Iterative Interference Cancellation for STBC-OFDM System Over Doubly Selective Channel

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Abstract. The space time block coded orthogonal frequency division multiplexing (STBC-OFDM) system performance is severely degraded due to occurrence of co-channel interference (CCI) and inter-carrier interference (ICI) effects in mobile environment. In this work, three joint CCI and ICI iterative interference cancellation techniques are proposed namely diagonalized zero forcing detection (DZFD)-parallel interference cancellation (PIC)-DZFD, order iterative decision feedback (OIDF)-PIC-DZFD and OIDF-PIC-OIDF to obtain the transmitted signal over doubly selective channel. These proposed methods cancel the interferences in three stages. The CCI cancellation is performed to obtain initial data symbol in the initial stage followed by parallel-interference-cancelation (PIC). In the third stage, the ICI free signal is processed again by CCI cancellation method to obtain the refined estimated data symbols. Finally, the proposed and conventional methods are compared with respect to complexity and symbol error rate (SER). From the results, it is demonstrated that the proposed OIDF-PIC-OIDF method significantly outperforms the conventional methods with lower complexity.

Keywords: STBC-OFDM · Signal detection · Inter-carrier interference (ICI) · Co-channel interference (CCI) · Doubly selective channel

1 Introductions

In modern days, the transmit diversity techniques have achieved significant interest because they provide reiability without additional increses in bandwidth and transmit power [1, 2]. Space time block code (STBC), often known as transmit diversity, was first proposed in [3]. The STBC schemes become the popular wireless communication techniques for a variety of applications including LTE, WiMAX, Wi-Fi [5] and design of radio receivers for military and civilian users [4]. The STBC technique is suitable for flat fading channels. In reality, the channel experiences time and frequency selective. To overcome the frequency selective issues, the STBC scheme can be combined with

K. K. Patel et al. (Eds.): icSoftComp 2023, CCIS 2031, pp. 122–136, 2024.
https://doi.org/10.1007/978-3-031-53728-8_10

OFDM modulation technique [6]. However, STBC-OFDM technique severely degrades in fast fading chennel due to the occurance of inter-carrier interference (ICI) and co-channel interferences (CCI) [7–14]. The CCI effect arises because of channel frequency response (CFR) variation for consecutive time periods. The orthogonality loss between subcarriers in OFDM modulation causes the ICI effects [15–17]. In literature, a number of signal detecting techniques have been suggested by suppressing CCI and ICI effects. In [7], successive interference cancellation (SIC) based signal detection technique was proposed. However, it has a problem with error propagation. In [8], list-SIC method was suggested which suppress the error floor in SIC and thus significantly boosts system performance. In [9], to cancel the CCI effects, diagonalized zero forcing detection (DZFD) was proposed. In [10], decision feedback (DF) technique was discussed. The maximum-likelihood (ML) technique was discussed in [11–13]. The ML technique has the highest computational cost but achieves the best performance. In [11–13], several low complexities and close to ML methods have been suggested. In [11], QR decomposition with ordering based signal detection was proposed. Spatial permutation modulation scheme based signal detection was proposed in [12]. A modified zero foring (M-ZF) signal detection method was proposed for STBC-OFDM system in accoustic channel [13]. An ordered iterative decision feedback (OIDF) signal detection method was proposed in [14]. All these signal detection techniques just suppress the CCI effects to obtain desired signals. To further enhance the performance of system, it requires supression of both CCI and ICI effects simultaneously. In literature, several methods have been addressed by combating both CCI and ICI effects in [18–25]. In [18], based on MMSE windowing technique time domain block linear filter (TDBLF) was proposed. However, this method is computationally intensive due to large matrix inversion. A low complexity frequency domain block linear filter (FDBLF) was proposed in [19] which has lower computational complexity as compared to TDBLF. However, the performance of FDBLF is poorer than TDBLF. In [20], sequential decision feedback sequence equalization (SDFSE) technique was proposed. In [21], SAGE based signal detection method was proposed for STBC-OFDM system in mobile environment. An ordered block decision feedback equalizer (OBDFE) was proposed in [22]. These signal detection methods proposed in [18–22] have high complexity as they involve in matrix inversion. An iterative interference cancellation method was proposed in [23]. In [24], an interference suppression approach was addressed which was based on optimal selection of data symbol pair ordering. To cancel both CCI and ICI effects concurrently, a low overhead interference cancellation method was developed in [25], however it is inferior to ML method. Recently, several joint decoding and channel estimation techniques are proposed for STBC-OFDM in [26, 27]. A joint decoding and channel estimation technique based on complex-valued neural networks (CVNNs) was proposed in [26]. An excepatation maximization based joint channel estimation and detection was proposed for STBC-OFDM system in [27]. This method provides near to ML method with few pilot subcarriers.

In this paper, three low complexity signal detection techniques namely DZFD-PIC-DZFD, OIDF-PIC-DZFD and OIDF-PIC-OIDF are proposed for STBC OFDM scheme. The performances of proposed and conventional methods are compared with respect to complexity and symbol error rate (SER).

The remaining of the paper is organized as follows. In Sect. 2, we discuss the STBC-OFDM system followed by OIDF signal detection method. The various proposed joint iterative cancellation methods are presented in Sect. 3. We calculate the complexity of proposed and conventional methods in Sect. 4 and present the symbol error rate performances comparison in Sect. 5. In Sect. 6, we conclude the paper.

2 System Model

This scetion describes the STBC-OFDM system model follwed by the OIDF signal detection technique.

2.1 STBC-OFDM System Model

We consider an STBC-OFDM system for two transmitting antennas and single receiving antenna. At transmitting end, binary data sequence is generated, mapped and forwarded to the STBC block. The STBC transforms the mapped data into coded data symbol matrix $X(k)$ as per Alamouti encoding [3] and is given as follow

$$X(k) = \begin{bmatrix} X^1_{(1)}(k) & X^2_{(1)}(k) \\ X^1_{(2)}(k) & X^2_{(2)}(k) \end{bmatrix} = \begin{bmatrix} X_1(k) & X_2(k) \\ -X^*_2(k) & X^*_1(k) \end{bmatrix} \quad (1)$$

where $X^i_{(t)}(k)$ is k^{th} subcarrier for i^{th} transmitting antenna at t^{th} time before the IFFT operation. The transmitted signal after IFFT operation is given by

$$x^i_{(t)}(n) = \frac{1}{\sqrt{N}} \sum\nolimits_{k=0}^{N-1} X^i_{(t)}(k) e^{\frac{j2\pi kn}{N}} \quad (2)$$

The time domain signal are then transmitted after adding cyclic prefix (CP). At receiver, the received signal is obtained as convolution operation bewteen channel impulse response (CIR) and transmitted signal as given below

$$y_{(t)}(n) = \sum_{i=1}^{2} \sum_{l=0}^{L-1} h^i_{(t)}(n, l) x^i_{(t)}(n - l) + w_{(t)}(n) \quad (3)$$

where $h^i_{(t)}(n, l)$ is the CIR for *l-th* channel tap during *n-th* sampling instant. The symbol $w_t(n)$ is additive white Gaussian noise (AWGN). The FFT operation is performed after the CP has been rempved and is written as

$$Y_{(t)}(k) = \sum_{i=1}^{2} \left[H^i_{(t)}(k, k) X^i_{(t)}(k) + I^i_{(t)}(k) \right] + W_{(t)}(k) \quad (4)$$

$$I^i_{(t)}(m) = \sum_{\substack{m=0 \\ m \neq k}}^{N-1} H^i_{(t)}(k, m) X^i_{(t)}(m) \quad (5)$$

$$H^i_{(t)}(k,m) = \frac{1}{N}\sum_{m=0}^{N-1}\sum_{l=0}^{L-1} h^i_{(t)}(n,l)e^{\frac{-j2\pi n(k-m)}{N}} e^{\frac{-j2\pi ml}{N}} \tag{6}$$

The received signal can be elaborated in matrix form as

$$Y(k) = \begin{bmatrix} Y_{(1)}(k) \\ -Y^*_{(2)}(k) \end{bmatrix} = \underbrace{\begin{bmatrix} H^1_{(1)}(k,k) & H^2_{(1)}(k,k) \\ H^{2*}_{(2)}(k,k) & -H^{1*}_{(2)}(k,k) \end{bmatrix}}_{H(k,k)} \underbrace{\begin{bmatrix} X_1(k) \\ X_2(k) \end{bmatrix}}_{X(k)} + \underbrace{\sum_{m=0 m\neq k}^{N-1} \begin{bmatrix} H^1_{(1)}(k,m) & H^2_{(1)}(k,m) \\ H^{2*}_{(2)}(k,m) & -H^{1*}_{(2)}(k,m) \end{bmatrix} \begin{bmatrix} X_1(m) \\ X_2(m) \end{bmatrix}}_{I(k)} + \underbrace{\begin{bmatrix} W_{(1)}(k) \\ W^*_{(2)}(k) \end{bmatrix}}_{W(k)} \tag{7}$$

The symbols $Y(k)$, $W(k)$ and $I(k)$ are received signal, AWGN, and interferences signal respectively. The effect of ICI is initially ignored and it can be considered as Gaussian process [17]. Hence, the received signal is modified as

$$Y(k) = H(k,k)X(k) + J(k) \tag{8}$$

$$J(k) = I(k) + W(k) \tag{9}$$

After performing multiplication operation between $H^H(k,k)$ with $Y(k)$, the estimated signal is written as

$$\tilde{X}(k) = H^H(k,k)Y(k) = G(k)X(k) + H^H(k,k)J(k) \tag{10}$$

$$G(k) = H^H(k,k) \times H(k,k) = \begin{bmatrix} \alpha_1(k) & \beta(k) \\ \beta^*(k) & \alpha_2(k) \end{bmatrix} \tag{11}$$

$$\alpha_1(k) = \left|H^1_{(1)}(k)\right|^2 + \left|H^2_{(2)}(k)\right|^2, \alpha_2(k) = \left|H^1_{(2)}(k)\right|^2 + \left|H^2_{(1)}(k)\right|^2 \tag{12}$$

$$\beta(k) = H^1_{(1)} * (k)\, H^2_{(1)}(k) - H^1_{(2)} * (k)\, H^2_{(2)}(k) \tag{13}$$

where $\alpha_1(k)$, $\alpha_2(k)$ are diversity gain term. The symbols $\beta(k)$, $\beta^*(k)$ are the unwanted CCI terms. The estimated signal $\tilde{X}(k)$ is exprseed in matrix form

$$\tilde{X}(k) = \begin{bmatrix} \tilde{X}_1(k) \\ \tilde{X}_2(k) \end{bmatrix} = \begin{bmatrix} \alpha_1(k)X_1(k) + \beta(k)X_2(k) + Z_1(k) \\ \beta^*(k)X_1(k) + \alpha_2(k)X_2(k) + Z_2(k) \end{bmatrix} \tag{14}$$

where $\alpha_1(k)X_1(k)$ and $\alpha_2(k)X_2(k)$ are diversity signals. $\beta(k)X_2(k)$ and $\beta^*(k)X_1(k)$ denote unwanted interferences signals. These CCI signals are mixed with original signals, thus degrades system performance. To improve performance of system, several methods have been proposed such as SIC, DZFD, DF, ML and OIDF. The ML signal detection technique provides optimal performance with high complexity. However, the order iterative decision feedback (OIDF) technique provides similar performance as ML with significaly reduced complexity.

2.2 Order Iterative Decision Feedback (OIDF) Method

The OIDF technique was proposed in [14]. The OIDF technique first obtains initial estimated signal using DZFD method and calculates the unwanted interreference signal. Later, it iteratively cancels the interreference to obtain refined data signal. The algorithm for OIDF method is illustrated below

Initialization: Apply DZFD Method

Since, multiplying $H^H(k, k)$ with the received signal Y(k) is not a diagonal matrix, Ω (*k, k*) matrix is multiplied in place of $H^H(k, k)$ and can be expressed as

$$\tilde{X}(k) = \Omega Y = diag(\phi, \phi)X + \Omega J \tag{15}$$

The transform matrix $\Omega(k)$ after simplification of (15) is given by

$$\Omega(k, k) = \begin{bmatrix} H_{21}^{*}(k, k) & H_{12}(k, k) \\ H_{22}^{*}(k, k) & -H_{11}(k, k) \end{bmatrix} \tag{16}$$

The value of ϕ (k) is obtained after multiplication of Ω and H matrix

$$\phi(k) = H_{11}(k)H_{21}^{*}(k) + H_{12}(k)H_{22}^{*}(k) \tag{17}$$

The estimated signal is obtained by dividing $\phi(k)$ with $\tilde{X}(k)$ as given in (15) followed by hard decision operation

$$\hat{X}(k) = Q\left(\frac{\tilde{X}(k)}{\phi(k)}\right) = X(k) + J(k) \tag{18}$$

where Q denotes hard decision function.

OIDF Algorithm:

[*Step* 1]: Set the variables as based on diversity gain

If $\alpha_1(k) \geq \alpha_2(k)$, set variable $a = 1$ and $b = 2$

If $\alpha_1(k) < \alpha_2(k)$, set variable $a = 2$ and $b = 1$

[*Step* 2]: Detect the data signal using DZFD output with larger diversity gain

$$\hat{X}_a(k) = Q((\tilde{X}_a(k)/\phi(k)) = X_a(k) + J(k) \tag{19}$$

[*Step* 3]: Detects the data signal through iteratively cancel the CCI effects

for $I = 1 : P$

$$\hat{X}_b(k) = Q\{(\tilde{X}_b(k) - \beta^{*}\hat{X}_a(k)/\rho_b(k)\} \tag{20}$$

$$\hat{X}_a(k) = Q\{(\tilde{X}_a(k) - \beta\hat{X}_b(k)/\rho_a(k)\} \tag{21}$$

end

where P denotes number of iterations.

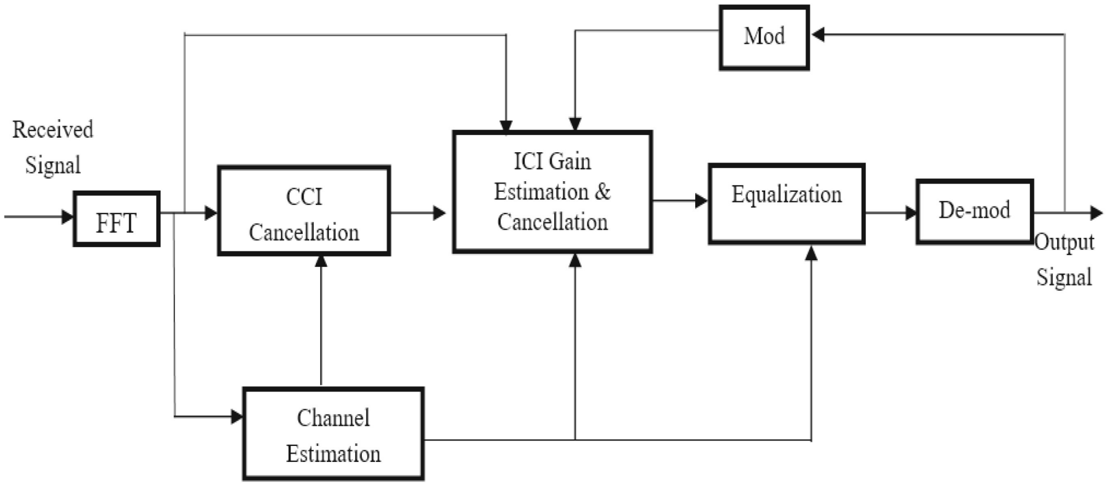

Fig. 1. Block diagram of proposed joint CCI-ICI cancellation method

3 Iterative Interference Cancellation Methods

This section describe the proposed iterative cancellation methods namely DZFD-PIC-DZFD, OIDF-PIC-DZFD and OIDF-PIC-OIDF are presented. Figure 1 illustrates working principles of propsed signal detection methods.

3.1 DZFD-PIC-DZFD Method

The DZFD-PIC-DZFD method cancels the interferences iteratively as shown in Fig. 1. This method estimates the transmitted signal using three stages. In first stage, DZFD technique is adopted to get initial signal. In second stage, ICI signals are calculated and removed from received signal as given below

$$Y^{I}_{offICI}(k) = Y(k) - \sum\nolimits_{m=0, m\neq k}^{N-1} H(k,m)\hat{X}^{I-1}(m) = H(k,k)\hat{X}^{I}(k) + W(k) \quad (22)$$

$$Y^{I}_{offICI}(k) = \left[\, Y^{I}_{(1)offICI}(k) \left(Y^{I}_{(2)offICI}(k)\right)^{*} \right] \quad (23)$$

where $\hat{X}^{I-1}(m)$ is the estimated signal obtained from DZFD in (18). In third stage, the DZFD method is again applied to ICI free signal as follows

$$R^{I}_{DZFD}(k) = \Omega(k,k) \times Y^{I}_{offICI}(k) \quad (24)$$

$$R^{I}_{DZFD}(k) = \left[\, R^{I}_{(1)DZFD}(k)\; R^{I}_{(2)DZFD}(k) \right] \quad (25)$$

The estimated signal is obtained after performing the hard decision function of (25) and is expressed as

$$\hat{X}^{I}(k) = Q\left(R^{I}_{DZFD}(k)\right) = X(k) + W'(k) \quad (26)$$

Since, the ICI effects is more prominent in neighboring subcarrier. Thus, only $2q$ subcarrier adjacent to desired subcarrier is considered as mentioned in [20]

$$H(k,m) = 0 for|k-m| > q \tag{27}$$

By applying the condition given in (27), the Eq. (22) becomes

$$Y^I_{offICI}(k) = Y(k) - \sum\nolimits_{m=k-q,m\neq k}^{m=k+q} H(k,m)\hat{X}^{I-1}(m) \tag{28}$$

where $2q$ is the number adjacent subcarriers which contribute the ICI effect significantly. Since, the ICI effects are considered from for $2q$ neighboring terms, the complexity is $O(2qN)$.

3.2 OIDF–PIC-DZFD Method

The working principle of OIDF–PIC-DZFD method is similar to DZFD–PIC-DZFD method. In OIDF–PIC-DZFD, OIDF method is used instead of DZFD method to estimate the initial rough signal in the initial stage.

3.3 OIDF–PIC-OIDF Method

This method is almost similar to the previous proposed cancellation methods. The first and second stage is exactly same as OIDF-PIC-DZFD method. The third stage is performed by adopting the iterative OIDF method and is given as follows. At first, temporary detected signal is obtained by multiplying $H^H(k,k)$ with ICI free signal $Y^I_{offICI}(k)$ as given below

$$Z^I_{offICI}(k) = H^H(k,k)Y^I_{offICI}(k) = G(k)\hat{X}^I(k) + W'(k) \tag{29}$$

$$Z^I{}_{off\ ICI}(k) = \left[Z^I_{(1)off\ ICI}(k)\ \left(Z^I_{(2)off\ ICI}(k)\right)\right]^T \quad W'(k) = \left[W'_{(1)}(k)\ W'_{(2)}(k)\right]^T \tag{30}$$

The OIDF method is applied to ICI free signal and is illustrated below.

[*Step* 1]: Set the variables as per higher diversity gain

If $\alpha_1(k) \geq \alpha_2(k)$, put variable $a = 1$ and $b = 2$

If $\alpha_1(k) < \alpha_2(k)$, put variable $a = 2$ and $b = 1$

[*Step* 2]: Detect initial data signal using DZFD method as given in (24) with respect to higher diversity gain

$$\hat{X}^I_a(k) = Q\left(R^I_{(a),DZFD}(k)\right) = X^I_a(k) + W'^I_a(k) \tag{31}$$

[*Step* 3]: Detects the final data signal through iteratively cancel the CCI effects

$$\begin{aligned} &\text{for}\, I = 1 : P \\ &\hat{X}_b(k) = Q\{(Z^I_{b,offICI}(k) - \beta^*\hat{X}^I_a(k)/\rho_b(k)\} \end{aligned} \tag{32}$$

$$\hat{X}_a(k) = Q\{(Z^I_{a,offICI}(k) - \beta\hat{X}^I_b(k)/\rho_a(k)\} \tag{33}$$

end

This method gives better performance than its counterpart OIDF-PIC-DZFD method as it has additional DF operation.

Table 1. Computational Complexity

Method	Multiplication
TDBLF	$3 \times (2N)^3 + (2N)^2$
SDFSE	$\left[4 \times (C)^{2(2q+1)}\right]N$
DZFD-PIC-DZFD	$[10 + (8 + 4 \times 2q)I]N$
OIDF- PIC-DZFD	$[22 + (8 + 4 \times 2q)I]N$
OIDF- PIC-OIDF	$[22 + (14 + 4 \times 2q)I]N$

4 Computational Complexity

The TDBLF was proposed in [18] and is based on MMSE filter design and filtering procedure to cancel the ICI effects and needs total $3 \times (2N)^3 + (2N)^2$ complex multiplications. The SDFSE was proposed in [20]. It needs $4 \times (C)^{2(2q+1)}$ states where C denotes the constellation size and q is number of nearest subcarrier adjacent to the main diagonal. The proposed DZFD-PIC-DZFD method uses DZFD method to estimate the initial data which requires 10 complex multiplications [9]. In the second stage ICI free received signal requires $4 \times 2q$ complex multiplications. In the third stage, the ICI free received signal uses one tap zero forcing equalization which requires 8 complex multiplications. Hence total $10 + (8 + 4 \times 2q)I$ multiplications are needed for DZFD-PIC-DZFD method. OIDF-PIC-DZFD method is similar to DZFD-PIC-DZFD method instead it uses OIDF method to estimate the initial data symbol. In OIDF detection method, DZFD requires 10 complex multiplications for initial estimates of data signal, 4 complex multiplications require for $H^H Y$ operations and 6 complex multiplications for $\beta, \alpha_1, \alpha_2$. The first step of OIDF method involves no complex operation. Step 2 adopts DZFD method and therefore needs 10 complex operations. Step (3) and (4) needs two complex multiplication operations for $\beta^*(k)\hat{X}_a(k)$ and $\beta(k)\hat{X}_b(k)$. Hence, OIDF method needs total 22 complex multiplications. Total number of complex multiplications of DZFD-PIC-DZFD requires $22 + (8 + 4 \times 2q)I$. The first and second stage of OIDF-PIC-OIDF is similar to the previously discussed OIDF-PIC-DZFD method and thus needs $22 + (4 \times 2q)$ complex multiplication. In the third stage, initial data symbol is estimated using ZF method which requires 8 complex multiplications. $Z^I_{offICI}(k)$ requires 4 complex multiplications. The value of β and α are calculated in the first stage and is stored in a buffer and hence needs no extra complexity. Step (3) and (4) involves two complex multiplication operations i.e., $\beta^{*}(k)\hat{X}_a^I(k)$ and $\beta(k)\hat{X}_b^I(k)$. Hence, total $22 + (14 + 4 \times 2q)I$ complex multiplications are needed. The computation complexity of these interference cancellation methods is given in the Table 1.

Table 2. Simulation Parameters

Parameter	Value
Size of FFT	128
Number OFDM subcarriers	128
Size of CP	16
Frequency of carrier	2.5 GHz
Bandwidth of OFDM	1 MHz
Type of modulation	QPSK
Channel model	Exponential decaying PDP
Channel delay spread (d)	3
Total number of multipaths	8
Velocity of mobile	200/400 km/h
Channel Doppler spread ($f_d\,NT_s$)	0.06/0.12

5 Simulation Results

This section compares the conventional and proposed methods performance with respect to symbol error rate (SER) for several normalized Doppler frequency f_dNT_s. In this work, we have modelled the channel using exponential decaying power delay profile (PDP) [28, 29]. The l-th path power is given by $\sigma_l^2 = \sigma_0^2\,\lambda^l, \quad l = 0, 1, 2, ...L$. Power of the first path is $\sigma_0^2 = 1 - e^{-1/d}\big/1 - e^{-(L+1)/d}$ and $d = \frac{-\tau_{rms}}{T_s}$ is the channel normalized delay spread. The symbol τ_{rms} denotes the rms delay spread of channel. The parameter $T_s = 1\big/W$ is the sampling time and W is bandwidth of OFDM system. Total number of multipaths (L) is calculated as $L = \tau_{max}/Ts$. $\tau_{max} = -\tau_{rms} lnA$, τ_{max} is the maximum delay of the chaanel. The parameter A is the ratio between the power of first path to the power of non-negligible path. For the parameters $d = 3$ and $A = -15$ dB, then number of multipaths is calculated as 8. Additionally, each multipath channel exhibits time variation and is modelled using Jakes sum-of-sinusoidal (SOS) [30]. The frequency of the carrier (f_c) is assumed as 2.5 GHz and bandwidth (W) is taken as 1 MHz. For mobile velocity of 200 and 400 km/h, the channel normalized Doppler spread (fdNTs) value becomes 0.06 and 0.12 respectively. Table 2 lists the total parameters and values used for simulation.

Figure 2 shows the performance of various CCI cancellation techniques for $f_d NT_s = 0.06$. The simulation result demonstrate that the Alamouti technique suffers performance degradation because of the occurance of both CCI and ICI effects. Although SIC technique achieves better result than the Alamouti method, its accuracy is limited to error propagation issue. The DZFD method outperforms SIC method, but as the Doppler frequency rises, its diversity gain declines. The DFD method produces superior results compared to DZFD. The List-SIC provides 10 significantly better result as compared to DFD method, but its complexity increases for higher order modulation. The OIDF method performs close to ML method. Following are the results of several CCI signal detection techniques listed in descending order: ML, OIDF, List-SIC, DF, DZFD, SIC and Alamouti.

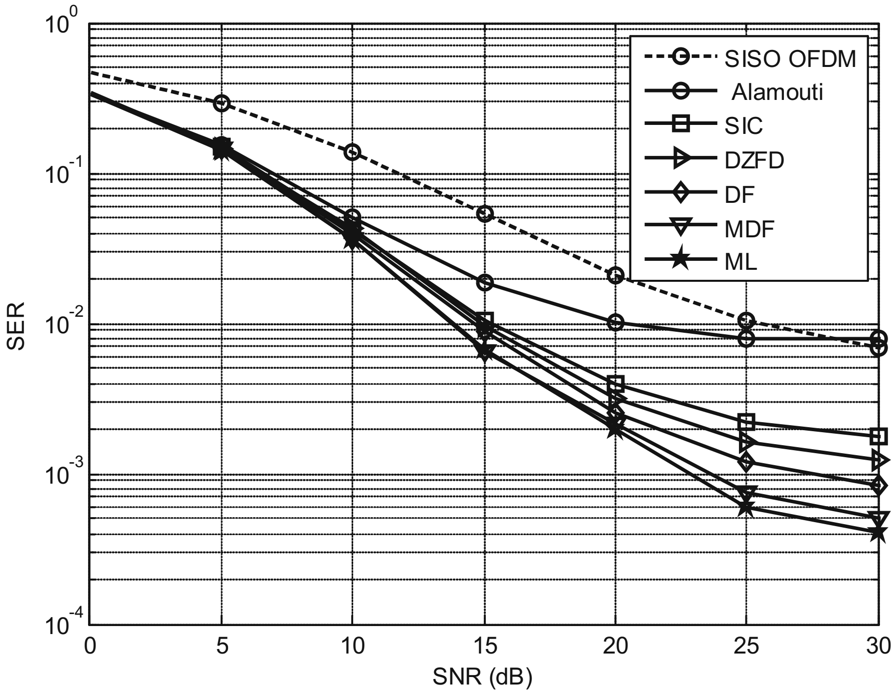

Fig. 2. Performance comparison of several CCI cancellation techniques for normalized Doppler spread $f_d NT_s = 0.06$

Figure 3 depicts the performance of DFD, ML and OIDF methods with various iterations (P) for $f_d NT_s = 0.06$ at 25 dB SNR. The result shows, the OIDF achieves significant performance than DFD method and is near to the ML method. It is demonstrated that the OIDF method achieves its optimal value with $P = 2$ iterations. However, it is seen from the simulation results that only cancelling the CCI effects does not provide sufficient performance.

The SER performance for various conventional which includes Alamouti, DZFD, OIDF, SDSFE, TDBLF and three proposed methods as shown in the Fig. 4 for $f_d NT_s = 0.6$. The result shows that the proposed DZFD-PIC-DZFD and OIDF-PIC-OIDF gives better performance than SDFSE method with q = 0. However, SDFSE with q = 2 outperforms the proposed DZFD-PIC-DZFD and OIDF-PIC-DZFD methods. The OIDF-PIC-DZFD gives better results than DZFD-PIC-DZFD method as it uses OIDF method instead of ZF to initial estimate the signal in the stage 1. The OIDF-PIC-OIDF gives better performance than its counterparts OIDF-PIC-DZFD method as it has additional OIDF operation but its computational complexity is slightly higher. From the Fig. 4, it is seen that the OIDF-PIC-OIDF method gives much better performance than TDBLF with much lower complexity as indicated in Table 1.

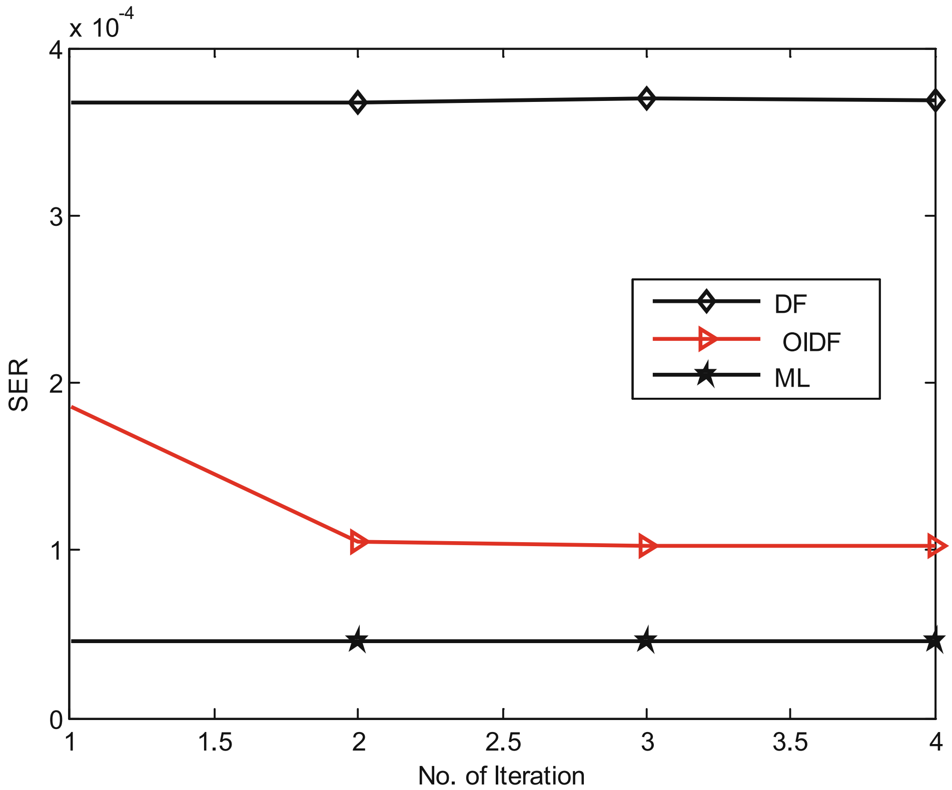

Fig. 3. SER vs no. of iteration of DF, ML and OIDF techniques for normalized Doppler spread $f_d NT_s = 0.06$

Figure 5 depicts the performance comparison of various signal detection methods for $f_d NT_s = 0.12$. It is observed that, TDBLF gives much better performance than OIDF-PIC-DZFD and DZFD-PIC-DZFD but lower as comparison to OIDF-PIC-OIDF method. The performance of several methods in ascending order are Alamouti, DZFD, DZFD-PIC-DZFD, OIDF, OIDF-PIC-DZFD, SDFSE, TDBLF and OIDF-PIC-OIDF. The BER vs normalized doppler spread performance of various signal detection methods is shown in Fig. 6. From the result, it is obvious that performance of various detection methods decreases with increases in normalized Doppler spread. The OIDF-PIC-OIDF method outperforms the SDFSE and TDBLF method irrespective of any mobile speed.

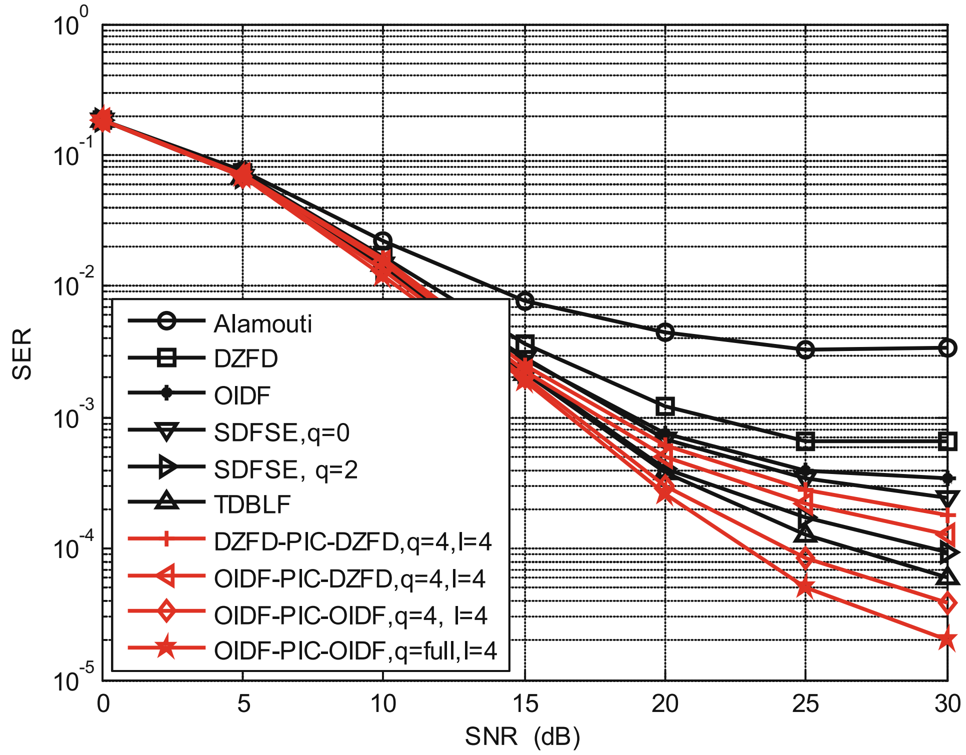

Fig.4. BER vs SNR performance comparison of several signal detection methods for $f_d N T_s = 0.06$

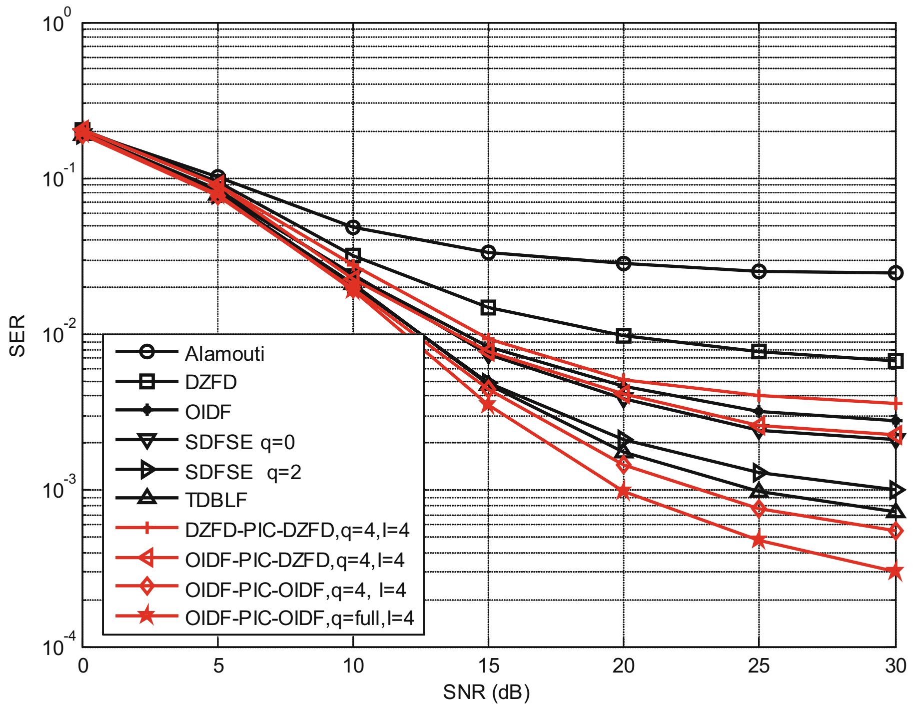

Fig.5. BER vs SNR performance comparison of several signal detection methods for $f_d N T_s = 0.12$

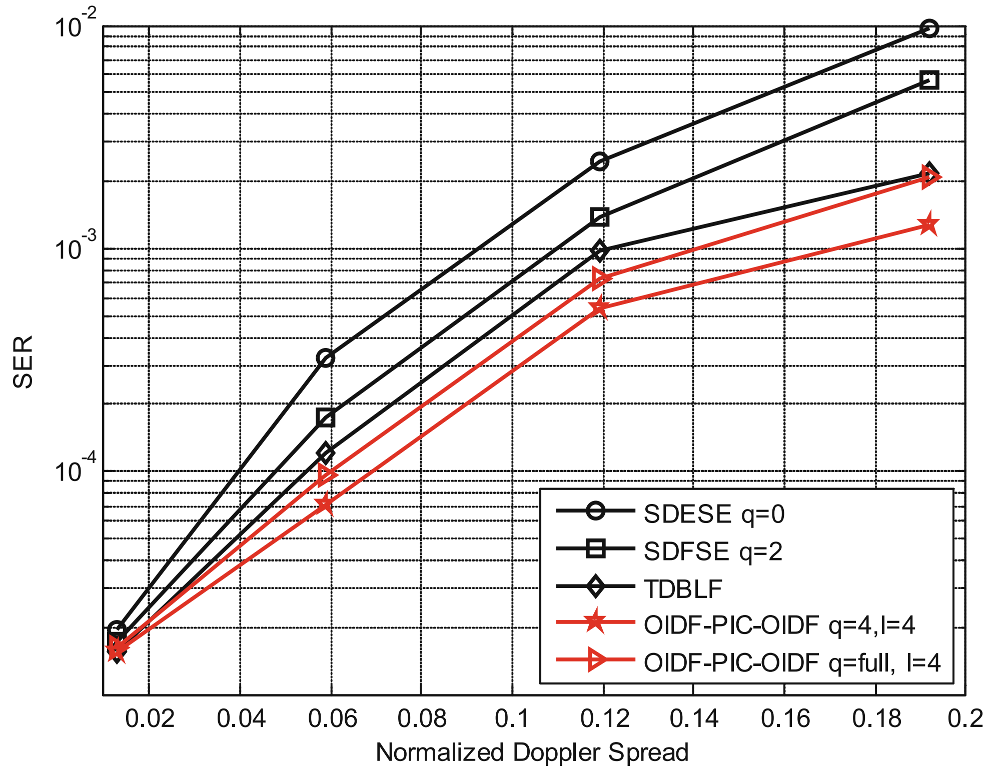

Fig. 6. SER vs normalized Doppler spread of various signal detection methods

6 Conclusions

The STBC-OFDM system suffres severely performance degradion due to CCI and ICI effects over doubly selective channel. To improve the system performance, three simplified joint iterative CCI and ICI interference cancelation schemes are proposed namely DZFD-PIC-DZFD, OIDF-PIC-DZFD and OIDF-PIC-OIDF. These proposed methods are compared with various conventional methods such as ML, TDBLF and SDFSE with respect to symbol-error-rate (SER) and complex multiplications operations. From the simulation results and complexity calculations, it is demonstrated that the proposed OIDF-PIC-OIDF method outperforms the conventional methods with significantly lower complexity.

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