DESIGN AND IMPLEMENTATION OF WCDMA RAKE RECEIVER USED IN 3G WIRELESS COMMUNICATION

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ABSTRACT

In this paper, we describe the design and implementation of WCDMA Rake receiver using VHDL. 3G generation mobile communication is advanced and emerging technology in the field of wireless communication. Third generation Communication has advanced facilities like multimedia accessing, internet service and higher capacity of data rates [1]. The Rake receiver involves descrambling, dispreading, channel estimation and fading cancellation [2]. The main principle behind Rake receiver is that they exploit multipath propagation by receiving the multipath components of the transmitted signal separately and combining their energies. The Rake receiver is used to tackle the problems of time dispersion (echoes) caused by multipath propagation in mobile communication [3]. RAKE receiver consists of four fingers and all the energies of four fingers are combined in a single block. Which is time delayed version of original signal and combining is done in such a way to improve signal to noise ratio and reduces the multipath delay [1]. The above paper solves the above mention problems we have proposed architecture of WCDMA Rake receiver which is implemented in VHDL. The synthesis done by Xillling and simulation is done by modelSim6.3f.

Keyword: 3G, Fading Cancellation, Multipath Fading, Scrambling, Spreading, WCDMA.

I INTRODUCTION

The W-CDMA is a Wideband Direct Sequence Code Division Multiple Access (DS-CDMA) system. This system provides very high bit rate (up to 2 Mbps) the use of variable spreading factor and multicode connections are supported. User information bits are spread over wide bandwidth by multiplying the user data with quasi-random bits (called chips) derived from CDMA spreading code. The chip rate of 3.84 Mcps and each channel bandwidth is approximately 5 MHz [1]. Compared to GPRS (171.0kbits/sec) ,IS95B(115.2kbits/sec),CDMA2000(614.2kbits/sec) and EDGE (473.0kbits/sec), WCDMA supports high user data rates(2072.0Kbps) and also has certain performance benefits such as increased multipath diversity.[4] The WCDMA supports highly variable user data rates (called Bandwidth on Demand) [1]. WCDMA supports Frequency Division Duplex (FDD) and Time Division Duplex (TDD). In FDD mode separate 5 MHz carrier frequencies are used for uplink and downlink respectively. WCDMA employs coherent detection on uplink and downlink based on the use of pilot symbols or common pilot. The WCDMA air interface has been crafted in such a way that advanced CDMA receiver concepts, such as multiuser detection and smart adaptive antennas, can be deployed by the network operator as a system option to increase capacity and/or coverage. This facility is not provided in second generation communication system. [5]

Third Generation is advanced technology in the field of communication, supports multiple services like voice transmission, sending messages through email, fax, medium and high rate multimedia like internet access and file transfer respectively. This third generation uses the technology called Code Division Multiple Access (CDMA).CDMA is used because of higher capacity, improved performance in multipath diversity and capable of handling high peak data rates (2Mbps). WCDMA is the enhanced technology of CDMA. In WCDMA in which for fading cancellation RAKE receiver is used.

The main principle of RAKE receiver is that they exploit multipath propagation by receiving the multipath components of the transmitted signal separately and combining their energies [3]. The complete design, for this purpose, can be segmented into distinct stages or blocks based on their functionality. The incoming data is fed to different fingers after different delays. In each finger the data is descrambled and then despreaded through a matched filter. For descrambling, a Gold code generator also has been implemented, which can be initialized by external controls. For despreading the OVSF code sequence is taken as input to the chip. From matched filter outputs we separate the information and pilot symbols. The pilot symbols are used to estimate the channel. After the channel characteristics are estimated finally the outputs of all the fingers are combined together through a fading cancellation block. Rake receiver handles QPSK and processes the in-phase and quadrature components of the data. [4] The main objective of using a RAKE receiver is to combine the energies of all the multipath signals that reach the receiver within a reasonable time window. The RAKE receiver is used to tackle the problems of time dispersion (echoes) caused by multipath propagation in mobile communication [3].

II DESCRIPTION OF THE PROBLEM

A RAKE receiver is used to tackle the problems of time dispersion (echoes) caused by multipath propagation in mobile communications, where we most often don't have any line-of-sight between the transmitter and the receiver. Instead the signal reaches the receiver through a number of different paths, undergoing different and varying amounts of delay and attenuation [3]. This phenomenon is termed as fading and is observed as rapid fluctuations of the amplitude of a radio signal over a short period of time or travel distance. Fading is caused by interference between two or more versions of the transmitted signal, which arrive at the receiver at slightly different times. The physical factors influencing fading are [6]

- Multipath Propagation
- Speed of mobile
- Speed of surrounding objects
- The transmission bandwidth of the signal.

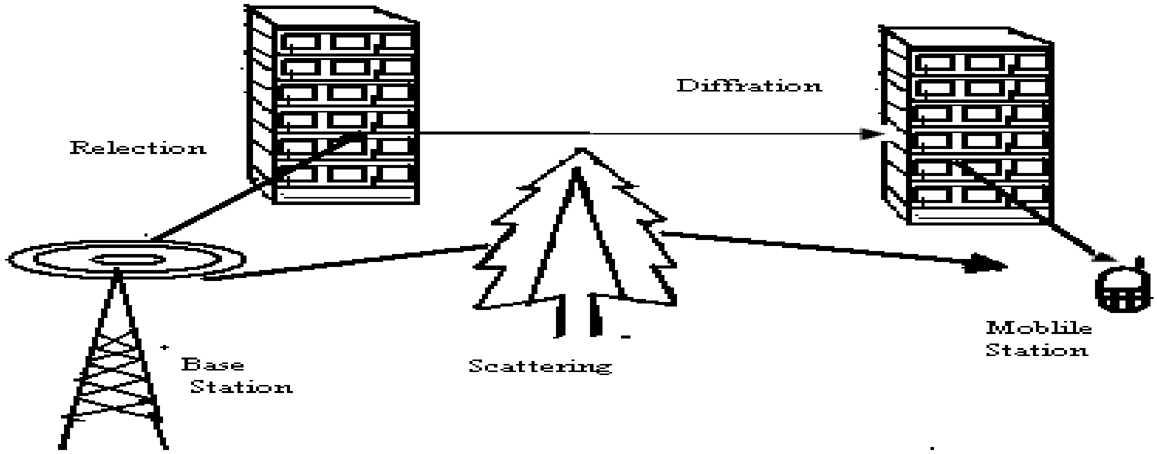

Fig. 1: Multipath propagation in mobile communications [3]

III PROPOSED SOLUTION

Overview of the Design, The main principle of Rake receivers is that they exploit multipath propagation by receiving the multipath components of the transmitted signal separately and combining their energies. The complete design, for this purpose, can be segmented into distinct stages or blocks based on their functionality. The incoming data is fed to different fingers after different delays.

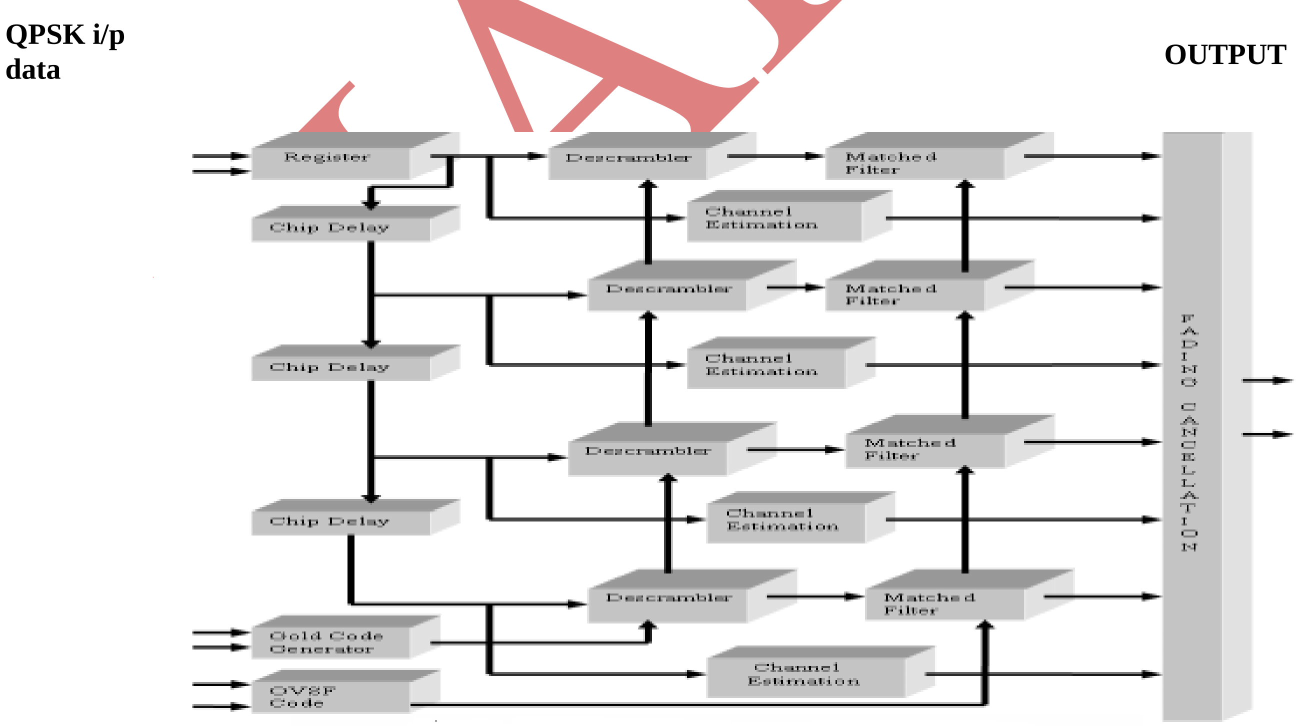

Fig. 2: Block diagram of rake receiver

In each finger the data is descrambled and then despreaded through a matched filter. For descrambling, a Gold code generator has also been implemented, which can be initialized by external controls. For despreading the OVSF code sequence is taken as an input to the chip. From matched filter outputs and channel estimation outputs, we separate the information and pilot symbols. The pilot symbols are used to estimate the channel. After the channel characteristics are estimated, finally, the outputs of all the fingers are combined together through a fading cancellation block. It should be noted that the design handles QPSK data and hence contains two parallel blocks, which interact with each other only in the 'Descrambler' & 'Fading Cancellation' blocks, to process the in-phase and quadrature components of the data. The backbone of RAKE receiver is shown in Fig. 2.

IV FUNCTIONAL BLOCKS DESCRIPTION

The above diagram shows the major functional blocks of the design. The functions of all these blocks are described here. Register block are designed using two flip-flops – 'toggle' and 'follow' and configure them to realize edge-triggered-reset registers. Register are designed on the basis of asynchronous reset with synchronous output. This reduces the delay time rather than asynchronous reset with asynchronous output. The chip delay is used to introduce one chip period. This is implemented using a register. [5] Descrambler multiplies the incoming QPSK data by a complex code sequence, which is the complex conjugate of a Gold code sequence at transmitter end. Gold code Generator block generates the Gold code whose complex conjugate is used as the 'Descrambling code' [10] . Matched Filter block performs the function of despreading the incoming data, by multiplying it by the same OVSF code that is used at the transmitter to spread the information symbols, and accumulating the result over each information symbol period. Channel estimation block finds the characteristics of the channel by processing the received values of the 'Pilot symbols' whose original sequence is known, in advance, at the receiver. The channel is estimated once every slot of data. Fading Cancellation block is used to neutralize the channel effects and combine the signal in each of the fingers so as to increase SNR. This is done by multiplying the outputs of each finger by the complex conjugates of the corresponding channel characteristics and then adding their results. So we have to perform four complex multiplications for each information symbol. However, for this purpose, we have used a single multiplier.

V IMPLEMENTED RESULT USING VHDL

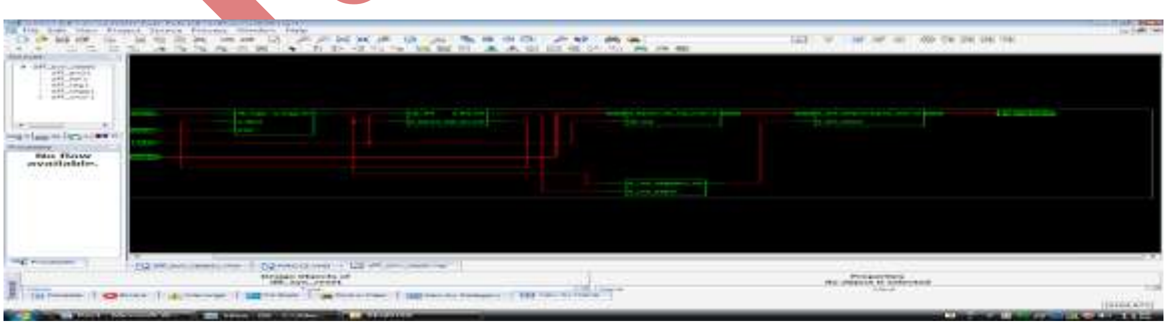

Fig. 3: Implementation of Register Block

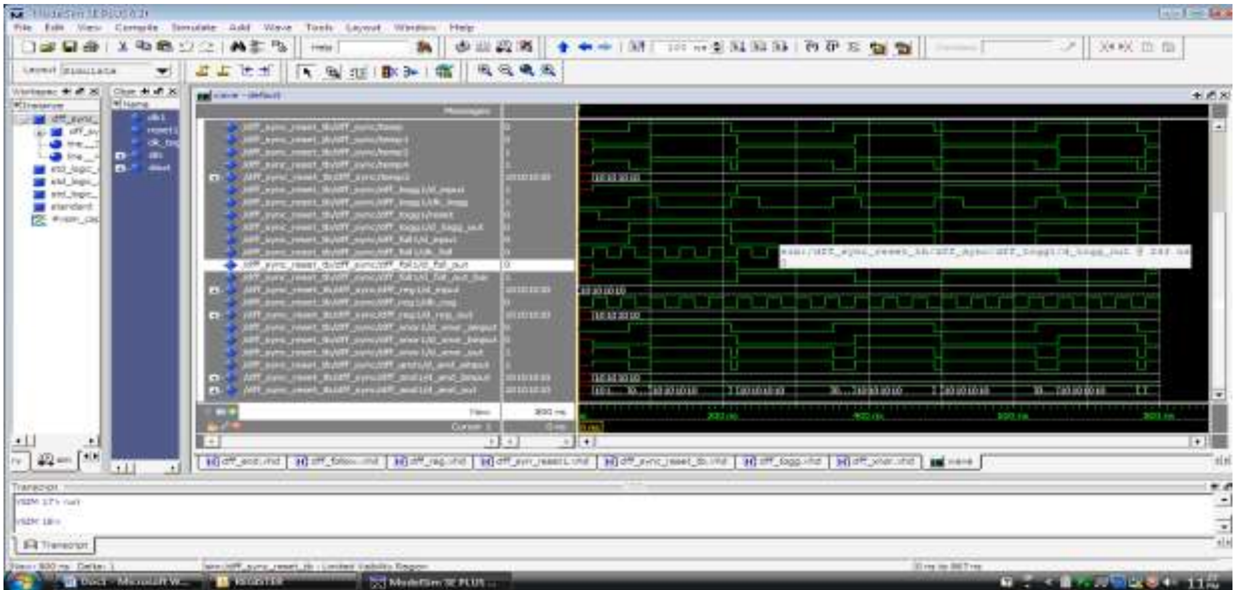

Fig. 4: Waveform results of register block

VI FUTURE ASPECT

Like the Rake receiver, it uses fingers and combining techniques to estimate a symbol. However, there are two important differences. Extra “interference” fingers are used to collect information about interference on the “signal” fingers. This interference might result from other symbols of interest (self-interference), symbols intended for other users in the cell (own-cell interference), or symbols intended for other users in other cells (other-cell interference). The extra fingers capture information about the interference. This is used to cancel interference on the “signal” fingers. To work well, the interference must pass-through a dispersive channel.

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