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Optimizing Channel Estimation for SCFDMA

Priyanka Malhotra*
EC&Chitkara University
Priyanka.malhotra@chitkara.edu.in

Garima Saini
EC&NITTTR, Chandigarh
garima@nitttrchd.ac.in

Abstract— The third generation partnership project has employed SCFDMA for its uplink transmission because of its low PAPR. SCFDMA signal while travelling through channel is affected by noise contained in the channel. Various channel estimation techniques has been given in the literature. This paper presents a channel estimation based on LMS with its parameters being optimised using PSO. The paper also compares result with existing LMS algorithm based systems. It has been observed that the proposed technique provides improvement in Bit Error Rate as compared to other technique.

Keywords— SC-FDMA, adaptive channel estimation, PAPR, LMS, PSO.

I. INTRODUCTION

In today's world, the wireless applications have grown much rapidly. There is a demand of high quality as well as high speed in wireless communication applications. To cater to it, there is a requirement of a much powerful modulation technique which can be employed for multi-carrier systems. Orthogonal Frequency Division Multiple Access or OFDMA is a multicarrier modulation scheme which uses orthogonal subcarriers to convey information and allow multiple users to access channel simultaneously. OFDMA is a preferred communication scheme as it provides high date rates, high spectral efficiency, flexibility of allocating subcarriers, robustness to inter-symbol interference and multipath interference. Long Term Evolution (LTE) Advanced standard has employed OFDMA for its downlink transmission.

OFDMA on the other hand, has a disadvantage of high Peak to Average Power Ratio (PAPR). High PAPR results due to superposition of many time-domain data subcarriers simultaneously. These large peak signals require power amplifiers of high power and causes various nonlinear distortions which leads to inefficient operation of amplifiers. To solve this problem of high PAPR, Single Carrier Frequency Division Multiple Access (SC-FDMA) was proposed for uplink transmission in LTE Advanced standard. SCFDMA can be considered as pre-coded OFDMA. In SCFDMA system, data symbols in time-domain are transformed into frequency-domain by using discrete Fourier transform process. SC-FDMA based system while providing low PAPR also, provides robustness against multipath signal propagation, high rate of data transmission, utilizes power amplifiers more efficiently. So LTE terminals can increase coverage and reduce their power consumption, which is extremely important in battery powered devices.

SC-FDMA system suffers from the problem of Inter Carrier Interference (ICI). ICI occurs because the user has high mobility, so the channel is not static during interval of a symbol. This destroys orthogonality among subcarriers and results into ICI.

An important factor for any wireless communication system is estimation of its channel and channel parameters. A good channel estimation technique can provide improvement in Signal to Noise Ratio, channel equalization, Co-channel Interference rejection and improvement in performance of network. This paper presents different channel estimation techniques for SC-FDMA system. Also a comparison of different channel estimation techniques is done on the basis of its Bit Error Rate

The remainder of this paper is organized as follows. In Section II, SC-FDMA system is presented. In Section III, different SC-FDMA channel estimation techniques are presented. In Section IV, a comparative analysis of different channel estimation is done. Finally, the paper is concluded in Section V.

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II. SC-FDMA SYSTEM

The block diagram of SC-FDMA system is shown in fig.1. The structure of SC-FDMA system is similar to OFDMA system except for the presence of a DFT block before subcarrier mapping. So, SC-FDMA is regarded as DFT mapped OFDMA. At transmitter end, a baseband modulator transforms the input bit stream into a multilevel sequence of complex numbers using modulation formats like Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), 8PSK, 16QAM, 64QAM. . The transmitter then performs *N*-point DFT operation to convert modulated signal into its frequency domain representation. It than maps each of its output N-DFT to any one of the *M* (> *N*) different orthogonal sub-carrier signals using distributed subcarrier mapping or localized subcarrier mapping. In distributed subcarrier mapping technique, different DFT output signals are distributed over entire bandwidth of the system where as in case of Localised sub carrier mapping, the outputs of DFT block are assigned to N consecutive subcarriers with total M number of subcarriers (M>N) available. A M-point IDFT operation then transforms these subcarrier amplitudes into a time domain signal. At the end, a cyclic prefix is added to IDFT output to prevent Inter Symbol Interference (ISI).

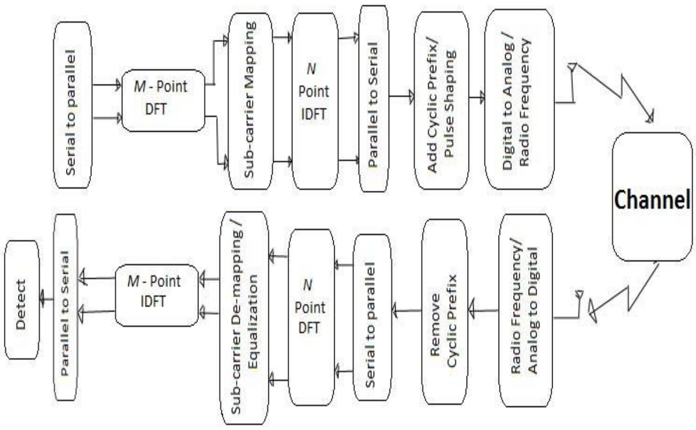

Fig. 1 Block diagram SCFDMA system

At the receiver end, first of all cyclic prefix is removed and the signal is processed by DFT operation to convert the received signal into frequency domain. Further subcarrier de- mapping is done using channel equalisation technique. A M-point IDFT is carried to convert signal to time domain. The received signal is demodulated and decoded to reconstruct back the original signal.

III.CHANNEL ESTIMATION

In order to achieve good performance a communication receiver needs to know the impact of channel on received signal. This is called channel estimation.[1] The motive of a channel estimation process is to minimise Mean Squared Error (MSE) between desired signal and received signal. Different channel estimation algorithm had been designed so as to achieve high performance. Using channel estimation algorithm impulse response of a channel and its behaviour can be approximated. By employing channel estimation techniques, coherent demodulation can be implemented at the receiver. In communication system for channel estimation a known signal sequence is inserted at specific location within the information signal. These symbol sequences allow receiver to extract channel attenuations and phase rotation estimates for each received symbol. By identifying channel parameters error in the received signal can be reduced. The aim of most channel estimation algorithms is to minimize the mean squared error (MSE), while utilizing as little computational resources as possible in the estimation process. Different authors had proposed various channel estimation techniques like Least square, Least Mean Square, Normalised LMS etc[2][3].

A. Adaptive LMS with PSO

Adaptive channel estimation process self-modifies coefficients of digital filtration process to minimize the error function of filter. The error function is defined as a distance between its desired signal and the output of an adaptive filter. Least Mean Square or LMS channel estimation algorithm uses fixed adaptation step size determined by considering convergence rate and miss adjustment.

The flow chart for the process is given below

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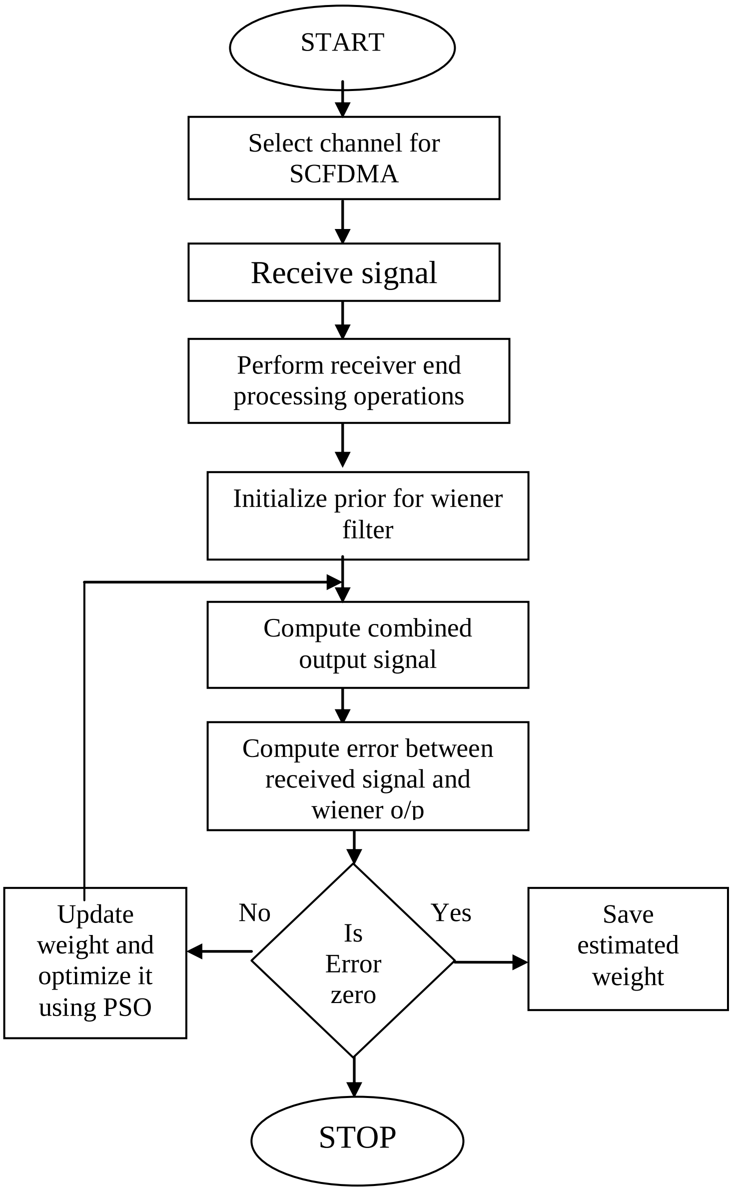

Fig.2 Flow chart of Adaptive channel estimation

If s(m) is the transmitted signal , n(m) is Additive white Gaussian noise, w(m) is Channel coefficient Then, signal received from channel will be

$$r(m)=w^T(m)s(m)+n(m)$$

Output of adaptive filter will be

$$y(m)=w_{est}^T(m)s(m)$$

where, $w_{est}(m)$=estimated channel coefficient at time m

The prior estimated error signal needed to update weights of adaptive filter is

$$e(m)=r(m)-y(m)$$
$$=w^T(m)s(m)+n(m)-w_{est}^T(m)s(m).$$

This error e(m) is used to adaptively adjust weight vector so that mean square error is minimised.

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IV. SIMULATION RESULTS

To evaluate the performance of LMS based channel estimation for LTE uplink system, simulations have been perform in AWGN channel. The parameters considered for simulation of design are given below in the form of table1 below:

Parameters	**Assumptions**
Modulation	BPSK
Carrier Frequency	16GHZ
Bandwidth	512Kbyte
FFT size	1024 bits
Cyclic Prefix	5 block
Subcarrier mapping	Interleaved FDMA
	120Km/hr

Table.1 Simulation Parameters

Using the above simulation parameters algorithm is simulated in MATLAB 12 environment. The simulation results are shown in fig 4. The simulation results provide comparison between LMS based, NLMS based and proposed channel estimation technique. From the results, it can be observed that the performance of proposed channel estimator is better than LMS based estimation technique in terms of signal to noise ratio as well as Bit Error Rate. But when compared with NLMS technique

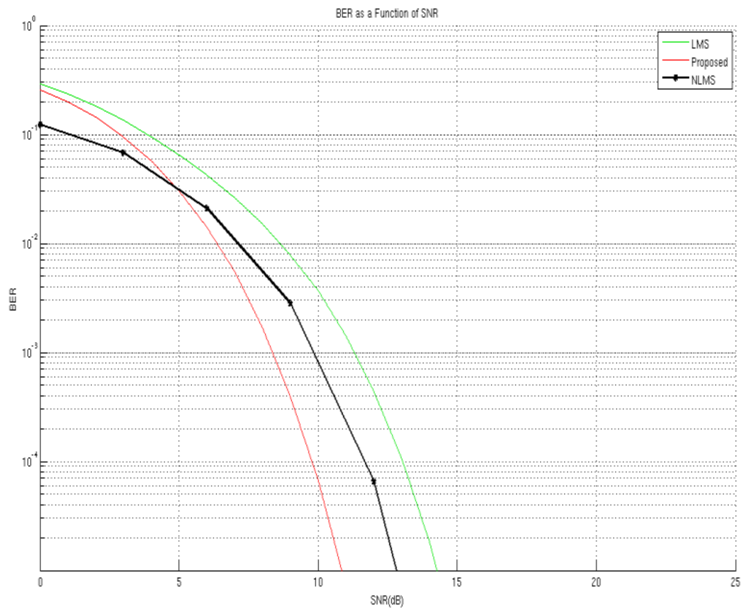

Fig 3: Comparison of different Estimation techniques in AWGN channel

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V. CONCLUSION AND FUTURE WORK

In this paper, we had optimized LMS based channel estimation technique for SCFDMA system. The parameters of the algorithm are optimized using PSO. The optimized parameters needed by the algorithm are obtained. It is shown that with optimization we can achieve better performance both in terms of BER as well as SNR. Further optimization can be done for various other modulation techniques. Also the performance of system can be analysed under different channel models

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