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Improved Performance of SAC-OCDMA system using SPD Detection Technique

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***Abstract*— Optical code division multiple access (OCDMA) systems allow several users to transfer data over a single optical channel simultaneously without any contention. In such systems each user is assigned a unique code which belongs to a family of orthogonal codes. A new detection scheme for spectral amplitude coding optical code division multiple access (SAC-OCDMA) system, namely single photodiode detection (SPD) is presented in this paper. The SPD detection technique is simulated with double weight (DW) codes via Optisystem software. Fiber Bragg gratings (FBGs) are used for encoding and decoding purposes. The entire effects of fiber nonlinearities, dispersion and attenuation were considered in the simulation of SAC-OCDMA system. The simulation results show that the single photodiode detection offer best bit-error rate (BER) performance as compared to other detection techniques proposed earlier.**

***Keywords*—** *Fiber Bragg grating (FBG), Multiple-access interference (MAI),Optical code-division multiple-access (OCDMA), Spectral-amplitude coding(SAC).*

I. Introduction

OCDMA systems allow several users to transmit simultaneously over a single optical fiber. In OCDMA the information is being transmitted in coded form so OCDMA systems provide better security against eavesdroppers. OCDMA technique offers several advantages such as flexibility in channel allocation, ability to operate asynchronously and increased capacity in bursty traffic. In general, there are two basic detection techniques namely coherent and incoherent. Coherent detection refers to detecting signals with respect to the phase information of the carriers while incoherent detection does not require any phase information. Alternatively a system having unipolar sequences in the signature code is called an incoherent system whereas a system using bipolar codeword is called a coherent system. Since phase synchronization is not necessary in incoherent systems so hardware complexity of the system is also reduced. This is the reason why we have chosen incoherent detection in this research. The main disadvantage of incoherent OCDMA systems is the presence of MAI and phase induced intensity noise (PIIN) which limits the capacity and performance of the system [13]. SPD detection technique is capable of eliminating the effect of both MAI and PIIN. In SAC-OCDMA system, as the name suggests, the optical spectrum is amplitude-encoded by a different code for each channel to produce the OCDMA signals. Moreover, these systems can use incoherent light sources such as LEDs.

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In OCDMA systems each user is assigned a unique code from a family of orthogonal codes. The orthogonal codes have a unique property of possessing minimum cross-correlation among them. These codes help in reducing the effect of MAI to a great extent. Some examples of such codes are double weight (DW), modified double weight (MDW), enhanced double weight (EDW), modified quadratic congruence (MQC) codes etc. In this paper the performance of DW codes is analyzed using SPD detection technique of SAC-OCDMA systems. At the receiver, all the codeword from different users are correlated. If a correct codeword arrives then an auto-correlation function with a high peak result is obtained at the receiver. MAI was generated whenever an incorrect codeword arrives at the receiver. Hence codes having low cross-correlation are preferred so as to reduce the interference between signals of different users.

In SAC-OCDMA systems, the source with a broad spectrum is used. Example of such sources includes light emitting diode (LED), EDF sources and CW lasers. The broad source spectrum is divided into several narrow spectral sub-bands called spectral bins or spectral chips. The amplitude of each bin is modulated in accordance with the user code applied. This modulation is also called on-off keying. With such modulation the bin is either off or on [2]. When a broadband signal is passed through the set of FBGs certain frequency bands are reflected which form the chips of the spectral code. The reflected frequency bands depend on the Bragg wavelength of a particular FBG. Weight w represents the number of occupied frequency bins in an encoder and in-phase cross correlation λ represents the maximum number of common frequency bins occupied by any two codes of the family.

In this paper, the performance of double weight code that has cross-correlation ($\lambda_c = 1$) utilizing single photodiode detection (SPD) technique is presented. The rest of the paper is organized as follows. SPD detection technique is clarified in Section II. The simulation setup is presented in detail in Section III. Finally, results and discussions are given in section IV and conclusions are drawn in Section V.

II. Single Photodiode Detection (SPD) Scheme

The proposed SAC-OCDMA receiver diagram of this technique is shown in fig. 1 [10, 11]. The received optical signal is passed through the decoder consisting of FBG1 and

FBG2 as shown in fig. 1. This decoder is having an identical spectral response as that of the encoder at the transmitter side. The output of this decoder is then transmitted to the subtractive decoder (s-decoder). This decoder cancels out signals having mismatched signatures i.e. interferers. In other words, the s-decoder contains only frequency bins from different interferers as shown logically in table 1.

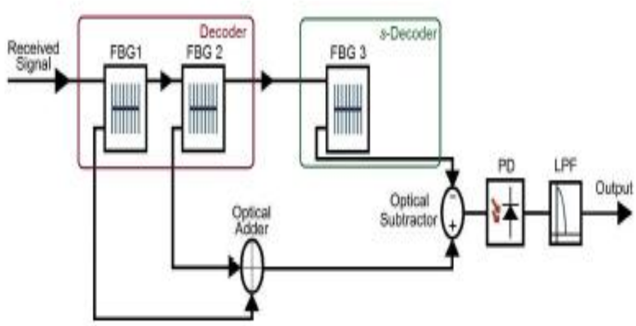

Fig. 1. SAC-OCDMA receiver based on SPD technique

FBGs are used for decoding the received optical signal. The output of the decoder can be either zero power unit for active user or cross-correlation power unit for an interferer. The additive signal of the decoder and s-decoder are applied to an optical subtractor. The two interference signals at the optical subtractor are assumed to be equal and ultimately cancel out each other. The output of optical subtractor is either code weight power unit for active user or zero power units for interferer. However, practically, there is a slight difference in the two interference signals at the optical subtractor and result in a small amount of optic power which will finally reach the photodiode. SPD detection technique results in the suppression of interference signals in the optical domain. With this, both PIIN and MAI are alleviated in the optical domain. Another advantage of using the SPD technique is that with the cancellation of the interference signals in the optical domain, only a single photodiode is required per user rather than two photodiodes as in a typical subtraction detection scheme. This reduces the optical-to-electrical conversion and shot noise generated at the receiver part. Finally, after the desired signal is detected by a photodiode, the data-carrying electrical signal is low pass filtered by a Bessel filter.

TABLE I. LOGICAL REPRESENTATION OF INTERFERENCE CANCELLATION

	Code Words
Main User (DEC)	0 1 1 0 0 0 1 1 0
1st Interfering User (I_1)	1 1 0 1 1 0 0 0 0
2nd Interfering User (I_2)	0 0 0 0 1 1 0 1 1
(DEC*I_1)	0 1 0 0 0 0 0 0 0
Sum (DEC*I_1)	1
(DEC)″	1 0 0 1 1 1 0 0 1
(I_1*I_2)	0 0 0 0 1 0 0 0 0
s-DEC= (DEC)″*(I_1*I_2)	0 0 0 0 1 0 0 0 0
(I_1*s-DEC)	0 0 0 0 1 0 0 0 0
Sum (I_1*s-DEC)	1
Sum (I_1*DEC) – Sum (I_1*s-DEC)	1-1 = 0

III. SIMULATION SETUP

The simulations of incoherent SAC-OCDMA have been performed in Optisystem version 13 which is very popular for conducting optical fiber simulations. The simulation setup for SPD detection technique is shown in fig. 2. The simulation was carried out for three users. The bit rate of each user is 200 Mbps. Each chip has a spectral width of 0.3 nm. The transmitter consists of an optical source such as LED, laser or white light source. Output of the source is modulated with a pseudo random bit sequence (PRBS) generator using Mach-Zehnder Modulator (MZM). Output of MZM is then encoded using Fiber Bragg Grating (FBG) and transmitted over single mode fiber. PIN photodiodes are used at the receiver side to convert the signal from optical to electrical domain. A low pass electrical Bessel filter is also used at the receiver.

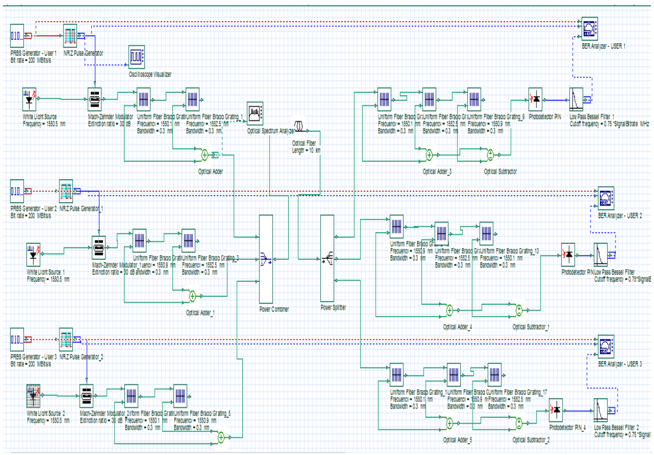

Fig. 2. Simulation setup for SPD detection technique

TABLE II
PARAMETERS

Parameter	**Value**
Bit Rate	200 Mbps
Attenuation	0.25 dB/km
Dispersion	18ps/nm/km
Dark Current	5nA
Thermal Noise	1.8×10^{-23}W/Hz
Spectral Width	0.3nm
Fiber Length	10km

The ITU-T G.652 standard single-mode optical fiber is employed for a 10 km optical transmission. The nonlinear effects were activated and specified according to the typical industrial values to simulate the real environment as close as possible. The performance of the system was characterized in terms of bit-error rate (BER) and eye pattern.

IV. RESULTS AND DISCUSSIONS

Fig. 3 and fig. 4 show the eye diagrams for user 1 and user 2 with SPD detection technique for SAC-OCDMA system. The BER for user 1 is equal to 3.60989×10^{-38}. The eye opening is also wide with Q-factor equal to 12. The BER for user 2 is equal to 8.422×10^{-41}. The Q-factor is of the order of 13. These values are better than other subtraction detection techniques proposed for SAC-OCDMA system.

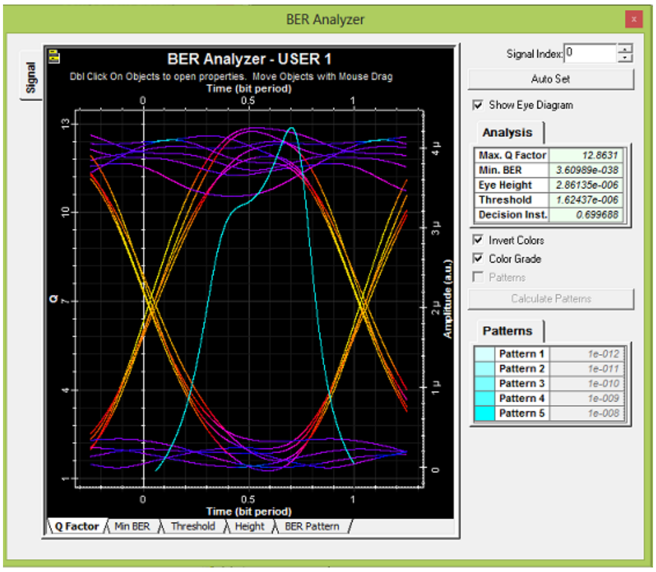

Fig. 3. Eye diagram for user 1 employing SPD detection technique

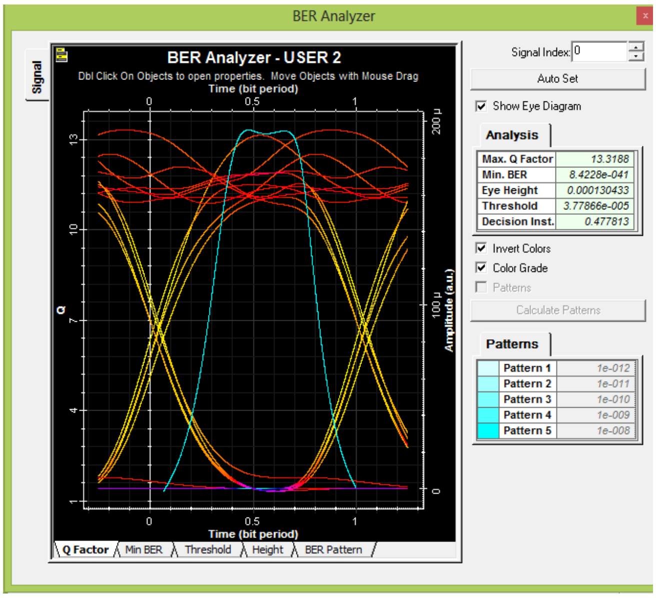

Fig. 4. Eye diagram for user 2 employing SPD detection technique

Therefore SPD technique shows significant improvement in the performance of SAC-OCDMA systems over other detection approaches at all fiber lengths and offers the advantage of increasing the length of the transmission link without affecting the QoS. It is evident that the SPD technique clearly enhances the throughput of SAC-OCDMA system.

V. Conclusion

In this paper, the transceiver design of SPD detection technique of SAC-OCDMA systems is highlighted. From the simulation analyses, it shows that the SPD technique shows the best performance for DW codes than other detection techniques. The enhanced performance of SPD technique is based on elimination of PIIN and MAI in the optical domain. This allows requiring only a single photodiode to be used rather than two photodiodes as in typical subtraction detection. The result explains that the type of detection used in SAC-OCDMA system plays the most important role in reducing the BER significantly instead of changing the type of code or other SAC-OCDMA system parameters or system properties.

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REFERENCES

[1] C.M.Negi, Amit Pandey, Gireesh G.Soni, Saral K.Gupta, and J.Kumar, “Optical CDMA networks using different detection techniques and coding schemes,” International Journal of Future Generation Communication and Networking, vol.4, No.3, September 2011.

[2] H.M.R.Al-Khafaji, S.A.Aljunid,and Hilal A.Fadhil’ “ Performance Enhancement of SAC-OCDMA system using Modified-AND subtraction detection,” 2011 IEEE International Conference on Computer Applications and Industrial Electronics.

[3] H.M.R.Al-Khafaji, S.A.Aljunid, and Hilal A.Fadhil, “Modified-AND subtraction detection technique based on weight division for SAC-OCDMA systems,” International Journal of Computer and Electrical Engineering, vol. 4, no. 6, pp. 861-863, December 2012.

[4] H.Yin and D.J.Richardson, “Optical code division multiple access communication networks- theory and applications”, Springer, 2009.

[5] M.B.Othman, J.B.Jensen, X.Zhang, and I.T.Monroy, “Performance evaluation of spectral amplitude codes for OCDMA PON,” 15th International Conf. on ONDM, Bologna, 2011.

[6] M.Z.Norazimah, Hamza M.R.Al-Khafaji, S.A.Aljunid, and Hilal A. Fadhil, “Performance Comparison of different detection techniques in long-haul fiber SAC-OCDMA systems,” IEEE 3rd International Conference on Photonics, pp. 199-203, Penang, 1-3 October 2012.

[7] M.Z.Norazimah, S.A.Aljunid, H.M.R. Al-Khafaji, and M.S.Anuar, “Impact of different transceiver design on the performance of SAC-OCDMA systems,” IEEE 2nd International Conference on Electronic design, pp. 122-126, August 19-21, 2014, Penang, Malaysia.

[8] S.A.Aljunid, S.Zarihan, M.S.Anuar, M.N.Junita, M.D.A.Samad, and M. K.Abdullah, “Improving bit error rate of OCDMA system using AND subtraction technique,” IEEE International RF and Microwave Conference proc., pp. 334-337, September 2006.

[9] S.Ayotte, M.Rochette, J.Magne, L.A.Rusch, and S.LaRochelle, “Experimental verification and capacity prediction of FE-OCDMA using superimposed FBG,” J. Lightwave Technology, vol. 23, pp. 724-731, February 2005.

[10] Sarah G.Abdulqader, Syed A.Aljunid, Hilal A.Fadhil, “Enhanced performance of SAC-OCDMA system based on SPD detection utilizing EDFA for access networks,” Journal of Communications, vol. 9, no. 2, pp. 99-106, February 2014.

[11] Somaya A.Abd El Mottaleb, Heba.A.Fayed, Ahmed Abd El Aziz, and Moustafa H.Aly, “SAC-OCDMA system using different detection techniques,” IOSR Journal of Electronics and Communication Engineering, vol. 9, issue 2, ver. 3, pp. 55-60, March 2014.

[12] Vandana Nath, Nakul Jain, and Sandeep Dogra, “Effect of fiber distance on various SAC-OCDMA detection techniques,” International Journal of research in Engineering and Tehnology, vol. 2, issue 3, pp. 290-293, March 2013.

[13] W.J.Huang, C.T.Niu, C.H.Lin,and J.Wu, “Spectral OCDMA system using partial modified prime codes and error-correction codes,” J. Lightwave Technology, vol. 26, pp. 3030-3040, September 2008.