

Comparison of ASI's Closed-loop DC Servomotor Stages and Control Electronics with Competing Products

ASI's closed-loop DC servomotor stages and control electronics have been designed to provide an extremely precise and highly repeatable platform for demanding microscopy applications. The stages are manufactured by skilled craftsmen in the United States with high quality components under stringent quality control procedures. Due to the quality of the components used, and extensive on-going research and development, ASI's stages are considered to be the best in the world and are covered by a 5-year warranty.

This technical note will address the specific reasons why ASI stages consistently out-perform competing products.

There are a number of factors to consider when choosing an automated XYZ stage to add to your microscope. These include the type of motor drive, feedback, resolution, repeatability, fit and flatness factors, as well as what application the stage will be used for. Basically there are three levels of automated stages offered:

1. Low-end low cost stages
2. Medium-level, moderately priced stages
3. Upper-end premium priced stages

Low-end, low cost stages

Low-end low cost stages are designed with the price-conscious consumer in mind. These stages are usually priced at around US\$4-5K, and are used primarily in applications where only automated movement is required, and resolution and repeatability issues are not important factors. ASI's MS-4 series, Ludl's Biopoint series, and Marzhauser's Econo line are examples of this type of stage. In order to keep the cost down, these stages are always manufactured with low-cost stepper motors operating in an open-loop configuration. Geared rack and pinion positioning elements are also used instead of more expensive lead and ball screws, and low cost bearing assemblies and guides are utilized instead of more expensive cross roller bearings and precision machined guides.

Medium-level, moderately priced stages

Medium-level moderately priced stages in the US\$10-12K range utilize higher quality components such as cross roller bearings and precision machined guides, as well as more expensive lead and ball screws. Other manufacturers such as Ludl, Marzhauser, and Prior utilize lower cost open loop stepper motors in their basic medium-level stages. In comparison, ASI utilizes high precision closed-loop DC servomotors with rotary encoders and antibacklash gear heads in their standard stages. This means that ASI's standard stages come in a closed-loop configuration right out of the box. Since DC servomotors have an infinite resolution, the accuracy of the stage system is determined by the resolution of the feedback encoders, the quality and rigidity of the mechanical components used in

the stage, and the control electronics. In comparison, the lower cost open-loop stepper motors that the other manufacturers use have a limited resolution, and must be micro-stepped in order to obtain sub-micron resolution. Since the stepper motors are usually provided without any feedback element, there is no way to determine if the commanded position is ever attained.

Feedback - The Importance of knowing where you are

As previously mentioned, no encoder or feedback is used in the basic open-loop system that the other manufacturers provide. Instead of using encoders, which can add a substantial cost to a system, the stepper motor's controller keeps track of the motor's alleged position by counting the pulses it sends to the motor. Since the pulses to the motor usually result in the proper linear movement of the XY stage, stepper motors are commonly used in lower-cost positioners. However, if something binds the stage's lead screw or the stepper motor's shaft and motion is lost, then an open-loop stepper system can lose its true position. When working at nanometer resolutions, the voltages and pulses applied to the motor are at very low levels, and it does not take much to hinder the motion of the stage. At these levels a speck of dust can create problems, and a small crystal from a saline solution can appear as a boulder. In an open-loop stepper motor system, the lost motion errors are accumulative and will result in poor repeatability specifications.

Upper-end premium priced stages

Upper-end premium priced stages in the US\$14-20K range utilize the same high quality components that the medium-level stages utilize, and in addition, a direct-motion feedback element is also added. ASI's premium stage systems utilize linear encoders to provide a resolution of 20 nm. However, due to the mechanical limits of cross-roller bearings and lead screws used, realistic resolutions at the optical axis are in the order of 50 nm or so. To do better than this, air bearings or more sophisticated designs offering much less friction need to be used. With standard designs utilizing cross-roller bearings and lead screws, and with well-designed controller electronics and motion-control algorithms, stages with linear encoders can achieve bi directional repeatability accuracies on the order of less than 200 nm RMS for small moves of a few hundred microns or so, and about twice this on larger moves. When working at these levels, the thermal expansion of the metal from which the stage is built must also be considered, and the resolution of the motor becomes a factor. Since ASI stages utilize DC servomotors rather than the lower cost stepper motors that the other manufacturers use in their basic stages, ASI stages out-perform the competition.

Links and supporting documentation

As noted above, ASI DC servomotor stages offer a more precise alternative to the common stepper motor stages provided by other manufacturers. For additional information, please see the links and supporting documentation listed below:

Zemek J, Monks C, Freiberg B; **Discovery Through Automation**. *Biophotonics International*. May 10, 2003: pages 54-57

Additional benefits that ASI stages offer over the competition

- Five year guarantee - Since ASI stages are built with the highest quality components available, we offer a five-year warranty on the stage components and control electronics. The DC servomotors are guaranteed for three years for biological research applications.
- Customer service - ASI takes great pride that, in addition to providing the highest quality products available, our technical support is also second to none.
- Unique Z-axis drives- Unlike other manufacturers whose Z-axis drives simply clamp on or are stuck to the fine focus knob of the microscope in an open-loop configuration, ASI's Z-axis drives are custom designed for each microscope, and when installed, become an integral part of the microscope. Advantages of this custom design include:
 - ASI drives use geared DC servomotors with position feedback from the focus shaft. This means, unlike stepper motors, full torque is available even for very small movements. A closed-loop servo system does the positioning; therefore, the stage position displayed on the control console is the actual stage position.
 - A switch located on the control console operates a clutch that disengages the motor drive from the fine focus shaft when the drive is not needed. When disengaged, the actual stage position is actively displayed and is available for interrogation by computer. When the clutch is disengaged, or the motor drive shut off, the microscope can be manually focused from either side with no added torque felt on the knob and no cable to twist up.
- ASI stages offer a much lower profile - Since our DC servomotors are embedded within the leadscrew cartridge, there are no motors that stick out.
- Proprietary antibacklash algorithm - ASI's control electronics utilize a proprietary antibacklash algorithm that has been refined over the past fifteen years. Our firmware, control electronics, and stages continue to evolve to stay at the cutting edge of technology.
- ASI is the leader in advanced technology - ASI has been motorizing microscopes since 1985; our technology has always spurred others to duplicate our efforts. In 2003, we released our new PZ-2000 piezo top plate stage, which offers many innovative solutions for optical serial sectioning. In 2004, we will also release many new innovative products to help our customers solve complex technical problems.
- ASI specializes in solving unusual and difficult problems. We have developed various auto-focus systems, precise scan routines, TTL-driven rapid movement options, and more. Your problems are our challenges.

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