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Reduction of Inter Carrier Interference in Time Varying Channels using SUI Modeling for MIMO-OFDM Systems

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ABSTRACT

Time varying channels in an orthogonal frequency division multiplexing (OFDM) system leads to damage the orthogonality among subcarriers, yielding inter carrier interference (ICI) in OFDM System. A time domain approach is used to reduce time variations in ICI-mitigating block. A time domain equalizer (TEQ) is often used at the receiver to mitigate the total response transmission time but the design of TEQ is a difficult task. In this paper, a linear time varying channel is considered to suppress inter carrier interference and to lower computational complexity. Time domain synchronous OFDM (TDS-OFDM) can easily estimate the linear time varying channels, which perfectly suits for proposed work. Multi input multi output OFDM system (MIMO-OFDM) needed channel estimation on no transmission overhead over SUI model. Two modulations schemes, QPSK and 16 QAM are used in proposed work to improve performance of two parameters bit error rate (BER) and minimum mean square error (MMSE). Simulation results show that the proposed work can sufficiently suppress the ICI in time varying channels by comparing linear time varying (LTV) channel and linear time invariant (LTI) channel in MIMO-OFDM.

Keywords:*Multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM), inter-carrier interference (ICI), and time domain synchronous orthogonal frequency division multiplexing (TDS-OFDM).*

I. INTRODUCTION

To boost performance of wireless communication high-speed data transmission is needed. To provide high speed data rates orthogonal frequency division multiplexing (OFDM) is used. It's an attractive technique which uses computationally efficient fast Fourier transform (FFT) in parallel to a large number of orthogonal subcarriers which has been applied to vast areas of broadband communications [1]-[2]. If the channel is not constant throughout the transmission of one OFDM symbol, inter-carrier interference (ICI) occurs. Time varying Channels causes ICI and destroy the orthogonality among sub carriers which in turn decreases the performance of the system [3]. If we introduce Multi Input Multi Output (MIMO) the problem gets worse and becomes much complicated because the receivers signals get mixed up with other signals. In ICI mitigation of OFDM systems, complexity exists in estimation of the time-varying channels by using complex frequency-domain channel estimation methods [4]. TDS-OFDM is used in time varying channel estimation for long delays PN-Extended and Rotated (PN-ER) sequence is a good choice for MIMO-TDS-OFDM channel estimation [5]. The major problem next to estimation is equalization of received signals, which is too complicated. So a low complexity scheme is used in order to solve the problem in MIMO-OFDM system.

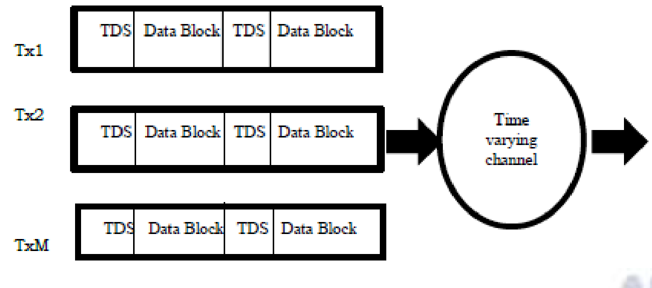

Fig. 1. MIMO TDS OFDM frame structure

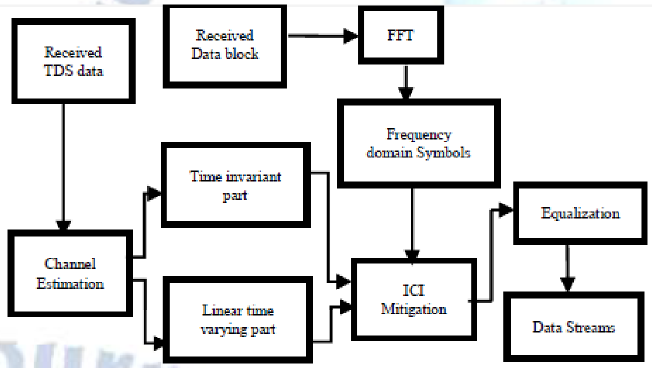

Fig. 2. MIMO TDS-OFDM Receiver Side

Enormous efforts are done to reduce ICI in OFDM such as a perfect matching filter, least square error (LSE), minimum mean square error (MMSE) methods are used in [6] to combat ICI .In [7], to maximize the output signal-to-interference-plus-noise ratio (SINR) a linear ICI-cancelation filters are used which suffers from computational complexity. A number of low complexity methods are introduced to reduce ICI mitigation during the years. In [8], the method used has a block diagonal channel matrix to suppress ICI, but the complexity is too high, although the matrix computation scale is reduced. To estimate ICI contaminated signal in [9] a low complexity equalization method is used in TDS-OFDM, but it do not have an inverse matrix. In [10], [11] further improved methods are developed and analyzed to get better performance. All these developed methods mostly are used for single-input single-output (SISO) structures. The developed methods for MIMO-OFDM are having too high complexity. Same approach is used in [12] which has applied in [11] where a Newton iteration is used up on inverse matrix.

In this paper, ICI is reduced by considering linear time varying channel on a Rayleigh fading channel compared with linear time invariant channel by different Doppler frequencies. The proposed method has been simulated, analyzed and we achieved a low complexity by efficiently reducing ICI in MIMO-OFDM and disjoints the ICI symbols on each sub carrier and retains the low complexity. Simulation results show that the proposed method outperforms conventional methods based on time varying channels and 2 dB SNR value is achieved when the uncoded bit error rate is 10^{-3}, when more number of receivers are used than transmitters then the proposed method show better performan--ce. The methodology implicit within the low-complexity MIMO ICI mitigation is to divide the equalization as per the structure of ICI on linear time-varying channels and the symbols are demodulated in parallel to each subcarrier.

The remainder of this paper is organized as follows. In section II, the MIMO TDS-OFDM system model based on LTV channel is described. The MIMO ICI mitigation algorithm is proposed in Section III. In section IV proposed work using SUI channel is discussed. Simulation results are addressed in section V and section VI concludes this paper.

II. SYSTEM MODEL

In this we are discussed about MIMO-OFDM transmission model in LTI channels. The MIMO TDS-OFDM frame structure is also discussed in detail as one of the possible frame structures that could be applied in our proposed approach to easily estimate LTV channels. In fig 1 and fig 2 MIMO TDS OFDM frame structure and proposed method receiver side with low complexity are illustrated.

2.1 Linear Time-Varying Channels in MIMO - OFDM

For MIMO-OFDM, number of transmitters are$M$, number of receivers are N and total number of subcarriers are k. Denote the l[st] channel tap for the transmission between the mth transmitter and the nth receiver at time slot t by $h_{l,m,n}^{(t)}, l = 0,1,\ldots,L-1$, where L is the channel length of transmission, $h_{l,m,n}^{(t)}$ is the time invariant part and $\alpha_{l,m,n}$ is the time-varying factor of its lth channel tapδ_i show the time varying step. Therefore, for LTI channel model in one frame is

$$h^{(t)}_{l,m,n} = h_{(l.m.n)} + \delta_{(t-1)}\alpha_{(l,m,n)} \quad (1)$$

$$h_{l,m,n} = \frac{1}{K}\sum_{t=1}^{l+k-1} h^{(t)}_{l,m,n} \quad (2)$$

$$y_{m,n} = (H_{m,n} + A_{m,n}B)x_m \quad (3)$$

In existing techniques, the input and output relation between the transmission channels is discussed for single input SISO-OFDM and is extended here for the transmission known as MIMO-OFDM and the time domain signal received at the n^{th} receiver from the m^{th} transmitter is given in (3), where x_m is known as time domain sequence transmitted from transmitter, $H_{m,n}$ and $A_{m,n}$ matrixes are $K \times K$ diagonal matrices according to the property of circulant matrices. $H_{m,n}$ first column to be $[h_{0,m,n}, h_{1.m.n}, \cdots, h_{L-1,m,n}, 0, \cdots, 0]^T$, $A_{m,n}$ with $[\alpha_{0,m,n}, \alpha_{1,m,n}, \cdots, \alpha_{L-1,m,n}, 0, \ldots 0]^T$. B is a diagonal matrix, $B = Diag([\delta_0, \delta_1, \ldots, \delta_{k-1}]^T)$.

Convert the signals from time to frequency domain

$$\mathrm{Y}_{m,n} = (\mathrm{H}_{m,n} + \mathrm{A}_{m,n}\mathrm{B})\mathrm{X}_m \quad (4)$$

Where $\mathrm{Y}_{m,n} = F_K y_{m,n}$ and $X_{m,n} = F_K x_{m,n}$ are received and transmitted frequency domain symbol vectors respectively. $H_{m,n} = F_K H_{m,n} F_K^H = Diag\left(\{H_{m,n,k}\}_{K=1}^{K}\right)$ (5)

$$A_{m,n} = F_K A_{m,n} F_K^H = Diag(\{A_{(m,n,k)}\}_{(K=1)}^{K}) \quad (6)$$

The ICI components exists in $A_{m,n}$ and the time invariant components exists in. $H_{m,n}$. For SISO-OFDM as we know, that $M = N = 1$, low complexity ICI compensation in LTV channel model could be achieved by using the frequency domain based input-output relationship as given in (4): with both $H_{m,n}$ and $A_{m,n}$ are diagonal by the property of circulant matrix and B is precalculated matrix calculated by fast Fourier transform, matrix inversion approximation by power series representation tremendously reduces the complexity of the equalized symbols of $Y_{m,n}$ .In MIMO-OFDM data transmission is interfered by one transmitter to another transmitter.by the use of multiple transmitters, the ICI interferences could not be decoupled in SISO-OFDM transmission. For increasing data transmission speed MIMO OFDM is developed. Therefore, in order to get new strategies to reduce inter carrier interference in MIMO-OFDM, we are going to derive the input-output relationship by considering all transmitters. The received signal from the n^{th} receiver is the superposition of the received signals from different transmitters for the transmission, contaminated by noise that may be internal or external.

$$Y_n = \sum_{m=1}^{M} Y_{m,n} = \sum_{m=1}^{M}(H_{m,n} + A_{m,n}) + V_n \quad (7)$$

Where V_n is the frequency domain noise vector present at the n^{th} receiver, V_n follows Gaussian distribution $V_n \sim \mathrm{N}(0_{1\times k}, \delta^2 I_{K\times K})$ Vectorization of all received signals, transmitted signals and the frequency domain noise vectors given below,

$$Y = [Y_1^T Y_2^T \ldots Y_N^T]^T \quad (8)$$

$$X = [X_1^T X_2^T \ldots X_N^T]^T \quad (9)$$

$$V = [V_1^T V_2^T \ldots V_N^T]^T \quad (10)$$

then

$$Y = \begin{bmatrix} H'_{1,1} & H'_{2,1} & \cdots & H'_{M,1} \\ H'_{1,2} & H'_{2,2} & \cdots & H'_{M,2} \\ \vdots & \vdots & \cdots & \vdots \\ H'_{1,N} & H'_{2,N} & \cdots & H'_{M,N} \end{bmatrix} X + V \quad (11)$$

with

$$H'_{m,n} = H_{m,n} + A_{m,n}B \quad (12)$$

2.2 Introductionto MIMO TDS-OFDM

In TDS-OFDM, some known reference symbols sequences taken as the guard interval between data to serve the purpose of both channel estimation and synchronization. MIMO TDS-OFDM uses PN sequences as the guard interval. TDS-OFDM uses pseudo noise sequences as the guard interval, which can be easily estimated. The PN sequences are given prior and posteriori to the OFDM data block which are used to estimate the channel variation model. The standard frame structure and receiver structure designed for MIMO TDS-OFDM using the proposed ICI reduction algorithm are given in proposed work in detail.

III. PROPOSED ALGORITHM

For proposed work, the equation (11) for the LTV in MIMO-OFDM can be given as shown below,

$$Y = (H + A\bar{B})X + V = [H\ A]\begin{bmatrix} I \\ \bar{B} \end{bmatrix} X + V$$

$$= (H + A)\tilde{X} + V = [H\ A]\begin{bmatrix} X \\ X' \end{bmatrix} + V, \quad (13)$$

Where

$$H = \begin{bmatrix} H_{1,1} & H_{2,1} & \ldots & H_{M,1} \\ H_{1,2} & H_{2,2} & \ldots & H_{M,2} \\ \vdots & \vdots & \ldots & \vdots \\ H_{1,N} & H_{2,N} & \ldots & H_{M,N} \end{bmatrix} \quad (14)$$

$$A=\begin{bmatrix} A_{1,1} & A_{2,1} & \dots & A_{M,1} \\ A_{1,2} & A_{2,2} & \dots & A_{M,2} \\ \vdots & \vdots & \dots & \vdots \\ A_{1,N} & A_{2,N} & \dots & A_{M,N} \end{bmatrix} \quad (15)$$

$$\bar{B}=\begin{bmatrix} B & & & \\ & B & & \\ & & \ddots & \\ & & & B \end{bmatrix} \quad (16)$$

$$\tilde{X}=\begin{bmatrix} I \\ \bar{B} \end{bmatrix} X=\begin{bmatrix} X \\ \bar{B}X \end{bmatrix}=\begin{bmatrix} X \\ X' \end{bmatrix} \quad (17)$$

The original transmitted symbols are present in vector X and vector X' stand for $X'=\bar{B}X$, and it is multiplied by A to construct ICI mitigation matrix as $X=\{X_{n,k}\}_{n=1,k=1}^{N,K}=[X_1^T,X_2^T \dots . X_N^T]^T$, X' is similarly formed as $X'=\{X'_{n,k}\}_{n=1,k=1}^{N,K}=[X_1^T,X_2^T,\dots X_N^T]^T$. It is known that the interferences which are present for different subcarriers are handled by $\bar{B}$, so $X'_{n,k}$ is the interference only on subcarrier k. Therefore, matrix H represents the channel time-invariant part as well as it will describes the signal transfer without interference matrix A represents the channel time-varying part which is new considerations of the proposed work. As given in the system transfer function in (13) as a $2M$-transmitter N-receiver MIMO-OFDM with K subcarriers. As mentioned in proposed work, there is no inter-carrier interference present in the equivalent system, therefore the equalizer can be parallelized on each subcarrier.

For subcarrier k,

$$\bar{Y}_k=[Y_{1,k} Y_{1,k} \dots . Y_{N,k}]^T \quad (18)$$

$$\tilde{X}_k=[X_{1,k} X_{1,k} \dots . X_{M,k}, X'_{1,k} X'_{2,k} \dots . X'_{M,k}]^T \quad (19)$$

$$\bar{H}_k=\begin{bmatrix} H_{1,1,k} & H_{2,1,k} & \dots & H_{M,1,k} \\ H_{1,2,k} & H_{2,2,k} & \dots & H_{M,2,k} \\ \vdots & \vdots & \dots & \vdots \\ H_{1,N,k} & H_{2,N,k} & \dots & H_{M,N,k} \end{bmatrix} \quad (20)$$

$$\bar{A}_k=\begin{bmatrix} A_{1,1,k} & A_{2,1,k} & \dots & A_{M,1,k} \\ A_{1,2,k} & A_{2,2,k} & \dots & A_{M,2,k} \\ \vdots & \vdots & \dots & \vdots \\ A_{1,N,k} & A_{2,N,k} & \dots & A_{M,N,k} \end{bmatrix} \quad (21)$$

and

$$\bar{Y}_k=[\bar{H}_k \ \ \bar{A}_k]\tilde{X}_k+\bar{V}_k \quad (22)$$

Above equation (22) is a standard flat-fading MIMO system transfer expression with the transmitted symbol vector $\tilde{X}_k$ and received vector $\bar{Y}_K$. Therefore traditional OFDM equalizer with $2M$ transmitters and N receivers could be used to equalize the transmitted symbols on subcarrier k.

When a LMMSE equalizer is used for channel equalization,

$$\tilde{X}_k \approx C_{\tilde{X}_k}\begin{bmatrix} \bar{H}_k^H \\ \bar{A}_k^H \end{bmatrix}\left([\bar{H}_k \ \ \bar{A}_k]C_{\tilde{X}_k}\begin{bmatrix} \bar{H}_k^H \\ \bar{A}_k^H \end{bmatrix}+\delta I\right)^{-1}\bar{Y}_k \quad (23)$$

The vector $\tilde{X}$ gives the estimation of the transmitted symbols. To achieve better estimation performance, X is can be estimated as given below,

$$\hat{X}=E\tilde{X}=C_{X\tilde{X}}C_{\tilde{X}\tilde{X}}{}^{-1}\tilde{X} \quad (24)$$

$$=[I \ \ \bar{B}^H]\begin{bmatrix} I & \bar{B}^H \\ \bar{B} & \bar{B}\bar{B}^H \end{bmatrix}^{-1}\tilde{X} \quad (25)$$

The matrix calculation are shown below for demonstration,

$$E=C_{X\tilde{X}}C_{\tilde{X}\tilde{X}}{}^{-1} \quad (26)$$

$$E=[I \ \ \bar{B}^H]\begin{bmatrix} I & \bar{B}^H \\ \bar{B} & \bar{B}\bar{B}^H \end{bmatrix}^{-1} \quad (27)$$

As the inversion of a large matrix is given in (24), the calculation of matrix E is determined only by M , N and K , for it's irrelevant to channel realization. Therefore E is a given matrix which is calculated above and acts like a predesigned linear filter, the complexity is limited to filtering itself. $C_{\tilde{X}_k}$ in (23) is known as covariance matrix of the transmitted symbol vector. The inversion of the $C_{\tilde{X}_k}$ can also be pre-calculated while the matrix is a $2M \times 2M$ sub-matrix composing of the elements at the k^{th}, $K+k^{th}$, ... and $(2M-1)K+k^{th}$ rows and columns of the matrix $C_{\tilde{X}\tilde{X}}$.

In comparison with the conventional LMMSE equalizer for MIMO-OFDM also works for subcarrier by subcarrier equalization. The only difference is that the subsystem transfer function in each subcarrier does not contain the time varying matrix $\bar{A}_k$,

$$\bar{Y}_k=\bar{H}_k\bar{X}_K+\bar{V}_k \quad (28)$$

So the demodulation can be given in LTI channels is as shown below

$$\bar{X}_k \approx C_{\bar{X}_k}\bar{H}_k^H\left(\bar{H}_k C_{\bar{X}_k}\bar{H}_k^H+\delta I\right)^{-1}\bar{Y}_k \quad (29)$$

IV. SUI CHANNEL MODEL

There are six SUI channel modeling parameters are there. Among them we are going to use SUI-3 model for modeling the LTI and LTV channels used in proposed work. We are going for modeling to use optimal values of some transmission parameters which are already studied and given best fit values to use the wireless environment.

SUI channel model is specific statistical parameters of effective microscopic parameters which are not considered in previous proposed work (parameters like antenna diversity, antenna correlation, tapped delay line as well as fading).Also we used macroscopic parameters such as path loss and shadowing which will help us to enhance the previous results. In this the proposed work using SUI channel model considering all parameters discussed in Table-1 and simulation results will show us that extension work will provide us better ICI mitigation compared to proposed work which is also shown by mathematical parameters like MMSE and BER.

Table-1

parameters	Tap 1	Tap 2	Tap3	Units
Delay	0	0.5	1	μs
Power K factor (omni ant)	0 1	-5 0	-10 0	dB
Power K Factor (30^0 ant)	0 3	-11 0	-22 0	dB
Doppler	0.4	0.4	0.4	Hz

Table 1. SUI-3 channel modeling parameters

The Table 1 shows the parameters used in the simulation of SUI channel model with the proposed work in MIMO TDS OFDM.

V. SIMULATION RESULTS

The proposed work is implemented specially for analysis and comparison of linear time variant (LTV) channel with linear time invariant channel (LTI) channel. We analyzed the proposed work with the help of two objective parameters viz. MMSE and BER. We showed in proposed work that it works more efficiently than other existing techniques.

The number of transmitters is chosen to be 2, and the number of receivers is 4, 8, and 12. MIMO-OFDM with PN-Extended and Rotated (PN-ER) as the time domain sequences to conveniently estimate the MIMO channels. The bandwidth is 1 MHz and the system has K = 1024 subcarriers, so each subcarrier bears about 1 kHz of bandwidth. The information bits are independent and uncoded, QPSK/16QAM modulation scheme is used. The simulation takes MIMO channel delay profiles and changes the Doppler frequency of the Rayleigh fading channels to test the performance of the proposed algorithm. The maximum Doppler shift in the simulation is 100 Hz, or equivalently a Doppler factor of 0 .1.

Two channels were used for analysis, channel-A is channel with the Doppler spectrum following a Gaussian distribution and the other channel is channel-B which is the Doppler spread which should follow the Jakes Doppler spectrum having maximum Doppler shift f_D .While analyzing we used different number of receivers and different Doppler frequencies and under this conditions we calculated the performance represented by the objective parameters like BER and MMSE.

We have observed that the channel B outperform the channel-A., also we have plotted performance of proposed work for different conditions of transmitting and receiving antennas as well as Doppler frequencies with different modulations.

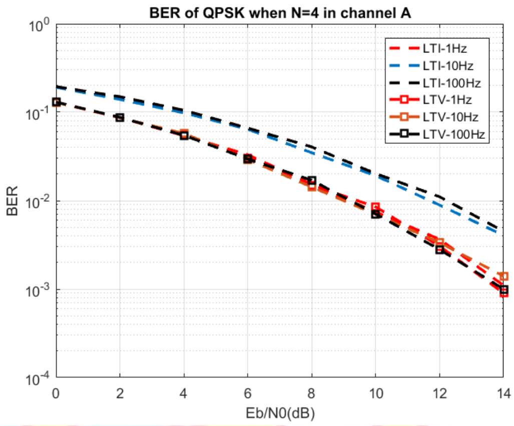

Fig. 3. Equalization of BER with QPSK when N=4 in channel A

In fig 3, we have plotted BER performance of the LTI and LTV channel under different conditions of Doppler frequency by using two transmitters and four receivers and the modulation scheme used is QPSK. The proposed algorithm outperforms LTI equalizer. In channel A when N=4 and Doppler frequency 100 Hz, E_b/N_0 at 6 dB BER is 0.068 for time varying channel.The SNR gain increases when Doppler frequency increases in OFDM.

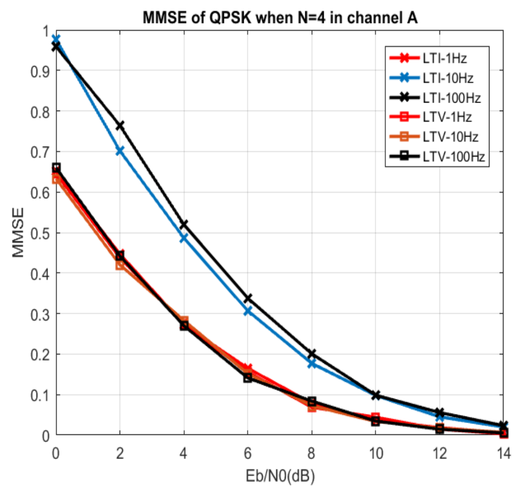

Fig.4. Equalization of MMSE with QPSK when N=4 in channel A

In fig. 4, we have plotted MMSE performance of the LTI and LTV channel under different conditions of Doppler frequency by using two transmitters and four receivers and the modulation scheme used is QPSK. The proposed algorithm outperforms LTI equalizer. In channel A when N=4 and Doppler frequency 100 Hz, E_b/N_0 at 6 dB MMSE is 0.34 for time varying channel. For LTI channel MMSE is 0.51. LTV has smaller MMSE than LTI channel.

In fig. 3 and fig.4, the MSE and uncoded bit error rate (BER) performance is compared in Channel A with QPSK modulation, when f_D=1 Hz, 50 Hz and 100 Hz.

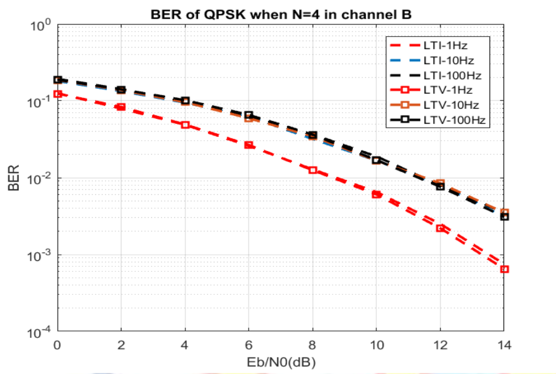

Fig. 5. Equalization of BER with QPSK when N=4 in channel B

In fig. 5, we have plotted BER performance of the LTI and LTV channel under different conditions of Doppler frequency by using two transmitters and four receivers and the modulation scheme used is QPSK. The proposed algorithm outperforms LTI equalizer. In channel B when N=4 and Doppler frequency 100 Hz, E_b/N_0 at 6 dB BER is 0.038 for time varying channel. The SNR gain increases when Doppler frequency increases. For LTI channel BER is 0.051. Comparing simulation results we have channel B out performs channel A.

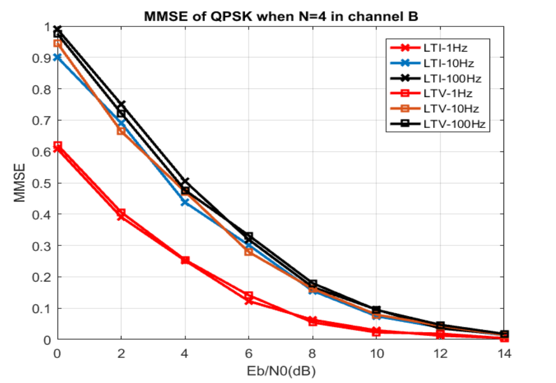

Fig. 6. Equalization of MMSE with QPSK when N=4 in channel B

In fig. 6, we have plotted MMSE performance of the LTI and LTV channel under different conditions of Doppler frequency by using two transmitters and four receivers and the modulation scheme used is QPSK. The proposed algorithm outperforms LTI equalizer. In channel B when N=4 and Doppler frequency 100 Hz, E_b/N_0 at 6 dB MMSE is 0.14 for time varying channel. For LTI channel MMSE is 0.33. LTV has smaller MMSE than LTI channel.

In fig. 5 and fig. 6, their performance is compared with Channel B by QPSK modulation. In both Channel A and Channel B, the proposed algorithm has shown the finest MMSE and BER performance.

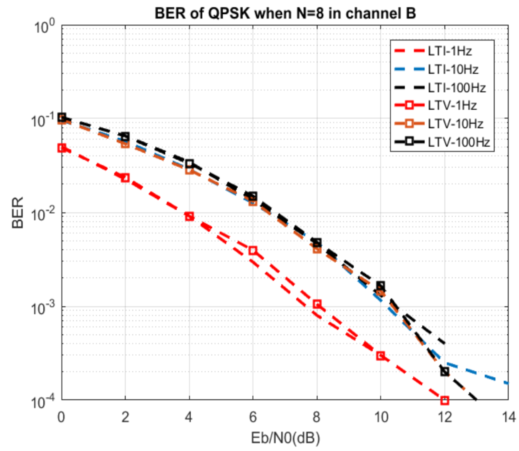

Fig. 7. Equalization of BER with QPSK when N=8 in channel B

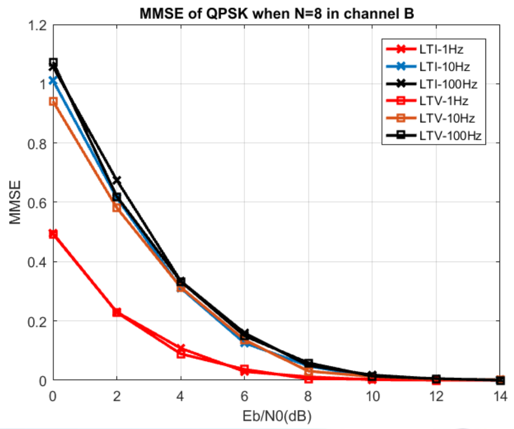

Fig. 8. Equalization of MMSE with QPSK when N=8 in channel B

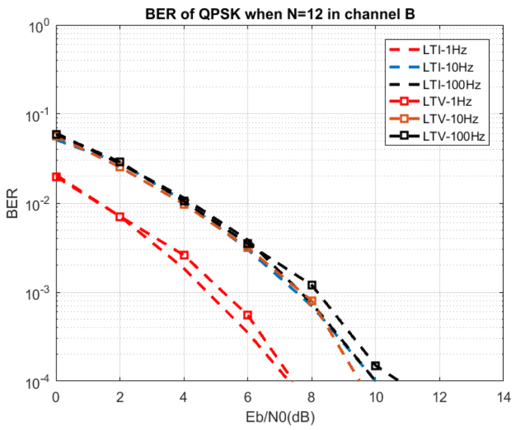

Fig.9. Equalization of BER with QPSK when N=12 in channel B

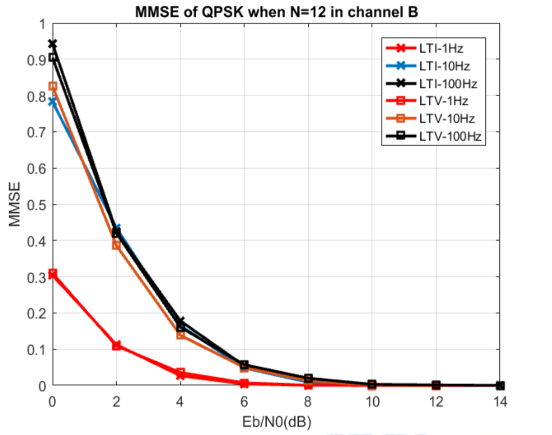

Fig.10. Equalization of MMSE with QPSK when N=12 in channel B

Channel-B is the Doppler spread which follow the Jakes Doppler spectrum having maximum Doppler shift f_D . The MMSE performance with different Doppler frequencies with N = 8,12 is shown in fig. 8 and fig. 10 for QPSK modulation. In fig. 7 and fig. 9 BER performance are plotted with different Doppler frequencies with QPSK modulation.

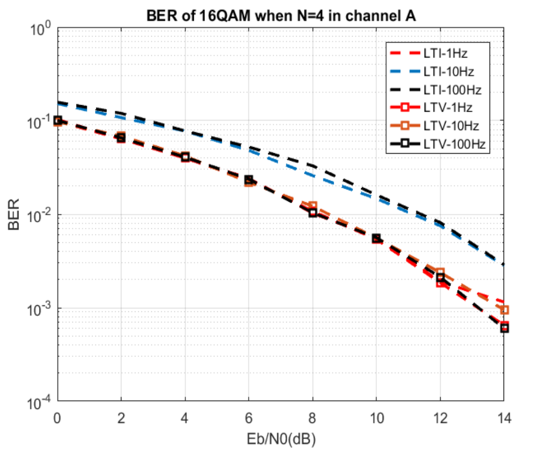

Fig.11. Equalization of BER with 16QAM when N=4 in channel A

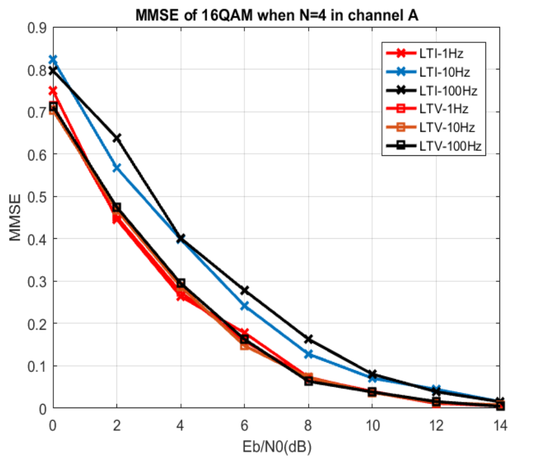

Fig.12.Equalization ofMMSE with 16QAM when N=4 in channel A

From the simulation results, in fig.12 and fig. 14 we shown that the MMSE in channel A and channel B increases when the maximum Doppler shift increases inter carrier interference increases. The MSE gets smaller when more receivers are used, which is a result of more diversity gain with more receiving units. At the same time, when f_D = 1 Hz, 50 Hz and 100 Hz, the proposed algorithm always has a smaller MSE than the conventional equalizer.

The BER performance is demonstrated in fig. 11 and fig. 13 for 16QAM. The proposed algorithm also outperforms the LTI equalizer when the Doppler frequency is 1 Hz, 50 Hz and 100 Hz. The SNR gain when the BER is around 10^{-3} gets larger when the Doppler frequency increases: 0.2 dB when f_D = 1 Hz, 0 .6 dB when f_D = 50 Hz and about 2 dB when f_D =100 Hz.

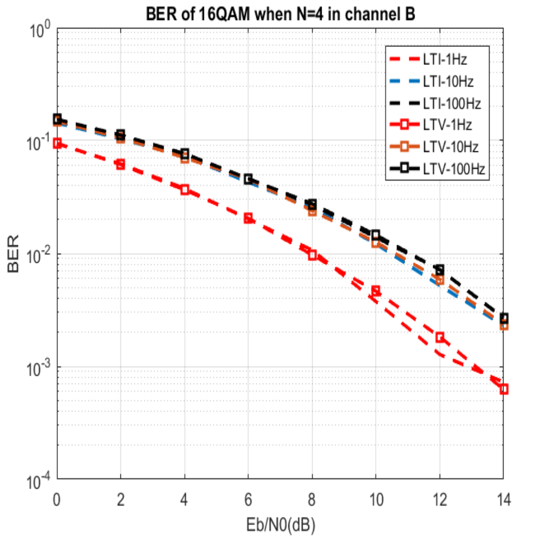

Fig.13. Equalization of BER with 16QAM when N=4 in channel B

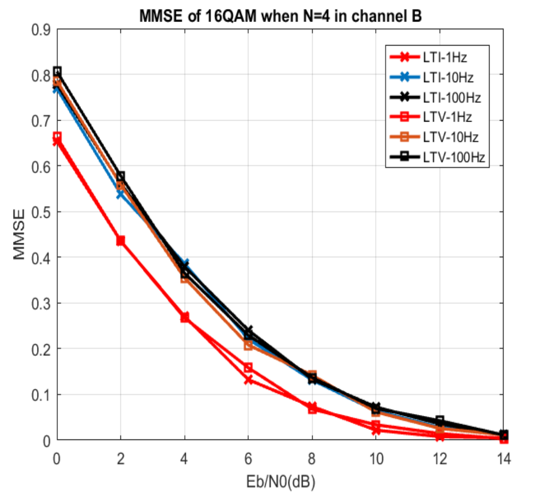

Fig.14. Equalization of MMSE with 16QAM when N=4 in channel B

When SUI channel model parameters such as antenna diversity, antenna correlation, antenna gain etc., are applied to the existing work. SUI channel model is applied on the existing LTI and LTV channel, from simulation results we show the better performance results outperforming the LTI and LTV channels. For simulation we have considered Doppler frequency = 1Hz, *N*=4 and modulation used is 16 QAM. These can be extended to different Doppler frequencies f_D = 1 Hz, 50 Hz and 100 Hz and for *N* =8, 12, modulation used is QPSK or 16 QAM. Here SUI channel modeling is applied on channel B because it has more generalized fading than channel A. The BER and MMSE performance of MIMO-OFDM system using SUI channel model are evaluated.

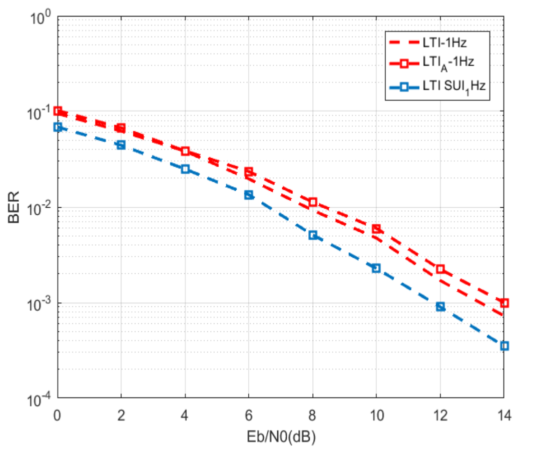

Fig. 15. BER performance of LTI channels with SUI model

In fig. 15 at 6 dB E_b/N_0 BER value for LTI SUI channel is 0.0134, for LTI in channel A BER is 0.023 and for LTI in channel B BER is 0.017. Clearly, by the simulation results we can say that application of SUI channel model on existing methods we obtained better results So, SUI channel model has better performance than other methods.

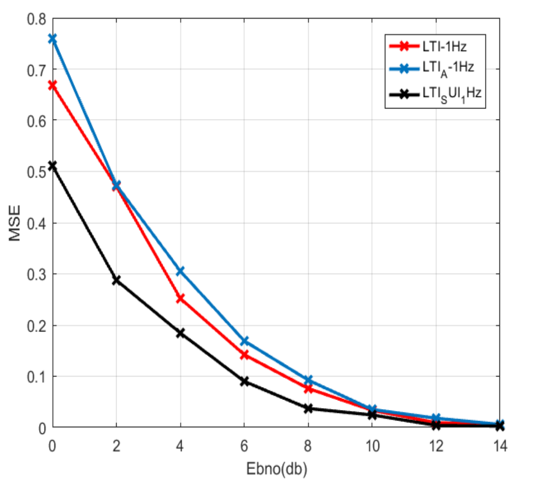

Fig. 16. MMSE performance of LTI channels with SUI model

In fig. 16, MMSE value at 6 dB E_b/N_0 in channel A is 0.169, for LTI in channel B is 0.142 and for SUI channel model MMSE value is 0.1005, when N =4, Doppler frequency is 1 Hz and modulation is 16 QAM. In short, the efficiency can be increased considerably by using high-order modulation in MIMO-OFDM transmissions, as demonstrated. We examine the performance of two channels with different Doppler shift 1 Hz, 10 Hz, 50 Hz and 100 Hz. The energy for the second channel is 6dB lower than the other channel. From simulation these results we can say that SUI channel model as better results than other methods.

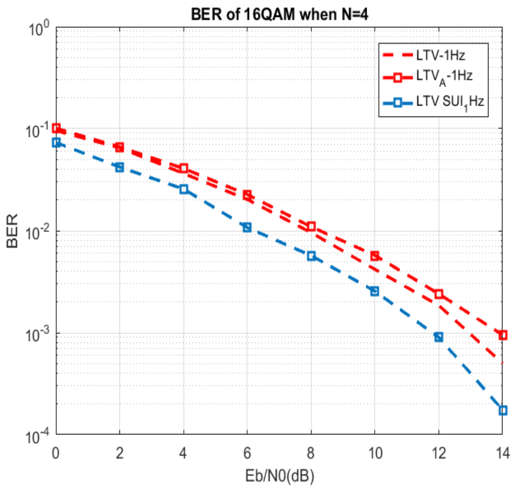

Fig. 17. BER performance of LTV channels with SUI model

In fig. 17, we have plotted BER performance by applying SUI channel parameters on LTV channel by considering various methods. At 6 dB E_b/N_0 BER for SUI model is 0.0107, for LTV in channel B BER is 0.019 and for LTV in channel A BER is 0.0226. From the plotted graph we can say that on linear time varying SUI channel model has better performance than LTI SUI channel model.

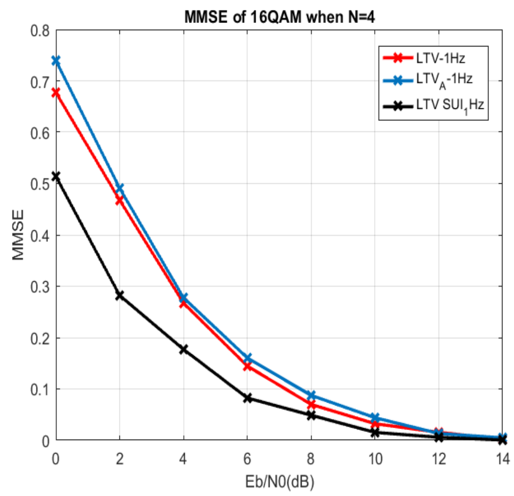

Fig. 18.MMSE equalization of LTV channels with SUI model

In fig. 18, MMSE value at 6 dB E_b/N_0 in LTV channel A is 0.1559, for LTV in channel B is 0.1331 and for LTV SUI channel model MMSE value is 0.0823. On comparing these values SUI channel model as better results than other methods.

Both MMSE and BER performance has shown that the proposed algorithm has an obvious advantage over the conventional LTI equalizer. Compared with the algorithm in LTI and LTV equalizer, the proposed SUI channel model is feasible to more sophisticated channel fading conditions, allowing independent time-varying profiles for different channel paths and for different transmitter-receiver pairs.

VI. CONCLUSION

In this paper, reduction of inter carrier interference with low computational complexity on time variation channels is proposed. We implemented a novel technique which will overcome the drawbacks of existing systems and gives 2 dB SNR when the relative Doppler factor is 0.1 and maintains low complexity. Simulation results show that BER and MMSE have a better value on comparing to LTV over LTI channel providing accuracy and reliability when compared to existing time varying channel. Finally we applied SUI channel model to existing LTI and LTV equalizer for better performance. Future work is related on such as equalization with iterative interference cancellation as well as the turbo equalization with soft information estimation. Also there are different channel models are recently under development with the help of which we can again estimate the outperforming results of execution for our proposed work on LTV channel in MIMO-OFDM.

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