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Developing a Novel Beamforming Technique in Antenna Diversity

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Abstract: The transmitted symbol is affected by the channel noise and diversity is an efficient method to reduce the noise and interference. Recently, the channel noise is cancelled by using a novel beamforming technique, where the transmitted symbols are weighted and the same weighting vectors are used at the receiver. In this paper, the authors use the proposed beamforming technique in antenna diversity to eliminate the channel noise and interference. The authors also compute the bit error rate (BER) performance for different diversity combiner and the result shows that the proposed beamforming algorithm with transmit diversity provide better BER performance than usual antenna diversity.

Keywords: Antenna array, transmit diversity, channel noise, diversity combiner, multi-path fading.

I. INTRODUCTION

In diversity technique same information transmitted through a number of transmission paths, named diversity branches that have uncorrelated multi-path fading. There are different types of diversity branches; generally, diversity branches are classified into one of the following categories, such as Space diversity, Angle diversity, Polarization diversity, Frequency diversity, and Time diversity. Space diversity is the widely used diversity technique which has a single transmitting antennae and a number of receiving antennas. Angle diversity requires a number of directional antenna, each antenna responds independently to a wave propagating at a specific angle.

Beyond 3G wireless communication data is transmitted through a fading and noisy channel at very high data rate usually several Mbps to 100 Mbps with an accepted BER performance. In practice, it is difficult to transmit binary information through wireless channel at high data rate due to the limitation of channel capacity. Equalizer can be used to reduce multi-path fading effect but the designed complexity of equalizer is increased with the data rate. To reduce the channel noise and interference diversity technique is more efficient than equalizer in term of design complexity. There are two types of diversity scheme: i) Transmit diversity and ii) Receive diversity. Transmit diversity is more efficient than receive diversity in reducing noise and multi-path fading effect [1]. The BER increases with the order of modulation and for this reason the wireless channel is bandwidth limited. The multiple input multiple output (MIMO) channel increases the wireless channel capacity. Alamouti proposed diversity is also used in Orthogonal Frequency Division Multiplexing (OFDM) to form MIMO channel to provide an efficient wireless communication system [2].

In beamforming technique signal quality can be improved by targeting to a particular direction. Beamforming is also a class of array processing algorithms that optimizes an array gain in a particular direction or a particular direction of arrival. Hence the bit error of the wireless channel is reduced by suppressing the channel noise and interference from other unwanted user. In this technique, the user signal is weighted according to the direction of transmission or direction of arrival, and the signal from other unwanted direction is suppressed, that is, the desired signal is mapped to a particular direction and other interfering signal is cancelled. Therefore, this technique improves the BER performance of a wireless channel by reducing the multi-path fading effects.

In this paper, recently proposed beamforming algorithm [3] is used in antenna diversity technique to reduce noise and interference by using weighting vector to each transmit and receive antenna. The weighting vector of each signal from different sources differentiates each signals transmitted through different fading channels. The weighting vector for a particular user signal is used at the receiver to receive the desired user signal and cancelled other unwanted signal from other path. The weighting vector also reduces the channel noise depending on the value of the weighting vector. In this paper, we use the proposed beamforming algorithm in Alamouti proposed transmit diversity for the diversity combiners such as Maximum Ratio Combiner (MRC), Selection Combiner (SC), and Equal Gain Combiner (EGC) to obtain better BER performance by reducing channel noise and interference. The BER performance of both Alamouti proposed transmit diversity and our proposed beamforming algorithm in conjunction with Alamouti transmit diversity are computed for different diversity combining scheme.

In section II and III, space time block code (STBC) and Beamforming technique are discussed. In section IV, we discussed the background of this work. In section V, the proposed beamforming algorithm is used in transmit diversity for different diversity combiner such as SC, MRC, and EGC. The BER performance of the transmit diversity in

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conjunction with proposed beamforming algorithm for different diversity combiner scheme is discussed in section VI.

II. STBC SCHEME

Space Time Block Pattern is proposed as in work [1], in which the transmit antenna transmits symbol at a time slot. In receive diversity one transmitter transmits symbol and two antennae receive the transmitted symbols that arrive *via* different multi-path. In this case, a single symbol s_o is transmitted by a single transmitting antenna at time T and this symbol arrive through two paths. The channel impulse response between transmitter and receiver is as:

$$h_0=\alpha_0 \exp\theta_0 \quad (1)$$

$$h_1=\alpha_1 \exp\theta_1 \quad (2)$$

where α_i and θ_i is the amplitude distortion and propagation angle for the i^{th} channel and different technique has been proposed in patent [4] to estimate the channel parameter. The resultant received base-band signals with addition of channel noise and interference can be given as:

$$r_0=h_0s_0+n_0 \quad (3)$$

$$r_1=h_1s_0+n_1 \quad (4)$$

where n_0 and n_1 are Gaussian distributed complex noise and interference. The maximum likelihood decision rule to choose signal s_i if and only if (iff)

$$d^2(r_0,h_0s_i)+d^2(r_1,h_1s_i)\leq d^2(r_0,h_0s_k)+d^2(r_1,h_1s_k),\ i\neq k \quad (5)$$

where d^2 (x,y) is the squared Euclidean distance between signals x and y calculated by the following expression [5]:

$$d^2(x,y)=(x-y)(x^*-y^*) \quad (6)$$

The combining scheme at the receiver for two branches MRC is as:

$$S_0=h^*_0r_0+h^*_1r_1 = (\alpha_0^2+\alpha_1^2)s_0+h_0^*n_0+h_1^*n_1 \quad (7)$$

The decision rule to choose s_i becomes

$$(\alpha_0^2+\alpha_1^2)|s_i|^2-\overline{S}_0s_i^*-\overline{S}_0^*s_i \leq (\alpha_0^2+\alpha_1^2)|s_k|^2-\overline{S}_0s_k^*-\overline{S}_0^*s_k$$
$$\forall i\neq k \quad (8)$$

The processing needed to obtain these outputs can be expressed as [6]:

$$S_0=h_0^*r_0+h_1r_1^*=(\alpha_0^2+\alpha_1^2)s_0+h_0^*n_0+h_1n_1^* \quad (9)$$

$$S_1=h_0^*r_1+h_1r_0^*=(\alpha_0^2+\alpha_1^2)s_1+h_0^*n_1+h_1n_0^* \quad (10)$$

These combined received signals from the fading channel are sent to the Maximum likelihood detector for detecting the transmitted signal as in (9).

In receive diversity scheme, single transmit antenna transmits signal and the transmitted signal as received by two or more receive antennae as in [1]. A symbol from the transmit antennae transmits and arrives at the receiver *via* two delay paths. In Alamouti model, a modulated complex symbol s_o is transmitted from transmitting antenna and arrived to receiver through two channels having channel impulse response denoted by h_o and h_1, and the received symbol can be given as in (7).

The two branches transmit diversity using two antennae at the transmitter site and one received antennae at receiver site. Let at a given symbol period signal transmitted from antenna zero is denoted by say s_o and from antenna one by s_1. Similarly, in the next symbol period signal $-s_1^*$ is transmitted from antenna zero, and signal s_o^* is transmitted from antenna one, here * represents the complex conjugate of the transmitted symbols. If the two channels are modeled at t by (1) and (2) then the received fading signal can be expressed as:

$$r_0=r(t)=h_0s_0+h_1s_1+n_0 \quad (11)$$

$$r_1=r(t+T)= -h_0s_1^*+h_1s_0^*+n_1 \quad (12)$$

where T is the symbol period, and r_0 and r_1 are received signals at time t and t+T respectively. The combined signal can be written as:

$$\overline{S}_0=h_0^* + h_1^*r_1 \quad (13)$$

$$\overline{S}_1=h_1^*r_0 - h_0r_1^* \quad (14)$$

III. BEAMFORMING TECHNIQUE

In a multi-path wireless channel, the signal transmitted from transmit antenna to receiver antenna through multi-path and at the receiver, the target signal may consist of desired energy and interference energy from other users. A beamformer uses weighting vector to each user to transmit and receive the desired signal of a target user, while suppressing the undesired interference signal. This technique increases the signal to noise ratio (SNR) and signal to interference ratio (SIR) by decreasing the noise and interference power level for desired user, and decreases the signal quality for the undesired user by increasing its noise power. In this technique, each transmitter transmits signal as a beam in the direction of a target location, and hence the wanted signal is transmitted at the target user and the unwanted signal from other source is diverted from the target user. A beamformer is shown below:

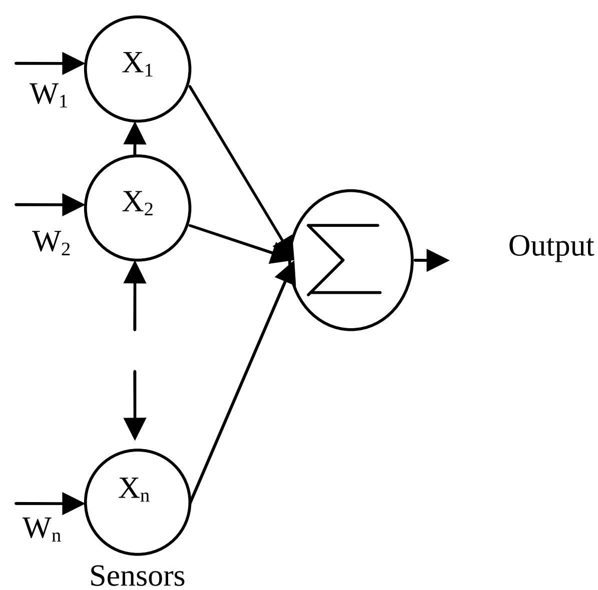

Fig. (1). Beamformer block diagram [7].

In Fig. (**1**), each user signal is beamed by multiplying a complex weighting vector to adjust the magnitude and phase of signals from different sources. The weighting vector corresponding to the transmit antenna is used at the receiver to extract the target user signal and suppress the interference signal from all other users. For M transmitting antenna and the fading path Xi can be represented as:

$$X_i=S(t) + n_i(t) \quad (15)$$

where S(t) is the modulated symbol and n_i is the background noise and interference. If each received signal is multiplied by a complex weight vector say W_i and added, then the resultant output signal becomes [7]:

$$y(t) = \sum_{i=1}^{M} W_i^{*} X_i(t) \quad (16)$$

Equation (16) can be written in vector form as-

$y= W^H X$ (17)

where the weight vector and the complex signal has the form as

$$W= [W_1, W_2 \ldots\ldots \ldots\ldots W_M]^T \quad (18)$$

$$X= [X_1, X_2 \ldots\ldots\ldots X_M]^T \quad (19)$$

IV. BACKGROUND

The modulated symbol consists of both real and imaginary part such as for a QAM symbol S_o, we have as [8]

$$S_o=a+jb \quad (20)$$

For a single transmit and receive antenna system, the symbol S_o transmitted from the transmitting antenna and received by a single receiving antenna with a Line-of-sight (LOS) path and the path having the impulse response in the form

$$h=\alpha_0 \exp(j\theta) \quad (21)$$

If the signal is multiplied by a complex weighting vector of form $w=w_1+jw_2$, then we have

$$S' = S_o{*}w=(a+jb){*}(w_1+jw_2) = aw_1-bw_2+j(aw_2+bw_1) \quad (22)$$

If the signal as in (22) is transmitted from the transmitter through a channel having noise n_0, then the received signal can be expressed according to [9, 10] as:

$$r_0=hS' \pm n_0 = haw_1-hbw_2+ (\pm n_1)+j(haw_2+hbw_1+(\pm n_2) \quad (23)$$

where $n_0=n_1+jn_2$. Dividing (23) by w_1, we have

$$r_0^{'} = ha - \frac{hbw_2}{w_1} + \frac{(\pm n_1)}{w_1} + j\left\{\frac{haw_2}{w_1} + hb + \frac{(\pm n_2)}{w_1}\right\}$$

Now, writing the condition w1>>w2, we have

$$r_0^{'} = h(a+jb) + j\frac{(\pm n_0)}{w_1} \quad (24)$$

It is shown form (24) that the noise effect is reduced by a factor of w_1.

V. BEAMFORMING TECHNIQUE IN ANTENNA DIVERSITY

Let the modulated complex signal S(t) is transmitted at symbol period T, then the received signal for a post-detection diversity receiver can be written as [6, 11]

$$r_k(t)=h_k S(t)+n_k(t),\ k=1, 2, \ldots, L \quad (25)$$

where h_k (t) is the channel impulse response for the k^{th} propagation path and $n_k(t)$ is the AWGN noise for the k^{th} fading channel. In this section, we used the novel beamforming technique in antenna diversity

A. Maximal Ratio Combiner (MRC)

In MRC, each diversity branch is weighted, co-phased, and added. The combiner combined all the L diversity branches to provide maximum SNR

$$r=(r_1, r_2, \ldots\ldots, r_L) \quad (26)$$

The diversity combiner generates the following sum for each branch fading gain h_k [6]

$$\overline{r} = \sum_{k=1}^{L} h_k^{*} r_k \quad (27)$$

Let at a given time signal S_0 to be sent from the transmitter to receiver through two diversity paths having impulse response as in (1) and (2), and the two received fading signal r_0, r_1 are defined in (3) and (4). Now the MRC generates the sum

$$\overline{S}_0 = \sum_{k=0}^{1} h_k^{*} r_k \quad (28)$$

For two branches transmit diversity at a given time, the signal from antenna zero is denoted by S_o and from antenna one by S_1, and in the next symbol period signal from the two antennae can be represented as $-S_1^*$, and S_o^*. The channel for antenna zero at time t is modeled by $h_o(t)$ and $h_1(t)$ for transmit antenna one, and is defined in (12). If the modulated symbol S_0 is a complex form of $S_0=S_1+jS_2$, then the received signal at receiver can be written as:

$$r_0 = h_0S_1+(\pm n_1)+j[h_0S_2+(\pm n_2)] \quad (29)$$

$$r_1=h_1S_1+(\pm e_1)+j[h_1S_2+(\pm e_2)] \quad (30)$$

where $n_0=n_1+jn_2$, and $e_0=e_1+je_2$ are the noise signals for the two diversity branches. In a beamformer if we select the weighting vector of form $w=w_1+jw_2$, then multiplying the modulated symbol by the weighting vector before transmission, we have the resultant transmitted symbol as:

$$S'_0=S_0w=(S_1+jS_2){*}(w_1+jw_2) = S_1w_1-S_2w_2+j(S_1w_2+S_2w_1) \quad (31)$$

The received signal can be expressed as:

$$r_0'=h_0S'_0+n_0 = h_0S_1w_1-h_0S_2w_2+(\pm n_1)+j[h_0S_1w_2+S_2w_1h_0+(\pm n_2)] \quad (32)$$

Dividing (33) by w_1, we have

$$r_0^{''} = h_0S_1 - \frac{h_0S_2w_2}{w_1} + \frac{(\pm n_1)}{w_1} + j\left\{\frac{h_0S_1w_2}{w_1} + h_0S_2 + \frac{(\pm n_2)}{w_1}\right\} \quad (33)$$

If w_1>>w_2, then we have

$$r_0^{''} \approx h_0S_1 + \frac{(\pm n_1)}{w_1} + j\left\{h_0S_2 + \frac{(\pm n_2)}{w_1}\right\} \quad (34)$$

$$r_0^{''} \approx h_0S_0 + \frac{1}{w_1}n_0 \quad (35)$$

It is observed from (35) that the noise and interference is decreased by a factor of w_1. Similarly, the received signal from other diversity path can be written as:

$r'_1=h_1S'_0+n_1 = h_1S_1w_1-h_1S_2w_2+(\pm e_1)$
$+j[h_1S_1w_2+S_2w_1h_1+(\pm e_2)]$ (36)

Dividing (36) by w_1 and considering $w_1>>w_2$, we have

$$r_1'' = h_1S_1 - \frac{h_1S_2w_2}{w_1} + \frac{(\pm e_1)}{w_1} + j\left\{\frac{h_1S_1w_2}{w_1} + h_1S_2 + \frac{(\pm e_2)}{w_1}\right\}$$

$$r_1'' \approx h_1S_1 + \frac{(\pm e_1)}{w_1} + j\left\{h_1S_2 + \frac{(\pm e_2)}{w_1}\right\}$$

$$r_1'' \approx h_1S_0 + \frac{1}{w_1}e_0 \quad (37)$$

The combiner combined these two received signals as in (36) and (35) according to the relation

$$\overline{S}_0' = \sum_{k=0}^{1} h_k^* r_k'' \quad (38)$$

This signal can be sent to the combiner to detect the transmitted signal.

At a given symbol period the signal S'_o is transmitted from antenna zero and the signal S'_1 is transmitted from antenna one, and in the next symbol period signal ($-S'_1*$) is transmitted from antenna zero, and signal (S'_o*) is transmitted from antenna one, the received signal can be written as:

$r_0=r_0(t)=h_0S'_0+h_1S'_1+n_0 = h_0a_1w_1-h_0b_1w_2+j(h_0a_1w_2+h_0b_1w_1)+$
$h_1a_2w_1- h_1b_2w_2+j(h_1a_2w_2+h_1b_2w_1) +n_0$ (39)

$r_1=r_1(t)=-h_0S'^*_1+h_1S'^*_0+n_1 = -h_0a_2w_1+h_0b_2w_2-j(-h_0a_2w_2-$
$h_0b_2w_1)+h_1a_1w_1-h_1b_1w_2-j(h_1a_1w_2+h_1b_1w_1)+n_1$ (40)

Dividing (41) and (42) by w_1 and applying $w_1>>w_2$, we have

$r'_0=h_0a_1 +j(h_0b_1)+ h_1a_2 +j(h_1b_2) +n_0/w_1 = h_0S_0+h_1S_1+n_0/w_1$ (41)

$r'_1=-h_0a_2 -j(-h_0b_2)+h_1 a_1 -j(h_1b_1)+n_1 = -h_0S_1^*+h_1S_0^*+n_1/w_1$ (42)

It is observed from (41) and (42) that the noise and interference terms for two transmitted symbols are reduced by a factor of w_1. The MRC combiner combined these signals and generated the following two signals:

$$\overline{S}_0' = h_0^* r_0' + h_1^* r_1' \quad (43)$$

$$\overline{S}_1' = h_1^* r_0' - h_0 r_1^* \quad (44)$$

These two signals can be applied to (9) to select the transmitted symbol.

B. Selection Combiner

The SC search the path having the highest signal energy (signal to noise ratio (SNR)) and this operation mathematically can be written as [6]

$$\overline{r} = \underbrace{\max}_{|h_k|}|r_k| \quad (45)$$

For receive diversity, the signal S_0 is transmitted to receiver through two diversity paths having impulse response in (1) and (2) the received two fading signals r_0 and r_1 have defined in (3) and (4). The SC performs the operation for two diversity paths as:

$P_k=2\times h_k^*r_k$; k=0,1 (46)

The output of the SC combiner is

Pr =max(P_1, P_2) (47)

For two branches transmit diversity, symbol S_o and S_1 are transmitted from antenna zero and antenna one, and in the next symbol period signal $-S_1*$ and S_o* are transmitted from the same antennae with the channel $h_o(t)$ and $h_1(t)$ respectively. The received signal at time t and t+T is defined in (13). The output signal of the SC combiner can be represented as:

$P_1=\max(2\times h_0^*\times r_0, 2\times h_1^*\times r_1)$ (48)

$P_2=\max(2\times h_1^*\times r_0, -2\times h_0\times r_1^*)$ (49)

The transmitted symbol can be identified using the Euclidean distance as in section (II). If the two paths are multiplying by weighting vector w_1 and w_2 then the noise term will be reduced by w_1 for first path and w_2 by second path as in (35) and (37). The combiner just selects the highest path having the highest SNR simply.

C. Equal Gain Combiner (EGC)

The EGC are same as MRC but the diversity branches are not weighted. All the diversity branches are co-phased and added, and mathematically represented as [6]

$$\overline{r} = \sum_{k=1}^{L} \exp(-\theta_k)\overline{r}_k \quad (50)$$

Let the signal S_0 be transmitted from transmitter to the receiver through two diversity paths having impulse response defined as in (1) and (2). Now, the EGC generates the sum for the two diversity paths r_0 and r_1 defined in (3) and (4) as:

$$\overline{S}_0 = \sum_{k=0}^{1} r_k \times \exp(-j\theta_k) \quad (51)$$

For two branches transmit diversity, the signal transmitted from antenna zero is denoted by S_o and from antenna one by S_1 and, in the next symbol period signal $-S_1*$ and S_o* are transmitted from the same antenna with the channel impulse response. The combiner combined the signals for the two received faded symbols at time t and t+T given by:

$$\overline{S}_0 = r_0 \times \exp(-j\theta_0) + r_1 \times \exp(-j\theta_1) \quad (52)$$

$$\overline{S}_1 = r_0 \times \exp(-j\theta_1) - r_1^* \times \exp(j\theta_0) \quad (53)$$

The received signal at receiver for the modulated complex symbol of the form $S_0=S_1+jS_2$ can be written as:

$r_0 =h_0S_1+(\pm n_1)+j[h_0S_2+(\pm n_2)$ (54)

$r_1=h_1S_1+(\pm e_1)+j[h_1S_2+(\pm e_2)$ (55)

where $n_0=n_1+jn_2$, and $e_0=e_1+je_2$ are the noise signals. Multiplying the symbol by the weighting vector $w=w_1+jw_2$, we have the transmitted and received signal as given in (32) and (33). The two received signals by applying the process as in (34) to (37), we have

$$r_0^{''} \approx h_0 S_0 + \frac{1}{w_1} n_0 \quad (56)$$

$$r_1^{''} \approx h_1 S_0 + \frac{1}{w_1} e_0 \quad (57)$$

The combiner makes the following operation

$$\bar{S}_0' = \sum_{k=0}^{1} \exp(-j\theta_k) \times r_k^{''} \quad (58)$$

For the transmitted symbols S'_o and S'_1 at time t, and symbols $-S'_1{}^*$ and $S'_o{}^*$ at t+T, the received signal is given by

$$r_0^{'} = h_0 S_0 + h_1 S_1 + n_0/w_1 \quad (59)$$

$$r_1^{'} = -h_0 S_1^* + h_1 S_0^* + n_1/w_1 \quad (60)$$

Hence, the noise and interference are reduced by a factor of w_1. The EGC combiner combined the signals as:

$$\bar{S}_0^{'} = \exp(-j\theta_0) \times r_0^{'} + \exp(-j\theta_1) \times r_1^{'} \quad (61)$$

$$\bar{S}_1^{'} = \exp(j\theta_1) \times r_0^{'} - \exp(j\theta_0) \times r_1^{'*} \quad (62)$$

VI. RESULT

The BER performance of MRC, SC and EGC for Transmit and Receive diversity is shown in this section through Rayleigh fading channel. The BER performance of MRC for transmit antennal and receive diversity is shown in Figs. (**2**, **3**) based on the method in [1].

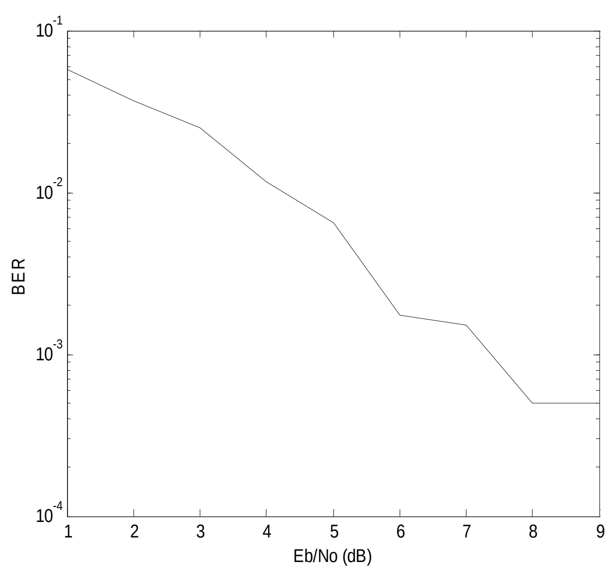

Fig. (2). BER performance of receive diversity (1×2 antenna array) through fading channel.

It is shown from Figs. (**2**, **3**) that the transmit diversity provides better BER than receive diversity. The fact is that in transmit diversity two antennae are used to transmit symbol through the channel and symbols are coded as STBC at two time slot. The beamforming algorithm is used in antenna diversity to reduce the noise and interference from other unwanted user as discussed in section (III). Any symbol transmitted at two time slots; at second time slot, complex conjugate of the symbol is transmitted and the receiver find the strongest signal. The receive diversity transmits symbol through a single transmit antenna *via* two paths, and the receiver select the strongest symbol in one time slot. The BER analysis of MRC for transmit and receive diversity with beamforming algorithm is shown in Tables **1** and **2** with considering the same parameter as in Fig. (**2**), the complex weighting vector is w=2+i0.001 for all the combiners.

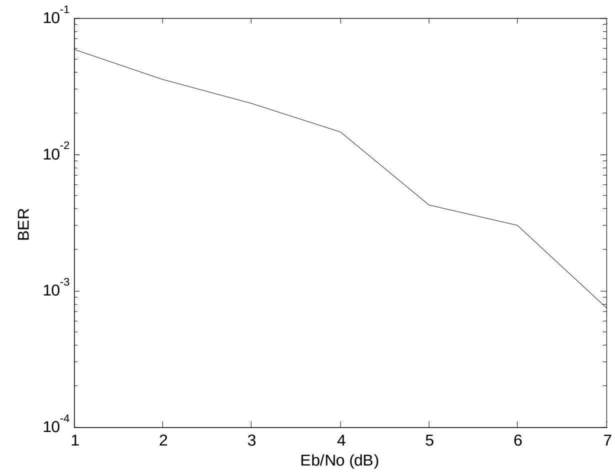

Fig. (3). BER performance of transmit diversity through fading channel.

Table 1. BER Value for Transmit Diversity with Beamformer

No. of Observation	E_b/N_0 (dB)	BER
1	1	0.0013
2	2	0.0
3	3	0.0
4	4	0.0
5	5	0.0
6	6	0.0
7	7	0.0
8	8	0.0
9	9	0.0
10	10	0.0
11	11	0.0
12	12	0.0
13	13	0.0
14	14	0.0
15	15	0.0

It is shown from Tables **1** and **2** that the beamformer improves the BER performance (for MRC) than the simulation result as in Figs. (**2**, **3**) and in [1] because the beamformer reduces the noise and interference effect by the factor of 1/w, where w is the complex weight vector. The BER performances of SC for transmit diversity with and without beamformer are shown in Figs. (**4**, **5**). The SC with beamformer provides better BER as in Fig. (**5**) than STBC SC in Fig. (**4**). For example the BER is 0.01for E_b/N_0=10 (dB) as in Fig. (**4**), and we have the BER value 0.001 for the same E_b/N_0 for SC with beamformer as in Fig. (**5**).

Table 2. BER Value for Receive Diversity

No. of Observation	E_b/N_0 (dB)	BER
1	1	0.0015
2	2	0.0005
3	3	0.0
4	4	0.0
5	5	0.0
6	6	0.0
7	7	0.0
8	8	0.0
9	9	0.0
10	10	0.0
11	11	0.0
12	12	0.0
13	13	0.0
14	14	0.0
15	15	0.0

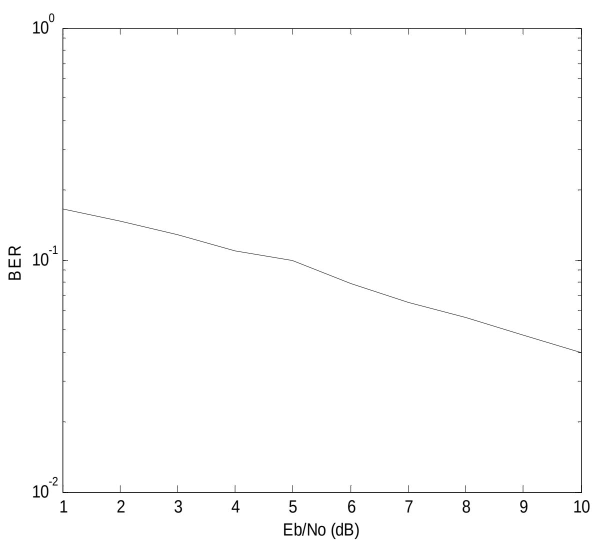

Fig. (4). BER performances of SC scheme without beamformer.

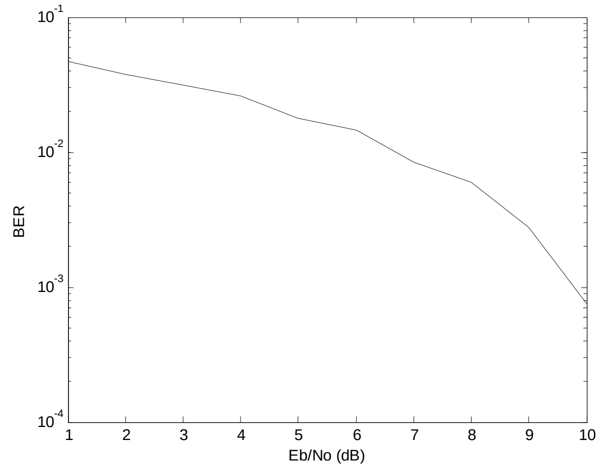

Fig. (5). BER performances of SC scheme with beamformer.

The BER performance for EGC with STBC scheme is shown is Fig. (**6**) and similarly the BER performance of EGC with beamformer to each diversity branch is shown in Fig. (**7**) for receive diversity in both cases. Similarly the BER performance of EGC for STBC is shown in Fig. (**6**). It is shown from Figs. (**6**, **7**) that the value of BER for EGC without the beamformer is 0.014 at E_b/N_0 equal to 8 dB and the BER with beamformer is 0.0004 at the same value of E_b/N_0. The beamforming technique is used in each diversity branch, and the EGC combiner provides the strongest signal.

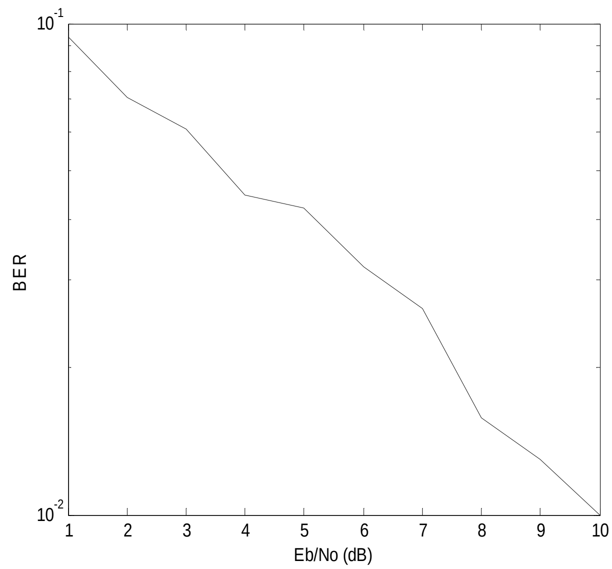

Fig. (6). BER performance of EGC for receive diversity without beamformer.

It is shown from Figs. (**8**, **9**) that the transmit diversity for EGC combiner with beamformer provides better bit error performance than without beamformer.

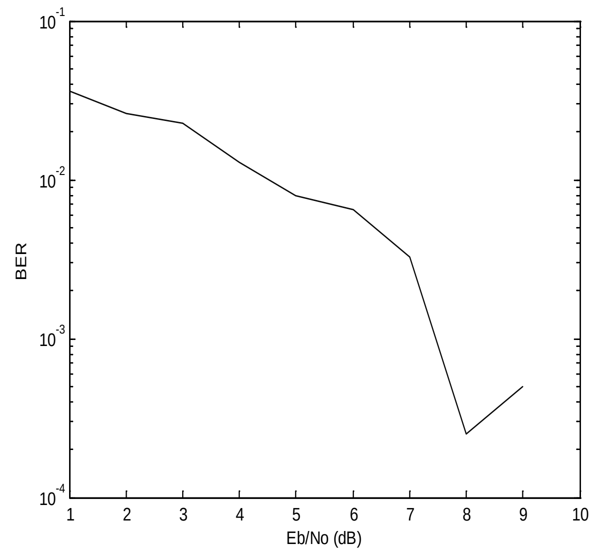

Fig. (7). BER analysis of EGC for receive diversity with complex weighting vector to each diversity branch.

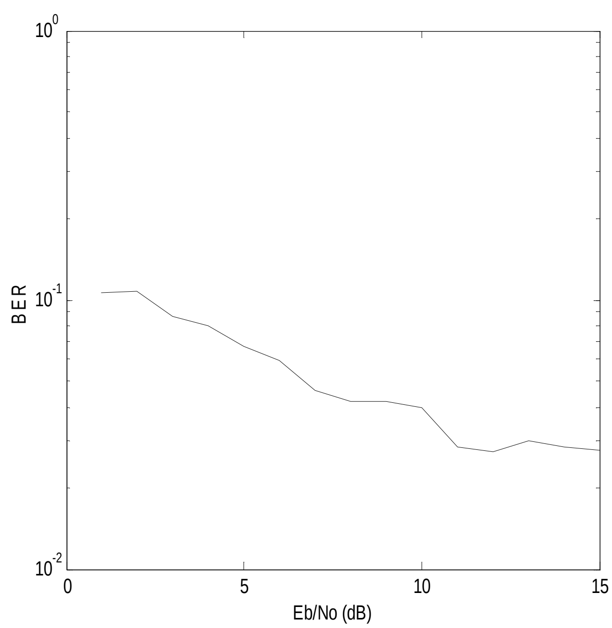

Fig. (8). BER performance of EGC for transmit diversity.

In this paper, the simulation is performed by sending a 16 QAM modulated symbol through a multipath fading channel whose noise is considered as AWGN (Additive White Gaussian Noise) with mean zero and variance σ2. The phase offsets are 250 and 300 respectively, for two-branch transmit diversity, and 350 for receive diversity. The BER for transmit diversity is calculated by sending two 16-QAM symbols through two diversity paths and adding AWGN noise independently to each diversity path. The faded signal is combined according to (14), and the received symbol is detected by sending to the decision device according to (8). In receive diversity, the modulated symbol is transmitted through a single transmitting antenna and combined according to (7). The BER for both transmit and receive diversity with beamforming is calculated by multiplying the modulated symbols by complex weighting vector, and the resultant symbols are transmitted through the channel as discussed in section V. Before combining, we divided the received symbol by the complex weighting vector to reduce both the effect of noise and interference for both transmit and receive diversities. We have considered the value of complex weight vector equal to 2+001i. The transmitted symbols are detected by MRC, and SC combining technique using MATLAB software.

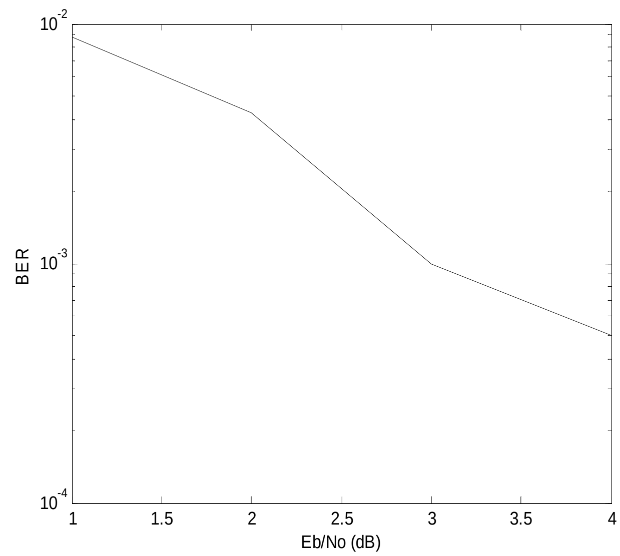

Fig. (9). BER performance of EGC with beamforming algorithm for transmit diversity.

VII. CONCLUSION

This paper compares the BER performance of different diversity combiners. From the simulation result in section VI it is shown that MRC provides better BER performance than the other two SC and EGC. The beamforming technique is used to concentrate energy to a particular direction. In this paper, we use the technique to decrease the noise and interferences from other sources. We proposed a novel beamforming algorithm to reduce the noise and interference without any complexity. This proposed beamforming techniques can be used in WiMAX for both transmit and receive diversities to send high data rate for 4G wireless communication with better BER performance. Our simulation result shows our proposed beamforming technique which provides excellent BER performance when it is used in antenna diversity, here we get BER=0 at E_b/N_0 beyond 2 dB for MRC but in work [12] BER=0 is obtained at very high value of E_b/N_0, typically beyond 30 (dB) and in all case the perfect channel estimation is used as in [13].

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