Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF LIGHT DEPENDENT RESISTOR (LDR) SENSOR IN DETERGENT FOR DIFFERENT CONCENTRACTIONS USING LED DETECTION

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Bachelor of Electronics Engineering Technology with Honours

2025

DEVELOPMENT OF LIGHT DEPENDENT RESISTOR (LDR) SENSOR IN DETERGENT FOR DIFFERENT CONCENTRACTIONS USING LED DETECTION

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**A project report submitted
in partial fulfillment of the requirements for the degree of
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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I approve that this Bachelor Degree Project 1 (PSM1) report entitled "Development of Light Dependent Resistor (LDR) sensor in detergent for different concentrations using LED detection" is sufficient for submission.

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DEDICATION

This work is lovingly dedicated to my cherished ***family****, whose unwavering support, encouragement, and sacrifices have been my constant source of strength and motivation. Your belief in me has inspired me to pursue my goals with determination and perseverance.*

To my ***friends****, who have stood by me through thick and thin, offering words of encouragement and moments of joy that lightened my journey. Your kindness, laughter, and companionship have made this endeavor all the more meaningful.*

Lastly, to my esteemed ***lecturer****, whose guidance, patience, and dedication to teaching have been invaluable in shaping my understanding and fostering my growth. Your encouragement has not only expanded my knowledge but also instilled in me a passion for learning and excellence.*

Thank you all for being a part of this journey. Your support has been the cornerstone of my success.

ABSTRACT

A system and medium for sending data as light pulses over a glass or plastic strand is known as fiber optics, or optical fiber. Total internal reflection is the term for the phenomenon where light signals bounce off the core of a fiber optic cable while being transmitted. Because of their high sensitivity, quick detection, and adaptability to harsh environments, optical microfiber sensors have attracted a lot of research attention recently. The goal of this project was to develop a Light Dependent Resistor (LDR) sensor for liquid detergent at various concentrations using microfiber optics and LED detection. The best size of microfiber optics will be used for additional research as a liquid sensor after the single mode fiber has been tapered using the tapering method. Additionally, tests will be conducted on the three samples containing varying concentrations of liquid detergent. The fiber would be measured and dipped in the samples prior to each test. As a result, the outcomes of every measurement would vary. The results of the experiment will be discussed in terms of the graph's sensitivity, correlation, and coefficient of determination, all of which are entirely dependent on the concentration of liquid detergent and light source.

ABSTRAK

Sistem dan medium untuk menghantar data sebagai denyutan cahaya pada helai kaca atau plastik dikenali sebagai gentian optik, atau gentian optik. Jumlah pantulan dalaman ialah istilah untuk fenomena di mana isyarat cahaya melantun dari teras kabel gentian optik semasa dihantar. Oleh kerana kepekaan yang tinggi, pengesanan pantas dan kebolehsuaian mereka kepada persekitaran yang keras, penderia mikrofiber optik telah menarik banyak perhatian penyelidikan baru-baru ini. Matlamat projek ini adalah untuk membangunkan sensor LDR untuk bahan pencuci cecair pada pelbagai kepekatan menggunakan optik mikrofiber dan pengesanan LED. Saiz optik mikrofiber terbaik akan digunakan untuk penyelidikan tambahan sebagai penderia cecair selepas gentian mod tunggal ditiruskan menggunakan kaedah tirus. Selain itu, ujian akan dijalankan ke atas tiga sampel yang mengandungi kepekatan detergen cecair yang berbeza-beza. Gentian akan diukur dan dicelupkan ke dalam sampel sebelum setiap ujian. Akibatnya, hasil setiap pengukuran akan berbeza-beza. Keputusan eksperimen akan dibincangkan dari segi kepekaan graf, korelasi, dan pekali penentuan, yang semuanya bergantung sepenuhnya pada kepekatan detergen cecair dan sumber cahaya.

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First and foremost, I would like to express my gratitude to my supervisor, Dr Aminah binti Ahmad for their precious guidance, words of wisdom and patient throughout this project.

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CHAPTER 1: INTRODUCTION

1.1 Background

An introduction in a report serves as a gateway, providing a clear understanding of the project's essence, objectives, problem statement, scope, and anticipated outcomes. It offers a concise overview of the report's contents, setting the stage for what follows. It outlines the purpose of the project, delineates its goals and objectives, briefly identifies the problem or challenge being addressed, defines the scope or boundaries within which the project operates, and hints at the expected results or outcomes. Essentially, the introduction acts as a roadmap, guiding readers through the report's landscape and preparing them for the insights and analyses to come.

1.2 Introduction

Liquid detergent has become a staple in households worldwide, offering convenience and efficiency in laundry care. Its fluid form and potent cleaning power have revolutionized the way to approach cloth care, replacing traditional powders and bars in many households. However, amidst its widespread use, it's crucial to understand both its benefits and potential risks.

In this subtopic will delve into the world of liquid detergent for cloth care, exploring its composition, effectiveness, and the considerations surrounding its usage. Liquid detergents offer a potent blend of surfactants, enzymes, and other active ingredients designed to tackle tough stains while being gentle on fabrics. This versatility makes them a popular choice for a wide range of clothing materials, from delicate silks to heavy-duty denims.While liquid detergents offer undeniable advantages, such as pre-measured dosing and easy dispensing, they also present challenges. Concerns regarding chemical exposure, environmental impact, and proper storage and handling are paramount. Liquid detergents do contain chemicals. These chemicals are carefully selected and formulated to fulfill specific functions in the detergent, such as cleaning, removing stains, and preserving the product's stability. Some common chemicals found in liquid detergents include;

- Surfactants, surface-active agents, help remove dirt and stains from fabrics by lowering water's surface tension, such as sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES) in liquid detergents.

- Enzymes are biological molecules that speed up chemical reactions by dissolving starches from food and proteins, fats, and carbohydrates found in stains like blood and perspiration.

- Preservatives are added to liquid detergents to prevent microbial growth and extend the product's shelf life. These chemicals help maintain the detergent's efficacy and stability over time.

While these chemicals are generally considered safe when used as directed, some individuals may be sensitive or allergic to certain ingredients. It's essential to follow proper usage instructions and precautions when handling and using liquid detergents to minimize any potential risks. Additionally, choosing detergents labeled as "fragrance-free" or "hypoallergenic" can be beneficial for individuals with sensitivities or allergies to fragrances or other ingredients.

Due to those subsequences, the project's goal is to demonstrates how optical microfiber sensors may be used to monitor the concentration of liquid detergent using a development of a novel Light Dependent Resistor (LDR) sensor system tailored for the precise analysis of varying concentrations in detergent solutions. Optical microfiber sensors are are used in this project.

1.3 Problem Statement

Since liquid detergent provides effective and convenient laundry care, it has become a household stapler everywhere. Its liquid form and strong cleaning ability have completely changed the way care for clothes, taking the place of conventional powders and bars in many homes. Most detergent tend toward the higher end of the range because if they are too acidic, they could damage fabrics and maybe human skins if the person have a sensitive skins. Another point is to detect the optimal performance. Correct concentration ensures that the detergent works effectively. Next, If the detergent have high concentration can cause burns or injuries upon contact with skin or eyes. Hence, to develop a system by using a microfiber to measure the concentration of liquid detergent.

1.4 Project Objective

The main aim of this project is:

a) To investigate LDR as a liquid sensor using LED detection.
b) To design LDR as a liquid sensor to detect detergent at different concentrations using LED.
c) To analyze the performance of LDR sensor in detergent for different concentration using LED.

1.5 Scope of Project

The scope of this project are as follows:

a) Aims to develop a system for monitoring liquid detergent concentration using LDR sensor paired with an LED.
b) The scope includes designing and implementing a prototype device capable of detecting detergent concentrations.
c) The project will analysed data concentration in detergent.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A revolutionary technique called fiber optics uses tiny glass or plastic fibers which is slightly thicker than a human hair. One of the functions is to send data as light pulses. These fibers make long-distance, high-speed, low-loss transmission possible, which is crucial for data networks, internet connectivity and telecommunications. The fundamental parts of fiber optic systems are light source, transmitters and receivers, which provide effective information encoding and decoding. It allows transmission over longer distance and at higher bandwidths compared to other forms of communication. Fiber optic are notable for their resilience to electromagnetic interference, which contributes to their dependability in a variety of settings. Beyond communication, this technology finds uses in precise sensing in fields including aeronautical, medical and structural monitoring including sensors and fiber lasers. Fiber optics, with its potential to transform data transmission and sensing capacities, is a fundamental component of contemporary innovation and communication. Fiber optic also used in medical and other application for example where bright light needs to be shone on a target with out a clear line of sight path, such as in microscopes for intense illumination of samples being studied.

Fiber optic sensors are extremely sensitive because of their special construction and working principles. Their sensitivity is mostly derived from their capacity to accurately detect minute changes in light signals. By utilising the way that light interacts with its surroundings, these sensors are able to convert even minute changes in variable like temperature, pressure, strain or chemical composition into observable changes in the light that is transmitted. Because of its intrinsic sensitivity, fiber optic sensors are essential for applications including industrial process control, biological diagnostics and environment monitoring that call for exact measurements. Their resilience to electromagnetic interference further increases their efficacy as sensors by guaranteeing functioning even in electrically loud surroundings.

2.2 Related Journal/Research

A related journal or research refers to articles, studies or papers that address similar topics or themes as those being explored in a current study. These related works provide context dan support such as picture or diagram to helping identify gaps in knowledge, validate findings and build on existing theories. By reviewing related literature, research can have a better understand current project and develop more robust and informed approach to own research.

2.2.1 Basic Structure of Fiber

Plastic or glass are used to make optical fibers. Many miles can separate them, and the majority have a diameter similar to that of a human hair. From one end of the fiber to the other, light travels along its centre, and a signal may be enforced. In many applications, fiber optic technologies are better than metallic conductors. The biggest benefit they have is capacity. Light has a wavelength that allows for the transmission of singnals containing far more information than those achievable with metallic condustors, or even coaxial conductors.

An optical fiber consists of three basic concentric element which is core, cladding and outer coating (Figure 2.1 and Figure 2.2).

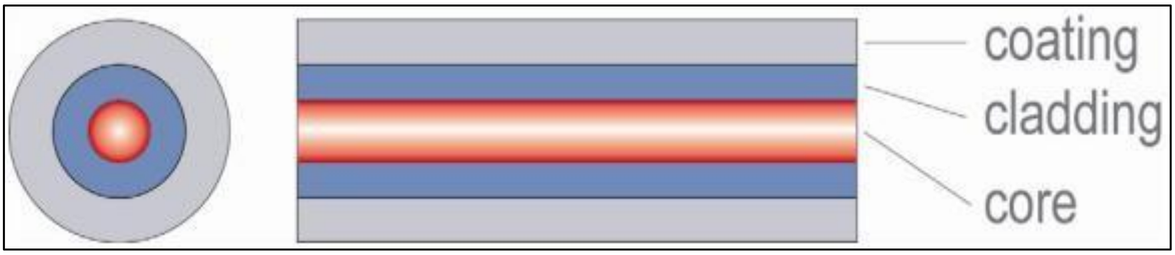


Figure 2.1 Basic Structure of Optical Fiber

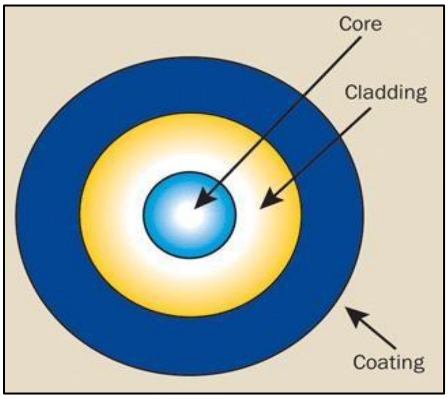


Figure 2.2 Basic Structure of Optical Fiber

In fiber optic technology, core, cladding and coating are essential components that work together to transmit light signals efficiently and protect the fiber. Below is overview of each part function;

1. Core

Function: The core is usually made of glass or plastic although other materials are sometimes used, depending on the transmission spectrum desired. The core is the light transmitting portion of the fiber.

2. Cladding: The cladding usually is made of the same material as the core, but with a slightly lower index of refraction (usually about 1% lower). This index difference causes total internal reflection to occur at the index boundary along the length of the fiber so that the light is transmitted down the fiber and does not escape through the sidewalls.

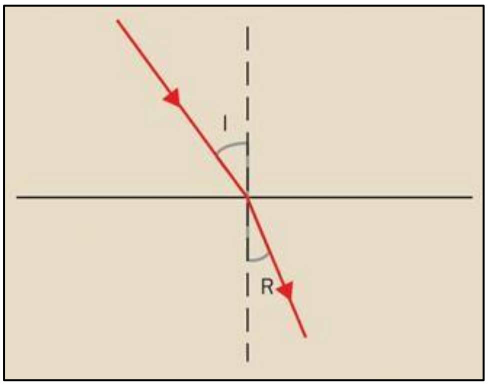


Figure 2.3 A beam of light passing from one material to another different index of refraction is bent or refracted at the interface

3.Coating:

Coating usually comprises one or more coats of a plastic material to protect the fiber from the physical environment. Sometimes metallic sheaths are added to the coating for further physical protection.

Optical fibers usually are specified by their size, given as the outer diameter of the core, cladding and coating. For example, a 62.5/125/250 would refer to a fiber with a 62.5µm core, a 125µm cladding and 0.25µmm outer coating.

2.2.2 Single Mode and Multimode Fiber

In fiber optic communication, single mode and multimode fiber construction are used depending on the application. Single mode fiber is a type of optical fiber designed to carry light directly down the fiber, allowing only a single mode of light to propagate. This type of fiber has a small core diameter, typically around 8 to 10 micrometers, and a cladding diameter of 125 micrometers. The small core size significantly reduces the potential for light reflection and interferences, allowing light to travel longer distance with higher bandwidth and minimal signal loss.

In multimode fiber (Figure 2.4), light travels through the fiber following different light paths called “modes”. In single mode fiber, only one mode is propagated “straight” through the fiber (Figure 2.5).

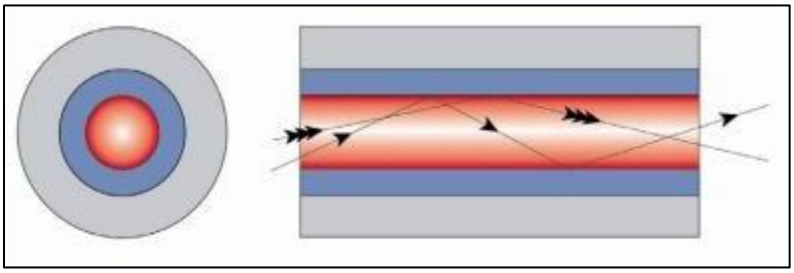


Figure 2.4 Multimode Fiber Light Propagation

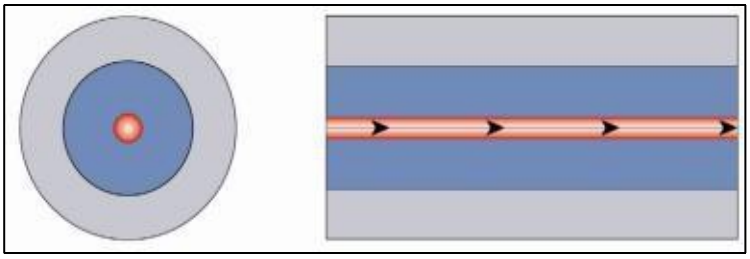


Figure 2.5 Single Mode Fiber Light Propagation

Typically multimode fiber have a core diameter/cladding diameter ratio of 50 microns/125 microns and 62.5/125 although 100/140 and other sizes are sometimes used depending on the application.

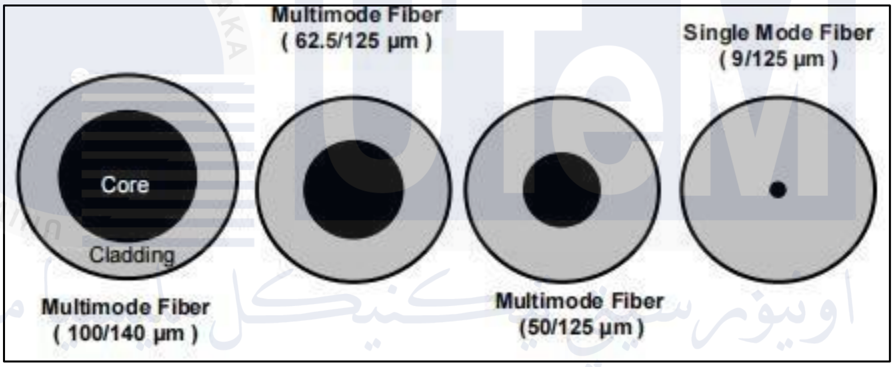


Figure 2.6 Popular optical fiber core/cladding diameter ratios

In multimode fibers propagate information according to modes or paths, ensuring it is spaced sufficiently to avoid overlap and ensure recovery at the end of the fiber. Too close information can lead to smearing the information. And of course, modal dispersion is not an issue in single mode fiber because only a single mode is propagated. Refer figure below for illustration.

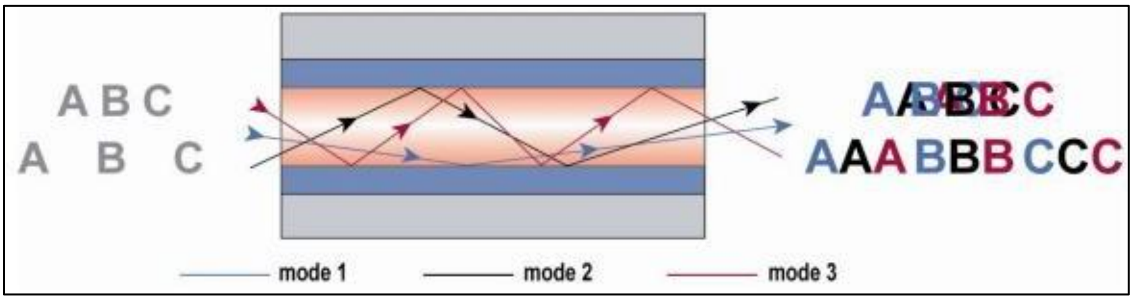


Figure 2.7 Modal dispersion in multimode fibers

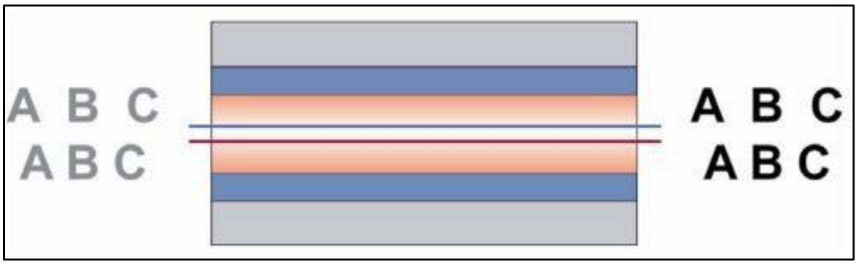


Figure 2.8 Modal dispersion in single mode fibers

2.2.3 Measurement of Refractive Index of Liquid Using Fiber Optic Displacement Sensors

The paper "Measurement of refractive index of liquid using fiber optic displacement sensors" presents a study conducted by Gobi Govindan, Srinivasan Gokul Raj, and Dillibabu Sastikumar from the Department of Physics at the National Institute of Technology Tiruchirappalli, India. The study focuses on the development of a technique to determine the refractive index of liquids using a reflective type fiber optic displacement sensor. The sensor comprises two multimode step index fibers and a mirror, and the output light intensity from the receiving fiber is measured as a function of displacement of the fiber with respect to the mirror in various solvents. The study explores the relationship between light peek intensity position and the refractive index of a medium using water, and two others liquid as mediums. From the experiments, can summarize the relationship beween the refractive index and light intensity peak position. Also highlight the independence of the light intensity peak in medium from changes in the light power or absorption. The study highlights the advantages of fiber optic sensors over conventional ones, such as high sensitivity, wide frequency response, and suitability for hostile enviroments.

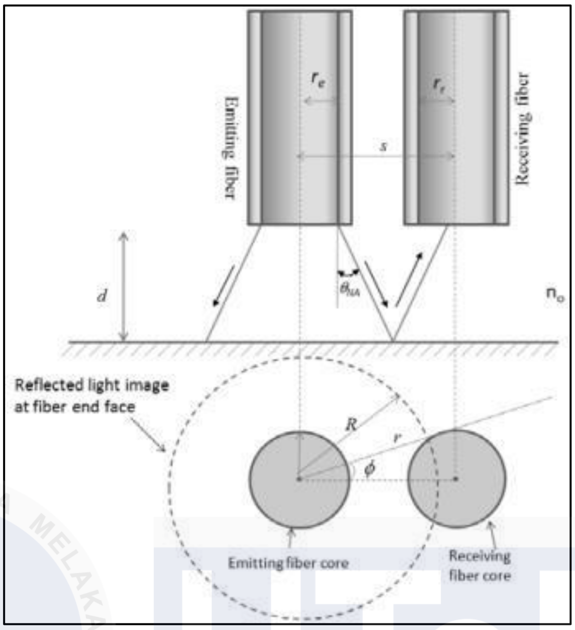


Figure 2.9 Fiber optic sensor schematic structure

The study explores the development and application of a fiber optic displacement sensor for measuring liquid refractive index, offering insights into its structure, working model, and result, highlighting its potential for various industries. When light rays move from a dense to a less dense medium, they bend away from the normal due to the increased speed of light. This phenomenon can be studied using a semi circular block, measuring angles inside and outside the block. As the angle of incidence within the block increases, so does the angle of refraction, until it reaches a point where total internal reflection occurs and the light ray reflect within the block as illustrated in Figure 2.10 and 2.11 below.

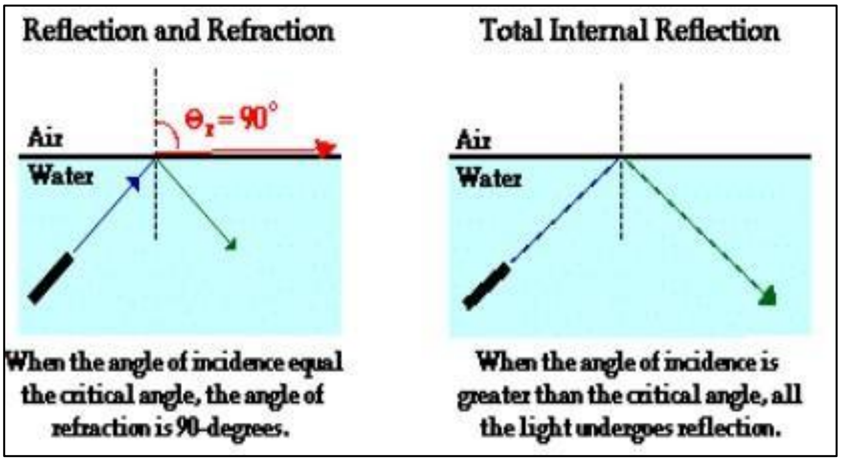


Figure 2.10 Total internal reflection

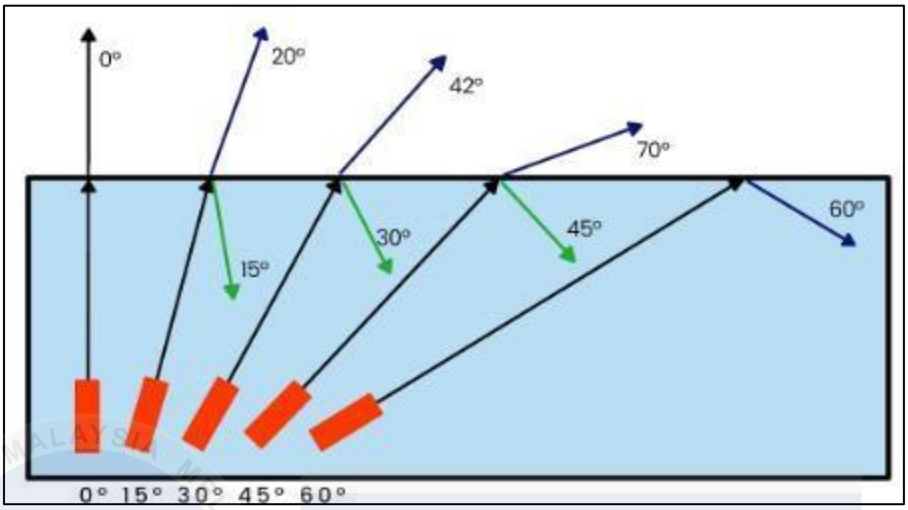


Figure 2.11 Total internal reflection (by angle)

2.2.4 Fiber Optic Cable Bending

Fiber optic cable bending is refers to the curvature or bending of fiber optic cables which can affect performance by causing signal loss, error rates and physical damage if bent beyond the specified radius, impacting the optical fibers functionality within. There are two types of bending. The first one is macro bending and the second one is micro bending. Before that, bend radius have a main functions in the bending method where each fiber optic cable has a minimum bend radius, which is the smallest cable can be bend without causing significant signal loss or damage. Macro bending is when the cable is bent in a large arc. Even gentle bends can cause signal attenuation if the bend radius is too small. Additionally, micro bending are small scale bends or imperfections in the fiber itself or within the cable structure. Micro bends can occur due to pressure or small bends in the cable and can also lead to signal loss. The impact of this loss or attenuation is can cause light to excape the fiber core, leading to a loss of signal strength. Additionally, excessive bending can physically stress the fiber and potentially causing cracks or breaks. Picture below(Figure 2.12) shows the different between macro bending and micro bending.

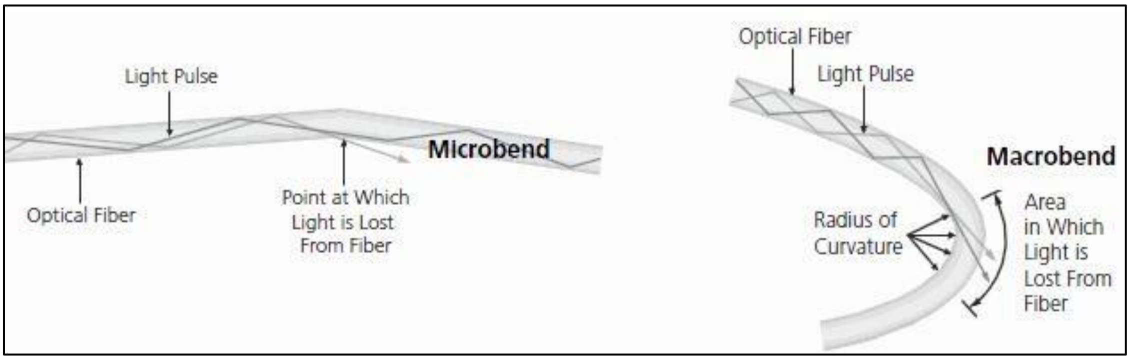


Figure 2.12 Different microbend and macrobend

2.2.5 How an Optical Fiber Works

Similar in operation to an optical microfiber, but much smallest, is a standard optical fiber. It is a thin filament, usually made of glass or another transparent material, with a diameter smaller than the wavelength of light. Light beams entering the optical microfiber interact with the substance flowing through because of its high surface area to volume ratio. As the light beam passes through the fiber's core, the evanescent field that stretches outside of it interacts with the surrounding material.

Because of their remarkable sensitivity to variants in their geometry and refractive index, optical microfibers can be used as sensors. When a sensitive substance, like a chemical or biological agent is coated on a fiber, changes in the transmitted light signal can be seen. It is possible to quantify this interaction between the material and the evanescent field of the fiber. These variants can be examined to determine the presence and concentration of the target molecule.

Optical microfibers are not only useful for sensing, but also for signal processing and transmission. Microfiber are ideal for long distance light signal transmission because of their low loss and tiny size, which make them easy to integrate into complex optical systems and devices. Nonlinear optical technique such as four wave mixing can be applied in microfibers to modify wavelengths and process signals. The strong light beam and the material of the fiber interact to produce these effects. Adaptable optical components, optical microfibers have a wide range of application in sensing, communication and signal processing.

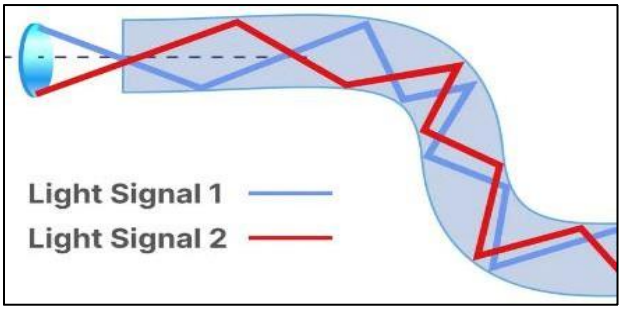


Figure 2.13 Illustration of fiber transmit light

2.2.6 Side Polish Plastic Optical Fiber Based SPR Sensor for Refractive Index and Liquid Level Sensing

The publication suggested a straightforward POF based SPR sensor to show how to measure liquid level and refractive index (RI) simultaneously. The sensor probe's side polished construction facilitates easy manufacture. There is a noticeable shift in the SPR peak strength when the liquid level changes. A gold coated side polish (POF) is present on a sensing probe (Figure 2.14). The letters L, d, and D stand for length of the polishing area, depth of the polished zone, and residual diameter of the fiber, respectively. Figure 2.15 shows a cross section of the sensing probe. Additionally, SPR sensing is involved in the thin remaining coating that has a gold film covering it. The low RI of 1.41 corresponds to the cladding thickness of 10µm. The result of the experiment indicate that the liquid level can be ascertained by monitoring the peak's depth and the RI can be ascertained by analysing the wavelength shift of the SPR resonant peak. Within the RI range of 1.335 to 1.39 is a possible RI sensitivity or 2008.58 nm/RIU. As a result, the performance of the probe sensor is analysed using a three layer structural model. The probe's ability to measure liquid and RI levels simultaneously was shown by the simulation results. Raising the RI, red shifting the SPK peak wavelength, raising the liquid level, and lowering the SPR peak intensity.

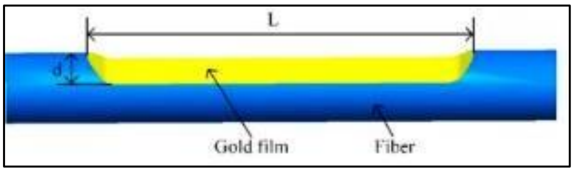


Figure 2.14 Side polish POF sensing probe schematic

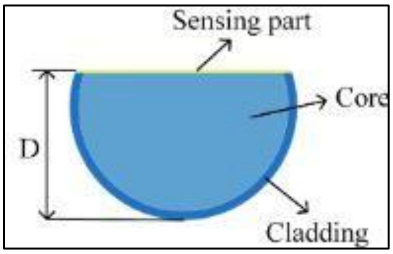


Figure 2.15 Side polish POF sensing probe cross section view

2.2.7 Fabrication of Microfiber by using a Tapering Method

2.2.7.1 The Flame Brushing Technique

Flame brushing is a rapid and effective method for turning glass or other transparent materials into optical fibers and microfibers. By heating a glass rod or applying a high temperature flame, the material is softened using this approach before being woven into a fine fiber or microfiber. A glass rod or other apparatus used to initiate the process is frequently made of high purity glass, such as silica. The rod or preform is held over a high temperature flame, such as a hydrogen oxygen flame, which softens and thickens the substance.

As it does so, two mechanical "brushes" driven by a computer programmer gradually separate the softer glass material. As the brushes separate from one another at certain speed, the material is stretched and thinned into a fiber or microfiber. After that, the resultant fiber, or microfiber is cooled and coated to improve its functionality and protect it from damage. The process can be repeated multiple times to provide fibers with different diameter or properties.

The flame brushing process is widely used in the production of high quality optical fibers and microfibers with low loss and high strength. The procedure can be used to create fibers with sizes ranging from a few microns, depending on the requirements of the application. The process is well liked for small scale production of optical fibers and microfibers since it is simple to do and can be done with reasonably priced equipment.

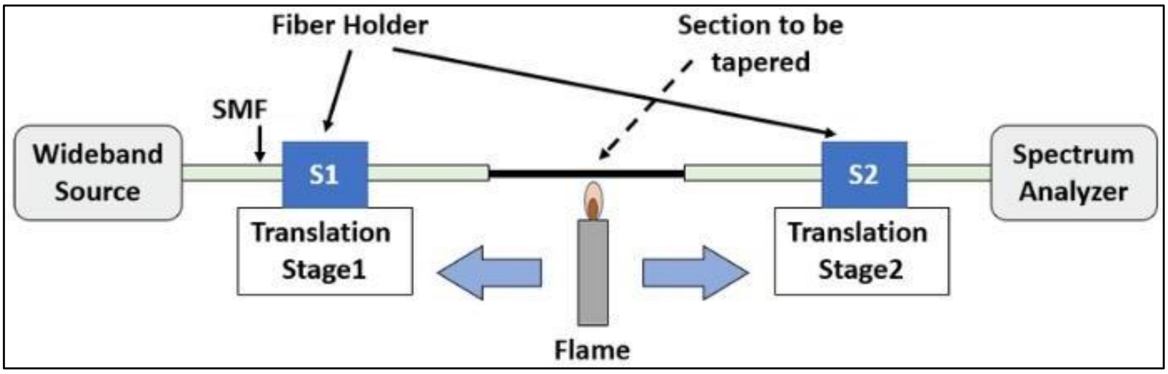


Figure 2.16 Flame brushing technique schematic

2.2.8 Refractive Index Based Detergent Concentration Method

Investigation of load profiles of residential, commercial and industrial load segments to determine load factor (LF) and loss factor (LsF) were considered in the analytical models. The document discusses a method for determining detergent concentration in membrane protein preparations based on refractive index of the detergent solution. The method was applied to quantitate the amount of detergent remaining in solution after concentration in various concentrators. The study found that the ability of the tested detergents to pass through the molecular weight cutoff membrane correlates well with detergent micelle size. The refractive index method, when coupled with size exclusion chromatography and light scattering, can be used to determine the oligomeric state of the membrane protein, the size of a protein associated micelle. Additionally, the document mentions the application of dynamic light scattering to characterize membrane proteins in detergent solution. It also discusses the characterization of new detergents and detergent mimetics by scattering techniques for membrane protein crystallization.

2.2.9 Arduino Uno

This journal explores the functionality and possible applications of an Arduino board. Addtionally, it looks at Arduino as a possible instrument for scholarly and research projects. Arduino boards are used to create effective VLSI test benches, particularly for sensors. The primary advantages are fast processing and an easy to use interface. Because more people are using open source hardware and software, technology is opening up new possibilities in the modern world by making complicated tasks look easy and fascinating. This open source technology is very dependable, fairly affordable, and available for free or at a minimal cost. In this paper, the types of Arduino boards, their applications, and their functioning principles are covered. Because Arduino can be quickly and easily programmed, deleted, and reprogrammed at any moment, it can be referred to as an open source microcontroller. Due to its low cost and ease of use, Arduino wan initially designed with professionals, hobbyists, and students in mind. Like other microcontrollers, it may also function as a minicomputer by taking in inputs and managing the outputs for a range of electronic devices. Additionally, Arduino shields enable it to broadcast and receive data over the internet. The Arduino Ethernet. The Arduino Ethernet shield, Arduino Wireless shield, and Arduino Motor Driver shield are the three different kinds of Arduino shields. Every single Arduino shield has a unique function. The term "sketch" refers to the programmer code for Arduino boards. The software used to build the sketches is called the Arduino IDE. One of the features of the Arduino IDE is the requirement to save projects with file names. You can also use the Ctrl+F keyboard shortcut to search for a word and replace it with another. This document also lists three Arduino compatible applications: ArduSat, ArduPilotMega (APM), and Lilypad Arduino. Overall, the Arduino concept, its hardware and software capabilities, and its application were all investigated in this article.

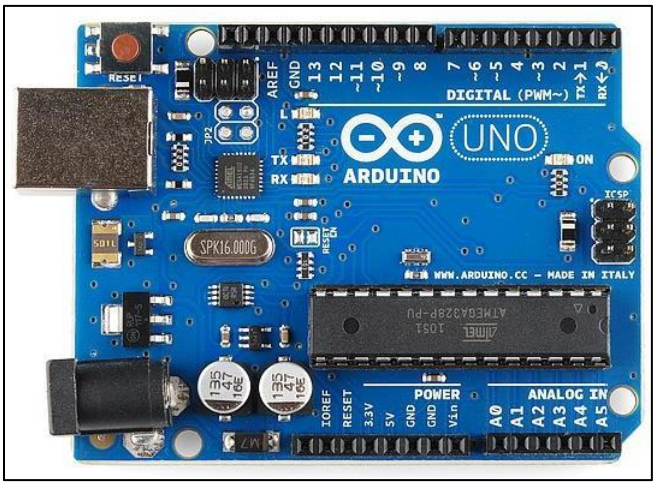


Figure 2.17 Arduino UNO

2.2.10 LED

Investigation of load profiles of residential, commercial and industrial load segments to determine load factor (LF) and loss factor (LsF) were considered in the analytical models. Over the past few decades, light emitting diode (LED) technology has gained popularity. Its may benefits have made it a crucial part of light technology nowadays. LED lighting is designed to provide longer lasting, energy efficient illumination. LEDs are excellent heat and light producing devices. Regretfully, they do marginally better at the latter than the former, and more lumens are generated per electrical energy unit as technology develops. Since LEDs can produce heat in addition to light, they must be cooled in order to keep the junction temperature within allowable limits. Since practically every performance metric LEDs like efficiency, stability of hue and longevity, diminishes with the temperature increase. They should be operating at the coldest temperature feasible. It is recommended to utilise circuit boards with extremely low thermal resistance between semiconductors so that conduction can cool the LEDs. In conclusion, heat from LED technology has the potential to boil eggs. Electricity is used to produce the heat. When electricity is provided to the lightbulb, heat is created. However, the heat generated by LEDs is much less than that of an incandescent bulb. The energy used by a 100 watt GLS incandescent bulb produces 12% heat, 83% infrared light, and 5% visible light. Conversely, a typical LED emits 85% of heat and just 15% of visible light. Effective thermal management is essential to dissipating this heat, especially when using high power LEDs.

Figure 2.18 LED

2.2.11 Light Dependent Resistor

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it. LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012 Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR Photocells or LDR's are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves. When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, LDR's are less sensitive than photo diodes and phototransistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a pn junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no pn junction in this nor it "converts" light to electricity).

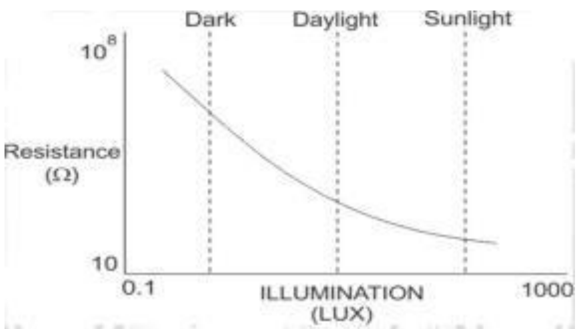


Figure 2.19 LDR Characteristic

2.3 Summary

This chapter covers the techniques for making tapered microfibers. This section also covers hows microfiber can be a sensor and process of generating microfiber by flame brushing. Thus, the many approaches of reating a fiber optic sensor have been explored in this chapter. There must have been numerous studies conducted to date on optical microfiber in terms of its qualities, uses, and technique of production. By reducing optical fiber widths to the wavelength scale, these minuscule fibers have offered several benefits for micro or nano scale light management, as well as a new platform for scientific and technological applications. Recent demonstrations of a multitude of novel uses for optical micro or nano in atom optics may lead to new applications of light beyond optics and bright futures for fiber optics and related technologies. These features include strong near field interaction, miniaturisation, and the capacity to create extremely contined evanescent fields with low losses.

CHAPTER 3: METHODOLOGY

3.1 Introduction

An overview of the research technique and the rationale for the selected approach will be given in this chapter. The project will start by applying a particular strategy. The use of different tools and techniques will come next, continuing until the project is finished. The process flow and design specifications required for this project's development will also be clarified in this chapter.

3.2 Hardware and Software Development

3.2.1 Arduino UNO R3 Board

In designing and implementing a weather sensing project with a focus on sustainability, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. A well liked microcontroller board for electronics projects is the Arduino UNO R3. With 14 digital input/output pins, 6 analogue inputs, a 16 MHz quartz crystal, a USB port and many more that build around the Arduino microcontroller. The Arduino IDE, which supports C++ and has a user friendly interface for uploading code to the board, can be used to progamme it. The Arduino UNO R3 is a popular board for electronics and programming education and prototyping.

Figure 3.1 Arduino UNO R3

3.2.2 LCD

An inexpensive, simple display module, the LCD 1602 is frequently utilised in Arduino and electronics projects. As shown in Figure 3.2 below, its come with 16 column by 2 row screen, which can display letters, numbers and basic characters. This device is excellent for showing messages or sensor data and other basic information. Its also simple to connect with microcontrollers.

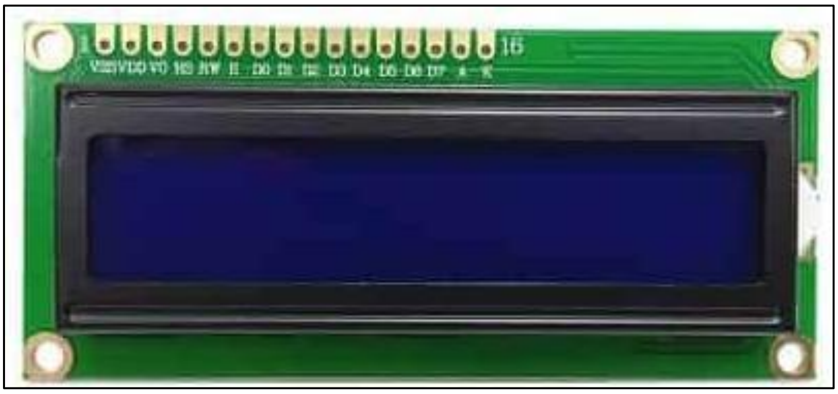


Figure 3.2 LCD 1602

3.2.3 LED

Small and energy efficient, LEDs (Light Emitting Diodes) are widely utilised in a variety of applications, ranging from electronic indicators to home light. LEDs as opposed to conventional bulbs, generate light by a process called electroluminescene, in which light is produced by an electric current flowing through a semiconductor subtance. LED available in a variety of colours and sizes. Futhermore, it also have a low power consumption.

Figure 3.3 LED

3.2.4 Light Dependent Resistor

A photo resistor , also know as a light-dependent resistor (LDR) as shown in Figure 3.5, is a resistor that becomes less resistant to light. It is frequently used, like in the case of autonomous cars, to detect whether it is day or night porch lighting. Due to the sensor's nonlinearity, when it is not in contact with light, its resistance can approach 500K ohm. However, when the light is off, the resistance normally falls between 10 and 20K ohm in a typical room. When the light is turned on, the resistance drops to 1 kilo ohm or less.

Figure 3.4 Light Dependent Resistor

3.2.5 Resistors

In designing and implementing a weather sensing project with a focus on sustainability, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. A resistor is a two terminal electrical component that offers electrical resistance, acting as a passive circuit element. Among their many uses in electronic circuits are the reduction of current flow, control of signal levels, division of voltages, biassing of active components, and termination of transmission lines. Resistors of 220 ohm and 10k ohm were employed for the BDP.

Figure 3.5 Resistor 220 ohm

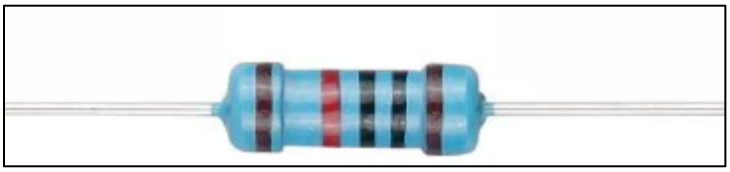


Figure 3.6 Resistor 10k ohm

3.2.6 Green PCB

These perforated prototyping boards, measuring 5 by 7cm, are perfect for developing circuit. On this board, soldering is permitted on both sides. This solderable printed circuit board (PCB) is made of glass and epoxy, a premium material known as FR4.

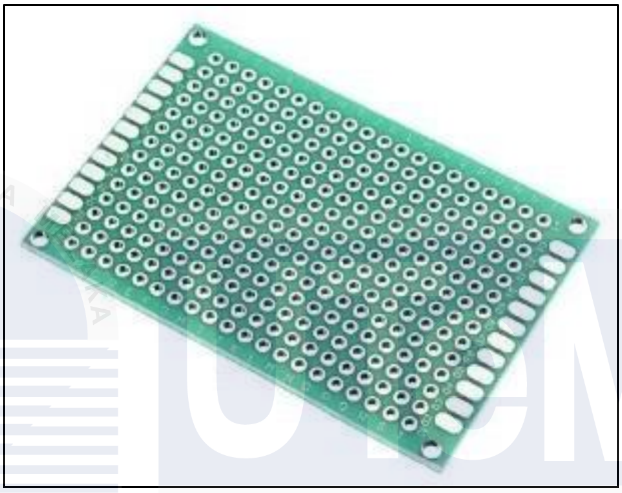


Figure 3.7 Green PCB

3.2.7 Jumper Wires

A jumper wire is seen in Figure 3.8. The purpose is to create short-term connections between electronic parts using a breadboard or other prototype tools. It is widely used in electronic projects, circuit design, and prototyping.

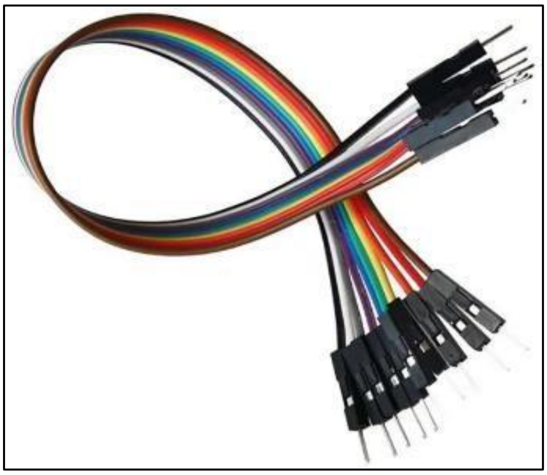


Figure 3.8 Jumper Wires

3.2.8 Wires

In designing and implementing a weather sensing project with a focus on sustainability, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. In order to create electrical conductivity between two devices in an electrical circuit, wires are joined onto a printed circuit board (PCB). They are incredibly low resistance to electric current flow.

Figure 3.9 Wires

3.2.9 Solder Lead

In designing and implementing a weather sensing project with a focus on sustainability, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. A thin, malleable metal strip used for soldering is called solder wire. It is frequently used to create electrical connections between printed circuit boards, or PCB's, and metal components. Solder wire can be used either alone or in conjunction with solder paste, a mixture that contains flux, a subtance that makes it easier to remove oxidation from metals while soldering. Lead content in solder is essential for increasing mechanical strength and electrical conductivity in addition to its melting point. In electronic applications, it is essential to ensure both effective current flow and mechanical stress resistance, especially in soldered connections.

Figure 3.10 Solder lead

3.2.10 PCB Standoff Spacer

Two essential types of fastener accessories are spacers and standoffs. These are used to crete spaces between two or more connected surfaces or components, and they are specifically designed to lift the PCB above the surface.

Figure 3.11 PCB standoff spacer

3.2.11 Storage Box

In designing and implementing a weather sensing project with a focus on sustainability, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. A storage container intended to house the hardware for my project is shown in Figure 3.12. This project has the benefit of being portable.

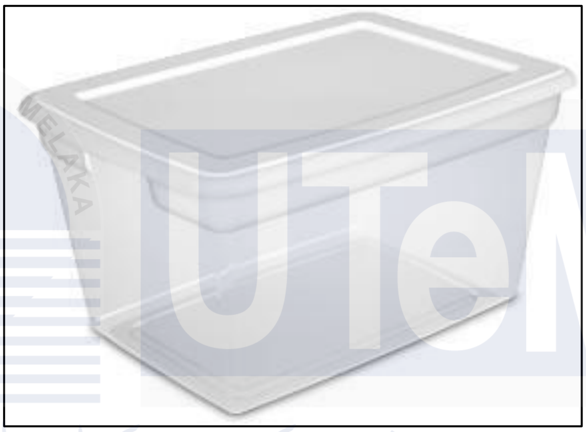


Figure 3.12 Storage box

3.2.12 Glass Slide

Figure 3.14 is a glass slide. Glass slides provide a flat, transparent surface for viewing samples. Glass slides hold specimens, especially in microscopic examination.

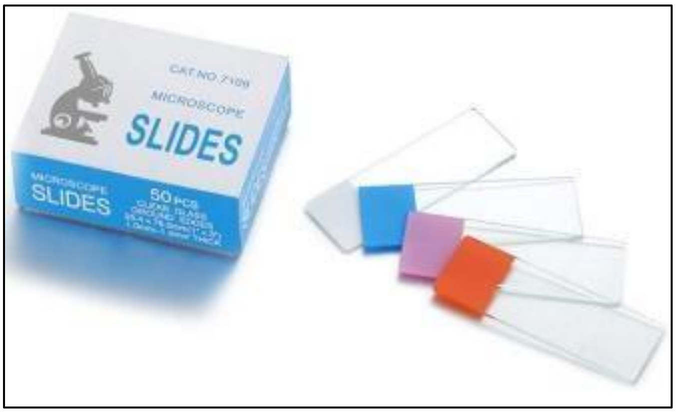


Figure 3.13 Glass slide

3.2.13 Arduino IDE

Programming Arduino microcontrollers is made easier with the help of the Arduino IDE software platform. It offers a user-friendly interface for writing, gathering, and uploading code to Arduino devices. An integrated code editor (IDE) with error checking and intuitive syntax highlighting is part of the IDE. Additionally, it provides a library manager for easy code library administration and installation. The interoperability of the integrated board manager with different Arduino boards is guaranteed. With the serial monitor, can debug code, check sensor data, and connect with the board. It's easy to upload code using the upload manager. For learning and reference, the IDE includes a substantial library of sample code and tutorials. Debugging tools like variable monitoring and breakpoints help find and correct issues in the code. Figure 3.14 the Arduino IDE is open-source, compatible with many operating systems, and appropriate for both beginners and experts.

Figure 3. 14 Arduino IDE

3.3 Methodology

A flowchart is a visual representation of a process, showing the sequence of steps needed to complete task. Below, in Figure 3.16, is the flowchart of the project. Begin with the first step, which is called "Start," which is the start of the flow project. The procedure then moves on to the blue LED, which emits the light that shows the project is ready to use. Next, after the LED emits the light, put a detergent on the glass slides, and then LDR will detect the light through the sample, which is liquid detergent. If the LDR can detect, then the LCD will display value from the sample; if it not detect, project will repeat from the red LED emitting the light, and then LDR will detect the light through the sample until the LDR can detect and LDC will display value. After successful LCD display, it will end.

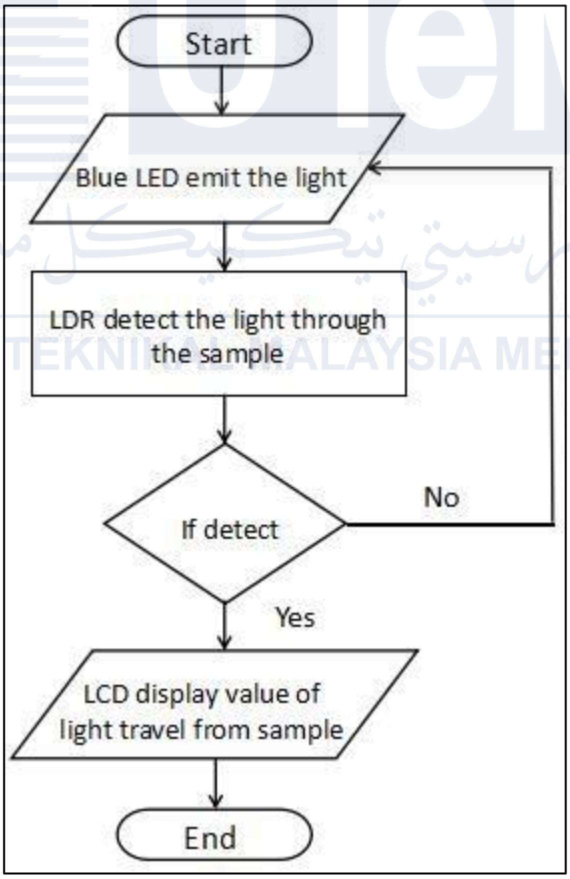


Figure 3.15 Flowchart of project

3.4 Design Prototype

Designing a prototype based on the components used involves creating a preliminary model that integrates all key elements to test and validate the intended functionality. This process begins by selecting suitable components that align with the desired specifications, for example in this project used LDR, LED, microcontroller and so on. These components are then arranged systematically. The prototype allows for evaluating the compatibility and efficiency of the chosen components and identifying areas for optimization. Iterative testing and refinement ensure the prototype meets the design objective, paving the way the further development and eventual production. Below is a prototype design for this project.

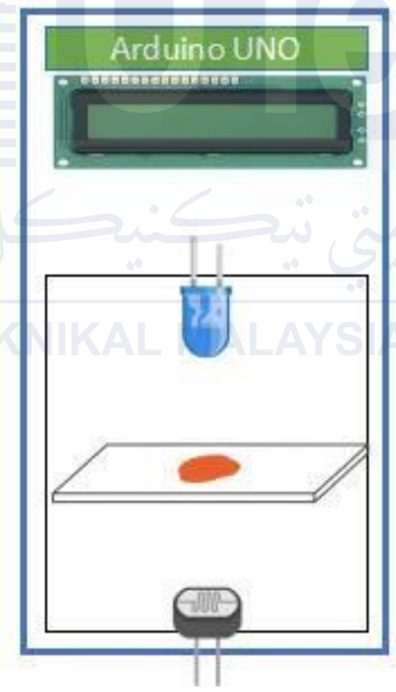


Figure 3.16 Prototype Design

3.5 Circuit Design

Designing a circuit based on the components used involves understanding the specific roles and limitations of each component within the desired functionality. The process begins with identifying the purpose of the circuit. Components like LDR, LED are selected based on their ratings, such as voltage. The layout is then planned to ensure proper connections and minimizing of interference. Tools like circuit design software can aid in visualizing and simulating the circuit before physical assembly. Once the design is finalized, the circuit can be prototyped and tested to ensure it meets the required specifications. Below is the circuit design for this project.

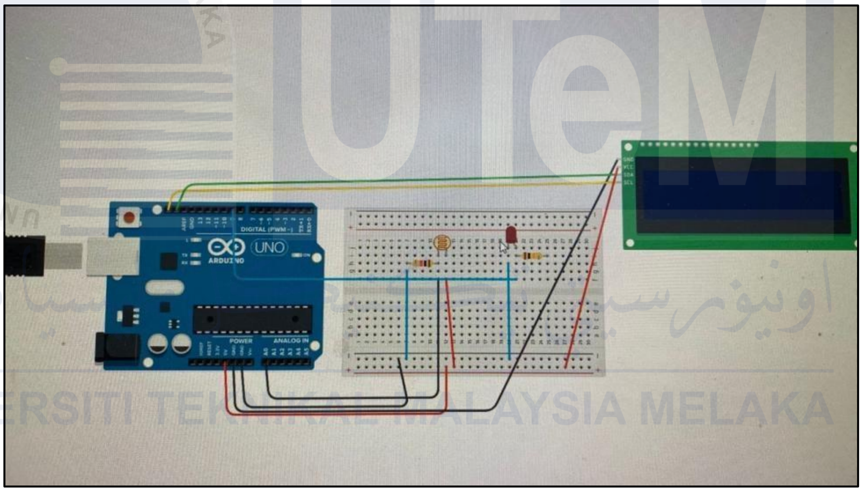


Figure 3. 17 Circuit Design

3.6 Project Prototype

This project prototype is a sensor based monitoring device housed in a transparent plastic casing. It incorporates an LDR sensor to measure light intensity, which is processed and displayed on an LCD screen. The screen shows real-time data, including the LDR value and a qualitative output such as “Conc: High”. The prototype is powered by an internal circuit, with visible wiring and electronic components, and is mounted on a wooden stand for stability. This setup appears to be a proof of concept for testing environmental monitoring or industrial safety applications.

Figure 3.18 Project Prototype (a)

Figure 3.19 Project Prototype (b)

Figure 3.20 Project Prototype (c)

3.4 Summary

This chapter describes the recommended procedure for using a LDR sensor for liquid detergent in different concentrations. The LDR sensor is a crucial part of the project, as it measures the intensity of light passing through detergent samples. The methodology section also outlines the tools and components used, such as the Arduino UNO, LED, LCD and a storage box for housing the prototype. The chapter provides a step-by-step guide to assembling these components into a functional circuit, with a clear flowchart illustrating the operation of the system. Futhermore, the design of the prototype and the process for testing detergent samples, ensuring the accuracy and sensitivity of the measurements. This structured approach ensures that the LDR sensor performs effectively as a liquid sensor for detecting and analyzing detergent concentrations.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

The result and analysis of the LDR sensor's growth in detergent at various concentrations are presented in this chapter. The project was developed sequentially in compliance with the defined methodology. Therefore, the experimental results will be provided in a case study in order to ascertain the graph's sensitivity, linearity, and repearability. All of which are entirely dependent upon the concentration of liquid detergent and the light source. It should be noted that the purpose of this case study is to illustrate the recommended procedures for evaluating different detergent concentrations. The concentration of detergent will be measure in three different sample, brand A, brand B and brand C.

4.2 Results and Analysis

The result and analysis of utilizing a Light Dependent Resistor (LDR) sensor for measuring the concentration of liquid detergent are presented in this chapter. To demonstrate the sensitivity and effectiveness of the LDR sensor. The project involved measuring the concentrations of three different detergent types using the LDR sensor to evaluate its performance. Three detergent concentrations were tested for each sample, and the corresponding light intensity changes were measured using the LDR sensor. The methodology included dripping the detergent samples onto a glass slide using a dropper feeder before the measurements. The LDR sensor detected changes in light transmission through the samples, which were then displayed on an LCD. The sensitivity and linearity of the system were analyzed by plotting the results on a line graph, where each measurement produces a distinct curve depending on the detergent concentration.

4.2.1 Result for Brand A

Table and graph below present the results for Detergent A, including concentration data, linearity and sensitivity analysis and the corresponding graph. The concentration data, as shown in Table 4.2.1(a), exhibited variability highlights the need for precise calibration of the system to account for potential fluctuations during measurements.

Table 4.2.1 (a) Result for Brand A

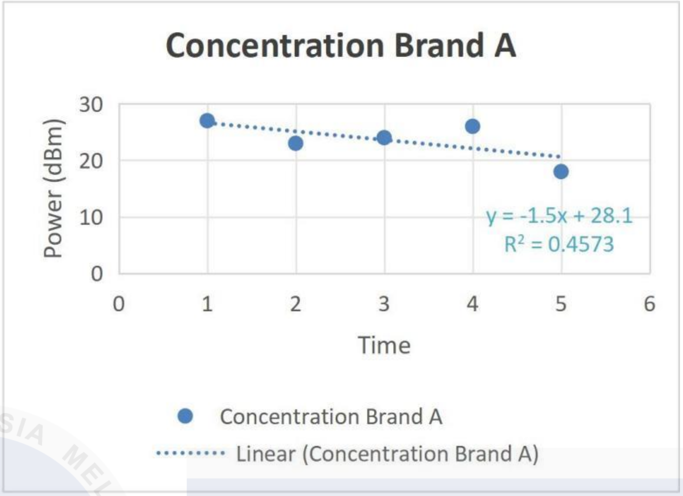
Time	Concentration Brand A (dBm)
1	27
2	23
3	24
4	26
5	18

The sensitivity of Brand A, calculated as 1.5dBm, indicates the system's responsiveness to changes in detergent concentration. While this demonstrates the LDR sensor's capability to detect subtle variations, the linearity value $R^2 = 0.4573$ suggests moderate correlation, indicating room for improvement in achieving consistent linear behaviour across the tested concentrations.

Table 4.2.1 (b) Sensitivity and Linearity for Brand A

Type of Detergent	**Sensitivity (dBm)**	**Linearity(R^2)**
Brand A	**1.5**	**0.4573**

Table 4.2.1 (c) Graph for Brand A



4.2.2 Result for Brand B

From the measurement shown in Table 4.2.2 (a), Brand B concentration values showed intial fluctuation between 17-21 dBm in the first 4 times periods, followed by a notable decrease to 11 dBm at time period 5. the calculated sensitivity of 1.8 dBm indicates moderate responsiveness to concentration changes.

Table 4.2.2 (a)) Result for Brand B

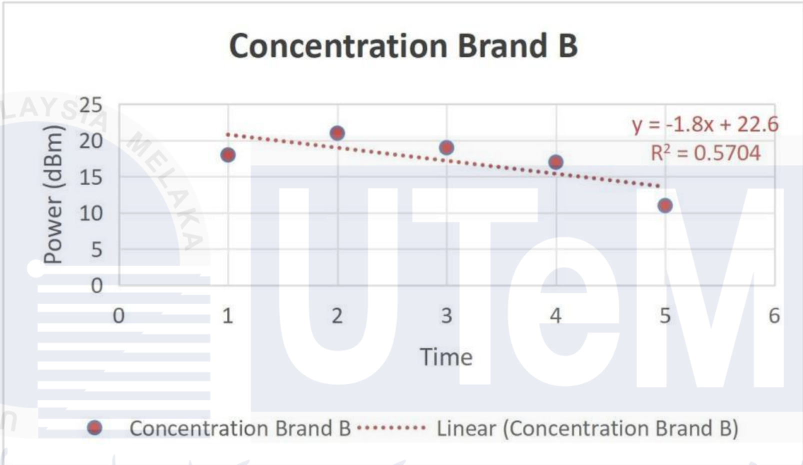
Time	Concentration Brand B (dBm)
1	18
2	21
3	19
4	17
5	11

However, the linearity (R^2) value of 0.5704 reveals relatively poor linear correlation in the measurements. This R^2 value, being well below 0.9, suggests relationship over time. This could indicate inconsistent performance or the presence of other factors affecting the measurement.

Table 4.2.2 (b) Result for Brand B

Type of Detergent	Sensitivity (dBm)	Linearity(R^2)
Brand B	**1.8**	**0.5704**

Table 4.2.2 (c) Graph for Brand B



4.2.3 Result for Brand C

The measurement for Brand C showns in Table 4.2.3(a) display highly erratic concentration values ranging from 1 to 8 dBm across the five time periods. The pattern shows an initial increase from 3 to 8 dBm in the first three periods, followed by a sharp drop to 1dBm in period 4, and then an increase to 6 dBm in period 5.

Table 4.2.3 (a) Result for Brand C

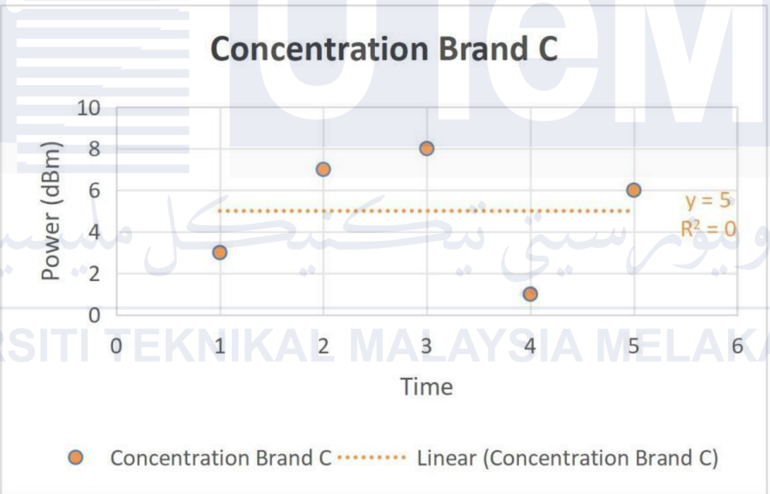
Time	Concentration Brand C (dBm)
1	3
2	7
3	8
4	1
5	6

The sensitivity value of 5 dBm indicates high sensitivity to concentration changes. Most significantly, the linear (R^2) value of 0 demonstrates a complete absence of linear correlation in the measurements. This indicates that Brand C concentration values are essentially random with no presictable pattern over time.

Table 4.2.3 (b) Result for Brand C

Type of Detergent	Sensitivity (dBm)	Linearity(R^2)
Brand C	**5**	**0**

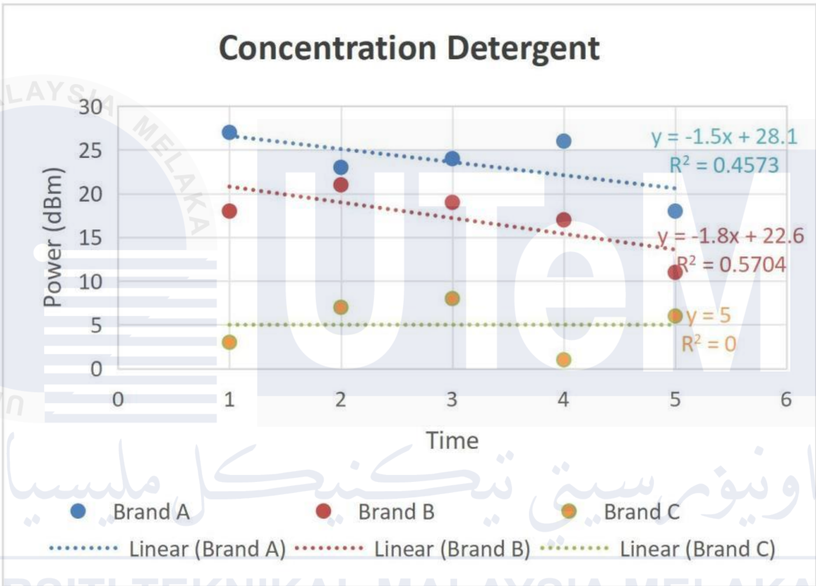
Table 4.2.3 (c) Graph for Brand C



4.2.4 Summary for Brand A, B and C

Based on the graph Concentration Detergent there appears to be a comparison of three different detergent brands: Brand A, Brand B, and Brand C. The data shows their performance or concentration levels over 5 time periods or measurement points. Brand A shows a gradual declining trend with a slope of -1.5x and starts at the highest concentration (around 27), maintaining relatively higher values throughout. Brand B also displays a declining trend with a slightly steeper slope of -1.8x, consistently showing medium range values. Brand C demonstrates a constant value of 5 (y = 5) with some minor fluctuations, maintaining the lowest concentration levels among the three brands. The R-squared values for Brand A (0.4573) and Brand B (0.5704) indicate moderate correlation in their linear trends, suggesting some variability in the measurements. Overall, Brand A appears to maintain the highest concentration levels despite the declining trend, while Brand C shows the most stable but lowest concentration throughout the measured period.

Table 4.2.4 Graph for Brand A, B and C



4.3 Summary

This chapter's case studies demonstrate how the suggested Light Dependent Resistor (LDR) sensor development system can be applied to measure various detergent concentrations using direct measurement techniques. The graph presents an evaluation of three different detergent brands focusing on the LDR sensor's sensitivity and linearity in measuring concentration levels. The results show varying linear trends, with Brand A exhibiting a gradual decline (slope -1.5x, $R^2 = 0.4573$) from higher initial values, Brand B showing a steeper decline (slope -1.8x, $R^2 = 0.5704$) from moderate values, and Brand C maintaining a constant low level ($y = 5$). The R-squared values indicate moderate correlation strength, suggesting the LDR sensor system provides reasonably reliable measurements for tracking detergent concentration changes over time, though with some inherent variability in the readings.

CHAPTER 5: CONCULSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis describes how to use Light Dependent Resistor (LDR) sensors for measuring liquid detergent concentrations. The proposed method is dependable and effective in yielding favorable outcomes with minimal measurement information and precise data. The correlation for each detergent sample at different concentrations was analyzed by combining linearity and sensitivity measurements. The study of the LDR sensor showed that even at small concentration changes, the measurements remain stable. Furthermore, LDR sensors have proven to offer special advantages over traditional optical sensors due to their cost-effectiveness and simple implementation. One such advantage is their reliable sensitivity for measuring changes in light intensity as affected by detergent concentration. In addition, the LDR's direct response to light variations makes it possible to attain good sensitivity with simple circuitry, which is a highly desirable attribute for a wide range of applications. Overall, this thesis's research has increased our understanding of LDR sensor applications in detergent concentration measurements. The method presented is effective in making use of minimal data, both in terms of quantity and type, and it doesn't require complex setup or processing procedures.

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