PERFORMANCE ANALYSIS OF CASCADED OPTICAL AMPLIFIER WITH DIFFERENT LOOP LENGTH

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Tajuk Projek : **PERFORMANCE ANALYSIS OF CASCADED OPTICAL AMPLIFIER WITH DIFFERENT LOOP LENGTH**

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"I declare that this report "Performance Analysis of Cascaded Optical A mplifier with Different Loop Length" is the result of my own research except as cited in the references".

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Special dedicate:

I dedicated in thankful appreciation for support, encouragement and understanding to my beloved family, supervisors and friends.

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ABSTRACT

Optical amplifiers have played significant role in optical communication since been first commercially used in mid 1980s. They have been preferable compare to conventional repeater due to their simple structure, low-cost and high performance. Most important, they can amplify the light signal directly, without the need to change the signal into electrical form. In this project, the optical transmission systems using cascaded optical amplifiers have been designed and their performance based on various parameters; such as loop length, input wavelength and configuration of amplifier have been analyzed. Two types of optical amplifier which are Erbium-Doped Fiber Amplifier and Raman Amplifier have been used in this project. The system is simulated using Optiwave Optisystem 7.0 software and the output parameter such as gain, noise figure, output power, optical signal-to-noise ratio, quality factor and Bit-error rate have been recorded and presented in graphical form.

ABSTRAK

Sejak mula di komersialkan pada pertengahan 1980 an, penguat optik telah memainkan peranan penting dalam industri perhubungan optik. Penguat optik telah di pilih berbanding pengulang isyarat di sebabkan strukturnya yang ringkas, kos yang murah dan prestasinya yang baik. Paling penting, penguat optik berkebolehan untuk menguatkan signal secara terus di dalam bentuk isyarat cahaya, tanpa perlu menukarnya kepada bentuk isyarat elektrik. Untuk projek ini, sistem perhubungan optik menggunakan penguat optik telah di reka dan prestasinya telah di nilai berdasarkan beberapa parameter boleh ubah; seperti panjang penguat, panjang isyarat gelombang dan konfigurasi penguat optik. 2 jenis penguat optic telah dipilih untuk projek ini iaitu Erbium Doped Fiber Amplifier dan Raman Amplifier. Sistem ini di simulasi menggunakan perisian Optiwave Optisystem versi 7.0 dan parameter output seperti penambahan kuasa, figura bunyi, kuasa output,ratio signal dan bunyi, faktor kualiti dan kadar kesilapan bit telah di rekodkan dan dipersembahkan di dalam bentuk graf.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Optical amplifiers will play an important role in future optical transmission system in telecommunication. Optical amplifier, different from the conventional repeater, amplifies the optical signal from the optical sources directly without the need to undergo the conversion process of optical to electrical and electrical to optical signal. It is also come with simpler structure and lower cost compare with conventional regenerative repeater. In this project, two types of optical amplifier; Erbium-Doped Fiber Amplifier (EDFA) and Raman Amplifier have been selected and extensively tested based on several parameters.

The main parameters for this project are loop length of the amplifier, or simply known as amplifier length, the configuration of cascaded optical amplifier and input wavelength of the optical transmission system. The loop length of the amplifier will be varying according to the optical amplifier used. For transmission input, laser diode are the best choice of transmitting the optical signal because it results less signal losses , even in long distance transmission system. The value of wavelength between 1530 nm and 1590 nm will be use, covering the C and L-band of transmission system. The pump wavelength and pump power for the optical amplifier are used based on the previous journals that has been studied. The statistic analysis involved in this project is: gain, Noise Figure (NF), quality factor (Q-Factor) and Optical Signal-To-Noise Ratio (OSNR).

1.2 Problem Statement

Before the optical amplifier was invented, the signal repeater was using semiconductor devices to convert optical signal to electrical signal before amplifying the signal. However, this process produce a lot of noise, results the poor reception of optical signal. When the signal are measured with eye diagram, the shapes are scattered, which indicates the poor reception of the optical signal. So, in this project, Raman and EDFA will be used to substitute the regular signal repeater. These optical amplifiers were used to eliminate the conversion between optical-electrical and electrical-optical.

Nowadays, most optical transmission system has been implemented in the range of C-band wavelength (1530 nm - 1560 nm) or 1550nm to be specific. This is particularly due to two main factors; the loss for the silica based fiber is said to be the lowest and the performance of Erbium-Doped Fiber Amplifier (EDFA) is considered as optimum to operate around that range of wavelength. However, due to the introduction of Wavelength Divison Multiplexing (WDM) system, where multiple number of input signals can be transmitted simultaneously in a single fiber, the use of this band need to be expanded. This limitation of EDFA contributes to the shift of interest by the researcher towards Raman Amplifier in recent years. Raman Amplifier, different from

EDFA can operate at any band of transmission wavelength. The major problem encountered by Raman Amplifier is, it needs a very high value of pump power to produce a good performance. Moreover, a multi pump wavelength needs to be added to the configuration to ensure the amplifier can produce a large bandwidth in terms of amplifier gain. In this project, a configuration of Raman Amplifier will be designed and its performance in C-Band and L-Band wavelength will be extensively tested and directly compared with the performance of EDFA.

1.3 Scopes of Project

The project will focus on 4 mains area:

I. Literature review of optical amplifier
II. Circuit design and simulation for optical amplifier using OptiwaveOptisystem software

- Single Stage EDFA
- Single Stage Raman Amplifier
- Two Stage Cascaded EDFA-EDFA
- Two Stage Cascaded EDFA-Raman
- Two Stage Cascaded Raman-EDFA
- Two Stage Cascaded Raman-Raman

III. Analyse the circuit using different loop length
IV. Analysis of results and performances for all tested cascaded amplifier Recommendation of the most efficient optical amplifier

1.4 Objectives

I. To design and analyze the performance of cascaded amplifier with different loop length

II. To demonstrate and extensively tested the operating performance of cascaded optical amplifier in C-Band (1530nm-1565nm) and L-Band (1565nm-1625nm) wavelength.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Optical Communication

Since been first commercially used in 1970s and early 1980s, optical communication system has shaped today's world, covering almost 80 percent of long distance data transmission and voice communication. Optical communication system basically consists of transmitter and receiver, connecting by optical fiber. Fiber optic is mainly made from silica for a long transmission distance communication purpose whereas plastic optical fiber can be used for short distance communication.

Figure 2.1 : Fiber Optic Cable

A basic optical communication link comprises a transmitter and receiver, with an optical fiber cable connecting them. Although signals propagating in optical fiber suffer far less attenuation than in other mediums, such as copper, there is still a limit of about 100 km on the distance the signals can travel before becoming too noisy to be detected[1-2].

Characteristics	
Bandwidth	Fibre optic cables offer a much greater bandwidth than metal cables. With the high performance single mode cable used by telephone industries for long distance telecommunication, the bandwidth surpasses the needs of today's applications and gives room for growth tomorrow.
Low Power Loss	An optical fibre offers low power loss. This allows for longer transmission distances. In comparison to copper; in a network, the longest recommended copper distance is 100m while with fibre, it is 2000m.
Interference	The transmission of data using optical fiber is carry on without the presence of electrical charge. Thus, electrical noise can be neglected.
Size	In comparison to copper, a fibre optic cable has nearly 4.5 times as much capacity as the wire cable has and a cross sectional area that is 30 times less.
Weight	Fiber optic cables are much thinner and lighter than metal wires. They also occupy

	less space with cables of the same information capacity. Lighter weight makes fibre easier to install.
Safety	Since the fibre is a dielectric, it does not present a spark hazard.
Security	Optical fibres are difficult to tap. As they do not radiate electromagnetic energy, emissions cannot be intercepted. As physically tapping the fibre takes great skill to do undetected, fibre is the most secure medium available for carrying sensitive data.
Flexibility	An optical fibre has greater tensile strength than copper or steel fibres of the same diameter. It is flexible, bends easily and resists most corrosive elements that attack copper cable.
Cost	The raw materials for glass are plentiful, unlike copper. This means glass can be made more cheaply than copper.

Table 1: Advantage of Optical; Transmission