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PARTIALLY COHERENT BPSK IN FADING CHANNELS AND INTERSYMBOL INTERFERENCE

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ABSTRACT

In this paper, we analyze the performance of partially coherent BPSK systems in the presence of intersymbol interference. Generalized flat fading channels including Rayleigh, Rician, and Nakagami-m are investigated, and Tikhonov-distributed phase error processes are assumed. We consider diversity system with L-branch signals that being detected using postdetection equal-gain combining (EGC) receiver. The diversity branches are assumed to experience slow, flat, and uncorrelated fading. Two performance criteria are considered: the average bit-error probability (BEP) and the signal-to-noise ratio (SNR) gain penalty due to the sampling time jitter. Quazi-analytical simulation results are also presented.

I INTRODUCTION

Intersymbol interference (ISI) is a signal-dependent form of interference that arises when digital data transmitted over a band-limited channel. The ISI typically results from the smearing of the transmitted signals by channel and receiver filtering such that each received pulse is affected somewhat by adjacent pulses. In wireless environment, ISI is basically results if the difference on the path delays (i.e. Delay spread) is significant compared to the symbol period. Furthermore, the receiver must recover symbol timing perfectly, and jitters in the receiver sampling instants may result in ISI whether the transmitted signals are distorted or not. Hence, ISI represents a kind of deterministic impairments, and is a major source of bit errors in the reconstructed data at the receiver especially as the transmission rate increases [1].

Because of the growing demand for wireless communication throughout the world, and the emphasis on achieving the highest spectral efficiency for each band of the spectrum, coherent PSK systems are increasingly being used in wireless systems. However, neither the carrier phase nor the symbol timing can be derived perfectly under the time-variant characteristic of wireless channel. Hence, under more realistic conditions, the carrier phase is partially detected and the error in sampling time will cause ISI. Since the exact evaluation of the performance and the resulting degradation is formidable task, we present a unified methodology to analyze the performance of partially coherent BPSK systems in the presence of ISI.

On the other hand, it is well known that space diversity is a powerful communication technique that provides wireless link improvement at relatively low cost. Therefore, our analysis considers one of the space diversity schemes called EGC. Such scheme is easy to implement and achieves a comparable performance when compared with the optimum maximum ratio combining (MRC) scheme.

A considerable amount of work has been done to evaluate the performance of digital communication systems corrupted by ISI. The BEP's of coherent BPSK system in the presence of ISI and Gaussian noise without fading were studied in [1]-[2]. The effect of cochannel interference (CCI) and ISI on the error rate performance of BPSK in Rayleigh fading and Nakagami-m fading are investigated in [3], and [4], respectively. All these works are for perfect coherent detection with no diversity. Abu-Dayya and Beaulieu [5] analyzed the BEP performance of perfect coherent BPSK for dual-branch EGC under Nakagami-m fading in the presence of CCI and ISI. Recently, the authors in [6] used Gram-Charlier series method to compute the error rate performance of partially coherent BPSK system in Rayleigh fading environment with EGC. But, in their study, perfect symbol synchronization is assumed so that the effect of ISI was not taken into account. Throughout our literature search, the effect of ISI on the performance of partially coherent BPSK faded signals in EGC reception has not been investigated so far. This will be the subject of this paper.

II SYSTEM MODEL

A EGC Receiver

In our study, we consider a BPSK signal transmitted over a wireless multipath fading channel. At the receiver side, we assume a total number of L independently fading branches are available and being combined using EGC technique. The received complex baseband signal on the lth branch can be written as

$$\tilde{r}_l(t) = g_l \tilde{s}(t) + \tilde{n}_l(t), \quad l = 1, 2, \cdots, L \tag{1}$$

where $g_l = \alpha_l e^{j\phi_l}$ is the channel flat fading gain in where ϕ_l is the fading phase and α_l is the fading envelope. Depending on the nature of the propagation medium, different models are typically used to represent α_l. The complex AWGN processes $\tilde{n}_l(t)$ are independent and identically distributed (i.i.d.) with zero means. Furthermore, the transmitted complex baseband signal $\tilde{s}(t)$ can be written as

$$\tilde{s}(t) = \sqrt{2P_b} \sum_{k=-\infty}^{\infty} b_k h_T(t - kT) \tag{2}$$

where P_b is the bit average power, b_k is the binary uncorrelated information bit in the kth signaling interval which can take one of the values {-1,+1} with equal probabilities. The pulse $h_T(t)$ is the impulse response of the transmitter filter and T is the bit interval. During the analysis, the transmitter filter is assumed