Rain Rain Go Away

REPORT FILE

HOSTEL ID - 84

5th February 2025

Contents

1 Flowchart

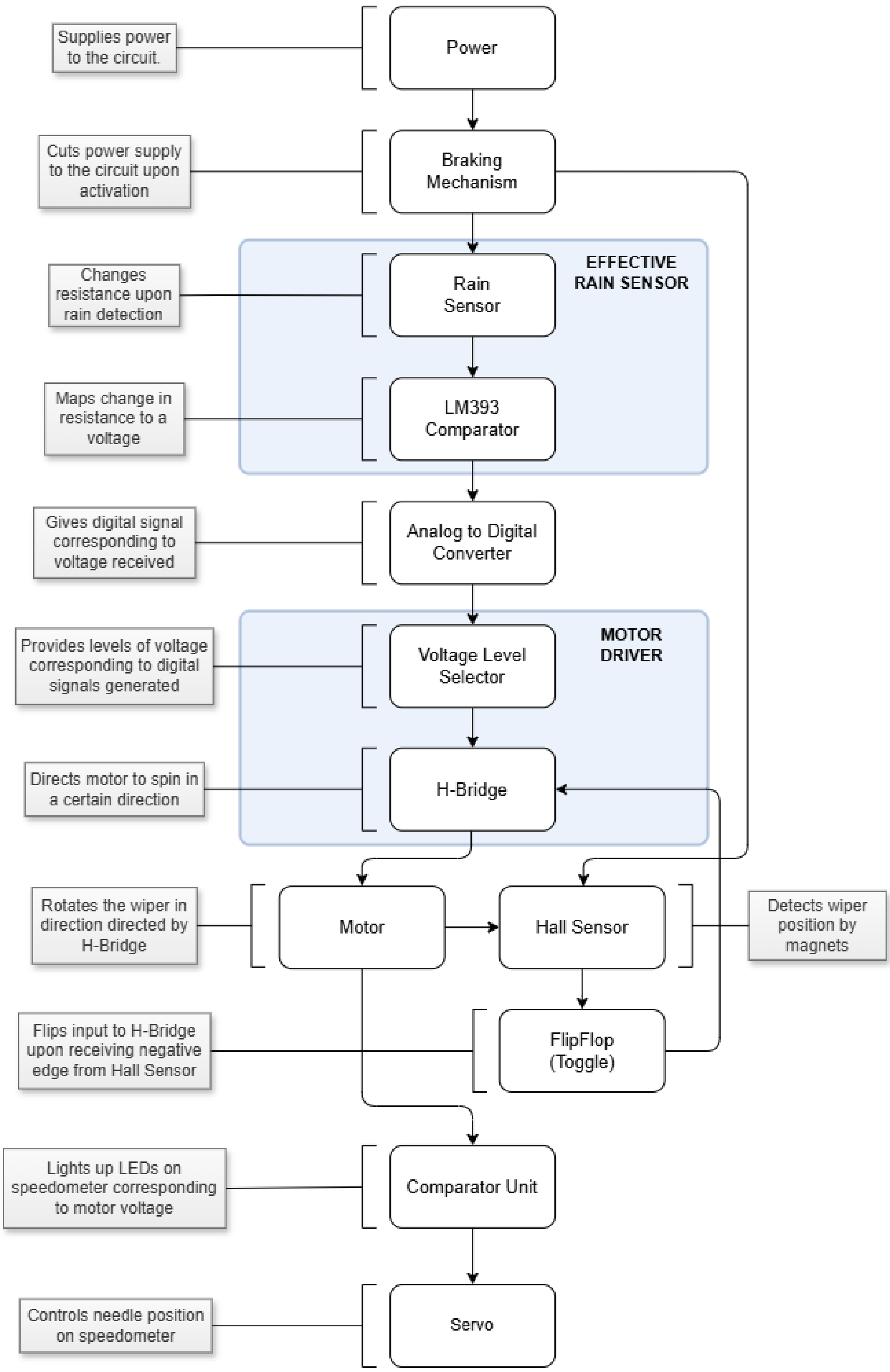

Figure 1: CIRCUIT FLOWCHART

2 Salient Features of the Circuit

- The circuit is very efficient in terms of power consumption due to the direct result of using only $5V$ power rails with no need for $12V$.

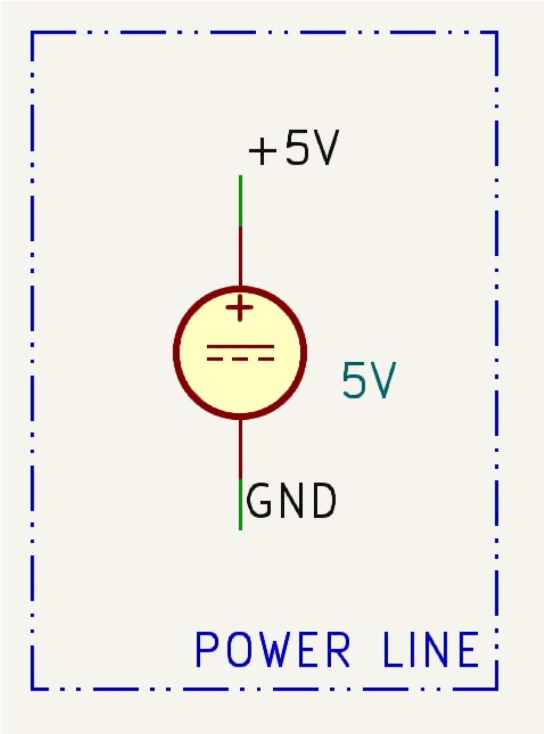

Figure 2: POWER

- The circuit also uses Buck Converters, which are very power efficient and have power dissipation in the order of microwatts.
- Hall Sensors have been used in the circuit, which offer an electrical solution with minimal mechanical elements.

3 Braking Mechanism

The braking mechanism is the top module, providing power to all interconnected breadboards. This design optimizes power consumption by ensuring that no other module draws power when the user pauses, thereby preventing unnecessary power dissipation.

For wireless control over the braking mechanism, we have implemented the microcontroller **Arduino UNO R3** module, which detects when the IR sensor has received a particular signal from the remote.

Under normal operating conditions, the **IR sensor** outputs a low signal, which is transmitted to a **PMOS transistor** acting as a switch. In this state, the PMOS remains in **ON** mode, allowing the **5V supply** to power the circuit components.

When the **Pause button** is pressed, the IR sensor generates a characteristic **PWM signal** which is read by the Arduino. Once the Arduino reads the signal, it sets the pin connected to the **gate of the PMOS** to be high, causing it to enter **OFF mode** (open circuit). As a result it shuts down the complete wiper system by cutting off its power supply.

This approach ensures **efficient power management**.

4 Rain Sensor

The rain sensor module is used to detect rainfall and measure its intensity. It consists of two main components: the Rain Detection Plate and the comparator module, together, they work to convert rainfall into voltage signal.

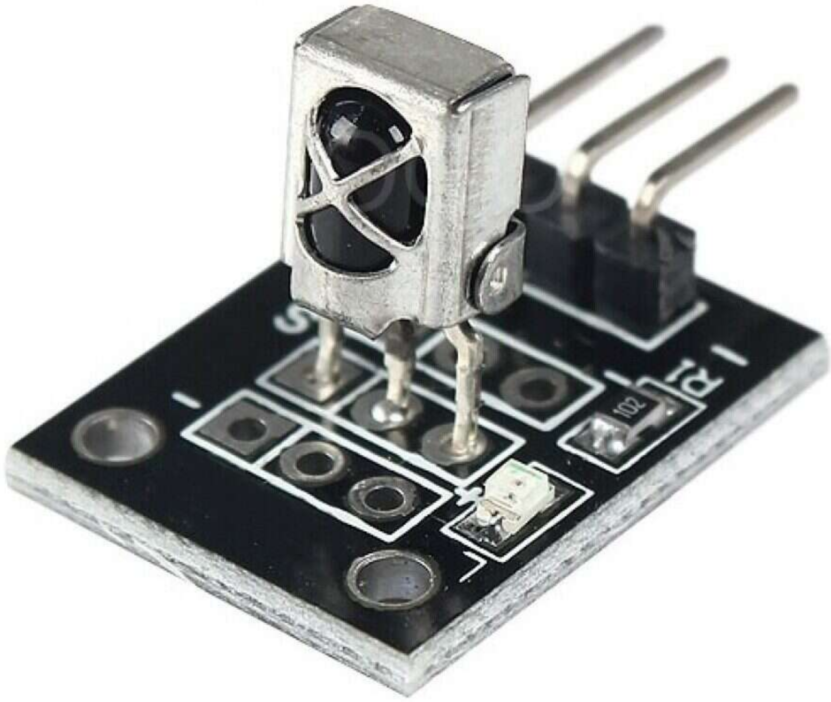

Figure 3: IR Sensor

When the rain falls on the board, it shorts the various resistances path effectively reducing the resistance.

- **Dry Plate:** When there are no rain drops on the sensor, it gives a high DC resistance.
- **Wet Plate:** When the rain sensor is wet it gives a lesser resistance than when it was dry, depending on the amount of water on the sensor.

The comparator module maps the resistance to DC voltage levels between the **VCC** and **GND**.

5 Analog to Digital Conversion (ADC)

The ADC circuit converts the analog signal (varying from GND to VCC) from the rain sensor module into a 4-bit digital representation using comparators and logic gates. The entire process is divided into three main components: Voltage Divider Network, Comparators and Logic Gates Network

5.1 Voltage Divider Network

A network of five 1kΩ resistors is used to create reference voltages (1V, 2V, 3V, 4V) from a 5V DC supply.These are used as reference voltages for the input voltage (Vin) from the rain sensor module by the comparators.

5.2 LM393 Comparators

We have used four LM393 comparators, labeled as $U_{1A}, U_{1B}, U_{2A}, U_{2B}$, The comparators compare the analog input voltage from the rain sensor module with the reference voltages we obtained using the voltage divider network. The LM393 has two

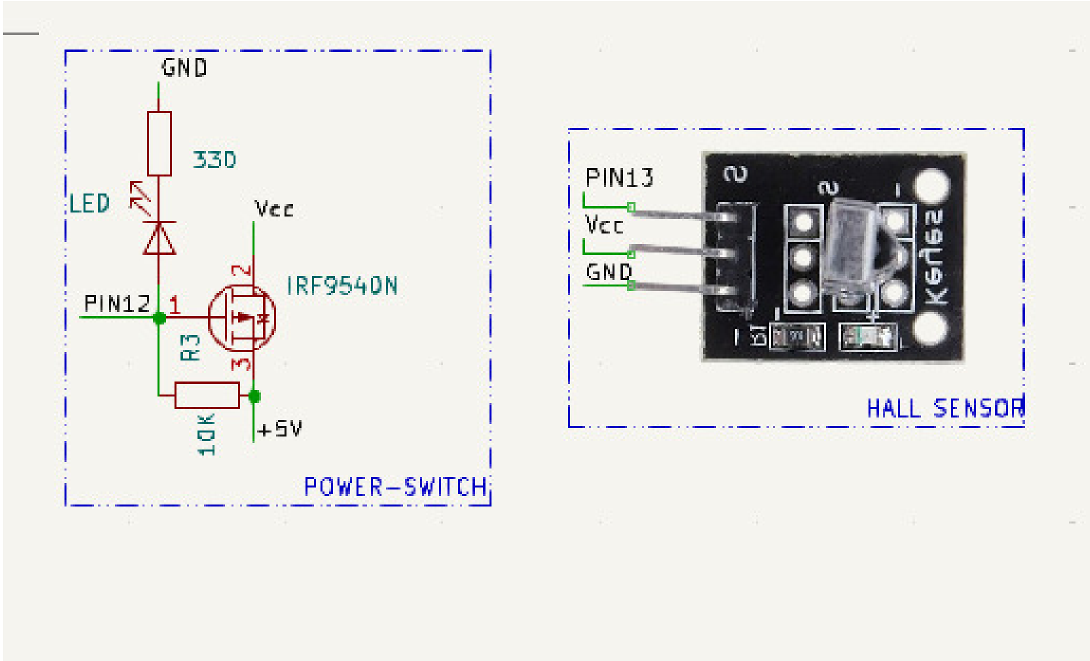

Figure 4: BREAKING MECHANISM

input pins: an inverting input labelled as V− and a non-inverting input V+. for proper working of the comparator we require an **external pull up resistor(4.7KΩ)** to be attached at the output .

The comparator compares the voltage at the two input terminals as follows:

- If the voltage at the non-inverting terminal (V^+) is higher than the inverting terminal (V^-), the output is pulled high (VCC).
- If the voltage at the non-inverting terminal (V^+) is lower than the inverting terminal (V^-), the output is pulled low (GND) through the pull-up resistor.

We are applying same voltage to the non-inverting terminal of each comparator. Each comparator compares the following two voltages:

- U_{1A}: Checks $V_{in1} > 4V$
- U_{1B}: Checks $V_{in1} > 3V$
- U_{2A}: Checks $V_{in1} > 2V$
- U_{2B}: Checks $V_{in1} > 1V$

For each of the above conditions, the comparator returns high (VCC) if the comparison is true.

5.3 Logic Gate Network

The logic gates network is used in the circuit to process the 4 bit-output (D3, D2, D1 and D0) from the comparators and generates a 4 bit-output (M3, M2, M1 and M0) according to the truth table given below:

(We have to process it as we have to give it to PMOS in the next stage and at a time if 4.1V is the voltage from rain sensor all 4 comparators would give high which we don't want we want output from only one to be high/low at a time.)

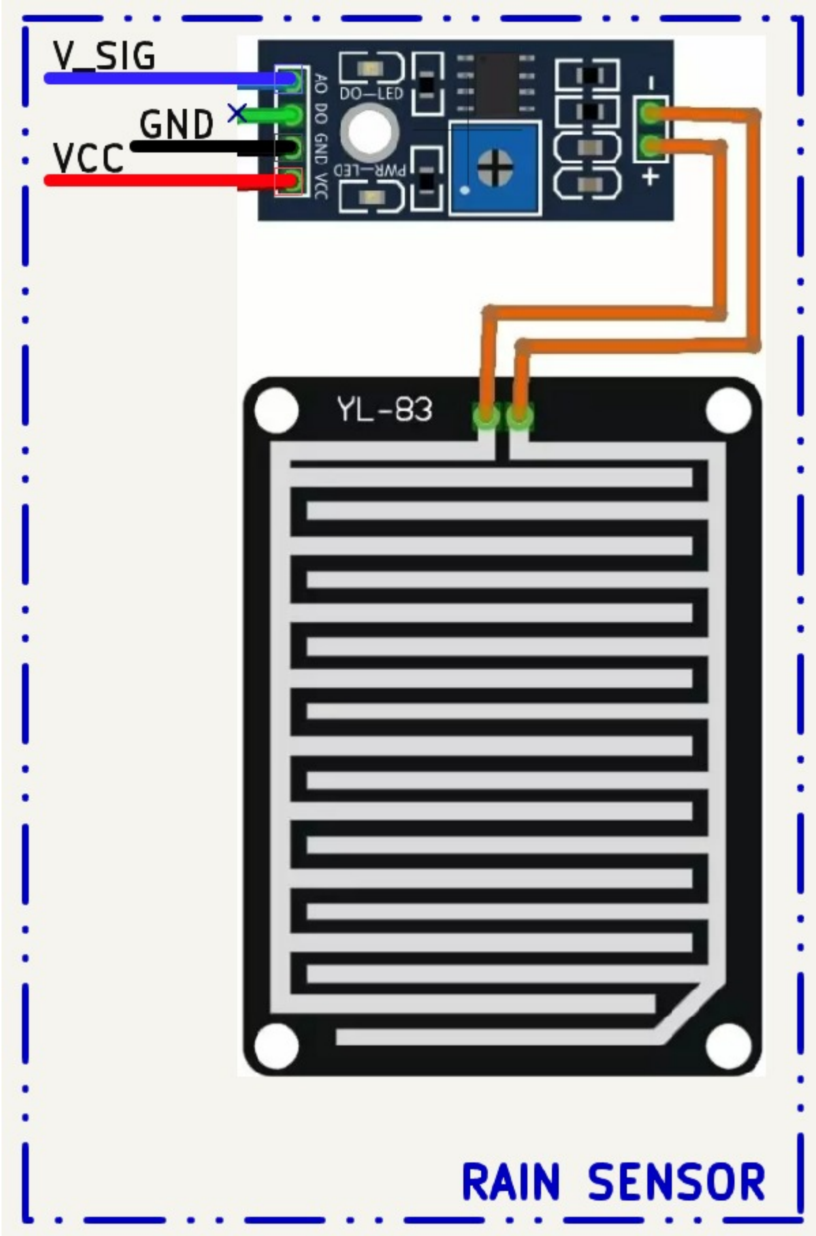

Figure 5: Rain Sensor

5.4 Overall Working of ADC

The rain sensor detects rain intensity and outputs an analog voltage proportional to the intensity. The analog voltage from the rain sensor is fed into the V_{in} input of the ADC circuit. The comparators compare V_{in} to the reference voltages (1V, 2V, 3V, 4V).

The outputs of these comparators are then processed by a combinational block of logic gates to generate the corresponding outputs of M_3, M_2, M_1, and M_0. As the V_{in} varies between 0V to 5V, representing the intensity of the rain detected by the rain sensor module, we divide it into five voltage ranges:

- $4V - 5V$: Represents no rain.
- $3V - 4V$: Represents light rain.
- $2V - 3V$: Represents moderate rain.
- $1V - 2V$: Represents heavy rain.

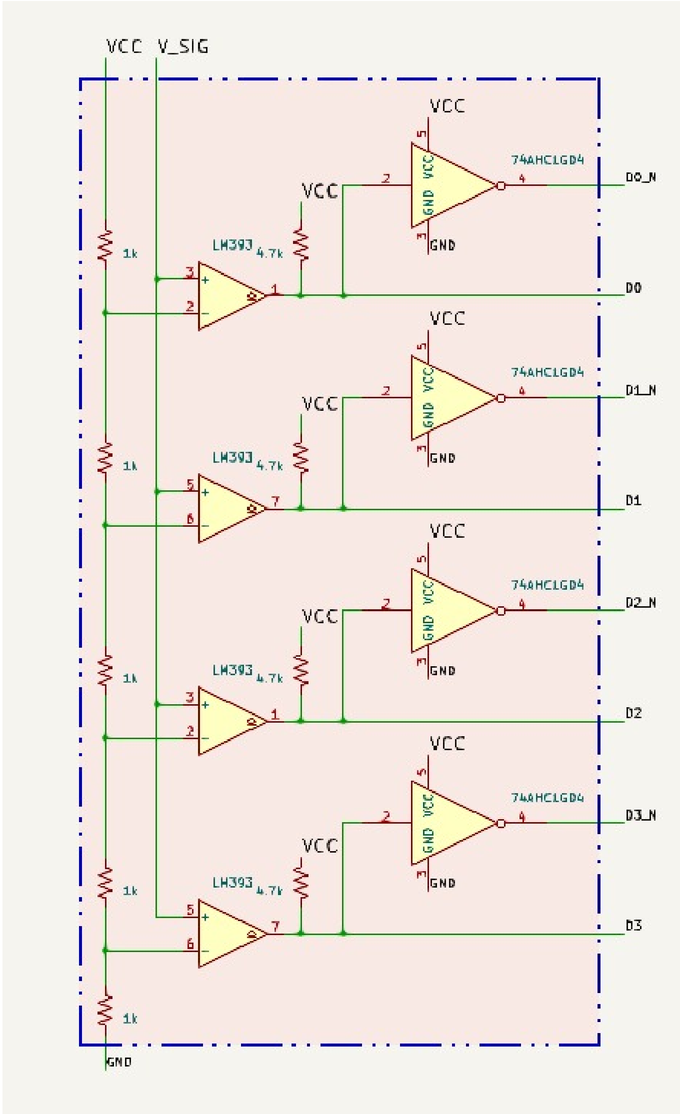

Figure 6: COMPARATOR

- $0V - 1V$: Represents the highest amount of rain.

The ADC used in this system is a flash-type ADC, known for its high-speed conversion and efficiency in real-time applications.

6 Motor Driver

6.1 Motor Driver Design Using Buck Converters and PMOS Transistors

In our custom built motor driver circuit, we have implemented **Buck Converter** in conjunction with four PMOS transistors (M_0, M_1, M_2, M_3). The gate terminals of these PMOS transistors are controlled by signals from the combinational logic block of the ADC. The **drain** of each PMOS transistor is connected to the **input of the buck converter,** while the source is connected to the **VCC** rail on the breadboard. This configuration ensures that when a gate signal is **active low**, when the corresponding PMOS transistor turns ON, allowing VCC to be supplied to the **buck converter**, thereby activating it.

We have incorporated **three buck converters** that step down the voltage to 4.5V, 4V, and 3.5V, respectively. Depending on the required operating condition, one of these voltages is transmitted to the **H-bridge,** which then drives the DC motor. Since the speed of a **DC motor** is directly proportional to the applied voltage, we have selected **five distinct voltage levels—5V, 4.5V, 4V, 3.5V, and 0V**—to control the motor speed efficiently.

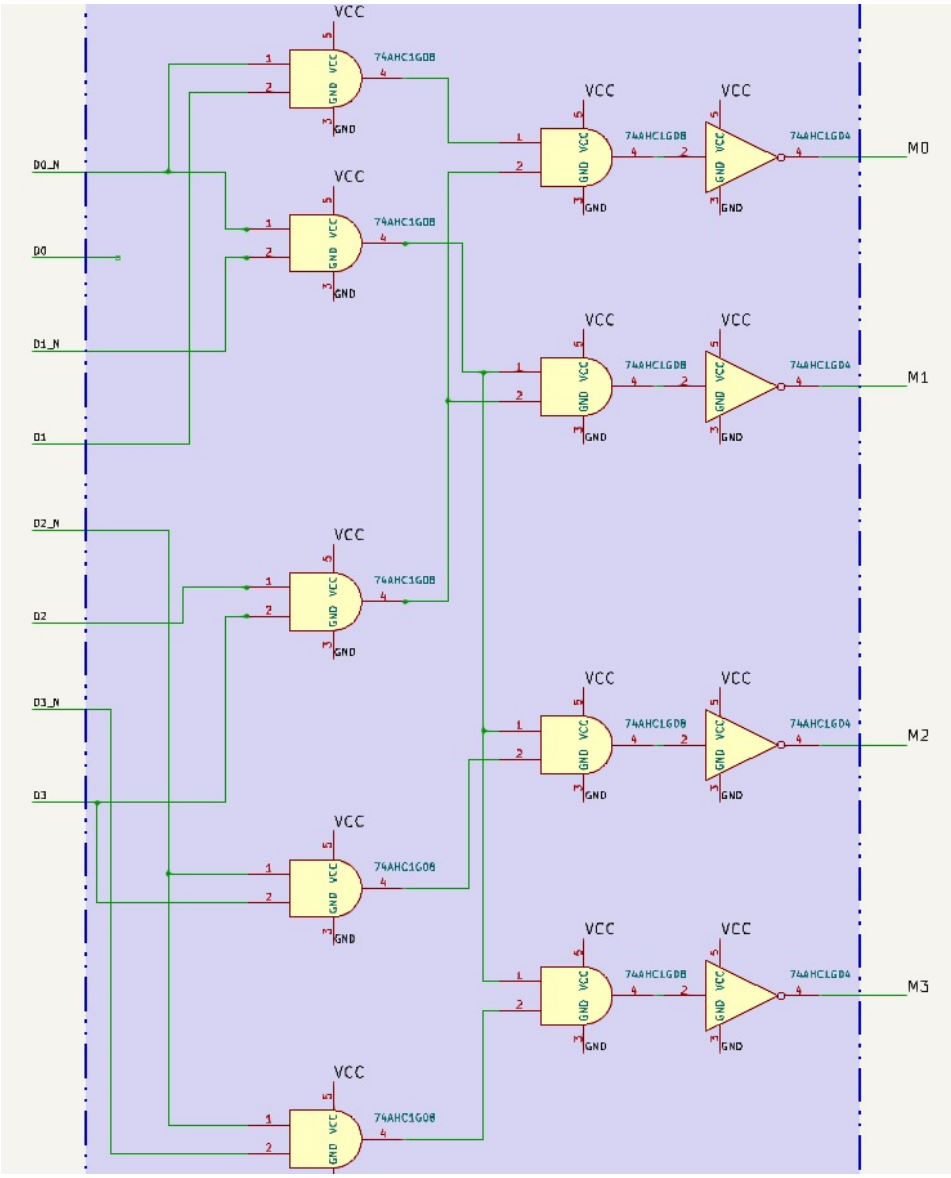

Figure 7: LOGIC CIRCUIT

One of the key advantages of using a **buck converter** in this design is its **exceptionally low power dissipation,** typically in the order of a **few hundred microwatts**. This makes the system highly efficient with minimal energy loss.

Additionally, we have chosen **PMOS transistors** over NMOS transistors for motor control. In an NMOS-based circuit, the **positive terminal (Vcc) remains continuously connected** to the motor, which can be detrimental. In contrast, a **PMOS-based circuit** ensures that the ground remains continuously connected to the motor, which is a safer and more reliable approach for motor operation.

This design provides efficient voltage control, minimal power dissipation, and enhanced motor protection, making it a robust solution for motor driver applications.

7 Switching Circuit

7.1 H-Bridge Motor Control Using a JK Flip-Flop

In our motor control circuit, we have implemented an **H-Bridge configuration** using **PMOS and NMOS transistors,** controlled by the output states of a JK flip-flop. The Q output of the JK flip-flop is connected to one set of PMOS and NMOS transistors, while the $\bar{Q}$ (complementary) output is connected to the other set.

V_{in} (V)	Inputs				Outputs			
	D_3	D_2	D_1	D_0	M_3	M_2	M_1	M_0
5 – 4	1	1	1	1	1	1	1	1
4 – 3	1	1	1	0	1	1	1	0
3 – 2	1	1	0	0	1	1	0	1
2 – 1	1	0	0	0	1	0	1	1
1 – 0	0	0	0	0	0	1	1	1

Figure 8: Truth Table for ADC decoder

Figure 9: Buck Converter

The operation of the motor is determined by the control signals 'A' and 'B':

- When $A = 1$ **and** $B = 0$**,** the motor rotates **clockwise.**, as the **PMOS on one side** and the **NMOS on the other side** are switched ON, establishing a specific current flow direction.
- When $A = 0$ **and** $B = 1$**,** the motor rotates **counterclockwise**.as the complementary set of **PMOS and NMOS transistors** are activated, reversing the current flow.

This **bidirectional motor control mechanism** ensures that when the wiper reaches **0 degrees or 180 degrees** on the windshield, the current flow reverses, allowing the wiper to change direction seamlessly.The **JK flip-flop-based switching logic** provides reliable and automatic control of the motor's movement, ensuring smooth and efficient operation of the wiper system.

The switching mechanism of our system is designed using **two Hall effect sensors**, an **AND gate**, and a **JK flip-flop** to enable precise control of the wiper movement.

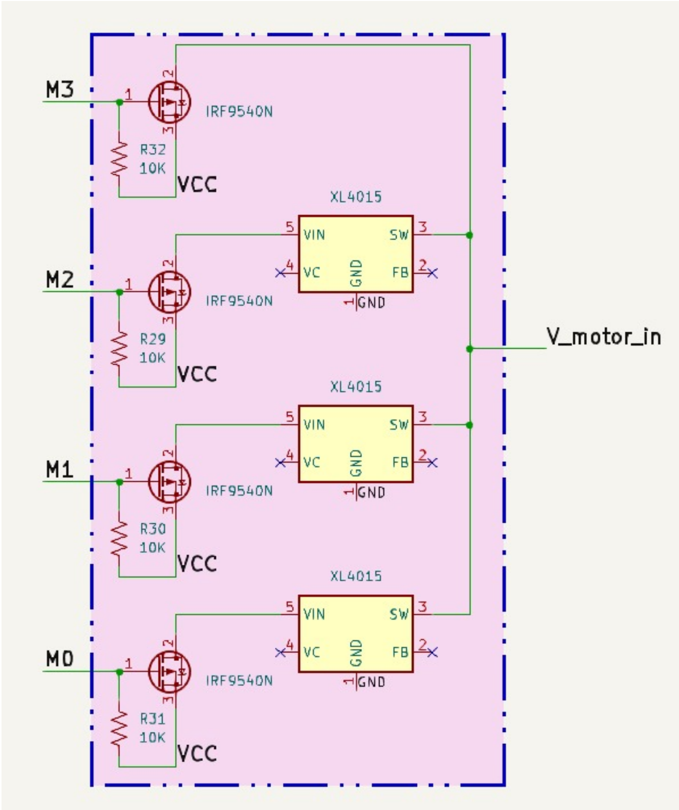

Figure 10: Buck Converter

7.2 Hall Sensor Operation

Each **Hall sensor** produces output of **HIGH** when no magnet is in front of it and **LOW** when a magnet is detected. A **magnet is attached to the back of the wiper,** and the Hall sensors are placed at **opposite corners** with the wiper positioned in the middle.

7.3 Logic Implementation

- The outputs of the **two Hall sensors** are fed into an **AND gate,** and the output of the AND gate serves as the **clock signal** for a **JK flip-flop,** where both **J and K inputs** are permanently set to 1 to ensure toggling behavior.

- Initially, when the wiper is positioned at an **angle to the horizontal,** both Hall sensors detect **no magnet** and output 1. This results in a **high (1) output** from the AND gate, providing a **clock signal (HIGH)** to the JK flip-flop.

- As the wiper moves and the magnet approaches one of the Hall sensors, the sensor's output changes to **LOW**. Consequently, the AND gate output also becomes **LOW**, causing a **falling edge trigger** on the JK flip-flop.

- This falling edge trigger toggles the JK flip-flop, **switching the values of Q (a) and $\bar{Q}$ (b).** These signals are then **fed into the H-Bridge, reversing the motor's direction, ensuring the wiper changes its movement when it reaches 0 degrees or 180 degrees.**

  This **automatic switching logic** ensures smooth and controlled bidirectional movement of the wiper, enhancing system reliability and efficiency.

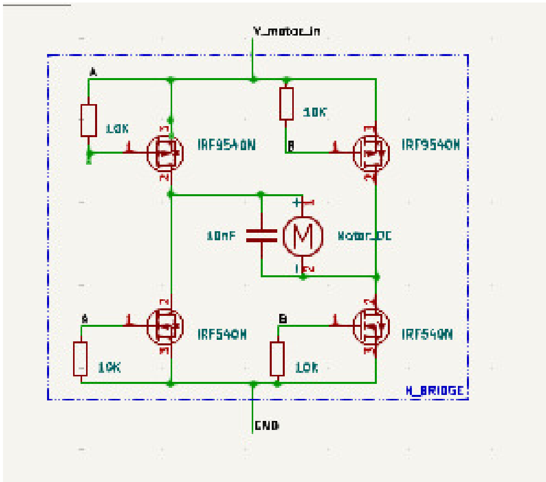

Figure 11: H Bridge

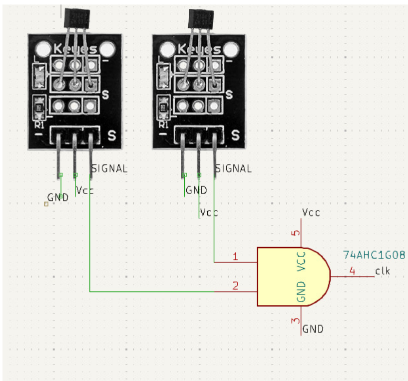

Figure 12: Hall Sensor

8 Speedometer

For the speedometer, an array of comparators is used with the V^- input of the comparators connected to a series of resistors that divide a voltage of $5V$ (V_{cc}), resulting in V^- inputs of the comparators to be $4.75V$, $4.35V$, $3.75V$, and $3.25V$ respectively.

Hence, upon receiving a voltage of $5V$, all the comparators will output V_{cc}, lighting up all the LEDs on the speedometer, indicating maximum speed. Upon receiving a voltage of $4.5V$, three of the LEDs will light up, indicating $\frac{3}{4}$ of the maximum speed. Similarly, for $4V$ and $3.5V$ cases, two LEDs and one LED will light up, respectively.

These comparator output signals will also go to the Arduino, which will move the needle of the speedometer to an appropriate degree to make it point at the most significant lit LED, which is distinct for each speed.

9 Estimated cost of project

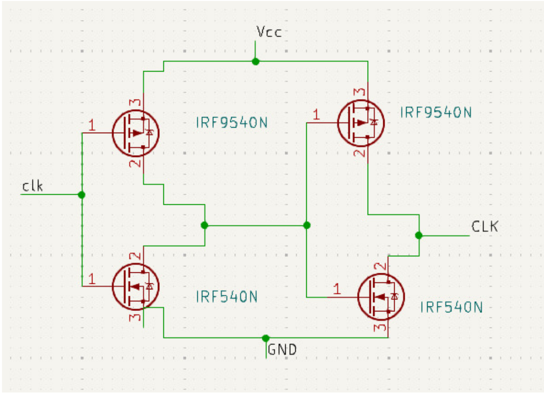

Figure 13: Buffer

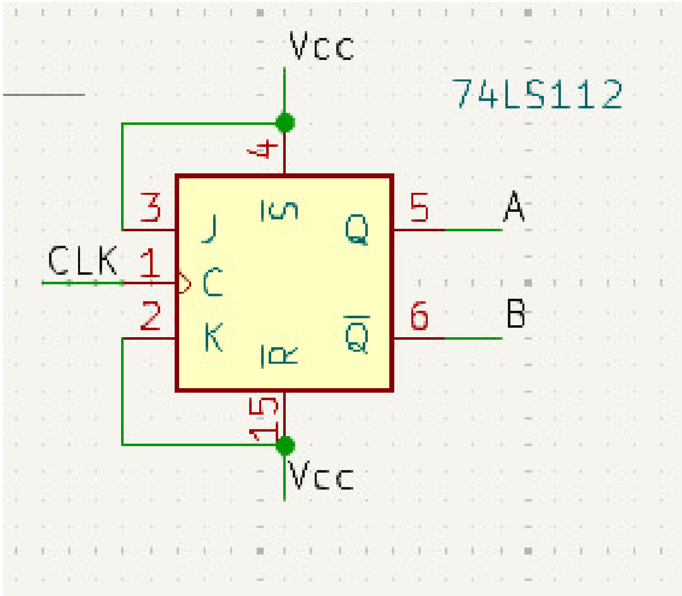

Figure 14: J K Flip Flop

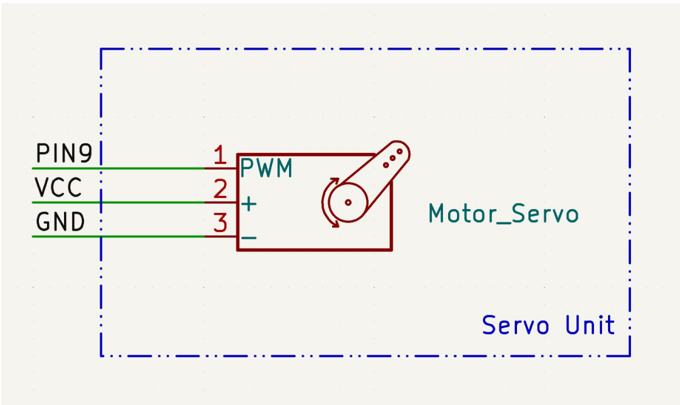

Figure 15: Servo Motor

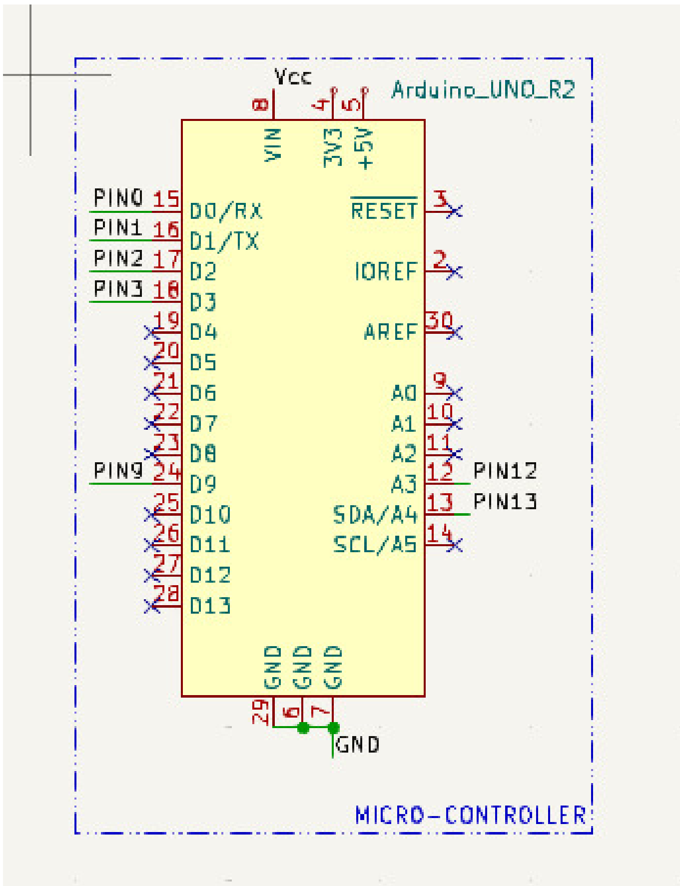

Figure 16: ARDUINO

Sr. No	**Item**	**Quantity**	**Price**
1	Buck Converter	3	207
2	Arduino Uno	1	218
3	AND ICs	3	140
4	OR ICs	1	40
5	JK FF ICs	1	15
6	NOT ICs	1	10
7	LM393 ICs	4	24
8	Rain Sensor	1	36
9	Hall Sensor	2	68
10	NMOS	4	86
11	PMOS	9	189
12	Breadboard	4	192
13	IR Sensor	1	22
14	Wires	-	100
15	DC Motor	1	59
16	Acrylic Sheet	1	60
17	LED	10	40
18	Resistor	200	175
19	Capacitor	1	6
		TOTAL SUM	**Rs 1687**

Table 1: List of Components with Quantity and Price