EEE 120

Capstone Design Project

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Instructor: Bassam Matar

Class Time: 3-4:15\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: 12/6/2024

**Task C-1: Planning the Synchronous Sequential Machines**

(5 pts) Interview at least 3 stakeholders, but 3 is preferred. Ask questions regarding the form, function, and features needed by potential customers for this design. Make sure to capture what the customer prefers from this type of solution, as well as what environment the customer plans to use this design. Summarize your findings here and document the names of who you interviewed.

stakeholder 1: Krishna Madhuri Vuppala

1)Emphasized the importance of simplicity in the design for better usability and troubleshooting, suggesting a modular approach to debugging.

2)Recommended focusing on minimizing the number of states and logic components to streamline the circuit.

3)Highlighted the need to ensure the system operates predictably even in ambiguous situations.

stakeholder 2: Sai Meghana Angara

1)Stressed the importance of strict adherence to the specification, particularly the rule limiting 𝐹 to 2 clocks and ensuring 𝑉 = 0 for at least one clock before 𝐹 can reassert.

2)Suggested using Karnaugh maps for one of the designs to optimize logic expressions and simplify the circuit layout.

3)Encouraged designing for scalability, ensuring the design could handle potential additional features or inputs in the future.

Stakeholder 3: Hasti Kumar

1)Focused on the reliability of the system, stressing the need for robust reset conditions to handle unexpected scenarios or input errors.

2)Recommended incorporating environmental considerations by ensuring the design minimizes power consumption and waste.

3)Highlighted the importance of cost-effectiveness, suggesting the use of fewer components to reduce manufacturing expenses while maintaining functionality.

(5 pts) Please include a comment on why your automation adds value from multiple perspectives (technological, societal, financial, environmental, etc.). (*What value does this add? What is the type of customer for whom this is designed? Where is this most needed? What couldn’t you do before?*)

Technological:

Replaces traditional mechanical float systems with precise electronic controls.

It ensures faster response times and low maintenance needs.

Ideal for modern pool management, offering reliability and flexibility.

· Societal:

Maintaining pool tasks manually is reduced, thereby increasing convenience for users.

Increases access for physically challenged people.

Increases safety by preventing pool overflow or underfill, avoiding structural or hygiene issues.

· Financial:

Saves on the water bill by avoiding overflow and optimizing the usage of water.

Reduces the cost of maintenance since no mechanical parts are involved, which may be subject to wear and tear.

Very cost-effective for residential and commercial pool owners in the long term.

Environmental:

Conserves water and reduces wastage.

Promotes eco-friendly and energy-efficient components.

Solves the problem of water shortage in areas where there is scarcity.

· Target Customer:

 Designed for pool owners who value convenience, efficiency, and sustainability.

 Extraordinarily useful for resorts and other fitness centers that have very large pools.

· Need and Innovation:

Fulfills a critical need in regions with strict water conservation laws or frequent shortages.

Replace less-accurate manual and mechanical systems with a modern reliable solution.

 Introduces advanced automation to ensure precision with ease of use.

(5 pts) It is allowable to continue to ask questions of stakeholders throughout the design process (and is preferred of a conscientious engineer). This can be done as you are designing, before you are designing if you need input and clarifications, or after you are done designing if you want feedback on improvements. Summarize any changes to your understanding or design based on the feedback you received during your initial interviews or continual interviews?

From Krishna Madhuri Vuppala :

Feedback: Emphasized simplicity and modularity in design to ease debugging and troubleshooting.

Changes Made: Streamlined the state machine by reducing unnecessary transitions and modularizing the logic to isolate specific functionalities. This simplified both the schematic and debugging process.

From Sai Meghana Angara :

Feedback: Highlighted the importance of adhering strictly to the specification and optimizing the design using Karnaugh maps.

Changes Made: Revised the state transition logic using Karnaugh maps to minimize logic expressions, reducing the circuit's complexity. Added extra checks to ensure the 2-clock rule for FFF was strictly enforced.

From Hasti Kumar:

Feedback: Stressed the importance of reliability and environmental impact, recommending robust reset conditions and power-efficient design.

Changes Made: Added a robust asynchronous reset mechanism to ensure reliable operation during ambiguous scenarios or unexpected inputs. Incorporated power-efficient logic gates to align with environmental considerations.

**Task C-2: Document the Synchronous Sequential Machines**

**Design #1:** (2 pts) What assumptions did you make in the design of this machine?

I have assumed a new state level check S4 which checks the water level before proceeding to slow fill after two clock cycles of fast fill. When the current state is level check, if the water level is not full, then it proceeds to slow fill otherwise it proceeds to idle state.

(3 pts) Create a state definition table here that describes in plain English what each state in your machine means and what binary values you have assigned to represent each state, inputs, and outputs.

A sheet of paper with writing on it

Description automatically generated

(12 pts) Show your state diagrams, state transition tables and your circuit planning work (Karnaugh maps/equations/MUX/DEC/etc.) used in your design process. (You can do this by hand if you wish, do **not** show the full circuit schematic here.)

A drawing of a diagram

Description automatically generated

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Q0 | Q1 | Q2 | L | V |  |  |  | R | F |
| S0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
|  | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| S1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
|  | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
|  | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| S2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
|  | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
|  | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| S3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
|  | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| S4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
|  | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
|  | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| S5 | 1 | 0 | 1 | 0 | 0 | X | X | X | X | X |
|  | 1 | 0 | 1 | 0 | 1 | X | X | X | X | X |
|  | 1 | 0 | 1 | 1 | 0 | X | X | X | X | X |
|  | 1 | 0 | 1 | 1 | 1 | X | X | X | X | X |
| S6 | 1 | 1 | 0 | 0 | 0 | X | X | X | X | X |
|  | 1 | 1 | 0 | 0 | 1 | X | X | X | X | X |
|  | 1 | 1 | 0 | 1 | 0 | X | X | X | X | X |
|  | 1 | 1 | 0 | 1 | 1 | X | X | X | X | X |
| S7 | 1 | 1 | 1 | 0 | 0 | X | X | X | X | X |
|  | 1 | 1 | 1 | 0 | 1 | X | X | X | X | X |
|  | 1 | 1 | 1 | 1 | 0 | X | X | X | X | X |
|  | 1 | 1 | 1 | 1 | 1 | X | X | X | X | X |

A white paper with writing on it

Description automatically generated

A close-up of a graph

Description automatically generated

(3 pts) List your final design equations and required logic gates (including types of Flip Flops) needed to complete this circuit.

A math equations on a white board

Description automatically generated

The required logic gates are 7 AND gates, 3 OR gates, ground wire, tunnels and 3 Asynchronous D-flip flops.

**Design #2:** (2 pts) What assumptions did you make in the design of this machine?

In this design, I assumed at state 2 for level check which checks the level of water after 1 clock cycle and then, decides whether to proceed to second clock cycle of fast fill or slow fill. When the current state is level, if the water level less than 50 percent, it proceeds to second clock cycle of fast fill otherwise to slow fill and then back to idle.

(3 pts) Create a state definition table here that describes in plain English what each state in your machine means and what binary values you have assigned to represent each state.

A white board with writing on it

Description automatically generated

(12 pts) Show your state diagrams, state transition tables and your circuit planning work (Karnaugh maps/equations/MUX/DEC/etc.) used in your design process. (You can do this by hand if you wish, do **not** show the full circuit schematic here.)

A drawing of a diagram

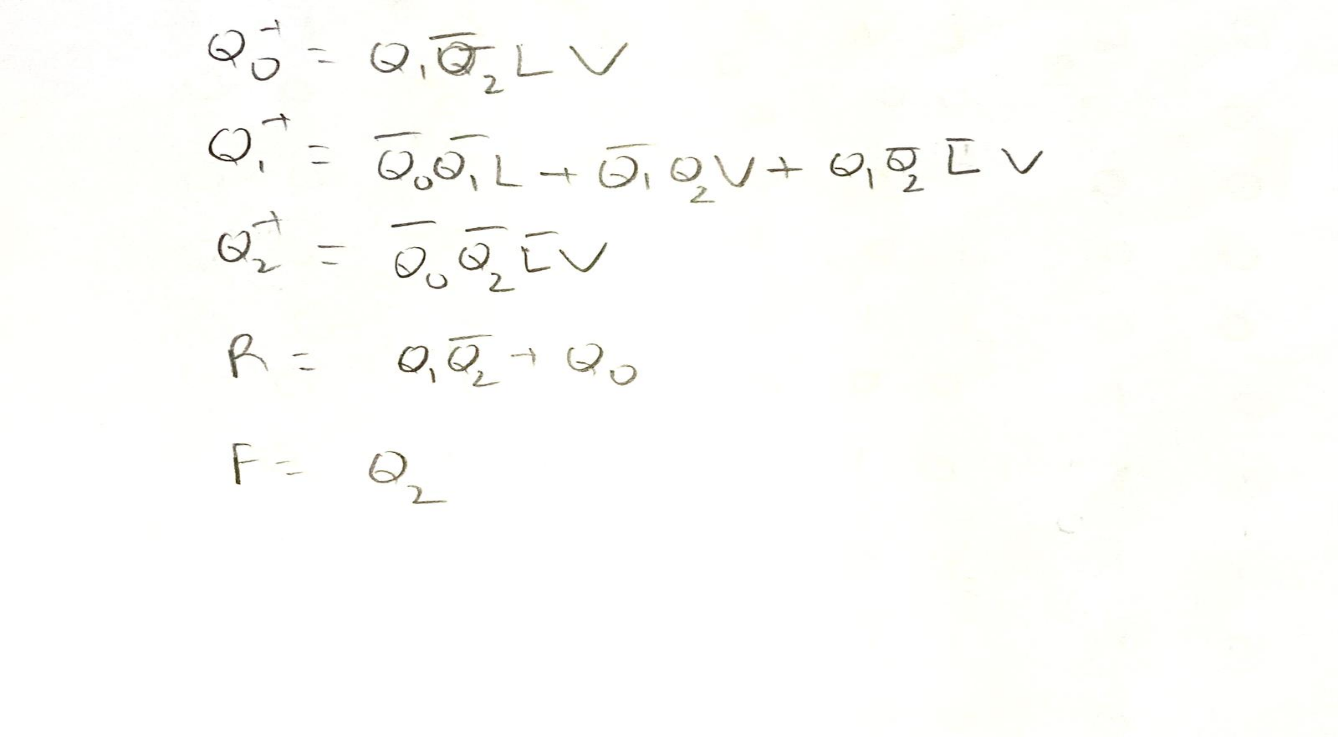
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|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Q0 | Q1 | Q2 | L | V |  |  |  | R | F |
| S0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
|  | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| S1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
|  | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
|  | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| S2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
|  | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
|  | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| S3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| S4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
|  | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| S5 | 1 | 0 | 1 | 0 | 0 | X | X | X | X | X |
|  | 1 | 0 | 1 | 0 | 1 | X | X | X | X | X |
|  | 1 | 0 | 1 | 1 | 0 | X | X | X | X | X |
|  | 1 | 0 | 1 | 1 | 1 | X | X | X | X | X |
| S6 | 1 | 1 | 0 | 0 | 0 | X | X | X | X | X |
|  | 1 | 1 | 0 | 0 | 1 | X | X | X | X | X |
|  | 1 | 1 | 0 | 1 | 0 | X | X | X | X | X |
|  | 1 | 1 | 0 | 1 | 1 | X | X | X | X | X |
| S7 | 1 | 1 | 1 | 0 | 0 | X | X | X | X | X |
|  | 1 | 1 | 1 | 0 | 1 | X | X | X | X | X |
|  | 1 | 1 | 1 | 1 | 0 | X | X | X | X | X |
|  | 1 | 1 | 1 | 1 | 1 | X | X | X | X | X |

A close-up of math equations

Description automatically generated

(3 pts) List your final design equations and required logic gates (including types of Flip Flops) needed to complete this circuit.



The required gates are 6 AND gates, 3 OR gates, ground wire, tunnels and 3- Asynchronous D-Flip flops.

**Task C-3: Determine Criteria and Weighting for Judging Your Designs**

(5 pts) Using the guidelines in the laboratory FAQ’s, list your 5 criteria and associated weights here used to help decide between the two design models (weights should add to 100%):

|  |  |  |  |
| --- | --- | --- | --- |
| Criterion | Weight (%) | Design #1 | Design #2 |
| Number of gates | 25% | 9 | 10 |
| Number of flip-flops | 25% | 9 | 9 |
| Understanding of the design | 20% | 10 | 7 |
| Functionality (working vs. not working) | 10% | 8 | 7 |
| Time required to implement | 20% | 8 | 6 |
| Total | 100% | 8.9 / 10 | 8.05/10 |

**Task C-4: Apply the Criteria to Pick the Best Design**

(2 pts) Describe how you applied each of the criteria and weighting system in the above task to pick the best design. How did you choose these criteria (customer interviews, engineering preference)?

In the above table the score for each design for each criteria is given out of 10, then the total score is calculated to 10 with differing weights for each criteria. These criteria were chosen in such a way that they play a major role in having a good experience for customers while using the product and for engineers while building the product. The no. of gates and flip flops play a major role in determining the time, cost and hardware requirements, which affects the final cost and understanding the design reduces implementation time and is also easy to use for customers. The understanding of design also decreases the scope for errors which improves functionality.

(3 pts) Which design is better based on your criteria and weighting system and why? Please explain how the winning design scored in each category and why (the winning design does not need to score the highest in every category, but it does need to score higher overall when applying the criteria weights).

According to the total scores above, design 1 has a higher score which makes it a better design. Though design 2 scored better in some criteria, the design is more balanced and suits all the criteria better. Also, a better overall score means better and balanced design.

**Task C-5: Build and Simulate Winning Design in Digital**

(15 pts) Insert a copy of your chosen Digital Schematic here. Please make sure that you have outputs or tunnels connected to each flip flop so that you can easily monitor your states. Make sure that the logic and equations match the final equations presented in either Design 1 or Design 2.

A screenshot of a computer

Description automatically generated

**Task C-6: Record a Video Demonstration of the Winning Design**

(15 pts) Record a video demonstration showing all positions being visited and various combinations of the inputs in Digital. For every clock cycle, explain the inputs, what current state you are in, and point out any outputs that should be noted. Be sure to show what happens for different input combinations at each position. That is, your demonstration should be able to showcase all possible states and transitions required to get there. If you include any asynchronous inputs, make sure to show those features as well. Add a link to your video below. Be sure to include any required password.

**Video link:** [**https://asu.zoom.us/rec/share/TmgBptuw-Qe9ObmyRHx33GveE6Ukhk1B4Yj3pYzZ6okRwVGtaYzb7d4tnNJnCfp8.\_l6Um4x5QI9\_Tro-?startTime=1733552233000**](https://asu.zoom.us/rec/share/TmgBptuw-Qe9ObmyRHx33GveE6Ukhk1B4Yj3pYzZ6okRwVGtaYzb7d4tnNJnCfp8._l6Um4x5QI9_Tro-?startTime=1733552233000)

**Passcode: P9@!eGHz**

**Task C-7: Fill Out the Self-Assessment and Turn in Your Design**

**There are two items to submit.** Turn in the zip file of your capstone project folder. Also turn in this template once it is filled out. There will be a deduction of 5 points if your template is only found inside the zip folder. The self-assessment is on the next page.

# Self-Assessment Worksheet

Put an ‘X’ in the table below indicating how strongly you agree or disagree that the outcomes of the assigned tasks were achieved. Use ‘5’ to indicate that you ‘strongly agree’ and ‘1’ to indicate that you ‘strongly disagree’. Use ‘NA’, Not Applicable, when the tasks you performed did not elicit this outcome. Credit will be given for including this worksheet with your lab report. However, your **responses will not be graded**, they are for your instructor’s information only.

**Table 1: Self-Assessment of Outcomes for the Capstone Design Project Lab.**

| **After completing the assigned tasks and report I am able to:** | **5** | **4** | **3** | **2** | **1** | **NA** |
| --- | --- | --- | --- | --- | --- | --- |
| Initiate a design process based on a value proposition and feedback from various stakeholders. |  | X |  |  |  |  |
| Make assumptions to complete an incomplete functional specification. |  | X |  |  |  |  |
| Use classical design techniques (i.e., state diagrams, state transition tables, and Karnaugh Maps), to design a synchronous sequential machine starting with a functional specification. | X |  |  |  |  |  |
| Build, and debug a synchronous sequential machine. | X |  |  |  |  |  |
| Develop reasonable engineering criteria for comparing different designs. |  | X |  |  |  |  |
| Apply engineering criteria to select a ‘best’ design. | X |  |  |  |  |  |

Write below any suggestions you have for improving this laboratory exercise so that the stated learning outcomes are achieved.

# Capstone Design Project: Lab Report Grade Sheet

**Name:**

| **Grading Criteria** | **Max Points** | **Points lost** |
| --- | --- | --- |
| **Template** |  |  |
| Neatness, Clarity, and Concision | 5 |  |
| **Description of Assigned Tasks, Work Performed & Outcomes Met** |  |  |
| Task C-1: Planning the Synchronous Sequential Machines | 15 |  |
| Task C-2: Document the Synchronous Sequential Machines | 40 |  |
| Task C-3: Determine Criteria and Weighting for Judging Your Designs | 5 |  |
| Task C-4: Apply the Criteria to Pick the Best Design | 5 |  |
| Task C-5: Build and Simulate Winning Design in Digital | 15 |  |
| Task C-6: Record a Video Demonstration of the Winning Design | 15 |  |
| **Self-Assessment Worksheet** (The content of the self-assessment worksheet will not be graded. Full credit is given for including the completed worksheet.) | (2 extra points) |  |
|  | **Points Lost** |  |
| **Lab Score** | **Late Lab** |  |
|  | **Lab Score** |  |