Design and Analysis of Two - Code Keying Approach based on MD code to Improve the Performance of OCDMA System

Mukesh kumar¹, Umesh Kumar Tiwari², Kanika Sharma¹, Sandeep Singhai²
ECE Department, NITTTR, Chandigarh, India¹
CSIR-Central Scientific Instruments Organisation, Chandigarh, India²

Abstract:
Two-code keying approach plays an important role to provide better security against eavesdroppers for OCDMA system. Basically, it is a bipolar coding approach to prevent the wire tapper before multiplexing the signal in the channel. In this paper, multi-diagonal codes are used for encoding the data and data bar in 2- code keying approach for OCDMA system Multi-diagonal code has zero cross correlation property; therefore the performance of OCDMA system based on 2- code keying approach is improved. The performance of the system is analyzed in term of quality factor and received optical power for variation of fiber length. Simulation results have shown by using an eye diagram and optical power meter.

Keywords: Multi-diagonal code, Optical code division multiple access (OCDMA) system, 2- code keying approach, Fiber Bragg grating.

I. INTRODUCTION
Twenty first century is era of optical communication. As the traffic is bursty in local area network (LANs), there is always a demand of high speed and large capacity communication. Optical network plays an important role to fulfill these demands with the help of various multiple access techniques [1]. Optical code division multiple access (OCDMA) system has a focus in optical fiber network development to get their desirable feature, such as support multirate service, extra high optical signal processing and efficient in bursty traffic [2]. OCDMA is a technology to realize multiplexing and multiple access by coding in optical domain that supports multiple simultaneous transmission in the same time slot and the same frequency [3]. Optical communication system has a variety of applications, such as personal, commercial and military communication [4]. The security of data is a requirement in communication system that meet by encoding the data, such a manner that decoding is difficult without some secret information, even if the coded or encrypted form of the data is easily read. Multiple access interference (MAI) is a serious problem in OCDMA system that limit the number of simultaneous users and produces floor to the bit error rate (BER). To avoid the effect of MAI on performance as well as low cost, spectral- amplitude coding, optical code division multiple access (SAC-OCDMA) system has been adopted. The basic block diagram of OCDMA system is shown in figure 1. Each transmitter consist of a data source and laser that convert the signal from electrical to optical pulse using a modulator, follow by an optical encoder which is mapped each bit into a very high rate optical sequence [5]. The encoded optical signal from all users is broadcasted floor to the bit error rate (BER). At the receiver side, all transmitted data signals are passed to each decoder. The original signal is recovered by correlating the incoming aggregate signal with a store code used in the encoding process. There are many types of optical network, ranging from local area network to optical network that form a backbone of the internet.

Fig. 1 Block diagram of OCDMA system

Although electromagnetic signature does not emit by the optical communication network, but any eavesdropper can eavesdrop the optical network using various approaches such as physical crosstalk from an adjacent channel [6]. Optical coding through OCDMA can provide confidentiality by originating from the encoding/decoding process and its multiplexing properties.

Table 1 Comparison of Different Properties of Codes for SAC-OCDMA System

<table>
<thead>
<tr>
<th>No</th>
<th>Codes</th>
<th>Number of zeros K</th>
<th>Weight W</th>
<th>Code length N</th>
<th>Cross Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OOC</td>
<td>30</td>
<td>4</td>
<td>364</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Prime code</td>
<td>30</td>
<td>31</td>
<td>961</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>RD</td>
<td>30</td>
<td>4</td>
<td>35</td>
<td>Variable λ in the code segment</td>
</tr>
<tr>
<td>4</td>
<td>MQC</td>
<td>300</td>
<td>8</td>
<td>56</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>MDW</td>
<td>30</td>
<td>4</td>
<td>90</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>EDW</td>
<td>30</td>
<td>3</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Walsh Hadamard</td>
<td>30</td>
<td>16</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>MD</td>
<td>30</td>
<td>2</td>
<td>60</td>
<td>0</td>
</tr>
</tbody>
</table>

There are various types of code which are used in encoding and decoding process such as OOK, Walsh Hadamard code, random diagonal code, multi diagonal code. Table 1 that shows a comparison of different properties of codes for SAC-OCDMA.

The Reminder of this paper is organized as follows; In section II, describe the analytical model for 2- code keying approach. Section III describes the proposed system and simulation setup for OCDMA system. In section IV evaluates the system performance in terms of eye diagram, received data, quality factor. In section V gives the conclusion of this paper.

II. ANALYTICAL MODEL FOR 2- CODE KEYING APPROACH

System confidentiality depends on the type of OCDMA code used. Apart from optical codes utilized, the data modulation format also contributes to the system confidentiality. On-off keying (OOK) approach used for modulation of data which consist of transmitting logic ‘1’ when data bit 1 is transmitting and nothing is transmitted for logic ‘0’. Since the energy level of bit 1 and 0 are different and can be easily distinguished using a photo detector even without a decoder.

There is some security vulnerability in the OOK OCDMA system. Security of OCDMA system is guaranteed only if the eavesdropper can tap into signal from the network after the OCDMA multiplexing because here the signal is present like a noise signal. So that eavesdropper cannot decipher the signal without knowledge of optical code. On other hand, if eavesdropper can tap the signal before the multiplexing at the end of transmitter of each user, even the data have been encoded using pseudorandom optical code, the eavesdropper could easily break the security by simple data rate power detection without any information about optical code.

Here a solution for the above problem that code can adopt 2-code keying approach, in this modulation technique, two different codes use to represent the bit 1 and bit 0 [9]. It is also known also bipolar coding. Figure 2 shows the block diagram of SAC-OCDMA transmitter and receiver based on 2-code keying approach when bit 1 transmitted; light is sent to encoder 1 while bit 0 is represented by light sent to encoder 2.

Step:1 First, let us construct a sequence of diagonal matrices using specific values of the weight W and the number of subscribers K. According to these values, we have the set i,jw.

Step:2 The MD sequences are computed for each diagonal matrix basing on the relations

\[ S_{i,jw} = \begin{cases} i_n + 1 - i, & \text{for } jw = \text{even number} \\ i, & \text{for } jw = \text{odd} \end{cases} \]  

Any element of the Siw Matrices represent the position of the one in Tij matrices with KxK dimensions. Where \( T_{i1} = [S_{i1}]_{kxk} \), \( T_{iw} = [S_{iw}]_{kxk} \), therefore we get

\[ T_{ij} = \begin{bmatrix} 0 & 1 & \cdots & 0 \\ 0 & 0 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 \end{bmatrix}_{kxk} \]

Step:3 The total combinational of diagonal matrices 3 represents the MD code as a matrix of power K x N.

\[ \text{MD} = [T_{i1}, T_{i2}, \ldots, T_{iw}]_{KxN} \]

In the basic matrix given by Eq. (2), the rows determine the number of users. Notice that the association between the code weight, the code length and the number of subscribers may be expressed as

\[ N = K \times W \]

Let us put, as an example, \( K = 4 \) and \( W = 2 \).

Then MD code matrix of power 4x8 is given below

\[ \text{MD} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \end{bmatrix} \]
Now, code word = \[
\begin{pmatrix}
\lambda_1, \lambda_8 \\
\lambda_2, \lambda_7 \\
\lambda_3, \lambda_6 \\
\lambda_i, \lambda_8
\end{pmatrix}
\]

Now, to implement these code words there have been many proposals using fiber Bragg grating (FBG). FBG is a type of distribution Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelength of light and transmit all other. FBG can be used as an inline optical filter to block certain wavelength or as a wavelength specific reflector [8]. FBG use as encoder/ decoder because it has some characteristics, its low insertion losses, stable operating point, easy integration and low priced material.

III. PROPOSED SYSTEM DESCRIPTION

The 2-code keying approach for OCDMA system implemented using MD code for one user is implementing in figure3. Fig 3 shows the transmitter side of 2-code keying OCDMA. The code length is 4 bit and weight is 2. A continuous laser array having equally spaced laser is used as a broadband light source. The range of laser array is 1550 nm to 1552.4 nm with 0.8 nm spacing. Here two different codes are generated by two branches using UFBGs to encode the data and data bar respectively. FBG based encoder/ decoder is recommended for reducing FWM effect present in optical system. Uniform FBG is a device that periodically modifies the phase or the intensity of a wave reflected on, or transmitted through it. Now combine these encoded signals using optical combiner and then transmit.

Fig. 3 Simulation setup for 2-code keying approach OCDMA for one users

There are some specific parameters which have been used in the proposed work, the data rate is 2.5 Gbps for various lengths of fiber with the ITU-T G.652 standard single mode fiber. All the attenuation (0.25db/km), dispersion (18 ps/nm km) and nonlinear effects were activated and specified according to the typical industry values to simulate the real environment as close as possible.

At the receiver side the received signal split into two different OCDMA decoders to decode the received bit ‘1’ and ‘0’and signals are detected by a photo diode. Figure 4 describes the decoder for user one.

IV. RESULTS & DISCUSSIONS

The simulation setup design for 2- code keying mechanism for OCDMA system on the optisystem 13. Here to encode the data FBG used as an encoder and multi-diagonal codes are used for coding. Using the simulation design the value of the input signal and wavelength spectrum, eye diagram and received output power are measured.

Figure 5 the wavelength spectrum of a laser array is 1550 nm to 1552.4 nm with 0.8 nm spacing.

Figure 6 (a) and 6 (b) shows the simulation of data and data bar. The code is used to modulate the data and data bar is used to modulate the data bar. In which a code is sent high bit of data and other code is sent for low bit of data.
When one user is transmitting the information using 2-code keying approach, then the eye diagram for a wiretapper is shown in figure 7. The eye diagram becomes the noise waveform due to 2-code keying mechanism. This means there is no intelligible signal at the wire tapper.

Figure 8 shows the output data pulse of an authorized user at the receiver side.

When FBG based encoder using with the multi-diagonal code the eye diagram is clear with the wide eye opening is observed at the authorized user as shown in figure 9.

When an encoder/decoder of 2-code keying approach is designed with multidimensional code instead of Walsh Hadamard code, then the effect of increasing length on the received optical power of the system is shown in figure 10.

Multi-diagonal code has zero cross correlation property. Figure 11 shows clearly that the quality factor has improved by using multidimensional code-based encoder as compared to Walsh Hadamard code-based encoder at different length of fiber.
In this paper, the implementation and simulation analysis of OCDMA is presented using 2-code keying approach for multi-diagonal code. Here to encode the data and data bar, FBG is used as an encoder to utilize its transmissive characteristics and multi-diagonal codes are used for coding, because multi-diagonal code has zero cross correlation property. The comparative analysis of proposed OCDMA system using 2-code keying approach improve the result in term of received optical power and quality factor. This shows that results are improved by 5.5% and 35% for received power and quality factor, respectively, with respect to hadamard code for 2-code keying approach at fiber length is 60 km. In continuation of this work, future work could involve the two dimensional code for encode the data with 2-code keying approach to improve the number of users, transmission length, quality factor.

V. REFERENCES


