UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

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FIBER OPTIC MICROBEND SENSOR

NIK NOZITA MOHD SAAD

This report was submitted in partial Fulfilment of requirement for the Bachelor Degree of Electronic Engineering (Telecommunication Electronics)

Faculty of electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

April 2009

DECLARATION

"I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references."

Signature : …….
Name : NIK NOZITA MOHD SAAD
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"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Electronic and Computer Engineering (Electronic Telecommunication) with Honours"

Signature : …….

Supervisor's Name : EN CHAIRULSYAH B. ABDUL WASLI

Date : 30 APRIL 2009

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ABSTRAK

Tujuan utama projek ini adalah untuk mencipta dan menghasilkan optic fiber microbend sensor, untuk mengukur kuasa yang keluar, kehilangan kuasa dan analisis keputusan. Tajuk sebenar projek ini adalah fiber optic microbend sensor. Projek ini menghasilkan system pengesan yang mana termasuk punca cahaya, elemen pengesan dan pengesan cahaya. Dalam keadaan yang normal, sesetengah aras boleh dikira dan sekiranya pengesan mengesan kehadiran tekanan, paras arus akan berubah dan menunjukkan tekanan. Dalam system fiber, gelombang optic ditukarkan kepada arus elektrik dengan menggunakan pengesan cahaya. Jumlah kuasa yang dikesan oleh penerima bergantung kepada jumlah kuasa yang keluar daripada pengeluar dan dikeluarkan oleh fiber optik. Bila wayar dalam keadaan normal iaitu lurus, kuasa yang hilang sedikit berbanding dalam keaadan bengkok yang mengeluarkan banyak kuasa kerana ada cahaya yang terpantul menyebabkan kuasa pada penerima berkurang. Perbezaan kuasa menunjukkan wayar fiber optik boleh diguna sebagai microbend sensor. Projek ini termasuk juga dengan pengiraan, simulasi, mereka dan menganalisa data.

ABSTRACT

The main purpose of this project is to design and to build fiber optic microbend sensor, measure the output power, power loss and analyze the results. The title of this project is fiber optic microbend sensor. This project consists the transmitter and the receiver between the fiber optic. This project will develop a sensor system that used fiber optic cable, which is consisting of light source, sensor element and the light detector. In normal condition the certain level will measure and if the sensor senses some pressure it will change the level and indicate the level of pressure. In fiber system, the optic wave is converted into an electric current by a photodetector. The power detect at the receiver is depend on the power feed at the transmitter and the attenuation of the fiber optic. When the cable in a straight line condition, the attenuation will be minimum but if there is bend or indentation on the cable, there will be additional attenuation on the cable because some of ray light will be reflected so the power at receiver will be drop. This power differences will show that the fiber optic cable can be use as microbend sensor. This project contains calculation, simulation, design and analyze result.

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P_i	Input power
Po	Output power
R	Radius
ℓ	Length
α_B	Bending loss
Ω	Ohms
V	Voltage
α	Attenuation coefficient
R	Responsivity

CHAPTER I

INTRODUCTION

This project provides the reader with the detailed and comprehensive study of theory, design, calculation, result and problem encountered in the designing fiber optic microbend sensor. The approaches used to achieve this project are through literature review, dimensional calculation, and computer simulation. It also approaches used to analyses the characteristic and required specification before designing fiber optic microbend sensor.

Computer simulation is best technique to get the solution because it is fast and economical. The Multisim software was used to get the solution to determine its suitable parameters.

This project is divided into three stages which includes literature review and calculation followed by software simulation and the lastly design the hardware, testing, analyze the results. The fiber optic microbend sensor is designed focus to find the power

loss in two conditions where in normal condition and the bend condition. The suitable formula to calculate the power loss to achieved the theory.

1.1 OBJECTIVE

Most of the mechanism sensors are made of switch, which can detect huge physical touch. It is very difficult to use this sensor to detect tiny touch. The fiber optic system will act as a sensitive sensor because of its power differences when there is bending at the fiber optic cable. The technology the fiber is widely is use and become one of the important technologies in new era. Fiber optic is one of ways to upgrade the communication system.

The objectives of this project are;

1. To design and build fiber optic microbend sensor that able to measure the differences power loss.

2. To compare the power loss between normal and bend condition of the fiber optic.

3. To prove that the fiber optic can act as a sensor.

1.2 SCOPE OF WORK

This project mainly focuses on the power loss from fiber optic where the system will act as a sensitive sensor because of its power differences when there is bending at the fiber optic cable. The first part of this project is to study literature. Then designing the system simulation and collecting the formula related to power loss to build the fiber optic microbend system.

From the theory, the formula power loss was found and from that, the calculation of power loss are determine where it is achieved the theory. The circuit transmitter and the receiver are designed and testing in Multisim software to determined the suitable parameters. From that, the simulations are making from the designed system. The hardware is designed and the system tested. The result were compared and analyzed.

There are six parts scope of works;

1. Study about fiber optic, power loss and transmitter and receiver circuit design. In this part, it need to find the formula to calculate the power loss, parameter of circuit and design the circuit with computer software to make sure the fiber optic microbend sensor design is perfect and success.

2. Develop the equations that related with the project to calculate the power loss in fiber optic in two conditions where normal and bend condition.

3. By using the multisim software the expected result for the power loss can be earned. Simulation process is one of the engineering methods to get the expected result without using any material that costly.

4. When obtain an applicable circuit from this simulation, the hardware can be started.

5. Test the hardware after the whole process is done.

6. Compare result with the expected result in simulation.

1.3 PROBLEM STATEMENT

These projects try to make the fiber optic act as a sensor and compare power loss between normal and bend condition. Fiber optic have many advantage compare where the physically small, high capacity, huge bandwidth where fiber can transmit a mind-boggling quantity of data with extremely good transmission quantity. So that we choose the fiber optic as a sensor and it is very sensitive where can detect the small power loss in normal or bend condition.

1.4 METHODOLOGY

At the first, start planning the project with the literature review for the related journal, books and all information from internet, magazine and each other. With the all information, develop an equation to get the expected result by simulation. Try to run the simulation to look their expected result before design the hardware. If not, back to simulation once again.

If the expected result shows the accurate value that we want, design the hardware and test it. Then measure and calculate the result to compare with the simulation result. If the hardware result shows the perfect result it seem the project is successfully done. If not, back to hardware and test it again until we get the accurate result. Lastly, at the end of the research the whole process of the project will be written into thesis.

1.5 THESIS OUTLINE

There are several outline contain in this thesis where the first one is objective of this project. To finish this project, the methodology was followed. After that, the simulation and measurement of the result were compared and analysed. The thesis outline is shown as below:

1. Objective
2. Scope of works
3. Problem Statement
4. Methodology
5. Literature review
6. Research methodology
7. Results and analysis
8. Discussion and conclusion

CHAPTER II

LITERATURE REVIEW

This chapter will explain the basic concept and theories needed for development and implementation of the project. Besides, this chapter will provide information about fiber optic bending loss.

2.1 INTRODUCTION TO FIBER OPTIC

Fiber optic data transmission systems send information over fiber by turning electronic signals into light. The electromagnetic spectrum is composed of visible and near-infrared light like that transmitted by fiber and all other wavelengths used to transmit signals such as AM and FM radio and television. The figure 2.1 shown the electromagnetic spectrum where there is contain the frequency and the wavelength used to transmit signal [1].

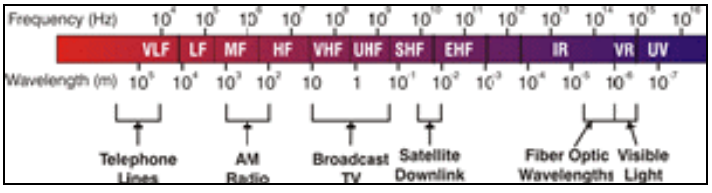

Figure 2.1 Electromagnetic spectrum

The term wavelength refers to the wave like property of light, a characteristic shared by all forms of electromagnetic radiation. Wavelength is the measurement of the distance a single cycle of an electromagnetic wave covers as it travels through a complete cycle. Wavelengths for fiber optics are measured in nanometers [1].

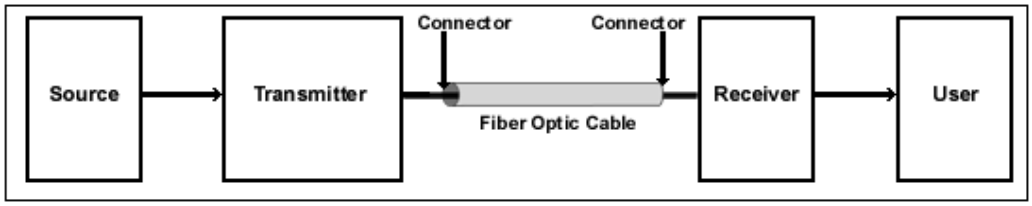

Figure 2.2 Basic fiber optic links

The figure 2.2 shown the basic fiber optic link is a fiber optic system where it is similar to the copper wire systems they are rapidly replacing. The principle of this system is use light pulses (photons) to transmit data down fiber lines, instead of electronic pulses to transmit data down copper lines. Transmitter is contains with driven, source, and source to fiber connection. It essentially converts coded electrical signals into equivalently coded light pulses. At the opposite end of the fiber optic, known as the optical receiver or detector. The purpose of an optical receiver is to detect the received light incident on it and to convert it to an electrical signal containing the information overcome on the light at the transmitting end [2].

2.2 SYSTEM DESIGN CONSIDERATIONS

The purpose of the fiber optic system is involves many interrelated functions and devices but all system is begin with the set of basic design specifications. The application requirements considered the types of signals, distances to be covered and number of connections to be made along with applicable performance standards and resources restrains [2].

2.2.1 System power budget

A point that have consistently presented in a variety of ways throughout is the important of optical power throughput in fiber optic communications systems. The most important parameter in fiber optic communication system is the optical power transfer function. Most importantly is the output power must be greater the input sensitivity of the receiver. The system power budget is then a calculation of the power loss in each component of the system to ensure that enough power reaches the receiver to accurately reproduce the original input information [2].

The loss in this system must be balanced with gains in order to produce a signal that is large enough in amplitude to be accurately interpreted by the receiver but not large enough cause saturation of system component. All power budgets must be major part of the system design and availability of options and the components that best satisfy both of these conditions must be considered [1].

2.2.2 Power at the source

Where the signal first enters the system, the transmitter selected must be appropriate for the application. The type and the number of the signals are in a particular source. The LED has less power and wider line widths than laser diodes, limiting their use to shorter distances and lower data rates. These are more stable and cheaper than laser diodes [3].

A 9V battery is used as a main voltage supply to this circuits as shown in figure 2.3. However, the circuits require both a 9-volt and a 5-volt power supplies. Therefore, a voltage regulator LM7805 has been used in order to provide both the 9V and 5V DC supply. The capacitor C_1 and C_2 is used to maintain the stability of the voltage supply.

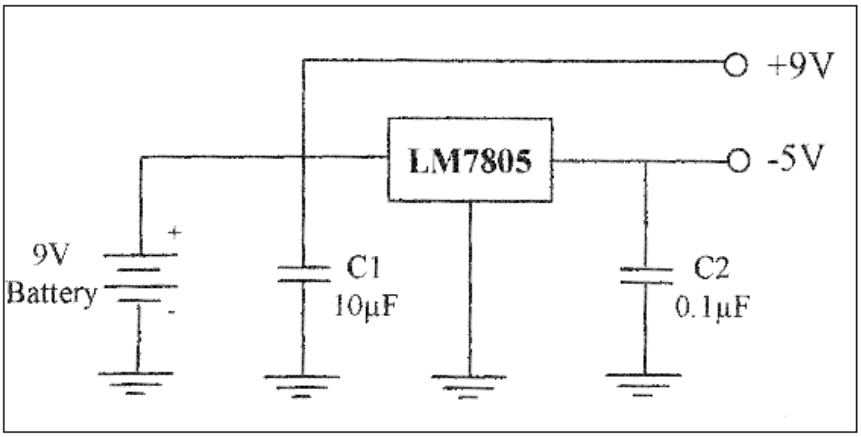

Figure 2.3 Supply by using the Voltage Regulator

The LM358 series consists of two which is independent and high gains. It is internally frequency compensated operational amplifiers which were designed purposely to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage [3].

Application areas include transducer amplifiers, dc gain blocks and all the conventional op- amp circuits which now can be more easily implemented in single power supply systems. For example, the LM358 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies [6].

The Characteristic of Operational Amplifier is;

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

The Advantages of the operational amplifier are;

- Two internally compensated op amps
- Eliminates need for dual supplies
- Allows direct sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

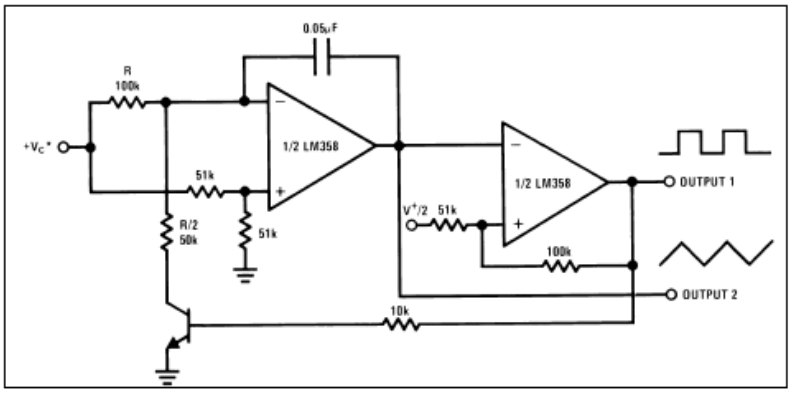

Figure 2.4 Voltage Controlled Oscillator (VCO)

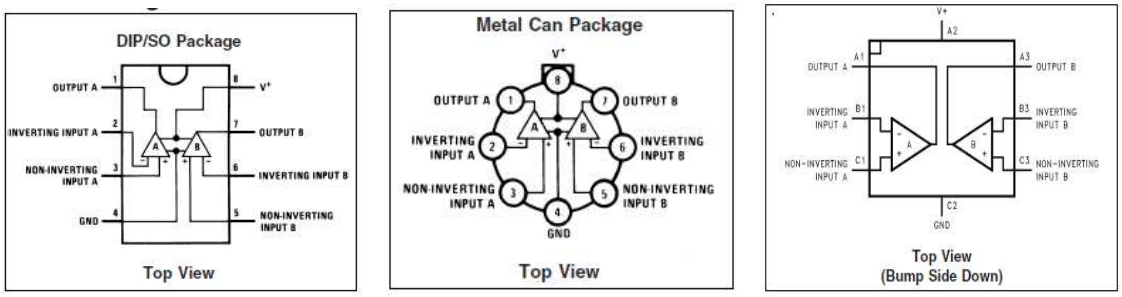

Figure 2.5 Connection Diagrams