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# A study of MIMO-OFDM System Channel Estimation

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**Abstract** - *The study of channel estimation is very important in MIMO-OFDM. Thus we study various techniques used in channel estimation of MIMO-OFDM systems. MIMO-OFDM technology is leading to a much wider range of applications. The proposed scheme firstly relies on a pseudo random preamble which is identical for all regular antennas to acquire the partial common support and inverse transmission scheme by using Genetic search helps fast convergence and can handle large allocations of subcarriers to users without performance deprivation theorem which utilizing the sparse common support property of the 2*2 MIMO channels. And then a very small amount of frequency domain orthogonal pilots are used for the accurate channel recovery. The proposed scheme is to evaluate by using ICI reduction using Genetic Multiple Input OFDM(GM-OFDM) technique that provide better performance and higher spectral efficiency than the conventional MIMO-OFDM schemes.*

***Key Words***: *MIMO, OFDM, antenna, Channel estimation, MAT LAB*

## 1. INTRODUCTION

Communication, the activity of conveying information, is the distinctive ability which has made possible the evolution of human society. The initial challenge for a person was to put forth his thoughts. As gestures and body language became inadequate to convey people's thoughts so languages were invented. Language is a tool which portrays thoughts in the form of words, though not a very effective tool but it has become a basic necessity for everyone to use it. As humans explored the world around, more knowledge occurred which were to be shared. So to share these knowledge communication techniques were invented. Previously, the technique used were TDMA, FDMA and CDMA, these techniques had some drawback like Multipath distortion, demand for high peak power, adjacent channel interference, self-jamming, near-far problem etc. So these drawbacks are overcome by recently introduced a MIMO-OFDM system that has gained considerable attentions from the leading Telecommunication companies. All the performance improvement and capacity increase of wireless communication system are based on accurate channel state information.

## 3 Introductions of OFDM and MIMO

**3.1 OFDM:** Orthogonal frequency division multiplexing (OFDM) is one promising multi-carrier technique adopted by wireless communication standards. Using fast Fourier transform (FFT) algorithm, OFDM becomes more popular due to its simple implementation. The basic idea of OFDM systems is to transmit symbols over multiple orthogonal subcarriers so IFFT is performed with transmitted symbols at the transmitter, and FFT is performed with received symbols at the receiver. Another advantage of OFDM is to convert a frequency-selective wideband channel into several frequency-flat narrow band channels. Thus the complexity of receiver for OFDM systems is much simpler than that of receivers in single-carrier systems. However, OFDM systems will be sensitive to channel variation, which induce inter-carrier interference (ICI) by destroying the orthogonality between subcarriers. Figure-1 shows the basic block diagram of OFDM

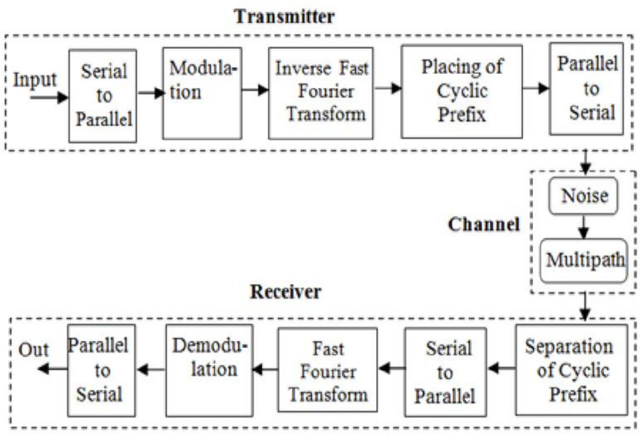


**Fig -1**: Block diagram of OFDM

**3.2 MIMO:** MIMO has become an essential element of wireless communication standards including IEEE 802.11n (Wi-Fi), IEEE 802.11ac (Wi-Fi), HSPA+ (3G), WiMAX (4G), and Long Term Evolution (4G). At one time in wireless the term "MIMO" referred to the mainly theoretical use of multiple antennas at both the transmitter and the receiver. In modern usage, "MIMO" specifically refers to a practical technique for sending and receiving more than one data signal on the same radio channel at the same time via multipath propagation.

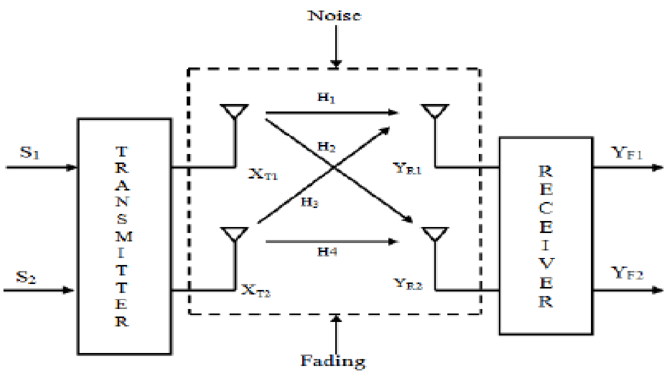


**Fig -2**: Block diagram of MIMO

### 3.3 System Model of MIMO OFDM

The aim motivation for using OFDM in a MIMO channel is the fact that OFDM modulation turns a frequency-selective MIMO channel into a set of parallel frequency-at MIMO channels. This renders multi-channel equalization particularly simple, the system consists of N transmit antennas and M receive antennas. The OFDM signal for individual antenna is acheive by using inverse fast Fourier transform (IFFT) and can be detected by fast Fourier transform (FFT).

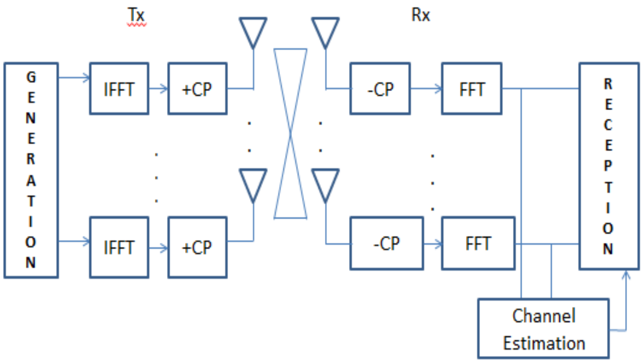


**Fig-3**: System Model of MIMO OFDM

## 4. SIMULATION

Channel estimation done using genetic algorithm and various other modulation techniques for data transmission in presences of ICI provided the following points:

1. Minimizing the value of bit error rate
2. Increasing the signal to noise ratio (SNR)
3. Reducing the complexity of the algorithm
4. Increasing the spectral efficiency.
5. Enhancing the performance, more robustness and error free transmission.

### 4.1 Mathematical Modelling

The mathematical approach used in the proposed work to fulfil all the demands are as follows:

The System has $n_T$ transmit antennas and $n_R$ receive antennas. The channel matrix H can be decomposed into product of three matrices :

$$H=USV^*$$

Where U are a unitary matrix of dimension $n_R \times n_R$, V are also a unitary matrix of dimension $n_T \times n_T$ and S is a $n_R \times n_T$ matrix whose elements are all zero except for the diagonal where there will be min($n_T$, $n_R$) of the H matrix eigenvalues. The V* represents the complex conjugate transpose of the matrix V. The three matrices corresponds to three different steps

1. Projection into Tx eigenmodes
2. Weighting by singular values
3. Mapping into Rx eigenmodes

The above discussion leads to some interesting conclusions:

- If $n_T > n_R$, some power is wasted on exciting a subspace orthogonal to the receiver. The receiver cannot interpret this subspace and it's totally unnecessary. If the power is designated uniformly over the transmitter there will be an average power loss of $10Log\left(\frac{n_T}{n_R}\right)$.
- If $n_T \leq n_R$, there is no power loss. There will be $n_R - n_T$ dimensions in the receiver space, which are not excited by the receiver eigenvectors.

### 4.2 Steps for Calculating Channel Estimation

Preamble of M length are denoted as

$$c = [c_1, c_2 \ldots\ldots c_M]^T$$

OFDM block of N length are denoted as

$$x_i = [x_{i1}, x_{i2}, \ldots \ldots. x_{iN}]^T$$

**Step 1**: Partial common support Acquisition Preamble length m should not be less than $N_t$ times of channel length L. For accurate channel estimation

M $\geq N_t * L$ therefore M $\geq L$

At receiver, the received preamble without interference correlate with the local preamble c to obtain the partial sparse common support.

$$\hat{z}_i = \frac{1}{MN_T} c \otimes \hat{c}_i$$

$= \frac{1}{N_T}\sum_{p=1}^{N_T} h_i^p$ + n $\hat{z}_i$ is the estimate of the superposition of all the CIRs associated with the $N_T$ transmitted antennas.

**Step 2:** Cyclicity Reconstruction of OFDM Block

It is achieved by overlapping and adding operation. In this function a signal is divided into multiple signal and discrete convolution of each signal is found. It is used for channel recovery with finite impulse response.

**Step 3:** Channel Estimation based on the algorithm

All the calculation for the received signal has been done previously, where we derived the channel impulse response which is used for the channel estimation. And after that genetic algorithm is applied.

## 5. Discussion on result obtained:

The simulation of Genetic multiplexing method is done by using MATLAB software. The result is centred on the average archival rate. OFDM becomes important parameter affecting MIMO systems as it applies to those Stations which have moderately long range multipath transmission. The results are as follows:

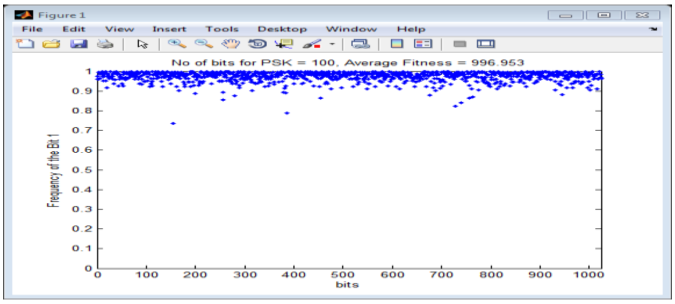


**Chart-1:** Performance of Fitness using Genetic multiplexing

In Chart-1 the plot is between frequency versus bits. It shows the generation of sub carriers. Generation here is no of bits. No. of iteration is 1000 and we see that by using genetic algorithm the average fitness is 996.953. Generation of bits take place using PSK because with this we are getting approximately all the data at the output.

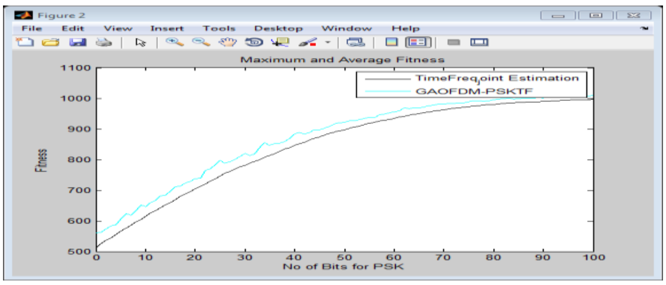


**Chart-2**: Comparison between GAOFDM_PSKTF and time freq-joint estimation over No of bits for PSK

Chart-2 shows that as no. of bits using PSK is increasing the fitness for previous work is reducing. While using genetic algorithm fitness of no of bits is increasing it means we are receiving maximum of data at the receiver.

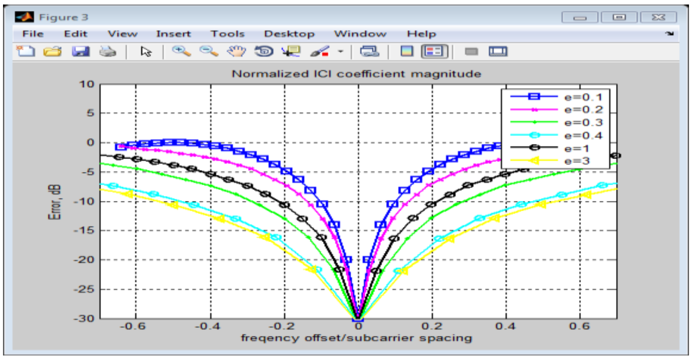


**Chart-3:** Normalization of ICI coefficient magnitude for frequency offset/subcarrier spacing

Here at different values of carrier frequency offset we see the relation between error and frequency spacing.With the increase in values of 'e' the error reduces.

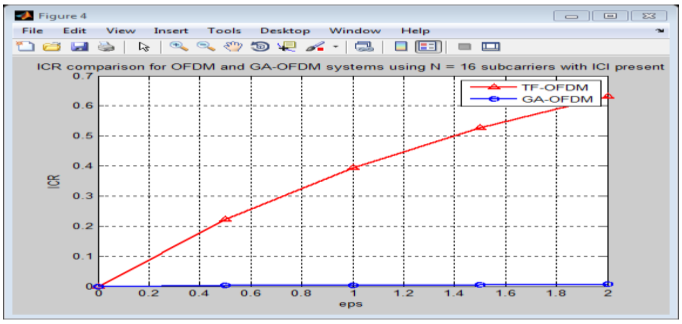


**Chart-4:** ICR comparison for GA-OFDM and TF-OFDM system using N=16 subcarrier with ICI

Thus from the above chart we see that by using genetic algorithm we have minimum ICR. Also it shows that genetic algorithm is an efficient method of channel estimation.

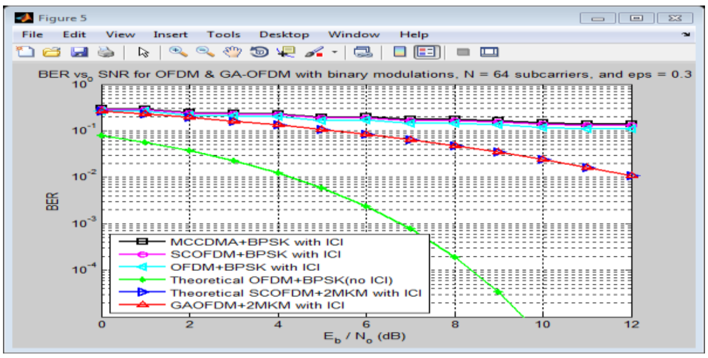


**Chart-5**: BER vs SNR for GAOFDM and other techniques with binary modulation N=64 subcarrier and eps=0.3

After comparison the conclusion drawn is that the proposed scheme which is GA-OFDM gives least BER with the increase in SNR. Also with MKM modulation we get less of error.

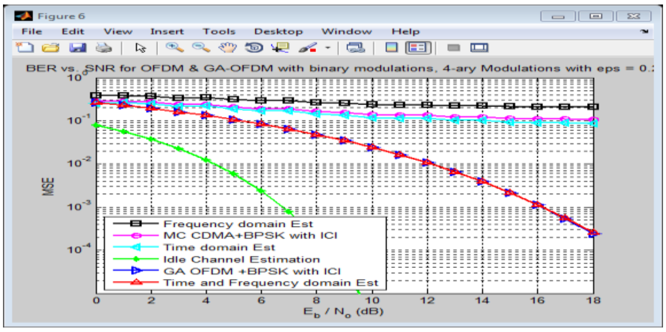


**Chart-6:** MSE vs SNR for different estimation techniques with binary modulation 4-ray modulation with eps =0.2

In chart-6 we see that the proposed work has less of MSE with the increase in SNR.

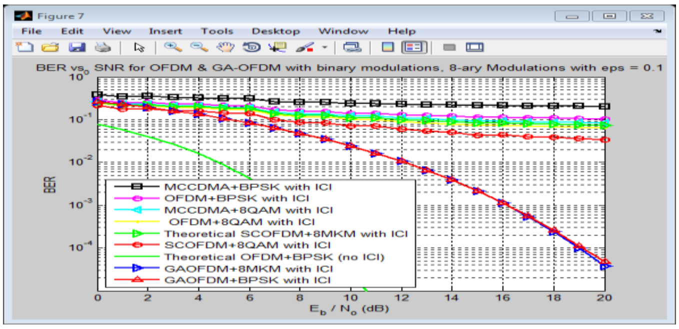


**Chart-7:** BER vs SNR for GA-OFDM with other techniques with binary modulation 8-ray modulation with eps =0.1

Transmission of data takes place either in the presences of ICI or in its absences. Thus all of them are compared and the conclusion drawn is that the proposed scheme which is GA-OFDM gives least BER with the increase in SNR. Also with MKM modulation we get less of error.

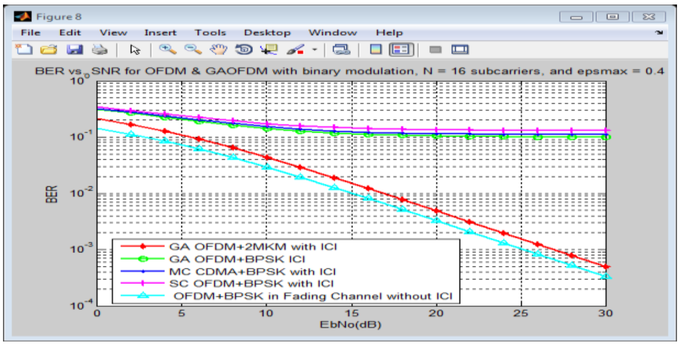


**Chart-8:** BER vs SNR for GA-OFDM and other techniques with binary modulation N=16 modulation and epsmax =0.4

After comparison the conclusion drawn is that the proposed scheme which is GA-OFDM gives least BER with the increase in SNR either using MKM or BPSK in the presences of ICI.

Thus using genetic algorithm gives us an efficient performance.

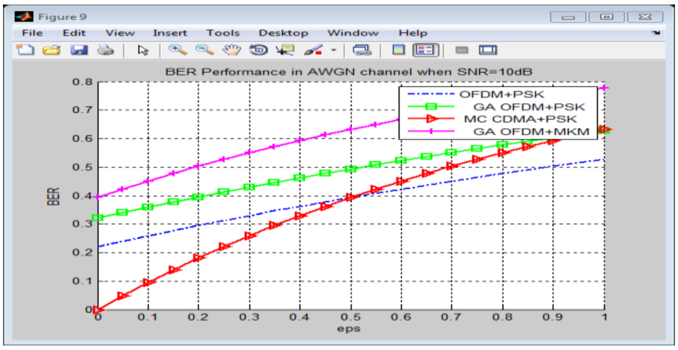


**Chart-9:** BER performance in AWGN channel when SNR=10db

In chart-9 we see that at fixed SNR GA-OFDM with MM gives us least BER in comparison to others. Thus, we see that Genetic algorithm gives us better result in performance.

## 6. CONCLUSION

In this research work we are using Genetic multiplexing algorithm based channel estimator to accomplish these tasks and to achieve results near to optimal solution. Comparisons between the results obtain from various other estimator technique and GA-OFDM estimator has shown better understanding. The performance of the OFDM system is compared by varying the size of the modulation. The BER performance of GA-OFDM improves with increasing size of binary modulation. In this research we analysed various modulation schemes used in wireless link adaptation.

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