numhsc

TOTAL SOLUTION FOR 5-AXIS MACHINING AND HSC

num
CNC HighEnd Applications

www.num.com

NUM Solutions and Systems
Established Worldwide

Outstanding solutions in machine automation have one thing in common: They are always the product of outstanding performance, exceptional technologies and a high degree of creativity!

num
CNC HighEnd Applications

And NUM has earned its exceptional reputation in the machinery and tools industry exactly with that. We develop customized automation solutions that ensure a high degree of added value both to the machine manufacturer and the user. With our expertise that we have developed over decades, we put our motto "NUM automation solutions provide machine builders with a competitive advantage" into practice.NUM had already developed the first CNC controller in 1961, i.e. 10 years before CNC– or NC control systems found a wide acceptance among users. With the launch in 1964, NUM was one of the first CNC providers in the world. Since then, we have maintained our position as a technology leader in this segment and are eager to expand it further. Today's systems, with their flexibility and our expertise, enable us to automate the most varied machinery. Our long, successful track record supports this finding in an impressive manner. We will continue to develop the readiness and flexibility of our systems in this direction and make the necessary investments in R&D as well as in our staff.

As an international company headquartered in Switzerland, we have sales, application development and service locations all over the world (see back cover) from which we operate worldwide. Our research and development departments are located in Switzerland, Italy and France. Our main production facility is located in Italy.

It is our clearly defined vision that we keep the development and manufacture of the core products in the CNC system, including the drives and motors, under our control. This enables us to adjust the important flexibility and readiness of the systems to new market requirements even in the short–term.

The ready and flexible NUM automation systems combined with our locally available engineering expertise and the machine manufacturer as a competent partner, results in a uniquely flexible and powerful team.

Customized Projects

NUM supports you with your projects in the same way as it is ideal for your business and infrastructure. The goal of our cooperation, however, always remains the same: To find the most efficient solution for your project together with you.

Project facilitation PRODESIGN

Efficient consulting for optimal application solutions
This model is ideal for companies with their own development teams and automation specialists. As an external partner, we provide our entire know–how in the field of CNC automation and take on an advisory role.

Project cooperation CODESIGN

Merging knowledge – potentiating results
Your development team will be combined with our team of specialists. Together we will realize the automation of your machine with clearly defined responsibilities. This form of cooperation has proven to be extremely efficient in many projects.

Total solutions ALLDESIGN

**Delegating responsibility – controlling result**
We assume the entire project management in the sense of a general contractor and are fully responsible for the successful implementation. Starting with the development of the requirements specification, over the development and commissioning, up to support and service.

NUM Solutions and Systems
Intelligent and Creative

We have developed countless customer- and application-specific solutions for different industries and thus mapped out practical solutions for professional requirements. Based on this, our engineers have created groundbreaking total solutions for demanding applications.

All of our solutions are based on a wide range of perfectly matched proprietary products such as CNC, drive amplifiers and motors. The partnership with our customers in the evaluation, project and installation phase is further maintained by our training, support and other services even after commissioning. We attach importance to ensuring that our customers are served by our professionals with specific knowledge.
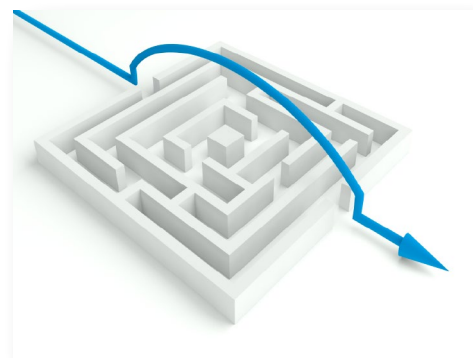
numroto

NUMROTO – successful trendsetter in high-precision tool grinding for many years

numspecial

NUMspecial – creative and practical solutions for your specific applications

numcut

NUMcut – a complete solution for advanced cutting machines

numgear

NUMgear – intelligent total solutions for new machines or as a retrofit in the field of gear machining

numtransfer

NUMtransfer – economical and flexible for all lot sizes for transfer, rotary transfer and multi-spindle machines

numhsc

NUMhsc – excellent quality at the highest speeds on machines with 5 or more axes

numgrind

NUMgrind – grinding and dressing cycles, with intuitive shop floor entry screens and 3D visual validation

nummill

NUMmill – flexible solution with a graphical interface for extensive milling cycles, including full 3D simulation

numwood

NUMwood – long tradition with powerful complete solutions in woodworking

numretrofit

NUMretrofit – rational extension of the service life of your machine by years

NUMhsc – First Choice for High Speed Cutting and 5-Axis Machining

Exceptional performance for exceptional requirements – this is why NUMhsc was developed. Successful companies in high-tech sectors have relied on complete HSC solutions from NUM for many years.

The NUMhsc solution blends state-of-the-art technology for the entire system with comprehensive specialist know-how and application expertise. Each NUMhsc solution is based on powerful hardware developed in-house, backed by a range of software functions especially developed for the application. Machine manufacturers are supported by our specialists in defining and fine-tuning the HSC solution to exactly suit their requirements, in order to achieve maximum performance, precision, speed and surface quality. Adapting and optimizing the hardware and software to each and every specific application provides unparalleled results.

NUM's CNC systems have always distinguished themselves through their openness and their versatile communication capabilities. These attributes have been continuously enhanced from one generation of controllers to the next. The current Flexium⁺ CNC control system is PC-based and includes a wide range of communication options, thus satisfying the basic prerequisite for a possible Smart Factory. Horizontal integration is mainly implemented using fieldbuses such as EtherCAT or CAN. Vertical communication to SCADA, MES and ERP systems can be carried out via OPC UA, OPC DA, MTConnect, MQgateway and other freely definable communication interfaces – any and all of which can be implemented efficiently and comprehensively using NUM's FXServer.

The machine operation was developed for use in sophisticated applications and is clearly structured. Even the most complex forms can be easily programmed and the logical user structure makes working on the machine far easier.

NUMhsc – high-performance as a principle

NUMhsc – team work in all areas
5-axis machining and high-speed cutting demand maximum performance from all components. The technical base is extremely rigid and has a good shock absorption system which is tailored for this application. High quality, dynamic and speed requirements demand a solid construction and appropriate clamping. The demands on the rigid and cooled spindle are also extremely high. This is manufactured and balanced precisely, and is housed in a dynamic motor which accommodates a very wide range of applications. The brackets and tools manufactured especially for HSC reflect the demands on the machine.

NUMhsc is the ideal complement for the type of machine designed to this degree of perfection. All elements are designed specifically for HSC applications, including the CNC, servodrive and motors, together with the associated dedicated software, intelligent algorithms and interpolations. NUM emphasizes the importance of creating an impressive overall system instead of just excelling in one single field. We symbolize perfection in surface quality, speed and efficiency, even for difficult procedures.

Our success can be seen in the workpiece
Fine adjustment of all elements on the machine, together with first and second grade precision interpolation in the servo motors, ensures the best possible machining. The simple operation of NUM's CNC systems enables this performance to be readily achieved. On the following pages, we present some of the functions which exemplify NUMhsc perfection.

Intelligence for exceptional precision and surface quality
NUMhsc can be easily integrated into your company's network and therefore your production system. CAD/CAM data can be imported directly into the system and is then processed by exclusively developed algorithms for production and precise interpolation in the servodrives. In this way, NUMhsc is able to achieve a surface quality which meets the very highest requirements.

NUMhsc – First Choice for High Speed Cutting and 5-Axis Machining

High-precision contours

A whole package of specific software developments serves to create high-precision contours. The Look Ahead function enables material removal as quickly and evenly as possible, processing the command in advance and acting accordingly. Jerk Control (smoothed Jerk) prevents chatter marks and also enables much higher speeds and significantly improved surface quality. Special algorithms increase the position accuracy of the control during high-speed machining and thus reduce geometry errors.

To compensate for machine tool errors arising from factors such as imperfect geometry and dimensions of machine components, axis alignment errors, motion errors of linear or rotary axes, thermal deformation, dynamic or structural deformation of the machine under load, NUM's CNC systems provide a Volumetric Error Compensation function (VEComp); this is a real time application which compensates for spatial machine errors.

The Advanced Resonance Suppression (ARS) in the servodrives compensates for active instabilities in the machine and suppresses resonance significantly. Other filters and functions are available for adjusting the rigidity of the drive to an even higher level. All these functions improve the quality of curves or edges and ensure that instructions are executed as precisely as possible.

Intelligent algorithms for the highest quality

RTCP

The RTCP (Rotation Tool Center Point) function was originally launched onto the market by NUM and is an essential part of CNC machining. RTCP is able to keep the tool tip continuously in the workpiece. The post-processor calculates the position of the rotating axes and the CNC does the geometric transformation in real time so that optimal cutting conditions are maintained at all times. This reduces the machining time, the surface quality is better and the tool is subject to less strain.

Inclined plane

Programming complex forms is greatly simplified and shortened, using the inclined plane function. In addition to the six levels already in the XYZ coordinate system, an inclined plane can be created at any rotation angle. The workpiece contour can now be programmed as in a normal level and the programmer is spared the complicated spatial thought processes altogether. If the program is interrupted during production, the "Inclined plane" function remains active and the user can, for example, maneuver the tool out of the drill hole manually if it is broken.

Workpiece positioning compensation

When a workpiece is positioned on a machine it might be very difficult to align it perfectly due to its weight, its structure, a previous machining operation or for some other reason. A shift parallel to the main axes is not a problem and merely requires an offset to adjust it. However, a tilt can become quite tricky because it implies compensation of the tool orientation. One common solution, after identifying the offsets and tilt angles, is to reprocess the program in order to take the misalignment into account, but this obviously takes some time. NUM offers cycles and parameters specifically to easily align the workpiece or to apply compensation – and the HMI provides a dedicated page to further help the end-user check the setting. The advantage is that the part program will not be changed but the CNC will compensate for misalignment automatically by a rotation of the tool vector.
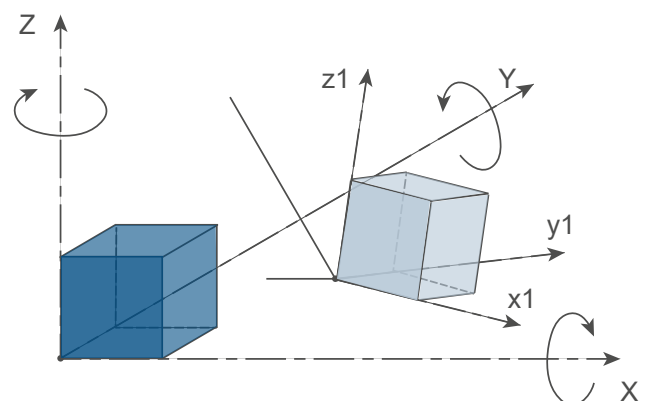
Tool vector programming

With the Workpiece misalignment compensation we introduced the concept of tool vectors. This approach can also be used to generate part programs independently from the machine. A part program written using tool vector orientation can run on machines with different kinematics. In fact, a CNC system that knows about the kinematics of a particular machine can compute the angles of physical rotative axes and the linked linear transformations. The advantage is that a part program can potentially be generated without needing to know the kinematics of the machine on which it will be executed.
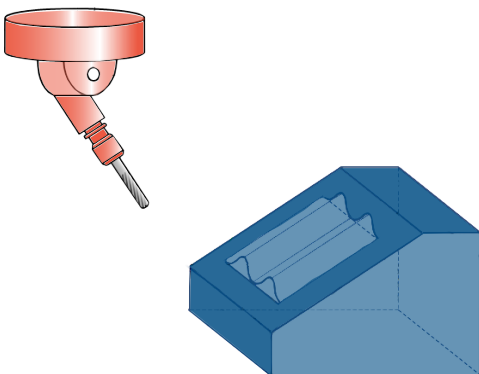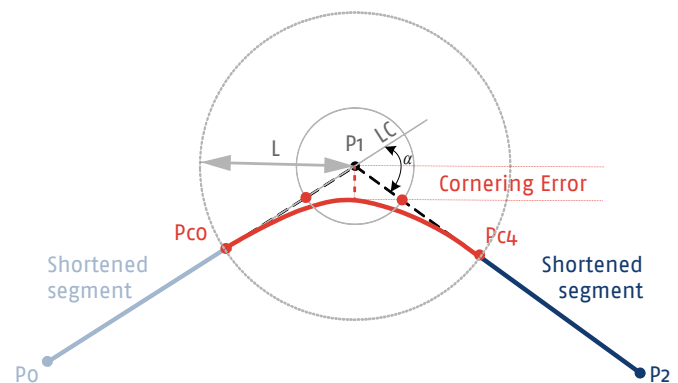

Polynomial interpolation

The polynomial interpolation calculates polynomials up to 5 degrees in real time. Facets are then suppressed, which results in a far better surface quality. Furthermore, the speed of complicated tracks can be better controlled, which also has a positive impact on surface quality and tool life.

Spline and NURBS interpolation

The interpolation of splines and NURBS (not uniform rational B splines) in CNC supports up to 6 axes and 5 degree polynomials. The RTCP function can continue to be used if required. The improved surface quality and smooth track specifications often go together. Complicated tracks can be better controlled with smaller workpiece programs, where the CNC has less to handle, which again has a positive impact on surface quality and tool life.

Contour rounding function

A tool path described by G1 linear segments, such as a program generated by CAD/CAM, induces some tangency discontinuities among blocks. A special algorithm has been introduced in order to have a more fluid feed-rate and to obtain a high and constant speed in corners. Based on the allowed corner error, the algorithm adjusts the path. The deviation is defined by parameters.

Smoothing: NUMcoss 3D simulation

High-level smoothing: NUMcoss

NUMcoss uses the polynomial interpolation from NUM and creates one continuous movement in real time from the individual, small instructions in the postprocessor. Geometric errors, as well as the number and size of facets, are reduced, resulting in higher precision and greatly improved surface quality. Reducing the amount of data and the number of braking procedures on the radius edges serves to accelerate the machining process. NUMcoss can also calculate in real time, exactly as used during preparation of the production program.

3D simulation and 3D collision monitoring

As well as perfect simulation of the complete workpiece, the software can also be used for measuring geometric features, creating cross-sections of the workpiece and analyzing the volume of removal for each machining process. The 3D collision monitoring function can check the complete machining process for collisions on command, fully-automatically or in parallel

NUMhsc – First Choice for High Speed Cutting and 5–Axis Machining

with CNC file transfer. The collision check only takes a few seconds when used with normal workpieces. In the manual operating mode, online collision monitoring can help the end-user to avoid machine damage, especially with inclined plain or RTCP active, where some axes' movements could be unexpected. The "online collision monitoring" function supervises the axes' movements in manual mode continuously, and in the event of a potential collision will stop the axes' movement in advance.

NUM CNC Systems: The modern heart of NUMhsc

Every NUMhsc solution offers a choice of CNC performance levels to best suit the application. The Flexium⁺ NCK stands out with its exceptional high performance and flexibility and is a key element of NUM's solutions and systems. The Flexium⁺ platform benefits from compact dimensions, reduced power input, efficient, modern processors with high computing speeds and an intelligent structure for further extensions. The reload mode and the very large memory ensure continuous operation for comprehensive programs. NUM's range of MDLUX servodrives also offer a choice of different performance levels. The Flexium⁺ platform is fully scalable and can accommodate all customer requirements, ranging from the simple to the most complex application.

Instruments for Optimization

For easy commissioning, a huge set of instruments is available: Ball-Bar, Contour Accuracy, Frequency Analyzer, Oscilloscope and others.

Ball-Bar
The Ball-Bar checks the behavior of the axes and allows adjustment of the servo drives' parameters. Thanks to circles drawn by G02/G03 or by small segments (Tabcyls), this function generates a diagram of the radial error on the main axes or other axis pairs, which facilitates adjustment of the following parameters:
- Acceleration anticipation coefficient
- CNC reference filter time constant
- Pitch compensation
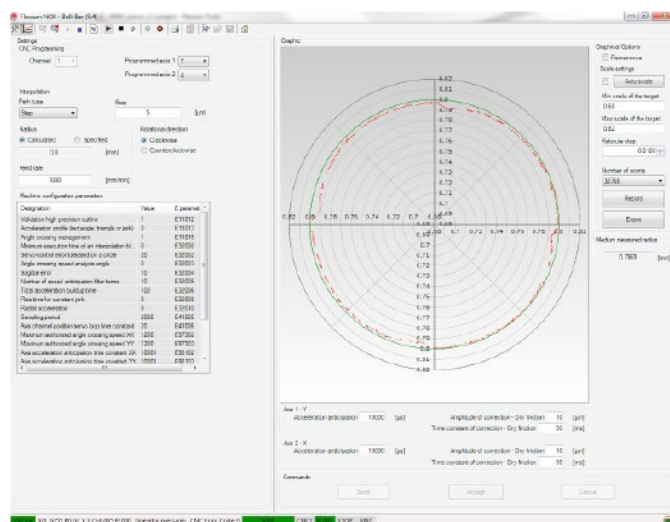
Example of a Ball-Bar trace

Frequency analysis
Frequency analysis is used to optimize the speed and position control loops of the drives. Different signals can be selected and displayed as a Bode plot. Based on it, the regulating quality can be determined. Unwanted resonances can be detected. They can be reduced by mechanical adjustments or a filter of the drive.
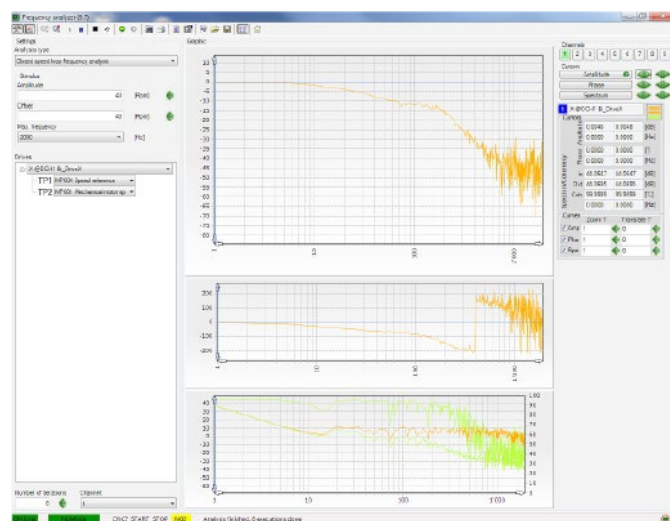
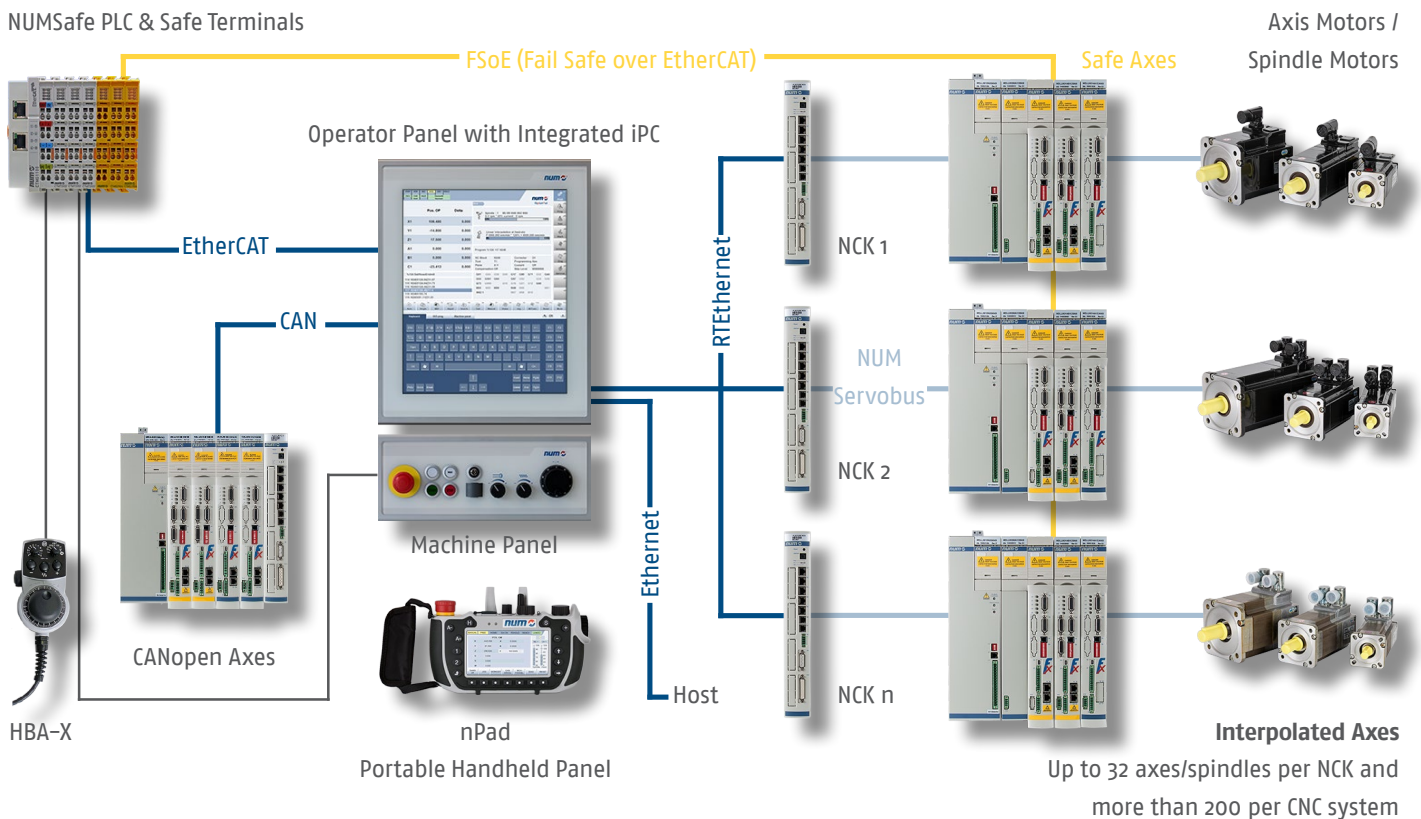*Example of a Frequency analyzer trace.*

Flexium+ CNC-System
Flexibility, Productivity and Safety

Flexium+
Extreme Scalability

flexium+

CNC System

NUM EtherCAT Terminals
NUMSafe PLC & Safe Terminals

FSoE (Fail Safe over EtherCAT)

Safe Axes

Axis Motors /
Spindle Motors

Operator Panel with Integrated iPC

EtherCAT

CAN

RTEthernet

NCK 1

NUM
Servobus

NCK 2

Machine Panel

Ethernet

Host

NCK n

CANopen Axes

HBA–X

nPad
Portable Handheld Panel

Interpolated Axes
Up to 32 axes/spindles per NCK and
more than 200 per CNC system

The control system is characterized by an extremely high scalability. It allows the perfect adaptation to the respective application solution. Thus, in a simple way, systems from 1 to over 200 CNC axes can be realized. The Flexium+ system has a secure PLC in addition to the normal PLC, which communicates via FSoE (Fail Safe over EtherCAT) with the secure inputs and outputs as well as with the NUMDrive X drive control systems. The system covers all necessary safety functions in a simple manner. The programming of the safety logic is carried out with the same software tool as the rest of the PLC. This same tool is also used for the entire system parameterization and commissioning of the machine.

The NUMDrive X drive solution is the result of more than 20 years of experience in the development of fully digital drive systems. It is available in different versions with different performance data. The wide range of drive amplifiers is available in single and dual axis versions and also in different performance levels (processing power). This allows a technical and financially optimum adaptation to every application. These modules are designed for rated currents of a few up to 200 amps. Another strength of the drive amplifier is its compactness and high energy efficiency.

NUM Motors
Perfect for all Applications

Excellent volume/performance ratio and great dynamics, so that our motors can satisfy almost all applications.

NUM has more than 50 years of experience developing servo and spindle motors. We pioneered the development and production of AC brushless servo motors, as well as synchronous spindle motors with flux weakening.

The comprehensive **servo-motor** series of NUM offer an excellent volume/output ratio, as well as first-class dynamic properties optimized for the machine tool industry. They, with perfect concentric run-out, satsify even at very low speeds. The so-called "single cable" motors offer the advantage that the complete measuring system cable is eliminated. This simplifies the wiring of the machine significantly and thus saves money.

The **asynchronous motors** of the AMS series offer excellent quiet running at low speed, quick and accurate positioning and are ideally suited as a C-axis and for spindle indexing.

The TMX series **torque motors** have an extremely low cogging torque as well as a very high S1 torque density. They are ideal for applications that require very smooth and precise motion, especially at low speeds. Typical applications are direct drive rotary tables or workhead axes of machine tools. The TMX motors are complemented by an extensive range of torque motors from our partner company Schaeffler Industrial Drives (IDAM), who's customers include many well-known European machine builders.

Key data of the motor series:
- Servo-motors from 0.318 to 160 Nm (IP65, IP67)
- Rated speeds of the servo-motors up to 8000 rpm
- Spindle motors up to 55 kW
- Special kit motors
- Liquid-cooled spindle motors
- Liquid-cooled servo motors
- Asynchronous and synchronous motor spindles (motor spindle)
- "Single cable" motors
- Custom motors
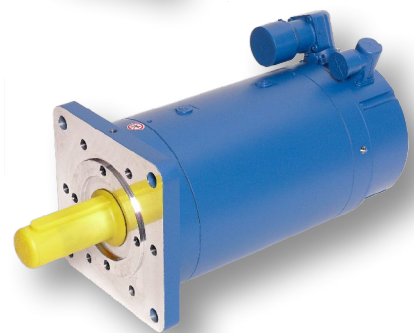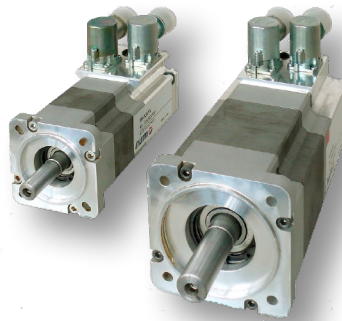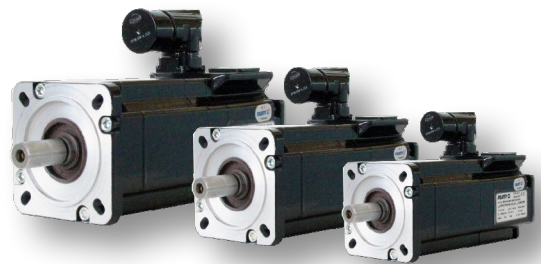
SCHAEFFLER

NUM Services
Worldwide at your Service

The decision for NUM is also the decision for a customer service that will support you long after the initial investment as on the first day – even after 20 years and on-site. Our specialists can ensure an extended life for your good (but old) machinery with NUM retrofits.

Worldwide support by experts

For professional analysis and trainings, a perfect infrastructure is available to our experts in all centers of excellence. So that we can assist you quickly and efficiently around the world, we also rely on the advantages of the most modern communication technologies, e.g. for remote maintenance via Internet. Of course, we will be happy to offer advice on site in your company.
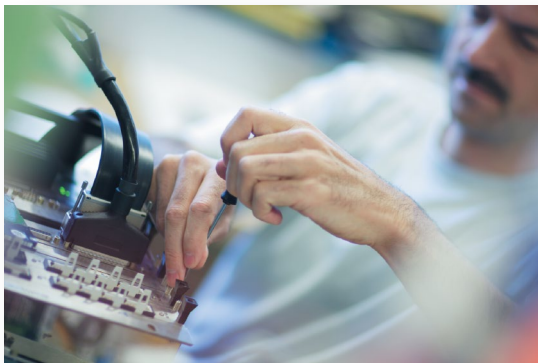
Comprehensive training offer

We orient our training to your indivual needs – whether its operator training, maintenance, repair and service training, PLC programming, or adjustment of servo drives.

NUM provides a training offer matched to the customer needs:
· CNC operation
· CNC programming
· PLC programming
· Commissioning and servicing
· Preparation of custom surfaces
· Customized customer training

Technically always up to date

Our team of specialists will actively inform you on the latest hardware- and software developments and provide you with useful technical information.

Repair- and spare parts service

If an error unexpectedly occurs in your CNC system in spite of proper maintenance, you can trust that this will be fixed by dedicated service employees of our global network.

Customer service

For you and your markets, we have a worldwide service organization. The International customer service provides telephone consultation, deployment on site, even for many years old installations. With a retrofit from NUM, the operating time of an excellent machine can be extended by many years.

Our customer service is available and responsive to help even with cutting edge products and custom developments. We carry local inventory and have your materials and components in stock ready to meet your requirements for quality and delivery times.

Complete CNC Solutions Worldwide

num
®
CNC HighEnd Applications

Finland

Sweden

Great Britain

Germany

Russia

Austria

France

Switzerland (Headquarters)

Spain

Italy

USA

Turkey

China

Mexico

Taiwan

India

Thailand

Brazil

South Africa

Australia

■ NTC (NUM Technology Center)
■ NUM Agent
■ NUM Contact

NUM systems and solutions are used worldwide.

Our global network of sales and service locations guarantees professional service from the beginning of a project to its execution and for the complete life cycle of the machine.

NUM has service centers around the world. Visit our website for the current list of locations.

Follow us on our social media channels for the latest information on NUM CNC Applications.

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