DESIGN AND ANALYSIS OF QUALITY ENHANCEMENT BY USING ERBIUM DOPED FIBER AMPLIFIER (EDFA) IN OPTICAL COMMUNICATION LINK

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A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Electronic Engineering (Wireless Communication) With Honours

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June 2014

DECLARATION

"I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references."

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"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering (Wireless Communication) with Honours"

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DEDICATION

To my beloved father and mother that support me so much

ABSTRACT

This project presented the calculation, simulation, measurement and analysis of quality enhancement by using Erbium Doped Fiber Amplifier (EDFA) in fiber optic communication link. Erbium Doped Fiber Amplifier (EDFA) is one of most popular fiber amplifier that is used in fiber optic communication since EDFA has the ability to amplify the optical signal without the need of optical-to-electrical signal converter. The EDFA system is designed at frequency band of C-band (1530nm – 1565nm) in Wavelength Division Multiplexing (WDM) system. Several processes need to be done for design and analysis of Erbium Doped Fiber Amplifier (EDFA). In designing the EDFA, the typical specification of EDFA is determined and the parameter of EDFA is calculated so that the expected result of the designed can be obtained. Next, the design is tested by using Optiwave Software and the results from simulation are recorded. The result from theoretical analysis and simulation are compared and analyzed whether the EDFA improved the fiber optic communication link.

ABSTRAK

Projek ini menampilkan pengiraan dan simulasi mengenai kualiti sambungan komunikasi gentian optik dengan menggunakan Erbium Doped Fiber Amplifier (EDFA). Erbium Doped Fiber Amplifier (EDFA) merupakan salah satu penguat yang popular digunakan dalam komunikasi gentian optic kerana kemampuannya untuk meningkatkan isyarat tanpa perlu menukarkan isyarat optik kepada isyarat elektrik. System EDFA direka bentuk dengan menggunakan jalur frekuensi C (1530 – 1565nm) di dalam sistem WDM. Beberapa proses perlu dilakukan dalam mereka bentuk dan menganalisis EDFA. Spesifikasi yang perlu ada dalam EDFA telah dikaji dan pembolehubah yang dipilih berkaitan dengan EDFA dikira dengan berpandukan formula yang dikaji di dalam teori. Kemudian, EDFA yang telah direka di uji di dalam simulasi dengan menggunakan perisian Optiwave. Segala bacaan dan pemerhatian dari simulasi direkodkan untuk dianalisis. Bacaan yang boleh diperoleh daripada pengiraan, dan simulasi dibandingkan dan dianalisis untuk mengetahui sama ada EDFA dapat meningkatkan kualiti sambungan komunikasi gentian optik.

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LIST OF ABBREVIATIONS

WDM	-	Wavelength Division Multiplexing
EDF	-	Erbium Doped Fiber
EDFA	-	Erbium Doped Fiber Amplifier
PSM	-	Projek Sarjana Muda
nm	-	nanometer
mm	-	millimeter
dB	-	decibels
km	-	kilometer
Mbps	-	Mega bit per second
ITU	-	International Telecommunication Union
ICT	-	Information and Communication Technology
S	-	Short Wavelength
C	-	Conventional
L	-	Long
O	-	Original
U	-	Ultra

E	-	Extended
FDM	-	Frequency Division Multiplexing
TDM	-	Time Division Multiplexing
IR	-	Infrared
Tx	-	Transmitter
Rx	-	Receiver
ASE	-	Amplified Spontaneous Emission
Er+3	-	Erbium
TFBG	-	Titled fiber Bragg gratings
SNR	-	Signal to Noise Ratio
NF	-	Noise Figure
DFB	-	Distributed Feedback
BER	-	Bit Error Rate
OSNR	-	Optical Signal to Noise Ratio
µm	-	micrometer
mW	-	milliwatt
dBm	-	decibels-milliwatt
m	-	meter
G	-	Gain
η_{sp}	-	Spontaneous Emission Factor
h	-	Planck constant

Δv	-	Bandwidth
V	-	Frequency of signal
λ_p	-	Wavelength of pump source
λ_s	-	Wavelength of signal
$P_{p,in}$	-	Input pump power
$P_{s,in}$	-	Input signal power
$P_{s,out}$	-	Output signal power
P_{ase}	-	Spontaneous Emission Power

CHAPTER 1

INTRODUCTION

Nowadays, fiber optic communication is well known in the telecommunication technologies and widely used to transport data from one point to any other point via fiber optic cable connections in the form of light. The composition of tiny glass fiber in that transmit light wave 10 000 greater than the highest radio frequencies in the fiber optic ensure a greater capacity of data and information than can be transported when compared with the standard cables. Capability to transport signals over long distances, minimum error rates, resistance to electrical interruption, security and light weight are the further benefits of using fiber optic over copper cables [1].

The Wavelength Division Multiplexing (WDM) systems appears as being a potential technological answers to achieved extremely high total capacity for far distance transmission mechanism. Throughout past decade, the possibility of the WDM systems for transporting huge transmitting capacities over extended ranges has long been experimented by various tests. In WDM, several different wavelengths are sent over one single mode fiber simultaneously. The best things about WDM technology are their ability of becoming well-matched to present device, being modular as well as possessing the capability of lessening loads of expensive machine in case it is designed in the right way.

Erbium Doped Fiber Amplifier (EDFA) is a method of straight away boosting optical signals without the requirement to first transform it into an electrical signal before boosting after that convert back to optical signal after the amplification. Erbium doped fibers (EDF) are optical fibers doped with rare-earth element that features the proper energy in their atomic compositions for enlarging light. Basically, the in line boosting which simply no coupling loss present has capability with reduce interference, and thus fewer crosstalk rather than semiconductor optical amplifiers. The gain of EDFA may possibly achieve to 30dB and also employ 980nm pump wavelength.

1.1 OBJECTIVES

The objectives for this project are:

1. To study the Erbium Doped Fiber Amplifier (EDFA) from a theoretical aspect of all parameter resulted.
2. To design and analyze the usage of high quality Erbium Doped Fiber Amplifier (EDFA) in optical communication link for theoretical analysis and simulation.
3. To compare the qualitative by the performance of optical communication link with and without Erbium Doped Fiber Amplifier (EDFA).

1.2 SCOPE OF WORK

The scope of work is divided into two parts which are PSM1 and PSM 2;

1.2.1. Projek Sarjana Muda I (PSM I)

The tasks done for PSM 1 are as follow:

1. Creating animation that describes the overall operation of the Erbium Doped Fiber Amplifier (EDFA) in fiber optic communication link. This animation gives full understanding on how the signal transmitted in fiber optic is amplified through the EDFA.
2. Design Erbium Doped Fiber Amplifier (EDFA) system by using calculation.
3. Analyze the fiber optic communication link without using Erbium Doped Fiber Amplifier (EDFA) through theoretical calculation.
4. PSM I report writng.

1.2.2. Projek Sarjana Muda II (PSM II)

For PSM 2, the task that has been done are shown below:

1. Simulate and measure the design Erbium Doped Fiber Amplifier (EDFA) system by using Optiwave software.
2. Testing and measurement of Erbium Doped Fiber Amplifier (EDFA) system at any company or university laboratory that have fiber optic communication and EDFA equipments.
3. Analyze the result from theoretical and simulation.
4. PSM II report writing.

1.3 PROBLEM STATEMENTS

In fiber optic communication, the transmitted signal in fiber optic communication may loss during transmission and the receiver may not able to receive the signal. Since to that problem, the use of amplifier is introduced to boost the attenuated signal so that the signal can reach the receiver. However, the electrical amplifier that commonly used to re-amplify the signal need optical to electrical signal converter which may cause problem to fiber optic communication system. Due to that problem, the necessity of optical amplifier that can enhance the quality of optical communication link has been considered.

1.4 PROJECT METHODOLOGY

The work flow for this project is shown in Figure 1.1.

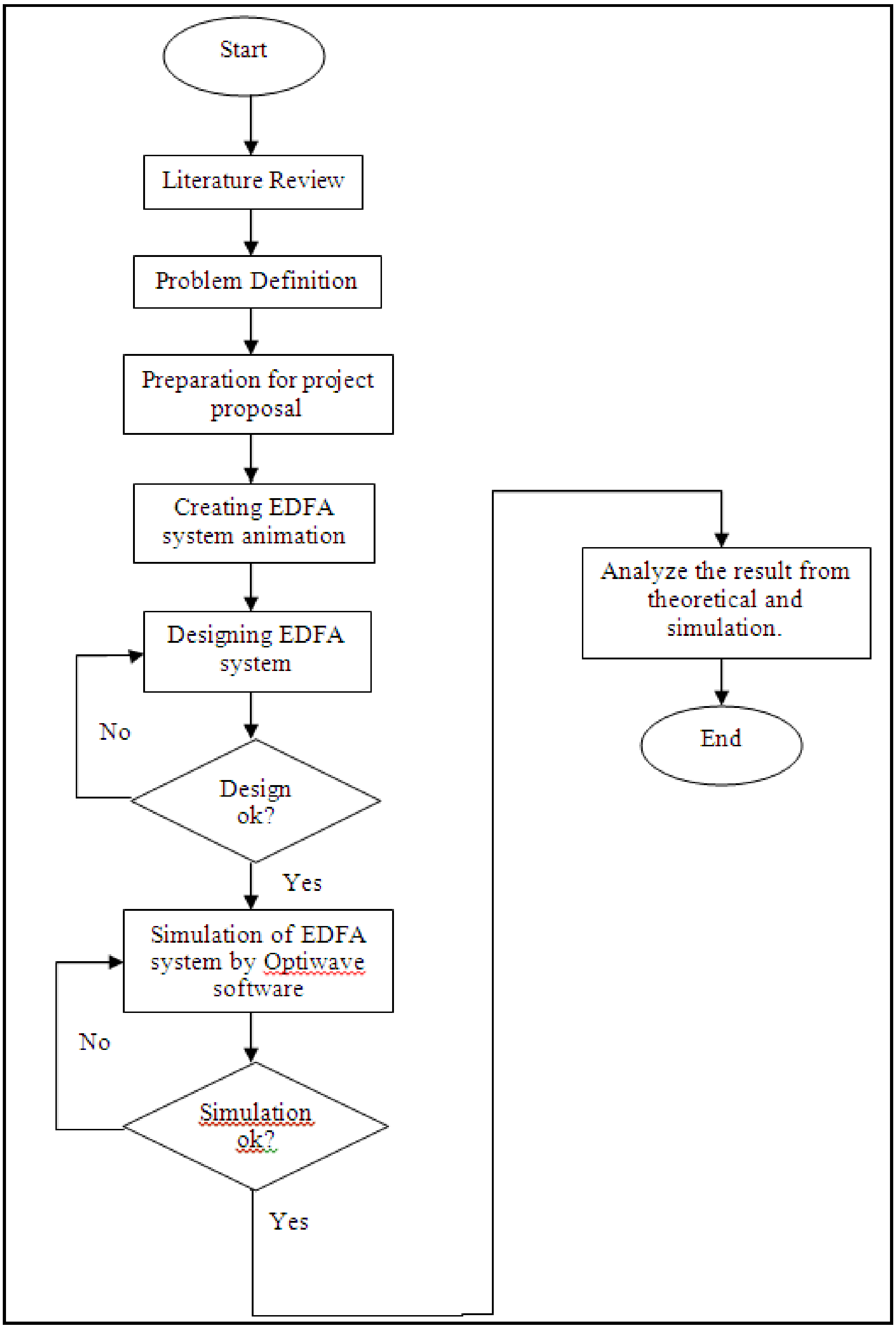

Figure 1.1 Flow Chart of Project

1.5 ORGANIZATION OF THESIS

In the Chapter 1, this report discuss on the introduction of the project where the problem statement for this project is defined, the objectives are stated and the scope of work is explained and the flow chart of process for this project is shown.

In Chapter 2, the overall theory and the past research about this project is explained. The block diagram of the fiber optic communication system and the EDFA is shown and explained. The overall system operation is stated and the characteristic of the each component in the system is described.

In Chapter 3, the methodology of the project is discussed. There are two part of project methodology which is theoretical analysis and simulation. In calculation, the proposed designed is discussed and the parameter is described. The simulation part, the Optiwave software is explained.

In Chapter 4, the construction of the EDFA system is described and the parameter of the EDFA system that has been chosen is explained result of simulation is recorded and analyzed. The readings and chart from the simulation is recorded and described.

In Chapter 5, the results from theory and simulation are discussed and compared. The relationship of the result from simulation is explained with the theoretical aspect. At the end of discussion, the optimum of value of parameter for the designed circuit is concluded and the future work that can be done for this researched is suggested.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND STUDY

A fundamental optical transmission link comes with transmitter and also receiver, with an optical fiber cable linking up both of them. Even though signals propagating in optical fiber experience way less attenuation compared with many other mediums, like copper, there may be still a constraint of roughly 100km on the range the signal are able to transmit before turning out to be too noisy to be detected [1]. Before the optical amplifier is developed, it was actually important to electronically reproduce the optical signals each 80-100km with a purpose to accomplish transmission over extensive distances. This resulted in accepting the optical signal, cleaning up as well as amplifying it electronically, after that retransmits it over the next section of the communication link.

A tremendous cascade of invention from 1985 to 1990 developed the erbium-doped fiber amplifier. The optical amplification was much more fantasy rather than reality in 1985 where semiconductor optical amplifiers as well as Raman fiber amplifiers had previously been experimented in the laboratory yet were not even close to practical. Five years afterwards, the erbium-doped fiber amplifier got here from nowhere to take over the industry. The development of practical optical amplifiers started out the opening to Wavelength-Division Multiplexing, which enhanced the total