



## Hardware in the loop technique for real-time control of electrical machines using LabVIEW software for laboratory works in electrical engineering faculties

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Cite this study: Dume, G., & Metalla, J. (2023). Hardware in the loop technique for real-time control of electrical machines using LabVIEW software for laboratory works in electrical engineering faculties. *Advanced Engineering Days*, 7, 155-157

### Keywords

Virtual Instrument  
Hardware in the Loop  
LabVIEW  
Laboratory work

### Abstract

The rapid developments of science and technology of the last decade have given a fundamental change to the way of conceiving and solving problems in every field of science and in particular in engineering disciplines. 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. In this work, we have created a closed-loop control system for testing the PID controller for a DC motor using the HIL technique and Ziegler-Nichols tuning rule for education purposes.

### Introduction

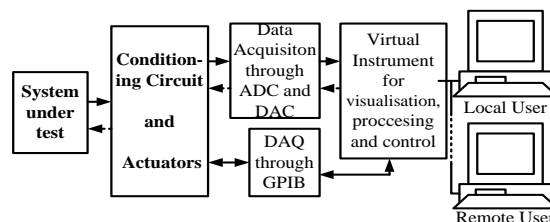
The rapid developments of science and technology of the last decade have given a fundamental change to the way of conceiving and solving problems in every field of science and in particular in engineering disciplines.

The revolution of personal computers (PC) has placed them in the position of an indispensable tool in solving many problems encountered by engineers in practice.

Until the 1990s, the focus was on computer architecture, which would be used in industry for a specific task, but today attention is increasingly directed towards the so-called: software architecture [1].

From several years of work, with students during teaching practices in several industrial enterprises, we have established that the process of control and monitoring of production lines is carried out by special software of leading companies in the respective fields.

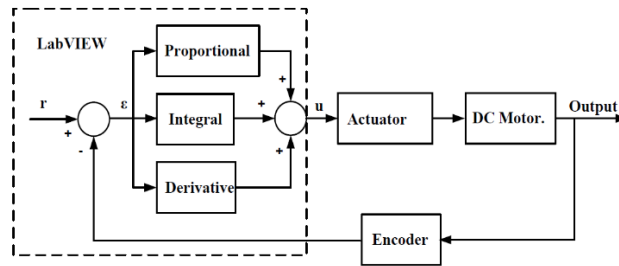
From the teaching point of view, to build the applications in the laboratory, all engineering problems deal with some physical quantities such as potential difference, electric current, temperature, pressure, speed, position, mechanical torque, moisture level, etc. We can see these quantities by using 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

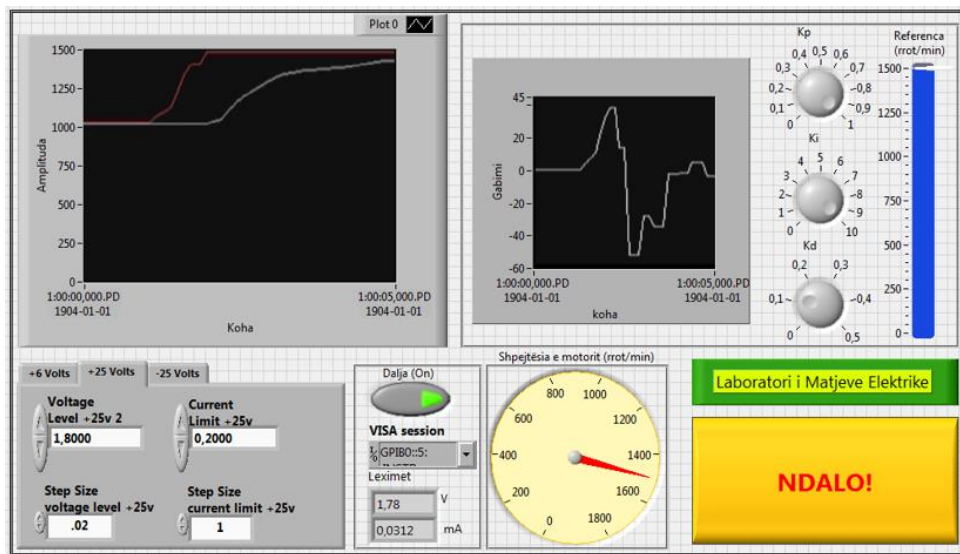
At the Automation Department of the Electrical Engineering Faculty in Tirana, we are working on implementing LabVIEW software, a well-known software for measurement, data acquisition and visualization, in creating new

prototypes of controlling desired parameters of electrical machines, since it is also a programming language. Below is an illustration of the concept of this implementation.



**Figure 2.** Block diagram of using LabVIEW as PID Controller for DC Motor Speed Control

In this work have built a virtual instrument for speed control of **220V, 1500 rev/min Separately Excited DC Motor** in our Electrical Measurement Laboratory “Fig. 3” and tested for finding the PID controller coefficients using the so-called Hardware in the Loop (HIL) technique and Ziegler-Nichols empiric tuning rule.



**Figure 3.** Virtual Instrument for DC Motor Speed Control and Monitoring

## Material and Method

To build the DC Motor speed control Virtual Instrument we relied on [2-3] for instrument programming.

For the DC Motor formulas and theory, plenty of literature can be found on the internet. However, we are referring to literature in Albanian [4] for the equation of the DC Motor angular speed  $\omega$ , that is:

$$\omega = \frac{U_i}{k \cdot \varphi} - \frac{R_i}{(k \cdot \varphi)^2} \cdot M \quad (1)$$

Where  $U_i$  is the armature voltage,  $R_i$  – armature resistance,  $M$ - motor torque,  $k$ - a coefficient and  $\varphi$ -field flux.

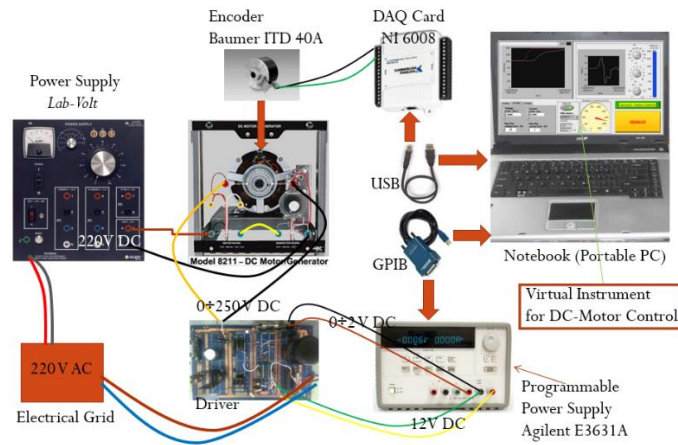
To measure the motor angular speed we have used an incremental encoder from Baumer model ITD 40A with 1024 pulse/rev, NI 6008 USB DAQ and LabVIEW to build a virtual instrument used as a subVI in the top application (Main VI).

The control of the motor speed is done by changing the armature voltage under the rated value by using a custom-built AC-DC converter [3]. The set point of the driver is set programmatically by the programmable power supply Agilent E3631A through the GPIB interface.

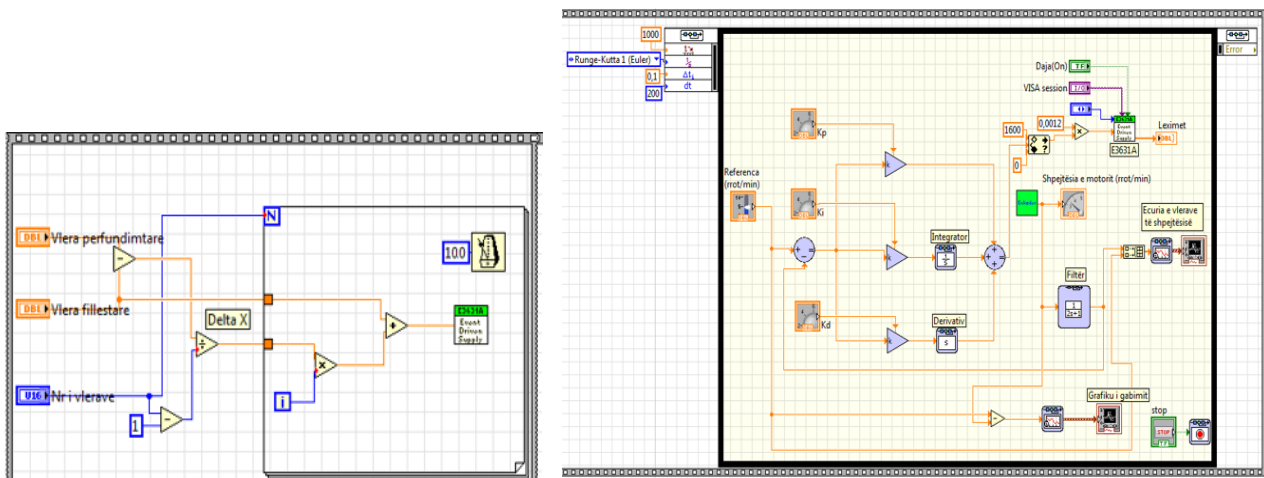
The Separately Excited DC motor coil is fed by a constant 220V DC voltage obtained by the LabVolt power supply used in the laboratory.

We built in LabVIEW also a soft starter to start the DC motor from the standstill to its rated value of 1500 rev/min by generating a ramp signal from the programmable power supply. The Overall system for DC Motor speed control is shown in “Fig. 4”.

The Virtual Instrument graphical code is shown below. It consists of 2 frames. The first frame (left) picture in “Fig. 5” soft start the DC motor and the second frame (right picture) is used to monitor the motor angular speed and to find the desired PID controller coefficient by interacting with the DC motor using the HIL technique and Ziegler-Nichols empiric tuning rule.



**Figure 4.** Overall system for DC Motor speed control



**Figure 5.** Virtual Instrument block diagram

## Results

From a teaching point of view, the speed control of a DC Motor with the LabVIEW software can be used to carry out laboratory work on the subject of Electric Drives, allowing the students to become familiar with computer-based control systems, despite the limitation in infrastructure, which our laboratories have in our faculty.

## Discussion

This approach lacks the problem that there must be always qualified personnel in the laboratory during tests to survey for any problem students may face during experimentation because the controller coefficient can be changed in real-time and can lead to unexpected behavior of the machine if not found correctly.

## Conclusion

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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