

EEE 120

Capstone Design Project

Name: Fauzan Amaan Mohammed

Instructor: Professor Josh Hihath

Class Time: Mon & Wed (3:00-4:15)

Date: 1st May 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.

- **Sai, a freshman at ASU:** Suggested that all traffic signals need to operate where both signals from either street in an intersection needs to be red before continuing with the next cycle. He also suggested that the traffic signals need to come quickly.
- **Arnav, a party guy:** Suggested that the traffic signal from the Main Street should sometimes be green 24/7 so cars can go extremely fast.
- **Lydia, a medical student:** Suggested that the main Street should have an emergency button where it turns green to ensure that all emergency services like the ambulances or police cars could go quickly to their destination to reduce wait time for emergency situations.

(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?*)

My automation will take in opinions that come from technological, societal, financial and environmental context and this will help me narrow down in how should design my circuit. I will be deciding on building a circuit that requires less states and less logic gates so this will ensure that the final product is as cost effective as possible. This will also reduce the energy used.

(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?

Throughout the design process, I had multiple encounters with the stakeholders and continued to inform them regarding my two most suitable choices. I didn't decide to go for the autobahn style idea given by Arnav as it could be dangerous in certain regions. One of the feedback I have received is that try to put flashing lights to alert drivers and pedestrians that a train is coming. My plan would be to involve the lights in a flashing of red and yellow in both signals. My second idea was the only make the signals flashes red and green to ensure that the people in the Side Avenue stops and the people in Main Street would either give way to the emergency responders or reduce traffic congestion. Throughout interactions, I made sure that the final design was both functional and practical and catered to real life needs.

Task C-2: Document the Synchronous Sequential Machines

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

I took safety into a massive consideration. I made sure all traffic lights go to red after the Main Street goes back to red from the green. I also made you the special case is if a train is approaching the traffic lights switch between red and yellow.

(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.

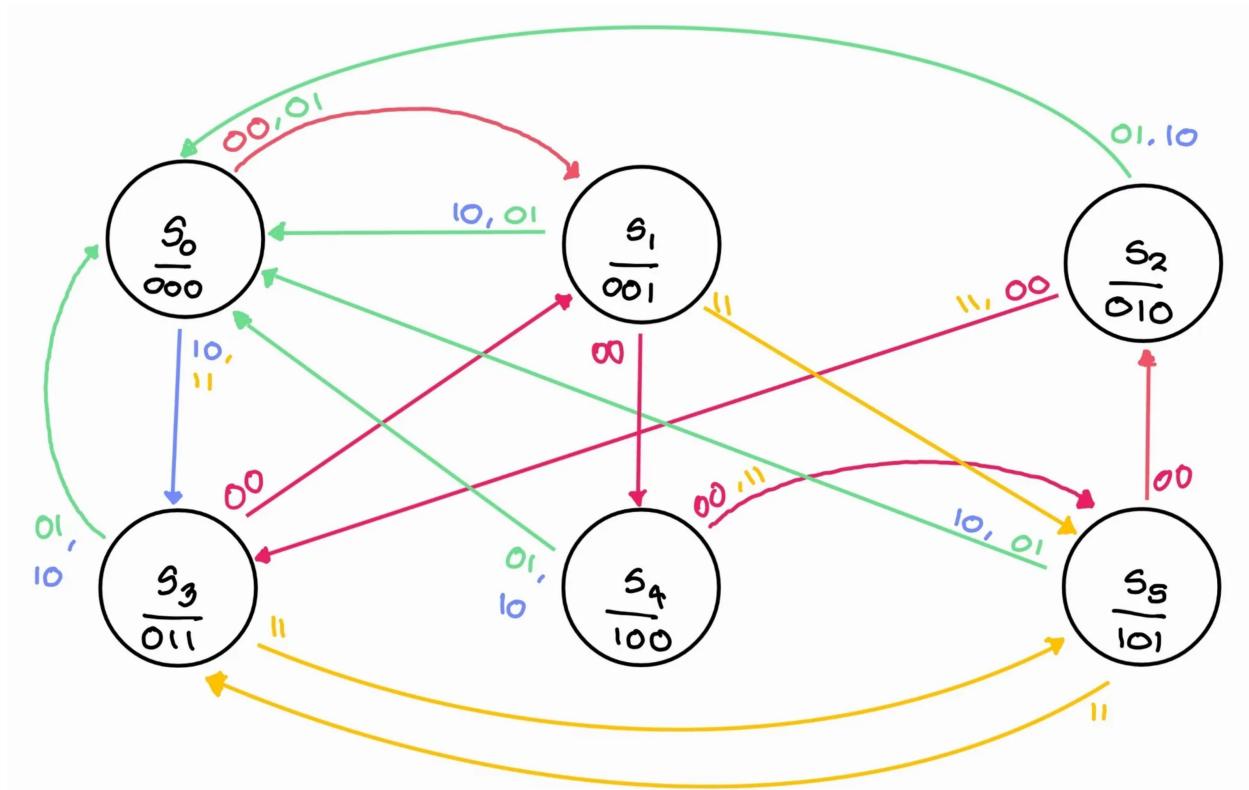
State	Name (Main St / Side Ave)	Definition	Binary
S0	No Light	The Main Street and Side Avenue had no lights, so the lights were turned off	000
S1	Red and Red	The Main Street and Side Avenue had red lights	001
S2	Green and Red	Main Street had Green while Side Avenue had Red	010
S3	Yellow and Red	Main Street had Yellow while Side Avenue had Red	011
S4	Red and Green	Main Street had Red while Side Avenue had Green	100
S5	Red and Yellow	Main Street had Red while Side Avenue had Yellow	101

(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.)

State Diagram

The circle is format in the following way: State and under it is the output.

The reset arrow would be towards the S1 State.



State Transition Table

Q2 Q1 Q0: Initial State													
A B: Inputs													
Q2+ Q1+ Q0+: Next State													
Q2	Q1	Q0	A	B	Q2+	Q1+	Q0+	MR	MY	MG	SR	SY	SG
0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	1	0	0	1	0	0	0	0	0	0
0	0	0	1	0	0	1	1	0	0	0	0	0	0
0	0	0	1	1	0	1	1	0	0	0	0	0	0
0	0	1	0	0	1	0	0	1	0	0	1	0	0
0	0	1	0	1	0	0	0	1	0	0	1	0	0
0	0	1	1	0	0	0	0	1	0	0	1	0	0
0	0	1	1	1	1	0	1	1	0	0	1	0	0
0	1	0	0	0	0	1	1	0	0	1	1	0	0
0	1	0	0	1	0	0	0	0	0	1	1	0	0
0	1	0	1	0	0	0	0	0	0	1	1	0	0
0	1	0	1	1	0	1	1	0	0	1	1	0	0
0	1	1	0	0	0	0	1	0	1	0	1	0	0
0	1	1	0	1	0	0	0	0	1	0	1	0	0
0	1	1	1	0	0	0	1	0	1	0	1	0	0
1	0	0	0	0	1	0	1	1	0	0	0	0	1
1	0	0	0	1	0	0	0	1	0	0	0	0	1
1	0	0	1	0	0	0	0	1	0	0	0	0	1
1	0	0	1	1	1	0	1	1	0	0	0	0	1
1	0	1	0	0	0	1	0	1	0	0	0	1	0
1	0	1	0	1	0	0	0	1	0	0	0	1	0
1	0	1	1	0	0	0	0	1	0	0	0	1	0
1	0	1	1	1	0	1	1	1	0	0	0	1	0

K-Maps (Main Circuit)

$Q_2 +$ 5-Variable K-Maps

$Q_2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	1	0	0
01	0	0	0	0
11	0	1	1	0
10	0	0	0	0

$Q_2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	x	x
01	0	0	x	x
11	1	0	x	x
10	0	0	x	x

$$\bar{Q}_2 Q_0 A B + \bar{Q}_2 \bar{Q}_1 Q_0 \bar{A} \bar{B} + Q_2 Q_0 \bar{A} \bar{B} + Q_1 \bar{Q}_0 A B$$

$Q_1 +$ 5-Variable K-Maps

$Q_2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	0	0	1
01	0	0	0	0
11	1	0	0	1
10	1	0	0	0

$Q_2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	1	x	x
01	0	0	x	x
11	0	1	x	x
10	0	0	x	x

$$\bar{Q}_2 \bar{Q}_1 \bar{Q}_0 A + Q_1 \bar{Q}_0 \bar{A} \bar{B} + \bar{Q}_2 \bar{Q}_0 A B + Q_2 Q_0 \bar{A} \bar{B} + Q_2 Q_0 A B$$

$Q_0 +$ 5-Variable K-Maps

$Q_2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	1	1
01	1	0	0	0
11	1	1	1	1
10	1	0	0	0

$Q_2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	x	x
01	0	0	x	x
11	1	1	x	x
10	0	0	x	x

$$\bar{Q}_2 \bar{Q}_1 \bar{Q}_0 + A B + Q_1 \bar{A} \bar{B} + \bar{Q}_0 \bar{A} \bar{B}$$

K-Maps(Traffic Lights)

MR

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	0	X	1
1	1	0	X	1

$$Q_2 + \bar{Q}_1 Q_0$$

MG

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	1	X	0
1	0	0	X	0

$$Q_1 \bar{Q}_0$$

MY

MY

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	0	X	0
1	0	1	X	0

$$Q_1 Q_0$$

SR

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	1	X	0
1	1	1	X	0

$$\bar{Q}_2 Q_0 + \bar{Q}_2 Q_1$$

SG

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	0	X	0
1	0	0	X	1

$$Q_2 \bar{Q}_1$$

SG

$Q_0 \backslash Q_2 Q_1$	00	01	11	10
0	0	0	X	1
1	0	0	X	0

$$Q_2 \bar{Q}_0$$

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

$$Q_2+ = A B Q_0 Q_2' + A B Q_2 Q_0' + A' B' Q_2 Q_0' + A' B' Q_2' Q_1' Q_0$$

$$Q_1+ = A B Q_0 Q_2 + A B Q_0' Q_2' + A' B' Q_0 Q_2 + A' B' Q_1 Q_0' + A Q_0' Q_1' Q_2'$$

$$Q_0+ = A B + A' B' Q_0' + A' B' Q_1 + Q_2' Q_1' Q_0'$$

$$MR = Q_1' \cdot Q_0$$

$$MY = Q_1 \cdot Q_0$$

$$MG = Q_1 \cdot Q_0'$$

$$SR = Q_2' \cdot Q_0$$

$$SY = Q2 \cdot Q1'$$

$$SG = Q2 \cdot Q0'$$

For this scenario, I will be using 3 D-Flip Flops

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

For this machine, I didn't make sure all the traffic signals go red before each cycle but I implemented an emergency function where if emergency responders need to clear traffic, the lights will flash Red and Green

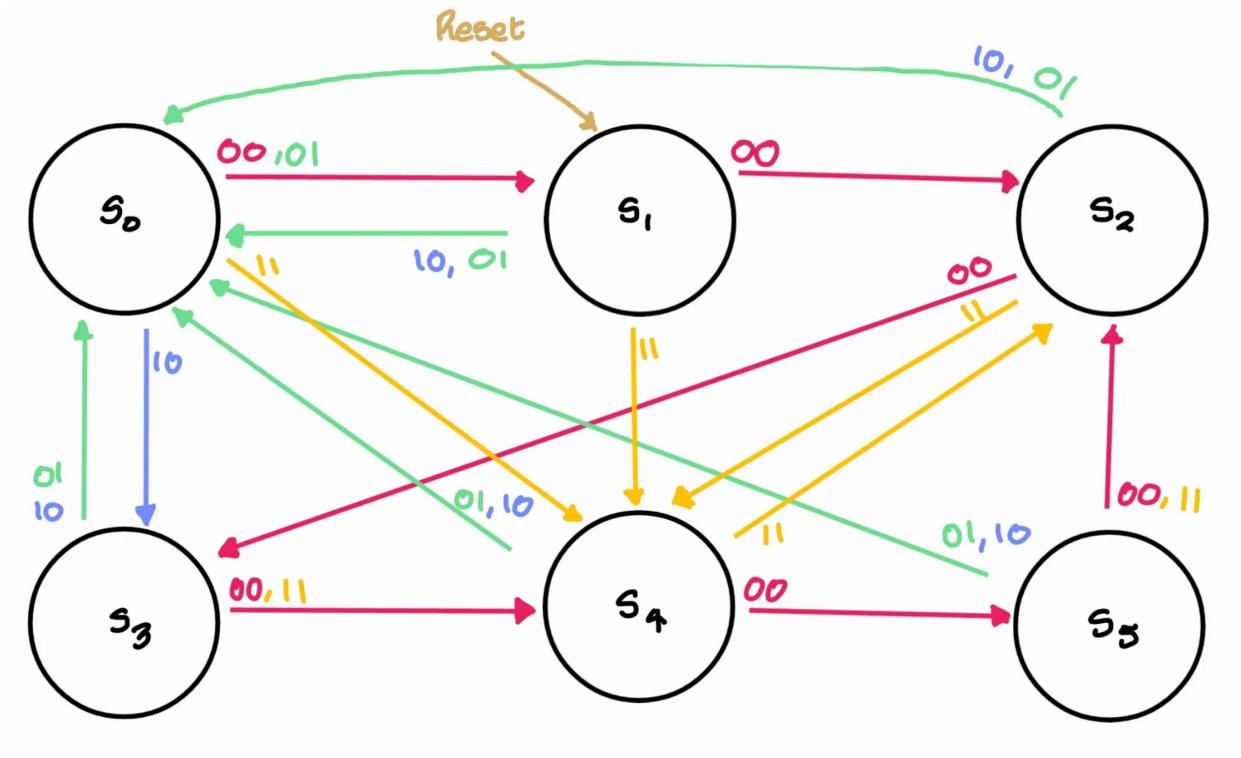
(3 pts) Create a state definition table here that describes in plain English what each state in your machine means and what binary values you have assigned to represent each state.

State	Name (Main St / Side Ave)	Definition	Binary
S0	No Light	The Main Street and Side Avenue had no lights, so the lights were turned off	000
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S2	Green and Red	Main Street had Green while Side Avenue had Red	010
S3	Yellow and Red	Main Street had Yellow while Side Avenue had Red	011
S4	Red and Green	Main Street had Red while Side Avenue had Green	100
S5	Red and Yellow	Main Street had Red while Side Avenue had Yellow	101

(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.)

State Transition Diagram

The circle is format in the following way: State and under it is the output.



State Transition Table

Q2	Q1	Q0	A	B	Q2+	Q1+	Q0+
0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	1
0	0	0	1	0	0	1	1
0	0	0	1	1	1	0	0
0	0	1	0	0	0	1	0
0	0	1	0	1	0	0	0
0	0	1	1	0	0	0	0
0	0	1	1	1	1	0	0
0	1	0	0	0	0	1	1
0	1	0	0	1	0	0	0
0	1	0	1	0	0	0	0
0	1	0	1	1	1	0	0
0	1	1	0	0	1	0	0
0	1	1	0	1	0	0	0
0	1	1	1	0	0	0	0
0	1	1	1	1	1	0	0
1	0	0	0	0	1	0	1
1	0	0	0	1	0	0	0
1	0	0	1	0	0	0	0
1	0	0	1	1	0	1	0
1	0	1	0	0	0	1	0
1	0	1	0	1	0	0	0
1	0	1	1	0	0	0	0
1	0	1	1	1	0	0	0
1	0	1	1	1	0	1	0

K-Maps (Circuit)

Q2 + 5-Variable K-Maps

$Q2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	0	1	0
01	0	0	0	0
11	1	1	1	1
10	0	0	0	0

$$\bar{Q}_2 AB + Q_1 Q_0 \bar{A} \bar{B} + Q_2 \bar{Q}_0 \bar{A} \bar{B}$$

$Q2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	x	x
01	0	0	x	x
11	0	0	x	x
10	0	0	x	x

Q1 + 5-Variable K-Maps

$Q2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	1	0	1
01	0	0	0	0
11	0	0	0	0
10	1	0	0	0

$$Q_1 AB + Q_1 Q_0 \bar{A} \bar{B} + \bar{Q}_1 Q_0 \bar{A} \bar{B}$$

$Q2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	0	1	x	1
01	0	0	x	x
11	1	1	x	x
10	0	0	x	x

$$+ \bar{Q}_2 \bar{Q}_1 \bar{Q}_0 \bar{A} \bar{B}$$

Q0 + 5-Variable K-Maps

$Q2 = 0$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	0	1
01	1	0	0	0
11	0	0	0	0
10	1	0	0	0

$$\bar{Q}_0 \bar{A} \bar{B} + \bar{Q}_2 \bar{Q}_1 \bar{Q}_0 \bar{A} \bar{B} + \bar{Q}_2 \bar{Q}_1 \bar{Q}_0 \bar{A} \bar{B}$$

$Q2 = 1$

$A_B \backslash Q_1 Q_0$	00	01	11	10
00	1	0	x	1
01	0	0	x	x
11	0	0	x	x
10	0	0	x	x

K-Maps(Traffic Signals)

MR

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	0	X	1
1	1	0	X	0

$$Q_2 + \bar{Q}_1 Q_0$$

MG

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	1	X	0
1	0	0	X	0

$$Q_1 \bar{Q}_0$$

SY

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	0	X	0
1	0	0	X	1

$$Q_2 \bar{Q}_1$$

MY

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	0	X	0
1	0	1	X	0

$$Q_1 Q_0$$

SR

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	1	X	0
1	1	1	X	0

$$\bar{Q}_2 Q_0 + \bar{Q}_2 Q_1$$

SG

$Q_2 Q_1$	00	01	11	10
Q_0	00	01	11	10
0	0	0	X	1
1	0	0	X	0

$$Q_2 \bar{Q}_0$$

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

$$Q_2+ = A B Q_2' + A' B' Q_2 Q_0' + A' B' Q_1 Q_0$$

$$Q_1+ = A B Q_2 + A' B' Q_1 Q_0' + A B' Q_2' Q_1' Q_0' + A' B' Q_2' Q_1' Q_0$$

$$Q_0+ = A' B' Q_0' + Q_2' Q_1' Q_0' B' + Q_2' Q_1' Q_0' A'$$

$$MR = Q_1' \cdot Q_0$$

$$MY = Q_1 \cdot Q_0$$

$$MG = Q_1 \cdot Q_0'$$

$$SR = Q_2' \cdot Q_0$$

$$SY = Q_2 \cdot Q_1'$$

$$SG = Q2 = Q0'$$

For this scenario, I would be using 3 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%):

<u>Criteria</u>	<u>Weight</u>
Safety	45%
Cost Effectiveness	15%
Customer Feedback	20%
Design Complexity	10%
Feasibility	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)?

Safety is a significant factor as we are trying to reduce the number of accidents and overall deaths from roads and having a more safety concerned traffic light will help us achieve this goal. We are trying to reduce costs but not too much that it would affect our main goal in having a traffic signal. We are trying to make the design as simple as possible to ensure that I will be using less states and it can be implemented easily.

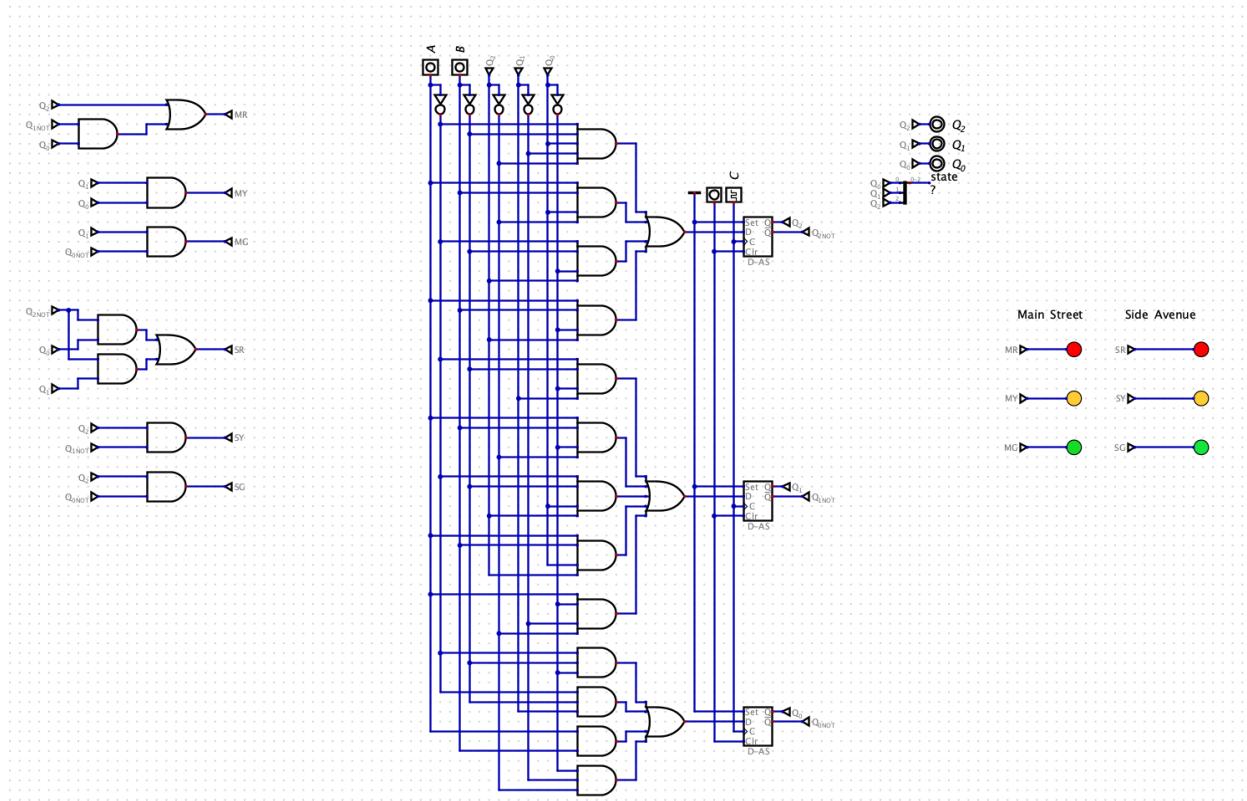
(3 pts) Which design is better based on your criteria and weighting system and why? Please explain how the winning design scored in each category and why (the winning design does not need to score the highest in every category, but it does need to score higher overall when applying the criteria weights).

Design 1 is better especially in the safety standard, though both designs have different purposes. Design 1 scored significantly higher in safety and customer feedback as I received the most feedback from Sai. In terms of Cost Effectiveness and Design Complexity, both designs very pretty close to each other and

only had a few differences. But at the end, idea 2 used less gates. Both were quite feasible and only people in the area needs to be aware of the new changes.

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.



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/LrUDM3Kxzjp2GqBjIEJPGSDy88LT6qL1mrjNlhv9KvwPgD6FtZLf-itt_ls26v.NtR0U0i_Qe4eJHRg?startTime=1746162704000

Passcode: B^U7@B8C

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)	
Lab Score	Points Lost	
	Late Lab	
	Lab Score	