

Digital Design and Computer Architecture

Kent Jones

FP / MP 4: Final Project

CATEGORY	POINTS
Exercise 1: Final Project Input Device List	5
Exercise 2: Final Project Output Device List	5
Exercise 3: Integrated Processor Project with I/O and Assembly Program / Machine Code	40
Exercise 4: Group Presentation	40
Exercise 5: Individual Reflection (in folder on CS1)	10
TOTAL	100

Introduction

For this project you will complete your Microprocessor and integrate some form of Input / Output hardware for your devices. The goal of this project is to have a working microprocessor, and in interesting application / demonstration of your microprocessor that demonstrates that the input/output works correctly.

EXERCISE 1: Final Project Input Device List

For this exercise you will decide on the external input devices that your microprocessor will interface with. Here are some potential input devices and relative levels of difficulty (1 – easy , 3 – medium, 5 – hardest)

Difficulty Level	Input Device
1	Buttons / switches on the Nexys4 DDR board are the easiest to interface with.
2	The Keyboard interface has medium difficulty to interface, but since I've given you code so it should be easier than a level 3 device.
4	The PMOD joysticks. These require talking over a serial interface (similar to what the keyboard does). There is example code on Digilent
4	The built in orientation sensors. There is example code on Digilent.
5	The Audio input Analog to Digital converter. There is example code on Digilent but you will need to spend effort to implement it in VHDL.

List the input devices that you hope to implement:

Buttons/switches.
PMOD joystick.

How will you interface these input devices to your processor (e.g. memory mapped i/o or a port based approach)?
Port based.

EXERCISE 2: Final Project Output Device List

For this exercise you will decide on the external output devices that your microprocessor will interface with. Here are some potential output devices and relative levels of difficulty (1 – easy , 3 – medium, 5 – hardest)

Difficulty Level	Output Device
1	Single LEDs on the Nexys4 DDR board.
2	Hexadecimal / 7-segment displays.
3	Simple hardcoded VGA outputs that the processor can turn on or off.
5	Memory mapped VGA screen buffer and bitmapped characters on the VGA. Processor writes to memory buffer and VGA driver displays memory.
5	Audio output D/A converter with sound generation of some form
6 – extra hard	Implement a driver that interfaces with any of the PMOD output display devices. (The OLED displays/touchscreen)

List the output devices that you hope to implement:

7-seg display to display instructions.

Single LEDs.

How will you interface these output devices to your processor (e.g. memory mapped i/o or a port based approach)?

Port based approach.

EXERCISE 3: Final Project Implementation

The final project implementation will be worth 40 points. The following rubric describes how points will be assigned based on the actual implementation.

Sample Project Ideas

- Create an **SDRAM interface** that allows your CPU to read/write from the SDRAM.
- Create a program that uses
- Create a **keyboard interface** that allows your CPU to read text/numbers from a keyboard buffer(kind of like cin)
- Create a **pong program** that uses the VGA interface
- Create a **serial interface** that allows your CPU to talk to an external device.
- Create a **digital filter** program that uses the audio codec on the XSTEND board.
- Create a **character generator**, present your final with your system.

CATEGORY	Beginning 70% – 79%	Satisfactory 80% – 89%	Excellent 90% – 100%
Advanced Features Up to 5 Bonus Points	Implemented a single input or a single output of difficulty level 4 or greater weak integration with CPU.	Implemented a single input or output of difficulty level 4 or greater, satisfactory integration with CPU.	Excellent implementation of both an input and an output of difficulty level 4 or greater.
Input / Output 5 Pts	Your CPU has an instruction that loads data input from an input device OR an instruction that sends data to an output device.	CPU has instructions for BOTH input AND output from/to I/O devices.	CPU can output and input from both I/O devices of level 3 or greater.
Working Processor 25 pts	Core of processor is working for at least 3 instructions.	Satisfactory processor, but not all instructions working as planned.	Processor implements all planned instructions correctly and interacts with I/O correctly.
Application 10 pts	Extremely simple ad-hoc program running that just tests instructions implemented.	Simple program running that interacts with either input or output.	Interesting application program that interacts with I/O successfully (e.g. an interesting game, etc.)

EXERCISE 4: *Final Project Presentation*

1. What was your original goal? What it what you ended up doing?
2. A hardware diagram of how your I/O is connected to your processor. What difficulty levels of I/O did you implement? See Exercises for difficulty levels assigned.)
3. Demo one of your programs running and interacting with I/O on the Nexsys4 DDR.
4. What challenges did you face? How did you overcome them?
5. Did you go above and beyond the assignment requirements in any way?

EXERCISE 5: *Final Project Reflection – One Page*

1. What did you learn doing this project?
2. What went well?
3. What challenges did you face individually?
4. How did your group function? What could have been improved?

What to Hand In:

Completed CPU and I/O Interface Design

- One Page Individual Summary of Group Project – in your individual folder on CS1
- Final electronic presentation – every group member must have a copy in their folder on CS1
- This document with answers for Exercises 1, 2 and 3. (only one per group necessary) – every group member must have a copy in their folder on cS1