ADLINK TECHNOLOGY INC.



White Paper

EtherCAT Solution Supercharges IoT-based Smart Factories

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EtherCAT Solution Supercharges IoT-based Smart Factories

Continued growth in popularity of Internet of Things technologies is redefining the parameters of industrial automation. In addition to conventional PLC-based machine automation with low networking capabilities, new generation-based automation has made possible the development of Smart Factories. Connection of multiple or all devices to the cloud, combined with the application of intelligent software, real time control and monitoring, and big data analysis have all contributed to optimization of product design, production process, and quality assurance. Results include higher throughput, lower defect rate, and enhanced competitiveness, all based on intelligent automation.

According to studies and forecasts by IHS and Echelon, 2025 will see 15 billion or more Industrial Internet of Things (IIoT) installations worldwide, with the share of IIoT installations doubling to 32% in 2016 from 16% in 2011. Upcoming manufacturing goals, including widespread implementation of Smart Factories, have been collectively referred to by some as Industry 4.0.

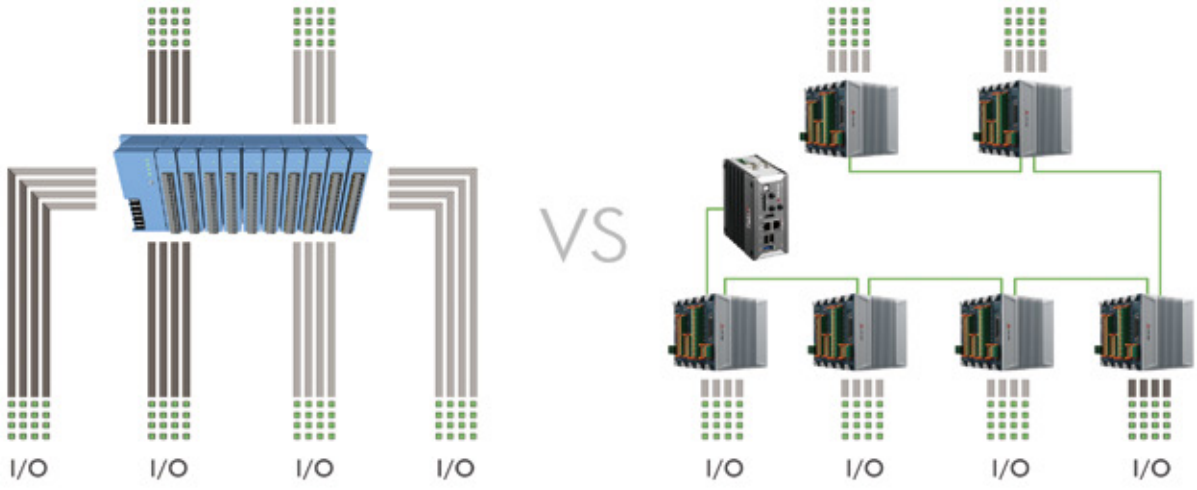
Centralized vs. Distributed Control

At the core of intelligent manufacturing is process control, with the first major challenge to control system designers the choice between centralized and distributed control systems.

Centralized systems utilize more conventional architecture, with a single controller governing all aspects of the process. As the system grows with increased axis count, however, overall system infrastructure complexity and costs swell, and maintenance burdens increase. Failure in any single area can easily trigger system-wide breakdown.

As computers become smaller and faster, small form factor controllers equipped with requisite computing power can be easily installed adjacent to machines, individually responsible for control of a discrete process. The result is a networked collection of islands with interconnected controllers. Due to their separation, any of the islands can be modified, repaired or upgraded without disturbing other networked elements. Accordingly, such distributed control system allows flexibility in installation, expansion, maintenance and retrofit, and is typically less expensive with reduced wiring and infrastructure.

As the volume of diversified designs and custom-ordered production increases, flexibility and cost control remain important factors in automated control systems. As a result, more distributed control models are gaining popularity.



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EtherCAT Benefits

Since 1990 numerous communication protocols have emerged, all in competition at the field level. The more prominent of these Ethernet-based fieldbus protocols include PROFINET, POWERLINK, SERCOS III, EtherNET I/P, MECHATROLINK III and, recently, EtherCAT.

Among these, EtherCAT (Ethernet for control automation technology) is the younger protocol but has nonetheless, gained growing popularity in control automation, due to its advantages in speedy data update, low communication jitter, and reduced hardware costs.

For distributed control utilizing a master controller and slave system, slave synching is a major challenge. EtherCAT achieves high synchronization using a distributed clock approach for slaves, which reduces jitter to as low as 1μs or even less.

High speed transmission and high synchronization make EtherCAT an ideal choice for distributed control systems enabling time-deterministic applications.

Since its establishment in 2003, the EtherCAT Technology Group (ETG) has drawn more than 2,920 members from all over the world providing over 200 brands of EtherCAT products. By incorporating COE (CANOpen over Ethernet) protocol, EtherCAT has experienced wide application in factory automation. Whereas before, a number of different fieldbus standards would have been deployed for controlling different processes, EtherCAT, with abundant products available, can easily integrate all processes. Versatile supply with high integration is a major benefit spotlighting EtherCAT's growing market position.

Smart Factory Requirements

As future manufacturing demands are expected to intensify with increased customization of products, Smart Factories in Industry 4.0 environments will requiremore flexible process as well as features as follow.

High Efficiency & Throughput

A main characteristic of Smart Factories is automatic system health monitoring and diagnosis, supporting timely maintenance and near-zero downtime, maximizing product quality, throughput, and profit. Cloud analysis of big data collected from every area of the manufacturing process provides insight on factory status for maximum productivity.

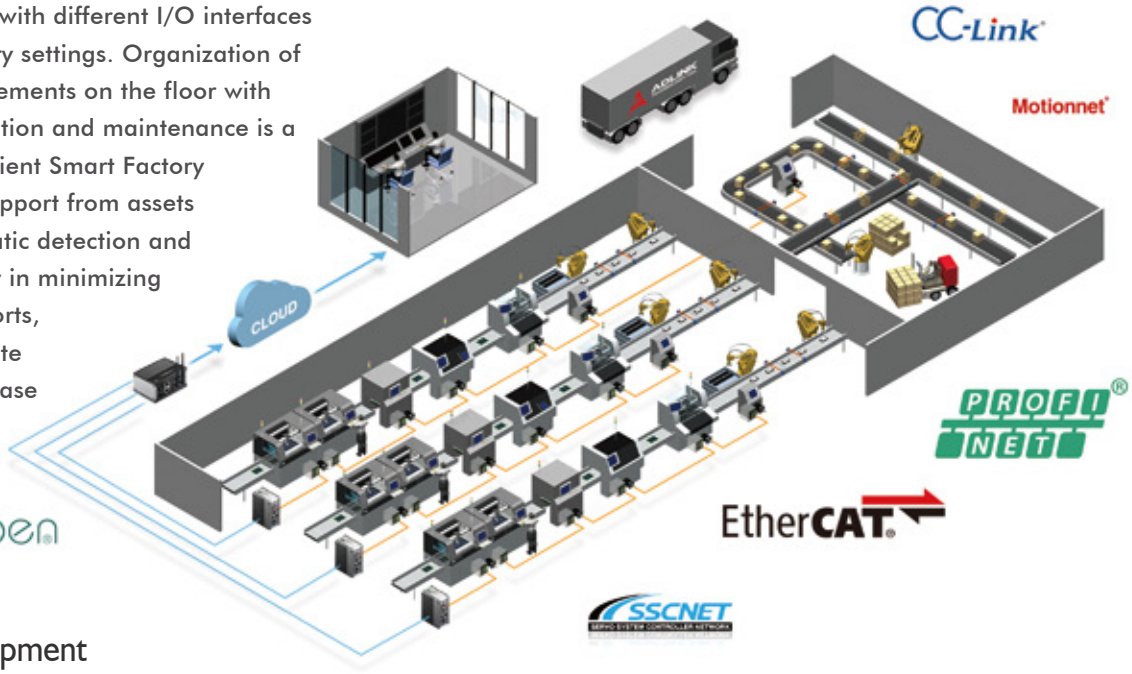
Ruggedness and reliability

Control systems installed in a manufacturing environment often face extreme conditions including extreme temperatures and excessive moisture, contaminants, and shock and vibration. Specialized mechanical and electronic capabilities are necessary to enhance ruggedness and reliability so that normal operation under such harsh conditions is enabled over extended periods.

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Integration with 3rd party equipment

Factories frequently comprise a variety of systems and components with different I/O interfaces and/or proprietary settings. Organization of such disparate elements on the floor with simplified installation and maintenance is a key issue for efficient Smart Factory environments. Support from assets providing automatic detection and recognition is key in minimizing configuration efforts, helping to facilitate integration and ease deployment.



Fast development

Modular structured products with tool kits providing startup features such as self-configuration APIs and pre-certified software such as motion control applications expedite system development and reduce costs and time to market, increasing market value.

EtherCAT Master Controllers

EtherCAT adopts a typical distributed control architecture comprising master/slave duplex physical layers. Currently several different types of master controllers are employed for implementing EtherCAT solutions:

Conventional high-end PLC

PLC is a more conventional architecture for motion control, typically with lower computing performance but delivering enhanced stability. As PLC is a proprietary architecture, however, it provides only limited I/O compatibility, expandability and connectivity, as well as fewer I/O accounts. Additionally it tends to usually be more costly than recently developed solutions.

Conventional IPC + RTOS

Some embedded system providers combine a full-fledged IPC with specific Real Time Operating System and EtherCAT-related control software, and call the IPC an EtherCAT controller. The hardware is not, however, actually configured for dedicated EtherCAT use with ready-made slave support, increasing the burden on system integrators to develop on a RTOS and integrate multiple components and elements into the entire control system. Costs and time for system development are thus increased, with lowered reliability and compatibility and royalty fees for software possibly incurred.

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x86 based processor master controller

Increased computing power and networking capability are current priorities, with x86 based processor master controllers meeting the need better than conventional PLCs. A single-core based controller is not, however, able to support multitasking needs, with several controllers required to implement different functions, compromising space and cost efficiency for larger scale or more complicated systems.

Continued technological evolutions make it possible to provide multi-core computation in small form factor computers, an ideal choice for dedicated EtherCAT solutions. Multi-core controllers can easily support higher channel density and multitasking functionality, whereby the number of controllers required is significantly reduced, lowering costs and boosting efficiency.

Pros and cons of different EtherCAT master controllers

	New Gen EtherCAT Solution	Conventional IPC + RTOS	Conventional High-end PLC
Footprint	Small	Large	Medium
Computing Power	Good	Best	Poor
I/O Compatibility	•EtherCAT compatible •IEC 61131-2 compliant	3rd Party I/O	IEC 61131-2 compliant
Connectivity for Data Exchange	Good	Good	Poor
Harsh OP Environment	-20°C - 60°C	0°C - 50°C (majority)	0°C - 50°C (majority)
Easy Development	Good	Poor	Good

Implementation Factors

When designing and implementing an EtherCAT solution, a number of factors should be taken into careful consideration.

CPU efficiency

Master controllers with high CPU performance support more I/O accounts for multitasking and time-deterministic control. A Smart Factory uses controllers to connect with peripherals such as HMI displays, machine control axes, and communication gateways. A high performance controller with multitasking will help to realize these functions in a single controller, thereby reducing costs.



Accurate multi-axis motion control

Synchronized, precise multi-axis motion control is a key consideration for EtherCAT solutions. With printing equipment, for example, performance requirements within ten m/sec feed rate for synchronization of the axis control must be accurate to within 0.1%. An efficient algorithmic kernel enables synchronous motion control and multiple I/O connections, for supporting implementation of complicated motion control.

Ease of development

An ideal EtherCAT solution should provide easy-to-use development software and APIs, for reduced development time.

Data exchange gateway

Machine-to-machine communication is essential for efficient intelligent manufacturing. Accordingly, EtherCAT master controllers rely on data exchange gateways and OPC servers to collect data from all factory elements, implementing algorithmic computations to enable control functions.

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Display

Data display on control panels is also important for machine monitoring and control. EtherCAT controllers that provide built-in middleware for users to configure HMI based on their specific applications can reduce development effort and cost and deliver custom benefits.

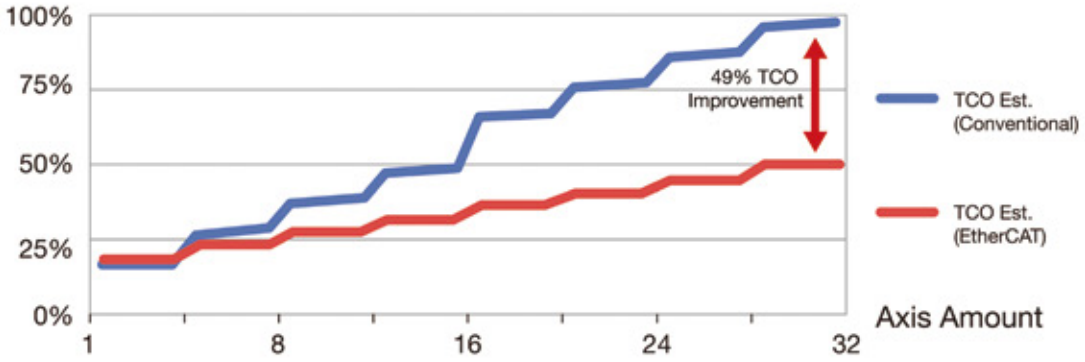
System storage

Data storage capacity also affects system performance. Additional SD or other removable data storage devices can allow logging of manufacturing data and increase data storage flexibility.

Total Cost of Ownership (TCO)

Compared with solutions requiring royalty fees for use of real-time OS and other third-party software applications, dedicated EtherCAT solutions provide fully pre-certified ready-to-use hardware-software bundles, reducing software development costs and license fees for developers and users. High-density systems in smaller form factors with intelligent maintenance capability and built-in pre-certified software are also instrumental in reducing total cost of ownership.

For example, compared with conventional IPC (OS included), motion cards and I/O cards supporting 32 motion axes, a dedicated EtherCAT solution with high performance processors can be expected to reduce TCO by nearly half.



Auto-recognition and auto-configuration

Theoretically, all EtherCAT products are compliant with standards stipulated by EtherCAT Technology Group. However, each manufacturer includes a certain degree of proprietary settings into their products, creating sometimes considerable effort to integrate third-party products. Ethernet products with automatic configuration software tools can help eliminate compatibility issues and speed system deployment.

Intelligent system monitoring

An EtherCAT-based automatic manufacturing process plant may contain a great number of distributed slave systems, with each slave looking after a process. Intelligent remote monitoring over the health status of controllers and slave modules including inner temperature, usage cycle of relay switching as well as motion control status for motor drive control will help to discover potential problems as earlier as possible and prevent system failure in time, thus reducing maintenance costs.

Maintenance

Slave products using flexible cards for I/O modules with hot-swap capability allow repair and retrofit of local control areas with little or no interruption of service, and the maintenance has no effect on other operating processes. Failure costs are dramatically reduced and throughput maximized.

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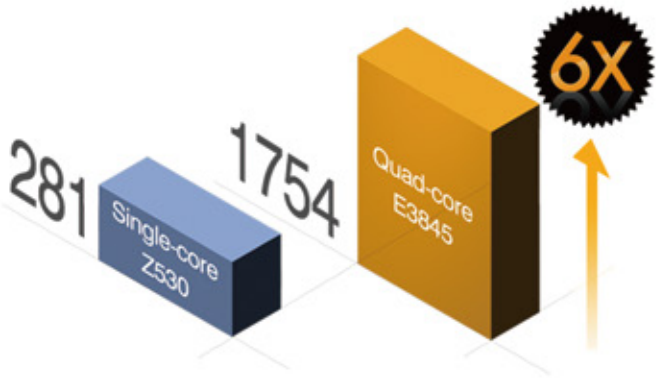
Winning Strategies of the New Generation EtherCAT Solution

As current manufacturing industry trends often favor lowered yield to accommodate variations in product design or increased customization. Against this backdrop, EtherCAT-based distributed control architecture continues to gain popularity among process plants.

The new generation EtherCAT solutions based on multi-core master controllers and daisy-chained slave systems, as exemplified by ADLINK, address this industrial trend and meet manufacturers' needs by providing high-performance, multitasking, high density I/O, flexible deployment and expansion, easy maintenance and cost-effectiveness.

For distributed systems, speed in data update is always a priority demand. The ADLINK EtherCAT solutions deliver impressive network performance, with update time for 1000 I/Os only 30μs, including I/O cycle time. Their Talos master controller can support 64 axes and 10,000 I/Os in a single system and synchronize all the elements with distributed clock in slave systems in achieve time-deterministic control.

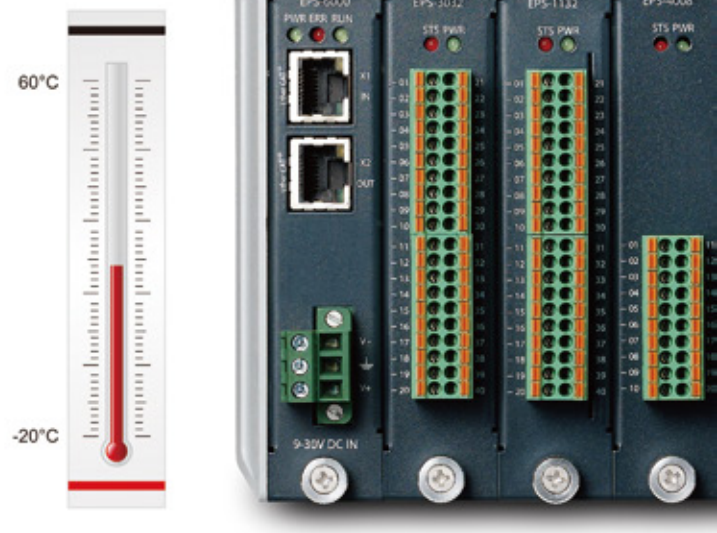
When it comes to enabling multitasking with high density channels, higher CPU performance is crucial, with x86-based systems more suitable for EtherCAT master controllers. ADLINK solutions adopt the Intel Atom quad-core processor E3845 1.9GHz and process Ethernet packets with software stacks, releasing more CPU resources to support more I/Os. This is one reason why ADLINK EtherCAT master controllers can deliver the highest performance in the smallest form factors.



The winning strategies of the ADLINK EtherCAT solutions also include many unique features enabled by ADLINK's self-developed technologies. One is modular design and automatic configuration, enabling daisy-chained expansion of the EtherCAT control system. ADLINK EtherCAT products are also pre-verified to cooperate with other control elements such as servo motors, ensuring compatibility with third party equipment. These measures facilitate system integration, thereby minimizing development and deployment efforts. The results significantly increase time/cost benefits to system integrators as well as owners.

ADLINK EtherCAT products also address easy maintenance, a critical factor in the reduction of total cost of ownership and maximized throughput. EtherCAT solutions are built in with remote monitoring and diagnostic capabilities, enabling automatic reporting and system status alerts, empowering prompt responses to avoid or minimize downtime. As well, hot-swap capability of EPS slave cards reduces MTTR (Mean-Time-to-Repair) to a minimum.

ADLINK's proprietary Extreme Rugged technology provides EtherCAT products that support -20°C to 60°C operating temperatures and IP31 rating, critical contributors to system reliability and stability under extreme conditions of manufacturing environments.



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About ADLINK's EtherCAT Solutions

Global embedded system leader ADLINK's newest EtherCAT solutions deliver high performance, flexible expansion, easy maintenance, and cost-efficiency, all in ultra small form factors.

The ADLINK EtherCAT solutions comprise a complete bundle from hardware to middleware to software, with every element tailored for dedicated EtherCAT functionality, including Talos master controllers, EPS slave systems, remote monitoring and control mechanisms, and configuration of APIs. ADLINK's Softmotion one-stop control kernel provides flexible and easy-to-use intelligent platforms for driving next-generation modern Smart Factories.

High Performance

At a compact 100 x 120 x 55 mm (L x W x H), ADLINK's newest Talos-3012 is a palm-size EtherCAT master controller powered by x86 processors. Based on the Intel Atom quad-core processor E3845 1.9GHz, with IEC-61131 compliant syntaxes, the Talos master controller allows easy emigration of legacy PLC programming to a PC-based environment, with a single master controller able to connect up to 64 axes and up to 10,000 I/O points of control through a daisy-chained slave system.

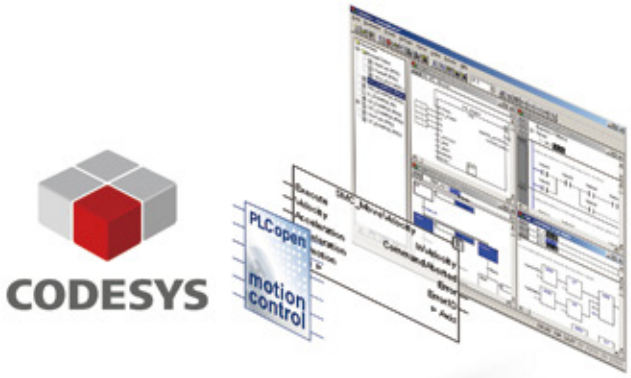
ADLINK's EPS slave system's modular design empowers flexible channel density in a 110 x 130 x 105 mm package. Incorporating the latest RISC processor and FPGA and leveraging the Softmotion control kernel and measurement technologies, ADLINK EPS slave systems provide a wide variety of I/O modules, including DI/O, AI/O, thermal measurement, motion control, and EtherCAT communication modules, easily daisy-chained for system expansion without any compatibility issues.

Assured Interoperability

ADLINK's EtherCAT solutions also minimize burdens on system developers and users for configuration and maintenance. With ADLINK's self-developed EtherCAT Configurator-LinkMasterPro, the master system is able to automatically detect slave systems and I/O modules of any make and create corresponding XML files to complete configuration without additional settings. ADLINK EtherCAT master controllers can easily connect to existing or expanded slave systems created by third parties for automatic recognition and configuration without no problems with compatibility.

Ease of Development

ADLINK's Talos series provides a complete IEC 61131-3 edition environment supporting 5 common PLC syntaxes, and powered by the ADLINK Softmotion kernel, with application-oriented functions and APIs simplifying use and shortening development time. ADLINK's Softmotion kernel, based on an efficient algorithm, increases precision, speed, and synchronous motion control, reducing operational complexity and development period for a wide variety of industrial applications.





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Intelligent Management

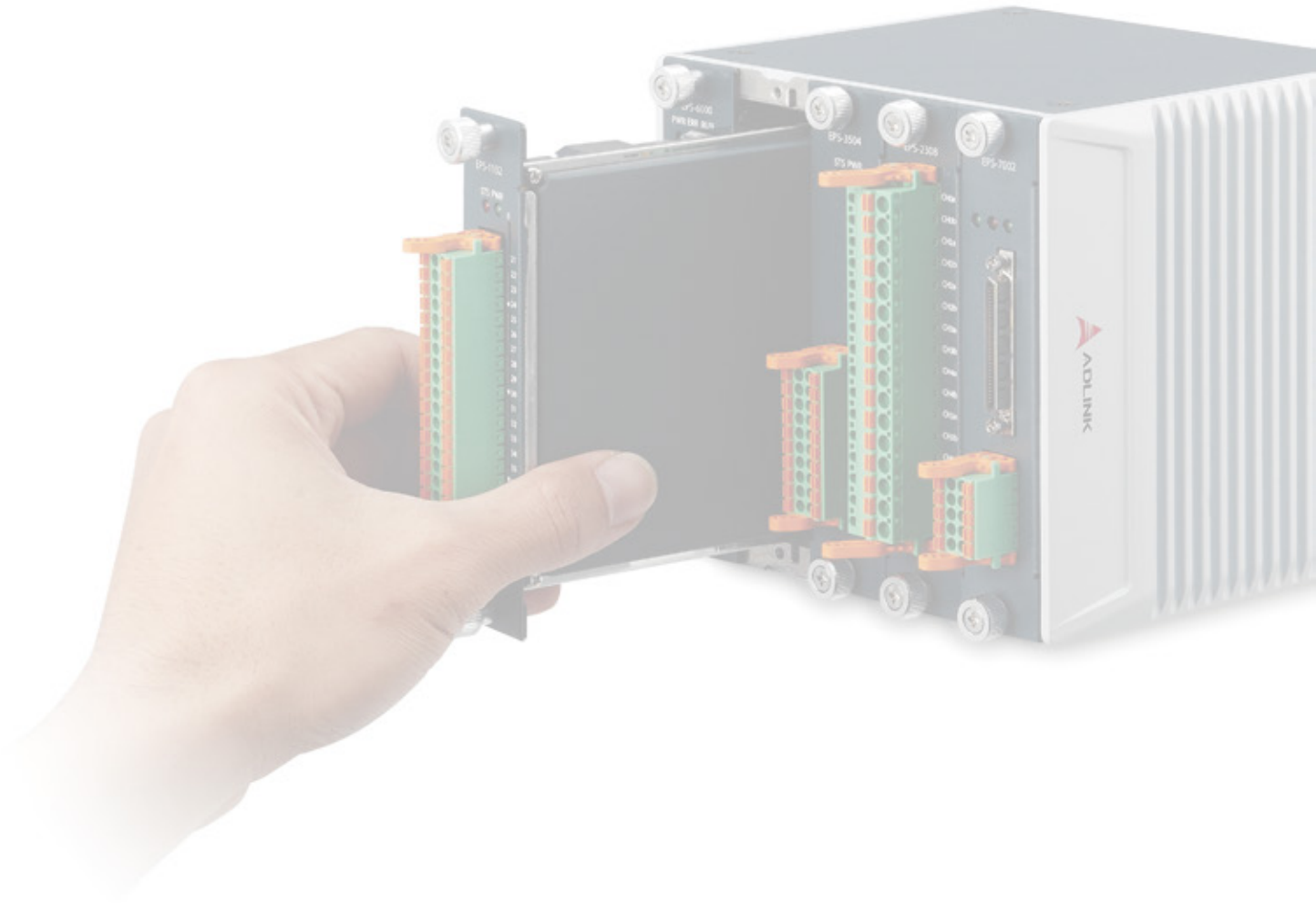
For maintenance tasks, ADLINK solutions provide intelligent remote monitoring of performance in all slave systems and I/O modules, allowing hot-swappability, allowing system repair or retrofitting in record time without affecting the operation of other processes.

Rugged Design

ADLINK's EtherCAT products boast a wide operating temperature range of up to -20°C to 60°C, the available in any current EtherCAT system, making them well suited to operation in harsh manufacturing conditions.

Conclusion

ADLINK EtherCAT products define a new category of EtherCAT solutions, realizing time-deterministic control over automatic process with high performance, fast development, efficient installation, easy maintenance, and minimal total cost of ownership. The ADLINK solutions integrate hardware and software elements dedicated to fast, high performance EtherCAT applications with many ready-to-use features, speeding development, deployment and expansion of Industrial IoT-based modern Smart Factories.



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About ADLINK

ADLINK Technology is enabling the Internet of Things (IoT) with innovative embedded computing solutions for edge devices, intelligent gateways and cloud services. ADLINK's products are application-ready for industrial automation, communications, medical, defense, transportation, and infotainment industries. Our product range includes motherboards, blades, chassis, modules, and systems based on industry standard form factors, as well as an extensive line of test & measurement products and smart touch computers, displays and handhelds that support the global transition to always connected systems. Many products are Extreme Rugged™, supporting extended temperature ranges, shock and vibration.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance and is active in several standards organizations, including PCI Industrial Computer Manufacturers Group (PICMG), PXI Systems Alliance (PXISA), and Standardization Group for Embedded Technologies (SGeT).

ADLINK is a global company with headquarters in Taiwan and manufacturing in Taiwan and China; R&D and integration in Taiwan, China, the US, and Germany; and an extensive network of worldwide sales and support offices. ADLINK is ISO-9001, ISO-14001, ISO-13485 and TL9000 certified and is publicly traded on the TAIEX Taiwan Stock Exchange (stock code: 6166).

About the Intel® Internet of Things Solutions Alliance

From modular components to market-ready systems, Intel and the 250+ global member companies of the Intel® Internet of Things Solutions Alliance provide scalable, interoperable solutions that accelerate deployment of intelligent devices and end-to-end analytics. Close collaboration with Intel and each other enables Alliance members to innovate with the latest technologies, helping developers deliver first-in-market solutions.

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