

A study on PRN Code Generation and Properties of C/A Code in GPS Based on MATLAB

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Abstract - The Global Navigation Satellite System (GNSS) plays a great deal for Civilians in many applications like positioning and navigation applications. Global Positioning System (GPS) provides an increasingly widespread application and GPS signal consists of Pseudo-Random code (PRN) codes (C/A for civil and P-code for military) satellite. The main part of GPS is PRN sequences which are the unique one required for an identity for any satellite. GPS receivers are implemented either in hardware or software. The motto is to examine the performance of GPS receivers easily in various environments. This paper deals with a study on the generation of C/A code and properties of the PRN codes. Hence as an initiation to greater attention this paper additionally exhibits the analysis of correlation properties for PRN sequences. The simulation of PRN code is done by Matlab and the result outcomes are compared within real C/A code.

Key Words: GNSS, GPS, Correlation, Matlab, C/A code generation.

1. INTRODUCTION

Global Positioning System, originally NAVSTAR is the world's most utilized satellite Navigation system and initially consists of up to 24 (current 32) satellites in 6 orbital planes. This system is owned by the US Department of Defense and operated by the US government and users can access freely with a GPS receiver. The GPS satellites transmit two low power radio signals designated as link 1 (L1) and link 2 (L2). The frequency of L1 is at 1575.42 MHz and L2 is at 1227.6 MHz. These two frequencies are coherent with 10.23 MHz clock. In general, GPS satellites transmit signals to receiver unit contains 3 different bits of information. In this, Pseudorandom noise (PRN) codes are an important element of code division multiple access (CDMA) based satellite navigation systems. It allows any receiver to identify which satellite it is receiving. PRN code seems to be random and it is generated by a known algorithm using shift registers. For each satellite, PRN codes are derived by selecting different pairs of cells from each register to define register output. Therefore each satellite has a unique PRN code.

As we know that conventional receivers are fixed platform and performance evaluation is slow. From the literature review it is clear that, in recent years, there is an increasing interest in developing software-defined receivers. In GPS receivers, the first signal processing stage is the acquisition which is used to find which satellites are available for the receiver and used to find the C/A code phase of each satellite. Therefore, identification of the PRN code is the most important process in the GPS receiver system. In order to find the visible satellite, C/A code generation is essential. This paper illustrates the generation of C/A code and it is verified with the standard C/A code of the satellite to identify the particular satellite number. This paper concludes the generation of properties of C/A code on Matlab.

2. GPS SIGNAL STRUCTURE

1.1. Generation of PRN sequences

The pseudorandom sequence (PRN) is a progression of 1s and 0s. In this, the value of each chip of sequences is based on mathematical and it a closed form algorithm. The well known PRN sequences are Gold codes and Kasami codes. Gold codes and Kasami codes are based on linear feedback shift registers (LFSR) and it can be set up for any length $N=2^n-1$, for integer values n that respect $\text{mod}(n, 4) \neq 0$. A simpler and faster Gold code is used because it is efficiently initialized to any desired code, with minimum delay.

1.2. Ranging code

GPS ranging code is called C/A (Coarse Acquisition) code and P(Y) code. The GPS C/A signals belong to the family Pseudo Random Noise code also known as Gold code which is formed by an optimized combination of m sequence pairs. The gold code is a code sequence which is formed by two m sequence's bit-by-bit mode 2 addition, the two m sequences are the same length and the maximum correlation between the two great series is the smallest. This code maintains not only good autocorrelation of m sequence but also has a good cross-correlation. So the Gold code is widely used in multiple access communications and

it is a sequence of 1023 chips. This code is repeated each one millisecond giving a chipping rate of about 1.023 MHz. Fig.1 shows the GPS modulation scheme. Only the C/A code is modulated into L1-1575.42 MHz and L2-1227.60 MHz carrier.

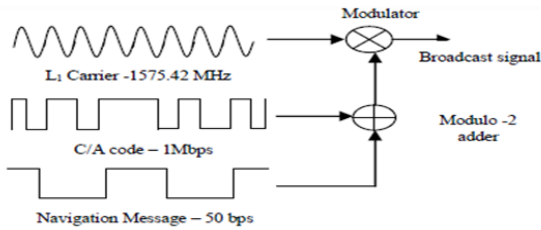


Fig.1 GPS Signal Modulation

3. GENERATION OF C/A CODE

3.1. The principle of Generating C/A code

Many modern GPS receivers have 8, 12, or 16 channels in parallel for to facilitate a faster search process. As we know that GPS system contains 32 codes. Each code is generated using a combination of two tapped linear feedback shift register (LFSR) G1 and G2. Each LSFR generates a maximum length PRN sequence of “ $N=2^n - 1$ ” elements, where $n=10$ in the GPS system, is the number of the LSFR stages as illustrated in fig 2. Each generator has its own linear feedback shift register (LFSR) and proper feedback, to generate a random sequence. Fig 2 shows the maximum length sequences of shift register G1 and G2. The MSB of G1 is considered as the G1 output, maximum length sequence (MLS), whereas the G2 output is taken from the phase selected bits of G2 LFSR, which is mentioned as the code phase selections through another modulo-2 adder. This G2 register output is a delayed version of the MLS output. The delay time is calculated by the positions of the two output points selected. Therefore, C / A code is generated by G1 modulo-2 add G2, which are generated by two 10 levels of the shift registers. The characteristic polynomial of G1 and G2 as follow

$$(G1) (x) = 1+x^3+x^{10} \quad (1) \quad \text{meaning that state 3 and 10 are feedback to the input.}$$

$$(G2) (x) = 1+x^2+x^3+x^6+x^8+x^9+x^{10} \quad (2)$$

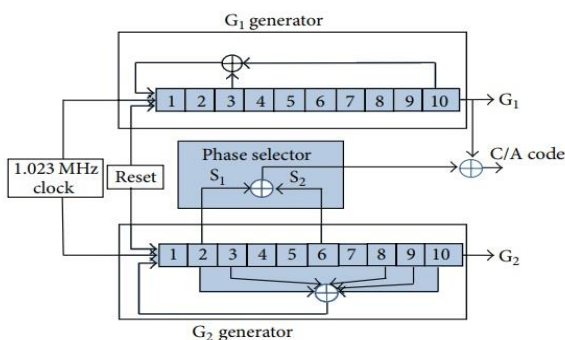


Fig.2 LFSRs Based Gold Codes (C/A) Generator

To make distinct codes for the satellites, the outputs of the two shift registers are combined in a very special manner. G1 register always supplies its output, but G2 supplies two of its states to a modulo-2 adder to generate its output. The selection of states for the modulo-2 adder is called the code phase selection. The operating rule of the modulo-2 adder is when the two inputs are the same the output is zero. Modulo-2 adder operation is shown in table 1. For example, if we choose satellite 6, which PRN is also 6, then one will tap output 2 and 10 as output in the G2 register and add it to G1 (output is always 10).

Table 1 Modulo-2 Addition

INPUT1	INPUT2	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	0

4. PROPERTIES OF C/A CODE

The important property of C/A code is their correlation result. The aim in computing the correlation is to measure which two signals are similar. The correlation process is often implemented in the receiver is used to find PRN code changing for each satellite. There are two important kinds of correlation. One is autocorrelation and the other one is cross-correlation.

4.1 Cross-Correlation Property

It is used to measure the similarity between two different signals and it is mathematically expressed in

$$\rho(\tau) = \frac{1}{T} \int_0^T x_1(t) x_2(t - \tau) dt \quad (3)$$

Where τ = is the delay time that $x_2(t)$ relates to $x_1(t)$. When $x_1(t) \neq x_2(t)$, $\rho(\tau)$ is the cross-correlation function.

4.2 Autocorrelation property

In the same way, autocorrelation is used to measure the relationship within the signal itself. This function is mathematically expressed in

$$\rho(\tau) = \frac{1}{T} \int_0^T x_1(t)x_2(t-\tau)dt \quad (4)$$

When $x_1(t) = x_2(t)$, $\rho(\tau)$ is the auto-correlation function.

5. SIMULATION RESULTS BASED ON MATLAB

5.1 C/A Code Generation

The C/A code uses two 10 bit shift registers named G1 and G2. The modulo-2 addition is performed between third and tenth-bit positions of register G1. The resulting output is fed to the first bit of G1 for shifting the purpose of all bits in G1. Likewise, in G2 modulo-2 addition is done between 2,3,6,8,9,10 bits and its output is fed to first positions of G2. C/A code phase assignment table is given in to identify the satellite C/A code. Finally, modulo-2 is done between the output of G1 and G2 to obtain a particular satellite. Fig 3(a) shows the 1023 chips of first satellite's C/A code. Fig 3(b) shows the 1023 chips of second satellite's C/A code. Fig 3(c) shows the 1023 chips of nineteenth satellite's C/A code.

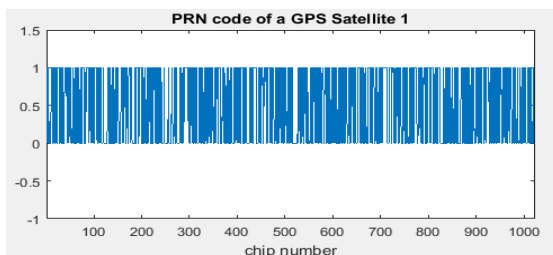


Fig 3. (a)

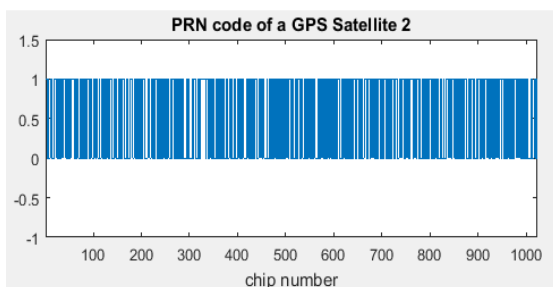


Fig 3. (b)

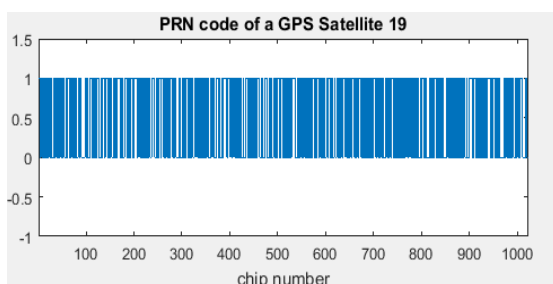


Fig 3. (c)

Fig 3. (a). The Generation of The 1st Satellite's C / A code (The 1023 Chips); (b). 2nd Satellite's C / A code; (c). 19th Satellite's C / A code.

The first ten chips are enough users to check if the generation of PRN (C/A) code is correct or not. For this purpose, randomly select satellite ID 1, 2 and 19. Hence, a result in fig 3 acknowledges the 10 first chips given on table 2.

Table 2- 1st 10 chips C/A octal

Satellite No. (SV ID)	GPS PRN signal No.	Code phase select	First 10 chips C/A binary	First 10 chips C/A octal
1	1	2⊕6	1100100000	1440
2	2	3⊕7	1110010000	1620
19	19	3⊕6	1110011011	1633

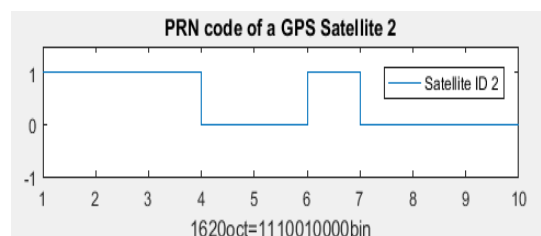
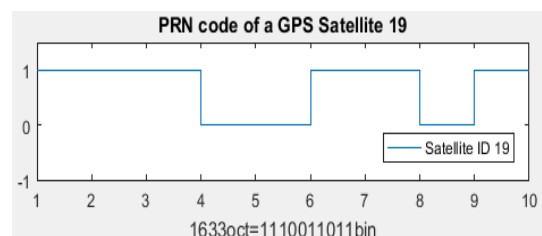
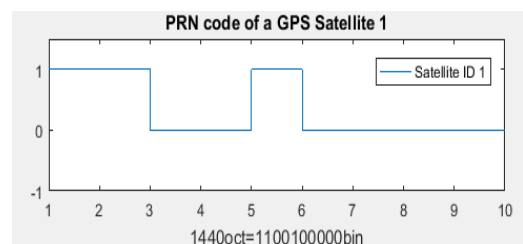


Fig 4. First 10 Bit for SV ID No 1, 2 and 19

5.2 Correlation of C/A code

High autocorrelation peak and low cross-correlation peaks can provide a wide dynamic range for signal acquisition. Fig (5), shows the obtained auto-correlation is high, achieving

the maximum value of 1023, which is equal to the code length. And in the fig (6), we still have values but they are smaller compared with the obtained in the auto-correlation. That means that we have a good way to distinguish if our codes are matching or not and therefore identify the correct satellite with which we want to transmit.

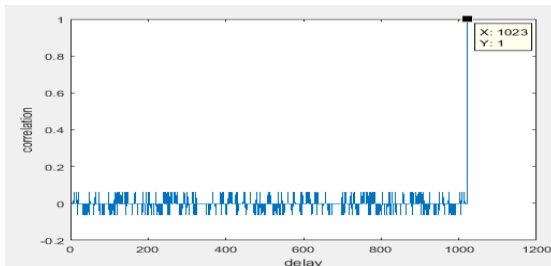


Fig 5. Auto-Correlation of C/A Code (PRN 1)

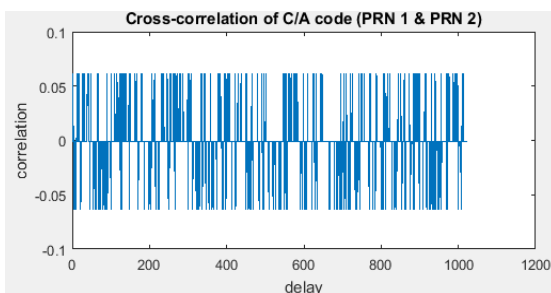


Fig 6. Cross-Correlation of C/A Code (PRN 1 and PRN 2)

6. CONCLUSION

A study on the generation of C/A code and properties of PRN code in GPS is proposed. Here we presented the simulated part which refers to the outline of PRN code using Matlab and presented the correlation properties of C/A code. To evaluate the performance randomly select satellites are taken into consideration. The simulated results which are similar to the real C/A code which is shown in the table that appeared in this paper.

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