Performance Evaluation of Maximum Ratio combining Scheme in WCDMA System for Different Modulations

Rajkumar Gupta
Assistant Professor, Amity University, Rajasthan, India.

Abstract – In this paper analyze the performance of single input single output antenna system (SISO) and single input multiple outputs antenna system (SIMO) using maximum ratio combining (MRC) diversity technique with binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK) modulation schemes in wide band code division multiple access (WCDMA) system. The performance analysis results showed that SIMO system give better performance compare to SISO system in various network conditions.

Index Terms – WCDMA, Antenna diversity, SISO, SIMO, Maximum ratio combining (MRC).

1. INTRODUCTION

Wireless communication is the fastest growth period in the history of communication technologies. The 3rd generation partnership project (3GPP) and 3rd generation partnership project two (3GPP2) had developed the wideband code-division multiple access (WCDMA) technologies and CDMA2000 respectively [1]. WCDMA is considered to be wideband technologies based on the direct sequence spread spectrum transmission scheme, where user information bits are spread over a wide bandwidth by multiplying the user data with quasi-random bits called chips derived from CDMA spreading codes. In order to support very high bit rates (upto 2 Mbps), the use of a variable spreading factor and multicode connection is supported. The chip rate 3.84 Mcps leads a carrier bandwidth of 5MHz [2]. When a signal is transmitted from source to destination through the channel, there are some factors which degrade the performance of signal and these degradation factors are path loss, noise, fading and interference. One of the most powerful techniques to mitigate the effects of fading is to use diversity combining of independently fading signal paths. The concept behind diversity is: if one signal path undergoes a deep fade at a particular point of time, another independent path may have a strong signal [3]. Here receiver is provided with multiple copies of the same information signal which are transmitted over two or more real or virtual communication channels. The work in this paper evaluates the performance of WCDMA system using diversity scheme with various modulations in presence of varying network conditions.

The next section presents the brief review of the related work.. The section 3 presents the methodology adopted to simulate the system. The maximum ratio combining (MRC) diversity scheme is presented in Section 4. The simulation results and discussion is presented in the Section 5. The last section concludes the paper and presents the future work.

2. RELATED WORK

Masud.M et.al [4] analyzed BER for WCDMA using 16-QAM and QPSK modulation techniques and studied the performance of W-CDMA system with QPSK and 16-QAM modulation technique in different channel such as AWGN, line of sight (LOS), Rayleigh fading channel Hoyong.L et.al [5] proposed a hybrid switched examine combining (SEC) SEC/MRC diversity scheme and studied BER over rayleigh fading channel using BPSK modulation technique. Tepedelenliog et al [6] analyzed performance of different diversity combining techniques over fading channels with impulsive noise. Thomas et.al [7] studied comparison of different diversity combining techniques for Rayleigh fading channels and studied that combining the two or three largest signals (SC2 or SC3) offers significant improvement over the performance of just selecting the largest signal (SC). Alamouti et. al [8] proposed a new transmit diversity scheme using two transmit antennas and one receive antenna, the new scheme provides the same diversity order as maximal ratio receiver combining (MRRC) with one transmit and two receive antennas.

Hemalatha et.al [9] analyzed diversity in CDMA based broadband wireless system and found that the diversity CDMA system with multiple antennas at the transmitter and receiver results in the improvement in SNR and reduction in the multipath fading and interference.
3. PORPOSED MODELLING

The signal in WCDMA system is degraded with various factors such as path loss, noise, fading and interference. The work in the present paper analyzed the performance of the maximum ratio combining (MRC) diversity scheme in WCDMA system to improve the signal quality. The simulated WCDMA system is designed in Matlab and the performance is analyzed for various modulations under varying network conditions. The bit error rate (BER) performance is evaluated with varying conditions of signal to noise (E<sub>b</sub>/N<sub>0</sub>). The block diagram of the simulated WCDMA system with proposed diversity scheme is presented in Fig.1.

4. ANTENNA DIVERSITY TECHNIQUES

The diversity scheme is the solution to improve the performance of system in fading environment is to ensure that the information symbols pass through multiple signal paths, each of which fades independently, making sure that reliable communication is possible as long as one of the paths is strong and it can improve the performance over fading channels. Antenna diversity can be obtained by placing multiple antennas at the transmitter and/or the receiver [10]. Antenna diversity techniques use some combining methods such as selection combining, maximum ratio combining, and equal gain combining. The diversity schemes for single input single output (SISO) and single input multiple outputs (SIMO) are presented in Fig.2 and Fig.3.

4.1 MAXIMUM RATIO COMBINING

In maximum ratio combining (MRC) diversity scheme, all the branches are used simultaneously. Each of the branch signals is weighted with a gain factor which is proportional to its own SNR. After that, co-phasing and summing is done for adding up the weighted branch signals in phase [11]. Fig.4 shows the configuration for a two-branch diversity system. Both the branches are weighted by their respective signal-to-noise ratios and the branches are then co-phased prior to summing in order to insure that all branches are added in phase for maximum diversity gain. The summed signals are then used as the received signal and connected to the demodulator [12]. In a Rayleigh fading channel MRC performance is best followed by equal gain combining and then selection diversity. The performance of MRC is the same as that of equal gain combining (EGC) if signals from each path are of equal strength.

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**Figure 1:** Block diagram for proposed WCDMA system

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**Figure 2:** Single Input Single Output Antenna System (SISO)
The noise component after MRC at $t_0$, $V_{N,M}(t_0)$, is also multiplied by the gains in both branches and evaluates after co-phasing and branch addition to

$$V_{N,M}(t_0) = n_1 \left( \frac{r_1(t_0)}{N} \right) + n_2 \left( \frac{r_2(t_0)}{N} \right) = \frac{n_1 r_1(t_0) + n_2 r_2(t_0)}{N}$$

(5)

The noise power is given by

$$P_N = E[n_1^2] = \int_{-\infty}^{\infty} n_1^2 f_{N_1}(n_1) dn_1 = N_1$$

$$P_{N,M}(t_0) = E\left[ \frac{n_1^2 r_1(t_0)^2}{N^2} + \frac{2n_1 n_2 r_1(t_0) r_2(t_0)}{N^2} + \frac{n_2^2 r_2(t_0)^2}{N^2} \right]$$

The middle term evaluates to zero since each noise source is independent of all other signals and has a mean of zero.

$$P_{N,M}(t_0) = E\left[ \frac{n_1^2 r_1(t_0)^2}{N^2} + \frac{n_2^2 r_2(t_0)^2}{N^2} \right]$$

$$P_{N,M}(t_0) = \frac{r_1(t_0)^2}{N^2} E[n_1^2] + \frac{r_2(t_0)^2}{N^2} E[n_2^2] = \frac{r_1(t_0)^2}{N^2} = \frac{r_2(t_0)^2}{N^2}$$

$$\text{SNR}_{M,M}(t_0) = \frac{\text{Power}_{\text{Signal}}}{\text{Power}_{\text{Noise}}} = \frac{S_{S,M}(t_0)}{S_{N,M}(t_0)} = \frac{V_{S,M}(t_0)}{E[V_{N,M}(t_0)^2]}$$

$$\text{SNR}_{M,M}(t_0) = \frac{r_1(t_0)^2 + r_2(t_0)^2}{N} = \frac{1}{N} \left( r_1(t_0)^2 + r_2(t_0)^2 \right)$$
\[ MGCOutput (dB) = SNR1 + SNR2 \]

\[ SNR_{\text{in}}(t_o) = \sqrt{SNR_{\text{in}}(t_o) = \frac{r_1(t_o)^2 + r_2(t_o)^2}{N}} = \frac{1}{\sqrt{N}} \sqrt{r_1(t_o)^2 + r_2(t_o)^2} \]

\[ SNR_{\text{in}} \bigg|_{N=1} = r_1^2 + r_2^2 \]  

5. RESULTS AND DISCUSSIONS

The performance of WCDMA system is analyzed for the maximum ratio combining diversity scheme with two antennas (nRx1 and nRx2) at the receiver. The BER v/s Eb/No relationship for the WCDMA system with nRx= 1, 2 is shown in Fig. 5 with QPSK modulation scheme using MRC technique. As can be seen from graph, in case of nRx=1, initially the BER can be obtained around 0.2898 and at higher value of Eb/No, the achievable BER decreases around 0.0094 for 19 dB Eb/No. In case of nRx=2, initially the BER can be obtained around 0.1389 and at higher value of Eb/No, the achievable BER decreases around 0.0001 for 19 dB Eb/No.

The BER v/s Eb/No relationship for the WCDMA system with nRx= 1, 2 is shown in figure 6 with QPSK modulation scheme and with convolution encoding using MRC technique. As can be seen from graph, in case of nRx=1, initially the BER can be obtained around 0.4938 and at higher value of Eb/No, the achievable BER decreases around 0.0042 for 20 dB Eb/No. In case of nRx=2, initially the BER can be obtained around 0.4144 and at higher value of Eb/No, the achievable BER decreases around 0.0001 for 14 dB Eb/No.

The BER v/s Eb/No relationship for the WCDMA system with nRx= 1, 2 is shown in figure 7 with BPSK modulation scheme using MRC technique. In case of nRx=1, initially the BER can be obtained around 0.2203 and at higher value of Eb/No, the achievable BER decreases around 0.0035 for 20 dB Eb/No. In case of nRx=2, initially the BER can be obtained around 0.0694 and at higher value of Eb/No, the achievable BER decreases around 0.0001 for 15 dB Eb/No.
The BER v/s Eb/No relationship for the WCDMA system with nRx= 1, 2 is shown in figure 8 with BPSK modulation scheme and with convolution encoding using MRC technique. As can be seen from graph, in case of nRx=1, initially the BER can be obtained around 0.4869 and at higher value of Eb/No, the achievable BER decreases around 0.0019 for 20 dB Eb/No. In case of nRx=2, initially the BER can be obtained around 0.2414 and at higher value of Eb/No, the achievable BER decreases around 0.0001 for 9 dB Eb/No.

6. CONCLUSION

In this paper, we analyzed the BER performance for SISO and SIMO using MRC with different modulation techniques. Hence SIMO give better performance compare to SISO. Results with BPSK modulation technique are better compare to QPSK for SISO and SIMO. In future work the same analysis will be carried out for MIMO system and implement on FPGA vertex pro II.

REFERENCES


Author

Rajkumar gupta received degree of M.Tech from NITJalandhar in 2012. He is enthusiastic to work in the field of communication and VLSI. His area of interest includes wireless communication and analog and digital system designs using CAD tools and Low power VLSI domain in addition to analog and mixed signal circuit design.