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Time Offset Comparison per Code Measurements in GPS Time Transfer

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Abstract. This paper shows the comparison result of time offsets using P1, P2 and P3 in GPS time transfer. We modified r2cggtts program in order to calculate time offsets for two single frequencies, P1 and P2. The result shows that time offsets using P1 and P2 are of wide dristribution comparing to time offsets using P3. As a further study, the error factors for wide distribution of P1 and P2 should be studied.

Keywords: GPS time transfer, P1, P2, P3, ionospheric free combination, Klobuchar model

1 Introduction

This paper introduces the time transfer technique using GPS code signal and presents the comparison results of time offsets using P3 code which use ionospheric free model of dual frequency and time offsets using P1and P2 codes which use the Klobuchar ionospheric model of single frequency. To obtain the comparison result, we modified the legacy r2cggtts software, which has been used in time laboratories for TAI(International Atomic Time) generation by BIPM(International Bureau of Weights and Measures), in order to generate the each time offset for single frequency P1 and P2 code measurements respectively using Klobuchar ionospheric delay model and write the 3 kinds of time offset results in the same CGGTTS file.

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1 Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

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2 GPS time transfer

The time comparison using GPS code signal starts from the process to obtain the time offsets between each specific satellite clock and a receiver clock of measurement laboratory. Through the comparisons of these time offsets of time laboratories, BIPM generates TAI. Therefore, it is essential to obtain the propagated time from a satellite to a receiver. Then, the time offset between a satellite clock and a receiver clock is calculated.

There are several error factors while the satellite signal is travelled to a receiver. Figure 1 shows these error factors. There are the satellite clock error, the satellite orbit error, the tropospheric delay, the ionospheric delay, the multipath, the receiver clock error, the cable delay, the hardware delay, and so on.

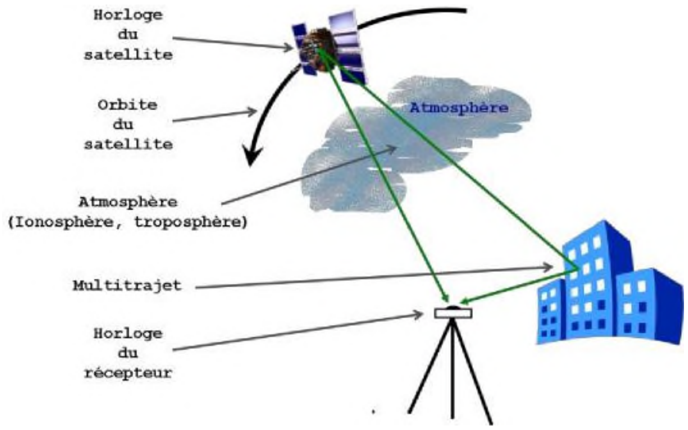

Fig. 1 Delay error factors while GPS signal is disseminated.

GPS uses two frequencies of 1575.42 MHz for P1 code and 1227.60 MHz for P2 code respectively. These two codes are used to make P3 code of ionospheric free combination which eliminates the ionospheric delay. Hence, r2cggtts software, which is used in time laboratories joining the TAI generation, uses the only P3 code[1,2,3].

This paper introduces the additional time offset comparisons using not only ionospheric free combination P3 code measurement but also P1 and P2 code measurements which applies Klobuchar ionospheric delay model used in GPS for single frequency receiver.

Though the dual frequency receiver is used, the study for characteristics and variations of time offsets for each P1, P2, and P3 code measurements is important for time synchronization.

The ionospheric delay is the distance error by the diffusion while the GPS signal propagates through the ionosphere which is extended in various layers from about 50km to 1,000km above Earth's surface[4].

The ionosphere, lower than 100km, does not affect the GPS signal. The main error factors of the ionosphere are day and night, the sunspot number, the location of the

GPS receiver, the elevation angle of satellites, and so on. GPS uses the Klobuchar model for the estimation of the ionospheric delay model for the single frequency receiver[5].

2.1 Klobuchar Model

The ionosphere changes according to the time for 24 hour and the terrestrial longitude and latitude and has a very close relation to activity of sunspots. Klobuchar proposed the ionospheric delay model considering these error factors like in the equation (1)[6].

(1)

Here, A_1 is the zenith delay of night time as $5\text{x}10^{-9}$(s), A_2 is the amplitude of the cosine function as $40.3\text{x}(1.6\text{x}10^{18}/1686.53\text{Mhz})$, A_3 is the phase of the maximum value of the cosine function as 14, A_4 is the period of the cosine function as 28 (□ 72,000s).

2.2 Ionospheric Free Combination

The ionosphere term can be eliminated by using the characteristic of the ionosphere term is inversely proportional to the squared respective carrier frequency. Thus, the P3, ionospheric free combination using dual frequency is obtained like in equation (2).

$$P_3 = \frac{f_1^2}{f_1^2 - f_2^2} P_1 - \frac{f_2^2}{f_1^2 - f_2^2} P_2 \approx 2.55 P_1 - 1.55 P_2 \qquad (2)$$

3 Comparison of time offsets for P1, P2, P3

r2cggtts software requires the GPS observation data and GPS navigation data written in rinex format for the measurement date. We use the observation and navigation data of January 1, 2015 (MJD 57023) provided by TTS timing receiver of KRISS(Korea Research Institute of Standards and Science). MJD is Modified Julian Day. In addition, we use the P3 result, GZSE2P-P3, which is generated by the TTS receiver in order to verify the modified r2cggtts software. Since commercial timing receivers provide only final results, the studies for the various basic techniques for time transfer using GNSS should be preceded.

Figure 2 shows the results using P1, P2, and P3 of the modified r2cggtts software and GZSE2p_P3.

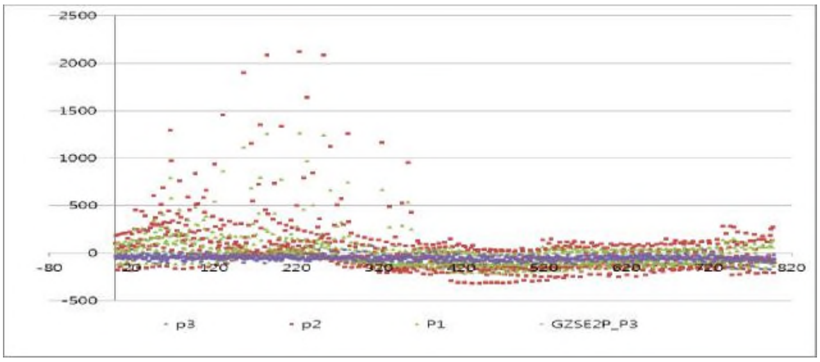

Fig. 2 MJD 57023 time offset results of P1, P2, P3 and GZSE2P_P3

In this figure, P3 from the r2cggtts software and GZSE2P_P3 from the TTS timing receiver are almost identified and time offsets of P1 and P2 are almost close to the time offsets of P3 except some section. Especially, P2 results show the large variation.

4 Conclusion

This paper shows the comparison result of time offsets of P1, P2 and P3 code measurements by analyzing and modifying the legacy r2cggtts software. P3 results use the ionospheric free combination using dual frequency. P1 and P2 use the Klobuchar model to eliminate the ionospheric delay using single frequency. The time offsets using single frequency show more various error conditions during some sections. As a further study, we are going to investigate the error factors for P1 and P2 time offsets and analyze the correlation. Then, we can secure a basic technique for the time offset generation according to the GPS code characteristics and national competiveness for GNSS time transfer.

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