



**HEIDENHAIN**

# Klartext

The TNC Newsletter



**30 Years of  
TNC Controls**



**New Functions  
of the iTNC 530**



**3-D Touch Probes  
for Workpiece  
Measurement**



Issue 45 • 6/2006

## Editorial

### Dear Klartext Reader,

30 years of TNC control. To us these are proud words. The number of controls shipped is also considerable—the 190,000th will be shipped this year! And regular TNC courses have been conducted here in Traunreut for some 25 years now. Every year, approximately 1000 participants take advantage of an extensive training curriculum.

At the METAV, too, there will be an impressive number of innovations around the iTNC 530! The topics of this year's METAV include the introduction of Dynamic Collision Monitoring (DCM) and the capability to process dxf files immediately with the iTNC, as well as other

improvements in user friendliness, for example the handy TNCguide help system. You'll find further information starting on page 6.

On page 12 we report on an interesting improvement in our touch probe product line. The contact-free laser systems and the TT 140 now provide a comprehensive product range for tool calibration.

The article on the Deuringer Maschinenbau OHG shows how retrofitting can guarantee higher profitability.

Have a good read! And let us know what you think of it.



The control continually remains in nominal position. If the axis remains in motion, when the axis at this point.





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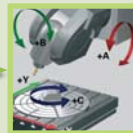
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**Klartext on the Internet**

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## 30 Years of TNC Controls

This year HEIDENHAIN will ship its 190,000th NC control. This is a remarkable achievement after a 30-year history of development.

### Thirty years of TNC development

Thirty years ago—in 1976—HEIDENHAIN began developing the first TNC control, the TNC 110, which was displayed at the FAMETA in Stuttgart in October 1976. All of three TNC 110 controls were sold. Its successor, the TNC 120, already featured a program memory with 64 program steps and sold a total of 70 units.

The successor model TNC 121 was already available in the fall of 1977. The TNC 121 was equipped with a memory of 128 blocks for program part repeats and subprogramming. The program memory was battery buffered, which ensured that the entered programs stayed in memory even after the machine was switched off. With the TNC 121 HEIDENHAIN attained total sales of 6200 units, which effectively marked the beginning of the TNC success story.

### The first contouring control

The first contouring control—the TNC 145—was introduced at the EMO 1981, followed two years later by the TNC 150, a contouring control with four axes and integrated PLC. In 1984, the TNC 155 came on the market—the first HEIDENHAIN control with graphic simulation of the machining process. It was also the first to permit G-code programming according to ISO 6983 (DIN 66025) in addition to conversationally guided plain language programming. This gave the TNC excellent qualifications both for shop-floor and offline programming.

With the TNC 355 in 1987, HEIDENHAIN separated the keyboard from the logic unit.

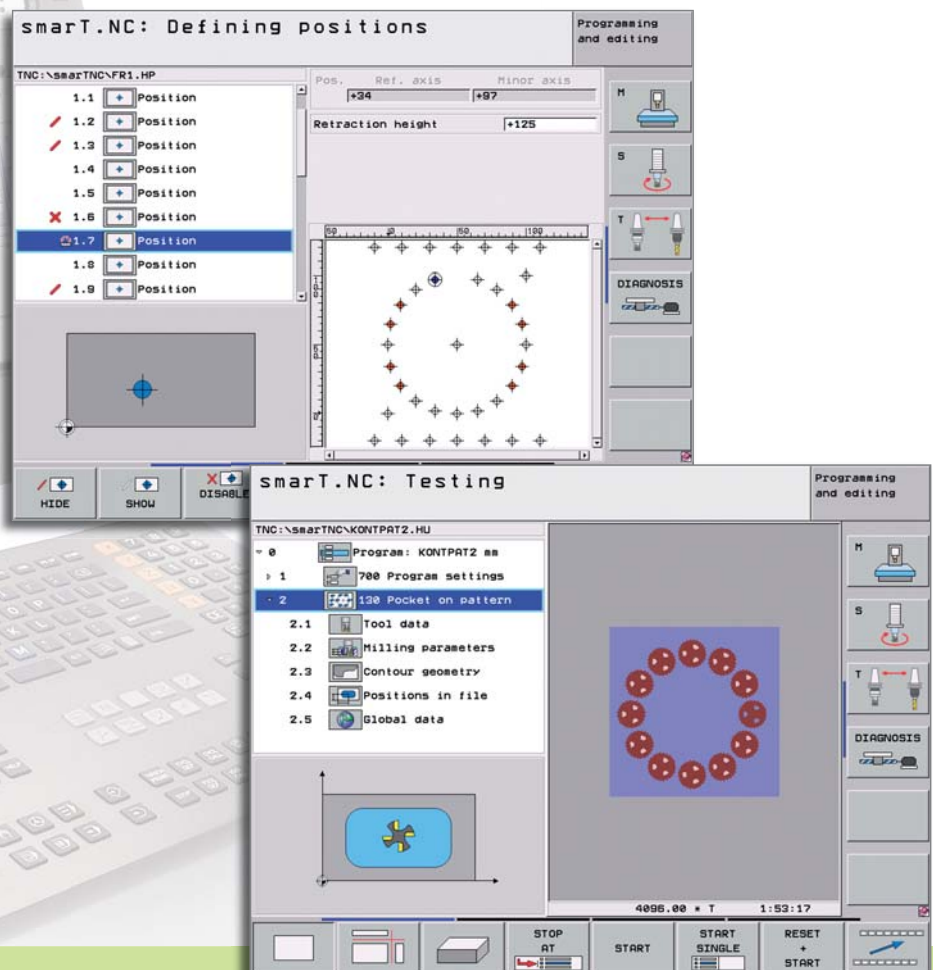
At the 1989 EMO in Hanover, an entirely new generation of controls was introduced: the TNC 415 with 32-bit processors, color screen and alphabetic keyboard.

### Integrated motor control

HEIDENHAIN has been working with digital motor control since 1989. First, the velocity controller was integrated in the TNC, thereby allowing the advantages of digital velocity controller to be used together with analog inverters. This control—the TNC 425—was presented in Paris at the EMO 1991. In the fall of 1994,

HEIDENHAIN came forward with the TNC 426 and made a further step toward integration: with the velocity and current controller all elements of drive control were incorporated in the TNC. The product line was expanded to include motors and inverters.

The introduction of the iTNC 530 at the EMO 2001 heralded a new age in TNC controls—with an entirely new hardware architecture. It continues the successful TNC contouring control idea and, with its short block processing times and optimum path control, sets new standards in high speed machining.



Since the EMO 2005, the compact contouring control TNC 320 is available as an alternative to the iTNC 530 for installation on simple 3-axis machines, on boring machines, and for retrofitting.

**smarT.NC**

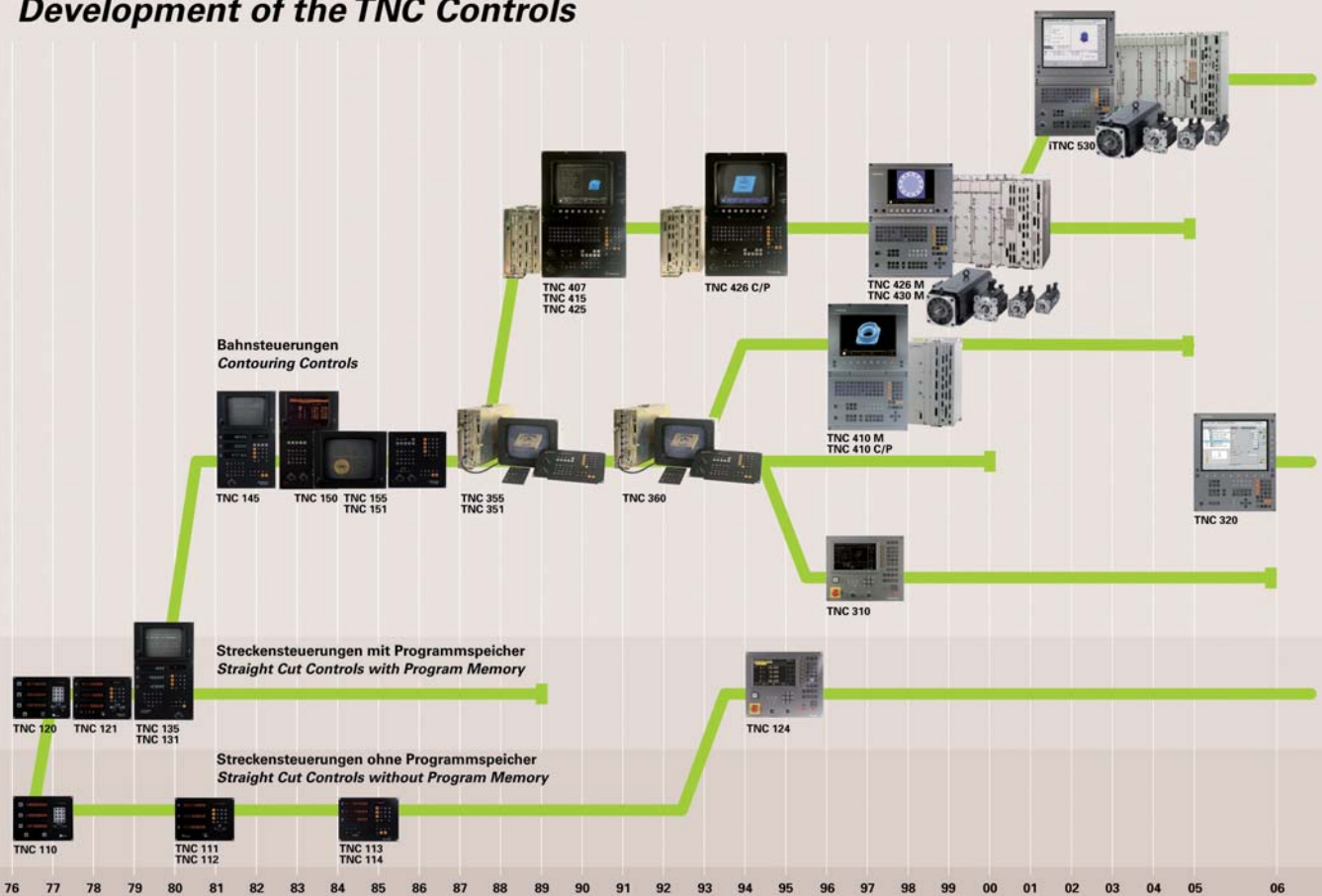
The new **smarT.NC** operating mode, which was presented at the METAV 2004, is yet another step forward toward greater ease of use. smarT.NC continues the success story of this shop-floor programmable user interface. Well-structured input forms, straightforward graphic support, and

comprehensive help texts combine with the easy-to-use pattern generator to form a compelling programming environment. And in spite of smarT.NC's entirely different user interface, it stands squarely on the proven HEIDENHAIN plain language dialog. Because in the background—out of view for the user—smarT.NC generates the program in conversational format.

**The TNC in numbers**

By the METAV, HEIDENHAIN will have built and shipped its 190,000th NC control. These comprise about 50 separate models. The most successful among them is the TNC 426 with 25,000 units sold since its introduction in 1994. With over 145,000 units, the contouring controls comprise about three fourths of the total number, as opposed to 45,000 straight cut controls. In 2006, an estimated 9,000 controls will leave the factory.

**Die Entwicklung der TNC-Steuerungen**  
*Development of the TNC Controls*




# New Functions for the iTNC 530

The topics of this year's METAV include the introduction of Dynamic Collision Monitoring (DCM) and the capability to process dxf files immediately with the iTNC. Other improvements in user friendliness include the handy TNCguide help system, which will be available by the end of 2006 as software version 03.

## TNCguide help system (FCL3 feature)

The iTNC 530 numerical control and iTNC 530 programming station now feature the TNCguide, a convenient help system that can show the user documentation through a browser. Pressing the HELP key calls the TNCguide, which in some cases opens at the page appropriate to the current situation (context-sensitive help).

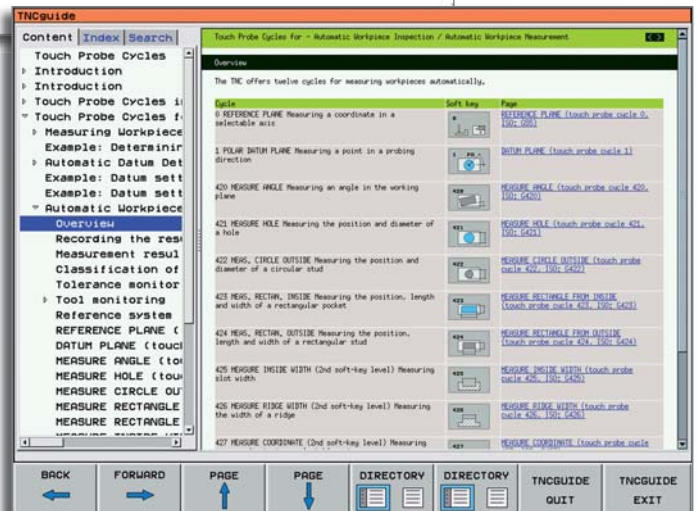
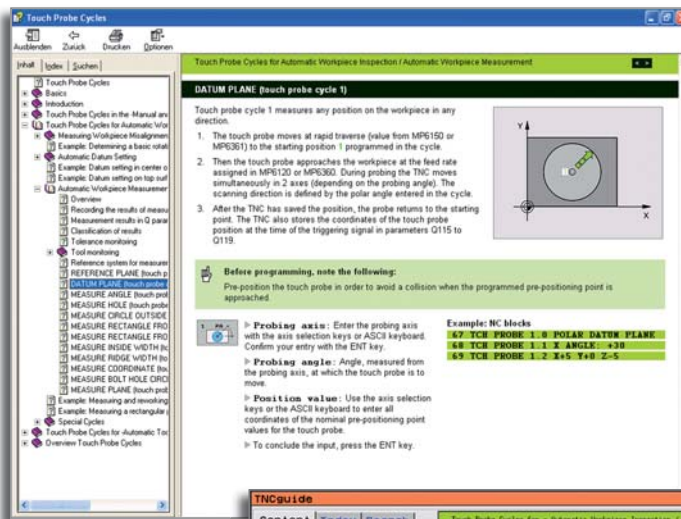
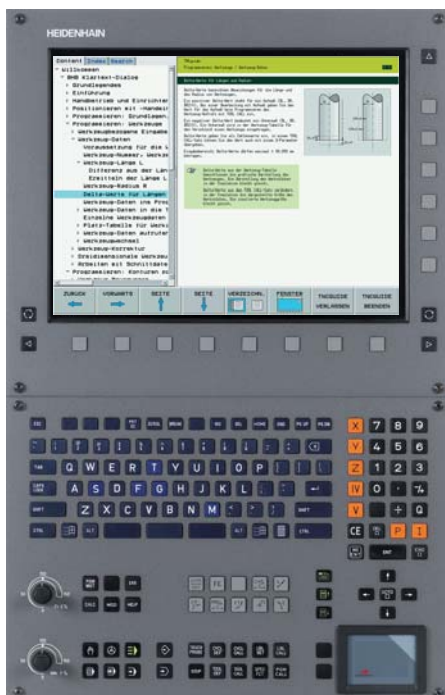
In addition, you can call the TNCguide by clicking the help command and pointing with the moving question mark at any soft key. To activate the question mark symbol, you simply click the help symbol always present at the lower right of the TNC screen .

With each NC software license, HEIDENHAIN supplies the German and English documentation. HEIDENHAIN provides the other conversational languages for downloading free of charge as soon as the translations become

available. After download, you can save the national language files in the corresponding language directory on the TNC partition.

The following manuals are available in the help system:

- User's Manual, conversational programming
- User's Manual for smarT.NC
- User's Manual for touch probe cycles
- User's Manual for the iTNC 530 programming station (installed only in the programming station)

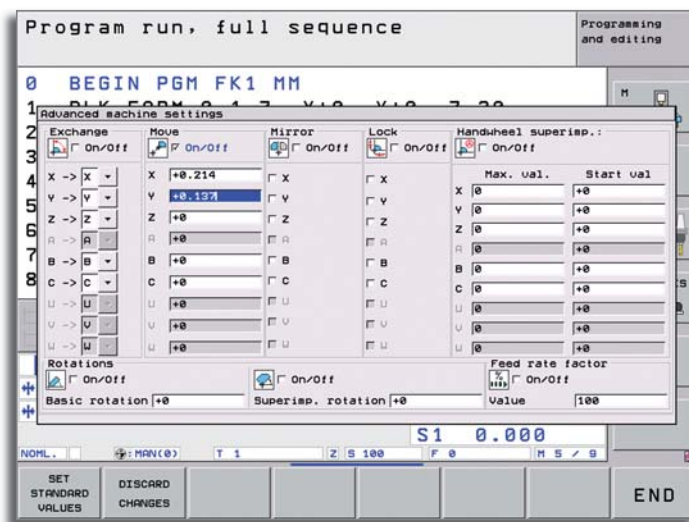


**Global program settings (option)**

The global program settings, which come into play particularly in large-scale mold making, it is available in the Program Run

and the MDI mode. It allows you to define various coordinate transformations and settings with global and priority effect for the respectively selected NC program, without having to edit it.

You can change the global program settings in the stopped condition even within a machining operation. After the TNC starts from this position, it moves, if necessary, to a changed position with a positioning logic influenced by you.



The following functions are available:

- Swapping axes
- Additive datum shift
- Superimposed mirroring
- Axis locking
- Handwheel superimposition, with axis-specific memory of paths covered per handwheel
- Superimposed basic rotation
- Superimposed rotation
- Definition of a globally effective feed rate factor

**Option for Adaptive Feed Control (AFC)**

With adaptive feed control (AFC), the feed rate is automatically regulated by the TNC according to the respective utilized percentage of spindle power. This is done with the aid of the feed-rate override factor, which is normally calculated from the position of the override potentiometer. When AFC is active, this factor is no longer derived from the potentiometer, but from the spindle power and other process data from which the feed rate is calculated.

In a teach-in cut, the iTNC records the maximum spindle power. Then, before actual machining, you define in a table the

respective limit values between which the iTNC can influence the feed rate in the adaptive control mode in the "control" mode. Of course, various overload reactions can be specified, which can also be defined by your machine tool builder.

Benefits of adaptive feed control:

- **Optimization of the machining time**  
Particularly on cast parts, fluctuations in dimensions or material and blow-holes often appear. With a corresponding adaptation of the feed rate, the control tries to keep the previously "learned" maximum spindle power during the entire machining time. The total machining time is shortened by

an increased feed rate in the machining zones with less stock removal.

- **Tool monitoring**  
When spindle power consumption is exceeded at the same time as the feed rate falls below minimum, the control responds with a programmed shut-down. This prevents damage resulting from tool breakage or wear.
- **Reduction of machine wear**  
Reducing the feed rate down to the reference value whenever the learned maximum permissible spindle power is exceeded also reduces the strain and wear on the machine. It effectively protects the spindle from overload.



# New Functions for the iTNC 530

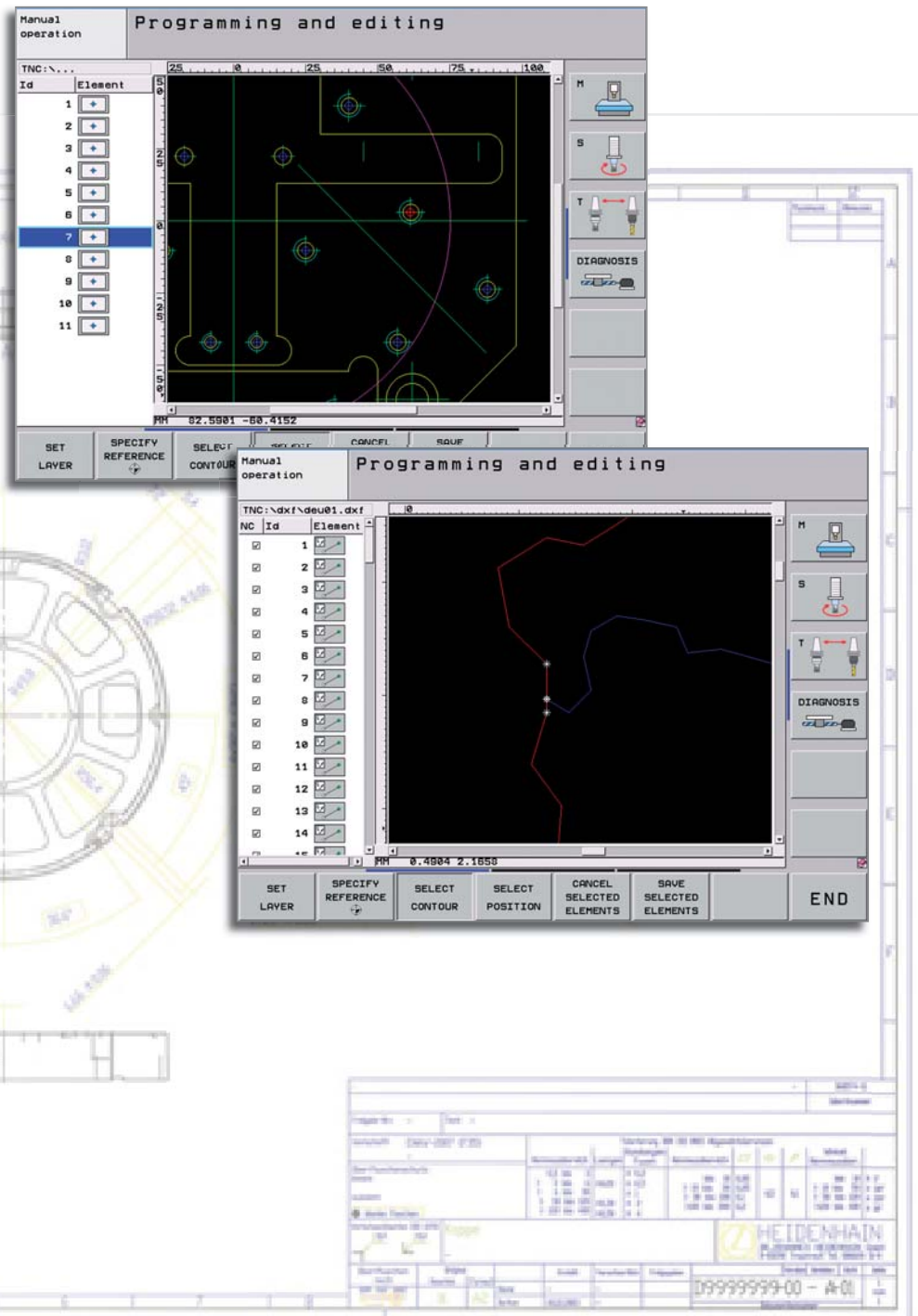
## Improvements in the DXF converter (option)

With the DXF converter you can now also select machining positions in addition to contours and save them as a point table. You can define the following locations as machining positions:

- The beginning, end or mid-point of a line
- At the beginning, end or center point of a circular arc
- Quadrant transitions or center point of a circle
- Intersection of two lines, regardless of whether it is located inside or outside the programmed segments
- Intersection of a line and a circular arc
- Intersection of a line and a circle

You can use the point tables generated in the DXF converter very conveniently in smarT.NC, however the function is also available in conversational programming.

The selection of contours was simplified as well. The design engineer does not always define the contours so that they can be selected directly without manual rework. For example, now you can separate laterally joined contour segments that would otherwise prevent contour selection. The extension and shortening of contour segments is now also allowed if the desired element limits are too far apart. Both functions are always available within the contour selection mode, by the way, so you need not decide beforehand which segments will have to be modified. The iTNC automatically detects critical places and indicates with symbols that the segments have to be separated, lengthened, or shortened.



# New E-Learning Module “Fundamentals of Machining in Tilted Working Planes”

Since October 2004, HEIDENHAIN has been a partner in a European project group. An e-learning project entitled “**Modular Interactive Training System for Vocational and Distance Training in Mechatronics (MITS)**” is being developed as a part of the “**Leonardo da Vinci**”\* program.

In this e-learning project, which extends over three years, members of the Technical Training department are developing the content of a web-based training program on the fundamentals of NC programming, from which they will prepare the individual learning modules.

The media that form the basis of the e-learning project are interactive, animated training sequences as well as interactive comprehension checks and tests with automatic scoring.

This type of training is intended

- as preparation for group instruction
- to supplement group instruction
- in the context of self-paced study

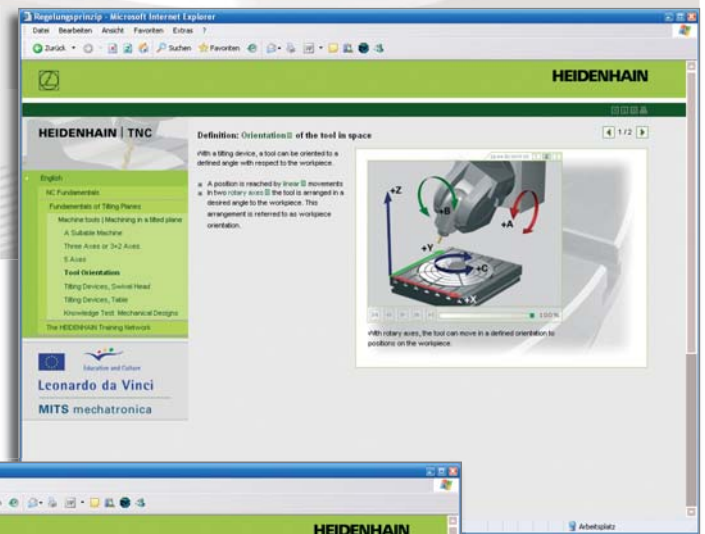
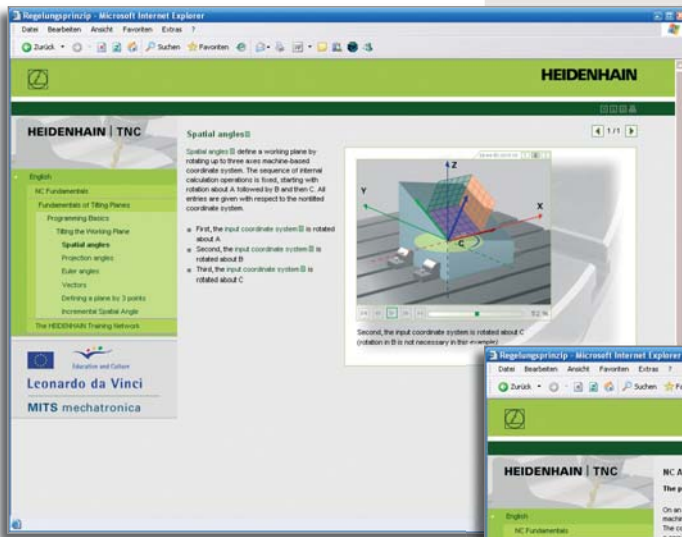
The following modules have been completed in German and English:

- Fundamentals of NC Programming
- Fundamentals of Machining in Tilted Working Planes

A further learning module is scheduled for 2007. HEIDENHAIN plans to produce additional modules after the project is concluded.

The 2nd module, “Fundamentals of Machining in Tilted Working Planes” became available in time for the METAV in Düsseldorf and is available free of charge on a “**TNC Training**” CD and for downloading from the HEIDENHAIN web site.

You can find more information at [www.heidenhain.de/schulung](http://www.heidenhain.de/schulung)



\* “Leonardo da Vinci” is a program of the European Union to promote vocational training.

## 25 Years of Technical Training

When the "Training and Documentation" office of the Service Department was founded in 1981, it consisted of a single man: Hannes Wechselberger. Today there is a number of professionals working on the training effort at HEIDENHAIN in Traunreut as well as in locations such as Fellbach, Hagen, Hanover, and in the regional agencies.

The first official TNC programming course at HEIDENHAIN took place in the fall of 1981.

Not more than a year later, HEIDENHAIN was providing regular TNC programming courses organized by Sales & Marketing personnel. They were intended primarily for machine tool builders, retrofitters and distributors. At the same time, courses were conducted—at that time exclusively for HEIDENHAIN agencies—in TNC field service and repair.

By the introduction of the TNC 150 in 1983 the range of courses given by Sales comprised basic and advance courses, and

### Interested in HEIDENHAIN training?

You can inform yourself conveniently on the Internet at [www.heidenhain.de/schulung](http://www.heidenhain.de/schulung). Here you will find not only the complete program of courses, but also the number of slots currently available. From here you can apply directly by e-mail for a desired course.

You'll also find addresses for training sources at HEIDENHAIN regional agencies and at authorized HEIDENHAIN training partners, as well as links to their home pages.



It was intended for employees from our regional agencies and was on the topic of the "Use and Repair of the TNC 121, TNC 125 and TNC 131 Controls."

The instructor for TNC programming was Klaus Loh of the Sales department. (Klaus began his well earned retirement in 2001 after 27 years with HEIDENHAIN.) Apart from his trusty blackboard, his resources included an overhead projector with transparencies and full-fledged HEIDENHAIN controls. The participants were given paper documentation with black-and-white illustrations to take home.

those conducted by Service were expanded by the additional topics of PLC programming, interfacing the TNC to the machine, and encoder service/repair.

In the course of a comprehensive company restructuring in 1992, TNC programming training and the Service courses were combined in the "Technical Training" section of the Service department.

As a result of the situation on the machine tool market in 1992, the type of participants changed significantly, particularly in the TNC programming courses. The number of

end users increased dramatically at the expense of personnel from machine tool manufacturers, retrofitters and distributors.

Since 2000, training in HEIDENHAIN conversational programming—and in the new smarTNC programming—has been conducted at many locations in Germany, several other European countries, and in China and South Africa.

Since mid-2001, courses at HEIDENHAIN have been conducted in new training rooms equipped with state-of-the-art media technology.

The course instructors at HEIDENHAIN—all of them experts in their respective fields—use a beamer and a special "Video Didact System" for data communication the participants.

Today, besides the conventional paper documentation, HEIDENHAIN provides the participants with numerous CD-ROMs and DVDs.

E-learning programs as CDs or on the Internet are available to help participants prepare for TNC programming courses. The



*Four training rooms, equipped with state-of-the-art media technology offer each participant an optimum setting for learning. In addition, a workshop is available with a 5-axis milling machine, machine simulation units and original HEIDENHAIN programming stations for practical applications and exercises.*

e-learning programs can be used as a self-teaching tool. They contain a comprehension test, and sections of the programs can be used to accompany courses in progress.

In 2003, the Technical Training department was assigned to the marketing division. Now, as a "marketing instrument" it has gained new significance and additional tasks.

Today, technical training courses are conducted at many HEIDENHAIN locations worldwide in the local language.

**Figures**

The number of course participants grew from 170 participants in 1982 to almost 1000, who in 2005 were trained in approx. 130 internal and external courses.

Add to this number another several hundred participants in TNC programming courses at the authorized training partners.

Beyond this, a trend has been developing toward customized courses for specific customers.

**Worldwide Network of Training Partners Has Been Expanded**

A technical course dramatically improves understanding of sophisticated products within a manufacturing company. Therefore, it has always been HEIDENHAIN's goal to provide the user with skillfully prepared training that has been tuned to the respective requirements. Until the end of 1998, these courses took place exclusively at HEIDENHAIN in Traunreut. To be able to train closer to the customer, HEIDENHAIN began considering in 1998 how to offer additional TNC programming training outside of Traunreut.

We implemented the following offers:

1. Individual customer-specific courses at the users' or the customers' locations.
2. TNC programming courses through **authorized HEIDENHAIN training partners** at "support points" that can be reached easily by many users.

Interested parties can still use the "collective training for up to 10 participants in Traunreut or in one of HEIDENHAIN's regional agencies.

**Authorized HEIDENHAIN training partners** are normally public educational institutions and/or advanced vocational training centers of the employers' and employees' associations. They must fulfill certain criteria defined by HEIDENHAIN regarding equipment, trainer qualification, and CNC training activity.

While our initial approach was to establish—at first in Germany—a broad network of training support points (authorized training partners), this approach has rapidly changed in the course of globalization. Today, TNC programming courses can be taken across the world in the local language at many HEIDENHAIN agencies and authorized training partners.

The following authorized training partners have been added in 2006:

- |   |                      |
|---|----------------------|
| Vocational Training Center of the Chamber of Commerce and Industry in Siegen, Germany | (since January 2006) |
| CNC Frästechnik in Holzkirchen/Sauerlach, Germany                                     | (since April 2006)   |
| Tampere College, Tampere, Finland   | (since January 2006) |
| Shanghai Vocational Training Directive Center, Shanghai, China                        | (as of mid-2006)     |

You can find more information at [www.heidenhain.de/schulung](http://www.heidenhain.de/schulung)

# 3-D Touch Probes for Tool Measurement

3-D touch probes from HEIDENHAIN have been at work for over 20 years on milling machines and machining centers, helping to reduce the cost of in small and medium-sized production runs. Setup, measuring and monitoring functions can be performed manually or under program control.

They offer particular benefit when connected with HEIDENHAIN TNC controls as the user learns to greatly appreciate a series of convenient cycles both for automation as well as for manual machining.

## Workpiece measurement

Some of the workpiece touch probe's typical tasks are workpiece alignment, presetting, and workpiece measurement. The TS 440, the TS 640 and the TS 220 touch probe systems are available in various versions to fit the application. While the compact TS 440 finds application in small machines with limited working envelopes, its larger brother, the TS 640 has for years found great success on all classical tasks. The blower jets typical for HEIDENHAIN touch probes free the workpiece of chips before measurement.

For both models, the signals are transmitted by infrared signal to the transmitter/receiver units. They can be placed immediately in the spindle, such as the SE 540, or anywhere in the work envelope, such as the SE 640. The TS 220 is available for signal transmission by cable. Thanks to their contact-free optical switch, HEIDENHAIN touch probes guarantee high long-term stability.

## Tool measurement

Successful series production hinges on the prevention of scrap or rework and the attainment of consistently good workmanship. The tool is of course a definitive factor. Wear or tool breakage that can go

undetected for extended periods, especially during unattended operation, produces defective parts and unnecessarily increases cost.

This means that an exact measurement of the tool dimensions and periodic checks for tool wear or breakage are necessary. The TT 140 and the TL laser systems, two different product groups are available for tool measurement directly on the machine.

## New TT 140 Tool Touch Probe

The TT 140 is a 3-D touch trigger probe for tool measurement and inspection. The trigger signal is generated through a wear-free optical switch that ensures high reliability. The TT 140 tool touch probe saves time by measuring almost any type of tool right on the machine.

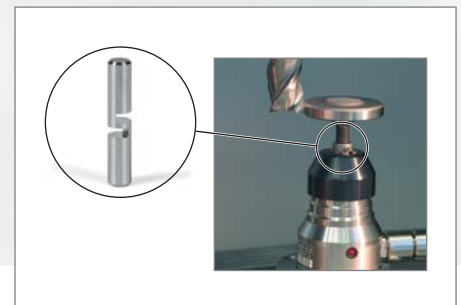


The rotating or stationary tool deflects the TT's contact plate. With an integrated optical switch a trigger signal is generated and transmitted to the CNC, where tool wear is compensated.

In this way the CNC works with the TT 140 fully automatically to find the length and radius of the tool without manual intervention. The function for measuring individual teeth makes it possible to ascertain the condition of each tooth of the tool. If specified tolerances are exceeded, the tool is exchanged automatically with a replacement.

## Rated break point

The new patented rated breaking point protects the touch probe from physical damage due to operator error. It is effective

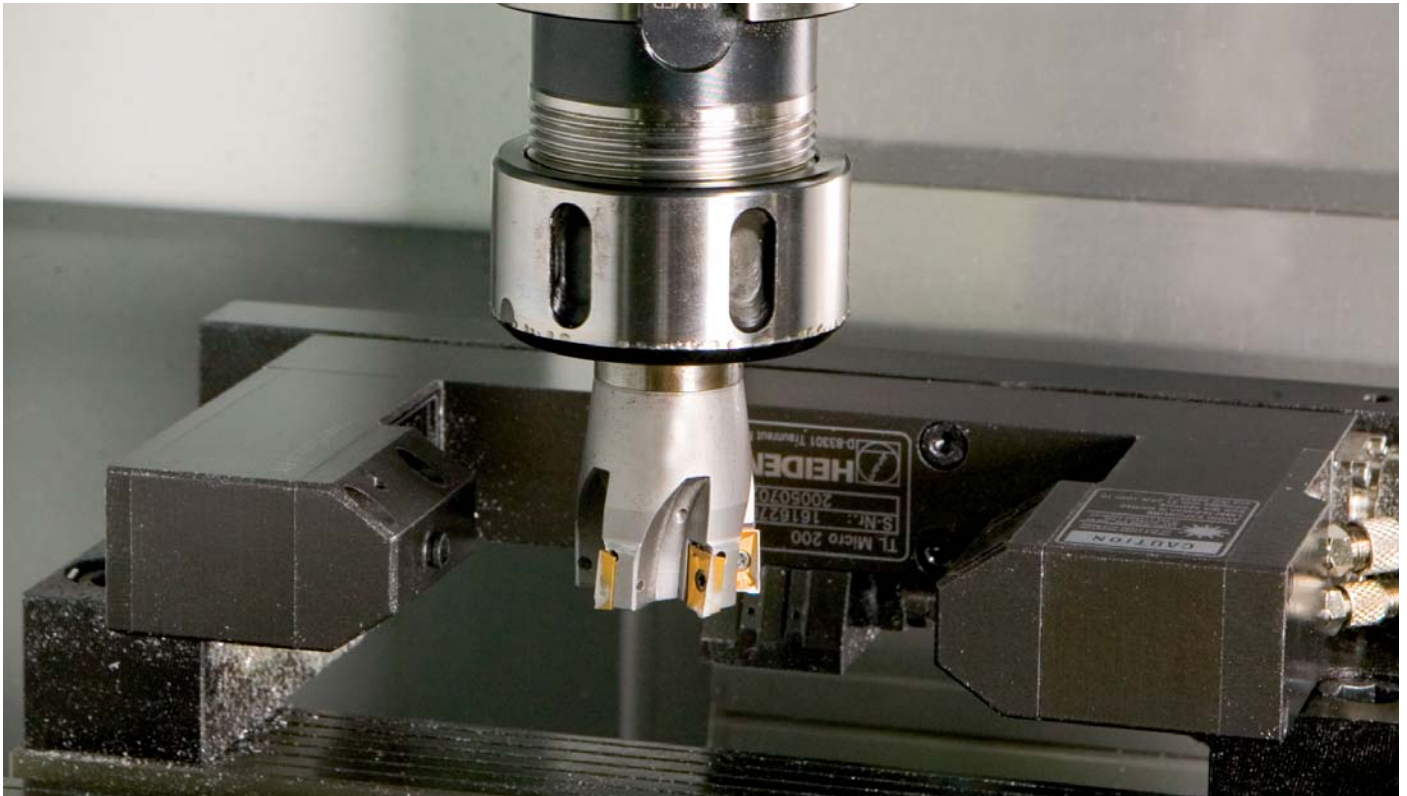


in all probing directions. The rubber sleeve offers protection from splinters. Broken pins are easily and quickly exchanged. There is no need to mechanically readjust the TT 140.

## Optical deflection display

In addition to the trigger signal, two LEDs on the TT 140 indicate deflection of the contact plate. This is especially useful for testing the correct operation. You can see at a glance whether the TT 140 is currently deflected.

The new Ø 25 mm contact plate allows it to also be installed horizontally in the machine. With the familiar Ø 40 mm contact plate, the touch probe can be positioned vertically in the work envelope. In its dimensions and electrical connection, the TT 140 is compatible to its predecessor, the TT 130.

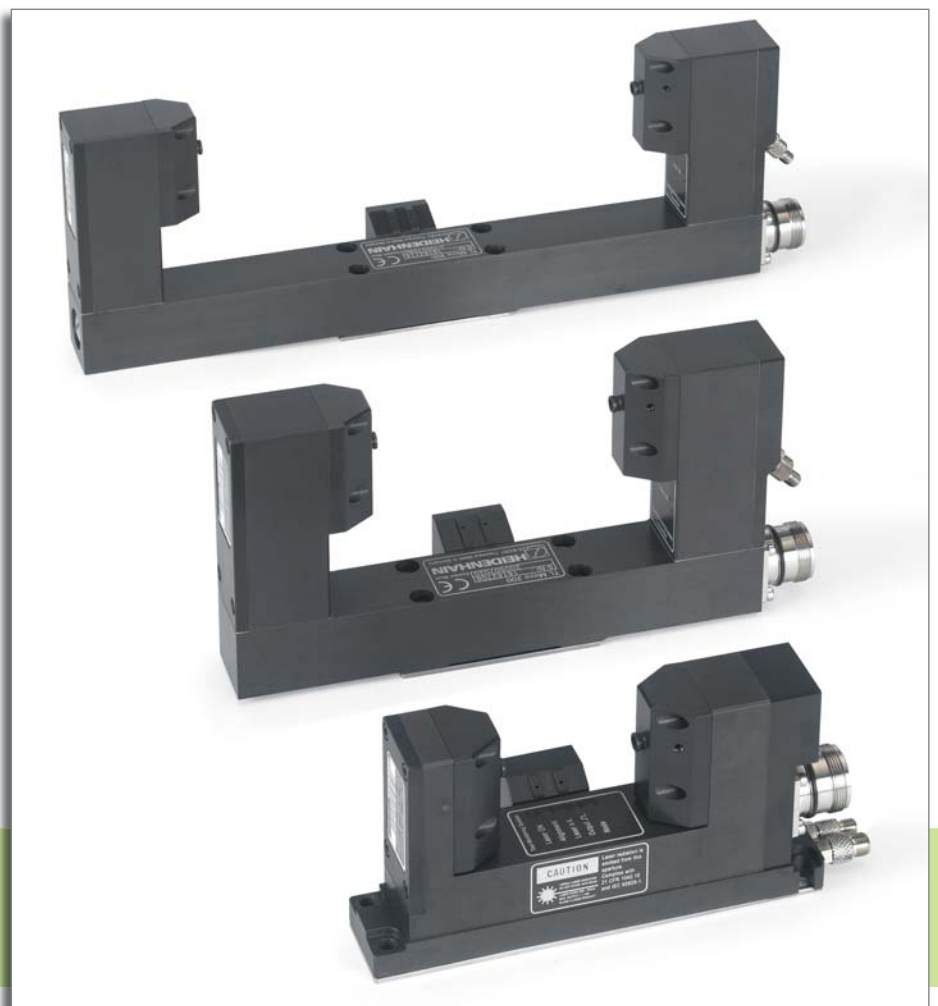


### New TL Micro and TL Nano laser systems

The TL Micro and TL Nano laser systems can measure tools directly on the machine without making contact. With the aid of the included measuring cycles you can measure tool lengths and diameters, inspect the form of the individual teeth and check for tool wear or breakage. The control automatically saves the results of measurement in the tool table.

The measurement is very fast and uncomplicated. Under program control, the TNC positions the tool and starts the measuring cycle. This is always possible: before machining, between two machining steps, or after machining is done.

The axially focussed laser beam enables you to measure tools as small as 0.03 mm in diameter at a repeatability of up to  $\pm 0.2 \mu\text{m}$ . The TL laser systems fulfill the requirements for IP 68 and can therefore be fixed directly in the machine's working space.



## User Report: Once TNC—Always TNC

A slogan that speaks to both the heart and the mind: "If you give us your trust, we'll respond with products of the highest quality." Who advertises like this? It's the Deuringer Maschinenbau OHG, founded 50 years ago in Königsbrunn (south of Augsburg), specialists for hydraulic forms such as are needed for manufacturing prefabricated garages. Deuringer engineers were the inventors and first manufacturers of hoisting and transporting vehicles required for hydraulic forms. At present, with 45 employees, the company makes two-thirds of its revenue through subcontracting. This requires even more manufacturing flexibility—and the TNCs from HEIDENHAIN provide it.

In 1956, Georg Deuringer, a talented mechanical design engineer, worked to build the basis for the company's success. Now in the second generation, his son Michael is continuing the path his father began. The hard proof is the large number of loyal customers and the many new customers won through mouth-to-mouth advertising and, lately, through the Internet. "We keep our promises—in terms of quality, accuracy, and reliable lead times," and he adds, "which naturally requires excellently trained, highly motivated personnel. Also, our manufacturing equipment—including of course the NC controls—must be dependable and easy to operate."

Experience pays, and for almost 30 years, Deuringer has been installing almost exclusively TNCs from HEIDENHAIN on their machine tools for milling, drilling, and boring. And for good reason: because of

their usually relatively low job quantities and the very diverse, geometrically complex configurations, at least 50% of their program blocks are generated on the shop floor right at the control. "And no other controls do that better than the TNCs from HEIDENHAIN," says Michael Deuringer. Michael Deuringer is in a good position to judge, too. He invests occasionally in rebuilding outmoded but mechanically sound used machine tools, which is particularly worthwhile with large machines that are still working with the controls originally installed—usually not TNCs.

Twice, with growing impatience, Michael Deuringer watched for 18 months the performance of such outdated machines before deciding after all to switch from the old CNC to the latest TNC from HEIDENHAIN. "It paid for itself both times in spite of the considerable investment," he recalls. "The first time was in 1995 with a 10 meter rigid bed milling machine from Colgar with automatic swivel head, where we had nothing but problems with the originally installed control," and points out that, "Not only was it very complicated to program, it was so unreliable that it wasn't able to earn any money with the it until I had the TNC 426 installed."

And how has it been since? Deuringer is quite certain: "The Colgar just was not cost economical until it was interfaced to the TNC," and he explains, "For eleven years now it's been working without any disruption, and that also applies for the even older TNC 355s on our two Butler bed-type milling machines. But just important for us is

its user friendly shop-floor programming with its many-sided input aids and the very straightforward programming," and continues: "That's why we always order new machine tools for milling, drilling and boring only with TNCs, and if a used machine has a non-HEIDENHAIN CNC, we exchange it."

A recent example is a Solon machining center built by Scharmann in 1986. It was actually designed as a boring machine equipped with a pallet changer and quill together with an NC rotary table, tool changer and magazine. Now it is controlled by an iTNC 530. Deuringer emphasizes: "While we do buy a used machine now and then, if we invest in controls we naturally want the newest technology from HEIDENHAIN."

Is it worth it? Benjamin Scholz, the Solon's 20-year-old operator (exactly the same age as the machine): "With the iTNC 530 my programming is at least twice as fast as with the old CNC." If you ask me, the TNCs are simply unbeatable at shop-floor programming," and adds: "Up to then, I only knew the HEIDENHAIN 355—but the change to the 530 was really easy for me: I didn't really have to learn anything essentially new, just add to what I already know" thereby pointing out a primary advantage of the TNCs—their consistent upwards compatibility.

An experienced mechanical engineering company knows their available know-how, for example whether they can retrofit a control themselves or not. To retrofit the iTNC 530 on the Solon, just as two years



before on the Colgar, they called the Braun Werkzeugmaschinen Vertrieb & Service GmbH from Emmering near Munich, which is also a regional agency for HEIDENHAIN. The CEO Siegfried Meissner explained to us, "For many years we've given the actual installation to a company that does it excellently—our primary job is to decide which components need to be exchanged, order them and see to it that new the PLC program is perfectly adapted and works."

And what had to be replaced? Not much: "As a preventive measure we exchanged the two rotary encoders for spindle orientation and the rotary table, also the linear scale for the Z axis. The all the cabling between the iTNC 530 and the two encoders had to be replaced, of course—because there's no point in working with adapters," says Meissner. Deuringer agrees. "Interfaces and terminals should be avoided wherever possible. Why save on small things at the cost of productivity? On the contrary, Deuringer also allowed himself an additional connection on the Solon for the 3-D touch probe system from HEIDENHAIN, which he immediately added to the retrofit order.

What did that cost in time and money? "After only two weeks' downtime, the Solon was ready for work with the iTNC 530, and it cost us 50,000 euros," he answers, and immediately answers our next question before we can ask it: "For a manufacturing tool in such good mechanical condition that works as automatically as the Solon, it is certainly worth it."

*Jürgen Kromberg, free-lance journalist*





HEIDENHAIN

## How do you avoid unplanned collisions?

If you want to make points at billiards, you have to avoid unplanned collisions. On your milling machine, too, collisions can make you a loser. Place your bets on the new Dynamic Collision Monitoring (DCM) from HEIDENHAIN. The TNC monitors your machine's work envelope at high cycle rates. If machine components are on a collision course, it stops the machine and shows a detailed warning message in plain language. The bottom line: DCM prevents expensive machine damage and downtime, and you gain more confidence in the use of your machine. DR. JOHANNES HEIDENHAIN GmbH, 83292 Traunreut, tel.: (08669) 31-0, fax: (08669) 5061, [www.heidenhain.de](http://www.heidenhain.de), e-mail: [info@heidenhain.de](mailto:info@heidenhain.de)