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Improving Signal Strength in Wireless Mobile Communication using Diversity Combining Technique over Rayleigh Fading Channels

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ABSTRACT
The error probability floor evolves due to performance loss, thus there is a requirement of high energy and high bandwidth to get a desired link. The branches are assumed to be Rayleigh fading. With the increase number of receiver the signal to noise ratio to be improved and bit error rate of all branches are compared. This work confirms the benefit of choosing 2x2MIMO system instead of 1 transmits 2 receive MRC case.

Keywords
Fading channels, Receive Diversity - Selection Diversity, Equal Gain Combining, Maximal Ratio Combining (MRC), Transmit diversity –Alamouti’s Scheme, Multiple Input–Multiple Output (MIMO), Rayleigh fading, Bit error rate, Performance loss.

1. INTRODUCTION
Wireless communication has become an important part of daily routine of human being, for voice as well as data traffic. Wireless network provides high speed mobility, Time varying fading results unreliable wireless transmission.

2. FADING
In case of destructive interference the power of signal significantly reduced at receiver that is known as fading.

The quality of signal get degrade at the receiver due to deep fades that may occur at particular frequency or time or in space ,this make the detection and decoding of signal impossible at receiver.

If the signal arriving at receiver are not in coherence than multipath fading arises, to mitigate multipath fading in wireless channel transmitter power control method is used, in this method transmitter on other side of the link preprocessed the signal according to the channel condition experienced by receiver on one side of the link, in order to overcome the effects of channel.

But in case of different uplink and downlink frequencies some problems occurs in this method due to dynamic range of transmitter, transmitter does not have the knowledge of channel information experienced by the receiver, so in this case this information is feedback to transmitter from the receiver.

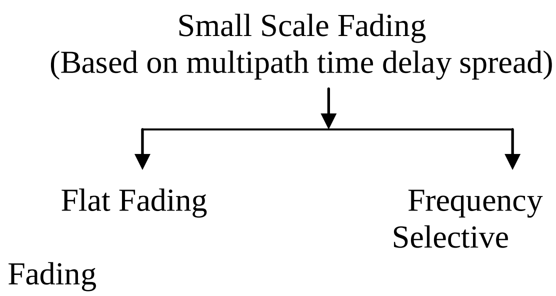
Diversity techniques are other effective techniques to overcome these problems. [1]

2.1. Parameter of Fading
Multipath spread- it defines maximum path delay between information signals in the channel.

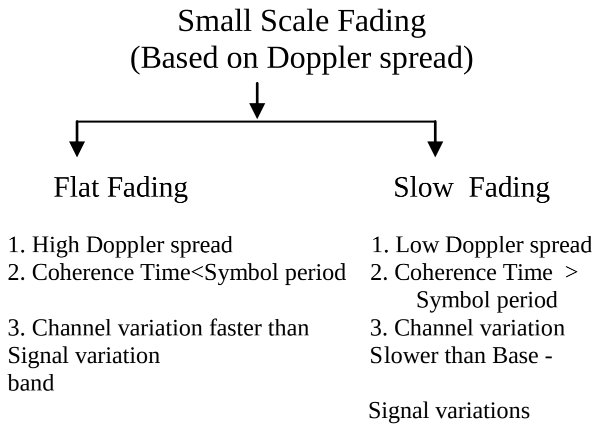
- Coherence bandwidth- it defines the range of frequencies in which transfer function of channel remain constant.
- Coherence time- it defines the time period during which the propagating wave (laser or maser beam) can be considered coherent.

2.2. CLASSIFICATION OF FADING
2.2.1. Large Scale Fading
This type of fading is the result of reduction in signal strength over large distances in the propagation path of signal.

2.2.2. Small Scale Fading
This type of fading is the rapid changes of amplitudes, phases or multipath delays of radio signal over small distances and small period of time. [5]



BW of Signal < BW of Channel   BW of Signal > BW of Channel
Delay Spread < Symbol Period   Delay Spread > Symbol Period



2.3. Classification of Fading Channels

Classification of fading channels depending on the characteristics of signal to be transmitted and the parameters of channels.

2.3.1. Frequency Non Selective Versus Frequency Selective

Frequency non selective fading is when all the frequency components of a signal undergo generally same level of fading. It occurs when the transmitted signal bandwidth is small as compared to coherence bandwidth of channel i.e. $B << B_c$ it is also known as flat fading. Frequency selective fading is when frequency components of transmitted signal attenuated differently. It occurs when transmitted signal bandwidth is large as compared to coherence bandwidth i.e. $B >> B_c$.

3. DIVERSITY TECHNIQUES

To improve the performance of wireless communication system over a fading channel diversity technique is used in the receiver end.

In this technique multiple copies of same information signal are provided to receiver over two or more different communication channel. Thus the main concept of using diversity techniques is repetition or redundancy of information signal to provide reliable wireless radio communication by selecting the signal of higher strength. The decisions made in diversity technique are unknown to receiver.

3.1. Types of Diversity Techniques

3.1.1. Microscopic technique

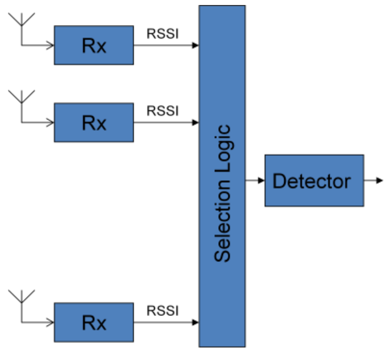
This technique is used to counteract small scale fading that is to avoid deep signal fading under distance of just a few wavelengths.

3.1.2. Macroscopic diversity

This technique is used to counteract large scale fading which occurs due to shadowing problems. [5]

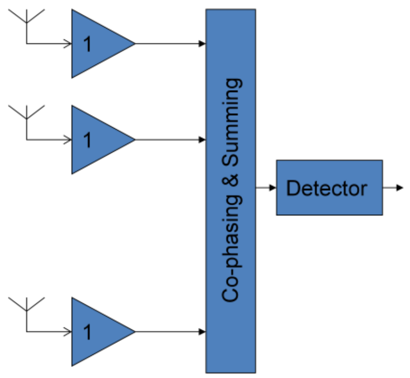
3.2. Diversity Combining Techniques

3.2.1 . Selection Combining



Uses M receivers-branches, compares signals and selects the best one.

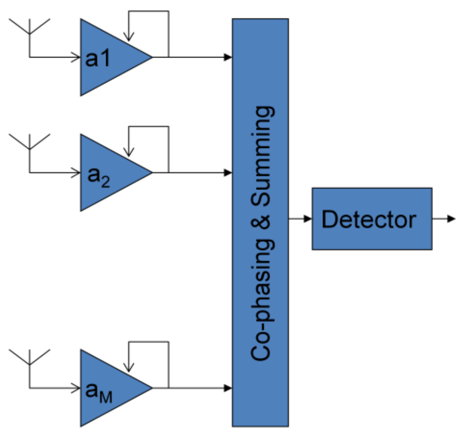
3.2.2. Equal Gain Combining



All branches are merely co-phased and summed

3.2.3. Maximal Ratio Combining (MRC)

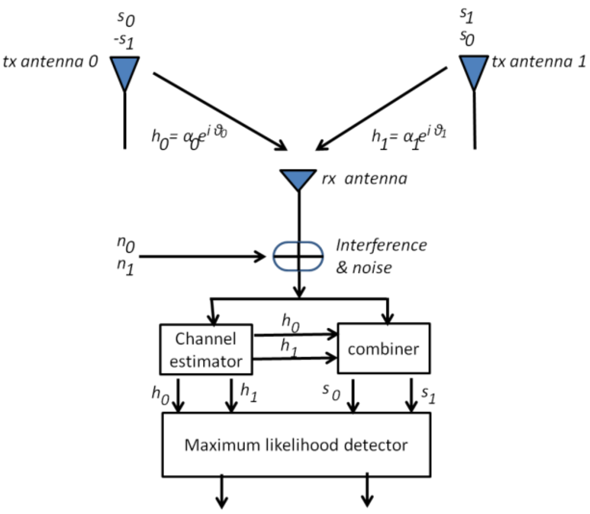
Each branch is weighted before summation in proportion to its own *signal-to-noise* ratio. Slightly better performance than EGC but more complex. [8]



4. THE NEW DIVERSITY SCHEME

4.1. Two Branch Diversity Techniques with One Receiver

Fig. 1



In this scheme two transmit antennas and one receive antenna be used and defined by following function:

The encoding and transmission sequence of information symbols at

- the transmitter;
- The combining scheme at the receiver
- The decision rule for maximum likelihood detection

Table A. The Encoding and Transmission sequence for the Two-Branch transmit Diversity Scheme

Time	antenna 0	antenna 1
T	s_0	s_1
t + T	$-s_1^*$	s_0^*

The channel at time t may be modeled by a complex multiplicative distortion *$h_0(t)$* for transmit antenna zero and *$h_1(t)$*for transmit antenna one. Assuming that fading is constant across two consecutive symbols, we can write:

$$h_0(t) = h_0(t+T) = h_0 = \alpha_0 e^{j\theta_0} \qquad (1)$$
$$h_1(t) = h_1(t+T) = h_1 = \alpha_1 e^{j\theta_1} \qquad (2)$$

where T is the symbol duration. The received signals can then be expressed as:

$$r_0 = r(t) = h_0 s_0 + h_1 s_1 + n_0 \qquad (3)$$
$$r_1 = r(t+T) = -h_0 s_1^* + h_1 s_0^* + n_1 \qquad (4)$$

Where r_0 and r_1 are the received signals at time t and t +T and n_o and n_1 are complex random variables representing receiver noise and interference.[4]

4.1.1. The Combining Scheme

The combiner builds the following two combined signals that are sent to the maximum likelihood detector:

$$\widetilde{S_0} = h_0^* r_0 + h_1 r_1^* \qquad (5)$$
$$\widetilde{S_1} = h_1^* r_0 - h_0 r_1^* \qquad (6)$$

It is important to note that this combining scheme is different from MRRC substituting the appropriate equations we have:

$$\widetilde{S_0} = (\alpha_0^2 + \alpha_1^2)s_0 + h_0^* n_0 + h_1 n_1^* \qquad (7)$$
$$\widetilde{S_1} = (\alpha_0^2 + \alpha_1^2)s_1 - h_0 n_1^* + h_1^* n_0 \qquad (8)$$

4.2. Two-Branch Transmit Diversity with M Receivers

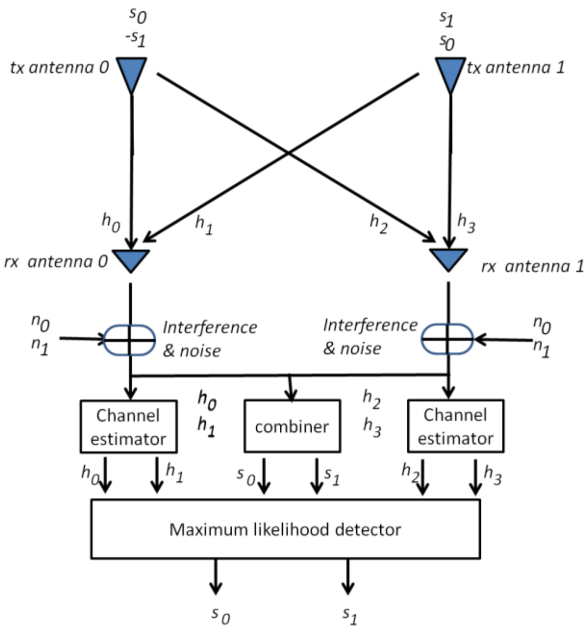


Fig. 2

There may be applications where a higher order of diversity is needed and multiple receive antennas at the remote units are feasible. In such cases, it is possible to provide a diversity order of 2M with two transmit and M receive antennas. For illustration, we discuss the special case of two transmit and two receive antennas in detail. The generalization to M receive antennas is trivial.The new two-branch transmit diversity scheme with two receivers.[2]

Table B. The definition of channels between the transmit and receive antennas.

	r_x antenna 0	r_x antenna 1
T_x antenna 0	h_0	h_2
t_x antenna 1	h_1	h_3

Table C. The notation for the received signals at the two receive antennas.

	r_x antenna 0	r_x antenna 1
T	r_0	r_2
t + T	r_1	r_3

For this configuration the encoding and transmission sequence of the information symbols is identical to the case of a single receiver, shown in Table A. Table B. defines the channels between the transmit and receive antennas, Table C. defines the notation for the received signal at the two receive antennas, where:

$$r_0 = h_0 s_0 + h_1 s_1 + n_0$$
$$r_1 = -h_0 s_1^* + h_1 s_0^* + n_1$$
$$r_2 = h_2 s_0 + h_3 s_1 + n_2$$
$$r_3 = -h_2 s_1^* + h_3 s_0^* + n_3$$

(9)

n_o, n_1, n_2 and n_3 are complex random variables representing receiver thermal noise and interference. The combiner in builds the following two signals that are sent to the maximum likelihood detector:

$$\tilde{s_0} = h_0^* r_0 + h_1 r_1^* + h_2^* r_2 + h_3 r_3^*$$
$$\tilde{s_1} = h_1^* r_0 - h_0 r_1^* + h_3^* r_2 - h_2 r_3^*$$

(10)

Substituting the appropriate equations we have:

$$\tilde{s_0} = (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2) s_0 + h_0^* n_0 + h_1 n_1^* + h_2^* n_2 + h_3 n_3^*$$
$$\tilde{s_1} = (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2) s_1 - h_0 n_1^* + n_0 h_1^* - h_2 n_3^* + h_3^* n_2$$

(11)

These combined signals are then sent to the maximum likelihood detector which for signal s_0 uses the decision criteria for PSK signals.

Choose s_i iff:

$$(\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i|^2 + d^2(\tilde{s_0}, s_i)$$
$$\leq (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k|^2 + d^2(\tilde{s_0}, s_k)$$

(12)

Choose s_i iff:

$$d^2(\tilde{s_0}, s_i) \leq d^2(\tilde{s_0}, s_k), \qquad \forall i \neq k$$

(13)

Similarly, for s_1, using the decision rule is to choose signal s_i iff:

$$(\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i|^2 + d^2(\tilde{s_1}, s_i)$$
$$\leq (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k|^2 + d^2(\tilde{s_1}, s_k)$$

(14)

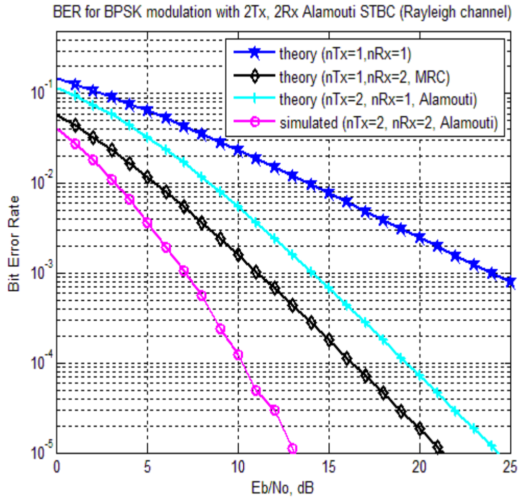
or, for PSK signals, choose s_i iff:

$$d^2(\tilde{s_1}, s_i) \leq d^2(\tilde{s_1}, s_k), \qquad \forall i \neq k\,.$$

(15)

The combined signals are equivalently to that of four branches MRRC. Therefore, the resulting diversity order from the new two- branch transmit diversity scheme with two receivers is equal to that of the four-branch MRRC scheme.[3,6]

5. RESULTS AND CONCLUSION



The BER Performance comparison for BPSK with MRC

Fig. 3

The bit error rate performance of a 2-Tx & 2-Rx MIMO in Rayleigh fading environment is shown in given figure

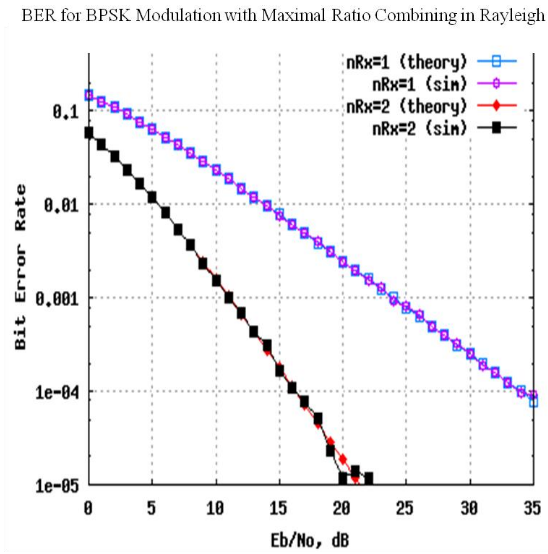


Fig. 4

At Eb/No=10 db the bit error rate for 2x2MIMO system is 10^{-4} and for 1 transmits 2 receive MRC case the bit error rate for Eb/No=10 db is around 10^{-4}. i.e for any value of Eb/No the BER is:

2Tx,2Rx< 2Tx,1Rx< 1Tx,2Rx(MRC) < 1Tx,1Rx.

So it is confirms that the BER performance of 2x2 MIMO System is much better than 1 transmits 2 receive MRC case.

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