BER Improvement of Rayleigh Flat Fading Channel

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Abstract : ***Now-a-days the requirements of wireless communication are to have high voice quality, high data rates, multimedia features, lightweight communication devices etc. But the wireless communication channel suffers from much impairment. One of them is fading which is due to the effect of multiple propagation paths, and the rapid movement of mobile communication devices. In a typical wireless communication environment, multiple propagation paths often exist from a transmitter to a receiver due to scattering by different objects. Signal copies following different paths can undergo different attenuation, distortions, delays and phase shifts. So, this is necessary to reduce the problem of fading, but not at the cost of additional bandwidth. One effective solution is proposed for wireless system named diversity, without the requirement of extra bandwidth. This paper deals with the Rayleigh flat fading channel and to overcome the effect of fading, diversity is used at the transmitter to get good signal at the receiver diversity combining technique Maximal Ratio Combining (MRC) is used for improving the overall performance of the communication system. The diversity is used to provide the receiver with several replicas of the same signal. Diversity technique is used to improve the performance of the radio channel.***

IndexTerms -Fading, Diversity, Fading channels, Combining techniques, Wireless Communications.

I. INTRODUCTION

During the last decades, wireless communications have advanced at an incredible pace. The first example which changes our life-style is the mobile phone. Mobile phones have evolved from the simple phones for voice-calling in 1970s to present smart-phones with computer-like functionality. The second example is wireless local area networks (WLAN), the so-called WiFi. Equipped with a WLAN device, a laptop or desktop computer can connect easily to the Internet without the use of wires. As WLAN devices have been installed in many personal computers, video game consoles, mobile phones, printers, and other peripherals, and virtually all laptop or palm-sized computers. The third example is the Global Positioning System (GPS), a space-based global navigation satellite system which provides reliable location and time information in all weather and at all times and anywhere on or near the Earth. With the navigation of GPS, we can drive easily in any cities. GPS has become a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance, and hobbies such as geo-caching and way-marking.

The basic concept of a wireless communication system is almost deceptively easy to understand. An electromagnetic signal is created, modulated, amplified, and broadcast to one or more receivers that can be fixed or mobile. The data in that signal is received and demodulated in order to recover the original information that was sent. A basic system will normally consist of a transmitter, receiver, and a channel (i.e. radio frequency) that utilizes different carrier frequencies for each baseband (information signal) that is transmitted. The basic issues that one must address in the design of wireless systems are common to all of telecommunications, namely the effective use of the available frequency spectrum and power to provide high-quality communications. Some wireless systems often involve mobile services; this implies a constantly changing environment with rapidly changing interference conditions and dynamically variable multi-path reflections. This condition, plus the potential of conflicting demands for the use of radio frequencies in a free-space medium, means difficult challenges for creating high-quality signals.

II. DIGITAL COMMUNICATION SYSTEMS

Figure 1 illustrates a general block diagram for a digital communication system. In this diagram, digital data from a source are encoded and modulated for transmission over a channel. At the other side, the data are extracted by demodulation, decoding, and then sent to a sink. The encoder can be divided into two blocks, namely the source encoder and the channel encoder.

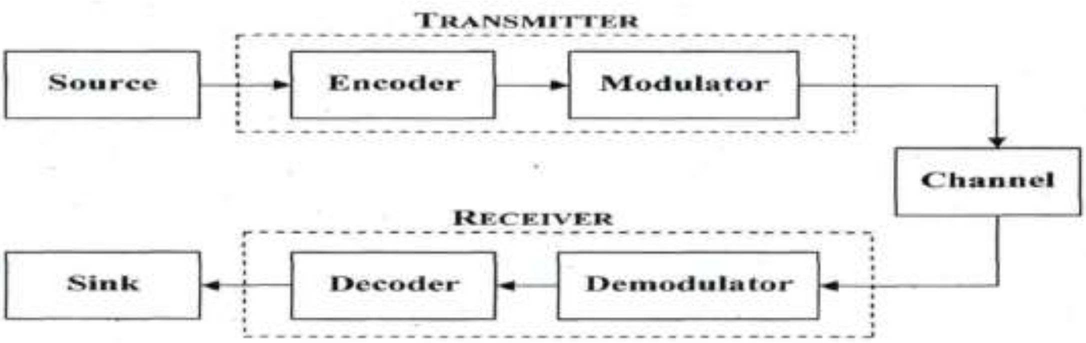

Figure 1: Block diagram of a digital communication system.

In some digital communication systems, channel coding and modulation are combined together; this is called coded modulation. In general, there are two main constraints in communication systems, the available spectrum (or bandwidth) and the power required for data transmission. The bandwidth is becoming a rare commodity with the demand of high speed and high quality of service (QoS) for wireless communications. In this paper M-ary phase shift keying (M-PSK) used for improving BER performances.

III. M- ARY PSK (MPSK)

In an M-ary signaling scheme, two or more bits are grouped together to form symbols and one of M possible signals, s_1 (t), s_2 (t)… S_M (t) is transmitted during each symbol period of duration T_s. Usually, the number of possible signals is $M = 2^n$ where n is an integer. M-ary modulation schemes have better bandwidth efficiency but they have less power efficiency. For example, a 16-PSK system requires a bandwidth that is $\log_2 16 = 4$ times smaller than a BPSK system, whereas its BER performance is significantly worse than BPSK since in the signal constellation the signals are packed more closely.

In M-ary PSK, the carrier phase takes on one of M possible values, namely $\Theta_i = 2(i-1)\,\pi/M$, where i = 1, 2…M. The modulated waveform can be expressed as

$$S_i(t) = \sqrt{\frac{2E_s}{T_s}}\cos\left(2\pi f_c t + \frac{2\pi}{M}(i-1)\right), \quad 0 \le t \le T_s$$

$$i = 1, 2, \ldots \ldots M$$

Where $E_s = (\log_2 M)\, E_b$ is the energy per symbol and $T_s = (\log_2 M)\, T_b$ is the symbol period.

IV. DIVERSITY TECHNIQUES:

Diversity technique is used to decreased the fading effect and improve system performance in fading channels. In this method, we obtain L copies of desired signal through M different channels instead of transmitting and receiving the desired signal through one channel. The main idea here is that some the signal may undergo fading channel but some other signal may not. While some signal might undergo deep fade, we may still be able to obtain enough energy to make right decision on the transmitted symbol from other signals. There is a number of different diversity which is commonly employed in wireless communication systems. Some of them are following:

1. Multipath/frequency diversity.
2. Spatial/space diversity.
3. Temporal/time diversity.
4. Polarization diversity.
5. Angle diversity.
6. Antenna diversity.

4.1 CONCEPTS OF DIVERSITY COMBINING TECHNIQUES

It is important to combine the uncorrelated faded signals which were obtained from the diversity branches to get proper diversity benefit. The combing system should be in such a manner that improves the performance of the communication system. Diversity combing also increases the signal-to-noise ratio (SNR) or the power of received signal. Mainly, the combining should be applied in reception; however it is also possible to apply in transmission. There are many diversity combining methods available but only three of them are prevalent.

1. Maximal ratio combining (MRC)
2. Equal gain combining (EGC)
3. Selection combining (SC)

The combining processes which use to combine multiple diversity branches in the reception, has two classes such as post-detection combing and pre-detection combining. The signals from diversity branches are combined coherently before detection in pre-detection combining. However, signals are detected individually before combining in post-detection. The performance of communication system is the same for both combining techniques for coherent detection. However, the performance of communication system is better by using pre-detection combining for non-coherent detection. It does mean that there is no effect in performance by the type of combining procedure for the coherent modulation case. The post-detection combining is not complex in non-coherent detection, results very common in use. There is a difference in system performance when used pre-detection combining and post-detection combining for non-coherent detection such as frequency modulation (FM) discriminator or differential detection schemes. Moreover, the terms pre-detection and post-detection are also indicates the time of combining means when the combining is performed, before or after the hard decision.

4.2 PERFORMANCE MEASURE OF COMMUNICATION SYSTEM

Some key measures of performance related to practical communication system design are as follows:

1. *Signal to noise Ratio (SNR):* It is a vital performance measure of a communication system. This performance measure is usually measured at the output of the receiver and indicates the overall quality of the system. For wireless communication system due to the presence of fading, the instantaneous SNR is a random variable.
2. *Outage Probability*: It is another important measure of performance to calculate the quality of service provided by wireless systems over fading channels and is defined as the probability that SINR falls below a certain threshold.
3. *Average Bit Error Probability (BEP):* It is one of the most informative indicators about the performance of the system. This measure can be obtained by averaging the conditional (on the fading) BEP over fading statistics.
4. *Bit Error Rate (BER):* In digital modulation techniques, due to some noise, interference, and distortion the received bits are altered .So bit error rate is defined as the no of error bits divided by total no of transmitted.

$$\text{Bit Error Rate (BER)} = \frac{\text{No of bits in error}}{\text{Total no of transferred bits}}$$

The performance of modulation is calculated measuring BER with assumption that system is operating with Additive white Gaussian noise. Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily produced as the number of users is increased and the mobile terminal is subjected to mobility. Thus, it has driven many researches into the application of higher order modulations.

V. STEPS INVOLVED IN THE PROPOSED ALGORITHM

Steps involved in the proposed system are:

1. At the transmitter Bernoulli binary generator is used to generate binary bits these binary bits are given as input to MPSK modulator. After which the signals are transmitted using antennas (In this work transmitter space diversity is used). These signals are transmitted over Rayleigh Flat fading channel.
2. At the receiver the signals from different transmitting antennas are received and these signals are combined using MRC diversity combining method.
3. The combined output is then given to MPSK demodulator.
4. BER is calculated for the received bits.

From the simulation diagram (figure 2) it is can be seen that on the transmitter side there is a Bernoulli binary generator, which generated binary bits. These binary bits are given to M ary phase shift keying modulator. After modulation these bits are transmitted through L antenna channels (Transmitter space diversity is used). At the receiver outputs from L antennas are combined using Maximal Ratio Combining (MRC), after that MRC output is given to m ary PSK demodulator. Bit Error Rate (BER) is computed for the proposed system.

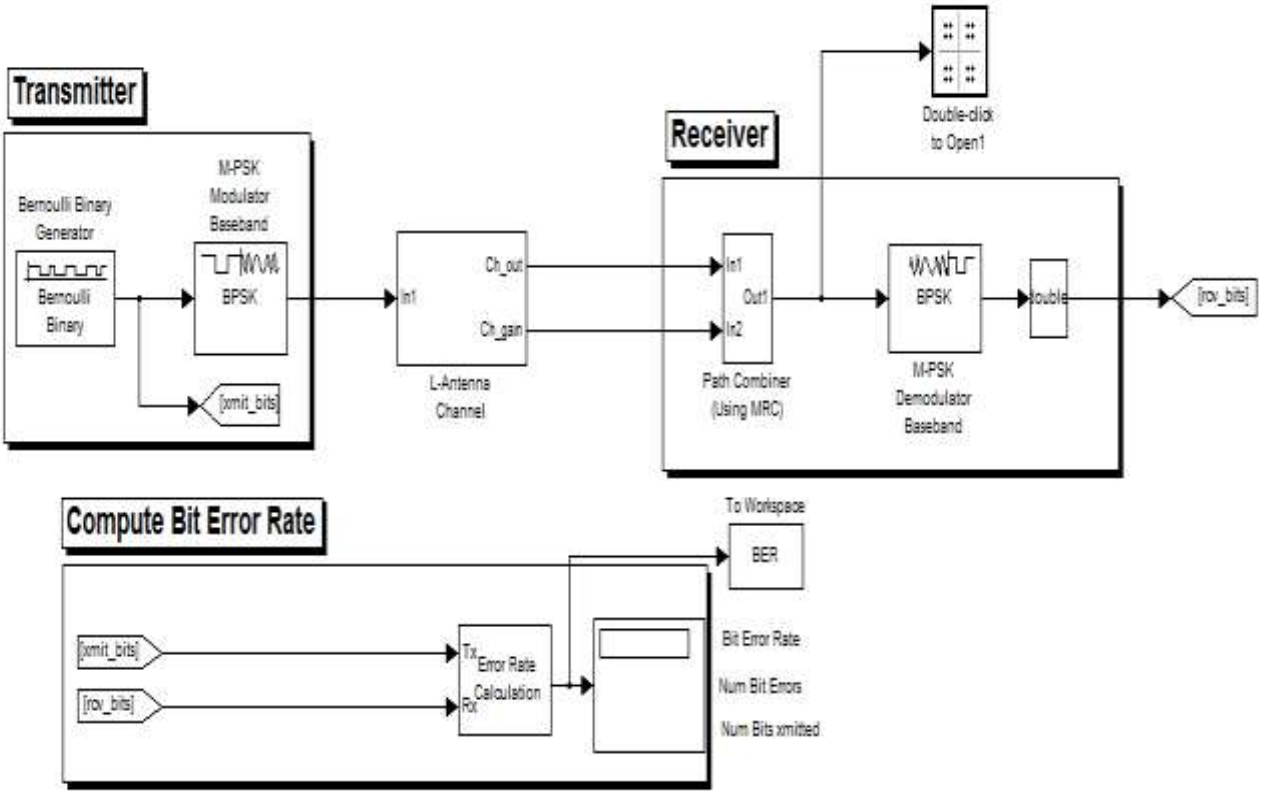

Figure 2: Simulation flow diagram

VI. SIMULATION RESULTS

The proposed system simulation outputs are as under.

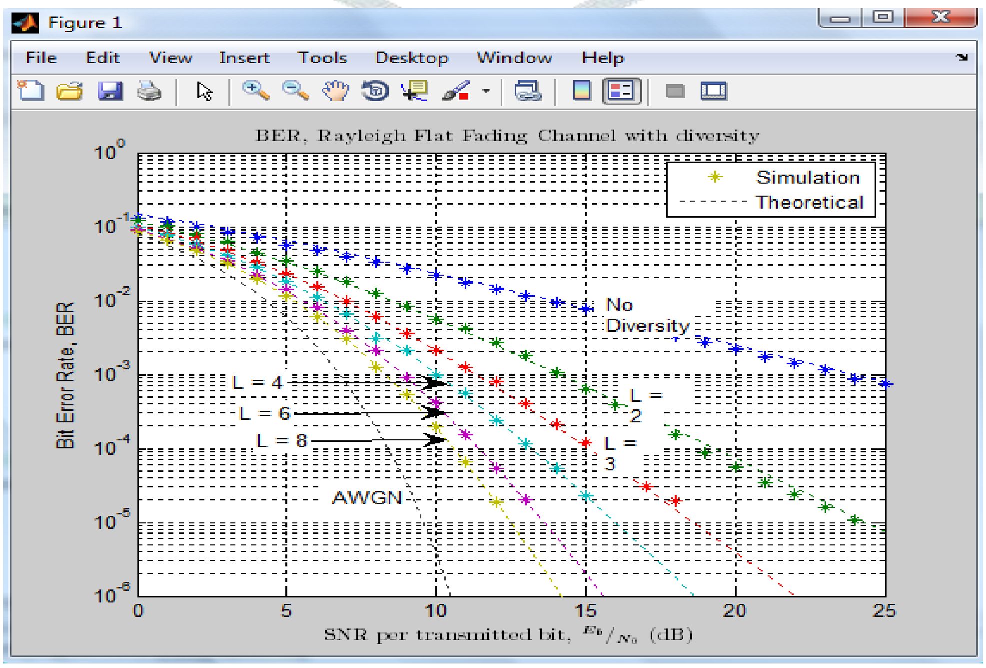

Figure 3: BER, Rayleigh Flat Fading Channel with Diversity.

Table 1: BER obtained for system with no diversity and for the proposed system

SNR per transmitted bit (dB)	BER of system with no diversity	BER of system with diversity				
		Order 2	Order 3	Order 4	Order 6	Order 8
2	9.489091e-002	8.445000e-002	6.549020e-002	5.661017e-002	5.025000e-002	4.731132e-002
4	6.681875e-002	5.115000e-002	3.111801e-002	2.475369e-002	2.392344e-002	2.022222e-002
6	4.457391e-002	2.620000e-002	1.331117e-002	1.130778e-002	7.710100e-003	6.142506e-003
8	3.032424e-002	1.336250e-002	6.326276e-003	4.123711e-003	2.063983e-003	1.268231e-003
10	2.020800e-002	5.976471e-003	1.925996e-003	9.633682e-004	3.808798e-004	1.840858e-004

From the table above it can be seen that bit error rate decreases with the increase in the order of diversity. The systems are analysed for the SNR values of 2dB, 4dB, 6dB, 8dB and 10dB.

V. CONCLUSION

The objective of this dissertation work is to develop an efficient wireless system based on MPSK by making use of diversity. The proposed system is analysed on Rayleigh flat fading channel using MPSK. Space transmitter diversity is used to reduce the bit error rate.
From the results it can be concluded that the proposed system has a better performance (reduced BER) over Rayleigh flat fading channel at SNR of 2dB, 4dB, 6dB, 8dB and 10dB. Diversity of order 2, 3, 4, 6 and 8 are analysed, it can be observed that with the increase in the order of diversity the BER goes on decreasing, but due to some limitations the diversity order can be increased up to a limit and it also depends on the application for which the system is being used.

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