

Achieving edge AI-enabled motor control in industrial automation and smart home appliance designs



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Key takeaways

- AM13E230x MCUs enable predictive fault detection and adaptive control algorithms in real-time control applications by combining an Arm® Cortex®-M33 CPU with a TI TinyEngine™ NPU in a single device.
- Local AI models in systems for humanoid robots and appliances can continuously monitor parameters and adjust performance based on real-world conditions without requiring cloud connectivity or additional discrete components.

Overcoming traditional design limitations for edge AI-enabled motor control

The need for real-time monitoring and control has become crucial to help minimize downtime, reduce energy consumption and improve overall system reliability in motor systems for industrial automation applications and appliances. Traditional design approaches often require multiple microcontrollers (MCUs) and discrete components to enable reliable motor function, resulting in increased complexity, cost and power consumption.

To solve this challenge, designers can use highly integrated MCUs like those in the AM13E230x family with hardware accelerators for edge AI, which includes the [AM13E23019](#). These MCUs feature a high-performance Arm Cortex-M33 core with an integrated TinyEngine NPU to give engineers a single-chip platform for precision motor control, real-time monitoring and local AI inference.

This level of integration brings edge AI functions to more motor control systems, enabling features like predictive fault detection, adaptive control algorithms, anomaly detection and intelligent load balancing where cost, size and power considerations have traditionally limited the use of edge AI. These MCUs are also supported by TI's free [CCStudio™ Edge AI Studio](#), a collection of graphical and command line tools designed to accelerate edge AI development.

This article explores how AM13E230x MCUs help designers address key design challenges in humanoid robot actuator and smart home appliance designs.

Humanoid robot: actuators

Humanoid robots use actuators for manipulation and locomotion, operating simultaneously across multiple degrees of freedom. Additionally, high-torque quick startups (for example, the ability of a motor to generate significant torque from a standstill) require low-noise operation for optimal performance.

Humanoid joints and fingers with high ranges of motion and multiple degrees of freedom directly benefit from locally run edge AI models, since these models can detect when motors perform above maximum levels and prevent long-term damage, extending motor lifetimes. [Figure 1](#) shows the number of motors in a typical humanoid robot hand, arm and shoulder.

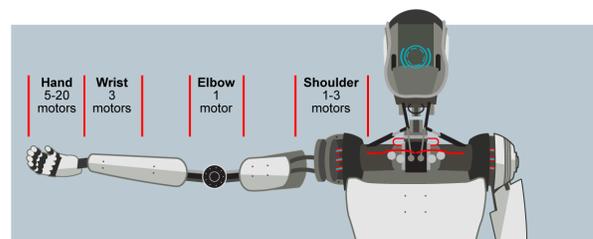


Figure 1. Simplified diagram showing possible motor distribution in a humanoid robot hand, arm and shoulder

Edge AI capabilities in AM13E230x MCUs provide advantages for motor longevity and protection in joint motion applications. Local AI models can proactively monitor motor parameters such as torque, load and current to detect when motors are not performing normally and then provide early notifications for potential issues.

Additionally, these MCUs were designed for humanoid robot applications where cost, compactness and

precision motor control are key design challenges. By using a device with integrated programmable gain amplifiers instead of using discrete CAN and IGBT peripherals (often used with MCUs), designers can reduce both bill-of-materials costs and external component count. This enables a more compact, cost-effective solution for applications where high accuracy isn't a system level requirement. AM13E230x MCUs have a 7 × 7mm² package which allows for a wider range of motion while also addressing space constraints in humanoid robot joint motors.

Edge AI-enabled motor control in washing machines

As smart home adoption accelerates, consumers now expect appliances that are quieter and more efficient and responsive. AM13E230x MCUs enable designers to more easily meet end user demands for quiet, fast and reliable operation, while providing tools to build intelligent appliances that can adapt to real-world use cases.

Engineers can use AM13E230x MCUs to optimize washing machine motor control designs by running AI models that continuously monitor motor load in real-time, automatically adjusting torque and speed profiles based on laundry weight to prevent motor strain. [Figure 2](#) shows a simplified block diagram of a motor control system in a washing machine that uses an AM13E230x MCU.

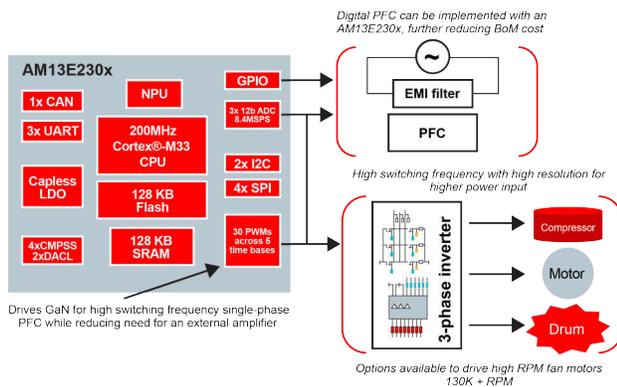


Figure 2. Simplified block diagram of a motor control system for a washing machine

The NPU offloads motor control algorithms from the main CPU, reducing system latency and power consumption, improving motor control without the need for additional discrete components.

Optimizing motor control in next-generation designs

Edge AI-enabled MCUs are transforming motor control across diverse applications by integrating intelligent processing directly at the motor level. By combining high-performance processing with neural processing capabilities, these solutions enable predictive maintenance, adaptive control, and precision motor management in single-chip implementations. As applications from humanoid robots to smart appliances continue evolving, edge AI integration in real-time motor control MCUs provides the foundation for more efficient, reliable and intelligent systems across industries.

Additional resources

- Read about the TinyEngine NPU and its benefits for edge AI-accelerated embedded designs in the product overview, [TI's TinyEngine™ NPU unlocks edge AI acceleration in more embedded systems.](#)
- Get started on your design today with TI's free [CCStudio Edge AI Studio tools.](#)

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