Comparative analysis of Spectral Phase Encoding/Decoding based OCDMA Communication System for two Optical Modulation Formats

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***Abstract**:In this paper a Simulative analysis of OCDMA system is demonstrated for DPSK and Duo-binary optical data formats using spectral phase encoding/decoding (SPE/SPD) in time and a single phase Modulator for different optical codes that can reconfigure using these optical codes with help of phase modulator this Spectral phase encoding technique can be realize using by the process of expanding and compressing the optical pulse with help of optical component having positive and negative dispersion value.SPD has similar configuration as SPE but here phase modulator is driven by the complementary code pattern that was used in SPE. In this simulative demonstration 2.5 Gbps DPSK and Duo binary data and chip rate of 40 GChips/s has transmitted over 50 km fibre and successfully decoded at receiver for four different OCs.*

***Keywords**-- Fibre optics, DPSK, Duobinary, Spectral phase encoding (SPE), Spectral phase decoding (SPD), Optical pattern, phase modulator (PM), OCDMA.*

1. INTRODUCTION

FibreOptical communication system gets the high attention due to economic advantages, and high information capacity. This systemhas multiplexing, demultiplexing, filtering, amplificati- on, correlation and optical signal processing is much faster than electrical signal processing, it can be directly done in optical domain. In optical fibre communication system OCDMA is one of the type of multiplexing technique in which this can be achieved by assigning different code sequences for different users. According to principle of working OCDMA is classified in two categories that are incoherent and coherent, incoherent is an intensity based and coherent which is phase shift based OCDMA technique, but due to overall performance coherent typegets more attraction for practicalthan incoherent OCDMA. Other hand is usefulfor development of compact and reliable encoding/decoding devices[1].In OCDMA spectral phase encoding time spreading SPECTOCDMA is performed in spectral domain by encoding different phase shift into different spectral components which will also result in pulse stretching or spreading in time domain. According to recent experiments a novel spectral phase encoding (SPE) scheme realized in time domain by using two opposite dispersive optical components and a high speed phase modulator[1-4].Time-domain spectral phase encoding has many advantages including itsflexibility in reconfiguring the optical codes and compatibility with the fibre optical system. It is also has the potential of combining the optical code (OC) generation and data modulation by using single phase modulator to provide high security optical communication.

This paper has five sections,first is Introduction part this paper which includes a brief introduction of system that is used in that paper, after introduction next sectionis defines the some optical data formats that are used in optical communication system like NRZ, DPSK, Duobinary etc. Modulation Formats section followed by Encoding decoding in this a detailed description of encoding and decoding scheme is discussed. Forth section is simulation setup and discussion section which describe how system works and at last result and conclusion which show the comparison of output result for these two data formats in thetermsof Q factor and min BER.

2. MODULATION FORMATS

(i) NRZ: In telecommunicationthis non return to zero type of binary code high level or positive voltage is represented by 1s and other side low voltage or low level is represented by 0s it is also known as on off keying. NRZ signal has more energy than RZ signal because it doesnot have rest conditions.

(ii) Duobinary: Duobinary is a binary modulation format that was introduced back in the 1960sfor electrical cable communications Duobinary transmission scheme for transmitting R bits/sec using less than R/2 Hz bandwidth [10]. As a matter of fact, Duobinary is usually thought of as a line coding technique that is used to shape up the spectrum of the signal rather than a modulation format[5-6].

(iii)Differential Phase Shift Keying (DPSK): DPSK is a binary modulation format that encodes information in the optical phase of the optical symbols. The DPSK signal has two phase states (0 or π) which can be generated either using an optical phase modulator or a MZM. The structure of the MZM-based DPSK transmitter is very similar to the OOK transmitter structure. However, in case of DPSK the MZM should be biased at the trough point and driven with a binary electrical driving signal that has an amplitude of 2Vπ[5]. Compared to OOK DPSK has a much better tolerance to nonlinear transmission effects, and it induces lessercross phase modulation (XPM) to its neighbouring channels due to its nearly constant power envelope [6].

3. ENCODING DECODING

In this experiment time domain SPE is designed by using an optical component having positive and negative dispersion value at operation wavelength of 1550nm it can be an optical fibre or a FBG or other optical component. At transmitter side optical component having negative dispersion is used to stretch or expand the optical pulse after optical pulse is feed into a phase modulator (PM) that is driven by DPSK data formats which is combined with the 16 bits chip length optical code driven at the rate of 40Gchips/sec. working of optical phase modulator is totally bases on bit of DPSK data phase modulator is driven by the optical code only is the DPSK data bit is '1' otherwise or for bit '0' it is driven by complement of optical codeby using this configuration it can be doneby using one Phase modulator. An optical fibre having single mode (SMF) with a positive and negative dispersionvalue of300 ps/nm are used tospread, optical pulse and generate the SPEsignal.At decoding side this part has the similar configuration as that of the encodingwith minor difference here phase modulator is driven only by the complementary optical codepattern that is used at encoding.

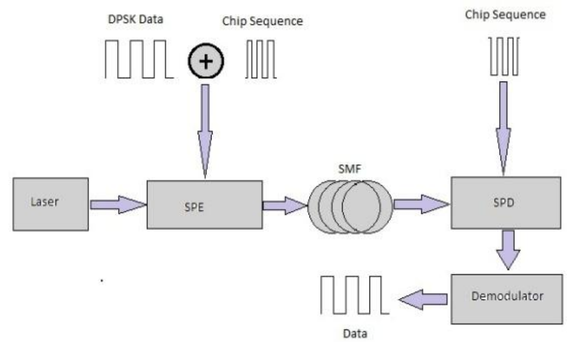

Figure 1: Basic structure of System

4. SIMULATION SETUP

In this section of paper abasic simulative setup ofOCDMA system with for generation Spectral Phase Encoding & Decoding and DPSK data modulation formats is shown in figure 1. At the transmitter side ultra-short mode locked optical source is used for generate the broadband optical pulse for time-domain Spectral Phase.An optical fibre with single mode (SMF) with dispersion value of 300 ps/nm are used to spread, optical pulse this stretched pulse is modulated using a phase modulator which is driven bycombination of 16-chip 40-Gchip/s OC pattern and 2.5-Gb/s DPSK data working of optical phase modulator is totally depends upon on bit of DPSK data. phase modulator is driven by the optical code pattern if the DPSK data bit is '1' otherwise (for bit '0') it is driven by complement of optical code After that, another optical fibre with negative dispersion of300ps/nm is used to compress the stretched pulse and generate the SPE signal. After this a span of 50 km single-mode fibre (SMF) is used as the transmission fibre.During transmission dispersion compensation technique can also be used to compensate the effect of dispersion. To recover the DPSK data that received signal first decoded using spectral phase decoding and passed to demodulator setup. Decoding part has the similar configuration as that of the encoding but the PM is driven only by the complementary optical code pattern that is used at transmitter side. Decoded signal is then feed into a 2.5-GHz DPSK demodulator followed by a balanced detector to recoverthe DPSK data. A bit rate*0.75 GHz low-pass filter Besselis used after the balanced detector to perform data-rate detection. The BER and Q factor are finally measured by BER analyser. Same simulative setup also tried forDuobinary format as shown in figure 3to compare the results between these two modulation formats for above system.

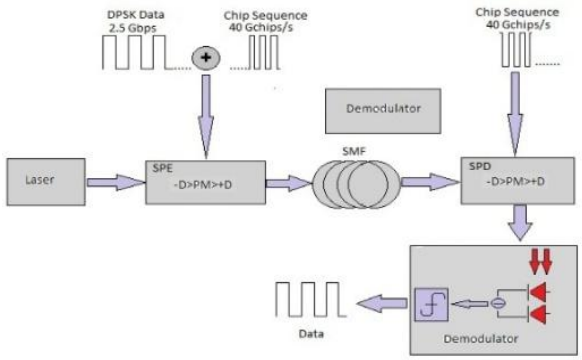

Figure 2(a): setup for DPSK based system

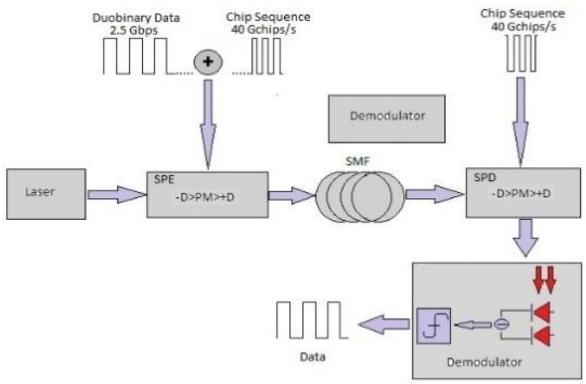

Figure 2(b): setup for Duobinary based system

5. RESULTS & DISCUSSIONS

This section of paper is mainly describe and shows the results that we have got from the system after the simulation study and discussed them accordingly. In this work we have carried out simulative study or analysis of spectral phase encoding and decoding for four users using four different 16 chips sequences for each user separately on the simulation setup of the OCDMA System that is shown in the figure 2 (a) & 2 (b). Performance of these system is analysed using output parameters as given below

(i) Input Signals: Input signal are generated at the transmitter for the both modulation formats input signal are shown in figures 3(a)for DPSK and Duobinary.

(ii)Optical Spectrum and Eye Diagram:in this section figure3(b) & (c) shows the optical spectrum& eye pattern of the DPSK and Duobinary modulation format, from the figure we can understand that Duobinary signal has better power at same input power. Which can easily retrieve at receiver side.

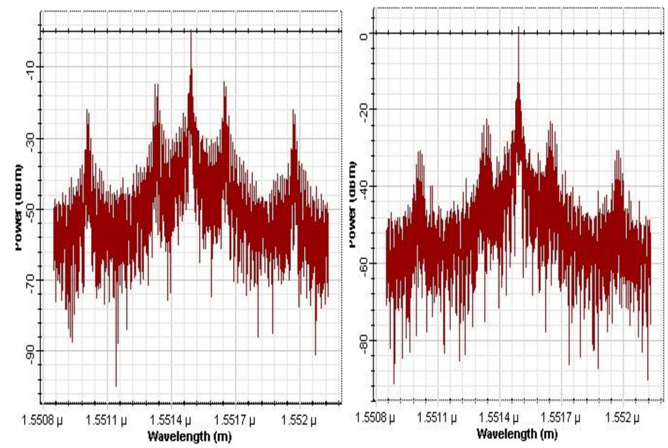

Figure 3(b) Optical spectrum for DPSK and Duobinary

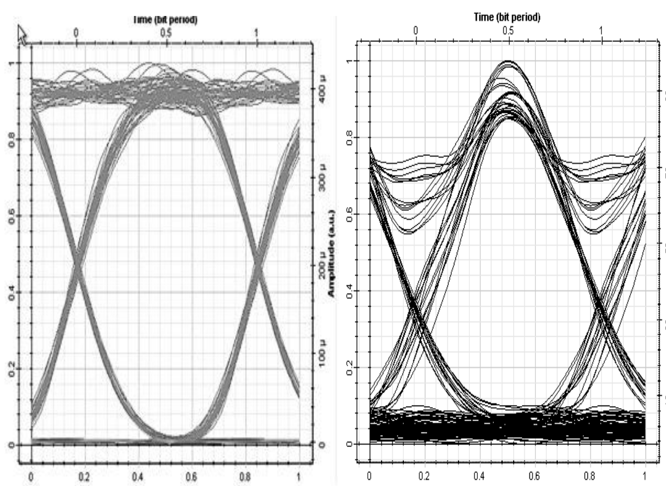

Figure 3(c) : Eye diagram for DPSK and Duobinary

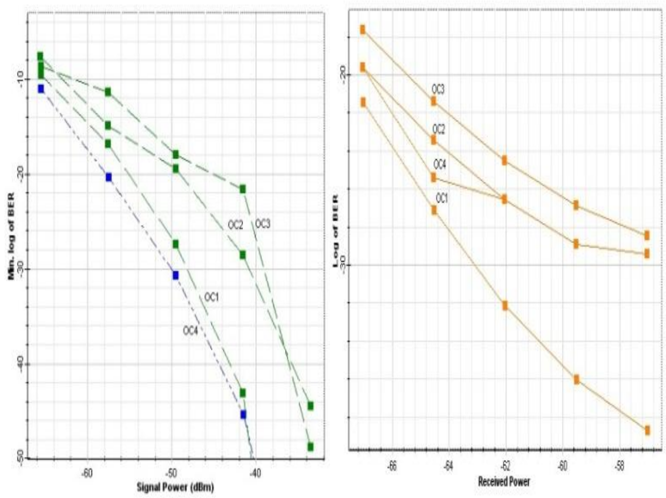

Figure3 (d): Min log BER and Received Power for DPSK& Duobinary

Above figure shows the Relation between Min log of BER and Received power for DPSK and Duobinary at four different optical codes (OC1, OC2, OC3 and OC4) and from this figure we analysed that Duobinary has the better performance than DPSK because it has more received power for the same values of Log of BER in both graph.

(iii)Input power and Received Po*wer:* Figure 3(e) is the graph which shows the Relation between Input power and Received power for optical codes (OC1) from this figure we conclude that Duobinary has the better performance than DPSK because Duobinary has more received power for low input power as compare to the DPSK.

CONCLUSION

In this paper a simulative demonstration of time domain spectral phase encoded and decoded OCDMAusing a single phase modulator (PM) is carried out for two different optical modulation formats DPSK and Duobinary using four different optical codes of 16 chip length at 40GChips/s chip rate and in this system DPSK and Duobinary modulation formats of data rate 2.5 Gb/s are generatedusing the one phase modulator for theoptical fibre span of 50 kms. After the detailed analysis of OCDMA system for above two modulation formats at different bit rates,we concluded that Duobinary gives better performance as compare to

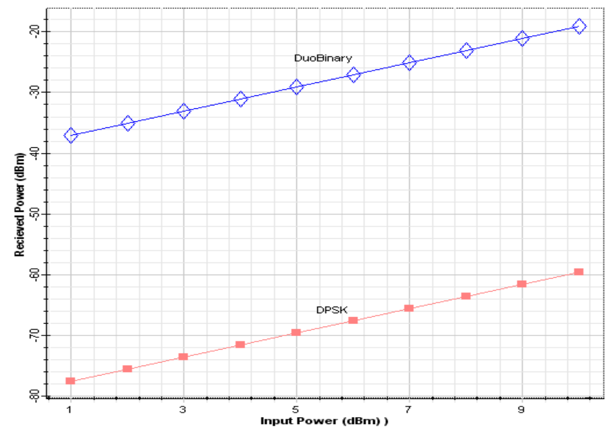

Figure 3(e): Power and Received Power (DPSK &Duobinary)

Table: Performance comparison of two modulation formats

Parameters / Formats	Chip Rates (Gcps)	Data Rats (Gbps)	Q-Factor	Min BER
DPSK	40	2.5	6.77	1.30*e-012
DPSK	40	3	6.32	7.61*e-011
Duobinary	40	2.5	22.45	1.03*e-098
Duobinary	40	3	7.41	7.84*e-014

DPSK.Duobinary format gives a better value of Q factor and lower the BER value.

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