Software Defined GPS

FUNCTIONAL REQUIREMENTS LIST AND PERFORMANCE SPECIFICATIONS

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November 11, 2008

Introduction

The Global Positioning System (GPS) consists of 32 medium earth satellites broadcasting on two different frequencies. The broadcasting frequency examined in this project will be the civilian L1 frequency which operates at 1575.42 MHz. The data sent includes the ephemeris data for calculating satellites' flight paths, satellite identification number also known as coarse/acquisition (C/A) code, and satellite health statistics. Using the delay from different satellites earth-centered earth fixed coordinates are found by solving for X, Y, and Z. If a receiver clock is not aligned with a satellite clock, then an incorrect delay time will be used for the calculation. Thus time bias is to be resolved. To solve for these four variables(X, Y, Z and time bias), a minimum of 4 satellites is needed.

This project is to explore Global Positioning System (GPS) algorithms that can run on an x86 Personal Computer (PC). One of the major reasons for this is that current hardware implementations use algorithms that work for the general case. Software allows for switching between algorithms depending on the received signal strengths. For example, the signals received from the satellites will be different depending upon surrounding environment. An area surrounded by buildings will have multipath effects that an open field will not. Also if a receiver is traveling then the Doppler Effect on frequencies needs to be accounted for.

This project is a continuation of last year's project by Tony Corbin. The previous project was successful in determining position however was unable to provide continuous updated positions.

The algorithms areas to be explored will include signal conditioning, satellite acquisition, and satellite tracking loops. Open source code libraries will provide the position, and velocity calculations from the tracking loops data.

Goals

The goals of this project are:

- Use received GPS L1 signals to determine position using a PC.
- Provide continuous GPS solutions in real time.
- Compare different GPS algorithms.
- Cost benefits of software defined GPS vs hardware receivers.

High-Level Block Diagram

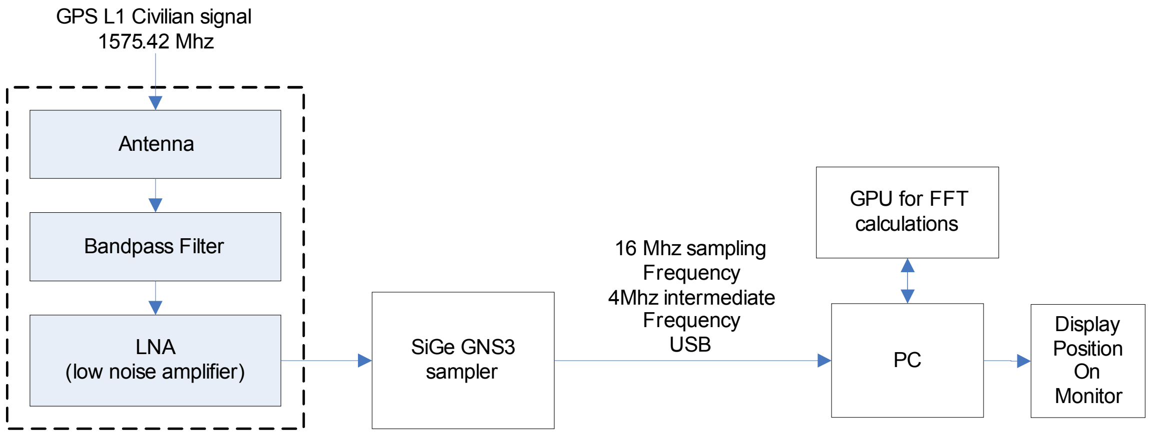

Figure 1 High level block diagram

Figure 1 displays the high-level block diagram for this project. GPS L1 signals are received through the Antenna stage. The SiGe GNS3 sampler takes the signal from the antenna and down converts it to an intermediate frequency (IF) of 4 MHz. The SiGe then samples the analog IF frequency at a rate of 16MHz and transmits the data to a USB port on a pc. The PC will then perform algorithms on the incoming data to determine position, and display such data. The GPU is used to assist in the signal processing.

Software Processing

The software for this project is shown in Figure 2. The software searches for satellites in the acquisition phase, tracks the satellites as they move, and provides a position estimate once enough data is collected from the tracking loop. In order to obtain continuous updates the software then returns to the tracking loop.

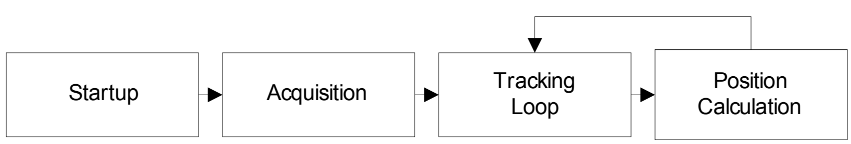

Figure 2 High level overview of the software

Software Requirements

From Figure 1, the incoming data to the PC is 16 MHz. Each sample is stored as a signed 1 byte character. The software must be capable of storing and processing 15.26 megabytes per second (MBps) of data if real time operation is to be achieved.

From Figure 2, the Acquisition stage must be fast enough to allow the tracking loop to process the accumulated data from acquisition, and continue on tracking live data. The acquisition stage requires at a minimum 20 ms of data to be read in order to find a satellite. This stage should last no more than 20 seconds in order to find a minimum of 4 satellites.

The tracking loop from Figure 2 must be able to process a navigation bit in less than 20ms as navigation data is sent at a rate of 50Hz. The tracking phase will provide recovery time to process data accumulated from the acquisition phase.

$$3x10^{8}\, m/s * \frac{1}{4.0932Ms} = 73.31m$$

Figure 3 Calculation of range Error

The error in position calculation is determined by multiplying the speed of light by the time between IF samples. As seen in Figure 3 the position range will have an error of approximately 73 meters. Other factors such as clock drift, atmospheric effects, rounding errors, and satellite flight path errors will further affect this. An overall range error of 100m is targeted.

The display block in Figure 1 will provide updates every minute to the user. It will also be in a graphical user friendly format.

Conclusion

This project will make use of existing software defined GPS project as a starting point and expand upon it. Several of the core algorithms used will be modified inside of the existing project. Understanding of communication theory, GPS communication scheme, and programming are all needed to accomplish this project. This project will provide further insight into these areas.

References

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