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Evaluation of BER using Different Adaptive Techniques in a Fading Channel Communication

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Abstract

Equalization of communication channel is a challenge because of extenuating the unfavorable belongings in a frequency-flat and/or selective fading dispersive communication tie among the correspondent and recipient. In this paper we have accessed receiver performances because of antenna diversity in flat fading environments by expressing in terms of bit error rate(BER). In SIMO and MIMO systems we have adapted different diversity techniques such as MRC,EGC,SC**,**ALAMOUTI-STBC and BEAMFORMING using some modulation schemes in channel equalization.

Keywords: Maximal-ratio combining ,EGC and Channel Equalization.

INTRODUCTION

In order to equalize the signal after it has passed through a dispersive channel, equalization is proposed. The channel itself can be described as channel impulse response and the noise. We have to identify a selective channel that have frequency selectivity as well as dispersion. As far as noise is concerned its variance should be selected such that the arriving SNR is 30 dB. For the additive noise we presume a complex Gaussian noise .Because of fast fluctuation in the received signal due to multipath environment makes it really hard for the recipient to decide the transmitted signal [5]. Generally in fading environment using different coding techniques needs SNR enhancement up to10 dB, whereas BER improvement of order $10^{-2}$to 10^{-3}.To develop high speed digital transmission SIMO and MIMO have been introduced. The word diversity can be described the recurrence or redundancy of information [7] which means that receiver is accepted with manifold copies of the identical messages. Diversity is such a method that are frequently used to battle the harmful result of channel fading [8,9]. To improve bit error rate[6] we have to develop the system which can apply with a technique such as MRC,SC and EGC.

System Model

When two or more channels with unlike frequencies, polarizations etc. causes fading . Fading can be reduced If we multiplexing two or or more such channels and it is also called as diversity. We assume signal to noise ratio at the receiver is a random variable ,same message signal can send through different channels It can be selected as to supplied the receiver with n self-governing replicas of the identical signal, can have to self-determining SNRs. If we properly mix together the arriving signals, the feeble consequence will be eliminated. Suppose the sending the band pass message signal is

$$x(t) = Re[\hat{x}(t)\dot{e}^{jwct}] \quad (1)$$

If we consider the channel is consist of M propagation path then noise free arriving signal is

$$y(t) = Re[\sum_{m=1}^{M} A_n e^{j2\pi[(f_c+f_D)(t-\tau_m)]} \quad (2)$$

Here τ is time delay related with mth propagation path.

Further arriving band pass signal is

$$y(t) = Re[\hat{y}(t)\dot{e}^{jwct}] \quad (3)$$

Channel impulse response can be taken as

$$h(t,\tau) = \sum_{m=1}^{M} A_n e^{-j\varphi_m(t)}\,\delta(t-\tau_m) \quad (4)$$

Rayleigh fading [13] is because of multipath intrusion of the signal and there is NLOS path between transmitter and receiver. The arriving signal can be described

as $y(t) = h(m,\tau)x(m-n) + \eta(m)$ (5)

$\eta(m)$ can be taken as AWGN.

Equation (4) can also be written as

$$h(n) = \sum \alpha(m) e^{-j\varphi(m)} \quad (6)$$

In the above equation(6) α and φ can be described as attenuation and phase shift for m^{th}path. Now the arriving signal can be expressed as $Y = Hx + n$ (7)

Where $Y = [y_1\ y_2\ .\ .\ .\ y_M]^T$, H is is the channel matrix and n is additive white Gaussian noise. Bit error rate designed for M receive antennas is specified with

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{ME_b}{N_0}}\right) \quad (8)$$

- The three key combining methods which can be used in combination with some of the diversity schemes are as given below Maximal ratio combining (MRC)
- Equal gain combining (EGC)
- Selection combining (SC)

Maximal Ratio Combining

There a different methods to unite the signals from many diversity branches. MRC can be multiplied with the signal coming from every branches at the receiver side.It amplifies the signal having highest characteristics parameter branch but block the feeble signals. It is one of the diversity method which can put in the signals from every channel and every channel use different proportionality constants and the gain of that channel is relative to the root mean square value and in reverse relative to the mean square noise level. For that reason the most favourable combiner for self-determining AWGN channels is MRC [1].MIMO systems mutual with utmost MRC receivers can accomplish the most accessible spatial diversity order. In figure 1 shows MRC with 1×2 i.e one transmitter and two receivers in digital communication system. The arriving signal can be described as [4]

: $Y_1 = h_{11}\hat{S_0} + \eta_1$ (9)

$Y_2 = h_{12}\hat{S_0} + \eta_2$ (10)

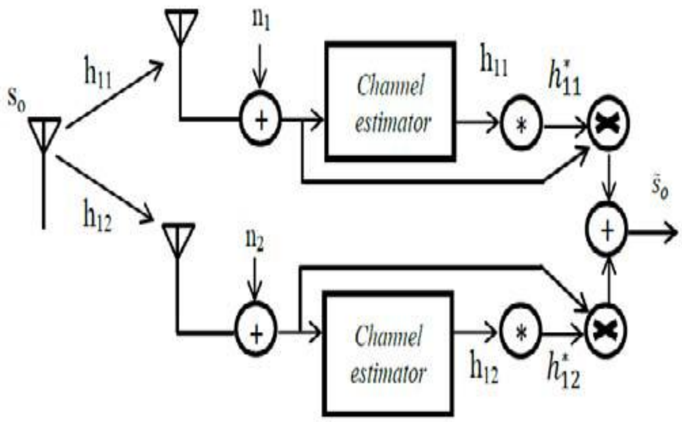

Figure 1: Maximal ratio combiner in digital communication system

Here h_{11} and h_{12} are channel parameters for receiver 1 and 2 respectively. η_1 and η_2 described as AWGN [8].The mutual signal can be described

as: $\hat{S_0} = Y_1 * h_{11} + Y_2 * h_{12}$ (11)

MRC realizes ML detector and the diversity combiner gives the sum i.e

$$Y = \sum_{N=1}^{M} h_{1N}^{*}\ Y_N \quad (12)$$

The envelope of the composite signal part can be expressed as: $\beta_K = \sum_{N=1}^{M} \beta_N^{2}$ (13)

The sum of the noise power can be expressed as $\sigma_n^{2} = N_0 \sum_{N=1}^{M} \beta_N^{2}$ (14)

Therefore the symbol energy to noise ratio is

$$\gamma_s^{ky} = \frac{E_{average}\,\beta_K^{2}}{\sigma_n^{2}} = \sum_{N=1}^{M} \frac{E_{average}\beta_N^{2}}{N_0} = \sum_{N=1}^{M} \gamma_N \quad (15)$$

We have assumed every antennas are impartial and uncorrelated , γ has a chi-

squared distribution with 2N degrees of freedom, then

$$P_{\gamma}^{ky} = \frac{1}{M-1!\,(\overline{\gamma_b})M} z^{M-1} e^{-z/\overline{\gamma_b}} \quad (16)$$

Here $\overline{\gamma_b} = E[\gamma_N]$

For BPSK the BER can be expressed as $P_b = \int_0^{\infty} P_b(z)P_{\gamma}(z)dz. = \int_0^{\infty} Q\sqrt{2z}\,\frac{1}{M-1!\,(\overline{\gamma_b})M} x^{M-1} e^{-z/\overline{\gamma_b}}\, dz$
(17)

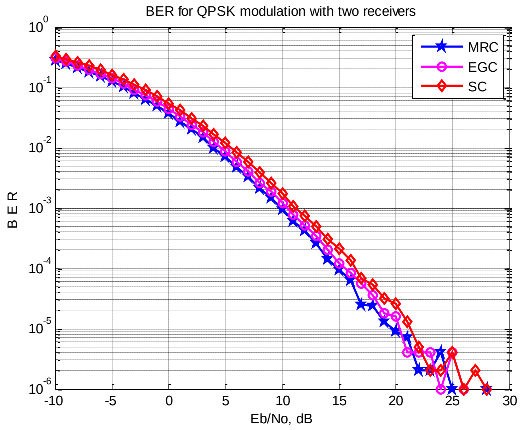

Figure 2: BER of BPSK in MRC,EGC and SC using two receiver

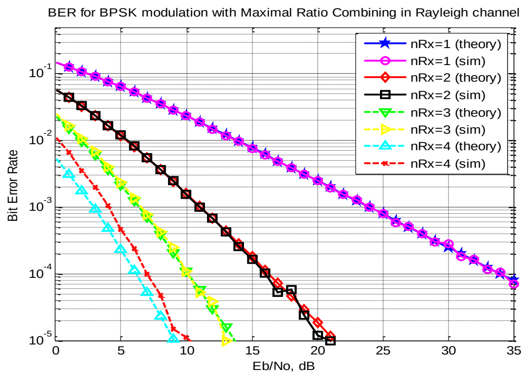

Figure 3: BER of BPSK in MRC in Rayleigh.

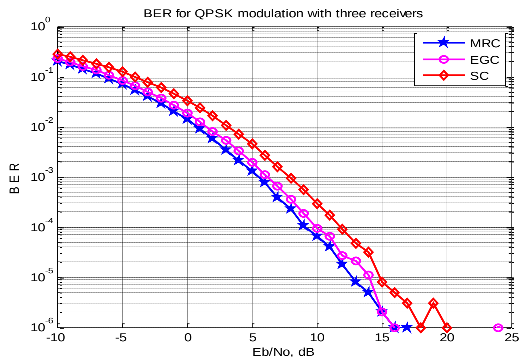

Figure 4: BER of BPSK in MRC ,EGC and SC using three receiver

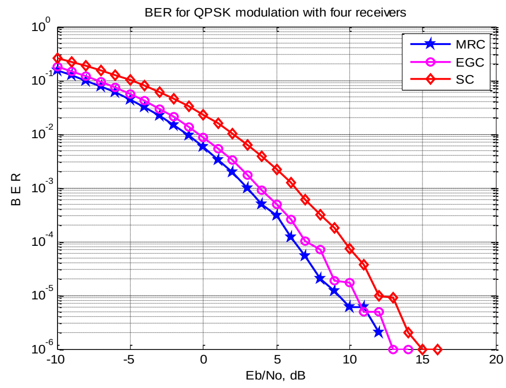

Figure 5: BER of BPSK in MRC ,EGC and SC using four receiver

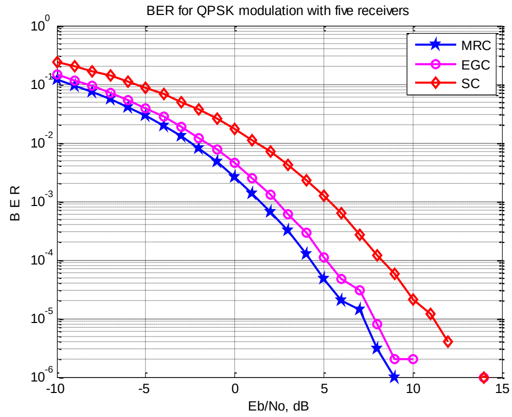

Figure 6: BER of BPSK in MRC ,EGC and SC using five receiver

MRC with Correlation

In this technique the arriving signal is processed at each antenna to break up the pilot and data symbols. Then the extracted pilot symbols are used to approximate the channel coefficients. These estimated channel coefficients are used by the MRC for the decision variable. Correlation filter [14] is used to remove required signal from the noisy signal. In receiving antenna pilot and data extraction can be achieved after arriving signal is multiplexed by the locally generated pilot chaotic sequence, the ensuing sequences are accumulated over the 2ξ period and nth user chaotic sequence to extract the pilot and nth user data, respectively. Thus two correlator outputs can be described as

$$Y_{j,data} = \sum_{M=2(j-1)\xi+1}^{2j\xi} b_j e^{k\varphi} \left(\sum_{k=r,k=1}^{n} (\beta_j^{\,k} s_m^{\,k}) s_m^{\,l} + \sum_{M=1}^{2\xi} \gamma_m s_M^{\,l}\right. \quad (18)$$

$$Y_{j,pilot} = \sum_{M=2(j-1)\xi+1}^{2j\xi} b_j e^{k\varphi} \left(\sum_{k=r,k=1}^{n} (\beta_j^{\,k} s_m^{\,k}) s_m^{\,r} + \sum_{M=1}^{2\xi} \gamma_m s_M^{\,r}\right. \quad (19)$$

Above two equations indicated that data and pilot in the jth antenna at time j of l-th user and extracted pilot can be taken as the input to the LMS filter and the follow-on algorithm . The minimum mean square error(MMSE) J_{MIN} for this algorithm is

$$J_{MIN} = 2\xi {b_j}^2 n r^2 + 2\xi N_0 r^2 \qquad (20)$$

The probability of error ($P_{(l)}(b_j)$) for j-th bit of l-th user is shown as follows[15]

$$P^{(l)}(b_j) = \frac{1}{2}\Pr(Y_j^{(l)} < 0 \mid \beta_j^{(l)} = 1) + \frac{1}{2}\Pr(Y_j^{(l)} \geq 0 \mid \beta_j^{(l)} = -1) \qquad (21)$$

$$= \frac{1}{2} erfc\left(\frac{E[Y_l^{(l)} \beta_j^{(l)} = 1]}{\sqrt{2var[Y_l^{(l)} \beta_j^{(l)} = 1]}}\right)$$

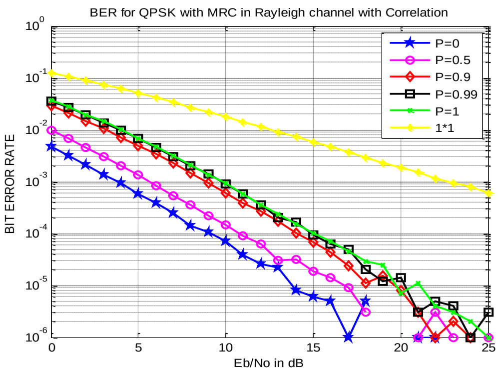

Figure 7: BER of QPSK in MRC in Rayleigh channel with Correlation

Equal Gain Combiner(EGC)

Generally diversity branches are not weighted in case of EGC but one resemblance involving EGC and MRC is that they are co-phased.The total channel vector is necessary anyhow and MRC capacity can fit to it. In this technique equalization can be done on the jth arriving antenna at the recipient by separating the arriving symbol Y_j by the a priori identified phase of channel h_j.The decoded symbol can be achieved by

$$\hat{r} = \sum_j \frac{r_j}{e^{\varphi_{lj}}} = \sum_j \frac{|h_j| e^{\varphi_{lj}} s + n}{e^{\varphi_{lj}}} \qquad (22)$$

The bit error rate can be evaluated with two receive antennas in the following formula

$$BER\ for\ BPSK = \frac{1}{2}\left[1 - \frac{\sqrt{E_b/N_0 \left(E_b/N_0 + 2\right)}}{E_b/N_0 + 1}\right. \qquad (23)$$

Selection Combining(SC)

In this method the receiver chooses the signal having maximum power and deselect from the other antennas. Suppose there are M self-determining channels and , every channel having diversity branch and all branch has the same average SNR. The probability that bit energy-to-noise ratio falls lower than a threshold say (β) called outage probability(P_{out}).

$$\text{Now}(P_{out}) = P[\beta_j < \beta] = \int_0^{\beta} \beta^{-1} e^{\frac{-\beta_j}{\beta}} d\beta_j = 1 - e^{\frac{-\beta_j}{\beta}} \qquad (24)$$

The joint probability with M arriving signal can be $P_{joint} = P[\beta_1 < \beta] P[\beta_2 < \beta]\ .\ .\ .P[\beta_M < \beta]$

$$= [1 - e^{\frac{-\beta_j}{\beta}}]^M \qquad (25)$$

Where $\beta_1, \beta_2, \ .\ .\ .\ \beta_M$ are bit energy-to-noise ratios of the 1st, 2nd, and so on the m-th arriving antenna. We know that PDF is nothing but derivative CDF.

$$P(\beta) = \frac{d(P_{out})}{d\beta} = \frac{M e^{\frac{-\beta_j}{\beta}} (1 - e^{\frac{-\beta_j}{\beta}})^{M-1}}{\bar{\beta}} \qquad (26)$$

Bit error rate can be calculated by substituting above equation

$$BER_{SC} = \int_0^{\infty} erfc(\sqrt{\beta}) \frac{M}{\beta} e^{\frac{-\beta_j}{\beta}} [(1 - e^{\frac{-\beta_j}{\beta}})^{M-1} d\beta \qquad (27)$$

Alamouti STBC

In Alamouti space-time code[1] two successive symbols $\{x0 , x1\}$ can be mapping are mapped into the following codeword **X**

In Alamouti space-time code[1] two successive symbols $\{x0 , x1\}$ can be mapping are mapped into the following codeword **X**

$$X = \begin{bmatrix} x_1 & x_2 \\ -{x_2}^* & {x_1}^* \end{bmatrix} \qquad (28)$$

Each rows stand for time diversity and the every columns for space diversity. The arriving signal vector Y can be represented as $Y = HX + n$ (29)

Where

$$Y = [y_1, y_2\ y_3,\quad y_r]^T \qquad (30)$$

$$X = [x_1, x_2 \quad x_{Nt}]^T \qquad 31)$$

And noise $n = [n_1, n_2 \quad n_{Nr}]^T$ (32)

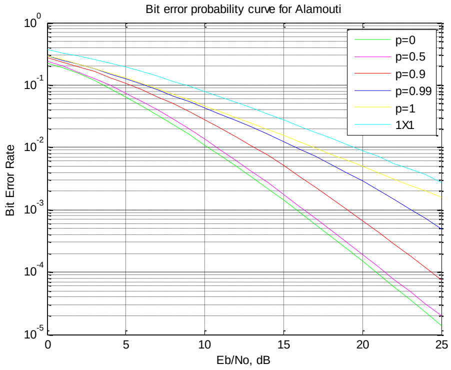

Figure 8: Bit error probability curve of ALOMOUTI STBC under different values of P.

BEAM FORMING

It is one of the method which involves sending the similar signal with varied gain and phase over each and every one source antennas such that the recipient signal is maximized [3].In other words an array of antennas is subjugated to accomplish highest response in a particular way by calculating the signal received from a required direction (being there of noise) even as signals of the similar frequency from previous information are discarded [6]. The signals arriving by the diverse elements of an antenna array can suitably combines to form a single output called beam former. Because of transmitter receiver pair can execute beam forming and through their key beams at each other, thereby rising the receiver's received power and as a result the SNR.In equation (7) the transmitted signal is:

$$x_l = a_l s_l \qquad 1 \leq l \leq M \qquad (33)$$

Where a_l is the transmit beamvector ,also receiver uses beam forming

$$r_l = b_l^H y_l \qquad 1 \leq l \leq M \qquad (34)$$

Here b_l is the accept beamvector and s_l is approximate symbol at the lth carrier.

We can calculate average power if transmtt is constrained.Therefore average power can be of the following calculations.

$$\sum_{l=1}^{M} E(\|x_l\|^2) = \sum_{l=1}^{M}(\|a_l\|^2) \leq P_t \qquad (35)$$

Simulation model:

- Take number of bits or symbols.
- Generate 0 and 1 with equal probability.
- Here modulation is BPSK,take additive white Gaussian noise with variance 0 dB and channel is Rayleigh channel.
- Perform equalization and consider receiver - hard decision decoding.
- Counting the errors

CONCLUSION

In this paper ,we have observed and analysed the performance of different receivers. On the basis of simulation result MRC method provides results than SC and EGC for different receivers. The results obtainable in this paper are usual to give helpful in order and strategy to radio systems propose engineers to develop the utilize of diversity combining under pragmatic imperfect channel estimation scenarios. We can extend our work on the use of MRC and ANN-equalization in multi-path fading non linear channel.

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