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Reducing Multipath Effects in Indoor Channel for Acquisition of GPS based Pseudolite Signals

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Abstract *:* The Global Positioning System (GPS) is an extremely mature technique in the navigation and positioning field. However, there are still some limits in some aspects and for some special applications. The main limitation of the GPS use indoors are the low signal power and the presence of multi-paths, which may affect significantly the signal acquisition and tracking accuracy. The performance of GPS needs to be improved with technological advances. As a GPS-like ground transmitter, the Pseudolite provides a new research direction to achieve high positioning accuracy and reliability. Pseudolites (short for pseudo-satellites) are local transmitters on Earth that output GPS satellite signals in order for augment the GPS system for use in locations where satellite signals may be obstructed. One of the challenges related to indoor positioning is to find suitable statistical models of the indoor propagation that give further insight on multi-path behavior and fading distributions.

In this paper, we describe the core technologies of designing and simulation on the coarse acquisition (C/A) codes in constructing the pseudolite system. In the GPS/pseudolite system, the signal PRN 36 of the pseudolite Generated by using (Interace Control Document) ICD-GPS-200C Date sheet and Considered Multipath Effects on the generated C/A code, Here in this paper we are Considered White Gaussian Noise and Rayleigh Noise as Multipath effects and the GPS/PL satellites signals are acquired. It is shown that the pseudolite technology is ideally suited to augment the GPS alone and provide greater integrity, availability, and continuity of the navigation positioning system, especially for indoor use.

Key words : GPS: Global Positioning System, PRN: Pseudo Range number, C/A: Course Acquisition, PL: Pseudolite

INTRODUCTION

The GPS constellation consists of nominally 24 to 32 satellites. GPS of US is very famous for its great performance of the navigation and positioning and it can be used anywhere, any weather, and any time on the earth. When the GPS receiver is used outdoors, at least four GPS satellites' signals need to be acquired and tracked to meet all kinds of the location based service requirements[1].

However, the satellite signal is sometimes blocked indoors so it is difficult for indoor positioning. The alternative for indoor positioning is Pseudolite. The pseudolite is not a real GPS satellite. It only transmits a GPS-like signal and the signals are received by modified GPS receivers. The broadcasted signals are not affected by the ionosphere because it is based on the ground[1],[2].

The aim of the paper is to analyze the indoor signal fading characteristics and multipath effects in indoor-to-indoor pseudolite signal propagation. We have focused our research on the GPS Coarse Acquisition (C/A) signal because it is the most used civilian navigation signal.

COURSE ACQUISITION CODE GENERATION

The GPS satellite transmits a microwave radio signal composed of two carrier frequencies at 1575.42 MHz as the L1 carrier and at 1227.60 MHz as the L2 carrier, modulated by two digital codes and a navigation message, and the digital GPS codes are called coarse acquisition (short for C/A code) and precision (short for P code). Each code is a stream of binary digits, zeros and ones, called bits or chips. The codes are commonly known as pseudo-range number (PRN) codes since they look like random signals. Generally, the pseudolite technology adopts the C/A code and L1 carrier to transmit the GPS-like signals[1],[2].

According to the signal structure, the pseudolite C/A code is generated according to ICD-GPS-200C[3]. Each $Gi(t)$ sequence is a 1023 bit Gold code which is itself the Modulo-2 sum (X-or Operation) of two 1023-bit linear patterns, $G1$ and $G2i$. The $G2i$ sequence is formed by effectively delaying the $G2$ sequence by an integer number of chips ranging from 5 to 950. The $G1$ and $G2$ sequences are generated, with $G1=1+X3+X10$ and $G2=1+X2+X3+X6+X8+X9+X10$, by 10-stage shift registers having the following polynomials referred to as the shift register input. The 10-stage shift registers are the vectors of $G1$ and $G2$, and the initialization setting is 1111111111.

The C/A code repeats itself every millisecond and the chipping rate of the C/A code is 1.023 Mbit/s. Presently, the C/A code is modulated onto the L1 carrier only[3]. Each satellite is defined by a unique C/A code, which is the ID of the transmit-ting signal of the GPS satellite[1,3,4]. The pseudolite signal is similar to the GPS signal in its structure and the generation theory[4].

The above concept of course acquisition code generation was implemented by below Fig.1

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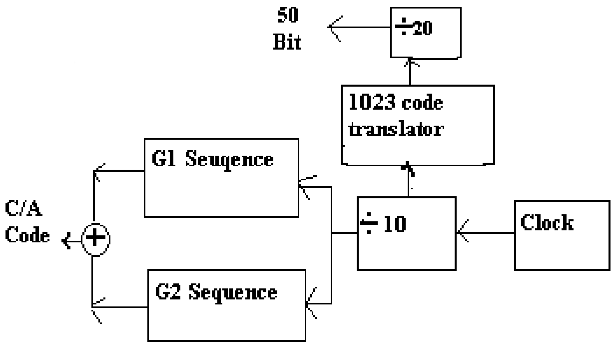

Fig 1: Concept of C/A code Generation

Theoretically, the C/A code generator can produce 1023 separate Gold codes besides the two base MLFSR codes according to ICD-GPS-200C [3]. 512 are not balanced, however, so that they are cancelled since the un-balanced codes are hard to modulate in the pseudolite system and may be vulnerable to narrow-band interference. Most receiver implementations cannot track the individual MLFSR codes. It reserves 36 of the remaining 511 balanced codes for the use by GPS satellites. Among the remaining 475 useful C/A codes, 10 with the best cross-correlation properties are chosen for the wide area augmentation system (WAAS) broadcast from geo-stationary satellites. The remaining 465 codes can be used as the pseudolite transmitting signals. This number is large enough for two or more than two pseudolites simultaneously visible to a user receiver, with proper coordination, not to share the same code (It is not large enough for every individual pseudolite to have its own distinct code.).Here, we simulate the C/A codes and configure the PRN 36, which are reserved for the GPS pseudolites[4]-[8].

By using above concept we have generated course acquisition code and we have collected some samples as shown below Fig 2. It shows characteristics of GPS/PL signal[9,10].

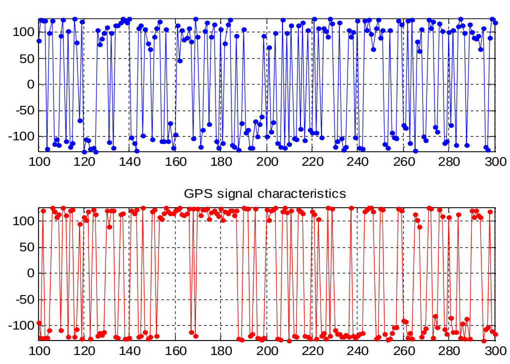

Fig 2: Generated GPS Signal Characteristics

GPS/PL signal Sample here we have taken GPS signal has length 32768 Divide this signal in to 8 frame that is 4096*8.

After generation GPS/PL signal We Obtained Power Spectural Density as shown Fig 3. At a frequency of 0.002188Mhz.

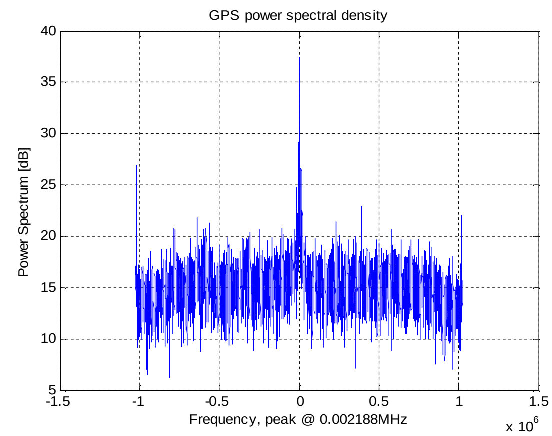

Fig 3: Generated Signal Power Spectrual Density

By observing Histogram we can undestand Normal signal how many times it repreats within the specified values it is shown in Fig 4 .

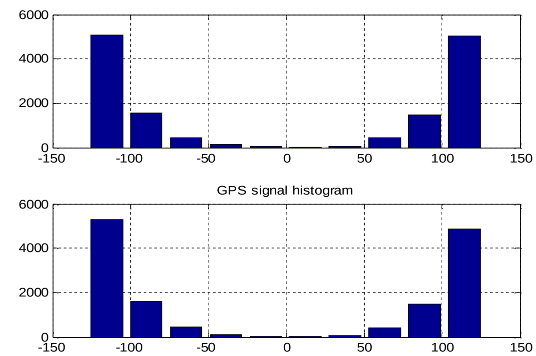

Fig 4: Generated Signal Histogram

MULTIPATH EFFECTS ON SIGNAL

Generally, The generated (C/A) code is transmitted by the pseudolite transmitter it is effected by the multipath transmission in indoor Environment. In this multipath transmission (multi path fading) includes Large scale fading and Small scale fading. Large scale fading corresponds to average signal power attenuation, Small Scale fading is due to dramatic alterations in amplitude and Phase[11]. Fig 5 Gives typical Scenario multipath reflected signal propagation indoor channel.

In this paper we have considered channel noise as Rayleigh noise and Gaussian noise. These Noises are added to PRN 36 of C/A code by using MATLAB tools to show Multipath Effects on the generated signal.

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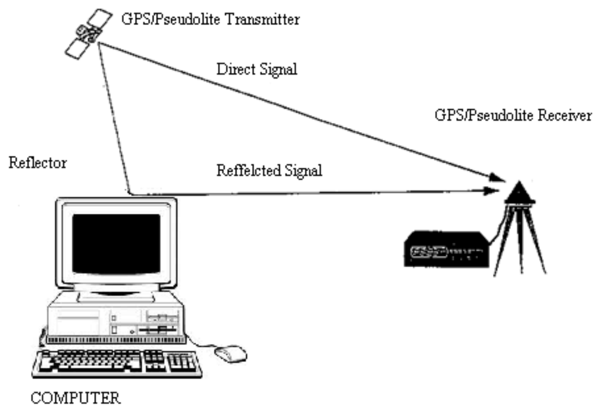

Fig 5: Signal Propogation in Indoor Environment

The magnitude of the multipath effect on a phase observation can be estimated from the following mathematical relation eq.(1) [12].

$$\tan\Delta\Phi m = \beta.\sin\Delta\Phi/1+\beta.\cos\Delta\Phi \qquad (1)$$

where

$\Delta\Phi m$: Is the shift in carrier phase of the combined signal received at the antenna due to multipath.
$\Delta\Phi$: Is the shift of the reflected signal with respect to the direct signal.

B : Is a damping factor which varies between o (no reflection) and 1 (reflected signal as strong as direct signal).

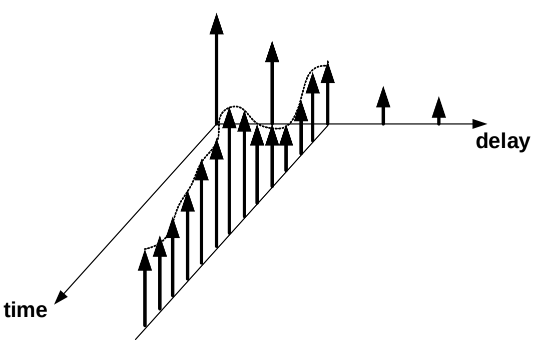

Fig 6: Each path at Certain delay

Fig .6 explain Each path changes with time, t, and has its delay, t ,[13].

It Can be represented by eq.(2) as per communication theory

$$h(t,\tau) = \sum_{l=0}^{L-1} g_l(t)\,\delta(\tau - l\tau) \qquad (2)$$

Due to Rayleigh and Gaussian Noise, Receiver cannot track exact signal. At receiver front end various signals are available i.e. (direct signal from the pseudolite transmitter and reflected signal from various object) so signal power degrades and noise power increases. This signal is not sufficient for accurate indoor positioning.

From probability theory we know that the Received amplitude follows Rayleigh distribution as shown below eq.(3).

$$p(r) = \frac{r\exp\left(-r^2/2\sigma^2\right)}{\sigma^2}, \quad r > 0 \qquad (3)$$

Below Fig 7. Shows the Characteristics of the Amplitude, Rayleigh Distribution[13].

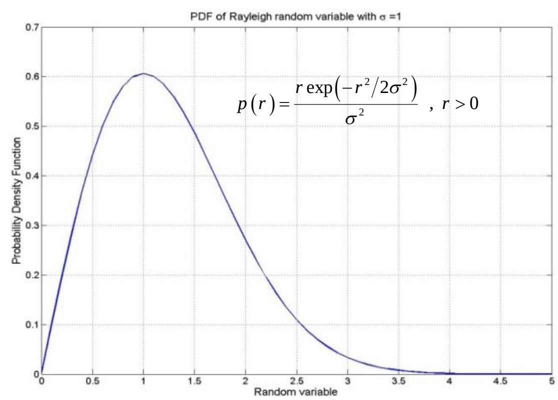

Fig 7: Rayleigh Distribution

In probability theory, the normal (or Gaussian) distribution is a continuous probability distribution, defined on the entire real line, that has a bell-shaped probability density function, known as the Gaussian function or informally as the bell curve it is given by eq.(4)[14].

$$f(x, \mu, \sigma^2) = (1/\sigma\sqrt{2\pi})e^{-\frac{1}{2}((x-\mu)/\sigma)^2} \qquad (4)$$

The parameter μ is the *mean* or *expectation* (location of the peak) and σ^2 is the variance. σ is known as the standard deviation. The distribution with $\mu = 0$ and $\sigma^2 = 1$ is called the standard normal distribution or the unit normal distribution.

A normal distribution is often used as a first approximation to describe real-valued random variables that cluster around a single mean value.

The Gaussian Distribution function is shown in Fig 8. in this characteristic of Gaussian Distribution changes as Standard deviation[14].

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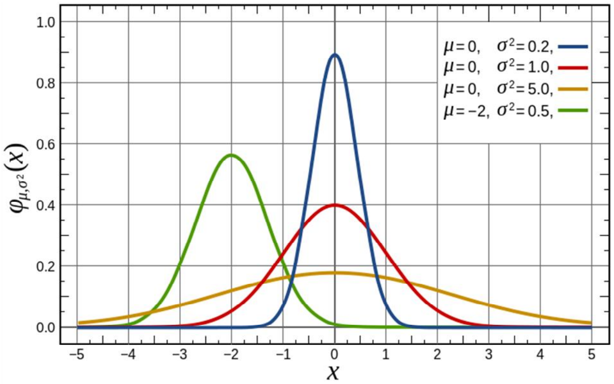

Fig 8 : Gassian Distirbution fuction

REDUCING MULTIPATH EFFECTS BY USING EQUAL GAIN COMBINING ALGORITH

At receiver front end various signals are available i.e. (direct signal from the pseudolite transmitter and reflected signal from various object) due to this exact Signal reception very is difficult. To Reduce multipath effects at receiver front- end we have used Equal gain Combining Algorithm (EGC). In this we are taking average signal power of all the signals. So that we can improve the average signal power at receiver side[15].

The goal of the equalization techniques should be to reduce the effect of the fading and the interference.

Consider a transmitted signal s(t) = A cos 2πfct through a fading channel. The received signal can be expressed as eq.(5).

$$y(t) = A\sum_{i=1}^{N} a_i \cos(2\pi f_c t + \theta_i) \quad (5)$$

Where:

ai is the attenuation of the ith multipath component.

ɵi is the phase-shift of the ith multipath component

It must be noted that ai and ɵi are random variables. The above expression can be re-written as eq.(6).

$$y(t) = A\left\{\left(\sum_{i=1}^{N} a_i cos(\theta_i)\right) cos(2\pi f_c t) - \left(\sum_{i=1}^{N} a_i sin(\theta_i)\right) sin(2\pi f_c t)\right\} \quad (6)$$

We Introduce Two Random Processes X1(t) and X2(t), Such that the above Equation becomes shown elow eq.(7).

$$y(t) = A\{X_1(t)\cos(2\pi fct) - X_2(t)\sin(2\pi fct) \quad (7)$$

The phase of the received waveform ɵ(t) is given by eq.(8).

$$\theta(t) = tan^{-1}(X_2(t)/X_1(t) \quad (8)$$

In Equal Gain Combining (EGC), all the received signals are co-phased at the receiver and added together without any weighting it by suing in eq.(9), eq.(10).

Yegc=y(t)*exp(-j*θ(t)) (9)

θ(t)=angle of Rayleigh channel (10)

SIGNAL ACQUISITION USING CORRELATION

The acquisition is the first step upon receiving the signals. The received signals *s* are a combination of signals from all n visible PL shown in eq.(11).

satellites described by $s(t) = s1(t) + s2(t) + \ldots + sn(t)$. (11)

When acquiring the pseudolite signal PRN 36, the incoming signal *s* is modulated by the locally generated C/A code corresponding to the pseudolite 36. The cross correlation between C/A codes for different Pseudolites implies that signals from other pseudoite are nearly eliminated by this procedure. To avoid eliminating the desired signal component, the locally generated C/A code must be properly aligned in time to have the correct code phase[4].

The correlation process is shown in Fig .9, in this un wanted signals are eliminated and we can obtain desired signal[4],[16].

Signals originating from PRN 36 of the pseudolite are present in the received signal. This can be seen In Figure 10, significant peak in the acquisition plot. The peak location is related to a C/A code phase and a frequency of the signal.

The signal power of the pseudolite was set for −80 dBm at 10−8 mW. And the PRN of the pseudolite was set for 36.

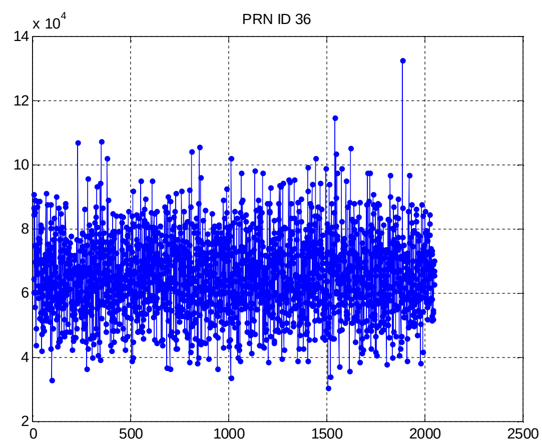

Fig9 : Obtaining PRN36 byCross correlation

For acquisition of pseudolite signal we have used Mat-lab tool. Fig 10. shows that the acquisition result of PRN36 in indoor channel.

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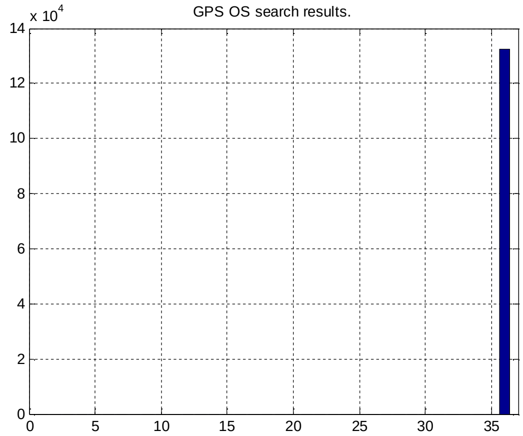

Fig 10: Desired Out put of the Recevier

APPLICATIONS

Pseudolite have wide verity of application in real life. It is mostly useful in door environment. But in some cases it is also useful in outdoor where GPS signal is very poor due to atmospheric (Ionosphere and Troposphere) effect or unhealthy whether conditions such as heavy rain, peak summer days and at Equatorial plan where GPS signal undergo various effect so it is difficult to identify exact location. In such cases GPS/pseudolites Integration is the other alternative .

In outdoor environment GPS /Pseudolite Integration can be most useful for Military Services, it is also useful to identify enemy activities under signal Jamming condition.

Below Fig.11 shows one of the application of GPS/Pseudolite Integration to identify object under the GPS signal jamming condition[17].

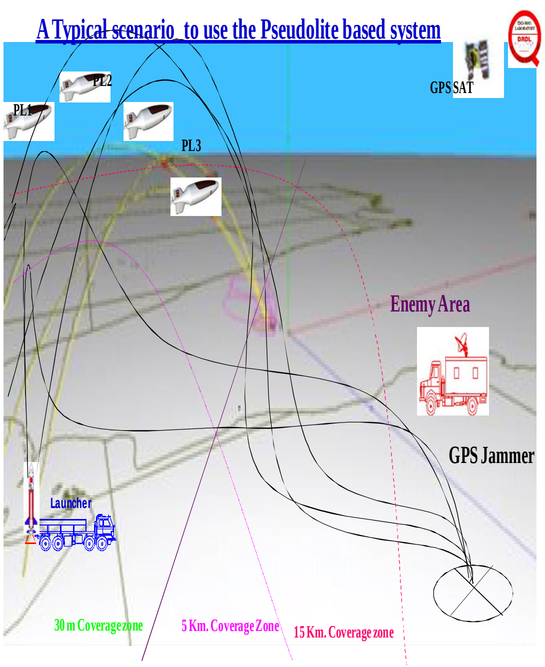

Fig 11: Application of PL in WAR envirobnemnnt

CONCLUSION AND FUTURE WORK

In this paper we have Generated C/A code of PRN 36 by using ICD-GPS-200C Document and Estimated multipath Effects l in Indoor (Channel) environment, Multipath Effects occurred in Transmission channel so we have considered Channel noise as white Gaussian and Rayleigh Fading.

Due to multipath effects pseudolite signals may not reach same time at the Receiver and signal power reduces and noise power increases. To compensate this Multipath effects on received signal We have equalized these effects by using Equal Gain Combining Algorithm further Correlating the received signal with reference signal so that we can eliminate other unwanted signals. But obtained Signal has more noise power this signal may not sufficient to locate Indoor positioning in Centimeter level or millimeter level.

In this paper we have discussed only multipath effects, but in Indoor Environment there is another problem that is Near-Far Problem. The future work for this paper is to develop new Algorithm reducing Near and Far problems and designing Sufficient Filter to Reduce noise power so that we can Improve the performance of Pseudolite to locate Centimeter or millimeter level positioning.

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