PILOT CONTAMINATION BASED ENERGY EFFICIENT MODEL FOR MASSIVE MIMO SYSTEMS FOR 5G

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ABSTRACT

Our communication lot of antennas, they can get a lot more spectrum and use less energy. This will be a big part of 5G. For wireless communication, MIMO is a way to use a multicarrier transmission method called "multicarrier transmission." High data rates were used in this case, and they were used to send the data. This huge amount of data can be broken down into many different types of data. Because of this, MIMO is very sensitive to the receiver synchronisation errors, such as carrier Channel offset (CCO) and Doppler shifts and local oscillator instability, which make inter carrier interference (ICI) even worse. Existing methods for estimating carrier Channel offsets have a problem called "particle impoverishment." This means that statistically, heavier particles are chosen for Channel estimation because they are more likely to be. This choice is not good for improving performance. This paper comes up with a way to deal with the Particle impoverishment problem. It proposes using DFT Based Superimposed Pilot Aided Approach with Winner Filter for Carrier Channel Offset Estimation in MIMO Systems. The Winner filter is used in the proposed method to figure out the density and weight of the particles that have been filtered. Finally, based on the weight of filter particles, the proposed system can figure out the CCO for a MIMO signal. An analytic expression of the mean square error (MSE) and the SNR ratio of Channel offset synchronisation is shown, and simulation results show that the theoretical analysis is correct. The simulation results show that the MSE is reduced by about 1.99X, 1.56% in energy and the SNR ratio is increased by about 73%.

Keywords: *MIMO, DFT, SNR, MSE, Channel Estimation, 5G, Carrier Interference*

I. INTRODUCTION

Multiple-input-multiple-output (MIMO) is a cuttingedge technology that is very important for high data rates, better coverage, more robustness, and more reliability in advanced wireless cellular networks [1]. Massive MIMO, which is now seen as a promising technique, increased the capacity of the wireless cellular network among the best fifth-generation (5G) high-techs. Massive MIMO has many advantages over its predecessor, traditional MIMO, when it comes to the number of antennas at base stations (BS). This change makes the system more powerful by orders of magnitude. It is important to note that Massive MIMO technology that uses single carrier frequency division multiple accesses (SC-FDMA) lets the system manage all users in a cell without having to think about orthogonal frequency division multiple access (MIMOA).

Another thing that makes a big difference is that it makes the antenna array even better, no matter what SE it has. Using resources more efficiently reduces noise variation and fast fading, which are two of the gains. Here, the fact that different people use the same channel vector orthogonality makes it easier to detect uplink signals and precode downlink signals. Most importantly, it also directs energy toward the user and reduces transmit power a lot instead of scattering radio waves in every direction. So, because of these powerful features, we can use cheap, lowpower amplifiers.

The traditional Massive MIMO system only looks at antennas that can be used in all directions. The new Massive MIMO system looks at antennas that can be used in specific directions [2–4]. There is a numerical comparison in [2] between a Massive MIMO system with an Omnidirectional antenna at every BS and a Massive MIMO system with a directional antenna at every BS. In [2], the author made this comparison. A Massive MIMO system with directed antennas has much better and more important performance than one with an Omnidirectional antenna. According to [5,] the standard number of antennas for MIMO and Massive MIMO systems is 8 and 16, but these aren't the only number of antennas.

In a Massive MIMO system, a BS with a lot of antennas can simultaneously allow many tens of users' equipment (UE)to use the same time and frequency resources at the same time [6]. How does it work? It utilises spatial multiplexing and intervention prevention to deal with the problem of data growing at an exponential rate in [7,8]. In order for a Massive Mimo to have a high capacity, one of the most important things is that the channel estimation is done well. Most of the time, the UE turns to orthogonal pilot sequences because the period of a pilot pattern is limited by the coherence time and the bandwidth of the radio channel. These orthogonal pilot patterns are indeed known to BS, so BS can use the pilot signal to make a good guess about the uplink channel matrix. The BS used information from the uplink channel matrix to make a detector matrix for uplink and a precoding matrix for downlink. Thus, an accurate estimate of the channel state (CSI) plays a critical role in increasing the quality of a Massive MIMO.

II. RELATED WORK

A limited constant envelope precoding (CEP) method was looked at by the author of [9]. This method was used for perfect CSI and imperfect CSI caused by PC in a multi-cell Massive Mimo. Here, this CEP method is used for a multi-cell case in order to get all of the cells to work together. Furthermore, it is suggested that CEP be done in a decentralised way to cut down on the amount of time it takes to do. It has been said in [9] that even though the suggested structures would cut down on system overhead, their performance
didn't change much when compared to full cooperation. Authors in [10] came up with a hybrid pilot disinfection method for a Massive MIMO 5G system based on time division duplex (TDD). This method shifts pilot locations in the time domain and uses a genetic algorithm (GA) to keep inter-cell interference (ICI) low and uplink sum rate (SR) high.

The author of [11] looked at how orthogonality noise and intracellular interference can be reduced as the number of BS antennas grows to infinity. Though, because of limited resources, a multi-cell Massive Mimo has to reuse a set of orthogonal pilot patterns to keep a precoding matrix from getting worse on the downlink. This interference problem, called pilot
contamination (PC), is called a stumbling block because the UE sends non-orthologous pilots to UEs in neighbouring or adjoining cells [12]. This
interference problem is called pilot contamination
(PC) As a result, it has a big impact on the capacity of a Massive MIMO system when it comes to cell-edge user throughput, signal strength, and beamforming gain.

To solve this problem, a number of possible solutions have been suggested. They could also be broken down into to the 4 groups. The first smart thing to do is to make more orthogonal pilot patterns, but this reduces the system's capacity. For that reason, we'll need to set aside so much assets for channel estimation. While another manner is to have the statistical information of channel matrix into observation and use signal processing techniques to get rid of ICI. Indeed, this method is based on the fact that the channel matrix is usually very scant in Massive MIMO systems. That's why it used only a small part of the dimension for data transfer. Subsequently, noise and interference could be reduced or eliminated by using aspects that aren't used.

In addition, there is a third way that could work: information channel model, rather than pilot sequences alone. These three types of methods assume that the cells near each other work mostly independently, except for a small amount of information exchange. The last kind of method, on the other hand, leads to multi-cell cooperation. All of these methods focus on how to set up communication protocols and how to allocate resources. They also assume that pilot sequences are orthogonal, which isn't always the case. To make things even better for PC, the right pilot design and assignment can be used with these methods to help PC even more.

In traditional MIMO systems, pilot scenes are given to each UE at random, and there are no extra checks to make sure they aren't bad.

Many studies have been done on pilot decontamination, and one clever arrangement of pilots was found to cut down on PC by a lot, as shown in [15]. It gets more difficult to run as the number of UE grows, but that doesn't mean it's impossible. A way to figure out how many channels there are without actually seeing them is called Eigenvalue or singular value deposition. This is what people have said in [16,17]. They use the exponential orthogonality of channel matrixes to help them. These algorithms are only useful when the channel is moving slowly, so they aren't very useful. Because it's hard to come up with a good precoding scheme, [16] used one based on the least mean squared error (MMSE). Joint precoding between many BS is used in [17], which takes advantage of the PC effect even though it also slows down the system because it costs more to communicate between BS, even though the PC effect makes it faster.

Large MIMO can make a big difference in how much power is used because it can get more spectral efficiency with less power. Because of this, the more antennas there are, the less good they are at picking up radio waves. People use a lot of electricity when they have a lot of antennas, so this is why. Soon, there will be a lot of wireless data traffic that needs to be handled by an efficient cellular spectrum that can keep up with the huge rise in traffic. To meet this global need, Massive MIMO wireless access is the best way to do it, and it works. Pilot Contamination and Channel Estimation are used together in Massive MIMO technology to get very high spectral and energy efficiency with very little processing. This means that it can be used for a lot of different things.

III. PROPOSED METHODOLOGY

DFT Based Superimposed Pilot Aided Approach for Sparse Channel Offset Estimation in MIMO Systems was proposed in this paper. It was used to avoid the problem of particle impoverishment.

In this paper, a pilot-based Hamming window filtering method for CEO estimation in MIMO was proposed. It used pilot tone insertion for the Channel domain and sent every MIMO symbol to cut down on the amount of data that had to be sent.

Toward the CEO estimation in MIMO at first, Pilot tones are added to the Channel and sent with each MIMO symbol to improve CEO estimation. A system with N subcarriers is called a MIMO system. From these subcarriers, n subcarriers are chosen as pilot subcarriers, which are known to the receiver. For ease of notation, the positions of the pilot tones that have been chosen can be shown as:

$$p = \{p_n\}_{n=0}^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where $p_n \in \{0.1\}$, n is the number of subcarriers, and pn is whether the nth subcarrier is chosen. The proposed method has been used to combine the frequency domain pilot spacing pattern with the proposed method, as shown. The pilot assembly of the channel frequency is very specific about which channel it is, which helps to overpower the negative effects of fast fading. This means that the carrier number for each MIMO symbol is the number N, which is an integer multiple of the number of M. Each symbol has a pilot number that is the same number as that of the first point on the carrier.

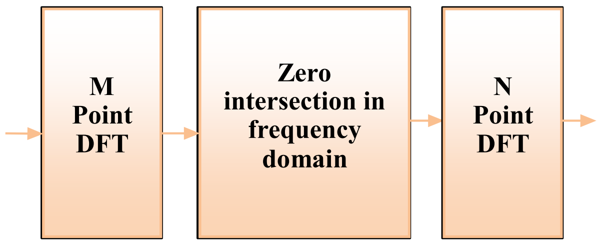

Figure 1: Channel estimation based on DFT interpolation

To even cut down on the complexity of MIMO channel estimation, this paper uses CEO based DFT-based interpolation, which is shown in Figure 1. The main idea of whose Algorithm is that zero interpolation in the frequency domain signal is the same as interpolation in the wavelength, so the channel frequency comeback is restored. DFT has an FFT algorithm that is very wasteful, so the complexity of its implementation can be cut down.

To get pilot tones, you use DFT (where PL[i] is the Lth transmit symbol at the ith sub-carrier) on or after where pilot tones are taken from. From pilot tones, equation 2 shows how to estimate CEO in the Channel domain (ie, the Channel offset estimation). Once this is done, equation 2 also shows how to estimate CEO in the time domain. In order to start this process, two types of CEO estimation are used, acquisition and tracking modes. Acquisition mode is in charge of figuring out a wide range of CEOs, while tracking mode is only in charge of figuring out very specific CEOs.

$$\acute{\alpha} = \left(\frac{1}{2\pi T_{SUB}}\right) max(\alpha)$$

$$\{\sum_{j=0}^{l-1} p_{l+d}[a[j],\alpha] p_l^*[a[j],\alpha] q_{l+d}^*[a[j]] q_l[a[j]] \quad \ldots(2)$$

Where a[j], and ql[a[j]] are the number of pilot tones, the location of the Jth pilot tone, and the pilot tone that is at the a[j] location at the lth symbol period. Then, filter particles move closer to Gauss (PF) to figure out how the carrier Channel offset (CEO) systems work.

If you want to solve a nonlinear problem, the PF in MIMO is better than the PF in traditional methods like the maximum likelihood estimator. Due to resampling the static parameter (i.e.CEO) estimation, PF reduces the standard particles (PI) because the standard particles are smaller than before. Hamming window PF (HWPF) stops the IP problem because the algorithm doesn't need to do a lot of resampling to work. When the HWPF is used, it can be used to figure out how many filtration and predictive Hamming window densities there are on a frame PF. The HWPF is updated over and over again as the posterior mean and covariance of the parameter of interest change (i.e.CEO). The basic idea is to show a PF density (for example, filtering or more dense) sample and its weight. Then, the approximate particle density and weight are shown. It is an approximation of the density of the particles that are filtered and the weight that they have.

$$p(x_k|y_k) = \sum_{i=1}^{M} w_k^i \alpha(x_k - x_k^i) \quad \ldots\ldots\ldots\ldots\ldots(3)$$

Where i represent particle and k represent its time index whereas M denote total particle number. Then on the basis of that particles weight proposed approach estimate as show in algorithm.

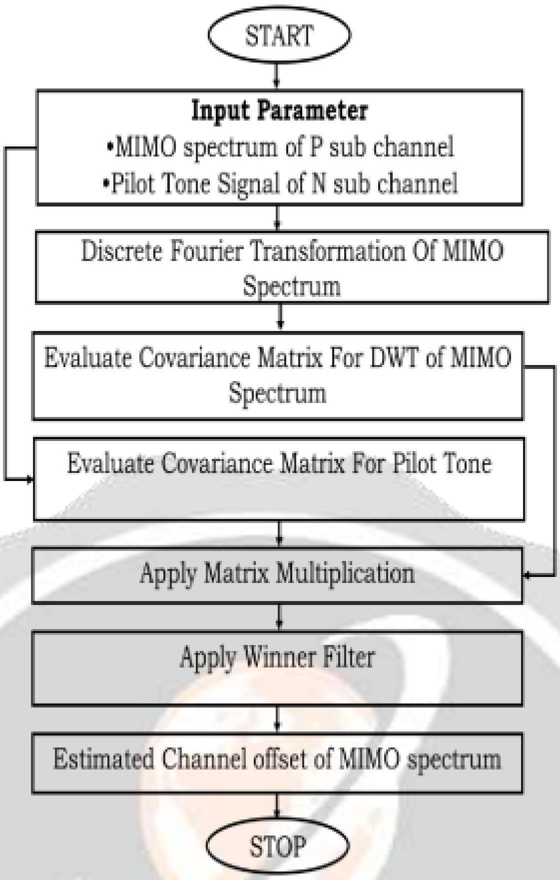

Figure 2: Proposed Methodology for Carrier Channel estimation

Particle impoverishment problem over MIMO means statistically selecting higher weight particles many times which is inappropriate for performance enhancement. Gaussian Particle Filtering Approach for Carrier Channel Offset Estimation in MIMO have particle impoverishment problem which degrade the performance. In order to overcome Particle impoverishment problem, this dissertation propose a solution that incorporate DFT Based Superimposed Pilot Aided approach with Winner Filter for Carrier channel Offset Estimation in MIMO Systems in order to detain particle impoverishment problem as shown in figure 2.

Assumptions

$X_p(t) =$ MIMO spectrum of p subchannel

$A_p(t) =$ Amplitude of the carrier

$\emptyset_p(t) =$ Phase of the carrier

Algorithm

Step 1:- Initiate MIMO spectrum sub channel signal

$$x_p(t) = \frac{1}{N}\sum_{p=0}^{p-1} A_p(t) e^{j|\omega_p^t + \theta_p^t|}$$

Step 2:- Apply P point DFT over MIMO spectrum

$$dft_p\left(x_p(t)\right) = \sum_{p=0}^{p-1} x_p[dft]e^{-j(2\pi/n)pn}$$

Step 3:- Generate auto covariance matrix for MIMO

$$\overline{M^P} = \left|dft_p\left(x_p(t)\right)\right|_{p*t}$$

Step 4:- Initiate Comb-Type Pilot tone signal

$$P_q(t) = \frac{1}{p}\sum_{q=0}^{q-1} P_q(t)e^{j|\omega_m^t+\theta_m^t|}$$

Step 5:-Covariance matrix for Comb-Type Pilot Tone

$$\overline{M}^P = \left|P_q(t)\right|_{p*t}$$

Step 6:- Principle Component Element for CombType Pilot Tone

$$\underline{M}^P = diag(\overline{X}^P)$$

$$\underline{M}^P = \begin{bmatrix} p_{1*1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & p_{t*m} \end{bmatrix}$$

Step 7:- InsertPCE of Pilot Tone over Diagonal Element of MIMO Spectrum

$$\overline{\boldsymbol{M}}^{P+S} = \begin{bmatrix} dft_p\left(x_p(t)\right) + p_{1*1} & \cdots & dft_p\left(x_p(t)\right) \\ \vdots & \ddots & \vdots \\ dft_p\left(x_p(t)\right) & \cdots & dft_p\left(x_p(t)\right) + p_{k} \end{bmatrix}$$

Step 8 :-ApplyKalman Filter for estimate the carrier Channel offset (CCO) systems and approximation of the density of particles filtered and weight as

$E(Xp)=H_P P_m + N$

Step 9 :- Then on the basis of that particles weight proposed approach estimate CCO for frequency offset.

Proposed methodology for Channel estimation initially takes MIMO spectrum of N sub channel as show in equation 4.1.

$$S_n(t) = \frac{1}{N}\sum_{n=0}^{n-1} A_n(t)e^{j|\omega_n^t+\theta_n^t|}$$

Where $S_n(t)$ is MIMO spectrum of N sub channel and An (t) is amplitude and $\theta_n(t)$ represent phase of the carrier.

After that proposed methodology apply DFT over MIMO signal for fragment out different channel separately. Then generate auto covariance matrix for these fragmented channel. Apart from that proposed methodology subsequently take equivalent pilot tone signal $P_m(t)$ and generate auto covariance matrix for it.

After generation of covariance matrix for both MIMO and Pilot tone signal proposed methodology perform comb- type pilot tone insertion. Diagonal element of covariance matrix of Pilot tone signal is to be inserted at diagonal element of covariance matrix of MIMO signal. This insertion lead lower noise generation in MIMO signals. Furthermore after pilot tone insertion Winner filter employed for approximation of the density of particles filtered and weight. Finally on the basis of filter particles weight proposed system estimated CFO for MIMO signal.

I. SIMULATION PARAMETER

There are number of papers can be used to analysis the frequency estimation but some of them has been discussed here. To simulate the proposed work the implementation has done in MATLAB. The execution has been done on the i3 processor with 4 GB RAM and 500 GB HDD. The comparison of MSE performance of previous approach and the proposed approach has been shown in the graphs.

Signal To Noise Ratio (SNR)

It is a general term, which in computer network and communication system is measure of how much true signal versus how much noise. It is a particular image has, which results in a grainy appearance.

$$SNR = \frac{Ps}{PN}$$

Where Ps is signal power and PN is noise power

Mean Square Error

The Signal processing used in communication system pay focus on fetching the raw signal for getting
information the complexity can be enhance with respect to signal by its characteristics. The SNR or signal-to-noise-ratio represents the strength of the signal and noise. When this ratio gets higher than the extracted information is more reliable

$$Mean = \bar{x}/s$$

Where $\bar{x} = MEAN$

S-= Standard Deviation

The performance of Physical layer has been evaluated with BER as function of DFT size, Modulation Schemes and Channel Estimation algorithms. DFT sizes used are 128, 256 and 512 .MMSE Modulation schemes are used for channel estimation algorithms used. Pilot frequency is 8 and the energy of pilot carriers is twice the energy of data subcarriers for channel estimation. The BER versus SNR plots have been obtained by simulation in Matlab to estimate the performance of Physical layer quantitatively. The combined BER verses SNR plot for different method for
DFT size of 128 under LMMSE, RP-LMMSE, LTT-LMMSE and proposed DFT-LMMSE channel estimation techniques is shown in Fig. 3 As seen from Fig. 4, the BER performance of all modulation schemes with DFT-LMMSE channel estimation technique is better than LTT-LMSSE channel estimation technique. The BER performance of RP-LMSSE modulation scheme is slightly better than LMMSE modulation scheme under MMSE channel estimation algorithm.

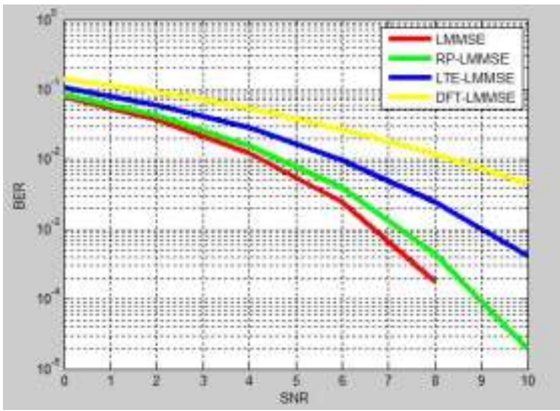

Figure 3. BER for DFT size of 128 under MSSE

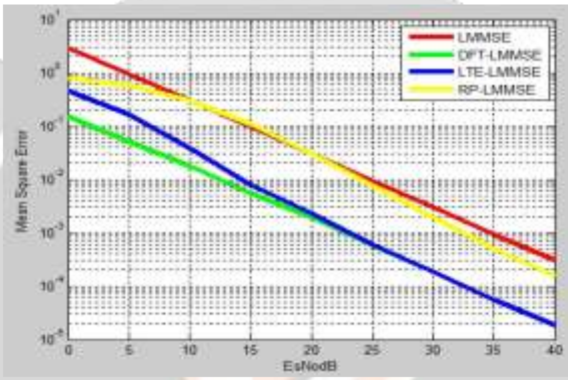

Figure 4 MSE for DFT size of 128 under MMSE

For MSSE modulation the BER performance with LTT estimation shows no improvement even with high SNR value. For other modulation schemes, BER is higher and improvement is marginal even with high SNR value. The combined BER verses SNR plots for different Modulation Schemes for DFT size of 128, 256 and 512 under LTT and MMSE channel estimation techniques are shown in Fig. 3, Fig. 6 and Fig. 8 respectively. As seen from these Figures, in general, the BER performance of DFT_LMSSEchannel estimation technique is better than other channel estimation technique under LTT-LMSSE and LMMSE channel estimation algorithms.

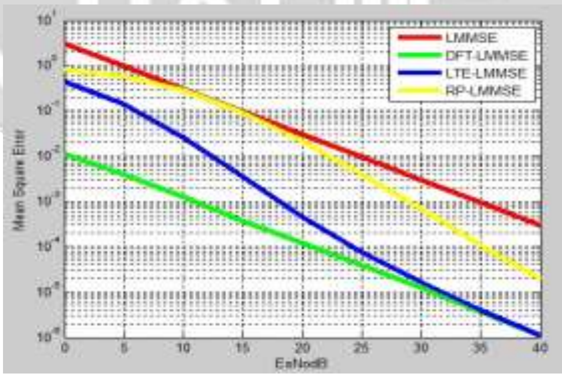

Figure 5: MSE for DFT size of 256 under MMSE

As seen from Fig. 5, for DFT size of 256, the improvement in BER performance of DFT-LMSSE channel estimation technique is better as compared to LTT-LMSSE and RP-LMSSE channel estimation techniques. However, the improvement with LMMSE technique is higher as compared to MSSE technique.

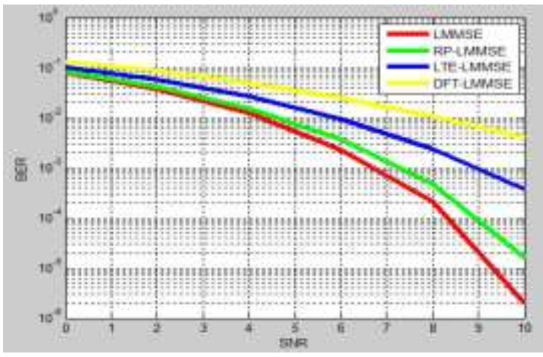

Figure 6. BER for DFT size of 256 under MSSE

But it is noted that BER performance of DFTLMSSE modulation scheme shows no significant improvement even with high SNR value. As seen from Fig. 5 and Fig. 6, for both LSE and MMSE channel estimation techniques, the BER performance of BPSK modulation scheme is better than other modulation schemes with DFT size of 256 and 512 respectively. All other modulation schemes have higher BER. For DFT size of 512, the BER performance of all modulation schemes shows no improvement even with MMSE channel estimation technique. However, for DFT size of 512, MMSE channel estimation technique shows slight improvement in the BER performance as compared to LTT channel estimation technique for all modulation schemes.

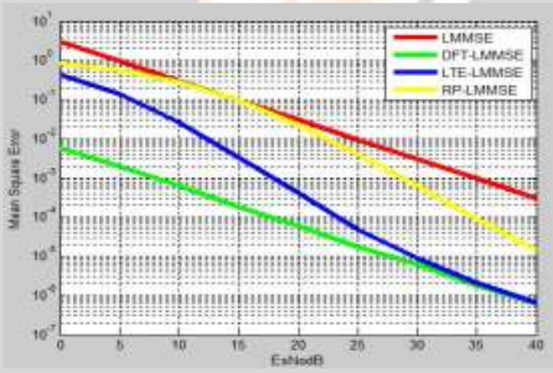

Figure 7: MSE for DFT size of 512 under MMSE

There is an improvement in the performance of the BER when the SNR value goes up, The reliability of the channel estimation algorithm gets better as the SNR gets better. At low SNR, noise and interference are the main causes of detection errors, not channel estimation error, which starts to play a bigger role at high SNR [6]. This means that at high SNR, channel estimation error starts to play a bigger role in detection errors.

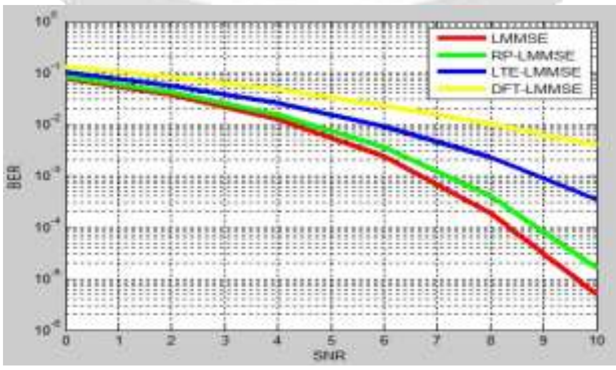

Figure 8. BER for DFT size of 512 under MSSE

The actual and estimated channel responses are compared, and are shown in Fig. 6 and Fig.7 for DFT size of 512 and 1024 respectively. The BPSK modulation scheme is chosen as example to illustrate the effect of

DFT size on channel response. As seen from Fig. 7 and Fig.8, the estimated channel response comes closer to actual response with increase in DFT size. Also, the performance of MMSE channel estimation algorithm is better than LTT channel estimation algorithm. As seen from Fig. 8, for DFT size of 1024, the estimated channel response with MMSE algorithm almost approximates the actual channel response.

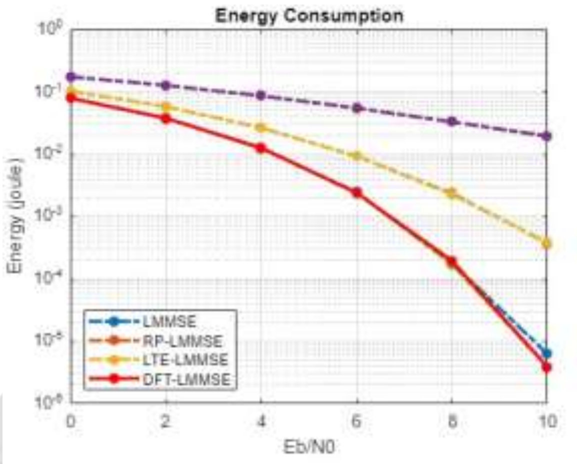

Figure 9: Energy Consumption for DFT size of 256 under MSSE

Whereas it is noted that Energy Consumption by DFT-LMSSE modulation scheme shows no significant improvement even with high Eb/No value. As seen from Fig. 9 and Fig. 10, for both LSE and MMSE channel estimation techniques, the energy consumption by BPSK modulation scheme is better than other modulation schemes with DFT size of 256 and 512 respectively.

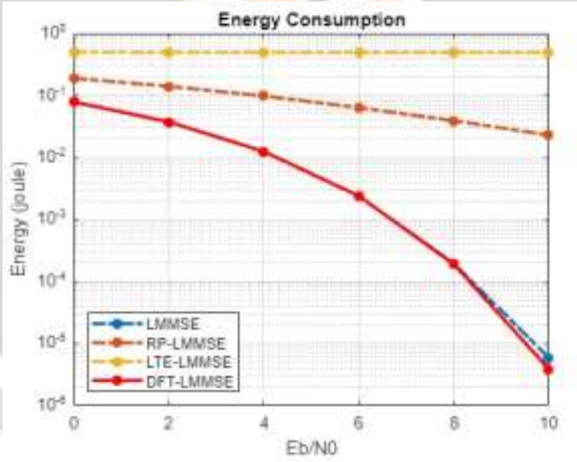

Figure 10: Energy Consumption for DFT size of 512 under MSSE

All other modulation schemes have higher energy consumption. For DFT size of 512, the energy consumption by all modulation schemes shows degradation even with MMSE channel estimation technique. However, for DFT size of 512, MMSE channel estimation technique shows slight improvement as compared to LTT channel estimation technique for all modulation schemes.

II. CONCLUSION

MIMO is an emerging field in the world of wireless communication. In this way there are lots of challenges in front of us. This dissertation gives a brief description on the MIMO and their issues. It also explore problem faced in the frequency offset estimation over MIMO. Existing Gaussian particle filtering approach for carrier frequency offset estimation suffer from particle impoverishment problem that statistically select higher weight particles for frequency estimation. This selection is inappropriate for performance enhancement. In order to overcome Particle impoverishment problem in this dissertation proposed solution incorporate DFT Based Superimposed Pilot Aided approach with Winner Filter for Carrier Frequency Offset Estimation in MIMO Systems. Proposed methodology employs Winner filter for approximating the density and weight of filtered particles. Finally on the basis of weight of filter particles proposed system estimated CFO for MIMO signal. The proposed pilot-DFT shows the outperforming results for the highly non-linear problem over all range of levels for this static parameter estimation by taking advantage of its robustness against PI problem. Mean square error rate of proposed DFT Based Superimposed Pilot Aided approach have much more less MSE and SNR than existing LTT based approach .Which is nearly 73 % improvement in SNR 1.56% in energyand 1.99 % improvement in MSE.

III. REFERENCE

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