BER AND CFO ANALYSIS OF MASSIVE MIMO SYSTEMS WITH QR-RLS TECHNIQUE

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Abstract With the advancement of the communication system, high speed data services are required, which is unfeasible to be achieved by the conventional serial data transmission system without swapping (trade-off) between high speed data services and QOS without ever-increasing the band width of the system. At this juncture both the options are tiresome, as one never demands the degradation of the service superiority and secondly the need for extra spectrum in a limited spectrum scenario. To conquer this crisis new parallel transmission system was anticipated which be identified as OFDM system. In order to overcome the above effects, this research work mainly focuses on the Square Root Recursive Least Square (QR-RLS) based channel estimation method for massive MIMO systems. The spectrum efficiency and Bit Errors Rate (BER) results are obtained for the proposed adaptive channel estimations for Massive MIMO system using QR-RLS algorithm and previous algorithm. Here in this work we also analyzed the system in presence of CFO-Carriers Frequency Offset, Timing Jitter and Phase Noises. The anticipated system has better performance than the other systems in terms of SNR improvement.

1. INTRODUCTION

The high data rate requirements of future wireless communication can be achieved by increasing spectral efficiency since the available Radio Frequency or spectrum Band-Width (BW) is limited in practical systems. The use of multiple antennas at both the transmitter and receiver, which is usually referred to as MIMO communication, offers improved capacity and significant potential for improved reliability compared to single antenna systems without additional transmission time or BW. The multiple antenna transmission is also challenging for the analog front-end and RF parts, and calls for methods to compensate for the no idealities. A MIMO system of transmit (N_T) and receive(N_R)antennas for a total of N_T-N_R links can be applied to performance improvements compared to single antenna systems [1]. The performance improvements achieved by the use of MIMO communication include array gain, diversity gain, interference reduction and Spatial Multiplexing (SM) gain. Several practical concepts, which are briefly introduced in this section, have been developed to realize the potential of MIMO communication.

Traditionally, multiple antennas have been used in wireless transmission in order to attain array gain or diversity gain. The array gain is achieved by processing at the transmitter or the receiver called beam forming, and results in an increase in average received Signal-to-Noise Ratio (SNR) via coherent combining, i.e., the operating range of the communication system can be extended. Beam forming uses multiple correlated antenna elements to focus the energy in the desired directions. Multiple antennas can also be used to reduce co-channel interference, which occurs due to use of the same frequency band in neighboring cells in a wireless system. This is carried out by adjusting the beam pattern so that there are nulls in the directions of the interfering co-channel users and high directivity towards the desired user. Interference reduction allows frequency reuse and thus an increase in multi-cell capacity.

The diversity gain can be used to mitigate fading in a wireless fading channel by transmitting the same signal multiple times over independently fading paths in time/frequency/space and combining the signal at the receiver. Thus, the diversity gain increases the link reliability and QoS in a wireless communication system. Spatial diversity can be gained if there are multiple spatially separated transmit and/or receive antennas that are used to transmit and/or receive multiple redundant signals. Space Time Codes (STC) can be designed to jointly correlate transmitted symbols in spatial and temporal domains in order to improve the reliability of the transmission and increase the data rate, when the Channel State Information (CSI) is only known at the receiver. Space-Time Trellis Codes (STTCs), which may be interpreted as a generalization of Trellis Coded Modulation (TCM) to multiple transmit antennas, achieve both diversity and coding gain with multiple antennas, but require rather high decoding complexity. A simple transmit diversity technique was proposed by Alamouti for two transmit antennas, which achieves full diversity gain, but requires only simple linear processing for decoding. A generalization of the technique, Space Time Block Codes (SBTCs), was introduced to an arbitrary number of antennas. The STBCs achieve full diversity with regard to the number of transmit and receive antennas, but do not offer any additional coding gain.

2. PRINCIPLE OF OFDM

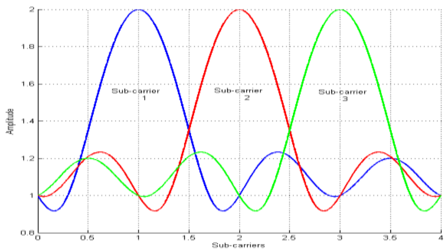


Figure 1 : Orthogonality among three Sub-Carriers

The basic principle of OFDM is to split a high rate data streams into number of lower rate data streams that are transmitted simultaneously over a number of sub-carriers. The comparative amount of dispersal in time caused by multipath delay spread is decreased, as the symbol duration increases for lower rate parallel sub-carriers. In OFDM, such as number of subcarriers, symbol duration, guard time, modulation type per sub-carriers, and sub-carrier spacing are the different parameters set up for consideration. The system requirements such as Doppler values, available bandwidth, tolerable delay spread, and required bit rate are influenced by the choice of parameters.

Consider the time limited complex exponential signal$\{e^{j2\pi t f_k}\}_{k=0}^{N-1}$ which represents the different subcarriers at $f_k = k/T_{sym}$ in the OFDM signal, where $0 \le t \le T_{Sym}$. These signals are defined to be orthogonal if the integral of the products for the common period is nil, so as to is,

$$\frac{1}{T_{sys}}\int_0^{T_{sym}} e^{j2\pi f_k} e^{-j2\pi f_k} dt =$$

$$\frac{1}{T_{sys}}\int_0^{T_{sym}} e^{j2\pi\frac{k}{Tsym}} e^{-j2\pi\frac{i}{Tsym}} dt \text{.......1.1}$$

$$= \frac{1}{T_{sys}}\int_0^{T_{sym}} e^{j2\pi\frac{k}{Tsym}} e^{-j2\pi\frac{i}{Tsym}} dt \text{........1.2}$$

$$= \begin{cases} 1, & \forall\ integer\ k = i \\ 0, & Otherwise \end{cases} \text{................1.3}$$

The above Orthogonality is a condition for an OFDM signal. Normally, in OFDM, spectrally overlapped sub-carriers can be used as they are orthogonal; they do not superposed with one other which in turn causes OFDM a bandwidth efficient modulation scheme. Orthogonality of sub-carriers must be guaranteed to avoid ICI.

3. MIMO SYSTEMS

Let us briefly review MIMO systems. Generally, MIMO systems are divided into two categories: single-user MIMO (SU-MIMO) and multi-user MIMO (MU-MIMO). Figure 2 illustrates the two categories. In SU-MIMO, the transmitter and receiver are equipped with multiple antennas. Performance gain in terms of coverage, link reliability and data rate can be achieved through techniques such as beam-forming, diversity-oriented space-time coding, and spatial multiplexing of several data streams.

These techniques cannot be fully used at the same time, thus we typically find a tradeoff between them. For example, adaptive switching between spatial diversity and multiplexing schemes is adopted in LTE [2]. The situation with MU-MIMO [3] is radically different. The wireless channel is now spatially shared by different users, and the users transmit and receive without joint encoding and detection among them. By exploiting differences in spatial signatures at the base station antenna array induced by spatially dispersed users, the base station communicates simultaneously to the users.

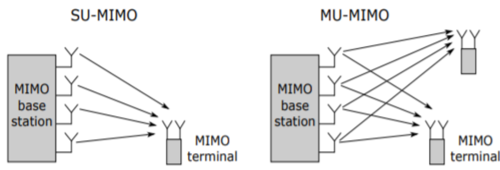


Figure 2: Single-user MIMO and multi-user MIMO

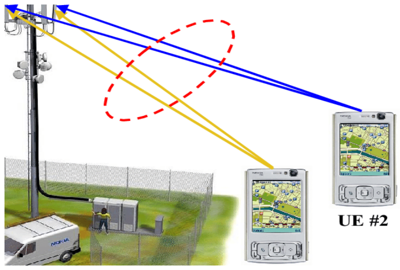


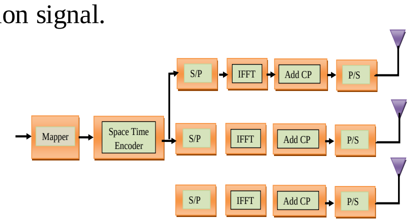
Figure 3: Examples of MIMO technology used in our everyday life.

As a result, performance gains in terms of sum-rates of all users can be impressive. A major challenge is, however, the interference among the co-channel users. Signal processing in MU-MIMO often aims at suppressing inter-user interference, so spatial channel knowledge becomes more crucial compared to SU-MIMO. In general, by exploiting the spatial domain of wireless channels, MIMO has the following key advantages compared to single-antenna systems:

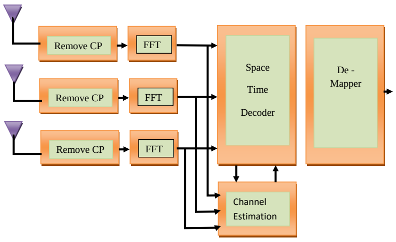
- Better coverage, through beam-forming that results in higher received signal power,
- Improved link reliability, through diversity schemes that combat fading effects in propagation channels and eventually reduce communication error probabilities,
- Higher capacity, through spatial multiplexing that transmits and receives several data streams in the same time-frequency resource,
- Decreased delay dispersion, due to channel shortening effect in beamforming, and
- Improved estimation of directional information, due to the ability of antenna arrays to resolve the spatial domain.

4. METHODOLOGY

The implementation of the system model in MATLAB software, with the main block described below. A random binary signal is generated in a serial manner. To analyze a signal in the time domain, apply IFFT (Inverse Fast Fourier Transform) and convert it from parallel-to-serial OFDM signal. The OFDM signal is added the Cyclic Prefix (CP) because of the remove interference between OFDM symbols. This signal is then feed through an Additive White Gaussian Noise (AWGN) channel. At the receiver site, the OFDM signal is CP removed and the signal is converted from serial-to- parallel then applied FFT (Fast Fourier Transform). Then Received the output of FFT signal, and then signal converted from parallel-to-serial converter to each symbol for analysis in the frequency domain is received. After demodulation, the signal is cross-correlated with that a time-shifted in demodulation signal.



(a) MIMO OFDM Transmitter



(a) MIMO OFDM Transmitter
Figure 4: Design of MIMO – OFDM System

The outputs of the OFDM demodulators are finally separated and passed through MIMO decoder as ML detector. This data is demodulated and then decoded. The MIMO-OFDM device modified into applied with the useful resource of MATLAB / SIMULINK. The execution device is binary facts this is modulated the use of QAM and mapped into the constellation elements. The virtual modulation scheme will transmit the records in parallel by means of manner of assigning symbols to every sub channel and the modulation scheme will determine the phase mapping of sub-channels thru a complex I-Q mapping vector show in figure 4. The complicated parallel facts stream must be converted into an analogue signal this is suitable to the transmission channel.

The radio stripe system, described earlier, represents a cost-efficient build practice of a ubiquitous "cell-free" Massive MIMO system. Furthermore, it might be an ideal solution in terms of flexibility and scalability of the deployment, and to provide coverage to environments where large and visible installations, typical of centralized network architectures, are not admissible either because of regulation or space constraints.

The complicated parallel facts stream has to be transformed into an analogue sign that is suitable to the transmission channel. It is performed to the cyclic prefix add to the baseband modulation signal because the baseband signal is not overlap. After than the signal is splitter the two or more part according to the requirement.

5.1 SIMULATION RESULTS FOR MASSIVE SYSTEM

MATLAB simulations are performed for various combinations of transmitted and received antenna in massive MIMO system. Simulation experiments are conducted to evaluate the SNR verse Bit Error Rate (BER) performance of the proposed QR-RLS based channel estimation with different modulation technique i.e. QAM-16, QAM-32 and QAM-64 for 8×8 system is shown in figure 5. For different value of SNR, the implemented QR-RLS based channel estimation for 8×8 system shows BER reduction performance.

The reproduction covers a start to finish framework demonstrating the encoded and additionally transmitted sign, channel model and gathering and demodulation of the got sign. It is accepted that the channel is known impeccably at the collector for all frameworks. At that point run the recreation over a scope of Eb/No focuses to create BER results that permit contrasting the 16×16 frameworks is appeared in figure 6.

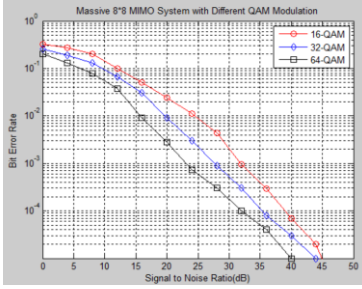


Figure 5: BER vs SNR for Massive 8×8 System with QR-RLS based Channel Estimation Technique

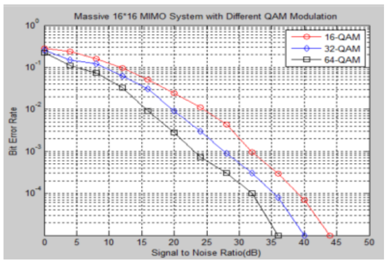


Figure 6: BER vs SNR for Massive 16×16 System with QR-RLS based Channel Estimation Technique

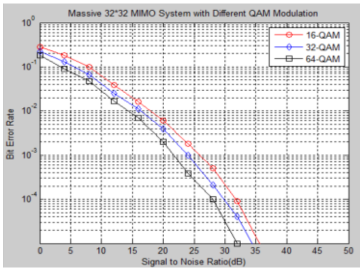


Figure 7: BER vs SNR for Massive 32×32 System with QR-RLS based Channel Estimation Technique

Figure 7 shows the simulation results using four transmit antenna and four receive antennas which provide the matched filter detection spectrum sensing MIMO system. It is observed that transmit diversity has a 3 dB disadvantage when compared to MRC receive diversity. From the analysis of MIMO system, the 32x32 antenna combination gives a minimum bit error rate.

Simulation experiments are conducted to evaluate the SNR verse BER performance of the proposed QR-RLS based channel estimation with different system is shown in figure 8. It is clear that the increase in the transmitter and receiver antenna than decrease the total error with respect to SNR. Table 5.1 shows the different value of bit error rate in different SNR for massive MIMO for QR-RLS based channel estimation technique. It is clear that the bit error rate for MIMO-OFDM system compared to other.

Simulation experiments are conducted to evaluate the SNR verse relative mean square error performance of the proposed QR-RLS based channel estimation for 8×8 system. To analysis random binary generator signal, a signal in the frequency domain, an IFFT is applied to the signal and converted from parallel-to-serial for the addition of the CP, four transmitter antenna and four receiver antenna through an additive white Gaussian noise (AWGN) channel.

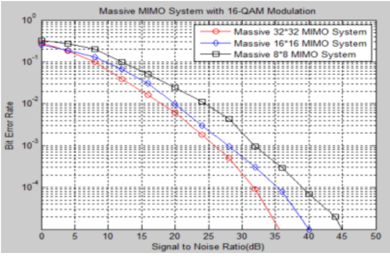


Figure 8: BER vs. SNR for Massive Different System with QR-RLS based Channel Estimation Technique

The spectrum efficiency (bps/Hz) versus signal to noise ratio (SNR) graph for 16×16 massive MIMO system with 16-QAM modulation technique. As the SNR increase, the spectrum efficiency value is increase. We have estimated the channel under additive white Gaussian noise (AWGN) channel condition. It is clearly that the increase the transmitter and receiver antenna than increase the spectrum efficiency with the help of QR-RLS based channel estimation.

Table 5.1: Comparison of BER vs SNR in Different Antenna for QR-RLS based Channel Estimation Technique

BER	SNR (dB)						
	0	5	10	15	20	30	40
8×8 Massive System	3×10^{-1}	2.3×10^{-1}	2×10^{-1}	6×10^{-2}	2×10^{-2}	6×10^{-3}	7×10^{-4}
16×16 Massive System	2.5×10^{-1}	1.8×10^{-1}	1×10^{-1}	4×10^{-2}	9×10^{-3}	4×10^{-3}	1×10^{-5}
32×32 Massive System	2.1×10^{-1}	1.3×10^{-1}	6×10^{-2}	2×10^{-2}	7×10^{-3}	2×10^{-3}	0

5.3 RESULT ANALYSIS

As shown in figure 9 the bit error rate result are obtained for the different modulation technique i.e. BPSK and 16-QAM. It is clear that the QAM modulation technique is best compared to BPSK modulation technique.

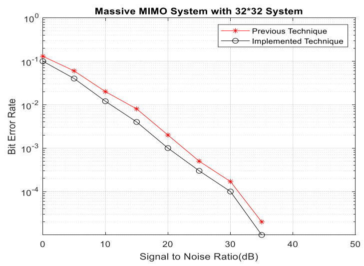


Figure 9: BER vs SNR for Different Modulation Technique

As shown in figure 10 and figure 11 the bit error rate result are obtained for the proposed Massive 32×32 System with QR-RLS based channel estimation technique and previous algorithm**.** From the analysis of the results, it is found that the proposed algorithm gives a superior performance as compared with previous algorithm

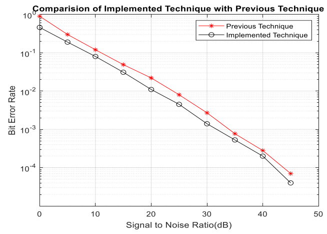


Figure 10: Comparison of Result for Massive 8×8 System with QR-RLS based Channel Estimation Technique

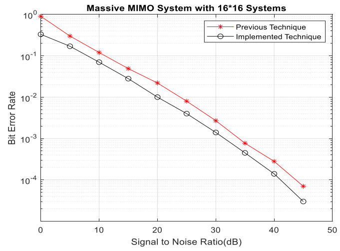


Figure 11: Comparison Result for Massive 16×16 System with QR-RLS based Channel Estimation Technique

Simulation experiments are conducted to evaluate the SNR VS BER performance of the proposed Massive 32×32 System with QR-RLS based channel estimation technique is shown in figure 12. Figure 13 the graphical illustration of the performance of different SNR discussed in this research work in term of Bit Error Rate (BER). From the analysis of the results, it is found that the proposed Massive 32×32 System with QR-RLS based channel estimation technique gives a superior performance as compared with the previous method.

1.1 SNR v/s Carrier Normalized Frequency Offset(CFO) Analysis –

In this section SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis of Multiple Antenna Based-OFDM system using Simple Novel Method is done. First, the analysis of Multiple Antenna Based-OFDM system using different Value of variance of phase noise (0.1, 0.2, and 0.3) is presented over No. of Subcarriers and then same procedure is done for different variance of phase noise of 0.3, 0.7 and 0.9.

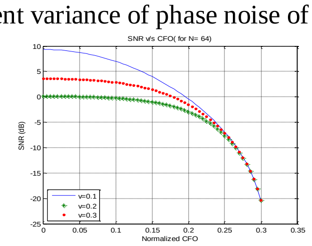


Figure 12 SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis for N = 64

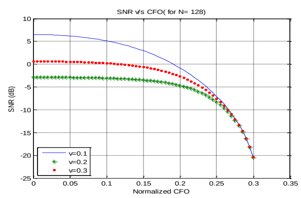


Figure 13 SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis for N = 128

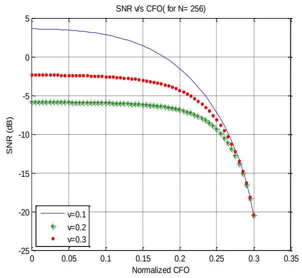


Figure 15 SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis for N = 256

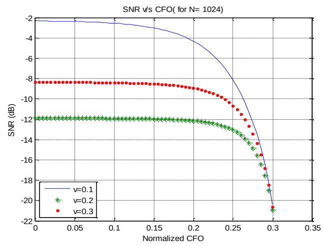


Figure 16 SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis for N = 102

SNR v/s Normalized Carrier Frequency Offset (CFO) Analysis plots for Multiple Antenna Based OFDM System employing different Phase Noise Variance have been presented in Figure 12 –16. Here the graph depicts that in Multiple Antenna Based- OFDM system as we goes on increasing the Phase Noise Variance the SNR would be decreases significantly.

6. CONCLUSION

In a cellular network, the demand for high throughput and reliable transmission is increasing in large scale. One of the architectures proposed for 5G wireless communication to satisfy the demand is Massive MIMO system. The proposed QR-RLS based channel estimation technique with different QAM modulation technique is applied for different transmitter and receiver antenna and calculated bit error rate (BER) and spectrum efficiency with respect to signal to noise ratio (SNR). Simulation result is clear that the 32×32 transmitter and receiver antenna is best performance compared to 16×16, 8×8 transmitter and receiver antenna.
It is observed that when CFO is zero then SNR is high. And after that SNR is exponentially decreasing with the increasing of CFO. There are three plotting shows in the figure for different variance of phase noise. It is also observed that the SNR decreasing significantly as the number of sub carrier N is increasing from N= 64 to 1024.

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