Jeide, Matthew Date 11/13/2024 Period 2

W15/16 DE [PROJECT] 2.1.6 Majority Vote (AOI Logic Design)

Read the introduction in each section carefully.

INTRODUCTION

The ability to cast your vote and to have your choice accurately counted is important whether it is for an election at your school or for community leadership. Depending on the needs of the voting system, voters use paper ballots or electronic voting systems to cast their votes.

In this project, you create an electronic voting machine using only AND, OR, and Inverter logic gates (AOI logic). You will design using circuit design software (CDS), simulate, and build a Majority Vote voting machine that meets the specifications in the design brief.

EQUIPMENT

- Computer with circuit design software
- Breadboarding Hardware *or* Digital MiniSystem
- Integrated Circuits (74LS08, 74LS32)
- 22-gauge solid wire
- Multipurpose Wire Stripper

Boolean Theorems

1) $X \cdot 0 = 0$
2) $X \cdot 1 = X$
3) $X \cdot X = X$
4) $X \cdot \overline{X} = 0$
5) $X + 0 = X$
6) $X + 1 = 1$
7) $X + X = X$
8) $X + \overline{X} = 1$
9) $\overline{\overline{X}} = X$

Commutative Laws

10) $X \cdot Y = Y \cdot X$
11) $X + Y = Y + X$

Associative Laws

12) $X(YZ) = (XY)Z$
13) $X + (Y + Z) = (X + Y) + Z$

Distributive Laws

14) $X(Y + Z) = XY + XZ$
15) $(X + Y)(W + Z) = XW + XZ + YW + YZ$

Consensus Theorems

16) $X + \overline{X}Y = X + Y$
17) $X + \overline{X}\overline{Y} = X + \overline{Y}$
18) $\overline{X} + XY = \overline{X} + Y$
19) $\overline{X} + X\overline{Y} = \overline{X} + \overline{Y}$

DeMorgan's Theorems

20) $\overline{XY} = \overline{X} + \overline{Y}$
21) $\overline{X + Y} = \overline{X} \cdot \overline{Y}$

Procedure

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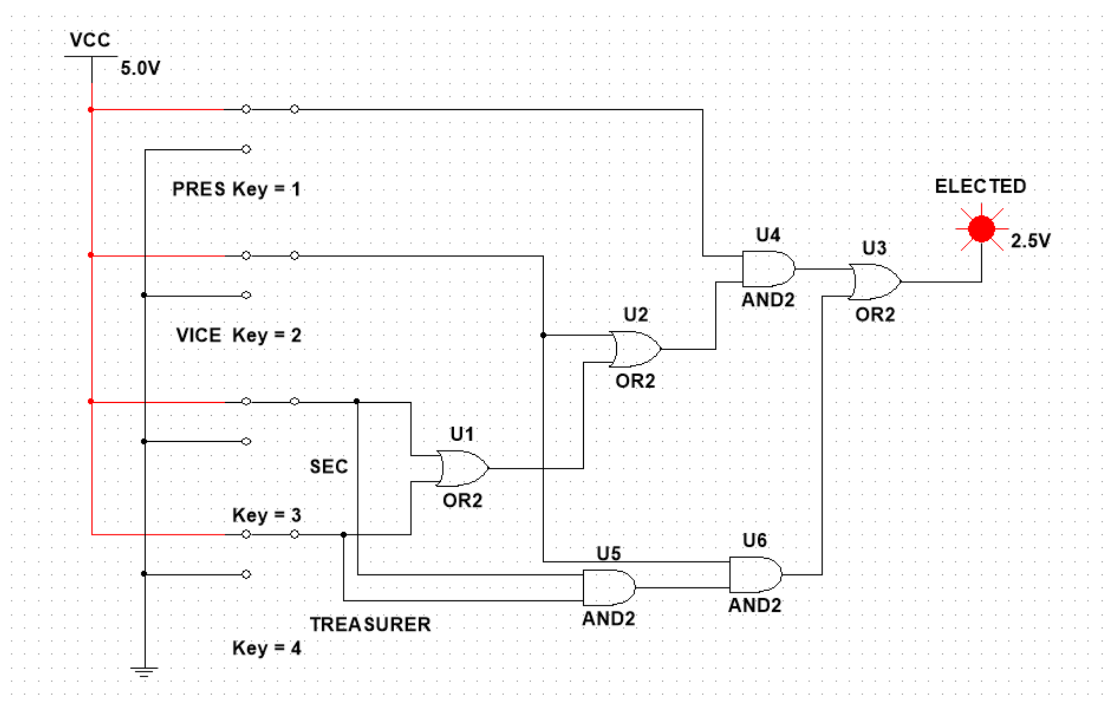
Design Brief	
Consumer	Boeing https://www.boeing.com/
Problem Statement	The board of directors at Boeing has four members: • President • Vice-president • Secretary • Treasurer Each member has a single Yes/No vote. For a candidate to be chosen, a majority of the board members must vote Yes. In the event of a tie, the president's vote is used to break the tie. (if the president votes Yes, the decision passes. If the president votes No, the decision fails.)
Design Statement	Must explain what you will make and attach the Multisim completed design. Must attach a Multisim screenshot. This section must only be completed once you are fully done designing your Voting Machine. 

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Criteria	Each member of the board of directors gets a yes or no vote on potential candidates to be chosen, if a majority of the board votes yes, the candidate is elected. In the event of a tie, the president's vote is used to break it.
Constraints	In the event of a tie, the president's vote will be used to determine the outcome.
Materials/ Equipment:	• Computer with circuit design software • Breadboarding Hardware *or* Digital MiniSystem • Integrated Circuits (74LS08, 74LS32) • 22-gauge solid wire • Multipurpose Wire Stripper

Brainstorming

Throughout this lesson, you learned skills that will help you design and build a Majority Vote voting machine. Stop and reflect on how you might use what you've learned. Use the prompts below to **plan** for the task at hand.

- What have I learned that will help me build a voting machine?
- What resources do I need to complete this project?
- Do I understand all aspects of the project? If not, who can I ask for help?
- What do I need to do first?

Definition of Variables

Use the table below to assign the values for the table that best represents the objective.

Variable Name	Assignment Condition for 0	Assignment Condition for 1
President	**The President voted no.**	**The President voted yes.**

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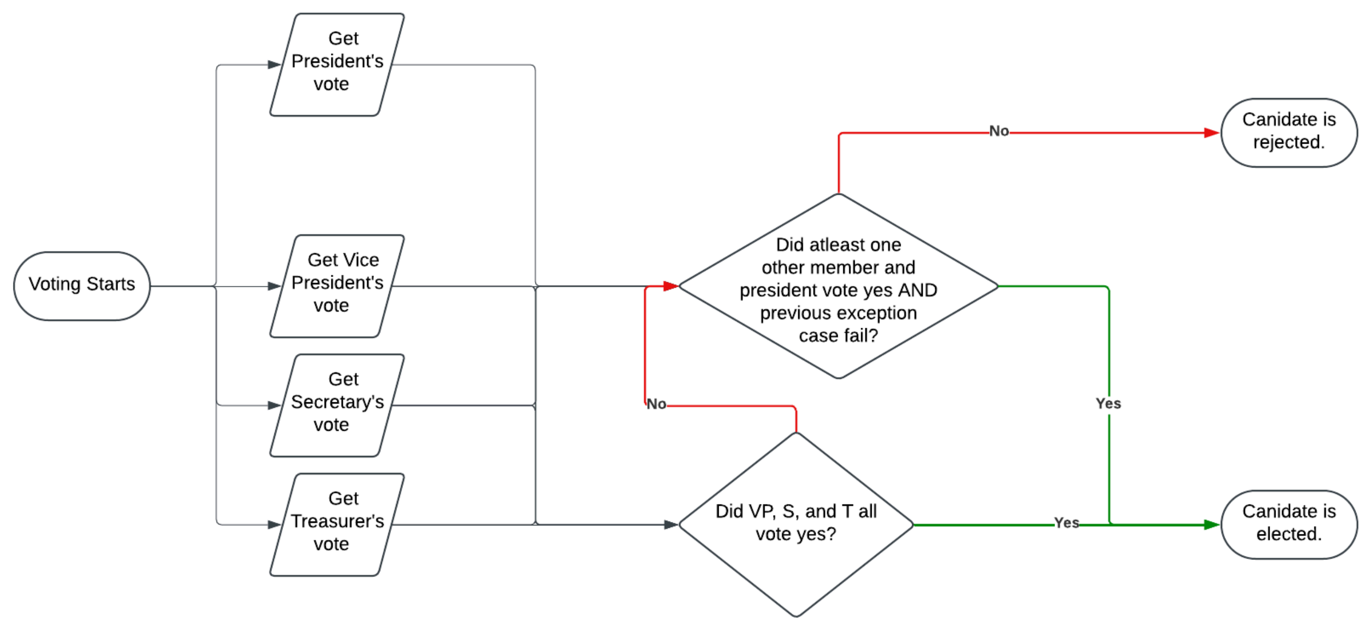
Vice President	**The Vice President voted no.**	**The Vice President voted yes.**
Secretary	**The Secretary voted no.**	**The Secretary voted yes.**
Treasurer	**The Treasurer voted no.**	**The Treasurer voted yes.**
Decision	**The candidate is rejected.**	**The candidate is accepted.**

Flowcharting

LucidChart-Flowchart Brainstorm



Truth Table

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Create a truth table using all variables

President Vote	Vice President Vote	Secretary vote	Treasurer Vote	Candidate elected?
0	0	0	0	**0**
0	0	0	1	**0**
0	0	1	0	**0**
0	0	1	1	**0**
0	1	0	0	**0**
0	1	0	1	**0**
0	1	1	0	**0**
0	1	1	1	**1**
1	0	0	0	**0**
1	0	0	1	**1**
1	0	1	0	**1**
1	0	1	1	**1**
1	1	0	0	**1**
1	1	0	1	**1**
1	1	1	0	**1**
1	1	1	1	**1**

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Boolean Algebra

Create a Boolean Algebra statement using all variables

√	1	1	1	0	$PVS\bar{T}$ ✓
√	1	1	1	1	$PVST$ ✓

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Th. 16 $x+\bar{x}y=x+y$

$F_1 = \bar{P}VST + P\bar{V}\bar{S}T + P\bar{V}S\bar{T} + P\bar{V}ST + PV\bar{S}\bar{T} + PV\bar{S}T + PVS\bar{T} + PVST$

$F_1 = \bar{P}VST + P(\bar{V}\bar{S}T + \bar{V}S\bar{T} + \bar{V}ST + V\bar{S}\bar{T} + V\bar{S}T + VS\bar{T} + VST)$

$F_1 = \bar{P}VST + P(\bar{V}(\bar{S}T + S\bar{T} + ST) + V(\bar{S}\bar{T} + \bar{S}T + S\bar{T} + ST))$

$F_1 = \bar{P}VST + P(\bar{V}(\bar{S}T + S(\underbrace{\cancel{\bar{T}+T}}_{1})) + V(\bar{S}(\underbrace{\cancel{\bar{T}+T}}_{1}) + S(\underbrace{\cancel{\bar{T}+T}}_{1})))$

$F_1 = \bar{P}VST + P(\bar{V}(\underbrace{S+\bar{S}T}_{S+T \text{ Th.16}}) + V(\underbrace{\cancel{\bar{S}+S}}_{1}))$

$F_1 = \bar{P}VST + P(\bar{V}(S+T) + V)$

$F_1 = \bar{P}VST + P(\underbrace{V + \bar{V}(S+T)}_{\text{Th. 16 } V+(S+T)})$

$F_1 = \bar{P}VST + P(V+S+T)$

$F_2 = \bar{P}VST + PV + PS + PT$

~~$F_2 = V + \bar{P}V$~~

$F_2 = V(\bar{P}(ST) + P) + PS + PT$

$F_2 = V(P + (ST)) + PS + PT$

$F_2 = VP + VST + PS + PT$

$F_2 = VST + P(V+S+T)$

As you work to build your voting machine, periodically stop to **monitor** your learning. Ask yourself whether the strategies you chose are working. If something isn't working, change your plan.

For more information about metacognition and how to apply the metacognitive regulation cycle to improve your learning, review Metacognition(see attached PDF).

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Instructions

Follow the following steps to guide you through the process:

1. Translate the project introduction into a design brief using the downloadable file as a guide. Follow your teacher's direction to complete the design brief in the file. Complete the design brief attached and use the information provided as a guide.
2. Using the following variable names and assignment conditions, create a truth table as shown for your Majority Vote – Voting Machine.

Variable Name	Assignment Condition for 0	Assignment Condition for 1
P (President)	No	Yes
V (Vice President)	No	Yes
S (Secretary)	No	Yes
T (Treasurer)	No	Yes
Decision	Fail	Pass

3. Using the truth table, write the *unsimplified* logic expression for the output function Decision. Be sure that your answer is in the Sum-of-Products form.
4. Design an AOI logic circuit that implements the unsimplified logic expression Decision. Limit your implementation to 2-input AND gates (74LS08), 2-input OR gates (74LS32), and inverters (74LS04).
5. Using the CDS, enter and test your *unsimplified* Majority Vote – Voting Machine. Use switches for the inputs *P, V, S,* and *T* and a probe or LED circuit for the output Decision. Verify that the circuit is working as expected. Print a copy of the final circuit and paste it in your engineering notebook.
6. Using the theorems and laws of Boolean algebra, simplify the logic expression Decision. Be sure to put your answer in Sum-of-Products (SOP) form.
7. Design an AOI logic circuit that implements the *simplified* logic expression Decision. Limit your implementation to 2-input AND gates (74LS08), 2-input OR gates (74LS32), and inverters (74LS04).

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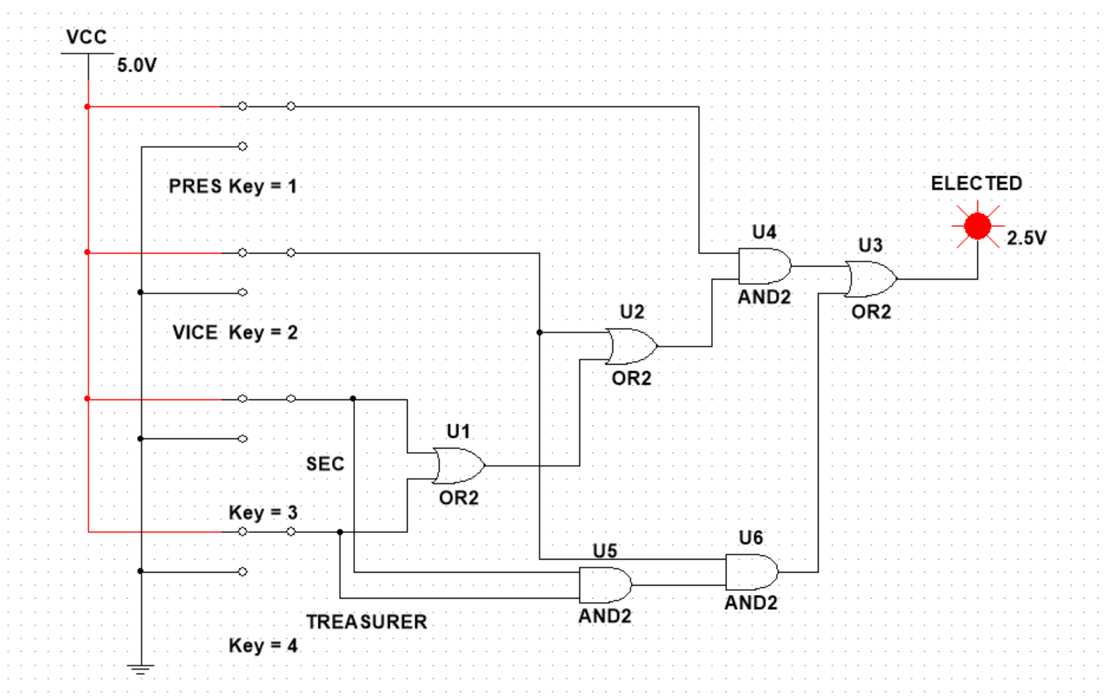
8. Using the CDS, enter and test your *simplified* Majority Vote – Voting Machine. Use switches for the inputs *P, V, S,* and *T* and a probe or LED circuit for the output Decision. Verify that the circuit is working as expected. Print a copy of the final circuit and paste it in your engineering notebook.
9. Using the Digital MiniSystem, build and test the *simplified* Majority Vote – Voting Machine logic circuit that you designed and simulated. Verify that the circuit is working as expected and that the results match the results of the simulation.

Sketch of Circuit Design (simplified or not simplified)
Sketch.pdf

Multisim Circuit (Screenshot and Video)



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Circuit Designed Physically (Screenshot and Video)
Presentation of Majority Voting System.MOV

E-Portfolio link with Project Updates
https://sites.google.com/riversideunified.org/matthewjeide/projects/de-2024-2025/majority-vote-system

Conclusion

1. For this project, write a conclusion (minimum 500 words) that describes the process you used to design, simulate, and build your Majority Vote Machine in the form of a letter to someone who has no previous knowledge of digital electronics.

Conclusion

DEar Person who does not know Digital Electronics,

Embarking on the journey to design, simulate, and build a Majority Vote Machine was an enlightening experience that showcased the principles of digital electronics in action. This project provided a hands-on understanding of AOI (AND, OR, Inverter) logic and its application in solving real-world problems, such as voting systems.

Designing the Machine

The first step was to conceptualize the problem and translate it into a digital logic design. In this case, the task was to create a voting system for a board of directors comprising a President, Vice President, Secretary, and Treasurer. Each member had a single vote, and the majority decision determined the outcome. The President's vote served as a tiebreaker in case of a deadlock. With this framework, I identified the variables (P, V, S, T) and established their respective outputs based on majority voting criteria. The assignment conditions for these variables were binary, representing "Yes" as 1 and "No" as 0.

Using this structure, I developed a truth table that detailed every possible voting combination. This table was the foundation for creating a Boolean algebra statement in the Sum-of-Products

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(SOP) form. This expression was a comprehensive representation of the decision-making process, ensuring all scenarios were covered.

Simulation and Testing

Next, I entered the Boolean equation into a circuit design software (Multisim). Using the logic gates available—2-input AND gates (74LS08), OR gates (74LS32), and inverters (74LS04)—I constructed an unsimplified version of the circuit. Testing this design involved toggling switches representing each director's vote and observing the output through LEDs. This phase was crucial for verifying the logical integrity of the design.

Following the initial testing, I used Boolean algebra laws to simplify the equation. The simplified design reduced the number of components needed, making the circuit more efficient. I recreated this circuit in Multisim and repeated the simulation process, ensuring the output matched the expected results from the truth table.

Physical Implementation

The final stage was to physically build the voting machine on a breadboard using the components specified. Working with 22-gauge solid wire, integrated circuits, and a multipurpose wire stripper, I meticulously assembled the circuit. The hands-on construction demanded attention to detail, as incorrect wiring could lead to faulty outputs. After completing the setup, I tested the circuit by mimicking real-world voting scenarios, confirming its reliability and accuracy.

Reflection

Throughout the project, I learned the importance of systematic problem-solving and iterative testing. Each step—designing, simulating, simplifying, and building—was a layer of learning that deepened my understanding of digital logic. By translating theoretical knowledge into a functional device, I gained invaluable experience in both software simulation and hardware implementation.

This project not only enhanced my technical skills but also highlighted the relevance of digital electronics in everyday applications. From voting machines to decision-making systems, the concepts explored here form the backbone of numerous technologies we rely on.

Sincerely,

Matthew Jeide