DESIGN AND EVALUATION OF GLOBAL POSITIONING SYSTEM BLOCK CODES

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ABSTRACT

The Global Positioning System (GPS) is a satellite-based navigation system made up of at least twenty four satellites. GPS works in any weather conditions and anywhere in the world. GPS satellites circle the Earth twice a day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information and trilateration to calculate a user's exact location. Fundamentally, the GPS receiver measures the distance to each satellite by the amount of time it takes to receive a transmitted signal. With distance measurements from a few more satellites, the receiver can determine a user's position and display it electronically to measure your running route, map a golf course, find a way home or adventure anywhere. The GPS will provide very accurate three-dimensional position, velocity and timing information to users anywhere in the world. In this paper, the design and study of global positioning system block codes have been carried out to find out the tolerance to signals from other GPS satellites sharing the same frequency band, to analyze the tolerance to some level of multipath interference, there are many potential sources of multipath reflection and to find out the tolerance to reasonable levels of unintentional or intentional interference, etc.

Keywords: Global Positioning System, Navigation, Block codes and Components

1. INTRODUCTION

In early days navigation was accomplished based on the movement of stars and the sun. As time progressed various instruments like the compass, the clock, the theodolite, the chronometer etc. came to the aid of the navigation. The radio navigation which makes use of electromagnetic waves in fixing the position of an aircraft has an accuracy far superior compared to the earlier navigational methods such as Navigation by pilotage, Celestial navigation, Navigation by dead reckoning etc. VOR, ILS, MLS, LORAN, OMEGA and DECCA are some of the radio navigation system used (Nagaraja, 1982). Transit is the first satellite based navigation system. It has six low orbiting satellites and works on Doppler principles. Some of the limitations of this system are: a fix can only be made in two dimensional interval between fixing positions is very long and about 1.5 hours on an average. However, this system was discontinued in 1996.In the tenth air Navigation Conference that was held in 1991, International Civil Aviation Organization (ICAO) established a special committee on future Air Navigation System (FANS) to look after the development of satellite Aided Communication Navigation and Surveillance (SACNS) system. The present CNS system suffers from propagation limitations of current line of sight system and /or accuracy and reliability limitations imposed by the variability of propagation characteristics of other system, compatibility between CNS system in different parts of the world, lack of digital air ground data interchange. The new system should be such that; it will have universal accessibility to air navigation safety communications from harmful interference to realize these objectives effectively Global Positioning System (GPS) is needed. Currently, only two satellite navigation systems are operating worldwide [1]. In 1973, the US Dept. of Defence decided to establish, develop, test, acquire and deploy a space borne Global Positioning System (GPS), The result of this decision is the present NAVSTAR GPS (Navigation Satellite Timing And Ranging Global Positioning System) (Hoffman,1992). The GPS is proved to be all- weather, space-based navigation system. The primary goal for developing the GPS was of military nature. The multi-purpose usage of NAVSTAR GPS has developed enormously within the last three decades. With the elimination of SA (Selective Availability) on May 2nd, 2000, the usefulness of the system for civilian users was even more pronounced. The GPS satellites provide a platform for radio transmitter, atomic clocks, computers and various equipment used for positioning and for a series of other military projects (e.g., atomic flash detection) (Parkinson, 1996). Today a full constellation of at least 24 satellites is available (30 satellites in July, 2009). Some of the prominent advantages of the GPS are: Land based system problems like ground reflections, electromagnetic interference, reflections from physical systems are avoided in GPS since it is space constellation, Intentional interference like jamming, unintentional interference will not affect GPS since spread spectrum techniques are used in it, System accuracy can be improved to the order of centimeters using differential techniques, Smaller size and reduced cost of the GPS receiver enable it to be used in 3G Communication.

2. GPS SYSTEM

GPS consists of three segments the space segment, the control segment and the user segment. The space segment comprises the satellites and the control segment deals with the management of the satellites operations. The user segment comprises the receiver equipment for processing of the received L-band frequency signals for obtaining PVT (Position, Velocity, and Time). The GPS satellite constellation consists of 21 main and 3 spare satellites in near circular orbits approximately 20,150 km above the earth. The nominal 24-satellites are positioned in six earth-centered orbital planes with four satellites in each plane. The orbits are equally spaced above the equator at a 60^0 separation with an inclination relative to the equator of nominally 55^0. The GPS satellites travel at a velocity of 3.9 Km/sec. The advantage of greater altitude is that the orbits will be less affected by the irregularities caused by unequal distribution of mass in the earth Satellite Vehicles are arranged such that observers anymore on the earth's surface will always have atleast four satellites in view. The nominal orbital period of a GPS satellite is one- half of a sidereal day or 11 hours 58 minutes.

The satellites transmit two spread-spectrum pseudo-random noise radio signals. The signals consist of a C/A (coarse acquisition) code at 1.023 MHz and a P (precision) code at 10.23 MHz bandwidths. The signals are transmitted at two frequencies, L_1 (1575 MHz) and L_2 (1227 MHz). Both are coherently derived from highly stable on board atomic clocks. Both C/A and P-codes are transmitted on the L_1 frequency, whereas either C/A or P-code is transmitted on the L_2 frequency depending on the ground command. The C/A code is available to all users; however the P-code is available to only authorized users because of anti-spoofing feature. In addition to the PRN range codes, 50 bps data, which consists of the navigation massage comprising both ephemeris and clock parameters are modulated on to the PRN sequence on both L_1 and L_2 frequencies [2,4,6,8].

Each GPS satellite transmits its identity number, the time (resolved to the nearest nano second) and orbital ephemeris correction, in addition to a host of other data (such as health, clock errors, drift rates etc. GPS basically offers two types of signals Standard Positioning Service (SPS) available for civilian use, broadcast at a single frequency and more accurate Precise Positioning Service (PPS) for military use, broadcast using two frequencies. The C/A code is available to all users (SPS), however the P-code is available to only authorized users (PPS) because of anti-spoofing feature. In addition to the PRN range codes, 50 bps data, which consists of the navigation message comprising both ephemeris and clock parameters are modulated on to the PRN sequence on both L_1 and L_2 frequencies. Each GPS satellite transmits its identity number, the time (resolved to the nearest nano second) and orbital ephemeris correction, in addition to a host of other data (such as health, clock errors, drift rates etc.) [2].

2.1 Control Component

The control component consists of the master control station located near Colorado Springs, which is responsible for all the data processing, worldwide network of monitor stations and ground antennas. The monitor stations are located globally at Ascension Island, Diego Garcia, Kwajalein, Colorado Springs and Hawaii. The positions of these monitor stations are known precisely. The radiometric data (pressure, temperature, humidity, etc.) are tracked by the monitor stations and transmitted to the master control station by communication lines. For better system accuracy the predicted navigation message is up linked three times daily. The other important aspect of the control segment is to maintain the health and welfare of the satellites. The predicted clock and ephemeris information in the form of navigation message is up linked to the satellite via the ground antennas.

2.2 User Component

The user segment consists of five principal components: antennas, receiver, signal processing and data processing capabilities input/output device such as a control display unit and a power supply. Satellite signals are received via the antenna, which is a right- handed circularly polarized (RHCP) and provides near hemispherical coverage. Since the satellite signals are RHCP, a conical helix antenna or variation is suitable.

Antenna designs vary from helical coils to thin micro strip (patch) antennas. High dynamic aircrafts prefer low profile, low air resistance patch antennas whereas land vehicles can tolerate a larger antenna. The GPS receiver processes the L-band signals transmitted from the satellites to determine user, position, velocity and time, GPS receivers that track P code on both L_1 and L_2 need to accommodate 20.46 MHz bandwidths on both frequencies. If only C/A code is tracked the receiver bandwidth of 2.046 MHz is sufficient. The measured transit-time includes the travel time between the SV and receiver and the clock bias. The user equipment generates the pseudo range measurement by tracking the satellite navigation signal by generating identical code of the transmitted signal [3].

2.3 Operational Principle

The user estimates an apparent or pseudo range to each SV by measuring the transit time of the signal. Using the pseudo ranges, user's position in 3-D (latitude, longitude and height) and the time offset between the transmitter and receiver clock (user) can be estimated. Let the user be at x_u, y_u and z_u in earth fixed, earth centered coordinate system and the SVs be at x_i, y_i and z_i (where i=1,2,3,4) in the same coordinate system as the user. Assume that the user starts his clock at t_u seconds, receives signals at t_i (i=1,2,3,4) seconds from SV and Δt is the time offset between the user and SV. User's position (in 3-D) and time offset are obtained by simultaneously solving the nonlinear equations.

$$\left(\mathbf{x_u}-\mathbf{x_i}\right)^2+\left(\mathbf{y_u}-\mathbf{y_i}\right)^2+\left(\mathbf{z_u}-\mathbf{z_i}\right)^2=\mathbf{c}\left(\mathbf{t_i}-\mathbf{t_u}+\Delta\mathbf{t}\right)^2,\ \mathbf{i}=\mathbf{1,2,3,4} \tag{1}$$

Where, c is the free space velocity of electromagnetic signals in m/s. The ranges measured from satellites are called pseudo ranges since biases in the receiver clock prevent the precise measurement of actual ranges (true ranges). Pseudo ranges from three satellites define three spheres, the intersection of which defines the user location.

2.4 Dilution of Precision

The satellite geometry (which cause geometric dilution) and the ranging errors under the assumption of uniform, uncorrelated, zero-mean, ranging error statistics affect the performance of GPS (Parkinson, 1990). This is expressed as:

RMS position error = Geometric dilution X RMS ranging error

Understanding position dilution of precision (PDOP) is important for defining the constellation value. PDOP reflects the geometry of the space vehicles in relation to the user and this can be derived from the basic navigation equations. Let the user be at x, y, z in an earth-fixed, earth-centered coordinate system and let the space vehicles be at x_i, y_i, z_i; i=1,2,3,4 in the same coordinate system as the user. The measurement equation is,

$$\sigma(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2 + T = R_i \; ; \; i= 1, 2, 3, 4 \qquad (2)$$

Where, T is the user clock bias and R_i; i=1,2,3,4 are the pseudo-range measurements from each satellite. The above equations can be linearized without loss of accuracy by assuming $x= x_0 + \Delta_x$, where, x_0 denotes nominal and Δ_x is the linear correction. By proper substitution and algebraic manipulation, these linearized equations can be conveniently written in matrix notation (Ananda, 1988).

$$\begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & 1 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & 1 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & 1 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & 1 \end{bmatrix} \mathrm{x} \begin{bmatrix} \Delta_x \\ \Delta_y \\ \Delta_z \\ \Delta_T \end{bmatrix} = \begin{bmatrix} \Delta R_1 \\ \Delta R_2 \\ \Delta R_3 \\ \Delta R_4 \end{bmatrix} \Rightarrow Ax = r \qquad (3)$$

Where, σ_{ij} is the direction cosine of the angle between the range to the ith coordinate, A is the information matrix, x is the vector estimates and r is the measurement residual vector. It is possible to estimate the covariance of the state (estimated parameters) vector by,

$$\mathrm{cov}(x)=A^{-1}\mathrm{cov}(r)A^{-T}=[A^T\mathrm{cov}(r)A]^{-1} \qquad (4)$$

Assuming pseudo range measurements has an error (1σ) of unity and the expected means of the measurement error is zero as well as that the correlation of errors between the satellite measurements is zero, the covariance equation reduces to

$$\mathrm{cov}(x) = [A^TA]^{-1} \qquad (5)$$

From this, it is evident that the estimation is purely dependent upon geometry of the satellites w.r.t users. Therefore, a measure of the 'goodness' of the geometry is determined by the term geometrical dilution of precision (GDOP), computed as the

$$\mathrm{GDOP} = [\mathrm{trace}\; (A^TA)^{-1}]^{0.5} \qquad (6)$$

Let σ_x^2, σ_y^2, σ_z^2 and σ_T^2 are diagonal components of the covariance matrix, then

$$\mathrm{GDOP} = [\sigma_x^2 + \sigma_y^2 + \sigma_z^2 + \sigma_T^2]^{0.5} \qquad (7)$$

The other related DOP parameters are,

$\mathrm{PDOP} = [\sigma_x^2 + \sigma_y^2 + \sigma_z^2]^{0.5}$ (Position DOP) (8)

$\mathrm{HDOP} = [\sigma_x^2 + \sigma_y^2]^{0.5}$ (Horizontal DOP) (9)

$\mathrm{VDOP} = \sigma_z$ (Vertical DOP) (10)

$\mathrm{TDOP} = \sigma_T$ (Time DOP) (11)

All DOPs are in effect, the amplification factors of pseudo-range measurement errors due to the effect of satellite geometry. It is clear that the lower the PDOP, the higher the accuracy [4].

2.5 GPS Radio Frequency Selection

The use of L band gives acceptable received signal power with reasonable satellite transit power levels and earth coverage satellite antenna patterns whereas the C band path loss is roughly 10db higher because the path loss is proportional to f^2 for an omni-directional receive antenna and fixed transit antenna bandwidth and range. The large ionospheric delay and fluctuation in delay weighs against UHF as does the difficulty in obtaining two large (approximately 20MHz) bandwidth frequency assignments in the UHF band for ionospheric correction. Therefore, L band was selected and dual frequencies permit ionospheric group delay measurements.

The signals L_1 and L_2 are coherently derived from a 10.23MHz basic clock and are given by

$$L_1 = 154 \times 10.23\mathrm{MHz} = 1575.42\mathrm{MHz}$$
$$L_2 = 120 \times 10.23\mathrm{MHz} = 1227.60\mathrm{MHz}$$

The dual carrier strategy serves two purposes:

(1) In case L_1 is lost or the receiver is being jammed on L_1, the L_2 serves as a backup.

(2) L_1 and L_2 combined provide dual frequency compensation for signal delay due to ionospheric refraction.

3. SPREAD SPECTUM TECHNOLOGY

The Spread Spectrum signals in communication are used for the purpose of combating the detrimental effects of interference due to jamming, interference arising from other user of channel and self-interference due to multipath propagation. Spread Spectrum technology, the enabling force behind the global positioning system, allows for all satellite to operate on common frequencies without interference, while at the same time allowing for precise time transfer. In its simplest form, spread spectrum in any communication system that uses a bandwidth that is very wide compared to the information bandwidth, to transmit information. Generally, in a spread spectrum, the transmission bandwidth is often hundreds or even thousands of times greater than the information bandwidth.

Worldwide 3G technology has been on use in recent years with the combination GSM technology, so that the frequency bands are used more efficiently. ISM 2.4 technologies is able to establish the connection to wireless local area networks (WLANs) without the need GSM or 3 G technologies and allows high speed internet access. The mobile devices which can operate on these communication technologies provide great advantages for users. It is desired that the mobile devices should be light weight and small. The size of mobile devices depends on antenna size too. Microstrip antennas have some advantages like having small size, low weight being durable, being mounted easily because of their geometry and being produced easily using printed circuit technique. Therefore they are widely used on mobile devices. But they have some disadvantages such as low radiation power, low bandwidth, surface waves and spurious radiation. Microstrip monopole antennas are widely used in wireless communication applications, because they radiate in wide frequency band and have an appropriate radiation pattern. A conductive patch and microstrip feeding lines which are directly connected to the patch are on one of the surfaces of the dielectric layer of the microstrip antenna. The ground plane being coated with metal only along the microstrip feed line is the main feature which separates these antennas from microstrip patch antennas. This structure of microstrip antenna provides radiation in both planes [5].

4. CHARACTERSTICS OF GPS SATELLITES

The GPS constellation has 24 satellites in 3 orbital planes, each inclined to the equatorial plane by 55 degree and offset from each other by 120 degree in longitude. Eight satellites are in circular prograde 12 sidereal hour in each orbital plane. Thus the sub-satellite point at noon slowly shift each day on its fixed ground track since the sidereal day is shorter than solar day by about 4 minutes. The satellite altitude is roughly 19652 km. each satellite crosses the equator in a northerly direction twice a day at two points separately by exactly 180 degree with fixed sinusoidal ground track. In a fully implemented 24 satellite system there are always at least 6 satellites in view. Thus one of the required characteristics of GPS signals is that one must be able to observe these signals from multiple satellites without mutual interference. This property is analogous to multiple-access in satellite communications.

5. DESIRED GPS SIGNAL PROPERTIES

The following are the criteria that decide the choice of the signal frequency and format for navigation:

- Allow accurate real time of arrival measurement without ambiguity.
- Allow accurate Doppler shift measurement.
- Provide an efficient data channel for the transmission of satellite ephemeris, clock correction information and other data at 50 bps.
- Provide a rapid acquisition navigation capability with good accuracy (C\A code) along with a high accuracy capability for more demanding users (P code).
- Provide dual frequency measurements to enable ionospheric group delay evaluation and correction (<20 % separation).
- Good multiple access properties. The users will typically receive 6-11 satellites.
- Ability to resist interference from narrowband low power sources as well as moderate power intentional interference.
- Ability to reject or greatly reduce multi path interference problem where differential multi path delay is 200 ns or greater.
- Signal generation compatible with current space electronic technology.
- Avoid excessive bandwidth relative to the centre frequency [6].

5.1 GPS Signal Structure

5.1.1 Frequency Characteristics

GPS signal consist of two right hand circularly polarized (RHCP) components, Link 1 or L1 at a centre frequency of 1575.42 MHz and Link 2 or L2 at a centre frequency of 1227.60 MHz The allocated signal bandwidth at both these frequency is 20 MHz The L-band centre frequency selection has the advantage over UHF (~ few hundred MHz) in that channel effects are substantially smaller. On the other hand as compared to C-band (4-6 GHz), the free space path losses are substantially smaller at L-band. Also, attenuation due to rainfall, fog etc. is substantially less at L-band as compared to C-band.

5.1.2 Ionospheric Delay Considerations

The frequency separation between L1 and L2 is 347.82 MHz or 28.3% relative to L2. This dual frequency allows measurement of ionospheric group delay error. The L1 and L2 carriers are coherently selected multiples of a 10.23 MHz clock. In particular the link frequency is,

L1 = 1575.42MHz = 154*10.23 MHz
L2 = 1227.60 MHz = 120*10.23 MHz

The ratio of L1/ L2 = 1.2833. The ionospheric group delay varies approximately as the inverse square of the carrier frequency and thus the measurement of the difference of the delay permits calculation of the delay at any one frequency follows.

5.1.3 Relativity Considerations

Relativistic effects are not negligible at the accuracy levels at which GPS operates. The primary effects here are,

(1) Lowering of fractional frequency of an electromagnetic signal (or red shift) in presence of a gravitational field due to the earth's mass,(G. M_e)/ (C^2 r).

(2) Second order Doppler due to orbit motion. The GPS satellite and a stationary observer on the surface of the earth are subjected to very different gravitational field and also possess different orbital velocity. On account of these two primary effects, the signal emitted by a GPS satellite in orbit undergoes a frequency shift about $44.46*10^{-10}$ from its normal value that had been set on the surface of the earth. To cancel this frequency shift. The primary clock frequency of 10.23 MHz on board the GPS satellite is intentionally offset by $-4.46*10^{-10}$ prior to launch.

5.1.4 Signal Power Characteristics

The power levels of the GPS L1 signal near the earth's surface, as would be received by a unity gain antenna, are -60 and -163 dBW for the C/A and P codes respectively. For the L2 signal it is -166dBW. Since the signal power is spread over a width bandwidth due to the use of Pseudo random modulation, the power spectral density is way below these total power values and as such is lower than the ITU flux density regulation of -154 dBW/m^2 over any 4kHz bandwidth for this frequency band. The radiation pattern of the GPS antenna has a beam pattern with a width of approximately 28 degree with a dimple of about -2 dB at the centre. The 28 degree width just enables a complete coverage of the earth's disc and the user receives maximum signal when the satellite is at a 40 degree elevation.

5.1.5. Signal Modulation Characteristics

Each of two carriers L1 and L2 is modulated by either or both a 10.23 MHz clock rate precision (P) signal for the US military user, and / or by a 1.023 MHz clear/acquisition (C/A) signal to be used by the civilian users. Each of these two signals has been formed by a P- code or a C/A code which is modulo-2 added to 50 bits per second (bps) data D, to from P convolution D and C/A convolution D respectively. The L1 carrier has an in – phase and a quadrature component, which are bi-phase modulated by the code. The in-phase component of the carrier is modulated by the P signal P convolution D and the quadrature carrier component is modulated by the C/A convolution D signal thus the L1 signal is of the form

$$S_{L/i}(t) = A_p . XP_i(t) . D_i(t) . \cos(\omega l t + \phi) + A_c . XG_i(t) . \sin(\omega l t + \phi)$$

Where ω_1 is the L1 frequency, φ represents a phase noise term and oscillator drift components. Long term oscillator stability at the level of $\cong 3*10^{-1}$ is ensured by using redundant Cs atomic frequency standards. The P-code, XP_i (t) is a ∓ 1 pseudo random sequence with a clock rate of 10.23 Mbps and a period of exactly 1 week. Each satellite transmits a unique P-code. The data D_i (t) also has amplitude of ∓ 1 at 50 bps. It has a 6 second sub-frame and a 30 second frame period. The C/A code, XG_i (t) is a unique Gold code of period 1 ms, i.e., 1023 bits at a clock speed of 1.023 Mbps. The relative amplitude of the P and C/A codes are controlled by the constants A_p & A_c. The C/A code is stronger than the P-code by 3-6 dB. The clocks for the codes and the carrier frequencies are coherently derived from the same of the board frequency source. The rms clock transition time difference between the C/A and P-code is less than 5 ns. The power spectrum density of the L1 carrier is show in fig. The peak power spectral density of the C/A signal exceeds that of the P signal by 13dB because it has a (1/10) the clock rate and bandwidth and is also nominally 3 dB stronger. The L2 signal is bi-phase modulated by either the P-code or the C/A code as selected by the ground command. The normal operation provides for the P-code, which may or may not have the data modulation, again depending on ground command. The absence of data permits the receiver tracking loops to be reduced further in IF bandwidth.

5.1.6 Details of P-Code

The P-code for each satellite is the product of 2 PRN sequence, X1t and X2(t + nit),where X1(t) has a period of 1.5 sec or 15,345,000 chips and X2 has a period of 15,345,037 or 37 chips longer. Both sequences are reset to begin the week at the same epoch time. Both X1 and X2 are clocked in phase at a chip rate 1/T = 10.23 MHz Thus the P-code is a product code of the from,

$$XP_i\ (t) = X1\ (t)\ .X2\ (t+n_i\ T)$$

Each satellite has a unique code offset n_it which makes the P-code unique as well.

5.1.7 Details of C/A Code

The C\A code is relatively short code of 1023 bits or 1ms duration at a 1.023 Mbps bit rate. This code is selected to provide good multiple access properties. The C/A codes for various satellites are Gold codes formed as the products of two 1023 bit PRN codes G1 (t) and G2 (t). Thus this product code is also a 1023 bit period and is represented by,

$$XG\ (t) = G1\ (t).G2\ [t + Ni\ (10T)]$$

Where, Ni determines the phase offset in chips between G1 and G2. There are different offsets for N_i and 1023 different codes of this form. Each codes G1, G2 generated by a maximal length linear shift register of 10 stages. The G1 and G2 shift registers are set to all 1 states in synchronism with the X1 epoch. The tap position specified by the generator polynomials for the two codes,

$$G1:\quad G1\ (X) = 1 + X^3 + X^{10}$$

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

Since the Gold codes have a one ms period there are 20 or C/A code epochs for every data bit. The 50 bps data clock synchronized with both the C/A epochs and the X1 epochs. The overall schematic of the generation of the show in figure. There are two PN generators with 10-stages linear feedback shift registers clocked at1.023 Mbps, having taps 3 and 10 for G1 and 2,3,6,8,9,10 for G2. Thy delay offset for G2 are generated by tapping off at appropriate points on the G2 register and modulo 2 adding the two sequences to get the desired delayed version of the G2 sequence. Epochs of the G code at 1 kbps are divided down by 20 to get the 50 bps data clock. All clocks are in phase synchronism with the X1 clock.

5.1.8 Elementary Description of PRN Code Generation

A Pseudo Random Noise (PRN) sequence is generated by a chain of serially connected shift registers (SR) with linear feedback from the output of one or more stage. In case combination of the output of several stages is to be used for feedback, these are combined using an EX-OR function.

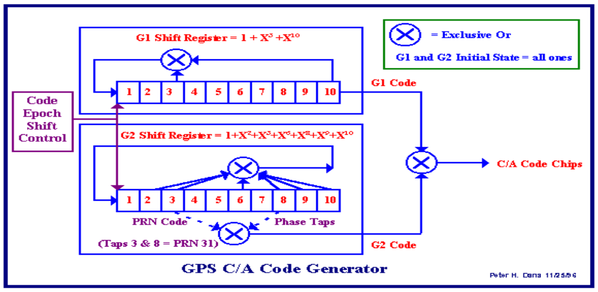

Figure 1: C/A code generation block diagram showing G epoch and clock generation

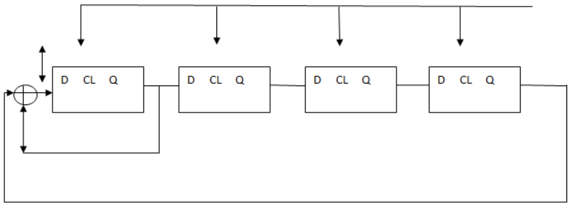

Figure 2: Schematic Diagram of Generation of PRN Sequence

clk	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a	0	1	0	1	1	0	0	1	0	0	0	1	1	1	1	0
b	1	0	1	0	1	1	0	0	1	0	0	0	1	1	1	1
c	1	1	0	1	0	1	1	0	0	1	0	0	0	1	1	1
d	1	1	1	0	1	0	1	1	0	0	1	0	0	0	1	1
e	1	1	1	1	0	0	0	1	0	0	0	1	0	0	0	1

Figure 3: Truth table for the PRN sequence generator

We take a chain of 4 shift registers as shown in fig.2. Here, the feedback is from the outputs of stages 1 and 4. If we start with all the shift register output being set to 1 than we have a truth table as in table 1 for successive clock cycles. Here the output, which has been called the output of the system of 4 shift registers is a PRN sequence with a periodicity of 15 clock cycles ($2^4 – 1$). All other outputs, b, c, d, e is also ideal sequences but are phase shifted [7].

5.1.9 Gold Codes (Elementary Description)

These are the family of codes formed as the product of two different PRN sequence both of the same period 2^n-1. All pairs of PRN sequences that yield Gold Codes are called preferred pairs. Using such a preferred pair, one can generate an entire family of Gold codes by using the phase shifted version of one of the sequences before taking the product. Their main advantage being that the cross-correlation between any two members of the same family is low. The highest value of cross correlation for two Gold Code sequences with a period of 1023 chips is -23.8dBFor real GPS signals, the Gold Code sequence modulates L1 or L2 carriers & the carrier of the received signals are Doppler shifted. In presence of Doppler shift the worst case cross correlation increases to -2.16 dB, which is still low enough to be of any concern.

6. PROPOSED PROBLEM DEFINITION

Global Positioning System (GPS) is a satellite based positioning system based on radio ranging technique. The GPS will provide very accurate three-dimensional position, velocity and timing information to users anywhere in the world. GPS can also be used in other applications such as vehicle monitoring for traffic management in urban areas, Geographical Information System (GIS), 3G Communications, marine navigation, search and rescue and military applications. As GPS accuracy is limited by ionospheric effects, this course also covers the basics of ionosphere and its effects on GPS. In India, GPS and Geo Augmented Navigation (GAGAN), is being jointly developed by ISRO and AAI to suit the Indian civil aviation requirements. The course will enable the participants to enrich their knowledge in the field of GPS and ionospheric effects and will familiarize the participants with latest trends in GPS.

The research objectives are:

(1) To find out the tolerance to signals from other GPS satellites sharing the same frequency band; i.e., multiple access capability.

(2) To analyze the tolerance to some level of multipath interference, there are many potential sources of multipath reflection; example man-made or natural objects.

(3) To find out the tolerance to reasonable levels of unintentional or intentional interference, Jamming or spoofing by signal designed to mimic a GPS signal.

The research method is entailed as below:

(1) Initially, the GPS signals are gathered by an omni-directional or hemispherical antenna. Given a recent almanac and a rough idea of the user location, the receiver determines which satellites are in view. Given the satellite ID, the receiver knows the structure of C/A code, being transmitted by it and attempts to tune to it to acquire the signal. The receiver generates a replica of the code of the incoming signal. From the auto-correlation property of the signals, the correlation function exhibits a sharp peak when the code replica is aligned with the code received from the satellite.

(2) Since, the direct acquisition of P(Y) code is difficult due to its long period; it is accomplished in two steps. Firstly, the receiver acquires the C/A code and then with the aid of timing information in the navigation message, it acquires the P(Y) code.

(3) GPS receiver captures the RF signals transmitted by the satellites spread out in the sky, separates the signals of the satellites in view, performs measurement of signal transit time & Doppler Shift, decodes the navigation message and determines the satellite position, velocity & clock parameters. Finally, it estimates the user position, velocity and time.

(4) The signal from each satellite carries only 10^{-16}watt power. The noise in the front end of the receiver can be 600 to 4000 times stronger than the signal from one satellite. It is more

challenging that all the satellite signals overlap in frequency and time. The front end of the receiver conditions the receiver signal. It amplifies the power of the signal by approximately 10^{10} and it reduces the carrier of 1575.42 MHz by a factor of 100 to 1000.

(5) The conditioning also removes interfering signals in adjacent frequency bands by decreasing the bandwidth of the received signal. After adequate conditioning, the received signal is converted to a sequence of digital numbers by an Analog to Digital Converter (ADC) as shown in the figure. The digital portion of the receiver contains a bank of estimators one for each satellite. Each estimator contains the means to track the key parameters for its satellite.

7. CONCLUSION

GPS signal received on earth be sufficiently low in power spectral density so as to avoid interference with terrestrial microwave line of sight communication. A satellite can radiate more total power and stay within the flux density limit if the signal energy is spread out fairly uniformly over a wider spectral band. GPS uses spread spectrum to achieve this goal. In this paper, the design and study of global positioning system block codes have been carried out to find out the tolerance to signals from other GPS satellites sharing the same frequency band; i.e., multiple access capability, to analyze the tolerance to some level of multipath interference, there are many potential sources of multipath reflection; example man-made or natural objects and to find out the tolerance to reasonable levels of unintentional or intentional interference, Jamming or spoofing by signal designed to mimic a GPS signal.

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