# Faculty of Electrical and Electronic Engineering Technology

# Development of Fiber Optic Sensor using Different Type of Cooking Oil.

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**Bachelor of Electronics Engineering Technology with Honours**

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**Development of Fiber Optic Sensor using Different Type of Cooking Oil.**

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**A project report submitted**
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## APPROVAL

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## DEDICATION

My special dedication goes to my beloved parents, siblings and friends who always support me behind and who always encourage me to help me finish final year project successfully. Meanwhile, I dedicate this thesis to my beloved supervisor, DR AMINAH BINTI AHMAD and co. supervisor, DR MD ASHADI BIN MD JOHARI who had taught me a lot and guided me how to achieve success for my final year project. I am humbled and grateful for their sacrifice, patience, and consideration, which were unavoidable in order for this attempt to be considered. I'm at a loss for words to express how grateful I am for their dedication, support, and belief in my abilities to achieve my goals. Thank you very much. I appreciate it.

# ABSTRACT

Fiber optics, commonly referred to as optical fiber, is a medium and system for transmitting information as light pulses over a glass or plastic strand. When light signals are transmitted through fiber optic cable, they bounced off the core and cladding in a sequence of zig-zag bounces, a phenomenon known as total internal reflection. Recently, fiber optic sensors receive considerable research efforts due to their high sensitivity, detection speed, and ability to use harsh environments. The bjective of this project was to use fiber optics as a liquid sensor to detect varying types of cooking oil. The end product will provide a better knowledge of fiber optic sensors and might be used other fields such as the food business. There will be three cooking oil samples tested: palm oil, olive oil, and corn oil. Before each test, the fiber would be dipped in the cooking oils and then measured. In a line graph, each measurement would have different results. The experiment's findings will be described in terms of sensitivity, correlation, and coefficient of determination of the graph, all of which are completely dependent on the cooking oil concentration and light source.

# *ABSTRAK*

Serat optik, biasanya disebut sebagai serat optik, adalah media dan sistem untuk mengirimkan maklumat sebagai denyut cahaya di atas helai kaca atau plastik. Apabila isyarat cahaya dihantar melalui kabel gentian optik, mereka memantul dari teras dan melekap dalam urutan memantul zig-zag, fenomena yang dikenali sebagai pantulan dalaman total. Baru-baru ini, sensor gentian optik mendapat banyak usaha penyelidikan kerana kepekaannya yang tinggi, kelajuan pengesanan, dan kemampuan untuk menggunakan persekitaran yang keras. Objektif projek ini adalah menggunakan gentian optik sebagai sensor cecair untuk mengesan pelbagai jenis minyak masak. Produk akhir akan memberikan pengetahuan yang lebih baik mengenai sensor serat optik dan mungkin digunakan dalam bidang lain seperti perniagaan makanan. Terdapat tiga sampel minyak masak yang diuji: minyak sawit, minyak zaitun, dan minyak jagung. . Sebelum setiap ujian, serat akan dicelupkan ke dalam minyak masak dan kemudian diukur. Dalam grafik garis, setiap pengukuran akan mempunyai hasil yang berbeza. Penemuan eksperimen akan dijelaskan dari segi kepekaan, korelasi, dan pekali penentuan graf, yang semuanya bergantung sepenuhnya pada kepekatan minyak masak dan sumber cahaya.

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| | | |
|---|---|---|
| $n_1$ | - | the refractive index of the medium the light is leaving |
| $\theta_1$ | - | the incident angle between the light beam and the normal |
| $n_2$ | - | refractive index of the material the light is entering |
| $\theta_2$ | - | the refractive angle between the light ray and the normal |

## LIST OF ABBREVIATIONS

$OSA$ - Optical Spectrum Analayzer

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Fiber optics, commonly referred to as optical fiber, is a medium and system for transmitting information as light pulses over a glass or plastic strand or fiber. Fiber optics is used in data networking for long-distance and high-performance communication. Fiber optics convey data using light particles, or photons, that pulse via a fiber optic connection. Each glass fiber core and cladding has a particular refractive index, which bends the incoming light at a distinct angle. When light signals are transmitted through fiber optic cable, they bounced off the core and cladding in a sequence of zig-zag bounces, a phenomenon known as total internal reflection.

Recently, fiber optic sensors receive considerable research efforts due to their high sensitivity, detection speed, and ability to use harsh environments. A few types of fiber optics but commonly used right now are multimode fiber and single-mode fiber. Because of the smaller diameter of the glass fiber core, which reduces attenuation probability, single-mode fiber is employed over longer distances. In comparison, its broader core diameter allows light signals to bounce and reflect more along the way. On the other hand, multimode fiber is employed for shorter distances. This research is about the Development of Fiber Optic Sensor using Different Type of Cooking Oil. This project requires an SMF28 optical cable under test, a laser source with a wavelength of 1550nm, an Optical Spectrum Analyzer (OSA) and three different cooking oil. And each oil is tested three times, and the results will be the value of loss (dB) at the peak of the spectrum acquired from the OSA instrument. By the end of the project, a single optical concentration with great sensitivity has been established.

## 1.2 Problem Statement

Currently, health is at the top of humanity's priority list. To be healthy, people must always monitor the amount of fat and cholesterol in their diet. It offers two options: exercise or dietary control. In each of cooking oil used nowadays have their concentration, so we are interested in knowing which oil has better concentration. There are three types of cooking oil under study: palm oil, olive oil, and corn oil. Therefore, fiber optic has been chosen to check each concentration of cooking oil.

## 1.3 Project Objective

The objectives for this project are as stated below:

a) To study the fiber optic sensor for varied cooking oils concentration detection.

b) To develop a Fiber Optic Sensor for varied cooking oils concentration detection.

c) To optimize the performance of fiber optic sensor for concentration detection activities

## 1.4 Scope of Project

This project's scope is to study fiber optic sensors and develop the fiber optic sensor for varied cooking oil concentration detection. The developed sensors will also be analyzed for their performance. This project ensures the project is heading in the right direction to achieve its objectives.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

In this chapter, we will go over the literature review. The identical parts have been offered to ensure that all data concerning this project may be classified. Several topics are crucially relevant in this section, such as those listed below, where they can be planned and executed correctly and in a timely and effective manner. This chapter also discussed fiber optic sensing, the application of fiber optic in various fields and some important works related to this project.

## 2.2 Fiber optic

Originally, fiber optic cable was known as the bundle of glass, transmitting modulated lightwave as massage data. Its capability has been tested over years which are more advantageous than metal cable in data transmissions. The optical fiber consists of the core and the cladding, which have different refractive indexes. The light beam travels through the core by repeatedly bouncing off the wall of the cladding. Fiber optic cable is used to transport data from an optical power source to an output device such as an optical power tester or an optical spectrum analyzer. Depending on the power and transmission distance requirements, the fibers are supposed to help propagate light in conjunction with the optical fiber.



The idea of total internal reflection governs the optical fiber's functioning. Light rays are capable of transmitting vast volumes of data. So, unless we have a long straight wire with no bends, leveraging this benefit will be tough. In contrast, optical devices are designed to bend all light rays inwards (using TIR). As a result, light beams bounce off fiber optic walls forever, transferring data from one end to another. Although light signals degrade with time, mostly on the purity of the material used, the loss is significantly less than when metal wires are used.

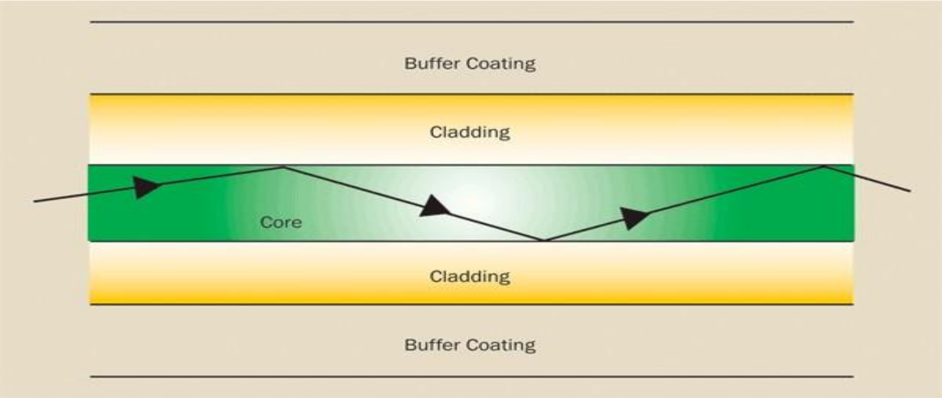


**Figure 2.1: Total Internal Reaction (TIR) of Fiber Optic**

There are few advantages when dealing with fibers. Firstly, its tiny size and cylindrical design integrate well into a wide range of structures, such as composite materials, with minimum interference. Next is Fiber optics are resistant to EMI, although they are combustible and hazardous to the environment. Finally, aside from being lightweight and sensitive, it is also more resistant to hard environmental conditions such as severe high and low temperatures, vibration, radiation, pressure, and corrosive environments.

There are two types of fiber optics which are plastic optical fiber and glass optical fiber. The usage determines the types of fiber optics used.

### 2.2.1 Plastic types



**Figure 2.2: Plastic Optical fiber**

The plastic fiber core is made up of one or more fiberglass fibers 0.25 to 1 mm in diameter that is enclosed in a polyethene sheath. Plastic fibers are the most prevalent form of fiber sensor because they are light, inexpensive, and flexible. It uses red and green light that is safe for the eyes and maybe put at home without endangering others. There are a few pros and cons when using plastic fibers.

**Table 2.1: Advantages and Disadvantages of Plastic Fiber**

| Advantages | Disadvantages |
|---|---|
| has a wide range of diameters which ranging from 0.15mm up to 20mm | narrower numerical aperture, which ranges from 0.48 to 0.63 |
| more flexible and able to bend farther without cracking or breaking | has low light gathering capability, which makes it capture less light |
| can withstand vibration and unsteady environments [1] | not able to withstand harsh environments, and the fiber will easily degrade over time |

### 2.2.2 Glass Type



**Figure 2.3: Glass Optical Fiber**

Glass optical fiber normally consists of pure glass or silica, $SiO_2$ as the core material and less pure glass or plastic as the cladding material [1]. It offers various benefits over plastic optical fiber. First, it has a wider numerical aperture for starters, letting more light into the system and varies from 0.25 to 1. Second, it can endure temperatures as low as -40F and as high as +900F. As a result, it is helpful and may be used in various applications such as ovens, engines, and cold storage. Unfortunately, it also has a few drawbacks, including a limited diameter size range of 0.05mm to 0.15mm and is more delicate and prone to breaking if not managed properly. Furthermore, it is more difficult to manage and fragile than plastic optical fiber. As a result, the cost of implementing glass optical fiber is higher.

**Table 2.2: Comparison Between Plastic And Glass Optical Fiber**

| Consideration | Glass optical fiber | Plastic optical fiber |
|---|---|---|
| Cost | More expensive | Cheaper |
| Transfer speed | Faster | Slower |
| Loss | Lower losses | Higher losses |
| Numerical Aperture | Higher | Lower |
| Temperature | Able to withstand extreme temperature | Not suitable for extreme temperature |
| Flexibility | More fragile | More flexible |
| Distance | Can be used for longer distance | Can be used for shorter distance |



## 2.3 Single Mode Fiber

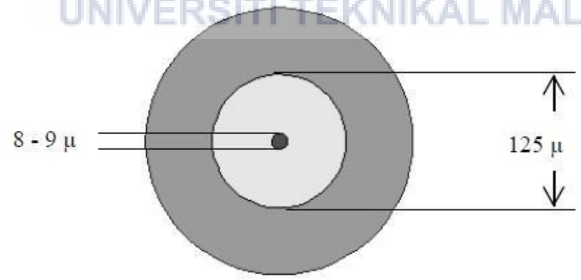


**Figure 2.4: Single mode core and Cladding Measurement**

As seen in the figure above, SMF has a modest core diameter of 8 to 9 m and a cladding diameter of 125 m. As a result, the core-to-cladding ratio is typically 9:125. Due to the narrow diameter design of the core only allows one light path of propagation, as displayed in Figure 2.4[2].

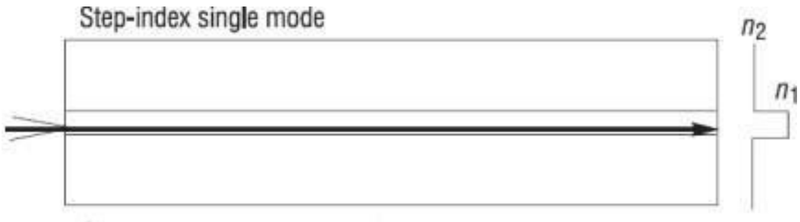


**Figure 2.5: Step-index Single Mode**

The benefit of having a tiny diameter is that light may travel longer with little attenuation due to the extremely low light reflection when it travels through the core. As a result, it has minimal data losses and a higher data transfer capacity, making it suited for communication. It can send data up to 40 GB over hundreds of kilometres with less data loss and quicker than MMF.

## 2.4 Fiber Optic as A Sensor

Recent advancements in fiber optic technology have substantially altered the telecommunications business. The capacity of optical fibers to transmit gigabits of data at light speed expanded their potential for study. Simultaneous improvements and lower costs in optoelectronic components led to the emergence of analogous new product categories. The previous revolution emerged as engineers combine the product outgrowths of fiber optic telecommunications with optoelectronic devices to create fiber optic sensors. It was soon discovered that material loss almost disappearing and the sensitivity to loss detection increased phase, intensity, and wavelength changes from external disturbances on the fiber itself could be sensed. Hence a sensor by using fiber optic was created [3].

The wavelength modulated fiber optic sensors are next, which detect changes in the wavelength of light. Fluorescence sensors, black body sensors, and the Bragg grating sensor are all examples of wavelength-modulated sensors. Fluorescent-based fiber sensors are widely utilized in medical applications, chemical sensing, and physical parameter measurements such as temperature, viscosity, and pressure. Bragg Grating Sensor is the most widely used wavelength-based sensor. Fiber Bragg gratings (FBGs) are created by periodic changes in the refractive index inside the centre of a single mode optical fiber. This periodic increase in refractive index is usually generated by exposing the fiber core to an extreme