INNOVATIVE OPTICAL SENSOR TO DETERMINE VIBRATION

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DEDICATION

For my beloved mom and dad

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ABSTRACT

Structural analysis includes localized vibration study of metallic, ceramic and composite structures. This document is to report on the project undertaken to design and develop the vibration sensor to measure the light received during transmission due to vibrations of structures over very small-localized surface area. Optical fiber based displacement is extended as a vibration sensor, based on the consideration that the vibration is a periodic variation of displacement. A fiber optic probe is designed using a well-polished plastic fibers, which ends respectively to each other. One of the fibers is connected to an LED and the other to a photo detector. The probe which is optic fiber cable is placed to the location of the structure where the vibration is to be measured. The vibration causes intensity changes to the light received at the photo detector. Experimental studies were carried out to optimize the response of the sensor probe by keeping the fibers at various displacement configurations. The detected voltage is digitized and fed to an oscilloscope.

ABSTRAK

Analisis struktur termasuk kajian terhadap getaran tempatan logam, seramik dan komposit bahan struktur. Tujuan dokumen ini adalah untuk melaporkan tentang projek yang dilaksanakan untuk membentuk dan mencipta pengesan getaran untuk mengukur jumlah cahaya yang diterima kesan dari getaran struktur di permukaan yang kecil. Pengesan optic fiber berdasarkan sesaran dijadikan pengesan getaran disebabkan faktor getaran ialah perubahan berkala dengan sesaran. Penunjuk optic fiber direka menggunakan dua plastik fiber dimana kedua-dua hujungnya disambung sekali. Di satu hujung disambungkan ke LED manakala hujung yang lain disambungkan kepada photo-pengesan. Kajian experimen yang diambil ialah untuk mengoptimaskan respon daripada penunjuk pengesan dengan menetapkan fiber pada sebilangan konfigurasi sesaran. Voltan yang dikesan akan digitkan dan dihubungkan ke osiloskop.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SYMBOL, SHORT FORM & TERM LIST

AC	-	Alternating Current
dB	-	Decibels
DC	-	Direct Current
LAN	-	Local Area Network
LASER	-	Light Amplification Stimulation Emission Radiation
LED	-	Light Emitting Diode
LD	-	Laser Diode
LDR	-	Light Dependent Resistor
POF	-	Plastic optical fiber
PSM	-	Projek Sarjana Muda
RX	-	Receiver
TX	-	Transmitter

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF THE PROJECT

Vibration study of structures at localized point on the application of various periodic forces is very important in nondestructive testing, damage monitoring and structural analysis. The application of metallic, ceramic and composite structures are increasing by the day in the industry and military. Techniques like finite element method and finite element analysis, when often applied to these structures, demands the evaluation of mechanical properties over very small area.

The study of vibration is concerned with the oscillatory motions of bodies and the forces associated with them. All bodies possessing mass and elasticity are capable of vibration. Most engineering machines and structures experience vibration to some

degree, and their design generally requires consideration of their oscillatory behavior. The ‘free vibration’ is the state of the system oscillating under the action of forces inherent in the system and if vibration taking place under the forced excitation of external forces, then it is called forced vibration.

This project came out with the idea where optical fibre cable is used in optical sensor as to determine the vibration during transmission. It came out with a system that can monitor the vibration which occurred on such a plane or structure like aircraft plane, bridge or building. The system will detect the vibration that affect the intensity of light being transmitted in the fibre cable. The signal detected by the system will send out an alarm to the authority to take an action.

A prototype system comprises of an optical transmitter an optical receiver will be the main block. This project applying basic of optical transmission where there are light emitted and received. Areas such as the type of optical transmitter, the optical sensor as the receiver and types of cable used as a medium transmission have to be given a comparison and in-depth researches. Deep knowledge in optical technology is necessary as well as the knowledge of vibration affected on a plane or structure to ensure the implementation of the whole system is successful.

1.2 PROJECT OBJECTIVES

The basic objective of the project is to study and analyze the areas and application of the monitoring of vibration to a particular system. Vibration measurement can diagnose problems to machinery that can affect output, quality and production downtime. It can also solve issues related to employee health and well-being when vibration creates unacceptable levels of noise that affect the health of workers. A

vibration measuring and monitoring system can provide further benefits such as predicting machine failures before they happen, providing trend information that can determine failure warning signs, and determining maintenance scheduling needs.

The main objective is to develop a system using optical fibre as an innovative sensor for the determination of vibration taking place as the effect of vibration can bring about cracks, wear and tear. Such stresses and occurrence especially to the body structure of a plane can lead to catastrophic consequences. The idea of this project is to detect, analyse and respond to the vibration that is occurring and then send out an early warning alarm for actions to be taken. It is hope that when this project is well developed, it can be recommended to be installed in all the application suitable and necessary to improve safety procedures and actions to be taken.

1.3 PROBLEM STATEMENT

Over the past 25 or 30 years, optical fibre sensors have emerged as an enabler for sensing techniques. Due to its physical properties and characteristics, optical fibre has replaced other medium of transmission such as conventional metallic transmission wires for both telecommunication and computer networking.

The application of the optical fibre as a sensor to monitor vibration is vital to a particular system. For example, the structural state monitoring has been adopted in many applications of various engineering fields such as in civil engineering on bridges, airports, railways, buildings, commercial and industrial facilities, dams, tunnels, offshore platforms, telecommunications lifelines, liquid and gases transmission systems, naval engineering on ship cruises and luxury yacht, and aerospace engineering on civil airplanes, unmanned air vehicles, military supersonic planes, space vehicles and stations.

These high technology methods are able to predict structure failure conditions well before any failure happens or gets deteriorated. Therefore, an optical fibre cable system can be deplored and be used to monitor the vibration in a particular situation.

Fiber optic sensor technologies are finding rapid growth and its application in the area of monitoring of civil structures has been employed. To a large extent, this is due to the advantages fiber optic technology can offer in terms of the cost for fiber sensors which is dropping steadily, and this trend will continue.

In aerospace, certain parameters are critical. Vibration occurs in the aircraft and it has to be within a certain limit. The limit varies in application and the vibration sensors can monitor and determine the degree and state of vibrations at the same time. It means that by using the raw data, the specific component with problem can be identified. Usually, a copper is used inside the aircraft as medium of transmission for vibration detected alarm system. The use of fiber optic sensor perhaps will improve the system better due to its high sensitivity

1.4 SCOPE OF WORK

As to ensure the project is well developed, a few considerations are taken to the limitations and facilities available during the project implementation. There are four major areas that were identified and required to be worked upon.

a) Type of transmitter used as to transmit light
b) Type of receiver used to receive light with high sensitivity.
c) The characteristic of optical fiber used as a medium to transmit and propagate the light.
d) Type of optical light sources and detectors used for good light transmission and reception respectively.

Table 1.1 below lists all the factors and operating conditions considered in this project.

Table 1.1 Parameters and its working operation condition

Factor	Operating Condition
Source of transmitter	LASER
Transmitter operating wavelength	650nm
Types of receiver	LDR
Distance between transmitter and receiver	1m and 3m of plastic optical fibre cable length
Types of optical fiber cable used	Plastic optical fibre cable

Several areas that are being identified or considered that need to be worked and included in the scope of work are listed as below:

a) The study and understanding of the optical fibre sensor.
b) Identification of the parameters and limiting errors to be considered in this project.
c) The understanding of the circuit operation (transmitter and receiver) of the project.
d) The development of a prototype for the project.
e) The analysis of the output data from the project circuit.
f) Finally to conduct and verify the functionality of the system.

1.5 METHODOLOGY

One of the most important aspects in undertaking a project is the methodology. It laid down the foundation and the execution of the process will be carried out as scheduled. The progress of the project is constantly checked and reviewed to ensure that the various scope of work to be carried out at each stage are carried out and completed

as planned. It will start from the beginning where the initial idea is proposed, up till the end of the project where outcomes as expected are obtained. The methods and processes involved are shown as below:

1. Project choosing
2. Project planning
3. Literature review
4. Circuit design
5. Hardware development
6. Data analysis
8. Preparation and presentation of technical report

1.6 REPORT STRUCTURE

The thesis is written to record what transpired from the initial form starting with the idea generated to overcome a problem, the concepts applied, the methods applied to implement the design, testing, analyzing and develop the product of the project itself. The thesis consists of five chapters, each chapter covering each aspect of the project implementation.

Chapter 1 introduces the idea of the project containing the introduction of the project, the project's objectives, the problem statement, the scope of work and the summary of methodology.

Chapter 2 consists of the literature review that covers both the PSM 1 and PSM II work. The theoretical principles and various applications and concepts are considered. The major aspect on the various methods and applications in vibration monitoring system are included for comparison and implementation of the project. This chapter also consist of the background study.

Chapter 3 consists of the project methodology. This chapter deals with the activities carried out during the development of the project, starting from choosing the project, project planning and hardware development that form the major bulk of the project.

Chapter 4 discusses the results found from the research and literature review. The improvements of the project are also discussed in this chapter as well as the suggestions for future development.

Chapter 5 concludes the overall task taken and a summary of the final outcome regards to the findings which include conclusion, suggestion and recommendation for the project are included. Problems that were encountered during the progress of the project were also discussed.