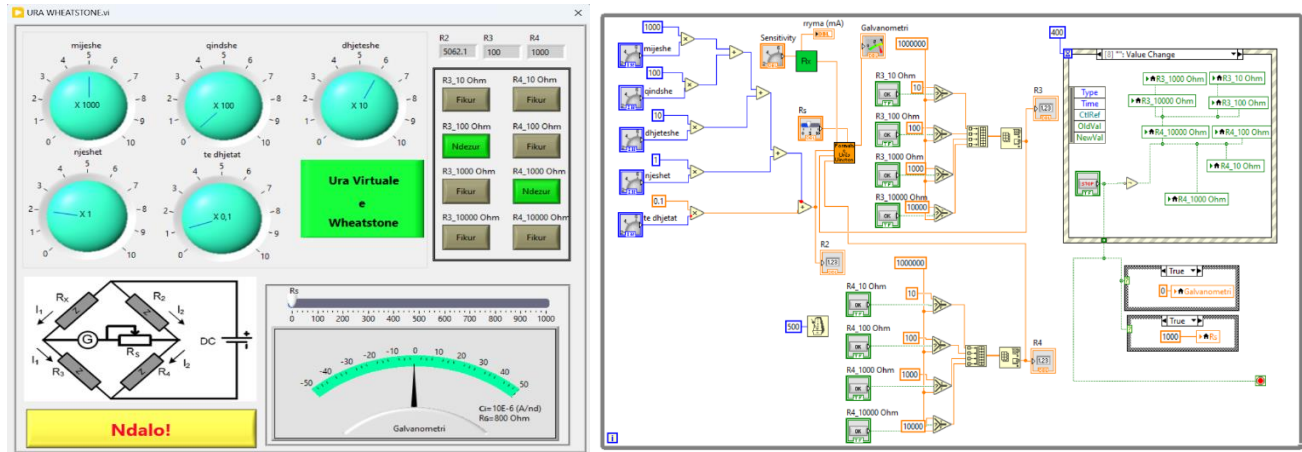


Figure 4. Virtual Wheatstone Bridge built in LabVIEW front panel (left) and its block diagram (right)

## Results

Using the Wheatstone bridge virtual instrument, students at Electrical Engineering Faculty in Tirana were able to perform remote laboratory work from home in the subject ‘Electrical Measurements’ during the pandemic covid-19.

## Discussion

This approach lacks the problem that there must be always qualified personnel in the laboratory during remote measurements to perform the changes in resistance values to be measured and to survey for any problem students may face during experimentation.

## Conclusion

Using remote virtual instrumentation is very helpful when the number of students is larger than the respective laboratory can accommodate or when it is not physically possible for the student to be present in the lab.

From an educational point of view, using this approach it is possible to help some of the laboratories in the Electrical Engineering Faculties which lack the infrastructure to perform specific laboratory work so the students narrow the gap between theory and practice.

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