Sound Reactive Straight-Run Car

ABSTRACT

The following report will cover the essential aspects of an audio-controlled car which integrates various concepts and involves issues that affect the developmental process. The various modules developed such as the H-Bridge, 5 Volt supplier, AND gate, Microphone Amplifier and MOSFET Switching Circuit. The objective of the circuit is to produce a straight run car that reverses for 1 second upon a sensory input. For this project, we will use an auditory input in the form of a clap which will result in the car reversing for 1 second and moving forward again.

INTRODUCTION

In this project, there were several different individual modules that contributed to the completion of the final circuit. To start, there was the "H-Bridge", which Patrick was responsible for, that essentially took the signals outputted from the other modules to control the motor speed/balance as well as the direction of the motors. Then, there was the "Microphone with the LM358 Amplifier", which Arham completed, that took an audio signal as input, converted it to a voltage signal, and then amplified this voltage. After this, there is the "PWM Straight Run Car", which Abhi finished, that controls the speed and balance of the car itself to ensure that the car travels in a linear path. Directly connected to the last module mentioned is the "Diode-based Logical AND", which Abhi also completed, that takes the speed and balance control signals as input and performs a "logical AND" operation on them to output a singular voltage. Next, there is the "MOSFET Switching Circuit", which Pratham worked on, that essentially controls the charging and discharging of a capacitor electronically, to produce the signal responsible for reversing the car . Finally, there is the "9 to 5 Supplier", which Arham finished, that takes a 9 Volt battery signal as input and converts it to output 5 Volts. The combination of these modules allow for the car to move in a straight line, reverse for a period of time after a loud sound is produced, and then, begin moving forward once again.

MICROPHONE with the LM358 AMPLIFIER (arham2)

OVERVIEW:

The microphone provides the sensory input to the straight run car. During the motion of the car, there will be no physical or remote contact to the circuit. The noise is the only new information that the circuit will receive from an external source.

THE COMPONENTS:

The amplifier- LM358- is responsible for amplifying the voltage such that it can trigger the Gate of the Transistor. It amplifies the voltage to 4.5 Volts. The chip by itself utilizes the concepts of a voltage divider so that the time-varying signal coming from the capacitor with the DC voltage allows shifting up and down utilizing one single voltage source. The capacitors in the circuit resist the large fluctuations in voltage since they take time to charge and discharge. Using this property, the 1000μF capacitor used across the battery gets rid of the voltage changes. The potentiometer allows us to change the output voltage by using the Voltage divider.

HOW IT WORKS:

The audio is captured by the microphone which allows small noises which when connected to small signals provides an output after passing through the Amplifier IC which provides a peak voltage of 4.5V which is enough to trigger the Transistor.

RELATION TO THE FINAL CIRCUIT:

At V1 in the circuit, it does not have an amplified voltage which upon crossing the LM358 is converted to an amplified voltage across V2 or V3 as shown in the diagram below. That creates a closed circuit and to allow the capacitor to discharge which provides a signal which is transmitted to the Schmitt trigger, triggering the motor to work in the opposite direction.

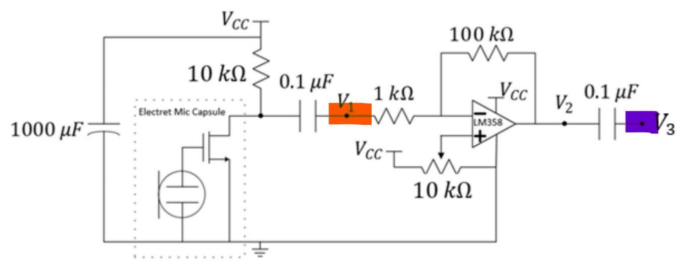


Figure 1.1: LM358 -Amplifier-Circuit with output point "V_3" for connection with the

<u>DIODE-BASED LOGICAL AND</u> (arnayak2)

OVERVIEW:

The purpose of this module was to simulate a logical AND gate without utilizing MOSFETs. Instead, we were instructed to use two diodes and a hex inverter TTL DIP.

THE COMPONENTS:

The circuit begins with the voltage source (the battery), which is directly connected to a 100 kΩ resistor. Then, the end of the resistor splits into three separate nodes, two leading to the anodes of diodes and the other leading to an input of a Schmitt trigger inverter gate (which is connected to ground and the voltage source). After the signal goes through the Schmitt trigger inverter gate, it is inverted again by a second hex inverter gate. The cathodes of the diodes are then connected to two different voltage sources, one being V_{spd} and the other $V_{bal,l}$ or $V_{bal,r}$ (both of which are outputs of the PWM)

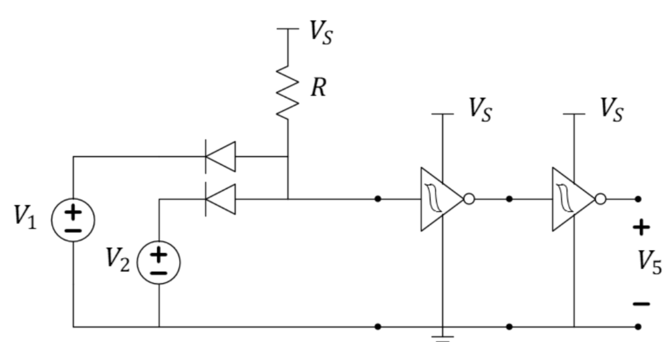


Figure 2.1: Diode-based AND Circuit Schematic

HOW IT WORKS:

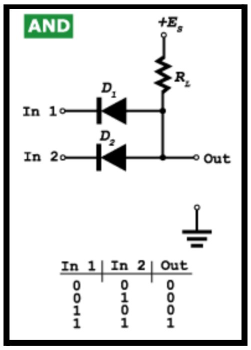


Figure 2.2 & 2.3: I/O for AND Gate with Circuit Drawing and Sample AND Gate Output

(Source: https://electronics.stackexchange.com/questions/131860/diode-logic-gates)

Essentially, this diode-based AND gate takes in two values as input, speed control and balance control. These are analog signals that can either be identified as being LOW or HIGH, and when they pass through their respective diode (this occurs when there is an electric potential difference between the voltage of the battery and the voltage of the source), they are converted into a single threshold limiting binary signal that can either take on the voltage of the battery or the voltage at ground. This signal is then directly connected to the input of an inverter gate whose output is connected to the input of another inverter gate to produce a "cleaner" output signal from the simulated logical AND gate.

RELATION TO THE FINAL CIRCUIT:

The outputs of the two separate AND gates (the first gate having V_{spd} and $V_{bal,l}$ as inputs and the second gate having V_{spd} and $V_{bal,r}$ as inputs) are directly connected to the enable pins of the H-bridge. The proper functioning of the H-bridge is entirely dependent on the outputs of the AND gates, in other words, the H-bridge only turns on when the voltage that is supplied from the AND gates are HIGH or within the range of 2 to 5.5 Volts.

<u>9 TO 5 VOLT SUPPLIER</u> (arham2)

OVERVIEW:

Many sub-components of the circuit utilize 5 volts such as the AND Gate as well as the H-bridge for efficient output. If these components receive a greater voltage even momentarily, it could damage their functionality.The end result of this circuit is to supply 5 Volts to the desired components.

THE COMPONENTS:

This circuit is made of various components such as the zener diode, resistors and a Capacitor. The Zener Diode allows for the current to flow in either direction which is determined by the voltage across the diode. The objective of the diode is to allow current to flow through it only at a specified voltage. The diode allows current to flow in the positive direction as well as the negative direction when it reaches its "Zener voltage" or "avalanche point". The benefit of using a diode is that it will consistently maintain the desired voltage value such that there is less discrepancy in the circuit. This is the benefit of using a zener rather than a voltage divider. When the voltage on the Capacitor is less than the zener voltage, the zener diode is not conducting and so the voltage on the capacitor rises as in an RC circuit. When the voltage on the capacitor reaches the Zener voltage then the diode starts breakdown and the voltage is clamped to this voltage. The diode bridge is connected with the capacitor to protect the diode from surges or spike voltages.sume more power than they are capable of. The resistors are connected in parallel such that they provide the desired equivalent resistance. We also have to ensure that none of the resistors get more power than they are rated for.

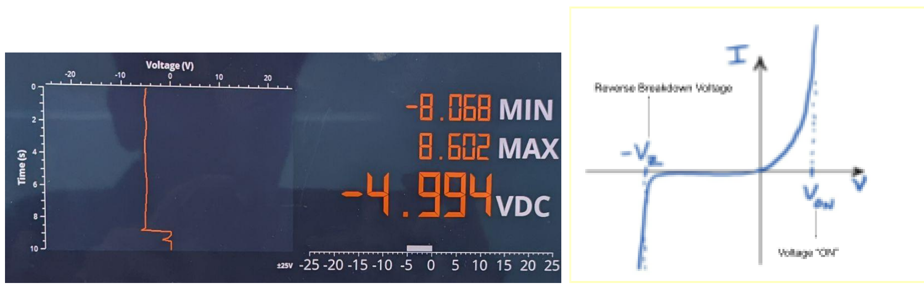


Figure 3.1 & 3.2: Voltage supply as a result of the circuit and the graph for reverse breakdown voltage graph

HOW IT WORKS:

The Zener diode maintains % volts across it because of its unique properties which allows us to provide the 5 Volt supply across it. The cathode of the zener diode is connected to the positive terminal unlike a regular diode since the zener allows the current to flow through the opposite direction when it reaches a certain voltage providing a reliable 5 volt source to the desired sub-components of the circuit. The equivalent resistance is 83.33ohm which is supposed to be around 8o ohms, so I adjusted the resistors such that each of the resistors does not exceed the power rating. The resistors used are 100ohms and 1000ohms.

RELATION TO THE FINAL CIRCUIT:

The connections are made such that the circuit can provide 5 volts when the nodes across the zener diode. The zener can act as a voltage provider if the node of the zener diode is connected to the power rail through the rail of the circuit.

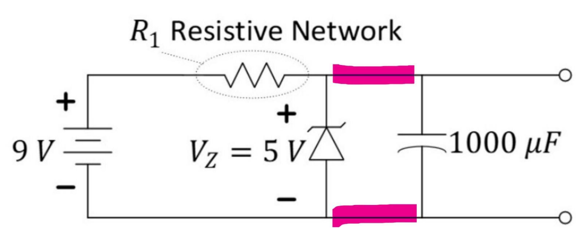


Figure 3.3: Diagram for the 5 Volt supplier with the outputs marked

https://resources.pcb.cadence.com/blog/2019-the-importance -of-zener-voltage-and-its-effects-on-circuit-functionality

MOSFET SWITCHING CIRCUIT (pnj2)

OVERVIEW:

The purpose of the MOSFET Switching Circuit is to electrically control the charging and discharging of a capacitor to control the reverse drive of the circuit. It uses a MOSFET which acts as a variable resistor.

HOW IT WORKS:

The Gate of the MOSFET receives an amplified signal from the microphone module. When the amplified signal from the microphone module is 'Low', the gate is closed causing there to be an open circuit between the drain and source terminals of the MOSFET consequently, preventing the capacitor from discharging. When the signal is 'High' the gate opens forming a short circuit between the Drain & Source terminals of the MOSFET, consequently, forming a path for the capacitor to discharge. The discharge signal is sent to a Schmitt-Trigger Inverter.

COMPONENTS:

The circuit consists of 3 components: a MOSFET, a 30 $k\Omega$ resistor and a 100 µF capacitor.

RELATION TO THE FINAL CIRCUIT:

The capacitor charges through the orange loop and discharges through the green loop. The discharging of the capacitor is instantaneous compared to the charging tof the capacitor. This can be deduced from the charging and discharging equations of the capacitor. The charging and discharging equations are determined by T = 2.2RC where R is the resistance (Ω) and C is the capacitance (F). The charging cycle consists of the 30 $k\Omega$ and 100 µF and the discharging cycle consists of the resistance between the drain and source pins of the MOSFET which is almost 0 due to a short circuit between the drain and source. We initially used a 10 $k\Omega$resistor but then replaced it with a 30 $k\Omega$ to increase the charging time to increase the reverse spinning time of the wheels. Hence, the charging time is around 6.6s and the discharge time is almost 0s. The capacitance of the discharge cycle remains the same value of 100 µF. Once the amplified signal reduces to its original value the gate opens up again causing the capacitor to charge through the orange loop until it is completely charged and the current in the loop is 0. In this manner the MOSFET Switching Circuit functions and assists in producing the signal for reversing the car.

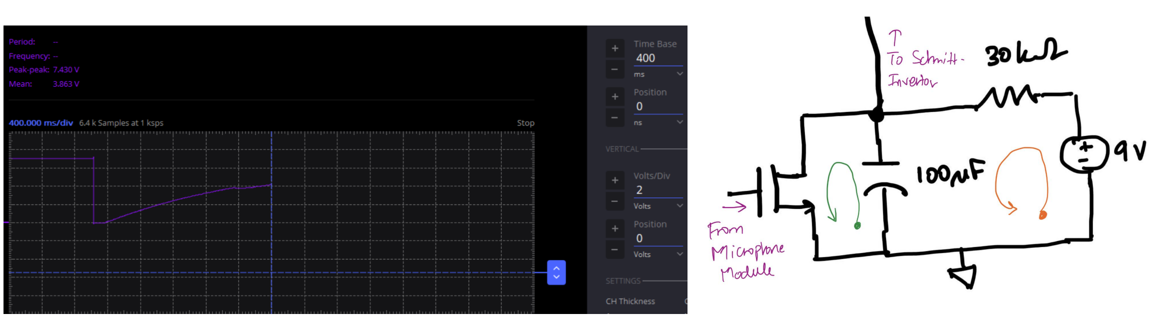


Figure 4.1 & 4.2: Charging & Discharging of Capacitor and MOSFET Switching Circuit

PWM STRAIGHT-RUN CAR (pnj2)

OVERVIEW:

The Straight-Run car is an amalgamation of various components and concepts which allow for the car to move in the desired direction.

THE COMPONENTS and HOW IT WORKS: :

The Pulse Width Modulation, or PWM, is responsible for controlling the amount of power delivered to the motors. In order for the consistent delivery of power to the motors, the battery provides it with a constant voltage which is turned on and off rapidly. This essentially forms a duty cycle.

Essentially the circuit consists of 2 main components. One component controls the speed whereas the other component controls the balance of the wheels. To control the duty cycle we use a potentiometer. We essentially want to achieve a 50% duty cycle to get an equal balance between both the right and left wheels.

An important component of the module is the schmitt trigger inverter. A special property of the schmitt trigger is something called hysteresis where there are basically two voltage thresholds that determine whether it is a low or high signal. This allows signals to be relatively clean and reduce any noisy signals that may affect the PWM by causing it to fluctuate improperly.

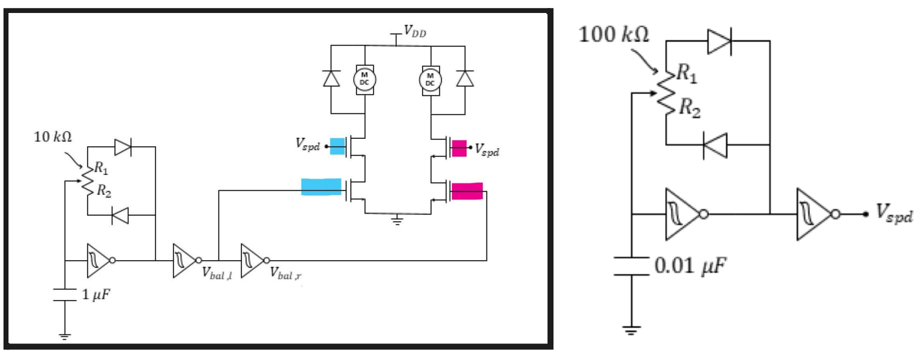
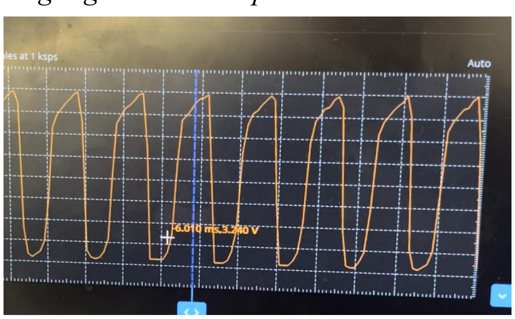


Figure 5.1: PWM Straight Run Car Circuit
(Blue Highlights are the Inputs to one AND Gate and Pink Highlights are the Inputs to the AND Gate)



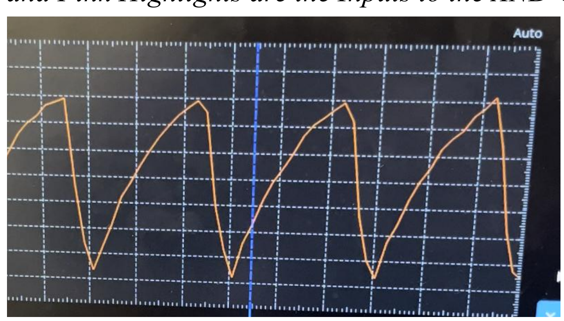


Figure 5.2: V_{spd} Oscillation Graph

Figure 5.3: V_{bal} Oscillation Graph

<u>H-BRIDGE</u> (psheng3)

OVERVIEW:

The H-Bridge acts as the brain of the circuit. It receives signals from all of the other modules and combines them in a way that they control the motor including the direction in which the motors turn and the speed/balance of the motors. This is done through the combined logic of both schmitt trigger inverters along with the logic pins of the H-Bridge IC itself.

THE COMPONENTS:

This module consists of the output signals of the other modules along with schmitt triggers inverters. Starting with the 16th pin, the IC Power, it is connected to the 5V power supply that comes from the Zener Diode module. This is important because the IC can only take the specified amount and anymore could damage the chip. The enable pins, pins 1 and 9, determine whether the H-Bridge is on or not. The outputs of the diode ANDs which combine the straight run circuit signals, are connected to these pins. The motor pins are connected to the motor terminals, pins 3,6 and 11,14. This is where the current will flow through to supply voltage to the motors. The output of the MOSFET switching circuit is the input of the first schmitt trigger inverter. The outputs from the schmitt inverters are connected to the motor logic pins, pins 2,7 and 10,15. This controls the direction the motor turns. Finally, the motor power supply, pin 8 is connected to 9V to supply power to the motors.

HOW IT WORKS:

By connecting the output of AND gates to the enable pins of the H-Bridges, a sort of oscillating wave is formed that turns the H-Bridges on and off causing the motors to turn at a certain speed by allowing the 9V current from the motor power supply pin to flow through the motor in short intervals. It switches between 0V when the enable is off and the voltage from the motor supply pin when enable is on.

The signal that is received from the MOSFET switching circuit is first sent through a schmitt trigger inverter. The output of the first inverter is connected to one motor logic pin of each H-bridge. The output of the second inverter is connected to the other motor logic pins. This allows for the desired switch combinations seen in figure 6.1 that will determine between the two current flow directions that cause the motor to turn in different directions. Thus, when a clap is registered by the microphone, causing the capacitor to discharge, the signal from the discharge and the changing voltage across the capacitor, through the schmitt inverters and the motor logic pins, causes the switches to switch their positions, reversing the motor direction. In terms of magnitude of the voltage, it remains the same. However, the sign of the voltage changes as the current direction is in the opposite direction.

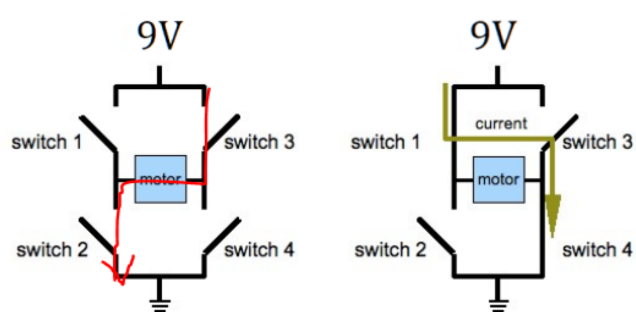


Figure 6.1: Different switch combinations allow for different current flow paths

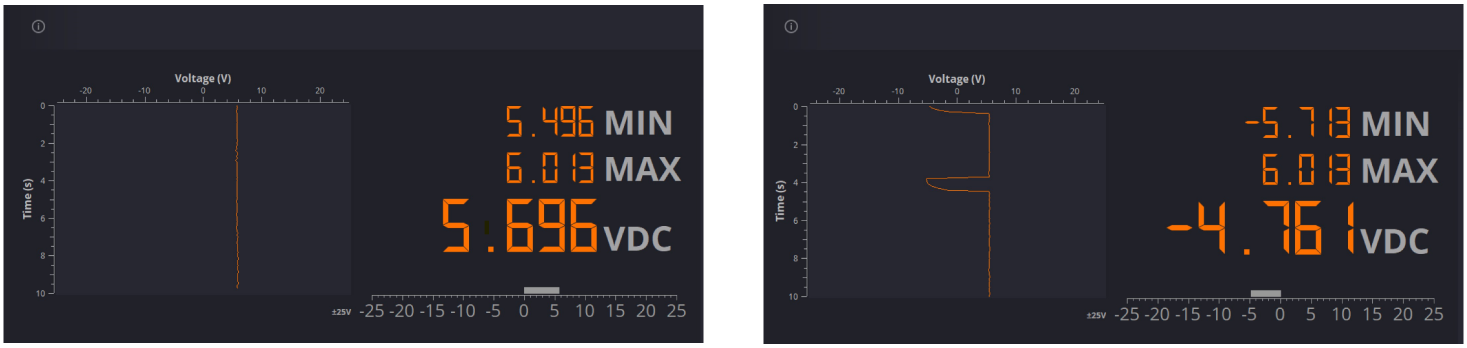


Figure 6.2: Reversed voltage signs when signal from clap received(different magnitude due to improper screen shot time)

RELATION TO THE FINAL CIRCUIT:

Once again, the H-Bridge acts like the brain of the circuit by combining the different output signals from other modules and interpreting them through logic to output the desired results. The AND gate outputs are inputted into the H-Bridge to control speed/balance, the signal from the capacitor of the MOSFET switching circuit is inputted into the schmitt trigger inverters/H-Bridge to control the logic that determines the direction of the motors. The 5V from the Zener diode is what powers the IC chip of the H-Bridge.

CONCLUSION

Through the course of this project, the team worked together to bring their individual modules together and used various innovations to get the desired output. The team came together six times over the course of 2 weeks and we troubleshoot various issues using the group's collective knowledge and come up with innovative ways to solve the issues. We repeatedly used the M2K and Ammeter to read the necessary inputs and retrace our steps. As a team, we learnt to work together and come up with innovations and reduce the number of connections in order to reduce the number of complexity and potential for errors due to weak connections. This process also provided us with a deeper understanding of the circuit. The same concept can be applied to real life. The sensory input can be switched to a light sensor to sense proximity or for a variety of other processes. For future considerations, the circuit should be elegant in terms that it should be more concise and easy to troubleshoot. If implemented, the team would save a lot of time on finding errors and they would be less likely to face "loose connection" errors.