INTERFACING OF MICROCONTROLLER TO CIRCULATOR USING EMBEDDED C PROGRAMMING IN DEVELOPMENT OF FIBER OPTIC SURFACE ROUGHNESS MEASUREMENT USING TIME OF FLIGHT

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Thank you.

Sincerely,

ASHOK A/L RAJANDRAN

ABSTRACT

This report represents the development of a fiber optic roughness measuring system using Time of Flight technique. As the main part of my final-year project, I developed a system where it will interface the circulator to microcontroller using embedded C programming to measure roughness of surfaces using optical fiber through Time of Flight technique. A lot of researches have been done to get a better view of surface roughness and this is described in detail in this report. Besides that, in this project, the transmitter and receiver chip (transceiver) to transmit and receive the light to scan on the surface needed. Light or pulse generated from optical switch goes through the laser diode in transmitter is sent out through one of the single mode optical fiber and received by pin detector at the receiver chip. The pulse is then detected and embedded into the microcontroller using C programming. The receiver circuit has added on circuits of amplifiers to get the outputs amplified. The methods used and steps taken throughout this project are also explained clearly in this report. The measured outputs are obtained through readings on digital millimeters and also through the oscilloscope. The measurement results and explanation for the results obtained are presented in the second last chapter. Finally, the last chapter as the conclusion exposes the overall view of the project and suggestions in order to make the system better besides the future prospect of the project. This is to avoid preventable problems during the implementation and usage of the system.

ABSTRAK

Laporan ini memaparkan perkembangan gentian optik dalam menentukan kekasaran sesuatu sistem menggunakan keadah "Time of Flight". Sebagai sebahagian besar daripada projek, saya telah menghasilkan satu sistem yang akan berkomunikasi dengan litar di mana ia akan membenamkan program C ke dalam microcontroller yang dihasilkan melalui MPLAB IDE untuk menentukan kekasaran permukaan dengan menggunakan gentian optik. Pelbagai kajian telah dilakukan untuk medapatkan pandangan yang lebih baik dalam menentukan kekasaran sesuatu permukaan dan ini diterangkan dengan lebih jelas dalam laporan ini. Dalam projek ini, saya menggunakan cip penghantar dan cip penerima bagi menghantar dan menerima cahaya untuk mengiam permukaan yang diperlukan. Cahaya daripada penghantar dihantar keluar menerusi salah satu gentian optik pelbagai ragam berkembar dan diterima oleh cip penerima menerusi satu lagi gentian optik yang terlekat bersama padanya.Isyarat yang dihantar melalui suis optik melalui diod laser akan diterima oleh penerima pin dan isyarat tersebut akan dikenalpasti oleh microcontroller yang berfungsi sebagai pengaktifan litar. Litar penguat ditambahkan pada litar penghantar untuk mendapatkan keluaran yang diperkuatkan.Keluaran pada litar akan dilihat pada oscilloscope. Kaedah yang digunakan dan langkah yang diambil dalam projek ini juga diterangkan dengan jelas dalam laporan ini. Keluaran yang disukat dari perintang R2 diperolehi menerusi bacaan pada oscilloscope digital. Keputusan kajian dan penerangan kepada keputusan yang diterima diterangkan dalam bab kedua terakhir. Akhirnya, bab terakhir sebagai konklusi memaparkan keseluruhan projek secara ringkas dan cadangan dalam membaiki sistem ini supaya lebih baik serta keadaan projek pada masa hadapan. Ini adalah untuk mengelakkan masalah yang tidak diingini ketika pelaksanaan dan penggunaan sistem tersebut.

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CHAPTER 1

INTRODUCTION

1.1 History of Fiber Optic

Water flowing from one container to another was the starting of invention of fiber optic. This simple experiment marked the first research into the guided transmission of light. In 1870, John Tyndall used a jet of water that flowed from one container to another and a beam of light, demonstrated that light used internal reflection to follow a specific path. As water poured out through the spout of the first container, Tyndall directed a beam of sunlight at the path of the water. The light followed a zigzag path inside the curved path of the water. In 1880, William Wheeling patented a method of light transfer called „piping light.‟ In that same year, Alexander Graham Bell developed an optical voice transmission system called „photophone‟. The photophone used free-space light to carry the human voice about 200 meters far. This invention was superior to telephone because it did not need wires to connect the transmitter and receiver. Free-space optical links find extensive use in today‟s metropolitan applications. (David, 2002)

Early success came during the 1950"s with the development of the fiberscope. In 1956, Narinder Kapany was the first one who coined the term "fiber optics". Glass fibers that included a separate glass coating were developed by the scientists to reduce the loss in the fiber optics. The **core** (innermost region of the fiber) was used to transmit the light, while the **cladding** (glass coating) prevented the light from leaking out of the core. The light will be reflected within the boundaries of the core. This concept was explained by Snell"s Law which states that the angle at the light reflected depends on the refractive indices of the two materials; the core and cladding. The lower refractive index of the cladding with respect to the core causes the light to be angled back into the core. This is illustrated in Figure 1.1.

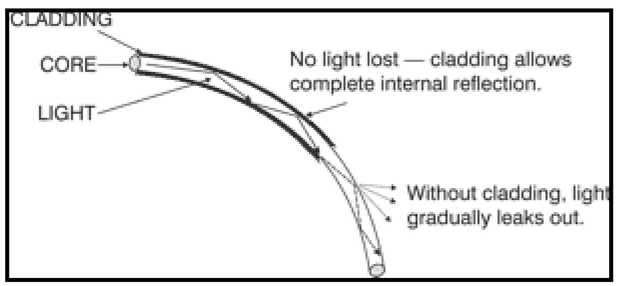

Figure 1.1: Structure of fiber optic (David, 2002)

The next important step in the establishment of the industry of fiber optics was the development of laser technology. **Laser diode** (LD) and **light emitting diode** (LED) had the potential to generate large amounts of light in a spot tiny enough to be useful for fiber optics. The idea of using lasers was popularized by Gordon Gould in 1957 and later was supported by Charles Townes and Arthur Schawlow from Bell Laboratories. In 1966, Charles Kao and Charles Hockham, from Standard Telecommunication Laboratory, England published a paper proposing that optical fiber can be a suitable transmission medium if its attenuation could be kept under 20 decibels per kilometer (dB/km). With a loss of only 20dB/km, 99% of the light would be lost over just only 3,300 feet. (David, 2002)

In 1970, glass researchers; Drs. Robert Maurer, Donald Keck, and Peter Schultz from Corning succeeded in developing a purest glass fiber. This fiber exhibited attenuation at less than 20dB/km, which is the threshold for making fiber optics a viable technology. This can be summarized that the optical power that reached the receiver is only 1/100th of the one transmitted. (David, 2002)

Fiber optics developed over the years in a series of generations that can be closely tied to wavelength. The earliest fiber optic systems were called "**first window**" and developed at an operating wavelength of about 850 nm in a silica-based optical fiber. This window refers to a wavelength region that offers low optical loss. The first window became less attractive as the technology progressed because of its high relatively 3dB/km loss. Most companies jumped to the "**second window**" at 1310 nm with lower attenuation about 0.5dB/km. Nippon Telegraph and Telephone (NTT) developed the "**third window**" at 1550 nm in 1977 which offered the theoretical minimum optical loss for silica-based fibers, about 0.2dB/km. A "**fourth window**," nearly 1625 nm is being developed with its loss not lower than the "third window". The loss is comparable and it might simplify some of the complexities of long-length multiple-wavelength communications systems. (David, 2002)

At early 1980‟s, single-mode fiber operates in the 1310 nm and later the 1550 nm wavelength windows became the standard fiber installed for networks. In 1980, broadcasters of the Winter Olympics in Lake Placid, New York requested for a fiber optic video transmission system for backup video feeds. The fiber optic feed soon became the primary video feed making the 1980 Winter Olympics the first fiber optic television transmission because of its quality and reliability. Later in 1994, Winter Olympics in Lillehammer, Norway used fiber optics to transmit the first ever-digital video signal, which was an application that continues to evolve till today. In that meanwhile, in 1990, Bell Labs transmitted a 2.5Gb/s signal over 7,500 km without regeneration or repeater. This system used a soliton laser and an erbium-doped fiber amplifier (EDFA) that allowed the light wave to maintain its shape and density. In 1998, the researchers did a better work by transmitting 100 simultaneous optical signals with each at a data rate of 10 gigabits per second for a distance of nearly 400 km. Figure 1.2 shows the growth of optical fiber transmission capacity which has grown by a factor of 200 in the last decade. (David, 2002)

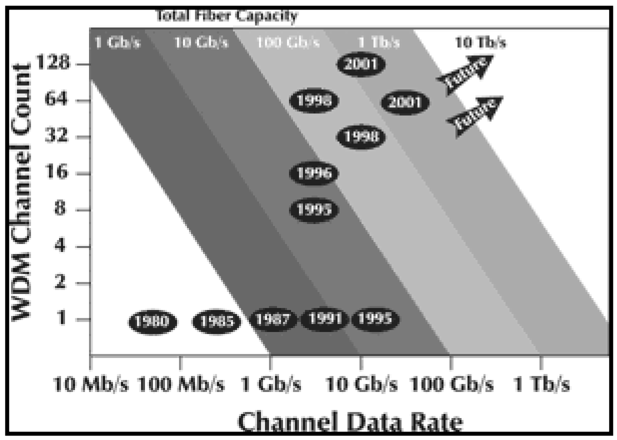

Figure 1.2: Growth in fiber transmission capacity (David, 2002)

There are extraordinary possibilities for future fiber optic applications because of the fiber optic technology‟s immense potential bandwidth. The idea to bring broadband services, including data, audio, and especially video into the home applicants is well underway. In today‟s world more than 80% of the world's long-distance voice and data traffic is carried over optical-fiber cables. (David, 2002)

1.2 General View

Generally after implementing any products or applications in any type of industry and when the quality inspection is done, we want the product to be perfect without any defects. However this does not happen at all the times. Some of the products are rejected because of the unevenness of its surface. Roughness of a wafer can be the best example why measuring roughness of its surface is important. All smooth surfaces possess some degree of roughness, even if only at the atomic level. For man-made surfaces, this roughness arises from the manufacturing process, which may involve chemical deposition, grinding, polishing, etching or several other commonly used techniques. Correct function of the fabricated component often is critically dependent on its degree of roughness.

The surface roughness of an object can be measured either mechanically or optically. Mechanical devices based on the profilometer principle are expensive, can be unreliable in certain applications, and require physical contact with the surface of interest. The surface damage that may result can corrupt the measurement data. Noncontact optical techniques eliminate the problems of surface damage and inaccurate data, but they require very precise optical elements that must be realigned continually. (Sensors Magazine Online - April 1999) However, this method is far cheaper compared to the some other methods. Therefore through this project, noncontact method of measuring roughness of a surface can be found and this can be applied in our industry as it might reduce the production cost.

1.3 Objective of The Project

There are few objectives that were outlined for the purpose of this project. They are as follows:

i. The main objective is this final year project (FYP) is a must in order to fulfill the four years of engineering course or degree in Universiti Teknikal Malaysia Melaka(UTeM). FYP is one of the main requirements in achieving degree in UTeM. A student is considered capable and qualified as an engineer after finishing his/her FYP under a qualified lecturer or others who have the same status as lecturers. It helps the students to expose themselves in organizing a project and to measure their ability in finding and selecting information, their communication skills, time management and self-management.

ii. The intrinsic objective of this FYP is to develop an interfacing between a micro-controller to circulator using embedded C programming for development of roughness measuring system using Time of Flight technique (ToF). The objective of this FYP is also to analyze and understand the development of roughness measuring system via Time of Flight technique.

iii. The objective of the present study is to develop a programme which will interface the software and the hardware which is circuit designation. Other than that, it is concerned in studying the history and theory of fiber optics and Time of Flight technique..The literature review of this project enlightens me with new methods of measuring surface roughness where new method of ToF is implemented and interfacing is being done.

iv. Last but not least, through this project I manage to improve my skills in many ways. My planning skills, analytical skills and calculative skills improved throughout this project. I got to know how great fiber optic plays its role in our modern society to gain more knowledgeable and useful tools for the customers. It really gives a big satisfaction in knowing and working with fiber optics and its applications. FYP also helps students to be independent while doing their project and this can help students to get a pre-working experience.

1.4 Scope of The Project

Firstly, there are many applications using fiber optic, which is implemented in industry, medical, security, telecommunication, submarine, laboratory fields, decorative purposes and others. In this project, fiber optics is used as transmitting and receiving light to and from targeted surface to measure the roughness of it and interfacing from micro-controller to circulator with embedded C programming to show the result and simulation. The scope of the project covers the software development of the fiber optic roughness measuring system. It will cover the interfacing of software to hardware and as well as simulation of this project. However, the scope of my project will not cover the hardware designing of the circuits.

1.5 Research Methods

The development of a fiber optic in measuring the system roughness involves a lot of research, which was done step by step. Interferences between one step to another do happen at times but this was unproblematic to handle when there is a clear view of overall flow of the project. The steps involved are elaborated briefly and shown in Figure 1.3.

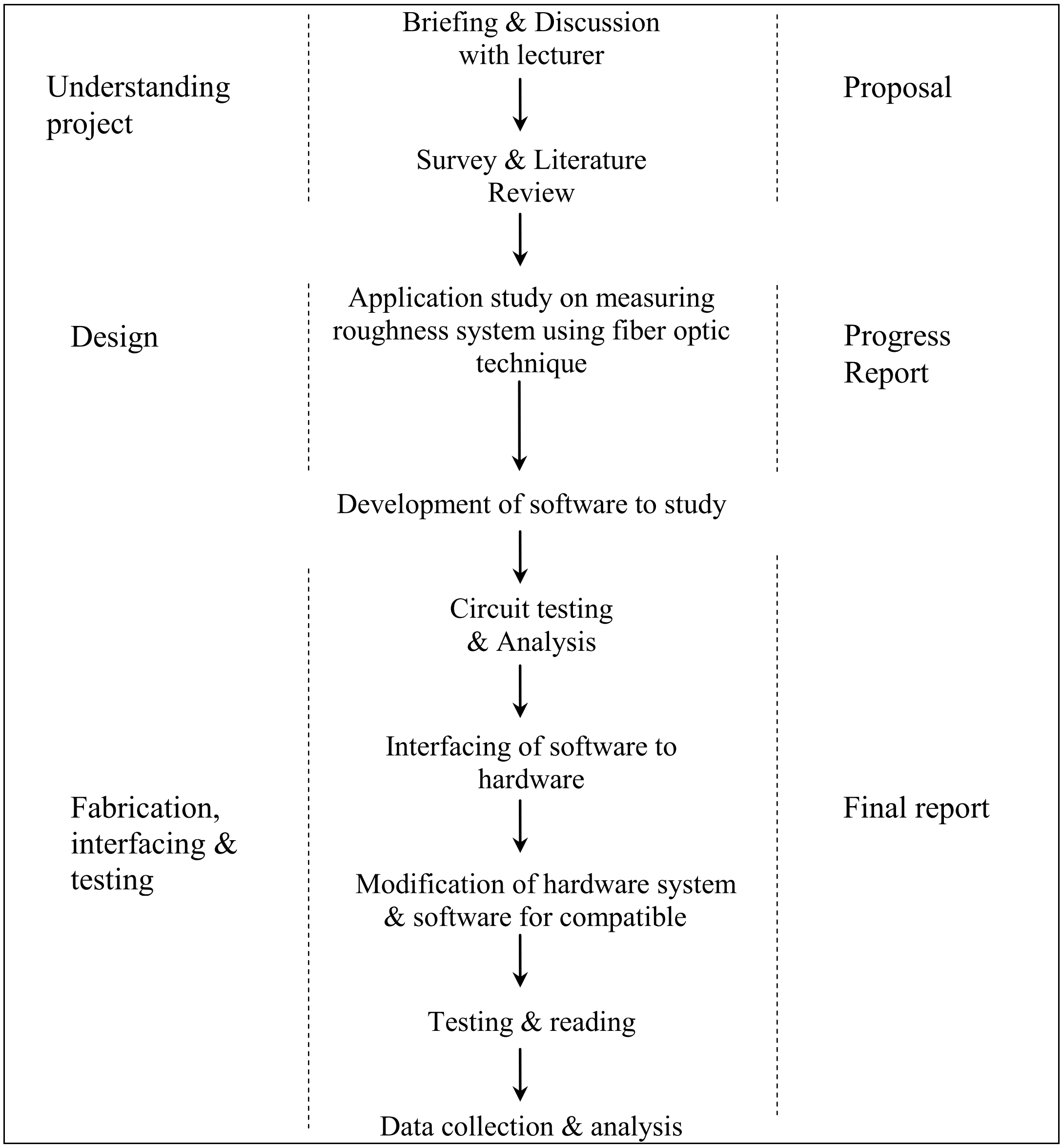

Figure 1.3: Overall flow of the project