7

MODULATION SCHEMS & SPREADING CODES USED FOR SIMULATION

7.1 INTRODUCTION

In telecommunications, modulation is the process of varying a periodic waveform. The aim of digital modulation is to transfer a digital bit stream over an analog band pass channel. In digital modulation, an analog carrier signal is modulated by a digital bit stream of either equal length signals or varying length signals. This can be described as a form of analog-to-digital conversion. As is common to all digital communication systems, the design of both the modulator and demodulator must be done simultaneously. Digital modulation schemes are possible because the transmitter-receiver pair have prior knowledge of how data is encoded and represented in the communications system. In all digital communication systems, both the modulator at the transmitter and the demodulator at the receiver are structured so that they perform inverse operations.

Spread-spectrum techniques are methods by which energy generated at one or more discrete frequencies is deliberately spread or distributed in time or frequency domains. This is done for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference and jamming, and to prevent detection. For the conventional CDMA receiver, the design of the set of spreading sequences to be used in a CDMA system is very important as to its performance. The design is usually based on a set of criteria.

7.2 DIGIAL MODULATION BASICS

The bit rate defines the rate at which information is passed. The baud rate defines the number of symbols per second. Each symbol represents n bits, and has M signal states, where $M = 2^n$. This is called M-ary signaling. The maximum rate of information transfer through a base band channel is given by:

- Capacity $f_b = 2\ W \log_2 M$ bits per second
- Where W = bandwidth of modulating base band signal

7.3 MODULATION SCHEMES

Relevant schemes are,

(1) QPSK

(2) 16-QAM

(3) 64-QAM

7.3.1. QPSK

- A QPSK –modulated signal carries 1 bit on the in-phase and quadrature-phase components, the original data stream is split into two bit streams.
- Raised cosine filtering can be used to achieve excellent out of band suppression in QPSK signal.
- The spectral efficiency of QPSK is twice the efficiency of BPSK, since both in-phase and the quadrature-phase components are exploited for transmission of information.
- Figure 7.1 shows QPSK scheme. Here Wc = Carrier Frequency, I = In phase Channel and Q = Quadrature Channel.

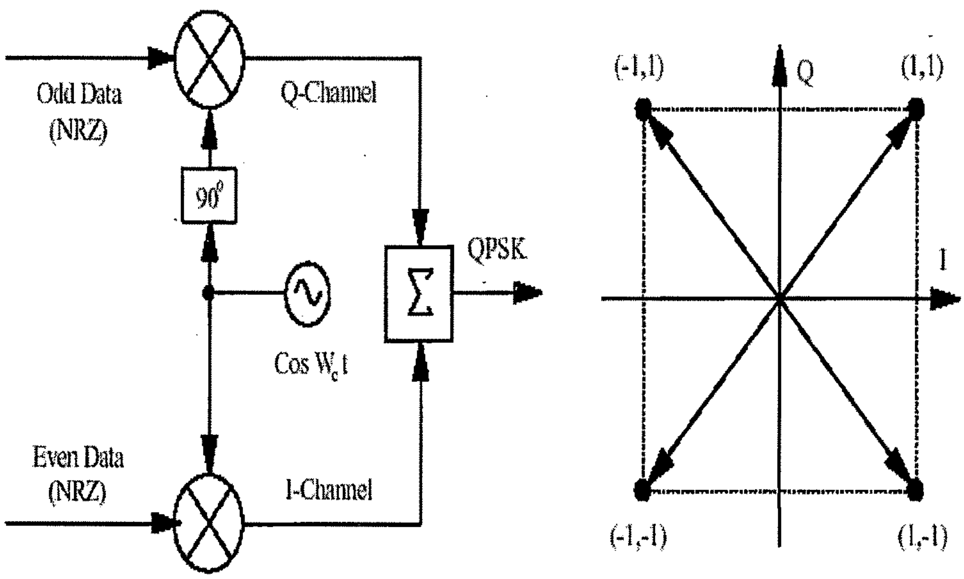

Figure 7.1: QPSK scheme

- Different types of QPSK are

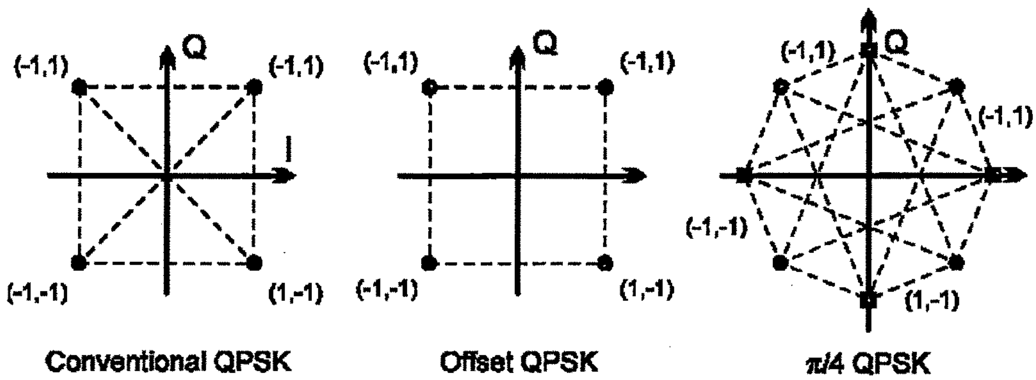

Figure 7.2: Different types of QPSK

- Conventional QPSK has transitions through zero (i.e. 180° phase transition). Highly linear amplifier required.
- In offset QPSK, the transitions on the I and Q channels are staggered. Phase transitions are therefore limited to 90°.
- In $\pi/4$ QPSK the ser of constellation points are toggled each symbol, so transitions through zero cannot occur. This scheme produces the lowest envelope variations.
- All QPSK schemes required linear power amplifiers.
- Nyquist bandwidth is the minimum bandwidth that can be used to represent a signal.
- It is important to limit the spectral occupancy of a signal, to improve bandwidth efficiency and remove adjacent channel interference.
- Root raised cosine filters allows an approximation to this minimum bandwidth.

7.3.2 16-QAM

- Amplitude and phase shift keying can be combined to transmit several bits per symbol, in the case of 16-QAM M = 16.
- These modulation schemes are often referred to as *linear*, as they require linear amplification.
- 16-QAM has the largest distance between points, but requires very liner linear amplification
- In figure 7.3shown is simple 16-QAM Signal Constellation

- In Figure 7.4shown is In-phase and Quadrature-phase signal in 16-QAM modulated signal
- Figure 7.5is 16-QAM modulated Signal.

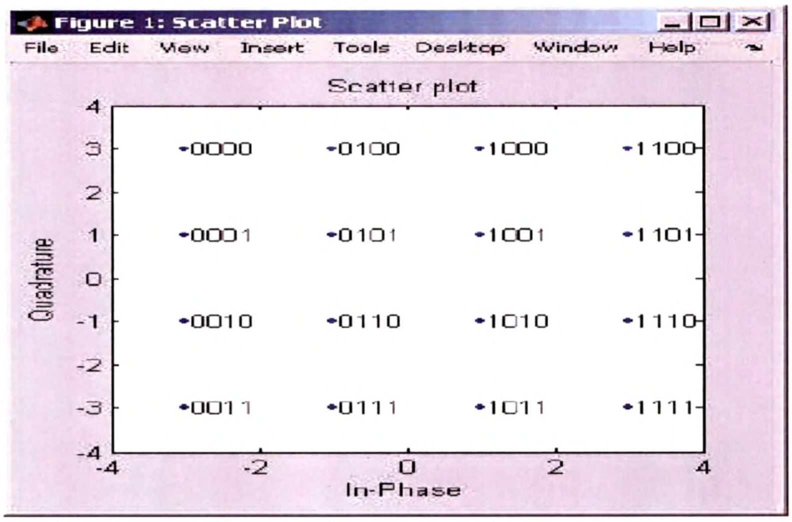

Figure 7.3 16-QAM Signal Constellation

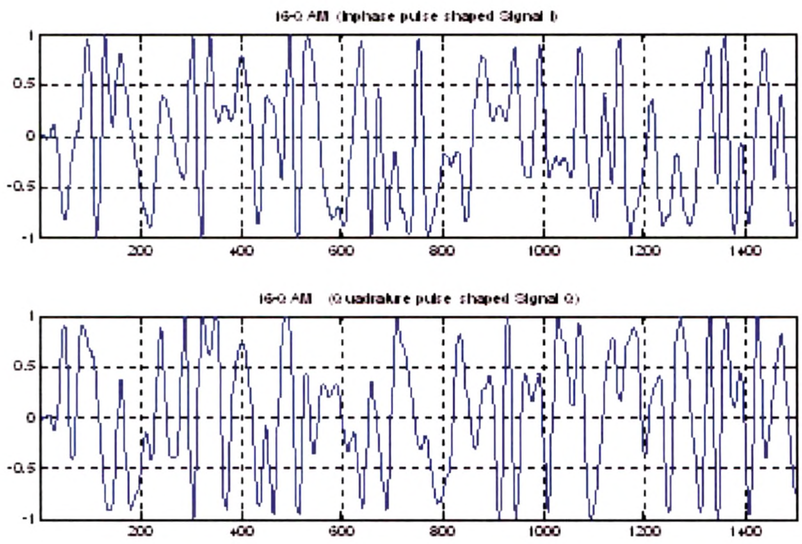

Figure 7.4 16-QAM In phase and Quadrature phase Signal

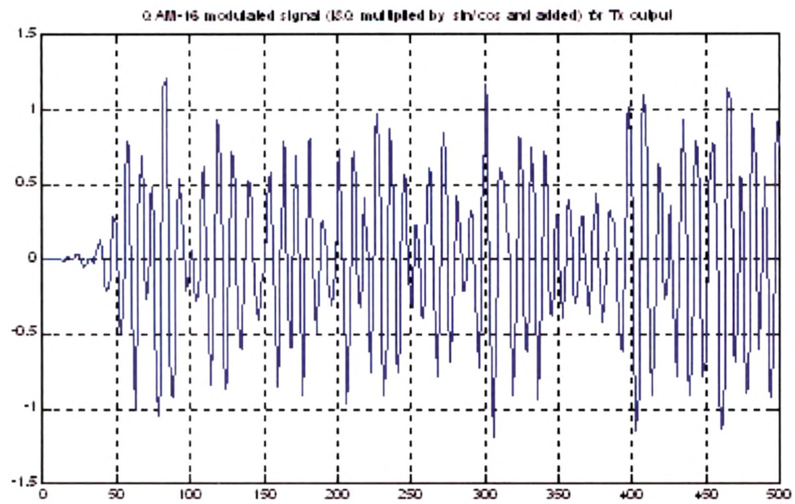

Figure 7.5 16-QAM Signal

7.3.3. 64-QAM

- Here M=64.
- In this scheme efficient bandwidth available, but more susceptible to noise and require linear amplification.

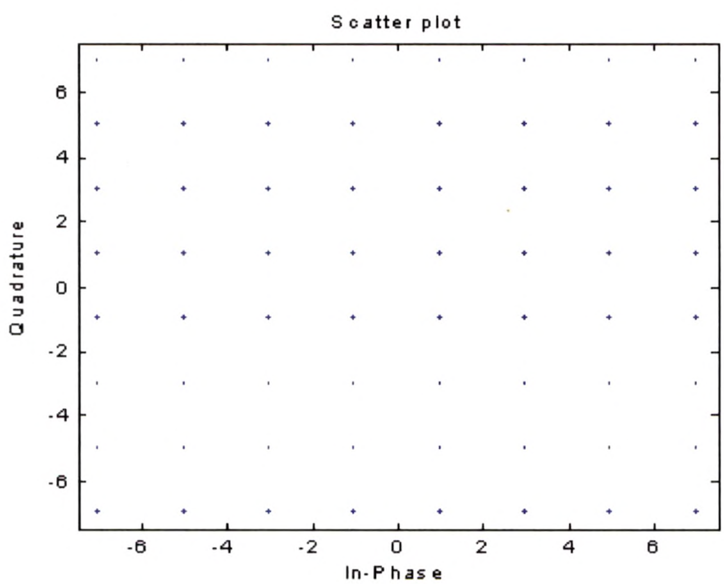

Figure 7.6 64-QAM Scheme

7.4 INTRODUCTION TO SPREADING SEQUENCES

A spread spectrum communication system spreads the original information signal using user-specific signature sequence. The receiver than correlates the synchronized replica of the signature sequence with the received signal, in order to recover original signal. DS-CDMA exploits the code's autocorrelation properties in order to optimally combine the multi-path signals of a particular signal. By contrast, the different user's codes exhibit a low cross-correlation, which can exploited for separating each user's signal. MC-CDMA also relies on this cross correlation property in supporting multi-user communication.

The three types commonly used codes are:

- Walsh Code
- PN Code
- Gold Code

7.4.1 Walsh Code

Walsh codes are generated by applying Hadamard transform to a one by one dimensional zero matrixes repeatedly. Hadamard transform is used to generate orthogonal codes. Orthogonal codes have zero cross-correlation.

Walsh codes are defined as a set of N codes, denoted Wj, for j = 0, 1, ..., N - 1, which have the following properties:

- Wj takes on the values +1 and -1.
- Wj[0] = 1 for all j.
- Wj has exactly j zero crossings, for j = 0, 1, ... , N - 1.
- $W_j W_k^T = \begin{cases} 0 (j \neq k) \\ N (j = k) \end{cases}$
- Each code Wj is either even or odd with respect to its midpoint.

7.4.2 PN Code

Various PN codes can be generated using Linear Feedback Shift Registers (LFSR).The so-called generator polynomial or LSFR connection governs all the characteristics of the generator.

One such PN generator is shown in figure-7.7-Figure-7.8 is the cross- correlation of PN sequence.

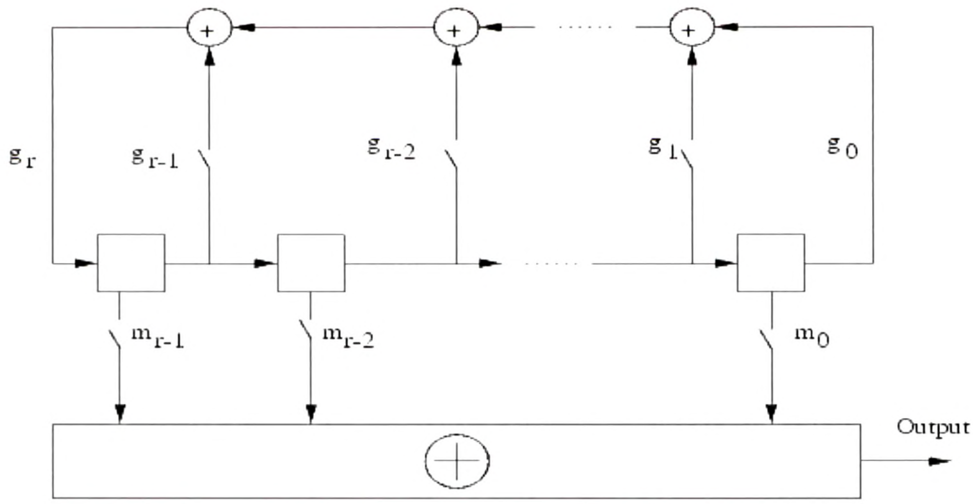

Figure 7.7 PN code Generator

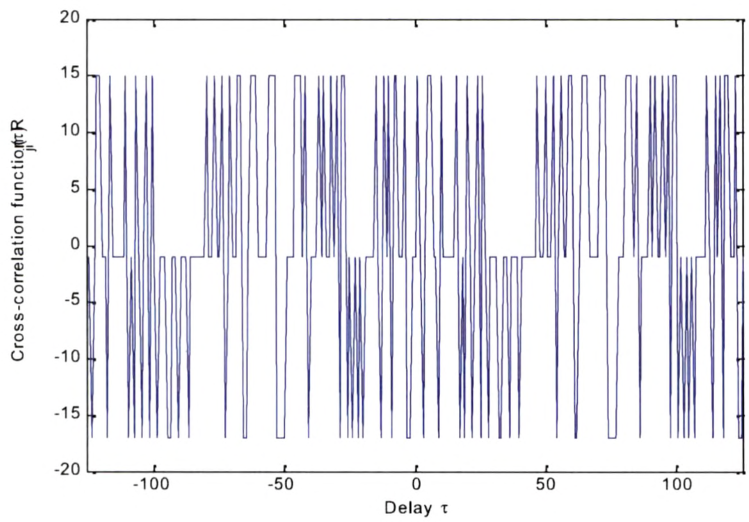

Figure 7.8 Cross correlation of PN sequence

Shift registers Sequence having maximum possible repetition period of $2^r - 1$ for an r-stage shift register are referred to as maximum length sequence or m-sequences. The m-length sequences have three different properties so-called balance property, the run length property as well as shift-and add property. The periodic autocorrelation function $R_a(k)$ of the sequence $\{a_n\}$ is defined as:

$$R_a(k) = 1/N \sum_{n=0}^{N-1} a_n a_{n+k}, \quad \text{Where N is the period of sequence.} \qquad (1)$$

7.4.3 Gold Code

Gold sequences exhibit lower peak cross-correlation, than m-sequence and hence they differentiate among different users more distinctively. Furthermore cross-correlation function of Gold codes exhibits numerous "-1" values, which is lowest value among the three possible cross-correlation values.

The Gold sequences are defined using a specified pair of sequences u and v, of period N = 2n - 1, called a preferred pair, as defined in the following section, Preferred Pairs of Sequences. The set G (u, v) of Gold sequences is defined by

$$G(u,v) = \{u, v, u \oplus v, u \oplus Tv, u \oplus T^2 v, \ldots\ldots, u \oplus T^{N-1} v\}$$

Where T represents the operator that shifts vectors cyclically to the left by one place, and represents addition modulo 2. Note that G (u, v) contains N + 2 sequences of period N.

Gold sequences have the property that the cross-correlation between any two, or between shifted versions of them, takes on one of three values: {-t (m), -1, or t (m) – 2}, where

$$t(m) = \begin{cases} 1 + 2^{\frac{m+1}{2}} \ldots\ldots\ldots\ldots m\ldots\ldots odd \\ 1 + 2^{\frac{m+2}{2}} \ldots\ldots\ldots\ldots nm\ldots. even \end{cases} \qquad (2)$$

The Gold Sequence Generator block uses two PN Sequence Generator blocks to generate the preferred pair of sequences, and then XORs these sequences to produce the output sequence, as shown in figure-7.9.

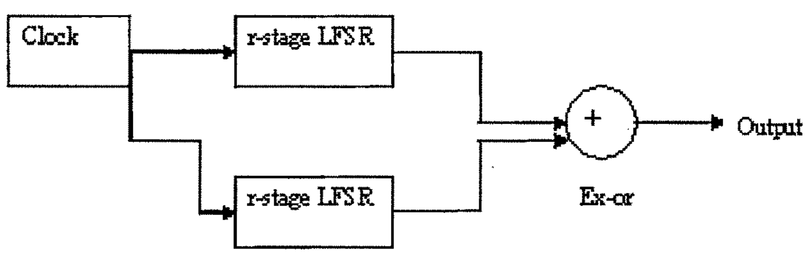

Figure 7.9: Schematic of a Gold Code generator

7.5 SUMMARY

In this chapter we discuss three different modulation techniques used in the simulation of project. We discuss about their properties, signal constellation, and their waveform .we also discuss about their advantages and disadvantages.

Next we discuss three different types of Spreading codes used in CDMA. We discuss their equation of generation, Block diagram, cross correlation and autocorrelation properties.