Design and Analysis of OCDMA System with Different Detection Technique

S. Deepika, I. Muthumani
Department of Electronics and Communication Engineering, ACCET, Karaikudi, Tamil Nadu, India

Article Info
Article history:
Received 5 February 2015
Received in revised form
20 February 2015
Accepted 28 February 2015
Available online 6 March 2015

Keywords
Optical CDMA,
Spectra Amplitude Coding (SAC),
Multiple Access Interference MAI,
Single Photodiode Detection (SPD)

Abstract

Optical code-division multiple access system has been very helpful in combining the unlimited bandwidth of fiber with the flexibility of CDMA technique to achieve a high quality transmission. However, the main degradation on the performance of OCDMA systems is essentially due to multiple access interference (MAI) originating from other simultaneous users. Spectral amplitude coding garners significant attention because of its ability to reduce MAI by employing an appropriate detection technique. Proposed paper uses a single photodiode detection technique for Spectral amplitude coding optical code division multiple access (SAC-OCDMA) system. When using this technique, the multiple access interference (MAI) is eliminated in the optical domain. This process provides a high value of Q-factor compared to the other detection techniques.

1. Introduction

Today's telecommunication networks have widely adopted optical fiber as the backbone transmission medium. It has the advantage of low loss, low noise and very high bandwidth. In order to make full use of the available bandwidth in optical fibers and satisfy the bandwidth demand in future information networks, it is a necessary to multiplex low rate data streams onto optical fiber to increase the total throughput [1].

A multiple access scheme is required for multiplexing and de-multiplexing traffic on a shared physical medium. The three major multiple access schemes are described. Digital communication allows the possibility of time division multiple accesses (TDMA). In a TDMA system, each channel occupies a time slot, which interleaves with the time slots of other channels. In a wavelength division multiple access (WDMA) system, each channel occupies a narrow bandwidth around a centre wavelength or frequency. A channel in a CDMA system occupies the same frequency-time space as all the other CDMA channels. Each CDMA channel is distinguished from other CDMA channels by a unique CDMA spreading code.

A. Problems in OCDMA

Technology

Two different types of problems are considered in OCDMA systems

- Multiple access interference (MAI)
- Phase induced intensity noise (PIIN)

a) Multiple Access interference (MAI)

In CDMA, user wants to transmit a data bit one, its send out a code word corresponding to the appropriate addressed signature of the intended receiver. In receiver detect the transmitted light signal by using correct key code performs the auto correlation function. Otherwise receiver detects a transmitted light by using the incorrect code word, the cross correlation functions are generated and they create multiple access interference (MAI).

Corresponding Author,
E-mail address: deepidasha@gmail.com
All rights reserved: http://www.ijari.org

b) Phase Induced Intensity Noise (PIIN)

When incoherent light fields are mixed and incident upon a photo detector, the phase noise of the fields causes an intensity noise term in photo detector output. These types of noise are called phase induced intensity noise (PIIN) [2].

These two types of noises are removed by using number of detection techniques like direct detection, complementary detection and new type of detection called single photodiode detection (SPD) techniques [3].

2. Encoding Methods

Optical CDMA provides different types of encoding methods depend on the selected wavelength, frequency spacing and types of optical sources used.

- Amplitude encoding
- Spectral encoding
- Coherent phase encoding
- Matrix coding
- Spatial coding

a) Amplitude Encoding

The amplitude encoding is very economical, as only the power of the signal is detected and phase information of the signal is not considered. Optical delay lines are used to encode the optical signals

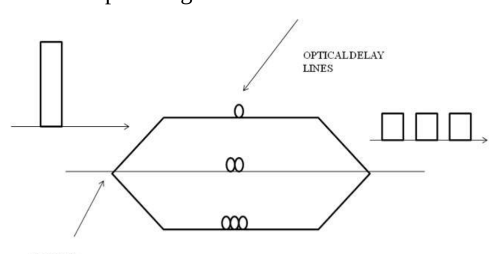

Fig: 1. Optical Delay Line Encoder

b) Spectral Encoding

Spectral encoding can use the either amplitude or phase of the spectral components in the signal to encode the information. The spectral encoding scheme uses a low-cost broadband optical source. The two types of spectral encoding are described.

- Spectral amplitude encoding
- Spectral phase encoding

c) Coherent Phase Encoding

Phase encoded optical pulses are generated using electro-optic modulators. Pulses are encoded by using tapped optical delay lines introducing different phase shifts in the different branches.

d) Matrix Encoding

Arrayed waveguide gratings are used for encode and decode optical signals.

e) Spatial Encoding

In spatial encoding multiple fibers are used as a space channel to encode the optical signal.

3. Detection Techniques

This project was carried out by using simulation software, OptiSystem13. The major aspect during methodology stage is simulation process. The Encoders and decoder structures can be implemented using any type of optical filtering technology, including thin-film filters, Fiber Bragg Gratings (FBGs), or free-space diffraction gratings. In this system the 200 Mb/s signal is generated and coded with suitable encoding scheme. Coded information signal is transmitted through single mode optical fiber and receiver side detection process is employed.

A) Direct Detection Technique

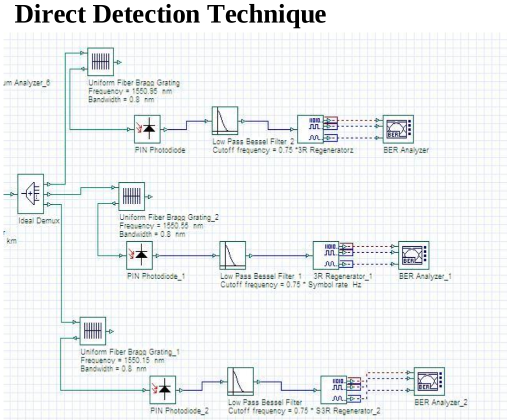

Fig: 2. Direct Detection Technique

The role of the optical transmitter is to convert the electrical signal into optical form, and provide the pseudo random code for each user. The optical transmitter consists of the following components, sequence generator, laser source and modulator. The coded optical signal is transmitted to the receiver via single mode optical fiber. Receiver applies a correct key code to detect the signal directly using FBG's and low pass filter.

B) Complimentary Subtraction Technique

The role of the optical transmitter is to convert the electrical signal into optical form, and provide the pseudo random code for each user. The optical transmitter consists of the following components, sequence generator, laser source and modulator. The coded optical signal is transmitted to the receiver via single mode optical fiber.

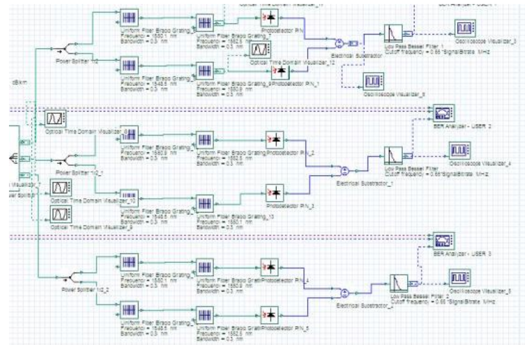

Fig: 3. Complementary Subtraction Detection

In complementary subtraction technique the each received channel is split into two branches. Both upper and lower branches are performing the detection operation separately and output of the each branch is subtracted by electrical subtraction. Multiple access interference in the receiver is partially removed in this process.

C) AND Subtraction Technique

In AND subtraction method, the optical transmitter is to convert the electrical signal into optical form, and provide the pseudo random code for each user. The optical transmitter consists of the following components, sequence generator, laser source and modulator. The coded optical signal is transmitted to the receiver via single mode optical fiber. In AND subtraction technique the each received channel is split into two branches similar to the complementary subtraction technique. Both upper and lower branches are performing the AND operation separately and output of the each branch is subtracted by electrical subtraction. Multiple access interference in the receiver is partially removed in this process

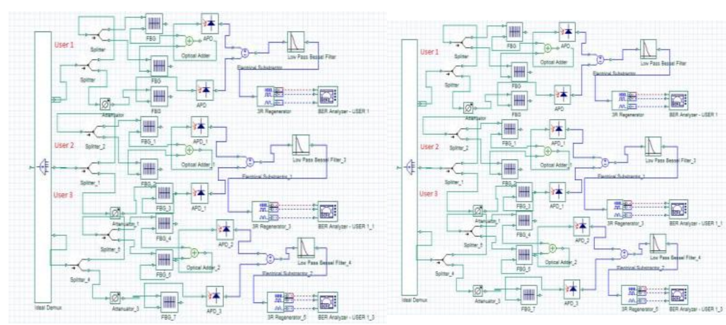

Fig: 4. AND Subtraction Detection

D) Single Photodiode Detection

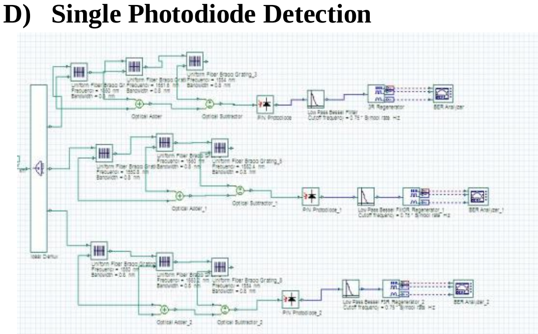

Fig: 5. Single Photodiode Detection

The incoming signal is decoded using the same spectral response of the encoder for. The decoder detects *w* power units (P.U.) for active user or λ P.U. for mismatched signals, where the weight *w* represents the number of occupied frequencies in the user's encoder, and the in-phase cross-correlation is λ the maximum number of common frequency signals occupied by any two codes of the family . The remainder of the signal from the decoder is then transmitted to the subtractive decoder (s-Decoder) to cancel out signals with mismatched signatures. The s-Decoder contains only frequency bins from different interferers. After optical subtraction, the output from the subtractive decoder is either zero P.U. for active user or λ P.U. for interferers. This technique can be performed using low cost uniform FBGs to decode the received signal. The interference signals are cancelled in the optical domain before the conversion of the signals to the electrical domain and this rejects both PIIN and MAI in the optical domain.

4. Results and Discussion

In our experiment, transmission of three and seven channels at 200 Mb/s is done and it is necessary to consider the effects: Q-factor, BER value, length of the fiber, bit rate.

A. Q Factor for 3 user Direct Detection method

USER	Q-FACTOR
User1	3.53491
User2	3.48406
User3	3.02224

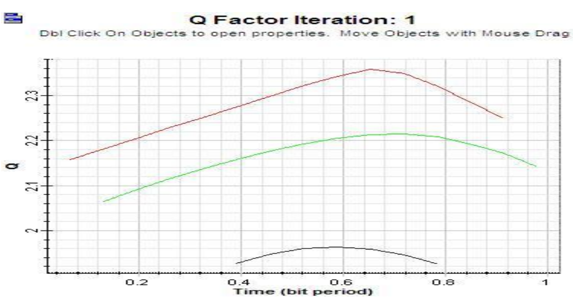

Fig: 6. Q-factor for Direct Detection Technique

B. Q factor for 3 user Complementary subtraction method

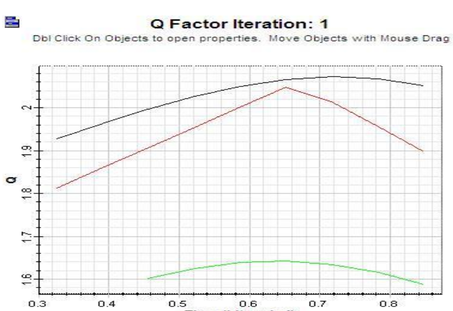

Fig: 7. Q-factor for Complementary Subtraction Method

USER	Q-FACTOR
User1	4.4283
User2	4.3212
User3	4.0043

C. Q factor for 7 user single photodiode Detection

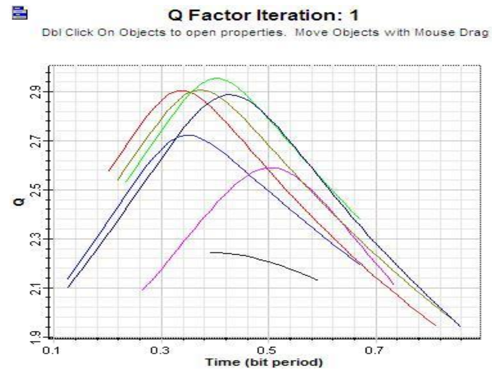

Fig: 8. Q-factor for Single Photodiode Detection

USER	Q-FACTOR
User1	4.98856
User2	4.58964
User3	4.90868
User4	4.72376
User5	4.95559
User6	4.90545
User7	4.74346

The fiber length increases causes dispersion of the fiber is also increases, so BER also increases with the fiber length. Single photodiode detection scheme shows the best performance compared to other methods. On performance basis we can arrange these configurations in the following order:

Single photodiode>direct>complementary>AND subtraction

When bit rate increases pulse width decreases, pulse become more sensitive to the dispersion.

Single photodiode>direct>complementary>AND subtraction

5. Conclusion

Thus a comprehensive study of detection of optical Code division multiple access system using different detection methods are designed. Using the Fiber Bragg Gratings (FBG) and filters, it was possible to achieve long transmission distance with more number of channels occupying the desired spectrum bandwidth. To enhance the system, it is necessary to redesign the encoding/decoding methods to increase the number of transmitted channels. Work is under way to improve the Q-factor of the design to eliminate the multiple access interference (MAI) and phase induced intensity noise (PIIN).

References

[1] J. A. Salehi, A. M. Weiner, J. P. Heritage, Coherent ultrashort light pulse code-division multiple access communication systems, *J. Lightw. Technol.*, 8, 1990, 478–491

[2] H. P. Sardesai, C. C. Chang, A. M. Weiner, A femtosecond code-division multiple-access communication system test bed, *J. Lightw. Technol.*, 16, 1998, 1953–1964

[3] J. H. Lee, P. C. Teh, P. Petropoulos, M. Ibsen, D. J.

Richardson, A grating-based OCDMA coding-decoding system incorporating a nonlinear optical loop mirror for improved code recognition and noise reduction, *J. Lightw. Technol.*, 20, 2002, 36–46

[4] R. Papannareddy, A. M. Weiner, Performance comparison of coherent ultrashort light pulse and incoherent broad-band CDMA systems, *IEEE Photon. Technol. Lett.*, 11, 1999, 1683–1685

[5] J. H. Lee, P. C. Teh, Z. Yusoff, M. Ibsen, W. Belardi, T. M. Monro, D. J. Richardson, A holey fiber-based nonlinear thresholding device for optical CDMA receiver performance enhancement, *J. Lightw. Technol.*, 14, 2002, 876–878