Session 1547

USING LOW COST GLOBAL POSITIONING SYSTEM (GPS) RECEIVERS TO TEACH INTERFACING

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ABSTRACT

One of the objectives of the junior and senior courses in Avionics at Parks College is to provide the students with practical design experience. One recent approach to this objective uses low cost (under $500) marine GPS Receivers, a digital storage scope, a laptop computer, and some simple circuitry.

One of the main objectives of the series of the design exercises and associated lab experiments is to provide experience in designing with serial data bus interfaces such as:

The National Marine Electronics Association (NMEA) 1803, commonly used with GPS and other marine navigation systems,

The RS232 standard commonly used with PC Com ports and

The Aeronautical Radio INC (ARINC) 429 serial avionics data bus.

This paper presents and interprets some of the waveforms captured by a digital storage scope for a series of interfacing experiments. The experiments, spread over junior and senior courses in Avionics, utilize the PC COM port to acquire data from various equipment..

INTRODUCING INTERFACE DESIGN

The following characteristics are judged to be desirable characteristics for design problems and associated lab experiments:

are within the capabilities of the students and their available time,
have sufficient interest to challenge the student's creativity,
are inexpensive and,
utilize equipment and instrumentation which is readily available,

The design experiments which will be described in this paper using inexpensive hand held GPS receivers satisfied all of the above criteria. The overall goal of the series of experiments is to characterize GPS and integrate a GPS receiver into an avionics system. The experiments which are now part of the Avionics II Lab, were broken down into the following steps to achieve this goal:

Characterize the two available hand held units in terms of finding locations and navigating to them,

Characterize the GPS environment (satellite locations and signal strength)

Characterize the interfaces of each of the receivers, Design diagnostic and simulation software for interfacing each of the receivers to a Personal Computer (PC).

CHARACTERIZING THE GPS RECEIVERS

Table I compares the characteristics of 2 GPS receivers used in the lab experiments.[1,2]

The objective of the first experiment (finding locations and navigating) was achieved by taking the two receivers on a tour of the campus and recording latitude, longitude elevation information and trying out the various navigation displays. The experiment was performed on a bright sunny fall day and was one of the most popular experiments in the course.

CHARACTERIZING THE GPS ENVIRONMENT

The purpose of this experiment was to become familiar with the orbital characteristics, the coverage and signal strength and geometry of the satellite constellations.[3,4] Figure 1 is a plot of the difference between the predicted Azimuth and Elevation and Azimuths and Elevations obtained from the Magellan units connected to the Parks College roof antennae. The predicted values were obtained from the web site http://sirius.chinalake.navy.mil/cgi-bin/satpred-query. The predictions are based on user inputs of site Lat and Lon and altitude together with the desired date and time.

CHARACTERIZING THE NMEA INTERFACES

The Department purchased bare wire interface cables for each of the receivers with the appropriate connectors and these were used to collect data on the electrical signal characteristics of the NMEA interface for each of the GPS receivers. This experiment pointed out some differences between the two Magellan NMEA interfaces. Figures 2 and 3 show oscilloscope traces for the MAP 7000 and the Trailblazer III XL (TBIII) NMEA signals.

The significant difference between the 2 receivers is that the MAP 7000 falls in to the RS232 category (it has a +/- 8.5 volt swing) as well as conforming to NMEA allowable voltages, while the TBIII voltages are 0 and 5 volts. The ensuing discussion regarding RS232 and NMEA led to the next experiment, an examination of the NMEA sentence structure.

DESIGNING DIAGNOSTIC SOFTWARE

To answer the question “do the pulses observed on the scope at the NMEA interface represent NMEA sentences?” a simple BASIC program was written for the laptop PC. Since the MAP 7000 output is RS232 and since the NMEA sentences are in ASCII, the program had only to display on the PC screen the data coming in the COM port of the PC. After determining that the MAP 7000 was indeed sending meaningful NMEA sentences, a simple modification to the BASIC program was made to record the data to disk. Since the data is in ASCII, it can be inserted in a wordprocessor and printed. Since the data is comma delimited, similar to the waveform files obtained from the Fluke oscilloscope, it can also be imported into a spreadsheet. Table 2 shows a sample of the NMEA sentence data recorded by the BASIC program.

DESIGNING SIMULATION SOFTWARE

The students became interested in using the GPS NMEA data to make a moving map display. A search on the World Wide Web found mapping software compatible with GPS NMEA data. The interface with the map program(AAA Map N Go), however, did not proceed as quickly as the basic PC to GPS interface. One of the reasons might be that the lab experiments were being performed using a stationary rooftop antenna or that the map software required a different combination of NMEA sentences or timing. The problem, however, provides an ideal spot at which to introduce the role of simulation in design and debugging.

A BASIC program (Figure 4) was used to send arbitrary sequences of GPS NMEA data from the COM port of one PC to the COM port of another PC using a null modem cable and the BASIC program used for displaying and recording the NMEA sentences.

Figure 5 shows a block diagram of how the simulation program was checked out.

Having checked out the simulation, the tools are now available for simulating motion and determining what combinations of sentences from the GPS are required for input to the mapping program.   At this point, however, the experiment was ended and the next objective of interfacing to an avionics system via the ARINC 429 bus was considered.

DESIGNING AN INTERFACE FOR AN AVIONICS SYSTEM

Prior to taking Avionics II, the students take a course, Avionics I in which the emphasis is on digital data communications[5]. In Avionics I the students perform lab experiments where they characterize the ARINC 429 Data Bus by generating ARINC 429 messages with a JCAir 429 transmitter and record voltage waveforms using a Digital Storage Oscilloscope (DSO). Figure 6 shows a typical ARINC 429 waveform.

The students also characterized RS232 signals using a PC Com port as the source of the RS232 signal and performed conversion from RS232 to TTL and vice versus using line driver and receiver chips (1488 and 1489). The same chips can be used to convert the Line A and Line B ARINC 429 signals to TTL levels and from there combinational logic can be used to extract the ARINC clock.   The JCAir Electronic Flight Instrumentation System (EFIS) Test set and a Bendix EFIS 10 were used to check ARINC 429 messages by observing the VHF Omni Ranging (VOR) and Distance Measuring Equipment (DME) indicators on the EFIS when it was displaying the data coupled to the bus from the JCAIR ARINC 429 generator.

Conclusions

At this point the students have achieved the goals set for the project with the exception of converting the GPS NMEA signals to ARINC 429 . Since they have, in the previous course, already formatted ARINC 429 words and converted TTL to ARINC 429, the remaining part of the project should be within the student's grasp. The major problem left will be software to extract the VOR and DME parameters from the NMEA GPS sentences and formatting the ARINC429 words. There is one other hurdle to overcome and that is the timing of the serial ARINC 429 pulses coming out of the PC Parallel Port. One possibility for handling this problem is the use of a microcontroller with the PC to perform the timing. The students have completed a course in microprocessors using the Motorola 68HC11 so they should be able to handle the remaining task to complete the integration of a hand held GPS receiver into an avionics system. These experiments are underway.

Magellan MAP 7000 GPS Receiver	Magellan Trailblazer III XL
Battery or external power operation	Battery or external power operation
Removable antenna	Removable antenna and optional remote antenna
Airport and NAVAID data base in memory	User Landmark memory (no airport/NAVAID database
Satellite Status Display showing relative signal strength and which satellites are being used for location determination plus polar display of satellites in view by Space Vehicle (SV) number	Satellite Status Display showing relative signal strength and which satellites are being used for location on a polar display (no identification by Space Vehicle (SV) number
Various navigation displays on a small LCD screen	Various navigation displays on a small LCD screen
Static simulation of the navigation displays (no motion)	Dynamic simulation of the navigation displays (motion between 3 simulation landmarks at 2.5 miles/hr.)
..Menu selection of various units for distance and speed and NMEA output options.	..Menu selection of various units for distance and speed and NMEA output options

TABLE 1 GPS CHARACTERISTICS

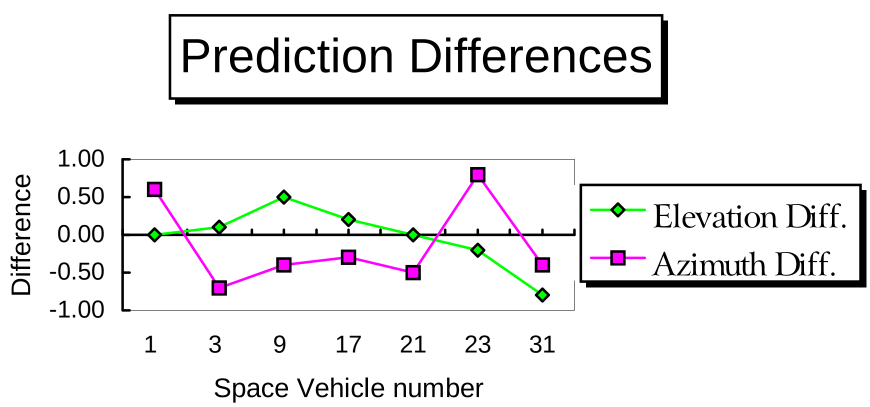

Figure 1 Comparison of Predicted and Reported GPS Satellite Locations (J-C Grimaud)

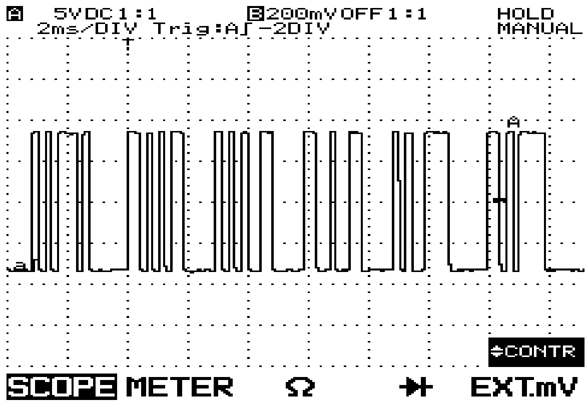

Figure 2 Magellan MAP 7000 NMEA 0183B (Aaron Maue)

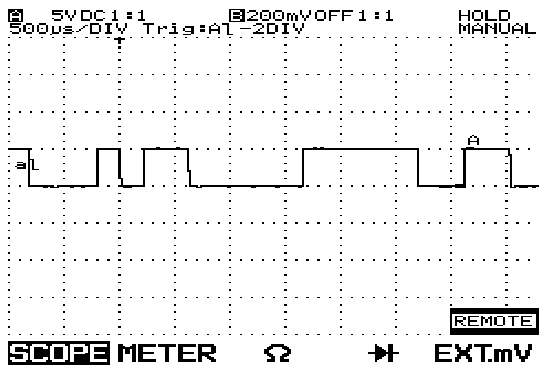

Figure 3 Magellan Trailblazer III XL(Maxwell Ntshupi)

NMEADAT1.WK4

```
$GPGLL,3838.213,N,09013.780,W,213443.848,A
$GPGGA,213443.85,3838.213,N,09013.780,W,1,04,02.73,00227,M,-0033,M,    ,
$GPVTG,203.,T,203.,M,00.2,N,00.4,K
$GPGLL,3838.213,N,09013.780,W,213445.848,A
$GPGGA,213445.85,3838.213,N,09013.780,W,1,04,02.73,00228,M,-0033,M,    ,
$GPVTG,203.,T,203.,M,00.3,N,00.6,K
$GPGLL,3838.212,N,09013.780,W,213447.848,A
$GPGGA,213447.85,3838.212,N,09013.780,W,1,04,02.73,00228,M,-0033,M,    ,
$GPVTG,204.,T,204.,M,00.3,N,00.5,K
$GPGLL,3838.212,N,09013.780,W,213449.848,A
$GPGGA,213449.85,3838.212,N,09013.780,W,1,04,02.73,00228,M,-0033,M,    ,
$GPVTG,204.,T,204.,M,00.3,N,00.5,K
$GPGLL,3838.211,N,09013.781,W,213452.848,A
```

Table 2 NMEA Data Recorded and imported in to Spreadsheet (Jeff Kahn)

GPS Simulator Program
Modified by Greg Trigg 10/97

```
5   REM GPS SIMULATOR PROGRAM GPSIMNM.BAS - JOHN CREMIN, 6/25/97
6   REM MODIFIED LORAN SIM PROGRAM BY WAYNE SIMPSON, 1991
8   DEFINT A-Z
10  OPEN "COM2:4800,N,8,1,RS,CS,DS,CD" FOR OUTPUT AS #1
15  REM SETUP RS232 TO PARAMETERS AND DISABLE REQUEST TO SEND
100 A$ = "GPGLL,3838.213,N,09013.780,W,213443.848,A"
```

```
110 B$ = "GPGGA,213443.85,3838.213,N,09013.780,W,1,04,02.73,00227,M,-0033,M,,"
120 C$ = "GPVTG,203.,T,203.,M,00.2,N,00.4,K"
200 PRINT A$
205 PRINT #1, A$
210 PRINT B$
215 PRINT #1, B$
220 PRINT C$
225 PRINT #1, C$
300 FOR I = 1 TO 12000
303 FOR J = 1 TO 30
306 NEXT J
310 NEXT I
320 GOTO 200
330 REM LINE 300 PROVIDES THE 2 SEC. REP RATE
340 REM LINE 320 REPEATS THE TRANSMISSION OVER AND OVER
350 REM USE CTRL-BRK KEYSTROKE TO TERMINATE TRANSMISSION
360 END
```

Figure 4 GPSIMN.BAS NMEA Sentence Generator

Block Diagram of Simulator

Greg Trigg 10/97

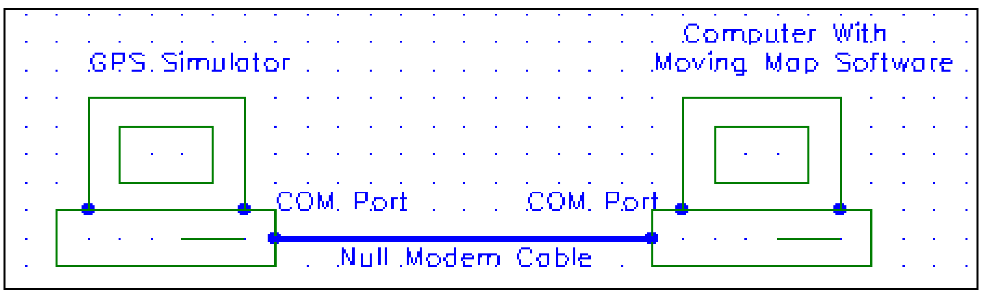

Figure 5 Simulation Checkout Block Diagram

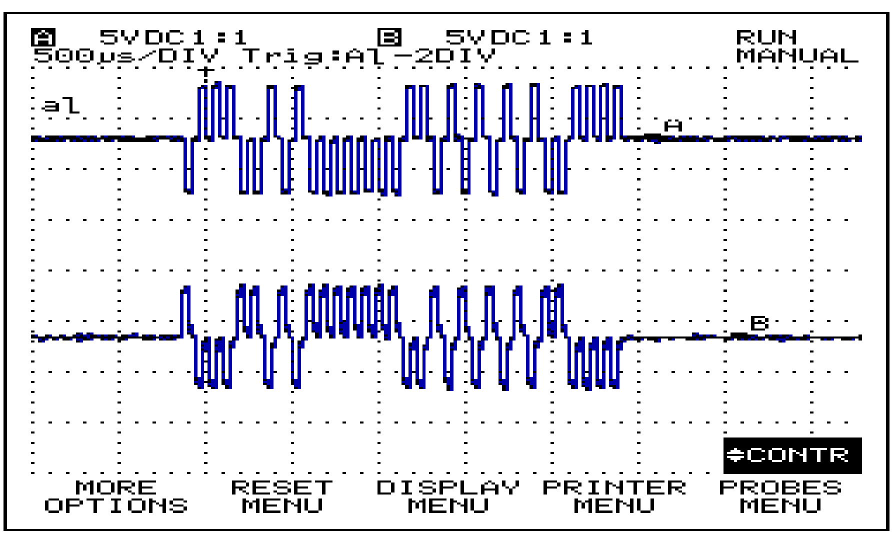

Figure 6 ARINC 429 Data Word F2AB014Ehex

ACKNOWLEDGEMENTS

The author appreciates the work done by the students in the Avionics II Lab. Their hard work resulted in the success of this experiment so far. Each of the students worked on one particular aspect of the experiment and also as a group to make the project work. The contributors were:

Jean-Christian Grimaud
Jeff Kahn
Aaron Maue
Maxwell Ntshupi
Greg Trigg

The author also appreciates the equipment grant provided through the Parks College FAA Program, Paul McLaughlin Director. The grant provided the Trailblazer III XL equipment.

The Magellan MAP 7000 was graciously loaned to the project by Mel Doerhoff of the Parks College Aircraft Maintenance Engineering Program in the Aerospace Technology Department. Mel also provided one of his classes as an audience for the student presentations on the experiment and the AAA Map N Go mapping software.

REFERENCES

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