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Laser Tracking Measurement System Based on Femtosecond Frequency Comb

Laser tracking measurement system is widely used in large-scale and high-precision measurement in the fields of particle accelerator positioning, automobile assembly, ship-building and other manufacturing. It obtain 3D coordinates of measured object by measuring the distance from the object to the origin of machine coordinate system as well as the horizontal and vertical angles of object. Traditional laser trackers measure the distance using interferometer or range finder with the accuracy of 5-10ppm. In this paper a novel laser tracking measurement system was presented which realized the distance measurement using femtosecond laser frequency comb with the accuracy of 0.5ppm. Firstly the measuring principle and overall design of the system were introduced. Then the components of the instrument were analyzed and designed including femtosecond laser frequency comb, dual-comb distance measurement, precision angular encoder , miss-distance detection, tracking control, calibration & error compensation and data processing software. The test results showed that the stability of repetition rate and carrier envelop offset of optical frequency comb reaches 3.0×10-12@1s and 1.0×10-10@1s respectively. The stability of miss distance measurement was better than 2.0μm. The angle measurement errors were compensated to less than 0.60″. The tracking control module is built based on DSP and FPGA, which can track a moving optical target with speed of 2m/s. Finally a prototype of the measurement system was completed. The system reached the measurement accuracy of better than 10ppm which showed its superiority over traditional laser tracking systems. Laser tracking measurement system as well as distance measurement device based on femtosecond light frequency comb are expected to have broad application prospect in accelerator alignment and positioning and other manufacturing fields.

Summary

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