# Timing method by simulated GPS radio signal

ShanQingXiao,Yang Jun, Wang YueKe, Chen JianYun
Affiliation: Department and Instrument Science, Mechatronic and Automation school, National university of defense technology, DeYa Road, KaiFu District, ChangSha, HuNan, China
Email: chorely@yahoo.cn

**Abstract*:*** Nowadays more and more distributed systems such as power system are synchronized by GPS. Because GPS receiver embedded in these systems can only receive GPS RF signal, it is difficult to realize redundance synchronization. If GPS failed, these systems can't normally function. So we develop a novel synchronization method by simulated GPS signal. Specifically, GPS RF signal is simulated base on pre-assigned time and position. Receiver gets the simulated signal and then synchronizes to pre-assigned time.

**Keywords:** time transfer， GPS simulator， NAV data;Fabricate

## I. Introduction

For GPS is applied long time, many device is designed timed only by GPS. There are no extra timing interface except GPS RF input for most device. So it becomes hard to add external time interface.

Now GPS simulate technique is applied in some field. GPS receiver can get the simulated signal and realize position and timing. If GPS signal is generated based on external time source, receiver can recover the external time after position. So if simulated GPS signal is sent to the receiver embedded in device, the original time can be recovered and device can synchronize to external time source. For no extra interface is needed, this method can be easy implemented and wide applied. This paper introduces the principle and procedure of this method. The design of software and hardware is provided in detail. Propotype is build and experiment result verified the valid of the proposed method.

## II. Time transfer by simulated GPS signal

First, In order to simulate GPS signal, GPS navigation data(NAV data) should be generated. Then Pseudo range and its derivative should be calculated which is called obersavation data (OBS data). Special software is designed to generate NAVdata and OBS data.

GPS simulation method is similar to GPS signal generator by SV. But in simulator, pseudo range is realized by digital process. Digital delay filter is applied to realize signal delay. At last digital signal is modified to 1575MHz carrier. The simulated GPS RF signal is input to device by GPS antena interface. GPS receiver get the signal, recover the original time. Time delay exist in simulate process, which should be compensated.

Fig.1 shows the principle of this method. GPS signal is simulated base on time A. Then signal is send to device. Gps receiver get the signal and recover time A.

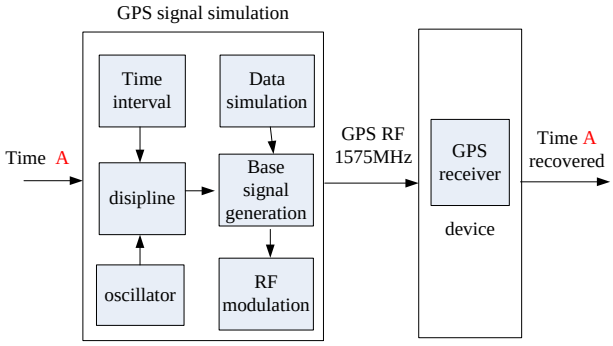


Fig.1 time transfer principle

## III. External time source and local frequency calibration

Time can be acquired by external time source. The external source can be satellite receiver, such as receiver of GLONASS of RUSSIA or of RDSS of China. The external time can also come from time standard device. Usually time information includes 1PPS(1 pulse per second) and time data. Time data indicates the absolute time of rising edge of 1pps and the rising edge of 1PPS provides ns time precision. Time information is updated per second. When satellite receiver is applied, there are dither in 1PPS. So local oscillate is needed, whose frequency is calibrated by 1PPS and provided more stable 1PPS.

## IV. Fabricate GPS NAV data to change time

It's difficult to simulate real GPS navigation data, which needs building satellite constellation and mass computation. So fabrication method is adopted. SV orbit model is built which can provide orbit data. Ephemeris data can be calculated. Then NAV data can be generated. With the SV orbit data and predefine user position, OBS data would be generated. Simulated data is stored in SD card.

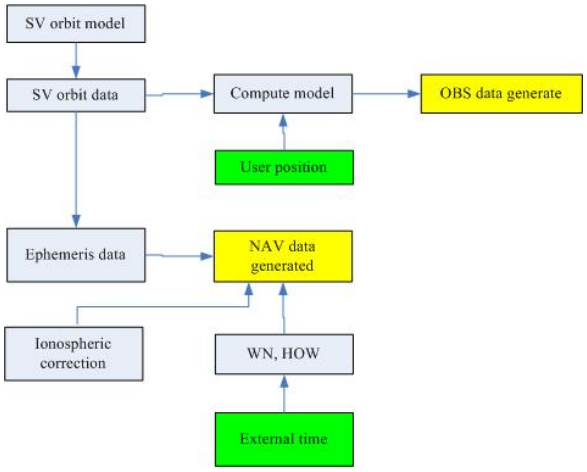


Fig.2 data simulation model

But position is not enough. GPS receiver must recover the external time. So change should be made to parameter related to time in fabricated data. The time related parameter are week number and Z-count, located in 31~52BIT and 61~70BIT in 1st frame. While system working, NAV data and OBS data are read from SD card, the time related parameter should be changed realtime.

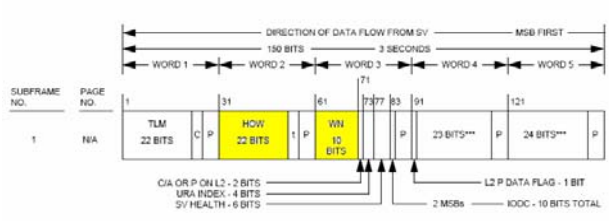


Fig.3 time related parameter in GPS NAV data

Over 4 GPS satellites signal must be provided to realize position. Data including navigation data and oberservation data is simulated. The format of navigation data is 300 BIT, 40byte, 20 BIT is left empty. Oberservation data is generated by configure position and satellite ephemeris to simulate the change of pseudo-range. Oberservation data is updated per 20ms. Oberservation data includes the 1st and 2nd differential coefficient of pseudo-range. So interposer is carried out to realize continious change of pseudo-range.

## V. RF signal simulation

Pseudo-number generator generate C/A code. Real SV signal is generated as follow: C/A random code is generated. The speed of GPS NAV data is 50bps, NAV data is modified by C/A code. Then code is modified to 1575MHz. Signal of multiple SV are synthesis in space.

The key problem is simulating signal delay and dopller effect. Pseudo-range represents the signal transport delay. The 1st derivative and 2nd derivative of Pseudo-range is included in OBS data which make continual pseudo-range data possible. Digital signal process is applied to realize delay and dopller effect. Digital delay filter realize the delay. Multiple digital filter and high quality digital process circuit can realize ns delay precise.

Digital signal of multiple SV are synthesis in digital field. Synthesis signal is transerred to analog signal, then modified to RF signal. The simulator can generate signal of 12 GPS SV.

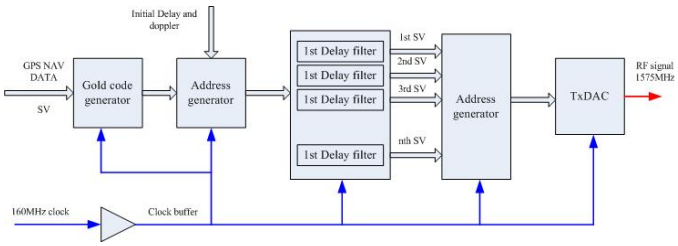


Fig.4 RF signal simulate procedure

## VI. System design

NAV and OBS data are stored in SD card. A FPGA is applied to realize the digital signal process. FPGA type is XC4VSX35 of Xilinx corp. FPGA read data from SD card and realize data assignment. Digital signal transfer to analog signal, then be modulated to RF signal. The simulator can realize 12 SV signal generating.

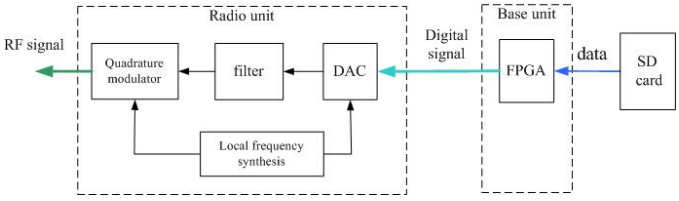


Fig.5 GPS simulate hardware

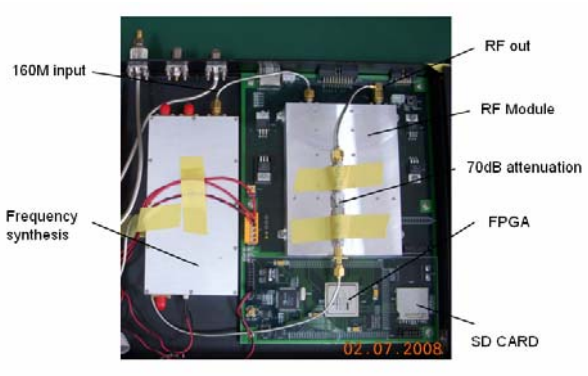


Fig.6 GPS simulate hardware

## VII. Experiment result

Amplitude of simulated GPS signal is between -20dBm~-40dBm. 70dB attenuation is applied. Resolution GPS timing module receives the signal. Time interval is measured between two 1PPS. Fig.7 shows test connection and test result shown in Fig.8. the average interval is 1.01333ns, deviaton is 11.06457ns.Test result show the proposed method can apply to ns timing precise.

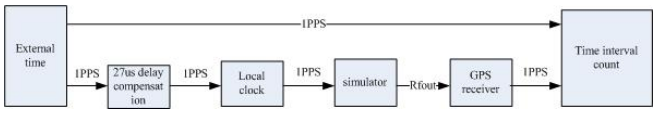


Fig.7 test connection

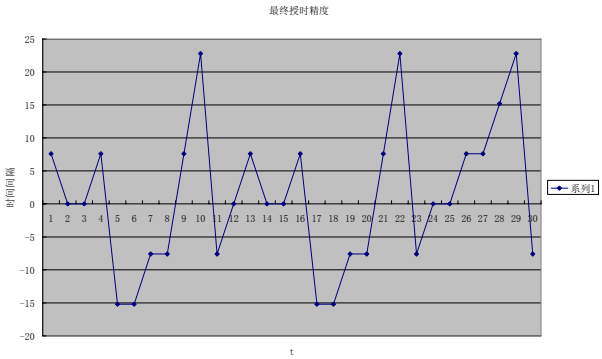


Fig.8 test result

## VIII. References

[1] Alison Brown and Neil Gerein N C. Advanced GPS Hybrid Simulator Architecture[J]. Proceedings of ION 57th Annual Meeting, Albuquerque, NM,2001, :

[2] Candy D W. NAVSTAR/GPS SIMULATOR.[J]. IEEE Proceedings of the National Aerospace and Electronics Conference, 1977, : 323～329.

[3] Kaplan E D. princile and application of GPS[M]. 2 ed. Electronic publication house of china, 2002.

[4] Plumb J, Larson K M, White J, et al. Absolute calibration of a geodetic time transfer system[J]. IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, 2005, : 1904～1911.