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The Performance Analysis of the OCDMA System with the Encoder/decoder Based on Step Chirped Fiber Bragg Gratings

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Abstract The performance of optical code-division multiple-access (OCDMA) system with an encoder /decoder based on step chirped fiber bragg gratings (SCFBGs) is presented. In the system, the multiple access interference (MAI) is the main noise and the unsuccessfully decoded pulse is assumed to be a Gaussian random process. Simulation shows that longer code length and narrow pulse improve the performance of system. And when threshold is 0.7, the best bit error rate (BER) can be obtained for this OCDMA system.

Keywords OCDMA; Encoder/decoder; Fiber Bragg Gratings; MAI; BER

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0 Introduction

OCDMA encoder/ decoder is a key component in OCDMA system. In[1], we have presented a new kind of all optical OCDMA encoder/decoder based on SCFBGs, this kind of encoder /decoder has the advantages of large simultaneous users and compatibility with optical communication system, et al. In[1], detail configuration of encoder/decoder is presented, and encoding / decoding is realized by introducing mapping code of Walsh code, and the phase shift can be inserted into the subgratings of the SCFBGs according to the mapping code. The factors that influence the correlation property of the encoder/ decoder are identified. However the performance of the OCDMA system with the encoder /decoder based on SCFBGs is not investigated. In this paper, we will first present a block diagrams of the OCDMA system with encoder /decoder based on SCFBGs. Then model of bit error rate (BER) analysis will be established. Finally the factors that influence the performance of OCDMA system are discussed.

1 Performance analysis

Fig. 1 shows block diagrams of a coherent ultrashort light pulse OCDMA transmitter and receiver. In Fig. 1, the data source is first encoded by an on - off keying (OOK) modulator. The pulses generated are sent to an OCDMA encoder based on SCFBGs, a Walsh-sequence address code is assigned to each data pulse, and the output pulses represent the spectral phase of OCDMA encoded signals. At the receiver end, the input signals consist of the information of desired user and other users at the same time, the decoder in the k^{th} receiver is designed to be a auto-correlation receiver matched to the encoder in the k^{th} transmitter, while for the information from other transmitters cross-correlation is operated, and MAI will be produced at the output of the k^{th} decoder. The desired OCDMA decoded data is recovered by OOK demodulator.

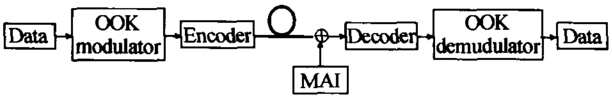

Fig. 1 Schematic diagram of a OCDMA systems

The shot noise and thermal noise are neglected in our system for MAI are the main noise source. And we assumed that communication between each of the transmitter and receiver pair is continuous. Walsh bursts generated by spectral phase coding based on SCFBGs are not stationary random processes in strict sense, hence it is also very difficult to precisely calculate the BER of the system. However, when index modulation Δn in SCFBGs is small, and there are large number of simultaneous users with long Walsh as the address codes in the decoder[2~5], the unsuccessfully decoded pulse can be assumed to be a Gaussian random process.

For a single user case the intensity signal I has the chi-square probability density function and can be shown to be

$$p(x)=\frac{1}{\sigma}e^{-x/\sigma^2} \tag{1}$$

where the variance $\sigma=1.263\sqrt{T_0/T_\sigma}$, T_0 is initial pulse width, and root-mean-square width of encoded pulse $T_\sigma\approx T_0F/\sqrt{2}$, F is code length.

Although multiple undesired users interfere with the desired user, the total interference can be taken as the summation of independent multiple random processes whose probability density function is

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$$p_n(x)=\frac{x^{n-1}}{\sigma^{2n}(n-1)!}e^{-x/\sigma^2} \tag{2}$$

And when the number of undesired users is large, according to the central limit theorem

$$p_n(x)\approx N(n\sigma^2,n\sigma^4) \tag{3}$$

$N(\bullet)$ means gussian distributing

In the following we denote the photocurrent detected by the photodetector of the k^{th} receiver as the random variable Y^k, and I_{th} as the threshold of decoder. Then the bit error rate of such a system can be expressed as

$$BER=\frac{1}{2}[\Pr(Y^k>I_{\text{th}}\mid b_n^k=0)+ \\ \Pr(Y^k\leqslant I_{\text{th}}\mid b_n^k=1)] \tag{4}$$

where[3]

$$P_r(Y^k>I_{\text{th}}\mid b_n^k=0)=\sum_{n=1}^{N-1}\binom{N-1}{n}p^n(1-p)^{N-1-n}\bullet \\ \int_{I_{\text{th}}}^{\infty}\frac{1}{\sqrt{2\pi n\sigma^2}}e^{-\frac{(x-n\sigma^2)^2}{2n\sigma^4}}\mathrm{d}x \tag{5}$$

$$P_r(Y^k\leqslant I_{\text{th}}\mid b_n^k=1)=\sum_{n=1}^{N-1}\binom{N-1}{n}\bullet \\ p^n(1-p)^{N-1-n}\int_{-\infty}^{I_{\text{th}}}\frac{1}{\sqrt{2\pi n\sigma^2}}e^{-\frac{(x-n\sigma^2-1)^2}{2n\sigma^4}}\mathrm{d}x \tag{6}$$

where $p=\frac{1}{2}\bullet\frac{T_\sigma}{T_b}$, T_b is period of data source.

2 Numerical Results and Discussions

Fig. 2 shows the simulation curves of the BER versus threshold when F is 16, 64 and 128 respectively, with $T_0=1$ ps and $T_b=500$ ps for all users. It can be observed that the BER becomes better when F increases , and when threshold is 0.7 the best BER is obtained.

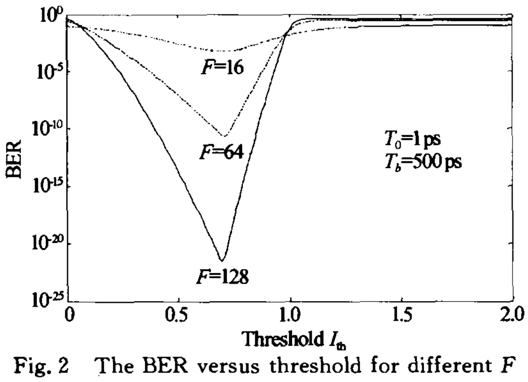

Fig. 2 The BER versus threshold for different F

Fig. 3 shows the curves of BER versus threshold when simultaneous users N is 20, 40 and 60 respectively, with $F=128$, $T_0=1$ ps and $T_b=500$ ps for all the users. The curves show that the BER is better with decreased N values. It also can be observed that the best BER is obtained when threshold is 0.7.

The curves of the BER versus N when F is 16 , 64 and 128 respectively are shown in Fig. 4 , with $T_0=1$ ps, $T_b=500$ ps and $I_{\text{th}}=0.7$ for all the users. A desired BER of 10^{-9} can be obtained when $F=128$ and $N=50$. This simultaneous users are enough to build into a local area network.

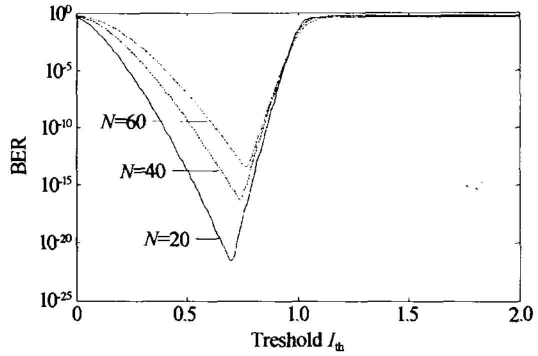

Fig. 3 The BER versus threshold for different simultaneous users

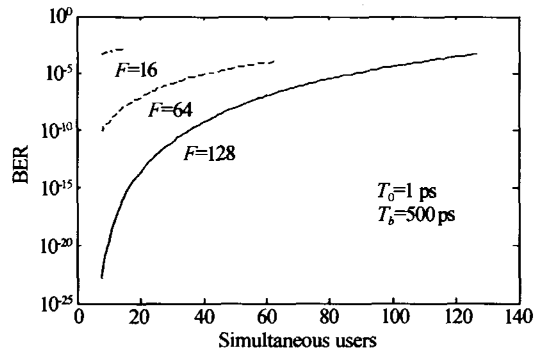

Fig. 4 The BER versus N for different F

Fig . 5 shows the BER versus N when T_0 is 6 ps , 3 ps, 1ps respectively, with $F=128$ and $T_b=500$ ps for all of the users. In this case we can observe that narrower pulse can provide better BER.

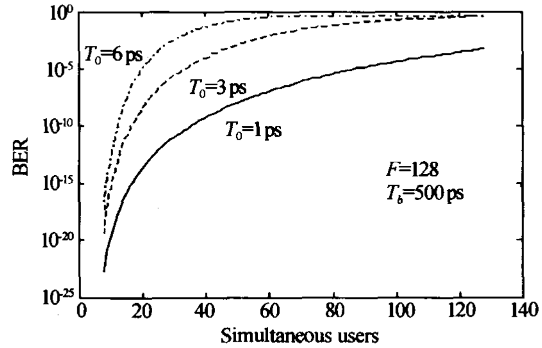

Fig. 5 The BER versus N for different T_0

3 Conclusion

The performance of the OCDMA system with encoder /decoder based on SCFBGs is presented. The shot noise and the thermal noise are neglected because the MAI is the main noise source in the system, and the unsuccessfully decoded pulse is assumed to be a Gaussian random process. Simulation result shows that the BER of system is depended on the code length, threshold and pulse width. Longer code length and narrow pulse improve the BER. And when threshold is 0.7, the best BER can be obtained for this OCDMA system.

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基于步进啁啾光纤光栅的编解码器的 OCDMA 系统性能分析

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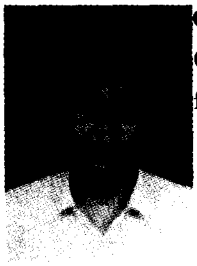
摘　要　本文对基于步进啁啾光纤光栅编解码器的 OCDMA 系统性能进行了分析，通过数值模拟得到系统性能与系统参数满足的关系，为改善系统性能提供可靠的依据．本文是对基于步进啁啾光纤光栅的 OCDMA 频阈相位编码一文的深化．

关键词　OCDMA；步进啁啾光纤光栅；系统性能；BER



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