DESIGN OF THE MOST EFFECTIVE METHOD FOR MINIMIZING THE FADING AND SEP ANALYSIS USING DPSK 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 SEP of Hybrid Selection/Maximal Ratio Combining (H-S/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 non coherent detection of differential phase shift keying (DPSK) is considered. Virtual branch technique is used. It transforms the ordered physical branches, which are dependent into independent, and identically distributed virtual branches.

Keywords: Differential phase shift keying (DPSK), Diversity reception, Rayleigh fading channel, Symbol error probability, Virtual branch technique.

1. 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 H-S/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 differential phase shift keying (DPSK) modulation with H-S/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 combiner output SNR of the H-S/MRC diversity system.

Selection combining (SC) and MRC are shown to be special cases of our results. Numerical results are illustrated for differential phase shift keying (DPSK) and finally remarks and conclusions are presented.

2. SYSTEM MODEL

It shows the system model of H-S/MRC in which L out of N diversity branches are selected and combined using Maximal Ratio Combining (MRC).

3. SEP FOR M-ARY DIGITAL MODULATIONS WITH H-S/MRC

Symbol error probability (SEP) for M-ary pulse amplitude modulation with H-S/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]

$$p_{e,S/MRC} = \sum_{k=0}^{M} \left[ \int_{0}^{1} a_k(\theta) \left[ \frac{1}{1 + \phi(\theta)\Gamma} \right]^{L} \prod_{n=L+1}^{N} \left[ \frac{1}{1 + \phi(\theta)\Gamma L \frac{L}{n}} \right] d\theta \right]^{L}$$

Fig.1 System Model of H-S/MRC
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 coherent modulations.

### 3.1 LIMITING CASES

#### 3.1.1 Selection Combining System

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

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

Note that SC is limiting case of H-S/MRC with L=1. Substituting L=1 into (1), the SEP with SC becomes

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

#### 3.1.2 Maximal Ratio Combining System

In 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

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

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

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

### 4. SEP OF DPSK MODULATION

The generalized expression for SEP for coherent detection of differential phase shift keying (DPSK) modulation using H-S/MRC is given by

$$p_{e,MRC} = \sum_{k=1}^{K} \int_{0}^{\theta} a_k \left[ \frac{1}{1+\phi_k(\theta)\Gamma} \right]^{L} \times \prod_{n=L+1}^{N} \left[ \frac{1}{1+\phi_k(\theta)\Gamma} \right]^{L-n} d\theta \tag{6}$$

Here K=2, By substituting the values, $\phi_k(\theta) = \csc^2(\theta), a_k(\theta) = \frac{2}{\Pi}, \text{ for } \theta_k = \frac{\Pi}{2}$ and $\phi_k(\theta) = \csc^2(\theta), a_k(\theta) = \frac{-2}{\Pi}, \text{ for } \theta_k = \frac{\Pi}{4}.$
5. RESULTS AND DISCUSSIONS

![Graph of Symbol Error Probability](image)

**Fig. 2** Symbol Error Probability of DE-PSK (DPSK) with H-S/MRC as a function of the average SNR per branch for various L with N=4

In Fig.2, 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 within 1 dB of MRC when L=N/2.

The diversity gain can be calculated from the above results and can be tabulated as below

<table>
<thead>
<tr>
<th>L</th>
<th>L=1</th>
<th>L=2</th>
<th>L=3</th>
<th>L=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity Gain(dB)</td>
<td>10.2</td>
<td>11.2</td>
<td>12.2</td>
<td>13.2</td>
</tr>
</tbody>
</table>

**Table 1** shows the Diversity Gain of H-S/MRC for various L with N=4 at $10^{-2}$

![Graph of Symbol Error Probability](image)

**Fig. 3.** Symbol Error Probability of DPSK with H-S/MRC as a function of the average SNR per branch for various N with L=2

From the above Fig.3, it can be observed that, 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 $10^{-3}$ SEP, H-S/MRC with N=8 requires about 11dB lower SNR than 2-branch MRC.
6. CONCLUSIONS

We design and analyzed the exact SEP expressions for coherent detection of differential phase shift keying (DPSK) modulation with H-S/MRC in multipath-fading wireless environments. A general expression was derived in terms of the parameters of the specific modulation schemes. With H-S/MRC, L out of N diversity branches are selected and combined using MRC. 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.

REFERENCES