

Design and Analysis of DS-CDMA Transceiver using VHDL

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Abstract— Code Division Multiple Access (CDMA) uses spread spectrum technology where each user is assigned a code and allows multiple users to be multiplexed over the same physical channel. Whereas the time division multiple access (TDMA) divides access by time, while frequency-division multiple access (FDMA) divides it by frequency. CDMA is a form of "spread-spectrum" signaling, since the modulated coded signal has a much higher bandwidth than the data being communicated. Now, the Spread spectrum is used in the commercial applications such as, mobile handsets, internet, and satellite applications. By using Spread spectrum communication we can achieve the secure communication. In this paper the pure digital BPSK modulation technique is used to implement the CDMA Transceiver. The whole system is implemented only in the digital form, so cost is reduced. This design will makes whole system as a system on chip. All the modules functionality is verified with Modelsim simulation results. Xilinx ISE tools are used for FPGA synthesis. Spartan 3E development board is used for FPGA implementation.

Key words: Code Division Multiple Access (CDMA), Binary Phase Shift Key (BPSK), Direct Sequence Spread Spectrum (DSSS), FPGA, TDMA, FDMA

I. INTRODUCTION

Multiple access techniques represent one of the most efficient functions of access networks whether based on coaxial cable, fiber, radio, and satellite. For increasing the system capacity, use lower power systems with shorter radius and to use numerous transmitters/receivers. An area can be divided into cells, each one served by its own antenna. Each cell is allocated a band of frequencies and is served by a base station.

A. Advantages of Cellular networks

- Highly capacity
- Reduced power
- Good coverage

In a cellular system, each cell has a base transceiver. The transmission power is carefully controlled to allow communication within the cell using a given frequency band while limiting the power at that frequency that escapes the cell into adjacent cells. Nevertheless, it is not practical to attempt to use the same frequency band in two adjacent cells. Instead, the objective is to use the same frequency band in multiple cells at some distance from one another. This allows the same frequency band to be used for multiple simultaneous conversions in different cells. Within a given cell, multiple frequency bands are assigned, the number of bands depending on the traffic expected. CDMA uses spread spectrum technology where each user is assigned a code and allows multiple users to be multiplexed over the same physical channel. Whereas the time division multiple access

(TDMA) divides access by time, while frequency-division multiple access (FDMA) divides it by frequency. In spread spectrum communication, spectrum of message signal is intentionally ENLARGED by using the modulation. At the receiver the signal is subjected to DESPREAD the spectrum and the message signal is extracted upon demodulated. A wide band signal with very low amplitude spectra is used for SPREADING the spectrum of the message. Spread spectrum is a signal is considered it must be convert into digital signal before spread spectrum modulation.

II. PREPARATION TECHNICAL WORK

The following are the important stages of DS- CDMA system used for transmission and reception of I/O signals:

A. Spread Spectrum

Spread Spectrum signal seems noise-like signals. So Spread Spectrum signals are harder to detect. They are hard to Intercept or demodulate. Spread Spectrum communication is widely used in military applications, because it has Low Probability of Intercept (LPI) and anti-jam (AJ) features. Spread signals are intentionally made to be much wider band than the information they are carrying to make them more noise-like. The "Spreading" codes are called "Pseudo Random" or "Pseudo Noise" codes. They are called "Pseudo" because they are not real gaussian noise.

B. Direct Sequence Spread Spectrum

Binary data is base band signal. In this method a high frequency PN code is generated. Both PN code and data must be of same type i.e. either non-return to zero (NRZ) type or return to zero (RZ) type. If both are NRZ, n then they must be multiplied. if both are RZ, then we have to perform modulo-2 addition. This process causes the bandwidth expansion of message signal. Any one of the digital modulation techniques may be employed for signal transmission. At the receiver, the signal is subjected to despread the spectrum and demodulated to recover the base band information. The block diagram of DS-CDMA Transmitter is shown in the figure 1.

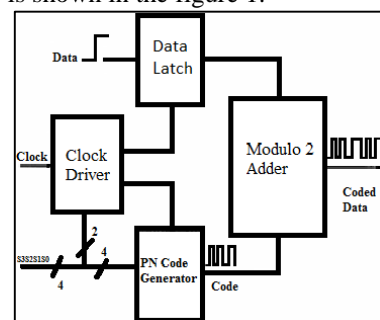


Fig. 1: DS-CDMA Transmitter [ref 2]

CDMA uses correlation property to receive the signals exactly. In hardware implementation the correlation

can be designed multiplier and accumulate (MAC). At the receiver, the same PN sequence which is used in the transmitter is correlated with incoming signal. The Block diagram of the DS-CDMA receiver is shown in figure 2.

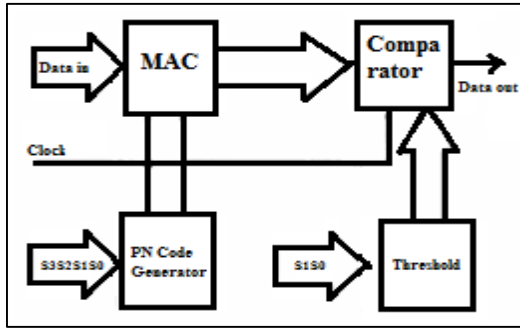


Fig. 2: DS-CDMA Receiver [ref 2]

The dot product of $a=(1,0,1,1)$ and $b=(1,-1,-1,0)$, can be written as a.b,

$(1)*(1)+(0)*(-1)+(1)*(0)=1+(-1)=0$ [ref 4] when the dot product of two vectors is identically 0, the two vectors are said to be orthogonal to each other.

For example, if $v=(1,-1)$, then the binary vector (1, 0, 1, 1) would correspond to (1,-1,-1, 1, -1, 1,-1). For the purposes of this article, we call this constructed vector the transmitted vector. The interference properties for two signals can be said that if the two signals are in phase, they will "add up" to give twice the amplitude of each signal, but if they are out of phase, they will "subtract" and give a signal that is the difference of the amplitudes. So, if consider two senders, both sending simultaneously, one with the chip code (1, -1) and data vector (1, 0, 1, 1), and another with the chip code (1, 1), and data vector (0,0,1,1), the raw signal received would be the sum of the transmission vectors (1,-1,-1,1,1,-1,-1,-1)+(-1,-1,-1,-1,1,1,1,1)=(0,-2,-2,0,2,0,2,0).

The first two components of the received vector that is, (0, -2). Now, (0, -2). (1, -1) = (0) (1) + (-2) (-1) = 2. Since this is positive, we can deduce that a one digit was sent. Taking the next two components, (-2, 0), (-2, 0).(1,-1)=(-2)(1)+(0)(-1)=-2. Since this is negative, we can deduce that a zero digit was sent. Continuing in this fashion, we can successfully decode what the transmitter with chip code (1, -1) was sending: (1, 0, 1, 1).

Apply same process for remaining bits with chip code (1, 1): (1, 1).(0,-2) = -2 gives digit 0, (1, 1).(-2,0)=(1)(-2)+(1)(0)=-2 gives digit 0, and so on, to give us the data vector sent by the transmitter with chip code (1, 1): (0, 0, 1, 1). The block diagram of the modified DS-CDMA transmitter shown in the figure 3.

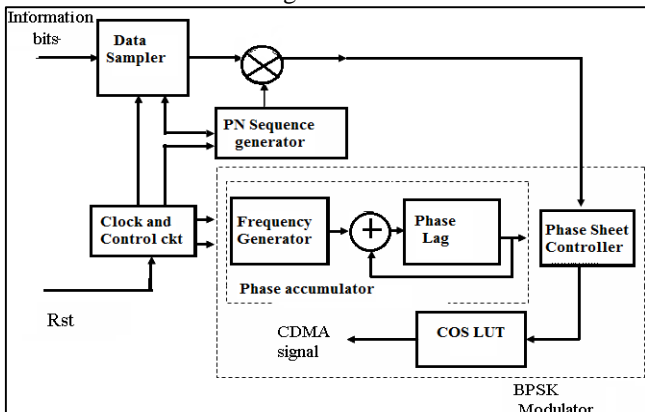


Fig. 3: Modified DS-CDMA Transmitter [ref 3]

The DS-CDMA Transmitter is implemented using pure digital architecture. The Direct Digital Frequency Synthesis (DDFS) technique with phase shifting provision is used for the signal generation.

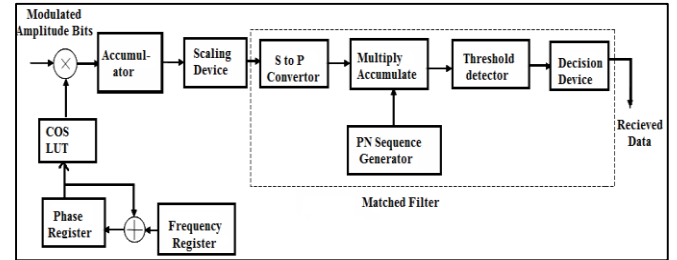


Fig. 4: Modified DS-CDMA Receiver [ref 3]

The figure 4 shows the block diagram of modified DS-CDMA Receiver. Digital coherent BPSK demodulator principle is used in this paper for receiving the DS-CDMA signals. The BPSK demodulator produce 15 (-7 to 7) digital words, unlike in conventional BPSK demodulator which produces only two symbols ('1' and '0'). This is necessary due to the low power spectral density of DS-CDMA signals and it is only possible to detect the information bits after correlation. The accumulator in the receiver corresponds to the integrator in the analog equivalent. The accumulator accumulates the outputs of multiplier for one symbol duration and outputs at the beginning of next symbol. The symbol timing recovery issues are not addressed in this paper, hence the symbol clock derived from clock distributor is used. The Scaling circuit scales input value to 4 bit signed number range, i.e., -7 to +7.

The PN sequence generator is same as the one which is discussed in transmitter, except in the output type. In the transmitter side the output of PN sequence generator continuously produces PN sequence on one bit output. But in the receiver side, since the complete PN sequence is required every time for correlating with the outputs of BPSK demodulator it is provided as a parallel vector. Another difference is the '1' of PN sequence is provided as +1 and '0' is provided as -1, which is the required form for correlator. Matched filter based correlator is used in this paper for receiving the DS-CDMA signals. The correlator accepts the demodulator outputs and multiplies with length PN sequence which is a sequence of +1 and -1. The outputs of multipliers are accumulated to produce the correlator output. The magnitude of the correlator output peaks whenever exact match occurs between the PN sequence and BPSK demodulator outputs. The output of the matched filter is given to the threshold detector, for detecting the information bits. The threshold detector compares the magnitude of the correlator output with the threshold value. If the magnitude of the correlator output is higher than the threshold value, then it rises a flag indicating that one bit is detected. If the sign of the correlator output is positive, then it will be interpreted as '1'. Otherwise it will be declared as '0'. This is the detected information bit.

S. No.	Component	Description
1.	Type of PN sequence	ML / gold code
2.	PN sequence length	64 in case of ML sequence, 128 in case of gold sequence
3.	Type of modulation	BPSK

