EB/N0 VS BER FOR BPSK OVER RICIAN FADING CHANNEL

In one of the previous article, simulation of BPSK over Rayleigh Fading channel was discussed. This article deals with simulation of another important fading type : Rician Fading.

Rayleigh Fading:

Rayleigh Fading model is used to simulate environments that has multiple scatterers and no Line Of Sight (LOS) path. If there are sufficient multiple scatterers in the environment, all the reflected signals that appear at the receiver front end becomes uncorrelated in amplitude (this brings mean =0) and phase evenly distributed between 0 to 2π. Eventually the I (inphase) and Q (quadrature) phase components become Gaussian distributed (by central limit theorem) and their envelope $Z = \sqrt{I^2 + Q^2}$ becomes Rayleigh distributed.

Note that distribution I^2 is called Chi-Square distribution. If I^2 has mean=0, then it is called central-Chi-square distribution and if mean ≠ 0 it is called non-central-Chi-square distribution

Rayleigh Distribution:

Consider two Gaussian random variables X and Y with zero mean and equal variance σ^2. Then the transformation $Z = \sqrt{X^2 + Y^2}$ is Rayleigh Distributed and Z^2 is exponentially distributed.

Rician Fading:

Rician Fading model is used to simulate environments that produces multiplath components and also a dominant Line Of Sight (LOS) component. The LOS component is called “specular” component and the multipath component is called “random or scatter” component. The amplitude distribution of the specular component will have non-zero mean, where as, the random component will have zero-mean.

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 σ^2. Then the transformation, $Z = \sqrt{X^2 + Y^2}$ is Rician Distributed.

The ratio of power of specular component to the power of random component is called Rician κ factor and it is defined as

κ=m22σ2

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).

Performance simulation of BPSK over Rician Fading Channel with AWGN noise:

The simulation strategy is very similar to the technique used for simulating Rayleigh Fading. The only difference here is that in Rician Fading, κ factor is one of inputs that defines the relative strength of LOS component and the multiplath scattered component.

To simulate a Rician Fading channel, mean and sigma has to be calculated with the given Rician κ factor.

Lets define mean (m) and sigma (σ) as given below, so that it satisfies the equation given above.

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

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

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 randn function generates Gaussian random numbers with mean=0 and sigma = 1. To generate X component with mean=m and sigma=σ, the output of randn has to be multiplied with σ and added with m. To generate Y component with sigma=σ, the output of the randn function has to be multiplied with σ. The rest of the simulation code is similar to that of BPSK over Rayleigh/AWGN channel simulation.

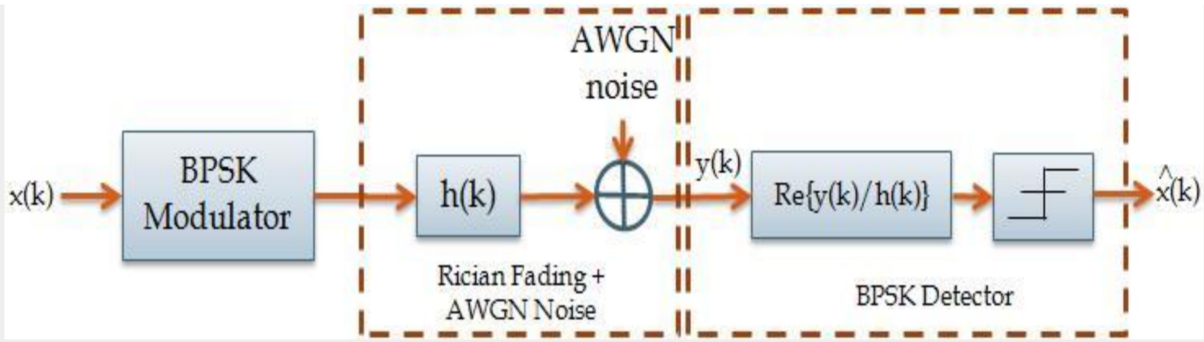
Theoretical BER :

Theoretical BER for BPSK over Rician Fading Channel with AWGN noise is given by the following expression:

$$P_b = \frac{1}{2} erfc\left[\sqrt{\frac{\kappa(E_b/N_0)}{(\kappa+E_b/N_0)}}\right]$$

Simulation Model:

The following model is used for the simulation of BPSK over Rician Fading channel (with AWGN noise).



Rician Fading Simulation Model

Source: http://www.gaussianwaves.com/2012/07/ebn0-vs-ber-for-bpsk-over-rician-fading-channel/