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 3.25 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, 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 IO components such as the Intel I210, and InTime real-time software, offer a new level of cost/performace 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.
“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.

The company developed a Sercos SoftMaster™ core application, which 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 unnecessary 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 standard off-the-shelf PCI Express® 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.

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