EEE/CSE 120
Capstone Design Project

Name:	Zachary Pines
Instructor:	Professor Goryll
Class Time:	M/W - 1:30 – 2:45
Date:	11/30/2023

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 those you interviewed.

Professor Goryll:

- The inputs can be thought of as a laser being cut off, so it's a quick trigger, only as they get on
- The output can be thought of as a door being opened or closed, so no illegal inputs can happen
- Only one person can enter per clock cycle per side
- Each person takes a uniform amount of time to cross the river
- People cant turn around on the bridge
- Everything said above can be changed with a different set of assumptions
- The world can be whatever I want it to be if it works

TA Who I feel really bad but didn't get the name of:

- Assuming you're not relying on the SPIT, you need to never have both outputs lit at once
- It's better to be safe than sorry when crossing
  - If 1 person is visiting Logictopia, even if theoretically they could get off and someone new could get on in a single clock cycle, room for error could break the bridge.
  - Similar point for 2 people. When the bridge is full, its safer to lock it down.
- If you want, you can think of the inputs as completely different systems, so long as it works

Justine Sanchez Morz:

- When building systems like this, the most valuable thing you can do is make each set of logic gates distinct, so its clear what everything does.
- Try to minimize the number of gates you end up using to get the cleanest possible design
- Make sure your decoding system is very simple, in real life if you were in charge of debugging a system like this, that's always the last place people check.

(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?*)

The main reason automation helps is accident prevention. It's not insane in our modern era for people to be so distracted that they don't look where they're going. On top of that, due to the horizon effect, sometimes people on the top of a ridge wotn see the people below until they're right there on top of them. Normally this would be an inconvenience, but with risk of the bridge collapsing with misuse, stopping accidents is incredibly important.

From a disability perspective, it's also very important. Without a system like this, people with impaired vision simply couldn't cross the bridge with certain safety. Now, it's impossible to get messed up, and with an accessible output display, you gain a large amount of autonomy.

Lastly, this system is useful for external monitoring. Due to the way the system has been created, it you could tap into this system incredibly easily remotely, to see exactly what's happening on the bridge. This can be helpful for monitoring safety, or for knowing when there's an opening to cross

As a general rule, automation towards safety is always a smart thing to include, especially when there's not much downside

(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?

I know this is a lame answer, but I honestly had a working prototype pretty quickly. Because of that, I didn't change any of my assumptions for the duration of the project. All of my things from above still apply to my end result. Really, the only major change that I didnt expect was that my final design uses the SPIT. I initially wanted my final design to be robust enough to avoid it, but the elegance of my initial answer, and the way it used B' and C' as outputs ended up being so clean that I decided to make it my final design. It also easily allowed me to make my digital display.

Task C-2: Document the Synchronous Sequential Machines

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

Universal:

1. People take the exact amount of time expected to cross the bridge (1 from the mainland to Logictopa and 2 from Logictopia to the mainland), no less and no more.
2. People won't turn around, or change direction while on the bridge.
3. The inputs are based on when somebody enters the bridge, and are only active for one cycle.
4. The outputs control physical barriers, meaning that people can't enter the bridge when they're not told they can from the system.

Specific:

5. The SPIT is operational, reliable, and cannot fail.
6. The SPIT blocks two people from coming in the same direction in the same clock cycle.

(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.

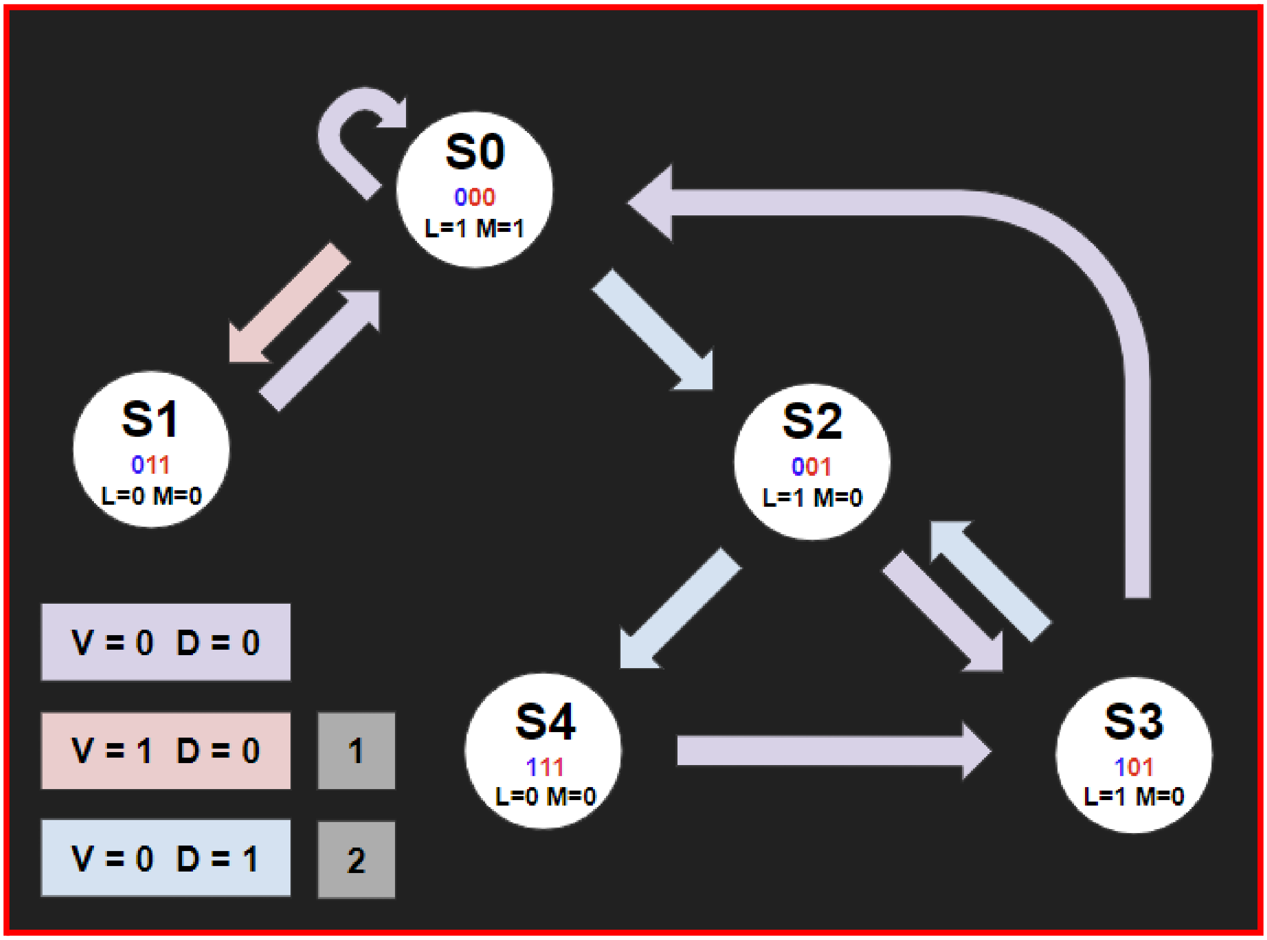
Note: I have very specific binary used for this project. This design has 5 states. One state outputs 11, two output 00, and two output 01. Because of this, I can use B and C as my outputs. It might make sense to use 011, 000, 100, 001, and 101 for that reason, but because I want my starting state to be 000, I opted for B' = L and C' = M. This makes the end of the circuit super small, while not being too hard to implement. With that understanding, my weird binary will make more sense. That's why State 1 isnt 001, and that's actually state 2 :)

For more, here's a quick video explaining it: https://youtu.be/rL-vuOmEcaM. **PLEASE WATCH IT!**

State	ABC Registers	Meaning	Output
S0	**000**	**The bridge is currently empty**	**L=1 C=1**
S1	**011**	**The bridge has one person coming from the mainland to logictopia**	**L=0 C=0**
S2	**001**	**The bridge has one person going from logictopia to the mainland, the person is on the first half of the bridge**	**L=1 C=0**
S3	**101**	**The bridge has one person going from logictopia to the mainland, the person is on the second half of the bridge**	**L=1 C=0**
S4	**111**	**The bridge has two people going from logictopia to the mainland, the people are on both halves of the bridge**	**L=0 C=0**

Note: Binary in ABC is curated such that B' = L and C' = M, Once again, please watch the video.

(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	B	C	D	V	A+	B+	C+
0	0	0	0	0	0	0	0
0	0	0	0	1	0	1	1
0	0	0	1	0	0	0	1
0	0	0	1	1	X	X	X
0	0	1	0	0	1	0	1
0	0	1	0	1	X	X	X
0	0	1	1	0	1	1	1
0	0	1	1	1	X	X	X

0	1	0	0	0	X	X	X
0	1	0	0	1	X	X	X
0	1	0	1	0	X	X	X
0	1	0	1	1	X	X	X
0	1	1	0	0	0	0	0
0	1	1	0	1	X	X	X
0	1	1	1	0	X	X	X
0	1	1	1	1	X	X	X
1	0	0	0	0	X	X	X
1	0	0	0	1	X	X	X
1	0	0	1	0	X	X	X
1	0	0	1	1	X	X	X
1	0	1	0	0	0	0	0
1	0	1	0	1	X	X	X
1	0	1	1	0	0	0	1
1	0	1	1	1	X	X	X
1	1	0	0	0	X	X	X
1	1	0	0	1	X	X	X
1	1	0	1	0	X	X	X
1	1	0	1	1	X	X	X
1	1	1	0	0	1	0	1
1	1	1	0	1	X	X	X
1	1	1	1	0	X	X	X
1	1	1	1	1	X	X	X

A^+ :

AB / CD	00	01	11	10
00	0	X	X	X
01	0	X	X	X
11	1	X	X	0
10	1	0	1	0

V = 0

AB / CD	00	01	11	10
00	0	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

V = 1

$A^+ = A'B'C + AB$

B^+ :

AB / CD	00	01	11	10
00	0	X	X	X
01	0	X	X	X
11	1	X	X	0
10	0	0	0	0

V = 0

AB / CD	00	01	11	10
00	1	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

V = 1

$B^+ = A'CD + V$

C+ :

CD \ AB	00	01	11	10
00	0	X	X	X
01	1	X	X	X
11	1	X	X	1
10	1	0	1	0

V = 0

CD \ AB	00	01	11	10
00	1	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

V = 1

$C^+ = AB + A'B'C + D + V$

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

Necessities

- Two Inputs
- Two Outputs
- One Clock
- Three D registers

Feedback (logic looping from ABC to $A^+B^+C^+$):

- 5 and gates
- 3 or gates

Decoding (Taking state and giving output)

- Nothing!
  - One of the reasons this design is so good is that B' = L and C' = M. Because of this, no logic is required to get the outputs from the current state

Strengths: No Kmap or logic required for L and M

Weakness: If the SPIT ever goes down, and D and V are both one, then the system breaks

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

Universal:

1. People take the exact amount of time expected to cross the bridge (1 from the mainland to Logictopa and 2 from Logictopia to the mainland), no less and no more.
2. People won't turn around, or change direction while on the bridge.
3. The inputs are based on when somebody enters the bridge, and are only active for one cycle.
4. The outputs control physical barriers, meaning that people can't enter the bridge when they're not told they can from the system.

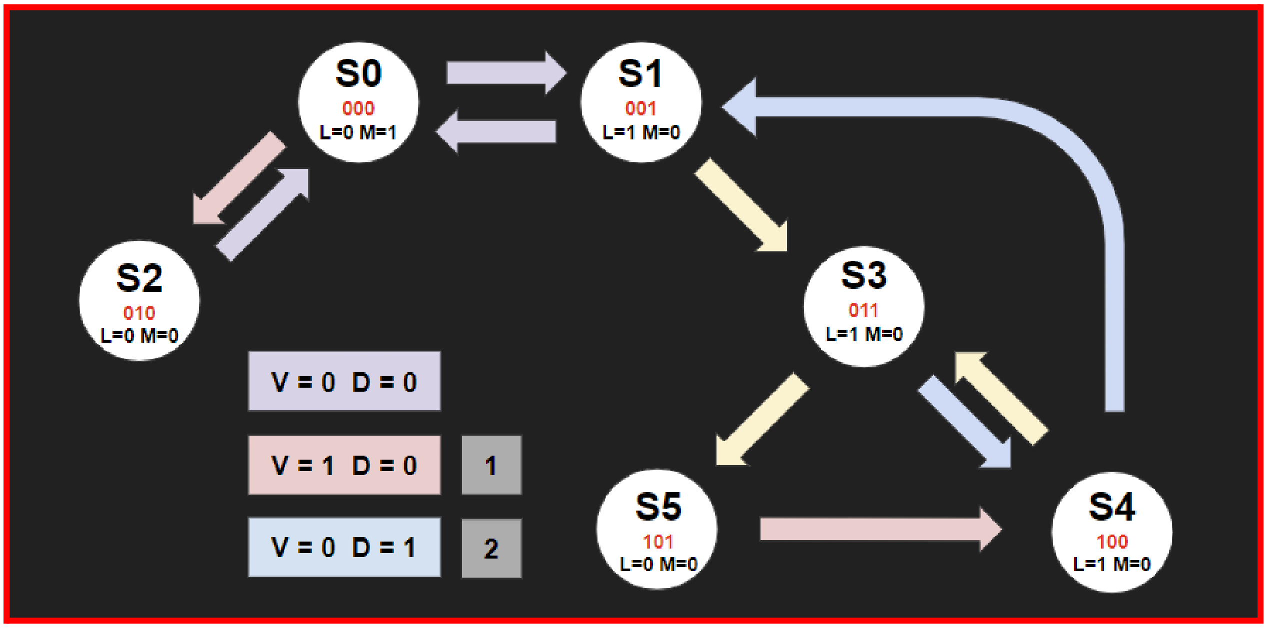
Specific:

5. The SPIT doesn't exist, so L and M can never be 1 at the same time.
6. There is a system in place to block two people from coming in the same direction in the same clock cycle (Such that any person entering on the clock cycle locks all doors until the clock cycle ends)

(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.

State	Binary	Meaning
S0	**000**	**The bridge is currently: People are allowed to leave Logictopia**
S1	**001**	**The bridge is currently: People are allowed to come to Logictopia**
S2	**010**	**The bridge has one person coming from the mainland to logictopia**
S3	**011**	**The bridge has one person going from Logictopia to the mainland, the person is on the first half of the bridge**
S4	**100**	**The bridge has one person going from Logictopia to the mainland, the person is on the second half of the bridge**
S5	**101**	**The bridge has two people going from Logictopia to the mainland, the people are on both halves of the bridge**

(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	B	C	D	V	A+	B+	C+
0	0	0	0	0	0	0	1
0	0	0	0	1	0	1	0
0	0	0	1	0	X	X	X
0	0	0	1	1	X	X	X
0	0	1	0	0	0	0	0
0	0	1	0	1	X	X	X
0	0	1	1	0	0	1	1
0	0	1	1	1	X	X	X
0	1	0	0	0	1	0	1
0	1	0	0	1	X	X	X
0	1	0	1	0	X	X	X
0	1	0	1	1	X	X	X

0	1	1	0	0	1	0	0
0	1	1	0	1	X	X	X
0	1	1	1	0	1	0	1
0	1	1	1	1	X	X	X
1	0	0	0	0	0	0	0
1	0	0	0	1	X	X	X
1	0	0	1	0	0	1	1
1	0	0	1	1	X	X	X
1	0	1	0	0	1	0	0
1	0	1	0	1	X	X	X
1	0	1	1	0	X	X	X
1	0	1	1	1	X	X	X
1	1	0	0	0	X	X	X
1	1	0	0	1	X	X	X
1	1	0	1	0	X	X	X
1	1	0	1	1	X	X	X
1	1	1	0	0	X	X	X
1	1	1	0	1	X	X	X
1	1	1	1	0	X	X	X
1	1	1	1	1	X	X	X

A^+ :

V = 0

CD \ AB	00	01	11	10
00	0	1	X	0
01	X	X	X	0
11	0	1	X	X
10	0	1	X	1

V = 1

CD \ AB	00	01	11	10
00	0	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

$A^+ = B + AC$

B^+ :

V = 0

CD \ AB	00	01	11	10
00	0	0	X	0
01	X	X	X	1
11	1	0	X	X
10	0	0	X	0

V = 1

CD \ AB	00	01	11	10
00	1	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

$B^+ = B'D + V$

C+ :

CD \ AB	00	01	11	10
00	1	1	X	0
01	X	X	X	1
11	1	1	X	X
10	0	0	X	0

V = 0

CD \ AB	00	01	11	10
00	0	X	X	X
01	X	X	X	X
11	X	X	X	X
10	X	X	X	X

V = 1

$C^+ = A'C'V' + D$

A	B	C	L	M
0	0	0	0	1
0	0	1	0	0
0	1	0	0	0
0	1	1	1	0
1	0	0	1	0
1	0	1	0	0
1	1	0	X	X
1	1	1	X	X

L:

AB / C	00	01	11	10
0	0	0	X	1
1	0	1	X	0

L = AC’ + BC

M:

AB / C	00	01	11	10
0	1	0	X	0
1	0	0	X	0

M = A’B’C’

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

Necessities

- Two Inputs
- Two Outputs
- One Clock
- Three D registers

Feedback (logic looping from ABC to $A^+B^+C^+$):

- 3 and gates
- 3 or gates

Decoding (Taking state and giving output)

- 3 and gates
- 1 or gates

Strengths: Works if the SPIT breaks

Weakness: Uses a lot more logic gates

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%):

Criteria	Weight
Uses the least amount of chips possible	25%
Is Visually clear [Destinct sections in build that are clean]	35%
Is Robust [Works if SPIT Breaks]	20%
Inputs and outputs are clearly understood from state	10%
Is clever [has something novel about the solution making it interesting]	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)?

With my above criteria, I chose design one. This is because the one thing my shareholders agreed upon was cleanliness. When creating a system like this, maintenance and repairs are important. This means that the smaller and more precise you make your system, the more user friendly it is. On top of that, having one circuit instead of two is a huge help. The biggest disaster that could happen in a stystem like this is that the state is correct, but the output is incorrect. This would mean that it's possible that the logic is correct, but the bridge still goes down. By eliminating this decoder circuit, we end up with a much safer design, which is my number one priority.

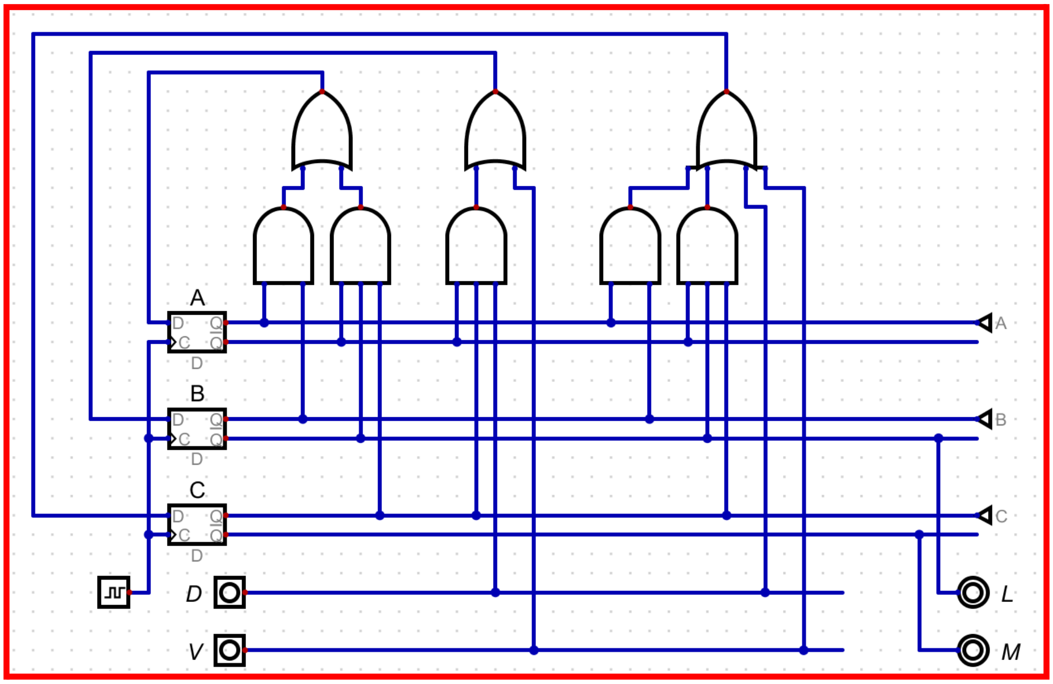
(3 pts) Which design is better based on your criteria and weighting system and why? Please explain how the winning design scored in each category and why (the winning design does not need to score the highest in every category, but it does need to score higher overall when applying the criteria weights).

As stated, this criteria picks solution one as the best. This is because it uses less chips, is more visually destinc, and is an overall cleaner solution. For me, having an interesting and pretty design that's easy to implement matters the most, as maintaining more bulky, complex systems can be hard. Because of that, design got the 25%, 35%, 10% and 10%. Notably, it didn't get the 20% award because it does rely on the SPIT being active. While it might seem like a problem, I've rationalized this is taking a system that could break from my circuit, and moving it to an external circuit. In programing, this is known as encapsulation, and I think it's more than good enough a reason to trust the SPIT to do its job.

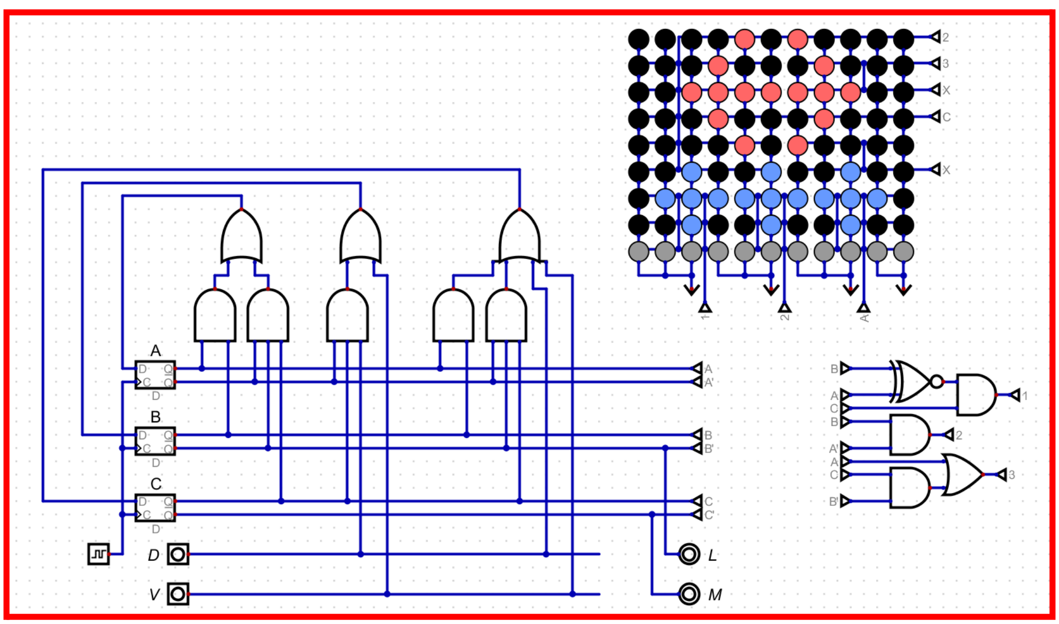
Task C-5: Build and Simulate Winning Design in Digital

(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.

Design without digital display:



Design with digital display:



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://youtu.be/YpvInYdJxIQ

Note: I recorded the video in Zoom only to learn that without subscription, the video is only saved locally. Because of this, I've uploaded the video to YouTube while keeping it unlisted. This means that googling it won't make it appear, which is the main reason we're discouraged from submitting it that way.

I've talked to Professor Goryll about this and I got it cleared, so we're good :)

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.

Zip file is added

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 **<u>responses</u> 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.

This lab was so fun, I had an absolute blast. Change nothing!!!

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)	
Lab Score	**Points Lost**	
	Late Lab	
	Lab Score	