Embedded Control Systems (ECS)

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I hear and I forget. I see and I remember. I do and I understand.

Confucius

Objectives of the course

The goal of this course is to provide attendants with specific methodologies, tools and tips in order to design, build and test mixed signal electronic circuits capable of: (i) acquiring a signal from a physical input; (ii) processing the signal exploiting analog and/or digital means in order to generate/control (iii) an appropriate output signal to an electromechanical actuator, and (iv) communicating with the external world.

During the course the attendants will be introduced to the **function** of the basic electronic devices which are commonly exploited to design control systems and drives for (biomedical) robots. Following an hands-on approach with data-sheet comparison and breadboard design, attendants will explore the functionality of significant circuits using diodes, transistors, operational amplifiers, differential amplifiers, comparators, multi-vibrators, multiplexers, and a microcontroller. A significant part of the course will focus on the description of the microcontroller and its peripherals and on how to program its firmware for practical applications, using C language. In this framework attendants will also learn how to use serial communication protocols (USART, SPI) to allow communication among multiple systems or peripherals. Attendants will learn how to use and integrate such devices and circuits in order to acquire, hardware/firmware process signals from a multitude of analog/digital sensors and to drive some of the common electromagnetic actuators (DC motor, servos, step motors, etc.) using the PWM technique. Attendants will finally learn practical design tips and how to use a computer aided design software (OrCAD) in order to transfer their ideas into *real* and *functional* printed circuit boards.

I aim to transfer to the attendants my technical know-how and experience gained over the years on how to design and build electrical control systems and drives for robots. Rather than focusing on the physical models and theoretical working principles of common electronic devices (which

can be found in any good microelectronics text-book and there should be studied), I wish to expose attendants to a multitude of practical circuits in order to demonstrate the marvellous potentials of electronics and provoke the attendants' creativity and imagination.

Course organization

The course foresees 20 hours of frontal lectures (chalk talks) backed by 20 hours labs. During the chalk talk I will introduce, describe and discuss a certain topic, that will be tested in practice by the students (divided into groups comprising of 2 people) during the lab hour. In general, each of the 20 hours of chalk talk will be followed by 1 hour of lab. Lectures on how to use OrCAD will be given by Eng. Roberto Lazzarini (3-4 hours).

Course materials

Each group will be given a kit of electronic components, 1 breadboard and 1 microchip programmer. Datasheets and required software (microcontroller programming environment) will also be provided. At specific lectures attendants (ether in groups or individually) should bring their laptop in order to program the microcontroller and learn OrCAD.

Required background

Any person with a M.Sc. in engineering should be able to follow this course. Attendants with other background should at least have:

- Basic knowledge of linear network analysis (electrotechnics) (what is an electrical current, voltage, electrical power, resistance, capacitance, inductance, an amplifier, etc.).
- Basic knowledge of C language (how a C code looks like);

Who should attend

Everyone with a sufficient theoretical background that would like to move from paper systems and equations to real devices interacting with the environment. Although the course is not designed for people with a degree in electrical/electronics engineering or closely related field, it can be useful to those with limited practice that would like to widen their design know-how.