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Diversity: A Fading Reduction Technique

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***ABSTRACT* - Fading is a major impairment in transmitting the signal in wireless communication. Thus, it becomes very necessary to nullify its effect to transmit the signal successfully and so the diversity technique along with its different types is being employed to combat the effect of fading. In this paper, different types of fading and different diversity techniques are being proposed.**

KEYWORDS: Fading, AWGN, shadowing, path loss, Diversity.

I. Introduction

Diversity is a powerful communication receiver technique that provides wireless link improvement at a relatively low cost. Diversity techniques are used in wireless communications to mitigate the effect of fading over a radio channel. The wireless communication channel suffers from much impairment such as Additive White Gaussian Noise (AWGN), the path loss, the shadowing and the fading. Fading is a major problem and in order to reduce it, diversity is being used. Thus in diversity technique, multiple copies of the same data is transmitted to the receiver via multiple paths or channels and the final decision is made by the receiver without knowing to the transmitter.

II. Fading

In a typical wireless communication environment, multiple propagation paths exist between transmitter and receiver due to scattering by different objects. Thus, copies of the signal following different paths can undergo different attenuation, distortions, delays and phase shifts. Constructive and destructive interference can occur at the receiver. When destructive interference occurs, the signal power can be significantly diminished. This phenomenon is called fading.

Types of fading

Frequency Selective fading: The transmitted signal reaching the receiver through multiple propagation paths, having a different relative delay and amplitude. This is called multipath propagation and causes different parts of the transmitted signal spectrum to be attenuated differently, which is known as frequency-selective fading. In this, the channel spectral response is not flat. It has dips or fades in the response due to reflections causing cancellation of certain frequencies at the receiver.

Frequency Non-Selective fading: If all the frequency components of the signal would roughly undergo the same degree of fading, the channel is then classified as frequency non-selective (also called flat fading).

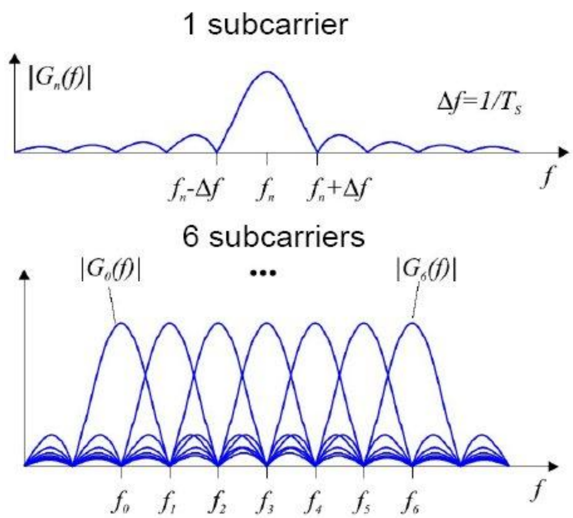

Fig 1: Frequency selective fading

Slow fading: Slow fading is a long-term fading effect changing the mean value of the received signal. Slow fading is usually associated with moving away from the transmitter and experiencing the expected reduction in signal strength. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver.

Fast fading: Fast fading is the short term component associated with multipath propagation. It is influenced by the speed of the mobile terminal and the transmission bandwidth of the signal.

Parameters of fading

Coherence Bandwidth: The coherence bandwidth of a wireless channel is the range of frequencies that are allowed to pass through the channel without distortion. Thus, it is the bandwidth over which the channel transfer function remains constant

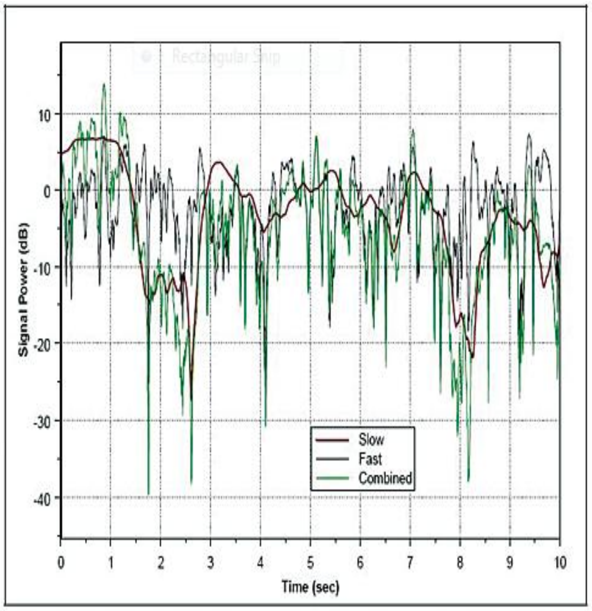

Fig 2: slow and fast fading

Coherence time: The coherence time is the time over which a propagating wave may be considered coherent means predictable. In long-distance transmission systems, the coherence time may be reduced by propagation factors such as dispersion, scattering, and diffraction.

Doppler spread: It gives the maximum range of the Doppler shift.

III. TYPES OF DIVERSITY

Space Diversity: The most common diversity scheme is space or spatial diversity. In this, no. of antennas is used to achieve different copies of the transmitted signal. Using two antennas with a distance between them the phase delay makes multi-path signals arriving at the antennas differ fading. Space diversity is nowadays in focus because of the higher frequencies used for transmission making it possible to apply this kind of diversity mechanics in smaller terminals.

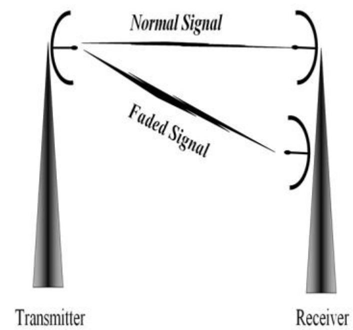

Fig 3: Space diversity scheme

Frequency Diversity: Frequency diversity utilizes transmission of the same signal at two different, spaced, frequency carriers achieving two independently fading versions of a signal. It is a costly mechanism to use because of the difficulties to generate several transmitted signals and the combining signals received at several different frequencies simultaneously.

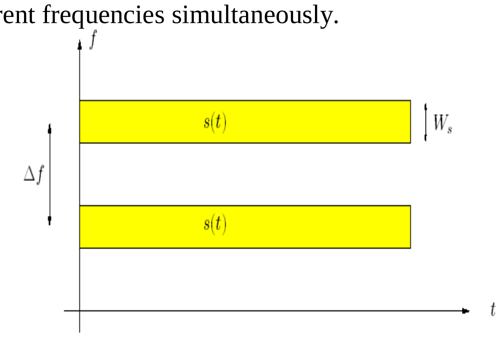

Fig 4: Frequency diversity scheme

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Angle Diversity: Signals arriving at the antennas are coming from different directions. Being independent in their fading variations these signals can be used for angle or angular diversity. At a mobile terminal angle diversity can be achieved using two Omni directional antennas acting as parasitic elements to each other changing their patterns to manage the reception of signals at different angles. As shown in fig., two orthogonal antennas are employed on a single base at different angles.

- Fig 5: Angle diversity scheme

Time Diversity: Time diversity is mostly applicable in the digital transmission. Time diversity is achieved by transmitting the same bit of information repetitively at short time intervals. A redundant forward error correction code is added and the message is spread in time by means of bit-interleaving before it is transmitted. Thus, error bursts are avoided, which simplifies the error correction. As shown in fig., same bit s(t) is transmitted after a time interval Δt.

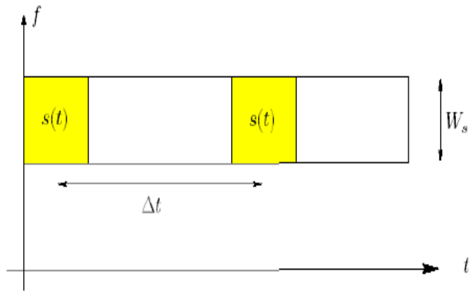

Fig 6: Time diversity scheme

Polarization Diversity: Multiple versions of a signal are transmitted and received via antennas with different polarization. A diversity combining technique is applied on the receiver side. This diversity mechanism is very practical because of the very small size of antennas that can be used. It is mostly combined with space diversity. As shown in fig., two antennas are employed with different polarization and then are connected to receiver through feeders and connectors.

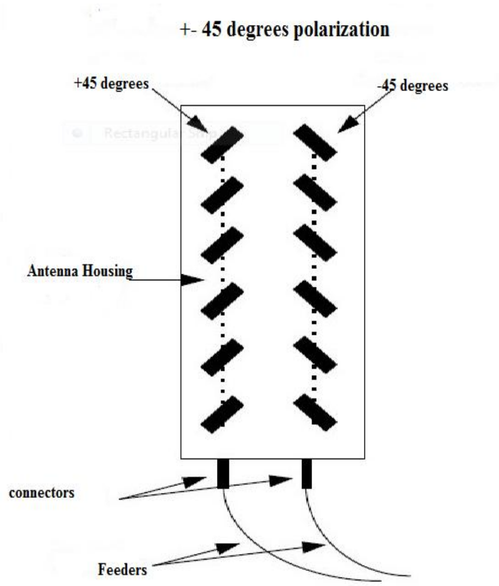

Fig 7: Polarization Diversity Scheme

IV. Diversity Processing Techniques

Switching: In a switching receiver, the signal from only one antenna is fed to the receiver for as long as the quality of that signal remains above some prescribed threshold. If and when the signal degrades, another antenna is switched in. Switching is the easiest and least power consuming of the antenna diversity processing techniques but periods of fading and de-synchronization may occur while the quality of one antenna degrades and another antenna link is established. The best example of switching technique is feedback diversity.

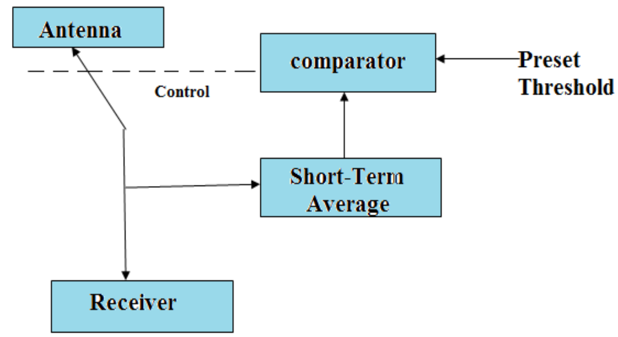

Fig 8: Feedback or Switching Diversity

Selecting: Selection processing presents only one antenna's signal to the receiver at any given time. The antenna chooses the best signal-to-noise ratio (SNR) among the received signals. The actual selection process can take place in between received packets of information. The diversity technique comes under selecting scheme is selection diversity. The selection diversity is shown in fig. 9, where signal having max SNR is taken by the receiver

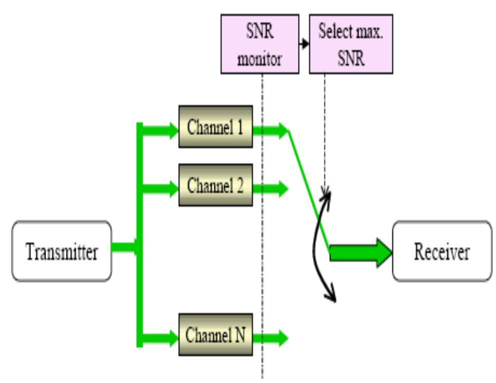

Fig 9: Selection Diversity

Combining: In combining, all antennas maintain established connections at all times. The signals are then combined and presented to the receiver. 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.

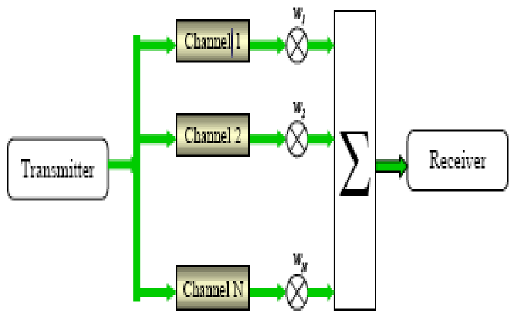

Fig 10: Maximal Ratio Combining

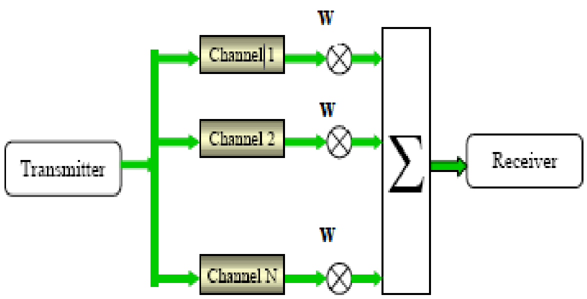

Fig 11: Equal Gain Combining

V. Conclusion

The diversity is used to provide the receiver with several replicas of the same signal. Diversity techniques are used to improve the performance of the radio channel without any increase in the transmitted power. Thus, various diversity combining techniques are used in order to reduce the impact of fading on the signal.

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