International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Integration of Multiple-Mode Subcarrier Index Modulation with OFDM

Prof. Chinmayee Panda
Asst. Professor,
Department of Electronics & Comm. Engg.,EATM, BBSR, Odisha, India

Prof. (Dr.) Urmila Bhanja
Professor –Cum- HOD,
Department of Electronics & Communication Engg. IGIT, Sarang, Odisha, India

Abstract - The Integration of Subcarrier index modulation with multiple-mode OFDM and SIM-OFDM are discussed in this paper. The other modulation schemes like OOK with SIM, PSK with subcarrier index modulation is discussed here and simulated by using MATLAB.A comparative analysis between OOK with SIM, PSK with SIM, SIM-OFDM & multiple modulations with SIM is performed and finally multiple-mode SIM OFDM shows BER in the order of 10-7 as compared to other modulation schemes associated with SIM.

Key Words: On-Off Keying (OOK), Phase Shift Keying (PSK), Orthogonal Frequency Division Modulation (OFDM), Sub-carrier Index Modulation (SIM), Multiple mode Sub-carrier Index Modulation OFDM,

I. INTRODUCTION

In Conventional modulation techniques such as BPSK, QAM a fixed number of information bits mapped into signal constellation symbols [1]. In OFDM the occupied bandwidth is divided into many sub channels and the subcarriers of the sub channels are orthogonal to each other by which the bandwidth is saved. For frequency selective radio channels, the channel coding is very important using OFDM for which conventional codes are well suited. The inter symbol interference is avoided in OFDM by inserting cyclic prefix into the transmitted OFDM block[2].The multiple-mode modulation technique is widely used combining in-phase and quadrature components of OFDM signal[3].The simplest form of amplitude shift keying is OOK representing the digital data at the presence and absence of carrier wave [4]. In subcarrier index modulation (SIM) technique the information is conveyed in an on-off keying (OOK) fashion [5]. The hybridization of multiple-mode SIM and OFDM technique is done in this paper. The sequence of paper is organized as follows. Section II describes different modulation schemes associated with SIM technology. Section III analyses the BER of SIM-OOK, SIM-OFDM and Multimode SIM OFDM. The simulated result is discussed in section IV and the Section V concludes the paper.

II. SIM-OFDM and Multiple-mode SIM-OFDM

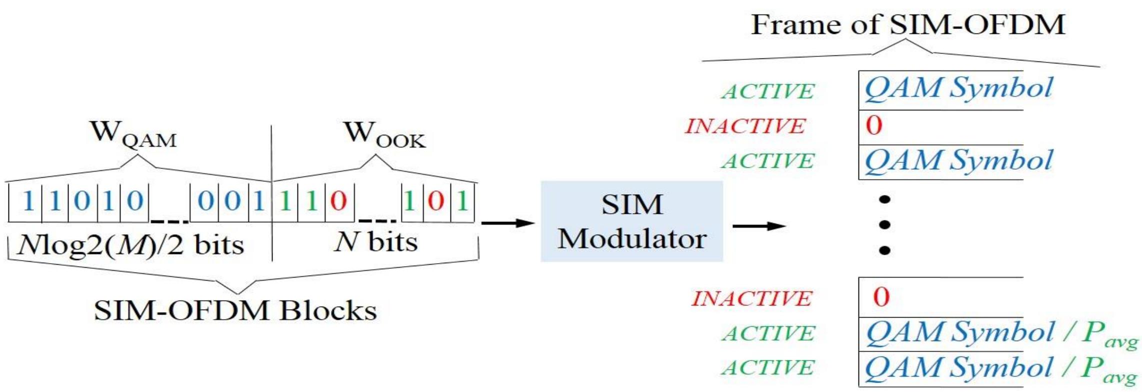

Fig 1. Block diagram of SIM-OFDM

The block diagram of SIM OFDM is given in Fig.1. In SIM-OFDM an additional module is present known as Subcarrier-index modulator. This module has two main functions. At first depending on the bit value of each bit in $W_{ook}$the subcarrier index modulator forms two subsets. By comparing the cardinality of these subsets the type of the majority bit-value is calculated. In second case the group of subcarriers combined with the subset of the majority bit value are selected to be modulated by second bit stream W_{QAM}.By using hamming weight of W_{ook} the type of majority bit-value is calculated. The number of bits of the majority bit value M_{maj} calculated as [6],

$$M_{maj}=\text{Max}\ \{M^{Wook}_{ones}(N_{FFT}-M^{Wook}_{ones}) \qquad (1)$$

WhereM^{Wook}_{ones} is Hamming weight of W_{OOK}.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

For high data transmission orthogonal frequency division multiplexing is often selected. In case of single carrier transmission over a frequency selective radio channel equalization becomes very complex and this problem avoided by using OFDM technique [7]. When subcarrier index modulation associated with OFDM all subcarriers are not modulated but a specific legitimate association of subcarriers carries important information which affects the bandwidth efficiency, power efficiency and peak to average power ratio (PAPR) etc. For OFDM the FFT length is taken as 1024 with sampling interval of 10ns having carrier frequency of 5GHZ and system bandwidth 100 MHZ.

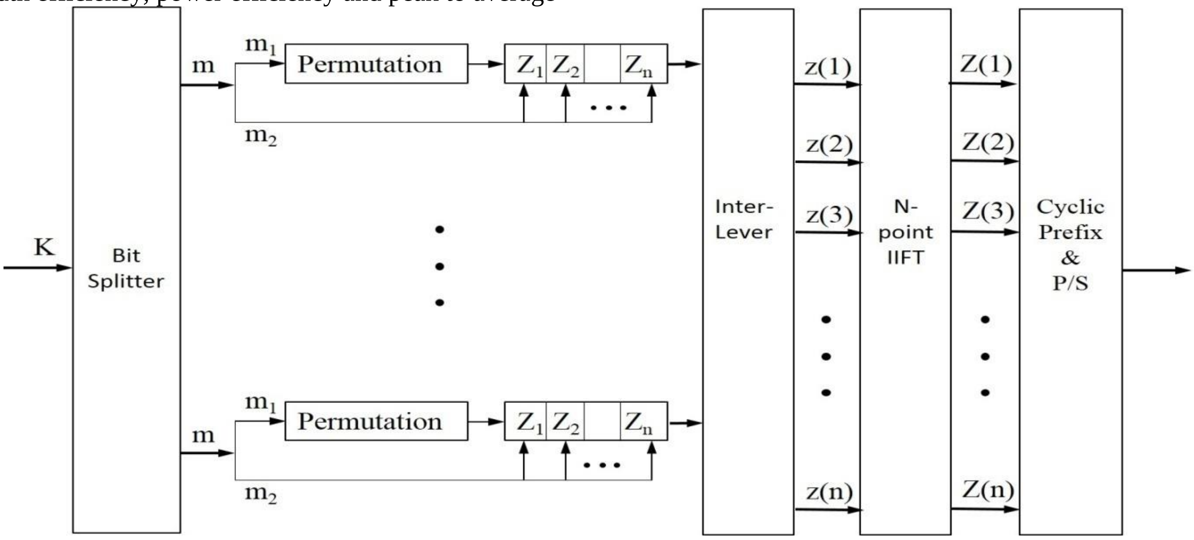

Fig 2. Transmitter Section of Multiple-mode SIM-OFDM

The transmitter structure of multimode OFDM –IM with N subcarriers is shown in the above figure. At each time a number of K bits on reaching to the transmitter splitted into l blocks containing K/l=m bits. These m bits divided into two parts for various purposes. The first part consists of m1 bits determining the order of modes $\{z_1.........z_n\}$. Then the mapping of m1 and m2 bits done by permutation methods & the symbols spread equally from which a frequency diversity is expected. These symbols passed through Inter-leaver, followed by N point FFT & P/S converter as in OFDM [8].

The transmitted signal is received at the receiver end by the reverse process of transmitter i.e after removal of the cyclic prefix the signal passed through the Serial to Parallel converter followed by N-point FFT and the signal is decoded through the SIM decoder. The original signal is obtained by passing the decoded signal through Parallel to Serial Converter and the BER is calculated. We perform computer simulations to examine the performance of SIM-OFDM and multimode SIM-OFDM systems, where Rayleigh fading channel and perfect channel estimation are assumed [8].

III. BER OF DIFFERENT MODULATION SCHEME WITH SIM

The analytical BER for SIM-OOK given as [9],

$$P_{ook}=1/2[1-\sqrt{\frac{\xi_{SNR}}{1+\xi'_{SNR}}}] \quad (2)$$

Where ξ'_{SNR} is the average SNR per symbol?

The BER for SIM-OFDM is given by [10]

$$BER_{SIM-OFDM}=BER_{OOK}+BER_{OOK}=P_0(1/(\log_2(M)+1))+P1(\log_2(M)/(\log_2(M)+1)) \quad (3)$$

Where P_0 and $P_1$are the probability for the QAM symbols close to 0 and 1.

The Spectral efficiency (SE) for MM SIM - OFDM given by [10]

$$P_{MM-OFDM-IM}\ (M, n) = \log_2 (n) - \log_2 (e) + \log_2 (M) \quad (4)$$

Where *M* to be an integer power of two and n is the number of modes.

IV. SIMULATION RESULT

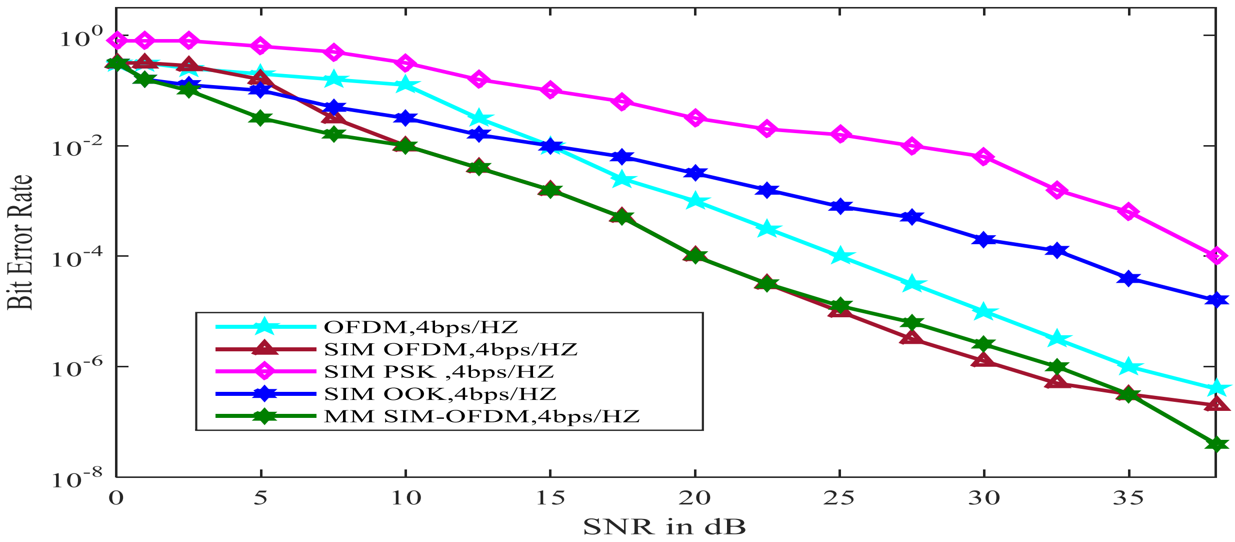

Fig 3. BER vs SNR plot for different modulation schemes with SIM at SE of 4bps/HZ.

Fig.3 shows the comparative Analysis of various modulation schemes associated with Subcarrier index modulation (SIM).The PSK modulated scheme exhibits about BER of 10^{-3} at SE of 4bps/HZ while OOK modulated scheme exhibits BER of 10^{-4}. At SE of 4bps/HZ conventional OFDM & SIM OFDM exhibits BER of 10^{-6} approximately whereas multiple-mode SIM-OFDM exhibit BER of 10^{-7}. Hence multiple-mode OFDM modulated

SIM exhibits better BER as compared to other modulation schemes associated with SIM.

V. CONCLUSION

In conclusion, the above discussions are proving that, we the researchers have trying to our level best to justified the taken research problem. Here, the Integration of Subcarrier index modulation with multiple-mode OFDM and SIM-OFDM are simulated in MATLAB, in order to carry the additional information bits multiple-modulation SIM OFDM allows multiple subcarriers to transmit in multiple modes. Different modulation schemes are integrated with SIM and the simulation result shows that MM-SIM OFDM gives better result (BER of 10^{-7}) as compared to other modulation schemes.

REFERENCES:

[1] H. Rohling and T. May, "COMPARISON OF PSK AND DPSK MODULATION IN A CODED OFDM SYSTEM", IEEE, 1997.

[2] R. Fan, Y. J. Yu, and Y. L. Guan, ``Generalization of orthogonal frequencydivision multiplexing with index modulation," *IEEE Trans. Wireless*

[3] E. Basar, ``Multiple-input multiple-output OFDM with index modulation,"*IEEE Signal Process. Lett.* vol. 22, no. 12, pp. 2259_2263, Dec. 2015.

[4] R. Abu-Alhiga and H. Haas, ``Subcarrier-index modulation OFDM," in*Proc. IEEE 20th Int. Symp. Pers., Indoor Mobile Radio Commun.*, Tokyo,Japan, Sep. 2009, pp. 177_181.

[5] A. Rami and H. Harald, "Subcarrier-Index Modulation OFDM", IEEE, 2009.

[6] D. Tsonev, S. Sinanovic, and H. Haas, ``Enhanced subcarrier index modulation (SIM) OFDM," in *Proc. IEEE GLOBECOM Workshops*, Houston, TX, USA, Dec. 2011, pp. 728_732.

[7] H. Ochiai and H. Imai, ``on the distribution of the peak-to-average power ratio in OFDM signals," *IEEE Trans. Common.*, vol. 49, no. 2, pp. 282_289, Feb. 2001.

[8] M. Wen, X. Cheng, and L. Yang, "Index Modulation for 5G Wireless Communications (Wireless Networks*)",* Berlin, Germany: Springer, 2017.

[9] R. Mesleh, H. Haas, S. Sinanovi´c, C. W. Ahn, and S. Yun, "Spatial Modulation," *IEEE Transactions on Vehicular Technology*, vol. 57, no. 4,pp. 2228 – 2241, Jul. 2008

[10] 10)W.Miaowen, B. Ertugrul, L. Qiang,Z. Beixiong, and Z. Meng, "Multiple-Mode Orthogonal Frequency Division Multiplexing with Index Modulation", **IEEE transactions On Communications, May 2017.**

Author Profile No: 01

Prof, Chinmayee Panda

She has Completed B.E in Electronics and Telecommunication Engineering from C.V. Raman College in 2004 & M.TECH in Communication Engineering from KIST, BBSR in 2012.Currently she is continuing PhD (cont.) from IGIT, Sarangi, Utkal University, on 'Free Space Optical Communication', since 2016.She is working as Asst. Prof. in ECE Dept. in Einstein Academy of Technology & Management, BBSR from July 2018.She Worked as Asst. Prof. in Electronics and Communication Dept. in KIST, BBSR from 17th July 2009 to June 2018.She has published 5 international journals and her area is free space optical communication.

Author Profile No: 02

Dr. Urmilla Bhanja is currently working as an Associate Professor –cum- HOD in Electronics and Telecommunication in IGIT, SARANG, Odisha .She has completed her M.Tech Degree from I.I.T Kharagpur & PhD from I.I.T Kharagpur. India Her Area of Research and expertise includes Optical Communication, Optimization Technique, Wireless Network, MANNET, Soft computing etc. She is an active member in different Electronics societies and published more than 50 National and International journals.