

CS-473

**Embedded systems**

Beuchat René

| <b>Cursus</b>                           | <b>Sem.</b> | <b>Type</b> |
|-----------------------------------------|-------------|-------------|
| Computer engineering minor              | H           | Opt.        |
| Computer science                        | MA1, MA3    | Opt.        |
| Electrical and Electronical Engineering | MA1, MA3    | Opt.        |
| Mineur STAS Chine                       | H           | Opt.        |
| SC master EPFL                          | MA1, MA3    | Opt.        |

|                            |                 |
|----------------------------|-----------------|
| Language of teaching       | English         |
| Credits                    | 4               |
| Session                    | Winter          |
| Semester                   | Fall            |
| Exam                       | Oral            |
| Workload                   | 120h            |
| Weeks                      | 14              |
| <b>Hours</b>               | <b>4 weekly</b> |
| Courses                    | 2 weekly        |
| Project                    | 2 weekly        |
| <b>Number of positions</b> |                 |

**Summary**

The main topics of this course are understanding and designing embedded system on a programmable circuit (FPGA). Students will be able to design a camera or a LCD controller on an FPGA in VHDL and will use their controller through a softcore processor.

**Content**

- Microcontrollers and their associated programmable interfaces (GPIO, Timer, SPI, A/D, PWM, interrupts)
- Hardcore/softcore processors (ie. NIOS II, ARM)
- Memory organizations, little/big endian
- Synchronous busses, dynamic bus sizing (ie. Avalon Bus in Memory Mapped mode)
- Processor busses, busses realized in a FPGA
- Serial busses (ie. UART, SPI, i2c, ...)
- How an LCD graphical screen and a CMOS camera work
- FPGA-based conception of Embedded Systems
- Embedded systems with processors on FPGAs

Laboratories provide knowledge & practice to develop an embedded system based on an FPGA device.

**Keywords**

microprocessors, microcontroller, FPGA, embedded systems, SoC, programmable interface

**Learning Prerequisites****Required courses**

Introduction to computing systems, Logic systems, Computer architecture

**Recommended courses**

Electronic, Programming (C/C++), Project System On Chip

**Important concepts to start the course**

- Computer architecture (processor, memory, programmable interfaces)
- Processor Architecture (PC, registers, ALU, instruction decoding, instruction execution)
- Knowledge of C programming language

- Knowledge of VHDL

### Learning Outcomes

By the end of the course, the student must be able to:

- Design an embedded system on an FPGA
- Analyze a specific problem to be solved and propose an FPGA-based system to solve it
- Implement a solution to the given problem
- Realize and simulate the design
- Test the developed solution on an FPGA
- Use complex development tools and hardware debugging tools such as a logic analyzer and an oscilloscope

### Transversal skills

- Use a work methodology appropriate to the task.
- Negotiate effectively within the group.
- Set objectives and design an action plan to reach those objectives.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Use both general and domain specific IT resources and tools
- Make an oral presentation.

### Teaching methods

Ex cathedra and exercises, laboratories by specific sub-topics, final mini-project

### Expected student activities

- Reading and deepening of course concepts
- Preparation of exercises performed in the laboratory
- Writing reports on different labs
- Realization of a final mini-project by group with oral presentation, report and demonstration

### Assessment methods

With continuous control.

all labs 30%, mini-projet 20%, oral exam 50%

### Supervision

|              |                             |
|--------------|-----------------------------|
| Office hours | No                          |
| Assistants   | Yes                         |
| Forum        | Yes                         |
| Others       | Course on Moodle with forum |

### Resources

#### Virtual desktop infrastructure (VDI)

No

### Bibliography

Teaching notes and suggested reading material on moodle

Specialized datasheets (micro-controllers, FPGA) and standards(ie, SPI, i2c, Amba, Avalon, etc )

### **Notes/Handbook**

Documents and slides provided on moodle

### **Websites**

- <http://fpga4u.epfl.ch>

### **Moodle Link**

- <http://moodle.epfl.ch/course/view.php?id=1231>

### **Prerequisite for**

CS-476 Real-time embedded systems