QPSK DS-CDMA SYSTEM OVER RICIAN FADING CHANNEL WITH RAKE RECEIVER FOR WIRELESS COMMUNICATION

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ABSTRACT

In this paper we have shown the performance analysis of DS-CDMA wireless communication system with Rake Receiver for Rician fading channel using QPSK Modulation using MATLAB simulator. Next generation requirement of multiple input environments could be satisfied by it. The MATLAB simulator is used here which simulates the multiple input waveform signals in the form of Rake fingers or channels over wireless network just before the Rake Receiver which follows through the DS-CDMA technique due to its performance. We know that the CDMA is an very good technique to analyze the cellular systems. The simulator will give the tremendous functional ideas about the different values of the design option. Here, the backbone of this system is a Matlab Simulator. As nowadays this becomes the iconic tradition to do the analysis. The effective method of system modeling is used to speed up the simulations. With the help of simulator we get the variations in the system parameters due to its different inputs. The transmitted data and the received data can be analyzed in the form of signal waveforms and channels. We can also analyze and Compare the BER for Rician and Rayleigh fading channel under QPSK Modulation scheme. For RAKE, we compare the parameters like SNR, BER in multipath environment. It will be shown that the use of number of bit error in the received data by the RAKE receiver is less than the received data without RAKE receiver

Keyword: - *BER, DS-CDMA, Fading, Multipath Fading Channels, SNR, QPSK Rake Receive*

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1. INTRODUCTION

As Code Division Multiple Access (CDMA) is an application which is concerned with accommodating a number of simultaneous signal transmissions on the same channel, Code division multiplexing systems uses the spread spectrum technology and the Rake receiver concept to minimize communication errors resulting from multipath effects. In general, the number of multipath signals in the wireless channel is unknown and difficult to predict. The spread spectrum technology designs to spread the information signal over a wider bandwidth to make jamming and interception more difficult [1, 12].
A rake receiver allows each arriving multipath signals to be individually demodulated and then combined to produce a stronger and create an accurate signal.
The Rake receiver from the IS-95A CDMA system will use the three correlators and also a searcher, while the CDMA system TIA/EIA-95B limits the number of correlators in the Rake receiver to Six [4, 8].
CDMA is the popular application of DS spread spectrum techniques made it as DS-CDMA concept.

1.1 Code Division Multiple Access

Code Division Multiple Access (CDMA) is a spread spectrum technique that uses neither frequency channels nor time slots. In CDMA, the narrow band message is multiplied by a larger bandwidth signal, which is a pseudo random noise code. All users in a CDMA system uses the same frequency band and transmit it very simultaneously.

The transmitted signal is then recovered by correlating the received signal with the PN code used by the transmitter [1, 12].

In the demodulation of each type of PN signal, the signals from the other side users of the channel appear as an additive interference. A major advantage of CDMA is that a large number of users can be accommodated if each transmits messages for a short period of time [12].

Some useful properties that have made CDMA stronger are: Signal hiding and non-interference with existing systems, Anti-jam and interference rejection, Information security, Accurate Ranging, Multiple User Access, Multipath tolerance.

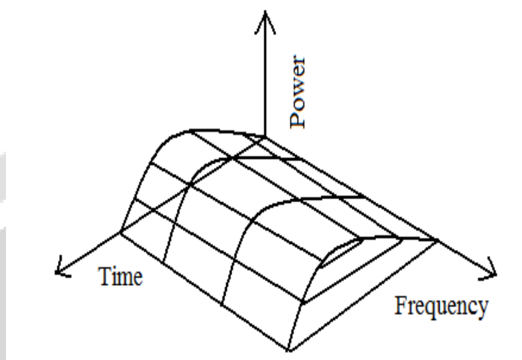

Fig -1: CDMA scheme

The data to be transmitted (a) is spread before transmission by modulating the data using a PN code. This broadens the spectrum as shown in (b).

In this example the process gain is 100 as the spread spectrum bandwidth is 125 times greater the data bandwidth. Part (c) shows the actual received signal. This may consists of the required signal with background noise and interference from any other CDMA users or radio sources.

The received signal is recovered by multiplying the signal by original spreading code. Also this process may cause the wanted effective received signal to be dispread back to the original effective transmitted data. When all the other signals are uncorrelated with the PN spreading code, they become more spread. The wanted signal in (d) is then filtered removing the wide spread interference and noise signal, it is shown in the Fig.2 below

1.2 Direct Sequence Spread Spectrum

The spread spectrum modulation techniques are originally developed for use in the military and intelligence communications systems due to their resistance against jamming signals and low probability of interception (LPI). They are immune to various kinds of noise and multipath distortion. The DS-SS technique is the most popular technique for spreading the signal in the form of spectrum. This is because of the simplicity with which direct sequencing can be implemented. Figure 3 shows the basic model and the key characteristics that make up the DSSS wireless communica-tion system. In this type of modulation technique, a pseudo-random noise generator will creates a spread spectrum code or better known as the pseudo-noise (PN) code sequence with the help of chip code. Each of bit from the original input data signal is directly modulated with this PN sequence and can be detected by multiple bit data in the transmitted data signal. On the receiving end, the same PN sequence is then capable of demodulating the spread spectrum data signal to successfully recover the input data signal.

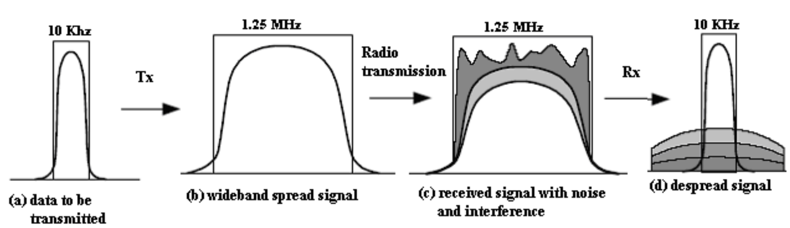

Fig -2: Basic CDMA Generation

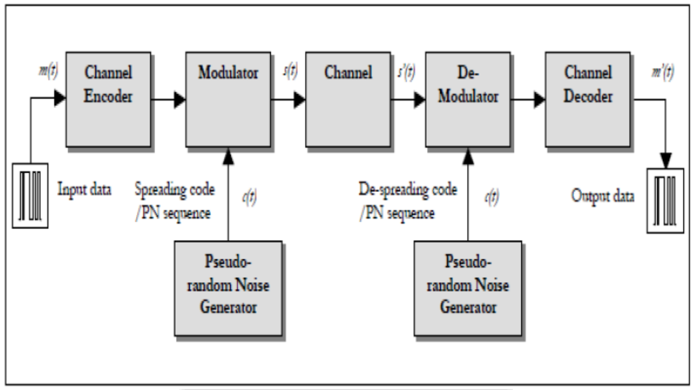

Fig -3: Basic model of DS-SS Communication System [12]

error bits and total number of bits transmitted during a specific period. Figure 4 gives the flowchart for the procedure to plot the BER vs. SNR response. It is the likelihood that a single error bit will occur within received bits, independent of rate of transmission. There are many ways of reducing BER. Here, we focus on spreading code & modulation techniques. In our case, we have considered the most commonly used channel the Additive White Gaussian Noise (AWGN) channel where the noise gets spread over the whole spectrum of frequencies.

BER has been measured by comparing the transmitted signal with the received signal and computing the error count over the total number of bits. For any given modulation, the BER is normally expressed in terms of Signal to Noise Ratio (SNR).

2. BER VS. SNR PROCESS

In any phase modulation scheme the information is expressed in terms of phase of the carrier. Phase of the carrier signal is shifted according to the input binary data. Two state phase shift keying is called BPSK where the phase of the radio carrier isset to 0 or π according to the value of the incoming bit. Each bit of the digital signal produces a transmit symbol with duration Ts, which is equal to the bit duration Tb.Four-state or quadric phase PSK is called QPSK, in which two bits are combined and the radio carrier is phase-modulated according to the four possible patterns of two bits.

Transmitting a symbol takes twice as long as a bit (Ts = 2·Tb) which means that the bandwidth efficiency of QPSK is twice that of BPSK [4], [10].Bit Error Rate (BER) of a communication system is defined as the ratio of number of error bits and total number of bits transmitted during a specific period.

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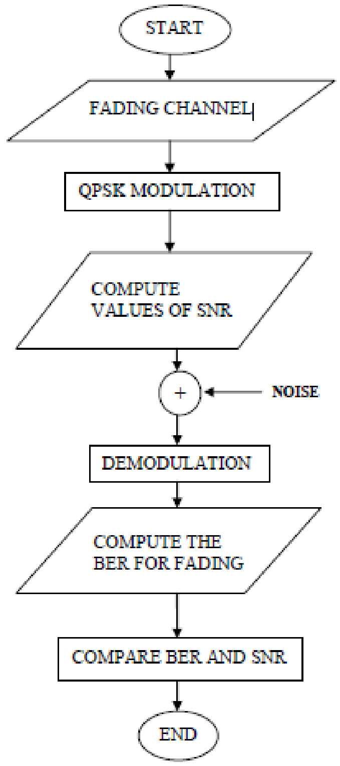


Fig -4: Flow Chart for obtaining BER vs SNR plot

2.1 Signal To Noise Ratio (SNR)

SNR is the ratio of the received signal strength over the noise strength in the frequency range of the operation. BER is inversely related to SNR, that is high BER causes low SNR. High BER causes increases packet loss, increase in delay and decreases throughput. The exact relation between the SNR and the BER is not easy to determine in the multi-channel environment. SNR is an indicator commonly used to evaluate the quality of a communication link and measured in decibels and represented by Equation

SNR = 10 log10 (Signal Power / Noise Power) dB

3. RAKE RECEIVER

In multipath channel, delayed reflections interference with the direct signal in a DS-CDMA can be detected by rake receiver, a RAKE receiver technique which uses several baseband correlators to individual process several signal multipath components. The correlates are combined to achieve improved communications reliability and performance [4]. RAKE receiver, used specially in CDMA cellular systems, can combine multipath components, which are time-delayed versions of the original signal transmission. Due to reflections from obstacles a radio channel can consist of many copies of originally transmitted signals having different amplitudes, phases, and delays, a RAKE receiver can be used to resolve and combine them. This combining is done in order to improve the signal to noise ratio (SNR) at the receiver. RAKE receiver attempts to collect the time shifted versions of the original signal by providing a separate correlation receiver for each of the multipath signals. The RAKE receiver uses a multipath diversity principle. It is like a rake that rakes the energy from the multipath propagated signal components [5].
The RAKE receiver consists of multiple correlates in which received signals are multiplied by time shifted versions of a locally generated code sequence. The intension is to separate signals such that each finger only attain signals coming in over a resolvable path. The spreading code is chosen to have a very small autocorrelation value for any non-zero time offset that avoids crosstalk between fingers. It is not a full periodic autocorrelation that determines the crosstalk between signals in different fingers, but rather two partial correlations with contributions from two

consecutive bits or symbols [6]. It has been attempted to find sequences that have satisfactory partial correlation values, but the cross talk due to non-periodic correlations remains substantially more difficult to reduce than the effects of periodic correlations the rake receiver is designed to optimally detect as DS-CDMA signal transmitted over dispersive multipath channel. Figure 5 Shows RAKE Receiver.

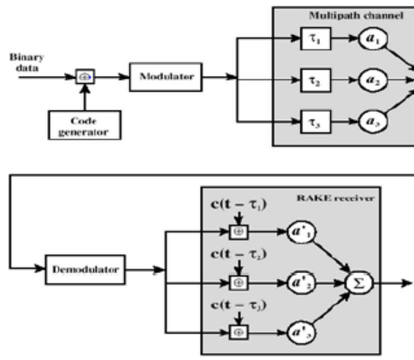


Fig -5: Principle RAKE Receiver

Like a garden rake, the rake receiver gathers the energy received over the various delayed propagation paths. According to the maximum ratio combining principle, the SNR at the output is the sum of SNR"s in the individual branches, provided that, We assume that only RICIAN channel is present and codes with time offset are truly orthogonal.

4. FADING CHANNELS

A Fading Channel is known as communications channel which has to face different fading phenomenon, during signal transmission. In real world environment, the radio propagation effects combine together and multipath is generated by these fading channels [5].

4.1 Types of Small Scale Fading

The terms slow and fast fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. Figure 7 shows types of small scale fading.

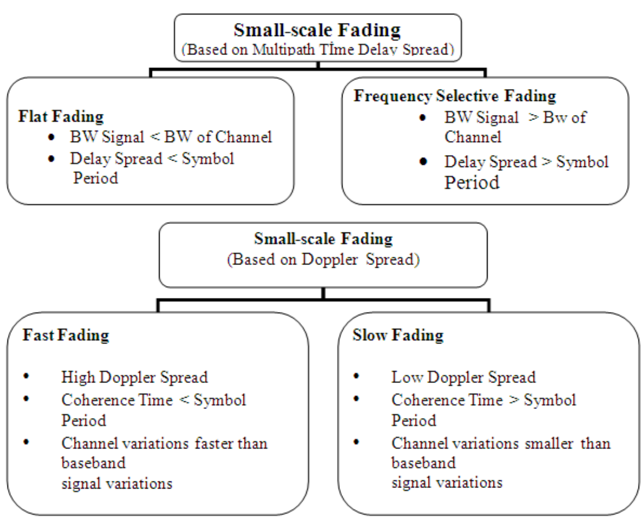


Fig -6: Types of Small Scale Fading

4.2 Rayleigh Fading Model

Generally, there are two fading effects in mobile communications, large-scale and small-scale fading. Large-scale fading represents the average signal power attenuation or path loss due to motion over large areas. On the other hand, small-scale fading refers to the dramatic changes in signal amplitude and phase that can be experienced as a result of small changes (as small as a half-wavelength) in the spatial separation between a receiver and transmitter. Small-scale fading is also called Rayleigh fading because the envelope of received signal can be represented by a Rayleigh pdf.

The Rayleigh fading is primarily caused by multipath reception [6]. Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal. It is a reasonable model for troposphere and ionospheres‟ signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is most applicable when there is no line of sight between the transmitter and receiver. Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. The central limit theorem holds that, if there is sufficiently much scatter, the channel impulse response will be well-modeled as a Gaussian process irrespective of the distribution of the individual components. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. Figure 8 gives the Rayleigh Fading Model.

4.2 Rician Fading Model

The Rician fading model is similar to the Rayleigh fading model, except that in Rician fading, a strong dominant component is present [6]. This dominant component is a stationary (non fading) signal and is commonly known as the LOS (Line of Sight) component. Rician fading is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself, the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution. Rayleigh fading is the specialized model for stochastic fading when there is no line of sight signal, and is sometimes considered as a special case of the more generalized concept of Rician fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution.

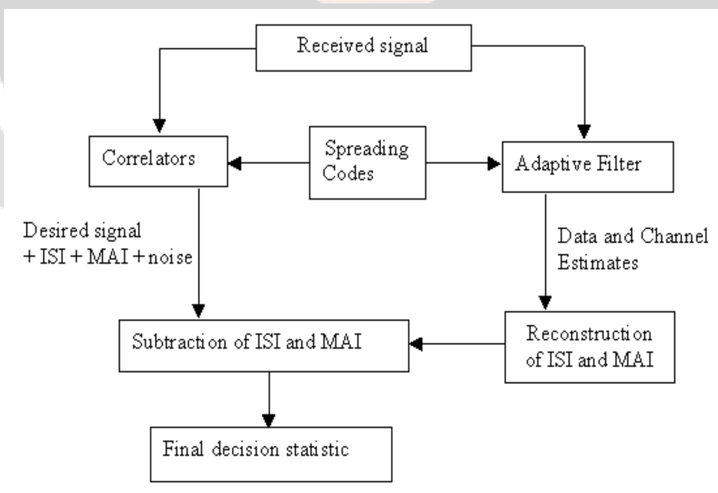


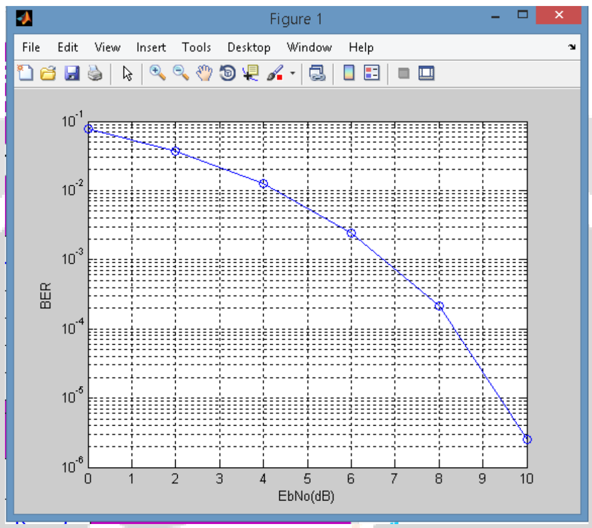
Fig -7: Rayleigh Fading Model

5. RESULT AND SIMULATION ANALYSIS

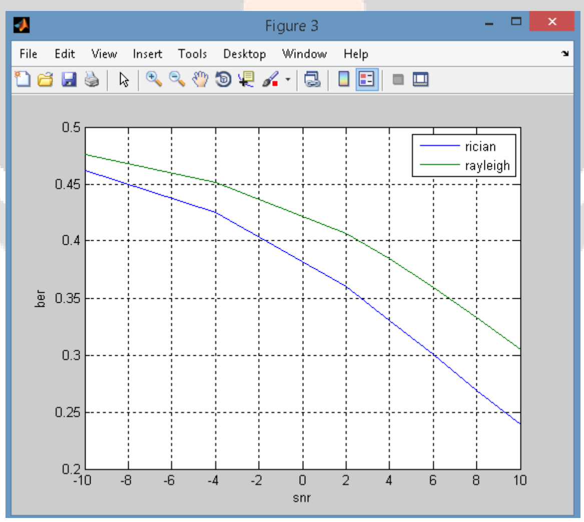
The performance of QPSK DS-CDMA system over Rician Fading Channel with Rake Receiver for Wireless Communication is simulated using MATLAB software. From MATLAB simulation following results are obtained that are shown below.

Graph 5.1 indicates BER performance over QPSK DS-CDMA system. Graph 5.2 and table 5.1 shows the comparison graph, in which RICIAN channel indicated in blue line shows lower BER value because it contains strong line of sight component compare to Rayleigh channel indicated in green line which does not contain line of sight component. Hence Rician channel is preferred over Rayleigh channel.

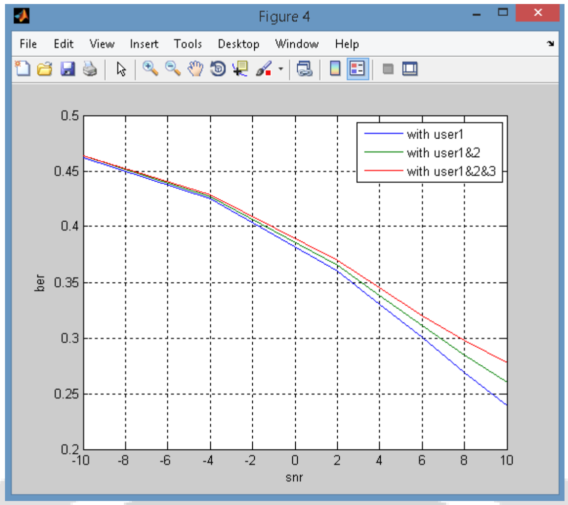
For single user, performance of DS-CDMA system for RICIAN channel using QPSK generates less BER due to absence of noise caused by other users. As we go on increasing the number of users, system performance is degraded which result in increase in BER values as shown in Graph 1



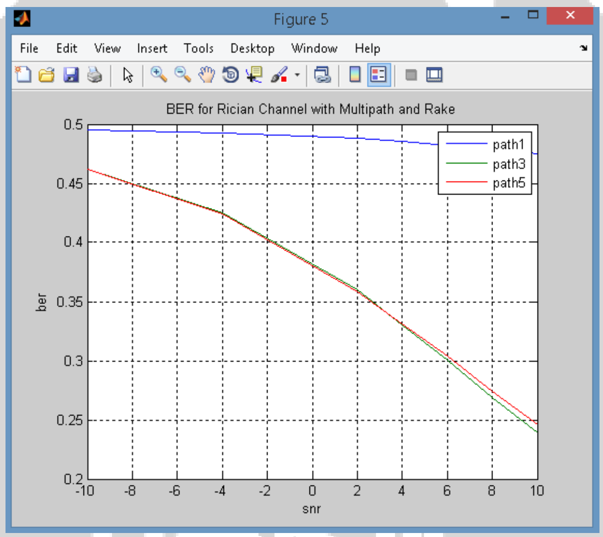
Graph -1: BER Performance of QPSK



Graph -2: BER Comparison over Rician and Rayleigh Fading Channel for QPSK



Graph -3: BER Comparisons over RICIAN Channel for QPSK with Different Users



Graph -4: BER for RICIAN Channel with Multipath and Rake Receiver for QPSK

If there is only one path then the system has lower BER value compare to multipath singles. As BER increases with the increase in the number of paths. To avoid increase in BER then we have to add more fingers in a rake receiver. It has been observed that as number of path (i.e. 1, 3, and 5) increases the fingers of rake receiver also increases which gives improved BER value.

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