IOT BASED WATER POLLUTION MONITORING MULTIFUNCTIONAL BOAT USING SOLAR PANEL WITH DUAL AXIS TRACKER.

An Undergraduate CAPSTONE Project
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Faculty of Engineering
American International University - Bangladesh

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A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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APPROVAL

The CAPSTONE Project titled **IOT BASED WATER POLLUTION MONITORING MULTIFUNCTIONAL BOAT USING SOLAR PANEL WITH DUAL AXIS TRACKER** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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ABSTRACT

For the health and well-being of all people, clean drinking water is a vital resource. A essential human right, access to safe water is a requirement for health and development. Monitoring the water quality in the reservoir is therefore crucial. For this purpose, we proposed an "Water quality monitoring system using solar panel with dual axis tracker". Smart technologies for monitoring water contamination are becoming more popular as communication technology advances. In-depth summaries of recent research on smart water pollution monitoring are provided in this paper. A low-power, less complex method of monitoring water quality based on Internet of Things (IOT) technology is also provided. The developed model is employed to assess water samples and examine data sent via the Internet. The system notifies a remote user when one of the predefined sets of standard values for the water quality parameters is violated. With improvements in communication technology, smart methods for monitoring water contamination are becoming more and more important. Our boat is a multi-purpose boat which is equipped with wireless cameras for vision, and GPS for localization of the polluted water. Our boat can be controlled from a base station equipped with location system via wi-fi. Mostly importantly, our boat contains dual-axis solar tracker so it can track the sun to collect more solar energy. So, the boat may have no issue with the power while monitoring the water level. We have tested our boat in different scenarios and found comprehensive results.

Chapter 1

INTRODUCTION

1.1. Overture

In this modern civilization, there were lots of inventions, but at the same time there were some major issues that modern civilization had to face which is water pollutions, environment pollution, global warming and climate change etc. Water pollution has become a big concern in recent years as a result of the deforestation, dumping of industrial waste, hazardous chemicals, agriculture and livestock farming, fuel spillages and other pollutants into bodies of water. Water quality is impacted by industrial sewage discharge and other man-made pollution. Global warming, overuse and exploitation of natural resources are the major causes of water pollution. Now a days water safety has become difficult to guarantee due to an abundance of pollution sources. Unsafe water has serious consequences for human health [1]. This is because water may dissolve a wide range of substances. If the water is polluted then, these substances may able to enter in the human body. Which may cause of waterborne disease to the human body like cholera, diarrhea, typhoid, hepatitis etc. People can also die due to those waterborne disease. Every year about 5 million people die from waterborne disease because of this pollutant water. Contaminated water can also be very harmful environment which maybe causes of Destruction of biodiversity. Which maybe cause of different kind of natural calamities in the world. Water pollution also affects in the ecosystem. It has the potential to create a phenomenon known as eutrophication. This can kill fish and other aquatic species. Water pollution depletes aquatic habitats and causes an explosion of phytoplankton in lakes. Water pollution can also create contamination of the food chain. As a result, there is a growing demand for real-time water pollution monitoring systems. As a result, better methods for monitoring water quality parameters in real time are required. Water quality monitoring is defined as the collecting of data at specific locations and at regular intervals in order to provide information that may be used to characterize present conditions and established patterns, among other things. Hence, to monitor the different pollutants present in water a RC boat equipped with different kind of sensors can be used. Which will monitor the water in different places. Turbidity sensor, pH sensor and temperature sensor can be used to monitor the pollution level in the water sources. The pH sensor can determine the concentration of hydrogen ions in water. It indicates whether the water is acidic or alkaline. Pure water has a pH of 7.00; water with a pH less than 7.00 is acidic, and water with a pH more than 7.00 is alkaline. The pH scale ranges from 0 to 14. The pH level for drinking should be between 6.5 and 8.5. The temperature sensor determines if the water is hot or cold. Turbidity is a measurement of the huge number of invisible suspended particles in water. The greater the turbidity, the greater the danger of diarrhea, cholera. When the turbidity is low, the water is clean. All of the mentioned issues make water quality monitoring significant.

1.2. Engineering Problem Statement

Our past research work survey can provide us with the solution to the Engineering Problem Statement. We discovered before those existing solutions are based on typical water pollution monitoring boats. In those circumstances, the solutions consist of classifying the datasets, which is time consuming and required high skills to operate. However, if we develop solutions in an engineering manner, we may save both time and cost. We use a variety of sensors in our architectural system design. So, we try to develop the device which can provide us the engineering solutions for our proposed idea. Safe water is a precondition for health and development and a basic human right. So, it's very important to monitor the quality of water available in reservoir. So, for monitoring the water level, the boat is built in such a way that it can monitor the water level and collect all the readings after specific intervals. Also, same readings and its location will be automatically uploaded to its web server using the Wi-Fi module. Monitoring the water level, gives users knowledge about the quality of water in the reservoir. So, we can easily monitor water quality in lakes and rivers.

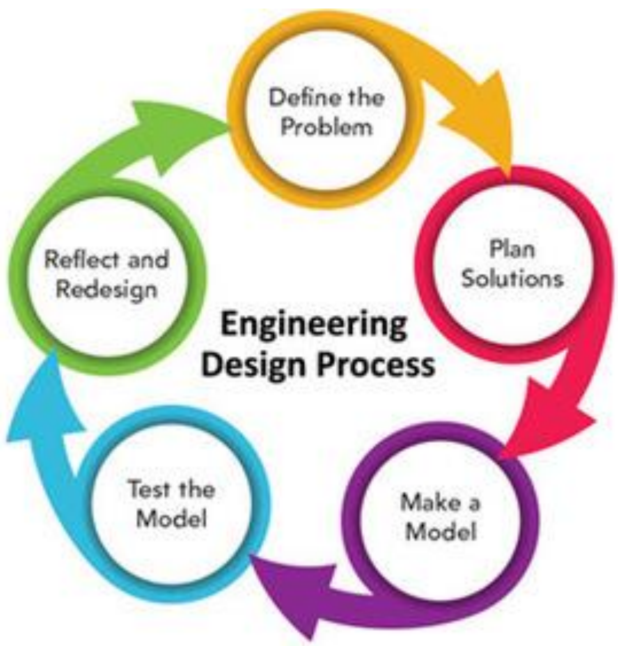


Figure 1.1: Engineering problem statement [26]

1.3. Related Research Works

The ongoing project is a continuation of previous studies and research conducted by various people and organizations. The construction of the boat, operation the boat, data collection from various sensors, and making the entire project IOT-based all are linked to each other. As a result, the field of research for installation and operating the boat with all data from the sensors would enrich the entire project.

1.3.1. Earlier Research

Gleick has researched and discussed the many water resources available on a worldwide scale (1993) [34]. Falkenmark (1993) has highlighted the value of clean water and its impending significance in his investigations. According to Edwards et al., water has several dimensions (1989). Dugan's study has included chemical and biological components and their interaction in contaminated water (1972). In comparison to rural civilization, urban civilization uses more water, and the quality of the discharged water from urban areas is likewise chemically more harmful (Bandy, 1984). Panesar et al. (1985) did a study on the chemical composition of waste water in the city of Amritsar and reported on the water's appropriateness for different purposes [22].

Olaniya et al. (1976) evaluated Chambal River pollution in Kota, and they found that most research locations had water that was just mildly contaminated. Mitra undertook a comparison of the chemical characteristics of the surface waters of the rivers Godavari, Krishna, and Tungbhadra (1982). Bhargava (1977) also carried out a comparable comparison research between the rivers Ganga, Yamuna, and Kali. Ganpati and Chacko studied the Godavari River's chemistry at Rajamundhary (1951). Mishra oversaw the management of the freshwater pond in Varanasi (1993). [19]

1.3.2. Recent Research

According to Singh et al. 2019, the study concentrated on the significance of several water contamination variables. In April 2017, Radhakrishnan et al. showed that flooding greatly alters the water quality. In terms of FCI concentration, Marina Salim et al. in 2019 discovered significant variances amongst the sub-basins. In 2018, Ioanna Zotou, et al. make an effort to evaluate the performance of seven various WQIs. In 2018, Nyanti et al. demonstrated the potential negative effects of biological assault and water quality decline on the survival of native fish in Malaysia.[2]

1.4. Critical Engineering Specialist Knowledge

IOT base control system is more suitable and relevant because our ultimate target is to ensure the discard the margin of error & getting quick response from our project. This system can reduce the amount of human effort. System can be control anywhere from the world. This project is built on

IOT which will be controlled by the NODE MCU via an application. A Wi-Fi module was also introduced to get the better output. One of the most specialist knowledge areas used which was Dual Axis panel Solar Panel. This system was automatically trac the position of sun to harvest the best solar energy. A dual axis solar panel can produce up to 40% more electricity than a traditional type solar system. So, this system can be most useful to solve critical Engineering Problem. In this modern arena rescue boat uses servo motor which helps to cover the distance quickly. Some sensors will be used to determine movement and distance (axis tracking system).

Through this system, a large part of human being can be benefitted. To make this smart system more suitable we need in depth knowledge, analysis and lots of research. Making this system requires the knowledge about deep learning, Arduino, Python, Sensor, module, Different types of sensors etc. which is not easy without research and critical specialist extensive knowledge.

1.5. Stakeholders

Because of the mutual effects of increased population, climate change and environmental pollution, safe water is becoming increasingly limited. Monitoring water quality is so critical, especially for residential water. Laboratory-based testing methods that have traditionally been employed are laborious, expensive, lack of real-time feedback and also it is time consuming. Wireless sensor network (WSN) systems which was developed recently have identified flaws in energy management, communication coverage and data security. We define a stakeholder as a party with an interest in an organization, such as workers, consumers, suppliers, or members of the local community. [33]. In a project, all associated interest parties are stakeholders. So, we can say those who are beneficial by our project and those who should using our project they can be stakeholders of our project. As our project is IOT based water pollution monitoring boat, so we can monitor the water quality of different area/ locations. We can monitor the water quality by using different kind of sensor like pH sensor, turbidity sensor and temperature sensor. And we are using a ESP-32 cam, GPS module, and Wi-Fi module. So, the results those are taken from the sensors can be uploaded in a mobile app the Wi-Fi module. By the ESP-32 cam and GPS module, we can detect the given results location and we can compare them to a reference value. So then, we can able to detect those area, where water is contaminated or safe. So rural areas people can be a part of stakeholders in of our project. In our project there are also ESP-32 cam and a GPS module. So, we can also use our boat as a navigation purpose.

And by the ESP-32 cam, the boat can be also used as surveillance boat. So those who can beneficial with this kind of features like navigation, surveillance they also can be our stakeholders. Because, they will be benefited by using our project in many purposes. According to the Project Management Institute, project stakeholders are "individuals and organizations that are actively participating in the project, or whose interests may be positively or adversely affected as a result of project execution or successful project completion." [33]. So, we can say that those who are beneficent by using our project, those are affected by our project, those who are actively participating in our project and whose interests may be positively or adversely affected as a result of our project execution or successful project completion are the main stakeholders of our project. This project provides an overview of recent research efforts to develop IOT-based smart water quality monitoring devices. This project includes PH sensors, turbidity sensors, and a temperature sensor. The presence of suspended particles in the water and the quality of the water will be detected by these sensors. We also have a camera, GPS module, and microSD card that will log data from sensors and GPS positions and communicate it online at regular intervals through IOT. As a result, we can monitor the quality of the water, and the boat may also be used for surveillance and navigation. As a result, the water quality monitoring boat may easily be used for water quality monitoring on lakes and reservoirs. Because of it is low powered and very efficient, allowing for continuous monitoring and alerts/notifications to be forwarded to the appropriate authorities for further processing. So, if our project achieves its objectives and meets or exceeds the expectations of the stake-holders our project will be successful.

1.6. Objectives

Every living thing on the planet needs water to survive. Our project's goal is to create a tool that can help and save individuals. The purpose of the works is listed below:

1.6.1. Primary Objectives

Monitoring Water Quality Objectives There are various reasons to monitor the water quality. Identifying waterways and spotting alterations in the quality over time. It can identify specific concerns with the current or projected quality of the water and gather information to create plans for the treatment or prevention of pollution. The objective is also ass the oxygen content, acidity, and turbidity of water that may be utilized for industrial and agricultural applications as well as drinking water.

1.6.2. Secondary Objectives

Reduced risk of system failure; improved compliance with social and environmental standards; improved planning, forecasting, and proactive asset management; managed to improve response to incidents and emergencies, thereby minimizing their effects; improved efficient use of energy; and improved resilience of the water supply system in combating extreme weather conditions are just a few of the benefits.

1.7. Organization of Book Chapters

This section discusses about organization of book chapter.

Chapter 1 is entitled ‘Introduction’. It introduces historical background and overview, evolution of the technology used in the project. The objective of the project is also described in this chapter.

Chapter-2: This chapter contains Literature Review with in-depth investigation. This chapter discusses the literature review with an in-depth investigation. In this chapter mainly focused on the related published work along with earlier research. Moreover, Critical engineering specialist knowledge related to the project are discussing here.

Chapter-3: Project Management. This chapter will discuss about the management procedure like different types of analysis so on which will help to prompt a suitable outcome of the project.

Chapter-4: Methodology and Modeling. The different process and modeling which will help to improvement of project will be elaborately discussed.

Chapter-5: Implementation of Project. This chapter will be discussed how the project will be implemented during the schedule time and most importantly hardware implementation of this project will be shown here.

Chapter-6: Results Analysis & Critical Design Review. This chapter is most important of this project because it will discuss the critical design and the most mandatory part which is result of this project. By this part it will express that weather our goal is achieved or not full filled.

Chapter-7: Conclusion. Conclusion part will be described about the future work, limitations of this project and observation will also include.

Chapter 2

PROJECT MANAGEMENT

2.1. Introduction

This study aims to discover project management features in order to improve our working process and make the project success. We are doing project based on I.O.T based water pollution monitoring boar using dual axis tracker. We must undertake project management to ensure the project's success. Project management is all about knowing exactly what our goals are, how we'll achieve them, what resources we'll need, and how long it will take us to achieve that specific goal [28]. In this chapter, we'll focus on project management. Project management is essential to the success of any project. It includes defining project objectives and milestones, as well as creating different scenarios and contingency plans. It's an important element for any engineering team since the unexpected can undermine the efforts of dozens or even hundreds of individuals. Project management teaches us how to manage the project's time or schedule, how to recover project time, and how to save money while acquiring or purchasing equipment to perform the project. Using the Gantt Chart, we can establish a project timetable. Using statistics, we can save money on project equipment purchases.

2.2. S.W.O.T. Analysis

SWOT is an acronym of strengths, weaknesses, opportunities, and threats. Analysis is a method for gaining a competitive edge by comparing your strengths to the weaknesses of your competitors and examining the possibilities and threats that exist. It is a strategic planning strategy to assist us examine the strengths and weaknesses of our projects, as well as to analyze and review any possibilities and dangers may face in the future. A SWOT analysis may help us to enhance our project planning process, reduced project risk, and raise the chance of our project's success [29]. By recognizing the project's strengths, weaknesses, opportunities, and threats, we will reduce the risks connected with tasks and provide a firm foundation for the whole project before the action begins.

Details information about SWOT is provided below.

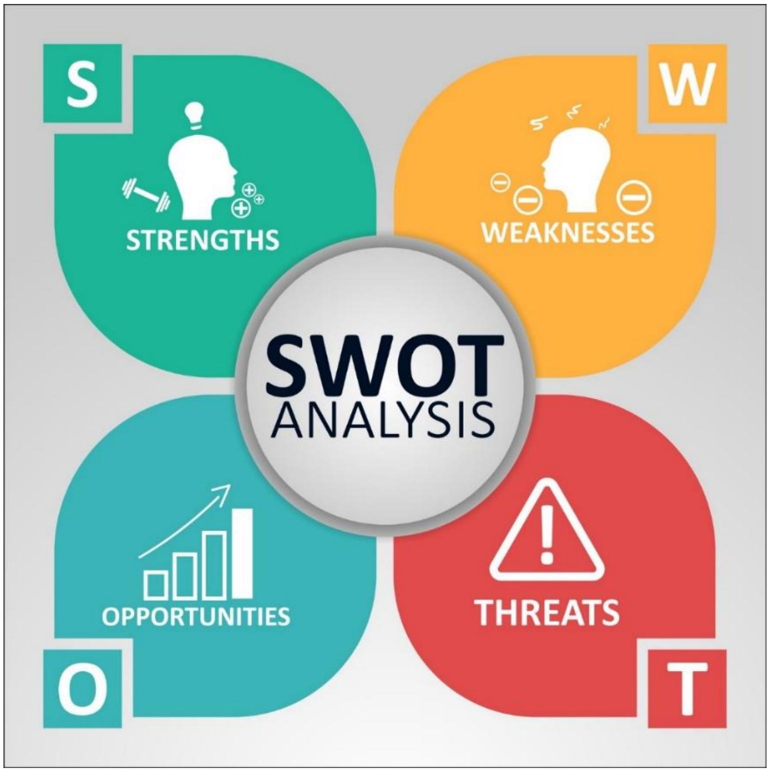


Figure 3.1: S.W.O.T. Analysis of the Project [24].

Strengths:

- Ensure the safety of water.
- No fuel required, so its environmentally friendly.
- Reasonable cost.
- Real time monitoring.
- Preventive Maintenance Checks
- Seamless Communication
- Effective ROI
- Scalable Solution
- Multiple Alerts
- No power issue because it has solar panel.

Weaknesses:

- Cannot control itself without a rigid structure.
- Not suitable to use in the extreme weather or deep sea.
- Obstacle Infront of the boat cannot detectable.
- The method is prone to human errors of various forms.

Opportunities:

- ESP-32 cam microcontroller or chip can be replaced with a more modern version.
- The use of high-range sensors allows this machine to detect a wider range of obstacles.
- The speed of the lifeboat can be improved.
- Technological advancements in the making of project.
- Some sensors can be extended.
- Wireless controlling can be upgraded.

Threats:

- If GPS technology fails, there are no alternative options for automating the operation.
- Because of the technology, we can only refer to this gadget as a smart device.
- The best output from this machine may not be obtained in extreme weather. So, machine's ability to perform its function may be impaired.
- Electrical faults, such as short circuits and current leakage, can also result in failure. If the sensors are providing incorrect data, they should be changed immediately.

2.3. Schedule Management

Schedule management is the thorough process of developing a project plan that describes the project phases, work under each stage, and dependencies. It also takes into consideration the skills and resources needed for each activity, as well as the sequence of occurrence, milestones, interdependencies, and timeline. This is essential in any project. It is the amount of time required to complete project tasks such as circuit modeling, hardware implementation, software simulation, and other project-related tasks. In a Gantt chart we have shown the proper schedule that we have maintained overall timeline of our proposed project. The Gantt chart shows the schedule for orientation, topic selection, writing thesis book chapters 1 and 2, progress defense preparation, hardware problem testing and error resolution, writing thesis book, submission of poster and summary, final defense materials preparation, component collection, and hardware implementation, among other things.

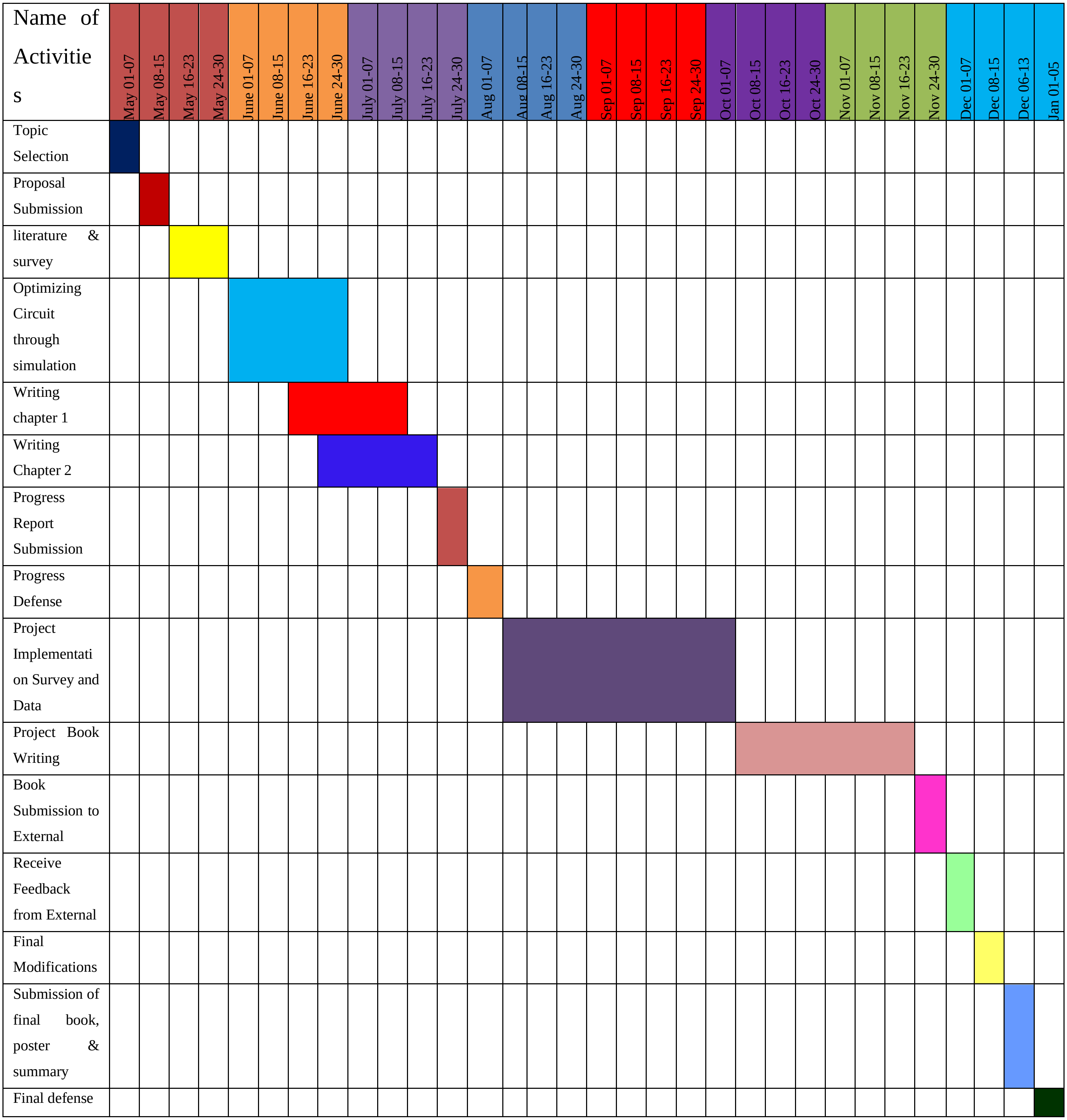


Figure 3.2: Gantt chart

2.4. Cost Analysis

Table 2.1: Cost analysis of the project

No.	Component Name	Quantity	Costing (Taka)
1.	Arduino Nano	1	1000
2.	Servo motor	3	380*3 = 1140
3.	Solar panel	1	450
4.	ESP8266 Wi-Fi Module	1	600
5.	3.7 V Battery	2	400*2 = 800
6.	Buck Converter	1	200
7.	ESP32-CAM	1	900
8.	20x4 Character LCD	1	600
9.	Turbidity Sensor	1	1400
10.	Analog pH Sensor	1	3400
11.	LM35 TEMPERATURE SENSOR	1	350
12.	NEO-M8N GPS Module	1	1600
13.	LDR	4	40*4 = 160
14.	L298N H-Bridge Dual Motor Driver	1	300
15.	DC Motor	1	300
16.	Propeller	2	100
17.	RC Boat Shaft Drive with Universal Joint	1	700
18.	Others		1000
			Total- 15,000 TK

Here, $\bar{X}$=Mean of the sample and X = component price and N = Number of components

$$\bar{X} = \frac{sum}{N}$$

$$= \frac{15000}{18}$$

$$=833.33$$

Standard Deviation

Now,

$$\sigma = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N-1}}$$

$$\sigma = \sqrt{\frac{\begin{array}{c}(1000-833.33)^2+(1140-833.33)^2+(450-833.33)^2+(600-833.33)^2+(800-833.33)^2+(200-833.33)^2+(900-833.33)^2+\\(600-833.33)^2+(1400-833.33)^2+(3400-833.33)^2+(350-833.33)^2+(1600-833.33)^2+(160-833.33)^2+(300-833.33)^2\\+(300-833.33)^2+(100-833.33)^2+(700-833.33)^2+(1000-833.33)^2\end{array}}{18-1}}$$

σ = 771.560

= 92.58%

So, it can be said that the cost would vary around 92.58% of the total cost depending on the availability and the situation.

2.5. P.E.S.T. Analysis

PEST analysis which is an acronym of political, economic, social, and technological analysis is a management technique that allows a company to examine important external elements influencing its operations in order to become more competitive in the market. It refers to the strategic analysis of business tool used by organizations to analyze, organize, identify, and track macroeconomic and other elements that might have an impact on their policy in current and future situations [30]. Economic, social, political, technological, and other forces create possibilities and threats in the framework.

2.6. Professional Responsibilities

This project stands out in many ways, including simulated design, implementation, programming, mechanical design, and many others. Turbidity sensor, pH sensor and temperature sensors will be used in IOT based water pollution monitoring boat using dual axis tracker. Here solar panel is also used for charging the battery and resolve the power issue. Dual axis solar tracker is also used for tracking the sun and consuming more energy from the solar [16]. So, there must be some professional responsibilities of engineers related to the project topic. Here all the sensors were must be on a maintenance process. So that the sensors can give proper results and we were able to compare the results to an ideal value [15]. Then we can detect the areas/ rivers where's water is polluted. And we can detect whose areas water is not suitable for mankind. These can be the professional responsibilities for an engineer. Monitoring provides the objective information required to make smart decisions about water quality management today and in the future. Water-quality monitoring is used to alert us to present, ongoing, and future concerns; to evaluate compliance with drinking water regulations; and to preserve other beneficial uses of water [20]. And engineers can make sure to be taken care of these responsibilities. And finally, it would be highly beneficial for the people because water is used widely not only by urban residents but also by rural residents.

2.6.1. Norms of Engineering Practice

Our project is about IOT based water pollution monitoring boat using dual axis tracker. So, project is about to ensure the safety of the water in various area. When the project will be completed, we will be able to make comparison of water on different reservoir and also able to detect whose areas water is not suitable for environment and humankind [8]. The quality of drinking water is critical to the health of both animals and humans. Lakes and reservoirs, as well as canals, are important sources of drinking water. Water quality monitoring in these bodies of water demands a significant amount of work since operators must board a boat equipped with all sensors and personally inspect the whole lake. In this project we can resolve this problem and make the system lot easier because we can get all the data by wireless communication system. These can be the general engineering practice [31]. Here, in this project engineering guidelines are also strictly followed. Engineering guidelines are a collection of best practices from your business; a distillation of institutional knowledge about "how things should be done here." They are a combination of your engineering department's Statement Of purpose, Values Of the organization, and Guidelines And procedures [31]. This project includes a way for easily monitoring the water quality of large bodies of water. The IoT-based water pollution monitoring boat can capture and transfer water quality data to an IOT server online [18]. This will help us keep the water clean even more.

2.6.2. Individual Responsibilities and Function as Effective Team Member

This water quality monitoring multifunctional boat is equipped with an inbuilt Global Positioning System (GPS), which provides the location of the spot where quality of the water is altering, there is also a radio frequency module which is used for wireless communication. With, all the findings are created, their readings and graphical analogue meters are shown using the graphical user interface GUI method. In addition to water impurities limitation points and hazardous level notification It has been demonstrated through this project's multiple experiments in reservoirs, lakes, and personal water storage tanks capable of efficiently proving these physicochemical properties as well as exhibiting these readings efficiently [15]
We were able to obtain one Arduino UNO, one turbidity sensor, one pH sensor, one temperature sensor, one LCD display (20*4), one GSM Neo 8m, and other electrical components. Servo motors, motor drivers,

12V motors, 12V 300 RPM motors, controllers, and other mechanical components have also been taken care of. The Arduino now has the programming for this machine. After uploading the scripts to the Arduino, everything worked perfectly.

2.7. Management Principles and Economic Models

Water pollution is become a biggest concern to every country in the world since it affects humans' health, environment, the economy and biodiversity. This project discusses the causes and impacts of water contamination, as well as an effective IoT-based technique for water quality monitoring. Despite the existence of several outstanding smart water quality monitoring devices, the research topic remains tough. This project aims to create the water quality monitoring systems highly efficient, cost efficient, smart, low-powered. So that monitoring may be done continuously and alerts/ notifications can be forwarded to the dedicated website for further action [15]. The designed model is inexpensive and easy to use.

In this project engineering management models and principles has been followed. Project management is all about knowing exactly what our goals are, how we'll achieve them, what resources we'll need, and how long it will take us to reach that specific goal is. These things were in our mind while doing our project. So, we can say that Engineering management models and principles was followed in this project. The success of each project is dependent on project management. Because management systems teach us how to manage the project's time or schedule, recover project time, and save money when acquiring or purchasing project-related equipment.

This project is a highly efficient and cost effective IoT-based smart water quality monitoring system that continuously checks quality parameter [16]. It is a study of recent research conducted by researchers in attempt to create smart, low-powered, and highly efficient water quality monitoring devices that would monitor continuously and send alerts/notifications to the appropriate authorities for further processing [20]. So, the designed model is cost-effective and simple to use (flexible) [22]. Budget is a matter of concern while doing a project and we have to keep in mind during implementation. At the end we can say, all class of people can use our project because it is affordable and cost effective.

2.8. Summary

The most important thing before completing a project is knowing exactly what is the goals are, how to achieve them, what resources will need to reach the goal, and how long it will take you to reach that specific goal and these all is also called project management. So, project management is mainly concentrated in this chapter. In this chapter also focuses on the scheduling of our project, cost analysis, individual task management, and the project's strengths, weaknesses, threats, and possibilities. Because management systems teach us how to manage the project's time or schedule, recover project time, and save money when acquiring or purchasing project-related equipment. Using the Gantt Chart, we can build a timetable for the project. Using statistics, we can save money while purchasing project equipment. This project provides an overview of recent research efforts to develop IOT-based smart water quality monitoring devices. This project includes PH sensors, turbidity sensors, and a temperature sensor. The presence of suspended particles in the water and the quality of the water will be detected by these sensors. We also have a camera, GPS module, and microSD card that will log data from sensors and GPS positions and communicate it online at regular intervals through IOT. As a result, we can monitor the quality of the water, and the boat may also be used for surveillance and navigation. A solar panel with a dual axis tracker is also used to resolve the boat's power problem. As a result, the water quality monitoring boat may easily be used for water quality monitoring on lakes and reservoirs. Because of it is low powered and very efficient, allowing for continuous monitoring and alerts/ notifications to be forwarded to the authorities for further processing. So, we can say, the project is both cost effective and simple to use (flexible).

Chapter 3

METHODOLOGY AND MODELING

3.1. Introduction

The project's main goal was to develop a solar-powered system for monitoring water contamination that would be ecologically benign and sustainable. Additionally, we have a backup battery and charger to power this boat for monitoring pollutants. We utilized Arduino to create our design. pH, temperature and turbidity sensors are used to monitor the water pollution in a certain region. This surveillance boat was constructed utilizing a combination of IoT technology expertise and includes solar panels and Wi-Fi capabilities. In this chapter, a methodology will be explained via the use of a block diagram that we have created, displayed, and described. There will also be a discussion of the qualities of the parts we utilized. We'll also demonstrate the simulation we developed using Proteus 8. The most important feature of this technology is that it appears to be immensely effective in developing nations like ours. It is inexpensive, needs little skill to use and readily available.

3.2. Block Diagram and Working Principle

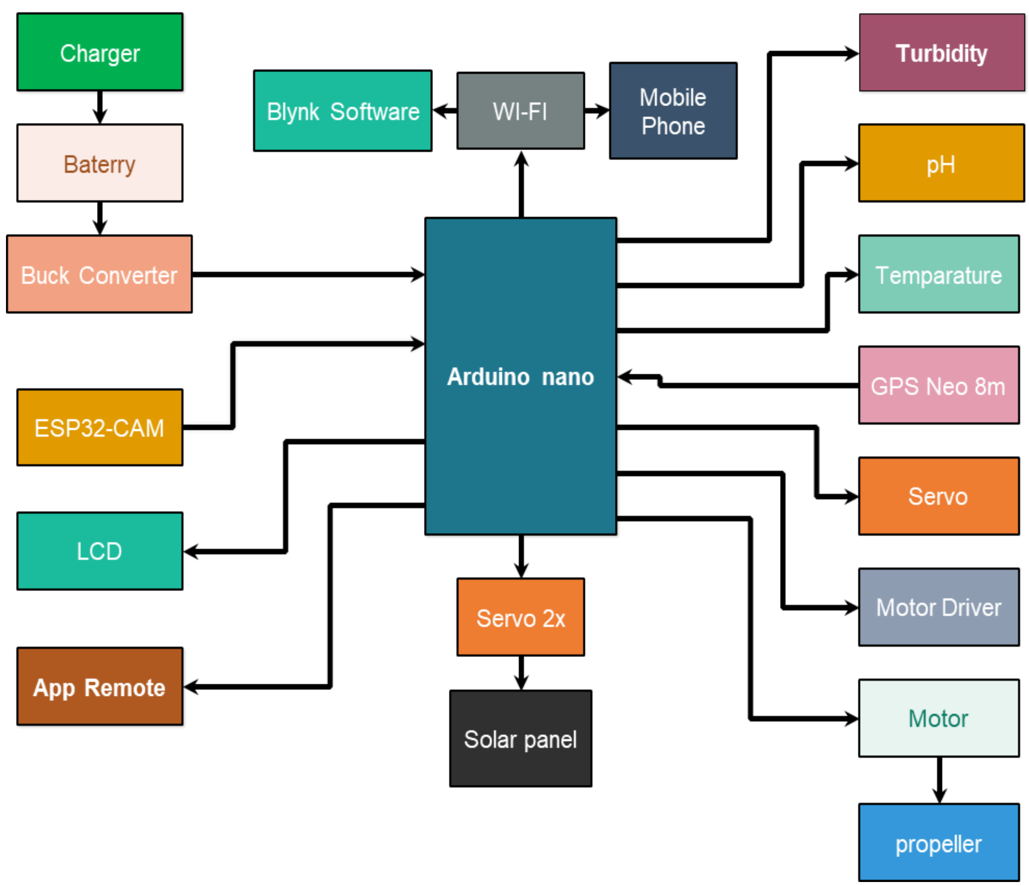


Figure 3.1: Block diagram of the project

Here we can see the flow chart and working principle in the block diagram. So here the charger and the battery were connected with buck converter and the buck converter is connected through an Arduino pin. An ESP32 module camera also connected through an Arduino pin. A connection from an Arduino pin is go to the LCD for displaying the data. For controlling the project there was a app remote where we can able to control the boat which is coming from an Arduino pin. A Wi-Fi module is directly connected through the Arduino where and we can connect it to our IP address where we can able to control the boat though a mobile app and also, we can get all the data those are given by the sensors wirelessly by specific website. There is also a solar panel with dual axis tracker in our project. So, an Arduino pin is connected to servo motors and then servo motors are connected to solar panel. As our solar panel is a dual axis tracker, the servos are used for rotating the solar panel while tracking the sun. Then, 3 separate pins from Arduino connected to Turbidity sensor, pH sensor, Temperature sensor which are the main thing of our project. By this sensor, we are able to determine the contamination of water. And we can get all the value wirelessly by the help of Wi-Fi and a specific website. Then, GPS neo 8m is connected to Arduino. It is used for the location of our boat.by these we can able to locate the boat. Then two separate pins from Arduino connected to servo and motor driver. These are used for the direction of the boat. They can make the boats speed and its left right direction. The servos can make the left right direction of the boat and the motor driver is used for speed control of the boat. Finally, an Arduino pin is connected to a motor and the motor is then connected to a propeller. These are used for controlling the speed of the boat and it can able to make the boat move forward and move backward. These are also very important for the direction of the boat. Finally, we can run our boat and it can get power from the solar panel if the battery’s power is low. And the camera is used for surveillance. In lcd we can able to see the value of our sensors and it can also show us many basic information. And we can control the boat by a app remote. By using this we can able to control the boat without any trouble. The Wi-Fi module is also used for communicating and controlling the boat wirelessly. We can also able to see all the data in specific website by using this Wi-Fi. All sensor can show their data separately by the Arduino and finally we can able to show all the data and make the comparison whether the water is contaminated or not. Then GPS module can locate our boat. And then, servo, motor driver, motor and propeller are used for direction and speed of the motor. These are the working principles of our project.

Pollution of water is becoming the most serious concerns for modern globalization. To maintain a secure supply of water, the quality of the reservoir's water (lake, canal, river) must be monitored in real time. As our project goal is to develop an efficient, secured and cheaper system with real time water level monitoring system, we can monitor the reservoir's water (lake, canal, river) in real time. And all the procedure of our project was followed to accomplished our project goal perfectly. Many problems were also faced while working on the implementation and also there is many components parts problem. All the challenges were solved in engineering way. Finally, we were able to accomplish our project goal which is to develop an efficient, secured and cheaper system with real time water level monitoring system to keep track of the reservoir's water quality (lake, canal, river etc.). As we are using some sensors for monitoring the quality of the water in real time such as monitoring of water turbidity, pH, and temperature using specific sensors with a distinct advantage and an existing GSM network. The device can automatically monitor quality of the water which is economical in cost, and does not require personnel to be on duty. As a result, water quality monitoring will most be less expensive, more efficient and convenient, and faster. The system is highly flexible.

3.3.Modeling

Although modeling on the Solid works platform of the 2019 edition is more convenient in a Windows environment, the interface is user-friendly and efficient. Depending on the size and form of the components. On the SolidWorks platform, it has been stretched and shell pieces to build the component model, which was subsequently assemble to the support shown in figure 3.2, figure 3.3, figure 3.3 and figure 3.4.

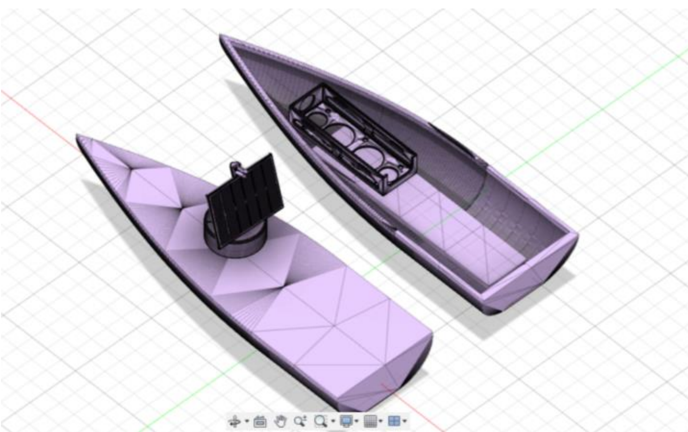


Figure 3.2: 3D model of project

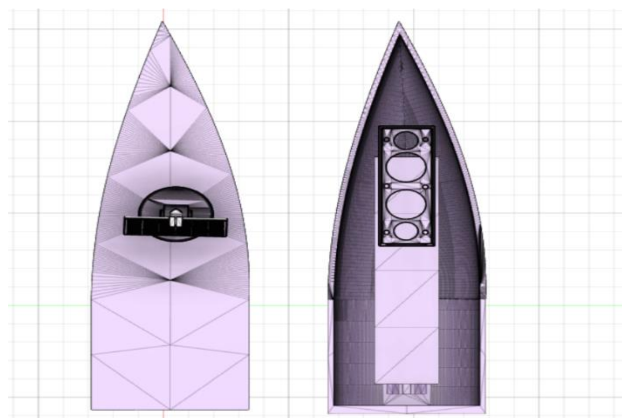


Figure 3.3: Top view of project

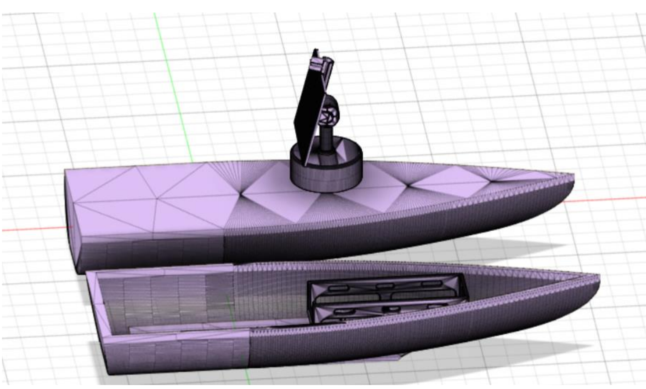


Figure 3.4: Side view of project

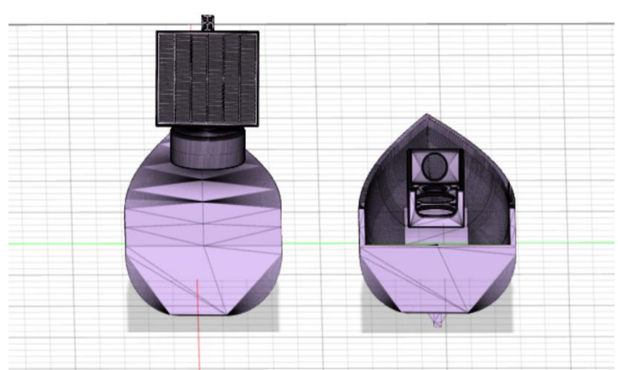


Figure 3.5: Back view of project

The figure 3.2 shows 3D model of project. The figure 3.3 shows the top view of the 3D model. The figure 3.4 shows the side view of 3D model of project. The figure 3.5 illustrate the back view of the 3D model of project.

3.4. Summary

To successfully construct the project prototype as well as the methodology and modeling must be completed and modeling is addressed in this chapter using fundamental block diagrams. All of the necessary hardware and software were listed in proper detail. Some portions of the project were simulated using basic. Overall, this Portion of this chapter was covered overall prototype, modeling also software details which has fundamental used.

Chapter 4

PROJECT IMPLEMENTATION

4.1. Introduction

Implementing hardware of the project was mainly focused in this chapter, which included the following components: Arduino nano, ESP32-CAM for surveillance, LCD, App Remote, GPS Neo 8m, Servo motor, Motor Driver, Motor, Propeller, battery as our primary power source, Buck converter, Wi-Fi module, Turbidity sensor, pH sensor, Temperature sensor, Solar panel, propeller, Shaft and LDR. The hardware component served as the foundation for every aspect of the project and the simulation component was also put into practice. An expected result from the simulation portion provides the correct understanding of the hardware implementation concept. Any rural, coastal, or ditch where it can assess water pollution and transmit feedback is a suitable location for this project. The whole Hardware implementation concept will be provided in this chapter, which also explains the basic concept.

4.2. Required Tools and Components

The used apparatus list of this project is shown as follows:

1. Rechargeable Battery
2. Buck Converter
3. ESP32-CAM
4. LCD
5. Wi-Fi module
6. Arduino Nano Microcontroller board
7. MG90S micro servo motor
8. 8V Solar panel
9. Turbidity Sensor
10. Analog pH Sensor
11. Temperature sensor
12. NEO-8M GPS Module
13. L298N H-Bridge Motor Driver
14. 6V DC motor
15. Propeller
16. Propeller shaft
17. Light Dependent Resistor

4.2.1. Rechargeable Battery

In contrast to a disposable or primary battery, which is delivered fully charged and discarded after use, a rechargeable battery may be recharged, drained into a load, and recharged several times [36]. Battery-powered batteries consider several applications for a cell, reducing waste and delivering a higher long-term profit in terms of money invested for useable gadget energy. Given the increasing expense of rechargeables as well as the requirement for a charger, this really is true in any scenario. A rechargeable batteries cell is a more cost-effective and long-lasting replacement to single-use batteries, which generate power through a chemical process that consumes a receptive anode. The anode in a rechargeable batteries battery is eaten in the same way, but at a slower rate due to the periodic charges and discharges [37]. Basically, these rechargeable batteries will run our project. It is one of the most important components because the whole project will be getting power from these batteries. Here we are using 3.5 V rechargeable Lithium Battery.

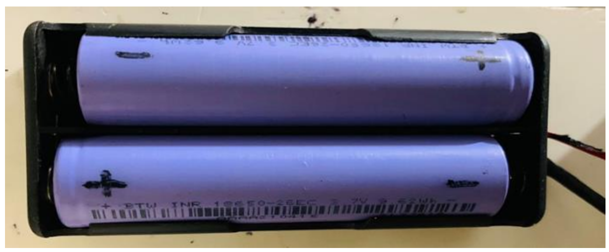


Figure 4.1: 3.7 V rechargeable Lithium Battery.

4.2.2. Buck Converter

It is a DC-to-DC power converter which may steps down voltage from its input to its output or load [38]. LM2596 HV DC-to-DC buck converter is used in this project. The LM2596 HV is a stepdown converter. This converter is a is a DC-to-DC power converter that reduces the voltage from the input to the output. First, correct the input power, then use a multimeter to verify the output voltage and adjust the potentiometer. The LM2596 HV is a common voltage regulator/buck converter IC that is well suited for the simple construction of a step-down or step-up switching regulator. It can drive a total load of 3.0 amps with good line and load control.

Figure 4.2: Buck Converter [38]

4.2.3. ESP32-CAM

The ESP32-CAM module is a portable, low-power consumption camera module which is based on the ESP32. It has an OV2640 camera and an inbuilt TF card slot. The ESP32-CAM may be extensively utilized used in intelligent Internet of Things applications such as wireless video monitoring, Wi-Fi picture upload, QR identification, and so on. As our project is IOT based water pollution monitoring boat, sometimes the boat might need some kind of surveillance [39]. So that we are using ESP32-CAM module. So that our boat can also use as surveillance purpose. As our boat is IOT based and it can be controlled via Wi-Fi, so ESP32-CAM module maybe a perfect use of it because it can also monitor via Wi-Fi. Wireless video surveillance, Wi-Fi image upload, QR identification, and other intelligent IoT applications can all benefit from the ESP32-CAM. This Cam module is a cost-effective and very flexible which is making it ideal for IoT devices that require complex functions.

Figure 4.3: ESP32-CAM Module [40]

4.2.4. LCD

LCD (Liquid Crystal Display) screens are electrical display modules that have many applications. In our project we are using LCD2004 Parallel LCD Display. This LCD2004 Parallel LCD Screen is a quick and inexpensive solution to incorporate a 20x4 White on Multicolor Liquid Crystal Screen into our project. The display is a 20-character-by-4-line display with extremely clear, high-contrast white writing on the a blue background/backlight.

Figure 4.4: LCD [41]

4.2.5. Wi-Fi module

In the project the ESP8266 Wi-Fi Module is used, which makes it IOT-based. The ESP8266 Wi-Fi is a self-contained SOC with an integrated TCP/IP protocol stack that allows any microcontroller to connect to your Wi-Fi network. The ESP8266 may run programs or offload whole Wi-Fi networking activities from another CPU. Because each ESP8266 module comes with pre with an AT command set firmware, we can simply attach it to our Arduino system and have nearly the same Wi-Fi capabilities as a Wi-Fi Shield. The ESP8266 module is a reduced board with a sizable and growing community [42]. This module's on-board processing and storage capabilities are robust enough for it to interface with sensors and other application-specific devices through its GPIOs with minimal programming and loading during runtime. Because of the high level of on-chip integration, little external circuitry is required, such as the front-end modules, which is intended to take up such little PCB space as possible. The ESP8266 offers APSD for Applications and Bluetooth co-existence interfaces, and it features a self-calibrated RF that allows it to operate in all operating scenarios without the need for additional RF components.

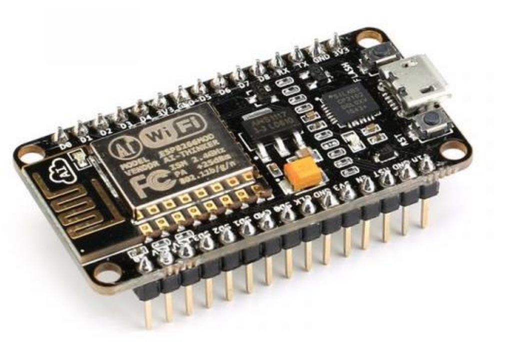


Figure 4.5: ESP8266 Wi-Fi Module [43]

4.2.6. Arduino Nano

In our project, we are using Arduino Nano Microcontroller board. When it comes to features and pinouts, it is quite similar to the Arduino UNO, but it has replaced the UNO because to its small size. Size is important in Embedded, as we are all aware. Smaller embedded devices are preferred. The Arduino Nano is a small sized, functional, and breadboard-friendly board which is based on the ATmega328. It features analogous competences as the Arduino Duemilanove, but in a changed packing. Arduino nano only loses a DC power connector and it is also using a Mini-B USB cable instead of a conventional one. The Getting Started with Arduino Nano section contains all of the information you need to configure your board, utilize the Arduino Software (IDE), and begin experimenting with code and electronics [44]. Arduino.cc created the Arduino Nano microcontroller board. The Arduino Nano use the same Atmega328 microprocessor as the Arduino UNO. Because of its tiny size and flexibility, it has a wide range of applications and is a significant microcontroller board. If we want to discuss about its features, it has a total of 22 input/output pins. 14 of these pins are digital. The Arduino Nano has 8 analog pins. Among the digital pins, there are 6 PWM pins. It has a 16MHz crystal oscillator. Its operational voltage ranges from 5V to 12V. It also supports many communication protocols, including Serial Protocol, I2C Protocol, and SPI Protocol. It also contains a small USB pin for uploading code. It also has a Reset button [10]. If we talk about Memory in Arduino Nano, The Arduino Nano's flash memory is 32Kb. It comes with a preinstalled bootloader that requires 2kb of flash memory. This Microcontroller board's SRAM memory is 8kb. It has a 1kb EEPROM memory [45].

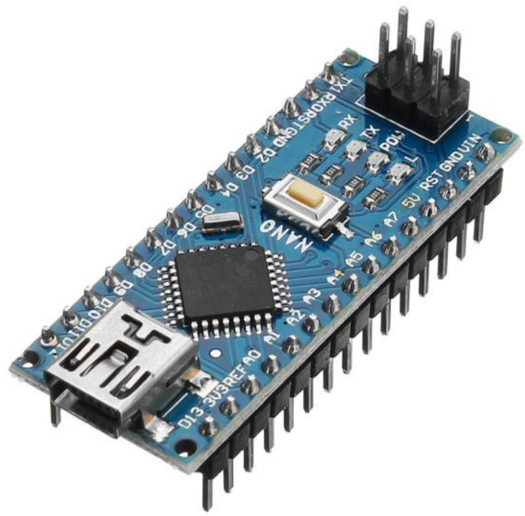


Figure 4.6: Arduino Nano Microcontroller board [46]

4.2.7. Servo Motor

A servo motor is a high-precision rotating motor. This type of motor that can rotate with great accuracy. In our project we are using 3 servo motor. 2 servo is for rotating the solar in dual axis. After using those, our solar can move in any direction. And the other servo is used for moving the left, right direction of our boat. Servo motors are perfect in this kind of things.

This type of motor usually consists of a circuit that offers response on the present position of the shaft which is placed in the motor, this response allows servo motors to rotate with remarkable accuracy. A servo motor is used to rotate an item at particular angles or distances. It is just a motor that operates using a servo system. Generally, a servo motors have a control circuit that provides feedback on the current position of the motor shaft, allowing them to rotate with extreme precision. A servo motor is required when we need to spin something at a certain angle or distance. It's simply a motor and servo mechanism. A DC servo motor is powered by a direct current power source, whereas an AC servo motor is driven by an alternating current power supply. [47]. For our project, we will use only DC servo motors so, we will only look at how a DC servo motor works. A DC engine operates on the same basic principles as other electromagnetic engines. This engine's rotors have a long rotor length and small distances across them.

Figure 4.7: MG90S micro servo motor [48]

4.2.8. Solar panel

As our project is IOT based water pollution monitoring boat using solar panel with dual axis tracker. So, we are obviously using solar panel in our project. Basically, we are using 8V solar panel. This frameless solar panel consists of a 16-solar cell assembly (8V) installed on a TPT backplate and protected by stiff tempered glass. The cell is a PERC monocrystalline solar cell with a high efficiency. This 8V solar panel is both lightweight and long-lasting. It's also scratch-resistant, waterproof, and UV-resistant. This compact solar panel is ideal for charging our 7.5-volt direct current batteries. The 8v 225mA Mini Photovoltaic System for DIY Projects is prepared to use, with no framework or other modifications necessary. They are laser etched to size and wrapped in sun and rain and wind materials to give them their individual characteristics. In the 8v 225mA tiny Solar Panel, crystalline solar panels are contained and secured by a robust outer poly frame. This 8v 225mA tiny Solar Panel for DIY Projects is constructed from lightweight, extremely durable, and rain and wind substrate or injection moulded trays that have been custom-designed for the intended purpose. These Small Epoxy Solar Panels are simple to install or integrate into your existing design, and they don't require a frame or any other special modifications.

Figure 4.8: 8V Solar panel. [49]

4.2.9. Turbidity Sensor

For monitoring water pollution, we need to measure the contamination of water. For measuring the combination of water, turbidity sensor can be a perfect use of it. Turbidity is defined as the dirtiness or mistiness of a fluid generated by a high number of separate particles that are normally invisible to the human eye, comparable to smoke in the air. The measurement of turbidity is a significant indication of water quality. Turbidity is caused by particles suspended or dissolved in water that scatter light and cause the water to seem foggy or murky. Particulate matter includes sediment, notably clay and silt, fine organic and inorganic debris, soluble colored organic compounds, algae, and other tiny creatures. [50].

Water turbidity refers to the amount of turbidity generated by suspended particles in the water such as mud, clay, organic matter, plankton, and bacteria. The cost of industrial-grade turbidity sensors or turbidity meters is prohibitively expensive in the design of electronic goods. As a result, we used a turbidity sensor that is often used in water turbidity metering project and also in some home appliances which are cost efficient. The sensor uses optical principles to assess turbidity in the solution by measuring light transmittance and scattering rate. An infrared tube is housed within the sensor. The quantity of light transmission occurs when light travels through a specific amount of water. A photosensitive sensor detects the amount of light that flows from the source of the light to the light receiver using an optical transistor and optical diodes in order to calculate the turbidity of water. [51].

Figure 4.9: Turbidity Value Detection Module Kit [52]

4.2.10. pH sensor

The pH of a solution is an important parameter that reveals its chemical conditions. The pH of a solution can has an impact on nutritional availability, biological processes, microbial activity, and chemical behavior. As a result, monitoring and managing the pH of soil, water, and food and beverage items is critical for a variety of purposes. As a result, the pH sensor is a critical sensor in our project for monitoring water quality.

The pH sensor is a type of sensor that detects the concentration of hydrogen ions in a solution and converts it into a useable output signal. It is typically made up of a chemical component and a signal transmission component. The measuring range is 0-14 in digital format. The number 7 denotes neutrality. The greater the value, the greater the alkalinity; the lesser the value, the greater the acidity. The pH sensor is frequently used in industry to test chemicals such as solutions and water. This analog pH meter was created exclusively for Arduino controllers and includes a simple and practical "Gravity" connector as well as a host of possibilities. Connect our probe to our Arduino in an instant to acquire pH values at 0.1pH (25 °C). This extraordinary precise range and low cost make this an excellent instrument for our project, such as a water pollution monitoring boat [53]. It has a power LED, a BNC connector, and a pH 2.0 sensor interface. To use it, just connect the pH sensor to the BND connector and plug the pH 2.0 interface into the analog input port of our Arduino controller. Because it was pre-programmed, obtaining the pH value was simple.

Figure 4.10: Analog pH Sensor [54]

4.2.11. Temperature Sensor

Temperature sensor can be an essential sensor in our water pollution monitoring project. When evaluating water quality, temperature is a crucial component to evaluate. Temperature impacts various other parameters and can change the physical and chemical characteristics of water in addition to its own effects. For that reason, we are using temperature sensor in our project to measure the quality of water perfectly.

The water temperature sensor has a 0.1 degree accuracy and can monitor temperatures ranging from -55 degrees Celsius to +125 degrees Celsius. This is a pre-wired and sealed (waterproof) digital temperature probe based on Maxim IC's DS18B20, 1-wire digital temperature sensor, which gives data in degrees Celsius with 9 to12 bit precision over the operational range (-55C to 125C). With a simple 1-Wire interface, this probe accurately measures temperatures in moist situations. Because they are digital, there is no signal deterioration over vast distances [55]. There is no signal degradation over long distances since they are digital. The inbuilt digital-to-analog converter allows these 1-wire digital temperature sensors to have an accuracy of up to 12 bits. They are compatible with any microcontroller with a single digital pin, and we can even connect many ones to the same pin; each one has a unique 64-bit ID that is burnt in at the factory to differentiate it. System voltages ranging from 3.0 to 5.0 volts are supported.

Figure 4.11: Temperature sensor [56]

4.2.12. GPS Neo 8m

The U-blox NEO-M8N GPS-GNSS Module is a stand-alone GPS module based on the NEO-M8 u-blox M8 concurrent GNSS chip. And it was very important part of our project because, it can able to give us the location of the boat continuously. By using this GPS neo 8m module, we can able to locate our boat any time.

This GPS chip is based on a high-performance 72-channel u-blox M8 engine (GPS, GLONASS, BeiDou, QZSS, SBAS, and Galileo-ready1) that can receive and monitor several GNSS systems at the same time. This chip is an update to and compatible with the NEO-7, NEO-6, and NEO-5 families, making the switch to the NEO-M8N a simple and quick alternative. The NEO-M8 series has a built-in flash memory that can be modified with simple software to provide updated GNNS systems. Instead of low power and low-cost use, this device delivers high sensitivity (-167 dBm navigation sensitivity with location accuracy of 2.0 m CEP), quick acquisition times, and excellent performance. The chip is about the size of a postage stamp, yet it contains a startling number of components. It can monitor up to 22 satellites on 50 stations and has the highest affectability in the industry, for example, 161 dB tracking while utilizing just 45 milliamps of stock current. It can conduct up to 5 area refreshes per second with a horizontal location precision of 2.5m, which is faster than typical GPS units. The u-blox 6 positioning motor has a Time-To-First-Fix (TTFF) of less than one second. The chip's best feature is probably its Power Save Mode (PSM). It decreases framework power consumption by turning certain collector parts on and off. [57]

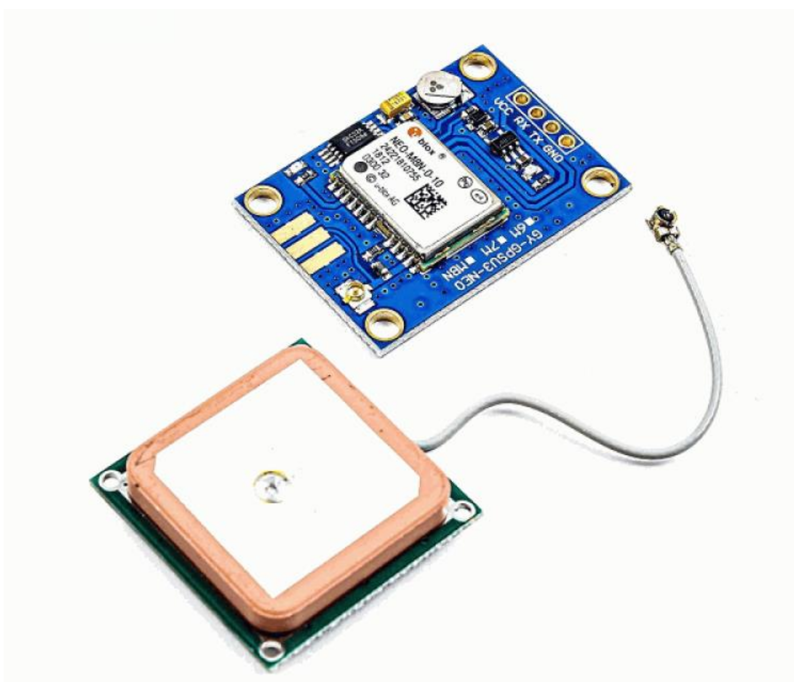


Figure 4.12: NEO-8M GPS Module [58]

4.2.13. Motor Driver

Motor drivers serve as a connection point between motors and control circuits. The motor demands a lot of current, while the controller circuit just needs a little bit. Motor drivers are responsible for converting a low-current control signal into a higher-current signal capable of operating a motor. In our project, we are utilizing the L298N Motor Driver. And this motor driver was utilized to manage the speed of our boat's motor. This high-power L298N Motor Driver Module can power both DC and stepper motors. This module employs an L298 motor driver IC and a 78M05 5V regulator. The L298N Module can control up to four direct current motors or two direct current motors with directional and speed control. The L298N Stepper Motor Driver Board Module is intended for use with the Arduino platform. The L298 motor driver chip can control two DC motors directly and includes a 5V output interface as well as support for 5V and 3.3V MCU control.We can simply regulate the speed and direction of the DC motor. The 2-phase stepper motor may also be controlled. The driver has control over both the RPM and the rotational direction of the motor. PWM input to ENA or ENB pins controls the RPM. The direction of rotation is regulated by sending high and low signals to EN1-EN2 for the first motor and EN3-EN4 for the second motor. This Dual H-Bridge driver can handle voltages of up to 46V [59].

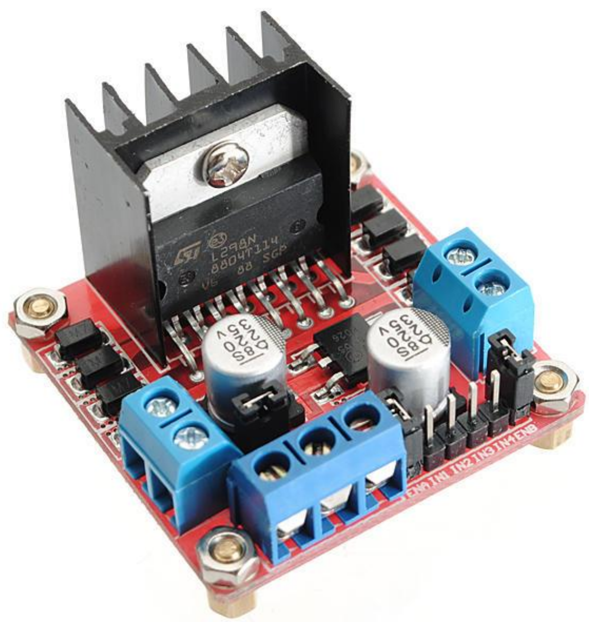


Figure 4.13: L298N H-Bridge Motor Driver [60]

4.2.14. DC motor

A rotary electric motor that converts direct current (DC) electrical energy into mechanical energy is known as a direct current (DC) motor. The most common types rely on the forces produced by induced magnetic fields provided by electricity flowing through a coil. Almost all types of DC motors include an internal mechanism, either electromechanical or electronic, that periodically switches the direction of current in a part of the motor. In our project, we are moving our boat with a dc motor. This motor allows our boat to go forward and backward. In our project, we are employing a 6v DC motor.

A rotary electrical motor that converts direct current electrical energy into mechanical energy is known as a 6V DC motor. Almost all types of DC motors include an internal mechanism, either electromechanical or electronic, that periodically switches the direction of current in a part of the motor. 6V DC motors were the first type of motor widely used because they could be powered by existing direct-current lighting power distribution networks. A 6V DC motor's speed may be changed across a wide range by modifying the supply voltage or adjusting the current intensity in its field windings. An electromagnetic field aligned with the center of a wire coil generated by a current flowing through it. The direction and size of the magnetic field created by the coil may be altered by varying the current flowing through it. A simple 6V DC motor consists of a stator with a fixed set of magnets and an armature with one or more windings of insulated wire wound around a soft iron core to focus the magnetic field. The windings frequently have many turns around the core, and several parallel current channels may occur in large motors. This motor is employed when a strong starting torque as well as good speed management are required. [61].

Figure 4.14: 6V DC motor [62]

4.2.15. Propeller

A propeller is a rotating hub with radiating blades set at a pitch to produce a helical spiral that exerts linear thrust on a working fluid such as water or air when turned. The most often used type of marine motor is the responsive diesel motor, which has a better productivity than other types. These motors are classified into three types based on the number of cycles they do at any one time (rpm). The three classes, slow, medium, and rapid, each have benefits depending on the type of boat being piloted. To handle large boats, for example, a low speed yet high force drive structure is required. A low yield speed motor can be used in such vessels. As our boats needs to move, so that a propeller can be a best thing for these. Propeller is basically connected with the dc motor and it rotates with a certain rpm as like the motor. The disadvantage of using slow-speed motors is the large amount of space they require when compared to other motors. In this fashion, a space-viable alternative is to install fast motors in the boat and then reduce the force before it reaches the propellers.

Figure 4.15: Propeller [63]

4.2.16. Shaft

A gearbox is a very useful component that may be used to manage rotational force movement. It is attached to the marine propeller shaft and reduces the force sent to the propeller. The slow-moving motors have no effect on the exchange of force and do not require an additional gearbox. The propeller shaft is a mechanical component that transmits mechanical power, torque, and spin. These shafts are also referred to as driveshafts, driving shafts, tail shafts, and Cardan shafts. The driveshaft is used to transfer torque between components that cannot be directly linked due to distance or the necessity for relative motion. The propeller shaft's function is to transfer torque between the transmission, transfer case, and driving axles. The propeller shaft connects two axes of rotation that are not perfectly in the same plane [64].

Figure 4.16: Propeller shaft [65]

4.2.17. Light Dependent Resistor (LDR)

As the name implies, an LDR (Light Dependent Resistor) is a type of resistor that operates on the photoconductivity principle, which means that resistance varies with light intensity. Its resistance reduces as light intensity increases. It is frequently used as a light sensor, light meter, automatic street lighting, and in situations where light sensitivity is required. It's also known as a Light Sensor. We are using LDR because in our project we are using solar panel with dual axis tracker. That means the solar panel have to move according to suns direction. For detecting the sun, we are using 4 LDR. So that it can detect both (N, E, S, and W) direction. And we are set our solar panel in to two servo motor. So, our solar panel can detect the sun by the use of LDR and move by the use of servo motor [66].

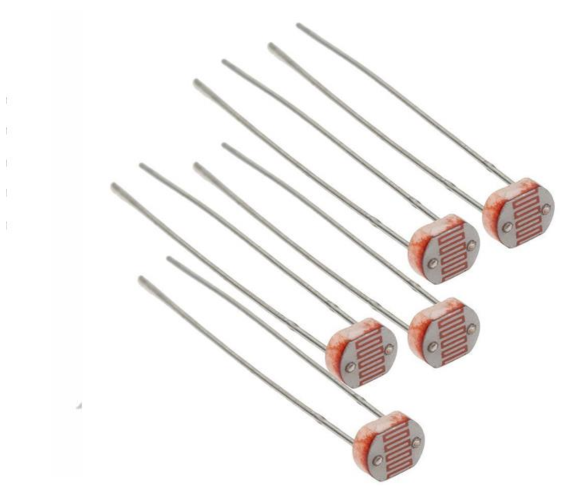


Figure 4.17: Light Dependent Resistor (LDR) [67].

4.3. Implemented Models

The simulation construction was done first and verified then later. The hardware model shown in figure 4.18 was carefully implemented.

Figure 4.18: Full Hardware Structure

4.3.1. Simulation Model

This is the basic simulation model shown in figure 4.19 of the main water pollution monitoring system with the main 3 sensors, Microcontroller, wireless data transmission and receiving, Motor driver, solar tracker servo, solar panel, LDRs for solar tracker and LCD display.

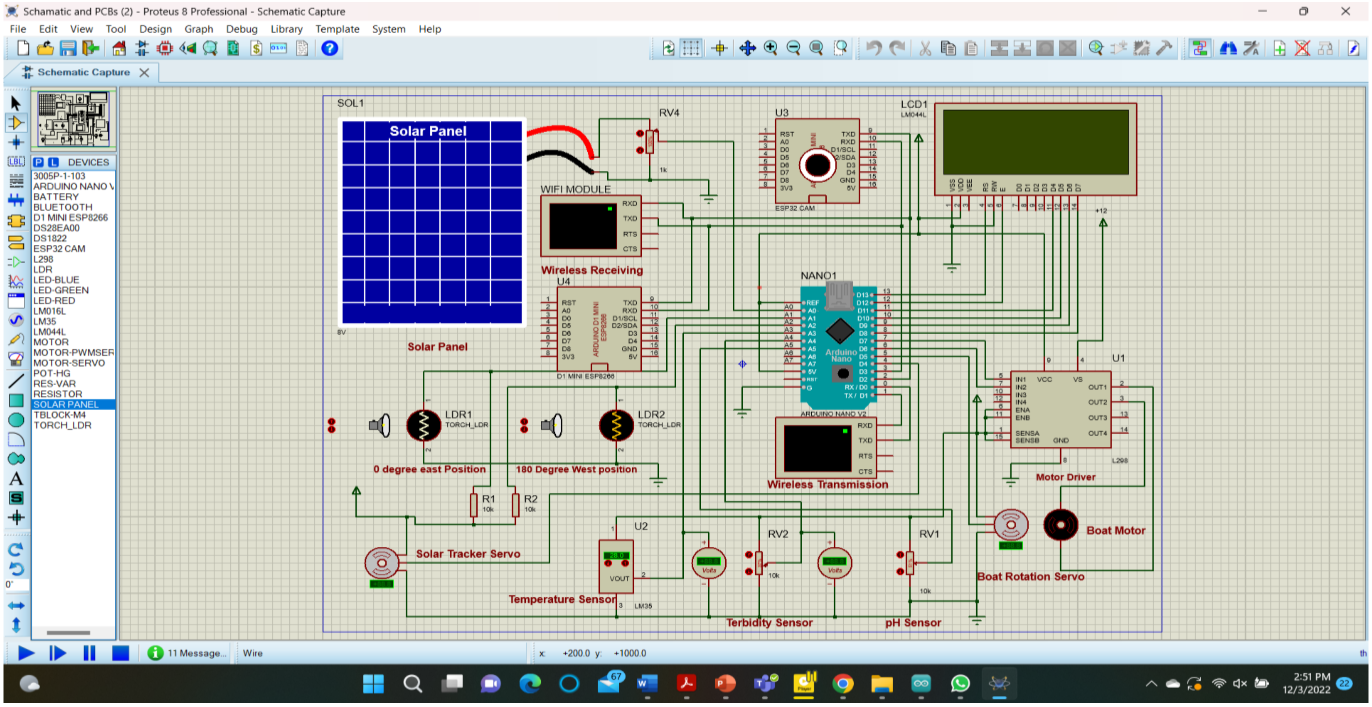


Figure 4.19: Simulation Circuit Diagram of whole project

This figure 4.20 shows the simulation implementation and the operation of the three sensors after running the simulation. The movement of the three motors can be shown in the figure 2. The temperature is represented by the temperature sensor. Turbidity and pH sensors are replaced by potentiometer. By the potentiometer the results are showing.

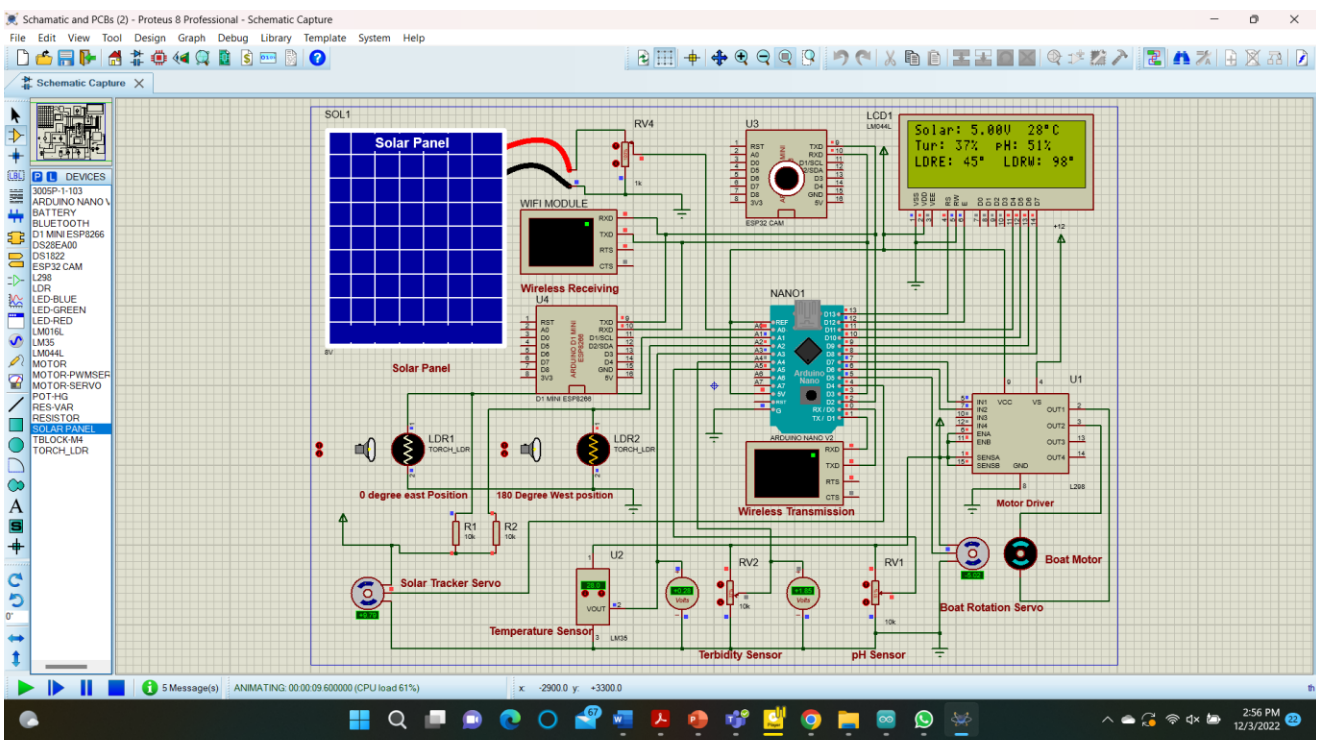


Figure 4.20: Running Simulation Circuit Diagram of project

This figure 4.21 shows the movement of solar panel. Two LDR sensors were used for solar tracker. This sensor senses the solar and move the solar panel according to sunlight. This figure is showing the angles of sunlight. These sensors track the sunlight and moves the solar panel.

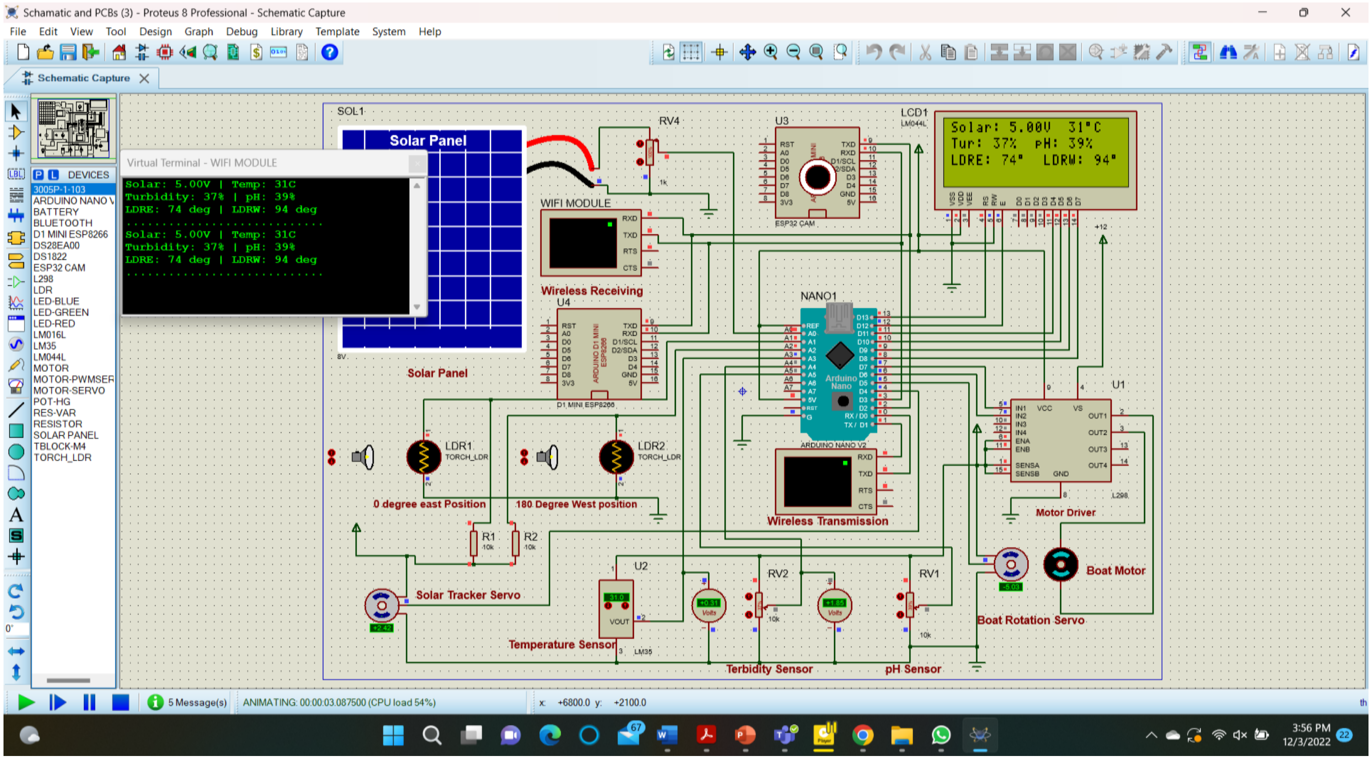


Figure 4.21: Running Simulation (movement of solar panel)

This figure 4.22 shows the values of Turbidity, Temperature, and measurements of pH on water. When the boat moves from one place to another place of water the values might vary. When these sensors collect data from the water, the LCD display will show the received data.

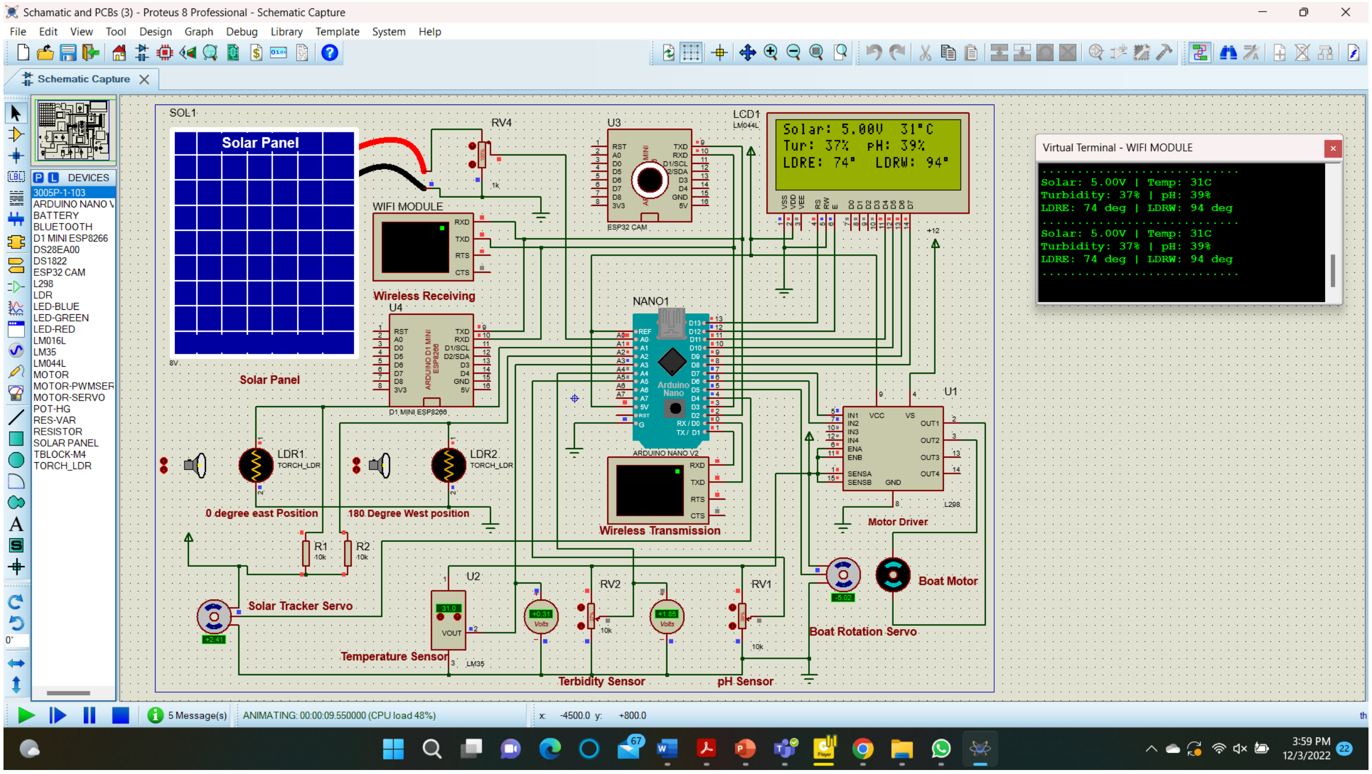


Figure 4.22: Running Simulation (sensors collecting data from water)

This figure 4.23 shows the complete running simulation of the project. It is showing the sensors are taking data from the water. Then it is showing the data to the display. And through the IOT system, we are getting data through internet. In the simulation it shows the virtual terminal.

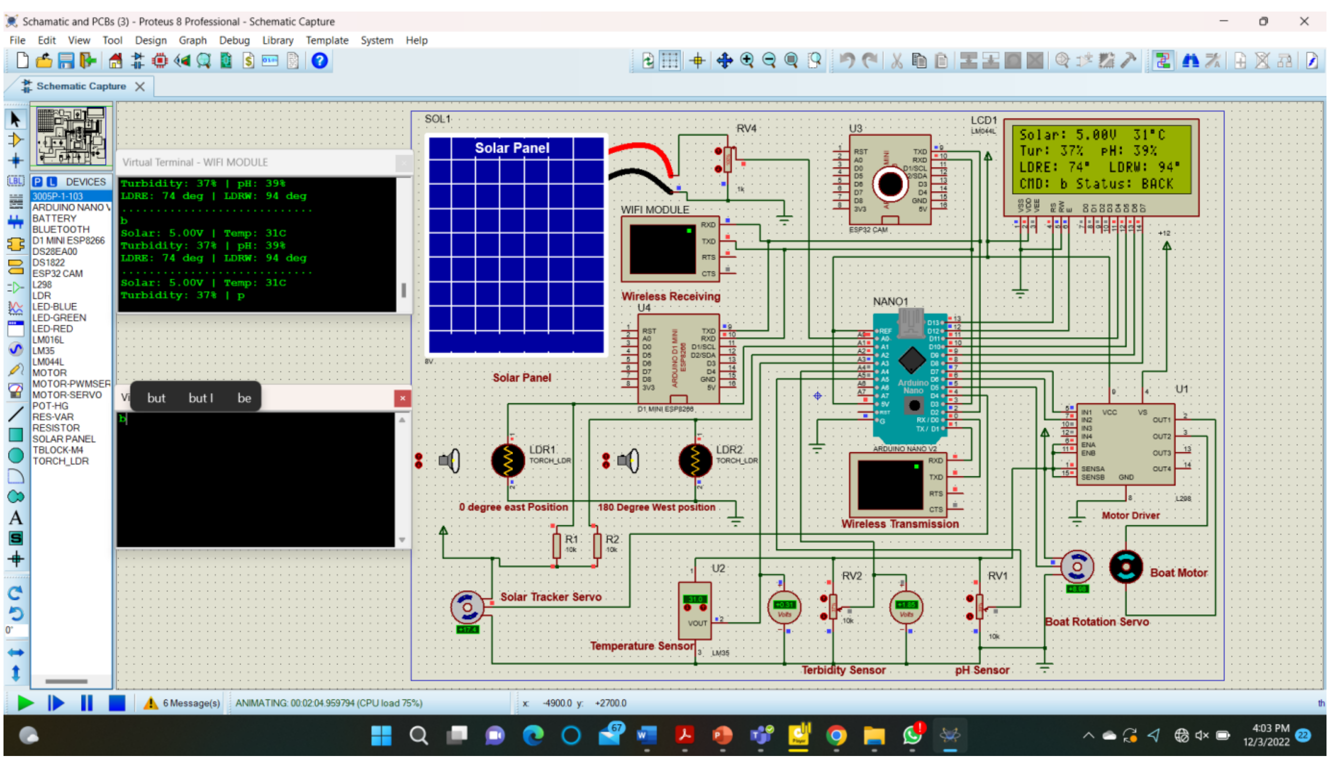


Figure 4.23: complete running simulation

To run the simulation perfectly the simulation codes were organized and verified using the Arduino IDE software. The figure 4.24 shows that the codes were successfully done and verified.

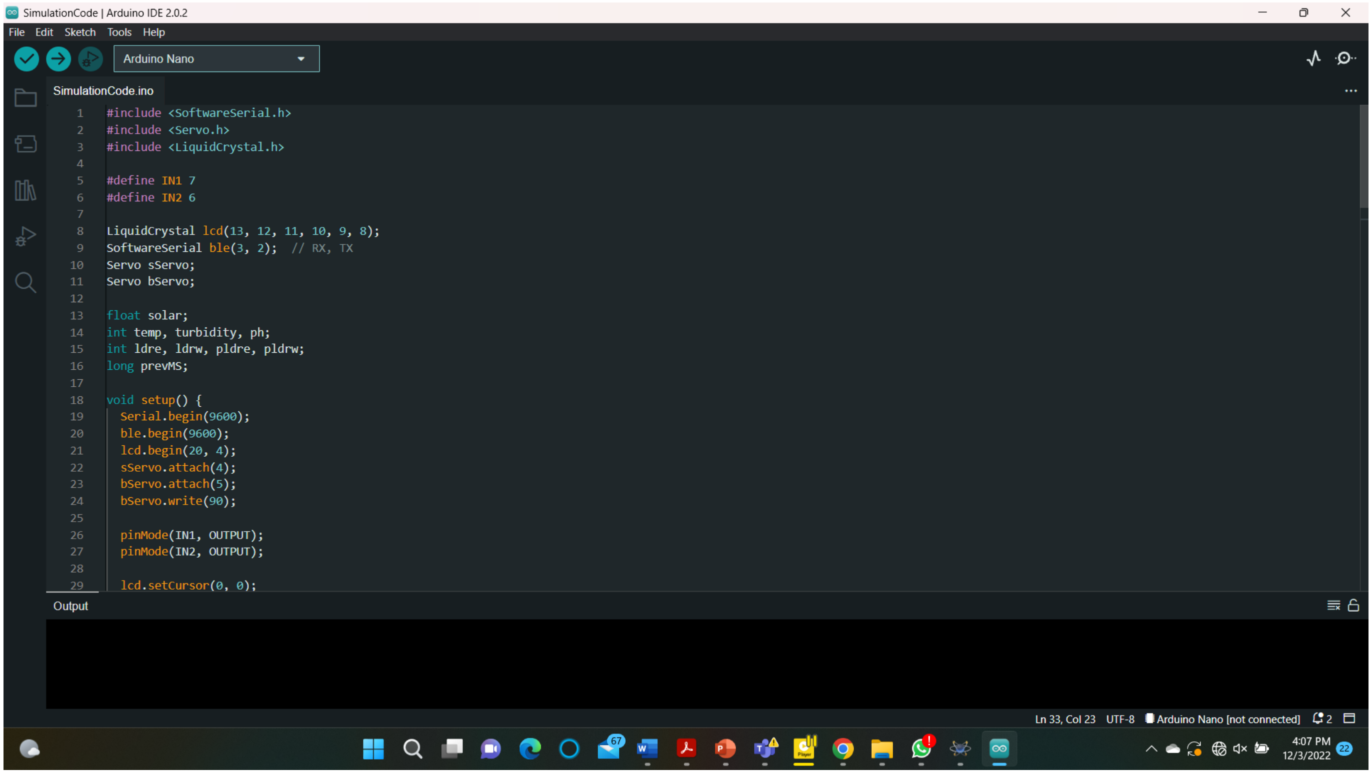


Figure 4.24: Arduino IDE Final Code run

4.3.2. Hardware Model

Here in the figure- 4.25, it can be seen that, the part where Arduino Nano Microcontroller board. It is the main control unit of the boat. Where the motor driver, Wi-Fi module, camera, GPS and sensors are connected.

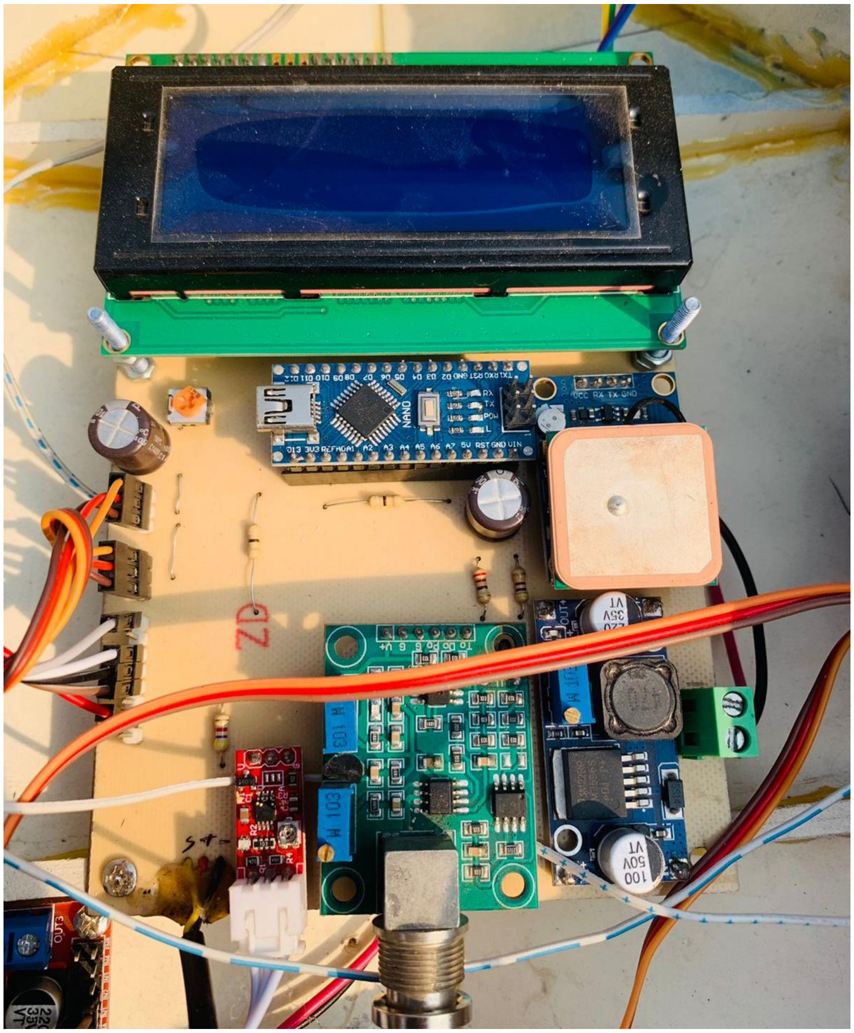


Figure 4.25: Central control Unit

The figure 4.26, shows the main power supply which provide power to the main control unit of the Boat. Where the microcontroller, Servo motor, camera, sensors, GPS and the Motor driver is connected.

Figure-9 shows the solar panel of the boat. There we used batteries. Which are charged through the solar panel.

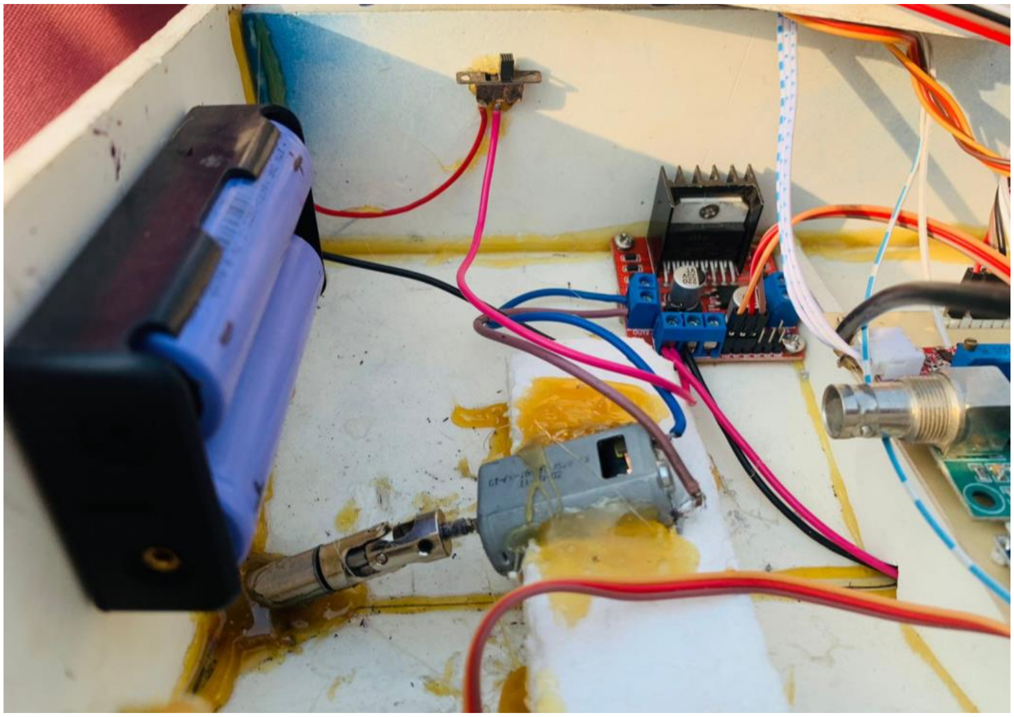


Figure 4.26: Power Supply & boat control Unit

Figure 4.27: solar panel of the boat

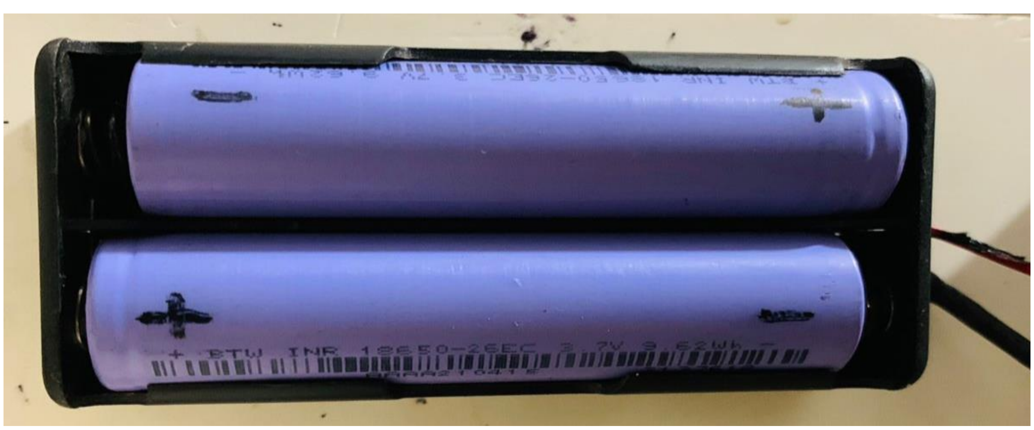


Figure 4.28: battery

Figure 4.29 -, shows the LDR of the boat. As we are using dual axis tracker for solar. So LDR is needed. The LDR sensors help the solar panel to rotate according to sunlight.

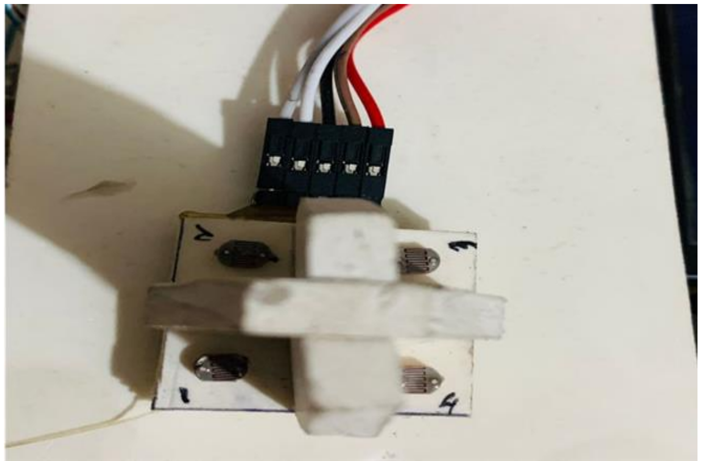
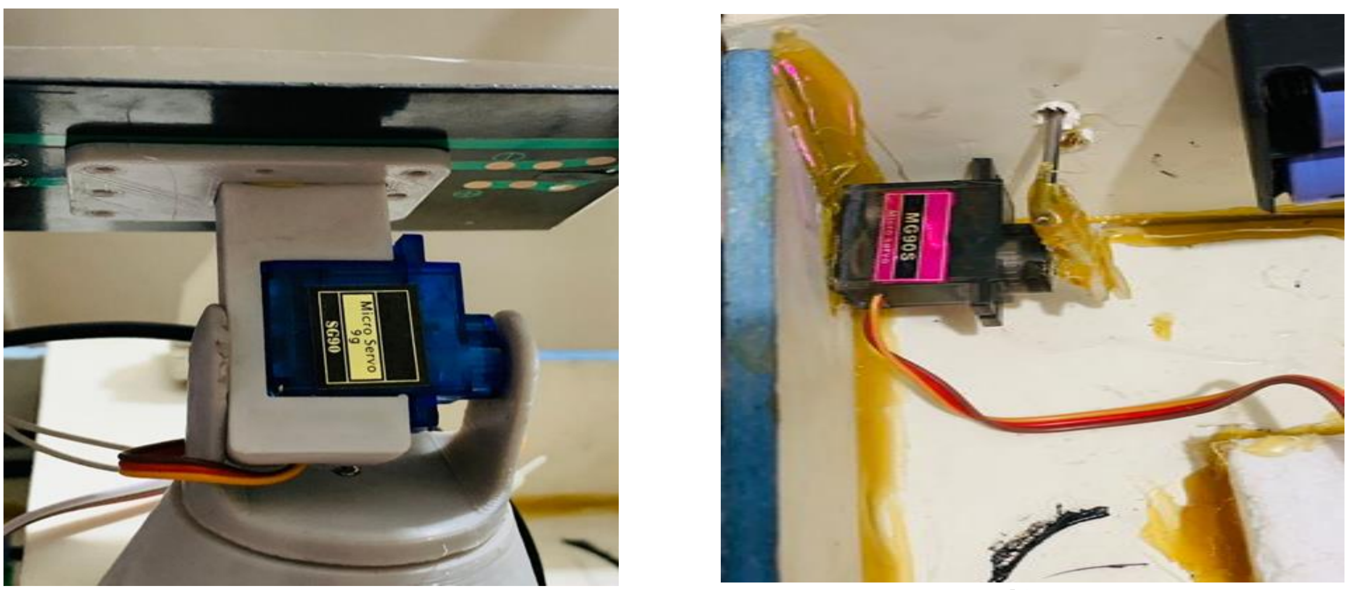


Figure 4.29: LDR sensors

Figure-11: shows the servo motors of the boat. The servo motors are used for different purpose. One servo motor is used for rotate the boat left and right. Two servo motors were used for rotating the solar panel according to sunlight.



(a) (b)

Figure 4.30 (a), (b): Servo motor for rotating solar panel and rotating boat

For the Surveillance of the water area an embedded camera as shown in figure 12 is setup. The ESP32 camera module is a very reliable and easy to use monitoring system. To monitor just put the IP address of the camera on any browser and it shows the real time surveillance of the area.

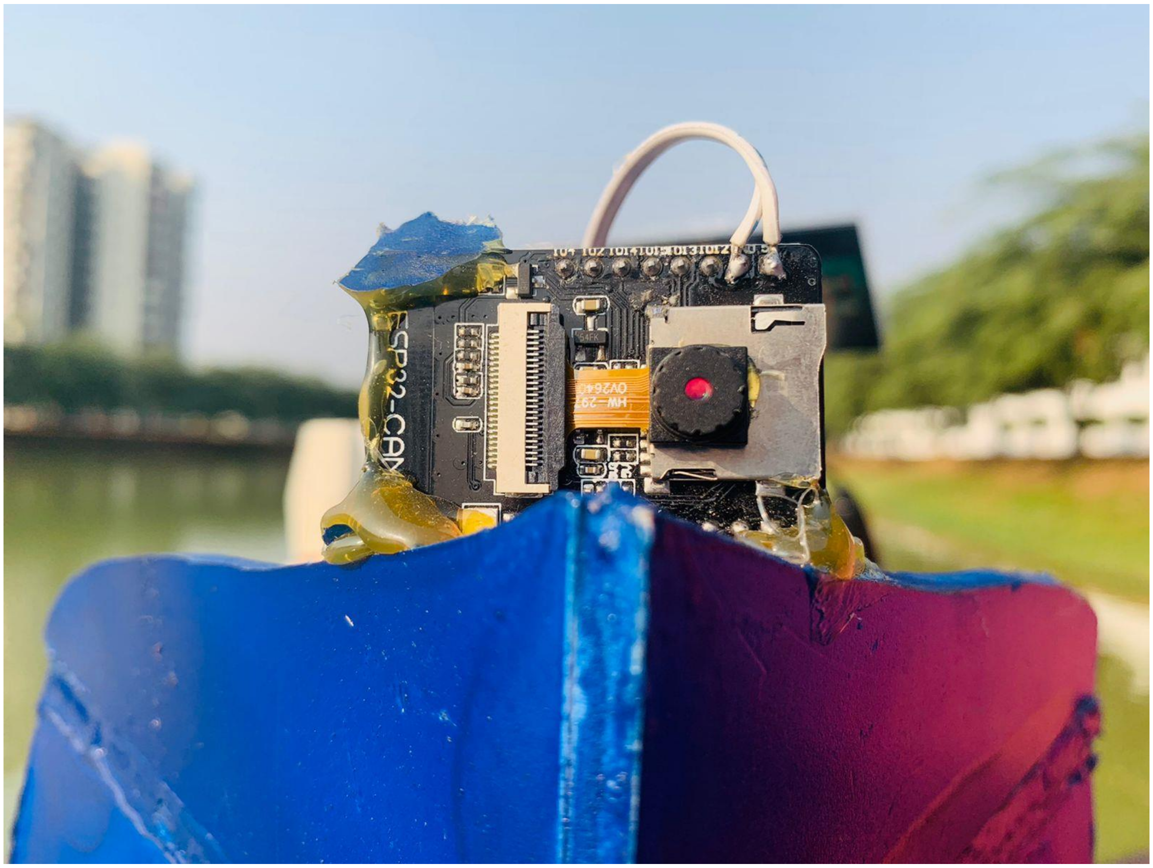


Figure 4.31: ESP32 Surveillance Camera setup

Figure 4.32 is showing the LCD display. In our project we are using LCD2004 Parallel LCD Display. This LCD2004 Parallel LCD Display is a simple and cost-effective way to include a 20x4 White on RGB Liquid Crystal Display into our project. The display is a 20 character by 4-line display with exceptionally clear, high-contrast white lettering on a blue background/backlight.

Figure 4.32: LCD display is showing results

4.4. Summary

The system which is built very much capable enough to monitor drinking water quality and able to parameter different level of infected water with a proper information. We are also adding advance quality sensors to develop the system and make it more accurate.

This device is small, compact and built-in system is user-friendly. With the help of the device, assuming that authority can minimize the infection ratio causes by deteriorated water. In our device, we are trying to overcome the disadvantages of existing safety devices. This device is very efficient and it can play a significant live-saving role in water level technology.

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

5.1. Introduction

This chapter discussed about workflow and outcomes. We worked on this project by using tools to determine the overall project outcome. We use Blynk server to detect outcomes. By using this server, we can also detect weekly or monthly reports. We also use the RoboRemoDemo to control the boat. We were able to complete our hardware implementation after extensive testing, improvement and modifications. The project has been completed successfully after all these efforts. Simulation work was also finished successfully. The simulation result was found according to the expectation and run successfully.

5.2. Results Analysis

While collecting each project system separately, the results and some errors are also collected. Each of the project's systems is designed exactly how it should be. We are successfully able to obtained both simulated and hardware results. There may be some errors are occurred but we are tried to fixed all of our error. As our project is a prototype device so there still might be some kind of error. And as soon as we will detect those error, we will try to fix them with the help of our instructor. There were systems that were promoted a long time ago. However, the majority of the systems in the project tried to modified that suits the time and era. Many of its features were created using modern technologies. At the same time, it contains numerous improvements. Its previous work as a first-rate primary researcher appeared to be wholly new to all members. Many of these may appear out of date to an expert or advanced researcher. All systems are self-taught by us using online resources. And finally, we are able implement and run the whole project both simulation wise and hardware wise. And accordingly, an attempt has been made to create a time-appropriate project with some innovation. The aim of our project was to monitor the water quality with the help of IOT. We are also using solar panel with dual axis tracker which can solve the power issue of our project. Because our battery can charge it self with the help of solar. And also, we can able to control our boat by the app remote and also, we can surveillance the boat with the camera. So, we are trying to achieve an easy way to monitor water in specific river/ ponds water. In this chapter an attempt is made to give some samples of the project's results analysis through step-by-step simulation and hardware.

5.2.1. Simulated Results

The Simulation of the project was done using the proteus 8.12 simulation software shown in the figure bellow.

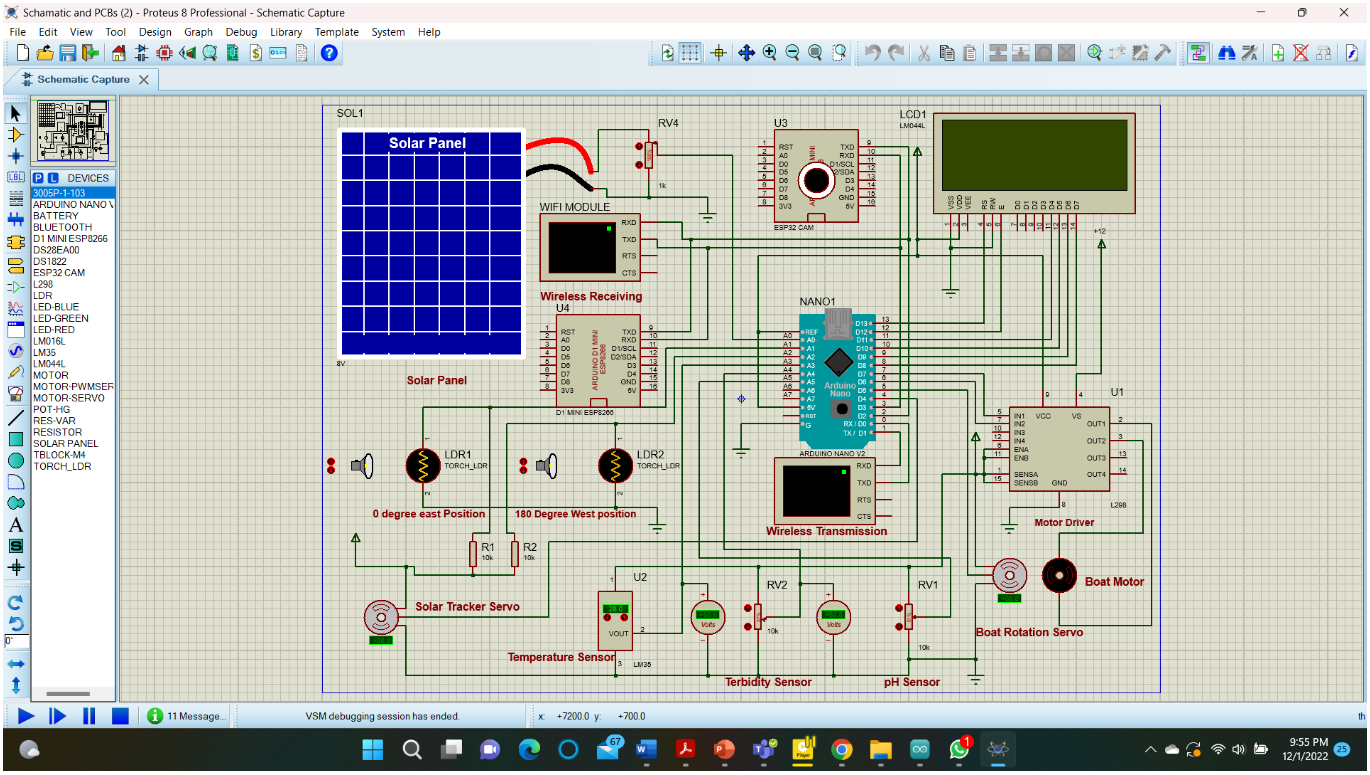


Figure 5.1: Simulation circuit of the project.

There are some limitations in our project in case of collection the data. As our project is IOT based water pollution monitoring boat using dual axis tracker, so our main goal of our project is to monitor the water quality by using some sensors like pH sensor, turbidity sensor and temperature sensor and collect those data by the use of IOT. If we look in the proteus simulation software, there are no built-in sensors like turbidity sensor and pH sensor. So, we are unable to use them. But for showing our data, instead of those sensors we used potentiometer. The value of the potentiometer ranges from 0% to 100% resistance. And we know the range of pH is 1 to 14. So, the percentage of the potentiometer determined the value of in the range of 1 to 14. For turbidity sensor, the same thing was applied. And we can able to show the collected value both in the LCD and virtual terminal that built in the circuit by Wi-Fi module. These are the limitation of our simulation. But we can able to accomplish our primary goal. Because we were able to show data in both LCD display which will be built in the project and in the virtual terminal which will work by a Wi-Fi module.

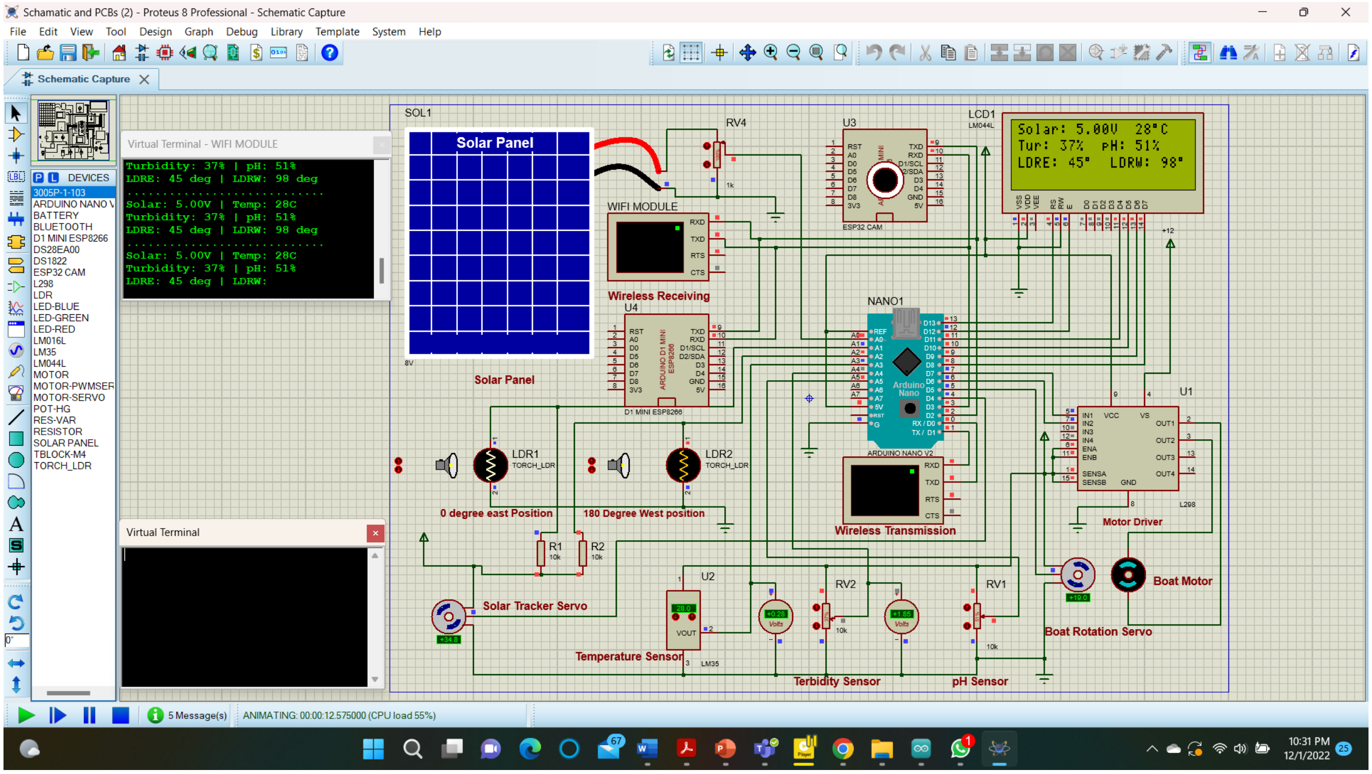


Figure 5.2: Simulation result from different sensor in both LCD and virtual terminal

In the secondary objective of our simulation there was no limitation. We can able to control our project by virtual terminal. If we give command in the virtual terminal like f, b, l, r (forward, backward, left, right) we can see the change occurs in the servo motor and boat motor. The boat motor is used for forward backward direction of the motor. When we command backward/ forward, we can see the motor start to rotate oppositely after each command. And the servo was used for left, right direction of the motor. When we command left/ right, we can see the servo change its direction that means the motor can move left right. So we can able to see physical change of the boat motor and servo motor. And, after each command, the command is also show in both virtual terminal and LCD. We used a motor driver where we can able to change the speed of the motor. Because, the motor driver can manage the speed of the motor. There is also a camera module in our simulation like our main project. But it is unable to show camera data in the simulation. So, we only show the camera module in the circuit. We also used a solar panel in the simulation as we are using solar panel with dual axis tracker in our main project. The solar panel is used for power and also for recharging the battery. There is also a dual axis tracker. So, we are using LDR for detecting the light. So the solar panel can detect the light by the help of LDR and move in x,y direction with the help of 2 servo motor. We can also see the solar voltage and direction of the LDRs in both LCD and virtual terminal.

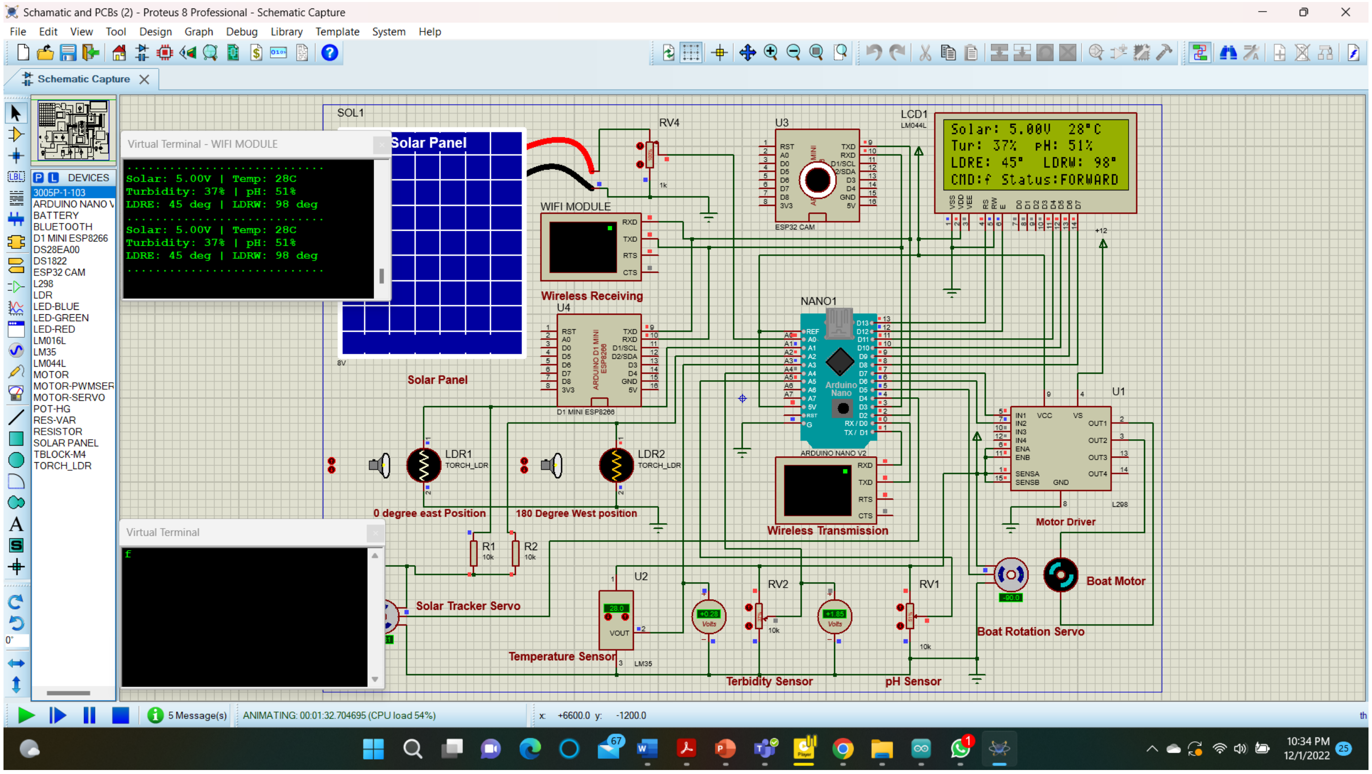


Figure 5.3: controlling command in the virtual terminal

5.2.2. Hardware Results

The Full hardware of the project can be considered as three separate system. First there is controlling system of the boat, secondly the data collection from different sensors and send the data to a dedicated server using Wi-Fi module and thirdly the surveillance system by the use of Esp-32 camera module and GPS module. When all the systems combined together the full hardware is then completed as shown in the Figure.

Figure 5.4: Hardware structure of the project

In our project we are using Arduino Nano as Microcontroller. We also used ESP8266 Wi-Fi Module and ESP32-CAM module which can also a kind of microcontroller. So, these are mainly the heart of our project. Form these we are able to controlling our boat, make the whole system IOT based, gather all the data that is given from the sensors and also it helps us in surveillance purpose of the boat.

The first part of our project goal is to monitor the water quality. For these we need to monitor the data that given by the sensors that used in our project. There are three sensors that used in our project. Turbidity sensor, pH sensor and temperature sensor. All these sensors are connected to 3 separate pins in the Auridon nano. And the data that is given by the sensors are showing in the LCD display that is placed on the boat. In the Arduino nano, all the equipment of our boat like motor driver, buck converter, solar panel, battery, Wi-Fi module and ESP-32 cam module are also connected separate pin in the Arduino nano. As the first part of our project is to collect data from the sensors and show them in the LCD and our website, how power is supplied in the project, configuration of buck converter and motor driver etc. First of all, we are using 2 batteries to run our boat. Each batterie is 3.5 V. So, in total batteries of 7V are making power supply in our boat. There is also a solar panel which is used for charging the battery. Here, the buck converter is used for steps down voltage from its input (supply) to its output (load). And the motor driver is used for controlling the motor speed of our boat. We can able to increase or decrease the speed of our motor by changing the code that is given to the Arduino and this speed controlling can happen because of the motor driver.

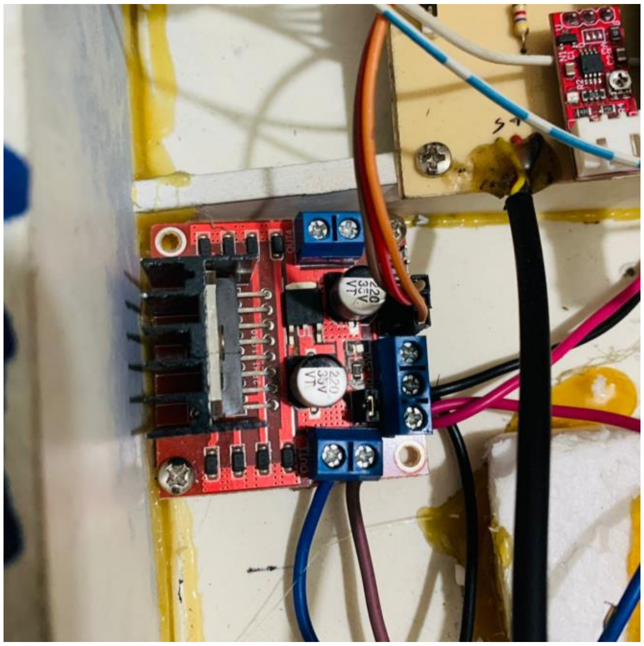


Figure 5.5: Motor driver

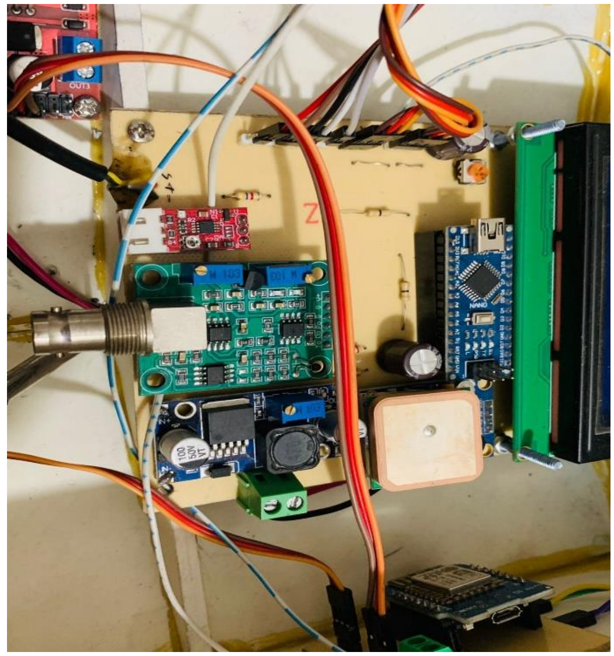


Figure 5.6: Buck converter

All the sensors that are using in our boat, operates in a specific voltage. The pH sensor operates in 5V. The Turbidity sensor operates on 5 V. And the temperature sensors can operate in 3.5-5.5 V. So, all the sensors can operate smoothly in our project. And the sensors can able to show data in both LCD and our dedicated website.

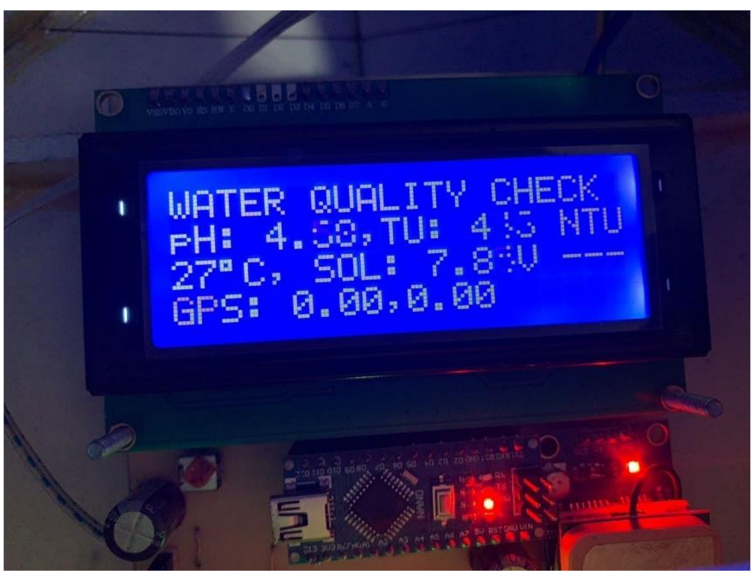


Figure 5.7: showing data in the LCD

We also using a dedicated website that is connected to the same hotspot network as the Wi-Fi module was connected to. If we make a hotspot network or Wi-Fi network that named ‘Hello’ and its password is 11223344 then our microcontroller will be connected to this hotspot or Wi-Fi network automatically. In our coding that was uploaded in the microcontroller, we see the code by this hotspot name and password so that all the microcontroller can connect to that hotspot automatically. And if we set our mobile or laptop to the same network and login to our dedicated server, then we can able to see the same data that was given in the LCD. We can able to see all the sensors data, remote IP address which is used for remote controlling the boat, cam IP address for browsing the camera for surveillance of the boat, GPS location of the boat (Longitude and Latitude) and here we can also see the current command of our boat like which direction the boat was moving.

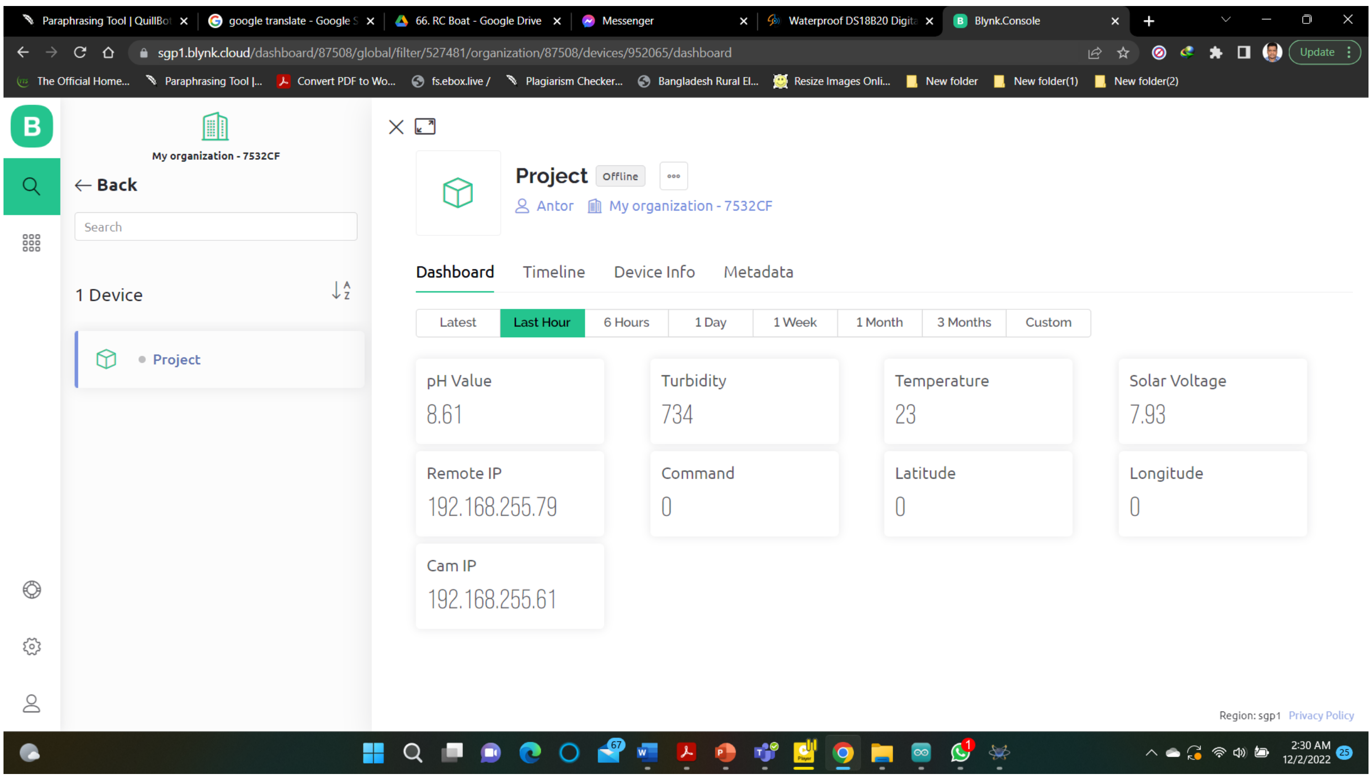


Figure 5.8: Showing results in the dedicated website

The second part of our project is to controlling our boat. Like in which way the boat will move and also the boat is capable of move forward and backward and also in left, right direction. And all these will be controlling by an app remote. Which makes the whole system IOT based. For using the app remote we have to download an android software named ‘RoboRemoDemo’ from google. And configure it in which way we want to use it. We also connect the same Wi-Fi or hotspot that the microcontrollers were connected to. Then we also need to connect to the IP address that given in our dedicated website which is named remote IP address. By this we can able to connect the app remote with our project and able to control our boat.

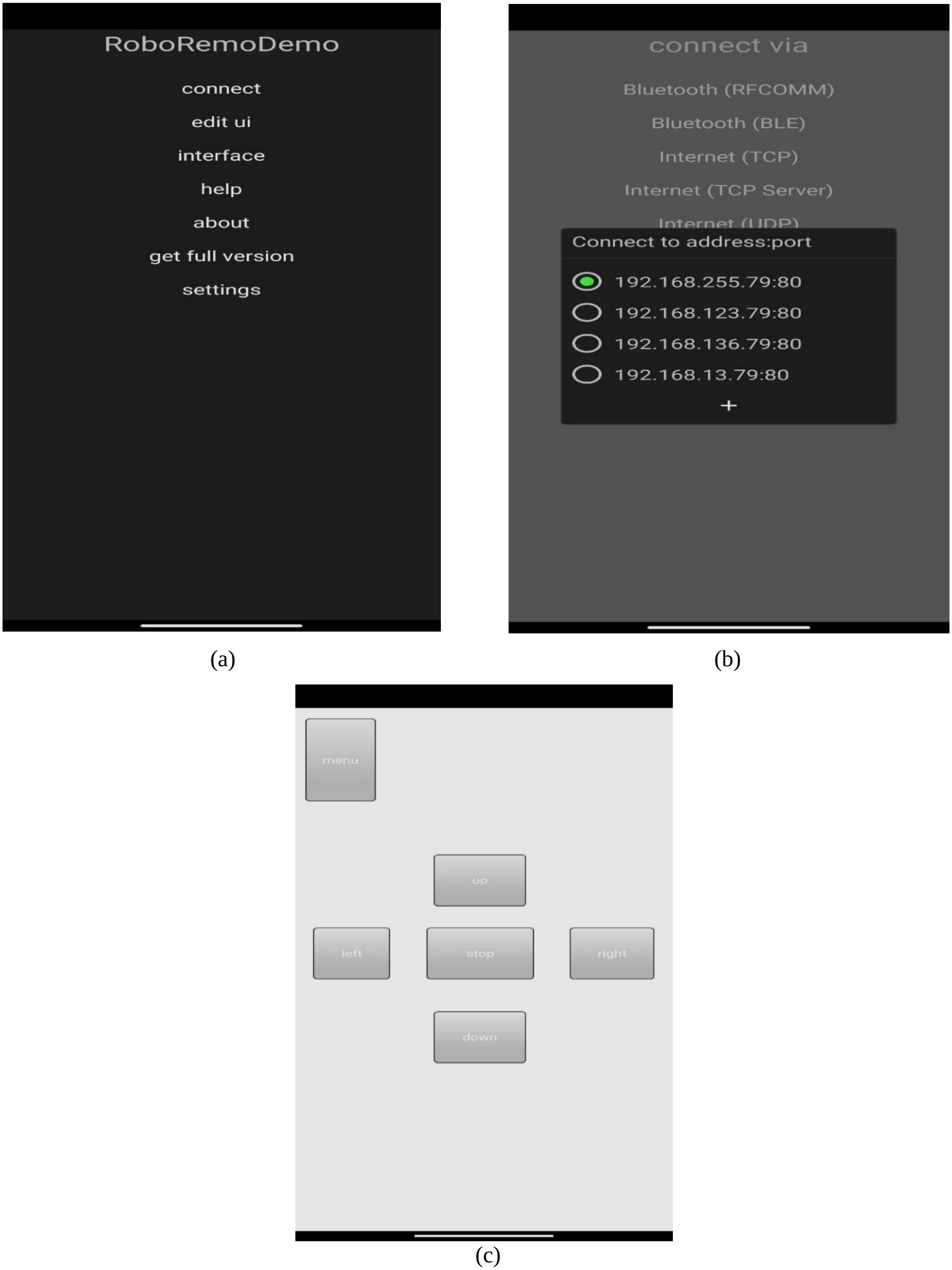


Figure 5.9 (a), (b), (c): Connecting the project with app remote.

There should be also a cam IP address in our blink website. If we connect the same Wi-Fi or hotspot as connected with the microcontroller and if we browse the IP address in our browser then we can able to view the camera data. The camera is placed Infront of our boat. And by these IP address we will able to surveillance our boat. By these, the boat can also use for surveillance purpose. And we can able to see the front view of the boat. So, we can able to see the obstacle and will able to avoid those obstacles. This camera is connected to an IP network. And if we browse that IP address then we will able to view the camera data. And we can use it for surveillance purpose.

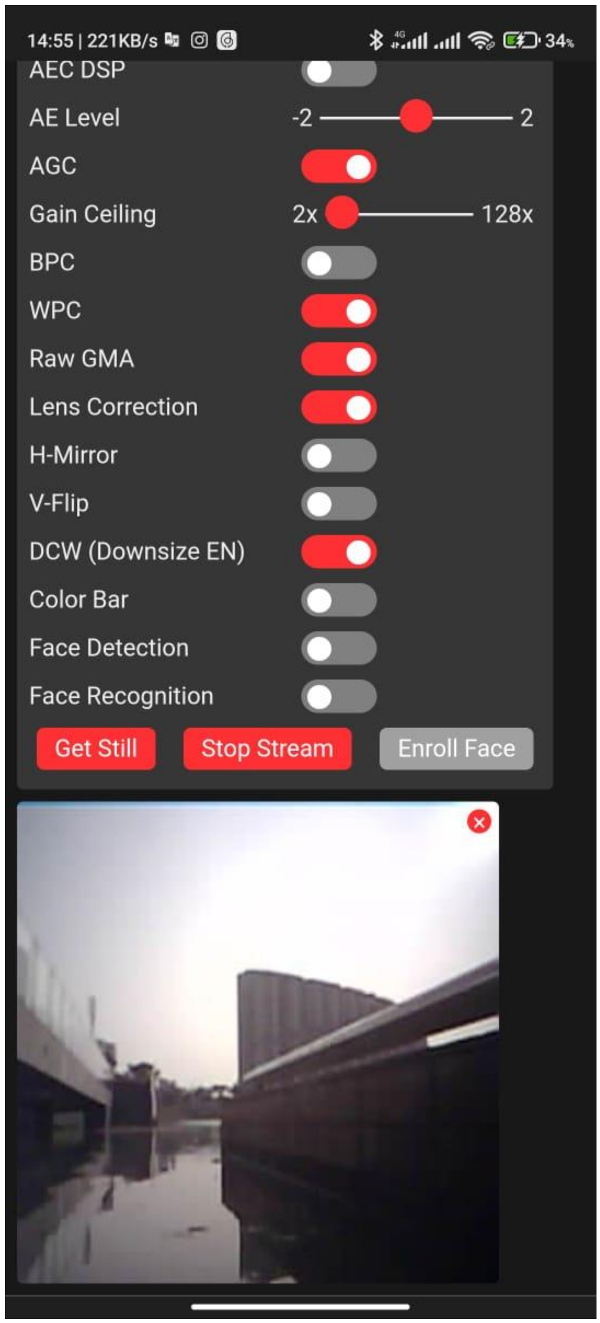


Figure 5.10: Surveillance of the boat using Cam IP address

We also used GPS module in our project for knowing location of our boat. From the GPS module the coordinate location is showed in the LCD display and there is also a GPS coordinate in our Blink browser that is dedicated to our project. There is a latitude and longitude coordinate that we can see in the LCD as well as the browser. When we are testing our boat and floated it in a lake then we collected an GPS coordinate given by the GPS module which is 23.8069 longitude and 90.3944 latitude. So, if we search that coordinate in any internet browser, like if we search 23.8069,90.3944 in any internet browser, we will able to see the location of the boat.

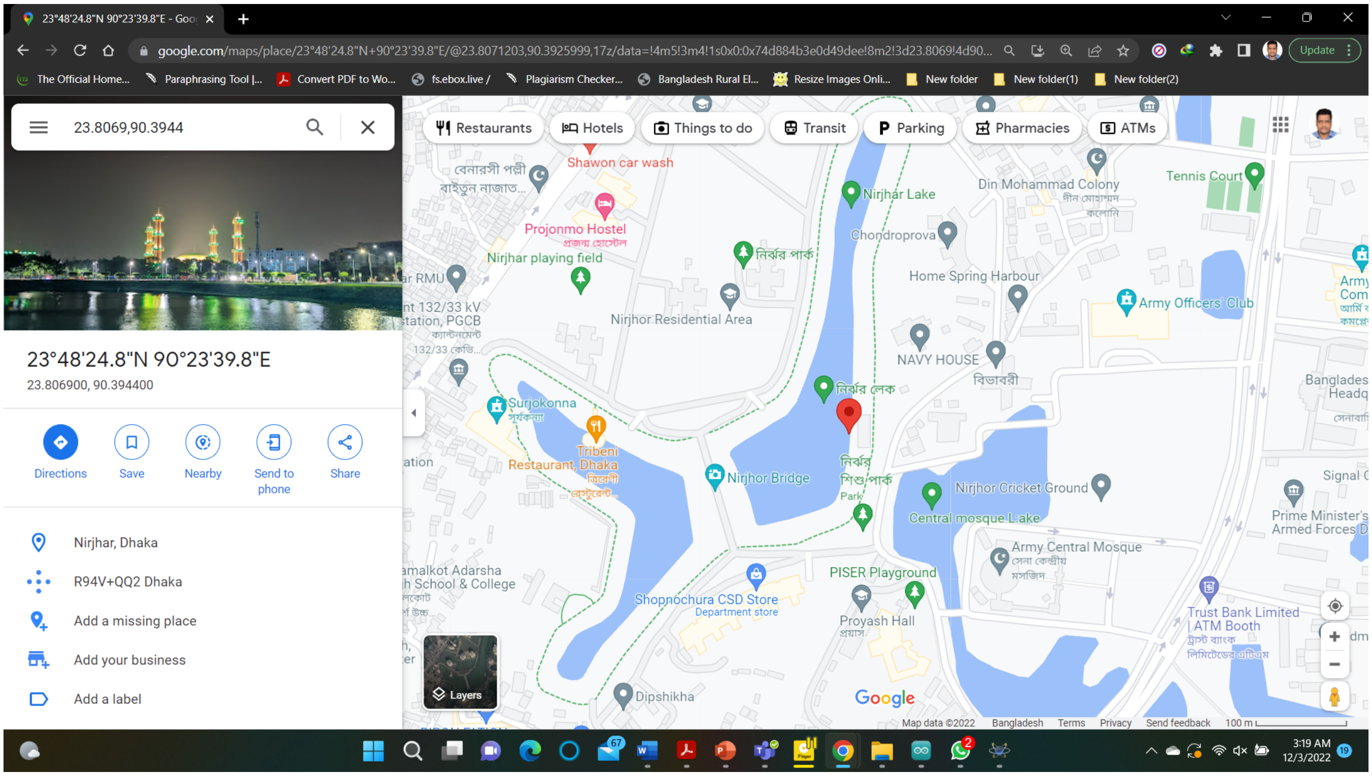


Figure 5.11: Exact Position of the project in the google map.

5.3. Comparison of Results

The presentation of a summary of the significance of this hardware work in comparison to simulations is shown in the table 5.1 in this section. As previously stated in the simulation and hardware portion. This is a project that aims to ensure the safe water quality and maintain a good aqua diversity. The simulation proteus program is used to display the results. In simulation we are getting data through LCD display. The same data is showing in the virtual terminal through wireless receiving. Showing this data in each display was possible because of Wi-Fi module. Software As a microcontroller, we used an Arduino nano. However, we did use the Wi-Fi module ESP8266 in practice. We had also used ESP32 camera for surveillance. A comparison of certain key research points has been presented in the table 5.1.

Table 5.1 Points of comparison

	Point of Comparison	Simulation	Hardware
1	Microcontroller	Arduino Nano	ESP8266
2	Use of the motor	Simulation Motor	DC motor
3	Operating Voltage level	5V	7.4V
4	Sensors used	pH, Turbidity (Potentiometer), Temp.	pH, Turbidity, Temperature
5	Power	Simulation Supply	Solar Panel
6	Controlling	Virtual Terminal	Mobile Application
7	Displaying Data	Virtual Terminal, LCD	LCD, Web browser

On the Other hand, we had compared the results of simulation and Hardware project. The data we are getting from the simulation are closed to Hardware data. And the data we are getting from the Hardware project are Almost same as Standard value. The temperature sensor is showing the same data as standard temperature of water. The pH sensor is showing the Acidic and Alkaline data perfectly. When the pH sensor was placed into the acidic water, it showed the value under 7. And when the pH sensor was placed into Alkaline water, the sensor showed the value over 7. pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. The Turbidity sensor also showed the value like standard value. [68]

5.4. Summary

This chapter covers critical design assessment and outcome analysis. There are several hardware components supporting this project. Here, simulation is performed using Proteus 8. This result contains two separate components called (simulated & hardware results), and we will explain result analysis in this section. The most significant section of this chapter. Both the simulation and result portions of our project have been discussed in this section. These results are ultimately contrasted in the best way possible.

Chapter 6

CONCLUSION

6.1. Summary of Findings

An IoT-based water pollution monitor containing pH, temperature and turbidity sensors and a solar system was successfully built using modeling and hardware implementation. Our project's framework is shaped like a solid, translucent body. This system can automatically give back the results after measuring the pH, turbidity and area temperature of a pool, canal, or riverside. Furthermore, it was remote operated to lower the risk. This system will assist in management or whoever it may concern monitoring. If this project can be completed while using the appropriate components, it will also be successful. It is anticipated that it won't harm any other aquatic life or plants. The results show that the project was effective after achieving its major goal.

6.2. Novelty of the work

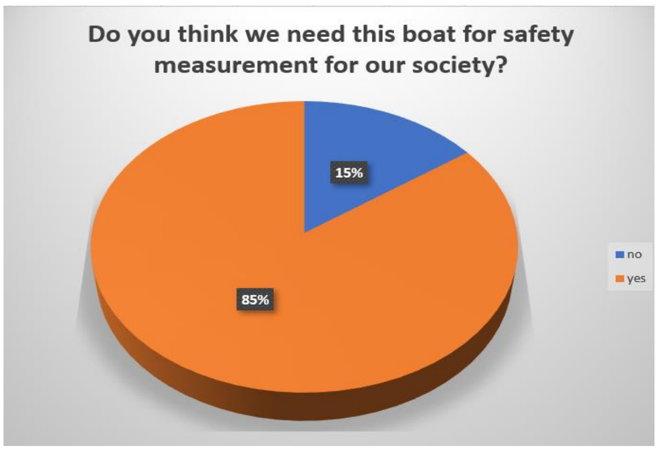
The pH, temperature, and turbidity of a pool, canal, or riverbank environment may all be measured by this Internet of Things-based pollution monitoring boat.

The ESP-32CAM may be used for intelligence IoT applications like video surveillance and GPS tracker remote control bases. Its low price and ease of use make it perfect for Internet of Things (IoT) devices that need complicated functionality, such sensing position and measuring water. The Arduino UNO gives creators the ability to detect and manage external electrical devices in the real world. This initiative will be a step toward addressing environmental safety concerns. As a result, there will be no need for labor, which will save money and reduce any potential for disaster. To gauge the pH of the water, we utilize a pH sensor. To measure temperature, we utilize temperature, turbidity. Solar panels are also used by us. In contrast, the majority of research articles published in various journals and conference papers identify one or two issues primarily conceptually rather than practically. The majority of the papers include concepts for projects in which various components were utilized. The new, improved components we used in our project, however, included ESP-32 CAM, solar panels, a servo motor, a pH sensor, a temperature sensor, a turbidity sensor, and wifi capabilities. This technology has the benefit that it can be utilized by anyone that has been educated to use it, not just for monitoring water contamination.

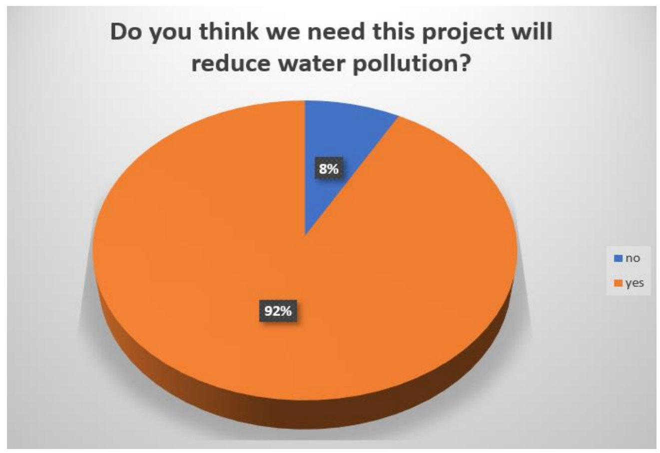
6.3. Cultural and Societal Factors and Impacts

The major objective of this issue was to monitor water pollution. It is poisonous water, unfit for consumption or use in agriculture, and it may also spread diseases like cholera, dysentery, typhoid, poliomyelitis, and diarrhea that can kill people everywhere in the world. The endeavor to control water contamination grew more quickly as the population grew. We consider cultural and socioeconomic elements when creating our designs. Individual growth and functioning are impacted by cultural and social influences. Support, pressures, and other factors all have a substantial impact on design results because they frequently have both large positive and negative effects on recovery outcomes. We pay special attention to each topic as we put our proposal into action.

About 100 people took part in the online survey that we ran using Google Forms to assess the value and necessity of the water pollution monitoring system. Below are a few responses expressed as percentages to illustrate how this initiative has affected them.



(a)



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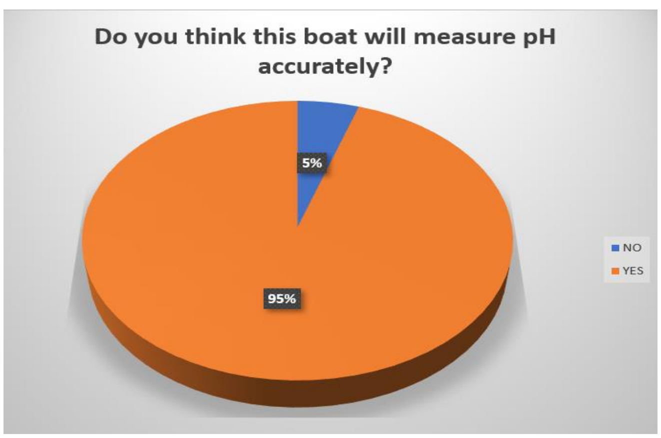

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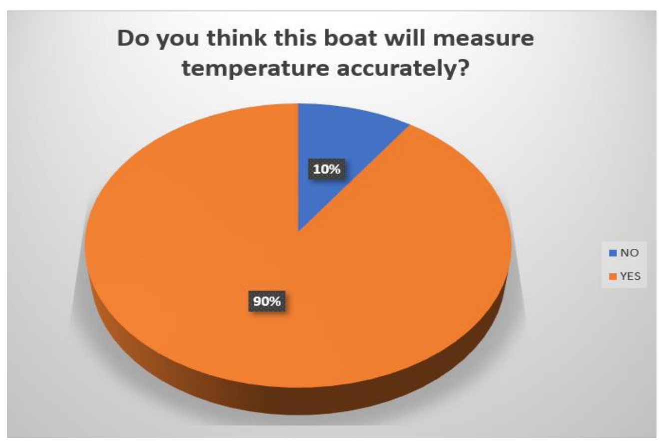

(d)

Figure 6.1 (a), (b), (c), (d): Survey on cultural and social impact.

6.4.Engineering Solution in accordance with professional practices

The model in our proposal is a useful tool for monitoring water pollution. The ESP-32 CAM and Wi-Fi used in this project make it helpful as well. We can obtain real-time data because of this. Most of our system is built around a microcontroller. The implementation of the prototype involved a block diagram, creation and testing of a simulation model, and implementation of the real hardware model. The system's performance was also checked by comparing the simulation model's and hardware's results. In the future, this idea may be used to a variety of green technology.

6.5. Limitations of the Work

Every developing scientific project has some limitations, and this project is no exception in this scheme. Nothing in this universe is perfect, especially as technology advances. If we talk about limitations, we should think of them as opportunities to improve the model in the future. As a result, others will be able to comprehend and improve it. There some limitations of this project are bellowed:

- Network range for controlling the boat is bounded.
- The camera is connected to the device's hotspot. As a result, it cannot be seen remotely.
- The sensors cost a lot of money. They also have very high maintenance costs. The expense to the regulatory body increases as a result.
- Mounted sensors may get damaged due to natural disaster and sometimes aquatic animals.

6.6. Future Scopes

Every scientific study has certain future scopes that show what advancements can be accomplished in the future. In this project, sensors were used to support manage the water pollution monitoring system. However, there is some future potential that might make the project more sustainable and beneficial.

- Using artificial intelligence to automate the Boat control management and monitoring system.
- More sensors can be utilized to collect more accurate data, and data analytics or machine learning can be employed to build predictive algorithms.
- A robotic arm can be installed to deploy the sensors to water.
- Detecting more parameters for the most secure purpose.

6.7. Social, Economic, Cultural and Environmental Aspects

6.7.1. Sustainability

Now A days Water is being a vital aspect in our daily life to be sophisticated pure water has always been 1st choice for every sector of people. The sustainability of this project is multifaceted, highly mentioned cost-effective, power demand and long-run utilization after implementation of this model for water monitoring purpose. Energy demanded by the IoT Based would also be a sustainability factor, due to high frequency of power outage areas we are able to get a proper information with help of IOT. As this device is used to monitor the PH and turbidity levels of water samples that ensures that it can be more sustainable when it comes in clean water sector. Technology improves day by day. With the improvement of technology, scope to improve this project will also increase.

6.7.2. Economic and Cultural Factors

Nowadays drinking water is the most vital and valuable for all the human beings, drinking water utilities faces new aspects in real-time operation. This challenge occurred because of limited water resources growing population, being newly infrastructure etc. As our whole project is iot based so it can be said that this model has a real time factor in economic sector. This system has unique monitoring system rather than traditional water monitoring system. Being a IOT based system it will help as definite growth in any economic sector. By using this monitoring system death case from water disease can be prevent which has a must growth in economic sector.

Many developing countries in south Asian region, there people still using traditional water monitoring system, which was not as expected in this technological arena. Traditional monitoring system includes;

- Manually collecting samples from water source.
- Carrying samples to exact center
- Error percentage can be high in this system.

Our System can able to demonetize all the issue which are caused in traditional water monitoring system. So, it can be added that using this system it can set a new addition in water monitoring sector specially make a change in cultural factor in Asian region.

6.8. Conclusion

This project's main goal is to monitor the water in order to provide a more secure environment for everyone. It measures the Ph, turbidity and temperature of the water. It gives accurate readings. Anyone can operate it easily with the help of remote present in mobile. The benefit of an IoT-based system for monitoring water pollution includes the fact that it is more creative, efficient, and useful for everyone in this nation. Additionally, it saves time and money. A water monitoring sensor is used to monitor the turbidity, pH, and temperature of water. The device can automatically monitor temperature, pH, and turbidity using a remote control, and it is affordable. As a result, water quality monitoring is expected to be less expensive, more comfortable, and faster. The system is highly adaptable. The procedure is uncomplicated. It offers a wide range of applications and extension opportunities.

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Appendix A

Datasheet of the ICs used

LM2596 Pinout Configuration & Datasheet:

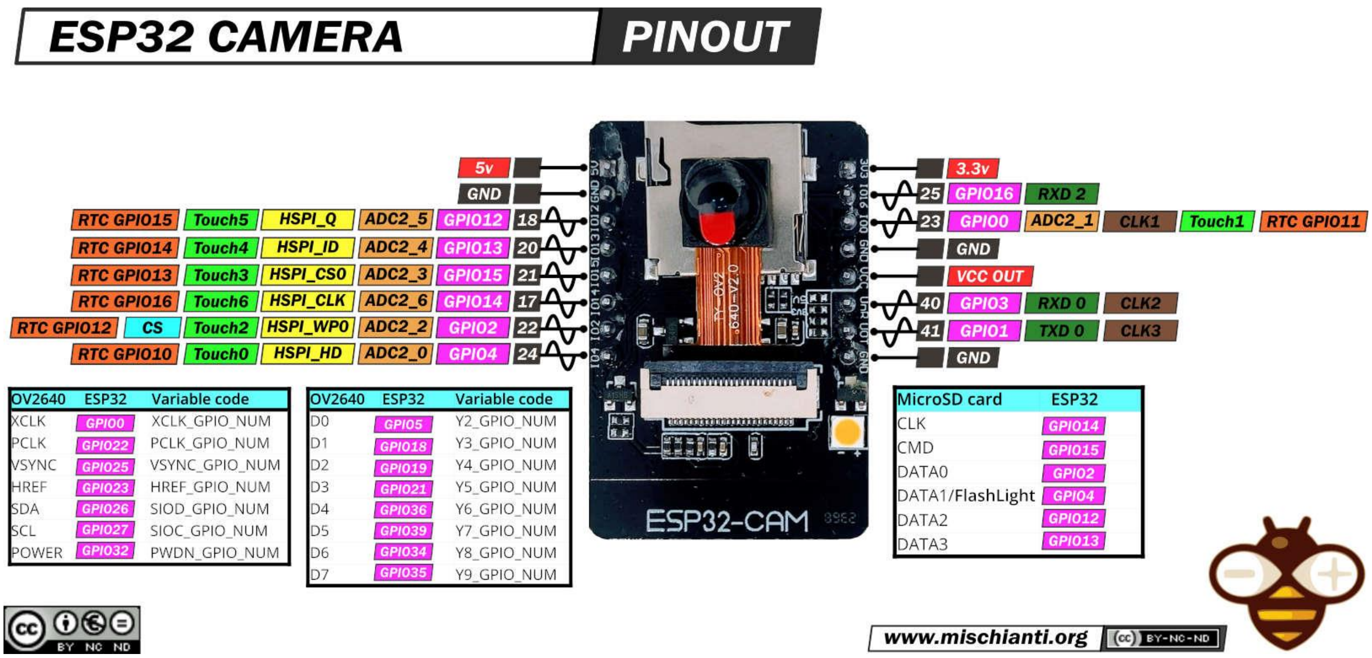
Pin Function Description:

Pin no.	Symbol	Description
1	V_{in}	This pin is the positive input supply for the LM2596 step−down switching regulator. In order to minimize voltage transients and to supply the switching currents needed by the regulator, a suitable input bypass capacitor must be present.
2	V_{out}	This is the emitter of the internal switch. The saturation voltage Vsat of this output switch is typically 1.5 V. It should be kept in mind that the PCB area connected to this pin should be kept to a minimum in order to minimize coupling to sensitive circuitry.
3	GND	Circuit ground pin. See the information about the printed circuit board layout.
4	Feedback	This pin is the direct input of the error amplifier and the resistor network R2, R1 is connected externally to allow programming of the output voltage.
5	ON/OFF	It allows the switching regulator circuit to be shut down using logic level signals, thus dropping the total input supply current to approximately 80 µA. The threshold voltage is typically 1.6 V. Applying a voltage above this value (up to +Vin) shuts the regulator off. If the voltage applied to this pin is lower than 1.6 V or if this pin is left open, the regulator will be in the “on” condition.

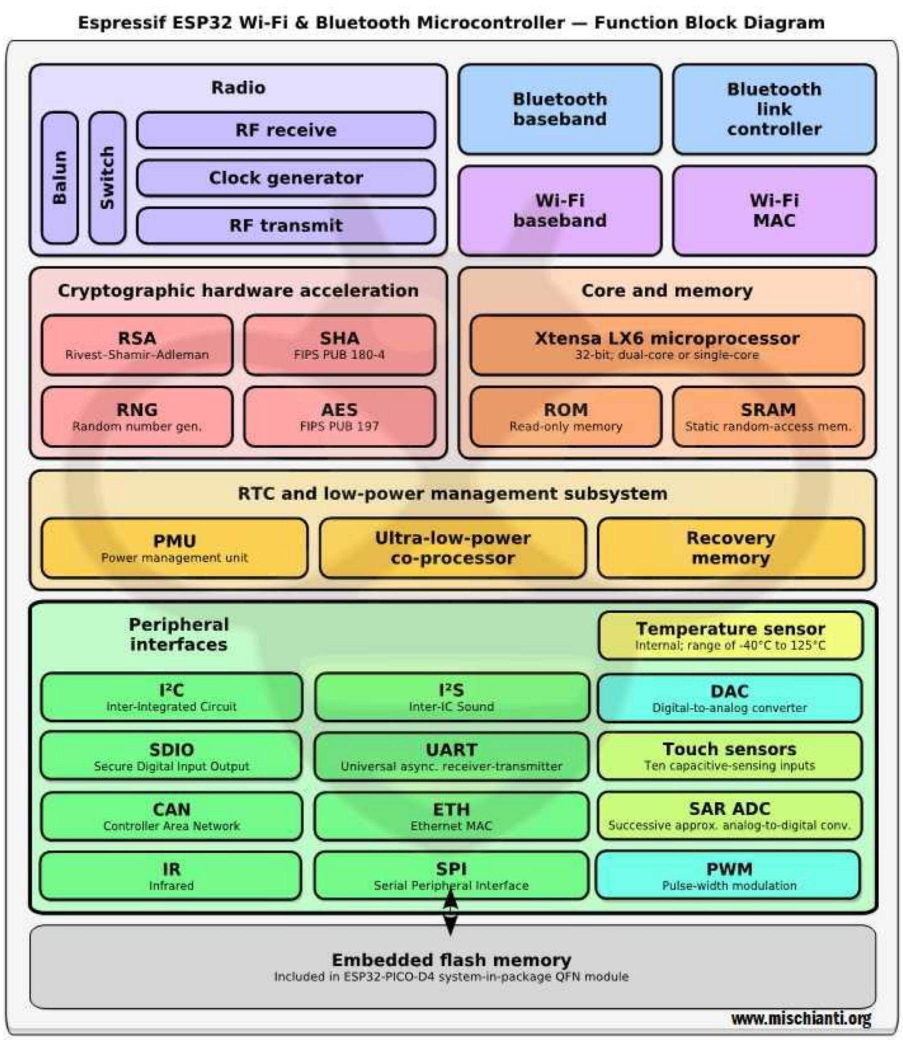
General specification:

Input Voltage (V)	4 ~ 35 VDC
Output Voltage(V)	3 ~ 35
Max. Output Current (A)	3
Conversion efficiency	92%(highest)
Switching frequency	150 KHz
Output ripple	30mA (maximum)
Load Regulation	± 0.5%
Voltage Regulation	± 0.5%
Dynamic Response speed	5% 200uS
Operating Temperature (°C)	-40 to 90
PCB Size (L x W) mm	40 x 20
Shipment Weight	0.095 kg
Shipment Dimensions	9 × 7 × 5 cm

ESP32-CAM Pinout Configuration & Datasheet:



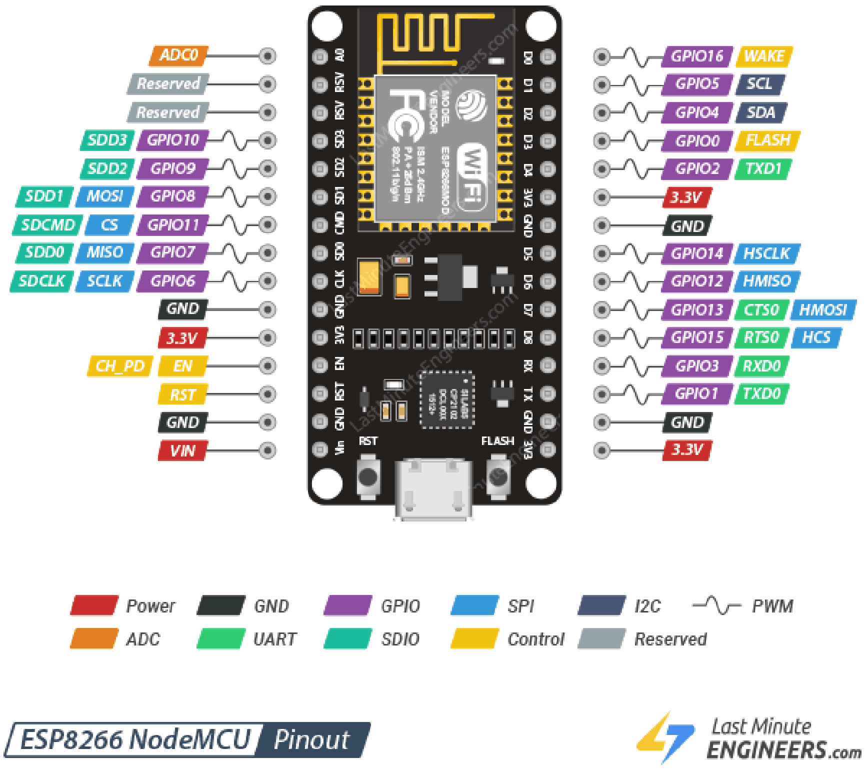
Function Block diagram esp32 Wi-Fi Bluetooth Microcontroller:

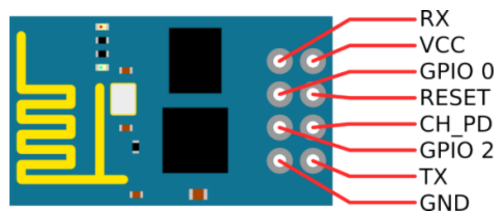


Name	No.	Type	Function
Analog			
VDDA	1	P	Analog power supply (2.3 V ~ 3.6 V)
LNA_IN	2	I/O	RF input and output
VDD3P3	3	P	Analog power supply (2.3 V ~ 3.6 V)
VDD3P3_RTC			
SENSOR_VP	5	I	GPIO36, ADC1_CH0, RTC_GPIO0
SENSOR_CAPP	6	I	GPIO37, ADC1_CH1, RTC_GPIO1
SENSOR_CAPN	7	I	GPIO38, ADC1_CH2, RTC_GPIO2
SENSOR_VN	8	I	GPIO39, ADC1_CH3, RTC_GPIO3
CHIP_PU	9	I	High: On; enables the chip Low: Off; the chip powers off Note: Do not leave the CHIP_PU pin floating.
VDET_1	10	I	GPIO34, ADC1_CH6, RTC_GPIO4
VDET_2	11	I	GPIO35, ADC1_CH7, RTC_GPIO5
32K_XP	12	I/O	GPIO32, ADC1_CH4, RTC_GPIO9, TOUCH9, 32K_XP (32.768 kHz crystal oscillator input)
32K_XN	13	I/O	GPIO33, ADC1_CH5, RTC_GPIO8, TOUCH8, 32K_XN (32.768 kHz crystal oscillator output)
GPIO25	14	I/O	GPIO25, ADC2_CH8, RTC_GPIO6, DAC_1, EMAC_RXD0
GPIO26	15	I/O	GPIO26, ADC2_CH9, RTC_GPIO7, DAC_2, EMAC_RXD1
GPIO27	16	I/O	GPIO27, ADC2_CH7, RTC_GPIO17, TOUCH7, EMAC_RX_DV
MTMS	17	I/O	GPIO14, ADC2_CH6, RTC_GPIO16, TOUCH6, EMAC_TXD2, HSPICLK, HS2_CLK, SD_CLK, MTMS
MTDI	18	I/O	GPIO12, ADC2_CH5, RTC_GPIO15, TOUCH5, EMAC_TXD3, HSPIQ, HS2_DATA2, SD_DATA2, MTDI
VDD3P3_RTC	19	P	Input power supply for RTC IO (2.3 V ~ 3.6 V)
MTCK	20	I/O	GPIO13, ADC2_CH4, RTC_GPIO14, TOUCH4, EMAC_RX_ER, HSPID, HS2_DATA3, SD_DATA3, MTCK
MTDO	21	I/O	GPIO15, ADC2_CH3, RTC_GPIO13, TOUCH3, EMAC_RXD3, HSPICS0, HS2_CMD, SD_CMD, MTDO

ESP8266 Pinout Configuration & Datasheet:

ESP8266 Pinout:





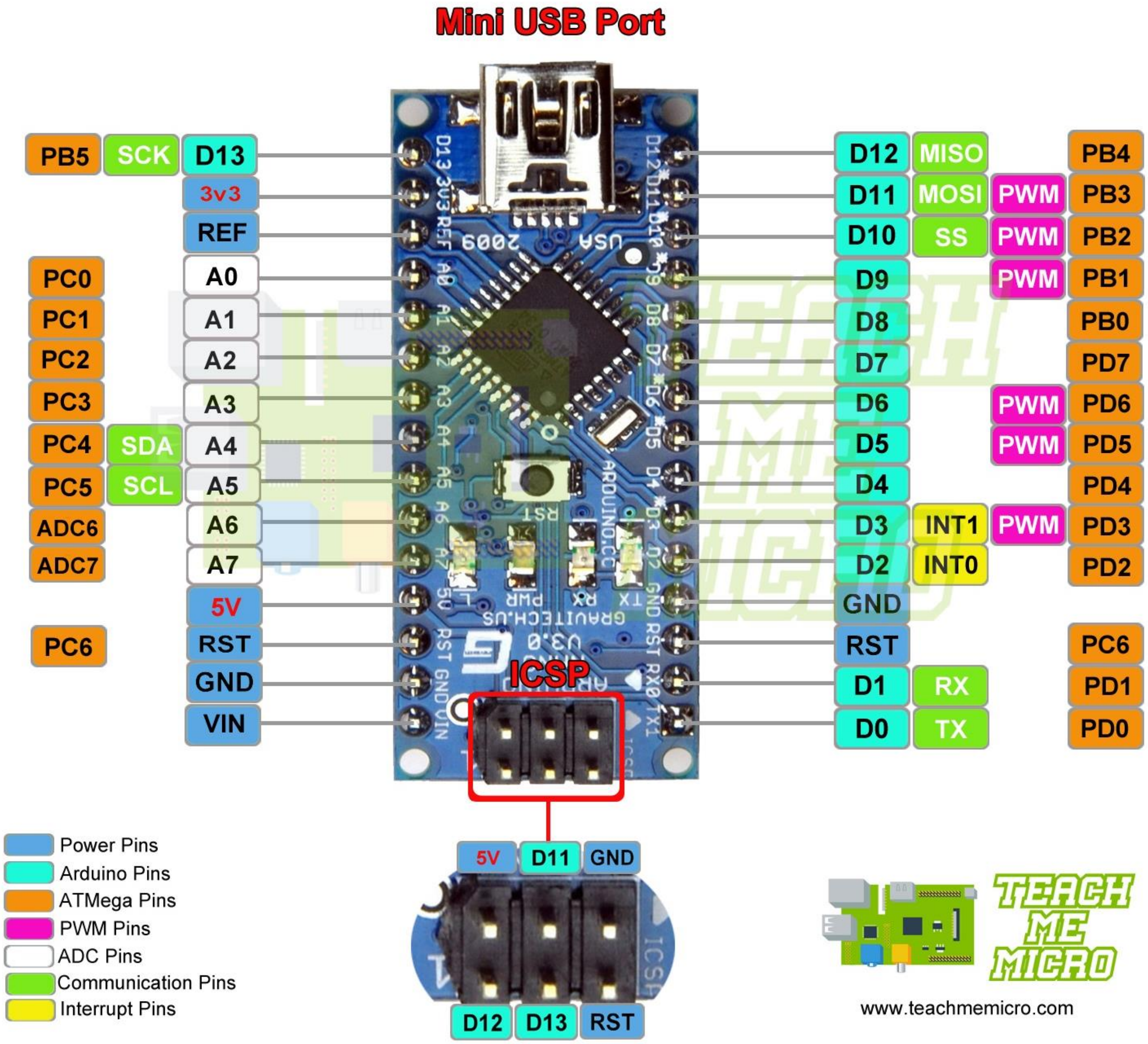
Pin configuration:

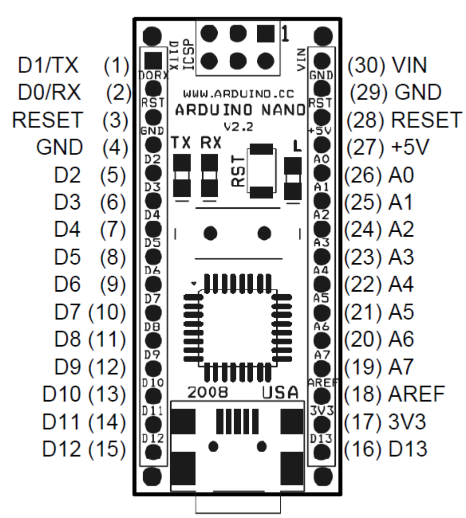
Pin	Name	Type	Function
1	VDDA	P	Analog Power 3.0 ~3.6V
2	LNA	I/O	RF Antenna Interface. Chip Output Impedance=50Ω No matching required but we recommend that the π-type matching network is retained.
3	VDD3P3	P	Amplifier Power 3.0~3.6V
4	VDD3P3	P	Amplifier Power 3.0~3.6V
5	VDD_RTC	P	NC (1.1V)
6	TOUT	I	ADC Pin (note: an internal pin of the chip) can be used to check the power voltage of VDD3P3 (Pin 3 and Pin4) or the input voltage of TOUT (Pin 6). These two functions cannot be used simultaneously.
7	CHIP_EN	I	Chip Enable. High: On, chip works properly; Low: Off, small current
8	XPD_DCDC	I/O	Deep-Sleep Wakeup；GPIO16
9	MTMS	I/O	GPIO14; HSPI_CLK

Pin	Name	Type	Function
10	MTDI	I/O	GPIO12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
12	MTCK	I/O	GPIO13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART Tx during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 200Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200Ω); SPI_MSIO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART Tx during flash programming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 3.0V~3.6V
30	VDDA	P	Analog Power 3.0V~3.6V
31	RES12K	I	Serial connection with a 12 KΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: Active)

Arduino Nano Pinout Configuration & Datasheet:

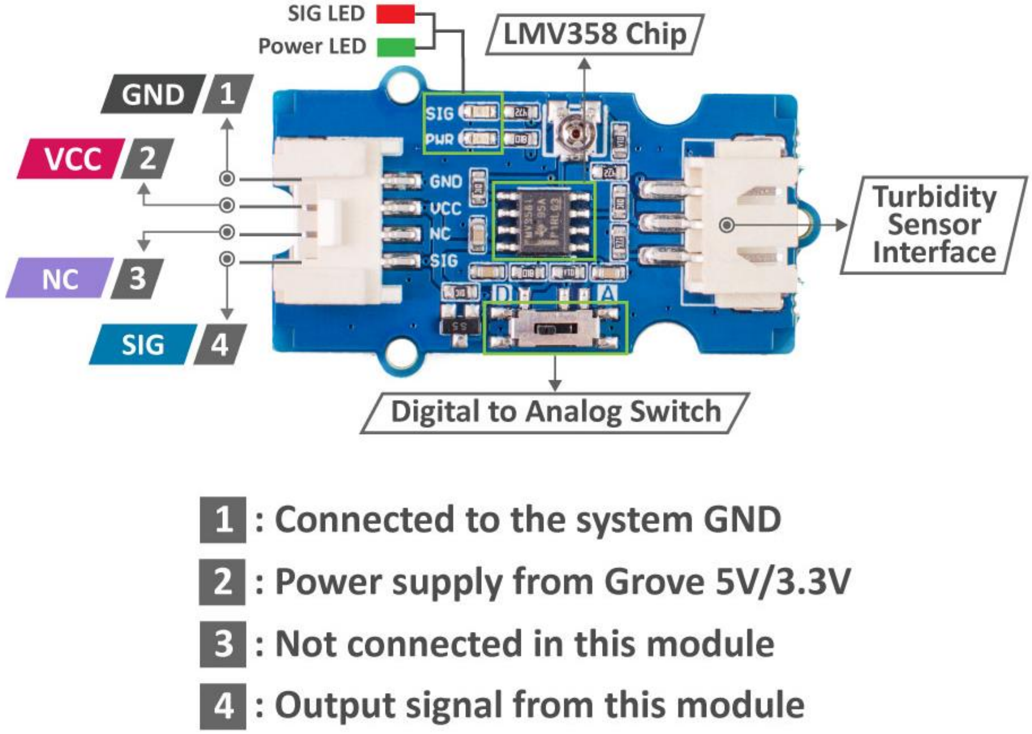
ARDUINO NANO PINOUT

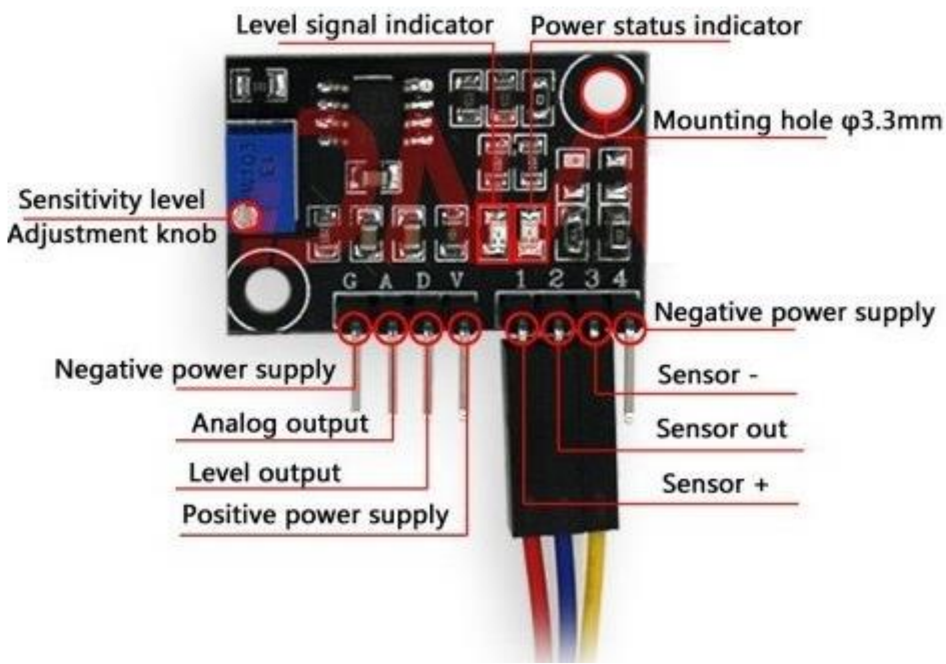




Pin no.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Turbidity sensor Pinout Configuration & Datasheet:


SIG LED
Power LED
LMV358 Chip
GND 1
VCC 2
NC 3
SIG 4
SIG
PWR
GND
VCC
NC
SIG
D
A
Turbidity Sensor Interface
Digital to Analog Switch
1 : Connected to the system GND
2 : Power supply from Grove 5V/3.3V
3 : Not connected in this module
4 : Output signal from this module


Level signal indicator
Power status indicator
Mounting hole φ3.3mm
Sensitivity level
Adjustment knob
G A D V
1 2 3 4
Negative power supply
Negative power supply
Analog output
Level output
Positive power supply
Sensor -
Sensor out
Sensor +

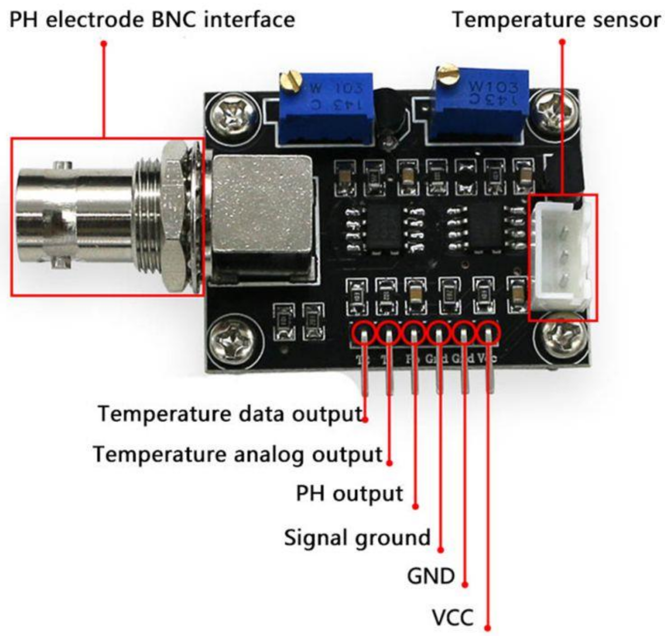
Technical specification:

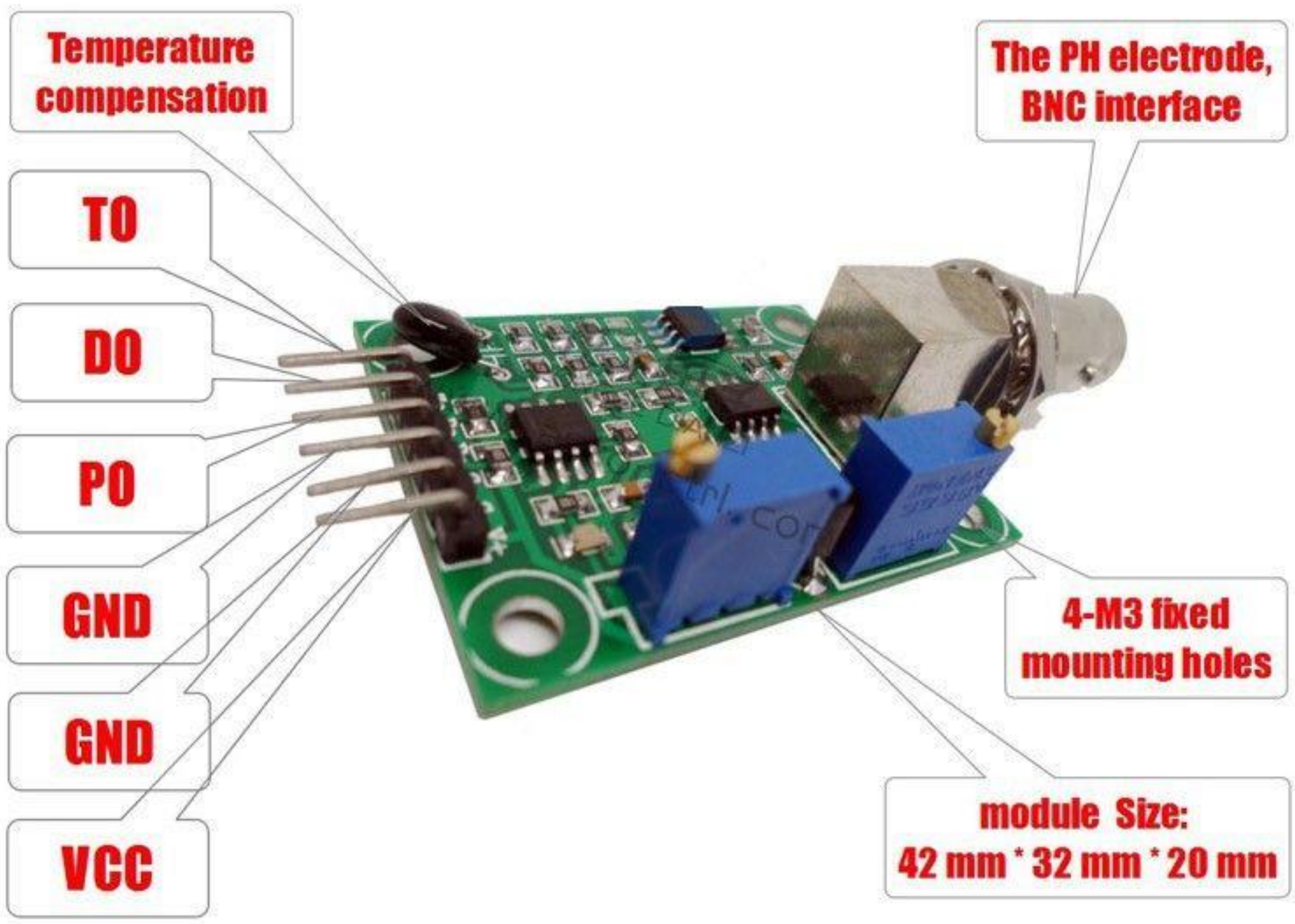
Supply voltage	DC:5.0 V (4.8-5.5 V)
Minimum supply current	20 mA
Typical supply current	25 mA
Maximum supply current	50 mA
Typical power	125 mW
Sampling period	>= 100 ms/time
Output method	Analog signal
Warm-up time	>= 100 ms
Operating temperature	4℃～85℃
Working humidity	0～95%RH
Service life	>10 years (25℃)

Pin Configuration:

Pin No	Pin Name	Description
1	VCC	Supply voltage +4.8V- 5.5V
2	AO	Analog signal output
3	DO	Digital signal output
4	GND	Supply voltage negative

Analog pH Sensor Pinout Configuration & Datasheet:





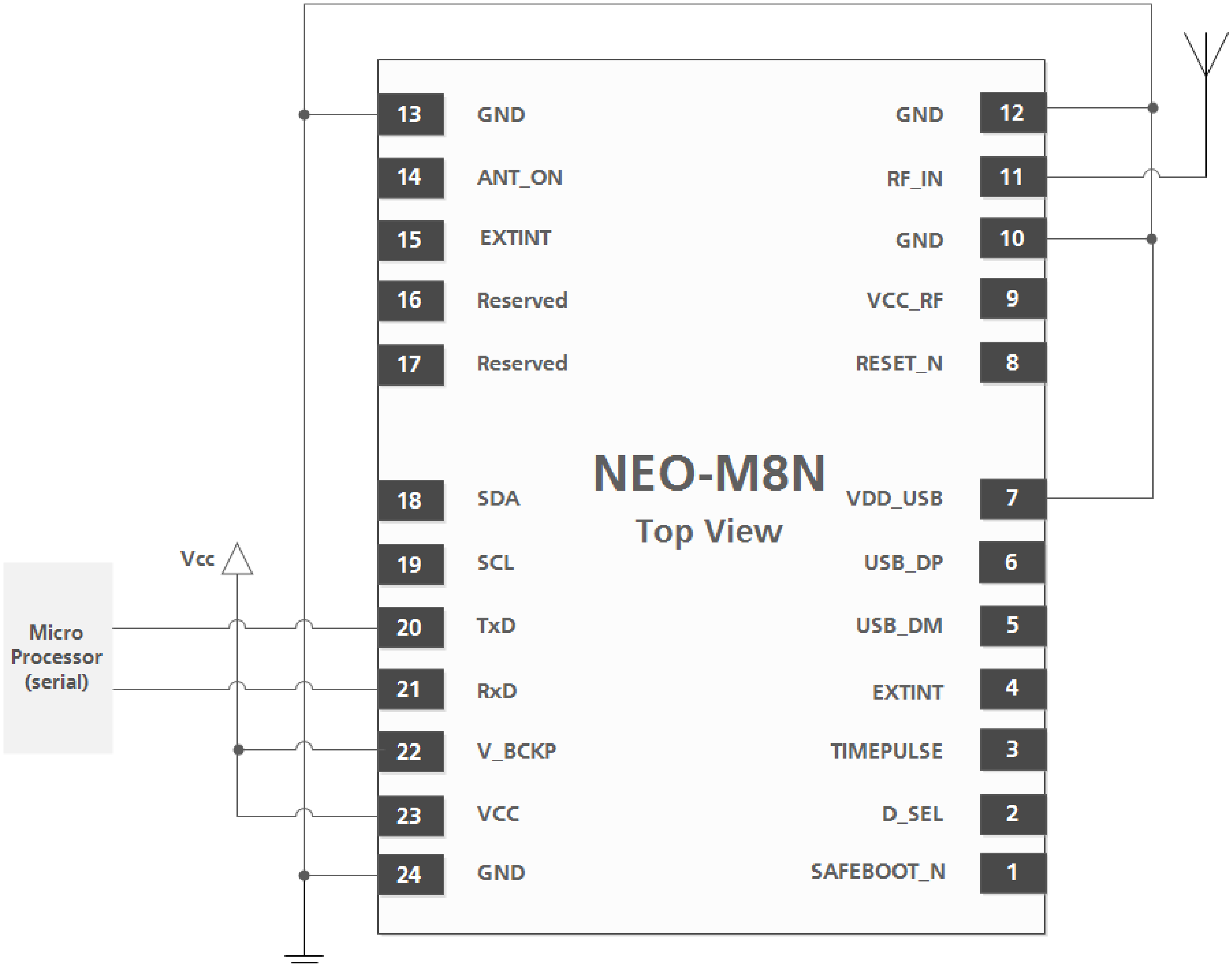
Pin Configuration:

Pin No.	Pin Name	Description
1	To	Temperature output (Analog)
2	Do	Threshold limit Output (Digital)
3	Po	pH meter output (analog)
4	Signal GND	Digital Ground
5	GND	Ground
6	VCC	Supply voltage +5V

General specifications:

Input voltage (V)	**5**
Accuracy	± 0.1pH
Response Time	≤ 1 min
Interface Type	pH2.0
Measuring Range	0 – 14PH
Operating Temperature Range (°C)	0 to 60
Length (mm)	43
Width (mm)	3200%
Weight (gm)	68

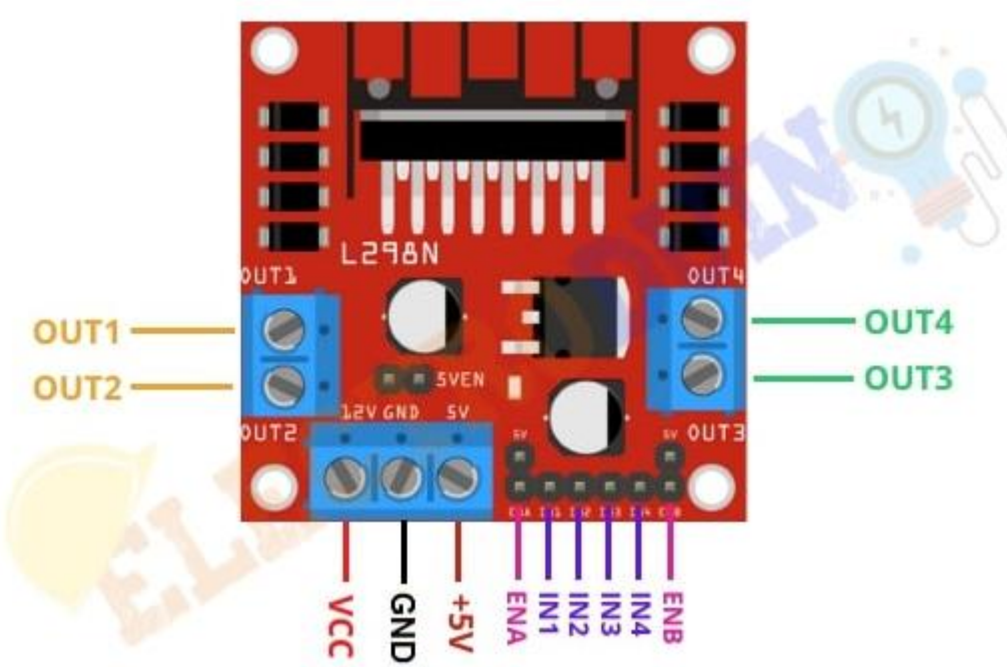
NEO-8M GPS Module Pinout Configuration & Datasheet:



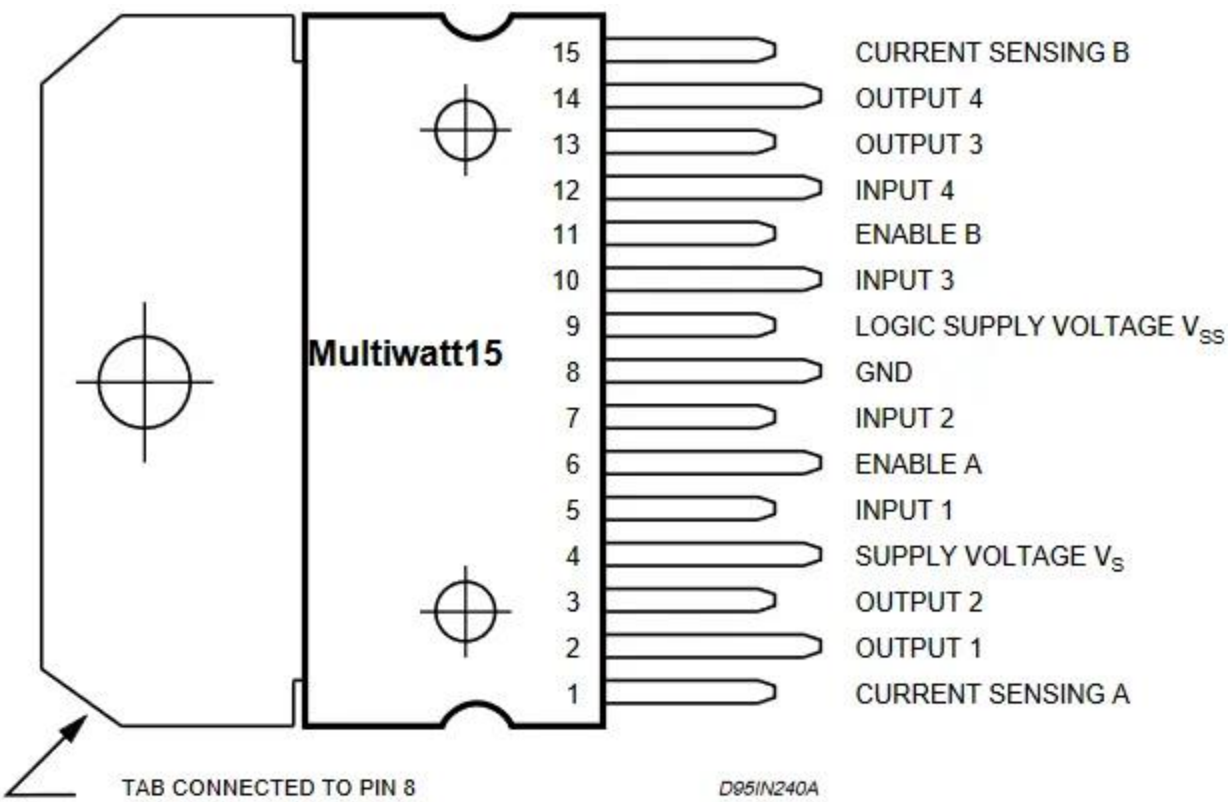
Pin configuration:

Pin No.	Pin name	I/O	Description
1	SAFEBOOT_N	I	SAFEBOOT_N (for future service, updates and reconfiguration, leave OPEN)
2	D_SEL	I	Interface select
3	TIMEPULSE	O	Time pulse (1PPS)
4	EXTINT	I	External interrupt pin
5	USB_DM	I/O	USB data
6	USB_DP	I/O	USB data
7	VDD_USB	I	USB supply
8	RESET_N	I	RESET_N
9	VCC_RF	O	Output voltage RF section
10	GND	I	Ground
11	RF_IN	I	GNSS signal input
12	GND	I	Ground
13	GND	I	Ground
14	LNA_EN / Reserved	O	LNA_EN (NEO-M8N/Q/J): Antenna/LNA control Reserved (NEO-M8M): Reserved
15	Reserved	-	Reserved
16	Reserved	-	Reserved
17	Reserved	-	Reserved
18	SDA / SPI CS_N	I/O	DDC data if D_SEL =1 (or open) SPI chip select if D_SEL = 0
19	SCL / SPI CLK	I/O	DDC clock if D_SEL =1 (or open) SPI clock if D_SEL = 0
20	TXD / SPI MISO	O	Serial port if D_SEL =1 (or open) SPI MISO if D_SEL = 0
21	RXD / SPI MOSI	I	Serial port if D_SEL =1 (or open) SPI MOSI if D_SEL = 0
22	V_BCKP	I	Backup voltage supply
23	VCC	I	Supply voltage
24	GND	I	Ground

<u>L298N H-Bridge Motor Driver Pinout Configuration & Datasheet:</u>



PINOUT of L298N Motor Driver IC:



Pin configuration:

Pin No.	Pin Name	Description
1	Current sensing A	Between this pin and the ground, a sense resistor is connected to control the current of the load.
2	Output 1	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
3	Output 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	Supply voltage V_s	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5	Input 1	TTL Compatible Inputs of the Bridge A.
6	Enable A	TTL Compatible Enable Input: The L state disables the bridge A
7	Input 2	TTL Compatible Inputs of the Bridge A.
8	GND	Ground
9	VSS	Supply Voltage for the Logic Blocks. (A100nF capacitor must be connected between this pin and ground.)
10	Input 3	TTL Compatible Inputs of the Bridge B.
11	Enable B	TTL Compatible Enable Input: The L state disables the bridge B.
12	Input 4	TTL Compatible Inputs of the Bridge B.
13	Output 3	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at the pin.
14	Output 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at the pin.
15	Current sensing B	Between this pin and the ground, a sense resistor is connected to control the current of the load.

Appendix B

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