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SAC-OCDMA with Zero Vector Combinatorial Code (ZVCC)

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Abstract

In this paper the performance of the incoherent SAC-OCDMA system using Zero Vector Combinatorial Code (ZVCC) has been observed by varying the code length and data rate. ZVCC is better than the other proposed code as it has small code length, accommodates more number of users and the design algorithm is simple. The results have been observed and analyzed in terms of BER. The simulated results show that the system at code weight 4 accommodates around 99 users at effective power -10dBm and as data rate is increased the BER degrades. The comparative study of the system using ZVCC with Zero Cross-correlation Code has been carried out. The results indicate that ZVCC truly performs better than ZCC code.

Keywords: *Optical Code Division Multiple Access (OCDMA), Zero Vector Combinatorial Code (ZVCC), Bit Error Rate (BER)*

1. Introduction

The success of fiber optic communication systems in past few years has shifted the focus of researchers from conventional communication systems to fiber optic system. The main concern of any communication system has always been the proper utilization of bandwidth and capacity enhancement of the system [1]. In order to enhance the capacity of the system many multiple access techniques like Time Division Multiple Access (TDMA), Wavelength Division Multiple Access (WDMA) etc. were being used in the traditional fiber optic communication system, but Optical Code Division Multiple Access (OCDMA) proved out to be the best alternative out of all. Unlike TDMA and WDMA, OCDMA does not require time or frequency management systems [1].

OCDMA offers several potential advantages in local area networks (LAN's) like more security due to use of optical codes, asynchronous transmission, variable data rate etc. OCDMA allows multiple users to access the channel asynchronously and also does not suffer from any kind of packet collisions [3]. Since packet collisions are reduced, thus the latencies or delays are less in OCDMA. Moreover in TDMA and WDMA, due to proper synchronization

requirement, the hardware is more complex and to no allocation or synchronization requirements the designing of a network based on OCDMA scheme is more flexible. The demand of high data rate has increased with time as more number of users are accessing the system and high speed application are being used for the exchange of data. Hence a system should be able to provide multiple accesses with high data rate. In this paper the effect of variable data rate on BER is analyzed.

The key to an effective OCDMA system is the choice of the code family being used for encoding and decoding of the signal [6]. Since in OCDMA, optical coding is used hence the only concern is the use of appropriate code set with maximum auto correlation and zero cross correlation properties. Till now many codes have been studied, implemented and analyzed but out of all Zero Cross-correlation Code (ZCC) has proved to be the best.

The system using ZCC gives better results than other codes like, MFH, MDW etc., in terms of SNR and BER but still there is scope for improvement as the system performance is limited by large code length and complex the algorithm used for designing. Hence the focus has been shifted from ZCC to ZVCC (Zero Vector Combinatorial Code) set which was proposed recently, as ZVCC has low code length and simple design algorithm [4].

In this paper the main aim is to observe the variation of data rate on the performance of incoherent SAC-OCDMA system using ZVCC, in terms BER.

2. System Specifications

The incoherent SAC-OCDMA system using ZVCC has been simulated using MATLAB 7.8. The system specifications considered are: Δv = 3.75 THz; R_L = 1030 Ω; bit rate = 160 Mbps; T_r = 300 K; photodiode efficiency 0.6; B = 80 MHz and central frequency wavelength 1550 nm [3]. In previous research many codes like MFH, MDW, ZCC etc, have been proposed and simulated, but out of these codes ZVCC has proved out to be the best suited code for Incoherent SAC-OCDMA system, in terms of BER and SNR [5].

BER of Incoherent SAC-OCDMA system can be easily calculated using the equation given as:

$$BER = P_e = \frac{1}{2} erfc\left(\sqrt{SNR/8}\right)$$

Where erfc is the error function given as

$$erfc(x) = \frac{2}{\sqrt{\Pi}} \int_x^{\infty} e^{-u^2} du$$

Where, 'u' is the unit step function.
The effect of variable code length on the system performance has also been simulated.

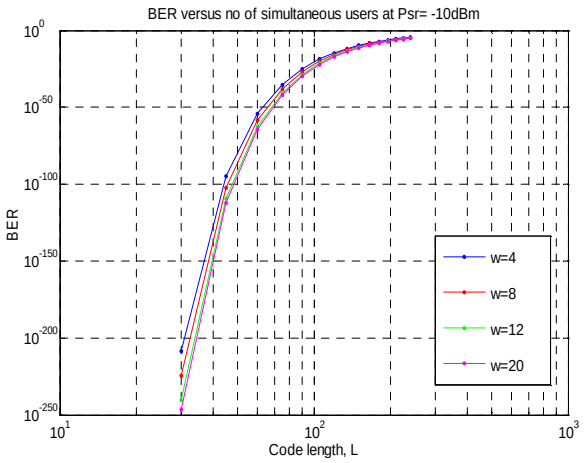

Fig.1 Effect of code length on BER of SAC-OCDMA system

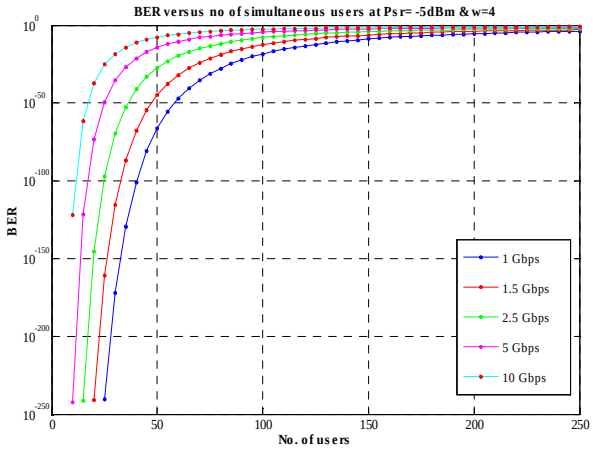

Fig 2: Effect of data rate on BER with P_{sr} = -5dBm & w=4 for ZVCC

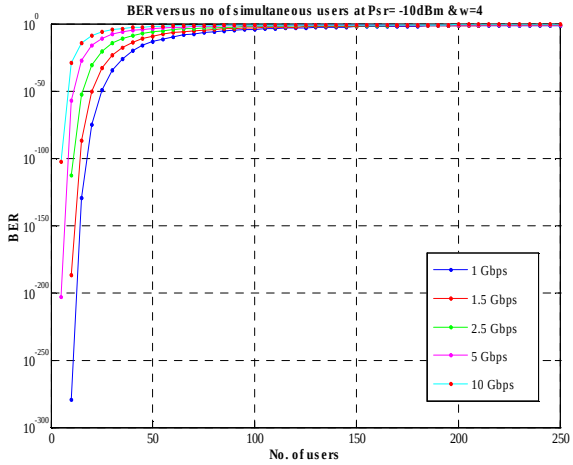

Fig 3: Effect of data rate on BER with P_{sr} = -10dBm & w=4 for ZVCC

As the code weight is increased, the code length also increases, in this way more number of users can be accommodated but along with this the error probability also increases, i.e the system performance degrades.

Fig.1 clearly shows that as the code weight is increased, the code length is increased and the system performance degrades with the increase in number of users. The effective power considered for the simulation is -10dBm. It is observed that for typical acceptable BER of 10^{-9}, the number of users accommodated is 99, and with the increase in code weight the BER is increased to 10^{-250} which is far better than 10^{-9}.

Fig.2 & Fig.3 clearly illustrates that in order to exploit the bandwidth, if the data rate is increase, the system performance degrades severely. It is also shown in the graphs that if the effective power is equal to -10dBm, the system improves in terms of BER.

From Fig.3, it is illustrated that as the data rate is increased to 10Gbps, the BER degrades to approximately 10^{-100}. When the effective power is increased from -10dBm to -5dBm , both shot noise and thermal noise are negligible but the effect of phase induced intensity noise (PIIN) is more dominant , which becomes the main factor in degradation of the system performance.

Thus it can be easily concluded form the simulation results that the sytem performance degrades with an incraese in data rate, but at the same time it is possible to accommodate more number of user, at same system parameters. Further the results of the system using ZVCC is compared with the system using ZCC, in order to observe the effect of varying the data rate of each user on the systems.

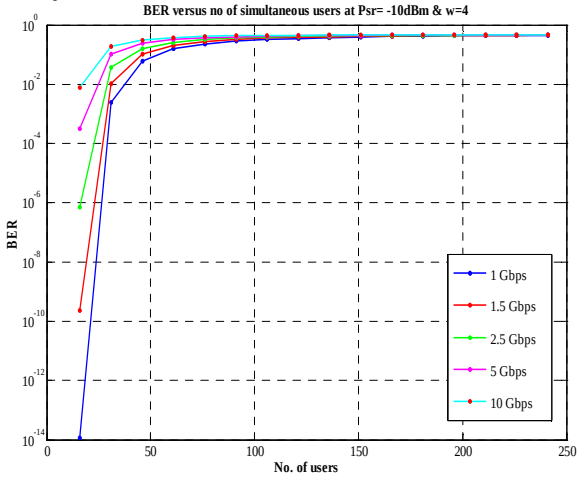

Fig.4 Effect of data rate on BER with P_{sr}= -10dBm & w=4 for ZCC

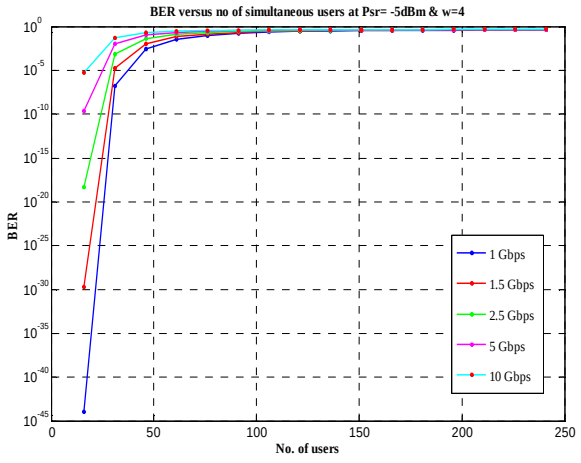

Fig.5 Effect of data rate on BER with P_{sr}= -5dBm & w=4 for ZCC

It is clearly illustrated in Fig.4 and Fig.5 that when the effective power is -5dBm and code weight is 4, at data rate i.e. 1Gbps, the BER is around 10^{-45} for ZCC which is far higher than 10^{-250} for ZVCC at the same parameters. Thus from the Fig.5 it can be concluded that a system using ZVCC shows better system performance in terms of BER.

3. Conclusions

In this work the two factors considered for the evaluation of the system performance are code length and data rate. It is concluded that when code length is increased more number of users are accommodated but at the same time BER increases which degrades the system performance. Moreover with the increase in the data rate the BER of the system degrades drastically.

ZVCC allows differentiated levels of services at the physical layer but do not allow QoS guarantees to be provided. No node in the local area network can assure that the level of service will not fluctuate as the network condition changes. The solution is to design a CDMA network with ZVCC to compensate for the degraded QoS, when new users are admitted. With the use of ZVCC, the multiple user interference is also eliminated.

Moreover from the comparative study of the system using ZVCC and ZCC, it is observed that ZVCC outperforms ZCC in terms of BER.

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