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Research Paper

BER PERFORMANCE OF BPSK AND QPSK OVER RAYLEIGH CHANNEL AND AWGN CHANNEL

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Fading problem is a major impairment of the wireless communication channel. To mitigate the fading and to have reliable communications in wireless channel, coding technique is often employed. In this paper it is the comparisons of BPSK and QPSK over Rayleigh Channel and AWGN channel in terms of bit error rate.

Keywords: Fading problem, Wireless communication, Coding technique, BER performance

INTRODUCTION

BPSK is the simplest form of Phase Shift Keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned. This modulation technique is the most robust of all PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. QPSK is known as quaternary PSK, quadriphase PSK, 4-PSK, or 4-QAM. QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol. The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed.

In telecommunication transmission, the Bit Error Rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power. For example, a transmission might have a BER of 10^{-6} meaning that, out of 1,000,000 bits transmitted, one bit was in error. The BER is an indication of how often a packet or other data unit has to be retransmitted because of an error. Too high a BER may indicate that a slower data rate would actually improve overall

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transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be resent.

Rayleigh Fading Model

The phase of each path can change by 2® radian when the delay $T_n(t)$ changes by $\frac{1}{f_c}$. If f_c is large, relative small motions in the medium can cause change of 2®-radians. Since the distance between the devices are much larger than the wavelength of the carrier frequency, it is reasonable to assume that the phase is uniformly distributed between 0 and 2® radians and the phases of each path are independent. When there are large numbers of paths, applying Central Limit Theorem, each path can be modeled as circularly symmetric complex Gaussian random variable with time as the variable. This model is called Rayleigh fading channel model.

Additive White Gaussian Noise

The transmitted waveform gets corrupted by noise '*n*', typically referred to as Additive White Gaussian Noise (AWGN). In communications, the AWGN channel model is one in which the only impairment is the 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. The model does not account for the phenomena of fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple, tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered. AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self-interference that modern radio systems encounter in terrestrial operation.

BER for BPSK in Rayleigh Fading Channel

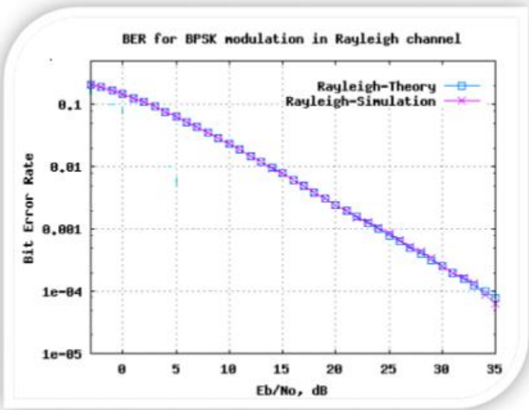
The previous chapter the discussion about BER (bit error rate) for BPSK modulation in a simple AWGN channel has been presented. The present chapter deals with the BER for BPSK in a Rayleigh multipath channel. In a brief discussion on Rayleigh channel, where we stated that a circularly symmetric complex Gaussian random variable is of the form

$$h = h_{re} + jh_{im}$$

where real and imaginary parts are zero mean independent and identically distributed Gaussian random variables with mean 0 and variance $\pm^2$. The magnitude $|h|$, which has a probability density,

$$P(h) = \frac{h}{\pm^2} e^{\frac{-h^2}{2\pm^2}}, h \ge 0$$

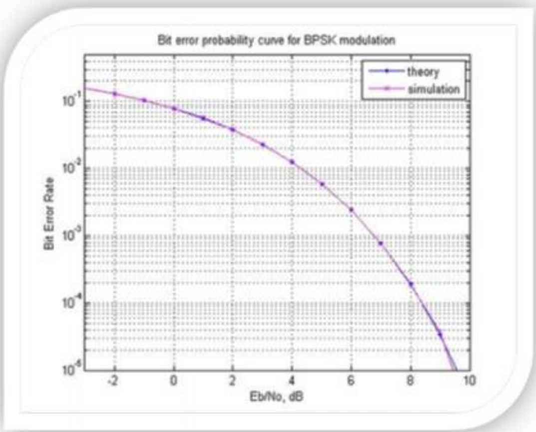
Figure 1: BER for BPSK Modulation in Rayleigh Channel



'*h*' is called a Rayleigh random variable. This model, called Rayleigh fading channel model, is reasonable for an environment where there present a large number of reflectors.

Keying (BPSK), the binary digits 1 and 0 maybe represented by the analog levels $+\sqrt{E_b}$ and $-\sqrt{E_b}$ respectively. The system model is as shown in the Figure below.

Figure 2: BER Probability Curv for BPSK Modulation



BER for QPSK Over AWGN

Consider that the alphabets used for a QPSK (4-QAM) is

$$\sim_{QPSK} = \{\pm 1 \pm 1j\}$$

BER for BPSK in AWGN Channel: Here, we will derive the theoretical equation for Bit Error Rate (BER) with Binary Phase Shift Keying (BPSK) modulation scheme in Additive White Gaussian Noise (AWGN) channel. The BER results obtained using Matlab simulation scripts show, good agreement with the derived theoretical results. With Binary Phase Shift E_b/N_0 vs BER for BPSK over Rayleigh Channel and AWGN Channel.

Figure 3: Constellation Plot for QPSK (4-QAM) Constellation

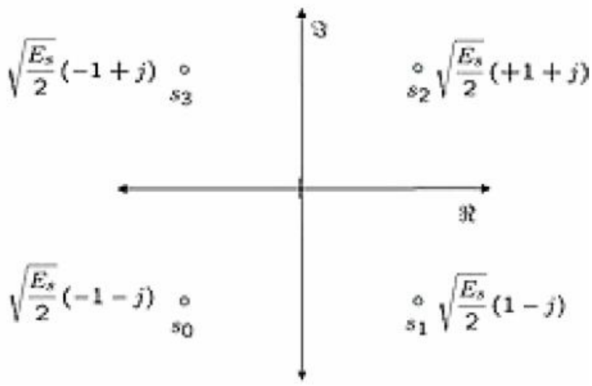
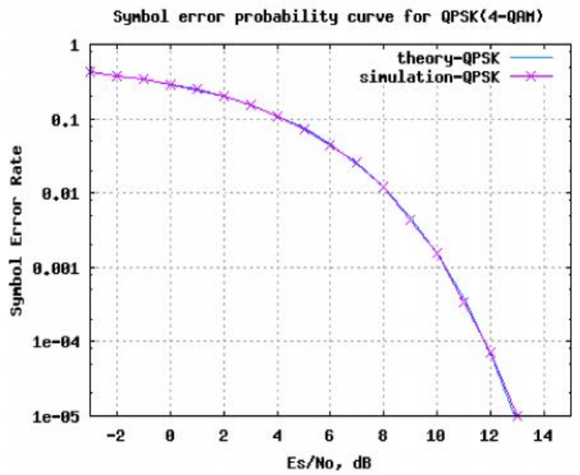


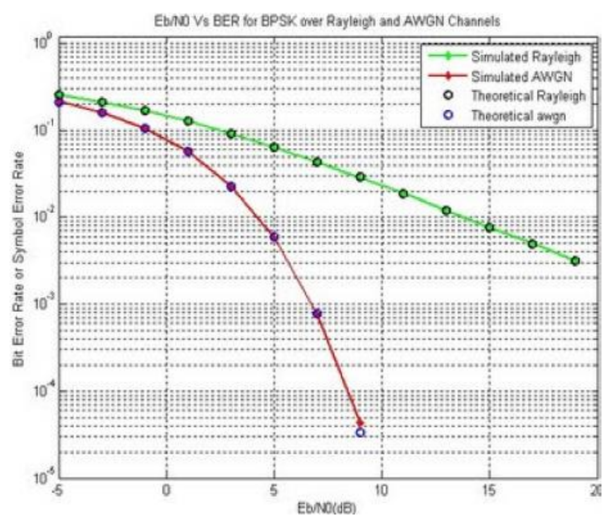
Figure 4: QPSK Symbol Error Probabilty Curv for E_b/N_0 vs BER for BPSK Over Rayleigh Channel and AWGN Channel



The performance (E_b/N_0 vs BER) of BPSK modulation (with coherent detection) over Rayleigh Fading channel and its comparison over AWGN channel is discussed.

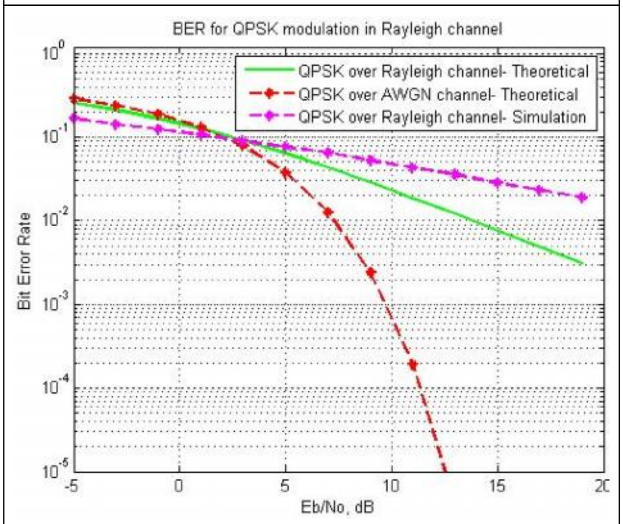
We first investigate the non-coherent detection of BPSK over Rayleigh Fading channel and then we move on to the coherent detection. For both the cases, we consider a simple flat fading Rayleigh channel (modelled as a single tap filter with complex impulse response *h*). The channel also adds AWGN noise to the signal samples after it suffers from Rayleigh Fading.

Figure 5: E_b/N_0 BER Over Rayleigh and AWGN Channel



Bit Error Rate (BER) versus Signal-to-Noise Ratio (SNR) over Rayleigh fading channel and the AWGN for QPSK modulation scheme.

Figure 6: BER for QPSK Modulation in Rayleigh Channel



SIMULATIONS RESULT

The simulations in this work are carried out using MATLAB software. The performance is simulated and evaluated for BPSK systems. Based on data generated by computer simulation of BPSK modulation techniques for BER calculation the following results are obtained. Bit Error Rate (BER) versus Signal-to-Noise ratio (SNR) over Rayleigh fading channel and the AWGN for BPSK modulation scheme.

CONCLUSION

In case of BPSK as compared to the AWGN case, around 25 dB degradation thus the study of BPSK over Rayleigh Channel and AWGN channel says that the amount of energy required for transmission over AWGN channel is lesser than the energy required for transmission over Rayleigh channel. We also observed that the BER for transmission over AWGN channel is lesser than that for Rayleigh channel. From our results, it is evident that QPSK modulation is preferred in cases where we need to consider small amounts of transmitting energy. The main reason is that the QPSK offers acceptable BER while transmitting signals of relatively low energy. This work further focuses on the ways to reduce BER and thus increase power efficiency. This in turn, results in the transmission of signals of specified quality with a smaller transmit power.

FUTURE WORK

The work in this project is Bit Error Rate and the E_b/N_0 vs BER for BPSK modulation over Rayleigh Fading channel and the AWGN for uncoded signal. The future work is bit error rate and the E_b/N_0 vs BER for BPSK modulation over Rayleigh Fading channel and the AWGN for coded signal using convolution codes and The Viterbi Algorithm.

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