Design and Implementation of a GPS Receiver

Functional Description and Complete System Block Diagram

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Introduction

The goal of this project is to explore the possibility of developing a GPS receiver using a software solution. In developing a receiver two possibilities exist:

1. Hardware-Based Design
    - Hardware chipsets are available from a number of suppliers including SiRF and Magellan. The hardware chipsets perform the correlation and signal acquisition. Most chipsets use an RS-232 interface supporting the NMEA command set.
2. Software-Based Design
    - Recently, chipsets have become readily available which sample and down-convert the C/A (Coarse-Acquisition) code. The sampled data can then be processed in software using various techniques.

This project will focus on the software-based design approach considering the hardware-based design a contingency. The contingency is necessary as obtaining the equipment required for the software-based design is difficult due to its recent availability.

Goals

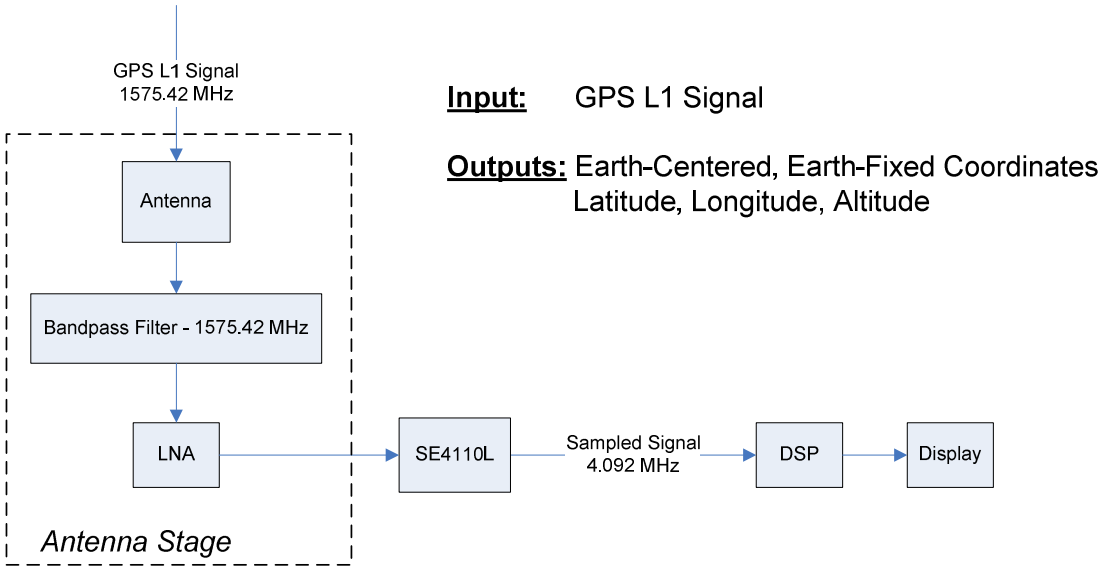
The goals of this project are described in detail below. The ultimate objective is to compute the user's position in real-time, while the rest of the objectives serve to make that goal achievable.

- Implement a software GPS L1 signal model
- Develop a software-based GPS receiver model for processing a sample input dataset
- Implement the model in a high-level language such as C or C++
- Process the raw data using an embedded system or DSP kit using the model developed
- Connect the embedded system or DSP kit to a sampling device and perform satellite signal acquisition
- Compute position in real-time

High-Level Block Diagram

Figure 1, below, shows the high-level block diagram for the project. The GPS L1 signal will be received through an active GPS antenna. After the antenna stage, the SE4110L chipset will be used to sample and down-convert the signal. A DSP kit will then perform software processing and display the results.

Figure 1 – High-level Block Diagram



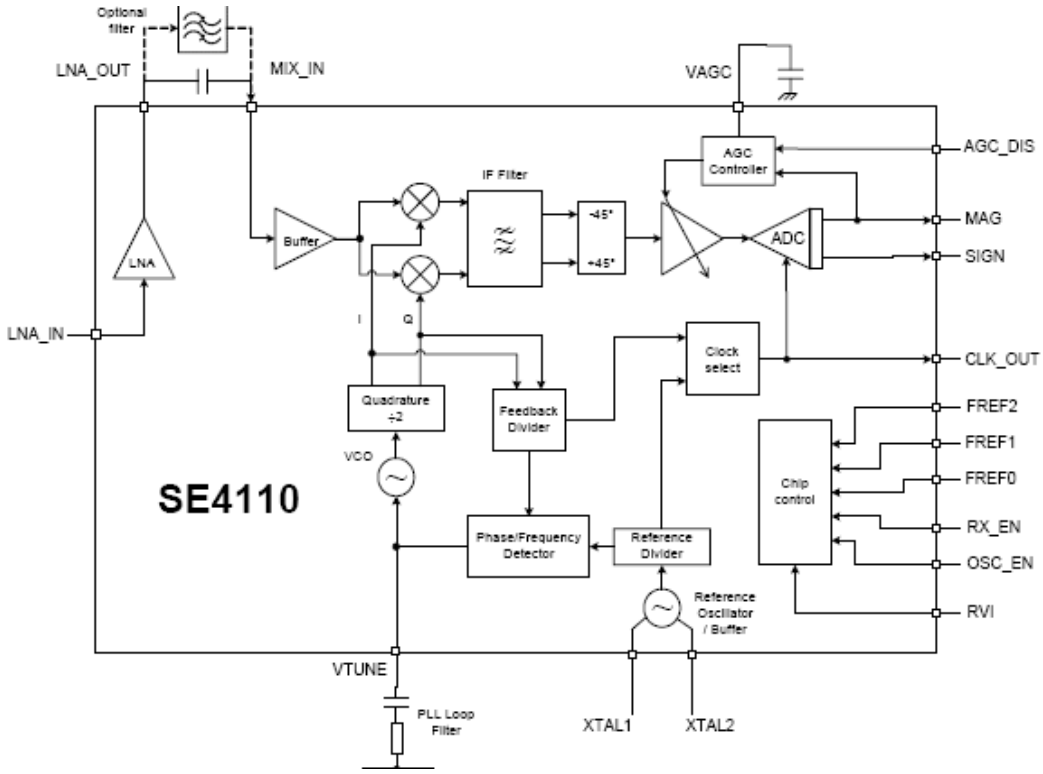
Antenna Stage

Active GPS antennas are available from a variety of manufacturers and include at a minimum a low-noise amplifier and a bandpass filter. An active antenna is necessary due to the low transmit power of GPS satellites and the degradation and attenuation of the signal as it goes through the atmosphere.

SE4110L

The SE4110L is a complicated chipset consisting of a several sub-stages. The subsystems are very similar to those of a superheterodyne receiver with the addition of a high-frequency A/D converter. The device outputs the magnitude and sign of the received signal at 4.092 MHz. [2]. Figure 2, below, the functional block diagram from the SE4110L datasheet. Functionally, the SE4110L will provide the digitally sampled GPS L1 signal to the DSP.

Figure 2 – SE4110L Functional Block Diagram [3]



DSP Kit

A Spectrum Digital DSP Development System will be used for signal processing. The development board is based on a TI C6000 DSP, which is capable of hardware floating-point operations. The DSP is clocked at 225 MHz, which should provide adequate processing power. The DSP will be used for most of the software operations and hardware interfacing.

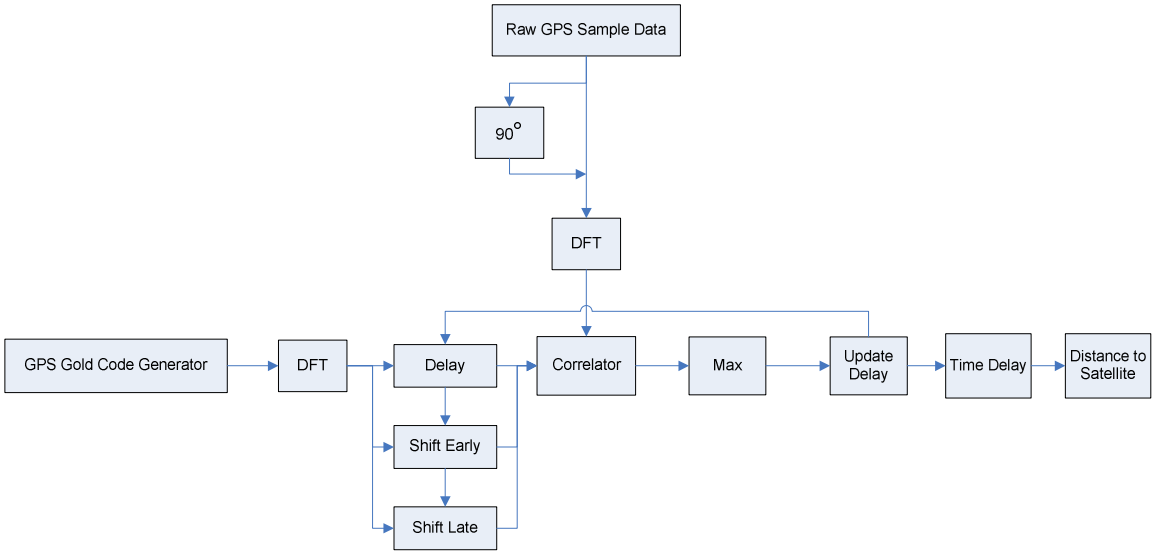
Software Processing

The bulk of this project involves software processing of the sampled signal data. Figure 3, below, shows a modification on the basic scheme as used by Kai Borre et al. for calculating the time delay in the signal. [1] The software will work by performing a discrete Fourier transform (DFT) on the input signal and comparing it to a similar signal generated by a C/A PRN sequence generator.

Various delays are then applied to the C/A code sequence and each is correlated to the input signal. The highest correlation value is then used to adjust the delay. The delay can then be used to determine the distance to a satellite.

Several of the blocks shown in Figure 3 must be used in parallel in order to process the signals from multiple satellites.

Figure 3 – High-Level Software Flowchart [1]



Conclusion

This project contains many challenges which can be foreseen and many more which cannot. Nonetheless, this project will provide insight into the practicality of software-based GPS systems as well as their accuracy.

References

[1] Kai Borre, Dennis M. Akos, Nicolaj Bertelsen, Peter Rinder, and Soren Holdt Jensent, *Software-Defined GPS and Galileo Receiver : A Single-Frequency Approach.* Birkhauser: Boston, 2007, p. 83, 105.
[2] SiGe, SE4110L-EK1 Evaluation Board User Guide.
[3] SiGe, SE4110L Datasheet.