



Smart Micro Grippers

for Automated Small-Part Assembly

How “all-in-one” micro-mechatronic modules meet emerging needs for precision, speed and flexibility in end-of-arm tooling for small-part assembly systems

David Henderson
Founder and CEO
New Scale Technologies



Executive summary

The demand for automated small-part assembly is growing world-wide. The latest innovations in small robot design meet the requirements for precision, speed and flexibility in small-part assembly systems. These small robots also need new innovations in their “hands:” the end-of-arm tooling (EOAT) designed specifically for small-part assembly. Innovative smart micro grippers based on proven “all-in-one” micro-mechatronic modules meet these emerging needs.

Automating precision small-part assembly

Shorter product life cycles and higher product mix are driving innovations in agile manufacturing. Agile manufacturing requires flexible automation using smart robotic systems that can:

- Complete multiple tasks.
- Be quickly reconfigured through software, with minimal hardware changes.

Flexible automation provides greater return-on-investment than fixed automation, spurring growth in the worldwide automation market. This trend is especially true for precision small-part assembly.

Precision small-part assembly can now be automated using the latest generation of small robots, with smart end-of-arm tools (EOATs) and user-friendly “teachable” software interfaces.

EOATs are the “hands” of multi-axis robots. They commonly take the form of grippers using two parallel fingers, multiple fingers, vacuum suction or magnetic attraction.

The newest precision robots are assembling parts with placement precision as fine as 25 micrometers. Examples include the DENSO HS Series SCARA, the Adept Quattro DELTA, the Universal Robotics UR-3 six-axis arm, and the ABB YuMi dual arm. All of these robotic systems are specifically designed for moving payloads of less than a few kilograms with high speed and precise part placement.

Small, precise robots include the HS Series SCARA, Quattro DELTA, UR-3 and YuMi.

Smart gripper requirements

Ideal grippers for small-parts assembly must match these small robots' innovations in size, speed and precision.

Small-part grippers must be low mass and small, with interchangeable jaws

A gripper with mass of less than 100 grams will use less than 10% of the robot load capacity, therefore having little impact on the dynamic performance.

A gripper must be small enough to place parts in tight clearance spaces and enable multiple grippers to be used on the same robot for multi-function tasks.

Interchangeable jaws make it easy to customize each gripper for a specific task and quickly reconfigure the automation system for new tasks.

Small-part grippers must have minimal connecting wires and tubing

Minimizing connecting wires and tubing is essential for robotic small-part assembly systems, to maximize flexibility and prevent interferences. "All-in-one" miniature motion modules have embedded sensing, drive electronics, control electronics and firmware in the EOAT gripper itself. Only DC power and digital commands are required as input, and can be provided over a single cable.

Electric servo grippers eliminate pneumatic tubing and require only a handful of existing slip ring circuits in some robot options. Multiple grippers can use the same power source and digital bus.

These grippers require a standard communications protocol that is plug-and-play with the robot control system. Preferred protocols include Ethernet, EtherCAT, Can Bus or RS485.

Small-part gripper control must match the robot precision

Control of the gripper motion and force must match the robot precision. Independent and bi-directional control of each gripper jaw's position and force can be achieved using independent actuators, sensors, bearings and servo controls.

Highly miniaturized mechatronics modules achieve sub-micrometer position resolution and sub-Newton force control. Bi-directional motion allows inside and outside gripping.

Precise position control allows real-time verification of part identity and dimension. For a specific part, the relative motion required for each cycle can be minimized.

In-situ force measurement verifies part acquisition and secure grasping.

Highly miniaturized mechatronics modules achieve sub-micrometer position resolution and sub-Newton force control.

Independent control of each jaw enables parts to be held consistently relative to the robot axes within 10 micrometers, and supports the most demanding requirements for part placement location. For example, a tiny threaded screw can be accurately centered on the mating tapped hole and rotated in-place with minimum wobble.

Integrated contact force sensing is also desired for micro grippers. Integrated force sensing provides independent verification that the robot has achieved a specific location relative to the part and assembly. One example is picking up a part from a flat surface by first touching the flat surface to establish the ‘bottom’ datum of the part.

Smart micro grippers for small-part assembly

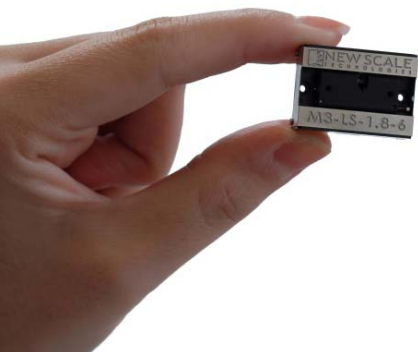
New Scale Technologies has applied its expertise in highly miniaturized motion systems to the problem of EOAT for precision small-part assembly.

New Scale’s M3 micro-mechatronics modules are “all-in-one” motion systems, integrating a patented SQUIGGLE micro motor, ASIC driver, Hall-effect position sensor, guide bearing and microprocessor with embedded firmware into a miniature smart module. No separate electronics are required to achieve precision motion in small spaces; for example, the M3-LS Smart Stage achieves 0.5 μm resolution with 6 mm of travel.

Applying M3 micro mechatronics module capabilities to micro grippers, New Scale is developing a parallel electric gripper for small robots. Preliminary specifications for this micro gripper include:

- Diameter less than 60 mm and mass less than 100 grams
- Independent servo control of force and position on each jaw
 - 0 to 24 mm range
 - 0.5 μm resolution
 - 10 μm repeatability of gripper centerline to part centerline
 - Holds position with zero power and no jitter
 - 0.1 N closed-loop force resolution
 - ± 4 N maximum force
 - 8 mm/sec maximum velocity (4 mm/sec per arm)
- Easy to install and operate on robot
- No separate electronics needed, only DC power and digital bus commands
- Optional contact force sensor

To be commercialized in 2016, this “all-in-one” micro-mechatronic module will meet the emerging needs for precision, speed and flexibility in end-of-arm tooling for small-part assembly systems. Companies that create small collaborative robots, provide systems integration, or use these systems in their small-part assembly process are invited to engage New Scale Technologies early in the commercialization process and influence the results.



M3-LS Smart Stage is a standard M3 all-in-one motion system with no external controller.



M3-based parallel electric gripper has 0.5 μm resolution and ± 4 N maximum force.

References and further reading

Advances in Micromechatronics Promote All-in-One Positioning Modules, D. A. Henderson, *Photonics Spectra*, May 2015.

www.photonics.com/Article.aspx?PID=5&VID=125&IID=817&AID=57373

Small Assembly Robots with Big Gains, T. M. Anandan, Contributing Editor, Robotic Industries Association, 09/28/2015

www.robotics.org/content-detail.cfm/Industrial-Robotics-Industry-Insights/Small-Assembly-Robots-with-Big-Gains/content_id/5708

Latest Trends in Intelligent Robot End-of-Arm Tooling, T. M. Anandan, Robotic Industries Association, 08/08/2013

www.robotics.org/content-detail.cfm/Industrial-Robotics-Featured-Articles/Latest-Trends-in-Intelligent-Robot-End-of-Arm-Tooling/content_id/4253#

The End of Separation: Man and Robot as Collaborative Coworkers on the Factory Floor, T. M. Anandan, Robotic Industries Association, 06/06/2013

www.robotics.org/content-detail.cfm/Industrial-Robotics-Featured-Articles/The-End-of-Separation-Man-and-Robot-as-Collaborative-Coworkers-on-the-Factory-Floor/content_id/4140

Contact

New Scale Technologies

121 Victor Heights Parkway

Victor, NY 14564

Phone (585) 924-4450

Email NSTsales@newscaletech.com

www.newscaletech.com/applications/eoat.php