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Interference Mitigation by CDMA RAKE Receiver With Walsh-Hadamard Sequence

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Abstract- Currently, a global third generation cellular system based on CDMA is being developed with a wider bandwidth than existing second generation system. The RAKE Receiver instead of completely eliminating multipath uses techniques to effectively utilize multipath to produce the desired signal. This paper proposes interference mitigation by CDMA RAKE receiver with Walsh- Hadamard Sequence for DS-CDMA systems. In CDMA RAKE receiver multiple correlator are used to dispread the multipath signals and before making a bit decision alignment and combination of those signal are necessary. Proposing aim of the study are- 1)Design and Implementation of CDMA RAKE Receiver 2) Implementation of Walsh-Hadamard sequence 3) Receiver structure is that it requires multiple correlators and to achieve better Bit Error Ratio(BER).

Index Terms – Code Division Multiple Access (CDMA), RAKE Receiver, Interference Suppression, Walsh-Hadamard Sequence, Correlators, Maximum Ration Combining (MRC),

I. INTRODUCTION

Wireless Communication has made a huge leap since its first commercial service. In the wireless communication, transmitted signals arrive at the receiver via a direct, unobstructed path or via multiple paths from the reflection, diffraction and scattering of surrounding objects such as buildings and trees. This multipath propagation causes the signal at the receiver to distort and fade significantly leading to inter-symbol interference (ISI). A Conventional CDMA Receiver ignores the multipath component and concentrates on the direct line of sights components. As Customer Demand for wireless communication continues to grow. We got third generation (3G) cellular mobile communication systems are being capable to provide flexible voice and multi data service. In America the second generation system (2G) DS-CDMA standard IS-95 is being used as a basis for third generation system (3G) with wider bandwidth.

The purpose of this paper to design and implementation of CDMA RAKE Receiver over the conventional CDMA Receiver in wireless communication and to achieve a better Bit Error Ratio (BER). CDMA RAKE Receiver consists of many correlators that correlate to spread signals. The simple RAKE Receiver structure is used in which despread values produced by RAKE "finger" and then combined to generate a decision statistics. In order to mitigate the multipath fading a diversity receiver is used in the DS-CDMA systems. The RAKE receiver uses the maximum ratio combining and multiuser interference suppression to get a considerable increase in performance and analysis of DS-CDMA system. Multipath fading is one of the major practical concerns in wireless communications. The RAKE Receiver has been used to reduce the multipath fading in DS-CDMA system. In order to mitigate the multipath fading a diversity receiver is used in the DS-CDMA systems in which considerable gain is achieves by the combination of multipath signal with the different delays and that is known as RAKE "finger" Receiver. Finally we will see that in our proposing work CDMA RAKE Receiver is better performer over the Conventional CDMA Receiver and achieve better Bit Error Ratio (BER).

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II SYSTEM DESCRIPTION ALONG WITH CONVENTIONAL CDMA RECEIVER

In the previous time single user detection methods have been developed which model interference in a similar way after that proposed a CDMA receiver. In CDMA system many user transmit information simultaneously. In CDMA system each user has a unique code because of it is known as code division multiple access techniques. User sends many information in the form of images, data message, audio, video etc. The communication system as in fig.1

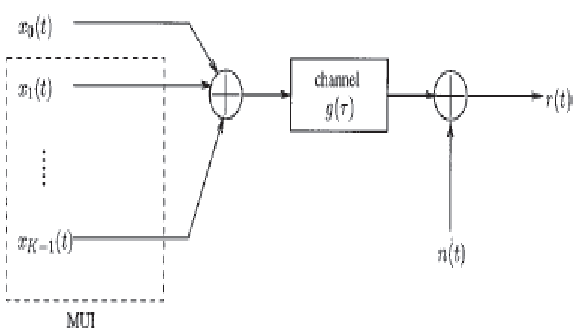


Fig no.1 System Model

In DS-Spread Spectrum, each user is assigned a unique Walsh code and transmitted data is multiplied by its corresponding spreading code. Modulated data through the spread code occupies more bandwidth than transmitted data.

One of the most important limitations in the field of digital communications is channel capacity. Cause of this, many methods has been designed to goal the usage of a channel in the most efficient way. For cellular mobile communications the most relevant method is multiple accesses techniques. This method allows us to transmit and receive information from different sources through the same channel. So, many users can communicate using the same channel. Some of the multiple access methods are Time-Division Multiple Access (TDMA), Frequency-Division Multiple Access (FDMA), and Code-Division Multiple Access (CDMA). There are two types of CDMA. The first is Frequency-Hopping (FH-CDMA), and the second is direct sequence (DS-CDMA).
Each user's data sequence is first modulated using QPSK modulation. Each user within a cell is assigned a unique code signal $c(t)$ called spreading or Walsh-Hadamard code, which is then used to spread the QPSK-modulated signal using direct sequence CDMA (DS-CDMA).

After mapping the Walsh-Hadamard code takes the form

$$c(t) = \sum_{k=0}^{N-1} c_k p(t-kT_C), \quad 0 \le t < T_b = NT_c \qquad (1)$$

With $c_k = +1,-1$ and p(t) is a rectangular pulse of duration T_c and unit amplitude

The transmitted signal of user k can be expressed as,

$$x_k(t) = \sqrt{E_K} \sum_{i=-\infty}^{\infty} s_K(i)\, a_{k,i}(t-IT) \quad (2)$$

Where E_k is the average symbol energy and T is symbol duration.

The spreading waveform for the k_{th} user,

$$a_{k,i}(t) = \frac{1}{\sqrt{N}} \sum_{j=0}^{N-1} c_{k,i}(j)\, p(t-jT_c) \quad (3)$$

The received signal can be obtained as,

$$r(t) = \sum_{l=0}^{L-1} gl x_0(t-T_l) + \sum_{k=1}^{K-1} \sum_{l=0}^{L-1} gl x_k(t-Tl) + n(t) \quad (4)$$

Transmitted signals propagated through a radio channel are affected by fading. Two major physical factors that influence the fading are multipath propagation and the Two major physical factors that influence the fading are multipath propagation and the a constantly changing environment that dissipates the signal energy in amplitude, phase, and time. The relative motion between the base station and the mobile results in a frequency modulation due to different Doppler shifts on each of the multipath components [Rap96].At the receiver front end, the additive white Gaussian noise (AWGN) is introduced by the thermal noise of the electric components of the receiver.

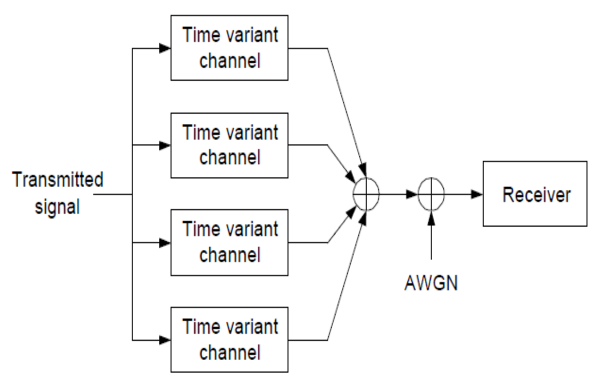


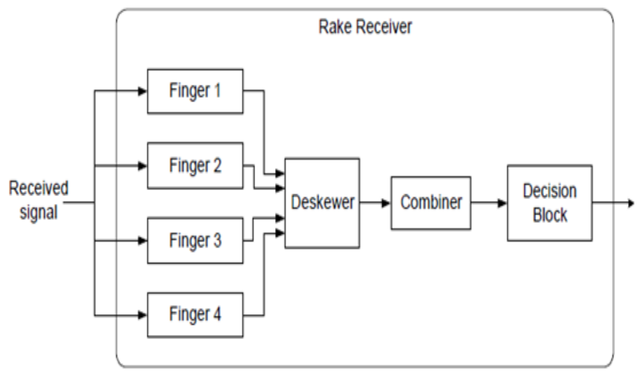
Fig no.2 Channel model for simulation

Figure no.2 shows the channel model with four multipaths, which is used for simulation of our rake receiver. The transmitted signal propagates through four different time variant channels and produces four multipaths. The rake receiver receives the multipath signals added with AWGN.

III. Proposed model

A. Receiver Structure

The receiver design should aim the recovery of data from a multipath environment. The most commonly adopted receiver architecture a multipath environment is a rake receiver shown in Figure3.



Conventional RAKE Receiver

A rake receiver has multiple fingers to resolve multipath component signals that have different path delays. A finger receives a signal containing all the multiple paths then processes one of the multipath component signals assigned to it. Each multipath has a different distortion, diffraction, scattering, reflection etc that is mainly caused by the Rayleigh fading, AWGN, and the frequency offset between the source and the destination site. Therefore, the received signal of a finger should undergo phase alignment and frequency offset alignment specific to the multipath as well as the despreading process. A power channel estimator measures the signal power of the multipath to determine if it is strong enough to be considerable. The deskewer compensates individual multipath delays. After these processes the multipathpath signals are combined to recover the desired data .Let $h_p(t)$ be the (physical) multipath channel impulse response. Channel models proposed by IEEE 802.15.3a Task Group [28, 52] are based on the famous multipath Saleh-Valenzuela model [58], in which the multipath components arrive at the receiver in clusters,

$$x_{i,n} = \int r(t)g(t - iT_{f-}\ \tau_n)\, dt \qquad (5)$$

The most well-known approach to deal with multipath wireless channels is to use RAKE receivers, as implemented successfully in the “traditional” wideband CDMA systems. Therefore, it is straightforward to apply this concept for channel estimation in IR-UWB. Basically, a RAKE receiver consists of multiple correlators (also called RAKE fingers). Each finger matches (correlates) the received pulse sequence (spread by the multipath channel) with a delayed version of a template pulse $g(t-\tau_n)$.The correlator’s output is an estimate of the amplitude a_n of the corresponding channel tap (from eq.5).

transmitted over a multipath channel then the received signal is,

$$r(t) = \sqrt{\epsilon}\sum_{i=0}^{\infty} s_{i/N_f}\, c_i h(t\text{-}It_F) + n(t) \qquad (6)$$

Where n(t) is additive noise , h(t) is the composite channel response $h(t)= h_p(t)*g(t)$.

$$h(t) = \sum_{n=0}^{\infty} a_n g(t\text{-}\ \tau_n) \qquad (7)$$

Matching the received signal with a template pulse, which is a delayed copy of the transmitted pulse *g*(*t*), the correlator’s output for a RAKE finger corresponding to the multipath component at τn delay in the *i*-th frame will be,

$$x_{i,n} = \int r(t)g(t - iT_{f-}\ \tau_n)\, dt \qquad (8)$$

$$= \int \sqrt{\epsilon}\, s_{i/N_f} c_i h(t - iT_f) g(t - iT_f - \tau_n)dt +\ n'_{in} \qquad (9)$$

$$h(t) = \sum_{n=0}^{\infty} a_n g(t\text{-}\ \tau_n) \qquad (10)$$

$$= \sqrt{\epsilon}\ s_{i/N_f} c_i a'_n + n'(t) \qquad (11)$$

The RAKE receiver is a matched filter (the received pulse is matched with a template that has the same waveform) and therefore (with known channel coefficients) optimum with respect to the BER performance, and it also benefits from the fact that many results in existing literature on RAKE receivers for wireless communication systems e.g. WCDMA can still apply. However, there are some serious practical issues in this kind of receiver.

B.Walsh-Hadmard sequence-

Basically for spreading data we used different types of sequence so we have P-N sequence and Walsh – Hadmard sequence but in this paper for spreading data and also for better orthogonally we used Walsh-Hadamard sequence so that sequence also called orthogonal code. For improving better efficiency we used orthogonal function or Walsh-Hadmard Orthogonal sequence. For generating Walsh-Hadmard sequence we have *NxN* square matrix. To get the desired length of Hadamard matrix can be generated by the following manner-

$$H_1 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$H_N = \begin{bmatrix} H & H \\ H & -H \end{bmatrix} \quad H_1 = \begin{bmatrix} H_{N/2} & H_{N/2} \\ H_{N/2} & -H_{N/2} \end{bmatrix}$$

Spreading sequence used for DS-CDMA system can be represented by JxK matrices $\mathbf{B_{JK}}$. Where **J** is the number of sequence and **K** is sequence code length. The code sequence is known as orthogonalSequence if, and only if matrix $\mathbf{B_{JK}}$ is orthogonal –

$$\mathbf{B_{JK}}\,\mathbf{B_{JK}}^{T} = k\,\mathbf{I_M} \quad (12)$$

Where k is the constant and B_{JK}^{T} is transposition of matrix B_{JK} of order N and I_N is the NxN unity matrix. In the DS-CDMA system the number of chips per data symbol is known as spreading factor (SF).

***C Maximal Ratio Combining* (Combining weight coefficient and finger delay)**

In the field of wireless communication we have much option to mitigate interference such as ISI, Equalizers and diversity. Diversity is techniques that will reduce amplitude fluctuation or fading mitigation. We have many type of diversity such as Antenna diversity, feedback diversity, Scanning diversity, Maximum ratio combining, Equal gain combining, etc. MRC is the optimist form of diversity combining cause of Maximum ratio combining all the integration result of code sequence by this we achieve better bit error ratio (BER) and maximum signal to noise ratio (SNR).

In Maximum ratio combining all integrated multipath components such as $x_1(t), x_2(t), x_3(t), \ldots\ldots\ldots. x_n(t)$ So whole of components are multiplied with complex conjugate weighted $\beta_1^*(t), \beta_2^*(t), \beta_3^*(t) \ldots\ldots \beta_n^*(t)$ of channel characteristics. Then

mathematical expression of the MRC can be written as-

$$x' = \sum_{k=1}^{M} \beta k * xk \quad (13)$$

IV PERFOMANCE ANALYSIS

The standard Gaussian approximation regarding fading is used with a signal to noise ratio analysis to derive the Bit error ratio for QPSK modulation and we have specific weighted vector ω then the signal to noise ratio at the output of the maximum ratio combiner can be easily shown a

$$\mathbf{SNR} = \omega^{K} gg^{k} \omega / \omega^{K} k\omega \quad (14)$$

Power spectral density of total noise after that Bit Error Ratio can be written as,

$$P_e(d) = ½\,\mathrm{erfc}(\mathrm{rootof}(\beta\ \mathrm{SNR}(C))) \quad (15)$$

V. RESULT AND DISCUSSION

QPSK modulation is a technique that will modulate the transnitted signal and used for the simulations or spread with the spreading code sequence. Impulse response channel measurement is also utilized in which multipath components are generated through Rayleigh fading channel characteristics. Channel noise is generated and added to the multipath components. So all the multipath components are added together for simulation at the receiver site. Integration process can take place after the multipath components is detected after that Maximum ratio combining can be used for storing the integration results here combining result of multipath components to send for the decision bit device after all data is decoded and probability of error is computed and simulation have run with the Walsh-Hadamard sequence. The purpose of this paper to design and implementation of CDMA RAKE Receiver over the conventional CDMA Receiver in wireless communication and to achieve a better Bit Error Ratio (BER). CDMA RAKE Receiver consists of many correlators that correlate to spread signals. Multipath fading is one of the major practical concerns in wireless communications.

Finally, We will see that signal to noise ratio(SNR) and bit error ratio (BER)graph comparison between CDMA receiver and CDMA RAKE receiver-

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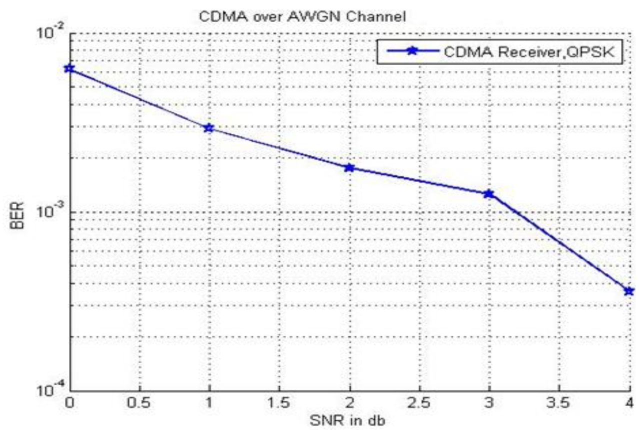
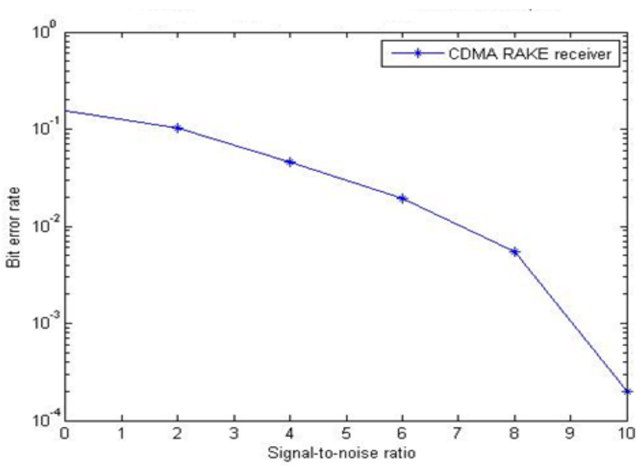
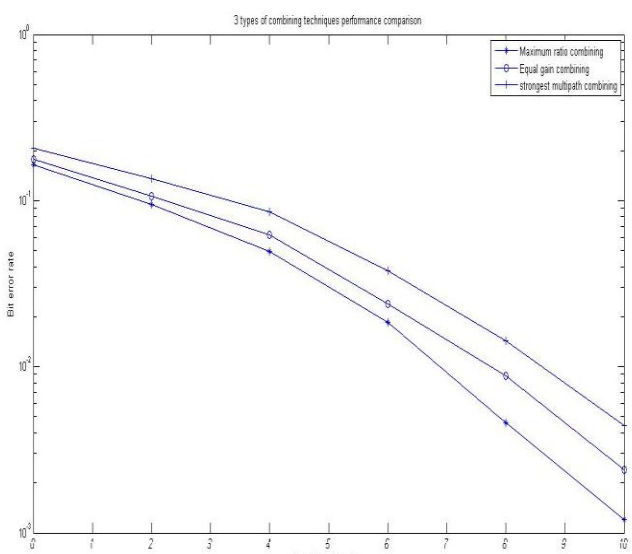


CDMA Receiver (plot SNR b/w BER)



CDMA RAKE Receiver (plot SNR b/w BER)



Comparison b/w different type of combining techniques (CDMA RAKE RECEIVER)

VI. CONCLUSION

Interference Mitigation by CDMA RAKE receiver with Walsh-Hadamard sequence as the spreading code has been introduced. We found that Conventional RAKE receiver gives the better performance in comparison with the conventional CDMA receiver in respect of system efficiency, SNR and BER preformance.In the proposed model each multipath component signal correlate with each other so that is big advantages cause of multiple code generators running continuously. So that proposed model with Walsh-Hadamard sequence gives an considerable result as compared to conventional CDMA receiver.

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