International Journal of Advanced Technology and Innovative Research
ISSN 2348–2370
Vol.07,Issue.01,
January-2015,
Pages:0013-0017
www.ijatir.org

VHDL Implementation of Digital GPS Signal Receiver

VUNDI SUSMITHA[1], G. SHANMUGAPRIYA[2], SRI BINDU[3]
[1]PG Scholar, Dept of ECE, C.M.R Institute of Technology, Medchal, TS, India, Email: susmithavundi@gmail.com.
[2]Associate Professor, Dept of ECE, C.M.R Institute of Technology, Medchal, TS, India, Email: spriyagsn@yahoo.com.
[3]Assistant Professor, Dept of ECE, C.M.R Institute of Technology, Medchal, TS, India, Email: sribindu.sattu@gmail.com.

Abstract: Global positioning system (GPS) is an advanced navigation and positioning system used today for various applications. These vary from GPS guided missiles for precision bombing in the military, to peace time and civilian uses, such as navigation, treasure hunt hobbies, and agriculture. GPS receivers incorporate Direct Sequence Spread Spectrum (DSSS) Techniques in their analysis. Traditionally, GPS receiver has been a chip set, consisting of two or more chips. With the advances in Integrated Circuit technology there is a trend towards a single chip solution, which is advantageous in many ways. Such a chip will help integration of a variety of applications from cell phones to wrist watches. It involves a high level of design integration. In this project a digital GPS signal receiver for a system on chip application is attempted using VHDL, aiming for FPGA synthesis. The digital GPS signal receiver takes satellite data in digital form, and performs the demodulation and dispreading of C/A code and outputs the navigational data bits. Various communication sub blocks such as C/A code generator, BPSK demodulator, Correlator and threshold detector are modeled in VHDL and simulated using Modelsim. A four channel receiver is modeled and tested with four satellite signal mixed input added with AWGN (Additive White Gaussian Noise). All the modules functionality is verified with Modelsim simulation results. Xilinx ISE tools are used for FPGA synthesis, Place & Route and timing analysis. Spartan 3E development board with chip scope Pro tools will be used for on chip analysis and debugging.

Keywords: GPS, DS-SS, AWGN, BPSK, FPGA.

I. INTRODUCTION

Global positioning system is an advanced navigation and positioning system used today for various applications. These vary from GPS guided missiles for precision bombing in the military, to peace time and civilian uses, such as navigation, treasure hunt hobbies, and agriculture. Exploration has been important to mankind which has resulted in discovery of continents and new worlds. In ancient times, navigation was based on the planetary and stellar positions. This changed to the use of magnetic compass in the medieval times up to very recent in the past. Such alternatives always had their disadvantages and misgivings when dealing with hostile weather conditions, for example, foggy conditions, reduced visibility, thereby hindering navigation. With the development of satellites and improvements in radio signal transmission and reception, these were used for the navigation purposes as well as for positioning. The advantage of using radio signals is that they are immune to the weather effects. Earlier systems included LORAN (Long-Range Navigation), OMEGA to guide aircraft and ships.

LORAN was restricted to the United States and Britain. OMEGA was a truly globally available positioning system. The use of satellites in positioning and navigation was first applied in TRANSIT (Navy Navigation Satellite System), a project developed at the Applied Physics Laboratory at Johns Hopkins University. The Doppler frequency shifts of the signals transmitted by satellites were used to determine the satellite orbit. The receiver on the earth could determine its position from the knowledge of the satellite orbit and the Doppler shift measurement of the frequency. Global Positioning System, in short GPS, is a product of the United States Department of Defense. Intended for military purposes, especially precise positioning for ammunition, it has been demonstrated that it could be used for civilian purposes as well. Its utilization has been demonstrated correctly during the two Gulfs war's where precision guided missiles have found target with a high probability destroying enemy positions. The target's co-ordinates are loaded in the computer of the missile which is guided by the satellites.

Apart from these military advantages civilian applications too such as navigation and surveying have found use for GPS. Connected Car is a more recent example of how GPS can be used as a navigation aid in co-ordination with other applications and frameworks such as Microsoft .Net Framework, Bluetooth etc. It can be used as a guide in new places. GPS has been used also to land an airplane in adverse weather conditions. A GPS measurement can have an error of 5-10 m (uncorrected) or up to 1m discrepancy (using WAAS and DGPS). Agriculture also has found use of the GPS - to control the distribution of the chemicals and fertilizers. In conjunction with Geographic Information System (G.I.S), GPS has found more use in tracking animals, humans, and knowing the seismology of the earth at a given place. Further advances in GPS signal reception could lead to indoor coverage, in downtown areas, and under trees etc., where the reception is low. This is what helps GPS to be a part of the emergency services. In this class of applications, another popular one is pervasive computing-location awareness. GPS presents a solution to this end in mobile communication electronics.

A lot of research goes into how to make the GPS signal more reliable, visible, and accurate. This system of navigation uses omnipresent radio waves and relative time of arrival of signals to determine positions. The two common frequencies used today by GPS satellites to broadcast are L1 (1575.42 MHz) and L2 (1227 MHz). L1 is primarily a civilian signal while L2 is used for military purposes. L1 is also used by the military and L2 by civilians though the civilians do not have a knowledge of the codes modulating the L2 frequency. From 2005 onwards, GPS satellites will be broadcasting new signals which could help eliminate positioning errors due to Ionosphere effects. The current civilian signals will be boosted by the addition of another civilian signal on L2. From 2008, a new frequency band called L5 will be emitted at 1176.45 MHz which is also a civilian signal. L3 and L4 will carry non-navigation information for the military.

II. SPREAD SPECTRUM TECHNIQUES

There are several techniques currently in use for generating Spread Spectrums. These include Direct Sequence Spread Spectrum (DSSS), Frequency Hopping Spread Spectrum (FHSS), and Time Hopping Spread Spectrum. Each technique differs in its implementation and has certain advantages/disadvantages. In addition to the above, there are a number of hybrid techniques which offer certain advantages over, or extend the usefulness of the other techniques. These hybrids are Frequency Hopped/Direct Sequence Modulation and Time-Frequency Hopping.

A. Direct Sequence Spread Spectrum (DSSS)

The basic principle behind the Direct Sequence Spread Spectrum (DSSS) technique is the modulation of the RF carrier with a digital code sequence. The code sequence utilizes a chip rate, which is much higher than the bandwidth of the data signal and is used directly to modulate the carrier, thus directly setting the transmitted bandwidth.

B. Frequency Hopping Spread Spectrum (FHSS)

The basic principle behind the Frequency Hopping Spread Spectrum (FHSS) technique is that the carrier frequency is periodically modified (hopped) across a specific range of frequencies. The frequencies, across which the carrier jumps is the spreading code. The shifting pattern is determined by the chosen code sequence (frequency shift key–FSK). The amount of time spent on each hop is known as the dwell time and is in the range of 3ms-100ms.

C. Time Hopping Spread Spectrum (THSS)

Time Hopping and FHSS are somewhat similar, but in Time Hopping, the transmitted frequency is changed at each code chip time. Time Hopping can be implemented in two ways. In the first technique, each binary is transmitted as a short pulse, known as a “chirp”. The PN generator is used to determine the actual interval in which the chirp is transmitted. By doing this, anyone attempting to intercept the signal will be uncertain as to when the next pulse will be transmitted.

D. C/A Code

The coarse acquisition code is provided by the GPS satellites. It is generated as a sequence of 1023 chips. This code is repeated every milli second with chipping rate of 1.023 MHz and modulated only in L1 frequency.

III. INTRODUCTION TO GPS

Global positioning system (GPS) is an advanced navigation and positioning system used today for various applications. These vary from GPS guided missiles for precision bombing in the military, to peace time and civilian uses, such as navigation and agriculture. The Doppler frequency shifts of the signals transmitted by satellites are used to determine the satellite orbit. The receiver on the earth could determine its position from the knowledge of the satellite orbit and the Doppler shift measurement of the frequency. This system of navigation uses omnipresent radio waves and relative time of arrival of signals to determine positions. The two common frequencies used today by GPS satellites to broad-cast are L1 (1575.42 MHz) and L2 (1227 MHz). L1 is primarily a civilian signal while L2 is used for military purposes.

A. GPS Segments

For the GPS to function smoothly there are three important constituents. They are:

1. User Segment (receiving segment)
2. The Satellite constellation
3. The control Segment

1. Satellite Constellation

The Satellite Constellation constitutes of 24 satellites at an altitude of about 20,000 km above the Earth’s surface. These satellites are arranged in sets of 4 satellites in 6 orbital planes. These orbital planes are inclined to the Earth’s equatorial plane at an angle of 55^0. The orbital plane location are defined by the longitude of the ascending node while the satellite location by the mean anomaly. These satellites are at such a height and in such orbits such that there are at-least four satellites visible to a user at any location and at any given time. At a time one can however receive signals from 7 to 9 satellites.

2. Control Segment

The Control segment consists of Master Control Station at Colorado Springs, 5 Monitor Stations located around the world to ensure maximum satellite coverage and ground antennas. The functions of the Operations Control Segment include maintaining the satellite orbital position, and monitoring the health of the satellite constellation. The health includes parameters like the power, fuel levels among others. The ground stations make pseudo range measurements by passively tracking the satellites. This updated information called TT&C (Telemetry, Tracking and Command) data. This information for each satellite is uploaded by a ground up link antenna when that particular satellite is in view of the antenna.

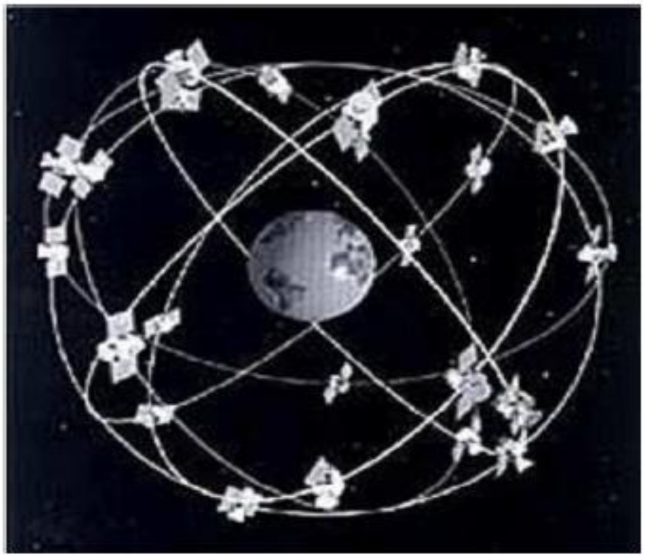

Fig.1. GPS Satellite Constellation.

3. User segment

Receives satellite signals and estimates the distance from satellite front end antenna and RF unit receives the signal and after sufficient level of amplification, it will be digitized. The digital GPS receiver applies DSSS correlation technique and extracts the base band data. GPS processor uses minimum four such channels data and calculates its location. Since the location of each GPS satellite is known, the receiver's location can be determined by "triangulating" the distances from several satellites.

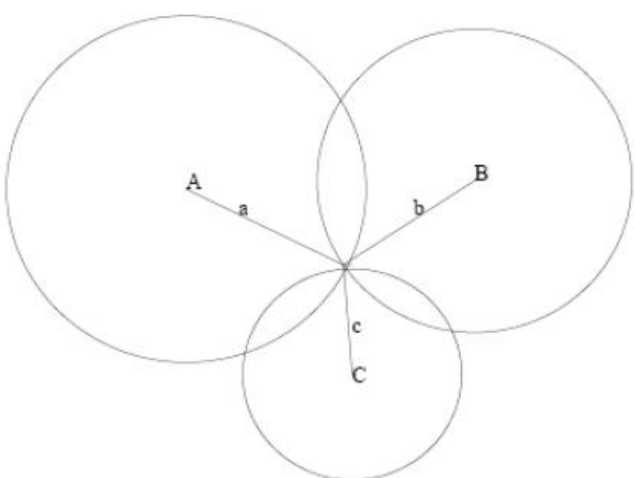

Fig.2. Triangulation.

B. GPS Receiver Channels

The signal processing for satellite navigation systems is based on a channelized structure. This is true for both GPS and Galileo. This chapter provides an overview of the concept of a receiver channel and the processing that occurs. Fig.3 gives an overview of a channel. Before allocating a channel to a satellite, the receiver must know which satellites are currently visible. There are two common ways of finding the initially visible satellites. One is referred to as warm start and the other is referred to as cold start.

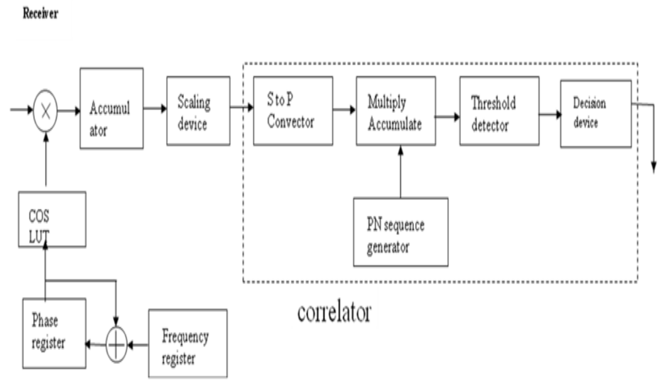

Fig.3. One receiver channels the acquisition gives rough estimates of signal parameters.

These parameters are refined by the two tracking blocks. After tracking, the navigation data can be extracted and pseudo ranges can be computed. Warm start in a warm start, the receiver combines information in the stored almanac data and the last position computed by the receiver. The almanac data is used to compute coarse positions of all satellites at the actual time. These positions are then combined with the receiver position in an algorithm computing which satellites should be visible. The warm start has at least two downsides. If the receiver has been moved far away since it was turned off (e.g., to another continent), the receiver position cannot be trusted and the found satellites do not match the actual visible satellites. Another case is that the almanac data can be outdated, so they cannot provide good satellite positions. In either case, the receiver has to make a cold start.

1. Synchronization

It is the process of matching the locally generated spreading signal with the incoming spread spectrum signal. Synchronization is a two step procedure:

1. Acquisition and
2. Tracking.

Acquisition: An acquisition search through all possible satellites is quite time-consuming. That is, in fact, the reason why a warm start is preferred if possible. The purpose of acquisition is to identify all satellites visible to the user.

Tracking: The main purpose of tracking is to refine the coarse values of code phase and frequency and to keep track of these as the signal properties change over time. The accuracy of the final value of the code phase is connected to the accuracy of the pseudo range computed later on. The tracking contains two parts, code tracking and carrier frequency/phase tracking

IV. SIMULATION RESULTS

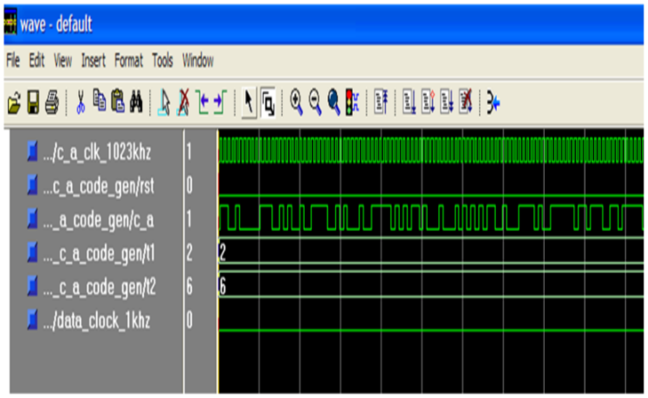

Fig 4: Simulated output of programmable C/A code generator.

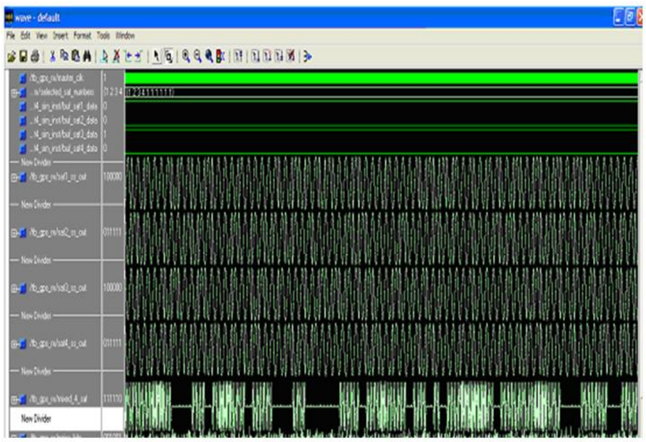

Fig 5: Simulation output for satellite data simulator.

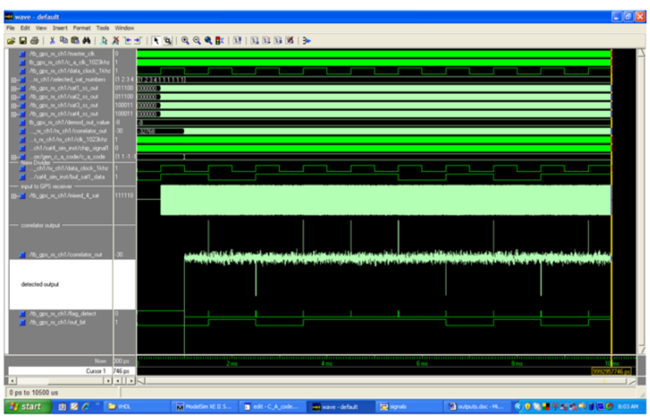

Fig 6: Simulation results of GPS Receiver.

V. CONCLUSION

This work outlined the implementation of a GPS receiver in time domain. It dealt with VHDL implementation of the digital backend of a GPS receiver. Different functional blocks and communication blocks were implemented as part of this work. The scope of this work was to develop a working code acquiring and tracking module, capable of acquiring a GPS signal and tracking it. Synthetic data was generated at the required rate and modulated the PRN sequence. This transmitted data was demodulated and detected and the expected data was recovered. Thus, a DS/SS receiver was implemented, in time domain, capable of acquiring and tracking a GPS C/A code signal. The receiver implementation assumed a coherent signal acquisition and tracking. This work also dealt with acquiring codes from multiple satellites. It used a dedicated channel for each of the satellites being tracked. Four satellites were continuously being acquired.

For this to be integrated as an independent module, the carrier acquisition has to be performed along with the code acquisition. This module has to be tested on original GPS data to validate it. The entire model has to be synthesized, to be used in conjunction with the tour guide being developed. Low power modes and functionalities have to be incorporated. Newer algorithms to speed up the acquisition times in the time domain could be worked upon. Acquiring data from a greater number of satellites and tracking them simultaneously is another aspect for future research. Integrating this module with the analog front end to achieve proper GPS functionality is a future work. Finally, developing algorithms for using the GPS receiver indoors is an aspect of future research.

VI. REFERENCES

[1] R. Prasad and T. Ojanpera “A Survey on CDMA: Evolution Towards Wideband CDMA’, Proc. Uf the IEEE SIh International Symposium on Spread Specrrum Techniques &Applications, Sun City, South Africa, September 1998, pp. 323-33 1.
[2] European Commission “Galileo -Involving Europe in a New Generation of Satellite Navigation Services”, Commission of the European Communities, COM(99) 54 final, February 1999.
[3] D.M. Akos “A software radio approach to global navigation satellite system receiver design”, Proc. of the 1996 Institute of Navigation Annual Meeting - Navigation Technology for the 3‘d Millenium, Boston, MA, lune 1996.
[4] B. Wolt and A. Brown 0-7803-6560-7/00/$10.00 (C) 2000 IEEE 514 en&, Salt Lake City, Utah, September 1993, pp. 985-991.
[5] A. Brown and B. Wolt “Digital L-band receiver architecture with direct RF sampling”. Proc. of the IEEE Position Location and Navigation Symposium, Las Vegas.
[6] A. Brown and B. Wolt “Digital Downconversion Test Results with a Broadband L-Band GPS Receiver”, Proc. of the AIAA/IEEE 13th Digital Avionics Systems Conference, 1994, pp. 426431.
[7] G. Heinrichs, S. Gotz, and M. Haunschild ”Recent Developments of GPS/GLONASS Receivers and their Applicability to Future GNSS”, Proc. of the International GPS Conference 1996, London, UK, April 1996.
[8] D.M. Akos and J.B.Y. Tsui “Design and Implementation of a Direct Digitization GPS Receiver Front End”, IEEE Transactions on Microwave Theory and Techniques. Vol. 44, No. 12, December 1996, pp. 2334-2339.

Author's Profile:

Vundi susmitha, Obtained B.Tech Degree In ECE From Aurora's Technological And Research Institute (Uppal) Hyderabad - 500 020. Telangana, INDIA. And Pursuing M.Tech in VLSI from C.M.R Institute Of Technology Kandlakoya(v), Medchal, Telangana. Email: susmithavundi@gmail.com.

G. Shanmugapriya, Working As A Assoc professor, in Department Of Electronics And Communication Engineering in C.M.R Institute of Technology Kandlakoya(v), Medchal, Telangana. Received B.E In ECE From Bharathi Dasan University (Trichy) And M.E in Computer And Communication Engineering From Anna university (chennai), Email: n spriyagsn@yahoo.com.

S. Sri Bindu, Working As A Asst proff in , in Department of Electronics And Communication Engineering in C.M.R Institute Of Technology Kandlakoya (v), Medchal, Telangana. Email: sribindu.sattu@gmail.com.