DEVELOPMENT OF FIBRE OPTIC ROUGHNESS MEASURING SYSTEM USING TIME OF FLIGHT METHOD (TOF)

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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ABSTRACT

This project is mainly about the development of Fibre Optics Roughness Measuring System using Time of Flight Method. This project is implemented by construction of hardware design and software programming. The components that involves in the construction of the circuit are PIC24FJ128GA006 microcontroller, optical switch, circulator, laser diode, pin detector and transimpedance amplifier. The heart of the surface roughness measuring system is the PIC24, 16-bit microcontroller whereby it works in a very high speed in order to capture the transmitted and received signal in light medium. The analog signal will be transmitted by the optical switch in to the microcontroller and it will be changed to digital signal before transmission. It will goes through the laser diode and detected by the pin detector. The digital signal is converted back to the analog signal by using the ADC read in the microcontroller before sending the signal to transimpedance amplifier. The output of the signal is observed by using oscilloscope and the signal is tapped at pin 6 of the transimpedance amplifier. Finally the time difference and the voltage difference is recorded when the laser is used to measure the surface roughness. The ALTIUM DXP software is used in order to design the circuit and for the programming part the MPLAB IDE is used in order to generate the C programming. The C programming code is embedded to the PIC24 by using PICKIT 2. The medium that have been used throughout the project is Fibre Optics and the wavelength is a non visible wavelength which is 1550nm. The main advantage of this project is the usage of the single mode fibre transmission. The advantage of this transmission is, it can measure for a long distance and it minimizes the loss along the signal transmission and this helps in producing a reliable signal when a surface roughness is measured.

ABSTRAK

Projek in adalah mengenai penghasilan sebuah system mengunakan jangkaian jalur optik untuk mengukur kekasaran sesuatu permukaan. Teknik yang ditekankan dalam projek in adalah teknik perbezaan masa antara masa maklumat dihantar dengan maklumat diterima. Projek in mengandungi pengimplimentasian hardware design dan programming. Komponen utama yang digunakan dalam projek in adalah PIC24FJ128GA006 microcontroller, suis optik, circulator, diod laser, pengesan optic dan amplifier transimpedansi. PIC24 bertindak sebagai komponen utama dalam sistem ini kerana ia berfungsi dengan kelajuan yang tinggi untuk mengesan cahaya daripada jalur optik ini dan pemindahan maklumat ke seluruh sistem perlu dilakukan dengan cepat untuk memperoleh maklumat yang tepat. Cara litar in berfungsi adalah bermula dengan penjanaan signal dari suis optic dan maklumat dari suis optic in akan ditukarkan kepada signal digital oleh PIC24 microcontroller. Setelah proses penukaran tamat, signal itu akan dihantar ke diod laser dan dikesan oleh pengesan optik. Maklumat akan dihantar semula ke PIC24 mikrocontroller untuk menukarkan maklumat kepada analog signal. Setelah proses in selesai signal itu akan dihantar ke ampflier transimpedansi untuk diamplifikan dan signal ini dapat diukur dengan mengunakan oscilloscope. Perbezaan masa dan voltan yang diperoleh daripada oscilloscope semasa mengukur kekasaran sesuatu objek direkodkan. Perisian yang digunakan untuk melakar litar in adalah ALTIUM DXP dan programming dilakukan dengan menggunakan perisian MPLAB IDE. Medium yang digunakan dalam projek in adalah rangkaian jalur optic dengan panjang gelombang 1550nm. Keuntungan projek ini adalah penghantaran maklumat dengan menggunakan jalur optic serat tunggal iaitu “single mode fibre”. Penggunaan jalur optik ini membolehkan maklumat diukur pada jarak yang jauh dan meminimumkan kehilangan maklumat yang banyak dalam seluruh proses penghantaran maklumat ini dan ia juga membantu untuk pemerolehan maklumat yang tepat apabila kekasaran sesuatu objek diukur.

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CHAPTER 1

INTRODUCTION

1.1 History of fibre optic

The important step in the establishment of the industry of fibre 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 fibre 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 fibre 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) [1].

In 1970, glass researchers; Drs. Robert Maurer, Donald Keck, and Peter Schultz from Corning succeeded in developing a purest glass fibre. This fibre exhibited attenuation at less than 20dB/km, which is the threshold for making fibre 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) [1]. The biggest challenge remaining for fibre optics is economic. Today telephone and cable

television companies can cost-justify installing fibre links to remote sites serving tens to a few hundreds of customers. However, terminal equipment remains too expensive to justify installing fibre all the way to homes, at least for present services. Instead, cable and phone companies run twisted wire pairs or coaxial cables from optical network units to individual homes. Time will see how long that lasts. Fibre have many uses in remote sensing. In some applications, the sensor acts as the optical fibre. In some other applications a non-fibre optic sensor is connected with fibre to a measurement system. The main advantage of fibre is because of its small size or the fact that nonelectrical power is needed at the remote location or because many sensors can be multiplexed along the length of the fibre by using different wavelengths of light for each sensor[2].

1.2 Overview

A fibre optic sensor system is developed to probe the surface texture of corroded metals. The present work is based on the principle of Time of Flight(TOF) method in order to measure the surface roughness. A pulse is transmitted and the time difference for the light takes to travel to a target and back is measured with a single roundtrip delay. The time delay is indirectly measured by comparing the signal from the laser with the delayed signal returning from the target. The fibre optic sensor system can be used to estimate the surface roughness of the measured material.

The surface roughness of an object can be measured either mechanically or optically. Mechanical devices based on the profilometer and digital photogrammetry 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 with implementation of the TOF method 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) [3]. However, this method is far cheaper compared to the some other methods. Therefore through this project, Time of Flight(TOF) method of measuring roughness of a surface can be develope 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 are 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 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 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 a fibre optic roughness measuring system by using Time Of Flight(TOF) method. This development consists of designing the transimpedance circuit, fabricating the hardware, interfacing of software, transmitting the pulse at different pulse

width, measuring the roughness of surfaces and finally evaluating the results to obtain the roughness of the surfaces.

iii. The objective of the present study is to measure the surface roughness and surface profile of the engineering materials by an optical system using the Time of Flight technique. Other than that, it is concerned in studying the history and theory of fibre optics and designing a system to measure roughness of given surfaces using fibre optics. The literature review of this project enlightens me with new methods of measuring surface roughness including the method used in this project, especially in transmitting and receiving the pulse using different pulse width from surfaces to get measurements of roughness.

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 fibre 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 fibre 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 fibre optic, which is implemented in industry, medical, security, telecommunication, submarine, laboratory fields, decorative purposes and others. In this project, fibre optics is used as transmitting and receiving light using different pulse width and the resolution of the pulse width to and from targeted surface to measure the roughness of the surface. The scope of the project is to measure the roughness of surfaces from the smooth ones until the rough ones, which can be proved that the idea is applicable, based on the experimental results and the resolutions measured. The scope of the project does not include the thickness and analysis of the surface roughness as this involves another method, which is not done through this project. This is because it requires other additional facilities and applications.

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.

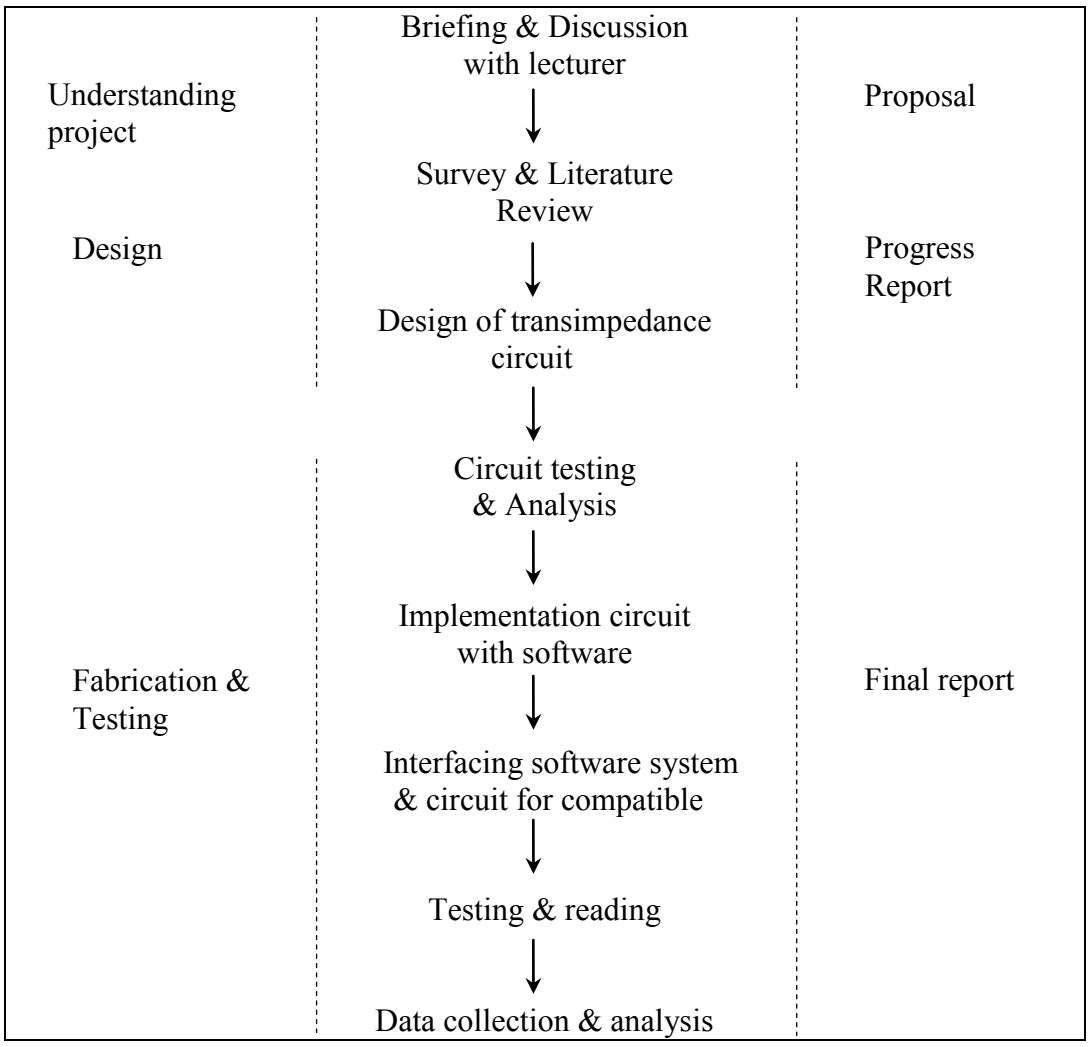

Figure 1.1: Overall flow of the project

1.5.1 Literature Review and Study

First of all, understanding the title chosen is very important in order to get a better view of the project and its scope. For this purpose, a lot of researches have been carried out through journals, Internet, and books from various sources. Related topics regarding the project were found to get a better understanding of the project as well as the flow of it. The conducted research was about history, constructions, types, advantages, disadvantages, propagation, applications in fibre optics and fibre optics as sensors. Overall, this step was a stepping-stone in understanding the general view of the project and a good start to begin the project.

1.5.2 Circuit Fabrication and Testing

The following step after designing of the circuits is the fabrication. These circuits consist of two parts: transmitter and receiver. These circuits are combined together as transimpedance circuit . Later once the circuits are giving satisfactory results, the hardware is interfaced with the software and testing is continued with the full connection of the system. The analysis for this fabricated circuit will be about the roughness and measuring the surface roughness using different pulse width and measure the resolution obtained. It also shows the differences between the theory and the practical results of the fabricated circuit and also problems while doing the testing. Graphical analysis is being used most in evaluating the results.

1.5.3 Complete Design and Test

Finally when all the testing is over with simulation result and circuit design, the schematic is implemented on Printed Circuit Board (PCB). ALTIUM DXP Software is used in order to draw the layout and the components are being soldered to the board. Again the testing is done to confirm the capability of the fibre optic system and its accuracy. Graphical method was used in determining the precision of the results.