UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF FIBRE OPTIC SENSOR FOR PH LEVEL DETECTION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Telecommunication) Honours

by

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I hereby, declared this report entitled "Development of Fibre Optic Sensor for pH Detection" is the results of my own research except as cited in the references.

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APPROVAL

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ABSTRAK

Kertas kerja ini membentangkan gambaran keseluruhan kemajuan dan peningkatan gentian optik dalam bidang inovasi. Di samping itu, sistem ini juga menonjolkan isu-isu sebenar menyokong penyelidikan semasa dan menggariskan pelbagai aplikasi kritikal gentian optik penderia bagi pengukuran keasidan dan kealkalian dalam sesuatu larutan. Reka bentuk sistem diberi pengutamaaan di dalam kajian ini manakala pembuatan dan ujian sensor diaplikasi untuk mengesan kehadiran alkali dan larutan berasid di dalam sistem penderia optik melalui jarak tertentu. Selain itu, gentian optik telah mengabungkan sistem penderai dengan larutan alkali dan berasid. Maklumat yang diperolehi digunakan untuk menganalisa larutan yang mencapai prestasi yang tertinggi pada masa tertentu melalui kaedah statistik. Penderia telah dipasang ke dalam konfigurasi kabel yang teguh yang membolehkan ia untuk dipasang ke dalam struktur kabel tanpa memerlukan pengendalian khas. Kualiti pH yang diuji boleh berada di bawah 0 atau lebih menonjol daripada 14 untuk asid sangat kukuh dan asas secara berasingan. Seluruh hasil projek ini adalah usahasama dalam percubaan untuk mencapai objektif eksperimen ini. Projek ini akan menghalang sebarang kerosakan kerana terdapat pelbagai langkah keselamatan diaplikasi. Keseluruhan projek berjaya dan objektif tercapai.Hasil kajian yang diperolehi diharapkan dapat dijadikan panduan bagi pemilihan penderai optik yang sesuai dimasa akan datang.

ABSTRACT

This work presents an overview of advancement and improvements in the field of fiber optic sensor innovation, highlighting the real issues supporting late research and delineating various critical applications and key ranges of successful fiber optic sensor advancement for pH identification.The design, construction and test of a sensor for detecting the presence of alkaline and acidic solution as a function of position along an optical fiber length .The system consolidates sensor with alkaline and acidic parameter which the gathered information are broke down utilizing regression technique as a part of statitiscal manner.The sensor has been assembled into a robust cable configuration which allowed it to be installed into a representative structure without the need for special handling precautions.The present acidic and alkaline solution is primarily a water detector however through varying the type of the solution the sensor can be tuned to respond to different trigger stimulus such as pH response. The pH quality can be under 0 or more prominent than 14 for exceptionally solid acids and bases separately. The whole venture is fruitful when we attempt to finish this anticipate with an assortment of strategies and configuration inside a couple of months and has been effective when run a test on this anticipate.

DEDICATION

There are a number of people without whom this thesis might not have been written, and to whom I am greatly indebted. I owe my gratitude to all those people who have made this project possible and because of whom my graduate experience has been one that I will cherish forever. I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Tharuma Rethinam Ponniah and Venee Veloo whose have been my constant source of inspiration. They have given me the drive and discipline to tackle any task with enthusiasm and determination. Without their love and support this project would not have been made possible. My brother Vishno kumar and Tanesh Nair have never left my side and are very special. My deepest gratitude is to my advisor, Mr. Mohd Ashadi Bin Mohd Johari. I have been amazingly fortunate to have an advisor who gave me the freedom to explore on my own and at the same time the guidance to recover when my steps faltered. He taught me how to question thoughts and express ideas. His patience and support helped me overcome many crisis situations and finish this project. I hope that one day I would become as good an advisor to my students as he has been to me. Many friends have helped me through these difficult years. Their support and care helped me overcome setbacks and stay focused on my graduate study. I greatly value their friendship and I deeply appreciate their belief in me. Particularly, I would like to acknowledge, Vinod Kumar Isweran for the many hours of proofreading. Besides, I am also thankful to lecturers for numerous discussions on related topics that helped me improve my knowledge in the research area better. All of them have been my best cheerleaders.

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LIST OF ABBREVATIONS, SYMBOLS AND NOMENCLATURES

FOS	-	Fibre Optic Sensor
pH	-	Power Of Hydrogen
RS	-	Recommend Standard Number
PCS	-	Plastic Clad Silica
ns	-	Nanosecond
TV	-	Televisions
PC	-	Personal Computer
RFI	-	Radio Frequency Interference
EMI	-	Electromagnetic Interference
LED	-	Light Emitting Diode
OH	-	Oxygen Hydroxide
H+	-	Hydrogen
HCI	-	Hydrochloric Corrosive
H2S04	-	Molecular Formula
mol/L	-	Molecules per liter
MFLD	-	Mode Filtered Light Detection
CCD	-	Charge-coupled Device
UTeM	-	Universiti Teknikal Malaysia Melaka
FYP	-	Final Year Project
R1	-	Fiber/air interface
R2	-	Reflected Air
OPL	-	Optical Way Length
FMI	-	Fiber Modular Interferometer
TCF	-	Thin Core Fiber
SMF	-	Single-mode fiber
dB	-	Decibels
mm	-	Millimetres
SM-SM	-	Single mode to single mode
OSA	-	Optical Spectrum Analyzer
ASE	-	Amplified Spontaneous Emission
dBm	-	Decibel-milliwatts

CHAPTER 1
INTRODUCTION

1.1 Project Background

In telecommunication field, fiber optic link is the primary piece of transmission of information. Fiber optic link is utilized broadly for correspondence framework which is working for transmitting information. The cable is the mechanical component that transports the light into and out of areas that are either too space constrained or too hostile back to the sensor. The sensor emits, receives, and converts the light energy into an electrical signal. The link comprises of a heap of glass strings, each of which is equipped for transmitting messages balanced onto light waves.

Recently, fiber optical sensors (FOS) have increased expanded popularity and market acceptance. In contrast with traditional sensors they offer various unmistakable focal points which makes them special for specific sorts of utilizations. The fiber optic sensor is a standout amongst the most fascinating and creating field. The fiber sensors are turning out to be more appealing over different reasons because of its physically like non-electrical, high accuracy, easy to install, non-contact, blast verification little size and weight. The fiber optic replaces other conventional sensor. Various assortments of parameters such as temperature, dampness, weight, focus and relocation can be measured.

The utilization of fiber optics for detecting applications really originates before its applications in correspondences systems. Fiber optical sensors (FOS) are broadly researched during last 20 year, because of their points of interest contrasted with the

routine measuring gadgets. They are utilized as a part of Chemical Engineering, Biotechnology, Medicine, Aeronautics, Material Sciences, and Civil Engineering.

Furthermore, this project focuses on Fiber Optic Sensor (FOS) that uses acidic and alkaline solution to determine the pH value. The FOS are more unique because they have many advantages such as the simplicity of design, accuracy, flexible dynamic range, and the low cost of fabrication are favourable attributes of the sensor and beneficial for real-field applications. Thus, the purpose of the projects to detect the acidity and alkalinity concentration which are measured with a logarithmic scale called pH.

1.2 Problem Statement

The current fiber optic sensor in market nowadays are essentially engaged to be utilized for measuring water level or as a water detector however through changing the organization of the arrangement the sensor can be tuned to react to various trigger stimulus, for example, pH reaction. The routine method utilized for pH estimation was utilized a pH-delicate film. However, this technique needed precision when measuring compelling pH arrangements, fluid suspensions of natural matter or low ionic quality solutions. Luckily, these limitations could be overcome by utilizing optical pH sensors and fiber optic pH sensors. It is very suitable to replace the existing conventional sensor to measure the water pH level in an acidic or alkaline solution because of it extraordinary qualities in terms of qualities as far as exactness, offer effortlessness, minimal effort and non-contact type sensing which able to perform without contacting the sample. Moreover the design, construction and test of a sensor for detecting the presence of water as a function of position along an optical fiber length.

1.3 Objectives

Due to the problem statement above, it is cleared that the objectives of the project are:

1. To understand or to study about fiber optic sensor.
2. To develop fiber optic sensor for different pH detection.
3. To analyses the performance of fiber optic sensor using statistical technique.

1.4 Scope of work

The scopes of work for the project include the following areas:

1. The study and understanding of fiber optic sensor in measuring pH.
2. Conduct the experiment using fiber optic to test acidic and alkaline solution.
3. Find the true result of measurement to prove the performance of pH.
4. The analysis of the result using statistical technique.
5. Improving the robustness of the design or process to variation.

This project covers the advancement of fiber optic sensor for pH recognition utilizing statistical technique. Besides the outline created ought to be improved for ideal configuration. Additionally, this task likewise covers the model manufacture of the recently outlined fiber optic sensor. Finally, product developed should be analyses and the data gained is used to make discussion and conclusion.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction of Fiber Optic

In principle, a fiber optics refers to the innovation of transmitting light down thin strands of very highly transparent material, generally glass however in some cases plastic. Fiber optics is utilized as a part of communications, lighting, pharmaceutical, optical examinations and to make sensors. The fiber itself is a strand of silica based glass, its dimensions like those of a human hair, encompassed by a transparent cladding. Light can be transmitted along the fiber over great distance giving a perfect medium to the vehicle of data. High information rate abilities, noise rejection and electrical segregation are only a couple of the essential attributes that make fiber optic innovation ideal for use in mechanical and commercial system.

Frequently used for point-to-point connections, fiber optic links are being utilized to amplify the distance limitations of RS-232, RS-422/485 and Ethernet frameworks while guaranteeing high information rates and minimizing electrical obstruction. Conventional electrical information signs are changed over into a regulated light beam, brought into the fiber and transported through a little measurement glass or plastic fiber to a collector that changes over the light once more into electrical signs. Fiber's capacity to convey the light signal, with low misfortunes, depends on some crucial material science connected with the refraction and reflection of light.

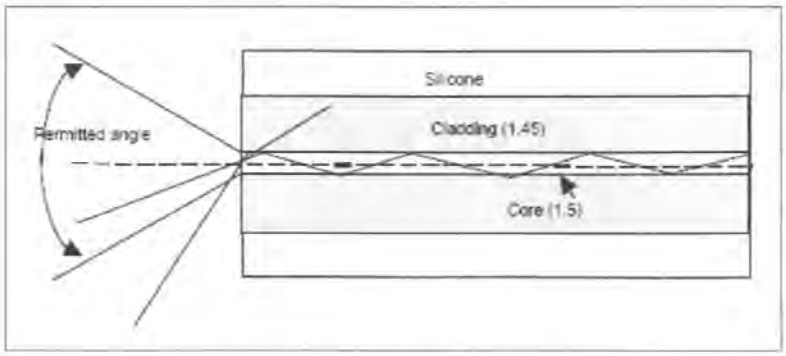

Figure 2.1 : Light travelling through a fiber

Optical fibers permit data signals to spread through them by guaranteeing that the light signal enters the fiber at an edge more prominent than the basic point of the interface between two sorts of glass. As shown in Figure 2.1, optical fiber is really comprised of three sections. The centre core is made out of pure glass, with a refractive list of 1.5. The encompassing glass, called cladding, is a marginally less surrounding glass with a refractive of 1.45.

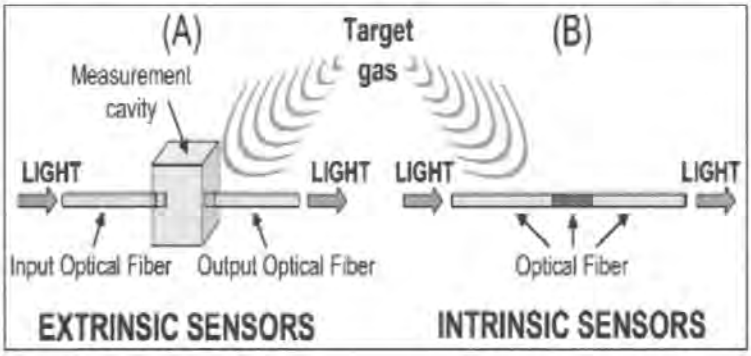

Figure 2.2 : Differences between extrinsic and intrinsic configurations.

As shown in Figure 2.2, fiber optic sensors are most ordinarily subdivided into intrinsic and extrinsic depending on where the transduction between light and measured takes place, in the fiber or outside it. Extrinsic sensors utilize the fiber to manage the light to a detecting locale where the optical sign leaves the waveguide and is adjusted in another medium while intrinsic sensor the light stays inside of the

waveguide with the goal that it measures the effects of the optical signal as it moves down the fiber.

2.1.1 Types of Fiber Optic

Optical fibers are manufactured in three main types:

1. Step Index Multimode Fiber
2. Graded Index Multimode Fiber
3. Single-Mode Fiber

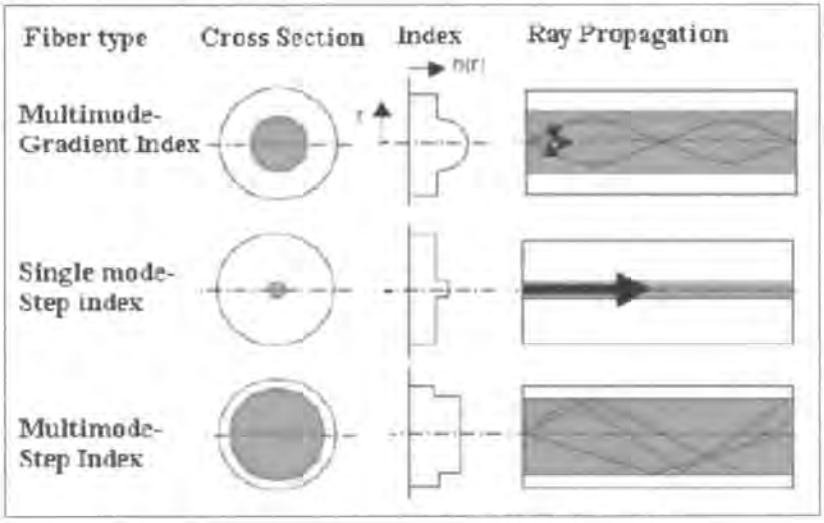

Figure 2.3 : Different types of optical fibers.

Mode is a scientific or physical idea depicting the propagation of an electromagnetic wave through any media. The quantity of modes that a given fiber will support ranges from 1 to more than 100,000 individual beams of light. This relies on upon the physical properties of the fiber and fiber distance across.

Based on figure 2.3, the multimode step index is the simplest type. It has a centre width from 100–970 microns. This fiber sort incorporates glass, PCS, and plastic filaments. The step index fiber is the most broadly utilized fiber sort. This is

regardless of generally low data transmission and high losses. Since light reflects at different angles in various ways, the distinctive beams of light take a shorter or more time to propagate down the fiber. The beam of light that travels straight down the focal point of the centre lands at the flip side first. Different beams of light arrive later, since they refract forward and backward in a zigzag path. [2]

Besides, the main element of multimode Graded Index is very narrow contrasted with the wavelength of light being used. The shorter paths are made slower so that they are held back to the pace of the faster (but longer) paths. Light travels faster in a lower index of refraction, so the further the light is from the centre axis, the greater the speed. The graded index reduces modal dispersion to 1 ns per kilometre or less. Light ventures quicker in a lower index of refraction, so the further the light is from the middle axis, the greater the speed. The graded index reduces modal dispersion to 1 ns for each kilometre or less.

In addition, single mode link might be just 8 microns in diameter compared to 62.5 microns utilized as a part of a multimode link. The outcome a single path exists through the cable core which light can travel. Centre diameter is a compromise. On the off chance that the centre is excessively tight, then the amount of losses that happens when the link twists turns out to be too high. On the off chance that the centre is made littler (of if the wavelength of light is made longer) then the proportion of measurement to wavelength gets littler. At very small ratios, a sharp bend in the cable will cause the light so simply.

2.1.2 Light Scattering

In fiber optic transmissions, scattering is the loss of sign brought about by the dispersion of a light beam, where the dissemination itself is created by minute varieties in the transmission medium. Scattering commonly happens when a light signal hits a polluting influence in the fiber.

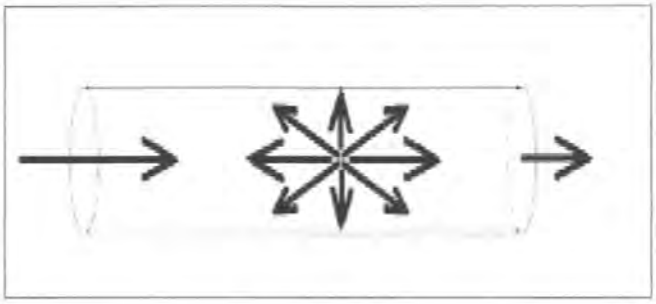

Figure 2.4 : Scattering in an optical fiber

The greatest variable in optical fiber loss is scattering. It is similar to billiard balls skipping off one another, however happens on a nuclear level between photons (particles of light) and molecules or atoms. For example, the light emission electric lamp radiating through foggy or Smokey air, which scattering. Dispersing is extremely delicate to the shade of the light, so as the wavelength of the light gets longer, the scrambling gets less. All that much less actually, by an element of the wavelength to the fourth power.

2.1.3 Advantages and Disadvantages of Fiber Optics

Figure 2.5 : Optical fiber cable

As the fiber optics was developed faster in technology, it frameworks have numerous appealing elements that are better than electrical frameworks. These include less expensive, a few miles of optical link can be made less costly than identical lengths of copper wire. This spares your supplier (satellite TV, Internet) and you cash. Other than it is thinner and can be attracted to littler distances across than copper wire. Higher conveying limit in light of the fact that optical filaments are thinner than copper wires, more strands can be packaged into a given-diameter cable than copper wires. This permits more telephone lines to go over the same link or more stations to get through the link into your satellite TV box. Less flag corruption where the loss of sign in optical fiber is not exactly in copper wire. The fiber optic is light signals dissimilar to electrical signs in copper wires, light flags from one fiber don't meddle with those of different strands in the same link. This implies clearer telephone discussions or TV gathering. Low power. Since signs in optical strands debase less, bring down force transmitters can be utilized rather than the high-voltage electrical transmitters required for copper wires. Optical strands are in a perfect world suited for conveying computerized data, which is particularly valuable in PC systems

Regardless of the numerous preferences of fiber optic frameworks, there are a few disadvantages. As a result of the relative freshness of the innovation, fiber optic segments are costly. Fiber optic transmitters and recipients are still generally costly compared with electrical interfaces. The lack of standardization in the business has likewise restricted the acknowledgment of fiber optics. Numerous commercial enterprises are more comfortable with the utilization of electrical systems and are hesitant to change to fiber optics. However, industry scientists are taking out these disadvantages.

Most likely everything in this world has pros and cons, however we generally search for the positive side, remember dependably the advantages, as in today's propelled innovation, everybody require quick information transmission and for that optical fiber link is the best source which transmit information effortlessly with quick speed, as information signs go with the light as medium.