

Pulse repetition frequency of 1Hz~1MHz industrial picosecond laser for satellite and space debris laser ranging

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Picosecond laser units are commonly used in satellite laser ranging (SLR) technology to achieve precise measurements. These lasers typically require a pulse energy of about one millijoule (mJ) and must be customized, which can be costly due to technical challenges in long-term operation. In the field of industrial manufacturing, ultra-fast picosecond lasers with short pulses and high peak power have become increasingly popular. These lasers have improved stability and environmental adaptability, making them a cost-effective option. The Shanghai Astronomical Observatory SLR station has successfully implemented an industrial-level picosecond laser with a pulse energy of approximately 380 microjoules (uJ), a pulse width of 10~15 picoseconds (ps), and a pulse repetition frequency (PRF) of 1Hz-1 MHz. After adapting the 60 cm telescope system, there are able to achieve a pulse repetition frequency (PRF) of 5kHz and an ultra-high pulse repetition frequency ($\geq 100\text{kHz}$, U-PRF) for satellite laser ranging with the MPD detector, and it also can be applied in space debris measurement with the U-PRF. The single-shot ranging precision for spherical satellites and calibration reaches the millimeter level. The statistical uncertainty of normal points for low Earth orbit (LEO) satellites can reach 10-20 micrometers (um), while it is approximately 100 um for high Earth orbit (HEO) satellites at the PRF of 100 kHz. The ability of space debris laser ranging is the RCS of 1.9 m² under at the ultra-high repetition frequency with the distance of 1000km; it fully verifies the application of a single industrial picosecond laser in high-precision satellite/space debris laser ranging, and provides a new way for the technological development of SLR with the U-PRF.

Keyword: satellite laser ranging; space debris laser ranging; industrial picosecond laser; ultra-high pulse repetition frequency; high ranging accuracy