Performance Evolution of Maximal Sequences for Rake Receiver Over Rayleigh Flat Fading Channel

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Abstract: **Rake receiver is used in Code Division Multiple Access (CDMA) systems that combine multipath components which are the time delayed versions of original transmitted signal by assigning a separate correlation receiver to each multipath signal [1]. The multipath signals are practically uncorrelated when their relative propagation delay exceed spreading code chip duration. Rake receiver comes under time diversity schemes and uses maximal ratio combining to improve the Signal to Noise Ratio (SNR) [2]. The objective of this paper is to evaluate the Bit Error Rate (BER) performance of Rake receiver in mobile multipath flat, slow fading channel using maximal sequences for spreading data. The performance of the spreading codes i.e. BER versus SNR in the receiver is shown using graphical approach using MATLAB®.**

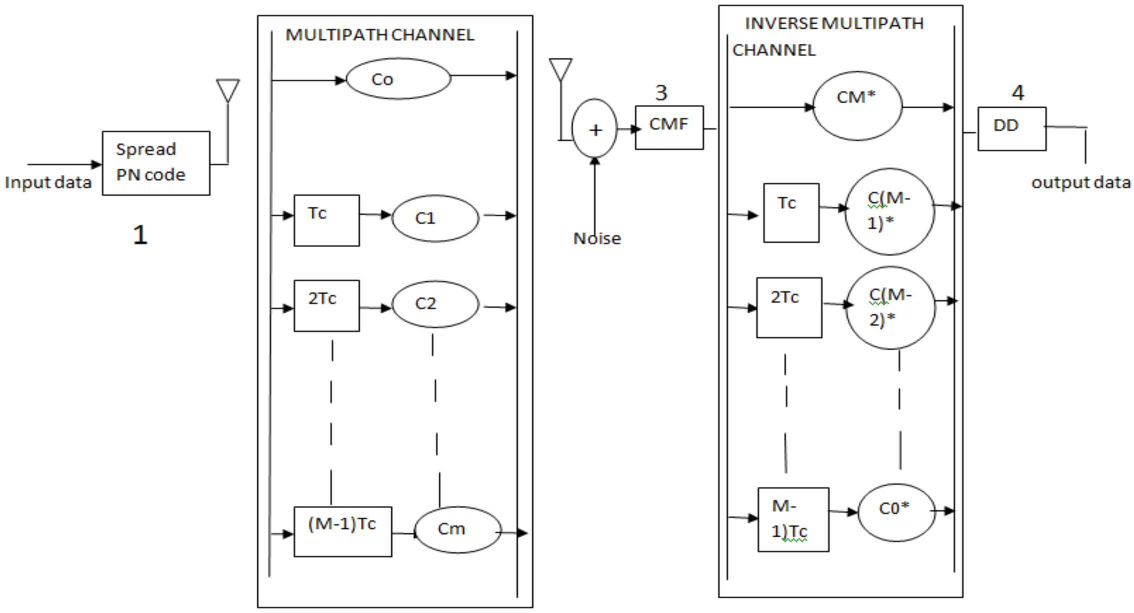
Keywords*: *AWGN, CDMA, Multipath, RAKE, SNR, BER.

INTRODUCTION

In CDMA cellular systems spreading is accomplished by Pseudo Noise sequences. PN sequences have transmission bandwidth typically many times greater than original information signal bandwidth as well as coherence band width of channel [2]. The propagation delay spread is natural phenomenon, caused by various objects in mobile wireless channel due to reflection, scattering, and diffraction mechanisms. Hence propagation delay spread in radio channel provides multiple versions of transmitted signal with different amplitudes, phases and time delays [2]. If multipath signals arrive at the receiver have time delay greater than chip duration then signals are uncorrelated to each other because spreading codes have low correlation between successive chips. Rake collects all multipath signals by providing a separate correlation receiver to each multipath component. This process of combining delayed version of multipath components improves the signal to noise ratio at the receiver [3]. If multipath components are delayed by more than one chip duration they appear like an uncorrelated noise at receiver hence the need for equalization is eliminated [2]. Remaining of this paper is organized as follows. Section2 gives description of Rake receiver. In section 3 simulation graphs plotted using matlab and detail discussion is presented, and section4 gives Conclusion.

2. RAKE Description

Rake receiver comes under time diversity schemes uses spread spectrum technology [1]. Multipath components are collected by separate correlators present in Rake and correlators signals are aligned in time, to have better estimate of transmitted signal there by providing an improvement in SNR. Basically Rake is designed to combat the effects of multipath fading [2].



The above Figure Shows Rake Receiver block diagram [4] where the input and output is binary bit stream. The first block is Pseudo Noise sequence generator that spreads the incoming bit stream having chip duration of Tc seconds. The second block is multipath channel assuming that each path is delayed by chip duration multiplied with channel impulse response coefficients (C). The propagation delay is assumed to be zero for Line Of Sight (LOS) component. Each multipath component is corrupted with Additive White Gaussian Noise, followed by code matched filter. Rake combiner block has inverse multipath channel (C*) followed by decision device that gives better estimate of transmitted bits [4].Rake combiner and code matched filter combined called Rake receiver.

3. NUMERICAL SIMULATION

A computer program in matlab software is used to simulate the Bit Error Rate performance in AWGN and Multipath flat fading channel. Impairments such as fading, multipath, Doppler spread are considered in evaluating the performance of modulation scheme in Mobile channel [2]. (C1,C2,C3..) are impulse response coefficient of channel. Γ= (Eb/No)*([C^2] avg); where Γ is average value of SNR. For [C^2] avg=1 corresponds to average Eb/No for fading channel. The probability of error for Rayleigh fading channel using coherent BPSK modulation is Pe, psk=0.5*{1-sqrt [Γ/(1+ Γ)]}. [2]. Channel is assumed to be flat, slow fading perfect (ideal) channel with real coefficients (time invariant). Generally ∑ (C.C*) =1 [2]. Matlab Simulator table is shown below:

parameter	Value
Spreading code	PN (Maximal)sequences
Code length	7,15,31,63.
SNR(db)	0 to 34 (DB)
Multipath case	3path, 4paths, 5paths.
channel	Multipath channel with awgn
modulation	Binary Phase Shift Keying
Fading type	Flat and slow fading channel
Channel impulse coefficients (C1,C2. .. Cm)	CH1=[0.35 0.435 0.7644 0.28 0.16] {5-multipath} CH2=[0.15 0.335 0.2644 0.18 0.8735]

Generation of PN sequences with 'm' stage feedback shift register produces maximal sequences of length N=2^m-1 [3]. Different maximal sequences of same length (N) are generated with various valid tap combinations. Spreading codes of fixed length that are generated from various valid taps combinations perform differently for static multipath flat, slow fading channel. Static in the sense that impulse response coefficient (α) set of channel is not varied. Correspondingly another channel impulse coefficient set produces different BER curves for same length sequences. FIG.2a and FIG.2b gives the plots for five Multipath static channel CH1 and CH2 with 31 length PN sequences generated from (5 2), (5 4 3 2), (5 4 2 1) valid tap combination. The channel CH1, CH2 are assumed to have zero phase (coefficients are real) with different amplitude and corresponding delay equal to chip duration. For channel CH1 data spreaded with the code generated from (5,4,3,2) tap has lower bit error rate. Similarly for CH2 flat fading channel (5,4,2,1) tap generated maximal sequence gives better performance than other 31 length valid tap sequences.

FIG.2a

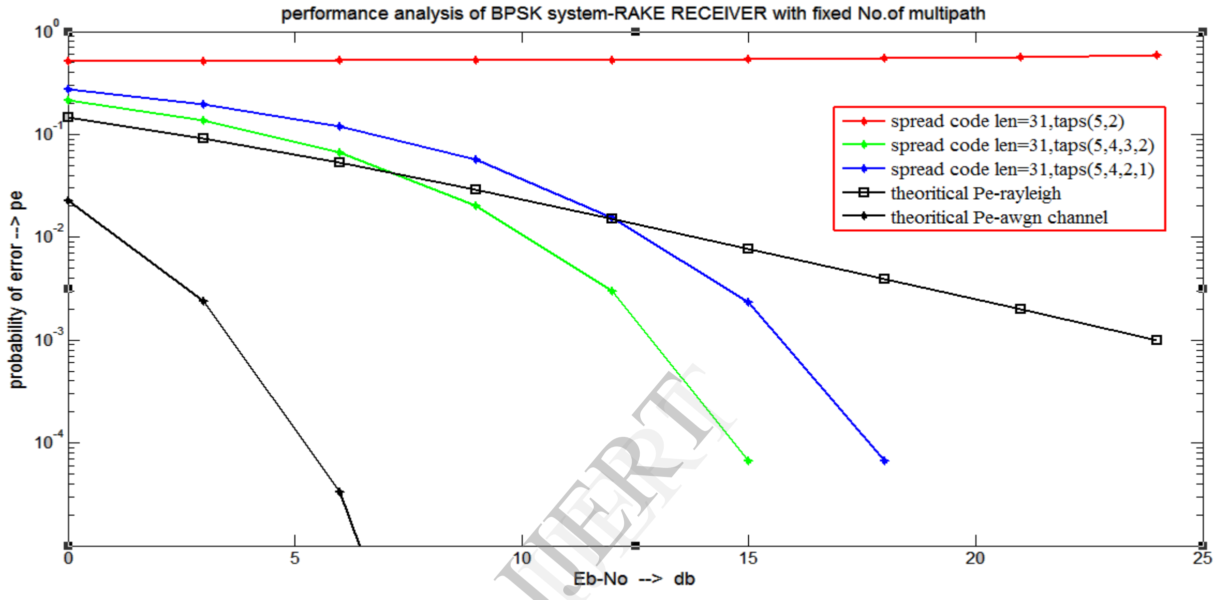
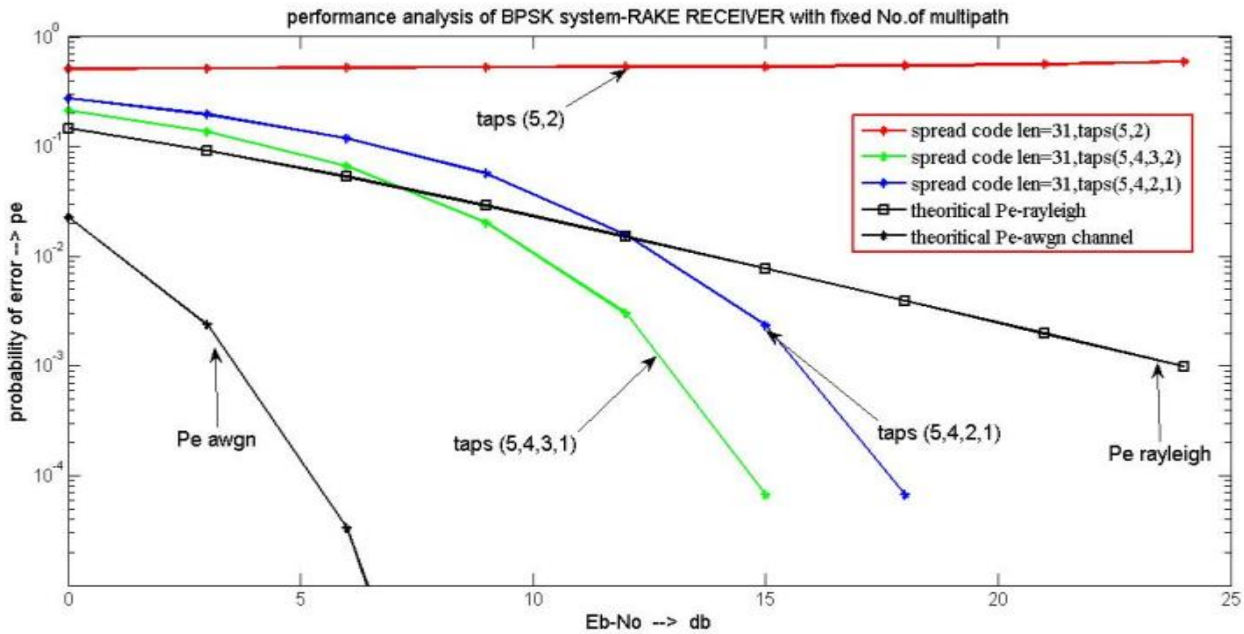
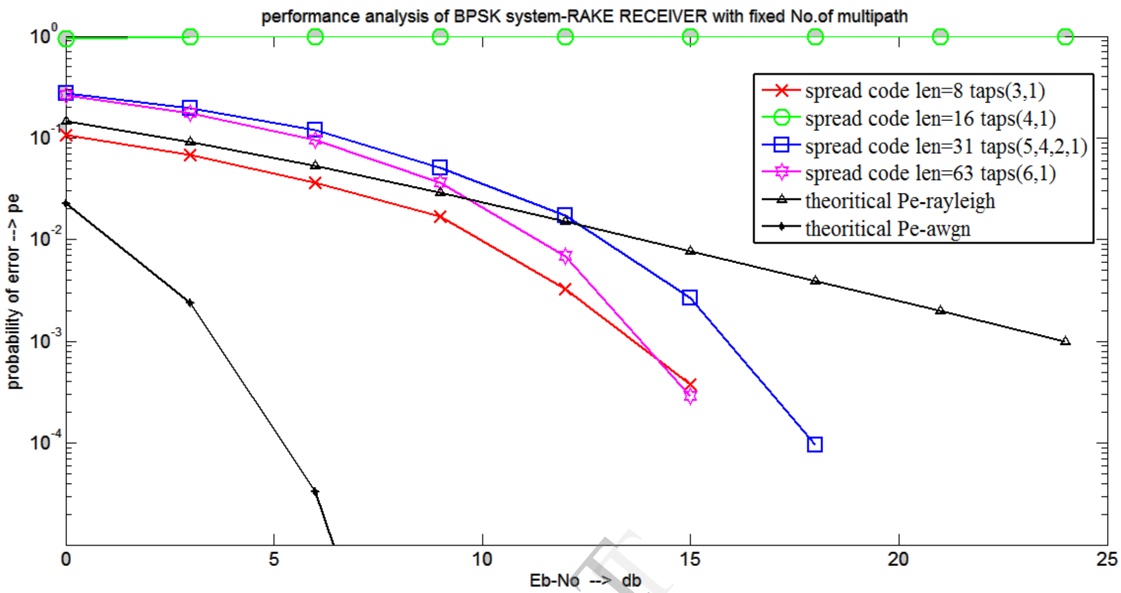


FIG.2b



From the above figures maximal sequences of fixed length have dissimilar BER curves for different flat fading channels. FIG.3a and FIG.3b gives the comparison of five multipath channel with impulse coefficients CH1 and CH2 for various maximal sequences of length 7, 15, 32,63, generated with (3,1) (4,1) (5,4,2,1) (6,1) valid taps respectively. For CH1 multipath channel 7 length maximal sequence generated by (3,1) tap has better performance. Likewise for CH2 multipath channel 31 length spreading code generated from (5,4,2,1) valid tap give lower bit error rate.

FIG.3a



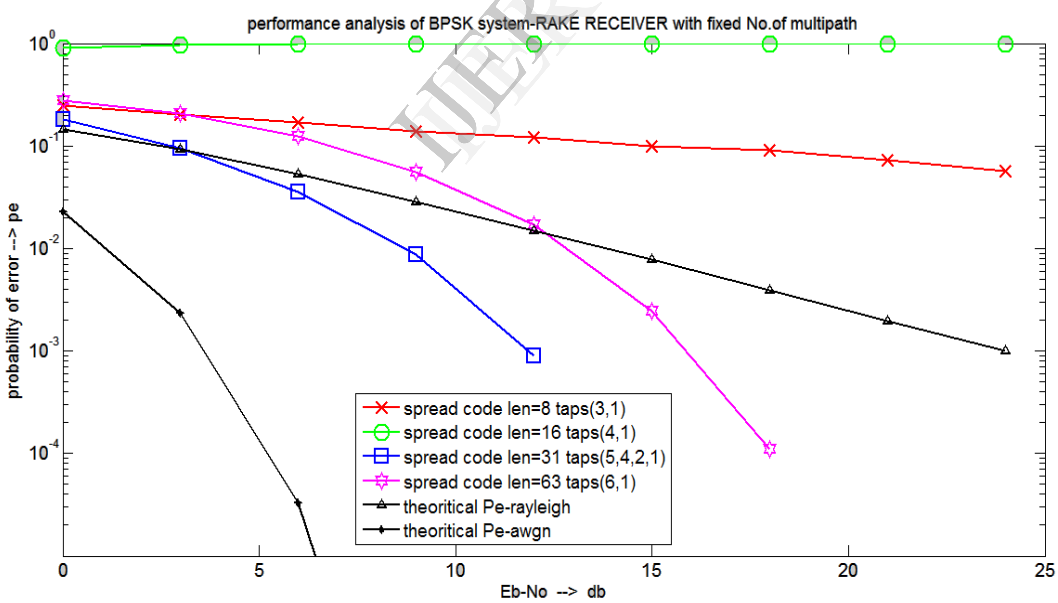
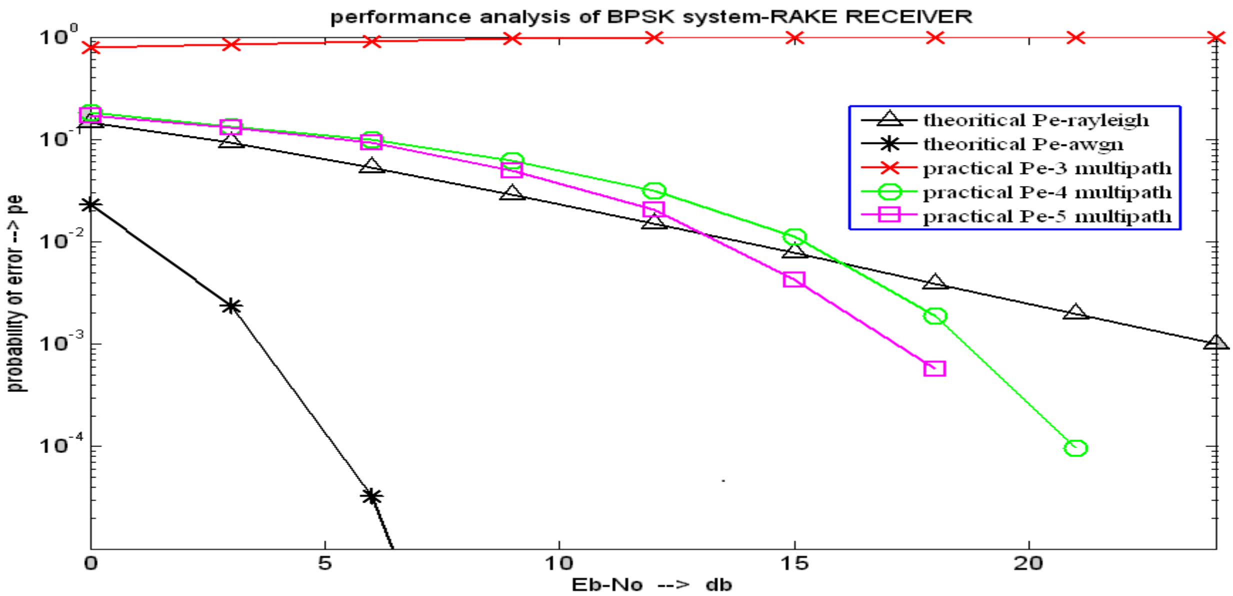


FIG.3b

From Fig.3.we conclude that increase in spreading length of maximal sequences does not guarantee in the improve performance but depends on fading channel conditions. Fig.4shows performance comparison of maximal sequence generated from (say) four stage linear feedback shift register with (3,2) tap combination of length N=7,With three, four, five multipath channel Ch3=[0.35 0.43 0.82], ch4=[0.35 0.25 0.435 0.78], ch5=[0.35 0.435 0.7644 0.28 0.16] respectively.

FIG.4



Performances curves are not similar for different number of multipath channel using same spread code for all channels.

CONCLUSION:

(1) Pseudo Noise sequences that are generated from the various valid taps combination using fixed length linear feedback shift register, posse's different BER curve for flat, slow fading fixed multipath channel. Similarly as the number of multipath components changes different ber curves are created for a particular spreading code and Increase in the length of maximal sequences does not guarantee in improving the SNR at receiver.

(2) The performance of rake receiver for different spreading sequences like gold and orthogonal variable spreading (OVSF) codes has to be estimated for flat fading channel. Similarly the performance of rake receiver over frequency selective fading channel has to be estimated using different spreading sequences.

(3) The performance of communication link can be improved by transmitting pilot bits that are spread with various length maximal codes generated from all valid tap combinations and performances are analyzed using rake receiver for particular falt fading channel and finally original data is spreaded with sequence that posses lower BER calculated for pilot data stream. Even though the bandwidth is wasted in such proposed method of transmission, the original information is sent with better fidelity using less transmitted power, this are extremely useful in applications where power is major constraint without the need for channel coding. However if the channel is frequency selective in nature the above mentioned scheme may not be effective.

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