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Original research article

Development and performance analysis zero cross correlation code using a type of Pascal's triangle matrix for spectral amplitude coding optical code division multiple access networks

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ABSTRACT

In this paper a new method to construct zero cross correlation code with the help of Pascal's triangle pattern called Pascal's Triangle Matrix Code (PTMC) for Spectral Amplitude Coding Optical Code Division Multiple Access (SAC-OCDMA) system is successfully developed. The advantages of this code are simplicity of code construction, flexibility of choosing code weight, number of users and acceptable code length. The numerical comparison shows that the newly constructed code is better code length than the existing codes such as Optical Orthogonal Code (OOC), Hadamard, Modified Frequency Hopping (MFH) and Modified Double Weight (MDW) codes and it supports more users than other Optical Spectrum Code Division Multiple Access (OSCDMA) codes.

1. Introduction

The primary feature that distinguishes Optical Code Division Multiple Access from other multiple access techniques is that usage of orthogonal codes to permit multiple users to permit the same overlapping spectral range without interfering with each other. While the Multiple Access Interference (MAI) problems existing in OCDMA systems. In OCDMA system, due to the overlapping spectra of different users the phase induced intensity noise (PIIN) is sturdily related to (MAI) [1].The multiple access interference can be removed by balance detection scheme but the PIIN from spontaneous emission of broad band source, is integrally remains. For the reason the researchers carry attention to develop the code word in which the effect of MAI and PIIN of the total received power is reduced [2,3].

The basic multiple access techniques are Wave Division Multiple Access (WDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). The main limitations of TDMA and WDMA technologies are it allows multiple users to access a channel by allocating time slots and allocating wavelength or frequency to each user within each channel respectively. Also, both technologies have a limited bandwidth for every user. The advantages of OCDMA systems are that the minimization of cross correlation to reduce a lesser value [4–7]. Although, the benefits of codes with zero cross correlation

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have less noise, which reduce the hardware complexity. Many of papers appeared in literature to study and analyze the performance of zero cross correlation code.

In [2] authors developed a new code structure for SAC-OCDMA system with zero cross-correlation. They showed that the zero cross correlation code that eliminate the PIIN and improve the system performance significantly.

The zero vectors combinatorial code family for spectral amplitude coding based on combination of specific vectors with combinatorial theories is presented in [8].The proposed code have the advantages of flexibility of choosing the number of users and weights.

Garadi Ahmed and Ali Djebbari [9] proposed a new technique for constructing zero cross correlation codes (ZCC). To overcome the difficulties of code weight selection such as weight W more than one, the weight is always fixed to the maximum number of users (i.e. the code size) authors constructed an efficient code word.

M.S.Anuar et al. [10] suggested a zero cross-correlation code to reduce the impact of system impairment and MAI in spectral amplitude coding optical code division multiple access system. They showed that the established system not only preserves the capability of suppressing MAI, but also improves bit error rate performance as compared to conventional codes.

Recently K.S. Nisar [11] constructed the zero cross correlation code using a type of anti-diagonal identity column block matrices. The newly constructed zero cross correlation code showed that the code has acceptable code length and it adjust more users than other OSCDMA codes.

In this paper, we present a new zero cross correlation code with the help of Pascal's triangle called Pascal's type Triangle Matrix Code (PTMC) to improve the performance of optical network. The gains of the new zero cross correlation codes are: i) any positive integer number of code weight; ii) larger flexibility in choosing the number of users (free cardinality); iii) easy way of code construction using Pascal's type triangle pattern; and iv) Cross correlation is equal to zero. The paper is organized as follows: The basic definitions of Pascal's triangle, Pascal's type triangle matrix, left Pascal's type and right Pascal's type matrix pattern, their properties are given in Section 2. The code construction and code properties of the codes are offered in Section 3. Comparison with reported codes and discussions are given in Section 4. Finally, conclusion is given in Section 5.

2. Definitions and properties

2.1. Pascal's triangle

In mathematics, Pascal's triangle is a triangular array of the binomial coefficients. The rows of Pascal's triangle are conventionally enumerated starting with row $n = 0$ at the top. The entries in each row are numbered from the left beginning with $k = 0$ and are usually staggered relative to the numbers in the adjacent rows. The Pascal's triangle construction is associated to the binomial coefficients by Pascal's rule, which says that if

$$(x+y)^n = \sum_{k=0}^{n} \binom{n}{k} x^{n-k} y^k$$

Then $\binom{n}{k} = \binom{n-1}{k-1} + \binom{n-1}{k}$, for any non-negative integer n and any integer k between 0 and n.

The following pattern shows the first six rows of Pascal's triangle [12,13]

$$\begin{array}{ccccccccccc} & & & & & 1 & & & & & \\ & & & & 1 & & 1 & & & & \\ & & & 1 & & 2 & & 1 & & & \\ & & 1 & & 3 & & 3 & & 1 & & \\ & 1 & & 4 & & 6 & & 4 & & 1 & \\ 1 & & 5 & & 10 & & 10 & & 5 & & 1 \end{array}$$

Now, we define the following

2.2. Pascal's type triangle matrix (PTM)

By considering the binary numbers, the Pascal's type triangle Matrix starts from second row of Pascal's triangle constructed as follows; *i*) replace all the numbers other than 1 by 0, *ii*) Fill the outer branches of the triangle by 0. A 4×8 Pascal's type matrix starting from second row of Pascal's triangle as follows

$$(PTM)_2 = \begin{bmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$