EEE 120 Capstone Design Project Spring 2024

Key Fob Project Summary

Read this entire specification carefully. Like a specification you will receive in industry, the information is spread out and not necessarily organized as you might expect. An important item might be buried in the middle of a paragraph where it is not expected. As you are responsible for meeting all the requirements, read this document slowly and carefully!

A car company has asked you to design the logic in the car to work with a new key fob. This is for a car they plan to introduce in the fall. The new fob works a bit differently than most.

- If the key fob moves "far" from the car for two clocks, the car automatically locks.
- If the car is unlocked, and the user presses the button on the fob, the car locks.
- If the car is locked, and the user presses the button on the fob, the car unlocks.
- Whenever the car unlocks, the lights flash for one clock.
- Whenever the car locks, the horn beeps for one clock.

There are two inputs and three outputs:

Inputs:

S: 0 means the fob is near the car; 1 means the fob is "far" from the car.
B: 0 means the fob button has not been pressed; 1 means the fob button has been pressed.

Outputs:

H: 0 means the horn does not honk; 1 means the horn should honk
F: 0 means the lights should not flash; 1 means the lights should flash
L: 0 means the car is unlocked, 1 means the car is locked

You do NOT need to worry about the definition of "far" – another engineering team is handling that.

Note that you design MUST have a minimum of 5 states.

You will need to design two different state machines that satisfy the above requirements. Think about different ways they might be implemented. Suggestions include how to handle the fact that the button on the fob is pressed while the fob is far away. Does the car unlock? What happens if unlock and lock directives conflict?

Come up with ideas on how you'd like to design the system. Interview three different stake holders to discuss your ideas. Stake holders may be other students, TAs, UGTAs, or family members. Be sure to document the names of the people you interview and their role. (That is, their role as student, TA, UGTA, family member, etc.)

Once you go through this customer discovery, create **two** finite state machine designs applying what you learned from your interviews and using different assumptions. This means documenting the assumptions made for each design and going through the design process (State Definition Table, State Transition Diagram, State Transition Table, Combinational Logic Design). Note that the two designs you create must be functionally different. That is, you can't create the same design once as a Mealy machine and once as a Moore machine. That is, the assumptions you make must be different for the two designs. In addition, at least one of the designs must be based on Karnaugh maps and logic gates. You will also need to incorporate flip-flops with asynchronous set and reset.

NOTE: Use the same type of flip-flops used in the labs as they have asynchronous set and reset!

Once you have completed two different designs, you will need to choose one design to implement and simulate in Digital. To do this, you will need to select at least 5 different criteria to use for comparison of each design and aid in your decision-making process. These criteria can originate from your customer interviews or from your own engineering intuition. Examples of criterion can be "ease of design, ease of understanding how it works, size of circuit, extra features." Each criterion must be given a weight (totaling 100%) of how important it is to include in the final design. Each design will then need to be rated against how well it meets each of the suggested criteria. Based on these ratings, select the best design that meets the customer's needs, and implement it in Digital, then simulate it through enough clock cycles showing each possible state transition. (Depending on your design, this may take multiple simulations.) In addition, you must show that each position can be visited using proper moves.

Items which go into your template include all your design documents. These include state definition tables, state transition diagrams, Karnaugh maps, behavioral equations, etc. When you implement the design in Digital, be sure to include a screenshot of your completed design.

You will also create a video in which you showcase your design. Topics to be covered in the video should include, but are not limited to,

1. The design assumptions you made.
2. A brief description of your two designs and why the one you built was best.
3. Showing your Digital design schematic and its features
4. Simulating the design in Digital showing some different scenarios and showing you visiting each state and enough of the transitions from each state to demonstrate your design.

NOTE: There are two valuable videos on Canvas that will help you with your design. The first explains the use of tunnels in Digital. Tunnels will help prevent your design from looking like someone dumped spaghetti all over it. The second video gives helpful hints on how to debug your design if the implementation does not work like you expect.

Deliverables

- You need to propose two different sets of assumptions. That is, how your two designs differ.
- You need to design two finite state synchronous machines that you can demonstrate to your stakeholders. This would usually be the company liaison, but in this class the stakeholders are your (UG)TAs, classmates, family members, and instructors.
- The designs must be different in their functionality.
- You should comment on why your controller adds value from multiple perspectives (technological, societal, financial, environmental, etc.). One or two sentences is sufficient.
- If something is not clearly documented in the summary, you need to make assumptions. The assumptions need to be documented.
- Please remember that you can design the state machines and add functionality to the design as you see fit. However, you need to collect feedback from at least three stakeholders. Again, stakeholders are your UGTAs, the lab TAs, family members, and the instructors.

- You should describe in a sentence or two how you changed your design based on the feedback you received.
- You can use D flip flops, T flip flops or J-K flip flops in your design. The type does not matter. Mixing different types of flip flops with different trigger edge sensitivity is possible but not recommended.
- You need to properly document your designs. If you do a “classic” paper-based design, you need to include diagrams and state tables as well as K-Maps and logic. If you decide to go with a different implementation (ROM, HDL), you need to comment your code. You must have a schematic design in Digital which matches your simulation.
- You need to pick the best design and explain why it is the best. It is very helpful to have judgement metrics in mind, for example, number of states, features, ease of building, number of logic elements, your understanding of the design, or others that you can come up with. You need to define the weight of each of these metrics. That is, ease of building is worth 10 points, number of logic elements 20 points, number of states 40 points, etc. Award points to each design. For example, if one design is easier to build than the other, it might get 6 of the 10 points in the category while the other design gets the remaining 4. The design which has the highest point total is the best! Again, it is up to you to define the categories (minimum of 5) and the number of points each category is worth. You must justify the points awarded with one sentence per category. (Do NOT write an essay!)
- You will need to simulate one design in Digital and show the simulation in your video. The simulation must demonstrate that you meet the rules and must also show how your assumptions modified the base specification.
- **A short video, the contents of which were described above.**
- **Upload your completed template (which must include a link to your video) and a zip file of your capstone folder. Upload the template separately even if it is in your zip file. There will be a 5-point deduction if your template is not submitted separately.**

Grading Policy

The grade will be allocated as follows:

- 5% for the value proposition.
- 5% for the stakeholder interviews.
- 5% for documenting the changes performed to your original idea.
- 20% for documentation in the report of how the first circuit performs the application.
- 20% for documentation in the report of how the second circuit performs the application.
- 5% for establishing reasonable criteria for picking one design as the “best” design. (The one design you build in the hardware lab does not need to be the “best” design.)
- 5% for picking a preferred, “best” design.
- 15% for Digital implementation
- 15% for the video demonstration.
- 5% for following design template guidelines (organization, legibility)

2% (Extra Credit) Completed Self-Assessment Worksheet