Electronics PS : Rain Rain Go Away

Hostel ID: 76

1 Introduction

We have implemented an automated rain-detection and wiper control mechanism that:

- Rotates the wiper upon rain detection
- Displays the speed level of the wiper based on the amount of rain falling

2 System Requirements

2.1 Block Diagram

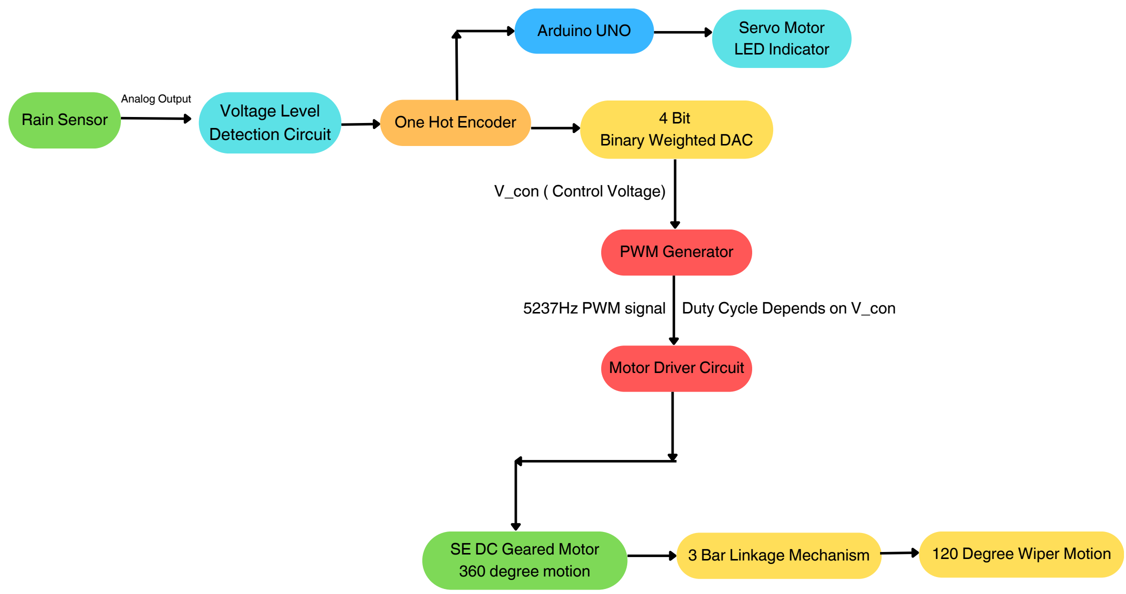

Figure 1: Schematic of the entire System

2.2 Hardware Components

The following tables list the active and passive hardware components used in this project.

2.2.1 Active Components

Table 1: Active Components List

Component	Quantity
Arduino UNO	1
Rain Sensor	1
SG-90 Servo Motor	1
SE Geared Motor (12V, 200 rpm)	1
Blue LEDs	4
7408 IC	2
7404 IC	1
7432 IC	1
LM741	5
LM324	2
IRF9540N	1
1N4007	1

2.2.2 Passive Components

Table 2: Passive Components List

Resistor Value	Quantity
100 Ω	2
120 Ω	1
220 Ω	2
240 Ω	3
330 Ω	1
868 Ω	1
910 Ω	1
1 kΩ	3
2.2 kΩ	1
10 kΩ	3
110 kΩ	1
330 kΩ	1

Component	Quantity
0.005 μF Capacitor	1

2.3 Input

- Rain Sensor: 5V DC power supply

2.4 Signal Processing Stage

- Comparator (LM324): 9V DC Power Supply
- AND(7408), OR(7432), NOT(7404) gates: 4.43V DC Power Supply
- LM741 and LM324 op amps: ±12V (In PWM generator circuit)

2.5 Output Stage

- NMOS Source Supply: 12V

3 Circuit Design

3.1 Rain Sensor Control Circuit

3.1.1 Voltage Level Detection

Uses LM324 quad comparator with reference voltages set for 4 threshold levels. Compares sensor output with reference voltages and generates digital outputs based on voltage thresholds.

3.1.2 Threshold Levels

- Level 1: 5-4.43 V
- Level 2: 4.43-3.72 V
- Level 3: 3.72-3.17 V
- Level 4: 3.17-0 V

3.1.3 One-Hot Encoding Implementation

Logic Configuration ensures only one output is kept active (HIGH/5V) at any time while all other outputs remain LOW (0V).

Output States:

- State 1: [5 0 0 0] - Highest water level
- State 2: [0 5 0 0] - Medium-high level
- State 3: [0 0 5 0] - Medium-low level
- State 4: [0 0 0 5] - Lowest water level

3.2 Control Circuit

We have implemented a 4-bit Binary Weighted Digital-to-Analogue Converter, which uses an Inverting Summing Amplifier Circuit using LM741 op amps.

$$V_{\text{OUT}} = -\left[\frac{R_F}{R_4}V_D + \frac{R_F}{R_3}V_C + \frac{R_F}{R_2}V_B + \frac{R_F}{R_1}V_A\right]$$

Where V_A, V_B, V_C, and V_D are the one-hot encoded input signals and R_A, R_B, R_C and R_D are the corresponding weighted resistors.

A triangular waveform is generated using a 0.005 μF capacitor and LM741 op amps which is then put through a comparator IC with V_{OUT} being the reference voltage. The frequency of the PWM signal is 5237 Hz. By controlling this reference voltage, we can effectively control the duty cycle of the PWM signal generated in the output of the comparator.

The circuit can generate the following signals:

- 74.6% Duty Cycle - Highest water level
- 59.4% Duty Cycle - Medium-high level
- 57% Duty Cycle - Medium-low level
- 52% Duty Cycle - Lowest water level

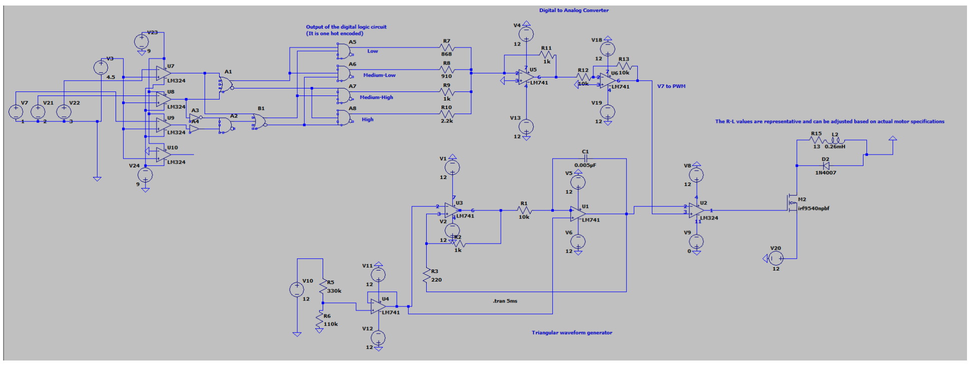

Figure 2: Entire circuit(excluding arduino part)

3.3 Speed Indicator Circuit

The output of the rain sensor output circuit is also used to indicate the speed of the motor. Depending on which speed level the motor is, a servo motor is controlled in a 180 degree fashion along with LED lights arranged in a semicircular fashion. We used an Arduino UNO microcontroller for this process, which takes in input from the one-hot encoder.

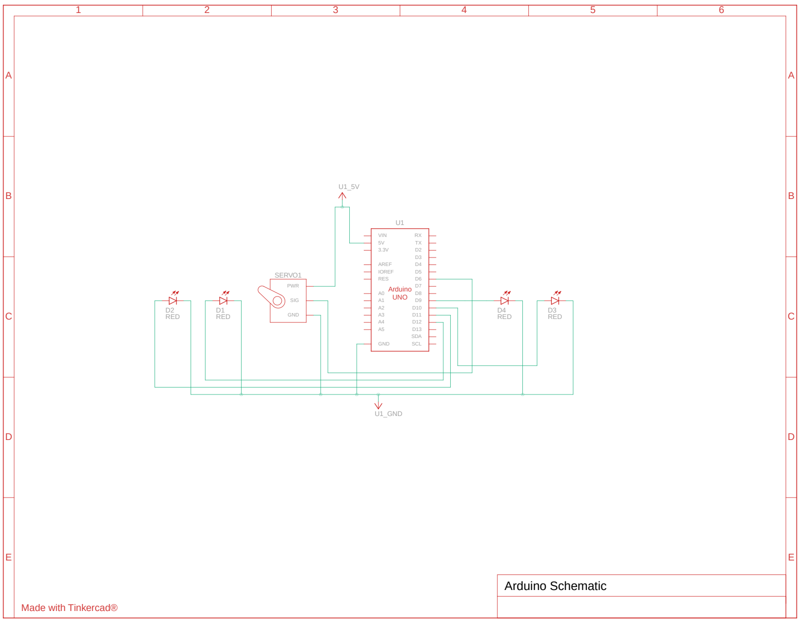

Figure 3: Schematic of the Speed Indicator Circuit, D_1, D_2, D_3 and D_4 are the digital inputs

3.4 Motor Driver Circuit

We have used a SE DC geared motor rated 12V-200RPM. The DC motor is controlled by a high-side P channel MOSFET (IRF9540N) motor driver.

When PWM signal is LOW:

- MOSFET turns ON
- Current flows through motor, powering it

When PWM signal is HIGH:

- MOSFET turns OFF
- Flyback diode conducts motor's inductive current, providing a path for energy dissipation

4 3-Bar Linkage Mechanism

In our design, a 3-bar linkage mechanism is implemented to convert the motor's 360° rotation into a 120° oscillatory motion of the wiper. This mechanism is effective for achieving the desired angular displacement, ensuring smooth and efficient wiper operation. The three bars consist of:

- Input Link: Connected to the motor shaft, providing a full 360° rotation.

- Coupler Link: Transfers motion from the input link to the output link while reducing the angular displacement.
- Output Link: Directly connected to the wiper arm, producing the required 120-degree oscillatory motion.

The mechanism leverages precise geometry and linkage ratios to achieve this conversion. Figure 4 illustrates the schematic representation of the 3-bar linkage mechanism used in the project.

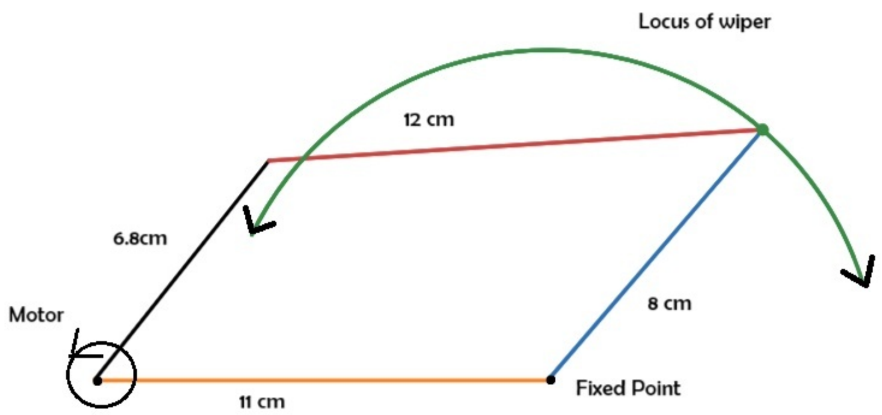

Figure 4: Schematic of the 3-Bar Linkage Mechanism converting 360° motor rotation to 120° wiper motion.