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# Performance Analysis of Communication System with Convolutional Coding over Fading Channel

Mamta Arora, Hardeep Kaur

**Abstract –** Multipath fading is a major problem of the wireless communication channel. To eliminate this fading problem and to have reliable communications in wireless channel, channel coding techniques are used. In this paper BER (bit error rate) performance is shown, by the means of Rayleigh and Rician multipath fading channels. Here the convolution encoding is used. The performance of convolution encoded binary phase shift keying (coded BPSK) and viterbi decoding is investigated. The performance of coded signal is better than uncoded signal. In this paper, how much improvement in BER is there when convolution code is employed for Rayleigh and Rician fading channel. Simulation results are shown graphically.

**Index Terms -** BER, BPSK, Convolution code, AWGN, Rayleigh multipath fading channel, Rician multipath fading, Viterbi decoding.

## 1 INTRODUCTION

In digital communication systems data is transferred from transmitter to a receiver across a physical medium of transmission. The channel is generally affected by noise or fading which introduces error in the data being transferred [1]. To improve the output, channel coding is employed. The maximum performance of the system is limited by Shannon limit. Forward Error Correction (FEC) and Automatic Repeat Request (ARQ) are two basic errors correcting schemes, [2] being used in communications systems. In this paper convolution code is used as error control code. The viterbi algorithm was proposed in 1967 as a method of decoding convolution codes [3]. The bit error rate performance is evaluated for convolution code and it is compared with the bit error rate for uncoded signal.

## 2 SYSTEM MODEL

Fig.1 shows the simple digital systems. Source data is firstly converted to binary data, and then convolution coding is applied on binary data. After encoding, modulation is performed. Additive white Gaussian Noise (AWGN) is added when coded data is passed through the channel. Fading is added to include the channel response as mostly noise is added to the data when it is passed through the channel (Rayleigh and Rician fading channel). Demodulation of data is performed at receiver end. After demodulation convolution decoding is performed and original transmitted data is retrieved.

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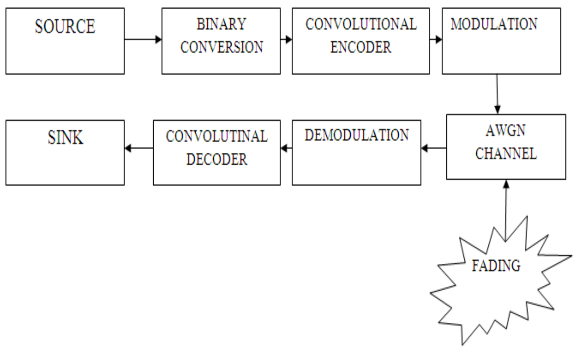


Fig 1: Simple digital communication system

## 3 CHANNELS USED

### 3.1 Additive White Gaussian Noise (Awgn) Channel:

In AWGN, channel noise is assumed to have Gaussian nature and additive. AWGN channel is having constant spectral density. In awgn, there is no phenomenon of fading, interference and nonlinearity.

The relation between Eb/No and Es/No by following equation [4]:

$$\frac{E_s}{N_o}(db) = \frac{E_b}{N_o}(db) + 10log_{10}(n)$$

Where, n is bits per sample.

### 3.2 Rayleigh fading channel :

Simple flat fading Rayleigh channel is considered. The AWGN noise is added to the channel to samples the signal after suffering from Rayleigh Fading.

The received signal y can be represented as [5]:

$$y = hx + n$$

Where n is the noise contributed by AWGN which is Gaussian distributed with zero mean and unit variance and h is the Rayleigh fading response with zero mean and unit variance.( For a simple AWGN channel without Rayleigh Fading the received signal is represented as y=x+n).

### 3.2.1 Coherent Detection:

In coherent detection, the receiver has sufficient knowledge about the channel impulse response. Let's consider that the channel impulse response estimate at receiver is known and is perfect and accurate. The transmitted symbols ('x') can be obtained from the received signal ('y') by the process of equalization as given below [5].

$$y^{\wedge} = \frac{y}{h} = \frac{hx+n}{h} = x+z$$

Here z is still an AWGN noise except for the scaling factor 1/h. Now the detection of x can be performed in a manner similar to the detection in AWGN channels.

The input binary bits to the BPSK modulation system are detected as[5]:

$$r = real(y^{\wedge}) = real\ (x+z)$$

$$d^{\wedge} = 1, if\ r > 0$$

$$d^{\wedge} = 0, if\ r < 0$$

### 3.2.2 Simulation Model:

The fig 2 represents the model which is used for the simulation of BPSK over Rayleigh Fading channel and it is compared with AWGN channel.

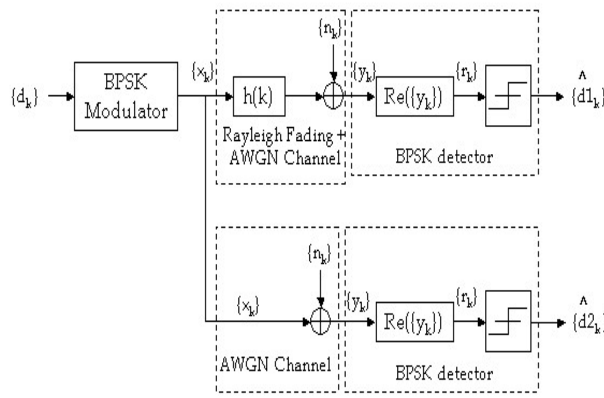


Fig2: Simulation of BPSK over Rayleigh Fading channel and compared with AWGN channel [5].

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### 3.3 Rician fading channel

#### 3.3.1 Rician Fading:

Rician Fading model produces multipath components and line of sight (LOS) component. The multipath component is known as "scatter" component and LOS component is "specular" component. The amplitude distribution of the specular component will have non-zero mean, where as, the random component will have zero-mean [5].

#### 3.3.2 Rician Distribution:

Consider two Gaussian random variables X and Y. Here X models the specular component (LOS) and Y models the random/scatter component. By definition, X has non-zero mean (m), Y has zero mean and both have equal variance $\sigma^2$. Then the transformation [5], $Z = \sqrt{X^2 + B^2}$ is Rician Distributed.

The ratio of power of specular component (m) to the power of scatter ($2\sigma^2$) component is called Rician factor (k) and it is taken in db, it is defined as[5]:

$$k = \frac{m}{2\sigma^2}$$

It can be immediately ascertained that Rayleigh Fading is related to central Chi Square distribution (due to zero mean) and the Rician Fading is related to non-central Chi Square distribution (due to non zero mean) [5].

The simulation of Rician Fading is similar to Rayleigh Fading. The only difference here is that Rician factor. The mean and sigma are calculated with the given Rician factor (k).

Let's define mean (m) and sigma (σ) as given below, so that it satisfies the equation given above [5].

$$m = \sqrt{\frac{k}{(k+1)}}$$

$$\sigma = \sqrt{\frac{1}{2 * (k+1)}}$$

As discussed above, in Rician Fading, the specular component (X) has to be a Gaussian random variable with mean=m and sigma=σ, but the scatter component (Y) has to be generated with mean=0 and sigma=σ.

In Matlab "rand" function generates Gaussian random numbers with mean=0 and sigma = 1.to generate specular component (X) with mean=m and sigma= σ, the output of randn has to be multiplied with σ and added with m. To generate scatter component (Y), with sigma=σ, the output of the randn function has to be multiplied with σ.

#### 3.3.3 Simulation Model:

Fig 3 represents the simulation of BPSK over Rician multipath fading with Awgn noise.

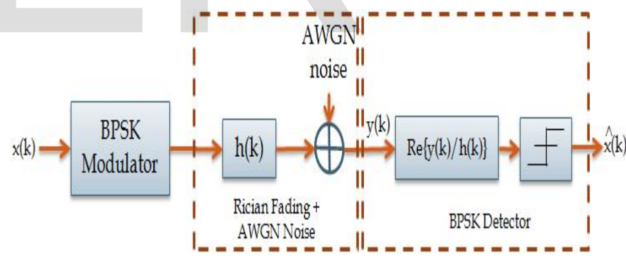



Fig 3: The simulation of BPSK over Rician multipath fading with Awgn noise.

## 4 SIMULATIONS

The simulation results of BER performance of AWGN, Rayleigh and Rician fading channels are shown below with the help of graph using MATLAB.

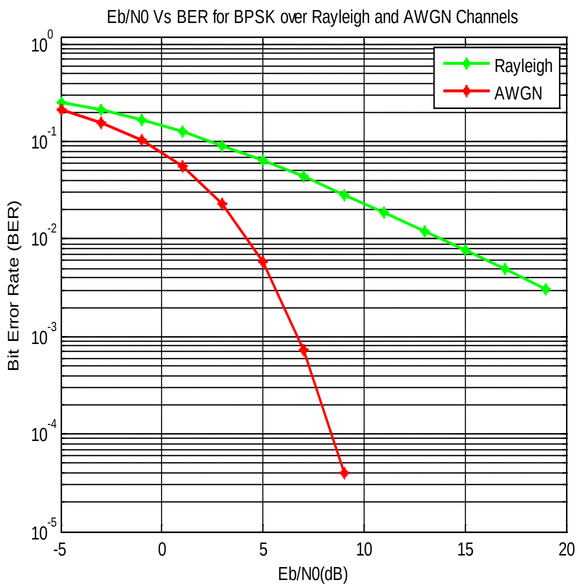



Fig 4: The Eb/N0 Vs BER for Rayleigh and AWGN channel.

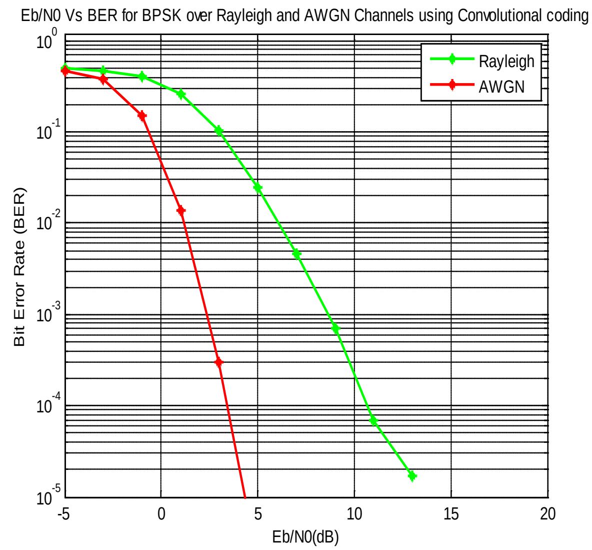



Fig 6: The Eb/N0 Vs BER for Rayleigh and AWGN channel using Convolutional coding.

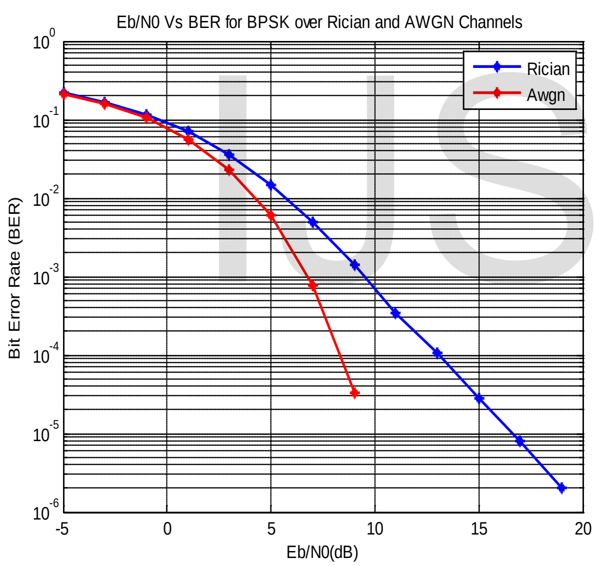



Fig 5 : The Eb/N0 Vs BER for Rician and AWGN channel.

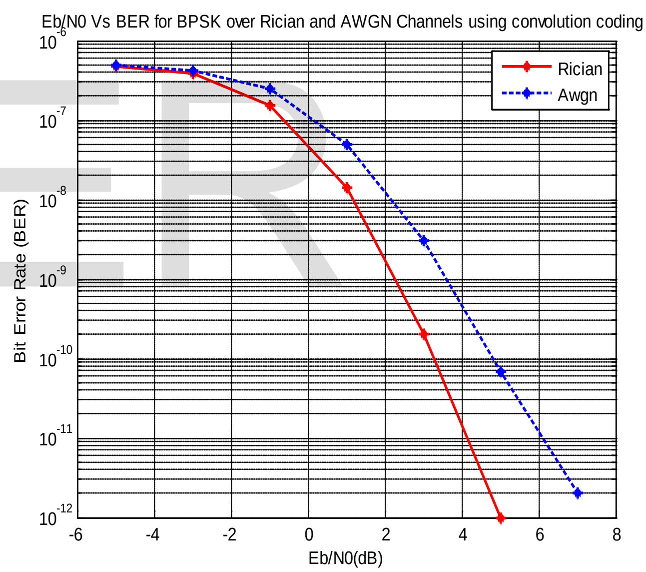



Fig 7: The Eb/N0 Vs BER for Rician and AWGN channel respectively with using Convolutional coding.

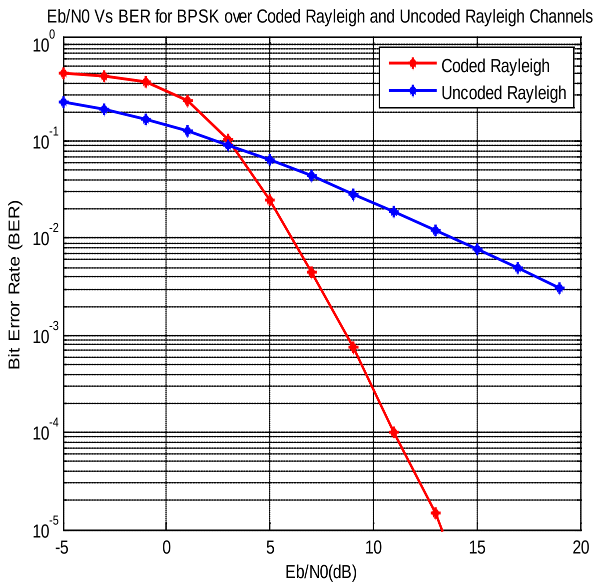
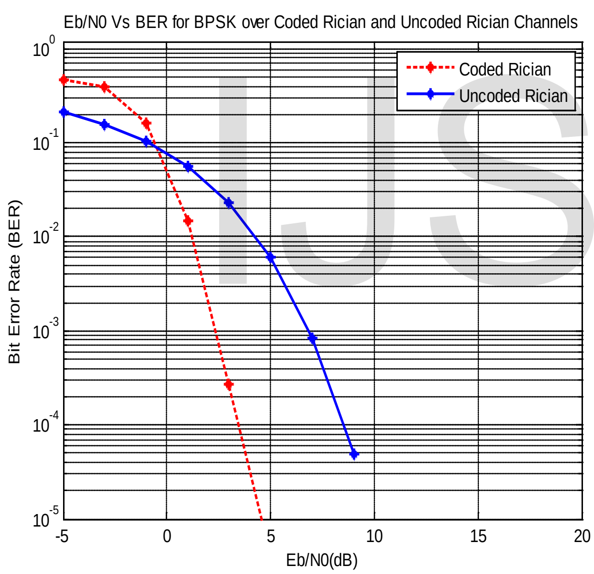



Fig 8: The comparison Eb/N0 Vs BER for the coded Rayleigh and uncoded Rayleigh channels.




(b)

Fig 9: The comparison Eb/N0 Vs BER for the coded Rician and uncoded Rician channels.



## 5 CONCLUSIONS

By simulation, it is shown that the improvement of BER using the Convolutional code in the presence of the fading provides a better performance than that of the uncoded signal. In real world fading is the part communication, which we have to consider while simulating any system.

- From Fig. 4,5,6,7 we conclude that, AWGN channel works only on small value of Eb/No (without fading). At high value of Eb/No (with fading) AWGN diminishes.
- From Fig. 6,7 we also conclude that, BER is decreased by using Convolutional coding.
- From Fig. 8,9 we conclude that, coded signal have less BER at high value of Eb/No (with fading).

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