Rexroth
Bosch Group

Drive & Control
profile

Industrial Ethernet:
The key advantages of SERCOS III

SERCOS III is the open, IEC-compliant third-generation SERCOS interface that "right engineers" real-time Industrial Ethernet.

By Scott Hibbard, Vice President of Technology

The use of Industrial Ethernet as the communications backbone for manufacturing automation continues to grow, driven by demand from both end-user manufacturers and OEMs. The increasing number of control components, actuators and sensors, as well as complex motion and control requirements on many high-volume manufacturing platforms creates increasing performance, throughput and stability challenges for manufacturing control networks. In addition, many enterprises seek a common communications architecture "from the office

SERCOS III offers several key performance and technology benefits:

- A very simple and efficient architecture, merging proven hard real-time motion control messaging mechanisms with the Ethernet physical layer and protocol
- Designed specifically to support a more efficient distributed control architecture, improving machine flexibility by moving processing power and decision-making from the motion control down into the drives and sensors
- Drives can communicate with one another without adding time delays and control processor overhead by going through the master
- Engineered to enhance reliability by supporting either line topologies or ring configurations
- Will not box manufacturers into a limited bus architecture that could impact long-term costs and platform flexibility

to the factory floor," and TCP/IP over Ethernet is the office/commercial data communications protocol and transport layer most commonly used.

Initially, specialized fieldbus systems were used for simplified networking of machine drives, I/O, PLCs and other devices, but fast Ethernet technology replaces these systems, and offers a number of advantages:

• Ethernet is a recognized, future-proof technology
• Offers high-speed data throughput 10 to 100 times faster than field bus solutions
• Use of standard components (CAT5e hardened cabling, connectors, etc.) eliminates more costly proprietary technology, offers cost-effective, widely available product
• Flexible, compatible automation solutions based on a global standard
• Enables consistent IT implementation stretching from the office to the machine level.

While these advantages are important, enabling Ethernet to provide high throughput and low costs, it is not designed to provide deterministic, real-time communications and synchronization of machine axes and devices. Basic I/O control over Ethernet is relatively straightforward; efficient coordinated motion control is not.

Standard TCP/IP communication is designed to allow large files to be transmitted across a network in segments, guaranteeing

Drive-to-drive cross communications is enabled with SERCOS III: allowing drives to communicate with one another without adding time delays and control processor overhead by going through the master.

delivery through timeouts and retransmissions. Some attempts to enable real-time motion control through Industrial Ethernet tried to overcome this by adding a new protocol to the Ethernet stack.

This approach has proved bandwidth intensive, limiting the number of nodes that can be networked when fast cycle times are required, and also requiring special switches in the network to support the determinism required for multi-axis synchronization and motion control.

To overcome these limitations, one of the most open, effective and successful Industrial Ethernet solutions is the SERCOS III platform: it combines the well-proven SERCOS I and II interfaces that have been optimized for high-speed motion control, with the stability, cost-effectiveness and widespread acceptance of the Ethernet physical layer.

SERCOS III: Hard real-time for motion control

SERCOS stands for **Se**rial **R**eal-time **Co**mmunications **S**ystem, a digital motion control bus that interconnects drives, motion controls, I/O, sensors and actuators for numerically controlled machines and systems. Launched in the 1990s, it is utilized in more than two and a half million real-time nodes in thousands of applications and is the de-facto standard for automation with high requirements for dynamics and precision.

SERCOS III is the open, IEC-compliant third-generation SERCOS interface that "right engineers" real-time Industrial Ethernet. It overcomes the wasted bandwidth in other TCP/IP-based Ethernet bus solutions, because it is based directly on Ethernet frames, defining a new, registered EtherType for SERCOS. This enables persistent, bi-directional motion control communications

Open architecture with SERCOS III gives manufacturers confidence that they will not be boxed into a limited bus architecture that could impact long-term costs and platform flexibility.

in real-time between all drives and the motion control, plus rich I/O communication capabilities, while also enabling all conventional protocols (TCP/IP, UDP and others) to be transmitted over the same Ethernet network efficiently in parallel with SERCOS real-time communication.

SERCOS III offers several fundamental performance and technology benefits for OEMS and end-users:
- Cycle times as low as 31.25 microseconds
- High speed: SERCOS III uses the speed of Fast Ethernet (100 Mb/s)
- Support for either line or ring topologies; in addition, hierarchical, synchronized and real-time coupled network structures can be implemented
- Bumpless cable break recovery in ring mode
- Advanced cross communications—both slave-to-slave, and controller-to-controller (sometimes called Machine-2-Machine)

- Capable of hot-plugging devices and network segments—adding machine or line components to a network with synchronization up and running, without having to reset the network or cycling power
- Support for safety functions up to SIL3 according to IEC 61508.

There are several key advantages that manufacturers, systems engineers and machine builders can leverage when using SERCOS III—advantages that enable drive and control systems with vastly improved flexibility and performance.

Key Advantage: Communications efficiency
SERCOS III provides a very simple and efficient architecture, merging proven hard real-time motion control messaging mechanisms with the Ethernet physical layer and protocol. A collision-free real-time channel with improved protocol efficiency transmits the motion control messages defined by SERCOS;

independent of this real-time channel, a parallel channel (time slot) can carry all other Ethernet messages and IP-based protocols such as TCP/IP and UDP/IP.

This approach means the SERCOS III network remains open to any other Ethernet protocol during non-real-time periods; alternative Industrial Ethernet architectures, in certain cases, "take over" the bus to obtain maximum possible speed, which has the effect of preventing other protocols from sharing the network, or tunneling their telegrams within the Industrial Ethernet telegram which usually fragments the message. Tunneling also prevents other protocols from using the network if the real-time system is not operating, blocking communication for troubleshooting and information retrieval.

SERCOS III communication is based on standardized parameter sets to control device functions, i.e. torque control, velocity control, position control, etc. When the manufacturing line or machine's network is initialized, the parameters that make up the real-time data set on the device channel are defined in the configuration. This tight, hardware-dependant synchronization, which is characteristic of all SERCOS interface generations, provides fundamental efficiencies in processing motion sequences across the network, making machines more efficient to design, build and operate.

Key Advantage: Multi-axis distributed control

Machine designers are on a constant search to cram more speed, performance and complex motion profiles into today's cutting-edge multi-axis automation solutions—and that can place punishing demands on PLC-based centralized control architectures. SERCOS III was designed specifically to support a more efficient distributed control architecture. Distributed control improves machine flexibility by moving processing power and decision-making from the CNC or motion control down into the drives and sensors.

SERCOS III is well-suited for distributed control because it supports the placement of axis-dependant control functions, such as loop closures, interpolation and registration in the drives, not only in the motion controller—giving the machine designer the option of having motion controllers concentrate on motion control profiles and tool paths independent of the axes.

SERCOS III also supports centralized control. With a minimum cycle time of 31.25 µs because of the greater bandwidth of the Ethernet physics, it is possible to implement both distributed control drive concepts, with all control loops closed in the drive, or centralized signal processing concepts where only the current loop is closed in the drive and all other loops are handled by the motion controller. SERCOS III is the only high-performance automation network that supports centralized and distributed drive concepts.

Key Advantage: Cross-communications capabilities

For high-performance deterministic motion control, the typical architecture (including the SERCOS I and II interfaces) utilize a master-slave communications path: If a drive is a slave of (that is, follows) another drive's velocity, the information must travel from the master drive to the control, and then to the slave drive. With SERCOS III, drive-to-drive cross communications is enabled: drives can communicate with one another without adding time delays and control processor overhead by going through the master.

This concept has been extended to support controller-to-controller (C2C) or machine-2-machine communication. The automation industry has long sought a standard solution to connect multiple motion controls together for synchronized applications, other than the traditional method: encoder signals and parallel I/O, which adds hardware and processing costs. SERCOS III provides a standardized method for exchanging controller-level synchronization information, allowing multiple machines to be linked and adding to the modularity of any machine or production line that implements SERCOS III—a key benefit for today's manufacturers that may need to expand or reconfigure production platforms in response to fast-changing market conditions.

Key Advantage: Enhanced reliability

In today's 24/7 world of highly competitive manufacturing, every step that can be taken to absolutely minimize machine or production downtime is crucial. SERCOS III is engineered to enhance reliability by supporting either line topologies (all devices connected in a series to a master) or ring configurations: SERCOS III devices feature a

SERCOS III was designed specifically to support efficient distributed control architecture, improving machine flexibility by moving processing power and decision-making from the motion control down into the drives and sensors.

second Ethernet port to support an additional cable. When a cable is connected between the two ends of a line network, SERCOS automatically initiates dual counter-rotating telegrams across the ring network.

This improves fault tolerance by supporting redundant data transfer: In case of a break at any point in the ring, the SERCOS III protocol automatically switches over to a dual-line structure. This "bumpless" recovery is "nearly" instantaneous: recovery occurs in 25 µs, which is less than one cycle.

This redundancy offers machine-users an additional advantage: "hot" replacement or installation of devices during machine operation, without requiring machine shutdown or cycling of power—allowing systems to be designed that continue operating using the new configuration and hardware.

Key Advantage:
Investment protection
One of the most important advantages SERCOS III offers is its open architecture: with over 30 drive manufacturers and over 50 controller companies supporting SERCOS (20 drive manufacturers and nearly 30 control companies now supporting SERCOS III), it gives machine builders and

end-users confidence that selecting SERCOS III will not box them into a limited bus architecture that could impact long-term costs and platform flexibility. It is also fully backwards compatible with SERCOS I and II bus architectures, for increased interoperability with existing installed systems.

SERCOS is an open approved international standard for real-time communications (IEC 61491) and the SERCOS III real-time Ethernet protocol is part of IEC 61158 and IEC 61784. SERCOS specifications are non-proprietary and fully published, and experts from SERCOS working groups (who contribute to national and international standards organizations) are under continuous development in response to new market conditions. SERCOS is the only Fieldbus to support technical working groups in both North America and Europe, providing the opportunity to influence the standards development based on local needs.

In addition, SERCOS III uses standard Ethernet physical layer technology, which is proven, widely available and provides cost-effective hardware implementation, and can help keep operational costs down (spare parts, repairs, maintenance) during machine lifecycles.

SERCOS III: Universal hard
real-time industrial Ethernet
A real-time, non-proprietary communications solution with the robust performance and cost-effective value of Ethernet has long been a goal in the world of industrial automation—and SERCOS III offers an open, feature-rich platform to fulfill that vision. Based on the 25 years of continuous development and field experience embodied in the SERCOS interface, the only worldwide, standardized real-time communication in drive technology, SERCOS III combines the proven SERCOS communication technology with the advantages of Ethernet.

For today's high-bandwidth multi-axis manufacturing systems, SERCOS III provides:
• Guaranteed hard real-time synchronous data exchange between controls and devices
• Direct communications between devices or controllers
• Redundant ring topology for the highest machine uptime
• A common Ethernet-based platform for consistent networks across the enterprise, from the machine to the front office
• A universal bus for the entire spectrum for industrial automation applications.

Rexroth
Bosch Group