PERFORMANCE EVALUATION OF HYBRID RAMAN AND ERBIUM DOPED FIBER AMPLIFIERS (HFAs)

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

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Tajuk Projek : Performance Evaluation of Hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs)

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Dedicated to my father, Chai Ming Aon and my beloved late mother, Loh Siew Kim.

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ABSTRACT

This report explores how to evaluate the performance of Hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) which are a technology for future dense wavelength-division-multiplexing (DWDM) multiterabit systems. The fundamental objective is to provide a design parameter for maximum reachable transmission distance in optical transmission system using the Hybrid Raman and Erbium Doped Fiber Amplifiers. All the basic parameter and fundamental theory are described in detail. The simulation result will be revealed and discussed.

ABSTRAK

Laporan ini menghuraikan bagaimana prestasi penguat “*Hybrid Raman dan Erbium Doped Fiber*” dapat dinilai. Ianya merupakan teknologi “*dense wavelength-division-multiplexing (DWDM)*” sistem multiterabit untuk masa depan. Tujuan utama projek ini adalah untuk mereka bentuk parameter untuk mendapatkan jarak penghantaran maksimum dapat dicapai bagi sistem penghantaran optik yang menggunakan penguat “*Hybrid Raman dan Erbium Doped Fiber*”. Semua parameter dan teori asas dijelaskan secara terperinci. Keputusan simulasi juga dinyatakan dan dibahas.

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LIST OF ABBREVIATIONS

ASE	-	Amplified Spontaneous Emission
BER	-	Bit Error Rate
DCF	-	Dispersion Compensation Fiber
DFB	-	Distributed Feedback Laser
DWDM	-	Dense Wavelength Division Multiplexing
EDFA	-	Erbium Doped Fiber Amplifier
FP	-	Fabry-Perot Laser
HFAs	-	Hybrid Raman and Erbium Doped Fiber Amplifiers
MMF	-	Multimode Fiber
NF	-	Noise Figure
OSNR	-	Optical Signal Noise Ratio
SMF	-	Single Mode Fiber

SNR	-	Signal Noise Ratio
SOA	-	Semiconductor Optical Amplifier
VSCEL	-	Vertical-Cavity Surface-Emitting Laser
WDM	-	Wavelength Division Multiplexing

CHAPTER 1

INTRODUCTION

1.1 Overview of Project

Hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) are a technology for future dense wavelength-division-multiplexing (DWDM) multiterabit systems. HFAs are designed in order to maximize the transmission length and to minimize the impairments of fiber nonlinearities, and to enhance the bandwidth of Erbium Doped Fiber Amplifiers (EDFAs).

This project simulates and evaluates the performance of hybrid Raman and Erbium-Doped Fiber Amplifiers in optical transmission systems using Optisystem software. Since the performance of the amplifier is influenced by the parameter of Optical Signal-to-Noise Ratio (OSNR), Bit Error Rate (BER), and Noise Figure (NF), the problem encounter in this project is to find the best design parameter for maximum reachable transmission distance using the hybrid amplifiers.

Optisystem software is used as the simulation tools for the whole project. Optisystem software is based on realistic modeling of fiber optic communications systems and serves a wide range of applications, thus it is an ideal simulation tools for this project.

1.2 Objectives

The objectives of the project are:

1) to design hybrid Raman and Erbium Doped Fiber Amplifiers using Optisystem software.
2) to provide a design parameter for maximum reachable transmission distance in optical transmission system using the hybrid Raman and Erbium Doped Fiber Amplifiers.
3) to evaluate the performance of the Hybrid Raman and Erbium Doped Fiber Amplifiers based on the amplifier's gain, Optical Signal-to-Noise Ratio (OSNR), Bit Error Rate (BER), Noise Figure (NF), and etc.
4) to analyze the simulated data obtained from Optisystem software.

1.3 Problem Statement

Optical amplifiers have become a necessary component in long-haul fiber optic systems due to the demand for longer transmission lengths. The effects of dispersion and attenuation can be minimized in long-haul optical systems due to the invention of Semiconductor optical amplifiers (SOAs), Erbium Doped Fiber Amplifiers (EDFAs), and Raman optical amplifiers.

One of the shortcomings of EDFAs is their non flat-gain characteristics across a given optical spectrum. In particular, the gain level is substantially less at the end of the L-band between about 1600 nm and 1620 nm. Fortunately, the gain level of such amplifiers can be rendered substantially flat across the L-band window by the use of gain flattening filters which are optically coupled between the coils of erbium doped fiber. However, the use of such filters results in a higher NF in the channels having wavelengths in the 1600-1620 nm range. The substantially higher NF in the 1600-1620 nm range lowers the usable bandwidth available from such EDFA amplifiers.

Raman amplifiers likewise have non-flat gain characteristics. A typical Raman gain level curve has minimum gains at about 1570 nm, 1595 nm, and 1620 nm, and maximums at 1585 nm and 1610 nm. A gain flattening filter can be applied to reduce this variation but will only be optimized at a single operating gain value. Additionally, there is the desire to minimize the number of gain flattering filters in the system and the loss they incur.

Clearly, there is a need to reduce the maximum NF in EDFA gain, as well as to further flatten the gain curve in Raman-type amplifiers in order to reduce signal losses throughout the network.

The invention is a hybrid optical signal amplifier that reduces the maximum NF of an EDFA while flattening the gain of a Raman amplifier without compromising laser pump efficiency.

Therefore, this project simulates and evaluates the performance of hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) in optical transmission systems to provide a design parameter for maximum reachable transmission distance using the hybrid amplifiers.

1.4 Scope

This project will focus primarily on the simulation of hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) using Optisystem software. The performance of the amplifier will be evaluated depend on amplifier’s gain, Optical Signal-to-Noise Ratio (OSNR), Bit Error Rate (BER), and Noise Figure (NF) obtained from the simulation of a single mode fiber transmission link. The fabrication or development of hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) will not be covered in this project.

1.5 Project Outcomes

It is expected that at the end of the project, a design parameter for maximum reachable transmission distance using the hybrid amplifiers can be obtained.

1.6 Methodology

This project starts with the searching of source and information regard hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs). The source and information are acquired from journal, reference books, e-Books, magazine and internet. The circuit schematic diagram of hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) is determined from the journal and simulate using Optisystem software. All the parameter likes amplifier's gain, Optical Signal-to-Noise Ratio (OSNR), Bit Error Rate (BER), and Noise Figure (NF) that determines the performance of the HFAs is analyzed. The simulation process is repeated until the design parameter for maximum reachable transmission distance using the hybrid amplifiers can be obtained.

1.7 Thesis Structure

Chapter 1: The first chapter provides a general inspiration for the project. It includes the overview of project; the objectives of project, problem statement, scope of the project and project outcomes.

Chapter 2: Project's background is illustrated in this chapter. Generally, this chapter summaries the literature review that have been studied. The concept and theory of the circuit schematic diagram of hybrid Raman and Erbium Doped Fiber Amplifiers (HFAs) that is used for simulation will be explained in this chapter.

Chapter 3: The third chapter is discussed about the methodology of the project. The method, materials and procedures used to conduct the project in achieving the objectives of the project is explained in details.

Chapter 4: The chapter four will present all the simulation result from the Optisystem software. All the graphs and tables obtained from the simulation will be discussed in details.

Chapter 5: The last chapter will conclude all the findings and results obtained throughout the project. The results will be evaluated based on the findings and the objectives of the project. Recommendations for future studies also will be included in this chapter.