

Application Note

Piezo Actuators provide flexibility to laser designers using compact optical mounts and motion stages



I. Introduction

Lasers require precise alignment in their design to simultaneously deliver optimal power and provide ultra-stability of the beam in position and quality. To meet this requirement, the laser designer must precisely control the optical path inside the laser. Guaranteeing a high level of precision and enabling nanometer level linear displacement and μrad rotation level, MKS Newport piezo products are ideal components to ensure the performance and quality of the laser beam over the long term and permit flexibility in the design.

II. Problem

The design of lasers requires very high precision in assembling the components and sub-assemblies that constitute them. In particular, the optical path must be precisely aligned to avoid any power loss or risk of damage to the internal components, given the energy carried by the laser beam. The Picomotor™ and Agilis series associated with MKS | Newport optical mounts can control the positioning/alignment of the laser beam and realize the necessary trajectory corrections to maintain an ideal optical path. This level of precision is particularly important in optical designs that extend to several meters inside the laser.

We identified three main types of applications for Picomotor™ and optical mounts in lasers:

- The first one consists of maintaining the correct positioning of the laser beam between the various internal components and, if necessary, being able to adjust the alignment without any manual service operation.

- The second consists of moving the laser's point of incidence on a non-linear crystal after surface damage/wear and extending the useful life of the crystal. In this case, a new area of the crystal surface is utilized, extending its lifetime without replacing it or performing a time-consuming maintenance event. It has the additional benefit of being done without opening the laser, eliminating any contamination risk.
- The third case of application is for precision linear motion (Agilis™) to enable moving mirrors to compress or expand the pulse width and act on the GDD dispersion in ultrafast lasers.

The Picomotor™ and optical mounts associated with the dedicated controllers offered by Newport are ideally suited to these use cases: because of their extremely fine resolution step, they allow stable and exact positioning (step < 30 nm, angular resolution < 1.5 μrad , no backlash) for the optical component, which can be a mirror or lens while occupying a restricted volume.

III. State of the art

Numerous laser manufacturers use Newport products in their laser systems. Their optical path includes the Picomotor™ and Super Agilis Series associated with Newport optical mounts. These devices are considered industry standard for the different applications listed above. In the laser optical path, often more than a meter long, our products are guaranteeing that the beam travels correctly from one internal module to another. Use of these devices enables the lifetime extension of the module comprising the non-linear crystal, which has the shortest lifespan (typically 3 to 5 years) and thus

reduces the Total Cost of Ownership, or TCO, of the complete laser. The system usually includes a feedback loop to identify when the system is aligned. It could be a photodiode measuring either position or power through the reflection of the signal. The end-user initiates the laser beam recalibration operation. Indeed, this operation must not occur unexpectedly when a job is ongoing, as it can damage the sample. It must be done after a proper warm-up of the system (stable environment). The nanometer/ μ rad level steps and the extremely reliable position holding without power consumption of the Newport Piezo products make them ideal to guarantee both the stability of the process and to improve its robustness since the laser beam is perfectly controlled and operates permanently in the optimal conditions. No overheating is generated by the piezo and these devices are fully compatible with the level of cleanliness required in lasers: no particles and no organic material are emitted by the piezo devices. These products are also compatible with usage in vacuum conditions.

This monitoring and calibration system is not only useful to reduce maintenance but also indirectly improves the quality of the manufactured parts or processed operations since the laser always works in optimal conditions at the required levels of precision and quality. In addition, it is possible in an Industry 4.0 environment to link the quality of the manufactured parts or operations to the laser calibration parameters. This enables the operator to plan preventive maintenance campaigns when the quality of the result obtained begins to drift from the optimal values.

Newport Piezo Picomotor™ family differentiates itself by providing very small steps, superior repeatability, and compactness. In addition, the associated range

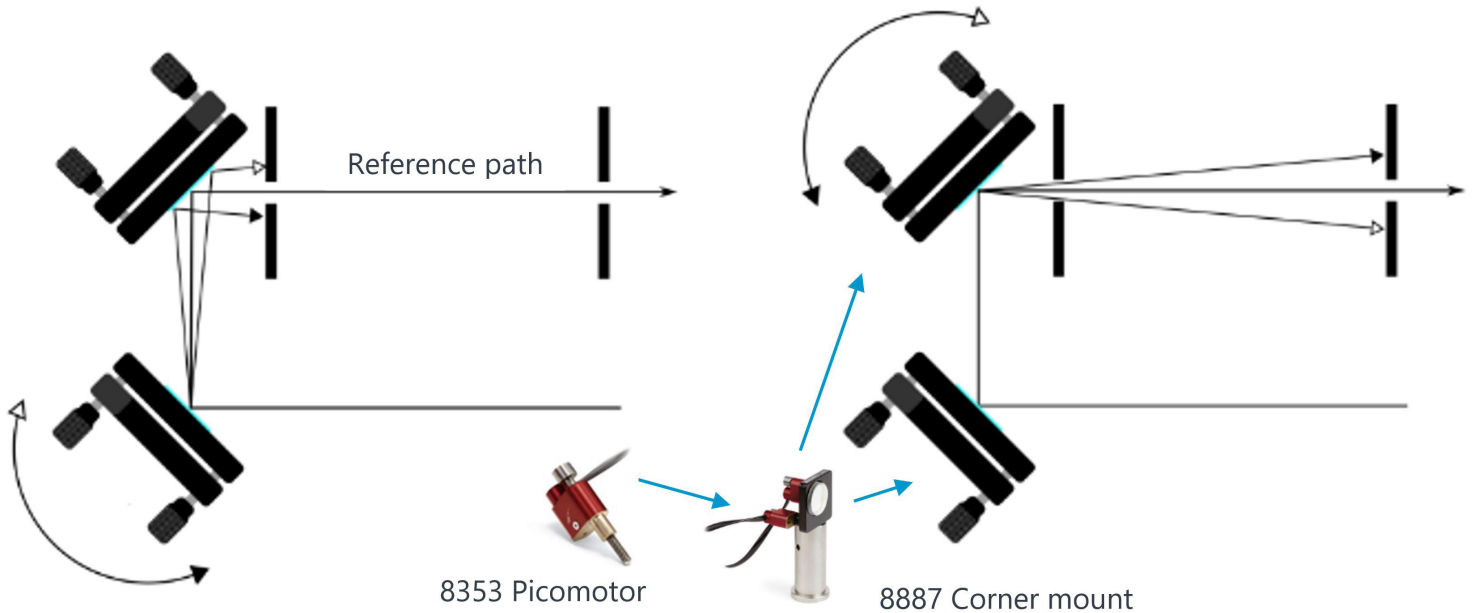
of Newport controllers provides a very compact and economical solution for driving piezo actuators (Picomotor™ and Super Agilis, closed-loop control for fine tuning, absolute positioning).

IV. Solutions

Thereafter are some reference use cases illustrating the applications described above where Newport piezo actuators are particularly well suited.

Principle of laser beam alignment:

- Two adjustable mirrors are used to align the laser beam inside the laser and maintain a fixed optical path to avoid any drift or position change at the output. The mirrors can be positioned in different ways inside the laser, depending on the design constraints of the manufacturer but the principle is always the same. Manual or motorized mirrors can be used to do the operation. The advantage with the motorized mirrors is that you can automate the alignment sequence to avoid opening the laser: it's quicker and you don't risk any particle contamination from opening.
- To realize the tuning, some leading lasers manufacturers use customized Picomotor™ actuated pint-sized corner mounts with our tiny picomotor actuators, available as vacuum compatible depending on required environment constraints. For instance, Newport 8887 Corner Mounts with 8353 Actuators are commonly used for laser beam $\theta \times \theta$ alignment. The high compactness, the degrees of freedom combined with our outstanding customization capabilities for ambient & vacuum use are highly valued by laser manufacturers.
- Motorized $\theta \times \theta$ Mirrors can align the laser parallel to the optimal path. If the laser design and embedded features also requires precise beam centering, then



additional degrees of freedom are required for the mirror mount. Newport 8081 XYZθxθy Motorized Five-Axis Tilt Aligner, is used for laser alignment and in-tune system by laser manufacturers who are looking for five degrees of freedom, compactness, and extremely high-resolution adjustment (< 30nm) in a compact product.

Two other applications mentioned previously use a Super Agilis stage with a controller:

- The Conex-SAG is employed in UV ns laser for shifting the beam spot to a clear (undamaged) area of crystal in the cavity of the laser.

The laser beam is focused on a non-linear crystal (BBO/ LBO) to generate the UV wavelength. After several thousand hours, the crystal surface can degrade, and the user needs to move the laser beam on the crystal to a pristine area to recover the laser properties and restore optimal operation. The incidence of the laser beam remains unchanged as long as the Conex SAG isn't energized and so the system for changing position is very stable. BBO: Beta Barium Borate, LBO: Lithium TriBorate

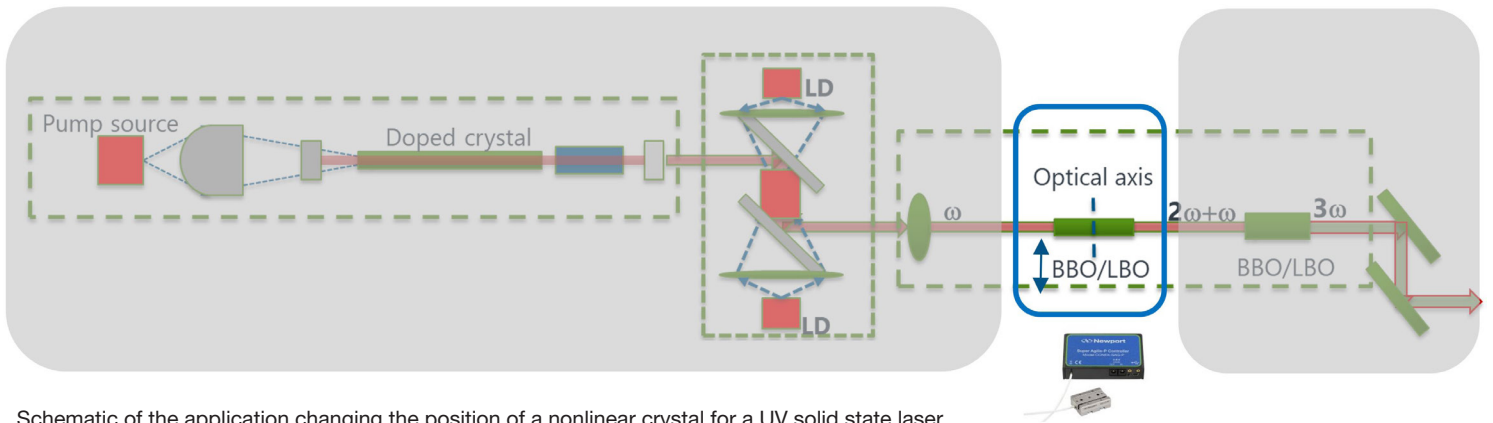


Newport 8081 XYZθxθy Motorized Five-Axis Tilt Aligner:

A very similar set-up enables the adjustment of pulse width for ultrafast lasers. In this case, the grid is used to stretch or compress the pulse width. For example, mirrors 6 and 7 in the upper view are mobile and mounted on CONEX™-SAG or CONEX™- AG



CONEX-SAG Super Agilis:



Schematic of the application changing the position of a nonlinear crystal for a UV solid state laser

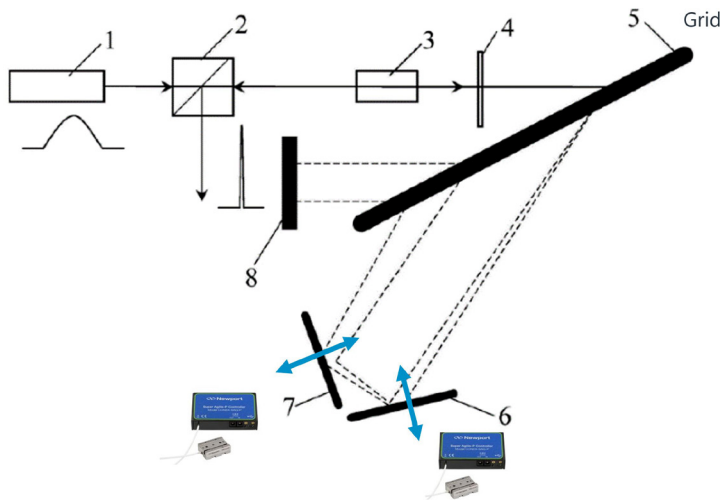
stages. By acting on the CONEX™-SAG stage, the distance between mirrors 6 and 7 and grid 5 is changed, modifying the dispersion (Group Delay Dispersion or GDD) to compress or stretch the pulse duration.

Because of their compactness, high accuracy and sub-micron step, Newport Agilis devices are good candidates for both use cases.

V. Conclusion

Newport's piezo-based nanopositioning and optical mount solutions (Newport™ or New Focus™ Picomotor™, Agilis™, Conex™) are ideal components for demanding laser applications. The product range includes a wide variety of picomotors, stages, actuators, lenses, & mirror supports for alignment control and demanding real-time compensation and adjustments when required.

Newport's wide product range allows customers to find the components that fit perfectly into their application (form factor, travel range, mounting, vacuum technology, or closed-loop options availability). All of these are easily controlled with Newport's plug-and-play controllers designed exclusively for these types of actuators. The compactness of the components, their exceptional accuracy, resolution, and stability performance make them very attractive. The standard piezo and picomotors can be used or customized to perfectly suit specific customer needs and will remain easy to implement and use thanks to the Newport's offer of dedicated controllers and accessories.



Schematic of the Conex-SAG is used to adjust the pulse duration for ultrafast lasers. Translation movement delivered by the Conex-SAG stage on mirrors 6 and 7

For additional information, please contact Newport sales and applications engineers at tech@newport.com.

Piezo Motor Laser Application Note - Support Products

8081: Motorized XYZ θ x θ y Tilt Aligner, 3 mm, 8°

The 8081 XYZ θ x θ y Motorized Five-Axis Tilt Aligner increases the utility of our popular kinematic stages by motorizing each of the axes. The addition of Picomotor™ actuators to each stage allows remote high-resolution (<30 nm) adjustment of various combinations of X, Y, Z, θ x, and θ y. Model 8081 five-axis aligners are ideal for positioning modulators or isolators and for coupling light into waveguide devices. Available with metric or SAE tapped holes.



CONEX-SAG-LS48P: High Speed Piezo Linear Stage, 48 mm Travel, Direct Encoder, Integrated Controller

The Super Agilis™ CONEX-SAG-LS48P is a piezo motor linear stage integrated with a closed-loop piezo motor controller/driver that provides 48 mm travel and up to 10 mm/sec speed. The compact linear stage has a built-in direct read linear encoder enabling high position repeatability, for sample positioning, as an optics inserter, for focusing, etc. The innovation in this encoder technology allows the footprint to be maintained while delivering sub-micron bi-directional repeatability. The CONEX-SAG-P controller's closed-loop algorithm combined with the direct read linear encoder, provides a system bi-directional repeatability of 25 nm. For stability in-position, the user can adjust the dead band parameter



that stops dithering when the stage is within a set position tolerance.

The CONEX-SAG-LS48P is a very compact and inexpensive single axis motion controller delivered already pre-configured for the stage. The controller is accessible via USB, with options for other serial connections, from an easy to use GUI or proprietary solutions using an extensive command set.

With MIM of 25 nm this stage is perfect fit for high precision applications also needing high speed. And it is easy to stack stages into a XY configuration without requiring an adapter.

8885: Piezo Mirror Mount, Pint-Sized, Center Mount, 0.5 in. Diameter

The 8885 Picomotor Actuated Pint-Sized Center Mounts eliminate problems usually associated with small systems where there is little room to make adjustments and there is high sensitivity to adjustments by hand. The two Picomotor actuators that allow remote adjustment of the tip and tilt axes add only 0.5 in. of depth to this 0.5 inch (12.7 mm) diameter mount.

Our Tiny Picomotor actuators allow for an angular resolution of 1.5 μ rad, allowing for very small, controlled movements of your optics. The Tiny Picomotor actuator offers the additional advantage of using the integrated knobs for quick, manual adjustment of all axes.

The Picomotor actuator moves when voltage is applied to the piezo, changing its length and in turn moving the jaws which turn the screw. When no power is applied, the actuator does not move. You can feel confident that



your mount will stay put, even when you power down your system.

Sapphire seats and optimized spring location and force provides for smooth, reliable motorized adjustment while maintaining a high level of thermal and mechanical stability.

8353-V: Piezo Mirror Mount, Pint-Sized, Center Mount, 0.5 in. Diameter

The 8353 Tiny Picomotor actuator is a smaller sized version of our standard Picomotor actuators. We have improved the design so that it will meet even more of your compact-area needs.

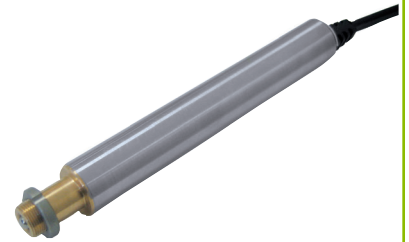


The 8353-V Vacuum Compatible Tiny Picomotor Actuator is designed for environments down to 10^{-6} Torr. It's perfect for moving small optics and stages in your vacuum chambers.

Our Picomotor actuators have a step size of less than 30 nm per step, allowing for very small, controlled movements. Note that the step size for open-loop picomotors varies from step to step and between forward and backward directions, and is directly related to payload – hence, position feedback should be provided by an external signal when operating an open-loop picomotor. For applications requiring absolute position calibration and high repeatability, consider a Closed-Loop Picomotor actuator.

TRA25CC: Motorized Actuator, Miniature, 25 mm Travel, DC Servo Motor

The TRA25CC Miniature DC Servo Actuator provides 25 mm travel in a slightly larger package than the other TRA actuators, while offering a Minimum Incremental Motion of 0.2 μm . It is the recommended choice for motorizing longer travel linear stages and other devices with longer travel range. TRA actuators incorporate an excellent space saving design that allows them to be used with a wide variety of linear stages, mirror mounts, and OEM applications.



TRA actuators offer a similar form-factor as micrometer drives, allowing them to be used to upgrade manual stages with ease.

TRA actuators also feature a hard-coated steel ball tip that minimizes contact surface wear compared to other designs that use regular steel ball tips.

All TRA actuators include integrated optical limit switches. These highly reliable switches not only protect investments from over travel damage, they also provide a method for repeatable referencing/homing, for instance after shut-downs.