Performance Analysis of Maximum ratio combining Technique for OFDM System

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Abstract- *Recent development in Multiple Input Multiple Output (MIMO) system has proved that it can provide significant improvement in capacity and with the help of antenna selection (AS) it reduces the complexity and cost without much sacrifice in performance. The proposed maximal ratio combining (MRC) technique will help in reducing the number of Radio Frequency (RF) chains and combiners required and still provide the diversity gain similar to that of multiple antennas. As the signal to noise ratio (SNR) at each antenna will differ, the SNR of the antennas will be combined and then it is maximized called as MRC. Simulation results obtained shows the improvement in Bit error rate (BER) and Capacity of the channel. The BER characteristics for the various models are simulated in MATLAB tool box .The results show that the BER decreases as the no of antenna configurations at the receiver is increased.*

Keywords- Antenna selection (AS), Bit error rate (BER), Maximal ratio combining (MRC), Orthogonal frequency division multiplexing (OFDM), Signal to noise ratio (SNR), Single Input Single Output (SISO), Selection combining (SC).

I. INTRODUCTION

OFDM which is a multi carrier modulation is considered as the most suitable modulation format for next generation wireless communication systems. OFDM has been deployed in various telecommunications standards such as Long Term Evaluation (LTE), Long Term Evaluation-Advanced (LTE-A), Worldwide Interoperability for Microwave Access (WiMAX) and also for various Wi-Fi standards. Diversity technique is well-known to mitigate the performance degradation of multipath fading and co-channel interference (CCI) in wireless systems [1]. In flat fading channels, MRC diversity is well known to be optimum in the sense of maximizing the output SNR. If the desired signal is affected by both co-channel interference (CCI) and flat fading, the diversity combining technique that maximizes the output signal-to-interference-plus noise ratio (SINR) is the so called optimum combining (OC). However, OC is much more complex than MRC and typically requires information about the CCI that may not be available at the receiver. Thus, in practice many wireless systems use MRC [2]. The transmit antenna array can also be used to provide diversity gain, and the optimum technique under background noise is Maximal Ratio Transmission (MRT), equivalent to MRC. MIMO systems employing both MRT and MRC are usually referred to as MIMO MRC [3].

It is well known that MRC [4] is the optimal linear combining technique. However, with receiver MRC, most of the system complexity concentrates at the receiver side. To decrease the receiver complexity in terms of the number of RF chains, a simple suboptimal combining scheme, referred to as selection combining (SC), was proposed in [5]. For SC the receiver chooses the antenna with the highest instantaneous SNR for reception. The SC scheme is then extended to the cases where the signals on more than one receive antenna with the largest instantaneous SNRs are combined [6]. This scheme is referred to as maximal-ratio combining. MRC which is a powerful technique is most common in SIMO channels.

In [7], it is proposed that signal received at each antenna can be combined using MRC technique. For AS, many algorithms have been proposed and developed that are useful for MIMO wireless systems. In [8] one of the advantage of AS is that the number of RF chains required will be less than the number of antennas in MIMO systems. The aim of AS is to choose the most reliable subset of antenna element and connect it with the RF chains. This reduces the hardware cost required to deploy RF chains in MIMO system. Similarly, in [9] a low complexity AS algorithm is proposed to achieve maximum capacity in MIMO-OFDM system. They used adaptive Markov chain Monte Carlo optimization method for the proposed algorithm to achieve minimum BER but it is effective only for low or moderate frequency selective faded MIMO-OFDM. In [10] authors have analyzed the performance of joint transmit and receive AS for Nakagami-m fading channels. The approach in [11] reduces the complexity by splitting the joint Transmitter and Receiver AS into separate Transmitter and Receiver selection.

In this paper we compared the result of BER of the MRC technique with SISO system which shows the improvement in the performance of the system. Further the algorithm is compared based on Capacity and the results illustrate great improvement incapacity when compared with SISO system. The paper is organized as follows, Section II, gives idea about the system model. Section III, describes about the methodology and section IV, illustrates the Simulation results. Section V, concludes the paper.

II. SYSTEM MODEL

The information bits applied to the input are modulated using BPSK modulation technique. The modulated signal is first converted into parallel form using serial to parallel converter and then applied to IFFT. Use of cyclic prefix eliminates the intersymbol interference (ISI) from the symbols. These symbols are then transmitted through single transmit antenna. The receiver contains multiple antennas and the MRC technique is applied. The cyclic prefix is removed and the symbol is applied to the demodulator. Thereby decoded signal is obtained at the user side.

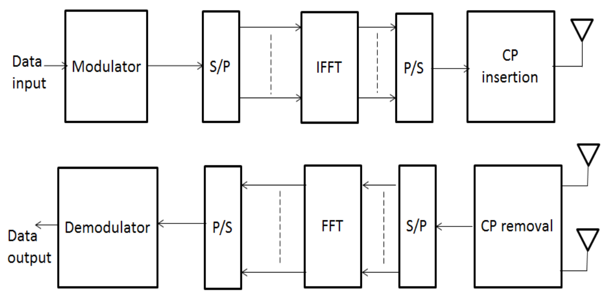

Figure 1 OFDM system with single transmitter and Nr receive antennas

III. METHODOLOGY

Various techniques are known to combine the signals from multiple diversity branches. In MRC each signal branch is multiplied by a weight factor that is proportional to the signal amplitude. That is, branches with strong signal are further amplified, while weak signals are attenuated. In telecommunications, MRC is a method of diversity combining in which the signals from each antenna are weighted according to their individual SNRs and then summed up.

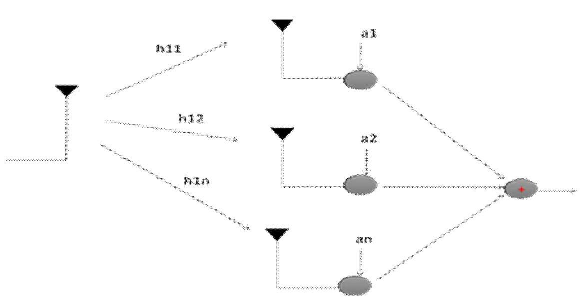

Figure 2 Maximum ratio combining with 1 transmitter and n receiver

MRC uses multiple copies of the same signal that arecombined to achieve maximized SNR at the receiver. Asnumber of receiver antennas are Nr , number of links will beNr and so will be the required number of RF chains. BER with Nr receiver antennas, after MRC combining is given as,

Avg. probability of error is

$$Pe = \int_0^\infty Q(\sqrt{gSNR}) f_G(g) dg \qquad (1)$$

Where $Q(\sqrt{gSNR})$ is instantaneous BER and

$$f_G(g) = \frac{1}{(Nr-1)|} g^{N_r-1} e^{-g}$$

is probability distribution of gain ‘ g ’

Capacity of a wireless system as per Shannon-Hartley theorem is given by

$$C = \log_2(1 + SNR) \qquad (2)$$

Capacity of a system with multiple receive antenna is given by

$$C_1 = \log_2(1 + |h^{m,1}|^2 \ SNR) \qquad (3)$$

IV.SIMULATION RESULTS

Graph of BER vs SNR for SISO, SIMO with antenna selection (selecting the antenna with the highest SNR) and MRC with 2 receive antennas is shown in Fig.3.Fig.4. illustrates the BER for MRC with no of receive antennas as 2, 3, 4 and 5. To achieve the BER of 10-4 the SNR required is 35, 32, 26 and 24 dB respectively. This shows that as the no of antenna increases the BER decreases. The graph of capacity vs SNR for SIMO with antenna selection and MRC with no of antennas as 2 is shown in fig 5. This shows that instead of selecting an antenna with highest SNR it is better if we combine the gain of the respective antennas available at the receiver and then try to maximize it

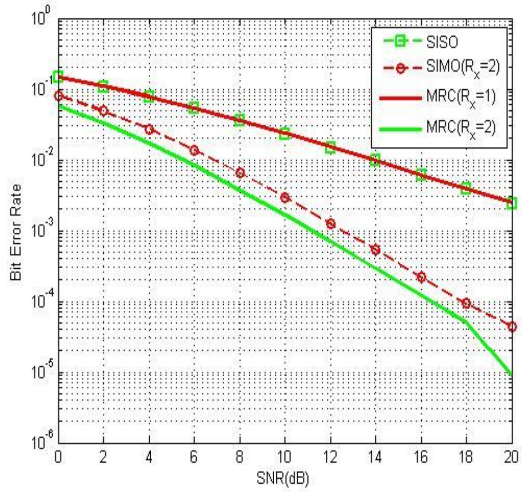

Figure 3 BER vs SNR (dB) for SISO, SIMO with antenna selection and MRC

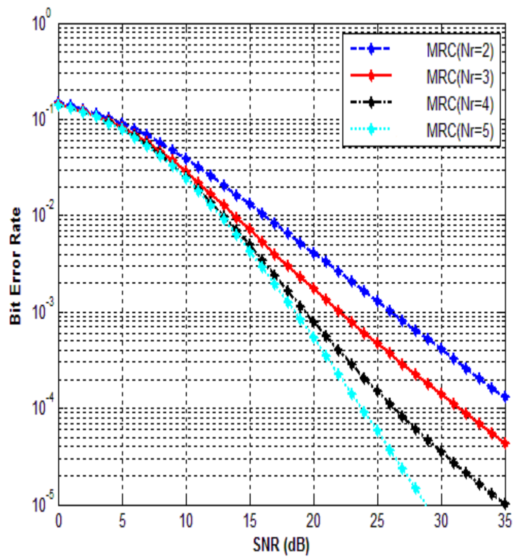

Figure 4 BER for MRC with 2, 3, 4 and 5 receive antennas

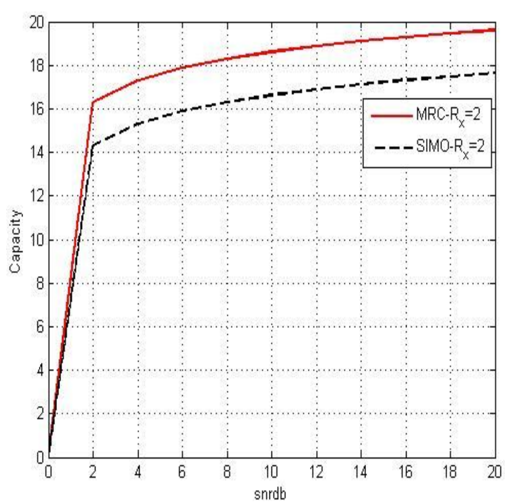

Figure 5 Capacity Vs SNR for MRC and SIMO with antenna selection

V. CONCLUSION

We proposed MRC technique which combines the SNR of all the receiving antennas and then try to maximize it instead of selecting one antenna at the receiver having highest instantaneous SNR. We also have analyzed the improvement in the BER for MRC when compared with SISO and SIMO with antenna selection. We also observed that as the no of receive antenna increases the BER reduces. The performance of MRC is compared to SIMO system for 2 receive antennas and observed that it leads to the improvement in capacity.

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