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EDUCATIONAL ASPECTS IN CONTROL SYSTEM DESIGN TECHNOLOGY

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ABSTRACT

Didactical technology in the field of automation implies not only the transfer of knowledges to the students, but also to create them the abilities to understand, describe, search, innovate, generate a solution for a technical problem. This paper presents a didactic activity according to the elements exposed, with a very intense impact to the students. Examples are considered only in the field of automation because this involves some particular features. Four examples are detailed. The conclusions were spectacular due to the massive involving of students in this activity.

KEYWORDS:

education, control systems, learning

INTRODUCTION

Engineering is a profession. Its members work closely with scientists and apply new and old scientific effects to produce products and services that people want. Engineers are professionally responsible for the safety and performance of their designs. The objective is to solve a technical problem with the simplest, safest, most efficient design possible, at the lowest cost [WAN01]. Design is a very important engineering activity. It involves meeting some need by applying the laws of physics and chemistry, using mathematics, and the computer [SHA01]. The purpose of this paper is to describe the educational aspects of four design projects in automation, according to the statements above, that were proposed for the first time to students in the fifth year.

During the design activity, the students will cover a wide area in the field of automation (electronics, measurement, microcontrollers-hardware and software, high technology boards, system theory), they are shown the steps of the project management, how to receive abilities, how to communicate and to innovate. The projects are rather small, hardware-ready and not very difficult, so the students can easily fulfill their tasks and see rapidly the results.

EXPERIMENTAL PART

The experimental part consists of four closed loop control systems. The structure and objectives for every application will be presented consequently.

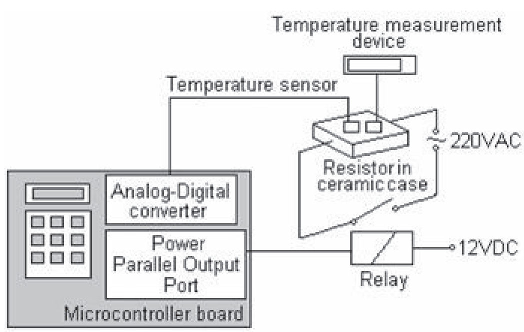
1. Temperature control system. In **Fig. 1** is depicted the block diagram and in **Fig. 2** the picture of this system. The process is represented by a 10k resistor encased in ceramic. It runs a current from a 220 VAC supply through a contact of a Relay driven by an open collector transistor from microcontroller board (Power parallel port). The temperature of the ceramic surface is read both by a LM335 temperature sensor that converts it in voltage conducted to the digital-analog converter on microcontroller board [***89] and an industrial temperature measurement device used only for monitoring purposes, with no duty in control.

The task for this application is to design a control system (the software) to control the temperature within the interval **[θ_{ω}-ε, θ_{ω}+ε]**, together with displaying both of actual and reference temperature and possibility to adjust from the keyboard of microcontroller board the prescribed temperature.

The objectives for the student are:

- to understand the electronic schematics (introducing the use of temperature sensor, relay actuation, open collector parallel output),
- to manage the signal conversion from temperature to voltage,
- to apply the knowledges of bi-positional controller (emphasizing the hysteresys) in solving the task,
- to ellaborate the structure of program for this task (is time critical?, which are the priorities between resources exploiting?),
- to practice the C programming in working with different resources (analog – digital converter, power parallel port, keyboard, display).

Fig.1



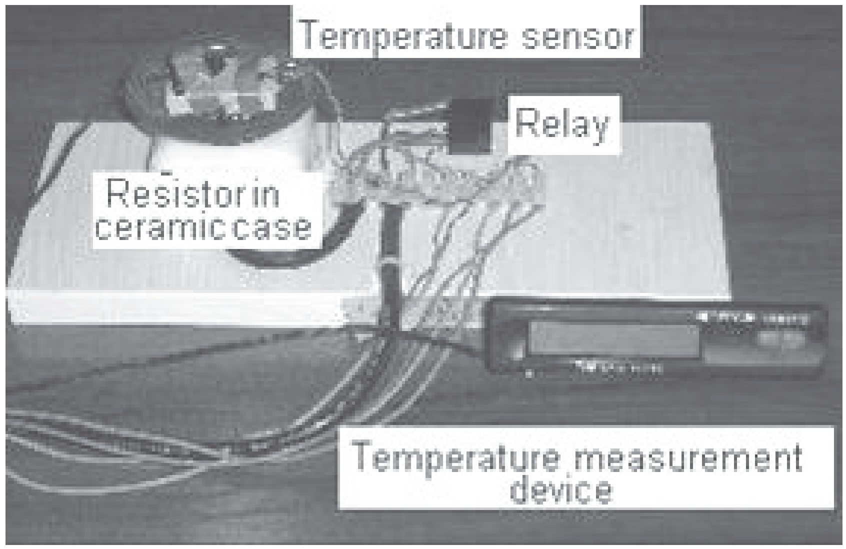


Fig.2

As this application is the easyest, the students managed very rapidly the bi-positional controller and this part was finished very quickly. Problems were encountered with signal conversion, working with display and especially with keyboard.

2. Position control system. In **Fig. 3** is represented the block diagram and in **Fig. 4** the picture of this system. The process is represented by DC motor that carries a slider along of a steel wire over two turning wheels. The cursor represents also a wiper of a long potentiometer used as a position sensor. The voltage collected by the wiper is provided to the Analog-Digital converter of the microcontroller board. The motor is actuated by a driver (BA6219 of ROHM) that has as inputs one analogic voltage in range [0, 5] V that controls the speed, and two digital signals that controls the direction of rotation. So microcontroller board receives the information about actual position and consequently provides three signals to control the motor according to a control law.

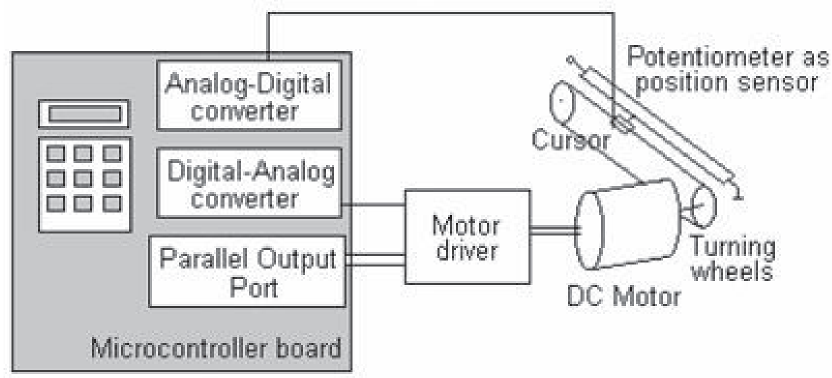


Fig. 3

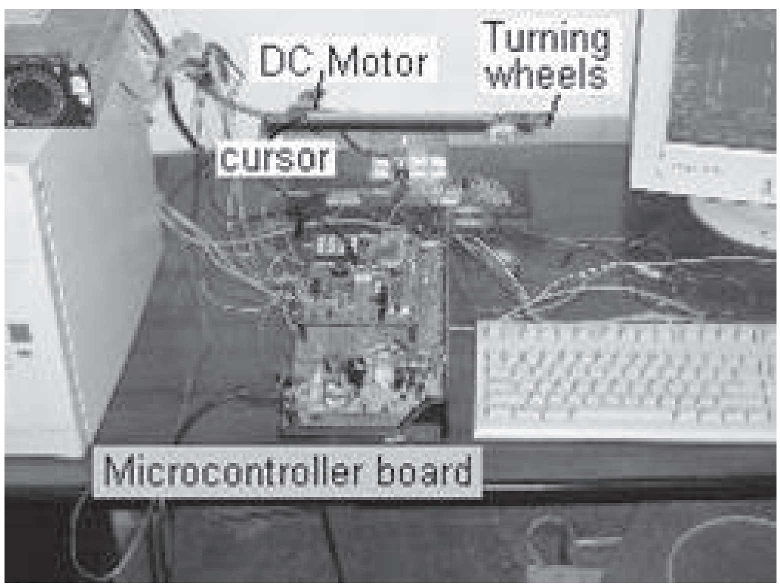


Fig.4

The task for this application is to design a control system (the software) to control the position of cursor along all path, together with adjusting from the keyboard of microcontroller board the reference position.

The objectives for the student are:

- to understand the electronic schematics (introducing the use of position sensor, motor driver, parallel output, digital-analog converter),
- to manage the signal conversion from position to voltage,
- to apply the knowledge of implementing a controller in solving the task (students were directed to implement a n-positional and a proportional controller),
- to elaborate the structure of program for this task (is time critical?, which are the priorities between resources ?),
- to practice the C programming in working with different resources (analog-digital converter, digital-analog converter, parallel port, keyboard, display).

In this application, students managed quite rapidly both the n-positional and the proportional controller. Also the working with display and keyboard run pretty fast. A particular feature was noticed regarding the proportional controller. They could appreciate quantitatively and qualitatively by watching on scope, the effect of the controller constant on the quality of control. It was a very good example for understanding the controllers.

3. Orientation after the light. This system consists of a rotating frame actuated by a 4 phases, unipolar stepper motor (see electric schematics in **Fig. 5**, functionality in **Fig. 6** and a picture in **Fig. 7**). Three light sensors oriented in proper positions (as in fig.6) sense the intensity of light.

As the light is making different angles with the sensors, the voltage issued by sensors differ consequently. A reference position (called 'closed') of the rotating frame is defined by a Hall sensor and a magnet. 4 Darlington transistors drive the motor.

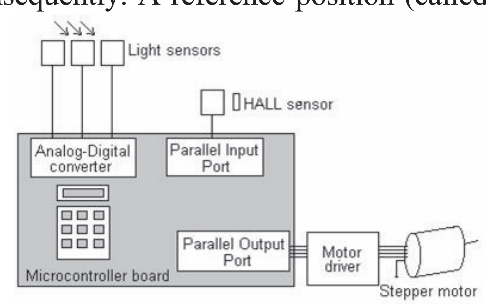


Fig. 5

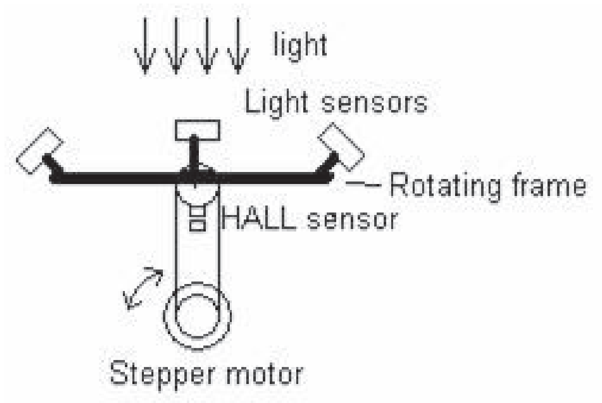


Fig. 6

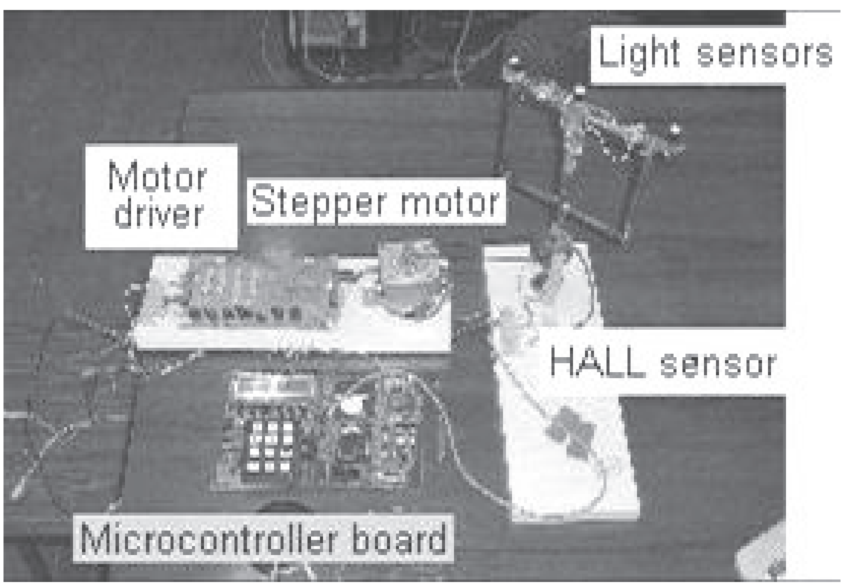


Fig. 7

The task for this application is to control the position of rotating frame in such a manner so it always stays perpendiculary on light beam. If there is no light, or the intensity stays below a certain limit, the frame has to go to the 'closed' position.

The objectives for the students are:

- to understand the electronic schematics (introducing the use of light sensor, Hall sensor, stepper motor, Darlington transistors as motor driver),
- to manage the signals coming from 4 sensors,
- to elaborate the structure of program for this task (how does the block diagram look like?),
- to practice the C programming in working with different resources (analog-digital converter, input and output parallel port).

This application is more complex than the previous, students made some experiments to understand the functioning of all sensors and stepper motor. There were some versions of structure of programme.

4. Motor speed control. This system consists of a DC motor driven by a L165 of Linear Technology amplifier, mechanically connected to a tachogenerator as transducer. To determine the absolute speed of the motor on the shaft is mounted a magnet, sensed by a Hall sensor from the base plate (see **Fig. 8** and **Fig. 9**).

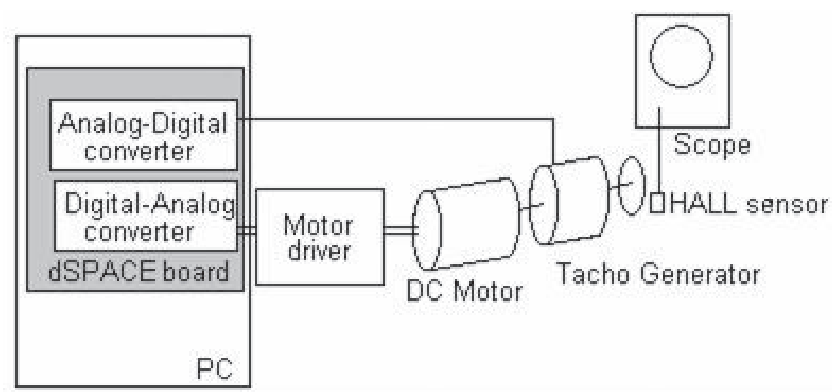


Fig. 8

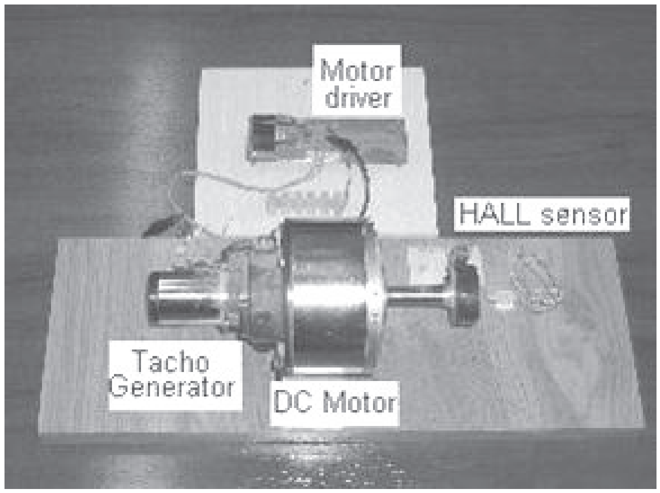


Fig. 9

The task for this application is to model the process and speed transducer and to design a control system using a dSPACE board, to control the motor speed. For modelling they had to determine the static characteristic of motor and tachogenerator and to proximate the dynamic constants. The objectives for the student are

- to be able to make an experiment to determine static characteristic of process and transducer, and to process the results,
- to design a controller,
- to understand and to implement a controller on a dSPACE board [***99],

Problems were encountered on managing the experiment for modelling. The implementation on dSPACE board was very simple, and students experienced a high technology board for rapid prototyping.

RESULTS AND DISCUSSION

During the design activity, many of the “learning principles” of [SHA01] were respected. The conclusions drawn from this intense design learning activity were spectacular.

1. Much more students (80% were extremely active) than in usual laboratory activities were deeply involved in design, after first two meetings they “fought” to be directly involved. A motivation for this could be the challenging aspect of the activity,
2. It was obvious that degree of understanding was very high, and it was seen in the questions asked after the closing of one project,
3. the degree of interest was very high,
4. one reason for efficiency was the fact that, because the students had the hard-ready projects, they had only to develop the algorithm and software, and the results were seen very fast.

Some of the students asked some things about the hardware design showing interest on it. So, can be stated that this can be the first step in a wider educational program in engineering.

CONCLUSION

This type of learning, with small, part ready design projects is very efficient. The degree of involving and understanding for students is very high, and it can prepare further more advanced items in control systems education.

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