

Performance analysis of Hybrid MRC/EGC Diversity Combining Technique over AWGN Channel

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Abstract : Diversity Combining Technique is well-known scheme used in wireless link having multiple antennas at receiver to improve the performance. A new hybrid diversity scheme MRC/EGC over AWGN channel in which M number of branches carry out maximal ratio combining and L number of branches carry out equal gain combining is evaluated in this paper. The outage probability and Average Bit Error Rate (ABER) are the parameters used for the performance analysis of this Hybrid diversity combining technique.

Keywords - ABER, Equal Gain Combining, Hybrid MRC/EGC, Maximal Ratio Combining, Outage Probability

I. INTRODUCTION

The diversity combining techniques are used to improve the performance of receiver having multiple antennas. The Selection Combining (SC), Maximal Ratio Combining (MRC) and Equal Gain Combining are various diversity combining techniques. The signal in the branch with highest signal to noise ratio (SNR) is selected among all the signals in all the branches in selection combining. In maximal ratio combining, the signals in all the branches are combined by multiplying with different weights. The signals in all the branches are combined by multiplying with equal weights in equal gain combining. Hybrid diversity combining techniques have been receiving great interest in recent days by considering various aspects like low power consumption and higher diversity gain.

Nitika Sachdeva et.al has evaluated the performance of selection combining, maximal ratio combining and equal gain combining over Rayleigh fading channel. It is found that maximal ratio combining has best performance. The performance of Hybrid (SC/MRC) over Nakagami-m fading channel was evaluated in [2] and it was found that when fading increases the hybrid system has good performance. The performance evaluation of two hybrid diversity combining techniques: H-SC/MRC and H-SC/EGC has been carried out in [3]; the H-SC/MRC system outperforms the H-SC/EGC system. In [4] a dual hybrid diversity scheme over Rayleigh fading channel in which among the connected branches, the two branches with SNR greater than specified threshold SNR is switched and given to dual branch MRC system. The hybrid MRC/SC system for Rayleigh fading channel has been proposed in [5]. Here the hybrid diversity scheme considered is having maximal ratio combining at the first stage and selection combining at the second. The M branches are combined using maximal ratio combining; out of L diversity branches the branch with the highest SNR is selected. The hybrid diversity scheme MRC/EGC over AWGN channel has not been found yet in all works considered. In this paper a new hybrid diversity scheme MRC/EGC over AWGN channel has been proposed. Here M number of branches carries out maximal ratio combining at the first stage and L number of branches carries out equal gain combining at the second stage.

The organization of this paper is as follows. The hybrid MRC/EGC system model for AWGN channel has been discussed in Section 2. In Section 3 PDF and CDF of hybrid MRC/EGC combiner output SNR have been provided. The parameters outage probability and ABER used for performance evaluation have been included in the Section 4. Section 5 provides the simulation results. The conclusion has been provided in the section 6.

II. Hybrid MRC/EGC System Model for AWGN Channel

Fig.1 illustrates the Hybrid MRC/EGC system for AWGN channel. The signals are transmitted through AWGN channel. At the receiver, M number of branches carries out maximal ratio combining where signals in all branches are combined by multiplying with different weights. Then L number of branches carries out equal gain combining where signals in all branches are combined by multiplying with equal weights.

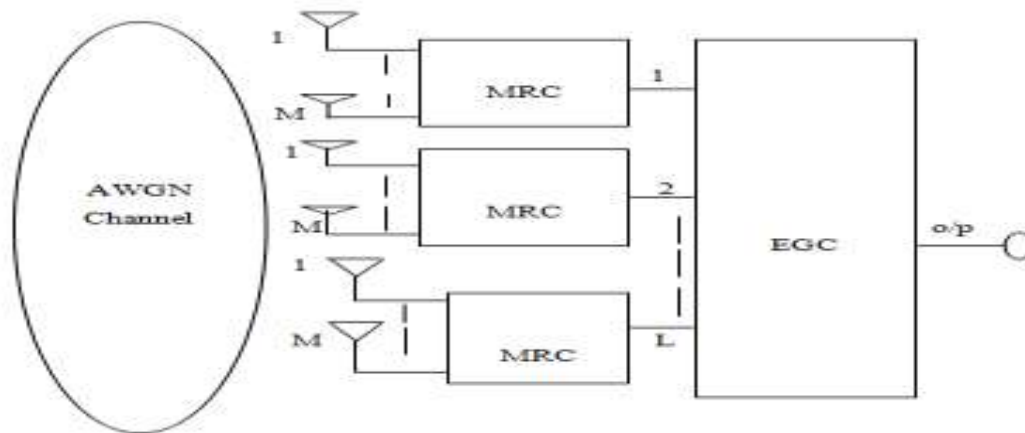


Figure 1: Hybrid MRC/EGC System over AWGN Channel [6]

III. PDF and CDF of Hybrid MRC/EGC Combiner Output SNR

Considering AWGN channel, MRC having M branches the output SNR is given by Eq. 1, [7]

$$: f_{MRC}(\gamma) = \frac{\gamma^{M-1} e^{-\gamma/\bar{\gamma}}}{\bar{\gamma}^M \Gamma(M)} \quad (1)$$

Where γ = instantaneous SNR
 $\bar{\gamma}$ = average SNR
 $\Gamma(M)$ = Gamma function

The inputs of EGC are MRC outputs. In EGC, the signals are equally weighted by their amplitudes. In other words, the branch weights are all set to unity [8]. By multiplying MRC outputs each with equal weights and then carrying L fold convolution of PDF of output SNR of MRC as in [3], PDF of hybrid MRC/EGC system can be obtained as in [9] using (2)

$$: f_{MRC,EGC}(\gamma) = f_{1MRC}(\gamma) \otimes f_{2MRC}(\gamma) \otimes f_{3MRC}(\gamma) \dots \otimes f_{LMRC}(\gamma) \quad (2)$$

The CDF of hybrid MRC/EGC receiver can be obtained as in [9] using the (3)

$$: F_{MRC,EGC}(\gamma_0) = \int_0^{\gamma_0} f_{MRC,EGC}(\gamma) d\gamma \quad (3)$$

IV. Performance of MRC/EGC receiver

The metrics used for performance analysis are outage probability and Average BER.

4.1 Outage probability

Outage probability is defined as the probability that output SNR falls below a certain specified threshold, γ_{th} . By referring [10] the outage probability can be obtained using (4)

$$: P_{OUT,MRC,EGC}(\gamma_{th}) = \int_0^{\gamma_{th}} f_{MRC,EGC}(\gamma) d\gamma \quad (4)$$

4.2 Average bit error rate

An expression for ABER can be obtained by averaging the conditional bit error rate (BER), for the modulation scheme used, over the PDF of EGC output SNR [6]. Mathematically, it can be given as in [5] using

$$: P_e(\bar{\gamma}) = \int_0^{\infty} p_e(\epsilon/\gamma) f_{MRC,EGC}(\gamma) d\gamma \quad (5)$$

Where $p_e(\epsilon/\gamma)$ = conditional bit error rate

$f_{MRC,EGC}(\gamma)$ = PDF of the output SNR of the hybrid MRC/EGC receiver

ABER for Non-coherent modulation is obtained. The expression for the conditional BER of non-coherent modulation [6] can be given as $p_{e,nch}(\epsilon/\gamma) = \frac{1}{2} \exp(-a\gamma)$, where $a=0.5$ for non-coherent frequency shift-keying (NCFSK) modulation. Putting $p_{e,nch}(\epsilon/\gamma)$ and $f_{MRC,EGC}$ from (2) together into (5) the ABER of hybrid MRC/EGC system can be obtained.

V. Results and Discussion

The Fig.2 and Fig.3 show the outage probability for Dual MRC/EGC and MRC/Dual EGC, respectively. The threshold value is set at 3 dB. In Dual MRC/EGC receiver, outage performance improves with the increase in the number of EGC branches, L. In MRC/ Dual EGC receiver, outage performance improves with the increase in the number of MRC branches, M. Outage performance improves due to the fact that as the number of diversity branches increases, the probabilities of all the fading paths going to deep fade decreases. In Fig.4, ABER of non-coherent modulation for MRC/EGC system has been provided. The performance improves with increase in number of diversity branches. The SNR required for having an acceptable level of performance (Average BER of 10^{-4}) decreases with increase in the number of EGC diversity branches. The SNR required for maintaining the ABER of Non-coherent modulation equal to 10^{-4} is given in TABLE 1.

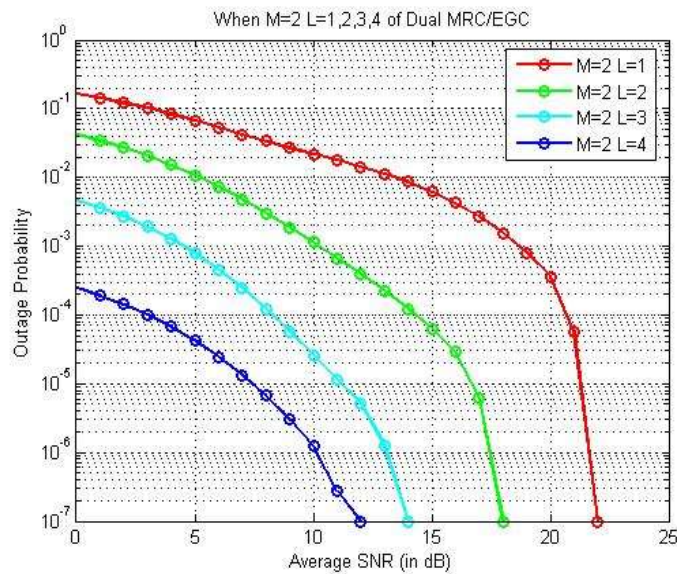


Figure 2: Outage Probability of Dual MRC/EGC receiver over AWGN Channel

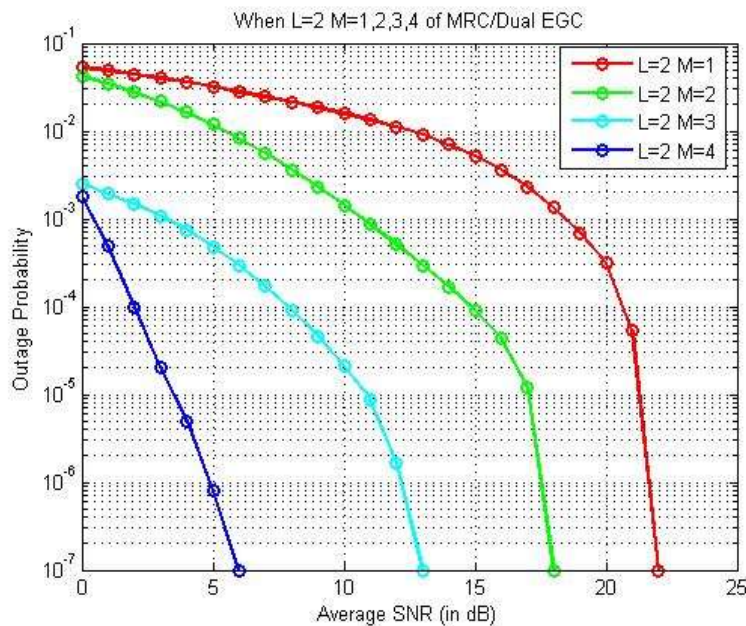


Figure 3: Outage Probability of MRC/Dual EGC receiver over AWGN Channel

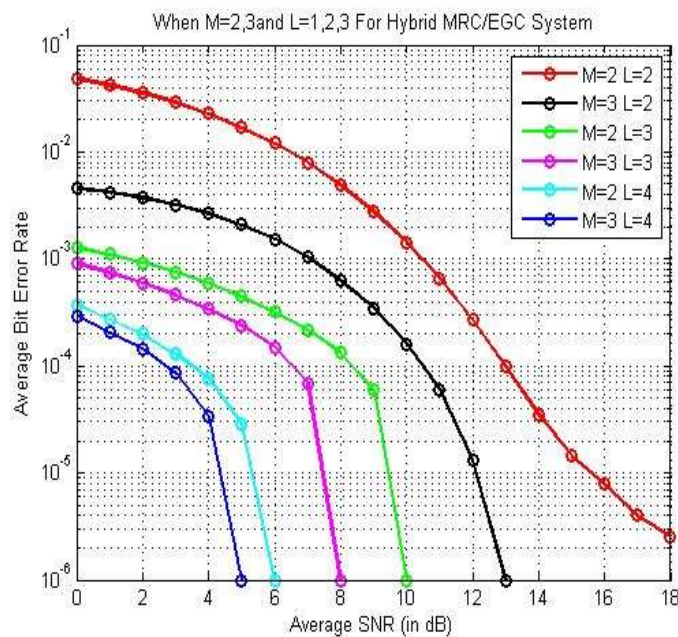


Figure 4: ABER of Non-coherent Modulation

TABLE 1: SNR required for maintain ABER of Non-coherent modulation equal to 10^{-4}

Hybrid Technique	M=2 L=2	M=3 L=2	M=2 L=3	M=3 L=3	M=2 L=4	M=3 L=4
MRC/EGC SNR (in dB)	13	10.4	8.4	6.6	3.8	3

VI. CONCLUSION

The Outage probability and the Average BER of Hybrid MRC/EGC system over AWGN channel are evaluated. Outage performance improves as the number of diversity branches increases. The SNR required for having an acceptable level of performance decreases with increase in the number of diversity branches. This work can be extended by evaluating the performance of Hybrid MRC/EGC system for different fading channels.

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