EDUCATION IN DIGITAL ELECTRONICS BASED ON TEAMWORK

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Keywords: Teamwork, learning by doing, logic design, finite state machine

This paper presents a different way of organising a laboratory exercise in the area of digital electronics. It is in fact a "learning by doing" process in a teamwork version based on problem-solving abilities. Students are involved in the theoretical analysis, the computer simulation and the practical implementation of two different versions of a finite state machine, followed by the presentation of a final, efficient solution.

1. INTRODUCTION

A continuous concern of the University teaching staff is to find the most convenient/suitable educational methods for the presented subject to be easier understood and learnt by the students. This implies to an equal extent an active participation of the students in the educational process. It can be assumed that those methods are to be successful, which succeed in capturing the students' interest, in convincing them of the usefulness of the studied subject and above all, in making them participate actively in the proposed educational activity.

The acquiring of knowledge regarding the structure, processing and use of digital circuits is one of the basic requirements for future engineers, irrespective of the area they specialise in.

With reference to the afore-mentioned facts, we have developed for the students in engineering and economics studying at the German Department of the University "Politehnica" of Bucharest an experiment related to the organisation of the laboratory exercises, that we are going to present to you next.

The involved students attend in their 3rd University year a class of Logic Design (in the first half-year) and one of microcomputers (in the second half-year) [1].

The laboratory exercise was tested during the second half-year while the class in microcomputers was held. Basically, the students received the task of setting up of a state machine with a reduced complexity degree. They were organised in teams of 2 or 3 people and were requested to perform their task in various ways, so as to eventually determine the optimal result by making a comparative analysis and taking into account the technical performance as well as the costs. Every team had to prepare a final written report in form of a scientific essay that it was going to present by means of PowerPoint slides in front of its colleagues. Hence, the teacher/professor had to assess the activity of every team as a whole and every team member as such.

The assessment considered the way the students worked together in the team, how they managed to tackle the tasks, the quality of the proposed solution and their ability to communicate in written and oral form. In fact, this test was a "learning by doing" process, in which teamwork based on problem solving was used.

The outcome of the experiment was remarkable in the sense that the participation of the students was much above that noticed during an ordinary laboratory activity. The above-mentioned test will be presented below in more detail.

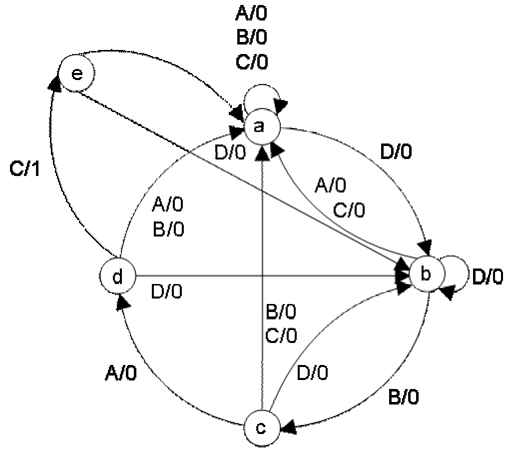

Fig. 1 State chart of control system

2. THE PROJECT

The proposed task consisted in developing a control system for door-closing from a keyboard made up of 4 keys labelled as A, B, C, and D. By typing the DBAC sequence, the control system had to move the key-lock in order to open the door. The development of the control system is shown by a state chart as in Fig. 1.

3. THE WORDING OF THE REQUIREMENTS

The requirements addressed to the students' teams were as follows:

- To determine out from the state chart the scheme of the finite state machine. An example of a scheme set up with J-K flip-flops is shown in Fig. 2 [2].
- To check the way of working of the scheme by deducting the representative signal forms.
- To simulate the circuit with the PSpice programme and to compare the functionality of such scheme with its theoretical analysis.
- To develop in practical form the scheme on a training board with standard TTL circuits and to analyse its way of working. The highest working / processing frequency will be determined from the electrical parameters of the applied circuits and consequently verified by the measurements done.
- To acquire from the given tutorial the basic knowledge needed to apply the development environment for the Philips 80C552 microcontroller with Intel 80(C)51/31 architecture.
- To work out the flow-chart of the programme and then write the assembler programme for the proposed embedded system.
- To set up the machine in a microprogrammed version on training board and assess its functionality and performance.
- To set up a comparative analysis of the technical performance and costs of the two versions and propose an optimal solution by having in view – where necessary – other means of establishing the machine.
- To prepare a written report in the form of a scientific essay. This will be presented by the team members via Powerpoint slides.

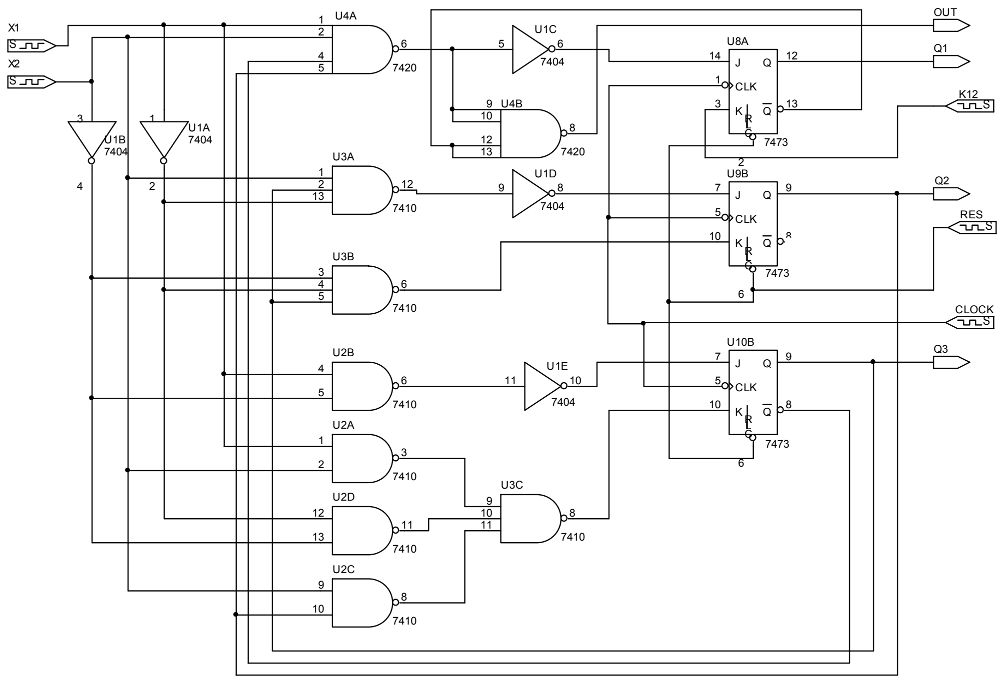

Fig. 2 Diagram of the state machine with J-K flip-flops

4. RESOURCES AVAILABLE TO THE STUDENTS

The student teams were given the following resources:

Logistic resources

- Computer network with the necessary programs to accomplish the practical exercise: Windows XP, Office XP end Orcad 9.0.

Resources required to develop the version in standard logic design

- IC catalogues for TTL standard circuits that allow choosing the necessary circuits for the practical work as well as the reading of the electrical parameters of the used circuits.
- Integrated TTL standard circuits (74xxx) requested by the students for the accomplishment of the practical exercise.
- Training Board for the development of the scheme with TTL circuits (Fig. 3).

Resources required to develop the version in programmed logic design

In order to create the machine in programmed logic design, the microcontroller 80C552 is used. The microcontroller's block diagram is shown in Fig. 4 [3].

To enable its practical usage by developing and testing several applications, the microcontroller was incorporated in a Training Board presented in Fig. 5 [4].

The Training Board has the following hardware components: Microcontroller 80C552; 64 KB external RAM divided in 32 KB program memory and 32 KB data memory; 8 LED display and a 2 digit display; D/A converter; Push buttons; External connectors for the ports.

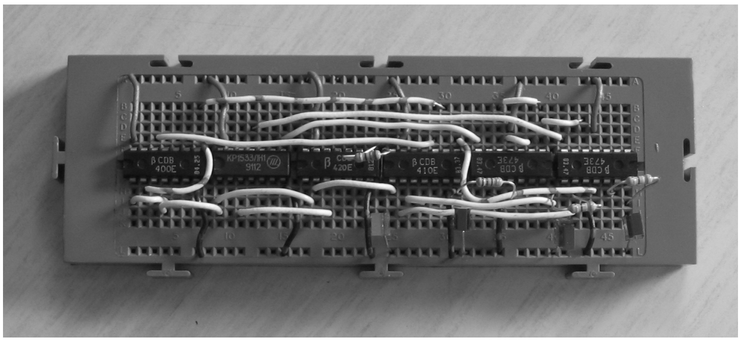

Fig. 3 Training Board for interconnecting the TTL standard circuits

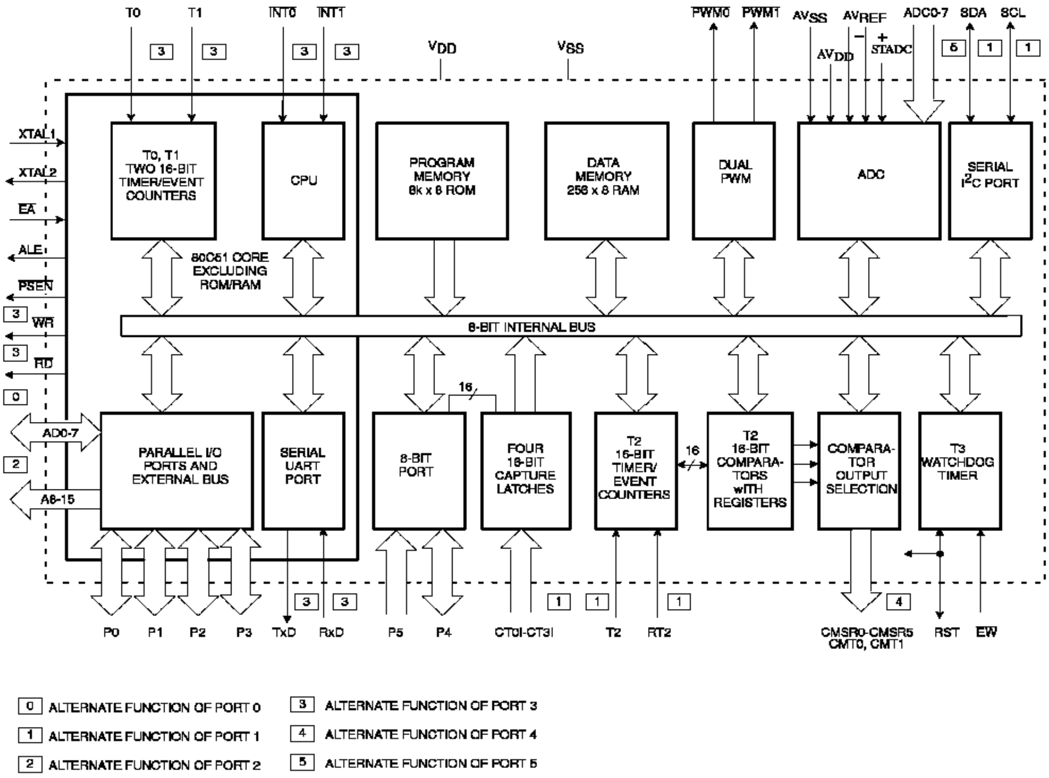

Fig. 4 Block diagram of the microcontroller 80C552

Since these laboratory exercises aim at testing the functionality of the microcontroller, its programming is done in the assembler's language.

The integrated programming environment used consists of: Editor; Assembler; Link editor; Debugger; Binary to hex file format converter.

The application program is first edited and assembled on a PC and then transferred in the memory of the microcontroller through a serial port.

In order to use the developing environment with microcontroller, a tutorial is made available to the students.

The tutorial refers to the following key aspects:

- description of the hardware structure of the developing system;
- presentation of the programming environment;
- examples of applications written in assembler.

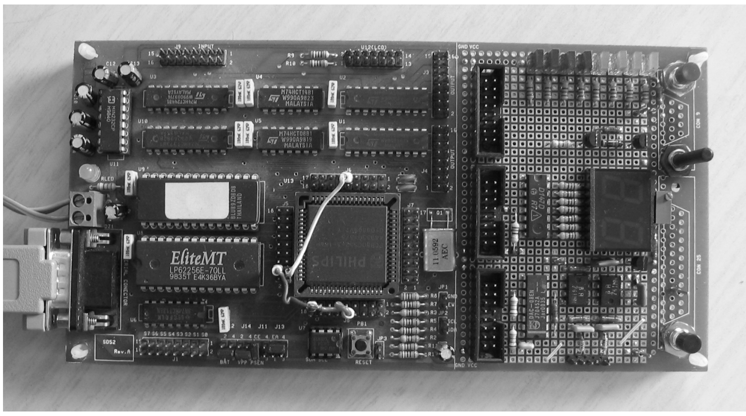

Fig. 5 Training Board with microcontroller 80C552

The applications are grouped according to the resources used and include: a description of the hardware components, examples of programs with a different level of difficulty, and proposed exercises.

The examples relate to: how to use the memory, the parallel ports, the timers, the PWM generator, and the data acquisition system.

The students involved in this experiment had to choose and understand only those parts of the tutorial, which they needed for their exercises to solve, i.e. the state machine.

5. EDUCATIONAL OBJECTIVES

The educational objectives are:

- development of the ability to solve engineering problems;
- acquiring experience in engineering projects;
- strengthening the ability of drawing electronic schemes by hand or by computer and of accurately interpreting them;
- understanding the existence of standards and codes for components and ICs which must be respected;
- acquiring the necessary knowledge to master and use the computer in an efficient way;
- developing the skills to specify, assess and plan the testing and practical design methods;
- being aware of the importance of the measurements in the experienced work as well as the use of the measuring instruments;
- ability to understand the constraints and perhaps the conflicts which might occur as a result of the technical solution (available time, existing resources, technical performance and incurred costs) during the design, construction and functioning of the embedded systems;
- considering the economic and regulatory framework which might influence the technical solution;
- ability to summarize the acquired experience, to draw conclusions and develop feasible engineering solutions for the given problems;

– developing written, oral, and interpersonal communication skills.

The students were organised in teams of 2-3 people, this having the following implications:

– students will be bound to work in groups and at the same time, solve the tasks attributed to everyone of them individually;
– students will have to organise themselves within a team, by dividing the tasks, the roles etc. in order to work out the given problem;
– students will be made to understand the importance of time-management etc.;
– students will develop communication skills within a team, solve the possible conflicts, prepare a written report in accordance with stated rules, and finally, present the achieved results in front of their colleagues [5].

6. CONCLUSIONS

The proposed topic requires the understanding and theoretical calculation of the scheme, the PC simulation and the practical implementation in two versions: one being the standard logic design and the other being the programmed logic design.

Referring to the practical development in standard logic design, the students will find out the existence of codes and prescribed values for fabricated components, which makes the theoretical results not to correspond with the measured ones.

In the microcontroller-based version, the students will understand the flexibility of the solution, the speed limitation but also the excess of hardware resources for the given finite state machine.

Both solutions will make the students identify the encountered difficulties posed by the practical development, so that they should be constrained to imagine new testing and measurement methods.

The overall conclusion is that the students showed an extremely high motivation in the organisation and problem-solving of the practical exercise. They succeeded in accomplishing successfully most of the proposed objectives, the teams grew closer together and a positive competition spirit arose in order to find original and on time solutions to the given problem.

In the end part of the presentation the students were invited to express their opinion about the whole activity in which they were involved. For this purpose Dr. de Bono's six thinking hats method was used.

7. REFERENCES

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