M-ARY PSK Scheme in Cellular Environment

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ABSTRACT

In digital communication scheme design, the foremost objective is to receive data as analogous as the data sent from the transmitter. To outlook the system's performance it is essential to examine the system in term of probability of error. This paper emphases on comparative performance analysis of M-ary PSK modulation schemes. The simulation results exhibit that increasing of M results in increase of BER. Error rates of M-ary PSK system versus the signal-to-noise ratio (SNR) are used to assess the performance of M-ary PSK system.

Keywords

IDMA Systems, M-ary PSK, multiuser detection, AWGN Channel, Bit Error Rate.

1. INTRODUCTION

Wireless Communication is fleeting through its rapid progresses and challenges in the history. This growth, in turn, has engendered an increasing need to seek automated methods of analyzing the performance of digital modulation types using the newest mathematical softwares. Though, there are a number of digital modulation schemes that have been proposed however there is a tradeoff between data rate and bit error rate among the transmitter and receiver [1]. M-ary PSK provide higher data rate and enhanced bandwidth efficiency, and thus regarded as one of the most proficient digital data transmission scheme [2]. In this paper, simulations are used to compare the performance of M-ary techniques which comprises M-ary Phase Shift Keying (M-PSK) and M-ary Differential Phase Shift Keying (M-DPSK) together with analysis of bit error rate (BER) in the presence of Additive White Gaussian Noise (AWGN).

2. ITERATIVE IDMA STRUCTURE

The structure of a transmitter and a receiver for an IDMA system with K simultaneous users is clearly displayed in Figure 1. The receiver part of the system which uses chip-by-chip (CBC) algorithm controls the iterative processing. Then $c_K=[c_k(1),\ c_k(2)\ldots c_k(j)\ldots\ldots c_k(J)]^T$ is created where J is the frame length and T signifies transpose. The coded bits c_k are interleaved by a chip-level interleaver π_k.

Afterwards, chip-level interleaving method, $x_K=[x_k(1),\ x_k(2)\ldots\ldots x_k(j)\ldots\ldots x_k(J)]^T$, is produced. We call the elements in x_K "chips" by following the convention of CDMA. The key principle of IDMA is that the interleavers should be different for different users. The MUD receiver embraces an ESE and a bank of K single-user a posteriori probability (APP) decoders (DECs). The interleaved information sequences are transmitted over Additive White Gaussian Noise (AWGN) or Rayleigh fading channel. Thus, the signal from K users at the receiver is expressed by

$$r(j)=\sum_{k=1}^{K} h_k\, x_k(j)+n(j),\quad j=1,2\ldots\ldots J \quad (1)$$

where $n(j)$ are samples of an AWGN process with zero-mean and variance $\sigma^2=N_o/2$ and h_k is the fading coefficient related to user k. $x_k(j)$ is the j^{th} chip transmitted by user-k. At the receiver side CBC algorithm is employed and IDMA system performs turbo-type iterative MUD.

We assume binary phase shift keying (BPSK) signaling, ($x_k(j)$€$\{+1,-1\}$, *for all k, j*). The outputs of ESE and DECs are extrinsic log-likelihood ratio (LLRs) about $x_k(j)$ by [3] [4]

$$e(x_k(j))=\log(P_r(x_k(j)=+1)/P_r(x_k(j)=-1)),\ \text{for all } K, j \quad (2)$$

The values of LLR are separated by subscripts, i.e. $e_{ESE}(x_k(j))$ and $e_{DEC}(x_k(j))$, which rest on generation technique in the ESE or DECs. For specific user-k equation (1) can be written as

$$r(j)=h_k x_k(j)+\zeta_k(j) \quad (3)$$

where

$$\zeta_k(j)=\sum_{k\neq k'} h_{k'}\, x_{k'}(j)+n(j)\equiv r(j)-h_k\, x_k(j) \quad (4)$$

$\zeta_k(j)$ specifies a distortion with related to $x_k(j)$ [5].

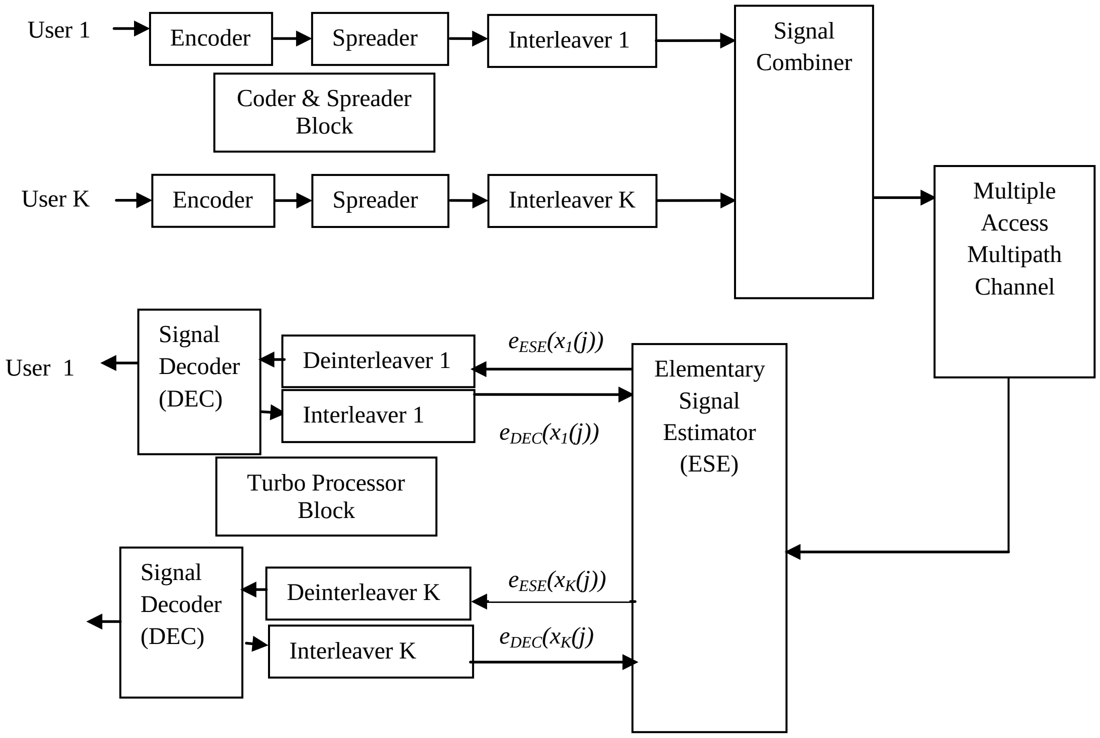

Figure 1: Transmitter and Receiver structures of IDMA scheme with K simultaneous users

2.1 Chip-by-Chip Detection Algorithm for a Single Path

DEC function can be calculated by using equation (2) and shown as

$$e_{DEC}(x_k(j))\equiv \log(P_r(x_k(j))=+1)-\log(P_r(x_k(j))=-1), \text{ for all } j \quad (5)$$

Step 1: Firstly allocate $e_{DEC}(x_k(j))=0$, *for all k, j*. It is supposed that the LLR of DECs is not received when iterative processing begins. The mean value and variance of x_k are written as $E(x_k(j))=\tanh(e_{DEC}(x_k(j))/2$ and $Var(x_k(j))=1-(E(x_k(j)))^2$ respectively. The mean value and variance for the signal from K simultaneous users at the ESE, *r(j)* is specified as [3] [4]

$$E(r(j))=\sum_k h_k\, E(x_k(j))$$

$$Var(r(j))=\sum_k mod^2\, h_k\, Var(x_k(j))+\sigma^2$$

The mean and variance of $\zeta_k(j)$ which indicates distortion (including interference plus noise) in relation with *r(j)* can be calculated as

$$E(\zeta_k(j))=E(r(j))-h_k\, E(x_k(j))=\sum_{k\neq k'} h_{k'}\, E(x_k{'}E(x_{k'}(j))$$

$$Var(\zeta_k(j))=Var(r(j))-mod^2\, h_k$$

$$Var(x_k(j))=\sum_{k=k'} mod^2\, h_{k'}\, Var(x_{k'}(j))+\sigma^2$$

Step 2: The expression for LLR can be written as

$$e_{ESE}(x_k(j))=2h_{k*}[\{r(j)-E(\zeta_k(j))\}/Var(\zeta_k(j))]$$

APP decoding is then applied in DECs. The similar procedure will be recurring for the next iteration. Consequently during the final iteration, the DECs produce hard decisions (d'_k) on information bits $d_k(j)$ [3] [4].

3. PERFORMANCE STUDY OF THE M-ARY DIGITAL MODULATION TECHNIQUES

Multi-level modulation techniques consent high data rates within fixed bandwidth constraints. The foremost idea behind digital modulation is to determine effectual schemes taking M different symbols in given digital information and transforming them into waveforms that can magnificently transmit the data over the channel. The most commonly used modulation scheme in digital communication systems is Phase Shift Keying (PSK). It is extensively used in military, deep space telemetry and commercial applications. The efficiency of the bandwidth is improved by using M-PSK modulation. Arithmetically M-PSK signal can be represented as [6]

$$s_i(t)=A\, Cos(2\pi f_c t+2\pi/M*i),\ i=1,\ 2,\ 3$$

where *A* is the signal amplitude, *M* is the number of possible phases of the carrier and f_c is the carrier frequency. As the order of PSK is increased, the performance will be degraded because the order of constellation is more liable to noise. The probability of error involves comparing the received phase at the receiver (in the presence of noise) to the actual phases.

The probability of error is

$$P_e\approx 2erfc\,(\sqrt{}2E_s/\eta\ Sin^2\pi/M),\ M>2$$

The bit error probability P_{MPSK} for M-ary PSK modulation scheme is given as

$$P_{MPSK}=2Q(\sqrt{}2\lambda Sin^2\pi/M)-1/\pi\int_{\pi/2-\pi/M}^{\pi/2} exp\{-\lambda*(Sin^2\pi/M)/(Cos^2\theta)d\theta$$

which gives

$$P_{MPSK}\approx 2Q\,(\sqrt{}2\lambda\ Sin^2\ \pi/M)$$

For large value of M above equation come to be

$P_{MPSK} \approx 2Q\,(\sqrt{2\lambda}\,(\pi^2/M^2)$

These equations can be used to evaluate the error probability in terms of SNR per bit. The transmitted power is increased so as to keep the same performance level for higher M. In M-ary PSK carrier recovery is more complicated than BPSK signaling. The requirement that the carrier be recovered can be alleviated by using a comparison between the phases of two successive symbols. This leads to M-ary differential PSK. For large SNR the probability of error is

$P_e \approx 2erfc\,\sqrt{2E_s/\eta}\;Sin^2\,(\pi/\sqrt{2}M)$

Differential Phase Shift Keying (DPSK) is regarded as the non-coherent version of PSK. In this modulation scheme, the symbols that are received are not decoded one-by-one to constellation points but are instead compared directly to one another [7] [8].

4. SIMULATION RESULTS & DISCUSSIONS

Performance of MPSK and MDPSK using phase-offset pi/M for various M in an AWGN Channel with fix values given below:

Number of blocks = 200

Spreading length = 16

Data length = 512

Number of iteration = 10

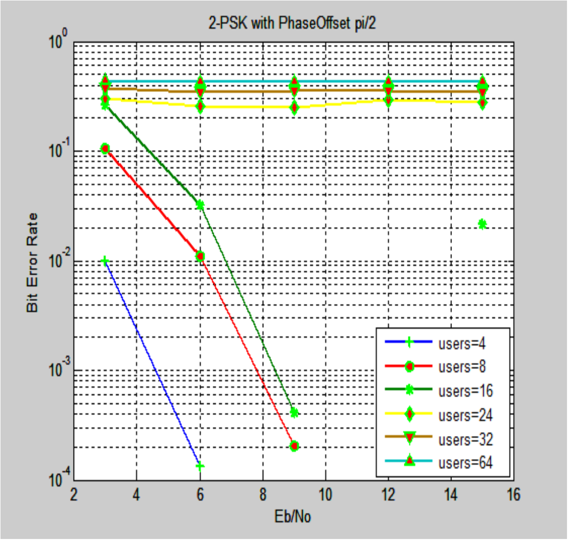

Figure 2: Bit error rate probability for 2-PSK using Phaseoffset pi/2

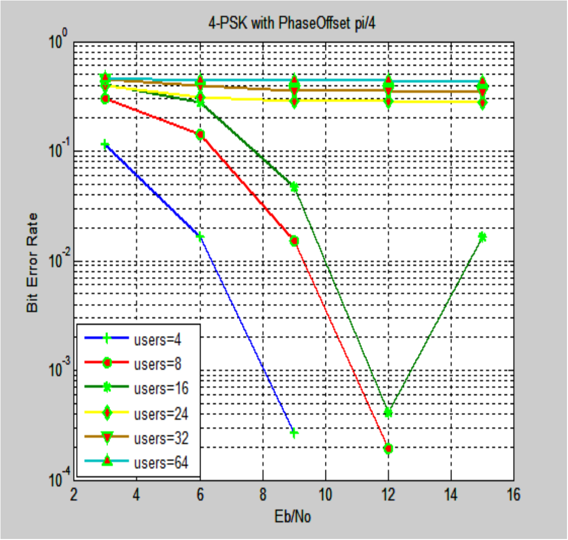

Figure 3: Bit error rate probability for 4-PSK using Phaseoffset pi/4

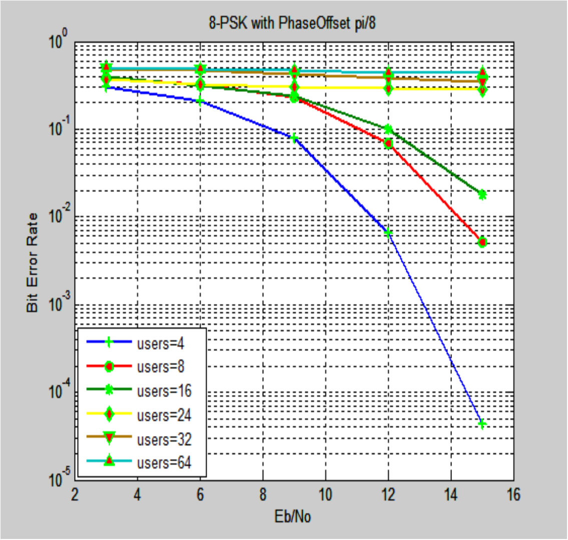

Figure 4: Bit error rate probability for 8-PSK using Phaseoffset pi/8

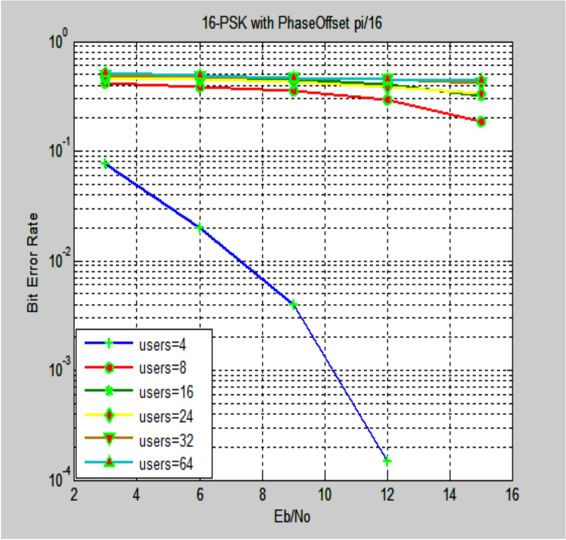

Figure 5: Bit error rate probability for 16-PSK using Phaseoffset pi/16

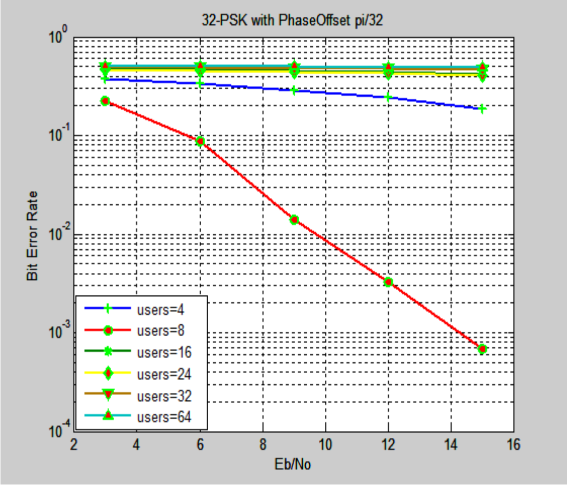

Figure 6: Bit error rate probability for 32-PSK using Phaseoffset pi/32

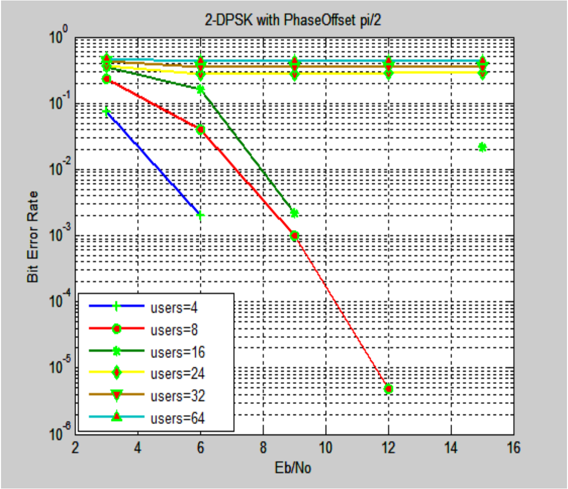

Figure 7: Bit error rate probability for 2-DPSK using Phaseoffset pi/2

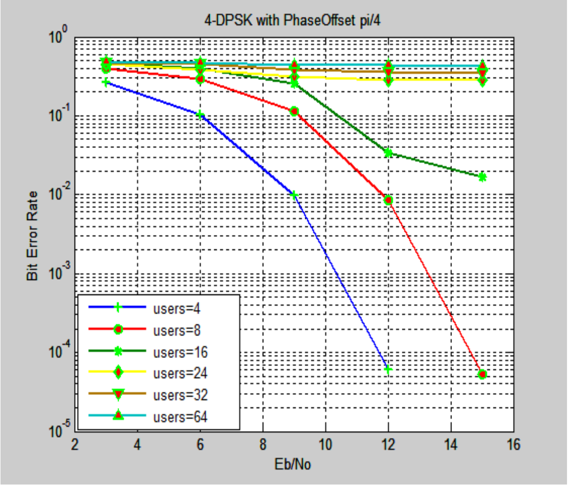

Figure 8: Bit error rate probability for 4-DPSK using Phaseoffset pi/4

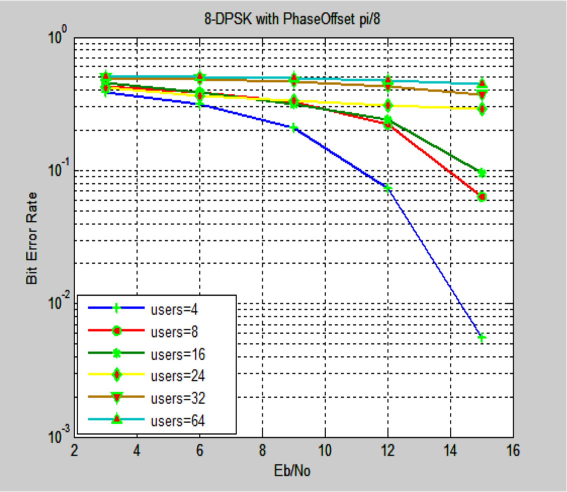

Figure 9: Bit error rate probability for 8-DPSK using Phaseoffset pi/8

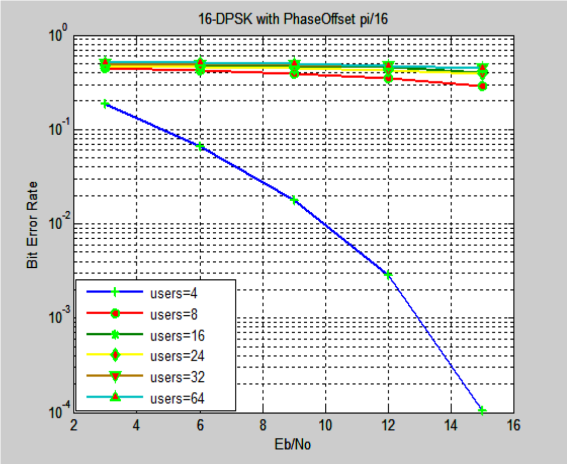

Figure 10: Bit error rate probability for 16-DPSK using Phaseoffset pi/16

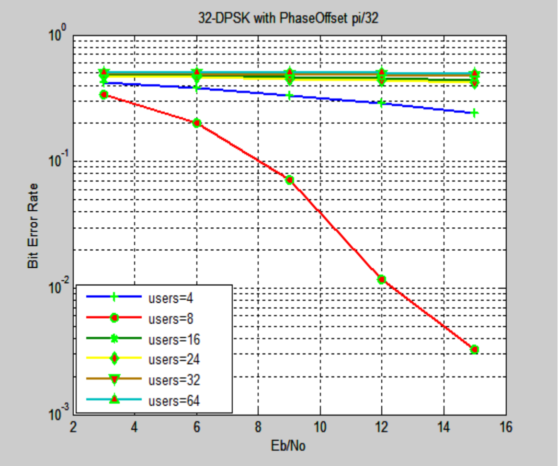

Figure 11: Bit error rate probability for 32-DPSK using Phaseoffset pi/32

The results of BER performance of M-ary PSK for M=2,4,8,16 and 32 using phase-offsets at pi/2, pi/4, pi/8, pi/16 and pi/32 respectively are shown in Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6. Similarly performance of M-ary DPSK is shown in Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11. The simulation is conceded out for different number of users without any coding scheme over AWGN channel. Other parameters have been kept constant for the purpose of simulation. According to the comparative performance analysis of simulated plots of MPSK and MDPSK, the plots with lesser number of users and with lower modulation order shows better performance than plots with high number of users and with higher modulation order.

5. CONCLUSION

With the aim of learning the techniques for occupying less bandwidth and reducing power consumption per channel, a closer study of transmission techniques are explored in order to determine a satisfactory modulation technique for a particular wireless application. In this study, we have performed simulations of error probability for MPSK and MDPSK using phase-offset in an AWGN channel. The analysis is done using MatLab 7.9 tool presenting that the BER for all the M-ary PSK based modulation schemes decrease monotonically when the values of E_b/N_o is increased. It is perceived that higher-order modulations reveal higher error-rates over AWGN channel. In MPSK, carrier recovery is complicated thus need for complex carrier-recovery is alleviated in MDPSK. However, MPSK shows better performance than MDPSK.

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