

Movement along the path – Software CNC solves complex tasks



→ Machines where several axes have to move simultaneously on freely programmable paths with defined path velocities for solving the machining task are usually equipped with CNC controls. Applications range from simple lathes with two axes to complex machining centers or transfer lines with many axes, spindles and channels. CNC controls have been the domain of classic hardware-oriented control systems for decades. They use the PC for no more than operation, visualization and data processing.

For years, the TwinCAT NC I (interpolation) software module from the TwinCAT product family has demonstrated that path control is possible as a pure software solution. The Beckhoff automation software has – added a new level called TwinCAT CNC – geared towards CNC solutions. TwinCAT CNC offers complete CNC functionality as a pure PC-based software solution. TwinCAT CNC covers the complete range of classic CNC path control, including high-end solutions for complex motion and kinematics requirements.

PC computing power without limits

Complex path movements with high velocity and precision place high demands on computing power, real-time capability and deterministic features of the control system in order to execute the tasks of CNC program execution, interpolation and position control. The powerful, continuously evolving PC platform with increasingly fast processors and the hard real-time base of the TwinCAT real-time kernel offer ideal preconditions for software CNC. The requirements of CNC path control, PTP positioning control, PLC sequential control and operation/visualization can easily be met with the single-processor PC-solution of the Beckhoff TwinCAT system.

The following diagram shows the different computing times of TwinCAT CNC for four different cases and with two common PC processor types. On an Industrial PC with Pentium 4/2.4 GHz processor, TwinCAT CNC needs 435 µs for set value generation and position control in an application for example with 8 interpolat-

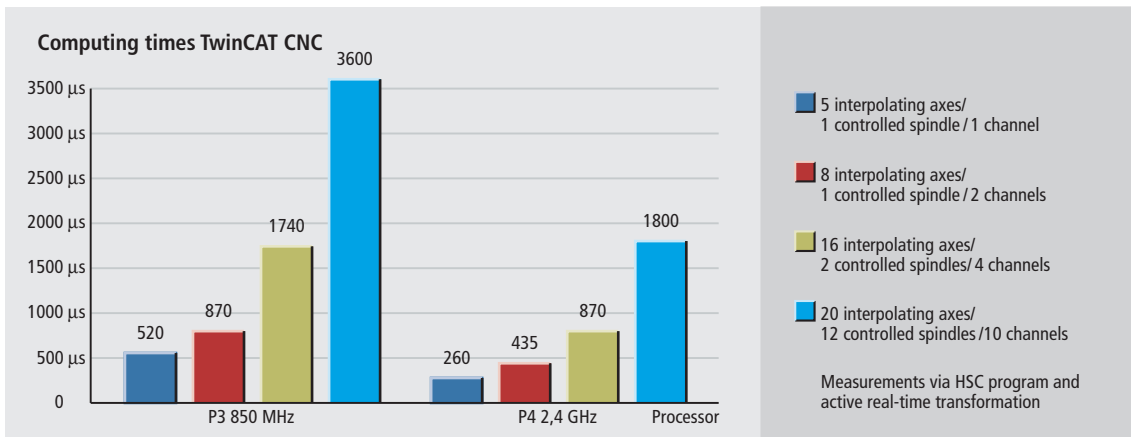
ing axes and a controlled spindle in two independent CNC channels. In each CNC channel, a CNC program for high-speed cutting (HSC) with active polynomial over-grinding and real-time transformation is executed.

If the commonly used cycle time of 2 ms is assumed, for example in connection with SERCOS drives, this relates to a computer workload of approximately 22% for this complex CNC application. The remaining processor capacity is available for PLC, PTP and HMI functionality. The TwinCAT CNC software solution therefore does not have to shrink from comparisons with conventional hardware-oriented CNC controls, even for demanding and complex tasks.

TwinCAT CNC can operate with up to 32 path axes and controlled spindles that can be distributed across up to 10 CNC channels with individual part programs. In one CNC channel, up to 32 axes and spindles can be interpolated simultaneously, enabling even the most difficult motion tasks to be solved. Axes can be exchanged and channels synchronized between the individual CNC channels. Based on these performance data, even large machining centers with several machining stations and integrated workpiece handling can be controlled with a single Industrial PC.

The range grows with demands

Since TwinCAT CNC is a member of the TwinCAT product range, the features of continuity and openness in terms of system functionality and the application of standardized programming tools and interfaces is a matter of course.





Dipl.-Ing. Thomas K. Pflug
Managing director of NC-Gesellschaft e. V.

The familiar configuration, programming and diagnostic tools of the TwinCAT system (System Manager, ScopeView etc.) offer the user the peace of mind of a uniform CNC solution.

TwinCAT CNC is based on TwinCAT PLC, the proven IEC 61131-3 software PLC and therefore has a powerful sequential control. If TwinCAT NC PTP is used as the basis, powerful motion functionality for positioning tasks is also available. Like in TwinCAT NC I, part programming in TwinCAT CNC utilizes subroutine techniques and high-level language extensions according to DIN 66025.

There is no question about functionality

The required axis and spindle functions, interpolation and feed functions, tool and help functions according to DIN 66025, and with specific expansions, are available for a variety of machining technologies (e.g. milling, drilling, handling, special machines).

But TwinCAT CNC also offers appropriate CNC functionality for high-end applications. Suitable interpolation and transformation functions are available, particularly for HSC machining of freeform surfaces and the classic "5-axis machining", in which the CNC programs are usually generated via CAD/CAM systems. Apart from the classic linear, circular and helical interpolations, the software CNC additionally offers convenient spline interpolation, optionally based on Akima or B-splines, for reducing the number of NC blocks.

In the interest of simple and flexible operation and programming, 5-axis machining with complex machine kinematics for difficult machining tasks requires real-time CNC transformations. They are used, for example, for defining different coordinate systems within the machining process or for generating automatic compensating movements of rotary axes. Optimum tool alignment and real-time corrections are thus possible without changing the CNC program. TwinCAT CNC provides the required CNC functions:

- | RTCP function (rotation tool center point)
- | TLC function (tool length compensation)
- | Kinematics selection from the kinematics library
- | Definition of different coordinate systems
- | Tool alignment in the chosen coordinate system
- | Linking/transition of coordinate systems

CNC controllers:

The subject of the NC-Gesellschaft e. V.

In 1975, "NC" was the big innovation and led to the foundation of the NC-Gesellschaft e. V. (NC Society – Application of New Technologies). This led to the concrete technology transfer task of enabling an efficient dialog between the machine tool manufacturers, the control partner and of course the end user.

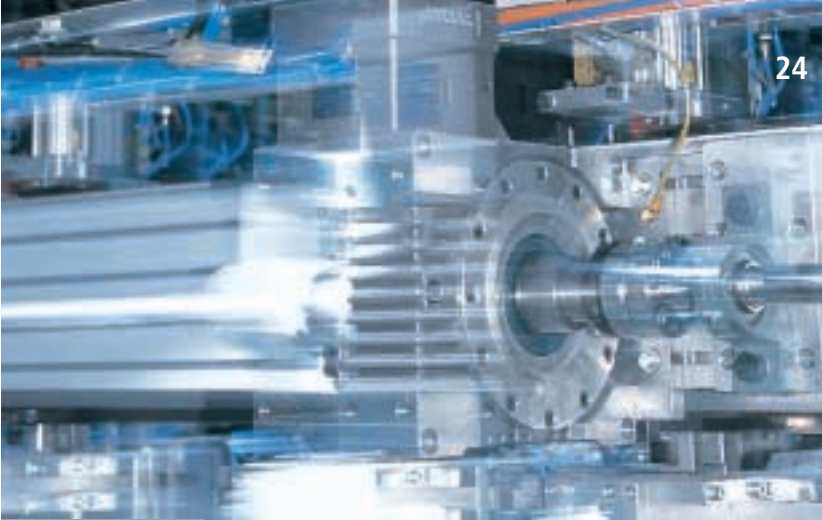
CNC controllers have therefore always formed one of the most important components in the process chain, which today has to be "uniform". With comparisons of CNC controls, the international HSC acceptance standard (3-axis milling) and the involvement in the subject of parallel kinematic systems (PKM), the NCG has accompanied this dialog continuously and in a practice-oriented way.

When Beckhoff joined the NC-Gesellschaft e. V. in 1994, the company was mainly interested in the activities of the NCG in the timber processing sector with its demanding automation aims. Today, Beckhoff is a Global Player in terms of automation and its components. It is therefore only logical that also 5-axis CNC controls and their requirements and targets are now at the centre of attention. With TwinCAT CNC, modern, open, PC-based CNC control is now available in the market.

A "5 axes" NCG working group is in preparation, which will be shaped by end users, machine tool manufacturers and of course the CNC control partners. As a member of the NCG, Beckhoff is very welcome in this working group.

NC-Gesellschaft e. V.:

→ www.ncg.de



Fieldbus technology – openness for I/O and drive technology

In the CNC world, TwinCAT CNC offers a new and unique openness in terms of machine periphery and drive systems through the consistent utilization of fieldbus technology. A variety of I/O modules and further automation components such as valve terminals, frequency converters etc. can be connected via all common fieldbus systems, enabling modern, decentralized interfacing of the machine. The drive systems are also consistently connected with the CNC via fieldbus systems. Depending on drive type, this can either be implemented via the classic analog/encoder interface with associated fieldbus modules or directly via a digital fieldbus interface (e.g. Profibus MC, SERCOS interface, Lightbus). This offers the user maximum openness and flexibility in the choice of drive systems.

Tailor-made CNC solutions

With TwinCAT NC I and TwinCAT CNC, Beckhoff offers two CNC products within the TwinCAT system with subtle differences. TwinCAT NC I is a slimline, flexible and cost-effective solution for CNC applications that require no more than 3 interpolating path axes and 5 auxiliary axes in one CNC channel. Up to 31 channels with a total of up to 255 axes can be used. In combination with the integrated TwinCAT PTP functionality for the complex control of positioning axes (master/slave, electronic gears, cam plate etc.), and through the option of on-line axis-exchange between TwinCAT PTP and NC I, an extremely flexible and powerful control solution for large systems with many axes and CNC channels is created.

In contrast, TwinCAT CNC is the solution for classic CNC application with up to 32 interpolating path axes and controlled spindles in one CNC channel or distributed across up to 10 CNC channels. In combination with comprehensive and powerful CNC functionality and the option of high-speed and 5-axis machining, TwinCAT CNC can cover the complete range of CNC applications in a variety of machining technologies.

With TwinCAT NC I and TwinCAT CNC, tailor-made software solutions are therefore available for the complete range of CNC path control, with a uniform PC-based hardware and software platform. What more could users wish for?!



Frank Saueressig,
manager of the Balingen branch
(Germany), CNC product marketing

With TwinCAT CNC, the new PC-based CNC control solution, Beckhoff opens up new, interesting automation technology market segments. On the one hand, we are now able to offer our customers in our core markets, such as special machine construction or wood-working machines, a uniform PC control including high-end CNC applications. On the other hand, for new customers in the classic CNC segments, such as machine tool manufacturers, we are also able to offer an attractive, powerful, flexible and open CNC control. With TwinCAT PTP and TwinCAT NC I, TwinCAT CNC rounds off the top end of our existing motion product range.

The unique continuity of the TwinCAT system from small PLCs to high-end CNC, and the continuous further development in the area of PC, fieldbus and drive systems offer our customers peace of mind in the form of a proven and at the same time innovative PC control solution.



Matthias Köster,
Software Engineering,
CNC product marketing

The new TwinCAT CNC product further underlines the Beckhoff philosophy of PC-based control technology. In combination with various fieldbuses, the TwinCAT CNC software is both open and very powerful. For programming and application, users have the familiar tools of the TwinCAT system available.

In addition to the ADS-OCX communication tool that enables access to CNC system parameters from outside, the HLI (High Level Interface) provides a direct connection between PLC and CNC, resulting in optimum data throughput. These TwinCAT CNC characteristics not only lead to significant time savings during commissioning, but also to process cost reductions, coupled with excellent performance.



TwinCAT NC I and TwinCAT CNC – ideal software solutions for path control



Properties	TwinCAT NC I	TwinCAT CNC
Max. number of controlled axes/spindles	255	32
Max. number of controlled spindles	–	12
Max. number of independent channels	31	10
Max. number of simultaneously interpolating axes/spindles per channel	3 path axes + 5 auxiliary axes	32 path axes/spindles
PLC programming	IEC 61131-3	IEC 61131-3
CNC programming	DIN 66025 extension High-level language extensions Subroutine techniques CNC function blocks from the PLC	DIN 66025 extension High-level language extensions Subroutine techniques User macros
Interpolation functions	Linear, circular, helical interpolation in the main planes Look Ahead	Linear, circular, helical interpolation in the main planes/ freely definable planes Look Ahead Spline interpolation Thread functions
Axis functions	Path override Axis fault compensation Gantry axes Tracking axes, Auxiliary axes Master/Slave coupling variable factor Axis exchange via channels Online changes of configuration of the axes Online axis exchange with PTP axes	Path override Axis fault/sag compensation Gantry axes Tracking axes, Auxiliary axes Master/Slave coupling Axis/spindle exchange via channels Spindle synchronization
Real-time transformations	Coordinate transformation	Coordinate and kinematic transformation 5-axis functionality
Axis interface	Analog/encoder axis interface via appropriate fieldbus Digital axis interface via Lightbus, Sercos, Profibus DP/MC, CANopen, real-time Ethernet	Analog/encoder axis interface via Lightbus Digital axis interface via Lightbus, Sercos, Profibus DP/MC
I/O system	Lightbus fieldbus system, Profibus DP, CANopen, DeviceNet, Interbus, Sercos, real-time Ethernet, PC interfaces	Lightbus fieldbus system, Profibus DP, CANopen, DeviceNet, Interbus, Sercos, real-time Ethernet, PC interfaces