



Case Study

Enhance Productivity, Reliability and Safety in Industrial Applications

EtherCAT Programmable Logic Controller (PLC) reference design

Challenge

Maintaining deterministic and real-time performance in the system is key for productivity, reliability and safety. Industrial Ethernet technologies like EtherCAT offer higher speed and lower cost communications over traditional fieldbus systems.

Solution

Hardware integration at the SoC level (core(s), memory, I/O, DMA, etc.) is critical, but so is software integration. The EtherCAT PLC reference platform for the QorIQ P1 processor integrates the KPA EtherCAT Master stack, ISaGRAF PLC Firmware and QNX Neutrino® RTOS. The ISaGRAF 6 Workbench and integrated KPA Studio combine to form the offline automation development environment.

Benefit

The EtherCAT PLC reference platform allows users to quickly create new solutions that take advantage of the latest Industrial Ethernet and real-time automation technology while allowing them to reuse or adapt existing automation algorithms built using ladder logic or functional block diagram. The reference platform delivers 1 ms cycle time with less than one percent CPU overhead.

The PLC is the workhorse of the industrial automation world. They are at the core of automation systems in factories; in oil, gas and water plants; industrial vehicles; building control; and in other civic infrastructure.

PLCs are designed to be programmed using simple and intuitive programming languages, allowing engineers with a limited background in computers and computer programming languages to develop automation systems with them. In a similar vein, Freescale and QNX Software Systems have combined with automation partners, KPA and ISaGRAF to create a PLC reference platform that allows automation companies to build their own PLC sub-system quickly and easily.



Freescale

Our control and network processor solutions are engineered to meet the challenging safety, security and reliability requirements of manufacturing, processing and critical infrastructure facilities. Ruggedized Freescale processors are frequently selected for industrial control, sensing, networking and human-machine interface (HMI) applications in smart grid and smart metering, healthcare, factory automation and drives, motor control, home appliance, building control, point-of-sale and kiosk, aerospace and defense and industrial transportation markets.

QNX Software Systems

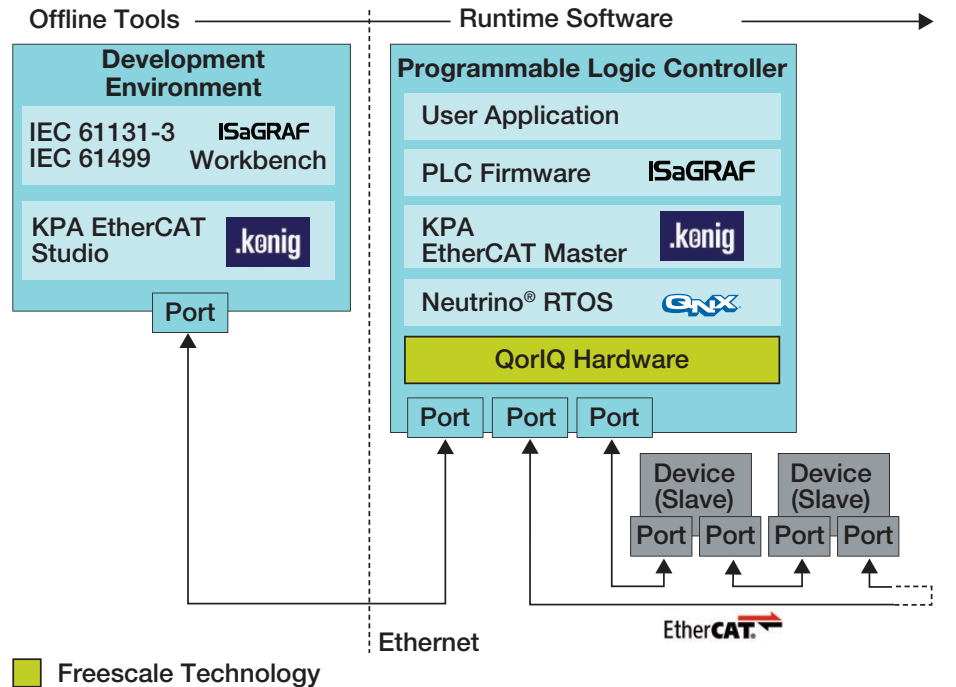
QNX Software Systems offers a comprehensive portfolio of industrial solutions for addressing today's challenges—be it a mission-critical wind-turbine controller, PLCs or a user-centric point of sale (POS) device with a rich HMI. QNX's unique field-proven industrial platform, deep embedded experience, and industry-leading reliability enable developers to create custom solutions with low bill of materials (BOM), development and maintenance costs. QNX's robust partner ecosystem and experienced services practice help customers speed up and build out solutions as needed. QNX's strategic certification programs ensure that customer solutions meet even the most stringent of industry standards.

Making Machines Work

EtherCAT is one of the fastest growing, Ethernet-based communication protocols used in industrial control systems. The Freescale QorIQ communications processors include single-, dual-, quad- and multicore processor architectures with integrated support for communications protocols such as EtherCAT.

The new PLC reference platform is equipped to ease development of industrial control systems. The PLC reference platform implements the KPA EtherCAT master protocol with ISaGRAF Firmware and QNX Neutrino RTOS on the high-performance Freescale QorIQ P1025 processor. It is supported by powerful development tools from all four companies, including the KPA EtherCAT Studio, ISaGRAF 6 Workbench, QNX Momentics® Tool Suite and Freescale CodeWarrior Development Suite.

EtherCAT Programmable Logic Controller (PLC) Block Diagram



Automation Solutions Using Industrial Ethernet

ISaGRAF, KPA, QNX and Freescale have joined forces to provide a complete PLC reference platform for OEMs that wish to develop a high-performance controller that acts as an EtherCAT master.

This complete solution consists of four levels of integration:

Offline Tools

1. ISaGRAF® Workbench and KPA EtherCAT Studio:

Allows users to run KPA EtherCAT Studio within the ISaGRAF environment and configure EtherCAT slaves. This configuration is done by:

- Reading the slave description xml files
- Generating the I/O devices in the project
- Associating the I/O device to a selected resource
- Using the I/O device within the resource

This is the environment in which users can develop their automation algorithms by reusing or creating new feature-rich control systems, utilizing programming languages like ladder logic and functional block diagram. Once compiled, the executable is loaded and runs on the QorIQ P1025 processor. At runtime,

KPA EtherCAT Studio provides further help with features such as data logging with triggering and timing analysis.

Runtime Software

2. ISaGRAF Firmware and EtherCAT stack:

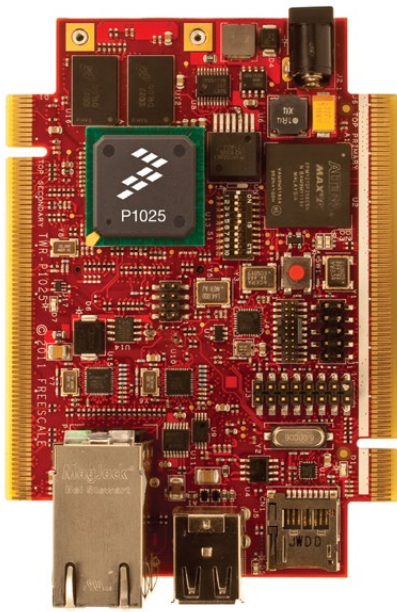
The KPA EtherCAT stack is integrated with the ISaGRAF Firmware. The communication between each resource and stack is done through shared memory. Access to this shared memory is done using the driver (.c and .h file) generated automatically by the EtherCAT Definition Builder.

3. ISaGRAF Firmware and QNX Neutrino RTOS:

Delivering millions of runtime hours of use in highly dependable embedded systems, such as PLCs, robotics, factory automation, automotive and medical applications, the QNX Neutrino RTOS is provided on the Freescale QorIQ P1 Tower System module with the ISaGRAF Firmware.

4. Freescale dual-core QorIQ P1025 processor:

The combined ISaGRAF PLC Firmware, KPA EtherCAT Master stack, and QNX Neutrino RTOS are integrated and optimized to run on the versatile Freescale dual-core QorIQ P1025 processor. This PLC reference platform delivers millisecond response time for EtherCAT



tasks, while using just one percent of one core in the P1025 processor. This leaves ample performance headroom for both the communications protocol and the control application in a single device.

Customers may choose to distribute processing functions across two cores, or isolate real-time control functions on one core while running maintenance and communications functions on the other core. QorIQ P1 processors can also provide simultaneous support for industrial protocols like PROFINET, PROFIBUS and EtherNet/IP™.

Freescale QorIQ SoCs

The PLC reference platform is deployed on the QorIQ P1 Tower System Module (TWR-P1025) that features the QorIQ P1025 dual-core processor. Freescale's QorIQ P1 processor family offers pin-compatible single-core variants for cost reduction, and dual-core variants that scale up to 5,700 million instructions per second (MIPS) for more complex applications. Software and hardware developed on TWR-P1025 can be very easily deployed on a range of QorIQ P1 processors, including the P1012, P1021, P1016, P1010 and P1014 processors.

The broader QorIQ P series and T series of control/communications processors provide further flexibility and scalable performance options ranging from single-, dual- and quad-core to multicore, all based on 32- or 64-bit Power Architecture® cores and including integrated double precision floating-point for motion control. The CoreNet multicore interconnect enables the processor cores and I/O controllers to maintain their workloads without interference. A wide range of I/O options are available, ranging from PROFIBUS (integrated PROFIBUS L2/FDL) via QUICC Engine, a range of serial interfaces (UART, SPI, I²C, UART) and high-speed connectivity via Ethernet, PCI Express® and Serial RapidIO®. Extensive use of ECC and parity help maintain reliability while the security acceleration and trust architecture provide mechanisms to protect against misuse of equipment or theft of intellectual property. For product specific information on QorIQ P and T series processors, visit freescale.com/QorIQ.

For advanced information on the QorIQ LS series built with Layerscape Architecture, visit freescale.com/Layerscape and read the "Layerscape Architecture: A Look Inside the Next-Generation QorIQ LS Series SoCs" white paper under the "Read More" section. Layerscape architecture is an evolution of the QorIQ P and T series processors—an infrastructure that supports sharing networking interfaces and accelerators by multiple CPUs, both Power Architecture and ARM® cores, and the accelerators themselves.

QNX Software Systems

The operating system needed for a PLC requires real-time support. To this end the QNX Neutrino RTOS, which has been powering mission-critical applications across the globe for over three decades, was used.

The real-time nature of QNX Neutrino RTOS provides deterministic response times at the application level and in all subsystems.

This is achieved with its pre-emptible microkernel and priority-based pre-emptive scheduler, the QNX Neutrino RTOS delivers response times that are both fast and highly predictable. High-priority threads can meet their deadlines on time, every time, even under heavy system load. Also the thread priority inheritance eliminates priority inversion problems.

In addition to the real-time nature, reliability is another key factor. Thanks to the microkernel architecture of the QNX Neutrino RTOS, virtually any component—even a low-level driver—can fail without damaging the kernel or other components. If a device driver, protocol stack, or application experiences a problem, it does not take other components down with it. The QNX Neutrino RTOS high availability manager can terminate and restore the faulting component in isolation—often in just a few milliseconds without a reboot.

These qualities provide a reliable and deterministic foundation for the ISaGRAF Firmware and KPA EtherCAT Master stack. To evaluate the PLC reference platform, visit qnx.com/goplc to download the software.

The feature set of the Freescale QorIQ processors also allows greater value add by combining additional elements other than the PLC base level functionality. To achieve this functionality, partitioning is required. This is fully supported in the QNX Neutrino RTOS, but goes even further in that it uses spare CPU capacity when available. If resources are constrained, processes get their budgeted share. If, however, a system has spare cycles, processes can exceed their budget limits. This is adaptive partitioning. Adaptive partitioning eliminates the over-engineering required by fixed-partitioning designs, which waste unused cycles and force designers to use more expensive CPUs. Adaptive partitioning improves product time to market by eliminating the complex task-starvation problems that typically arise during a project's integration phase.

For more information on the ISaGRAF Firmware, KPA EtherCAT Master and QNX Neutrino RTOS for the EtherCAT PLC reference platform, please visit freescale.com/goPLC

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