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Performance Evaluation of Hybrid Diversity Technique Using Minimum Shift Keying Over Rayleigh Fading Channel

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Abstract

The most effective method for minimizing the fading is designed and analyzed by deriving the exact expression for symbol error probability of Hybrid Selection-Maximal Ratio Combining (HS-MRC) is carried out. Independent Rayleigh fading diversity branch is assumed for analysis with equal Signal-to-Noise Ratio averaged over the fading channels. and Minimum shift keying (MSK) is considered. Virtual branch technique is used. It transforms the ordered physical branches which are dependent into independent, and identically distributed virtual branches is used, thereby permitting the derivation of exact SEP expressions.

Keywords: Diversity reception, Symbol error probability, virtual branch technique, Minimum shift keying, Rayleigh fading channel.

INTRODUCTION

The mechanisms behind electromagnetic wave propagation are diverse, but can generally be attributed to reflection, diffraction, and scattering. Most cellular radio systems operate in urban areas where there is no direct line-of-sight path between the transmitter and receiver, and where the presence of high-rise buildings causes severe diffraction loss. Due to multiple reflections from various objects, the electromagnetic waves travel along different paths of varying lengths. The interaction between these waves causes multipath fading at a specific location, and the strengths of the waves decrease as the distance between the transmitter and the receiver increases. Diversity combining has been considered as an efficient way to combat multipath fading because the combined signal-to-noise ratio (SNR) is increased compared with the SNR of each diversity branch. The Selection combiner (SC)selects the signal from that diversity branch with the largest instantaneous SNR. The optimum combiner is the maximal ratio combiner (MRC) whose SNR is the sum of SNR's of individual diversity branch. In this paper we design and analyze a hybrid diversity scheme in which both MRC and SC were combined. In HS-MRC scheme L out of N diversity branches are selected and combined using Maximal Ratio Combining (MRC) [1]. This technique Provides improved performance over L branch MRC when additional diversity is available. In this paper we extend [2],[3] to derive analytical symbol error probability (SEP) for minimum shift keying (MSK**)** modulation with HS-MRC for any L and N under the assumption of independent Rayleigh fading on each diversity branch with equal SNR averaged over the fading. Virtual branch technique is introduced to succinctly derive the mean as well as the variance of the combined output SNR of the HS-MRC diversity system. Selection combining (SC) and MRC are shown to be special cases of our results. Numerical results are illustrated for minimum shift keying (MSK**)** at different conditions is tabulated and finally remarks and conclusions are presented.

SYSTEM MODEL

Figure 1 shows the system model of HS-MRC in which L out of N diversity branches are selected and combined using Maximal Ratio Combining (MRC).

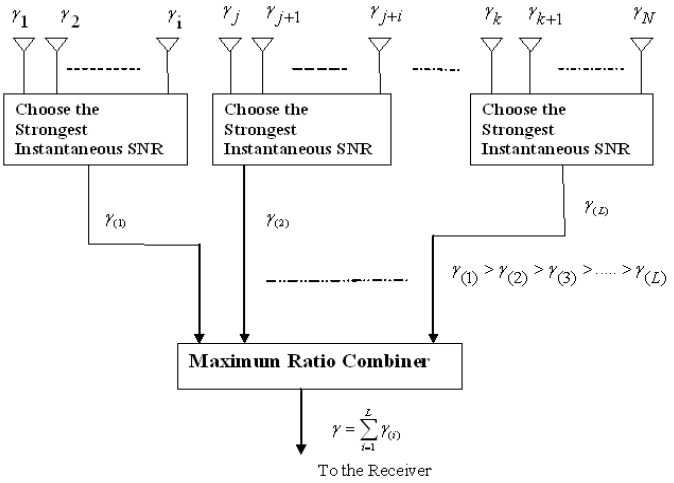

Figure 1. System Model of HS-MRC

SEP FOR DIGITAL MODULATION WITH HS-MRC

Symbol error probability (SEP) for digital modulation with HS-MRC for any L and N under the assumption of independent rayleigh fading on each diversity branch with equal SNR averaged over the fading is given by [4]

$$p_{e,HS-MRC} = \sum_{k=1}^{K} \int_{0}^{\theta_k} a_k(\theta) \left[\frac{1}{1+\phi_k(\theta)\Gamma} \right]^{L} \times \prod_{n=L+1}^{N} \left[\frac{1}{1+\phi_k(\theta)\Gamma \frac{L}{n}} \right] d\theta \quad (1)$$

Where $a_k(\theta), \theta_k, \phi_k(\theta)$ are the parameters particular to a specific modulation format and are independent of the instantaneous. These parameters are different for different modulations.

LIMITING CASES

Limiting Case 1: Selection Combining (SC) System

Selection combining (SC) is the simplest form of diversity combining whereby the received signal from one of N diversity branches is selected [5]. The output SNR of SC is

$$\gamma_{SC} = \max\{\gamma_i\} = \gamma(1) \quad (2)$$

Note that SC is limiting case of HS-MRC with L=1. Substituting L=1 into (1), the symbol error probability with SC becomes

$$p_{e,HS-MRC} = \sum_{k=1}^{K} \int_{0}^{\theta_k} a_k(\theta) \prod_{n=1}^{N} \left[\frac{1}{1+\phi_k(\theta)\Gamma \frac{1}{n}} \right] d\theta \quad (3)$$

Limiting Case 2: Maximal Ratio Combining (MRC) System

In maximal ratio combining (MRC), the received signals from all diversity branches are weighted and combined to maximize the SNR at the combiner output [6]. The output SNR of MRC is

$$\gamma_{MRC} = \sum_{i=1}^{N} \gamma_i = \sum_{i=1}^{N} \gamma(i) \quad (4)$$

MRC is a limiting case of HS-MRC with L=N. Substituting L=N into (1), the SEP with MRC is

$$p_{e,HS-MRC} = \sum_{k=1}^{K} \int_{0}^{\theta_k} a_k(\theta) \left[\frac{1}{1+\phi_k(\theta)\Gamma} \right]^{N} d\theta \quad (5)$$

SYMBOL ERROR PROBABILITY FOR MINIMUM SHIFT KEYING

Here K=2, By substituting the values, $\phi_k(\theta) = \csc^2(\theta)$, $a_k(\theta) = \frac{2}{\pi}$, for $\theta_k = \frac{\pi}{2}$ and $\phi_k(\theta) = \csc^2(\theta)$, $a_k(\theta) = \frac{-1}{\pi}$, for $\theta_k = \frac{\pi}{4}$.

$$\mathrm{P_{e,S/MRC}} = \int_{0}^{\frac{\pi}{2}} \frac{2}{\pi} \left[\frac{1}{1+\csc^2(\theta)\Gamma} \right]^{L} \times \prod_{n=L+1}^{N} \left[\frac{1}{1+\csc^2(\theta)\Gamma \frac{L}{n}} \right] d\theta + \int_{0}^{\frac{\pi}{4}} \frac{-1}{\pi} \left[\frac{1}{1+\csc^2(\theta)\Gamma} \right]^{L} \times \prod_{n=L+1}^{N} \left[\frac{1}{1+\csc^2(\theta)\Gamma \frac{L}{n}} \right] d\theta \quad (6)$$

ESULTS AND DISCUSSIONS

Fig.2. shows the Performance of MSK of HS-MRC for various L with N=4. When L=1 the diversity system becomes selection combining and when L=4, it becomes maximal ratio combining. It is seen that most of the gain of H-S/MRC is achieved for small L, e.g the SEP for H-S/MRC is with in 2 dB of MRC when L=N/2.

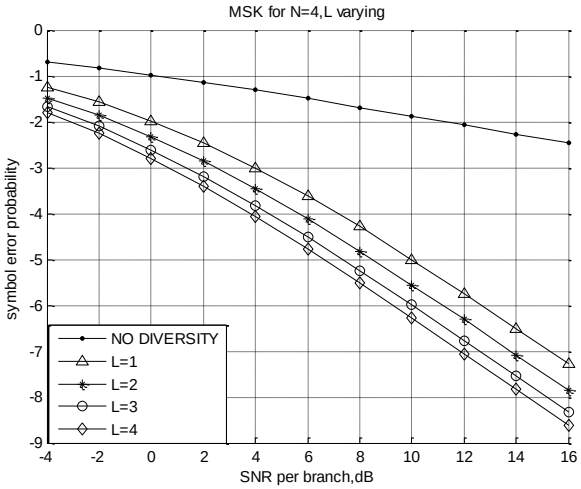

Figure 2. Symbol Error Probability of MSK with HS-MRC as a function of the average SNR per branch for various L with N=4.

Table 1. Diversity Gain of HS-MRC for various L with N=4 at 10^{-2}

	L=1	L=2	L=3	L=4
Diversity Gain (dB)	11.2	12.4	13.4	14.2

Fig.3. shows the performance of MSK of HS-MRC for various N with L=2. Although the incremental gain with which additional combined branch becomes smaller as N increases, the gain is still significant even with N=8. Furthermore, for L=2 at a 10^{-4} SEP, HS-MRC with N=8 requires about 15 dB lower SNR than 2-branch MRC.

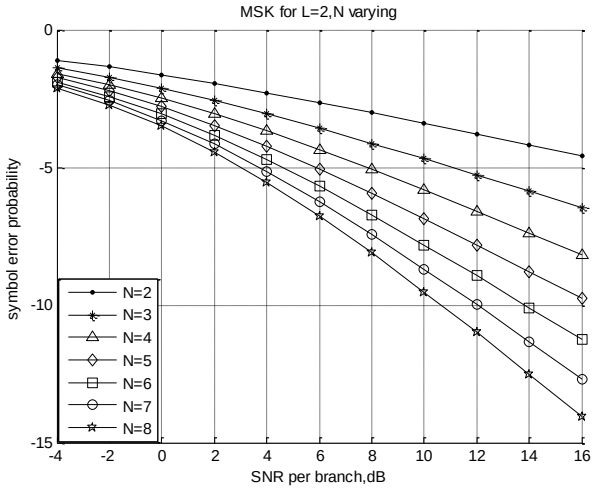

Figure 3. Symbol Error Probability of MSK with HS-MRC as a function of the average SNR per branch for various N with L=2.

CONCLISIONS

Hybrid Selection-Maximal Ratio Combining (HS-MRC) in Rayleigh fading wireless environments is derived and analyzed the exact SEP expressions for the detection of minimum shift keying (MSK). With HS-MRC, L out of N diversity branches are selected and combined using MC. This technique provides improved performance over L branch MRC when additional diversity is available. We considered independent Rayleigh fading on each diversity branch with equal SNR's, averaged over the fading. We analyzed this system using a "virtual branch" technique which resulted in a simple derivation of the SEP for arbitrary L and N.

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