On Investigating The Performance Gain Of Receiver Diversity To Mitigate Fading In Wireless Channels

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Abstract: Due to time varying nature of wireless channel and due to limited sources of signal transmission and various effects such as path loss.Doppler spread,shadowing and interference make it difficult to achieve satisfactory data rates. Diversity is a technique which is used for combating fading and co channel intereference and error bursts.In this paper various concepts of antenna diversity and combining techniques such as SC,MRC are discussed to combat multipath fading.BER and SNR performance of the various combining techniques are analyzed using MATLAB simulation.

Keywords: Maximal ratio combining,Selection combining,Rayleigh channel,Antenna diversity

1. Introduction

The mobile communication channel is susceptible to multi path fades due to a large number of scatterers and reflectors.For appectable performance in a communication system certain amount of signal level is required .Fading occurs when the signal level is less than minimum threshold. Typically, this phenomenon is described as the constructive / destructive interference between signals arriving at the same antenna via different paths, and hence, with different delays and phases, resulting in random fluctuations of the signal level at the receiver. Deep-fades that may occur at a particular point in space, or at a particular time or frequency, result in severe degradation of the quality of signals at the receiver making it impossible to detect and decode.In order to mitigate the effect of fading concept of diversity is used, that is providing the receiver with multiple copies of the same message[1]. Space diversity, also known as Antenna diversity, is the wireless diversity technique in which multiple antennas are used to improve the reliability and quality of the wireless link.In case of indoor and outdoor environments there is no clear line of sight available between transmitter and receiver as a result the signal is reflected along multiple paths before finally being received. As a result of these reflections there are phase shifts ,time delays ,attenuations and distortions which can cause destructive interference at the aperture of the receiving antenna. Antenna diversity is especially effective at mitigating these multi path situations. This is because multiple antennas[2] offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Diversity combining is another technique applied in which multiple received signals of diversity reception are combined to provide improved signal.SC,MRC,EGC are various techniques used in diversity combining.The motivation behind introducing diversity is that it is an effective method for increasing the SNR in a flat fading environment(i.e.nearly constant fading over entire bandwidth).Another motivation is that diversity provides alternate paths to the signal in fading environment such that there is reliability of signal.In this paper contribution is made[3] towards various combining schemes MRC,EGC,SC.Some combining techniques outperform others under certain conditions and implementation issues determine which combining is preffered.Various parameters such as BER and SNR are analyzed and the results are compared for these techniques.Comparitive analysis is made for technique which provides better SNR and BER Research works and contribution towards these mitigation techniques have been performed. Shruti sridharan[1] proposed the users nowadays want high data rates,good voice quality but system suffers from fading.In this paper various diversity techniques are used to avoid fading. Shekhar pundir[2] evaluated the performance of SISO,SIMO,MISO and MIMO systems. EKWE, O. A, Anorue [3] suggested that MIMO is one of the most smart antenna technology and dynamic control processes for reducing fading over channels by multiple antenna diversity techniques. Savita[4] proposed BER estimation of AWGN channel is compared with that of Rayleigh fading channel. MATLAB based Monte Carlo simulation example is presented, which comprises performance estimation of Binary phase shift keying (BPSK) signaling over a Rayleigh fading channel. Sang Wu kim[5] proposed forward error correction coding, space diversity, power control, and rate control techniques for fading mitigation. Zhou chen[6] investigated a MIMO scheme combining transmitting antenna selection and receiver maximal ratio combining. Arun rangarajan[7] considered the problem of optimal power allocation in an MISO system with perfect/partial channel state information (CSI) at the transmitter and perfect CSI at the receiver. Nitika sachdeva [8] considered different types of fading and different diversity techniques to combat fading. Jack winters[9] studied the ability of transmit diversity to provide diversity benefit to a receiver in a Rayleigh fading environment.

System model

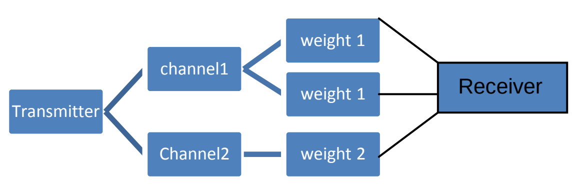

Figure1.*Maximum ratio combining*

The received equivalent SNR Signal for lth diversity branch is:

$$r(t) = a(t)e^{je^{\theta(t)}}u(t) + z(t),$$

$$0 < t < T, \dots, L; k = 1, \dots, K$$

Where u(t) is one of the transmitted complex lowpass information signals (i.e., is the alphabet size),T is the symbol duration, and z(t) is zero-mean complex additive white Gaussian noise (AWGN) with a power spectral density of N.

$$S = A\sum_{l=1}^{L} a^2$$

And the noise component is given by:-

$$N = \sum_{l=1}^{L} z(t)e^{-j\theta t}\ a$$

And the instantaneous SNR for MRC is given by

$$\frac{S^2}{2\sum_{l=1}^{L} a^2 P} = \sum_{l=1}^{L}\frac{A^2a^2}{2P} = \sum_{l=1}^{L}\gamma \quad \sum_{l=1}^{L}\frac{A^2a^2}{2P} = \sum_{l=1}^{L}\gamma$$

P is the noise power.

a)Spatial diversity

Space diversity, also known as Antenna diversity, is any one of several wireless diversity schemes that uses two or more antennas to improve the quality and reliability of a wireless link.This is the most common type of diversity scheme.Different copies of the signal are taken.Antenna diversity is especially effective at mitigating these multi path situations. This is because multiple antennas offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. The use of time and frequency diversity techniques requires extra temporal and spectral resources to ensure that the copies of the signal are sent through different channel conditions or paths. This situation can be avoided by using the additional dimension of space.The use of multiple antennas and RF chains makes the system complex and more complex.Spatial diversity is of great interest nowadays because high frequencies are used for transmission nowadays making it possible to apply in smaller terminals.

b) Combining Diversity:

In combining diversity, all copies of the signal are combined and the combined signal is decoded. Depending on the sophistication of the system, the signals can be added directly (equal gain combining) or weighted and added coherently (maximal-ratio combining). Such a system provides the greatest resistance to fading but since all the receive paths must remain energized, it is also consumes the most power.

Maximal Ratio Combining(MRC): In MRC, all the branches are taken into consideration simultaneously. Each of the branch signals is weighted with a gain factor proportional to its own SNR. Branches with strong signal are amplified,while weak signal is attenuated.

Equal Gain Combining: It is also a co-phase combining technique that brings all phases to a common point and then combines them. Here, all the amplitude weights are taken to be the same. The performance of the Equal Gain Combining is worse than the MRC. MRC being the best technique,therefore the system model is considered.

Simulation environment and methodology

In this section, we discussed the simulation parameters in case of antenna diversity and angle diversity. BER and SNR performance of with MRC and SC diversity combining techniques over Rayleigh fading channels using one or more receiving antennas with the help of MATLAB is dicussed.Alogrithm concerned are given below:-

Alogrithm for calculation of BER with MRC

Step1. Generate random binary sequence of +1's and-1's.

Step2. Multiply the symbols with channel and add white gaussian noise.

Step3. Chose that receive path,equalize the received symbols per maximal ratio combining.

Step4. Perform hard decision decoding and count the bit errors.

Step5. Repeat for multiple values and plot the simulation and theoretical results.

Alogrithm for calculation of BER with SC

Step1.Generate random binary sequence of +1's and-1's.

Step2. Multiply the symbols with channel and add white gaussian noise.

Step3. At the receiver,find the receive path with maximum power.

Step4. Chose that receive path,equalize the received symbols with the known channel.

Step5. Perform hard decision coding and count the errors.

Step6. Repeat for multiple values and plot

Case1.

Scenario1		Scenario2	
Antenna spacing	Lamda/8	Antenna spacing	Lamda/4
Carrier frequency	2000	Carrier frequency	2000
Sampling rate	100	Sampling rate	100
No of points in FFT	128	No of points in FFT	128
No of samples	1000	No of samples	1000
Av power	-20	Av power	-20

***Table1.**Parameters used in antenna diversity concept.*

In case 1.Carrier frequency is set to 2000.No of FFT points are set to 128.No of samples are set to 1000.Av power is -20.

Case2.

Carrier frequency	2000
Sampling rate	16
Eplison angle	90
Seperation between BS antennas	1
No of simulations	50
No of samples	1000
No of point scatterers	100

***Table 2.**Parameters used for cross co relation coefficient and received signal*

Results and discussions

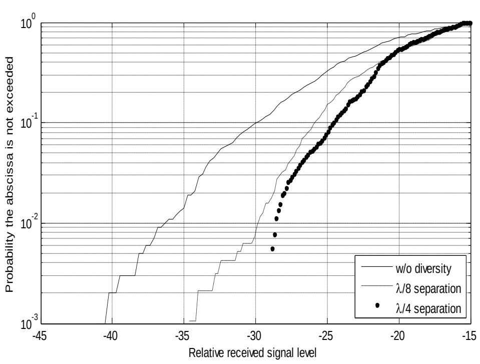

***Figure 1.** Antenna diversity*

CDFx values at lamda/8 seperation	CDFy values at lamda/8 seperation	CDFx values without diversity	CDFy values without diversity
-33.1677	0	-41.1554	0
-33.0771	0.0020	-41.0248	1.0000e-03
-32.8958	0.0041	-40.7637	1.0000e-03
-32.7145	0.0051	-40.5025	1.0000e-03

In figure 1 as we can increase the antenna separation better signal strength is received as compared to without antenna diversity.

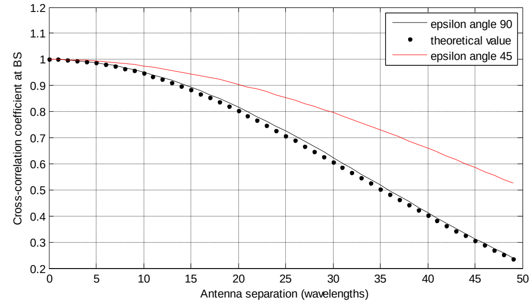

***Figure 2.**Cross correlation coefficient variation.*

Cross correlation coeffecient	10 Antenna separation(45degrees)
0.9933	5
0.9739	10
0.9427	15
0.9001	20

In figure 2.Angle 90 degrees has smaller co rrelation coefficient and provides better diversity gain.

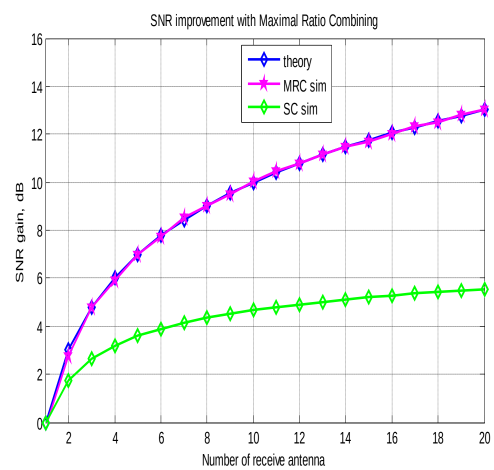

***Figure 3.** SNR improvement using MRC and SC*

No of receive antennas	MRC(snr gain)	SC(snr gain)
10	10.04	4.667
14	11.47	5.121
16	12.03	5.29

In figure 3 MRC is a better technique as compared to SC as better snr gain is obtained.

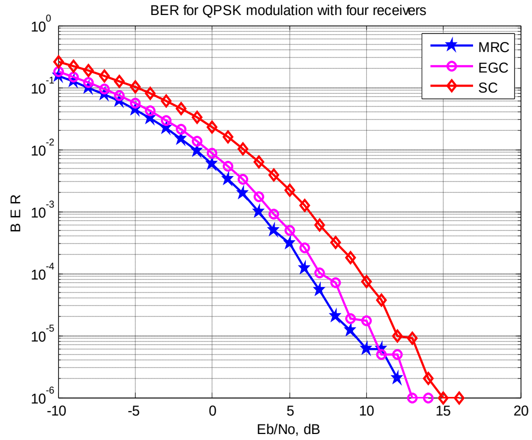

Figure4.*BER performance with qpsk modulation in SC,MRC,EGC*

BER	E/N (MRC)	E/N(EGC)	E/N(SC)
0.0001	6	7	10
0.000001	12	13	16

In figure4 MRC technique shows better BER performance as compared to EGC and SC.

Conclusion

Antenna diversity concept is discussed by changing antenna separation which provides better diversity gain as compared to without diversity. Combining techniques is one of the most efficient methods to combat the effects of fading .However there are various drawbacks in terms of bandwidth,complexity. There are various levels of complexity in various combining techniques.MRC offers the best performance however has the highest complexity whereas SC offers the least performance and has the least complexity.To compare the BER and SNR performance of MRC and SC no of receive antennas are changed ,MRC has better performance.

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