# Revolutionizing Performance in Real-Time Control, Networking and Analytics With Sitara™ AM2x MCUs

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**It is no secret that the demand for automation has had a profound impact on the world, from automated factories to autonomous vehicles.**

# At a glance

This paper explores how Sitara™ AM2x microcontrollers (MCUs) from Texas Instruments (TI) solve the performance challenges of traditional MCUs to meet demands in real-time control, networking and analytics.



## Technology pillars of industrial automation

As a result of the Industry 4.0 trend and massive increase in industrial automation, today's smart factories are characterized by faster and distributed computing, faster and flexible networking, and more intelligence at the edge. Designers of manufacturing robots, mechanical assistants and connected factories are adding features such as industrial communications, functional safety and predictive maintenance, made possible through the advancement and convergence of real-time computing, ubiquitous networking and edge analytics. Realizing these advancements requires seamless connectivity from the real world to the cloud, pushing technology on multiple vectors at the same time. **Figure 1** illustrates an automated factory where real-time control, industrial networking and edge analytics maximize efficiency and productivity.

***Figure 1.*** *Robotics need higher performance control, communication and analytics*

There are three key technology pillars for industrial automation.

### Real-time control

Because every nanosecond counts, systems requiring real-time control need both raw processing power and the ability to control signals at the exact time they are needed. Precise analog signal control is key to translating the gains from improved control algorithms into more reliable motor drives and more efficient electric vehicles. The processing demands of these improved algorithms have outpaced the capabilities of the traditional MCU.

## Industrial networking

The need for different types of data exchange in the factory led to the rapid adoption of several multiprotocol industrial Ethernet standards to enable real-time communication between machines. This connectivity become mandatory to achieve targeted gains in syste performance, safety and reliability. System designers are looking for integrated networking solutions that ar compatible with the many different protocol standards and that can operate at speeds as high as 1 Gbps.

## Analytics at the edge

Just as systemwide connectivity is enabling real-time communication, improvements in machine-learni algorithms are enabling local optimizations, where eac machine or node can take actions without waiting for centralized decision. Processing at the edge significantly reduces response times, which translates into better and safer collaboration between humans and machines.

## The role of high-performance MCUs in modern factories

Just as a chain is only as strong as its weakest link, the link between the analog world and the digital world is only as strong as its weakest link. An often-overlooked element in this chain is the MCU. In many factory systems, such as motor control and robotics, this unheralded processor oversees the transformation from analog to digital and back, but the need for both high performance computing and control is placing overwhelming demands on its capabilities.

TI's Sitara AM2x MCUs bring a new level of MCU performance to meet growing automation demands in the factory. The portfolio combines processor-level computing with the simple, power-efficient packages and high levels of integration typical of MCUs for applications needing precise real-time control. It further enables new capabilities such as edge analytics and real-time multiprotocol networking that are central to factory efficiency and intelligence.

**Figure 2** shows the core building blocks of a Sitara AM2x MCU: processing cores, networking, analog integration, security and safety features, and custom acceleration.

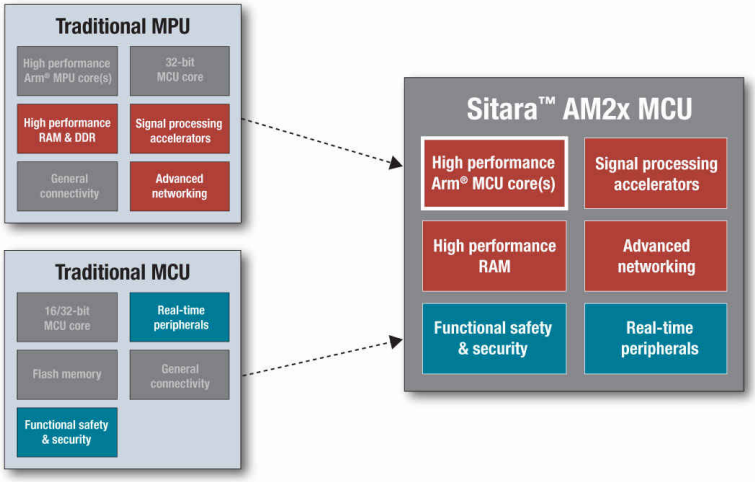


***Figure 2.*** *Sitara AM2x MCU combines fundamental building blocks from traditional MCUs and microprocessors*

The first device in the Sitara AM2x MCU family is the AM2434, as shown in **Figure 3**. This device includes many of the fundamental features, with a quad-R5F processing subsystem, a flexible industrial networking engine (the industrial communications subsystem [ICSS]), tightly coupled analog peripherals and a security engine supporting the latest cryptographic standards.

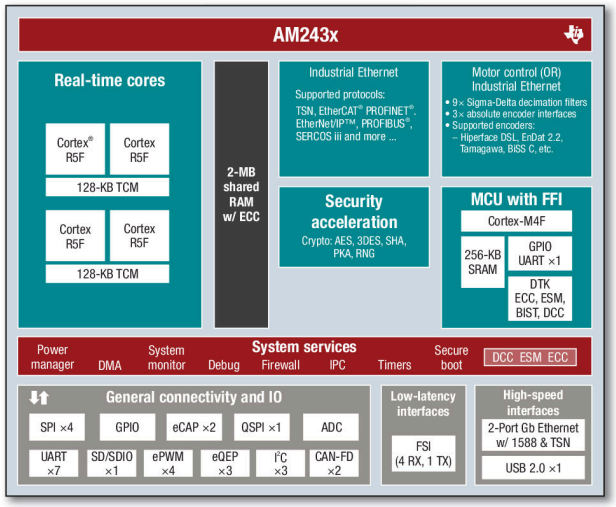


***Figure 3.*** *Block diagram of the Sitara AM2434 MCU*

## The fundamentals of the Sitara AM2x MCU portfolio

Categorizing the building blocks of a Sitara AM2x MCU into a few distinct categories shows how these devices bring higher performance to the three key technology pillars. The combination of these building blocks yields a system on chip that can provide groundbreaking performance with very low power consumption.

### Power-efficient processing

The first building block unlocks new possibilities, with as many as four low-power Arm® MCU cores each operating at 800 MHz. Power-efficient processing improves the performance of real-time control systems by enabling the use of improved algorithms. For example, motor-control systems can measure vibrations to help prevent wear and energy loss, or add anomaly detection to detect imminent catastrophic failures. These new features require a large increase in computational power, and traditional MCUs have not kept up given their lower clock speeds.

High-performance multicore processing is central to the Sitara AM2x MCU architecture, and provides a combination of performance, efficiency and flexibility. With the flexibility to scale up from single-core up to quad-core, and speeds from 400 MHz to 1 GHz, you can add functionality to your applications without compromising latency. With four R5F cores each running at 800 MHz, the AM2434 can deliver up to 6,400 real-time Dhrystone million instructions per second of computing capability for real-time control. The device's multicore architecture also allows you to spread operations across different cores, simplifying software scheduling where different functionality runs at different timing intervals.

Separating real-time control from networking, for example, reduces the number of interrupts for a given core and makes it easier to maintain precise control of all operations.

### Multiprotocol networking

Networking has become a key requirement for next-generation smart factories, but is complicated by the many standards currently in use, as well as the push toward 1-Gbps networks. Multiprotocol networking enables the broadest set of industrial networking standards with integrated, programmable networking acceleration. Traditional MCUs do not have the ability to interoperate with these various protocols, forcing designers to use external communication devices and adding cost and power to their designs.

Sitara AM2x MCUs integrate TI's ICSS, a programmable, flexible, gigabit networking engine. Along with industrial toolkit software, the ICSS enables out-of-the-box connectivity for industrial protocols including Profinet®, EtherNet/IP™, EtherCAT® and IO-Link. This integration removes the need for additional devices and brings ease of use for factory connectivity.

### Advanced analog integration

Advanced analog integration is another key aspect of the Sitara AM2x MCU architecture and offers specialized analog and control peripherals such as high-resolution pulse-width modulators (PWMs) and analog-to-digital converters (ADCs). These peripherals are critical for realizing performance gains such as improved motor stability or higher energy efficiencies. The new portfolio leverages advancements in analog design from other TI products in a single, integrated solution. Integrating such features simplifies system designs, reducing the need for additional components, lowering cost and speeding time to market. The integrated ADCs and PWMs improve overall control accuracy and reduce latency, enabling control cycle times as low as 3 µs.

## Processing accelerators

Many applications have very specialized computing requirements that can be enabled and integrated with custom acceleration modules. For example, radar processing systems for driver assistance require the computation of many fast Fourier transforms every few microseconds and would overwhelm any programmable core. Devices built to support radar processing need a dedicated accelerator to offload these calculations. Another example is from machine learning, where inference engines can be quite heavy in terms of calculations per second and may also require acceleration to support. Adding custom acceleration offers specialized processing blocks that go beyond the capabilities of standard microprocessor cores, improving system performance in these applications 10 to 100 times without significant cost or power increases.

## Integrated safety and security features

As the number of connected systems increases, the need for enhanced security increases as well. At the system level, devices must include protections to mitigate the possibility of security holes and support the latest encryption standards. The Sitara AM2434 MCU was designed from the ground up with careful attention to system-level system-on-chip design that can enable improved security and safety in a system, including programmable security keys and flexible firewall configurations. As security standards evolve, the Sitara MCU architecture is flexible and will adjust and adapt as well to continue offering support for the latest standards.

A system-on-chip design also needs to comply with the safety standards required throughout the industrial and automotive industries, such as Automotive Safety Integrity Level (ASIL)-D and SIL-3. It supports system level-safety solutions, enabling developers to use the integrated M4F core as a watchdog for the system and offering the ability to reset the rest of the device while continuing to run. The networking peripherals can also run independently of the main Arm® Cortex®- R5F processors enabling seamless rebooting.

## Power efficiency

Many systems requiring real-time control operate in very high ambient temperatures without the benefits of cooling air flow. In many motor-drive systems and electric vehicles, ambient temperatures can reach as high as 85°C, leaving little room for temperature dissipation for the electronics. For this reason, processors in such environments need to be very power-conscious and efficient.

The Sitara AM2x MCU portfolio offers tremendous power efficiency, with devices like the AM2434 consuming <1 W while still offering all the integration and computing performance. It can operate under very high-heat conditions reliably, without the need for cooling fans or costly heat sinks.

## Conclusion

It is clear that trends toward higher flexibility and performance are pushing the limits of today's MCUs. Overcoming performance barriers without adding complexity is a challenge for those designing real-time control and edge systems. The Sitara AM2x MCU family breaks these performance barriers to enable the Fourth Industrial Revolution, offering a portfolio of devices targeted at optimizing current systems that is also flexible enough to support the unknown demands of future systems.

## Resources

- Learn more about the **Sitara™ AM243x MCU**
- Read about the **high-performance MCUs**
- Start your evaluation with the **AM243x LaunchPad™ Development Kit** and MCU+ **software development kit**.
- For demos and training, see the Sitara **MCU+ Academy**.

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