

Chapter 15

EDFA and EDFL Review

Belloui Bouzid

Hafer Al-batin Community College & King Fahd University of Petroleum & Minerals, Saudi Arabia

EXECUTIVE SUMMARY

In this chapter, I propose a comprehensive study of erbium-doped fiber amplifier (EDFA) and erbium doped fiber laser (EDFL). The chapter is based on three principal levels: the first is at the atomic level, where it is evident and meaningful to give general and deep studies on erbium spectra at theoretical background angle. The important part that needs to be understood in the erbium is its energy level splitting and lasing. The second level is based on the EDFA and EDFL critical, where many research papers have been reviewed to show and clarify their strong and weak side at different views. To specify the weakness of the classical EDFA and EDFL, and to describe the future generations and its characteristics, it is very important to review the recent published papers and books. At the experimental level a full investigation is given. Vast and new designs were invented showing high-gain and low-noise-figure (NF) utilizing a new technique called double pass with filter. An efficient amplification occurs at the signal wavelength of 1550 nm when it travels along the design quadruple pass double stages with filter amplifier (QPDSF). The highest gain of 62.56 dB with a low NF of 3.98 dB was achieved for an input signal power of -50 dBm and pump powers of 10 and 165 mW in the second and first stage amplifiers respectively. This important result shows also, a large difference of 40 dB gain between the QPDSF and the single stage single pass (SPSS) EDFA configuration. This design is used to show high gain of 62.56 dB compared to SPSS which records only 20 dB. A higher power and wider spectrum of ASE is observed for the double pass compared with single pass. A comparative investigation is presented and analyzed for various configurations. At the end, a high output power EDFL configuration is reported. It incorporates a double stages linear cavity with fiber loopback and a tunable bandpass filter TBF. The configuration increases the output power by suppressing the amplified spontaneous emission and achieves a highly stable output power of more than 18 dBm at 1560 nm. A standard spectrum is attained with TBF adjustment.

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INTRODUCTION

As it is found in the vast literature review, laser and amplifier take an important part in this scientific age due to their effects in this new generation of communications and Tbps transmission [1]. The importance of EDFA and EDFL are owing to their ability to amplify the signal and revive it through millions of kms on this earth. The lasers phenomena in general, let the researchers focus on the development and enhancement of optical amplifier and give wide and deep understanding of amplification and lasing. Thousand of books and millions of papers have been published since the early discover of laser in 1960 by Theodore Maiman. The roots of the fiber amplifier began in 1964 with the first amplification experiment of Snitzer. It is an interesting task to study, illustrate, and investigate the beneath behavior of laser at specific conditions of design, and verify their performance parameters.

The laser was discovered but the modeling was followed to much the experiment results. And the base was the quantum theory based on Planck and Einstein formulas. To understand and elaborate the construction of laser phenomena, it is of great consequence to combine theory and experiment in one thinking head.

The elucidation of laser and amplifier is related to what we call the energy level or the atomic structure that emit the photon. How this photon is born? How it is constructed within the sublevel of the atomic orbits? Or what is the physical meaning of the electron jumping? How the amplification phenomena can be explained? All these questions are important to be answered to understand the laser and amplifier conceptions.

The rare earth with its puzzle of emission and absorption played latter an important role in lasing and amplifications due to the 4fn, where n varied from 1 to 14 electrons. The erbium ion is the main part in the optical amplifier and laser, this importance is owing to the overlap of lowest

absorption in fiber optic and erbium emission at C and L bands.

In general, all the scientific community in the photonics fields knows, what is the real effect of optics and laser on the huge development of internet, and on the progress of terabits transmission? [1]. Laser with the stimulated emission phenomena are considered to be the main key to the future revolution of communication. Let us think internet without fiber optics or without fiber amplifier? How the narrow band of electronics can be solved? I believe this huge communication that we are living in, will be abolished without fiber optics, laser, and EDFA. At the beneath of the laser phenomena there are many promising future developments and new discoveries that can be achieved. Optical amplifier and lasers are used nearly in all the wide spectrum of science such as medicine, military, education and manufacturing.

After a decade of research in amplifier and laser, and after a deep study of EDFA and EDFL in the past and present design, a remarkable effect of configuration is observed. The simple EDFA configuration is used by splicing the WDM with the active medium EDF and with the pump power, an amplification of an input signal will occur with the generation of amplified spontaneous emission (ASE) noise. In all cases of single pass single stage (SPSS) the gain shows small increase even by changing the pumping power 980nm or 1480nm or using the co-propagating or the forward propagating or even putting the 980 and 1480 in one direction. The gain gap between the SPSS types of configurations doesn't show high difference and the saturation will occur at a low pump power.

The vast published papers of SPSS don't show a sufficient increase of gain difference. In the double passes double stages (DPDS) the circulators are used as loop-back of ASE and laser beam. It was observed a high difference between gains. It can be noticed, that the configuration structure has the most important part in the design of EDFA. This impressed result is due to the output power that can be generated after a specific change of

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