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A COMPREHENSIVE COMPARATIVE STUDY OF FADING CHANNELS

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ABSTRACT

For Design And performance evolution of wireless digital communication system the most important part is the simulation of wireless channel as whole performance of the system is depend upon the channel. In this paper the performance of three wireless channels, AWGN, Rayleigh and Rician have been evaluated. These three channels are most widely used in Single Input Single Output (SISO) and Multiple Input Multiple Output (MIMO) communication system. The performance is evaluated on the basis of Bit Error Rate (BER) versus signal to noise ratio (SNR) . The stimulation results shown the performance of different channel models based on BER at different SNR. The Rayleigh channel model is the most suitable model for urban areas as it is the model which simulates a channel with no Line of Sight (LOS) path and is the most difficult environment.

KEYWORDS: Fading Channels, Rayleigh, Rician, BER

INTRODUCTION

Wireless communication has become a most important area of technology development as it is a prominent part of everyday life. Due to the increasing demand of data communication through mobile or wi-fi, wireless channels plays an important role as they induced distortion results in Inter Symbol Interference (ISI), which if left uncompensated can cause higher error rates. The best compensation for ISI problem is the equalizer. To design a good equalizer we must have to model the channel accurately. The three important channel models to describe a time-variant nature of a channel, frequently used, are AWGN, Rayleigh and Rician [1].

Fading or loss of signals is a very important phenomenon that revealed to the wireless communication field. The better a model can describe a fading environment the better it can be compensated at the receiver with the help of equalizer, as an equalizer is an inverse filter which models a channel [2]. Our purpose is to receive a signal at the receiver error free or close to being error free. It would result in better clarity of voice in case of audio transmission or higher accuracy of data in case of data transmission. Therefore in a wireless communication system the selection of fading model plays a very important role [2].

WIRELESS CHANNEL MODELING

A wireless channel may be modelled as a linear filter with a time varying impulse response, where the time variation is due to receiver motion in space. Due to the different multipath waves which have propagation delays which vary over different spatial locations of the receiver, the impulse response of the LTI channel should be a function of the position of the receiver.

$$y(d,t) = x(t) * h(d,t) = \int_{-\alpha}^{\alpha} x(\tau)\, h\big(d,(t-\tau)\big) d\tau \quad (1)$$

$h(d,t)$ is the channel impulse response.

$x(t)$ is the transmitted signal.

$y(d,t)$ is the received signal at position "d".

FADING AND MULTIPATH

In wireless communication system fading is due to the multipath i.e the received signal reaching the receiver antenna by two or more path. Due to the result of fading the received signal includes multiple versions of the transmitted signal which are attenuated and delayed in time. A multipath channel induces Inter Symbol Interference (ISI). According to the effect of multipath the fading can be classified as:

- Large scale Fading in which received signal power varies due to attenuation in the signal.
- Small scale Fading results due to rapid fluctuations of phase and amplitude of the signal.

TYPES OF SMALL SCALL FADING

Rayleigh Fading Model

It is the model which describes the effect of heavily built up urban environment on wireless signal. It is most applicable when there is no line of sight (LOS) path or a direct path between transmitter and receiver.

Rician Fading Model

It is similar to the Rayleigh fading model with only the difference that in Rician fading there is a strong dominant component known as LOS component

AWGN Model

This is the simplest radio environment which added the background noise to the transmitted signal thus received signal r(t) can be written as r(t)=x(t) + n(t) where x(t) is the transmitted signal and n(t) is the background noise. This channel added the while Gaussian noise to the signal that passes through it and used as a standard channel model.

SIMULATION PROCEDURE

To study the various fading channel model a bit error rate testing is used . MATLAB is an ideal tool for this purpose, thanks to its easy scripting language and excellent data visualization capabilities. The bit error rate performance of a receiver is a figure of merit that allows different designs to be compared in a fair manner.

Run Transmitter

This is the first step in the simulation. One million data bits are generated and modulated using BPSK modulation. We call this signal as x.

Establish SNR

The signal to noise ratio (SNR) usually expressed in decimal are first converted to ordinary ratio using MATLAB

command

Ebno=10^(snrdb/10)

Generate Noise

Any MATLAB command can be used to generate noise. MATLAB also provide a direct built in function to generate AWGN noise. In our program we have used the following function

N=sqrt(pn)*randn(1,length(x))

Add Noise

Now we create a noisy signal by adding the noise vector to the signal vector.

y=x+n

Add Channel Effect

This signal is pass through different channel such as Rayleigh and Rician to further introduce the fading effect.

Run Receiver

Once we have created a faded noisy data we use the receiver to demodulate this signal. The demodulated signal is then compare with the original transmitted signal to determine how many demodulated bits are in error.

Plotting

Finally we plot all the result. The x-axis will contain SNR values while the y-axis will contain the Bit error rate (BER).

SIMULATION DIAGRAM

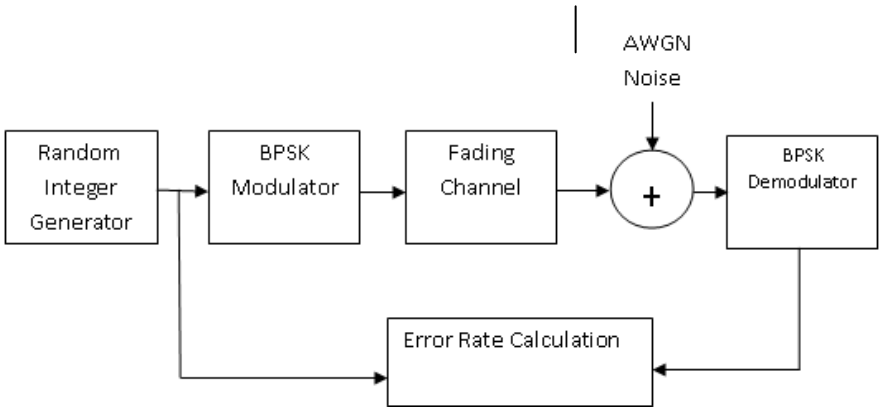


Figure 1: Simulation Diagram

SIMULATION RESULTS

In this the concept of fading is demonstrated with the help of Inbuilt MATLAB functions. Due to its easy scripting and excellent data visualization capability the MATLAB is an ideal tool for simulating various communication systems and channels. Bit Error Rate is the figure of merit of all communication system. The binary data is generated and modulated by BPSK modulation. Figure 1 and 2 shows the original and distorted data. The modulated data is passed

through the fading channels and the faded data is as shown in Figure 3 and 4. The AWGN noise is also added during transmission. At the receiver the corrupted data is demodulated and the bit error rate is calculated first by adding only AWGN noise and then passing the data through Rician and Rayleigh channel individually. Table 1 compare the BER of the three channels. A graph is plotted using MS Excel.

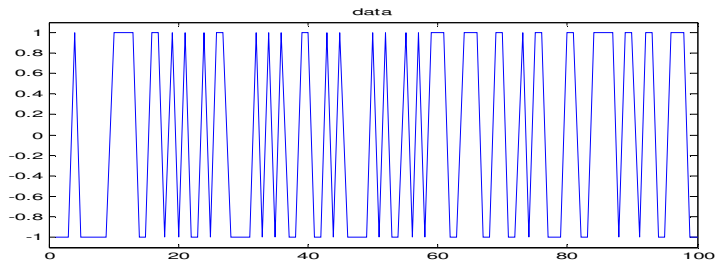


Figure 2: Original Data

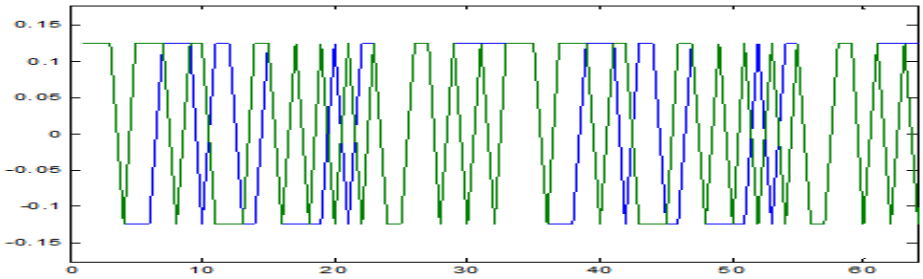


Figure 3: BPSK Modulated Data

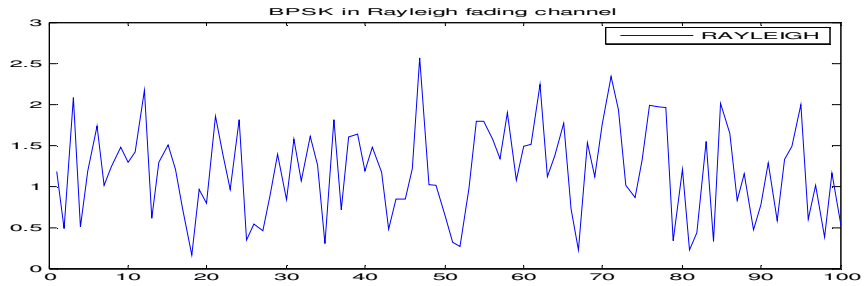


Figure 4: Rayleigh Fading Channel Output

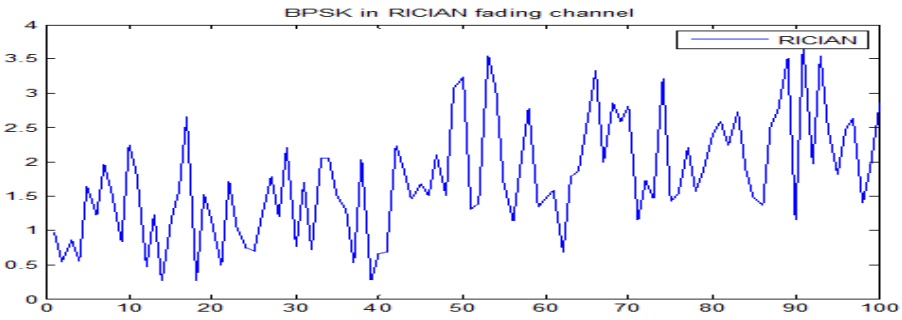
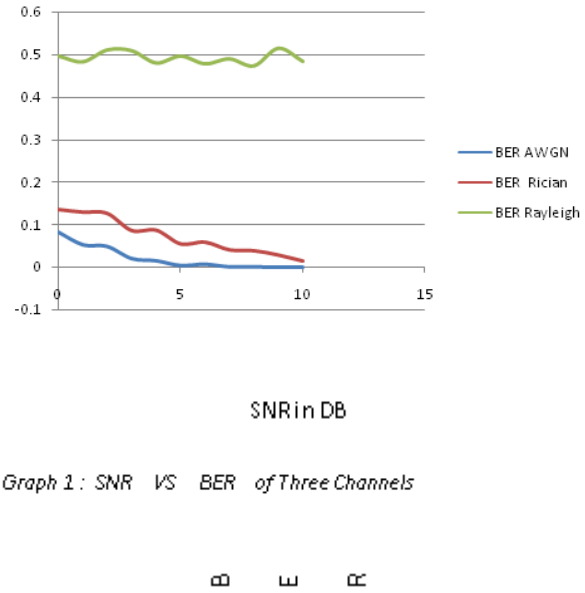


Figure 5: Rician Fading Channel Output

Table 1: Comparison SNR VS BER of Three Channels

SNR Db	BER AWGN	BER Rician	BER Rayleigh
0	0.0810	0.1340	0.4960
1	0.0520	0.1280	0.4820
2	0.0480	0.1250	0.5110
3	0.0200	0.0850	0.5090
4	0.0150	0.0860	0.4790
5	0.0040	0.0540	0.4960
6	0.0070	0.0580	0.4770
7	0.0010	0.0400	0.4890
8	0.0010	0.0380	0.4720
9	0	0.0280	0.5150
10	0	0.0140	0.4830



Graph 1 : SNR VS BER of Three Channels

CONCLUSIONS

Rayleigh fading channel is much more difficult environment than AWGN. Rician fading channel has less errors as it has a LOS path which gives more SNR and less BER. In case of Rayleigh 10 DB extra (10 times higher) power is needed as compare to AWGN to have equal results.

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