

Laboratory Activity during COVID- 19 as a “Virtual Experience”: Restriction or Chance?

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Abstract: COVID-19's widespread has infected about 3 million world population, and the countries have enforced a complete lock down that has created a severe economic and health crisis. In presence of this pandemic, the educational activity, tutorial courses and laboratory saw a drastic change. In this context, important modifications have been imposed mainly related to the structure, the way of operating, and the operational phase which involve students and teachers. Even more difficult is the implementation of laboratory and experimental activities through remote labs. In this paper we address this latter point, a possible implementation of a remote laboratory through the adoption of a software platform to connect students to the real lab will be presented. The use and the interconnection of TeamViewer software, LabVIEW, MATLAB and Arduino, will allow the students, at home, to carry out remote routines, program for conditioning circuit and see remotely the effect of the “virtual” lab implemented at distance. The hardware part is installed in the “real” research laboratory at the university and they can remotely perform measurements, characterizations and test validating the theory through experiments. This approach can be implemented with various experiments, here we will show a study of a DC motor with an analysis of vibrations and transient by using MATLAB for dynamic simulations. LabVIEW for the characterization, Arduino for the acquisition/ driving, and TeamViewer software has been used to virtually connect the students to the real lab.

Keywords: *TeamViewer software, LabVIEW, MATLAB Simulink, Arduino Uno, ADXL 335 accelerometer, DC motor and characterization.*

I. INTRODUCTION

During the ongoing outburst of COVID-19, the number of cases and fatalities gradually increased and the World Health Organization (WHO) described it as a pandemic. This situation has forced all countries to enforce a total lock-down and everywhere there has been a severe economic crisis [1]. Not only schools and universities have been shut down, but all government and private organizations have also been shut down, and all several solutions have been taken for everyone to work from home [2].

Due to the closure of university premises and in order to continue academic and laboratory activities for students, universities have decided to take online lessons as well as many of the laboratory activities have been cancelled to avoid student agglomeration and risk of infections.

It is worth noting that, considering the various disciplines of engineering, measurement systems, characterization procedures, theory and experiments play a key role for students and their education. The study of measurement systems helps one to calculate and interpret a signal from the physical world (real case). These systems include sensors, transducers, instruments etc., that transform data from one form to another for the user to be decipher. It helps to equate the unknown quantity to the known quantity. Accuracy and precision are the keys to reliable performance for measurement architectures and an experimental study of various systems is important for student knowledge. Obviously, it is not possible to deny these studies or avoid experimental activities for students due to infections. Literature presents several papers on measurement systems based on smart devices, virtual scenario/ educations for students, E-teaching and E-learning also based on web. For example, in [3], authors propose a solution for data acquisition by means of a telematic measurement system with a smartphone-based measurement system for the road vehicle monitoring system. The authors in this paper have clearly shown a measurement probe technology installed on the vehicle to monitor the driver's performance and transmit the information for the risk assessment to insurance-related companies.

The authors [4] presented a web-based solution for intelligent agricultural applications, in which real time soil fertility measurement parameters are monitored. This paper discusses measurements of soil fertility using sensors and the data is transmitted to the internet through a Wi-Fi module and stored to be accessible for anybody.

The trend evinces that now the universities are focused on virtual laboratory. Any student can work directly from home and perform practical experiments with ease of access. The results presented in [5] suggest a new solution to the virtual laboratory concept, through which students can easily access the laboratory to validate the theoretical results. The impact of digital learning [6,7] in this modern world has shown a drastic change in which anyone can access any study of literature or conduct research using the internet. The virtual laboratories [8]

are the revolutionary way to teach and to learn students, handy in any emergency or unexpected working situation. This helps students to perform the practical demonstrations virtually at any time.

Digital learning does not come exclusively to the university, influences many sensor industries [9], robotics, etc., and relieves staff from the burden on the job.

This paper improves the state of the art through an implementation of “virtual” lab, used during covid-19, by using TeamViewer software to connect to students to the real laboratory, a MATLAB® script to simulate the hardware system to be studied from an experimental point of view, a LabVIEW routine to realize the characterization routine, and Arduino to connect the hardware part.

The student can interact with the “real” research laboratory through internet and a platform based on various interconnected software to analyze the obtained experiments.

A demonstration of a DC motor has been simulated and an analysis of vibrations and transient by using a virtual instrument for the characterization has been accomplished. Arduino for the acquisition/driving, and TeamViewer software has been used to virtually connect the students to the real lab.

The paper is organized as follows: Section II will describe the working principle and the implementation of the virtual lab. Section III reports the experimental part and the results, while the concluding remarks are given in Section IV.

II. IMPLEMENTATION OF THE LABORATORY AT DISTANCE

The advance of technology has given employees an additional benefit in working from home when they are in emergencies. In universities, the same method is used to pursue laboratory work for students from a remote location.

First the desktop must be set up in the university laboratory to remote desktop mode, and the TeamViewer software needs to be installed on both the student’s and the host pc.

TeamViewer [10] software allows the free remote access to the personal computers running the host application. It is a free open source software available on the internet for platforms such as Windows, MacOS, Linux etc.

The TeamViewer software gives each computer a unique ID of the software installed and enables students to connect directly to the host computer with the respective ID and start to work at home. After the connection to the host pc has been established, the student will be able to start DC Motor modeling in MATLAB Simulink and validate it from the host desktop LabVIEW routine in order to perform characterization and validate the theory.

This allows to remotely access the host desktop and can virtually carry out the laboratory activity. This brings the ease of performing laboratory activity remotely and calls it distance learning. The architecture for the implementation of the laboratory at distance is shown in Figure 1.

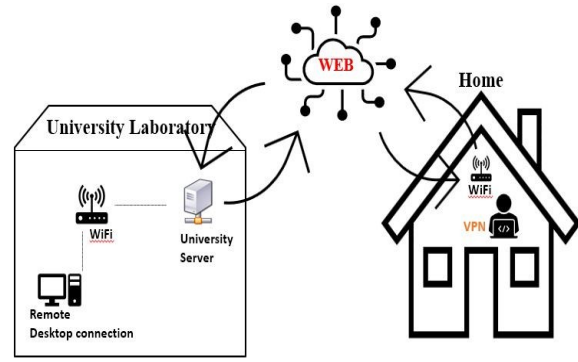


Figure 1 Architecture for the implementation of the laboratory at distance

The following section demonstrates a modeling of the DC motor in the MATLAB Simulink, and an experiment with Arduino and LabVIEW interface to study the electrical machine in terms of transients and vibrations also using an accelerometer to characterize the correct functioning of the device. Theoretical and experimental validation will be conducted through the virtual experience.

III. THE VIRTUAL EXPERIMENT OF THE DC- MOTOR, SIMULINK MODELING, LABVIEW ROUTINE AND ARDUINO

In most control systems, such as homes, automobiles, industries, etc., the DC machine is the important one. Evidently, mathematical modeling [11] is very important for understanding the system’s performance and behavior.

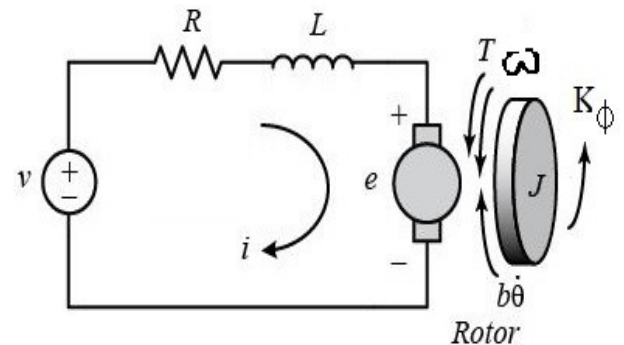


Figure 2 DC motor modeling circuit

The DC motor is the most common actuator considered in various disciplines of engineering and for this reason the knowledge of electrical machines is fundamental for the background of the students, both from the theoretical and experimental point of view. A simple DC motor modeling circuit is assumed here and is shown in Figure 2. From the study [12], the system final equations are

$$\frac{di}{dt} = \frac{v}{L} - \frac{R}{L}i - \frac{k\phi}{L}\omega \quad (1)$$

$$\frac{d\omega}{dt} = \frac{k\phi}{J}i - \frac{b}{J}\omega \quad (2)$$

Where b is the friction, J is the moment of inertia, ω is the angular velocity, i is the armature current, v is the supply voltage, R is the resistance, L is the inductance and k_ϕ is the armature constant and t is the time. Thus, a Simulink model based on the equation (1) and equation (2) has been implemented as shown in Figure 3. The following parameters have been considered and declared in the MATLAB's command window.

Inductance (L)= 0.1 H
 Armature constant (k_ϕ)=0.1 V s
 Moment of Inertia (J)= 0.1 kg-m²
 Friction (b)= 0.01 N m s
 Resistance (R)= 0.5 Ω
 Input voltage (v)= 5 V

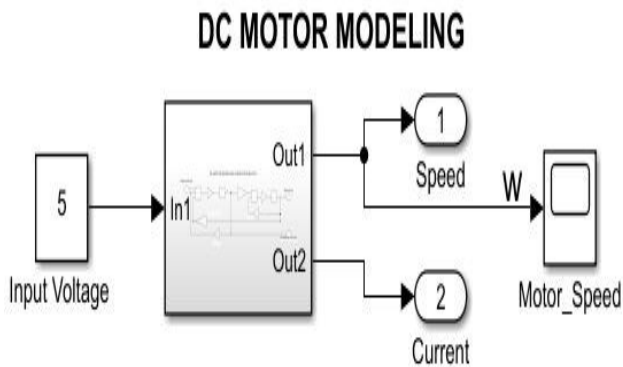


Figure 3 DC motor modeling in MATLAB Simulink

The DC motor modeling has been implemented through the TeamViewer and in the MATLAB Simulink and is shown in Figure 3. The subsystem block for the DC motor modeling is shown in Figure 4.

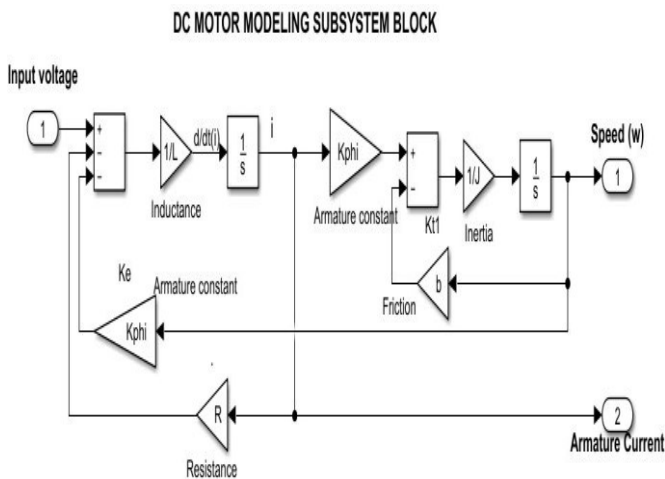


Figure 4 DC machine modeling subsystem block

The DC motor speed response has been obtained from the Simulink model with a graph and is shown in Figure 5.

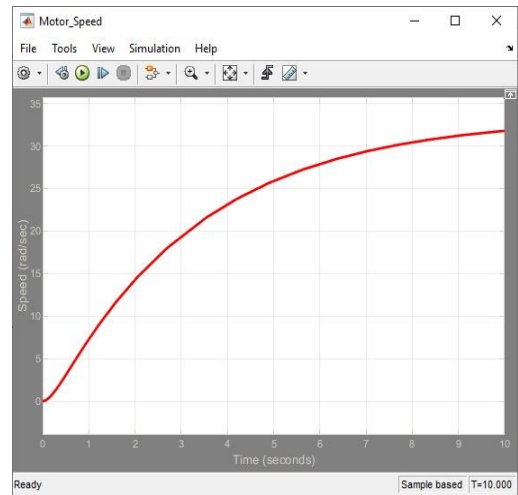


Figure 5 DC motor output characteristics

The Simulink modeling of the DC motor is further validated with the Arduino and LabVIEW experimental setup with a DC motor.

The following are the components used for the experimental setup.

- Arduino Uno microcontroller [13]
- L293DNE motor drive controller [14]
- DC motor [15]
- Accelerometer (ADXL 335) [16]
- Bread board
- USB cable

To control the speed of the DC motor (simulated in the previous step) and to drive in the motor in clockwise or anti-clockwise, a motor drive controller has been utilized.

The DC motor is connected to the Arduino board through the motor drive control and the acquisition has been carried out in LabVIEW routine.

To monitor the vibrations generated on the DC motor, an accelerometer is affixed to the DC motor, thus obtaining the acceleration and the response with respect to time is shown in Figure 5.

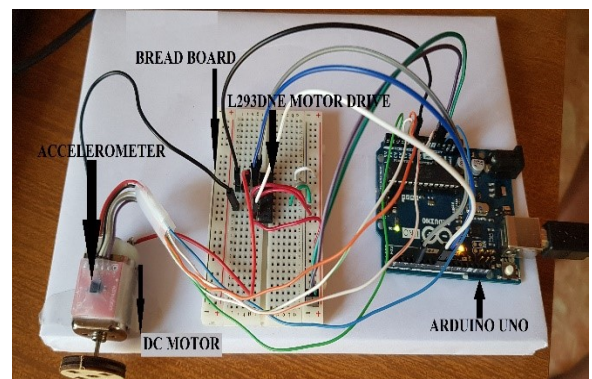


Figure 6 Connection schematic from the Arduino Uno microcontroller to the pc

The connection schematic of the DC motor and an accelerometer connected to the Arduino Uno microcontroller to the pc is shown in Figure 6. Measurements of excitation voltage and vibration will be considered and compared with the theory. In this context, both the DC motor and the accelerometer have been powered from the Arduino through the power supply ports.

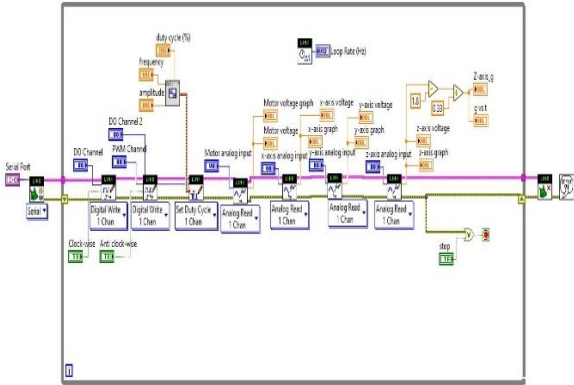


Figure 7 LabVIEW block diagram for the DC motor and an accelerometer connected to the Arduino to the pc

The LabVIEW block diagram, that the student performs at distance, for the DC motor and an accelerometer connected to the Arduino to the pc is shown in Figure 7. The PWM signal is chosen to control the speed of the DC motor. It is basically TON and TOFF pulses which tend to give the DC motor the way the motor rotates. The LabVIEW front panel for the output response of DC motor and an accelerometer connected to the Arduino to the pc is shown in Figure 8.

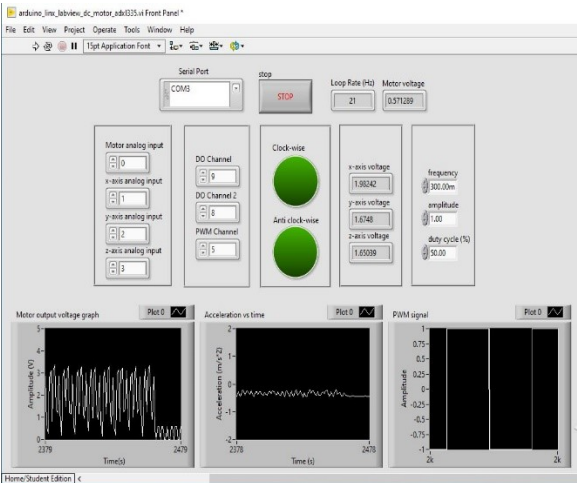


Figure 8 LabVIEW front panel for the DC motor and an accelerometer connected to the Arduino to the pc

An external accelerometer which is used to sense the vibrations coming from DC motor. The property of this accelerometer is

that it senses the vibrations of DC motor and provides an output voltage across the axis corresponding to the motor vibrations. Fast Fourier Transform (FFT) has been applied in the Matlab® command window to the accelerometer’s output and the response is shown in Figure 9.

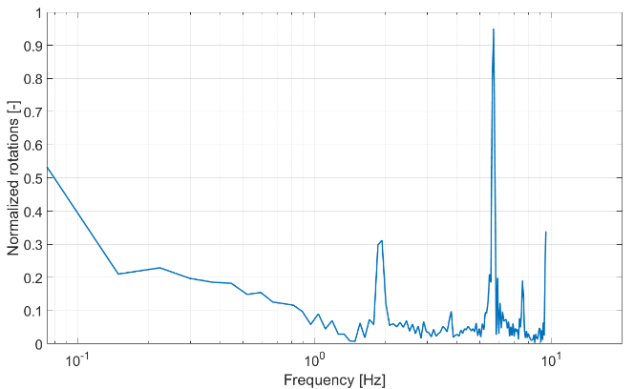


Figure 9 FFT of the output of the accelerometer

From Figure 9, it is evident that the spike at 5 Hz is in correlation with the Simulink model shown in Figure 5.

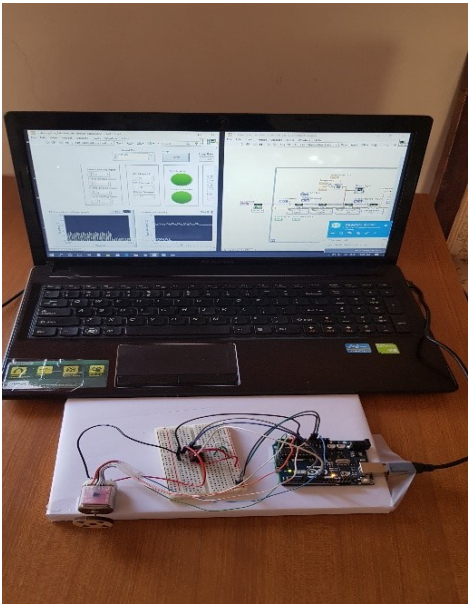


Figure 10 Experimental setup of DC motor and accelerometer connected to the pc through Arduino uno and LabVIEW

The experimental setup in Figure 10 shows the DC motor and accelerometer connected to the pc through Arduino and LabVIEW in the laboratory. The setup has been made and the students can now remotely access this pc from their home using TeamViewer software. The students at home can now easily access the laboratory pc for performing the test in which they can visualize the hardware setup using the pc’s webcam and can control the pc using TeamViewer software.

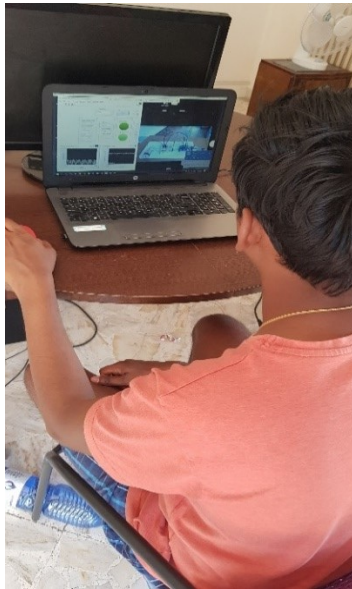


Figure 11 The student performing the validation and verification of the LabVIEW routine from his home remotely accessing the laboratory pc

IV. CONCLUSIONS

In this paper we present a virtual experience for students who cannot attend labs during the health emergency COVID- 19. The solution proposed is based on a “virtual” lab by using TeamViewer software to connect the students to the real laboratory, a MATLAB script to simulate the hardware system to be studied from an experimental point of view, a LabVIEW routine to realize the characterization routine, and Arduino to connect the hardware part. In particular, the experience here proposed regards a platform for characterization of DC motors. The students, at home, can validate the theory from an experimental point of view, through simulations, control routine and perform measurements in an electrical machine installed in the laboratory at the university. The results presented here illustrate how laboratory work can be handled remotely and benefit students without any interruption of the training activities.

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