UNICUSANO
ROME

Code: ING-INF/01 **Credits: 9**
Matter: Digital Electronics
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Andrea Orsini - andrea.orsini@unicusano.it

Introduction

1. *Objective of the course :*

The teaching of "Digital Systems" is designed to provide the methodologies and skills necessary for the analysis and to the design of systems purely based on digital electronics, without however losing sight of the concepts fundamentals of more strictly analog electronics (signal propagation times, noise and stability, e.g. example). The teaching has a theoretical character, but the approach is often practical, linked to elements of the modern microelectronics technology and the design methodologies adopted in the synthesis of digital systems too complexes, such as microprocessors. For the latter, the guidelines in the design of microprocessors, with particular reference to ARM processors, their fundamental components and the problems faced in the design phase. Finally, also through interactive activities (etivity, virtual classes and forum) examples of implementation of more or less complex digital systems will be proposed. This teaching is part of the electronics disciplines, deepening the knowledge and the skills on the design and analysis of electronic systems in general acquired in the teaching of "Electronics".

Objectives

2. *Course Structure:*

- Illustrate the fundamentals of Boolean logic.
- Describe the techniques necessary for the analysis and synthesis of logic circuits, both combinational and sequential. Static Logic and its optimization.
- Explain the structure of programmable logic systems and the differences with wired logic systems
- Describe the fundamental issues relating to the analysis and design of systems architectures a microprocessor.

- Latches and static and dynamic registers, memories.
- To illustrate the characteristics and design elements of basic structures for the synthesis of digital systems.
- Describe the environments for developing microprocessor system designs

Competencies:

A. Knowledge and understanding.
At the end of the course, the student will demonstrate knowledge of the main characteristics of digital systems, combinational and sequential, as well as the fundamental characteristics of microprocessor systems. The student, moreover, will acquire the knowledge of the most suitable tools for the development of digital systems projects, by simplest to more complex, such as microprocessor-based systems. The student will know the terminology and the fundamental characteristics of digital components and systems.

B. Applying knowledge and understanding.
At the end of the course, the student will be able to use the knowledge acquired for the analysis and the synthesis of digital systems, from the simplest to those of medium complexity, having acquired the ability to design a digital system distinguishing the functional blocks that will be able to compose it. The student will also be able to appropriately size a digital system, starting from the assigned specifications. The integrative activities, e-tivities, also provide the knowledge for precisely developing digital systems project and also simple microprocessor systems.

C. Making judgements.
At the end of the course, the student will have the ability to choose a specific type of circuit or digital system based on design specifications. You will also have developed the ability to identify the fundamental blocks useful for synthesizing a logical function, even a complex one, as well as the relative interconnections between blocks. Finally, the student will have developed a critical ability to interpret results obtained during the performance of an analysis or synthesis exercise, both in terms of consistency functional, both in terms of engineering feasibility of the solution identified.

D. Communication skills.
At the end of the course, the student will have acquired an adequate technical-scientific language correct and understandable that will allow him to express knowledge in a clear and unambiguous way techniques acquired in the field of architecture and operation of digital systems.

E. Learning skills.

At the end of the course, the student will have developed the ability to apply the knowledge and skills acquired for solving unfamiliar problems that have as their object the analysis or synthesis of digital systems. This will contribute to his formative growth in the engineering field for to be able to face problems posed both in the academic and work environment.

Syllabus

3. *Programme of the course:*

Subject 1. Recalls of numerical and boolean logic.
Positional numbering systems: decimal, binary and hexadecimal; conversion from decimal to binary and viceversa; truncation and rounding.
Combinatorial functions: examples of truth tables; two-way synthesis levels.
Boolean algebra rules and theorems; XOR operation. Synthesis by sum of products and products of sums.

Subject 2. Mosfet and Digital Registers.
From switches to logic gates: logical NOT, AND and OR operations based on switches; MOSFET and CMOS logic elements.
Decoders and multiplexers.
Consequence of feedback between logic gates: sequential circuits; latch SR.
State definition; synchronism signal in sequential systems.
Flip-flop: clocked SR latch; data-latch; flip flop master slave;
flip-flop JK; flip-flops D. Timing for flip-flops.

Subject 3. State machines synthesis.
Mealy and Moore machines: representation by state diagram; principle schemes.
Summary of sequential networks: representation of states and inputs; synthesis method.
Synthesis of sequenced systems micro-programmed.

Subject 4. Representation of combinatorial functions and synthesis methods.
Truth tables compressed into two-dimensional maps.
Karnaugh maps: definition and properties; adjacency; XOR case.
Using MUX. Synthesis by ROM.
PAL: examples of synthesis using Programmable Logic Array.

Subject 5. Microprocessor architecture.
Microprocessors, history and general characteristics.

Classification: architecture by Von Newman and Harvard; RISC and CISC architectures.
Components, functional blocks, architecture.
Minimum microprocessor MU0: set of instructions; instruction format; datapath level project; ALU; control logic; level project RTL.
The pipeline and further extensions. RISC architecture and introduction to ARM processors.

Subject 6. ARM processors.
Introduction and historical notes on ARM processors.
Architecture and instruction set. Format of instructions and their execution.
Types of registers; datapath; pipeline.
Interrupt management.
Memory management: hierarchy; addressing mode.
Bus architecture.
Architecture and Thumb instruction set.
Generalities on architectures for high-level languages.
Evolution of ARM processors and state of the art.

Subject 7. Microcontrollers Peripherals.
General architecture of a microcontroller as an example of a microprocessor system.
System memory: Flash memories, EPROM, EEPROM.
A / D and D / A conversion: examples of converters.
Peripherals and communication:
UART, I2C, SPI.
Timing: Timer, Watchdog.
Interrupts and their management.

Evaluation system and criteria

The examination consists of a quiz test with 30 questions (1 marks each for a total of 30 out of 30 marks).

In addition, two e-tivities, consisting of microcontroller programming, are compulsory. These need to be sent to the instructor in advance of the examination. Each e-tivity counts 3 marks for a total of 6 out of 30 marks.

Bibliography and resources

4. *Materials to consult*

Notes written by the instructor are available in English. The notes cover the course contents and examination program.

5. *Recommended bibliography*

Suggested readings are:

1. Steve Furber (2000), ARM System-on-chip Architecture.
2. Stefano Salvatori, Quaderni di Microelettronica: Introduzione alla progettazione di sistemi elettronici dedicati - Volume 1
3. Stefano Salvatori, Quaderni di Microelettronica: Introduzione alla progettazione di sistemi elettronici dedicati - Volume 2