Summarizing the Cost/Performance Options

Depending on the way that the Sercos interface is implemented, cycle times vary. With a completely hardware-based implementation using an FPGA, a minimum cycle time of 31.25 µs is achievable. The Bosch Rexroth Sercos SoftMaster implementation using a PC with standard Ethernet interface can produce a cycle time of just under 500 µs. If the Sercos Soft-Master is combined with the Intel I210, the cycle time can be shortened to 125 µs, yielding improved performance, plus significant cost advantages over the FPGA implementation, along with the cost and software compatibility advantages of using a standard PC platform (see Figure 2).

The main reason for the difference in maximum cycle times for PC-based implementations is jitter, the amount of variability between individual cycle times. In the case of standard Ethernet interfaces, cycle time is heavily dependent on the network card used, the operating system, the processor architecture and system load. With the parallelism offered by the Intel I210 and a deterministic RTOS, packet jitter can be reduced to almost zero (see Figure 3).

"As the performance data shows, a software-based implementation of the Sercos III standard, when used along with the latest PC I/O components such as the Intel I210, and INtime real-time software, offer a new level of cost/performance and functionality that were previously unavailable to industrial system integrators," said Michael Beier, Product Manager, Firmware and Software for Electric Drives at Bosch Rexroth.

Integrated multi-function PC-compatible platforms are revolutionizing the factory floor in the Industrial IoT. With software and hardware developments such as described above, machine builders and integrators can contain their costs while giving their customers a new level of functionality, making their operations more productive and ready to capitalize on future technology developments.

Comparison Packet Jitter Standard and Intel® Ethernet Controller I210

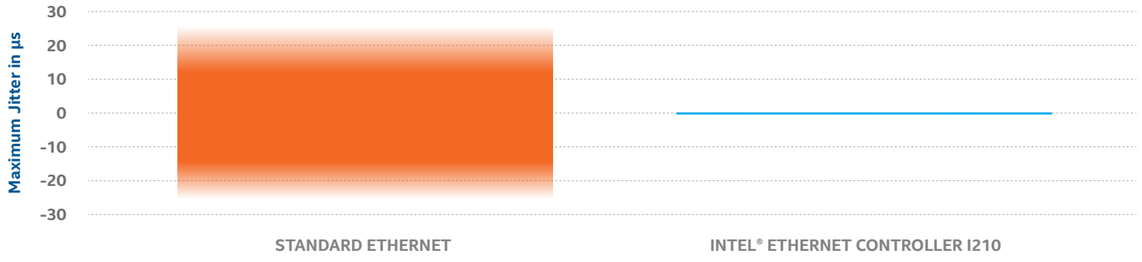

Figure 3. Comparison of packet jitter between SoftMaster* implemented with Standard PC Ethernet interface and PC with Intel® I210 interface.

For more information on:

TenAsys and INtime, visit **www.tenasys.com**

Intel® Ethernet Controller, visit **www.intel.com/ethernet**

Sercos SoftMaster, visit **www.sercos.org**

Bosch Rexroth, visit **www.boschrexroth.com**

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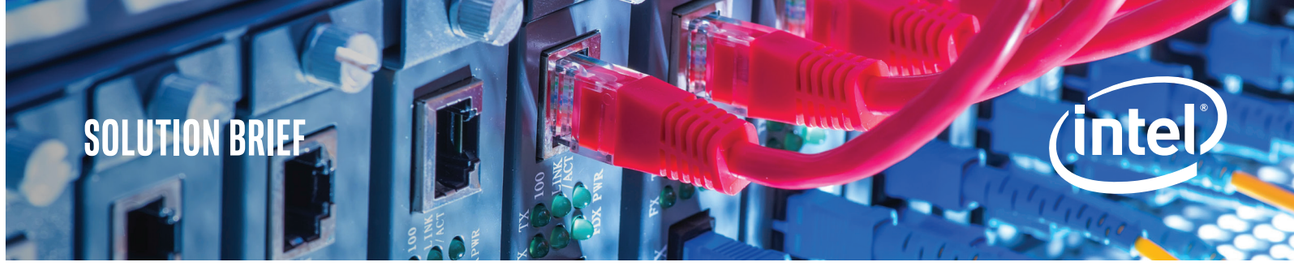

Bosch Rexroth* Innovates Sercos SoftMaster* for the Industrial PC Platform with the Intel® Ethernet Controller I210

TenAsys* INtime* real-time software enables the solution on a standard, multi-core Windows* PC

The Industrial Internet of Things (IIoT) represents industry-oriented applications where devices are machines that interpret, analyze, and make decisions almost instantly from widely distributed sources in industrial automation environments.

A leading trend in industrial automation is the consolidation of machine control and human interface applications, typi-cally performed by separate computers, onto a single Intel® architecture-based PC platform. Reasons for this include the economies of scale that continue to bring down the cost of PC hardware, and the potential for decreasing the cost of application development and maintenance through the use of standardized software environments which remove dependencies on ever changing hardware. Enabling this trend is the growing availability of multi-core processor chips that allow different types of application software to run on different processor cores, and a software platform that supports the building of cooperative heterogeneous operating environments. These trends, combined with IIoT advantages, facilitate efficiency gains in industrial control by making their operations more productive and ready to capitalize on future technology developments.

One area of advancing technology involves adapting Ethernet interfaces for industrial applications, so that data senders and receivers can count on a transfer to take place reliably, and at a predictable point in time. For example, Sercos III* is a third-generation industrial control interface that merges a hard real-time communications protocol with Ethernet by introducing a synchronized cyclic communication over Ethernet.

"Soft Master" Software Emerges

High-performance fieldbus interfaces initially relied on custom built hardware, such as Field Programmable Gate Arrays (FPGAs) or ASICs, to manage the complexity and timing of the communication protocols, but as with other special-purpose hardware designs, custom hardware is more expensive than componentry that can ride the "learning curve" of a high-volume market. To provide a lower-cost alternative, suppliers began to develop "soft master" software that makes use of standard PC Ethernet interfaces. Bosch Rexroth based in Lohr am Main, Germany, is one such supplier. The company developed a Sercos SoftMaster* core application, which it is making available as open-source software through the Sercos user organization Sercos International e.V.

The Bosch Rexroth Sercos SoftMaster software has been developed to provide an interface that is 100% compatible with that of a previous generation of hardware-implemented Sercos interfaces. This enables the existing library of CoSeMa (Common Sercos Master) driver software to be used without modification.

All Bosch Rexroth hydraulic and electric drives, from 100 W (IndraDrive Cs) to 4 MW (IndraDrive ML) as well as cabinet-free drives (IndraDrive Mi), can be connected. And all operating modes such as velocity and position synchronization can be used. Also some interesting Sercos features like Hotplug are possible. The Hotplug feature gives users the flexibility to add several drives to a running control system. This gives systems a high level of redundancy because defective or unneeded drives can be removed while the other drives are still working. A wide range of I/O interface modules can also be used with the drives, including the fast IndraControl S20* and IndraControl S67* for usage in IP67 environments.

Component Vendors Support the Trend

Vendors of I/O components are supporting the trend to move more industrial control functions into the PC. For example, Intel Corp. has introduced the Intel® Ethernet Controller I210 product family, a single-port, compact, low power Ethernet controller that supports 1 Gigabit Ethernet designs. The Intel I210 is available as a LOM (LAN on Motherboard) controller or as a standard off-the-shelf PCI Express* add-in card, the Intel® Ethernet Server Adapter I210-T1. The Intel® I210 has multiple Tx/Rx queues and IEEE 1588/802.1AS-compatible timing services to support the very precise timing demanded by high-performance interfaces such as Sercos. For example, the Sercos protocol allows for regular Ethernet traffic to be merged with the strictly-timed Sercos traffic, enabling non-deterministic Ethernet packets to be transferred in the idle gaps within information prescribed by the Sercos protocol. Bosch Rexroth uses the Intel I210's ability to send time-triggered packets in order to ensure that the real-time and non-real-time traffic flows can pass through a single Ethernet port.

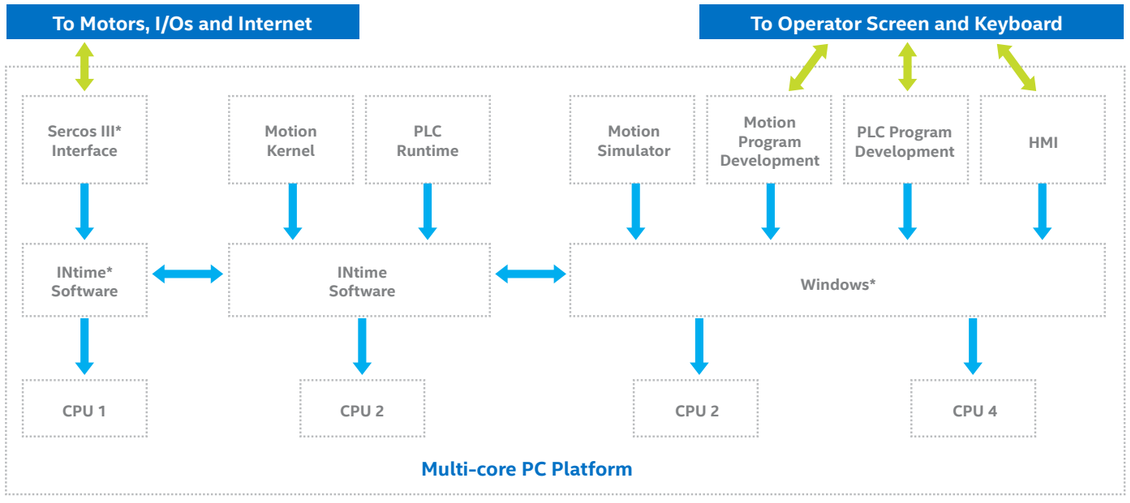

Figure 1. The INtime* for Windows* software environment enables multiple computing workloads associated with machine operation, both real-time and non-real-time, to be consolidated on a single PC-compatible platform.

Bosch Rexroth* Innovates Sercos SoftMaster* for the Industrial PC Platform with the Intel® Ethernet Controller I210

The Right Operating Software Makes it all Possible

Tight timing constraints have required a hardware implementation of the Sercos protocol in the past, but with the latest real-time operating software technology for the PC architecture, responsiveness and determinism have reached the levels where a "soft master" application can be employed reliably and performance goals are achieved. But the ideal operating environment to enable the construction of an integrated industrial software platform requires more than just real-time support for running the I/O and drive interfaces and control algorithms. The integrated industrial workcell also needs to run human- or data-directed software, such as the operator interface(s), data acquisition software, or machine maintenance and programming software. That requires combining the real-time OS with an operating system such as Microsoft Windows*.

An example of a software environment that combines real-time and general-purpose computing on a multi-core Intel processor platform is INtime* for Windows* by TenAsys Corp. of Beaverton, Oregon. INtime software supports the allocation of separate cores for different processing workloads, partitioning the platform's I/Os such that real-time tasks are not subject to Windows' non-deterministic tasking model. With INtime software, the soft Sercos driver application could be hosted on its own CPU core to ensure that its strict timing requirements are met, while another core runs real-time motion control software and yet other cores run Windows applications relating to the machine (see Figure 1).

One of the requirements for combining machine functions on a single platform is to provide a means of signaling and data transfer between the modules on different processor cores. For this purpose, TenAsys includes software drivers with the latest INtime software that enable on-chip tasks to communicate using global objects or high-performance Ethernet-compatible protocols.

The resulting system is highly scalable, both in terms of processing power, as platforms with different numbers of cores can be used, and also in capability, as the support for Windows in the system enables the use of a variety of best-in-class standard application packages that are available today and in the future. For example, motion control software development and execution environments have been developed by several companies that can operate in this environment. Scalability is also important in systems that don't use Windows, such as distributed controllers based on low-cost Intel architecture processors.

Sercos SoftMaster* with Intel® Ethernet Controller I210 vs. Sercos Master FPGA*

Comparison Sercos Master Variants	HardMaster with Sercos FPGA	SoftMaster with standard Ethernet	SoftMaster with Intel® I210	
	Application Master stack CoSeMa Sercos FPGA Ethernet PHYs Spec H/W	Application Master stack CoSeMa SoftMaster core Std Ethernet Standard H/W	Application Master stack CoSeMa SoftMaster core 2x I210 Standard H/W	ARCHITECTURE
	Sercos Master FPGA, 2x Ethernet PHY	1 standard Ethernet controller (only line topology)	2x Intel Ethernet controller I210	HARDWARE
	- Benchmark -	• Standard hardware; div. manufacturers and types • Cost advantages • Chiefly space advantage	• Standard hardware • Cost advantages • Chiefly space advantage	ADVANTAGES
	- Benchmark -	• Lower synchronicity • Only line topology • UCC with restrictions • Minimum cycle time ~ 500 µs	• Minimum cycle time ~ 125 µs	DISADVANTAGES

Comparison of various Sercos architectures. SoftMaster and Intel® I210 fully develop their cost/performance advantages.

Figure 2. Comparison of Sercos III Master implementations.