UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIBER OPTIC SENSOR OF GLUCOSE LEVEL DETECTION FOR VARIOUS BICARBONATE DRINK

This report submitted in accordance with requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology Electronic (Telecommunications) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Fiber Optic Sensor of Glucose Level Detection for Various Bicarbonate Drink” is the result of my on research except as cited in references.

Signature	:	……………………………….………
Author’s Name	:	…………………………………..…
Date	:	……………………………....….

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

……………………………………………..

(Mr. Md Ashadi bin Md Johari)

ABSTRAK

Tesis ini berkaitan dengan analisis atas permohonan sensor gentian optik untuk tahap kepekatan glukosa pada jenis minuman berkarbonat yang berbeza. Objektif tesis ini adalah untuk memahami dan menganalisis operasi sensor gentian optik. Kemudian, tujuannya adalah untuk membangunkan sensor gentian optik bagi kepekatan yang berbeza mengenal pasti tahap glukosa dalam minuman berkarbonat. Seterusnya, bagi menganalisis prestasi gentian optik khas untuk mengesan kepekatan glukosa.

ABSTRACT

The thesis deals with the analysis on the application of the fiber optic sensor for glucose level in a different type of bicarbonate drinks. The objective for this thesis is to understand and to analyze fiber optic sensor operation. Then, to develop fiber optic sensor for a different concentration of glucose in bicarbonate drink as identifying its level. Next, to analyze the performance of fiber optic specially for detecting the concentration of glucose.

DEDICATIONS

This humble effort specially dedicated to my beloved parents, family, lecturers and friends, whose love can never be forgotten for their support, guidance and encouragement upon completing this project and report.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

FOS	–	Fiber Optic Sensor
ASE	–	Amplified Spontaneous Emission
OSA	–	Optical Spectrum Analyzer
LED	–	Light Emitting Diode
ELED	–	Edge Emitting LED
SLED	–	Surface Emitting LED
LD	–	Laser Diode
EMI	–	Electromagnetic Interference
RFI	–	Radio Frequency Interference
OMF	–	Optical Microfiber
SMF	–	Single Mode Fiber
UV	–	Ultra Violet
PPM	–	Part Per Million
POF	–	Plastic Optical Fiber
µ	–	Micro
mV	–	Milli Volts
T/bit	–	Terabit
dB	–	Decibel
COD		Coefficient of Determination

CHAPTER 1

INTRODUCTION

1.0 Introduction

This is the first time of this research which is responsible to give a general explanation regarding the purpose of this research. In this chapter, it will give an overview about the title of this research, history of the research had done before, the problem statements, the objective of this study and the scopes of study for this research. The overview will only be general information and the details for this research are discussed in other chapter. An optical fiber (or optical fiber) is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter bigger than that of a human hair that have range from 17µm to 181 µm (millionths of a meter). Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables. Fibers are used instead of metal wires because signals travel along them with lesser amounts of loss; in addition, fibers are also immune to electromagnetic interference, a problem from which metal wires suffer excessively. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces, as in the case of a fiberscope. Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers.

A fiber optic sensor is a sensor that uses optical fiber either as the sensing element ("intrinsic sensors"), or as a means of relaying signals from a remote sensor to the electronics that process the signals ("extrinsic sensors"). Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or because no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using light wavelength shift for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer and wavelength shift can be calculated using an instrument implementing optical frequency domain reflectometry.

Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well. Optical fibers can be used as sensors to measure strain [2], temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber optic sensors is that they can, if required, provide distributed sensing over very large distances.

Extrinsic fiber optic sensors use an optical fiber cable, normally a multimode one, to transmit modulated light from either a non-fiber optical sensor, or an electronic sensor connected to an optical transmitter. A major benefit of extrinsic sensors is their ability to reach places which are otherwise inaccessible. An example is the measurement of temperature inside aircraft jet engines by using a fiber to transmit radiation into a radiation pyrometer located outside the engine. Extrinsic sensors can also be used in the same way to measure the internal temperature of electrical transformers, where the extreme electromagnetic fields present make other measurement techniques impossible.

Extrinsic fiber optic sensors provide excellent protection of measurement signals against noise corruption. Unfortunately, many conventional sensors produce electrical output which must be converted into an optical signal for use with fiber. For example, in the case of a platinum resistance thermometer, the temperature changes are translated into resistance changes. The PRT must therefore have an electrical power supply. The modulated voltage level at the output of the PRT can then be injected into the optical fiber via the usual type of transmitter. This complicates the measurement process and means that low-voltage power cables must be routed to the transducer. Extrinsic sensors are used to measure vibration, rotation, displacement, velocity, acceleration, torque, and temperature.

Glucose is a sugar with the molecular formula C6H12O6. The name "glucose" meaning "sweet wine, must". The suffix "-ose" is a chemical classifier, denoting a carbohydrate.[3] It is also known as grape sugar. Glucose is made during photosynthesis from water and carbon dioxide, using energy from sunlight. The reverse of the photosynthesis reaction, which releases this energy, is a very important source of power for cellular respiration. Glucose is stored as a polymer, in plants as starch and in animals as glycogen, for times when the organism will need it. Glucose circulates in the blood of animals as blood sugar. Glucose can be obtained by hydrolysis of carbohydrates such as milk, cane sugar, maltose, cellulose, glycogen etc. It is however, manufactured by hydrolysis of cornstarch by steaming and diluting acid.

Diabetes is a metabolic disorder where the body isn't able to regulate levels of glucose in the blood. The cause of this is the lack of insulin in the body. Insulin is a hormone that regulates glucose levels, allowing the body's cells to absorb and use glucose. Without it, glucose cannot enter the cell and therefore cannot be used as fuel for the body's functions. Glucose levels can also be tested using multiple methods such as Fasting glucose which measures the level of glucose in the blood after 8 hours of fasting. Another test is the 2-hour glucose tolerance test (GTT) – for this test, the person has a fasting glucose test done (see above), then drinks a 75-gram glucose drink and is retested. This test measures the ability of the person's body to process glucose. Over time the blood glucose levels should decrease as insulin allows it to be taken up by cells and exit the blood stream.

1.1 Problem Statement

A bicarbonate drink or known as soft drink is a drink that typically contains carbonated water, a sweetener, and a natural or artificial flavoring. The sweetener may be sugar, high-fructose corn syrup, fruit juice, sugar substitutes (in the case of diet drinks), or some combination of these. Soft drinks may also contain caffeine, colorings, preservatives, and other ingredients.

The over-consumption of sugar-sweetened soft drinks is associated with obesity, type 2 diabetes, dental caries, and low nutrient levels. Experimental studies tend to support a causal role for sugar-sweetened soft drinks in these ailments, though this is challenged by other researchers. "Sugar-sweetened" includes drinks that use high-fructose corn syrup, as well as those using sucrose.

Main problem is users didn't know whether the sugar content in soft drink is really low as described or vice versa. Therefore, by using fiber optic sensor that use beam through technique, users can determine the concentration of sugar level in various bicarbonate drinks.

1.2 Objectives

The objectives of this project are to:

i. To understand the concept of fiber optic sensor operation.
ii. To develop fiber optic sensor for different concentration of glucose in various bicarbonate drinks.
iii. To analyze the performance of fiber optic.

1.3 Scope Of Study

Before a new technology or technique is applied, the system must be tested so that the performance of the design and analysis can be known. However, for any project to be done, the limitation of the scope of work must be very realistic and applicable. In order to achieve the objective of the study, the following were outline as follows:

i. Analyze on fiber optic sensor capability.
ii. Design and develop the fiber optic sensor to detect the concentration of glucose.
iii. Applying the various glucose concentration in bicarbonate drinks to obtain the result required which are closed to the theoretical results.
iv. Analyze the data obtained and select the data that have optimum results.
v. Report writing.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the research has been done by other persons which are related with this research were discussed. The facts form their research were used to guide this research in correct way. the source came from the journals and articles wrote by the previous researcher which related to this project. Their theory and results help this research as they can be a comparison between this research and theirs.

2.1 Fiber Optic

2.1.1 Fiber-Optic Communications

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information.[8] First developed in the 1970s, fiber-optics have revolutionized the telecommunications industry and have played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Researchers at Bell Labs have reached internet speeds of over 100 petabit×kilometer per second using fiber-optic communication.[9]

The process of communicating using fiber-optics involves the following basic steps: Creating the optical signal involving the use of a transmitter,[10] relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal.

Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications. However, infrastructure development within cities was relatively difficult and time-consuming, and fiber-optic systems were complex and expensive to install and operate. Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost. Since 2000, the prices for fiber-optic communications have dropped considerably. The price for rolling out fiber to the home has currently become more cost-effective than that of rolling out a copper based network. Prices have dropped to $850 per subscriber in the US and lower in countries like The Netherlands, where digging costs are low and housing density is high.

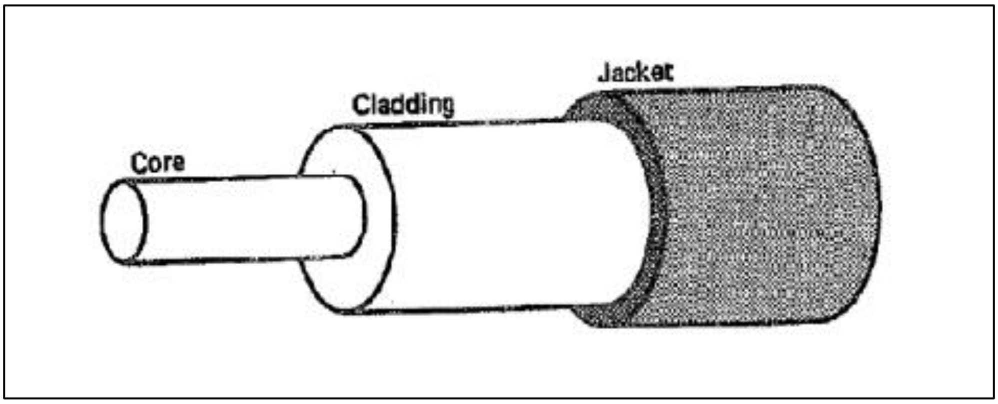

Figure 2.1: A basic structure of fiber optic.

2.1.2 Fiber Cable Types

An optical fiber cable consists of a core, cladding, and a buffer (a protective outer coating) as in Figure 2.1, in which the cladding guides the light along the core by using the method of total internal reflection. The core and the cladding (which has a lower-refractive-index) are usually made of high-quality silica glass, although they can both be made of plastic as well. Connecting two optical fibers is done by fusion splicing or mechanical splicing and requires special skills and interconnection technology due to the microscopic precision required to align the fiber cores.[11]

Two main types of optical fiber used in optic communications include multi-mode optical fibers and single-mode optical fibers. A multi-mode optical fiber has a larger core (≥ 50 micrometers), allowing less precise, cheaper transmitters and receivers to connect to it as well as cheaper connectors. However, a multi-mode fiber introduces multimode distortion, which often limits the bandwidth and length of the link. Furthermore, because of its higher dopant content, multi-mode fibers are usually expensive and exhibit higher attenuation. The core of a single-mode fiber is smaller (<10 micrometers) and requires more expensive components and interconnection methods, but allows much longer, higher-performance links.

Figure 1.2: A stripped multi-mode fiber

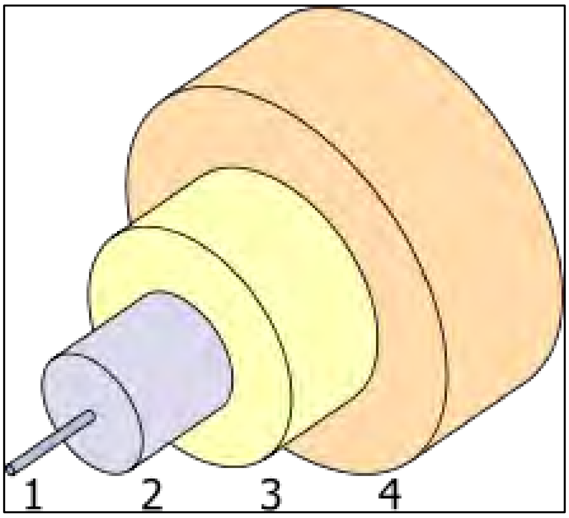

Figure 2.3: The structure of a typical single-mode fiber.

1. Core 8 µm diameter
2. Cladding 125 µm diameter
3. Buffer 250 µm diameter
4. Jacket 400 µm diameter

In order to package fiber into a commercially viable product, it typically is protectively coated by using ultraviolet (UV), light-cured acrylate polymers, then terminated with optical fiber connectors, and finally assembled into a cable. After that, it can be laid in the ground and then run through the walls of a building and deployed aerially in a manner similar to copper cables. These fibers require less maintenance than common twisted pair wires, once they are deployed.[12]

Specialized cables are used for long distance subsea data transmission, e.g. transatlantic communications cable. New (2011–2013) cables operated by commercial enterprises (Emerald Atlantis, Hibernia Atlantic) typically have four strands of fiber and cross the Atlantic (NYC-London) in 60-70ms. Cost of each such cable was about $300M in 2011. source: The Chronicle Herald.

Another common practice is to bundle many fiber optic strands within long-distance power transmission cable. This exploits power transmission rights of way effectively, ensures a power company can own and control the fiber required to monitor its own devices and lines, is effectively immune to tampering, and simplifies the deployment of smart grid technology.

2.2 Fiber Optic Sensor (F.O.S)

2.2.1 Fiber Optic Sensor for Temperature Measurement

Fiber optics are essentially light pipes. The group of sensors known as fiber optic thermometers (Figure 2.4) generally refer to those devices measuring higher temperatures wherein blackbody radiation physics are utilized. The principle of operation is based on the temperature dependence of the band gap of GaAs. The light is directed via the optical fiber to the crystal, where it is absorbed and partially reflected back into the fiber. A miniature spectrometer provides a spectrum with the position of the band edge, from which the temperature is calculated. Lower temperature targets from -100°C to 400°C--can be measured by activating various sensing materials such as phosphors, semiconductors or liquid crystals with fiber optic links offering the environmental and remoteness advantages.

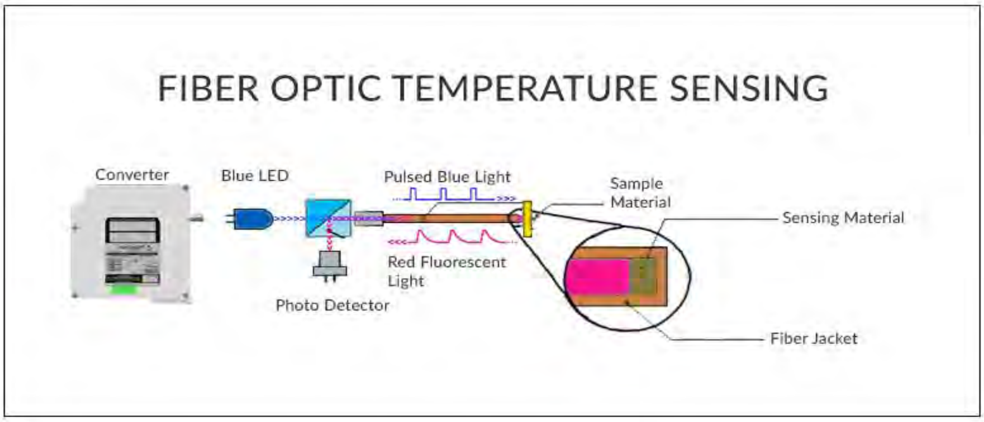

Figure 2.4: Fiber Optic for Temperature Measurement

2.2.2 Fiber Optic Sensor for Glucose

Fluorescent glucose biosensors are devices that measure the concentration of glucose in diabetic patients by means of sensitive protein that relays the concentration by means of fluorescence, an alternative to amperometric sension of glucose. No device has yet entered the medical market but, due to the prevalence of diabetes, it is the prime drive in the construction of fluorescent biosensors.

Keeping glucose levels in check is crucial to minimize the onset of the damage caused by diabetes. As a consequence, in conjunction with insulin administrations, the prime requirement for diabetic patients is to regularly monitor their blood glucose levels. The monitoring systems currently in general use have the drawback of below optimal number of readings, due to their reliance on a drop of fresh blood. Some continuous glucose monitors are commercially available, but suffer from the severe drawback of a short working life of the probe. The majority of these work amperometrically. As a result, there is an effort to create a sensor that relies on a different mechanism, such as via external infrared spectroscopy or via fluorescent biosensors.

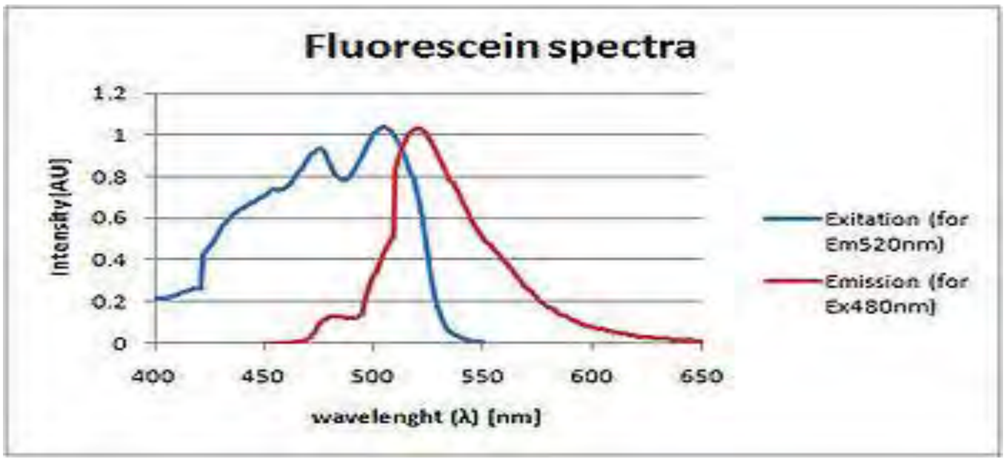

Figure 2.5: Absorption and emission spectra of fluorescein.

2.3 Glucose

Glucose is a common medical analyte measured in blood samples. Eating or fasting prior to taking a blood sample has an effect on the result. A high fasting glucose blood sugar level may be a sign of prediabetes or diabetes mellitus. A glucose test is a type of blood test used to determine the amount of glucose in the blood. It is mainly