All Fiber Free-Running Dual-Comb Ranging System

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Abstract

Fast, real-time and high-precision distance measurement is of great significance to satellite Lidar system, precision equipment manufacturing, gravitational wave detection and many other fields. As a new measuring tool of ultra-fast optics study, optical frequency comb is a hot topic of laser technology. It has the characteristics of wide spectral range, high measurement accuracy and strong pulse stability, which can give full play to its advantages in the field of large-scale and high-precision absolute distance measurement. However, optical frequency comb still has a limitation of several time jitter, frequency noises and phase noises, which is a great challenge for signal procession and further applications.

This paper introduces an all fiber free-running dual-comb ranging system. The repetition frequency of the two optical frequency combs is slightly different. The optical sampling can be realized through multi-heterodyne detection, then the optical spectrum information can be reappeared in the ratio frequency domain. Distance measurement can be obtained by extracting the peak position of interferograms in ratio frequency(RF) time domain.

In this system, the target distance can be adjusted by variable optical fiber delay line. During the signal processing, the peak position of the signal is accurately extracted by tracking the pulse repetition frequency jitter of the optical combs and adaptive signal filtering. Two adaptive signal filtering methods are used to locate the peak position in the process. One is adaptive digital filtering, the other is adaptive auto-correction filtering. The two process methods show good consistence with measuring results.When the repetition frequency of the two optical frequency combs is about 181 MHz and the repetition frequency difference is about 1.6 kHz, the ranging accuracy of this dual-comb system can reach a distance precision of 22 microns, which can meet the need of high-precision range detection in many fields.

The whole ranging system is connected with all fibers and does not need extra mode-locking equipment. The devices are all mature devices in 1550nm communication band, which ensures the robust stability of the experiment system. The paper provides a new way for high-precision distance measurement and lays a good foundation for the application of dual-comb ranging system in many fields.