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Mr. Md. Mahbubul Hoque Bhuiyan

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Table of Contents

Information Technology Papers

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Diversity Combining Techniques under Employment of Generalized Receiver in Wireless Communication Systems with Rayleigh Fading Channels

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The bit error rate (BER) performance of wireless communication system employing the generalized receiver (GR) under the binary phase shift keying (BPSK) modulation over Rayleigh fading channel with three common diversity combining techniques, namely, the selection combining, equal gain combining, and maximal ratio combining with the purpose to mitigate the effects of multipath fading is investigated. Simulation demonstrates a high performance gain under employment of GR in wireless communication system in comparison with modern approaches.

Keywords: generalized receiver (GR), diversity combining, selection combining (SC), equal gain combining (EGC), maximal ratio combining (MRC), and Rayleigh fading channel.

1. Introduction

In urban and indoor environments, the line-of-sight between the transmitter and receiver has a random character and the transmitted signal is distorted along multiple paths. Each of these bounces can introduce phase shifts, time delays, attenuations, and distortions that can destructively interfere with one another at the aperture of the receiving antenna. Antenna diversity is especially effective at mitigating these multipath situations (Proakis, 1995). This is because multiple antennas offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. Diversity combining is the technique applied to combine the multiple received signals of a diversity reception device into a single improved signal. The experimental results of dual and triple diversity are presented in (Wambeck, 1951). The derivation of the combining weights of the optimal linear combiner for dual diversity is discussed in (Kahn, 1954), and generalization of the Kahn's results for higher orders of diversity is presented in (Brennan, 1955). The technique described by Kahn and Brennan is commonly known as maximal ratio combining (MRC). A thorough treatment of the more commonly-used diversity combining techniques is presented in (Schwartz, 1966). The performance of diversity combiner is measured by diversity gain which is the difference in signal-to-noise ratio (SNR) between the output of a diversity combiner and the signal on a single branch measured at a given probability level. Diversity gain quantifies the improvement in SNR of a received signal that is obtained using signals from different receiver branches. Equalizers or rake receivers employed in wideband radios cannot mitigate flat fading with a single antenna (Benvenuto, 1997), but when combined with

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antenna diversity they can improve performance in both flat fading and frequency-selective fading channels. Predetection combining using space-diversity antenna array is commonly used to combat fading in mobile radio systems. These methods have been extensively studied in (Brennan, 1959) and (Jakes, 1971). The most widely considered predetection combining techniques are selection combining (SC), equal-gain combining (EGC), and maximal-ratio combining (MRC). SC is a suboptimal combining scheme in which the branch signal with the largest amplitude or SNR is selected for demodulation (Altman, 1956), (Mack, 1955), and (Kavehrad, 1985). SC scheme is used to decrease the receiver complexity in terms of the number of radio frequency (RF) chains, proposed in (Chen, 2005) and (Jakes, 1994). The SC scheme has been extended to the cases where the signals on more than one receive antennas with the largest instantaneous SNRs are combined (Eng, 1996), (Kong, 1999), (Win, 1999), and (Bjerke, 2004). This scheme is referred to as hybrid selection/maximal-ratio combining (HS/MRC) (Win, 1999). MRC is one of the most widely used diversity combining schemes in which SNR is the sum of the SNR's of each individual diversity branch. It is the optimal but the most complex combining model, since MRC requires cognition of all channels fading parameters (Suzuki, 1977).The bit error rate (BER) of MRC receiver for BPSK signals in the presence of log-normal and Rayleigh fading is derived in (Nikolic, 2011). The BER of MRC receiver is presented in the presence of log-normal and Rice fading in (Nikolic, 2008); and Nakagami-*m* fading and shadowing in (Nikolic, 2010). The performance analysis of MRC receiver in the presence of Weibull fading and shadowing are described by both log-normal and Gamma distributions in (Nikolic, 2010). The performance analysis of EGC has been extensively reported for the case when channel information is perfectly known at the receiver (Beaulieu, 1991), (Zhang, 1999), (Annamalai, 2000), (Alouini, 2001), and (Qi, 2003). To evaluate the performance of the EGC, a decision variable based approach is presented in (Annamalai, 2000) and (Alouini, 2003) and the simplifying analysis of that performance is presented in (Beaulieu, 1991). Closed form error probability expressions for the case of dual branch EGC over Rayleigh fading channels have been presented in (Qi, 2003).

In this paper, we employ the generalized receiver (GR), which is constructed based on the generalized approach to signal processing (GASP) in noise (Tuzlukov, 1998), and (Tuzlukov, 2001) in wireless communication system with *one* transmit antenna and *N* receive antennas. The multiple-input multiple-output (MIMO) wireless communication system employing GR over Rayleigh fading channel shows high performance gain in comparison with NP receiver (Das, 2012). We study the SC, MRC and EGC techniques used by GR under BPSK modulation over Rayleigh fading channel. The BER performance of wireless communication system over Rayleigh fading channel employing the GR with discussed diversity combining techniques has a great advantage in comparison with widely used receivers, for example, receiver based on the Neyman Pearson criterion employing the same diversity combining procedures.

The paper is organized as follows. In section 2 we describe the generalized receiver (GR). Diversity combining techniques for wireless communication system are discussed in section 3. Simulation results are given in section 4 and some