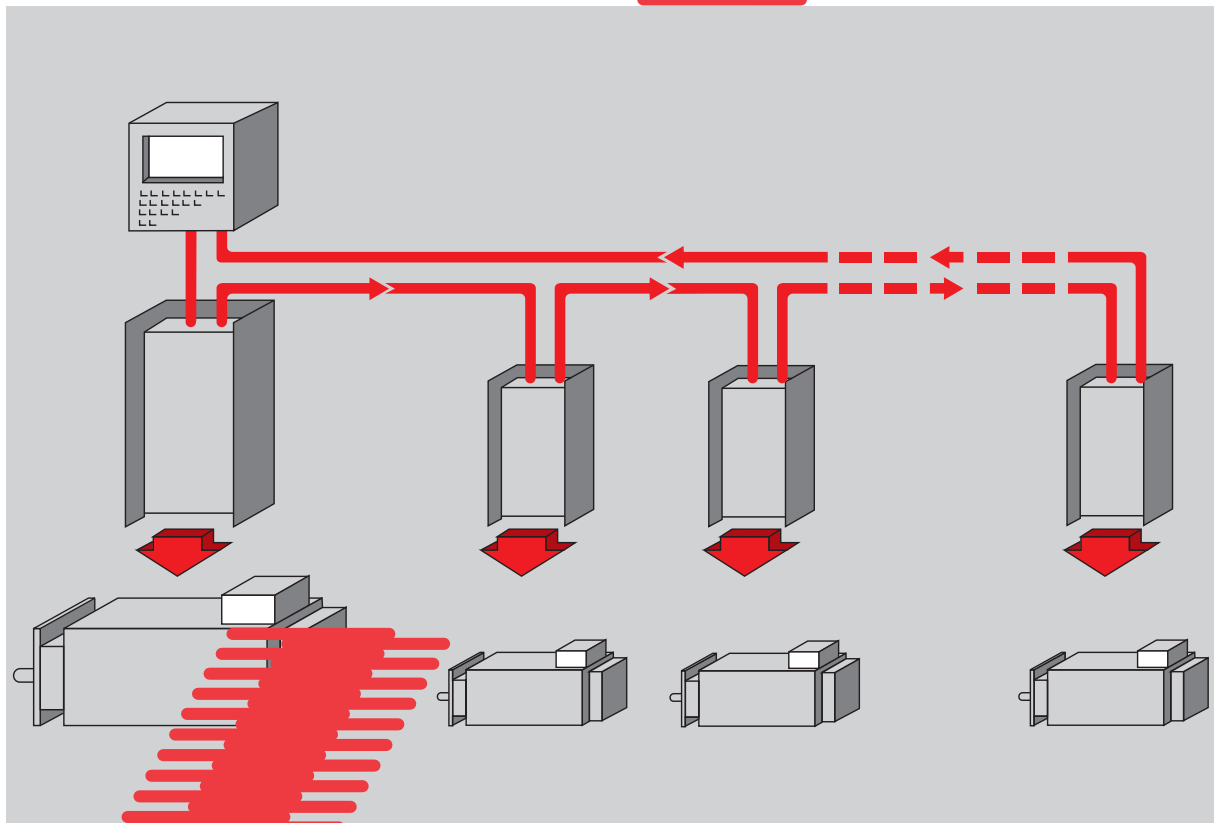




IEC 61491, EN 61491 SERCOS interface
The internationally-standardized digital
interface for communication between
controllers and drives in numerically-
controlled machines

IEC 61491
EN 61491
SYSTEM INTERFACE



Technical Short Description

SERCOS

interface

For numerically controlled machines, digital intelligent drives offer maximum precision and speeds while minimizing equipment costs.

High performance digital interface is required to make use of these advantages.

In the interest of product choice, optimum configuration, and standardization, in order to simplify procurement and operational maintenance, a digital drive interface not only has to meet the functional requirements of different applications, but it must also ensure, through openness and standardization, problem-free operation between various controllers and drives from different manufacturers.

The SERCOS digital drive interface meets all these requirements and has been the international standard interface for drives on numerically controlled machines, i.e., IEC 61491, since November 1995, EN 61491 since August 1998.

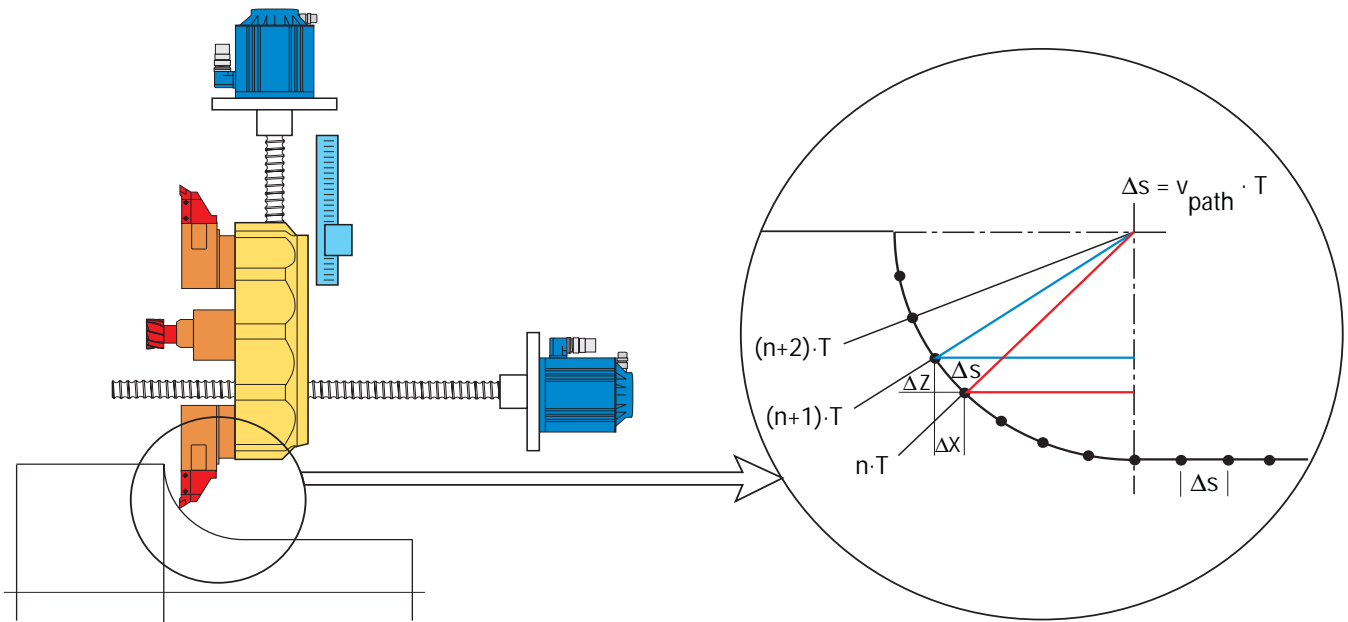
Major advances have been achieved in several thousand applications in virtually all machining technologies and advantageous new machine designs have been implemented since the beginning of the '90s with digital, intelligent drives using the SERCOS interface.

Leading companies worldwide have selected the SERCOS interface. Well-known vehicle manufacturers name the SERCOS interface as a major component in their equipment specifications.

This technology has proven itself to be superior to conventional CNC machines for fast and precise motion control in the automation field, as well as in new, advantageous machine concepts for packaging, textile and printing machines.

The numerical motion controller

CNC axes control



T [ms]	10	2	0,5	0,25	0,1
Δs [mm]	5	1	0,25	0,125	0,05

Mathematical example for high speed machining $v_{\text{path}} = 30 \text{ m/min} \cong 500 \text{ mm/s} \cong 0,5 \text{ mm/ms}$

The numerical control of machine axes is achieved with position control.

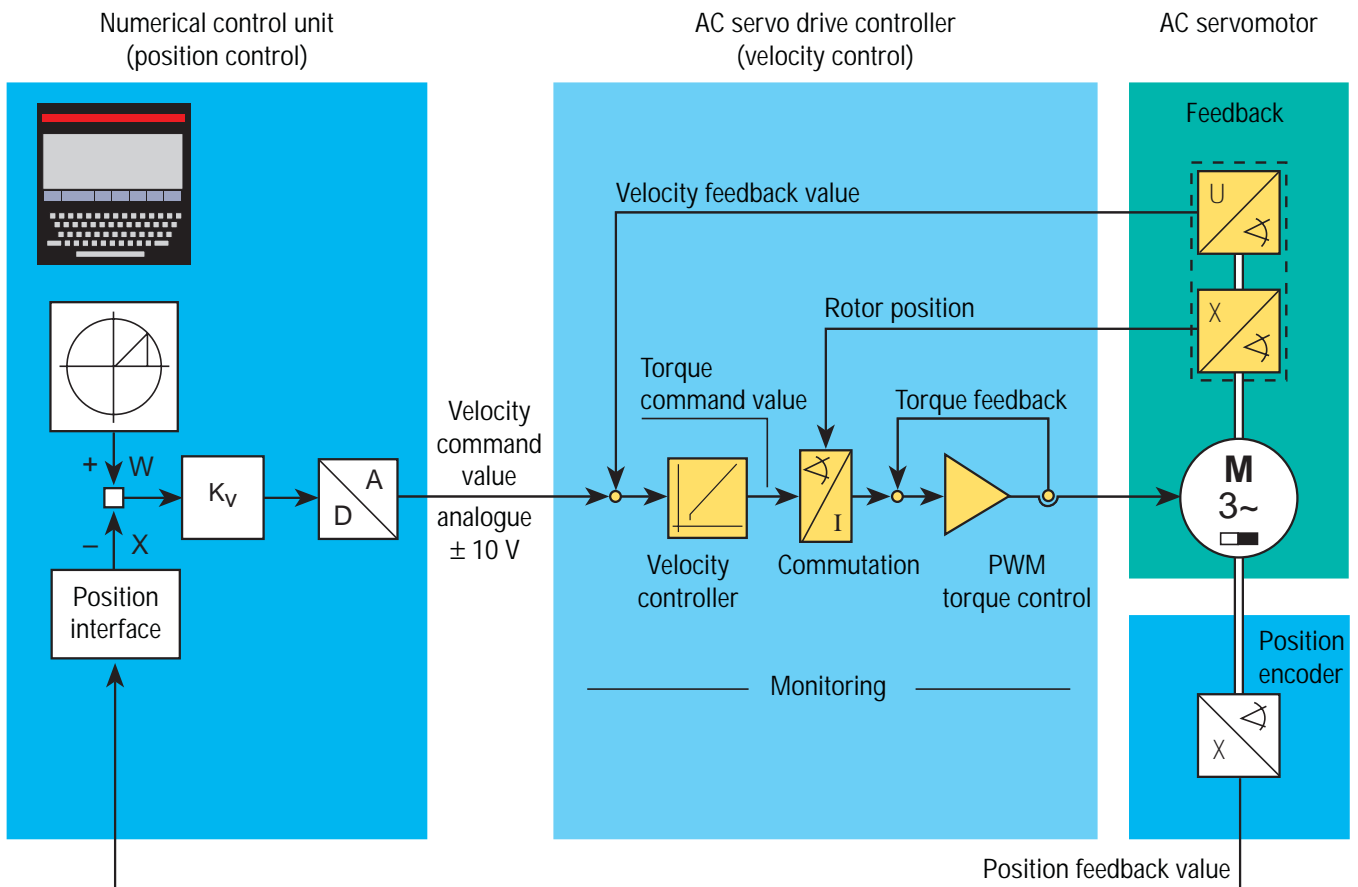
Position command values are calculated cyclically for each machine axis at identical, short intervals by an interpolator and the numerical controller.

With its own position control, each axis follows the cyclical position command values supplied by the interpolator, with a high dynamic response and high precision. This produces both precise control of individual axes, and exact interpolation with any number of axes.

The intervals at which the position actual values are measured, and the times at which the command values become effective in the drive are just as important for the precise coordination of the axes as the accuracy of the interpolated position command values and the measuring accuracy.

At a speed of 60 m/min., a dimensional accuracy of 1 micrometer corresponds to a time accuracy of 1 microsecond.

Conventional NC drive technology



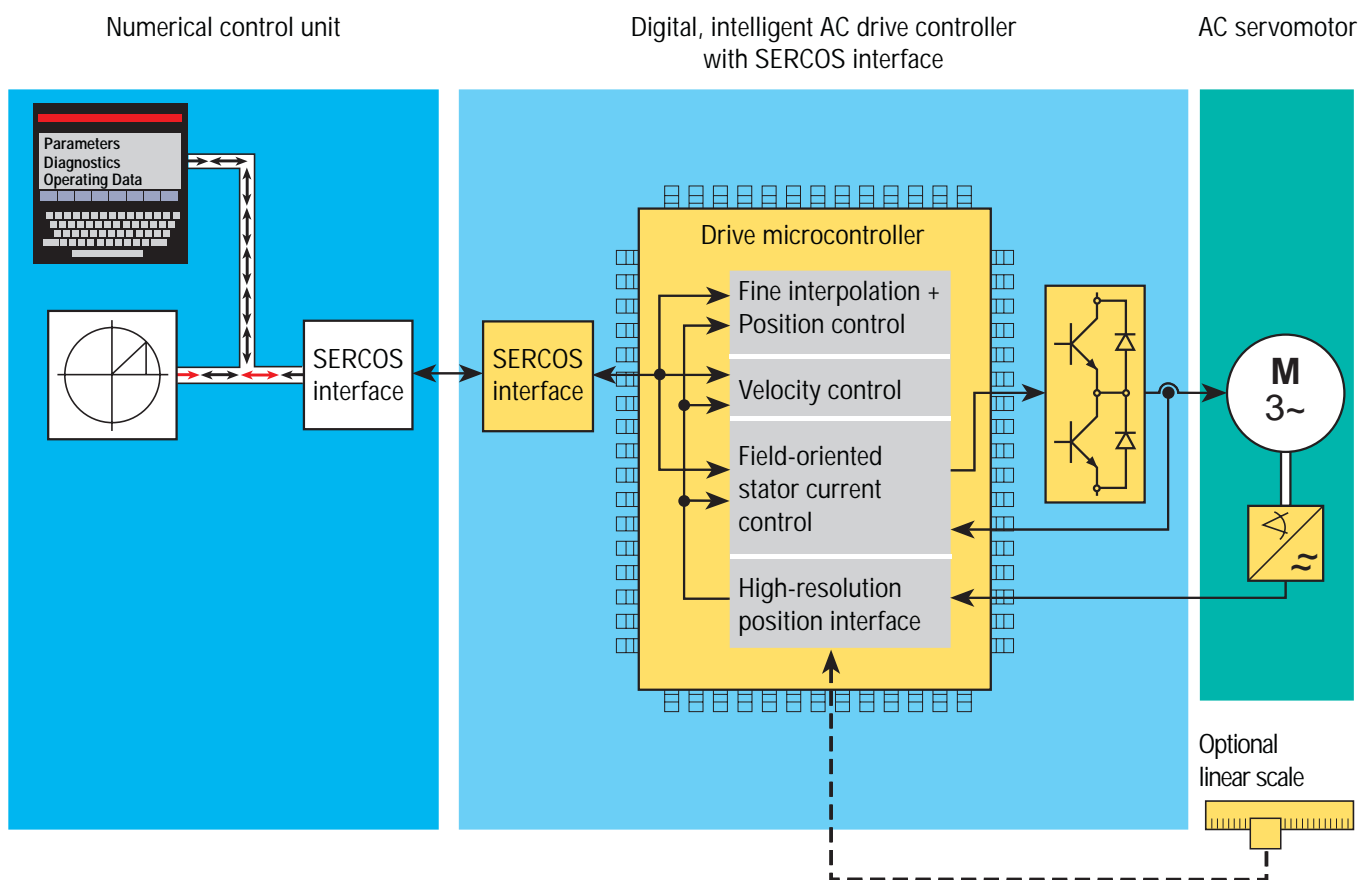
In previous years, NC controller and drive technology achieved a high standard of performance with controlled analog drives.

Although position control forms with the drive a functional, closed control loop, position control is conventionally carried out in the numerical controller because analog drives do not have the necessary digital processing capability.

With analog drives, a $\pm 10\text{ V}$ velocity command values interface for the controller is an international standard.

For 25 years this standard analog drive interface ensured problem-free interaction between controllers and drives from different manufacturers, and provided the user a wide choice of products for optimal machine configuration.

Digital, intelligent NC drive technology



Today, all the signal processing of a digital, intelligent drive can be done with a microcontroller.

The microcontroller enables not only conventional torque and speed control, but fine interpolation and position control with extremely short cycle times. Maximum precision can also be realized in the digital drive.

Compared to conventional position control in the CNC, much higher accuracies are achieved, especially at high speeds.

Cost reductions due to the simplification of the controller hardware, and savings on cabling and position encoders are also made possible by these facilities.

Of course, to make use of the above advantages, a suitable digital interface is required for the controller.

Real-time requirements of a digital drive interface

With conventional NC drive technology using the ± 10 V interface, there were no real-time problems between the controller and the drives. The analog command values are always processed immediately by the continually operating analog drives.

Digital transmission of command values and actual values

Digital drives operate cyclically. In each interpolation cycle of the controller, all command values and actual-values have to be updated in all drives.

The **SERCOS interface** offers cyclical exchange of command values and actual values for all drives with a selectable cycle time of 62 μ s, 125 μ s, 250 μ s and every whole multiple of 250 μ s up to 65 ms.

Synchronization

The digital drive interface must provide synchronization between the cyclic controller and the equally cyclic digital drives. The synchronization must have microsecond accuracy since precise coordination of the drives is only guaranteed if the actual values are measured at exactly the same time in all digital drives and all command values become effective simultaneously.

The **SERCOS interface** offers synchronization with microsecond accuracy for any number of digital drives.

Parameterization and diagnostics via controller terminals

Digital drives are matched to different applications and controllers by parameters.

Digital drives permit the drive's internal data and diagnostic signals to be output and displayed.

Suitable display and input facilities on the digital controller are absolutely necessary since simple checks and adjustments, as with analog drives, are virtually impossible.

The **SERCOS interface** enables internal drive data, parameters and diagnostics to be displayed, input, and saved via NC controller terminals, a service channel and a standardized service data routine.

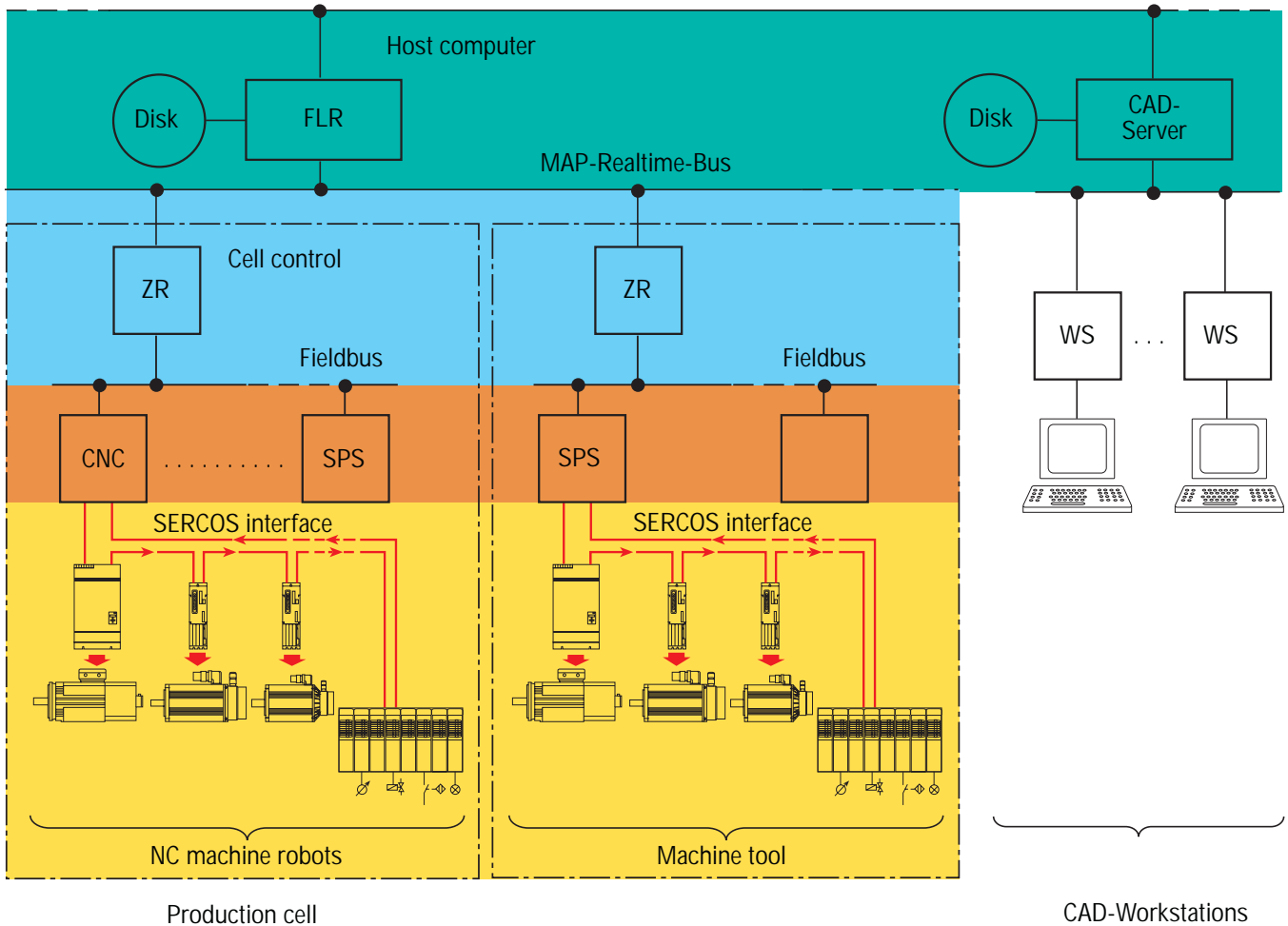
Transmission rates

SERCOS interface offers following transmission rates: 2, 4, 8 and 16 MBit/s.

The SERCOS interface fiber optic rings

Networking in the automation industry

ex. MAP-BUS



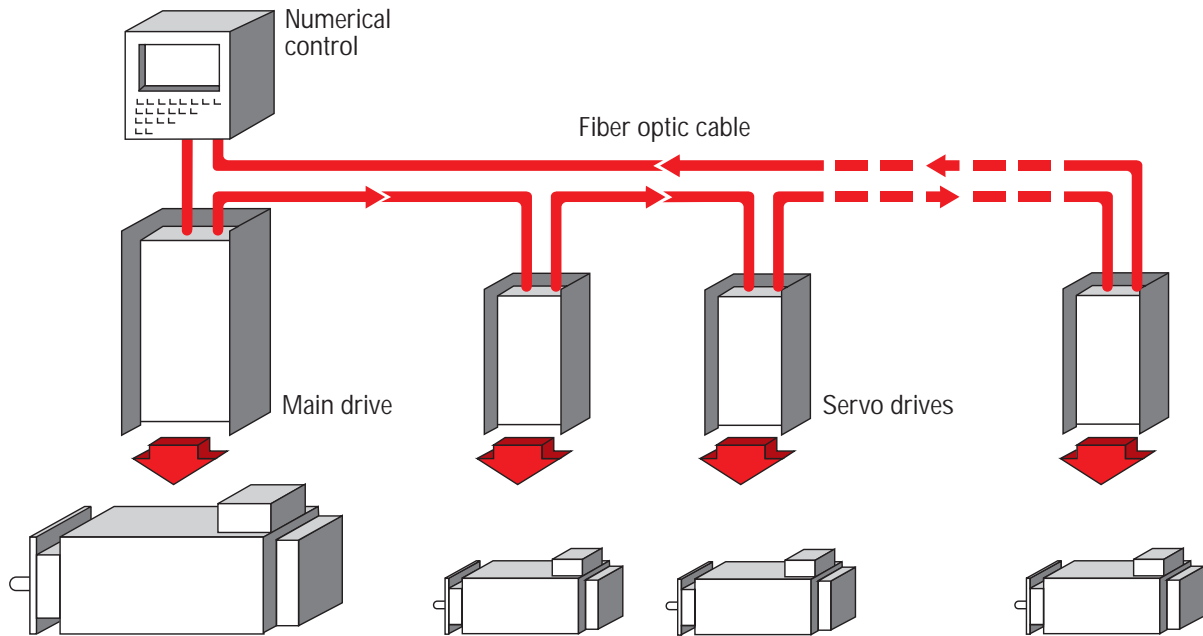
The **SERCOS interface** meets all the requirements by employing a fiber-optic ring structure.

Fiber optic cables were chosen to provide high immunity against electromagnetic interference.

In industrial applications, unforeseen noise levels must be expected in cable ducts. Furthermore, HF interference resulting from power control by pulse-width modulation, and separately-sited AC line and ground connections on controllers and drives must be reliably eliminated.

The ring structure has the smallest number of fiber optic cables and requires no complicated T-branches.

Digital AC drives with the SERCOS interface



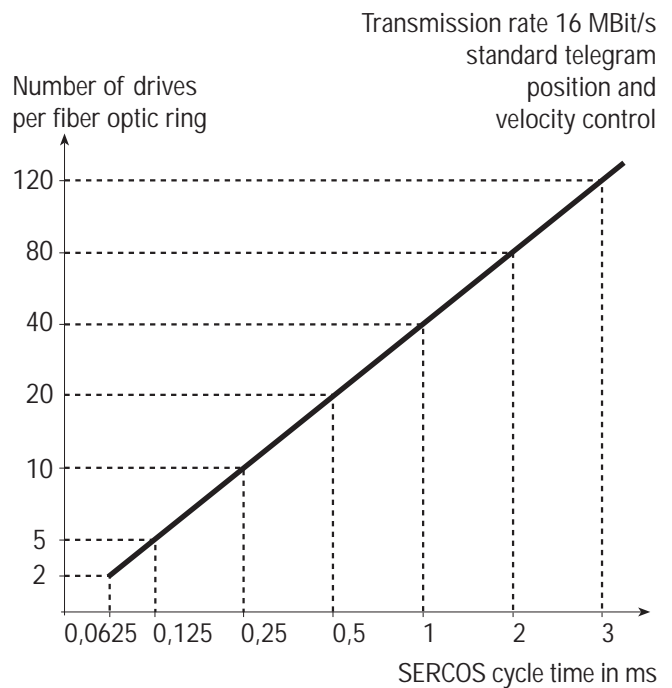
The length of each transmission section can be up to 50 meters with plastic fiber optic cables and up to 250 meters with glass fiber cables.

The maximum number of subscribers per fiber optic ring is 254.

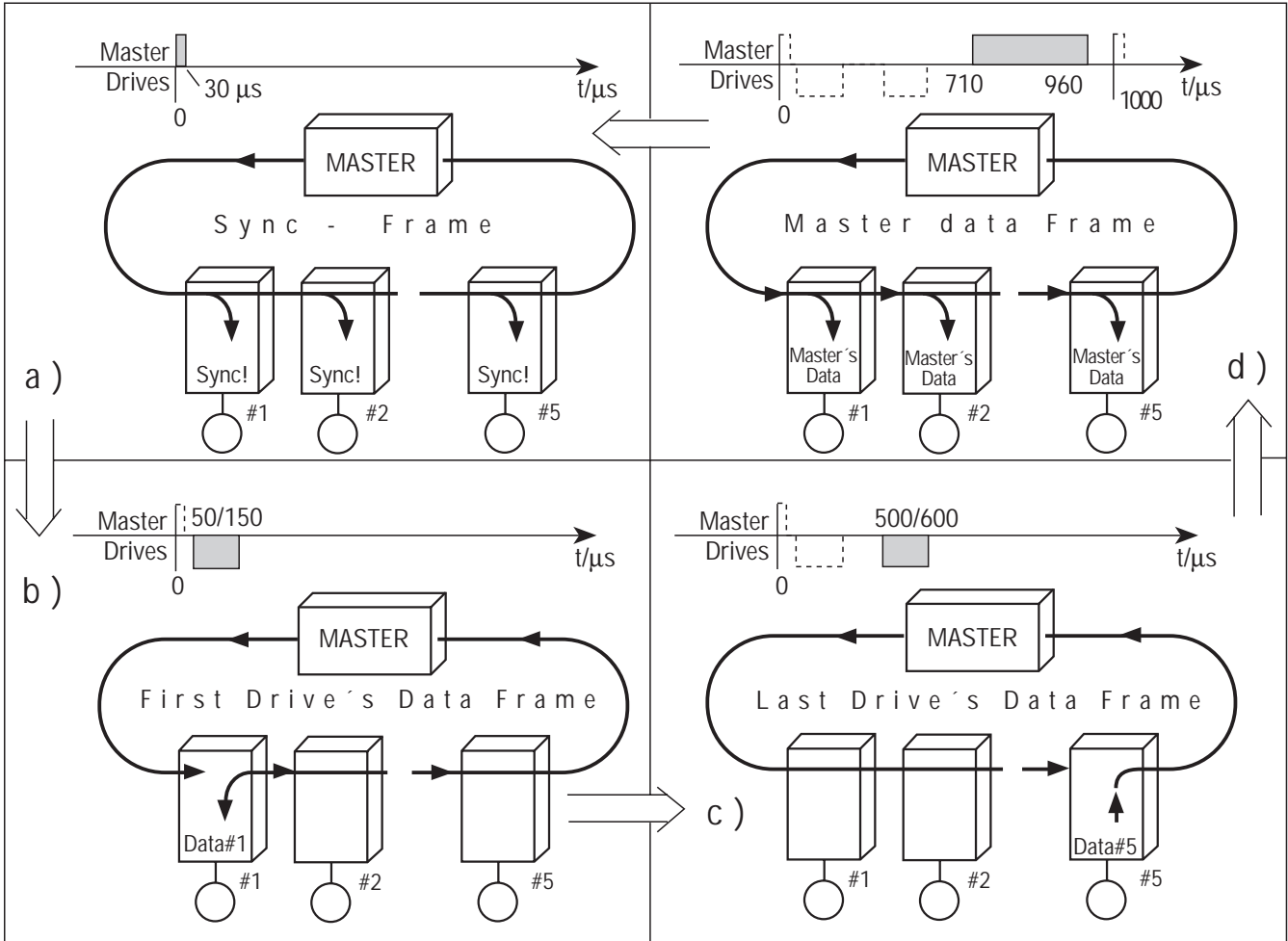
The maximum number of drives that can be operated per fiber optic cable depends on the required communication cycle time, the chosen amount of operating data and the data rate.

The graph shows the number of drives which can be connected to each fiber optic ring for a typical CNC application with speed control and position control modes.

The number of drives per controller can be extended as required by using several fiber optic rings.



Communication



In operation, communication takes place cyclically as master/slave communication at the cycle time selected at initialization. This can be $62 \mu\text{s}$, $125 \mu\text{s}$, $250 \mu\text{s}$ or any whole multiple of $250 \mu\text{s}$ up to 65ms .

The cycle times are specified in order to obtain the necessary synchronization with fixed working cycle times in the controller and the drives.

The numerical controller is always the communication master in a SERCOS interface.

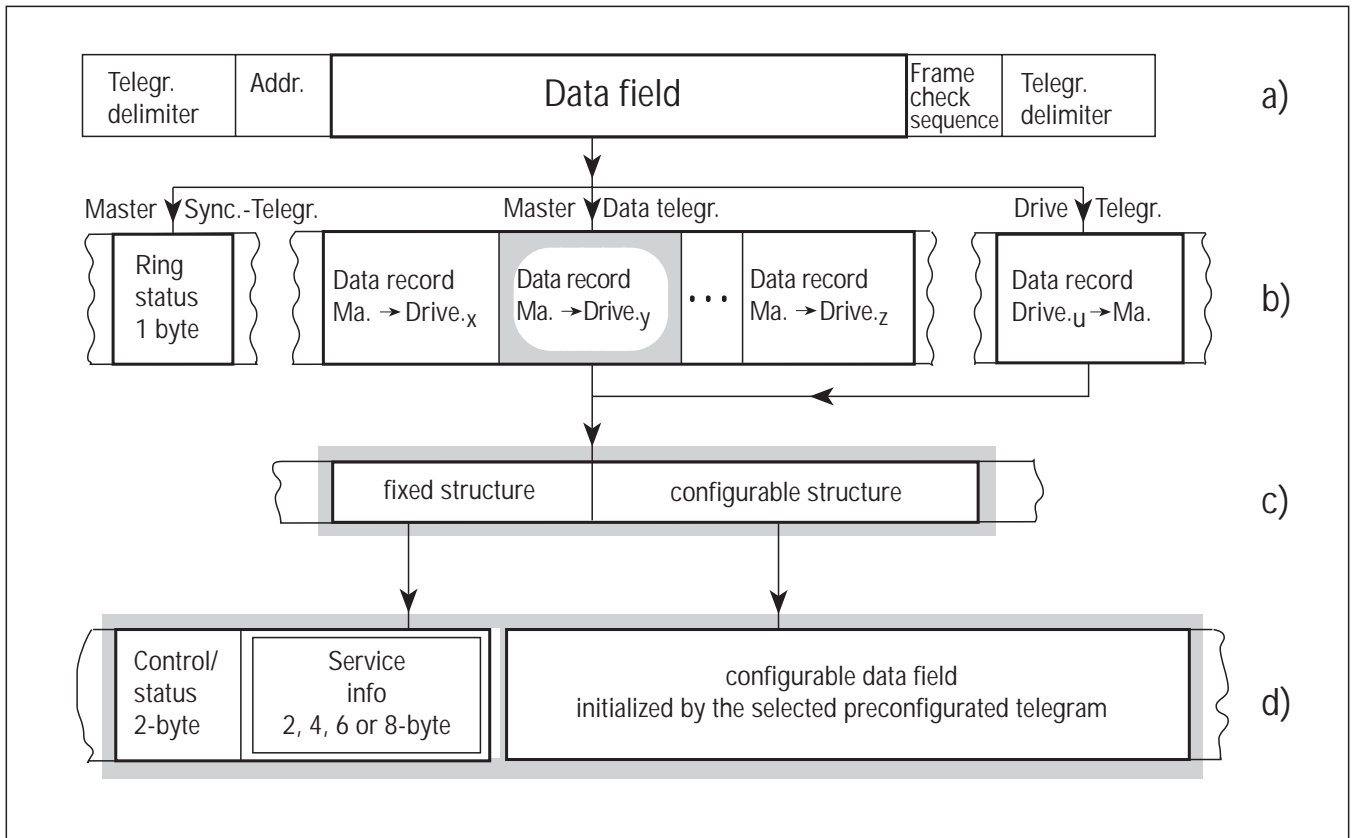
Communication takes place via three different types of messages:

The master sync message is received simultaneously by all drives and is used to synchronize all time-related actions in the NC and drives.

Like the master sync message, the master data message is also received simultaneously by all drives. It contains the cyclical data and the service data for all drives on the ring.

The drives send their messages in succession in allotted time slots.

Message structure



NRZI-coded HDLC protocols are used for communication.

In each communication cycle, the real-time data is transmitted in the so-called configurable data field.

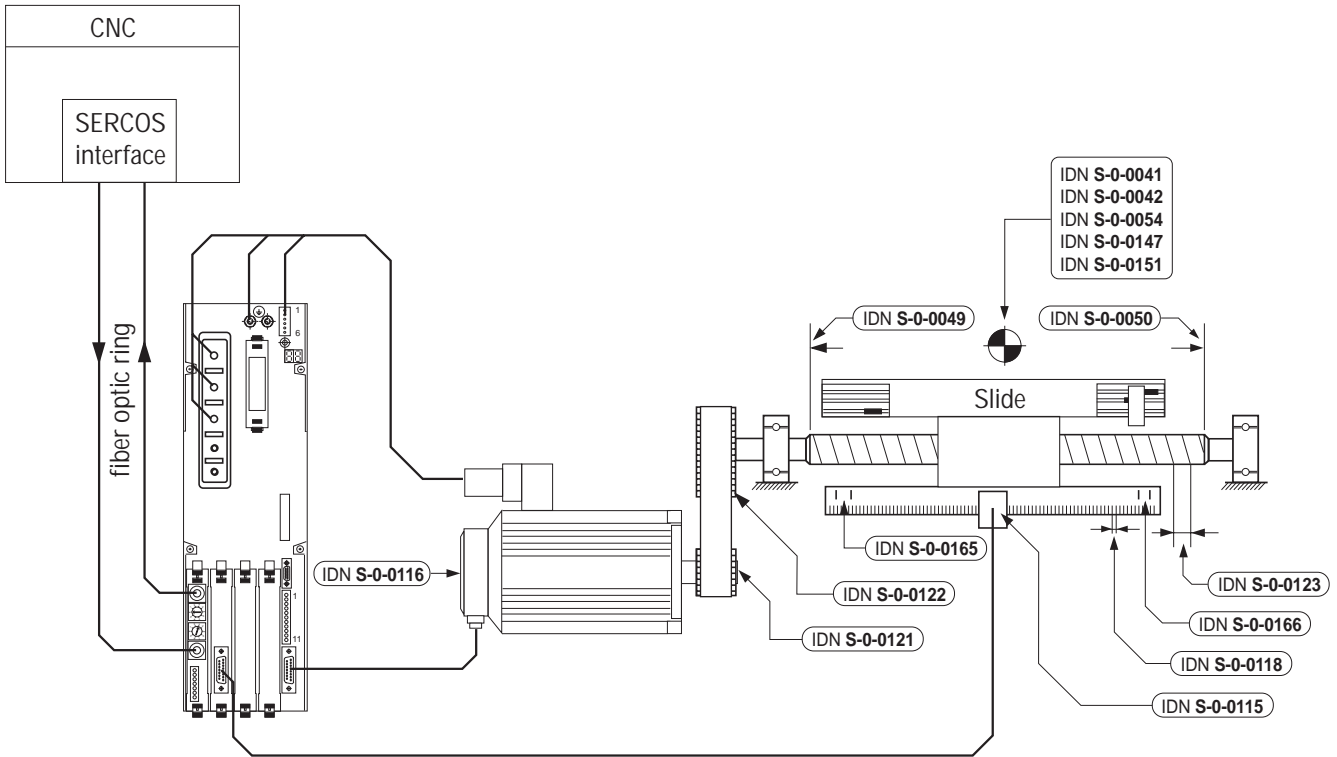
At initialization, the identification number system specifies which real-time data is transmitted. Apart from numerical data such as command values and actual-values, these can also be bit lists with I/O instructions.

Priority messages with specific real-time data have been specified for the three basic operating modes - torque control, velocity control and position control - as well as combined velocity/position control.

The configurability of the real-time data allows any other operating modes to be used independently.

Service data is exchanged only at the request of the master. Service data is transmitted with a handshaking procedure in 2, 4, 6 or 8-byte portions in the service info field and then reassembled at the receiver.

Standardized data



Drive operation modes					
Explanation	Position control		Velocity control		Torque control
Feedback type	Motor feedback	Linear feedback	Motor feedback		Motor shaft
Following error	with	without	with	without	-----
Command/actual value (data length)	32 Bit		32 Bit		16 Bit
Scaling type	preferred	0,000 1 mm ; 0,000 001 inch	0,001 mm/min ; 0,000 01 inch/min	1,0 N ; 0,1lbf	
parameter		yes	yes	yes	
Unit (linear)	mm ; inch		mm/s ; mm/min inch/s ; inch/min	N (Newton) lbf (pound-force)	

Standardization of communication methods is not enough. Controller and drive interoperability can only be guaranteed if the type of data being exchanged is also standardized.

Over 400 data blocks and the effect of commands were specified in the SERCOS interface to ensure that products from different manufacturers work with each other.

Excerpt from drive and control adaptation parameters			
Controller-specific applications parameters		Machine-specific applications parameters	
IDN:	Function:	IDN:	Function:
S-0-0032	Primary mode of operation	S-0-0041	Homing velocity
S-0-0033	Secondary operation mode 1	S-0-0042	Homing acceleration
S-0-0034	Secondary operation mode 2	S-0-0049	Positive position limit value
S-0-0035	Secondary operation mode 3	S-0-0050	Negative position limit value
S-0-0044	Scaling of velocity data	S-0-0054	Actual position feedback 2
S-0-0076	Position data scaling type	S-0-0115	Position feedback type parameter
S-0-0079	Rotational position resolution	S-0-0116	Resolution of rotational feedback 1
S-0-0086	Scaling type for torque force data	S-0-0118	Resolution of the linear feedback
S-0-0160	Scaling type for acceleration data	S-0-0121	Input revolutions of load gear
		S-0-0122	Output revolutions of load gear
		S-0-0123	Feed constant
		S-0-0147	Homing parameter
		S-0-0151	Reference offset 2
		S-0-0165	Distance coded reference dimension 1
		S-0-0166	Distance coded reference dimension 2

In addition to the real-time data to be exchanged during operation, the following parameters are specified:

- Communication settings
- Mode selection
- Matching to different mechanical systems
- Matching to different measuring transducers and arrangements
- Matching command values and actual-values to the NC

During service data exchange and the definition of real-time data, data is addressed in the SERCOS interface via of identification numbers.

A numerical range of 2^{16} is specified for ID numbers.

The ID numbers 1 to 32767 are reserved for data specified by the SERCOS interface association.

The ID numbers 32768 to 65535 are available to product manufacturers for defining data or parameters not covered by the standard but which are required for the operation of a product.

A complete data block is always stored in the drive under the ID number of each data.

The data block enables all addressable data, parameters and diagnostic signals to be displayed, input and saved via control terminals using a standardized routine.

Block-by-block operation

The SERCOS specification also includes block-by-block operation for operating digital, intelligent drives with PLC controllers and as auxiliary axes.

I/O functions

The SERCOS interface is designed not only as a digital drive interface, but also as a fast I/O bus with a built-in service channel. An additional specification - "SERCOS I/O functions" - is available for this application.

Detection and handling of communication errors

In the SERCOS interface, communication errors are detected with high reliability by the HDLC protocol and additional monitoring of the known message lengths and the known transmission times. The Hamming distance is greater than 4.

Errors in the transmission of service data (parameters and diagnostic signals) are corrected via a handshaking procedure. Erroneous data is retransmitted.

Real-time data (command values and actual values) is corrected automatically by updating in each communication cycle. In the case of communication errors, the last valid command values are used until the next cycle.

The drives are stopped in the event of two successive erroneous transmissions.

System safety with the SERCOS interface

Digital, intelligent drives with the SERCOS interface provide outstanding protection against uncontrolled drive movements and excessive velocities.

The drives' internal intelligence provides perfect self-monitoring with the aid of the position values, command values, actual values and drive parameters, combined with forced shutdown in the event of a mal-function or failure of the drive processor.

Furthermore, excessive axis velocities or run-away due to faulty or incorrectly transmitted position command values can be completely eliminated by logical monitoring in the drive processor of the command values received by the controller.

Safety redundancy is achieved by monitoring the actual value data fed back to the controller via the SERCOS interface.

Even in the event of a communication failure, safe shutdown of the drives is ensured by the drive's internal monitoring and also by monitoring at the controller in conjunction with a higher-order emergency-stop circuit.

Available services and products

The SERCOS Interface Association (IGS) was founded in 1990 with the aim of launching the SERCOS interface worldwide and supporting potential users.

SERCOS N.A. with its head office in Bloomingdale, Illinois, is a user group of American companies, started in 1993.

SERCOS Japan with a head office in Tokyo, Japan, is a user group of Japanese companies, started in 1998.

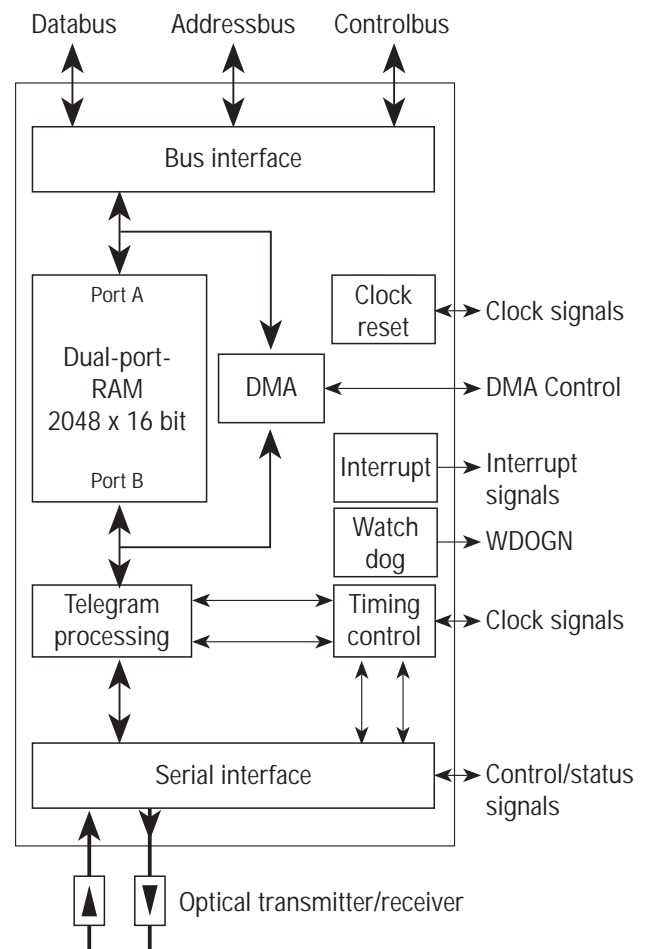
The right to carry the SERCOS interface marking on products is granted by the IGS after testing the characteristics laid down in the SERCOS specification.

Conformity checks on SERCOS interface products are carried out by ISW, University of Stuttgart (Germany) under authorization of IGS.

User support and tools for the development, testing and installation of SERCOS interface products are offered by several suppliers and the IGS.

An overview of the services and products currently available is obtainable from the IGS under the title "A brief overview of products equipped with the SERCOS interface".

SERCOS interface ASIC



The IGS has commissioned the development of the ASIC SERCON 816 for simple and cost-effective use of the SERCOS interface.

As an intelligent interface chip, SERCON 816 handles all the communications between the fiber optic ring and a microprocessor.

The ASIC SERCON 816 can be obtained worldwide from the sales branches of STMicroelectronic.

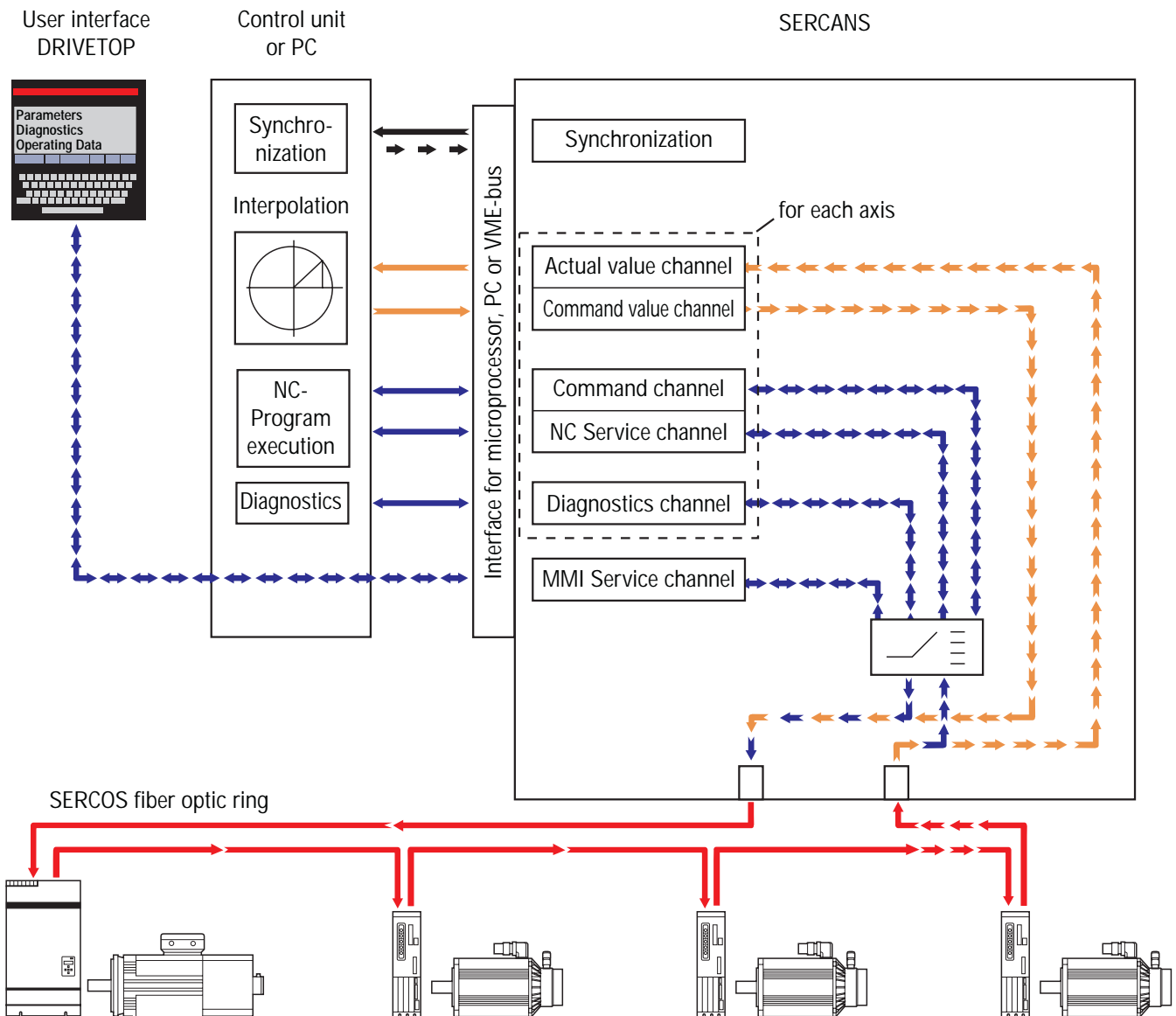
SERCON 816 development tools and user support are obtainable from several companies.

SERCOS interface for controllers

SERCANS and DRIVETOP provide simple and high-performance use of the SERCOS interface with controllers.

SERCANS is a complete, operational add-on module which enables digital, intelligent drives with SERCOS interface to be used with CNCs, PCs and VME bus controllers.

SERCANS automatically handles all communication, synchronization and error recovery between the controller and the digital, intelligent drives.



The SERCANS application

The exchange of cyclical data such as command values and actual value control and status signals is controlled by transmitting a synchronization clock signal per interpolation cycle between the controller and SERCANS.

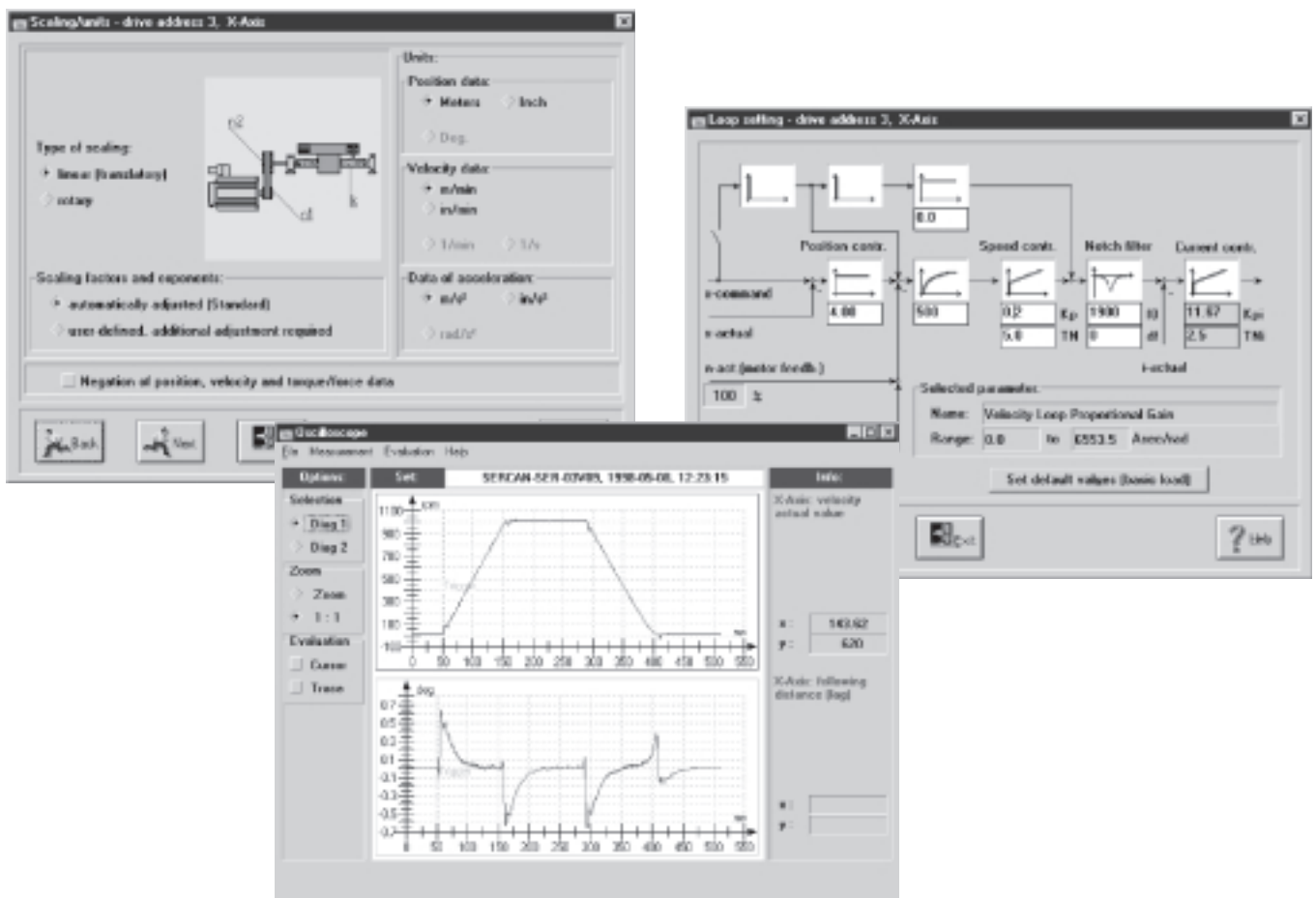
The controller cyclically determines new command values within a time window based upon the synchronization clock signal, writes these command values into the dual-port RAM and reads the actual values from the dual-port RAM.

The controller, therefore, has access to all data to be exchanged with the drives, as if it were an internal register.

The DRIVETOP user interface

DRIVETOP is a SERCANS-compatible convenient drive user interface running under Windows™.

DRIVETOP provides commissioning, parameterization and diagnostics of digital drives, as well as the storing and loading of drive parameters. A powerful oscilloscope function enables the attained path velocity to be checked, as with a measuring machine.

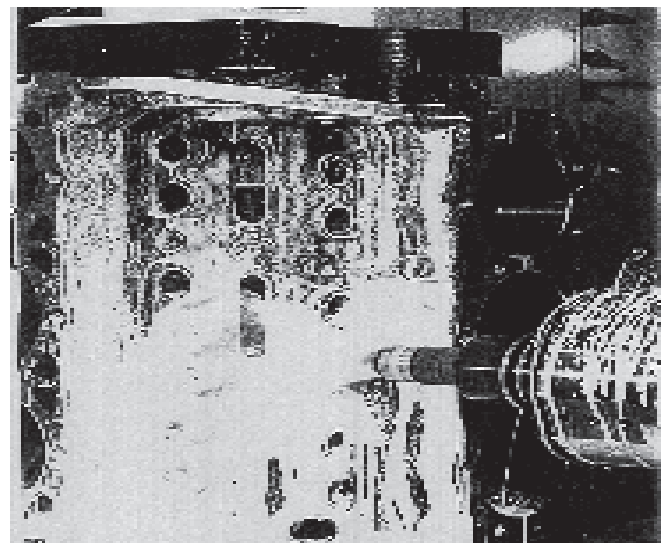
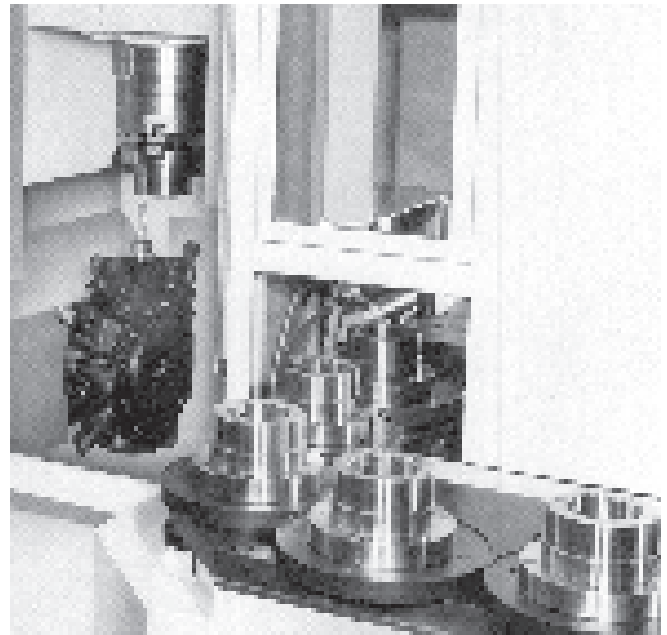


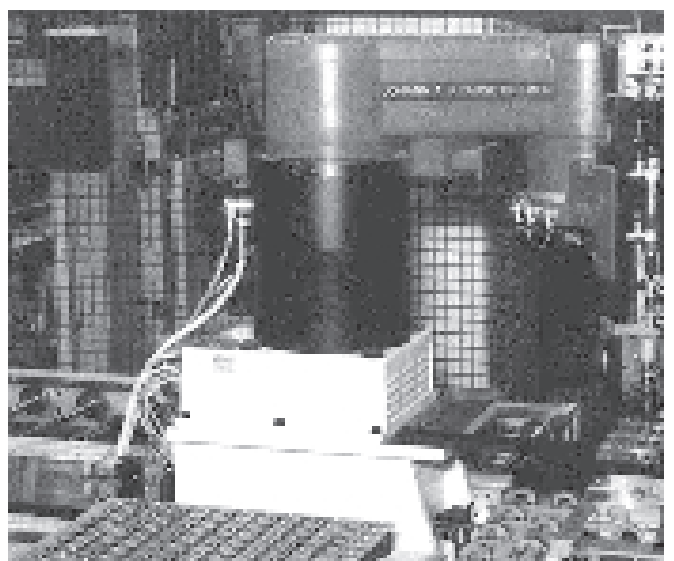
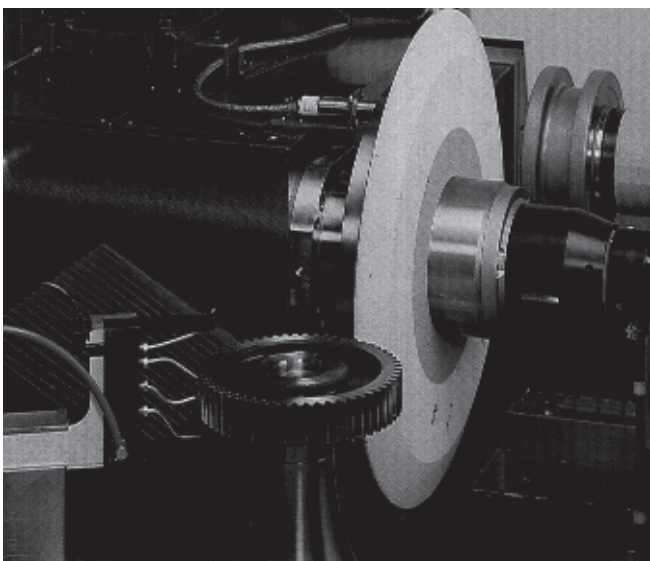
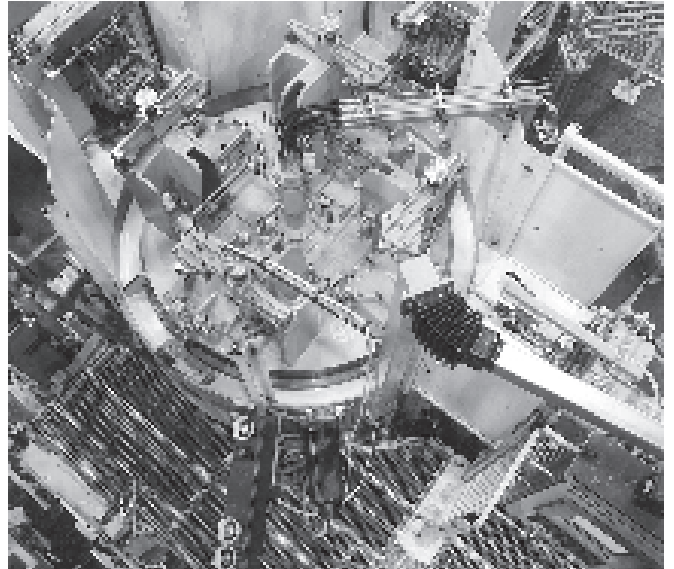
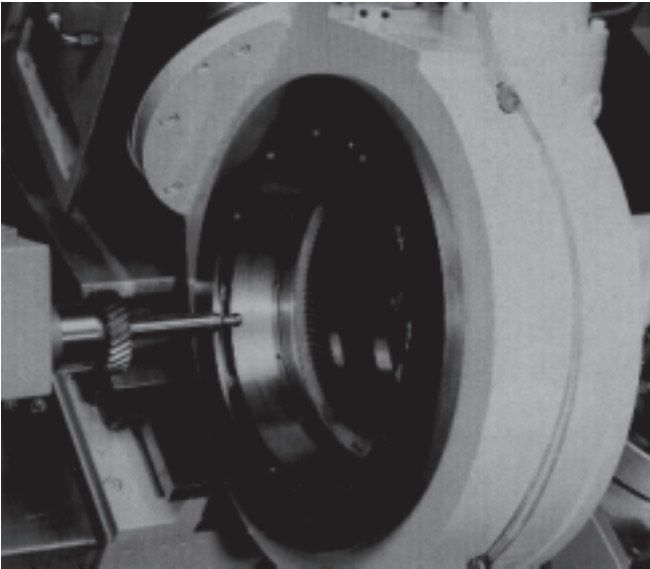
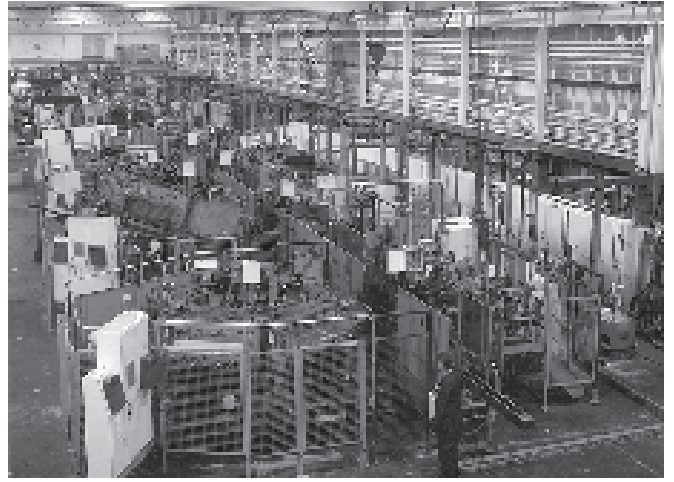
SERCOS interface applications

Advances have been achieved in several thousand applications in virtually all machining technologies and advantageous new machine designs have been implemented since the start of the '90s with digital, intelligent drives using the SERCOS interface.

The range of applications includes:

- Turning and complete machining
- Free-form milling, including HSC
- Machining centres, including HSC
- Crankshaft orbital grinding
- Cam profile grinding
- Tool grinding machines
- Precision gear cutting
- Transfer lines
- Rotary transfer tables
- Assembly lines
- Assembly robots

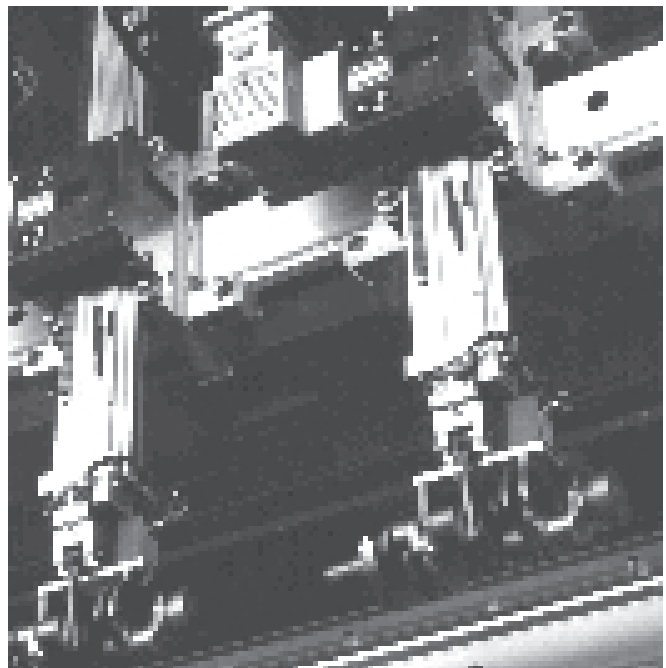


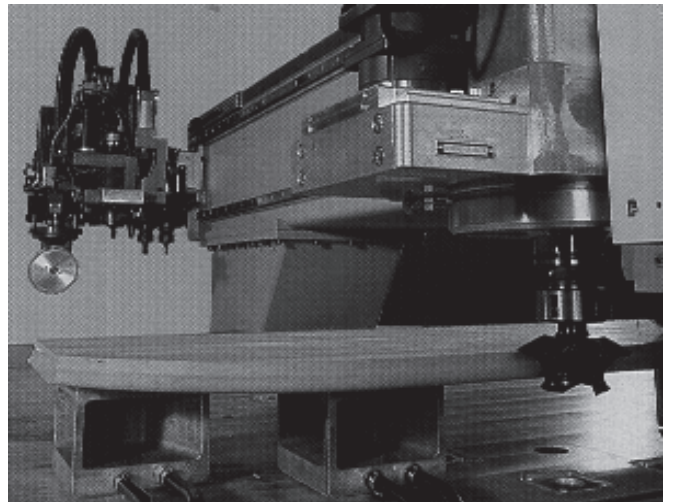
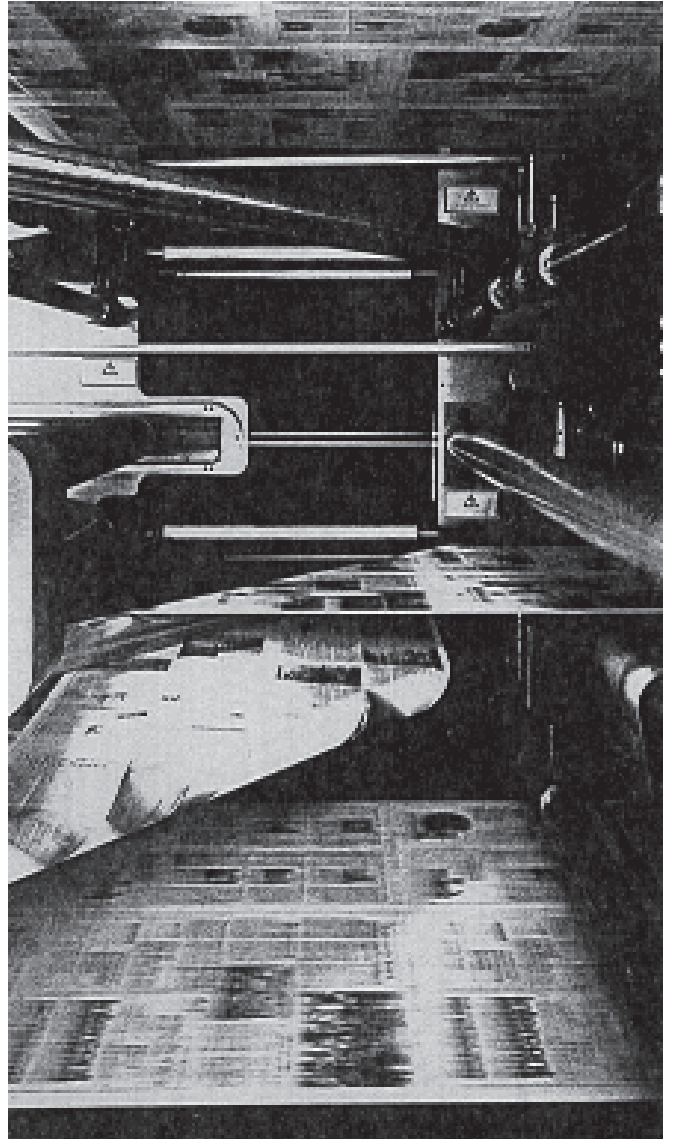
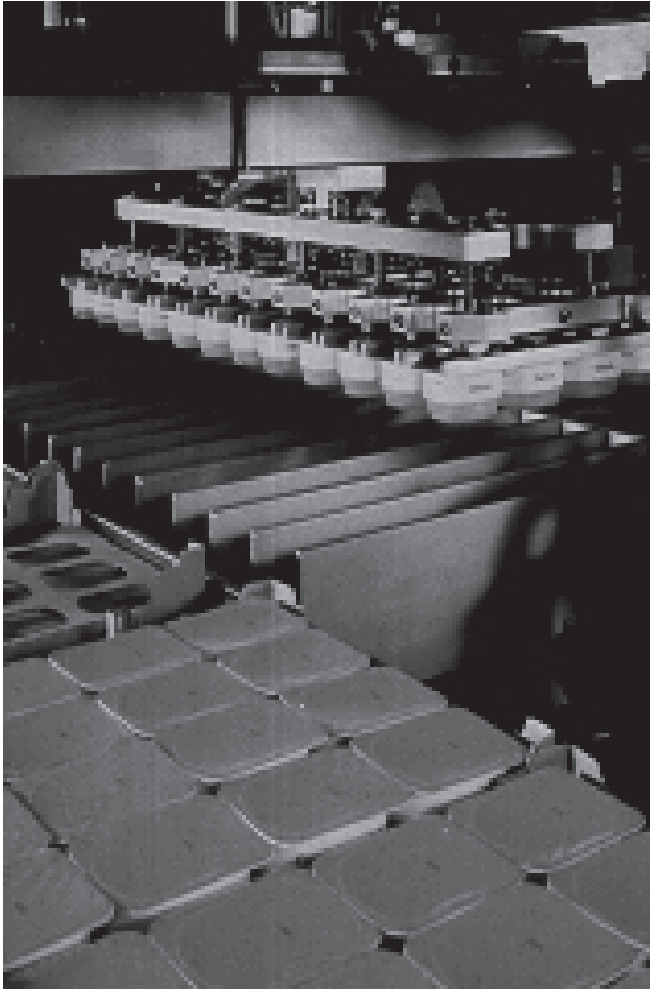


This technology has proven itself to be superior to conventional CNC machines for fast and precise motion control in the automation field, as well as in new machine concepts for packaging, textile and printing machines.

Examples are:

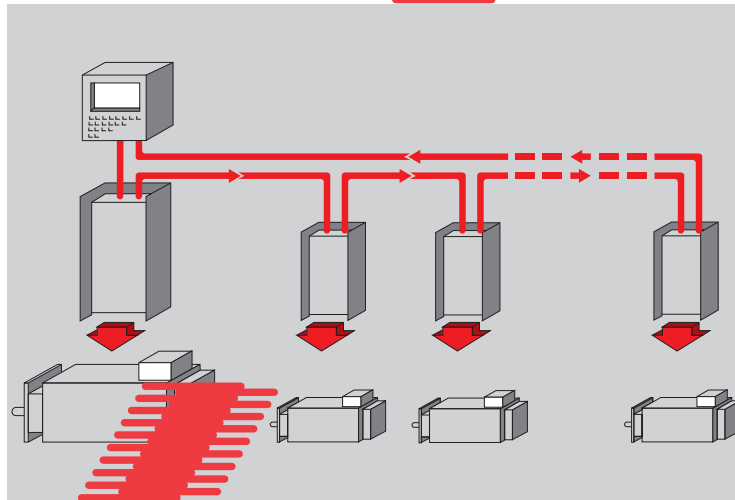
- Press lines
- Gantry loaders
- Stackers
- Electronic gearboxes and cam drives on packaging, textile and printing machines
- Electronic gearboxes on packaging machines and newspaper printing presses.







IEC 61491
EN 61491
SYSTEM INTERFACE



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