ISSN: 2455 - 9172

EIJO Journal of Engineering, Technology And Innovative Research (EIJO–JETIR)

Einstein International Journal Organization (EIJO)

Available Online at: www.eijo.in

Volume – 4, Issue – 2, March – April -2019 , Page No. : 01 - 07

Performance analysis of SA-OCDMA Systems

Poonam[1], Prashant Kumar Singh[2]

Jaipur Institute of Technology-Group of Institutions Jaipur, India

Abstract

In this paper we simulate the incoherent spectral amplitude optical code division multiple access (SA-OCDMA) system with three simultaneous users. The effect of dispersion on the bit rate and fibber length is analyzed. In our analysis the intensity noise suppression was performed by adding the semiconductor optical amplifier (SOA) in each individual channel and estimates the optimum fiber length according to input and received optical power. The performance of the system tested by using the BER and eye diagram criteria

Keywords: Optical code division multiple access (OCDMA), Spectral amplitude coding (SAC), Diagonal Eigen value Unity (DEU)

Introduction

CDMA is used in optical domain, it is referred to as optical CDMA (O-CDMA). OCDMA is an alternative optical multiplexing technique which has many features such as optical transparency to data format and rate, flexible asynchronous access and improved cross-talk performance. Also, it provides much higher speed for data transport and routing than the conventional electronics technologies. Therefore, OCDMA is a promising technology for next generation ultra high speed, cost effective broadband access network [6].The implementation of the SAC-OCDMA system was done with the help of codes and there were many code families available like OOC, Prime Codes, Modified Double Weight (MDW) code, Hadamard code and Modified Frequency Hopping (MFH) code [2]. Comparison of all these codes was done for number of users being 30. The results reveal that the MDW codes are better than the Hadamard and MFH codes because MDW codes have code lengths larger although the code weight was less. The LEDs were also used as theoptical sources in the SAC-OCDMA system [3]. For the code weight 4 the number of users was made to vary from 12 to 48 for the LED power of -16.77dBm. Moreover, LEDs were preferred because their outputs were composed of many wavelengths compared to lasers where one laser gave only wavelength. The presentation of SAC-OCDMA system was more accurately made to analysis the mean and the variance of the decision current [9].

Most of the researchers used the upper and the lower bound to obtain the BER. At the receiver side the balanced detection was used for the recovery of the data where upper branch detected the codeword 1 and the lower branch detected the complement of the codeword 1. The currents from the upper and the lower branches were subtracted to get the decision current which was further compared with the threshold current. The derived BER was evaluated numerically and compared to upper and lower bounds of the BER for two different SAC-OCDMA codes that was Modified Quadratic Congruence (MQC) code and Walsh Hadamard code. To reduce MAI the simplest technique used was the direct detection technique for ZCC code in an OCDMA system [8].

Literature Survey

The implementation of the SAC-OCDMA system was done with the help of codes and there were many code families available like OOC, Prime Codes, Modified Double Weight (MDW) code, Hadamard code and Modified Frequency Hopping (MFH) code [2]. The results reveal that the MDW codes are better than the Hadamard and MFH codes because MDW codes have code lengths larger although the code weight was less. Moreover, the MDW codes had cross correlation value 1, high signal to noise ratio (SNR) and gave BER up to 1012 for 10 Gbps communication system. The LEDs were also used as the optical sources in the SAC-OCDMA system [3]. The results revealed that the ZCC codes performed better than other codes as they accommodated up to 100 active users while having BER 109. Moreover, LEDs were preferred because their outputs were composed of many wavelengths compared to lasers where one laser gave only wavelength. The presentation of SAC-OCDMA system was more accurately made to analysis the mean and the variance of the decision current [9].The derived BER was evaluated numerically and compared to upper and lower bounds of the BER for two different SAC-OCDMA codes that was Modified Quadratic Congruence (MQC) code and Walsh Hadamard code. To reduce MAI the simplest technique used was the direct detection technique for ZCC code in anOCDMA system [8]. The performance of the OCDMA system using the direct detection totally eliminated the MAI and PIIN. The OOCs were used in the implementation of the OCDMA system for communicating over the atmosphere [4]. The results showed that the code family used along with the multi-level signaling made an OCDMA system less prone to MAI and increased the throughput significantly which resulted in improvement in QoS. The different data formats could be used in the OCDMA system like Non Return to Zero (NRZ) and Return Zero (RZ) data formats [7]. Both the data formats were used for the AND as well as Modified AND detection techniques and the performance were analyzed. It was found that the NRZ data format yielded better results than RZ data format but the type of the detection technique used matters more in suppression of MAI and PIIN. The Prime codes were employed for the MAI cancellation for an OCDMA system [10].

Code Properties

In linear algebra, a diagonal matrix is a matrix (usually square matrix) in which the entries outside the main diagonal are all zero. The diagonal entries themselves may or may not be zero. Thus, the matrix D = (di,j)with n columns and n rows is diagonal if: [1]

$$d_{i,j} = 0 if i = / j \forall i, j \in \{1, 2, ..., n\} \quad (1)$$

Eigenvectors and Eigen values

The eigenvectors of a square matrix are the non-zero vectors that, after being multiplied by the matrix, remain parallel to the original vector. Let V be a vector space, and let A be a linear operator in vector space V, then the vector x is called eigenvector of the operator A if there is exist a number which is called Eigen value such that [1]:

$$A(x) = \lambda x \quad (2)$$

Jordan form (JF) If A has s independent eigenvectors, then the matrix JF has Jordan block on its diagonal,which can be written as:

$$JF = \begin{bmatrix} j_1 & .. & .. \\ .. & .. & .. \\ .. & .. & j_s \end{bmatrix}$$

Spectral Amplitude Coding (SAC)In spectral amplitude coding (also known as frequency encoder CDMA) the available optical source spectrumis divided into multiple spectral sliced (chip) that are then used to form a given user code spectrum (A(w))as shown in gure (1) [5]. In spectral amplitude coding optical CDMA systems the frequency slots of di erentuser will always be in use and multiuser interference can be completely canceled out as long as the used code((0,1) sequences) satisfy the following conditions :

1. All the code words have the same weight W (de ned as the number of '1"s in it.

2. For every two different codeword (X) = (X1, X2,….. Xn) and (Y) = (Y1, Y2,…..Yn)

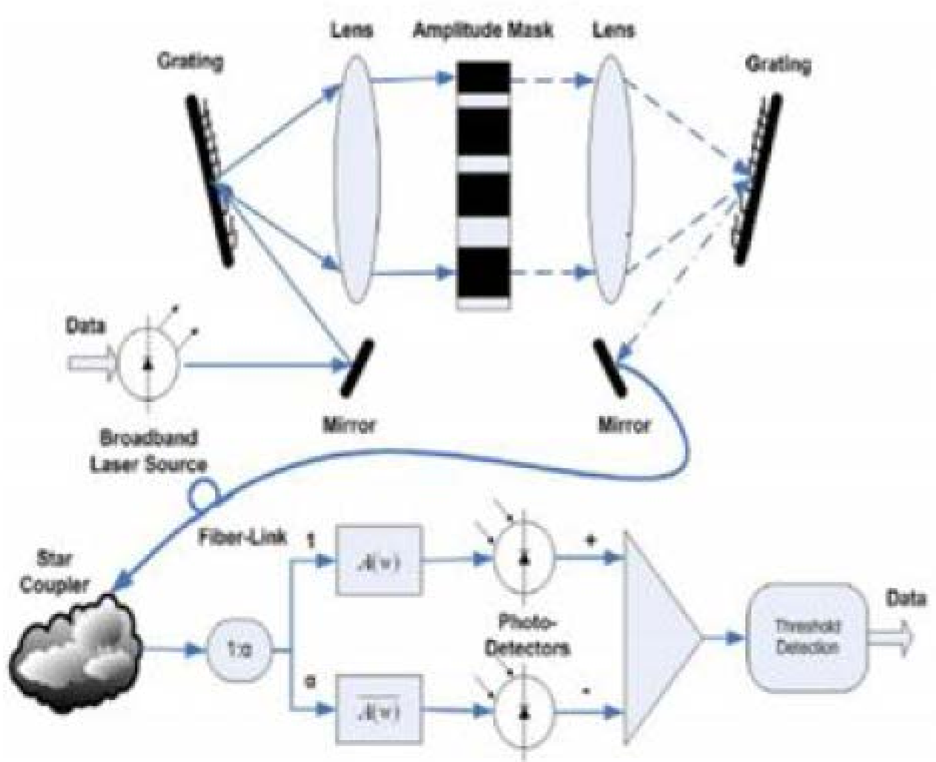

Fig. 1. Principle of the SAC-OCDMA scheme

We have

$$\theta_{xy} = \sum_{i=1}^{N} X_i Y_i = \lambda \quad (3)$$

Where λ is a constant. Indeed any receiver that compute

$$\theta_{XY} = [\lambda/(w-\lambda)]\theta_{XY}$$

Will then reject the interference from any user having sequence (Y) where)]

$$\theta_{XY} = \sum_{i=1}^{N}(1-X_i)Y_j = (w-\lambda)$$

Modified Prime Sequence Codes

The prime codes are a set of code sequences with code length p2 derived from prime sequences, where p isa prime number. Elements of a prime sequence can be obtained by multiplying each element in the Galoiseld GF(p) = 0, 1, , p-1 by a preset number chosen from GF(p). Hence, there are p prime sequences. The modified prime sequence (MPS) codes are generated from prime codes using time shifting property. Taking prime sequence PSx=(PSx,0 ,PSx,1 ,PSx,2 PSx,j PSx, (p-1)) and rotating it by p-1 times creates new prime sequences

$$PSx,r = (PSx,r_{,0}\ , PSx,r_1, PSx,r_2 \cdots PSx,r,j \cdots PSx,r,(p-1)).$$

,

Table 1. Modified prime sequences for GF (5)

Group 0	Group 1	Group 2	Group 3	Group 4
00000	01234	02413	03142	04321
44444	12340	24130	31420	43210
33333	23401	41302	14203	32104
22222	34012	13024	42031	21043
11111	40123	30241	20314	10432

A mapped code sequence PSx,r= (PSx,r,0 ,PSx,r,1 ,PSx,r,2 PSx,r,j PSx,r,(p-1)).

Performance Analysis

An expression for the SNR and BER performance of the SACOCDMA system can be represented by [3]

$$SNR = \frac{\frac{R^2 P_s^2 W^2}{N^2}}{2eBP_s R\frac{wk}{N} + \frac{4k_B T_N B}{R_L}} \qquad (4)$$

Here, R is the responsively of the photodiode and is given by R = (e) / (hfc), where h is the planks constant (6.626×10^{-34}), fc is the frequency of the broad band optical pulse in Hz, is the quantum efficiency (0.6),e is the electronic charge $(1.602 \times 10^{-19}C)$, Ps is the effective source power at the receiver in watts, KB is Boltzmanns constant (1.379×10^{-23}), , RL is the Load resistance in ohms 1030 and Tn is Absolute Temperature in degrees Kelvin 300K. The bit error rate (BER) performance of the system can be calculated from signal to noise ratio using

$$BER = \frac{1}{2} erfc \sqrt{\frac{SNR}{8}} \quad (5)$$

Where erfc - complementary error function.

2D-Deu System Performance

By considering the PIIN, shot and the thermal noises and using the Gaussian approximation, we can estimatethe Bit Error Rate (BER) The photocurrent noise is expressed as:

$$(i^2) = (i^2_{short}) + (i^2_{PIIN}) + (i^2_{thermal}) = i_r^2 B\tau_c + 2eBI_{total} + \frac{(4K_bT)}{R_L}$$

where I_r and I_{total} are the average and the total photo currents, B, K_b, T, R_l represent the electric and width, Boltzmanns constant, the absolute temperature, and the load resistance, respectively. c is the coherent time of light incident to the photo diode (PD). It can be written as a function of power spectral density (PSD) noted G(f) of the light incident to the PD

$$\tau_c = \frac{\int_0^\infty G^2(f)df}{[\int_0^\infty G^2(f)df]^2} \quad (6)$$

All spectral components received by different users have the same power; Broadband light sources are ideally unpolarized and have a flat spectrum over $[f0 - \Delta f/2, f0 + \Delta f/2]$, where f0 and Δ f are the central frequency and the bandwidth, respectively. Based on these assumptions, the PSD of the received optical signals is expressed as:

$$S_0(f) = \frac{P_{Sr}}{P_2 \Delta f} \sum_{k=1}^{k} d(k) \sum_{i=0}^{m-1} \sum_{j=0}^{p-1} a_{mn}^{(0)} a_{g,h}(K) * F(f,i) \quad (7)$$

$$S_1(f) = \frac{P_{Sr}}{(P_1 - 1) P_2 \Delta f} \sum_{k=1}^{k} d(k) \sum_{i=0}^{m-1} \sum_{j=0}^{p-1} a_{mn}^{(1)} a_{g,h}(K) * F(f,i) \quad (8)$$

$$S_2(f) = \frac{P_{Sr}}{(P_2 - 1) P_2 \Delta f} \sum_{k=1}^{k} d(k) \sum_{i=0}^{m-1} \sum_{j=0}^{p-1} a_{mn}^{(2)} a_{g,h}(K) * F(f,i) \quad (9)$$

$$I_0 = \frac{RP_{Sr}}{P_2 M} \left[P_1 P_2 + 2P_1 \frac{k-1}{c-1} + 2P_2 \frac{k-1}{c-1} + 4\frac{k-1}{c-1} \right] \quad (10)$$

$$I_1 = \frac{RP_{Sr}}{P_2 M} \left[2P_2 \frac{k-1}{c-1} + 4\frac{k-1}{c-1} \right] \quad (11)$$

$$I_2 = \frac{RP_{Sr}}{P_2 M}\left[2P_1\frac{k-1}{c-1} + 4\frac{k-1}{c-1}\right] \quad (12)$$

$$I_3 = \frac{RP_{Sr}}{P_2 M}\left[4\frac{k-1}{c-1}\right] \quad (13)$$

Where, R is the photodiode responsively.
Thus, the average output received photocurrent (I_r) can be expressed as:

$$I_r = I_0 + I_3 + -I_1 - I_2 = \frac{RP_{sr}}{M}P_1 \quad (14)$$

Conclusions

This paper deals with the design procedure and performance analysis of four kinds of novel code families, namely,

1. Split-expand modified prime codes
2. Single weight zero cross-correlation codes
3. Constant weight variable length prime codes
4. Variable length variable weight prime codes

From the analysis of SAC-OCDMA systems with SEMP codes, it is found that they have the simple code construction procedure, higher cardinality and low cross-correlation value. The bit error rate is analyzed with respect to k and Ps by considering the presence of phase induced intensity noise, shot noise and thermal noise. The proposed SEMP codes support Mp2 number of users. Further, for the given bit error rate of 10-9,p=21 and M=7, the proposed code family can support a maximum of 150 number of simultaneous users and this number is only 75 and 110 by the systems with MQC (p=21) codes and PMP (p=21 and M=7)codes respectively. When p=7 and M=7, SEMP supports 140 simultaneous users but MQC (p=7) and PMP (p=21and M=7) codes respectively supports 49 and 110 users. Also, BER is analyzed in terms of effective source power with p=21 and M=7 or 5 when the number of simultaneous users is 100.

Future Scope

Thus, in this thesis, some new code families are constructed for SAC-OCDMA system to completely eliminate the effects of MUI and PIIN and the performance is analyzed by taking the effects of PIIN, shot noise and thermal noise. So, in future, the performance can be analyzed by considering the other photo detector impairments like surface leakage current and dark current. Also, suitable encoder/decoder architecture can be designed for the proposed codes. Further, these codes can be tested for use in wireless optical systems. Some of the other analyzes techniques like analyzes of the materials which are used for fabricating the optical sources and detectors, analyzes of suitable optical amplifiers and analyzes of encoder/decoder circuit with suitable optical devices can be introduced to reduce the PIIN and to improve the system performance. Also, since spectrum slicing plays an important role in encoding of the spectrum, new methods can be studied for use in SAC-OCDMA system.

References

1. H. Y. Ahmed and K. Nisar, \Reduction of the _ber dispersion e_ects on mai for long span high-speed ocdma networks using diagonal eigenvalue unity (deu) code," Optik-International Journal for Light and Electron Optics, vol. 124, no. 22, pp. 5765{5773, 2013.

2. S. Aljunid, M. Ismail, A. Ramli, B. M. Ali, and M. K. Abdullah, A new family of optical code sequences for spectral-amplitude-coding optical cdma systems," IEEE photonics technology letters, vol. 16, no. 10, pp. 2383, 2385, 2004.

3. M. Anuar, S. Aljunid, A. Arief, and N. Saad, \Led spectrum slicing for zcc sac-ocdma coding system," in High-Capacity Optical Networks and Enabling Technologies (HONET), 2010. IEEE, 2010, pp. 128{132.

4. M. Jazayerifar and J. A. Salehi, \Atmospheric optical cdma communication systems via optical orthogonal codes," IEEE transactions on communications, vol. 54, no. 9, pp. 1614,1623, 2006.

5. M. M. Karbassian, \Design and analysis of spreading code and transceiver architectures for optical cdma networks," Ph.D. dissertation, University of Birmingham, 2009.

6. X. Lu and R. T. Chen, \Polymeric optical code-division multiple-access (cdma) encoder and decoder modules," Polymers, vol. 3, no. 3, pp. 1554{1564, 2011.

7. M. Norazimah, S. Aljunid, H. M. Al-Khafaji, H. A. Fadhil, and M. Anuar, \Performance of different sac-ocdma detection schemes with nrz and rz data formats," in 2013 IEEE Symposium on Industrial Electronics & Applications. IEEE, 2013, pp. 66-70.

8. C. Rashidi, M. S. Anuar, and S. Aljunid, \Study of direct detection technique for zero cross correlation code in ocdma," in Computer and Communication Engineering (ICCCE), 2010 International Conference on. IEEE, 2010, pp. 1-5.

9. H. M. Shalaby, \Closed-form expression for the bit-error rate of spectral-amplitude-coding optical cdma systems," IEEE Photonics Technology Letters, vol. 24, no. 15, pp. 1285,1287, 2012.

10. M. H. Zoualfaghari and H. Ghafouri-Shiraz, \A novel multi user interference cancellation scheme for synchronous ocdma networks," Journal of Lightwave Technology, vol. 31, no. 11, pp. 1813{1820, 2013.