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BER improvement of DS-CDMA for AWGN and Rayleigh fading channel with Kasami code

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***Abstract* — In this paper we represent the work to improve the quality or reducing the effective BER in a multipath fading channel. BER is inversely proportional to SNR so high SNR results in low BER and vice versa. The study of this paper is to have focus on the performance of digital communication system. For reliable communication system, its BER should be as low as possible i.e. improvement in BER. BER performance of Kasami code for AWGN channel is studied and result is given for comparison of DPSK and BPSK modulation. The simulation is carried out with MATLAB. BER improvement of DS-CDMA system for different codes using baseband modulations for AWGN is discussed.**

***Keywords:* BER, DS-CDMA, Fading, Multipath Fading Channels , Spreading Codes, SNR.**

I INTRODUCTION

As wireless communication becomes a worldwide communication standard for transferring the data, the main challenge is to transfer the information as efficiently and reliably as possible through the limited bandwidth [1].There is always more than one propagation path in between each transmitter and receiver. Transmitted signals reach at the receiver via a direct path which is known as Line of Sight (LOS) or through multiple paths by the reflection, scattering and diffraction of surrounding things such as buildings, trees or any obstacles so a received signal is actually addition of two or more components irrespective of main component and each of which traveled with a different path from the transmitter. Due to which each multipath component reaches with a delay depending on its path length. Delayed multipath components results in Inter-Symbol Interference (ISI) and it applies limit on the corresponding data rate that the channel may support. Fading is another main problem faced by multipath channel [5]. This “multipath fading” occurs as general multipath components arrive with various phases and at some of the points in free space, the components cancel each other, which cause deep fades in the received signal level. Now when simultaneous multiple communications are carried out, then in the multipath environment, the interference causes from different directions will also increase respectively. This multipath propagation results in the signal, present at the receiver side to distort and fade significantly, reducing Signal to Noise Ratio (SNR) and hence results in higher Bit Error Rate (BER) [4]. BER is used to check the performance of wireless communication system which measures the reliability of that communication system [4].

CDMA is a well known and famous technology in cellular system due to its higher performance and capacity. It works on DS-SS modulation so it is called as DS-CDMA system. Number of users can transmit data simultaneously over a common channel [5]. The transmitter of DS-CDMA multiplies each user’s data signal by an unique and distinct code waveform and it’s detector receives a signal which is the addition of the sum of all users’ signals, that overlap in frequency and time. In a conventional DS-CDMA system, a specific user’s signal is identified by correlating the whole received signal with the same user’s code waveform. It is difficult to judge the number of path at receiver and then allocate them the number of correlators [2]. Multiple Access Interference (MAI) is a factor which limits the performance and capacity of DS-CDMA systems [6]. In a wireless telecommunication system, a signal goes from transmitter to respective receiver over multiple reflective paths and this phenomenon is known as multipath propagation [1].

The distortion of many signals caused by multipath is called as fading. Due to fading in a wireless communication system, the signal received with multiple numbers with deep fade then received power is less than noise power hence performance of wireless system is not good i.e. BER is greater [1].

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II. Direct Sequence-Code Division Multiple Access System

Spread spectrum is a media of transmission, where the signal occupies a bandwidth in excess amount of the less necessary to transfer the information; the band spread is covered by means of a code which is not dependent of the data and a reception of signals will be synchronized with the code at the receiver that is used for de-spreading and subsequent data recovery [4].

The spread spectrum signals are generally used for the applications like:

- Getting message privacy in the presence of other listeners.
- If we are transmitting a signal with low power and making it difficult for an unknown user to detect in presence of background noise.

The DS-SS method is one of the most famous form of spread spectrum. This is due to the simplicity by which direct sequencing can be implemented.

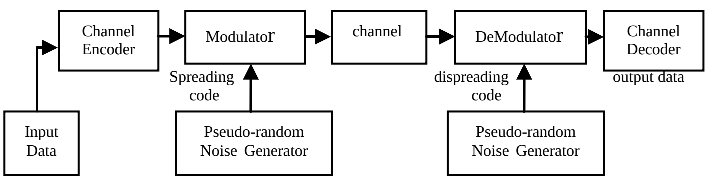


Figure 1: General implementation model of the DS-SS communications system

Figure 1 shows the basic model of DS-SS communication system. In given form of modulation, a block i.e. pseudo-random noise generator provides a spreading code which is also called as the pseudo-noise (PN) code sequence or signal. Every bit of the original input data that is directly modulated with the PN sequence and is representsd by multiple bits in the transmitted signal. So on the receiving side, only the same PN sequence is able to demodulate the spread spectrum signal for successful recovery of the input data [5]. The bandwidth of the transmitted data signal is directly proportional to that of number of the bits that are used for the PN sequence, at the transmitter side. A 7-bit data sequence spreads the signal across a frequency band which is seven times greater than that of one-bit code sequence or it is said to be having a processing gain of seven.

There are some features of spread spectrum that one of the key spread spectrum modulation property is that it's ability to avoid pass band noise, so it improves coverage range for given transmitter power. Another advantage is that transmitter and receiver PN sequence synchronization is eliminated by sliding correlator. So sensitivity can be adjusted by changing the sliding factor and correlator filter bandwidth and also required transmitter power can be considerably less than comparable direct pulse system due to inherent processing gain of spread spectrum.

In CDMA systems, all users transmit the data in the same bandwidth simultaneously and communication systems following this concept are said to be "spread spectrum systems" so in this transmission method, the frequency spectrum of a code-signal is spreaded by using a code uncorrelated with that same signal so in a result we get more bandwidth occupancy than required one. The codes that are used for spreading, that have minimum cross-correlation values that are unique to each and every user. This is the reason for a receiver that has prior knowledge related to the code of the intended transmitter and that is capable of choosing the required signal data [4].

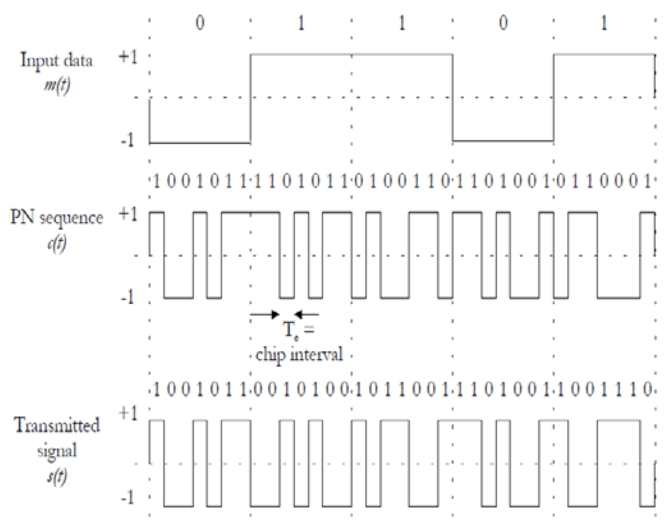


Figure 2: DS-CDMA communication system generation of signal

Figure 2 shows the generation of a DS-SS signal by using an Exclusive-OR (EX-OR) operation. An input data bit of zero results in the PN sequence coding bits which are to be transmitted without inversion of it, an given input data bit of one inverts the coding bits. Instead of representing the binary data with bits 0's and 1's, the given input signal and PN sequence both are converted into a bipolar waveform with respective of amplitude levels of ±1.

Direct sequence signals are generated by modulating a carrier signal with a code sequence and in a DS-CDMA communication system the incoming information data is digitized if it is not in a digital format, modulo-2 added to a higher speed code sequence. The combined information and code together then are used to modulate on RF carrier by using BPSK modulation method. As high speed code sequence dominates the modulating function, it finds the RF signal bandwidth and it gives rise to the spread spectrum signal [3].

III. MULTIPATH PROPAGATION AND FADING

Fading means distortion which is experienced by a carrier-modulated telecommunication signal over a certain propagation media and in any wireless system, fading is due to multipath propagation that is sometimes mentioned to as multipath induced fading. So to understand concept of fading, it is necessary to understand multipath. In wireless telecommunication system, multipath is the propagation concept that results in radio signals' coming to the receiving antenna by two or multi paths. Causes of multipath are atmospheric ducting, refraction and ionospheric reflection, and reflection from terrestrial objects like buildings and mountains. The effects of multipath has constructive and destructive interference and also phase shifting of the signal so the distortion of the various signals caused by multipath is said to be as fading or in the real world, the multipath of signal occurs if there is more than one path is available for transmitted radio signal travel. The phenomenon of diffraction, reflection and scattering all are the reasons for extra additional radio propagation paths that are beyond the direct optical LOS path in between the transmitter and receiver [10].

IV. FADING CHANNELS

A Fading Channel is said to be a communication channel which has to face various fading phenomenon's, during transmission of the signal [9]. But in real world application, the radio propagation effects add together and multipath is generated by the same fading channels and due to multiple signal propagation paths, that multiple signals will be received by the receiver and the actual received signal level at the receiver is the vector summation of the all the received signals [3].These signals may incident from any angle of arrival or any direction. So in multipath fading, some signals add the direct path or some others subtract it. In a wireless communication channel, the signal which is transmitted from transmitter can go from transmitter to receiver over multiple of reflective paths and this gives rise to multipath fading that causes fluctuations in phase, amplitude or angle of arrival of the received signal [9]. So for example, the data signal which is transmitted from the BTS (Base Transceiver Station) can suffer multiple reflections from the nearby buildings, before coming to it's mobile station. Such multipath fading channels are generally divided into slow fading or fast fading and frequency-selective or flat fading channels.

V.TYPES OF FADING CHANNELS

a). Rayleigh fading channel:
The Rayleigh fading is primarily occurred by multipath reception of signals [4]. This is used to simulate an environment that has multiple scatters of signal and not a single Line of Sight (LOS) path. But if there are sufficient multiple scatters in the environment, then all the reflected signals which are appearing at the receiver side becomes uncorrelated in amplitude level (this brings mean = 0) and phase is evenly distributed between the limit of 0 to 2π.

b). Rician fading channel:
The Rician fading channel is same as that of Rayleigh fading channel, except in Rician fading, a strong main dominant component is there which is a stationary (non fading) signal and it is generally said to be the LOS (Line of Sight) Component.

- Rician Distribution:

Consider about two Gaussian random variables that are A and B. Here A models the specular component (LOS) and B models the random/scatter component. By definition, model A has non-zero mean (m), B has zero mean and they both have same variance σ2. Then the transformation $Z= (I^2+Q^2)\wedge^{1/2}$ is Rician Distributed for BPSK. The ratio of power of specular component to that of power of random component is said to be Rician factor 'k' and it is defined as

$$k= m/2\sigma^2$$

c). Additive White Gaussian Channel:

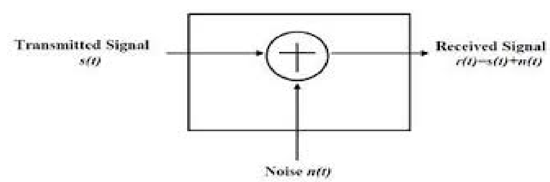


Figure 3 AWGN Channel

It is the simplest radio environments where a wireless communication system, a local positioning system or proximity detector which is dependent of Time of- flight that have to operate and that is the AWGN environment [4]. AWGN channel is the commonly used to transfer signal while signals propagate through the channel [7] and it simulates present background noise of channel [8] and the mathematical equation in received signal which is r(t) = s(t) + n(t) that is passed via the AWGN channel, where s(t) is for transmitted signal and n(t) is for present background noise [9] as shown in fig.3.

VI. VARIOUS MODULATIONS

a) Binary Phase Shift Keying Modulation:

Modulation is termed as the process by which, characteristic of a carrier signal is varying in accordance with a modulating wave. Digital transmission generally needs CW modulation to generate a band pass signals for the reliable transmission of the signal over the medium of transmission. A digital signal can modulate the amplitude, frequency, phase of a sinusoidal carrier wave and if the modulating waveform consists of NRZ rectangular pulses, then the modulated parameter will be keyed or switched from one discrete value to another. There are three basic modulation methods for the transmission of digital data; that are known as frequency-shift keying, phase-shift keying and amplitude-shift keying. There are a multiple of modulation/detection schemes available to the designer of a digital communication system required for data transmission over a band-pass channel and each scheme gives system trade-offs of its own. The final selection made by the designer of system is determined by the method in which the available primary communication resources channel bandwidth and required power are best exploited [11]. Following design goals will help to make a selection to favor of the selected schemes that are

- Less complexity of circuit.
- Low probability of bit error.
- Minimum transmitted power.
- Resistance to interfering signals is more.
- Minimum bandwidth of channel.

Signal changes its phase values that are 0 and π, depending on the polarities of the message signal at a time in with respect to the truth table [10]. The phase of a constant amplitude carrier signal is switched between two levels according to the two possible signals x1 and x2 which are corresponding to binary values '1' and '0', respectively. Generally, these two phases are separated by 2π. If the sinusoidal carrier has an amplitude level of Ac and energy per bit is E_b , then that transmitted BPSK signal for time period $0\leq t \leq T_b$ is either:

$S_{BPSK}(t) = (2\epsilon_{b}/\tau_b)^{\wedge 1/2} \cos(\Pi 2 f_c t+\Theta_c)$… For binary 1 input (Signal x1)

$S_{BPSK}(t) = -(2\epsilon_{b}/\tau_b)^{\wedge 1/2} \cos(\Pi 2 f_c t+\Theta_c)$… For binary 0 input (Signal x2)

Where,

$$E_b = ½ A_c{}^{\wedge 2} T_b$$

b) Differential Phase-Shift Keying modulation

In this system, the demodulator identifies the variations in the phase of that of received signal instead of the phase (which is relative to a reference wave) itself. Since the scheme depends on the difference in between successive phases then this is defined as differential phase-shift keying (DPSK).It can be significantly easier to implement than any other ordinary PSK as there is no requirement of the demodulator to have a copy of that reference signal to get the accurate phase of the received signal (as it is a non-coherent scheme) [2].On other side, it produces more erroneous demodulation. DPSK signaling has an advantage of reduced receiver complexity and its energy efficiency is inferior to that of coherent PSK by 3dB.

Average probability of error is

$$P_{DPSK} = ½ \exp(E_b/N_0)$$

VII .SPREADING CODE

Various spreading codes are there like Gold, MLS Barker and Kasami, here results are obtained for Kasami sequence.

- Kasami Code:

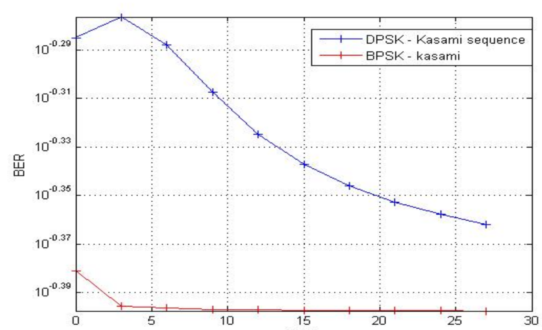
Kasami sequences are actually binary sequences that having length of 2^N-1, where N is an even integer [3] and Kasami sequences have good cross-correlation values that approaches the Welch lower bound. There are generally two types of Kasami sequences – one is the small set and the another is large set and the process of generating a Kasami sequence which is initiated by creating a maximum length sequence *x(n)*, here value of n=1…. 2^N-1. Maximum length sequences are generally periodic sequences with a time period of exactly 2^N-1 and a secondary sequence is obtained from the initial sequence by cyclic decimation sampling as *b(n)* = *x(q*n)*, where q = $2^{N/2}$+1 and newly generated sequences are then created by simply adding *x(n)* sequence and cyclically time shifted versions of *b(n)* by using mod-two arithmetic that is also called as the ex-or operation [11].

VIII. RESULTS

The simulation was held using MATLAB application package. BER performance of BPSK modulation is compared with DPSK modulation for AWGN fading channel and also for Rayleigh fading channel with Kasami code in figure 5.

For AWGN channel:

a. Kasami Sequence



For Rayleigh Channel

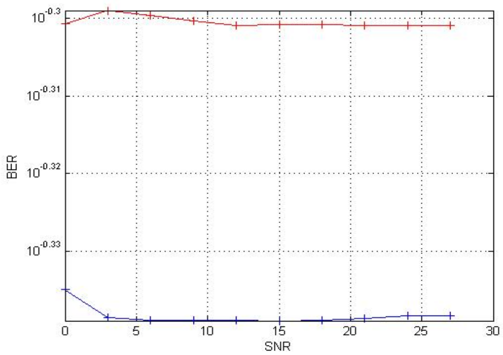


Figure 5 Performance of Kasami code with AWGN and Rayleigh fading channel

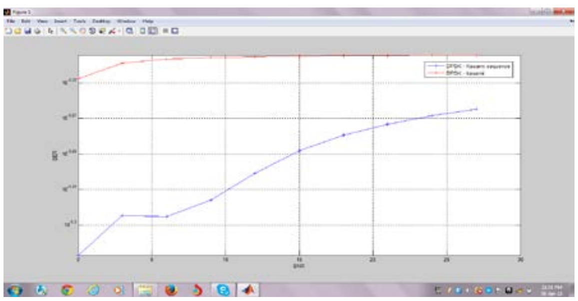


Figure 6 Performance of Kasami sequence for multiuser system

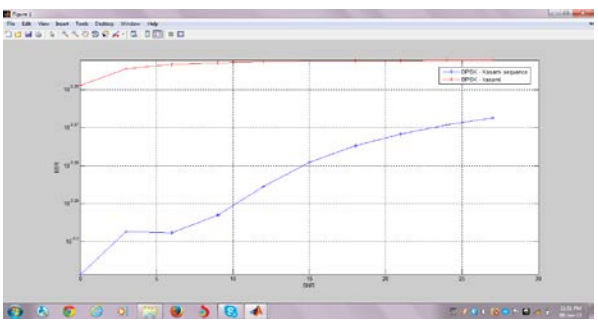


Figure 7 Performance of Kasami sequence for multipath system

IX. CONCLUSION

We have evaluated the BER performance of DS-CDMA for Kasami code under AWGN channel and Rayleigh for various modulation schemes. For AWGN channel, it was found that BER is the minimum. So, we will prefer AWGN channel. As BER is the major concept for communication; we have to maintain its value as low as possible and as SNR increases BER decreases and vice versa.

We conclude that for Kasami code BER is minimum for BPSK rather than DPSK modulation and also BER is less for Kasami code compare to other spreading codes.

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