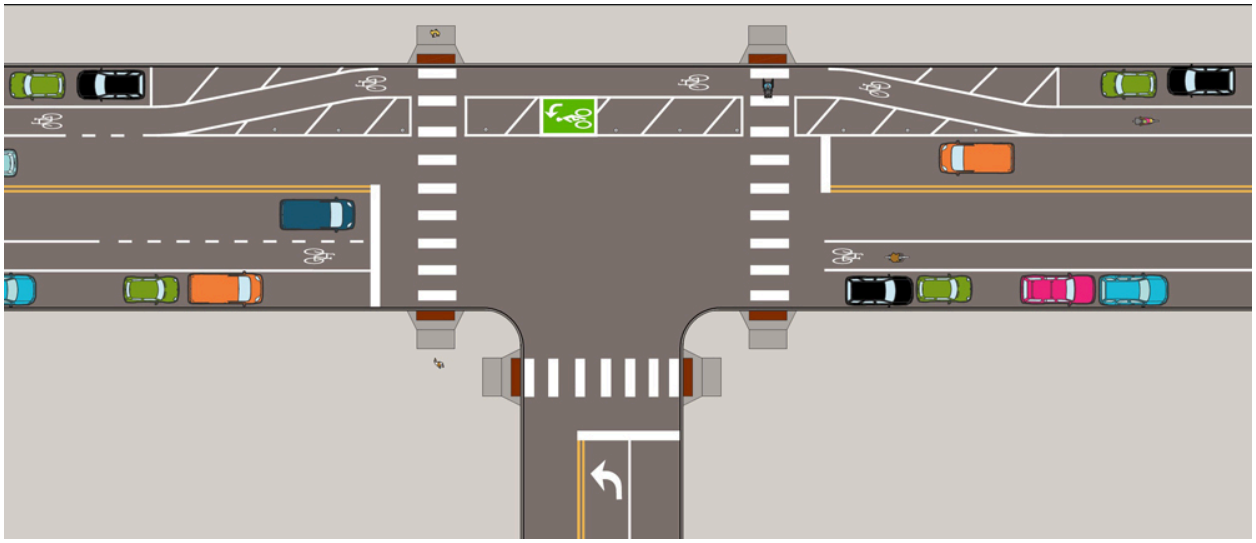
P1.2.6 - SAFE-T 🚦



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Project Manager: Adrian Lai

Mrs.Chou - Period 6

October 17, 2025 - October 31, 2025

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Team Norms and Consequences

Respectful Communication: Everyone listens actively, speaks kindly, and values each other's input.
Consequence: 1st: Apology and reflection discussion.
2nd: Temporary removal from group decisions.
3rd: Teacher mediation or individual work assignment.

Punctuality: Meetings and deadlines are respected—show up on time and be prepared.
Consequence: 1st: Reminder from project manager.
2nd: Required to stay after class to finish or help another teammate.
3rd: Meeting with the teacher.

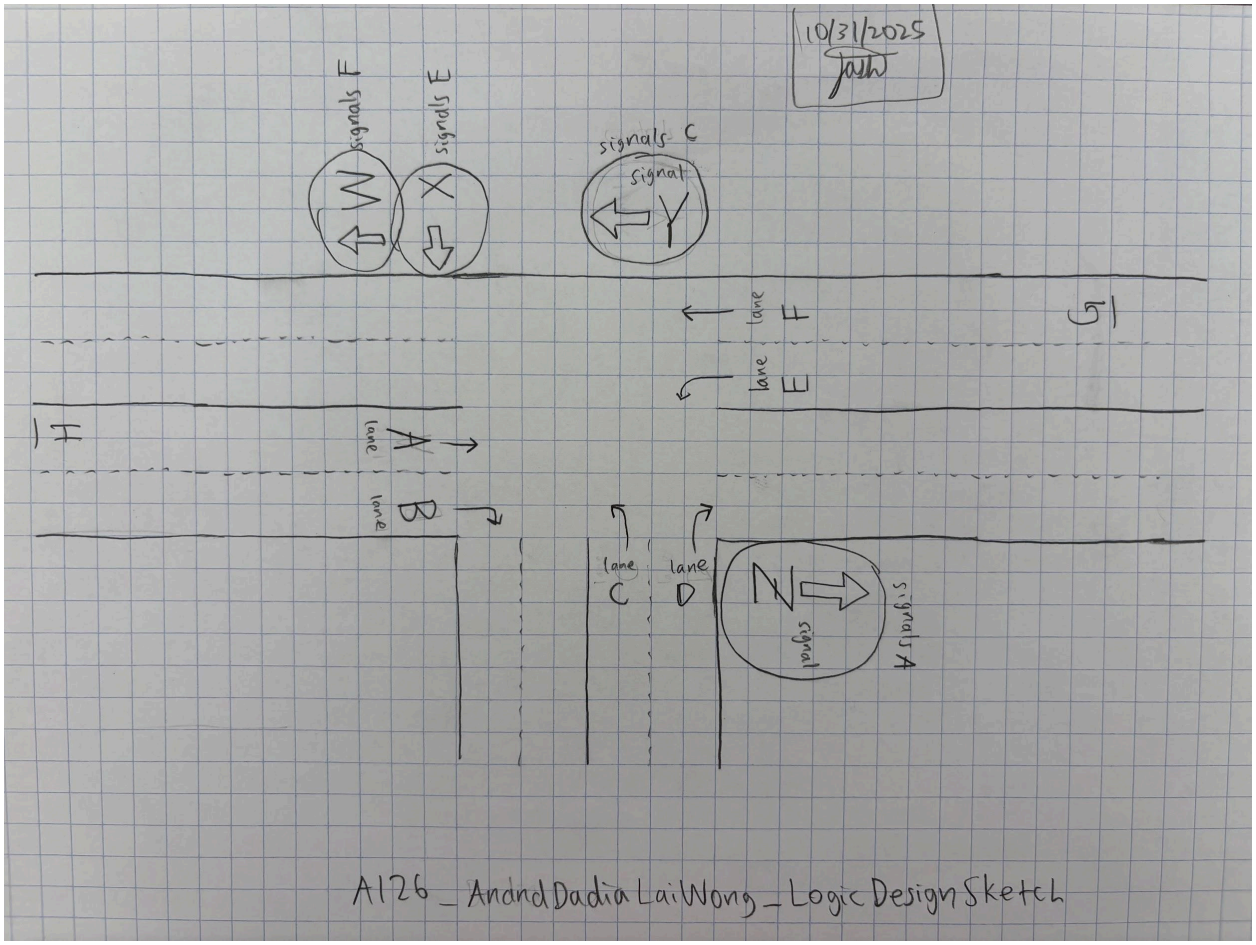
Accountability: Team members own their tasks and deliver on commitments.
Consequence: 1st: Reminder to take on tasks.
2nd: Team lead assigns specific measurable responsibility.
3rd: Notify the teacher, negative impact on grades.

Collaboration First: Work together, share knowledge, and help teammates when needed.
Consequence: 1st: Reminder to update team members on activities.
2nd: Required to post updates in group log daily.
3rd: Report to teacher for lack of communication.

Brainstorming

- 7 inputs (different lanes & turns), 4 outputs
- The lanes had to interact with each other somehow so incorporate turning lanes
- Different lights control which lanes can go straight and which can turn

Diagram:


10/31/2025
signals F
signals E
signals C
signal
W
X
Y
lane F
G
lane E
H
lane A
lane B
lane C
lane D
N
signal
signals A
A126_AnandDadiaLaiWong_LogicDesignSketch

Design Brief

Project Title: SAFE-T (Smart AOI Flow Engine for Traffic)

Background & Context:
We have a busy T-intersection with no lights connecting the most important roads in the city. It has three approaches, with each having two lanes which are each labeled by variables. Congestion and odd arrival patterns seem to cause long waits and occasional car accidents. The city commissioned us to create traffic lights which would control the intersection. They require a logic-controlled signal system which gives certain lanes time on a green light based on sensors tracking which lanes are occupied and when they got there, using the most simple system possible.

Objective:
To design and develop a traffic light control system for a T-intersection which has two lanes per approach which uses sensors and manual inputs to determine which lights are allowed to be green. The system will detect when cars are at the intersection and which lanes they are in, prioritizing the cars that arrived first, and automatically change lights depending on the situation. Right turning vehicles are not included, as they are a redundant variable due to being able to easily decide when it is safe to proceed or not.

Target Audience: Urban cities

Constraints:
- Classroom breadboards
- Design and implementation in 2 weeks
- Comply with basic traffic safety conventions

Design Specifications

Inputs

- A - Straight Lane 1
- B - Right Turn 1
- C - Center Left Turn
- D - Center Right Turn
- E - Right Turn 2
- F - Straight Lane 2
- G - Lane A deny right-of-way
- H - Lane F deny right-of-way

Outputs

- W - Light Signal 1 (Kevin)
- X - Light Signal 2 (Jash)
- Y - Light Signal 3 (Adrien)
- Z - Light Signal 4 (Aiden)

Output Logic Expression & Simplification + TT

Kevin's Part

C (Center Left Turn)	F (Straight Lane 2)	G (Lane A Deny Right-Of-Way)	W (Light Signal 1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

1 = Light Signal On
0 = Light Signal Off

Simplification	Simplification Laws Used
~CF~G + ~CFG + CF~G	Unsimplified Equation
~CF(~G + G) + CF~G	Distributive Law
~CF1 + CF ~G	Complacent Law
~CF + CF ~G	Identity Law
~CF(~G + G) + CF~G	Distributive Law
F(~G + ~C)	Absorption Law
F~G + F~C	Distributive Law

Simplified Equation (SOP): F~G + F~C
Unsimplified Equation: F~G + F~C

Jash's Truth Table

A (Straight Lane 1)	C (Center Left Turn)	E (Right Turn 2)	H (Lane F Deny Right-Of-Way)	X (Traffic Signal 2)
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	0
1	1	0	0	0
1	1	1	0	0
0	0	0	1	0
0	0	1	1	1
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	1

SOP Method (Jash)

~H~AE(~C + C) + H~A~CE + H~ACE + HA~CE + HACE ***Unsimplified Equation***

~~HAE1 + H~~~A~CE + H~ACE + HA~CE + HACE Complement Law

~H ~AE + H ~A ~CE + HA ~CE + HACE Identity Law

~AE (H~C + ~H) + H~ACE + HA~CE +N HACE Distributive Law

~AE (~C + ~H) + H ~ACE + HA ~CE + HACE Absorption Law

~AE(~C + ~H) + HCE(~A + A) + HA ~CE Distributive Law

~~AE (~~C + ~H) + HCE1 + HA ~CE Complement Law

~AE (~C + ~H) + HCE + HA ~CE Identity Law

~~AE (~~C + ~H) + HE (A ~C + C) Distributive Law

~AE (~C + ~H) + HE(A + C) Absorption Law

~AE ~C + ~AE ~H + HE(A + C) Distribution

~AE ~C + ~AE ~H + HEA + HEC Distribution

~AE~C + ~AE~H + HEA + HEC ***Simplified Equation***

Adrien Truth Table

A (Straight Lane 1)	C (Center Left Turn)	F (Straight Lane 2)	G (Lane A Deny Right-Of-Way)	H (Lane F Deny Right-Of-Way)	Y (Traffic Signal 3)
0	0	0	0	0	0
0	0	0	0	1	0
0	0	0	1	0	0
0	0	0	1	1	0
0	0	1	0	0	0
0	0	1	0	1	0
0	0	1	1	0	0
0	0	1	1	1	0
0	1	0	0	0	1
0	1	0	0	1	1
0	1	0	1	0	1
0	1	0	1	1	1
0	1	1	0	0	0
0	1	1	0	1	0
0	1	1	1	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	0	0	0	1	0
1	0	0	1	0	0
1	0	0	1	1	0
1	0	1	0	0	0
1	0	1	0	1	0
1	0	1	1	0	0
1	0	1	1	1	0
1	1	0	0	0	0
1	1	0	0	1	1
1	1	0	1	0	0
1	1	0	1	1	1
1	1	1	0	0	0
1	1	1	0	1	0

1	1	1	1	0	0

SOP Method (Adrien)

Full equation:

~AC~F~G~H+~AC~F~GH+~A+C~FG~H+~AC~FGH+~ACFG!H+~ACFGH+AC~F~GH+AC~FGH

Unsimplified equation:

~AC~F~G(~H+H)+~AC~FG~H+~AC~FGH+~ACFG~H+~ACFGH+AC~F~GH+AC~FGH(Disturibuative law)
~AC~F~G+~AC~FG~H+~AC~FGH+~ACFG~H+~ACFGH+AC~F~GH+AC~FGH(Complement Law)
~AC~F(G~H+~G)+~AC~FGH+~ACFG~H+~ACFGH+AC~F~GH+AC~FGH(DIstributive Law)
~AC~F(~H+~G)+~AC~FGH+~ACFG~H+~ACFGH+AC~F~GH+AC~FGH(Consensus theorem)
~AC~F(~H+~G)+~ACGH(~F+F)+~ACFG~H+AC~F~GH+AC~FGH(Distribuitive law)
~AC~F(~H+~G)+~ACGH+~ACFG~H+AC~F~GH+AC~FGH(Complement Law)
~AC~F(~H+~G)+~ACG(F~H+H)+AC~F~GH+AC~FGH(Distribuitive law)
~AC~F(~H+~G)+~ACG(F+H)+AC~F~GH+AC~FGH(Consensus theorem)
~AC~F(~H+~G)+~ACG(F+H)+AC~FH(~G+G)(Distribuitive law)
~AC~F(~H+~G)+~ACG(F+H)+AC~FH(Complement Law)
~AC~F~H+~AC~F~G+~ACGF+~ACGH+AC~FH(Distirbute)

SOP Method (Aiden)

Full equation: A~C~E~H + A~C~EH + A~CE~H + AC~E~H + ACE~H

A (Straight Lane 1)	C (Center Left Turn)	E (Right Turn 2)	H(~A) (Lane F Deny Right-Of-Lane)	Z (Traffic Signal 4)
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	0
1	0	0	0	1
1	0	0	1	1

Unsimplified equation:

A~C~E(~H+H) + A~CE~H + AC~E~H + ACE~H Distributive Law
A~C~E + A~CE~H + AC~E~H + ACE~H Identity Law
A~C(E~H+~E) + AC~E~H + ACE~H Distributive Law
A~C(~H+~E) + AC~E~H + ACE~H DeMorgan's Thm
A~C(~H+~E) + AC~H(~E+E) Distributive Law
A~C(~H+~E) + AC~H Identity Law
A~C~H + A~C~E + AC~H Distribution
A~H(~C + C) + A~C~E Distributive Law
A~H1 + A~C~E Complement Law
A~H + A~C~E ***Simplified equation***

Key:

A - There is a car in Lane A
C - There is a car in Lane C
E - There is a car in Lane E
H - Lane A cars do not have the right of way
Z(output) - Light Z turns on

Final Solution Description

Performance:
The final simulation successfully displays all intended outputs, and follows the truth tables. Each subsystem from all of the team members was integrated into one final Multisim, proving that the circuit worked as designed through the LEDs. Due to complications of not being able to have a final connected breadboard at the time of writing this, we cannot say for sure that it will work, however, finished individual breadboards performed perfectly fine.

Real-World Implementation:
Although the project was only demonstrated using simple Integrated Circuits and LEDs, the same AOI logic could be expanded to larger-scale systems like smart traffic control. In a real-world version, the switches would be replaced by sensors or clocks to control when the right of way for cars are given, and the LED indicators would be replaced by a red, yellow, green light. Of course, this is a more simplified version, but a real world traffic light would also have the yellow light function which would require some sort of timing with the other lights in order to not let cars crash into each other or give late signals. Our design shows how AOI logic can make decisions automatically, given the conditions of the intersection.

Challenges and Troubleshooting:
Throughout the project, there were many struggles like not knowing how to split up the large truth tables into different outputs. At first, some outputs behaved incorrectly due to the inputs being connected to the wrong gates, causing faulty logic. Aiden's breadboard ICs were not plugged in, causing the false impression that it didn't work, but was found by Jash. Furthermore, organizing the wiring was very difficult, but circuits were remade using color-coded wiring in order to organize the wires to be easy to see, however, limited wire selection made it hard to do this.

Cost analysis:

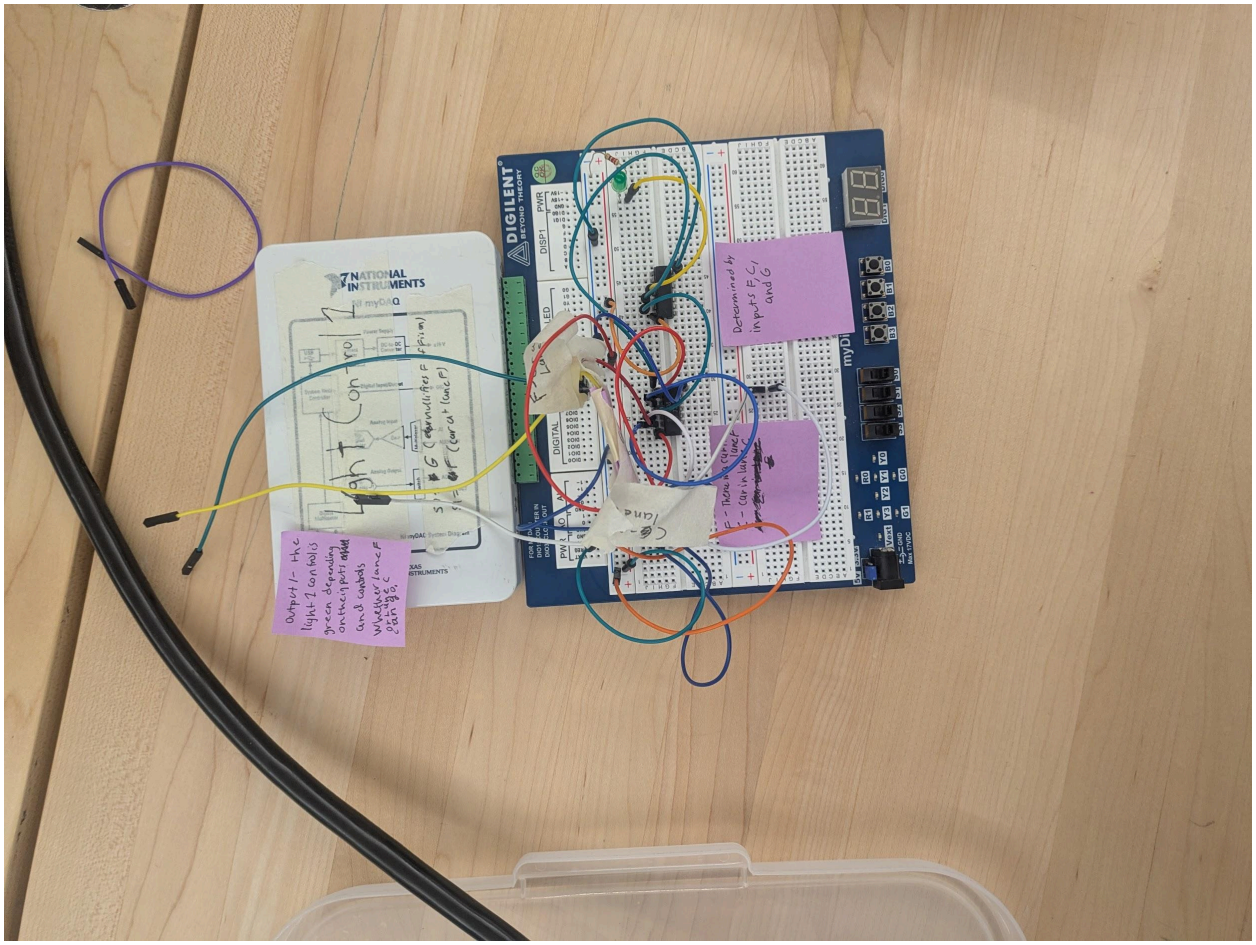
Final Cost: $70k-120k Initial Cost + $2.5k-5.5k/year in maintenance

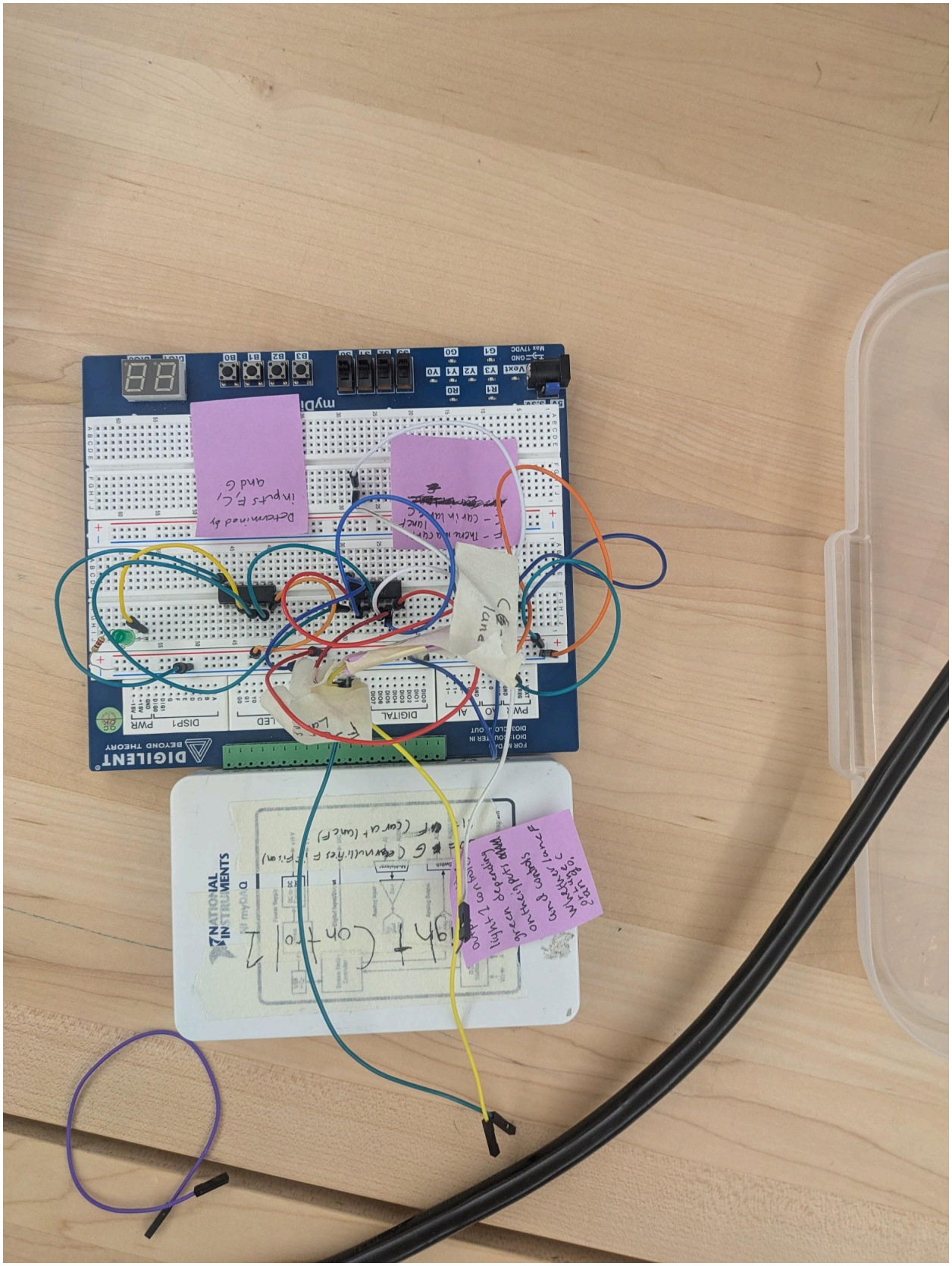
- IInitial Implementation Costs ($70k-120k)
    - Hardware ($53k-67k) including poles, signal heads, vehicle detections, pedestrian signals, controller, communication equipment, etc.

    - Installation ($16.5k-30k) (excavation, wiring, pole setup, road markings, temporary traffic control)
    - Software/Programming ($2k-19k) - signal timing, optional adaptive traffic management
- Recurring/Annual Costs
    - Maintenance of signals & detectors ($1.5k-3k)
    - Electricity for 24/7 operation ($500-1k)
    - Controller/software updates ($500-1.5k)

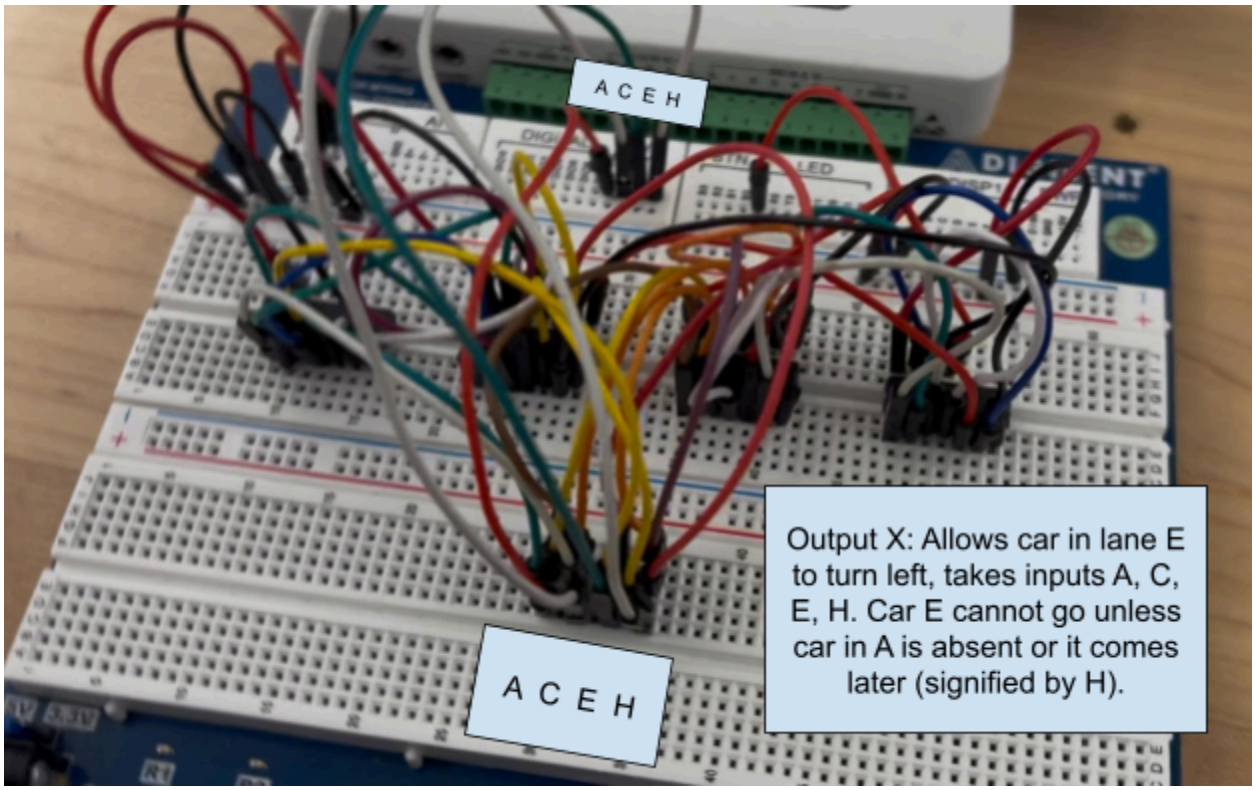
Final Breadboarded Circuit

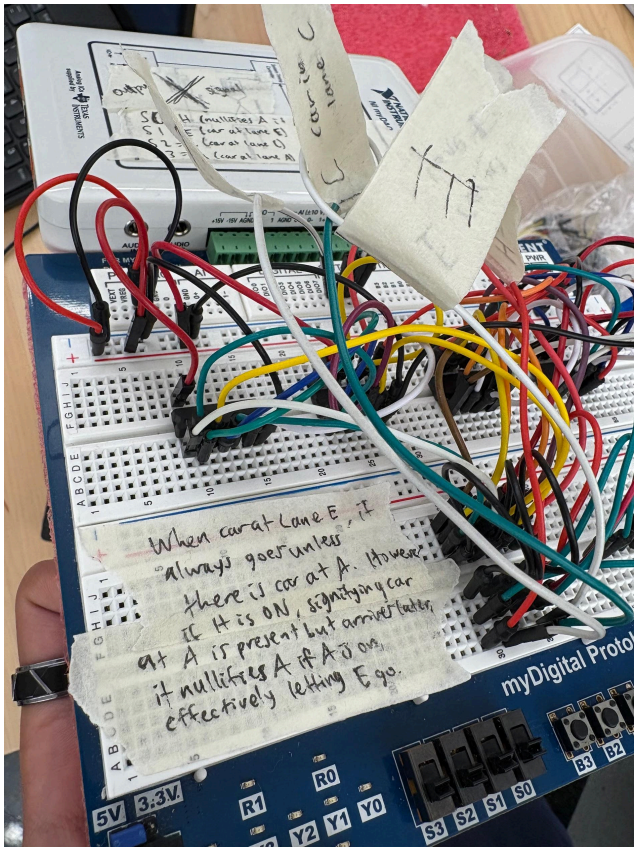
Kevin's Part

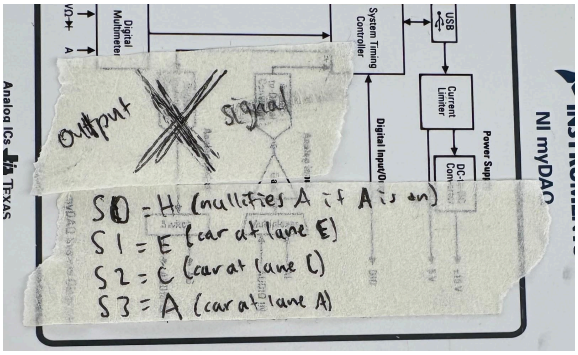



Determined by
inputs E, C,
and G
DIGILENT
BEYOND THEORY
NATIONAL
INSTRUMENTS

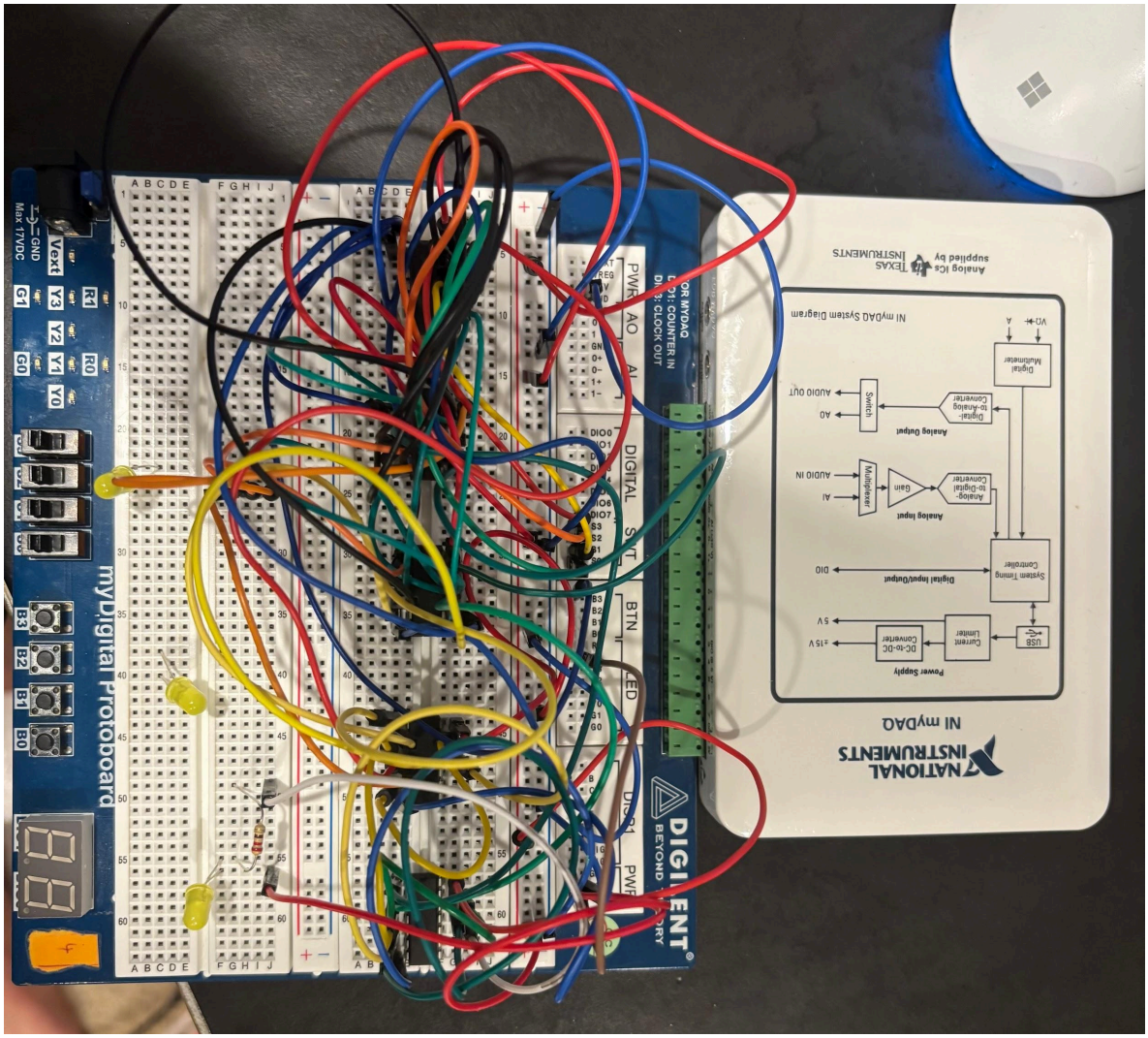
Jash's Part


A C E H
A C E H
Output X: Allows car in lane E to turn left, takes inputs A, C, E, H. Car E cannot go unless car in A is absent or it comes later (signified by H).

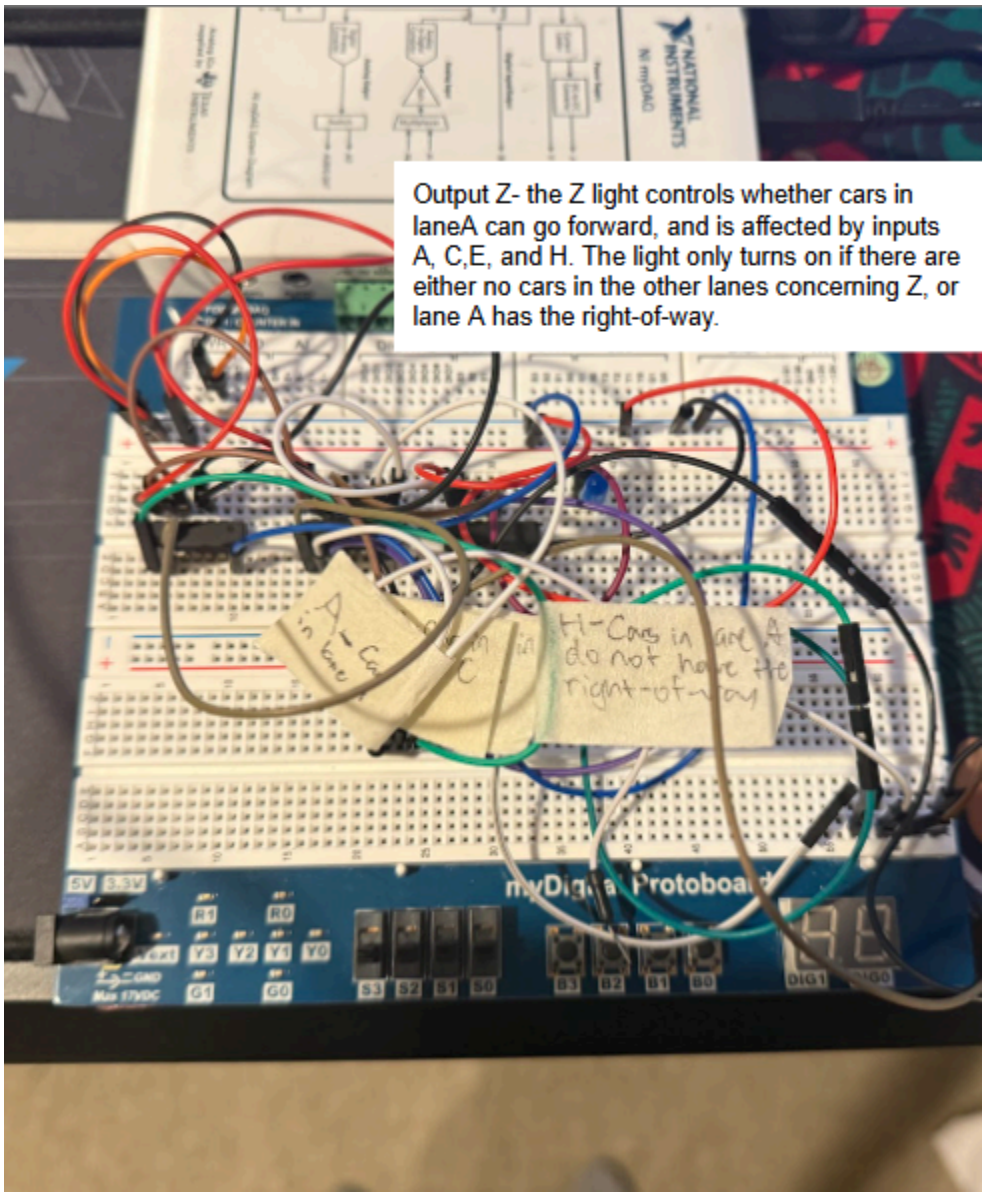

When car at Lane E, it always goes unless there is car at A. However, if H is ON, signifying car at A is present but arrived later, it nullifies A if A is on, effectively letting E go.
myDigital Proto
5V
3.3V
R1
R0
Y2
Y1
Y0
S3
S2
S1
S0
B3
B2


Output
Signal
S0 = H (nullifies A if A is on)
S1 = E (car at lane E)
S2 = C (car at lane C)
S3 = A (car at lane A)
Digital Multimeter
System Timing Controller
USB
Current Limiter
Digital Input/Output
Analog I/Os
TEXAS
NI myDAQ

Adrien's Part



Aiden's Part


Output Z- the Z light controls whether cars in laneA can go forward, and is affected by inputs A, C,E, and H. The light only turns on if there are either no cars in the other lanes concerning Z, or lane A has the right-of-way.

Final Simulation