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Analysis of Symbol Error Rate For η-μ/ κ- μ Fading Channel

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Abstract: In this paper average symbol error rate (ASER)has been calculated in interference limited environment while assuming that desired signal has been affected by η-μ fading and interference signal has been affected by κ- μ fading.Error has been calculated for coherent frequency shift keying (CFSK) and coherent phase shift keying (CPSK). Evaluated results have been plotted for different parameters.

Key-Words: η-μ fading, κ- μ fading, interference, ASER, CFSK,CPSK

I. INTRODUCTION

As the demand of wireless communication applications is increasing day by day, availability of bandwidth is reducing. So, sharing of spectrum is required, but at the cost of interference. In wireless communication, fading and interference degrades the performance of the wireless communication system severely. So, in this paper effect of interference inη-μfading channel has been studied. Average bit error rate has been calculated in [1] using η-μ fading channel and same fading has been considered for interfering signal. In [2], outage probability has been calculated for maximal ratio combining receiver subjecting η-μ fading for both desired signal and interfering signal. Outage probability has been calculated in [3] using κ- μ fading for both desired signal and interfering signal but in the presence of noise. In [4] outage probability and probability error for non - coherent frequency shift keying modulation have been calculated for selection combining receiver. In this η-μ fading has been considered for desired signal and κ- μ fading for interference signal. In this paper, probability of error has been calculated for η-μ fading and interference signal has been assumed to be affected by κ- μ fading. Probability of error has been calculated for coherent frequency shift keying and coherent phase shift keying for different values of μ_c, κ_c and μ_d.

II. CHANNEL MODEL

For this paper, desired signal is assumed to be effected by η-μ fading which is given by [5]

$$p_R(R) = \frac{4\sqrt{\pi}{\mu_d}^{\mu_d+\frac{1}{2}}{h_d}^{\mu_d}R^{2\mu_d}}{\Gamma(\mu_d){H_d}^{\mu_d-\frac{1}{2}}\Omega_d^{\mu_d+\frac{1}{2}}}e^{\frac{-2\mu_d h_d}{\Omega_d}R^2}I_{\mu_d-\frac{1}{2}}\left(\frac{2\mu_d H_d}{\Omega_d}R^2\right), \quad (1)$$

Where $\Gamma(.)$ is the gamma function $I_v(.)$ is the v^{th} order Bessel function of first kind. The parameters h_d, H_d are given as $h_d = (2+\eta_d^{-1}+\eta_d)/4$ and $H_d = (\eta_d^{-1}-\eta_d)/4$ in Format1 while $h_d = 1/(1-\eta_d^2)$ and $H = \eta_d/(1-\eta_d^2)$ for Format 2.In Format 1, the in phase and quadrature phase components with each cluster are considered to be independent from each other and having different powers.The parameter 0<η< ∞, is the power ratio of in phase and quadrature scattered waves in each multipath cluster. In Format 2, the in phase and quadrature phase components are assumed to be correlated within each cluster and having identical powers. In Format 2, η gives the correlation between the power of these components in multipath clusters and its value is -1<η<1.These two Formats are related mathematically by relation $\eta_{\text{Format 2}} = \frac{1-\eta_{\text{Format 1}}}{1-\eta_{\text{Format 2}}}$.Interfering signal is assumed to be affected by κ- μ fading. Probability density function (PDF) of κ- μ fading is given below [4]:

$$p_r(r) = \frac{2\mu_c {\kappa_c}^{\frac{1-\mu_c}{2}}(1+\kappa_c)^{\frac{\mu_c+1}{2}}r^{\mu_c}}{e^{+\mu\kappa}{\Omega_c}^{\frac{\mu_c+1}{2}}}e^{\frac{-\mu_c(1+\kappa_c)r^2}{\Omega_c}}$$

$$\times I_{\mu_c-1}\left(2\mu_c\sqrt{\frac{\kappa_c(1+\kappa_c)}{\Omega_c}r^2}\right), \quad (2)$$

Considering that desired signal is affected by η-μ fading and interference signal is effected by κ- μ fading , PDF is taken from [4]:

$$p_\lambda(\lambda) = \sum_{p=0}^{\infty}\sum_{l=0}^{\infty}\frac{2\sqrt{\pi}H_d^{2p}{\mu_d}^{2\mu_d+2p}{\mu_c}^{\mu_c+2l}{\kappa_c}^{l}(1+\kappa_c)^{\mu_c+l+1}\Gamma(2\mu_d+\mu_c+2p+l)}{2\exp(\mu_c\kappa_c)\,\Gamma(\mu_d)\Gamma\left(\mu_d+p+\frac{1}{2}\right)\Gamma(\mu_c+l)p!\,l!}$$

$$\times \frac{\lambda^{2p+2\mu_d-1}S^{\mu_c+l}}{(\mu_c(1+\kappa_c)S+2\mu_d h_d\lambda)^{2\mu_d+\mu_c+2p+l}}, \quad (3)$$

$$ABER = Pe = \int_0^\infty p_\lambda(\lambda)\overline{P_e}\, d\lambda \qquad (4)$$

Where $\overline{P_e} = Q(\sqrt{2a\lambda})$ is the conditional Symbol error probability for coherent frequency shift keying (a=0.5) and coherent phase shift keying (a=1). After putting $\overline{P_e}$ and $p_\lambda(\lambda)$ in eq. (4), as $Q(\sqrt{2a\lambda}) = \frac{1}{2}erfc(\sqrt{a\lambda})$ and using the following relation [6], probability of error is calculated.

$$erfc(x) \simeq \frac{1}{6}e^{-x^2} + \frac{1}{2}e^{-4x^2/3}, \qquad x > 0.5$$

$$\begin{aligned} Pe &= \sum_{p=0}^{\infty}\sum_{l=0}^{\infty} \frac{2\sqrt{\pi}H_d^{2p}{\mu_d}^{2\mu_d+2p}{\mu_c}^{\mu_c+2l}{\kappa_c}^{l}(1+\kappa_c)^{\mu_c+l+1}\Gamma(2\mu_d+\mu_c+2p+l)}{12\times 2\,exp(\mu_c\kappa_c)\,\Gamma(\mu_d)\Gamma\left(\mu_d+p+\frac{1}{2}\right)\Gamma(\mu_c+l)p!\,l!} \\ &\times \frac{S^{\mu_c+l}}{(\mu_c(1+\kappa_c)S)^{2\mu_d+\mu_c+2p+l}} \times \left(\frac{2\mu_d h_d}{\mu_c(1+\kappa_c)S}\right)^{-(2p+2\mu_d)} \times \Gamma(2p+2\mu_d) \\ &\times \Psi\left(2\mu_d+2p, 1-\mu_c-l, \frac{a(\mu_c(1+\kappa_c)S)}{2\mu_d h_d}\right) \\ &+ \sum_{p=0}^{\infty}\sum_{l=0}^{\infty} \frac{2\sqrt{\pi}H_d^{2p}{\mu_d}^{2\mu_d+2p}{\mu_c}^{\mu_c+2l}{\kappa_c}^{l}(1+\kappa_c)^{\mu_c+l+1}\Gamma(2\mu_d+\mu_c+2p+l)}{12\times 2\,exp(\mu_c\kappa_c)\,\Gamma(\mu_d)\Gamma\left(\mu_d+p+\frac{1}{2}\right)\Gamma(\mu_c+l)p!\,l!} \\ &\times \frac{S^{\mu_c+l}}{(\mu_c(1+\kappa_c)S)^{2\mu_d+\mu_c+2p+l}} \times \left(\frac{2\mu_d h_d}{\mu_c(1+\kappa_c)S}\right)^{-(2p+2\mu_d)} \times \Gamma(2p+2\mu_d) \\ &\times \Psi\left(2\mu_d+2p, 1-\mu_c-l, \frac{2a(\mu_c(1+\kappa_c)S)}{3\mu_d h_d}\right) \quad (5) \end{aligned}$$

Where $\Psi(a, b, c)$ is the confluent hyper geometric function.

III. RESULTS&DISCUSSIONS

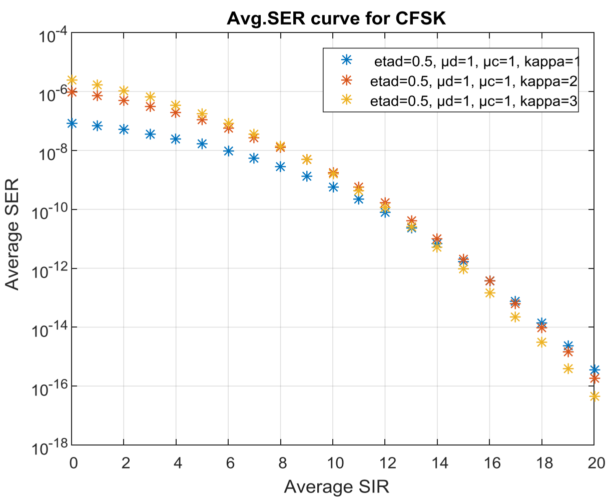

Figure 1: ASER for CFSK for different values of κ_c(FORMAT I)

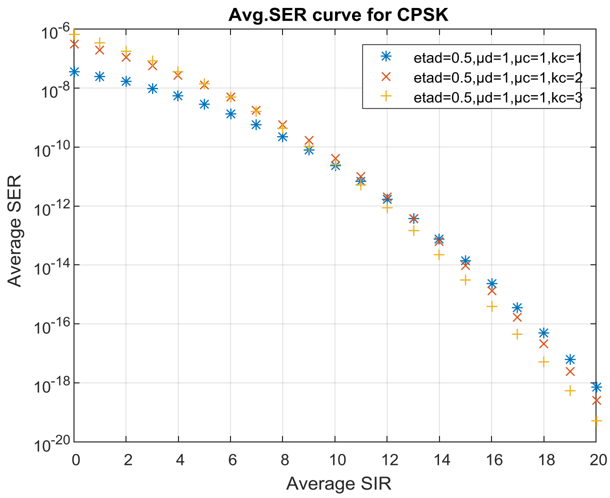

Figure 2: ASER for CPSK for different values of κ_c (FORMAT I)

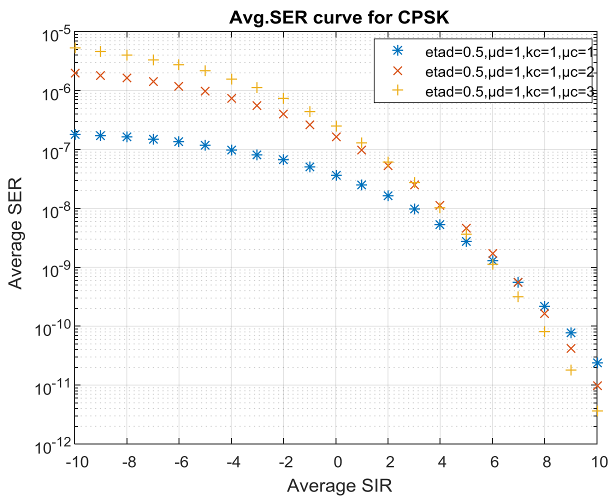

Figure 3: ASER for CPSK for different values of μ_c (FORMAT I)

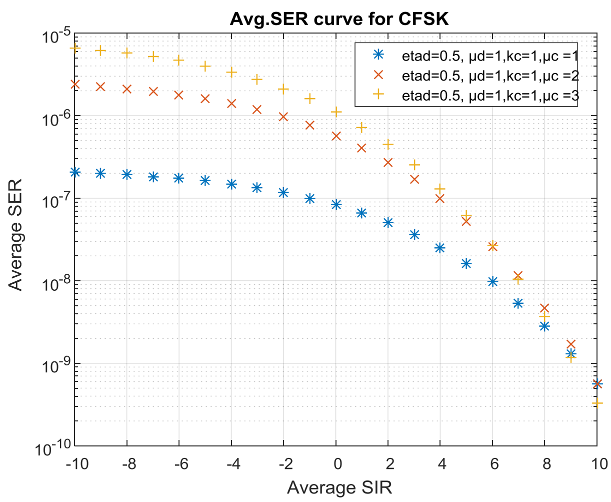

Figure 4: ASER for CPSK for different values of μ_c (FORMAT I)

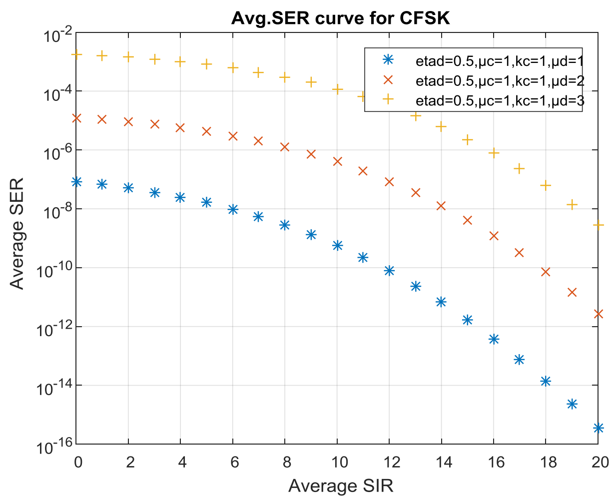

Figure 5: ASER for CFSK for different values of μ_d (FORMAT I)

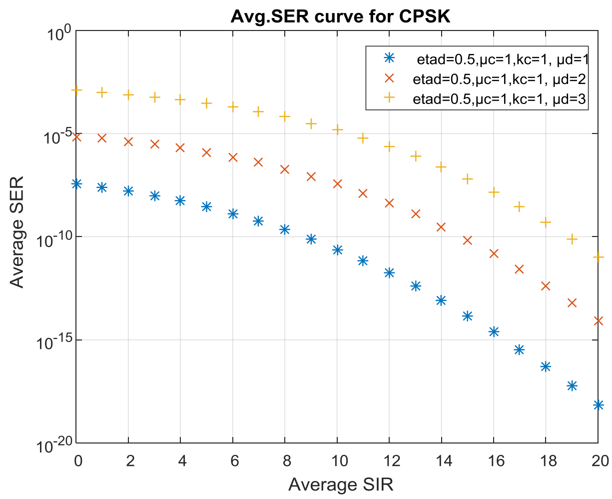

Figure 6: ASER for CPSK for different values of μ_d (FORMAT I)

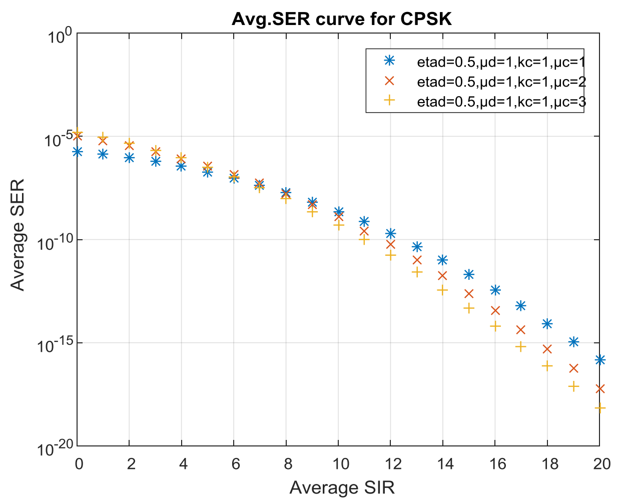

Figure 7: ASER for CPSK for different values of μ_c (FORMAT II)

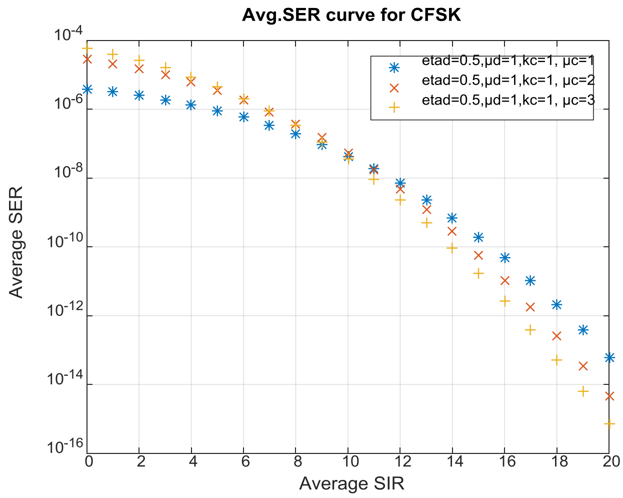

Figure 8: ASER for CFSK for different values of μ_c (FORMAT II)

ASER for CPSK and CFSK are calculated and plotted in this paper for Format 1 and Format 2. Relation of Q function used heregives simple solution. As, the value of κ_c increases, ASER degrades. This behavior is shown in both cases i.e. for CPSK and CFSK. When κ_c is increasing, ASER decreasing at lower values of signal to interference ratio (SIR). When number of clusters increase, the performance of both modulations degrades, as shown in figure 5 & 6.

IV. CONCLUSION

It is concluded that when effect of interference is more in η-μ/ κ- μ Fading Channel (means desired signal is η-μ faded and interference signal is κ- μ faded),CPSK and CFSK performs better at low values of SNR. It is also concluded that ASER calculated is simpler and easier to plot. It has beenobserved that number of clusters also affect the performance of the receiver.

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