The High Efficiency of Slotted optical time division multiplexing

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Abstract— **In optical time division multiplexed (OTDM) optical data streams are constructed time multiplexing a number of lower bit rate optical streams. The advances in OTDM systems and components research show the technique to be highly suited to the generation and transmission of high capacity data on a single optical carrier. In this work, Spectrum compression based on filters for improving bandwidth efficiency is presented and demonstrated experimentally in 40 GB/s OTDM system. Even after 100km transmission, de multiplexing and clock recovery can be implemented successfully, and the data rate-to-bandwidth ratio has been improved.**

***Keywords:** Slotted Optical time division multiplexing, Arrayed Waveguide Grating, electrical multiplexing. Erbium- doped fiber amplifier. Electro-absorption Modulator.*

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I. INTRODUCTION

The expected increase of transmission capacity in optical fiber networks presents us with many technology challenges [1]. One of these challenges is an optimized combination of wavelength-division multiplexing (WDM) and time-division multiplexing (TDM). TDM may be realized by electrical multiplexing (ETDM) or by optical multiplexing (OTDM) to a high-speed data signal, i.e., by electrical signal processing or optical signal processing. Presently, the first 40 Gb/s systems based on ETDM have been installed and in laboratories the first 100 Gb/s ETD Experiments have been performed[2]. In contrast, at the same data rates, OTDM transmission experiments have been carried out more than 10 years earlier. For instance, the first 100 Gb/s OTDM transmission experiment over a 36 km fiber link was reported already in 1993[3].Since then, OTDM transmission technology has been made a lot of progress towards much higher bit rates and much longer transmission links. Recently, OTDM transmission technology succeeded in the transmission of a TDM data rate of 160 Gb/s over a record fiber length of 4320 km and of a TDM data rate of 2.4 Tb/s over a fiber link length of 160 km[4]. The past has seen that OTDM will be replaced by ETDM as soon as electrical signal processing becomes available at the required TDM data rate. Therefore, OTDM transmission technology is often considered to be an interim technique with which to investigate the feasibility of ultra-high-speed data transmission in fibers. Today, the ultimate limits of ETDM technology are not known. An ETDM data rate of 160 GB/s is very likely in the future. However, the performance of the ETDM terminal equipment may eventually be worse than the OTDM terminal Optical Fiber Telecommunications equipment. OTDM receivers perform better than ETDM receivers already at data rates of 80 GB/s. In this chapter we will show that the OTDM terminal equipment for 160 GB/s TDM data transmission provides already very stable operation conditions. These results suggest that 160 GB/s OTDM transmission systems can be used in deployed systems and can be operated error-free for years. ETDM technology must work hard to compete with these systems for instance as regards receiver sensitivity. Moreover, it is not sure that ETDM terminal equipment for 160 Gb/s will be less expensive and less energy consuming than the corresponding OTDM terminal equipment. The ultimate limits of OTDM transmission technology are not given by the terminal equipment but by the transmission properties of the fiber link including all repeater or amplifier stages[5] [6]. With higher TDM bit rate data transmission in fiber is stronger affected by chromatic dispersion (CD), polarization-mode dispersion (PMD), fiber nonlinearity, and the limited bandwidth of repeaters or amplifiers in the transmission link. This is independent of the signal processing in the terminal equipment whether it is based on ETDM or OTDM technology. At present therefore, a main task of OTDM technology is to explore the ultimate capacity for fiber transmission in a single wavelength channel. The most challenging view as regards OTDM technology is that optical networks will evolve into "photonic networks," in which ultra-fast optical signals of any bit rate and modulation format will be transmitted and processed from end to end without optical–electrical–optical (O/E/O) conversion. This "photonic network" is a target for the distant future, and it presents us with the present challenge of investigating and developing high-speed optical signal processing and exploring the ultimate capacity for fiber transmission in a single wavelength channel 7][8].

II. OPTICAL TIMED DIVISION MULTIPLEXING MODEL

In optical time division multiplexing we used many component in transmitter such as laser in optical source and modulation , but in receiver we can use erbium-doped fiber amplifier , Electro-absorption Modulator and demodulation. Our model used an optical fiber as shown in figure1.

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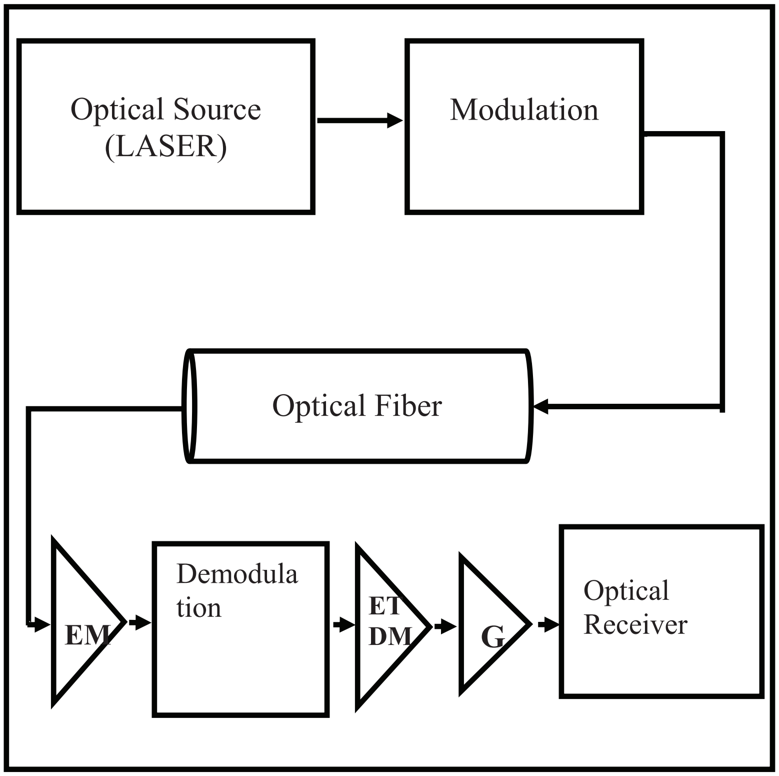

Figure.1, OTDM system model

III. Simulation Description and Results

In this part, we describe an optical time division multiplexing system model shown in figure.1, which created by optical communication system design software systems engineers. We implemented our model and analyzed the system then we used erbium- doped Amplifier and Electro-absorption Modulator to improve the system. To study and explain the efficiency of OTDM We used some methods such as using lenses after transmitter and before receiver to improve the efficiency from 30% to 90%, using filters after modulation to minimize the need of using repeaters. During our simulation we take the displacement in account.The results shows that The output of the system before using erbium- doped fiber amplifier and log BER in 0.2 bit period become under -1.4dBm as shown in figure.2 The output of the system after using erbium- doped fiber amplifier and log BER in 0.2 bit period improve to -1.4dBm as shown in figure.3.We found that the output power after modulation is 33.317 10-3 W (15.23dBm) ,the output power after the Optical Fiber without erbium- doped fiber amplifier is 3.33x10-3(5.23dBm), the output power after the Optical Fiber with erbium- doped fiber amplifier1.35x10-3 W(1.3dBm),the link is almost not ideal, because we have major losses or misalignments between the transmitter and receiver. The spatial connector is not ideal and there is loss due to the difference between the input signal spot size and active area of the photodetector (10µm and the mode spot size of 15µm). The fiber optics in case of displacement in the position of contact leading to the phenomenon of inter symbol interference. Where the greater displacement led to an increase inter symbol interference as shown in figure.4. The sections of the fiber optic in case of displacement in the position of contact leading to the phenomenon of inter symbol interference. Where the greater displacement led to an increase inter symbol interference in eye diagram as shown in figure.5. The link is almost ideal, because we do not have any major losses or misalignments between the transmitter and receiver. The spatial connector is ideal and there is only a small loss due to the difference between the input signal spot size and active area of the Photodetector (10µm and the mode spot size of 10µm). The section fiber optic after correcting mode fiber and removed displacement resulting in the disappearance of inter symbol interference. This in turn leads to reused BER as shown in figure.6. The section of the fiber optic in case of placement in the position as shown in figure.7.The signal to noise ratio it is noticeable that largest power signal of power noise and this indicates that the content of the reference in the acceptable rate as shown in figure.8.The signals are combined in order to generate an 40 GB/s bit rate at the multiplexer output as shown in Figure 9.The demultiplexer stage in Optical time division multiplexing shown in figure.10.

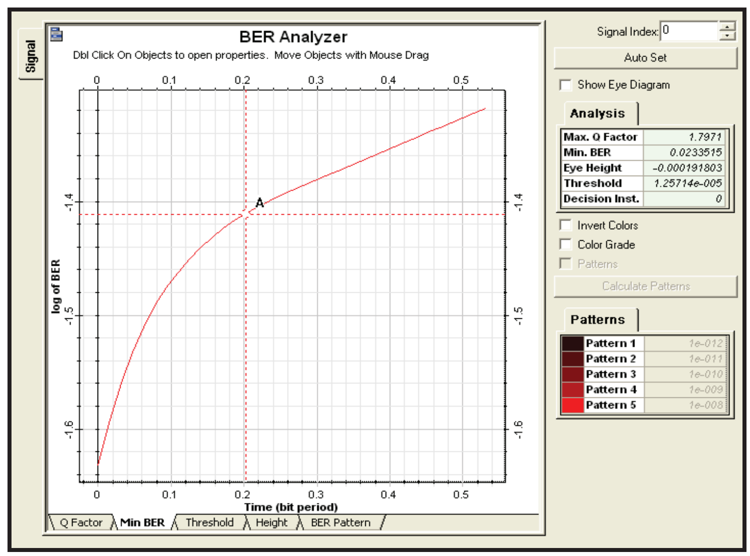

Figure .2, BER vs time without erbium- doped fiber amplifier

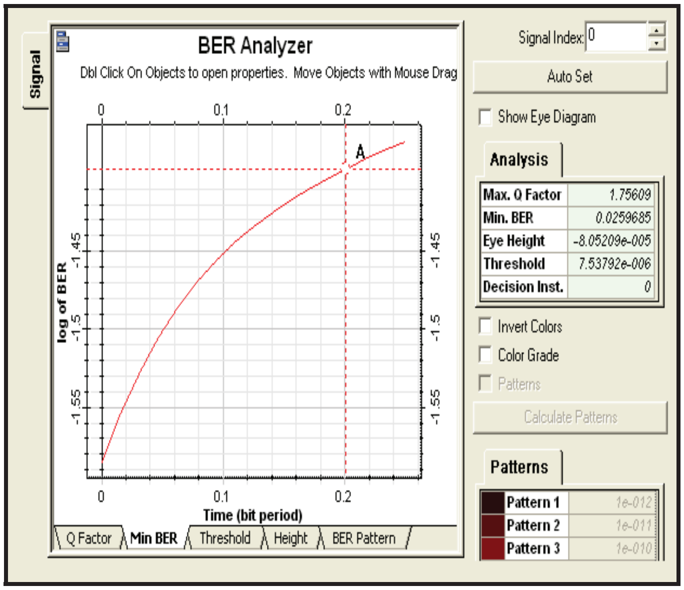

Figure .3, BER vs time with erbium- doped fiber amplifier

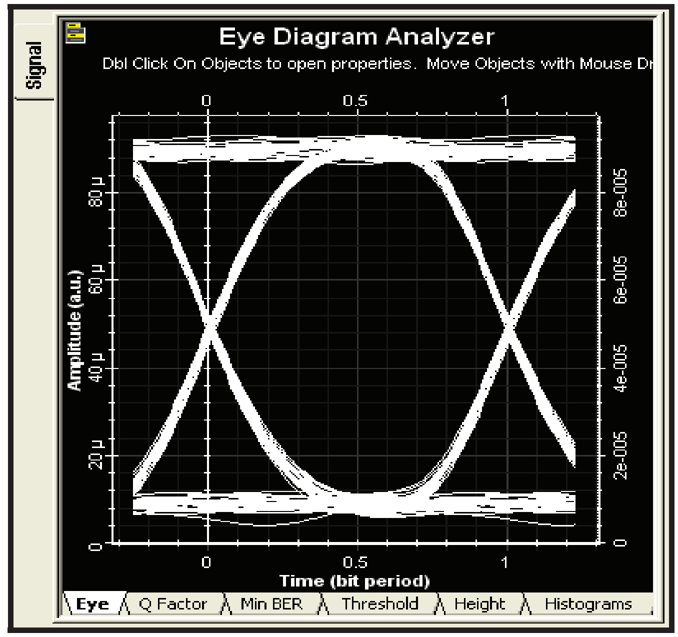

Figure.5, eye diagram inter symbol interference Before treatment displacement

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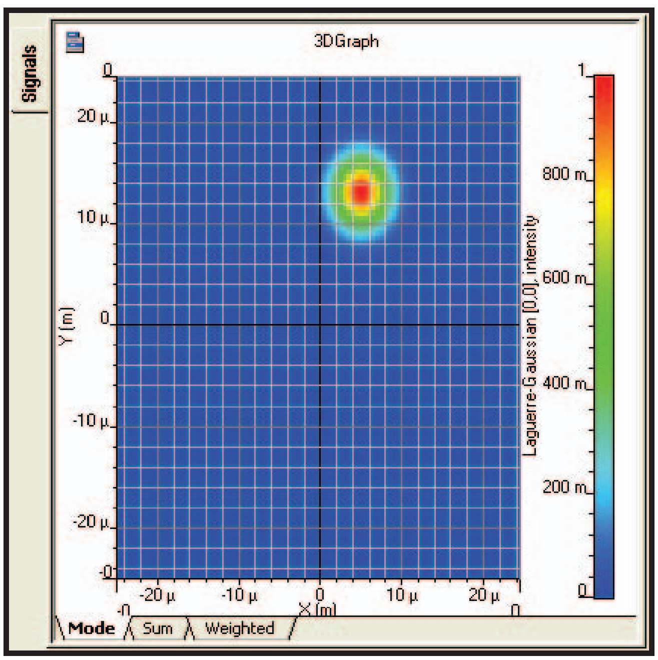

Figure.4, position of two fibers optic in the connection point with displacement

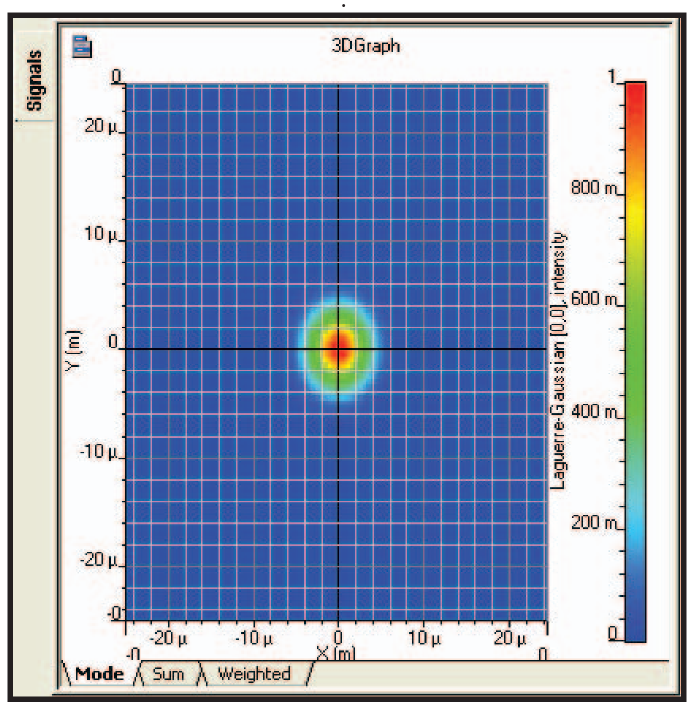

Figure.6, position of two fibers optic in the connection point without displacement.

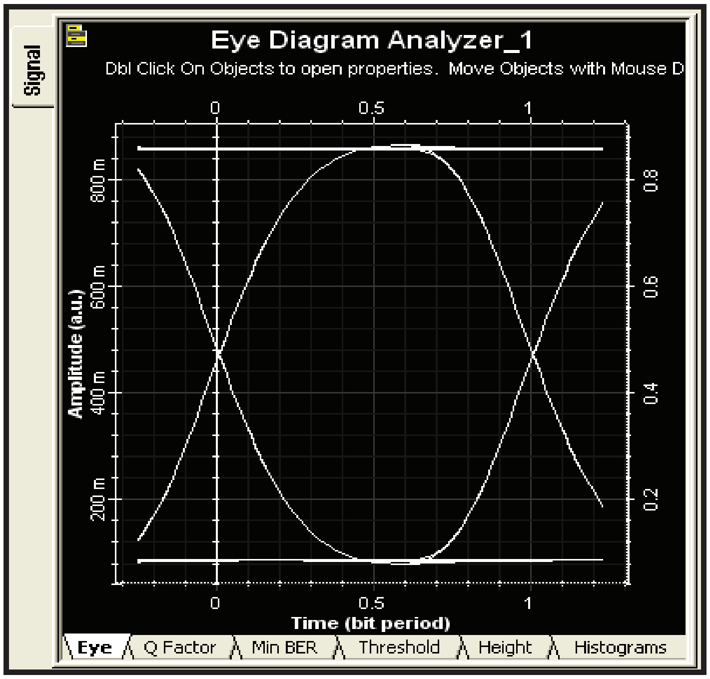

Figure.7, eye diagram without inter symbol interference After treatment displacement

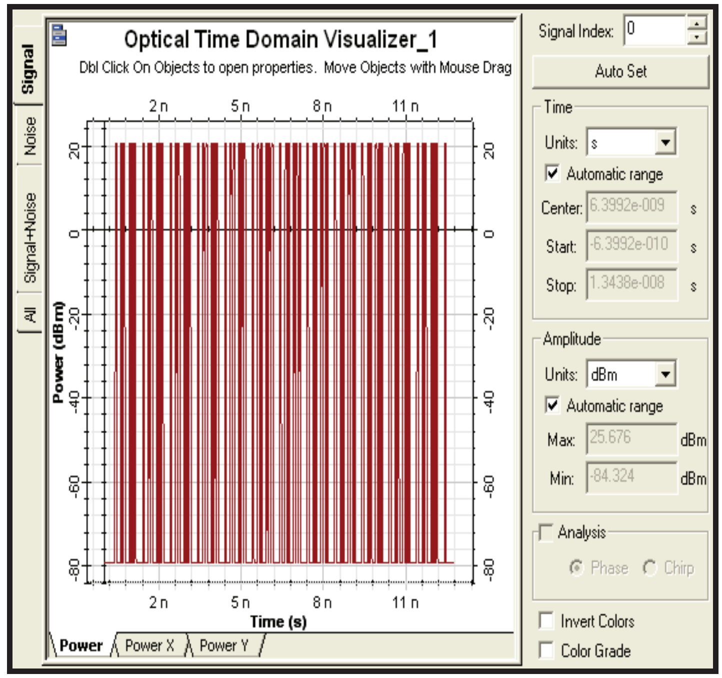

Figure.9, time vs. power in multiplexer stage

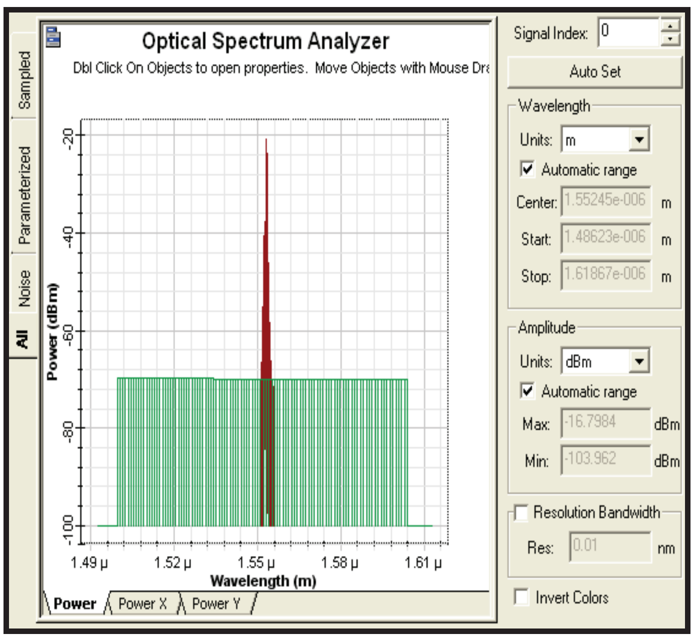

Figure.8, wavelength vs. power.

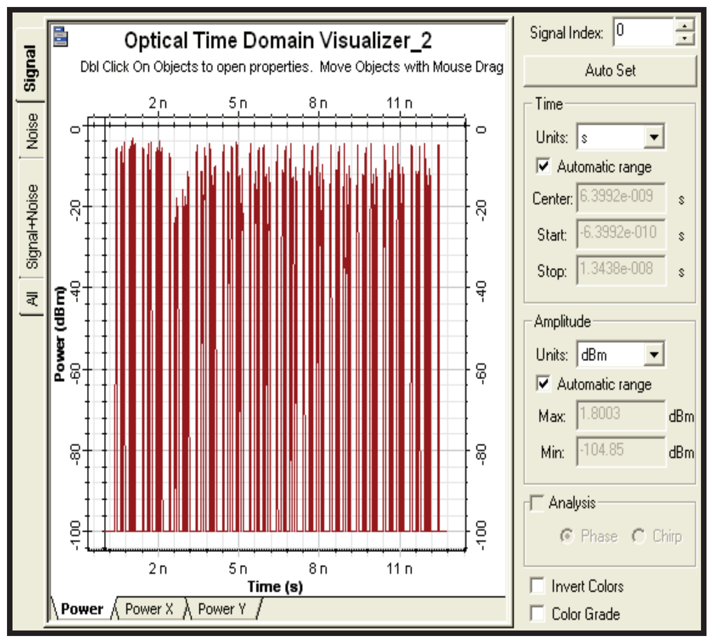

Figure.10, time vs. power in demultiplexer stage

IV. CONCLUSION

The method of improving bandwidth efficiency based on spectrum compression utilizing filters is successfully demonstrated in 40Gb/s OTDM 100km transmission system. Since AWGs are compatible totally in WDM systems, WDM and OTDM can be easily applied to highly increase the communication capability using the method. Meanwhile, the deep research in 80 GB/s and upper rates OTDM signal will be considered in the latter work.

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