Faculty of Electronics and Computer Technology and Engineering

DEVELOPMENT OF SALINITY LEVEL OF WATER SENSOR VIA BLUE LED DETECTION

NURBALQIS BAHIRAH BINTI NAZRI

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

2024

DEVELOPMENT OF SALINITY LEVEL OF WATER SENSOR VIA BLUE LED DETECTION

NURBALQIS BAHIRAH BINTI NAZRI

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Faculty of Electronics and Computer Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI DAN KEJURUTERAAN ELEKTRONIK DAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Development of Salinity Level of Water Sensor via Blue LED Detections

Sesi Pengajian : 2023 / 2024

Saya Nurbalqis Bahirah binti Nazri mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

[ ]	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
[ ]	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
/	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

Alamat Tetap: Lot 4114, Kampung Gadek Dalam, 78000, Alor Gajah, Melaka.

(COP DAN TANDATANGAN PENYELIA)

MUHAMMAD IZZAT ZAKWAN BIN MOHD ZABIDI
PENSYARAH
Fakulti Teknologi dan Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Tarikh: 19 / 1 / 2024

Tarikh: 19 / 1 / 2024

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled “Development of Salinity Level of Water Sensor via Blue LED Detections” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Student Name	:	NURBALQIS BAHIRAH BINTI NAZRI
Date	:	19 / 1 / 2024

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours.

Signature :

Supervisor Name : MUHAMMAD IZZAT ZAKWAN BIN MOHD ZABIDI

Date : 19 / 1 / 2024

Signature :

Co-Supervisor Name (if any) : DR ARSHADI BIN JOHARI

Date : 19 / 1 / 2024

DEDICATION

To my beloved mother, Norfabialhaiyu binti Ali, who taught me be patient & be kind to others.

ABSTRACT

Agriculture, environmental studies, aquaculture, industries, and natural waters all benefit from salinity. However, some mining and industrial processes generate saline wastewater, which can contaminate natural water sources if not adequately handled. High quantities of salt in naturally occurring water sources could make them unsafe for human consumption. Salty water has a bad flavor and might make human dehydrated if human drink too much of it. Moreover, it has the potential to affect human health, which can lead to hypertension, kidney issues, and electrolyte abnormalities. Therefore, the purpose of the project is to develop of salinity water level sensor via blue LED detections. The objectives of this project are to develop water concentration sensor using LDR sensor, analyze the sensor performance through blue LED power transfer and optimize the sensor performance by sensitivity, linearity and stability results. The system's inputs and outputs are controlled by an Arduino UNO processor, which is used to measure the saltiness of the water. It is in charge of how the blue LED worked, like turning it on or off. The Arduino UNO send data on how much light reflected from water samples to the LCD so that they could be observed. LDR is the sensor that found out how bright the light is as it went through the water. As a result, a sensitivity value and three kinds of graphs have been made that show linearity, repeatability, and stability. It shows that the more the concentration of salt in water, the less light comes out of it. This invention introduces an improved understanding of salt in drinking water at a low cost and with minimal effort on the part of the user.

ABSTRAK

Pertanian, kajian alam sekitar, industri akuakultur dan perairan semula jadi mendapat manfaat daripada kemasinan. Walau bagaimanapun, sesetengah proses perlombongan dan perindustrian mengalirkan air sisa masin yang boleh mencemarkan sumber air semula jadi sekiranya tidak dikendalikan dengan tepat. Kuantiti garam yang tinggi dalam sumber air semulajadi boleh menjadikannya tidak selamat untuk diminum oleh manusia. Air masin mempunyai rasa yang kurang baik dan boleh menyebabkan manusia dehidrasi sekiranya manusia minum terlalu banyak. Selain itu, ia berpotensi menjejaskan kesihatan manusia, yang boleh menyebabkan hipertensi, masalah buah pinggang, dan abnormal elektrolit. Oleh itu, tujuan projek ini adalah untuk membangunkan penderia kadar kemasinan di dalam air melalui pengesanan LED berwarna biru. Objektif projek ini adalah untuk membangunkan penderia kadar kepekatan kemasinan di dalam air menggunakan penderia LDR, menganalisis prestasi penderia melalui pemindahan kuasa LED biru dan mengoptimumkan prestasi penderia mengikut keputusan kepekaan, kelinearan dan kestabilan. Input dan output sistem dikawal oleh pemprosesan Arduino UNO, yang digunakan untuk mengukur kadar kepekeatan kemasinan air. Ia bertanggungjawab terhadap LED biru yang berfungsi sebagai pemancar cahaya. Arduino UNO menghantar data kadar cahaya yang dipantulkan daripada sampel air ke LCD supaya ia boleh diperhatikan. LDR ialah sensor yang mengetahui kadar keamatan cahaya sewaktu melalui air. Hasilnya, empat jenis graf dapat dihasilkan bagi menunjukkan kepekaan, kelinearan, kebolehulangan dan kestabilan. Hal ini menunjukkan bahawa semakin banyak kepekatan garam dalam air, semakin kurang cahaya yang dapat menembusinya. Ciptaan ini memperkenalkan pemahaman yang lebih baik tentang garam dalam air minuman pada kos yang rendah selain usaha yang minimum bagi tujuan penggunaan kepada pihak pengguna.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my sincere gratitude to several individuals and organizations for supporting me throughout my study. I would like to extend my heartfelt appreciation to my supervisors, Mr. Muhammad Izzat Zakwan Bin Mohd Zabidi and Dr Ashadi bin Md Johari, for their enthusiasm, patience, insightful comments, helpful information, practical advice, and unceasing ideas that have helped me tremendously at all times in my research and writing of this thesis. Their immense knowledge, profound experience, and professional expertise in electronics and statistics have enabled me to complete this research successfully. Without their support and guidance, this project would not have been possible. I could not have imagined having better supervisors in my study.

I also wish to express my sincere thanks to the Universiti Teknikal Malaysia Melaka for accepting me into the graduate program. I am grateful for the financial support through the Bachelor Degree Project (BDP) I and II, which enabled me to accomplish the project.

My highest appreciation goes to my mother and family members for their love and prayers during the period of my study. An honorable mention goes to my mom for all the motivation and understanding. Thank you for always being the best mom ever! And to him, thank you for the support.

Finally, I would like to thank all my friends for their cooperation, advice, motivation, and support while working on my BDP. I am grateful for your moral guidance and support throughout this semester at Universiti Teknikal Malaysia Melaka, lecturers, and staff.

Thank you all for your encouragement!

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATIONS		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vii**
LIST OF FIGURES		**viii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Introduction	1
1.2	Background	1
1.3	Problem Statement	3
1.4	Objective	4
1.5	Scope of Project	4
1.6	Thesis Structure	5
CHAPTER 2	**LITERATURE REVIEW**	**6**
2.1	Introduction	6
2.2	Past Related Research	6
	2.2.1 Salinity	6
	2.2.2 Determination of Salt Concentration in Water using Trees and Electromagnetic Waves	7
	2.2.3 Remote Monitoring of Water Salinity by using Side-Polished Fiber-Optic U-shaped Sensor	9
	2.2.4 Density, Temperature and Salinity	10
	2.2.5 Arduino UNO-based Water Turbidity Meter using LDR and LED	11
	2.2.6 Measuring Salinity of Water	12
	2.2.7 Refractometric Fiber Optic Sensor for Detecting Salinity of Water	13
	2.2.8 Designing and Modeling of Arduino Based Light Sensor	15
	2.2.9 Combined Theoretical and Experimental Study of Refractive Indices of Water-Acetonitrile-Salt System	16
	2.2.10 Measurement of Refractive Index of Liquids using Fiber Optic Displacement Sensors	17
	2.2.11 Relationship between Refractive Index and Molar Concentration of Multi-Component Solutions	18

2.2.12 The Relationship between The Salinity of Water and The Refractive Index of Water 19
2.2.13 Side-Polish Plastic Optical Fiber Based SPR sensor for Refractive Index and Liquid-Level Sensing 20
2.2.14 Light-Emitting Diodes 21
2.2.15 Measurement of Seawater Refractive Index and Salinity by Means of Optical Refraction 22
2.2.16 Review of Seawater Fiber Optic Salinity Sensors Based on The Refractive Index Detection Principle 23
2.2.17 Working Principle of Arduino and Using it as a Tool for Study and Research 24
2.2.18 Sensing Using Light: A Key of Sensors 25
2.2.19 Measurement of The Degree of Salinity of Water with Fiber-Optic Sensor 26
2.2.20 LED Journal 27
2.3 Summary of Related Work 29
2.4 Summary 34

CHAPTER 3 METHODOLOGY 35
3.1 Introduction 35
3.2 Flowchart 35
3.3 Milestone of BDP I & II 40
3.4 Hardware and Software Development 42
3.4.1 UNO R3 Board 42
3.4.2 1602 Display 42
3.4.3 Arduino IIC I2C 43
3.4.4 Blue LED 43
3.4.5 Light Detector 44
3.4.6 Resistors 44
3.4.7 Green PCB 45
3.4.8 Jumper Wires 45
3.4.9 Wires 46
3.4.10 Solder Lead 46
3.4.11 Glass Beaker 10ml 47
3.4.12 9V Battery Connector 47
3.4.13 PCB Standoff Spacer 48
3.4.14 Storage Box 49
3.4.15 Arduino IDE version 2.1.0 49
3.5 Project Layout 50
3.6 System Hardware Design 51
3.7 Flowchart of Coding 52
3.8 Project Prototype 54
3.9 Estimated Cost 56

CHAPTER 4 RESULTS AND DISCUSSIONS 57
4.1 Introduction 57
4.2 Sensor Performance of Rainwater 59
4.3 Sensor Performance of Coway 62
4.4 Sensor Performance of Spritzer 64

4.5	Sensor Performance of Evian	66
4.6	Sensor Performance of Pipe Water	69
4.7	Summary	72
CHAPTER 5	**CONCLUSION AND RECOMMENDATIONS**	**73**
5.1	Introduction	73
5.2	Chapter 2	73
5.3	Chapter 3	73
5.4	Chapter 4	74
5.5	Future Recommendation	74
REFERENCES		**76**

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2-1	Performance metrics obtained when the aim was to predict whether liquid samples were salt water or pure water	9
Table 3-1	Gant Chart for BDP I	38
Table 3-2	Gant Chart for BDP II	39
Table 3-3	Milestone BDP I	40
Table 3-4	Milestone BDP II	41
Table 3-5	Estimating cost of the project	56

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2-1	Experimental setup include VNA and an antenna	8
Figure 2-2	Block diagram setup for water salinity measurements using fiber-optic U-shaped sensor, photodarlington, LED, microcontroller and analog digital converter	10
Figure 2-3	Demonstrate the effects of mass and volume in density.	11
Figure 2-4	NaCl curve	13
Figure 2-5	Arrangement of refractometric fiber optic chemical sensor	14
Figure 2-6	Sensor response in nonlinear region	14
Figure 2-7	Received at light intensity at Z=7mm	15
Figure 2-8	Refractive index n as a function of salt concentration at composition of solvent, c= (a)0.000 (b)0.018 (c)0.128	16
Figure 2-9	Fiber optic sensor schematic structure	18
Figure 2-10	The variation of refractive index water with respect to salt concentration of water	20
Figure 2-11	(a) Side-polish POF sensing probe schematic (b) Side-polish POF sensing probe cross-section view	21
Figure 2-12	Simple refractometric setup	23
Figure 2-13	Arduino Shields – Ethernet, Wireless, Motor Driver	25
Figure 2-14	Sensor schematic	27
Figure 3-1	Flowchart for overall Bachelor Degree Project (BDP I and BDP II)	37
Figure 3-2	UNO R3	42
Figure 3-3	1602 Display	42
Figure 3-4	Arduino IIC I2C	43
Figure 3-5	Blue LED	43
Figure 3-6	LDR 44	

Figure 3-7 Resistor 220 ohm	44
Figure 3-8 Resistor 10k ohm	45
Figure 3-9 Green PCB	45
Figure 3-10 Jumper wires	46
Figure 3-11 Wires	46
Figure 3-12 Solder Lead	47
Figure 3-13 Glass beaker 10 ml	47
Figure 3-14 9V Battery Connector	48
Figure 3-15 PCB Standoff Spacer	48
Figure 3-16 Storage Box	49
Figure 3-17 Arduino IDE	50
Figure 3-18 Project simulation layout	51
Figure 3-19 Block diagram of the project	52
Figure 3-20 Flowchart of the coding	53
Figure 3-21 Project layout	55
Figure 3-22 Flowchart of project	55
Figure 4-1 Repeatability graph for Rainwater	59
Figure 4-2 Linearity graph for Rainwater	60
Figure 4-3 Stability graph for Rainwater	61
Figure 4-4 Repeatability graph for Coway	62
Figure 4-5 Linearity graph for Coway	63
Figure 4-6 Stability graph for Coway	64
Figure 4-7 Repeatability graph for Spritzer	64
Figure 4-8 Linearity graph for Spritzer	65
Figure 4-9 Stability graph for Spritzer	66
Figure 4-10 Repeatability graph for Evian	66

Figure 4-11 Linearity graph for Evian 67

Figure 4-12 Stability graph for Evian 68

Figure 4-13 Repetability graph for Pipe Water 69

Figure 4-14 Linearity graph for Pipe Water 70

Figure 4-15 Stability graph for Pipe Water 71

Figure 4-16 Power versus sample graph 72

CHAPTER 1

INTRODUCTION

1.1 Introduction

The main purpose of this chapter is to establish the framework and provide a concise introduction to the project. it primarily presents an overview of the project, outlines the objectives, briefly discusses the problem statement and scope also provides an overview of the expected outcomes. The structure of the entire project can be clearly visualized through this chapter by providing a solid foundation for further exploration and understanding.

1.2 Background

Degradation of water quality occurs as a result of natural processes that are influenced by a variety of factors, including soil-matrix, hyporheic exchange, climate change, natural disasters and geological factors. Saline wastewater from mining and industrial processes can contain harmful substances include radioactive or toxic materials or heavy metals. Those substances can absorb into the drinking water sources like lakes, rivers and seawater could present additional health risks to human. The salinity of the water's varying mineral composition may have negative effects on health [1]. It can effect on human health which can cause high blood pressure, kidney problems and electrolytes imbalances. According to the Total Dissolved Solids (TDS) method, drinking water is considered to be of high quality when the salt content is below 600 mg/L. Fair quality drinking water is defined as having a salt content between 600 and 900 mg/L. Finally, the term "poor quality drinking water" is used to describe water with a salinity level ranging from 900 to 1200 mg/L [2].

Salts contains a lot of sodium. Human body holds onto more water when consume too much sodium. This implies that human body retains more water than usual, increasing the volume of blood in human bloodstream through veins. Kidneys, arteries, heart and brain all put under stress by this extra water that has been stored in human body. Increasing sodium intake promotes increasing blood pressure via extracellular fluid volume expansion[1]. As a consequence, human with high blood pressure frequently can be found in chronic kidney disease patients [3]. Consuming highly salinized water over an extended period of time can strain the kidneys. Excess salt in the body must be removed by kidneys and over time can cause kidney damage or failure.

Sodium is significant electrolytes that possible to get from drinking water. A vital electrolyte in the body, sodium aids in balancing electrical charges within cells and facilitating the production and transmission of nerve and muscle signals depend heavily on electrolytes [4]. Electrolyte imbalances can lead to either excessive or insufficient levels. Excessive sodium intake from high-salinity water can throw off this equilibrium and result in symptoms like fatigue, headaches, nausea and irregular heartbeats. Such imbalances interfere with the body’s normal processes and can result in serious problems that are potentially fatal.

Due to those subsequences, salinity water level sensor using blue LED detections had been developed to measure the salinity level in water. It is low-cost project development if compare with portable conductivity and salinity meters. This project is using refraction theories to determine the salinity level water. The project is using blue light that LEDs emit into the water sample. The performance of the sensing process from photodiode may be influenced by the wavelength of blue light due to refraction fields caused by transmitted spectral information.

1.3 Problem Statement

Salinity is a valuable property of agriculture, environmental science, aquaculture, industries and natural waters. However, if improperly managed, saline wastewater is generated from some mining and industrial processes that can contaminate natural water sources. Natural water sources with high salinity levels may not be safe to drink. If consumed in large quantities, salty water can have an unpleasant taste and cause dehydration. In addition, it can effect on human health which can cause high blood pressure, kidney problems and electrolytes imbalances. Portable conductivity and salinity meters have been produced to measure the electrical conductivity of water which directly related to salinity. Unfortunately, the portable conductivity and salinity meters is overpriced for people to check the salinity level by themselves. High price would unfairly disadvantage people with limited financial resources, resulting to an imbalance in access to information about salinity levels. As a consequence, there is a need to design and develop a salinity water level sensor using blue LED detections for accurate measurement of salinity levels. The use of light refraction as a salinity water level sensor was investigated in this project. The blue light of the LED is chosen by the range of the acceptance of the wavelength to emits. The sensor designed by combination of the blue LED, photodetector and power meter as the data collector. Due to the reflection and refraction field created by transmitted spectral information, the wavelength of light may have impact on the performance of sensing.

1.4 Objective

The main objectives of this project are:

a) To develop water concentration sensor using LDR sensor.

b) To analyze the sensor performance through blue LED power transfer.

c) To optimize the sensor performances by sensitivity, linearity and stability results.

1.5 Scope of Project

Recording scopes helps to ensure that a project will be successfully completed within the budget that has been allocated. The scopes will be operational in order to provide assurance that the project is moving in the appropriate direction to achieve the goal. The salinity water level sensor via blue LED detections is designed to investigate if the blue LED can function as a sensor for detecting various levels of salinity in different samples. The Arduino UNO, a blue LED, a LDR and a LCD will all be utilized in this project.

Due to the nature of the project, it can only be considered an experimental test. In order to determine the salinity of the water at the level, the project must be prepared. A blue LED emits incoherent light, characterized by waves with non-phase-aligned wavelengths. Therefore, the blue LED light exhibits a limited focus and brightness when projected across long distances. This assertion is one of the factors that contribute to the low cost and affordable price that aims to produce a salinity water level sensor via blue LED detections. In addition, the design makes use of glass beaker to fill in the samples of water with varying levels of salinity. It is very difficult to demonstrate the project layout for the project when completing PSM I. The reason for this is that almost all of the simulation software does not come with a glass beaker.

1.6 Thesis Structure

Chapter 1:

In the initial chapter, the feasibility of the project is briefly explained. This section will go over the context of the tasks. The focus will be on providing an overview of the project, including the objectives, problem statement and scope.

Chapter 2:

The second chapter will cover in more detail on the concept, hypothesis and characteristics of the equipment and components that be used in this project. it also defines the terms used in the project and explores the research concept, emphasizing on how it relates to the hypothesis.

Chapter 3:

The third chapter will delve into the project's methodology. The methodology chapter outlines the steps that need to be followed and provides detailed reports of the studies that must be completed in order to achieve the project's objectives. This chapter will provide comprehensive information about the project's development as well as a thorough explanation of the methods used to complete the project.

Chapter 4:

The fourth chapter will be focused on the outcomes and subsequent discussions in relation to the employed approach. A comprehensive analysis and description of the data gathering and analysis technique will be provided. This chapter provides an explanation of the four types of graphs: stability, repeatability, linearity, and power versus sample.

Chapter 5:

In this last chapter will draw the conclusion based on the outcomes. This chapter will provide a comprehensive summary of the research findings and project results from the Bachelor Degree Project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To ensure the success of this project, various studies and inquiries has been conducted. Information and data have been gathered from a variety of sources, including books, articles and journals to accurately represent both the benefits and limitations of the project's objectives. All of this information has been used as a reference to ensure that the project could be completed within the timeframe specified. The studies and information that has been gathered are focused on the topics that relevant to the project.

2.2 Past Related Research

The educational research will be primarily focused on the educational field. The research materials used are determined by the theories, equipment and system being used. The sources chosen must follow the format specified such as research books, journals or articles.

2.2.1 Salinity

Salinity can define as amount of concentration salt that dissolve in water. The most common salt that had been measured is sodium chloride, NaCl. Salinometer is being used to measure salinity by determine the quantity of salt present in a specific volume of water. Parts per million (ppm) is units that use to express the concentration of salt in water. This article emphasizes about salinity in ocean and freshwater. It mentions that freshwater has salt concentration less than 1000 ppm while ocean water is highly saline with salt concentrations average about 35000 ppm [5]. The article state that there are two important concepts about salt in ocean. Firstly, oceans are seen to be in a stable state, getting as much salts as they are losing. Secondly, the oceans have been blended throughout long time period that the creation of sea salt is similar wherever in the open ocean. The amount salt in ocean causes the salinity slightly varies via time or space. Besides, the article also mentions about the effects of excess salinity. Saline water is unsuitable for drinking because it can harm human health that can cause an imbalance of sodium and potassium levels in body. This can lead to kidney disease. Plus, it is also can harm the plants if the level of salt in water high, salt level in soil also high. Thus, the water tends to flow in opposite direction (roots to soil) that cause dehydration of the plants. All in all, this article is more focusing about salinity in ocean and freshwater. The useful information that can be used for my project is saline water has higher electrical conductivity, higher density, a lower freezing point and lower specific heat capacity.

2.2.2 Determination of Salt Concentration in Water using Trees and Electromagnetic Waves

This journal is using a set of S parameter measurements to determine salt concentration in water. Thus, a system for non-contact to determine salt concentration has designed. During the procedure to measure salt concentration in water, a microstrip patch antenna was used in this journal. Analysis was carried out on the interaction of salt concentration in water and permeability values that are a distinguishing feature for liquids. That relationship resulted in the understanding that it was possible a relationship between sat concentration and scattering (S) parameters. Therefore, S parameters were to be measured by a measurement system. A microstrip patch antenna designed and produced as well as a commercially available Vector Network Analyser VNA are part of measurement system. VNA’s and antenna were used to measure S parameters of the liquid which is different salt content level with different brand of waters. The Smax value relationship with salt concentration was established by means of a curve fitting approach, having been calculated in order to link the permeability values derived from these measurements and the S parameter. This journal preferred decision tree algorithms as classifiers because their performances well known in order to make fair comparison for salt concentration [6]. There are four tree algorithms which are Hoeffding tree, Logistics Model Tree (LMT), Random Forest and Rep Tree. As a results, the most suitable to determine salt concentration is Hoeffding tree algorithm and Rep tree had the worst result. As shown from Table 2.1 a recall value of 1 for predicting wither or not salt water has been detected in any sample, indicates that Rep tree correctly identified all the samples. In view of classification of pure water samples there is a decrease in its recall value. When estimating salt water sample classes, this shows Rep tree did not make the correct classification. F-Score value supports this. All clean water samples were correctly selected by Rep tree with precision value of 1. The most important limitation in this journal proposal is it can deliver uncertain results when salinity is below 5 %

Figure 2-1 Experimental setup include VNA and an antenna

Table 2-1 Performance metrics obtained when the aim was to predict whether liquid samples were salt water or pure water

Class	Without Cross validation				With Cross validation			
Hoeffding Tree								
	Precision	Recall	F-Score	MCC	Precision	Recall	F-Score	MCC
Salt water	1	1	1	1	1	1	1	1
Pure water	1	1	1	1	1	1	1	1
Average	1	1	1	1	1	1	1	1
LMT								
	Precision	Recall	F-Score	MCC	Precision	Recall	F-Score	MCC
Salt water	1	1	1	1	1	1	1	1
Pure water	1	1	1	1	1	1	1	1
Average	1	1	1	1	1	1	1	1
Random Forest								
	Precision	Recall	F-Score	MCC	Precision	Recall	F-Score	MCC
Salt water	1	1	1	1	1	1	1	1
Pure water	1	1	1	1	1	1	1	1
Average	1	1	1	1	1	1	1	1
Rep Tree								
	Precision	Recall	F-Score	MCC	Precision	Recall	F-Score	MCC
Salt water	0.83	1	0.90	0,84	1	0,80	0.88	0.83
Pure water	1	0.85	0.92	0.84	0.87	1	0.93	0.83
Average	0.93	0.91	0.91	0.84	0.92	0.91	0.91	0.83

2.2.3 Remote Monitoring of Water Salinity by using Side-Polished Fiber-Optic U-shaped Sensor

In this paper, remote water salinity measurement system based on the polished fiber optic U-shaped sensor is presented. In order to achieve the best sensitivity and extend the range of measurements, the sensing system uses a side-polished U Triod shape. The sensor is made of multimode plastic optical fiber also to obtain the salinity by measuring the refractive index[7]. This paper also informs that solution with higher level of salinity (higher degree of concentration sodium chloride) has a higher refractive index. The refractive index is measured by fiber-optic salinity sensors frequently based on intensity modulation [7]. The optical power that is transmitted by the fiber and recorded by the photodetector is diminished as the refractive index rises. To determine the salinity degree, sensor is immersed into liquid with various of salt concentration. LED and photodarlington are been used for light source and photodetector. Benefits project in this paper are simple, low-cost and flexible. Furthermore, the sensor that be used is electrically safe and resistant from electromagnetic interferences. However, bending optical fibers leads to loss of optical power and reduces sensor performance. The losses because bending optical fibers are used as operating principle in many fields of fiber-optic sensors.

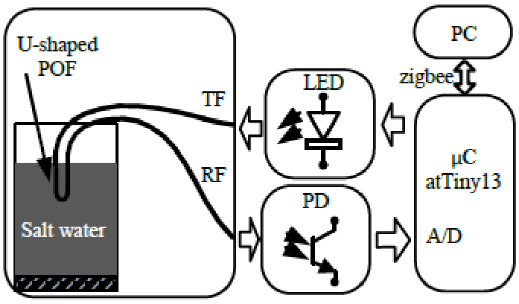

Figure 2-2 Block diagram setup for water salinity measurements using fiber-optic U-shaped sensor, photodarlington, LED, microcontroller and analog digital converter

2.2.4 Density, Temperature and Salinity

In this article, give understanding on how salinity and temperature variations impact the density and buoyancy of ocean water layers. Models are created to explain the atomic structure of extended structures and simple molecules. The investigation has been planned to show the combination of the object's mass and the applied forces determines when object moves. Salinity affects density when water's density increase at the same time salt is dissolved in fresh water. Thus, the volume is increase. As Figure 2.3(A) to Figure 2.3(B) amount of matter increased with constant volume, the density increases. Figure 2.3(A) to Figure 2.3(C) volume increase with constant mass, density decreases. Figure 2.3(A) to Figure 2.3(D) adding additional matter to the constant volume, density increases although different type of matter is added. Amount of salt that dissolve in water is describing salinity. Increase salt dissolve in water, increase the salinity. If we compare two sample of water with constant volume, water sample with higher salinity will have greater mass so denser[8]. Temperature affects density when water is heated, density decreases because the volume is increases. More space is needed because the matter is expanding. This cause light to travel faster in the medium. Thus, value for refractive index become smaller due to smaller ratio.

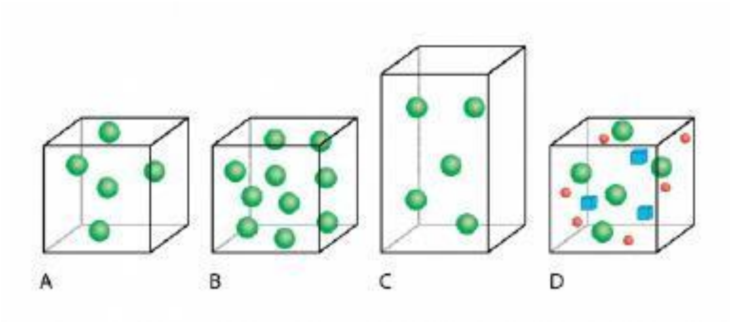

Figure 2-3 Demonstrate the effects of mass and volume in density.

2.2.5 Arduino UNO-based Water Turbidity Meter using LDR and LED

Turbidity is when there are numerous suspended particles in water. The water becomes hazy and turns brownish appearance. Turbidity is a result of the presence of sludge, clearly defined organic components and other suspended particles. This journal is using Arduino Uno to measure water turbidity value. LDR sensor and LED as light source to measure the water turbidity value while data processing using Arduino UNO. Nephelometric Turbidity Units (NTU) are used to measure turbidity. As a general rule, nephelometry uses bright sources that have shorter wavelength than 500 to 800 nanometers so it can be effective to detect microscopic particles. Turbidity will use light sources with long wavelength 800 to 1100nm to detect larger particles in an effective manner. Those are the reasons this journal been use LDR and LED in their project. The light pass through the turbidity water sample, its intensity is reduced by scattering depends on concentration and distribution of the particle size[9]. From this journal, Arduino Uno can be used in my project by program it to determine the value of salt concentration of water. Besides, I need to identify the right wavelength of LED to detect the salinity value. Disadvantage from this project, it is only to determine the turbidity in water to find out water quality in drinking water.

2.2.6 Measuring Salinity of Water

In this article, the purpose of the study is to measure the level of salinity in water for aquatic organisms, farm animal and agriculture at a variety of salty levels. Generally, for freshwater, salinity levels are below 0.5 ppt while 35 ppt is for seawater salt level. Measurements of electrical conductivity (EC) are frequently use to determine the salinity. When EC is measured, an electric current is passed between two metal plates or electrodes in a water sample at the rate the current flows between the plates is recorded. Thus, in 1978 Practical Salinity Scale was created by using EC to measure the ionic content of seawater. By that LAQUAtwin Salt 11 pocket meter had been created to determine the conductivity value of a sample. It then converts it to the salinity value via the chosen salinity standard curve. It has a temperature sensor for precise measurement and two titanium metals coated in platinum black to resist corrosion. Both a seawater calibration curve and a NaCl calibration curve are pre-programmed into the meter. When ppt is selected as the measurement unit, the meter only shows the salinity reading. The results, freshwater organisms cannot survive in salinities greater than 1 ppt, whereas saltwater organisms can survive in salinities up to 40 ppt [10]. The amount of dissolved oxygen in water is influenced by salinity. Increase the salinity will decrease oxygen solubility in water. At the same temperature, the solubility of oxygen in seawater is about 20% lower than in fresh water[10]. All in all, this article did not explain the specific sensor that be used. It only mentions about the temperature sensor that affect the oxygen level in water.

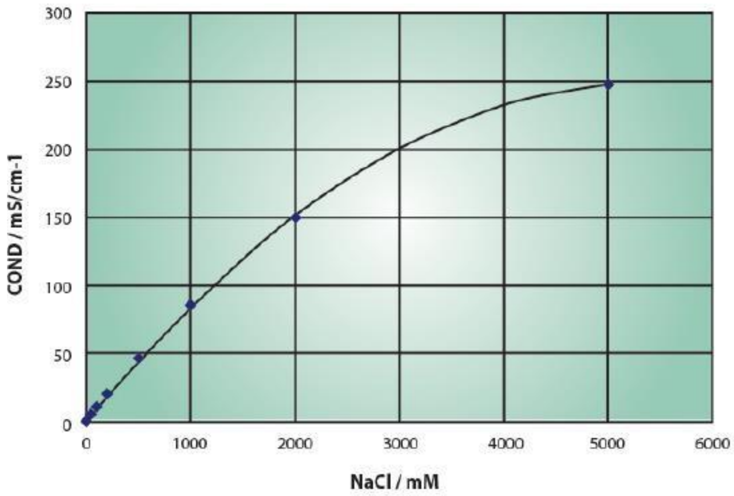

Figure 2-4 NaCl curve

2.2.7 Refractometric Fiber Optic Sensor for Detecting Salinity of Water

A crucial characteristic of both industrial and natural waters is salinity. Salinity is described as a measurement of the mass of salts that have dissolved in specific mass of solution. High salinity affects both people and water-dependent industries. Increased salt concentrations over extended periods of time can kill trees and render land unusable for farming, reduce agriculture output and restrict the types of crops that can grow. Due to the loss of some components, drying and weighing the salt content experimentally presents some challenges. The valid method to determine the true absolute salinity of natural water is through chemical analysis [11]. The process takes a long period and cannot produce the precision needed for accurate work. As a result, a common process to figure out salinity entails measuring a physical characteristic like conductivity, density or refractive index. This paper is using refractometric fiber optic sensor for measuring water salinity. MATLAB is using to determine the liquid's refractive index. The fiber optic sensor probe is design to determine the refractive index of solutions with various molar concentrations of salt dissolved in water. The developed probe is used in experiments. To optimize the gap length, simulations are run using the developed model based on the ray method. Received light intensity is plotted as a function of distance Z for each value of refractive index between

1.33 (pure water) and 1.36 (water with 50 % salinity), where distance Z is the distance Z is the distance between the sensor probe and reflector. Over the specified range of refractive indexes, the sensitivity is calculated while holding Z constant. The optimal gap length for detecting variations in the refractive index is chosen to be value of Z for which sensitivity is highest. On the graphs, the optimized gap length is indicated by dotted line. All in all, the experiments are using distilled water with different value concentration of salt. The probe sensor is very useful to detect the salinity level in distilled water in percentage.

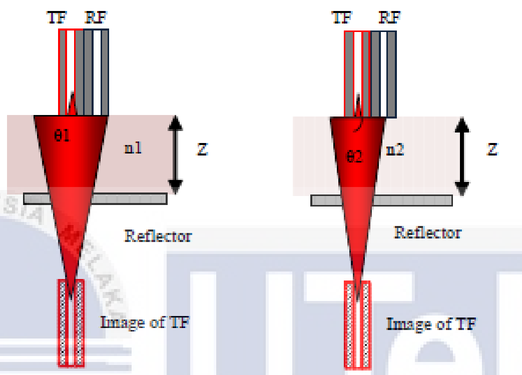

Figure 2-5 Arrangement of refractometric fiber optic chemical sensor

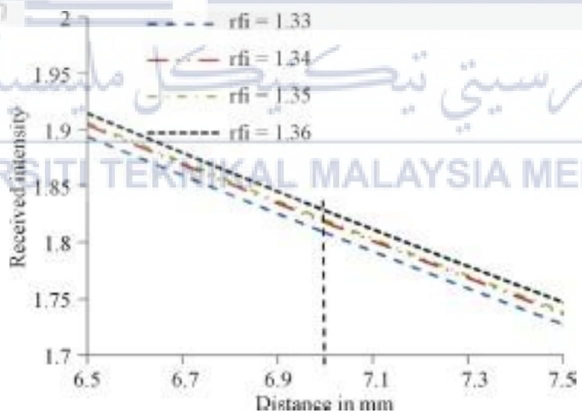

Figure 2-6 Sensor response in nonlinear region

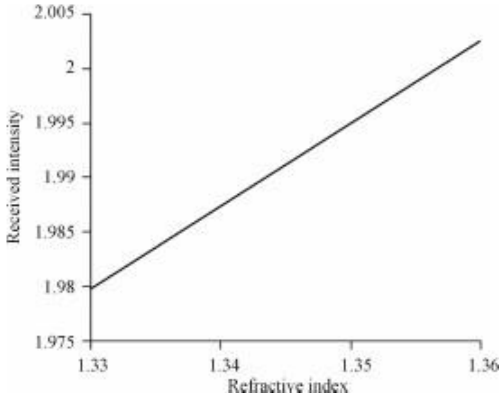

Figure 2-7 Received at light intensity at Z=7mm

2.2.8 Designing and Modeling of Arduino Based Light Sensor

A tool that recognizes light is called a light sensor. It produces an output signal whose amplitude is proportional to the light's intensity. A light sensor measures the radiant energy spread across the wide frequency range of light [12]. Infrared, visible and ultraviolet frequencies are few common ones. For various applications, various types of light sensors are available. The most common is a photocell or photo resistor. In this paper, Arduino light sensor circuit is created to detect exposed light and sends a signal to the buzzer, and the buzzer blows. When light strikes a photo resistor, its resistance changes. Consequently, a photo resistor is also known as a Light Dependent Resistor (LDR). The LDR's resistance reduces when light is incident upon it. From this paper, to avoid deterioration of signal by outside noise or picked up, light sensor (light detector) is intended to convert small amounts of light onto an electrical signal with appropriate amplitude. Light sensor detects the light intensity at wavelength between 320 to 700 nm. Thus, the light detector can be used to detect the blue LED in my project.

2.2.9 Combined Theoretical and Experimental Study of Refractive Indices of Water-Acetonitrile-Salt System

In this paper propose a simple theoretical formula of describing the refractive indices in binary liquid mixtures containing salt ions. The theory is based on Clausius-Mossotti equation which correctly accounts for the volume change during mixing and gives the refractive index of the mixture in terms of the refractive indices of the pure liquids and polarizability of the ionic species [13]ance with an odor of colorless ether and sweet, burnt taste. It is an extremely dangerous substance and must be handled with caution because it can cause death or health problems. In this paper experiment use NaCl, NaBr, KCl and KBr solutions. Even though KBr is the most polarizable salt and NaCl is the least, closer examination revels that NaBr solution has the highest refractive index while KCl was the lowest. As a result, the volume change and the polarizability of the ions play important roles in determining the salinity refractive index. This paper finding demonstrate that the anion plays a major role in determining the refractive index of the solutions. Increase anion will increase refractive index. To conclude, the theoretical formula presented can be applied backward to calculate the polarizabilities of fresh materials or the salinity water level.

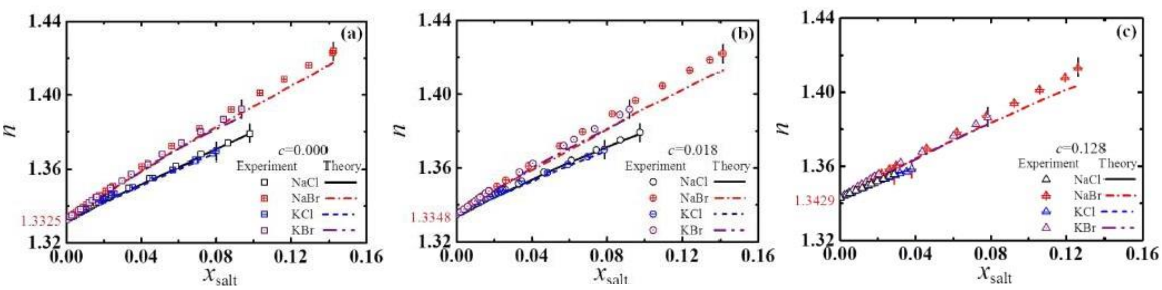

Figure 2-8 Refractive index n as a function of salt concentration at composition of solvent, c= (a)0.000 (b)0.018 (c)0.128

2.2.10 Measurement of Refractive Index of Liquids using Fiber Optic Displacement Sensors

This article paper, tell the method to determine the refractive index of liquids using a reflective type fiber optic displacement sensor. This paper proposed a fiber optic sensor with high sensitivity and simple method. A mirror and two multimode step index fibers are making up the sensor. Two multimode step index optical fibers that were closely spaced apart and cemented together were used to create the sensor. One of these serves as an emitting fiber, while the other arrange side by side serves as receiving fiber. As a function of separation between the mirror and the fiber, the receiving fiber output intensity has been measured for various liquids. The intensity peak for given liquid reaches its maximum at a specific location. The fiber core diameter, numerical aperture, distance between two fibers and refractive index of the medium all affect the sensor's characteristics while numerical aperture, fiber core diameter and distance between two fibers constant. It was discovered that the sensor could distinguish between liquids with different refractive indices if the separations is greater than 6 mm [14]. The output intensity of the receiving fiber was used to determine the refractive index of liquids. This method involves linearly displacing the sensor probe and measuring the output for each displacement. The medium's refractive index affects the peak in the intensity profile. As the results, there is a linear relationship between the output light intensity peak, which is observed in different liquids, and the refractive index of the medium. Increase the refractive index, the peak position at larger displacement occurs. The paper suggests when increase the sensitivity, the numerical aperture will be large [14].

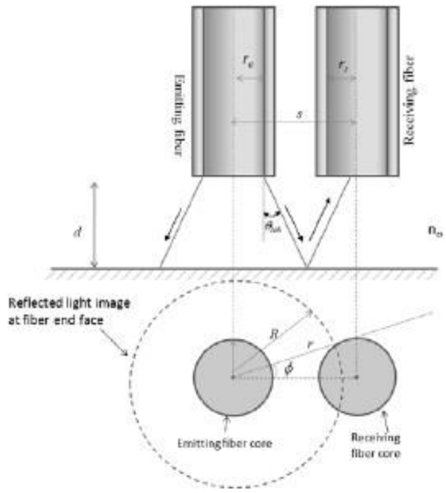

Figure 2-9 Fiber optic sensor schematic structure

2.2.11 Relationship between Refractive Index and Molar Concentration of Multi-Component Solutions

This paper was conducted using Snell's law's refractive index correlation to determine CuSO4-NaCl-H20 solution's refractive index. By examining light passing through solutions with various molar concentrations, it was possible to determine how changes in a molar solution's concentration affect its refractive index. After controlling for dissolution, under the interaction conditions between solute ions and different volumes, the refractive index of the multi-component solution varied linearly with each solute's molar concentration. The model of ternary system solution is using Snell's law. Based on the Snell's law, if the light incidence (vacuum) into medium, the refractive index of a medium is the ratio of the incident angle (sine) to refractive angle (sine) [15]. To conclude, based on the amount of time required for monochromatic light to traverse the medium, a multi-component solution was modeled and deduced. The refractive index of the multi-component system was discovered to be linearly related to the molar concentration of each solute. A ternary system solution experiment was used to validate a detailed correlation model that was put forth for the refractive index of multi-component solutions. It would not be effective for a solution like water and ethanol where the volume are significantly reduces after dissolution. This is because the model was created without taking interaction between solute ions. Thus, to make the necessary volume change correction, more research is required.

2.2.12 The Relationship between The Salinity of Water and The Refractive Index of Water

This paper, discuss about the effect on refractive index from various salinity of water. It used A4 paper to determine the refractive angle. The normal line that will help to measure the refractive angle which happen when a line passing through the center of circle that had been marked on the paper and perpendicular to the side is drawn. This experiment is to investigate the relationship between salinity water and the changes in refractive index. There are six beakers for six different concentrations of salt in water which are 0, 5, 10, 15 and 25 grams. The main goal is to observe light refraction in water at various salinity levels. By examining the angles between the light rays and normal line which perpendicular to the line separating the mediums, Snell's law is being used to observe the impacts of salinity. The variable that changes in this experiment is the mass of the salt dissolved in water. The variable to observe is the refractive index of water. The variable that be fixed is temperature, pressure and volume of water [16]. This is because those constant variable effects the refractive indexes. Applying the Snell's law, the smallest index that medium can have been 1 and all other mediums are said to have higher index than 1. To conclude, from the figure graph, high water salinity will high the refractive index. The reason is achieving a linear graph with $y = mx + c$.

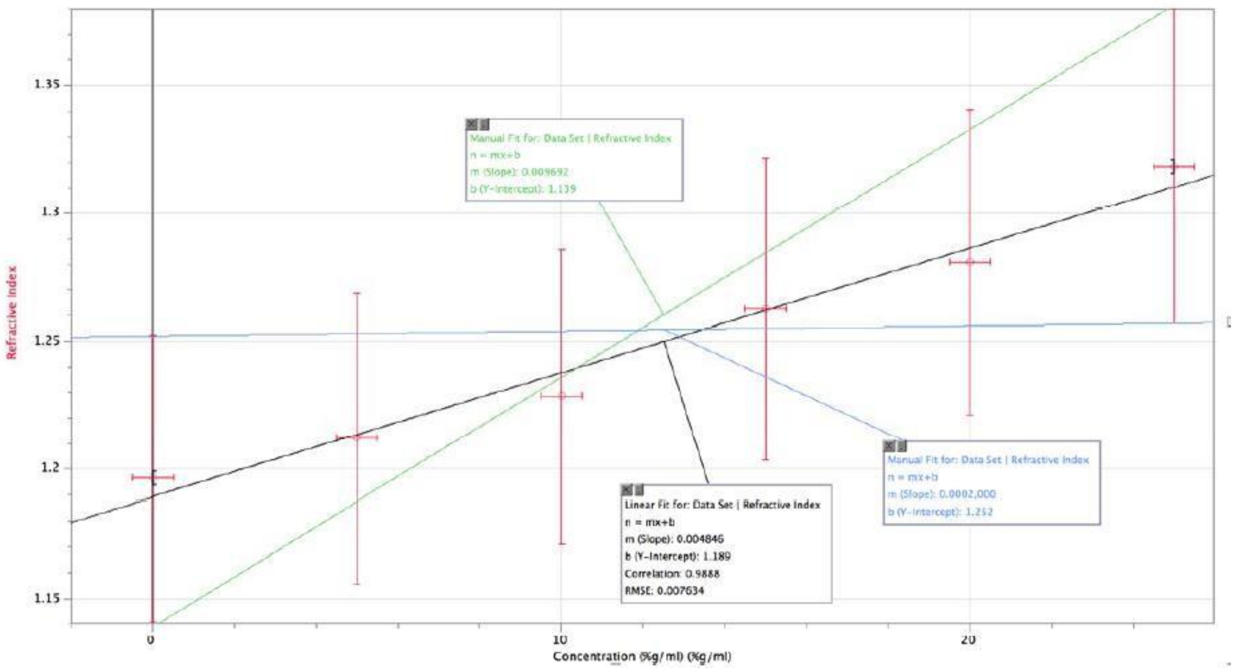

Figure 2-10 The variation of refractive index water with respect to salt concentration of water

2.2.13 Side-Polish Plastic Optical Fiber Based SPR sensor for Refractive Index and Liquid-Level Sensing

This journal proposed a simple POF-based SPR sensor for demonstrate the simultaneous measurement of refractive index (RI) and liquid level. The side-polished structure of the sensor probe makes for simple fabrication. If liquid level varies, an obvious change in SPR peak intensity can be seen. A sensing probe has a gold-coated side-polish POF (Figure 2.11(a)). L stands for the length of the polishing area, d for the depth of the polished region and D for the residual diameter of the fiber. (Figure 2.11 (b)) the sensing probe in cross section. Besides, the thin leftover cladding coated with a gold film also is part of SPR sensing. The cladding thickness is 10µm with a low RI of 1.41. According to experimental findings, the RI can be determined by observing the SPR resonant peak's wavelength shift and the liquid level can be determined by keeping track of the peak's depth. An achievable RI sensitivity of 2008.58 nm/RIU is in the RI range of 1.335 to 1.39. As a results, there is three-layer structural model that used to analyze the performance of the probe sensor. The simulation results demonstrated that the probe was capable of measuring liquid and RI levels simultaneously. Increase the RI, the SPK peak wavelength redshifted, increase the liquid level and decrease the SPR peak intensity [17].

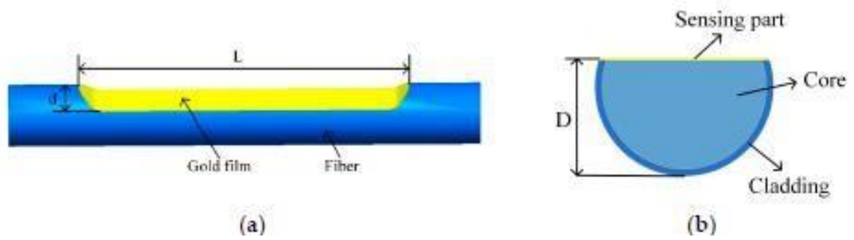

Figure 2-11 (a) Side-polish POF sensing probe schematic (b) Side-polish POF sensing probe cross-section view

2.2.14 Light-Emitting Diodes

Light-emitting diodes (LED) was discovered in early 1990’s. Since that, a lot of research have been done for effects of various light sources. This paper’s authors have found several of case-based reports and brief case series that employ LEDs with four distinct wavelengths. LED consist a semiconductor chip that situated upon a reflective surface. The light will produce when electricity flow into the semiconductor. The wavelength of light that can be produced depends upon the composition of semiconductor chip [18]. My interest in this paper is about blue LED. Blue LED has 400 to 470 nm. The depth of LED light is less than 1 mm. the deepest target the blue LED can go is into the epidermis. Thus, blue LED can cure the acne. Through the blue LED influence on Propionibacterium acnes and anti-inflammatory properties, it seems have an impact on acne. Natural porphyrins, especially coproporphyrin IX that has in P. acnes are thought to produce a natural photodynamic therapy (PDT) effect by absorbing blue light that kills bacteria by generating oxygen free radicals. This cause anti-inflammatory that changes in cytokine production. To conclude this paper, different wavelengths of LED devices have many positive effects, including wound healing, acne treatment, prevent sunburn, phototherapy for facial rhytids and skin rejuvenation. In other words, different wavelength of LED give different function in same fields.

2.2.15 Measurement of Seawater Refractive Index and Salinity by Means of Optical Refraction

This paper has been built and test a compact refractometer for measuring salinity and the refractive index of seawater precisely. The main intention was to measure the water sample's refractive index with precision of 106 refractive index units (RIU). A cylindrical container with 36 mm diameter and an 80 mm height was chosen as size target. The instrument (cuboid and an additional electronic compartments)'s basic concept is a laser beam that transmitted through a prism setup. A water pump is used to transfer the water sample into the compartment. A position sensitive light detector then detects the beam's lateral displacement that varies depending on the water sample's refractive index and thermistor measures the water sample's temperature. Besides, along with the temperature voltage from the thermistor, the photocurrent from the detector is amplified and acquired to a computer. This paper experiments, 10 sample of seawater with a practical salinity ranging from 0 to 36, 10 samples of crystalline sodium chloride dissolved in pure water with a concentration ranging from 0 to 5 g/100g were measured for laser beam displacement and temperature. The samples' refractive index was determine using empirical algorithms. This paper explains four types method to measure refractive index which are refractometer, interferometer, total internal reflection and other techniques. The most method that get my intention is refractometric methods. The laser beam strikes the air-prism interface perpendicularly and travels straight through to the prism sample interface without being refracted. The laser beam forms an incident angle with the interface followed the Snell's law [19]. Snell's law state that the refracted angle differs from the incident angle depending on the refractive index of the prism and the sample [19]. The refracted angle will be smaller than the incident angle if the refractive index of sample is greater than the prism. Thus, the same chronology is happened as laser beam passes through the sample and strikes the prism. To conclude, this paper is determining the refractive index and salinity of seawater and NaCl solutions by built a compact refractometer.

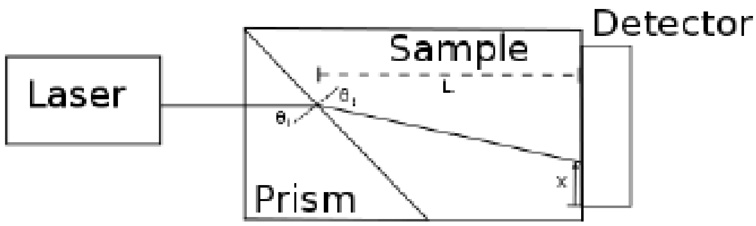

Figure 2-12 Simple refractometric setup

2.2.16 Review of Seawater Fiber Optic Salinity Sensors Based on The Refractive Index Detection Principle

In order to meet the actual measurement demand for seawater salinity in marine environment monitoring, this paper introduce a systematic review of the literature in salinity optic fiber sensors (OPFs) for seawater based on the refractive index (RI) measurement principle, the meaning of seawater salinity and the relationship between RI and salinity. For further examine the development of in situ measurements of absolute salinity by OFSs, the sensing mechanisms, research developments and measurement performance indices of various existing fiber optic salinity sensors are compiled. Comprehensive domestic and international research progress demonstrates that fiber-optic RI sensors have magnificent potential for use in long-term in situ measurements in deep ocean and perfect for real time, in situ measurement of the absolute salinity of seawater [20]. To summarize this paper, the development of the currently available research on RI based fiber optic seawater salinity sensors. A more direct way to determine absolute salinity is to measure the RI of seawater using a fiber optic sensor (TEOS-10). The pros and cons of various research methods as including optical fiber SPR, optical fiber grating, interferometric OFS, hybrid OFS and microfiber are differentiated and compared. This paper also discusses the outlook of OFS salinity sensors as they advance toward applications in marine environment monitoring and the current challenges that need to overcome.

2.2.17 Working Principle of Arduino and Using it as a Tool for Study and Research

This paper examines an Arduino board's operation and potential uses. Plus, it also examines Arduino as potential tool for academic and research endeavors. Arduino board develop an efficient tool of VLSI test bench especially for sensors. The main benefits are simple interface and quick processing. Nowadays technology is creating a new dimension by making complex things seems simple and interesting as more user use an open-source hardware and software. This open-source offer free or low cost, highly dependable and reasonably priced technology. This paper is discussed about the type of Arduino boards, operating concepts, software implementation and applications. Arduino can call as an open-source microcontroller because it is quick, easily programmed, erased and reprogrammed at any time. At first Arduino was created to students, professionals and hobbyist because its easy way and inexpensive. It is also can act as minicomputer like other microcontrollers by accepting inputs and controlling the outputs for a variety electronic device. Plus, it is also capable to receive and send data over the internet with the aid from Arduino shields [21]. There are three types of the Arduino shields those are Arduino Ethernet shield, Arduino Wireless shield and Arduino Motor Driver shield. Each of those Arduino shield have their own functionality. A sketch is the term that used to describe the Arduino program code. The Arduino IDE is the name of the program that used to create the sketches. The feature that include in Arduino IDE are a project need to save with the file name .ino, copy and paste or cut are capable and to find a particular word or to replace it with another can do by pressing Ctrl+F. in this paper also state three application that can use with Arduino which are

ArduSat, ArduPilotMega (APM) and Lilypad Arduino. All in all, this paper studied about the principle of Arduino, its hardware and software features also its application.

Figure 2-13 Arduino Shields – Ethernet, Wireless, Motor Driver

2.2.18 Sensing Using Light: A Key of Sensors

This paper provides a doctrinal conception of sensing using light (SuL) that can be easily used to include any sensing approach using light sciences and technologies [22]. A bottom-up methodology used to quickly introduce the essential specifications of sensing system. Using light techniques, it will be possible to understand a sensor in general and learn about some related topics like the different types and main components of a sensor. When discussing the generation, propagation, control, amplification, detection, storage, processing and other applications of light signals, photonics is understood to be a broad or inclusive field of knowledge that encompasses all of these elements. The development of science, technology and all types of organizations relies heavily on the fields of electronics and photonics. Those have profound effects on the economy and society. The field of photonics can be divided into a number of subfields with sensing based on light or photonics being one of the most important subfields. There are three main components of a photonic sensor that produce representative and accurate electrical signals of the measure on the optical transducer, optical channel and optoelectronic unit [22]. The sensing device becomes a Smart Photonic Sensor when it has intelligence that provide actuation signals. All in all, this article paper introduces a doctrinal conception of sensing using light as an "umbrella" that make it simple to include any method using light sciences and technologies. All the terms, concepts, methods, techniques, technologies and sensing devices that be mentioned in the paper article can take into “umbrella”. By the paper proposal, any method of light-based sensing will be quickly considering inside the photonic sensors.

2.2.19 Measurement of The Degree of Salinity of Water with Fiber-Optic Sensor

In this article paper suggest an application of refractive index sensors to measure the salinity of water. This parameter has been linked empirically to the refractive index and significant biological and environmental interest. Typically, the salinity level is determined by measuring conductivity but optical measurements have some advantages due to fiber-optic sensors’ magnificent properties as well as their potential for integration with the sensor systems [23]. The attenuation of the power transmitted along a fiber as a result of the excitation of surface plasmons in a multilayer structure deposited on the fiber constitutes the physical basis of the sensor. The results of the experiments demonstrate that response of transducer can be modified to achieve linear behavior in the region of interest (refractive index close to 1.33). an empirical algorithm had been used to determine the salinity level. If an optical fiber is side-polished and a thin metallic layer is deposited on it, the coupling with evanescent field of the guided mode results in the surface plasmons in the metallic layer being excited. This effect decreases the power transmitted by fiber, and attenuation is significantly influenced by external medium’s refractive index when it comes into contact with metallic layer. Thus, it possible to measure any change in that index. The effective refractive index of a multilayer structure that is deposited on a fiber is determined by the thickness of the layers and each layer’s refractive indices including external mediums. For an external medium with a refractive index value that aligns effective index of structure with effective propagation index of the mode guided by fiber, maximum coupling and minimal transmitted power are predicted [23]. To determine location and sharpness of that minimum is by structure’s parameters. In conclusion, to demonstrate the device’s suitability for measure the salinity of water, refractive index optical sensor based on surface plasmon excitation need to be used. The accuracy is sufficiently high, the response is linear and the results are repeatable. Besides, any combination of liquids with different refractive index can be used and instrument requires only quick calibration if, the response for any reference is been aware.

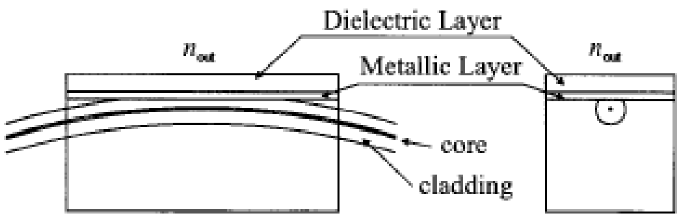

Figure 2-14 Sensor schematic

2.2.20 LED Journal

Light emitting diode (LED) technology has been popular over the past decades. There are a lot of advantages that made it an essential component of modern lighting technology. LED is intended to offer energy-efficient illumination with a longer lifespan. LEDs are very good at producing light and heat. Unfortunately, they perform slightly better at the latter than the former and as technology advances, more lumens are produced per unit of electrical energy. LED need to be cooled in order to maintain the junction temperature within acceptable ranges because can generate heat in addition to photons [24]. Since nearly every performance metric LEDs like efficiency, stability of hue and lifetime, declines as the temperature increase. It is ideal for them to operate at the lowest temperature possible. Circuit boards with very low thermal resistance should be used between semiconductors and the LEDs are cooled by conduction. In conclusion, LED technology produce heat that can cause eggs to cook. The heat is produced from electricity. Heat is produced as electricity is supplied to the bulb. However, compared to an incandescent bulb, the heat produced by LEDs is significantly lower. A 100-watt GLS incandescent bulb uses energy that results in the production of 12% heat, 83% IR and 5% visible light. On the other hand, the average LED emit 15% visible light and 85% heat. It is crucial to remove this heat through effective thermal management, particularly with high power LEDs.

2.3 Summary of Related Work

NO	TITLE	AUTHOR	PLATFORM	COMPONENTS	PURPOSE	ADVANTAGE	DISADVANTAGE
1	Salinity	Encyclopaedia Britannica, Inc	Salinity	-	-Introduction about ocean and freshwater salinity and effects of excess salinity.	-Saline water has higher electrical conductivity, higher density, lower freezing point and lower specific heat capacity.	-Only focus on salinity in ocean and freshwater.
2	Determination of salt concentration in water using decision trees and electromagnetic waves.	Ebru Efeoglu and Gurkan Tuna	Hoeffding tree algorithm	VNA and antenna	-To determine the salt concentration of water by using four different type of decisions tree algorithms.	-Salt concentration can be measured by electromagnetic waves. -It is low-cost system.	-Focus on evaluate the success of different decision tree algorithms for the most suitable one for salinity detection. -Can deliver uncertain results when concentration of salinity is below 5%.
3	Remote monitoring of water salinity by using side-polished fiber-optic U-shaped sensor	Dragan Z. Stupar, Jovan S. Bajić, Ana V. Joža, Bojan M. Dakić, Miloš P. Slankamena, Miloš B. Živanov, Edvard Cibula	Microcontroller	Fiber-optic sensor	-Using fiber-optic U-shaped sensor to remote measurement of water salinity.	-Simple -Flexible -Cheap	-Bending of optical fiber causes loss of optical power and reduces sensor performance.

4	Density, Temperature and Salinity	University of Hawaii	Salinity	-	- Give understanding on how salinity and temperature variations impact the density and buoyancy of ocean water layers.	-More salt dissolved in water, greater the salinity.	-Focus on general relationship between density, temperature and salinity
5	Arduino Uno-Based water turbidity meter using LDR and LED sensors.	A.P.U. Siahaan, Nogar Silitonga, Muhammad Iqbal, Solly Aryza, Wirda Fitriani, Zuhri Ramadhan, Zuraidah Tharo, Rusiadi, Rahmad Hidayat, H. A. Hasibuan, M. D. T. P. Nasution, Ali Ikhwan, Zulfi Azhar, Mhd. Irwan, Dwitama Harahap	Arduino	Arduino Uno, LED (light source)	-Using Arduino Uno to measure water turbidity value.	-Arduino UNO as data processing -LED as light source to measure water turbidity. -Amount of light scattered depends on concentration and distribution of particle size.	-Focus on measure turbidity of water.
6	Measuring Salinity of water	Laqua	Salinity	Sensors	- To measure the level of salinity in water for aquatic organisms, farm animal and agriculture at a variety of salty levels	-Salinity affects the dissolved oxygen levels in water. - Increase the salinity will decrease oxygen solubility in water.	-Not specified the sensor that had been used.

7	Refractometric Fiber Optic Sensor for Detecting Salinity of Water.	Supriya S. Patil, Arvind D. Shaligram	MATLAB	Fiber optic sensor	-Refractometric fiber optic sensor for detection of salinity of water. The mathematical model is developed and simulated using MATLAB.	-The Z value is useful to optimize gap length to detect various refractive index.	-Using MATLAB is costly. -Fiber optic sensor is pricey.
8	Designing and modelling of Arduino based light sensor	Deepak Kumar, Lovepreet Singh, Gagandeep Singh Virdi, Gurleen Singh, Harpreet Kaur Channi	Arduino	Light sensor	-Using Arduino light sensor to detect exposed light.	-converts light energy to electrical signals. -measure radiant energy present in the wide range of frequencies in the light spectrum.	-need to calibrate the light based on condition.
9	Combined Theoretical and Experimental Study of Refractive Indices of Water−Acetonitrile−Salt Systems	Ni An, Bilin Zhuang, Minglun Li, Yuyuan Lu, and Zhen-Gang Wang	Salinity	-	-A simple theoretical formula of describing the refractive indices in binary liquid mixtures containing salt ions.	- Increase anion will increase refractive index	-Focusing on theoretical of refractive indices of water.
10	Measurement of refractive index of liquids using fiber optic displacement sensors	Gobi Govindan, Srinivasan Gokul Raj, Dillibabu Sastikumar	Microcontroller	Fiber optic sensor	-Telling the method to determine the refractive index of liquids using a reflective type fiber optic displacement sensor.	-High sensitivity of fiber optic sensor. -Simple method.	-Focusing on certain solution to determine salinity levels.
11	Relationship between Refractive Index and Molar Concentration of Multi-Component Solutions	Zhu Xingyu, Mai Tiancheng and Zhao Zilong	Molar concentration	-	-Using Snell's law's refractive index correlation to determine CuSO4-NaCl-H20 solution's refractive index.	-Focusing on concept of refractive index by Snell's law.	-To general about molar concentration. -Lab experiment.
12	The relationship between the Salinity of water and the Refractive index of water	Bartu Or	Salinity	-	-Discussing about the effect on refractive index from various salinity of water.	-Temperature, pressure and volume of water are affect the refractive indexes.	-There is no electronic component is using in the experiment.

13	Side-Polish Plastic Optical Fiber Based SPR Sensor for Refractive Index and Liquid-Level Sensing	Chuanxin Teng, Shiyuan Ying, Rui Min, Shijie Deng, Hongchang Deng, Ming Chen, Xiaoxue Chu, Libo Yuan, Yu Cheng and Minmin Xue	Microcontroller	SPR sensor	-A simple POF-based SPR sensor for demonstrate the simultaneous measurement of refractive index (RI) and liquid level.	-Easy fabrication -Simple structure. -Low cost.	-Specification about refractive index level in liquid-level sensing.
14	Light-emmiting diodes	Daniel R. Opel, Erika Hagstrom, Aaron K. Pace, Krisanne Sisto, Stefanie A. Hirano-Ali, Shraddha Desai and James Swan	LEDs	LEDs	-The authors identified several case-based reports, small case series that use four different wavelengths of light-emitting diodes.	-Explanation about each LED colours. --Blue LED light has maximal penetration of up to 1mm.	-Focusing LEDs for face skin treatment.
15	Measurement of seawater refractive index and salinity by means of optical refraction.	Oyvind Aasen Tengesdal	Microcontroller	Laser, prism, PSD	-The aim of the work has been to construct and test a compact refractometer for accurate measurement of seawater refractive index and salinity.	-Comparing the methods to measure the refractive index.	-In plane mirror some energy is absorbed inside.
16	Review Of seawater fiber optic salinity sensors based on the refractive index detection principle.	Gaochao Li YongjieWan, Ancun Shi, Yuanhui Liu and Fang Li	Microcontroller	Optical fiber sensor	-Introduce a systematic review of the literature in salinity optic fiber sensors (OPFs) for seawater based on the refractive index (RI) measurement principle, the meaning of seawater salinity and the relationship between RI and salinity.	-weighing nor chlorine titration can be used for in situ measurement. -Conductivity method is widely used.	-High temperature compensation of the sensor and has problem with long term zero drift. -highly sensitive to external RI.

17	Working Principle of Arduino and Using it as a tool for study and research.	Leo Louis	Microcontroller	Arduino	-Explores the working principle and applications of an Arduino board.	-Easily programmed and erased -reprogrammed at any instant of time -inexpensive	-limited memory storage
18	Sensing using light: A key of sensors	Jose Miguel Lopez-Higuera	Microcontroller	Photonic sensors	-Offers a Doctrinal Conception of sensing light as “umbrella” in which any sensing approach using Light Science and Technologies can be easily included.	-Returning object consequence of the interrogation light -Produced as a consequence of a pumping light	-Presence cut-off frequency. -Absent of lag time. -Can get radiation.
19	Measurement of the Degree of Salinity of Water with a Fiber-Optic Sensor	Oscar Esteban, Maria Cruz-Navarrete, Agustı´n Gonza´lez-Cano, and Eusebio Bernabeu	microcontroller	Fiber-optic sensor	-In this paper we propose an application of these refractive-index sensors to determine the degree of salinity of water. This is a parameter of great bio- logical and environmental interest, and its relation with the refractive index has been established empirically.	-high level accuracy -low cost -small size	-development the reliability of the sensor is not yet same as that conductivity meter mainly because of problems of repeatability associated with stability of source.
20	LED Journal	Fardin	Microcontroller	LED	-Illustrate on how LED can be demanding device and their ability to scale the manufacturing.	-saving cost -Carbon dioxide emissions reduction -Save energy	-Focus on marketing of LED and wisely usage of LED

2.4 Summary

To summarize, using the laws of refraction, the salinity level in water can be determined. Light undergoes refraction as it travels through a medium and is refracted by another. The refractive index of the two mediums establishes the amount of bending. The angle of refraction varies with the salt level because the refractive index of water varies with salinity level. Different light sources, such as LEDs (Light Emitting Diodes) and lasers, can be utilized for the project, each with their own set of benefits and limitations. They emit a wider range of colors of light, which might be useful in some contexts. Lasers, on the other hand, generate extremely coherent and powerful light. This indicates that the light waves are in phase with one another and that there is a high concentration of light. This can lead to more precise and accurate refraction measurements. Lasers, in contrast to LEDs, are often more expensive and wear out faster. When travelling from one medium to another, both LED and laser light will undergo refraction. The coherence and intensity of the light make a difference and both can affect the reliability of the measurements. LED is selected because it best addresses the problem statement and objectives of the project.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter will provide a rough explanation of the research methodology and the reasons behind the chosen approach. The project will commence with the utilization of a specific approach. This will be followed by the application of various tools and methods until the project reaches its completion. The chapter will also shed light on the process flow and design requirements necessary for the development of this project.

3.2 Flowchart

Project planning, which is regarded as the most important aspect, is heavily relied upon to ensure the successful completion of this project. Proper organization must be prioritized and stresses in order to ensure project development success and reduce obstacles along the way. It is imperative to create a systematic flowchart with a clear objective in mind, enabling the project to be completed within the designated timeframe. The flowchart presented in the figure 3.1 below illustrates the progression of the bachelor degree project, which is divided into two phases, Bachelor Degree Project I (BDP I) and Bachelor Degree Project II (BDP II). The initial step was to identify and approach a suitable supervisor who could guide throughout the project. The involved researching and reaching out to potential supervisors who had expertise in the field of study and project area. Once, secured the supervisor, we worked together to determine an appropriate project title. This involved considering my interests, the supervisor’s expertise and the relevance of the topic within my field.

With the project title in place, the next step was to clearly define the problem statement. This required to specify the issue or challenge that wanted to tackle with the research. It also needed to set up specific objectives that described what wanted to accomplish with the project. Conducting a comprehensive literature review was crucial in gaining an understanding of existing research and knowledge relevant to the project. This step involved familiarizing with the state of knowledge in the field by reading scholarly books and article. Once a solid understanding of existing research, proceeded to develop the methodology for the project. This included determining the project layout, system hardware design, flowchart of coding and estimated cost. Last step for the BDP I process was established the expected results and outcomes of the project.

For BDP II, the initial step involved designing and building the hardware system required for the project. this entailed selecting and assembling the necessary components according to the project's requirements and specifications. Once the hardware system was in place, the subsequent step was to develop the software code that controlled and interacted with the hardware components. The coding process also involved integrating the software with the hardware system, resulting in a cohesive working unit. It was essential to thoroughly test the design following the completion of the coding and its integration with the hardware. This required executing a number of test scenarios and simulations to confirm the project's functionality, performance and reliability. To find and fix any potential problems, bugs or errors in both the hardware and software components, testing was crucial. The next step was to compile and examine the results after the design had successfully passed the testing phase. In order to do this, data from experiments carried out as part of the project had to be gathered. Following collection, the data was subjected to analysis using the proper statistical or analytical methods. The objective was to draw conclusions and evaluate the project's performance in relation to its objectives.

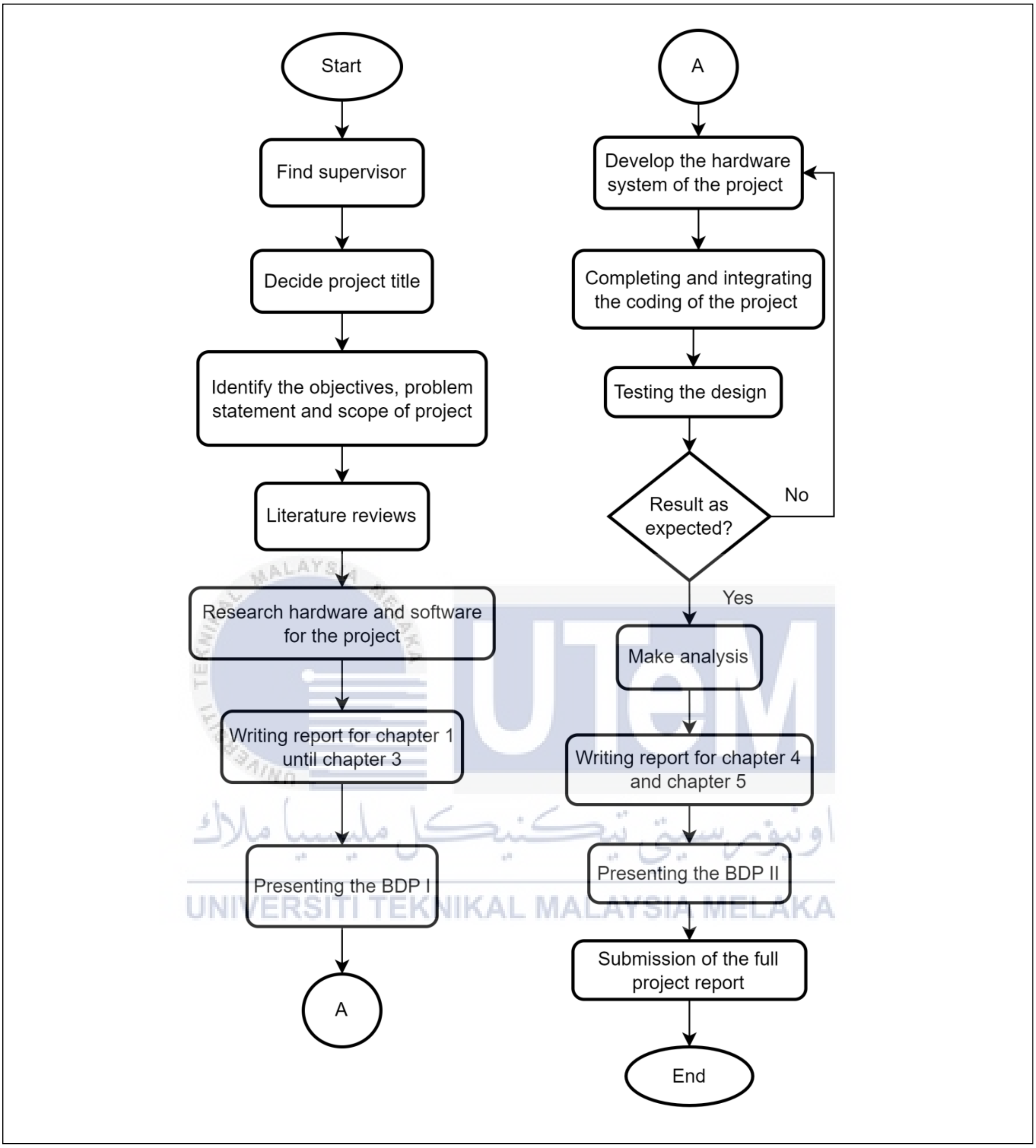

Figure 3-1 Flowchart for overall Bachelor Degree Project (BDP I and BDP II)

Table 3-1 Gant Chart for BDP I

PROJECT PLANNING PSM I																				
PSM 1	March		April				May				June					July				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Proposed Project • Find supervisor • Decide project title • Identify the objective, problem statement & scope of project • Find project related for literature review	PSM BRIEFING					MIDTERM BREAK										STUDY WEEK	FINAL EXAM		SEMESTER BREAK	
Research for Software and Report • Learning Arduino and hardware for the project • Chapter 1: Introduction • Chapter 2: Literature Review • Submission of 1st Progression																				
Selection of Software and Database Used • Chapter 3: Methodology • Finalize hardware • Design Expected Project Results																				
Project deliverable • Completing report • Slide presentation preparation • Presentation to SV • Submission final report																				

Blue box: Expected Progress, Fill Grey: Actual Progress

Table 3-2 Gant Chart for BDP II

PROJECT PLANNING PSM II																				
PSM 2	October				November				December				January					February		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Develop the hardware • Testing each of the components • Integrate components into a complete circuit • Solder components on PCB board • Test functionality	PSM 2 BRIEFING							MIDTERM BREAK								STUDY WEEK	FINAL EXAM		SEMESTER BREAK	
Results • Collecting all data • Generating all the data into graphs • Analysis the graphs • Submission of 1st Progression																				
Conclusion • Concluding Chapter 2 to 5 • Including SDG in Chapter 5																				
Project deliverable • Thesis writing and correcting • Slide presentation preparation • Presentation to SV • Thesis Binding																				

Blue box: Expected Progress, Fill Grey: Actual Progress

3.3 Milestone of BDP I & II

The completion of a major task or section of the project is marked by a milestone on the project's timeline. In order to successfully manage a project and keep schedule, milestone must be established.

Table 3-3 Milestone BDP I

Num	Task Name	Start Date	End Date	Duration
1	Briefing	20/3/2023	24/3/2023	5 days
2	Project Finding	27/3/2023	31/3/2023	5 days
3	Chapter 2: Literature Review	3/4/2023	7/4/2023	5 days
4	Understanding Existing System	10/4/2023	14/4/2023	5 days
5	Chapter 1: Introduction	17/4/2023	21/4/2023	5 days
6	Submission of 1st Progress	1/5/2023	5/5/2023	5 days
7	Understanding Existing System	8/5/2023	12/4/2023	5 days
8	Discuss with SV about project	15/5/2023	19/5/2023	5 days
9	Chapter 3: Methodology	22/5/2023	26/5/2023	5 days
10	System Requirement	29/5/2023	2/6/2023	5 days
11	Design the Project	5/6/2023	9/6/2023	5 days
12	Submission of 2nd Progress	12/6/2023	16/6/2023	5 days
13	Preparation for Report and Slide Presentation	19/6/2023	23/6/2023	5 days
14	Presentation of PSM 1	26/6/2023	30/6/2023	5 days

Table 3-4 Milestone BDP II

Num	Task Name	Start Date	End Date	Duration
1	Briefing	9/10/2023	13/10/2023	5 days
2	Weekly Meeting with SV	16/10/2023	20/10/2023	5 days
3	Methodology	23/10/2023	27/10/2023	5 days
4	Result & Analysis	30/10/2023	3/11/2023	5 days
5	Report Writing	6/11/2023	10/11/2023	5 days
6	Submission of 1st Progress	13/11/2023	17/11/2023	5 days
7	Hardware problem	20/11/2023	24/11/2023	5 days
8	Discuss with SV about project	4/12/2023	8/12/2023	5 days
9	Report Writing	11/12/2023	15/12/2023	5 days
10	1st Draft Report to SV	18/12/2023	22/12/2023	5 days
11	Report Writing	25/12/2023	29/12/2023	5 days
12	Submission of 2nd Progress	1/2/2024	5/1/2024	5 days
13	Submission BDP Report to Panels	8/1/2024	12/1/2024	5 days
14	Presentation of PSM II	15/1/2024	19/1/2024	5 days
15	Submit Final Report	8/2/2024	12/2/2024	5 days

3.4 Hardware and Software Development

3.4.1 UNO R3 Board

Figure 3.2 depicts that the Atmega328P-based UNO R3 board is a popular microcontroller board. It is a component of the Arduino ecosystem and is extensively used for prototyping and developing electronic projects.

Figure 3-2 UNO R3

3.4.2 1602 Display

Figure 3.3 is a 1602 display, also refferred to as a 16x2 character LCD (Liquid Crystal Display), is a common alphanumeric display module with a resolution of 16 columns by two rows. It consists of a backlit LCD panel and a display-controlling integrated circuit (IC).

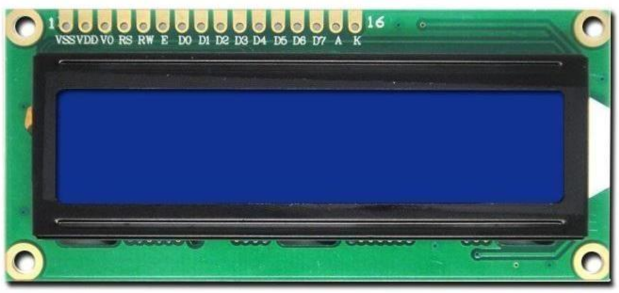

Figure 3-3 1602 Display

3.4.3 Arduino IIC I2C

The 2x16 Character LCD is a widely used display component for small controllers such as Arduino. However, it is worth noting that most of these LCDs utilize a parallel interface. Typically, 10 pins are required for controlling or displaying messages on it. The 8-pin connectors are used for transmitting data, while the Enable and Latch pins are responsible for controlling the signal. At a minimum, you will want a 6-pin interface for the 4-bit mode. There is still a significant depletion of pins. Figure 3.4 is an Arduino IIC I2C module for LCD enables the conservation of valuable pins. This module requires only 2 GPIO pins, namely I2C pins, in order to transmit messages to a Character LCD.

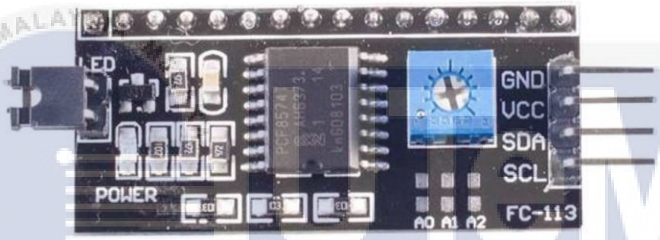

Figure 3-4 Arduino IIC I2C

3.4.4 Blue LED

When an electric current travels through blue Light Emitting Diode (LED) as Figure 3.5, light is emitted. The wavelength of the blue LED determines its colour which is between 400 nanometers.

Figure 3-5 Blue LED

3.4.5 Light Detector

Figure 3.6 is a Light Dependent Resistor (LDR), also referred to as a photoresistor that exhibits a decrease in resistance when exposed to light. It is commonly employed to determine whether it is daytime or nighttime, as seen in the case of automatic automobile porch lights. The sensor is nonlinear, meaning that its resistance can reach up to 500K ohm when not exposed to light. However, under regular room conditions, the resistance typically ranges from 10 to 20K ohm when the light is not illuminated. Upon activation of light, the resistance decreases to 1 kiloohm or below.

Figure 3-6 LDR

3.4.6 Resistors

A resistor is an electrical component with two terminals that serves as a passive circuit element by providing electrical resistance. Resistors are employed in electronic circuits to diminish current flow, regulate signal levels, divide voltages, bias active components, and terminate transmission lines, among various other applications. For the BDP, resistors 220 ohm and 10k ohm were used.

Figure 3-7 Resistor 220 ohm

Figure 3-8 Resistor 10k ohm

3.4.7 Green PCB

These 5x7cm perforated prototyping boards are ideal for the development of your circuit. This board allows for soldering on both sides. This is a solderable printed circuit board (PCB) built of FR4, which is a high-quality material composed of glass and epoxy.

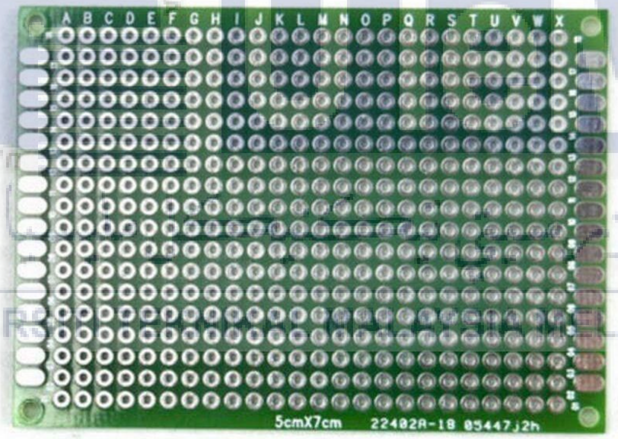

Figure 3-9 Green PCB

3.4.8 Jumper Wires

Figure 3.10 is a jumper wires. It is to establish temporary connections between electronic components on a breadboard or other prototyping platforms. It utilized frequently in electronic tasks, circuit design and prototyping.

Figure 3-10 Jumper wires

3.4.9 Wires

Wires are connected onto a printed circuit board (PCB) to establish electrical conductivity between two devices in an electrical circuit. They have extremely low resistance to the flow of electric current.

Figure 3-11 Wires

3.4.10 Solder Lead

Solder wire is a slender and pliable metal strip that is used for soldering. It is commonly employed to establish electrical connections between metal components and PCBs (printed circuit boards). Solder wire can be utilized independently or in combination with solder paste, a compound that includes flux, a chemical that facilitates the elimination of oxidation from metals during the soldering process. In addition to its melting point, the presence of lead in the solder plays a crucial role in improving both mechanical strength and electrical conductivity. Ensuring effective current flow and withstanding mechanical stress is very crucial in electronic applications, particularly in soldered connections.

Figure 3-12 Solder Lead

3.4.11 Glass Beaker 10ml

Figure 3.13 is a 10 ml glass beaker. It is a lab container made of glass that can accommodate up to 10 mililitres (ml) fo liquid. Beakers made of glass are frequently used in scientific experiments and other laboratory procedures.

Figure 3-13 Glass beaker 10 ml

3.4.12 9V Battery Connector

The 9V Battery Connector consists of a snap on one end for the 9V battery, and a standard DC jack (2.1mm) on the other end. If you are utilizing a 9V battery to supply power to your Arduino board, this cable will prove to be convenient and ideal for your needs. The positive terminal of the DC barrel plug is located at the center pin, while the negative terminal is located on the outer barrel. This configuration makes it compatible with Arduino's DC barrel jack. The battery securely attaches to the connector and is equipped with 110mm cables, providing sufficient flexibility for battery positioning without occupying excessive space within your enclosure.

Figure 3-14 9V Battery Connector

3.4.13 PCB Standoff Spacer

Spacers and standoffs are crucial categories of fastener accessories. These are specifically engineered to raise the PCB above the surface and are employed to establish gaps of space between two or more connected surfaces or components.

Figure 3-15 PCB Standoff Spacer

3.4.14 Storage Box

Figure 3.16 depicts a storage container designed for holding the hardware components of my project. The advantage of my project is its portability.

Figure 3-16 Storage Box

3.4.15 Arduino IDE version 2.1.0

The Arduino IDE is a software platform that simplifies Arduino microcontroller programming. It provides an intuitive interface for composing, compiling, and uploading code to Arduino boards. The integrated development environment (IDE) includes a code editor with intuitive syntax highlighting and error checking. It also offers a library manager for simple installation and administration of code libraries. The integrated board manager guarantees compatibility with various Arduino boards. You can communicate with the board, monitor sensor readings, and debug your code using the serial monitor. Using the upload manager, uploading your code is simple. The IDE contains a vast library of example codes and tutorials for learning and reference purposes. Tools for debugging, such as breakpoints and variable monitoring, aid in locating and fixing code errors. Figure 3.17 Arduino IDE is available for multiple operating systems, is open-source, and is suitable for both novice and advanced users.

Figure 3-17 Arduino IDE

3.5 Project Layout

When talk about a project layout, it is referring on how different components and elements are arranged and organized within a simulation environment. The placement of objects, machinery and other important components as well as the physical and virtual aspects of the project being simulated are included in this layout. Recreating a real-world scenario or system that the project intends to model or simulate is the main objective of the simulation layout. This gives the project a visual and spatial representation, allowing users to interact with and take in simulated environment.

Figure 3.18 show the project simulation layout. Refraction was observed as the bending of light when it passed from one medium to another with a different optical density. In this project, we observed the salinity in water via refraction by looking at the LDR readings on the LCD. The blue LED (Light Emitting Diode) as a light source to illuminate the water. The blue LED emitted light to provide illumination for the different water concentration. LDR (Light Dependent Resistor) utilized to detect the intensity of light that passed through the water. The LDR measured the intensity of light as it interacted with the different water concentration. A 10ml glass beaker used and placed in between of blue LED and LDR to fill the different concentration of water. The project was controlled by the Arduino Uno which served as a microcontroller board. It processed data it received from

LDR to determine the salinity level. The salinity readings were shown on an LCD (Liquid Crystal Display).

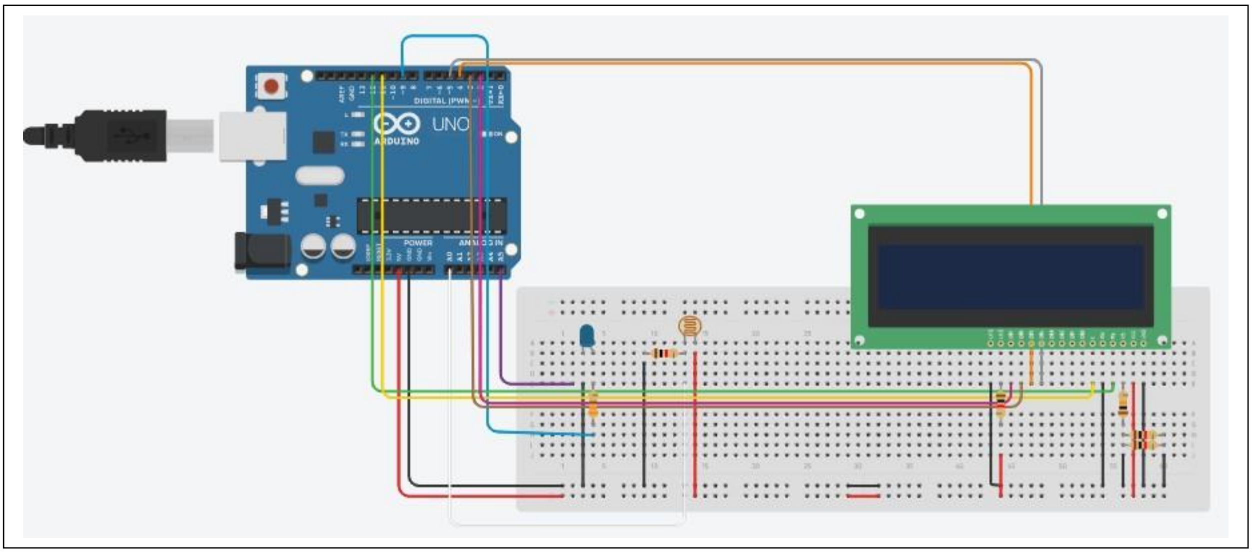

Figure 3-18 Project simulation layout

3.6 System Hardware Design

The creation and planning of a computer systems or electronic device's overall physical structure and components is known as system hardware design. In order to achieve the desired functionality and performance objectives, it includes tasks like figuring out the hardware requirements, carefully choosing the right components and designing the system's architecture. To provide an explanation figure 3.19 of the block diagram for the project employed the following components and their respective connections. LED served as the light source responsible for illuminating the water samples. LED connected to a digital pin on the Arduino Uno. Through the Arduino Uno, LED controlled by sending signals to turn in or off. LDR acted as the sensor that detected the intensity of light as it passed through the water. By processing the analog values received from the LDR, the Arduino Uno furthered the data analysis.

Arduino Uno functioned as the microcontroller board that controlled the project and processed the data. It received the analog values derived from the LDR's measurements. The

Arduino Uno performed calculations to determine the salinity level via its processing power. It also dynamically controlled the LED's behavior such as turning it on or off. The measured of light that refracted from water samples readings were transmitted by the Arduino to the LCD for visual display. LCD served as the display module that presented the salinity readings in a visually accessible format. A necessary connection to interface the LCD with the Arduino Uno. The amount of light that refracted from water samples readings were seamlessly transmitted from the Arduino Uno to the LCD. The LCD displayed the readings visually.

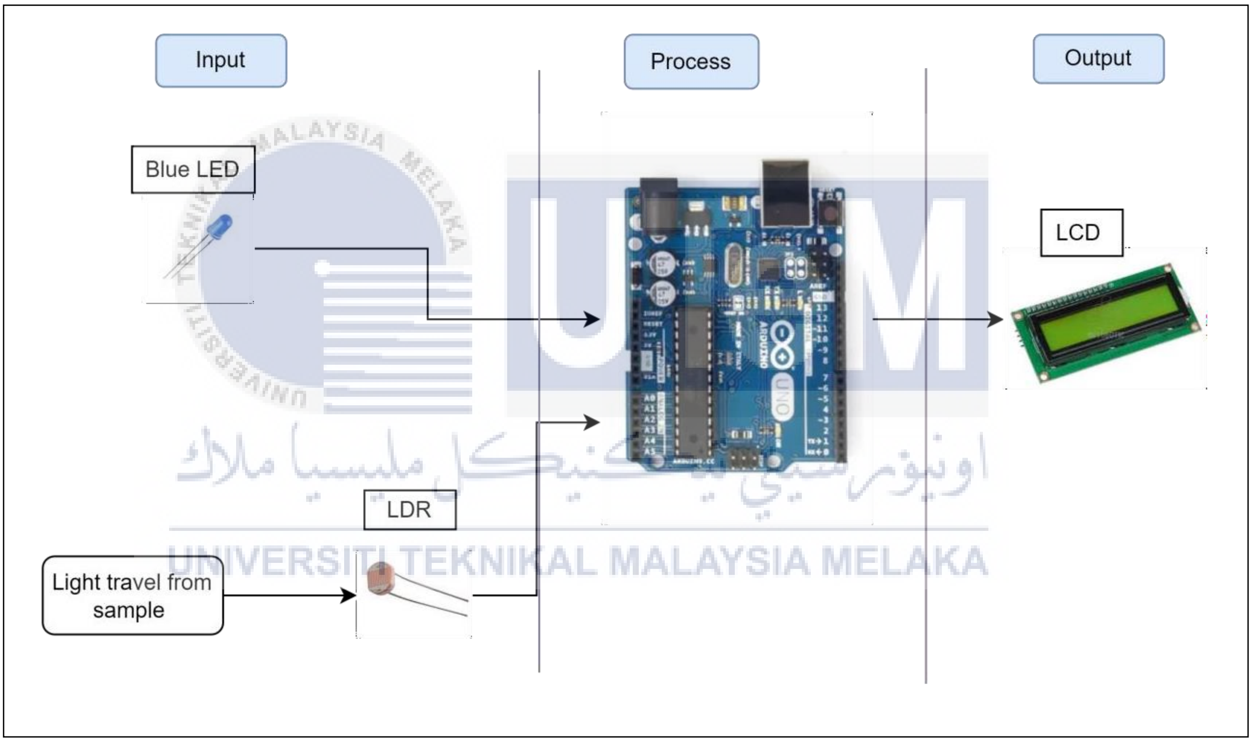

Figure 3-19 Block diagram of the project

3.7 Flowchart of Coding

A flowchart is a type of diagram that displays the various steps and their relative priority in an algorithm or program. To show how the code develops and where decisions are made, various symbols and connection are used. Here's an explanation of the figure 3.20 flowchart of the coding. To start the coding, need to define all the sensors which are LED, LDR and LCD to their pin and choose the suitable library for the project coding. Next, LED and LDR are initialized to zero to avoid logical errors that hard to debug certain time. Blue LED emit the light towards the 10ml glass beaker that contain the different water concentration. The light that travels from 10ml glass beaker is detected by LDR sensor. Lastly, the LCD display the value of light travel that had been measured by LDR.

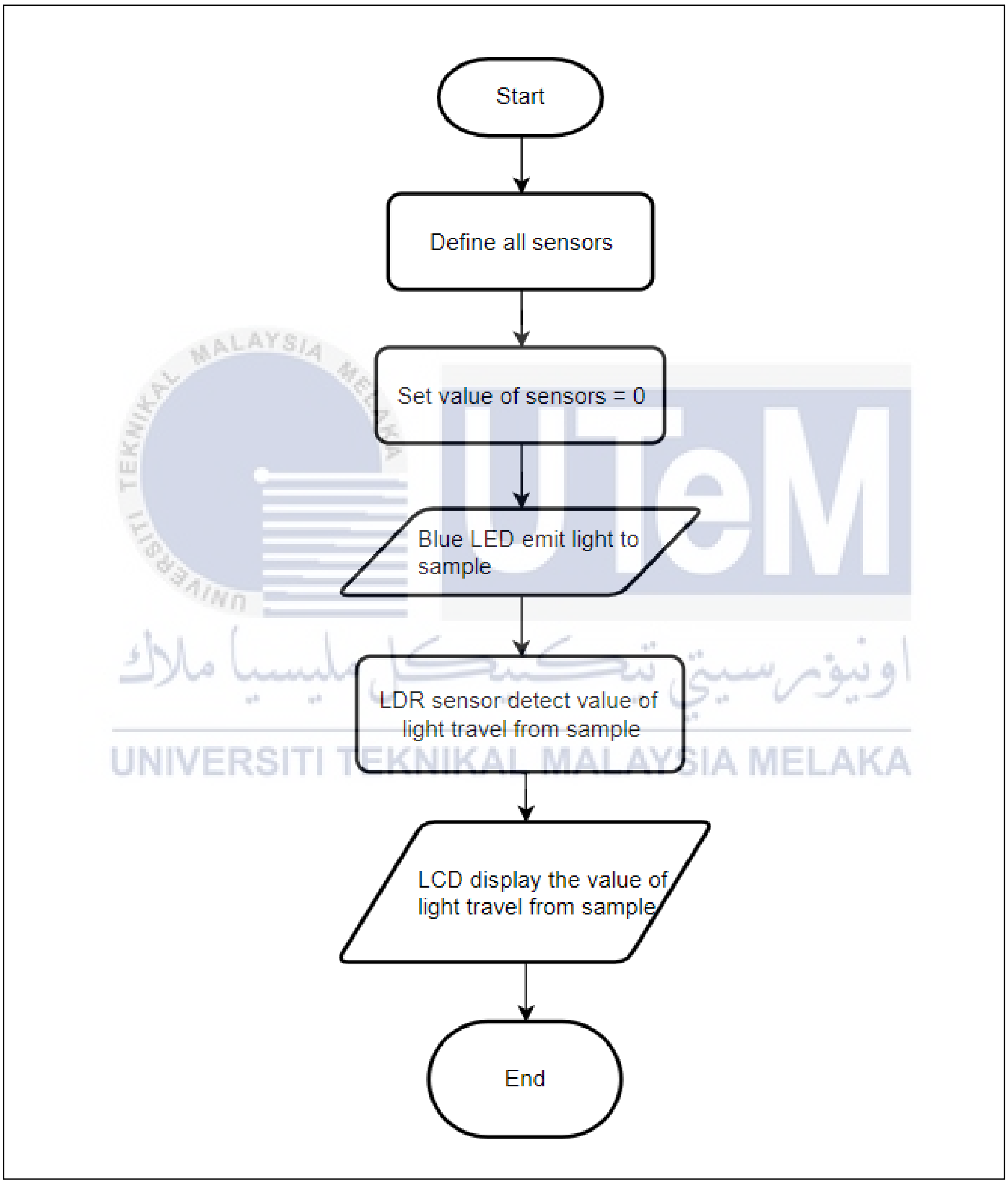

Figure 3-20 Flowchart of the coding

3.8 Project Prototype

A prototype is an initial iteration, model, or version of a product that is constructed to evaluate a concept or procedure. Typically, it is employed to authenticate the design and functionality of the product and collect feedback from end-users prior to committing to large-scale production. Additionally, it aids in the formulation of specifications for the final product.

Figure 3.21 represents the prototype of my project. As depicted in the diagram below, a storage box has been utilized to organize and store all the components, resulting in a more organized arrangement. The components had been attached to the storage box using PCB standoff spacers. Furthermore, a hot glue gun was utilized to attach the 9V battery holder. The Arduino UNO and battery were positioned next to one another for the purpose of facilitating the power supply. Positioning the LCD screen faced to outside of the storage box enhances the easy of reading the dBm measurement. The LCD was connected to the Arduino using the IIC I2C protocol, which reduces the number of wires needed by using a two-line SDA and SDC connection. The blue LED and LDR were mounted on the PCB. The blue LED was linked to a digital pin in order to detect the existence of a high or low voltage level, while the LDR was attached to an analog pin to provide an analog voltage that can be converted into a digital value. The beaker was positioned between the Light Dependent Resistor (LDR) and the blue Light Emitting Diode (LED).

Figure 3.22 depicts a flowchart illustrating the project. Once receiving power, the Arduino UNO will activate the blue LED, enabling it to emit light. The LDR will analyze the light sample by passing it through the sample. If a detection occurs, the LCD will exhibit the dBm value of the light that has traveled from the sample. Otherwise, the process will continuously repeat to emit the blue LED light.

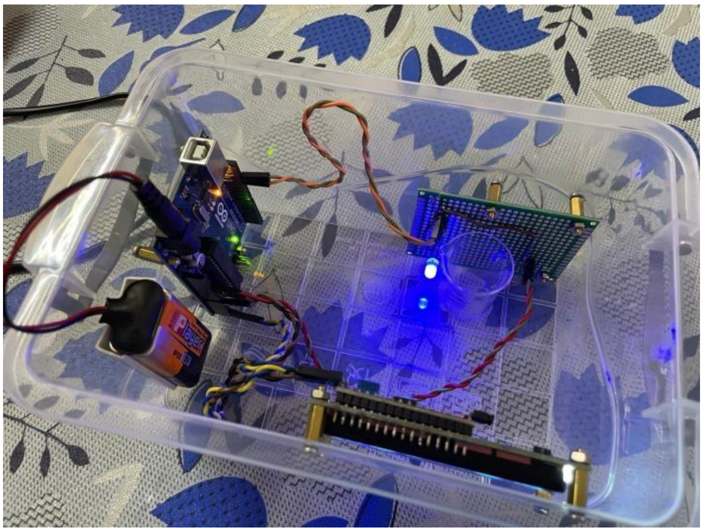

Figure 3-21 Project layout

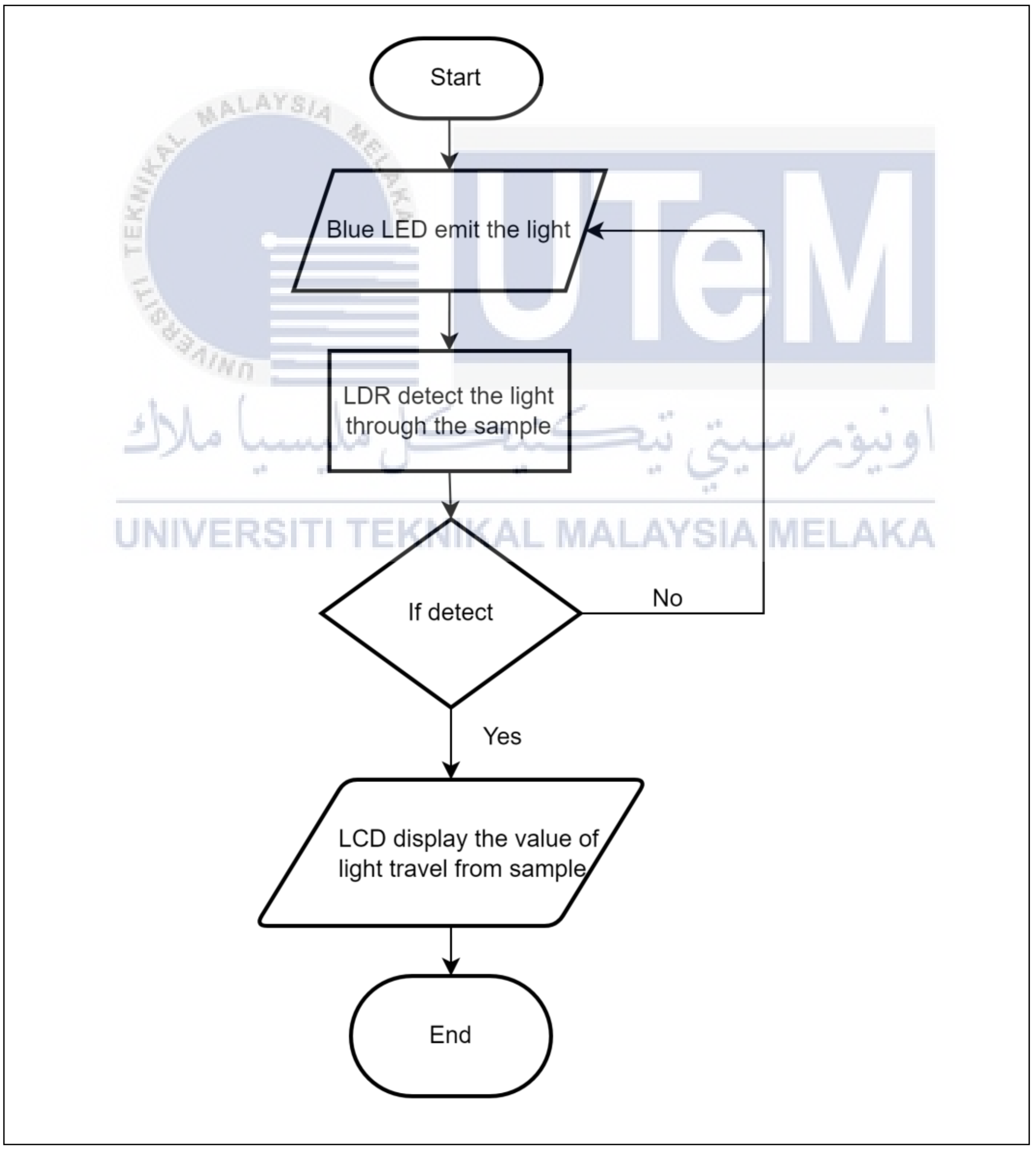

Figure 3-22 Flowchart of project

3.9 Estimated Cost

Table 3.6 shows estimated cost of the project. The components required for the project are an Arduino Uno R3, a 1602 LCD, a blue LED, a 10ml glass beaker, a LDR, a jumper, a breadboard and transistors for 330 ohm, 1k ohm and 10k ohm. All of those components can be found through Shopee and electronic components shop. The total price needed for the project is RM 78.18 through Shopee website excluded postage fee. This total price might vary if buying from the store or when there is short circuit happen that need to replace the existing components. Considering the potential benefits and available resources, the estimate cost of the project is affordable and manageable. It is also significantly less expensive than alternatives, making it a cost-effective choice for the project.

Table 3-5 Estimating cost of the project

NUM	COMPONENT	UNIT	PRICE PER UNIT (RM)	PRICE (RM)
1	UNO R3 Board	1	38.38	38.38
2	1602 Display	1	7.00	7.00
3	Arduino IIC I2C	1	6.50	6.50
4	Blue LED	1	0.10	0.10
5	Resistor 220 ohm	1	0.10	0.10
6	LDR	1	1.00	1.00
7	Resistor 10k ohm	1	0.10	0.10
8	Green PCB	1	1.90	1.90
9	Jumper	1	2.70	2.70
10	Wire	1	1.00	1.00
11	Solder Lead 0.8mm	1	8.90	8.90
12	Glass beaker 10ml	1	21.00	21.00
13	9V Battery Connector	1	1.00	1.00
14	PCB Standoff Spacer	11	0.70	7.70
15	Storage Box	1	2.40	2.40
Total				**99.78**

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the outcomes and analysis of the development of salinity level of water sensor via blue LED detections are detailed. Sequentially, the project was developed in accordance with the established methodology. The project will generate three distinct types of graphs namely, stability, linearity, and repeatability to illustrate the overall performance of the blue LED. Each graph utilized scattered plotting.

Variation that occurs when the same component is measured multiple times with the same instrument is known as repeatability. The repeatability graph for this project represents the blue LED sensor's ability to consistently produce the same output under identical conditions and when exposed to the same input for an extended duration and across multiple tests. This quantifies the degree of accuracy exhibited by the blue LED. A sensor must possess a high degree of repeatability in order to produce the same output consistently when the same input is received. The quality of high repeatability is highly desirable in a sensor. To ascertain the repeatability graph for this undertaking, it is necessary to execute the project thrice to mitigate the extent of error.

A linear graph show how two things are related in a straight line on the coordinate plane. A linear relationship is one in which a one-unit change in the independent variable causes the dependent variable to change by a set amount. These linear equations also show these relationships and can help figure out what the linear graph is telling. The term “linearity” graph refers to how well the output response of a blue LED sensor correlates to the input across the entirety of the sensor’s range of operation. If the value of the input parameter in an ideal linear blue LED sensor is doubled, then the value of the output will also be doubled. From the graph, performance of sensitivity and linearity can be analyzed. The sensitivity value, m gets from the gradient of the line. The m is come from the formula $y = mx + c$ which the equation of straight line. The linearity, R will get from the equation:

$$R^2 = x$$

$$R = \sqrt{x} \times 100\%$$

The stability graph is a good way to show the modes of a structure being tested and figure out what they are. The stability graph is the usual way to figure out what the modal parameters are. The physical poles (modes) of the structure being tested will be marked on the stability with the same or very close values. For this project, the capacity of a sensor to keep its performance parameters constant over the course of its lifetime is referred to as its stability. When a consistent input is applied over an extended period of time, a stable sensor will have very little drift in its output throughout that time. Alterations in temperature of the sensor components are one of the many elements that have the potential to influence stability. The stability graph for this project will be generated after one hour.

For this project, five types of commonly consumed samples were utilised, including rainwater, coway, pipe water, spritzer, and evian water. The Total Dissolved Solids (TDS) concentration in the rainwater is 20 milligrammes per litre (mg/L)[25]. Coway water is available in three distinct types: alkaline, reverse osmosis (RO), and mineral. For the project, has selected a reverse osmosis (RO) system with a total dissolved solids (TDS) value of 5mg/L[26]. This occurs due to a significant decrease of 92.6% in minerals and heavy metals. The TDS value of Spritzer water is 345mg/L[27], whereas Evian has a TDS value of 357mg/L[28]. The final sample consists of water from a pipe, which contains a concentration of 1000mg/L[29].

4.2 Sensor Performance of Rainwater

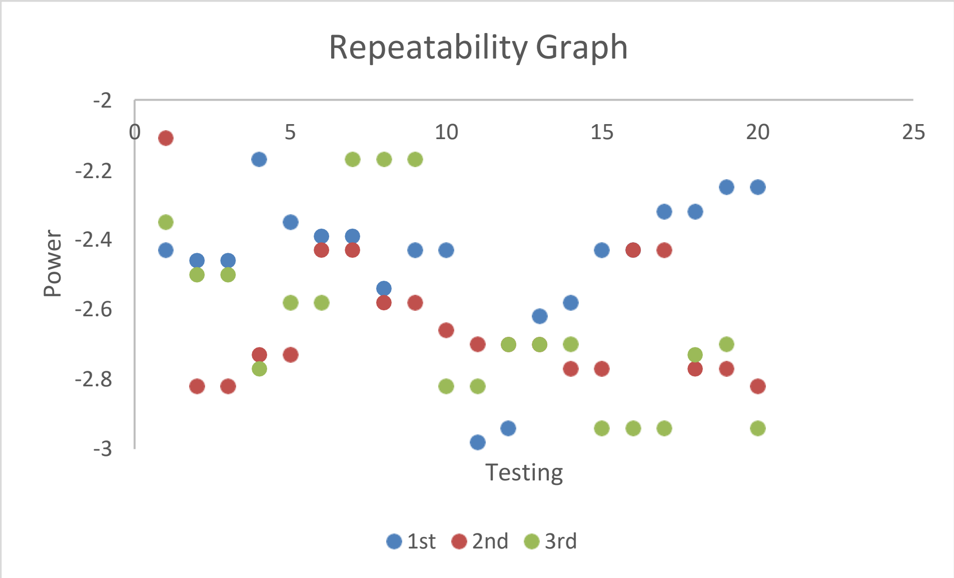

Figure 4-1 Repeatability graph for Rainwater

The initial data point of the blue trend on the graph indicates a value of -2.43dBm, whereas the last data point corresponds to a value of -2.25dBm. This observation demonstrates a rising pattern. In the second reading (designated as "orange"), the power level ranges from -2.11dBm to -2.82dBm, indicating a declining trend. The third category, represented by the color grey, exhibits a declining trend within the range of -2.35dBm to -2.94dBm. Therefore, each alteration in power results in a divergence from the minute-level data gathering.

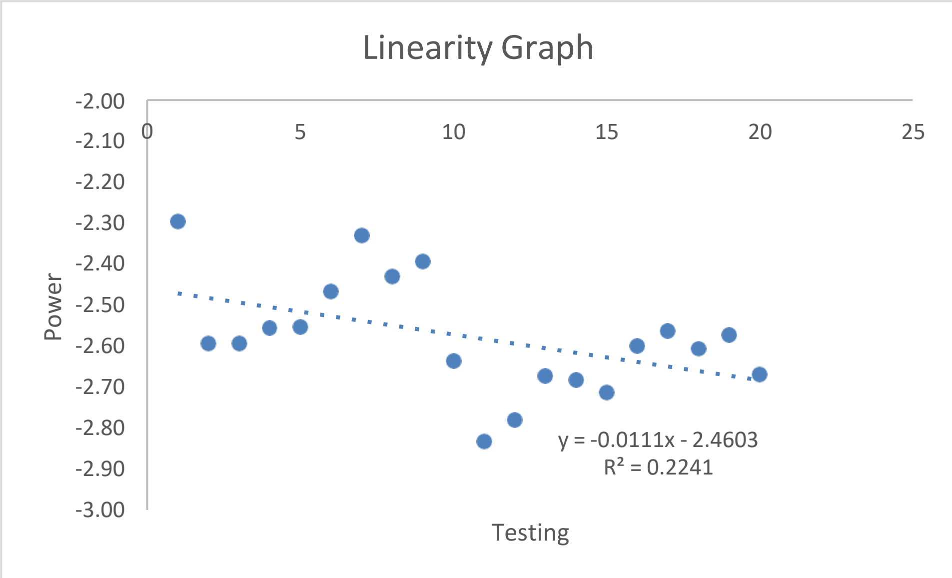

Figure 4-2 Linearity graph for Rainwater

The graph depicted in Figure 4.2 represents the mean values derived from the data presented in Figure 4.1. Based on the data presented in Figure 4.1, the experiment exhibited repeatability on three separate occasions. The graph presented in Figure 4.2 represents the average values derived from the repeatability data. Based on the available data, it can be observed that there is a declining tendency in the range of -2.30dBm to -2.67dBm. In this analysis, the performance of sensitivity and linearity is evaluated, yielding values of 0.0111 dBm per percent parts per million (%ppm) and 47.34%, respectively. The average performance of the newly developed sensor in my project is considered satisfactory.

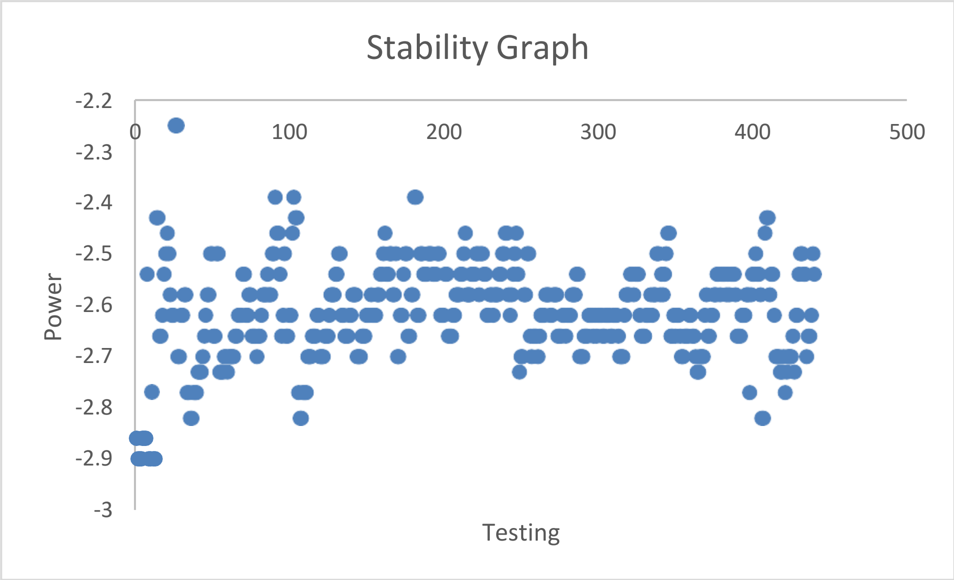

Figure 4-3 Stability graph for Rainwater

The stability analysis reveals that this sensor exhibits limited stability during the initial water sample measurement. This is evident from the scatter plot displayed in the stability graph, which does not exhibit a clear linear trend. However, the maximum recorded value is typically -2.25dBm, while the average of the lowest recorded values is -2.90dBm. Although it lacks stability, it can nonetheless be deemed usable.

4.3 Sensor Performance of Coway

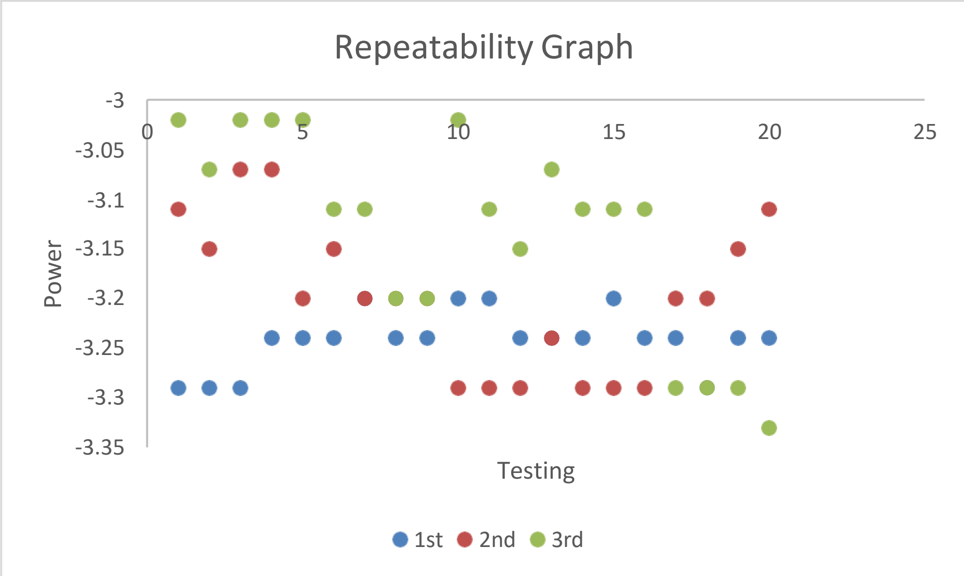

Figure 4-4 Repeatability graph for Coway

The initial data point of the blue trend on the graph indicates a value of -3.29dBm, whereas the final data point shows a value of -3.24dBm. This observation demonstrates a noticeable upward trajectory. The second reading (orange) exhibits a consistent decrease in power level, starting from -3.11dBm and remaining at -3.11dBm throughout. The third category, represented by the color grey, exhibits a declining trend within the range of -3.02dBm to -3.33dBm. Therefore, each alteration in power exhibits variability distinct from the minute-by-minute data gathering.

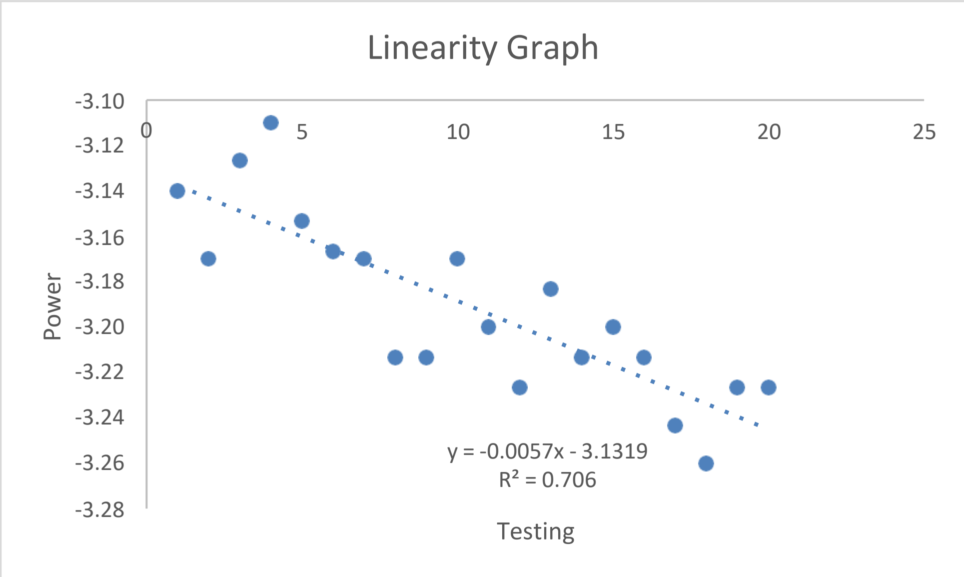

Figure 4-5 Linearity graph for Coway

The Figure 4.5 graph represents the mean value derived from the data shown in the Figure 4.4 graph. The Figure 4.4 graph provided three instances of experimental reproducibility. The Figure 4.5 graph represents the mean value of the repeatability data. Based on the available data, it can be observed that there is a downward tendency in the values, specifically ranging from -3.14dBm to -3.23dBm. In this analysis, the performance of sensitivity and linearity is examined, yielding values of 0.0057 dBm per percent parts per million (%ppm) and 84.02%, respectively. This signifies that it is the greatest average value achieved in the development of the new sensor within my project.

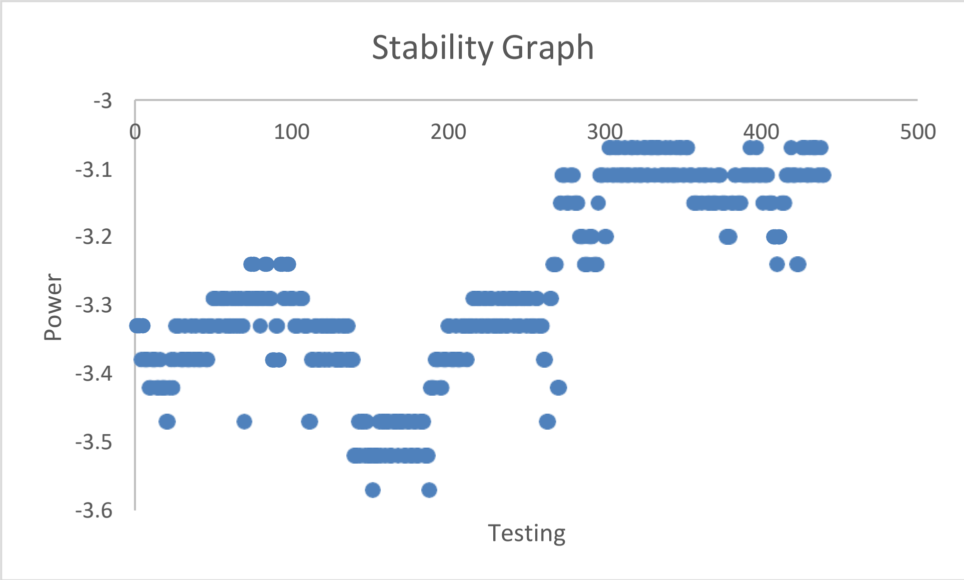

Figure 4-6 Stability graph for Coway

The stability of this sensor is demonstrated by the scatter plot in the stability graph, which indicates consistent measurements of the second water sample at various power levels, ranging from -3.07dBm to -3.52dBm. It is reliable and suitable for use.

4.4 Sensor Performance of Spritzer

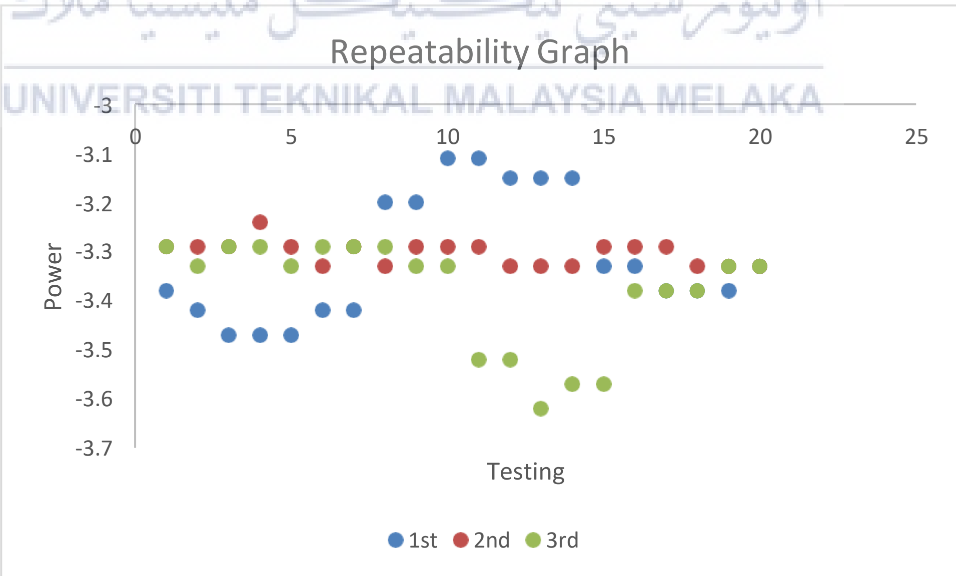

Figure 4-7 Repeatability graph for Spritzer

The initial data point of the blue trend on the graph indicates a value of -3.38dBm, whereas the last data point shows a value of -3.33dBm. This demonstrates a rising pattern.

In the second reading (shown as orange), the power level commences at -3.29dBm and gradually decreases to -3.33dBm. The third (grey) data point exhibits a declining trend within the range of -3.29dBm to -3.33dBm. Therefore, each alteration in power exhibits variability distinct from the minute-level data collection.

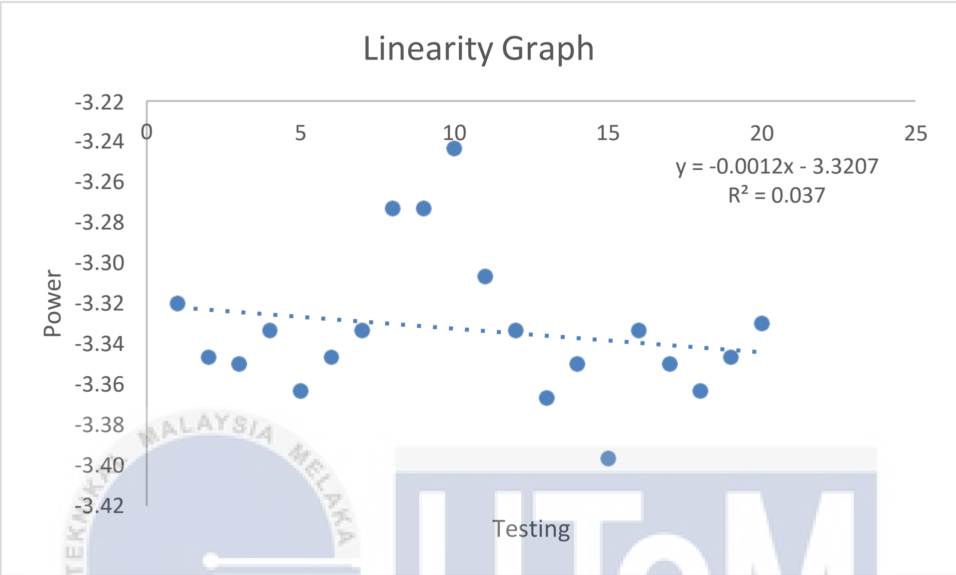

Figure 4-8 Linearity graph for Spritzer

The Figure 4.8 graph represents the mean value derived from the Figure 4.7 graph. Based on the data presented in Figure 4.7, the experiment was repeated three times, demonstrating repeatability. The graph labelled Figure 4.8 represents the average values derived from the repeatability data. Based on the available data, it can be observed that there is a downward trend in the values, specifically from -3.32dBm to -3.33dBm. In this analysis, the performance of sensitivity and linearity is examined, yielding values of 0.0012 dBm per percent parts per million (ppm) and 19.24%, respectively. The average performance of the new sensor development in my project is relatively low.

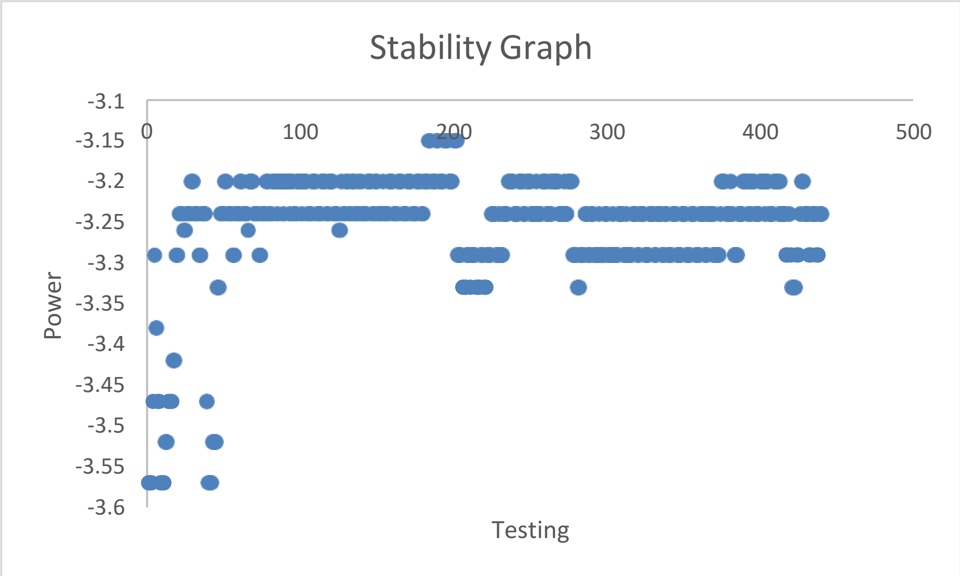

Figure 4-9 Stability graph for Spritzer

The stability analysis reveals that this sensor exhibits some degree of instability when measuring the initial water sample. This is evident from the scatter plot displayed in the stability graph, which does not exhibit a clear linear trend. However, the maximum recorded value is typically -3.15dBm, while the average of the lowest recorded values is -3.57dBm. Although it lacks stability, it can nonetheless be deemed usable.

4.5 Sensor Performance of Evian

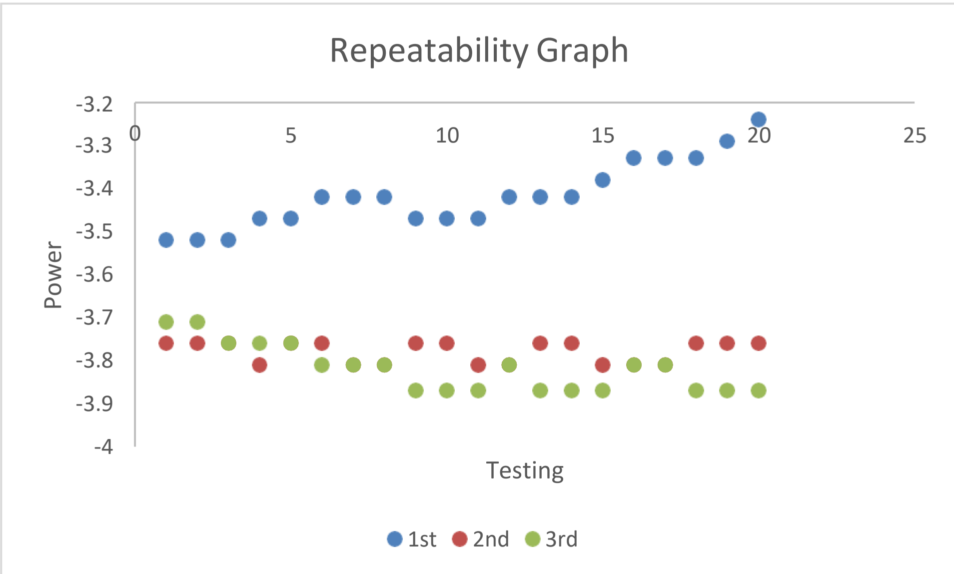

Figure 4-10 Repeatability graph for Evian

The initial data point of the blue trend on the graph indicates a value of -3.52dBm, whereas the final data point corresponds to a value of -3.24dBm. This observation demonstrates a rising pattern. The second reading (orange) exhibits a consistent trend, beginning and concluding at -3.76dBm. The third data point (represented by the color grey) exhibits a declining trend within the range of -3.71dBm to -3.87dBm. Therefore, each alteration in power exhibits variability distinct from the minute-by-minute data gathering.

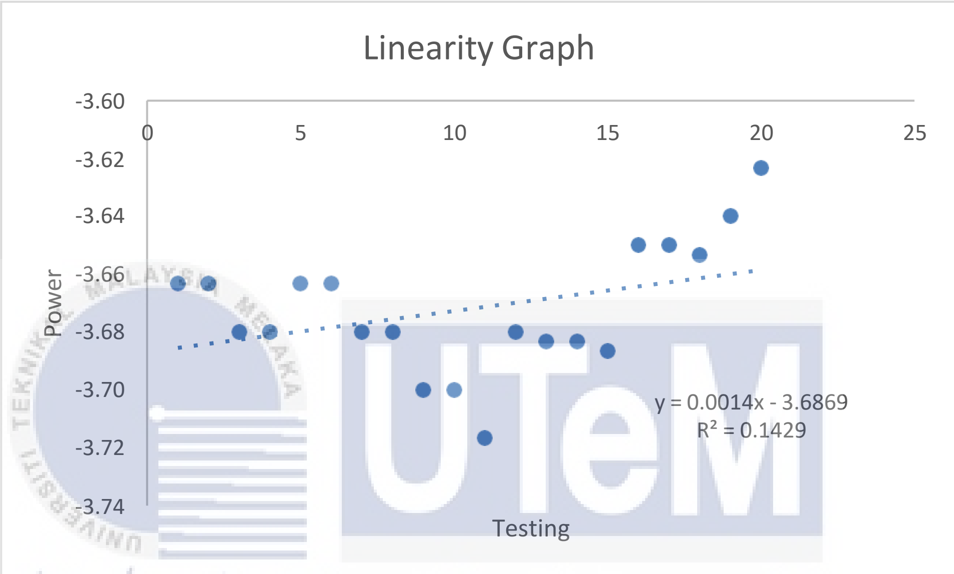

Figure 4-11 Linearity graph for Evian

The Figure 4.11 graph represents the mean value derived from the Figure 4.10 graph. The graph in Figure 4.10 demonstrates the repeatability of the experiment, which was observed three times. The graph labelled Figure 4.11 displays the average values derived from the repeatability data. Based on the available data, it can be observed that there is an upward trend in the values, starting from -3.66dBm and progressing to -3.62dBm. In this analysis, the performance of sensitivity and linearity is examined. The sensitivity is found to be 0.0014 dBm per percent parts per million (%ppm), while the linearity is determined to be 37.80%. The average performance of the newly developed sensor in my project is considered satisfactory.

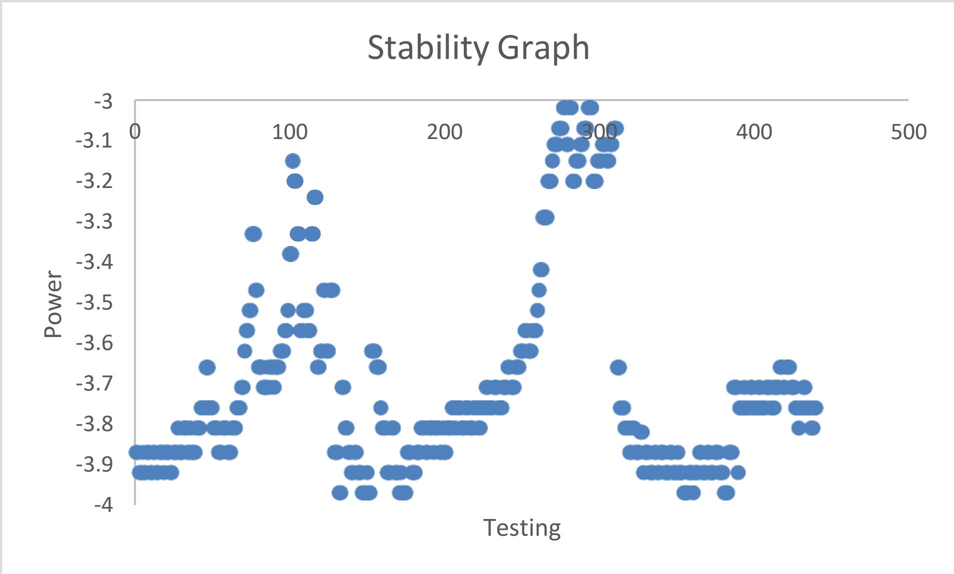

Figure 4-12 Stability graph for Evian

The stability analysis reveals that this sensor exhibits limited stability during the initial water sample measurement. This is evident from the scatter plot displayed in the stability graph, which does not exhibit a clear linear trend. However, the highest recorded value is typically -3.15dBm, while the average lowest value is -3.57dBm. Although it lacks stability, it can nonetheless be deemed usable.

4.6 Sensor Performance of Pipe Water

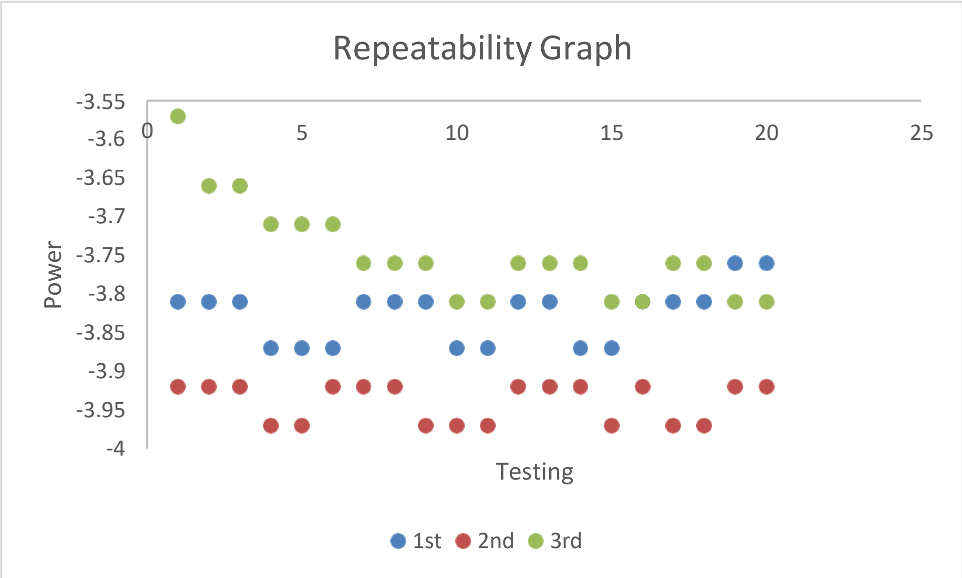

Figure 4-13 Repetability graph for Pipe Water

The initial data point of the blue trend on the graph indicates a value of -3.81dBm, whereas the last data point shows a value of -3.76dBm. This data exhibits a noticeable upward trajectory. In the second reading, the signal strength commences and concludes at a level of -3.92dBm, exhibiting a consistent pattern. The third data point (represented by the color grey) exhibits a declining trend within the range of -3.57dBm to -3.81dBm. Therefore, any alteration in power exhibits variability compared to the continuous gathering of minute data.

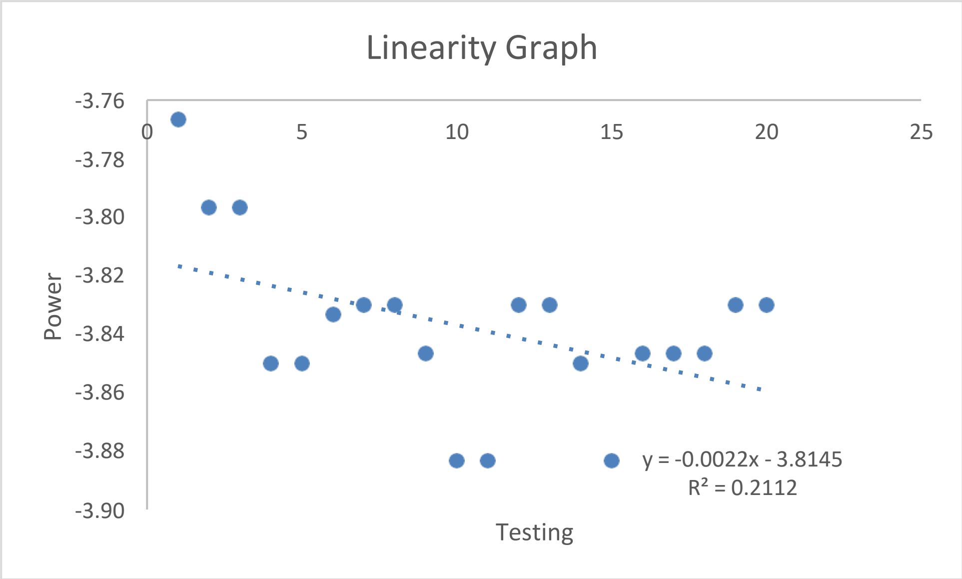

Figure 4-14 Linearity graph for Pipe Water

The graph labelled Figure 4.14 represents the mean value derived from the data shown in the graph labelled Figure 4.13. The graph presented in Figure 4.13 demonstrates the reproducibility of the experiment, which was observed to occur three times. The graph labelled as Figure 4.14 represents the average values obtained from the repeatability data. Based on the available data, it can be observed that there is a downward tendency in the values, specifically ranging from -3.77dBm to -3.83dBm. In this analysis, the performance of sensitivity and linearity is examined, yielding values of 0.0022 dBm per percent parts per million (%ppm) and 45.96%, respectively. The average performance of the newly developed sensor in my project is considered satisfactory.

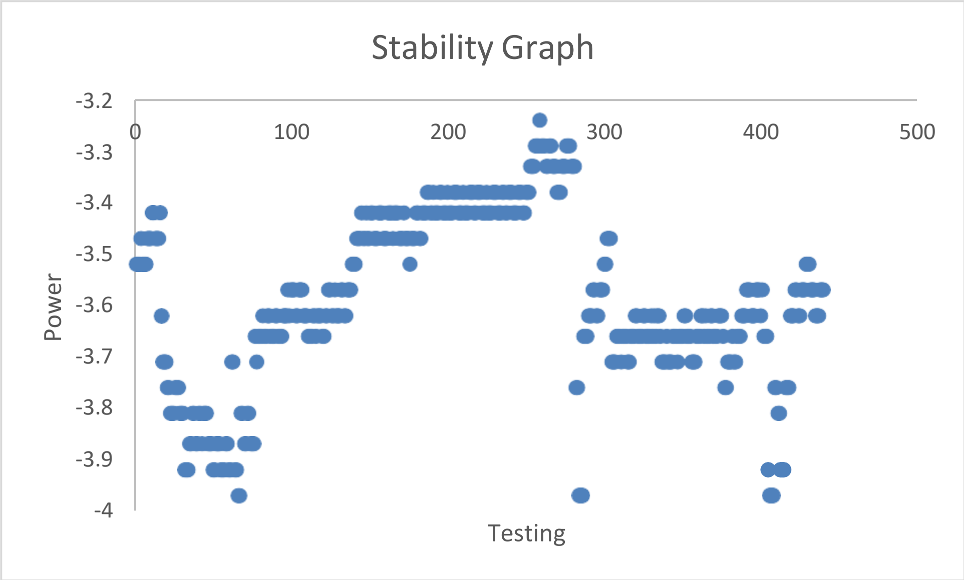

Figure 4-15 Stability graph for Pipe Water

The stability analysis reveals that the sensor exhibits limited stability when measuring the initial salinity water concentration. This is evident from the scatter plot displayed in the stability graph, which does not exhibit a consistent linear trend. The highest recorded value is -3.24dBm, while the average of the lowest recorded values is -3.97dBm. The stability of the system is somewhat limited, although it remains viable for potential utilization.

4.7 Summary

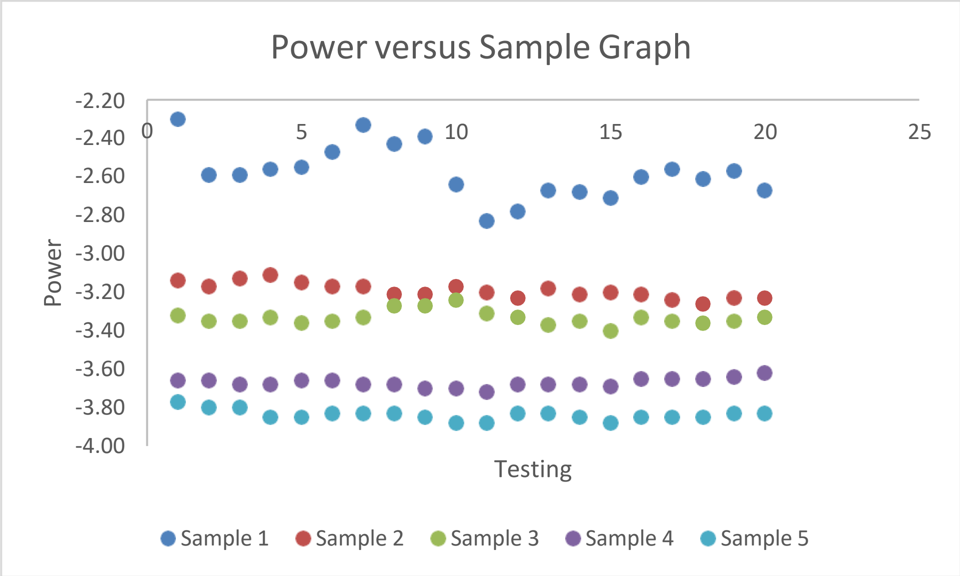

Figure 4-16 Power versus sample graph

To summarize, this chapter culminates in the development of Figure 4-16, which depicts the correlation between power measured in dBm units and the sample water. The effectiveness of the sensor was demonstrated in Figure 4-16 for all five separate water samples. Overall, the sensor demonstrates exceptional performance when exposed to Coway water. This is due to the high level of interaction between the light used in the experiment and the evaluating particle. However, the optimal choice of water for human consumption is Evian water. The reason is that it has the greatest Total Dissolved Solids (TDS) value, which contains beneficial amounts of calcium and magnesium for the human body. The second option is Spritzer water, while the third option is rainwater. In order to consume rainwater, it is important to maintain the cleanliness of the water in the catchment areas. The lowest grade is assigned to piped water. Water from pipes is unsuitable for human consumption. The TDS value of 1000mg/L found in it falls within the region of poor quality.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The subsequent chapter will provide an exposition of the conclusion that is derived from the project's outcomes. In accordance with the Bachelor Degree Project (BDP I and II) tasks, this section of the report will present a conclusion.

5.2 Chapter 2

Chapter Two discusses the study of water salinity, including several research approaches and methodology. This text provides an overview of salinity, including its fundamental aspects, its impact on the environment and human well-being, and several techniques used to quantify salinity. Refractive index measurements can be conducted using sensors, devices based on Arduino technology, light-emitting diodes (LEDs), and lasers. An analysis is conducted to evaluate the advantages and disadvantages of each method in order to identify the most suitable strategy for each specific case. Based on the findings of the chapter two, the project selected LEDs due to their alignment with the project's objectives and problem statement, despite their inherent limitations in comparison to lasers. The conclusion emphasizes the need of employing appropriate tools and techniques for the proper development of salinity water sensor via blue LED.

5.3 Chapter 3

Chapter Three focus on objective number one which is to develop water concentration sensor using LDR sensor. A blue LED was used as the primary light source for the project illuminate water samples. An Arduino Uno used digital data to control how it worked. A LDR sensor recorded amount of light was passing through the water. The Arduino Uno then used these analog values to do data analysis. The Arduino Uno, which was the main microcontroller, controlled the LED and used the LDR data to figure out the salinity levels. A LCD showed the readings in power value (dBm) based on the measures of the water samples' refracted light sent by the Arduino. This smooth connection between the LCD and the Arduino Uno made it possible to show the data well, which made the project's results easy to understand and get to.

5.4 Chapter 4

Chapter Four concludes by discussing the stability, repeatability, and performance stability of the sensor. This chapter demonstrates the efficacy of the sensor in quantifying salinity across five samples. Remarkably, the sensor exhibits exceptional performance even subjected to Coway water. This chapter showcases the effective achievement of objective number two, which entails evaluating the sensor's performance using blue LED power transfer (graph). Furthermore, it successfully fulfils objective three by enhancing the sensor's performance in terms of sensitivity, linearity, and stability results.

5.5 Future Recommendation

To summaries, the blue LED can function as a sensor for detecting various salinity levels in samples through the development of salinity level of water sensor via blue LED detections project. The suggested sensor design aims to be more cost-effective than current salinity measuring equipment, hence increasing its accessibility for broader use, particularly in settings with limited resources. This project can be based on Sustainable Development Goal 6 (SDG 6), which aims to guarantee universal access to and sustainable management of water and sanitation. Nevertheless, the project does have certain limitations and areas for improvement.

Multiple improvements can be done for the project. Improving the sensor's sensitivity and selectivity is crucial, especially in the presence of various ions and substances. The research should prioritize enhancing the sensor's ability to distinguish salinity from other parameters associated with water quality. This improvement directly helps to the attainment of Sustainable Development Goal 6, which specifically aims to ensure universal access to clean water and sanitation. Additional research should focus on the phototransistor, which functions by turning incoming photons into electrons in the base of a bipolar transistor. The project has the capability to seamlessly incorporate Internet of Things (IoT) technology and utilize advanced data analytics. By integrating Internet of Things (IoT) technology, the sensor can be converted into an intelligent device with the ability to remotely monitor and process data in real-time. This integration supports SDG 9 by fostering innovation in the management of water resources.

REFERENCES

[1] N. Z. Bispham and K. L. Nowak, "Drinking Water: The Saltier The Better?," *Journal of the American Heart Association*, vol. 8, no. 9. American Heart Association Inc., May 07, 2019. doi: 10.1161/JAHA.119.012758.

[2] "Salinity and drinking water."

[3] S. Borrelli *et al.*, "Sodium intake and chronic kidney disease," *International Journal of Molecular Sciences*, vol. 21, no. 13. MDPI AG, pp. 1–13, Jul. 01, 2020. doi: 10.3390/ijms21134744.

[4] I. Shrimanker, ; Sandeep, and B. Affiliations, "Electrolytes."

[5] "1 salinity -- Britannica Online Encyclopedia".

[6] E. Efeoglu and G. Tuna, "Determination of salt concentration in water using decision trees and electromagnetic waves," *J Water Health*, vol. 20, no. 5, pp. 803–815, May 2022, doi: 10.2166/wh.2022.302.

[7] D. Z. Stupar *et al.*, "Remote monitoring of water salinity by using side-polished fiber-optic U-shaped sensor," in *15th International Power Electronics and Motion Control Conference and Exposition, EPE-PEMC 2012 ECCE Europe*, 2012. doi: 10.1109/EPEPEMC.2012.6397458.

[8] "4_7 Density, Temperature, and Salinity _ manoa.hawaii.edu_ExploringOurFluidEarth".

[9] A. P. U. Siahaan *et al.*, "Arduino Uno-based water turbidity meter using LDR and LED sensors," *International Journal of Engineering and Technology(UAE)*, vol. 7, no. 4, pp. 2113–2117, 2018, doi: 10.14419/ijet.v7i4.14020.

[10] "Measuring Salinity of Water." [Online]. Available: www.horiba-laqua.com.

[11] S. S. Patil and A. D. Shaligram, “Refractometric Fiber Optic Sensor for Detecting Salinity of Water,” *J Sens Technol*, vol. 03, no. 03, pp. 70–74, 2013, doi: 10.4236/jst.2013.33012.

[12] D. Kumar, L. Singh, G. Singh Virdi, G. Singh, and H. K. Channi, “Designing and Modeling of Arduino Based Light Sensor,” vol. 3, 2017, [Online]. Available: www.ijsart.com

[13] N. An, B. Zhuang, M. Li, Y. Lu, and Z. G. Wang, “Combined Theoretical and Experimental Study of Refractive Indices of Water-Acetonitrile-Salt Systems,” *Journal of Physical Chemistry B*, vol. 119, no. 33, pp. 10701–10709, Aug. 2015, doi: 10.1021/acs.jpcb.5b05433.

[14] G. Govindan, S. G. Raj, and D. Sastikumar, “Measurement of refractive index of liquids using fiber optic displacement sensors,” 2009.

[15] Z. Xingyu, M. Tiancheng, and Z. Zilong, “Relationship between Refractive Index and Molar Concentration of Multi-Component Solutions,” 2017.

[16] “PHYSICS EXTENDED ESSAY THE RELATIONSHIP BETWEEN THE SALINITY OF WATER AND THE REFRACTIVE INDEX OF WATER.”

[17] C. Teng *et al.*, “Side-Polish Plastic Optical Fiber Based SPR Sensor for Refractive Index and Liquid-Level Sensing,” *Sensors*, vol. 22, no. 16, Aug. 2022, doi: 10.3390/s22166241.

[18] D. R. Opel *et al.*, “Light-emitting Diodes A Brief Review and Clinical Experience,” 2015.

[19] Ø. Aasen Tengesdal, “Measurement of seawater refractive index and salinity by means of optical refraction Instrumentation and Measurement Science,” 2012.

[20] G. Li, Y. Wang, A. Shi, Y. Liu, and F. Li, “Review of Seawater Fiber Optic Salinity Sensors Based on the Refractive Index Detection Principle,” *Sensors*, vol. 23, no. 4. MDPI, Feb. 01, 2023. doi: 10.3390/s23042187.

[21] L. Louis, “Working Principle of Arduino and Using it as a Tool for Study and Research,” *International Journal of Control, Automation, Communication and Systems*, vol. 1, no. 2, pp. 21–29, Apr. 2016, doi: 10.5121/ijcacs.2016.1203.

[22] J. M. López-Higuera, “Sensing using light: A key area of sensors,” *Sensors*, vol. 21, no. 19, Oct. 2021, doi: 10.3390/s21196562.

[23] Ó. Esteban, M. Cruz-Navarrete, A. González-Cano, and E. Bernabeu, “Measurement of the degree of salinity of water with a fiber-optic sensor,” *Appl Opt*, vol. 38, no. 25, p. 5267, Sep. 1999, doi: 10.1364/ao.38.005267.

[24] “20_17 LED Journal – The Magazine of Solid-State Lighting”.

[25] “Salinity Management Guide,” 2007.

[26] “Coway Water Filtration Device Removable internal water tank for cleaning purpose Fine particle filtering system Plus Inno-Sense Filter minimizes the amount of fine dust that can enter the internal water tank. DEAR CUSTOMERS COWAY.”

[27] M. Mu, “Thirst for more Water sommeliers and factors that affect the taste of water.”

[28] “Evian Evian FINE WATER ACADEMY FINE WATER SOCIETY FINE WATER CONSULTING.”

[29] “Drinking Water Quality Standard.”