

Simplify Real-time Control and Industrial Communication with a Single Chip



Gina Hann

A typical factory automation environment has multiple levels of operator and field control to establish device-to-device communication. As smart factories become more prevalent, it's a challenge to design systems that not only address the complex computational needs of larger data sets throughout the factory, but to do so in a way that addresses multiprotocol real-time communication, as shown in [Figure 1](#), with readiness for future system management and upgrades.

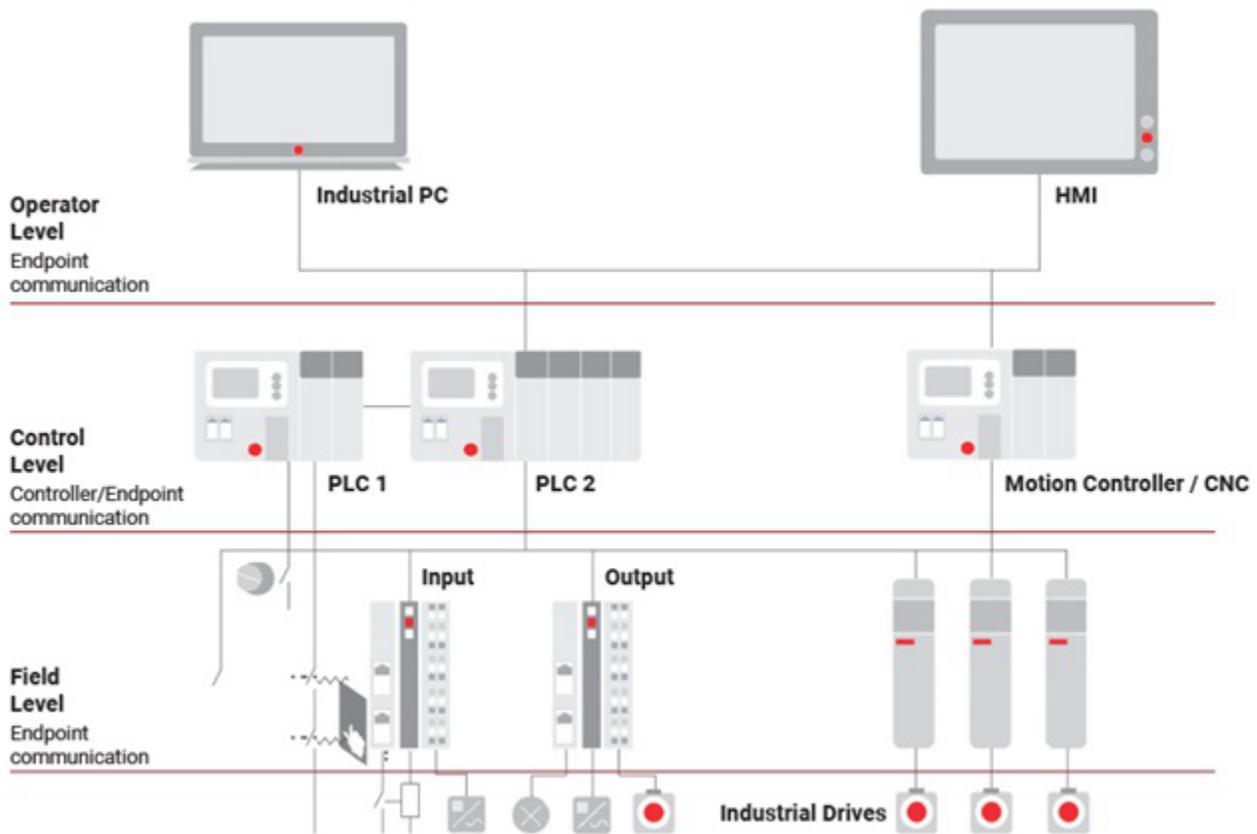


Figure 1. Factory Automation Platforms Often Have Multiple Communication Endpoints Requiring Different Industrial Protocols

To truly address the evolving demands of smart factories, modern processors must address the challenges of computational demands for real-time control, safety and reliability, as well as the flexibility of multiprotocol communication, in a scalable design for future solutions.

Enabling Real-time Control for Edge Computing

Edge computing localizes data computation close to the point of origin in order to achieve efficient data processing for both local and cloud-based systems. For factory automation, edge computing achieves real-time control by enabling low-latency computation and communication at the data source. In a robot arm, for example,

multiple motors are controlled locally, while a central programmable logic controller (PLC) controls the whole arm.

Addressing computation and communication challenges traditionally required multichip solutions, sometimes including a networking chip for high-speed industrial communication as well as a processor for data computation. By combining the processing capability for real-time edge computing with a pre-certified integrated multiprotocol industrial stack, TI's Sitara™ AM64 microprocessor unit (MPU) family and the AM243 microcontroller (MCU) family simplify the development process for real-time industrial communication and control.

The AM64 MPU and AM243 MCU families of devices are each able to manage industrial communication with a programmable real-time unit industrial communication subsystem (PRU-ICSS), a co-processor subsystem containing PRU cores and Ethernet media access controllers. This structure enables the management of low-level Industrial Ethernet and field-bus protocols through firmware, making AM64 MPU and AM243 MCU application cores available to process – in parallel – both communication and data computation for low-latency, real-time control and communication at the edge.



Figure 2. The PRU-ICSS in Both the AM64 MPU and AM243 MCU Families Provides a Single-chip Solution for Real-time Control and Communications

It is possible to configure the AM243 MCU family for real-time control of multiple motors in a robot arm, sensing position or speed at the point of feedback. The data from this feedback then passes to a central unit, where the AM64 MPU family computes multiple input data streams for higher-level PLC control. To manage real-time control with multipoint data-sharing scenarios such as these, processors require low latency, low jitter and multicore parallel processing capability. The AM64 and AM243 families can connect tens or even hundreds of devices with only one cable and port at the controller, and still meet cycle times ≤ 11 ms for real-time control. The AM64 and AM243 families' scalable hardware and software solutions, shown in [Figure 3](#), offers the ability to choose from multiple protocol options using the TI-certified stack available in each device's respective software development kit (SDK), meaning either can be used to achieve integrated industrial protocol solutions with a single chip.

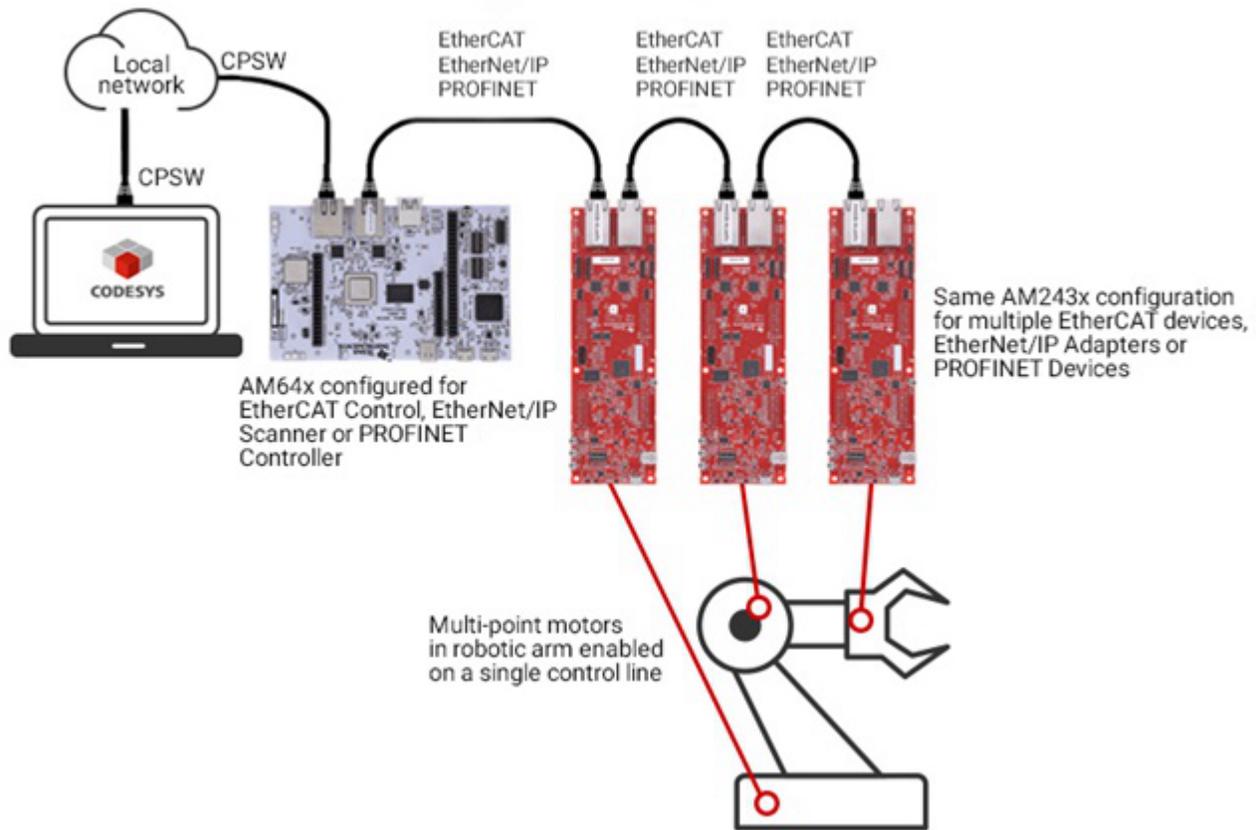


Figure 3. Choose from Multiple Protocol Options with the AM64 and AM243 Families

Implementing Multiple Industrial Protocols

Implementing edge computing for a multisystem design includes having to manage multiple communication protocols. While each subsystem on a factory floor may need to communicate information to a central control unit individually, they often operate on different industrial communication protocols. Truly achieving real-time control and communication in a single chip requires the integration of a multiprotocol programmable software solution so that you can select the best protocol for your design and scale easily for reuse. TI's AM64 MPU and AM243 MCU families SDKs enable you to connect to multiple industrial protocols including Ethernet, Profibus or IO-Link for easy reuse across multiple device interfaces.

Integrated industrial protocols from TI are an optional feature in both the Sitara AM64x and AM243x A53 Arm® core processor families, designed to simplify communication with a pre-certified multiprotocol stack for the Industrial Ethernet protocol and IO-Link standard. You can choose from three stack types for industrial protocol development:

- Fully licensed integrated stacks from TI.
- Third-party protocol stacks from developers such as [Kunbus](#).
- Your own custom stack.

[Table 1](#) summarizes the supported protocols and minimum timing at a high level, with a detailed feature set for each protocol available in the industrial communications tool kit within the SDKs for [AM64x Sitara processors](#) and [AM243x Sitara MCUs](#).

Table 1. Integrated Industrial Protocol Stack for the AM243 MCU and AM64 Processor Families

Protocol	Min. cycle time	Conformance test/ certification	Key features supported
EtherCAT®	31.25 us	ETG.7000.2	CiA402, CAN over EtherCAT (CoE), Servo Drive Profile (SoE), Ethernet over EtherCAT (EoE), File Access over EtherCAT (FoE), Distributed Clocks
EtherNet/IP™	1 ms	CT18.1	Address COntlict Detection (ACD), Quality of Service (QoS), Device Level Ring (DLR), Precision Time Protocol (PTP)
PROFINET®	250 us (IRT) 1 ms (RT)	2.4.2	Conformance Class A, B (RT), and C (IRT), Precision Time Control Protocol (PTCP), Media Redundancy Protocol (MRP)
IO-Link®	All communication classes supported	1.1.2	Up to 8 channel IO-Link Master per ICSS, IO-Link standard-compliant with Standardized Master Interface (SMI)

The integrated multiprotocol stack provides licensed protocol software in a TI-supported firmware solution to reduce cost and development time and is accessible through the SDKs, which use a common application programming interface to facilitate multiprotocol use from a single platform. Integrated protocols enable a single-chip solution for industrial communication and control by using one of the quad R5 cores for real-time communication; offloading application cores to enable parallel processing to support control functions; and including the industrial Ethernet protocol and IO-Link standard for a comprehensive industrial communication platform. It's also possible to use the separate application core from Codesys Control operating on both an AM64 processor and an AM243 MCU connected to an endpoint device, such as an input/output controller. The flexibility of this solution lets you change the industrial protocol from EtherNet/IP™ to PROFINET® or to EtherCAT® without modifying any hardware.

Managing for System Upgrades and Scalability

As smart factories and Industry 4.0 continue to develop, design engineers will continue facing the challenge of developing evolving solutions for real-time control. Scalable hardware and software from the TI Sitara™ processor portfolio and integrated industrial protocols available in the AM243x MCU and AM64x processor families help to simplify real-time control and communication design.

Additional Resources

- Check out [the full training from the Sitara MCU+ Academy](#) for getting started with EtherCAT, EtherNet/IP, and PROFINET for the AM243 MCU family.
- Download the application note, "[Industrial Communication Protocols Supported on Sitara Processors and MCUs.](#)"
- Watch these TI training videos:
 - "[Process This: Using Codesys Control for PLC Controller Stacks, Enabled by AM64x and RT Linux.](#)"
 - "[Process This: Process TSN using Linux.](#)"

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated