Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

INCREASING PERFORMANCE OF SAC-OCDMA BY COMBINE OFDM TECHNIQUE

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ABSTRACT

Optical CDMA playing significant roles to extend from local area networks to longer span telecommunication type networks. In order to play a significant role in these longer span with higher data rate networks. Optical CDMA code Prefer to have OFDM technique. In this letter, combine SAC-OCDMA with OFDM, operate high data rates and propagate with high fidelity over fiber links. The design of hybrid system with code weight equal to 2 for operation at 10 Gb/s and evaluate their propagation over an existing 100 km network link by means optisystem software. The proposed system using multi diagonal (MD) code gives a good performance based on bit error rate (BER) and long distance. As a result, the BER improved 10^-4 for the OFDM-OCDMA than conventional OCDMA systems at distance 100 Km, as well as the data rate reached to 10 Gbps with desired bit error rate (BER).

Keywords: *Spectrum Amplitude code OCDMA; OFDM; MD.*

1. INTRODUCTION

The increasing demand for higher data-rates has inspired tremendous interest in combining subcarrier multiplexed (SCM) and optical code division multiple access (OCDMA) to the fiber optic communication systems [1]. Optical Code Division Multiple Access (optical CDMA or OCDMA), supports multiple asynchronous, concurrent users which occupy the same time slots and frequency domain.in addition, OCDMA systems have the advantages of providing multiple users to simultaneously access the same bandwidth with high-level security. On the other hand, subcarrier multiplexing (SCM) technique is able to enhance the channel data rate of OCDMA systems and increase the number of users [2].but in contrast, the hybrid SCM/OCDMA systems have limitation in the number of subcarriers because it is take a large bandwidth. Thus, OFDM systems use fast Fourier transform (FFT) and offer significant advantages such as reduced frequency selectivity fading, provision for a higher number of subcarriers, high data rate, and spectrum efficiency and provide a way for several radio signals to access the OCDMA networks [3],there for hybrid OFDM and optical code division multiplexing access (OFDM-OCDMA) improve the transmission bandwidth and provide some robustness against interference. The maximum permissible number of simultaneous users can be enhanced by increasing the OFDM subcarriers and/or the OCDMA code words [4]. Among all type of OCDMA system spectral amplitude coding (SAC) is chosen due to its ability to allow many users to share the same transmission medium asynchronously and simultaneously with a high level of transmission security [1,5], However, the SAC-OCDMA system suffers from various noises such as shot noise, thermal noise, dark current and multiple access interference (MAI) from other users. Among these noises, MAI is considered as a dominant source of system performance degradation. Therefore, an intelligent design of code sequence is necessary to reduce the effect of MAI [6], to overcome these problems, the authors suggest the use of Multi Diagonal (MD) code which is designed based on a combination of diagonal matrixes[7].The MD code has several advantages such as, zero cross-correlation code which cancels the MAI (multi access interference), flexibility in choosing weight(W) [8], and users(K) [9] parameters over

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

other codes like Modified Quadratic Congruence (MQC), and Khazani–Syed (KS) codes, simple design, supports a large number of users at a high data rate compared to other codes, no overlapping of spectra for different users and theoretical cross correlation equal to zero[10]. The corresponding SAC-OCDMA systems can suppress the phase induced intensity noise (PIIN) [11].

In this paper we propose a new technique which is OFDM/SAC-OCDMA system, this enhance the OCDMA system performance by increasing the data rate and reach to long distance compare to conventional OCDMA system. The proposed system is evaluated based on multi diagonal (MD) code, the performance of the hybrid system investigated by simulation based on BER versus by data rate and distance.

The remainder of this paper is organized as follows. OFDM SAC-OCDMA system, result and discussion. Finally, the conclusion.

2. OFDM -SAC-OCDMA SYSTEM ARCHITECTURE

The proposed OFDM SAC-OCDMA system architecture is shown in Fig. 1. The OFDM data are modulated with I/Q modulator at Frequencies 7.5 Gbps. This OFDM signal are optically modulated onto a code sequence using Mach Zehnder optical external modulator, each code sequence is assigned with a different code based on the multi diagonal (MD) code structure. Then m modulated code sequences are combined together via an optical combiner and transmitted through the optical fiber. At the receiver, an optical splitter is used to split the modulated code sequences to various paths according to the number of receivers. Only the matched code sequences are decoded while the unmatched code sequences will be filtered out. Through the decoder the decoded signal is detected and the MAI from unmatched transmitters can be completely canceled. Each channel is assigned a particular code sequence.

Table 1: Typical Parameters Used in Simulation

Parameters	Values
Power	-4 dBm
Number of subcarriers	256
Data rate	10 Gb/s
Distance	100 Km
Number of samples	65536

2.1. MD CODE

The MD code is characterized by the parameters N, W and λc, where N is the code length (i.e., the number of total chips), W the code weight (the number of chips having the unit value), and λc the in-phase cross-correlation. it can be defined for three users as follows [5]:

$$I = \begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix} \qquad (1)$$

The orthogonal matrix represents a square matrix with real entries whose columns and rows are orthogonal unit vectors. In other words, a matrix A is orthogonal if its transpose is equal to its inverse: A^T A = A A^T = I.

Now, the cross-correlation theorem states that certain sets of complementary sequences have cross-correlation functions that sum to zero by using all pairwise permutations. Here, all cross correlation function permutations are required in order that their sum be identically equal to zero. For example, if the rows and columns of a (K × N) matrix are orthogonal and all the columns except one sum to zero, then the sum of all cross-correlations among non-identical code words is zero.

It is considered that the code possesses zero cross-correlation properties. The matrix of the MD code represents a K×N matrix depending functionally on the number of users K, and the code weight W. For the MD code, the choice of the weight value is free, though it should be larger than unity (W > 1).in our design we use w=2 and number of user equal to three. The matrix become as:

$$I = \begin{matrix} 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \end{matrix} \qquad (2)$$

The structure of MD code explained in detail in [5].

ISSN: **1992-8645** www.jatit.org E-ISSN: **1817-3195**

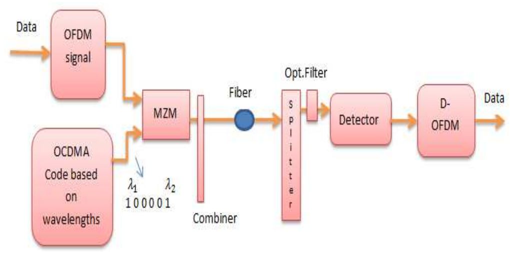

Figure 1: Shows the Structure of OFDM SAC-OCDMA

3. RESULT AND DISCUSSION

The transceiver OFDM part has 256 subcarriers used at 10 Gbps with 4-QAM modulation for each channel and 7.5 GHz RF frequency. In SAC- OCDMA based on MD code The length, weight, and cross-correlation (L, w, λ) of these codes are (6, 2, 0) respectively and the number of users equal to three.

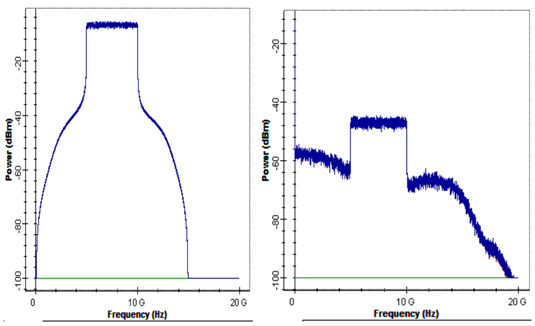

Figure 2, electrical spectral of the proposed system at the transmitter and receiver

In figure 2, the electrical spectra of the OFDM which carried over optical CDMA code at the transmitter and the receiver respectively, it can be seen the signal at receiver similar to signal at transmitter due to accurate design by using optical FBG filter to assign apart of optical spectrum for each user based on code sequence, even though still some noise appears due to the noise and dispersion.

BERs are plotted in Figure 3, versus different values of data rate, it is clear from the figure that the system with OFDM modulation has better performance compare to conventional OCDMA system, when the number of simultaneous channels are 3 and the effective source power is -4dBm. At 10 Gbps the OFDM SAC-OCDMA has10^-25 BER compare to 10^-5 for conventional OCDMA system with 50 km distance. The enhance in performance of proposed system coming from the many of subcarriers used for each user. This increase the signal power, therefore signal to noise ratio increased.

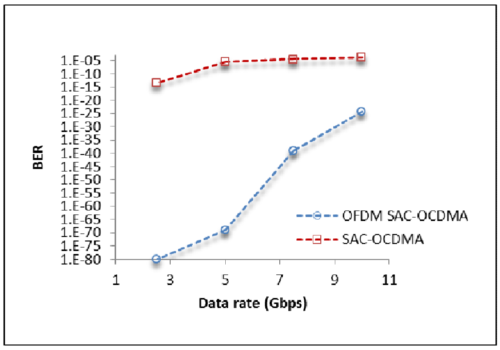

Figure 3: BER versus different values of data rate

Figure 4, depicts the performance of a hybrid system that uses MD code for different distances; it is shown that the BER variations decrease with increasing the distance. Also, with similar code weigh, the OFDM SAC-OCDMA (MD) system at 100 km has 10^-9 BER compare to the conventional OCDMA (MD) system has 10^-6 BER at same distance. The performance in proposed system has higher performance because the data rate in Optical OFDM divided among the subcarriers, thus each subcarrier has low date rate which is not affected by dispersion and other impairments, there for new system using OOFDM reached to longer distance.

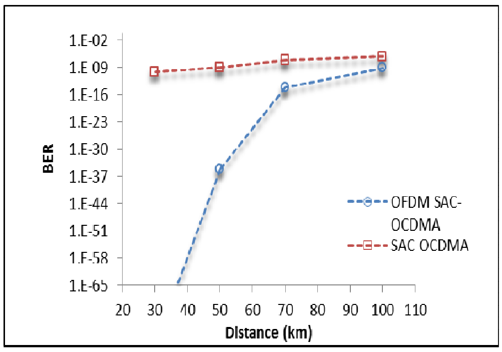

Figure 4: BER versus distance

4. CONCLUSION

Orthogonal frequency division multiplexing (OFDM) combined with spectral amplitude coding optical code division multiple access (SAC-OCDMA) is a new technology investigated. The data rate and distance in SAC-OCDMA System has been developed. The BER of OFDM SAC-OCDMA has been evaluated by *Optisis* simulation and compared to the BER for convention SAC-OCDMA code. As a result, the BER for proposed

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

system improved 10^{-4} compare to conventional OCDMA systems at distance 100 Km, as well as with desired bit error rate (BER) the data rate reached to 10 Gbps.

ACKNOWLEDGEMENT

The author would like to acknowledge the support from Fundamenal Research Grant Scheme (FRGS) under Prof .Dr. Syed Alwee Aljunid, Department of Higher Education, Ministry of Higher Education Malaysia for the assistance with the grant.

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