

This project gave us a hands-on experience in designing and implementing a micro-processor. We became familiar with VHDL language, Modelsim, Quartus tools and programming on Altera FPGA Boards. This project gave us a complete understanding of the Multi-Cycle Datapath. Designing the FSM was challenging and interesting. We now better understand the different steps involved in designing a Multi-Cycle Datapath. Once again, the challenging part was integrating the Control Unit with the Datapath. It was an up-hill task but eventually we succeeded. Time management is very important in doing such projects, and starting early is necessary. We chose the Multi-cycle design over single cycle design because it allows the instructions to have different clock cycles as well as enables to share the functional units within the execution of a single instruction. Also the more effective use of hardware in the multi-cycle implementation has tilted our decision towards it. Overall, it was a good learning experience and exciting too!

If we had to do the project again, we would start really early and be ahead of the deadlines. Like we mentioned above, Time management is important and gives you scope to try new things with your datapath. Starting early would give us enough time to try different and complex programs and better understand the errors we may run into. Now that we believe we understood multi-cycle datapath, next time we would implement the Pipelined datapath with Hazard Detection and Forwarding unit.

### Advice to Future Students

Start your project early to meet deadlines and try to make your design simple. The project may look simple but, do not wait until the last minute. De-bugging is a very tedious task so, check each component thoroughly one by one in the datapath.

We would suggest that students, who prefer to implement the multi-cycle datapath do the Datapath verification part along with the Control Unit part. This would help them verify their datapath successfully. Verification of the Datapath after designing the control unit becomes much simpler and less time consuming. In part 1, the Instruction Set has to be defined (16 instructions), it may so happen that during the later stages of your project the 16 instructions that you started with may not remain the same because depending on your datapath you may have to change or remove some instruction and add some other instruction in its place. So, keep an eye on your ISA and opcodes all the time. For example, in our part 1 of the project, we had instructions jalr and li (load immediate) but, as we implemented the datapath and control unit, we changed these to halt and jal. Check if all your instructions work or not. If possible, try to work in pairs, it helps a lot! When in doubt approach your GTA.

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