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Frequency Selective Fading in Wireless Communication using Genetic Algorithm

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Abstract: *Mobile communications and wireless network have experienced massive growth and commercial success in the recent years. With the prevalence of higher bandwidth application, such as 3G, WiFi, WiMax, UWB and other such technologies, the frequency selective fading issue becomes more important for wireless network simulation. It will be of great interest to implement more functionality support for frequency selective fading using genetic algorithm.*

The methodology implemented involves simulating a GSM carrier frequency and bandwidth, and use pilot data to estimate the channel phase. These are simulated in MATLAB environment using genetic algorithm toolbox. The model was then integrated into image processing, which will give a better environment to simulate a wireless network model. PSK, ASK and QAM modulation models are used to test the effect of different channels to the received data.
The O-MPSK schemes were compared with MPSK scheme in terms of BER for SNR values of 0 to 20 dB. The O-MPSK investigated include $\pi/2$ *-QPSK,* $\pi/4$ *-8PSK,* $\pi/8$ *-16PSK,* $\pi/16$ *-32PSK and* $\pi/32$ *-64PSK. The results reveal that the O-MPSK schemes outperform the MPSK schemes for both MIMO-SM and MIMO-BF as the O-MPSK schemes give relatively lower mean BER compared to the MPSK schemes*

1. Introduction

The goal of an ideal digital wireless communication system is to produce the exact replica of transmitted data at the receiver(Harjot, Bindiya and Amit, 2011). This has necessitated the corresponding numerous tremendous researches carried out in digital communications industry which leads to rapid growth recorded in the past two decades especially in its various applications (Gesse and Oladele, 2010). This growth, in turn, has spawned an increasing need to seek automated methods of analyzing the performance of digital modulation types using the latest mathematical software or programming language. Modulation is the process by which some characteristics, usually the amplitude, frequency or phase of a carrier is varied in accordance with instantaneous value of some other voltage, called the modulating voltage or signal (Carlson, Crilly and Rutledge, 2002). Forms of digital modulation practically in use now include Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM) with each having their distinctive features and characteristics. In the case of ASK, the use of amplitude modulated analogue carriers to transport digital information always results in a relatively low quality output. Although it is a low cost type of digital modulation, this is seldom used except for a very low speed telemetry circuits. FSK has a poorer error performance than PSK or QAM and consequently is not used regularly for high-performance digital radio systems (Proakis and Salehi, 2002).

The demands for high data rate wireless communication in recent years have continued to increase rapidly for wireless multimedia services. Multiple-input, multiple-output (MIMO) systems are now the popular approaches to meet these demands (Foschini and Gans, 1998). The use of multiple antennas at both transmitter and receiver in wireless communication links provides a means of maximizing the system performance of wireless systems. MIMO technology provides diversity by making the receiver to receive multiple replicas of the same information-bearing signal; and this provides a more reliable signal reception (Gesbert*et al*, 2000).

II. Previous Research

2.1 BER Performance of MPSK and MQAM in 2x2 Almouti MIMO Systems

Mindaudu and Miyim (2012) investigated the error performance of the 2x2 MIMO system using the Almouti (1998) space-time coding with M-PSK and M-QAM modulation schemes of modulation orders M = 4, 8, 16, 32 and 64. The problem of increasing error rates and power consumption is associated with using the MIMO for the provision of high speed multimedia wireless services. The aim of the investigation was to develop a MIMO system that would mitigate error rates and also provide better efficiency in power and bandwidth consumption.. The simulation results show that the scheme with the M-QAM modulation gives better BER performance compared to the M-PSK modulation. The proposed scheme shows good BER performance, but it is limited to only a 2x2 MIMO antenna configuration. Also, the energy needed to achieving a given error probability increases with the modulation order.

2.2 Performance Comparison of MIMO Systems over AWGN and Rician Channels

A dense multipath fading environment stands as a bottleneck to achieving high data rate wireless transmission. Kaur and Kansal (2013) aimed at exploiting the multipath effect of the wireless communications environment for the enhancement of diversity and capacity gains. The method involved utilizing a MIMO-STBC system with zero-forcing (ZF) equalizer and higher order M-PSK modulation schemes; that is M = 32 and above. The system was simulated over a multipath Rician fading channel. Simulation results for 32-PSK, 64-PSK, 128-PSK, 256-PSK and 1024-PSK showed good BER performances due to space diversity provided by the MIMO system. However, the BER increased with increase in the value of *M* for *M*-PSK as a result of decrease in the space between different constellation points, and the energy needed to achieving a given BER increases with the modulation order *M*.

2.3 Bit Error rate Performance of MIMO Spatial Multiplexing with MPSK Modulation

The achievable data rate of the MIMO system with space-time trellis codes (STTC) is limited by the complexity of the ML decoder which grows exponentially with the number of bits per symbol. With a view to reducing the complexity of the ML decoder in a MIMO system, Vishal and Mahesh (2013) investigated the BER performance of MIMO system utilizing a layered space-time coding (LSTC) technique with MPSK modulation schemes and ZF receiver. The system was simulated over the Rayleigh fading channel. Simulation results showed significant improvement in BER for the proposed technique compared to the STTC technique. The BER of the system, however, increases with increasing modulation order.

2.4 Performance Comparison of MIMO-OFDM Transceiver Wireless Communication System

The MIMO system helps to achieve high spectral efficiency, but the system still suffers from the problem of inter-signal interference (ISI) in a frequency-selective mobile communication environment. The aim is to mitigate the problem of ISI in MIMO systems at the same time achieving high spectral efficiency in mobile communication environments. Mangla and Singh (2013) compared the BER performances of higher order M-QAM and M-PSK modulation schemes in a MIMO-OFDM system. The system was simulated for M = 16, 64, 256, 512 and 1024. The results showed that spectral efficiency increases with increasing modulation order M. Also, M-QAM gives better BER performance than M-PSK. The BER of the higher order modulations can be reduced but at the cost of increasing the SNR. Increasing the SNR is however not advisable because excessive power consumption would adversely affect system lifespan.

III. Methodology

3.1 Design of the Offset MPSK Schemes

A modulated signal consists of a combination of the carrier signal and the message (or information) signal. The *M*-ary PSK modulation is achieved by shifting the carrier in phase according to the message data. A modulated signal$s(t)$ in time (t) domain can be expressed as:

$$s(t) = Re\{g(t)\exp(j\omega_c t)\}$$

3.1 where $Re\{.\}$ denotes the real component of the complex function indicated by j,

$\omega_c = 2\pi f_c$,

f_c = The carrier frequency,

$g(t)$ = The complex baseband envelope of $s(t)$.

This complex baseband envelope $g(t)$ is a function of the message signal $m(t)$ and can be expressed as:

$$g(t) = Am(t)\exp[j\theta(t)] \quad 3.2$$

where$A$ is a constant amplitude

and, $\theta(t)$ = The phase of the signal

Substituting equation (3.2) into (3.1) gives:

$$s(t) = Am(t)\cos[\omega_c t + \theta(t)] \quad 3.3$$

Applying trigonometric identity to Equation 3.3, the equation can be expressed in cosine and sine forms as:

$$s(t) = Am(t)[cos\omega_c tcos\theta(t) - sin\omega_c tsin\theta(t)] \quad 3.4$$

The constant amplitude A is a function of the signal power; and it is given as:

$$A = \sqrt{2P} \quad 3.5$$

where$P$ is the signal power. Also, P is a function of the energy contained in a symbol duration; and is given as:

$$P = \frac{E}{T_s} \quad 3.6$$

whereT_s is the symbol period;

E is the energy contained in the symbol period.

Substituting Equation 3.6 into 3.5 gives:

$$A = \sqrt{\frac{2E}{T_s}} \quad 3.7$$

With‘ A ’ into equation 3.4 gives:

$$s(t) = m(t)\sqrt{\frac{2E}{T_s}}[cos\omega_c tcos\theta t - sin\omega_c tsin\theta t] \quad 3.8$$

By shifting the carrier in phase, Equation 3.8 becomes:

$$s(t) = m(t)\sqrt{\frac{2E}{T_s}}[cos\omega_c tcos(\theta_i - \theta_0)t - sin\omega_c tsin(\theta_i - \theta_0)t] \quad 3.9$$

With $\theta_i = \frac{2\pi}{M}i, \quad for\ i = 1,2,3, \dots M$ 3.10

andθ_o is the initial phase given as:

$$\theta_0 = \frac{2\pi}{M} \quad 3.11$$

where$M$ is the constellation size of the M-ary PSK; the phase takes on one of M possible values.

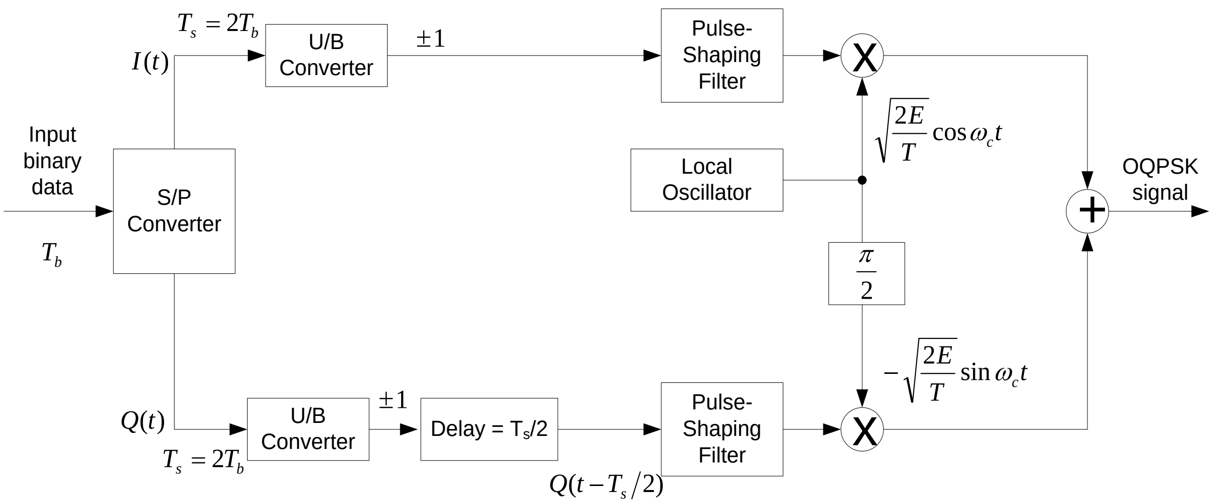
Equation 3.9 represents an M-ary PSK modulated signal. The phases of an MPSK constellation can be represented with a polar diagram in Inphase/Quadrature (I/Q) format. The cosine component of the modulated signal $s(t)$ takes the inphase axis while the sine component takes the quadrature axis.

The offset MPSK (OMPSK) modulation can be implemented by delaying the input bit stream of the quadrature part by one bit period T_b. The bit period is given as:

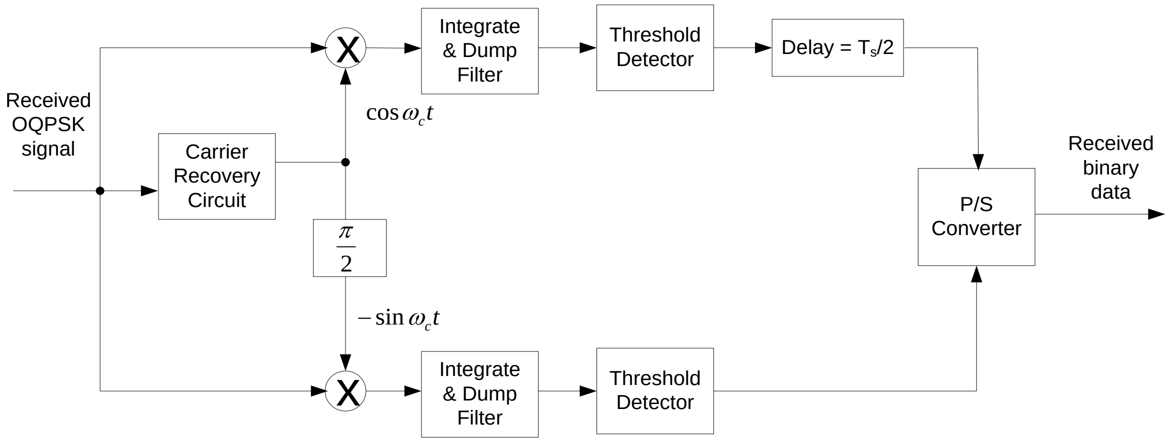
$$T_b = \frac{T_s}{k} = \frac{T_s}{\log_2 M} \quad 3.12$$

where k is the number of bits that represents a symbol. Therefore, the conventional MPSK modulation Equation 3.9 can be modified for the OMPSK as:

$$s(t) = m(t)\sqrt{\frac{2E}{T_s}}[\cos\omega_c t\cos(\theta_i - \theta_0)t - \sin\omega_c t\sin[(\theta_i - \theta_0)(t - T_b)]] \quad 3.13$$



(a)



(b)

Figure 3.1: Offset QPSK Scheme (a) Modulator (b) Demodulator

IV. Result and Discussions

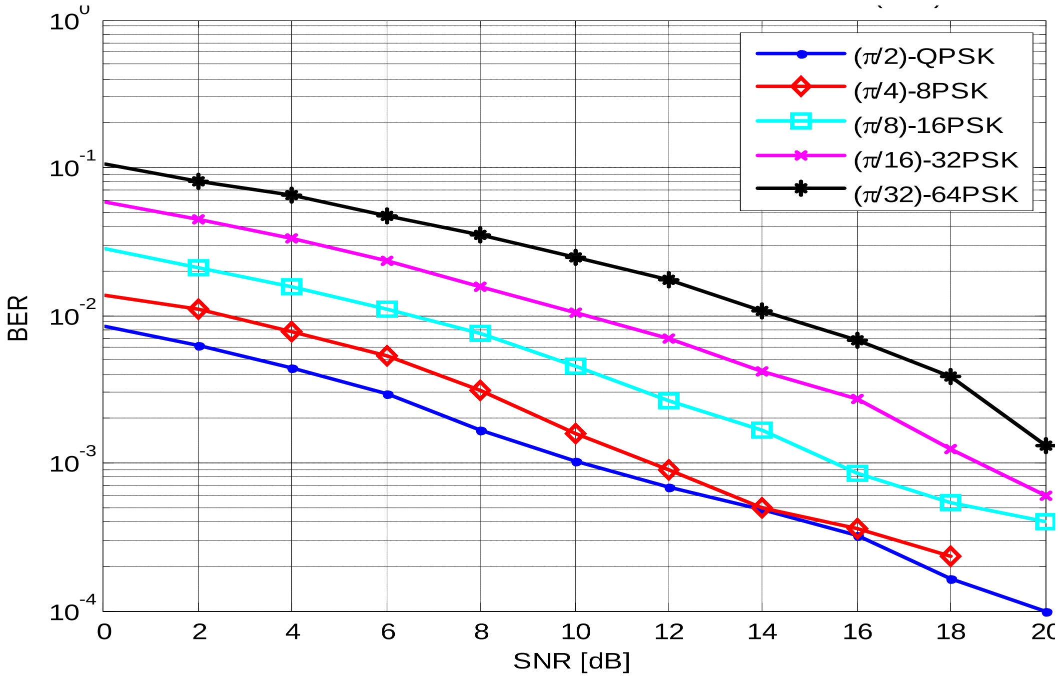


Figure1: Comparison of the O-MPSK in 2x2MIMO-SM over Rayleigh Fading Channel

The mean BER values for $\pi/2$ -QPSK, $\pi/4$ -8PSK, $\pi/8$ -16PSK, $\pi/16$ -32PSK and $\pi/32$ -64PSK in MIMO-BF are 0.0016, 0.0025, 0.0038, 0.0064 and 0.0107 respectively. Also, the mean BER values for $\pi/2$ -QPSK, $\pi/4$ -8PSK, $\pi/8$ -16PSK, $\pi/16$ -32PSK and $\pi/32$ -64PSK in MIMO-SM are 0.0024, 0.0040, 0.0085, 0.0183 and 0.0360 respectively. The results reveal that the best BER performance is obtained with $\pi/2$ -QPSK of MIMO-BF and the worst with $\pi/32$ -64PSK of MIMO-SM.

The comparison between MIMO-SM and MIMO-BF for $\pi/2$ -QPSK is illustrated graphically in Figure 1. The mean BER values obtained for MIMO-SM and MIMO-BF are 0.0024 and 0.0016 respectively; this shows that MIMO-BF gives a lower BER compared to MIMO-SM. Figure 2 shows the comparison between MIMO-SM and MIMO-BF for $\pi/8$ -16PSK. The BER values obtained for MIMO-SM and MIMO-BF are 0.0085 and 0.0038 respectively; this also shows that MIMO-BF gives a lower BER compared to MIMO-SM.

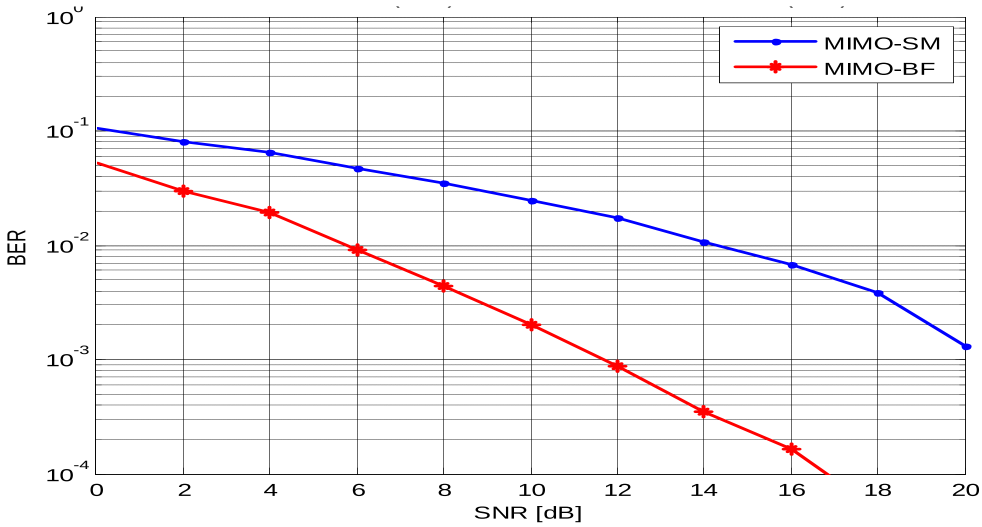


Figure 2: Comparison between 2x2 MIMO-SM and 2x2 MIMO-BF with $\pi/32$ -64PSK

V. Conclusion

In this work, offset MPSK (O-MPSK) modulation schemes in wireless communication using genetic algorithm were developed and the performances evaluated in 2x2 MIMO-SM and 2x2 MIMO-BF communication systems over Rayleigh fading channel. The O-MPSK schemes were compared with MPSK scheme in terms of BER for SNR values of 0 to 20 dB. The O-MPSK investigated include $\pi/2$ -QPSK, $\pi/4$ -8PSK, $\pi/8$ -16PSK, $\pi/16$ -32PSK and $\pi/32$ -64PSK. The results reveal that the O-MPSK schemes outperform the MPSK schemes for both MIMO-SM and MIMO-BF as the O-MPSK schemes give relatively lower mean BER compared to the MPSK schemes. Also, the results reveal that the best performance is obtained with the $\pi/2$ -QPSK scheme.

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