GPS POSITIONING SIMULATION

Marek GNIDA, Doctoral Degree Programme
Dept. of Air Defense, Military Academy Liptovský Mikuláš
E-mail: MarekG@szm.sk

Supervised by: Ing. Jozef Tkáč, PhD

ABSTRACT

The work deals with the basic principle of the ranging method that is used for determining position in the GPS (Global Positioning System). It consists of two parts. The first part is a theoretical description of the principle of position determining within the GPS and a description of the passive ranging method. The second part contains a software product created in the MATLAB-GUI and Matlab Simulink environment and it is designed for simulation of the ranging method and GPS.

1 INTRODUCTION

Determining position anywhere on Earth has recently become a very important piece of information not only in the military but also in the civilian sector. The work deals with the basic method used as a basis for the GPS navigation system and with a simple simulation of this method and the GPS system

2 PRINCIPLE OF POSITION DETERMINING IN GPS

The navigation GPS system nowadays is one of the few fully functional systems. Position determining in this system is based on a passive ranging method which suited its primary functioning for military purposes. The principle of this method consists in determining the distance between the receiver and individual satellites. The distance is determined from time difference between transmition of information from a satellite and its reception by the user as well as from the well-known speed of electromagnetic wave propagation. Since the received signal contains information on the satellite position (x_i, y_i , z_i), the user (on the basis of the measured distances and positions) can determine his own position (x, y, z) from the system of three equations with three unknown quantities:

$$\sqrt{(x_i - x)^2 + (y_i - y)^2 + (z_i - z)^2} = \tau_{di} c = d_i \qquad (1)$$

where τ_{di} is the time difference between the transmission and reception of the information and c is the speed of light.

According to the method of navigation message processing, we can divide ranging systems into passive and active.

3 PASSIVE RANGING METHOD

The basic principle of the system using this method is that the satellite trasmits a signal (navigation message) and the user finds out the time of its reception. From the lagging between the transmission and reception of a given signal, the distance to the measured satellite is found out. The user´s position is determined from the positions of satellites and measured distances. Positions of satellites are computed by the receiver from parameters of trajectories (ephemerides) that are transmitted by satellite in the navigation message.

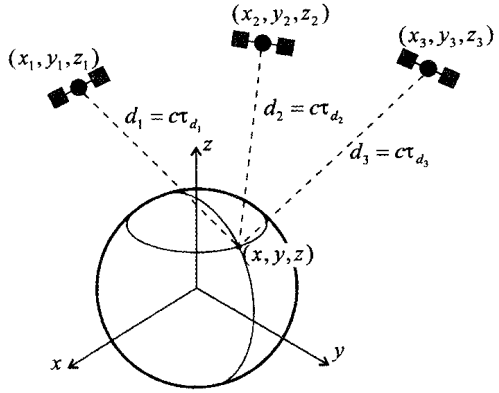

Fig. 1. Principle of point position computation in 3D space

The lagging measurement of the transmitted signal is carried by the user so that he generates a copy of the signal transmitted by the chosen satellite (Fig. 2), the copy is synchronized with the received signal and the time shift of the generated copy is measured with respect to his own time base. After this time is re-calculated to distance, we arrive at the so called pseudo-distance. When measurements to all four satellites have been carried out, the user has got all the necessary information needed to determine his own position.

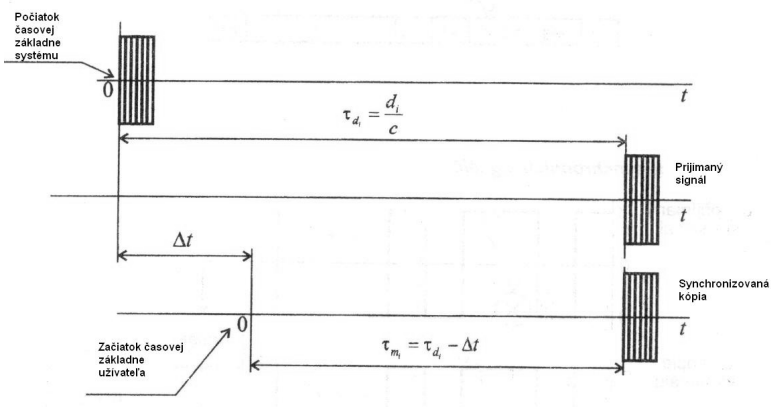

Fig. 2. Principle of ranging

In order to synchronize the signal copy with its original it is necessary that the copy generator is controlled by voltage *u(τ)*, whose magnitude and polarity corresponds to

magnitude and shift $u(\tau)$. Such voltage is obtained by a circuit whose basic part is a *correlator.*

A correlator is a circuit that realizes the correlation function $R(\tau)$ which is a product integral of the received signal values and the received signal generated copy. The correlation function is computed as follows:

$$R(\tau) = \int s_p(t) s_k(t+\tau) dt \qquad (2)$$

where $s_p(t)$ is the received signal from satellite and $s_k(t+\tau)$ is the copy of the received signal generated by receiver.

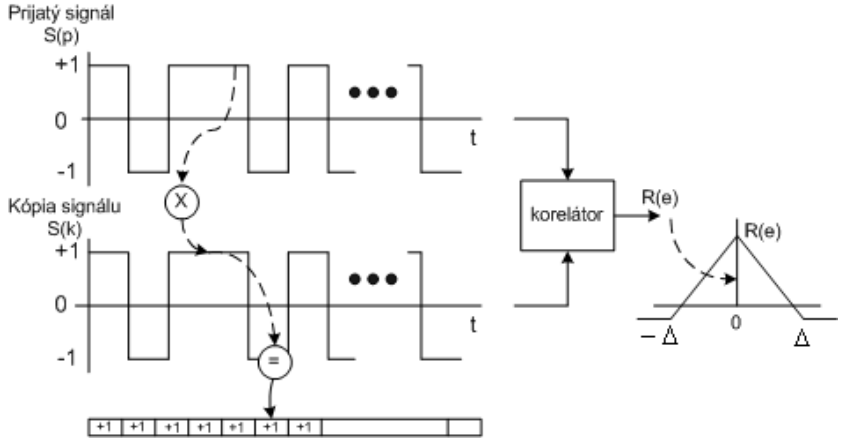

Fig. 3. Correlation of signals

The value of the correlation function depends on the mutual shift of both signals and the biggest is when this shift equals zero as can be seen in Fig. 3.

4 SIMULATION OF THE RANGING METHOD

The software product created in MATLAB-GUI serves for illustrative rendering of the ranging method principle used for calculation of the receiver position in the GPS system. In front of the user there is a window where he can set the position of individual satellites by means of a cursor and position of the receiver by means of the "Užívateľ" button and by setting the altitude. After pressing the "Výpočet" button, the distance between the receiver and individual satellites appears in the windows "satellite 1,2,3". The „Model“ button serves to start the model of the GPS system which is described below. Basic information on the installation and procedure in starting the program is accessible through the "On program" button. The program run is ceased by the "Koniec" button.

5 MODEL OF GPS

The model is closely related to the simulation program of position determination. It is based on many simplifications that allow an easy and illustrative simulation of the GPS sytem in the MATLAB-Simulink environment. The model consists of a cosmic segment, segment of the atmosphere and the receiver.

The MATLAB-Simulink environment was chosen due to the fact that it not only allows simulation of mathematical functions without knowledge of commands of the MATLAB

program but mainly because it provides the possibility for illustrative arrangement of simulation by blocks and subsequent simpler explanation of the running simulated processes.

6 CONCLUSION

The aim of the work is to elucidate the principle of position determination in the GPS system which has turned out to be increasingly popular recently also in the civilian sector. The work is mainly oriented to explanation of the passive ranging method, its simulation in the MATLAB environment and to simulation of the GPS system. The work, together with the documentation describing composition and principles of position determination in the GPS system is a suitable teaching aid for students who are concerned with the GPS navigation system and other systems based on the principle of the passive ranging method.

REFERENCES

[1] HRDINA,Z.-PÁNEK,P.-VEJRAŽKA,F: Rádiové určovanie polohy, Praha, ČVUT, 1996

[2] ero.org/publications/GPSPRIMER

[3] http://www.colorado.edu/geography/gcraft/notes/gps

[4] http://www.aero.org/communications

[5] http://www.gpsworld.com

[6] http://www.utexas.edu/depts/grg/gcraft/notes/gps/gps.html