ECE318 Design Project

1. Introduction

The goal is to come up with a digital system, to design and simulate it and, finally, to synthesize the system on the Altera DE2 board. Digital systems surround you in everyday life and range from the digital alarm clock that wakes you up to the computer that you sit in front of every day. The objective is to take a fairly simple system and to move through the design process from the paper design phase to execution on an FPGA board. You will learn a lot from the project but should be prepared to spend a good amount of time in designing and debugging your system.

2. Project Description

Ideally, you will come up with a project of your own to work on. Some examples are given below but you are free to implement any system you choose. Before you start to work on the project you should complete these steps:

a) **Describe the project clearly in words.** Then, explain carefully the behavior of the system. You may want to include some typical inputs and outputs at this stage and how these are generated.
b) **Define the system inputs and outputs (the top level entity)**. Draw a block diagram of the top level of the system and show all inputs and outputs. Describe what each input and output does.
c) **Define any subsystems which you will design and give a block diagram of their interconnection**. This will help you later to design the code for each block – this technique should be familiar to you from the VGA and Keyboard labs. You can incorporate some of the blocks from these labs into your design if you need them.
d) **Describe how you will test your system in the simulation phase.** This should include a description of the simulation inputs and what the expected outputs are.
e) **Describe the interaction with the UP2 board.** How will the inputs be generated and the outputs displayed. Most projects will use the push button switches, 7 segment displays, keyboard or monitor. If you need any external sensors, you should check that we have these in the ECE workshop or that we can easily (and cheaply!) obtain them or more likely a full module. Chapter 12 in the book has some ideas on sensors but going this route will require some A/D conversion and some playing around with electronic components. This is a potentially risky route given the short time available to complete the project.

3. Project Ideas

Here are some examples of digital systems:

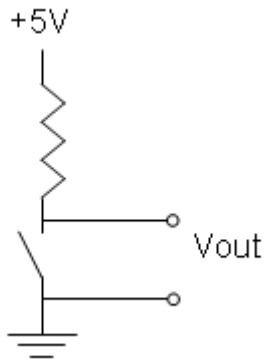
3.1. Digital combination lock
3.2. Digital alarm clock
3.3. Virtual ATM
3.4. Bowling score keeper
3.5. Tennis score keeper
3.6. Game with keyboard/mouse input (Read chapters 9 and 11 of the lab manual to think about projects with a mouse and the VGA screen).
3.7. Traffic light system (a more realistic version than that covered in class)
3.8. A more complicated processor than that covered in class which includes pipelining (see chapter 8 of the lab manual)

To give you an idea of how you might start to think about projects, two examples are given in the following subsections. These are also acceptable as design projects.

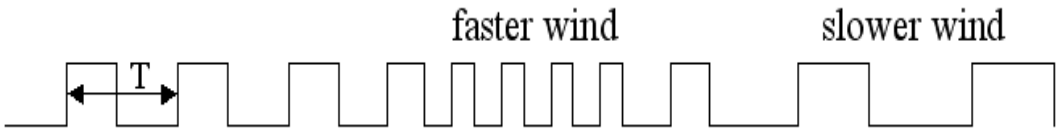
3.1. Wind Sensor Display System

The idea of this project is to design a system that takes input from a wind sensor, converts it to real world units (miles per hour, or kilometers per hour) and displays it on a CRT monitor.

The wind sensor consists of a set of cups attached to a shaft that rotates when wind hits the cups. A magnetic switch is attached to the shaft so that it closes once per shaft rotation. The switch is connected as follows.



The resulting signal from the wind sensor is a pulse signal that has a frequency that is proportional to the wind speed. Assume for this sensor that the wind distance traveled per revolution (T) is .1m. (We will use the function generator to simulate this waveform)



Suggested Steps

1. Develop a formula that relates the period, T, to the wind speed. Develop 2 equations - one for km/hour and one for m/s.

2. Assume that you want to display speeds from 0 (or less than a certain measurable threshold) to 119 km/h (level 1 hurricane). What are the corresponding T values for these extremes? (for the low speed, find a T value that can be represented by 16 bits)

3. Using the 25MHz system clock, develop an ASM chart that will measure T and then convert it (using one of the formulas you have developed) to a wind speed. Use this as a guide for your design.

3.2. Square Root Calculator

This circuit finds the square root of a number via a "trial and error" algorithm. We will use 8-bit numbers and the algorithm goes as follows:

```
loop for (input bitsize)/2 times
    double left shift input into working_reg
    copy 2*root to temp
    shift a 1 into rightmost bit of root
    shift a 1 into rightmost bit of temp
    is temp > working_reg?
       yes, invert last bit of root
       no, working_reg :=  working_reg - temp
```

For this algorithm you will need to input the number to be operated on, X, and an initial "guess" of the root. There is a working register which is initialized to the leftmost 2-bits of X.
Here is an example:

```
input: 10011111
initial root guess is 1
root = 0001
working register = 10



temp        X
|
        10011111
10        1    <--- initial root value for first loop
        --------
```

```
        0101  <--- working register after second loop
10 1     101
        --------
110 0      011 <--- working register after third loop
           000
        --------
1100 0      1111 <--- working register after fourth loop
            0000
            1111  <---- remainder left in working register
```

	temp	root	X	working register
init		1	10011111	
loop1	101	10		10
loop2	1001	101		0
loop3	10101	1010		11
loop4	101001	10100		1111

You should design this circuit starting with an ASM chart.

3.3. Simple Video Games

Some successful projects over the last few years have been based on implementing some older video games on the FPGA chip and using the keyboard and video interfaces that we have worked with in lab. You are free to use any of the logic blocks or modules that you have worked with in lab up to this time. There have been successful implementations of Pong, Snake, and Tic-Tac-Toe.

4. Project Timeline

Here is a summary of the dates and milestones. These are explained more fully below.

Milestone	Due Date
Project Proposal	2/19 by 10:55am
Project Labs	2/26, 3/5, 3/12
Status Report Due	2/29 by 10:30am
Project Presentations Due	3/12 by 4:45PM
Project Presentations	3/14, 10:55-12:40am
Project Reports	3/21 at the final exam

Table 1. Milestones and due dates

4.1 Project Proposal

For the proposal, you should hand in a brief (1-3 pages) description of a system which you will implement on the DE2 board. Follow the description format given in section 2 in defining your system.

4.2 Project Labs

We will use the lab time to work on the projects. I will give you feedback on the proposal prior to the first lab on 2/26. It is not compulsory for you to attend each lab but it is a good time to ask questions or to interact with your classmates. If you will be diligent in working on the project in your own time, you do not need to attend but if the set time will help you then plan on attending. You should plan on completing your coding by the end of the second lab, i.e., 3/5. You should be mainly testing in the final lab session.

4.3 Status Report (25%)

The status report should include a more thorough design than your initial proposal. It should also include code listings and a description of what you have done to date. Any potential problems which have been identified should be outlined. This material can be used again in your final report.

4.4 Project Presentations Due

You must email me the project presentation by 4:45 PM on Tuesday 3/12 and it should have the title in the format <name>_318project (e.g., John_Smith_318project.ppt). This will make it easier to run the presentations.

4.5 Project Presentations (25%)

The presentations will be on Thursday 3/14 from 10:55-12:40.

Each presentation is 10 minutes and should be

- 5 minutes presentation (=> 5-10 slides) + 5 minutes demo
- 10 minutes presentation (more slides, problems explained, code explanation, simulation results of each working block) if there is no demo

4.6 Project Reports (50%)

The final report on your project is due at the final exam 2:30 PM on 3/21. The report will be graded based on the difficulty of the project, the quality and quantity of the work on the project, and the quality of the writing.

5. Grading

The project will be graded using this breakdown:

Status Report	25%
Project Presentation	25%
Project Report	50%

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