Sumo Robot Design Document

Terreon Brewster
Ged Miller

Components

Resistors Ω	Type	Quantity
	670	11
	1k	3
	2.2k	2
	10k Potentiometer	2
	50k Potentiometer	1
Capacitors (Farad)		
	0.1u	4
	22u	2
	1000u	2
	2200u	4
MOSFETS		
	ZVP 3306	5
	2N7000	11
	IRF9520	6
	IRF9530	2
Integrated Chips		
	NE555P	2
	LM293P	1
Diodes		
	LED's	9
	IR LED	1
	Phototransistor	1
	N52309	2

Introduction

This document will explain the designing process, functions and results of the sumo robot that was used for competition. There were three phases that needed to be completed to ensure that the sumo robot was functioning as intended. Each phase required the robot to execute a specific function automatically without any human input after the robot is set in the ring. This document will also explain the issues we faced in each phase before getting to the final design product.

The expected outcome for the sumo robot was to be able to detect a beacon and, once the beacon was detected, navigate to the beacon to knock the other competitors out of the ring. This outcome could be achieved through various designs, but this robot mainly utilized CMOS logic for the final product.

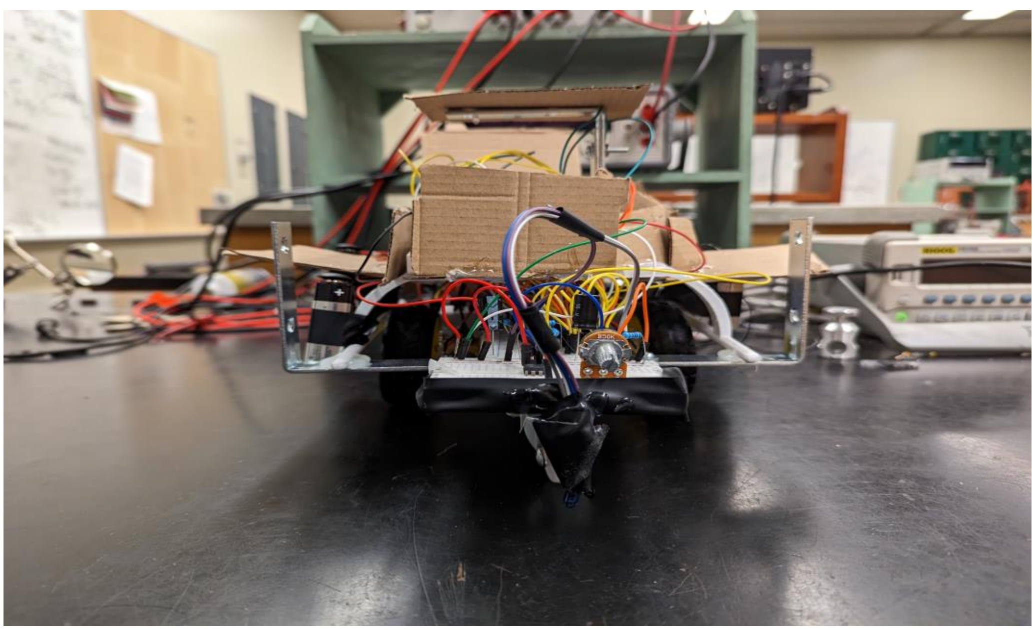

Figure 1.) Front view of the sumo robot.

Phase 1

For the first phase of the competition, the goal was to get the robot to move forward. During this phase, our robot consisted of a 555 PWM circuit powered by a 9-volt battery. This circuit would give power to both motors, enabling the robot to move forward when a Cds cell detected light. This circuit worked as intended, however the motors did not provide enough speed for the robot to move without an outside force when placed in the ring. This was due to both the circuit and the motors being powered by one battery. To overcome this issue during this phase, another 9-volt battery was implemented so that the motors would have their own voltage supply separate from the 555 PWM circuit. This allowed the motors to have power to operate the robot without an outside force. Figure 2 and Figure 3 show the Multisim schematics used for the 555 PWM circuit on the robot during this phase.

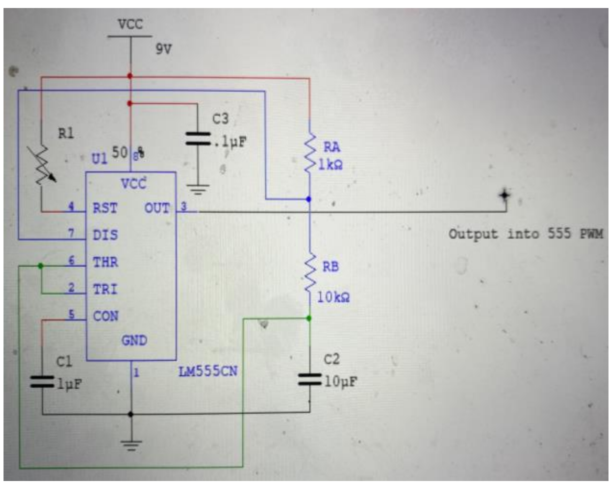

Figure 2.) 555 Astable circuit used in phase 1

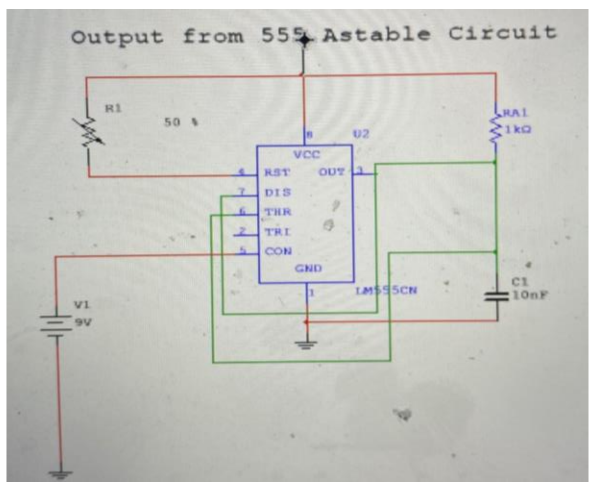

Figure 3.) 555 PWM circuit used in phase 1

Phase 2

For the second phase, in addition to the robot moving forward, it would now have to turn left or right when detecting a beacon. To achieve this outcome, we utilized two TSOPs. The TSOPs were used to detect beacons that emitted a 38KHz frequency. Each TSOP was placed on either side of the robot and powered their own detector circuit. To test that these circuits were working, a remote was used to produce the 38KHz frequency. If the TSOP detected the frequency, it would power a 555 timer that would turn on an LED wired to the output. After verification of the working detector circuits, we implemented the first iteration of our CMOS logic. This CMOS logic contained one AND gate and one OR gate. The two inputs to the CMOS logic would be the detector circuits that are on both sides of the robot. Having the TSOPs on both sides of the robot made it easier to detect beacons and provide a more accurate detection. Table 1 shows each state of the logic for this phase. With this logic, the robot would turn in a certain direction when a beacon is detected by either TSOP.

TSOP 1	TSOP 2	Motor 1	Motor 2
0	0	1	1
0	1	1	0
1	0	0	1
1	1	1	1

Table 1.) Two input CMOS logic for phase 2. A high input and output is represented with a 1 and a low input and output is represented with 0.

One issue that was faced during this phase was both TSOPs detecting frequencies at the same time no matter which side the beacon was on. This was due to using remotes with different signal strengths. To resolve this issue, we used a beacon that was built and produced the appropriate signal strength.

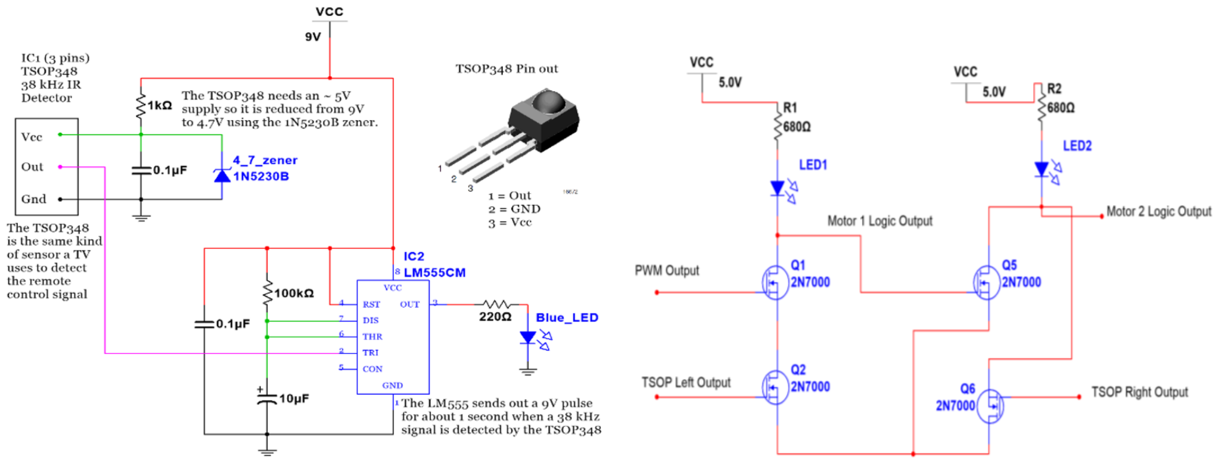

Figure 4) TSOP circuit used to detect the beacons.

Phase 3:

Introduction:

In the third design phase of the project, the logic was reworked to enable more complex logic operations, said operations can be seen in **Figure 5**. The PWM and Limited CMOS logic from phase 2 was replaced with more comprehensive CMOS Logic (**Figure 6**). To solve motor power problems that were encountered when powering the logic from both motors from the same supply, more CMOS logic was added and the logic for each motor was then powered separately to solve this issue. It is important to note, that each motor ran off the different power supplies from their corresponding logic. The TSOP's and IR LED logic ran off a separate 9V battery from the motor logic. There were also a number of minor changes, such as, adding potentiometers on the IR LED logic to adjust sensitivity, adding potentiometers to the motor power supplies to adjust speed, adding carboard to shield the TSOP's from motor interference, adding large capacitors to on all power rails to deal with motor interference, and adding structural changes to support a beacon and second platform for more logic.

CMOS Logic:

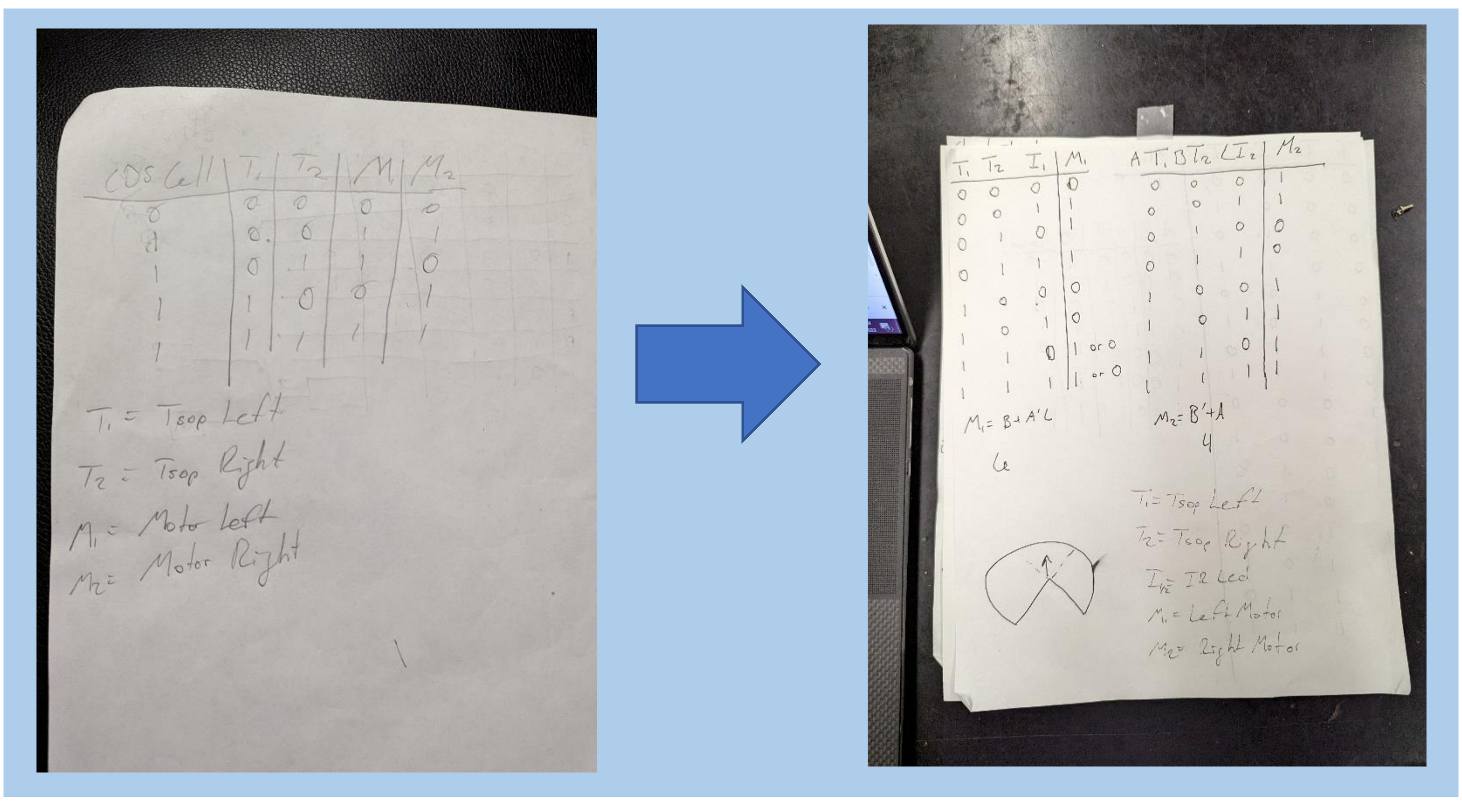

Figure 5: Logic for each motor was prescribed and a new variable, the IR LED, was added to allow for more complex operations of the robot.

The CMOS logic described above was implemented in two main circuits seen in **Figure 6** and **Figure 7** in Multisim. The CMOS inputs A, B, and C correspond to the left TSOP logic, right TSOP logic, and IR LED logic respectively.

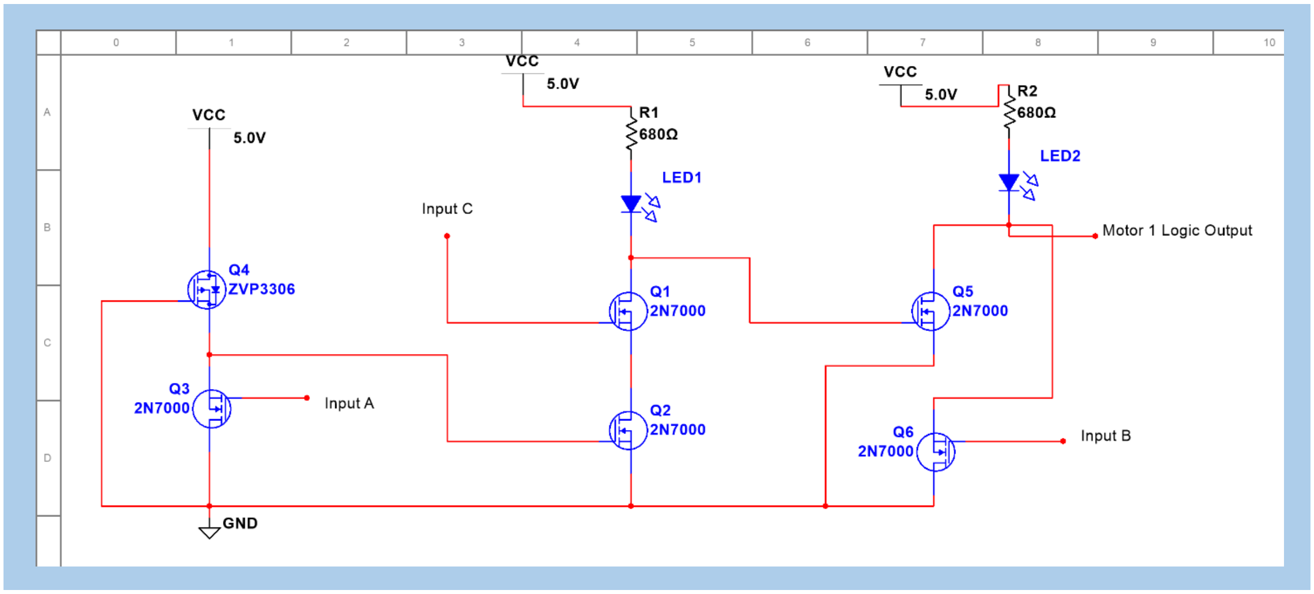

Figure 6: CMOS logic for Motor 1, tells the robot to drive forward when no signal, to go faster when right TSOP gets a signal, to go slower when left TSOP gets a signal, and to turn when the IR LED detects the white line around the ring.

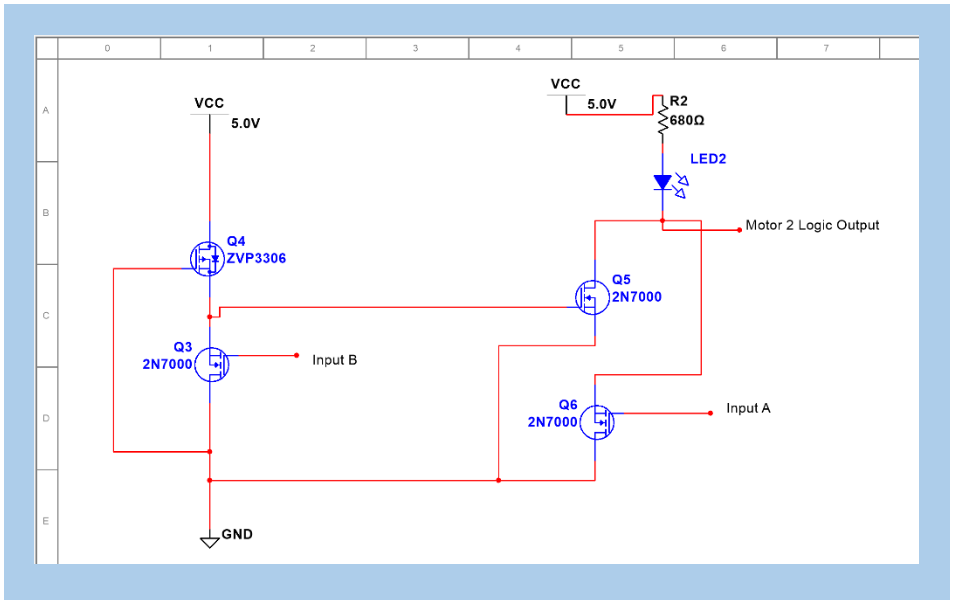

Figure 7: CMOS logic for Motor 2, tells robot to spin faster when right TSOP has a high signal and to spin slower when left TSOP has a high signal.

Once the logic for both motors was created, more logic was required to make it readable to the motors. NMOS IRF9520's and PMOS IRF9530's were used to create inverters and AND logic to transition the previous CMOS logic to the higher voltage motors. The CMOS outputs were AND'd with the power supplies of each Motor, them being a 9V battery for each motor (**Figure 8**). Each output was AND'd to allow the motors to run off of distinct power supplies whilst only running when the CMOS logic dictated. 10K ohm potentiometers were also added between the AND gates and the motor batteries to allow voltage control over each motor. Each output from the Motor 1 and Motor 2 IRF CMOS logic was inverted, using an inverter made of IRF9520's and IRF9530's (**Figure 9**). The outputs from the CMOS logic described above was inverted since the output from the logic was a logic low, and motors need a logic high to run.

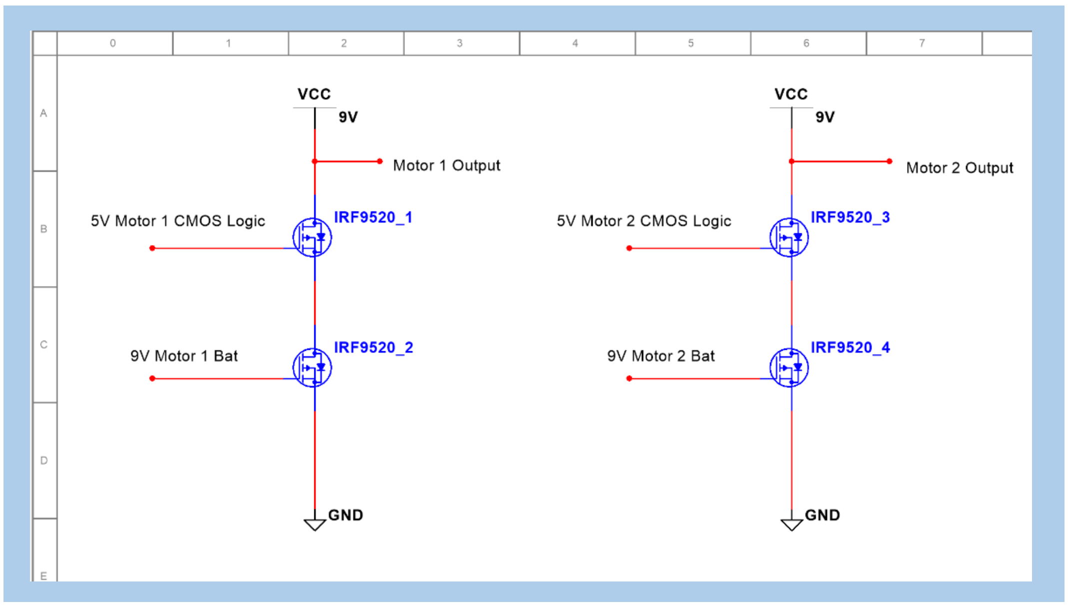

Figure 8: AND Logic for the respective outputs of the 5V CMOS logic for motors 1 and 2.

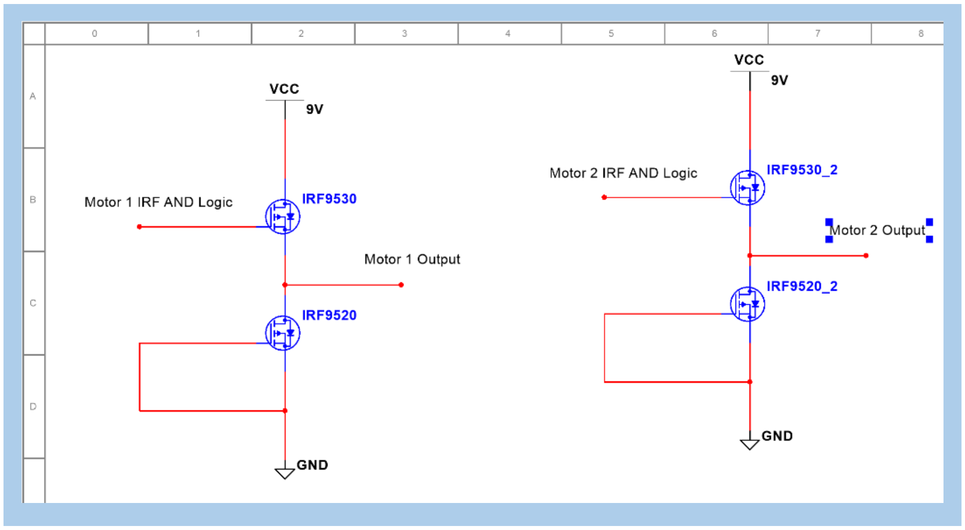

Figure 9: Inverting IRF logic for motors 1 and 2. This output feeds directly into the motor's power input.

Line Detector Circuit:

The Line Detector Circuit used a single IR LED and phototransistor diode to detect the white line around the arena. The circuit is uses an LM293P to compare the phototransistor output between a high contrast material and a low contrast material (**Figure 10**). The output of the circuit was then used as the 'C' input to the robot's CMOS logic.

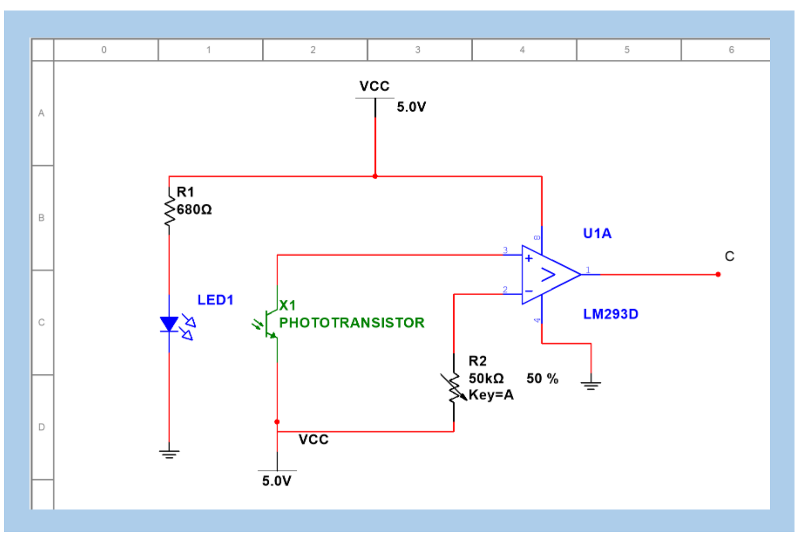

Figure 10: This is the Line Detection circuit using a comparator to compare the difference in voltage from the IR LED and Phototransistor between a high contrast material and a low contrast material. The output from the circuit is logic C.

Conclusion:

After the iterative design of phases 1 – 3, the robot could functionally track a 38kHz signal and detect a high contrast line. The final iteration of the robot can be seen in **Figure 11**, the design includes bi-directional signal detection from the left and right mounted TSOP's, a line detector circuit at the front, and motor speed controls at the rear of the robot.

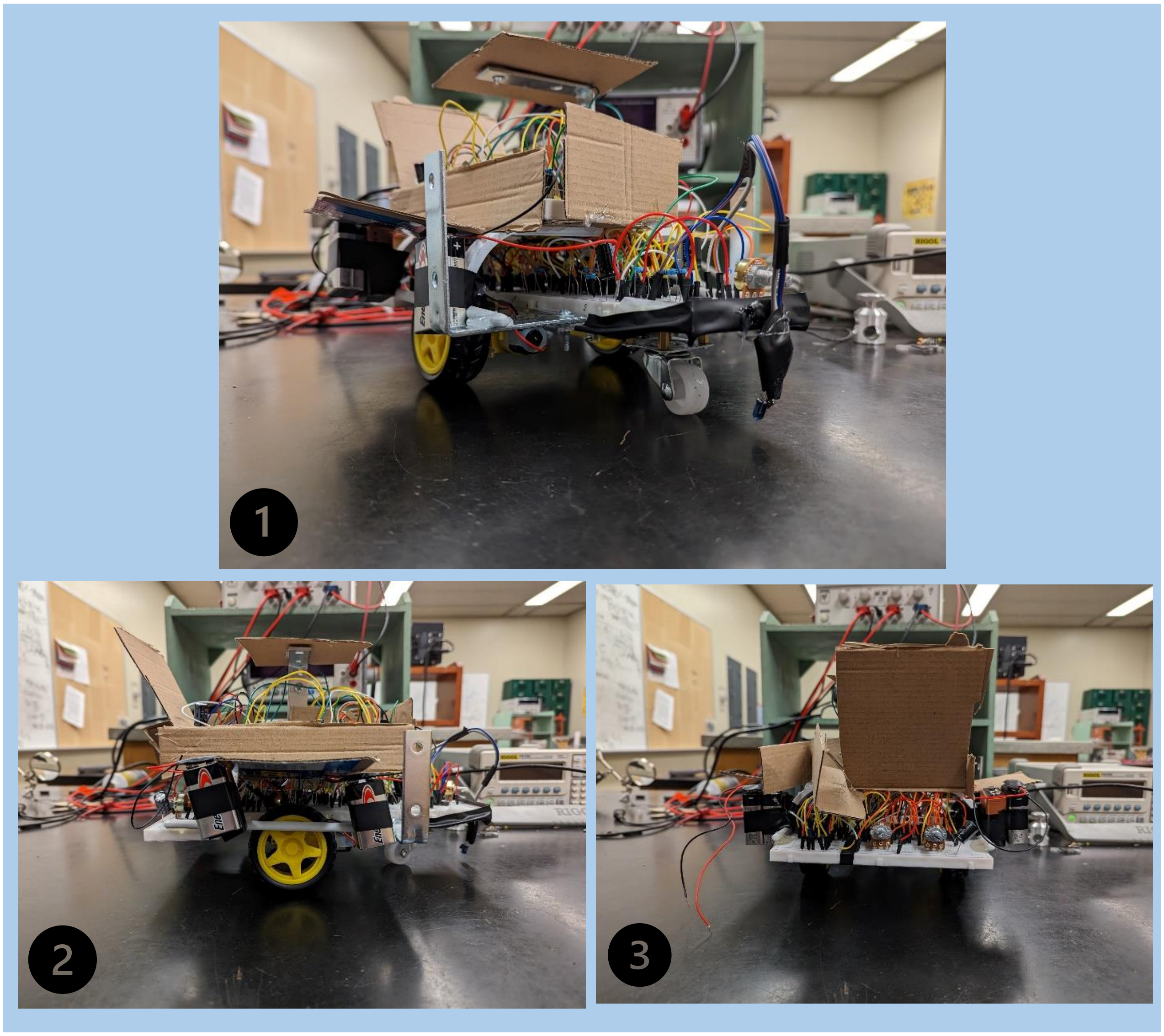

Figure 11: Picture 1 is an isometric view of the phase 3 robot, with all features included. Picture 2 is the side view of the robot. Picture 3 is the rear view of the robot.