## CS-473 Embedded systems

<table>
<thead>
<tr>
<th>Cursus</th>
<th>Sem.</th>
<th>Type</th>
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<tbody>
<tr>
<td>Cybersecurity</td>
<td>MA1, MA3</td>
<td>Opt.</td>
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<tr>
<td>Génie électrique et électronique</td>
<td>MA1, MA3</td>
<td>Opt.</td>
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<tr>
<td>Informatique</td>
<td>MA1, MA3</td>
<td>Opt.</td>
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<td>Microtechnique</td>
<td>MA1, MA3</td>
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<td>Mineur STAS Chine</td>
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<td>Robotique</td>
<td>MA1, MA3</td>
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<td>SC master EPFL</td>
<td>MA1, MA3</td>
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<tr>
<th>Language</th>
<th>English</th>
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<tbody>
<tr>
<td>Credits</td>
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</tr>
<tr>
<td>Session</td>
<td>Winter</td>
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<tr>
<td>Semester</td>
<td>Fall</td>
</tr>
<tr>
<td>Exam</td>
<td>Oral</td>
</tr>
<tr>
<td>Workload</td>
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<tr>
<td>Weeks</td>
<td>14</td>
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<tr>
<td>Hours</td>
<td>4 weekly</td>
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<tr>
<td>Lecture</td>
<td>2 weekly</td>
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<tr>
<td>Project</td>
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### Summary

The main topics of this course are understanding and designing embedded systems 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
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