Analysis of Multiuser DSSS with Different M-PSK Modulation Under Noise Effects

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Abstract: *Lot of applications in these days is using Spread spectrum communication systems. Direct Sequence Spread Spectrum (DSSS) system can reduce the effects of interference on the transmitted information and it is suitable for design of multi-user systems where the entire bandwidth of the RF carrier is made available to each user. It is robust against channel impairments. The aim of this paper is to study the performance of multiuser DSSS system under adaptive white Gaussian noise AWGN radio impairment for different types of baseband phase shift keying modulation. The simulation process is performed using Simulink tool where the signals from the base station are modulated using M-PSK method and then transmitted to varying number of mobiles (one to eight). The signal received at each mobile will be demodulated using the same M-PSK method and then estimated separately. The simulation results show that the bit error rate (BER) increases as a result of increasing the number of users and/or the M value of the M-PSK modulation mode. So, M-PSK is better in term of BER when the value of M is small.*

KEYWORDS: *DSSS, M-PSK, BER, AWGN Channel.*

I. Introduction

The wideband Spread Spectrum (SS) communication systems [1,2,3,4]are widely used today in a variety of applications for different purposes such as access of same radio spectrum by multiple users (multiple access), anti-jamming capability (so that signal transmission cannot be interrupted or blocked by spurious transmission from enemy), interference rejection, secure communications, multi-path protection, etc. However, irrespective of the application, all spread spectrum communication systems satisfy the following criteria- (i) as the name suggests, bandwidth of the transmitted signal is much greater than that of the message that modulates a carrier. (ii) The transmission bandwidth is determined by a factor independent of the message bandwidth. The power spectral density of the modulated signal is very low and usually comparable to background noise and interference at the receiver.

The SS signal is generated from a data-modulated carrier. The data-modulated carrier is modulated a second time by using a wideband spreading signal. The spreading modulation may be phase modulation or a rapid change of the carrier frequency, or it may be a combination of these two schemes [5].

The most known spread spectrum techniques are frequency hopping spread spectrum and direct sequence spread spectrum. In Frequency Hopping Spread Spectrum,the signal is broadcasted over a random series of radio frequencies, hopping from one frequency to another frequency at fixed intervals a receiver, hopping between frequencies in synchronization with the transmitter picks up the message. When spectrum spreading is performed by phase modulation, the resultant signal is called direct-sequence spread spectrum (DSSS)[6].

The aim of this paper is to study the performance of simulated DSSS system when transmitting signals from the base station to varying number of mobiles. The transmitted signalsare modulated using M-PSQ method with different M values (2,4,8 and 16) and are demodulated at the receiving sets at the same manner. The transmission channel is assumed to be adaptive white Gaussian noise AWGN radio impairment with different cases of signal to noise ratio Eb/No (-100 to 40 dB).The rest of the paper is organized as follows. Section II illustrates the concept of DSSS. Section III discusses the suggested simulation platform, and the performance measurements results are discussed in Section IV. Finally, the paper is concluded in Section V.

II. Direct Sequence Spread Spectrum

In DSSS, each bit in the original message is represented by multiple bits in the transmitted signal. This is achieved by modulating a bit sequence known as the Pseudo Noise (PN) code by the original signal; this PN code consists of a sequence of ones and zeros (called chips), which alternate in a random fashion and a much shorter duration (larger bandwidth) than the pulse duration of the message signal. Therefore, the modulation by the message signal has the effect of chopping up the pulses of the message signal and thereby resulting in a signal which has a bandwidth nearly as large as that of the PN sequence[1]. In this context the duration of the pulse of the PN code is referred to as the chip duration and the smaller this value, the larger the bandwidth of the resultant DSSS signal and the more immune to interference the resultant signal becomes. There are many DSSS transceiver implementations. Figures 1 and 2 represent both the DSSS transmitter and receiver block diagrams respectively.

Dispreading can be considered as mathematical correlation of the transmitted PN sequences with the PN sequence that the receiver believes the transmitter is using. For dispreading to work correctly, transmit and receive sequences must be synchronized. Enhancing effect can be improved by employing a longer PN sequence and more chips per bit, but physical devices used to generate the PN sequence impose practical limits on attainable processing gain.

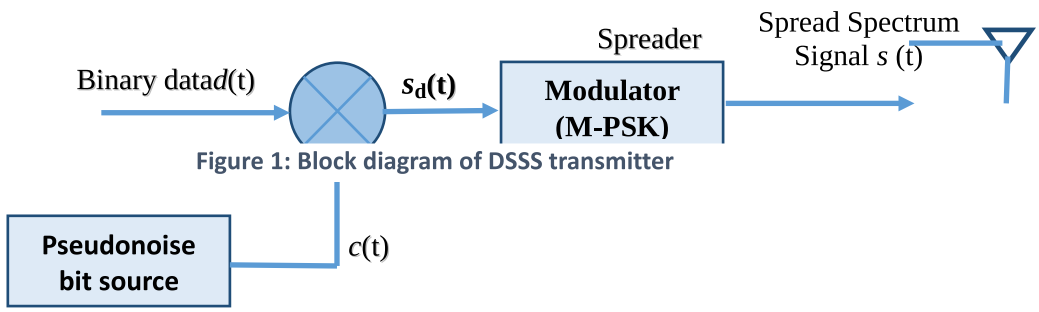


Figure 1: Block diagram of DSSS transmitter

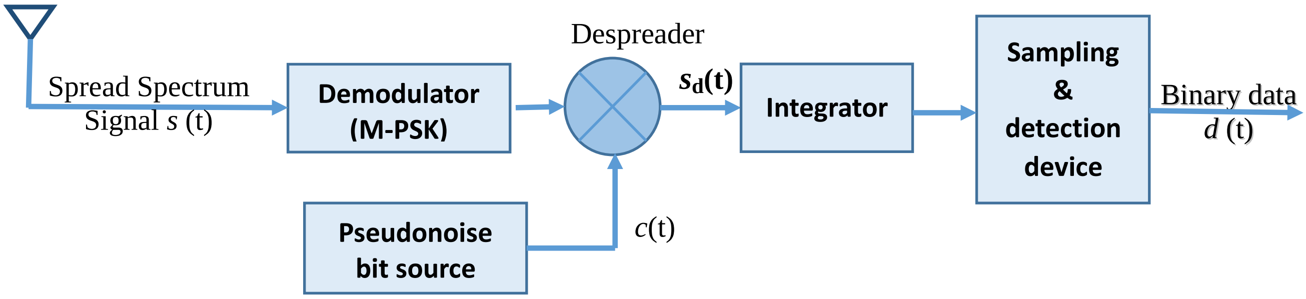


Figure 2: Block diagram of DSSS receiver

III. Simulink Design and Implementation

All the models in this paper are developed in accordance with the block diagram shown in Figure 3. Thefigure shows four basic communication stages used for a single user:

The Transmitter Stageprocesses the input signalreceived from the source. The source of information is the random integer element, which generates random uniformly distributed integers in the range [0, M-1], where M is the M-ary number (M=2 for binary information).The output from the random integer generator is used to modulate the output from the PN sequence generator. The PN sequence generator produces a pseudorandom noise (PN) sequence using a linear feedback shift register (LFSR). In Simulink [y], the LFSR is implemented using a simple shift register generator (SSRG, or Fibonacci) configuration. The modulated (spreaded) signal is converted from one form toanother according to the type of the transmission medium that represents the signalnature.In the current scheme for single user (Fig.3), the spreaded signal is modulated by a RF carrier which is represented by theM-PSK modulation element

(M varies as =2, 4, 8 or 16).Owing to PSK's simplicity, it is widely used in existing technologies. The wireless LAN standard, IEEE 802.11b-1999[7, 8] uses a variety of different PSKs depending on the data rate required. Referring to the M-PSK [4] modulation technique, the phase of the carrier signal is altered in response to the incoming data signal. Since the data to be conveyed are usually binary, the PSK scheme is usually designed with the number of constellation points being a power of 2. For example, In case of binary phase-shift keying (B-PSQ), where M=2, the phase of the carrier is switched between two values to represent binary 0 and 1.

The Transmission Channel. The transmission channel represents the physical or wireless medium, which can be used to transmit a signal from the transmitter to the receiver. Due to the channel impairments, the information sent and received will not be the same. AWGN channel is used in this scheme to add white Gaussian noise to the input signal when it passes through the channel. AWGN is often used as a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude[10,11,12].It contains a uniform continuous frequency spectrum over a particular frequency band. The swept signal to noise ratio, in SNR, Eb/N_0 or Es/N_0 can then be directly specified at the AWGN block. Eb/N0 (Energy per bit to Noise power spectral density ratio) is an important parameter in digital communication or data transmission. It is a normalized signal to-noise ratio (SNR) measure, also known as the "SNR per bit". It is especially useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account. Eb /N0 is equal to the SNR divided by the "gross" link spectral efficiency in (bit/s)/Hz, where the bits in this context are transmitted data bits, inclusive of error correction information and other protocol overhead [9].

The Receiver Stage processes the input signal received from the transmission media through antenna. The received signal is demodulated by a RF carrier which is represented by the M-PSK demodulation element (M varies as =2, 4, 8 or 16) with the same order as the order of the modulator in the transmitter stage. The output from the demodulator is multiplied withthe output from the PN sequence generator. The PN sequence generator produces a pseudorandom noise (PN) sequence which must coincide and is synchronized with that produced from the corresponding PN sequence generator of the transmitter stage. The output signal is Integrated over number of samples in integration period and reset at the end of integration passing its output to a sign element yielding 1 for positive input, -1 for negative input, and 0 for 0 input.

The Error Calculation Stage Computes the error rate of the received data by comparing it to a delayed version of the transmitted original data. The block output is a three-element vector consisting of the error rate, followed by the number of errors detected and the total number of symbols compared.

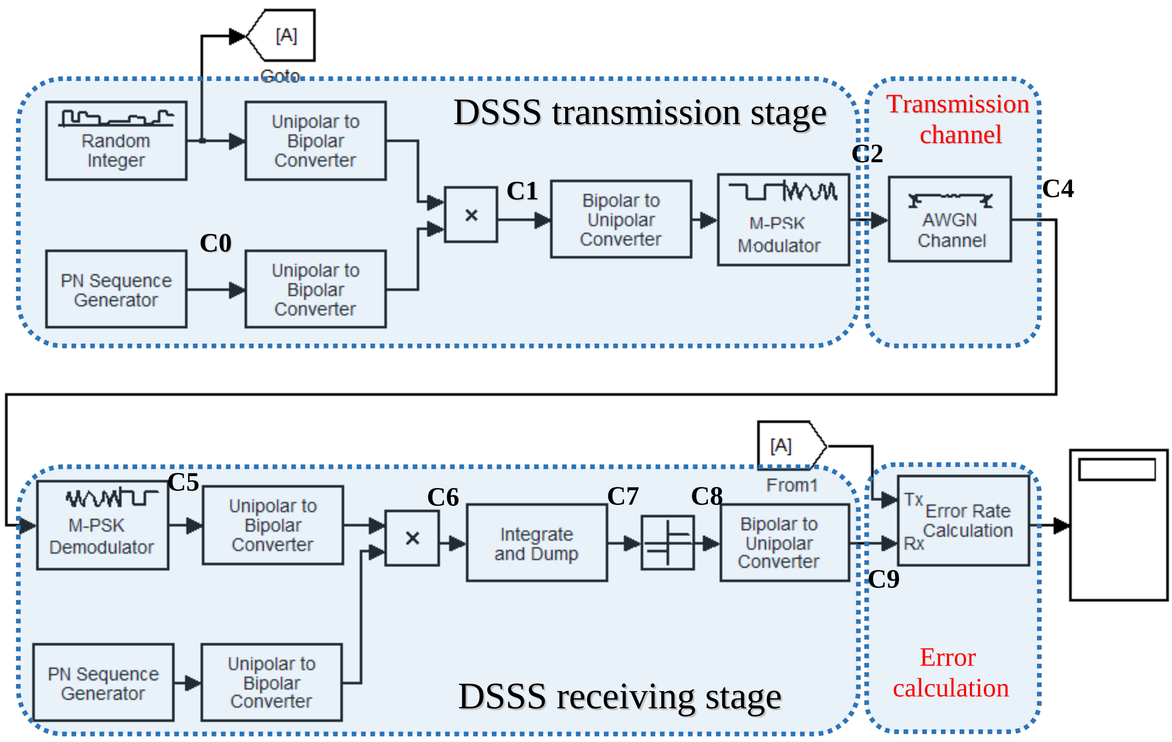


Figure 3 the block diagram of the single user DSS simulation using Simulink

The Simulink scheme for multiuser platform is shown in Fig.4. Each user's track is developed in accordance with the stages prescribed in Figure 3 where the signals are collected in the base station before transmitting them in the common transmission media. Each mobile station receives the transmitted signal and handles with the corresponding PN sequence generator yielding the original transmitted signal.

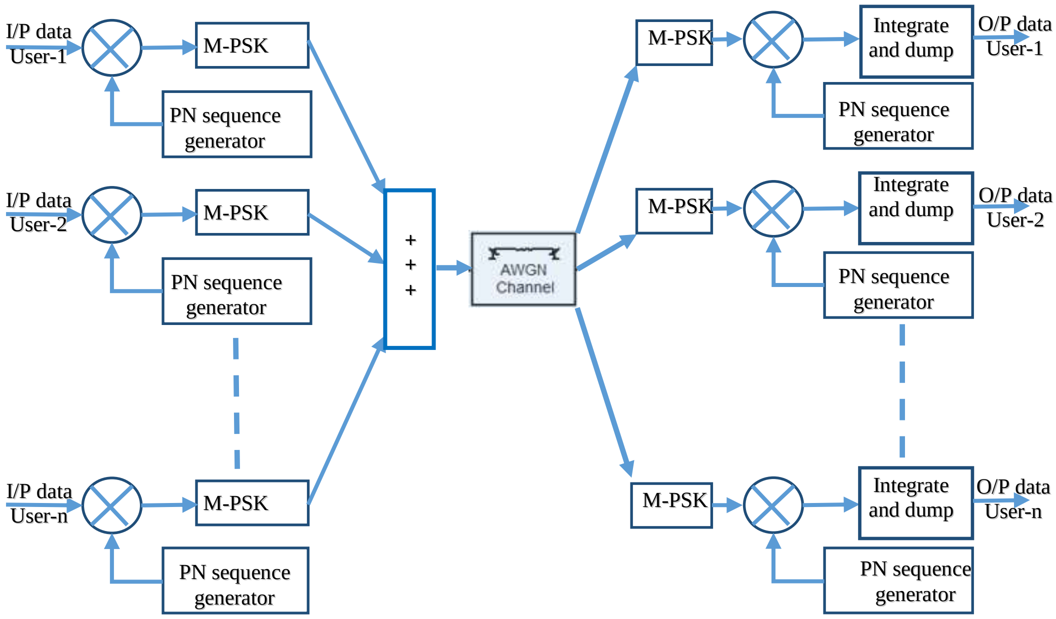


Figure 4: The block diagram of the multiuser DSS simulation using Simulink

The overall behavior of the Simulink scheme (Figures 3 and 4) are traced by displaying the signal for one of the eight users at different points of the scheme (Figure 5) where the EB/No value is set to 40. It is found that the input data (at point A in Figure 3) coincides with the obtained output data (at point C9 of the same figure). The signals displayed at points C3 and C4 of the same figure represent the summed signals of eight users before and after the transmission channel (AWGN block) respectively.

IV. Performance Measurements

According to the prescribed Simulink scheme shown in figures 3 and 4, the performance of DSS system for a single user is analyzed and estimated for different M-PSK modes (M=2,4,8 and 16) respectively. The bit error rate (BER) is measured for different Energy per bit to Noise power spectral density ratio (Eb/No) in the range from -100 to 40 dB. The obtained results are plotted as shown in Figure 6.A. For single user, the BER value remains zero for all Eb/No values less than zero. The same procedure is performed again increasing the number of users up to eight users yielding the results shown in Figure 6. As expected, it is noticed that the BER valuesfor lower values of M-PSK are less than that for the higher values of M-PSK. Comparing the results for different number of users, it is noticed that the BER value increases with increasing the number of users.

The same results are displayed in different manner in Figure 6 considering the M value of M-PSK. It is shown that the minimum value of BER increases with increasing the number of users and this coincides with the conclusion obtained from Figure.6.

In Figure 7, regardless of the minimum value of BER, it is noticed that the BER value increases slowly for the higher number of users more than that for lower number of users. This note can be explained with that the peak value of the summed signal for high number of users is high and this makes the signal more immune to the noise effect.

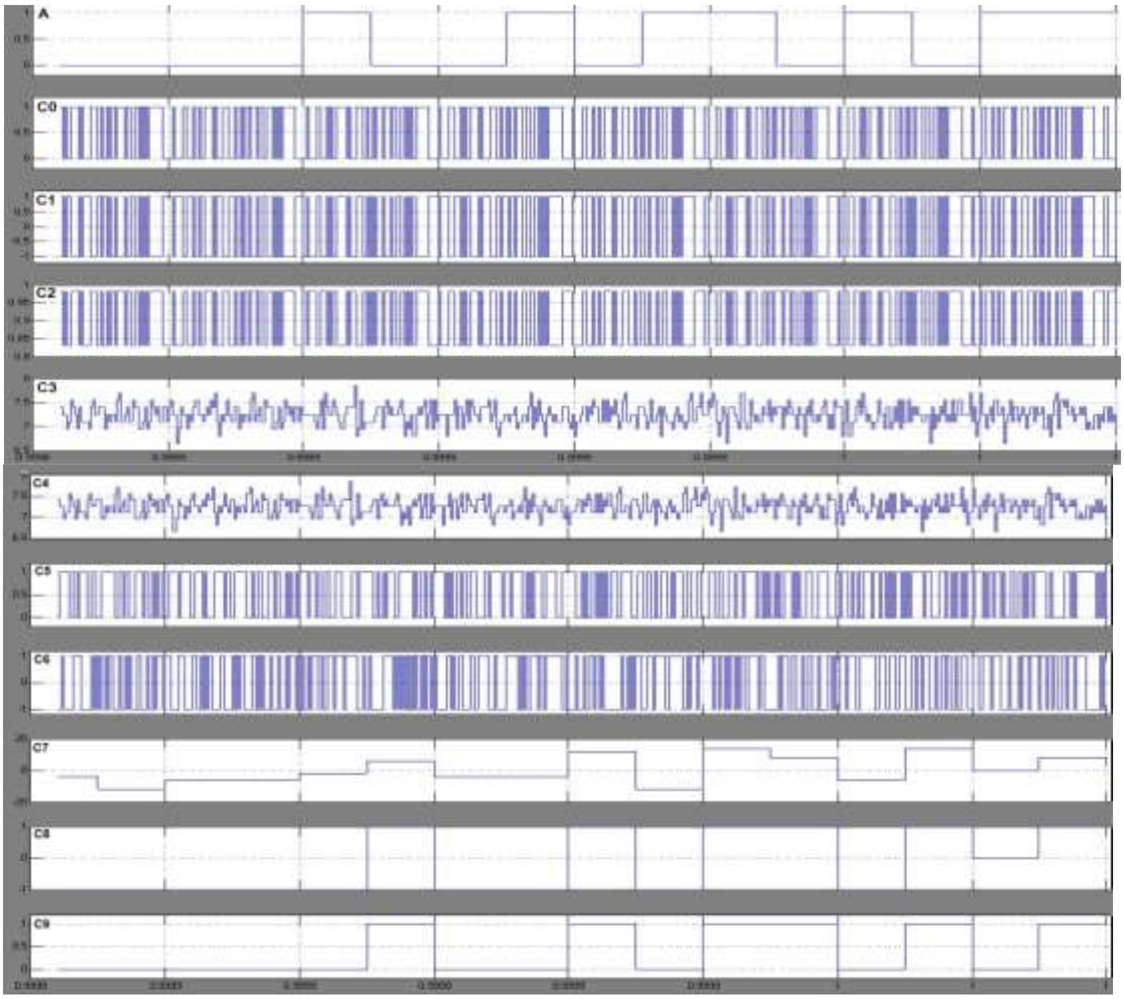
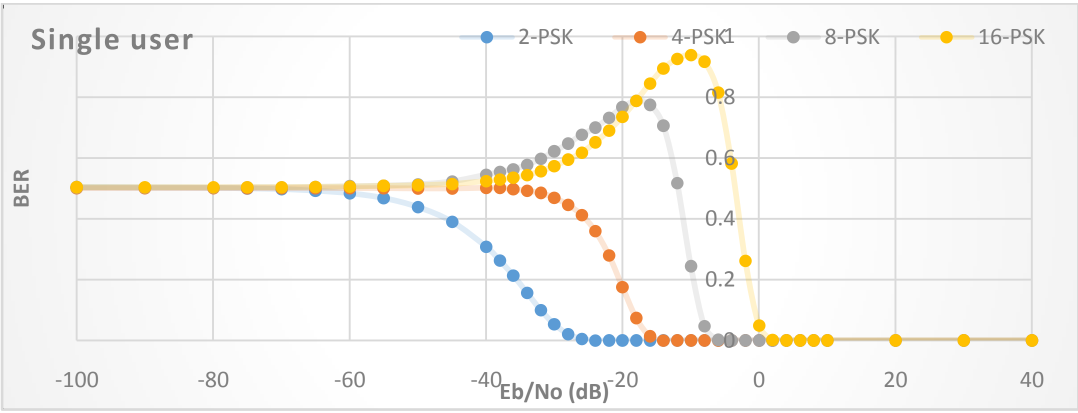
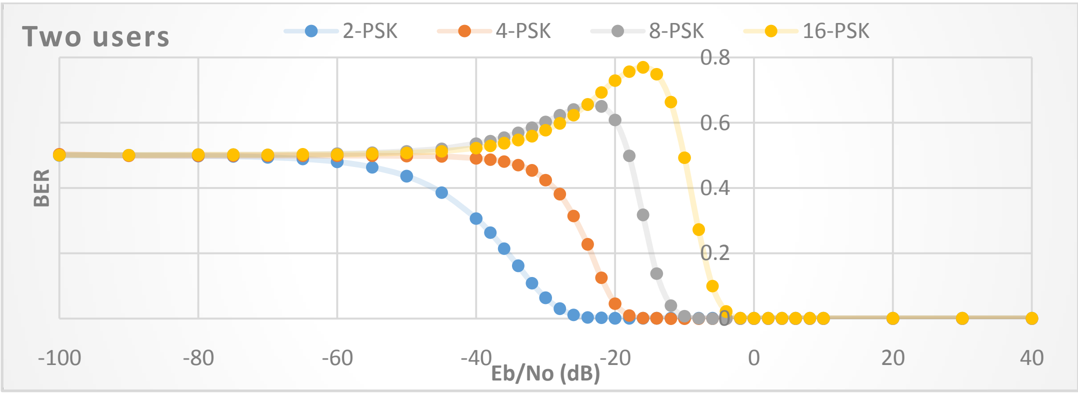
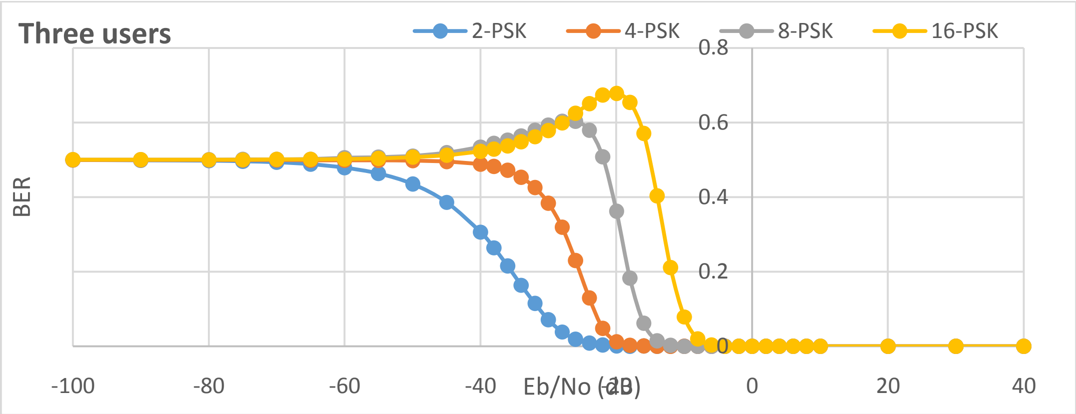
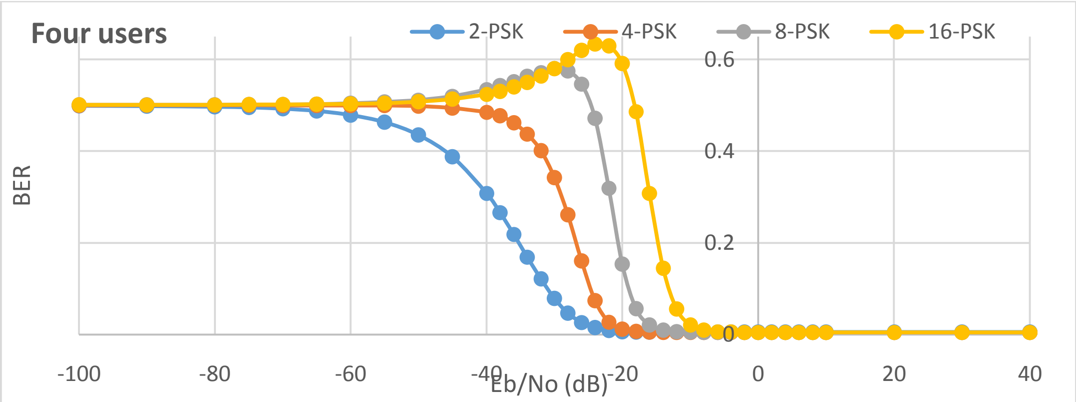


Figure 5: Signal tracing at different points of the Simulink svheme


Single user
2-PSK
4-PSK
8-PSK
16-PSK
BER
Eb/No (dB)


Two users
2-PSK
4-PSK
8-PSK
16-PSK
BER
Eb/No (dB)


Three users
2-PSK
4-PSK
8-PSK
16-PSK
BER
Eb/No (dB)


Four users
2-PSK
4-PSK
8-PSK
16-PSK
BER
Eb/No (dB)

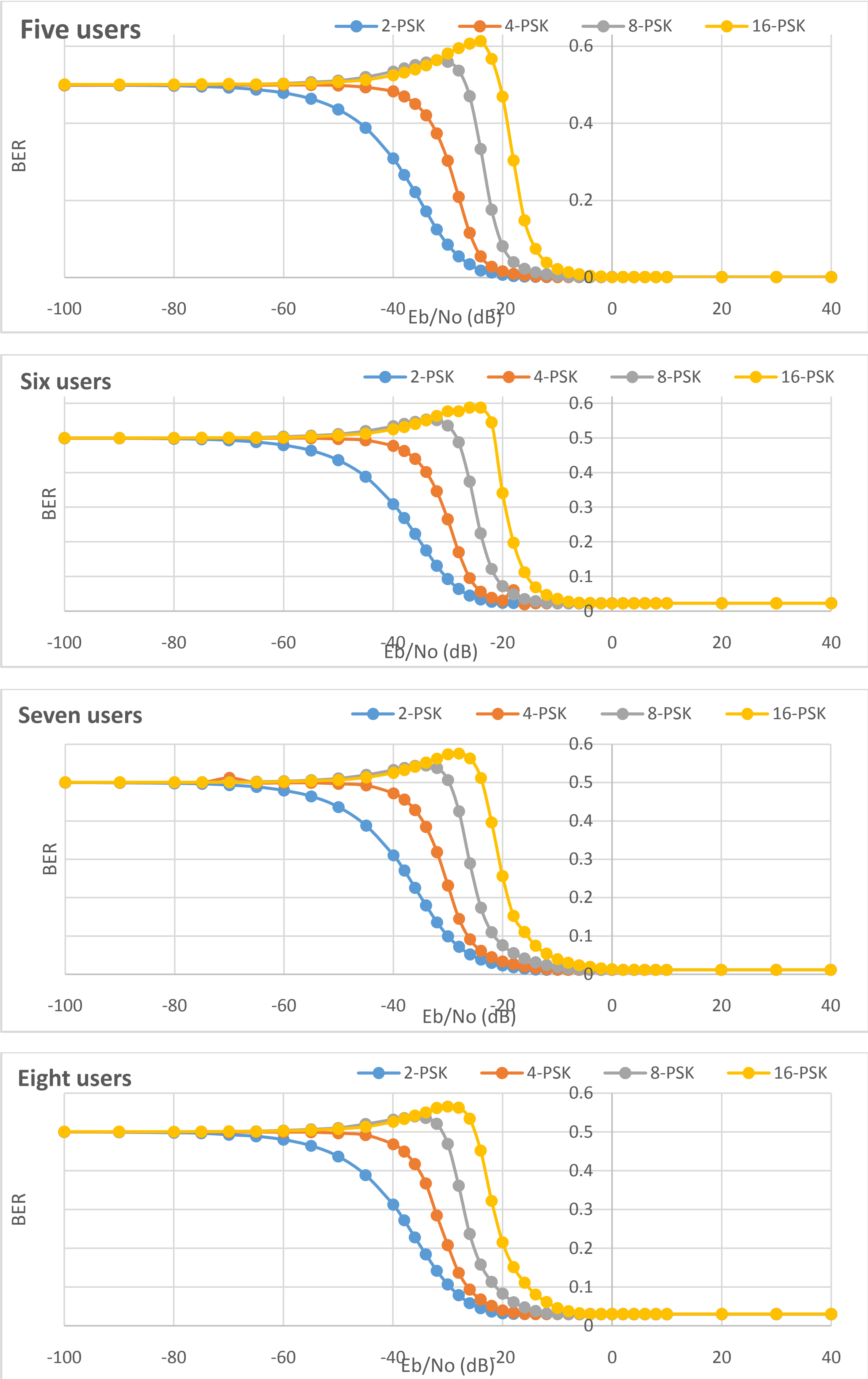
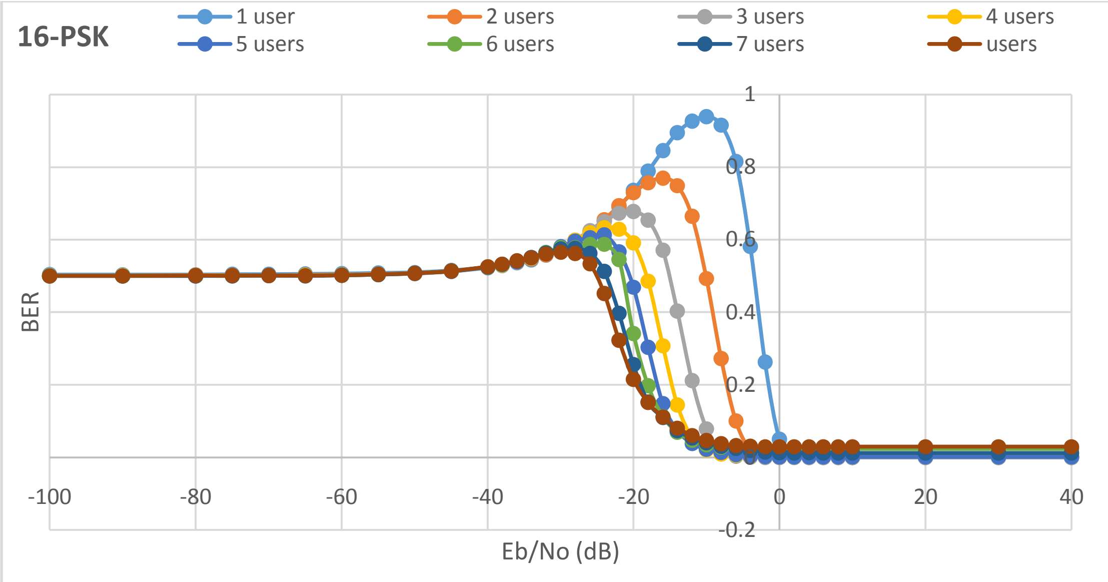
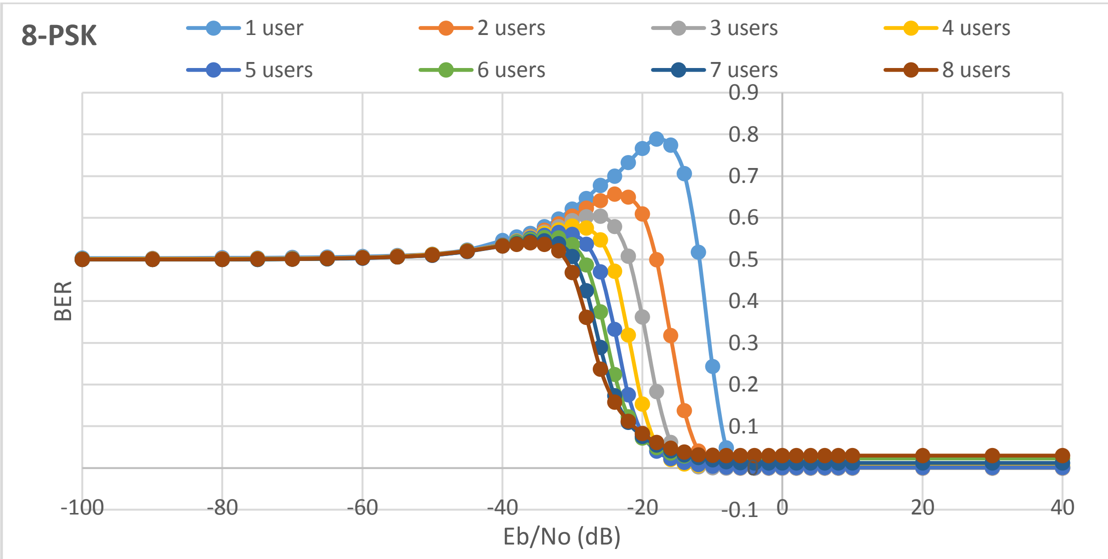
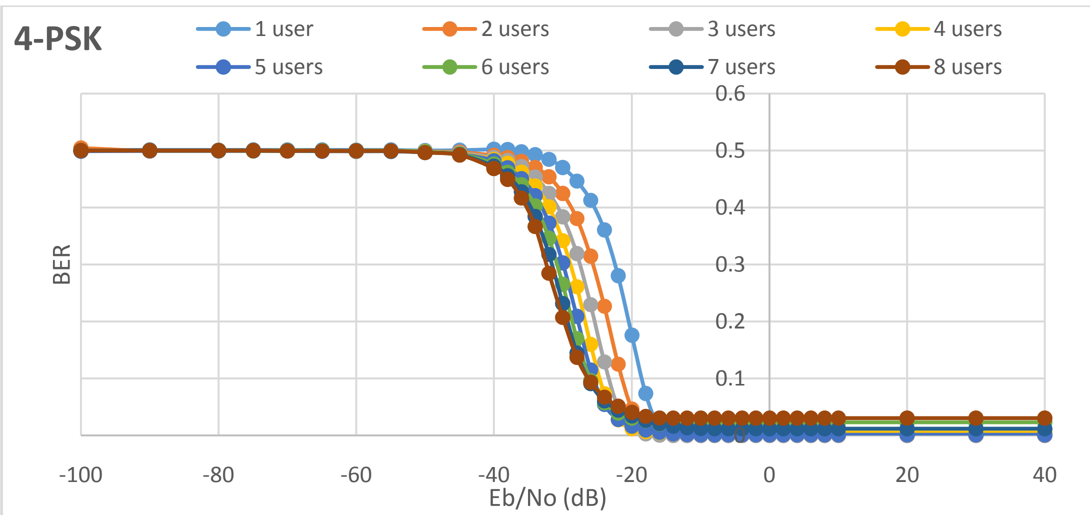


Figure 6: BER vs Eb/No for different M-PSK modes and different number of users


16-PSK
1 user
2 users
3 users
4 users
5 users
6 users
7 users
users
BER
1
0.8
0.6
0.4
0.2
-0.2
-100
-80
-60
-40
-20
0
20
40
Eb/No (dB)


8-PSK
1 user
2 users
3 users
4 users
5 users
6 users
7 users
8 users
BER
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.1
-100
-80
-60
-40
-20
0
20
40
Eb/No (dB)


4-PSK
1 user
2 users
3 users
4 users
5 users
6 users
7 users
8 users
BER
0.6
0.5
0.4
0.3
0.2
0.1
-100
-80
-60
-40
-20
0
20
40
Eb/No (dB)

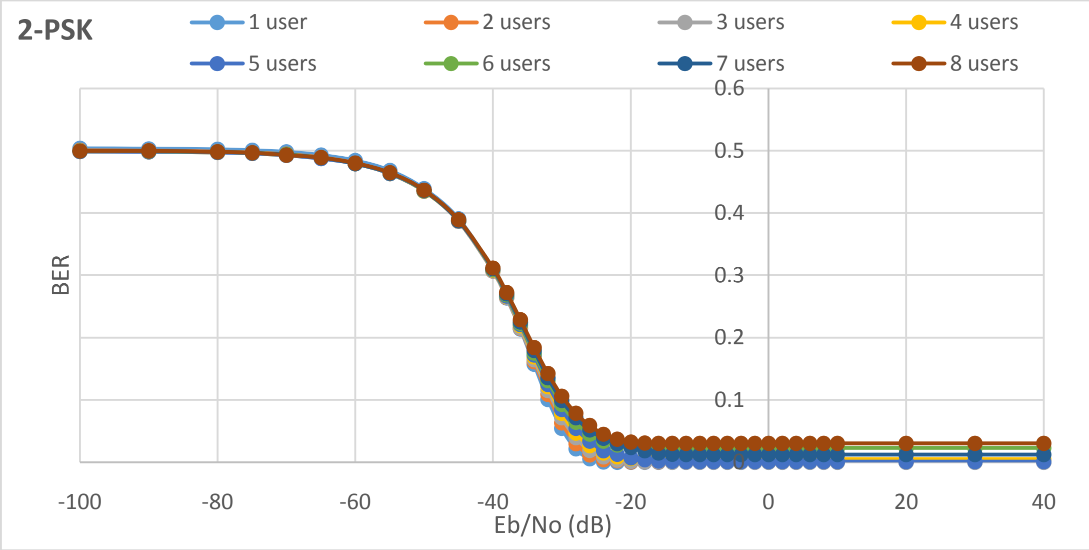


Figure 7 BER vs Eb/No for different M-PSK cases for different number of users

V. Conclusion

The performance of multiuser DSSS system under Adaptive White Gaussian Noise AWGN radio impairment for different types of baseband phase shift keying modulation has been studied in this paper. The simulation process is performed using Simulink tool where the signals from the base station are modulated using M-PSK method and then transmitted to varying number of mobiles (one to eight). The signal received at each mobile is demodulated using the same M-PSK method and then estimated separately. The obtained measurements shows that the bit error rate (BER) increases as a result of increasing the number of users and/or the M value of the M-PSK modulation mode. So, M-PSK is better in term of BER when the value of M is small.

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