Optimization of EDFA Operating Parameters of Gain, SNR and Input Power in Frequency Transfer System

Xuan Yang[1], Panxue Ma[1], Yufei Zhang[2], Guohua Wu[1,*], Ziyang Chen[2], Bin Luo[1], Hong Guo[2]
1. State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, Beijing 100876, China
2. State Key Laboratory of Advanced Optical Communication Systems and Networks, School of Electronics, and Center for Quantum Information Technology, Peking University, Beijing 100871, China
Email: *wuguohua@bupt.edu.cn

***Summary*—In this paper, the characteristics of EDFA have been measured under different experimental conditions based on optical comb frequency transfer, evaluated by NF and Gain curves. In the case of high input SNR, the stability increases with the increase of EDFA gain, but in the case of low input SNR, the conclusion is opposite. At the same gain level, the stability will be better with the increase of input SNR and input power. These conclusions can be used to optimize the parameters to achieve higher stability in our frequency transfer system.**

Keywords—optical comb; stability; EDFA; NF; gain

I. Introduction

In recent years, optical comb has become an important tool for frequency transfer [1]. An important indicator of frequency transfer is stability. EDFA is used for light amplification in long distance transfer. However, the amplification function of EDFA will inevitably introduce noise which leads to the deterioration of stability [2]. Therefore, it is necessary to quantitatively analyze the characteristics and stability of EDFA in optical comb frequency transfer. In this paper, an experiment is designed to measure the characteristics and stability of EDFA based on optical frequency comb. The experiment is divided into three parts, and the characteristics of each part are reflected by NF and Gain curves. Representative data are selected for stability measurement in each part of the experiments.

II. Methods/Results

Firstly, we define two curves, NF (Noise Figure) [3] and Gain:

$$NF(\mathrm{dB}) = 10\lg\left(\frac{SNR_{\mathrm{in}}}{SNR_{\mathrm{out}}}\right), \quad (1)$$

$$Gain(\mathrm{dB}) = 10\lg\left(\frac{P_{\mathrm{out}}}{P_{\mathrm{in}}}\right). \quad (2)$$

The experimental setup is shown in Fig.1. It should be noted that the input SNR is directly connected to the photodetector after the coupler and then sampled by a spectrometer. Besides, output SNR is input SNR amplified by EDFA and measured by photodetector. This experiment uses a 100 MHz optical comb signal to transfer in the link.

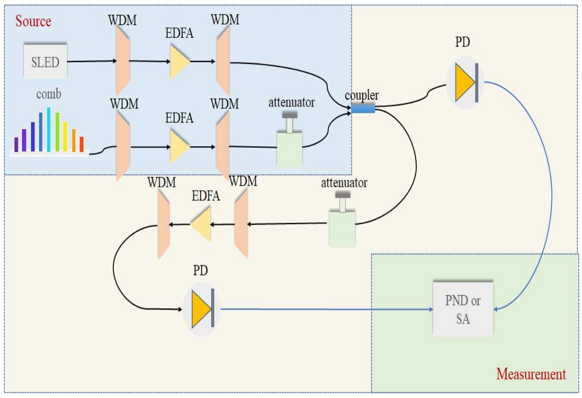

Fig.1. Experimental setup. PD represents photo detector, WDM represents wavelength division multiplexing and PND represents phase noise detector, SLED represents super luminescent diodes, SA represents spectrum analyzer. SLED is used to add noise, while the EDFA behind SLED and Comb is used to adjust optical power and noise power. The attenuator behind the coupler is used to adjust the input power.

The experiment results are shown in Fig.2, 3, 4, and 5.

The results above can be used to guide the experiment of frequency transfer using optical comb. The characteristics of EDFA based on the optical comb signal are measured. Through the characteristics, we can clearly know how to adjust the gain of EDFA and how much signal power into EDFA is. The influence of EDFA on the short-term stability of frequency transfer is also explored, which is of great significance for the study of the whole frequency transfer system.

III. Conclusions

We study the characteristics of EDFA experimentally: with the increase of pump power, the frequency transfer stability decreases under low SNR. Therefore, the pump power as small as possible should be used in long-distance frequency transfer. In addition, the lower the input SNR, the worse the stability. Optimizing the SNR is one of the important considerations in frequency transfer system.

The significance of optimizing EDFA characteristics and stability is to solve the problem of stability deterioration caused by a series of EDFA over long distance frequency transfer in a specific system, so as to improve the short-term stability of the system.

This paper serves as a reference on the experiment of frequency transmission based on optical comb, and the measurement used in the experiment provides an idea of measuring the device stability and analyzing SNR in the frequency transfer system.

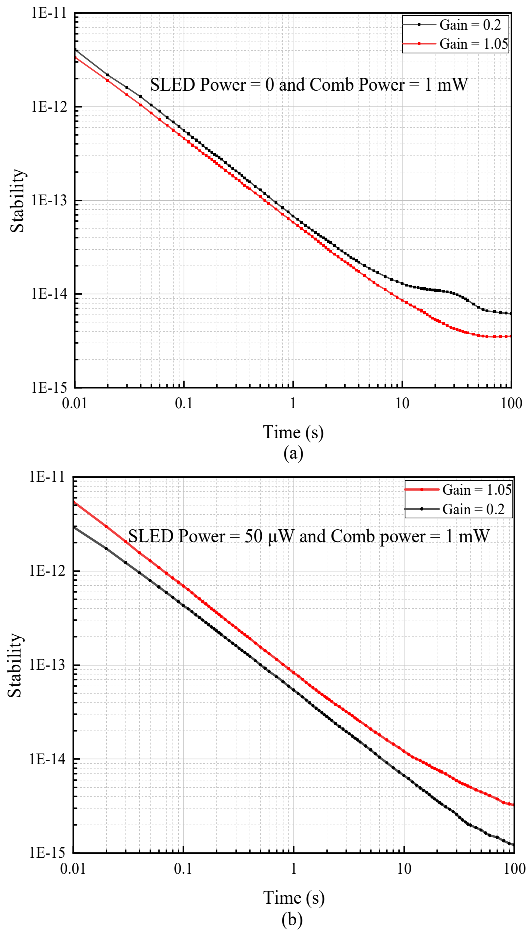

Fig.2. Measure the influence of EDFA gain (pump power) at the same input SNR. (a): In this experiment, an interesting phenomenon is discovered that when the input SNR is low, if we increase the gain, the EDFA amplifies the noise more than the signal, indicating the reduce of the stability; (b): On the contrary, the conclusion is opposite when the input SNR is high.

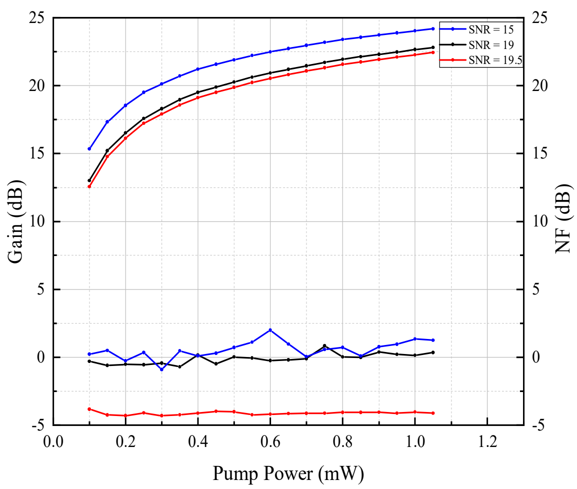

Fig.3. This experiment is the same as Fig.2. As shown in this figure, the lower the input SNR, the higher the NF curves. The Gain curves are the same.

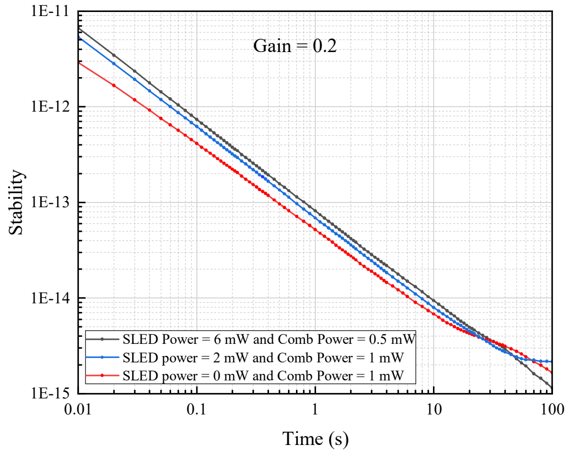

Fig.4. Under the same gain, the influence of different input SNR on the output signal is measured. The lower the input SNR, the worse the stability.

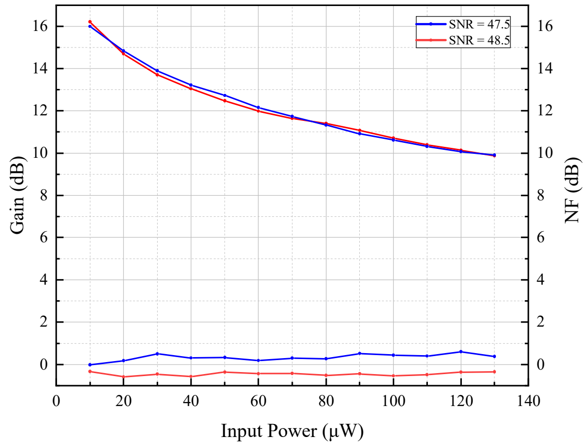

Fig.5. Under the same gain, but different input power, measure the output SNR change. The purpose is to measure the saturation characteristics of EDFA. The saturation characteristics of EDFA are found. As the input power of EDFA increases, the curve gradually flattens out.

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