Aalto University
School of Electrical
Engineering

Postgraduate course on electronic circuit design
Memory mapped microcontroller configuration on FPGA for controlling custom things.

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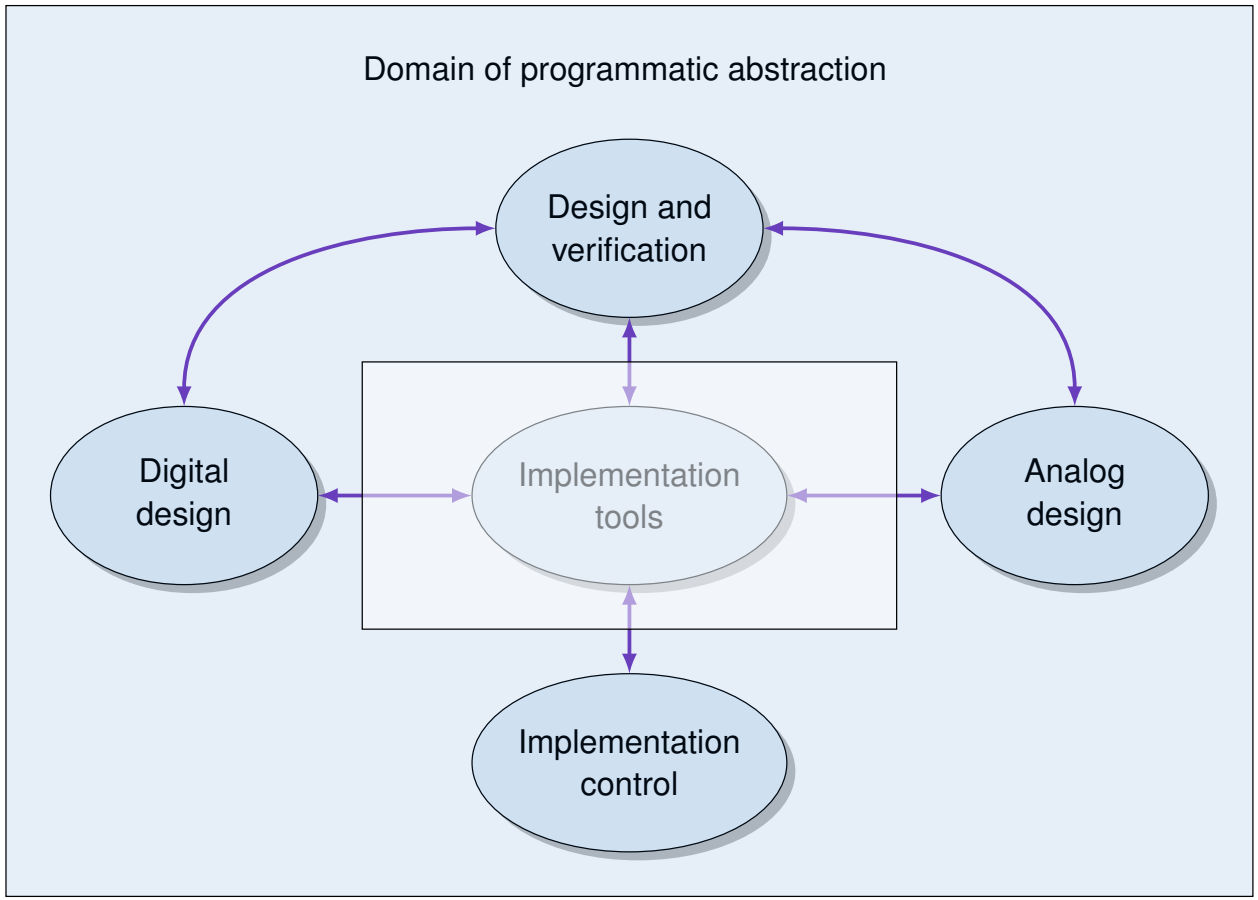
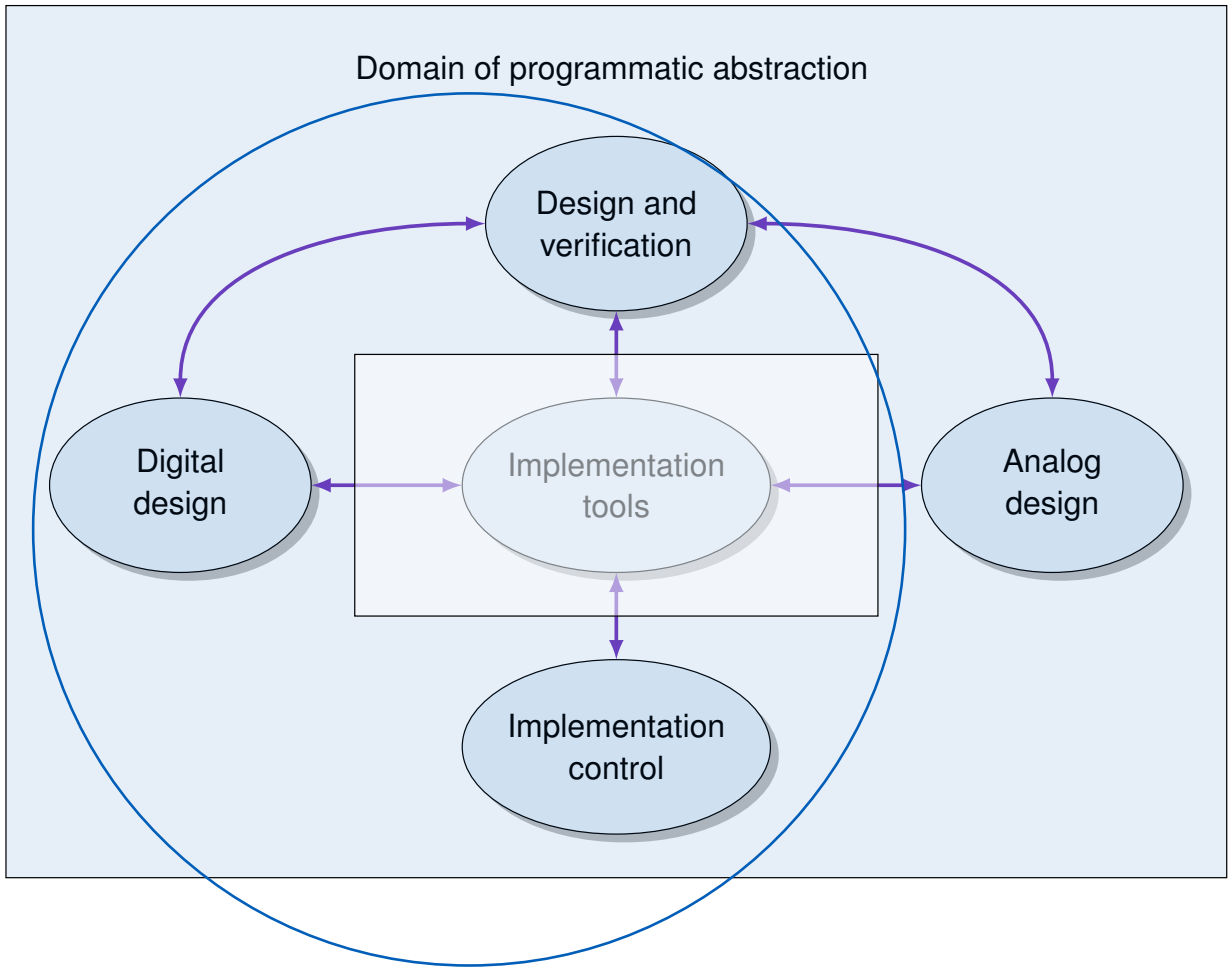
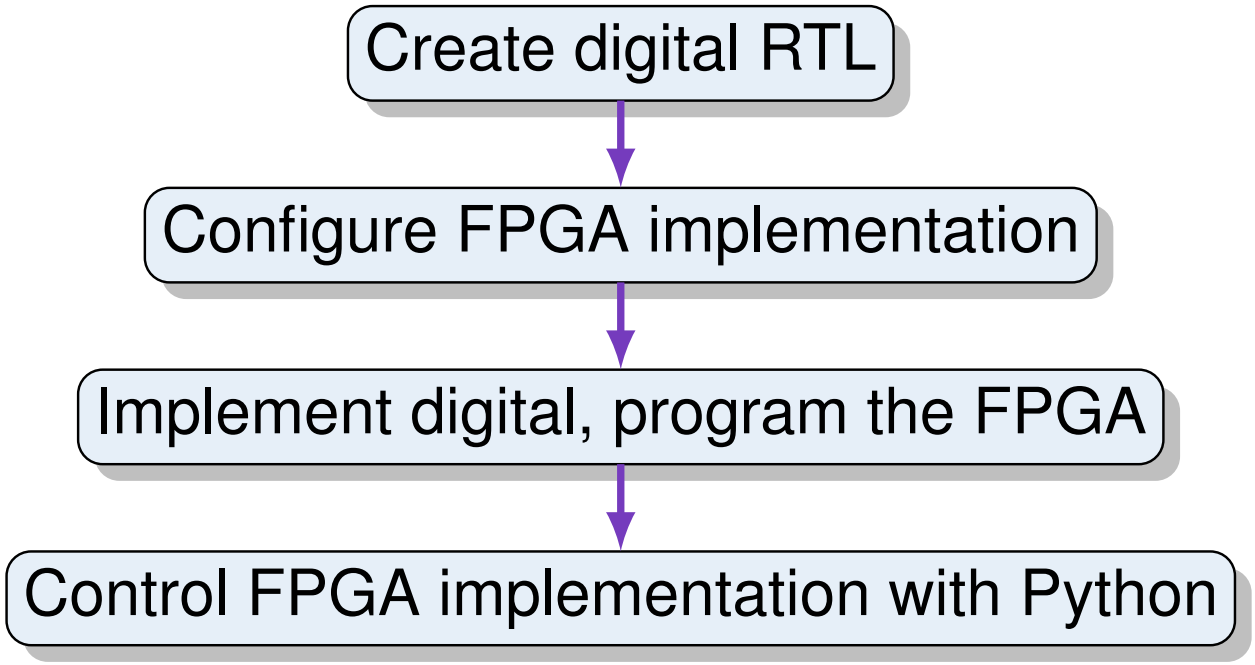
Programmatic circuit design



Programmatic circuit design

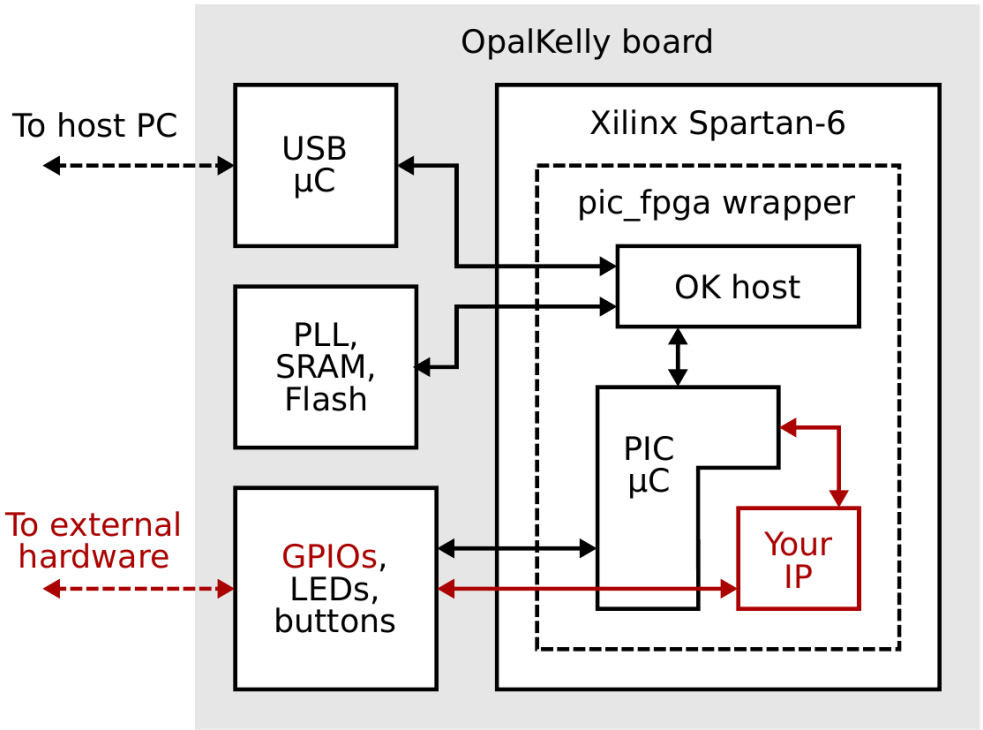


Product of year 2019: seamless FPGA implementation toolchain



Course objective:
Memory mapped microcontroller configuration

- Host runs python
- FPGA contains PIC16F34 microcontroller
- PIC runs assembly
- PIC *may* communicate with host during execution



Course objective

- Course is done in groups of 2
- You are given VHDL for PIC16F84A microcontroller.
- You are given example program in assembly and example how to simulate it on with Modelsim.
- You are given a toolchain to push it and run it on FPGA.
- Task:
  - Implement and control something with microcontroller on FPGA, (E.g. debug SPI slave controller with FPGA).
  - Control something with the FPGA dev board containing microcontroller and program. E.g. Control your chip with SPI-master implemented as PIC on FPGA.
  - Your imagination (and FPGA capacity) is the limit.
- Build process should use Configure && make, GUI for debugging and studies.
- Extend your capabilities by designing an *Exercise* or *Demo* that can be executed based on given instructions.
- Presentation or demo session, $\approx$ 15 min.

Programmatic project management

- We use Git for everything on this course in order to learn how to use it

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- We use Git issues and Slack for (shared) communication

Implementation platform

- OpalKelly XEM6001 (2 pcs.)
  - Xilinx Spartan-6 (XC6SLX16 FTG256)
- OpalKelly XEM6010 (5 pcs.)
  - Xilinx Spartan-6 (XC6SLX45 FGG484)
- ModelSim (Student edition available at https://www.mentor.com/company/higher_ed/modelsim-student-edition)
- Python 3.6 or newer.

Phase 1-Implementation platform and Toolchain

- OpalKelly FPGA. API's and FrontPanel available at Aalto Version https://version.aalto.fi
- Log in there, and I will add you to the Course Group
- Xilinx ISE required for programming the FPGA. Available:
  Windows 10:
  https://www.xilinx.com/support/download/index.html/content/xilinx/en/dow
  tools/14_7-windows.html
  Other:
  https://www.xilinx.com/support/download/index.html/content/xilinx/en/dow
  tools/v2012_4—14_7.html
- License is "ISE WebPack" it's downloadable during/after the install procedure.

Phase 1-Test the implementation platform and toolchain

- See the Gitlab issue board at https://version.aalto.fi/gitlab/elec-l3510_exec/main/-/boards
- Examples and documentation available:
  - Simulation: https://version.aalto.fi/gitlab/elec-l3510_exec/pic16f84a-vhdl/-/blob/master/README.md
  - FPGA implementation: https://version.aalto.fi/gitlab/elec-l3510_exec/pic-fpga/-/blob/master/README.md
- Fork these projects to you Groups Gitlab group. Instruction provided https://version.aalto.fi/gitlab/elec-l3510_exec/pic16f84a-vhdl
- Study how to program and simulate program the assembly code with VHDL with examples.
- Study how to implement the microcontroller on FPGA by getting acquainted with the code in pic-fpga
- Obtain FPGA board from course personnell and test the flow.

Phase 1-Test the implementation platform and toolchain

- First phase goal is to establish a script-based programming environment where you can push the design and program on FPGA without opening the gui.
- We have multiple groups, and collaboration is OK, but leeching is not. Each groups develops a toolchain of their own, but after X weeks you should (perhaps) converge to use the best one of them.

Phase-2 Implement a memory mapped microcontroller configuration for control of custom blocks.

- Use SPI as a test case. https://version.aalto.fi/gitlab/elec-l3510_exec/spi_slave
- We give you SPI slave VHDL to program on FPGA, but you need to write a Python interface and assembly program to control it (read and Write).

Phase 3-Excercise or demo

- You may skip Phase-II if you can.
- Develop any kind of a memory mapped microcontroller configuration to control anything you want/need in your work or just out of interest.
- Prepare a demo or course exercise out of your work.
- Best works are used in coming Bachelor's course "Programmatic circuit design". Eternal glory will be yours.

Phase 4-Presentations

- Each group gives a 15 minute slide presentation of their demos/exercises

Hints-Modularity is the key

- The most important thing in terms of re-usability:
  - Example templates are a git module that can be used for project initialization.
  - Every design should be a Git module
  - Every sub-design should be utilized as a git sub-module
  - Using sub-modules requires some advanced Git skills, thus we practice.
- On git related problems: *every one of them has been solved by someone*. Do a web search git <myproblem>.