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Performance Analysis of OCDMA System using W/T Codes

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Abstract

In 1-D optical orthogonal codes, the ratio of code length to the code weight grows rapidly as the number of users increase. If we consider two-dimensional optical orthogonal code then it reduces the length of the code as a result of which BER performance of the system improves. In this paper we have discussed the performance analysis of an incoherent optical code division multiple access scheme based on wavelength/time codes. The OCDMA system is designed for 36 users at 1 Gbps. It is observed that the system can support only 25 users for permissible BER of 10^{-9},with 15db received power. The performance of the system is also analyzed based on BER and eye diagram under the influence of number of simultaneous users with different received power.

Keywords: Bit error rate, Decoder, Encoder, Optical code division multiple access

Introduction

The OCDMA systems play a vital role in long haul and high-speed communication networks like LAN and MAN. These systems have the advantage of high speed, large capacity and huge bandwidth.

The TDMA, WDMA and CDMA are the available major multiple access techniques. The throughput of the TDMA system is limited by the product of number of users and their respective transmission rate. In WDMA system each channel is transmitted on a single wavelength of light. This allows each user to transmit at the peak speed of network hardware, but the complexity of the system increases for a dynamic system of multiple users because of the significant amount of the coordination among the nodes required for successful operation. If a dynamic user base has to be built with WDMA system the control channels and collision detection schemes would need to be implemented but that would waste significant bandwidth. Both TDMA and WDMA systems require time or frequency management system however the CDMA system does not require any centralized control and thereby reduce the complexity of the system. Optical CDMA combines the large bandwidth of the fiber medium with the flexibility of the CDMA technique to achieve high-speed connectivity.

The establishment of OCDMA needs to overcome the code orthogonality problem. In the optical orthogonal code family many researchers have worked on 2-Dimensional (2-D) codes by using different construction methods. Antonio J. Mendez et. al. [1] presented a technique for constructing 2-D codes from sets of optimum Goloumb ruler. It is also shown that 2-D codes have higher cardinality and spectral efficiency .

K. Yu et. al. [2] proposed a 2-D code structure demonstrated on signals upto 3 GHz. time-chip rate with 4 X 15 codewords. The combination of metal-coated reflection delay lines and arrayed wave-guide gratings gives the proposed optical coder/decoder much flexibility in accommodating different code sets.

In this paper the authors have described the design and construction of W/T code matrices, their implementation in OCDMA system and analyze the performance of the system in terms of BER, eye diagram under the influence of simultaneous users with different received power. The encoders/decoders are realized using optical filters delays

Coding architecture

The codes have been constructed by redesigning the existing 1-D optical orthogonal codes and with the help of optimum Goloumb ruler. Here we have considered two sequences from the Goloumb ruler with length L=18 and weight, W=6 i.e. code1={1,1,1,0,0,1,0,0,0,0,0,1,0,1,0,0,0,0} and code2= {1,0,0,1,0,1,0,0,0,1,0,0,0,0,0,1,1} respectively. These 1-D codes are converted to 2-D codes by using ruler to matrix transformation. The dimension of the matrix has been decided for the condition (W x T) ≥ L where w is the number of wavelength and T is number of time slots. If (WxT)>L then the number of filler zeros N, where N=(W x T)-L has to be added at the end of the code word to form a proper matrix set. The number of filler zeros required will be 2 with W = 5 and T= 4 to make a proper matrix.

If we choose W=3 and T=6 a (3x6) matrix can be formed without any need of filler zeros and serves as optimum solution as it saves the cost of laser by increasing the time slot. Thus code 1 can be designed by using wavelengths (W1, W2 and W3) and whereas code2 is designed by using (W4, W5 and W6) wavelengths.

Table 1: Code1

C_2	T_0	T_1	T_2	T_3	T_4	T_5
W_1	1	1	0	1	0	0
W_2	0	0	0	0	0	1
W_3	0	1	0	0	0	1

Table 2: Code2

C_1	T_0	T_1	T_2	T_3	T_4	T_5
W_4	1	0	0	0	0	0
W_5	1	0	0	0	1	0
W_6	1	1	0	1	0	0

System Design

The system can be designed by using 6 mode locked lasers [36 codes can be designed] of different wavelength ranging from 1550 nm to 1554.2 nm with spacing of 0.7 nm which generates the pulses of width equal to the data rate of the system.

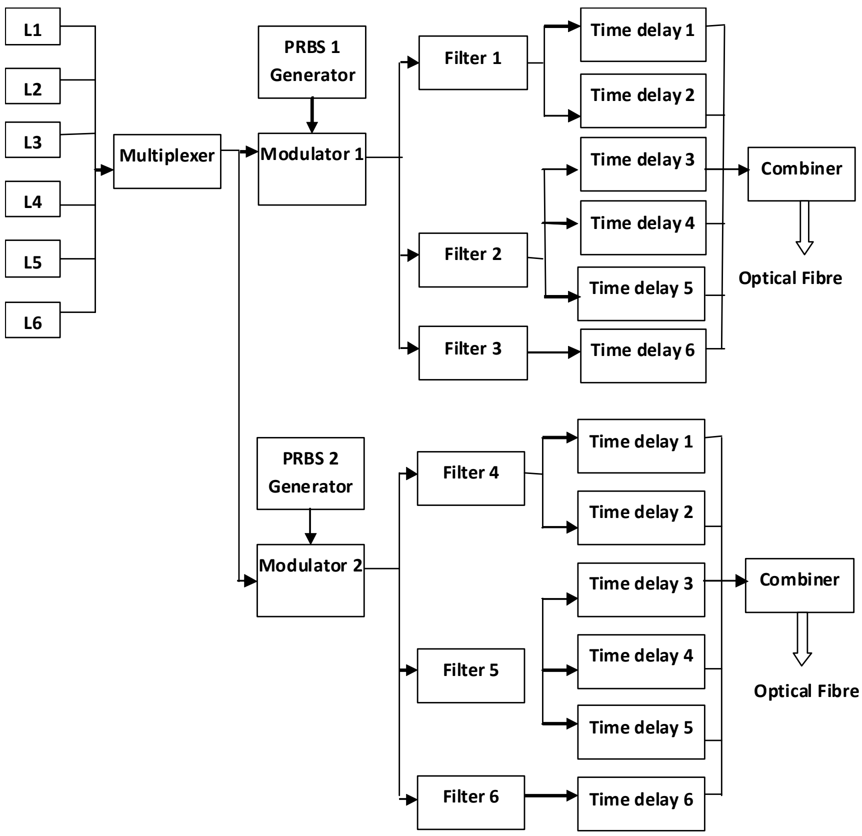

Figure 1: Optical CDMA design

In this system 36 codes can be designed for different wavelength and time delay combinations. The bit period of 1 Gbps is $1.0e^{-9}$ s and $1.67e^{-10}$ s respectively.

The Machgender modulator LINbO3 modulates the data generated by PRBS with the carrier, which is then fed to the encoder. In the encoder the corresponding wavelength according to the codes are filtered out and time delays places the pulses in their appropriate time slots which are further combined with the help of combiner. The encoded codes from all the users are then multiplexed and passed through the 60 km span of single mode fibre followed by a loss compensating EDFA amplifier. Figures 2 and 3 represent the signal diagram and eye diagram of the encoded signals.

The decoder, tuned to user 1, has the same structure as the corresponding encoder, but it has inverse delays, which realign the pulses. The filters used in the decoder section filter out the corresponding wavelengths according to the encoder wavelengths.

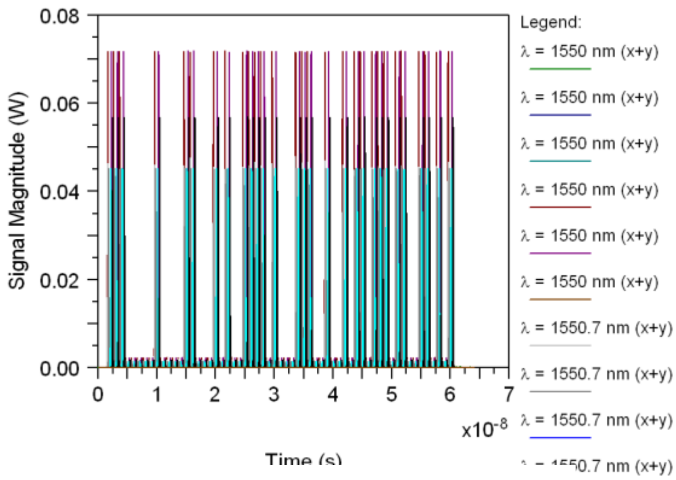

Figure 2: Signal output at Encoder

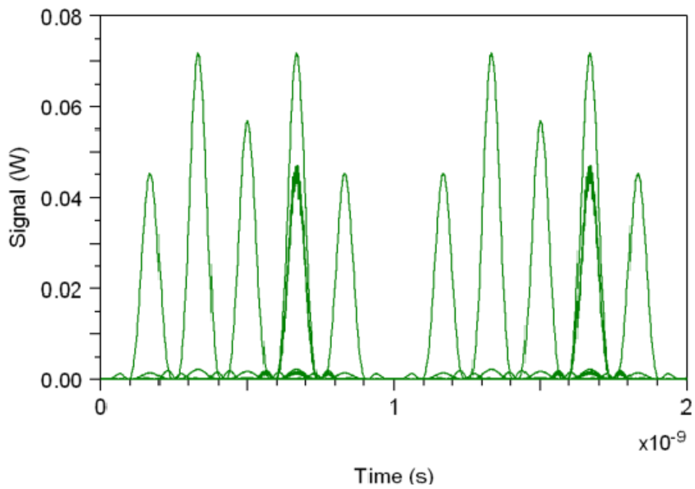

Figure 3: Eye diagram output at Encoder

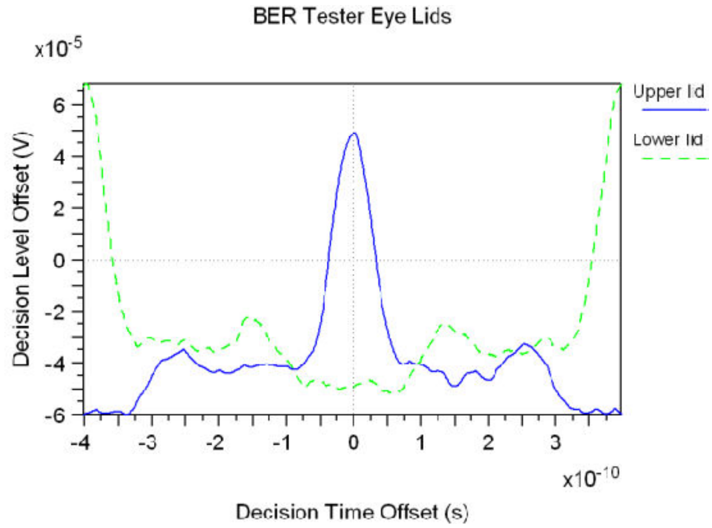

Figure 4: BER Eyelids at receivers

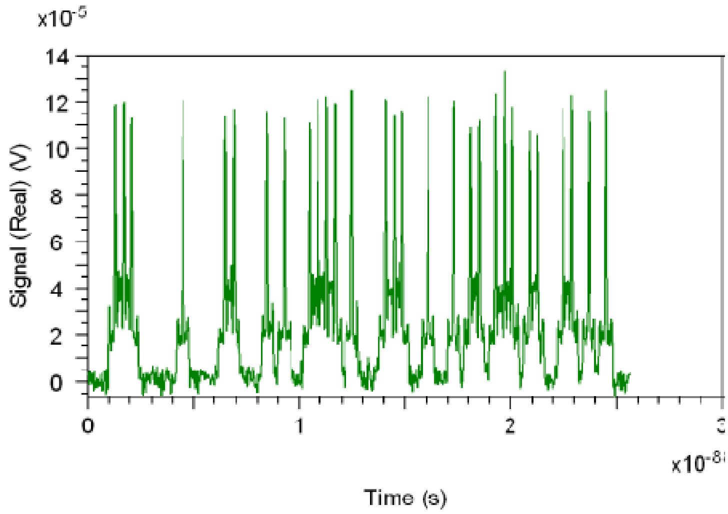

Figure 5: Signal diagram at receiver

Decoder

Each code is designed using 3 lasers with 3 wavelengths. The decoder has the similar structure as that of encoder. The only difference is it has inverse delays to realign the pulses.

Results and Discussions

The graphs in figures 6,7,8 and 9 illustrate that as the number of users increase the signal amplitude start decreasing. For 5 users the maximum amplitude is 0.004V, which decreases to 0.003V for 8 users, which further degrades to 0.0017V for 27 users. The system performs very well for -15db received power and can accommodate 25 simultaneous users for bit error of e^{-9}. If the received power is kept low -22db then the OCDMA system designed can accommodate only 16 simultaneous users.

It can be see from Figures 10 and 11 that BER performance degrades. As the received power decreases from –15db to –30db the BER decreases from 1.06 e^{-77} to 1.69 e^{-34} for 8 users.

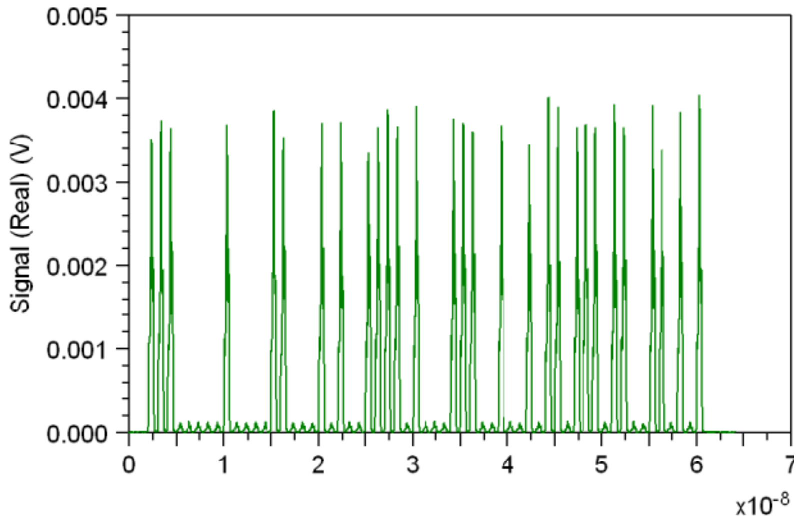

Figure 6: Signal Diagram for single User

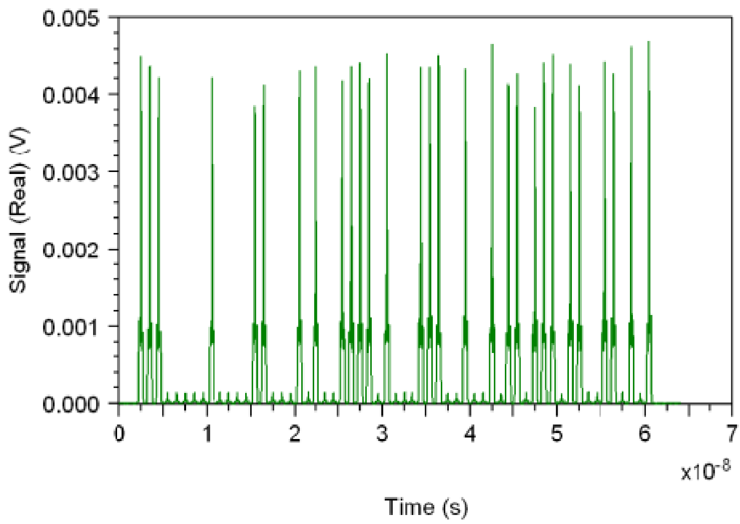

Figure 7: Signal Diagram for 5 Users

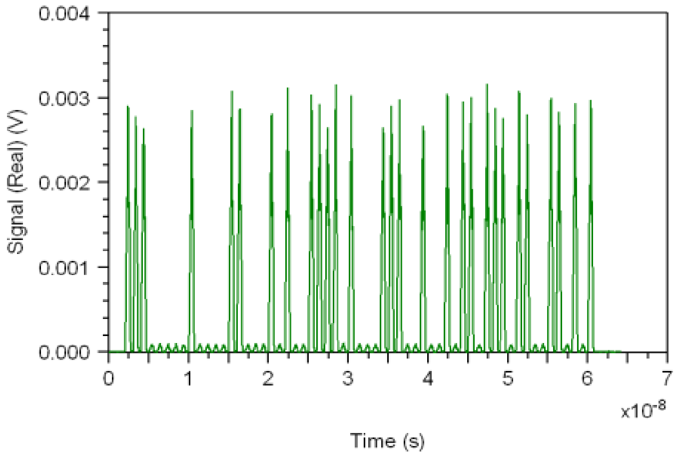

Figure 8: Signal Diagram for 8 Users

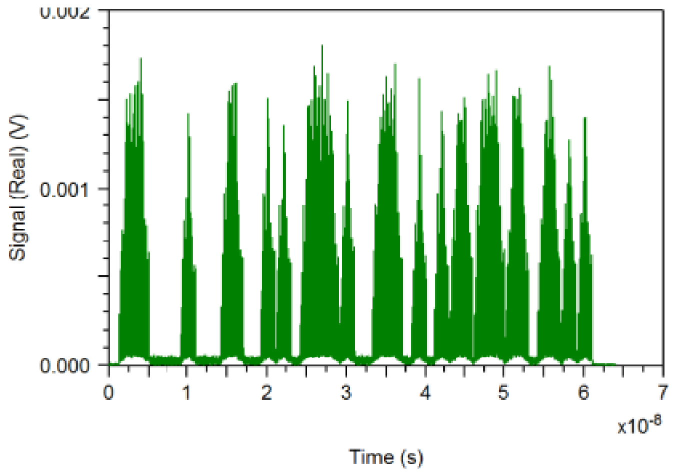

Figure 9: Signal Diagram for 27 Users

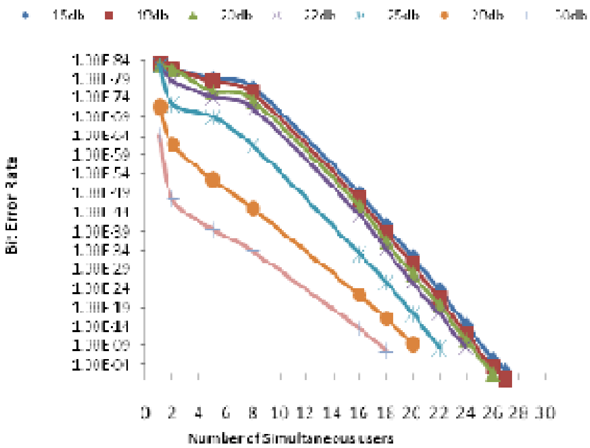

Figure 10: BER Vs. Number of simultaneous users

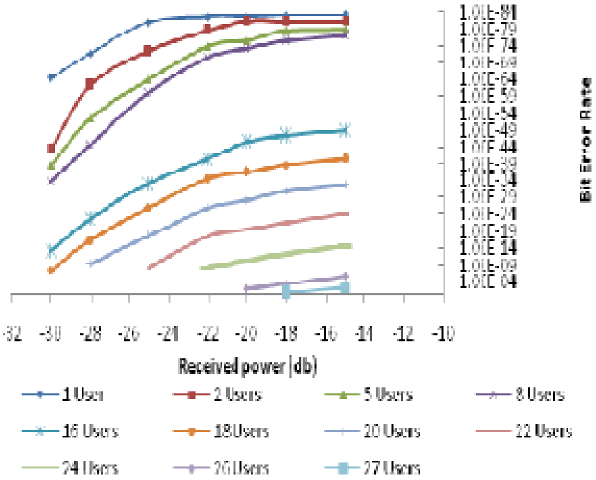

Figure 11: BER Vs. received power

Conclusion

Results show that the system under study can accommodate 25 users for permissible BER of 10^{-9}, with -15db received power at 1 Gbps bit rate respectively. If the received power is kept low –22db then the system can support only 16 user with permissible BER of 1.58^{-41}. The system is designed for 60 kms. which can be further extended to long haul communication using optical amplifier.

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