Investigation on coherent optical orthogonal frequency division multiplexing using coherent detection in optical communication system

GURPREET KAUR[a,*], RAJINDER SINGH KALER[a], RAJNEESH RANDHAWA[b], ANKIT KUMAR[a]
[a]*Optical Fiber Communication Research laboratory (OFCR Lab), ECE Department, Thapar University, Patiala, 147004, Punjab, India*
[b]*Department of Computer Science, Punjabi University, Patiala, India*

The effect of various subcarriers is investigated on coherent optical orthogonal frequency division multiplexing (CO-OFDM) using Dual Polarization Quadrature Phase Shifting Keying (DP-QPSK) modulation technique. In proposed system, we have used coherent detection to improve the system performance. The performance of proposed system is investigated in terms of bit error rate (BER), received optical power and constellation diagrams of the received signals. The results show that the network performance is improved by decreasing the overall dispersion of the fiber link us ing coherent detection.

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1. Introduction

Optical transmission technology has progressed extensively in current years to encounter the growing demands of users and broadband service providers. So, it's high time for the development in a technology that can support the rapidly growing internet bandwidth necessity [1-5]. One of the possible solutions for providing broadband capacity and transmission stability is OFDM [6]. The OFDM based setups are globally accepted as optical access network solutions for allotting judiciously high bandwidth to the users [7-11]. But the major drawback of WDM is that it possess a lot of complexity in the transmitter and receiver domain, and it is uneconomical to use WDM for this purpose because of its wide channel application. On the other hand, OFDM offers flexibility and reasonably priced for the users. OFDM also satisfies the people craving for the high bandwidth requirement [12]. So there is a need to develop a convergent network architecture, which can exploit the benefits of wired and wireless technologies, provides multiple services to both mobile and fixed users. Coherent optical OFDM scheme is used to transmit data at terabit rate for long haul purposes [13].

Procedures corresponding to flexible grid, allocation of an elastic channel and cognitive optical networks are constantly under many researcher's concern [14]. Many of the optical networks which are flexible in nature and widely used in numerous optical topologies, the CO-OFDM are strappingly capable to substitute WDM. To use effective adaptive transponders performance, they must have the capability to perform while dealing with adaptable quantity of subcarriers and data rates [15].

Many researchers have already addressed the same problem and made progress to provide a solution. Silva et al. [16] developed a coherent optical transmission system to increase spectral efficiency in a WDM system. It was reported that, the proposed system achieved 287.5 GHz bandwidth with spectral efficiency of 3.75 b/s/Hz. Huang et al. [17] experimentally demonstrated the generation and detection of 400 Gb/s single carrier DP-16QAM using 100GbE-grade. Various analog components are also incorporated in proposed system such as modulators, drivers and photodetectors. It was conveyed that, WDM transmission was successfully demonstrated over 121.2 Km distance with 5.33 b/s/Hz spectral efficiency. L. Jianping et al. [18] theoretically studied the stability of single sideband modulator based on recirculating frequency shifter (RFS). It was conveyed that, multipath interference induced crosstalk is an important factor that distresses the stability of the RFS and optimal operation conditions can be obtained with the help of given system parameter. Kaur et al. [19] and singh et al. [20] developed DWDM system and enhance the system performance with hybrid optical amplifier and with optical phase conjugation. Singh et.al. [21] proposed semiconductor optical amplifier to improve the system performance. They have also optimized its parameters to get better results.

Previously proposed frameworks were suitable for short haul signal transmission where the number of subcarriers needed a reduction in order to increase the transmission distance and eliminate inter-carrier interference, which as a result diminishes the system performance. Other schemes will take the advantage of Raman amplification and various techniques like NGI-OFDM, dense wavelength division multiplexing (DWDM) in order to accomplish further high transmission distances and which were relatively expensive to implement practically.

In this paper, CO-OFDM is proposed and the dispersion is compensated using post coherent detection module. After introduction, the paper is sorted out as follows: In section II, the simulation setup of the proposed scheme is discussed. In section III, results are discussed in detail and conclusion is drawn in section IV.

2. Simulation setup

The block diagram of proposed framework is shown in Fig. 1. At the transmission side, a CW laser with a functioning frequency of 193.1THz and linewidth of 0.1MHz is used. The input power of channel is set to 0dBm. A pseudo random bit sequence (PRBS) generator (whose baud rate is initialized at the value of 12.5 Gbaud, whose lengh is fixed at 2^{15}-1) is used to initiate an OFDM modulator in order to generate a 25Gbps baseband signal. This is divided into two parts using a polarization splitter, which is connected to their corresponding OFDM blocks (OFDM X and OFDM Y) due to the use dual polarization technique.

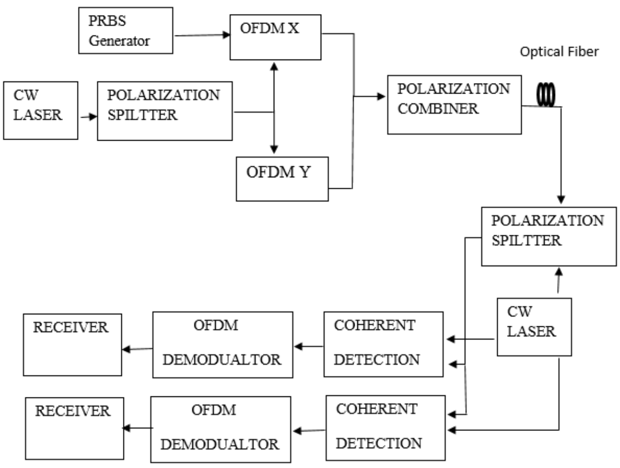


Fig. 1. Block diagram of CO-OFDM with DP QPSK

Then these signals after undergoing through OFDM modulation are constructively interfered using the polarization combiner. After the synchronization of these OFDM modulated signals it is transmitted through the simple single mode fiber which is accompanied with a loop controller which assists in varying the distance of the system and verifying the extent through which signal the signal can be transmitted. At the receiver side, after travelling through the recirculating loop the signal is again divided into two parts with the help of polarization splitter. These divided signals have to confront the coherent detection. This coherent detection is done with the help of the laser source whose frequency is 193.1 THz which is divided into two parts with the help of polarization splitter. Each of them will go through coherent detection. After coherent detection, these two polarized signals X and Y are demodulated with the help of OFDM demodulators X and Y respectively.

3. Results and discussions

Fig. 2(a) to 2(b) shows the optical spectrum of the transmitted signals and received signal at various distances Fig. 2(a) represents the optical spectrum of the transmitted signal. Fig. 2(b) shows the optical spectrum of the transmitted signal after the single mode fiber. From the following diagrams we can infer that optimum optical spectrum is achieved when the signal can be propagated through the distance of 300 km with acceptable range of power.

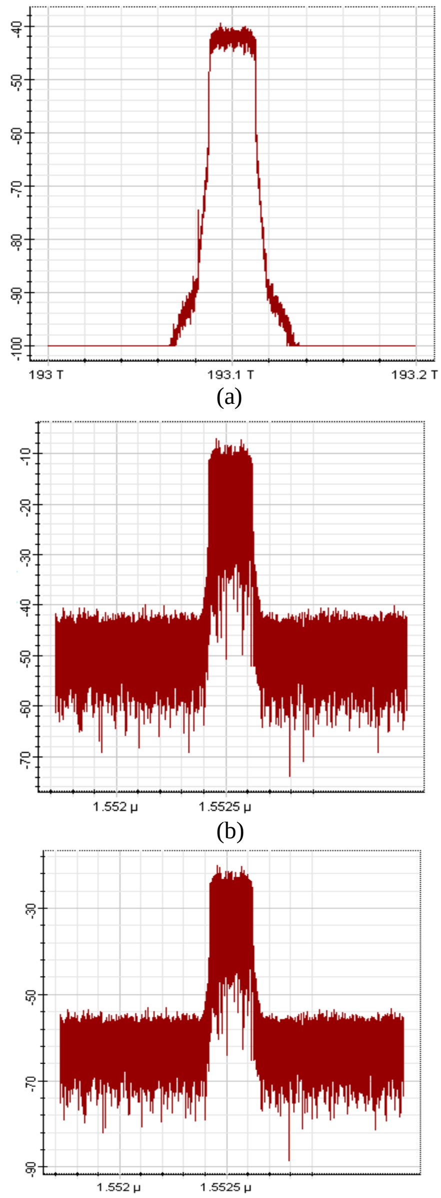


Fig. 2. Optical spectrum of: (a) transmitted signal after the OFDM modulation (b) transmitted signal after the fiber length 10 km (c) transmitted signal after the fiber length 100 km (d) transmitted signal after the fiber length 300 km

From Fig. 3, it can be resolved that the behavior of central subcarriers and its two neighboring subcarrier with respect to the distance travelled through the recirculating loop and the fiber.

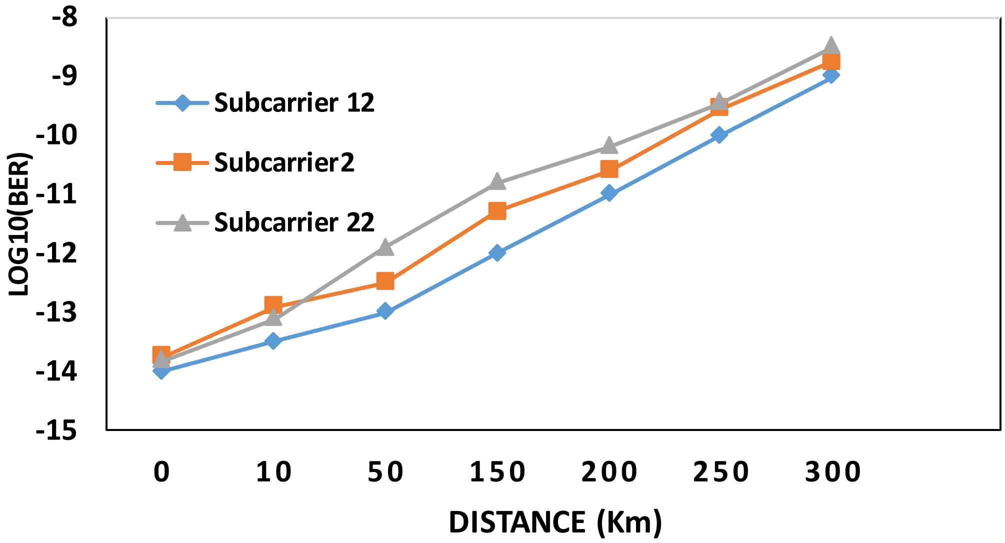
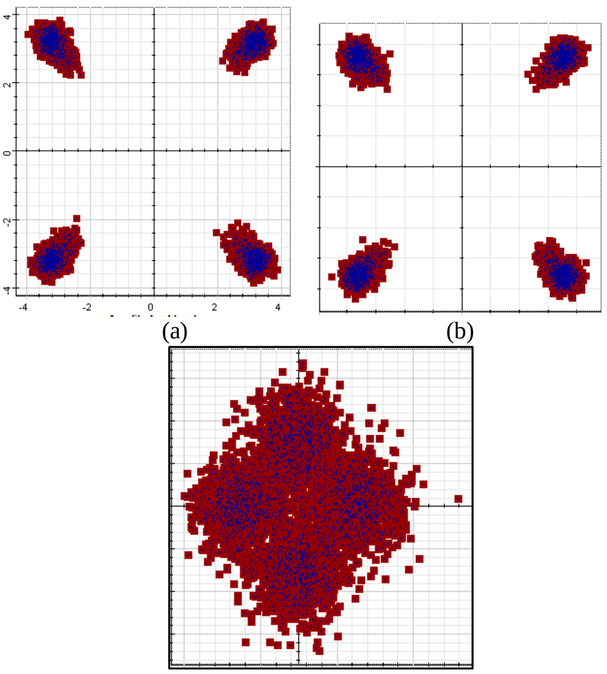


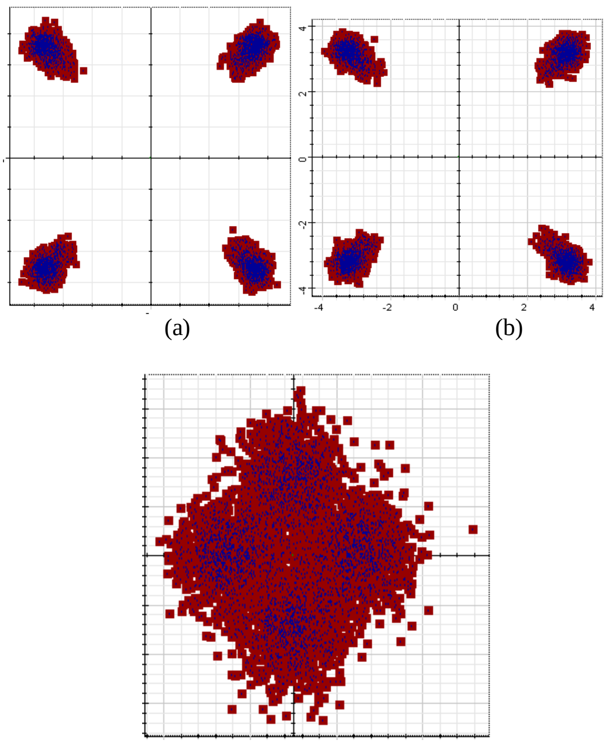
Fig. 3. BER as function of distance for different subcarriers

From Fig. 3, it can be resolved that the subcarrier 12 gives the better performance when compared to other carriers. For instance, at a distance close to 50 km, the corresponding values of BER for subcarriers 2, 12 and 22 from the above graph are $10^{-12.5}$, 10^{-13}, $10^{-11.9}$ respectively. For better clarification, constellation diagrams are taken for the proposed system. Fig. 4 to 5 shows the constellation diagram at the coherent detector for X polarization signal and for Y polarization signal at different length of fiber.



(a) (b) (c)

Fig. 4. Constellation diagram for coherent detector for X polarized signal at (a) 10 km (b) 100km (c) 300 km



(a) (b) (c)

Fig. 5. Constellation diagram for coherent detector for Y polarized signal (a) 10 km (b) 100 km (c) 300 km

From the graphs and constellation diagrams of each coherent detectors, we came to this deduction that we are getting the desired outcomes up to the distance of 250 km.

4. Conclusion

In this paper, CO-OFDM modulation technique with DP-QPSK scheme using EDFA amplification is proposed and investigated. We demonstrated that using coherent detection at the receiver end reduces the dispersion. The system provides satisfactory values of BER upto a transmission distance of 300 km. Thus, the proposed system can be implemented for long distance propagation. The system competence can further be enhanced by incrementing the number of users in the arrangement.

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*Corresponding author: gksumman@gmail.com