Design and Development of Code Acquisition Technique in CDMA system

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***Abstract-* This paper describes the novel algorithm for Code Acquisition in CDMA systems especially for GPS receiver applications. *In* cold start stage of GPS receiver, there is no prior information about visible GPS signals. The receiver needs to acquire all possible GPS satellite in the sky, and each has a specific Doppler shift and code phase. There are three signal acquisition approaches mainly: the serial search algorithm, circular correlation and the delay and-multiply approach. The main purpose of acquisition algorithm is to perform coarse synchronization. The acquisition algorithm output parameters (code phase and frequency) are carried to tracking loop for fine synchronization. In this paper, the serial search algorithm is implemented in time domain and this algorithm can be used in various GPS receiver applications.**

***Keywords*— GPS, CDMA, serial search, Doppler.**

I. Introduction

In digital communication systems, by using CDMA technique we can achieve secrecy and anti jamming. This also reduces the frequency usage. In CDMA, each user is distinguished by PN (Pseudo random Noise) code. The data/information is spread over the PN sequence thus CDMA is called Spread Spectrum technique. Since data hides in PN code, it helps in maintaining the secrecy. The spread data is modulated using Direct Sequence Spread Spectrum modulation technique. The conventional receiver block diagram is shown in Fig.1

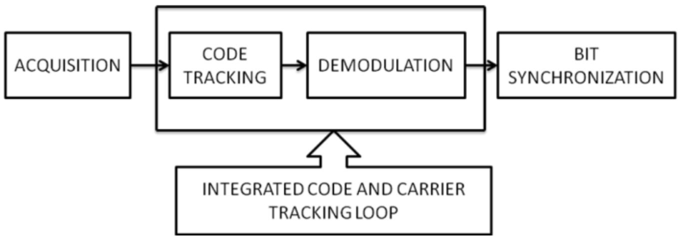

Fig.1 CDMA Receiver

Global Positioning System (GPS) has been extensive applications and wide prospects in the field of spacecraft, aviation, sea engineering, civil surveying and land navigation. In order to track and decode the information in GPS (Global Positioning System) signal, an acquisition method must be used to detect the presence of the signal. The purpose of acquisition is to determine visible satellites and coarse values of carrier frequency and code phase of the satellite signals. The satellites are differentiated by the 32 different PRN sequences. The second parameter, code phase, is the time alignment of the PRN code in the current block of data. It is necessary to know the code phase in order to generate a local PRN code that is perfectly aligned with the incoming code. Only when this is the case, the incoming code can be removed from the signal. PRN codes have high correlation only for zero lag. That is, the two signals must be perfectly aligned to remove the incoming code. The third parameter is the carrier frequency, which in case of down conversion corresponds to the IF(Intermediate Frequecy). The Line-of-sight velocity of the satellite (with respect to the receiver) causes a Doppler effect resulting in a higher or lower frequency. In the worst case, the frequency can deviate up to ±10KHz. It is important to know the frequency of the signal to be able to generate a local carrier signal. This signal is used to remove the incoming carrier from the signal.

Problem definition

To develop an Acquisition algorithm for CDMA receiver with following salient features:

- The algorithm must be able to perform acquisition on the input data in a continuous manner.

- Once the signals are found, algorithm should be able to measure the necessary parameters and immediately pass to the tracking hardware.
- Serial search acquisition algorithm is developed and implemented.

II. SERIAL SEARCH ACQUISITION

In an ordinary receiver, the acquisition is usually performed in an Application Specific Integrated Circuit (ASIC). In a software receiver it is implemented in software.

Serial search acquisition

This method is an often-used method for acquisition in code division multiple access system (CDMA). GPS is a CDMA system. Fig.2 is a block diagram of the serial search algorithm.

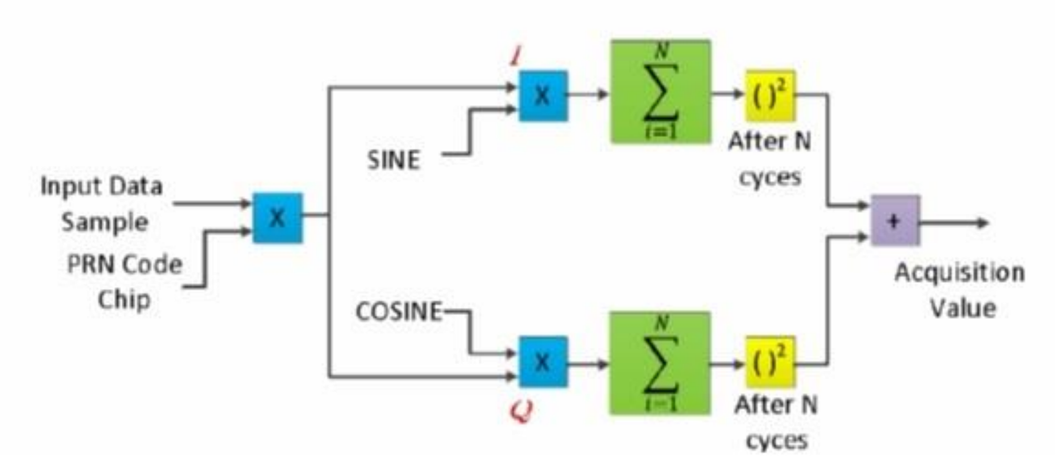

Fig. 2 serial search acquisition

The algorithm is based on multiplication of locally generated PRN code sequence and locally generated carrier signals. The PRN generator generates a PRN sequence corresponding to a specific satellite. The generated sequence has a certain code phase, from 0 to 1022 chips. The incoming signal is initially multiplied by this locally generated PRN sequence followed by multiplication by locally generated carrier signal. This multiplication results in the generation of in-phase signal I, and multiplication with a 900 phase-shifted of the locally generated carrier signal generates the quadrature signal Q.

The I and Q signals are integrated over 1 ms, corresponding to the length of one C/A code, and finally squared and added. The output is a value of correlation between the incoming signal and locally generated signal. If the predefined threshold is exceeded, the frequency and code phase parameters are correct, these parameters are passed on to the tracking algorithm.

PRN Sequence Generation

The first and foremost task in serial search acquisition id to multiply in the incoming signal with the locally generated PRN sequence. This of course involves the generation of this PRN sequence. Instead of generating PRN sequences every time the algorithm is executed, all possible PRN sequences are generated offline. The 32 different PRN sequences are generated by the PRN generator implemented according to the following figure.

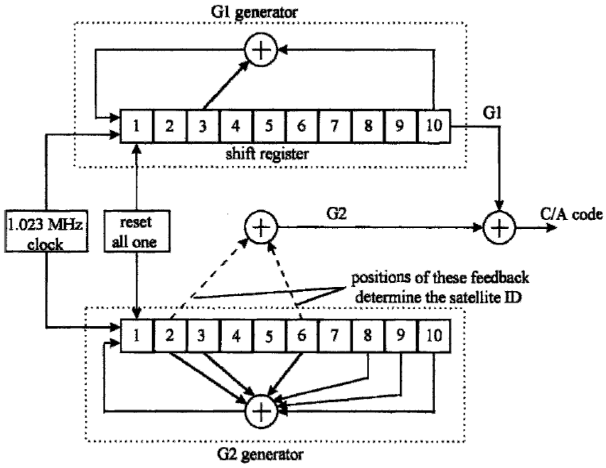

Fig. 2 C/A code generator

The code generator contains two shift registers, G1 and G2. The output from G2 depends on the phase selector. The different configuration of the phase selector makes the different C/A codes based on the specific satellite.

With 32 generator PRN sequences, all possible sequences originating from GPS satellites are created. However serial search acquisition involves multiplication with all possible shifted versions of the PRN codes. That is, besides saving the 32 possible PRN codes all possible shifted versions should also be saved.

Carrier Generation

The second step is multiplication with a locally generated carrier wave. The carrier generator must generate two carrier signals with a phase difference of 900, corresponding to a cosine and sine wave. The carrier must have a frequency corresponding to the IF ± Doppler frequency range. It must be sampled with the sampling frequency of 5 MHz and have a length of 1 ms. A complex signal is generated using the natural exponential function $e^{j2\pi f}$.

Integration and Squaring

The last part of serial search algorithm involves integration and squaring of the two results of the multiplications with the cosine and sine signals, respectively. The squaring is introduced to obtain the signal power. The integration is simply a summation of all points corresponding to the length of the processed data. The squaring is then performed on the result of summation. Finally add two values from I and Q arms. If the locally generated code is well aligned with the code in the incoming signal, and the frequency of the locally generated carrier matches the frequency of the incoming signal, the output will be significantly higher than if any of these criteria were not fulfilled.

III. RESULTS

Serial search method

In the MATLAB implementation for code period, N=1 and the number of sequential correlation to e accumulated, K=1, provides the fastest acquisition. However choosing larger values for N and K will improve the acquisition of week satellite signals and will also reduce the probability of false acquisition. One problem with choosing larger values for N is that is possible that a data signal transition can occur during the correlation process. The data transitions are synchronized to the code periods and can occur at maximum every 20^{th} code period. Choosing N>1 will not e sensitive to data it transitions, but expected value of the noise will not e zero since the noise is squared. This must be considered when the detection threshold is selected.

Usually when serial search is performed the code phase is incremented ½ chips when one code phase has been tested. The reason for choosing a ½ chip increment is obvious when examining the autocorrelation function of one typical C/A code. So there are 2*1023=2046 code phases that must be tested. The MATLAB implementation however, shifts the code phase by one sample between each dump. One sample corresponds to approximately 1/5 chip so here 5000 code phases are tested. 10000 samples of received data is correlated y sliding the replicated code over the 10000 samples.

Number of operations for one bin 1023 $\times$ (5000multiplctions + 5000addtions)

Since there are 21 Doppler bins, this sums up to a total of: 21$\times$1023$\times$ (5000multiplctions + 5000addtions)

Complicating things, the Doppler effects on the carrier must be taken into account. For a stationary receiver it is common to assume a ±10KHz Doppler offset on the carrier. The acquisition process for each code period is stepped in the Doppler range in 500Hz frequency increments. Choosing 500Hz steps is a compromise in accuracy and speed. If the step was 1 KHz there would be less frequency bins to test, but with the possibility that the residual carrier of the I and Q components can cancel out the correlation, since 1KHz corresponds to the code period of 1 ms.

The MATLAB implementation utilizes an exhaustive search, that is, all possible combinations of code phases and Doppler offsets are tested. Fig. 4 shows the integrator output after the PN sequence is perfectly matched. Fig. 5 shows the output of sample and hold circuit, in which the peak value is sustained for every sampling instant. Fig. 6 shows the acquisition lock indicator which remains constant after the acquisition

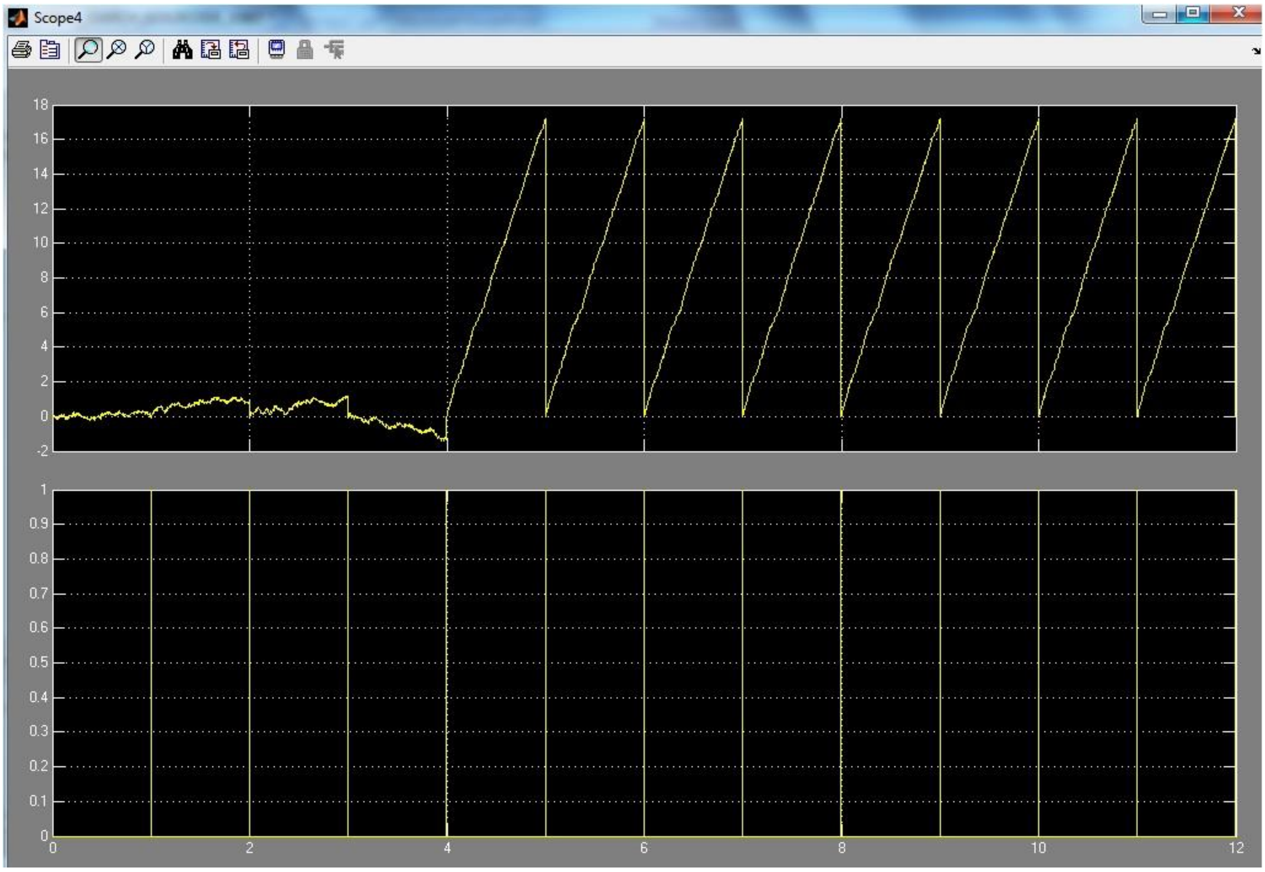

Fig. 3 integrator output

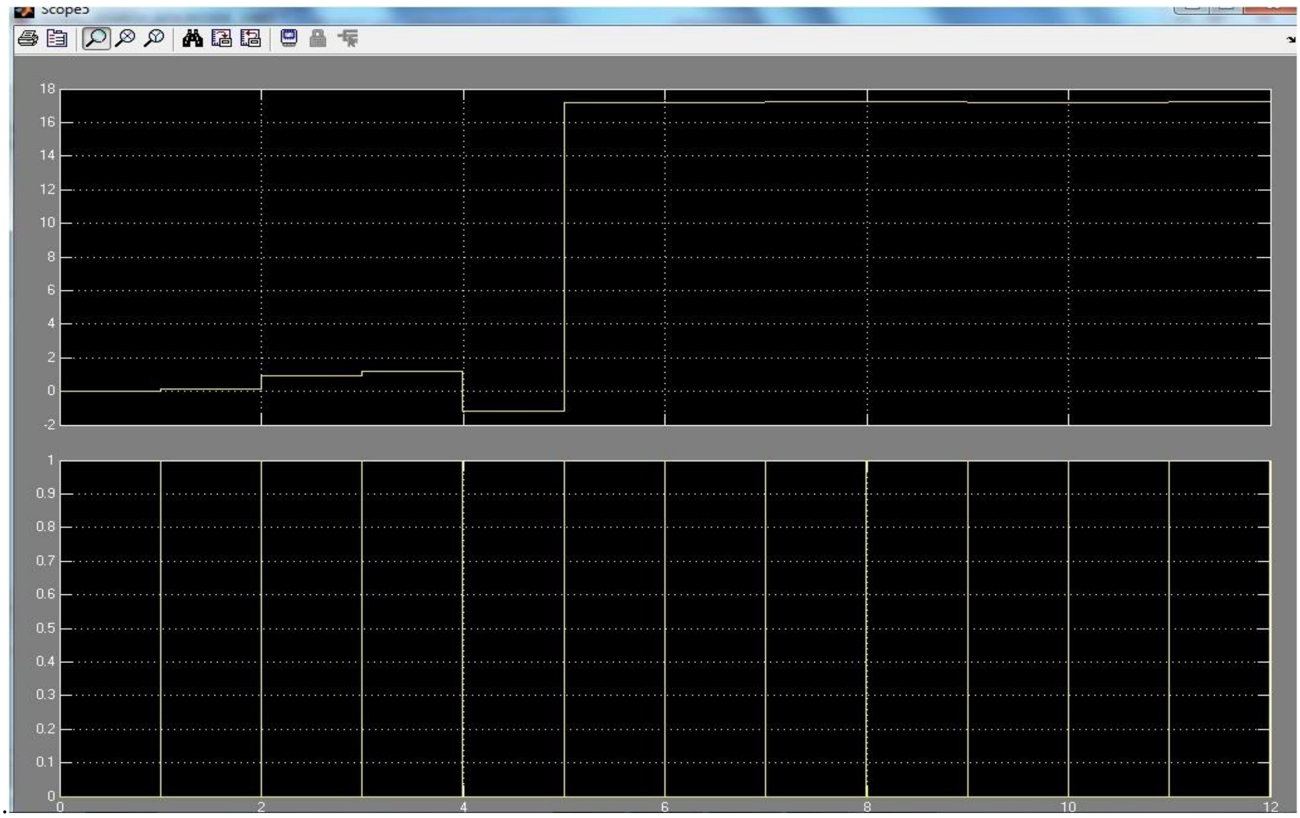

Fig. 4 sample and hold output

Fig. 6 acquisition lock indicator

IV. Conclusions

In this paper, serial search algorithm is implemented for GPS receivers. Serial search acquisition algorithm searches for a satellite sequentially at each possible code delay and Doppler shift in time domain. Only addition and multiplication operations are needed, it is easy to implement in time domain in real time. The proposed algorithm is demonstrated through extensive simulations. The proposed algorithm is planning to implement on-board GPS receivers.

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