Performance Evaluation of Optical CDMA Transmission System

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Abstract— Today Optical Code Division Multiple Access (OCDMA) is receiving more attention due to its potential for information security, simplified and decentralized network control, high speed and virtually infinite user capacity. Hence the multiple access technique in optical communication is gradually migrating towards Optical CDMA. CDMA is a spread spectrum technology, allowing multiple users to occupy the same time and frequency allocations in a given band. There are many techniques to provide Multiple Access in optical domain such as TDMA, WDMA and CDMA. High speed and signal security is available in optical domain than wireless domain, hence optical domain is use these days. Among Multiple Access techniques Optical Code Division Multiple Access (OCDMA) is the best one suited for optical communication as OCDMA have lower latencies than TDMA and WDMA. The objective of the paper is to analyze the performance of optical code division multiple access (OCDMA) system. From results it is observed that MAI is the major limiting factor of Optical CDMA system efficient performance.

Keywords- *Code division multiple access (CDMA), bit error rate (BER), multiple access interference (MAI)*

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I. INTRODUCTION

In long haul networks optical communication systems are main part as they provide high speed, large capacity and high reliability by using optical fiber. In optical domain we have large bandwidth, low losses, high signal security and high speed then the wireless domain and also in optical domain signal is free from the effect of fading and electromagnetic interference. To achieve high capacity spectrum sharing of available bandwidth among multiple users is required [1]. Major multiple access techniques in optical domain are time division multiple access (TDMA), wavelength division multiple access (WDMA) and code division multiple access (CDMA). TDMA is efficient for heavy traffic but in case of sparsely used channels it is inefficient. WDMA is used as a degree of design freedom with respect to wavelength selection but in this technique sophisticated hardware and high quality narrow band filters are required. Optical CDMA operates asynchronously, without centralized control, and it does not suffer from packet collisions. As a result, optical CDMA systems have lower latencies than TDMA or WDMA. Furthermore, since time and frequency (or wavelength) slots do not need to be allocated to each individual user, significant performance gains can be achieved through multiplexing. Also, optical TDMA and WDMA systems are limited by hardware because of the slot allocation requirements. In contrast, OCDMA systems are only limited to the tolerated bit error rate relationship to the number of users [2]. In mid-1980s CDMA was applied in optical domain. Use of optical fiber with laser transmitter has made it possible to transmit high data rate with low loss [3].

Each bit is divided up into *n* time periods, called chips in Optical CDMA system. By sending a short optical pulse during some chip intervals, but not others, an optical signature sequence, or codeword, can be created. A user on the Optical CDMA system has unique signature sequence. The encoder of transmitter represents each bit by sending signature sequence and the receiver decodes the data by using the same signature sequence. This technique is flexible, allowing the spectral spreading to be tailored to the most appropriate domain: time, wavelength, or a combination of both [4]. CDMA uses unique spreading codes whose bandwidth is much larger than that of input data to spread the baseband data before transmission [5]. The signal is transmitted in a channel, which is below noise level. The receiver then uses a correlator to dispread the desired signal which is passed through a narrow band pass filter. Unwanted signals will not be dispread and will not pass through the filter. CDMA system has soft capacity and it permits growing the users beyond the nominal maximum capacity with some quality of service degradation but without extensive upgrades to the infrastructure [6]. In the high bit rate long haul communication links single mode fibers are used due to low propagation loss and large bandwidth availability [7]. Multiple access interference (MAI) in the optical CDMA system appears in the system due to simultaneous access by many users [8]. Optical CDMA system has the advantage of being able to provide each user asynchronous access to the network, without strict wavelength controls, and provide a graceful degradation in performance as the number of users increases [9].

There are different parameters that affect the performance of an Optical CDMA system such as non-linear effects, dispersion, code design, MAI etc. [10-13]. Among these MAI is the major limiting factor. The transmission distance in the system is limited mainly by the multi-access interference (MAI) which arises when there are a large number of users in the system because of the fact that one user data becomes noise for all other users in the channel and hence degrades the system efficiency [12].

In this paper we have analyzed the performance of the system based on BER for different parameters and eye diagram under the influence of simultaneous users with MAI. This paper is organised as follows: in section II simulation setup is discussed after introduction in section I, section III results of different parameters are given and

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discussed and section IV conclusion is given while in section V references are given.

II. System Description

Optical CDMA transmission link's setup uses four mode locked lasers to create a Dense WDM multi frequency light source. Data signal of 4Gbps is generated and then modulated by Mach-Zehnder modulator and then modulated data is encoded using pseudo random codes. Pseudo orthogonal codes are popular for Optical CDMA applications because they retain correlation advantages of pseudo orthogonal linear sequences while reducing the need for bandwidth expansion. These codes also generate larger code set. Encoded Optical CDMA data signal is transmitted over single mode fiber. In the receiver section desired user's information is retrieved by a decoder using the same pseudo orthogonal code and then optical signal is converted back into electrical signal through a PIN photo diode. In this way optical CDMA data is recovered successfully.

III. Results and Discussion

The performance of Optical CDMA system depends on number of factors such as data rate, transmission distance, number of simultaneous users etc. In this paper performance of Optical CDMA system is analyzed for following cases: A. describes the analysis of Optical CDMA transmission system with the increasing transmission distance. B. describes the impact of 2mW power levels of source on the Optical CDMA system with the transmission distance. C. investigates the impact of multiple access interference on the system when we gradually increase the number of users in the system. Dense WDM spectrum generated at the source by four mode locked laser is shown in figure 1.

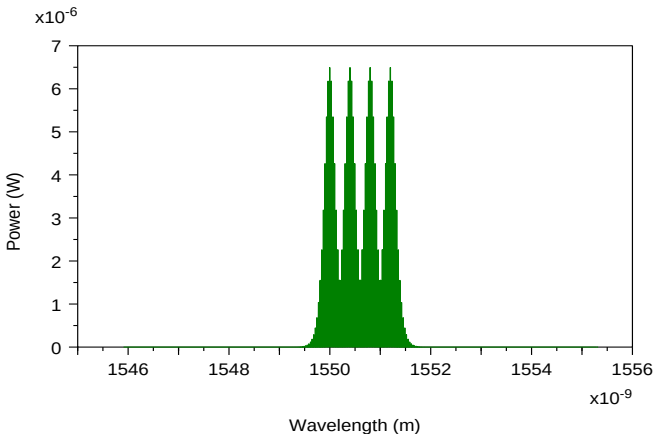


Figure 1: Spectrum of Dense WDM Signal

A. *Performance evaluation at different Transmission Distances*

Graph of BER versus transmission distance is presented in figure 2. From the results shown in graph it is observed that there is significant increase in the BER value when the transmission distance is increased. So according to the BER and Q-value relation ship as they are inversely proportional Q-value gradually decreases when the transmission distance is increased.

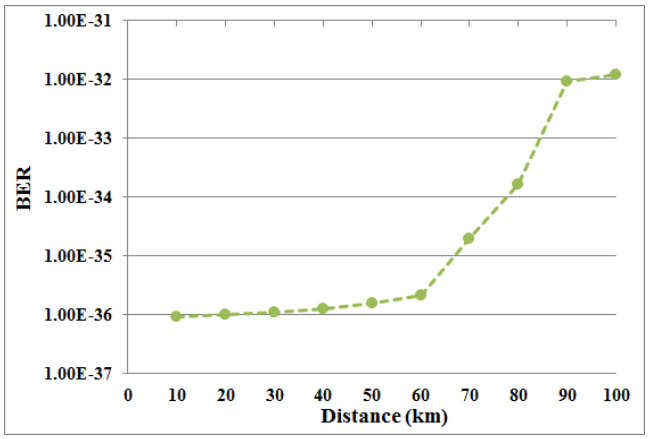


Figure 2: BER versus transmission distance

B. *Performance evaluation at 2mW power level*

Graph of BER versus transmission distance at 2mW input power level is presented in figure 3. From the results shown in graph it is observed that there is significant increase in the BER value when the transmission distance is increased and according to relationship with Q-value of BER, it gradually decreases with increase in transmission distance.

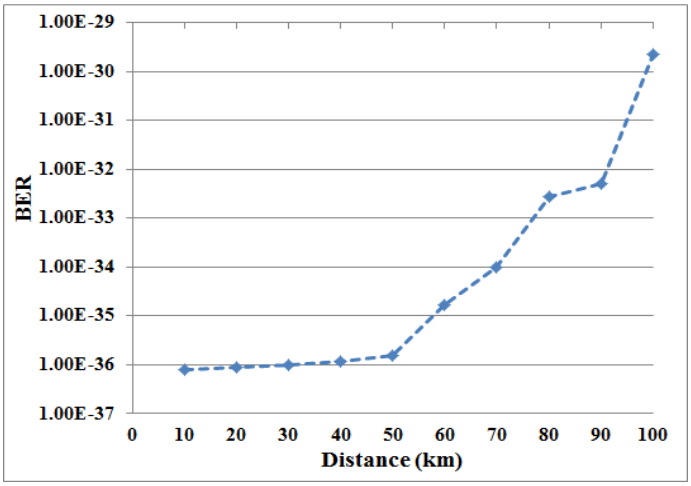
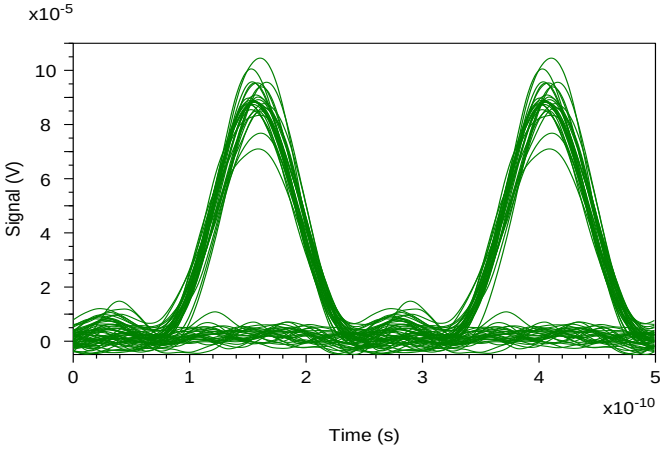


Figure 3: BER versus transmission distance at 2mW input power levels

C. *MAI impact on Optical CDMA transmission system*



(a) Single user eye diagram

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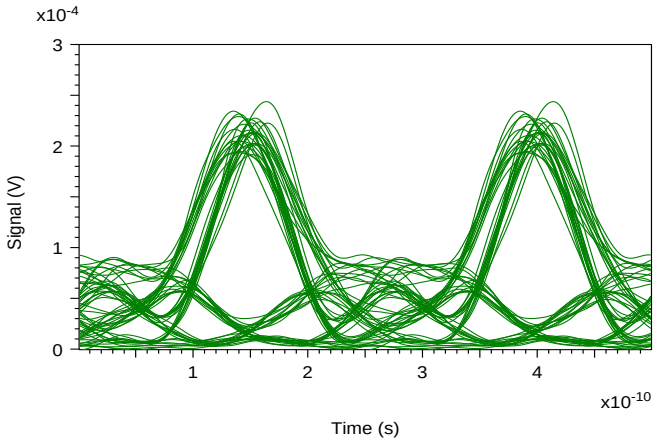

(b) 2 user MAI affected eye diagram

Figure 4: Eye diagram of received signal for (a) single user and (b) 2 user with -15dBm received power

The eye diagram for single and two users for transmission distance of 120km at -15dBm received power are shown in figure 4 (a) and (b). It is observed from the figure that as number of simultaneous users increase in the Optical CDMA transmission system efficiency of the system degrades gradually. Hence it can be concluded that MAI plays an important role in Optical CDMA transmission system.

IV. CONCLUSION

In this paper setup of an Optical CDMA transmission system at 4Gbps data rate is presented for transmission distance of 100km. In this setup of Optical CDMA performance investigation was carried out with different parameters and MAI effect is studied. From results of power source BER and Q-value it is observed that transmission distance can be increased with the increase in transmitter power. From above results it is observed that as the number of simultaneous user's increases BER and Q-value degrades gradually i.e. MAI is increasing in the system. Hence MAI plays very important role in the efficient performance of the Optical CDMA system.

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