**Code:** ING-INF/01 **Credits:** 9
**Matter:** Microelectronics
**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 course of Microelectronics aims to give the student the basis for the microelectronic design of digital circuits, starting from the single elementary unit to the design of digital architectures with medium-low complexity functionality. The course proposes the basic concepts of the various phases of design and development of an integrated circuit commonly used in digital electronic design, with particular reference to dynamic problems and the study of transients. The E-tivity associated with the course develop the skills necessary to formulate the problems of design through the use of CAD tools to aid the project itself.

## Objectives

*2. Course Structure:*

The course is organized in ten subjects. The first two part regards a brief summary of MOS transistors theory in order to have the basis to understand the fundamental behavior of CMOS inverters, the basic structure of all modern digital systems. In the third part we focus on circuit fabrication in order to have an idea of what are the physical parts really contributing to the management of the digital signals in a chip. The following argument to be analyzed will be the design of standard logic ports with different architectures: ratio logic, pass transistor, dynamic logic. We will study in detail the differences in power consumption, signal integrity and speed. In subject five the student will see the essential design of latch and static registers with the techniques used to build pipelines and avoid clock-skew. Furthermore, it will be shown the architecture of dynamic registers, pulsed registers and sense amplifiers.

In subject six, is presented the methodology for designing large digital circuits based on macrocells or megacells. In subject seven and eight we will deepen the analysis of circuit interconnections and timing for advanced digital design. In subject nine we build an arithmetic logic unit, while in the last subject we analyze the design of the different types of digital memories.

**Competencies:**

- knowledge of the CMOS inverter's behavior depending on the geometric design parameters
- knowledge of the functioning of the main digital logical structures: Complementary CMOS, pseudo nMOS, transmission gate and dynamics.
- to implement simple codes calculation for the solution of static and dynamic problems of the logic of digital signals.
- the ability to size the layout of the individual transistors inside the chip according to the project specifications
- to realize interconnection schemes robust to electrical noise and with optimized delay times to the design of the chip designed as global system.
- the ability to interpret project layouts for the purposes of microelectronic manufacturing on silicon wafers.
- the ability to apply the acquired knowledge to the design of digital circuits whose object is the analysis, transmission and reception of data on microchip.
- through the E-tivity students will acquire the ability to create digital ports within the Magic-VLSI and software to simulate circuits at a schematic level based on their characteristics within HSPICE.

**Syllabus**

*3. Programme of the course:*

**Subject 1.** Summary of diode and transistors theory
**Subject 2.** CMOS inverter
**Subject 3.** Microfabrication
**Subject 4.** Combinatorial logic ports
**Subject 5.** Sequential logic ports
**Subject 6.** Digtal systems
**Subject 7.** Advanced interconnections

**Subject 8.** Timing techniques
**Subject 9.** ALU
**Subject 10.** Memories

## Evaluation system and criteria

The exam consists in carrying out a written test aimed at ascertaining the abilities of analysis and re-elaboration of the concepts acquired and a series of activities (E-tivity) carried out during the course in the virtual classes.

The evaluation of the two E-tivity, which must be delivered to the teacher via message, varies from 0 to 4 points each. The material to be delivered for each E-tivity consists of a file related to the software used for the layout design and performance simulation and it is carried out, in itinere, during the duration of the course at least one week before the exam to which the student has booked..

The written test includes 8 questions regarding microelectronic design, practically one per subject, but not always strictly with this provision. All questions are evaluated by a minimum of 0 to a maximum of 3 points and require a reworking of the concepts of theory to apply them to a simple case concrete.

## Bibliography and resources

*4. Materials to consult:*

The educational material on the platform is divided into 10 modules. They completely cover the program and each of them contains lecture notes, slides, video lessons and exercises in which the teacher comments on the slides. This material contains all the elements necessary to deal with the study of the subject.

*5. Recommended bibliography:*

J.M. Rabaey, A. Chandrakasan e B. Nikolic Digital Integrated Circuits: A design perspective