**ECE 383 – Embedded Systems II**

**Final Project Format Guidelines**

# Final project

The final project in this class will be the design and implementation of an engineering prototype to address some need. The final projects in this class are to be completed individually. The following are significant deliverables in the completion of the final project.

## Proposal

The proposal describes the requirements that your prototype will achieve. Project specifications may be modified by the instructor.

## Plan

The project plan describes the hardware organization used to realize your design. In addition, it defines the technical accomplishments for the first and second milestones.

## Milestone I

A milestone is an intermediate level of technical accomplishment required in the final system. The first milestone will generally focus on getting the low-level units of the design operational.

## Milestone II

The second milestone generally seeks to integrate the units of the design. You should aim to have a simplified version of your design complete.

## Presentation

A presentation in front of the class covering the design needs, high-level architecture, detailed design, and a demo of the final product.

## Write-up

A written document describing your design, its performance, and its operation.

# Proposal

You final project proposal outlines the requirements your solution must meet, and the behavior of your solution. The proposal will start out by defining the name of the project and your name (with signatures) on the project. The following is the suggested format.

The project proposal will then have the following three sections in the following order.

**The Bicycle Computer**

A final project proposal for ECE 383

by

C3C Cadet Jones \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

March 10, 2020

## Objective Statement

The objective statement defines the purpose of the system you are designing and the need the project supposes to fulfill.

## Requirements

Define the requirements that you will need to be meet in order to achieve minimum functionality. Likewise define B and A-level functionality. In previous years, to achieve minimum functionality (20 points), you must incorporate a new external input or output device we haven’t previously used in this course. However, this year the new external input or output device is not required for minimum functionality, but instead can be used to achieve either B or A functionality (10 points each). The other 10 points will be for extra features you implement above the minimum functionality. These 40 points will be weighted by a “difficulty factor”. Those students with a more challenging project can receive more points.

## Level-0 Description & Top Level Design

A level-0 function table defines the overall input, output, and behavior of the system that you are building. You need to carefully consider what interactions a user will have with your system. This will give you clear goals for your project.

* **Graphical** - Draw your system with a box for each major subsystem (For example, FPGA, Input Sensors, Output Displays) and with the top level signal inputs and outputs between the subsystems. Have a specific line for each input/output signal, defining what the signal is (i.e., temperature, velocity, etc), what the specific interface link is (i.e., USB, Bluetooth, etc), and what port it connects to on each device (i.e., UART port, GPIO pin, etc). For the FGPA, draw internal blocks to delineate if the system is just Custom Hardware (FSM and Datapath), just Microblaze, or a combination of Microblaze and custom hardware.
* **~~Function Table~~** ~~- Describe the input, output and behavior of the system using this table format.~~

|  |  |
| --- | --- |
| ~~Module~~ | ~~The module name~~ |
| ~~Inputs~~ | ~~Users inputs and sensors which are inputs to the modules~~ |
| ~~Outputs~~ | ~~All forms of outputs from the modules~~ |
| ~~Behavior~~ | ~~Describe the behavior of this module. Make sure to talk about all the modes that the module can be in.~~ |

# Plan

The project plan defines how you are going to go about implementing the design set forth in your proposal. ~~All project plans should have the following information at the top of the first page. Your signature certifies that you agree to the plan set forth in this document.~~

**~~The Bicycle Computer~~**

~~A final project plan for ECE 383~~

~~by~~

~~C3C Cadet Jones \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_~~

~~March 20, 2020~~

The plan should then go on to include the following sections.

## Proposal

Include the body of the updated proposal document - include any edits made to the original proposal by the instructor.

## Detailed Architecture and Sub-System Design

You need to provide the detailed design of your system. A detailed design should be split into level-1 subsystems, such as datapath and control.

### Level-1 Design

A level-1 design breaks the level-0 design into further subsystems and modules; each module generally corresponds to some physical chip, sensor, or actuator. A system boundary should be drawn showing where the system interacts with the user (signals which cross this boundary are the I/O from the level-0 function table). Example subsystems within your FPGA include Datapath, Control (FSM), Microblaze, and Key I/O ports (like UART, Bluetooth, etc). Describe the internal organization of the chip using a datapath and control similar to those presented in Lab 1, 2, and 4. Your datapath should be composed of several basic building block (BBBs), like in Lab 1, 2, and 4. Make sure that the top level-0 signals match those in the Level-1 diagram.

The Level-1 Design should include a block diagram, showing all I/O signals and interfaces between the subsystems. Subsystems requiring software should have either a flowchart or FSM design.

## Calculations/Analysis/Drawings

You may need to perform some calculations, equations, or analysis in order for your project to work or to derived the key specifications for your system. Any unusual data structures which have bit fields which meet some requirements should be explained in this section, e.g. fixed point. Any math functions implemented in look-up-tables should be defined.

If your system is creating images on the HDMI monitor (like scopeface), you should include a drawing of the example scopeface display with the objects and game area drawn to scale (row/col pixel scale)

## ~~Bill of Materials~~

~~Include a list of the parts that you will need to complete the project; include parts that you may already own. For each component, please indicate if we have it and if not, will you be purchasing it, or will USAFA need to purchase it. If you need an item purchased, please provide the exact part number, cost, and URL where it can be ordered.~~

## Milestone I

A milestone represents an intermediate level of technical accomplishments required in the overall system. Your first milestone should focus on getting every unit defined in your level-1 design operational and communicating with your reprogrammable chip. The milestones will take on the form of tests which will be run to verify that each milestone was met. For example, if you are interfacing a thermometer to your chip then a milestone would be, "move thermometer from hot water to cold water and observe temperature change." Make sure to document these tests with pictures or measurements, so that they can be included in the final project write-up.

## Milestone II

The second milestone will represent a more advanced level of system functionality. At this point you should be examining the interactions between combinations of level 1 components. Again, the milestones should take the form of tests which verify that modules are working correctly. These tests should be built around the overall stimulus response of your final project. A second milestone based on the previous example might be, "move thermometer into hot water and wait for warning LED to come on."

## Functionality and Requirements

Define the detailed requirements that you will need to be meet in order to achieve minimum functionality. Likewise, define the detailed requirements of B and A-level functionality. The specifications for each grade level must include:

* Behavioral – tell me what the system should do
* Measurable Requirements -- These technical requirements are numerically defined performance goals that you need to meet. For each technical requirement give some justification for the values choose. (Example: Must measure temperature from 0 to 100 degrees Celsius, with an accuracy of 0.1 degrees Celsius)
* Testing – describe tests that will be performed demonstrating unit-level functionality and system performance, demonstrating the system meets the measurable requirements.

# Milestone I

You need to document that you have or have not met your deliverable obligations for the first milestone. In order to do this you will produce a document with the following sections.

## ~~Detailed Architecture~~

~~Cut-and-paste the level-1 and datapath and control designs from the project plan. Incorporate any edits suggested by the instructor.~~

## Unit Test Plan and Test Results

Enumerate the tests defined for the first milestone in the project plan along with, how it was performed, and the results of the test. Give details on any special programs written to perform these tests.

# Milestone II

You need to document that you have or have not met your deliverable obligations for the second milestone. In order to do this you will produce a document with the following sections.

## ~~Detailed Architecture~~

~~Cut-and-paste the level-1 and datapath and control designs from the project plan.~~

## Integration Test Plan and Test Results

Enumerate the tests defined for the second milestone in the project plan along with, how it was performed, and the results of the test. Give details on any special programs written to perform these tests.

# Final Demonstration and Test Results

This section should document the test and demonstration results the overall system was able to achieve.

# Presentation

You will be giving a technical presentation on your design. This presentation may be attended by other cadets. Thus, you must strive to have something in this presentation for everyone. The most common problem is design presentations is that students jump too quickly into the technical details of a project without first establishing the overall scope of your project. The second slide of every presentation must be titled "I built an embedded system which..." This slide should be comprehensible by the average 10-year old. You might want to give a demo of your circuit (or a video of it in action) at this point so that everyone absolutely positively knows what you have built. Your technical explanation should start with your level-0 diagram, then to your level-1 and then onto your datapath and control. For each component in level-1 you should show the tests (and their results) that verify its operation. Don't be afraid to get into the nitty-gritty details after you have properly addressed what you are building; just remember to keep your presentation within the time limits.

# Write-up

~~The final write-up should be hard copied, bound (GBC or spiral) with a clear cover and heavy weight back cover. The final write-up should have the following organization.~~

The final write-up should have sections 2 to 6 above. If you have modified your milestone goals, functionality goals, Level-0 or Level-1 Designs since your proposal/plan, then these should be updated in your final report. Don’t forget section 6.

The write-up should be posted in bitbucket in either markdown, word, or pdf format.

Also include this appendix:

**Appendix A: Running the Project**

Describe the procedure for a faculty member or student to duplicate your demo. I would like to have your project as a resource for students in later semesters so its important describe for them all the details necessary to make your project work. Include any special assembler or compliers that you used.

# Git Repo (Bitbucket)

You should provide the faculty member with a BitBucket repository containing four directories. These four directories can be included in your current ECE 383 repository in a folder called FINAL PROJECT. SOURCE should contain all the project files (include all intermediate files generated by the compiler), PRESENTATION should contain your final power point presentation, DEMO should contain a mpeg, mov, avi, etc. of your project in action along with any documented tests (or a link to a video hosting site like youtube), and REPORT should contain your report.

**~~Final Written Report Guidelines~~**

~~The following are guideline that you are expected to follow in your final written report.~~

* ~~Include page numbers in the bottom center of each page.~~
* ~~Brief code snippets are OK, but do not hardcopy your entire source file.~~
* ~~Double-sided copies are mandatory for the final bound report.~~
* ~~Single space the body of your text.~~
* ~~Correct spelling mistekes.~~
* ~~Make sure that you do have not grammar mistakes.~~
* ~~Consider the logical flow of the material; try to paint a complete picture in a logical manner.~~
* ~~Font should be Times Roman 12 point (except software printouts as indicated above, which will be 10 point Courier).~~
* ~~Use 1” margins for the left, right, top, and bottom the page.~~
* ~~Each chapter of the report must begin on a new page. The heading for each chapter should be bolded 14 point font and the sections should be numbered consecutively.~~
* ~~Figures in the text should be numbered consecutively, and properly labeled with the figure number and caption underneath the Figure. The figure numbers should be used to refer to figures in the body of text. An example Figure caption would be: Figure 1. Proposed conceptual design. If you have a figure in your text then it must be referenced somewhere within the body of your text.~~
* ~~Tables in the text should be numbered consecutively, and properly labeled with the table number and caption underneath the table. The table numbers should be used to refer to tables in the body of the text. An example table caption would be: Table 1. Design specifications.~~
* ~~All equations should be numbered consecutively, with the equation centered and the number right justified and inside parentheses. For example an equation would be shown as~~

 (1)

~~You then use the equation number inside parenthesis to refer to it in the body of the text.~~

* ~~Example for references~~

~~In body of report: “Analog LVDT signal conditioners that operate by demodulating~~ *~~s(t)~~* ~~utilizing op amps and transistors can be designed, but they require stable sine wave generators and phase compensation networks to operate properly [1].”~~

~~Then refer to it in the reference section as follows:~~

~~[1] G. Novacek, “Accurate Linear Measurement Using LVDTs,”~~ *~~Circuit Cellar Ink, Issue #106~~*~~, pp. 20 – 27, May 1999.~~