GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Digital Building Blocks (E031341)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2026-2027

A (semester 2)	Dutch	Gent	lecture
			practical
			independent work

Lecturers in academic year 2026-2027

Doutreloigne, Jan	TWO6	lecturer-in-charge

Offered in the following programmes in 2026-2027	crdts	offering
Master of Science in Electrical Engineering (main subject Communication and Information Technology)	6	A
Master of Science in Electrical Engineering (main subject Electronic Circuits and Systems)	6	A
Master of Science in Electrical Engineering	6	A

Teaching languages

Dutch

Keywords

digital CMOS circuits, power dissipation, speed, deep-submicron, micro-electronics

Position of the course

This course aims at acquiring knowledge and expertise in the design of good digital CMOS circuits that can be used as building blocks in digital system design.
The circuits are studied at circuit level and logic level, and important metrics like area, speed and dissipation are addressed. The lab work involves the effective design of circuits and the analysis of their properties using modern CAD software (Cadence).

Contents

- Introduction: metrics for digital circuits
- CMOS Semiconductor components: semiconductor properties, the CMOS diode, the MOSFET transistor
- Post-CMOS technologies
- Integrated wires: properties, design
- Combinational CMOS Circuits: the CMOS Inverter, static circuits, dynamic circuits
- Sequential CMOS Circuits: static circuits, dynamic circuits
- Timing and Clock Distribution: timing and synchronisation of sequential circuits, synchronous circuits
- Special Building Blocks: arithmetic building blocks, memories
- Standard-cell design flow: optimization, technology mapping, automated physical design (placement, routing)
- Testing and testability
- Design, layout and characterize simple digital building blocks (logic gates, flipflops)
- Advanced topics in research and development: topics depending on recent evolutions and class preferences

Initial competences

Required prior knowledge: linear electrical networks (charge, current, potential,

voltage, power, resistance, capacitance, induction, rc-networks), basic knowledge about digital gates (AND, OR, INVERTOR, ...), elementary logic synthesis, , combinational and sequential digital circuits, basic knowledge of computer architecture (components of a processor, memory hierarchy, ALU-components: binary addition, multiplication, ...), switch model for the MOSFET transistor, physical meaning of the term 'semiconductor', notions of VLSI-technology (physical structure of a MOSFET, most common process steps)

At Ghent University, this can be obtained by following:
- courses from the Bachelor in Electrical or Computer Science Engineering: Electrical circuits and networks, Digital electronics, Computer architecture;
- courses from the Master in Electrical Engineering: VLSI technology and design.

Final competences

1 Thouroughly understand the operation of (deep-)submicron MOSFET transistors.
2 Understand the impact of scaling on the properties of integrated digital gates and interconnections.
3 Know the structure and properties of the most common families of digital gates and memory cells.
4 Understand the principles of fundamental approaches to technology-dependent optimization at the logic level and apply these techniques to simple examples.
5 Explain the principles and main difficulties of technology mapping, placement, routing and testing.
6 Design digital gates at the transistor level, from schematic design to layout, including the back-annotation of layout information to performance analysis.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, Practical, Independent work

Extra information on the teaching methods

- Independent work: self-study on the basis of the proposed text book by J. Rabaey, where students can get feedback on theory or exercises from the lecturer by appointment.
- Lecture: response college: during these sessions theory and exercises will be analyzed and discussed in an interactive way and upon request from the students together with the lecturer.
- Practicals: students will carry out several lab assignments about the analysis or synthesis of CMOS circuits, using the Cadence software platform for IC design. They will do so in small groups of 2 or 3 persons.

Study material

Type: Handbook

Name: "Digital Integrated Circuits: a Design Perspective", by J. Rabaey, A. Chandrakasan and B. Nikolic, second edition, Pearson Education, New Jersey, 2003
Indicative price: € 50
Optional: yes
Language : English
Author : J. Rabaey, A. Chandrakasan, B. Nikolic
ISBN : 0-13-090996-3
Number of Pages : 760

References

Course content-related study coaching

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Written assessment

Examination methods in case of periodic assessment during the second examination period

Written assessment

Examination methods in case of permanent assessment

Participation, Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Extra information on the examination methods

During examination period: written open-book exam about exercises.
During semester: assessment of the student's participation during the lab sessions, together with the rating of the lab session reports.

Calculation of the examination mark

During examination period: written exam that represents 60% of the total score.
During semester: assessment of participation and lab reports that represents 40% of the total score.