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Compensation of ISI Accomplished by CMA Eqalizer in WCDMA Communication System

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Abstract: Due to propagation delay differences from source to destination in various multipath traced by the signal, the pulse width of the received signal may increase from that of the transmitted signal. Propagation delay differences constitute dispersion which introduces Inter Symbol Interference (ISI).The errors induced by ISI results in reduced bit rate of the communication system. In order to enhance the overall system's performance, equalizers are introduced which aim for minimizing the ISI to allow recovery of transmit symbols. This paper deals with Constant Modulus Algorithm (CMA) Equalizer, the blind adaptive equalizer, to decrease the Bit Error Rate (BER) of the Wide Band Code Division Multiple Access (WCDMA) downlink system thereby improving the system's performance. Reduction in BER lessens the radiation effects that lead to several health hazards.

Keywords: Multipath propagation, ISI, Blind adaptive equalizer, CMA equalizer, WCDMA

I. INTRODUCTION

WCDMA which stands for Wide Band Code Division Multiple Access is developed under the frame work of IMT-2000(International mobile telecommunications) and ITU (International telecommunications union). The main objective of WCDMA is to serve higher data rates with increased capacity. It is one of the five radio interfaces of the 3G Wireless communications. WCDMA is officially known as IMT-2000 direct spread.

The specifications of WCDMA system are developed by the 3rd Generation Partnership Project (3GPP). Most of the applications considered for UMTS (Universal Mobile Telephone System) require a service where its traffic flow goes mainly in the downlink direction, so most of the work is focused on the downlink

II. WCDMA DOWNLINK SYSTEM

This paper emphasizes on WCDMA Frequency Division Duplex (FDD) downlink system where data is exchanged between eight transport channels. Each transport channel possesses a different transport format on how the data needs to be processed by physical layer before sending it to the channel.

A. WCDMA system

The WCDMA FDD downlink system (Fig.1) is comprised of an information source, encoder, mapper, base station transmitting antenna, channel, receiving antenna, demapper, decoder and destination.

The information needs to be transmitted longer distances with less distortion for the purpose of which it is converted into code symbols in the encoder section of the transmitter. The base station transmitting antenna further modulates this encoded data with a high frequency carrier in order to make the signal suitable for transmission over a desired channel and consequent reception.

Propagation of signal through the channel induces noise and interference due to channel imperfections resulting in distorted version of the original message signal.

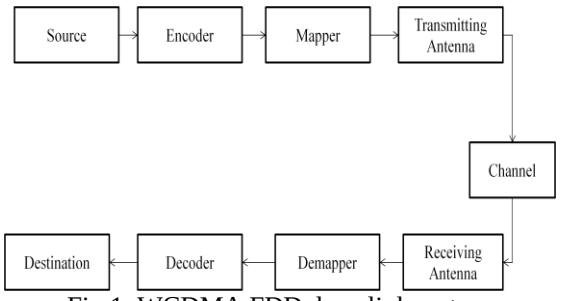

Fig 1: WCDMA FDD downlink system

The purpose of the receiver synchronized in carrier and time with the transmitter is to reconstruct the original signal from the modified version of the transmitted signal. WCDMA system makes use of a rake receiver associated with digital signal processing capability consisting of four rake fingers. Each rake finger is used for the reception of multipath components of the received signal independently which are later multiplexed before being fed to the decoder. The decoder performs the inverse function of the encoder.

This paper considers two different multipath profiles that differentiate the signals arriving through reflected paths from those traversing a direct path.

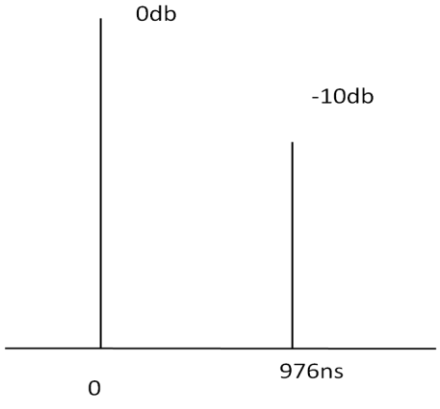

Fig 2: Multipath profile for case 1

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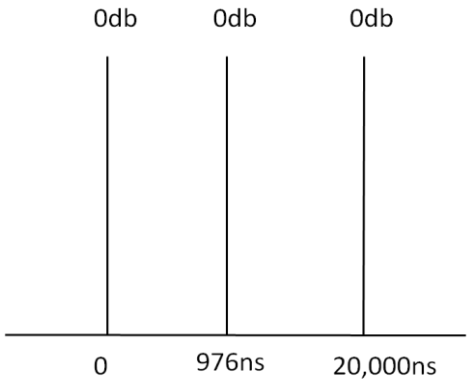

Fig 3: Multipath profile for case 2

The first fading profile (Fig.2) has a single reflected path which is delayed by 976ns from the direct path whereas the second fading profile (Fig.3) has two reflected paths delayed by 976ns and 20,000ns respectively.

B. Power Vs BER for two different data rates

First, simulation results are obtained for the actual WCDMA communication system. This is done by plotting power Vs BER for two different data rates, 12.2Kbps and 64Kbps.

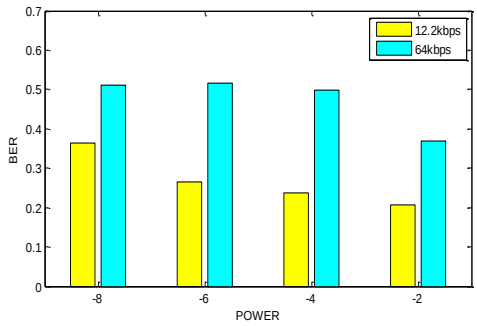

Fig.4: Simulation results between BER and power for actual WCDMA downlink system

From the above Fig.4 it is observed that, as power is increased from -8 to -2 decibels, BER decreases from 0.3648 to 0.2059 for 12.2kbps and it decreases from 0.5105 to 0.3695 for 64kbps respectively.

As a result, bit error rate increases for increased data rates. Now, in order to observe the improvement in the performance of the same WCDMA FDD downlink system, an equalizer is introduced in this communication system.

III. EQUALIZERS

An equalizer is a device that attempts to reverse the distortion incurred by a signal transmitted through a channel. The purpose of equalization is intended to envisage the ISI introduced by a transmission and modify the signal in accordance, so that the desired information is recovered at the receiver. As inter-symbol interference is high in the case of high speed digital data transmission over a wireless channel, the concept of equalization is introduced. Equalization technique improves the received signal quality and the radio link performance by minimizing the instantaneous bit error rate. Equalizers ought to be adaptive for implementation in time varying dispersive channels.

A. Adaptive Equalizers

The process of equalization is said to be adaptive in the sense, the behaviour of the equalizer varies automatically with the changing signal environment. Adaptive equalizers track the time varying characteristics of the channel and based on this information, they operate on the signal in two modes including training and tracking. The training sequence is typically a pseudo random binary signal of a fixed length being transmitted by the transmitter, for the equalizer at the receiver to adapt accordingly in such a manner to reduce the BER. As the user data is received, the adaptive algorithm of the equalizer tracks the changing channel on whose basis, the adaptive equalizer continuously varies the filter characteristics over time.

Equalizers are mainly classified into two types namely linear equalizer and non linear equalizer. These are categorized based on the feedback mechanisms involved in the functioning of the adaptive equalizers.

If no feedback path is used in the process of equalization, then the equalizer is said to be linear. Linear Equalizer makes use of the current and past values of the received signal and assigns linear weights to each of them which are later summed up to produce the output. An equalizer may be a linear filter or a complex algorithm. If there exists a feedback path in the equalizer to change the subsequent outputs, then it is referred to as non-linear.

The digital systems are more reliable than the analog systems in providing data, voice and video communications. The most unreliable channel is obviously a wireless channel. The inadequate channel affects the signal in amplitude, phase and time. These effects result in multiple versions of transmitted signal arriving at the receiving antenna, displaced with respect to one another in time and spatial orientation.

The random phase and amplitudes of the different multipath components cause fluctuations in the signal, thereby giving rise to small-scale fading, signal distortion, or sometimes both. Multipath propagation often lengthens the time taken by the baseband signal to reach the receiver causing signal smearing which is due to inter-symbol interference. Thus nullifying the inter-symbol interference enhances the system's performance.

Based on this, performance of WCDMA Communication system is studied with a CMA equalizer.

B. CMA Equalizer

In order to reduce ISI the more efficient and direct approach is to search for the best possible equalizer weight vector. This paper uses CMA equalizer to assign the weight vectors adaptively. CMA equalizer is a linear equalizer which uses Constant Modulus Algorithm (CMA). CMA forces the equalizer weights to maintain a constant envelope on the received signal.

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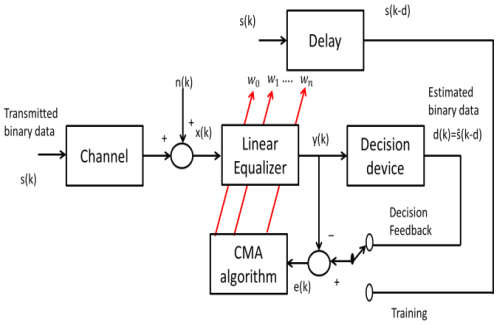

Fig.5: Basic linear equalization system

In the above Fig. 5 the transmitted binary data s(k) is added with noise n(k). The received signal x(k) which has undergone multipath propagation is multiplexed into y(k) whose error is calculated to be e(k) on comparison with the reference signal d(k). Using this error signal, the CMA algorithm assigns weights adaptively. The reference signal is typically a training sequence used to train the adaptive array or a desired signal based upon a prior knowledge of nature of arriving signals. CMA algorithm uses the equation, $w(k+1) = w(k) + u(1-(1/|y(k)|)) y^*(k). x(k)$ for assigning weights.

C. Simulation results with and without CMA equalizer

Now, the simulation results are obtained for the WCDMA Communication system with an embedded CMA equalizer. These results depict power Vs BER of the system with and without CMA equalizer, only a single data rate being considered (12.2kbps).

From the Fig.6 it is concluded that there is an improvement in the bit error rate of the WCDMA Communication system with CMA equalizer as compared to that of the actual model. That is, without equalizer as power increases from -12dB to -4dB BER decreases from 0.5307 to 0.5225 whereas with equalizer it decreases from 0.4713 to 0.4603.

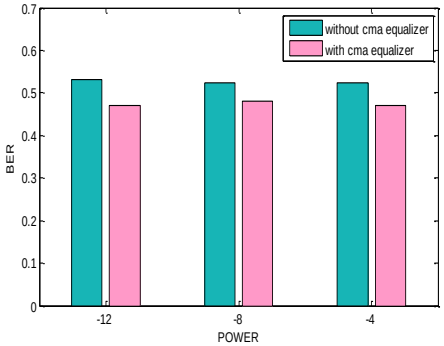

Fig.6: Simulation results showing BER Vs power of actual WCDMA system with and without CMA equalizer.

IV. CONCLUSION

Finally CMA equalizer minimizes ISI. These results in improved performance of WCDMA downlink Communication system. Pictorial representation of the system's performance in terms of BER is shown in the simulation results. This paper mainly concentrated on abating BER because as BER dwindles the radiation becomes less. The consequences of high radiation are skin redness and burning, DNA damage, vulnerability of thyroid hormone glands to cancer, Leukaemia and other immune system diseases. Apart from this, radiation has been a major cause for the extinction of a wide variety of bird species. Thus, improved BER proves itself to be one of the radiation protecting factors.

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