M3 Smart Module Technical Bulletin

Custom micro beam steering solutions

Precision two-axis beam steering modules are easily integrated into portable instruments

New Scale's miniature M3 beam steering modules are designed for precise point-to-point positioning and dynamic movements up to 1K Hz. Our direct-drive piezoelectric motors inside the modules hold position with zero power and no servo jitter. The effects of external vibrations on the mirror position are highly damped.

M3 smart modules have *fully-integrated closed-loop controllers* and communicate directly with your system processor over a standard serial interface. They have low drive voltage and low power use, making them ideal for portable instruments.

Tiny M3 beam steering systems are comparable in size to MEMS devices, but offer a larger range of motion and accommodate higher-power lasers with larger beam diameters. They are the smallest and easiest-to-integrate beam steering solutions available.

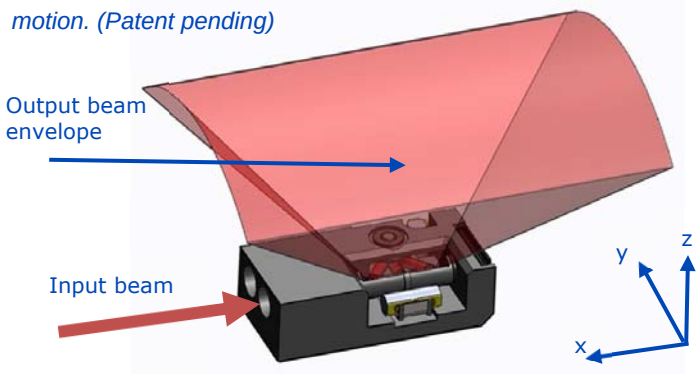
This bulletin describes several different custom M3 modules developed for specific beam steering requirements. **We also offer standard M3-RS rotary stages for beam steering using a familiar galvano-scanner style form factor (see the DK-M3-RS-U-1M-20 data sheet).**

Custom two-mirror beam steering solution

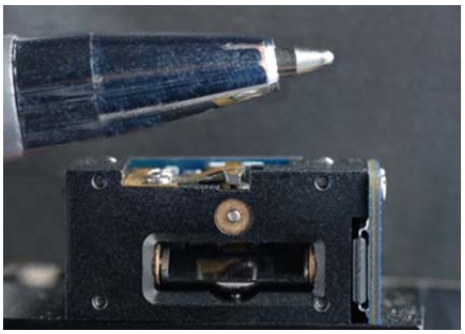
Advantages: Largest range of motion.
Compact optical path and mechanical size.
Limitations: Optical path requires collimated beam.

The two-mirror M3 module *(figure 1)* features two mirrors that rotate independently on orthogonal axes, with motion similar to that of a commercial galvo. The mirrors angles Φ_X and Φ_Z are equal to half the beam angles Θ_X and Θ_Y respectively. The large range of motion delivers a wide beam range of +/-40 degrees.

Figure 1: Custom two-mirror M3 beam steering module has wide range of motion. (Patent pending)



NEW SCALE TECHNOLOGIES
small, precise, smart... in motion



Applications of M3 Smart Modules for beam steering

Medical

- Scanning dermatology lasers to achieve precise exposure levels
- Scanning a laser sources in fluorescence microscopes and imaging instruments
- In-vivo and in-vitro micro laser surgery

Industrial

- 3D printers
- Positioning laser beams for range finding (LIDAR), 3D measurement, spectroscopy
- Remote sensing of atmospheric conditions, pollution sources, explosives, etc.
- Optical image stabilization to correct for hand tremors
- Laser marking, engraving and machining

Telecommunications

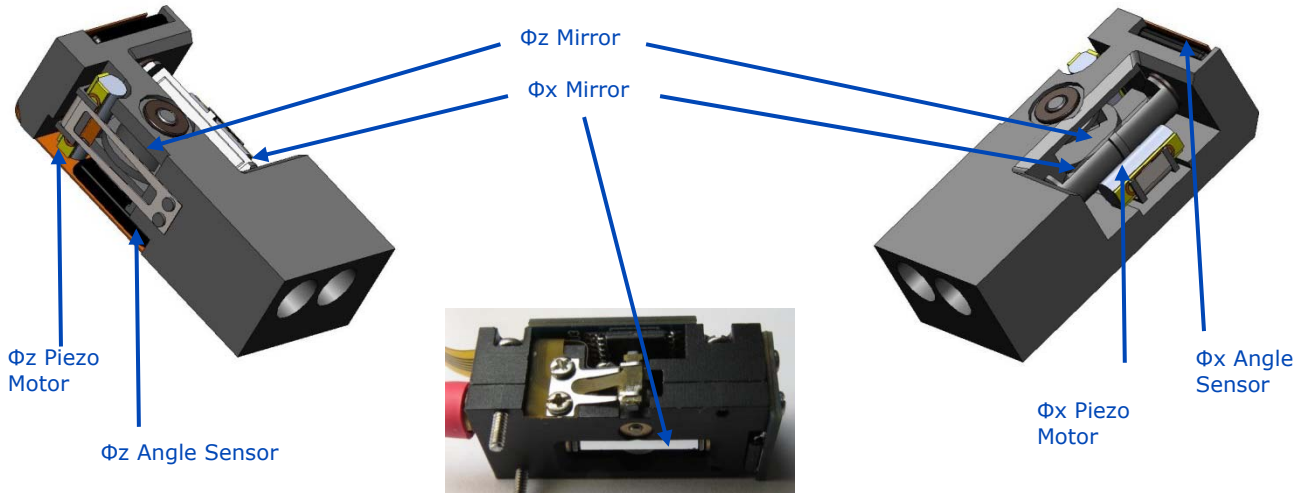
- Laser beam pointing and tracking for free-space optical communication systems
- Variable optical attenuation
- Fiber-to-fiber optical switching

Aerospace and Defense

- Designation and jitter compensation of targeting lasers
- Automated obstacle detection, tracking and avoidance for robots, vehicles, UAVs, etc.

The two-mirror module contains two UTAF™ piezoelectric motors, two angle sensors, driver ICs and a microcontroller with closed-loop firmware. The 6 mm thick module is incorporated into a 20.5 x 10 x 7.8 mm³ package (*figure 2).* This module is significantly smaller than a galvo, needs no separate controller, uses less than 0.9 W while moving, and holds mirror position in sleep mode to further minimize power consumption.

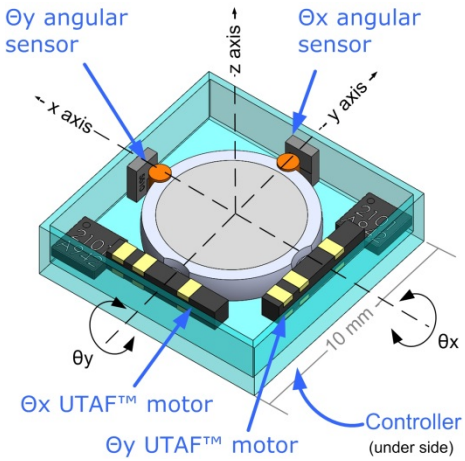
Figure 2: Custom two-mirror M3 beam steering module with piezo motors and angle sensors for closed-loop control. (Patent pending)



Custom single-mirror beam steering solution

Advantages: Fastest response.
Smallest system size and moving mass.
Works with convergent and divergent beams.
Limitations: Smaller range of motion than other M3 modules.
Input beam must be 45° to mirror face when mirror position is in the center of its range.

Figure 3: Custom single-mirror module is the smallest, fastest M3 beam steering solution. (Patent pending)



The single-mirror M3 module *(figure 3)* has one mirror that rotates around two orthogonal axes Θ_X and Θ_Y to create a tilting mirror system without a nested gimbal mechanism. The X and Y axes are in the plane of the mirror. The Z axis is orthogonal to the mirror surface. This simple and compact design has a single pivot point at the center of and slightly behind the mirror surface.

Two UTAF™ piezoelectric motors drive the outer edge of the mirror in the +/- Z direction to rotate the mirror in Θ_X and Θ_Y. The motors and contact points are oriented at 90° to produce independent and orthogonal rotations. Opposite each motor contact is a position sensor that independently measures the Θ_X and Θ_Y rotations. Behind the mirror assembly, the drive and control electronics are integrated on a rigid PCB.

This novel tilting mirror module offers greater range of motion in a MEMS-sized package with excellent dynamic response. The typical arrangement has the nominal incident beam angle at 45° and the reflected beam at 90°. The beam rotation angle is twice the mirror rotation. The mirror shape, material and coating reflectivity can be optimized for each application. For example, an elliptically shaped mirror can be specified with an aluminum substrate and dielectric coating with extremely high reflectivity at a specific laser wavelength.

Custom ultra-compact Risley device

Advantages: Highest power laser beam of the M3 beam steering solutions.
Efficient and in-line optical path.
Limitations: Highest inertia (slowest response) of M3 solutions.
Requires non-linear conversion of prism rotation angle to beam angle.

A dual-wedge Risley device has two co-axial wedge-shaped prisms that rotate independently around the optical axis, steering an incident beam over a continuous range of directions. The prism rotation angles Θ_{z1} and Θ_{z2} are converted to beam directions Θ_X and Θ_Y *(Figure 4).*

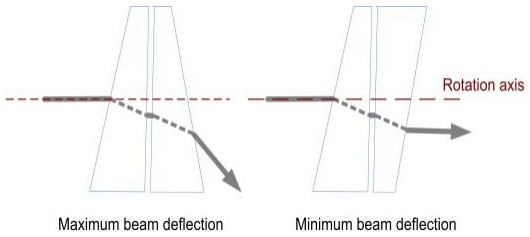


Figure 4: Risley prism pair beam steering

The Risley device's straight clear aperture delivers high transmission and opto-mechanical simplicity. It is smaller, uses less power, and weighs less than a gimbal mirror system.

New Scale's ultra-compact Risley M3 module *(Figure 5)* has micro ball bearing guides that support each prism with very low friction and low wobble. A UTAF™ piezoelectric motor is frictionally coupled to the outside diameter of each prism, enabling continuous bi-directional rotation with +/- 0.35° resolution, +/- 2° accuracy and no jitter. Position sensors and control electronics are integrated in the module.

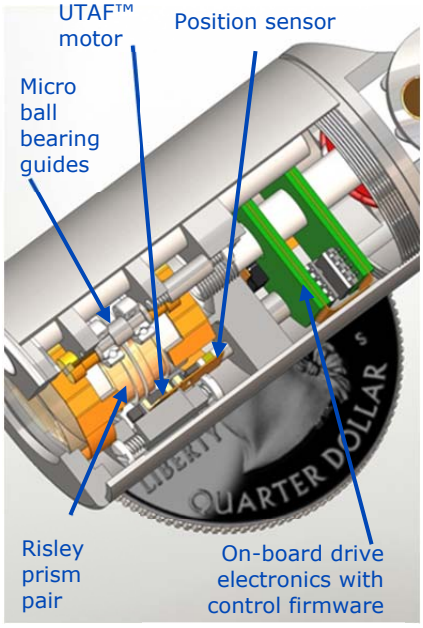


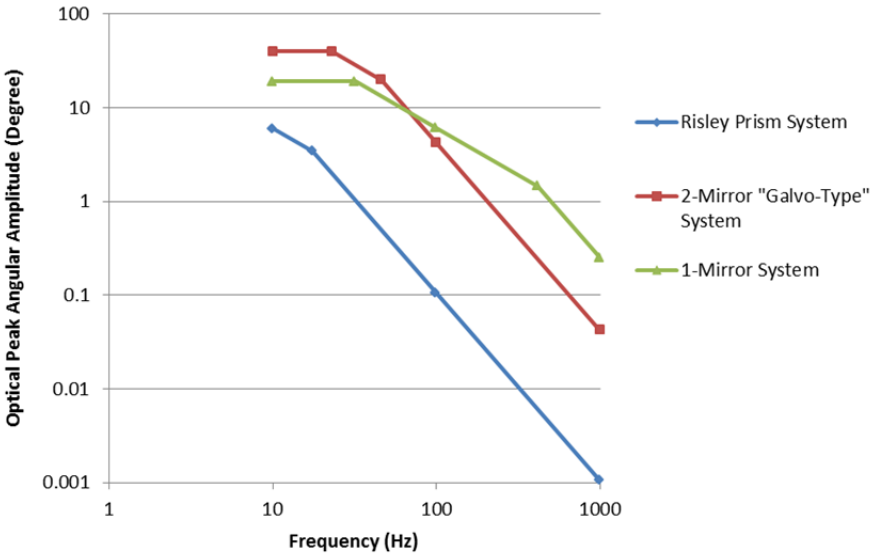
Figure 5: Custom Risley M3 module in an endoscopic laser scalpel head with a 17 mm outer diameter.

Performance comparison for custom M3 beam steering modules

	Two-Mirror M3 Module	Single-Mirror M3 Module	Risley Device M3 Module
Beam Motion			
Range of Θ_X and Θ_Y (deg)	+/- 40	+/- 19	+/- 6
Speed (deg/s)	5760	3820	379
Acceleration (deg/s^2)	1,664,000	10,000,000	41667
Resolution (deg)	0.04	0.04	0.1
Accuracy (deg)	0.1	0.1	0.6
Maximum Beam Diameter (mm)	2	3	6
Fastest beam stepping time for:			
0.1 deg (msec)	0.49	0.2	4.38
1 deg (msec)	1.55	0.63	13.86
10 deg (msec)	4.9	3	61.88
Approx. Module Size (mm)	~ 20 x 10 x 10	~10 x 10 x 5	~ Dia. 16 x 15 Length
Approx. Module Volume (mm^3)	2000	500	3000
Controller	Built in	Built in	Built in

Performance data is typical. Contact New Scale for custom solution development.

Figure 6: Custom M3 beam steering solutions optical peak amplitude (0-peak) vs. frequency for sinusoidal motion



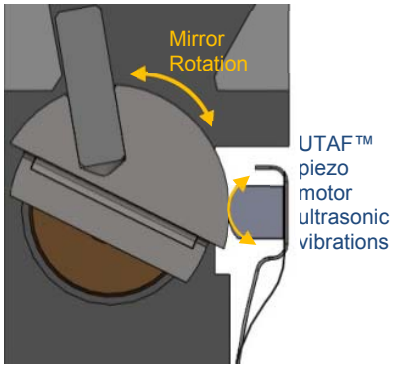
M3 Smart Modules: simple, precise, smart

With our M3 (micro-mechatronic) smart module design platform, we can quickly develop closed-loop motion modules customized for your OEM application. Building on our miniature piezoelectric motor and position sensor technology, this design platform yields complete closed-loop motion modules with high precision and tiny footprint.

The M3 beam steering modules incorporate UTAF™ piezoelectric motors frictionally coupled to the mirror or prism. Tiny, ultrasonic vibrations of the motor cause the mirror to move with smooth and precise motion (*figure 7*).

These “all in-one” smart modules require no separate electronics and are ready to plug-and-play directly with your system processor and power supply. Send simple serial commands from your processor directly to the module’s built-in controller using a standard I2C or SPI interface. This enables you to achieve the fastest time to market with the lowest total cost.

Figure 7: UTAF™ piezoelectric motor causes precise and smooth motion of micro optics.



M3 modules have low power consumption and low input voltage for battery-powered operation.

About New Scale Technologies

New Scale Technologies develops small, precise and smart motion systems for critical adjustments of optics, and many other micro positioning applications. Our simple and elegant solutions deliver best-in-class performance in handheld, portable and mobile instruments for medical, scientific and industrial applications. Our customers benefit from complete, "all-in-one" motion solutions that are tailored to their unique requirements and easily integrated into their next-generation instruments. Contact New Scale at NSTsales@newscaletech.com or call +1 (585) 924 4450.