INVESTIGATION ON SENSITIVITY OF FIBER BRAGG GRATINGS BASED ON OPTICAL ATTENUATION

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

For mom and dad

ABSTRACT

This study is conducted to investigate the sensitivity of Fiber Bragg Gratings (FBG) based on optical attenuation by varying the parameter that contribute toward attenuation. Generally, FBG is one of the important component in optical system hence knowing its sensitivity help the researcher to design optical system with better performance. An output signal passing through optical communication system with and without the implementation of FBG is compared. Basic communication block diagram that made up simple optical system consisted of broadband sources, pulse generator, modulator, optical fiber, FBG and visualizer were designed and analysed. It is appeared that from the simulation that have been done, the output signal with implementation of FBG is less dispersed and scattered compared to the system without the FBG. The three parameter that was selected to be varied for the analysis is fiber length, attenuation coefficient and input power. The results was tabulated, eye diagram and a graph of noise figure and gain versus varied parameter was plotted and analyses. It is found that output signal with implementation of FBG at 10 km with attenuation coefficient 0.2 dB/ km results in clean and wide eye diagram with less dispersed and scattered compared to the system without the implementation of FBG.

ABSTRAK

Kajian ini dijalankan untuk menyiasat kepekaan Fiber Bragg Gratings (FBG) berdasarkan pelemahan optik dengan pelbagai parameter yang menyumbang kepada pelemahan isyarat. Secara amnya, FBG adalah salah satu komponen penting dalam sistem optik maka dengan mengetahui kepekaannya dapat membantu penyelidik untuk merekabentuk sistem optik dengan prestasi yang lebih baik. Isyarat keluaran yang melalui sistem komunikasi optik dengan dan tanpa FBG dibandingkan. Rangka blok komunikasi asas yang membentuk sistem optik mudah terdiri daripada sumber jalur lebar, penjana denyut, modulator, gentian optik, FBG dan visualizer direka dan dianalisa. Daripada simulasi yang telah dilakukan, isyarat keluaran dengan pelaksanaan FBG kurang disebarkan dan bertaburan berbanding dengan sistem tanpa FBG. Tiga parameter yang dipilih untuk diubah adalah, panjang serat, pekali pelemahan dan kuasa masukan. Hasilnya diukur dan graf angka bunyi dan gandaan terhadap parameter bolehubah telah diplot dan dianalisa. Di dapati isyarat keluaran sistem dengan aplikasi FBG pada 10 km dan pemalar pelemahan 0.2 dB/ km menghasilkan rajah mata yang jelas dan besar, kurang tersebar dan kurang bertaburan berbanding sistem tanpa aplikasi of FBG.

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LIST OF SYMBOLS AND ABBREVIATIONS

LED	:	Light Emitting Diode
NA	:	Numerical Aperture
FBG	:	Fiber Bragg Grating
LD	:	Laser Diode
MZI	:	Mach-Zender Interferometer
MI	:	Michelson Interfermeter
FPI	:	Fabry-Perot Interferometer
OPD	:	Optical Path Differences
FSR	:	Free Spectral Range
LPG	:	Long Period Fiber Grating
EDFA	:	Erbium-Doped Fiber Amplifier
WDM	:	Wavelength Division Multiplexing
NF	:	Noise Figure
ISI	:	Intersymbol Interferences

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CHAPTER 1

INTRODUCTION

This chapter consist of the project background which describe the detail information about the research. Next, the main goal is presented and what should be accomplished after the research is completed is described. Furthermore, the project scope of the research will be explained and elaborate. Finally, for the project significance on more how this research will bring benefit to mankind and vital element of sustainability of the research is elaborated.

1.1 Project Summary

Optical fiber is used in telecommunication system because of its characteristics which include small size or dimension, low loss and low interferences from outside environment that lead to low attenuation. The Fiber Bragg Grating (FBG) is commonly chosen as important components to compensate the dispersion in optical

communication system cause by attenuation and other limiting factor. The objectives of this project are to design and simulate optical communication system for FBG focusing on the sensitivity of FBG based on optical attenuation. The scope of this project is limited to simulation using Optisystem software. The simulation for FBG will be using a fixed parameter with different attenuation value, fiber length, and input power. Firstly, the optical communication system for FBG will be design and then the circuit will be simulate and analyzed with different value of attenuation, fiber length and input power. It is expected that there will be different output signal that was affected by FBG with different parameter such as fiber length, attenuation value and input power that was simulated in Optisystem.

1.2 Problem Statement

There are various type of component of that was used to compensate for the dispersion in optical communication system. One of the important component that was used is FBG. For long distance signal transmission using dispersion compensator will help improve the signal quality and reducing the attenuation. It is necessary to investigate the sensitivity of FBG in optical communication system based on optical attenuation.

1.3 Objectives

The objectives for this project are:

1. To Design optical communication system with implemented FBG
2. To Simulate the designed optical communication system with implemented of FBG using Optisystem software

3. To Observe and analyze the sensitivity of optical signal using FBG based on optical attenuation

1.4 Project Scope

The scope of this project is to design and test the sensitivity of FBG based on the optical attenuation criteria. This project will be designed by using Optisystem software which is a software for simulating optical communication system. The design will consider the broadband sources, the modulator, and optical fiber of 5 km length and attenuation value of 0.2 dB/km. The design is expected to get the data for analyzing the effect of attenuation on optical communication system using FBG.

1.5 Report Structure

This report is a combination of five chapters that consists of introduction, literature review, methodology, results and discussion and finally the conclusion and recommendation of the projects. Details of this report structure are as follows:

Chapter 1 is an introduction of the projects. This chapter will explain the objectives of the project, problem statement and the scope of the project.

Chapter 2 discuss the background study related to the project which included the fundamental and theory of optical fiber and FBG. Also, how the FBG was fabricated and type of interferometer explained here.

In Chapter 3, the methodology or approach taken to run the project is discussed. Each selection and actions that may be done during project implementation will be discuss. The process on how the circuit for simulation also will have clear and deep explanation.

Chapter 4 describe the result obtain from the project. It will include the of output signal from optical communication with implemented FBG and a table and graph to study the effect of attenuation will be tabulated and plotted.

Finally, Chapter 5 is a conclusion for the whole project and the recommendation for future implementation related to this project

CHAPTER 2

LITERATURE REVIEW

This chapter will give a brief explanation about optical fiber and FBG. Literature review is used to find out as many as possible facts and finding that related to the project topics in order to complete the project successfully. Based on this finding a right methodology or approach will be select and used for this project. It will describe the fundamental study, theory and working principles for optical fiber and FBG. Its application and uses of FBG also will be described to give insight about its advantages and disadvantages.

2.1 Introduction to Optical Fiber

The industry of optoelectronics has delivered many products such as compact disc player, laser printer, bar code scanners and laser printers. In the telecommunication industry, fiber optic communication had successfully bring changes and revolutionized the telecommunication industry by providing greater performance with lesser bandwidth cost. The results of this changes has bring benefits of high volume production to the component users. The advancement of technology from the copper

wire of a century ago to today's fiber optic cable has drastically increase the ability to transmit more information with faster and longer distances. This has expanded the boundaries of our technological development in all areas [1].

2.1.1 Fundamental of Optical Fiber and Fiber Optic Sensor

The optoelectronics and fiber optic communication industries always had fiber optic technology as a major user of technology associated with it. Fiber optic sensors have taken over traditional sensors such rotation, acceleration, electric and magnetic field measurement, temperature, pressure, acoustics, vibration, linear and angular position, strain, humidity, viscosity, chemical measurements and host of other application to enhanced its capability as working sensors[1][2].

An optical fiber is a waveguide which is a device that allow light signal (electromagnetic radiation) to travel through over long distance with little dispersion or losses. These signal represent electrical signal, for example any combination of video, audio or data transmission.

Basically, Fiber optic sensor operate by modulating one or more properties of a propagating light waves. This include intensity, phase, polarization and frequency, responding to the environmental characteristics being measured. Within the core of optical sensor technology is the optical fiber which is a thin strand of glass that transmit light within its core [2][3].

2.1.2 Optical Fiber Structure

There are three components that composed the structure of optical fiber which is the core, the cladding and buffer coating.