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Performance Analysis of 3D W/T/S MPR OCDMA System

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ABSTRACT: In this paper, a third dimension i.e. space is added in earlier proposed Wavelength/Time Multiple Pulses per Row (W/T MPR) codes. An OCDMA system is designed using the 3D W/T/S MPR codes by using zero transmission length of the system. The performance of this system is analyzed at different data rates. The simulation has been carried out on OPTSIM.

KEYWORDS: OCDMA Optical code division multiple access, 3D three dimensional, W/T/S MPR Codes Wavelength/Time/Space Multiple pulses per row codes, LAN Local area network.

I.INTRODUCTION

OCDMA is an asynchronous multiplexing technique used in bursty LAN environment. OCDMA codes play very important role in analysing the performance of OCDMA systems [1]. In the past many researchers have proposed codesets with different dimensions [2, 3, 5, 7]. We have designed 3D W/T/S MPR codes and using these codes 3D OCDMA system is analysed.

There have been various papers published related to OCDMA coding techniques. These codes based upon dimensions used can be divided as one dimensional, two dimensional and three dimensional codes. One dimensional codes are spread in time domain. But as the number of users increases the code length also increases which makes the system bulkier. To overcome the disadvantage of one dimensional codes, two dimensional codes are designed. Shivaleela et.al proposed 2D MPR codes. These codes have good cardinality, spectral efficiency and minimal cross correlation values [6]. Shurong et.al. proposed 2D codes which have good correlation properties [3]. Kim et.al. proposed 3D W/T/S codes based on prime sequence algorithm [7]. Jindal et.al. proposed 3D W/T/S codes based on Modal A and Modal B [4]. The codes proposed in this paper shows performance better than already existing codes. The performance analysis of these system has been done in terms of eye diagrams and BER.

This paper is organized as follows: In section II mathematical modelling of 3D W/T/S MPR codes is discussed. In section III design of OCDMA system using 3D W/T/S MPR codes is given with description of its optical encoder and decoder. In section IV performance of this OCDMA system is analysed. The conclusions are drawn in section V.

II. MATHEMATICAL MODELLING

The codes used in this work are 3D W/T/S MPR codes. W/T/S MPR codes can be characterized as by N(R X L_T X S, W, λ_a=1, λ_c=1) where, N is the number of codes, R is the number of wavelengths, L_T is the number of timeslots, S is no of code channels, W is the weight of the code, W_P = W/R is the weight per row, λ_a is the peak out-of-phase autocorrelation and λ_c is the peak cross-correlation.

The earlier proposed codes i.e. W/T MPR codes are further extended using space as third dimension. W/T/S 3D codes can be constructed by extending 2D W/T MPR codes [6]. For a fixed W/T MPR code, we can generate as many codes as we want by changing the spatial channel S. But the number of spatial channel is limited by number of wavelengths i.e. S ≤ R. So only fixed number of 3D codes can be generated but we can increase number of wavelengths used so number of spatial channels can also be increased.

In assigning wavelength to each spatial channel, we need to keep the orthogonality by constraining cross-correlation between any two codewords with different temporal distributions of pulses over spatial channels less than or equal to 1. Note that cross-correlation between any two codewords with the same temporal distribution cannot be greater than 1

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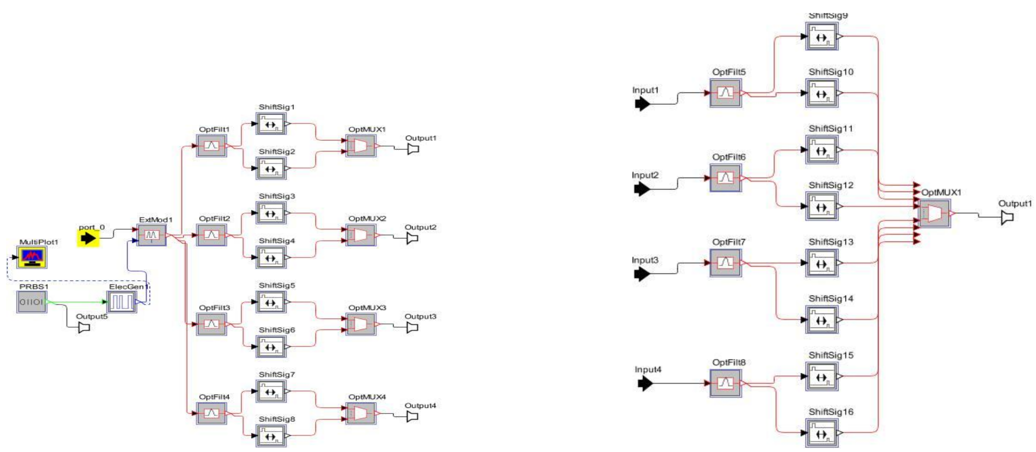
because of the orthogonality of the 2-D code. To extend 2-D codes to 3-D codes without losing orthogonality, we only need to assign wavelengths to each spatial channel such a way that any two distinct codewords have no more than one spatial channel of the same wavelength. Hence using method we can generate new 3D code.

III. DESIGN OF 3D OCDMA SYSTEM

Fig. 2 shows the schematic of 3D W/T/S OCDMA system for zero transmission length. In this system, W/T/S code is implemented when transmission length is 0 Km. This system is used to analyze the performance of the system when a 3D MPR code is implemented. This system has 4 wavelengths, 97 timeslots and 4 spatial channels. This system is supporting 8 active users simultaneously.

Fig. 2 Schematic of 3D OCDMA System.



(a) (b)

Fig. 3 Schematic of (a) Optical Encoder and (b) Optical Decoder.

Fig. 3 shows the schematic of optical encoder and decoder used in OCDMA system. Each signal in encoder is provided with time delay. This time delay can be calculated using equation 1.

Time delay= Code* Chip period, (1)

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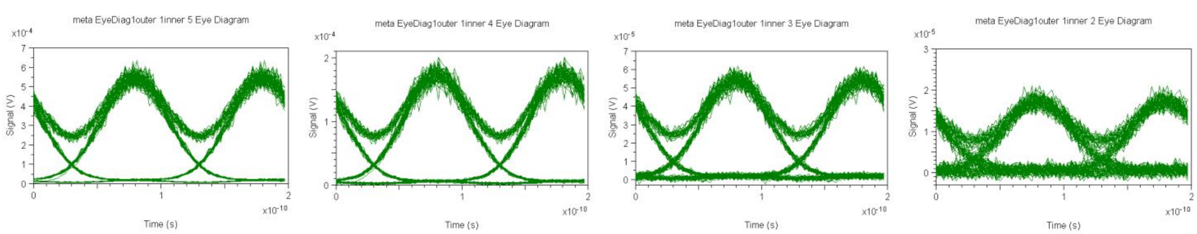
Where Chip period (T_c) = Bit period (T_b)/Total Number of Time slots (L_T).
In this system multiple pulses per row are used, so there will be multiple delays provided to each wavelength. Then signal from delay line are multiplexed.
Table 1 shows the parameters employed during the simulation of OCDMA System.

S. No.	Parameter	Value
1)	Bit rate	Variable
2)	Bit Period	1/ Bit rate
3)	Time slots	97
4)	Chip Period	Bit period/ Time slots
5)	Laser Wavelengths	1.55e-6 to 1.5524e-6
6)	Delta	8e-10
7)	Peak Power of Laser	0.003 W
8)	Rep Rate	5Gbps
9)	No. of Lasers	4
10)	Combiner loss	3dB
11)	Pattern Type	PRBS
12)	Pattern length	7 bits
13)	Pre bits	2
14)	Post Bits	3
15)	Fiber Attenuation	Variable in dB

Table 1. System Parameters of 3D W/T/S OCDMA System.

IV. RESULT AND DISCUSSION

The system uses 4 different wavelengths λ_1= 1.55e-6, λ_2= 1.5508e-6, λ_3= 1.5516e-6 and λ_4= 1.5524e-6. Now the performance of system is analysed at different data rates and attenuations. The data rates used in this system are 10 Gbps, 12 Gbps, 14 Gbps, 16 Gbps and 18 Gbps. Fig. 4 to Fig. 8 shows eye diagrams obtained at different data rates and attenuations.



(a) (b) (c) (d)

Fig. 4 Eye Diagrams at a bit rate of 10 Gbps and attenuation of (a) 0dB, (b) -5dB, (c) -10db, (d) -15dB

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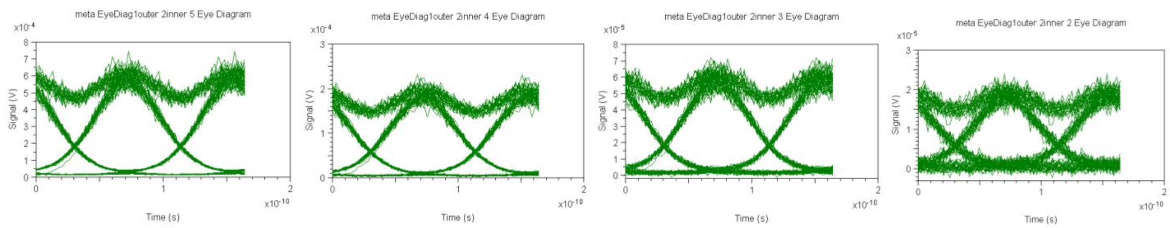
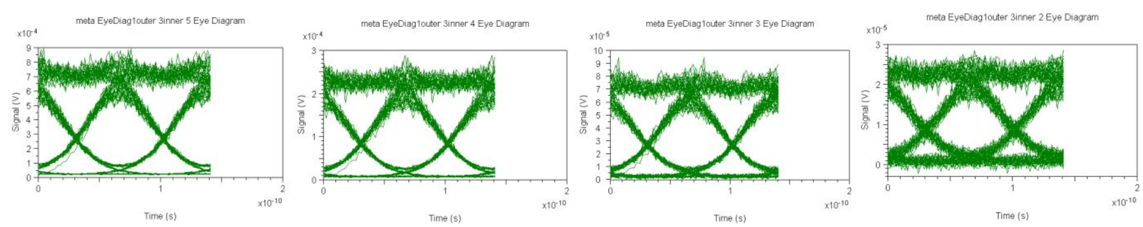
These are the eye diagrams observed at a bit rate of 10 Gbps. These results are obtained for zero transmission length and various attenuations. We can observe from the eye diagrams as attenuation increases interference increases and signal gets distorted.



(a) (b) (c) (d)

Fig. 5 Eye Diagrams at a bit rate of 12 Gbps and attenuation of (a) 0dB, (b) -5dB, (c) -10db, (d) -15dB

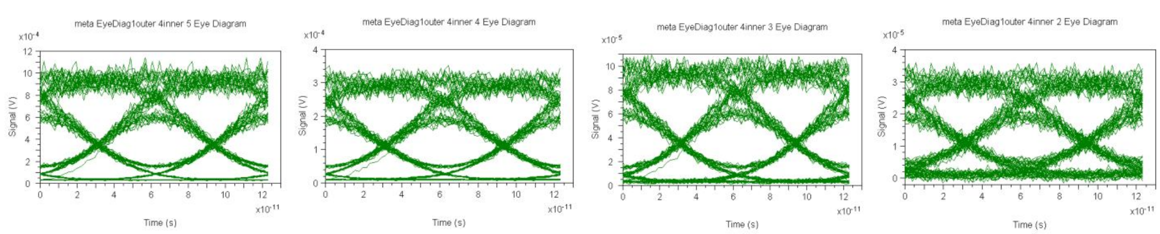
These are the eye diagrams obtained at a data rate of 12 Gbps. These results are observed for various attenuations values. It can be observed from the eye diagrams as attenuation increases interference increases and signal gets distorted.



(a) (b) (c) (d)

Fig. 6 Eye Diagrams at a bit rate of 14 Gbps and attenuation of (a) 0dB, (b) -5dB, (c) -10db, (d) -15dB

Fig. 6 shows the eye diagrams obtained at a data rate of 14 Gbps. The observations are made for various attenuations values. It is observed from the eye diagrams as attenuation increases interference increases and signal gets distorted.



(a) (b) (c) (d)

Fig. 7 Eye Diagrams at a bit rate of 16 Gbps and attenuation of (a) 0dB, (b) -5dB, (c) -10db, (d) -15dB

Fig. 7 shows the eye diagrams observed at a data rate of 16 Gbps. The results have been observed for various attenuations values. The eye diagrams shows that attenuation increases with increase in interference and signal gets distorted.

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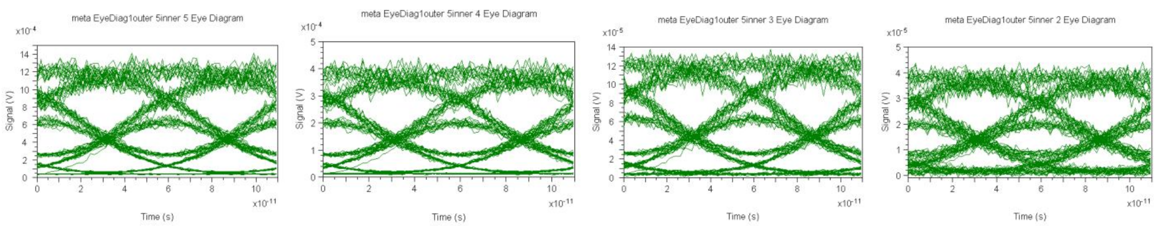

(a) (b) (c) (d)

Fig. 8 Eye Diagrams at a bit rate of 18 Gbps and attenuation of (a) 0dB, (b) -5dB, (c) -10db, (d) -15dB

Fig. 8 shows the eye diagrams obtained at a data rate of 18 Gbps. The observations are made for various attenuations values. It is observed taht this system can work up to a data rate of 18 Gbps and attenuation of -15 dB.

Attenuation	0dB	-5dB	-10dB	-15dB
BER at 10Gbps	4.7870e-056	8.1734e-050	2.0462e-035	7.8694e-014
BER at 12Gbps	1.5904e-049	3.0115e-047	1.6424e-033	1.1045e-013
BER at 14Gbps	2.3766e-038	1.3369e-036	2.4120e-028	2.2861e-012
BER at 16Gbps	3.5481e-024	7.7422e-024	5.7613e-020	7.2371e-010
BER at 18Gbps	5.5711e-013	8.5459e-013	1.6440e-011	6.8891e-007

Table 2. BER at various data rates and attenuations.

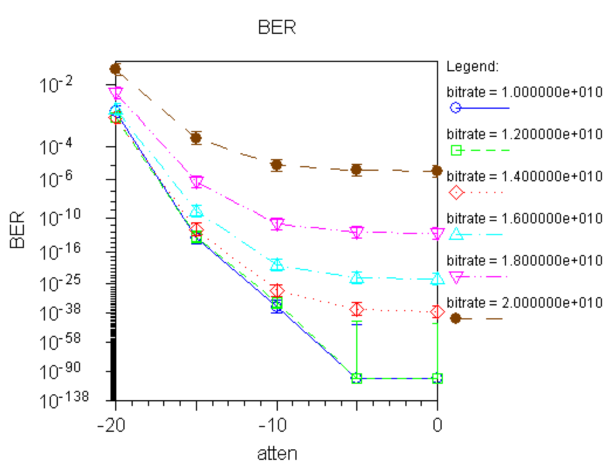

Fig. 9 BER versus attenuation curve at different data rates.

Fig. 9 shows the BER v/s attenuation curve at different data rates. In this curve it can be observed that as attenuation goes from 0 to -20dB BER increases which mean noise gets added into the system. The output of this system is unacceptable at data rate of 20 Gbps. This system can support bit rate up to 18 Gbps and an attenuation of -15 dB.

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In earlier proposed system given by Jindal et.al. [1,4] the data rate supported by those systems was 10 Gbps at maximum attenuation of -5dB. But the systems presented in this paper can support data rate of 18 Gbps at an attenuation of -15dB. Hence using 3D W/T/S MPR codes the performance of system improves.

V.CONCLUSION

In the present work, an OCDMA system is designed successfully using 3D W/T/S MPR codes. The performance of this system is analysed. This system can support 8 active users and 18 Gbps of data rate. BER of this system is less than 1.0e-9 which is acceptable. Even in the presence of attenuation this system gives satisfactory results which make the 3D W/T/S MPR OCDMA system suitable for LAN networks. Proposed system is compared with already existing 3D OCDMA system given by Jindal et.al. [1,4] and found that these systems work at higher data rate and gives satisfactory performance even at high attenuation.

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