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Web Based Remote Controlled Electrical Motor Laboratory used as Educational Tool

Abstract. *In this study, a web-based remote-controlled motor educational tool for electrical, electronic and computer education was formed. The educational tool involves three different motor experiment, which are direct current motor, stepper motor and servo motor The users can interact with the educational tool by using any computer connected to the Internet, and can conduct the experiments in a real-time manner. Each experiment can be used simultaneously. Users work with a camera connected to the system that transmits an image of a laboratory.*

Streszczenie*. Przedstawiono system komputerowy do celów dydaktycznych wykorzystujący zdalne sterowanie za pośrednictwem Internetu. Studenci mogą przeprowadzać trzy eksperymenty badania maszyn elektrycznych: silnik prądu stałego, silnik krokowy i serwomechanizm. System wspomagany jest kamerą pokazującą obraz z laboratorium. (****Laboratorium Internetowe do przeprowadzania eksperymentów z silnikami elektrycznymi****)*

Keywords: Electric motors, LabView, Educational tools, Real time
Słowa kluczowe: Silniki elektryczne, laboratorium, laboratorium Internetowe.

Introduction

The most important characteristic of the schools providing vocational and technical education is to increase the quality of the courses and the preparedness of the students for work conditions [1]. As a result of the advancements in technology, continuous improvements in the course contents and experiment sets are needed. The increases in the number of students in technical schools and in the laboratories or experiment sets used in the laboratories are not compatible. This inadequacy prevents required application studies [2]. The conventional remote-controlled educational systems, and later, remote-controlled real-time experiment set-ups are evaluated as educational systems developed as a supply to these requirements, where test and information transfers are remotely provided without the limitations of students or responsible teaching staff [3]. Since the visual and interactive training are of primary importance in remote control systems, the two most basic conditions of pedagogic appropriateness are provided [4], [5].

Today, many studies are being carried out regarding remote control and real-time motor controls. These studies are focused on PID control in servo motors by using FPGA and MATLAB [6], PI control in induction motors by using dSPACE and DSP [7], PID controlled ball and hoop system control by using java and simulink[4], velocity control in three-phase brushless direct current motors by using C++ [8], RC oscillator and DC motor controls based on MATLAB and DSP [9], formation of PI controlled DC motor training sets by using MATLAB [10], PID control in DC motors by using LabVIEW [11], DC motor control by using TINI microprocessor and java applets [12], PID control in induction motors with a two level inverter by using PLC and scada [13], PI velocity control in DC motors by using MATLAB [14], four-quadrant velocity control in microcontroller [15], and error detection in induction motors by using LabVIEW [16]. DC motors by using MATLAB and PIC18F4520 In addition to these, there are also studies on comparative analysis of remote control laboratories and conventional laboratories [17], [18].

In this study, attempts were made to fulfill the lack of application experience of the users with sufficient theoretical background by means of experiments prepared in accordance with today's technology and up-to-date curricular programs. The established experiment set-ups were optimized to make them easy, and low-cost and user friendly. Every student can use them in a one-to-one manner. These experiments play an important role in the engineering faculties of the universities and in the electronics, electrical machines, and power electronics course curriculums of the vocational schools.

Remote-Control Laboratory Architecture

The developed remote-control educational laboratory is composed of two parts, which are the software and the hardware.

Hardware Architecture

The block diagram is shown in Figure 1. The remote-control laboratory is composed of a server computer with an National Instruments PCI 6221 M data acquisition card, where the experiments are formed, a direct current motor, stepper motor, a servo motor, the driver circuits of the motors and a camera displaying these. No special instrumentation or software is needed to for users to use the system, just a computer with internet access.

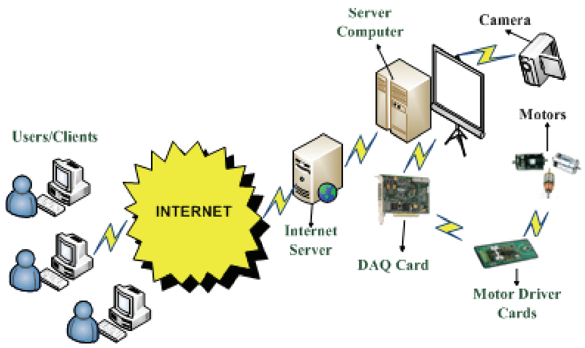

Fig. 1. System block diagram

Software Feature

In the developed system, LabVIEW 8.6 software was used in order to construct the experiments, data acquisition, formation of HTML exit codes, image reception by web camera and user interface. In addition, "ASP and Acsess" and "Dreamweaver" software was used for user access and site design, respectively.

After accessing the system by means of a user name and a password, the experiment selection screen, which is seen in Figure 2, is reached. After selecting the desired experiment, theoretical information regarding the selected experiment, the used equations and the intended use and usage modes of the selection buttons on the experiment interface are explained. After reading these information, the experiment is started by using the “click to see the simulation” button at the bottom of the page.

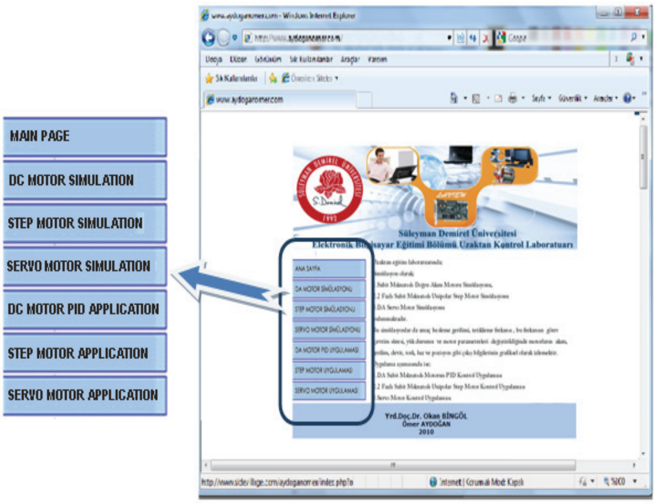

Fig. 2. Test explanation and selection page

Experimental Studies

In the experimental studies, for the data acquisition purposes Multifunction DAQ PCI 6221 from M series of National Instruments was used.

PID Control in DC motor

The permanent magnet direct current motors are capable of reacting very rapidly to velocity change commands and instantaneous loadings. In order to use these characteristics in an efficient manner in approximately 95% of industrial applications, DC motors are used with PID (Proportional-Integral-Derivative) control. PID control is advantageous since it increases accuracy of the systems, economizes power consumption, provides remote control, and reduces the effect of the noise [20].

The input variable of the PID controllers, used in the experiment, is defined as the velocity error (ω_e) in reference velocity (ω_r^*) and the actual velocity of the motor (ω_r). The actual velocity of the motor is calculated as taking the derivative of position information(Q_r), read from the outlet of the encoder, which is connected to the motor shaft. The outlet of the PID controller (Ut) is adjusted according to the reference velocity and the actual velocity. The block diagram of the PID control of a DC motor is given in Figure 3. The PID controller outlet adjusts the voltage level at the outlet of the driver circuit by increasing or decreasing the duty cycle rate of the PWM (Pulse Width Modulation) signal. In case that the actual velocity is higher than the reference velocity, the duty cycle rate at the PWM producer outlet is reduced, and therefore the motor gets slower. In the opposite case, on the other hand, duty cycle rate is increased and motor gets faster.

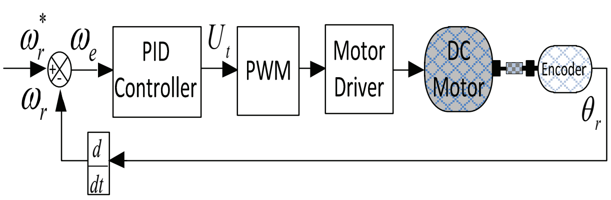

Fig. 3. Block diagram of the PID control of a DC motor

The mathematical expression of the PID control, given in Figure 3, is given in (1) and (2).

$$\omega_e(k) = \omega_r^*(k) - \omega_r(k) \tag{1}$$

$$U_t = K_p\omega_e(k) + K_i\sum_{j=0}^{k}\omega_e + K_d\big(\omega_e(k)\big) \tag{2}$$

where, ω_e stands for velocity error, ω_r^* for reference error, ω_r for the motor’s actual velocity, U_t for PID output, *Kp* for fractional coefficient, *Ki* for integral coefficient, and *Kd* for derivation coefficient.

In Figure 4, the front panel of the PID control of a DC motor is shown. Each area in the panel is numbered. Area “1” indicates PID gain control section, where Kp, Ki and Kd values are determined. Area “2” shows graphical screens. Here, “a” indicates PWM output, “b” PID output, “c” actual and reference velocity values, “d” voltage values at the motor terminals, and “e” current values at the motor terminals. These voltage and current values are read from the “analog in” terminal of DAQ card. Area “3” shows set-up point and process values.

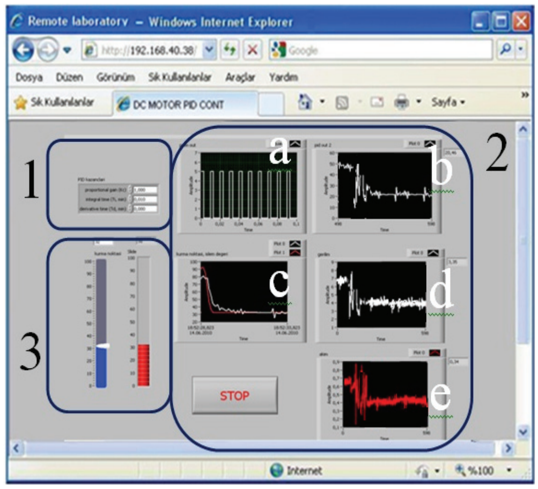

Fig. 4. Front panel of PID control application of a DC motor

In Figure 5, the block diagram formed for the PID control of a DC motor is shown.

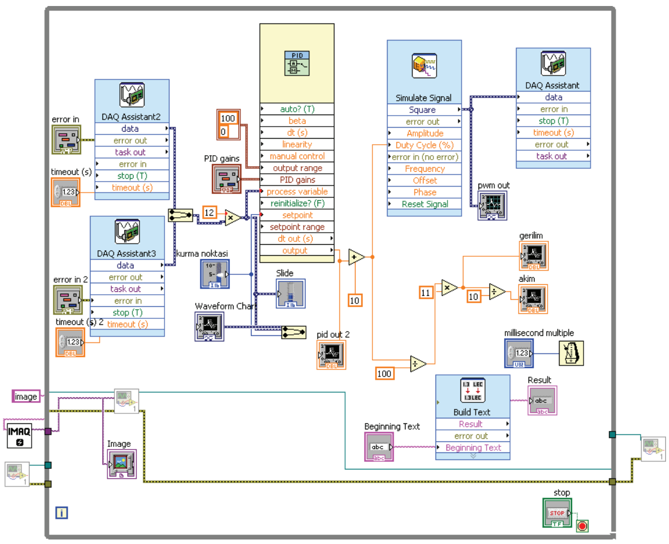

Fig. 5. Block diagram of PID control application of a DC motor

Control in stepper motor

Stepper motors transfer current impulses to stepwise rotor movements. The direction of rotation is determined by the effect of currents, alternately flowing in the winding. The stepper motor driver equivalent circuit and trip sequence, providing the continuous rotational movement of the motor, are given in Figure 6.

The block diagram of the control of a stepper motor is given in Figure 7. The movement of the motor is determined by means of a logic-controller, composed of a computer and a DAQ card. The information taken from the logic-controller is transferred to the stepper motor by means of a motor driver circuit. The driver circuit design was made according to a stepper motor, with 1,875 degrees of step angle and with a maximum phase current equal to 2A. The angular velocity information is taken from the encoder, connected to the motor shaft while the voltage and current values at the motor terminals are taken from the “analog in” terminal of the DAQ card. In the experiment, the trip sequence needed for a certain change in the movements of the motor, and the current, voltage and angular velocity values during these movements are investigated.

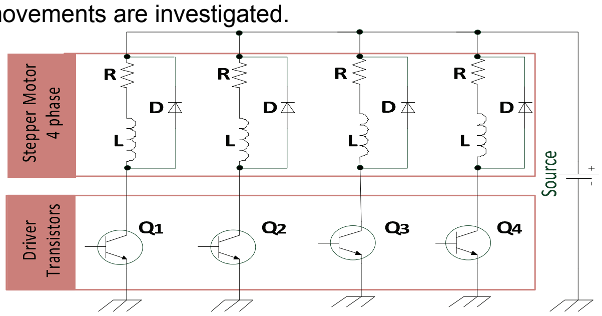

Fig. 6. Stepper motor driver equivalent circuit

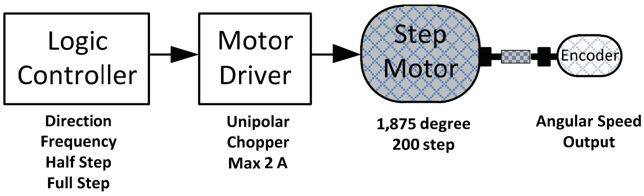

Fig. 7. Block diagram of the control of a stepper motor

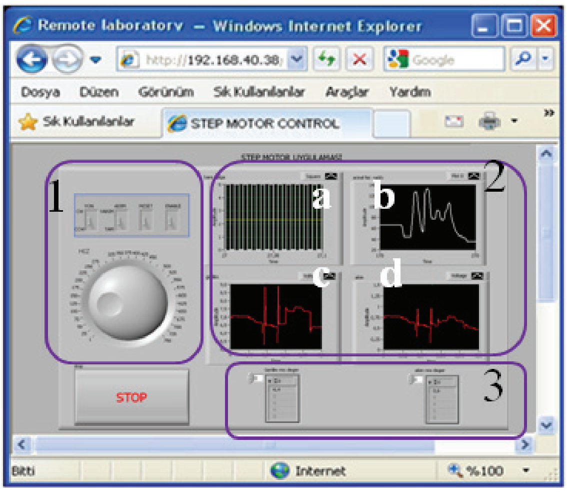

Fig. 8. Control front panel of a stepper motor

The interface regarding the stepper motor driver application is shown in Figure 8. Where Area “1” indicates the “direction”, “step”, “reset“, and “enable” buttons, used for the motor control, and the frequency information needed for the rotation of the stepper motor, while area “2” indicates the zone where the applied pulse, motor’s angular velocity, and the graphics of current and voltage values formed the motor are shown. In area “3”, on the other hand, “effective (rms)” values, obtained from the graphics, are shown.

In Figure 9, the block diagram formed for the control of a stepper motor is shown.

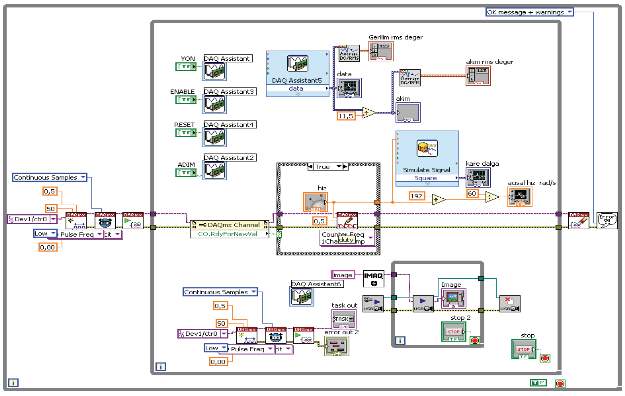

Fig.9. Control block diagram of a stepper motor

Control in servo motor

Servo motors are used in the systems, where position control, high power, high moment and fast response are needed. The change in position in servo motors is provided by adjusting the voltage, applied to the motor. In Figure 10, how to change the position of a servo motor by changing the frequency and cycle time of PWM signal is shown. The opto-insulators, shown in the block diagram, prevent the terminals of the data acquisition cards from any possible damage due to currents and voltages forming on the motor.

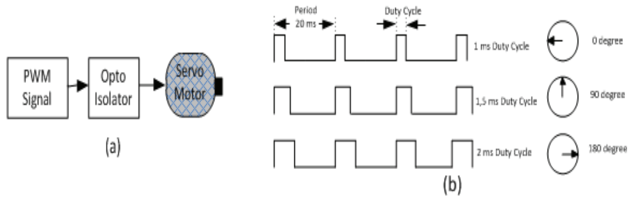

Fig. 10. a) Control block diagram of a stepper motor b) Duty cycle rates

In the experiment, the angular value of the stepper motor is automatically or manually adjusted. When the selection button is set to automatic control, the PWM signal is automatically formed for 0, 90 and 180 degrees. When the selection button is set to manual control, on the other hand, the frequency and cycle time of the PWM signal is determined based on the angle value defined by the user.

In Figure 11, “1” indicates the buttons, used to adjust frequency and cycle time, “2” indicates PWM signal index, and “3” indicates the automatic and manual control options and the buttons used to set the angle.

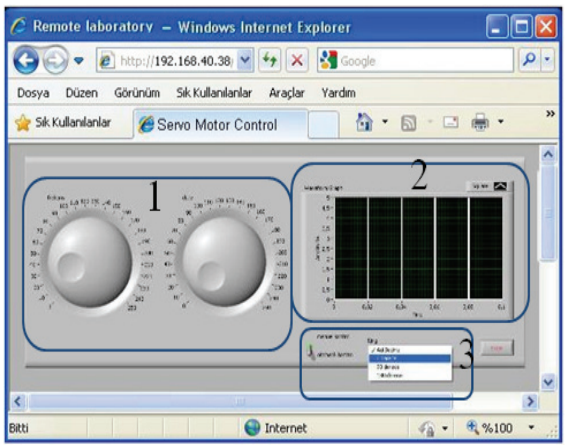

Fig. 11. Control front panel of a servo motor

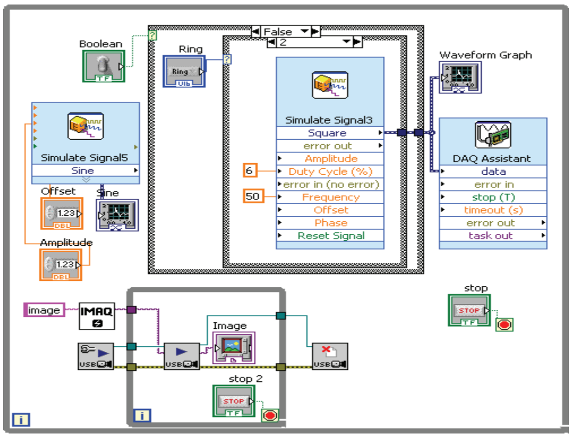

Fig.12. Control block diagram of a servo motor

In Figure 12, the block diagram formed for the control of a servo motor is shown.

Image Capture

In LabVIEW, the image reception processes were carried out by a Vision Acquisition Software tool and a web camera. In each test, the camera images are given in a different window. In each open window, there are "save" and "zoom in" options for the images. An image of the test set-up, taken from the camera, is given in Figure 13. The block diagram needed for capturing a camera image is shown in Figure 14.

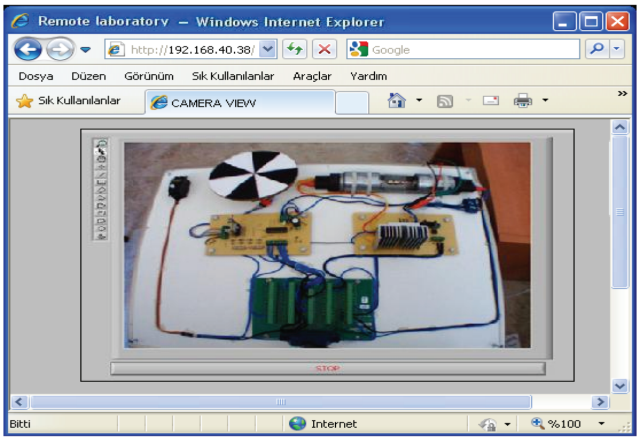

Fig. 13. Camera image front panel

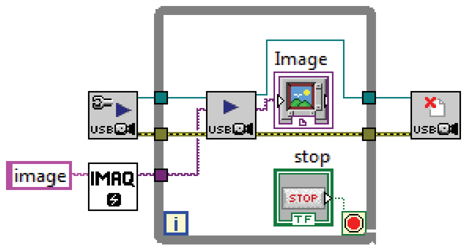

Fig. 14 .Camera image block diagram

Web-based laboratory application image

The developed system is shown in Figure 15. where, "1" indicates the computer, on which LabVIEW is installed, "2" indicates the web camera providing the image transfer, "3" indicates the screen image, "4" indicates the connection block needed for the DAQ 6221 card, "5" indicates DC motor driver card, DC motor itself, and the encoder connected to the motor shaft, "6" indicates the stepper motor, stepper motor driver card, and the encoder connected to the motor shaft, and "7" indicates the area where the servo motor is placed.

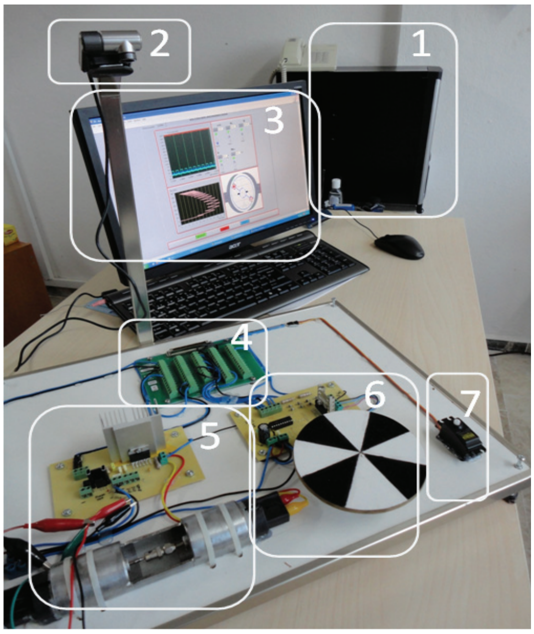

Fig. 15. Completed state of the system

Conclusions

In this study, a remote-controlled motor educational tool was formed, aimed at undergraduate or associate students, involving direct current motor, stepper motor and servo motor experiments. The system was developed as an alternative to the laboratories that are insufficient in number and quality in the conventional education system, and provides low cost and pedagogically appropriate application opportunity, which allows performing experiments anywhere in a short time, and the convenient saving of results. In addition to the other remote control laboratories, the most commonly used three motor types were collected in a training set package, and therefore the users are given the opportunity to carry out all these three experiments simultaneously.

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