C# APPLICATION FOR STEPPER MOTOR CONTROL IN REMOTE EXPERIMENT

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Abstract: *The paper presents implementation of developed C# application for stepper motor control for the purpose of creating remote experiment within CEyeClon remote environment. This laboratory exercise enables students to apply knowledge of basic object - oriented programming in a digital control application. In this remote experiment, a stepper motor is controlled by the microcontroller via the application written in the programming language C#. Students are enabled to remote control the direction and the speed of rotation of a stepper motor by changing the parameters in the application. The achievement of educational goals of this remote lab module is checked through anonymous student survey in the form of questionnaire. Students' feedback will be used for further improvement of the created remote lab experiment.*
Key Words: Remote experiment; C# application, Stepper motor, Real time

1. INTRODUCTION

Innovative teaching method based on remote experiments enables to students to do experiments and gain practical engineering knowledge and skills, without being physically present in the laboratory. This offers great advantages because it gives the possibility to supplement theoretical with practical knowledge, relatively easily, by accessing the experiment remotely.

The paper presents a brief overview of the theoretical basis of the stepper motor control, as proportional executor in digital control systems [1-2]. Also, a brief description of developed appliication which enables remote control of stepper motor, is given. At the end, the achievement of educational goals of this remote lab module is presented through analysis of the anonymous student surveys [3-7]. The results will serve to further experiment improvement.

2. REMOTE CONTROL OF STEPPER MOTOR

In the development of digital control systems, stepper motor is a unique component in the class of executors which requires no D/A conversion on its input. It can be seen as alternating current motor, whose stator windings are induced with rectangular voltage pulse trains, causing the rotor step-by-step rotation. It belongs to the class of executors of proportional type − the angle step on its output is proportional to the number of control impulses on its input.

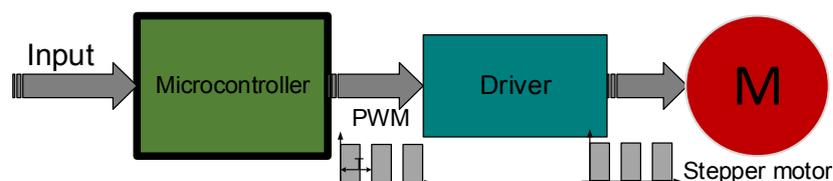The block diagram of the remote experiment with open-loop control of stepper motor, is shown in Figure1.

Figure 1. Open loop control of the stepper motor

Within the developed C# application, the desired input (the motor speed, number of steps, i.e. the angular displacement) is forwarded to microcontroller as an appropriate digital pulse trains. The pulse width modulated signal of low energy level at the output of microcontroller is than converted in the driver, to current pulses, which successively can excite the stator windings of the motor. Figure 2 shows laboratory setup consisting microcontroller and stepper motor. The excitation signal of the stepper motor, realized as PWM signal is shown in Figure 3.
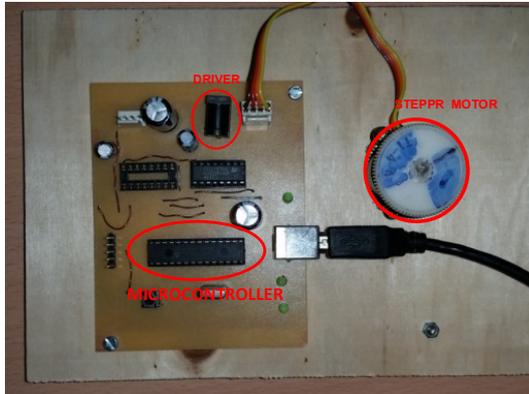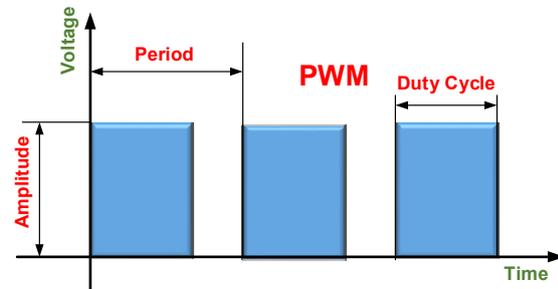

Figure 2. The hardware system   Figure 3 PWM signal

3. C# APPLICATION FOR STEPPER MOTOR CONTROL

The motor speed is determined by the breaking routine of timer 1. The time interval of interruption is 10ms, and on the basis of that interval and the set speed it can be calculated if the motor is allowed to take the next step or not. In this way it is ensured that ProcessIO function smoothly handles all other requirements, and, if necessary, calls the function for the new motor step in the given direction, for example, function Motor1StepCW. CDC mode of USB stack ensures that the device is to PC characterized as USB serial port. For the control realization a simple protocol is used, from which are, through PC, commands sent for motor control.

The application consists of two main modules. The first module is a USB handler which implements the Serial Port Control which comes with .NET. USB handler provides a simple method to send a string message to the serial port. On the other hand, from the serial port an event is provided, which ensures that the regularly processed message is sent from the microcontroller. The second module is a simple win forms application which references USB handler project and sends messages after the specified protocol depending on the activated button and the selected option. An example of sending a message to the microcontroller is reduced to the simple call Send Command method of the USB handler. In this application Communicator is the object of USB handler class.

4. IMPLEMENTATION OF REMOTE LAB MODULE

For the purpose of starting a remote experiment placed in a remote laboratory, CEyeClon viewer is the only additional software that has to be installed on user's computer. The user interface for the remote experiment with stepper motor is shown in Figure 4. The application also gives possibility to integrate a camera after activating the Start button, so that the remote experiment can be seen at any time. Connection to COM3 port enables access to the microcontroller which performs control for the given modes such as 1) Free run - with requested speed in a given direction 2) Step run - with requested number of steps in a given direction 3) Set angle - with requested angular displacement in a given direction. Direction of the motor rotation is made by selecting one of the modes: CW (clockwise direction) or CCW (counterclockwise).
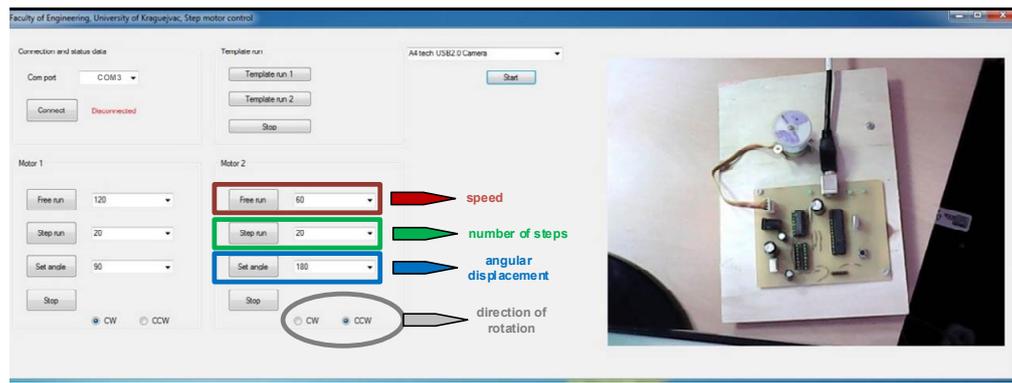
Figure 4. The user interface for remote experiment with stepper motor

5. EVALUATION

The evaluation questionnaire consists of 18 questions. First part of questionnaire, consisting of 15 questions, relates to evaluation of remote experiment and its usefulness in learning related course topic. Second part of questionnaire consists of 3 essay questions related to student's opinion about advantages and disadvantages of the remote experiments. In conducting this remote experiment and evaluation process, 10 undergraduate students, attending study course in Remote Control within study program in Computer Science in this school year, were participated in the survey. Regarding the first part of questionnaire, the questions were as followed:

1. Conducting of this remote experiment helped me to achieve learning module's objectives
2. Conducting of this remote experiment helped me to achieve learning module's outcomes
3. The remote experiment facilitated better understanding of module's theoretical background
4. The remote experiment helped mi to learn to use lab equipment
5. Remote experiment within this learning module is prepared on appropriate technical level
6. Experiment is easy to understand and use
7. Written manual for remote experiment is clearly understandable and helpful
8. Remote experiment was supported by adequate explanations of teacher/teaching assistant before its starting
9. User interface for remote experiment within this learning module is easy to use
10. Response time after user action within running experiment is satisfying
11. Capture of experimental results is enabled
12. Storage of experimental results is enabled
13. Quality of visual display is satisfactory
14. There was no problem or stalling while working with remote experiment
15. I would like to use remote lab in other lessons of this subject too

Highest grades were given to the questions referring to: easiness of usage and understanding 6 (4.9); understandability and helpfulness of the written manual 7 (5.0); adequate explanations of teacher/teaching assistant before its starting 8. (4.9); easyness to use of the user interface 9. (4.8)

Lowest grades were given to the questions referring to: enablness of storage of experimental results 12 (3.4); problems or stalling during work on the remote experiment 14 (3.2).

In the second part of questionnaire, students gave their opinion about advantages and disadvantages of experiment. Biggest disadvantage referred to camera which could not be integrated in the application for a while and also slow response time. Advantages were different: they can do experiment from home, the whole process was easy to understand, experiment help them in understanding of some theoretical concepts, etc.

Table 1. The total number of grades from the (5) to (1) from the answers to the first Part of the questionnaire

Question	Not relevant	1	2	3	4	5	Average grade
1				3	4	3	4
2				3	4	3	4
3			2	3	2	3	3.6
4				2	3	5	4.3
5				2	3	5	4.3
6					1	9	4.9
7						10	5.0
8					1	9	4.9
9					2	8	4.8
10			2	3	4	1	3.4
11			2	3	2	3	3.6
12			3	3	1	3	3.4
13			2	2	5	1	3.5
14			4	2	2	2	3.2
15				1	2	7	4.4

Meaning: 5- I completely agree; **4**-I mostly agree; **3**-I partially agree **2**- I mostly disagree **1**- I fully disagree
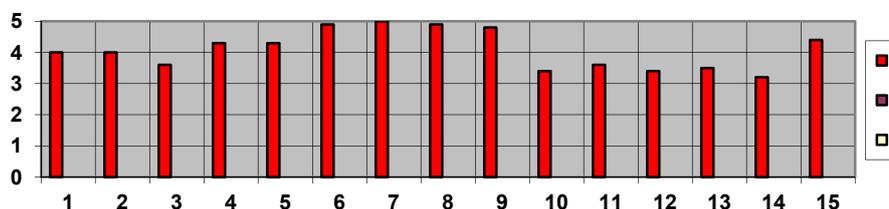

Figure 5. Average grades to first 15 questions from the first part of the questionnaire

6. CONCLUSON

By using described experiment students have opportunity to control remotely the direction and the rotation speed of a stepper motor by changing the parameters in the application. Performing this remote experiment individually, at any time and repeatedly if one needs, enables to students better understanding of coupling the digital control algorithms with a stepper motor.

ACKNOWLEDGMENT

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