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Investigation of Roll off Factor in Pulse Shaping Filter on Maximal Ratio Combining for CDMA 2000 System

G. S. Walia, H. P. Singh, Padma D.

Abstract**—**The integration of wide variety of communication services is made possible with invention of 3G technology. Code Division Multiple Access 2000 operates on various RF channel bandwidths 1.2288 or 3.6864 Mcps (1x or 3x systems). It is a 3G system which offers high bandwidth and wireless broadband services but its efficiency is lowered due to various factors like fading, interference, scattering, absorption etc. This paper investigates the effect of diversity (MRC), roll off factor in Root Raised Cosine (RRC) filter for the BPSK and QPSK modulation schemes. It is possible to transmit data with minimum Inter symbol Interference and within limited bandwidth with proper pulse shaping technique. Bit error rate (BER) performance is analyzed by applying diversity technique by varying the roll off factor for BPSK and QPSK. Roll off factor reduces the ISI and diversity reduces the Fading.

Keywords**—**CDMA2000, Diversity, Root Raised Cosine, Roll off factor.

I. Introduction

NOW-A-DAYS wireless communication systems are facing problems mainly multi-path fading, frequency fading, Inter Symbol Interference (ISI), Inter Carrier Interference (ICI), lower bit rate capacity, requirement of larger transmit power for high bit rate, less spectral efficiency etc. [1], [2].

Wireless cellular communication system has experienced a rapid growth during the last two decades. The major improvement in the transition to second generation (2G) systems was the digital transmission technology, which enabled the use of error correction coding and capacity and increased service quality. The 2G systems have evolved further to provide packed - switched data service in addition to the conventional circuit – switched services like the familiar speech service. Today, data rates of the order of tens or even hundreds of kilobits per second are provided. Still the 2G systems were designed mainly for wireless speech service [3]. As the markets have emerged for high speed wireless multimedia, the old speech – optimized infrastructures are no longer enough. 2G systems like the global system for mobile communication (GSM) will continue to evolve to provide data services with data rates up to 384 kb/s. The new infrastructures called third generation (3G) systems are specified to provide data rates up to 2 mbps, which enable many new services streaming video, file transfer and web browsing. To the interest of the customers, the new services should be cheap and of high quality compared to first generation and second generation system. An important step for achieving these goals is the selection of the multimedia access method. CDMA 2000 has been selected as the air interface for these networks. The 3G system in Europe is called the Universal Mobile Telecommunication System (UMTS).In CDMA systems; the users transmit their signal simultaneously in the same frequency band. Each user is given a dedicated spreading code which is used to identify the users in the receivers of correlating the received signal with a replica of the desired user’s code. The cross-correlation of different spreading codes is ideally zero, but due to multi path propagation and non-ideal spreading codes, this is not the case in practice. The receiver, therefore, sees the other users big as interference and more the users in the system, more is the interference generated. The general diagram of CDMA2000 is presented in Fig. 1. Main Challenges in CDMA 2000 are multipath fading, interference, noise, path loss, security.

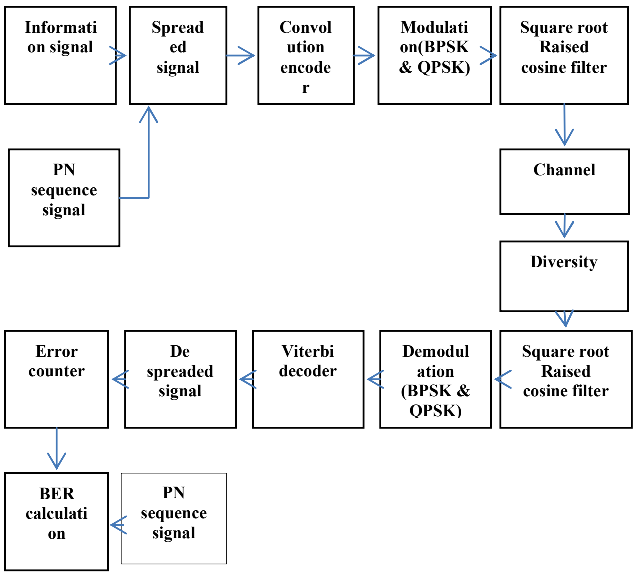

Fig. 1 Block Diagram of CDMA 2000

The future mobile systems should support multimedia services. CDMA2000 systems have higher capacity, better properties for combating multipath fading, and greater flexibility in providing multimedia services with different

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transmission rates and different QoS requirements and has been investigated worldwide [14]-[15].

In this paper, Section II presents the literature review, Section III presents the CDMA 2000 system model, and Section IV presents Pulse Shaping Filter.

II. Literature Review

Sense amplifiers are the main circuits used in the memory design. There are mainly two types of sense amplifiers and they can be used to sense the low power signals which are stored in the memory cell and it amplifies the small voltage levels to detectable logic levels. Mahmood et al. [1] analyzed the performance of linear multiuser CDMA receivers under traffic and queuing delay constraints. An ON/OFF source was used to model the traffic burstiness and stochastic network calculus incorporates the queuing delay constraints in the analysis. At the physical layer, adaptive modulation and coding scheme were adopted and the channel service process was modeled by using a finite-state Markov chain. The following receivers were considered for performance evaluation: single-user matched filter, de-correlator, and linear minimum mean square error detector. They quantify the effect of these multiuser receivers on the traffic carrying capacity of uplink CDMA channels in the large system limit. Khairudin et al. [2] presented implementation of Root Raised Cosine (RRC) filter at transmitter of WCDMA wireless communication by using VHDL programming language on Field Programmable Logic Array (FPGA). The main objective of this project was to reduce the inter-symbol interference (ISI) which will affect the bandwidth required for transmission of the data. Haiyangfu et al. [3] discussed the working principle, implementation circuit and performance analysis of complex spectrum spreading and scrambling code in TD-SCDMA (TD) in this paper. Assuming 8 users and 3-path propagation channels or without multi-path fading environment, the performance comparison between TD and CDMA 2000 was studied in this paper. With three-level mode in base-band signal and small spreading factor for voice service, the performance of TD in both scenarios was worse. Moreover, in contrast to CDMA2000 and WCDMA-TD doesn't have the 1+1 backup function of orthogonal diversity transmission, which decreases its stability further. In TD the value for half of the transmission chips is 0, so the transmission power and spectrum efficiency for user had decreased. Xiangbin Yu et al. [7] had designed a low-complexity multiuser receiver scheme for imperfect channel state information (CSI) considering that existing space-time coded CDMA (STC- CDMA) system has high decoding complexity. The scheme made full use of the complex orthogonality of STC to simplify the high decoding complexity of the existing scheme, and achieved almost the same performance as the existing scheme. Foo, J. et al. [9] proposed fairer multiuser diversity with Capture (FMDC) to improve the fairness performance of MDC and developed a fairness measure for wireless systems that exploit multiuser diversity. By simulations, the throughput and temporal fairness performance for FMDC, MDC and the Medium Access diversity (MAD) schemes evaluated and proposed in the literature. The results showed that with a small degradation in throughput performance, FMDC achieves much better fairness performance than MDC. Furthermore, FMDC achieved much better throughput performance than MAD, with comparable fairness performance. Soni A. R. et al. [4] discussed the analysis of orthogonal transmit diversity and space time spreading diversity and concluded that both the schemes provide varying levels of performance advantage over a single transmit antenna approximately 5 to 8 dB. STS offers better gains over OTD. Pinter, S.Z. et al. [8] presented an estimation algorithm for the fibre-wireless uplink in a multiuser code division multiple access (CDMA) environment using pseudo noise training sequences. It has already been shown that identification of the fibre-wireless uplink is possible in a single user CDMA environment. However, more difficult task of identification in a multiuser spread spectrum environment, which was more realistic, was shown. In the multiuser case, the cumulative effect of multiuser interference, multipath dispersion, nonlinear distortion and noise all were handled together. T. Cihan et al. [6] analyzed the performance of post detection combining over Rayleigh Fading channels with impulsive noises and it was compared with MRC and it was concluded that impulsive noise deteriorates the performance compared with Gaussian noise. Rose et al. [10] analyzed the access security systems found in CDMA 2000 and compared the approaches to access securities between UMTS and CDMA 2000 and observed that CDMA2000 security was far superior to that of its predecessors.[11] Diversity is basically used for the compensation of fading channel impairments and is implemented by using two or more receiving antennas, it improves the quality of wireless link without disturbing the common air interface and without increasing power or bandwidth.

III. Pulse Shaping Filter

Linear modulation methods such as QAM, QPSK, OQPSK have received much attention to their inherent high spectral efficiency. However for the efficient amplification of transmitted signal, the Radio Frequency Amplifier is normally operated near the saturation region and therefore exhibit nonlinear behavior. As a result significant spectral spreading occurs, when a signal with large envelope variations propagates through such an amplifier and creates large envelope fluctuations [13].To satisfy the ever increasing demands for higher data rates as well as to allow more users to simultaneously access the network, interest has peaked in what has come to be known as code division multiple access 2000. The basic characteristics of CDMA2000 and WCDMA waveforms that make them attractive for high data rate transmissions are their advantages over other wireless systems. It emphasizes that how the choice of spread bandwidth affects the bit error rate of system [12]. The raised-cosine filter is frequently used for pulse shaping in digital modulation. Its spectrum exhibits odd symmetry about, 1/2T where T is the symbol-period of the communications system. Different raised cosine filters are used in modern communication system. In this paper mainly square root raised cosine filter are used [5]. At low frequencies the ideal root raised cosine filter possesses unity gain, the square root of raised cosine function in the middle and at higher frequencies total attenuation is achieved. The width of the middle frequencies is defined by roll off factor constant α. The precise parameter α lies in the range 0≤ α ≤1. Mainly α governs the bandwidth occupied by the pulse and the rate at which the tails of the pulse decay.

Specially a value α = 0 offer the narrowest bandwidth, but when α =1 the slowest rate of decay occurs in the time domain. The pass band frequency is defined as the .707 half power points. For the best SNR and bandwidth efficiency the roll off factor should be from 0.22 to 0.33[7].The advantage is that the impulse response at transmitter side and receiver side is same, thereby setting up a matched filter and maximizing signal to noise ratio while at the same time minimizing ISI. Group delay of filter is defined by initial response and its peak response. The group delay influences the size of output as well as order of filter. The spectrum of square root raised cosine (SRRC) spectrum is given in following equation.

$$\frac{\left(sin\left(\pi\frac{1}{T_e}(1-\alpha)\right)+4\alpha\frac{t}{T_e}cos\left(\pi\frac{t}{T_e}(1+\alpha)\right)\right)}{\pi\frac{1}{T_e}\left(1-\left(4\alpha\frac{t}{T_e}\right)^2\right)} \quad (1)$$

IV. Result and Discussion

The interference in the transmitted signal has been added due to various network parameters. The performance of the CDMA2000 is evaluated to mitigate the effect of the fading and interference with maximum ratio combining method of diversity along with root raised cosine pulse shaping filter. The effect of the MRC scheme has been evaluated at varying roll off factor of RRC filter. The interpolation factor of RRC filter has been fixed at 6 and the value of the roll off factor is varied from 0.1 to 1.0.The line with circle represents BER with diversity and the line with star represents BER without diversity. It has been observed from the results that the joint scheme of the diversity and RRC filter mitigates the effect of distortion in the received signal. The optimum value for the Roll off factor is between 0.2 to 0.4 for both BPSK and QPSK modulation schemes.

Case –A BER Analysis of BPSK by Varying Roll off Vector (α)

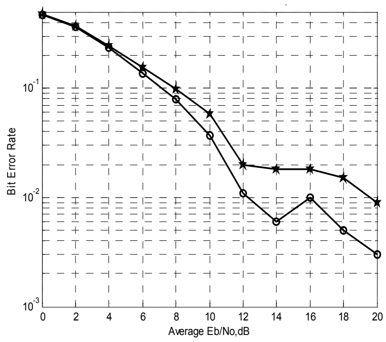

Fig. 2 α = 0.1

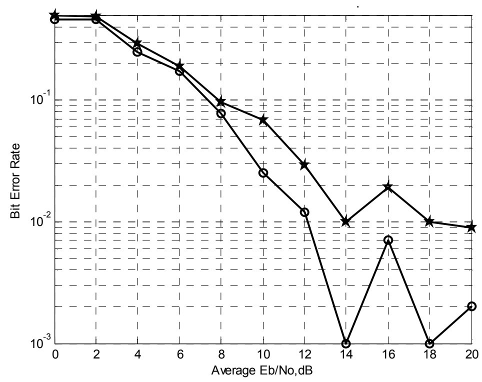

Fig. 3 α = 0.22

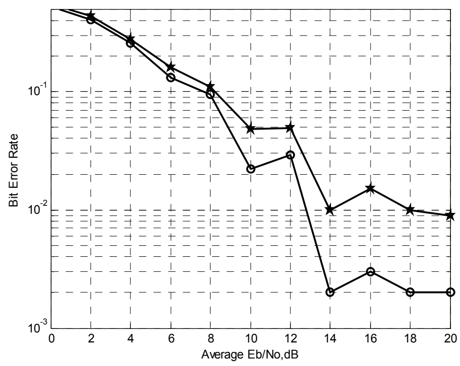

Fig. 4 α = 0.35

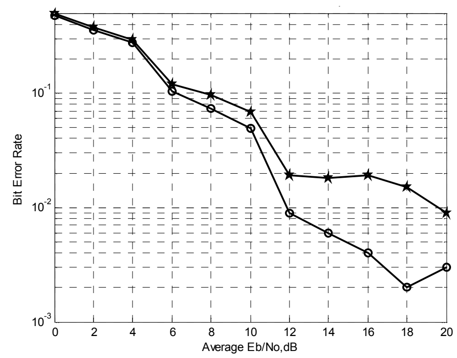

Fig. 5 α = 0.6

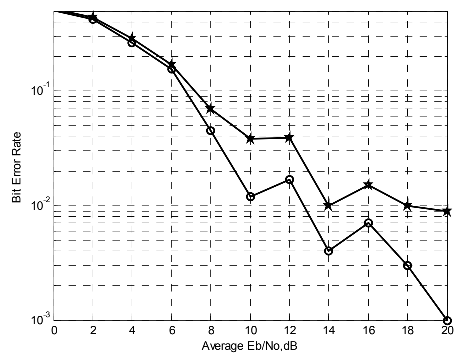

Fig. 6 α = 0.8

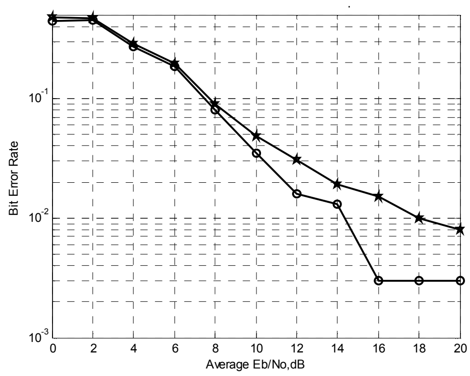

Fig. 7 α = 1.0

Case–B BER Analysis of QPSK by Varying Roll off vector (α)

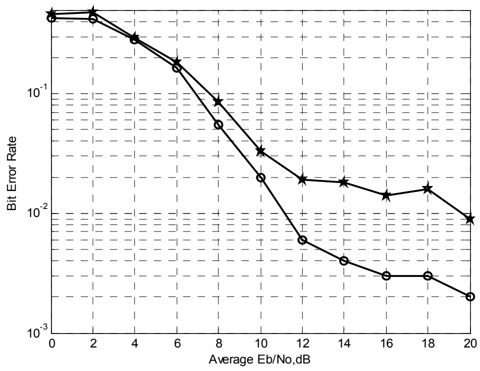

Fig. 8 α=0.1

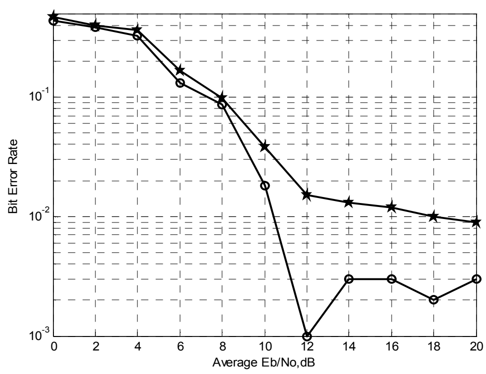

Fig. 9 α = 0.22

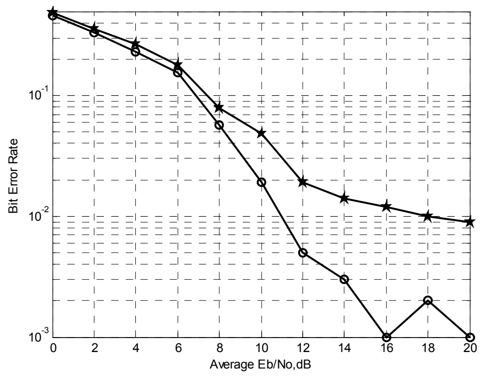

Fig. 10 α = 0.35

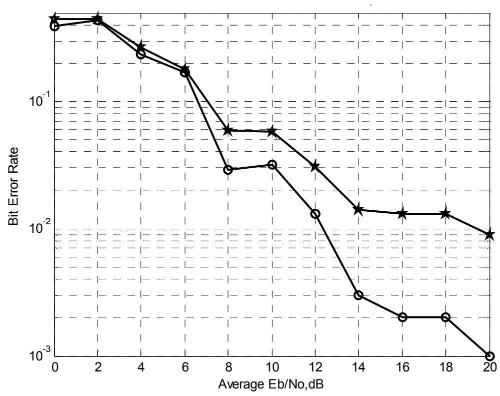

Fig. 11 α = 0.6

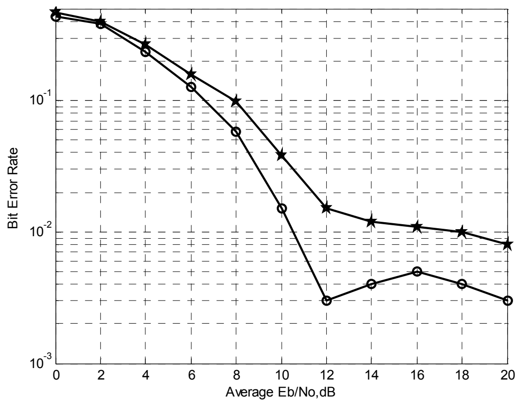

Fig. 12 α = 0.8

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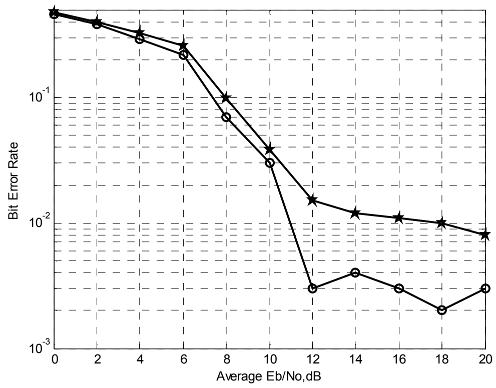

Fig. 13 α = 1.0

V. Conclusion

The work in present paper analyzed the joint effect of roll off factor in RRC filter along with MRC scheme with different modulation scheme for CDMA2000 environment. The performance had been analyzed by varying the roll off factor of RRC filter with MRC and from the results; it can be observed that best performance for CDMA2000 system could be found with roll off factor in range of 0.2 to 0.4 along with MRC. In future the same scheme will implement for multiuser and multiple input multiple output systems.

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