Faculty of Information Technology

Project Title

Microcontroller Based Automated Acid Diluting System

Group No:23

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1. Introduction

In many laboratories, the task of mixing acids with other substances is both essential and hazardous. This project seeks to enhance safety in this process by developing an automated acid dilution system using microcontroller technology. The system is designed to mitigate human error and enhance safety, as manual acid mixing is often a complex and high-risk operation.

At present, laboratories employ relatively few automated systems for acid dilution, which increases the potential for mistakes and accidents. Manual methods can lead to incorrect acid concentrations, spills, and dangerous chemical exposure. These risks underscore the critical need for a more secure and reliable method for acid dilution, minimizing human error.

Our automated acid dilution system addresses these concerns by significantly reducing the chances of harmful exposure, thereby enhancing the safety of laboratory personnel. The system is user-friendly, allowing lab technicians to operate it with confidence and ease. By automating the dilution process, we aim to eliminate the variability and associated dangers of manual mixing, ensuring a more consistent and controlled outcome.

The introduction of this automated acid dilution system aims to improve both safety and efficiency within laboratories. Our goal is to develop a system that is easily adoptable, contributing to the protection and well-being of laboratory staff. This system safeguards the health of lab personnel and enhances the reliability of laboratory procedures.

In conclusion, the microcontroller-based automated acid dilution system represents a substantial advancement in laboratory safety and efficiency. By reducing the scope for human error and placing a strong emphasis on user safety, this system sets a new benchmark for laboratory practices, facilitating safer and more effective scientific operations.

2. Literature Survey

2.1 Current Practices in Large-Scale Factories

In large-scale industrial settings, automated acid dilution systems are widely implemented as a critical safety measure. These systems significantly reduce human interaction with hazardous chemicals, thereby minimizing the risk of chemical exposure, accidents, and associated health hazards. By automating the dilution process, industries ensure a more controlled and precise handling of acids, enhancing workplace safety and operational efficiency.

2.2 Challenges in Educational Institutions

Conversely, educational institutions such as schools and universities predominantly rely on manual methods for acid dilution. This reliance on manual processes introduces significant safety risks, as both students and staff are exposed to hazardous chemicals. The continued use of these methods is often driven by budgetary constraints and the lack of access to advanced equipment, despite the potential dangers associated with manual handling. These limitations underscore the need for safer, more modernized approaches to acid dilution in educational laboratories.

2.3 Need for Safer Methods

Manual laboratory procedures pose numerous risks, including the potential for harm to individuals handling acids and inaccuracies in the dilution process. These risks are particularly pronounced in educational settings, where individuals may lack the requisite expertise and experience in handling hazardous materials. Consequently, there is a critical need for safer acid dilution methods to safeguard the well-being of those involved and ensure accurate, controlled procedures.

2.4 Drawbacks of Manual Procedures

Manual acid dilution methods are associated with several significant drawbacks, with safety being the foremost concern. The manual handling of acids increases the risk of chemical burns, inhalation of hazardous vapors, and accidental spills. These safety hazards underscore the need for more controlled and automated processes to mitigate the risks inherent in manual acid dilution.

3. Problem in Brief

In many laboratories, the manual mixing of acids with other substances is a critical but hazardous task, prone to errors and safety risks. The process of manually diluting acids can lead to inaccurate concentrations, spills, and harmful exposure to dangerous chemicals. Currently, educational institutions and smaller laboratories primarily rely on manual methods due to budget constraints and lack of advanced equipment, further increasing the risks for students and staff.

There is a pressing need for a safer, automated solution to mitigate human error, enhance precision, and reduce the potential for accidents during acid dilution processes.

4. Aim and Objectives

4.1 Aim

The aim of our project is to develop a microcontroller-based Automated Acid Dilution system that addresses the challenges inherent in manual acid dilution. This system aims to enhance safety, reduce human error, and improve overall efficiency in the acid dilution process.

4.2 Objectives

Prioritize:
The development of a system that automates the acid dilution process is intended to eliminate the need for manual handling, thereby mitigating the risks associated with direct exposure to hazardous chemicals.

Safety:
The implementation of safety features, such as emergency shutdown and reset functions, is crucial to safeguarding personnel and the environment from potential hazards associated with acid handling, including chemical spills. These features are designed to mitigate risks and ensure a safe operating environment during the acid dilution process.

Optimize Resource Usage:
The system is designed to optimize the use of acids and other resources, thereby minimizing waste, and reducing operational costs while ensuring the effectiveness of the dilution processes.

Reduce Human Errors:
The objective is to minimize human errors inherent in the manual acid dilution process, thereby ensuring the production of precise and accurate mixtures.

These objectives collectively aim to enhance laboratory safety, improve operational efficiency, and minimize human errors in experimental results through the development of an advanced Automated Acid Dilution system.

5. Proposed Solution

- **Automated Acid Dilution:** The core functionality of the system is to automate the dilution of acids, eliminating the need for manual handling. It ensures precise acid-to-water ratios, significantly reducing the risks of exposure to hazardous chemicals and human error.

- **User Input via Keypad:** The system allows users to input specific parameters, such as the desired dilution ratio, using a keypad. This provides an easy and intuitive way for lab technicians to set the operation according to their requirements.

- **Real-Time Water Level Measurement:** The VL53Lox Time-of-Flight (TOF) sensor measures the water level with high accuracy. This ensures that the system dispenses the correct volume of water for the acid dilution process, maintaining precision throughout.

- **Safety Features:** The system incorporates multiple safety measures, such as an emergency shutdown function, reset mechanisms, a buzzer for alerts and LEDs for emergency indications. These features are essential for preventing accidents like spills or overflows and protecting laboratory personnel.

- **Level Monitoring with Gyroscope:** The GY-521 MPU-6050 gyroscope sensor ensures that the system is positioned on a level surface, maintaining accuracy in measurements and functionality. This is crucial for precise liquid dispensing and overall system stability.

- **Water Flow Control:** The 5V water solenoid valve and water pump work together to control the flow of water during the dilution process. The system dispenses water accurately and stops once the required amount is achieved, ensuring that no manual intervention is needed.

- **Beaker Detection and Overflow Prevention:** The ultrasonic sensors ensure that the beaker is correctly positioned to receive the diluted solution and detect the liquid level to prevent overflow. This functionality ensures safe and efficient operation by stopping the process if any issues arise.

- **Wireless Communication:** Two ESP32 boards communicate wirelessly using the ESP-NOW protocol, coordinating system functions without the need for a traditional Wi-Fi network. This ensures smooth communication between the system's components for proper synchronization and real-time data transmission.

- **Temperature Monitoring:** The DS18B20 temperature sensor monitors the temperature of the acid during dilution, helping to classify the process as a 'Heat Sink' or 'Heat Absorber.' This ensures that temperature variations are accounted for, improving safety and process control.

- **Auditory Alerts:** The buzzer and LEDs alerts users during different operational phases, such as emergency situations, work completion, and cleaning intervals. This provides essential feedback, enhancing system usability and ensuring the process runs smoothly.

- **Display Output:** A display interface shows real-time system status, including dilution progress, temperature readings, and error messages. This functionality helps users easily monitor and control the process, ensuring transparency and ease of use.

- **Efficient Power Management:** Buck converters manage power distribution across the system, stepping down input voltages to provide the correct voltage to different components. This ensures stable and efficient power usage throughout the process.
- **System Finishing and Enclosure:** The system is housed in a durable, well-designed enclosure that protects internal components from damage and ensures a clean, professional look, essential for operational environments such as laboratories.

6. System Description

VL53L0X Time-of-Flight Ranging Sensor:

The Time-of-Flight (TOF) sensor is used to measure the water level in the measuring flask with precision. The sensor works by emitting a laser beam toward the water surface, and the reflection is used to calculate the distance between the sensor and the water. The system takes 30 readings over 5 seconds to reduce errors, averaging these values to determine the accurate water level required for the dilution process.

Water Pump:

The water pump operates based on the height measurements from the TOF sensor. It controls the water flow with millisecond precision, ensuring the exact amount of water is dispensed into the beaker for dilution. This guarantees consistent and accurate acid-to-water ratios.

5V Water Solenoid Valve:

The solenoid valve halts the water flow once the desired amount of water has been dispensed by the pump. It ensures no further water enters the system after the required quantity is reached, preventing overfilling.

GY-521 MPU-6050 3-Axis Gyroscope Sensor:

This sensor ensures that the entire system is positioned on a flat surface. Proper leveling is essential for maintaining accuracy in all measurements, especially for liquids in the dilution process.

Ultrasonic Sensors:

Ultrasonic Sensor 1: Detects the presence of the final output beaker, ensuring that the beaker is correctly positioned to receive the diluted solution.

Ultrasonic Sensor 2: Monitors the cleaning base and cleaning water levels to ensure they are maintained at the required levels during operation.

DS18B20 Temperature Sensor:

The temperature sensor takes readings every second and calculates the difference between the previous and last values. If the difference is positive, it indicates a heat-releasing (exothermic) reaction, displayed by custom characters (Up arrow) in the LCD display. If the difference is negative, it indicates a heat-absorbing (endothermic) reaction, also shown by custom characters (Down arrow).

DC Motors:

DC Motor FoV-86600-32 (X-Axis): Controls the horizontal movement of the main actuator arm for precise positioning.

RF-300FA-12350 DC Spindle Motor (Y- Axis): Controls the vertical motion of the actuator, aiding in the accurate mixing and handling of liquids.

Servo Motors:

Servo 1 (Vertical Axis): Provides fine control over vertical movements to position the actuator arm precisely.

Servo 2 (Syringe Clinger): Controls the syringe mechanism responsible for injecting acid into the mixture during dilution.

L298N DC Motor Driver:

This driver regulates the DC motors, providing precise control over their speed and direction. It ensures smooth operation of the actuator arms, contributing to accurate liquid handling.

ESP32 Micro Controller:

Two ESP32 boards, each with 38 pins, are employed for their memory capacity and I/O capabilities. Due to the pin limitations of a single board, two ESP32 boards are connected and communicate wirelessly using the ESP-NOW protocol, which supports low-latency, direct data exchange without requiring a traditional Wi-Fi network. Both boards are configured as Wi-Fi stations (clients) and communicate via their unique MAC addresses.

Buck Converters:

Buck Converter 1: Steps down the input voltage from 12V to 10V, which powers the L298N motor driver and Buck Converter 2.

Buck Converter 2: Further reduces the voltage from 10V to 5V, supplying power to the PCB and other 5V components.

2-Channel 5V Relay Module:

This relay module is used to control both the water pump and solenoid valve. It allows switching between the two components based on the system’s requirements, ensuring precise control over water flow during the dilution process.

Keypad and Display:

Keypad: Allows the user to input desired dilution ratios and other operational parameters.

Display: Provides real-time feedback to the user, showing system status, errors, and operational outputs.

Buzzer:

The buzzer is programmed to signal errors and provide alerts. It issues different sound patterns to indicate emergencies, work completion, or cleaning intervals, ensuring the system's safe and efficient operation.

6.1 Flow Chart

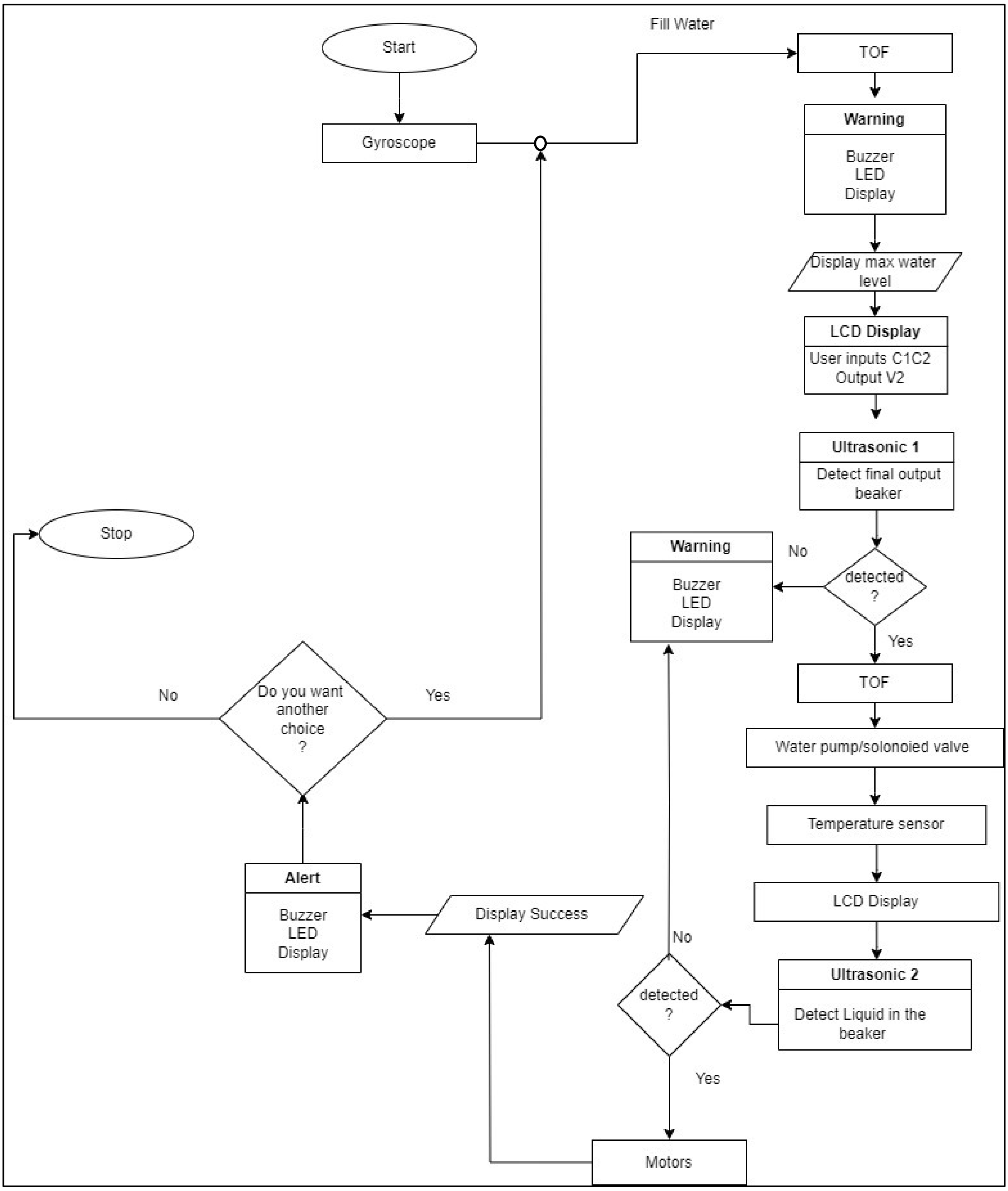


Figure 01

6.2 Block Diagram

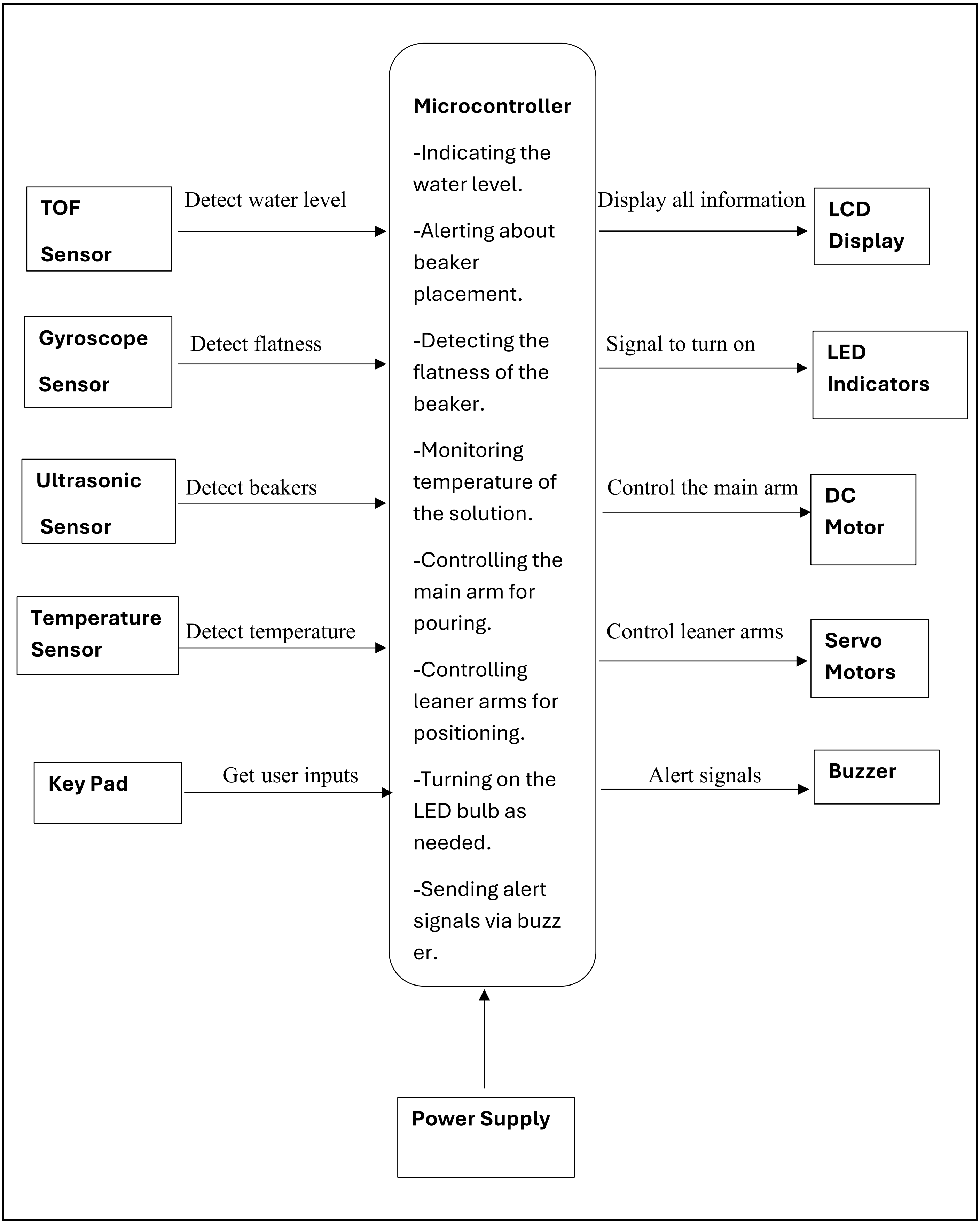


Figure 02

6.3 Schematic Diagram

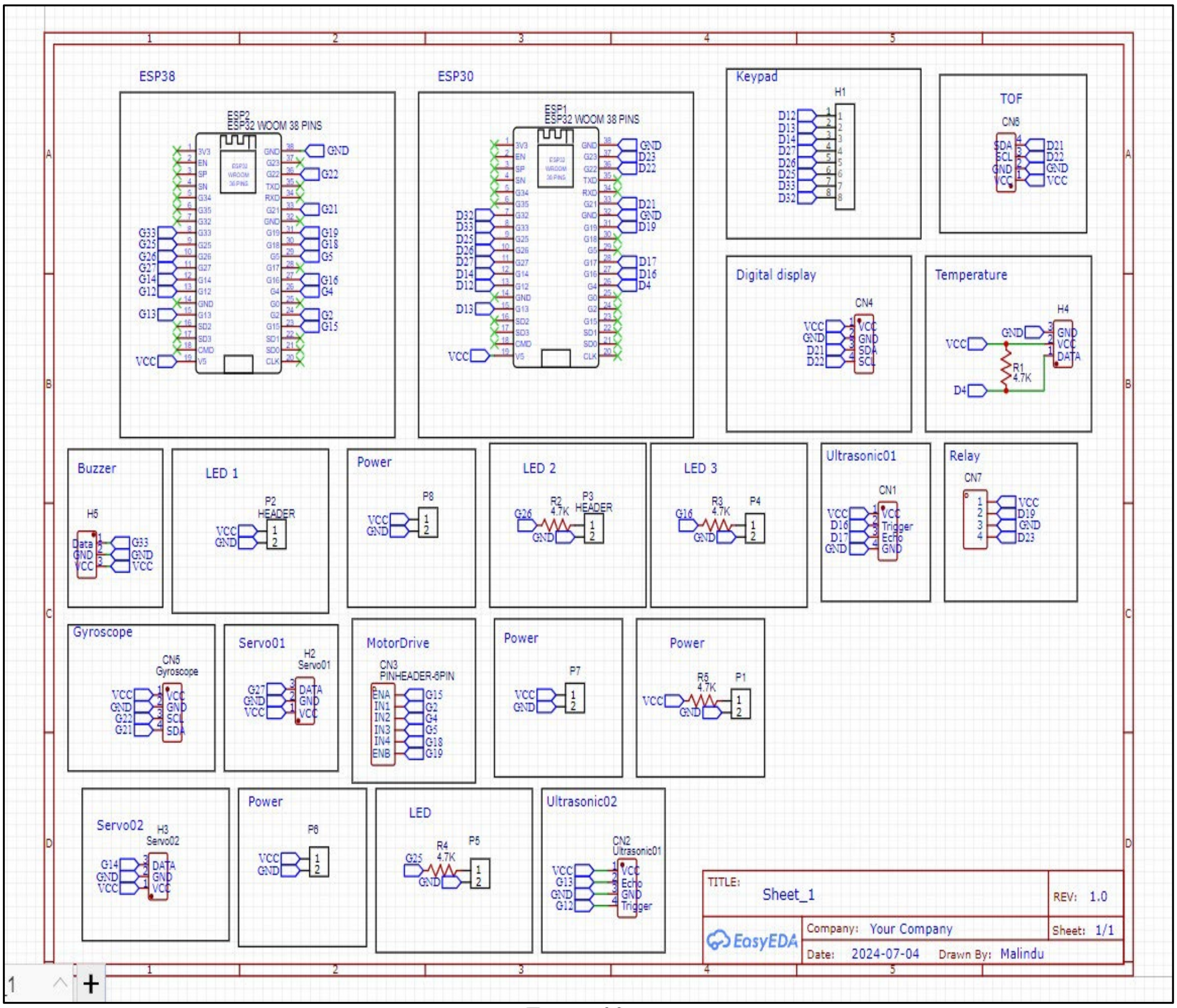


Figure 03

6.4 Graphical Representation

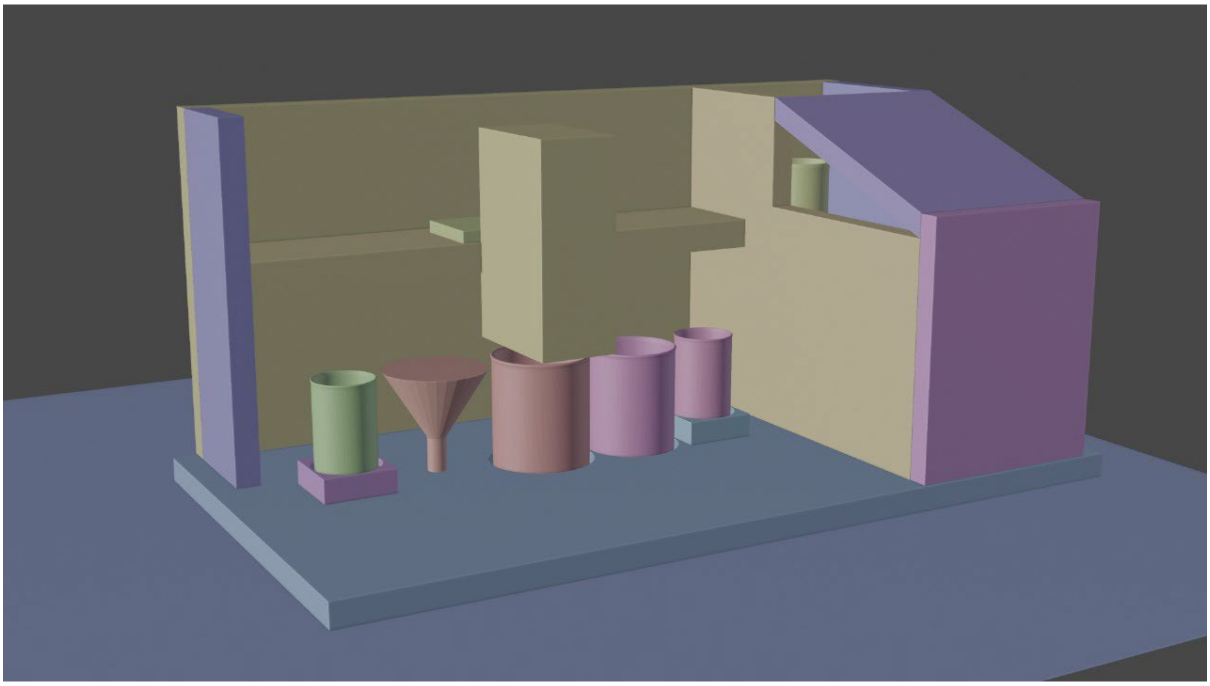


Figure 04

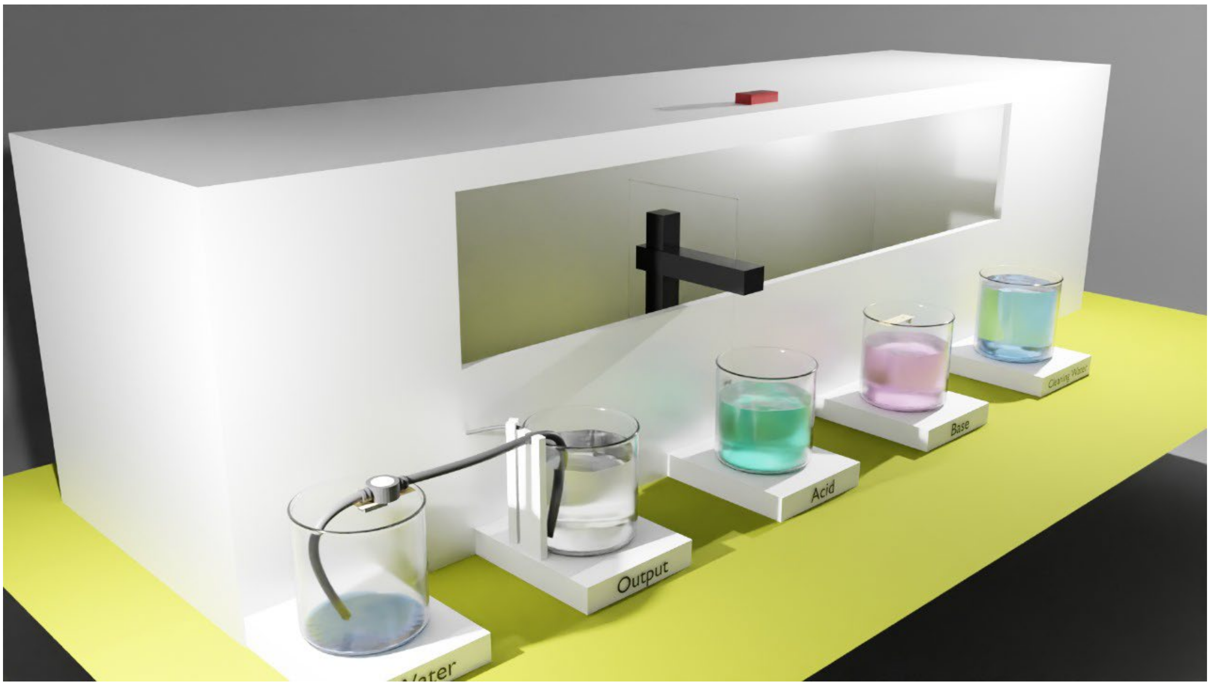


Figure 05

7. Test and Implementation

7.1 System Testing

Before full-scale implementation, the system undergoes a rigorous testing process to ensure the accuracy, safety, and functionality of all components. This phase includes both hardware and software tests, designed to identify potential errors and optimize system performance.

7.1.1. Component Testing

- **VL53L0X Time-of-Flight Ranging Sensor**: The TOF sensor is tested for accuracy in measuring the water level. The system performs multiple tests with different water volumes to verify that the sensor readings are consistent and precise. Any deviations are logged and used for recalibration.

- **Water Pump and Solenoid Valve:** These components are tested together to ensure that the water pump dispenses the correct volume of water and that the solenoid valve stops the flow exactly when required. Multiple tests are conducted at varying flow rates to ensure smooth operation.

- **GY-521 MPU-6050 3-Axis Gyroscope Sensor**: The system is placed on uneven surfaces, and the gyroscope's ability to detect imbalances is verified. If the system is not level, an alert is triggered to prevent further operation.

- **Ultrasonic Sensors:** The presence and liquid level detection capabilities of both ultrasonic sensors are tested. The sensors are evaluated for their ability to accurately detect the final output beaker and the liquid level inside, ensuring proper operation and spill prevention.

- **Temperature Sensor (DS18B20):** The temperature sensor is tested to ensure accurate readings of liquid temperature before and after the dilution process. Tests are performed at different temperatures, and the results are compared to expected values.

- **Motors and Motor Driver:** Both DC and servo motors are tested for precision movement. The motors are run through different motions to confirm that they respond correctly to input commands from the ESP32 boards.

- **ESP32 Boards and ESP-NOW Protocol:** The two ESP32 boards are tested for seamless communication using the ESP-NOW protocol. Data transmission is verified by sending test commands between the boards and ensuring that both boards respond appropriately.

- **Keypad and Display:** The keypad's input functionality is tested by entering various dilution ratios and operational commands. The display is tested for accurate and real-time feedback to the user, such as system status, alerts, and results.

- **Buzzer:** The buzzer is triggered under different conditions (emergency, work completion, cleaning) to ensure it emits the correct sound pattern for each scenario.

7.1.2. Software Testing

Code Debugging: The code controlling each component, including the TOF sensor, motors, pump, and communication protocol, is tested to identify and eliminate bugs. Error handling routines are thoroughly examined to ensure system stability during unexpected conditions.

User Interface: The user interface, controlled through the keypad and display, is tested for ease of use and accuracy. The system is run through various operational modes, and the display is monitored to confirm that all commands and alerts are shown correctly.

7.2. Implementation

Once the system is tested and verified, the implementation phase begins. This involves the deployment of the system in a laboratory setting, where it will be integrated into daily operations for acid dilution.

7.2.1. Calibration and Setup

The system is calibrated in the laboratory environment. The TOF sensor, water pump, solenoid valve, and temperature sensor are all fine-tuned to the specific conditions of the lab.

The system is placed on a flat, stable surface, and the gyroscope sensor ensures the correct positioning. If the system detects any imbalance, adjustments are made until the system is level.

The ultrasonic sensors are adjusted to detect the presence of the final output beaker and the liquid level, ensuring no overflow or spill occurs.

7.2.2. System Integration

Water Supply Integration: The system is connected to a reliable water source to ensure continuous operation. The water pump and solenoid valve are tested again to confirm that the water supply meets the system's operational needs.

Acid Handling Protocols: Safety protocols for acid handling are integrated into the system. This includes emergency shutdown procedures and alerts triggered by the buzzer in case of system malfunction or hazardous conditions.

User Training: Laboratory personnel are trained to operate the system, including setting desired dilution ratios, responding to alerts, and performing routine maintenance. User manuals are provided, detailing all the operational steps and safety features.

7.2.3. Initial Trial Runs

Controlled Environment: The system is initially implemented in a controlled environment where operators perform several acid dilutions under supervision. All components, including the sensors, motors, water pump, and relays, are monitored during these trial runs.

Data Logging: The system records data during these initial runs, including water volumes, temperatures, and sensor readings. This data is analyzed to confirm that the system operates within acceptable parameters.

7.2.4. Full Deployment

After successful trials, the system is fully deployed into the laboratory's regular operations. Continuous monitoring ensures that the system maintains accuracy and safety during extended use.

7.3 Post-Implementation Monitoring and Maintenance

Periodic Testing: To ensure continued accuracy, periodic testing of the TOF sensor, water pump, and other components is conducted. Regular recalibration may be required based on system usage.

Component Maintenance: Motors, sensors, and relays are checked regularly for wear and tear. Any malfunctioning components are replaced promptly to avoid system downtime.

Software Updates: The system's code is updated periodically to improve functionality, fix bugs, or add new features. The ESP32 boards are updated with firmware as needed.

7.4. Safety and Error Handling

Emergency Shutdown: The system is equipped with an emergency shutdown function, triggered if any sensor detects an unsafe condition. This ensures that the system stops immediately to prevent accidents.

Error Alerts: The buzzer provides audible alerts for any errors or critical issues, allowing laboratory personnel to intervene quickly.

7.5. Performance Evaluation

After a period of use, the system's performance is evaluated based on the following criteria:

Accuracy of Dilution: The precision of the water and acid mixture is measured to ensure consistent results.

Safety Improvements: The system's ability to reduce human exposure to hazardous chemicals is assessed through safety reports.

Operational Efficiency: Time and resource savings are evaluated, including reductions in water and acid waste.

7.6. Tasting photograph

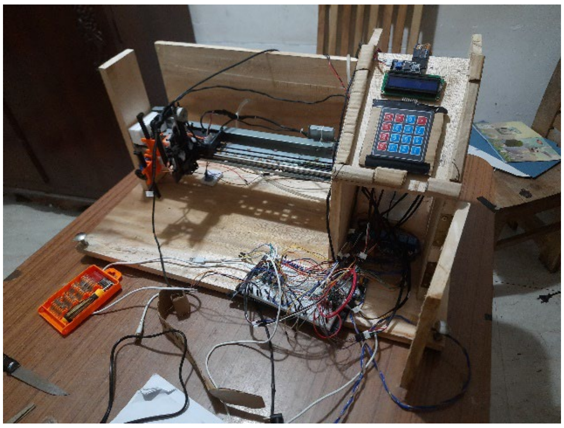


Figure 06

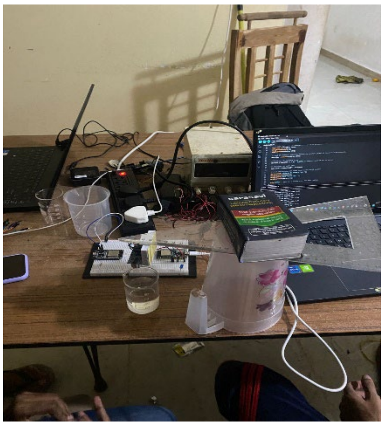


Figure 07

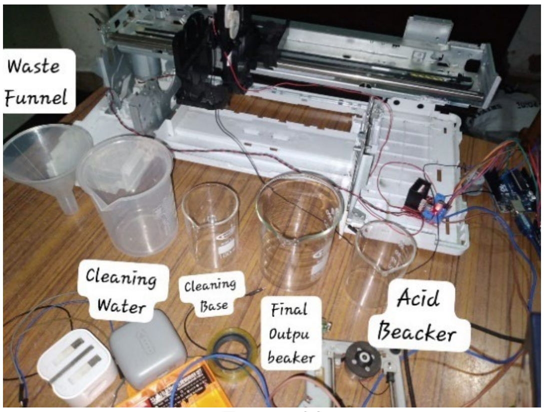


Figure 08

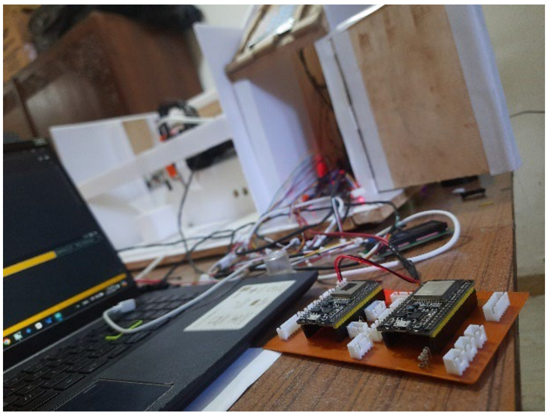


Figure 09

Figure 10

7.4. Final Output

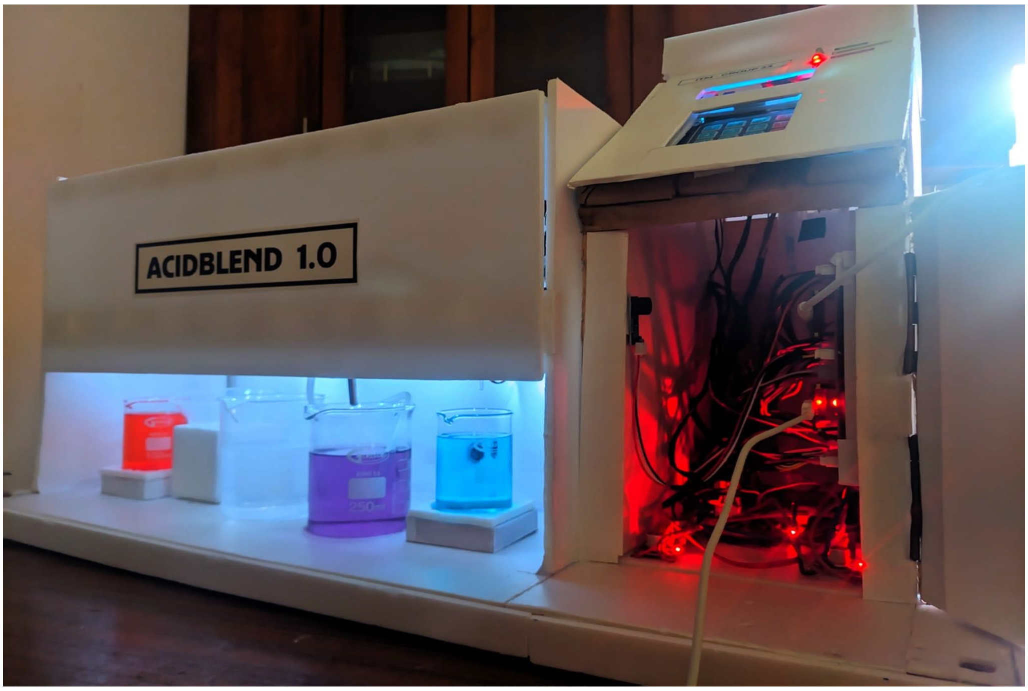


Figure 11

8.Cost Estimation

Component	Quantity	Unit Price	Total Price Rs.
ESP32 Microcontroller	2	1500	3000
Ultrasonic Sensor - HC-SR04	2	280	560
TOF Sensor VL53L4CD	1	800	800
DS18b20 (Temperature Sensor)	1	400	400
DC 12V Micro Mini Electric Solenoid Valve	1	200	200
DM0001 - 1602 16x2 Blue Backlight LCD Display	1	500	500
5V Buzzer / Alarm	1	100	100
GY-521 MPU-6050 3-Axis Gyroscope Sensor	1	700	700
Water Pump	1	250	250
DC Motor FoV-86600-32	1	500	500
RF-300FA-12350 DC Spindle Motor	1	200	200
Servo Motors	2	500	1000
L298N DC Motor Driver	1	530	530
Buck Convertors	2	450	900
2 Channel 5V Relay Model	1	420	420
Keypad	1	290	290
LED s	15	10	150
LCD Display	1	800	800
Buzzer	1	200	200
Wooden Frame	1	4000	4000
Lab Essentials		5000	5000
Others		2000	2000
Total			**22500**

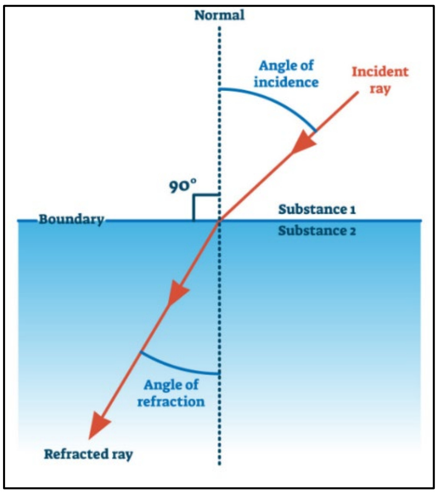
9. Individual Contribution

R.E.M.H.M. Rajakaruna – 225085A

I worked on integrating the **VL53L0X Time-of-Flight (ToF) Ranging Sensor**, **DC motors**, **servo motors**, and the **L298N DC motor driver** into the automated acid dilution system. My role involved ensuring that these components functioned together seamlessly to automate the liquid handling process.

I integrated the **VL53L0X ToF sensor** to accurately measure the water level in the Measuring flask by programming it to take 30 readings over 5 seconds. This provided precise data to control the water pump and ensure the correct volume of liquid was dispensed during the dilution process.

In order to mitigate refraction errors caused by a laser beam passing through water, I incorporated the law of refraction into the program.



$$n_1\sin\theta_1 = n_2\sin\theta_2$$

n_1 = Air index

n_2 = Water index

θ_1 = incident angle

θ_2 = refracted angle

The refractive index of water at 20°C for visible light is 1.33

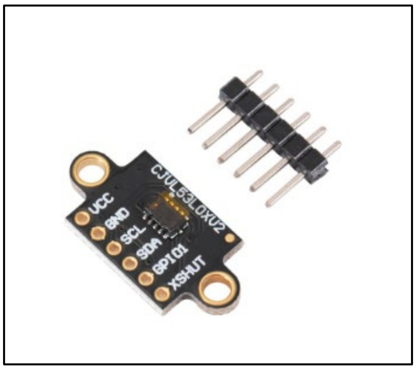
Figure 12

The **DC motors**, responsible for controlling both horizontal (X-axis) and vertical movements, were critical for positioning the actuator arm and handling liquids. I ensured that the motors provided smooth and accurate movements. These motors, driven by the **L298N DC motor driver**, were precisely controlled by converting signals from the ESP32 boards to regulate speed and direction, allowing for both forward and reverse movements.

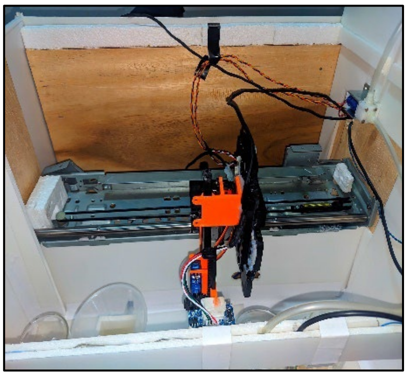
I also integrated the **servo motors**, where **Servo motor 1** controlled the vertical axis for precise positioning of liquid dispensing nozzles and **Servo motor 2** managed the syringe clinger, ensuring secure handling and movement of the syringe. Together, these components automated the positioning and liquid dispensing, contributing to the safe and efficient operation of the system.

Figure 13

Figure 14



ToF Sensor



Mechanical Part

VL53L0X Time-of-Flight (ToF) Ranging Sensor

The VL53L0X is a highly precise sensor that measures the distance between the sensor itself and the surface of the water using Time-of-Flight (ToF) technology. It emits a laser beam that reflects off the water surface, and the sensor calculates the time taken for the reflection to return, allowing it to determine the distance. This distance is essential for calculating the volume of liquid present in the container.

In this system, the VL53L0X sensor continuously monitors the water level by taking multiple readings then averaging them to improve accuracy and minimize measurement errors. It ensures that the system can accurately track the liquid level before and during the dilution process, contributing to precise control over the amount of liquid dispensed. The readings directly impact the control of the water pump, ensuring the system dispenses the correct amount of liquid.

DC Motors

DC motors play a crucial role in the movement and actuation of different parts of the system. Specifically:

- **X-Axis Motor (FoV-86600-32):** This motor is responsible for controlling the horizontal movement of the main actuator arm. Its smooth and precise motion ensures that the arm can position itself accurately when handling liquid containers or adjusting any other mechanical part of the system.
- **Vertical Axis Spindle Motor (RF-300FA-12350):** This motor handles the vertical movements of the system, particularly useful for adjusting the height of the actuator or any component interacting with the liquid containers. It provides a steady and controlled lift, essential for tasks such as raising or lowering syringes, beakers, or nozzles during the dilution process.

The contributions of these motors are vital for the automation of tasks that would otherwise require manual effort, improving efficiency and precision in the system's operation.

Servo Motors

Servo motors in the system offer high-precision control of specific mechanical movements. They are used in two key areas:

- **Vertical Axis Control (Servo 1):** This servo motor controls another vertical axis, possibly in a more fine-tuned manner compared to the DC motor. It ensures precise adjustments, such as the positioning of liquid dispensing nozzles or arms handling the beakers, ensuring that the system operates with high accuracy.
- **Syringe Clinger (Servo 2):** This servo motor operates the mechanism that grips and manipulates the syringe. The motor's precise movements ensure that the syringe is securely held and moved to the correct position for liquid dispensing or extraction, contributing to the automated and safe handling of liquids.

Servo motors are crucial for tasks requiring fine control and exact positioning, making them key to the system's overall automation and precision.

L298N DC Motor Driver

The L298N motor driver is responsible for controlling the operations of the DC motors in the system. This dual H-bridge motor driver enables both motors to be driven in forward or reverse directions with adjustable speeds. It converts control signals from the ESP32 boards into the necessary power and direction commands for the DC motors.

By regulating the power supplied to the motors, the L298N ensures smooth operation, precise control, and the ability to perform complex movements (such as moving the actuator arm or vertical axis). It also protects the motors from overloading and ensures efficient power consumption, making it a critical component for managing the mechanical aspects of the system.

H.M.M.D. Herath – 225036C

I worked on integrating the **GY-521 MPU-6050 3-Axis Gyroscope Sensor**, designing the **PCB**, setting up the **power supply system**, and completing the overall **board finishing** for the automated acid dilution system.

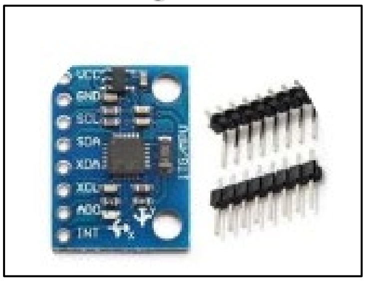
The **GY-521 MPU-6050 Gyroscope Sensor** was integrated to ensure the system was correctly placed on a flat surface. I configured this sensor to provide real-time data on the system's orientation, ensuring the accuracy of the liquid measurement and dispensing processes by maintaining a stable setup.

For the **PCB design**, I developed the layout to ensure efficient placement and routing of components such as sensors, relays, and power management units. This involved designing connections for power lines, signal lines, and critical components, ensuring that the system operated seamlessly and reliably.

In the **power supply system**, I integrated **buck converters** to step down voltages from 12V to 10V and 5V, providing stable power to different components, including the L298N motor driver and the PCB itself. I ensured that each component received the correct voltage for optimal performance, contributing to the system's overall stability and safety.

Finally, for the **board finishing**, I worked on securely mounting all components within a well-designed enclosure, ensuring that the system was both robust and visually polished. This finishing work helped protect the system's hardware while maintaining an organized, professional appearance suitable for laboratory environments.

Figure 15

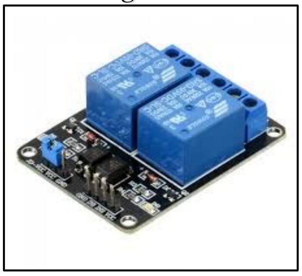


Gyroscope Sensor

Figure 16

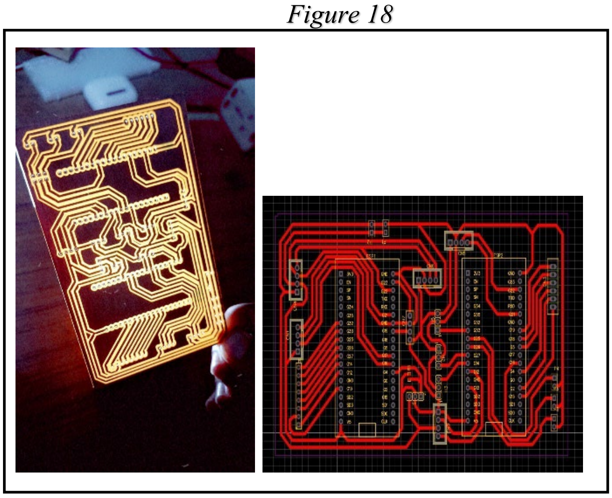
Buck Convertors

Figure 17



2 Channel Relay MOdule

Figure 18



PCB

GY-521 MPU-6050 3-Axis Gyroscope Sensor

The GY-521 MPU-6050 is a crucial component for maintaining system stability. It measures the orientation of the automated acid dilution system to ensure that it remains level. I integrated this sensor to provide real-time data on the system's orientation, which is essential for accurate liquid measurement and dispensing. By ensuring the system is placed on a flat surface, the sensor helps maintain the precision of the dilution process and prevents measurement errors caused by an unstable setup.

PCB Design

The PCB design involved creating an efficient layout to accommodate and connect various system components. I developed the routing for power lines, signal lines, and connections to critical components such as sensors, relays, and power management units. This design ensures that all components are properly connected, and the system operates seamlessly. The PCB layout facilitates reliable communication and power distribution, contributing to the system's overall efficiency and performance.

Power Supply System

In setting up the power supply system, I integrated buck converters to manage voltage requirements.

- **Buck Converter 1:** Steps down the input voltage from 12V to 10V, which powers the L298N DC motor driver and provides the required voltage for certain components.
- **Buck Converter 2:** Converts the 10V input to 5V to power the PCB. This ensures that all components receive the correct voltage for optimal performance and stability.

By managing voltage levels effectively, the power supply system enhances the system's reliability and safety, ensuring that each component operates within its specified voltage range.

G.D. Punchihewa – 225083P

I worked on establishing **two-way communication between the ESP boards**, finalizing the **code**, and managing the **water pump, solenoid valve, relay**, and **water measuring** functions, as well as integrating the **keypad** into the system.

For the **two-way communication between the ESP boards**, I utilized the **ESP-NOW protocol**, which allowed for direct, low-latency communication between the two ESP32 boards without needing a traditional Wi-Fi network. I configured both ESP32 boards as Wi-Fi stations, ensuring accurate data exchange and synchronization between them using their MAC addresses.

In **code finalization**, I developed and debugged the software required for the system's operation. This involved writing and refining the code to handle communication between the ESP boards, managing the sensors and actuators, and controlling various system functions. The finalized code ensured smooth operation and integration of all system components.

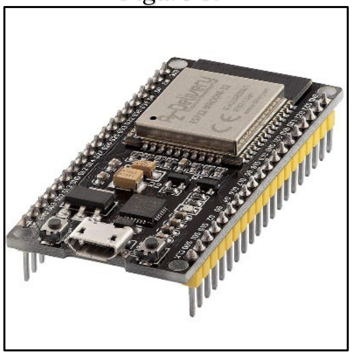
My responsibilities included:

- **Water Pump and Solenoid Valve:** I integrated and programmed the control of the water pump and solenoid valve. The water pump was managed based on measurements from the VL53L0X ToF sensor to dispense precise amounts of water. The solenoid valve was controlled to stop the water flow once the desired volume was reached.

- **Relay:** I worked on connecting and controlling the relay module, which managed the operation of the water pump and solenoid valve. The relay allowed for safe and effective switching of high-power components using low-voltage control signals.
- **Water Measuring:** I handled the integration and calibration of the water measuring components, including the ToF sensor, to ensure accurate liquid level readings and proper control of the dilution process.
- **Keypad:** I integrated the keypad to provide an intuitive interface for user input. This allowed users to enter parameters such as dilution ratios and operational settings, enhancing the system's usability and flexibility.

Overall, my work ensured that the system was fully functional, reliable, and user-friendly, contributing to the successful automation of the acid dilution process.

Figure 19



ESP32 Module

Figure 20

Gyroscope Sensor

Figure 21

Gyroscope Sensor

Figure 22

Key Pad

Two-Way Communication Between ESP Boards

Establishing two-way communication between the ESP boards involved utilizing the ESP-NOW protocol. This protocol allows for direct, low-latency data exchange between ESP32 devices without requiring a traditional Wi-Fi network. Both ESP32 boards were configured as

Wi-Fi stations, with data synchronization achieved through their unique MAC addresses. This setup facilitated seamless coordination and accurate data transmission between the boards.

Code Finalization

The code finalization process involved developing, testing, and debugging the software required for the system's operation. This included managing interactions between the ESP boards, controlling sensors and actuators, and overseeing system functions. The finalized code ensured that all components operated harmoniously, with precise handling of tasks such as data communication and actuator control.

Water Pump and Solenoid Valve

The integration and programming of the water pump and solenoid valve involved controlling the water pump based on measurements from the VL53L0X ToF sensor. The water pump was programmed to dispense precise amounts of water, while the solenoid valve was used to stop the water flow once the desired volume was reached. This setup ensured accurate and reliable liquid dispensing, essential for maintaining correct dilution ratios.

Relay Module

The relay module was integrated and controlled to manage the operation of the water pump and solenoid valve. This module allowed for safe switching of high-power components with low-voltage control signals. Reliable operation of the relay ensured efficient and secure management of the system's high-power elements.

Water Measuring

The integration and calibration of the water measuring components, including the VL53L0X ToF sensor, were essential for accurate liquid level readings. Proper setup and calibration ensured precise control over the dilution process, contributing to the overall accuracy and reliability of the automated system.

Time(ms)	1st Measurement	2nd Measurement	3rd Measurement	4th Measurement	5th Measurement	Average
1000	22	22	22.2	23.4	23.5	22.775
1500	28	28	28.2	28.1	28.3	28.15
2000	33.8	33.7	33.8	33.7	33.6	33.7
2500	39.6	39.5	39.8	39.5	39.4	39.55
3000	45.5	45.6	45.5	45.7	45.6	45.6
3500	51.2	51.4	51.3	51.2	51.1	51.25
4000	56.3	56.6	56.1	55.7	55.4	55.95
4500	60.1	59.7	59.9	60.2	60.3	60.025
6000	74.6	74.9	74.8	74.6	74.4	74.675
7500	91.2	90.6	90.8	90.6	91.2	90.8
9500	107.4	107.1	106.8	107.7	107.2	107.2
11500	129.2	129.5	129.1	128.8	129.2	129.15
13500	151.4	152.1	151.6	151.5	151.7	151.725

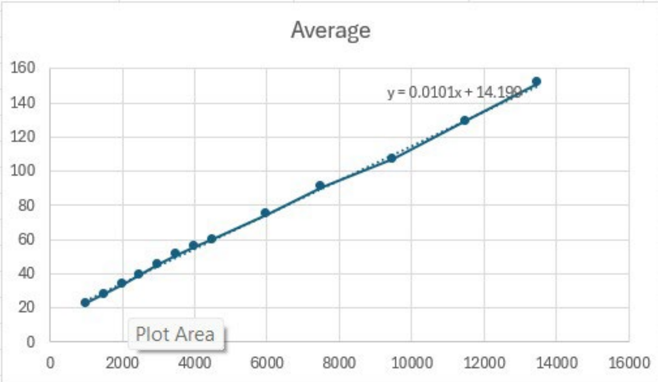


Figure 23

Keypad

The keypad was integrated to provide a user-friendly interface for inputting parameters such as dilution ratios and operational settings. This enhancement facilitated intuitive interaction with the system, allowing users to easily configure settings and control the automated process.

S.J. Mayadunna – 225070A

I worked on integrating the **ultrasonic sensors**, managing the **LCD display with I2C module**, and overseeing the **water pump, solenoid valve, relay**, and **water measuring functions**, as well as completing the **board finishing**.

I integrated two ultrasonic sensors into the system:

- **Ultrasonic Sensor 1:** This sensor detects the presence of the final output beaker, ensuring it is correctly positioned to receive the liquid.
- **Ultrasonic Sensor 2:** This sensor monitors the liquid level in the beaker, preventing overflow or dry pumping by providing real-time feedback on whether there is liquid present.
- **LCD Display and I2C Module:** I managed the integration of the LCD display with the I2C module to provide clear and real-time output to users. The I2C module enabled

efficient communication between the ESP32 boards and the LCD display, allowing users to view system status, prompts, and operational feedback with ease.

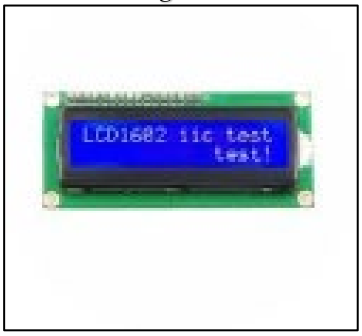
- **Water Pump, Solenoid Valve, Relay, Water Measuring:**
    - **Water Pump:** I ensured accurate control of the water pump to dispense the required amount of water based on measurements from the VL53L0X ToF sensor.
    - **Solenoid Valve:** I controlled the solenoid valve to halt the water flow once the desired volume was reached, ensuring precise liquid dispensing.
    - **Relay:** I connected and managed the relay module to control the operation of the water pump and solenoid valve, allowing for safe switching of high-power components.
    - **Water Measuring:** I integrated and calibrated the water measuring components to accurately gauge and regulate the liquid levels during the dilution process.

- **Board Finishing:** I completed the board finishing by securely housing all components in a robust and aesthetically designed enclosure. This ensured that the hardware was protected, organized, and presented a professional appearance, contributing to the overall functionality and reliability of the system.

Figure 24

Ultrasonic Sensor

Figure 25



16x2 LCD Display

Figure 26

Water Pump

Figure 27

Board Finishing

Ultrasonic Sensors

Ultrasonic Sensor 1: This sensor is tasked with detecting the presence of the final output beaker. By ensuring that the beaker is correctly positioned, it facilitates accurate liquid dispensing and prevents errors in the process.

Ultrasonic Sensor 2: This sensor monitors the liquid level within the beaker. It provides real-time feedback on whether there is liquid present, helping to prevent overflow or dry pumping by ensuring the beaker contains liquid before further dispensing occurs.

LCD Display: The LCD display provides users with clear, real-time output on system status and operational feedback. It enables users to monitor the system's performance and view important prompts and messages.

I2C Module: The I2C module facilitates efficient communication between the ESP32 boards and the LCD display. It simplifies the connection process and ensures reliable data transfer, allowing for seamless integration and display of system information.

Water Pump: The water pump is controlled to dispense the precise amount of water as required, based on measurements from the VL53L0X ToF sensor. This ensures accurate dispensing and proper control of the liquid.

Solenoid Valve: The solenoid valve is managed to stop the water flow once the desired volume has been dispensed. This precise control is crucial for accurate liquid dispensing and preventing overfilling.

Relay: The relay module is used to manage the operation of the water pump and solenoid valve. It enables safe and efficient switching of high-power components through low-voltage control signals.

Water Measuring: The water measuring components, including the VL53L0X ToF sensor, are integrated and calibrated to ensure accurate liquid level readings. This component is essential for regulating and maintaining the correct liquid levels during the dilution process.

C.B.R.N.D. Bandara – 225013E

I worked on integrating the **DS18B20 Temperature Sensor**, setting up the **buzzer**, and completing the **board finishing** for the automated acid dilution system.

I integrated the DS18B20 temperature sensor into the system to accurately measure the temperature of the liquid in the output beaker. I programmed the sensor to provide precise digital temperature readings, which were then used to monitor and control the temperature of the solution during the dilution process. The sensor's high accuracy and straightforward communication protocol ensured reliable data collection for proper system operation.

I incorporated a buzzer into the system for auditory alerts and notifications. I programmed the buzzer to produce distinct sound patterns for different scenarios, such as emergency alerts, completion of tasks, and cleaning intervals. This functionality provides clear and immediate feedback to users, enhancing safety and operational efficiency.

DS18B20 Temperature Sensor

The DS18B20 temperature sensor was integrated into the system to provide accurate measurements of the liquid's temperature in the output beaker. The sensor’s high precision and digital communication capabilities enabled reliable temperature monitoring, crucial for controlling and adjusting the solution during the dilution process. Its integration ensures that temperature data is consistently captured and used for maintaining optimal conditions throughout the operation.

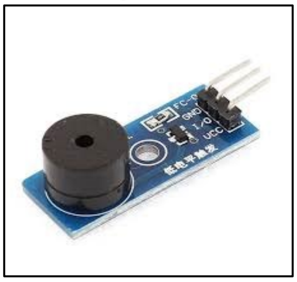
Buzzer

The buzzer was incorporated to provide auditory alerts and notifications within the system. It was programmed to emit specific sound patterns for various events, such as emergency warnings, task completions, and cleaning reminders. This functionality enhances user interaction by delivering clear, immediate feedback, which improves safety and operational efficiency.

Figure 28

Temperature Sensor

Figure 29



Buzzer

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