Phase-Modulation-Based Coarse Time Synchronization for Linear Optical Sampling System

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***Summary*—With the rapid development of atomic clock technologies, the accuracy and stability of atomic frequency standard are increasing day by day, which puts forward higher requirements for the corresponding time-frequency transfer technology. The accuracy and stability of the traditional time synchronization are difficult to meet higher requirements for time synchronization. The accuracy of time synchronization can be significantly improved by using linear optical sampling (LOS), in which coarse time synchronization also plays a very important role. Here we study the coarse time synchronization technology based on phase modulation, and the timing jitter of the signal obtained by the receiving module is less than 20 ps when the sending module and the receiving module are directly connected without fiber link. This system is expected to be used in the LOS system.**

Keywords—linear optical sampling; time synchronization; coarse time synchronization; phase modulation

I. INTRODUCTION

In the past, the researches on time synchronization of optical comb are mostly focused on space [1], transmission of time and frequency signals in optical fiber has lower loss and stronger anti-interference ability. Coarse time synchronization is indispensable and it is one of the keys to calculate the time offset in the linear optical sampling (LOS) time synchronization system [2]. This paper mainly studies the time synchronization technology based on phase modulation, which uses the methods of phase modulation and the interference demodulation to transmit the pulses, where the timing jitter of the signal obtained by the receiving module is less than 20 ps when the sending module and the receiving module are directly connected without fiber link, namely, the back-to-back system. This coarse time synchronization scheme has a good stability, so it is proposed as an alternative method for coarse synchronization of LOS system in the future.

II. METHODS

In this paper, the pulsed signal is modulated by Binary Phase Shift Keying (BPSK) modulation in the transmitting module, which is demodulated by mutual interference of received signals in the receiving module [3]. Faraday rotating mirror is used to reduce the influence of polarization on interference process. The modulated and the demodulated signals are input into the time interval counter (TIC) for data acquisition and measurement. The experimental diagram is shown in Fig. 1.

III. DISCUSSION

Fig. 2 shows the results of TIC which is used to measure the time interval of the modulated and the demodulated pulse signals. The root mean square (RMS) of data is used to characterize the instability of coarse time synchronization system, and the results of the data is 1.9158E-11 (the accuracy of TIC is 20 ps). The results show that the coarse synchronization system has a good stability, so the scheme is feasible and can be adopted in the double optical comb time synchronization system in the future. The next step is to add a proportion integration differentiation (PID) feedback to the demodulation module to keep the phase difference of two interfering signals stable. Then, we will connect a 50 km optical fiber between the modulation module and the demodulation module to measure the timing jitter of the recovered pulsed signals. Finally, we will combine it with LOS time synchronization (fine synchronization) to form the complete time synchronization system.

IV. CONCLUSIONS

Because the pulse sequence of the optical comb is a headless and tailless sequence, we need to find the beginning pulse when the LOS system is used to calculate time offset. Coarse time synchronization can help us find the pulse of "zero time" at the receiving module, so the coarse time synchronization is necessary for LOS time synchronization system [3][4]. Improving and optimizing the coarse time synchronization scheme can improve the accuracy and stability of the time synchronization system. By analyzing the results of TIC, it can be concluded that the transmission timing jitter is less than 20 ps. With the results above, we can continue to conduct the following experiments to accomplish the combination of the LOS time synchronization (fine synchronization) and the coarse time synchronization.

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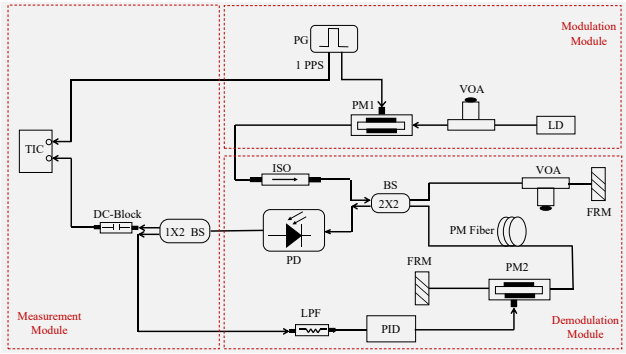

Fig. 1. Experimental setup of 1 PPS time signal modulation and demodulation system. LD, laser diode; PG, digital delay pulse generator; PM, phase modulator; ISO, isolator; BS, beam splitter; FRM, Faraday rotator mirror; PD, photodetector; TIC, time interval counter; LPF, low-pass filter.

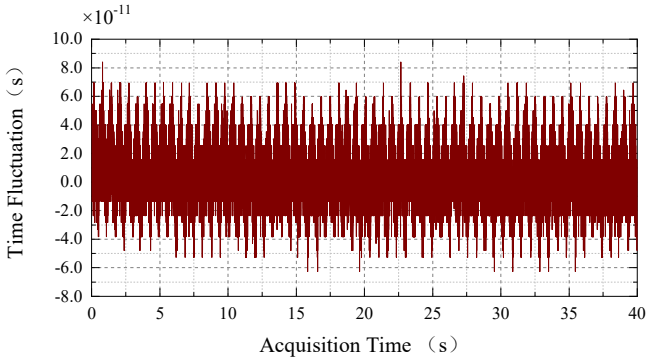

Fig. 2. The fluctuation of the time interval relative to the average of the interval. The input signals are modulation signals and demodulation signals respectively.