DEVELOPMENT OF A FIBER OPTIC ROUGHNESS MEASURING SYSTEM

oleh

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ABSTRACT

This report represents the development of a fiber optic roughness measuring system. As the main part of my final-year project, I developed a system to measure roughness of surfaces using optical fiber. 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, I am using transmitter and receiver chip to transmit and receive the light to scan on the surface needed. Light from transmitter is sent out through one of the multimode optical fiber twin pack and received by receiver chip through the other attached optical fiber. The hardware system is made of mild steel and the transmitter and receiver circuits are designed in such a way that can be compatible with the system hardware. 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 multimeter. 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. Sebagai sebahagian besar daripada projek, saya telah menghasilkan satu sistem 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. Perkakasan sistem ini diperbuat daripada keluli lembut dan litar penghantar serta litar penerima direkabentuk supaya kedua – duanya serasi dengan perkakasan sistem. Litar penguat ditambahkan pada litar penghantar untuk mendapatkan keluaran yang diperkuatkan. Kaedah yang digunakan dan langkah yang diambil dalam projek ini juga diterangkan dengan jelas dalam laporan ini. Keluaran yang disukat diperolehi menerusi bacaan pada meter pelbagai berdigit. 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.

ACKNOWLEDGEMENT

This project would not have been a success without the help and attention of many parties. I would like to take this opportunity to express my sincere gratitude to all those who have contributed in completing this project.

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My special acknowledgement goes to the School of Electrical & Electronic Engineering for providing me with this wonderful opportunity to carry out the final year project. I was also exposed to do a proper research in order to get a clear idea on the selected topic.

Thank you very much to all the technical staffs in the School of Electrical and Electronic Engineering, especially Mr. Abdul Latip, the lab technician of Communication Lab for his warmest helping hand. Not forgetting the lab technician of

Fiber Optic Lab, Mr. Rozaidee, who helped and guided me throughout my project in using fiber optic.

My sincere gratefulness and love to my adored parents and siblings for their love, moral support and motivation in successfully accomplish my studies. Finally, I wish to express my sincere thanks to all my friends for their cooperation, assistance, patience and thought that helped me to complete this project on time.

Thank you.

Sincerely,

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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.

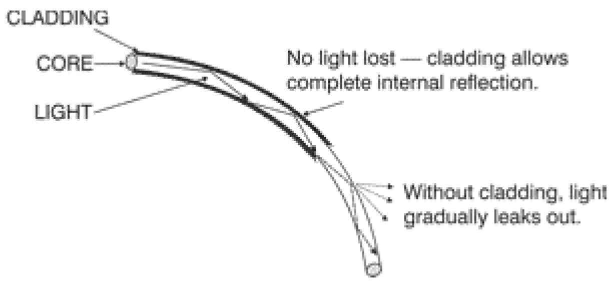

Figure 1.1: Structure of fiber optic (David, 2002)

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)

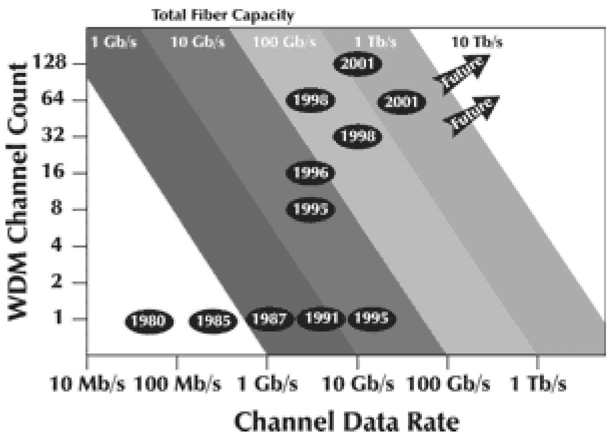

Figure 1.2: Growth in fiber transmission capacity (David, 2002)

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 <u>General View</u>

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 USM. FYP is one of the main requirements in achieving degree in USM. 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 fiber optic in measuring roughness of targeted surface such as metal and plastic. This development consists of designing the transmitter and receiver circuit, fabricating the hardware, 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. Other than that, it is concerned in studying the history and theory of fiber optics and designing a tool to measure roughness of given surfaces using fiber 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 light 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 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. 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. 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 1.3.

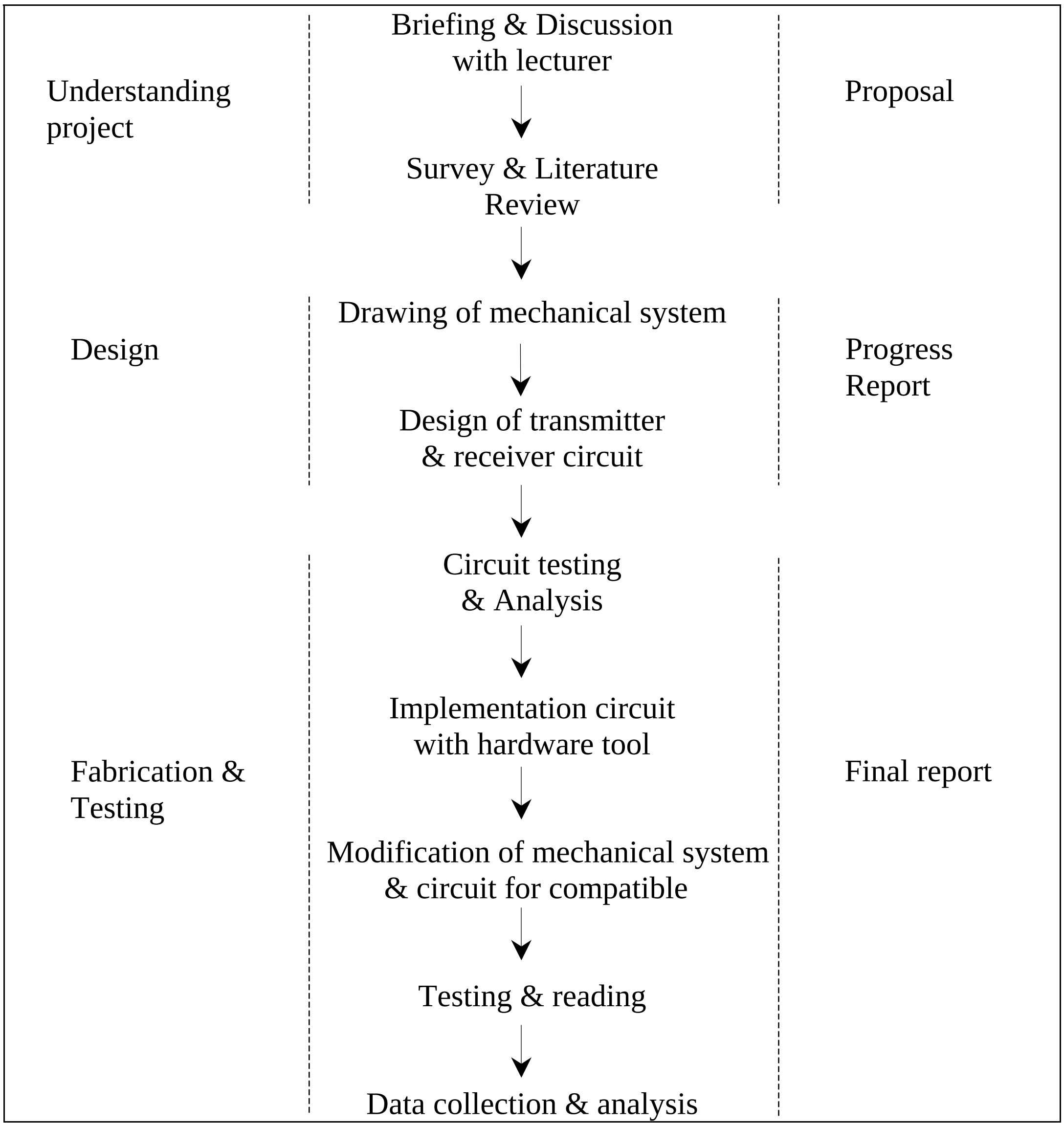

Figure 1.3: Overall flow of the project

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 fiber optics and fiber 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 Mechanical System Description and Design

The second step, after understanding the topic of the project, is designing the tool (steel hardware), which is one of the main items in the project. During this process few designs were discussed and finally the best design of all was finalized. This finalized design will have the capability of measuring (scanning) any surface vertically and horizontally. After all these considerations were taken care of, the proposed mechanical system drawing was sent to fabrication center in India to be fabricated.

1.5.3 Circuit Fabrication and Testing

The following step after fabrication is the designing of the circuits. These circuits consist of two parts: transmitter and receiver. Earlier, these circuits are tested separately meanwhile waiting for the mechanical system to be fabricated. Later once the circuits are giving satisfactory results and the fabrication of the mechanical system is over, the testing is continued with the full connection of the system. The analysis for this fabricated circuit will be about the roughness and thickness of specimens' surface used in the testing. 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.

1.5.4 Complete Design and Test

Finally when all the testing is over with the fabricated mechanical tool and circuit, the schematic is implemented on Printed Circuit Board (PCB). Orcad 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 fabricated mechanical system and its accuracy. Graphical method was used in determining the precision of the results.

1.6 Report Organization

Report organization for this project was done methodically according to the requirements needed. This report is also attached with needed images, tables, graphs and data sheets of the chips used.

Chapter 1 is mainly about the introduction of fiber optic in today's world. It covers from the history of fiber optics and general view of this project. This chapter also covers the objectives of the project, scope of the project and methods used in completing the project, briefly with help of an overall flow chart.

Meanwhile *Chapter 2* discusses the literature review of the project, which consists of the roughness of surfaces, description and effect of surface roughness and methods in measuring surface roughness. This chapter also describes the researches done by others using optical methods and the method used in this project. Besides that, it explains the applications in measuring the roughness of surfaces in industry.

Chapter 3 is the core part of this project, where the methodology is being discussed completely. This includes the introduction of the method used in the project; design of system and optical fibers, which take count of the construction, advantages, disadvantages, propagation of light, and its general uses. In this chapter, ways of handling and polishing fiber optics during the project, model development for measuring roughness of surfaces, transmitter and receiver circuits and also amplification design in order to obtain the amplified values through multimeter is being discussed in detail. Finally, this design is being implemented in PCB.

Chapter 4 is about the results and discussion regarding the results obtained through out the project. In this chapter, the results are explained clearly and the reasons for each data or output from all the surfaces are stated undoubtedly. This gives a better understanding for each output shown.

Finally, *Chapter 5* provides the overall conclusions, which are derived from the results and discussion from the previous chapter. It also covers the future prospect of the project and suggestions to improve the measurement of surface roughness for the system used in the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Roughness of surfaces

A surface is a boundary that separates an object from another object or substance. (Prevision Devices, 1998, 2001) Surface topography is important in specifying the function of a surface. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality. The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is essential to control quality of machining work piece. (John W.S, 2002) All smooth surfaces possess some degree of roughness, even though it is only at the atomic level.

Roughness for man-made surfaces arises from the manufacturing process, which may involve chemical deposition, grinding, polishing, etching or several other commonly used techniques. Correct function of fabricated component often dependent on its degree of roughness. (Shmitt Industries, 1998-2004) Typical surface areas are not 100% uniform, so it is best to get the average. There are few definitions of surface roughness and its measurement methods, which is explained in following subtopics.

2.1.1 <u>Description of Surface Roughness</u>

The roughness of a surface can be measured in different ways and they are classified into three basic categories: statistical descriptors, extreme value descriptors and texture descriptors. Statistical descriptors give average behavior of the surface height such as average roughness (Ra); the root mean square roughness (Rq); the skewness (Sk) and the kurtosis (K). Meanwhile, extreme value descriptors depend on isolated events such as the maximum peak height Rp, the maximum valley height Rv, and the maximum peak to valley height Rmax. Texture descriptors describe variations of the surface based on multiple events like the correlation length. (John W.S, 2002)

Among these descriptors, the Ra measurement is the most effective surface roughness measurements that are commonly adopted in general engineering practice. It gives a good general description of the height variations in the surface. Figure 2.1 shows a cross section through a surface where a mean line that is parallel to the general surface direction is found. This mean line divides the surface in such a way that the sum of the areas formed above the line is equal to the sum of the areas formed below the line. The surface roughness Ra is now given by the sum of the absolute values of all the areas above and below the mean line divided by the sampling length. (John W.S, 2002) Therefore, the surface roughness value is given by formula in Equation 2.1 below.

$$Ra = \frac{|\text{area abc}| + |\text{area cde}|}{\text{f}} \qquad (2.1)$$

where f is the feed.

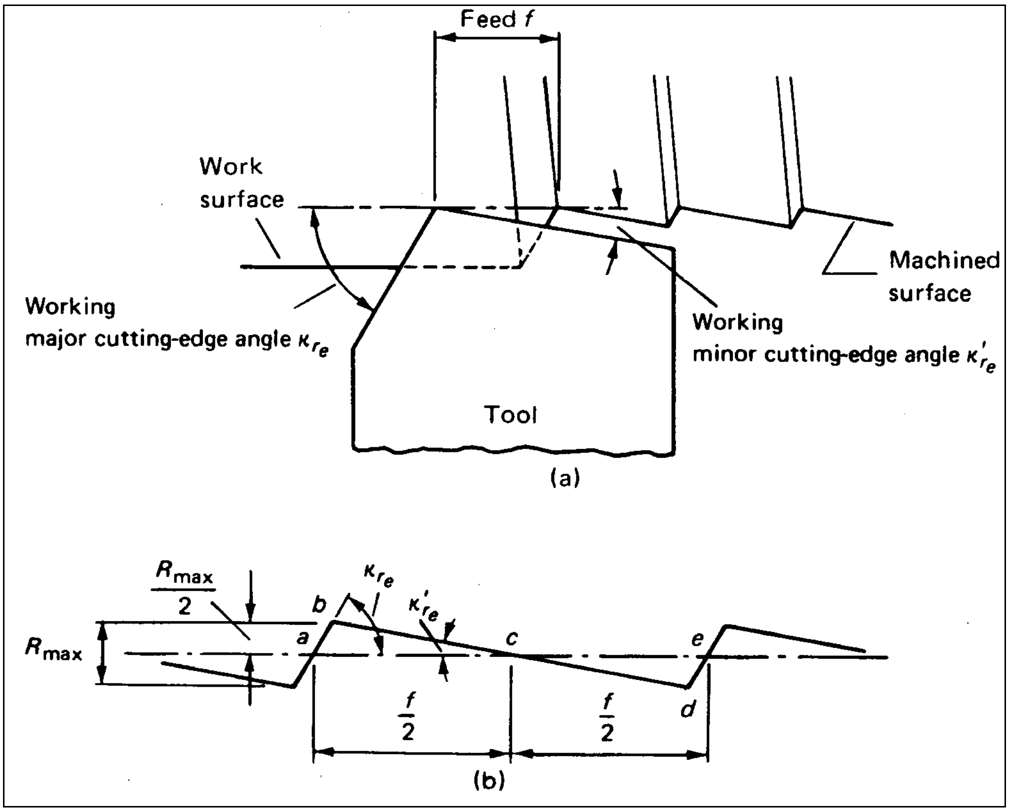

Figure 2.1: (a) (b) A cross section through a surface where a mean line that is parallel to the general surface direction is found to calculate Ra (John W.S, 2002)

2.1.2 Effects of Surface Roughness

There can be a lot of problems caused by roughness of surfaces. These problems can be grouped into four: excess light scatter, mechanical malfunction, environmental instability, and cosmetic acceptability. In optical applications, the amount of surface that will scatter light at the projected wavelengths of operation can be estimated by measuring the roughness of surfaces. Excess scatter can result in system nonperformance for sensing optics, imaging optics, and laser optics. For example, if a polished optic is to be used at 650 nm, then the best specification is the scatter measured at 650nm. (Shmitt Industries, 1998-2004)

In non-optical applications, excessive of surface roughness can lead to mechanical malfunctions. This can be explained with the mechanical malfunction that can be found in high performance engine machine parts. Normally these machines are required to move or rotate at high speed without wear and excess surface roughness can lead to high levels of frictional heating, damage and failure of the machines. Rollers used in computer printers and plotters to press metals, papers and films in factory environments require good control of surface quality to ensure the product's quality. Periodic surface testing for the rollers can alert manufacturers to refinish the roller surface before the process degrades to an unacceptable level. Besides that, the roller surface can be brought to the required smoothness with minimum amount of processing by testing the surface quality during the grinding and refinishing process. (Shmitt Industries, 1998-2004)

Surface roughness can also affect a component's chemical and physical stability. Some surfaces need stand with hostile environments such as temperature, humidity, or hostile chemicals and must be as smooth as possible. This is to get the minimum surface area for attack, and have few defects or weak spots only. Surface roughness can affect the cosmetic appearance of a surface. Even though the problems caused are not important but they can give income losses while marketing the product. For example, a rough paint surface may function perfectly well on an automobile to protect its surface but it would reduce the customers' perception of quality and value. (Shmitt Industries, 1998-2004) Figure 2.2 shows the roughness and waviness of a texture surface.

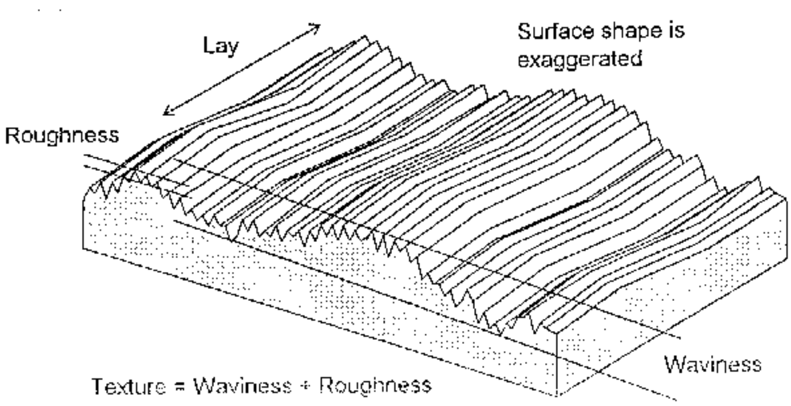

Figure 2.2: Texture surface showing the roughness and waviness (Shmitt Industries, 1998-2004)

2.1.3 Main measurement methods of surface roughness

There are many problems occurs due to the roughness surfaces of finished products. Therefore, ways to reduce the roughness is important. Human observation method is the most basic method used in measuring surface roughness. Other methods used in determining the roughness of surfaces are such as direct measurement methods, comparison based techniques and non-contact methods. There are also other methods on process measurements on the way to measure the roughness.

Human observation method can be used however human perception is highly relative. This means there is a need in comparing feeling from one surface to another surface by using human tester (commercial sets of standards) are available as a reference for the touch made. Comparison will be made against matched identical processes. Fingernail assessment of roughness and touch method is used for draw dies in the auto industry. (Hugh J., 2001)

Direct methods assess surface by means of stylus type devices. Measurements are obtained using a stylus drawn along the surface to be measured: the stylus motion perpendicular to the surface is registered. This registered profile is then used to calculate the roughness parameters. This method requires interruption of the machine process, and the sharp diamond stylus may make micro-scratches on surfaces. (John W.S, 2002) One example of this is the Brown & Sharpe Surfcom unit. Basically this technique uses a stylus that tracks small changes in surface height, and a skid that follows large changes in surface height. The use of these two together reduces the effects of non-flat surfaces on the surface roughness measurement. The relative motion between the skid and the stylus is measured with a magnetic circuit and induction coils. Figure 2.3 shows the Brown & Sharpe Surfcom unit stylus equipment device that is used in measuring surface roughness. (Hugh J., 2001)

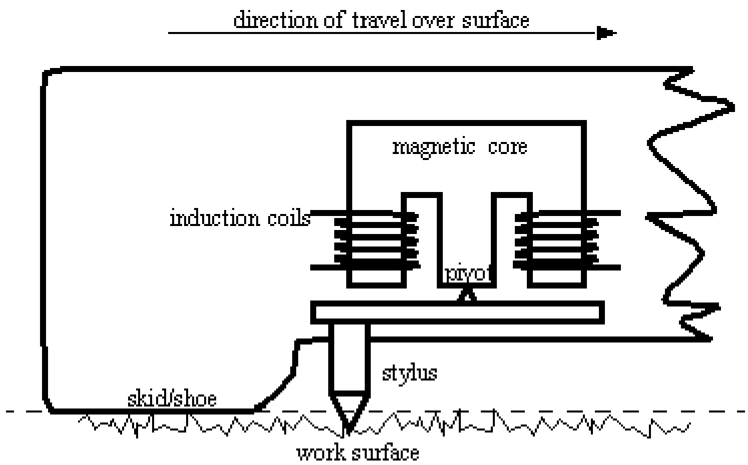

Figure 2.3: Brown & Sharpe Surfcom unit stylus equipment device

(Hugh J., 2001)

Comparison techniques use specimens of surface roughness produced by the same process, material and machining parameters as the surface to be compared. Visual and tactile senses are used to compare a specimen with a surface. Because of the subjective judgment involved, this method is useful for surface roughness where the root mean square roughness Rq more than 1.6 micron. (John W.S, 2002)

Non-contact technique also used in measuring roughness of surfaces. Electronic speckle correlation method is one of the popular non-contact methods. When coherent light illuminates a rough surface, the diffracted waves from each point of the surface mutually interfere to form a pattern, which become visible as a grain pattern of bright and dark regions. The spatial statistical properties of this speckle image (small colored mark) can be related to the surface characteristics. Two different illumination beams from the same surface can produce the degree of correlation of two speckle patterns that can be used as a roughness parameter. (John W.S, 2002)

Besides that, there are also other types of methods used to measure surface roughness in process such as machine vision, inductance method and ultrasound. In **machine vision**, a light source is used to illuminate the surface with a digital system to view the surface and the data will be sent to a computer to be analyzed. The digitized data is then used with a correlation chart to get actual roughness values. An **inductance** pickup is used to measure the distance between the surface and the pickup. Through this, a comparative roughness will be obtained. However, this method is limited in measuring magnetic materials. Spherically focused **ultrasonic** sensor, which is positioned with a non-normal incidence angle above the surface, will be another system to measure surface roughness. The sensor sends out an ultrasonic pulse to a personal computer for analysis and calculation of roughness parameters. (John W.S, 2002)

2.2 <u>Researches done with optical method</u>

Optical method is also another way of determining the roughness of surfaces given. This is a non-contact method used other than the methods explained earlier. Many intellectual researchers from various countries did research in using fiber optic to measure roughness of surfaces through out the past few years to get a better method in evaluating surfaces. Z. Yilbas & M. S. J. Hashmi from Faculty of Engineering, University of Dublin, Ireland did a research on “An Optical Method and Neural Network for Surface Roughness Measurement”. They also studied the development of the computer-controlled electro-fiber-optic system for surface roughness measurements and demonstrated that the measurement of the surface roughness could be possible within a limited accuracy. (Z. Yilbas & M. S. J. Hashmi, 1997) Again in 1997, their journal “Surface roughness measurement using an optical system” was received. In this journal, an optical method relying on the reflected beam intensity profile is introduced. (Zahide Yilbas and M.S.J. Hasmi, 1999)

In 1995, S. Ramesh and B. Ramamoorthy from Manufacturing Engineering Section, Department of Mechanical Engineering, Indian, Institute of Technology, Madras 600036, India did researches about “Measurement of surface finish using an optical diffraction technique”. (S. Ramesh and B. Ramamoorthy, 1996) In 1997, Kuiwei Zhang, Clive Butler, Qingping Yang, Member IEEE and Yicheng Lu. had a journal about “A Fiber Optic Sensor for the Measurement of Surface Roughness and Displacement Using Artificial Neural Networks”. This paper presents a fiber optic sensor system where artificial neural networks (fast back-propagation) are employed for the data processing. The use of the neural networks makes it possible for the sensor to be used both for surface roughness and displacement measurement at the same time. (Kuiwei *et al.*, 1997)

S.H. Wanga, C.J. Jinb, C.J. Taya, C. Quana, H.M. Shanga from Department of Mechanical Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore and School of Manufacturing, Sichuan University, Chengdu 610065, People’s Republic of China researched about “Design of an optical probe for testing surface roughness and micro-displacement”. Their journal was received on 5 May 2000; received in revised form 29 September 2000 and accepted on 19 February 2001. This paper presents a practical monitoring tool for measurements of surface roughness and micro-displacement. An optical probe of the methods based on light scattering for measuring surface roughness and optical triangulation for measuring micro-displacement is described. (S.H. Wanga *et al.*, 2001)

In Tribology International Vol. 31, No. 5, pp. 281–287, 1998, W. Wang, P. L. Wong, J. B. Luo and Z. Zhang completed a journal on “A new optical technique for roughness measurement on moving surface”. A new optical technique, which allows the roughness of moving surfaces to be determined, was developed. The new technique is called the dark/bright ratio (DBR) method and utilizes the combined effects of speckle and scattering phenomena. (W. Wang, 1998) Guiseppe Schirripa Spagnolo, Domenica Paoletti, Alfonso Paoletti, Dario Ambrosini from Dipartimento di Energetica, Universitd degli Studi di L'Aquila, Localitd Monteluco di Roio, 67040 Roio Poggio - L'Aquila, Italy studied about "Roughness measurement by electronic speckle correlation and mechanical profilometry". In this study, a practical optical sensor for rough surface diagnostics has been developed for applications in mechanical engineering and optical measurements on different rough surfaces are compared with mechanical stylus measurements and these two methods results are compared. (Guiseppe *et al.*, 1997)

2.3 Optical method in this project

There are many ways in evaluating surface roughness using optical fiber. In this project, optical fiber is used in a simple way to measure surface roughness. It is less costly compared to some of the methods explained earlier and user-friendly, as operating this system does not really need expertise in fiber optics field. Anyone who is able to follow instruction from readings can use this system to measure surface roughness. This method uses multimode optical fiber, transmitter chip, receiver chip and operational amplifiers chips. The block diagram for this method is shown in Figure 2.4. The block diagram shows briefly about the system used with the optical method. This method is self-explanatory and can be implemented by beginners.

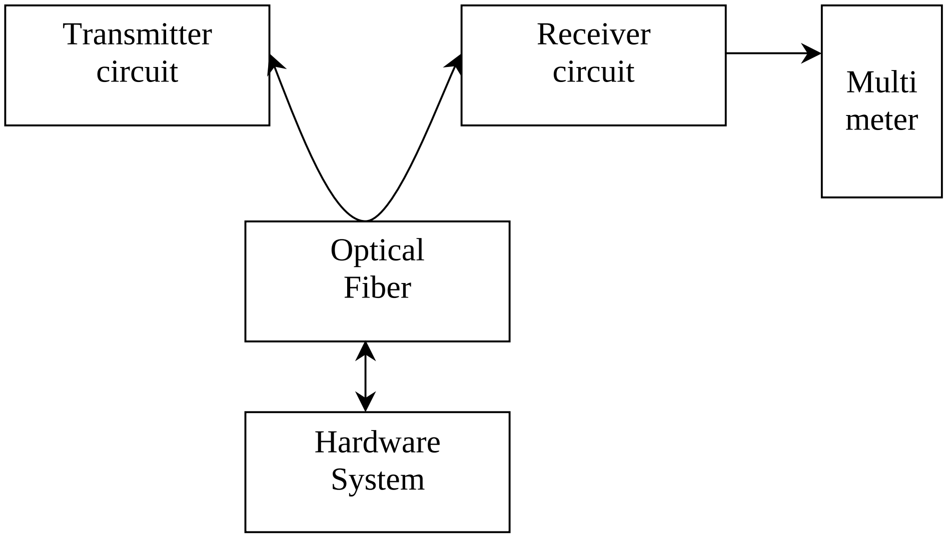

Figure 2.4: Block diagram for optical method used in this project

2.4 Application in measuring surface roughness

Measuring roughness of surface is important in many industry applications. This is to ensure that the product created is applicable in industry without any problem or lost of production cost when it is in the industry. There are numerous products that need fine assurances of its surfaces smoothness before being sent to the sales. Measuring the roughness is essential in applications such as contact lens surfaces, molds, laser texture analysis, polymer surface, bearing surface wear, coated paper, printing plate, silicon wafer, hard disk flatness and prism. (ADE Corporation, 2005) In all these applications, different methods are used in measuring according to its acceptance of equipments in order to measure the roughness of the surface. The conclusion is whatever method is being used, measuring the roughness of surface is an important process and using optical fiber for measurement is one of the best ways.

CHAPTER 3

METHODOLOGY

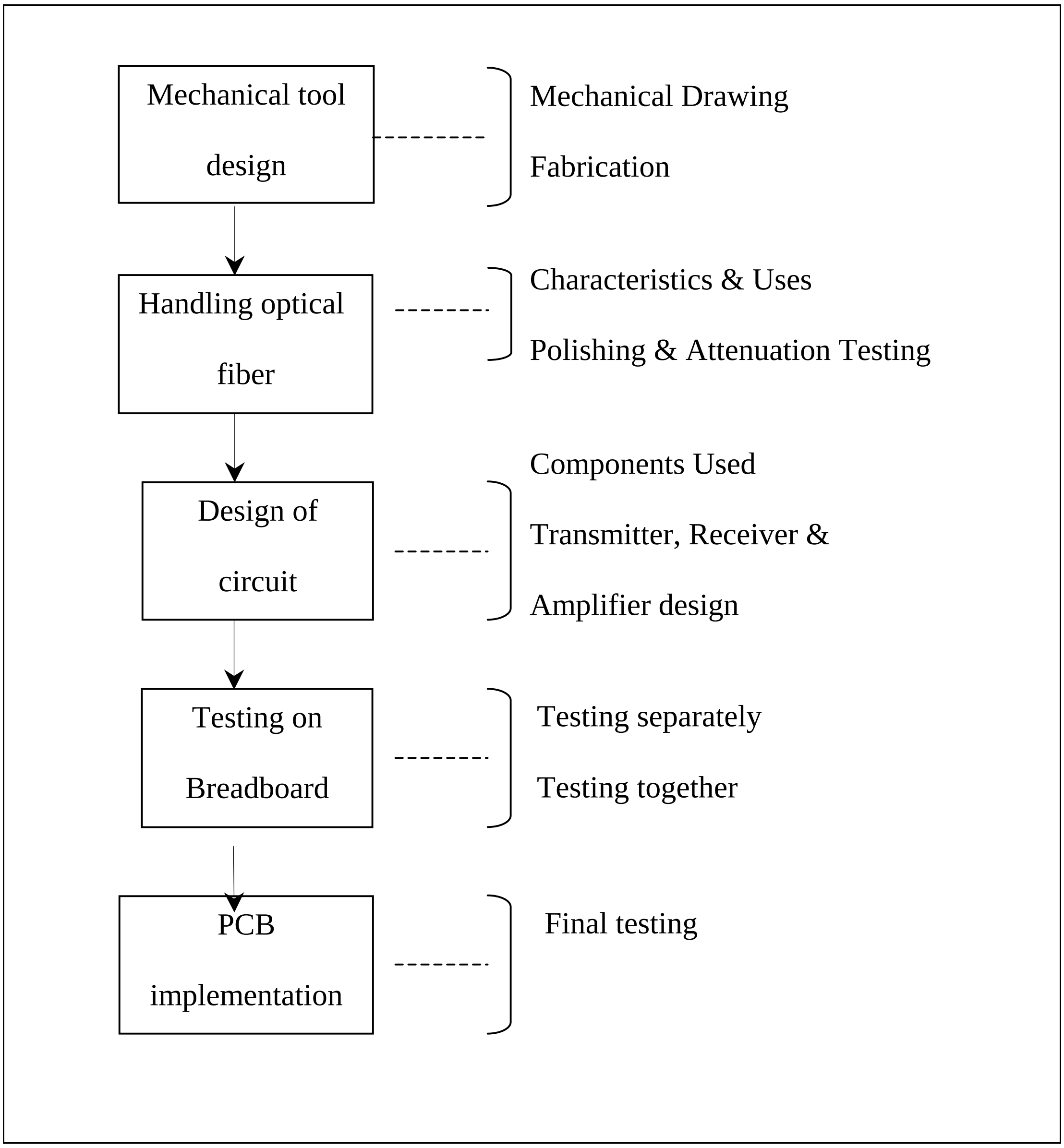

Figure 3.1: Flow chart of overall methodology