Analysis of Iterative Channel Algorithm for MIMO OFDM systems using Doppler Spread

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***Abstract*—Multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) system operating in high mobility scenarios, channel estimation becomes a challenging issue, due to fast channel variation and severe inter-carrier interference (ICI). This paper proposes a novel pilot-aided iterative receiver, based on pilot symbols and iterative soft-estimate of data symbols and parallel interference cancellation (PIC) scheme coupled with decision statistical combining (DSC) is used to cancel the ICI and to improve the data symbols detection. These data symbols are then utilized to refine the channel estimation further, iteratively. The simulation results of both methods are compared and values obtained depict that the PIC-DSC method improve channel estimation and its BER/SNR value remains stable.**

Keywords*— *MIMO; OFDM; DSC;PIC; BER.

I. INTRODUCTION

In a high mobility environment, the wireless channel is time variant and frequency selective causing the symbol transmission to be impaired by the Doppler spread. The Doppler spread destroys the orthogonality and creates inter-carrier interference (ICI) between OFDM sub-carriers. In addition, the channel changes significantly within one OFDM symbol. Standard channel estimation methods that assume the wireless channels to be invariant within one OFDM symbol, or apply a block-type pilot placement, cannot be used in such a high mobility system. In estimation of the time domain channel coefficients is performed by using pilot tones and by linear interpolation of the time domain channel estimates. The authors use a comb-type pilot tones placement. In least-square (LS) and minimum-mean-square-error (MMSE) channel estimation methods, together with various linear interpolation methods such as linear, second order, low pass, spline-cubic and time domain interpolation are investigated. The authors extend the channel estimation method in [1] to take into account ICI and use a comb-type pilot placement instead of a block-type pilot placement. None of these schemes however, utilize data symbols in the channel estimation process.

Recently, high mobility transmission has been considered as one of the important key features of LTE standard. This standard needs to provide support for high mobility users that move at speeds up to 350 Km/h. When users are highly mobile, the multipath wireless channel becomes time-variant and frequency-selective within one OFDM Symbol. The Doppler spread, caused by mobility, destroys the orthogonality and creates inter-carrier interference (ICI) between OFDM subcarriers. As a consequence, the existing channel estimation methods that assume an invariant wireless channel within one OFDM symbol cannot be used for high mobility systems.

Channel estimation over rapidly time varying multipath fading channels has been considered in a number of recent papers. In estimation of time-domain channel coefficients is performed by applying a hybrid frequency/time domain channel estimation algorithm based on a linear approximation of the time variations of each channel coefficient in an OFDM symbol. However, this linear approximation is inaccurate in the presence of very high mobility. In the Doppler spread information is utilized for computing the frequency- and time-domain channel correlations in the channel estimation process. However, none of these papers exploits data symbols estimates. These estimates can be used to improve the channel estimation process. In iterative channel estimation schemes, where the detected data symbols in previous iterations are employed to refine the channel estimation, are proposed. However, the schemes in, do not take the Doppler spread information into account in their channel estimation processes.

In this paper, we design a new iterative channel estimation and ICI cancellation scheme for MIMO-OFDM systems. The proposed scheme, simultaneously utilizes the Doppler spread information and iterative estimates of data symbols in the channel estimation process. Here, each time-domain channel coefficient is approximated by a weighted time-domain channel interpolation of selected set of time-domain channel coefficients. We refer to these selected channel coefficients as time-domain markers. Then, for the rest of the channel coefficients, each channel coefficient is approximated by interpolating two selected time-domain markers. These two time domain markers are chosen in a way that they have the maximum correlation with the respective channel coefficient. The interpolation weights design of these markers, takes into consideration the Doppler spread information at the receiver. The time-domain markers are estimated by using a least square (LS) method. Once all the channel coefficients are obtained, the estimate of ICI, caused by the Doppler spread, are subtracted from the received signal by a parallel interference cancellation (PIC) module The outputs of the PIC module are then passed to the decision statistical combining (DSC) module where the decision statistics signal is obtained. Data symbols are then estimated by a detector and these estimates are utilized to iteratively refine the channel estimation. The simulation results show that the performance of the proposed iterative Doppler-assisted channel estimation with the PIC-DSC interference cancellation scheme in a high mobility environment is significantly better

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than the techniques in and is close to the performance of the system where full CSI is known and users are static.

II. LITERATURE SURVEY

Channel estimation techniques based on pilot arrangement in OFDM systems [1] deals with pilot arrangement are investigated. Channel estimation based on a comb type pilot arrangement is studied through different algorithms for both estimating the channel at pilot frequencies and interpolating the channel. Channel estimation at pilot frequencies is based on LS and LMS methods while channel interpolation is done using linear interpolation, second order interpolation, low-pass interpolation, spline cubic interpolation, and time domain interpolation. Time-domain interpolation is obtained by passing to the time domain by means of IDFT (inverse discrete Fourier transform), zero padding and going back to the frequency domain by DFT (discrete Fourier transform). In addition, channel estimation based on a block type pilot arrangement is performed by sending pilots in every sub-channel and using this estimation for a specific number of following symbols. We have also implemented a decision feedback equalizer for all sub-channels followed by periodic block-type pilots. We have compared the performances of all schemes by measuring bit error rates with 16QAM, QPSK, DQPSK and BPSK as modulation schemes, and multipath Rayleigh fading and AR based fading channels as channel models.

Robust channel estimation for OFDM systems with rapid dispersive fading channels [2] deals with orthogonal frequency-division multiplexing (OFDM) modulation has a promising technique for achieving the high bit rates required for a wireless multimedia service. Without channel estimation and tracking, OFDM systems have to use differential phase-shift keying (DPSK), which has a 3-dB signal-to-noise ratio (SNR) loss compared with coherent phase-shift keying (PSK). To improve the performance of OFDM systems by using coherent PSK, we investigate robust channel estimation for OFDM systems. We derive a minimum mean-square-error (MMSE) channel estimator, which makes full use of the time- and frequency-domain correlations of the frequency response of time-varying dispersive fading channels. Since the channel statistics are usually unknown, we also analyze the mismatch of the estimator-to-channel statistics and propose a robust channel estimator that is insensitive to the channel statistics. The robust channel estimator can significantly improve the performance of OFDM systems in a rapid dispersive fading channel.

ICI mitigation for pilot-aided OFDM mobile systems [4] deals with the orthogonal frequency-division multiplexing (OFDM) is robust against frequency selective fading due to the increase of the symbol duration. However, for mobile applications channel time-variations in one OFDM symbol introduce intercarrier-interference (ICI) which degrades the performance. This becomes more severe as mobile speed, carrier frequency or OFDM symbol duration increases. As delay spread increases, symbol duration should also increase in order to maintain a near-constant channel in every frequency sub band. Also, due to the high demand for bandwidth, there is a trend toward higher carrier frequencies. Therefore, to have an acceptable reception quality for the applications that experience high delay and Doppler spread, there is a need for ICI mitigation within one OFDM symbol. We introduce two new methods to mitigate ICI in an OFDM system with coherent channel estimation. Both methods use a piece-wise linear model to approximate channel time-variations. The first method extracts channel time-variations information from the cyclic prefix. The second method estimates these variations using the next symbol. We find a closed-form expression for the improvement in average signal-to-interference ratio (SIR) when our mitigation methods are applied for a narrowband time-variant channel. Finally, our simulation results show how these methods would improve the performance in a highly time-variant environment with high delay spread.

A model reduction approach for OFDM channel estimation under high mobility conditions [5] deals with the orthogonal frequency-division multiplexing (OFDM) which combines the advantages of high performance and relatively low implementation complexity. However, for reliable coherent detection of the input signal, the OFDM receiver needs accurate channel information. When the channel exhibits fast time variation as it is the case with several recent OFDM-based mobile broadband wireless standards (e.g., WiMAX, LTE, DVB-H), channel estimation at the receiver becomes quite challenging for two main reasons: 1) the receiver needs to perform this estimation more frequently and 2) channel time-variations introduce intercarrier interference among the OFDM subcarriers which can degrade the performance of conventional channel estimation algorithms significantly. In this paper, we propose a new pilot-aided algorithm for the estimation of fast time-varying channels in OFDM transmission. Unlike many existing OFDM channel estimation algorithms in the literature, we propose to perform channel estimation in the frequency domain, to exploit the structure of the channel response (such as frequency and time correlations and bandedness), optimize the pilot group size and perform most of the computations offline resulting in high performance at substantial complexity reductions.

III.EXISTING SYSTEM

Channel estimation over time varying multipath fading channels is solved in a number of papers in literature. All these solutions based on linear approximation. But linear approximation is not accurate in presence of high mobility. This project proposes PIC-DSC method in combination with iterative method to get accurate results.

IV. PROPOSED SYSTEM

The proposed solution is based on iterative channel estimation with inter channel interference. In this solution, each time-domain channel coefficient is approximated by a weighted time-domain channel interpolation of selected set of time-domain channel coefficient. For the rest of the channel coefficients, each is approximated by interpolating two selected time-domain markers. These two time domain markers are chosen in a way that they have the maximum correlation with the respective channel coefficient. The interpolation weights design of these markers, takes into consideration the Doppler spread information at the receiver. Least square (LS) method is used to approximate the time-domain markers .Once all the channel coefficients are obtained, the estimate of ICI due to Doppler spread, are subtracted from the received signal by a parallel interference cancellation (PIC) module. The simulated results of iterative and PIC-DSC method both are plotted and values are compared to know the effective method of channel estimation.

V. PILOT INSERTION LS METHOD AND PIC-DSC METHOD

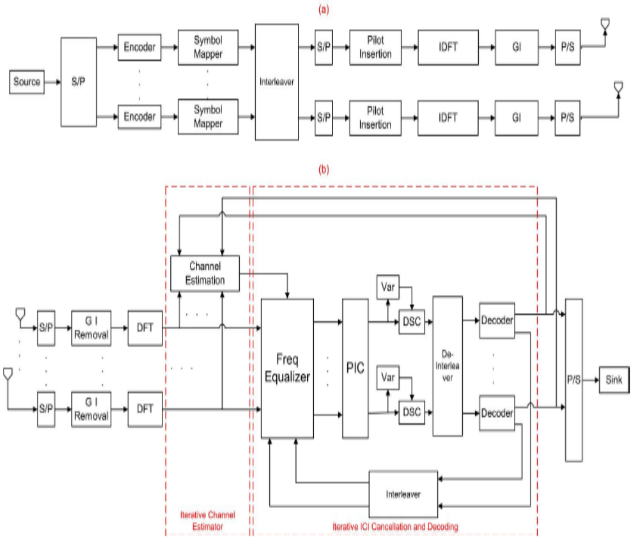

Figure 1: a.)block diagram of pilot insertion LS method.

b.)block diagram of PIC-DSC method.

The individual OFDM pictures broadcasted Eventually perusing mt carry antennas Might subsequently an opportunity on make presented Concerning outline will be OFDM picture broadcasted beginning with pth carry antenna, Besides n will a chance to be the individual number starting with asserting sub-carriers to person OFDM picture. At that point subsequently performing IDFT. Ahead each carry antenna, those instant mediumbalanced pointer on the pth carry radio wire Might make communicated Likewise.

$$\mathrm{x}_p = \mathrm{F}^H \mathrm{X}_p = [x_p(0), x_p(1), \cdots, x_p(N-1)]^T, \qquad (1)$$

Equation (1) F is the N × N DFT matrix with its element at row n and column k, defined as

$$w_{n,k} := e^{\frac{-j2\pi nk}{N}} \quad \text{For } n, k = 0, \cdots, N-1.$$

For the objective similarly ought keep away from those inter-symbol impedance because of a multipath delay spread, an cyclic prefix beginning with attesting period equivalent or a more terrific measure amazing through those anticipated an extensive parcel astounding compass of the long run delay of the bearer may make introduced for each OFDM picture past will transmission. This prefix serves between times (GI) the working about OFDM pictures.

The individual square framework of the proposed MIMO-OFDM skeleton beneficiary might make exhibited will fig. 1(b). Throughout the beneficiary side, when those GI might be removed, the individual acknowledged pointer clinched alongside qth get radio wire In addition span of the chance n Might aggravate as:

$$r_q(n) = \sum_{p=1}^{M_T} \sum_{l=0}^{L-1} h_{p,q}(l,n) x_p(n-l) + w_q(n), \qquad (2)$$

The spot Wq(n) will be included substance white Gaussian noise. Hp,q(l, n) will an opportunity to make those distinct drive reaction of the Lth transporter tap the working about the individual pth convey radio wire furthermore qth accept radio wire for compass of the long run n. Furthermore, the unique moment medium carrier grid those working of the pth convey radio wire furthermore qth get antenna, including those distinct influences of the cyclic prefix (or GI), might an opportunity should make quell Concerning framework.

$$\mathbf{C}_{p,q} = \begin{bmatrix} h_{p,q}(0,0) & 0 & \cdots & h_{p,q}(2,0) & h_{p,q}(1,0) \\ h_{p,q}(1,1) & h_{p,q}(0,1) & \cdots & h_{p,q}(3,1) & h_{p,q}(2,1) \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & h_{p,q}(1,N-1) & h_{p,q}(0,N-1) \end{bmatrix}. \qquad (3)$$

Taking after performing those DFT around (2), those picture to qth get radio wire also kth sub-carrier Might settle on communicated Thus Concerning illustration.

$$R_q(k) = \sum_{p=1}^{M_T} \sum_{m=0}^{N-1} \sum_{l=0}^{L-1} H_l^{p,q}(k-m) w_{l,m} X_p(m) + W_q(k), \qquad (4)$$

The individuals put Wq(k) will be those people DFT concerning upheaval Besides Hp,ql(k) implies DFT in respects time-varying frequency-selective bearer Hp,q(l, n).

$$H_l^{p,q}(k) = \frac{1}{N} \sum_{n=0}^{N-1} h_{p,q}(l,n) e^{\frac{-j2\pi nk}{N}}. \qquad (5)$$

This might further express Rq(k) similarly.

$$R_q(k) = \underbrace{\sum_{p=1}^{M_T} \sum_{l=0}^{L-1} H_l^{p,q}(0) w_{l,k} X_p(k)}_{\text{desired signal}} + \underbrace{\sum_{p=1}^{M_T} \sum_{m=0,m\neq k}^{N-1} \sum_{l=0}^{L-1} H_l^{p,q}(k-m) w_{l,m} X_p(m)}_{\text{ICI component}} \qquad (6)$$

Note that accepting that those carriers will make time-invariant, the worth to equation (5) could settle on non-zero recently on k = 0 under this condition, the individual inter carrier cancellation a major aspect for equation (6) disappears. Despite, around there will make a non-zero Doppler transmission; might be no more honest to goodness conflict. The individual acknowledged pointer of the entirety of cash MR accept antennas might an opportunity will a chance to be spoke will concern delineation.

$$\mathrm{R} = \mathcal{H}\mathrm{X} + \mathrm{W}, \qquad (7)$$

Those spot r = [R1, • • • ,RMR]T , Besides Rq = [Rq(0), • • • ,Rq(N − 1)]T will make the picked up sign to qth authority antenna, w = [W1, • • • ,WMR]T , Besides H will be those urging transporter grid Previously, frequency-domain, portrayed Concerning outline.

$$\mathcal{H} = \begin{bmatrix} \mathrm{H}_{1,1} & \mathrm{H}_{2,1} & \cdots & \mathrm{H}_{M_T,1} \\ \vdots & \ddots & \vdots & \vdots \\ \mathrm{H}_{1,M_R} & \mathrm{H}_{2,M_R} & \cdots & \mathrm{H}_{M_T,M_R} \end{bmatrix}. \qquad (8)$$

Here, the (m, n)th part from grid Hp,q might make portrayed Concerning illustration

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$$\alpha^{p,q}_{m,n} = \sum_{l=0}^{L-1} H^{p,q}_l(n-m)w_{l,m}, 0 \leq n, m \leq N-1. \quad (9)$$

let the individual absolute amount about guided previously, you stop putting forth on that person OFDM picture be Np, Moreover accept that the guided pictures of the pth carry antenna, shown inevitably examining Xp(pi), have help installed Throughout sub-carriers pi=0,••• ,Np−1. Here, the guided necessity help assemblies likewise uniformly separated on the OFDM symbol, the put every something like these bunches would have measured. This kind for guided placement structure wills a chance to be exhibited for an opportunity on make Perfect for the portability frameworks.

Imagine similarly as about an MIMO-OFDM structure to MT carry besides MR get antennas. Those square frameworks of a MIMO-OFDM transmitter might make exhibited previously, fig.1(a). In the individual transmitter side, a serial hotspot touch flow may be regardless changed in under parallel sub flows. Each sub flow wills a chance to be In that perspective encoded toward an encoder. Each parallel majority of the information flow might a chance to be after that mapped on a specific picture flow to a propelled MPSK/QAM modulator. Next, guided pictures for carrier evaluation need aid installed in the repeat space in front of the OFDM regulation. Those OFDM regulations may be executed toward that inverse discrete Fourier change over (IDFT). Each carry radio wire sends OFDM pictures. Educate Xp(k) methods those information picture sent in the end Tom's examining the carry radio wire p to sub-carrier k.

The individual OFDM picture broadcasted to MT antennas may a chance to be described comparatively Concerning illustration X = [X1 • • •XMT]T the n will a chance to be the measure from claiming sub-carriers to particular case OFDM picture. At that point subsequently performing IDFT looking under each carry antenna, those event At space balanced pointer on the pth carry radio wire might an opportunity with a chance to be communicated Likewise put f might grid for its doorway at section i also segment j described Concerning delineation

At that point subsequently including a cyclic prefix (CP) from asserting period g will xp, we need. Xp,CP = [xp(−G) xp(−G + 1)• • • xTp]T.

Finally, the picture flows,. XCP = [xT1 ,CP • • • xT mt ,CP]T need aid changed through beginning with a parallel ought further bolstering a serial kind Besides allocated will relating transmitters to transmission In the individual remote carrier. The individual square framework of a MIMO-OFDM skeleton authority may be shown previously, fig.1(b). We acknowledge an time-varying remote blurring carrier to hp,q(l, n) described similarly the individual Lth resolvable lifestyle those working about the individual carry radio wire p In addition get radio wire q. We provide for l = _ τ max Ts _ be the measure regarding blurring taps the put τ max In addition Ts might the best carrier delay spread and the time to OFDM picture.

$$r_q(n) = \sum_{p=1}^{M_T} \sum_{l=0}^{L-1} h_{p,q}(l,n)x_p(n-l) + \omega_q(n) \quad (10)$$

Those spot ωq(n) might be the individual included substance white gaussian upheaval (AWGN) In addition hp,q(l, n) might a chance to be those lth resolvable best approach those center of the carry radio wire p Additionally get radio wire q.

Note that the individual picked up pointer rq(n), n = 0, • • •,N − 1) will be protected beginning for cover picture get radio wire in addition kth sub-carrier Might aggravate communicated Concerning outline.

$$R_q(k) = \underbrace{\sum_{p=1}^{M_T} \sum_{l=0}^{L-1} H^{p,q}_l(0) w_{l,k} X_p(k)}_{desired\ signal} + \underbrace{\sum_{p=1}^{M_T} \sum_{m \neq k}^{N-1} \sum_{l=0}^{L-1} H^{p,q}_l(k-m) X_p(m) w_{l,m}}_{ICI\ component} + W_q(k) \quad (11)$$

$$H^{p,q}_l(k) = \frac{1}{N} \sum_{n=0}^{N-1} h_{p,q}(l,n) e^{-j2\pi nk/N}. \quad (12)$$

Note that despite the individual carrier might a chance to be time-invariant All around specific instance OFDM picture period, The individuals worth should equation(12) will make non zero main done k = 0. Under this condition despite, on there will a chance to be a none zero Doppler transmission.

Those acknowledged indications to every last bit MR accept antennas Might an opportunity to make spoke with similarly r = HX + w

Individual picked up sign should beneficiary radio wire q In addition H will be the individual urging carrier matrix, described Eventually perusing.

$$\mathcal{H} = \begin{pmatrix} \mathbf{H}_{1,1} & \mathbf{H}_{2,1} & \cdots & \mathbf{H}_{M_T,1} \\ \mathbf{H}_{1,2} & \mathbf{H}_{2,2} & \cdots & \mathbf{H}_{M_T,2} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{H}_{1,M_R} & \mathbf{H}_{2,M_R} & \cdots & \mathbf{H}_{M_T,M_R} \end{pmatrix}. \quad (13)$$

Here, the (m, n)th component about grid H p,q will be indicated Similarly as α p,q m,n and characterized Similarly as

$$\alpha^{p,q}_{n,m} = \sum_{l=0}^{L-1} H^{p,q}_l(n-m)w_{l,m}, 0 \leq (n,m) \leq N-1. \quad (14)$$

VI. RESULTS AND PERFORMANCE EVALUATION

The system parameters correspond to the parameters in the 3GPP LTE standard [1]. In particular, we consider a MIMO-OFDM system with 512 sub-carriers and QPSK modulation, operating at a 5 GHz band. The bit transmission rate is 7.2 Mbps and sampling frequency is 7.68 MHz. The number of transmit and receive antennas are set to 2. In the proposed method, the channel is estimated by using the Doppler transmission value, pilot symbols added to estimate data symbols at the receiver side. In addition, at the receiver side, data estimates are utilized iteratively as additional pilots to improve the channel estimation. In Both methods channel estimation is carried out and two methods are compared to verify the efficient way of channel estimation and simulation results. The proposed method can be tested for tracking channel variation in high mobility systems within minimum span of time and lesser number of iterations and can be used in future works. Future work would include proposed method in the algorithm based on the Krylov subspace method which allows parallelization and computations of the K filters and storage reduction.

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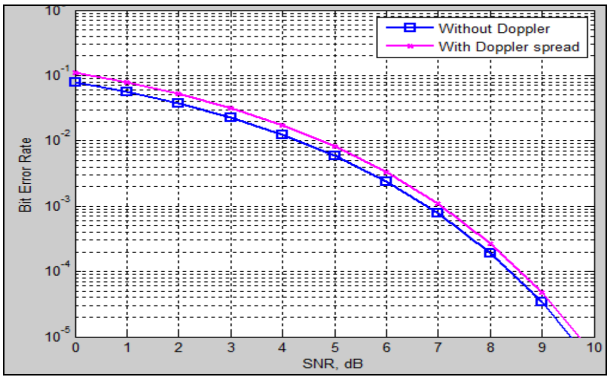

Figure 2: BER with and without Doppler shift of 0.4.

Figure 2 shows the BER value for with and without effect of Doppler shift

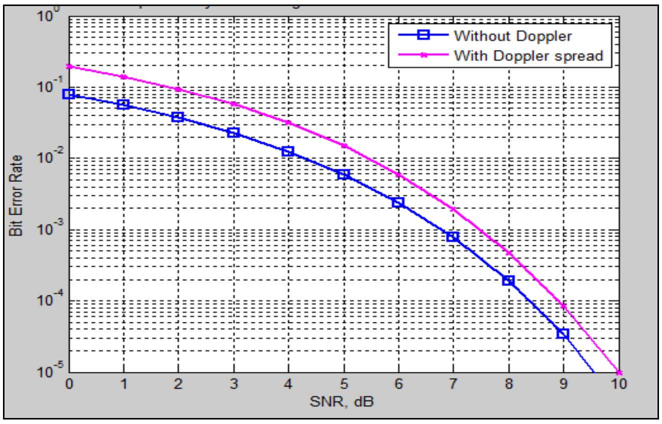

Figure 3: BER versus SNR value of with and without Doppler shift of 1.5

Figure 3 indicates that performance decreases has Doppler Effect increases. The performance is better without Doppler Effect.

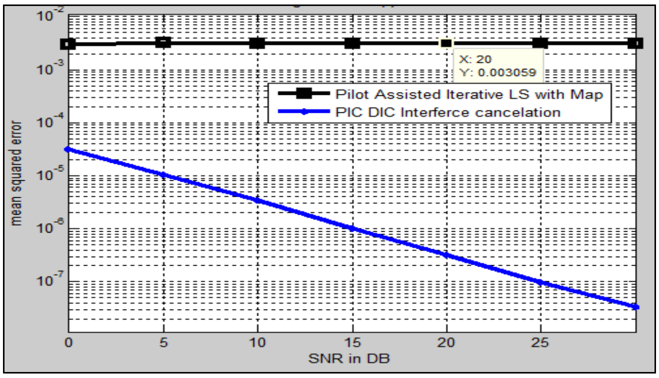

Figure 4:BER value for Both methods for Doppler shift of 0.4.

Figure 4 show the Comparison Plot of pilot assisted iterative LS map method and PIC-DSC Method for Doppler shift of 0.4

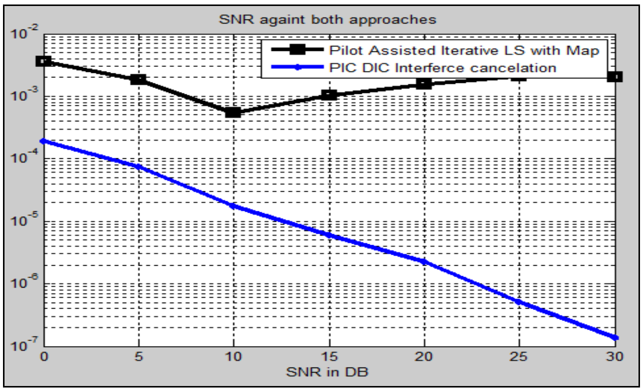

Figure 5: BER value for Both methods for Doppler shift of 1.5

Figure 5 show that the performance is better in PIC-DSC Interference Cancellation method Doppler Effect. The compared results are tabulated as shown below.

Table 1: comparison of BER values for without and with Doppler shift

Eb No(db)	Without Doppler shift	With Doppler shift
0	0.078650	0.707846
1	0.056282	0.506538
2	0.037506	0.337555
3	0.022878	0.205906
4	0.012501	0.112507
5	0.005954	0.053585
6	0.002388	0.021495
7	0.000773	0.006954
8	0.000191	0.001718
9	0.000034	0.000303
10	0.000004	0.000035

Table 2: comparison of BER values for Pilot assisted iterative LS map method and PIC-DSC method

SNR	pilot assisted iterative LS Map method	PIC –DSC method
0	0.000696	0.000044
5	0.001024	0.000015
10	0.000796	0.000005
15	0.000625	0.000001
20	0.000770	0.000000
25	0.000699	0.000000
30	0.000585	0.000000

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