WHITE PAPER

Embedded Motion Modules Make Great Products Smaller

Start new designs with all-in-one positioning modules to achieve smallest system size

Embedded motion modules are a new option for product design teams. Combining mechanical and electrical functions in one optimized, easy-to-integrate device, they speed the design process and ensure smallest system size. To avoid adding needless space and complexity for motion components, product designers should consider embedded motion modules *at the beginning of the design process.*

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A New Option to Miniaturize Product Designs

Designers are racing to miniaturize instruments for handheld, portable, mobile and battery-powered applications. These accelerating markets require shorter development times with no compromise in performance.

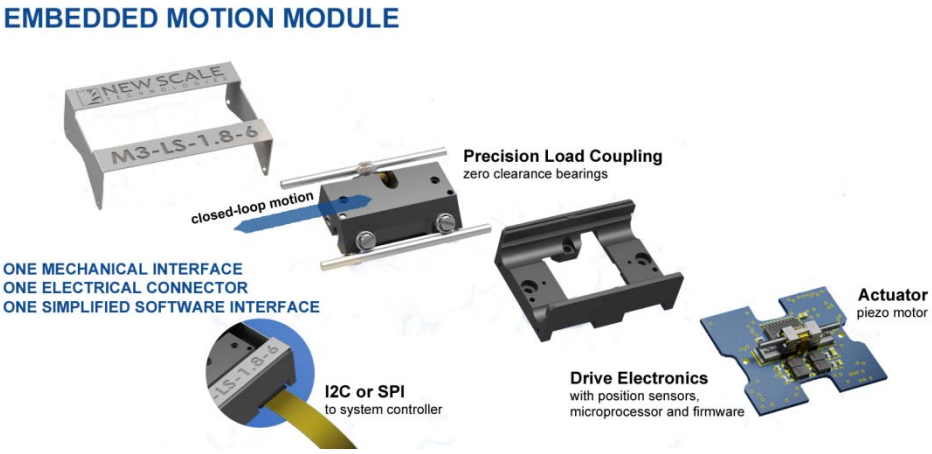
Examples of product miniaturization are everywhere, from our smart phones to the doctor's office. The micro innovations inside these smaller products include advances in silicon electronics, sensors, optics, actuators, materials, packaging and software.

Embedded motion modules are a new option for product design teams. These modules combine mechanical and electrical functions in one device to achieve the highest performance in the smallest possible size.

The integrated functions include actuators, position sensors, precision mechanisms, drive electronics, and microprocessors with control firmware *(see figure below).* The embedded motion module is a **single part** that simplifies design and integration tasks to:

- one mechanical interface
- one electrical connector
- one simplified software interface

***An embedded motion module** combines multiple components in one device to simplify your new product design and integration tasks*



To embed a motion module in a product, designers need only connect the power and digital bus, and write code to send high-level motion commands.

In contrast, the conventional approach to creating motion using discrete components involves multiple parallel design tasks to integrate mechanical stages, electronic drives, computer control hardware, positon sensor feedback, motion control software, and numerous cables and connectors.

Using embedded motion modules lets your team achieve the smallest system size, reduce the risks of product development, and get to market faster.

Making Your Great Products Smaller

Instrument designers are using embedded motion modules and other micro innovations to re-invent smaller products for many applications. These include spectroscopy, microscopy, imaging, biometric identification, point-of-care diagnostics, DNA sequencing, and navigation.

It is now possible to create portable instruments to replace systems that previously required a large lab bench. The companies selling these products are reaching new markets, creating new business models, and increasing growth and profitability.

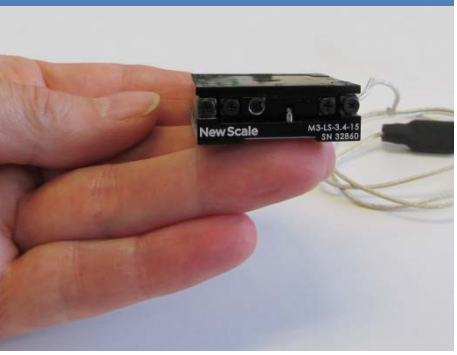
***Smaller products** with embedded motion modules allow companies to reach new markets, create new business models, and increase growth and profitability.*

Beyond the financial benefits, these smaller instruments are accelerating new scientific discoveries and bringing modern services and advanced medical care to under-served populations.

Take Advantage of Micro Component Innovations

Embedded motion modules leverage several “micro component innovations” to create fully-engineered mechatronic systems. These include innovations in motors, electronics, sensors, optics, materials, packaging and software.

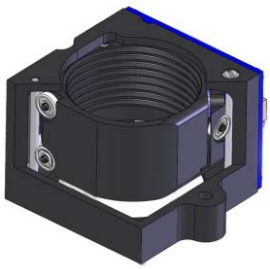
Micro Mechatronic Motion (M3) Modules Fit On Your Fingertips



M3 (Micro Mechatronic Motion) modules leverage many micro innovations and combine them with precision mechanisms, the latest microprocessors and integrated control firmware.

Miniaturization has unique design challenges that require new approaches for bearings, materials, part tolerancing and manufacturing methods.

It is not practical to simply scale down the conventional parts used in larger motion systems. Tiny moving mechanisms must be optimized for friction, precision, strength and cost. For example:



The M3-F focus module from New Scale uses a linear pin-bushing guide in polymer structures to minimize cost while maintaining sufficient precision and low friction. The pin-bushing clearance is less than 20 micrometers which achieves a dynamic tilt of < 0.15 degrees.

The more expensive **M3-FS focus module** uses tiny ball bearings and aluminum structures. Straight movement along the optical axis is achieved using six rolling ball bearings that are preloaded against two pins to produce zero lateral clearance, high stiffness and extremely low, uniform friction over the entire

travel range, even under high direct loads and side loads. This bearing design has low sensitivity to particles, an advantage in portable systems for field use.

The M3-RS-U rotary micro stage integrates two ball bearings on a rotating shaft and two UTAF motors working together to generate continuous rotation in both directions. One NSD2101 driver IC operates both motors and an AS5038 sensor measures angular position with 0.025 degree resolution.

The table below shows the micro component innovations used in several different embedded motion modules.

Model	Volume	Motor Type	Sensor Type	Guide Bearings	Motion Parameters			Target Applications
					Stroke	Resolution	Payload Mass	
M3-F Focus Module	20 x 22 x 16 mm	SQUIGGLE piezo motor	NSE5310 Hall Sensor	Pin-bushing guide	1.5 mm	0.5 µm absolute	5 g all orien-tations	**Focus Mechanism** • Iris imaging • Assistive vision eyewear • Ophthalmic imaging • Laser beam quality optimization • In-vitro diagnostics (microscopes)
M3-FS Focus Module	20 x 23 x 16 mm	SQUIGGLE piezo motor	NSE5310 Hall Sensor	Six ball bearings in a kinematic guide-way				
M3-L Linear Actuator Module	28 x 13.2 x 7.5 mm	SQUIGGLE piezo motor	NSE5310 Hall Sensor	Pin-bushing guide	6 mm	0.5 µm	20 g	**Linear Actuator** (Push and Pull only) • Optical, photonic and RF tuning • Micro surgical devices
M3-LS-1.8 Linear Micro Stage Module	29 x 20 x 9.5 mm	SQUIGGLE piezo motor	NSE5310 Hall Sensor	Six ball bearings in a kinematic guide-way	6 mm	0.5 µm absolute	20 g horiz. 10 g vertical	**Linear Stage** • Optical alignment and stabilization in small UAVs • Neural probe manipulators • Microscope objective focusing • Optical tuning and alignment • Moving samples and photonics elements
M3-LS-3.4 Linear Micro Stage Module	32 x 32 x 11 mm	SQUIGGLE piezo motor	NSE5310 Hall Sensor	Crossed roller bearings	15 mm		200 g horiz. 100 g vertical	
M3-RS-U Rotary Micro Stage Module	12 mm diameter x 18 mm length	UTAF piezo motor	AS5038 Hall-Sensor	Two ball bearings and rotating shaft	360° contin-uous rotation	0.025 degree absolute	3 g	**Rotary Stage** • Point-to-point laser beam steering • Tuning gratings and filters • Switches and shutters • LIDAR

***Embedded Motion Modules** incorporate a range of micro component innovations*

Application Examples

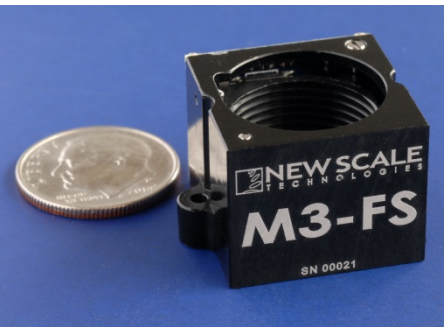
M3 motion modules enable instrument designers to easily embed motion in their new products, thereby creating smaller, more precise instruments for a wide range of industrial, commercial and scientific applications.

With only 3.3V input and all control electronics integrated inside, M3 modules help companies get to market faster with high-performance handheld devices. We present some examples on the following pages.

Micro Innovation #1
Micro Motors

Tiny and powerful piezoelectric ultrasonic motors, such as the patented Squiggle® motor and UTAF™ motor, fit on the head of a pin and can move optical elements, sensors and other devices that are 100 times larger than the motor. This outstanding force density is achieved by generating controlled vibrations that cannot be seen or heard. The vibrating motor touches a moveable surface and generates many millimeters of stroke with sub-micrometer resolution. The newest Squiggle and UTAF motors have **reduced voltage requirements**, as low as 3 volts thanks to advanced piezoelectric ceramic materials. These motors also hold position with zero power.

Application Examples
Companies rely on embedded M3 modules as a small, precise and battery-powered focus mechanism that is simple and fast to integrate into their systems.



Application: Super-resolution microscope

Super-resolution microscopes achieve image resolution higher than the diffraction limit and are transforming optical microscopy.

One manufacturer achieves super-resolution through precise X-Y movement of micro optical elements using two M3-LS-1.8 linear stages. With the embedded controller, the M3-LS is easy to integrate in a very small space and operates directly and seamlessly from the system PC.

The stages fit inside a complex desk-top sized optical system while meeting all performance requirements.

Application: Shrinking spectroscopy instruments

An M3-L linear actuator in an industrial Raman spectroscopy instrument allows the designer to shrink the scanning mechanism that tunes the laser wavelength. The actuator's small size, battery power and SPI digital interface gave the system new portability.

The hand-held instrument identifies chemical and explosive hazards without the need to open the suspect containers.

Application: High-performance lasers

An M3-FS focus module enables a manufacturer of high-performance laser light sources to achieve greater efficiency, power and beam quality while minimizing maintenance costs and downtime.

The focus module provides a 16 mm clear aperture for a threaded lens assembly and moves the assembly parallel to the optical axis with sub-micrometer closed-loop precision. Zero clearance bearings minimize lateral shift and tilt under all operating conditions.

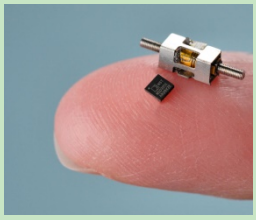
Application: Point-of-care blood analyzer

The M3-F focus module is a key element in a backpack-portable blood analyzer used in resource-limited medical facilities.

The focus module moves a cytometer microscope objective to automatically compensate for non-flatness in the low-cost microfluidic sample cartridge. The result is accurate particle counts per unit volume of the target pathogen.

This new "near patient" instrument brings advanced medical care to communities without hospitals or testing laboratories.

Micro Innovation #2
Micro Drives



The reduced operating voltage of Squiggle and UTAF motors takes maximum advantage of analog integrated circuit technology to create a **single driver ASIC that** is at least 1,000 times smaller than earlier discrete drive circuit boards requiring hundreds of volts. One example is the NSD2101 IC that is 1.8 X 1.8 mm and was created in partnership with ams. This ASIC produces a two-phase drive for the Squiggle and UTAF motors. It incorporates patented high-efficiency full-bridge switching, automatic drive frequency optimization, and two methods of velocity control. Charge control reduces system power 30%. External control input is via I2C.

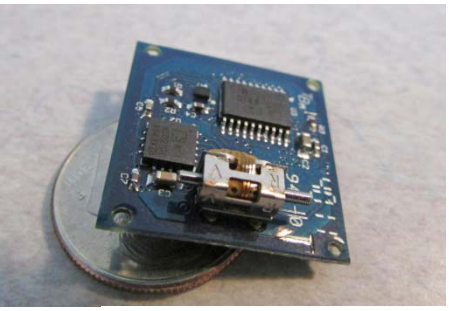
Application: Focusing for vision

Several companies are using the M3-F focus modules in instruments that save or enhance vision.

One is an ophthalmic instrument that uses motorized focus to enhance diagnosis and detection of eye disease. Another is a wearable headset for assisted vision that enables legally blind individuals to see.

In both cases, these companies rely on the embedded M3 module as a small, precise and battery-powered focus mechanism that is simple and fast to integrate into their systems.

Advantages of Using Embedded Mechatronic Motion Modules



Smallest System Size
An M3 module works as a simple I2C or SPI slave. A single PCB integrated into the module holds the motor, driver, sensor and microprocessor.

Smaller system size

The integral controller dramatically reduces the size and space requirements for the motion components.

An M3 module works as a simple I2C or SPI slave. This eliminates bulky electronics, cables and connectors, which can be many times larger than the discrete moving stage.

The integrated modules also combine part functions to further reduce space used. For example, in an M3 module a single printed circuit board holds the motor, driver, sensor and microprocessor.

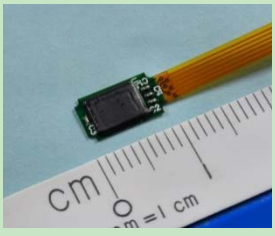
Finally, these miniature motion modules are more compatible with the newest and smallest micro optical elements and photonics sensors. They allow designers to more easily take advantage of the latest advances in optical miniaturization.

In many cases the reduced mass, lower part count, and fewer electrical connections also increase system reliability.

Lower-risk product development

Micro-mechatronics is a highly specialized engineering discipline. By choosing an embedded motion module, your design team takes advantage of thousands of

Micro Innovation #3
Micro Sensors



Magnetic Hall-effect position sensors in a single IC with embedded A-D functions and I2C control provide sub-micrometer precision in the smallest possible space. Two examples are the AS5510 and NSE5310, also created in partnership with ams. These sensors perfectly complement UTAF and Squiggle motors since they are similar in size. The NSE5310 integrates a Hall-sensor array that measures the magnetic field changes of a moving multi-pole magnet. For this sensor the pole pitch is 2 mm and the resolution is 0.5 micrometers. The magnet length can be many poles, supporting very long strokes. Automatic gain control insures accurate measurements even when exposed to changing external magnetic fields.

hours and millions of dollars invested in mechatronic system development by our team of micro mechatronic experts.

Our pre-engineered solution is ready to plug and play with your product, allowing your in-house development team to focus on your company's core competencies.

Faster time to market

The pre-tested embedded motion modules are ready to install. They require no matching of the motor to the controller, nor even control engineering skills such as tuning a PID control loop. Electrical connections are DC power and digital bus. Motion system integration time is reduced from weeks to hours.

Summary

Smart embedded motion modules are a new option for product designers. They let instrument designers accelerate miniaturization, add high-value features, reduce technical risk, multiply their in-house capabilities, and speed time to market.

Learn More

New Scale Technologies M3 Micro Motion Modules
https://www.newscaletech.com/micro-motion-modules/

VIDEO: Inside the M3 All-in-One Smart Module
https://www.newscaletech.com/video-inside-m3-one-smart-module/

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