Optimization of GPS Receiver to Mitigate Near-Far Problem for Acquisition of GPS/ PL Signals

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ABSTRACT

The GPS is best technique in the navigation and positioning field. The main limitation of the GPS use indoors are the low signal power and the presence of multi-paths, Inter Symbole Interference (ISI) and near-far Problems which may affect significantly the signal acquisition and tracking accuracy[1],[2]. 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 (pseudo-satellites) are local transmitters on Earth that transmits GPS like raning signals in order for augment the GPS system for use in locations where satellite signals may be obstructed.[4]

In this paper, we have focused on Generation of C/A code using ICD-GPS-200C Data sheet, explaine the effects of near-far problems and describe the various solutions to overcome near-far Problems, Finally we have acquired GPS/Pseudolite signals using cross-correlation.

Keywords - GPS: Global Positioning System, C/A: Course Acquisition, PL: Pseudolite, Near-Far, AGC, Pulse Blanking.

I INTRODUCTION

The GPS constellation consists of 24 to 32 operational satellites. GPS of US is plays vital role in positioning and navigation and it can be used anywhere, any weather on the earth. For navigation and positioning the GPS receiver must receive at least four GPS satellites' signals to meet all kinds of the location based service requirements[1][2]. However, the satellite signal is sometimes blocked indoors so it is difficult for indoor positioning[2]. 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].

The aim of the paper is to discuss near-far problems and various solutions available for overcome near-far problems. In this we have focused on Sequential Interference Cancellation (SIC) Algorithm, Parallel Interference Cancellation - PIC Algorithm and pulse blanking method. We have focused our research on the GPS Coarse Acquisition (C/A) code it is freely accessed by the civilians.

II Coarse Acquisition Code Generation

The GPS satellite broadcast a microwave radio signal consists of two carrier frequencies L1=1575.42MHz and L2=1227.60MHz, modu-lated by two digital codes and a navigation message[1],[2]. Two GPS codes are called coarse acquisition (C/A code) and precision (P code). 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[2].

According to the signal structure, the PL 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 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[4-6].

In this paper we are not going to discuss C/A code generation in detailed it was well explained by previous research members. Here we have used previous researchers concept to develop C/A code shown in below Fig.1.

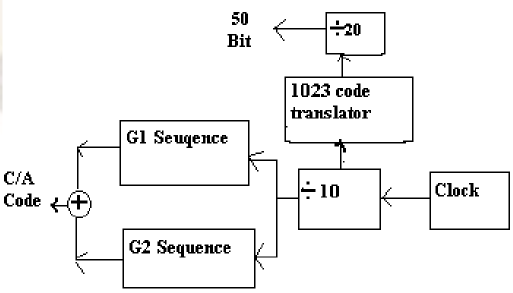

Fig 1: Concept of C/A code Generation

By using above concept we have generated C/A code below Fig 2. It shows characteristics of GPS/PL signal.

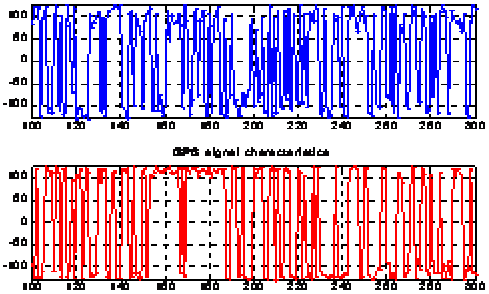

Fig 2: Generated GPS Signal Characteristics

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

III Near-Far Problems

The near-far problem is a situation that is common in wireless comuunication specially in CDMA like GPS/pseudolite integrations system. The near-far problems disturb the GPS/PL communications.

The near-far problem , which occurs due to interference of strong PL signal and weak navigatgion satellite signals over certain range[12]. There are some issues that the dyanamic range of one or more stages of a receiver can limit that receiver's ability to detect a weak signal in the presence of strong signal. The near-far problem usually refers to specific case of this in which ADC resolution limits the range of signals a receiver can detect in direct sequence spectrum system such as CDMA. The receiver AGC must reduce its gain to prevent ADC saturation, which causes the weaker signal to fall into the noise of the ADC. This is different from a condition of one signal interference with another because if the ADC had sufficient resolution, it would be possible to recover both signals[13].

Consider a receiver and two transmitters, one close to receiver, the other far way, if both transmitters transmit simultaneously and at equal powers, then due to the inverse square law the reveiver will receive more power from the nearer tranmitter. If the nearer transmitter transmits a signal that is orders of magnitude higher than the farther trnasmitter then the SNR for the farther transmitter may be low and the farther transmitter may just as well not transmit, This effectively jams the communication channel[13]. Below Fig.3 shows near-far effect on Receiver.

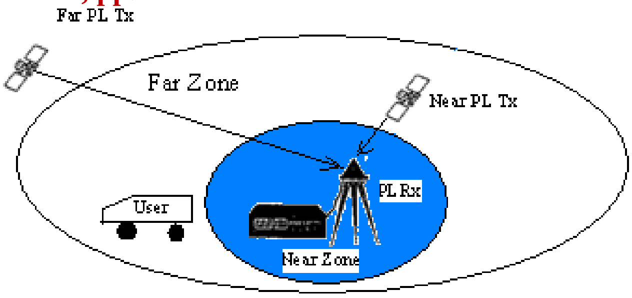

Fig 3: Near-FarProblem

IV Near-Far problem solutions

The near-far problem is commonly solved by dynamic output power adjustment of the transmitters. That is , the closer transmitter use less power so that the SNR for all transmiiter at the receiver is roughly the same.

Other possible solutions for near-far problem:

• Increased receiver dynamic range
•Dynamic output power control
•Adaptive signal Processing
•Sequential Interference Cancellation SIC Algorithm
• Parallel Interference Cancellation- PIC Algorithm
•Pseudolite Blanking etc.,

The existing solutions to the near–far problem can be classified to CDMA, FDMA and TDMA groups. Among them the TDMA is the most superior scheme with the pseudolite signals transmitted in frequent, short, strong pulses. [13].

A. Sequential Interference Cancellation SIC Algorithm

The Principle of sequential interference cancellation (SIC) shown in Fig.4.

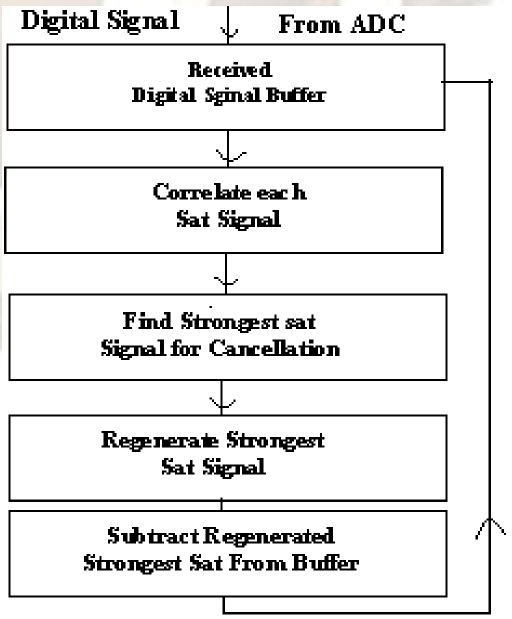

Fig 4: Block Diagram of the Sequential Interference Cancellation

All the Signals are estimated at each iteration of the scheme. The signal with the largest power is then regenerated and subtracted from the buffered received signal.The remaining signals are now re-estimated, and the new strongest satellite signal is selected, regenrated, and subtracted. The process continues until all the signals have been recovered or the maximum number of cancellations is reached. After satellites 1 through k-1 have been removed, the decision statistic for the kth satellite is given by eq(1) [11].

$$Z^k = \int_0^{Tb} r^k(t) a_k(t - T) dt \quad \text{eq (1)}$$

where rk is the received signal after satellites 0 through k-1 have been cancelled, which is given by eq(2) [11]

$$r^k(t) = r(t) - \frac{2}{T_b} \sum_{j=0}^{k-1} Z^k a_k (t - T_k) \cos(\omega + \theta_k t) \quad \text{eq(2)}$$

It has been shown that SIC is very robust to diverse power levels (e.g., Patel & Holtman, 1994). This is due to the strongest satellite signals all being cancelled from the received waveform.

The SIC is considered as one of the simplest forms of MAI-mitigation and near-far resistance receiver structures. However, the algorithm for the cancellation must perform all the cancellations while maintaining the necessary navigation data rate. Obviously, the larger the number of satellite signals, the longer the processing time[11].

B. Parallel Interference Cancellation- PIC Algorithm

The principle of the Parallel Interference Cancellation (PIC) has various stages of operation. In Stage 1, a bank of correlators correlate all the satellite signals received[11]. Then, each satellite signal is estimated and regenerated. In the next stage, a new estimate for each satellite is formed by taking the received signal and subtracting from it all other estimated signals. The first stage of this PIC receiver structure consists of a bank of correlators that are used to generate decision statistics for every bit i for the kth satellite, Zk,i. These decision statistics then generate the estimation of the satellite's signal, s(k). In the next stage, as stated previously, a new estimate for the kth satellite is formed by taking the received signal and substrating from it all s(k) such that j=1, …, N; j≠k. This process may be repeated for a number of stages. Consequently, the received signal at stage s for the kth atellite's signal path is given by eq(3)[11]

$$r_k^{(s)}(t) = r(t) - \sum_{\substack{j=1 \\ j \neq k}}^{k} S_k^{(s)}(t - T_k) \quad \text{eq(3)}$$

The decision statistic for the *ith* navigation data bit of satellite *k* after *s* stages of interference cancellation is then given as eq(4)[11]

$$Z_{ki} = \int_{T+\tau_k}^{(i+1)T+\tau_k} r_k^{(s)}(t) a_k(t - \tau_k) \cos(\omega t + \Phi_k) dt$$

eq(4)

In comparison with the SIC algorithms, the processing time with the PIC algorithms is greatly reduced for the large number of satellites, but its hardware is considerably more complicated than that of the SIC[11].

These two algorithm was Implemeted by using MatLab simulink tool but it need more mathematical operations. In case of GPS/PL integration. among all these methods Pulse blanking or PL blanking is very efficient[11].

V Impact of Pulsed Interference on GPS Receiver

Impact of Pulsed Interference on GPS Receiver The effects of Pulse interference signals on the GPS receivers depend on its characteristics such as pulse width, duty cycle and power. These signals continue to affect the receiver components even during their off state because the active components in the GPS receiver may require recovery period after a pulse to resume their normal operation. Therefore, they tend to saturate the AGC (Automatic Gain Control) and the ADC(Analog to Digital Convertor) in a receiver front-end. As a result, GPS like weak signals cannot be received even in the off state i.e between the pulses. AGC plays a major role in pulsing scheme since it sets a limit on the allowable duty cycle for the pulsing pattern. It is used to provide constant output amplitude irrespective of the signal variations at the input. Generally, AGC is divided into three types, Fast AGC, Slow AGC, and Very slow AGC [12].

A. Fast AGC

A fast AGC reacts very quickly to an incoming pulse, keeping it within the working range of the ADC or at saturation. When the pulse ends, it reacts immediately, setting the thresholds correctly for the satellite signals which are buried below the thermal noise as shown in the Fig. 2. Generally, fast AGC are used for pulsed signals as slow AGC does not respond to low duty cycle. This is because, whenever a strong pulse arrives, the receiver gets saturated by the strong signal. In that case, the fast AGC sets the threshold for the incoming pulse, while resetting the threshold quickly when the pulse ends to receive the satellite signals. Otherwise, the pulse will have an effect for more time on the satellite signal. As a result, both the signals can be received without interference thereby overcoming the Near-far problem[12].

B. Slow AGC

A slow AGC will react in the same way as fast AGC when a pulse occurs, but will not reset the threshold by the time the pulse ends i.e. it reacts slowly. This sets the thresholds too high for proper satellite tracking[12].

C. Very Slow AGC

Where as, in a very slow AGC system, the threshold will be set to a constant level, that is too high for tracking satellite signal in the presence of pulsed pseudolite signals[12].

D. Pulse Blanking

Pulse blanking is the simple suggested method for overcoming the interference caused by pulsed pseudolite signals. Fig. 5 shows the pulse blanker circuitry that is implemented in a receiver after ADC.

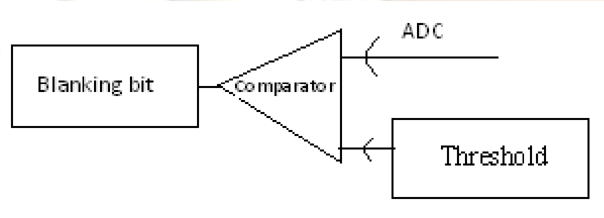

Fig 5: Blanking Circuit

The ADC output is given to a blanker where it compares against a given threshold. When the received signal samples exceeds the given threshold, the blanker replaces signal samples by zero ("blanked") thereby eliminating the pulse interference in the off state . Fig. 6 shows the operation of blanking circuit[12].

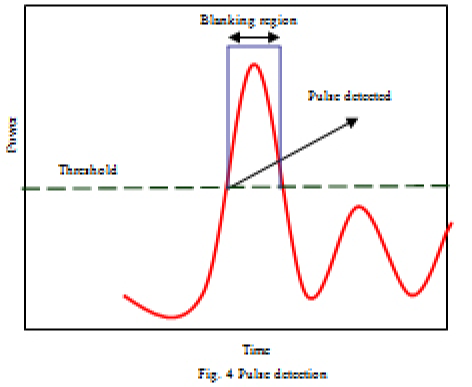

Fig 6: Pulse Detection

The SNR degradation due to perfect blanking for a strong pulsed signal is given by [5].

$$S / N(loss) = 10\log(1 - BPDC) \qquad \text{eq(5)}$$

where BPDC is the duty cycle of the blanking signal.

VI. Signal Acquisition

The acquisition is the first step in receiving the signals. The received signals *s(t)* is a combination of signals from all *n* visible PL shown in eq.(6). In this paper we have used previous research concept to acquire desired signal.

satellites described by $s(t)= s1(t)+ s2(t)+\ldots+ sn(t)$. (6)

When acquiring the GPS and pseudolite signal the incoming signal *s* is modulated by the locally generated C/A code corresponding to the GPS pseudolite signal. The cross correlation between C/A codes for different Pseudoliteso 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. The correlation process without pulse blanking is shown in Fig 7.

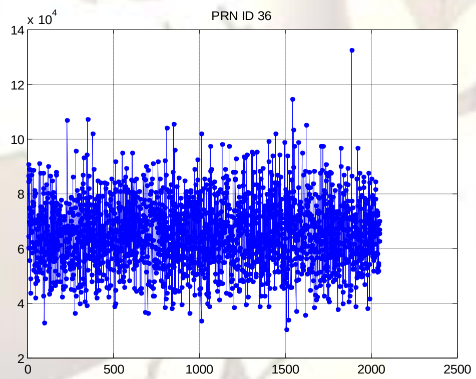

Fig 7: Acquisition of GPS signals with out pulse blanking

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

For acquisition of GPS and pseudolite signal we have used Mat-lab tool. And PRN of the GPS and pseudolite was set for PRN1 to PRN32 and PRN36 respectively as shown in below Fig 8 and Fig 9.

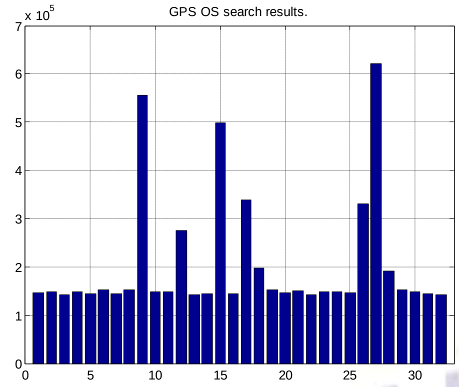

Fig 8 : Acquired GPS PRN1to PRN32 without pulse blaning

Fig 9:Acquired PL PRN36 without pulse blaning

In case of Pulse blanking is used in GPS/Pseudolite Integration system the obtained results is shown in Fig.10 [4].

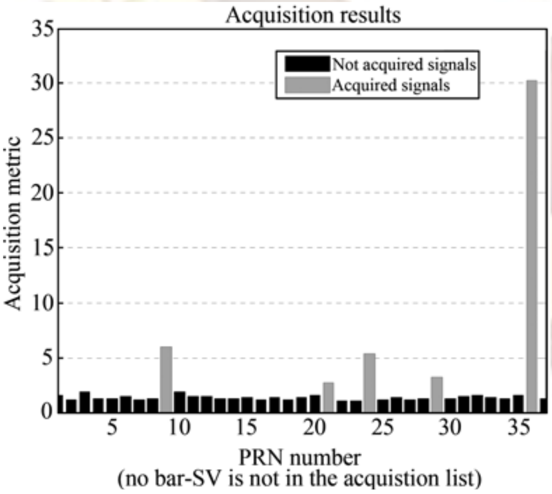

Fig 10: Acquired GPS/PL signal with pulse blanking

VII. Conclusion and Future Work

In this paper we have Generated C/A code of PRN 1 to PRN32 of GPS and PRN36 of PL , Modulated with the help of BPSK modulator and Estimated Near-Far Problems. To compensate this near-far Problem on received signal We have explained various techniques availalbe, Finally obtained desired signal by Correlating the received signal with reference signal.

In this paper we have discussed only near-far Problems but in Indoor Environment there are another problems such as multipath effects and Inter symbol Interference. The future work for this paper is to develop new Architecture for compansate Indoor Channel Fading Effects and designing Sufficient Filter to Reduce noise power so that we can locate Centimeter or millimeter level positioning.

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