From Ergonomics to Accuracy: The Hidden Role of Motion Systems in Electronic Pipetting

25 August 2026

Across laboratories worldwide - from research and development to clinical diagnostics - laboratory professionals rely on pipettes to measure and dispense precise liquid volumes. Even small inconsistencies at this early step can cascade into costly failed assays, repeat testing, or compliance risks, making accuracy and repeatability essential. As a result, air-displacement micropipettes are often the primary choice in modern testing environments.

Air-displacement micropipettes became particularly visible during the global response to COVID-19, where vital RT-PCR sample preparation required consistent, high-volume pipetting and expedited the uptake of electronic pipette use. Sample preparation has historically used both manual and electronic pipettes, but as laboratories increasingly prioritize efficiency, consistency and associate comfort, electronic pipettes have become the more popular choice.

Manual vs. electronic pipettes

In an air-displacement pipette, manual or electric action of a piston drives changes in the air column that ultimately aspirate and dispense liquid. Manual pipettes rely on the operator to compress and release a spring-loaded mechanism, generating the required pressure changes. While effective, this design introduces natural variations in force, speed, and timing, each of which can subtly influence the resulting liquid volume. Repeated manual pipetting also presents ergonomic challenges, as frequent use can lead to discomfort and an increased risk of repetitive strain injuries for the operator.

Electronic pipettes remove much of that burden. Instead of a thumb-controlled plunger, a digital interface controls a motorized piston via a more user-friendly button. The outcome is more consistent aspiration and dispense profiles based on predictable motion, as well as reduced operator strain.

As an additional design feature, digital interfaces can improve the accuracy of volume settings and monitor output, while automated functions like sequential multi-dispensing, mixing and tip detection can further reduce the likelihood of human error. The digital interface can even store programs, reducing time for set-up and thus further improving efficiency.

Motor selection for electronic pipettes

As the first step in many laboratory workflows, pipetting performance has a direct impact on downstream results, reproducibility and operational efficiency. For instrument designers, motor selection influences not only motion performance and accuracy, but also calibration stability, maintenance demands, and long term cost of ownership.

Motor choice plays a key role in the precision and accuracy of electronic pipettes by defining the force, speed, smoothness and positional fidelity of the piston's movement. The two most common options are brushed DC motors and stepper linear actuators.

Brushed DC Motors

Brushed DC motors translate direct current (DC) power into rotational motion without complex electronics. Their smooth operation and straightforward control make them attractive for handheld devices like pipettes. However, as pipetting requires linear movement, DC motors require additional components to convert the plane of movement. This system approach increases the considerations for instrument designers, requiring integration which must be competed under strict specifications.

As such, systems using DC motors typically incorporate feedback devices like magnetic encoders, to ensure accurate piston positioning and compensate for backlash or mechanical tolerances within the screw-driven assembly.

Stepper Actuators

Stepper linear actuators offer a more integrated solution and are popular in electronic pipettes due to their direct linear motion and high positional resolution. A common example of this approach combines a can-stack stepper motor with a threaded rotor and integrated lead screw in a single, compact assembly.

As electrical pulses drive the motor, the rotor advances in discrete steps, producing predictable linear motion without the need for external gearing or complex mechanical conversion. For laboratories, this architectural simplicity can translate into improved repeatability and reduced dependence on frequent recalibration.

Stepper actuators can operate in open-loop mode without relying on an encoder for precise positioning as each step corresponds to a fixed increment of travel. This reduces system complexity and provides high resolution and predictable motion, ensuring consistent liquid handling across users and workloads.

Proper sizing for stepper motors is important to avoid performance issues like missed steps. Key stepper actuator considerations for pipetting applications must include ensuring adequate force margin, avoiding low-frequency resonances and the prevention of sudden back-driving events. Addressing these factors early supports consistent performance under high throughput conditions and helps protect instrument reliability over time.

The following comparison highlights how different motor technologies can influence electronic pipette performance and system design.

Parameter	Brushed DC motor system	Stepper linear actuator
Motion Type	Rotary → linear (requires gearbox + screw)	Native linear motion
Feedback	Requires encoder/optical sensor	Not required (open-loop)
Positioning Accuracy	High when closed-loop	High due to discrete step control
Mechanical Complexity	Higher (multiple components)	Low (integrated mechanism)
Speed	Higher	Medium
Cost	Higher due to added components	More cost-effective
Efficiency	Higher due to coreless technology	Lower based on stepper technology
Noise & Vibration	Low but dependent on mechanics	Low; requires resonance avoidance
Integration Effort	Medium	Low
Suitability for Pipettes	Ideal for ultra-smooth, closed-loop designs	Excellent for compact, high-volume designs

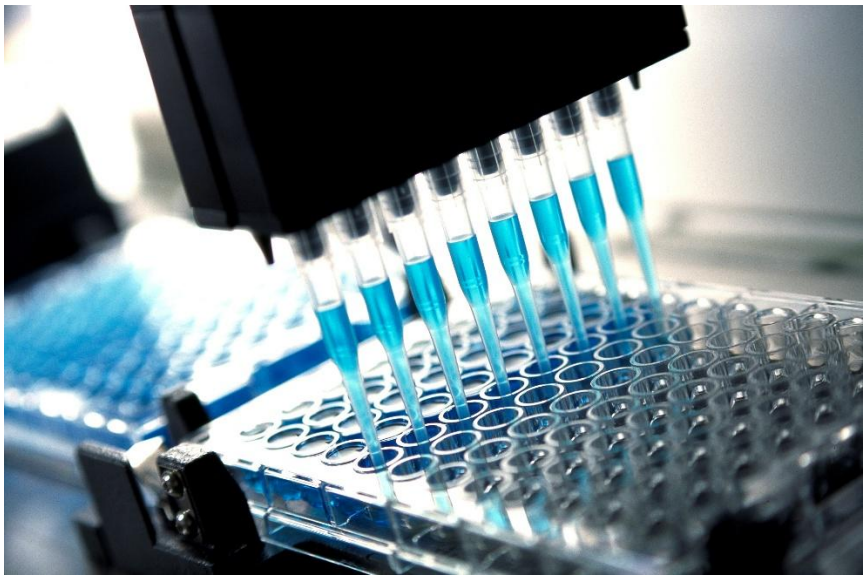
Essential considerations

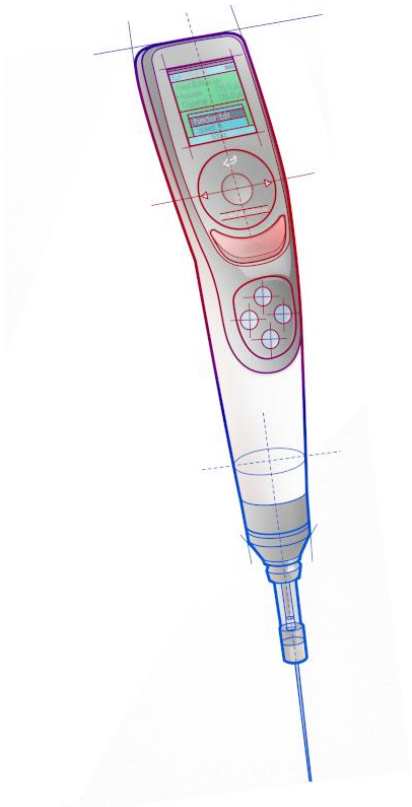
Both brushed DC motors and stepper linear actuators can be engineered to meet the precision demands of electronic pipettes, with the most appropriate choice ultimately depending on intended usage. DC motors deliver smooth motion but require additional components and closed-loop control to achieve microliter accuracy. Superior speed and efficiency come with increased system complexity and cost.

The direct linear motion of stepper linear actuators enables strong repeatability and accuracy from simplified architecture. These qualities have made stepper actuators the preferred option for many pipette platforms.

Selecting the right motor technology is vital as laboratories rely on precise results no matter what industry or field of research they serve. Across disciplines, laboratories continue to balance the need for repeatable, consistent output with the equally critical priority of minimizing operator strain - making thoughtful motion system design an increasingly important factor in electronic pipetting performance.

Images:





About Portescap

Portescap, a proud member of Regal Rexnord, excels in addressing critical motion challenges with premium miniature electronic motors and components. For over 70 years, our extensive product range – including coreless brush DC, brushless DC, stepper, gearhead, encoder, and controller technologies – has powered applications across the aerospace and defense, automation, industrial power tools, medical, robotics, and surgical hand tool industries. Expert engineers collaborate with you from prototype to production, ensuring exceptional performance tailored to your specific needs.

As part of Regal Rexnord, customers benefit from seamless access to a vast brand portfolio and a robust global manufacturing and sourcing network. Dedication to innovation and sustainability drives us to design products that significantly impact daily life. Leveraging Regal Rexnord's broader expertise and resources, we aim to deliver sustainable solutions that power, transmit, and control motion, helping to create a better tomorrow.

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