Effect of varying Threshold over BER Performance

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Abstract-In this paper, Bit Error Rate (BER) performance is analyzed using different value of threshold over varying Nakagami fading parameter channel. Simulations have been carried out using MATLAB for multiple co-channel interferers under Rayleigh and Nakagami fading conditions using Binary Phase Shift Keying (BPSK) modulation scheme. Threshold based Generalized Selection Combining (T-GSC) technique is used which combines only those branches at receiver which are above certain threshold value. Nakagami fading parameter is varied with different values of threshold over Nakagami channel and its effect over BER performance is observed and analyzed.

Index terms - Combining techniques, fading channels, diversity.

I. INTRODUCTION

Due to the modernization of the urban cities with skyscrapers, effects of environment and other manmade obstacles the transmission quality of the signal degrades. With the technology advancement in today's society, it is noted that the ability to communicate with people on move has evolved remarkably [2]. This results in the transmitted signal having to take multiple paths before reaching the intended receiver. The signal is severely distorted and attenuated due to multipath transmissions. To improve signal quality different methods have to be developed. Demand of wireless communication has increased very vastly. New wireless techniques and architectures must be developed to meet this increasing demand by maximize capacity and quality of service. Time varying nature of radio propagating channel and multipath phenomenon are the major obstacles for mobile wireless systems. Wireless system designers are faced with a number of challenges in addition to limited radio spectrum and a complex wireless environment (fading and multipath) [3]. Multiple access wireless communications is being deployed for next generation cellular networks.

Diversity techniques can be used to improve system performance in fading channels. In this scheme, instead of receiving the desired signal through one channel, we obtain replica copies of the desired signal through M different channels. If some copies may undergo deep fades, others may not. The BER performance of T-GSC was simulated over a Nakagami fading environment, and compared with Maximal- Ratio Combining (M-GSC) [1, 4]. The T-GSC scheme combines all the strong diversity branches available at any time instant by discarding only the weak ones. In [4] BER performance was simulated over fading parameters (m=1, m=2 and m=4) with varying threshold value from T=0.9 to T=0.25. In this work, BER is observed at lower value of threshold by varying Nakagami fading parameter over Nakagami fading channel using BPSK modulation scheme.BER performance is analyzed over Nakagami-m fading parameter (m=1, m=2 and m=3) using threshold value from T=0.6 to 0.1. The threshold value that gives lowest BER over Nakagami fading parameter is observed and analyzed.

This paper is organized in V sections. The nature of the fading channel is described in Section II. In Section III, the system model is presented. Effect of varying threshold over BER performance is simulated and analyzed in section IV. Finally, the conclusion is presented in section V.

II. FADING CHANNEL

A channel is referred as fading channel if the strength of the received signal is not constant.Fading channel model describes the rapid fluctuation of amplitude, phase, or multipath delay of radio signal due to multipath propagation, shadowing from obstacles etc. The time varying nature of received envelope is described mainly by Rayleigh distribution and Nakagami-m distribution which are described as follows:

A. RAYLEIGH DISTRIBUTION

The Rayleigh distribution is the most widely used distribution to describe the received envelope value. To describe the statistical time varying nature of the received envelope of a flat fading signal, or the envelope of an individual multipath component, Rayleigh distribution is commonly used. In the Rayleigh flat fading channel model, it is assumed that the channel induces amplitude, which varies in time according to the Rayleigh distribution [6].

When the channel impulse response is modeled as a zero-mean complex-valued Gaussian process, the envelope at any instant is Rayleigh-distributed. The Rayleigh distribution of a received complex envelope of a signal *r*(*t*) at any time t is given as

$$f_\gamma(\alpha) = \begin{cases} \frac{\alpha}{\sigma^2}\exp\left(-\frac{\alpha^2}{2\sigma^2}\right), & 0 \le \alpha < \infty \\ 0, & \alpha < 0 \end{cases} \quad \text{.............................(1)}$$

Where σ is the root mean square value of the received voltage signal and σ^2 is the time-average power of the received signal before envelope detection.

B. NAKAGAMI-M DISTRIBUTION

The Nakagami-m distribution is a versatile statistical model because it can model fading amplitudes that experience either less or severe fading than that of Rayleigh variants. The Nakagami-m distribution of envelope of the received signal is given by [6]

$$f_\gamma(\gamma) = \begin{cases} \frac{2m^m\alpha^{2m-1}}{\Gamma(m)\sigma^{2m}}\exp\left(\frac{-m\alpha^2}{\sigma^2}\right), & \alpha \ge 0 \\ 0, & \alpha < 0 \end{cases} \quad \text{..........................(2)}$$

Where m is Nakagami fading parameter, which ranges from 1/2 to ∞, σ is the received rms envelope level, and Γ denotes the Gamma function. When m = 1, Nakagami distribution degenerates to a Rayleigh distribution.

III. SYSTEM MODEL

The diversity combining technique used in this work is TGSC scheme. In this scheme, for every path, we determine the Branch Relative Strength (BRS) which is defined as the ratio of the Signal to Noise Ratio (SNR) of each branch to the SNR of the best branch at the same instant of time as given below [5]:

$$BRS_i = \frac{\gamma_i}{\gamma_{max}}, \; i = 1, 2, \ldots, M \quad \text{.....................(3)}$$

Where M is the number of branches, γ_{max} is the maximum SNR received at each time instant and γ_i is the SNR in the ith branch, i = 1, 2 . . . , M. In T-GSC scheme, if the BRS_i is greater than or equal to a specified threshold T only then the branch is combined.The branches whose energy is below than specified threshold value are discarded.

To select significant branches at any time, depending upon the fading environment and other propagating conditions, the value of selected threshold must be such that no useful information is “thrown off.” Channel fading level defines the number of branches to be combined at each time instant. The scheme is as illustrated in Fig. 1 for M=5, where M is the number of branches. In this figure, only branches 1, 3, and 5 are above threshold, and are therefore combined.

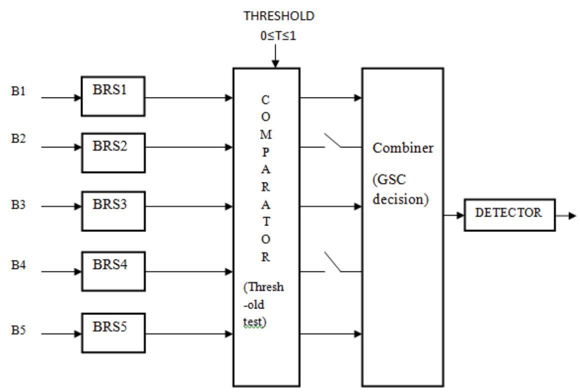

Fig.1 Block diagram of T-GSC scheme (GSC combinig diversity branches using a threshold criteria)

IV. RESULT AND DISCUSSION

To analyze BER performance, firstly binary sequence of ones and zeros is generated and then BPSK modulation of generated binary sequence is performed. The Nakagami fading channel is taken and the fading parameter 'm' is varied from m= 1 (Rayleigh), *m*=2 and *m*=3. For T-GSC diversity technique five branches have been used in this simulation work and a threshold value is set. The Signal to Noise Ratio (E_b/N_o) of all branches is found at the receiver and the paths with E_b/N_o above the chosen threshold are combined. The signal is demodulated at the receiver, hard decision decoding and bit error rate is observed by varying E_b/N_o and keeping fading parameter 'm' and threshold at some predefined value. It is observed that good results for BER performance are observed for threshold values of T=0.1, 0.2, 0.4 and 0.6. The variation of BER with E_b/N_o are observed and plotted for T=0.1, 0.2, 0.4 and 0.6 and are shown in Figures 2, 3 and 4 for Nakagami fading parameter *m*=1, 2 and 3 respectively. The simulation results for BER for different values of E_b/N_o and threshold have also been presented in Table 1, 2 and 3 for m=1, 2, and 3 respectively.

From the results, it is seen that for m=1 (Rayleigh channel), the best BER performance is obtained for threshold T=0.1 whereas for T=0.6 maximum BER is observed as shown in fig.2. For m=2, BER is less for T= 0.1 but maximum BER is observed for T=0.6, whereas performance for T=0.4 lies in between as shown in fig. 3. For m=3 as Nakagami fading parameter, BER performance is best for threshold T= 0.2 and BER is maximum for T=0.6 and 0.1 as shown in fig. 4. BER rate is equal for both the threshold values of 0.1 and 0.6. It is observed that the BER decreases as E_b/N_o is increased and the value of threshold is reduced.

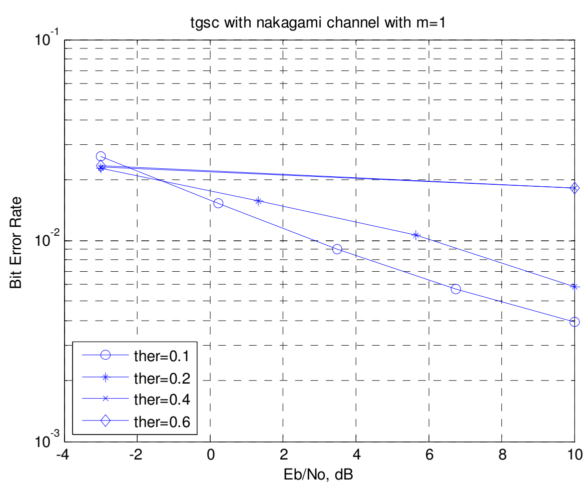

Fig.2 Comparison of BER performance of T-GSC with different threshold over Nakagami fading channel (m=1)

E_b/N_o	BER			
	For T=0.1	For T=0.2	For T=0.4	For T=0.6
0	$1.5x10^{-2}$	$2.15x10^{-2}$	$2x10^{-2}$	$2.4x10^{-2}$
4	$0.5x10^{-2}$	$1.4x10^{-2}$	$1.8x10^{-2}$	$2.15x10^{-2}$
6	$8x10^{-3}$	$0.1x10^{-2}$	$0.6x10^{-2}$	$2x10^{-2}$
8	$5.2x10^{-3}$	$8x10^{-2}$	$0.4x10^{-2}$	$1.9x10^{-2}$

Table 1 BER performance for different threshold values at different E_b/No values (for m=1)

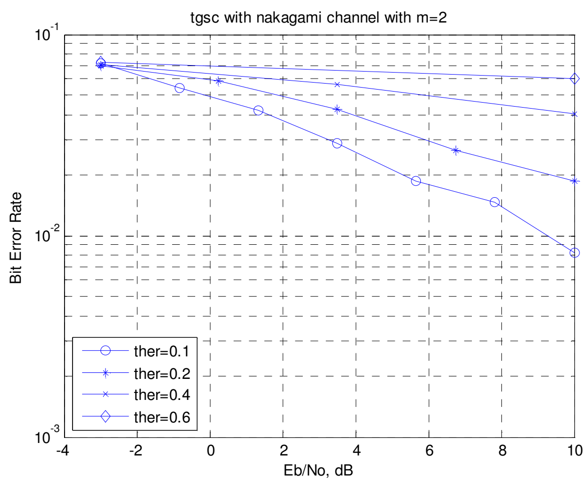

Fig.3 Comparison of BER performance of T-GSC with different threshold over Nakagami fading channel (m=2)

E_b/N_o	BER			
	For T=0.1	For T=0.2	For T=0.4	For T=0.6
0	$5x10^{-2}$	$6x10^{-2}$	$6.1x10^{-2}$	$6.2x10^{-2}$
4	$2.9x10^{-2}$	$3.8x10^{-2}$	$5x10^{-2}$	$5.8x10^{-2}$
6	$1.8x10^{-2}$	$3.1x10^{-2}$	$4.6x10^{-2}$	$5.5x10^{-2}$
8	$0.5x10^{-2}$	$2.5x10^{-2}$	$4.3x10^{-2}$	$5x10^{-2}$

Table 2 BER performance for different threshold values at different E_b/No values (for m=2)

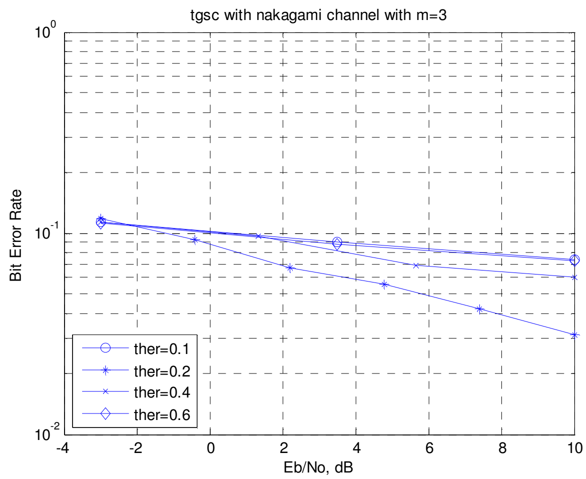

Fig.4 Comparison of BER performance of T-GSC with different threshold over Nakagami fading channel (m=3)

E_b/N_o	BER			
	For T=0.1	For T=0.2	For T=0.4	For T=0.6
0	$0.1x10^{-1}$	$8.8x10^{-2}$	$9.8x10^{-2}$	$0.1x10^{-1}$
4	$9.5x10^{-2}$	$6.2x10^{-2}$	$7.8x10^{-2}$	$9.5x10^{-2}$
6	$8.6x10^{-2}$	$5x10^{-2}$	$6.9x10^{-2}$	$8.5x10^{-2}$
8	$8x10^{-2}$	$4x10^{-2}$	$6.1x10^{-2}$	$8x10^{-2}$

Table 3 BER performance for different threshold values at different E_b/No values (for m=3)

V. CONCLUSION

In this paper, BER performance of T-GSC scheme over Nakagami fading channel is simulated and analyzed using MATLAB software. In this work, threshold value is reduced to get best BER performance and this is analyzed for different values of threshold that is 0.6, 0.4, 0.2, and 0.1, with varying Nakagami fading parameter (m) that is m=1, 2 and 3.After analyzing different results it is observed that for m=1 (Rayleigh channel) the best BER performance is for threshold T=0.1. For m=2 best BER is for T= 0.1, whereas T=0.2 gives best BER performance for m=3.It is concluded that decreasing the threshold to a lower value improves the BER performance.

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