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Generating Low Cost Serial Waveforms For Global Positioning System (GPS) Applications

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Abstract

The purpose of this paper is to present a number of techniques for generating serial waveforms associated with the Global positioning System (GPS) in a laboratory environment. The incentive for this project was the need for simulating GPS data in a lab environment. The waveforms of interest are the output data signals provided by GPS receivers and used by applications such as navigation computers, autopilots, street atlas software, and Differential GPS (DGPS), a system for improving the position accuracy of GPS receivers.

Introduction

A previous paper [1]described the use of low cost GPS receivers to teach interfacing. One of the formats described was the National Marine Electronics Association (NMEA) format. Examples of the format using a Magellan Trail Blazer XL (TBXL) NMEA interface were presented. The paper also described a simulation for the NMEA GPS messages. In addition to the NMEA interface for outputting navigation data, the TBXL has an interface for accepting differential corrections[2] to the internal position data. This interface uses an RTCM SC104, (Radio Technical Commission Maritime) standard for DGPS data broadcast by the US Coast Guard and other services, some of them commercial. In order to explore other applications for the GPS receiver, documentation of the interface characteristics for the NMEA, ARINC 429 and the RTCM interfaces is required.

To understand where these interfaces occur in the larger system context, Figure 1 was generated. The TBXL falls in the category labeled Airborne/Marine GPS Receivers. Using signals from the GPS satellites and error correction signals from an Airborne/Marine DGPS Receiver, the TBXL can internally correct errors in the measurement of range to the satellites, which the TBXL uses to triangulate its position. The range errors, which can be corrected by the DGPS capability in the TBXL, are errors detected by the DGPS Ground System shown in Figure 1. The DGPS calculates range errors by comparing the ranges to the GPS satellites using its own GPS receiver and then calculating the ranges from the surveyed location of the receiver on the ground. The ranges from the surveyed site to the GPS satellites can be calculated because the locations of the satellites are transmitted along with the information used to determine range by the GPS receivers. The assumption is that the range errors experienced at the surveyed DGPS site will be about the same as Airborne/Marine GPS Receivers in proximity to the DGPS site. Typically, the errors are broadcast by a marine beacon, hence the need for an Airborne/Marine DGPS receiver with the Airborne/Marine GPS receiver.

Figure 2 shows where the NMEA, ARINC and RTCM interfaces are located relative to an Airborne/Marine GPS Receiver, an Airborne/Marine DGPS Receiver, and equipment using The GPS navigation data. The following sections of this paper will expand on the interfaces shown in

NMEA and Aeronautical Radio Inc (ARINC) 429 Formats

Reference 1 presented oscilloscope data showing the NMEA and ARINC 429 waveforms as well as a program listing of a QBASIC program for simulating data for an Electronic Flight Instrumentation System (EFIS). Figure 2 shows in block diagram form where simulations require waveforms for the NMEA and ARINC interfaces. Table 1 summarizes the waveform characteristics of the interfaces.

Interface Type	Waveform Type
NMEA 0183	Unipolar, 0 to 5v observed on TBXL and Garmin 100. May also be Bipolar and differential per the Standard
ARINC 429	Differential, Return to Zero (RZ), +/- 5v

Table 1 Characteristics of NMEA and ARINC 429 Waveforms

The following low cost techniques can be used to implement NMEA 0183 waveforms:

Using a Personal Computer (PC) a BASIC program can generate the ASCII characters which make up the NMEA sentences. Timing is achieved by selecting a COM port baud rate matching the equipment shown in Figure 3

The desired ASCII bit patterns can be stored in an EEPROM and clocked using a counter and clock.

The following technique was used to generate an ARINC 429 waveform:

An arbitrary Function Generator programmed using a spreadsheet can provide the 32-bit RZ waveform. A Hewlett Packard HP33120A Arbitrary Function Generator followed produced the ARINC 429 Line A waveform and an op amp inversion of the Line A waveform produced the ARINC 429 Line B waveform. A Bendix EFIS was used as the equipment in Figure 3 to check the waveform. Some lower cost circuits were tried but without success.

RTCM SC104 and Differential GPS (DGPS)

Referring to Figure 2, RTCM SC104 is shown as the format for the interface between a receiver, which provides error corrections to improve the accuracy of GPS receivers and the GPS receiver. There is a large amount of information available on DGPS. The United States Coast Guard web site at www.navcen.uscg.mil is an excellent source. Parkinson and Enge have a detailed treatment of DGPS in Volume II of an AIAA book[5].

The RTCM SC104 messages are 30 bits long and contain 24 data and 6 parity bits. An extended Hamming Code is used for the error detection and correction. A complete set of words for correcting 3 GPS satellites requires 2 header words and 5 satellite error words. For 6 satellites, 16 words are required.

Figure 4 illustrates the problem encountered in generating RTCM SC104 messages in a lab. The RTCM SC104 messages require synchronization with the GPS messages from the satellites to the receiver

Conclusion

Both NMEA and ARINC 429 waveforms have been simulated in the laboratory and compared with waveforms from actual equipment.

Generating lab DGPS waveforms which can be used with low cost GPS receivers presents a challenging problem, but one which should provide students with much insight into GPS and DGPS theory and operation.

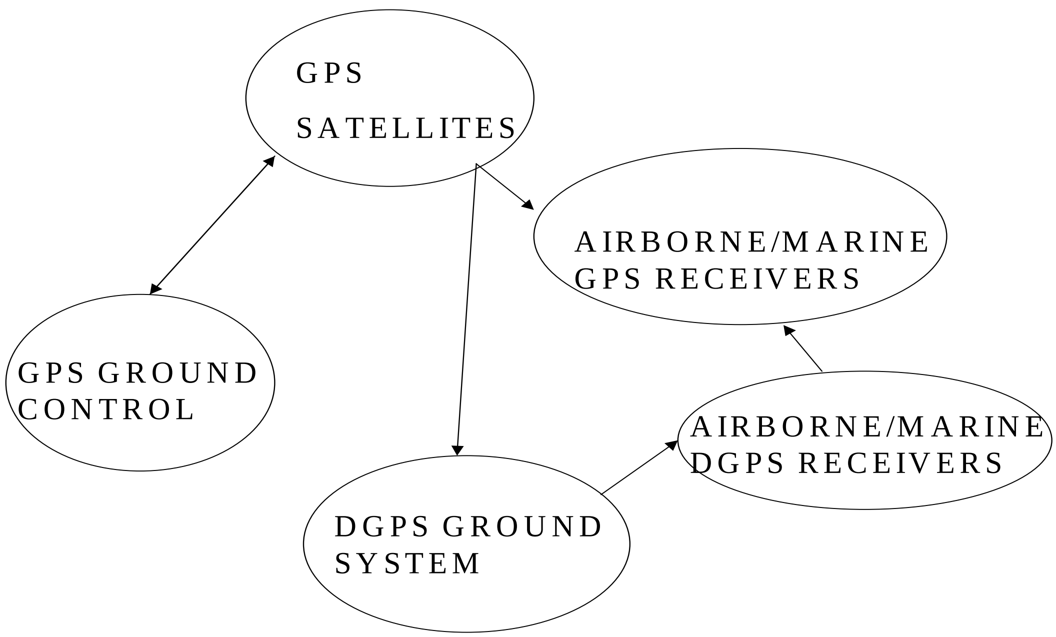
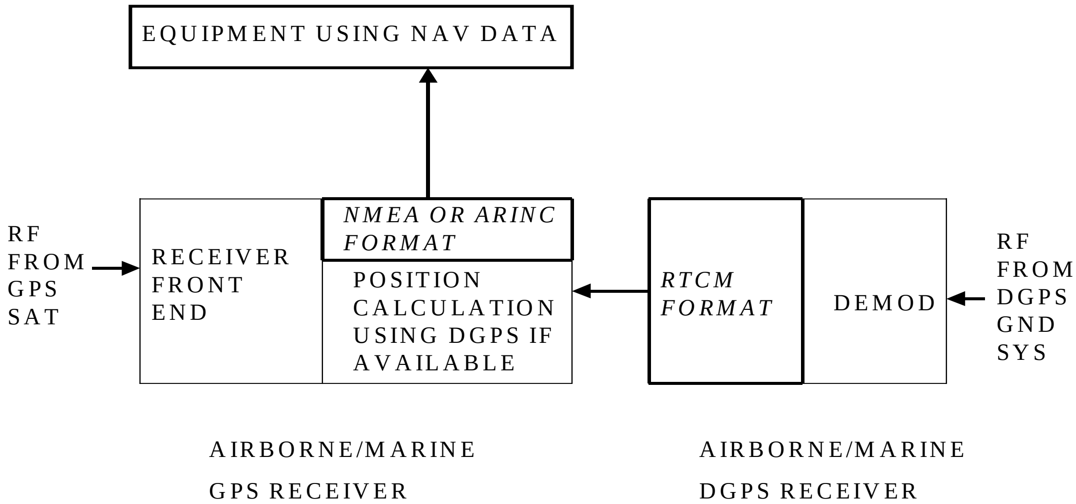


Figure 1 Block Diagram of GPS and DGPS Configuration



.Figure 2 Block Diagram of GPS and DGPS Receivers

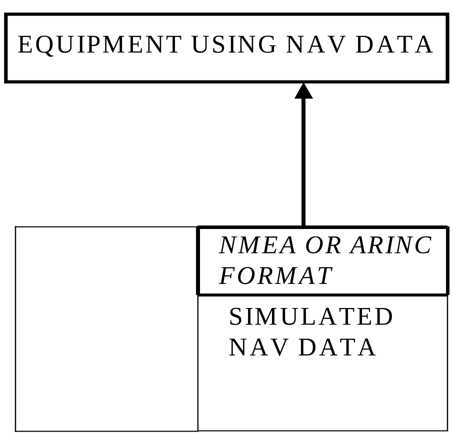


Figure 3 Block Diagram of Real Equipment Using Simulated Data

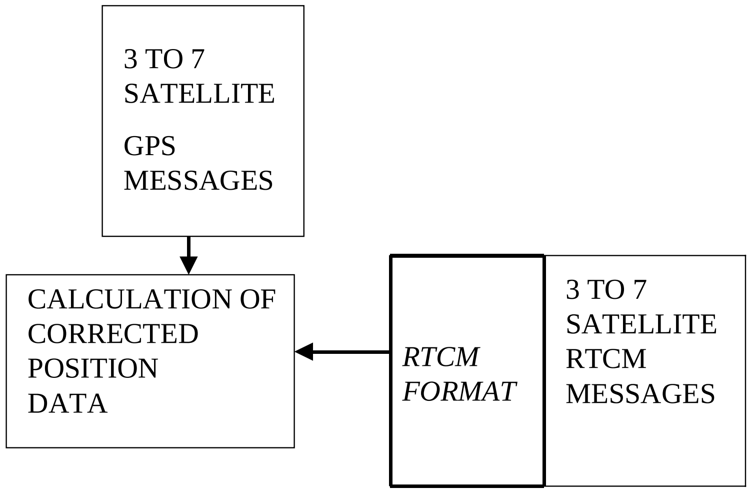


Figure 4 Block Diagram of a Proposed GPS and DGPS Simulation Checker

Acknowledgements

The author acknowledges the fine work, which Aaron Maue performed in a Special Topics course programming the HP33120A Arbitrary Function Generator to produce ARINC 429 waveforms.

References

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2. Magellan Systems Corp., **Magellan GPS Navigator, User Manual, Trailblazer XL**, San Dimas, CA 91773.

3. http://www.rtcm.com

4. http://www.nmea.org

5. Parkinson, B.W. and Spilker, J. J., Jr., Eds**. Global Positioning System: Theory and Applications, Vol. II**, AIAA, Washington DC, 1996

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Applied Research Laboratories, The University of Texas at Austin (ARL:UT) exam-ined the performance of the Global Positioning System (GPS) throughout 2018 for the U.S. Air Force Space and Missile Systems Center Global Positioning Systems Directorate (SMC/GP). This report details the results of that performance analysis. This material is based upon work supported by SMC/GP through Naval Sea Systems Command Con-tract N00024-17-D-6421, task order 5101192, â€œGPS Data Collection and Performance Analysis.â€Â Examples of the latter application include the areas of Continuity (3.4), Availability (3.5), and Position/Time Availability (3.6). In these cases, data from two networks are used. Modern Global Positioning System (GPS) receivers require: Low Noise analog front ends to enable reception of weak signals Low Jitter LOs and clocks to maximize the performance of the.Â Our integrated circuits and reference designs help you to develop high accuracy and jamming resistant GPS receivers. Modern Global Positioning System (GPS) receivers require: Low Noise analog front ends to enable reception of weak signals. Low Jitter LOs and clocks to maximize the performance of the digitizer. Low noise power and efficient power solutions. View more. Related applications. GPS personal navigation device. Technical documentation. Application notes & user guides. Application Notes (8). Title. Type. GPS (Global Positioning System) â€“ working. Table of Contents. Coordinates of GPS.Â The GPS based system use geographic coordinate system which is basically a coordinate system that enables every location on earth with the specified set of symbols, letters or numbers. The coordinates mostly choose in a such of way that one number represents the vertical positon .and two or three numbers represents the horizontal position. The GPS based system use the three coordinates angle of latitude, angle of longitude and angle of longitude.Â There are some sources which generates the error in global positioning system signal. Satellite Geometry Error. Satellite Orbit Error. GPS (Global Positioning System). A network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring the distance from the satellites. As stated in the definition above, GPS stands for Global Positioning System and refers to a group of U.S. Department of Defense satellites constantly circling the earth. The satellites transmit very low power radio signals allowing anyone with a GPS receiver to determine their location on Earth. The 3 Segments of GPS. The NAVSTAR system (the acronym for Navigation Satellite Timing a Chapter 2. Low-cost Precise Positioning for Road Users: Overview and Challenges. 21. 2.1 GPS and GLONASS Measurement Models.Â The use of very low-cost multi-constellation (GPS/GLONASS/Galileo/COMPASS/SBAS L1) receivers recently released on the market and capable of outputting raw code, Doppler, carrier phase and C/N0 measurements at a cost of around 50 euros is then particularly indicated to apply precise positioning algorithm.