PERFORMANCE ANALYSIS OF TRANSMISSION OF 5 USERS BASED ON MODEL B USING GF (5) WITH VARYING BIT RATES FOR 3D OCDMA SYSTEM

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ABSTRACT

We present transmission of five users with 5 WDM × 4 TDM × 5 CODE channel on 3D OCDMA system based on Model B using GF (5) with varying receiver attenuation at 1Gbps, 2 Gbps, 5Gbps and 10Gbps data rates on OPTSIM.

KEYWORDS

Optical Code Division Multiple access, Optical Orthogonal Codes(OOC), linear congruent operator, cubic congruent operator, Galois field (5), 3 Dimensional, Model B.

1. INTRODUCTION

Coding schemes play a major role in analyzing the performance of OCDMA system. In this direction many researchers have proposed signature sequences in different dimensions [2, 7, 11, and 12]. We had modeled these sequences based on algebraic coding theory in two categories Model A and Model B [1, 3, 4, and 5].

In this paper we have used the OPTSIM simulation tool to evaluate the performance of transmission of five users based on Model B using optical orthogonal codes, Cubic Congruent Operator and Linear Congruent Operator from algebra theory with varying bit rates. The paper is organized as follows. In Section II, Mathematical Modeling of 3D OCDMA system along with Model B is discussed. Section III shows the 3D Codeset and calculates the system parameters required for simulation. Section IV shows the implementation details on the simulation software along with the results for five users with 5 WDM × 4 TDM × 5 CODE Channel 3D OCDMA system based on Model B using GF (5) with varying attenuation at the front end of the receiver at variable bit rates. Finally conclusion is drawn in section V.

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2. MATHEMATICAL MODEL

In Model B, OOC code is used to spread in time domain and is taken from literature C= 1011000100000 is a (13,4,1) code with c={0,2,3,7} where n=13,w=4 and λa = λc =1, coding scheme of cubic congruent operator based on Table 1 is used for spreading in spectral domain and coding scheme of linear congruent operator is used for spreading in spatial domain as shown in Fig 1. The multiplicative inverse for GF (5) and. Cubic and linear Algebraic Congruent operators values are given in table 1 and are defined by following equations [6]

$$s_m(n,a,b) = \left(m(a+n)^3 + b\right)(\bmod p) \quad \text{a= b=0} \quad \text{Cubic Congruent Operator} \quad \text{Eq 1}$$

$$s_m(n,a,b) = [m.(n.a+b)][(\bmod p)] \quad \text{a=1 \& b=0 Linear Congruent Operator Eq 2}$$

Where n and m are the indexes and elements of the Galois field and their values are expanded in Table 1.

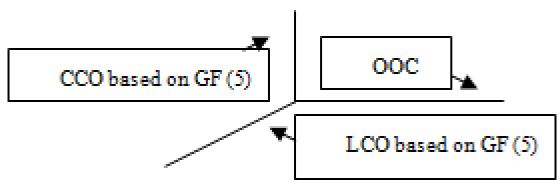

Fig. 1: Model B [1]

Table 1. Multiplicative Inverses for GF (5) and Sequences over GF (5) using cubic Algebraic Congruent operator and linear algebraic congruent operator

×	0	1	2	3	4
0	0	0	0	0	0
1	0	1	2	3	4
2	0	2	4	1	3
3	0	3	1	4	2
4	0	4	3	2	1

m,n	0	1	2	3	4
0	0	0	0	0	0
1	0	1	3	2	4
2	0	2	1	4	3
3	0	3	4	1	2
4	0	4	2	3	1

m,n	0	1	2	3	4
0	0	0	0	0	0
1	0	1	2	3	4
2	0	2	4	1	3
3	0	3	1	4	2
4	0	4	3	2	1

3. 3D CODESET AND OCDMA SYSTEM

In accordance with Model B shown in Fig 1, the signature sequence is spreaded as follows. For temporal spreading: Optical orthogonal code is taken from literature C= 1011000100000 is a (13,4,1) code with c={0,2,3,7} where n=13,w=4 and λa = λc =1.here, n denotes length of the codeword, w is the weight of the codes and λa &λc denotes auto correlation and cross correlation constant [10]. For spectral hopping: codes from cubic congruent operator as calculated in Table 1, from algebra theory are taken based on GF (5) and for spatial encoding codes from linear congruent operator are taken based on GF (5) using Model B. These codes are expanded in Table 3.

Table 2. Encoder and Decoder time delay values for variable bit rate systems

Data rate	1 Gbps	2 Gbps	5Gbps	10Gbps
bit period	1e-9	.5e-9	.2e-9	.1e-9
Time Slot	13	13	13	13
Chip period	.0769e-9	.0384e-9	.0153e-9	.0076e-9
TD t_0 E	0	0	0	0
TD t_2 E	.1538e-9	.0768e-9	.0306e-9	.0152e-9
TD t_3 E	.2307e-9	.1152e-9	.0459e-9	.0228e-9
TD t_7 E	.5384e-9	.2688e-9	.1071e-9	.0532e-9
TDt_{13} D	.9997e-9	.4992e-9	.1989e-9	.0988e-9
TD$_{11}$ D	.8459e-9	.4224e-9	.1683e-9	.0836e-9
TDt_{10} D	.7690e-9	.3840e-9	.1530e-9	.076e-9
TDt_6 D	.4614e-9	.2304e-9	.0918e-9	.0456e-9

Table 3. Code Sequences

BLOCK 0			
SET 0	SET1	SET2	SET3
$\lambda_0 S_0 \lambda_0 S_0 \lambda_0 S_0 \lambda_0 S_0$	$\lambda_0 S_0 \lambda_1 S_1 \lambda_3 S_2 \lambda_2 S_3$	$\lambda_0 S_0 \lambda_2 S_2 \lambda_1 S_4 \lambda_4 S_1$	$\lambda_0 S_0 \lambda_3 S_3 \lambda_4 S_1 \lambda_1 S_4$
$\lambda_0 S_1 \lambda_0 S_1 \lambda_0 S_1 \lambda_0 S_1$	$\lambda_0 S_1 \lambda_1 S_2 \lambda_3 S_4 \lambda_2 S_3$		
$\lambda_0 S_2 \lambda_0 S_2 \lambda_0 S_2 \lambda_0 S_2$	$\lambda_0 S_2 \lambda_1 S_3 \lambda_3 S_0 \lambda_2 S_4$		
$\lambda_0 S_3 \lambda_0 S_3 \lambda_0 S_3 \lambda_0 S_3$	$\lambda_0 S_3 \lambda_1 S_4 \lambda_3 S_1 \lambda_2 S_0$		
$\lambda_0 S_4 \lambda_0 S_4 \lambda_0 S_4 \lambda_0 S_4$	$\lambda_0 S_4 \lambda_1 S_0 \lambda_3 S_2 \lambda_2 S_1$		
BLOCK 1			
SET 0	SET1	SET2	SET3
	$\lambda_1 S_0 \lambda_2 S_1 \lambda_4 S_3 \lambda_3 S_2$		
BLOCK 2			
SET 0	SET1	SET2	SET3
	$\lambda_2 S_0 \lambda_3 S_1 \lambda_0 S_2 \lambda_4 S_3$		
BLOCK 3			
SET 0	SET1	SET2	SET3
	$\lambda_3 S_0 \lambda_4 S_1 \lambda_1 S_2 \lambda_0 S_3$		
BLOCK 4			
SET 0	SET1	SET2	SET3
	$\lambda_4 S_0 \lambda_0 S_1 \lambda_2 S_3 \lambda_1 S_3$		

Table 4. System Parameters [6]

S.No.	Parameter	value
1)	Bit rate	1,2,5 and10e9
2)	Bit period	Variable (Table2)
3)	Chip period	Variable (Table2)
4)	Time slot	13
5)	Laser wavelength	λ_1= 1550.0e-9m to λ_5= 1553.2e-9m
6)	Rep rate of source	Variable(Table2)
7)	Peak power of laser	1.0e-3w
8)	Delta[2]	.8e-9(DWDM)
9)	No. of lasers	5
10)	Combiner/ Mux	5×1
11)	Combiner loss	3dB
12)	Pattern type	PRBS
13)	Pattern length	7 bits
14)	Fibre Attenuator	Variable in dB

Simulation parameters: For 3D OCDMA system design, time delay for encoders and decoders for variable data rate is calculated as under and is summarized in table 2.

The bit rate is taken as 1 Gbps for each channel and time slot is the length of the temporal codes. In this simulation (13, 4, 1) OOC is taken for spreading in time domain.

Thus the bit period is calculated as:

Bit Period=1/Bit Rate =1/1e9= 1e-9 and Chip period=Bit Period/Time Slot
=1e-9/13 = .0769e-9.

Now the time delay lines for temporal code (1011000100000) [8] are calculated as

Time Delay lines for Encoder

$\mathbf{t_0}$ = 0×.0769e-9=0; $\mathbf{t_2}$=2×.0769e-9=.1538e-9

$\mathbf{t_3}$= 3×.0769e-9=.2307e-9; $\mathbf{t_7}$= 7×.0769e-9=.5384e-9

Inverse delay lines for Decoder

$\mathbf{t_{13}}$= 13×.0769e-9=.9997e-9; $\mathbf{t_{11}}$= 11×.0769e-9=.8459e-9

$\mathbf{t_{10}}$=10×.0769e-9=.7690e-9; $\mathbf{t_6}$=6×.0769e-9=.4614e-9

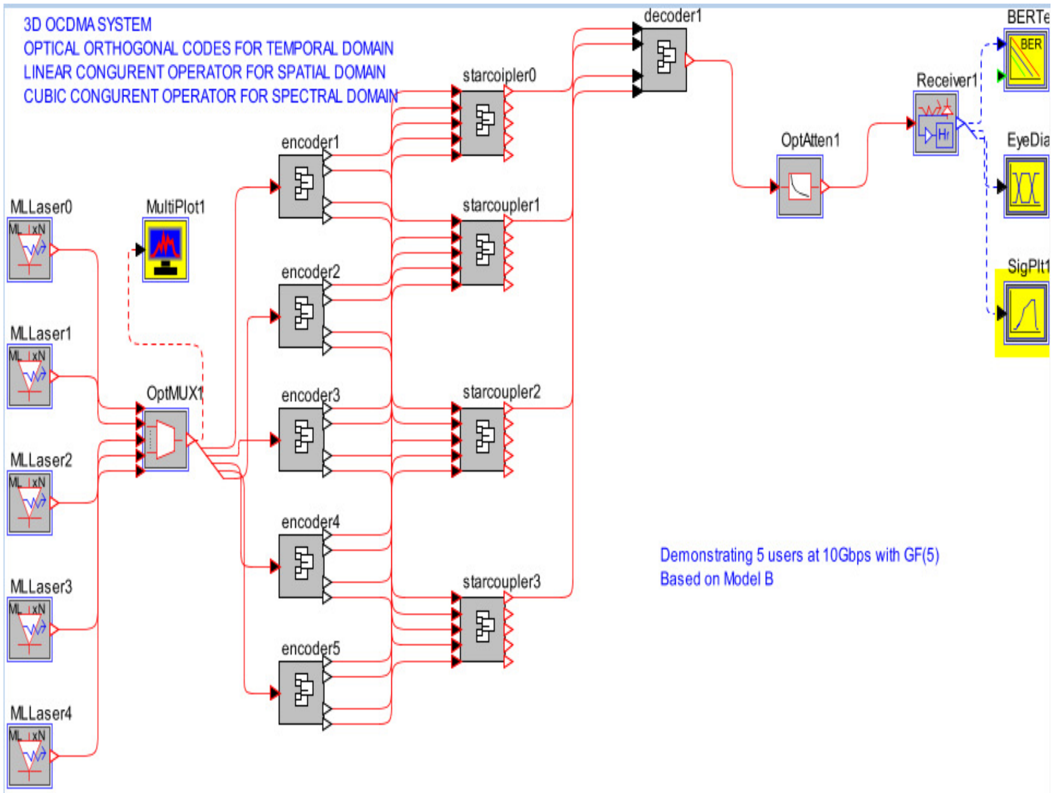

Fig 2: Technology Demonstrator of 3D OCDMA system based on Model B

4. SIMULATION AND RESULTS

Table 4 shows the practical parameters that were taken while simulating the proposed 3D codeset based on Model B using cubic and linear congruent operator with GF (5).Proposed System have 5 Operating wavelengths in C band i.e. λ_1= 1550.0e-9m, λ_2= 1550.8e-9m, λ_3= 1551.6e-9m, λ_4= 1552.4e-9m and λ_5= 1553.2e-9m with variable repetition rate=1e9, 2e9 ,5e9 and 10e9 and peak power= 1.0e-3 w of MLL (Laser). And Delta =.8e-9 (i.e. spacing between the wavelength) is based on Dense Wavelength Division Multiplexing [9]. Fig 2 shows the snapshots of 3D OCDMA, in OPTSIM Simulation Software.

This schematic evaluates the 3D OCDMA link with encoding/ decoding based on Model B with 5 users each transmitting at variable data rate coding based on Galois field GF (5) with cubic and linear congruent operator and optical orthogonal codes.

Fig 3 through 6 shows the signal strength in terms of eye diagram, signal spectrum and auto correlation function at 1Gbps, 2Gbps, 5Gbps and 10 Gbps data rates. These diagrams illustrate that as the bit rate increases from 1Gbps to 10Gbps the eye diagram approaches towards close and signal spectrum deteriorates.

The above said signals when passed to 3D OCDMA system results in successful transmission at variable attenuation with data is given in Table 5 through 8, yellow marks in the table shows minimum and maximum attenuation values and Figures 8 through 11 shows output signal strength in terms of eye diagram and signal spectrum with data rates varying from 1 to 10 Gbps with variable attenuation at each data rate.

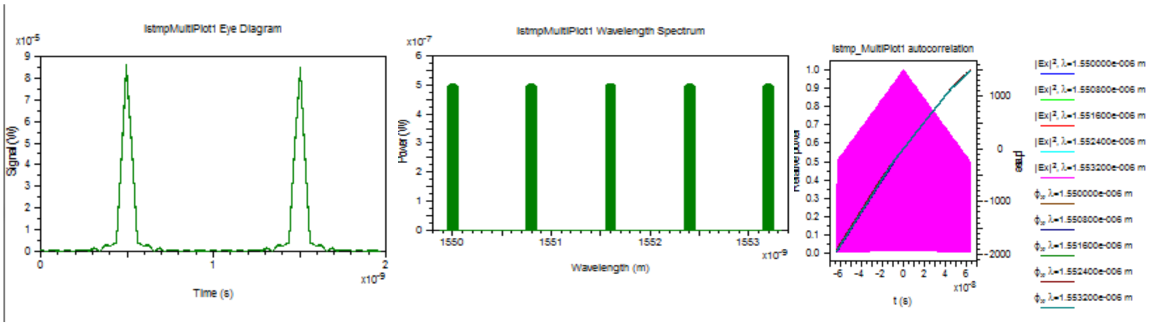

Fig. 3. Input signals: eye diagram, signal spectrum and auto correlation function at 1Gbps

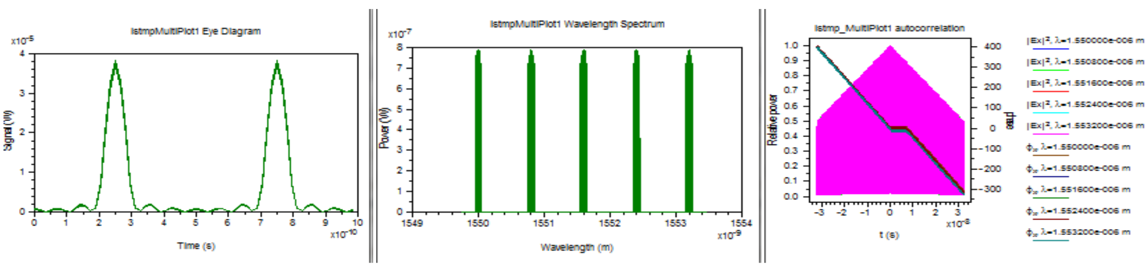

Fig.4. Input signals: eye diagram, signal spectrum and auto correlation function At 2 Gbps

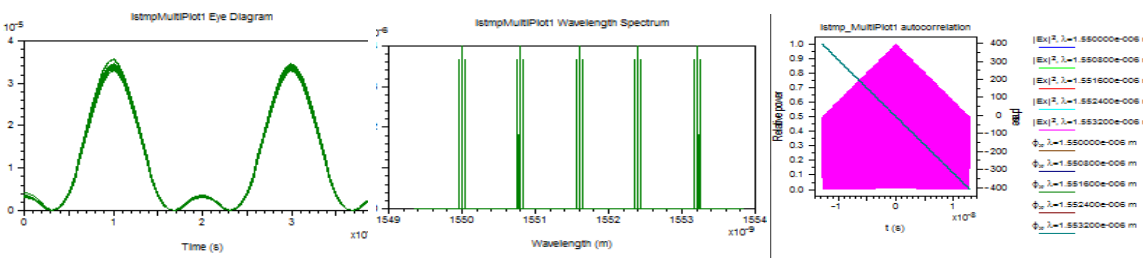

Fig. 5. Input signals: eye diagram, signal spectrum and auto correlation function At 5 Gbps

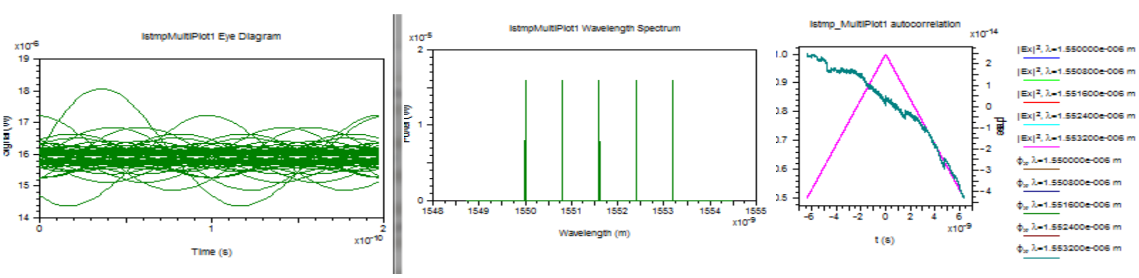

Fig 6: Input signals: eye diagram, signal spectrum and auto correlation function At 10 Gbps

Table 5. BER v/s Attenuation values at 1GBPS

5 users	-.2	-.25	-.5	-.1	-1	-2
BER	1.9983e-092	2.1730e-091	6.0347e-083	2.1171e-094	2.5980e-073	2.4898e-005

Table 6. BER v/s Attenuation values at 2GBPS

5 users	-.2	-.25	-.5	-.1	-1
BER	4.5609e-062	2.8166e-061	3.1484e-058	1.1249e-062	3.2295e-053
	-2	-2.5	-5	-6	-7
	4.3917e-043	4.2558e-038	3.5682e-018	6.3758e-013	4.0290e-009

Table 7. BER v/s Attenuation values at 5GBPS

5 users	-.2	-.25	-.5	-.1	-1	-2	-2.5	-5
BER	3.0159e-014	3.3352e-014	5.3649e-014	2.4190e-014	2.1605e-013	3.7118e-012	1.7374e-011	7.6418e-008

Table 8. BER v/s Attenuation values at 10GBPS

5 users	-.2	-.25	-.5	-.1	-1	-2	-2.5
BER	3.1738e-013	3.7543e-013	9.2242e-013	2.2391e-013	5.8913e-012	2.6864e-010	1.8277e-009

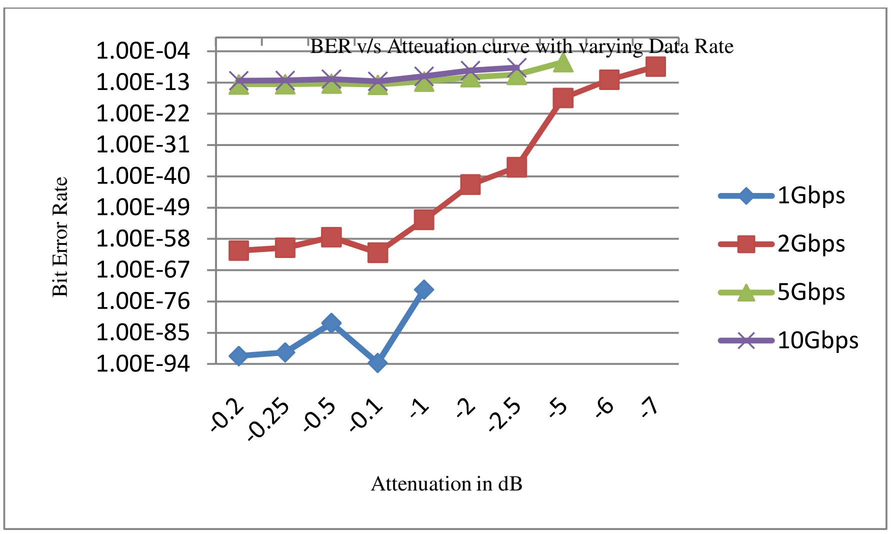

Fig. 7. BER v/s Attenuation curve with varying Data Rate

BER v/s Attenuation curve with varying Data Rate is drawn in Fig 7. As clear from this figure, for each data rate for example at 1Gbps, BER decreases as the attenuation at the front end of the receiver increases shown in blue color, also if the simulation is run for different data rates, BER increases with the increase in data rate with same attenuation .Output signals showing Eye diagram and signal spectrum with variable bit rate and attenuation are shown in Fig 8 through 11.

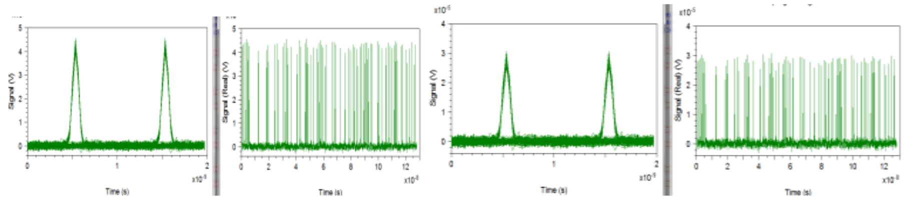

Fig. 8. Eye diagram and signal spectrum At 1 Gbps with attenuation -.2 &-2dB

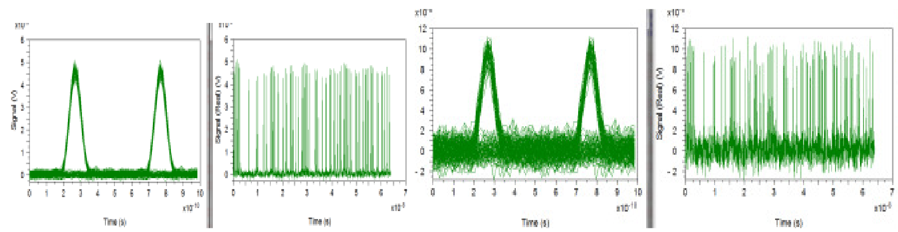

Fig 9. : Eye diagram and signal spectrum At 2 Gbps with attenuation -.2 &-7dB

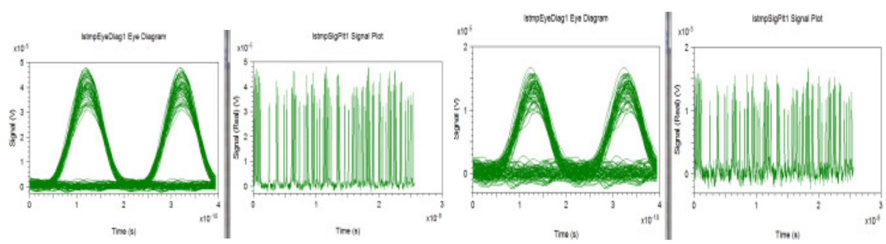

Fig. 10. Eye diagram and signal spectrum At 5 Gbps with attenuation -.2 &-5dB

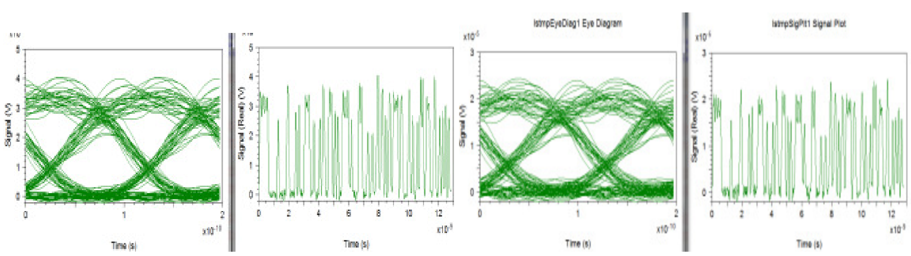

Fig. 11 Eye diagram and signal spectrum At 10 Gbps with attenuation -.2 &-2.5dB

5. CONCLUSION

In this paper we have presented transmission of five users with 5 WDM × 4 TDM × 5 CODE channel on 3D OCDMA system based on Model B using GF (5) with varying receiver attenuation at 1Gbps, 2 Gbps, 5Gbps and 10Gbps data rate . At 1Gbps, BER decreases as the attenuation at the front end of the receiver increases, for attenuation -.2 dB, Bit Error Rate is 1.9983e-092 and for attenuation of-2dB BER is 2.4898e-005, also if the simulation is run for different data rates, BER increases with the increase in data rate with same value of attenuation. This novel 3D OCDMA System based on code sequences generated trough algebraic operators Supports transmission of maximum of five users with attenuation of-2.5dB at 10 Gbps bit rate with BER 1.8277e-009.

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