UNICUSANO
ROME

Code: LM-32 **Credits: 12**
Matter: Embedded Systems
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Armando Piccardi - armando.piccardi@unicusano.it

Introduction

1. *Objective of the course:*

The teaching of the course aims to provide fundamentals about microprocessors and microcontroller systems, together with competencies to implement simple devices employing programmable development boards. With a bottom-up approach, the course introduces digital electronic devices and systems, continues with microprocessor architecture, with reference to ARM microprocessors. Then, it explores the microcontroller systems architecture. After the hardware description, the student is introduced to the microcontroller systems programming, starting with the fundamentals of C/C++ language, towards the design and the implementation of some simple control systems.

Objectives

2. *Course Structure:*

The course aims to give an overview of the development of embedded systems, from the hardware to the firmware design, through different abstraction layers, starting from the logic gates and ending with the high-level programming.
The course is organized into 3 main subjects.
The first is dedicated to the analysis of the hardware of microprocessors, focusing on those used in control systems and including an introduction to the low-level programming in Assembly. The second subject focuses on microcontroller hardware and architecture, including an introduction to sensor interfacing. The last part is dedicated to the firmware/software design, programming through the Finite State Machine approach. During the course, both analysis and design problems will be considered, also based on exercises and case of studies.

Competencies:

- To understand the difference between wired logic and programmable logic.
- To design and analyze simple examples of digital electronic circuits.
- To know the difference between microprocessor and microcontroller systems.
- To understand the fundamentals of microprocessor systems.
- To analyze the correlation between hardware and firmware design.
- To be able to examine a microprocessor block scheme and recognize the data path.
- To know the architecture of microcontroller systems.
- To know and examine the hardware of a microcontroller systems.
- To compare different sensor specifications and their interface with microcontroller systems.
- To be able to implement simple programs in C/C++.
- To be able to program a microcontroller through a development tool.
- To be able to design simple devices controlled by the microcontroller.
- To be able to communicate in a proper technical language.
- To be able to approach new problems based on the course subjects.

Syllabus

3. *Program of the course:*

Subject 1. Digital Electronics 1/2. From transistor to logic gates. Combinatory and logic: logic gates, multiplexers, demultiplexers, encoders, decoders.
Subject 2. Digital Electronics 2/2. Latch and flip-flop, registers, counters, memories. Wired and programmable logic. Fundamentals about microprocessors and microcontroller systems.
Subject 3. Microprocessors: fundamentals and history. Classification: Von Newman and Harvard architectures, RISC and CICS architectures. Mu0 processor: components and architecture, instruction set, datapath and control logic, ALU, pipeline. RISC architecture.
Subject 4. ARM microprocessor: fundamentals and history. Architecture and instruction set. Instruction format and execution. Registers, datapath, pipelines. Interrupt managing. Memory hierarchy and address managing. Thumb instruction set.
Subject 5. Assembly Language: introduction, general overview. ARM Assembly: processing, data transfer, flux control instructions. Directives. Connection with the machine language. General structure of an Assembly program.

Subject 6. Fundamentals of microcontrollers architecture. Memory system: PROM, EPROM, EEPROM, Flash. A/D and D/A converters. Peripherals and communication: UART, I2C, SPL. Timing: timer, watchdog, interrupt.
Subject 7. Sensors and Actuators. Sensors: general features and classification. Principal Figures of Merit. Examples: Light Sensors and Actuators. Interfacing sensors with microcontroller systems. Case studies.
Subject 8. Programming in C/C++: fundamentals. Program structure and hierarchy. Identifiers: variable kinds and declaration. Operators. Conditional instructions. Functions.
Subject 9. Development environment and tools, IDE. Fundamentals of coding: finite state machine, code structure. Examples. Design of microcontroller-based systems and devices: interfaces, output ports, devices control. High level programming: Mbed simulator. Use of API.
Subject 10. Design of a control system based on microcontroller systems and implementation of the corresponding firmware.

Evaluation system and criteria

The assessment of course is based on the following criteria:

I) **Written exam** (**75%** of grade):

This written exam consists of a number of open questions on the contents of the course. The exam aims to verify the competencies acquired by the student on the topics of the course. The evaluation will be based on the degree of knowledge and the correct language used.

II) **Final project** (**25%** of grade):

The last module of the course is entirely dedicated to the design an realization of a simple microcontroller system, in order to asses the student competences on the development of control systems and the applications of the course contents. A final report will be evaluated to assess the student ability to communicate in a scientific context

II) **Etivity** (**5%** of grade):

During the course there will be a few interactive activities, about analysis or design problems on the course subjects, to be completed as a part of the evaluation.

Bibliography and resources

4. *Materials to consult:*

Provided video-lectures, slides and notes will cover the whole program and they contain the necessary material to assess the course.

5. *Recommended bibliography:*

- S. Furber , "ARM, System on Chip Architecture", Addison Wesley
- Mbed website: www.mbed.com