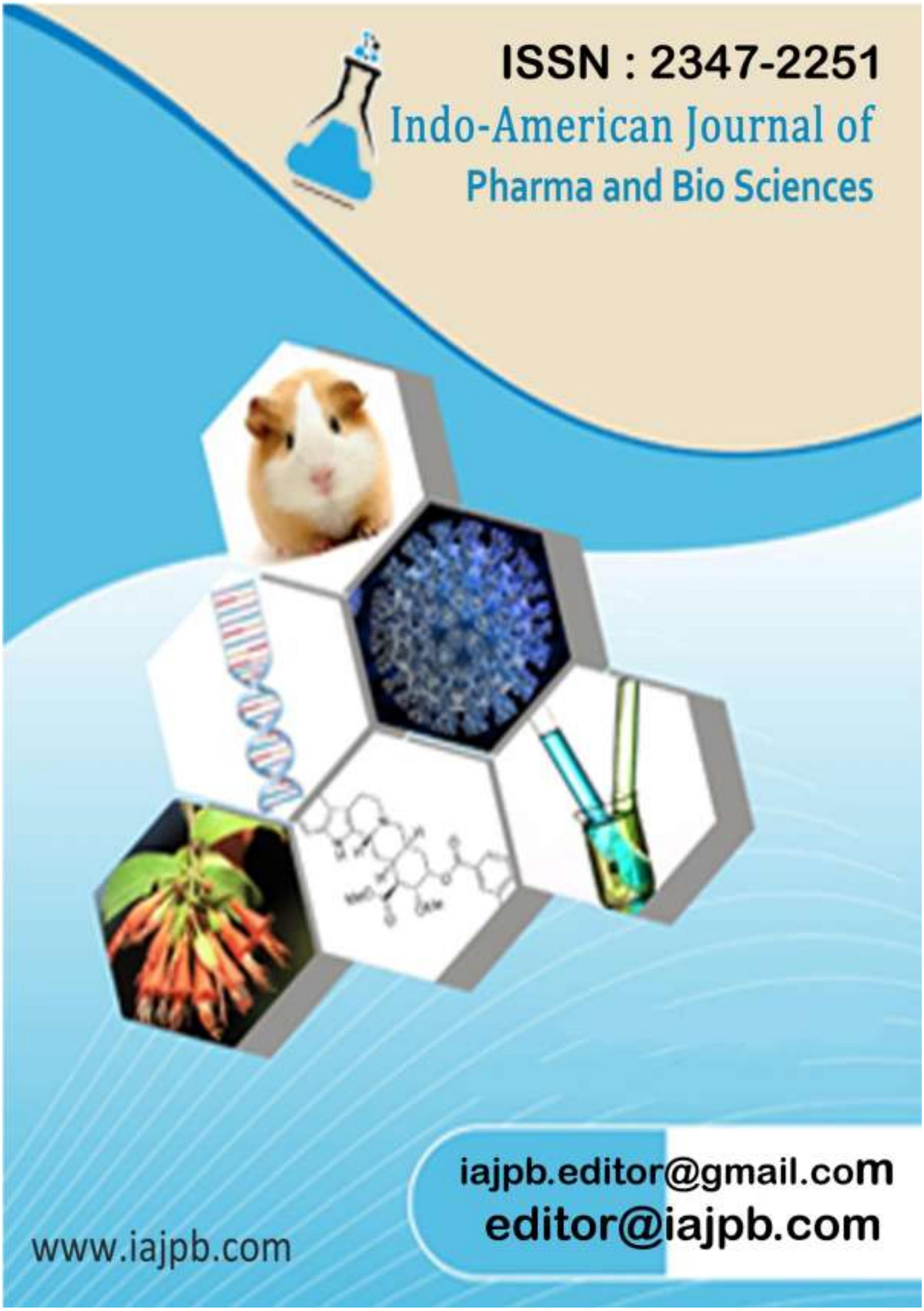

ISSN : 2347-2251
Indo-American Journal of
Pharma and Bio Sciences
iajpb.editor@gmail.com
editor@iajpb.com
www.iajpb.com

Evaluating Bit Error Rate Performance of CPM modulation technique in MIMO and SISO systems using MATLAB

C.Hussain Peera

Abstract

Due to CPM's advantages of a constant envelope and phase continuity over linier modulation, it is chosen in this project. Space time codes (STC) and CPM have been regarded as an ideal combination in satellite and terrestrial communication that can increase capacity without sacrificing power or spectrum efficiency. Single Input Single Output (SISO) and Multi-Input Multiple Output (MIMO) systems are examples of wireless communication systems. The current wireless network relies heavily on Multiple Input Multiple Output (MIMO) technology. Multiple transmit and receive antennas are used in MIMO systems to increase transmission dependability. We simulate Rayleigh and Rician fading to determine the Bit Error Rate (BER) of CPM modulated data transmissions in MIMO and SISO systems. Finally, we may determine the error probability of CPM's performance based on the simulated outcomes.

Keywords:Several Inputs Continuous phase modulation (CPM), space time codes (STC), and bit error rate (BER) (BER), Input/Output (SISO): A single point of entry).

1. Introduction

This modulation technique, called continuous phase modulation (CPM), is not linear in nature. CPM MIMO systems with STC design requirements have been constructed, however the evaluation of performance requires more general results like linear modulations, such as QAM and the like. A combination of space time codes (STC) and CPM[1] is the best option for increasing capacity without sacrificing power or spectrum efficiency. It is possible to apply and expand the rank criterion for linear modulation (PSK and QAM) in a quasi-static fading channel to get generic STC design guidelines for CPM MIMO systems. An earlier version of this idea was put forth by Zhang and Fitz[2]. This system was later defined by Zhao and Giannakis in the context of binary CPM[3]. Unfortunately, because there is no guarantee that CPM phase continuity can be partial response CPM. Additionally, Bell Lab's layered Space Time (BLAST) methodology is another method for ensuring that the CPM signal's phase continuity is maintained while simultaneously boosting the capacity of the rich scattering channel [4]. [5–7]. It's more convenient to use Laurent decomposition [8] to evaluate the above STC design in CPM MIMO system, which we represent as a superposition of many PAM (Pulse Amplitude Modulated) signals, to overcome the discomfort caused bynonlinearity in the CPM signalling scheme [9]. The STC–MIMO system's performance can be evaluated if the PEP (Pairwise Error Probability) is allowed [9]. According to BEP (Bit Error Probability), in several cases The PEP result can be used as a rough approximation. [10] provides a mathematical framework for analyzing the performance of various existing systems in multipath

M.Tech (Digital Electronics and Communication Systems)JawaharlalNehru Technical University Ananthapuramu, India.hussainthecreator1515@gmail.com

fading channels. Monte-Carlo simulations[11] are used to calculate Bit Error Rate. The research of Bit Error Rate (BER) in various fading conditions is carried out using Matlab's Simulink models (Rayleigh and Rician fading is used in this project). Decomposing CPM signals into a series of PAM signals is presented in Section 2 of this study. We derive their exact bit error rate from the decomposed version (EBEP). Sect. 3 of this study then explains how to apply the method and how it differs from previous studies. Comparing the simulated BER curves in Section 4 allows for inferences to be drawn about the results. This is all summarized in Section 5.

2. Existingresearch

2.1. CPMSignalModel

TheCPMsignalcanberepresented incomplexenvelope formas

$$s(t,a)=e^{j\phi(t,a)} \quad (1)$$

Where$\phi(t,a)$iscarrierphase

$$\phi(t,a)=2\pi h\sum_i a_i q(t-iT) \quad (2)$$

Here modulation index is denoted with symbol h, signalling interval is denoted withsymbol$T$,informationsymbolsofM-aryalphabet{±1,±3, ⋯ , ±(M – 1)}aredenotedas$a$={a_i}andphaseresponseofthesystemisdenotedwith$q(t)$anditcanberelated tothefrequencyresponse$f(t)$as

$$q(t)=\int_{-\infty}^{t} f(\tau)d\tau \quad (3)$$

Thepulse$f(t)$istimelimitedintheinterval(0,LT)andhastosatisfytheconditions

$$f(t)=f(LT-t) \quad (4)$$

$$\int_0^{LT} f(\tau)d\tau=q(LT)$$

If we consider frequency response of rectangular shape it is generally indicated withacronym LREC, in the raised cosine case it is LRC etc. Rewritten equation of CPM signalviaLaurentdecompositionis [8][12]

$$s(t,a)=\sum_{k=0}^{K-1}\sum_n a_{k,n} g_k(t-nT) \quad (6)$$

where$g_k(t - nT)$ represents kth PAM waveform for nthsymbol period, and $a_{k,n}$termrepresentstheinformationsymbols.

2.2. ChannelModel

$$r=s_m+w \quad (m=1,2,\cdots,M) \quad (7)$$

2.2.1. Single path channel: For simplicity, let's pretend that an M-ary signal w is being sent across a Gaussian channel, and that the noise w has contaminated both the original signal and its reception. Assume that noise has a mean of zero and a variance of zero. It's given as a 2 in this circumstance.

Analyticalerrorprobabilitiesarederivedin[10][12]

$$P_{e,M=2}^{SISO}=Q\left(\sqrt{\frac{d^2\varepsilon_g}{N_0}}\right) \quad (8)$$

$$P_{e,M=4}^{SISO}=Q\left(\sqrt{\frac{d^2\varepsilon_{g1}}{N_0}}\right)+\frac{1}{2}Q\left(\sqrt{\frac{d^2\varepsilon_{g2}}{N_0}}\right) \quad (9)$$

2.2.2. Multipath fadingchannel:

MIMOsystemisconsistsof$N_t$transmitantennaand $N_r$receiveantenna.Thereceivedsignalsrepresentedas

$$R=HS+W \quad (10)$$

where$S$areCPMsignalstransmittedfrom$N_t$antennas,Histhechannelmatrix.Analyticalerror probabilities are derived in[12]

ε_g $2n-1$ k

$$P_{MIMO\,SS\,e,M=2} = \frac{1}{2}\left[1-\frac{N_R}{N_0} \sum_{k=0}^{\ldots} \frac{2k}{k} \frac{1}{4\left(1+\frac{\varepsilon_{gg}}{N_0}\right)} \ldots \frac{0}{1+\frac{\varepsilon_{gg}}{N_0}} \right] \quad (11)$$

$$P_{MIMO\,SS\,e,M=4} = \frac{1}{2}\left[1-\frac{N_R}{N_0} \frac{\varepsilon_{g1}}{1+\frac{\varepsilon_{g1}}{N_0}} \sum_{k=0}^{2n_R-1} \binom{2k}{k} \ldots \right] + \frac{1}{2}\times\frac{1}{2}\left[1-\sqrt{\frac{\frac{\varepsilon_{g2}}{N_0}}{1+\frac{\varepsilon_{g2}}{N_0}}}\right] \sum_{k=0}^{2n_R-1} \binom{2k}{k} \ldots$$

3. Methodofimplementation

Matlab's SIMULINK models were used to implement the proposed study. To begin, select what you want to do. Data rate, sample period, and the amount of bits per frame determine the type of the input data. The bit sequence is generated using the Bernouli binary generator. M-ary data is then generated using the PAM modulator, which is complicated in nature. We must isolate the complex part of the modulated PAM before feeding it to the CPM modulator since the CPM modulator receives genuine M-ary data 1, 3,, (M 1). Choosing the appropriate modulation index h, pulse shape q(t), and modulation memory L are the next steps in the process. Then we must decide how many sampled CPM symbols we need for each of the three parameters. AWGN (Additive White Gaussian Noise) channel model is now used to introduce noise. The Eb/No workspace variable must be accessed in the AWGN block. To configure an AWGN channel block, you must specify the amount of bits per signal, its symbol period, and its energy. Symbol sampling rates, modulation indices, and phase pulse phases all need to be compatible with CPM demodulator standards. Pass the BER values from the CPM demodulator's Error Calculator to a different workspace variable, as shown in the figure. With BERTOOL in Matlab, you may simulate Monte Carlo games. Similarly, Rayleigh and Rician experienced the same problem. in both SISO and MIMO systems The Monte Carlo simulator must be able to access workspace variables, as well as your Simulink model, in order to produce graphs. Using the jakes model, three pathways with varied path delays, attenuation constants, and Doppler shifts were employed to mimic multipath fading effects in MIMO 2x2, 4x4 Rayleigh fading in deep fading. Similarly, Rician fading is also investigated for other k factors and the same path delays.

4. ResultsandAnalysis

An evaluation of the bit error rate performance of the CPM modulation approach has been carried out in various simulated settings. AWGN, Rayleigh multipath fading, and Rician multipath fading settings are used to test the data. It is analogous to FM (frequency modulation) in that a higher modulation index results in a wider spectrum and greater error performance, just like FM. However, this isn't always the case with CPM, and it's up to us to choose the best index for our needs. Researchers have provided graphs demonstrating modulation index vs square of a minimal distance, which can be observed to readily avoid weaker modulation indices for picking optimal modulation. As can be seen in Figure 1, which depicts BER curves simulated in an AWGN channel with CPM modulation indexes of 0, 3, and 5 pointing downwards. One Eb/No value for example at 10 has the BER closer to 103 for index 0.3, less than 104 for index 0.4, and near to 105 for index 0.5 for this Eb/No.

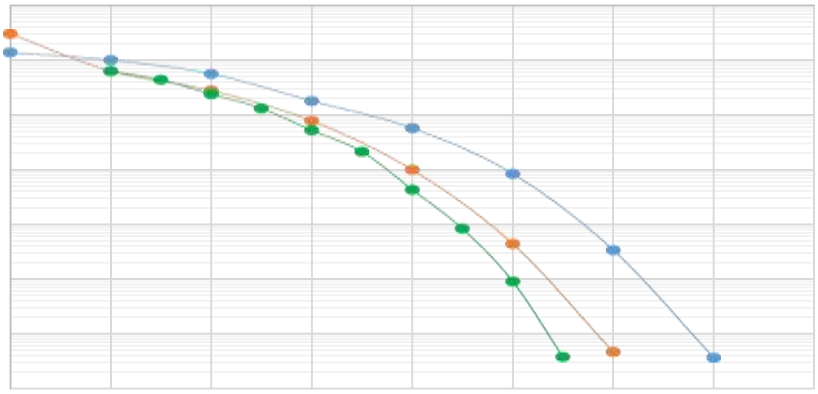


Figure1. Effect ofmodulationindex

With four alternative pathways and path delays, SISO-BER CPM's performance in AWGN, Rayleigh, and Rician multipath channels is examined. An error-prone signal's performance can be adversely affected by signal distortion caused by transmission delay, which is equivalent to a phase shift term in transform domain. A modulation technique that uses phase fluctuations to transmit information has a significantly greater impact. This project uses route delays of 0, 2, 4, and 8 microseconds. Zero, -3,-6,-9 attenuation constants are employed. According to the nature of the input and the modulation scheme specifications, Doppler shifts are employed correspondingly. While Rayleigh fades have no dominant path, Rician fades have one, and the dominance is determined by the K factor in this case. For k = 1, 3, and 10, simulations are run. Figure 2 displays the BER curves of SISO-CPM systems, which indicate that fading has a significant impact on SISO systems. Fading is extremely similar to that of Rician for k = 1.The Rayleigh effect fades. There appears to be an improvement in error performance with an increase in the value of the K factor in both theoretical and simulated BER curves.

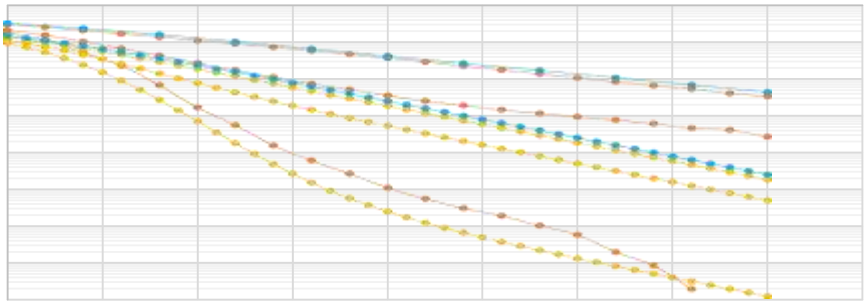


Figure2.SISO-CPMsystemPerformanceinRayleighandRicianfading

An error-prone signal's performance can be adversely affected by signal distortion caused by transmission delay, which is equivalent to a phase shift term in transform domain. A modulation technique that uses phase fluctuations to transmit information has a significantly greater impact. Errors can also be caused by a decrease in the signal's energy. We also see Doppler shift in real-world scenarios, which is caused by the transmitter and receiver moving relative to one another. The type of input has an effect on mistake probability. M-ary data is more difficult to decode since the minimum distance between two constellation points is reduced, and the distance between two states in the trellis is reduced, making it easier to cross a predetermined threshold while making decisions. Figure 3 depicts the simulated BER curves for M = 2 and M = 4 in the AWGN channel. Due to route delays and the Doppler effect, phase shifts occur in the form of phase trellis in CPM, a modulation technique with trellis structure that transports information in the form of phase states. As a result, the likelihood of an error is substantially higher. SISO-CPM without fading in an AWGN channel is compared to Rayleigh and Rician channels with a K factor of 10 in figure 3.From this, one can determine how much improvement or other transmission methods are needed. As a means of enhancing performance without altering the transmission method, one can use any of the best adaptive filter equalization techniques or simply change the transmission method. The utilization of MIMO systems, which are recognized for their high data rates and throughput, is used in this project as an alternative method of transmitting data.

Receiver diversity allows for the addition of received signals to the symbol energy during transmission.

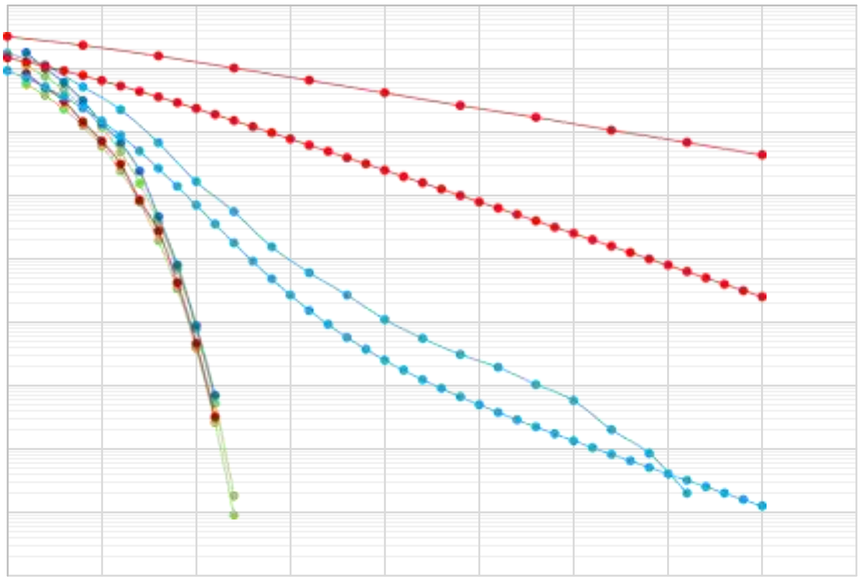


Figure 3.comparison of SISO-CPM system Performance with fading andwithoutfading.

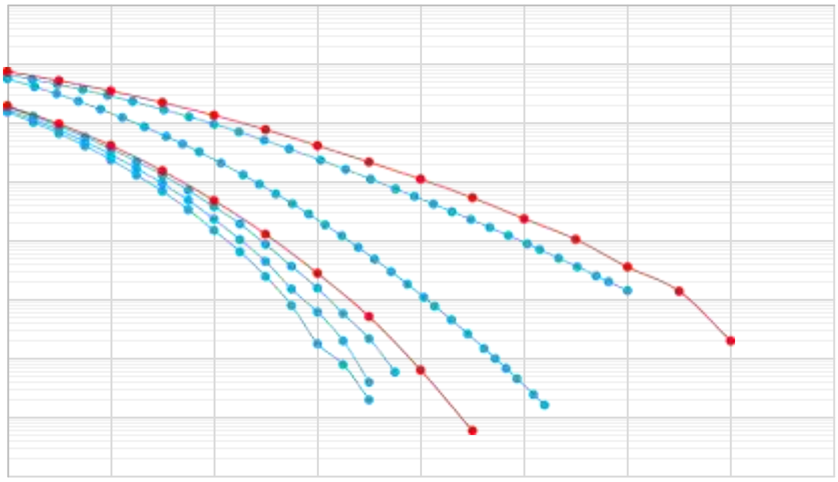
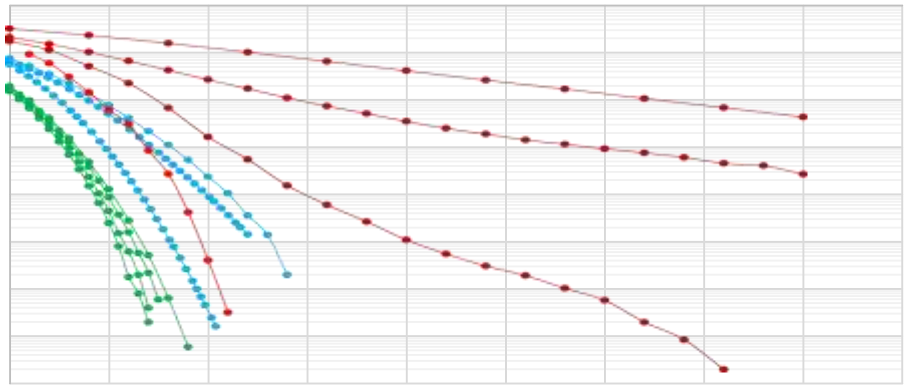


Figure 4. MIMO-CPM systems (2x2, 4x4) Performance in Rayleigh and Ricianfadingchannel

In the near future, it will be possible to use MIMO systems that use four broadcast and four receive antennas, instead of just two. OSTBC (Orthogonal Space Time Block Coding) is used to achieve spatial multiplexing for parallel data transfer. Figure 4 shows the error handling performance of both systems in terms of BER curves. In Rayleigh fading and Rician fading with K factor 1, the curves for both systems are identical, and performance improves with increasing K factor. This is because K factor is 1. The MIMO 4x4 system outperforms the MIMO 2x2 system by a wide margin. Thus, increasing the number of antennas or increasing the diversity order improves performance.



mimo4x4rician_k1_pd=12e-06_g=-50_fd=400 mimo4x4rician_k3_pd=12e-06_g=-50_fd=400 mimo4x4rician_k10_pd=12e-06_g=-50_fd=400 mimo2x2rician_k1_pd=12e-06_g=-50_fd=200 mimo2x2rician_k10_pd=12e-06_g=-50_fd=200 mimo2x2_rayleigh mimo4x4_rayleigh rlg_3p_1M_sim k10_sim k3_sim awgn_cpm2_emp

Figure5. Comparisonofperformanceamongdifferentchannels

Overall picture of BER performance of CPM among AWGN, Rayleigh, RicianchannelsinSISOandMIMOsystemsisshowninfigure5.PerformanceinAWGNchannelgives the capability to handle the noise interference. Rayleigh fading in SISO systems isworse among all simulated results and Rician fading performs better with increment in Kfactor means with more dominance of LOS path. MIMO systems uses multipath fading toitsownadvantageandperformbetter ineachscenarioascompared withSISOsystems.

InternationalJournalofResearch ISSNNO:2236-6124

5.Conclusion

In SISO and MIMO systems, the BER of CPM modulation is evaluated. In order to counteract the detrimental effects of fading on SISO systems, MIMO systems were implemented, which considerably improved BER performance. Phase continuity cannot be guaranteed in Alamouti's code since it uses CPM's phase trellis structure and OSTBC's blocked structure. BLAST (Bell Labs) and STTC (Space Time Trellis Coding)

The layers of Space Time are without a doubt responsible for maintaining phase continuity. To keep receiver design and channel modeling simple, it is assumed that the number of transmitters is equal to the number of receivers. Antenna diversity increases the mathematical complexity of channel decomposition algorithms when receivers outnumber transmitters.

References

[1] "Space time trellis code architecture using binary CPM," Electronics Letters, A. R. & R. R. K. AhmadiPages. 168-170, 2006

For example, the IEEE Journal on Selected Areas in Communications, Volume 5, Number 21, pp. 783-792, 2003, offers an article entitled "Space time code design using continuous phase modulation."

A layered space-time CPM with reduced complexity receivers was published in the IEEE Transactions on Wireless Communication, volume 2, issue 4, 2005, pp. 574-582 (Williams and Zhao).

According to the IEEE GlobeCom'06 conference, "optimization of coding gain for full response CPM space time codes" was published in 2006, pgs. 1-4.

Asymmetric information rate for continuous phase channels and the BLAST architecture with the CPM MIMO system, in ICC'2003 USA: Alaska, pp. 3051-3055 (X.X.&F.M Zhang), 2003

Continuous phase modulation detection using the TURBOBLAST method was presented at

Wireless VITAE'2009 in Copenhagen, Denmark, pp. 212-216.
[7] "Decomposition of M-ary CPM signals into PAM wavwforms," U. & M. M. Mengali
Volume 5, Number 41, 1995, Pages 1265-1275 of Transactions on Information Theory.
If you have two transmit antennas that are orthogonal to each other, then you can use a CPM system that uses orthogonal space-time coded CPM with quick decoding for fast transmission.
According to the IEEE Transactions on Information Theory, [9] "Space time codes for high data rate wireless communication: performance requirement and code development."
Bit Error Probability for CPM MIMO Systems in Rayleigh Channels is evaluated in Wireless Pers Communications, 2015, by Guowei Lei, Yuan-An Liu and Xuefang Xiao.

In the International Journal of Electrical and Computer Engineering (IJECE), volume 5, number 1, pp. ISSN: 2088-8708, M. M. S. K. Vaibhav S. Hendre performed an analysis of the performance of transmit antenna selection with MRC in MIMO for image transmission in multipath fading channels.
The 3rd edition of J. G. Proakis' "Digital Communications" is available from McGrawHill.