2 CASCADED EDFA's OPTIMIZATION FOR WDM SYSTEM

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	**2 CASCADED EDFA's OPTIMIZATION FOR WDM SYSTEM**
Sesi Pengajian	:	**2008/2011**

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ACKNOWLEDGEMENT

Special thanks to my supervisor, Mrs Noor Shahida Bte Mohd Kasim for her support, idea, knowledge and sharing her experience to fulfill the objective of this final year project. I would like to take this opportunity to express my deepest gratitude to her, as I gain much new knowledge about optical communication system from this project. Without her encouragement, feedback, and motivation, this project would not have been completed. I have learned a lot of project management skill which include the time and cost effective to realize the project.

Also thanks to my friends for spending their time teaching me about the software Optisys Optiwave version 7.0, which seems to be very difficult for me to understand before. Million of thanks to all my friends that giving me so much supports to obtain the objectives of this project.

Not forgetting, a special thanks to all of my lovely parents and big family – **Mohd Shah Bin Haji Saad, Nor Aishah Bte Haji Othman, Nur Sya' Wana, Muhammad Nasruddin, Muhammad Salman, Nur Anis Syazani, Haji Othman, Hajah Normah , Haji Saad, Hajah Mariam** and all my relatives around the world that has spending many a lot of money and the most important of a never-ending support. Without them my life would be nothing. Lastly, I would like to say thanks others who I may have left out for their help and encouragement.

ABSTRACT

Erbium Doped Fiber Amplifier's (EDFA) is a main element of Gain and fibre loss of Noise Figure in single stage of EDFA in realising a good point-to-point fibre optical communication links and optical networks. However, the advance technologies achieved in recent years have enabled the cascaded or multistage of Erbium Doped Fibre Amplifiers (EDFAs) that has more ability as a good optical amplifier in an optical fibre to be amplified directly in desired system.

This project is all about two cascaded EDFA that have been simulate by using simulation of software Optisys Optiwave version 7.0 in order to characterize the Gain and Noise Figure Performance of two Cascaded EDFA. It is also needs to manipulate key for optimized fibre length and pump power to wavelength division multiplexing (WDM) application in modern optical network systems. Thus, the performance of Gain and Noise Figure of two Cascaded EDFA given can be graphically obtained, and achieve Gain within 15dB of and Noise Figure less than 6 dB performance can easily be optimised.

ABSTRAK

Penguat Fiber Berasaskan bahan kimia Erbium atau lebih dikenali dengan nama EDFA mempunyai elemen yang begitu penting, iaitu Gandaan (Gain) dan Kehilangan Fiber (Noise Figure) didalam sebuah EDFA (single stage) adalah punca asas keterhadan dalam merealisasikan sebuah komunikasi optikal yang baik dan rangkaian optik. Bagaimanapun, dengan adanya kecanggihan teknologi yang dicapai dalam masa kini telah membolehkan wujudnya berbagai tahap dalam sesebuah EDFA, iaitu bukan hanya satu tahap penguat saja bahkan mampu memuatkan dua dan tiga serta lebih banyak penguat didalam sebuah EDFA. Ini juga bermakna kebolehannya sebagai penguat sesebuah isyarat optik menjadi lebih baik dan sempurna kearah objektif yang diidamkan oleh sesebuah sistem.

Projek ini semuanya berkisar tentang dua Tahap Penguat EDFA yang telah dibangunkan dengan menggunakan simulasi dari perisian Optisys Optiwave versi 7.0, untuk mencapai dan memahami ciri-ciri dan prestasi Gandaan (Gain) dan Kehilangan Fiber (Noise Figure). Selain itu, perlunya untuk memanipulasikan faktor-faktor yang menjadi anak kunci perubahan seperti panjang fiber dan daya pam kedalam sistem panjang gelombang yang digandakan (WDM), untuk disesuaikan dengan aplikasi rangkaian dan perhubungan optik moden. Seterusnya, prestasi Gandaan dan Kehilangan Fiber pada dua Tahap Penguat EDFA yang optimum dapat diambil secara grafik dan mencapai segala objektif iaitu Gandaan sebanyak 15 dB dan Kehilangan Fiber kurang dari 6 dB.

TABLE OF CONTENT

CHAPTER	2 Cascaded EDFA's Optimization For WDM System	PAGE
	Project Title	i
	Acknowledgement	v
	Abstract	vi
	Abstract	vii
	Table List	xi
	List of Content	xii
	List of Abbreviations	xiv
	Appendix List	xv
I	INTRODUCTION	
	1.1 Background Project	1
	1.2 Problem Statement	3
	1.3 Objective	4
	1.4 Scope	4
	1.5 Project Outline	4

II	**LITERATURE REVIEW**		
	2.1	Fundamentals of Erbium Doped Fibre Amplifier	6
	2.2	Stimulated Emission and Spontaneous Emission	9
	2.3	Erbium Doped Fibre Amplifier Constructions	12
	2.4	Gain Characteristics	14
	2.5	Homogeneous and Inhomogeneous Broadening	15
	2.6	Output Power	17
	2.7	Optical Noise Figure	18
	2.8	Physical Model of EDFA	19
	2.9	Performance of Gain	20
	2.10	Journals Review	21
III	**METHODOLOGY**		
	3.1	Introduction	24
	3.2	Flowchart	25
	3.3	Project Methodology	26
	3.4	The Modelling Process	26
IV	**RESULTS**		
	4.1	Introduction	28
	4.2	Double Stage EDFA Analysis	29
	4.3	Triple Stage EDFA Analysis	36

V	**DISCUSSION**		
	4.1	Introduction	43
VI	**CONCLUSION**		
	5.1	Introduction	47
VII	**FUTURE DEVELOPMENTS**		
	6.1	Introduction	49
REFERENCES			51
APPENDIXES			53

TABLE LIST

TABLE	TITLE	PAGES
4.2	Double Stage EDFA Analysis	29
4.2	Triple Stage EDFA Analysis	36

List of Figure

No.	TITLE	PAGE
2.1	Schematic Diagram of EDFA	7
2.2	Erbium ion energy level and corresponding spontaneous lifetime	8
2.3	EDFA Transition Analysis	10
2.4	Stimulated Emission Process	10
2.5	Stimulated emission in an atom with two energy level E_1 and E_2	11
2.6	EDFA Constructions	12
2.7	Fiber Optic Amlifier Repeaters	13
2.8	Transmitter and receiver power spectrum	14
2.9	Gain Spectrum Structure	15
2.10	Gain spectrum with spectral hole burning	16
2.11	Gain Saturation	17
3.1	Flowchart of Project	25
4.1	Circuit of Double Stage EDFA – 8 Channels	30
4.2	Dual Port WDM 1	31
4.3	Dual Port WDM 2	31
4.4	Optical Spectrum Analyzer	32
4.5	BER Analyzer 1	33
4.6	BER Analyzer 2	33
4.7	Differences of Optical Spectrum Analyzer	34
4.8	Differences of BER Analyzer	35
4.9	Circuit of Triple Stage EDFA – 8 Channels	37
4.10	Dual Port WDM 1	38
4.11	Dual Port WDM 2	38
4.12	Optical Spectrum Analyzer	39
4.13	BER Analyzer 1	40

4.14	BER Analyzer 2	40
4.15	Sampled Power Pumped on Optical Spectrum Analyzer	41
4.16	Noise Figure on OSA	42

LIST OF ABBREVIATIONS

EDFA	-	Erbium Doped Fibre Amplifier
IR	-	Infrared
WDM	-	Wavelength Division Multiplexing
NM	-	Nanometers
ASE	-	Amplified Simultaneous Emission
SHB	-	Spectral Hole Burning
SNR	-	Signal to Noise Ratio
BER	-	Bit Error Rate
PSM	-	Projek Sarjana Muda

APPENDIX LIST

APPENDIX	TITLE	PAGES
	Poster & Gantt Chart	53

CHAPTER I

INTRODUCTION

1.1 Background Project

The rapid growth of optical networks requires capable systems to cope with improving fiber optic technologies. Innovation in optical fibre communication systems such as Erbium Doped Fibre Amplifier (EDFA) also have leads to the deployment of Wavelength Division Multiplexing (WDM), which made optical fibre communication systems to operate at higher level with motivation to create new developments with high transmission fidelity, faster data rate, and increase transmission distance.

Actually, EDFA can manage to overcome signal losses by directly amplify signal without the need of opto-electronic and electro-optical conversions. In other words, optical amplifiers amplify signals entirely in optical domain. Demands of the consumers also leads to the innovation and competitions, results the telecommunication equipment sales increased, and cost of international calls and internet reduced.

Erbium Doped Fiber Amplifier's (EDFA) main element of Gain and fibre loss of Noise Figure in single stage of EDFA is a fundamental limitation in realising a good fibre optical communication links and optical networks. However, the advance technologies achieved in recent years have enabled the cascaded or multistage of Erbium Doped Fibre Amplifiers (EDFAs) that has more ability as a good optical amplifier in an optical fibre to be amplified directly in desired system.

In WDM networks, power transient are important effects that need to be considered. WDM enables multiple signals with different wavelengths or channels to propagate through a single fibre. Photonic technology is the main revolutioner that has revolutioned long distance communications, and offer better capabilities to support its growth [2].

This project is all about two cascaded EDFA have been developed by using simulation of software Optisys Optiwave version 7.0 in order to characterize the Gain and Noise Figure Performance of two Cascaded EDFA. It is also needs to manipulate key for optimized fibre length and pump power to wavelength division multiplexing (WDM) application in modern optical network systems. Thus, the performance of Gain and Noise Figure of two Cascaded EDFA given can be graphically obtained, and achieve Gain within 15dB of and Noise Figure less than 6 dB performance can easily be optimised.

1.2 Problem Statement

Several experiments that have combined wavelength division multiplexing (WDM) with optical amplifiers such as fiber optic in long distance have shown good system performance. We also must realise that fiber optic needs using conventional repeater as the signal travel so far. The repeaters have more complex system , as the optical signal have to convert to electronic signal, then amplified by using electronic amplifier circuit, then transform back from the electronic signal to optical signal. Moreover, even that optical signal transmitted as fast as laser which transmits several gigabits per second of data, but when using electronic circuit to amplify signal, there's still much delay in communication system [3].

However, when single stage EDFA occurs, it has given another perspective that there's a chance to revolution the optical communication to the higher stage. Even the fiber optic technology has good performance, the single stage of EDFA's performance is even better. EDFA also have used optical signal, so it is no need to the electronic circuit to amplify the signal, and then it makes the communication faster.

Fortunately, when EDFA's are cascaded, this makes the Gain of single stage have been multiplied for every stage, such as Gain for single stage have 5 dB, then when EDFA have two cascade, so the Gain amplified to 10 dB. Also note that, software Optisys Optiwave trainer have stated that for every 3 dB Gain amplified, it's actually have double the original signal gain. So there's so much advantage of cascaded EDFA to be explored.

1.3 Objectives

a) To study the two Cascade Erbium-Doped-Fibre-Amplifier (EDFA) characteristics (Pump Power, Gain, and Noise Figure).
b) To achieve good BER & Eye Pattern of EDFA in WDM system.
c) To identified the variables that affects the characteristics of EDFA.
d) To find the optimization way that leading to maximum gain and minimum Noise Figure.

1.4 Scope

Scope for this project involves a research and development that operates in the arena of cascade EDFA's. The primary purpose of research is to find the optimization way, and develop the simulation that leading to maximum within 15 dB, and minimum Noise Figure (NF) less than 6dB.

1.5 Project Outline

Chapter 1 consist the introduction part of the project such as the background, problem statement, objectives of the project and also the scopes of the project.

In chapter 2, it consist literature review about the Erbium Doped Fibre Amplifier (EDFA). This is including the history, an application, working principle and also it's about the concept and the importance of optical gain. explains about the performance of Gain and Noise Figure of two Cascaded EDFA given can be graphically obtained, and achieve Gain within 15dB of and Noise Figure less than 6 dB performance can easily be optimised.

Chapter 3 is basically explaining the methodology on simulation of the two cascaded EDFA developed by using software Optisys Optiwave in order to characterize the Gain with Noise Figure Performance of an EDFA, and to achieve good BER and eye pattern that are the most important in this research. During this, it will review about the method, mathematical model and the transfer function of the quarter car suspension system**.**

In chapter 4, all the simulation results of the two cascaded EDFA and collected data are documented using the table and discussed it. This is including the graphical measurement that has obtained during the simulation. Now, it only concern about how far information signals can be send in an optical fiber, before the loss becomes too high and effect the BER and eye pattern.

Chapter 5 is totally about the discussion of entire controller that has been implemented simulation of the 2 cascaded EDFA developed by using software Optisys Optiwave. It is started from to achieve Gain and Noise Figure of EDFA is a key for optimized fibre length and pump power to wavelength division multiplexing (WDM) application in modern optical network systems. All parameters can be characterizing the properties of Erbium Doped Fiber Amplifier analyzed by Optical Spectrum Analyzer (OSA).

In the last chapter, chapter 6 the conclusion has been made and for the future works, there is also recommendation added. While, chapter 7 is about the recommendation of future development is added to give an opinion and also an improvement on how the future works should have done.

CHAPTER II

LITERATURE REVIEW

2.1 Fundamentals of Erbium Doped Fibre Amplifier

Erbium Doped Fibre Amplifier is an optical or infrared (IR) Repeater that amplifies a modulated laser beam directly, without opto-electronic and electro optical conversion. The device uses a short length of optical fibre doped with the rare-earth element Erbium. When the signal carrying laser beams pass through this fibre, external energy is applied at infrared (IR) wavelengths [4]. This 'pumping' excites the atoms in Erbium Doped section of optical fibre, thus increasing the intensity of the laser beams passing through. The beams emerging from the EDFA retain all of their original modulation characteristics, but are brighter than the input beams.

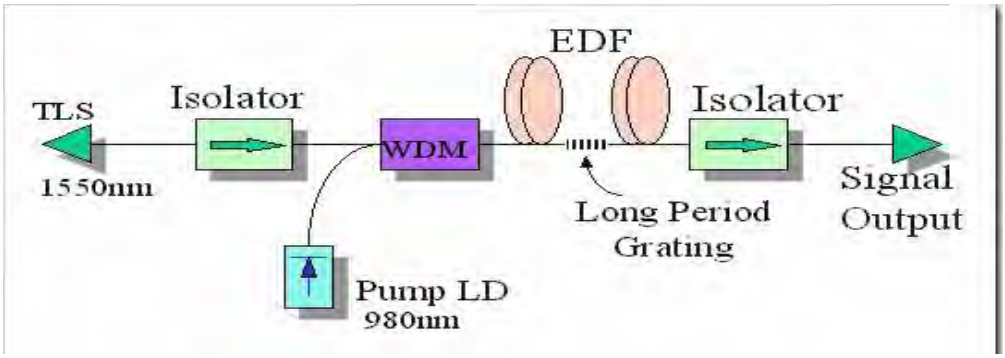

Figure 2.1 Schematic Diagram of EDFA [1]

Basic elements of an EDFA are shown in the figure above. The gain medium in the amplifier is a specially fabricated optical fibre with its core doped with erbium (Er). The erbium-doped fibre (EDF) is pumped by a semiconductor laser, which is coupled by using a wavelength selective coupler, also known as a WDM coupler that combines the pump laser light with the signal light. The pump light propagates either in the same direction as the signal (co-propagation) or in the opposite direction (counter-propagation) [6]. Optical isolators are used to prevent oscillations and excess noise due to unwanted reflection in the assembly. More advanced architecture of an amplifier consists of multiple stages designed to optimize the output power and noise characteristics.

Problems arise from the fact that no fibre material is perfectly transparent. The visible-light or infrared (IR) beams carried by a fibre are attenuated as they travel through the material. These necessities the use of repeaters in spans of optical fibre longer than about 100 kilometres. A conventional repeater puts a modulated optical signal through 3 stages

1. Optical to Electronic conversion
2. Electronic Signal amplification
3. Electronic to Optical conversion

Repeaters of this type limit the bandwidth of the signals that can be transmitted in long spans of fibre optic cable. This is because, even if a laser beam can transmit several gigabits per second of data, the electronic circuits of a conventional repeater cannot do that.

Besides eliminating complex and inefficient conversion and electronic amplification stages, the EDFA allows the transmission of signals that employs Wavelength Division Multiplexing (WDM). This increase the realizable bandwidth relative to conventional repeaters still furthers.

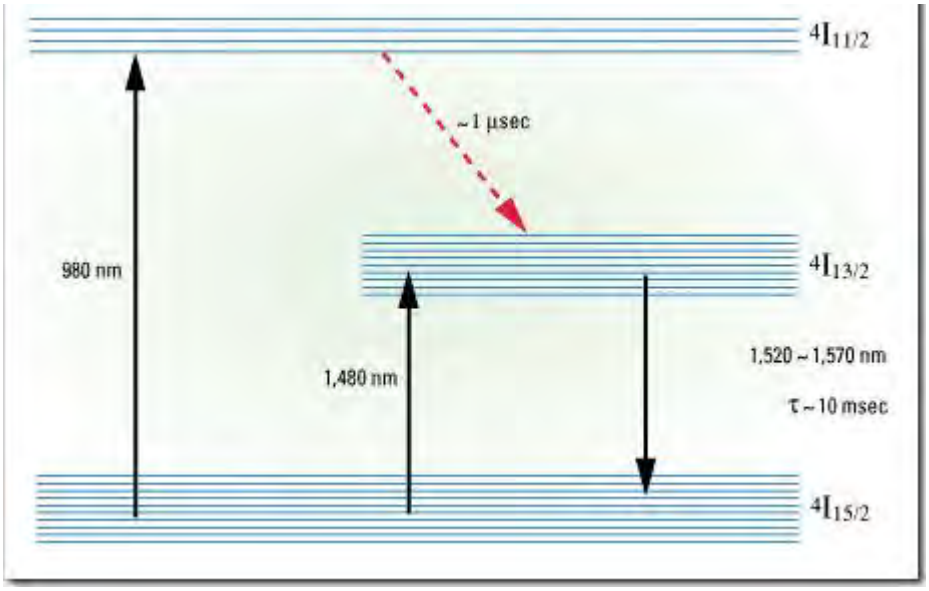

Figure 2.2 Erbium ion energy level and corresponding spontaneous lifetime [2]

The energy level scheme of the erbium ion and the associated spontaneous lifetime in the glass host are shown above. The atomic levels of Er-ions are broadened by local field variations at the microscopic level in the glass host [6].

Doping also known as activation, this is intentionally to introduce impurities into the semiconductor to change its electrical properties. That is what actually happened for the Erbium chemical when multiplexed with the optical signal.

The erbium ions can be excited to the upper energy levels by 980nm or 1480nm pumps. In both cases, it is the first excited state that is responsible for the amplification of optical signals. The amplification is achieved by the signal photons causing stimulated emission from the first excited state.

A three-level model can be used to describe the population of energy levels in the case of 980nm pumping, while a two-level model usually suffices for the 1480nm pumping case. Nearly complete inversion of Er ions can be achieved with 980nm pumping, whereas due to the stimulated emission at the pump wavelength the inversion level is usually lower in the case of 1480 nm pumping.

2.2 Stimulated Emission and Spontaneous Emission

Before describing the operation of an amplifier, it is necessary to understand the physical phenomenon behind signal amplifications. The two physical phenomenons are stimulated emission and spontaneous emission. The process of stimulated emission. An atom with two energy levels, E_1 and E_2 are considered with a condition of energy level E_2 is larger than energy level E_1. An electromagnetic field induces transitions of atoms between energy levels E_1 and E_2 [7].