UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF FIBER OPTIC SENSOR FOR WATER LEVEL MEASUREMENT USING FIBER OPTIC APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) with Honours

by

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APPROVAL

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

………………………………..

(En. Md Ashadi Bin Md Johari)

ABSTRACT

The purpose of this project was to investigate the development of fiber optic sensor for water level measurement by using fiber optic sensor application. Fiber optic are going used widely nowadays along with the greatest technology used. Besides, fiber optic used as the sensor to detect much kind of parameters likes example humidity, temperature, concentration and water level. This project used fiber optic cable as the main components and measured the transmission loss in different water level by using OSA instrument. The fiber optic was function as the sensor and used to detect the water level measurement. Furthermore, this project is to develop the fiber sensor application as the water level detection. The ASE instrument was used to emit light source into the fiber optic cable while the OSA instrument will analyse the output loss in the transmission. Thus, the true result of fiber optic measurement was defined by using the instrument. The results will performance by using analysis technique. From this project, students can easy to understand the application of fiber optic sensor and investigate a few of events in fiber optic cable efficiently.

ABSTRAK

Tujuan projek ini adalah untuk mengkaji pembangunan sensor gentian optik untuk mengukur paras air dengan menggunakan aplikasi gentian optik sensor. Gentian optik telah digunakan secara meluas pada masa kini bersama-sama dengan teknologi yang paling besar digunakan. Selain itu, gentian optik digunakan sebagai sensor untuk mengesan beberapa jenis parameter contohnya kelembapan, suhu, kepekatan dan paras air. Projek ini menggunakan kabel gentian optik sebagai komponen utama dan mengukur kehilangan ketika penghantaran mengikut paras air yang berbeza dengan menggunakan instrumen OSA. Optik gentian adalah berfungsi sebagai sensor dan digunakan untuk mengesan ukuran paras air. Tambahan pula, projek ini adalah untuk membangunkan aplikasi sensor gentian sebagai pengesanan paras air. Instrumen ASE telah digunakan untuk mengeluarkan sumber cahaya ke dalam kabel gentian optik manakala instrumen OSA akan menganalisis nilai kehilangan dalam penghantaran. Oleh itu, hasil sebenar pengukuran gentian optik telah ditakrifkan dengan menggunakan instrumen. Seagala data yang diambil akan dikaji dengan menggunakan teknik analisis. Daripada projek ini, pelajar boleh mudah difahami cara penggunaan sensor gentian optik dan menyiasat beberapa peristiwa dalam kabel gentian optik secara cekap.

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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First of all, thanks to ALLAH S.W.T for his mercy and guidance in giving me full strength to complete this "DEVELOPMENT OF FIBER OPTIC SENSOR FOR WATER LEVEL MEASUREMENT USING FIBER OPTIC APPLICATION" task. Even facing with some difficulties in completing this task, I still managed to complete it. Next, I give a lot of thanks to my supervisor, En. Md Ashadi Bin Md. Johari for all his support and guidance in helping me to finish my task that really tested my abilities mentally and physically. Then, I would like thanks to my parents for supporting me not just during finishing this task but also during my whole studies in order to born as an engineer one day. In syaa Allah.

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LIST ABBREVIATIONS

OF	=	Optical Fiber
FODS	=	Fiber Optic Displacement Sensor
ASE	=	Amplified Spontaneous Emission
OSA	=	Optical Spectrum Analyzer
TIR	=	Total Internal Reflection
LED	=	Light Emitter Diode
POF	=	Plastic Optical Fiber
GAP	=	Graph of Displacement
TGP	=	Transmissive Grating Panel
NA	=	Numerical Aperture
OFAT	=	One-Factor-At-Time
NaCl	=	Sodium Chloride
LID	=	Local and Injection
dB	=	Decibel

CHAPTER 1

INTRODUCTION

1.1 Project Background

In telecommunication field, fiber optic cable is the main part of transmission of data. Fiber optic cable is used widely for communication system which is functioning for transmitting the signal or data. Besides, fiber optic also used as the sensor to detect much kind of parameters likes example humidity, temperature, concentration or water level. Another side, fiber optic communication is simple as an electrical signal that is converted to light and then transmitted through an optical fiber to a distant receiver where it is converted back into the original signal. Fiber optic has many advantages over other transmission methods. One of the advantage is a signal can be sent over longer distances without being boosted. There are also no interference problems from nearby electrical field.

The fiber optic sensor is one of the most interesting and developing field. The fiber sensors are becoming more attractive over other sensors due to its physically like non-electrical, high accuracy, easy to install, noncontact, explosion proof small size and weight, the fiber optic replaces other sensor. A number of varieties of parameters like temperature, humidity, pressure, chemical concentration and displacement can be measured accurately [Yoany R, 2010].

Furthermore, in this project is focusing about Fiber Optic Displacement Sensor (FODS) that uses water as the parameter and level of water as the measurements. The FODS are more attractive because they have many advantages, such as light weight, compact size, good flexibility, electrical isolation and capability of multiplexing.

Thus, the purpose of this project is to measure the water level by using fiber optic sensor. It allows locating and detecting liquids by measuring the time delay between short light pulses entering the fiber. The sensors are placed along a standard single mode fiber cable. Although that, the fiber optic cable segments are typically connected by fusion splices. It will detect the water level whether in short, normal or overflow level. This project can be used in tunnel as to measure the water level that flow in it.

1.2 Problem statements

Nowadays, there has many sensor can be used for measuring water level in a place like example movement sensor. Since the sensors are usually come from mechanical or electrical components, they have many effects in long-time used. It means that the components can be easily broken in short period and cause the measurement become inaccurately. As the fiber optic become more popular, it also looks powerful in measuring any parameters accurately. Besides, the fiber optic sensors have not limitation, very sensitive and good condition for every temperature changing. Thus, the fiber optic sensors are very suitable to replace the exist sensor to measure the water level in tunnel or river. The purposes of measuring the water level is to maintain the water from overflowing and can prevent flood occur at the near place. Meanwhile, fiber optic is very accuracy sensor in measuring and data from this project will be observed by using analysis technique.

1.3 Project Objectives

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

1. To understand and study about fiber optic.
2. To develop fiber optic sensor for water level detection.
3. To analyze the performance of fiber optic sensor by using analysis technique.

1.4 Scopes of work

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

1. The study and understanding of fiber optic sensor in measuring water level.
2. Do the experiment work by using fiber optic and OSA and ASE instruments.
3. Find the true result of measurement to prove the performance of water level.
4. The observation of the result by using analysis technique.

CHAPTER 2

THEORITICAL BACKGROUND

2.1 Introduction of Fiber Optic

In theory, a fiber optic is a flexible, transparent fiber that made by drawing glass (silica) or plastic to a diameter slightly thicker than of a human hair. 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. Thus, fibers are used instead of metal wires because signals travel along them with small amounts of loss. In addition, fibers are also immune to electromagnetic interference, a problem which metal wires suffer from excessively [John M, 2009].

The simple fiber optic data link is the main part in fiber optic which should be considered for the premises environment. The link of fiber optic data communication should be learned to know how the data is transferred from source to user. The model of simple fiber optic data link is shown in **Figure 2.1**. The principle of an optical communications system is to transmit a signal through an optical signal through an optical fiber to a distant receiver. The electrical signal is converted into the optical domain at the transmitter and is converted back into the original electrical signal at the receiver.

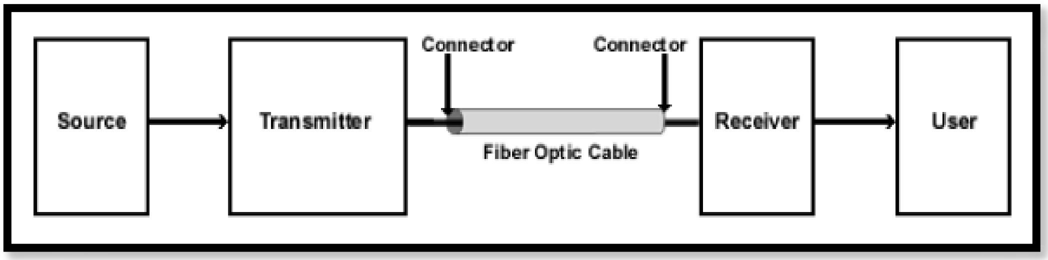

Figure 2.1: Model of “simple” fiber optic data link

There are three main parts in a model of simple fiber optic which are known as source-user pair, transmitter and receiver. In fiber optics, a source of light is used to emit electromagnetic radiation in order to perform a specific task, whether detecting faults, breaks or characterizing link-loss. While, the transmitter is transmitted the source to the receiver as well.

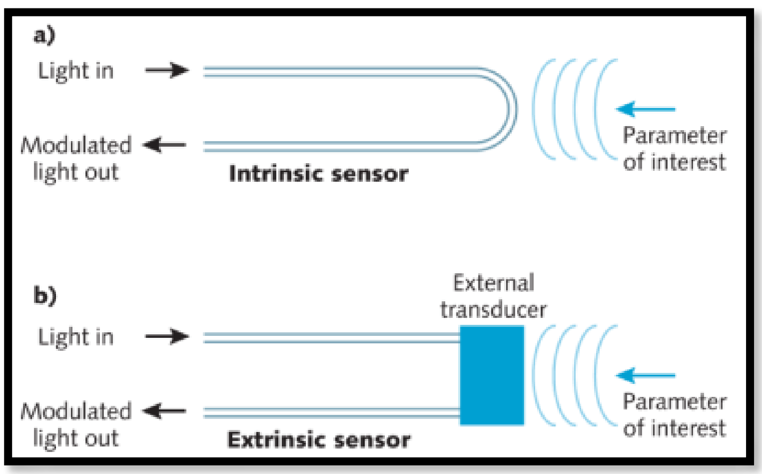

Figure 2.2: Two distinct ways of fiber optic

Furthermore, optical fibers are used to sense environmental effects in two distinct ways. The methods are called extrinsic and intrinsic sensing. Extrinsic or hybrid fiber optic sensor consisting of input and output fibers carrying light to and form a black box which modulates the light beam upon activation by an environmental signal. While, for the intrinsic sensing or all-fiber optic sensor, it properties are modulated by an impacting environmental signal.

2.1.1 Types of Fiber Optics

There are some types of Optical Fibers such as:

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

2.1.1.1 Single Mode Fiber

Single mode fiber is one of type fiber optic. It has very thin core 9 microns in diameter. In a single mode fiber, all signal travel straight down the middle without bouncing. The advantage used single mode fibers is only one mode with one group velocity, so it had short pulse of light arrives with delay distortion. Next the rate power attenuation is lower in single mode and higher data rates to transmit. There are usually used on cable tv, internet and telephone signal. The information can send over 100km.[Chris Woodford, 2015]. Application of fiber optic typically used in long distance, higher bandwidth runs by Telecommunication, CATV companies, and Colleges and Universities.

Single-mode fibers (also called *monomode fibers*) are optical fibers which are designed such that they support only a single propagation mode per polarization direction for a given wavelength.

Figure 2.3: Diameter of single mode fiber.

Single-mode guidance is important for many applications. Examples are in fiber lasers and amplifiers made of rare-earth-doped fibers, single-mode guidance is the basis for achieving a high beam quality of the output. Besides, in optical fiber communication systems, single-mode guidance avoids the problem of intermodal dispersion, which (in multimode fibers) would lead to the occurrence of multiple copies of the input signals at the receiver. Single-mode fibers are used for connecting different components in fiber-optic setups, such as interferometers. They can be fusion-spliced or put together with fiber connectors. In measurement setups, the fact is often exploited that the output of a single-mode fiber has a fixed spatial shape, independent of the launch conditions. A single-mode fiber may serve as a kind of mode cleaner. Nonlinear interactions in long single-mode fibers may be exploited. For example, this can be signal amplification via stimulated Raman scattering, or strong spectral broadening (supercontinuum generation).

2.1.1.2 Multimode Fiber

Another type is multi-mode, each optical fiber in a multi-mode cable is about 10 times bigger than one in a single-mode cable. This means light beam can travel thought the core following a verity of different paths create to ability for more data pass thorough at given time. Chris Woodford (2015). The application is typically used for short distance, the example in data and audio/video applications in LANs. RF broadband signals. Multimode fiber is usually 50/125 and 62.5/125 in construction. This means that the core to cladding diameter ratio is 50 microns to 125 microns and 62.5 microns to 125 microns.

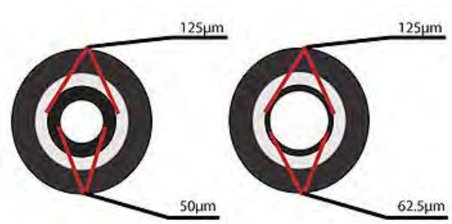

Figure 2.4: Diameter of multi-mode fiber

2.1.1.3 Step-index Single Mode Fiber

In single mode step index has a central core that is really small so that there is potentially only one path for light ray through the cable. The light ray is propagated in the fiber through reflection in the fiber optic cable. Common core sizes are 2 until 15µm. The extremely small size interconnection of cables and interfacing with source are the benefits of this type of cable.

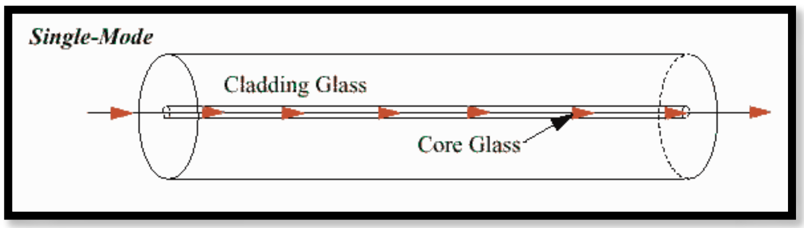

Figure 2.5: Single-mode fiber illustration

2.1.1.4 Step-index Multi Mode Fiber

The most widely used type is multimode step index fiber. It easy to produce and its core diameter is 50 to 100 µm such as large aperture and allow more light to enter the cable. There are several paths that a light ray may follow during the propagation. For example, it may propagate down the core in zig-zag manner. The principle of total internal reflection (TIR) is used to propagate the light ray. The light enters at less than critical angle is guided along the fiber because the core index of refraction is higher than the cladding index of refraction.

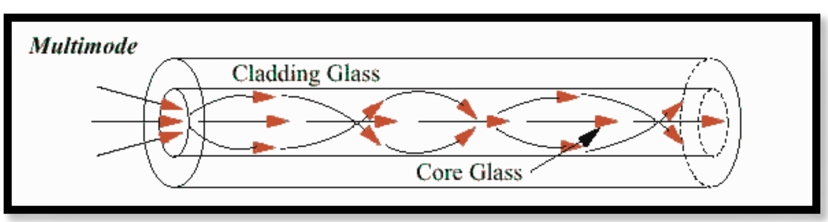

Figure 2.6: Multi-mode fiber illustration

2.1.1.5 Multimode Graded Index Fiber

In fiber optics, a graded-index or gradient-index fiber is an optical fiber whose core has a refractive index that decreases with increasing radial distance from the optical axis of the fiber. Because parts of the core closer to the fiber axis have a higher refractive index than the parts near the cladding, light rays follow sinusoidal paths down the fiber. The most common refractive index profile for a graded-index fiber is very nearly parabolic. The parabolic profile results in continual refocusing of the rays in the core, and minimizes modal dispersion. Multi-mode optical fiber can be built with either graded index or step index. The advantage of the multi-mode graded index compared to the multi-mode step index is the considerable decrease in modal dispersion. Modal dispersion can be further decreased by selecting a smaller core size (less than 5-10μm) and forming a single mode step index fiber.

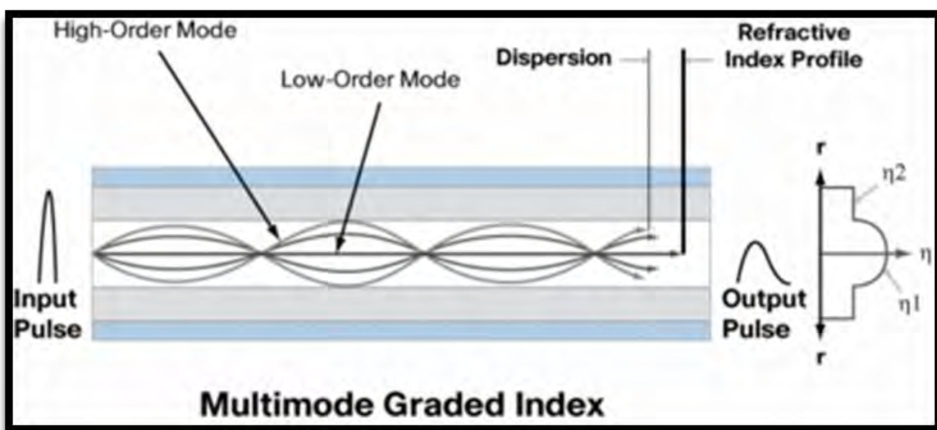

Figure 2.7: Multimode Graded Index.