Disturbance rejection of the WIYN telescope position control servosystem

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ABSTRACT

The performance of a telescope position control servosystem depends on its ability to minimize changes in position due to wind and other disturbances. Modern, lightweight telescopes such as WIYN rely on feedback to achieve good disturbance rejection. While the simplicity of a direct, friction-drive system is attractive, the small drive ratio greatly diminishes the effectiveness of motor velocity control in reducing disturbance sensitivity. The WIYN servosystems use position feedback and motor torque control to achieve tracking accuracy and disturbance rejection. This type of control allows the use of larger position control bandwidth than is possible with motor velocity control.

The factors affecting disturbance rejection are discussed. Motor velocity controlled and motor torque controlled servosystems are described and compared. The WIYN telescope is analyzed to show the expected performance of each type of system, and measured performance is presented.

Keywords: telescope, position control, disturbance, telescope servosystems, control systems.

1. GENERAL CONSIDERATIONS

Pointing stability is an important factor in telescope performance. The telescope and its control system must minimize the effects of torque disturbances, particularly those due to wind, known as wind shake. The high quality of the WIYN telescope optics means that disturbances of just a few hundredths of an arcsecond may result in significant image degradation. The total error budget for wind shake is 0.12 arcseconds.

The WIYN telescope depends on its position control servos to manage disturbance response to a greater degree than many larger telescopes. The short focal length of the 3.5 Meter f/1.75 WIYN primary mirror means the telescope dimensions, total mass, and moments of inertia are small compared to older, larger designs. As a result, a simple and economical direct friction-drive system can drive the Azimuth and Elevation axes. However, as the overall dimensions of a telescope decrease, the moments of inertia decrease much faster than wind torque, making the inherent sensitivity to wind disturbance greater for a small telescope. Also, a lower drive ratio greatly decreases the effective inertia of the motors, further increasing the inherent sensitivity to disturbances. Effective motor inertia can be increased using a modest amount of motor velocity feedback, but this is effective only in systems with large drive ratios. Because the inherent disturbance sensitivity of a large telescope can be made quite small, a limited position control loop bandwidth has little effect on overall disturbance sensitivity. With the WIYN telescope, the moments of inertia are small and the effective motor inertia is negligible. Because of its small drive ratio, motor velocity feedback would not be effective unless the velocity loop bandwidth was impracticably large. Only the position control servo can reduce disturbance sensitivity to an acceptable value in the crucial 1 to 5 Hz frequency range, where wind disturbances may be significant.

This discussion considers only the effects of disturbance torque on the Azimuth and Elevation servos. Of course, other sources of image motion can result from disturbance torque, such as tilting of the fork and flexure of the telescope structure, which the Azimuth and Elevation servos do not affect.

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