The Vending Machine

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April 10, 2025

Overview

- Your final grade
- Online exam
- The Vending Machine project
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- How did it go with the UART?

Your Final Grade

1. Your lab work, the vending machine
   - What is working (TA checks)
   - Your report
   - Basic functions is a 7, extra functions needed for a 10 or 12
2. Written exam
   - Two hour written exam

Exam Topics and Questions

- The pensum (reading lis) is on the web site
- Compute maximum frequency and delays of a given circuit
- Given a Chisel description of a circuit, draw it
- Given a circuit drawing, sketch the Chisel description
- Basically what we have done in the lab
- No surprises (at least not too many ;-)
- I have uploaded some in DTU Learn

A Vending Machine from 1952

Source: Minnesota Historical Society, CC BY-SA 2.0

The Vending Machine

- Final project is a vending machine
- Description is on GitHub: README.md
- Will repeat the overview now
- Group work
- Final version shall be run in an FPGA
- A lot can be done with testing and simulation

The Vending Machine

- Inputs: coins, buy
- Display: price and current amount
- Output: release can or error
- Small challenge to multiplex the display
- State machine with data path is the *brain* of the VM
- Guided step by step over several weeks

Vending Machine Specification I

- Sell 1 item and not returning any money
- Set price with 5 switches (1–31 kr.)
- Display price on two 7-segment displays (hex.)
- Accept 2 and 5 kr. (two push buttons)
- Display sum on two 7-segment displays (hex.)
  - Amount entered so far
- Does not return money, left for the next purchase

Vending Machine Specification II

- Push button *Buy*
  - If not enough money, activate *alarm* as long as buy is pressed
  - If enough money, activate *release item* for as long as *buy* is pressed and reduce *sum* by the price of the item

Optional Extras

- Needed for a 10 or 12
- Display decimal numbers
- Supplement alarm by some visuals (e.g., blinking display)
- Count coins and display an alarm when compartment is full ($>$ 20 coins)
- Have some text scrolling on the display
- Connect a UART to your VM and sending messages to your laptop
- ...
- Your ideas :-)

Design and Implementation

- Implementation shall be a state machine plus datapath
- Design your datapath on a sheet of paper
- Datapath
  - Does add and subtract
  - Contains a register to hold the sum
  - Needs some multiplexer to operate
- Display needs multiplexing
  - Implemented with some counters and a multiplexer
- Show each part of your design to a TA
  - 7-segment decoder, 7-segment with a counter, display multiplexer, complete vending machine

Draw Figures

- Drawings/schematics is another language to describe (digital) circuits
- Draw, draw, draw boxes and arrows!
- Use drawing during development
- If you cannot draw your circuit you do not understand it
- Use drawings to communicate with the TA
- Have drawings in your report
- You will *for sure* need to draw circuits at the exam ;-)

Vending Machine Design and Implementation Steps

- We started in week 6 (now we are in week 10)
- lab 6: Hexadecimal to 7-segment decoder and counter
- lab 8: Multiplexed Seven-Segment Display
- lab 10–13: Complete Vending Machine
- *Show your working design to a TA*

Final Report

- One report per group
- A single PDF
  - Your group number is part of the file name (e.g., group7.pdf)
  - Code as listing in an appendix (no .zip files)
  - Hand in in DTU Inside
- Content
  - Abstract
  - Preface (Who did what)

1. Introduction and Problem Formulation
2. Analysis and Design
3. Implementation
4. Testing
5. Results
6. Discussion
7. Conclusion

- List of References
- Appendix: Chisel code

Material on the Lab GitHub

- A top-level component
- XDC file for Basys pins and frequency
- A start of a tester generating waveforms
- A simulation of the board
- Show it (in IntelliJ)

An Optional Lab

- Testing the a Vending Machine
- Black box testing (you don't see the implementation)
- I give you two implementations
- One is OK, one is broken
- Which one is broken, and what it the error?
- Issue is that you need Verilator and a C compiler to run the tests
- WSL (with Linux Ubuntu) will make it relatively easy to use Verilator (and other tools)
- Icarus Verilog could be easier?
- Therefore, only if you really, really want to do it
- Lab 10

Questions on Final Project?

Summary

- Now you have four weeks for the Vending Machine
- Should be plenty of time
- Standard solution is good for a standard grade
- Add features as you like
- Have a good time with your Vending Machine construction