Performance Comparison between Modified Prime Sequence Codes and Superimposed Optical Cyclic Orthogonal Codes for OCDMA System at 5Gbps Bit Rate

Gurjit Kaur and Neena Gupta

***Abstract*-In this paper the performance of two coding techniques named Modified Prime Sequence Codes (MPSC) and Superimposed Cyclic Optical Orthogonal Codes (SCOOC) is compared for Optical Code Division Multiple Access (OCDMA) system. A realistic simulation model of OCDMA system is designed for analyzing the performance of these codes. The performance analysis in terms of bit error rate, quality factor is carried out at extremely high bit rates of 5Gbps. The research shows that both the coding techniques give an improved performance compared to previous researches in terms of quality factor and bit error rate with minimum input requirements of power, bit rate etc for even in case of larger number of users. Results shows that at -15db received power for permissible BER of 10-9 the MPSC and SCOOC based OCDMA system can accommodate up to 17 and 18 users respectively at 5 Gbps bit rate. For SCOOC based OCDMA system, the bit error rate degrades very slowly as the number of users increases from 2 to 16 but it deteriorates very fast once the number of users goes beyond 18 . Also, if the number of users are upto 16 and the received power is more i.e. -15db then one can choose MPSC based OCDMA system whereas for more number of users as well as for less received power SCOOC based OCDMA system is recommended. So it is advisable to use the high received power system when the bit rate is high i.e. 5Gbps.**

***Index Terms* - Optical Code Division Multiple Access (OCDMA), Modified Prime Sequence Codes (MPSC), Superimposed Cyclic Optical Orthogonal Codes (SCOOC), Bit Error Rate (BER)**

I. Introduction

The performance of an optical CDMA system depends upon a number of parameters e.g. types of codes, data rate, transmitter power, received power, number of simultaneous users etc. However, the types of codes and data rate become the most important parameters as they directly decide the numbers of users that can access the network [1], [2].

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Therefore, in the present analysis, performance of Modified Prime Sequence Codes (MPSC) [3] and Superimposed Cyclic Optical Orthogonal Codes (SCOOC) [4] for OCDMA systems is analyzed and compared in terms of bit error rate and quality factor at different received powers for various number of simultaneous users at 5Gbps bit rate. The paper also discusses the minimum input requirements for various number of users for fixed quality standards.

II. Encoder design for MPSC and SCOOC for OCDMA system

Two different encoders have been designed for MPSC and SCOOC coding techniques as represented in Fig. 1 and 2. The first coding technique i.e. Modified Prime Sequence Code (MPSC) is based on the prime sequence combinational pattern. In this technique one code from prime sequence code family becomes the master code in MPSC code structure which ultimately fixes the time slot pattern while the other dimension i.e. wavelength is varied with various combinations according to prime sequence code structure. The benefit of this type of coding architecture is the generation of huge code set by using weight =3. This technique also uses optical delay which further reduces the complexity and makes the system more cost effective. In this technique seven mode locked lasers along with three time delay lines are used for designing of 49 codes [3]. The second coding technique i.e. Superimposed Cyclic Optical Orthogonal Codes (SCOOC) is designed by using optimum goloumb ruler. This coding technique is designed by using two sequences of the optimal goloumb ruler. These two sequences becomes the 1D superimposed cyclic code which is further converted to 2D superimposed codes by using ruler to matrix transformation. In this coding architecture only six mode locked lasers along with six time delay lines are used to construct 36 codes. The benefit of this coding architecture is its security because codes are designed not only by varying wavelength but time slots as well [4]. Then a model of OCDMA system is designed by way of simulation by looking all the practical impairments e.g. transmitter, channel and receiver noise etc. The performance of both the codes is evaluated using this simulation model by varying number of users at different received power i.e. -15db,-18db,-20db,-22db,-25db,-28db and -30db for various data rates. A

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complete set of possible values of input parameters with respect to number of users is derived for adequate standard of performance e.g. to achieve minimum bit error rate of e-9, minimum received power for various number of users , quality factor etc.

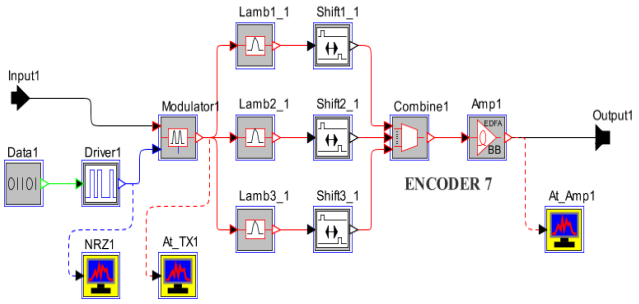

Fig 1: MPSC Encoder Structure

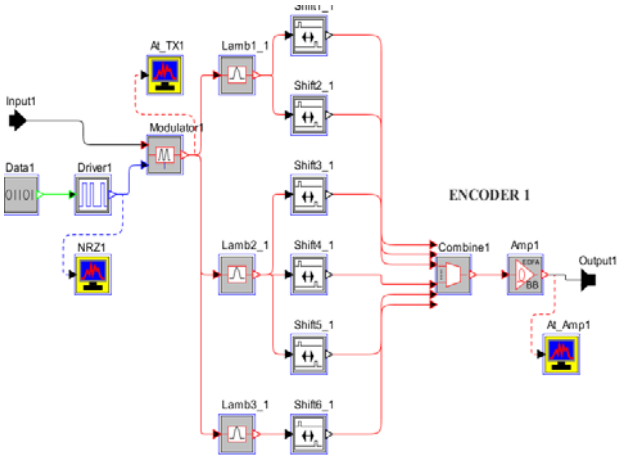

Fig 2: SCOOC Encoder Structure

III. Results and Discussions

In this paper the results are consolidated by four different ways.

(a) The first analysis gives maximum number of users supported at various received powers with minimum permissible BER at e^{-9}.

(b) As BER neglects some bit pattern effects which might occur practically through interaction of the following or predeceasing pulses due to the Kerr nonlinearity of the fiber or its chromatic dispersion, so this research also determine a Q factor that takes significant contributions of pattern effects into account. In this system maximum number of users supported is determined at various received powers with minimum permissible quality factor at 15.

(c) The third analysis, for both the coding techniques, is carried out to determine the minimum power requirement for various numbers of users for a fixed BER e^{-9}.

(d) The fourth analysis again determines the minimum power requirement for various number of users but for fixed quality factor 15.

(a) Performance Comparison of 5Gbps System in Terms of Bit Error Rate versus number of Simultaneous Users for Both the Systems

At -15db received power, the SCOOC based OCDMA system can accommodate 18 users where as the MPSC based OCDMA system can support 17 users with same system parameters as represented in Fig. 3. For SCOOC based OCDMA system, the BER degrades very slowly as the number of users increases from 2 to 16 but it deteriorates very fast once the number of users goes beyond 18 .

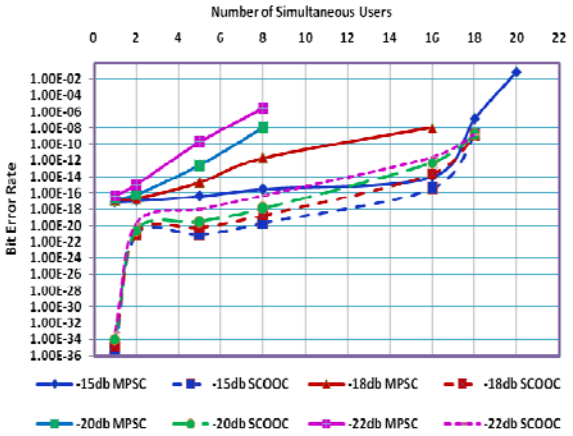

Fig. 3 Bit Error Rate versus number of Simultaneous Users for Both the Systems

Also, if the number of users are upto 16 and the received power is more i.e. -15db then one can choose MPSC based OCDMA system whereas for more number of users as well as for less received power SCOOC based OCDMA system is recommended. So it is advisable to use the high received power system when the bit rate is high i.e. 5Gbps.

(b) Performance Comparison of 5Gbps System in Terms of Quality Factor versus Number of Simultaneous Users for Both the Systems

For fixed quality factor value of 15, the MPSC and SCOOC based OCDMA can accommodate 17 and 20 users respectively at -15db received power as shown in Fig. 4. At -22db received power SCOOC based OCDMA system can accommodate 19 users whereas the MPSC system can support just 03 users for all other parameters remaining the same. So for higher values of received power SCOOC based OCDMA system is preferable.

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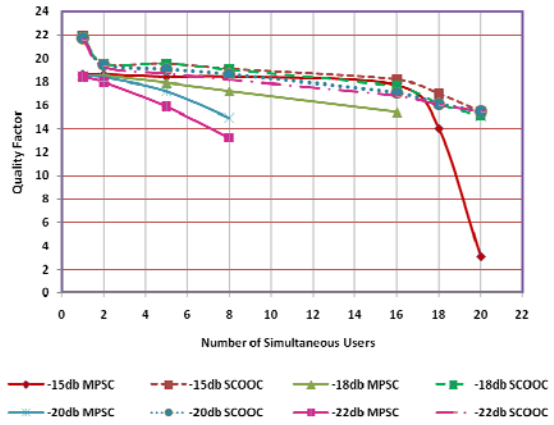

Fig. 4 Comparison of MPSC and SCOOC codes in terms of quality factor and number of users

(c) Performance Comparison of 5Gbps System in Terms of Bit Error Rate versus Received Power for Various Numbers of Simultaneous Users for Both the Systems

In 5Gbps system, as the number of users increases the SCOOC based OCDMA system performs better even at -25db received power as depicted in Fig.5. It can accommodate maximum of 18 users at -25db received power. Further, for the same bit error rate of e^{-9}, the MPSC and SCOOC based OCDMA can accommodate 16 users at -17db and -25db received power respectively.

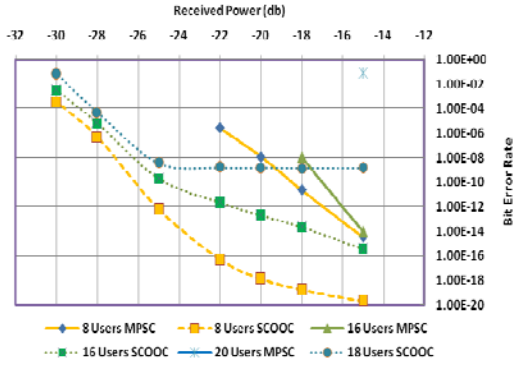

Fig. 5 Comparison of MPSC and SCOOC codes in terms of bit error rate versus received power

(d) Performance Comparison of 5Gbps System in Terms of Quality Factor versus Received Power for Various Numbers of Simultaneous Users for Both the Systems

The MPSC based OCDMA system is suitable for 8 users with -19db received power. To accommodate 16 users, only the SCOOC based OCDMA system is suggested with -25db received power. Further, for the same quality factor of 15, the MPSC and SCOOC based OCDMA can accommodate 5 users at -22db and -27db received power respectively. Fig. 6(a) and (b) represent the comparison of MPSC and SCOOC codes in terms of quality factor and received power for various number of users.

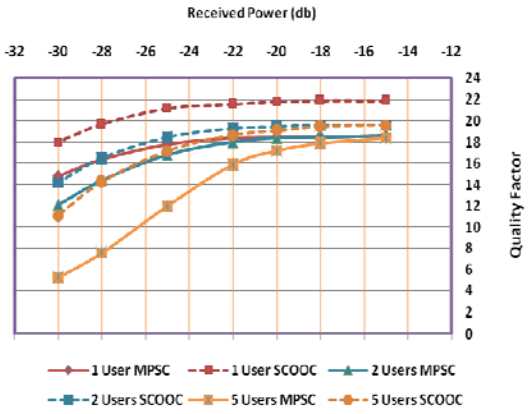

Fig. 6(a) Comparison of MPSC and SCOOC codes in terms of quality factor and received power for 5Gbps system at upto 5 number of users

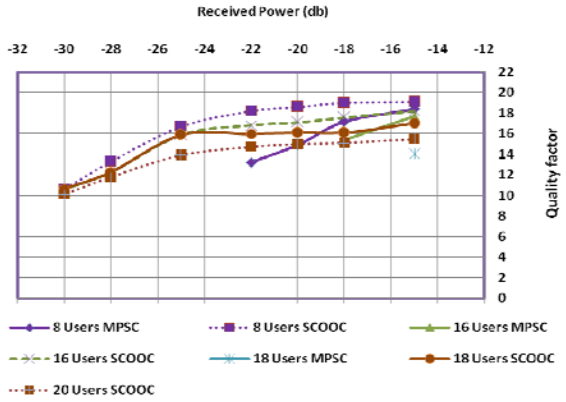

Fig 6(b) Comparison of MPSC and SCOOC codes in terms of quality factor and received power for 5Gbps system for more number of users

IV. Conclusion

By fixing the BER to e^{-9}, it has been seen that the MPSC based OCDMA system can accommodate up to 17 users at 5 Gbps bit rate at -15db received power while the SCOOC based OCDMA system can support 18 users for the same system parameters. On the basis of quality factor analysis the MPSC based OCDMA system can support 17 users at -15db received power while the SCOOC based OCDMA system can support 20 users for the same system parameters. The comparison between coding techniques clearly brings out the tradeoff between the number of users supported and the hardware requirement at transmission end for fixed output quality factor. The MPSC coding based OCDMA system is simple coding scheme and has lesser hardware requirement while SCOOC based OCDMA system can support more number of users with much advanced hardware requirement.

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REFERENCES

[1]. J. Vincent. Hernandez , Antonio J. Mandez, Corey V. Bennett, Robert M. Gagliardi and William J. Lennon," Bit error rate analysis of a 16 user gigabit Ethernet optical CDMA (O-CDMA) Technology demonstrator using wavelength/time codes," IEEE photonics Technology Letters, vol. 17, no. 12,Dec 2005 , pp. 2784-2786.

[2]. Alan E Willner, Poorya Saghari , Vahid R. Arbab , "Advanced techniques to increase the number of users and bit rate in OCDMA networks," IEEE Journal of Selected Topics in quantum Electronics , vol. 13,2007, pp. 1403-1414.

[3]. G. Kaur and N. Gupta, "Design and performance analysis of 2.5Gbps OCDMA System by using newly constructed MPSC Code set for metropolitan area" International Journal of Engineering Research And Industrial Applications (IJERIA), vol. 2, no. II, 2009,pp 245-257.

[4]. G. Kaur and N. Gupta, "Design and performance evaluation of new improved multidimensional optical orthogonal codes for 2.5Gbps OCDMA system", International Journal of Electronics and Electrical Engineering, vol. 5, no 7, , June-Aug 2009, pp.52 -57

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