



UNIVERSITY OF LIBERAL ARTS BANGLADESH (ULAB)

Smart Aquaponics and Digital Control System

Submitted By:

Sumaya Tasnur	ID: 191016026
Abdul Aziz Sakil	ID: 173016005
Joy Kumar Ray	ID: 183016009

A project submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering from

University of Liberal Arts Bangladesh (ULAB)

Supervised By:

A O M Shamsuddoha

Lecturer

Department of Electrical and Electronic Engineering

University of Liberal Arts Bangladesh

688 Beribadh Road

Mohammadpur, Dhaka -1207,
Bangladesh.

26 January,2025

DECLARATION

This Final year Capstone Project report is submitted to the department of Electrical and Electronic Engineering, University of Liberal Arts Bangladesh in partial fulfillment of the requirements for the degree of Bachelor of Science. So, we hereby, declare that this report is based on the work done by us. Materials of work found by other researchers are mentioned by reference. This project report, neither in whole, nor in part, has been previously submitted for any degree.

1. Name: Sumaya Tasnur

Signature: _____

Date: _____

2. Name: Abdul Aziz Sakil

Signature: _____

Date: _____

3. Name: Joy Kumar Ray

Signature: _____

Date: _____

SUPERVISOR'S CERTIFICATION / APPROVAL

The Final year Capstone Project report entitled “**Smart Aquaponics and Digital Control System**” is submitted to the department of Electrical and Electronic Engineering, University of Liberal Arts Bangladesh, Dhaka in partial fulfillment of the requirements for the degree of Bachelor of Science.

A.O.M Shamsuddoha

Supervisor

Lecturer

Department of Electrical and Electronic Engineering

University of Liberal Arts Bangladesh

Signature

Date:

Prof. Mahbubur Rahman

Head of Department

Dean, School of Science and Engineering

Department of Electrical and Electronic Engineering

University of Liberal Arts Bangladesh

Signature

Date:

ACKNOWLEDGEMENT

First of all, we would like to pay our sincerest gratitude to the almighty Allah for keeping us in sound mind and health during the work and giving us the ability to work hard successfully. We are grateful to **A O M Shamsuddoha**, Lecturer, Department of Electrical and Electronic Engineering, University of Liberal Arts Bangladesh (ULAB). His constant supervision, constructive criticism, valuable advice, Scholarly guidance, and encouragement at all stages of our work have made it possible to complete this project.

We would like to give thanks to all the teachers of the Department of Electrical and Electronic Engineering for their constructive criticism and valuable advice and cordial co-operation during the study at the University. Specially thank my family members who gave us huge support and inspiration during our whole B.Sc. Course in EEE.

In this connection, we also thank the officers and staff of the university for their cooperation and to all others not stated here for their help and co-operation. Science & Engineering, University of Liberal Arts Bangladesh (ULAB), who has supported us in any case with his kind and all the time during our project.

Finally, we would like to give thank our course mates, friends, and well-wishers who gave us huge support inspiration and their friendly and lovely company during our project.

Abstract

Aquaponics, a sustainable farming method combining aquaculture and hydroponics, is gaining recognition for efficient resource use in food production. However, traditional systems often demand constant manual monitoring, which is time-consuming and inefficient. This project introduces a Smart Aquaponics and Digital Control System utilizing IoT technology and advanced sensors to automate and optimize the process.

The system integrates sensors to monitor key parameters like water quality (pH, temperature), light intensity, and nutrient levels, with data processed on a cloud platform for real-time visualization. Automated controls handle tasks such as feeding, water flow, and lighting adjustments. A user-friendly app enables remote monitoring and control, enhancing convenience and accessibility.

By reducing manual intervention and improving efficiency, the system boosts productivity while maintaining ecological balance. Its scalable design suits both urban and large-scale agricultural setups, promoting sustainable food production and addressing global food security challenges. This innovation demonstrates how IoT can revolutionize aquaponics for smarter, self-sustaining farming practices.

TABLE OF CONTENTS

Name of the Contents	Page No
Declaration	iii
Certificate	iv
Acknowledgement	v
Abstract	vi
Table of Contents	vii
List of Figures	x
List of Tables	xi
List of Abbreviations	xi
Chapter 1: Introduction	01
1.1 Introduction	02
1.2 Objective of the Project	03
1.3 Background of the Project	03
1.4 IoT System	05
1.5 Methodology	06
1.6 Motivation for Project	07
1.7 Project Management	08
Chapter 2: Literature Review	10
2.1 Introduction	11
2.2 Algorithms and Implementations	11
2.3 Existing Systems	11
2.4 Software Tools	12
2.5 Arduino IDE	13
2.6 Programming	13
2.7 Arduino Program Development	13
2.8 Android Apps	14
2.9 Proposed Project in Proteus 8.9	14
2.10 Literature Survey	15
2.11 Time Plan	17

Chapter 3: Experimental Design **20**

3.1	Introduction	21
3.2	Smart Water Quality System	21
3.3	System Architecture	21
3.4	Block Diagram of This Project	22
3.5	Circuit Diagram of This Project	22
3.6	The list of Devices used in the Project is Given Below	23
3.7	ESP32	23
3.7.1	Technical Specifications	24
3.8	Buck Module	25
3.9	Power Supply	25
3.9.1	Specifications	27
3.10	LCD Display	27
3.11	pH Sensor	28
3.11.1	Technical Specifications	28
3.12	TDS Sensor	29
3.12.1	Technical Specifications	30
3.13	Temperature Sensor	30
3.13.1	Technical Specifications	31
3.14	Float Sensor	31
3.14.1	Technical Specifications	32
3.15	LDR Sensor	32
3.16	Relay Module	33
3.16.1	Features	34
3.16.2	Interface Specifications	34
3.17	Pump Motor	35

Chapter 4: Results and Discussion **36**

4.1	Introduction	37
4.2	Result	38

Chapter 5: Conclusion and Recommendations **41**

5.1	Discussion	42
5.2	Advantage	42
5.3	Application	42

5.4	Future Scope	43
5.5	Conclusion	43
References		44
Appendix		47

List of Figures

Figure No	Figure Contains	Page No
Figure 1.1	IoT System	05
Figure 1.2	Block Diagram of IoT	06
Figure 1.3	Methodology	06
Figure 1.4	Project Management	09
Figure 2.1	Program Installation Process	12
Figure 2.2	Flowchart of the Compiling Process	13
Figure 2.3	Blynk Android Webapps	14
Figure 2.4	User Interface of Proteus 8.9	15
Figure 3.1	Block Diagram	22
Figure 3.2	Circuit Diagram	22
Figure 3.3	ESP-32	25
Figure 3.4	LM2596 Voltage Converter	25
Figure 3.5	SMPS Power Supply	26
Figure 3.6	LCD Display	28
Figure 3.7	pH Sensor	29
Figure 3.8	TDS Sensor	30
Figure 3.9	Temperature Sensor	31
Figure 3.10	Float Sensor	32
Figure 3.11	LDR Sensor	32
Figure 3.12	Relay Module	33
Figure 3.13	Schematic of Relay Module	34
Figure 3.14	Pin Out of Relay Module	35

Figure 3.15 Pump Motor	35
Figure 4.1 Project Picture	37
Figure 4.2 Experimental Results Via LCD Display	38
Figure 4.3 Experimental Results Via Webapp	39
Figure 4.4 Experimental Results Via Mobile	44
Figure 4.5 Quantifiable Results	45

List of Tables

Table No	Table Contains	Page No
Table- 01	Time Scheduled Table for Project Introduction	17
Table- 02	Time Plan Table for Project Introduction	18
Table- 03	Time Scheduled Table for Project	18
Table- 04	Time Plan Table for Project	19
Table- 05	LCD Display Outline	27

List of Abbreviations

IoT	Internet of Things	IR	Infrared
ESP	Extra Sensory Perception		
IDE	Integrated Development Environment		

Chapter 01

Introduction

1.1 Introduction

The growing global demand for food, combined with the adverse effects of climate change and limited natural resources, has led to an increased interest in sustainable agricultural practices. Aquaponics, a method of food production that combines fish farming (aquaculture) with soil-free plant cultivation (hydroponics), has emerged as a promising solution. This closed-loop system leverages the symbiotic relationship between fish and plants to create a highly efficient and resource-conserving environment. However, despite its potential, traditional aquaponic systems require frequent manual monitoring and intervention, limiting their scalability and overall efficiency.

To address these challenges, the development of a Smart Aquaponics and Digital Control System has been proposed. By integrating modern technologies such as the Internet of Things (IoT), sensors, and digital control mechanisms, this system aims to automate the monitoring and management of critical variables within the aquaponics ecosystem, ensuring optimal conditions for both aquatic life and plant growth with minimal human intervention.

The core of the system lies in the use of real-time data collection through various environmental sensors, which monitor parameters such as water temperature, pH, TDS levels and light intensity. These sensors are connected to a centralized control platform, which processes the data to trigger automated actions, such as regulating water flow, controlling feeding schedules, and adjusting environmental settings like lighting and temperature. The entire system can be accessed and controlled remotely via a userfriendly web and mobile application, enabling users to monitor their aquaponics system from anywhere at any time.

This approach not only enhances the efficiency of aquaponics systems but also ensures greater consistency in environmental conditions, leading to improved plant growth and healthier fish. Furthermore, by reducing the need for manual labor, the system offers a more cost-effective solution for small and large-scale farming applications.

The Smart Aquaponics and Digital Control System represents a significant step forward in integrating technology with sustainable farming practices. It holds the potential to revolutionize the way food is produced, offering a scalable and efficient solution that aligns with the growing need for eco-friendly and resource-efficient agricultural systems.

1.2 Objective of the Project

The main objective of this project is to “**Smart Aquaponics and Digital Control System**” Project for the main purpose is to create a smart system so that we can take many benefits from one project. The primary objective of the Smart Aquaponics and Digital Control System is to develop a technologically advanced and sustainable farming solution that automates and optimizes aquaponics operations. This system aims to:

- Enhance Monitoring and Control.
- Automate Operational Processes.
- Enable Remote Management.
- Improve Resource Efficiency.
- Increase Crop Yield and Fish Health.
- Ensure Scalability and Flexibility.
- Promote Sustainable Agriculture.

1.3 Background of the Project

The growing global population and increasing demand for food have placed significant pressure on traditional agricultural systems. Conventional farming methods often result in high water consumption, extensive land use, and substantial environmental impact. In response, alternative and sustainable food production methods, such as aquaponics, have gained popularity. Aquaponics is a closed-loop, symbiotic farming system that integrates aquaculture (raising fish) and hydroponics (growing plants without soil) to create an efficient and environmentally friendly ecosystem.

In aquaponics, fish waste provides essential nutrients for plant growth, while plants help purify the water for the fish. This natural cycle minimizes resource wastage and eliminates the need for chemical fertilizers or pesticides. Despite its benefits, traditional aquaponics systems face challenges such as labor-intensive management, inconsistent environmental conditions, and difficulty scaling operations to meet larger demands.

Recent advancements in technology, particularly the Internet of Things (IoT), digital automation, and data analytics, offer solutions to overcome these limitations. IoT enables real-time monitoring and data collection from sensors embedded within the system, while digital control systems automate key processes, ensuring consistent and optimal environmental conditions.

Here's a breakdown of the typical components and functionalities of such a system:

Sensors: Various sensors are used to measure parameters such as temperature, PH, TDS Sensor, light intensity sensor and water level. These sensors are often connected to a microcontroller or a single-board computer that collects data from them.

Data Communication Infrastructure: The data collected by the sensors need to be transmitted to a central server or cloud platform for storage and analysis. This is usually done using wireless communication protocols such as Wi-Fi, Bluetooth, LoRa, or cellular networks (3G/4G/5G).

Data Storage and Processing: The data received from the sensors is stored in a database for further analysis. Cloud platforms like AWS, Azure, or Google Cloud are commonly used for this purpose. Data processing algorithms can be applied to detect trends, anomalies, or patterns in the data.

Visualization and User Interface: The processed data is then presented to users through a user interface, which could be a web dashboard, a mobile application, or both. This interface allows users to monitor water quality parameters in real-time, view historical data, and set up alerts for abnormal conditions.

Alerting System: The system may be equipped with an alerting mechanism to notify relevant stakeholders (such as environmental agencies, water treatment plants, or local authorities) in case of any deviations from predefined thresholds or norms.

Power Supply and Management: Since these systems are often deployed in remote or inaccessible locations, they need to be powered by reliable and sustainable sources such as solar panels, batteries, or a combination of both. Power management techniques are also employed to optimize energy usage and extend the system's operational lifespan.

Integration with Decision Support Systems: In some cases, the data collected by the water quality monitoring system may be integrated with decision support systems or models that help in making informed decisions regarding water management, treatment, or regulatory compliance.

Maintenance and Calibration: Regular maintenance and calibration of sensors are essential to ensure the accuracy and reliability of the monitoring system. Automated calibration routines and self-diagnostic features can help in minimizing downtime and manual intervention.

Overall, an IoT-based water quality monitoring system provides a cost-effective, scalable, and efficient solution for monitoring and managing water resources, ensuring their sustainability and safety for both human consumption and environmental health.

1.4 IoT System

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

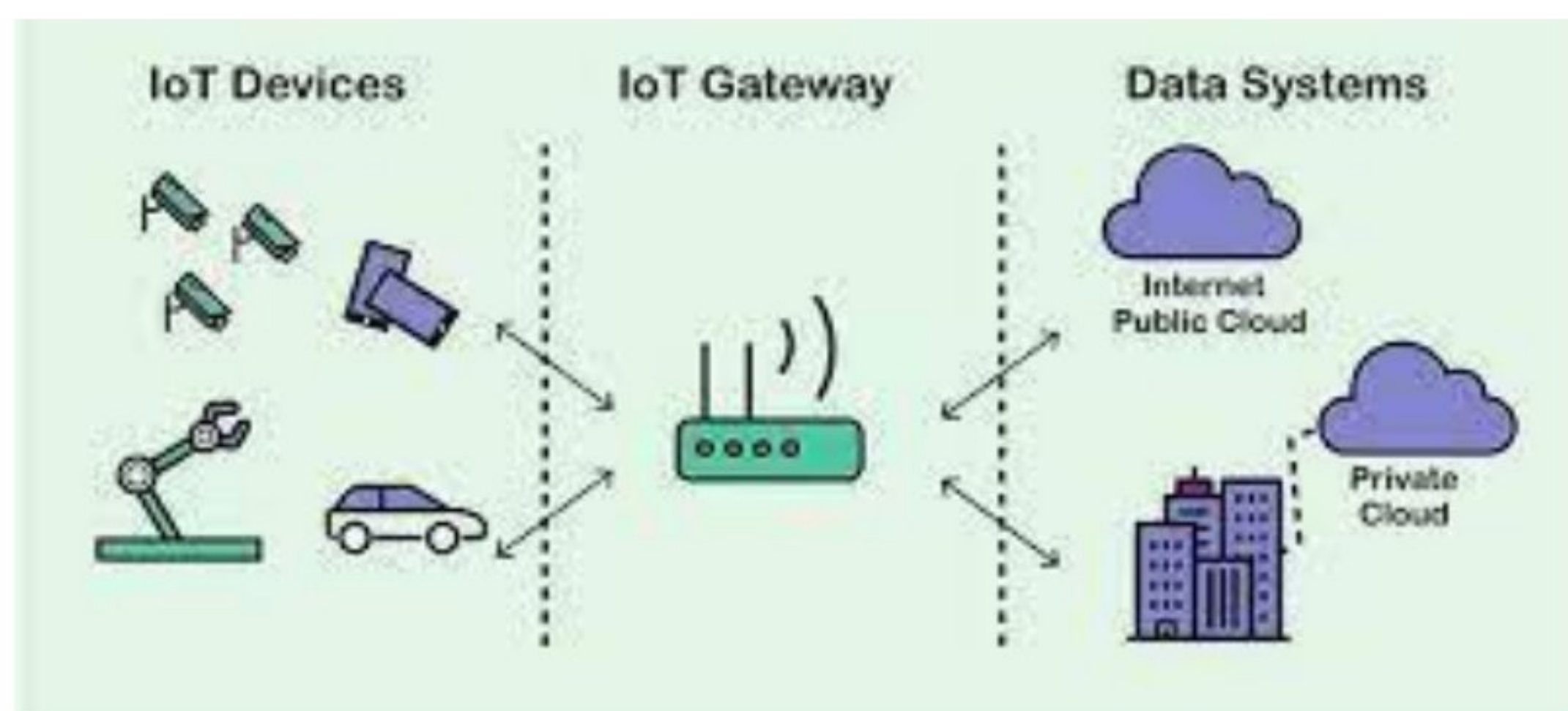


Fig- 1.1: IoT System

The definition of the Internet of Things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems.

Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of Things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the **Smart Aquaponics and Digital Control System** ", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as

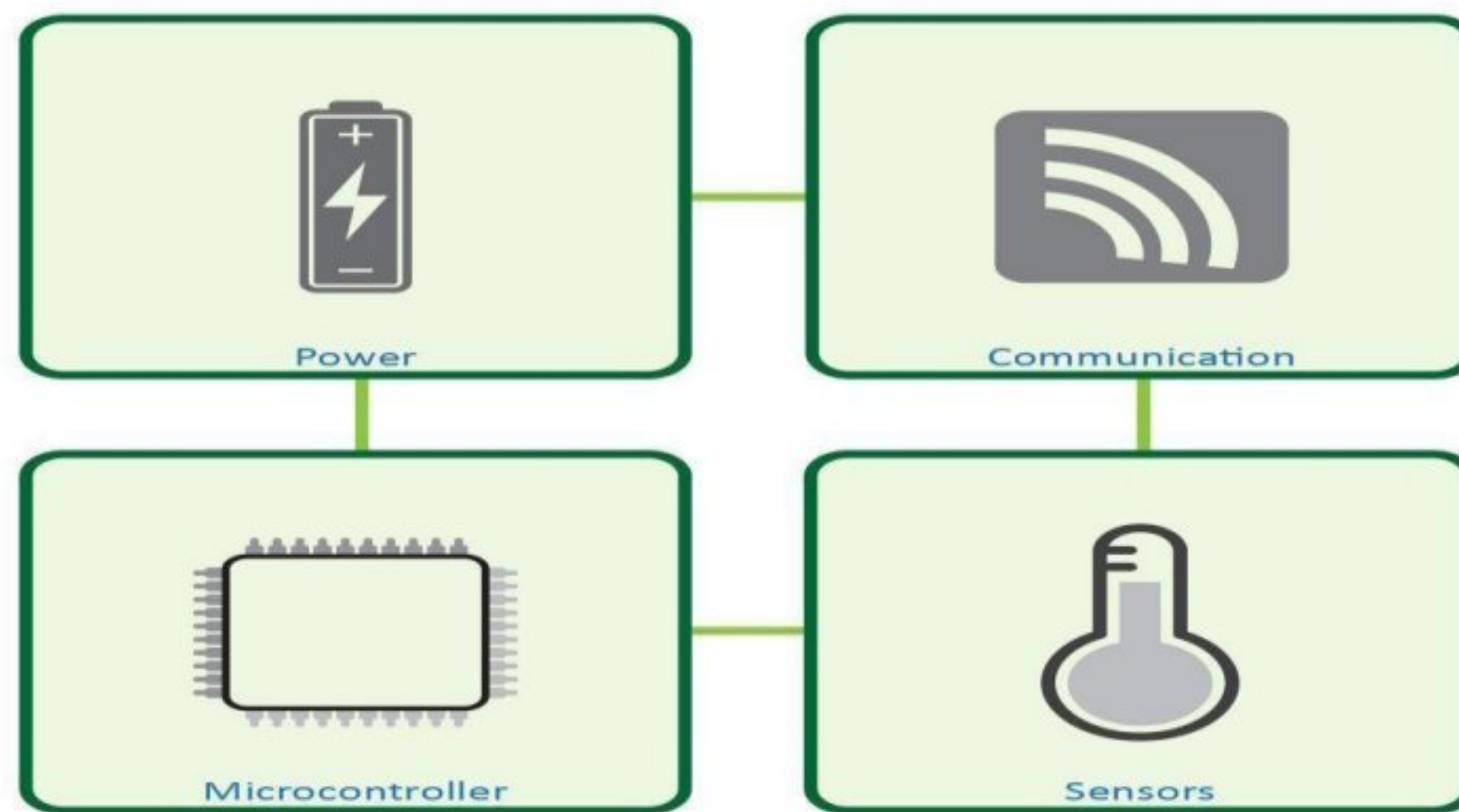


Fig- 1.2: Block Diagram of IoT

Smart phones and smart speakers. There are a number of serious concerns about dangers in the growth of IoT, especially in the areas of privacy and security; and consequently industry and governmental moves to begin to address these.

1.5 Methodology

The Smart Aquaponics and Digital Control System methodology involves a systematic approach to design, implement, and evaluate an IoT-enabled, automated aquaponics system. The process is structured into the following key stages:

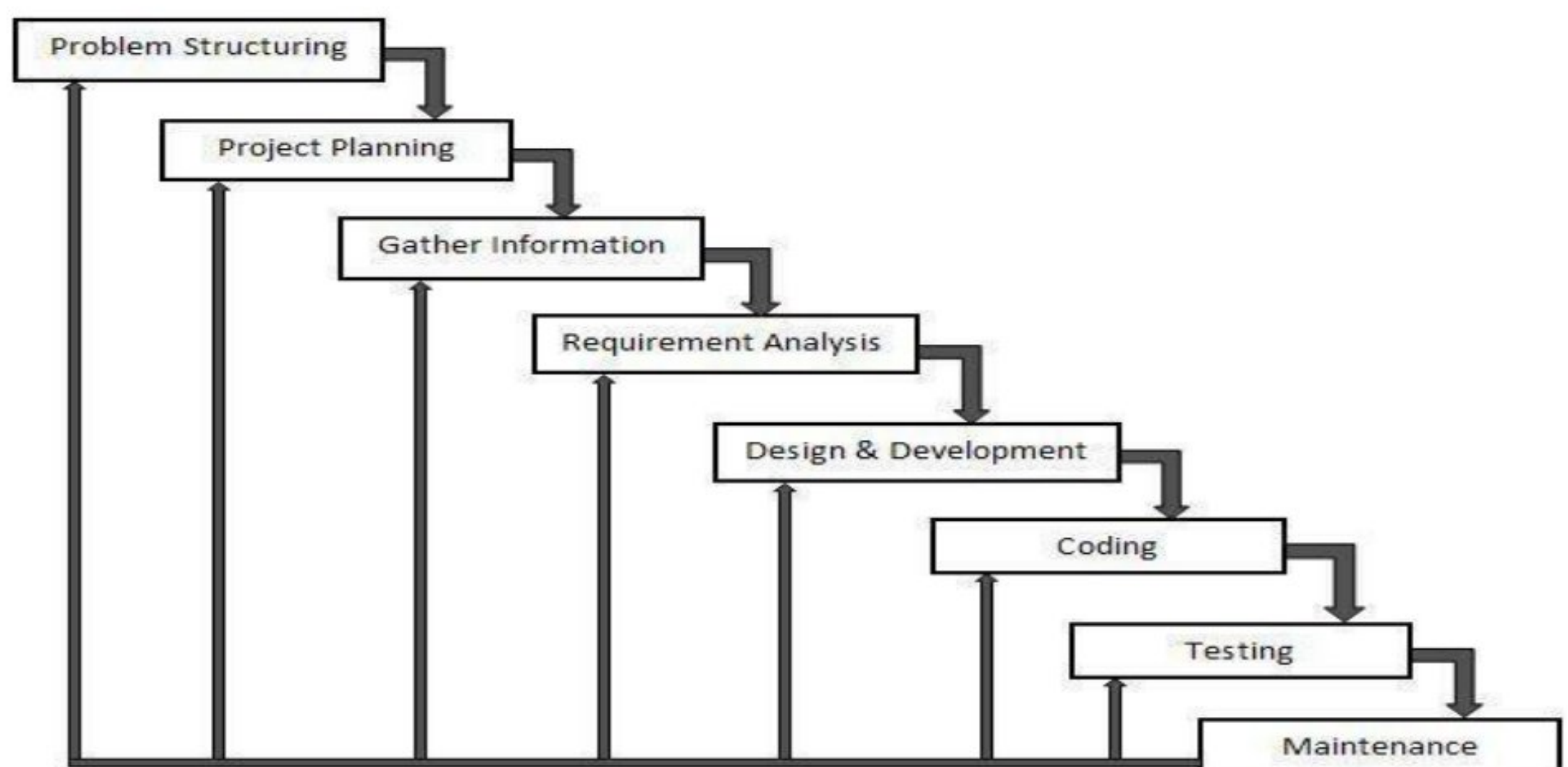


Fig- 1.3: Methodology

- System Design
- IoT and Cloud Integration.
- Automation and Control.
- System Implementation.
- Testing and Calibration.
- Performance Optimization.
- Evaluation and Scalability.

1.6 Motivation for Project

The motivation behind the development of the Smart Aquaponics and Digital Control System arises from the growing need for sustainable, efficient, and scalable agricultural practices in response to global challenges. These challenges, combined with the opportunities presented by technological advancements, drive the pursuit of this innovative solution. Key motivating factors include:

1. Addressing Food Security:

The global population is projected to reach nearly 10 billion by 2050, creating an urgent need for efficient food production systems. Traditional farming methods are often resource-intensive and vulnerable to environmental changes, making it difficult to meet the growing demand.

Aquaponics offers a sustainable alternative, capable of producing high-quality fish and crops using minimal resources. By integrating digital controls, the system ensures consistent and optimal production, helping address food security issues.

2. Sustainable Resource Management:

Agriculture accounts for significant water and energy consumption worldwide. Aquaponics systems inherently use less water than traditional farming, as they recirculate water in a closed-loop system.

The integration of IoT and automation in aquaponics further optimizes resource usage, reducing waste and promoting sustainability.

3. Reducing Labor Intensity:

Traditional aquaponics systems require continuous manual monitoring and management of parameters like water quality, nutrient levels, and feeding schedules.

Automating these processes through digital control systems reduces labor requirements, making aquaponics accessible and manageable for diverse users, including urban farmers and small-scale operators.

4. Leveraging IoT and Smart Technologies:

Advances in IoT, sensors, and cloud computing provide an opportunity to revolutionize agricultural practices by enabling real-time monitoring, data-driven decision-making, and remote management. The Smart Aquaponics System demonstrates how these technologies can be applied to enhance efficiency, scalability, and precision in farming.

5. Climate Change and Urbanization:

Climate change poses a significant threat to traditional farming, with unpredictable weather patterns, water scarcity, and land degradation becoming more prevalent. Urbanization further reduces available arable land, necessitating innovative solutions like aquaponics, which can be implemented in urban settings such as rooftops, basements, or vertical farms.

6. Improving Yield and Quality:

Consistent environmental conditions are critical for healthy fish and optimal plant growth. Manual systems often result in fluctuations that impact yield and quality. A digitally controlled aquaponics system ensures stability, improving both productivity and product quality.

7. Fostering Environmental Stewardship:

Aquaponics aligns with the principles of sustainable and eco-friendly farming by eliminating the need for chemical fertilizers and pesticides while reducing the carbon footprint. By incorporating smart technologies, the system promotes a greener and more responsible approach to food production.

8. Encouraging Technological Innovation in Agriculture:

The project demonstrates the potential of integrating cutting-edge technology into agriculture, inspiring further innovations in sustainable farming practices.

1.7 Project Management

Effective project management is essential for the successful design, development, and implementation of the Smart Aquaponics and Digital Control System. The project

management framework ensures that all objectives are met within scope, time, and budget constraints. The management process is divided into key phases:

1. Initiation Phase
2. Planning Phase
3. Execution Phase
4. Monitoring and Control Phase
5. Testing and Implementation Phase
6. Closure Phase

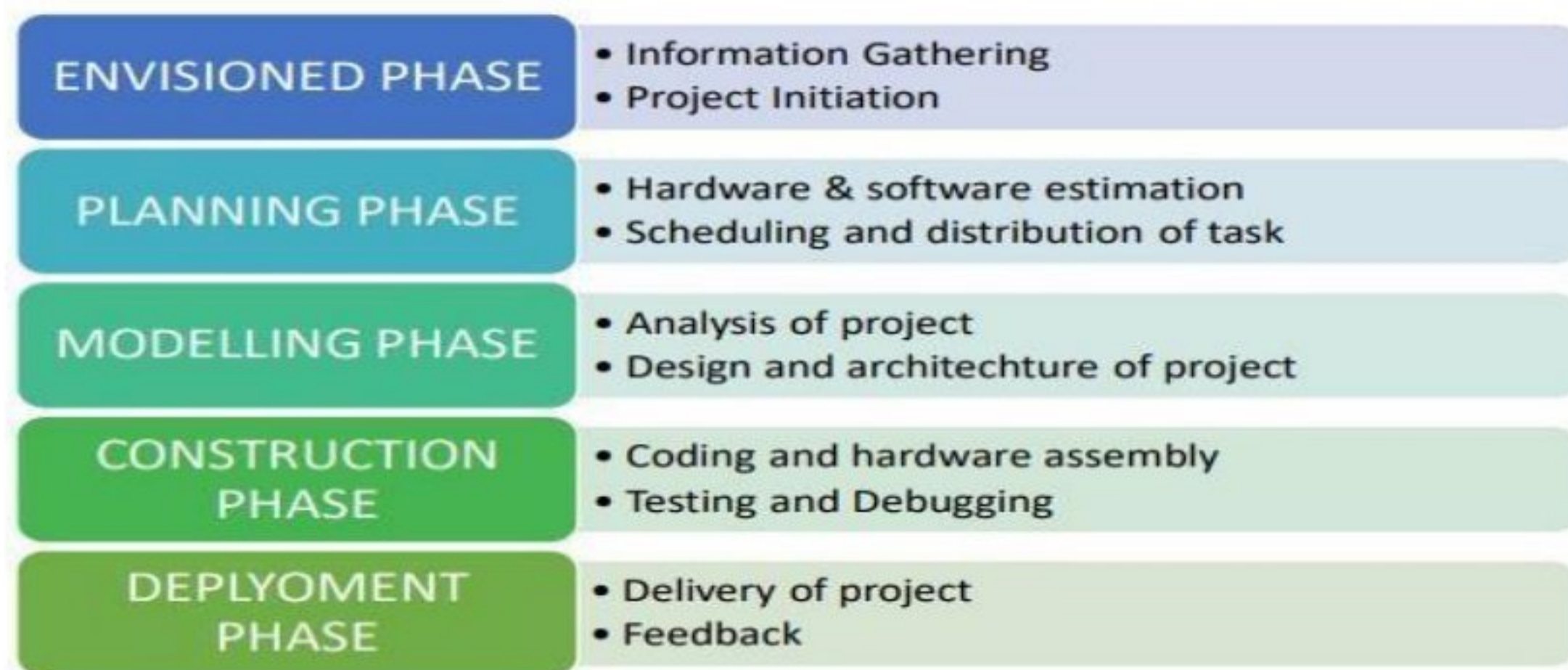


Fig-1.4: Project Management

Chapter 02

Literature Review

2.1 Introduction

Smart aquaponics integrates modern technology with the traditional aquaponic farming method to create a more efficient, automated, and sustainable system. Aquaponics is a closed-loop system that combines aquaculture (raising fish) and hydroponics (growing plants without soil). Fish waste provides natural nutrients for the plants, while the plants filter and purify the water, creating a symbiotic relationship.

With the integration of a digital control system, smart aquaponics takes this concept to the next level by utilizing IoT (Internet of Things), sensors, and automated controls to monitor and optimize environmental parameters. This approach ensures that the system operates at peak efficiency, reducing manual labor and improving yields.

2.2 Algorithms and Implementations

The implementation of a smart aquaponics system relies on well-designed algorithms that enable real-time monitoring, automated control, and efficient management. These algorithms are executed using microcontrollers, sensors, actuators, and IoT platforms, ensuring a seamless and autonomous operation.

2.3 Existing Systems

Several smart aquaponics and digital control system projects have been developed worldwide, showcasing the integration of IoT, automation, and data-driven management in aquaponics systems. These existing systems provide valuable insights into the possibilities and applications of smart aquaponics.

- AquaGrow Integrated System
- Blynk Open Agriculture Initiative
- SmartAqua System
- Agrofresh IoT Aquaponics
- AquaShield – Smart Aquaponics Monitoring
- FarmBot with Aquaponics
- AquaIoT by AgriTech Solutions

2.4 Software Tools

The software that is used to program the microcontroller is open-source-software and can be downloaded for free on www.arduino.cc. With this “Arduino software” we can write little programs with the microcontroller. These programs are called “Sketch”. In the end the sketches are transferred to the microcontroller by USB cable. More on that later on the subject “programming”.

Installation Now one after another the Arduino software and the USB driver for the board have to be installed.

Installation and setup of the Arduino software

1. We have downloaded the Arduino software from www.arduino.cc and installed it on the computer (This was NOT connected to the PC). After that we opened the software file and installed the program named `arduino.exe`.

Two set ups on the program are important and should be considered.

- a) The board that we want to connect has to be selected on the arduino software. The “Arduino Uno” is here known as “Arduino / Genuino Uno”.
- b) We have to choose the right “Serial-Port”, to let the Computer know to which port the board has been connected. That is only possible if the USB driver has been installed correctly. It can be checked this way:

At the moment the Arduino wasn’t connected to the PC. If we now choose “Port”, under the field “Tool”, we will already see one or more ports here (COM1/ COM2/ COM3...). The quantity of the shown ports doesn't depend on the quantity of the USB ports on the computer. When the board gets connected to the computer, we will find one more port.

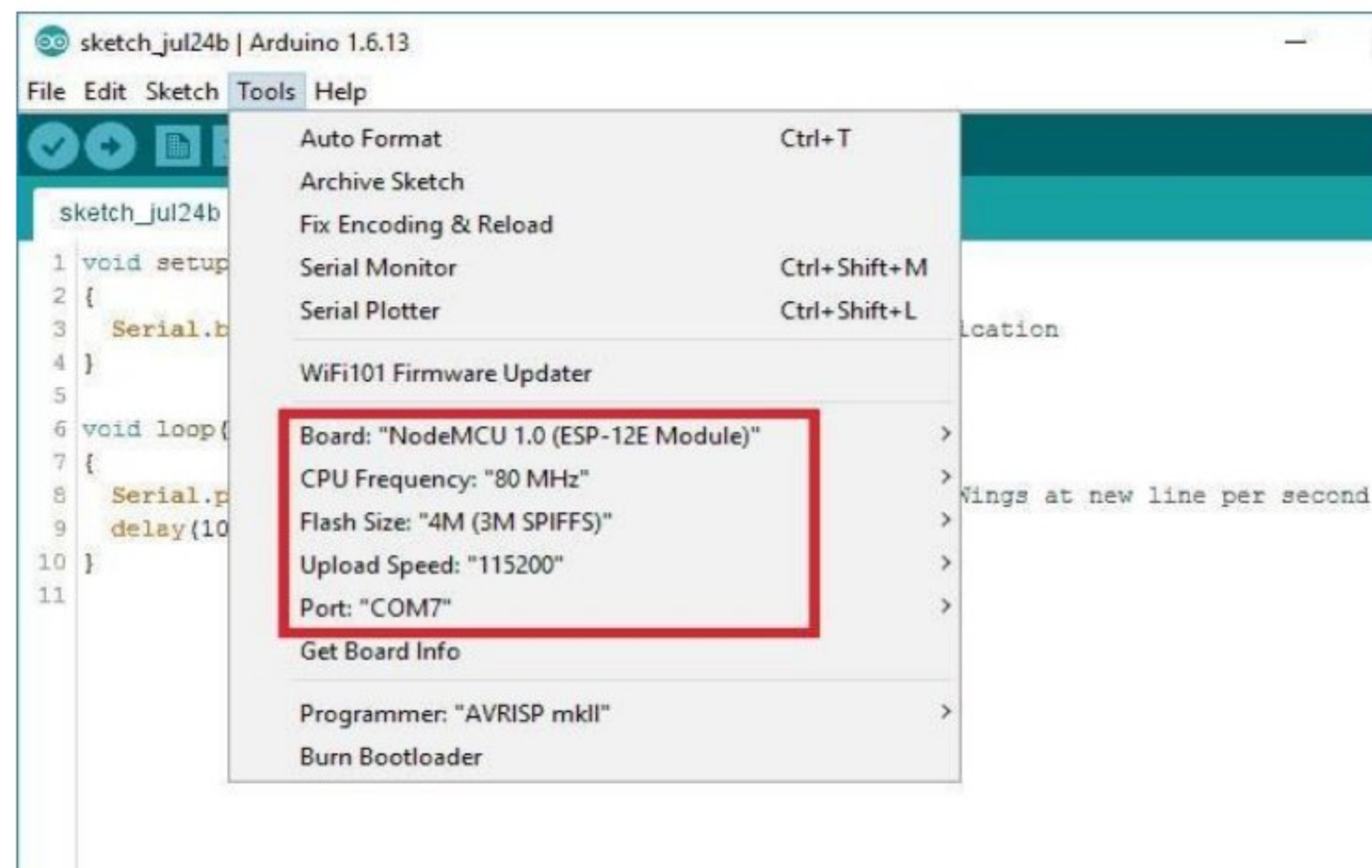


Fig- 2.1: Program Installation Process

2.5 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. `.ino`. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow verifying and uploading programs, creating, opening, and saving sketches, and opening the serial monitor.

2.6 Programming

The development cycle is divided into 4 phases:

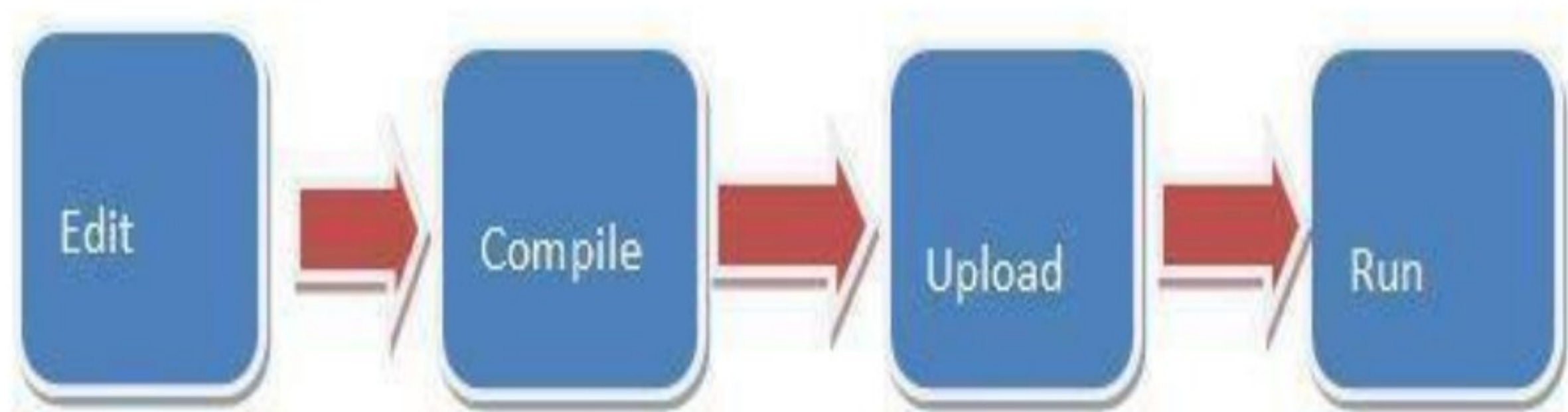


Fig-2.2: Flowchart of the Compiling Process

Compile: Compile means to translate the sketch into machine language, also known as object.

Code Run: Arduino sketch is executed as soon as terminates the step of uploading on the board.

2.7 Arduino Program Development

- Based on C++ without 80% of the instructions.
- A handful of new commands.
- Programs are called 'sketches'.
- Sketches need two functions:
 - `void setup ( )`
 - `Void loop ( )`
- `Setup ( )` runs first and once.
- `loop ( )` runs over and over, until power is lost or a new sketch is loaded.

2.8 Android Apps

The Blynk software is mainly operated over the Internet. This software has a specific server for sending data. This software has to be registered on the specified server, then login to the software with user name and password. Data is passed to the server through the controller's Internet head, the server sends software data, which we can monitor from anywhere.

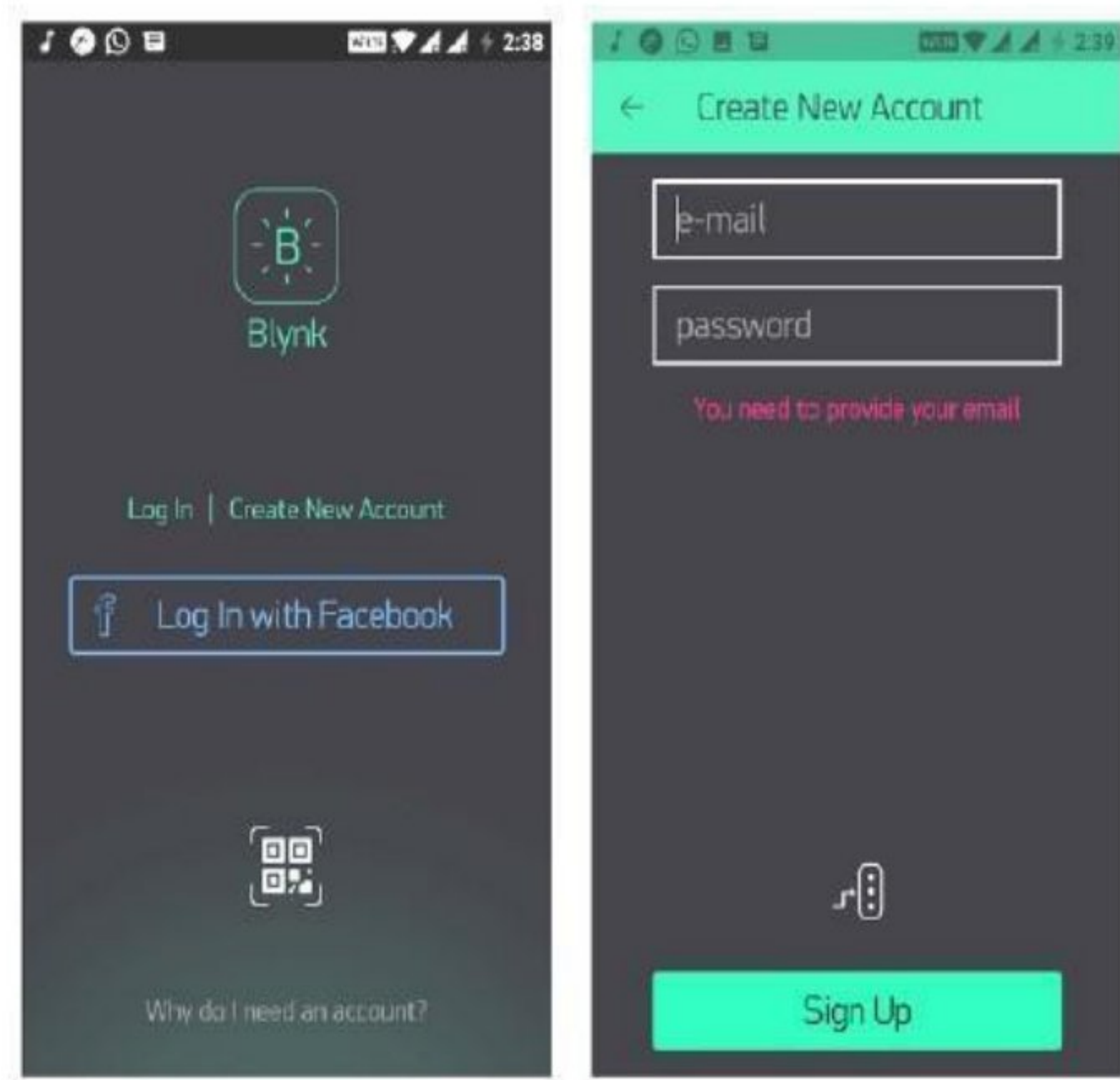


Fig- 2.3: Blynk Android Webapps

2.9 Proposed Project in Proteus 8.9

Proteus 8 is best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist. You can simulate your programming of microcontroller in Proteus 8 Simulation Software. After simulating your circuit in Proteus 8 Software you can directly make PCB design with it so it could be a all in one package for students and hobbyists. So I think now you have a little bit idea about what is proteus software.

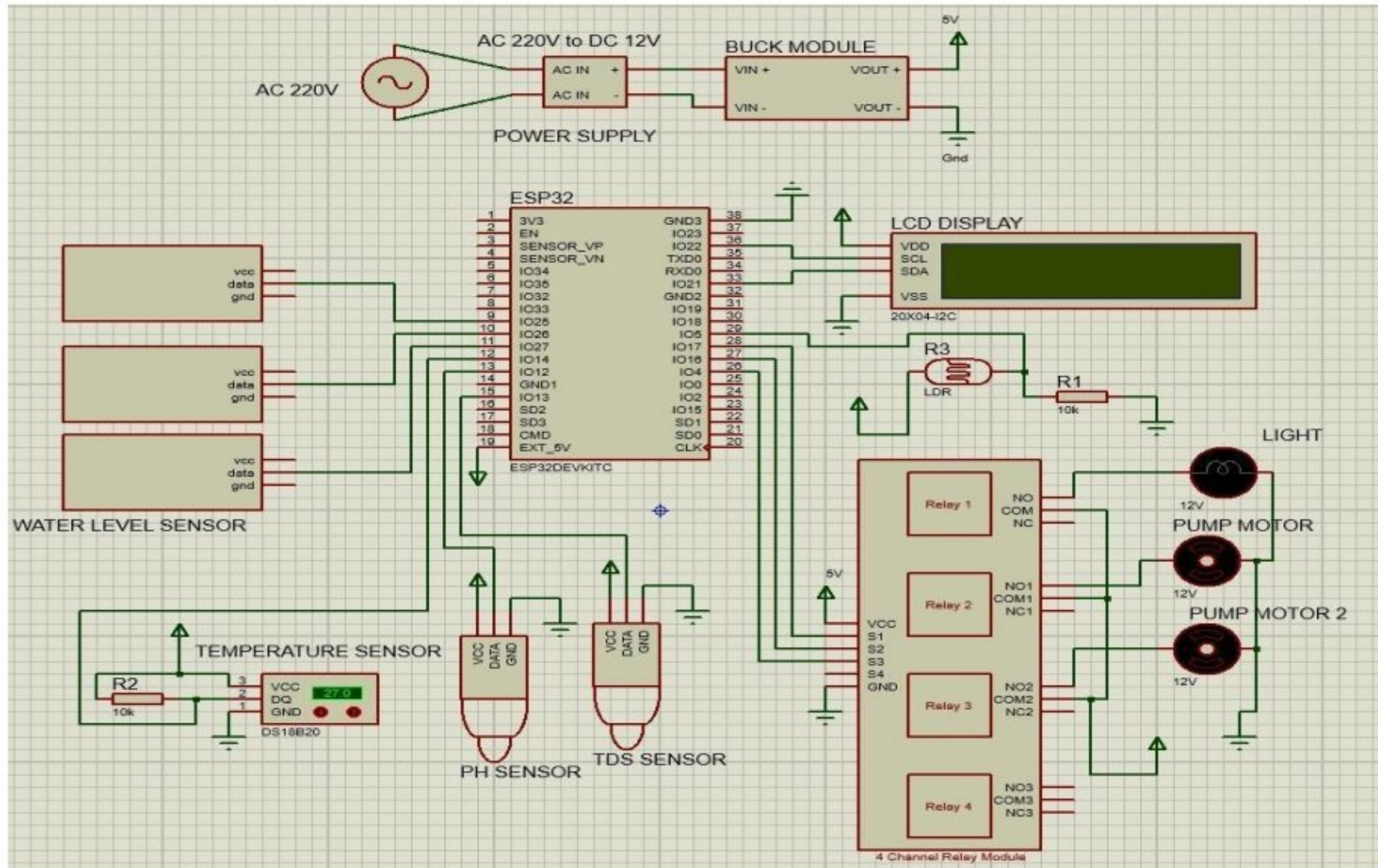


Fig- 2.4: User Interface of Proteus 8.9

2.10 Literature Survey

Nikhil Kedia entitled “Water Quality Monitoring for Rural Areas-A Sensor Cloud Based Economical Project.” Published in 2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015) Dehradun, India. This paper highlights the entire water quality monitoring methods, sensors, embedded design, and information dissipation procedure, role of government, network operator and villagers in ensuring proper information dissipation. It also explores the Sensor Cloud domain. While automatically improving the water quality is not feasible at this point, efficient use of technology and economic practices can help improve water quality and awareness among people.[1] Jayti Bhatt, Jignesh Patoliya entitled “Real Time Water Quality Monitoring System”. This paper describes to ensure the safe supply of drinking water the quality should be monitored in real time for that purpose new approach IOT (Internet of Things) based water quality monitoring has been proposed. In this paper, we present the design of IOT based water quality monitoring system that monitor the quality of water in real time. This system consists some sensors which measure the water quality parameter such as pH, turbidity, conductivity, dissolved oxygen, temperature. The measured values from the sensors are processed by microcontroller and this processed values are transmitted remotely to the

core controller that is raspberry pi using Zigbee protocol. Finally, sensors data can view on internet browser application using cloud computing.[2]

Michal Lom, Ondrej Pribyl, Miroslav Svitek entitled “Industry 4.0 as a Part of Smart Cities”. This paper describes the conjunction of the Smart City Initiative and the concept of Industry 4.0. The term smart city has been a phenomenon of the last years, which is very inflected especially since 2008 when the world was hit by the financial crisis. The main reasons for the emergence of the Smart City Initiative are to create a sustainable model for cities and preserve quality of life of their citizens. The topic of the smart city cannot be seen only as a technical discipline, but different economic, humanitarian or legal aspects must be involved as well. In the concept of Industry 4.0, the Internet of Things (IoT) shall be used for the development of so-called smart products. Subcomponents of the product are equipped with their own intelligence. Added intelligence is used both during the manufacturing of a product as well as during subsequent handling, up to continuous monitoring of the product lifecycle (smart processes). Other important aspects of the Industry 4.0 are Internet of Services (IoS), which includes especially intelligent transport and logistics (smart mobility, smart logistics), as well as Internet of Energy (IoE), which determines how the natural resources are used in proper way (electricity, water, oil, etc.). IoT, IoS, IoP and IoE can be considered as an element that can create a connection of the Smart City Initiative and Industry 4.0-Industry 4.0 can be seen as a part of smart cities.[3]

Zhanwei Sun, Chi Harold Li, Chatschik Bisdikian, Joel W. Branch and Bo Yang entitled “QOI-Aware Energy Management in Internet-of-Things Sensory Environments”. In this paper an efficient energy management frame work to provide satisfactory QOI experience in IOT sensory environments is studied. Contrary to past efforts, it is transparent and compatible to lower protocols in use, and preserving energy-efficiency in the long run without sacrificing any attained QOI levels. Specifically, the new concept of QOI-aware “sensor-to-task relevancy” to explicitly consider the sensing capabilities offered by an sensor to the IOT sensory environments, and QOI requirements required by a task. A novel concept of the “critical covering set” of any given task in selecting the sensors to service a task over time. Energy management decision is made dynamically at runtime, as the optimum for long-term traffic statistics under the constraint of the service delay. Finally, an extensive case study based on utilizing the sensor networks to perform water level monitoring is given to demonstrate the ideas and algorithms proposed in this paper,

and a simulation is made to show the performance of the proposed algorithms.[4] Sokratis Kartakis, Weiren Yu, Reza Akhavan, and Julie A. McCann entitled “Adaptive Edge Analytics for Distributed Networked Control of Water Systems” This paper presents the burst detection and localization scheme that combines lightweight compression and anomaly detection with graph topology analytics for water distribution networks. We show that our approach not only significantly reduces the amount of communications between sensor devices and the back end servers, but also can effectively localize water burst events by using the difference in the arrival times of the vibration variations detected at sensor locations. Our results can save up to 90% communications compared with traditional periodical reporting situations.[5]

2.11 Time Plan

The following tables define the main tasks in the project introduction and project itself.

Table- 01: Time Scheduled Table for Project Introduction

T1	Project Definition	1 Week
T2	Collecting data	11 Weeks
T3	Analysis	7 Weeks
T4	Theoretical calculation	4 Weeks
T5	Documentation	10 Weeks
T6	Prepare for presentation	2 Weeks

The time of the project introduction is scheduled over 16 weeks, table 2 shows how the work was scheduled over this time:

Table-02: Time Plan Table for Project Introduction

Week \ Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																
T6																

The following table defines the main tasks in the project:

Table-03: Time Scheduled Table for Project

T1	Collecting data	3 Week
T2	Implementation	10 Weeks
T3	Analysis	5 Weeks
T4	Building and testing the system	8 Weeks
T5	Documentation	10 Weeks
T6	Prepare for presentation	2 Weeks

The time of the project is scheduled over 16 weeks, table 4 shows how the work was scheduled over this time:

Table-04: Time Plan Table for Project

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																
T6																

Chapter 03

Experimental Design

3.1 Introduction

The Smart Aquaponics and Digital Control System Project aims to modernize traditional aquaponic farming by integrating advanced technologies such as IoT (Internet of Things), automation, and data analytics. Aquaponics combines aquaculture (raising fish) with hydroponics (growing plants in a soilless environment), creating a self-sustaining, closedloop ecosystem. In this system, fish waste serves as a natural fertilizer for plants, while plants purify the water for the fish.

The incorporation of digital control systems enhances the efficiency and scalability of aquaponics by automating critical processes, providing real-time monitoring, and enabling remote management. This smart approach addresses the challenges of resource management, environmental control, and productivity optimization in modern agriculture.

3.2 Smart Aquaponics and Digital Control System

Smart Aquaponics and Digital Control System is an innovative approach to sustainable agriculture that combines the ecological benefits of aquaponics with the efficiency of digital technology. This system integrates advanced automation, IoT (Internet of Things), and data analytics to create a self-sustaining ecosystem that maximizes resource use and optimizes production.

3.3 System Architecture

The Smart Aquaponics and Digital Control System architecture integrates hardware, software, and communication layers to create a seamless, automated, and intelligent ecosystem. The architecture ensures efficient monitoring, decision-making, and control of the aquaponics system while enabling remote management and scalability.

1. Overview of the Architecture
2. Components of the Architecture
3. Functional Flow of the System
4. Architecture Diagram
5. Benefits of the Architecture

3.4 Block Diagram of This Project

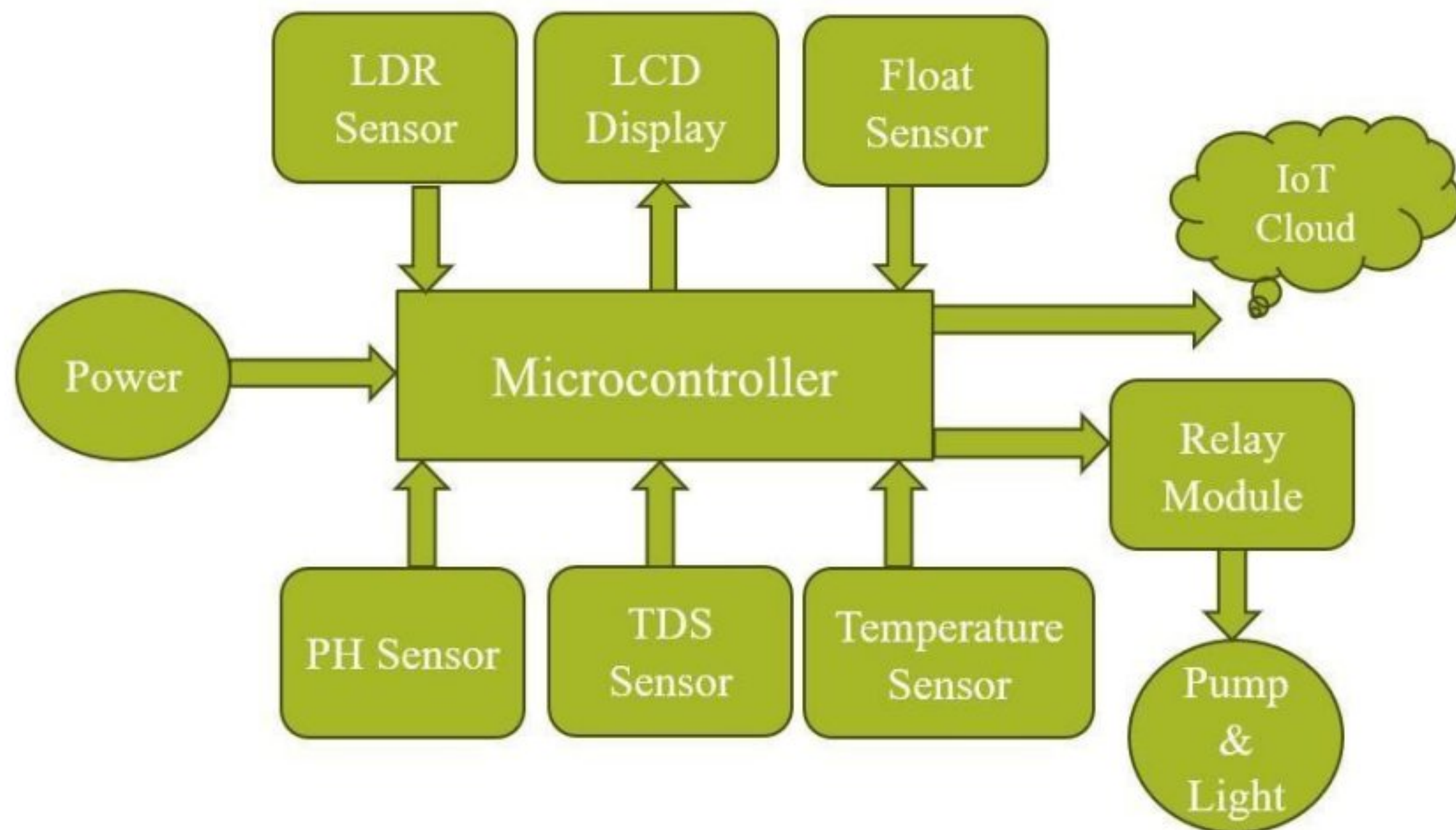


Fig-3.1: Block Diagram

3.5 Circuit Diagram of This Project

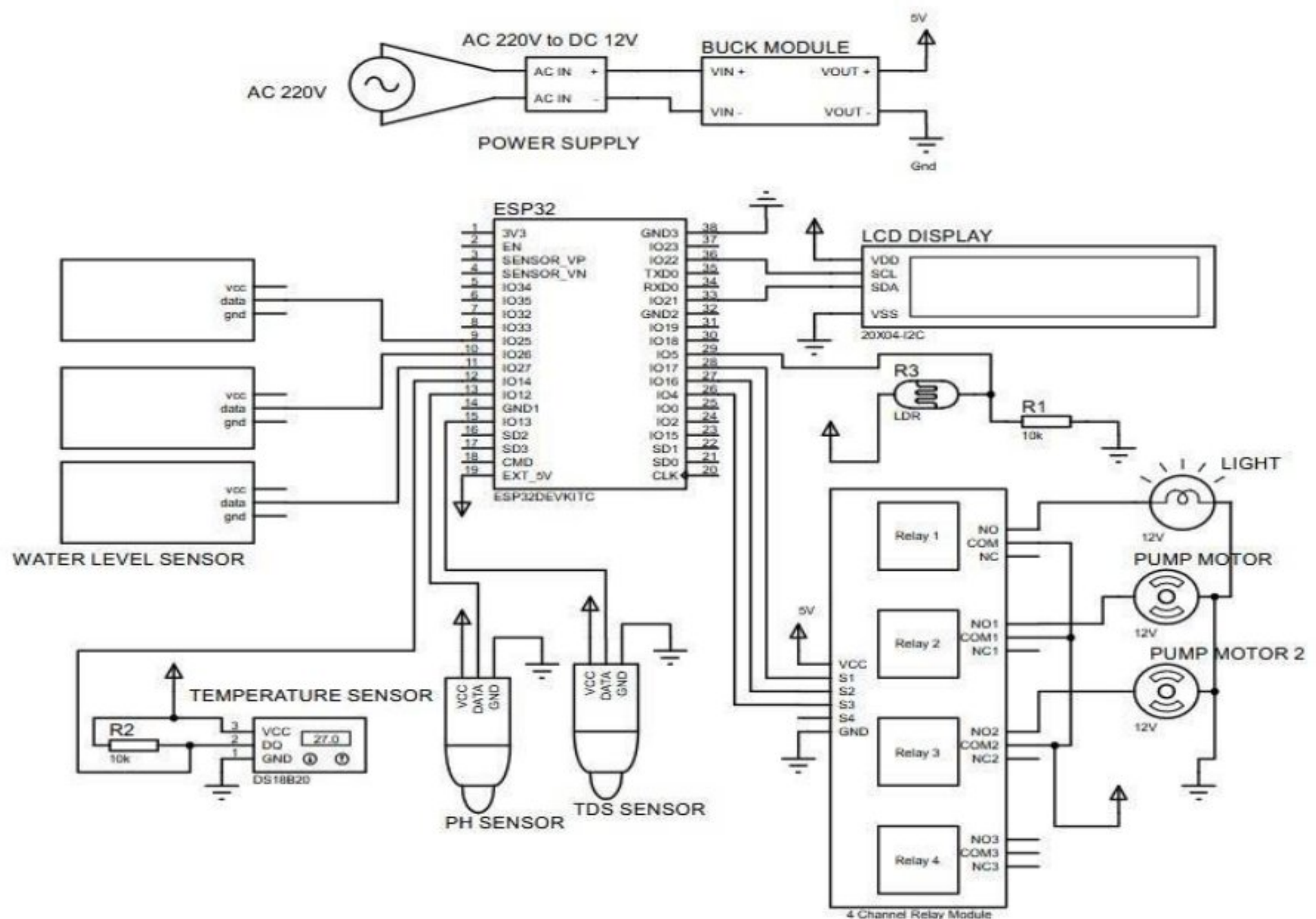


Fig-3.2: Circuit Diagram

3.6 The list of Devices used in the Project is Given Below

- ESP32.
- Buck Module.
- Power Supply.
- LCD Display.
- PH Sensor.
- TDS Sensor.
- Temperature Sensor.
- Float Sensor.
- LDR Sensor.
- Relay Module.
- Pump Motor.

3.7 ESP32

The ESP32 is a powerful microcontroller and system-on-chip (SoC) developed by Espressif Systems. It's widely used in various IoT (Internet of Things) applications due to its versatility, low cost, and rich set of features. Here are some details about the ESP32:

Microcontroller: The ESP32 features a dual-core Xtensa LX6 microprocessor, which can be clocked at up to 240 MHz. Having dual cores allows for better multitasking capabilities and performance optimization.

Wireless Connectivity: One of the key features of the ESP32 is its built-in Wi-Fi and Bluetooth connectivity. It supports Wi-Fi 802.11 b/g/n/e/i, Bluetooth v4.2 BR/EDR and BLE (Bluetooth Low Energy), making it suitable for a wide range of IoT applications that require wireless communication.

Memory: The ESP32 typically comes with various configurations of Flash memory (up to 16 MB) and RAM (up to 520 KB SRAM), providing ample storage space for program code and data storage.

Peripheral Interfaces: The ESP32 offers a rich set of peripheral interfaces, including SPI, I2C, UART, I2S, PWM, ADC, DAC, and more. These interfaces allow the ESP32 to interact with a wide variety of sensors, actuators, displays, and other external devices.

Security Features: Security is a priority in IoT applications, and the ESP32 includes

several security features such as hardware-accelerated encryption (AES, SHA-2, RSA), secure boot, and flash encryption to protect data and firmware integrity.

Low Power Consumption: The ESP32 is designed to operate efficiently in low-power scenarios, making it suitable for battery-powered IoT devices. It includes various powersaving modes and features such as deep sleep mode, which allows the device to consume minimal power when idle.

Development Environment: Espressif provides comprehensive development tools and resources for programming the ESP32, including the ESP-IDF (Espressif IoT Development Framework) for low-level programming and the Arduino IDE with ESP32 board support for easier development using the Arduino ecosystem.

Community Support: The ESP32 has a large and active community of developers and enthusiasts who contribute libraries, examples, and tutorials, making it easier for newcomers to get started and for experienced developers to find solutions to their problems.

Overall, the ESP32 is a versatile and capable microcontroller platform that has become a popular choice for IoT projects due to its combination of features, performance, and affordability.

3.7.1 Technical Specification

- Microcontroller: Tensilica 32-bit Single-/Dual-core CPU Xtensa LX6
- Operating Voltage: 3.3V
- Input Voltage: 7V to 12V DC
- Digital I/O Pins (DIO): 25
- Analog Input Pins (ADC): 6
- Analog Outputs Pins (DAC): 2
- UARTs: 3
- SPIs: 2
- I2Cs: 3
- Flash Memory: 4 MB
- SRAM: 520 KB
- Clock Speed: 240 Mhz
- Wi-Fi: IEEE 802.11 b/g/n/e/i



Fig- 3.3: ESP-32

3.8 Buck Module

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed frequency oscillator. The LM2596 series operates at a switching frequency of 150 kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators. Available in a standard 7-pin TO-220 package with several different lead bend options, and a 7-pin TO263 surface mount package.



Fig- 3.4: LM2596 Voltage Converter

3.9 Power Supply

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that

incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switchingmode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. This is because it operates on the switching frequency which ranges from several hundred kHz to several MHz in contrast to the 50-60Hz which is typical for the mains AC frequency. Despite the reduction in size, the power supply topology itself and the requirement for electromagnetic interference (EMI) suppression in commercial designs result in a usually much greater component count and corresponding circuit complexity. Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.



Fig- 3.5: SMPS Power Supply

3.9.1 Specification

- INPUT POWER SOURCE- AC 100-120 volt or 200-240 volt (both option)
- OUT POWER- 5 volt / 30 ampere
- Can be used in computers ▪

Can be used in industries ▪

can be used in panel's

3.10 LCD Display

A Liquid crystal display (LCD) is a flat display that uses the light modulating properties of liquid display. They are common in consumer devices such as video players, gaming devices, clocks, telephones, computers, calculators etc. A (20×4) LCD panel consists of 20 columns and 4 rows. It can show upto 16 characters in 2 lines.

You may want to have a look on these similar products:

1. LCD Display (20×4) with Header soldered
2. LCD display module (20×4)
3. LCD display module advanced (20×4)
4. 3 wire LCD module (20×4)
5. I2C LCD Display (20×4)
6. Arduino LCD keypad shield
7. LCD Display (20×4)

Table 05: LCD Display Outline

Pin	Function
VSS	connected to ground
VDD	connected to a +5V power supply
VO	to adjust the contrast
RS	A register select pin that controls where in the LCD's memory you are writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
R/W	A Read/Write pin to select between reading and writing mode
E	An enabling pin that reads the information when High level (1) is received. The instructions are run when the signal changes from High level to Low level.
D0-D7	to read and write data
A	Pins that control the LCD backlight. Connect A to 3.3v.
K	Pins that control the LCD backlight. Connect K to GND.

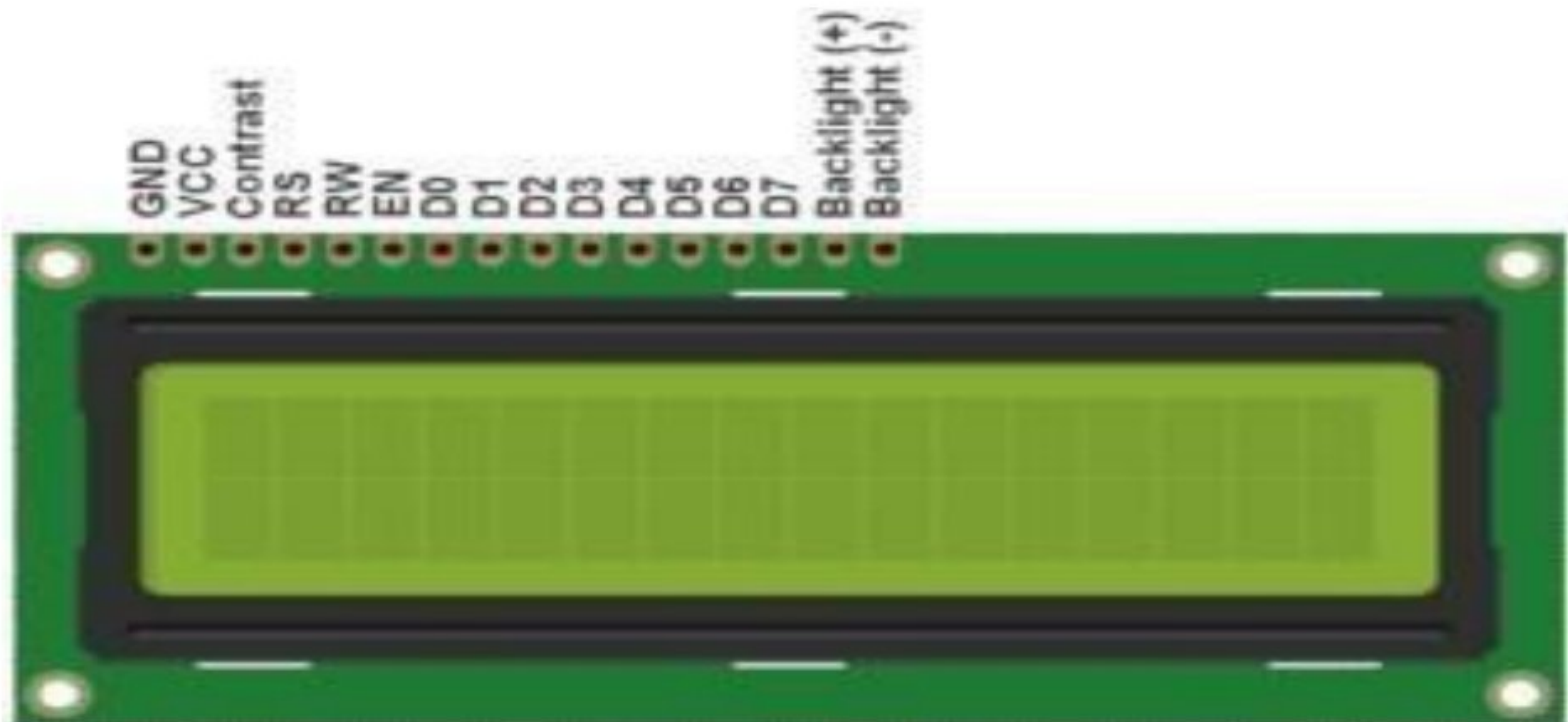


Fig- 3.6: LCD Display

3.11 PH Sensor

PH is a measure of acidity or alkalinity of a solution, the pH scale ranges from 0 to 14. The pH indicates the concentration of hydrogen $[H]^+$ ions present in certain solutions. It can accurately be quantified by a sensor that measures the potential difference between two electrodes: a reference electrode (silver / silver chloride) and a glass electrode that is sensitive to hydrogen ion. This is what form the probe. We also have to use an electronic circuit to condition the signal appropriately and we can use this sensor with a microcontroller, such as Arduino.

3.11.1 Technical Specifications

- The electrode used for the first or long set without re-use, the electrode bulb and the sand core, immersed in the 3NKCL solution activated eight hours.
- The electrode plug should be kept clean and dry.
- Electrode reference solution is the 3NKCL solution.
- Measurement should be avoided staggered pollution between solutions, so as not to affect the accuracy of measurement.
- Electrode blub or sand core is defiled which will make PTS decline, slow response. So, it should be based on the characteristics of the pollutant, adapted to the cleaning solution, the electrode performance recovery.

- The electrode should not be long-term immersed in acid chloride solution.
- Electrode when in use, the ceramic sand core and liquid outlet rubber ring should be removed, in order to make salt bridge solution to maintain a certain velocity.



Fig- 3.7: PH Sensor

3.12 TDS Sensor

TDS meter can be applied to domestic water, hydroponic and other fields of water quality testing. You may also check Liquid Sensor Selection Guide to get better familiar with our liquid sensor series.

TDS (Total Dissolved Solids) indicates that how many milligrams of soluble solids dissolved in one liter of water. In general, the higher the TDS value, the more soluble solids dissolved in water, and the less clean the water is. Therefore, the TDS value can be used as one of the references for reflecting the cleanliness of water.

TDS pen is widely used equipment to measure TDS value. The price is affordable, and it is easy to use, but it is not able to transmit data to the control system for online monitoring to do some water quality analysis. The professional instrument has high accuracy and can send data to the control system, but the price is expensive for ordinary people. To this end, we have launched an analog TDS sensor kit that is compatible with Arduino, plug, and play, easy to use. Matching with Arduino controller, you can build a TDS detector easily to measure the TDS value of liquid.

This tds sensor supports 3.3 ~ 5.5V wide voltage input, and 0 ~ 2.3V analog voltage output, which makes it compatible with a 5V or 3.3V control system or board. The excitation source is an AC signal, which can effectively prevent the probe from polarization and prolong the life of the probe, meanwhile, increase the stability of the

output signal. The TDS probe is waterproof, it can be immersed in water for a long time measurement.

This tds meter can be used in water quality application, such as domestic water, hydroponics. With this product, you can easily DIY a TDS detector to reflect the cleanliness of water to protect your health.

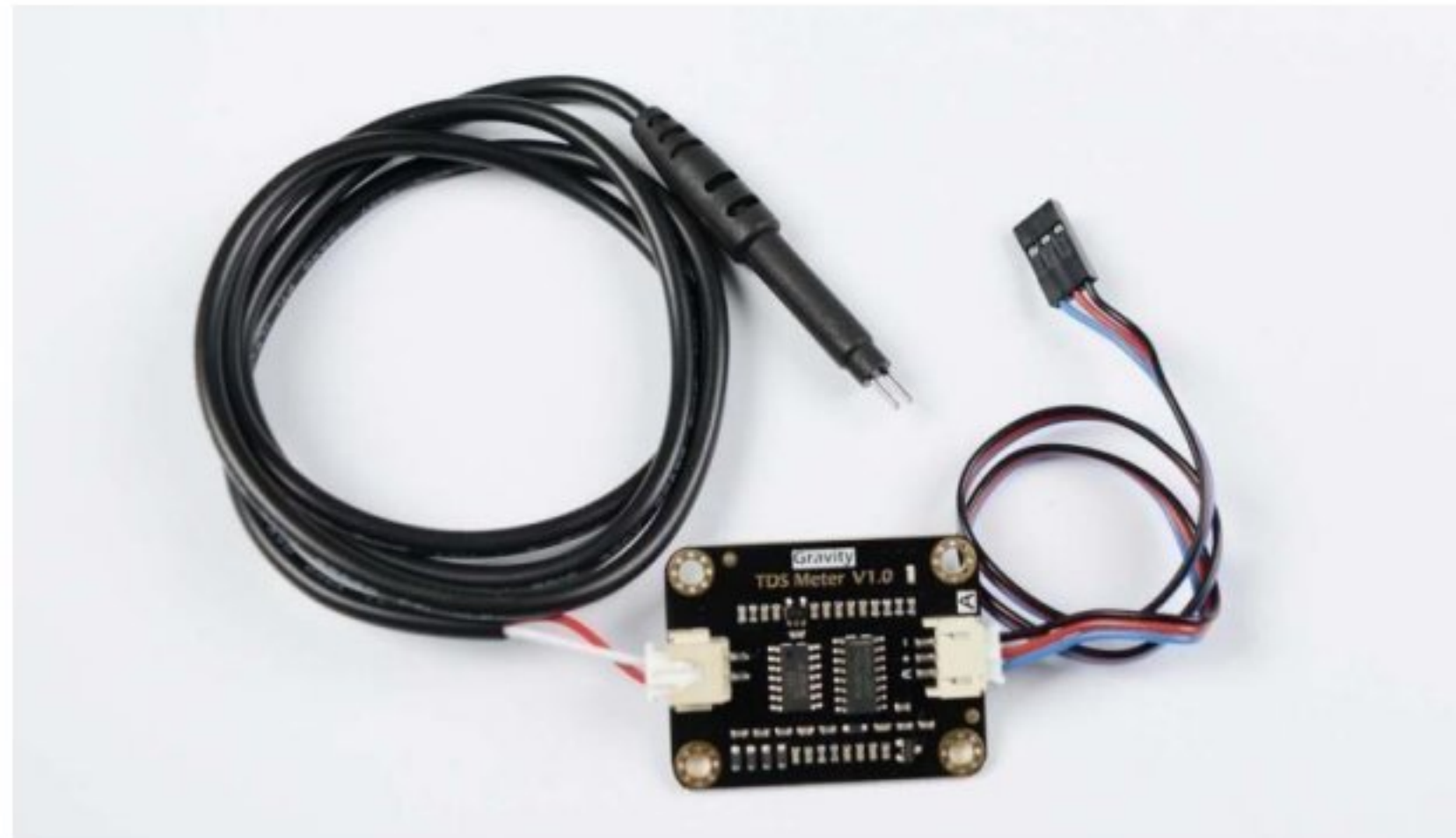


Fig- 3.8: TDS Sensor

3.12.1 Technical Specifications

- Input Voltage: 3.3 ~ 5.5V
- Output Voltage: 0 ~ 2.3V
- Working Current: 3 ~ 6mA
- TDS Measurement Range: 0 ~ 1000ppm
- TDS Measurement Accuracy: $\pm 10\%$ F.S. (25 °C)
- Module Size: 42 * 32mm
- Module Interface: PH2.0-3P
- Electrode Interface: XH2.54-2P

3.13 Temperature Sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line (“parasite power”), eliminating the need for an external power supply. Each DS18B20

has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.



Fig- 3.9: DS18B20 Temperature Sensor

3.13.1 Technical Specifications

- Length: 1 meter
- Stainless Steel Sheath Size: 6 x 50mm
- Power Supply Range: 3.0V to 5.5V
- Operating Temperature: -55c to 125c
- Storage Temperature: -55c to 125c
- Accuracy throughout range: -10c to 85c: +/- 0.5c
- Output Leads: Red (VCC), Blue (Data), Black (GND)
- Waterproof
- Colour: Black

3.14 Float Sensor

This switch is a device used to sense the level of liquid within a tank, it may actuate a pump, an indicator, an alarm, or other devices. When the float ball rises or falls with the liquid to the level of the switch, The magnetic force of magnet which inside of the float ball will cause the reed switch to turn ON. When the float ball move away from the reed switch, the reed switch will turn OFF.



Fig- 3.10: Float Sensor

3.14.1 Technical Specifications

- Cable length: 40cm
- Maximum load: 10w
- Max Switching voltage: 100V DC
- Max BreakDown Voltage: 250v DC
- Maximum Switching Current: 0.5A
- Max load current: 1.0A
- Max contact resistance: 0.4 Ω
- Temp Rating: -10 ~ +80°C ▪ Net weight: 16g

3.15 LDR Sensor

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light. It is often used as a light sensor, light meter, Automatic street light, and in areas where we need to have light sensitivity.



Fig- 3.11: LDR Sensor

3.16 Relay Module

A relay is an electrically operated device. It has a control system and (also called input circuit or input contactor) and controlled system (also called output circuit or output contactor). It is frequently used in automatic control circuit. To put it simply, it is an automatic switch to controlling a high-current circuit with a low-current signal.

The advantages of a relay lie in its lower inertia of the moving, stability, long-term reliability and small volume. It is widely adopted in devices of power protection, automation technology, sport, remote control, reconnaissance and communication, as well as in devices of electro mechanics and power electronics. Generally speaking, a relay contains an induction part which can reflect input variable like current, voltage, power, resistance, frequency, temperature, pressure, speed and light etc. It also contains an actuator module (output) which can energize or de-energize the connection of controlled circuit. There is an intermediary part between input part and output part that is used to coupling and isolate input current, as well as actuate the output. When the rated value of input (voltage, current and temperature etc.) is above the critical value, the controlled output circuit of relay will be energized or de-energized.

NB: input into a relay can be divided into two categories: electrical quantities (including current, voltage, frequency, power etc.) and non- electrical quantities (including temperature, pressure, speed, etc.)



Fig- 3.12: Relay Module

3.16.1 Features

The features of 1-Channel Relay module are as follow:

- Good in safety. In power system and high voltage system, the lower current can control the higher one.
- 1-channel high voltage system output, meeting the needs of single channel control
- Wide range of controllable voltage.
 - Being able to control high load current, which can reach 240V, 10A
 - With a normally-open (NO) contact and a normally-closed (NC) contacts

3.16.2 Interface Specifications

The output contacts of a relay (including NO, NC, and the common port) works as a SPDT – Single Pole Double Throw switch. Its operating principle is as follow: VCC--5V, GND----for ground IN1 connects to the control valve which output 3V-5V Output contacts: connect to applications Interface Connecting and Setting:

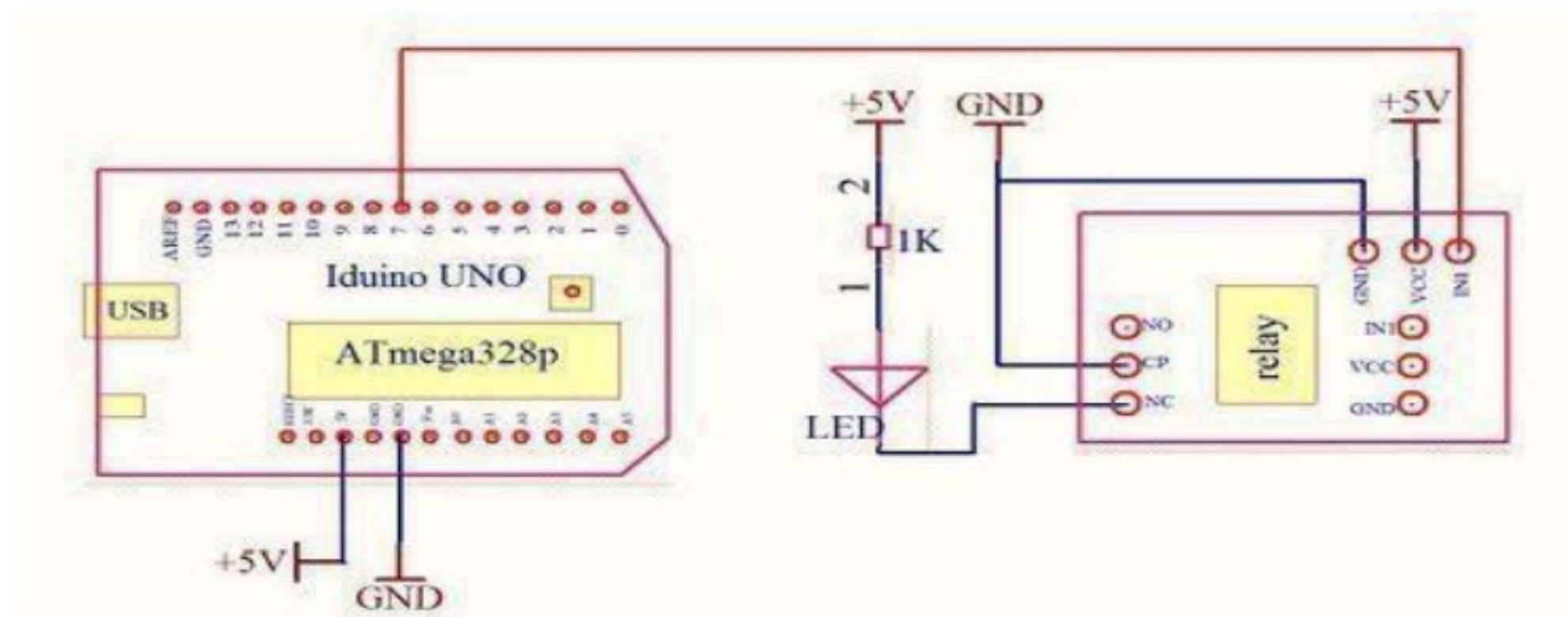


Fig- 3.13: Schematic of Relay Module

Arduino board (any versions), wires, LED, 5v power supply. Software resource: Arduino IDE The one-channel relay can be programmed to realize the open and close automatically. NB: customers can use any software or firmware to control the module as long as the IN1 of which can input a voltage of 3V-5V.

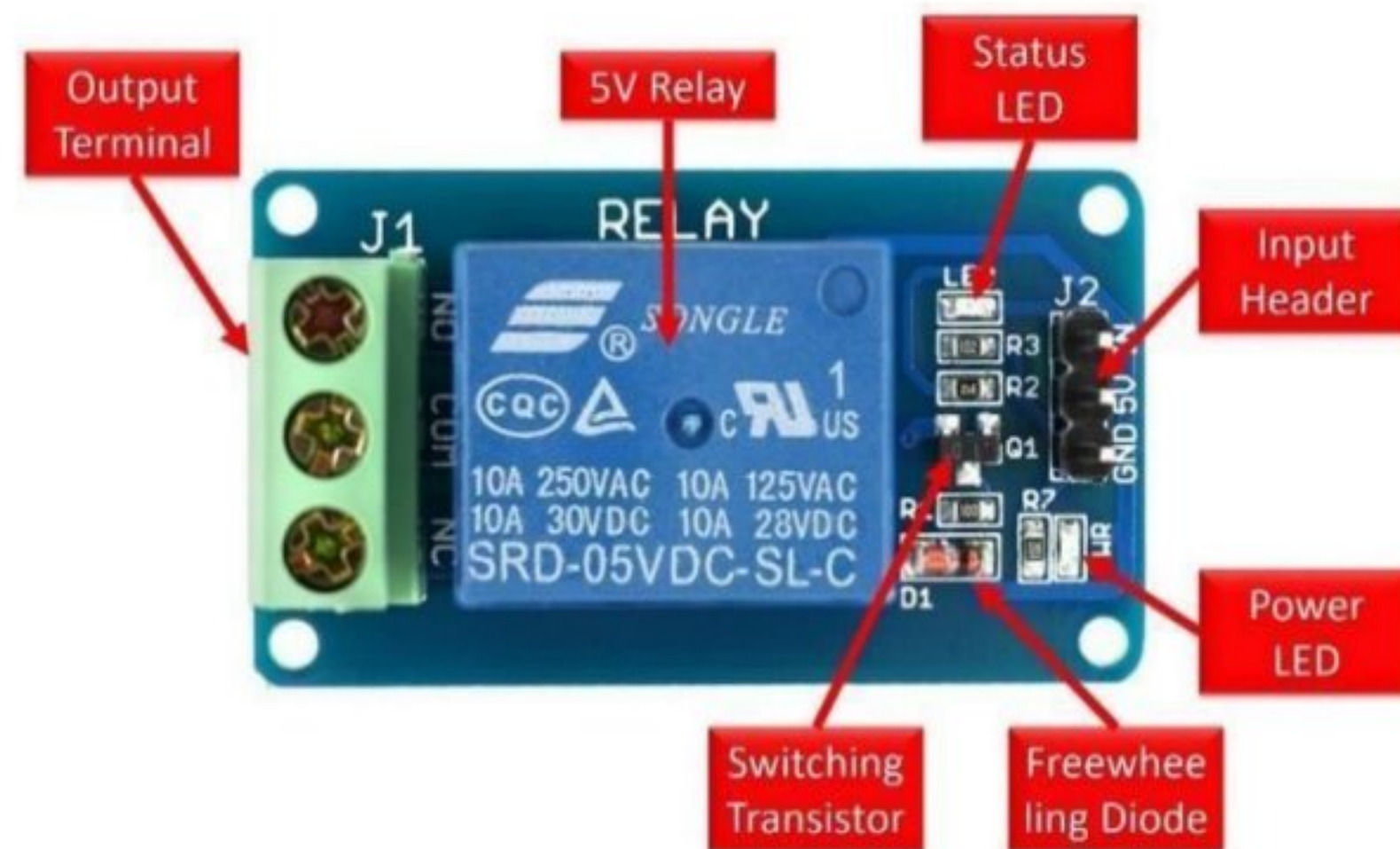


Fig- 3.14: Pin Out of Relay Module

you can do further development with the development tool you like as well as test it in the way of testing firmware. Firmware test: after the connection as in picture1-4, pay attention to the blink of LED, listen to the flicker of relay when it is working.

3.17 Pump Motor

Shafi Water Pump Brand: Shafi Color: Black Material: ABS Solar Panel: 12V / 5W Voltage: 12V DC Maximum Rated Current: 1.2A Power: 8W Max Flow Rate: 10 L/Min Max Water Head: 5M Max. Water Height: 40-100cm Max. Lift: 150cm / 59in Waterproof Grade: IP65



Fig- 3.15: Pump Motor

Chapter 04

Results and Discussion

4.1 Introduction

The Smart Aquaponics and Digital Control System Project is an innovative agricultural solution designed to merge ecological sustainability with modern technology. Aquaponics, a system that combines aquaculture (fish farming) and hydroponics (soilless plant cultivation), creates a self-sustaining ecosystem where fish waste fertilizes plants, and plants purify water for fish. By integrating a digital control system, this natural process is optimized through real-time monitoring, automation, and data analytics. The project aims to enhance the productivity, efficiency, and scalability of aquaponics while addressing challenges like water scarcity, climate change, and the need for sustainable food production.

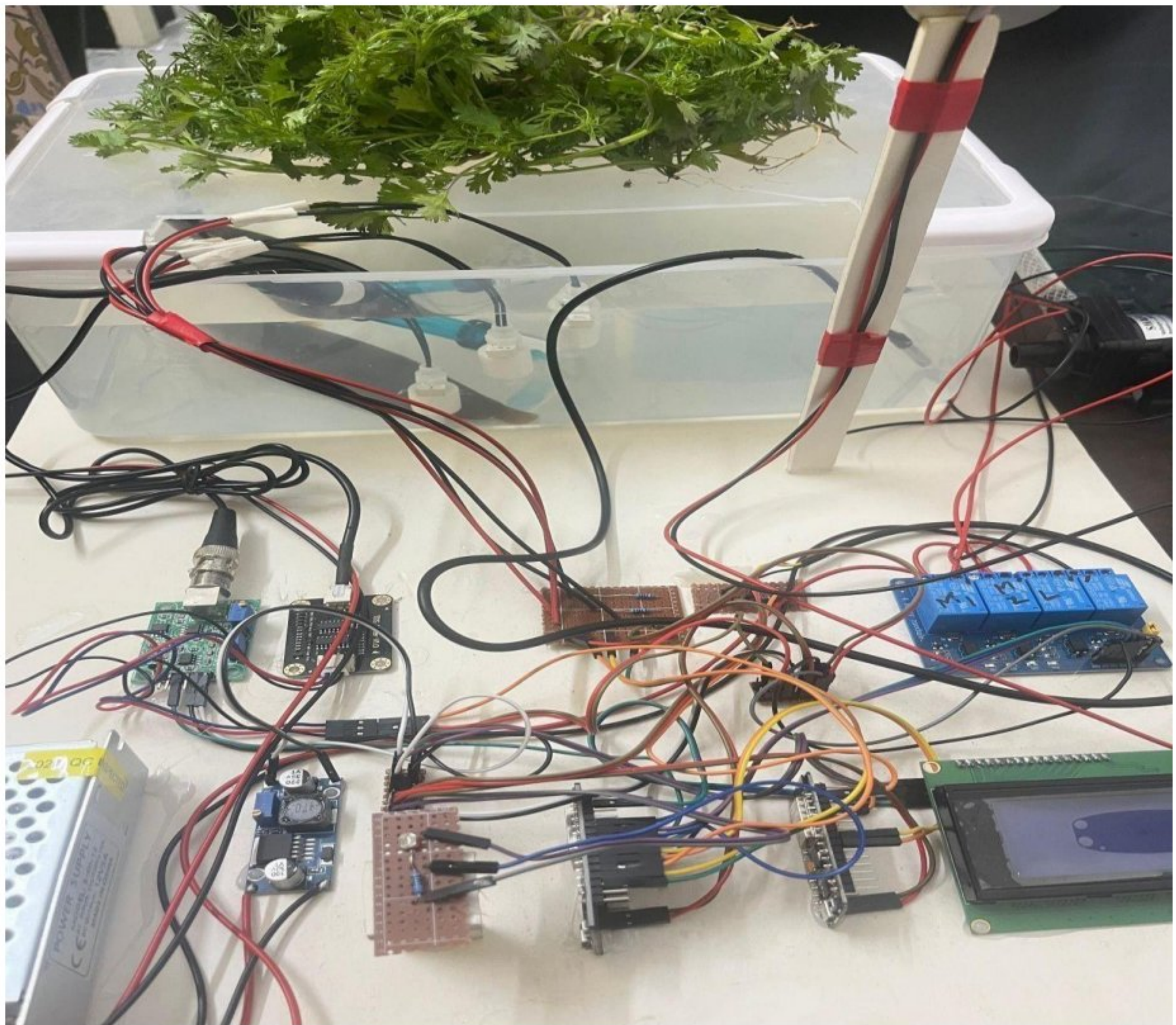


Fig- 4.1: Project Picture

4.2 Result

The implementation of the Smart Aquaponics and Digital Control System Project yielded promising results, demonstrating the effectiveness of integrating digital technologies with aquaponic farming practices. The outcomes showcase advancements in resource efficiency, productivity, and system reliability.

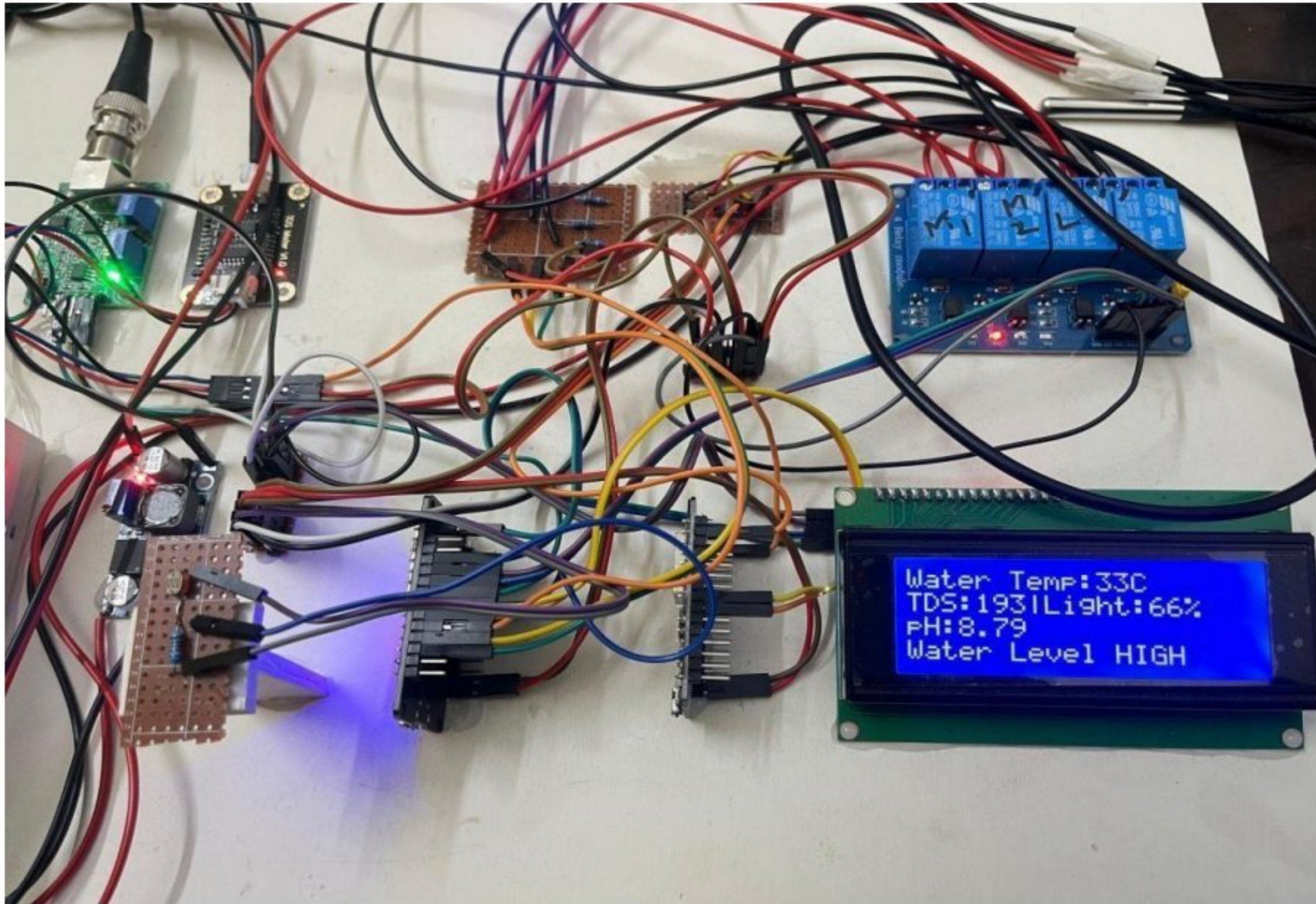


Fig- 4.2: Experimental Results Via LCD Display

The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, PH, TDS Sensor, light intensity sensor and water level of the water can be measured. We also have a memory card system to ensure project data storage and security.



Fig- 4.3: Experimental Results Via Webapp

The measured values from the sensors can be processed by the core controller. The ESP32 Development Board can be used as a core controller. Finally, the sensor data can be viewed on internet using internet system.

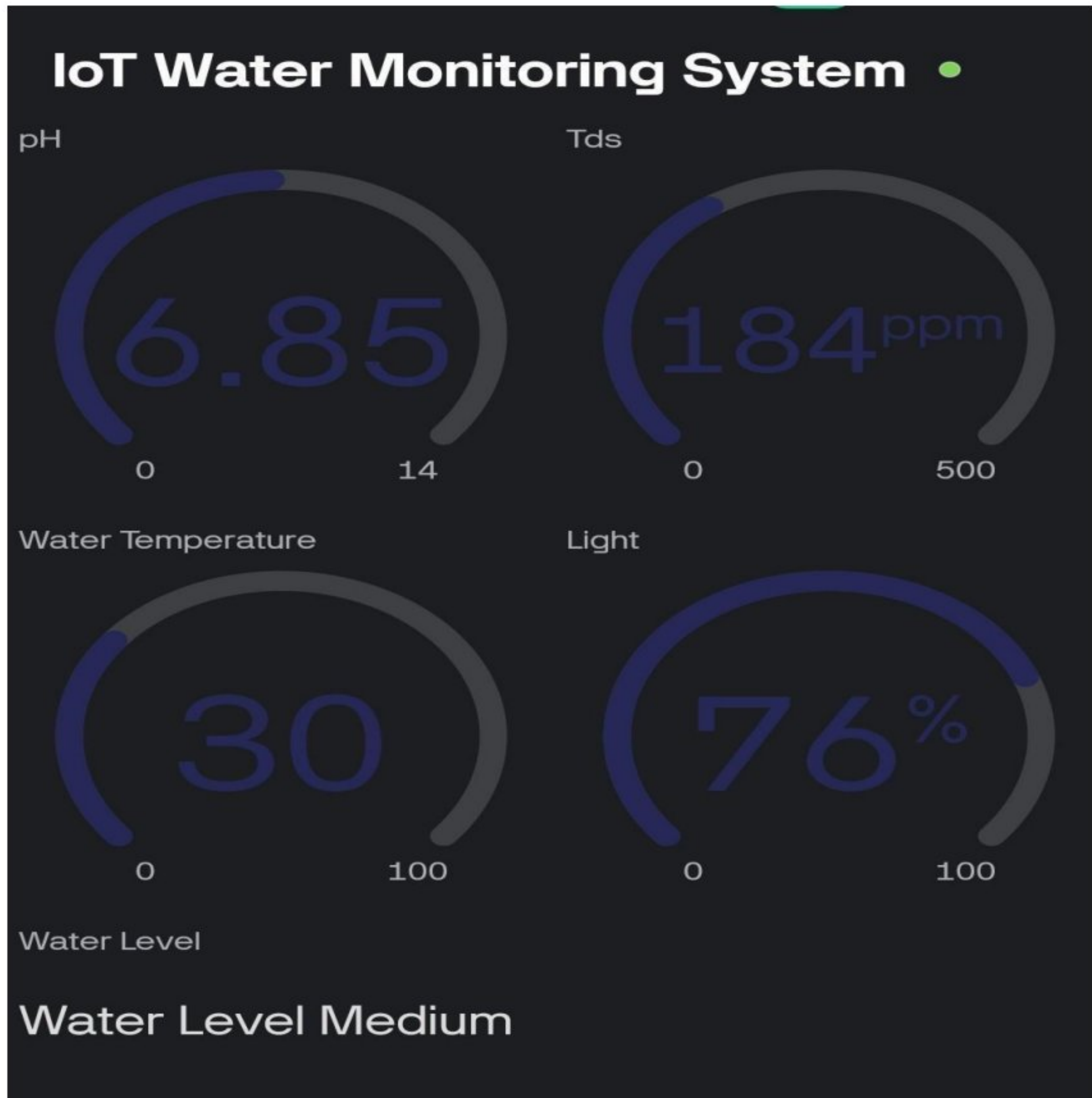


Fig- 4.4: Experimental Results Via Mobile

Parameter	Traditional Method	Smart Aquaponics	Improvement
Water Usage (Liters/Day)	~100	~10	~90% reduction
Plant Growth Rate (Days)	45-50	30-35	~30% faster growth
Fish Survival Rate (%)	70-80	90-95	~15% increase
Labor Requirement (Hours/Week)	15-20	3-5	~70% reduction

Fig- 4.5: Quantifiable Results

Chapter 05

Conclusion and Recommendations

5.1 Discussion

The Smart Aquaponics and Digital Control System Project bridges the gap between sustainable agriculture and modern technology, offering an innovative solution to challenges such as resource inefficiency, labor dependency, and food security. The project's outcomes provide valuable insights into the potential and limitations of integrating digital systems with aquaponics.

5.2 Advantage

The Smart Aquaponics and Digital Control System offers numerous benefits by combining sustainable agricultural practices with modern automation and digital technologies. These advantages span environmental, economic, and operational domains, making it a transformative solution for contemporary farming challenges.

1. Resource Efficiency
2. Enhanced Productivity
3. Automation and Reduced Labor
4. Cost Savings
5. Environmental Sustainability
6. Scalability and Adaptability
7. Improved Food Security
8. Data-Driven Insights
9. Accessibility and User-Friendly Design
10. Economic and Social Benefits

5.3 Application

The Smart Aquaponics and Digital Control System has diverse and impactful applications across various sectors. By integrating aquaponics with modern digital technologies like IoT, automation, and data analytics, the system offers innovative solutions to many global challenges, particularly in food production, resource conservation, and sustainability.

1. Urban Farming and Vertical Agriculture
2. Commercial Aquaponic Farms
3. Educational Institutions

4. Research and Development
5. Disaster Relief and Humanitarian Aid
6. Environmental Conservation
7. Commercial Food Production and Local Markets
8. Aquaponic Food Systems in Developing Countries
9. Research in IoT and Smart Agriculture
10. Space Farming and Space Exploration

5.4 Future Scope

The **Smart Aquaponics and Digital Control System Project** represents a significant leap toward sustainable, resource-efficient farming. However, as technology and agricultural practices continue to evolve, there are numerous opportunities for expanding and improving the system. The future scope of this project lies in advancing its capabilities, scalability, integration with emerging technologies, and its impact on global food production and environmental sustainability.

5.5 Conclusion

The Smart Aquaponics and Digital Control System Project represents a significant advancement in sustainable farming, blending traditional aquaponics with cutting-edge digital technologies. By integrating IoT (Internet of Things), automation, and data analytics, the project addresses the growing need for resource-efficient and scalable food production systems. The results demonstrated the effectiveness of automating critical farming tasks, optimizing water and nutrient use, and enabling real-time monitoring to improve productivity, reduce environmental impact, and make farming more accessible.

References:

- [1] Nikhil Kedia, Water Quality Monitoring for Rural Areas- A Sensor Cloud Based Economical Project, in 1st International Conference on Next Generation Computing Technologies (NGCT-2015) Dehradun, India, 4-5 September 2015. 978-1-467368094/15/\$31.00 ©2015 IEEE
- [2] Jayti Bhatt, Jignesh Patoliya, Iot Based Water Quality Monitoring System, IRFIC, 21feb,2016.
- [3] Michal lom, ondrej priby & miroslav svitek, Internet 4.0 as a part of smart cities, 978-1-5090-1116-2/16/\$31.00 ©2016 IEEE
- [4] Zhanwei Sun, Chi Harold Liu, Chatschik Bisdikia_, Joel W. Branch and Bo Yang, 2012 9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks
- [5] (SECON), 978-1-4673-1905-8/12/\$31.00 ©2012 IEEE
- [6] Sokratis Kartakis, Weiren Yu, Reza Akhavan, and Julie A. McCann, 2016 IEEE First International Conference on Internet-of-Things Design and Implementation, 978-14673-9948-7/16 © 2016IEEE
- [7] Mithaila Barabde, shruti Danve, Real Time Water Quality Monitoring System, IJIRCCE, vol 3, June 2015.
- [8] Akanksha Purohit, Ulhaskumar Gokhale, Real Time Water Quality Measurement System based on GSM , IOSR (IOSR-JECE) Volume 9, Issue 3, Ver. V (May - Jun. 2014)
- [9] Nidal Nasser, Asmaa Ali, Lutful Karim, Samir Belhaouari, 978-1-4799- 0792-

- [10] Niel Andre cloete, Reza Malekian and Lakshmi Nair, Design of Smart Sensors for Real-Time Water Quality monitoring, ©2016 IEEE conference.
- [11] Kumar, S. S., Rao, B. V. S., & Prasad J. R. (2020, September). Design and Development of a Water Quality Monitoring System by Using IoT. *International Journal of Emerging Trends in Engineering Research*, Vol. 8, pp. 6441 – 6447.
- [12] Chowdury, M. S. U., Emran, T. B., Ghosh, S., Pathak, A., Alam, M. M., Absar, N., ... & Hossain, M. S. (2019). IoT based real-time river water quality monitoring system. *Procedia Computer Science*, 155, 161-168.
- [13] Pappu, S., Vudatha, P., Niharika, A. V., Karthick, T., & Sankaranarayanan, S. (2017). Intelligent IoT based water quality monitoring system. *International Journal of Applied Engineering Research*, 12(16), 5447-5454.
- [14] Perumal, T., Sulaiman, M. N., & Leong, C. Y. (2015, October). Internet of Things (IoT) enabled water monitoring system, in 2015 IEEE 4th Global Conference on Consumer Electronics (GCCE) (pp. 86-87). IEEE.
- [15] Koditala, N. K., & Pandey, P. S. (2018, August). Water quality monitoring system using IoT and machine learning, in 2018 International Conference on Research in Intelligent and Computing in Engineering (RICE) (pp. 1-5). IEEE.
- [16] Huan, J., Li, H., Wu, F., & Cao, W. (2020). Design of water quality monitoring system for aquaculture ponds based on NB-IoT. *Aquacultural Engineering*, 90, 102088.
- [17] Miry, A. H., & Aramice, G. A. (2020). Water monitoring and analytic based ThingSpeak. *International Journal of Electrical and Computer Engineering*, 10(4), 3588.
- [18] Chen, Y., & Han, D. (2018). Water quality monitoring in smart city: A pilot project.

Automation in Construction, 89, 307-316.

- [19] Pasika, S., & Gandla, S. T. (2020). Smart water quality monitoring system with costeffective using IoT. Heliyon, 6(7), e04096

- [20] Shu, T., Xia, M., Chen, J., & De Silva, C. (2017). An energy efficient adaptive sampling algorithm in a sensor network for automated water quality monitoring. Sensors, 17(11), 2551.

Appendix:

Program for ESP32:

```
#define BLYNK_PRINT Serial

#define BLYNK_TEMPLATE_ID "TMPL6TYO2VPTx"

#define BLYNK_TEMPLATE_NAME "IoT Water Monitoring System"

#define BLYNK_AUTH_TOKEN "xAvchch4BwyIFOTJScgv0OO7Kwx-F8tU"

#include <Arduino.h>

#include <WiFi.h>

#include <WiFiClient.h>

#include <BlynkSimpleEsp32.h>

#include <Wire.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 20, 4);

float calibration_value = 21.34 - 0.7;

int phval = 0; unsigned long int

avgval; int buffer_arr[10], temp;

float ph_act; int tds;

char auth[] = BLYNK_AUTH_TOKEN; char

ssid[] = "student"; char pass[] =

"iotstudent";


int salain = 32; float

salinedata; #define RXD2

16

#define TXD2 17

String recv_str_jsondata;

String data; String

tempstr; int

tempds18b20; int

light = 33; int

lightdata;
```

```

int low_water = 15; int
midium_water = 2; int high_water
= 4;

int low_water_data; int
midium_water_data; int
high_water_data;

int pump = 5; int
pump1 = 18; int led
= 19;

void      setup()      {
Serial.begin(9600);
  Serial2.begin(9600);      //
pinMode(TdsSensorPin,  INPUT);
pinMode(light,          INPUT);
pinMode(low_water,      INPUT);
pinMode(midium_water,   INPUT);
pinMode(high_water,     INPUT);
pinMode(pump,           OUTPUT);
pinMode(pump1,          OUTPUT);
pinMode(led,            OUTPUT);
digitalWrite(pump,      HIGH);
digitalWrite(pump1,     HIGH);
digitalWrite(led,       HIGH);
pinMode(salain, INPUT); lcd.init();
lcd.backlight(); delay(100);
  Blynk.begin(auth, ssid, pass);
}

void loop() {

```

```

Blynk.run();

for (int i = 0; i < 10; i++) {
buffer_arr[i] = analogRead(34);  delay(30);
  for (int i = 0; i < 9; i++) {    for
(int j = i + 1; j < 10; j++) {

        buffer_arr[i]      =      buffer_arr[j];
buffer_arr[j] = temp;
    }
  } avgval = 0;  for (int i = 2; i < 8; i++)  avgval
+= buffer_arr[i];  float volt =
(float)avgval * 3.3 / 4096 / 6;  ph_act =
5.70 * volt + calibration_value; analog
value from the ADC value and store into
the buffer
4096.0;                                     // read the analog
value more stable by the median filtering algorithm, and convert to voltage value
// float compensationCoefficient = 1.0 + 0.02 * (temperature -
25.0);                                     //temperatur
e      compensation formula:      fFinalResult(25^C)  =
fFinalResult(current)/(1.0+0.02*(fTP25.0));  // float compensationVolatge =
averageVoltage /
compensationCoefficient;

//temperature compensation
//  tdsValue  =  (133.42  *  compensationVolatge  *  compensationVolatge  *
compensationVolatge - 255.86 * compensationVolatge * compensationVolatge +
857.39 * compensationVolatge) * 0.5; //convert voltage value to tds value  bool
Sr = false;  if (Serial2.available() > 0) {
    recv_str_jsondata = Serial2.readStringUntil('\n');  Sr
= true;  delay(100);

    // }

```

```

    // if (Sr == true //&& digitalRead(D4) == 1) {
data = recv_str_jsondata;    int fristCommaIndex
= data.indexOf(',');

    int secondCommaIndex = data.indexOf(',', fristCommaIndex + 1);

    String tempstr = data.substring(0, fristCommaIndex);

    String tdsstr = data.substring(fristCommaIndex + 1, secondCommaIndex);
tempds18b20 = tempstr.toInt();    tds = tdsstr.toInt();

    }

    lightdata = analogRead(light); //
Serial.println(lightdata); lightdata =
map(lightdata, 0, 1600, 0, 100); if
(lightdata <= 0) {    lightdata = 0;
    }

    if    (lightdata    >=    100)    {
lightdata = 100;
    }

    low_water_data = digitalRead(low_water); midium_water_data
= digitalRead(midium_water); high_water_data = digitalRead(high_water);
    Serial.println(low_water_data); Serial.println(midium_water_data);
    Serial.println(high_water_data);

    // tdsValue = tdsValue * 10;
Serial.print("tds raw:");
Serial.println(tds); if (tds >
8) {    tds = random(150,
250);
    }
    Serial.print("Temperature: ");

    Serial.print(tempds18b20);

    Serial.print(" *C ");

```

```

Serial.print(" %\t");
Serial.print("pH:");
Serial.print(ph_act);
Serial.print(" %\t");
Serial.print("TDS:");
Serial.print(tds);
Serial.print("ppm %\t");
Serial.print("Light:");
Serial.print(lightdata);
Serial.println("% ");

static unsigned long printTimepoint = millis();
if (millis() - printTimepoint > 1000U) {
printTimepoint = millis();
Blynk.virtualWrite(V0, ph_act);

    Blynk.virtualWrite(V1, tds);
    Blynk.virtualWrite(V2, tempds18b20);
    // Blynk.virtualWrite(V3, h);
    // Blynk.virtualWrite(V4, salinedata);
    Blynk.virtualWrite(V3, lightdata);
    // delay(1000); lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Water Temp:");
lcd.print(tempds18b20);
lcd.print("C"); lcd.setCursor(0,
1);
lcd.print("TDS:");
lcd.print(tds);

    // lcd.setCursor(10, 1);
lcd.print("|Light:");
lcd.print(lightdata); lcd.print("% ");

```

```

    lcd.setCursor(0, 2);
    lcd.print("pH:");    lcd.print(ph_act,
2);
    }

    if (low_water_data == 0 && midium_water_data == 0 && high_water_data == 0) {
    lcd.setCursor(0, 3);    lcd.print("Water Level LOW");
        Blynk.virtualWrite(V6,    "Water        Level  LOW");                //virtual
            pin    V0    digitalWrite(pump, LOW);
        }

    if (low_water_data == 1 && midium_water_data == 0 && high_water_data == 0) {
    lcd.setCursor(0, 3);    lcd.print("Water Level LOW");
        Blynk.virtualWrite(V6, "Water Level Low"); //virtual pin V0
    }

    if (low_water_data == 1 && midium_water_data == 1 && high_water_data == 0) {
    lcd.setCursor(0, 3);    lcd.print("Water Level Medium");
        Blynk.virtualWrite(V6, "Water Level Medium"); //virtual pin V0
    }

    if (low_water_data == 1 && midium_water_data == 1 && high_water_data == 1) {
    lcd.setCursor(0, 3);
        lcd.print("Water Level HIGH");
        Blynk.virtualWrite(V6,    "Water        Level  HIGH");                //virtual
            pin    V0    digitalWrite(pump, HIGH);
        }

    if    (tempds18b20 >        32)    {
    digitalWrite(pump1, LOW);
    }

```

```
    if (tempds18b20 < 32) {  
digitalWrite(pump1, HIGH);  
    }  
  
    if (lightdata < 20) {  
digitalWrite(led, LOW);  
    }  
  
    if (lightdata > 20) {  
digitalWrite(led, HIGH);  
    }  
    // delay(1000);  
}
```