Final Design Report: Robotic Car

Abstract

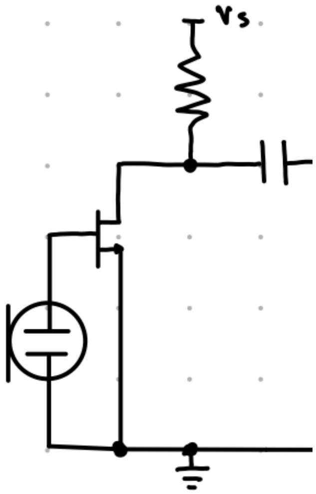
This report describes the construction and functionality of a sound-controlled robotic car. The microphone module converts sound signals into electrical signals that activate the DRAM, which stores the car's state. An amplifier with two resistors and an operational amplifier amplifies and inverts the output of the microphone. The DRAM circuit stores the state of the car and controls its on/off button, and a restore circuit ensures a constant high voltage output. A capacitor, resistor, schmitt trigger, and diode create a square wave restore circuit, and a resistor, potentiometer, capacitor, and three schmitt triggers are used to change the capacitor's state. The report also describes the calculations involved in determining the theoretical gain of the amplifier. The final product is a sound-controlled car that changes direction according to the sound signals it receives.

Introduction

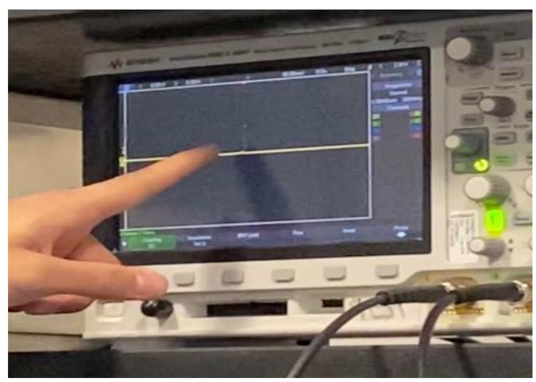
This report provides an overview of the design elements that we have built and learned about over the last fourteen weeks. Throughout this period, we have dived into learning how each subcircuit worked, tested different components, and built circuits around them. This project aims to utilize these components to design and build a car that moves away from sound. This report serves as a reference for us to consolidate our understanding of these components and their functions, and to use as a guide as we embark on our final project. In the following sections, we will delve into each component in detail, highlighting its unique properties and how it can be incorporated into the design of our sound-avoiding car.

<u>Microphone (suvids2)</u>

The microphone module consists of a microphone and a capacitor. The microphone generates electrical signals from sound signals. The diaphragm on the microphone vibrates with



the vibrations generated from a “clap” or any sound in the proximity of the microphone. We could have directly used the output of the microphone for activating the DRAM to change its state, but we don’t do that because this signal from the microphone is a mixed signal. It is DC and AC signal combined in one, together coming out as output from the microphone. Thus we use a capacitor to filter out the DC part of the signal. This is called AC coupling. The capacitor is used to filter out the DC component from the mixed signal and only let the AC signal pass through. The DC signal is only used to power the microphone, we

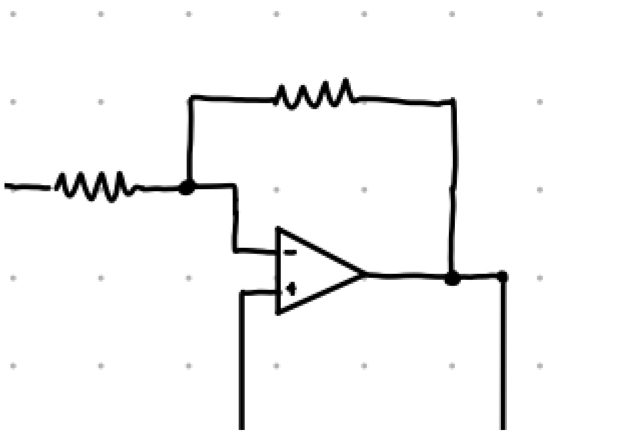


don’t want that as the output of the microphone. The output of the microphone should only be the audio that it received, which is a wave of compressions and rarefactions, and will thus generate a AC signal by vibrating the diaphragm. This filtered signal is then transmitted further to activate the DRAM, to change its state.

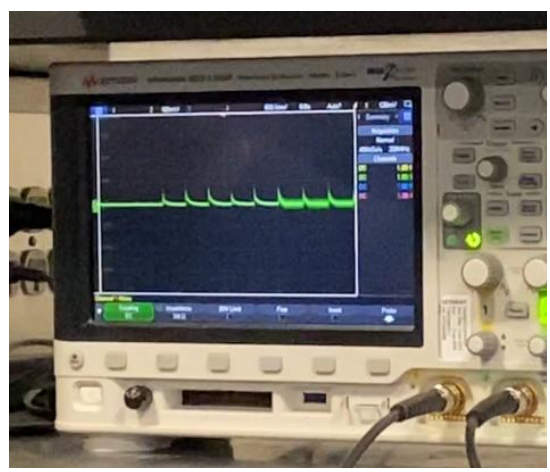
When we use an oscilloscope to measure the voltage at the capacitor we see a single spike in voltage everytime there is a clap. There is also a lot of noise coming from the surroundings so without any clap there are still signal measurements showing up, but the graph is very erratic.

Amplifier (zyli2)

The amplifier component of our circuit consists of two resistors and an operational amplifier. Our amplifier is built to amplify and invert the millivolt output generated by the microphone. If we measure the output of the amplifier on an oscilloscope, whenever the microphone receives a loud enough input the graph should show an input-inverted voltage spike. This voltage spike is used to temporarily activate the two of DRAM's MOSFET gates, allowing a change in our car's state. This is how we make our car sound controlled.



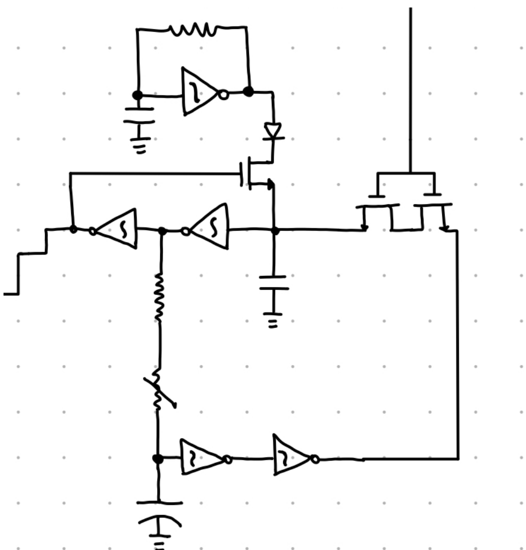
To be more specific with how our amplifier functions, an amplifier's theoretical gain can be measured by this gain formula: $Vout \; = \; -\frac{R2}{R1}Vin$. Vin here refers to the voltage coming into the amplifier circuit and Vout refers to the amplified voltage coming out of the circuit. R2 is the resistor on top of the operational amplifier and R1 is the resistor at the very beginning of our circuit. This equation was derived from analyzing current at the node connected to the negative terminal of the operational amplifier. If we perform a KVL analysis at the first point where the op amp's negative terminal's node divides, we find that $\frac{Vin - Vminus}{R1} + \frac{Vminus - Vout}{R2} = 0$ using Ohm's law, $I \; = \; \frac{V}{R}$. By doing some algebra, we can find the gain formula.



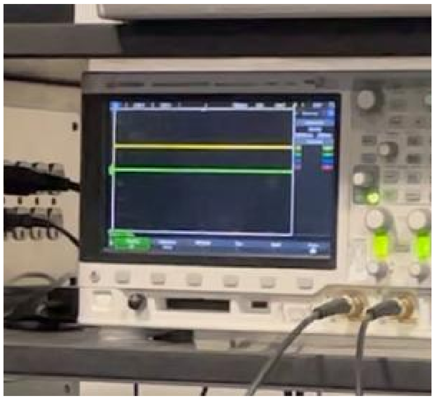
In the actual design process of our car, we also tried using a potentiometer as our R2. This is because we weren't sure what the threshold voltage of the DRAM's MOSFET gates was. A potentiometer allowed us to easily change the amplified voltage by increasing the numerator of the gain formula. Ultimately, we were able to tune a fitting R2 for our amplifier.

<u>DRAM (roshnim3)</u>

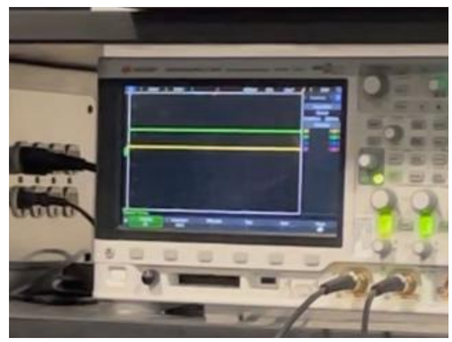
The DRAM circuit is used to store the state of the car, or which direction the car is moving. The “on/off button” is controlled by the microphone/amplifier circuit. When voltage is supplied to the gates of the transistors, it turns them on allowing the circuit with the capacitors and schmitt triggers to close. Let’s say the middle capacitor which is connected to the restore circuit is charged (storing the state 1). This means the voltage at the first schmitt trigger is high which causes the output voltage to be 0. Then the second schmitt trigger inverts the low voltage to high. At first this part of the circuit may seem excessive because the output of the second schmitt trigger is similar to the output of the capacitor used to store the state. However, we use a set of two schmitt triggers because capacitors lose charge over a period of time which means the output voltage would be decreasing over time. By connecting to two schmitt triggers, we guarantee a constant high voltage output. Now to combat the part with the capacitor losing charge, we have a restore circuit which outputs a square wave.



The square wave restore circuit uses a capacitor, resistor, schmitt trigger and diode. At first the schmitt trigger takes the low input and inverts to a high output. That high voltage output is sent two ways: one back through the transistor to charge the capacitor and a second way through the diode. By going back through the resistor, the schmitt trigger charges the capacitor. As the capacitor charges, the input voltage to the schmitt trigger becomes high which reverts the output to a low voltage. During this phase the capacitor discharges. This means the schmitt trigger keeps flip flopping from a high to low voltage causing a square wave voltage output via the diode. The transistor which is powered by that second transistor lets the square wave reach the capacitor only when the capacitor's state is one.

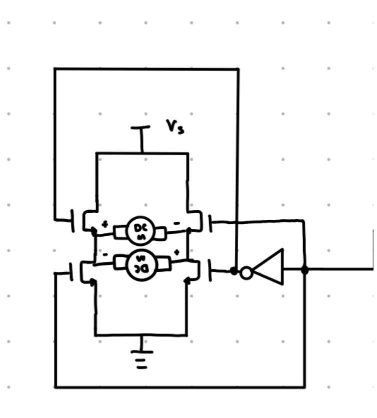


Finally, in order for the capacitor to switch states we have an additional circuit part that consists of a resistor, potentiometer, capacitor, and three schmitt triggers. This part of the circuit becomes "closed" when there is output from the microphone/amplifier circuit. At this point if that capacitor storing the state is charged, it discharges via the first schmitt trigger, thereby charging the other capacitor. If the capacitor storing the state is discharged, it becomes charged by the other capacitor. Regarding the graphs, we have signals connected to both capacitors. When we clap, the capacitors switch states: one charges while the other discharges.



H-Bridge (liannam2)

An H-bridge is a type of electronic circuit that is commonly used to control the direction of rotation of a DC motor. In other words, it allows the motor to spin either clockwise or counterclockwise, depending on the direction of the current that is being sent through it.



The H-bridge is an essential component in many robotics and automation applications, including car projects, because it provides a simple and effective way to control the motion of a motor. By using an H-bridge, it becomes possible to build complex systems that require precise control over the movement of a vehicle or other mechanical device. For example, in a car project, an H-bridge might be used to control the speed and direction of the wheels, allowing the car to move forward, backward, turn left or right, or even stop completely.

The two MOSFETs on the left side of the H-bridge are connected in parallel between the motor and the ground, while the two MOSFETs on the right side of the H-bridge are also connected in parallel, but between the motor and the positive power supply. The gate of each MOSFET is controlled by a pushbutton, so that pressing a combination of two push buttons will turn on the MOSFETs in the corresponding part of the H-bridge and allow current to flow through the motor in a specific direction. For example, to make the motor run forward, we need to turn on the left-side bottom MOSFET and the right-side top MOSFET, while turning off the other two MOSFETs. In our case, we use an enabler to determine the on/off state of the circuit. This will create a current path from the positive power supply through the right-side top MOSFET, the motor, and the left-side bottom MOSFET, and back to the negative power supply.

It's important to note that care must be taken to avoid a "shoot-through" condition, where both MOSFETs on one side of the H-bridge are turned on at the same time, creating a short circuit across the power supply. To prevent this, we can use a logic circuit to ensure that only one MOSFET on each side of the H-bridge is turned on at a time. Additionally, we need to consider the voltage and current ratings of the MOSFETs, as well as the power requirements of the motor, to ensure that the H-bridge can handle the load and operate safely and reliably. When nMOS B and nMOS C are on but nMOS A and B are off, the motors turn counter-clockwise. When nMOS A and nMOS D are on but nMOS B and C are off, the motors turn clockwise.

Conclusion

In conclusion, the sound-controlled robotic car described in this report is an interesting project that combines various circuits and components to create a functional device that can move and change direction based on sound signals. The microphone module is used to convert sound signals into electrical signals that activate the amplifier circuit, which amplifies and inverts the output of the microphone to activate the DRAM circuit, which controls the on/off button and stores the car's state. The restore circuit ensures a constant high voltage output and the capacitor and schmitt trigger circuits are used to change the capacitor's state. By combining all of these components, the final product is a sound-controlled car that changes direction based on the sound signals it receives. This project can serve as a great starting point for anyone interested in electronics, circuits, and robotics.