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Performance Evaluation of MIMO LTE Downlink OFDM Using FDADFE

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Abstract— The 3GPP standard LTE uses OFDMA in downlink, which experiences severe inter-symbol interference (ISI) in highly frequency selective fading channels. The conventional MMSE or ZF equalizer is not effective enough for these channels to deal with ISI. In this paper, a frequency domain adaptive decision feedback equalizer (FDADFE) is introduced which has both the feed-forward and feedback filters operating in the frequency domain. The equalizer uses RLS and LMS algorithms to adapt the filter coefficients making the system more convergent with less execution time.

Index Terms— LTE, MIMO, orthogonal frequency division multiplexing (OFDM), decision feedback equalization (DFE), recursive least squares (RLS) algorithm, least mean squares (LMS).

1 Introduction

ORTHOGONAL Frequency Division Multiplexing (OFDM) is a promising multicarrier modulation technique that includes robustness to the multipath fading channel, high spectral efficiency, low complexity implementation, and the ability to provide flexible transmission bandwidths and supports advanced features such as frequency selective fading, MIMO transmission, and interference coordination [1]. The 3GPP (Third Generation Partnership Project) standard LTE, which is the representative of the fourth generation wireless system, has been developed to respond to the requirements and to realize the goal of the era of a mobile data revolution. In the LTE standard, the downlink transmission is based on an OFDM scheme, which is a multicarrier transmission methodology that represents the broadband transmission bandwidth as a group of many narrowband subchannels. In OFDM technique, the use of the frequency domain MMSE (Minimum Mean Squared Error) or ZF (Zero Forcing) equalizer is not effective enough for highly frequency-selective fading channels with spectral nulls that result in considerable noise enhancement. The frequency domain Decision Feedback Equalizer (DFE) can outperform most in such a case. Several research outcomes are available in the literature that describes the possible ways to reduce, or even completely eliminate the noise, in an OFDM transmission system using more refined receiver signal processing. Most works have been done with the Single-Carrier Orthogonal Frequency Division Multiplexing (SC-OFDM) in the LTE. In a work, Hybrid-DFE and iterative block decision feedback equalization are considered to improve the equalization performance of SC-FDMA, where the feed-forward filer is implemented in the frequency domain but the feedback filter is realized in time domain[2]. Therefore, the complexity reduced considerably due to the frequency domain feed-forward filter comparing to its time domain equivalent. In [3], an MMSE multiple input multiple output frequency domain decision feedback equalizer is introduced in OFDM for Wireless Local Area Networks (WLAN) standard, namely, IEEE802.11a. All of DFEs mentioned above are non-adaptive frequency domain and require Channel State Information (CSI) at the receiver. In another work, a low complexity Adaptive Frequency-Domain Decision Feedback Equalizer (AFD-DFE) is introduced, where both the feed-forward and feedback filters operate in the frequency domain, and the weights are adapted using the block Recursive Least Squares (RLS) algorithm for uplink SC-FDMA[4],[5].

Different diversity techniques are in practice to combat multipath fading efficiently. The most popular transmit diversity scheme with two antennas was proposed by Alamouti [5][6]. Despite of not increasing the overall throughput, several interesting features of this simple technique make it useful for realization. Besides the simple encoding and decoding techniques and linear processing at the terminals, it does not require Channel State Information (CSI) at the transmitter (open-loop technique), therefore complexity is reduced by achieving full spatial diversity gain at rate 1. Furthermore failure of one antenna chain does not result in data loss [5].

The scheme proposed by Alamouti is a special case of space-time block codes (STBCs) [5,7]. Alamouti's STBC can be applied to the 3rd Generation Partnership Project (3GPP) LTE downlink over two OFDM symbols and two transmit antennas [1].

In this paper, an effective Frequency-Domain Adaptive Decision feedback Equalizer (FDADFE) is designed for 3GPP MIMO LTE OFDM system. We propose a DFE with an adaptive algorithm system with feed-forward and feedback filters both of which operate in frequency domain. Due to the fast tracking/convergence properties, the Recursive Least Squares (RLS) algorithm[8] is used to

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update the set of weights of the feed-forward and feedback filters; however due to its computational complexity, it executes slowly. Hence the next iteration shifts to the most popular Least Mean Square (LMS) algorithm [8] due to its fast execution properties.

Following this introduction, the organization of this paper is devoted to the system model in Section 2. In Section 3, the development of the FDADFE is presented. The performance and simulation results are discussed in Section 4. Finally, Section 5 draws the conclusions of the work.

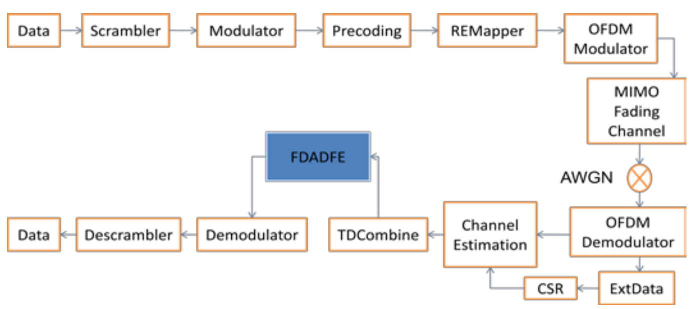

Fig.1. Block diagram of an OFDM transmission system in 3GPP LTE MIMO with Transmit Diversity

2 SYSTEM MODEL

Throughout this paper, the system model used is shown in the Fig.1. A set of binary data is generated as payload. Modulation is followed by the scrambling of the data. Three types of modulation techniques are assumed in three different cases. Working with the precoding and LTE Resource Mapping, the modulated symbols are fed to the OFDM Modulator. Fig. shows the Resource elementgrid for MIMO LTE [1].

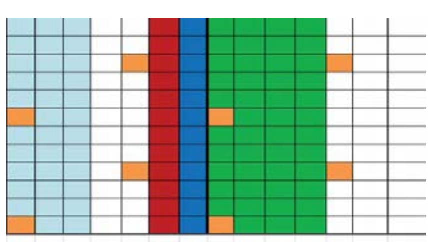

Fig.2. Resource element mapping : central resource blocks of subframe 0 including BCH, PSS, SSS, DCI,CSR, and user data

The resource elements are IFFT (Inverse Fast Fourier Transform) transformed to produce the OFDM modulated signal. The IFFT output is the summation of basis funcions or complex exponential functions, complex sinusoids and harmonics or tones of a multitone signal.[1] One of these tones or harmonics can be considered as:

$$x(n)|_{\omega=k\Delta f}= a_k e^{j2\pi kn/N} \quad (1)$$

The transmitted signal is passed through the MIMO fading channel with an impulse response h(m) providing the received signal $y(n)$.

$$y(n)|_{\omega=k\Delta f} = \sum_{m=0}^{M} h_m\, x(n)|_{\omega=k\Delta f} \quad (2)$$

The received component of the each OFDM signal can be computed as the convolution of the transmitted component and the channel impulse response.

$$y(n)|_{\omega=k\Delta f} = a_k e^{j2\pi kn/N} \sum_{m=0}^{M} h_m\, e^{-j2\pi k d_m/N} \quad (3)$$

Finally, the following expression can be obtained for the received OFDM signal component.

$$y(n)|_{\omega=k\Delta f} = H_k a_k e^{j2\pi kn/N} \quad (4)$$

where, $H_k = \sum_{m=0}^{M} h_m\, e^{-j2\pi k d_m/N}$ is a gain which is applied to the complex exponential component and is a function of the subcarrier index k.

The OFDM modulated symbols are transmitted through the wireless channel corrupted by additive white Gaussian noise (AWGN) and the received discrete-time baseband equivalent signal is given by

$$Y(\omega)=\sum_{n=0}^{N} y(n)\, e^{-j2\pi\omega n/N} + \boldsymbol{\eta}(n) \quad (5)$$

where, $\boldsymbol{\eta}(n)$ is denoted as the additive white Gaussian noise.

After substituting the expression for the received OFDM signal component, the following equation can be obtained:

$$y(n)|_{\omega=k\Delta f} = 1/N \sum_{n=0}^{N} H_k a_k e^{j2\pi k\Delta f n/N} e^{-j2\pi k\Delta f n/N} \quad (6)$$

Finally, after simplification, we can get a perceptive formula for the received signal at a given subcarrier component:

$$y(\omega)|_{\omega=k\Delta f} = H_k a_k \quad (7)$$

This is the simple expression of the received signal at any subcarrier.

By extracting the resource element from the output signal, the process of channel estimation is performed. After the combination of transmit diversity decoding and MMSE equalization of the "conventional" LTE, thr resulting output is processed by the proposed FDADFE for equalization.

3 FDADFE FOR OFDM

In this paper, MIMO system is used to enhance the transceiver performance. We applied our FDADFE design to the MIMO system for Transmit Diversity by implementing 8 at the block level. At the transmitter, the data block is represented after scrambling and modulation, as $\chi^{(m)}=[X(0)^{(m)}, X(1)^{(m)}, \ldots, X(M-1)^{(m)}]^T$. Using 7, we get $\chi_1^{(m)}=[X(0)^{(m)},-X^*(1)^{(m)},\ldots X(M-2)^{(m)},-X^*(M-1)^{(m)}]^T$ and $\chi_2^{(m)}=[X(1)^{(m)},X^*(0)^{(m)},\ldots X(M-1)^{(m)}, X^*(M-2)^{(m)}]^T,$

where (.)* denotes the complex conjugate operation. After mapping the resource elements for LTE downlink applying the N-point IDFT, the transmitted signals are denoted by $\varkappa_1^{(m)}$ and $\varkappa_2^{(m)}$ corresponding to $\chi_1^{(m)}$and $\chi_2^{(m)}$.

The received signal for the m_{th} user, after SFBC [9], can be expressed as

$$\boldsymbol{y}_{oe}=\begin{bmatrix} Y_o \\ Y_e^* \end{bmatrix}=\begin{bmatrix} \boldsymbol{\Lambda}_{10} & \boldsymbol{\Lambda}_{20} \\ \boldsymbol{\Lambda}_{2e}^* & -\boldsymbol{\Lambda}_{1e}^* \end{bmatrix}\begin{bmatrix} \boldsymbol{\chi}_o \\ \boldsymbol{\chi}_{oe} \end{bmatrix}+\begin{bmatrix} N_o \\ N_e^* \end{bmatrix} \quad (8)$$

$$\triangleq \boldsymbol{\Lambda}\boldsymbol{\chi}_{oe} + N_{oe} \quad (9)$$

Where $Y_o(\boldsymbol{\chi}_o)$and $Y_e(\boldsymbol{\chi}_e)$ represents the odd ad even components, respectively, of the frequency domain received signal $\boldsymbol{Y}(\boldsymbol{\chi})$. $\boldsymbol{\Lambda}_{io}$ and $\boldsymbol{\Lambda}_{ie}$ are the diagonal matrices which contain odd and even components, respectively, of the frequency-domain channel corresponding to the ith

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transmit antenna. We assumed,

$\boldsymbol{\Lambda}_{ie} = \boldsymbol{\Lambda}_{io}$, i=1, 2

After MMSE, we get

$$\begin{bmatrix}\hat{\mathbf{X}}_o\\ \hat{\mathbf{X}}_e\end{bmatrix}=\left(\boldsymbol{\Lambda}^H\boldsymbol{\Lambda}+\frac{1}{SNR}\mathbf{I}_{2M}\right)^{-1}\boldsymbol{\Lambda}^H\,\boldsymbol{\mathcal{Y}}_{oe} \quad (10)$$

where SNR is the signal-to-noise ratio at the receiver. Since $\Lambda^H\Lambda$ has an Alamouti-like structure, therefore

$$\begin{bmatrix}\hat{\mathbf{X}}_o\\ \hat{\mathbf{X}}_e\end{bmatrix}=\begin{bmatrix}\boldsymbol{\varphi}_1 & \boldsymbol{\varphi}_2\\ \boldsymbol{\varphi}_2^* & -\boldsymbol{\varphi}_1^*\end{bmatrix}\begin{bmatrix}\mathcal{Y}_o\\ \mathcal{Y}_e^*\end{bmatrix} \quad (11)$$

where $\boldsymbol{\varphi}_1$ and $\boldsymbol{\varphi}_2$ are diagonal matrices. Alternatively, it can be written as

$$\begin{bmatrix}\hat{\mathbf{X}}_o\\ \hat{\mathbf{X}}_e\end{bmatrix}=\begin{bmatrix}\mathrm{diag}(\mathcal{Y}_o) & \mathrm{diag}(\mathcal{Y}_e^*)\\ -\mathrm{diag}(\mathcal{Y}_e) & \mathrm{diag}(\mathcal{Y}_o^*)\end{bmatrix}\begin{bmatrix}\boldsymbol{\Upsilon}_1\\ \boldsymbol{\Upsilon}_2\end{bmatrix} \quad (12)$$

where $\boldsymbol{\Upsilon}_1$ and $\boldsymbol{\Upsilon}_2$ are the vectors which contain the diagonal elements of $\boldsymbol{\varphi}_1$ and $\boldsymbol{\varphi}_2$. For a DFE, we have

$$\hat{\mathbf{X}}_{oe}=\begin{bmatrix}\hat{\mathbf{X}}_o\\ \hat{\mathbf{X}}_e\end{bmatrix}=\begin{bmatrix}\mathrm{diag}(\mathcal{Y}_o) & \mathrm{diag}(\mathcal{Y}_e^*)\\ -\mathrm{diag}(\mathcal{Y}_e) & \mathrm{diag}(\mathcal{Y}_o^*)\end{bmatrix}\begin{bmatrix}\boldsymbol{\Upsilon}_1\\ \boldsymbol{\Upsilon}_2\end{bmatrix}+\begin{bmatrix}\mathrm{diag}(\boldsymbol{\mathcal{D}}_o) & 0\\ 0 & \mathrm{diag}(\boldsymbol{\mathcal{D}}_e^*)\end{bmatrix}\begin{bmatrix}\boldsymbol{\psi}_1\\ \boldsymbol{\psi}_2\end{bmatrix}$$

$$\triangleq \boldsymbol{\mathcal{Z}}\boldsymbol{\mathcal{F}}+\boldsymbol{\mathcal{D}}\boldsymbol{\mathcal{B}} \quad (13)$$

where $\boldsymbol{\mathcal{D}}_o$ and $\boldsymbol{\mathcal{D}}_e$ are $\boldsymbol{\chi}_o$ and $\boldsymbol{\chi}_e$, for the training mode and decision-directed mode, respectively, on $\boldsymbol{\chi}_o$ and $\boldsymbol{\chi}_e$. $\boldsymbol{\mathcal{F}}$ and $\boldsymbol{\mathcal{B}}$ represents the feed-forward filter and feed-back filter co-efficients in the frequency domain. The contain elements $\{\boldsymbol{\Upsilon}_1, \boldsymbol{\Upsilon}_2\}$ and $\{\boldsymbol{\psi}_1, \boldsymbol{\psi}_2\}$, respectively. $\boldsymbol{\mathcal{Z}}$ is an MxM matrix containing received symbols and $\boldsymbol{\mathcal{D}}$ is a diagonal matrix containing the decisions. These co-efficients are computed adaptively using the RLS and LMS algorithm.

At the k_{th} instant, the output of the equalizer can be given as

$$\hat{\mathbf{X}}_{oe,k}=\boldsymbol{\mathcal{Z}}_k\boldsymbol{\mathcal{F}}_{k-1}+\boldsymbol{\mathcal{D}}_k\boldsymbol{\mathcal{B}}_{k-1} \quad (14)$$

3.1 RLS Update

The mean square error (MSE) at the i_{th} frequency is given by

$$\mathrm{MSE}(i)=\mathrm{E}\left|\mathbf{D}(i)-\hat{\mathbf{X}}_{oe}(i)\right|^2 \quad (15)$$

where E[.] represents the expectation operation. Minimizing (16) for the feed-forward filter and the feedback filters separately results in the following updates

$$\mathcal{F}_k(i)=\mathcal{F}_{k-1}(i)+\frac{\mu_k}{\epsilon_k+\mathrm{E}|\mathcal{Y}(i)*\mathcal{Y}(i)|}\mathcal{Y}_k^*(i)\times\{\mathrm{D}_k(i)-[\mathcal{Y}_k(i)\mathcal{F}_{k-1}(i)+\mathrm{D}_k(i)\mathcal{B}_{k-1}(i)]\} \quad (16)$$

$$\mathcal{B}_k(i)=\mathcal{B}_{k-1}(i)+\frac{\mu_k}{\epsilon_k+\mathrm{E}|\mathcal{D}(i)*\mathcal{D}(i)|}\mathcal{D}_k^*(i)\times\{\mathrm{D}_k(i)-[\mathcal{Y}_k(i)\mathcal{F}_{k-1}(i)+\mathrm{D}_k(i)\mathcal{B}_{k-1}(i)]\} \quad (17)$$

Next, $\mathrm{E}|\mathcal{Y}(i)*\mathcal{Y}(i)|$ and $\mathrm{E}|\mathcal{D}(i)*\mathcal{D}(i)|$ are replaced by their estimates, which are chosen to be the exponentially weighted sample averages for some scalar $0<<\lambda\leq 1$. Choosing the step size as $\mu_k=1/(k+1)$ and the regularization factor as $\epsilon_k=\frac{\lambda^{k+1}\epsilon}{k+1}$.

Using the same approach as in [5], we have

$$\boldsymbol{\mathcal{P}}_k^1=\lambda^{-1}[\boldsymbol{\mathcal{P}}_{k-1}^1-\lambda^{-1}\boldsymbol{\mathcal{P}}_{k-1k}^1\psi_k^1\boldsymbol{\mathcal{P}}_{k-1}^1] \quad (18)$$

$$\boldsymbol{\mathcal{P}}_k^2=\lambda^{-1}[\boldsymbol{\mathcal{P}}_{k-1}^2-\lambda^{-1}\boldsymbol{\mathcal{P}}_{k-1}^2\psi_k^2\boldsymbol{\mathcal{P}}_{k-1}^2] \quad (19)$$

where λ is the forgetting factor chosen close to 1 and $\psi_k^2=(|\boldsymbol{\mathcal{D}}_k|^{-2}+\lambda^{-1}\boldsymbol{\mathcal{P}}_{k-1}^2)^{-1}$. However, matrix $\boldsymbol{\mathcal{P}}_k$ has a diagonal structure, i.e., $\boldsymbol{\mathcal{P}}_k=\mathrm{diag}([\boldsymbol{\mathcal{P}}_k^1\ \boldsymbol{\mathcal{P}}_k^2])$, where $\boldsymbol{\mathcal{P}}_k^1$and $\boldsymbol{\mathcal{P}}_k^2$ are diagonal as well. Finally, collecting all the coefficients in one vector $\boldsymbol{\mathcal{W}}$, the RLS recursion has the form

$$\boldsymbol{\mathcal{W}}_k=\boldsymbol{\mathcal{W}}_{k-1}+\mathrm{diag}([\boldsymbol{\mathcal{P}}_k^1\ \boldsymbol{\mathcal{P}}_k^2])\boldsymbol{\mathcal{A}}_k^H\boldsymbol{\mathcal{E}}_k \quad (20)$$

where $\boldsymbol{\mathcal{A}}_k$and $\boldsymbol{\mathcal{E}}_k$ are given as

$$\boldsymbol{\mathcal{A}}_{\mathbf{k}}=\begin{bmatrix}\boldsymbol{\mathcal{Z}}_k & 0\\ 0 & \boldsymbol{\mathcal{D}}_k\end{bmatrix} \quad (21)$$

$$\boldsymbol{\mathcal{E}}_{\mathbf{k}}=\begin{bmatrix}\boldsymbol{\mathcal{D}}_k-\hat{\mathbf{X}}_k\\ \boldsymbol{\mathcal{D}}_k-\hat{\mathbf{X}}_k\end{bmatrix} \quad (22)$$

where $\boldsymbol{\mathcal{D}}_{\mathbf{k}}$ denotes the decisions at the k_{th} instant, i.e., $\boldsymbol{\mathcal{D}}_{\mathbf{k}}=\begin{bmatrix}\boldsymbol{\mathcal{D}}_{o,k}\\ \boldsymbol{\mathcal{D}}_{e,k}^*\end{bmatrix}$.

3.2 LMS Update

Once the weight has been updated by the RLS algorithm, it becomes easy to use the LMS algorithm with the updated weights. The LMS algorithm uses the $\mathcal{W}_k$ as the previous weight and therefore

$$\boldsymbol{\mathcal{W}}_{k+1}=\boldsymbol{\mathcal{W}}_k+2\mu e_k\hat{\mathbf{X}}_{oe,k} \quad (23)$$

where μ controls stability and rate of convergence and

$e_k=\boldsymbol{\mathcal{Y}}_{oe,k}-\boldsymbol{\mathcal{W}}_k^T\hat{\boldsymbol{X}}_{oe,k}$

The weights of the LMS algorithm improve fast as the weights are adjusted and the filter learns the signal characteristics. Eventually, the weights converge. The condition for convergence is set as $0<\mu<1/\lambda_{max}$.

4 Simulation Results

Performance of the proposed MIMO LTE OFDM system with FDADFE is evaluated by computer simulations using LTE Downlink PDSCH with Transmit Diversity. MATLAB14(a) is used for all the simulations presented in this dissertation. The work is done in the LTE PHY layer in MATLAB for downlink transmission i.e., the system consists of three sections, namely the transmitter, the channel and the receiver, and each section consists of a number of blocks. The system is designed for 2x2 antenna configuration for MIMO with Transmit Diversity.

The simulation has been done with the communication system toolbox that provides algorithms and tools for the design, simulation, and analysis of communications systems. Most of the system parameters are used as the existing system.

The "conventional" MIMO LTE uses 1.4, 3, 5, 10, 15 and 20 MHz bandwidth depending on different channel parameters. In this simulation, 20 MHz bandwidth is used. The MIMO channel parameters are set by 'user-defined' channel configuration with low-correlation level. Maximum Doppler Frequency is set to 5Hz. The path delays are set to as multiples of channel input sample time as 0, 5, and 8 µs with the path gains as 0, -3, and -6, respectively. The simulation is performed only for the PDSCH (Physical Downlink Shared Channel) of the LTE Downlink. No frequency offset is assumed in this paper. The algorithms for FDADFE are chosen as RLS and LMS algorithm. The initial forgetting factor of the RLS algorithm is 0.99. The initial step size of the LMS algorithm is set to 0.003. The RLS algorithm is pointed to first iteration.

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The performance of the simulation is evaluated with the SNR(dB) vs. BER(dB) plot.

The Additive Gaussian White Noise (AWGN) is assumed with zero mean and variance σ2.

The illustrations of the constellation diagrams of the Fig.3 and Fig.4 for the QPSK modulation technique show that the FDADFE can compensate for the effects of fading channel and the ISI and ICI effects due to the channels[1]. The power spectral density of the transmitted and the received signal is shown in the Fig.5, where the transmitted signal has a spectrum with a normalized magnitude response to one, and the received signal magnitude spectrum shows the effects of the response to ISI and ICI due to the multipath fading of the channel[1]. It can be also noted from the received signal that, the effect of multipath fading is almost mitigated and displaying a flat-frequency nature look.

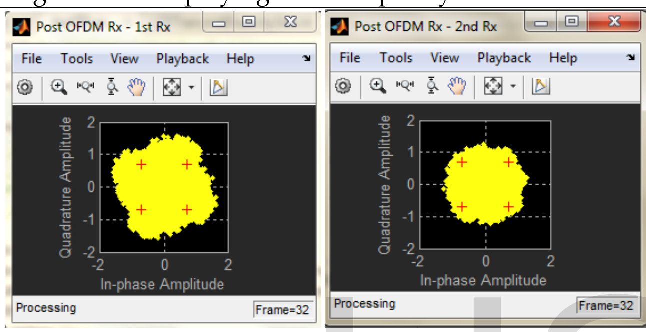

Fig.3. Constellation diagram of the received signal at the two receiver antennas before equalization for QPSK modulation technique

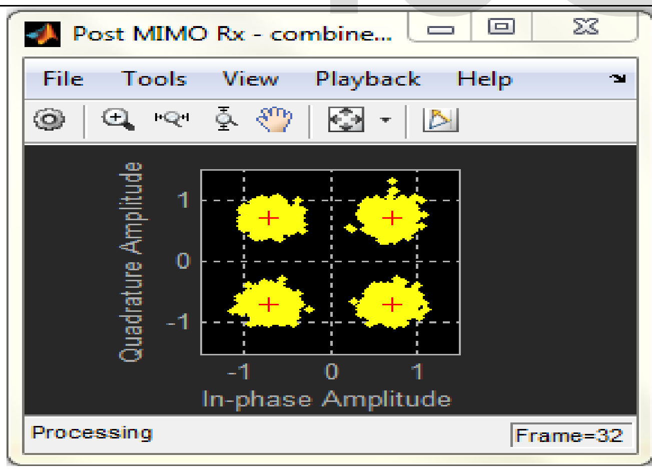

Fig.4. Constellation diagram of the received signal after combination and equalization

The average bit error rate (BER) of the proposed LTE MIMO OFDM system with FDADFE is shown in Fig.6 as functions of SNR (Signal-to-Noise Ratio) for QPSK modulated signal. The number of feed-forward coefficients and feedback coefficients are set as N_f=10, N_f=15 and N_b=5, and N_b=5, respectively. In addition, the "conventional" MIMO LTE OFDM system without the FDADFE (N_f=N_b=0) is also simulated.

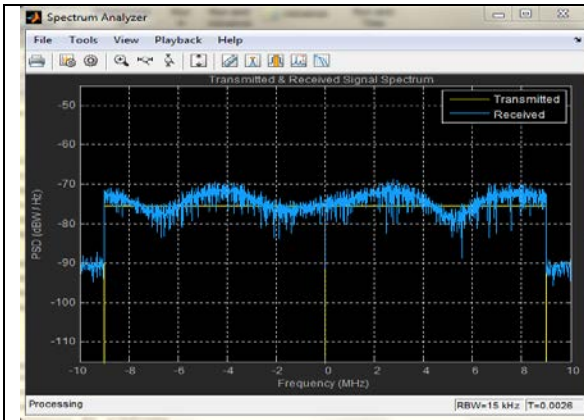

Fig.5. Spectra of the transmitted and received signal for the QPSK modulated signal

It can be seen from the Fig.6 that, the average BER of a conventional MIMO LTE OFDM system floors at 10-4 at the SNR value of 13, whereas, the proposed LTE MIMO OFDM system with FDADFE floors at the SNR of 12. It can be exposed that, the FDADFE with N_f=10, and N_b=5 gives better performance than the other one.

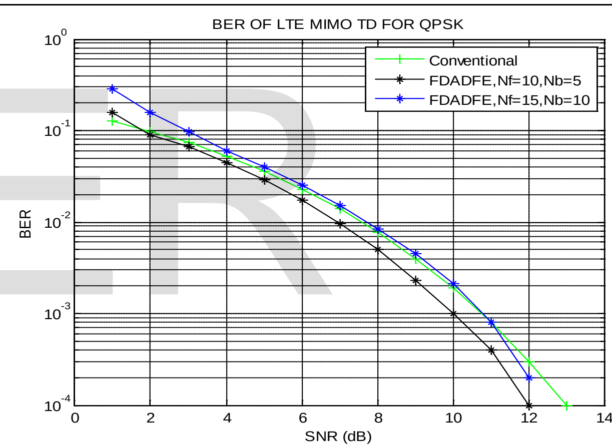

Fig.6. Performance of LTE MIMO OFDM with FDADFE for QPSK

Fig.7 shows the average bit error rate (BER) of the proposed LTE MIMO OFDM system with FDADFE as functions of SNR(Signal-to-Noise Ratio) for 16QAM modulated signal. The number of feed-forward coefficients and feedback coefficients are set as the same as for QPSK. The conventional system without the FDADFE (N_f=N_b=0) is also simulated in the Fig.7.

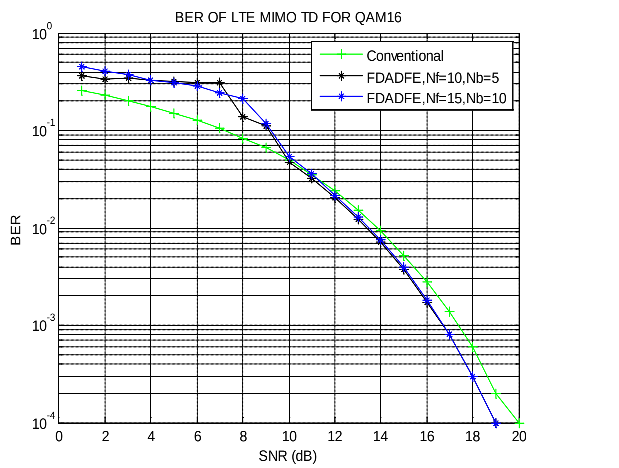

Fig.7 Performance of MIMO LTE OFDM with FDADFE for QAM16

From the Fig.7, it is shown that, the proposed MIMO LTE OFDM system with FDADFE floors faster at the BER level of 10-4 than the conventional system. It can be also noted that, both of the FDADFE with N_f=10, N_b=5 and N_f=15, and N_b=10 gives approximately same response. It is also noted from the Fig.7 that, up-to 10 dB of the SNR value, the FDADFE cannot perform well, because the adaptive algorithms cannot adopt the set of weights properly. But after 10 dB, the performance becomes better than the conventional system.

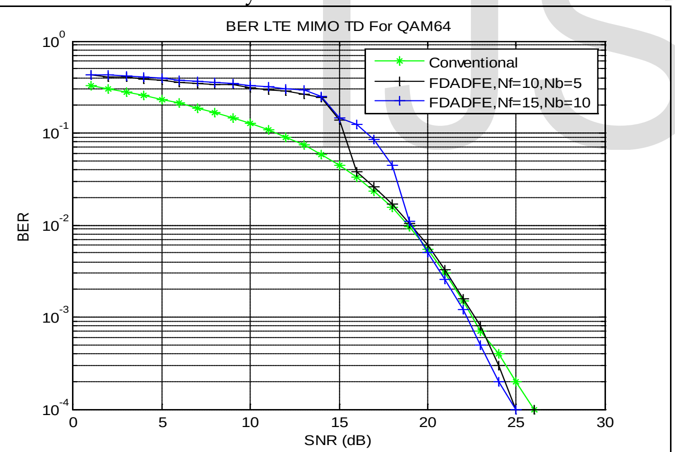

Fig.8. Performance of MIMO LTE OFDM with FDADFE for QAM64

Fig.8 shows the SNR vs. BER performance of MIMO LTE OFDM with FDADFE for QAM64 modulated signal. As QAM64 modulation technique uses 6 bits to modulate one symbol, it needs more power to perform better. Although the performance of the FDADFE becomes better than the conventional MIMO LTE OFDM from approximately 18dB of SNR value. In this case, it can be noted that, before 15dB, the performance of the FDADFE is low. But after 15dB the FDADFE starts performing better than the conventional system. This observation suggests that the FDADFE is efficient for the use of the path diversity of the wireless channel. This is exactly the motivation why an LTE system with the FDADFE outperforms the conventional system.

5 Conclusion

In this paper, A Frequency-Domain Adaptive Decision Feedback Equalizer (FDADFE) with both the feed-forward and feedback filters operating in the frequency domain is proposed for MIMO LTE OFDM system. Two adaptive algorithms (RLS and LMS algorithms) are merged to update the scheme for the FDADFE. Simulations using the 3GPP LTE downlink with transmit diversity demonstrate that the FDADFE can reveal significant performance gain and robustness of the proposed algorithm for a time-varying high frequency selective fading channel under the effect of high Doppler frequency. For certain combination of both filter coefficients, stable BER performances are obtained for QPSK, 16QAM, and 64QAM modulation techniques

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