BER Analysis of MIMO-OFDM System under Variation in Cyclic Prefix
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Abstract—In recent years, the need for high speed data transmission is increased. OFDM is a promising solution for achieving high data rates in mobile environment, due to its resistance to ISI, which is a common problem found in high speed data communication. A multiple input multiple output(MIMO) communication system combine with the orthogonal frequency division multiplexing (OFDM) modulation technique can achieve reliable high data rate transmission over broadband wireless channels. MIMO-OFDM combination is widely used in 4G technologies such as WI-MAX and LTE. Cyclic Prefix is very important aspect in OFDM systems. Interference can be reduced by increasing Cyclic Prefix length. But it can have adverse effect on Bit Error Rate performance. Research can be done on determining optimum length of Cyclic Prefix which can provide optimum solution in terms of BER and interference. Key words: MIMO-OFDM, AWGN, Cyclic Prefixes.

I. INTRODUCTION
Traditional single carrier modulation techniques can achieve only limited data rates due to the restrictions imposed by the multipath effect of wireless channel and the receiver complexity. High data-rate is desirable in many recent wireless multimedia applications. However, as the data-rate in communication system increases, the symbol duration gets reduced. Therefore, the communication systems using single carrier modulation suffer from severe inter-symbol interference (ISI) caused by dispersive channel impulse response, thereby needing a complex equalization mechanism. Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multicarrier modulation scheme, which divides the entire frequency selective fading channel into many orthogonal narrow band flat fading subchannels.

The basic principle of OFDM is to split a high-rate data-stream into a number of lower rate streams that are transmitted simultaneously over a number of sub-carriers. The relative amount of dispersion in time caused by multipath delay spread is decreased because the symbol duration increases for lower rate parallel subcarriers. The other problem to solve is the inter-symbol interference, which is eliminated almost completely by introducing a guard time in every OFDM symbol. This means that in the guard time, the OFDM symbol is cyclically extended to avoid inter-carrier interference.

OFDM has several advantages like high spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, capacity to handle very strong echoes and less non-linear distortion. OFDM is the modulation technique used in many new broadband communication systems. In recent years OFDM has emerged as the standard of choice in a number of important high data applications. OFDM is the modulation technique used in many new broadband communication systems. In recent years OFDM has emerged as the standard of choice in a number of important high data applications.

II. MIMO OVERVIEW
Now a days, the most promising technology for that is MIMO in which multiple antenna are used at the transmitter side as well as at the receiver side shown in fig.1.

Spatial multiplexing requires MIMO antenna configuration. In spatial multiplexing, a high-rate signal is split into multiple lower-rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures and the receiver has accurate CSI, it can separate these streams into (almost) parallel channels. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher signal-to-noise ratios (SNR). The maximum number of spatial streams is limited by the lesser of the number of antennas at the transmitter or receiver. Spatial multiplexing can be used without CSI at the transmitter, but can be combined with precoding if CSI is available. Spatial multiplexing can also be used for simultaneous transmission to multiple receivers, known as space-division multiple access or multi-user MIMO, in which case CSI is required at the transmitter. The scheduling of receivers with different spatial signatures allows good reusability.

III. MIMO OFDM SYSTEM
Different techniques are there to improve the performance of the system in MIMO system. In order to attain a diversity gain to combat signal fading or capacity gain, MIMO system can be implemented in different ways. Spatial Diversity, Spatial Multiplexing, Beam forming. In spatial diversity (SD) techniques, the transmitter sends the multiple copies of the same signal or symbols. SD technique requires a number of signal transmission paths which are known as the diversity paths and each diversity path carries the same information. To multiplex (divide) and transmit a data stream into several paths and transmit via independent...
channels in space and different bits are transmitted via different antennas is the basic concept of Spatial Multiplexing (SM). At transmitter end in MIMO system, beamforming exploits the knowledge of the channel. Beamforming technique provides gain in between capacity gain and diversity. In single-layer beamforming, same signal is transmitted from each of transmitting antennas with the appropriate gain and phase weighting such that the signal power at the input of receiver is maximum.

The key advantage of beamforming is to increase the received signal gain, by making signals transmitted from independent antennas add up constructively, and reduce the multipath fading effects. Signal in MIMO system is suffered from the ISI and ICI, which is responsible for the poor BER performance. To improve the BER performance, to get high efficient spectral efficiency and to get high system capacity, MIMO system is combining with the OFDM. In real situation, multipath propagation usually occurs and causes the MIMO channels to be frequency selective.

**IV. INTER SYMBOL INTERFERENCE (ISI)**

Fig. 3: Combating ISI using a guard period

Basically two types are used.
1. zero padding
2. cyclic prefix

The Guard Period In OFDM System can be inserted in two different ways. One way is the zero padding (ZP) i.e. pads the guard interval with zeros. The other way is the cyclic extension of the OFDM symbol (for some continuity) by insertion of CP (cyclic prefix) or CS (cyclic suffix). CP is to extend the OFDM symbol by copying the last samples of the OFDM symbol into its front.

**V. GUARD PERIOD**

We may insert zero into the guard interval, the particular approach is adopted by multiband OFDM(MB-OFDM) in an Ultra Wide-band (UWB) system.

**VI. ZERO PADDING**

\[
T_{sym} = T_{sub} + T_{CP} + T_{zero}
\]

Fig/4: OFDM symbol with ZP

**VII. CYCLIC PREFIX**

Let. \( T_{CP} \) denoted the length of CP in terms of samples. then, the extended OFDM symbol now have the duration of \( T_{sym} = T_{CP} + T_{sub} \). Eq.(3)

Fig. 5: OFDM symbol with CP
VIII. SIMULATION SETUP AND RESULT

A. Parameters assumptions for the OFDM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Assumption</th>
</tr>
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<tbody>
<tr>
<td>Number of Symbols</td>
<td>10000</td>
</tr>
<tr>
<td>FFT size</td>
<td>64</td>
</tr>
<tr>
<td>Number of Subcarrier</td>
<td>52</td>
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</tbody>
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B. BER calculation

The BER expression for M-ary QAM signalling for AWGN channel is given below.

1) Flow Chart of The System Without OFDM

First serial data is converted into parallel data. After that data is modulated according to modulation scheme (BPSK). After that data is transmitted through channel. When data is received first it is converted from parallel to serial data and then demodulated according to modulation scheme (BPSK). After that BER is calculated by comparing transmitted and received data.

IX. BPSK FOR AWGN

Fig. 6: Bit error probability curve for BPSK without OFDM

Fig.6 shows BER performance of BPSK modulation scheme in AWGN channel. As bit energy/noise is increasing BER is decreasing.

X. QAM FOR AWGN

A. Flow Chart of MIMO with OFDM

First signal is modulated as per modulation scheme than serial data is converted into parallel form and after that IFFT is applied. After this CP is added again parallel data is converted into serial form and transmitted through channel. After reception first serial data is converted into parallel form and CP is removed, after that FFT is applied, again parallel data is converted into serial form and demodulated as per modulation scheme.

XI. BPSK FOR AWGN

Fig. 8: Bit error probability curve for BPSK With OFDM

In system with OFDM BER performance is improved (BER is decreased) as compared to system without OFDM.
XII. QAM FOR AWGN

Fig. 9: Bit error probability curve for QAM with OFDM

XIII. COMPARISON

A. BPSK FOR AWGN

Fig. 10: Bit error probability curve for BPSK With and Without OFDM

Fig. 8 shows comparison of BPSK modulation scheme under AWGN channel with and without OFDM. In system with OFDM, BER performance is improved (BER is decreased) as compared to system without OFDM.

XIV. QAM FOR AWGN

Fig. 11: Bit error probability curve for QAM With and Without OFDM

Fig. 11 shows comparison of QAM modulation scheme for different modulation index (M) values under AWGN channel with and without OFDM. In system with OFDM, BER performance is improved (BER is decreased) as compared to system without OFDM.

XV. CONCLUSIONS

The BER Performance of MIMO OFDM system has been analyzed for two scenarios, one is with Guard period (32) inclusion and the other one without Guard period inclusion. The comparison shows that the performance with guard period is better than without guard period.

REFERENCES


Books :
