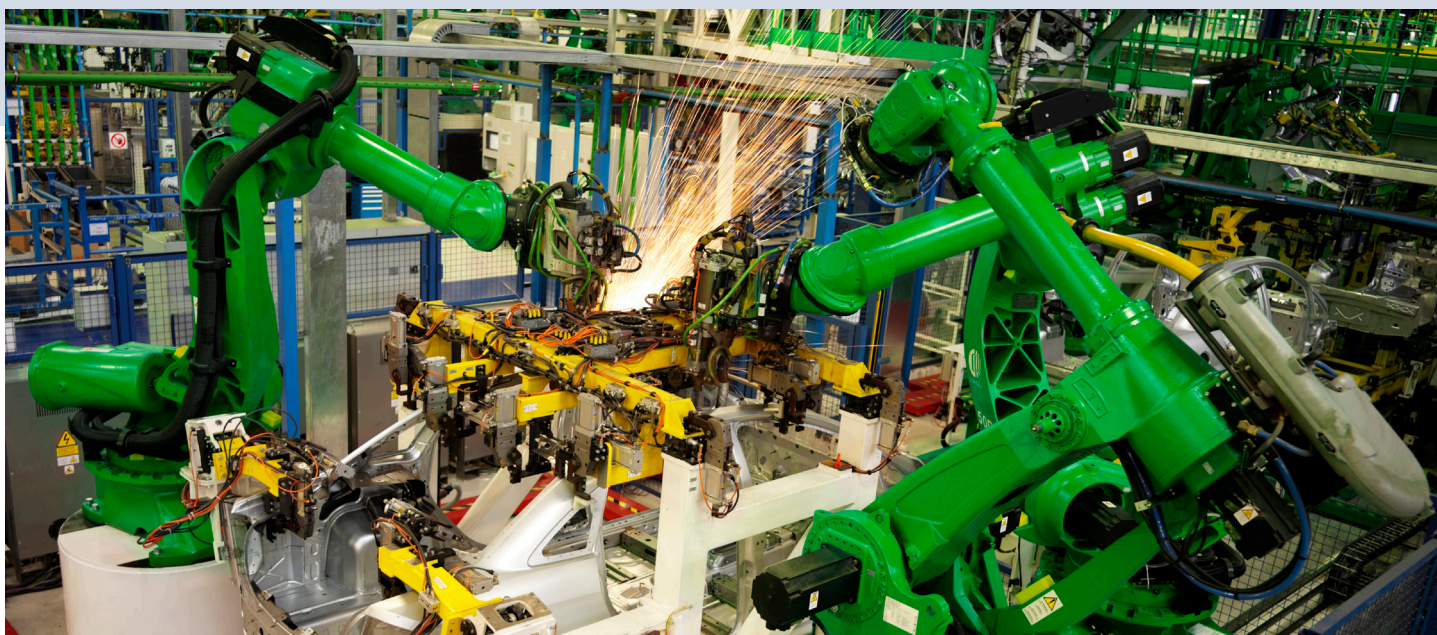


Solving Tough Robotics Challenges

The Robot Revolution





The Robot Revolution

The world of robotics is constantly chasing after the ideal machine, one that's powerful yet nimble. Imagine a robot that can handle heavy lifting on a construction site while still being lightweight and energy efficient enough to operate for long hours without recharging. Striking this balance between brawn, brains and power efficiency remains a major hurdle in robotics development.

Power, Heat and the Agile Machine

Power and thermal dissipation are persistent challenges for robots. High power consumption translates to shorter battery life, limiting operation time. Robots are often designed for mobility and tight spaces, but bulky batteries and cooling systems can prevent robots from being agile. Overheating can damage components, reduce lifespan and operation time and even pose safety risks. Engineers try to combat these drawbacks with energy-efficient designs, advanced batteries, thermal management systems and smart power management strategies, which are crucial for creating reliable and long-lasting robots.

Precision in Motion and Perception

A robot's movements need to be graceful and repeatable. Whether it's performing intricate surgery or traversing uneven ground, flawless precision is key. This extends to a robot's perception and reaction time. To be truly intelligent, robots need to be masters of their environment, able to sense their surroundings, understand what's happening in real time and react with lightning speed.

High-Resolution Vision: A Double-Edged Sword

High-resolution images are essential for robots that perform intricate tasks, providing incredible detail for tasks like screw identification during assembly. However, the massive data load associated with high-resolution images can overwhelm processing power, causing delays and potential safety risks. Limited onboard storage leads to additional complications because constant transfers to external storage strain bandwidth and hinder performance. Robotic vision demands high resolution and energy-efficient processing is crucial to bridge this gap.



Security

Physical hardware and cybersecurity in robotics are crucial to ensure safety, protect data, thwart unauthorized access and maintain operational reliability. Implementing security in robotics also fosters trust, safeguards intellectual property and helps to comply with regulations and protect national security. As robots become more advanced and integrated into our daily lives, robust security measures are essential. These measures help mitigate risks and unlock the full potential of this transformative technology.

Safety, Reliability and the Future of Robotics

Safety becomes top priority when robots (and co-bots) become our coworkers. They need to be reliable partners, functioning flawlessly for extended periods without posing any risk of harm or malfunction. In addition, the increasing capabilities of robots come with a rising price tag. Finding the right balance between cutting-edge performance, affordability and other crucial factors is a constant challenge for designers in the field of robotics.

The Need for Speed: The Role of Real-Time Technology Infrastructure

Real-time computation is crucial in robotics because it allows robots to react instantly and accurately to their environment. This ensures precision in tasks, safety when interacting with humans and adaptability to changing conditions. Adding another layer of complexity is the need for real-time secure communication within the robot. Imagine a robotic arm needing to react instantly to sensor data to avoid a collision. Traditional networking protocols can introduce delays, which compromises performance and safety. Time-Sensitive

Networking (TSN) emerges as a game changer. By guaranteeing prioritized and deterministic data transmission, TSN ensures that critical information flows seamlessly within the robot, enabling precise and timely actions.

Artificial Intelligence (AI)

AI is indispensable in robotics because it empowers machines with human-like intelligence, enabling them to perceive their surroundings, make decisions, learn from experience and interact with humans more naturally. This is crucial for applications where robots need to adapt to dynamic environments and perform complex tasks, like self-driving cars, warehouse automation, manufacturing, health care and agriculture. However, AI implementation in robotics faces challenges in power consumption and real-time processing due to the computationally intensive nature of AI algorithms. Additionally, integrating AI hardware into robotic systems can be complex, and ensuring safety and reliability remains a top concern as robots become more autonomous and interact closely with humans.

This white paper will explore the components of successful robotics solutions across diverse applications such as industrial automation, medical advancements and agricultural optimization. This white paper will also examine the range of technological solutions available to address these specific needs. Ultimately, this white paper will provide the knowledge to discover how Microchip FPGAs can facilitate robotics solutions, from the initial prototyping stages to full-scale production.



Maximizing Power Efficiency

Energy efficiency is critical in the design of industrial robots and encompasses mechanical components, sensors, control circuits and often embedded systems. Researchers have explored hardware- and software-based approaches to minimize energy consumption. Hardware strategies include selecting energy-efficient components, optimizing mechanical design and implementing energy recovery systems. On the software side, optimizing robot trajectories, scheduling operations and implementing advanced control strategies contribute to significant energy savings. Thermal management is crucial in robots with computationally intensive tasks to prevent damage and optimize energy usage. A multifaceted approach that considers both hardware and software is essential for achieving energy-efficient and high-performance industrial robots.

Microchip FPGAs Are Optimized to Deliver the Lowest Total Power Solution

Microchip FPGAs and SoC FPGAs use up to 50% less power than competing devices. Thanks to our nonvolatile process, these FPGAs are live at power-up with minimal in-rush current and much lower leakage compared to SRAM-based alternatives.

Thermal runaway can be a problem for SRAM FPGAs. The PolarFire® family of FPGAs is specifically engineered for low power consumption. You should always use power estimators to sweep the temperature to determine when a heat sink is needed for SRAM FPGAs. Our advanced transceiver designs further reduce total power usage. Consequently, PolarFire FPGAs deliver the lowest power consumption in the smallest form factors, providing enhanced compute capability within a fixed power or thermal budget.

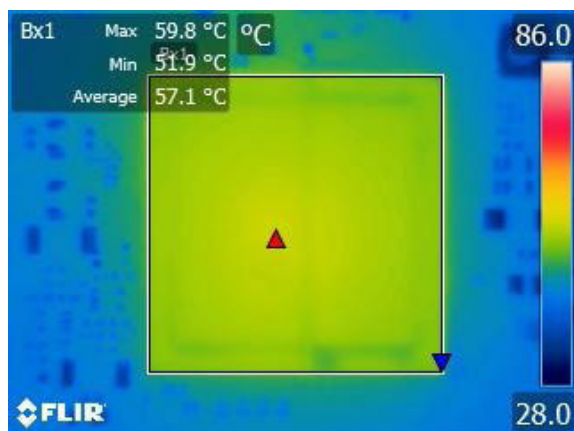


Figure 1: Microchip PolarFire® FPGA at 3.5W,
24.2 FIT, 28 nm

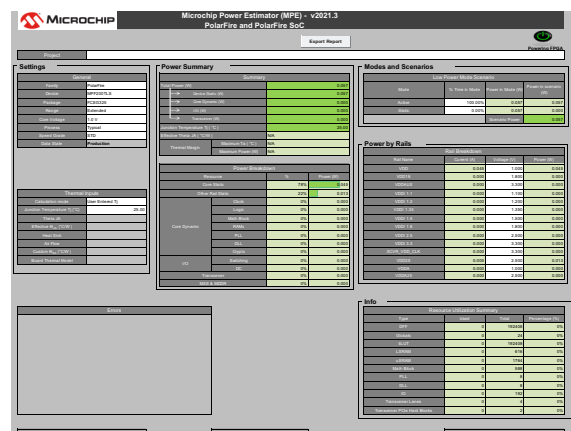


Figure 2: Microchip Power Estimator Tool



Lowest-Power SoC FPGAs

Using the EEMBC's CoreMark®-PRO benchmark, this graph illustrates the PolarFire SoC FPGA's low-power advantage. Built on the award-winning, mid-range, low-power PolarFire FPGA architecture, PolarFire SoCs deliver up to 50% lower power than comparable SoC FPGAs.

At 1.3W, PolarFire SoC FPGAs deliver a CoreMark score of 6,500 while competing SoC FPGAs deliver a CoreMark score of 0. PolarFire SoC FPGAs consume 55% lower power at a CoreMark score of 8,000.

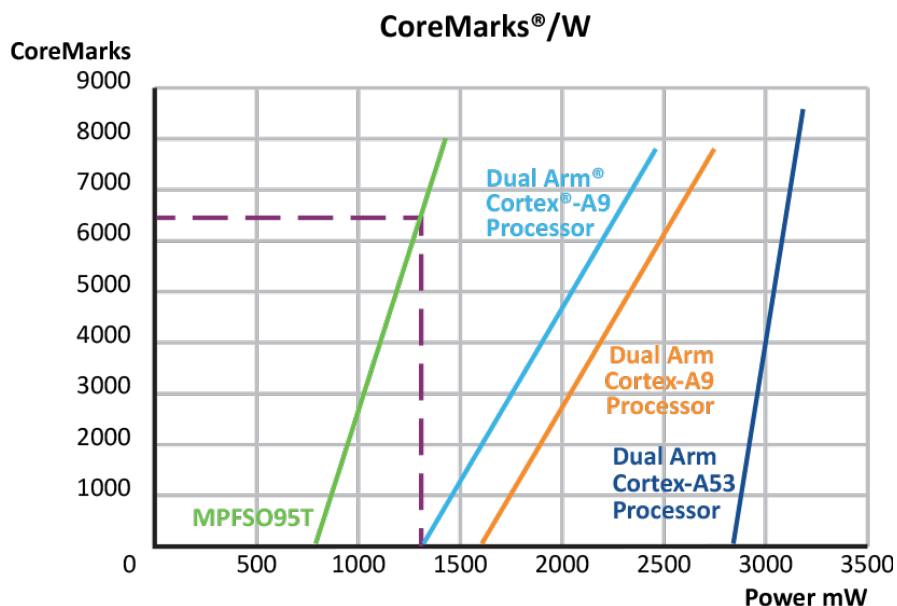
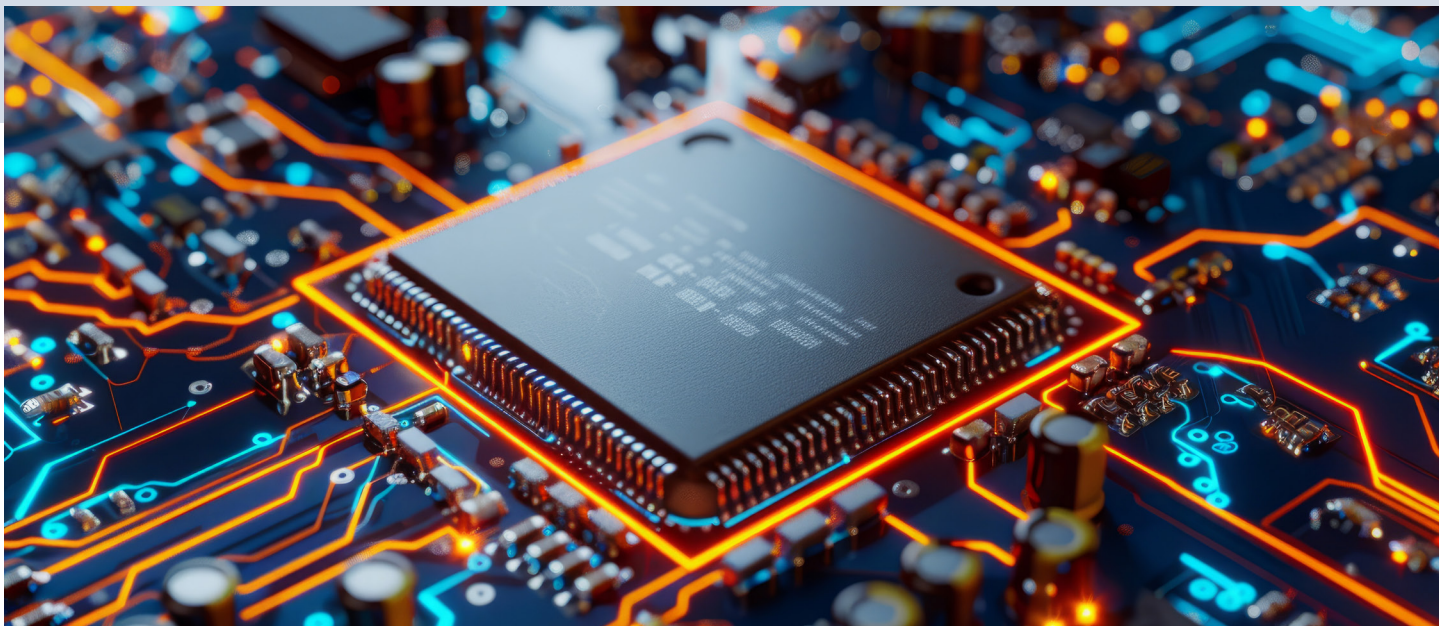


Figure 3: PolarFire® SoC Low-Power Comparison



[Learn More About Low Power FPGAs and SoC FPGAs](#)



Building Resilient Security in Connected Robotic Systems

Military-Grade Security With Anti-Tamper Features

As robots and machines become more connected, linking to the cloud can tap into the benefits of the Industrial Internet of Things (IIoT), which also brings significant security challenges. While these smart machines can enhance production speeds, improve data collection and streamline operations, they also introduce new vulnerabilities. Industrial robots are prone to cyberattacks, which can disrupt control parameters, tamper with calibration and more. Such attacks on Industrial Control Systems (ICSs) can halt production, damage equipment and potentially injure workers.

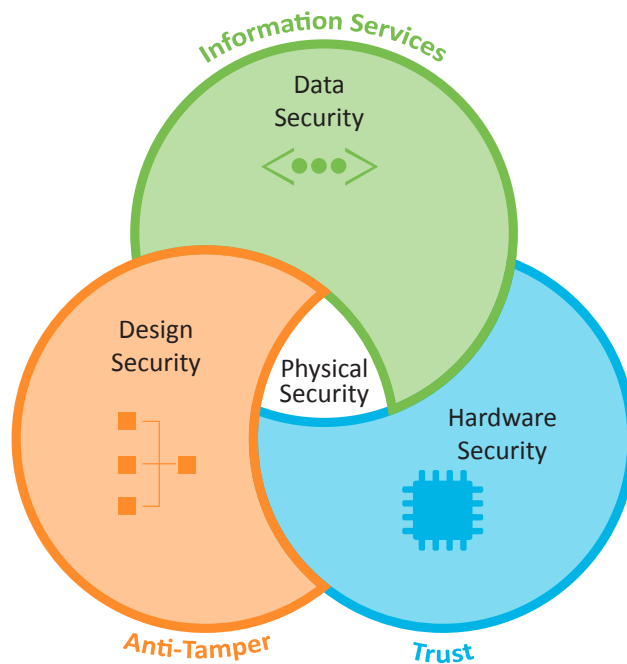
To guard against these threats, it's essential to incorporate cybersecurity measures early in the development process. Important steps include assessing security risks, securing each endpoint and staying updated with industry standards like ISA and IEC 62443, which provide guidelines for managing vulnerabilities in industrial automation and control systems.

Building a Secure Robotic System

Ensuring robust security in robotics isn't just about cybersecurity; it's also about securing hardware and design. Operations Technology (OT) and Information Technology (IT) teams must collaborate to protect both physical and digital assets. Securing each network endpoint with hardware-based solutions can contain the damage of any single breach. Our FPGAs come with advanced security features, including cryptographically secured supply chains, anti-tamper mechanisms and NIST-certified cryptographic algorithms. These features, along with secure manufacturing processes, provide a robust platform for developing and deploying secure robotic systems. By ensuring the confidentiality, integrity and authenticity of data at rest and in transit, we address a wide range of security needs—from cyber threats to hardware vulnerabilities—to create a secure and reliable foundation for the future of robotics.



[Learn More about Secure FPGAs and SoC FPGAs](#)



There is no cybersecurity without physical security. With the following security features, PolarFire FPGAs prevent overbuilding, cloning and tampering:

PolarFire Design Security for Information Assurance

- DPA countermeasures
- AES
- GMAC
- HMAC
- CMAC
- Key tree
- True random number generator
- ECC
- IFC
- FFC
- NRBG
- SHA

PolarFire Design Security for Anti-Tamper

- Digest check
- Bitstream versioning

- Bitstream security
- Temperature tamper detection
- Voltage tamper detection
- Clock frequency tamper detection
- Clock glitch detection
- User security locks
- Debug locks
- Permanent locks
- Programming locks
- FPGA and sNVM locks
- DPA countermeasures
- NIST CAVP
- Physically Unclonable Function (PUF)
- Crypto secure supply chain
- Active mesh
- Hardware root of trust

Our SHIELDS UP! webinar series provides educational information from our security experts and trusted partners about developing secure robotics systems.





Ensuring Safety and Reliability in Industrial Robotics

The necessity of safety standards for industrial robots has never been more evident. With industrial robots becoming increasingly common in manufacturing and logistics. While these robots enhance productivity and address labor shortages, they also introduce safety risks. Robust safety standards are essential to protect human workers in environments densely populated with robots.

A crucial aspect of these standards is ensuring immunity to single-event upsets (SEUs), which are disruptions caused by high-energy particles that can affect electronic circuits and lead to data or control errors. SEU immunity is vital for the reliability and safety of robots, especially in environments with potential radiation exposure. For instance, SEUs could cause a robotic arm in manufacturing to malfunction, potentially causing damage or injury. Incorporating SEU immunity through radiation-hardened components and error detection algorithms helps robots operate safely and reliably, even in challenging environments.

Integrating technological solutions with safety standards is crucial for protecting industrial mobile robots and ensuring safer work environments.

Get Defense-Grade Reliability for Any Design—Because Just One SEU Resets Your System

Microchip FPGAs are a game-changer for robots that need to work reliably in tough situations. They leverage nonvolatile configuration technology, which is resistant to ionizing radiation and subatomic particles. This technology shields against configuration upsets caused by natural radiation. The microprocessor subsystem on PolarFire SoC is protected by built-in SECEDED and supports system controller suspend modes for all safety-critical operations. PolarFire has been rigorously tested to meet the highest industry standards and are already trusted in critical applications like flight control and medical devices.

Microchip is also committed to supporting our customers for the long haul, ensuring these FPGAs are available for 20-30 years and as long as they're needed. If you're building robots or any systems that demand rock-solid reliability, our FPGAs are the perfect foundation to keep your operations running smoothly for years to come.



Safeguarding the Human-Robot Partnership

Functional Safety and Security in the Industry 5.0 Era

Robotic systems are evolving to be more collaborative and dynamic. In industrial, health care and domestic environments, robotic systems are increasingly working alongside humans and moving freely in shared spaces. Functional safety standards are crucial for manufacturers to design robots and mechanical systems with built-in “fail-safe” measures. Key

international standards for industrial robot safety include IEC 61508, which provides functional safety guidelines for electrical and electronic systems, and ISO 26262, an automotive safety standard that helps prevent systemic issues and random hardware faults in robotic systems.

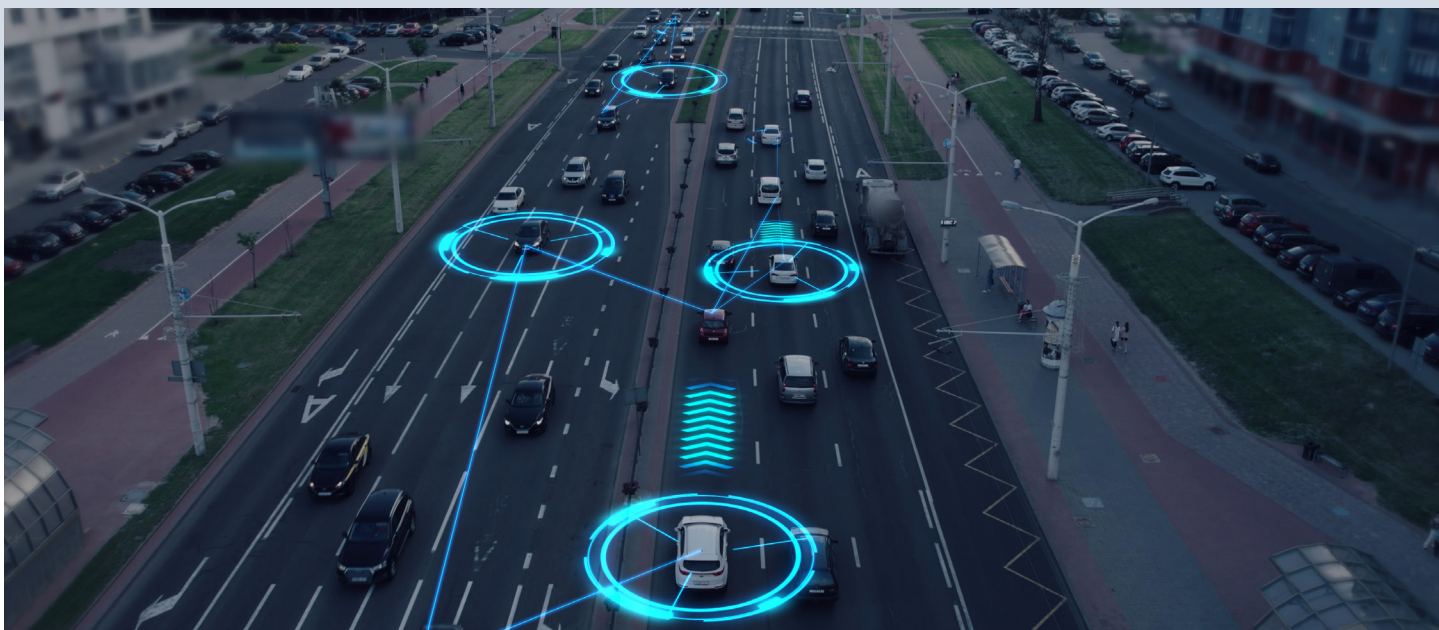


[Learn More about Functional Safety with FPGAs](#)



Functional Safety Support

Our functional safety life cycle process is externally certified up to SIL 3 under IEC 61508 and up to ASIL C under ISO 26262. We provide technical documentation and software libraries to help customers develop high-performance, functional safety-compliant systems that are affordable and scalable. Visit our website to learn more about functional safety with FPGAs.



Additionally, compliance with evolving industry standards such as IEC 62443 helps reduce risks. The IEC 62443 standard serves as a comprehensive guideline for enhancing cybersecurity in industrial automation, control systems and robotics. Our FPGAs are designed with this standard in mind, offering robust security features like secure boot, authentication, data encryption and tamper detection. These measures are particularly crucial in the evolving landscape of robotics, where interconnected systems and autonomous decision making demand heightened security. By incorporating IEC 62443-aligned FPGAs, into your designs, you can fortify robotic systems against cyber threats, supporting the integrity, confidentiality and availability of critical data and operations.

IEC 61508 SIL 3: Available Now

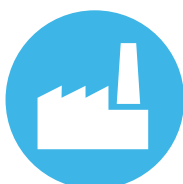
ISO 26262 ASIL B: Available September 2024



We have what you need to certify your products with the IEC 62443 standard. Click the icons below to learn more about each element.



Secure Boot



**Secure
Manufacturing**



Functional Safety



**Supply Chain
Assurance**



**Defense in Depth
Architecture**



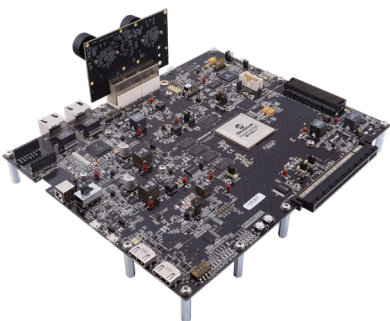
Enhancing Perception and Interaction in Robotic Vision

Smart Embedded Vision (SEV) is revolutionizing robotics by granting machines the ability to perceive and interact with their surroundings in a way that was once confined to science fiction. Through real-time object recognition, precision tracking, secured communication and a comprehensive understanding of the environment, robots are now capable of autonomous navigation, precise manipulation of objects and efficient quality inspections. These systems need to strike a balance between power efficiency and high-resolution image processing, ensuring they can operate effectively within the constraints of their platforms. Thermal management is crucial due to the intensive computational demands involved in vision processing and integrating AI and ML algorithms is essential for enabling real-time image analysis and informed decision making. Overcoming these challenges will pave the way for the next generation of intelligent, adaptable and highly functional robots that can truly transform our world.



PolarFire® Video Kit

Dual 4K60 MIPI® Cameras With FMC and HDMI®



PolarFire SoC Video Kit

Adds Linux®, PCIe®, Dual-1G Ethernet and MIPI Tx



1G to 10G
Ethernet
USXGMII



12.5G CoaXPress®



3G, 6G, 12G
Serial Digital
Interface



4.7x8 Gbps
SLVS-EC™ FMC



2.5x 4 Gbps
MIPI Transmit FMC



8.1 Gbps
DisplayPort FMC

Figure 4: Solution-Specific Evaluation and Prototyping Kits



Our PolarFire FPGAs and SoCs support a broad and complete portfolio of vision-processing IPs, including some advanced IPs to support modern robotics applications. Visit our Smart Embedded Vision (SEV) [web page](#) to learn more.

Smart Embedded Vision (SEV)

Sensor Interfaces (Rx)

- MIPI CSI-2 receive (1.5 Gbps/lane)
- SLVS-EC (4.7 Gbps/lane)

Deep Learning Inference

- VectorBlox™ SDK

Image Processing

- Alpha blending
- Bayer interpolation
- Sobel

- Uncanny edge detector
- Display controller
- Image edge detection
- Image enhancement
- Image sharpen
- RGB to YCbCr
- YCbCr to RGB
- Test pattern generation
- Gamma correction
- Histogram
- White balance

Encode (Decode)

- H.264 partner IP
- mJPEG compression
- H.264 baseline/iframe

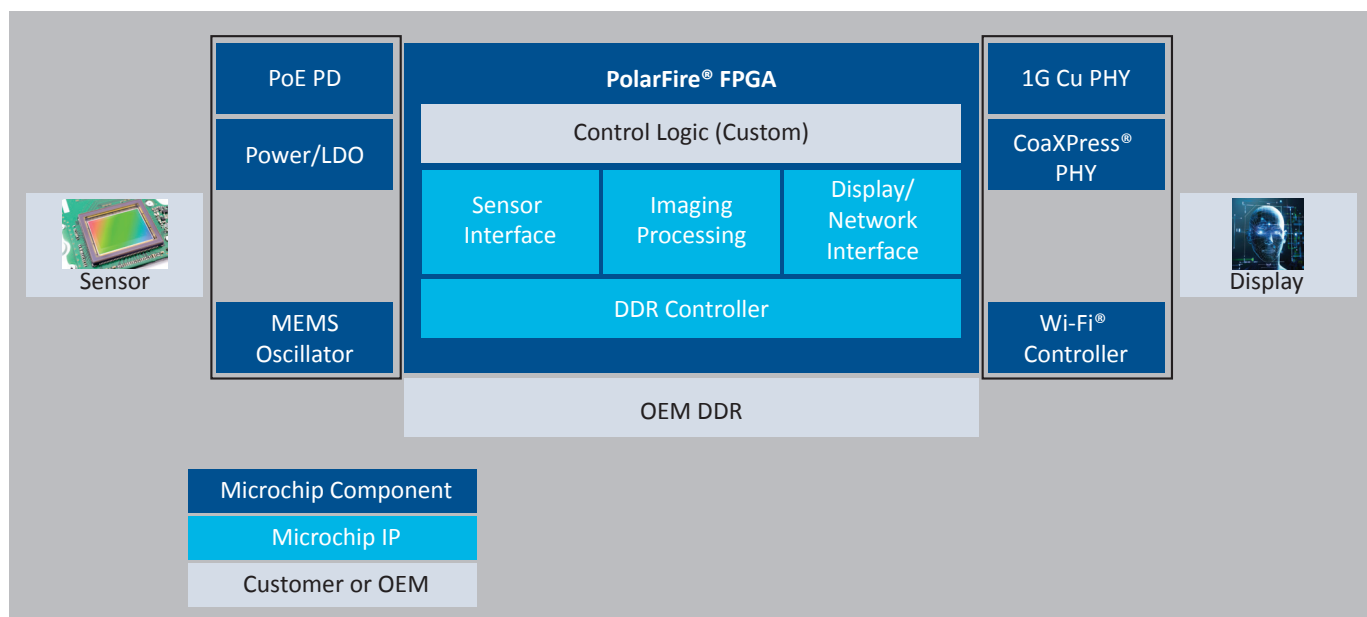
Display Interfaces

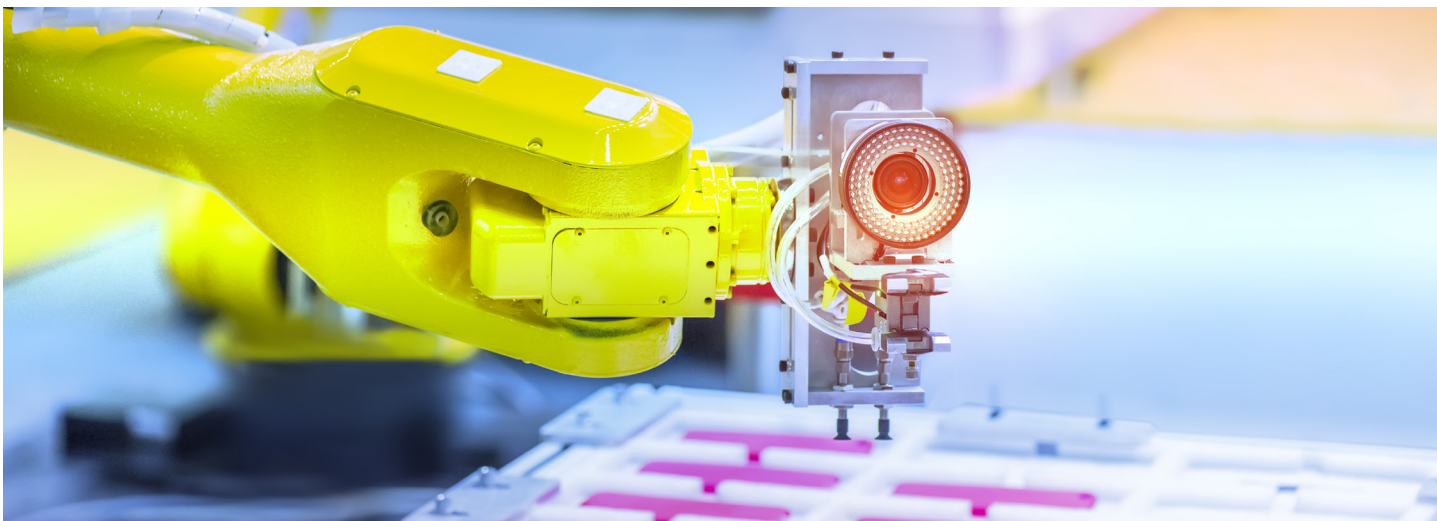
- MIPI Tx on SerDes

Transport Interfaces

- CoaXPress 6.25/12.5G
- 10G MAC/10G PHY
- USXGMII (1/2.5/5/10G)

- HDMI 2.0 Rx/Tx
- MIPI Tx on SerDes
- USB 2.0, USB 3.1 Gen 1 and Gen 2





CoaXPress® (CXP) is a high-speed digital interface designed for industrial applications that is known for its robustness and ability to transmit high-resolution images over long distances. Our PolarFire FPGA, paired with CoaXPress 2.0 transmitter/receiver, enhances this technology to facilitate seamless integration and efficient image processing. This combination is particularly effective in applications such as inspecting products on fast-moving assembly lines.

Scalable Low Voltage Signaling for Embedded Cameras (SLVS-EC™) provides a low-power, scalable solution for transmitting video data at various resolutions and frame rates. This is well suited for space-constrained robotic systems, such as medical robots used in minimally invasive surgeries or endoscopic procedures. SLVS-EC supports high-resolution images and global shutter functionality, essential for capturing clear visuals in dynamic environments. Our PolarFire FPGAs, with high-speed SerDes, address the growing need for higher resolution and faster data rates in robotic vision systems. A solution for SLVS-EC to four-channel CoaXPress is an easy route for the transport of high-bandwidth, high-resolution video.

H.264 is a widely adopted video compression standard for applications with bandwidth or storage constraints. It compresses video data efficiently while maintaining high visual quality, making it well suited for transmitting video feeds from surveillance drones or teleoperated robots. Our PolarFire SoCs feature an in-house H.264 encoder IP to enable real-time 4K compression over MIPI® CSI-2 RX links. This supports the development of high-quality H.264 cameras with advanced image processing capabilities.

Learn More

<https://www.microchip.com/en-us/solutions/industrial/smart-embedded-vision>





The Mi-V ecosystem is Microchip's collection of resources to support RISC-V® development using PolarFire SoC FPGAs and soft CPUs. With the Mi-V ecosystem, PolarFire SoCs support a broad range of Linux distributions, builds and real-time operating systems.

Resources on GitHub

Linux Build Systems

[PolarFire SoC Yocto BSP](#)

Yocto based Linux build system for PolarFire SoC

[Microchip BuildrootExternal](#)

Buildrootbased Linux build system for PolarFire SoC & other Microchip SoCs.

Linux Distributions

[Ubuntu Server](#)

Ubuntu Server images for the PolarFire SoC Icicle Kit.

Real Time Operating Systems (RTOS)

[Zephyr](#)

Fork of the upstream Zephyr repository with support for PolarFire SoC

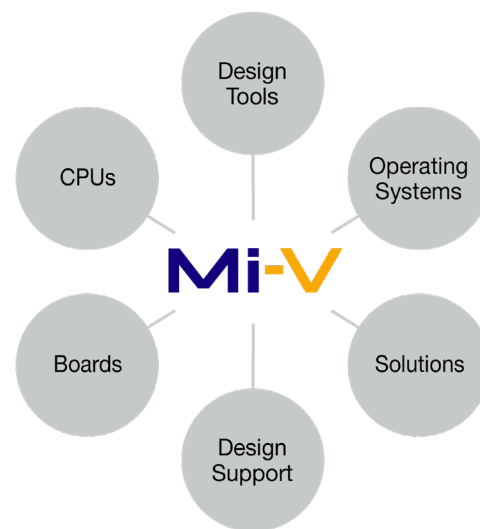
[RTEMS](#)

Fork of the upstream RTEMS repository with support for PolarFire SoC

FPGA Build Systems

[Icicle Kit Bitstream Builder](#)

Example scripted flow for a version-controlled FPGA bitstream generation system



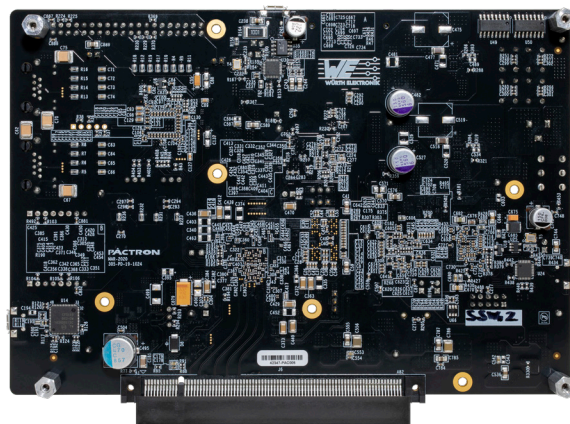


Building Efficient Robot Brains

The Roles of AMP, ROS 2, OPC UA and TSN

Robotics involve the intricate task of integrating real-time systems. Robots operate as deterministic machines, ensuring they meet computation deadlines effectively. The brains and behaviors of robots are structured like computational graphs, where data flows between nodes and across communication buses, connecting with sensors and actuators underneath.

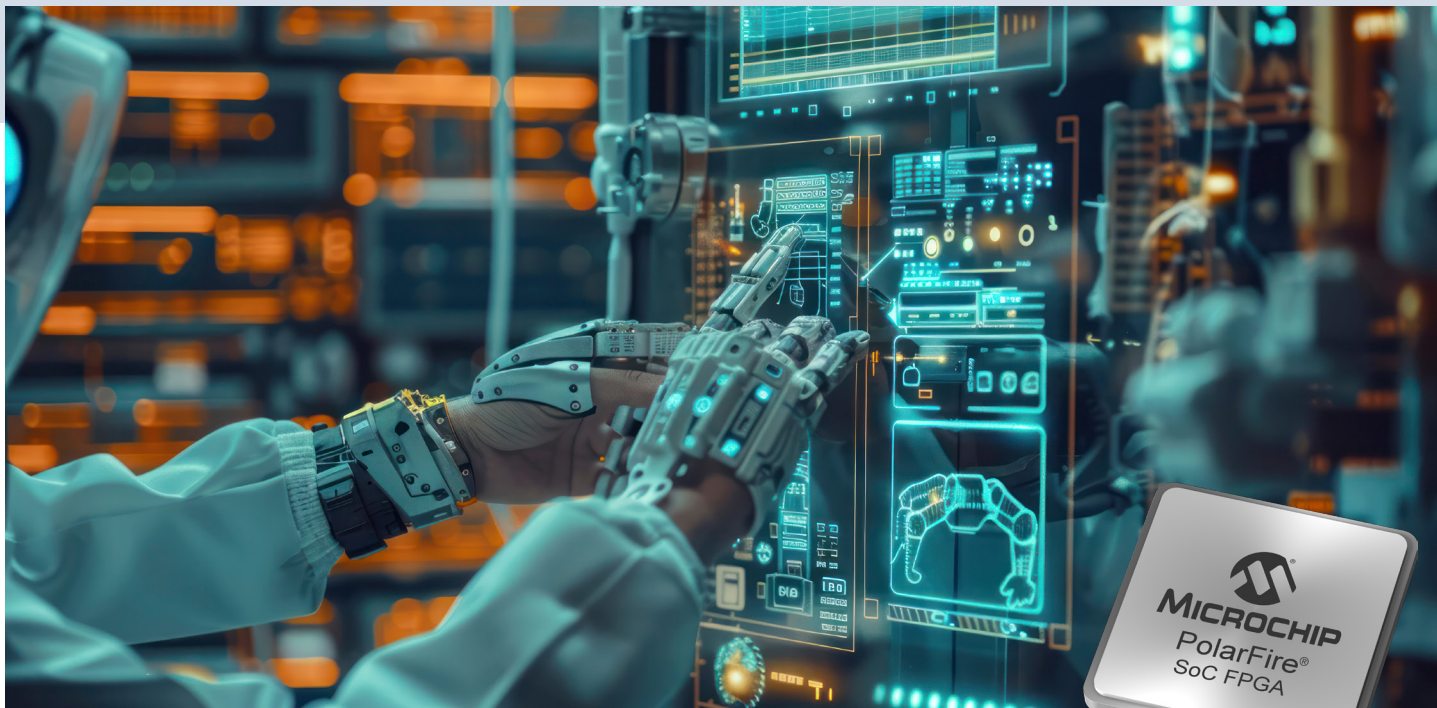
The Robot Operating System (ROS) is the dominant framework for building robot applications, serving as a universal language for robotics developers and companies. Its modular architecture and extensive libraries make it a versatile tool for creating complex robotic systems. Most robots today rely on ROS or similar event-driven frameworks. PolarFire SoC FPGAs seamlessly integrate with ROS 2 Humble using the Yocto build system.



Learn More About ROS 2



Figure 5: ROS 2 Humble for PolarFire Icicle Kit Enables Support for Yocto Honister Release



Asymmetric Multiprocessing (AMP)

PolarFire® SoC's Asymmetric Multiprocessing (AMP) architecture further enhances the capabilities of ROS by allowing multiple operating systems, such as bare-metal, RTOS, or Linux, to run concurrently to create high-performance and hard real-time systems. This unique feature enables robots to meet diverse application demands, including real-time response, security, and safety requirements.

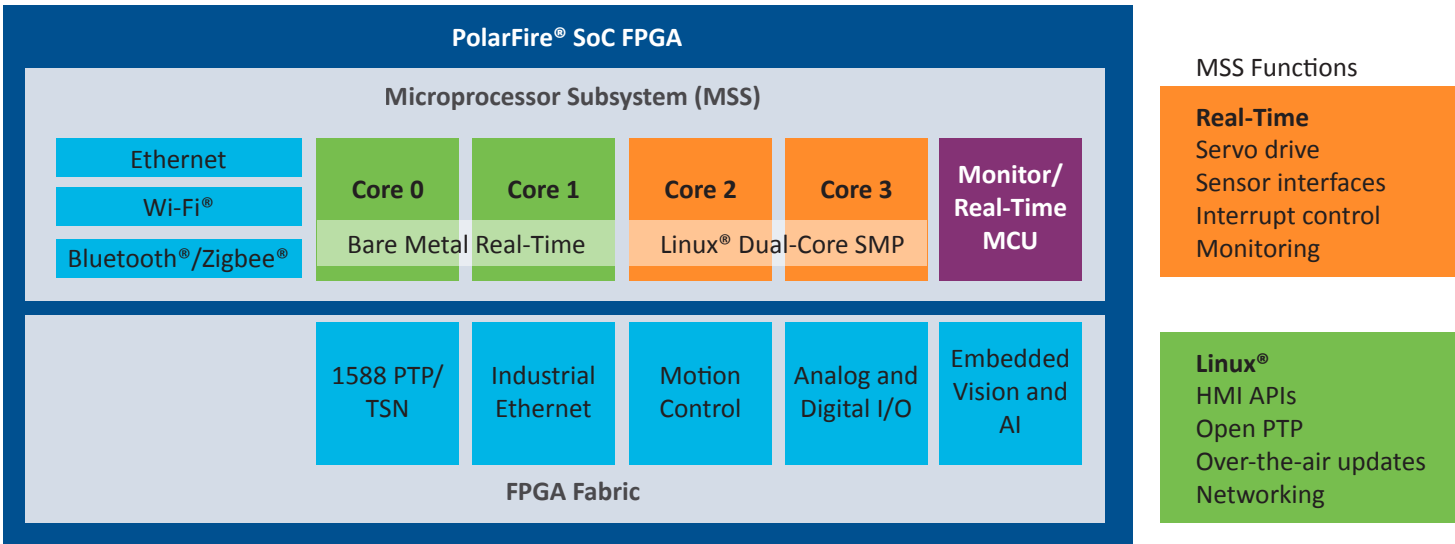


Figure 6: Quad-Core, RISC-V Application-Class Cluster for Mixed-Criticality in Industrial Automation



Time-Sensitive Networking (TSN)

Unlocking the full potential of intelligent robotics requires a robust network infrastructure to support real-time communication. Time-Sensitive Networking (TSN) standards, developed by an IEEE® 802.1 working group, enable the integration of critical process data with less time-sensitive information, which streamlines costs, maintenance and project timelines. TSN ensures optimal performance by seamlessly integrating real-time process traffic with asynchronous data streams. The TSN implementation on PolarFire SoCs includes IPs for 1588 and TSN, Linux drivers, a user application interface and a pre-configured design for rapid prototyping. Features include:

- 1 Gbps TSN Ethernet endpoint
- Compliance with IEEE 802.1 standards
- Precise timing and synchronization with IEEE 802.1 AS-2020 and IEEE 1588
- Efficient traffic management with IEEE 802.1Qbv and IEEE 802.1Qbu
- Enhanced traffic control with IEEE 802.1Qci
- Versatile deployment options with GMII Ethernet PHY interface, 32-bit APB and 32-bit AXI4-Stream

TSN utilities and example configurations are available on GitHub for easy implementation.

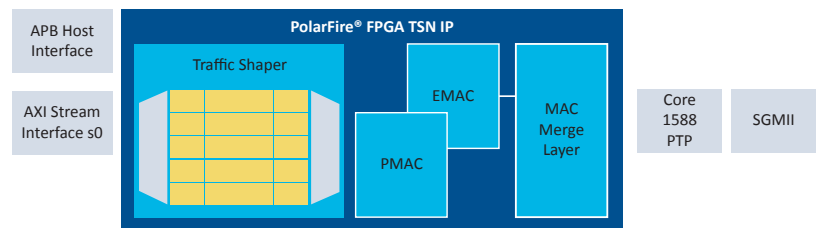


Figure 7: PolarFire® FPGA TSN IP

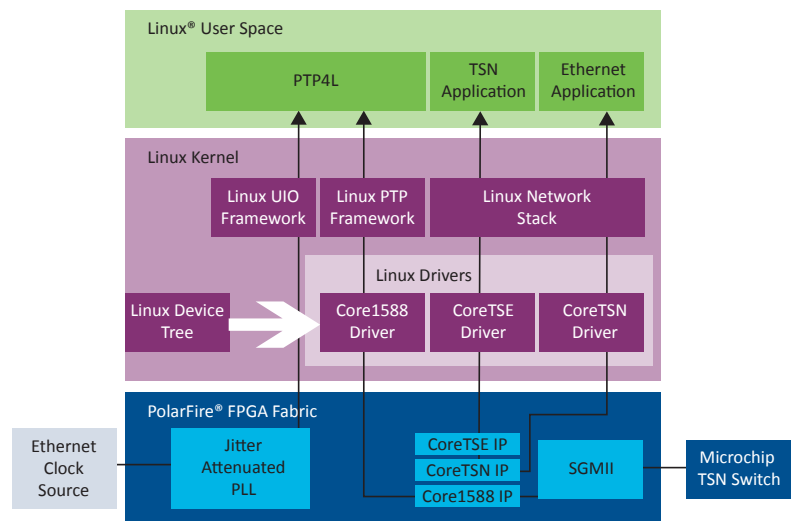


Figure 8: PolarFire® FPGA TSN Software Stack



TSN Enhances OPC UA

Moreover, for industrial automation, PolarFire SoCs offer comprehensive support for OPC UA, a platform-independent standard for secure machine-to-machine communication. This enables the SoC to function as both a server and a client, facilitating seamless integration and communication within complex industrial networks. TSN enhances OPC UA communication, ensuring synchronized operations across multi-vendor robotic environments with secure, standardized data structuring. This interoperability provides flexibility and smooth operations at affordable costs.

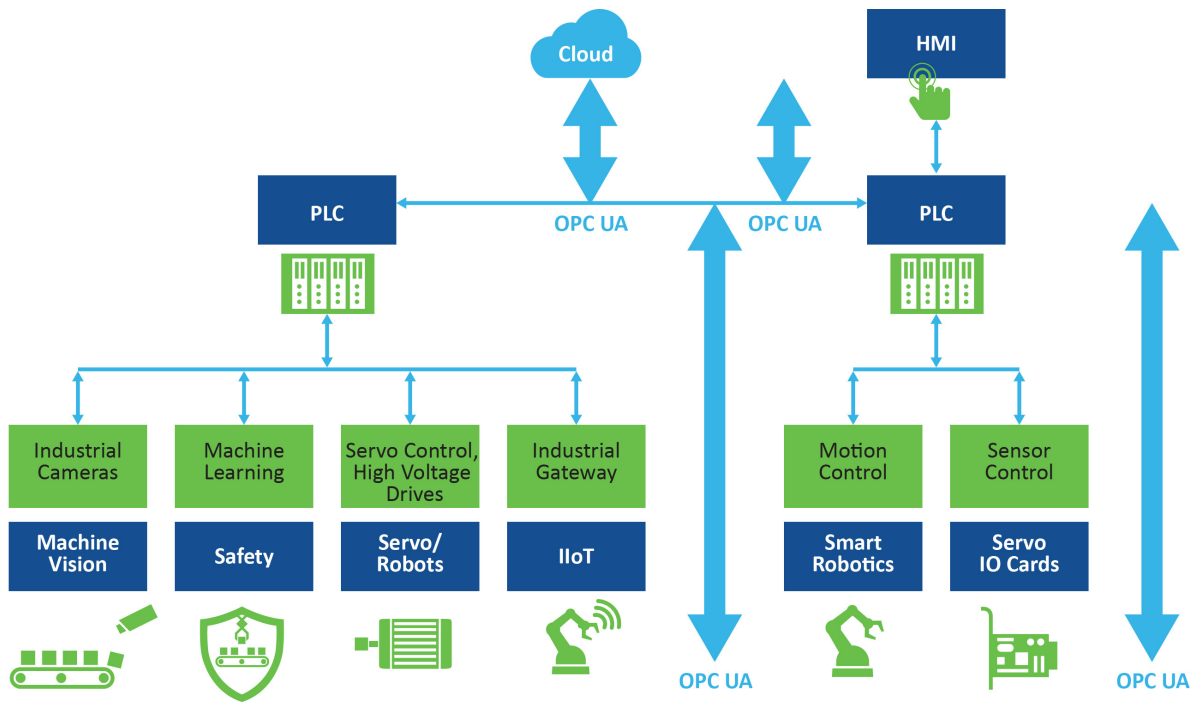


Figure 9: Smart Robotics in OPC UA Architecture

Other emerging communication standards include RDMA over Converged Ethernet (RoCE). AA networking technology that enables Remote Direct Memory Access (RDMA) over Ethernet networks, this standard allows computers to access memory on another computer without involving the operating system, resulting in lower latency, higher bandwidth and reduced CPU utilization. In a factory setting, RoCE allows multiple robots on an assembly line to synchronize their movements with extreme precision, preventing collisions and optimizing production speed. In health care, surgical robots can leverage RoCE to transmit high-definition video feeds from internal cameras with minimal latency, ensuring surgeons have the clearest possible view for precise operations. Additionally, in autonomous vehicles, RoCE ensures real-time communication between sensors, cameras and the central processing unit, enabling rapid decision making for safe navigation.

AI — The Driving Force Behind Intelligent Robotics

AI is the catalyst for transforming robots from pre-programmed machines to intelligent entities capable of adapting to complex and dynamic environments. AI is not just a nice-to-have feature in robotics; it's a fundamental enabler for the next generation of intelligent machines. By leveraging AI, robots can perceive their surroundings more accurately, make smarter decisions, adapt to changing circumstances, and interact with humans more naturally. This leads to improved efficiency, productivity, and safety across a wide range of applications.



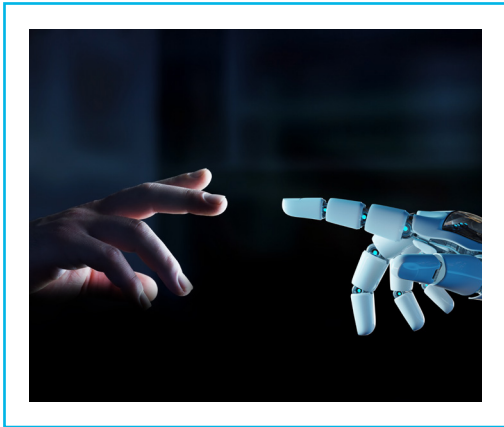
A self-driving car uses AI-powered computer vision to identify pedestrians, traffic signs, and obstacles in real time, allowing it to make split-second decisions and navigate safely.



A warehouse robot equipped with AI can analyze inventory levels, predict demand, and autonomously optimize its path to pick and pack items with maximum efficiency. Reinforcement learning algorithms enable the robot to learn from its actions.



A robotic arm in a manufacturing plant can use machine learning to adapt to different tasks, such as assembling various products or handling delicate materials. It learns from its experiences and refines its movements to optimize performance and avoid errors.



A social robot designed for elder care can use natural language processing to understand and respond to voice commands and questions. AI algorithms enable it to recognize emotions and provide appropriate social responses, enhancing the quality of interaction.



In agriculture, AI-powered drones can analyze crop data, detect pests and diseases, and optimize irrigation patterns, leading to increased yields and reduced resource consumption.



Speed, Accuracy and Flexibility with VectorBlox SDK

The VectorBlox Accelerator Software Development Kit (SDK) offers the most power-efficient Convolutional Neural Network (CNN)-based Artificial Intelligence/Machine Learning (AI/ML) inference with PolarFire FPGAs. VectorBlox software enables:

- OpenVINO toolkit-based front-end tools
- Support for most common frameworks like TensorFlow, Caffe, MxNet, PyTorch and DarkNet
- Quick evaluation without prior FPGA knowledge
- Software-overlay-based implementation; there's no need to reprogram the FPGA while updating CNNs

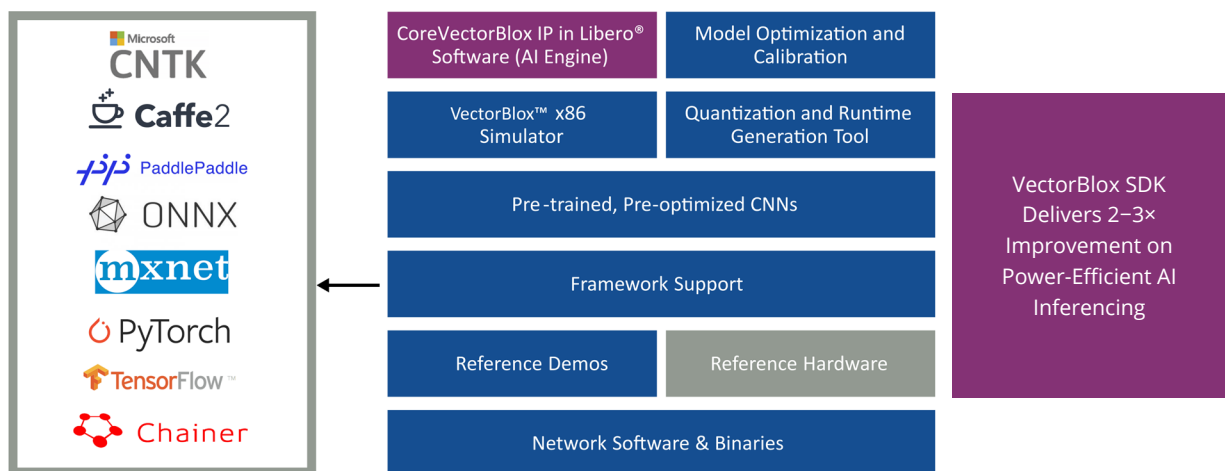
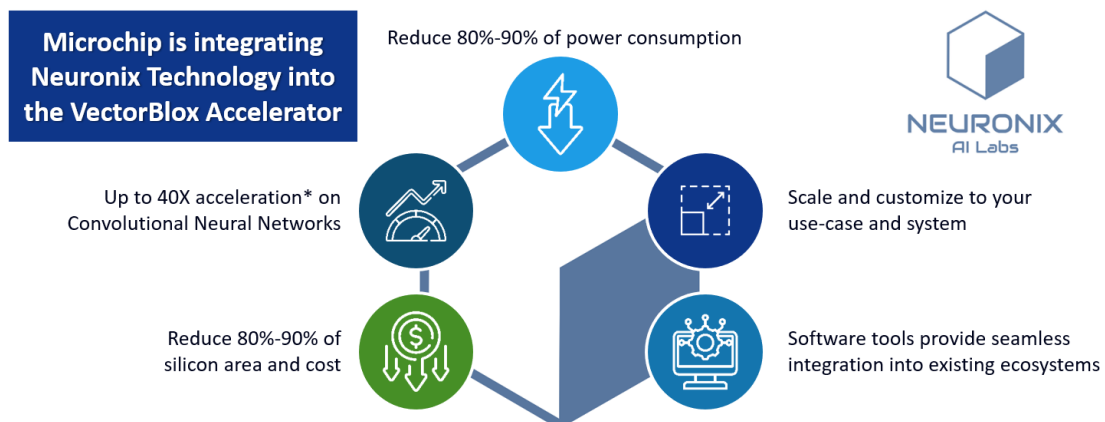
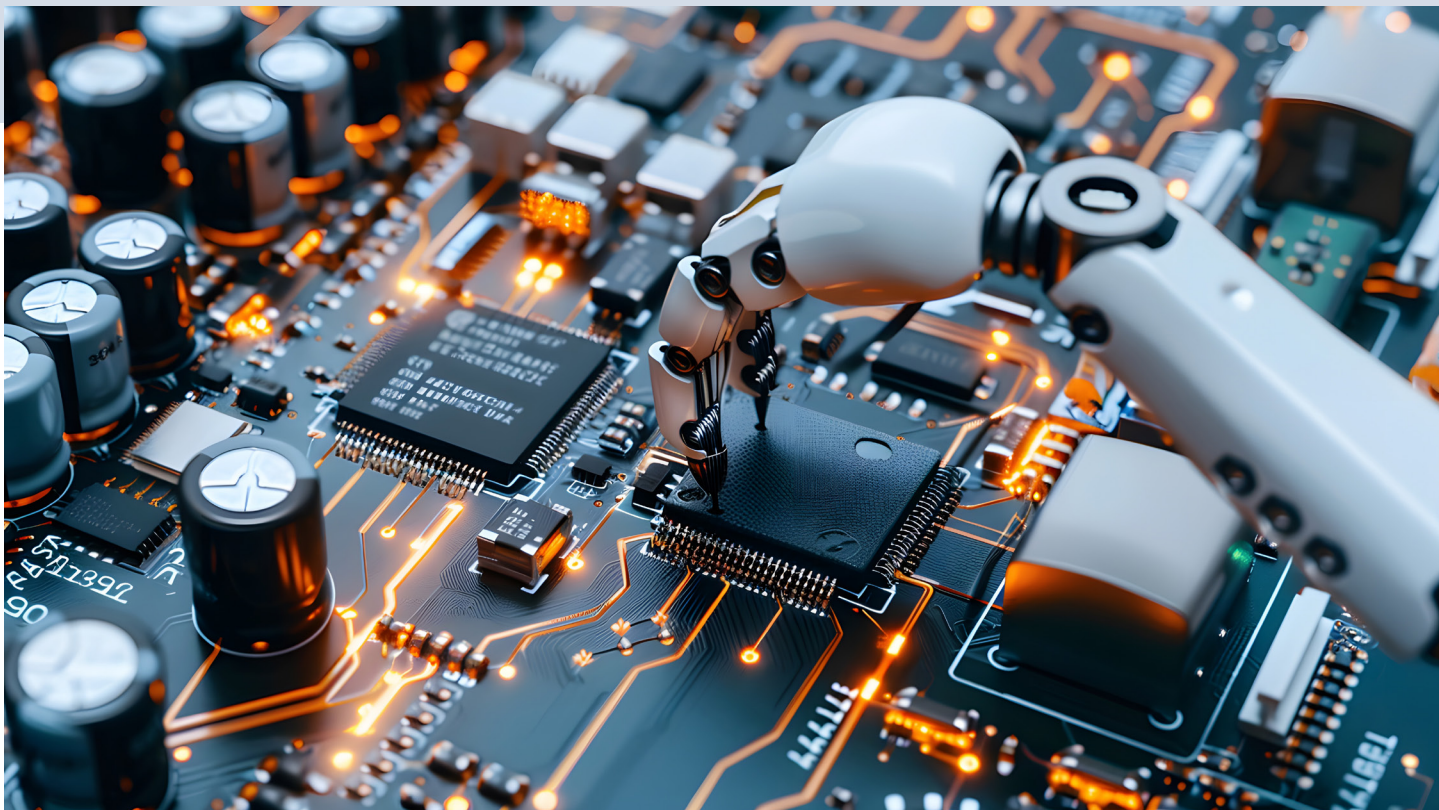


Figure 10: VectorBlox™ SDK Framework





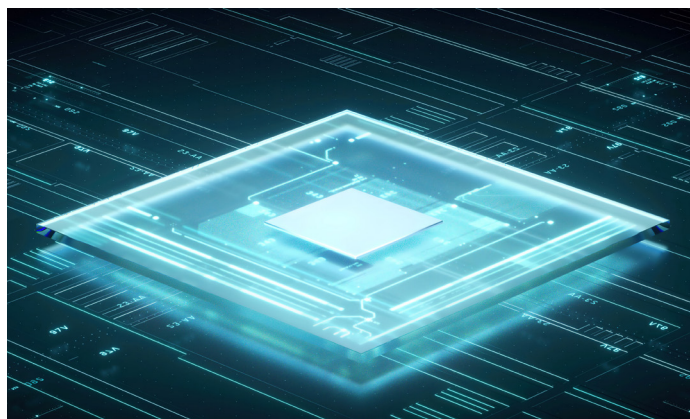
Solving Precision and Reliability in Motion

Multi-Axis Motion Control

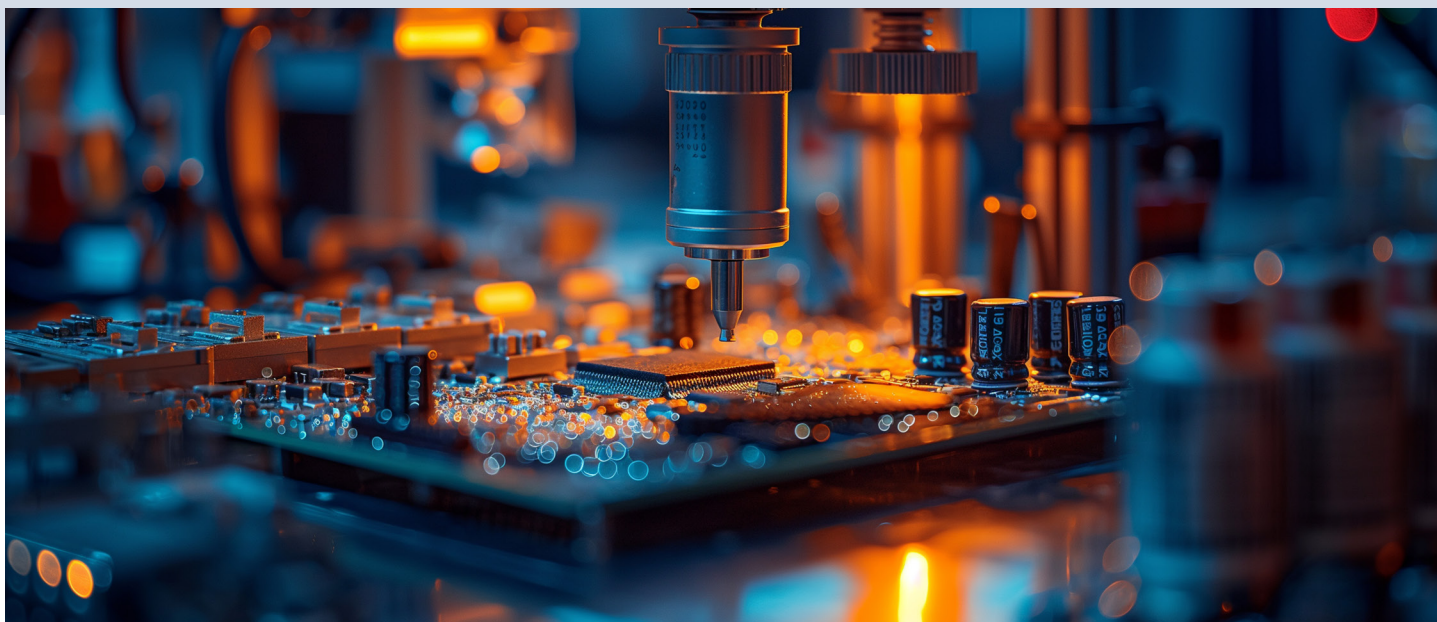
The relentless march of automation hinges on robotic systems that function with unwavering precision and reliability. Even seemingly minor delays, like those caused by traditional boot times, can translate to lost revenue and reduced efficiency. Eliminating unnecessary costs associated with boot times ensures that systems are operational immediately, maximizing uptime and significantly reducing potential financial losses. A single motor breakdown can bring a factory floor to a halt, disrupting productivity and incurring crippling costs.

Physical security is non-negotiable, especially in human-facing systems like medical robotic arms where sabotage or unauthorized access can have severe consequences.

Webinar: Improve Productivity in Motor Control Applications Using C++ With HLS



Learn more about Motion Control with FPGAs and SoC FPGAs.



As the automation landscape evolves, so too do the demands placed on motor control systems. They face the increasing complexity of coordinating multiple axes and diverse sensor data while meeting demanding performance requirements. They must drive high-powered Servos, control multiple motor types (Stepper, BLDC, AC Induction), maintain tight control loops, and drive wide band gap SIC MOSFETs. Microchip's FPGA family tackles these challenges head-on, offering a comprehensive solution for multi-axis and high-RPM applications. Choose from our PolarFireSoC, PolarFire and SmartFusion2 to combine a flexible motor control IP suite and reference designs with deterministic performance and low latency for real-time control.

Advanced Multiprocessing (AMP) support on the PolarFire® SoC allows for optimized resource allocation, while built-in safety features and IEC 61508 compliance ensure reliable and secure operation.

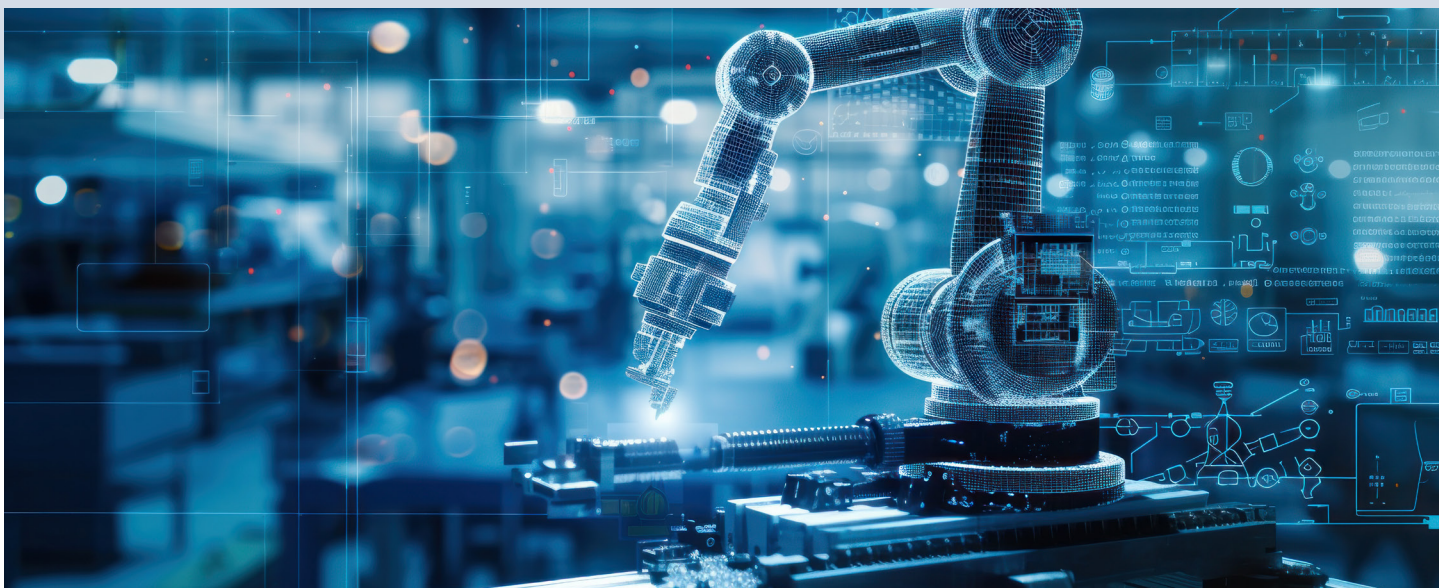
Design with Microchip FPGAs for high-performance, efficient, and safe motor control systems at a lower Total Cost of Ownership (TCO), making them the perfect partner for building the future of automation.

Multi-Axis Motor Control Solution

For PolarFireSoC, PolarFire and SmartFusion2 Classic FPGA

Get Started Now

FOC Transformation IPs	Rate Limiter
PI Controller	Position and Speed Estimator
Space Vector	Encoder, HALL, Resolver Interface
Core 3 Phase PWN	Stepper Angle Generator



Microchip Technology FPGA and SoC FPGA Portfolio

Power and Thermal Efficiency, Military-Grade Security, Exceptional Reliability

Family	SmartFusion [®] , ProASIC [®] 3 and IGLOO [®] FPGAs	SmartFusion [®] 2 and IGLOO [®] 2 FPGAs	PolarFire [®] FPGAs	PolarFire SoCs
Description	Smallest packages CPLD replacements	Low-density FPGAs with more resources and the lowest power	Mid-range density Lowest power, smallest form factors	Mid-range density Hard quad-core RISC-V [®] 64-bit CPU Real-time Linux [®]
Logic Elements	100–30K	5K–150K	50K–480K	25K–460K
Transceiver Rates	–	1–5 Gbps	250 Mbps–12.7 Gbps	250 Mbps–12.7 Gbps
I/O Speeds	400 Mbps LVDS	667 Mbps DDR3 750 Mbps LVDS	1600 Mbps DDR4 1.6 Gbps LVDS/1.5 Gbps MIPI [®]	1600 Mbps DDR4/ LPDDR4 1.6 Gbps LVDS/1.5 Gbps MIPI [®]
DSP (18 × 18 Multipliers)	–	240	1480	1420
Max RAM	144 Kb	5 Mb	33 Mb	32 Mb
Processor Options	Hard 100 MHz Arm [®] Cortex [®] -M3 core	Hard 166 MHz Arm Cortex-M3 core Soft RISC-V	Soft RISC-V Soft Arm Cortex-M1 core Hard crypto processor	64-bit hard quad-core RISC-V CPU (600 MHz) Hard crypto processor/2 MB L2 cache
On-Board Flash	Up to 512 KB code storage	Up To 512 KB code storage	56 KB secure NVM	56 KB secure NVM 128 KB boot Flash



The Rapid Evolution of Robotics: Opportunities and Challenges

The rapid evolution of robotics is reshaping industries and transforming our daily lives, bringing both opportunities and challenges. Smart embedded vision, powered by advanced FPGAs like Microchip's PolarFire SoC, is driving this revolution, enabling robots to perceive and interact with their environment with unprecedented precision and autonomy. From autonomous vehicles and industrial automation to medical robotics and smart agriculture, the applications are vast and ever-expanding. [Click to learn more:](#)



Robotics With Microchip FPGAs

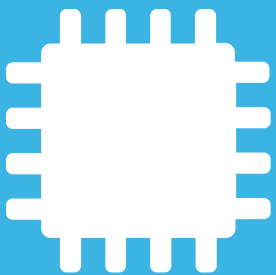


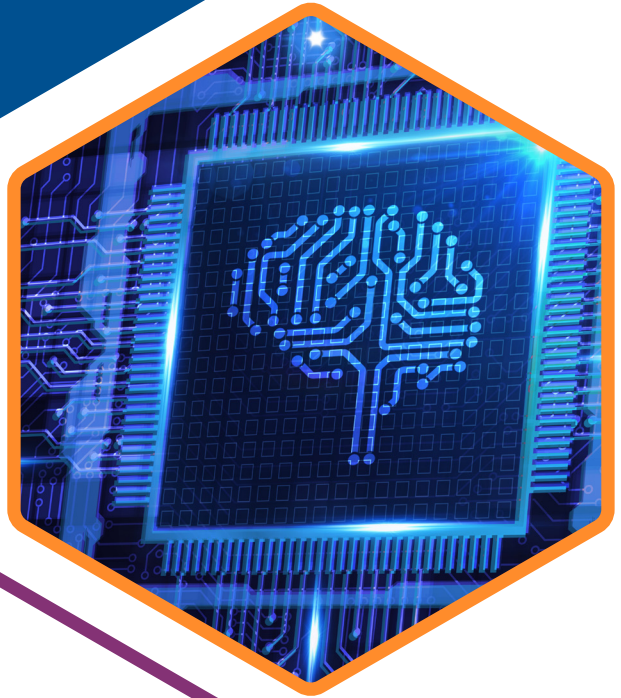
Designing a Smart Factory With Microchip Products

However, as we embrace these advancements, ensuring the safety, security, and reliability of robotic systems becomes important. The integration of robust cybersecurity measures, adherence to industry standards like IEC 62443, and a focus on power-efficient hardware design are non-negotiable aspects of this technological journey. Addressing concerns related to single-event upsets (SEUs), which can disrupt electronic circuits in harsh environments, is crucial for mission-critical robotic applications.

The path forward involves a collaborative effort between technology providers, developers, and policymakers to establish a framework that fosters innovation while upholding the highest standards of safety and security. As we continue to push the boundaries of robotics, it is imperative to strike a balance between technological progress and responsible implementation.

The future of robotics is undeniably bright, and with continued innovation and collaboration, we can expect even more sophisticated and capable robots to emerge, further integrating into our lives and industries. By embracing a holistic approach that prioritizes safety, security, reliability, and ethical considerations, we can ensure that this transformative technology continues to benefit society in a sustainable and responsible manner.







SMART | CONNECTED | SECURE

Microchip Technology Inc. | 2355 W. Chandler Blvd. | Chandler AZ, 85224-6199 | microchip.com