

Analysis of BER of OFDM in Optical Domain with Different Modulation Techniques

A. R. Gifty Arul Marin, D. Balasubramanian

Abstract – In OFDM system, the subcarrier frequencies are chosen so that the subcarriers are orthogonal to each other, meaning that cross talk between the sub channels is eliminated. Priority of OFDM system is given to minimizing the interference or crosstalk among the channels and symbols comprising the data stream. The primary advantage of OFDM is its ability to cope with severe channel conditions like attenuation of high frequencies, narrowband interference and frequency selective fading due to multipath. The existing OFDM systems were modelled based on frequency domain using various modulation techniques in AWGN channel. This is a research analysis to calculate the efficient BER of the OFDM system in the optical domain using BPSK and QPSK modulation techniques. This project can be used for high speed applications requiring more bandwidth. Finally, performance comparison of BPSK and QPSK modulation schemes in OFDM system and the calculation of BER (Bit Error Rate) using these modulation techniques is to be done. The entire OFDM system is implemented using SIMULINK tool in MATLAB.

Keywords – OFDM, BPSK, QPSK, BER, MZM.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a bandwidth efficient signalling scheme where the orthogonality among the subcarriers should be maintained to a high degree of precision. OFDM is a multi-carrier system where data bits are encoded to multiple subcarriers, while being sent simultaneously. OFDM subcarriers are shown in Fig. 1. This results in the optimal usage of bandwidth. A set of orthogonal sub-carriers together forms an OFDM symbol.

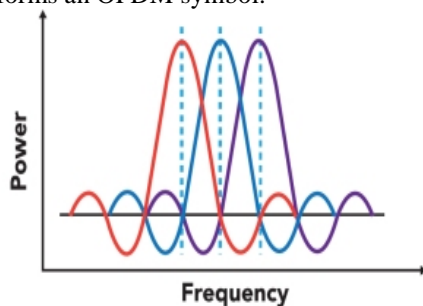


Fig.1. OFDM Subcarriers

To avoid ISI due to multi-path, successive OFDM symbols are separated by guard band. This makes the OFDM system resistant to multi-path effects. OFDM is a widely used because of its high bandwidth efficiency and robustness against frequency fading due to multipath propagation. Optical communication is very much efficient especially in terms of large capacity and distance. As OFDM has better tolerance to fibre dispersion, it has shown great potential in the field of fibre optic communication.

II. OFDM SYSTEM MODEL

The schematic model for OFDM system used in the paper is shown in Fig. 1. The basic and main building blocks of model shown in Fig. 2 are transmitter, channel and receiver.

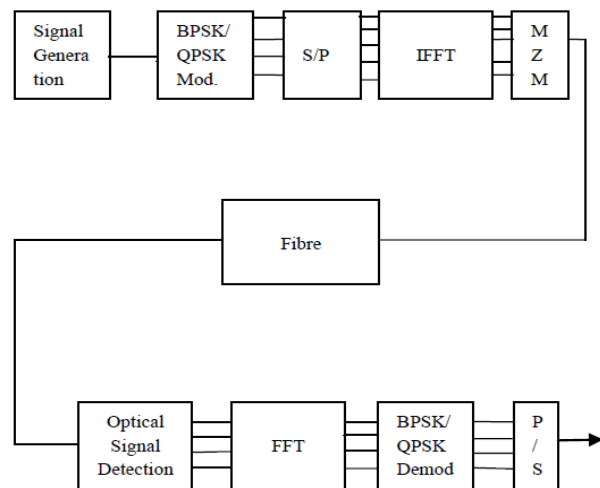


Fig.2. OFDM Simulation Model

A. Optical Signal Generation

The optical communication uses light as the transmission medium. An optical communication system consists of a transmitter which encodes a message signal into an optical signal, a channel which carries the signal to its destination and a receiver which reproduces the message from the received optical signal. The optical signal generators are usually LEDs or laser diodes. Optical signal modulation can be done using MZM modulator. A beam splitter divides the laser light into two paths, one of which has a phase modulator. The beams are then recombined. Changing the electric field on the phase modulating path will then determine whether the two beams interfere constructively or destructively at the output and thereby control the amplitude or intensity of the existing light. This device is called a Mach-Zehnder Modulator as shown in Fig. 3.

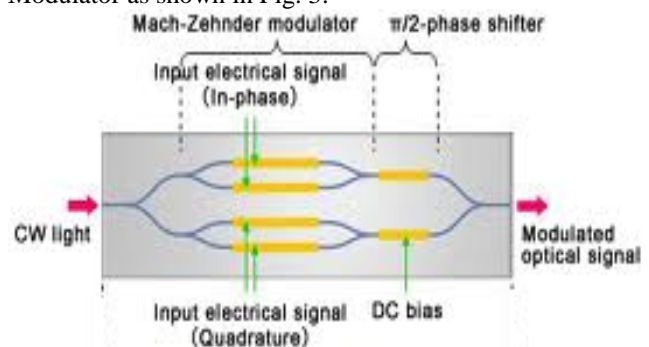


Fig.3. Mach-Zehnder Modulator

B. Transmitter and receiver section

This segment consists of following blocks.

1) *S/P converter and P/S converter*: This block is used at both, transmitter and receiver. These blocks convert random generated data with high rate into low data rate (serial to parallel) and vice versa.

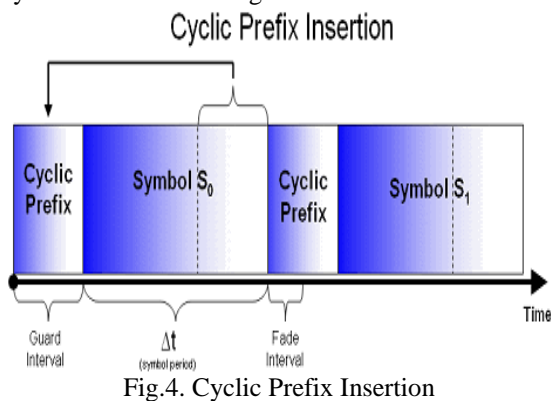
2) *Data to symbol mapper and Demapper*: This block provides modulation. The input data bits are grouped decrease data rate. When input stream is of low rate, a simple BPSK modulation works well; otherwise, QPSK is used. The selection of modulation scheme applied to each sub channel depends solely on the compromise between the data rate requirement and transmission robustness.

3) *IFFT/FFT*: IFFT converts frequency domain data into time domain, maintaining the orthogonality of subcarriers. Before IFFT, numbers of zeros are inserted in the input to make its length equal to IFFT bin size. This addition of zeros is called zero padding, and is used only when the subcarriers are less than bin size. Generally, in OFDM system, we select the number of data symbols equal to 52 giving 12 zero symbols. Zero padding removal does the reverse at receiver.

4) *Cyclic Prefix and Cyclic Prefix Removal*: The cyclic prefix is used to mitigate ISI effect in original OFDM symbol. This is achieved by adding partial symbol information of each cycle to the beginning of the symbol. Higher is the delay spread, higher is the length of cyclic prefix (CP), and in this paper, the CP length is chosen 1/4 of the symbol period. After CP insertion, the symbols from parallel paths are combined to make a serial data. In OFDM, one frame length is

$$T = T_S + T_{CP} \quad (1)$$

Where $T_S = NT$, N is number of carriers, and T_{CP} is cyclic prefix duration. The cyclic prefix insertion between the symbols is shown in Fig. 4.



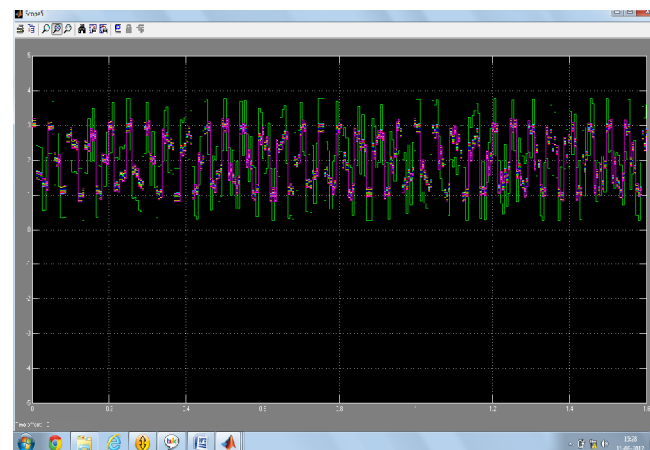
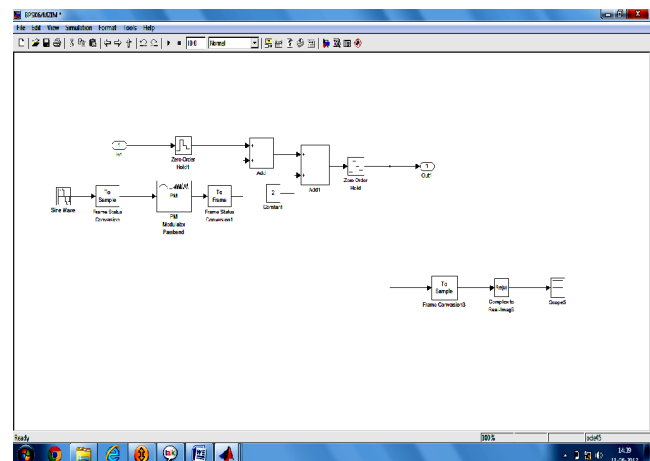
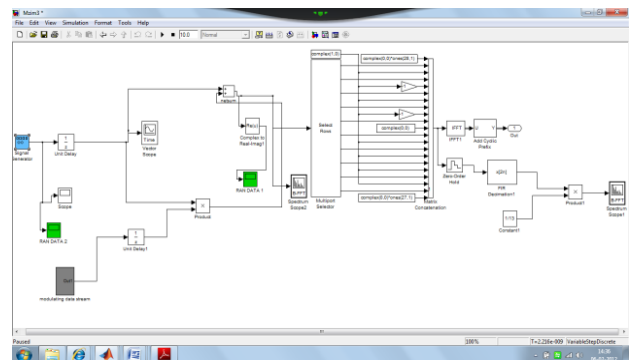
C. Fibre

The transmitting medium for optical OFDM system is fibre. The signals passed through fibre will be in the form of light signal. The main advantage of using fibre is immunity to electromagnetic interference, data security and high bandwidth over long distance. The fibre optic communication leads to faster transmission of signal with efficient bit error rate. Copper wire communication can be efficiently replaced with the fibre for efficient and faster transmission of data. Single mode fibre is used for broadband systems as the core of a single-mode fibre is

smaller that is less than 10 micrometers and requires more expensive components and interconnection methods, but allows much longer, higher-performance links.

III. SIMULATION RESULTS

The simulation model block is shown in Fig. 5. The Electrical to Optical Signal Conversion Block is shown in Fig. 6. The Electrical to Optical Conversion Output subcarrier is shown in Fig. 7. The signal generation output is shown in Fig. 8. The Fibre Channel Output in BPSK Modulation is shown in Fig. 9.



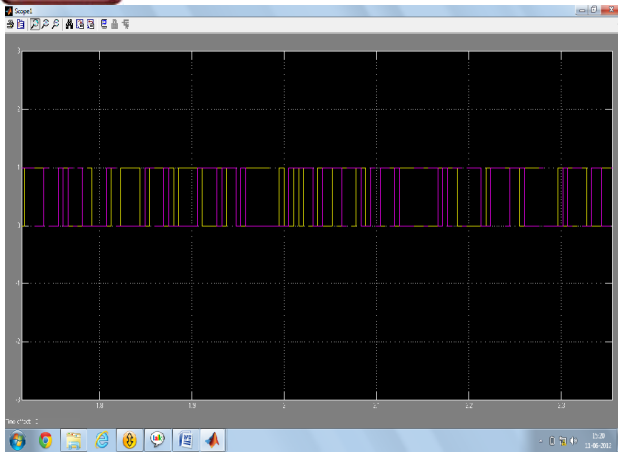


Fig.8. Signal Generator Output

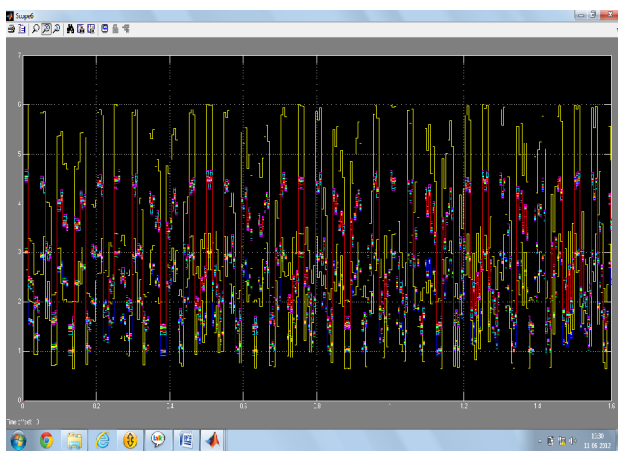


Fig.9. Fiber Channel Output in BPSK Modulation

IV. CONCLUSION

The transmitter output of optical OFDM system is thus obtained. The result in Fig. 10 shows that, using QPSK the transmission can tolerate a SNR of greater than 10 to 12dB in the copper wire transmission. The bit error rate BER gets rapidly worse as the SNR drops below 6dB. However, using BPSK allows the BER to be improved in a noisy channel, at the expense of transmission data capacity.

Using BPSK the OFDM transmission can tolerate a SNR of 6 to 8dB. In a low noise link, the capacity can be increased by using 16PSK. If the SNR is greater than 25dB, 16PSK can be used, doubling the data capacity compared with QPSK. In optical transmission the data rate is very high and the BER can be improved to 10^{-9} to 10^{-12} .

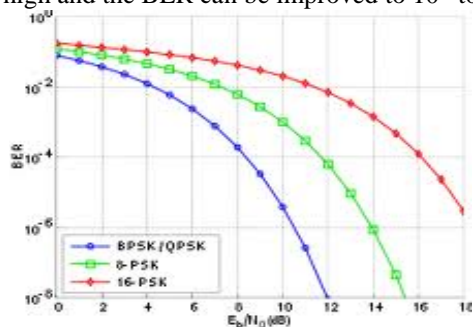


Fig. 10 BER plot for BPSK and QPSK

REFERENCES

- [1] Chin-Liang Wang, Ying-Chang Lin, and Po-Chung Shen, "Design of an Adaptive Receiver for OFDM Systems Using Conjugate Transmission", 2010
- [2] P. C. Weeraddana, Nandana Rajatheva, "Probability of Error Analysis of BPSK OFDM Systems with Random Residual Frequency Offset", 2009.
- [3] LiBaohong, WuYanyan, LuTingji, Beijing University of Posts and Telecommunication, "Performance Comparison of High Rate Ultra-Wideband OFDM System between Two Different Modulation Techniques", 2006.
- [4] Zhiyong Wang "Performance Analysis of Different Modulation Schemes for Coherent Optical OFDM System", 2010.
- [5] Jigisha N. Patel, Prof.Upena D.Dalal, "A Comparative Performance Analysis of OFDM using MATLAB Simulation with M-PSK and M-QAM Mapping", 2007.
- [6] Chempaka Mohd Din, Wahidah Mansor, Roslina Mohamad "A Review on Modulation Techniques in Multiband Orthogonal Frequency Division Multiplexing in Ultra-Wideband Channel", 2011.
- [7] "The suitability of OFDM as a modulation technique for wireless telecommunications, with a CDMA comparison", Eric Lawrey, 1997.
- [8] Mohammed Safiqul Islam, Gouri Rani Barai , Atiq Mahmood "Performance analysis of different modulation schemes using OFDM techniques in Rayleigh fading channel", 2011.
- [9] Wallace, Martins and P. S. R. Diniz, "Suboptimal Linear MMSE Equalizers with Minimum Redundancy," IEEE signal process. Lett., vol. 17, no. 4, pp. 387-390, April 2010.
- [10] A.Ali, J.Leibrich and W.Rosenkranz, "Spectral efficiency and receiver sensitivity in direct detection optical-OFDM", in Proc. OFC, 2009.
- [11] G.P.Agrawal, "Fiber optic Communication Systems", 2nd ed. N.Y.: Academic Press, 2002.
- [12] Bhasker Gupta, Gagan Gupta, and Davinder S.Saini "BER performance improvement in OFDM system with ZFE and MMSE equalizers", 2011.

AUTHOR'S PROFILE



Mr. Gifty Arul Marin. A. R.

is a P G Scholar in the department Communication systems from S.A Engineering College, Chennai. His area of interest includes networking and optical communication. He has presented two papers based on optical communication in the year 2012 in a National conference organised by PARK college of engineering, Coimbatore. Mr. Bala Kumaran. D, Lecturer, Department of P.G studies in S.A Engineering College, Chennai. He completed Master of Engineering in Communication systems from SSN Engineering College, Chennai. He has expertized himself in networking & VLSI design. He has also presented so many papers on internetworking and VLSI design in national and international conferences.