OPTICAL FIBER AUDIO COMMUNICATION SYSTEM

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Saya MOHD SHARULRIZAM BIN ABD RAHIM

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DEDICATION

To my beloved father and mother

ACKNOWLEDGEMENT

Alhamdulillah, thank to Allah for His divinity and blessing. I have completed my final year project for Bachelor of Electronic Engineering (Industrial Electronics) successfully. I would like to thanks my lovely family for their encouragement and support. I also would like to thank my supervisor, Pn. Zaiton binti Abdul Mutalip, whose patience in supporting, helping and guiding me on my project. Thanks also to my friends and people that has helped me along the course of finishing this project. Thank you all.

ABSTRACT

The application of the optical fiber technology in telecommunication daily can be label as a new technology because it rarely use. This problem occurs maybe due to lack of expertise in the field and the cost to buy equipment is quite expensive for fiber optic.

Through this project, it can give some exposure to the people about the fiber optic. This project was concentrated on the audio communication in fiber optic. As known, the audio communication in fiber optic was high cost to adapt for two – ways communication.

This is the challenge of this project which to design and built two – ways audio communication using optical cable. Generally, this device will need an optical transmitter, optical transceiver, and of course the optical fiber cable. Besides, this device also have the lower price compared with the available product in the market.

ABSTRAK

Penggunaan fiber optik masih boleh dikatakan sebagai teknologi yang baru kerana pengaplikasiannya didalam industri telekomunikasi masih lagi berkurangan. Ini kerana mungkin kurangnya kepakaran dalam bidang tersebut atau disebabkan kos untuk membeli peralatan fiber optik yang agak mahal.

Melalui projek ini, ia merupakan salah satu cara untuk memberi pendedahan yang luas dalam bidang fiber optik ini kepada semua pihak. Projek ini lebih menumpukan penggunaan fiber optik dalam komunikasi audio. Seperti mana yang diketahui, pengguaan fiber optik di dalam komunikasi audio pada masa kini lebih terhad kepada komunikasi satu hala yang mana hanya satu pihak sahaja yang menyampai dan di pihak yang satu lagi hanya mendengar.

Jadi, cabaran pada projek ini adalah untuk menghasilkan alat komunikasi daripada fiber optik yang membolehkan komunikasi dua hala berlaku. Jika dilihat secara amnya, alat ini semestinya memerlukan pemancar optik, penerima optik dan medium yang merupakan kabel fiber optik. Selain daripada itu, alat yang direka ini mempunyai harga yang murah berbanding dengan produk yang sedia ada di pasaran sekarang.

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CHAPTER I

INTRODUCTION

1.1 PROJECT BACKGROUND

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. First developed in the 1970s, fiber-optic communication systems 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.

Nowadays, there are a lot of communications like audio communication and video communication using optical fiber. As long as it is use the light as a transmission medium, so it can call an optical communication. The project is about to design and built two ways audio communication system using the optical cable. Generally, this audio communication system consist of a transmitter, which encodes a messages into an optical signal, a channel (optical cable), which carries the signal and convert the signal into form that can be understood like an audio. LM386 ICs will be used for an audio amplifier in the transmitter and receiver circuits. A Light – Emitting Diode (LED) will be use at the transmitter to transmit the optical signal through the optical cable to the receiver because it’s commonly used and cheaper than laser.

1.2 OBJECTIVE

The objective of this project is to design and built a two-ways audio communication by using an optical cable. Since the fiber optic is one of the new fields in Malaysia, so the exploration in the application of an optical cable in the communication system is very important for the future. Plus there are more exploration should be done in this project to analyze on how to convert audio signal to the form that can be used in transmitting using optical cable with minimum loss.

1.3 PROBLEM STATEMENT

Nowadays, optical fibers are widely used in communication, which permits transmission over longer distances and at higher data rates than other forms of communications. Optical fibers are used instead of copper wires because signals travel along them with less loss, and they are immune to electromagnetic interference. Plus, the signal security in the fiber optic cable is more guaranteed than in the copper cables. This because the transmitted signal through the fiber does not radiate. Unlike in copper cables, a transmitted signal cannot be drawn from a fiber without tampering it. Thus the optical fiber communication provides 100% signal security.

However, currently the audio communication using optical cable is only available in simplex. So the users need to wait their turns to speak because it is only support one – way communication. This project is the solution for this problem by design and built the system that can transfer and receive audio simultaneously.

1.4 SCOPES OF WORK

The working scope of this project is to design and built two – ways audio communication system using the optical cable. The literature review that has been made seems that basically this project consists of two transmitters, two receivers and an optical cable as a channel as in Figure 1.

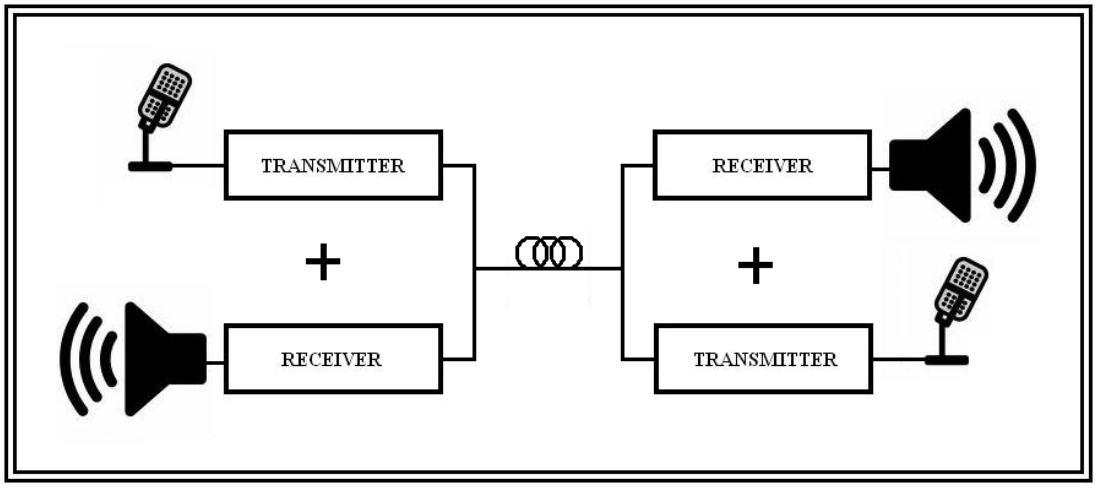

Figure 1.1: Project's diagram

First thing that need to be done is to choose the type of optical cable whether to use a multimode or singlemode. Since this project just demonstration in short distance transmission, so it is better to use multimode because it compatible with LED based fiber optic equipment. So in the transmitter, LED will be use to transmit the signal. It is not very suitable to use laser diode as a transmitter because the price is expensive. Plus, laser diode only suitable if dealing with long range transmission and singlemode optical cable. Then the other thing that needs to be done is selecting the connector type. This is very important because it will determine the qualities of the signal that will be transmit and receive. A variety of optical fiber connectors are available. The main differences among types of connectors are dimensions and methods of mechanical coupling. The standard fiber optic connector series is available in SC, ST, FC and LC and many others. Next step is to design and construct a transmitter and receiver circuits. The circuit will be use LM 386 as an audio amplifier to amplify the signal before transmitting and after receiving. The circuit will be test and if there was no error, so the casing will be design and built for a better look.

1.4.1 Hardware Design

The hardware design includes PCB fabrication, LED fiber optic 660nm red and phototransistor fiber optic sensor development. In the PCB fabrication, the circuits that were successfully simulated in the simulation software transfer to PCB layout drawing software. These to ensure that the components were properly arranged on the PCB without any clash on their connections in the copper line. The complete design then printed on the transparent paper and transferred to PCB by UV process. Finally, the PCB fabrication's completed by the etching process.

For the LED fiber optic 660nm red and phototransistor fiber optic sensor development, the driver circuit was built for the components to make it to be used for the transmitting and receiving. The audio amplifier was used to amplify the transmitting and receiving signal due to the loss while transferring the signal through the optical cable.

CHAPTER II

LITERARUTE REVIEW

2.1 BACKGROUND STUDY

Cable TV shows, phone calls, or Internet files normally travel through copper wire cables in the form of electrical signals. In a fiber optic system, a transmitter converts these electrical signals into pulses of light. It shoots them down glass fibers, until they reach the far end of the line. Here, receivers re-convert the light pulses to electrical signals, which then are turned back into voice, video, and data files.

The optical fibers are dielectric waveguides which transmit the optical signals or data through them with a very low attenuation and very low dispersion. For example, using soliton laser pulses one can transmit the signals almost without any loss or dispersion. Thus one can achieve very high bandwidth or high data rate using fiber optic cables. Nowadays, a lot of dispersion free and dispersion compensation fibers was available in the market. This make optical fiber communication more advantages than conventional system like:

- **Enormous Bandwidths**

  The information carrying capacity of a transmission system is directly proportional to the carrier frequency of the transmitted signals. The optical carrier frequency is in the range of 10^{14} Hz while the radio frequency is about 10^{6} Hz. Thus the optical fibers have enormous transmission bandwidths and high data rate. Using wavelength division multiplexing operation, the data rate or information carrying capacity of optical fibers is enhanced to many orders of magnitude.

- **Low transmission loss**

Due to the usage of ultra low loss fibers and the erbium doped silica fibers as optical amplifiers, one can achieve almost loss less transmission. Hence for long distance communication fibers of 0.002 dB/km are used. Thus the repeater spacing is more than 100 km.

- **Immunity to cross talk**

Since optical fibers are dielectric wave guides, they are free from any electromagnetic interference (EMI) and radio frequency interference (RFI). Since optical interference among different fibers is not possible, cross talk is negligible even many fibers are cabled together.

- **Electrical isolation**

Optical fibers are made from silica which is an electrical insulator. Therefore they do not pick up any electromagnetic wave or any high current lightening. It is also suitable in explosive environment.

- **Small size and weight**

The size of the fiber ranges from 10 micrometers to 50 micrometers which is very small. The space occupied by the fiber cable is negligibly small compared to conventional electrical cables. Optical fibers are light in weight. These advantages make them to use in aircrafts and satellites more effectively.

- **Signal security**

The transmitted signal through the fiber does not radiate. Unlike in copper cables, a transmitted signal cannot be drawn from a fiber without

tampering it. Thus, the optical fiber communication provides 100% signal security.

- **Ruggedness and flexibility**

The fiber cable can be easily bend or twisted without damaging it. Further the fiber cables are superior than the copper cables in terms of handling, installation, storage, transportation, maintenance, strength and durability.

- **Low cost and availability**

Since the fibers are made of silica which is available in abundance. Hence, there is no shortage of material and optical fibers offer the potential for low cost communication.

- **Reliability**

The optical fibers are made from silicon glass which does not undergo any chemical reaction or corrosion. Its quality is not affected by external radiation. Further due to its negligible attenuation and dispersion, optical fiber communication has high reliability. All the above factors also tend to reduce the expenditure on its maintenance.

2.2 LITERATURE REVIEW

2.2.1 Optical communication

Optical communication technologies are employed in a wide variety of communication environments such as telecommunications, networking, data communications, industrial communication links, medical communications links, etc. Fiber optic networks are becoming increasingly commonplace in telecommunications applications due to their increased bandwidth and distance capabilities relative to copper networks. Optical fiber is the workhorse of the typical optical communication system, and the low loss, light weight, small size, flexibility and high intrinsic bandwidth of optical fiber help make optical communication systems more desirable than competing systems for the communication of both of digital and analog signals.

Fiber optic transmission devices, also called optical-electronic devices or optoelectronic devices, are coupled with optical fibers for data and signal transmission by converting optical signals into electrical signals, electrical signals into optical signals, or both. Fiber optic communication utilizes optical transmitters, optical receivers and optical fiber, among other components, to transmit light signals through the fiber.

Optical fibers are thin transparent fibers of glass or plastic enclosed by material having a lower index of refraction and transmit light throughout their length by internal reflections. The fibers and cladding are typically enclosed in a protective polymer jacket. The transmitters and receivers are often integrated into a single component called a transceiver. Transmitters are light sources, such as lasers or light-emitting diodes. Receivers usually include a photo detector.

In communications, fiber optic cables carry pulsed modulated optical signals, originating from lasers or light emitting diodes, for communicating voice signals as

in Figure 2.1. In industry, fiber optic sensors transmit over fiber optic cables signals whose intensity and wavelength indicate the nature of a sensed parameter.

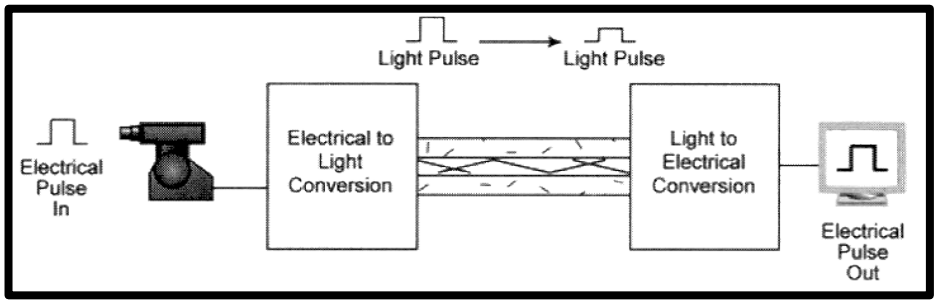

Figure 2.1: Transmission of signal [4]

2.2.2 Optical Fiber Cables

An optical fiber is a glass or plastic fiber that carries light along its length. Fiber optics is the overlap of applied science and engineering concerned with the design and application of optical fibers. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communications. Fibers are used instead of metal wires because signals travel along them with less loss, and they are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so they can be used to carry images, thus allowing viewing in tight spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers.

Light is kept in the core of the optical fiber by total internal reflection. This causes the fiber to act as a waveguide. Fibers which support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those which can only support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a larger core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 550 meters.

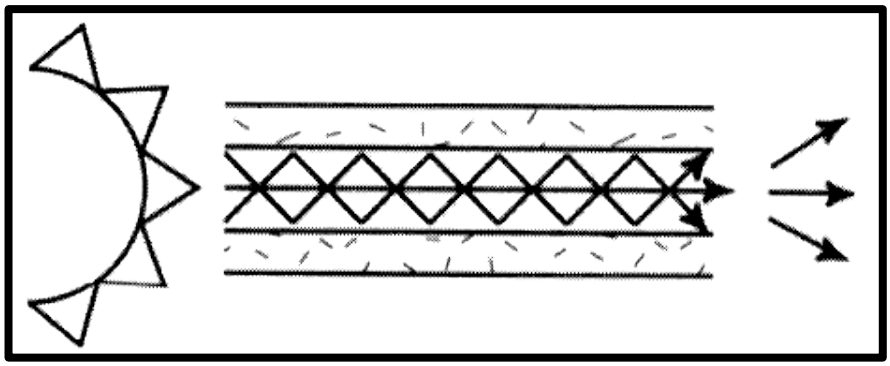

Figure 2.2: Light transmission in optical fiber cable [4]

Joining lengths of optical fiber is more complex than joining electrical wire or cable. The ends of the fibers must be carefully cleaved, and then spliced together either mechanically or by fusing them together with an electric arc. Special connectors are used to make removable connections. [1][3]

2.2.2.1 Construction of Optical Fiber Cable

A fiber optic cable is composed of two concentric layers termed the core and the cladding. These are shown on the right side of Figure 2-2. The core and cladding have different indices of refraction with the core having n_1 and the cladding n_2. Light is piped through the core. A fiber optic cable has an additional coating around the cladding called the jacket. Core, cladding and jacket are all shown in the three dimensional view on the left side of Figure 2-2. The jacket usually consists of one or more layers of polymer. Its role is to protect the core and cladding from shocks that might affect their optical or physical properties. It acts as a shock absorber. The jacket also provides protection from abrasions, solvents and other contaminants. The jacket does not have any optical properties that might affect the propagation of light within the fiber optic cable.

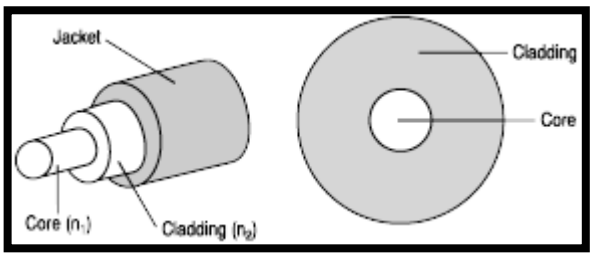

Figure 2.3: Fiber Optic Cable, 3 dimensional view and basic cross sectional area [5]