

## **Less Expensive Equipment for Mechatronics Training and Education**

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### **Peculiarities of the education in the field of Mechatronics**

Mechatronics is a technology which combines mechanics with electronics and information technology to form both functional interaction and spatial integration in components, modules, products and systems, [1,2]. Mechatronics spans over several traditional academic disciplines (mechanical and electrical engineering, control theory and computer science). In contrast, most traditional academic subjects have a disciplinary identity.

The mechatronic engineer is a product developer and the required skills can be related to the ability to develop products. He must be capable of addressing a variety of basic issues in electromechanical system design and implementation and must understand how to effectively communicate and utilize all of the modern tools that are at his disposal. The education in this field should exemplify certain themes rather than try to span over the entire field. According to [2,3], education in Mechatronics should be supported by experimental learning not only by reading textbooks. Mechatronics is learnt by studying mechatronic products and systems. There are special requirements regarding the development of new laboratory and student projects.

There are many researches trying to find out what are the key components in a Mechatronics course, what subjects are necessary, and what should be in a Mechatronics laboratory. Such a course contains information about sensors, transducers, and interface, conditioning hardware, microprocessors, software and actuators. The laboratory is critical in the development of a Mechatronics course.

Generally, any equipment for educational purposes has to satisfy the following requirements:

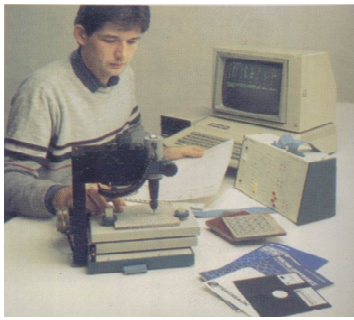
- providing the students with the challenge of implementing the concepts learned in the lectures and open new perspectives;
- allowing the performance of a complete system investigation, through relevant measurements and viable results;

- facilitating the understanding the studied physical phenomena, in a well-defined manner, clearly;
- permitting a wide spectrum of learning experiences, in adequate work conditions;
- understanding the nature of the given problem, theory validation through experiments;
- modular design in order to obtain large functional flexibility and different difficulty levels;
- design in accordance with the ergonomic rules referring to the visual sense, hearing, noise, lighting, manual tasks, a.s.o.
- safety operation, without risks for students and supervisors;
- allowing individual and group experiments;
- structure and operation in accordance with students' background and target competences.

Particularly, the Mechatronics educational aids must fulfil following requirements, [1- 4]:

- allowing the students to develop familiarity and confidence with electronic and mechanic fundamentals, providing them with a procedure to follow when using a new electrical or mechanical component for the first time;
- introducing the students to a representative sample of integrated circuits, sensors and actuator options, understanding the physical principles of the sensors / actuators; input and output signals;
- establishing the control elements, input to and output from a control element;
- developing different control algorithms;
- calibrating and wiring the system;
- giving the students the opportunity to work with systems they will use in next projects;
- providing the students with the ability to integrate knowledge from many different fields;
- every experiment must be based on a written report containing the necessary instructions.

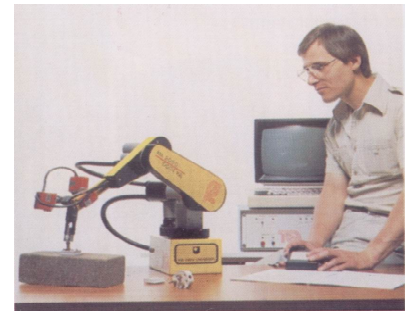
It results that, due to the highly applied nature of Mechatronics, any course has to be supported by well-equipped laboratory facilities. These facilities must be used as demonstrators, for research and for providing the students with hands-on experience.



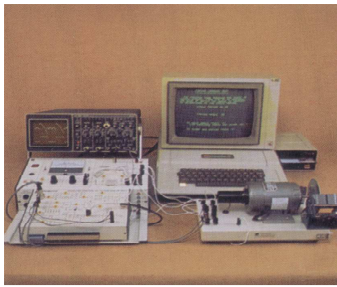
a)



b)



c)



d)



e)



f)

**Fig. 1. Equipment for mechatronics laboratory**

### Comparative Study of Mechatronics Laboratory Equipment

Some Mechatronics laboratory work stations are described in [4], including a stepper motor open-loop / closed-loop control system, a closed-loop temperature control system, a DC motor closed - loop speed control, a magnetic levitation system and a pneumatic system. In [5] the area of computer-controlled fluid power systems is described as an area with a wide variety of applications, with various levels of complexity, developed for laboratory activities. A 3-wheeled mobile robot, intended to serve the didactic process in training for the control and operation of mechatronic systems, is described in [6]. Paper [7] describes a set of mobile robots (tracked, wheeled, a.s.o.) to introduce students by hands-on experiments to mechatronic systems.

Figure 1 shows several systems commercially available, belonging to well-known companies working for educational, training and research institutes: model of a CNC Machine for practical study demonstration of programming techniques (Fig. 1a); Control Systems Laboratory (Fig. 1b); MA2000 Robotic System which is a versatile educational machine based on advance industrial robots (Fig. 1c); test bed for various electrical actuators (Fig. 1d); equipment for training in the field of control and instrumentation (Fig. 1e); microprocessor controlled tensile testing machines (Fig. 1f). A new trend in this field is the development of the Internet based learning facilities to demonstrate all aspects of mechatronic engineering teaching, including practical work – necessary to give students a taste of real situations, measurement and instrumentation. The aim is that students become able to perform real experiments, in real time, on real equipment, but over the internet.

### The developed equipment

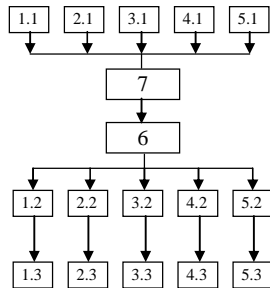
A specific design and manufacturing process was applied for development of the new, less expensive, laboratory equipment, [8]. An interdisciplinary approach was performed overlapping the design of mechanical, electrical and control subsystems. The stand is modular permitting five different applications, but a single application at once. The block diagram of the prototype is presented in Figure 2, with.

- 1.1 Delphi interface of the first application;
- 1.2 Electrical diagram for step motors control;
- 1.3 Positioning system with gear rack-pinion transmission;
- 2.1 Delphi interface for the second application;
- 2.2 Electrical diagram for DC motor;
- 2.3 Adjustment system of a rear-view mirror from a car;
- 3.1 Delphi interface for the third application;
- 3.2 Electrical diagram for LCD display;
- 3.3 Base location for temperature sensor;
- 4.1 Delphi interface for the fourth application;
- 4.2 Electrical diagram for seven segments display;
- 4.3 Base location for optical barrier;
- 5.1 Delphi interface for the fifth application;
- 5.2 Electrical diagram for temperature control;
- 5.3 Base location for temperature sensor and the cooler;
- 6 Electrical diagram for the motherboard;
- 7 Computer and the communication system with the microcontroller.

The main module includes a microcontroller Atmega 8535, the communication module with PC (in this case Max 232 for serial communication RS232), and a series of connectors for the communication with the other five applications.

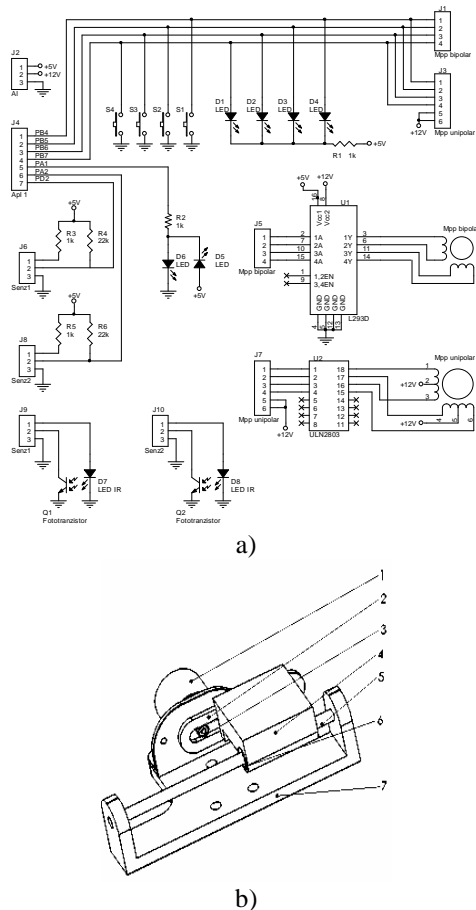
The first application is referring to a positioning system actuated by stepper motors. It responds to unipolar

and bipolar stepping motors control. The hardware of the positioning system (Fig. 3) includes IR positioning sensors, placed at the end of the stroke. The work frequency, the number of steps (distance), the work condition (normal-steps, micro-steps) and the direction of movement can be controlled by the user using a Delphi menu.



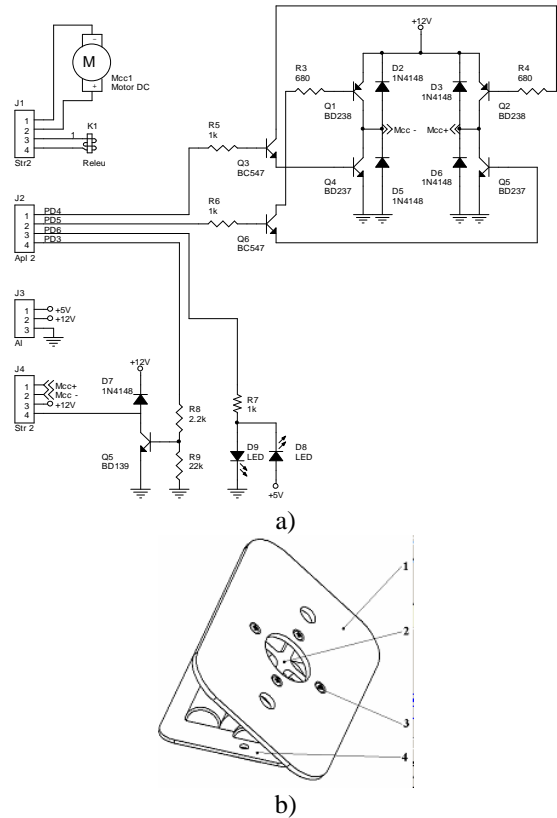
**Fig.2.** The block diagram of the prototype

The second application is the control of a direct current servomotor which actuates a platform along two axes. As a mechanical structure, a rear-view mirror from a car was used.



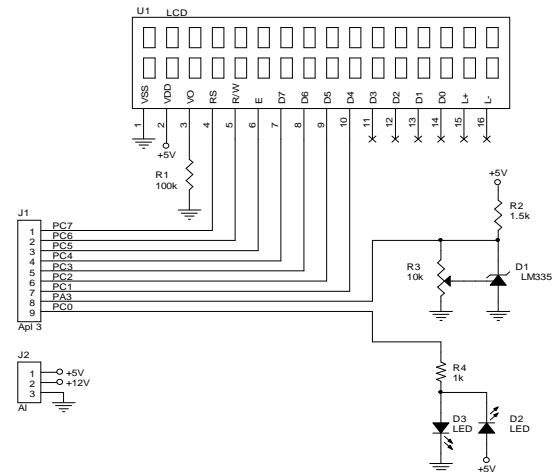
**Fig. 3.** Application No.1: Stepper motor control. a) Electrical diagram, b) Mechanical structure

The program interface offers the possibility to select the communication port COM, the direction of the revolute movement and the axis, also and to display the electrical diagram. The commands are sent to the motherboard which interprets the signals and controls the motor in accordance with the electrical diagram in Fig. 4.



**Fig. 4.** Application no. 2: a) Electrical diagram of DC motor control, and b) mechanical structure

The temperature measurement using a LM35 sensor is the object of the third application. The measured value of the temperature is displayed on a digital display and PC. The way how the data was prevailed and how the transfer was realized is shown in Fig. 5.



**Fig. 5.** Application No.3: Electrical diagram of temperature measurement and displaying

The fourth application refers to counting and displaying the numbers from an optical barrier (see Fig. 6). The Delphi interface has the option to select the counting order. It offers the possibility to select the start value. The current value is displayed on seven - segments display. This application could be easy adaptable in order to upgrade the measurement devices.

The fifth application is the control of the temperature of an electrical resistance using a cooler actuated by a D.C.

[illegible]

The circuit diagram illustrates a motor speed controller. It features a power supply section (J1) providing +5V and +12V. A microcontroller (J2, PA0) is connected to the +5V line. The microcontroller controls two LEDs (D4, D5) through a series of transistors (D1, D3) and resistors (R1, R2, R3, R4, R5, R6, R7). The motor (MG1) is connected to the +12V line and controlled by transistor D3. The motor is labeled MG1 MOTOR AC.

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## Conclusions

This prototype was used for the first time at the beginning of academic year 2005-2006. At each laboratory, a single application was studied, in groups of 3-5 students. A number of lessons were learned during the use of the described system. Thus, a strong platform for students' more advanced design and laboratory courses is provided, yielding better prepared engineers. The design of the above-presented equipment allows its future development.

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Submitted for publication 2007 09 15