Senior Capstone Project:

GPS Signal Simulator Project Proposal

by
Benjamin Herreid and Anthony Hoehne

Advisor: Dr. In Soo Ahn

November 29, 2005

Summary

This project involves the development of a GPS signal simulator capable of driving a GPS receiver. The user can supply a receiver trajectory and starting location, an antenna gain pattern file, a GPS almanac file, and the date and time. These selections will be made using a GUI on a PC, and the PC will then communicate with a DSP board. The DSP board, in combination with an up-conversion mixer, will generate an analog GPS signal such that a receiver will track the specified locations and times.

Project Description

Functional Description

The purpose of this system is to generate a simulated GPS signal based on user inputs, which will be entered using a GUI on a PC. There are several inputs for the system, as shown in Table 1. The only output is the simulated GPS signal.

Input	Source	Description
Date and Time	GUI input	
Starting Location	GUI input	ECEF or Geo coordinates
Trajectory	Frame File	Specified in durations and magnitudes of jerk (3rd derivative) in roll, pitch, yaw, and thrust axes
GPS Almanac	Almanac File	RINEX2 format navigation file
GPS Antenna Characteristics	Antenna File	Antenna gain in dB specified for given azimuth and elevation angles

Table 1 - System Inputs

There are two modes of operation. The first mode is when the user is entering information into the GUI and setting up a simulation. Then the user will start the simulation and enter the second mode. In this mode the system will be running and generating a GPS signal. It will continue in this mode until the user cancels the simulation or the simulation ends, at which point it will return to the first mode.

System Block Diagram

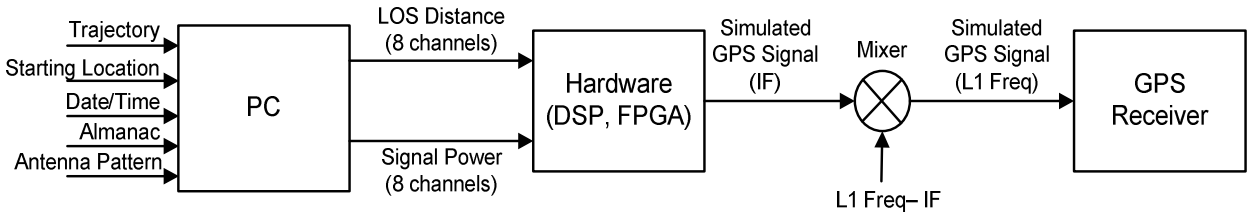

Figure 1 – System Block Diagram

A high-level system block diagram is shown in Figure 1 and explained in the following sections.

PC

The primary input to the PC is a frame file that contains a receiver trajectory in terms of duration of jerk in 4 axes: thrust, roll, pitch, and yaw. This data is passed through several programs and stored in several intermediary files, as shown in Figure 2. Two files are used to generate the output from the PC to the DSP. These are the phase file and the VIS file, which contain the line of sight (LOS) distance and the signal strength for each satellite. All of these programs have already been supplied by Tracking and Imaging Systems, Inc. A GUI will be developed for the user of the GPS Signal Simulator which calls these programs automatically. Additional inputs to the process include an antenna pattern file and almanac file, which will be selected or supplied by the software user. This software will also be responsible for selecting the best set of 8 satellites to send to the DSP board, and maintaining the PC half of the communication link between these systems.

Hardware

Figure 3 shows the software flowcharts for the hardware portion of the system. There will be a 2 kHz interrupt that retrieves the next values of distance and amplitude for each channel from the PC. The primary interrupt will run at the D/A sample rate which should be at least 5 MHz to meet the sample rate requirements for the GPS signal. For each sample the current distance and amplitude will be interpolated, then used to calculate the current value of the output. The inclusion of the GPS Navigation Data is shown with a dashed line because it is an optional portion of the product which will be implemented if time permits.

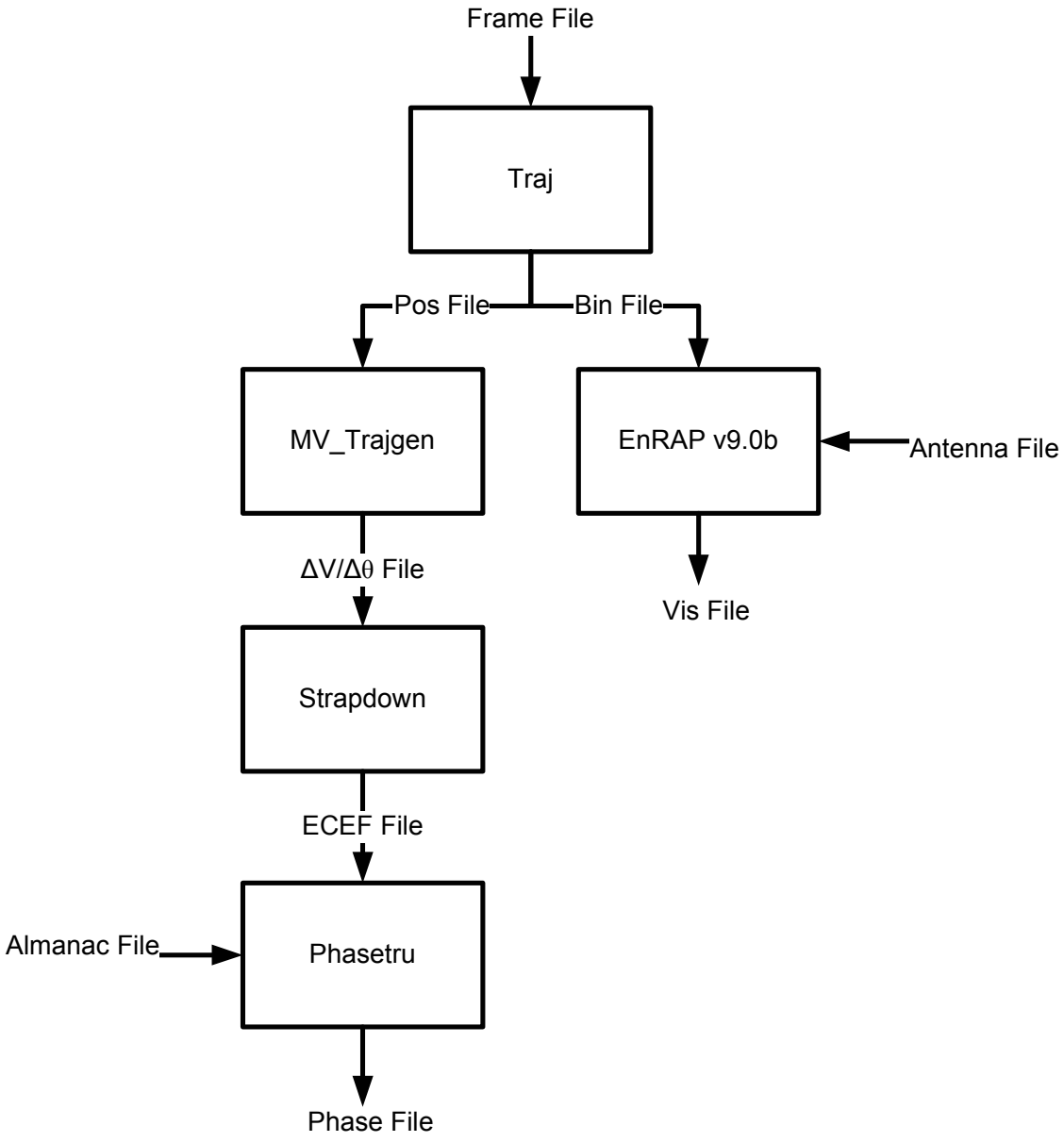

Figure 2 - PC Data Path

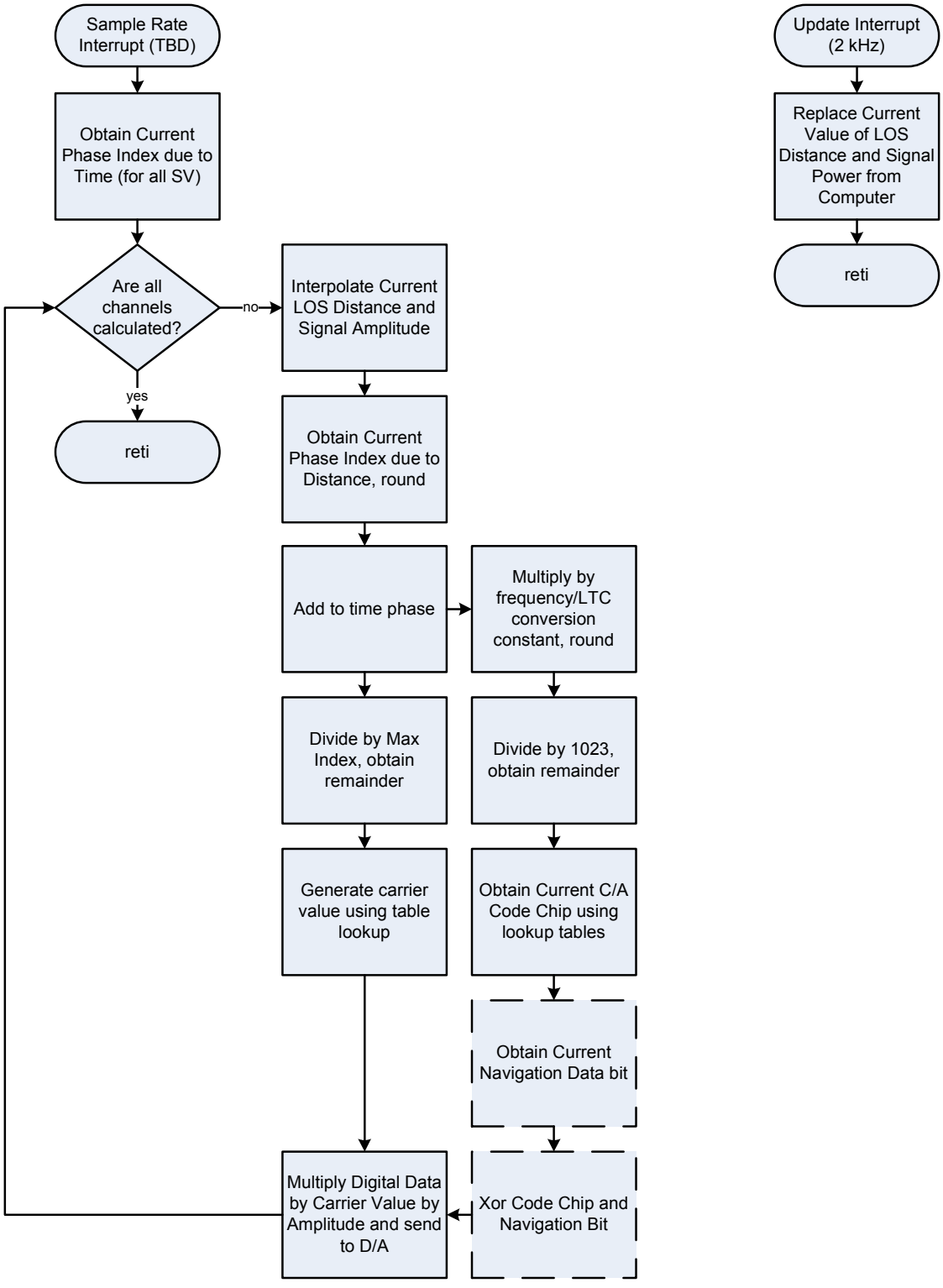

Figure 3 - Software Flowcharts for the Hardware Subsystem

Standards and Patents

RINEX2 Data Format

The almanac file that is input to the system is in RINEX2 format. Details of this specification can be found at http://www.ngs.noaa.gov/CORS/Rinex2.html.

Serial/Parallel Communication

The interface between the PC and hardware will need to follow a set communication protocol. One possible standard is EIA232, a serial communication standard. Details of this specification can be found at http://www.camiresearch.com/Data_Com_Basics/RS232_standard.html.

Project Specifications (Datasheet)

There are two specifications, labeled Plan A and Plan B. Plan A represents a fully valid GPS signal capable of driving a receiver. If this becomes unrealizable with the available time and equipment, we will revert to Plan B, which is a relaxed specification.

Specification	Plan A	Plan B
Chipping Rate	1.023 MHz	102.3 kHz
Carrier Frequency	1.575 GHz (L1)	1.575 GHz (L1)
Navigation Data Rate	50 bps	50 bps
Number of Channels	8	4
Range of Power	±20dB	±10dB
Positioning Accuracy (Note 1)	10m	10m

Note 1: Positioning Accuracy is primarily determined by the accuracy of the GPS receiver. However, there is an error component due to the simulated signal, which will not be greater than this value.

Schedule

Lab Date	Benjamin Herreid	Anthony Hoehne
Jan 19	Evaluation of Technologies	
Jan 26		
Feb 2	GUI Programming	Hardware Programming
Feb 9		
Feb 16		
Feb 23		
Mar 2	Communication between PC and Hardware	
Mar 23		
Mar 30	Mixer/Oscillator Design	
Apr 6	Testing	
Apr 13		
Apr 20	Preparation for Presentation	
Apr 27	Final Presentation	

Bibliography

[1] L.W. Couch, "Digital and Analog Communication Systems" 6th ed. Upper Saddle River, New Jersey: Prentice Hall, 2001.

[2] P. Misra and P. Enge, "Global Positioning System: Signals, Measurements, and Performance" Lincoln, Massachusetts: Ganga-Jamuna Press, 2004.

Equipment List

Part	Part Number	In-Stock
PC	N/A	Yes
DSP Board	TMS320C6713 (TI)	Yes
Interface Board for DSP		Possibly
D/A Converter	???	No
Up-Conversion Mixer	???	No
Oscillator	???	???
GPS Receiver (for testing)	Ashtech ???	Yes