110. Design Implementation and Performance Comparison of ZCC code and MDW code for 10Gbps Optical CDMA System

[1]Siddharth Vadhera, Vipul Singh[2]
[1]ECE Department, Jaypee Institute of Information Technology, A-10, Sector 62 Noida 201 307, Uttar Pradesh, India
siddharth.vadhera@gmail.com
[2]ECE Department, Jaypee Institute of Information Technology A-10, Sector 62 Noida 201 307, Uttar Pradesh, India
neoeahit@gmail.com

Abstract. OCDMA is an efficient method of optical communication in which Optical codes is used at transmitter end in order to encode the data and correspondingly it is decoded at receiver's end. Every user has a specific code through which it encodes the data and thus minimizes the error rate in the system. Here a comparison between the codes ZCC and DW is done. As these codes have a correlation value of either zero or close to the ideal value. In this research, we have designed a system to incorporate both these codes separately and analyse the performance on the basis of BER and Q-factor taking a 50km of fibre and sending the data at 10Gbps. Further, the results are analysed using eye diagram and signal diagram for both the above mentioned codes and it was observed that DW code support only 16 users whereas ZCC code supports 18 users with minimum BER as $^{e-9}$. The codes where constructed using MATLAB and implemented in Optisystem 7.0.

Keywords: Zero cross-correlation (ZCC), Double word (DW), Optical code division multiplexing (OCDMA), Multiple access interference (MAI), Optical communication, bit error rate (BER), Quality factor (Q-factor)

Introduction

The optical CDMA systems suffer from MAIs from other simultaneous users. As the number of simultaneous users increases, the bit error rate (BER) degrades because the effect of MAIs increases. In this method, our data is being encoded through time delays representing providing the necessary chip rate for the given code. Thus, similar time delay is employed at receiver's end in order to decode the incoming signal. Optical Fibre is used as a channel for sending information and thus, this type of communication is referred as OCDMA. All the data is sent through the same frequency but every user has a unique code through which data encryption is done and this reduces MAI, thereby supporting more number of users efficiently. In OCDMA system Phase Induced Intensity Noise (PIIN) is strongly related to MAI due to overlapping of spectra from different users [1]. Thus, ZCC codes and DW are compared in terms of BER and Q-factor for same number of users. Comparison is done between the eye diagram and signal diagram in order to find out which has a minimum MAI. The result is being simulated in optisystem7.0 for 50km fibre and 10Gbps bit rate maintaining the laser frequency at 193.1THz. This paper will follow the sequence given as under:-

In Section 2.0 code construction and properties are mentioned, Section 3.0 design of the system is being discussed and results is followed in Section 4.0

Code Construction

DW CODE

The DW code has a fixed weight of two. By using a mapping technique, codes that have a larger number of weights can be developed. Modified double-weight (MDW) code is a DW code family variation that has variable weights of greater than two [1]. Here we are not using MDW code because it has a code length more than that of DW code. So in order to make our system cost efficient we choose DW code rather than MDW code.

The proposed DW family can be constructed as follows:

This code is represented by using a matrix of size UxL where; U = number of users, L = code length.

The initial (basic) matrix for U = 2 and L = 3 is given as:

$$D1=\begin{bmatrix}0 & 1 & 1\\ 1 & 1 & 0\end{bmatrix}$$

D2= $\begin{bmatrix} 0 & D1 \\ D1 & 0 \end{bmatrix}$ D2= $\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$ D3=

And likewise DW matrix is constructed.

L = ½ U when U is even
L = ¼ U + ½ when U is odd

ZCC CODE

The ZCC code is derived from family of DW codes. The key to an effective OCDMA system is the choice of efficient address codes with good or almost zero correlation properties for encoding the source. The use of ZCC code can eradicate phase induced intensity noise (PIIN) which will contribute to better BER.

The proposed ZCC family can be constructed as follows:

This code is represented by using a matrix of size UxL, where U = number of users, L = code length.

The initial (basic) matrix for U = 2 and L = 2 is given as:

C1= $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

C2= $\begin{bmatrix} 0 & C1 \\ C1 & 0 \end{bmatrix}$ C2= $\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$ C3=

And likewise ZCC matrix is constructed.

$U = 2^T$; $L = 2^T$

Where T is the mapping process.

System Designing

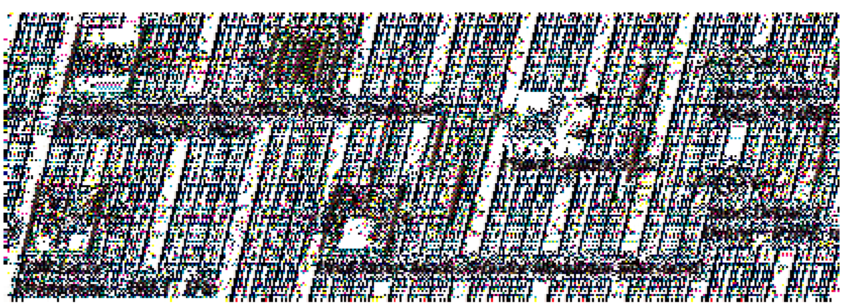

Fig 1: Transmitter circuit

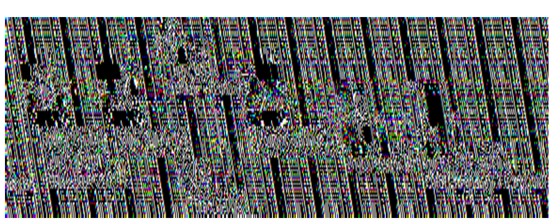

Fig 2: Receiver circuit

Bit Rate = 10Gbps
Time period of data = (1×10^{10}) ^-1 sec = (1×10^{-10}) sec

Table 1: System Parameters

Fibre Length	50km
Bit rate	
10Gbps Source Frequency	
193.1THz Attenuation	
0.2dB/km	
Filter cut-off frequency	0.75*Bit rate Hz
Dark Current	
5nA Number Of Users	
16	

Chip Rate = $\frac{(1\text{x}10^{-10})\ \text{sec}}{L}$

Time Delay = (Chip Rate) * (Y)
Where; Y = number of zeros sent in a coded sequence before a '1'.
Here to avoid complexity of system and making it cost efficient we minimum weight.
W = 1 (ZCC), W = 2 (DW).

Results and Discussion

It is evident from Fig 3(a) and 3(b) the major effect of MAI is on DW code as its eye diagram is not as wide as that of ZCC code when the fibre length is taken to be 50km and number of users are 16, data transmitting at the rate of 10Gbps. Here heavy weight codes are not included so that the designing of the circuit should be cost effective.

Based on the analysis of BER and Q-factor it is shown in the figure that ZCC is a better code having BER as (2.935×10^{-12}) and Q-factor as (6.86066) when U=16 compared to DW with BER as (6.8984×10^{-9}) and Q-factor of 6.03669.

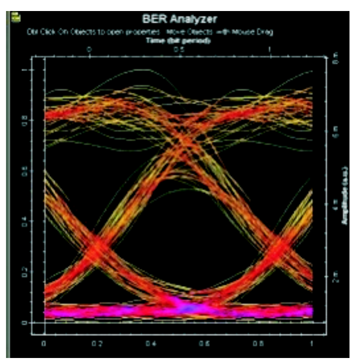

Fig 3(a):Eye diagram of DW code U= 16

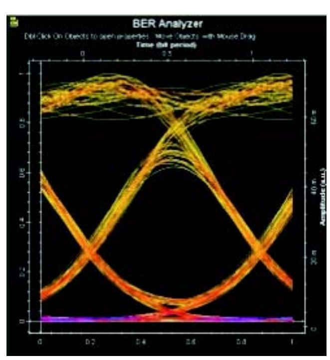

Fig 3(b): Eye diagram of ZCC code U=16

Fig 3(c): Variation of BER with increasing users

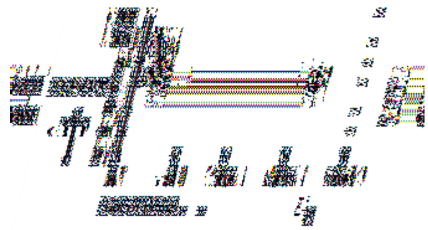

Fig 3(c): Variation of Q-factor with increasing users

It is more evident from the signal diagram that loss in signal is more in DW code as that in ZCC code and also the amplitude has fallen in DW code as a result of which the output received in DW code has more noise as compared to that of data encoded by ZCC code.

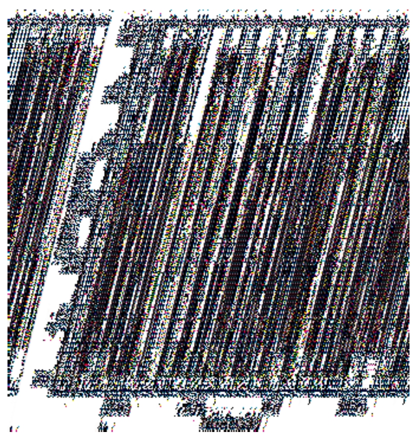

Fig: 4(a): Signal Diagram of DW code with U=16

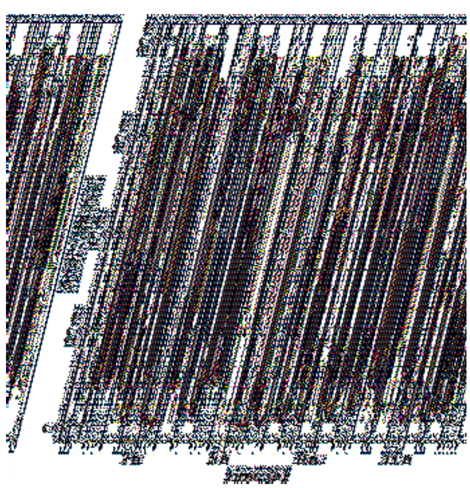

Fig: 4(B): Signal diagram of ZCC code with U=16

Conclusion

The OCDMA system so designed and implemented gives the result that ZCC code has a low BER of (2.935x) and high Q-factor of (6.86066) as compared to those results obtained from DW code with 10Gbps as the Bit rate and 50km as fibre length. This system supports about 16 users efficiently when DW code is applied and the users can extend to about 18 when ZCC code is used.

Acknowledgement

The authors are extremely thankful to Jaypee Institute of Technology, Noida for providing their necessary and priceless help and support without which this research would not be possible.

References

[1] S. A. Aljunid, et al: A New Family of Optical Code Sequences for Spectral-Amplitude-Coding Optical CDMA Systems, IEEE Photonics Technology Letters, vol. 16. No. 10, Oct 2004.

[2] S. V. Maric, Z. I. Kostic, and E. L. Titlebaum,, A New Family of Optical Code Sequences for use in Spread Fibre-Optic Local Area Networks, IEEE Trans. Communication, vol. 41, pp. 1217-1221, Aug 1993.

[3] P. Prucnal, M. Santoro, and F. Ting, Spread Spectrum Fibre-Optic Local Area Network Using Optical Processing, J. Lightwave Technol, vol. LT-4, pp. 547–554, May 1986.

[4] Kavehrad and D. Zaccarin, "Optical code- Division-multiplexed systems based on spectral encoding of noncoherent sources," J. Lighisruve Technol., vol. 13, pp. 534-545, Mar. 1995.

[5] A. Salehi. A. M.Weiner, and j. P. Heritage, "Coherent ultrashort light pulse code-division multiple-access communication systems," J LightsraveTechnol..vol.8 pp. 478-491, Mar. 1990.

[6] Zou Wei, H. Gbafouri-Shiraz, and H. M. H. Shalaby, "New code families for fiber-bragg-grating-based spectral- amplitude-coding optical cdma systems", IEEE Photonic Tech. Letters, VOL. 13, NO.8, pp890-892 August 2001

[7] Vincent J. Hernandez, Yixue Du, Wei Cong, Ryan P. Scott, Kebin Li, Jonathan P. Heritage, Fellow, IEEE,Zhi Ding, Fellow, IEEE, Brian H. Kolner, Senior Member, IEEE, and S. J. Ben Yoo, Senior Member, IEEE, "Spectral Phase-Encoded Time-Spreading (SPECTS) Optical Code-Division Multiple Access for Terabit Optical Access Networks, " J. Lightwave Technol., vol. 22, No. 11, November 2004

[8] V. J. Hernandez, et al., "Spectral phase-encoded time-spreading(SPECTS) optical code-division multiple access for terabit optical access networks," J. Lightwave Technol. 22, 2671-2679 (2005).