Noise (AWGN) Avoidance in CDMA Systems Using the Mechanism of Spread Spectrum

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Abstract
In today communication systems the most probable problems are that of channel capacity, jamming and interference or noise. The channel capacity can be maximized by multiplexing the channel. While the jamming problem and for noise reduction the most important technique that we can apply is spread spectrum. That by spreading the spectrum of the original message signal, the impact of noise upon the message signal can be reduced. For that purpose, two different techniques that is DSSS(Direct Sequence Spread Spectrum) and FHSS (Frequency Hoping Spread Spectrum) can be applied. Since the two approaches are core ideas upon which CDMA system is based, so in this paper we have analyzed both the techniques to observe that h up to what extent they are efficacious in removing AWGN in CDMA systems communication.
IndexTerms:DSSS, FHSS, Code Division Multiple Access (CDMA), Additive White Gaussian Noise (AWGN), spread spectrum.

INTRODUCTION

The rapid advancement of communication technology paved the way of progress for nearly every walk of life of human being. Mobile phone has become inevitable gadget for an individual. The earth has turned into global village in true sense. The challenges and problems to achieve such seamless communication also grow with the same pace. New techniques and tactics are being devised to cope up with the growing challenges. Among the many emergent and widespread technologies, CDMA has gained the unrivalled applications. With its many traits, especially bandwidth efficiency and noise immunity, CDMA has found applications everywhere in wireless communication, from cellular to satellite communication. Two signal spreading techniques, Direct Sequence Spread Spectrum and Frequency Hopping Spread Spectrum, make CDMA very resilient against noise, interference and security threats. The main problem in CDMA is Additive White Gaussian Noise (AWGN). This noise is very hard to combat and eliminate. By dint of wise selection of spreading signal, effect of AWGN can, however, be mitigated to a greater extent. In this paper, we analyse effect of AWGN on CDMA signal and, subsequently, pacifying the effect by application of DSSS and FHSS. Remaining of this paper is organized as follow. Section II presents literature review. Section III elaborates spreading techniques. Section IV presents simulation results. Section V concludes the paper. Section VI presents references.

Literature Review

Code division and multiple access (CDMA) and spread spectrum is a technique that has got too much influence in today communication systems. The main reason behind its importance and widely application is that it offers reluctance to the jamming of signal and they are immune to noise that noise has little or no impact upon a spread spectrum signal. In the past different researchers and scholars have worked on it. Some of the prominent work concerned with noise, interference and spread spectrum is presented here.

Heath et al. [1] pointed out that in synchronous code-division multiple -access (CDMA) sum capacity optimal signatures are functions of strength of active users and codebook length .in this network the variation of active user required new signature set .this states that it is not subjected to the changes in active user . In this paper work a technique of equiangular signature sequences is suggested. The result of this technique shows that it suppressed the maximum signal to interference plus noise issue.

brindha [2]pointed out thatfor high speed wireless communication multi carrier code division multiple access (mc-CDMA) is supreme option as it violate the issue of inter symbol interference and uses frequency diversity. In addition to increase the system capacity with high speed data communication also mc-CDMA network is used to acquired it. Multipath fading is a big challenge to mc-CDMA network because it degrades its performance multicell interference in fading channel effects the efficiency of system. In this research work a technique bpsk modulation for different number of subcarrier is used to studied the ber performance under rayleigh fading channels of mc- CDMA while awgn(additive white gaussian noise) is activated. This project work offers a comparison between simulated results which proof degrades in ber efficiency.

Howard et al.[3] presented that in multi carrier direct sequence code division multiple access (mc-ds-CDMA) the orthogonality of spreading code is annihilated by frequency selective fading. In this project a new technique of multiple access interference (mai) co-efficient which foretell the conflict of time and frequency domain with inter code interference dispersed in frequency selective fading medium. Interference avoidance code assignment method is suggested in mai co-efficient. By combination of acquired mai effect and blocking probability in code tree architecture. The MAI for mc-ds-CDMA can be violate through the suggested avoidance code assignment technique.

David et al. [4] states that femtocells is an attractive choice for crushing the growth of traffic within microcells and indoor coverage challenges. But the efficiency of microcells layer is badly ruined by using of femtocells layer. Avoidance of electromagnetic interference and apportionment of spectrum resources are two big problems before using femtocells. In this research work a study of interference and coverage depend upon OFDMA femtocells\macro script is offered also gives some instruction on how interference palliation and spectrum apportionment can be achieved in this system. The most state of this paper work is the use of self-optimization and self-configuration method for interference violation.

Morelli et al. [5] presented that in quasi synchronous multicarrier code-division-multiple-access system interference may be due to carrier frequency offsets and multipath distortion. In this research work for violating multiple access interference(mai) different technique are offered. particularly exponential orthogonal codes are employed or allocating particular subset of walsh- hadamard code family. In this paper another method presented for mai suppression is transmission scheme display a lower peak-to-average power ratio.

Ulukus and Yates [6] pointed out that the capacity of single cell synchronous code-division-multiple-access (CDMA) network is maximize by the technique optimum signature sequence sets. This technique states an algorithm in which transmitter signature sequence is updated by each user successively using available receiver measurement in distributed mode. The algorithm prove that a super signature sequence is generated and total squared correlation(tsc) is reduced with each update. in this algorithm form a set of welch bound equality(wbe) when the number of users is greater than processing gain and form a set of orthogonal signature sequences when processing gain is greater than or equal to number of users. The signature sequence is substituted by algorithm with normalized minimum mean squared error(mmse) receiver analogous to date signature sequences.

Dimitrie and Otilia [7] pointed out that for simple code-division-multiple-access(CDMA) channel models greedy interference avoidance method is perfect to gain optimum codeword. This paper show that how for general multiaccess vector channels greedy interference avoidance method can be applied for gain optimum codeword in a distributed mode. This work presented two techniques i.e distributed codeword adaption and iterative water filling based on greedy interference avoidance for codeword optimization. Iterative water filling is found best on comparing because of maximum sum capacity. For simple integrated adaptive receiver structural properties(identical signal to noise ratios for each codeword and identical receivers structure for each codeword) is also discussed.

Ling Lu and Menon [8] suggested that the interference in wireless communication system can be avoid by adaptive modulation/demodulation scheme. In adaptive modulation/demodulation method the signature waveform of user can be changed by increasing the signal to interference ratio that depend upon state-of-art interference avoidance algorithm and wavelet packet analysis.

Kamath [9] pointed out that optical code-division-multiple-access(CDMA) technology utilize the large capacity of an optical fiber. But due to multiuser interference the efficiency of broadcast local area network (lan) optical CDMA network is effected badly. This research work presented a technique of interference avoidance. This technique suppressed interference and don't let effected the performance of the optical CDMA due to multiuser interference. This technique is based on transmission scheduling and state estimation. Algorithm for transmission scheduling and state estimation is simulated and proved how they prevent the reduction of performance at high loads of an optical code-division-multiple-access(CDMA) network.

Joseph et al. [10] presented that in broadcast channels optical CDMA local area network shared access is allowed. In optical CDMA local area network each node has its own optical orthogonal codeword(ooc) through which it receives or transmit. The efficiency of oocs is very low because when many codewards are simultaneously transmit then between codewards interference maximizes and performance of network is reduced. In this paper a method is analyzes in which there is no media access control(mac) layer and its proved that when more codewards are transmitted the efficiency is degrades. This work presented a technique known as interference avoidance in which media access mechanism is used by each node to violate interference and increase system performance. This method is analyze and show that it improve the performance upto 30% with no collapse in throughput and low delay.

Pushpan and Jayaraman [11] suggested a technique of almouti STBC (stop time block codes) to improve performance of DS-CDMA system. This work analyzes the performance of DS-CDMA system over Rician, AWGN, and Rayleigh fading channels. STBC uses antenna diversity for securing communication and reducing interference so that system efficiency is improved. The simulation shows that STBC CDMA improved efficiency in cellular networks. Comparison of the performance of typical DS-CDMA and STBC CDMA system is also provided which shows that by using STBC and multiple transmit antennas in DS-CDMA the performance has increased.

Wang et al. [12] this research work examine differences between various multiple access techniques. It states that the merit of non-orthogonal approaches over orthogonal ones in fading situations is spectral- power efficiency due to delay sensitive applications. This paper also suggest that in case of utilization of recent progress in transmission and detection techniques this theoretical merit can also be used in practice. The practical features of these multiple access techniques are also compared and discussed.

Reza Pakravan et al. [13] proposed that in Optical code-division-multiple-access(OCDMA) packet networks media access control(MAC) layer protocol can be used for the purpose of providing different quality of services. The MAC layer protocol uses signaling(multilevel and multiclass signaling) method. In the suggested method the users are divided into two different categories i.e. high classes and low classes services. The transmission power level of each category users will be the same but different from other class. In order to increase network performance the MAC of each user will estimate the interference of channel and will adjust the packet transmission time. The simulation shows that the combination of proper MAC algorithm and appropriate power assignment to users will gives us various Quality of Services(QoS). The resources of OCDMA network must be divided between the users of each class.

Syed Shakeel at al. [14] Proposed techniques for improving Quality of Service(Qos) of CDMA systems. Switching coding scheme and Bandwidth scheduling scheme are techniques for gaining high throughput services in CDMA systems. Based on the demanded service bandwidth the Bandwidth scheduling scheme schedule the available resources. For multi access interference(MAI) suppression which is caused by simultaneous requests Code Switching Scheme is used. Comparison of metrics of Qos for conventional approach and developed system is also discussed.

G. Andrews et al. [15] Suggested a network for clustered wireless ad hoc networks for purpose of spatial reuse and simultaneous transmissions by combing CSMA and CDMA systems. Generally fine-tuned power control is basic requirement in CDMA system but in this paper this requirement is isolated by combination of successive interference cancellation(SIC), open loop power control and user ordering. Through broadcast CSMA channel a network topology is obtained with high network conscious. The developed system suppressed existing problems with IEEE 802.11 and increases network throughput.

Mansour Zuair [16] suggested that the femtocell works like a cellular base station which is installed in homes and offices it can combine internet technologies and mobiles. As compared to less populated regions the cellular system is more better for high populated regions. Capacity and range are two major limitation of wireless communication. The avoidance of electromagnetic interference, the allocation of spectrum resources and network architecture are the difficulties for the installation of femtocells. Although, femtocells have some limitations but it also have some advantages such as capacity, scalability, expenditure and power. This research paper pointed out the simulation and models to improve the range of the system as well as to give access to subscriber at low cost. This simulation also allows sharing between operator and subscriber.

Saravanakumar and Nagarajan [17] pointed the concatenated code for multi carrier direct sequence CDMA technique at transmitter side. The cadence software is used to demonstrate the different parameters which is related to the result of the MC-DS-CDMA uplink system. The different parameters which is necessary and estimated for the execution of MC-DS-CDMA uplink system are memory, execution and number of transient steps, and the power consumed was also evaluated for every block of transmitter. For uplink mobile communication the better concatenated code model is utilized. The simulation shows that the efficiency of the network can be achieved by concatenating inner code and outer code.

Mustafa and Arslan [18] the ultra wideband is better due to minimum power decipation and maximum data rates along with less expenditure of hardware. However, due to the handling of very wide frequency band the ultra wideband is forced to coexist with powerful licensed communication networks which is transmitting in the same band. The interference made due to these networks are difficult and avoid the UWB communications. The literature states for narrowband interference avoidance large amount of work is required. There are several techniques which are NBI cancellation technique and NBI avoidance. This research work suggest the NBI identification approach. The purpose of NBI identification is by demonstrating useful interference statistics through some basic information about the resources of NBI.

Thomas Hou et al. [19] successive interference cancellation(SIC) is an advanced technique to avoid interference because of simultaneous reception from multiple transmitter and suppression of interference. But it is not unbearable to suppressed interference in multi-hop wireless networks. In this work for the purpose of avoiding interference in multi-hop wireless system combination of SIC and interference avoidance is used. Cross layer optimization framework is suggested to bunch up variable at physical, link and network layers. The validity and incorporation of SIC and interference avoidance are also shown mathematically. The paper also shows the limitations of SIC in multi-hop wireless system and how to overcome that limitations.

Charles and pottie [20] this research work states in the internal environment of wireless communication, the channel are changing slowly with respect to the users and the interference maintain the motion at slow speeds. In the hopping patterns for various interference levels the frequency hopped system become familiar for the increasing of system capacity allocate the slots different bit rates. It is shown that the NP-hard is the higher throughput bit or channel allocation problem. The interference avoidance is performed by the algorithm which have greater system capacity. By sending a greater signal constellations with little interference the users avoids the channel with greater interference and gives attention on their throughput in little portion of slots. Simulation demonstrate that the capacity of the network maximized through the adjustment of their bit rates performed by the users in the interference environment.

SPREAD SPECTRUM TECHNIQUES

Spread Spectrum techniques may be divided into two main groups.

1) DSSS (Direct Sequence Spread Spectrum)
2) FHSS (Frequency Hopping Spread Spectrum)

1) In case of spread spectrum, we use thousands of different carriers. These carriers are modulated with the original signal in order to generate thousands of DSBSC signals. The carriers are basically spread over a wide bandwidth which is much more than 2B and hence the resultant DSBSC signals are also spread out over a wide bandwidth.

As far as the question of the power of the transmitted signal is concerned, if the spread spectrum modulated signal total power is equal to the modulated power of DSBSC, then the power of the individual DSBSC signal (in case of spread spectrum) would be thousands time less. The reason being that in case of normal DSBSC signal the whole power is concentrated in the 2B bandwidth while in case of spread spectrum, the whole power is divided into thousands of DSBSC modulated signals. Thus the SNR in case of spread spectrum for each DSBSC component is very low, normally much lesser than 0db.

In case of spread spectrum, to recover the original signal at the receiver side what is really in need is the thousands of carriers exactly synchronized with frequency and phase with that of the transmitted thousands of carriers. All these carriers can be obtained by generating PRBS (psudo random binary sequence). In spread spectrum, we basically need to generate a psudo random binary sequence at the transmitter side and a similar psudo random binary sequence, clocked at the same time and of the same type as the transmitter sequence at the receiver side. And if the two psudo random binary sequences are properly aligned with each other, it is sufficient to regenerate all the carriers that are required at the receiver side for the purpose of demodulation. In literature, in the context of spread spectrum, psudo random binary sequence (PRBS) is known as a psudo noise (PN) because of its spectral resemblance with that of random noise.

Figure 3.1 depicts the operation of a DSSS spread spectrum system. The original message signal is encoded before transmission. The encoded signal is the output of two signals, among which one is the input message signal and the second one is the high frequency signal known as Psedo Noise Seqence--PN Sequence. (Pickholtz et al., 1991). This encoded signal is normally known as modulated signal and the operation increases its bandwidth that is spreads out its frequency contents. The encoded or modulated signal is then transmitted through the channel. At the receiving end, to de-spread the received signal one needs to apply the same process as applied at the transmitter side with the same PN Sequence. (Magill et al., 1994). The complete working of operation and the general model of the whole DSSS Spread System is given below.

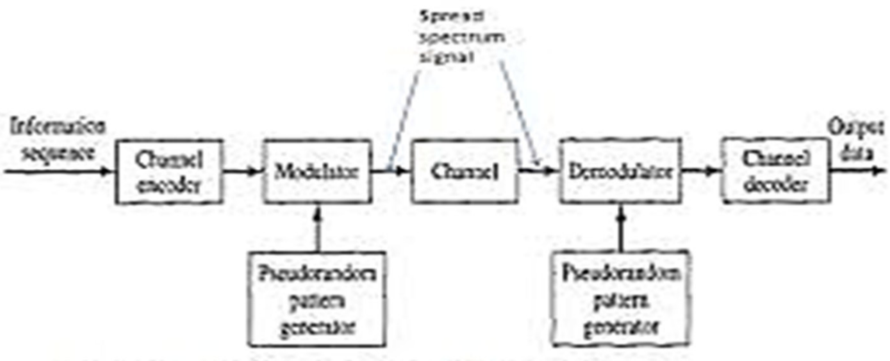

Figure3.1 General Model of DSSS Communication [22]

In case if the two psudo random binary sequences are not coherent, synchronized and aligned with other, the message contributions from the DSBSC signals at the receiver side will add out of phase and they will fail to generate the original signal. In fact, they will end up by generating a small noise like output.

2) Now it is pertinent to shower some light on the mechanism, working and importance of the second form of spread spectrum which is known as frequency hopping spread spectrum (FHSS). As we saw that in DSSS, we convolve the original message signal with the spreading sequence and as a result we can minimize the impact of noise and also we can transmit at more higher rates than data rates. But FHSS has got some importance over DSSS for example, DSSS is difficult to implement as it is more complex; also DSSS is not suitable for

lower power systems as it implies high data rates. On the other hand, FHSS is more suitable for low power systems as it enjoys low data rates.

As clear from the name, FHSS utilizes the technique of frequency hopping that is changing the frequencies of the carrier during communication. Its importance is that jamming such communication become difficult as the communication's frequency changes with time. Until one knows the hoping difference, it is difficult to jam such communication. So with the passage of time, the frequency will change. The time interval of one hope in which data cannot be transmitted or received, is known in literature as blanking time or interval. And the time in which data can be transmitter or received is known in literature as dwell time.

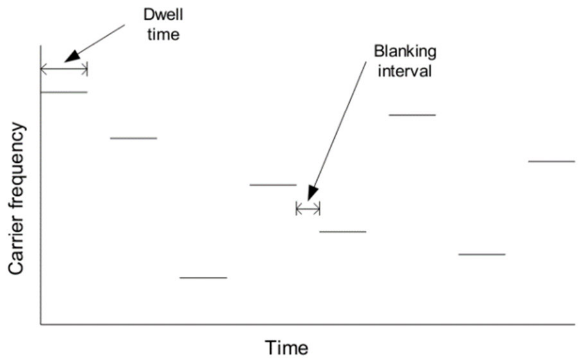

Figure 3.7 Frequency Hopping Spread Spectrum [29]

The main objective of the pseudo-irregular jumping example is to stop or refrain from meddling flags by not investing all that much time on any particular recurrence. In the process that impedance is available on any of the diverts in the jumping example, despite the fact that the RF sign will encounter obstruction now and again, it will be minimized by the little measure of time used transmitting on that recurrence (Proakis, 1994).

SIMULATIONS AND RESULTS

All the techniques and ideas that have been discussed in last sections was implemented by designing codes of each of the mechanism. The implemented mechanisms in the form of Matlab codes was simulated in Matlab environment. The results of the simulation processed is presented and discussed here.

In the first part an algorithm is implemented for generating a data message of any kind that would be intended to transmit over the channel. The bit stream is named as original data bits. To observe the frequency contents of the data message, an algorithm is designed that is plot the spectrum of the message bits. In the next stage, an algorithm is designed to generate a random sequence that is meant to modulate with the original data bits so that the spectrum of the original message bits can be spreader. To check out the frequency contents of the random code sequence, the FFT of the code sequence is generated and plotted in Matlab software. At the next level, the original data bits are modulated with the random sequence that has been generated and the modulated signal is plotted in the Matlab software. To analyze the frequency contents of this modulated signal, FFT of the generated modulated signal is calculated and hence is plotted. To verify the impact of spread spectrum on the noise and original data bits, the modulated signal is generated at different SNR values let us say 5, 10 and 15. All these cases is implemented and simulated in this Chapter. Also the spectrum of the modulated signal at each SNR value is observed and analyzed through their plots. Then noise is added to this modulated spread spectrum signal and the signal is transmitted. The modulated signal is received at the receiver side. It is demodulated and the original message or data bits is recovered and the result is deduced that with spreading the spectrum of the message or data bits, the impact of interference or noise signal upon the original signal is minimized.

To meet the second objective of the research project, both the mechanisms of spread spectrum that is DSSS and FHSS is implemented in the Matlab software and the bit error decay rate (BER) of both the mechanisms is plotted in order to compare the performance and efficiency of both of these mechanisms.

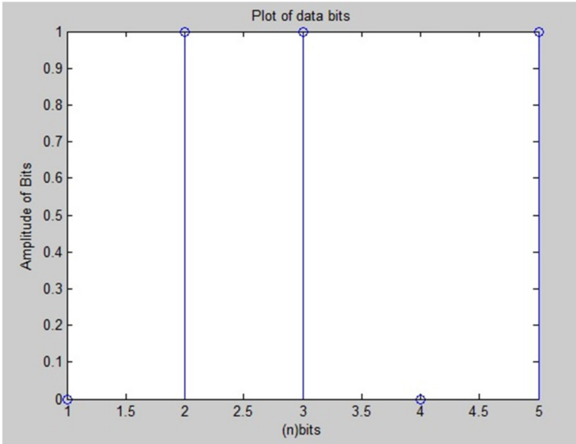

Figure .1 Original Information or Message Signal

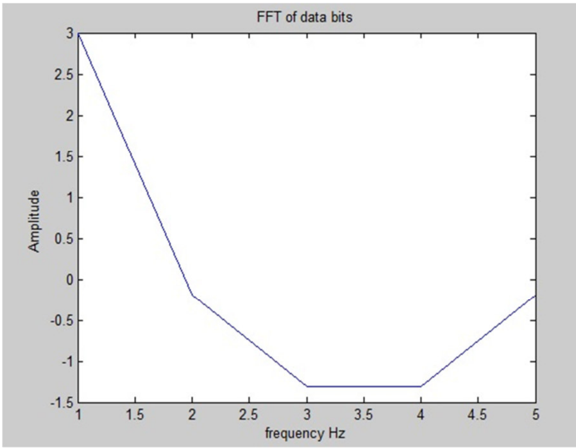

Figure 2 Spectrum (FFT) of Information or Message Signal

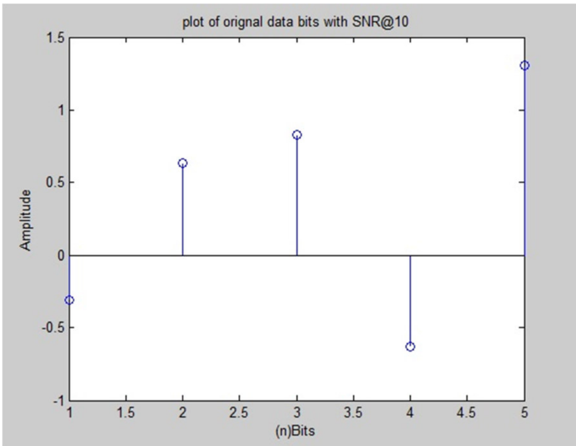

Figure 3Original Message Signal at SNR 10

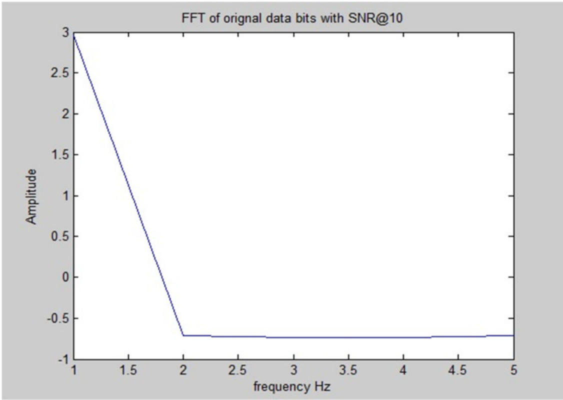

Figure 4Spectrum (FFT) of original message signal with SNR

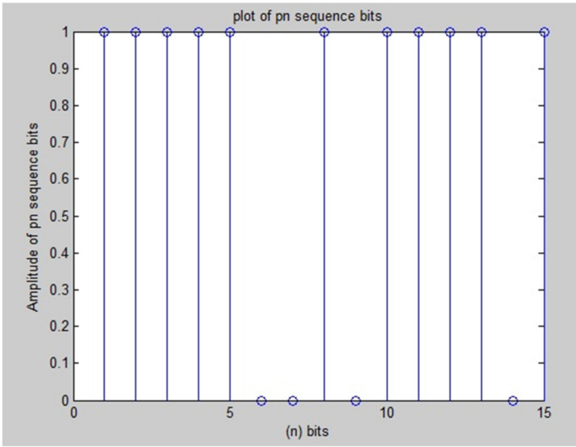

Figure 5 PN Seqence (Amplitude Vs n)

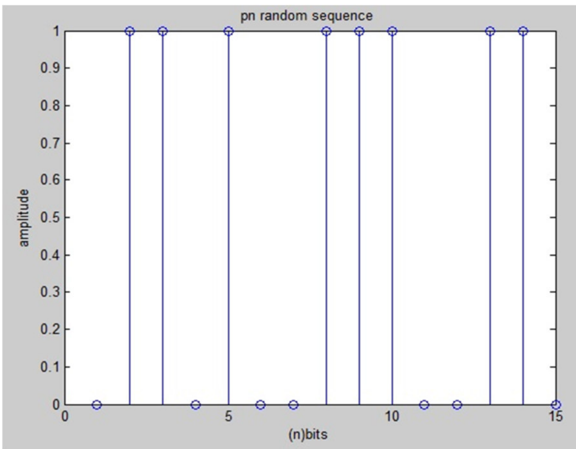

Figure 6 Random PN Sequence

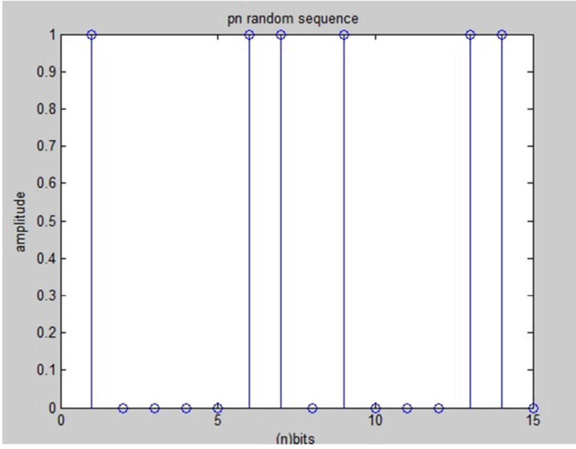

Figure 7 Plot of Random pn Sequence

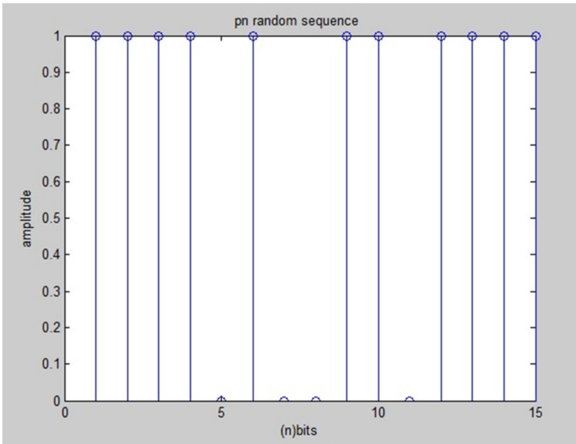

Figure 8 Random PN Sequence

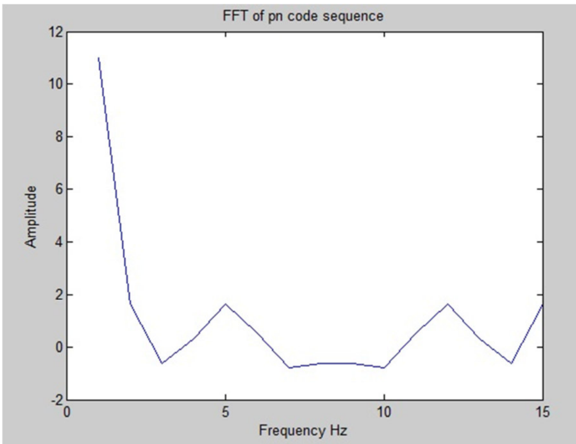

Figure 9 Spectrum(FFT) of PN sequence

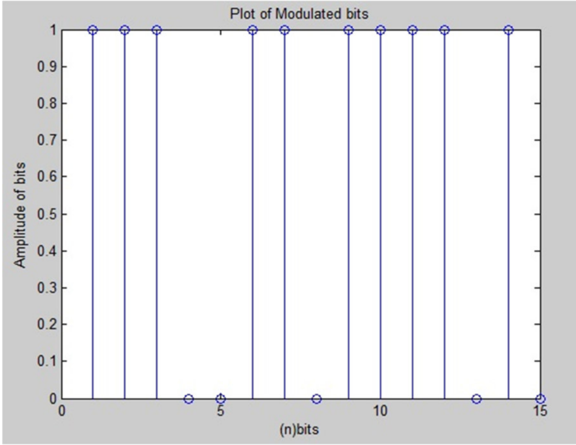

Figure 10 modulated Signal

Now to check that the Spread Spectrum system is less susceptible to noise, as it spreads the noise uniformly in the Spectrum, I have introduced White Gaussian Noise in the system. The Fourier Transform of the spectrum is not so much distorted or changed because a little noise doesn't effect the wide bandwidth of the signal as shown in figure 8 Now we have to see does this effect the original bits on the receiving side and gives some errors. If the received bits are received as they were transmitted without any error, it will show that Spread Spectrum ignores and neglects a small noise introduced in the system.

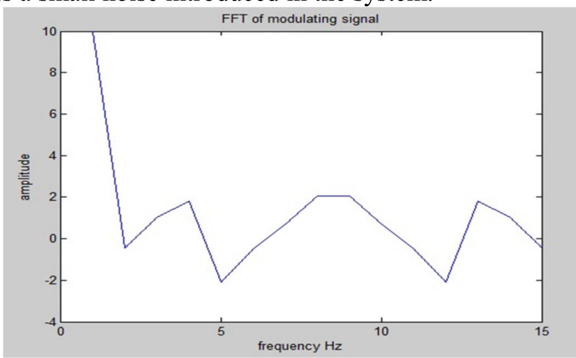

Figure 11 Spectrum(FFT) of modulated signal

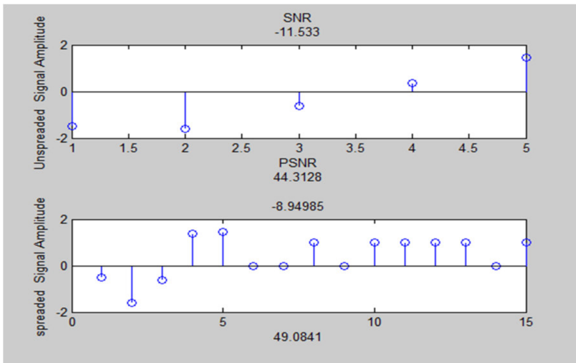

Figure 12 Modulated Signal With SNR

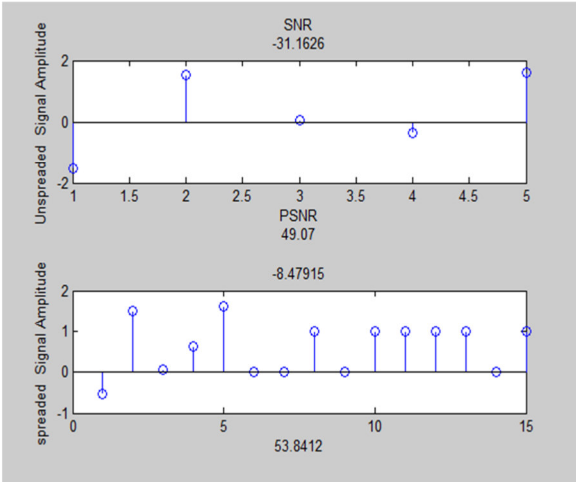

Figure 13 Modulated Signal With SNR

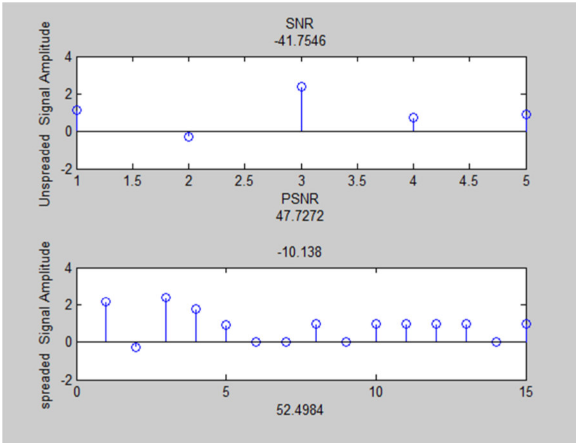

Figure 14 Modulated Signal With SNR

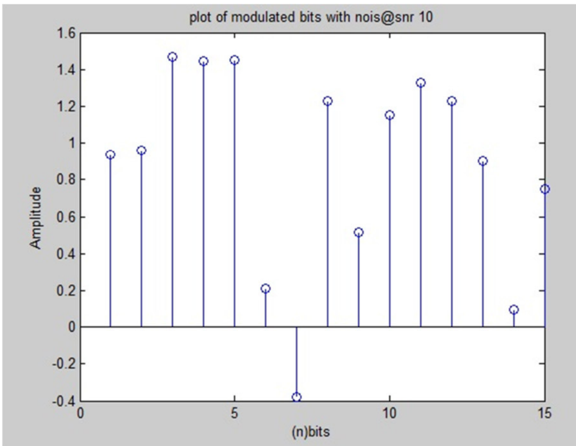

Figure 15 Modulated Signal With Noise

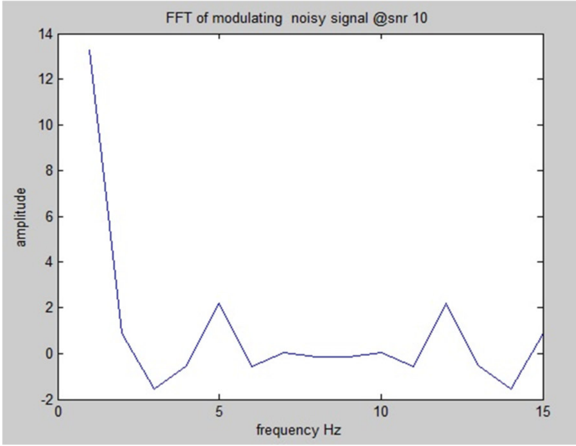

Figure 16 Spectrum (FFT) of modulated Signal With Noise

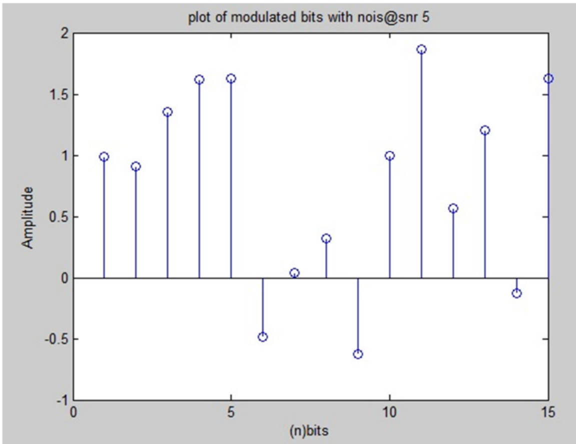

Figure 17 Modulated Signal With Noise

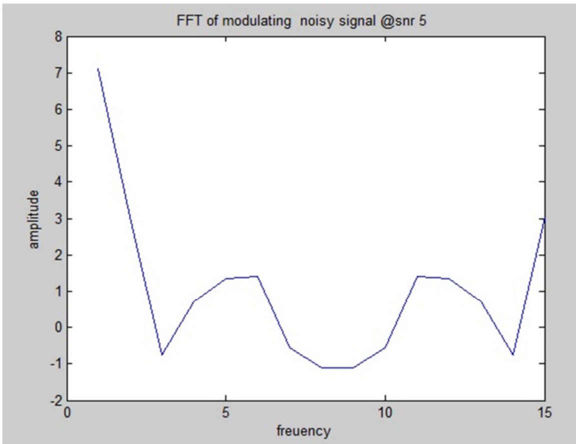

Figure 18 Spectrum(FFT) of modulated Signal with noise

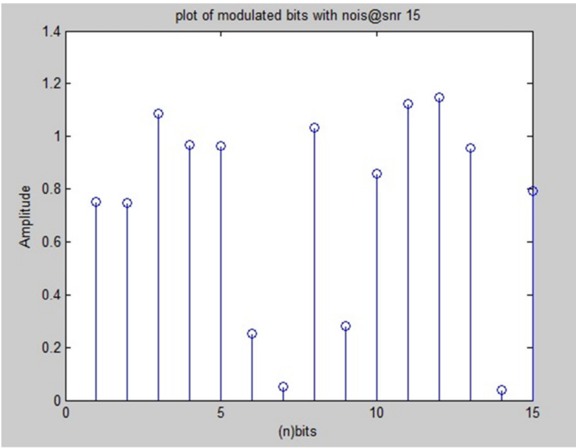

Figure 19 Modulated Signal With Noise

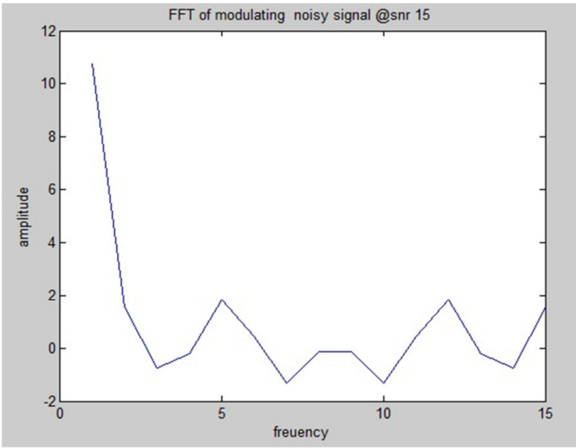

Figure 20 Spectrum(FFT) of modulated signal with noise

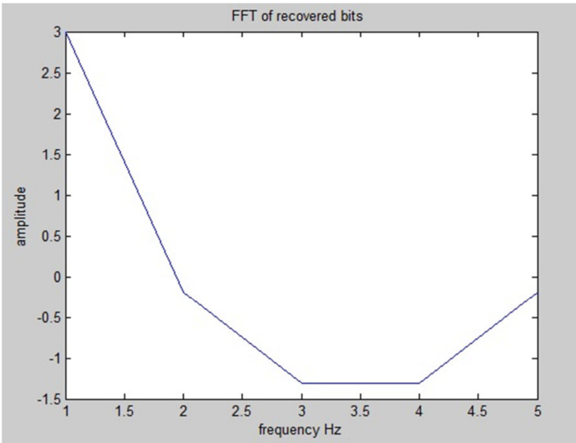

Figure 21 Spectrum(FFT) of recovered bits

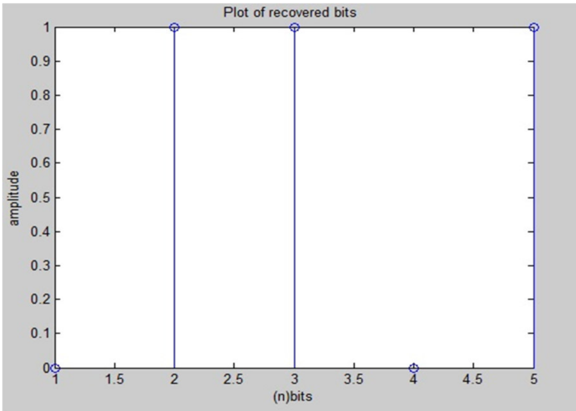

Figure 22 Recovered Original Message Signal (De-Spreaded)

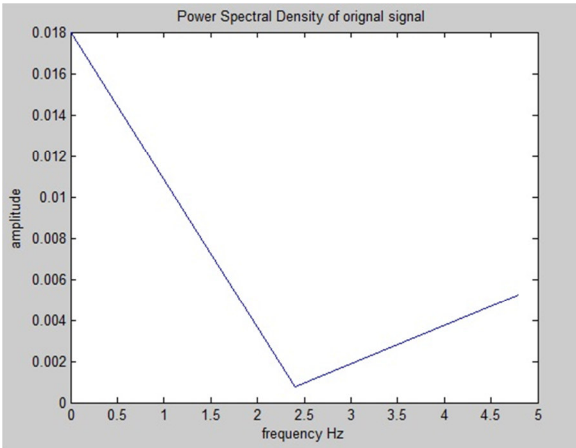

Figure 23 PSD (Power Spectral Density) of Recovered Message Signal

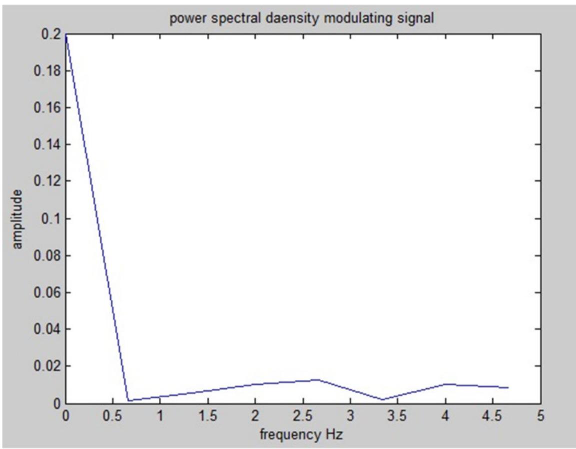

Figure 24 Power spectral density (PSD) of modulated Signal

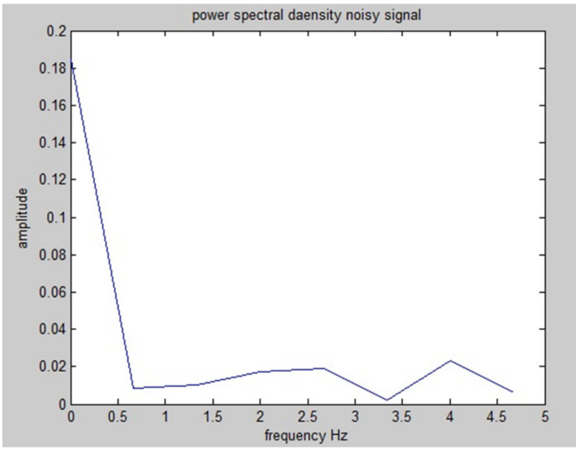

Figure25 Power spectral density (PSD) of noisy signal

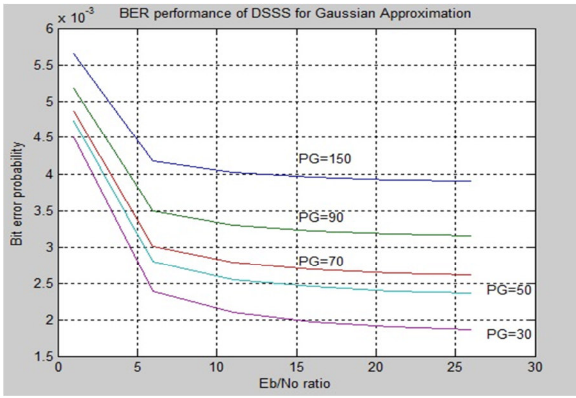

Figure 26 Bit Error Decay Rate performances of DSSS for Gaussian Approximation

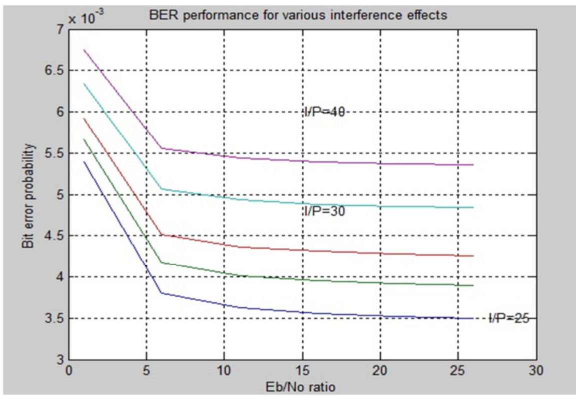

Figure 27 Bit Error Decay Rate performance for various interference effects

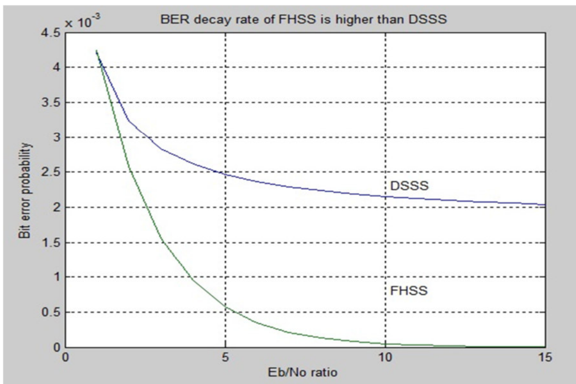

Figure 28 Bit Error Decay Rate of FHSS and DSSS

CONCLUSION

It is clear from the simulation results that if interference inputs have lower gains then error probability will reduce. In figure 26 the two spread spectrum techniques have been compared in terms of bit error probability. It is clear from the simulation results that FHSS has faster bit error decay rate than DSSS.

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