A PROJECT REPORT ON

Automated Chemical Mixer

SUBMITTED BY

Aditya Avinash Bodhi

UNDER THE GUIDANCE OF

Prof. Kapil Chaurasiya:

Department of Robotics & Mechatronics

**INSTITUTE FOR DESIGN OF ELECTRICAL
MEASURING INSTRUMENTS**
SWATANTRAVEER TATYA TOPE MARG, CHUNABHATTI, SION, MUMBAI-400022

CERTIFICATE

This to certify that

Aditya Avinash Bodhi

has undertaken this project **"Automated Chemical Mixer"** under our guidance as prescribed by the IDEMI, as the curriculum for the Diploma in Robotics & Mechatronics for the academic year 2024-2025.

Project Guide: **HOD**

Prof. Kapil Chaurasiya **Robotics & Mechatronics**

Examiner

Date -___________

DECLARATION

We declare that this written submission represents our ideas in our own words and where others' ideas and words have been included. We have adequately cited and referenced the original sources. We also declare that we adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from then sources which have thus not been properly cited or from whom proper permission has not been taken when required.

Aditya Bodhi

Acknowledgement

It is our privilege to express our sincerest regard to our project guide **Prof. Kapil Chaurasiya,** who gave us the golden opportunity to do this wonderful project on the topic Automated Chemical Mixer for his valuable inputs, guidance and encouragement, whole-hearted cooperation and constructive criticism throughout the duration of our project. We deeply express our sincere thanks to our HOD of Robotics & Mechatronics for encouraging and allowing our department premises for the partial fulfilment of the requirements. We also extend our deepest gratitude to all the esteemed faculty members and dedicated workers who credited their invaluable expertise and support to this project. Last but not the least we express our sincere thanks to all our friends and our parents who have patiently extended all sorts of help for accomplishing this undertaking.

Project Details

Project Name: Automated Chemical Mixer

Group Members:

Sr. no	Name	Enrolment no.
1	Vinayak Renukdas	2111011
2	Aditya Bodhi	2211011
3	Ghananshu Desale	2212025

Branch: Robotics & Mechatronics

Year: Third (Final)

Semester: Sixth

College Name: Institute for Design of Electrical Measurement Instruments

Assigned Faculties: Prof. Kapil Chaurasiya

Project Duration: January 2025 – June 2025

Table of content

Bill of material

Sr. no.	Component	Quantity	Price (₹)
1	ESP32 devkit V1	1	350
2	L298N motor driver module	1	180
3	16 x 2 LCD module	1	89
4	I2C module	1	46
5	4x 4 matrix keypad	1	145
6	GPIO expander module	1	83
7	R385 pump	2	298
8	Geared motor	1	120
9	5V Relay Module	1	32
10	Printed circuit board	5	2880
Total			**4218**

Aim of the Project

Our project's primary goal was to advance our technical skills and knowledge while contributing to societal welfare. This project is budget friendly as well as beginner friendly from the perspective of someone who wants to learn about robotics and mechatronics. The emphasis was on expanding our knowledge and skills in mechanical, electronic and software engineering aspects.

Initiation of the Idea

The idea for this project was conceived with the intent to develop a practical yet innovative solution to simplify chemical mixing process for farmers. Observing the increasing demand for automation and efficiency in the agricultural industry, we aimed to design a versatile chemical mixer that integrates basic mechatronics principles. The concept evolved from the desire to create a functional prototype that not only showcases technical feasibility but also serves as an educational tool for aspiring engineers. The focus was on using readily available and budget-friendly components to ensure accessibility and replicability for beginners in the field.

Key Factors of Consideration

Control System: A robust control system was implemented to manage the operation of all components. It ensured precise coordination and smooth functionality.

Programming: The mixer was programmed with logical algorithms for pump control, user input, live display and mixing. The code was designed to be efficient, modular, and easy to debug.

Power Supply Management: Efficient power management was prioritized to maintain consistent performance and ensure that all components operated reliably within their power limit.

Mechanical Design: The mixer's mechanical design was optimized for sturdiness, portability and durability.

Modular Integration: The system was built with modularity, enabling easy replacement or upgrading of individual components without affecting overall functionality.

Process of Making

Conceptualization: The project began with brainstorming ideas for automated chemical mixer, focusing on its functionality to pour two different liquids with precise measurements that will be input by the user and the solution will be mixed inside a mixing container for amount of time input by user.

Design: In the design phase, we created a detailed block diagram of the mixer's control system. This diagram helped in understanding how each component would interact with others, providing a clear roadmap for the system's functionality. Based on the design, we could visualize the necessary features and functions, which guided the selection of specific components.

Component Selection: Once the control system was mapped out, we moved to selecting the appropriate components. We carefully chose pumps, motor, the microcontroller, and other electronic components based on their compatibility and functionality. The goal was to ensure seamless communication between all parts, balancing performance with budget.

PCB Design: components We designed a printed circuit board for our project using the Easy EDA software where all the important components will be placed, this PCB will serve as the control panel of our project.

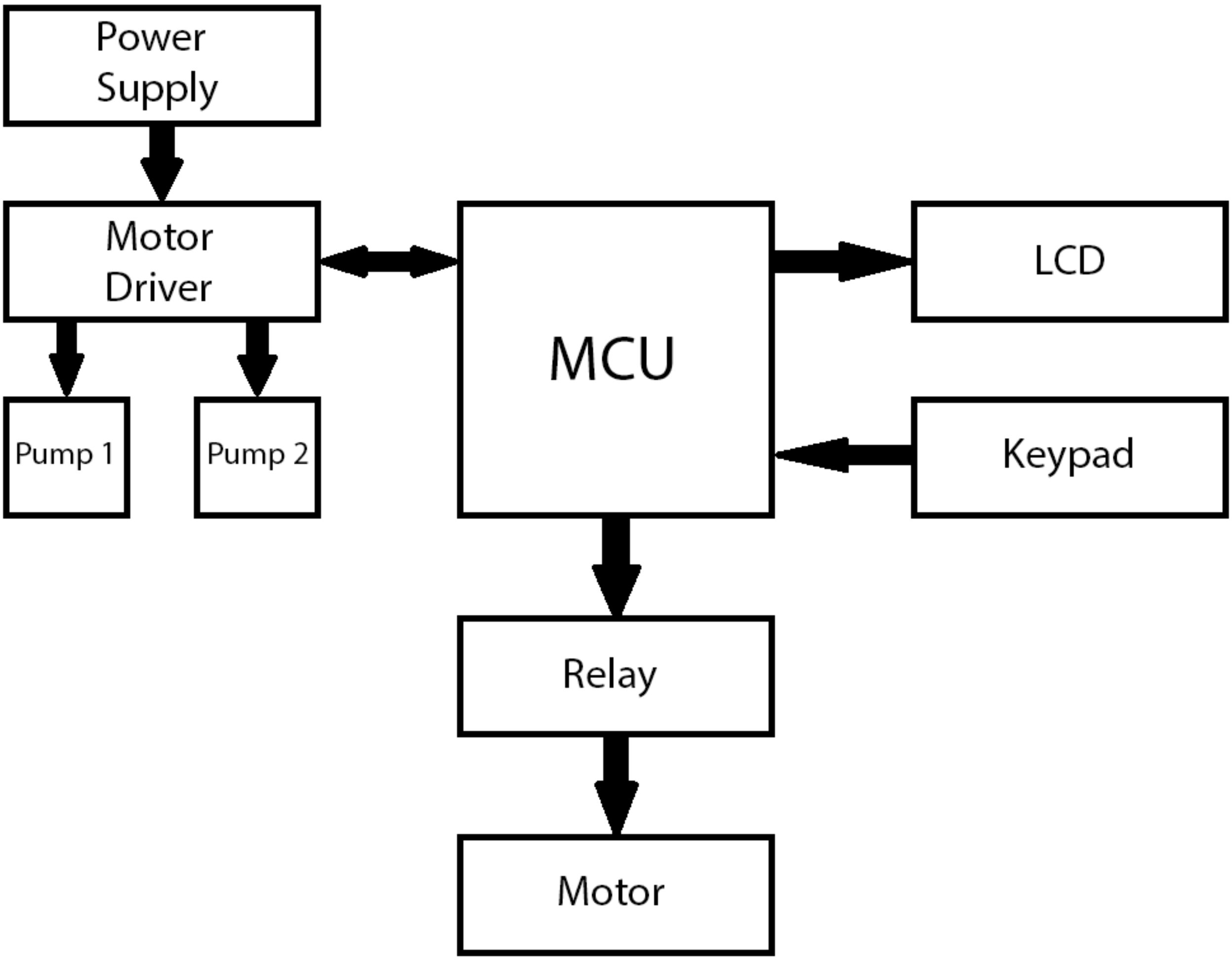
Assembly: With all the components ready, we began assembling the mixer. This step involves placing all the components like the ESP32, for LCD for volume and time display and keypad for user input, creating control panel.

Programming: After the assembly, we moved on to the programming phase. We first wrote and tested individual programs for each component, such as pump control, LCD display, keypad input etc. Then we integrated two or more components, for example LCD display with keypad input.

Testing & Troubleshooting: With the system assembled and programmed, we conducted extensive testing. Each component was tested separately to ensure functionality, and then the entire system was tested as a whole. We observed how the components interacted, verifying that the system behaved as expected. Any issues, such as design flaws, loose connections, or programming errors, were promptly identified and resolved through troubleshooting.

Documentation: Throughout the process, we maintained thorough documentation. This included detailed notes on the design, assembly steps, component selection, wiring diagrams, and programming. Additionally, a comprehensive user manual was created to guide future users in building, using, and maintaining the robot.

Block Diagram



Electronic Components

ESP32 Devkit V1

The ESP32 Devkit V1 is a development board that consists of the ESP32 WROOM 32 Module. The ESP 32 WROOM 32 is a powerful, generic Wi-Fi + BT + BLE MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming and MP3 decoding. At the core of this module is the ESP32-D0WDQ6 chip*. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the clock frequency is adjustable from 80 MHz to 240 MHz. The user may also power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds. ESP32 integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, low-noise sense amplifiers, SD card interface, Ethernet, high speed SPI, UART, I2S and I2C.

In this project, The ESP32 serves as the brain of the system. It controls the operation of the L298N motor driver, the LCD display, the keypad and the relay module. (1)

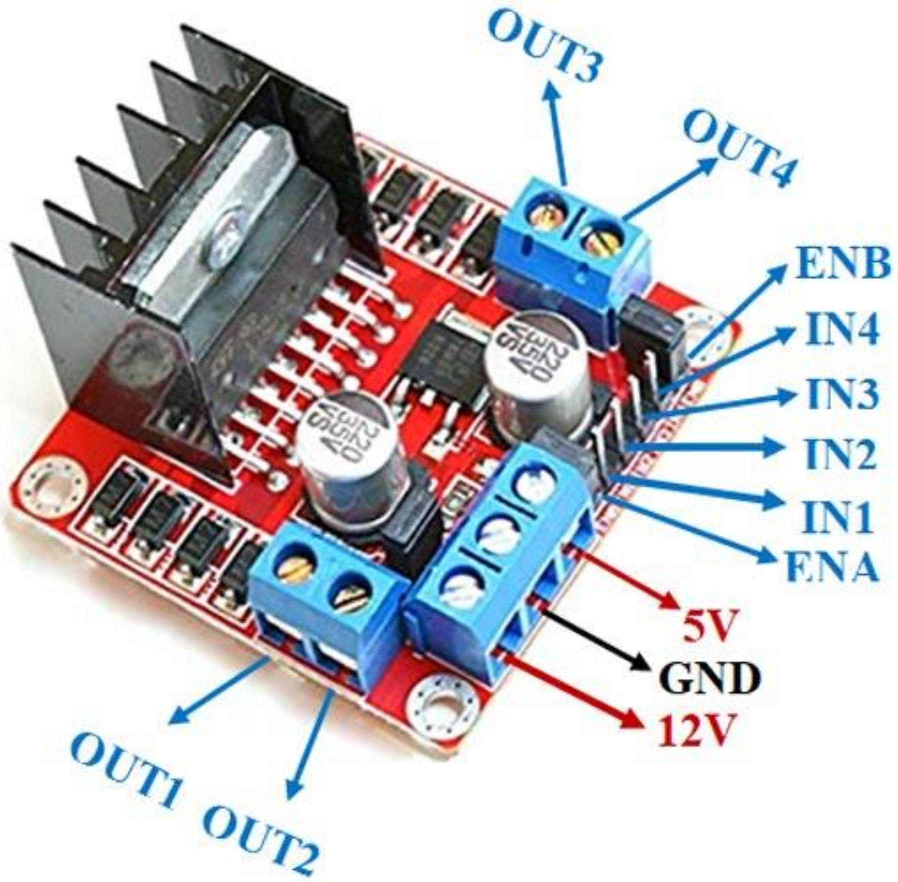
Specifications

Feature	Items	Details
Wi-Fi	RF certifications	FCC/CETELEC/KCC/SRRC/NCC
	Protocols	802.11 b/g/n/e/i (802.11n up to 150 Mbps)
		A-MPDU and A-MSDU aggregation and 0.4 µs guard interval support
	Frequency range	2.4 ~ 2.5 GHz
Bluetooth	Protocols	Bluetooth v4.2 BR/EDR and BLE specification
	Radio	NZIF receiver with -97 dBm sensitivity
		Class-1, class-2 and class-3 transmitter
		AFH
	Audio	CVSD and SBC
Hardware	Module interface	SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I2S, IR
		GPIO, capacitive touch sensor, ADC, DAC, LNA preamplifier
	On-chip sensor	Hall sensor, temperature sensor
	On-board clock	40 MHz crystal
	Operating voltage/Power supply	2.7 ~ 3.6V
	Operating current	Average: 80 mA
	Minimum current delivered by power supply	500 mA
	Operating temperature range	-40°C ~ +85°C
	Ambient temperature range	Normal temperature

	Package size	18±0.2 mm x 25.5±0.2 mm x 3.1±0.15 mm
Software	Wi-Fi mode	Station/SoftAP/SoftAP+Station/P2P
	Wi-Fi Security	WPA/WPA2/WPA2-Enterprise/WPS
	Encryption	AES/RSA/ECC/SHA
	Firmware upgrade	UART Download / OTA (download and write firmware via network or host)
	Software development	Supports Cloud Server Development / SDK for custom firmware development
	Network protocols	IPv4, IPv6, SSL, TCP/UDP/HTTP/FTP/MQTT
	User configuration	AT instruction set, cloud server, Android/iOS app

L298N Motor Driver Module

This dual bridge bi-directional motor driver, is based on the very popular L298 Dual H-Bridge Motor Driver Integrated Circuit. The circuit will allow you to easily and independently control two pumps of up to 2A each in both directions. It is ideal for robotic applications and well suited for connection to a microcontroller requiring just a couple of control lines per motor. It can also be interfaced with simple manual switches, TTL logic gates, relays, etc. This board equipped with power LED indicators, on-board +5V regulator and protection diodes. (2)

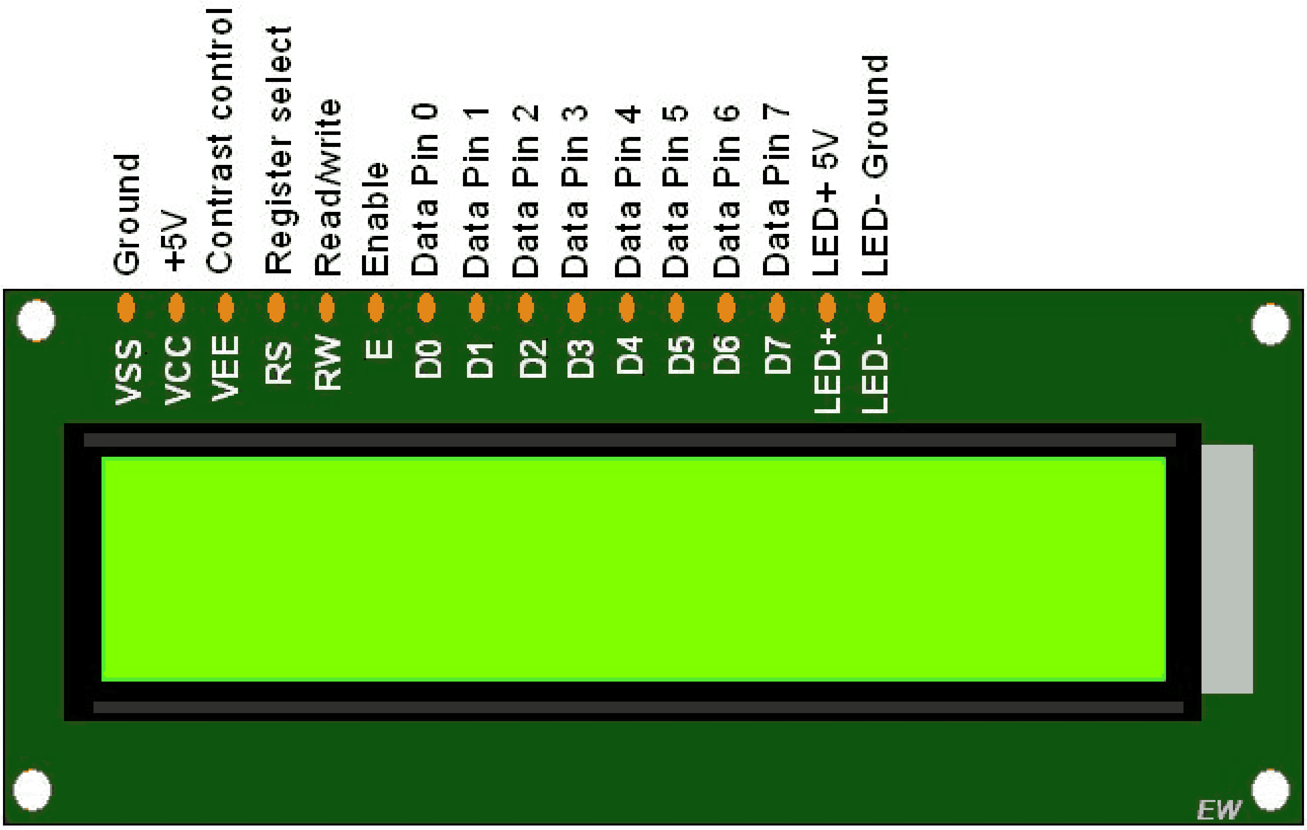


Specifications

Feature	**Details**	
Input voltage	3.2V - 40V DC	
Driver	L298N Dual H Bridge DC Motor Driver	
Peak current	2A	
Operating current range	0 – 36mA	
Control signal input voltage range	Low	High
	-0.3V ≤ Vin ≤ 1.5V.	2.3V ≤ Vin ≤ Vss.
Enable signal input voltage range	Low	High
	-0.3 ≤ Vin ≤ 1.5V	2.3V ≤ Vin ≤ Vss
Max power consumption	20W	
Storage temperature	-25 ℃ ~ +130 ℃	
Dimensions	44.00 x 44.00 mm	

16x2 LCD Module

A 16x2 LCD (Liquid Crystal Display) is a common alphanumeric display module. Here, “16” refers to the number of characters in a line and “2” refers to the number of character lines. There for the 16x2 module can display total of thirty-two characters, sixteen characters per line. It is paired with an I2C module to reduce the number of pins required on the ESP32 development board. In this project the LCD will be used to display things like the volume selection menu, the mixing time menu, the mixing time countdown etc. (3)

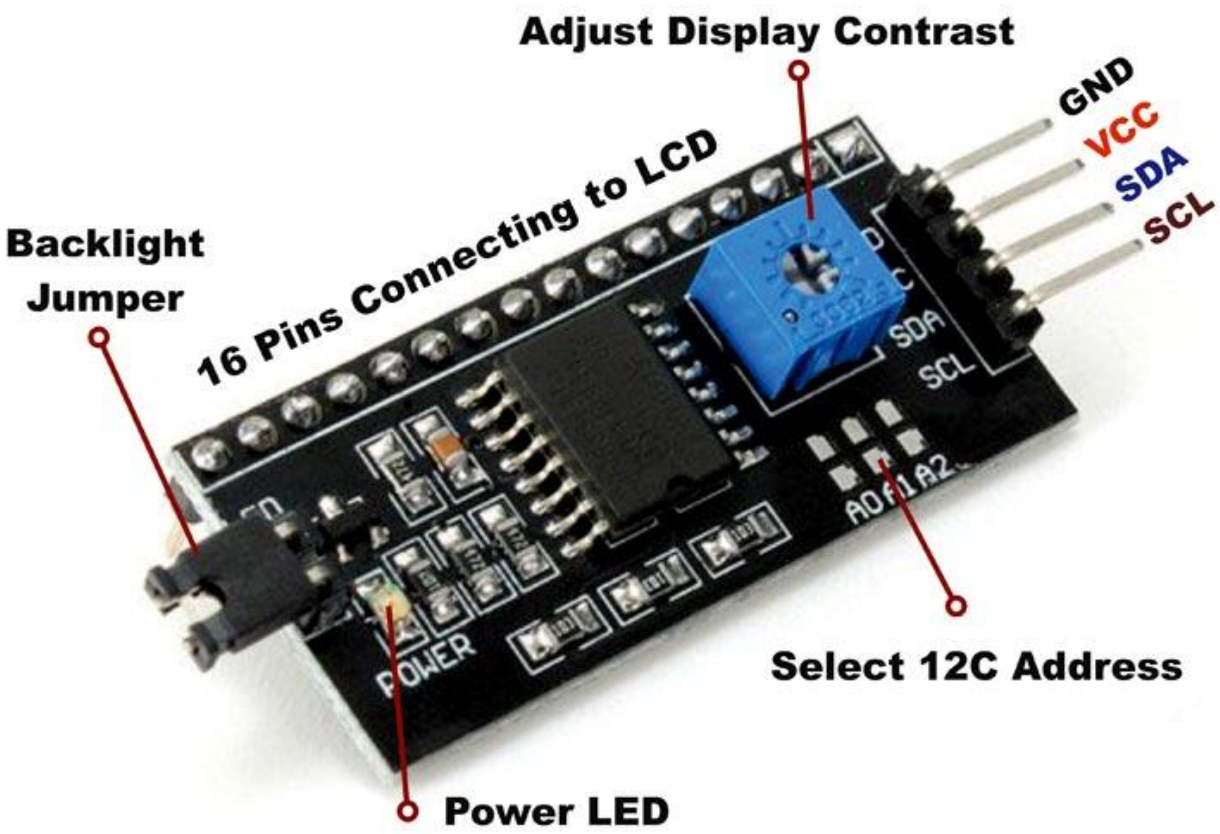


Specifications

Feature	Details
Display format	16 x 2 characters
Input voltage	5V DC
Duty cycle	1/16
Viewing area	66.0 x 16.0 mm
Dot size	0.55 x 0.65 mm
Dot pitch	0.60 x 0.70 mm
Character size	2.95 x 5.95 mm
Dimensions	80.00 x 36.00 mm

I2C Module

The I2C (Inter-Integrated Circuit) module used with a 16x2 LCD display is a small add-on board that enables communication between a microcontroller (like an Arduino, ESP 32, or Raspberry Pi) and the LCD using the I2C communication protocol, which significantly reduces the number of required GPIO pins. In this project, we have connected the LCD module to the I2C module and the I2C module is connected to ESP 32 to control the display of the LCD module. The I2C module consists of a potentiometer to adjust the contrast of the LCD's display, so that an external potentiometer is not required. (4)

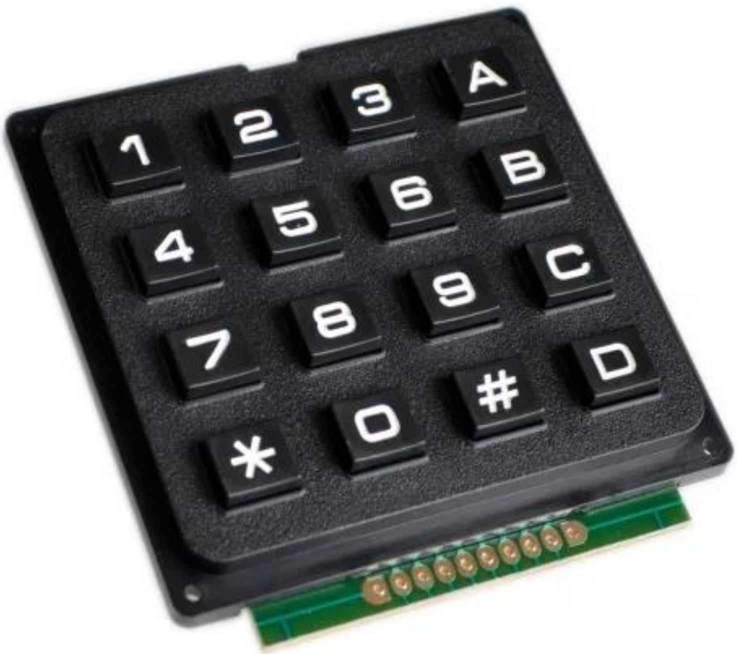


Specifications

Feature	Details
Chip	PCF8574
I2C protocol	Compatible with standard I2C (100kHz) and Fast I2C (400kHz)
Operating voltage	5V DC
Dimensions	42.00 x 19.00 mm

4x4 Matrix Keypad Module

The 4x4 matrix keypad module is an input device that consists of 16 push buttons arranged in 4 rows and 4 columns, forming a grid. This keypad allows the user to interact with the system and give input. In this project we have used this keypad module to interact with the mixer, selecting the volume of the liquid that needs to be dispensed and setting the duration for mixing. They keypad is paired with a GPIO expander that helps in reducing the number of pins required on the ESP 32 development board. (5)

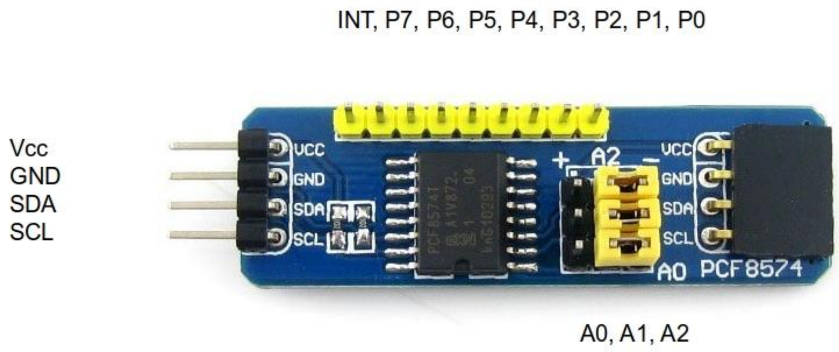


Specifications

Feature	Details
Number of keys	16
Key layout	0 – 9, A – D, *, #
Key type	Tactile push button
Switch type	Normally open
Operating voltage	3.3 V
Operating current	< 1 mA per key press
Dimensions	65.00 x 69.00 mm

GPIO Expander Module

The GPIO expander is an I2C based device that reduces the number of pins being used. It incorporates the PCF8574 IC. It is paired with the 4 x 4 matrix keypad module to reduce the number of pins being used on the ESP 32 from eight pins to four pins. (6)

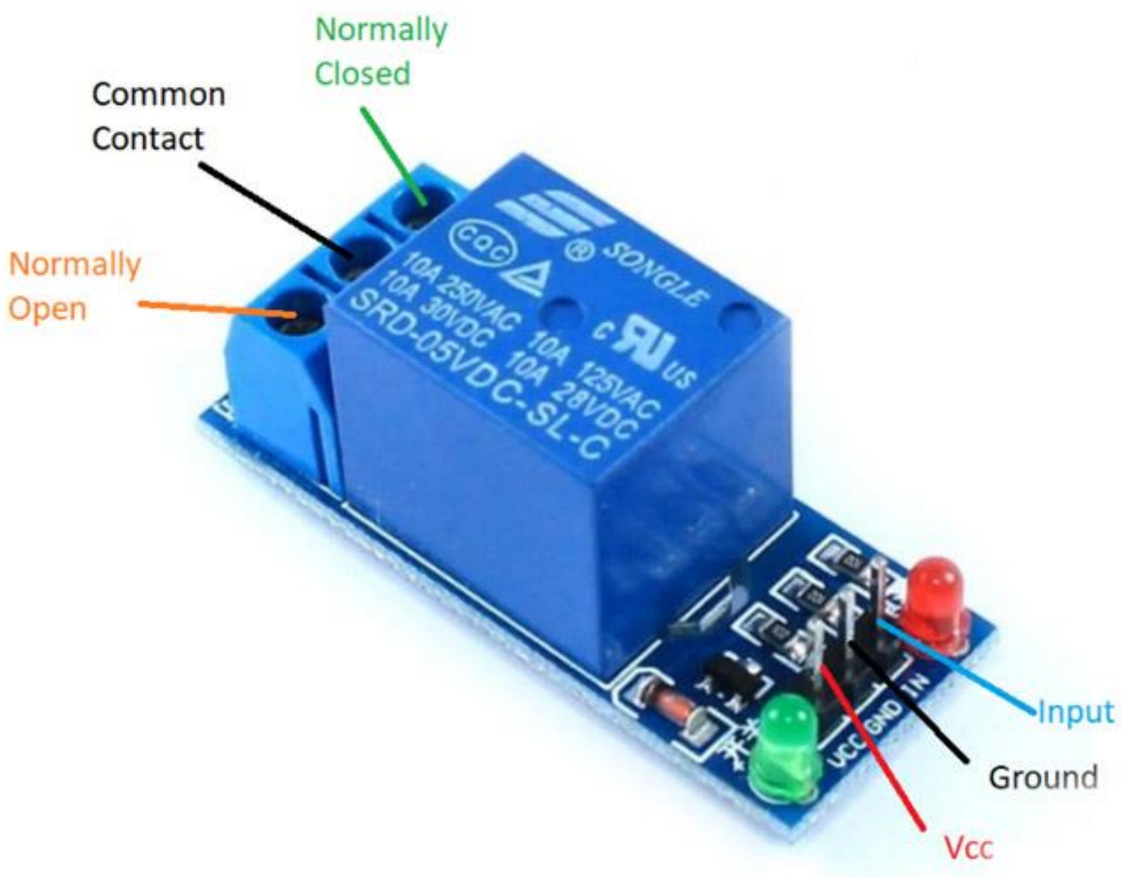


Specifications

Feature	Details
Chip	PCF8574
I2C protocol	Compatible with standard I2C (100kHz) and Fast I2C (400kHz)
Operating voltage	5V DC
Dimensions	42.00 x 19.00 mm

Relay Module

Relay is an electromechanical device that uses electric current to open or close the contacts of a switch. The single-channel relay module is much more than just a plain relay, it comprises of components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active or not. In this project, the relay is used to control the operation of the mixing motors. (7)



Specifications

Feature	Details
Supply voltage	3.75 V – 6 V
Quiescent current	2 mA
Active relay current	70 mA
Maximum contact voltage	250 V AC or 30 V DC
Maximum current	10 A
Dimensions	46.0 x 17.5 mm

R385 Pump

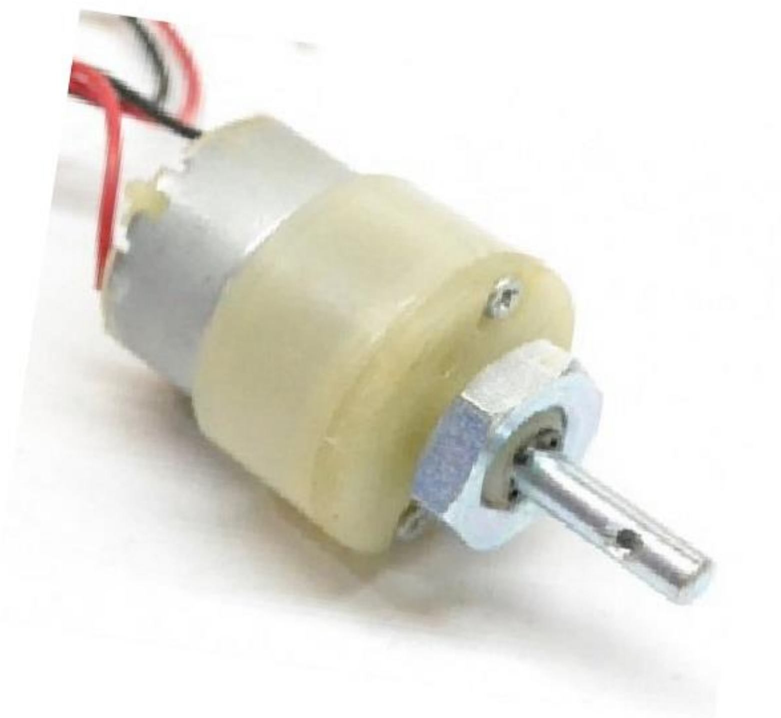
The R385 pump is water pump powered by a 12V DC motor. The motor is connected to a diaphragm via a cam, as the cam rotates it causes the diaphragm to move up and down or in and out to pump water. The pumping mechanism is housed inside a plastic casing. In this project, we have used two R385 pumps to pump the liquid from the source container to the mixing container. The operation of the pumps is controlled by the L298N motor driver. (8)

Specifications

Category	Specifications	
Rated voltage	9V to 12V DC	
Load current	0.7A	
Max current	2A	
Power rating	4W - 7W	
Flow	1.5 - 2 L/min	
Max lift	3m	
Max suction	2m	
Max water temperature	70 °C	
Input/output tube diameter	Outer	Inner
	8.5 mm	6 mm
Dimensions	Motor	Pump
	52.00 x 39.00 mm	42.50 x 46.00 mm

Geared Motor

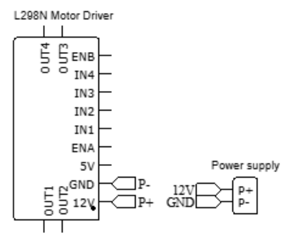
The motor that we used in this project is for rotating the stirrer for mixing is a 100 RPM geared DC motor, it has a voltage rating of 12 V and it spins at a moderate speed and provides enough torque for stirring more viscous chemicals. The shaft of the motor has a socket wrench attachment that fits perfectly onto the stirrer of the mixing container which is an m6 bolt. The motor is turned on and off with the help of the relay. (9)



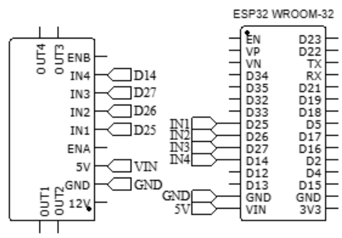
Specifications

Feature	Details	
Voltage rating	12 V DC	
No load current	800 mA	
Output speed	100 RPM	
Base motor speed	18000 RPM	
Shaft dimension	Length	Diameter
	22.00 mm	6.00 mm
Gearbox dimensions	Length	Diameter
	21.50 mm	37.00 mm
Base motor dimensions	Length	Diameter
	20.00 mm	32.00 mm

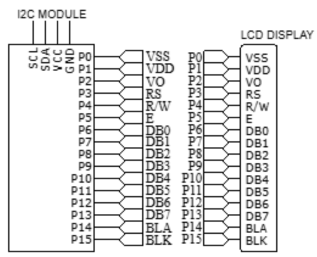
Schematic



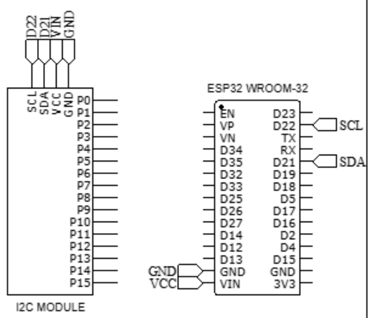
Power Supply - Motor Driver Circuit



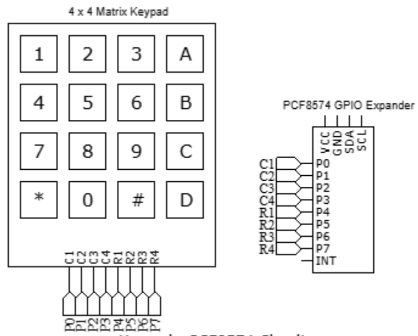
Motor Driver - ESP32 Circuit



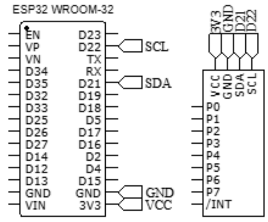
LCD - I2C Circuit



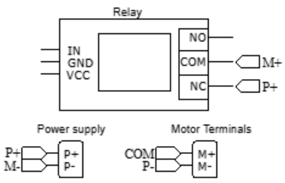
I2C - ESP32 Circuit



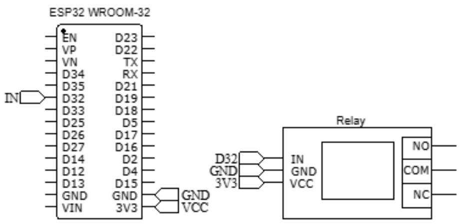
Keypad - PCF8574 Circuit



ESP32 - PCF8574 Circuit



Motor Circut



ESP32 - Relay Circuit

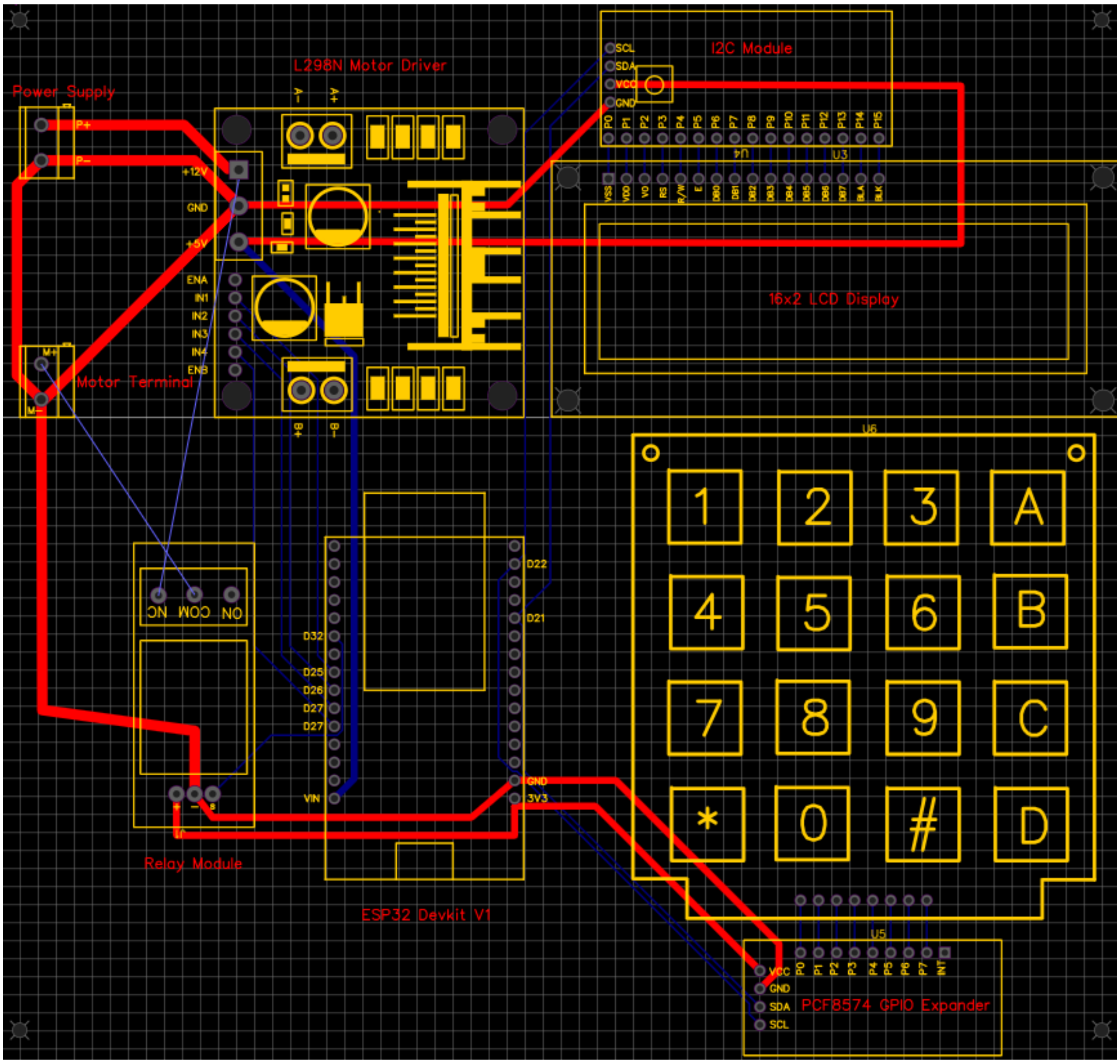
PCB Design & Fabrications

With the schematic diagram given above we designed a PCB using the EasyEDA software. Then we sent the Gerber file to a local PCB manufacturer for PCB fabrication. We designed the PCB layout to resemble a control panel, containing all the important components in this circuit but focusing on the lcd and keypad specifically. The other components that it consists of are ESP 32 devkit V1, L298N motor driver and the relay module.

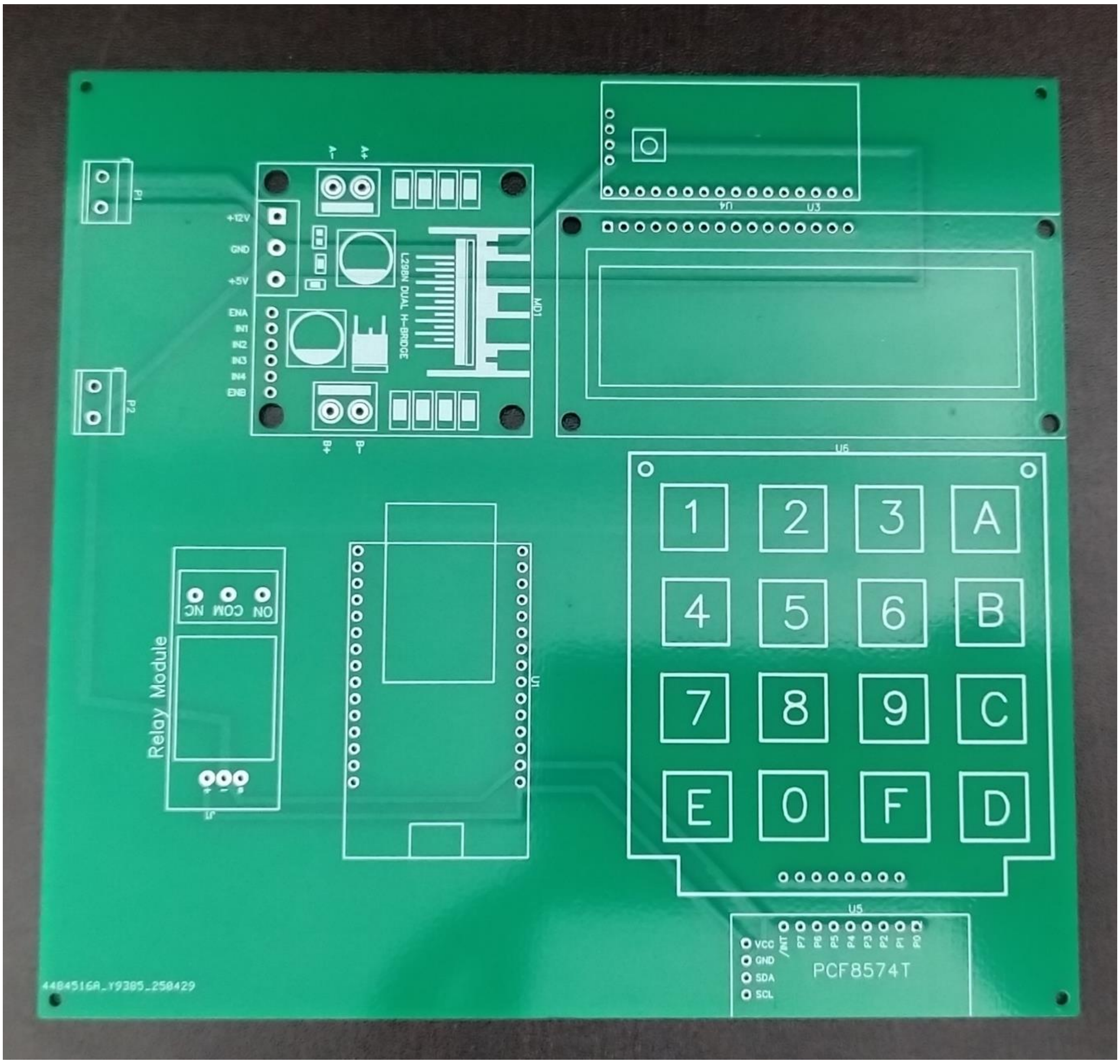
PCB Specifications

Category	**Specification**
Base material	FR-4
Number of layers	2
Thickness	1.6 mm
Dimensions	157.48 x 147.32 mm
Colour	Green
Surface finish	HASL
Track width	1.500 mm, 1.000 mm, 0.254 mm

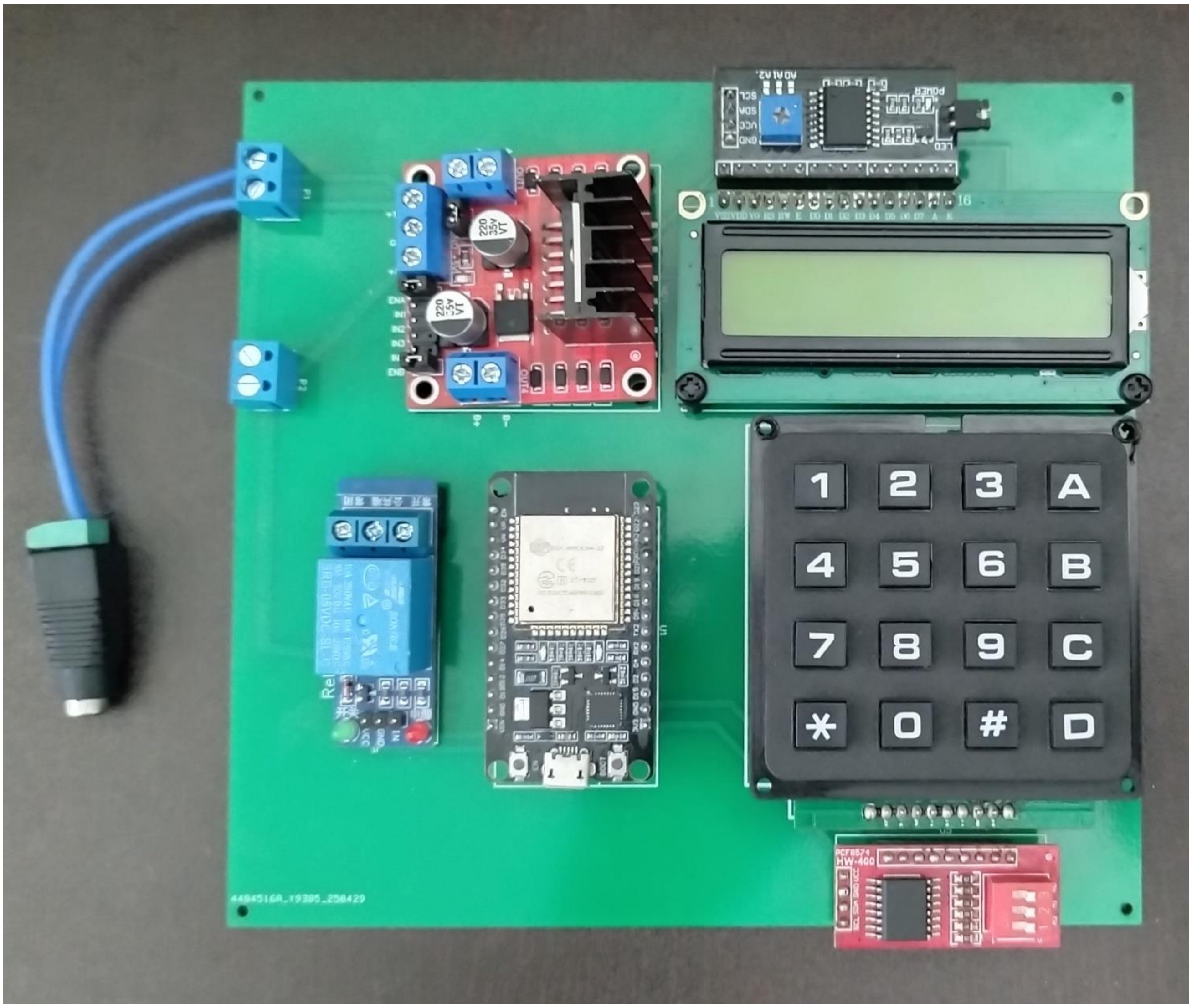
PCB Layout


Power Supply
L298N Motor Driver
I2C Module
16x2 LCD Display
Motor Terminal
Relay Module
ESP32 Devkit V1
PCF8574 GPIO Expander
1
2
3
A
4
5
6
B
7
8
9
C
*
0
#
D

Manufactured PCB



Assembled PCB



Program

```
#include <Wire.h>
#include <PCF8574.h>
#include <LiquidCrystal_I2C.h>

// I2C Addresses
#define KEYPAD_I2C_ADDRESS 0x20
#define LCD_I2C_ADDRESS 0x27

// Pump control pins (L298N)
#define IN1  25
#define IN2  26
#define IN3  27
#define IN4  14

// Relay control pin (Active LOW)
#define RELAY_PIN 32

PCF8574 pcf(KEYPAD_I2C_ADDRESS);
LiquidCrystal_I2C lcd(LCD_I2C_ADDRESS, 16, 2);

char keys[4][4] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};
```

```
uint8_t rowPins[4] = {4, 5, 6, 7};  // PCF8574 row pins

uint8_t colPins[4] = {0, 1, 2, 3};  // PCF8574 column pins


int containerA = 0, containerB = 0;

int mixMinutes = 0, mixSeconds = 0;


const int pumpTimes[] = {2500, 5000, 6950, 8600, 10400, 12365, 14420, 16480, 18300, 20500};

const int volumes[] = {50, 100, 150, 200, 250, 300, 350, 400, 450, 500};


void setup() {

  Serial.begin(115200);

  Wire.begin(21, 22);


  pinMode(IN1, OUTPUT);

  pinMode(IN2, OUTPUT);

  pinMode(IN3, OUTPUT);

  pinMode(IN4, OUTPUT);

  pinMode(RELAY_PIN, OUTPUT);


  digitalWrite(IN1, LOW);

  digitalWrite(IN2, LOW);

  digitalWrite(IN3, LOW);

  digitalWrite(IN4, LOW);

  digitalWrite(RELAY_PIN, HIGH);  // Relay off (active LOW)


  if (!pcf.begin()) {
```

```
    Serial.println("PCF8574 not found!");
    while (1);
  }

  lcd.init();
  lcd.backlight();

  for (int i = 0; i < 4; i++) pcf.write(rowPins[i], HIGH);

  showWelcomeScreen();
}

void loop() {
  while (true) {
    containerA = selectVolume("Select Volume A");
    containerB = selectVolume("Select Volume B");
    dispenseLiquids();
    getMixingTime();
    startMixingCountdown();
  }
}

void showWelcomeScreen() {
  lcd.clear();
  lcd.setCursor(3, 0);
  lcd.print("WELCOME");
  lcd.setCursor(0, 1);
```

```
  lcd.print("Chemical Mixer");
  delay(2000);
}

int selectVolume(String message) {
  int index = 0;
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(message);

  while (true) {
    lcd.setCursor(0, 1);
    lcd.print("        ");
    lcd.setCursor(0, 1);
    lcd.print(volumes[index]);
    lcd.print(" mL");

    char key = getKey();
    if (key == 'A') index = (index > 0) ? index - 1 : 9;
    else if (key == 'B') index = (index < 9) ? index + 1 : 0;
    else if (key == '*') return volumes[index];
  }
}

void dispenseLiquids() {
  lcd.clear();
  lcd.setCursor(0, 0);
```

```
  lcd.print("Dispensing A...");
  pumpLiquid(containerA, IN1, IN2);
  delay(1000);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Dispensing B...");
  pumpLiquid(containerB, IN3, IN4);
  delay(1000);
}

void pumpLiquid(int volume, int pin1, int pin2) {
  int duration = 0;
  for (int i = 0; i < 10; i++) {
    if (volumes[i] == volume) {
      duration = pumpTimes[i];
      break;
    }
  }

  if (duration > 0) {
    int step = 5;
    int steps = volume / step;
    int stepTime = duration / steps;

    digitalWrite(pin1, HIGH);
    digitalWrite(pin2, LOW);
```

```
    for (int disp = 5; disp <= volume; disp += step) {
        lcd.setCursor(0, 1);
        lcd.print("Dispensed: ");
        lcd.print(disp);
        lcd.print(" mL ");
        delay(stepTime);
      }

      digitalWrite(pin1, LOW);
      digitalWrite(pin2, LOW);
    }
  }

void getMixingTime() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Enter time (m):");
  mixMinutes = getNumericInput();

  if (mixMinutes > 30) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Limit is 30m");
    delay(2000);
    getMixingTime();
    return;
```

```
}

lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Enter time (s):");
  mixSeconds = getNumericInput();

  int totalSec = mixMinutes * 60 + mixSeconds;
  if (totalSec > 1800) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Limit is 30");
    delay(2000);
    getMixingTime();
    return;
  }

  mixMinutes = totalSec / 60;
  mixSeconds = totalSec % 60;
}

void startMixingCountdown() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Mixing");

 digitalWrite(RELAY_PIN, LOW); // Motor ON
```

```
  for (int t = mixMinutes * 60 + mixSeconds; t >= 0; t--) {
    int min = t / 60;
    int sec = t % 60;
    lcd.setCursor(0, 1);
    lcd.print("Time: ");
    lcd.print(min);
    lcd.print("m ");
    lcd.print(sec);
    lcd.print("s   ");
    delay(1000);
  }

digitalWrite(RELAY_PIN, HIGH); // Motor OFF

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Mixing Done");
  delay(3000);
}

int getNumericInput() {
  String input = "";
  char key;
  lcd.setCursor(0, 1);
  lcd.print("> ");
```

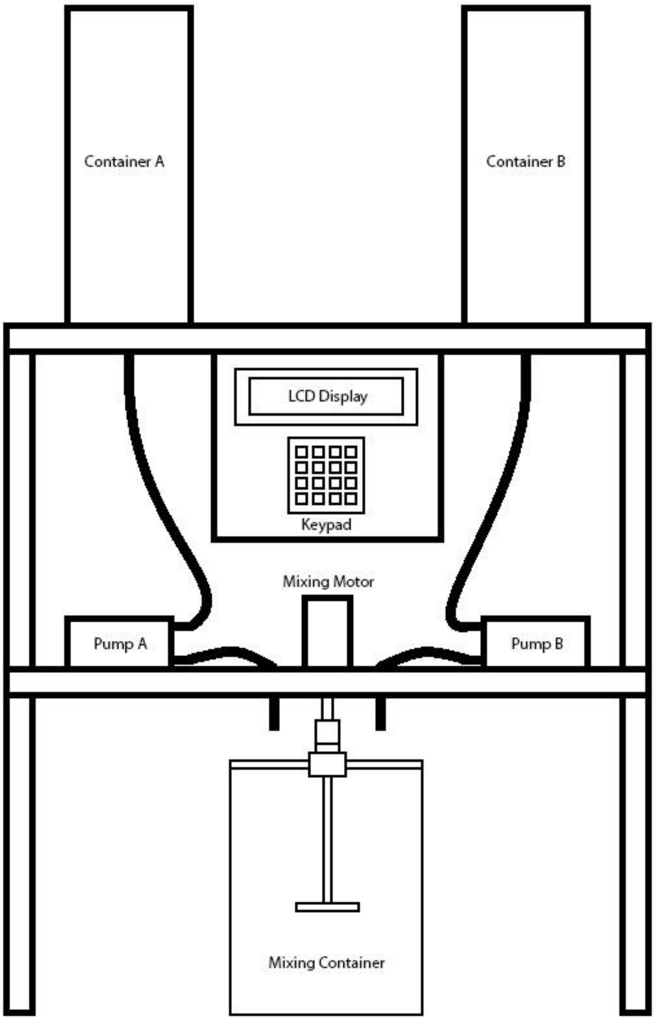
```
  while (true) {
   key = getKey();
   if (key >= '0' && key <= '9') {
    input += key;
    lcd.print(key);
   } else if (key == '*') {
    if (input.length() == 0) continue;
    return input.toInt();
   }
  }
}

char getKey() {
  for (int row = 0; row < 4; row++) {
   for (int i = 0; i < 4; i++) pcf.write(rowPins[i], (i == row) ? LOW : HIGH);

   for (int col = 0; col < 4; col++) {
    if (pcf.readButton(colPins[col]) == LOW) {
     delay(200);
     while (pcf.readButton(colPins[col]) == LOW);
     return keys[row][col];
    }
   }
  }
  return 0;
}
```

Mixer Structure

To construct the structure for the chemical mixer, we used a three-shelf plastic table. Two plastic bottles are mounted on the top shelf, serving as containers for two different chemicals. The second shelf houses both pumps and the mixing motor, with the motor shaft oriented downward. Silicone rubber tubes connect each container to its respective pump, enabling fluid transfer.

The PCB is mounted on an acrylic sheet fixed to the top shelf at an angle for better accessibility. All wiring for the pumps and motor is routed through the hollow legs of the table, ensuring a clean and organized setup. We used 26 AWG PVC-insulated wires for all electrical connections. A 12V DC jack is installed on the angled acrylic sheet, allowing the system to be powered by simply inserting a 12V adapter plug into the jack.

Structure Diagram



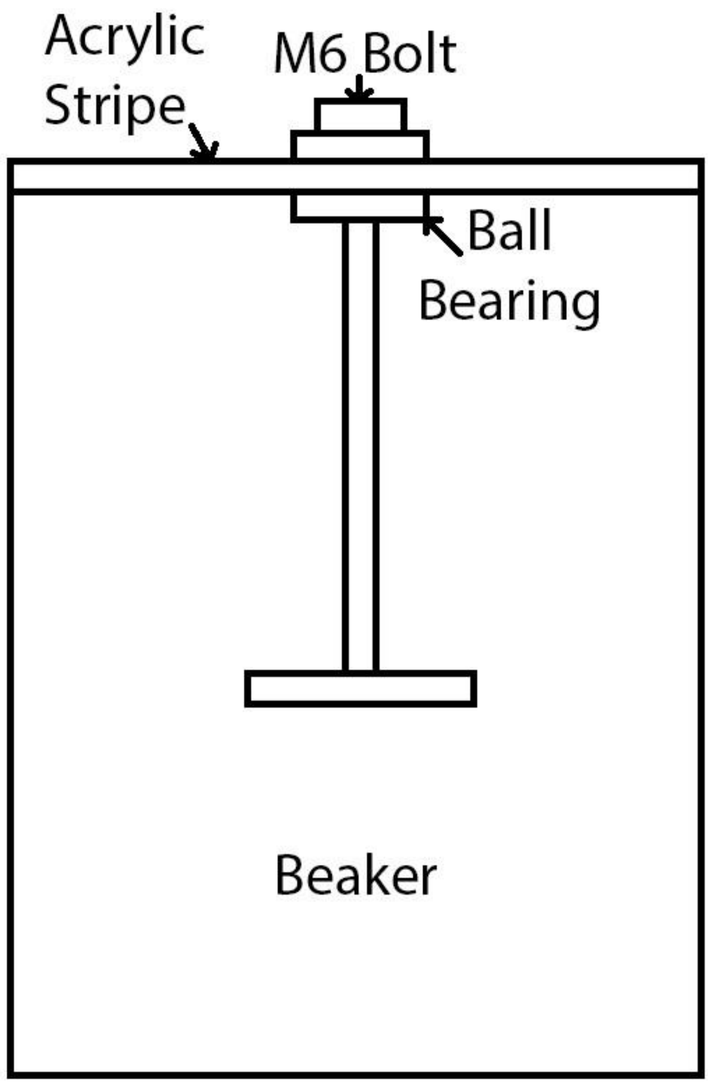
Assembled Structure

Mixing Container

We have designed a customized mixing container for the chemical mixer. It features an acrylic strip mounted on top of the container, with a ball bearing positioned at its center. A 4-inch M6 bolt is inserted vertically through the bearing and secured on the opposite side using a nut. A blade is attached to the lower end of the bolt, forming the stirring mechanism of the container.

A socket wrench is connected to the shaft of the mixing motor and is capable of limited vertical movement. To operate the mixing container, lift the socket wrench and position the container such that the bolt head aligns directly below it. Releasing the socket wrench allows it to automatically lock onto the bolt head. When the motor is activated, it rotates the bolt, effectively stirring the contents of the container.

Container Diagram



Testing & Calibration

To ensure accurate operation of the liquid dispensing mechanism, extensive testing and calibration of the pump motors were carried out. Since this project uses a time-based liquid dispensing method instead of flow sensors, it was essential to determine how long each pump needs to run to dispense specific volumes of liquid.

The motors connected to Pump 1 and Pump 2 were individually tested using a stopwatch and a measuring container. The aim was to establish a correlation between motor run-time (in milliseconds) and the volume of liquid dispensed (in milliliters). Each test was repeated 2–3 times to ensure consistency.

Testing was performed for all the values from 50 ml to 500 ml with a 50 ml difference and the follwing observations were made.

- The flow rate of water is not linear.
- The time value for each volume did not increase linearly.
- The observed time values are given in the table below.

Volume	Time
50 ml	2500 ms
100 ml	5000 ms
150 ml	6950 ms
200 ml	8600 ms
250 ml	10400 ms
300 ml	12365 ms
350 ml	14420 ms
400 ml	16480 ms
450 ml	18300 ms
500 ml	20500 ms

Project working

As the system powers up, the LCD module displays the message "Welcome Chemical Mixer" followed by the volume selection menu. The user is prompted to select the volume for Container A first. Using the "A" and "B" keys on the keypad, the user can navigate through the available volume options (e.g., 50 mL, 100 mL, 150 mL, etc.). Once the desired volume is highlighted, pressing the "*" key confirms the selection. The system then moves to the volume selection for Container B, where the same procedure is followed.

After both volumes are selected, the system begins dispensing. Pump 1 (connected to Container A) is activated first, and the live volume being dispensed is displayed on the LCD in steps of 5 mL. After Pump 1 finishes, Pump 2 (for Container B) is activated and operates in the same way.

Once both liquids are dispensed, the LCD prompts the user to select the mixing time in minutes and seconds. If the entered time exceeds the 30-minute limit, an error message is displayed. After a valid time is set, the mixing motor is turned on, and the LCD shows a countdown timer alongside the message "Mixing". When the countdown ends, the motor stops automatically, completing the mixing process.

Conclusion

The Chemical Mixer project successfully demonstrates an automated system designed for agricultural applications, where the accurate dispensing and mixing of liquids such as fertilizers, pesticides, or nutrients is essential but extreme precision is not critical. Using an ESP32 microcontroller, submersible pumps, keypad input, and an LCD display, the system provides an easy-to-use interface for selecting volumes and mixing times, making it practical for farmers and agricultural technicians.

By automating the mixing process, this system helps reduce manual labor and minimizes errors in liquid measurement, improving efficiency and consistency in field operations. The time-based dispensing approach is suitable for typical agricultural needs, offering a cost-effective and reliable solution. This project also lays the groundwork for future improvements like sensor feedback and remote monitoring, which could further enhance its usability in agriculture.

References

(1) ESP 32 devkit V1:
https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32_datasheet_en.pdf

(2) L298N motor driver module:
https://www.handsontec.com/dataspecs/L298N%20Motor%20Driver.pdf

(3) 16 x 2 LCD module:
https://www.vishay.com/docs/37484/lcd016n002bcfhet.pdf

(4) I2C module
https://www.handsontec.com/dataspecs/module/I2C_1602_LCD.pdf

(5) 4 x 4 matrix keypad module:
https://mm.digikey.com/Volume0/opasdata/d220001/medias/docus/761/3844_Web.pdf

(6) GPIO expander module:

https://www.ti.com/lit/ds/symlink/pcf8574.pdf

(7) Relay module:

https://components101.com/switches/5v-single-channel-relay-module-pinout-features-applications-working-datasheet

(8) R385 Pump:

https://5.imimg.com/data5/SELLER/Doc/2021/4/RH/JK/XD/1833510/r385-dc-9-12v-water-pump-maximum-lift-3-meters.pdf

(9) Geared motor:

https://potentiallabs.com/cart/dc-motors-100rpm

Notes