Closed-Loop Motor Control Solutions by ModuSystems

Enhancing Stepper and Servo Motor Performance Across Industrial Applications

Executive Summary

This white paper outlines the closed-loop control strategies available from ModuSystems, detailing four primary methods of motor control supported across various controller platforms. Each method is designed to improve motion accuracy, prevent motor stalls, and optimize performance under varying load and interference conditions. Solutions range from enhanced stepper control to high-performance servo systems, allowing ModuSystems to meet diverse application demands with precision and efficiency.

Problem Statement

In high-performance motion systems, maintaining motor synchronization, ensuring accurate positioning, and mitigating disturbances are critical. Open-loop stepper systems are prone to stalls, vibrations, and inaccuracies under torque spikes or mechanical interference. In these situations, the need for closed loop control is essential to improve reliability, safety, and system intelligence in modern automation environments.

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A) Commutation-Based Closed-Loop Control (Stepper Motor)

- Use Case: Prevents stalls and restores motor position after overload events.
- Functionality: Encoder monitors rotor torque limit; halts motion on excessive resistance; resumes motion and position recovery once cleared.
- Advantages: Silent stoppage under interference; auto-recovery of missed steps; supports fault detection.
- Supported Controllers: MMC-T, IMC, TMC (not BLC series).
- Ideal For: Systems prone to transient force spikes or occasional mechanical interference.

B) Dual Loop Closed-Loop Control (Stepper Motor)

- Use Case: Eliminates steady-state errors and compensates for mechanical compliance.
- Functionality: Constant error correction between encoder and commanded position; improves tracking accuracy.

- Advantages: Enhanced motion fidelity; eliminates elastic rotor deflection and stepper construction limitations.
- Supported Controllers: All ModuSystems controllers with encoder input.
- Ideal For: Applications requiring high positioning precision without upgrading to servo hardware.

C) HyTorq Servo (Advanced Servo Stepper control)

- Use Case: High-torque, low-speed servo performance with fine-tuned control.
- Functionality: Sophisticated servo control using a stepper motor requires precise tuning under load.
- Advantages: Best-in-class damping, silence, and torque output; true servo-grade behavior.
- Supported Controllers: MMC series only (MMC-H).
- Ideal For: High-performance automation needing low-speed torque with maximum control.

D) Traditional Servo Motor Control (3Phase Brushless)

- Use Case: Fast, quiet operation with sustained torque over high-speed ranges.
- Functionality: PID control of brushless servo motors using Hall sensors and encoders.
- Advantages: High speed (5–10x that of steppers), minimal noise, sustained torque.
- Supported Controllers: MMC-V (up to 48V, 10A).
- Ideal For: Precision applications demanding high-speed, continuous operation.

Conclusion

ModuSystems provides a versatile suite of closed-loop control options tailored to the specific needs of modern motion control systems. From basic error correction to advanced servo capabilities, engineers can match their performance requirements with the right controller and strategy. With growing demand for reliability, noise reduction, and torque consistency, ModuSystems' flexible control architecture delivers robust solutions for OEMs and integrators alike.

Comparison Matrix

Control Method	Motor Type	Stalling Protection	Precision	Tuning Required	Noise Level	Supported Controllers
Commutation (Closed Loop)	Stepper	Yes	Moderate	No	Low	MMC-T, IMC, TMC
Dual Loop Control	Stepper	No	High	No	Moderate	All encoder-compatible
HyTorq Servo	Stepper	Yes	Very High	Yes	Very Low	MMC-H
Servo Control	Brushless Servo	Yes	High	Yes	Very Low	MMC-V