

Development of Any Frequency Fire Rate SLR Control System

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Abstract

This paper presented the high repetition-rate control system which was developed by Changchun SLR group. The system can make the SLR system work at from several hertz to more than 2 kilohertz frequencies. The real-time control hardware and software under Windows XP environment are introduced in detail. The hardware control circuit includes three parts: accurate timing part, range gate control part and laser firing control part. A 2 KHz laser which borrowed from Wuhan was used to work together with the control system to test the performance. The experimental results show that the any frequency fire rate control system can work very well at or less than 2 KHz. If there is a suitable high repetition rate laser instrument (up to several KHz), Changchun SLR system can work at that frequency now.

Key words: Any Frequency, Windows XP, SLR, Real-Time

1. Introduction

SLR was sprung up at 1960s, and has been developed rapidly during these decades ^[1]. With the development of scientific technique, the applications in SLR technologies have been widely used, the accuracy has been higher, and the method has been updated rapidly. At the end of 1990s, National Aeronautics and Space Administration (NASA) commenced researching Kilohertz SLR research, but have not completed yet. At 2004, Graz observatory in Austria achieved 2 KHz SLR for the first time, and we could easily drawn a conclusion from the date size and accuracy observed that Kilohertz SLR has some considerable advantages compared with traditional low frequency SLR ^[2, 3]. High frequency SLR does increase data number largely, from which the accuracies of normal point and orbit determination could be improved, and it would be the important direction for SLR in the future.

The capability of Changchun SLR system was improved in 1990s, its single shot precision has been less than 2 cm, and it also achieved 10Hz SLR owing to A032-ET at the end of 2006 ^[4]. Now Changchun observatory is under the development of Kilohertz SLR, and has already completed hardware and software subsystems at from several hertz to more than 2 kilohertz frequencies under Windows XP environment. This new system has been applied in Changchun SLR system only at 20Hz due to lack of Kilohertz laser, and if there is a suitable high repetition rate laser instrument (up to several KHz), Changchun SLR system can work at that frequency now.

2. Hardware design

The hardware control system is mainly composed of three parts: accurate timing part, range gate control part and laser fire control part.

Accurate timing part needs standard 1pps signal and 10MHz signal to support its normal running, which are provided by HP58503A GPS time and frequency receiver. The time is 24 hours display and it is synchronized every second to ensure the dependability of the timing subsystem.

Range gate control part calculates and generates range gate signals. The method used in this system is different from that in the old 10Hz frequency system. 10Hz SLR system uses three same counters, and the three counters generate gate signals circularly. As the rate being doubled, the number of counters will become two times of the old size. It is unimaginable for KHz system designing in the same method. While the new design of range gate control system for any frequency only needs a piece of range gate circuit, which depends on timing system and range gate value being calculated. But the real time of control system is highly needed.

In detail, the range gate signals depend on the main pulse. Once the main pulse signal is detected, the range gate signal is allowed to be generated. At this moment, read the accurate time-tag from timing system, calculate the range gate, put it into the FIFO buffer, and send the range gate at the corresponding time to produce range gate signal.

The method used in firing control part is similar with that in range gate control part. But one problem should be considered additionally, that is, the range measurement may be corrupted when a transmitted laser pulse is close to the received one, being called back scatter. By virtue of higher frequency, the time interval between main pulse and return pulse is greatly decreased, and some main pulse may be sent at the meantime the return pulse is back. In that case, the detector can not receive return pulse normally. The solution is that, the laser fire signal be delayed for 50us if the back scatter is appeared. The control system frame is shown as figure 1.

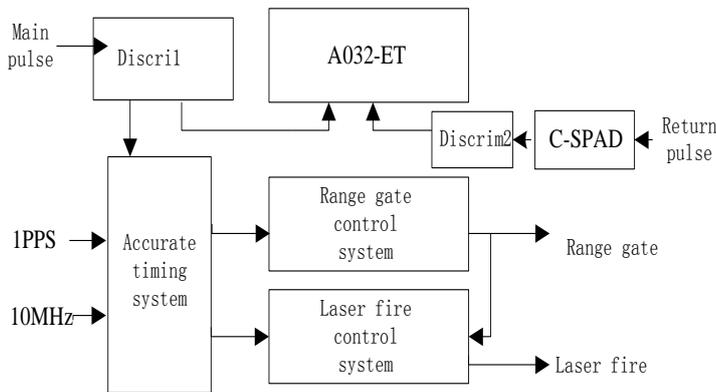


Figure 1. Control system Frame

In figure 1, 1PPS signals and 10MHz signals are provided by HP58503A GPS time and frequency receiver, and range gate control system is used to produce the range gate and laser fire control system to produce laser fire. ISA bus is used to transfer the data in real-time between PC computer and control circuit.

3. Application program design

The software is compiled in VC++6.0 language, running under Windows XP environment. Windows XP is a multiply users' operating system, thence its real-time capability is not as well as single user's operating system such as DOC. To guarantee the real-time capability of control system, the main control program is running in a dependent thread, completing the following functions, such as data calculation, range gate and fire control, data collection, and tracking control and display. While the interface capability provided by Windows XP is well. The runtime environment as follows: Windows XP, CPU Pentium 4 3.0, Resolution 950*680, Main memory 1G. The software flow chart is in figure 2.

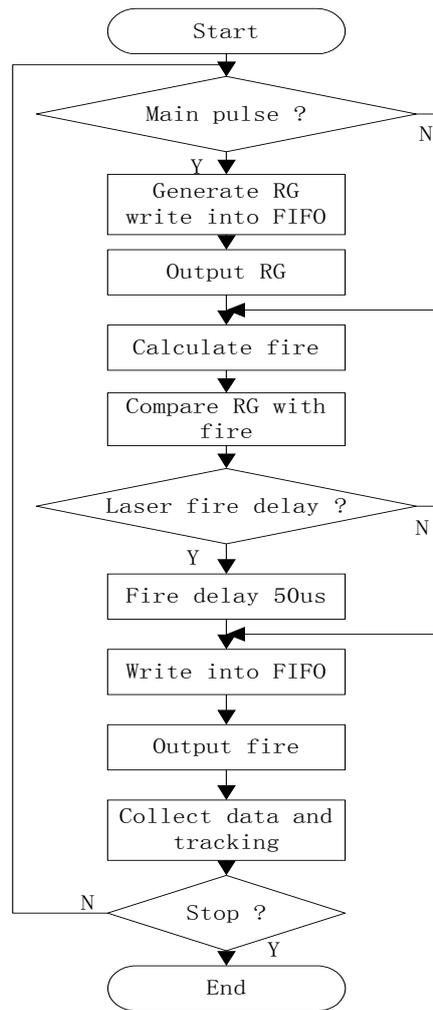


Figure 2. Software flow chart

Software flow in one circle is departed in three steps: 1) In the first step, the range gate control circuit waits for a main pulse, calculates the rang gate and write it into the FIFO buffer, and sends out the rang gate signal at the corresponding time. 2) In the second step, the laser fire control circuit calculates the fire time according to the frequency, compares the fire time and the range gate time worked out in the first step, if the back scatter would happen, the fire time would be delayed by 50us, writes the fire time into the FIFO buffer, and sends out the fire signal at the corresponding time. 3) In the last step, the software collects all kinds of

observed data, including time, azimuth, altitude, range of satellite and so on, achieving the track control.

4. Main performances of Laser

There is a very important instrument in kilohertz SLR system—the laser. It could influence the quality of data greatly. The laser used in changchun kilohertz system was borrowed from Wuhan, and its specifications was shown in table 1. The appearance is shown in figure 3.

Table 1. Laser Specifications

Model	DS20-532
Wavelength	532 nm
Average Power @ 10 kHz	18 Watts
Nominal Pulse Width @ 10 kHz	40 ns
Pulse Energy @ 10 kHz	1.8 mJ
Beam Mode	TEM ₀₀ - M ² < 1.1
Polarization	100:1 Vertical
Beam Diameter	1.0 mm
Beam Divergence	1.6 mrad
Pulse-to-Pulse Instability	<3% rms
Long-Term Instability	+/- 3%
Pointing Stability	< 25 μrad
Pulse Repetition Rate	500 to 10kHz



Figure 3. Appearance of the laser

5. Results and analysis

Figure 4 shows real-time tracking interface. The fire rate is 2 KHz. From the picture we can see that the hardware circuits run well such as fire control circuit and range gate control circuit, and the software could complete all works such as collection data and tracking.

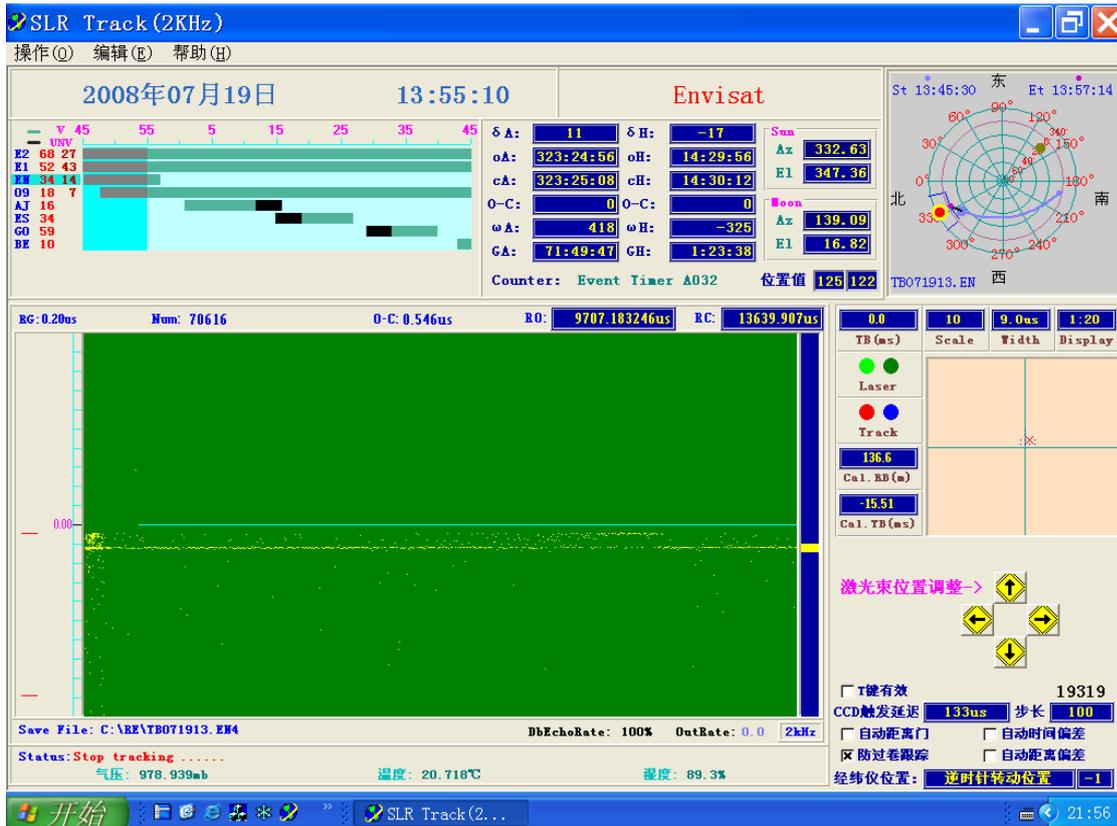


Figure 4. Real-time tracking interface in 2KHz

6. Conclusion

We can draw a conclusion from the experiment above changchun KHz SLR system that it provides good practicability, strong dependability, and wide compatibility. If there is a suitable high repetition rate laser instrument (up to several KHz), Changchun SLR system can work at that frequency now.

7. Acknowledgements

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