SIEMENS

SINUMERIK 840D
Software Version 4

Description of Functions **07.99 Edition**

Digitizing

Manufacturer Documentation

Overview of SINUMERIK 840D/810D/FM-NC Documentation

General Documentation

- *SINUMERIK* 840D/810D/FM-NC — Brochure
- *SINUMERIK* 840D/810D/FM-NC/611 — Catalog Ordering Info NC 60.1 ***)**, Technical Info. NC 60.2
- *SINUMERIK SIROTEC SIMODRIVE* Accessories — Catalog Accessories NC-Z

User Documentation

- *SINUMERIK* 840D/810D/FM-NC — **AutoTurn**
  - Short Guide
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- *SINUMERIK* 840D/810D — Operator's Guide
  - **Unit Operator Panel**
  - **HPU**
- *SINUMERIK* 840D/810D/FM-NC — **Diagnostics Guide *)**
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  - Short Guide
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- *SINUMERIK* 840D/810D/FM-NC — **Program. Guide**
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Manufacturer / Service Documentation

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- *SINUMERIK* 840D/810D/FM-NC — **Configuring Kit** MMC 100/101
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- *SINUMERIK* 840D/810D/FM-NC — **Screen Kit** MMC 100/101 SW Update and Configuration
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Manufacturer / Service Documentation

- *SINUMERIK SIMODRIVE* — Description of Functions SINUMERIK **Safety Integrated**
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- *SINUMERIK SIMODRIVE* — **Installation & Start-up Guide *)**
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  - 840D/611D
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- *SINUMERIK SIMODRIVE* 840D/810D FM-NC 611D — **Lists *)**
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- *SINUMERIK SIMODRIVE* 840D 611D — Description of Functions **Hydraulics Module**
- *SINUMERIK SIMODRIVE SIROTEC* — **EMC** Guidelines

Electronic Documentation

- *SINUMERIK SIMODRIVE* 840D/810D/FM-NC 611, Motors — **DOC ON CD *)** The SINUMERIK System

Manufacturer / Service Documentation

- *SINUMERIK* 840D/810D — Description of Functions **ISO Dialects** for SINUMERIK

***)** These documents are a minimum requirement for the control

SIEMENS

SINUMERIK 840D
Software Version 4
Digitizing

Description of Functions

Valid for

Control	*Software version*
SINUMERIK 840D	4
SINUMERIK 840DE (Export version)	4

07.99 Edition

SINUMERIK® documentation

Printing history

Brief details of this edition and previous editions are listed below.

The status of each edition is shown by the code in the "Remarks“ column.

Status code in the"Remarks" column:

A .... New documentation.
B .... Unrevised reprint with new Order No.
C .... Revised edition with new status.

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07.99	6FC5297-4AC50-0BP0	C

This manual is included in the documentation on CD-ROM(**DOCONCD**)

Edition	Order No.	Remarks
09.99	6FC5 298-5CA00-0BG1	C

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Preface

Overview of the Documentation

The SINUMERIK documentation is organized in 3 parts:

- General Documentation
- User Documentation
- Manufacturer/Service Documentation

Target group

This documentation is intended for the manufacturer of machine tools with SINUMERIK 840D.

Aim

The function description explains the functional scope of digitizing:

- Acquisition of geometry data with a tactile sensor (scancad scan)
- Acquisition of geometry data with a laser (scancad laser)
- Further processing of the data acquired to generate milling programs (scancad mill)

Standard scope

The document consists of:

- Part 1: /DI1/ Startup MMC
- Part 2: /DI2/ Scanning with Tactile Sensors (scancad scan)
- Part 3: /DI3/ Scanning with Lasers (scancad laser)
- Part 4: /DI4/ Milling Program Generation (scancad mill)

Search aids

To help you find information more easily, the following aids have been included in the appendix in addition to the table of contents:

1. Separate index for each part of the document
2. References

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Notes

SINUMERIK 840D Digitizing

Part 1: Startup

Notes

1 Introduction

Reverse engineering

Molds and tools are designed, machined, and changed using both CAD/CAM and by hand. Reverse engineering (= 3D digitization + milling program generation + surface reconstruction) combines manual skills with NC production and CAD/CAM. This opens up new ways of getting from the idea to ideal workpieces.

SIEMENS or BCT provides all products and services for efficient reverse engineering from a single source.

SIEMENS has taken over the following software from BCT as licensed products:

BCT product	SIEMENS product
scancad scan	Scanning with tactile probes (Digi Scan)
scancad laser	Scanning with laser sensors (Digi Laser)
scancad mill	3D digitizing software on MMC 103 (Digi Mill)
scancad geo	-

The scancad product family

scancad is the name of a product family of software and control components for acquisition and processing of digitized data. On the basis of the various ways of acquiring the data of real three-dimensional models (scancad scan, scancad laser), two different software packages are available for processing. One package contains all the functions required to prepare the digitized data subsequently required for milling (scancad mill). An other package has the functionality to edit and change digitized data in the CAD/CAM system (scancad geo).

scancad scan
scancad laser

scancad scan and scancad laser are digitization systems with which you can acquire 3D geometries from real models. Whereas scancad scan scans in the data using a tactile sensor, scancad laser uses a laser distance sensor, as its name suggests. You can use both systems on a machine to meet different requirements.

scancad mill

The data scanned in this way, can then be processed to form milling programs with scancad mill before they are used in NC production.

scancad geo

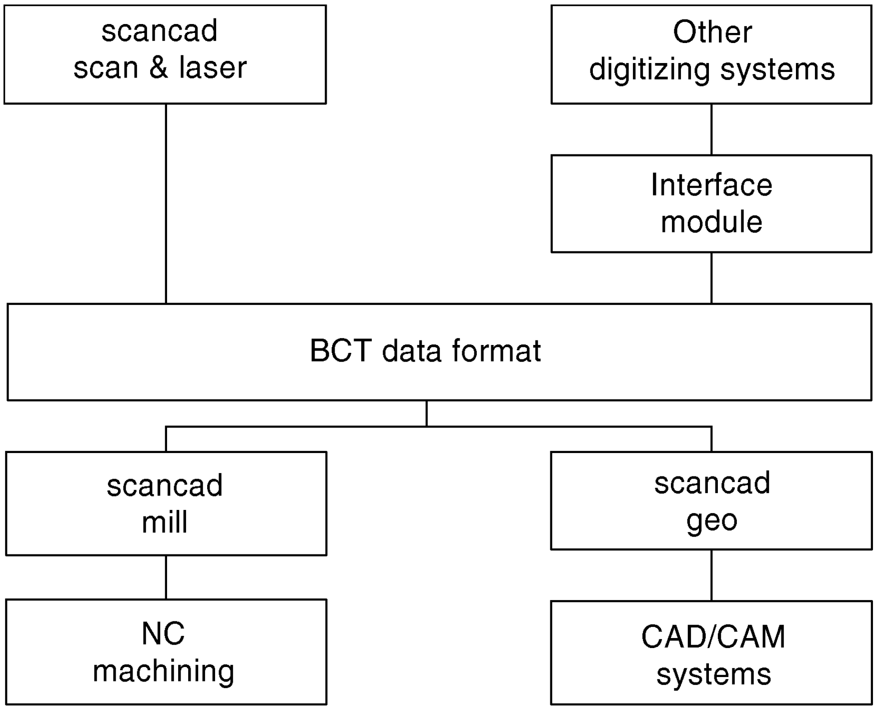
The scancad geo software package converts point data into a mathematical surface description. This is then used as a basis for further processing in CAD/CAM systems.

Import interfaces with non-Siemens systems

scancad mill and scancad geo can not only process data from the BCT digitizing systems scancad scan and scancad laser but also data from all commonly used copy milling controls and tactile and optical digitizing systems. This "non-Siemens" data are converted into BCT data format by an interactive interface module. Any information which is not contained in the files of the non-Siemens systems but is required for further processing are prompted for and entered in the BCT database.

Output interfaces with non-Siemens systems

The NC programs and CAD/CAM data generated can be output from scancad mill and geo into many specific formats and via many different standard interfaces.



Required hardware / software components:

System / software	**Hardware**	**Sensors**
scancad scan	SINUMERIK 840D, MMC 103	Tactile probe
scancad laser	SINUMERIK 840D, MMC 103	Laser distance sensor
scancad mill	MMC 103 (WIN95 or Win-NT computer)	
scancad geo	WIN95 or NT computer	

1.1 Basics of the scancad system

This chapter describes the classical fields of application of digitizing and the options available for processing the data further.

3D digitizing

Digitizing as opposed to copying

The digitizing of models refers to the acquisition and storage of measured values that describe the surface of a workpiece of any shape. In the simplest case, a 1:1 copy of the model is then subsequently milled. This process is essentially identical to copy milling.

Disadvantages of copying

Copy milling has some serious disadvantages compared with digitizing, owing to the inflexibility of a combination of scanning and milling technologies:

- Extensive design measures are required for the mechanical decoupling of both sides, in order to prevent vibrations from the mill from penetrating the scanning side.
- The inflexible interface requires that the machine be operated such that the feedrates are equally suitable for scanning and milling.
- For roughing, the model is scanned in a succession of layers, areas which do not belong to the surface of the model are also "scanned".
- It is almost impossible to introduce changes between the original and the copy (except for shrinkage or finishing allowances).
- The probe and the mill must always have the same geometry.
- A new scanning process must be initiated for each copy.

Advantages of digitizing

Digitizing, in contrast, allows almost complete decoupling of the scanning and milling processes because they take place at different times. In the first step, the model is scanned. The milling process is then performed as the second step. This independence enables the optimum technology to be used for both scanning and milling. The scanning process only ever records the actual model surface. It is not necessary to scan in layers for subsequent roughing. The complicated design measures required for copying are not necessary in this process so that the digitizing system can be connected to any machine tool or measuring machine.

Single scan

A further advantage of the separation of the scanning and milling processes in digitizing is that the electronic model can be edited after scanning is complete and that the various NC programs required for roughing and finishing can be generated from a single scan.

Digitizing with different styluses

Another of the advantages of digitizing is the free selection of different stylus geometries. It is even possible to use a combination. The milling tools are not affected by this. Any number of copies can be generated without needing to perform another scan.

scancad scan Tactile digitizing
scancad laser: Laser digitizing

Different tasks require different digitizing processes. BCT with its three scancad digitizing systems always offers a suitable solution. The systems can be connected to any digitizing, milling machine or measuring machine. We offer retrofit kits and CNC-integrated systems for this. scancad scan is the tried and tested workshop solution for tactile digitizing. Even complex models can be acquired quickly and precisely with this system. scancad laser scans the models point by point with a laser sensor. This means that delicate and filigree models can be acquired without making contact.

The digitizing data are recorded on any three-axis machine with a measuring probe (scancad scan) or a contactless laser sensor (scancad laser). The actual scanning process is controlled by a special BCT digitizing control. The sensor is guided in dense contours across the model surface, while the measured data are stored. Storage of the model data on diskette or hard disk permits an archive to be set up in the form of an "electronic" model store.

Before scanning, the operator defines the areas on the model to be digitized. The most suitable scanning strategies can be selected for each individual area. The operator can also define the sequence in which the automatic scanning process is to be performed.

When a workpiece is canned, 250 measurements are performed per second which can be stored in a file on the hard disk of the MMC 103. These data occupy approx. 4 kilobytes of memory per second (data reduction = OFF).

Data format

The digitizing data are stored in a special compact internal format that can only be read with the appropriate utility programs. In addition to the scan data the file also contains information about the scanning parameters and division of the scanning area into segments and lines.

These data should be saved to an archive on a regular basis. Installation of a local network for managing large files is also recommended.

Data reduction during scanning

As mentioned above, 250 measuring points per second are recorded during digitizing with scancad scan and scancad laser. If all these measured points were saved, the storage capacity of the hard disk would soon be exhausted.

It is necessary to reduce the data set during scanning such that a small number of points is stored for gently curved contour areas, while a large number of points is stored for areas with significant changes in the contour. The online data reduction facility does this automatically. All you need to do is enter the required tolerance value that defines the extent of the data reduction. A narrow tolerance is usually selected for the actual digitizing task to ensure that the archived "master" model is as accurate as possible.

The scan data can then be displayed graphically on the screen and then processed with scancad mill to create NC programs for a particular control.

Further processing

Digitized 3D data can be used to generate milling programs for NC manufacturing.

The digitized data can either be processed on an installed digitizing control or on an external PC. The latter solution allows the operator to digitize and process digitized data simultaneously and is therefore preferable.

Data from other systems

The software packages scancad mill and scancad geo can also process digitizing data that were not recorded with the BCT digitizing system. However, these external data must first be converted to the file format described above using special programs. This file format forms the basis for all scancad program modules and need not be known to the operator.

Changing the geometry

Since the geometry of the model is stored as measured points, it is possible to make global changes to the geometry during the ensuring milling program generation.

Model data can be

- reduced
- magnified
- translated
- rotated
- mirrored
- thinned out
- excluded from the data set
- used to calculate the model surface (contour)
- converted from positive to negative.

scancad mill: Milling Program Generation

scancad mill comprises all the CAM functions required to calculate an optimized milling program. This allows efficient NC processing of models, tools and electrodes.

Avoiding contour violation

As mentioned above, any milling tool can be selected irrespective of the probe used. In order to avoid damage to the workpiece during this process, contour-avoidance calculations must first be performed. These calculations are necessary if:

- The selected diameter of the mill is larger (e.g. for roughing) than the diameter of the probe for digitizing
- the mill geometry differs from the probe geometry
- the negative of a mold is to be milled
- a magnification or reduction (scaling) of the model is to be performed.

The detection and prevention of possible violations of the contour by the mill is a vital requirement in the cases described above.

Collision-free milling path

In the collision calculation, milling paths are generated which use sophisticated avoidance strategies to mill without violating the contour.

NC code according to DIN 66025

An NC program which complies with DIN 66025 or a similar standard can be generated from the scanning data or the modified data. You can generate various programs for roughing, rough finishing and finishing the workpiece. The size and shape of the milling tools, milling direction, allowance etc. can be chosen freely. You can also allow a constant gap for spark erosion, metal thickness, etc.

scancad geo: Surface conversion

Interface with CAD/CAM

scancad geo is the interactive software system for creating CAD-compatible surface descriptions. The converted surfaces are characterized by a high degree of precision and surface quality. Entire models or partial areas can be exported simply into CAD/CAM systems.

The contour points of a model can be exported to CAD/CAM systems in different formats (e.g. VDAFS 2.0 or IGES) for further processing of the geometry.

Points

First, a scan simulation is employed to determine the exact surface of the workpiece in the form of points arranged at regular intervals. In order to arrive at an acceptable precision during scanning the point density must be sufficiently high. Depending on the size of the digitized area a very large number of points may result. Anything from several hundred thousand to several million points is not unusual.

Surfaces

Data volumes of this size can only be processed by CAD/CAM systems with difficulty or not at all making it necessary to first convert the data to a format that CAD systems can cope with: the surface representation. We no longer see thousands of individual points but smaller subsurfaces. This not only means that the operator can now display a clear number of elements, but some operations are only possible in the surface representation (e.g. alterations to the contour itself). In order to further process the model in the CAD system it is therefore absolutely necessary to first derive a CAD-compatible surface representation from the digitized points. This is extremely to do with the user-friendly semi-automatic, interactive software package scancad geo.

Topology recognition

For a conversion to CAD all the digitizing data is searched for characteristic form lines. The topology module subdivides the cluster of points into homogenous segments along these form lines. This ensures optimum matching of the surface pattern to the model geometry. A large number of functions is available for setting up the topology framework. This includes, for example, smoothing and editing.

Surface approximation

The framework of the form lines provides the basis for the surface approximation. The digitized model geometry is approximated within the segments by 3rd degree Bezier surfaces. A full range of functions supports the user in the generation of smooth, accurate and structured surface patterns.

Further processing in the CAD/CAM system

Further processing in the CAD system allows extensive manipulation of the surface and is of special interest to users who have designed a model in the CAD system and who want to scan later modifications to the workpiece and reconstruct them on the system.

Manual for scancad geo

For more detailed information on digitizing data processing please refer to the manual of the software package scancad geo.

2 Hardware

2.1 Design of the components for digitizing

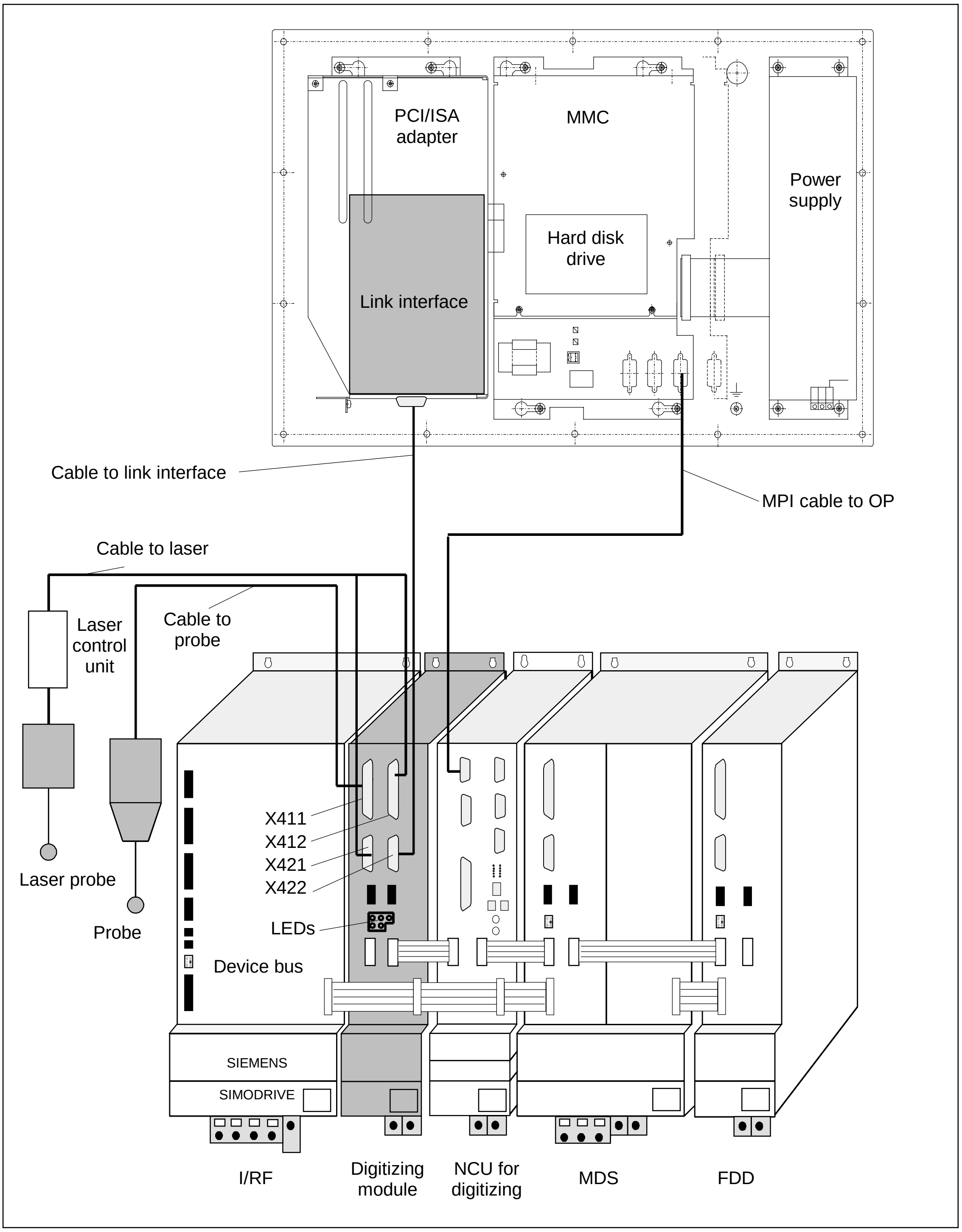


Fig. 2-1: Design of the components for digitizing

Link interface

Please make the following settings on the jumper on the rear of the link interface:

	1	2	3	4	5	6	7	8
ON		●	●	●	●	●	●	●
OFF	●							

Digitizing module

The upper row of LEDs on the digitizing module has the following meaning:

1st row:
Green LED: Voltage applied to digitizing module
Yellow LED: Data transfer between link interface and digitizing module
Red LED: No meaning

2nd row:
Yellow LED: Data transfer between operator panel and digitizing module
Red LED: Processor error in the digitizing module

Connection conditions

For general connection conditions see:
/PHD/, Configuring Manual NCU 561.2-573.2, Chapter 2

2.2 Hardware requirements

- MMC 103 MLFB No. 6FC5 210 - 0DA□□ - 2AA0
- PCI/ISA adapter MLFB No. 6FC5 247 - 0AA02 - 1AA0
- Digitizing module MLFB No. 6FC5 212 - 0AA00 - 0AA1
- Link interface MLFB No. 6FC5 210 - 0AA00 - 0AA0
- Connecting cable from the digitizing module (X422) to the link interface:
  (see also Fig. 2-1) MLFB No. 6FX2 002 -1DA01-1□□0
- NCU module holder MLFB No. 6FC5 247 - 0AA00 - 0AA2
- NCU 573.2 f. digitizing MLFB No. 6FC5 357 - 0BB31 - 0AE0
- NCU-SW (up to 12 axes) MLFB No. 6FC5 250 - 0BX30 - 0AH0
- NCU-SW (up to 31 axes) MLFB No. 6FC5 250 - 0AX30 - 0AH0
- Renishaw probe SP2-1
  Tool holder for Renishaw probe SP2-1
  Styluses for Renishaw probe SP2-1
  Adjustment funnel for Renishaw probe SP2-1
  or
  Laser sensor OTM3-XX from Wolf & Beck
- Connecting cable from the digitizing module (X411) to the probe:
  (see also Fig. 2-1) MLFB No. 6FX2002 -1DB01-1□□0
  or
  Connecting cable
  - from the digitizing module (X412) to the laser control unit and
  - from the digitizing module (X421) to the laser control unit
  The cables themselves can be configured (see Section 2.4 Cables)
- MF II-SNI keyboard MLFB No. 6FC5 203 - 0AC01 - 0AA0
  or
  CNC complete keyboard MLFB No. 6FC5 203 - 0AC0□ - 0AA0
- Touch panel or mouse
- Diskette drive 3.5“ for MMC 103 is required
  MLFB No. 6FC5 235 - 0AA05 - 0AA1

Reference: /BU/, Catalog 60.1

2.3 Assembly of the components for digitizing

Assembly of the digitizing module

The digitizing module is 50 mm wide and implemented in the SIMODRIVE 611 packaging system. It is mounted as far left as possible next to the NCU 573.2. The digitizing module is connected to the NCU using the connecting cable supplied. NCU connector X130A (RS422 interface) acc. to X341 on the digitizing module. The intermediate circuit and the device bus must also be connected.

Assembly of the link interface

The link interface is mounted in the PCI/ISA adapter and establishes the connection with the MMC 103.
Please take ESD precautions when handling the module.

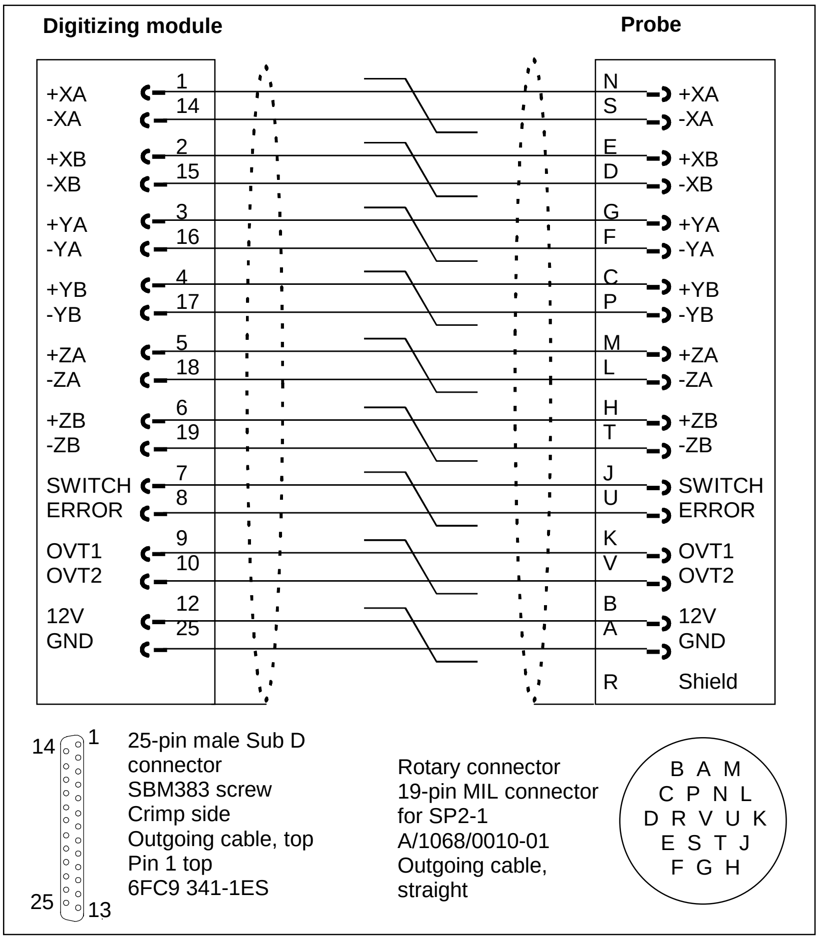
Power supply

The link interface is powered via the PCI/ISA bus. The digitizing module receives the power supply from the device bus connected.

2.4 Cables

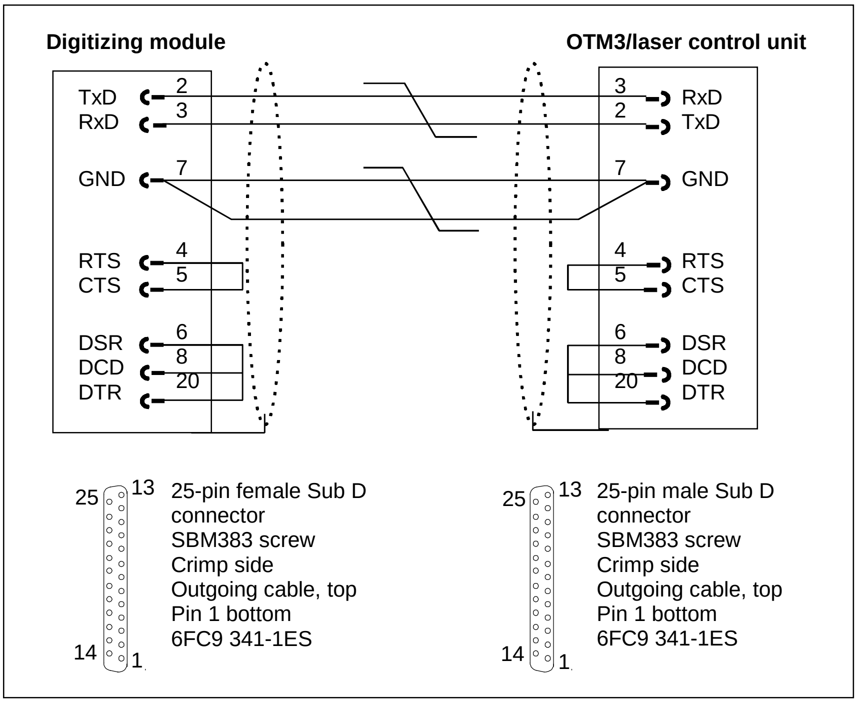
Renishaw probe interface X411

Pin	Signal, name	Pin	Signal, name
1	**+XA**	14	**-XA**
2	**+XB**	15	**-XB**
3	**+YA**	16	**-YA**
4	**+YB**	17	**-YB**
5	**+ZA**	18	**-ZA**
6	**+ZB**	19	**-ZB**
7	**SWITCH**	20	Not used
8	**ERROR**	21	Not used
9	**OVT1**	22	Not used
10	**OVT2**	23	Not used
11	Not used	24	Not used
12	**12 V**	25	**GND**
13	Not used		



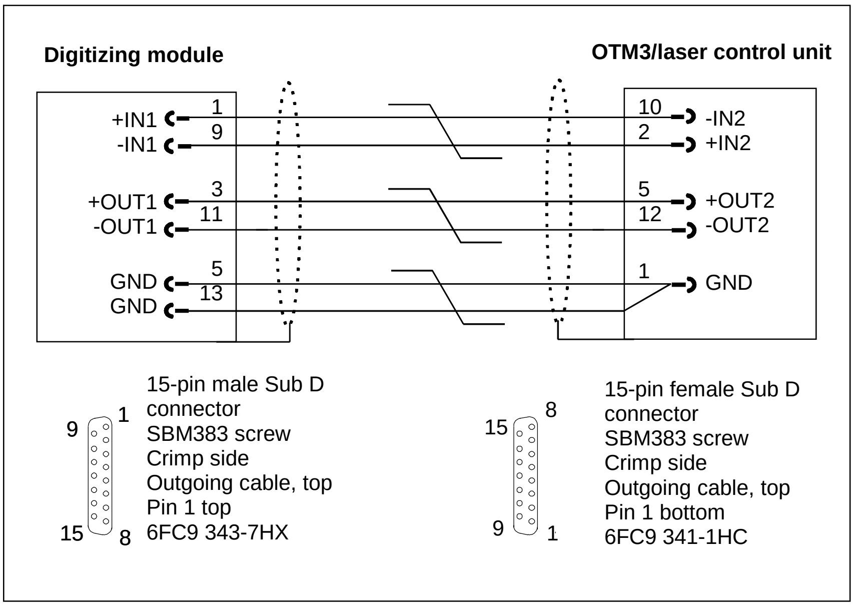
Laser interface X412

Pin	Signal, name	Pin	Signal, name
1	**Shield**	14	Not used
2	**TxD**	15	Not used
3	**RxD**	16	Not used
4	**RTS**	17	Not used
5	**CTS**	18	Not used
6	**DSR**	19	Not used
7	**GND**	20	**DTR**
8	**DCD**	21	Not used
9	Not used	22	Not used
10	Not used	23	Not used
11	Not used	24	Not used
12	Not used	25	Not used
13	Not used		



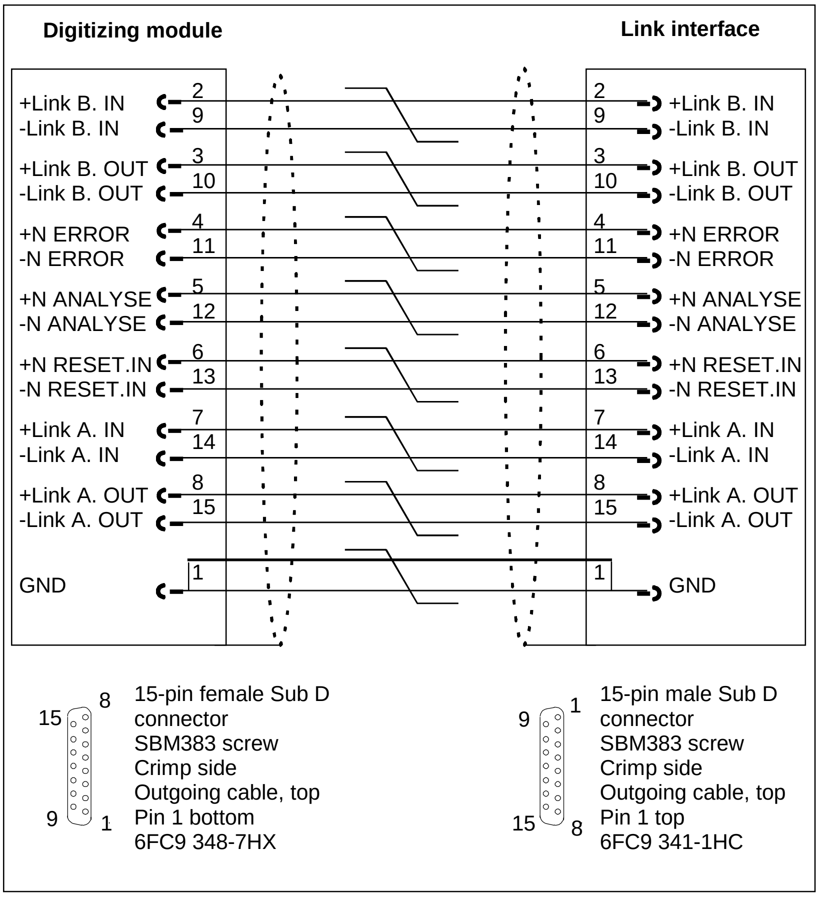
Laser interface X421

Pin	Signal, name	Pin	Signal, name
1	**+ IN1**	9	**- IN1**
2	**+ IN2**	10	**- IN2**
3	**+ OUT1**	11	**- OUT1**
4	**+ OUT2**	12	**- OUT2**
5	**GND**	13	**GND**
6	Not used	14	Not used
7	Not used	15	Not used
8	Not used		



Link interface X422

Pin	Signal, name	Pin	Signal, name
1	**GND**	9	**- Link B. IN**
2	**+ Link B. IN**	10	**- Link B. OUT**
3	**+ Link B. OUT**	11	**- N ERROR**
4	**+ N ERROR**	12	**- N ANALYSE**
5	**+ N ANALYSE**	13	**- N RESET.IN**
6	**+ N RESET.IN**	14	**- Link A.IN**
7	**+ Link A.IN**	15	**- Link A.OUT**
8	**+ Link A.OUT**		



Notes

3 Starting and Exiting scancad

3.1 System requirements

Hardware requirements

See Section 2.2 Hardware requirements.

Software requirements

1. 3-axis digitizing software on MMC 103 (Windows 95): Digi Mill
   MLFB No. 6FC5 260- 0FX20 - 0AB0

   Scanning with tactile probes (Windows 95): Digi Scan
   MLFB No. 6FC5 260- 0FX21 - 0AB0

   Scanning with lasers (Windows 95): Digi Laser
   MLFB No. 6FC5 260- 0FX22 - 0AB0

2. NCK software 4.4.18 or higher
   MLFB No. 6FC5 250-□□□□ 0 -□ AH□

3.2 Software scope of supply

Digi Scan	2 diskettes
Digi Laser	2 diskettes
Digi Mill	3 diskettes
Upgrade (Digi Scan and Digi Mill)	5 diskettes

3.3 Installation

See:

- ReadMe file
- /IAM/, Installation and Startup Guide MMC, IM3 Startup Functions for the MMC 103

3.4 Starting the program

1. Switch the system off and on after installation.

   CAUTION
   To activate the machine data, it is always necessary to switch the system off completely and then on again. Only then is machine data transfer from the NCK to the digitizing module or link interface initiated.

2. Set machine data for digitizing.

3. Switch the system off and on.

4. Put the system in the operating state (reference axes...).

5. Select operating mode automatic. (Feed stop must not be pending.)

   CAUTION
   The corresponding spindle interlocks must be active so that no unwanted rotation of the spindle occurs while the probe is inserted.

6. Create the operating state for digitizing with the NC program.
   (Digi_ein.mpf: e.g.: Feedforward control ON (FFWON)
   Initial position for digitizing)

7. Feed enable must be set.

8. Start digitizing software with the appropriate softkey.

9. Press the NC start key to switch from passive mode to active mode.

3.5 Exiting the program

1. Press the NC stop key to switch from active mode to passive mode.

2. Close the scancad program.

Notes

4 Interface Signals and Machine Data

4.1 Interface signals

DB11 **DBX7.3** Data module	**Digitizing** Signal(s) from BAG1 (NCK → PLC)		
Edge evaluation: no		Signal(s) updated: cyclically	Signal(s) valid as from SW version: 840D SW 1
Signal meaning	The signal returns the feedback that digitizing is active within BAG1.		

DB11 **DBX27.3** Data module	**Digitizing** Signal(s) from BAG2 (NCK → PLC)		
Edge evaluation: no		Signal(s) updated: cyclically	Signal(s) valid as from SW version: 840D SW 2
Signal meaning	The signal returns the feedback that digitizing is active within BAG2.		

4.2 Setting the closed-loop control parameters

The machine data description is used to adapt the digitizing control to the NC machine. These machine data are passed from the CNC control to the *scancad system* in the initialization phase . Many constants have default values. These are explained in the list at the machine data in question. The units of measurement used are also listed here.

The closed-loop control parameters are DIG_P_HAND, DIG_P_SCAN, and DIG_T_SCAN.

Parameter DIG_P_HAND influences the machine behavior during manual operation. The default setting is "1st smaller value" and causes very soft traversing with a tendency to overshoot. Higher values cause a harder control response during manual traversing.

Parameters DIG_P_SCAN (proportional component) and DIG_T_SCAN (integral component) influence the control response of the control during the actual digitizing operation. The proportional component has the default setting 1 and the integral component 0.150 s. If the proportional component is set to high, the system tends toward oscillation on linear or slightly curved paths. If a low value is set, the machine is corrected too little at sharp corners causing frequent loss of contact. Similarly, selecting an excessive integral component would cause permanent deviation from the set deflection.

4.3 Setting of the parameters for acceleration

The parameters to be set for acceleration are DIG_A_MAX, DIG_A_MAX_MOVE, and DIG_A_MAX_SCAN. These values affect the deceleration and acceleration response of the machine during digitization. Parameter DIG_A_MAX is also relevant to learning mode and is usually set a little smaller or equal to DIG_A_MAX_MOVE. Parameter DIG_A_MAX_SCAN affects the scanning behavior especially during deceleration or acceleration at corners. If loss of contact frequently occurs traveling into or out of corners, this parameter should be reduced further. Values between 0.05 and 0.15 are realistic.

4.4 Determining the axis assignment for the 3D probe

When using the Renishaw probe SP2, the probe axes are transformed with parameter DIG_L_ORDER via manual operation. The direction of the axis can be altered via parameter DIG_L_INKR.

4.5 Digitization-specific machine data

4.5.1 General machine data

11430 MD number	**DIG_ASSIGN_DIGITIZE_TO_CHAN** Channel definition for digitization	
Default value: 0	Lower input limit: 0	Upper input limit: 10
Check = ON	Protection level: 2 / 7	Unit: -
Data type: DWORD	Valid as from software version: 2	
Meaning:	With this machine data you can configure the channel in which the digitizing function can be activated. Value 0 means that the digitizing function is not active.	
MD irrelevant for ...		
corresponding to ...		

4.5.2 Channel-specific machine data

21420 MD number	**DIG_L_ORDER** Axis arrangement of the probe during digitization	
Default value: 0	Lower input limit: 0	Upper input limit: 5
Check = ON	Protection level: 2 / 7	Unit: -
Data type: BYTE	Valid as from software version: 2	
Meaning:	The axis arrangement of the probe is defined with this machine data. 0: X, Y, Z 1: Z, X, Y 2: Y, Z, X 3: Z, Y, X 4: X, Z, Y 5: Y, X, Z	
MD irrelevant for ...		
corresponding to ...		

21422 MD number	**DIG_L_OFF_Z** Pretension in the Z direction for probe adjustment	
Default value: 1.0	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	The pretension in the Z direction is set with this machine data Probe adjustment specified with the reference funnel. Possible value for the Renishaw SP2: 1 mm.	
MD irrelevant for ...		
corresponding to ...		

21424 MD number	DIG_L_INKR[n] Resolution of the probe during digitization	
Default value: 1.0	Lower input limit:	Upper input limit:
Check = ON	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	The resolution of the probe is defined with this machine data. Possible value for the Renishaw SP2: 1 mm. The index[n] of the machine data has the following coding: [axis]: 0-2	
MD irrelevant for ...		
corresponding to ...		

21430 MD number	DIG_L_MIN Minimum deflection of the probe during digitization	
Default value: 0.15	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With the machine data, the minimum deflection of the probe is defined for digitization. The value depends on the probe used and is set to 0.15 mm for the Renishaw SP2.	
MD irrelevant for ...		
corresponding to ...		

21432 MD number	DIG_L_NORMAL Typical deflection value for digitization	
Default value: 1.0	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 4	
Meaning:	The typical deflection value is set for digitization with this machine data. Possible values for the Renishaw SP2: 0.8 to 1.2 mm.	
MD irrelevant for ...		
corresponding to ...		

21434 MD number	DIG_L_NOTAUS Deflection of the probe, at which emergency off is triggered	
Default value: 2.0	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 4	
Meaning:	With this machine parameter, the deflection value is defined at which an error is detected but at which the scanning function is continued with a retry. Possible values for the Renishaw SP2: 2.5 to 4.5 mm.	
MD irrelevant for ...		
corresponding to ...		

21436 MD number	DIG_L_NOTAUS_EXT Deflection of the probe at which emergency off is triggered with an extended deflection range.	
Default value: 3.5	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the deflection value of the probe is defined at which emergency off is triggered with an extended deflection range. Possible values for the Renishaw SP2: 2.5 to 4.5 mm.	
MD irrelevant for ...		
corresponding to ...		

21450 MD number	DIG_V_EILGANG Typical rapid traverse velocity during digitization	
Default value: 10000	Lower input limit: 0.0	Upper input limit:plus
Check = PLUS	Protection level: 2 / 7	Unit: mm/min
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the typical rapid traverse velocity is defined for digitization.	
MD irrelevant for ...		
corresponding to ...		

21460 MD number	DIG_A_MAX Maximum path acceleration for digitization	
Default value: 100.0	Lower input limit: 0.0	Upper input limit: plus
Check = PLUS	Protection level: 2 / 7	Unit: mm/s²
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the maximum path acceleration is defined for digitization.	
MD irrelevant for ...		
corresponding to ...		

21462 MD number	DIG_A_MAX_MOVE Maximum path acceleration for positioning in digitizing mode	
Default value: 0.0	Lower input limit: 0.0	Upper input limit: plus
Check = PLUS	Protection level: 2 / 7	Unit: mm/s²
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the maximum path acceleration is defined for positioning in digitizing mode.	
MD irrelevant for ...		
corresponding to ...		

21464 MD number	**DIG_A_MAX_SCAN** Maximum path acceleration for digitizing function	
Default value: 0.0	Lower input limit: 0.0	Upper input limit: plus
Check = PLUS	Protection level: 2 / 7	Unit: mm/s²
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the maximum path acceleration is defined for the digitizing function.	
MD irrelevant for ...		
corresponding to ...		

21470 MD number	**DIG_P_HAND** Proportional factor for manual mode	
Default value: 1.0	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: 1000/min
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the proportional factor is configured for manual operation. deflection * factor = velocity To obtain a higher velocity, the factor must be increased. If the machine does not run smoothly in manual operation, the factor must be reduced. Possible values (machine-dependent): 0.6 to 1.2 1000rpm.	
MD irrelevant for ...		
corresponding to ...		

21472 MD number	**DIG_P_SCAN** Proportional factor for probe correction	
Default value: 1.0	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: 1000rpm
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the proportional component of the probe correction is configured for digitization. DIG_P_SCAN, together with DIG_T_SCAN, configures a PI controller and is largely dependent on the sensor. Possible value for the Renishaw SP2: 1 1000rpm.	
MD irrelevant for ...		
corresponding to ...		

21474 MD number	DIG_T_SCAN Time constant for probe correction	
Default value: 0.15	Lower input limit: 0.0	Upper input limit: plus
Check = PLUS	Protection level: 2 / 7	Unit: s
Data type: DOUBLE	Valid as from software version: 2	
Meaning:	With this machine data, the time constant is defined for probe control. DIG_T_SCAN, together with DIG_P_SCAN, configures a PI controller and is largely dependent on the sensor. The smaller the value, the larger the I component. Exception: The value 0 means infinite lead time, i.e. no I component. Possible value for the Renishaw SP2: 0.15 s.	
MD irrelevant for ...		
corresponding to ...		

21476 MD number	DIG_SENSOR_OFFSET Vector of the tool holder for stylus holding	
Default value: {0.0, 0.0, 0.0}	Lower input limit:	Upper input limit:
	Protection level: 2 / 7	Unit: mm
Data type: DOUBLE	Valid as from software version: 4.2	
Meaning:	The vector of the tool holder for stylus holding is defined with this machine data.	
MD irrelevant for ...		
corresponding to ...		

4.5.3 Axis-specific machine data

37300 MD number	**DIG_P_MIN** Lower working range limit (software limit) for digitization		
Default value: -1.0e8	Lower input limit:	Upper input limit:	
	Protection level: 2 / 7	Unit: mm	
Data type: DOUBLE		Valid as from software version: 2	
Meaning:	The lower limit if the working range (software limit) for digitization is defined with this machine data.		
MD irrelevant for ...			
corresponding to ...			

37310 MD number	**DIG_P_MAX** Upper working range limit (software limit) for digitization		
Default value: 1.0e8	Lower input limit:	Upper input limit:	
	Protection level: 2 / 7	Unit: mm	
Data type: DOUBLE		Valid as from software version: 2	
Meaning:	The upper limit if the working range (software limit) for digitization is defined with this machine data.		
MD irrelevant for ...			
corresponding to ...			

37320 MD number	**DIG_V_MAX** Maximum axis velocities for digitization		
Default value: 1.0e4	Lower input limit:	Upper input limit:	
Check = PLUS	Protection level: 2 / 7	Unit: mm/min	
Data type: DOUBLE		Valid as from software version: 2	
Meaning:	With this machine data, the maximum axis velocities are configured for digitization.		
MD irrelevant for ...			
corresponding to ...			

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SINUMERIK 840D Digitizing

Part 2: Scanning with Tactile Sensors (scancad scan)

1 Introduction

Before we deal with the operation and various functions of scancad scan in the following chapters, let us take a look at some basic notions that are important for understanding. Not only these basic aspects of digitization but also the operating concept of scancad scan are explained.

1.1 Basics	Basic concepts of the scancad scan tactile digitization system
1.2 Digitizing project	Structured operating concept for digitization

1.1 Basics

Basic terms

Here are some frequently used terms for your better understanding. They will be explained in more detail throughout the manual:

Scanning method:	The scanning methods is the strategy (also known as "pattern") with which the surface of the workpiece is to be recorded with the stylus.
Segment:	A segment is a sub area of the workpieces that is digitized with a certain scanning strategy.
Line:	The path of the stylus from one boundary of the scanned area to the opposite boundary is termed a line.
Partial line:	The part of a line that can be scanned without lifting the probe is termed a partial line.

Why are there different scanning strategies?

During digitizing, the stylus is guided across the surface of the workpiece in specific paths by the digitization control. The type of movement depends on the selected scanning method. During digitizing, the measured values are transferred to the PC and stored there.

To make the system easy to operate, it would actually be desirable to be able to scan a workpiece with a single scanning strategy. The necessary inputs must be limited to definition of the scan area and a few additional traversing parameters.

"Pushing away"

In tactile digitization, this is a physical effect that makes it impossible: "Pushing away". By "pushing away" we mean deflection of the stylus perpendicular to the set scanning plane. This effect occurs at positions at which the contour runs parallel with the actual scanning path ("transverse inclination"). In such cases, the closed-loop control can no longer decide using the probe deflection alone whether the path of the stylus is to run perpendicular to the scanning path (past the obstacle) or precisely on the scanning path (over the obstacle). This effect is one reason why scancad scan provides different scanning methods. The aim is to route the scanning paths in such a way that, if possible, steep edges of the model are perpendicular to the scanning path. This ideal digitizing is possible on many workpieces but rarely with only one scanning method. scancad scan is very robust against the pushing way effect and has a number of automatic strategies to counter critical pushing away.

With the different scanning methods, the scanning process can also be adapted to different tasks definitions. This is especially important if the scanning paths are to be used for direct milling ("1-to-1 milling").

Segments

Both the reasons stated above mean that it is better to subdivide the model into segments. These can then be digitized with a suitable scanning strategy.

Further reasons for subdivision of the workpiece into segments are the choice of suitable stylus, optimum line width, and scanning velocity. If an area of the workpiece has soft contour changes and large radii, the probe diameter and line width can be wide and the set velocity must be high. The opposite applies to a workpiece with a thin, highly variable structure.

By subdividing the workpiece into segments, it is only necessary to digitize difficult subareas with a low scanning velocity or small line width. But, there too, scancad scan provides powerful control options with adaptive digitizing velocity and adaptive line width.

Scanning plane

One fundamental distinguishing feature between different scanning strategies is in the choice of scanning plane. That is the plane in which the scan path runs. This plane can either be horizontal or vertical. If the scanning plane is horizontal, the vertical component of the measured data is approximately constant. The scanning planes are moved from path to path parallel with the selected scan strategy, or rotated, or arranged along a route.

Horizontal scan planes are used for outline scanning methods, vertical scanning methods for all other scanning methods. Manual scanning does not have any special scan plane.

Scanning area

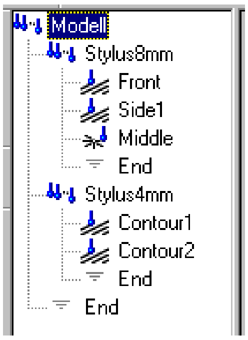
One further distinction between scan strategies is the way in which individual scanning areas can be defined. This is important for subdivision of the workpiece into segments. The working area of the machine is a natural restriction of the area. In particular, please note that all ranges stated are only two-dimensional. At the moment, there is no way of defining a 3D limitation uniquely.

The following table summarizes the relationships between the scanning methods, the associated working planes, and the possible limitations. It can be used as a simple way of selecting a suitable scanning methods.

	Scanning method					
	Parallel	Radial	Line	Outline	Partial outline	Manual
Scanning plane						
None						●
Vertical	●	●	●			
Horizontal				●	●	
Scanning area						
Unlimited						●
Rectangle	●					
Fence	●					
Circle segment		●				
Route range			●			
Cir-cumference				●	●	
Partial cir-cumference					●	

Working planes and scanning area for the various scanning methods (see also Chapter 6)

1.2 Digitizing project



The operating concept of scancad scan is heavily based on the execution of projects. To fulfill the actual task, complete digitization of a workpiece, several working steps are necessary. They are the scans of the individual segments with a suitable scanning methods. To structure the task better, special structuring elements are available.

Model level

In the hierarchical display, fulfillment of the work task is naturally in the top position. This level is called the "model level" in the documentation to follow. Below this level, there are all the other working steps involved in digitization. Only one model level is used to scan a model.

Group level

To structure the working procedure still further, you can use group levels. The group together the scan below them segment by segment. One feature of all segments that are grouped together under a group level might be, for example, use of the same stylus.

Segment level

The required scans of the individual segments form the smallest unit in the structure.

The options of this new structuring must now be illustrated by a few practical considerations.

Automatic acceptance

For many digitization tasks, only a limited number of different styluses are used. Very often some parameters, like retraction height, file name, or tolerance for data reduction do not differ. This data applies to the entire model. For that reason, they are defined at the top level, called the model level.

Because of the structure, these parameters are automatically bequeathed by the higher level to the lower elements - the individual scans - or group levels, unless, other values are explicitly entered at those levels. This considerably simplifies the entire input process for a digitizing project because duplicate entry is no longer necessary. For a finer subdivision, it is also possible to insert additional subgroups, e.g. for the various styluses used. The general parameters for the stylus in question are then defined on this group level. The individual scanning methods then only need to be defined by stating the scanning area. The structure described by way of example is illustrated in the above figure.

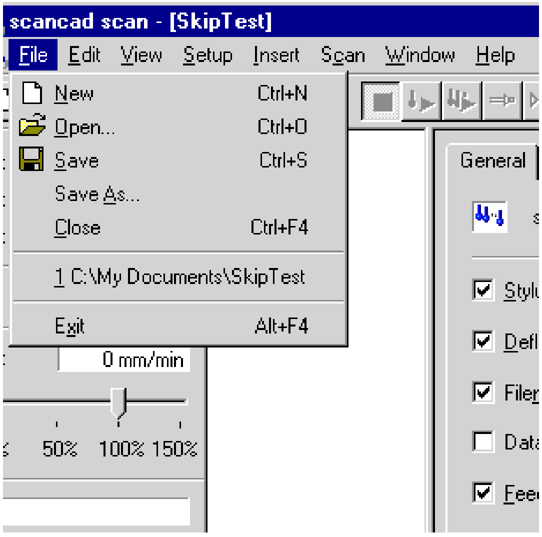
One further example for user of this grouping is the scanning of various models within a digitizing process. Here, a separate group level can be constructed for each module that can contain all the data important for scanning.

The parameters of the group level are also available to the lower segment level. It is a general rule in handling that all values that are not explicitly entered on the level in question are inherited from the higher level.

Notes

2 File

Menu



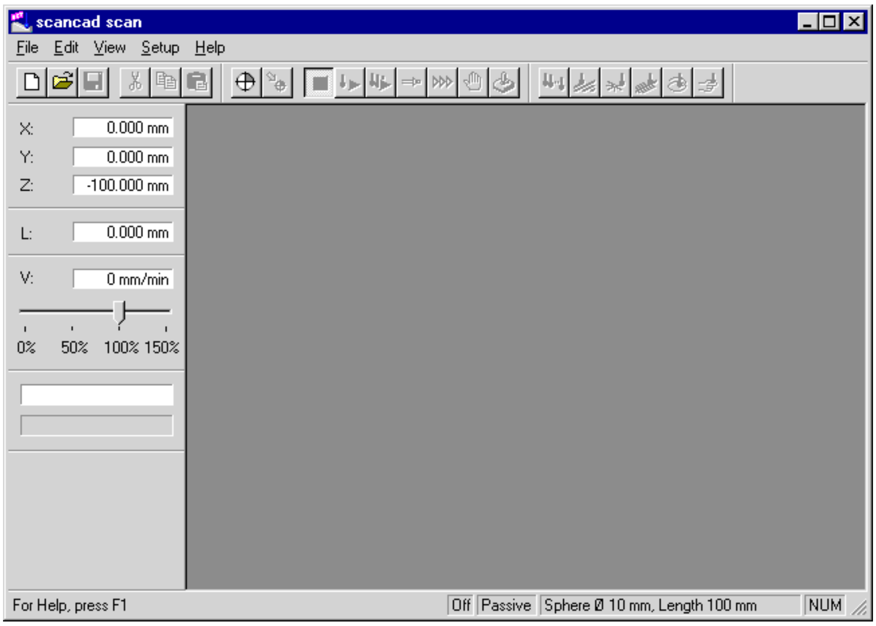
Functions

After you have selected the menu item *File* you can select one of the functions listed below.

2.1 New	To create a new digitizing project
2.2 Open	To open an existing digitizing project
2.3 Save	To save a digitizing project for subsequent re-use
2.4 Save as	To save a digitizing project with a different name
2.5 Close	To close the digitizing project
2.6 Exit	To terminate digitizing

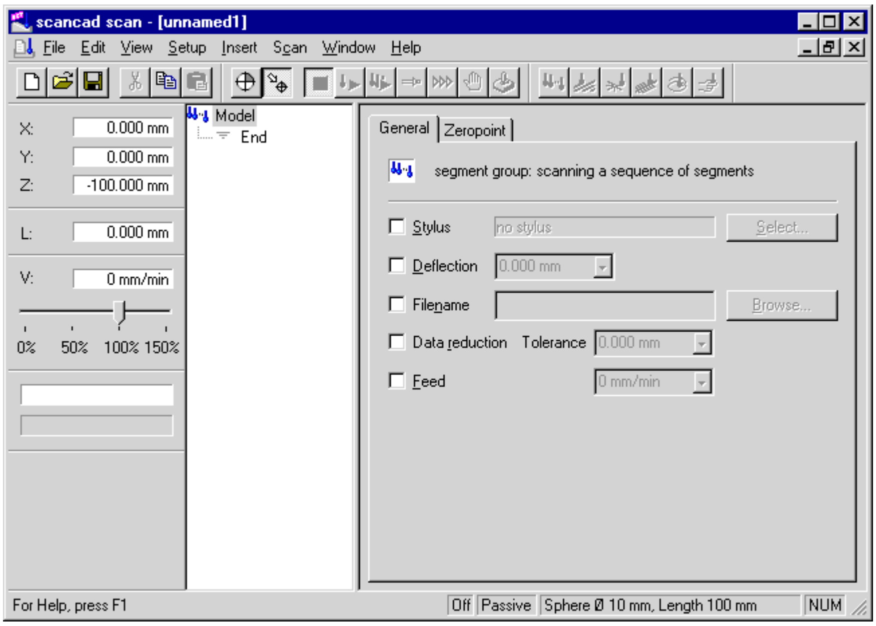
2.1 New

Screen
without an opened digitizing project



Select this menu item to create a new digitizing project. That is always necessary when you want to set up a new digitizing operation. scancad scan provides an initial structure which only consists of the model level. You can then insert groups and scanning segments by the methods described in the manual (see Section 6).

Screen
with an opened digitizing project



Because many functions of scancad scan are only available when a project is opened, the appearance of the digitizing window changes when you open a project.

Additional menu items are displayed. The following sections describe the screen layout in more detail. For example, options for customizing the screen are described.

2.2 Open

You can open an existing digitizing project with this function. You can then process the project.

2.3 Save

This command is used to save your current digitizing project. It makes sense to save a project when you want to resume setup later on, or if, while you are creating it, it seems likely that you will need to use the project again some time. Also, if you do not scan immediately after setup, you must save the project first.

2.4 Save as

Unlike the operation *Save* described above, here the system asks you for a name for the digitizing project. This dialog also appears if you have not yet saved the project under a name.

2.5 Close

If work on the current digitizing project is completed or interrupted, you can close the project with this function. If it has not been saved first, you are requested to do so now. This command only closes the digitizing project which is currently open. The digitizing software scancad scan remains active. If you want to exit the scanning system altogether, you must use the command *Exit* described below.

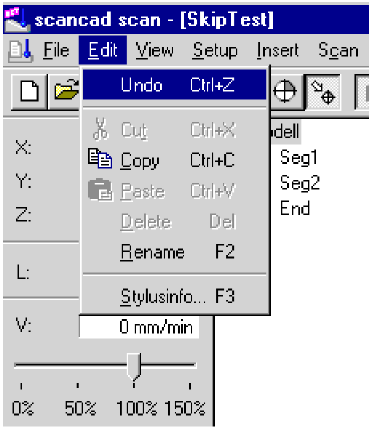
2.6 Exit

With this function you can exit the scancad scan digitizing system. Depending on how the program was installed, either the digitizing position control will also be deactivated or only link between scanning software and the control will be broken.

Notes

3 Edit

Menu



Functions

After you have selected the menu item *Edit* you can select one of the functions listed below. Not only the commands for copying, deleting and renaming elements of the project but also the stylus management module are contained in this menu.

3.1 Cut	Cuts segments and groups
3.2 Copy	Copies segments and groups
3.3 Insert	Inserts segments and groups
3.4 Delete	Deletes segments and groups
3.5 Rename	Renames segments, groups and models
3.6 Stylus list	Stylus management 3.6.1 Select 3.6.2 Add 3.6.3 Edit 3.6.4 Delete 3.6.5 Adjust 3.6.6 Import 3.6.7 Export

3.1 Cut

If you want to create new projects or edit existing digitization projects you can cut individual elements of a project and paste them at a different location. In this case the elements are not irrevocably lost as they are when you use the *Delete* function described below but are placed in a clipboard.

The way in which the function works depends on which part of the project is to be cut:

Project element	Effect of the cut function
Model level	This level cannot be cut.
Group level	Removes the entire group with all its subgroups and segments from the project hierarchy.
Segment:	The current segment is cut out of the project.

3.2 Copy

If you want to use parts of a project at a different location in the same/in a different project you can copy individual sections of the project. However, unlike the *Cut* function described above, the copied element is not removed from the project.

Again, the way in which the function works depends on which part of the project is to be copied:

Project element	Effect of the copy function
Model level	Copies the entire model level with all its subgroups.
Group level	Copies the entire group with all its subgroups and segments.
Segment:	Copies the current segment in the project.

3.3 Insert

Once you have cut or copied individual elements or entire groups using one of the above functions to the clipboard you can then insert them again at a location of your choice with this command.

The element is always inserted above the current selection. If you want to insert it at the end you must mark the end mark.

If you have put a single segment in the clipboard, for example, you only have to mark the point in the project above which the new object is to be inserted. If the object in the clipboard is a group of subsegments, the entire group with all its components will be inserted at the marked point.

3.4 Delete

When editing a project you can also delete groups or scanning segments. You can therefore use existing projects as a basis for creating new digitization projects. If you want to use an existing project for scanning individual areas only, simply remove the segments or groups that you no longer need. You can minimize the setup time in this way. The way in which the function works depends on which part of the project is to be deleted:

Project element	Effect of the delete function
Model level	This level cannot be deleted.
Group level	Deletes the entire group with all its subgroups and segments from the project hierarchy.
Segment:	The current segment is deleted.

3.5 Rename

You should give the individual levels of your new project structure applicable names. To support this, the rename mode is called up automatically whenever you insert a component.

3.6 Stylus list

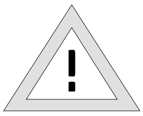
Different styluses

A selection of styluses are available so that you can select a diameter and stylus shape suited to the requirements of the various digitization tasks. The range covers everything from spherical ruby tips with a diameter of 0.5 mm to semi-spherical and cylindrical styluses with a diameter of up to 40 mm. If necessary, you can also create your own styluses.

Stylus management

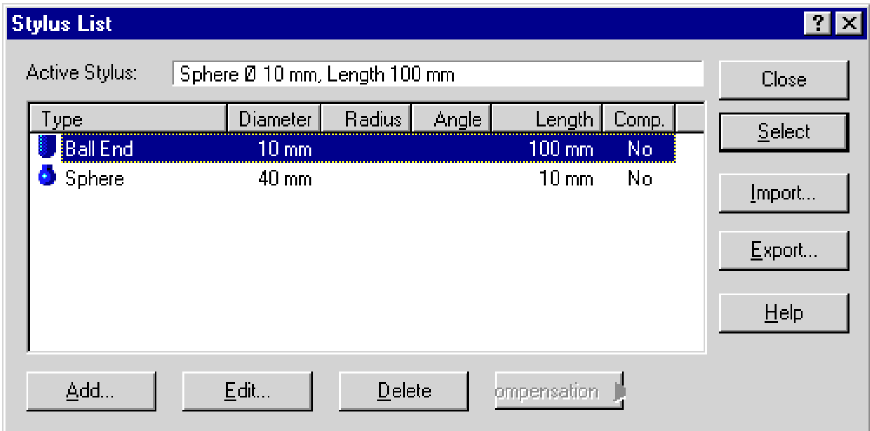
scancad scan manages all the styluses available to you in a stylus list. This list contains all the stylus details. The stylus management also manages the offset tables for the styluses.

Working with the stylus list, adding and altering stylus descriptions and the meaning of the offset table are described in more detail below. Importing and exporting stylus lists is also described.



Caution: The software does not have a function for checking that the correct stylus has been inserted. It assumes that the stylus indicated as being active has actually been placed in the sensor. If the values do not correspond, the ensuing calculations will not be correct! As the stylus length is also taken into account for scanning, the sensor might be damaged if the incorrect length is specified!

Dialog box



When you select the function *Stylus list* the dialog box shown above appears. The stylus currently being used appears in the top line. The list below that contains all the available styluses. The contents correspond to the scope of supply when you open the list for the first time. If you click on a column header the list is sorted according to the criterion of that header. For example, if you click on *Type* the list is sorted according to stylus types.

You will see the buttons with the different editing functions at the bottom and right-hand side of the dialog box. These will now be explained in more detail.

3.6.1 Select

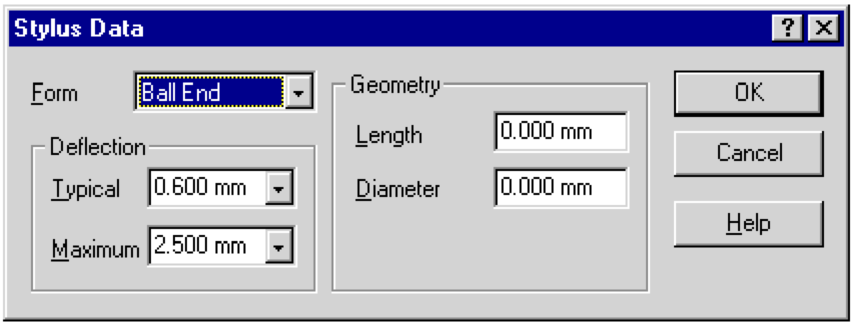
Activating a stylus

If you want to select a stylus from the stylus list you can either double-click on the stylus you wish to select or select the stylus with the *Select* button. At the same time the offset table for that stylus is loaded and activated. That stylus is now the active stylus.

3.6.2 Add

If you want to add a new stylus to the list simply select that button. A new dialog box in which you can enter all the necessary data about the stylus is displayed.

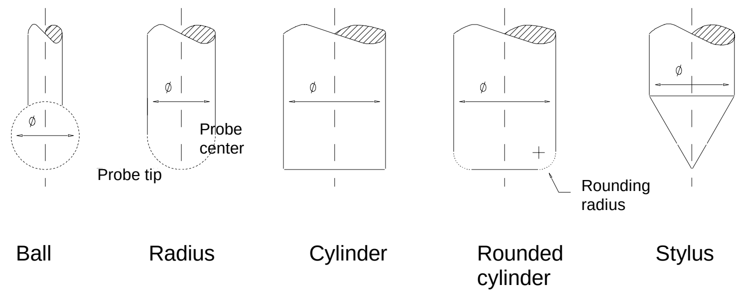
Dialog box



Shape

The digitization software scancad scan allows the use of different stylus geometries. These are also supported by the software for continued processing of the data. The stylus forms shown in the drawing below are currently used:

Stylus shapes



Deflection

In digitization the stylus in the probe housing is deflected from its home position. This value is called the deflection. A more detailed description of the correlation between deflection and control response of the control is given in Section 6. As the pressure placed on the model changes with the deflection due to the spring rigidity of the suspension, it is quite clear that smaller deflections should be used on smaller styluses used for acquiring filigree model areas.

Typical deflection

It is therefore generally possible to state a standard value for deflection for every stylus operation. You will be given tips on sensible values for deflection during system start-up and training. These values are also contained in the stylus list supplied with the stylus.

Maximum deflection

For the reasons given above, a value for the maximum deflection that must not be exceeded during operation must also be stated. If the software detects that this value will be exceeded, EMERGENCY OFF is triggered. Specification of a maximum deflection is especially important for small styluses because the stylus is deflected to its maximum deflection when the probe is adjusted.

Dimensions

Depending on the type of stylus used, a range of different parameters is available for defining the geometry.

Length

This value represents the length of the stylus insert from the tip to the area of contact on the sensor. This is taken into account by the software when the stylus is exchanged. It may then not be necessary to reset the zero point.

Diameter

Enter the diameter of the stylus here.

Rounding radius

If you have entered a stylus in the shape of a rounded cylinder, you must enter the rounding of the radius here.

Angle

A stylus-shaped probe is described by entering an angle. scancad mill used to continue processing of the data currently only supports a 60º stylus.

3.6.3 Edit

When editing an existing stylus description you can select one from the list. Once you have selected the function *Edit* you can change the individual details. This dialog box is the same as that described in subsection 3.6.2.

3.6.4 Delete

If you want to delete a stylus from the list mark the entry in the list. When you press the *Delete* button the entry is immediately removed from the list.

3.6.5 Adjust

Stylus bending

The styluses available differ in terms of shape of the tip, length, diameter and material. Each stylus type has its own sag depending on the deflection. Above a certain size the sag will have a negative influence on the measuring precision. It is especially important to monitor the sag on thin styluses.

Stylus twisting

Another source of error when recording digitizing data is the twisting of the sensor in the holder on the machine. In spite of the locating element in the holder inaccuracies of up to 1° degree cannot be ruled out.

If digitizing is to be performed with the greatest possible precision, adjustment (calibration) of the sensor/stylus combination should be performed before scanning is started. To do this select *Adjust* once you have selected your stylus.

To do this first clamp the adjustment funnel (part of the scope of supply of the sensor) at a suitable position on the machine and guide the stylus in the funnel opening with the function described in Chapter 5 (e.g. manual mode). Calibration is started as soon as you call the adjustment function.

The full permissible stylus deflection range (+/- maximum deflection) is now traversed separately for each axis. A characteristic for the compensation of the stylus sag is generated for each stylus used. This is stored together with the stylus geometry data in the stylus list. The entry *Adjust* is set to *yes* for the stylus currently in use.

The characteristic is activated as soon as it has been recorded. The sensor can now be moved out of the funnel.

If you select a stylus from the stylus list for which a compensation table already exists, it is automatically loaded. It is therefore not necessary to perform calibration anew every time. This saves time but can in fact only be used when the same stylus is used and the sensor has not been removed from the holder in the meantime. Of course, separate compensation also has to be performed for stylus extensions.

3.6.6 Import

It is not only possible to create and edit stylus lists in the programming system scancad scan. They can also be generated externally, for example, in a spreadsheet program. Such a "CSV" (comma-separated values) format file can be read directly into the stylus list. If styluses are supplied by BCT this file is part of the scope of supply. The new styluses can then be used immediately.

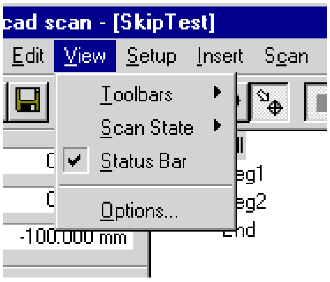
3.6.7 Export

You can export the stylus list if you want to edit it with an external program. The data are then output in CSV format. This means that all the values are stored separated from one another by a comma. This format is supported by all common spreadsheet programs.

Notes

4 View

Menu



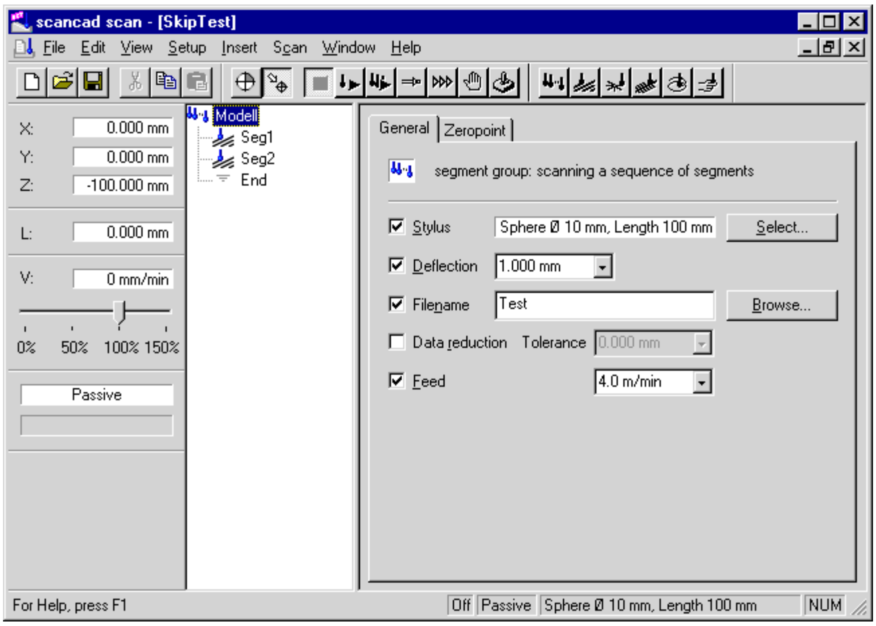
Functions

As is the case with all Windows programs, with scancad scan, too, you can adapt the screen window to your needs. You can organize your displays and activate or deactivate them. The various possibilities are described in more detail in this section of the manual. The individual functions available are listed below.

4.1 Function bar	Activate/deactivate function bar
4.2 Status bar	Activate/deactivate status bar
4.3 Scan status	Activating displays for - machine position - absolute deflection - deflection in X,Y,Z - override display - Action display
4.4 Options	dialog boxes for various default settings

Before the various ways of changing the window environment of scancad scan are demonstrated let us first look at all the elements of the scan window.

scancad scan screen



The scancad window is given in brackets in the title bar.

The permanent menu bar is located below the title bar.

Below that you can see the tool bar with buttons for fast execution of functions or commands.

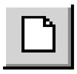
The status bar is located at the bottom of the window. Short help texts are displayed in the status bar. Important operating states are displayed in the boxes further to the right. Digitizing switch ON/OFF, digitizing READY and information about the active probe Taster.

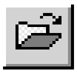
On the left edge of the window you will find the individual displays of the control system. The standard order in which they appear is: Machine position, sensor measured value (deflection), override for feedrate and the velocity display. At the bottom you will see action display that displays the progress of various processes.

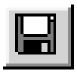
4.1 Tool bar

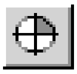
You can activate and deactivate the tool bar with this command. As all the buttons are also displayed in the dialog boxes or menus you can still perform these functions even if the tool bar is deactivated.

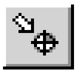
You can click on any of the tool bar buttons listed below to select functions quickly.

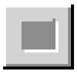

Creates a new document

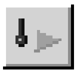

Opens an existing document


Saves the active file

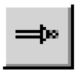

Set zero point

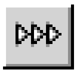

Accept zero point

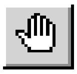

STOP


Scan segment


Scan all

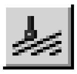

Position

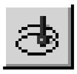

Jog step


Manual mode

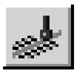

Joystick

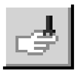

Segment group

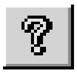
 Parallel scanning

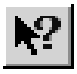
 Outline scanning

 Radial scanning

 Transverse scanning

 Manual scanning

 Help

 What is it ?

4.2 Status bar

If you need more space, for example, to display the digitization project, you can switch off the status bar.

4.3 Scan status

You can switch off some of the displays to individually adapt your scan environment. These are:

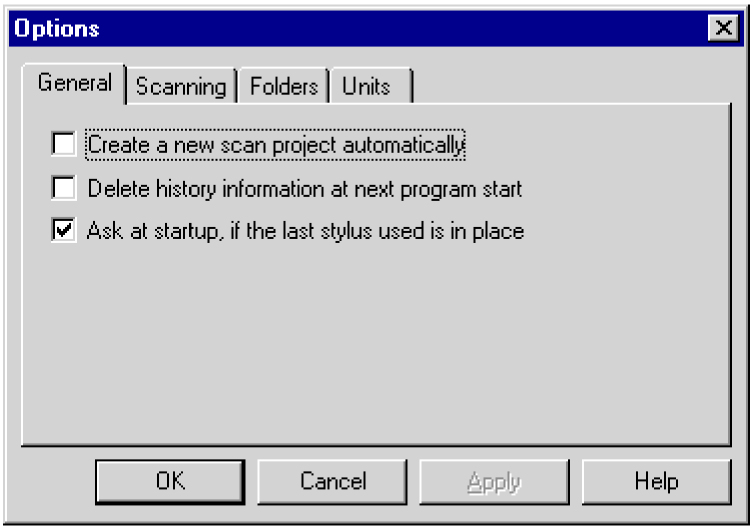
Machine position
Sensor measured value, absolute
Sensor measured value for each axis separately
Override and velocity display
Action display

4.4 Options

A variety of different parameters are available for configuring scancad scan. For clarity, these settings are located in several dialog boxes. These parameters are described in the next section.

4.4.1 General notes

Dialog box



Open new scan project automatically

By default, the window described above is displayed when you start scancad scan. The operator decides whether a new project is created or an existing project is opened. If mainly small digitization projects are executed, scancad scan can automatically start a new project each time it is started.

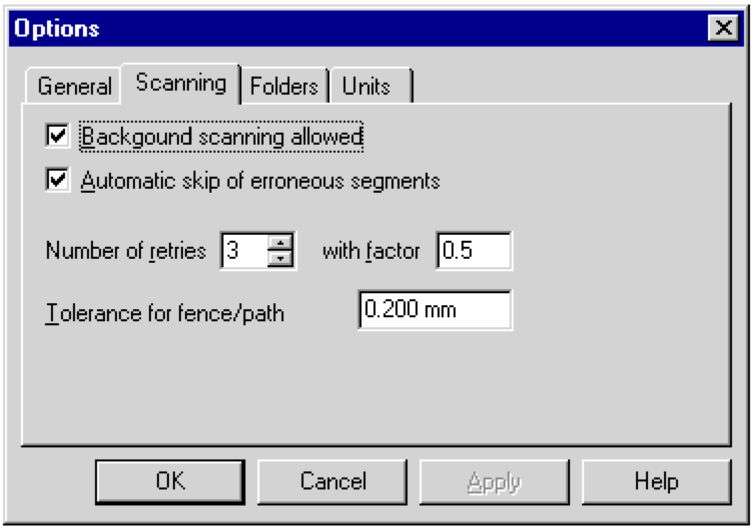
This setting is not suitable for largely complex digitization tasks that are processed by calling up the same project several times.

Delete history information the next time the program is started.

In order to simplify parameter input scancad scan uses history boxes. The last parameter values to be used are stored in these boxes and do not therefore have to be entered anew each time. However, if the digitization projects differ so much that the history box values cannot usually be used again, you can undo this setting when you start the program. They are then only used for the current project.

4.4.2 Scanning

Dialog box



Enable scanning in background

As with other Windows programs, scancad scan can also run in the background. The operator must decide himself whether this is sensible. By default this setting is disabled.

Caution: If scancad scan is running in the background, direct access to the stop function is no longer guaranteed. To stop scanning quickly you must always use the EMERGENCY STOP button on the machine. To close the scancad scan application in the routine way you must place it in the foreground again.

Number of repetitions with factor..

When digitizing with scancad scan situations can occur which the software detects as an error, e.g. because unsuitable scanning parameters have been chosen or because the local scanning behavior is inferior. Lines in which these situations occur can be dealt with in different ways depending on the settings of the parameters described here.

1. Number of repetitions "N" is > 0

   In this case scancad scan will try to scan the scanning line in which the error occurred up to "N" times at a velocity reduced by the specified factor.

   Example: N = 3 repetitions, factor = 0.5 results in:

   1. Repetition at 50% of the digitization speed,

   2. Repetition at 25% of the digitization speed,

   3. Repetition at 12.5 % of the digitization speed. If it is not possible to scan the line at these speeds either, the digitizing task for this segment is canceled. The next segment is started.

2. Number of repetitions = 0

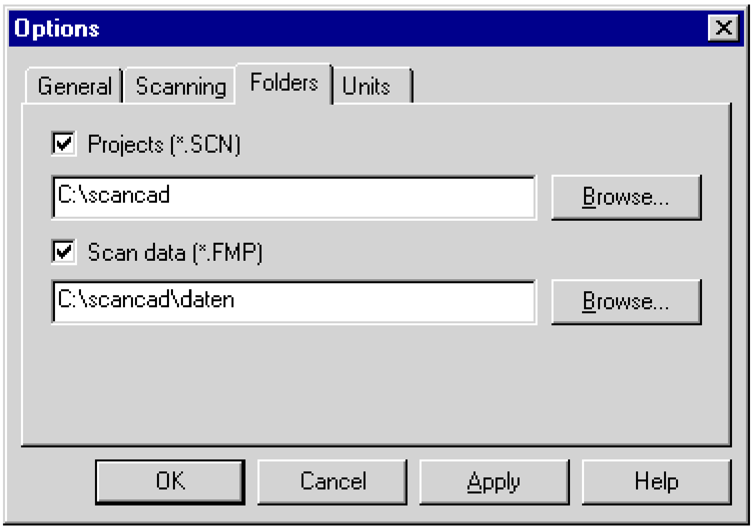
With this setting, scancad scan discontinues the scanning procedure as soon as the error occurs for the first time and then continues from the next segment.

Tolerance

Fences and lines are often recorded manually. To avoid recording too many data due to unsteady movements, the data set can be reduced by an automatic process. The tolerance defines a permissible range of deviation for the data.

4.4.3 Directories

Dialog box



Only two different file types are used by the program system scancad scan. All the information for a specific digitization project is stored in the SCN files. The actual scanning data are stored in the FMP files (see Section A.2).

Project information (*.SCN)

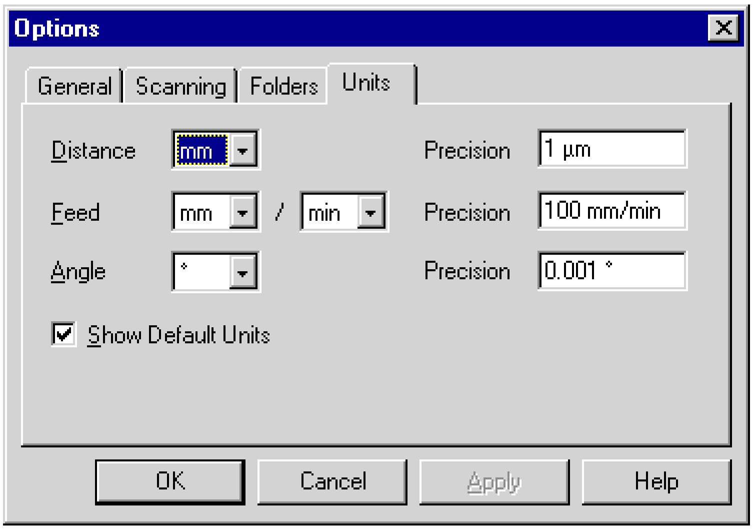
Here you select the directory in which you want to save the information for a specific digitization project. The default setting is the directly that Windows also uses.

Scanning data (*.FMP)

Here you select the directory in which you want to save the actual scanning data. The default setting is the directly that Windows also uses.

4.4.4 Units

Dialog box



In the dialog boxes for the individual parameters scancad scan uses units that you can define here.

Distance

Here, you can specify to the software the units in which the parameters for path/length/distance are to be entered. You can also define the precision for the display. Example:

Units	Precision	Display
mm	µm	23.009mm
m	mm	1.234m
m	µm	1.234567m

Velocity

The units for velocity can be defined with these parameters.

Angle

The format for entering angles can also be defined.

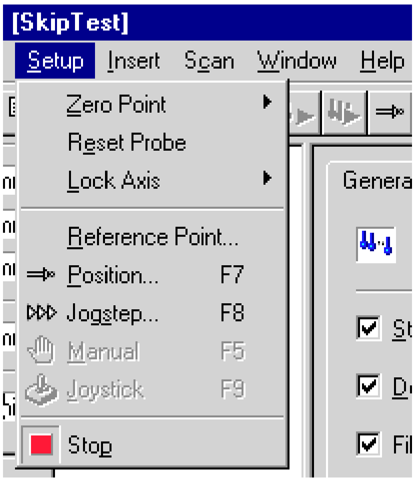
Also display default units

If the display for default units is activated, they are also displayed in the dialog box. If this option is disabled only the units that deviate from the default settings are displayed.

Notes

5 Setup and Preparatory Tasks

Menu



Functions

When you select the menu item *Setup* the functions that you need to prepare digitization are displayed. This includes both the functions required to position and move the machine as well as an easy-to-use alignment wizard. This supports the various methods for aligning the models and setting the zero point.

5.1 Zero point	Submenu with functions for aligning and setting the zero point 5.1.1 Set 5.1.2 Wizard 5.1.3 Accept zero point from segment 5.1.4 Reset zero point
5.2 Zero calibration of probe	Sets the probe deflection to zero
5.3 Disable axis	Disable individual machine axes
5.4 Reference point travel	Synchronization of machine and control
5.5 Position	Absolute positioning of the axes
5.6 Jog step	Step-by-step positioning
5.7 Manual mode	Enable/disable manual mode
5.8 Joystick mode	Activate/deactivate joystick
5.9 Stop	Terminates movement

Requirements

The following conditions must be fulfilled before the digitization control scancad scan can be used:

- The electrical connections between the machine, probe and digitization control have been correctly made.
- The scanning software is fully installed on the PC/control.
- The machine description file "mc.con" and the machine constants it contains have been adapted to the machine being used.

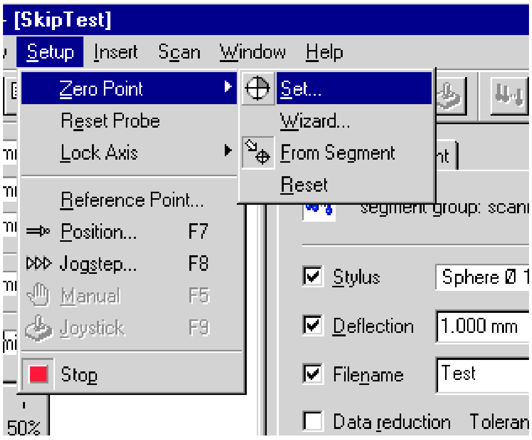
If all these conditions have been fulfilled you can proceed with your work with scancad scan.

Digitizing switch to OFF

First you must switch on the PC and the machine. You should now be able to see the scancad scan window on the monitor of the PC. If you cannot, activate the program. If you use several machines for digitizing, you must set the configuration file for the machine you are using. The digitization switch should still be in the "OFF" position! Now connect the probe if you have not already done so.

5.1 Zero point

Dialog box



When processing the digitization data you must make sure that the position/alignment of the model is correct as soon as you set up scanning. It is also important that you set the zero point for digitization at a position that will also be correct for subsequent processing. All digitization data will then be saved in the coordinate system defined here.

Types of zero points

Two different zero point types are used by scancad scan. Machine zero is active after reference point traverse. It cannot be altered. By contrast, additional zero points are used for defining the scans for the models or the individual segments. However, the coordinate display always used the active zero point, i.e. the coordinates shown in the display refer to the active zero point.

If a zero point is defined using the function *Set* or the alignment wizard, the active zero point is automatically entered here.

Different zero points can be used for different segments within a single digitization project. When scanning, the control always activates the zero point defined in the segment. The coordinates displayed during scanning always refer to this zero point.

Alignment wizard

The shape and size of some models makes it very difficult to align them on the machine table. scancad scan therefore provides various methods for performing alignment of the model internally. Not the model but the scanning data are "rotated" and "translated".

Wizard

A wizard is provided to support you in the selection and execution of these methods.

Set/Reset

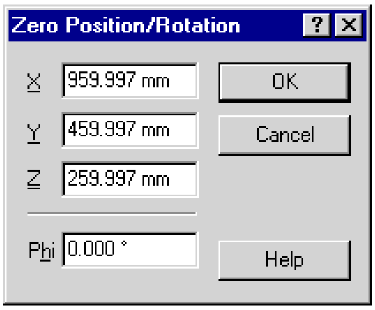
It is not only possible to set a zero point at the current machine position easily but also to reset the zero point at the origin of the unchanged machine coordinate system.

All the functions available for this purpose are described in detail below.

5.1.1 Set

You can easily define the zero point and the alignment of a model for digitization with this function. First of all move the probe to the positions for which the coordinates are known. Then enter the coordinates in the corresponding dialog fields X, Y and Z.

Dialog box



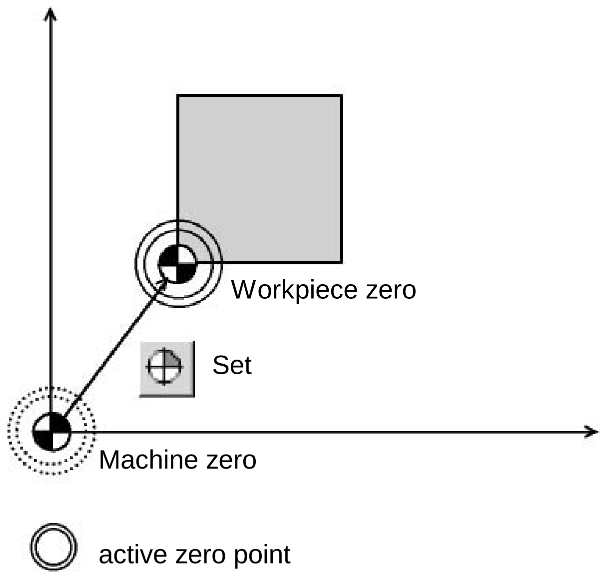
If the position of the rotated model with reference to the machine axes is also known, you can enter that value, too. 0° corresponds to the machine axis in the X direction. The angles of rotation are measured in the counterclockwise direction. All the scanned data are then stored having been rotated about the Z axis by that value.

The system then takes over this coordinate system. All the specified coordinates from now on always refer to the coordinate system defined by the user and not to the fixed machine coordinate system.

5.1.2 Wizard

Wizard -> active zero point

As explained in the introduction above, scancad scan provides various methods for aligning and setting the zero point. Because of the many methods available, a menu that contained them all would be much too large and therefore very difficult to use. A wizard is available to help you use the various functions available. The wizard guides you through the individual steps required to align your model and set the zero point. As soon as you have defined the zero point using the wizard it is activated immediately. It is now the "active zero point".

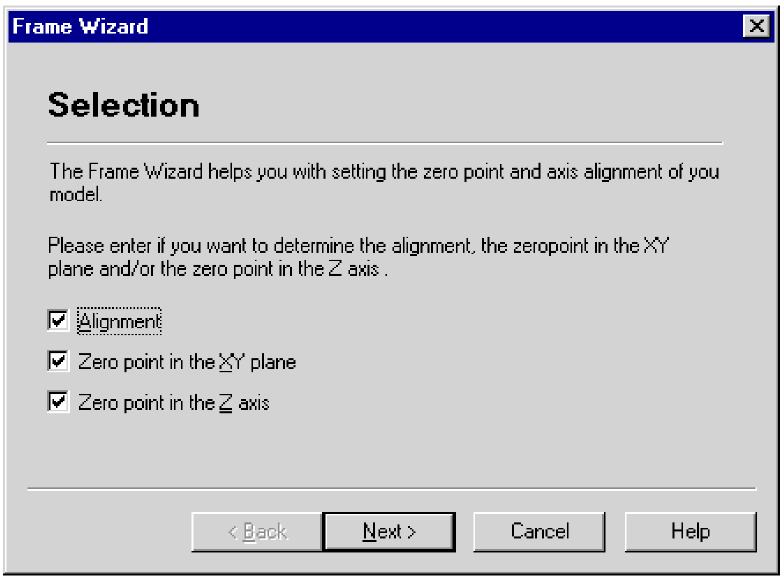


Selection

The procedures for

- alignment
- setting zero points in X and Y
- setting the zero point in Z are all summarized in the wizard.

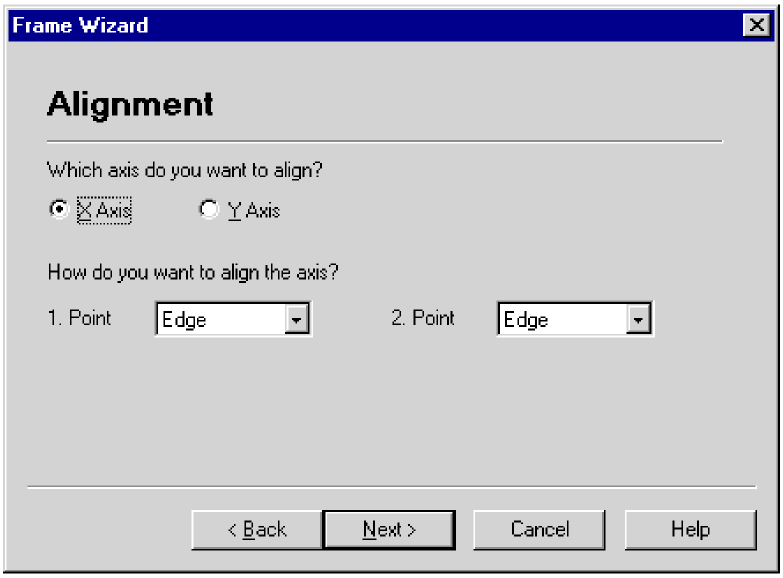
Make a selection to define the procedure and support given by the wizard.



The individual functions of the wizard are described in more detail below. Using the buttons *Next, Back* and *Cancel, Finish* you can move from one dialog box to the other within the wizard.

Align

The wizard offers various options for aligning a model in the X or Y axis.

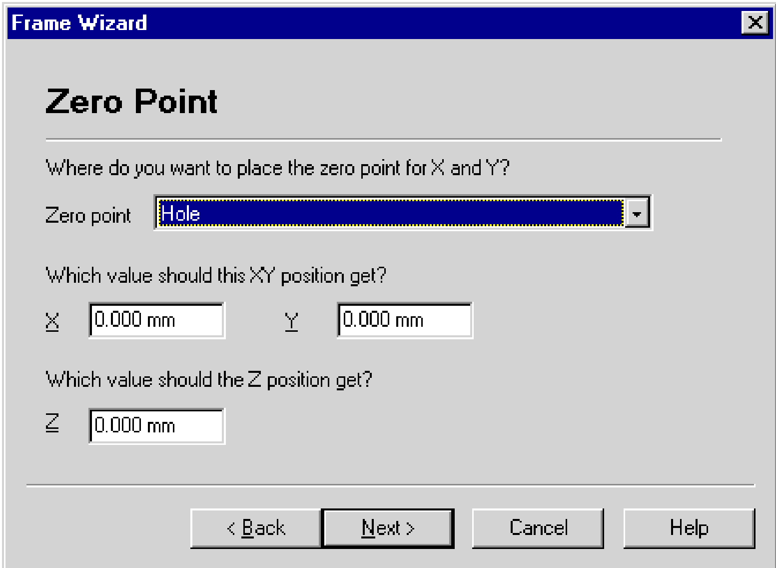


Two different points are usually needed to define the angular position of an axis. This can be ascertained by touching the points listed in the table below. The following combinations are possible:

Acquire 1st point by touching a:	**Acquire 2nd point by touching a:**
point on an edge	point on an edge
Center point of a hole	Center point of a hole
Center point of a hole	Center point of a pin
Center point of a pin	Center point of a hole
Center point of a pin	Center point of a pin

Using these points the software then calculates the rotated position of the model and takes it into account when storing the digitization data. The scanning data are also correct if the model is not exactly parallel to the machine axes on the machine table.

Setting zero point in X and Y



The second function that is integrated in the alignment wizard is the determination of the zero point along the XY plane. The options available with this function depend on whether an alignment is to be performed. If so, the points touched in this procedure can also be used to define the zero point. The possible combinations are listed in the table below:

Alignment	**Set zero point in XY**
No alignment has been performed	- at the center point of a hole - at the center point of a pin
by touching 2 points on an edge	- on the point of intersection of the edge touched on alignment and an additional edge - at the center point of a hole - at the center point of a pin

Alignment	**Set zero point in XY**
using all combinations of touching holes and pins	- on the 1st point of the alignment - on the 2nd point of the alignment - at the center point of P1 and P2 - at the point of intersection of a line touched on alignment and an additional edge - in a hole - at the center point of a pin

Special coordinate values can then be assigned to the point acquired in this way.

Setting the zero point in Z

The zero point in Z can be set even if the touching procedure described above has not been performed. Touching is always performed from above when setting a zero point in Z. You can assign a special value to this point, too.

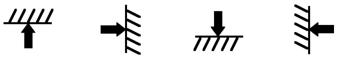
Touching

The steps described above help you to prepare the necessary touch procedures. On the basis of the information it has received, the alignment wizard creates a new dialog which is used to define the touch procedure to be used. In this dialog box you can then select a touch direction from the several types available.

The wizard then asks you to start the touch procedure with the stylus. The touching procedure is therefore an integral part of the alignment wizard.

The following touching methods are available:

Different touching methods

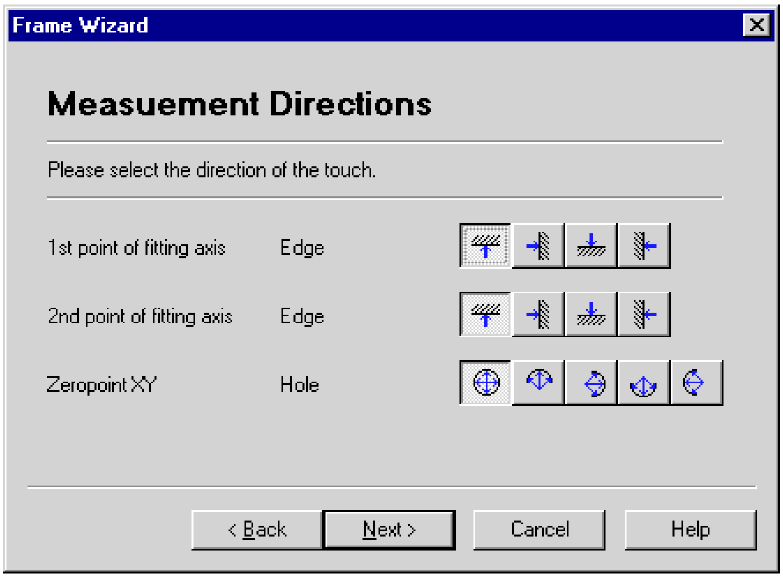
Edges 	Touching from all four directions possible
Holes 	Five touching methods possible. Four of them can also be used for semicircular elements
pins 	As for edges, touching can be performed from four directions. The contour of the pin is touched automatically.

Different sequences

Using any of the touching methods described above, you can perform alignment and determine the zero point in a number of different ways.

The following example demonstrates how you are guided through a "touching" task by the wizard.

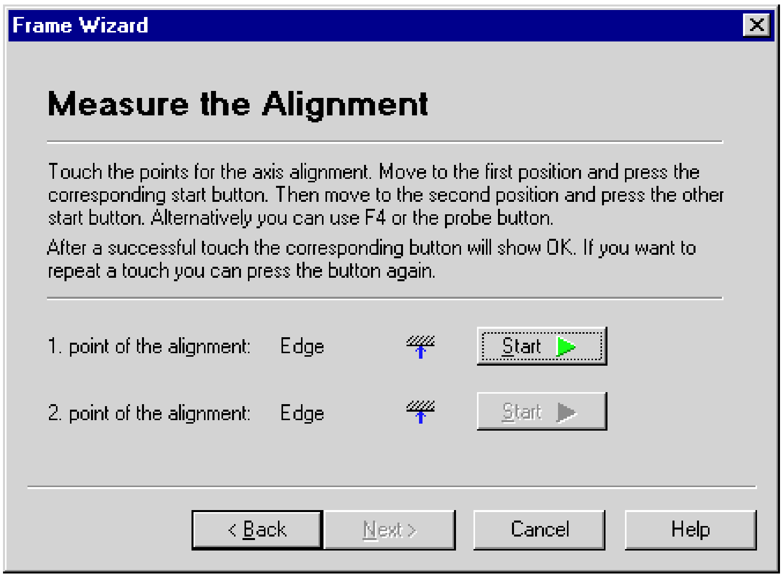
Sequence of operation: Touching



The dialog box that then appears asks you to carry out the touch procedure required for alignment. To do this you must position the stylus near to the edge, the pin or the hole in question. You can do this using the positioning functions described above.

In most cases, the easiest method is to move the stylus manually.

As soon as the touching procedure is successfully completed, the start button is checked.



The last dialog box then asks you to perform the touching operations that define the zero point.

5.1.3 Accepting the zero point of a segment

The zero point is often determined using the wizard. In that case the zero point is activated immediately. However, scancad scan also allows you to set the zero point while you are defining the scanning methods (see Section 6). In order to activate a zero point set in this way it can be taken over from a segment using the function described here.

This procedure is also suitable for another application described here. The fixed machine zero is activated as soon as you switch on the machine and reference it. The coordinate display always refers to that zero point. If you now load an existing project, the zero point defined within that project can be activated by performing this function.

5.1.4 Resetting the zero point

You can define a new coordinate system for working with scancad scan with the function *Set zero point*. This coordinate system is different from the fixed machine coordinate system. The function *Reset* calls up the machine coordinate system again.

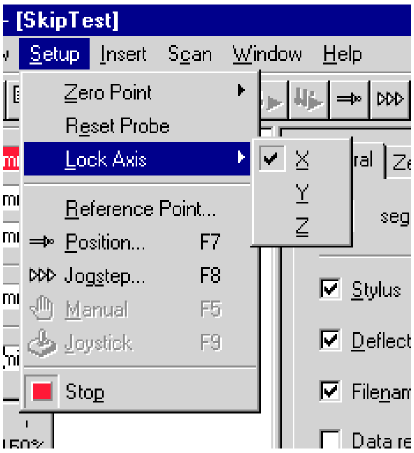
5.2 Probe zero calibration

Hysteresis in the sensor can cause the display to show a small deflection even if the sensor has not made contact with the model. If this hysteresis is greater than 10µm the deflection in all axes can be set to zero with the *probe zero calibration*.

Caution: The *probe zero calibration* must never be used if the stylus is in contact with any object, i.e. is already genuinely deflected. This can cause unpredictable movements because the control can no longer distinguish correctly between when the stylus is in contact and when it is not.

5.3 Disable axis

Menu

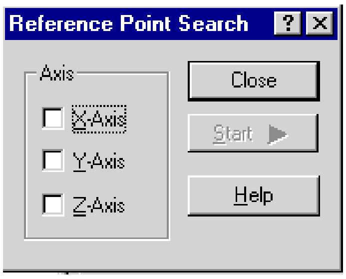


For setup it is often an advantage not to traverse all axes during manual or joystick operation. You can disable individual axes for that purpose. This disable can be canceled by reselecting the axis. You can activate and deactivate the disable using the context-menu of the axis position display. If an axis is disabled, the corresponding display in the position window is displayed with a red background and a checkmark is shown next to the axis in the menu.

5.4 Reference point approach

After the digitizing control has been switched off, it is always necessary to perform a reference point approach in all machine axes. In this case, the position measuring system is synchronized with the digitizing control. The reference point approach can be active, i.e. with the NC control, or passive, i.e. with the NC control if scancad scan is installed parallel with the NC control. Any combination of axes is possible. Whether an active or a passive reference point approach is necessary depends on the NC control and is stated in the machine constant file "mc.con". The procedure for selecting the reference point approach is identical for both methods.

Dialog box



Select the axes you want to reference. If the control has been switched off, you must approach the reference point for every axis. Clicking the *Start* button sets the machine in motion immediately. The progress display depicts the progress of the reference point approach. Now wait until the selected axes have reached their reference point. The dialog will not disappear until you have approached the reference point of all axes.

To avoid collisions with workpieces in the working zone of the machine, the vertical axis is always traverse first.

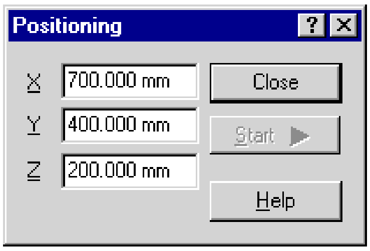
Active/passive reference point approach

During an active reference point approach, you must set the digitizing switch to the "ON" position before starting. During a passive reference point approach, it must be in the "OFF" position. Reference point approach is then performed by the NC control. Passive reference point approach is seldom needed and depends on the particular circumstances under which the NC control is used and the link between the digitizing and NC controls.

After successful completion of the reference point approach, the dialog is closed automatically. All functions of the digitizing control can be used. If you exit scancad scan and start it up again later on, the reference points are retained. Of course, that only applies if no other reference point approach has been performed with the NC control and the digitizing has not been switched off in the meantime.

5.5 Positioning

Dialog box



The function described can be used to approach a defined and known position. After activation of the positioning command, a new dialog is displayed. You enter the axis values of the end point here.

Motion starts immediately you click that the *Start* button. So that a sequence of positioning movements can be performed, the dialog remains open until it is closed by the operator.

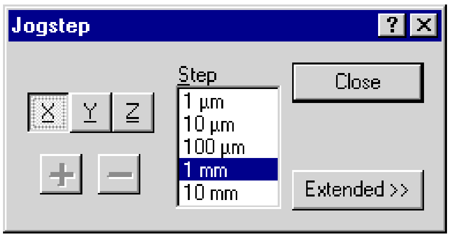
Caution: When the target position is entered, the operator must make sure that the movement does not cause a collision with the workpiece or other parts of the machine. The movement is performed in such a way that all axes reach the target position at the same time.

Despite extensive safety checks before staring digitizing the machine can move out of the permitted working zone, especially during manual operation.

If the sensor is outside the permitted working zone, it is possible to move it back into the valid zone again with this function.

5.6 Jog step

Dialog box



Unlike the positioning function described above, in jog step operation, the machine can move in small, settable steps. The dialog remains open until it is closed by the operator. In this way, you can perform any number of movements.

To perform a movement, first select the size of the step from a list of values. After that, you can select the axis you want to move. You can start the movement and define the direction by clicking the +/- buttons.

With is function, you can move the sensor back into the valid working zone. You only have to enable the relevant direction keys.

5.7 Manual operation

Manual operation = Teach-in

When you set up digitizing you must enter parameters that contain coordinates at several points. Of course, you can enter this values on the keyboard by hand. But it is simpler and safer to enter the data by a method similar to teach-in. The control is switched to manual operation for that purpose.

The sensor is now used to move the axes in the direction of the probe deflection. For example, pulling the stylus down moves the stylus axis down vertically. Pressing it up moves the axis up. Do not deflect the stylus too much, or there is a danger of overdeflecting it. For safety reasons, the maximum possible traverse rate is limited in manual operation too.

Manual operation is activated by selection from the menu or the toolbar. If you select the function again or operate the stop function you deactivate manual operation. While manual operation is active, this is indicated in the toolbar and in the menu.

This mode can be activated to test the function of the digitizing control after every reference point approach in order to detect a malfunction of the system from the outset. Manual operation is especially useful for aligning and for recording limits.

5.8 Joystick operation (optional)

Joystick = Option

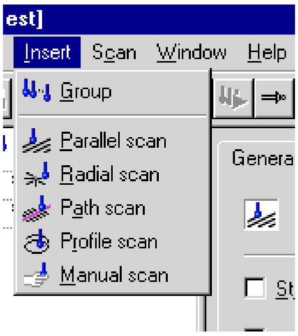
This function is very similar to manual operation, but instead of the stylus, a joystick is used to control the machine. Connection of a joystick is recommended on machines with a large working zone and where a laser sensor is used. For further information about operation, see the documentation about the joystick.

5.9 Stop

If you select this function, all machine movements are stopped immediately.

Notes

6 Inserting Scanning Methods



Functions

After you have selected the menu item *Insert* you can select one of the functions listed below. You can add both groups and individual scanning methods to the project. A detailed description of how the scanning methods work is given in this Section.

6.1	General parameters	Description of the general parameters
		6.1.1 The parameters on the "General" tab
		6.1.2 The parameters on the "Zero point" tab
		6.1.3 The parameters on the "Area" tab"
		6.1.4 Conclusion
6.2	Group	Inserting groups into the hierarchy
6.3	Scanning methods	Description of the scanning methods
		6.3.1 Parallel scanning
		6.3.2 Radial scanning
		6.3.3 Transverse scanning
		6.3.4 Profile/partial profile scanning
		6.3.5 Manual scanning
6.4	Fence editor	Description of the editor for defining boundaries
		6.4.1 Editing polygons
		6.4.2 Editing points

Whereas the previous sections of this manual explain setup of the workpieces and the related functions of the system in detail, this section describes the individual scanning methods, how and when they are used.

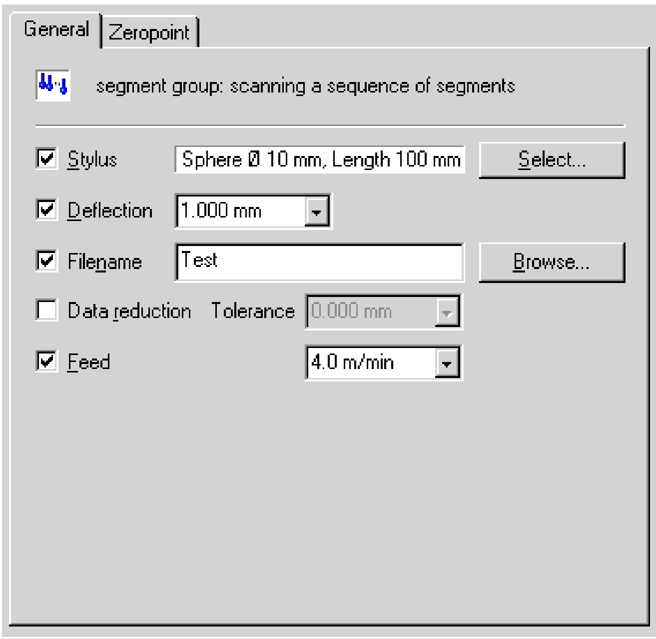
The steps taken to define a scanning method are described in depth. The different scanning options and their parameters are described in detail.

To avoid repeating descriptions of the individual parameters, all the general parameters are dealt with in the initial subsection 6.1. The tabs "General" and "Zero point" only contain parameters that are used by all the scanning methods. Only the tab "Area" contains some parameters that are different depending on the scanning method used. These special parameters are dealt with together with the individual scanning methods.

6.1 General parameters

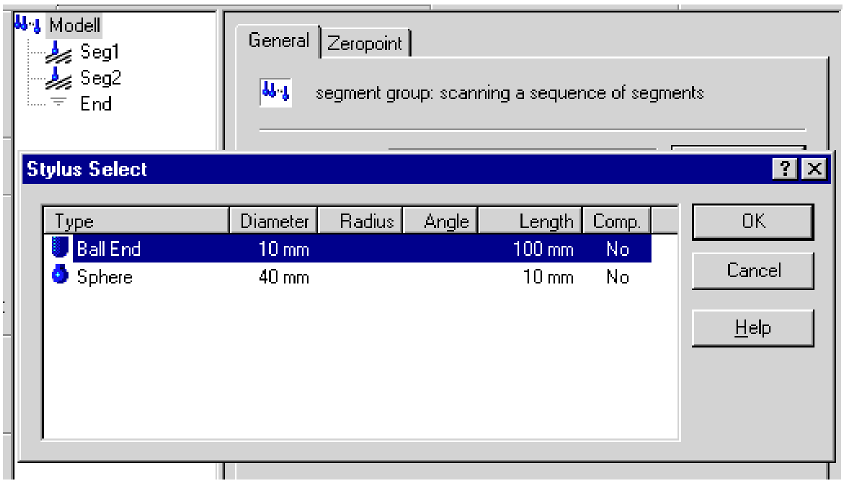
As already explained in the introduction, we will first describe the parameters that are used by all the scanning methods. Several of these parameters are used so often that they appear on both the "General" and "Zero point" tabs on the group level.

6.1.1 The parameters on the tab "General"



Stylus

It is important that the geometry of the stylus used is stored together with the scanning data. Only then can the actual model surface be calculated by contour back calculation. A stylus from the stylus list is selected for this.



This does not mean that the stylus entered now actually has to be inserted. The selection only states that this stylus will be used for digitization. scancad scan will request you to insert the stylus in question when necessary if you have not already done so.

Activating a stylus

However, if you want to designate the selected stylus as the active stylus you can activate it directly with the function *Select*. You will then be asked to insert that stylus immediately. If available, the offset table for that stylus is loaded and activated. Handling of the stylus list is described in more detail in Section 3.

Deflection

This value defines the deflection of the stylus for digitization (s. also Section 3.6.2). A value must be entered because deflection cannot be controlled at ZERO. However, unlike copying, this precise value does not have to be held throughout digitization.

Both overdeflection of the stylus and loss of contact depend not only on the digitization speed but also on the deflection selected. As the deflection value is increased the likelihood of loss of contact is decreased but that of an overdeflection increased. It also increases the pressure of the stylus on the model surface and therefore the friction.

Reducing the deflection has the opposite effect: Less likelihood of overdeflection, lower pressure and friction but greater likelihood of loss of contact.

As the surface of a segment can contain both inside and outside corners, it is a matter of experience until the right parameter settings are found.

File

A file name under which the digitization data are saved is entered here. If the file name at the highest model level is not changed later on when the individual scanning definitions are defined, all data are written to a single file and stored there.

Data reduction, tolerance

This parameter is used to reduce the data set. By defining an "online tolerance" the "insignificant" measured values of a line are not stored. Insignificant data are data that are not required to describe a part within a specified tolerance. The data that are in a tube of radius *tolerance* around a straight line formed by the data are therefore irrelevant. They do not describe any changes to the surface. The tolerance should be set such that as many data as possible are reduced but the precision for continued processing is still sufficient. It is best to select a value between 0.01 mm and half the required reproduction precision. It is important to remember that reducing the data set also reduces the time needed to process the data. As a general rule, a tolerance of at least one hundredth of a millimeter should be set.

Velocity

The scanning speed of the individual segments defines the greatest permissible digitization speed in each case. It therefore has a direct influence on the scanning time and the resulting data set.

With the function *Learn mode* (s. Section. 6.1.3) scancad scan controls the digitization speed automatically as a function of the model geometry.

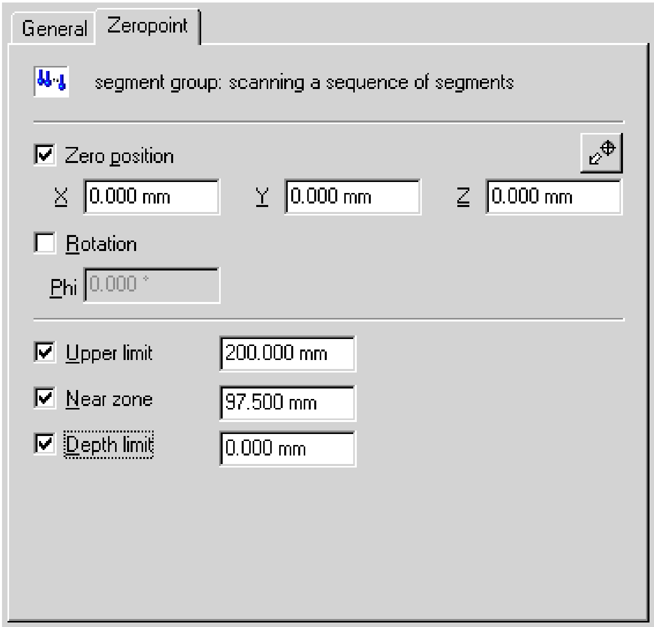
Inside corners

High scanning speeds are possible on surfaces with low friction and smooth gradient transitions. On the other hand, a lower speed is required on surfaces with stark changes in the contour. It is essential to control scanning correctly at corners. If the speed is too high at inside corners, it may no longer be possible to change the direction of movement by up to 90°. Overdeflection of the stylus in the corners and a subsequent "Emergency stop" could be the result.

Outside corners

If the speed is too high at outside corners the stylus may shoot off beyond the corner. The measurement taken at the corner may indicate that the stylus is deflected, but the following measurement may give a deflection that is too small, or in extreme cases, no deflection at all. In this case the control reports loss of contact. The system then automatically tries to acquire those targets with a lower speed.

6.1.2 The parameters on the tab "Zero point"



Zero offset

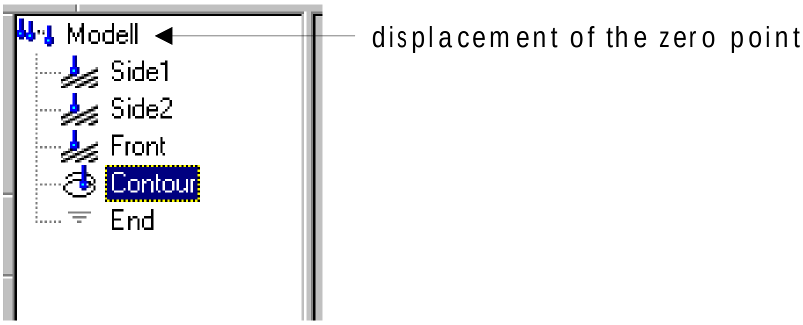
Here you can enter the offset values of each of the axes to activate a zero offset. You can enter the values in a context menu.

The zero point wizard is often used for alignment. The zero point derived in this way automatically becomes the "active zero point". A special button on the zero point tab allows you to transfer these settings directly to a project.

With these settings, the parameters of the higher level are automatically taken as the default. This speeds up input of the zero offset and changes then only have to be made at one place.

Here are three different application examples:

1. A model is to be split up into several segments and scanned.

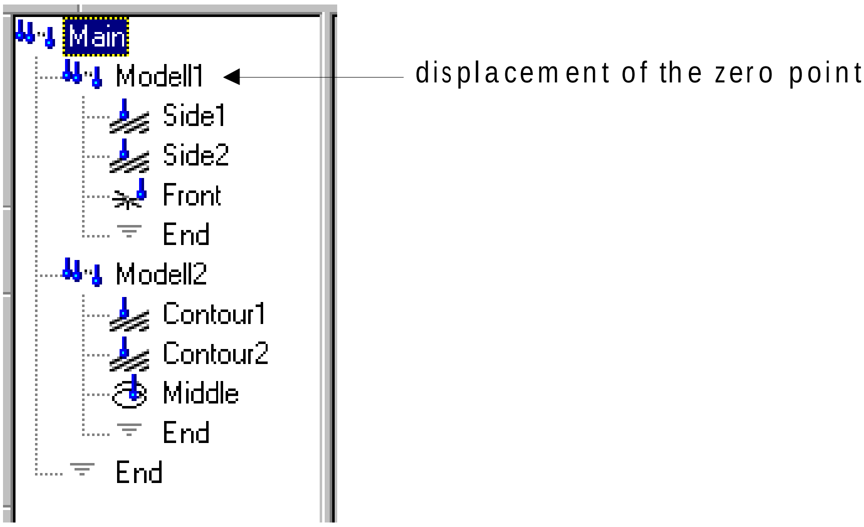


To define a zero point for all segments, the zero point is only defined once at the model level. The value is automatically accepted and all the associated segments are scanned with that offset.

Accepting the offset from a higher level

The grayed out zero offset display X=0, Y=0 and Z=0 means that the offset has been taken over from the higher level, in this case the model level. To make any changes, it is only necessary to adapt the offset value on the model level.

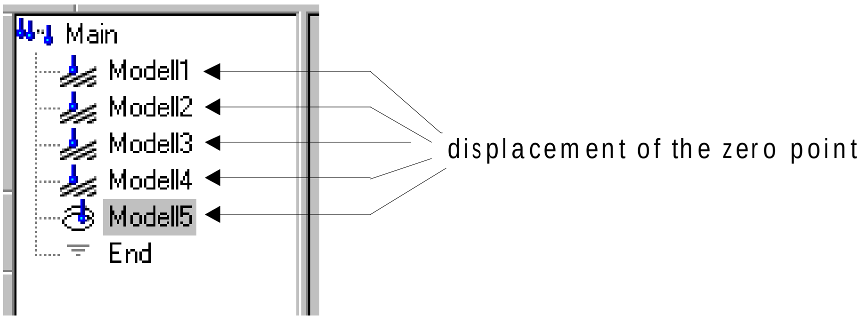
2. Two models on the machine table are to be digitized one after the other.



In this case it is preferable to use a method other than that described in the first example. A separate subdirectory (part1 and part2) should be defined below the model level (main) for each workpiece. In this case, it is not a good idea to accept the zero offset from the model level. For this reason, no zero offset is defined at the model level. The zero offsets should be defined at the group level.

This ensures that a different offset is used for each group. The values are transferred to the segments under each group level automatically as described above.

3. Several models on the machine table are to be digitized with a single segment.



Two different methods can be used for entering the parameters. If the parameters are entered as described in example 2 a large number of group levels are created in which the zero points then have to be set for each workpiece. In this case it would be simpler to enter the zero offsets directly at the segment level. It is then not necessary to create the group levels. Input at the model level is not necessary because no segment is to be scanned with these offset values.

Alignment

The alignment defines the rotation about the Z axis. The procedure is the same as that for the zero offset.

Retraction height

Several parameters are used to describe the movement from the current position of the sensor to the starting position of the next segment or next line/partial line.

The retraction position is traversed in rapid traverse upwards from the current position. Collision-free horizontal positioning must then be possible at this height. If the current sensor position is already above the retraction height, the sensor is not moved.

Near zone

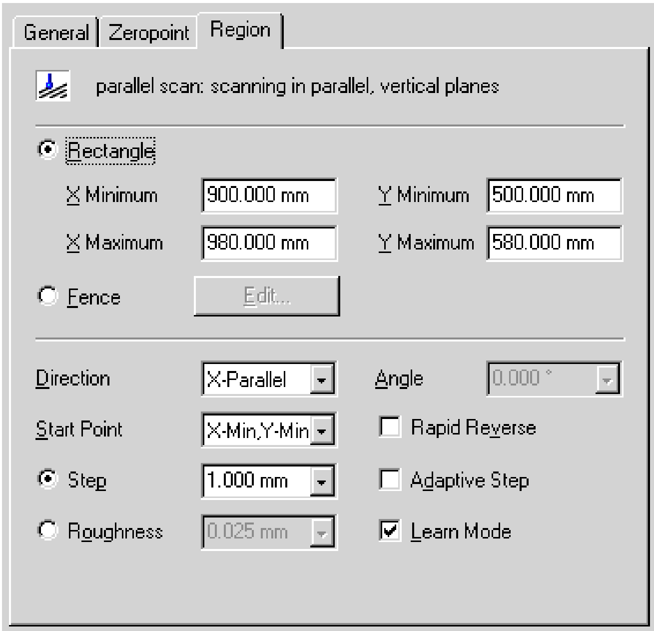
Starting from the retraction position the machine travels at rapid traverse down to the height that is defined by the near zone.

Depth limit

From the near zone the machine travels slowly downwards to the height of the depth zone. If the stylus meets the workpiece before the depth limit is reached the approach movement stops as soon as set deflection is reached. Digitizing is started or continued.

The depth limit is also relevant during digitization if some parts of the workpiece surface lie below this height. In this case the stylus traverses at the depth limit "virtual horizontal surface" to the end of the partial line or until it makes contact with the surface again.

6.1.3 The parameters on the tab "Area"



Line width/Surface roughness/Adaptive line width

Line width, surface roughness

The line width defines the distance between two adjacent lines. For spherical/radius styluses this distance can also be defined by specifying the required "surface roughness". The distance is only measured in the XY plane. That is why the lines on gradients that run parallel to the scanning paths may be a greater distance apart on the gradient surface than is defined by the line width. The difference in height between the individual lines bears no influence on the distances between the lines.

Adaptive line width

The *adaptive line width* can be activated to gain more information about the model. It ensures that the distance between the lines is automatically reduced to a tenth of the preset line width as a function of the inclination of the model across the scanning path ("transverse gradient") of the model area. As the gradient is reduced the distance between the lines is automatically increased to the preset value. Activating the *adaptive line width* can result in a longer scanning time and larger volume of data because of the automatic reduction of the line width that goes with it. However these two values can be reduced if a larger line width is selected. Whichever way, the data recorded in this way will result in a better description of the surface. Areas with a small gradient are described by fewer data and areas with a larger gradient are described by a greater number of data. It is therefore recommended that adaptive line width is activated as often as possible.

Reciprocation or rapid return

The type of infeed movement used to travel from one scanning line to the next has a great influence on the scanning time. It is decisive whether the following line is to begin directly next to the end of the current line (reciprocation) or on the other side (rapid return). Rapid return requires a long infeed movement along the part to the beginning of the next line. This, of course, takes considerably longer than the short infeed needed in reciprocation.

No data are acquired during infeed. The type of infeed chosen does not therefore affect the volume of data stored. Even through rapid return is disabled, the sensor may lift off if the infeed path is greater than the stylus radius or if the scanning area has gaps. These lifting movements are performed for safety reasons because no information is available about the gaps and traversing with contact could cause problems.

Learn mode

The scanning speed selected always depends on the shape of the scanning segment and the size of the stylus used. Complex areas should be scanned at a low speed. scancad scan provides a special function to avoid, for example, digitizing a whole segment with only one complex section at a very low speed: *Learn mode*. Like adaptive line width, Learn mode is also called adaptive speed control. Whereas the transverse gradient between two adjacent lines is important for the adaptive line width, Learn mode takes account of the shape of the model surface in the direction of the scanning line. Assuming that adjacent lines are similar, the speed profile of the current line is calculated and used for precontrol of the next line. It is right to assume that adjacent lines are similar if the line width is significantly smaller than the stylus radius. Unknown areas, e.g. the first line of a segment, are always scanned slowly.

If the Learn mode is active, the user can select a relatively high set speed. This speed is then automatically reduced at critical points by the Learn mode. Both with this function and time-discrete recording of data, smooth areas are described with fewer scanning data and heavily undulating areas are described with significantly more data.

Starting position

The starting position to be approached is calculated from the selected scanning area. If a scanning method permits several starting points, the user can define with position is selected. The starting position is approached along the retraction plane in rapid traverse.

6.1.4 Conclusion

Precision

Most of the parameters described above have an immediate effect on the resulting volume of data and scanning time. They also play an important role in the precision of the digitization.

Precision is only ensured if measured values are acquired at small spatial intervals. Larger intervals could cause gaps and therefore loss of important information required to maintain precision. This results in a lower scanning speed, smaller line widths, smaller tolerances and larger volumes of data. These parameter settings also result in longer processing times of the resulting data.

However, if suitable parameter settings are used, such effects will only result in exceptional cases.

Learn mode and adaptive line width

Initially, the set speed and line width heavily depend on the surface of the segment to be scanned. If there are no severe gradients, the segment can be digitized at high speed and large line widths. Large deviations between the measured values in one line and those of adjacent lines are not to be expected. Only a few data are required to acquire a representation of a surface with the necessary precision. However, in the case of sharp contour changes learn mode helps in the line direction by providing extra information at important points. Perpendicular to the line direction, the adaptive line width provides more relevant information by generating denser lines. Both functions allow use of a higher scanning speed and optimally distributed data. The set tolerance should always be as large as possible and as small as necessary. A tolerance corresponding to half the required precision is recommended. Different segmentation can also help by ensuring that scanning is only slower at especially critical areas.

6.2 Group

The management of individual digitization tasks within a digitization project is one of the important features of scancad scan. Its significance and the possibilities it offers have already been described in detail in Section 2.2.

Settings are always taken over from the higher level.

The feature allowing the insertion of groups in the project as hierarchical levels, reduces parameter input at the segment level to a minimum. This feature takes advantage of the fact that all settings are taken over from the upper hierarchical level.

The individual groups should therefore always be structured in a meaningful way. If, for example, several segments are to be scanned with a single stylus, the parameters for this can be defined at the group level. It is no longer necessary to make separate entries at the segment level.

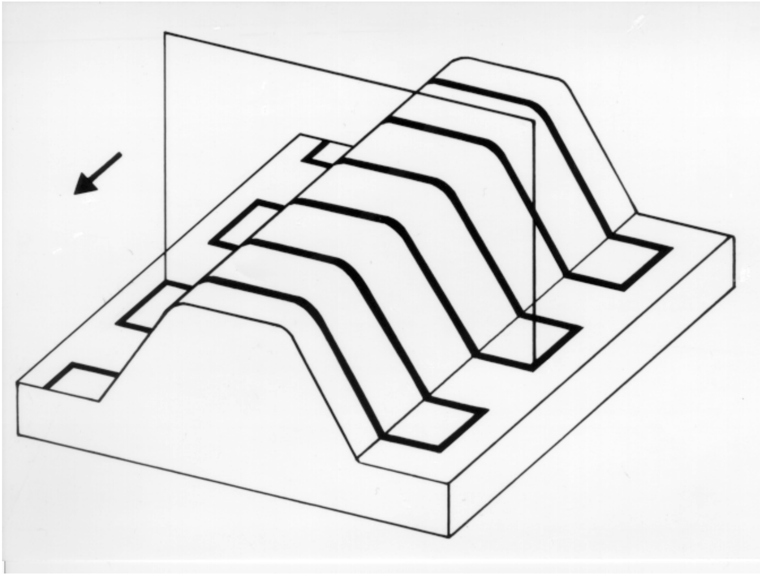
6.3 The scanning methods

Now that the fundamentals of scancad scan and the functions and general parameters available for setup have been described, we at last come to the scanning functions themselves. The various scanning types are each described in greater detail in the following part of this section. Only those input variables that exist in addition to the general parameters (see Section 1.1) will be explained here.

6.3.1 Parallel scanning

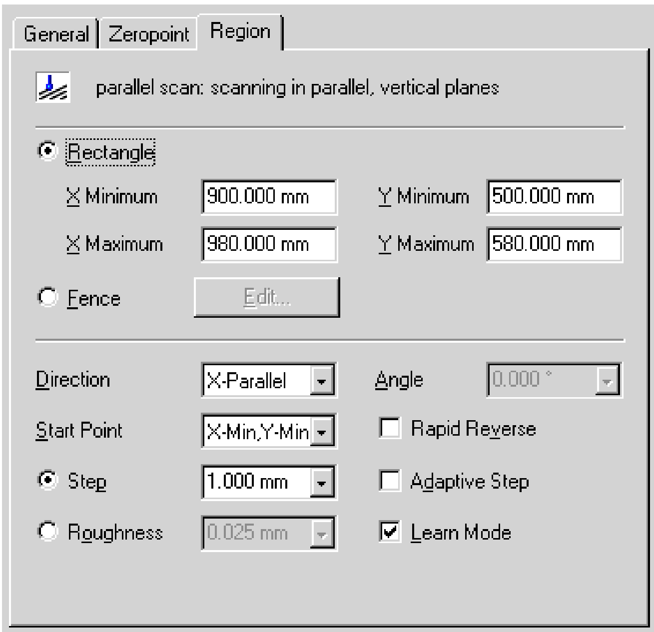
Parallel scanning is the most important scanning method for the digitization of models. Although simple to use, many areas of a model can be acquired by this model. Because of its importance, this scanning method will be described first.

With this scanning strategy a segment can be acquired by digitization in parallel lines. You can set the direction of the lines and the type of infeed. The area can be enclosed either by a rectangle or a fence.



Three tabs are available under this scanning type for entering parameters. The tabs "General" and "Zero point" have already been introduced to you at the model level for defining the general parameters (stylus, deflection, file etc.) and the zero point (offset, alignment etc.). This tab also contains parameters for defining the scanning range and other digitization settings. The general parameters and zero offset settings are taken over by the higher level as described in the previous section. Of course, it is possible to change these parameters.

Area tab
Parallel scanning



Limitation of the digitization area

This scanning method allows both the digitization of rectangular areas and areas delimited by fences. You define the rectangle by entering two corner points. If you select a fence for delimitation you can define it using the fence editor.

Rectangle

In the simplest case you can use a rectangle to define a scanning area. To do this simply enter the diagonally opposite corners in the fields in the dialog box supplied for this purpose.

Rectangle XMinimum, XMaximum, YMinimum, YMaximum

You enter the coordinates for the diagonally opposite corners of the rectangle under *XMinimum*, *YMinimum* and *XMaximum*, *YMaximum*. You can do this either by entering a numerical value or transferring a value. The latter is usually the easiest method for which the exact coordinates need not be known and typing errors are avoided.

Transferring a position

In order to enter parameters by accepting a value you must move the machine manually, by positioning or using the NC control around the corner of a rectangle. A context menu for the dialog boxes then appears in which you accept the values for the parameters. This is how you enter the current position of the sensor or the position of the stylus. You then enter the opposite corner position in the same way.

Fence

Defining a fence

If a scanning area is not enclosed in a rectangle, with this scanning method you can also use fences to delimit an area.

Fence editor

Once you have selected the delimitation type you want you can call the fence editor (see Section 6.4) with *Edit*. Here you can define a delimitation as a series of polygons and edit them.

It is not necessary to understand exactly how the fence editor works at this point. We will therefore not interrupt the description of the scanning methods to give a detailed description of the fence editor. The fence editor and the way it works is dealt with in detail in a separate subsection 6.4 at the end of this section.

Polygon

Polygons in the mathematical sense are used for limitation. A rectangle, for example, is a polygon with 4 corners whose edges are parallel to the machine axes. For the purposes of entering a fence these polygons can consist of several thousand points.

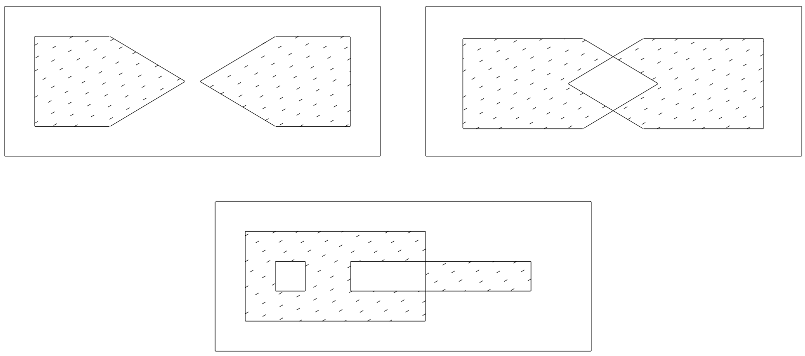
Overlapping polygons

A limitation defined by a fence can consist of several polygons. Each polygon then consists of a self contained object with n corners. If a fence consists of two or more polygons, the scanning area corresponds to the union of the areas without the overlapping area.

Island

If one polygon contains another complete polygon, the area enclosed by the smaller polygon is interpreted as an island that is not scanned. Yet another polygon within that island is however scanned.

Several examples are given in the drawing below. The hatched area is digitized.



Representation: Overlapping polygons within a model

Direction, angle

The entries you make for the direction and the angle define the position of the individual scanning paths. An angle of 0°/180° defines a scanning path parallel to the X axis. A value of 90°/270° a scanning path parallel to the Y axis. The angle is mathematically positive, i.e., it is read in the counterclockwise direction.

Starting point

The point at which digitizing starts is defined by the starting point. In the case of a rectangular limitation and scanning directions of 0º and 90º four different options are available. Scanning can start in any of the four corners. If the area is limited by a fence or if digitizing is only to be performed below a certain angle, only two possible starting points are possible.

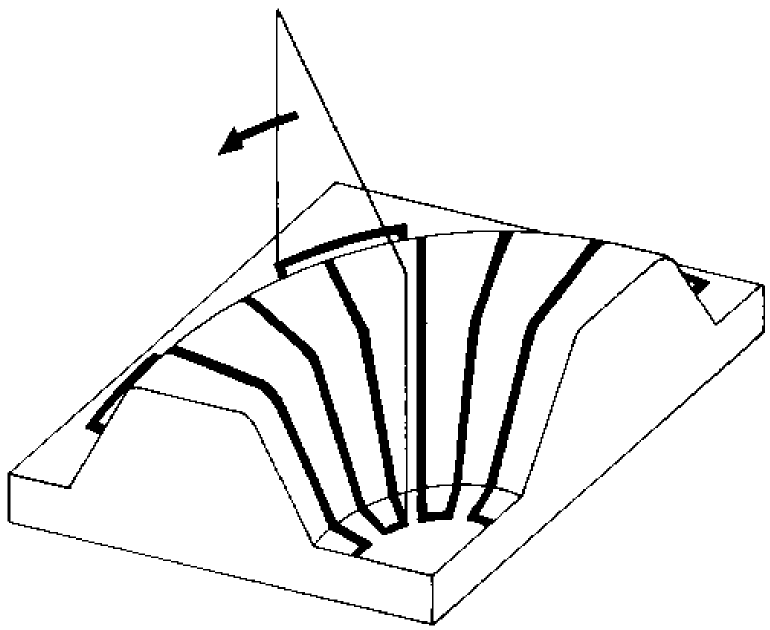
When you can an area delimited by a fence partial lines can occur if the fence cuts across the scanning line. The area outside the fence is then traversed in rapid traverse on the retraction plane.

Conclusion: Parallel scanning

Area of application	All objects which do not have mainly vertically running limitations.
Advantages	Easy to set up, does not cause any overlapping of scanning paths and usually allows high scanning speeds, i.e. short scanning times.
Disadvantages	Not suitable for hemispherical or cylindrical objects.
1:1 milling	Suitable

6.3.2 Radial scanning

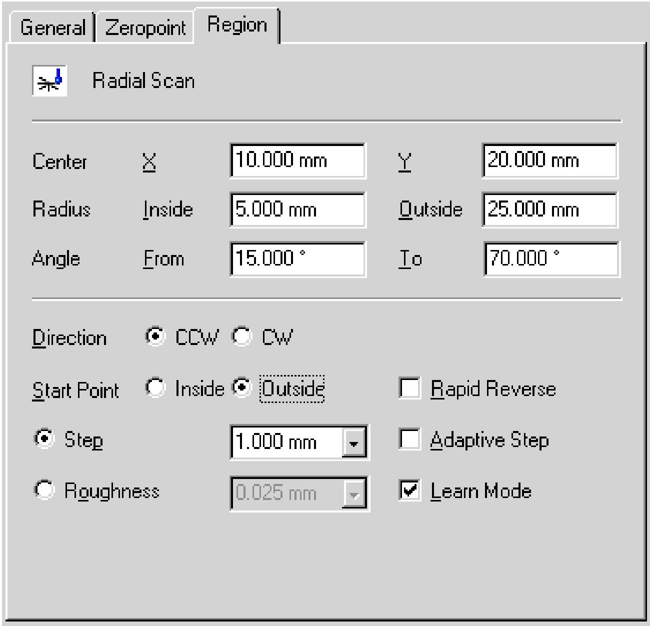
This scanning type is especially suitable for acquiring circular or round contour areas. With this strategy, circular segments or entire circular areas can be digitized radially. The individual scanning planes are rotated around the center point during digitization according to the line width selected.



Scanning area for radial scanning

The scanning area for radial scanning is a circular segment. It is made up of two concentric circles and a start and end angle.

Area tab "radial scanning"

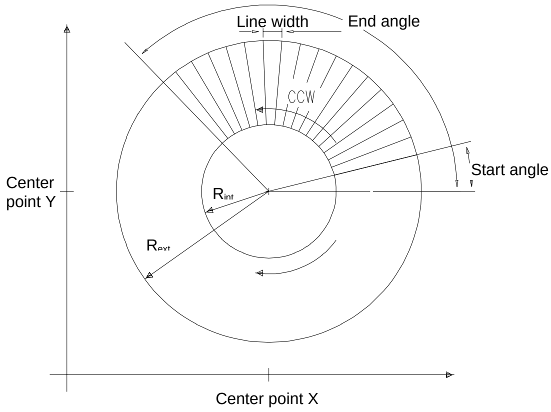


Center point/radius/angle

The two concentric circles of limitation are defined by specifying a common center point and their radii. The scanning area lies between these two arcs. The start and end angle limit it to a circular sector. An entire circle is scanned if an angular range of 0° to 360° and an internal circle radius of 0 has been defined.

Direction/starting point

The four possible scanning directions can now be selected by defining a starting point (on the internal or external circle) and the direction of movement ("cw" for clockwise direction and "ccw" for counterclockwise direction).



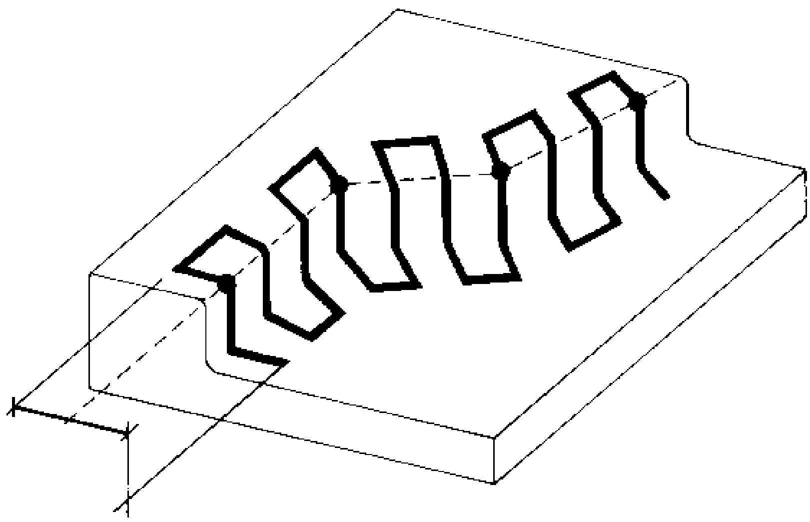
Conclusion: Radial scanning

Area of application	Cylindrical or dome-shaped objects that might also contain horizontally running surfaces.
Advantages	Simple to set up.
Disadvantages	Overlapping of scanning paths in the direction of the center point of the scanning area and often low scanning speeds result in high scanning times.
1:1 milling	Not so suitable

6.3.3 Line scanning

In contrast to the scanning methods described above that can digitize areas delimited by a rectangle, fence or circular segment, digitizing in line scanning is performed along the planes that are vertical to a defined center line. This center line is the line referred to in line scanning.

This type of delimitation makes line scanning suitable for the acquisition of boundaries running in any direction or the edges of a model.

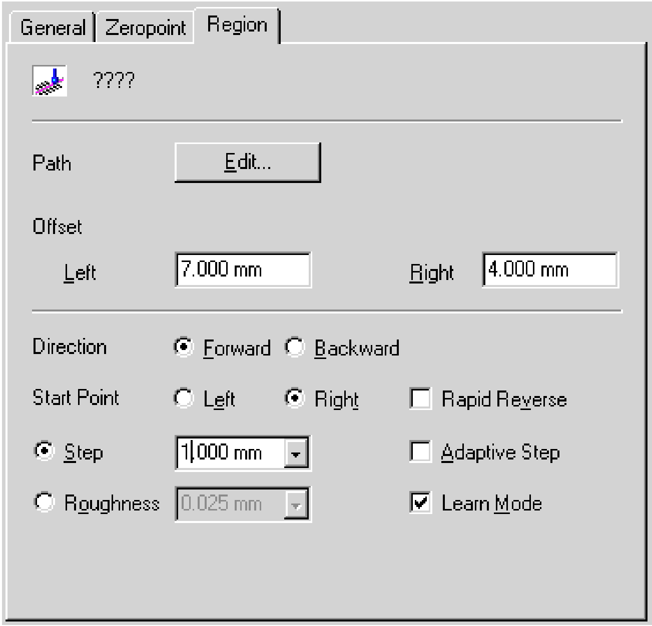


Scanning area for line scanning

A polygon (the route taken in line scanning) is used to define the scanning area in line scanning. This line defines the route taken by digitization later on. This line is the leader for the actual scanning action left and right of it. The scanning action can be imagined as a band either side of the leader.

The fence segments are used to generate scanning paths that lie vertically to them and which are delimited by *offset left* and *offset right*. Arcs are formed at the fence segment transition points and then run tangentially into the next segment.

Area tab "Line scanning"



Offset right/left

As described above, in this scanning method, scanning is performed vertically to the defined line. The distance left and right of the line is defined.

Direction/starting point

Both the starting position left and right of the line and execution in the direction of the line or in the opposite direction can be defined depending on the application.

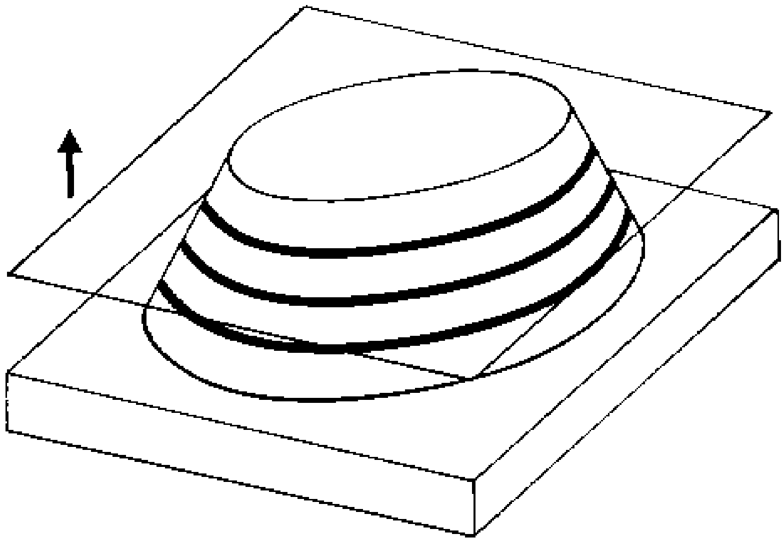
Conclusion: Line scanning

Area of application	Boundaries of objects running any direction
Advantages	Usually short scanning times
Disadvantages	Few scanning path overlaps, setup takes longer.
1:1 milling	Suitable

6.3.4 Outline/partial outline scanning

Horizontal scanning planes

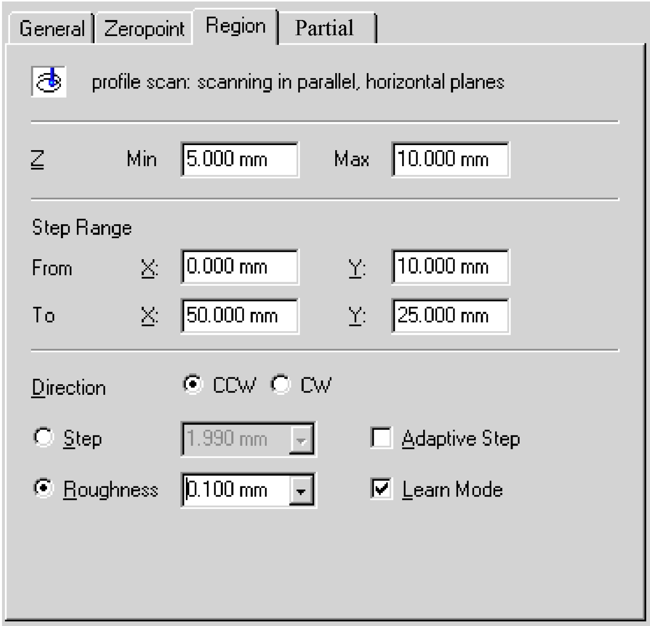
Both of the scanning method described here unlike the methods described above use horizontal scanning planes. This scanning method is especially suitable for acquiring circular and round parts. Definition of the scanning areas differs considerably from the methods described above because it does not directly define an area. Input of values is therefore described in more detail here.



Scanning area for outline scanning

In outline scanning the scanning area is only defined by a starting height and a stop height above that. An infeed range must also be defined so that the control knows in which direction the object is located.

Area tab "outline scanning"



Z area

Here you enter the values for the start and stop height for digitization.

Infeed range beginning/end

As stated above, when defining the area two other points are required in addition to the Z values. The first point is always outside the actual scanning area. The other point is always inside the scanning area. The control is traversed along the connecting line of these two points until it makes contact with the object.

In order to simplify input of the parameters, the starting point outside the area, for example, can also define the starting height. The Z coordinates define the scanning area at that height.

If a circular area is not to be scanned right up to its maximum height, it is, of course, possible to define a stopping height that is lower than the height of the part. The stopping point is then within the model.

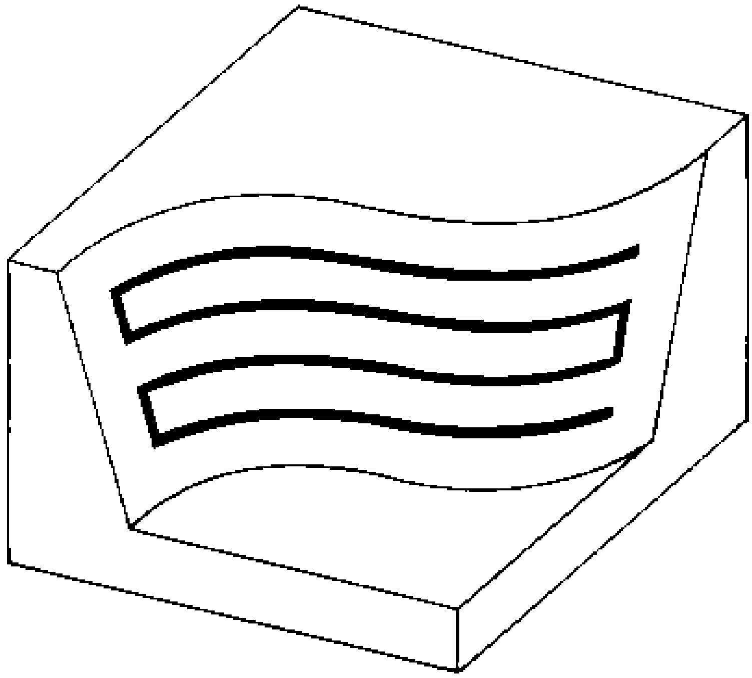
When scanning spherical parts there is a danger of deflection in the upper section where the contour gradient is smaller. Here it is possible that the deflection in the Z axis is greater than in the actual travel plane (XY). As a remedy the model can be divided into an outline segment for the lower area and a radial segment for the upper, flatter area.

Direction

By entering a direction of rotation it will later be possible to perform 1-to-1 up and down finish milling. In outline scanning the lines run in the same direction.

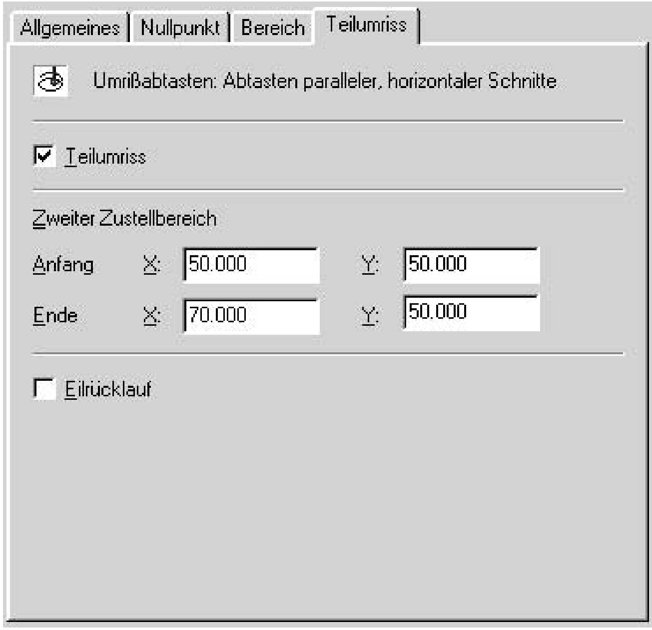
Scanning area for partial outline scanning

For partial outline scanning the area is delimited by a second straight line segment. Scanning can be performed without angular segments. Twisted contours can also be acquired easily.



Both the "starting" line and the "finish" line must be defined for the scanning procedure. If these lines are identical a full outline is the result which can be scanned in reciprocation mode. A second area tab is provided for entering the additional line of limitation. To do this, first activate the partial outline mode on this tab. Only then can you enter the additional infeed range.

Area tab "partial outline scanning"



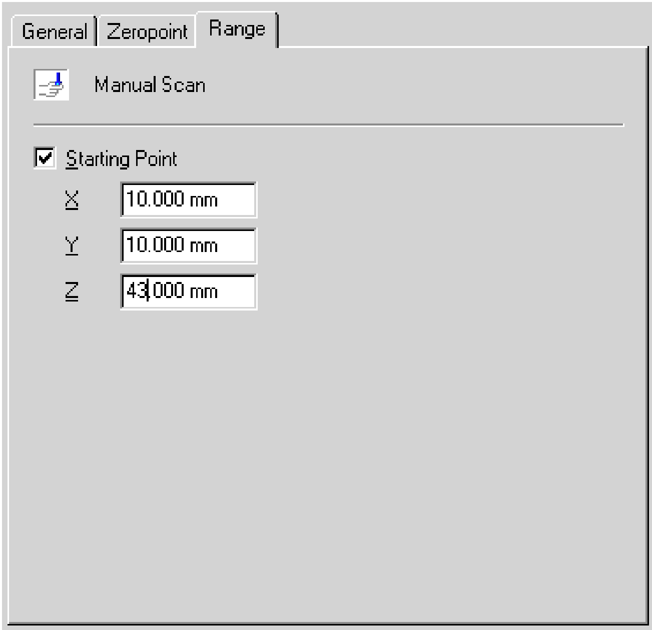
Conclusion: Outline/partial outline scanning

Area of application	Suitable for objects whose sides are limited by nearly vertical surfaces. Especially suitable for cylindrical objects or objects that rise to a point.
Advantages	Easy to set up, does not cause any overlapping of scanning paths and usually allows high scanning speeds, i.e. short scanning times.
Disadvantages	Nearly horizontal surfaces cannot be scanned.
1:1 milling	Suitable

6.3.5 Manual scanning

Manual scanning is a special scanning method. The area to be scanned is not delimited and the direction of the lines is defined by the user only. The digitizing data are recorded according to the manually controlled scanning paths. To make operation easier, individual axes can be disabled during digitization. That means that the axes cannot be moved.

Area tab "manual scanning"



Manual scanning is a scanning method that is intended for special digitization cases only. You can use it to scan specific points for which the setting up of other strategies would be too complicated. Manual scanning is also important for setting up the other scanning methods. Using the sensor you can enter the individual values in teach-in mode, as described, correctly and easily.

Starting point

To simplify the procedure with large areas, the control traverses to the starting point before manual mode is activated. Only then does a movement cause digitization data to be recorded.

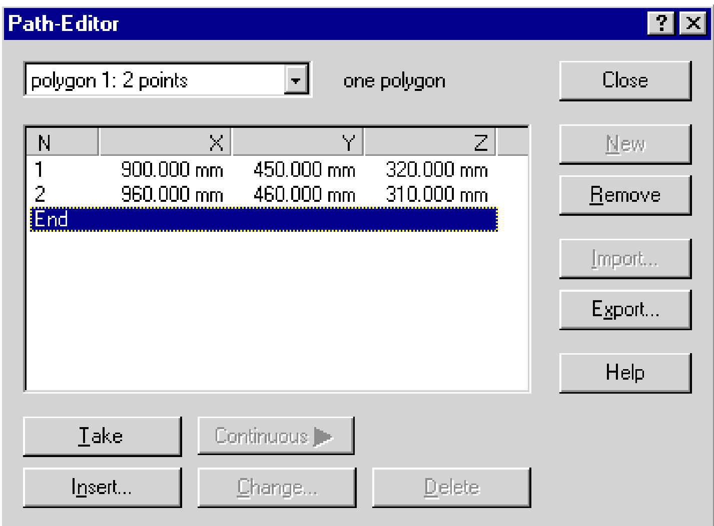
Once you have started this scanning method you can enable and disable data recording with a special button. You can use this button, for example, to disable data recording of positioning and infeed movements for a short time.

Conclusion: Manual scanning

Area of application	Any tasks that are not that simple to scan with the other scanning methods.
Advantages	Nearly anything can be scanned, setup is very easy, sharp edges can be generated with this scanning mode using a stylus in the shape of a rounded cylinder.
Disadvantages	In manual scanning the control cannot distinguish whether the measured values are generated by guiding the stylus manually or by contact with the model, i.e. errors in the scanning data cannot be ruled out.
1:1 milling	Not very suitable

6.4 Fence editor

In the description of the individual scanning methods, the various types of delimitation were only briefly explained. Due to the significance of the different types of scanning area in selection of the digitization method, definition of these limitations using the fence editor is described in greater detail in this section. The term "fence" used in copy milling is used for freeform, polygon limitations of digitizing areas.



The fence editor dialog box is divided into three elements. The largest element is a box displaying the polygon in terms of coordinates. The name of the current polygon is displayed in the selection box above this list. To the right of this you will see the buttons with the different functions that affect the entire fence. Below the point list you will see the functions for editing the individual polygon points.

6.4.1 Editing polygons

Close

When you have finished editing your polygon you can save the limitations by closing the fence dialog box. Make sure that you save the limitations for a particular project in the project files (*.SCN). There are no special files for fences.

New

To create a new limitation for a segment select the function *New* to define a new polygon. An END mark is then inserted in the so far empty field used to display the fence points. You can now define the individual fence points. The functions available for this step are described below.

Delete

If you want to delete the existing definition of a fence from a project you can do this with the *Delete* function. Once a fence is deleted it is irretrievably lost!

Import

In some cases it makes sense to use outlines that you have already scanned as limitations for other digitization projects. You can use the import function to read in scancad scan files (*.FMP) for limitations.

Export

If you want to use the fences you have set up in scancad scan in scancad mill to further process data, you can export them with this function. The format corresponds to that of the scanning data (*.FMP). You can use these areas as limitations for milling or in scancad mill to define new areas.

6.4.2 Editing points

Apply

Usually fences are only used if several points are required to define a boundary. It therefore does not make much sense to enter all point coordinates manually. It is simpler and safer to define them using the *Apply* button to accept the current stylus position. Whenever you click on Apply or press F4, the fence editor enters the current position in the list of limitation points. The polygon point number is automatically incremented.

Continuous

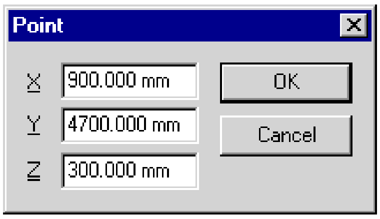
The method for described above using *Apply* to enter points is much easier then entering them via the keyboard. However, this method is still too long-winded if you have to enter several hundred points.

Continuous recording of data goes one step further to support the operator. If this function is activated the control is in a state that is comparable with manual scanning. That means that measured values are recorded while the machine traverses the stylus. These are the corner points of the polygon and are continuously displayed in the point window.

Because the stylus is guided manually along the required boundary the preset data reduction ensures that not too many data are recorded.

Insert

If you have already created a list of points you can enter additional points in the list/polygon with *Insert*. Select the point at which the new point is to be entered. Then enter the coordinates in the relevant dialog box.



Edit

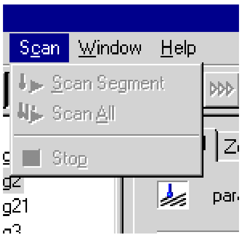
If you want to correct or change coordinates in the list, select the point in question. Now you can change the coordinates.

Delete

If you want to delete individual points from the list you can use *Delete*. You can also use the functions offered by the operating system to select the points.

7 Scanning

Menu



Functions

This section is not only the last in the sequence of menu items. It is also the last step to be performed in digitizing.

Up until this point, this manual has explained how to build up digitizing projects with scancad scan. The different functions for setting up the control and workpieces have been dealt with in detail. The previous section contains a description of each scanning method. Once you have performed all this preparatory steps, there is no reason why a scanning operation should not be successful. The functions required to perform digitizing are grouped together in the menu described here.

After you have selected the menu item *Scan* you can select one of the functions listed below.

7.1 Scan segment	Starts digitizing of one segment, of one group
7.2 Scan all segments	Starts execution of the entire project
7.3 Stop	Terminates scanning

7.1 Scan segment

Segment level

If you have selected a segment in the display of the project, it is possible to start digitizing with the function described here. This command is very useful for testing the parameter entered for digitizing. For example, you can select the line width to be very large in this dry run to assess the scanned area or the scanning behavior.

Group level

If you call up this command from a group level, all the segments belonging to the group are scanned. This function must be used whenever you want to scan a model with different probes, and you want to determine the process your self.

Model level

Calling up this command - on the model level - causes the complete project to execute. The system will request you to change the styluses.

Before actual scanning is started, numerous safety checks are performed. For example, a check is made that the working range is within the permitted limits and that the filename has not been assigned to another segment already. If these checks come up with an error in the data entered, the operator is prompted to change the entries by a warning message.

7.2 Scan all segments

This command is equivalent to the start command of the model level described above. If the active probe does not match the probe used in the definition of the project, the system prompts the operator to insert the correct probe. The same situation arises if different probes are used within a single project. Because an automatic probe changer is not possible, the control software must prompt the operator to change the probe with appropriate messages.

Like for scanning single segments, various checks are make before starting.

7.3 Stop

With this function the scanning procedure is terminated. Of course, this function is also available on the tool bar. If you press the space bar scanning is stopped too.

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SINUMERIK 840D Digitizing

Part 3: Scanning with Lasers (scancad laser)

1 Introduction

Before we deal with the operation and various functions of scancad laser in the following chapters, let us take a look at some basic notions that are important for understanding. Not only these basic aspects of digitization but also the operating concept of scancad laser are explained.

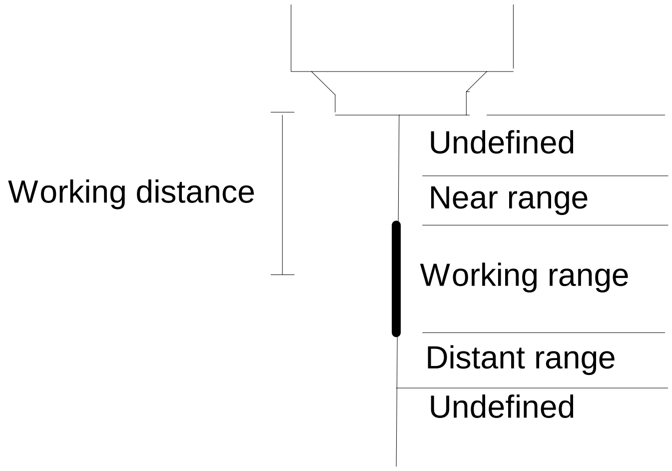
1.1 Basics

Method of operation

During digitization with scancad laser, a contactless laser sensor is used for distance measurement The most important parts are the laser diode for generating the laser beam and for evaluating the point of laser reflection. The two components are laterally offset.

If the laser beam hits a model, a bright point is reflected. This point is mapped on the line receiver. Depending on the distance from the sensor to the object, the position of the reflection point on the receiver changes. The position is therefore an indication of the distance measured. For further information about the measuring principle, please refer to the sensor manual or further literature.

Because of the structure of the laser sensor, each sensor type has a certain working range. That is the range in which the object must be located to be detected by the receiver. Objects that are nearer the sensor or objects that are further away from the sensor can no longer be measured. The data are given in the technical description of the sensor.



The digitization software scancad laser attempts to move the laser sensor in such a way that the surface of the object is always in the working range of the sensor.

The system has no influence on the different reflection properties of the models. Especially dark or strongly reflecting surfaces should be coated with a diffusely reflecting material. That ensures that the light intensity is not too high or too low for the receiver. To avoid secondary reflections, a coating is recommended as it is for transparent materials.

After this preparations, work with scancad laser can begin.

Basic terms

Here are some frequently used terms for your better understanding. They will be explained in more detail throughout the manual:

Scanning method:	The scanning methods is the strategy (also known as "pattern") with which the surface of the workpiece is to be recorded with the laser beam.
Segment:	A segment is a sub area of the workpieces that is digitized with a certain scanning strategy.
Line:	The path of the laser beam from one boundary of the scanned area to the opposite boundary is termed a line.
Partial line:	The part of a line that can be scanned without lifting the probe is termed a partial line.

Different scanning strategies

During digitizing, the laser beam is guided across the surface of the workpiece in specific paths by the digitization control. The type of movement depends on the selected scanning method. During digitizing, the measured values are transferred to the PC and stored there.

With the different scanning methods, the scanning process can be adapted to different tasks definitions.

Segments

This means that it is better to subdivide the model into segments. These can then be digitized with a suitable scanning strategy.

Further reasons for subdivision of the workpiece into segments are the optimum line width, and scanning velocity. If an area of the workpiece has soft contour changes and large radii, the line width can be wide and the set velocity high. The opposite applies to a workpiece with a thin, highly variable structure.

By subdividing the workpiece into segments, it is only necessary to digitize difficult subareas with a low scanning velocity or small line width.

Scanning plane

All scanning methods of scancad laser work with a perpendicular scanning plane. That is the plane in which the scan path runs. The scanning planes are moved from path to path parallel with the selected scan strategy, or rotated, or arranged along a route.

Scanning area

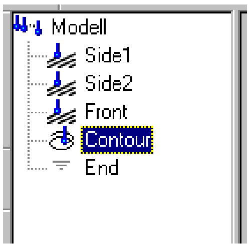
One distinction between scan strategies is the way in which individual scanning areas can be defined. This is important for subdivision of the workpiece into segments. The working range of the machine is a natural restriction of the area. In particular, please note that all ranges stated are only two-dimensional. At the moment, there is no way of defining a 3D limitation uniquely.

The following table summarizes the relationships between the scanning methods, the associated working planes, and the possible limitations. It can be used as a simple way of selecting a suitable scanning methods.

	Parallel	Radial	Line
Scanning plane			
Vertical	●	●	●
Scanning area			
Rectangle	●		
Fence	●		
Circle segment		●	
Route range			●

Working planes and scanning area for the various scanning methods (see also Chapter 6)

1.2 Digitizing project



The operating concept of scancad laser is heavily based on the execution of projects. To fulfill the actual task, complete digitization of a workpiece, several working steps are necessary. They are the scans of the individual segments with a suitable scanning methods. To structure the task better, special structuring elements are available.

Model level

In the hierarchical display, fulfillment of the work task is naturally in the top position. This level is called the "model level" in the documentation to follow. Below this level, there are all the other working steps involved in digitization. Only one model level is used to scan a model.

Group level

To structure the working procedure still further, you can use group levels. The group together the scan below them segment by segment. One feature of all segments that are grouped together under a group level might be, for example, use of the same line width.

Segment level

The required scans of the individual segments form the smallest unit in the structure.

The options of this new structuring must now be illustrated by a few practical considerations.

Automatic acceptance

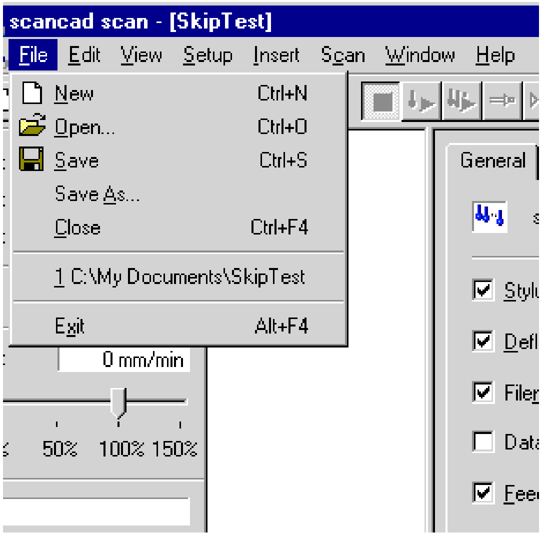
For many digitizing tasks, some parameters do not differ from segment to segment, e.g. the retraction height , file name, or tolerance for data reduction. This data applies to the entire model. For that reason, they are defined at the top level, called the model level. Because of the structure, these parameters are automatically bequeathed by the higher level to the lower elements - the individual scans - or group levels, unless, other values are explicitly entered at those levels. This considerably simplifies the entire input process for a digitizing project because duplicate entry is no longer necessary. For a finer subdivision, it is also possible to insert additional subgroups, e.g. for the various surface matching methods used. The general parameters for the surface types in question are then defined on this group level. The individual scanning methods then only need to be defined by stating the scanning area. The structure described by way of example is illustrated in the above figure.

One further example for user of this grouping is the scanning of various models within a digitizing process. Here, a separate group level can be constructed for each module that can contain all the data important for scanning.

The parameters of the group level are also available to the lower segment level. It is a general rule in handling that all values that are not explicitly entered on the level in question are inherited from the higher level.

2 File

Menu



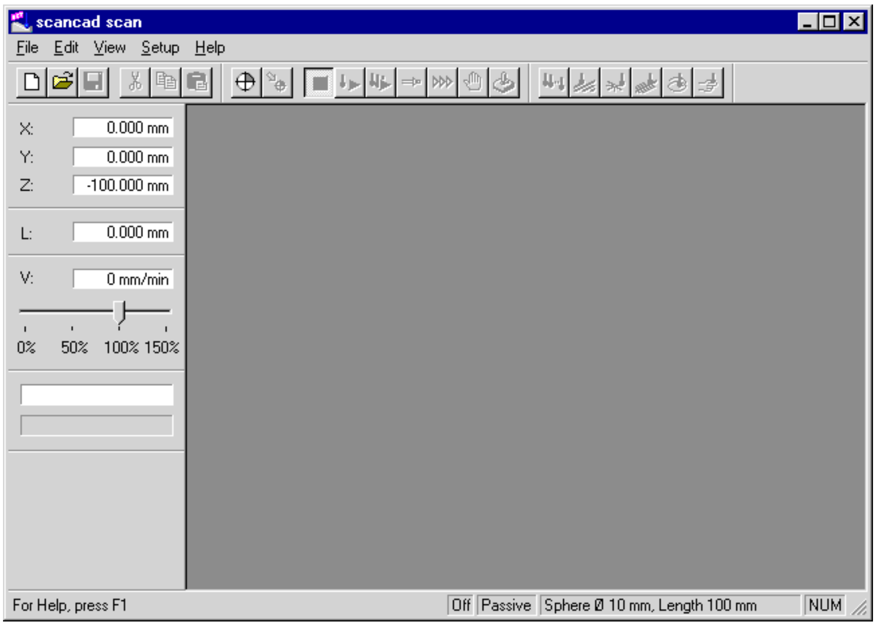
Functions

After you have selected the menu item *File* you can select one of the functions listed below.

2.1 New	To create a new digitizing project
2.2 Open	To open an existing digitizing project
2.3 Save	To save a digitizing project for subsequent re-use
2.4 Save as	To save a digitizing project with a different name
2.5 Close	To close the digitizing project
2.6 Exit	To terminate digitizing

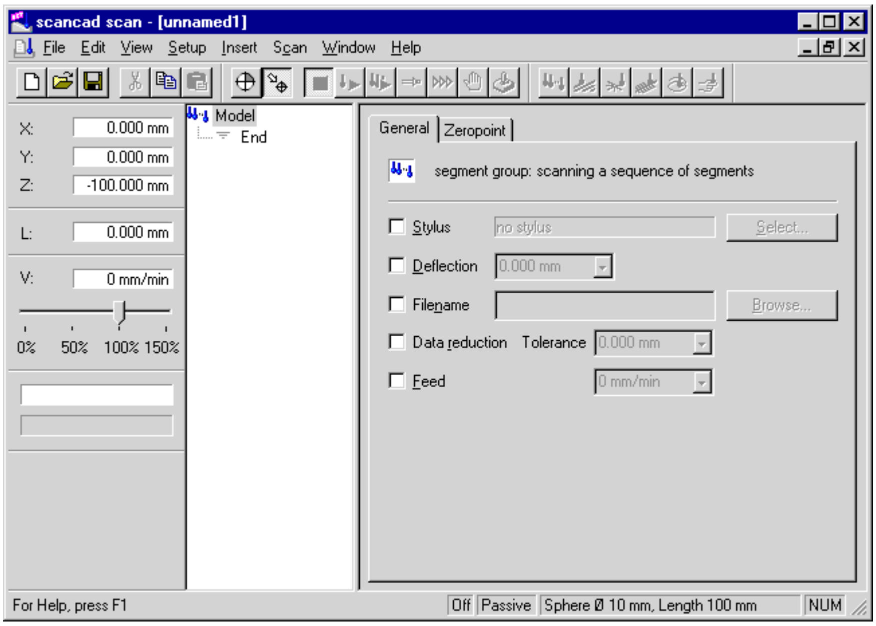
2.1 New

Screen
<u>without</u> an opened digitizing project



Select this menu item to create a new digitizing project. That is always necessary when you want to set up a new digitizing operation. scancad laser provides an initial structure which only consists of the model level. You can then insert groups and scanning segments by the methods described in the manual (see Section 6).

Screen
<u>with</u> an opened digitizing project



Because many functions of scancad laser are only available when a project is opened, the appearance of the digitizing window changes when you open a project.

Additional menu items are displayed. The following sections describe the screen layout in more detail. For example, options for customizing the screen are described.

2.2 Open

You can open an existing digitizing project with this function. You can then process the project.

2.3 Save

This command is used to save your current digitizing project. It makes sense to save a project when you want to resume setup later on, or if, while you are creating it, it seems likely that you will need to use the project again some time. Also, if you do not scan immediately after setup, you must save the project first.

2.4 Save as

Unlike the operation *Save* described above, here the system asks you for a name for the digitizing project. This dialog also appears if you have not yet saved the project under a name.

2.5 Close

If work on the current digitizing project is completed or interrupted, you can close the project with this function. If it has not been saved first, you are requested to do so now. This command only closes the digitizing project which is currently open. The digitizing software scancad laser remains active. If you want to exit the scanning system altogether, you must use the command *Exit* described below.

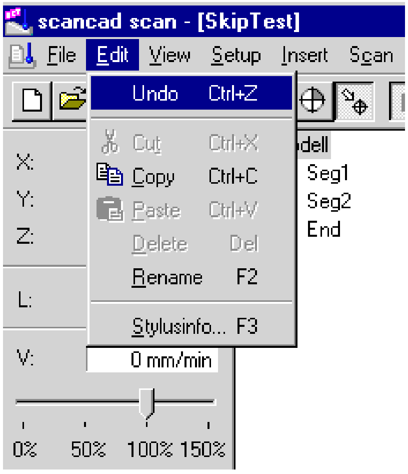
2.6 Exit

With this function you can exit the scancad laser digitizing system. Depending on how the program was installed, either the digitizing position control will also be deactivated or only link between scanning software and the control will be broken.

Notes

3 Edit

Menu



Functions

After you have selected the menu item *Edit* you can select one of the functions listed below. Not only the commands for copying, deleting and renaming elements of the project but also the laser management module are contained in this menu.

3.1 Undo	Inputs, changes to tab cards can be undone
3.2 Cut	Cuts segments and groups
3.3 Copy	Copies segments and groups
3.4 Insert	Inserts segments and groups
3.5 Delete	Deletes segments and groups
3.6 Rename	Renames segments, groups and models
3.7 Laser list	Laser management 3.6.1 Select 3.6.2 Add 3.6.3 Edit 3.6.4 Delete 3.6.5 Import 3.6.6 Export

3.1 Undo

When entering parameters within the dialogs on the tab cards, incorrect inputs can be deleted by the *Undo* function. The state before the parameters are input is restored automatically.

3.2 Cut

If you want to create new projects or edit existing digitization projects you can cut individual elements of a project and paste them at a different location. In this case the elements are not irrevocably lost as they are when you use the *Delete* function described below but are placed in a clipboard.

The way in which the function works depends on which part of the project is to be cut:

Project element	Effect of the cut function
Model level	This level cannot be cut.
Group level	Removes the entire group with all its subgroups and segments from the project hierarchy.
Segment:	The current segment is cut out of the project.

3.3 Copy

If you want to use parts of a project at a different location in the same/in a different project you can copy individual sections of the project. However, unlike the *Cut* function described above, the copied element is not removed from the project.

Again, the way in which the function works depends on which part of the project is to be copied:

Project element	Effect of the copy function
Model level	Copies the entire model level with all its subgroups.
Group level	Copies the entire group with all its subgroups and segments.
Segment:	Copies the current segment in the project.

3.4 Insert

Once you have cut or copied individual elements or entire groups using one of the above functions to the clipboard you can then insert them again at a location of your choice with this command.

The element is always inserted above the current selection. If you want to insert it at the end you must mark the end mark.

If you have put a single segment in the clipboard, for example, you only have to mark the point in the project above which the new object is to be inserted. If the object in the clipboard is a group of subsegments, the entire group with all its components will be inserted at the marked point.

3.5 Delete

When editing a project you can also delete groups or scanning segments. You can therefore use existing projects as a basis for creating new digitization projects. If you want to use an existing project for scanning individual areas only, simply remove the segments or groups that you no longer need. You can minimize the setup time in this way. The way in which the function works depends on which part of the project is to be deleted:

Project element	Effect of the delete function
Model level	This level cannot be deleted.
Group level	Deletes the entire group with all its subgroups and segments from the project hierarchy.
Segment:	The current segment is deleted.

3.6 Rename

You should give the individual levels of your new project structure applicable names. To support this, the rename mode is called up automatically whenever you insert a component.

3.7 Laser list

Different lasers

Whereas in tactile scanning adaptation to the peculiarities of the model can be implemented by changing the stylus, in contactless scanning it may be necessary to use another laser sensor. Although this is only necessary in a few individual case, scancad laser does provide a way of managing different types of sensors.

Managing the laser sensors

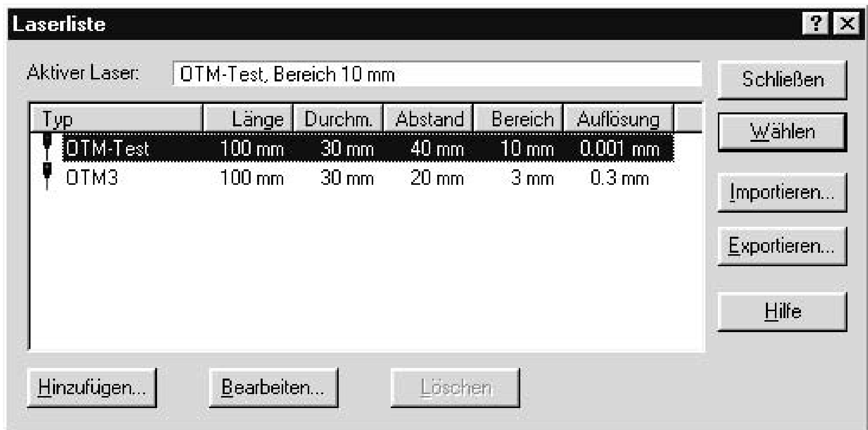
scancad laser manages all the laser sensors available to you in a laser list. This list contains all the sensors.

Working with the laser list, adding and altering laser descriptions are described in more detail below. Importing and exporting laser lists is also described.

Caution: The software does not have a function for checking that the correct laser has been inserted. It assumes that the laser indicated as being active has really been activated.

If the values do not correspond, the ensuing calculations will not be correct during storage!

Dialog box



When you select the function *Laser list* the dialog box shown above appears. The sensor type currently being used appears in the top line. The list below that contains all the available sensors. The contents correspond to the scope of supply when you open the list for the first time. If you click on a column header the list is sorted according to the criterion of that header. A click, e.g. on *Resolution,* sorts the list by resolutions of the measuring systems.

You will see the buttons with the different editing functions at the bottom and right-hand side of the dialog box. These will now be explained in more detail.

3.7.1 Select

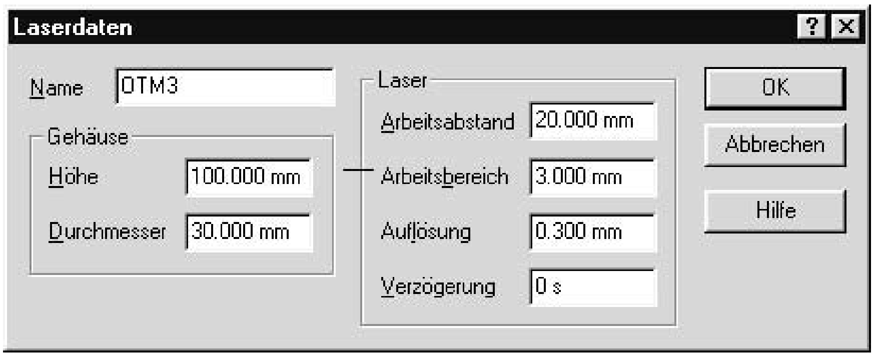
Activating a sensor

If you want to select a sensor from the laser list you can either double-click on the sensor you wish to select or select the sensor with the *Select* button. This sensor is now the active sensor.

3.7.2 Add

If you want to add a new sensor to the list simply select that button. A new dialog box in which you can enter all the necessary data about the sensor is displayed.

Dialog box



Name

The digitization software scancad laser allows the use of different laser sensors. You can give them an appropriate name to distinguish them.

Housing

In a similar way to the stylus length for tactile digitization, in laser digitization the length of the sensor housing is taken into account.

Height

The height specifies the distance from the contact surface of the holder at the sensor to the lower edge of the outlet lense.

Diameter

These data state the outer diameter of the outlet lense.

Laser

Depending on the type of laser sensor used, a range of different parameters is available for describing its characteristics.

Working distance

Each type of laser sensor has a specific value for the working distance. This is the distance from the outlet lense to the center of the measuring range. For digitization of small objects with thin structures, sensor with a small working distance are used. The laser scans the object near to the surface. Large working distances are required to measure objects with pronounced, large contour variation to avoid collisions of the sensor with the object.

Working range

The working range is the measuring range of the laser sensor. During scanning the sensor must be moved by the control in such a way that the object is always in the working range. The center of the working range is precisely the working distance below the outlet lense.

The smaller the working range of a sensor, the more precise correction must be. Otherwise, there is a danger of moving out of the valid working range. For small models, a small working range is sufficient, whereas to measure strongly curved parts, a sensor with a larger working range is used.

Resolution

The resolution of the sensor describes the precision with which the measured values are acquired. IN principle, sensor with a large working range have a lower resolution than sensor with a small working range.

Delay

To ensure that the measured value of the laser is acquired in synchronism with the measured values of axis XYZ, a trigger signal must be triggered this time (delay) ahead of acquisition of the other measured values. The value for the delay is to be found in the laser description.

3.7.3 Edit

When editing an existing laser description you can select a sensor from the list. Once you have selected the function *Edit* you can change the individual details. This dialog box is the same as that described in subsection 3.7.2.

3.7.4 Delete

If you want to delete a sensor from the list mark the entry in the list. When you press the *Delete* button the entry is immediately removed from the list.

3.7.5 Import

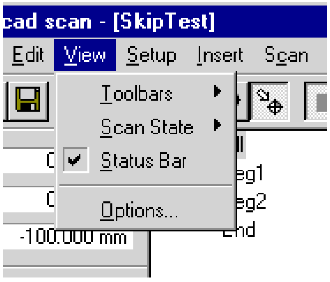
It is not only possible to create and edit sensor lists in the programming system scancad laser. They can also be generated externally, for example, in a spreadsheet program. Such a "CSV" (comma-separated values) format file can be read directly into the laser list.

3.7.6 Export

You can export the stylus list if you want to edit it with an external program. The data are then output in CSV format. This means that all the values are stored separated from one another by a comma. This format is supported by all common spreadsheet programs.

4 View

Menu



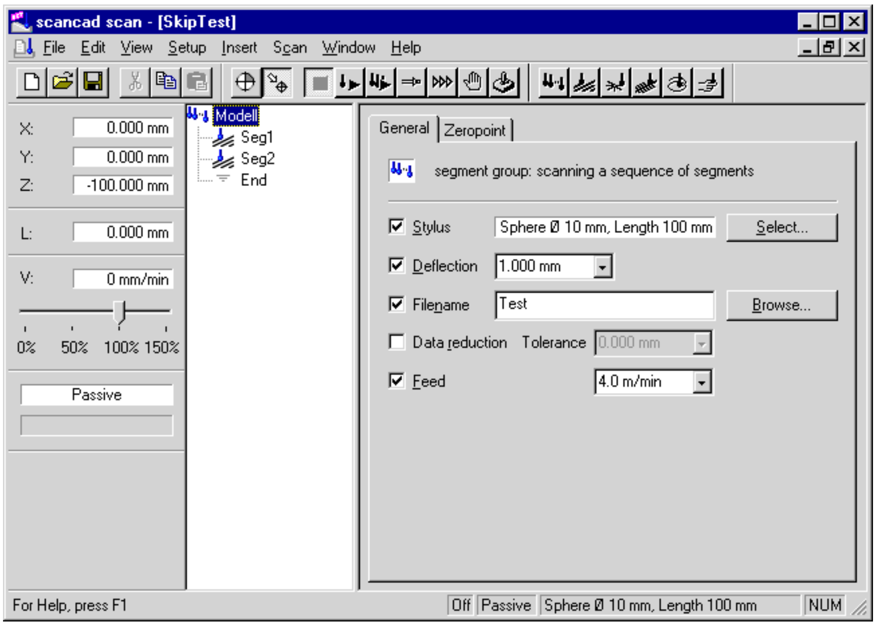
Functions

As is the case with all Windows programs, with scancad laser, too, you can adapt the screen window to your needs. You can organize your displays and activate or deactivate them. The various possibilities are described in more detail in this section of the manual. The individual functions available are listed below.

4.1 Function bars	Activate/deactivate function bars
4.2 Scan status	Activating displays for - machine position - laser measured value - override display - action display
4.3 Status bar	Activate/deactivate status bar
4.4 Options	dialog boxes for various default settings

Before the various ways of changing the window environment of scancad laser are demonstrated let us first look at all the elements of the scan window.

scancad scan screen



The scancad laser window is given in brackets in the title bar.

The permanent menu bar is located below the title bar.

Below that you can see the tool bar with buttons for fast execution of functions or commands.

The status bar is located at the bottom of the window. Short help texts are displayed in the status bar. Important operating states are displayed in the boxes further to the right. Digitizing switch ON/OFF, digitizing READY and information about the active sensor.

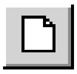
On the left edge of the window you will find the individual displays of the control system. The standard order in which they appear is: Machine position, sensor measured value, override for feedrate and the velocity display. At the bottom you will see action display that displays the progress of various processes.

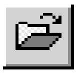
4.1 Tool bar

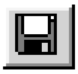
You can activate and deactivate the various tool bars with this command. As all the buttons are also displayed in the dialog boxes or menus you can still perform these functions even if the tool bar is deactivated.

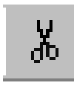
You can click on any of the tool bar buttons listed below to select functions quickly.

Toolbar "General"


Creates a new document


Opens an existing document

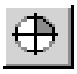

Saves the active file

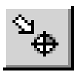

Cut

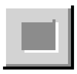

Copy

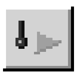

Insert

Toolbar "Setup"

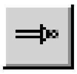

Set zero point

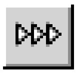

Accept zero point


STOP


Scan segment


Scan all

 Position

 Jog step

 Joystick

4.2 Scan status

You can switch off some of the displays to individually adapt your scancad laser window. These are:

Machine position
Override and velocity display
Action display
Laser measured value

4.3 Status line

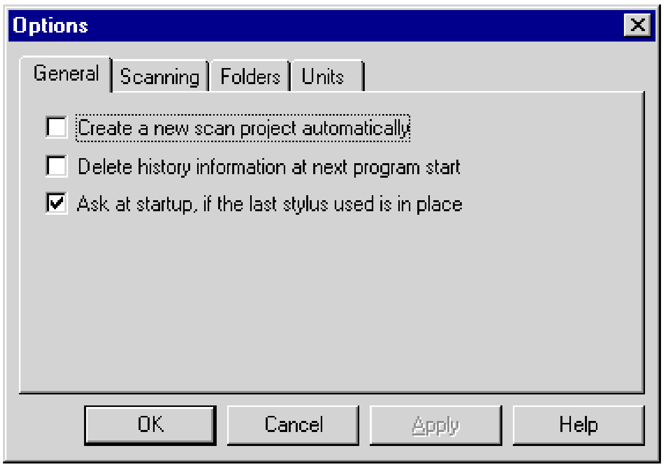
If you need more space, for example, to display the digitization project, you can switch off the status bar.

4.4 Options

A variety of different parameters are available for configuring scancad laser. For clarity, these settings are located in several dialog boxes. These parameters are described in the next section.

4.4.1 General notes

Dialog box



Open new scan project automatically

By default, the window described above is displayed when you start scancad laser. The operator decides whether a new project is created or an existing project is opened. If mainly small digitization projects are executed, scancad laser can automatically start a new project each time it is started.

This setting is not suitable for largely complex digitization tasks that are processed by calling up the same project several times.

Delete history information the next time the program is started.

In order to simplify parameter input scancad laser uses history boxes. The last parameter values to be used are stored in these boxes and do not therefore have to be entered anew each time. However, if the digitization projects differ so much that the history box values cannot usually be used again, you can undo this setting when you start the program. They are then only used for the current project.

Query on starting whether to use last sensor

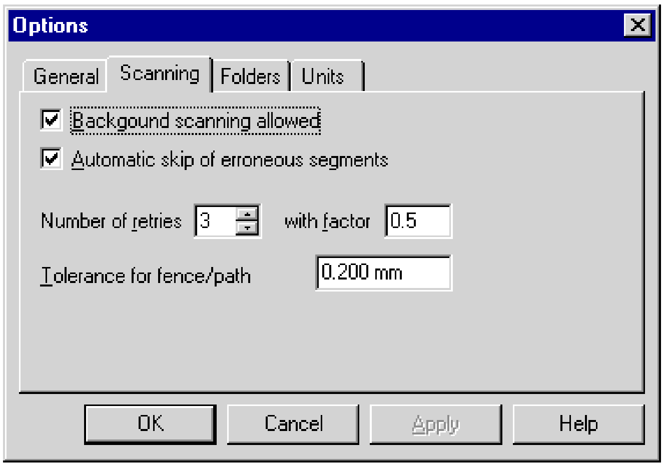
The software normally asks the operator after each start, whether he wants to use the sensor last used again. This is intended to ensure that a file is correctly saved. However, if you are only using one type of sensor, you can deactivate this query.

Activate screen saver

You can define whether scancad laser is to run in the background or not. This setting can be made in a later dialog. Normally, this option is ruled out. This causes scancad to stop when a screen saver is started. To prevent that, you can deactivate the screen saver for as long as scancad laser is active with this option.

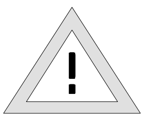
4.4.2 Scanning

Dialog box



Enable scanning in background

As with other Windows programs, scancad laser can also run in the background. The operator must decide himself whether this is sensible. By default this setting is disabled.



Caution: If scancad laser is running in the background, direct access to the stop function is no longer guaranteed. To stop scanning quickly you must always use the EMERGENCY STOP button on the machine. To close the scancad laser application in the routine way you must place it in the foreground again.

Number of repetitions with factor..

When digitizing with scancad laser situations can occur which the software detects as an error, e.g. because unsuitable scanning parameters have been chosen or because the local scanning behavior is inferior. Lines in which these situations occur can be dealt with in different ways depending on the settings of the parameters described here.

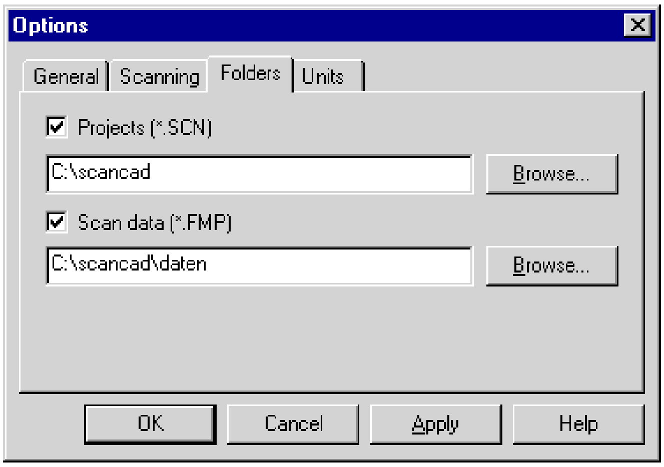
1. Number of repetitions "N" is > 0
   In this case scancad laser will try to scan the scanning line in which the error occurred up to "N" times at a velocity reduced by the specified factor.
   Example: N = 3 repetitions, factor = 0.5 results in:
   1. Repetition at 50% of the digitization speed,
   2. Repetition at 25% of the digitization speed,
   3. Repetition at 12.5 % of the digitization speed. If it is not possible to scan the line at these speeds either, the digitizing task for this segment is canceled. The next segment is started.
2. Number of repetitions = 0
   With this setting, scancad laser discontinues the scanning procedure for one segment as soon as an error occurs for the first time.

Tolerance

Fences and lines are often recorded using the joystick. To avoid recording too many data, the data set can be reduced by an automatic process. The tolerance defines a permissible range of deviation for the data.

4.4.3 Directories

Dialog box



Only two different file types are used by the program system scancad laser. All the information for a specific digitization project is stored in the SCN files. The actual scanning data are stored in the FMP files (see Section A1.2).

Project information (*.SCN)

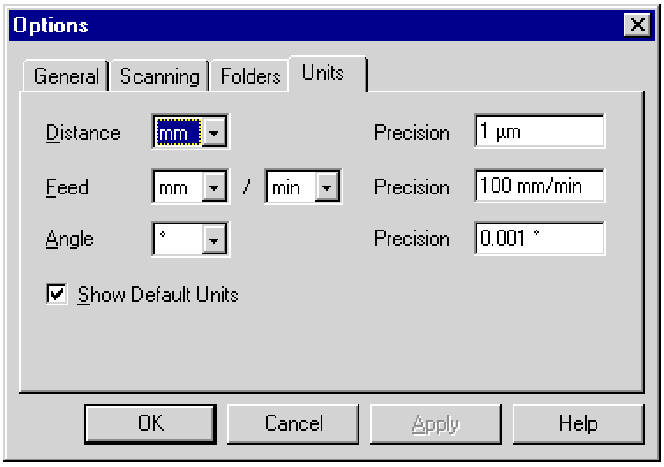
Here you select the directory in which you want to save the information for a specific digitization project. The default setting is the directly that Windows also uses.

Scanning data (*.FMP)

Here you select the directory in which you want to save the actual scanning data. The default setting is the directly that Windows also uses.

4.4.4 Units

Dialog box



In the dialog boxes for the individual parameters scancad laser uses units that you can define here.

Distance

Here, you can specify to the software the units in which the parameters for path/length/distance are to be entered. You can also define the precision for the display.

Example:

Units	Precision	Display
mm	µm	23.009mm
m	mm	1.234m
m	µm	1.234567m

Velocity

The units for velocity can be defined with these parameters.

Angle

The format for entering angles can also be defined.

Time

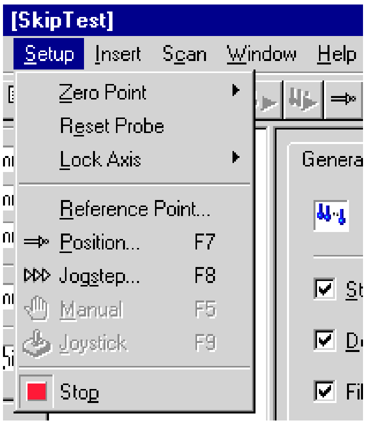
With the two assigned parameters unit and precision, you can define the format for output of time values.

Also display default units

If the display for default units is activated, they are also displayed in the dialog box. If this option is disabled only the units that deviate from the default settings are displayed.

5 Setup and Preparatory Tasks

Menu



Functions

When you select the menu item *Setup* the functions that you need to prepare digitization are displayed. This includes both the functions required to position and move the machine as well as a way of defining the zero point.

5.1 Zero point	5.1.1 Setting the zero point 5.1.2 Zero point of segment 5.1.3 Resetting the zero point
5.2 Reference point travel	Synchronization of machine and control
5.3 Position	Absolute positioning of the axes
5.4 Jog step	Step-by-step positioning
5.5 Joystick mode	Activate/deactivate joystick
5.6 Stop	Terminates movement

Requirements

The following conditions must be fulfilled before the digitization control scancad laser can be used:

- The electrical connections between the machine, laser sensor, and digitization control have been correctly made.
- The scanning software is fully installed on the PC/control.
- The machine description file "mc.con" and the machine constants it contains have been adapted to the machine being used.

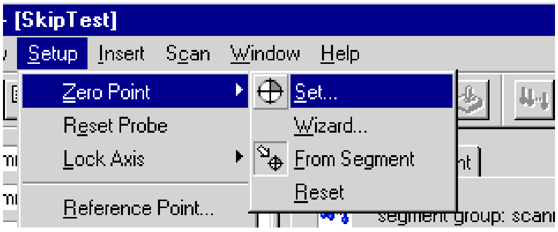
If all these conditions have been fulfilled you can proceed with your work with scancad laser.

Digitizing switch to OFF

First you must switch on the PC and the machine. You should now be able to see the scancad laser window on the monitor of the PC. If you cannot, activate the program. If you use several machines for digitizing, you must set the configuration file for the machine you are using. The digitization switch should still be in the "OFF" position! Now connect the sensor if you have not already done so.

5.1 Zero point

Dialog box



When processing the digitization data you must make sure that the position/alignment of the model is correct as soon as you set up scanning. It is also important that you set the zero point for digitization at a position that will also be correct for subsequent processing. All digitization data will then be saved in the coordinate system defined here.

Types of zero points

Two different zero point types are used by scancad laser. Machine zero is active after reference point traverse. It cannot be altered. By contrast, additional zero points are used for defining the scans for the models or the individual segments. However, the coordinate display always used the active zero point, i.e. the coordinates shown in the display refer to the active zero point.

If a zero point is defined using the function *Set*, the active zero point is automatically entered here.

Different zero points can be used for different segments within a single digitization project. When scanning, the control always activates the zero point defined in the segment. The coordinates displayed during scanning always refer to this zero point.

Set/Reset

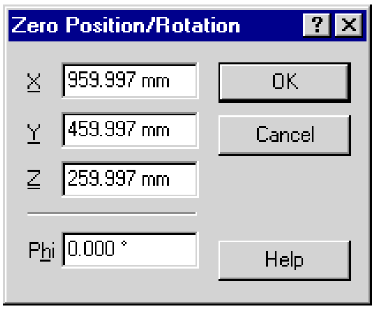
It is not only possible to set a zero point at the current machine position easily but also to reset the zero point at the origin of the unchanged machine coordinate system.

All the functions available for this purpose are described in detail below.

5.1.1 Set

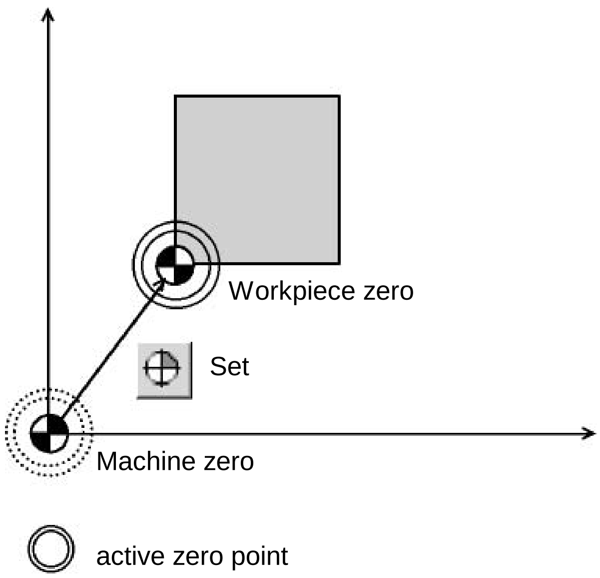
You can easily define the zero point and the alignment of a model for digitization with this function. First of all move the sensor to the positions for which the coordinates are known. Then enter the coordinates in the corresponding dialog fields X, Y and Z.

Dialog box



If the position of the rotated model with reference to the machine axes is also known, you can enter that value, too. 0° corresponds to the machine axis in the X direction. The angles of rotation are measured in the counterclockwise direction. All the scanned data are then stored having been rotated about the Z axis by that value.

The scanning system then takes over this coordinate system. All the specified coordinates from now on always refer to the coordinate system defined by the user and not to the fixed machine coordinate system.



5.1.2 Accepting the zero point of a segment

The zero point is often defined using the function mentioned above. In that case the zero point is activated immediately. However, scancad laser also allows you to set the zero point while you are defining the scanning methods (see Section 6). In order to activate a zero point set in this way it can be taken over from a segment using the function described here.

This procedure is also suitable for another application described here. The fixed machine zero is activated as soon as you switch on the machine and reference it. The coordinate display always refers to that zero point. If you now load an existing project, the zero point defined within that project can be activated by performing this function.

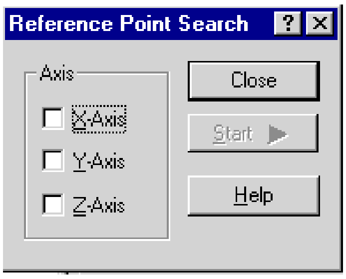
5.1.3 Resetting the zero point

You can define a new coordinate system for working with scancad laser with the function *Set zero point*. This coordinate system is different from the fixed machine coordinate system. The function *Reset* calls up the machine coordinate system again.

5.2 Reference point approach

After the digitizing control has been switched off, it is always necessary to perform a reference point approach in all machine axes. In this case, the position measuring system is synchronized with the digitizing control. The reference point approach can be active, i.e. with the NC control, or passive, i.e. with the NC control if scancad laser is installed parallel with the NC control. Any combination of axes is possible. Whether an active or a passive reference point approach is necessary depends on the NC control and is stated in the machine constant file "mc.con". The procedure for selecting the reference point approach is identical for both methods.

Dialog box



Select the axes you want to reference. If the control has been switched off, you must approach the reference point for every axis. Clicking the *Start* button sets the machine in motion immediately. The progress display depicts the progress of the reference point approach. Now wait until the selected axes have reached their reference point. The dialog will not disappear until you have approached the reference point of all axes.

To avoid collisions with workpieces in the working zone of the machine, the vertical axis is always traverse first.

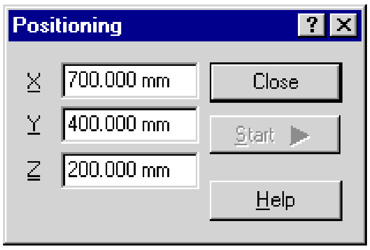
Active/passive reference point approach

During an active reference point approach, you must set the digitizing switch to the "ON" position before starting. During a passive reference point approach, it must be in the "OFF" position. Reference point approach is then performed by the NC control. Passive reference point approach is seldom needed and depends on the particular circumstances under which the NC control is used and the link between the digitizing and NC controls.

After successful completion, all functions of the digitizing control can be used. If you exit scancad laser and start it up again later on, the reference points are retained. Of course, that only applies if no other reference point approach has been performed with the NC control and the digitizing has not been switched off in the meantime.

5.3 Positioning

Dialog box



The function described can be used to approach a defined and known position. After activation of the positioning command, a new dialog is displayed. You enter the axis values of the end point here.

Motion starts immediately you click that the *Start* button. So that a sequence of positioning movements can be performed, the dialog remains open until it is closed by the operator.

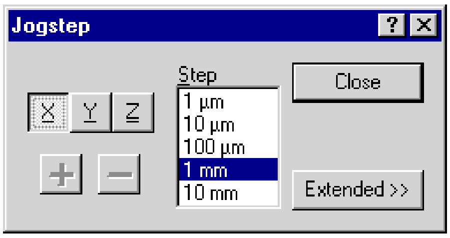
Caution: When the target position is entered, the operator must make sure that the movement does not cause a collision with the workpiece or other parts of the machine. The movement is performed in such a way that all axes reach the target position at the same time.

Despite extensive safety checks before staring digitizing the machine can move out of the permitted working zone, especially during joystick operation.

If the sensor is outside the permitted working zone, it is possible to move it back into the valid zone again with this function.

5.4 Jog step

Dialog box



Unlike the positioning function described above, in jog step operation, the machine can move in small, settable steps. The dialog remains open until it is closed by the operator. In this way, you can perform any number of movements.

To perform a movement, first select the size of the step from a list of values. After that, you can select the axis you want to move. You can start the movement and define the direction by clicking the +/- buttons.

With is function, you can move the sensor back into the valid working zone. You only have to enable the relevant direction keys.

5.5 Joystick operation (optional)

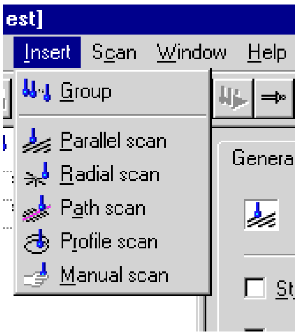
Joystick = Option

A joystick is used to control the machine. Connection of a joystick is recommended on machines with a large working zone and where the laser sensor is used. For further information about operation, see the documentation about the joystick.

5.6 Stop

If you select this function, all machine movements are stopped immediately.

6 Inserting Scanning Methods



Functions

After you have selected the menu item *Insert* you can select one of the functions listed below. You can add both groups and individual scanning methods to the project. A detailed description of how the scanning methods work is given in this Section.

6.1 General parameters	Description of the general parameters 6.1.1 The parameters on the "General" tab 6.1.2 The parameters on the "Zero point" tab 6.1.3 The parameters on the "Area" tab" 6.1.4 Conclusion
6.2 Group	Inserting groups into the hierarchy
6.3 Scanning methods	Description of the scanning methods 6.3.1 Parallel scanning 6.3.2 Radial scanning 6.3.3 Transverse scanning
6.4 Fence editor	Description of the editor for defining boundaries 6.4.1 Editing polygons 6.4.2 Editing points

Whereas the previous sections of this manual explain setup of the workpieces and the related functions of the system in detail, this section describes the individual scanning methods, how and when they are used.

Although availability of different scanning methods is not as important for contactless digitization as for tactile scanning, scancad laser provides various scanning methods to be able to adapt to the situation of the model better during set up.

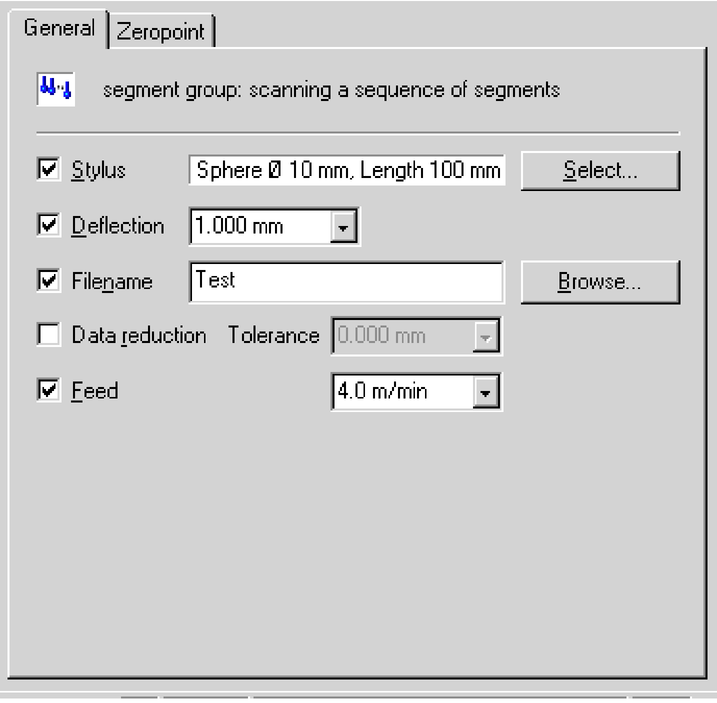
The steps taken to define a scanning method are described in depth. The different scanning options and their parameters are described in detail.

To avoid repeating descriptions of the individual parameters, all the general parameters are dealt with in the initial subsection 5.1. The tabs "General" and "Zero point" only contain parameters that are used by all the scanning methods. Only the tab "Area" contains some parameters that are different depending on the scanning method used. These special parameters are dealt with together with the individual scanning methods.

6.1 General parameters

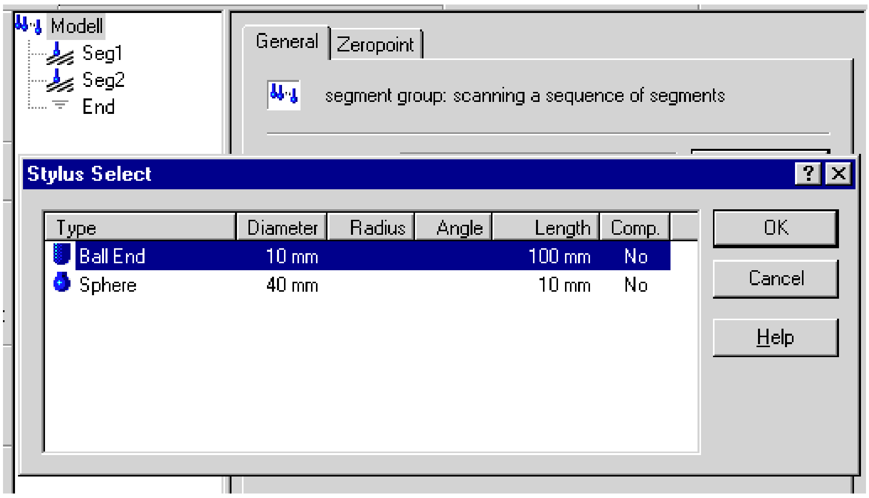
As already explained in the introduction, we will first describe the parameters that are used by all the scanning methods. Several of these parameters are used so often that they appear on both the "General" and "Zero point" tabs on the group level.

6.1.1 The parameters on the tab "General"



Sensor

For closed-loop control of scanning it is important to state the sensor type. A sensor from the laser list is selected for this. This list will normally only contain one sensor type.



Selection of the sensor at this point means that the sensor type entered here must be used directly. The selection only states that this sensor type will be used for digitization. scancad laser will request you to insert the sensor in question when necessary if you have not already done so.

Activating a sensor

However, if you want to designate the selected sensor as the active sensor you can activate it directly from the laser list with the function *Select*. You will then be asked to insert that sensor immediately. Handling of the laser list is described in more detail in Section 2.

File

A file name under which the digitization data are saved is entered here. If the file name at the highest model level is not changed later on when the individual scanning definitions are defined, all data are written to a single file and stored there.

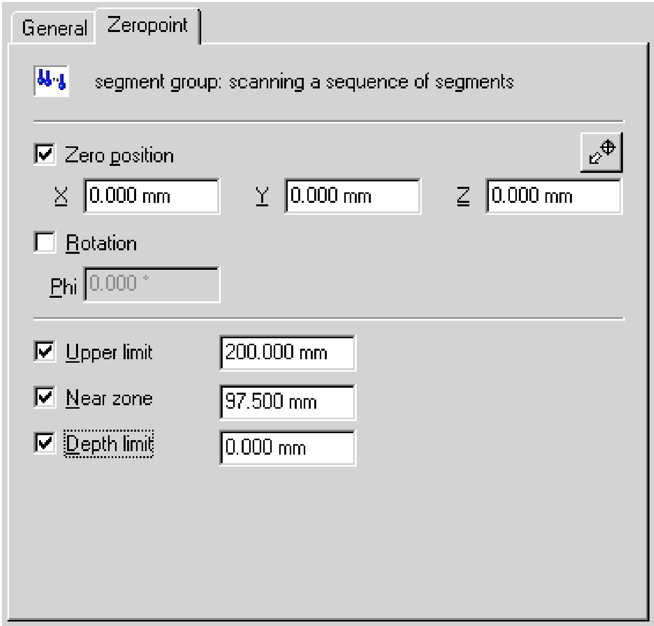
Data reduction, tolerance

This parameter is used to reduce the data set. By defining an "online tolerance" the "insignificant" measured values of a line are not stored. Insignificant data are data that are not required to describe a part within a specified tolerance. The data that are in a tube of radius *tolerance* around a straight line formed by the data are therefore irrelevant. They do not describe any changes to the surface. The tolerance should be set such that as many data as possible are reduced but the precision for continued processing is still sufficient. It is best to select a value between 0.01 mm and half the required reproduction precision. It is important to remember that reducing the data set also reduces the time needed to process the data. As a general rule, a tolerance of at least one hundredth of a millimeter should be set.

Velocity

The scanning speed of the individual segments defines the greatest permissible digitization speed in each case. It therefore has a direct influence on the scanning time and the resulting data set.

6.1.2 The parameters on the tab "Zero point"



Zero offset

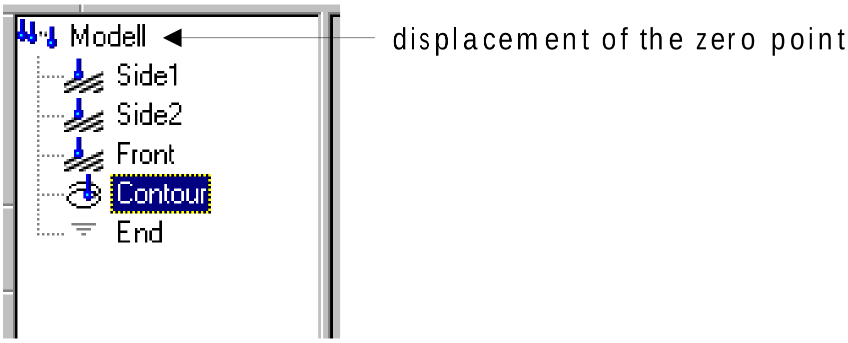
Here you can enter the offset values of each of the axes to activate a zero offset. You can enter the values in a context menu.

A special button on the zero point tab allows you to transfer the "active zero point" directly to a project.

With these settings, the parameters of the higher level are automatically taken as the default. This speeds up input of the zero offset and changes then only have to be made at one place.

Here are three different application examples:

1. A model is to be split up into several segments and scanned.

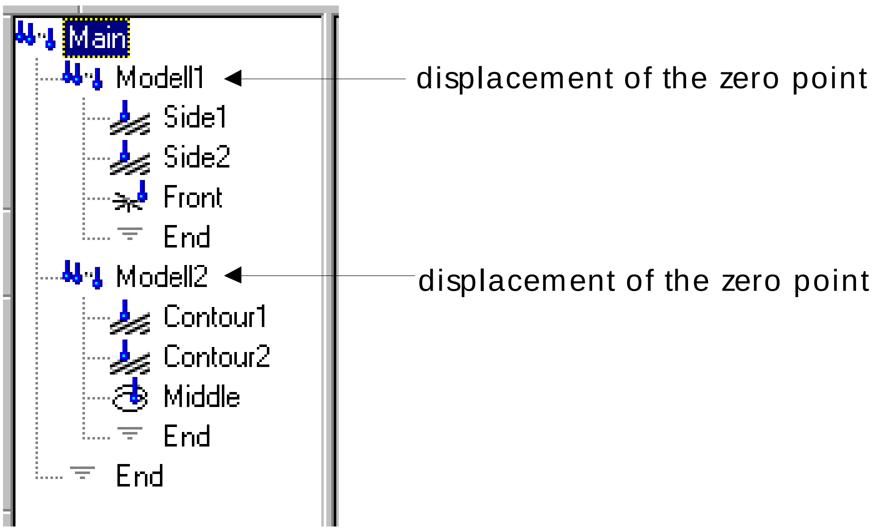


To define a zero point for all segments, the zero point is only defined once at the model level. The offset only applies to the segments below it.

Accepting the offset from a higher level

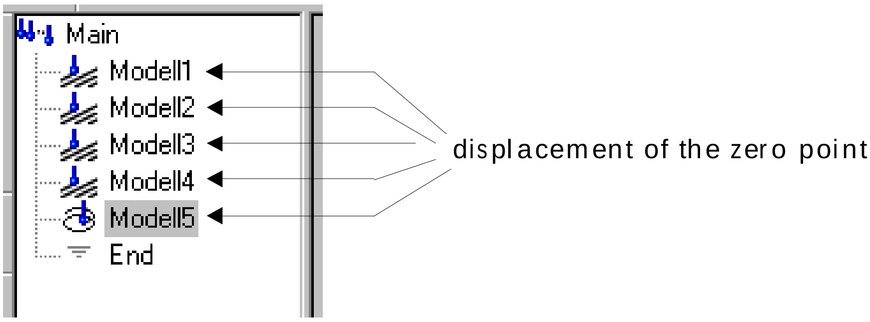
The grayed out zero offset display X=0, Y=0 and Z=0 means that the offset from the higher level, in this case the model level, applies. An addition offset is added on the segment level. To make any changes, it is only necessary to adapt the offset value on the model level.

2. Two models on the machine table are to be digitized one after the other.



In this case it is preferable to use a method other than that described in the first example. A separate subdirectory (part1 and part2) should be defined below the model level (main) for each workpiece. In this case, it is not a good idea to define the zero offset from the model level. For this reason, no zero offset is defined at the model level. The zero offsets should be defined at the group level. This ensures that a different offset is used for each group. This then also applies to the segments below the group levels.

3. Several models on the machine table are to be digitized with a single segment.



Two different methods can be used for entering the parameters. If the parameters are entered as described in example 2 a large number of group levels are created in which the zero points then have to be set for each workpiece. In this case it would be simpler to enter the zero offsets directly at the segment level. It is then not necessary to create the group levels. Input of the offset at the model level is not necessary because no segment is to be scanned with these offset values.

Alignment

The alignment defines the rotation about the Z axis. The procedure is the same as that for the zero offset.

Retraction height

Various parameters are used to describe the movement from the current position of the sensor to the starting position of the next segment or next line/partial line.

The retraction position is traversed in rapid traverse upwards from the current position. Collision-free horizontal positioning must then be possible at this height. If the current sensor position is already above the retraction height, the sensor is not moved.

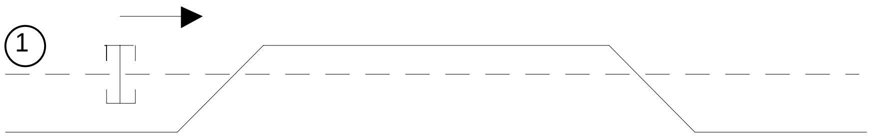
Depth limit

From the near zone the machine travels slowly downwards to the height of the depth zone. If the sensor provides a measured first, the approach movement stops. Digitizing is started or continued.

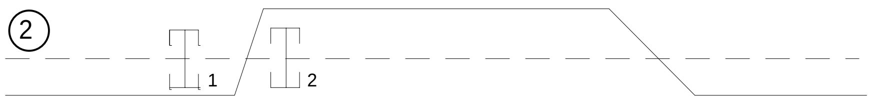
The depth limit is also relevant during digitization if some parts of the workpiece surface lie below this height. In this case the sensor traverses at the depth limit "virtual horizontal surface" to the end of the partial line or until it makes contact with the surface again.

When using the depth limit, it is important to note some special features of laser digitization. Traversing to the depth limit means that the sensor is not measuring a surface. The data passed to the software are therefore marked as "undefined". The values of the depth limit are used for these values in the software.

Please pay attention to the transition from traversing to the depth limit to traversing with acquisition of the surface. It is necessary to explain the response of the system using different examples.



In example 1, the sensor will measure to some extent without any problem without a contour because of the relatively soft transition from the depth limit. The transition from measured values marked as "undefined" to values in the validity range of the sensor can be detected by the software.

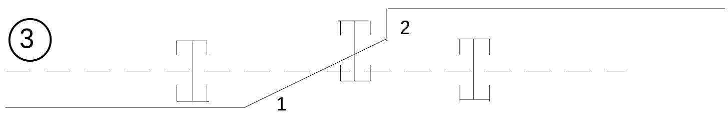


The contour shown in this example varies very sharply. The transition from the depth limit to the surface of the part is very abrupt. If the transition is too fast (too steep), it is to some extent impossible for the software to acquire the change from the depth limit to the real model. Measured value 1 is still at the depth limit, measured value 2 is already on the part.

Because both values (1+2) were marked as undefined by the sensor, it is not possible for the software to distinguish between the completely different situations for the software. In that case, scanning continues at the depth limit.

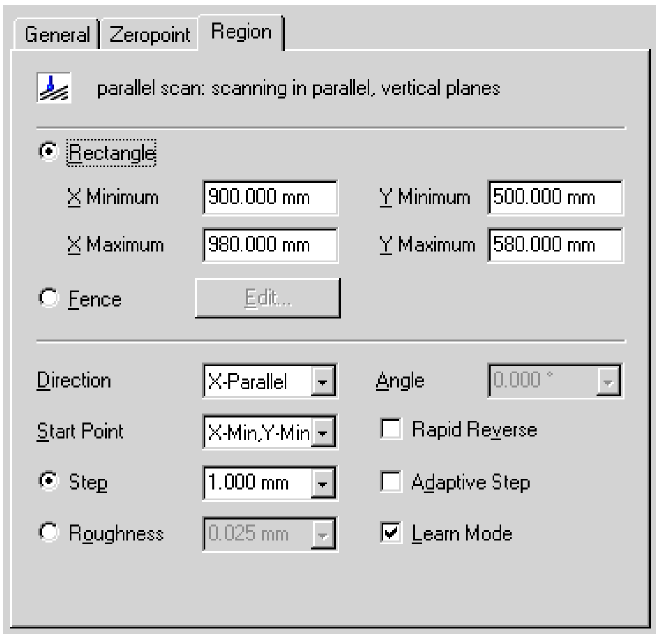
This can cause collisions with the part!

To avoid such cases, the model must be divided into two segments that are scanned in rapid traverse starting from the contour. It is also possible to rescan the transition subsequently.



The transition shown here consists of two consecutive contour changes. This transition from the depth limit to the first contour range is relatively soft. The sensor finds the contour and attempts to follow it. Soon after that, the state of the data changes back to "undefined" because no measurements are possible due to the steepness of the edge. These "undefined" values are now interpreted as if the sensor were continuing at the depth limit because it is within the measuring range of the sensor. Here too, it is advisable to scan from the top down and to subdivide the model.

61.3 The parameters on the tab "Area"



Line width

Line width

The line width defines the distance between two adjacent lines. The distance is only measured in the XY plane. That is why the lines on gradients that run parallel to the scanning paths may be a greater distance apart on the gradient surface than is defined by the line width. The difference in height between the individual lines bears no influence on the distances between the lines.

Reciprocation or rapid return

The type of infeed movement used to travel from one scanning line to the next has a great influence on the scanning time. It is decisive whether the following line is to begin directly next to the end of the current line (reciprocation) or on the other side (rapid return). Rapid return requires a long infeed movement along the part to the beginning of the next line. This, of course, takes considerably longer than the short infeed needed in reciprocation.

No data are acquired during infeed. The type of infeed chosen does not therefore affect the volume of data stored. Even through rapid return is disabled, the sensor may lift off if the infeed path is greater than a limit value depending on the line width or if the scanning area has gaps. These lifting movements are performed for safety reasons because no information is available about the gaps.

Starting position

The starting position to be approached is calculated from the selected scanning area. If a scanning method permits several starting points, the user can define with position is selected. The starting position is approached along the retraction plane in rapid traverse.

Correction

Normally, the laser sensor is moved by the scanning software in such a way that the object is in the measuring range of the sensor. This is achieved by correction of the sensor. On parts that completely within the scanning range of the sensor, correction is not necessary. The sensor then moves at a constant height above the module. This enables you to achieve maximum digitizing velocity. If the software detects measured values outside the measuring range, a retry function is activated. These is explained in more detail below.

Retry

As described above, different effects can cause the laser sensor not to supply useful measuring results. To prevent scanning stopping because of that, the software incorporates a retry function. This function attempts to restart scanning at a different but nearby position. The behavior of the retry function is affected by the three parameters described as follows.

Maximum gap

This parameter defines the range that can be skipped without useful measured values. If the distance defined here is exceeded, the software starts the retry function.

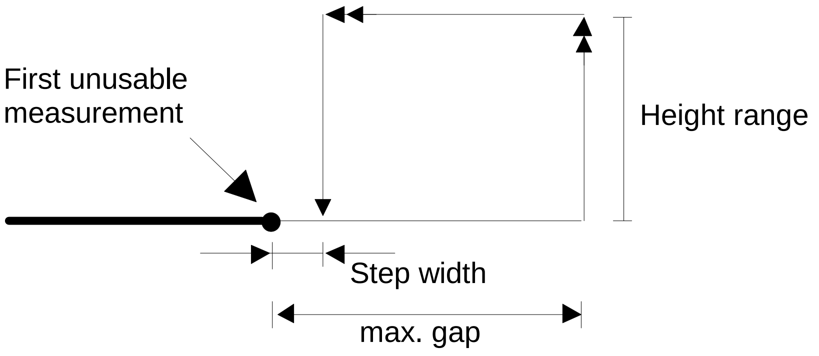
Height range

After the retry function has been triggered, the software raises the sensor away from the model by the value defined here. It is advisable to choose a height such that the object is no longer in the measuring range of the sensor.

Step width

The system restarts scanning at a calculated position after the sensor has been lifted. This position is the step width away from the position at which the first unusable measured value was obtained.

The parameters of the retry function are summarized in the following figure.



6.1.4 Conclusion

Precision

Most of the parameters described above have an immediate effect on the resulting volume of data and scanning time. They also play an important role in the precision of the digitization.

Precision is only ensured if measured values are acquired at small spatial intervals. Larger intervals could cause gaps and therefore loss of important information required to maintain precision. This results in a lower scanning speed, smaller line widths, smaller tolerances and larger volumes of data. These parameter settings also result in longer processing times of the resulting data.

However, if suitable parameter settings are used, such effects will only result in exceptional cases.

Initially, the set speed and line width heavily depend on the surface of the segment to be scanned. If there are no severe gradients, the segment can be digitized at high speed and large line widths. Large deviations between the measured values in one line and those of adjacent lines are not to be expected. Only a few data are required to acquire a representation of a surface with the necessary precision. The set tolerance should always be as large as possible and as small as necessary. A tolerance corresponding to half the required precision is recommended. Adjusted segmentation can also help by ensuring that scanning is only slower at especially critical areas.

6.2 Group

The management of individual digitization tasks within a digitization project is one of the important features of scancad laser. Its significance and the possibilities it offers have already been described in detail in Section 1.2.

Settings are always taken over from the higher level.

The feature allowing the insertion of groups in the project as hierarchical levels, reduces parameter input at the segment level to a minimum. This feature takes advantage of the fact that all settings are taken over from the upper hierarchical level.

The individual groups should therefore always be structured in a meaningful way. If, for example, several segments are to be scanned with the same parameters, the parameters for this can be defined at the group level.

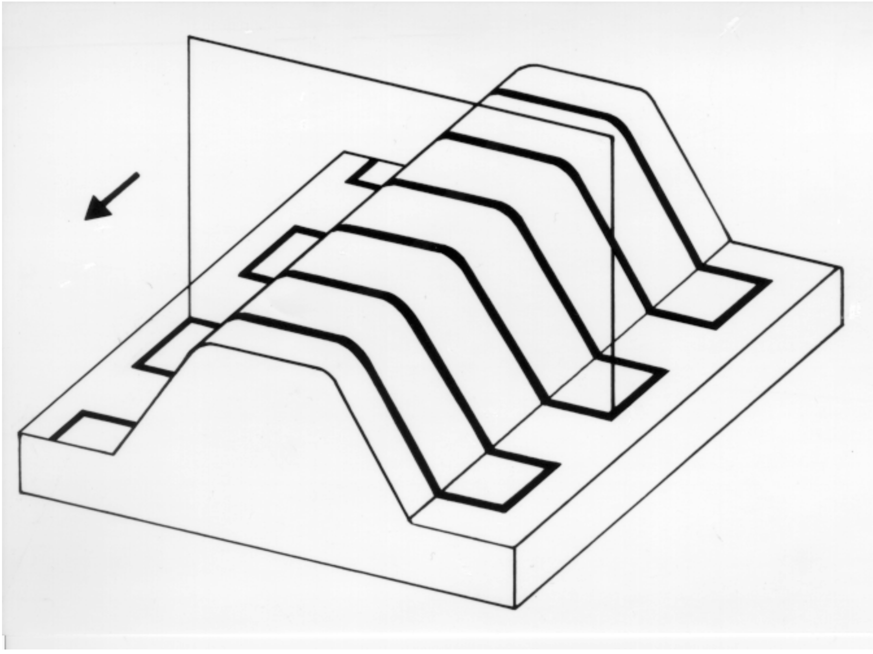
6.3 Scanning methods

Now that the fundamentals of scancad laser and the functions and general parameters available for setup have been described, we at last come to the scanning functions themselves. The various scanning types are each described in greater detail in the following part of this section. Only those input variables that exist in addition to the general parameters (see Section 6.1) will be explained here.

6.3.1 Parallel scanning

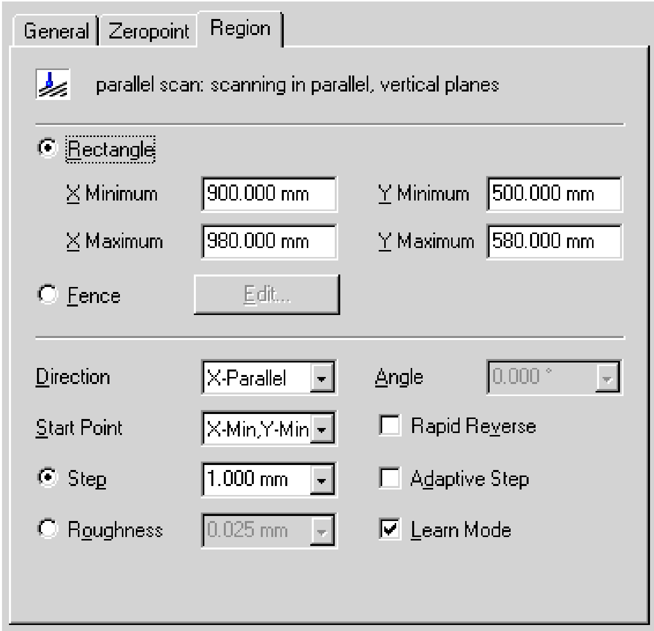
Parallel scanning is the most important scanning method for contactless digitization of models. Although simple to use, many areas of a model can be acquired by this model. Because of its importance, this scanning method will be described first.

With this scanning strategy a segment can be acquired by digitization in parallel lines. You can set the direction of the lines and the type of infeed. The area can be enclosed either by a rectangle or a fence.



Three tabs are available under this scanning type for entering parameters. The tabs "General" and "Zero point" have already been introduced to you at the model level for defining the general parameters (file, retraction height, etc.) and the zero point (offset, alignment etc.). This tab also contains parameters for defining the scanning range and other digitization settings. The general parameters and zero offset settings are taken over by the higher level as described in the previous section. Of course, it is possible to change these parameters.

Area tab
Parallel scanning



Limitation of the digitization area

This scanning method allows both the digitization of rectangular areas and areas delimited by fences. You define the rectangle by entering two corner points. If you select a fence for delimitation you can define it using the fence editor.

Rectangle

In the simplest case you can use a rectangle to define a scanning area. To do this simply enter the diagonally opposite corners in the fields in the dialog box supplied for this purpose.

Rectangle XMinimum, XMaximum, YMinimum, YMaximum

You enter the coordinates for the diagonally opposite corners of the rectangle under *XMinimum*, *YMinimum* and *XMaximum*, *YMaximum*. You can do this either by entering a numerical value or transferring a value. The latter is usually the easiest method for which the exact coordinates need not be known and typing errors are avoided.

Transferring a position

In order to enter parameters by accepting a value you must move the machine using the joystick, by positioning or using the NC control around the corner of a rectangle. A context menu for the dialog boxes then appears in which you accept the values for the parameters. This is how you enter the current position of the sensor. You then enter the opposite corner position in the same way.

Fence

Defining a fence

If a scanning area is not enclosed in a rectangle, with this scanning method you can also use fences to delimit an area.

Fence editor

Once you have selected the delimitation type you want you can call the fence editor (see Section 5.4) with *Edit*. Here you can define a delimitation as a series of polygons and edit them.

It is not necessary to understand exactly how the fence editor works at this point. We will therefore not interrupt the description of the scanning methods to give a detailed description of the fence editor. The fence editor and the way it works is dealt with in detail in a separate subsection 6.4 at the end of this section.

Polygon

Polygons in the mathematical sense are used for limitation. A rectangle, for example, is a polygon with 4 corners whose edges are parallel to the machine axes. For the purposes of entering a fence these polygons can consist of several thousand points.

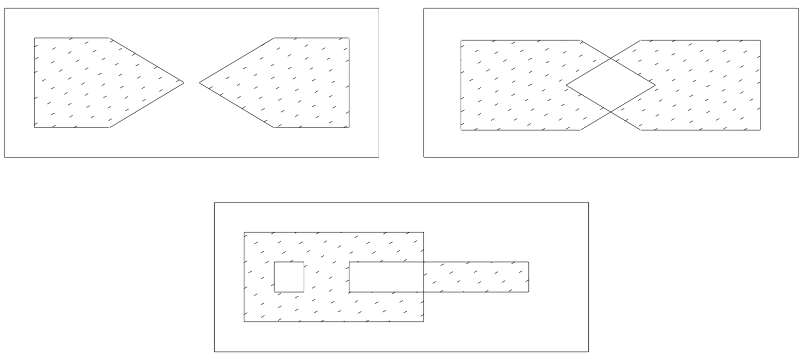
Overlapping polygons

A limitation defined by a fence can consist of several polygons. Each polygon then consists of a self contained object with n corners. If a fence consists of two or more polygons, the scanning area corresponds to the union of the areas without the overlapping area.

Island

If one polygon contains another complete polygon, the area enclosed by the smaller polygon is interpreted as an island that is not scanned. Yet another polygon within that island is however scanned.

Several examples are given in the drawing below. The hatched area is digitized.



Representation: Overlapping polygons within a model

Direction, angle

The entries you make for the direction and the angle define the position of the individual scanning paths. An angle of 0°/180° defines a scanning path parallel to the X axis. A value of 90°/270° a scanning path parallel to the Y axis. The angle is mathematically positive, i.e., it is read in the counterclockwise direction.

Starting point

The point at which digitizing starts is defined by the starting point. In the case of a rectangular limitation and scanning directions of 0º and 90º four different options are available. Scanning can start in any of the four corners. If the area is limited by a fence or if digitizing is only to be performed below a certain angle, only two possible starting points are possible.

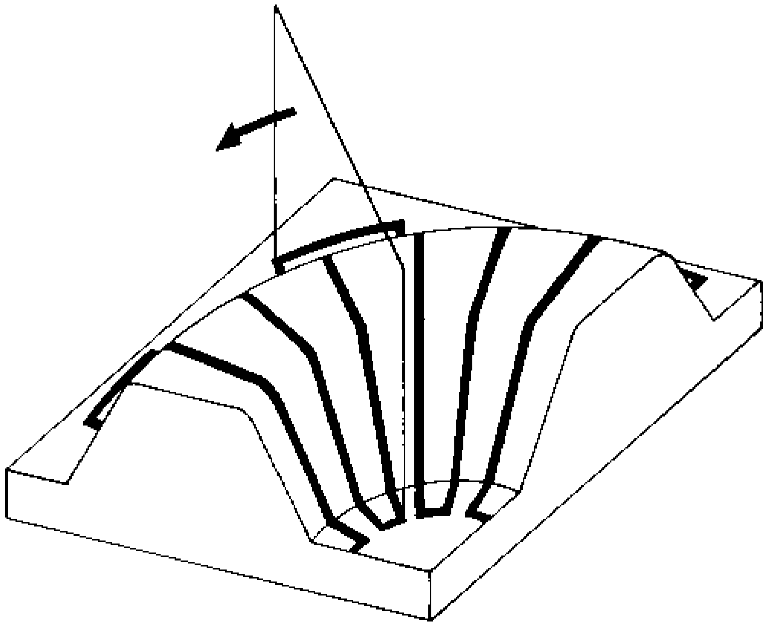
When you can an area delimited by a fence partial lines can occur if the fence cuts across the scanning line. The area outside the fence is then traversed in rapid traverse on the retraction plane.

Conclusion: Parallel scanning

Area of application	All objects which do not have mainly vertically running limitations.
Advantages	Easy to set up, does not cause any overlapping of scanning paths and usually allows high scanning speeds, i.e. short scanning times.
Disadvantages	Not suitable for hemispherical or cylindrical objects.

6.3.2 Radial scanning

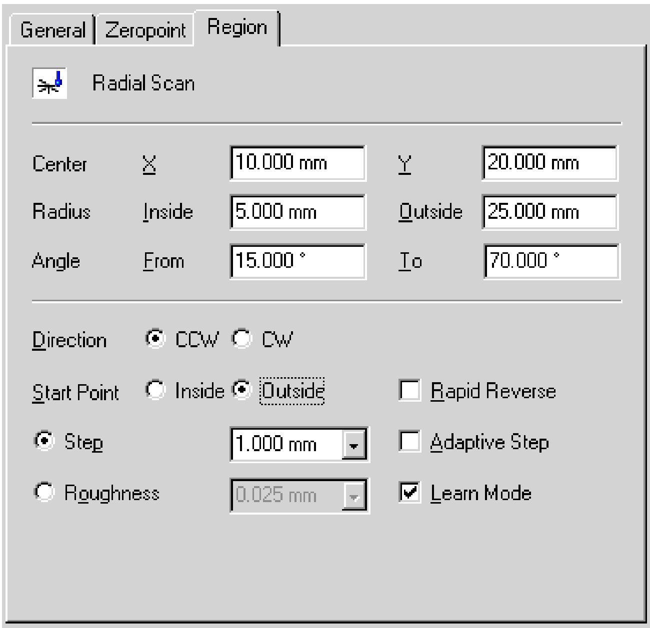
This scanning type is especially suitable for acquiring circular or round contour areas. With this strategy, circular segments or entire circular areas can be digitized radially. The individual scanning planes are rotated around the center point during digitization according to the line width selected.



Scanning area for radial scanning

The scanning area for radial scanning is a circular segment. It is made up of two concentric circles and a start and end angle.

Area tab "radial scanning"

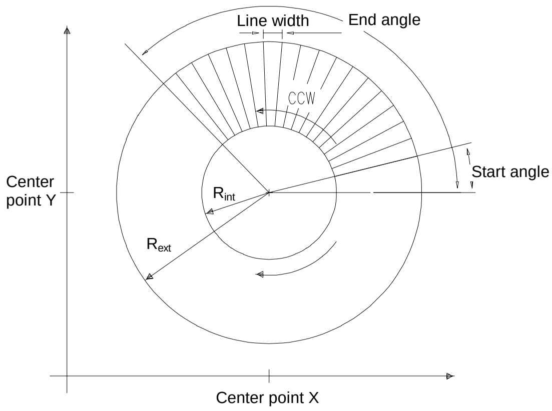


Center point/radius/angle

The two concentric circles of limitation are defined by specifying a common center point and their radii. The scanning area lies between these two arcs. The start and end angle limit it to a circular sector. An entire circle is scanned if an angular range of 0° to 360° and an internal circle radius of 0 has been defined.

Direction/starting point

The four possible scanning directions can now be selected by defining a starting point (on the internal or external circle) and the direction of movement ("cw" for clockwise direction and "ccw" for counterclockwise direction).



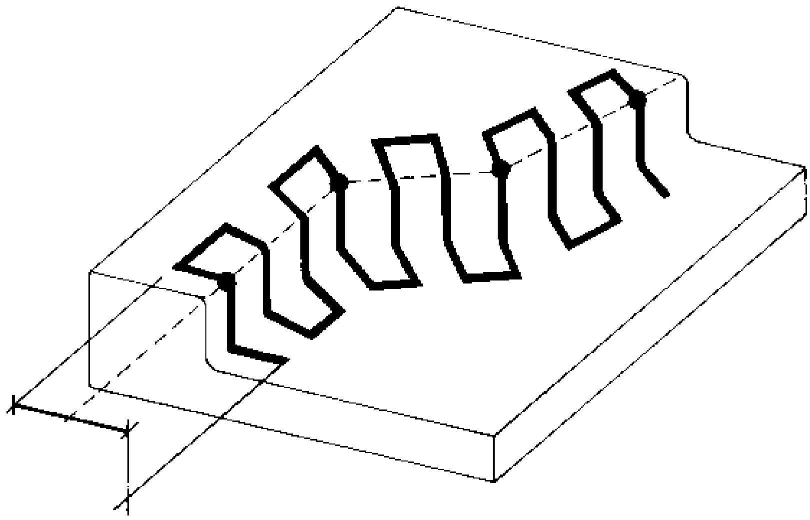
Conclusion: Radial scanning

Area of application	Cylindrical or dome-shaped objects that might also contain horizontally running surfaces.
Advantages	Simple to set up.
Disadvantages	Overlapping of scanning paths in the direction of the center point of the scanning area and often low scanning speeds result in high scanning times.

6.3.3 Line scanning

In contrast to the scanning methods described above that can digitize areas delimited by a rectangle, fence or circular segment, digitizing in line scanning is performed along the planes that are vertical to a defined center line. This center line is the line referred to in line scanning.

This type of delimitation makes line scanning suitable for the acquisition of boundaries running in any direction or the edges of a model.

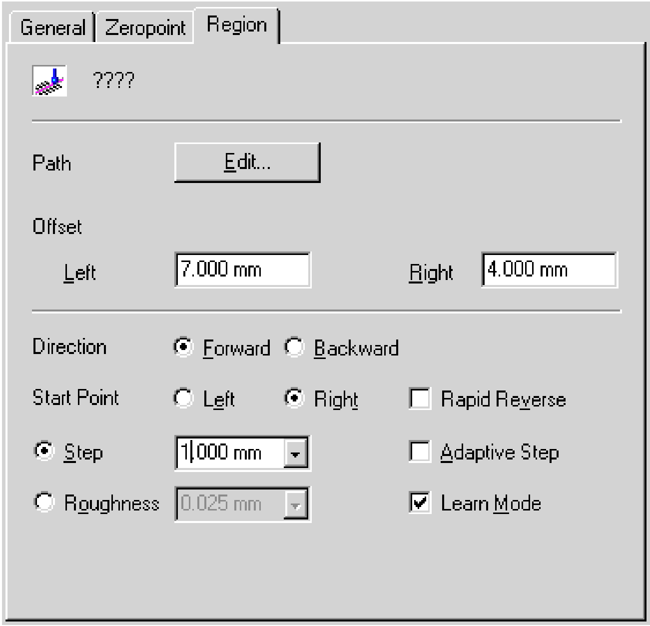


Scanning area for line scanning

A polygon (the route taken in line scanning) is used to define the scanning area in line scanning. This line defines the route taken by digitization later on. This line is the leader for the actual scanning action left and right of it. The scanning action can be imagined as a band either side of the leader.

The fence segments are used to generate scanning paths that lie vertically to them and which are delimited by *offset left* and *offset right*. Arcs are formed at the fence segment transition points and then run tangentially into the next segment.

Area tab "Line scanning"



Offset right/left

As described above, in this scanning method, scanning is performed vertically to the defined line. The distance left and right of the line is defined.

Direction/starting point

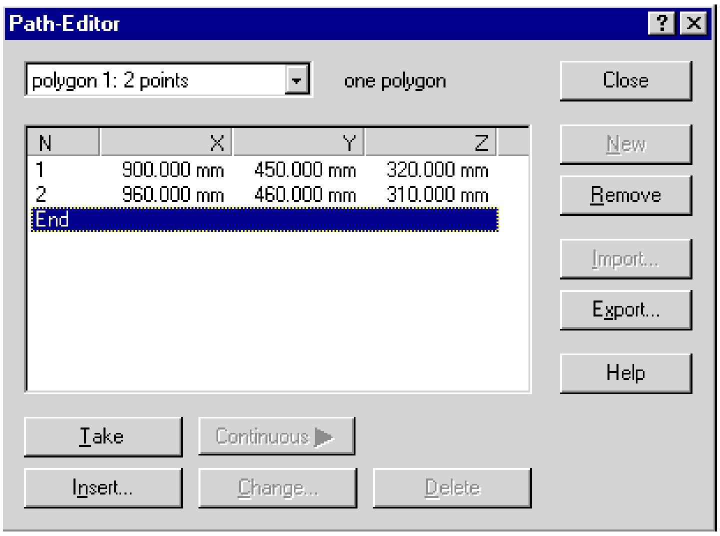
Both the starting position left and right of the line and execution in the direction of the line or in the opposite direction can be defined depending on the application.

Conclusion: Line scanning

Area of application	Boundaries of objects running any direction
Advantages	Usually short scanning times
Disadvantages	Few scanning path overlaps, setup takes longer.

6.4 Fence editor

In the description of the individual scanning methods, the various types of delimitation were only briefly explained. Due to the significance of the different types of scanning area in selection of the digitization method, definition of these limitations using the fence editor is described in greater detail in this section. The term "fence" used in copy milling is used for freeform, polygon limitations of digitizing areas.



The fence editor dialog box is divided into three elements. The largest element is a box displaying the polygon in terms of coordinates. The name of the current polygon is displayed in the selection box above this list. To the right of this you will see the buttons with the different functions that affect the entire fence. Below the point list you will see the functions for editing the individual polygon points.

6.4.1 Editing polygons

Close

When you have finished editing your polygon you can save the limitations by closing the fence dialog box. Make sure that you save the limitations for a particular project in the project files (*.SCN). There are no special files for fences.

New

To create a new limitation for a segment select the function *New* to define a new polygon. An END mark is then inserted in the so far empty field used to display the fence points. You can now define the individual fence points. The functions available for this step are described below.

Delete

If you want to delete the existing definition of a fence from a project you can do this with the *Delete* function. Once a fence is deleted it is irretrievably lost!

Import

In some cases it makes sense to use outlines that you have already scanned as limitations for other digitization projects. You can use the import function to read in scancad scan files (*.FMP) for limitations.

Export

If you want to use the fences you have set up in scancad laser in scancad mill to further process data, you can export them with this function. The format corresponds to that of the scanning data (*.FMP). You can use these areas as limitations for milling or in scancad mill to define new areas.

6.4.2 Editing points

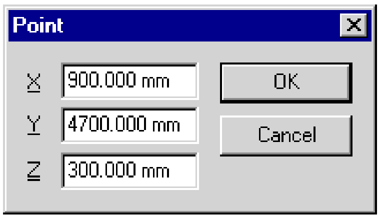
Apply

Usually fences are only used if several points are required to define a boundary. It therefore does not make much sense to enter all point coordinates manually. It is simpler and safer to define them using the *Apply* button to accept the current stylus position. Whenever you click on Apply, the fence editor enters the current position in the list of limitation points. The polygon point number is automatically incremented.

Insert

If you have already created a list of points you can enter additional points in the list/polygon with *Insert*. Select the point at which the new point is to be entered.

Then enter the coordinates in the relevant dialog box.



Edit

If you want to correct or change coordinates in the list, select the point in question. Now you can change the coordinates.

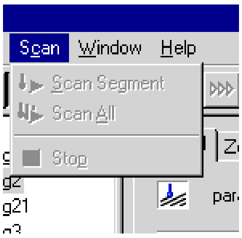
Delete

If you want to delete individual points from the list you can use *Delete*. You can also use the functions offered by the operating system to select the points.

Notes

7 Scanning

Menu



Functions

This section is not only the last in the sequence of menu items. It is also the last step to be performed in digitizing.

Up until this point, this manual has explained how to build up digitizing projects with scancad laser. The different functions for setting up the control and workpieces have been dealt with in detail. The previous section contains a description of each scanning method. Once you have performed all this preparatory steps, there is no reason why a scanning operation should not be successful. The functions required to perform digitizing are grouped together in the menu described here.

After you have selected the menu item *Scan* you can select one of the functions listed below.

7.1 Scan segment	Starts digitizing of one segment, of one group
7.2 Scan all segments	Starts execution of the entire project
7.3 Stop	Terminates scanning

7.1 Scan segment

Segment level

If you have selected a segment in the display of the project, it is possible to start digitizing with the function described here. This command is very useful for testing the parameter entered for digitizing. For example, you can select the line width to be very large in this dry run to assess the scanned area or the scanning behavior.

Group level

If you call up this command from a group level, all the segments belonging to the group are scanned. This function must be used whenever you want to scan a model with different lasers, and you want to determine the process your self.

Model level

Calling up this command - on the model level - causes the complete project to execute. The system will request you to change the lasers.

Before actual scanning is started, numerous safety checks are performed. For example, a check is made that the working range is within the permitted limits and that the filename has not been assigned to another segment already. If these checks come up with an error in the data entered, the operator is prompted to change the entries by a warning message.

7.2 Scan all segments

This command is equivalent to the start command of the model level described above. If the active probe does not match the laser used in the definition of the project, the system prompts the operator to insert the correct laser. The same situation arises if different laser types are used within a single project. Because an automatic laser changer is not possible, the control software must prompt the operator to change the laser with appropriate messages.

Like for scanning single segments, various checks are make before starting.

7.3 Stop

With this function the scanning procedure is terminated. Of course, this function is also available on the tool bar. If you press the space bar scanning is stopped too.

8 Window

Menu

Functions

You will find the following functions under menu item *Windows*:

8.1 Cascade windows	Windows displayed overlapping
8.2 Split horizontally	Horizontal arrangement of the windows
8.3 "1, 2"	Fast selection of individual windows

8.1 Cascade windows

When you select this function, the windows are displayed overlapping.

8.2 Split horizontally

In this mode, the windows are arranged horizontally, one above the other.

8.3 "1, 2"

At the end of the Window menu item, a list of all open documents is displayed. The currently active window is marked with a checkmark. You can activate a window from this list by clicking on it with the mouse.

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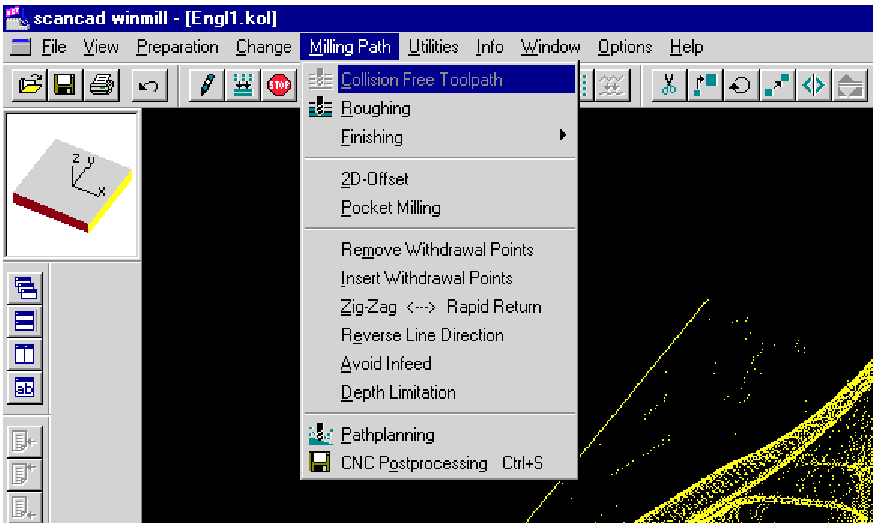
SINUMERIK 840D Digitizing
Part 4: Milling Program Generation (scancad mill)

Notes

1 File

Menu



Functions

After you have selected the menu item *File* you can select one of the following functions.

1.1 Read in/Import	Input interfaces for reading in external data 1.1.1 VDAFS -> DIGIT 1.1.2 IGES -> DIGIT 1.1.3 NC-ASCII -> DIGIT 1.1.4 DIGIT/ASCII -> DIGIT
1.2 Output/Export	Output interfaces for exporting to external systems 1.2.1 DIGIT -> VDAFS 1.2.2 DIGIT -> IGES 1.2.3 DIGIT -> NC-ASCII 1.2.4 DIGIT -> DIGIT/ASCII 1.2.5 DIGIT File
1.3 Merge	Merges different DIGIT files
1.4 Separate	Separates a DIGIT file

Data transfer

Transfer of data between different companies has become common practice. scancad mill therefore provides various methods for data transfer. You will find them under menu *File*, under the menu items *Open* and *Save as*. Standard formats such as VDAFS and IGES and other commonly used formats are available to you. Various tools to help you split up and merge files are described at the end of this section.

Internal, binary data format DIGIT

All data of the product family scancad are stored in the internal data forma called "DIGIT". The binary data format DIGIT allows you to transfer data between the individual program parts in an optimum way.

Note:

Tips on operation

When you use the import/export interfaces we recommend that you first select the file type and then the file in question. The file type plays a decisive role in the subsequent sequence of operations. The file extension is simply used here as a name. If you select file type VDAFS when opening a file the system only displays VDAFS files.

Note:

Please refer to Section A1, Operating instructions for more detailed information on the subjects file names, extensions and types and notes on software operation.

1.1 Read in/Import

The processing of digitizing data with scancad mill for Windows is not limited to BCT digitizing data. External data can also be converted to the internal binary DIGIT format via suitable read-in interfaces.

Input interfaces for reading in external data

You can read in the following file formats:

VDAFS	Reads in a file with VDAFS 2.0 (PSET point sequence)
IGES	Reads in a file with IGES point sequences
NC-ASCII	Read in a simple NC-ASCII format
DIGIT/ASCII	Reads in the internal data format in the form of an ASCII file

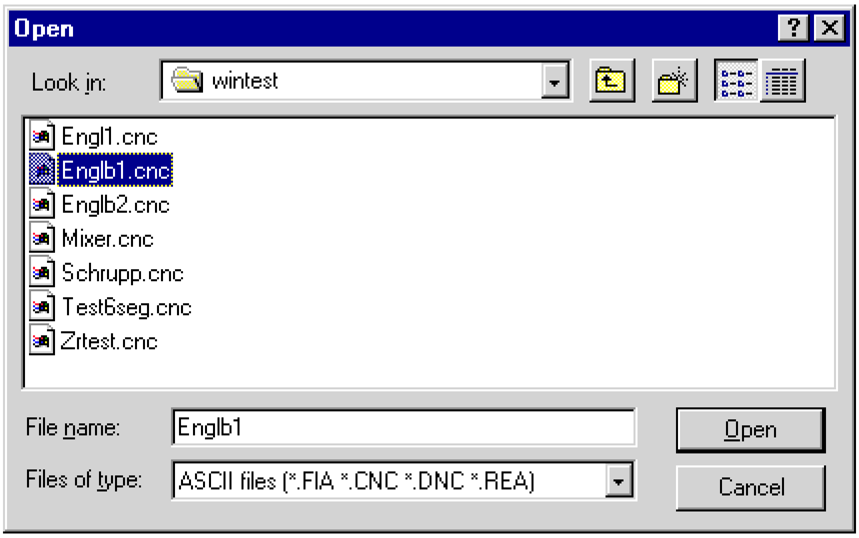
Information that is required for processing but which cannot be extracted from the data set must be entered by the operator. The section below describes the procedure to be followed.

Read in via dialog box File/Open

You can call up the functions described in Sections 1.1.1 to 1.1.4 for reading in specific file formats by clicking on a file in one of the above formats in menu *File, Open*.

Example:

Dialog box



1.1.1 VDAFS -> DIGIT

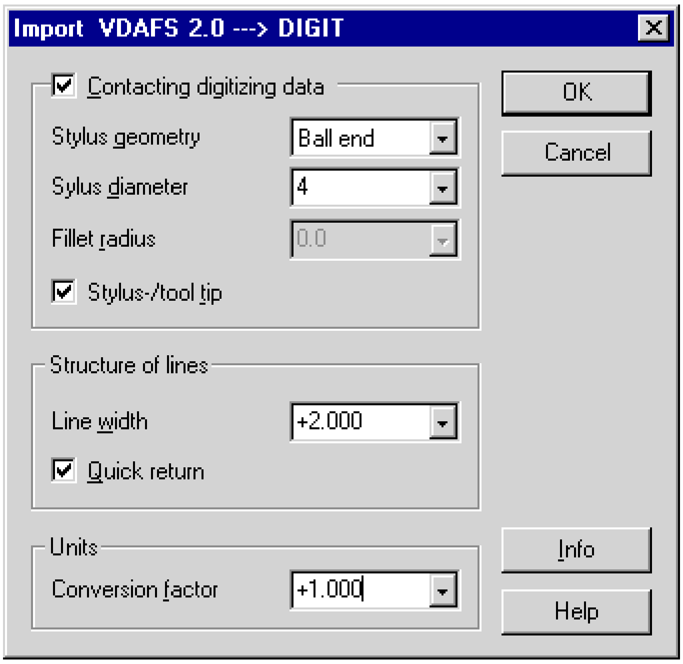
VDAFS file
DIGIT file

With this function scancad mill can convert files in VDAFS-PSET format to the internal binary format DIGIT. However, this format does not contain all the information that is required to continue processing. The following dialog box appears in which the operator enters additional necessary data.

Input file

VDAFS file

Dialog box



Output file

Binary file with the extension "DAT"

Tactile digitizing data

OFF = optical digitizing data

Switch the *tactile digitizing data* switch to "OFF" if you want to read in digitizing data from optical digitizing systems ("stylus radius = 0").

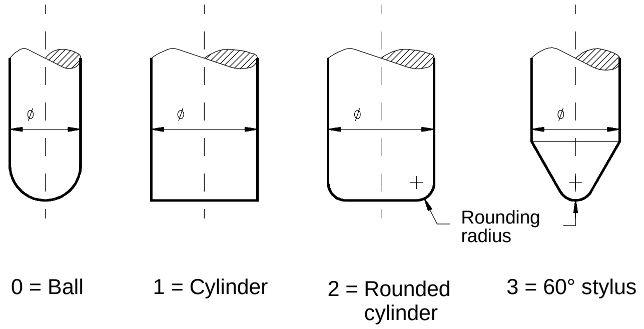
ON = tactile digitizing data

Switch the *tactile digitizing data* button to "ON" if you want to read out tactile digitizing data. You must define the following parameters.

Stylus geometry

Stylus geometry

You enter the geometry of the stylus you are using here. The following stylus types are possible:



Stylus diameter (for tactile digitizing data)

Stylus diameter

See drawing above.

Rounding radius (for tactile digitizing data)

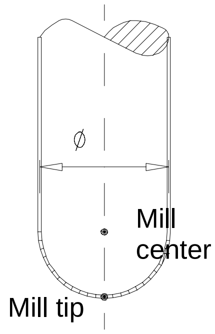
Rounding radius

If a probe in the shape of a rounded cylinder or rounded cone is used the radius of the rounded edges must also be entered.

Stylus/mill tip (for spherical styluses only)

Stylus/mill tip

You define whether stylus center points or stylus tip coordinates are contained in the input file via the button *Stylus tip* (for spherical styluses only) (s. drawing below).



Line width

Line width

Parameters for the *line width* are not compulsory but considerably simplify the input of parameters later on.

Rapid return

Rapid return

Via the button *rapid return* you tell scancad mill whether the file was scanned in a zigzag movement or in rapid return.

Unit of measurement/conversion factor

Conversion of different units

When importing data the system assumes that the external data are in "mm". If this is not the case the factor entered must be such that the input data can be converted to mm.

Example:

Factor "10" is set if the input file contains values in "cm".

1.1.2 IGES -> DIGIT

IGES file
DIGIT file

See also Section 1.1.1

With this function scancad mill can convert files in IGES format to the internal binary format DIGIT. Like VDAFS format, this format does not contain all the information that is required to continue processing. A new dialog box appears in which the operator enters other data required by the system . It is exactly the same as the dialog box for the VDAFS interface. These parameters are therefore not described in any more detail here. (see Section 1.1.1, VDAFS -> DIGIT).

1.1.3 NC-ASCII -> DIGIT

NC-ASCII file
DIGIT file

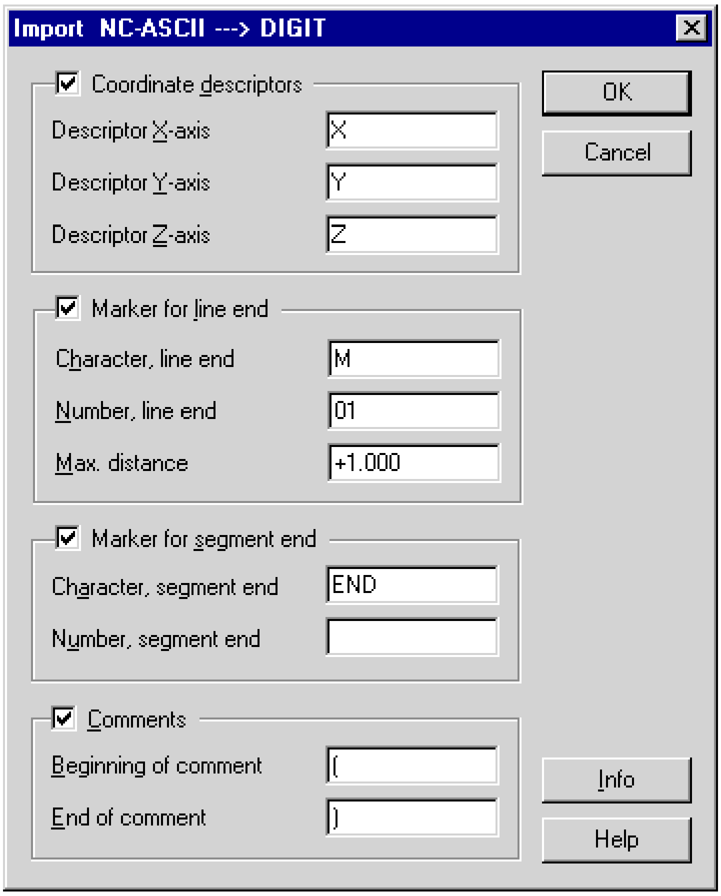
See also Section 1.1.1

The NC-ASCII format is a useful compact format for simple transfer of digitizing data. For further details see Section 1.2.3, DIGIT -> NC-ASCII. Unlike the VDAFS and IGES formats, NC-ASCII format is not a defined standard. In addition to the information about the stylus, line representation and unit of measurement used described in Section 1.1.1, VDAFS -> DIGIT, the system also requires other information about the format used before it can convert a file to the internal binary format DIGIT.

Input file

NC-ASCII file

Dialog box



Output file

Binary file with extension "DAT"

Coordinate names

Coordinate output

The format can used axis names for outputting the coordinates. You can enter the individual axis names here. Output for NC controls usually uses the designations X, Y and Z.

Next segment / Next line

In order to convert the structure of the input file the identifiers used to identify the end of a line or segment must be entered here. In this way, the division of the input file into segments/lines is maintained in scancad mill.

Maximum distance between lines

These parameters are used for files that do not identify a line structure. In order to identify a line structure a maximum distance between lines can be defined. If this distance is exceeded, the read-in interface generates a new line identifier at this position.

Comment

Identifiers for the beginning and end of a comment must be communicated to the program so that it can detect the comments.

1.1.4 DIGIT/ASCII -> DIGIT

ASCII file
DIGIT binary

This is how an ASCII file (American Symbolic Code for Information Interchange) that is both syntactically and structurally identical to the internal data format can be converted to a binary file in the internal data format. As this ASCII format contains all the necessary information, no further dialog box is necessary.

Example of application

In the first step an ASCII file is generated with the function *DIGIT -> DIGIT/ASCII*. This file can then be edited either with an editor or a text processing system.

With the function *DIGIT/ASCII -> DIGIT* the format of the file is converted back so that it can be used in the program system again.

The ASCII file must contain exactly the same structure as the internal binary data, otherwise format conversion will not be possible.

1.2 Output/Export

Output interfaces for exporting to external systems

Unlike the DOS version, the Windows version provides various options for outputting digitized and/or calculated data under menu item *File, Save as*. These functions will be described in greater detail in a subsequent section.

You can read out the following file formats:

VDAFS	Output of a file according to VDAFS 2.0
IGES	Output of a file according to IGES•
NC-ASCII	Read out a simple NC-ASCII format
DIGIT/ASCII	Reads out the internal data format in the form of an ASCII file
Digit.	Reads out a file in the internal binary format.
NC files	see Section 5, Milling Path

Output via the VDAFS and IGES interfaces generates very large files because of the complex format. This is not always desired or necessary when transferring digitized data. Output of the internal data structure in ASCII format (DIGIT/ASCII) requires a precisely matched input interface on the receiver side.

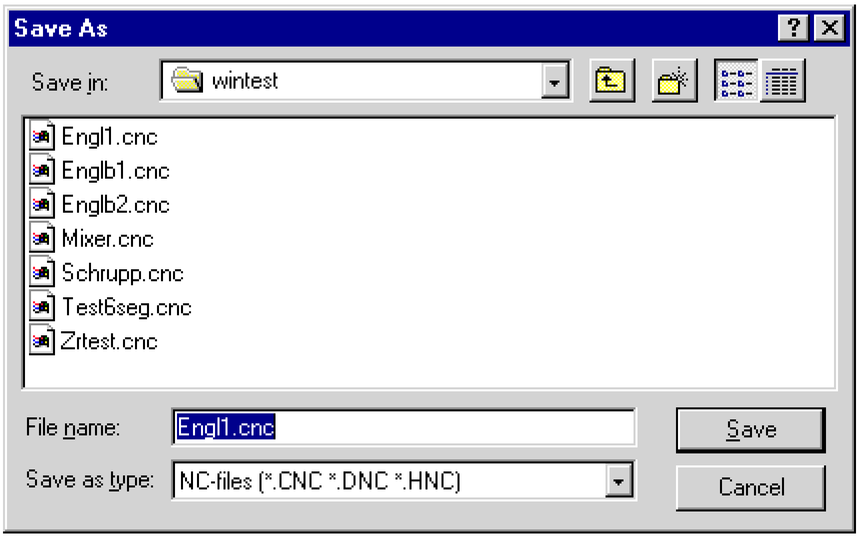
NC-ASCII format is an ASCII format that has been devised especially for the transferring digitizing data. It is easy to use, very compact and is therefore used as an interface for any systems.

Note:

You can call up the functions described in Sections 1.2.1 to 1.2.5 for reading out specific interface formats by clicking on a file in one of the above formats in menu *File, Save as*.

Example:

Dialog box



Note:

The operator can use whatever extension he wants for the output files. However, we recommend that you use the extension indicated for the file type. This will ensure clarity. Important: The extension must be three characters long.

1.2.1 DIGIT -> VDAFS

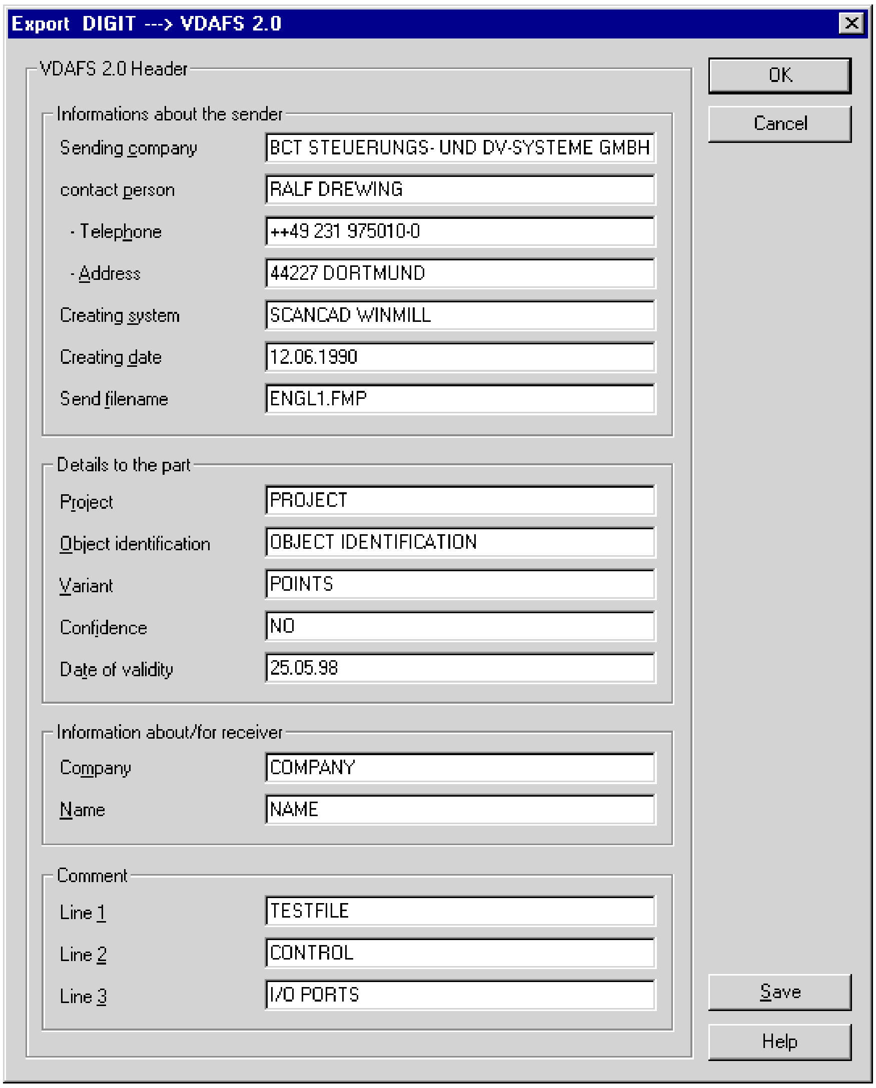
VDAFS interface

Various standard formats are available under *File, Save as* for continued processing of data in external systems. One possibility is output in VDAFS format which is described in more detail below. This format is suitable for transferring surface data but can also be used for point data.

Defining the interface leads to output files that are considerably larger than input files. For more information please refer to the definition of the VDAFS interface.

Input file DIGIT binary file ⇩ Contour ⇩

Dialog box



⇩

Output file ASCII file in VDAFS format with extension "VDA"

Additional information for VDAFS output

File contents

Information to identify and describe the contents of the file can be entered when the VDAFS file is created.

Sender information

To provide more detailed information about the sender, information about the company, contact with telephone number and address and information about the system that generated the file is available. You can also enter the date of creation and a name.

Information about the project

This information is limited to the project, identifier, name of the version as well as information about confidentiality and validity date of the file.

Recipient

The recipient is identified more closely by a company name and name.

Comments

Additional lines are available for entering comments.

Entering a comment

Even if it seems tedious at the time, we recommend that you enter as much information as possible. This will make handling of the file and later maintenance of the data by you and your customers easier.

Structure of a VDAFS file

```
---------------------------------
              Header

---------------------------------
          Comment
---------------------------------

        Geometry data
           .                     .
           .                     .
           .                     .

---------------------------------
```

Example of a file in VDAFS format

```
BCTVDA = HEADER/20                                00000001
*********************************************00000002
VDAFS-VERSION      : 2.0                          00000003
--------INFORMATION ABOUT SENDER--------          00000004
*SENDER COMPANY       : EXAMPLE & Co.             00000005
*CONTACT   : MR BLOGGS                            00000006
* -TELEPHONE         : 030/999999                 00000007
* -ADDRESS         : .....                        00000008
GENERATING SYSTEM : .....                         00000009
DATE OF CREATION    : 01.04.1997                  00000010
SENDER FILE NAME     : C:\NEWDIGIT\DATA\HOLE      00000011
--------INFORMATION ABOUT PART--------            00000012
*PROJECT           : SECRET                       00000013
*OBJECT NAME     : V.007.99.999                   00000014
 VERSION         : .....                          00000015
 CONFIDENTIALITY   : .....                        00000016
 VALIDITY DATE  : 01.05.2000                      00000017
--------INFORMATION ABOUT/FOR RECIPIENT------ 00000018
*RECIPIENT COMPANY    : OTHER & Co.               00000019
*RECIPIENT NAME/DEPT.: MR WILHELM                 00000020
*********************************************00000021
$$ Number of segments : 1                         00000022
$$ Minima : -10.000 -10.002 -2.502                00000023
$$ Maxima : 10.000 9.998 5.009                    00000024
$$                                                00000025
$$ N E W  S E G M E N T                           00000026
$$ ---------------------------------              00000027
$$                                                00000028
Seg1 = BEGINSET                                   00000029
$$ Number of lines : 21                           00000030
$$ Current stylus radius : 5.000                  00000031
$$ Minima : -10.000 -10.002 -2.502                00000032
$$ Maxima : 10.000 9.998 5.009                    00000033
$$ -------------------------                      00000034
$$ Line : 1                                       00000035
$$ -------------------------                      00000036
PS1 = PSET /21,                                   00000037
 -10.000, -10.002,   5.000,                       00000038
  -9.000, -10.002,   5.006,                       00000039
  -8.000, -10.002,   5.006,                       00000040
            .                                         .
   5.000,   9.998,   5.006,                       00000573
   6.000,   9.998,   5.006,                       00000574
   7.000,   9.998,   5.006,                       00000575
   8.000,   9.998,   5.006,                       00000576
   9.000,   9.998,   5.006,                       00000577
  10.000,   9.998,   5.006                        00000578
P21 = POINT /  10.000,   9.998,   5.006           00000579
Seg1 = ENDSET                                     00000580
BCTVDA = END                                      00000581
```

1.2.2 DIGIT -> IGES

IGES interface

Like the VDAFS interface described in the previous section, the IGES output, too, is used to generate files that can then be read in and processed by outside companies.

However, the IGES output does not offer a user dialog. As soon as you select the *file type, IGES file* and then confirm your entry with *Save* the file is immediately output in the relevant format.

Other CAD interfaces

The output format you select principally depends on the recipient's equipment. Because CAD interfaces are relatively complicated and expensive, not every CAD user will have all interface types. You should therefore agree on the most suitable format together with your customer. However, if you need special interfaces for data transfer please consult us.

1.2.3 DIGIT ->NC-ASCII

NC interface

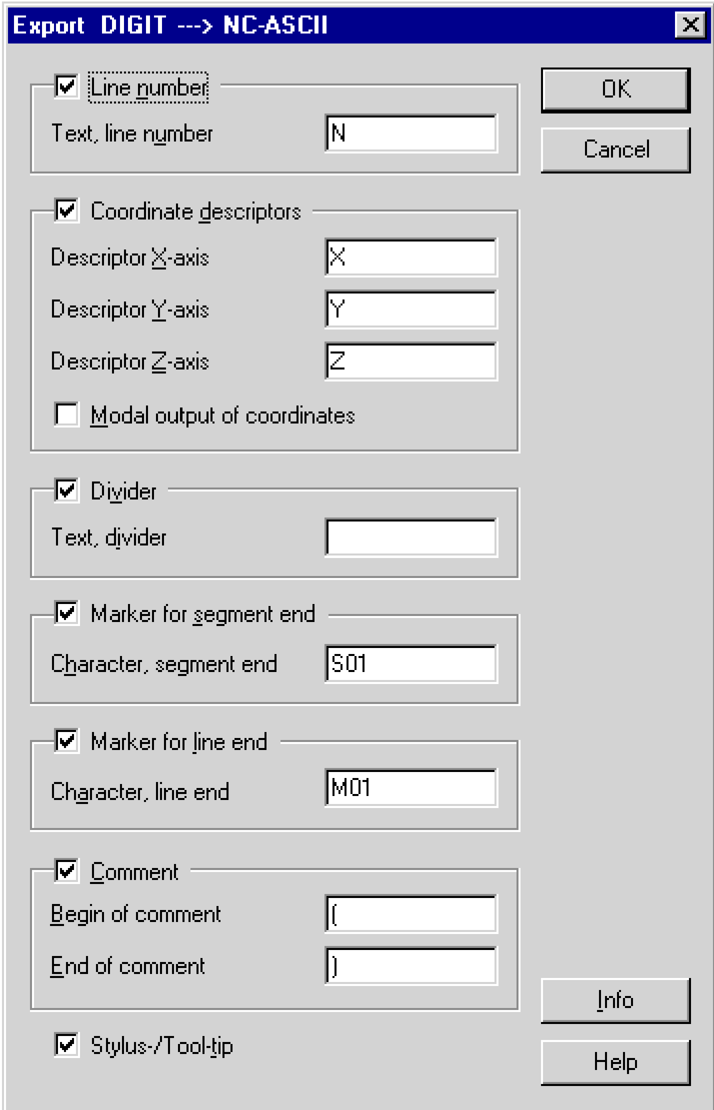
The output type described in this section is intended for data transmission to systems set up for processing data that are in an NC-type format. The output interface provides a number of settings whose parameters can be changed to suit these systems. These will now be explained in more detail. The example given at the end of this section again makes clear how important these parameters are in this context.

In order to test the effect of these parameters, take a small file and then observe the effect of the various settings. As this function can also be used to output milling path files (from the path calculation), this output type can also be used as a very simple NC post processor. Information about the speed and feedrate must however be entered in the NC control.

Input file

DIGIT file

Dialog box



Output file

File with selectable extension

Block number

Block number

In order to output the block numbers check the relevant box. You can also define the block number letter that you wish to use.

Coordinate names

Coordinate output

For outputting coordinates you can select or deselect the axis name. You can define the individual axis names. Output for NC controls usually uses the coordinate designations X, Y and Z. However, if you are making definitions for a very simple ASCII output that is only to contain the coordinates you do not need these designations. By checking the box *Modal output* or leaving it empty you can either force or suppress the output of data that do not change.

Separators

Separator characters

You can define separators that separate the coordinates. These are not usually required for NC output where the coordinate identifiers perform that function. However, if you have selected ASCII output without coordinate identifiers you will need these separators. If you omit them, the coordinates appear directly behind each other.

Next segment / Next line

Segment/line identifiers

In addition to scancad mill, several other systems also evaluate the end of line separately. To write an identifier into the output file you must activate the relevant option and define the identifier. Segments are identified in the same way.

Comment

Comments

Identifiers for the beginning and end of a comment for outputting comments can be selected by the user. Make sure you use the characters used in the NC control or external system.

Stylus/mill tip

Stylus/mill tip

If you select the option *Stylus/milling tip* you can switch between the stylus/milling tip coordinate output and the stylus/milling center point coordinate output.

Example of an NC-ASCII file

```
N1  (FILE: G:\DATEN\SEG.DAT)
N2  (CREATED BY: SCANCAD WINMILL)
N3  (UNIT = MM)
N4  (POINT-TYPE = MILL)
N5  (D = 12.000)
N6  (R = 0.000)
N7  (PRESET = TIP)
N8  (STROKE-WIDTH = 5.000)
N9  (SCANMODE = ZIG-ZAG)
N10  X0.000  Y10.000  Z20.000
N11  X20.000  Y10.000  Z20.000
N12  X30.000  Y10.000  Z30.000
N13  X30.000  Y10.000  Z30.000
N14  X70.000  Y10.000  Z30.000
N15  X80.000  Y10.000  Z10.000
N16  X90.000  Y10.000  Z10.000
N17  X110.000  Y10.000  Z50.000
N18  X130.000  Y10.000  Z50.000
N19  X140.000  Y10.000  Z30.000
N20  X170.000  Y10.000  Z30.000
N21  M01
N22  X170.000  Y15.000  Z33.000
N23  X140.000  Y15.000  Z30.000
.
.
N77  X70.000  Y35.000  Z30.000
N78  X30.000  Y35.000  Z30.000
N79  X20.000  Y35.000  Z20.000
N80  X0.000  Y35.000  Z20.000
N81  M01
N82  S01
N83  X0.000  Y60.000  Z20.000
N84  X20.000  Y60.000  Z20.000
N85  X30.000  Y60.000  Z30.000
N86  X30.000  Y60.000  Z30.000
.
.
N440  X80.000  Y285.000  Z10.000
N441  X70.000  Y285.000  Z30.000
N442  X70.000  Y285.000  Z30.000
N443  X30.000  Y285.000  Z30.000
N444  X20.000  Y285.000  Z20.000
N445  X0.000  Y285.000  Z20.000
N446  M01
N447  S01
```

1.2.4 DIGIT -> DIGIT/ASCII

DIGIT binary ASCII file

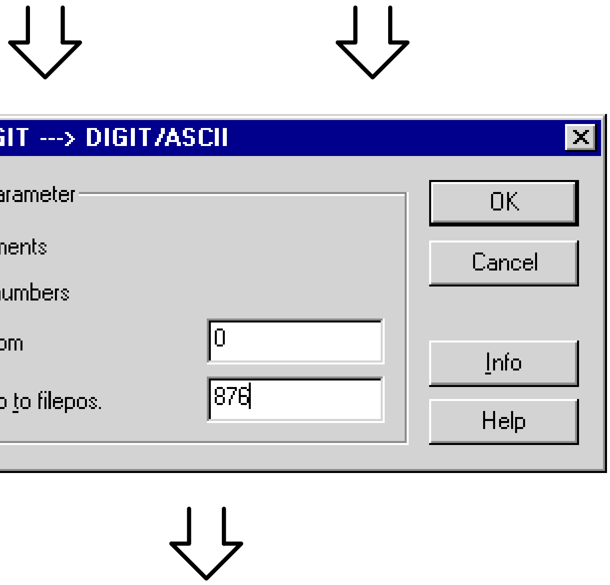
All data of the scancad product family are stored in the internal binary data format DIGIT which allows optimum transfer of information between the individual program parts. However, you cannot change the contents of the files with an editor or text processing system because such systems cannot process the special data format.

The function *DIGIT -> DIGIT/ASCII* converts a file from the internal binary format into an ASCII file (American Symbolic Code for Information Interchange).

Input file

Path Contour

Dialog box



Output file

File with extension "ASC"

ASCII files generated in this way can be processed with any editor or text processing system or transferred to other program systems for further processing.

Comment

When converting the file you can select whether the lines of an output file are to be accompanied by a comment.

Line numbers

For better orientation a number can be placed at the beginning of every line in the output file.

From file position

Digitizing files are usually very long, sometimes several lines long. It is therefore possible to define the section that is to be converted. This parameter defines the starting position of that section.

To file position

This parameter defines the final position of that section.

Example of a DIGIT file converted to ASCII

Line no., HT, UT, Comp1, Comp2, Comp3, Comment

```
  0:   20  2       1     9774 16909060  { BEGIN FileHeader }
  1:  120  2       1      117        1  {  Version-No., Filetype }
  2:   70  2      12        6     1990  {  Digitizing date }
  3:   70  3      25        3     1993  {  Calculation date }
  4:   90  2  -60014        0     1500  {  Area min }
  5:   90  3       4    59971    10722  {  Area max }
  6:   21  2        0        0        0  { END FileHeader }
  7:   20  9        0        0        0  { BEGIN File }
  8:     20  3       300        0        0  { BEGIN SegmentHeader }
  9:       70  2       12        6     1990  {  Digitizing date }
 10:       70  3       25        3     1993  {  Calculation date }
 11:       80  2        0     1000        0  {  Stylus type, radius }
 12:       81  2      500     8333        0  {  Stylus-deflection,-speed}
 13:      130  2     1000        0        0  {  Millinfo ,rad, tp,fillet}
 14:      100  2        0        0        0  {  Grid base }
 15:      100  3        0        0        0  {  Grid size }
 16:      100  4        0        0        0  {  Grid width }
 17:       60  2        0       20        0  {  Reduct. ONLine }
 18:       60  3        0      100        0  {  Reduct. OFFLine }
 19:       82  2        1        0      200  {  Scanmode, fence, step }
 20:       83  2        0        0        0  {  Scanmode, angle }
 21:      133  2        1        0        0  {  Milling-mode, -angle }
 22:      133  3        0        0        0  {  Milling-step, -startPt. }
 23:      133  4        0        0        0  {  Milling-overm.,-sheetth.}
 24:      133  5        0        0        0  {  Milling-blankp.,-blank Z}
 25:      134  2        0        0        0  {  Drill., No. of pts., Rad}
 26:      134  3        0        0        0  {  Drill., Distance, Overm.)
 27:       90  2   -60014        0     1500  {  Area min }
 28:       90  3        4    59971    10722  {  Area max }
 29:     21  3         0        0        0  { END SegmentHeader }
 30:     20  7         0        0        0  { BEGIN Segment }
 79:       20  4         2       88       70  { BEGIN LineHeader }
 80:         85  2        0        0        0  {  No. of pts. lift up }
 81:         90  2   -60002     1002     1500  {  Area min }
 82:         90  3       -4     1014     1500  {  Area max }
 83:       21  4         0        0        0  { END LineHeader }
 84:       20  8       199        0        0  { BEGIN Line }
 85:         40  2   -60002     1014     1500  {  StylusCenterPt. }
 86:         40  2   -59888     1002     1500  {  StylusCenterPt. }
 87:         40  2   -57009     1005     1500  {  StylusCenterPt. }
 88:         40  2   -56790     1007     1500  {  StylusCenterPt. }

.
198:         40  2       -4     1002     1500  {  StylusCenterPt. }
199:       21  8        84        0        0  { END Line }
200:     21  7         0        0        0  { END Segment }
201:   21  9        0        0        0  { END File }
```

1.2.5 DIGIT file

DIGIT file

The program system automatically stores intermediate files that occur as the result of a sequence of operations. The file name is also automatically generated. However, if you want to store a specific file in the internal binary format DIGIT under a special name, this output option is available to you.

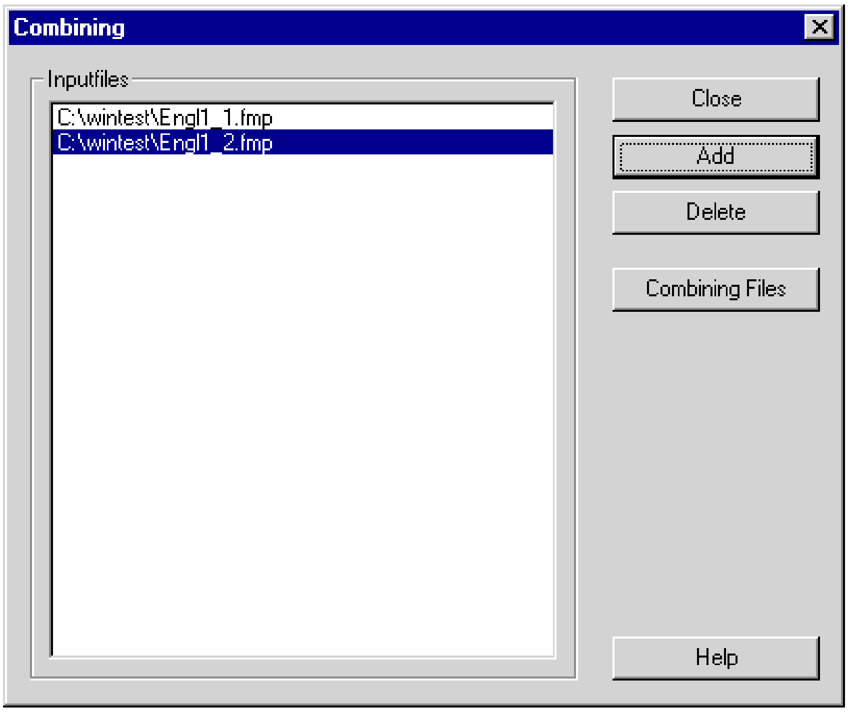
1.3 Merge

With this function you can merge up to 250 files that contain, for example, different digitized partial areas of a model to form one file. The segment structure is not lost. Make sure that the files you want to merge are all the same file type. There is no point in merging a contour file with a milling path file.

Input file

Path, contour

Dialog box



Output file

File with extension "CMB"

The individual files are stored as separate segments in the combined output file. You can divide them up into separate files again with the function *Divide*.

Append / Delete

With the button *Append* you can select the files by the usual Windows method that you want to merge. To correct the selection list use the button *Delete*. This deletes the file from the selection list but not from the hard disk.

Merging files

As soon as a selection list contains more than one file you can merge the files with the button *Merge files*. You can also store the file under a name in the usual way with the *Save as* dialog box.

1.4 Divide

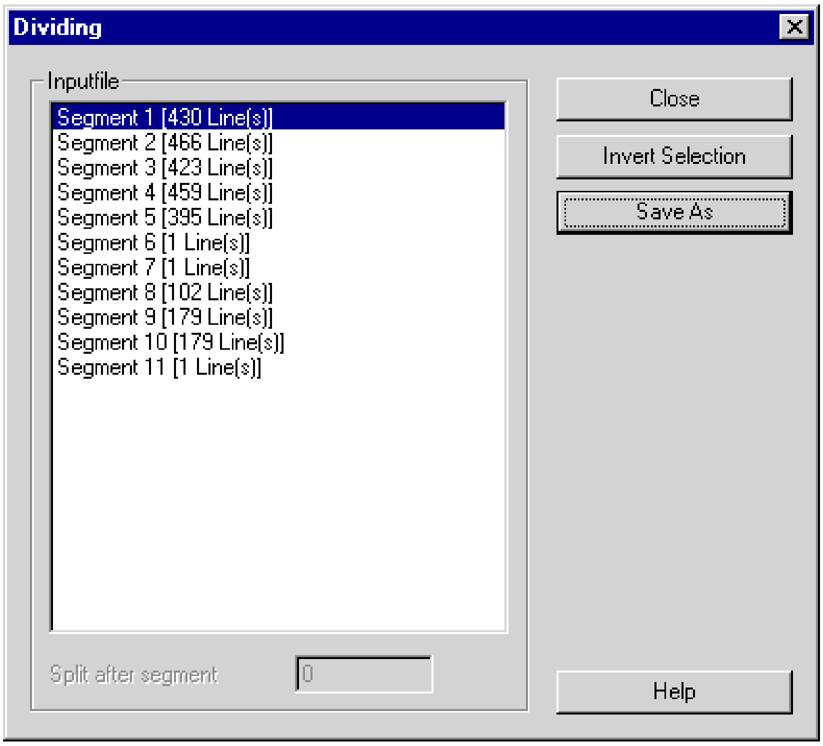
Information about the structure of the digitization is also stored in the scancad data format. This means that the segment division/line division is not lost during calculation. An exception to this is *contour calculation*. It is intended to keep this function entirely separate from the scanning function. The output therefore always consists of a single segment.

Detection of the file structure allows the function *Divide* to divide a file into several separate files (reversal of the function *Merge*). It is also possible to remove individual lines or segments from a file.

Input file

Path, contour

Dialog box



Output file

File with input file extension

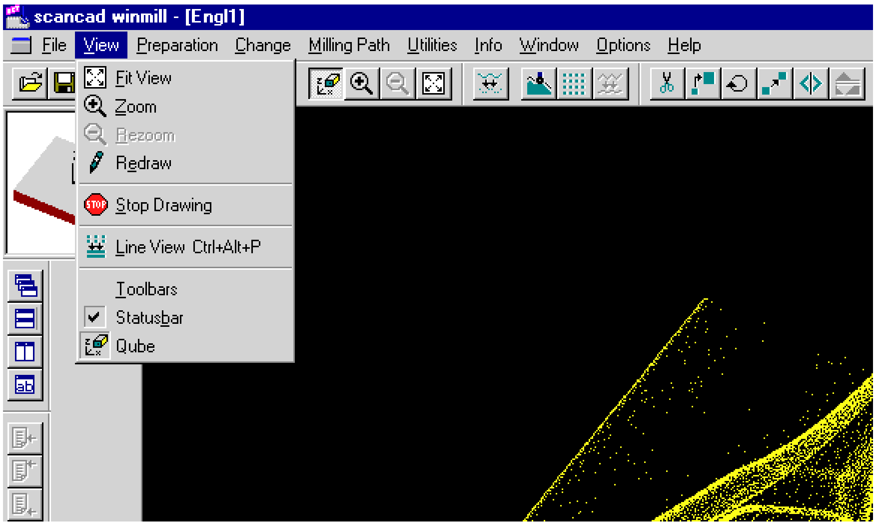
The possibilities of the function *Divide* depend on the structure of the input file. If it consists of more than 250 segments, you must define where the file is to be separated with the parameter *Divide according to segment*. If the number of segments in the input file is smaller than/equal to 250, the individual segments are displayed in a selection list. You can now mark the segments that are to be transferred to the output file by the usual Windows method. To simplify the process you can *invert* the selection.

If the input file only consists of a single segment you follow the steps described above for processing lines.

If the input file only consists of a single line you follow the steps described above for processing points.

2 View

Menu



Functions

Under menu item *View* you will find the following functions with which you can modify the graphic display and tool bar to you requirements. More detailed information on operation is given in Section 7, Operating instructions.

2.1 Full view	Display the entire data set
2.2 Zoom	Display a section
2.3 Re-zoom	Return to previous display
2.4 Redraw	Rebuild display
2.5 Cancel draw	Cancel display building
2.6 Line display	Toggle display between points and lines
2.7 Tool bar/ Status bar	Individual adaptation of the system
2.8 Cuboid	Activate cuboid input help

Graphic display

An essential difference between the Windows version described here and the older DOS version is that the file you are currently processing is constantly displayed. This makes it easy to check the calculation as it runs. Menu *View* comprises the functions that are required to change or adapt the display to individual requirements. Both the view onto the model and the tool bar can be modified.

2.1 Full view

If you select this menu item the display of the entire data set is rebuilt, however many *zoom/re-zoom* operations have already been executed. The size is automatically set to display the entire data set on the screen.

2.2 Zoom

Display a section

With this function you can zoom a section of the current display. You select the section that you wish to display by dragging open a window with the mouse. When you click on the second corner of the zoom area the model is enlarged.

2.3 Re-zoom

Return to previous display

Selecting this function after you have zoomed the display takes you back to the previous view. With this function you can therefore "undo" zooms one after the other.

2.4 Redraw

Rebuild display

With the function *Redraw* you can repeat a drawing operation. This function is frequently called by the software automatically to obtain a full representation of the data set. In this way, the "gaps" that result when dialog boxes are moved are automatically closed when a dialog is canceled.

2.5 Cancel draw

Also cancel with<ESC>

In order to cancel generation of a display, you can cancel the drawing operation at any time with the <ESC> key. Of course, you can also use the function *Cancel draw*. You can start drawing again with the command *Redraw*.

2.6 Line display

Display with points or lines <ALT+P>

When processing a data set is often makes sense to switch the graphic display between *point* and *line display* . Whereas point display is more suitable, for example, for displaying limitation lines, milling paths can be displayed more clearly in line display. A hot key is also available for quick switchover from one type of display to the other. You can toggle between the two settings with the key combination <ALT+P>.

2.7 Tool bars/Status bars

As in other Windows programs, too, you can change the appearance of your Windows user interface. You can modify your tool bar under menu item *Tool bars*. You can then devise a tool bar adapted to your individual requirements.

Along the lower edge of the window, messages or information about functions currently active or entries you have made are displayed. You can deactivate this if you want. A checkmark next to the menu item *Status bar* shows whether the function is active or not.

2.8 Cuboid

View of model

When you activate this function an additional small window is displayed on the screen. It shows a box in the proportions of the minimum/maximum coordinates of the data record. The colored edges are used for orientation. The coordinate axes in the box show the orientation of the cuboid in space.

This additional window is an important tool in operating the graphic display because with it the user can easily change the view onto the data for the representation.

Turning the cuboid

To do this position the mouse pointer in the cuboid box and press the left mouse button. Now move the mouse keeping the button pressed in the X direction to turn the cuboid about the Z axis. The object is turned about the Z axis in the same way as it would be on a rotary table.

If you drag the mouse keeping the button pressed in the Y direction within the window, your view of the part is altered. You can therefore choose whether you want to view the part from a shallow or steep angle.

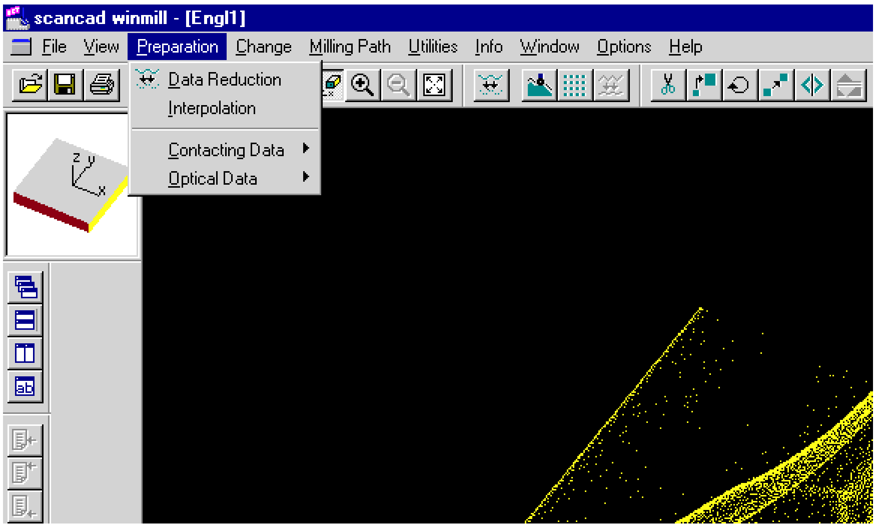
Basic views

A context menu also exists for this window. You can activate it in the normal way by pressing the right mouse button. The menu offers various functions for simple positioning. You can select any one of seven basic views:

- Top
- Bottom
- Front
- Back
- Left
- Right
- ISO

3 Preparation

Menu



Functions

After you have selected the menu item *Preparation* you can select one of the functions listed below.

3.1 Data reduction	Calculate a reduced data set
3.2 Interpolation	Interpolate a data set
3.3 Prepare tactile data	Prepare digitizing data scanned by tactile probe
	3.3.1 3D contour calculation 3D calculation of a contour representation based on the digitizing data
3.4 Prepare optical data	Prepare optically scanned digitizing data
	3.4.1 Grid Conditions the optical digitizing data to form a regular grid.
	3.4.2 Filtering

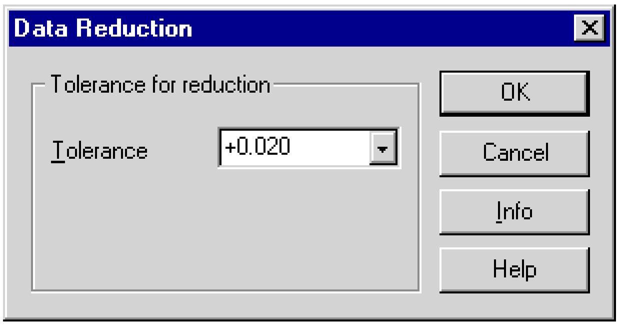
3.1 Data reduction

The tactile scanning system scancad scan stores the digitizing data in a form similar to milling paths. In addition to the data reduction performed during scanning (online), offline data reduction can also be performed with this function.

Input file

Path Contour

Dialog box



Output file

Path Contour

with extension "FMP" with extension "KON"

Tolerance

When you enter the tolerance width you define the diameter of the tolerance tube in millimeters. (see also explanation below about the "tangential distance step method").

This process has also been integrated in many other functions, for example, *contour calculation*, *collision-free tool* and *contour processing* as well as *allowance* and *metal thickness/gap width.* It is used to reduce the output files directly with the function *data reduction* to avoid producing intermediate files and thus save space on the hard disk.

Explanation: Data reduction according to the TDV method

Data reduction

Thinning out by the *tangential distance step method* (TDV) reduces the scanning data in an economic way.

When sculptured surfaces are digitized with scancad scan and scancad laser, 250 measuring points are recorded per second without online data reduction. To ensure efficient processing only those measuring points should be stored that are actually required for the description.

If, for example, several measuring points lie along a strait line, it is enough to store the beginning and end point of this straight line. Not all the intermediate points are required for the model description and can therefore be omitted. This saves time in processing and NC programs are much shorter as a result.

Tolerance = diameter of the tolerance tube

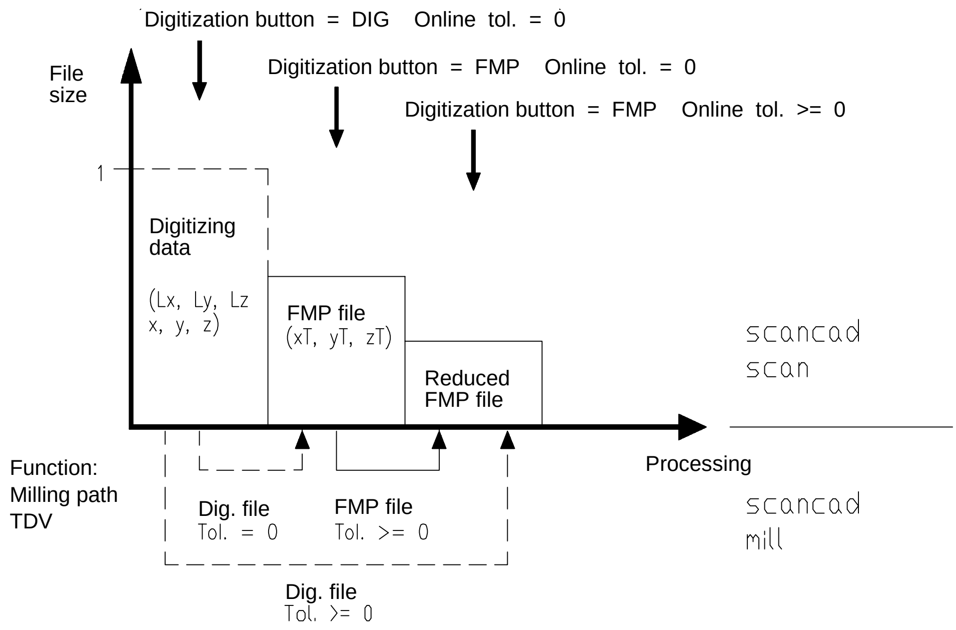
This procedure calculates a "tolerance tube" with a diameter defined by the "tolerance". If points lie within this tolerance tube they can be omitted. If a point lies outside the tolerance tube, the last point that lies within the tolerance tube is stored.

Tolerance = 0: No data reduction

The larger the tolerance area, the fewer the number of points that have to be stored in the target file. If tolerance = 0 no reduction is necessary.

The diagram below gives a summary of the combination digitizing button during scanning (scancad scan and scancad laser) and calculations with the function *Data reduction*.

Although it is always possible to reduce the data set after it has been recorded with the software scancad mill described here, the diagram shows that if the digitization button is set to "FMP" and online data reduction is used, a practical "FMP" file can be generated as soon as the data are recorded.



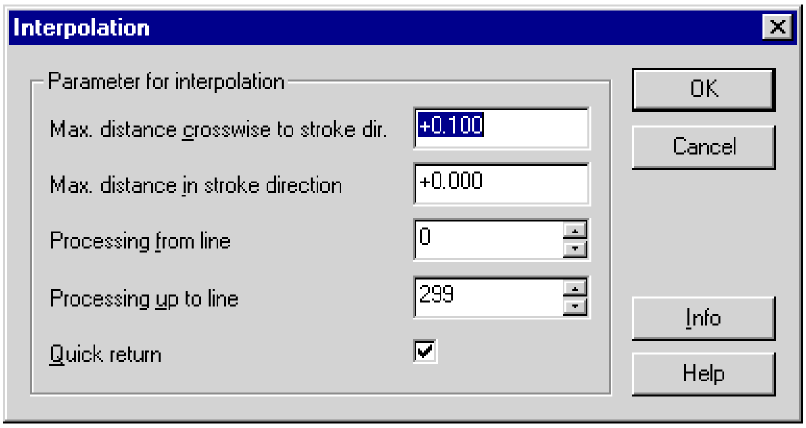
3.2 Interpolation

If digitizing machines are guided manually the user cannot always record the data as finely as is needed for later processing of the data. I.e., the distance between the digitized paths - the line width - is very large. The function *Interpolation* is available in such a case. In this way data can be calculated for areas not acquired by digitization. In exceptional cases this interpolation can also be used for computer digitization in order to reduce the scanning times for very simple parts. Areas not scanned are then calculated automatically. Not only is it possible to define a filling method, but the area can also be defined in lines in which the data are to be filled. When the entire file is then output you can choose between reciprocation and rapid return.

Input file

Path

Dialog box



Output file

Path with extension "CMP"

Max. distance diagonally to line direction

The distance diagonally to the line direction used in scanning determines the line width for the calculation of new lines. You should choose a value that approximately corresponds to an adapted scanning line width for the workpiece/stylus combination in each case (see next Section).

Max. distance in line direction

Whereas the parameter just described defines the line distance, this parameter defines the maximum distance between the measuring points in a line. Please note that coarse scanning in the direction of the line cannot be canceled by subsequent interpolation in this direction. If the actual contour points that are required are not known to the system they cannot be subsequently generated by the computer on the basis of a few known points.

Process line

This parameter determines the line in the input file at which interpolation starts.

Process up to line

This parameter defines the line in the input file up to which the data are to be filled with interpolation.

Rapid return

The data can be output both in reciprocation/zig-zag and in rapid return. The output direction at this point in the data processing will not affect subsequent milling. Here, it is only of significance for the direct transfer of data to other systems.

3.3 Preparation of tactile data

Stylus radius compensation

Processing of the digitizing data acquired by scanning with *contour calculation* described below is a decisive operation in the processing sequence. With this function, the data can be converted to a representation independent of the scanning with stylus radius compensation. This then forms the basis for generating machining programs which are completely separate of the actual digitizing process.

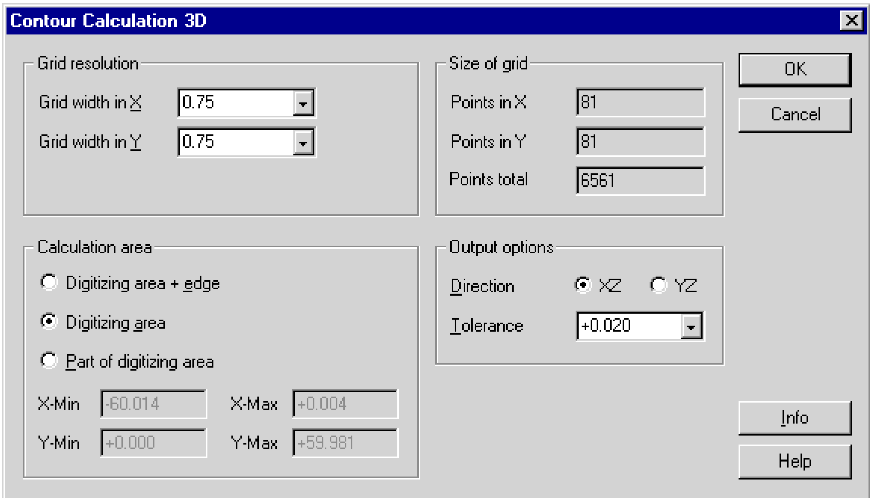
3.3.1 3D contour calculation

The function *contour calculation* derives the contour representation = surface of the digitized model from the stylus center point path (milling path, see file types). In this calculation, both the stylus geometry and the stylus dimensions are compensated for.

Input file

Path

Dialog box



Output file

Contour with extension "KON"

What is a contour calculation needed for?

A contour file is need if

- the milling paths and milling strategies are to be independent of the digitization paths
- a negative of the model is to be calculated
- the workpiece is to be scaled to any size

F∅≠T∅
FForm≠TForm

- the milling diameter for the final milling process is to be larger or smaller than the diameter of the stylus used for scanning (collision avoidance) or if the shapes of the stylus and miller are not identical.
- the surface data are to be transferred to a CAD system in the form of points, splines and surfaces.

In contour calculation, the path that the stylus follows when it records data is generated automatically. The original contour of the model is calculated on the basis of the known stylus geometry and stylus diameter. This calculation is not distorted by the friction effect caused by tactile scanning. The result is a model surface described by regularly arranged contour points.

Grid width

Grid width

You can specify the resolution of the calculation by defining the grid width in X and Y.

The following input range applies:

Limit values

0.01 mm <= grid width <= stylus diameter

In certain cases the grid widths in X and Y can be different. When defining them you should consider what the contour data are later to be used for (e.g. collision-free tool paths or CAD description with surfaces).

E.g.: Grid width X corresponds to the distance between the intermediate points in the milling direction.
Grid width Y corresponds to the distance between the milling paths (diagonally to the milling direction)

Resolution too fine

If the resolution selected is too fine it might mean that so many surface points have to be calculated and stored that the data set becomes very large and processing times become very long.

Max. 5 million points

The number of grid points has therefore been limited to five million. If this limit is exceeded when you define your grid widths, an error message appears. You must then select coarser grid widths or divide your model into individual sections.

Area of calculation

Area

Here, you can define the size of the calculated contour.

1. Boundary area:

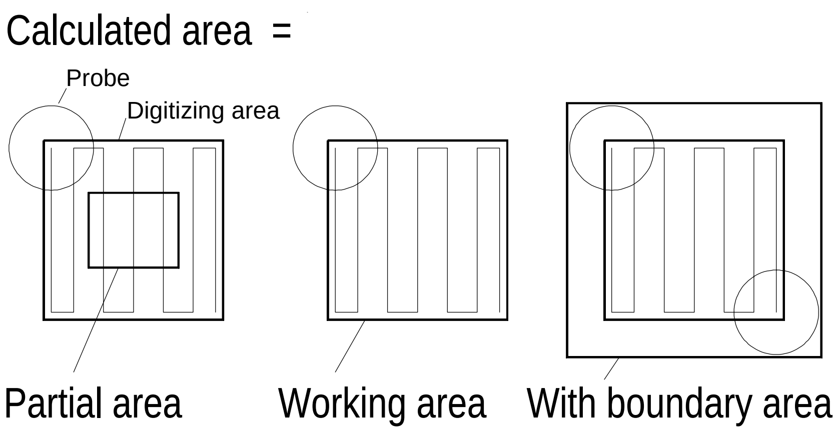
A contour calculated in this way contains information about the run-out area of the digitizing data.

2. Working area:

The size of this contour corresponds to the area which is acquired in full by the scanning operation (center points of the stylus sphere).

3. Partial area:

The calculated contour lies within a partial area of the scanning paths. The relevant dimensions must be entered.



Output options

Direction

Output direction

Once you have entered the grid width you can define the direction in which the contour points are to be output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until the collision-free tool or NC path is calculated.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

Note:

In order to filter and smooth tactile digitization data of low quality that have been recorded on rough model surfaces, you can use the filter and smoothing functions described in Section 3.4.2.

3.4 Preparation of optical data

Result corresponds to the contour

With the program package scancad mill you can not only process the data of tactile digitization systems but also the scanning data of laser and camera digitization systems. Because of some differences compared with recorded tactile data, these data must first be processed by the functions of the module described here before they can be processed with scancad mill. After they have been processed the data of non-contact systems are handled in the same way as the data of tactile systems.

A total of five different functions are available for conditioning and processing optical scanning data:

- Rasterize data

- Filter outliers
- Delete outliers
- Fill holes
- Smooth data

- Rasterize data

Data rasterization is a separate function within menu item *Optical data.*

Filter data..

The other calculation functions are combined in a single function because they work in a similar way. Another reason for organizing them in this way is that these calculations are often performed in a specific order one after the other. With the filter function you can now perform these steps as one calculation.

3.4.1 Rasterize

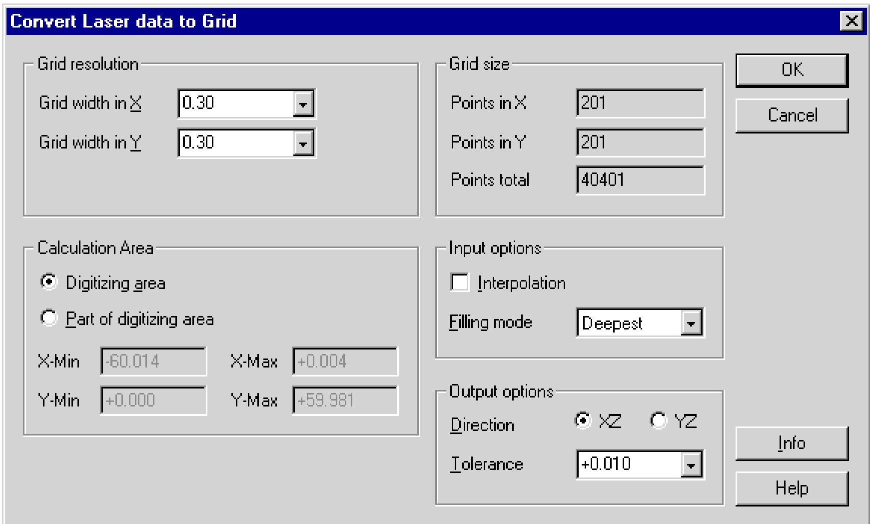
Unlike tactile data, data scanned without contact always lie directly on the model surface. However, they are unevenly distributed.

Because scancad mill assumes that the contour points are arranged in a regular pattern (see Function *contour calculation* for tactile digitizing data Section 3.3.1), the laser data must be converted to this form with the function *Preparation*, *Optical data*, *Digitize*.

Input file

Laser data

Dialog box



Output file

Contour with extension "KON"

Grid width

Grid width

You can specify the resolution of the calculation by defining the grid width in X and Y.

When entering a range remember that the grid width should not be much smaller than the distance between the points in data acquisition. Otherwise too many holes will appear in the grid.

However, if you want to produce a finer grid, you must either scan with a higher resolution, or compress the data with the option *Interpolate data* (s. Section 3.2) to the required resolution.

The grid widths in X and Y may be different sizes. When defining the grid widths you should consider what the data are later to be used for (e.g. collision-free tool paths or CAD description with splines and surfaces).

E.g.: Grid width X corresponds to the distance between the intermediate points in the milling direction.
Grid width Y corresponds to the distance between the milling paths (diagonally to the milling direction)

Resolution too fine

If the resolution selected is too fine this could mean that so many surface points have to be calculated and stored that the data set becomes too large and the processing times too long.

Max. 5 million points

The number of grid points has therefore been limited to five million. If this limit is exceeded when you define your grid widths, an error message appears. You must then select coarser grid widths or divide your model into individual sections.

Area of calculation

Just like the function *contour calculation* (s. Section 3.3.1), here too, you define the area for the calculation. However, in contrast to contour calculation, here the grid does not have a boundary area. Area limits have to be entered for the partial area.

Data handling

Two additional parameters are available in the area *data handling* for special handling of the input data set.

Longitudinal interpolation

Interpolation

With the parameter *Longitudinal interpolation* you can determine whether the input data are interpolated in the feed direction (only advisable for input files with data reduction).

In this way holes in the output grid that can arise if the distance between the individual measuring data is too large are avoided.

Filling mode

Overlapping of several digitizing areas

In overlapping areas, especially, several digitization points from different digitization subareas or views are often available for the calculation of one grid point.

Filling mode

You can select which located input points are to be stored at which grid node in the input field *Filling mode*.

1. Lowest:

If several points lie within a grid node, the lowest point is stored.

2. Highest:

If several points lie within a grid node, the highest point is stored as the grid point.

3. First:

This mode stores the first (as seen from the position in the file) point in the proximity of the grid node as the grid point.

4. Last:

This mode stores the last (as seen from the position in the file) point in the proximity of the grid node as the grid point.

5. Average:

It can often happen that several points lie in the vicinity of a grid node. If you set *Average* the average height, the arithmetic mean, of the measuring points are determined and stored.

Output options

Direction

Output direction

As for contour calculation, here, too, you can determine in which direction the grid points are output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until a later point in the calculation.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

3.4.2 Filter

As already explained in the introduction to this Section, the function *Filter* comprises four different calculation functions. The functions which are described in more detail below all operate according to the same basic principle. They examine the area around the current grid point and then apply different operations to that point. The results of the calculation are influenced to a large extent by the size of the area examined. It is therefore obvious that a large area will produce a softer surface in smoothing than a small area.

The parameter *intensity* determines the local area taken into consideration

- Intensity = small: Area= small, effect = small
- Intensity = large: Area = large, effect = large.

Filter outliers

Laser scanning data, unlike data from tactile systems, can contain outliers. These are individual measuring points that lie either above or even below the model surface because of the influence of errors.

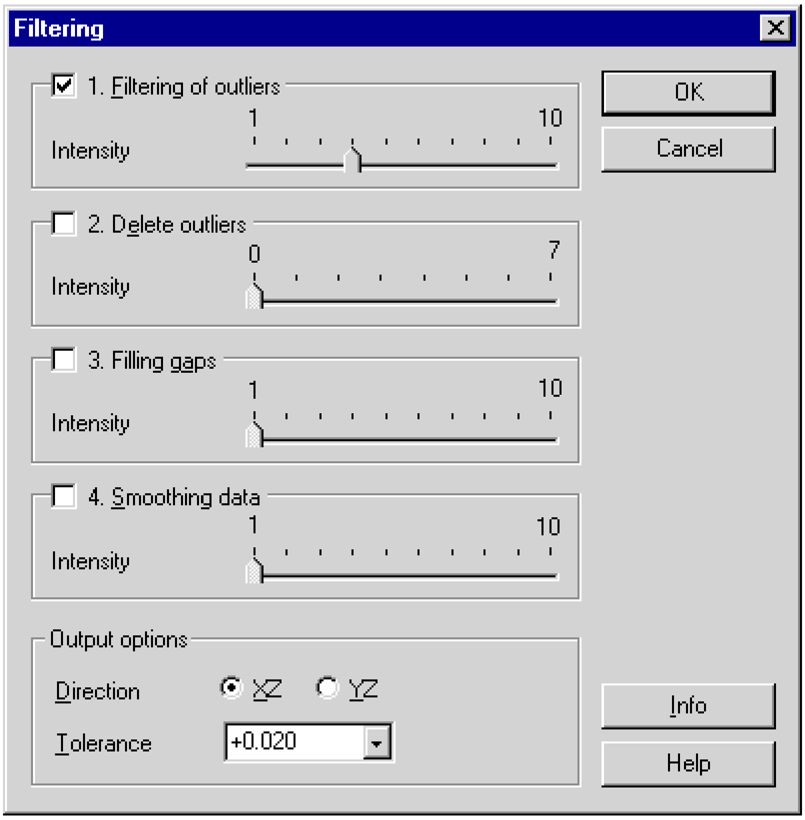
Difference from tactile digitizing data

These effects do not occur in tactile scanning because a measured value a long way above a model means loss of contact and stops tactile scanning; nor can the stylus sink into the model.

Input file

Contour

Dialog box



Output file

Contour with extension "FIL"

Filter outliers:
- after rasterizing
- before filling/ smoothing

In order to prevent outliers from negatively influencing the other processing results, they should be suppressed with the function *Filter outliers* after rasterizing. The function should only be used when real "outliers" exist in the data. It must be used after *rasterizing* and usually before *filling* and *smoothing* if it is executed separately.

Intensity (1 = weak... 10 = strong)

The intensity specifies the strength of the filter with which the data are processed. To avoid contour violations, the intensity should be as strong as necessary but as weak as possible. The larger the number of outliers / errors in the input file the stronger the intensity setting has to be.

Direction

Output direction

As for contour calculation, here, too, you can determine in which direction the grid points are output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until a later point in the calculation.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

Delete outliers

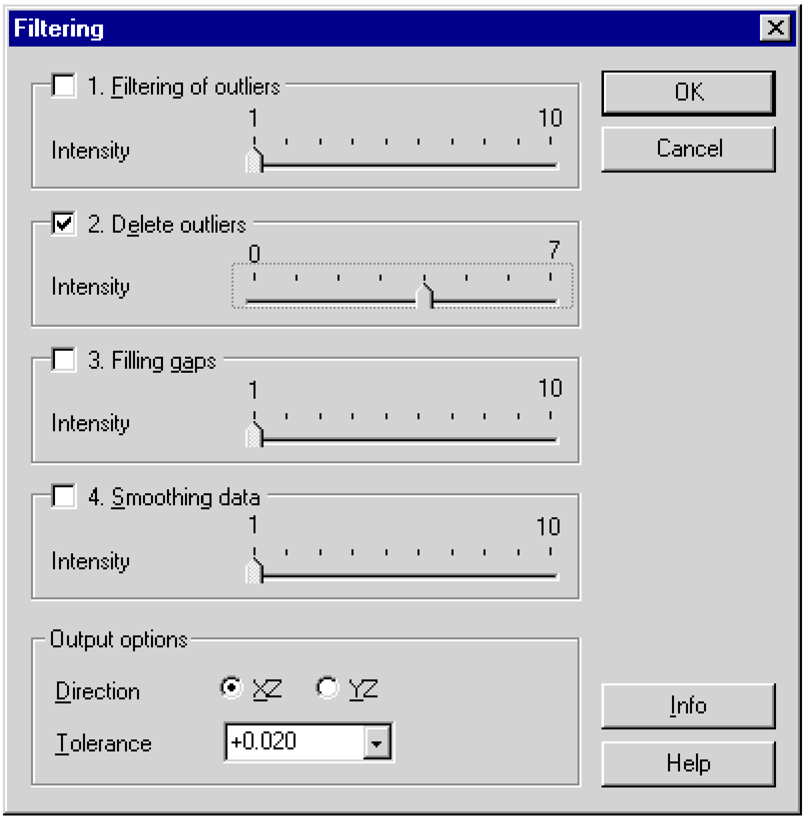
Unlike outliers that can be removed with the function *Filter outliers*, optical scanning often produces points that are a large distance away from the actual object and which might therefore not have any adjacent points; in this case, for example, part of the adjacent area has also been acquired or some measurements are incorrect.

In order to eliminate the measured values that lie outside the area under consideration, the function *Delete outliers* can be applied.

Input file

Contour

Dialog box



Output file

Contour with extension "DEL"

Intensity (0–7)

This function is used to delete isolated points. The intensity therefore identifies the number of adjacent points. A grid point can have up to 8 adjacent points. Intensity 0 in this case means that all points that have no adjacent points are deleted. Intensity 7 means that all points that have fewer than or exactly 7 adjacent points are deleted. This setting will seldom be used in practice because with it only those points that have all 8 adjacent points will be left.

Direction

Output direction

As for contour calculation, here, too, you can determine in which direction the grid points are output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until a later point in the calculation.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

Fill holes

Fill holes:
- after filtering
- before smoothing

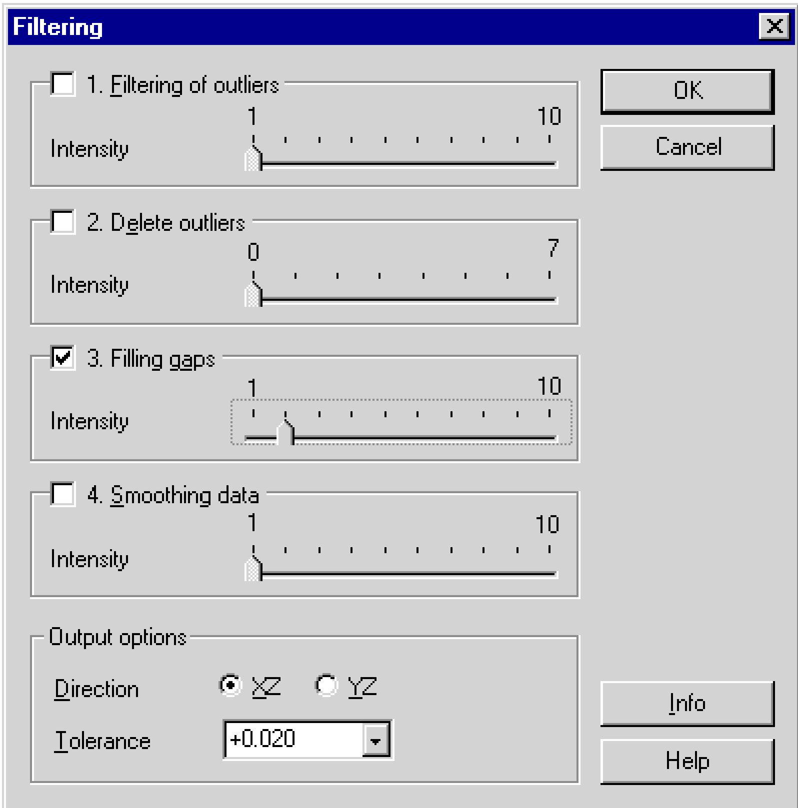
Optical scanning data, unlike data from tactile systems can contain isolated holes / outliers. They can be caused, for example, by shading or missing reflections; no valid value can be determined for these measuring points.

These holes can be closed using the function *Fill holes* taking account of the adjacent area. The function *Fill holes* should be performed after *filtering* but before *smoothing*.

Input file

Contour

Dialog box



Output file

Contour with extension "FUL"

Intensity

Intensity (1 = weak... 10 = strong)

The intensity describes the size of the area in which the intermediate points for filling lie. To avoid contour violations, it should be as large as necessary but as small as possible. The larger the area selected, the softer the effect of interpolation.

Direction

Output direction

As for contour calculation, here, too, you can determine in which direction the grid points are output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until a later point in the calculation.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

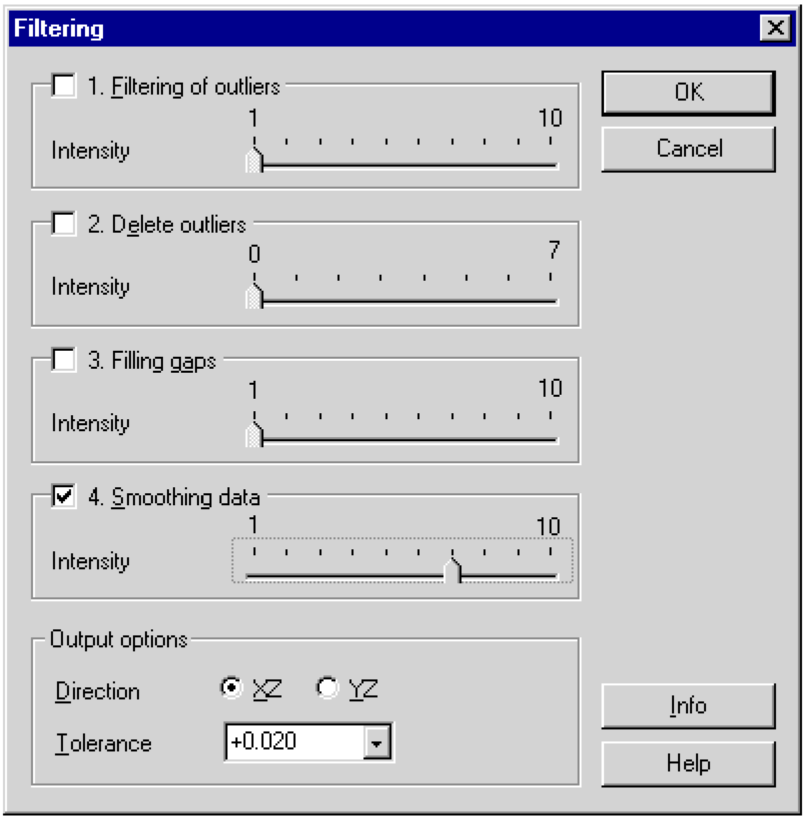
Smooth data

The effect of "noise" on the scanning data can be minimized with the function *Smooth data*. Small ripples can be smoothed with this function. If smoothing is too high, important contour elements might be lost; e.g. sharp corners rounded off.

Input file

Contour

Dialog box



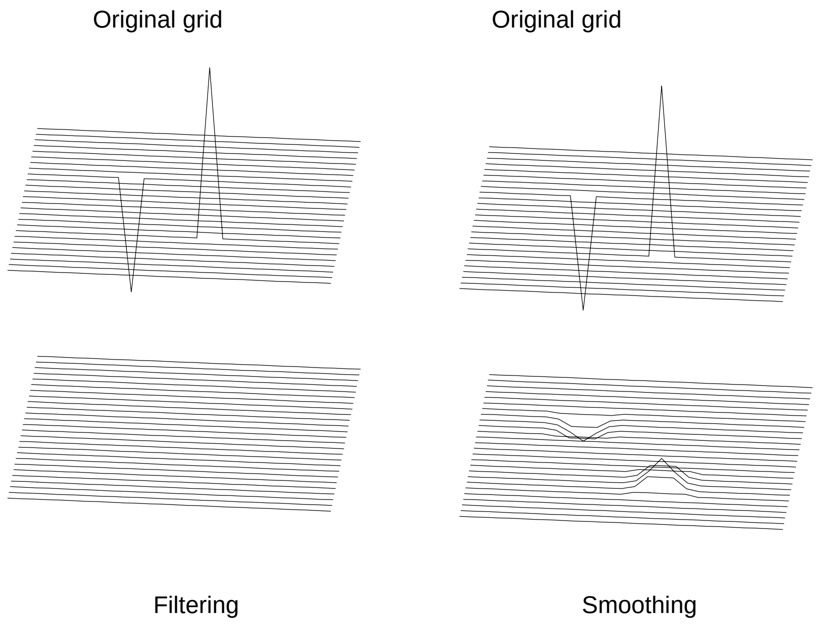
Output file

Contour with extension "SMO"

The sequence of operation laid down by the filter function should be followed to avoid mistakes in the calculations. However, individual steps in the operation can be omitted.

For example, *Fill holes* is not necessary if the data record does not contain any holes or outliers.

The drawing below shows two files before and after filtering and smoothing.



It shows that the two outliers in the input file have been detected and removed. The function *Smoothing*, however, attempts to smooth the data and in so doing does reduce the maximum height of the peaks but also raises the adjacent area slightly.

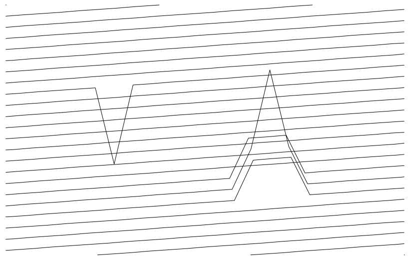
Intensity (1 = weak... 10 = strong)

Intensity

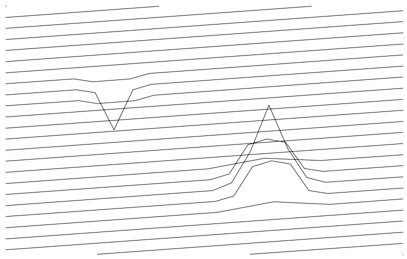
The intensity describes the size of the area in which the interpolation points for smoothing lie. To avoid contour violations, it should be as large as necessary but as small as possible. The larger the area selected, the stronger the effect of smoothing but the larger the contour violation (see drawing below).

Caution: A high intensity can cause extensive rounding of sharp corners.

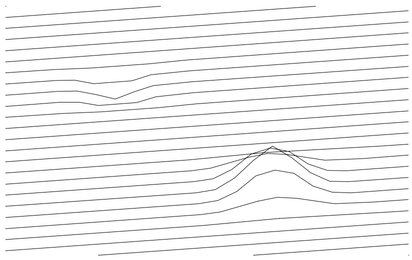
Original grid



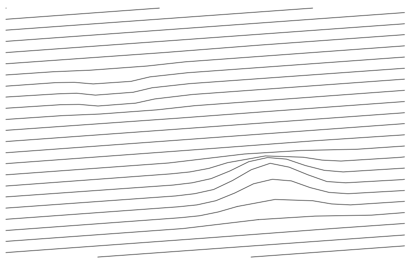
Intensity 1



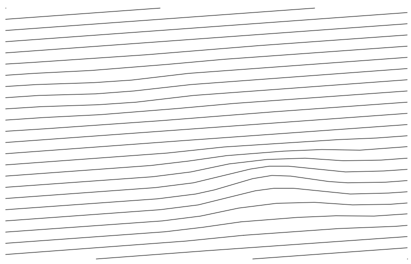
Intensity 2



Intensity 3



Intensity 4



Direction

Output direction

As for contour calculation, here, too, you can determine in which direction the grid points are output. The direction is independent of the order in which the data were recorded and is only important if the data are transferred to a CAD system or for display by the internal graphics. The milling direction is not defined until a later point in the calculation.

You can choose between:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

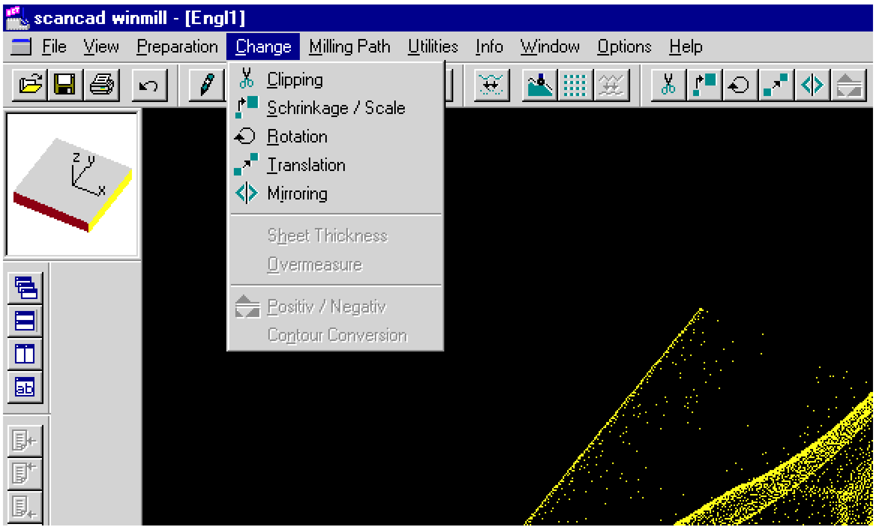
Tolerance

Tolerance

Entering a tolerance width > 0 initiates an offline data reduction before the data are written to the hard disk (see Section 3.1, Data reduction) and thus reduces the amount of disk space need considerably. This option is comparable with the online data tolerance on the scanning side and is also incorporated in other further processing functions.

4 Modify

Menu



Functions

Menu item *Modify* contains the following functions:

4.1 Cutout	Cuboid cutout from full data record
4.2 Shrinkage/ Scaling	Shrinkage and scaling for paths and contours
4.3 Rotation	Rotation of paths and contours about the 3D axes
4.4 Translation	Offsetting paths and contours
4.5 Mirror	Mirroring of paths and contours
4.6 Allowance	Inclusion of large allowances
4.7 Metal thickness/ Width of gap	Inclusion of large metal thicknesses and gap widths
4.8 Positive/Negative	Conversion of a positive contour to a negative contour (opposite part)
4.9 Contour conversion	Modifies existing contour files

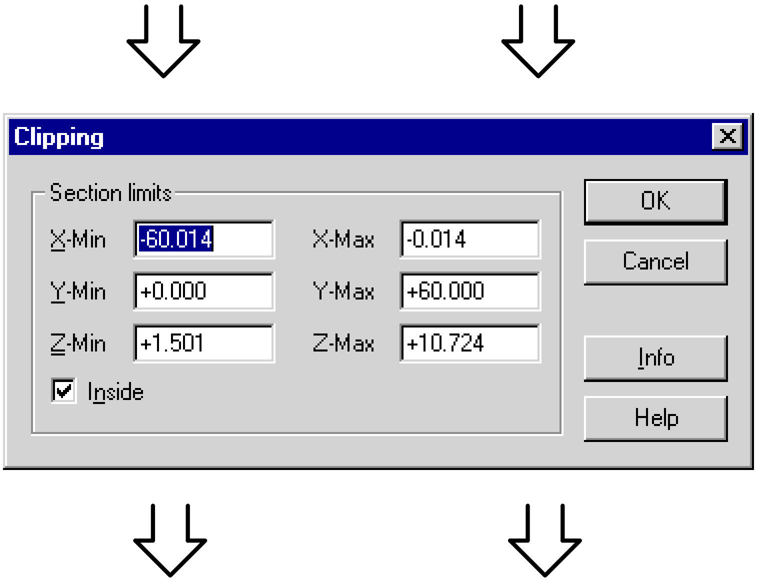
4.1 Cutout

This function releases cuboid areas from the total data set. The output data can lie in or outside the cuboid limits. This function can also be used to cut off digitizing data above a defined height, for example. Data are automatically interpolated at the edges to obtain tidy boundaries.

Input file

Path Contour

Dialog box



Output file

Path with extension "AUS" Contour with extension "AUS"

Cutout

Parameter: Cuboid limits in X, Y, Z

Only enter the boundaries of the cuboid as the parameters for the function. The boundaries of the area of digitization are displayed as default values.

Parameter: inside/outside

You can also decide whether the data within the cuboid or outside the cuboid are to be stored in the output file. To do this, select the relevant option in the dialog box.

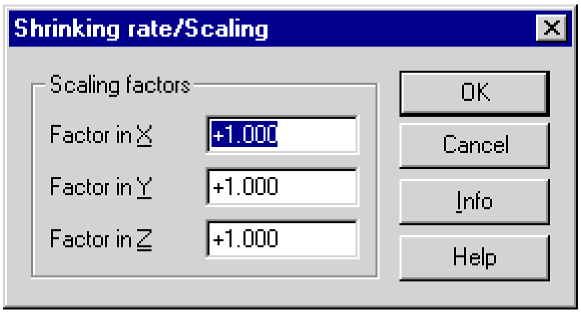
4.2 Shrinkage/Scaling

This function scales the paths and contours in the three directions X, Y, Z. Depending on the type of input file, different value ranges are produced for the possible factors.

Input file

Path	Contour
Factors in X ≠ in Y ≠ in Z: Value range in X=any; Value range in Y,Z = X value ± 5 %	Factors in X ≠ in Y ≠ in Z: Value range: 0.001...100,000

Dialog box



Output file

Path	Contour
with extension "DAT"	with extension "DAT"

4.2.1 Scaling factors

1) Type of input file: Path

For scaling, you can enter the same factor for all three axes or one factor for each.

Different factors

a) Different scaling factors:

If you want to enter different factors for all three axes, you must only enter a shrinkage of ±5% with reference to the X factor for milling center-point paths so that no large errors occur. Theoretically, the tool must also be adapted to suit the factor in this function. However, different tools for the X and Y axis that might result from the adaptation are not possible because of their rotation. That is why the limitation mentioned above is used.

However, more extensive elongations or compressions can be made on the basis of contour descriptions (see Section 3.3.1, Contour calculation).

Common factor

b) Common scaling factor:

For scaling with a common factor for all three axes, a value range of

0.001 <= factor <= 100,000

is available.

The milling diameter must be adapted to the same proportion!

2) Type of input file: Contour

Contour = "neutral" geometry description

The contour files contain a workpiece description in the form of surface points. These data are a "neutral" representation of the workpiece. As no direct milling process is directly linked to these data - a collision-free tool path is not calculated until later in the process - factors from a wide range can be selected.

For scaling contours a value range in all three axes of

0.001 <= factor <= 100,000

is available.

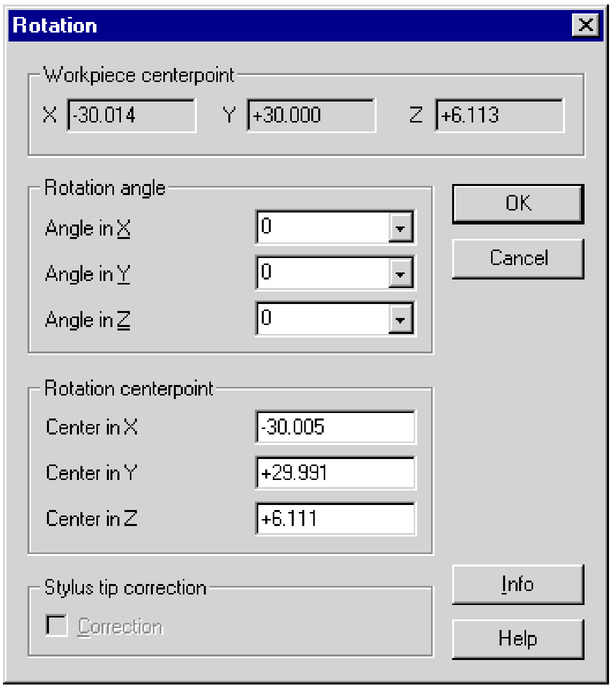
4.3 Rotation

This function rotates paths and contours of a selectable angle about one, two or three axes.

Input file

Path | Contour

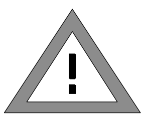
Dialog box



Output file

Path | Contour

with extension "ROT" | with extension "ROT"



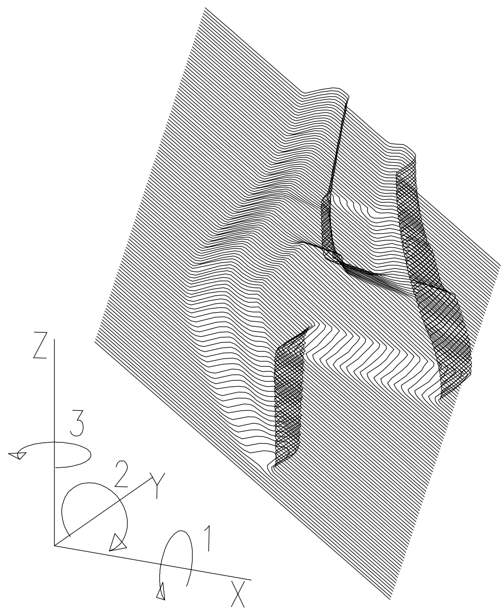
The rotation of contour files is only suitable for output in CAD systems. The resulting "rotated contour file" cannot be used to calculate milling paths.

The following applies: First calculate the rotation, then the contour!

Rotation angle about X, Y, Z

Parameter: Angle of rotation about X, Y, Z

Here you enter the angle of rotation in degrees for the individual axes. Rotation is performed in the mathematically positive direction (see figure). For axes about which the model is not to be turned, confirm the default 0.000.



Rotation center point

Parameter: Rotation center point

With this function you can also define the center of rotation. The suggested default is the coordinates of the workpiece center point.

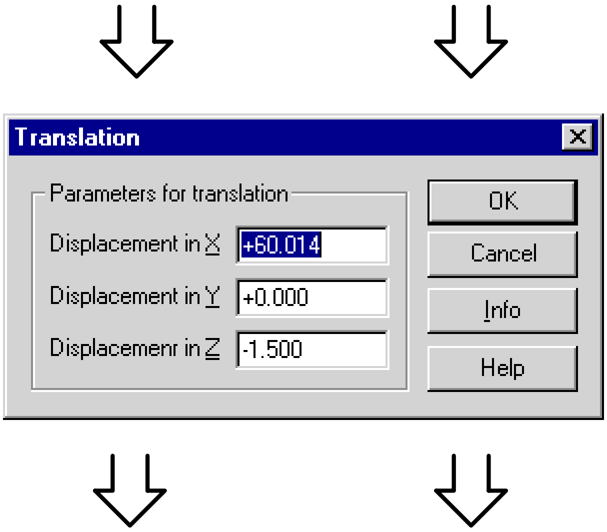
4.4 Translation

This function translates the paths and contours in all three axes.

Input file

Path Contour

Dialog box



Output file

Path Contour

with extension "TRA" with extension "TRA"

Translations in X, Y, Z

Parameter: Translations in X, Y, Z

Here you enter the values by which the coordinates are to be translated in the each of the axes. The default values are such that the min. coordinates of the data set are (0,0,0,) after translation.

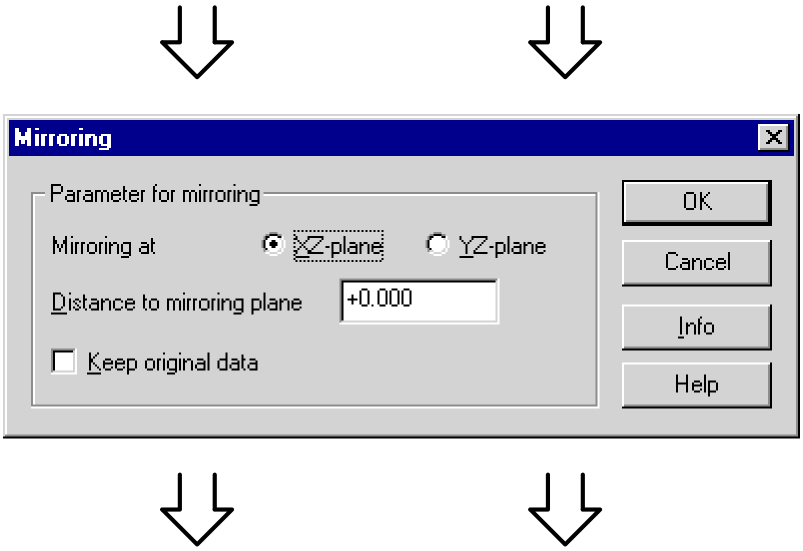
4.5 Mirror

This function mirrors the paths and contours in all three axes. You can thus generate a "left side" from a "right side". Instead of then having to join the two halves, the mirrored data can be joined directly to the original data.

Input file

Path Contour

Dialog box



Output file

Path Contour

with extension "MIR with extension "MIR"

Parameters for mirroring

Mirroring plane XZ or YZ, distance between planes

In the dialog box first select the plane that is to be mirrored. Then enter the distance of the mirrored plane from the zero point. If you check box *Original file* the input data will be included in the output file. The merge operation can then be omitted.

4.6 Allowance

Inclusion of an allowance in the calculation of the collision-free tool path is limited to a range that depends on the diameter of the milling tool used. As a reminder; the value range used in the collision calculation is:

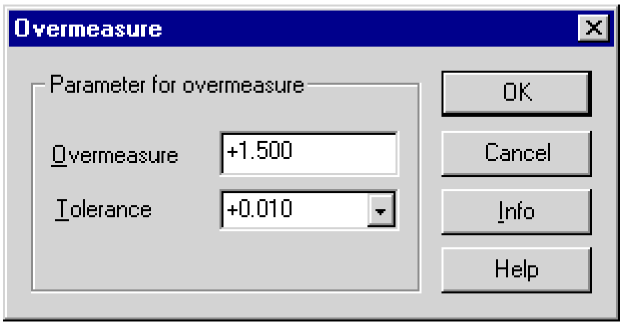
2 x MAX(grid width in X/ in Y) <= allowance <=100.

This special allowance function is available to you for calculating allowances that are greater than the value range specified above.

Input file

Contour

Dialog box



Output file

Contour with extension "AUF"

Allowance, tolerance

Parameter: Allowance, tolerance

With this function you only have to specify the values for the allowance and the desired tolerance. The tolerance is used to reduce the output data set. It does not affect the type or precision of the calculation.

4.7 Metal thickness/Gap width

Inclusion of the gap width in the calculation of the collision-free tool path, like the allowance, is limited to a range that depends on the diameter of the milling tool used, the desired allowance and the selected grid width. As a reminder; the value range used in the collision calculation is:

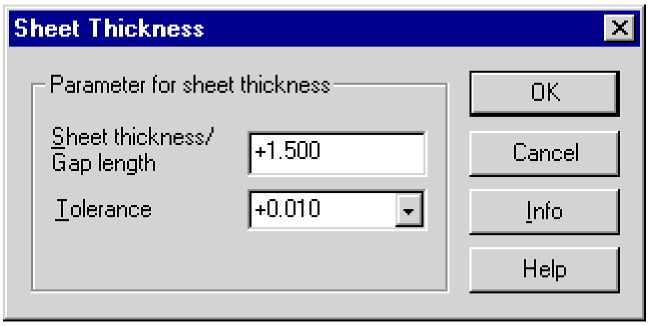
2 x MAX(grid width in X/ in Y) <= gap width <=100.

This special allowance function is available to you for calculating gap widths/metal thicknesses that are greater than the value range specified above.

Input file

Contour

Dialog box



Output file

Contour with extension "BLE"

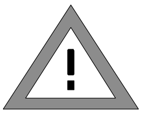
Metal thickness/gap width, tolerance

Parameter:
Gap width/tolerance

With this function you only have to specify the values for the gap width and the desired tolerance. The tolerance can again be used to reduce the output data set.

4.8 Positive/Negative

This function converts contours (see Section 3.3.1, 3D contour calculation and 3.4.1, Grids) from a positive to a negative representation.

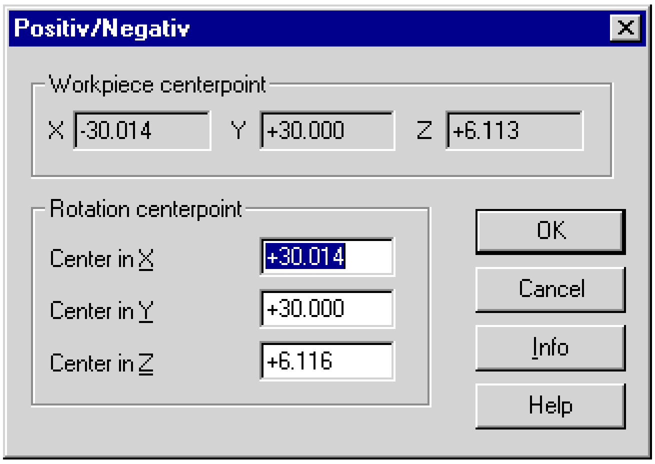


Because the positive/negative conversion based on a path makes little sense (a positively scanned web would produce a negative "dent"), this function can only be used for contours! This menu item is therefore only available for contour files. It is disabled for all other file types.

Input file

Contour

Dialog box



Output file

Contour with extension "NEG"

Rotation center point

Rotation center point Parameter: New origin

Because a positive/negative conversion is actually a special type of rotation, you can define the center point of rotation just as you do for *rotation*. The default setting is the workpiece center point so that the same working range is used for a part even after a positive/negative conversion. However, the zero point is usually changed. If the zero point is not to be changed, the origin of the coordinate system (0, 0, 0) can be set. In this case, the position/alignment of the part usually changes.

4.9 Contour conversion

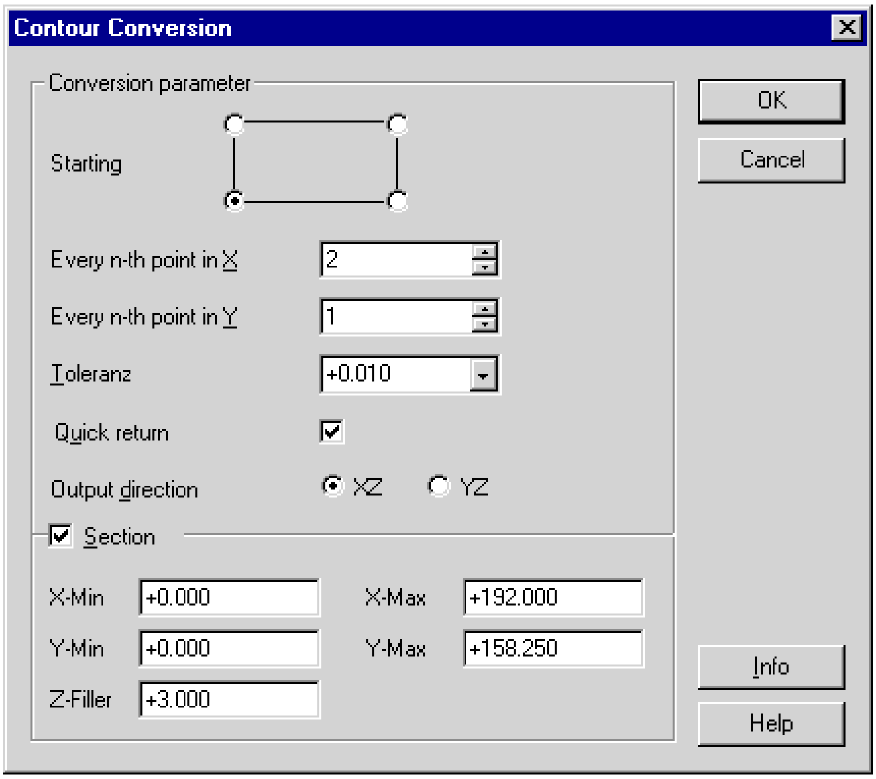
Quite often additional contour files with, for example, greater line widths are required for contour files that have already been calculated. In order to avoid recalculating a contour file existing contour files can modified with this function. The output direction can be altered and lines/columns can be omitted. It is also possible to undo the data reduction when outputting the contour.

You can enlarge a contour that has already been calculated with this function. You can therefore calculate and generate an area that has not been scanned.

Input file

Contour

Dialog box



Output file

Contour with extension "RST"

The info window gives you information about:

- the model dimensions
- the actual line width as used in the contour calculation
- the diameter and geometry of the stylus
- grid widths in X and Y

Starting point

Parameter: Starting point

For further processing you can select not only a direction but also a starting point. To do this, select the corresponding corner point in the dialog box.

Skipping lines/columns

Parameter: Accept every nth line/column only

An existing contour grid can be thinned out by accepting only every n-th line or n-th column in the output file.

Tolerance

Parameter: Tolerance width > 0 thin out grid

Entering a tolerance width < 0 thins out the contour grid and reduces the memory requirement.

Tolerance width = 0 Fully reconstruct grid

If the tolerance width = 0 all the grid points are stored. In this way you can fill up contour files again that have been reduced.

Output direction

Parameter: Output direction

Irrespective of the output direction used in the original contour calculation you can choose between:

- Output in the XZ plane - parallel to the X axis
- Output in the YZ plane - parallel to the Y axis

The output direction, too, is only required if the data are to be transferred to a CAD system or displayed in the internal graphics.

4.9.1 Area

You can choose whether you merely want to convert a partial area of the input contour or whether you want to enlarge the area.

X/Y min/max

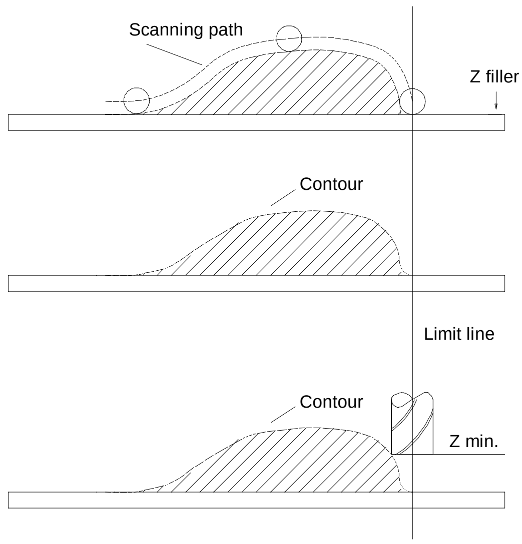
With X min, X max, Y min and Y max you define the cutout in the X/Y plane.

Z filler

If the X/Y area described above is larger than the extent of the input contour the system fills up the surrounding boundary area to a constant level. The parameter *Z filler* defines the height of the surrounding boundary area.

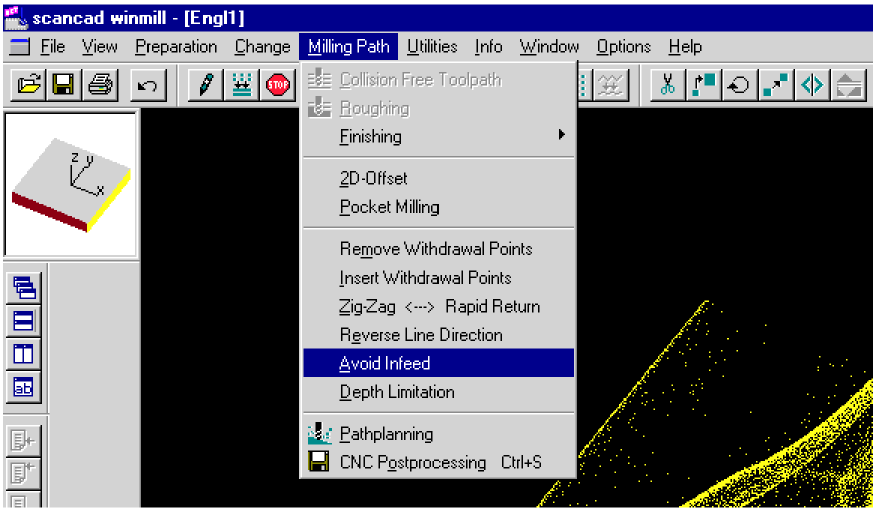
Note:

The function for completing unscanned contour areas is useful when it comes to subsequent calculation of the collision-free tool path. Here is a brief example to show how the function works (see drawing): In order to save time during scanning the model is only scanned by a small stylus point as far as necessary. The resulting contour calculation gives a description of the workpiece but no information about the boundary areas. If merely the tool path for a larger tool is to be calculated on the basis of these data, the tool is not traversed to the end of the contour at the edges. The tool center point cannot violate the area of the calculated contour (boundary line). The milling tool stops at height Z min. This problem is solved by enlarging the contour.



5 Milling Path

Menu



When you select menu item *Milling path* the following functions are available to you, depending on the scope of supply:

5.1 From the digitizing data to the milling program	The various ways of generating a milling path
5.2 Collision-free tool path	Calculates a collision-free milling path
5.3 Roughing	Calculates the rough milling paths (machining in layers)
5.4 Finishing	Calculates the finish milling paths
	5.4.1 General parameters
	5.4.2 XZ finishing
	5.4.3 YZ finishing
	5.4.4 Oblique finishing
	5.4.5 Radial finishing
	5.4.6 Circular finishing
	5.4.7 Spiral finishing
	5.4.8 Line finishing
	5.4.9 Guide line finishing

5.5 2D offset	Calculation of offsets
5.6 2D pocket machining	Calculates the milling path of a pocket
5.7 Delete retraction points	Delete retraction from a file
5.8 Insert retraction points	Insert additional retraction points
5.9 Reciprocation/rapid return	Conversion of reciprocation milling paths into milling paths with rapid return
5.10 Reversal of line direction	Turns line direction around
5.11 Inward interruption	Calculates milling paths with inward interruption
5.12 Depth limit	Calculates milling paths with depth limit
5.13 Path planning	Calculates all the NC milling paths
5.14 NC code generation	Postprocessing to create a control-specific NC program

5.1 From the digitizing data to the milling program

The functions of digitizing data processing described so far are specifically for the preparation and modification of data.

The functions described below are used to create NC programs. The menu *Milling path* comprises functions for generating three-axis machining programs *collision-free tool path*, *roughing*, *finishing*) and 2D functions (*2D offset*, *pocket machining*). *Path planning* is used for the simple division of cuts or for changing the line width in milling. *NC code generation* is then merely used to output tool paths in a format that can be processed by the NC control used. The menu also contains several special functions to processing path files.

Collision-free tool path

The *collision-free tool path* is used if the original scanning data are not to be or cannot be used. If, for example, a milling tool is selected that is larger than the stylus used for digitizing, this function can be used to calculate a tool path on the basis of the contour description (see Sections 3.3.1 and 3.4.1) which will not cause damage to the model. Additional parameters are available for calculating allowances in either direction.

Roughing, path planning

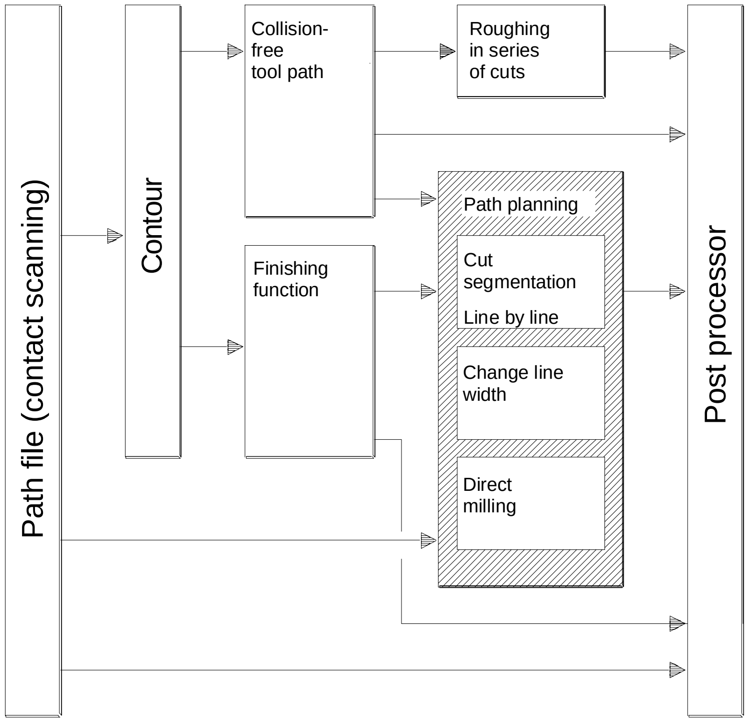
The tool path calculated in this way usually has to be divided into individual steps before it can be used for milling. The material to be removed is subdivided into a series of cuts with the function *Roughing*. The function *Path planning* quickly calculates a simpler cut segmentation to be performed line by line.

Finishing

If only individual sections of a contour are to be machined, these sections can be machined with the different *finishing* strategies.

Digitizing data can also be converted into an NC program directly with NC code generation if 1:1 machining along the digitizing paths is required. For this, the milling tool must be the same size and of the same geometry as the stylus. With the path planning function these data can also be used for roughing in line by line cut segmentation.

The diagram below shows the relationship between the various processing and machining operations.



5.2 Collision-free tool path

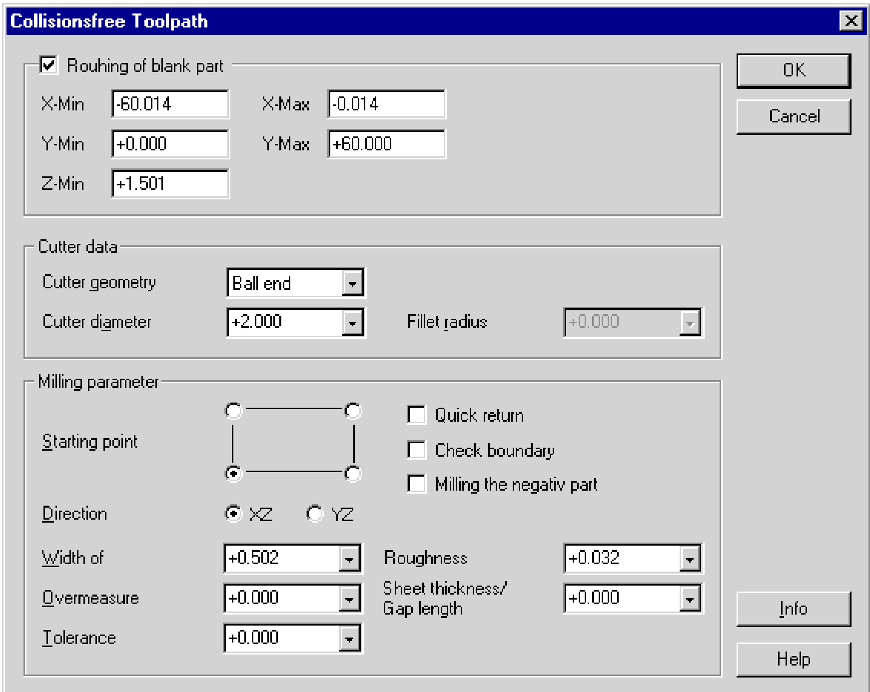
One advantage that digitizing has over conventional methods is that the milling operation can be separated from the scanning procedure. The digitization strategies and stylus geometries used in scanning do not have to be used for milling. Nor is this possible in contactless scanning which does not use scanning geometry in its real sense. Although the laser beam has an expansion it is practically equal to zero.

Calculating a collision-free tool path on the basis of a contour description allows simple and user-friendly preparation for the subsequent machining process. In the calculation, the mill geometry and the milling strategies can be adapted to the various conditions. They do not depend on the scanning method.

Input file

Contour

Dialog box



Output file

Collision-free milling path with extension "KOL"

When is a collision calculation necessary?

A collision-free tool path must be calculated if:

- the milling paths and milling strategies are to be independent of the digitization paths
- a negative of the model is to be calculated
- the workpiece is to be scaled to any size
- the milling diameter for the final milling process is to be larger or smaller than the diameter of the stylus used for scanning (collision avoidance) or if the shapes of the stylus and miller are not identical.
- the surface data are to be transferred to a CAD system in the form of points, splines and surfaces.

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FForm≠TForm

The next section describes the individual parameters with which the collision-free tool path can be modified by the user. Not only can the operator define a milling tool, he can also define the line width and the output direction. Parameters are also available for defining allowances and metal thicknesses/gap widths.

5.2.1 Roughing on blank

Roughing on blank

In many cases, only the model itself is scanned but in the subsequent milling operation the adjacent area is also machined down to a specific height. In such cases, a rectangular roughing area can be defined with the function *Roughing on blank*.

X/Y min/max

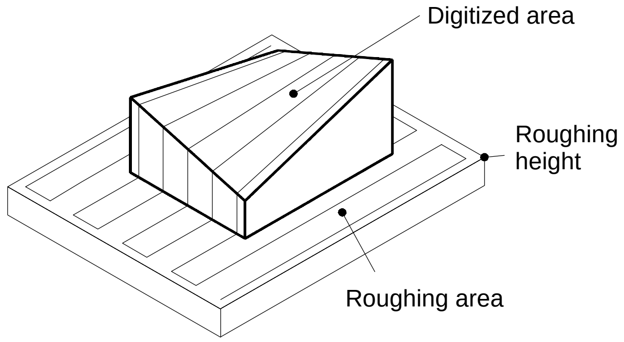
Roughing area

The values X min and Y min must each be either less than or equal to the smallest area dimensions. The values X max and Y max must either be greater than or equal to the largest area dimensions. The dimensions of the area of the digitized model are suggested as the default.

Z min

Roughing height

The roughing height *Z min* defines the height for machining the areas of the workpiece that lie outside the digitized model area.

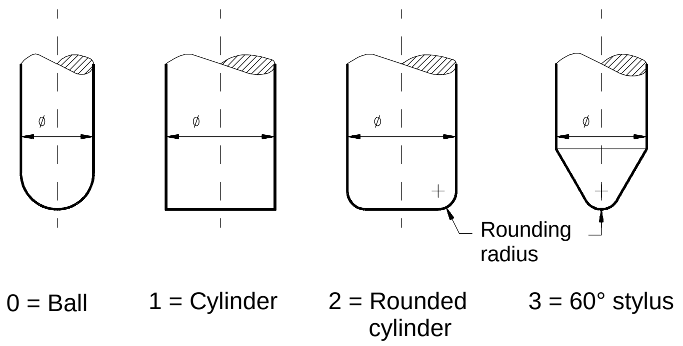


5.2.2 Milling data

Mill geometry

Mill geometry

Here, you can select a mill geometry, irrespective of the geometry of the stylus being used. The following geometries are available:



Mill diameter

Mill diameter

The mill diameter must be greater than or equal to 4 times the grid width and less than or equal to 92 mm:

4 x grid width <= mill diameter <= 92 mm

Rounding radius

Rounding radius

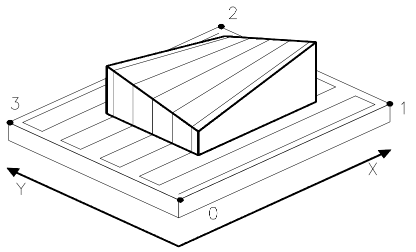
If you have selected a radius end mill or chisel, you must now enter the rounding radius of the corners or the chisel.

5.2.3 Mill parameters

Starting point

Starting point

You can not only enter the machining direction but also the starting point for the milling operation.



Milling direction

Output direction

As for calculation of the contour grid, here too you must enter the output direction, i.e. the direction in which the lines are stored in the output file. Here you define the path the mill takes when it machines the workpiece. You can select the following:

Output in the XZ plane - parallel to the X axis
Output in the YZ plane - parallel to the Y axis

Line width

Line width

The permissible value range is calculated as follows:

grid width in infeed direction <= line width <= mill diameter

As only multiples of the grid width can be used for the line width, the line width is automatically adapted to the next smallest possible value.

Surface roughness (for ball mills only)

Surface roughness for ball mills

The default setting for surface roughness is derived from the selected line width and the mill diameter used.

Instead of entering the line infeed directly, you can enter the surface roughness for a ball mill. From this, the program calculates the necessary line infeed and automatically adapts it to the nearest possible value.

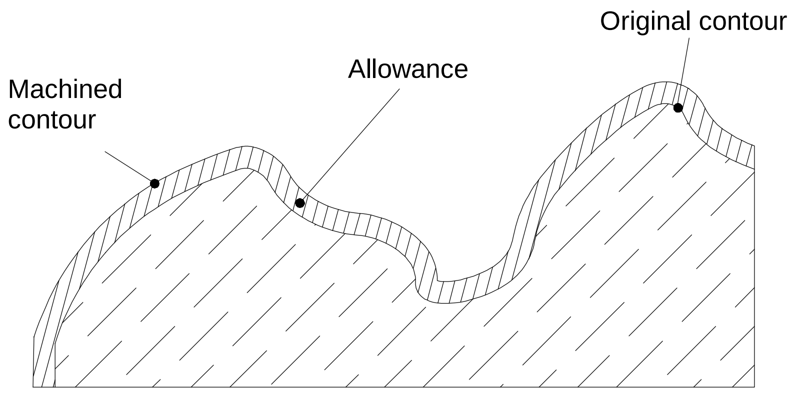
Allowance

Allowance

By entering an allowance you ensure that the mill maintains a distance to the model in all three coordinate directions. This is important when machining a workpiece in several roughing and finishing operations. When roughing with an allowance the tool does not make contact with the final contour anywhere.

Permissible value range:

0 mm <= allowance <= 46 mm - milling radius + metal thickness

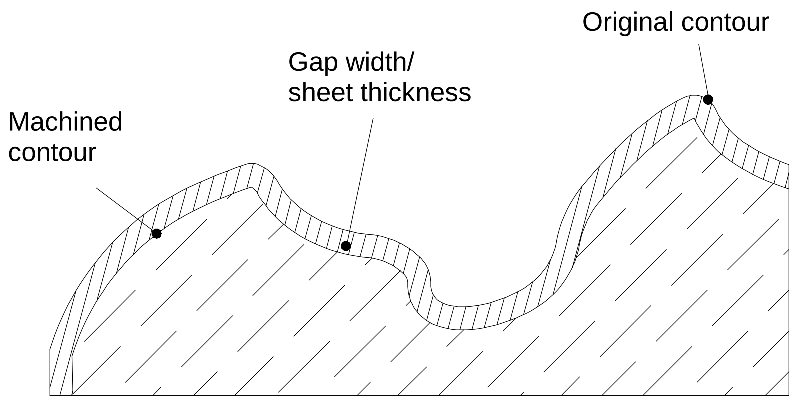


Gap width/metal thickness

Gap width/metal thickness

In contrast to the allowance, this function allows you to define a constant gap width (negative allowance, undersize). This is important if the stamp is to be made for an existing part. A gap must be reserved for the metal. A further application is the manufacturing of erosion electrodes, injection molding tools etc. The permissible value range is calculated as follows:

0 <= gap width/metal thickness <= mill radius + allowance - 2 x grid width



Tolerance

Tolerance

Entering tolerance width > 0 initiates a data reduction immediately before the data are written to the hard disk and reduces the required storage capacity considerably. This option is comparable with the on-line data reduction function used in scanning and is also included in the *contour calculation* and *contour machining* as an off-line function.

Rapid return

Rapid return

This parameter defines whether the tool is lifted at the end of a line and moved down again at the beginning of the opposite line or whether it is to perform a zig-zag movement. Up/down milling can also be defined with this parameter.

Edge monitoring

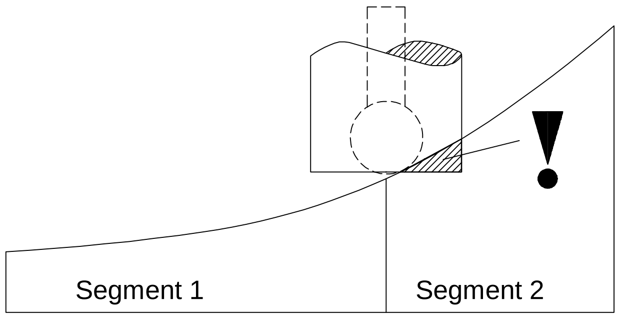
Edge monitoring

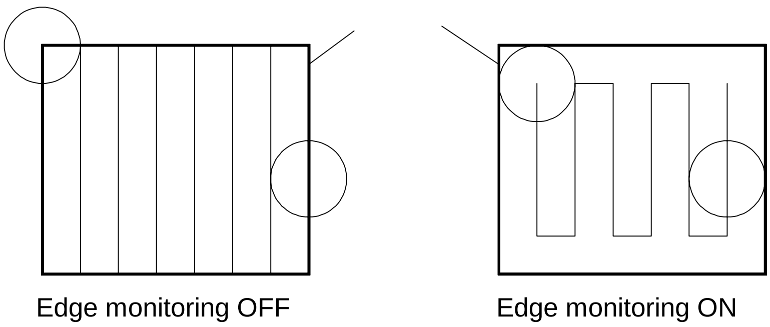
With this option you define how far the workpiece is to be milled at the edges.

If edge monitoring is disabled no collision check is performed at the edges of the scanned areas. The center point of the milling cutter then always travels the same distance as has been scanned.

Cutouts and segments

This can lead to contour violations in the neighboring segment, especially during subsequent machining of cutouts or separate segments with a milling cutter that is larger than the probe used.





When edge monitoring is enabled the milling paths are calculated such that the cutter only covers the scanned area.

If edge monitoring is activated, all the milling paths on the workpiece from roughing to finishing must be machined with edge monitoring. Otherwise milling problems can occur at the edges and the cutter can even break due to the overloading caused by jerky movements.

Negative milling

Positive or negative milling

Finally, you can also define whether a positive or negative contour is to be milled. Negative contour milling can also be defined by explicitly converting a contour file with the function *positive/negative conversion*. Calculation of a negative at this point, however, does not generate a separate file with a description of the negative.

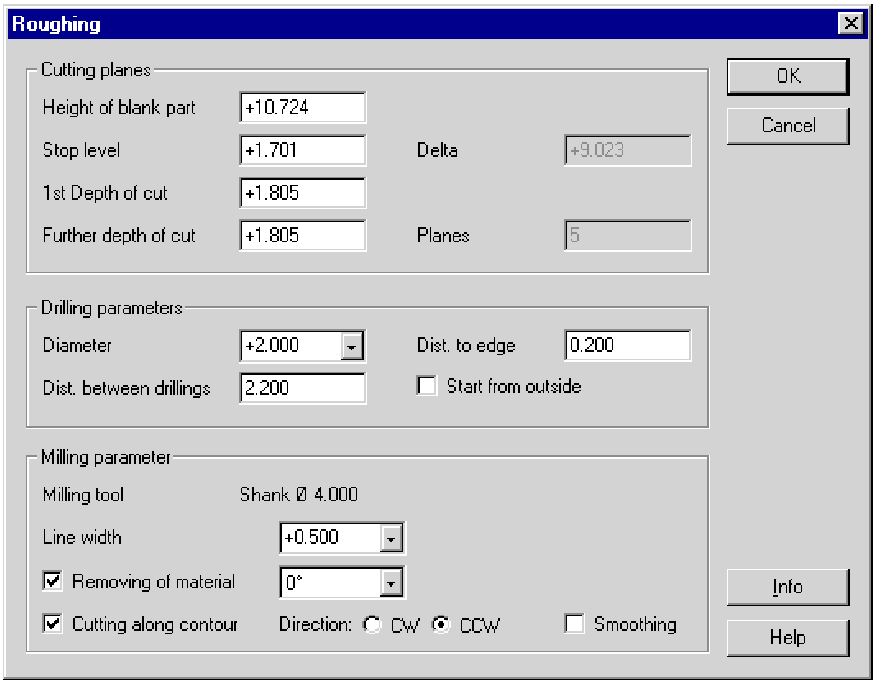
5.3 Roughing

This function calculates a special cut segmentation for roughing on the basis of a contour representation or a collision-free tool path. The milling operation is calculated layer by layer with a minimum number of lift movements. Any necessary plunge points are detected automatically. The software generates drilling holes at these points. The resulting output file contains all the tool movements and now only has to be converted to an executable NC program by the postprocessor.

Input file

Milling path (collision-free tool path)

Dialog box



Output file

Collision-free milling path with extension "KOS"

Method of this function

The essential differences between conventional cut segmentation familiar to us and which is still available and path generation for layer-by-layer roughing are described below.

Cut segmentation of the previous version

Cut segmentation performed by the old NC module generally operates line by line. The milling cutter remains in action until it finds an area that has already been machined. Such an area is passed over in rapid traverse at a safe height. This lifting movement is performed after each successive layer is cut. In the past, this method meant that the roughing programs contained several movements made when the tool was out of action, called idling times. These movements are performed during productive time but do not contribute to the actual machining of the workpiece. A further disadvantage of this conventional line-by-line approach to roughing segmentation is presented by the up and down movement of the tool. Previously, only tools which were capable of cutting beyond the center could be used.

New cut segmentation of the current software version

The function *roughing* operates according to a different principle. In this type of cut segmentation, the milling paths all lie on one level and are path optimized. When the new cut segmentation is used, the first step is a subdivision into so-called height levels. Following this operation, the resulting areas must be cut out using optimized milling strategies. Before the milling paths are actually calculated, the optimum insertion points are determined. The operator can decide later in the NC module whether these insertion points are to be predrilled or whether the tool is to be inserted directly in the form of a helix. With helical insertion, the diameter of the helix must be entered as the drill diameter. This eliminates a tool change from drill to mill later on. The milling paths are optimized such that the cutters are inserted in the predrilled holes (or helical insertion) and machine the individual levels with the smallest possible lifting movements (see drawing).

The operator can use a special parameter to define that the area borders are to be milled additionally as the last contour of a level. In addition to the parameters for cut segmentation, the interactive dialog also requests the parameters for calculating the insertion holes (diameter, clearance between neighboring holes, clearance between the holes and the edge).

This new roughing technology enables roughing times to be reduced considerably compared with line-by-line roughing. It also enables the use of mills with tool inserts.

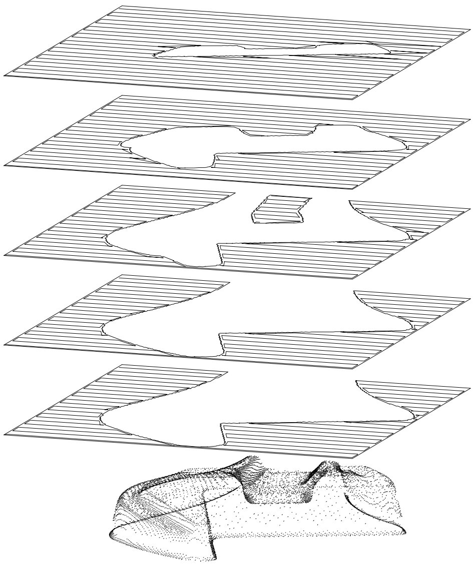
Input file Collision-free tool path

In order to produce a good milling result the function requires as much information about the model/milling path as possible. Even when calculating the collision-free tool path the line width should be kept as small as possible.

If a file with a larger line width is used the error message, "Error: Machining only possible on full contour collision grid" appears.

5.3.1 Cutting planes

The following sketch shows a roughing process with the individual roughing levels. In the operation shown, the individual planes have already been machined. To eliminate the waviness in the proximity of the contour, a second cut was subsequently milled parallel to the contour.



Roughing

Blank height

Blank height

Enter the height of the blank. Cut segmentation starts here with the first infeed.

The maximum height of the scanned area is suggested (see drawing). However, a larger height can be selected.

Stop plane

Stop plane

The stop position is the height at which the last milling path is to be traversed. The minimum height of the scanned area is suggested (see drawing). If the workpiece is not to be milled right to the bottom, enter a stop plane that is higher than the suggested value.

1st cutting depth

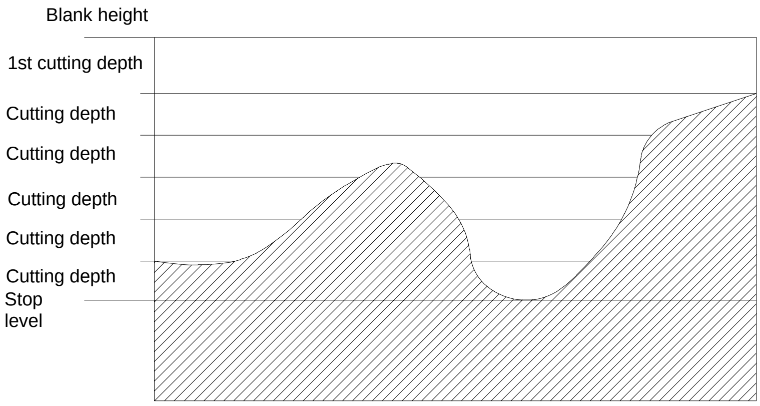
1st cutting depth

First cutting depth (see drawing)

Cutting depth

Additional cutting depths

Depth of any following cuts (see drawing).



5.3.2 Holes

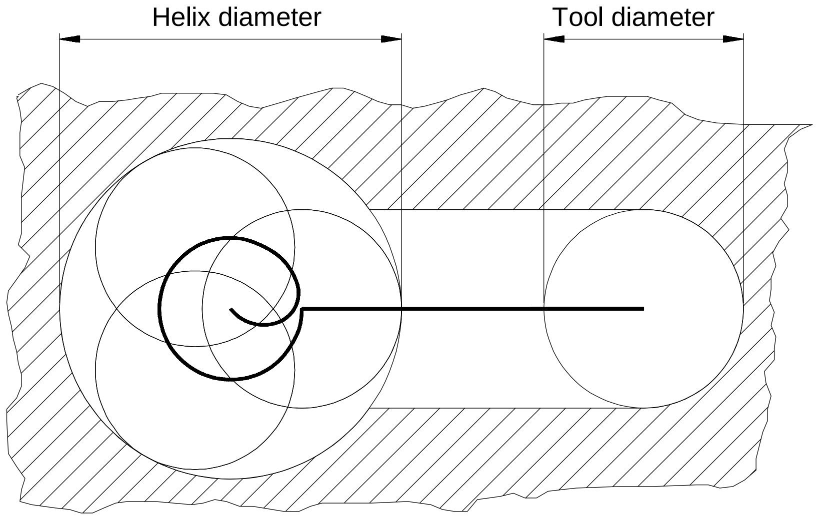
Drill diameter

Drill diameter

With this parameter you define the diameter used for calculating the insertion position. It can, of course, only be greater than or equal to the mill diameter.

Helix diameter

If the mill is to be inserted in helical form during machining, the diameter of the helix must be entered here.



Hole clearance

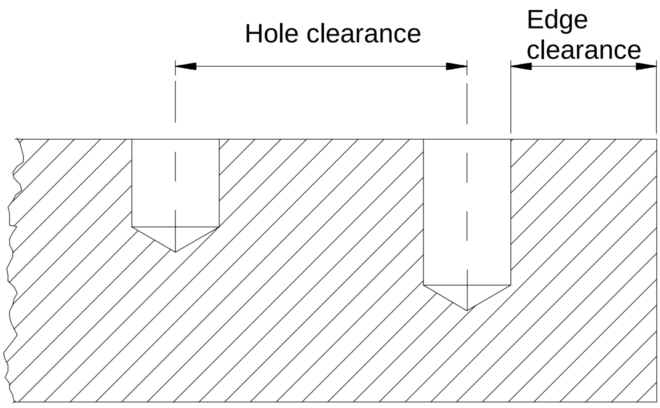
Hole clearance

This parameter defines the smallest possible distance between two adjacent holes.

Edge clearance

Edge clearance

Here, the distance between a hole and the edge of the part is defined.



Approach from outside

Approach from outside

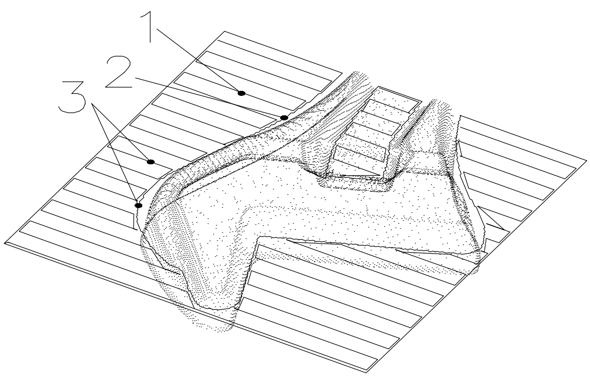
In special circumstances it is also possible to approach the workpiece from outside. This sometimes allows the omission of a drilling operation or helical insertion. The milling tool always infeeds from the outside of the part and then approaches from the side of the workpiece.

When using this type of machining, please ensure that no clamping elements are located within the area of the milling operation. You cannot specify a special insertion point.

5.3.3 Milling parameters

Three machining options

You can machine the individual layers in three different ways (see drawing): *Solid machining*, *parallel to contour*, and the combination *solid machining* + *parallel to contour*.



Solid machining

Solid machining

The part is solid machined line by line. You can select a line width and a milling angle.

Line width for solid machining

Line width for solid machining

Here, you enter the distance between two adjacent milling paths. The default is the line width that was used for the collision calculation. However, you can also enter multiples (two times, three times ....). If you enter a line width that is not a multiple of that value, the next smallest multiple is used.

Milling angle for solid machining

Milling angle for solid machining

This parameter defines the direction of the milling paths. You can enter multiples of 45 degrees.

Milling angle = 0 degrees is parallel to the X axis (90 degrees = parallel to Y axis etc.) The milling angle is read counterclockwise.

Parallel to contour

Solid machining + parallel to contour

In the combination *solid machining* + *parallel to contour* , machining parallel to the contour is used to remove residual material at the edges of the solid machined areas.

Parallel to contour

Machining parallel to the contour can also be used as a separate function for a second roughing operation. If a cutting depth of 10 mm has been used, for example, for *solid machining*, it is easier to machine the edge layers in steps parallel to the contour in a second machining run at a cutting depth of 5 mm.

Smoothing with machining parallel to the contour

Smoothing with machining parallel to the contour

Calculation of the cutting planes also includes the calculation of the edge curves to the workpiece itself. Differences in the size of the line width can occur. The edge curves are relatively square. In order to achieve a softer movement along the cutting lines, the path can be smoothed with this function.

Direction for machining parallel to contour

Direction for machining parallel to contour

Here, you can define the direction of movement for milling of the roughing area parallel to the contour. Possible settings are *clockwise (CW)* and *counterclockwise (CCW)*.

5.4 Finishing

As the arrow next to this menu item suggests, this is not a just a single function but a whole series of new machining options. They are all listed in a separate menu called *Finishing.*

Usually, the workpiece is prepared with the function *roughing*. In the first stage, individual areas of a contour are selected on the screen interactively for finishing. Each of these areas can then be finished with the most suitable strategy. Calculation of the milling paths is the second step towards generating a finishing program. The line width does not depend on the scanning line width or grid width of the contour. This means that for finishing, too, the milling operation can be completely separated from the digitizing process.

This new operation can also be used for prefinishing. On the screen you can select the areas that still contain a large amount of residual material after the roughing stage. Subsequent machining is then only performed in the defined areas. This saves a lot of time during milling. The time-consuming pre-roughing operation along the entire part can then usually also be omitted.

The finishing module also provides advantages when it comes to the machining of "negative parts". Here again, milling paths can be optimally adapted to the contour. With this measure, the machining quality can be considerably improved and remachining reduced to a large extent. In spite of all these options the functions are very simple to use.

The input file for all the finishing functions in this menu is always a contour file. For some of the functions, a description of the area to be machined can/must also be given.

The menu *Finish* comprises the following finishing functions:

1. XZ: X-axis-parallel finishing with infeed in Y
2. YZ: Y-axis-parallel finishing with infeed in Y
3. Oblique: Finishing oblique to the main axes
4. Radial: Radial machining of a circle segment full circle
5. Circle: Circular machining of a circle segment or full circle
6. Spiral: Spiral machining of a circle or annulus
7. Line: Machining of an area across a line; infeed is performed along the line
8. Guide line: Machining along an existing/ defined guide line

5.4.1 General parameters

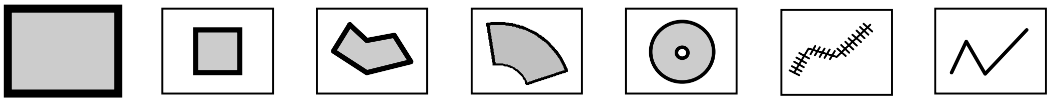
Before the special features of individual machining strategies is explained, let us first look at the most important parameters. Their meaning is the same for all strategies.

Area boundaries, lines and guide lines

This section describes the use of area boundaries, lines and guide lines.

The interactive input of area boundaries, lines and guide lines plays a central role in the operation of these new functions (see Section 6.1, Polygon).

Permissible combinations of area boundaries/lines/guide lines and the various finishing functions are summarized in the table below.



Area / Finishing function	All	Partial area	Fence	Circle segment	Circle	Line	Guide line
XZ	●	●	●				
YZ	●	●	●				
Oblique	●	●	●				
Radial				●	●		
Circle				●	●		
Spiral					●		
Line						●	
Guide line							●

Main parameters of the finishing functions

The following parameters are identical for all finishing functions

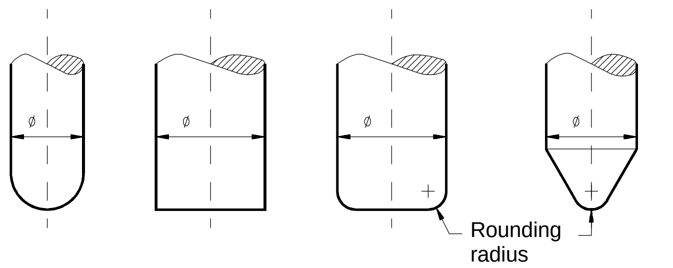
The user can choose from a total of eight different machining methods to ensure the best possible adaptation of the finishing operation to the requirements of the workpiece. These functions differ both in terms of milling strategy and the machinable areas. The relationship between finishing functions and possible finishing area is shown in the table above. This table will help you to plan the finishing operation.

This section describes the main parameter entries for the individual finishing functions. As these parameters are identical for all finishing functions, they are summarized below.

Milling data

Mill geometry

Here, you can select a mill geometry, irrespective of the geometry of the stylus being used. The following mill geometries are possible:



0 = Ball 1 = Cylinder 2 = Rounded cylinder 3 = 60° stylus

Mill diameter

The diameter of the mill selected does not depend on the size of the stylus. However, it must be smaller than 92 mm.

Rounding radius

If you have selected a radius end mill or chisel you must also enter a rounding radius for the corners or the chisel.

Mill parameters

Line width

The line width defines the distance between the finishing paths. It does not depend on the scanning line width or contour grid width. The line width is measured at different points for each of the individual finishing functions. The precise description may be found in the relevant section for each finishing function.

Surface roughness

If a ball mill is used the surface roughness is displayed as an indication of the surface quality.

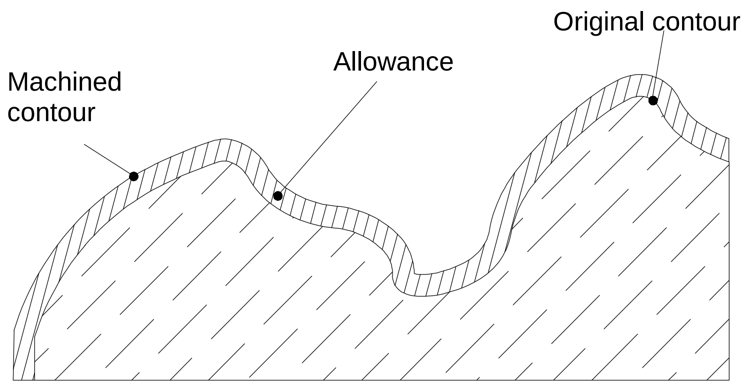
Instead of entering the line infeed directly, you can enter the surface roughness for a ball mill. The program then calculates the required line infeed from this.

Allowance

By entering an allowance you ensure that the mill maintains a specific distance to the actual contour in all directions. This is especially useful when using finishing functions for prefinishing. You can thus leave a small material allowance for the last finishing operation.

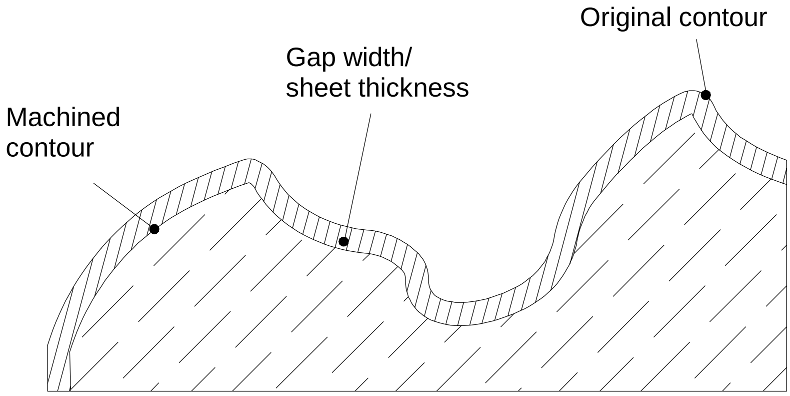
Permissible value range:

0 mm <= allowance <= 46 mm - milling radius + metal thickness



Gap width/ metal thickness

In contrast to the allowance, this function allows for a constant gap when you enter a gap width/metal thickness. This is important, for example, for manufacturing pressing tools based on a specific metal geometry. Another application is the manufacturing of electrodes and injection molding tools.



0 <= gap width/metal thickness < mill radius + allowance

Tolerance

When you enter the tolerance width you define the diameter of the tolerance tube in millimeters (see Section 3.1). The process described here has also been integrated in various other postprocessing functions. It is used to reduce the output files directly with the function *data reduction* to avoid producing intermediate files and thus save space on the hard disk.

Additional parameters

The supplementary functions described below are not always available for every finishing method.

Rapid return

This parameter defines whether the tool is lifted at the end of a line and moved down again at the beginning of the opposite line or whether it is to perform a zig-zag movement. Up/down milling can also be defined with this parameter.

Machine parallel to edge

With the option *machine edge* a milling path is also generated along the edge. If, for example, an area is limited by a polygon, the mill traverses along these boundary lines if the option *machine edge* is enabled.

Edge monitoring

The button *Edge monitoring* familiar to us from the calculation of collision-free tool paths is also available for the calculation of finishing paths. If this option is enabled, the mill remains within the specified range.

If edge monitoring is disabled no collision check is performed at the edges of the scanned areas. The center point of the milling cutter then always travels the same distance as has been scanned.

Mill negative contours

In order to avoid separate calculation of a negative, the button *Negative* can be selected so that the tool paths for machining a negative are calculated on the basis of a "positive" contour.

Note:

Now that all the general parameters have been described let us now turn to the individual finishing functions. Only those parameters not dealt with in Section 5.4.1 are explained here.

5.4.2 XZ finishing

With this finishing function the entire contour, a rectangular partial area or an area delimited by a polygon can be machined. A common application is the finishing of partial areas in a milling direction vertical to the actual machining path.

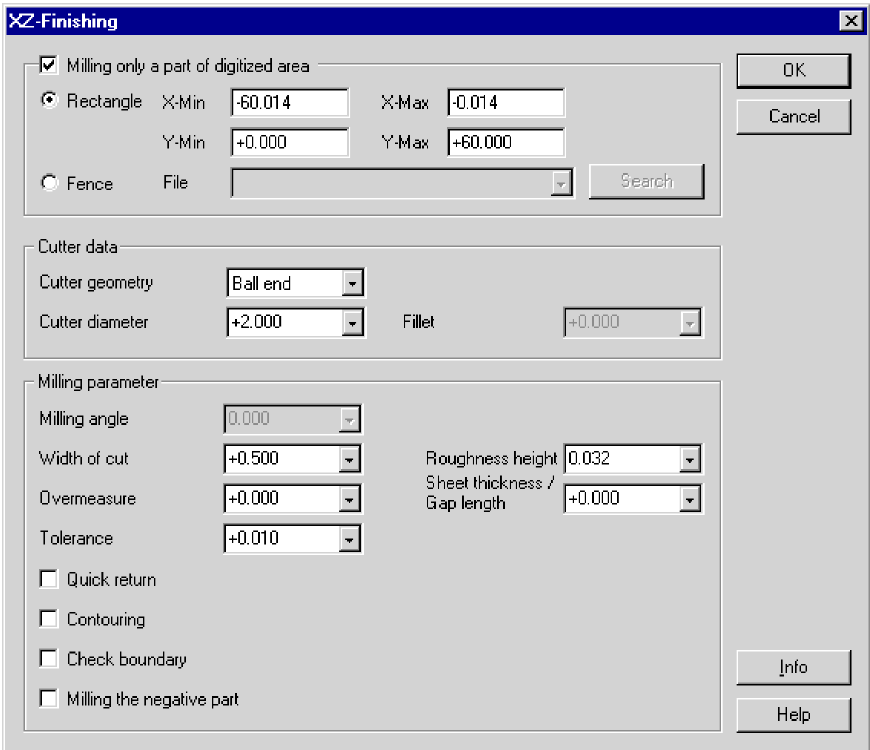
Milling a partial area

Here you enter the area to be machined. The default setting is milling across the entire contour area. If you select the button *Mill partial area* you can choose between a rectangle and a fence to delimit the area to be milled (see Section 5.4.1).

Input file

Contour

Dialog box



Output file

Milling path with extension "FIN"

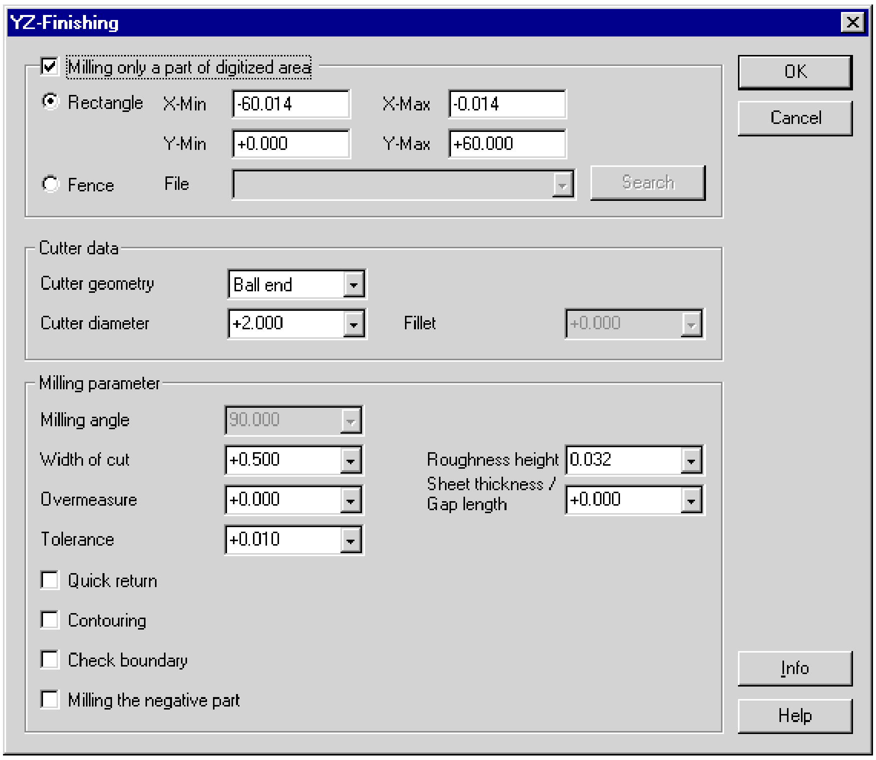
5.4.3 YZ finishing

The only difference between YZ finishing and XZ finishing is the infeed direction (here in X). All parameters are the same as for XZ finishing.

Input file

Contour

Dialog box



Output file

Milling path with extension "FIN"

5.4.4 Oblique finishing

The only difference between oblique finishing an XZ and YZ finishing is that in this case you can select a milling angle. All the parameters - except for the additional milling angle - are the same as for XZ and YZ finishing (see Section 5.4.2 and 5.4.3).

Milling angle

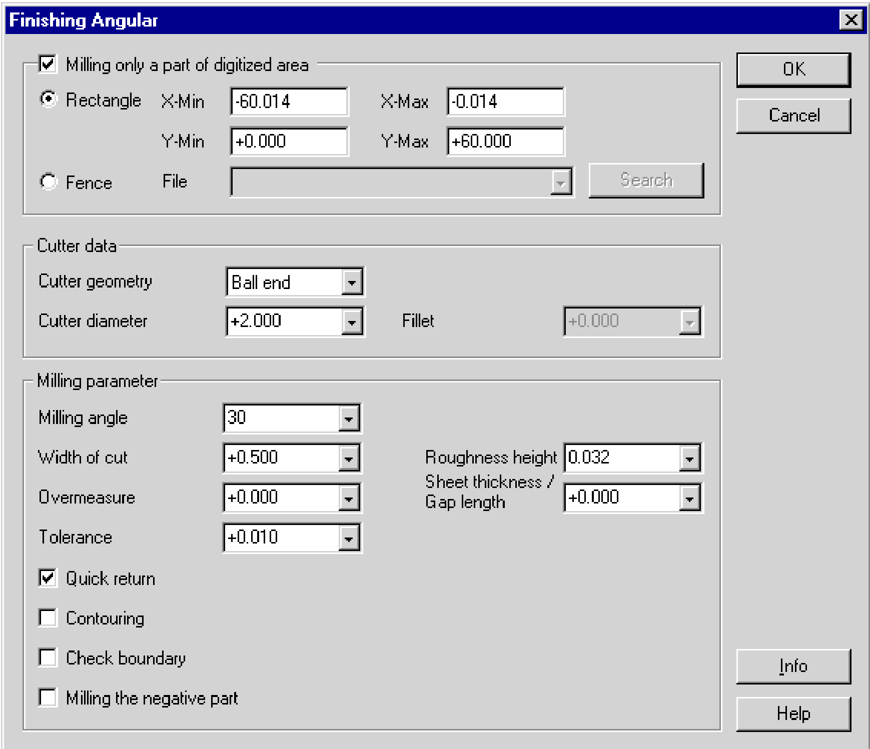
Milling angle

This parameter defines the direction of the milling paths. Milling angle = 0 degrees is parallel to the X axis (90 degrees = parallel to Y axis etc.) The milling angle is read counterclockwise.

Input file

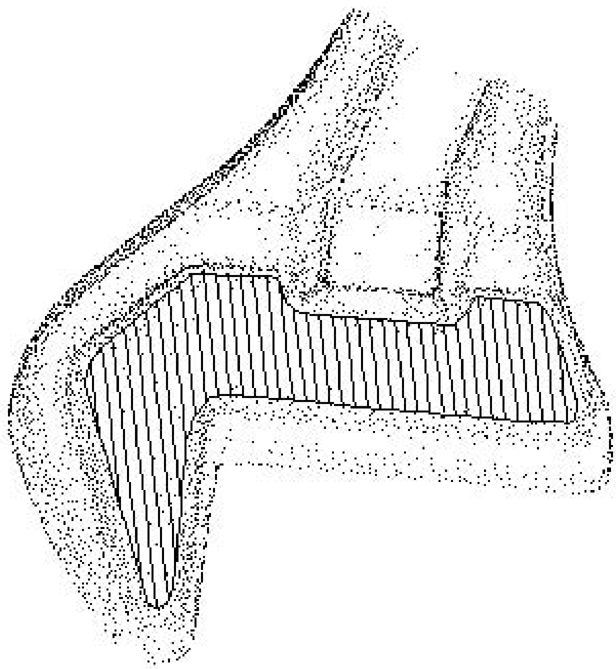
Contour

Dialog box



Output file

Milling path with extension "FIN"



Example of a milling path generated with oblique finishing inside a polygon boundary.

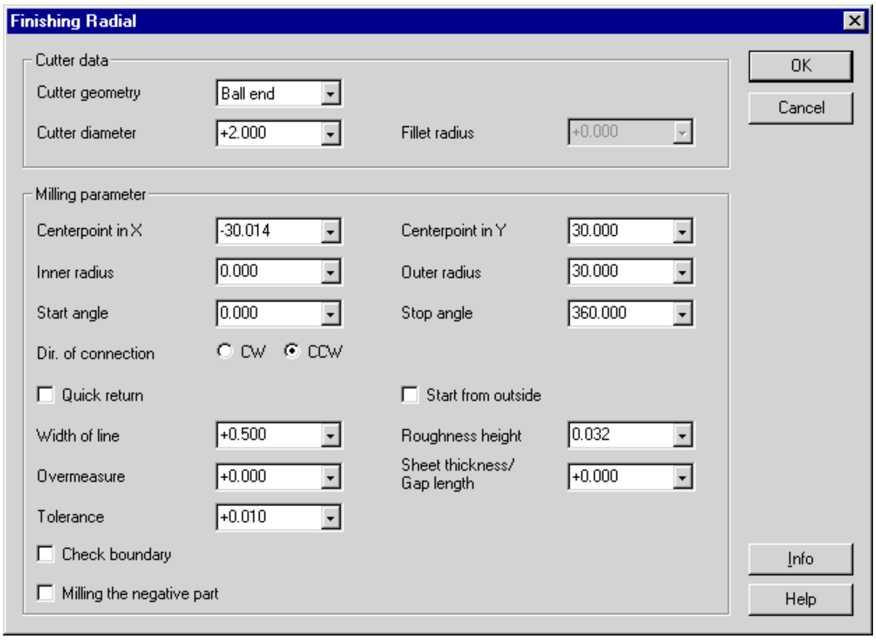
5.4.5 Radial finishing

The finishing module provides radial finishing for machining circular and round partial areas. With this function it is both possible to machine circular segments and an entire circular area.

Input file

Contour

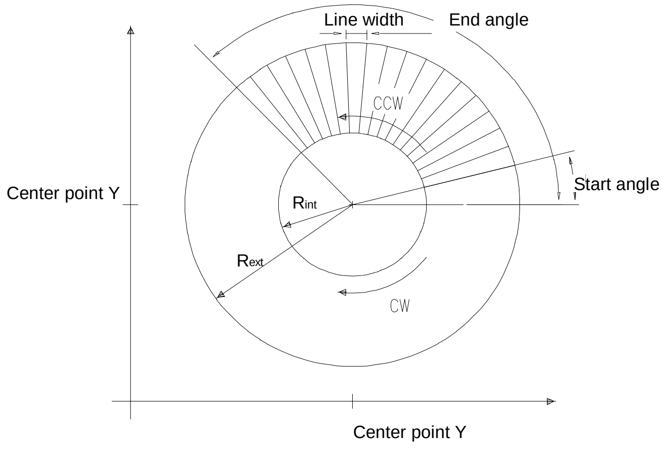
Dialog box



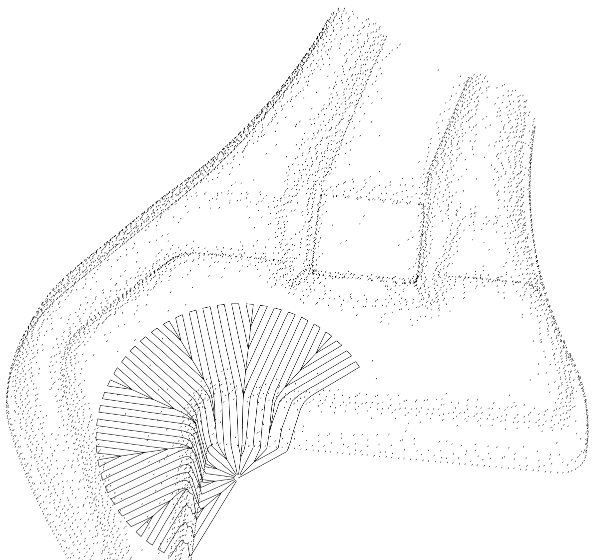
Output file

Milling path with extension "FIN"

The meaning of the special parameters for radial finishing is explained in this diagram:



The following diagram shows an example with finishing paths machined radially. Only one circular segment has been machined here.



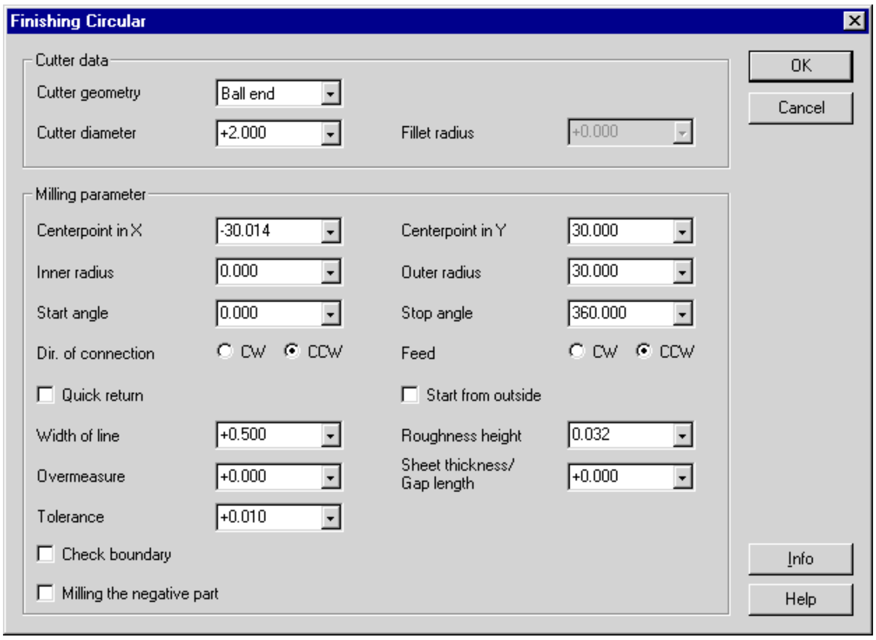
5.4.6 Circular finishing

As with radial finishing, with circular finishing, too, you either machine an entire circular area or a circular segment. In circular finishing, the milling paths run along concentric arcs and not towards the center point as they do in radial finishing.

Input file

Contour

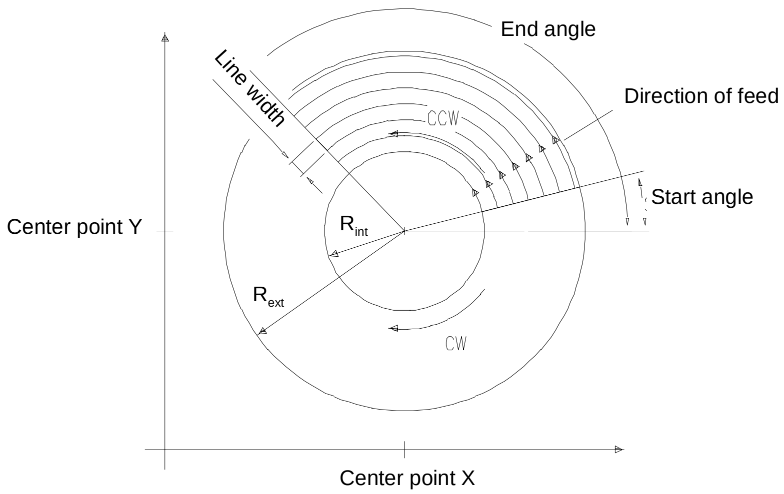
Dialog box



Output file

Milling path with extension "FIN"

<The special parameters for circular finishing are shown in the diagram.



Feed direction

With the feed direction you define the direction of the milling paths. This is especially important in combination with rapid return. With this parameter you can define whether up or down milling is to be performed.

Start outside

To cover all machining directions, you can define whether the milling paths are to run from the outside to the inside or vice versa.

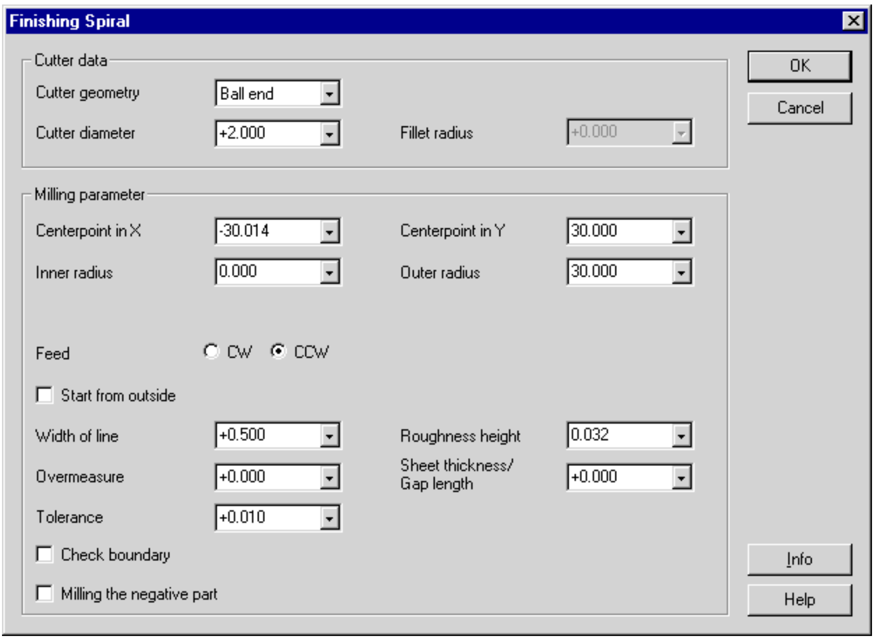
5.4.7 Spiral finishing

This function which is similar to circular finishing machines a circular area with spiral milling paths. The absence of infeed movements means that the machining sequence is very uniform.

Input file

Contour

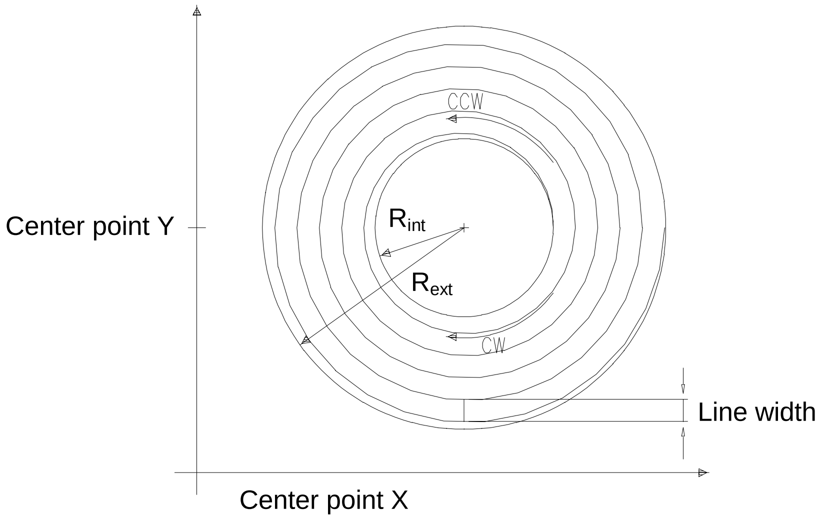
Dialog box



Output file

Milling path with extension "FIN"

The special parameters for spiral finishing are shown in the diagram.



5.4.8 Line finishing

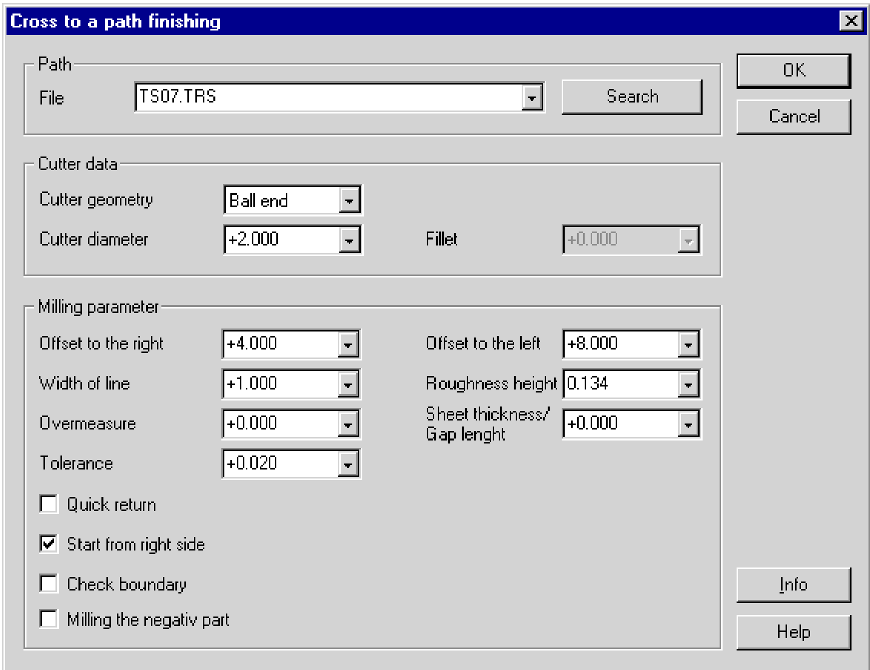
In contrast to the finishing functions described above, the area to be machined with line finishing is defined by a polygon or line which consists of a center line and the distances left and right of this line. This line can either be recorded by the digitizing system or subsequently generated interactively with the function *Polygon* (s. Section 6.1).

Milling is performed along this center line along paths that li vertically to it. This machining strategy is especially useful for remachining edges and fillets. Any residual material remaining from previous machining stages can be removed by this process.

Input file

Contour

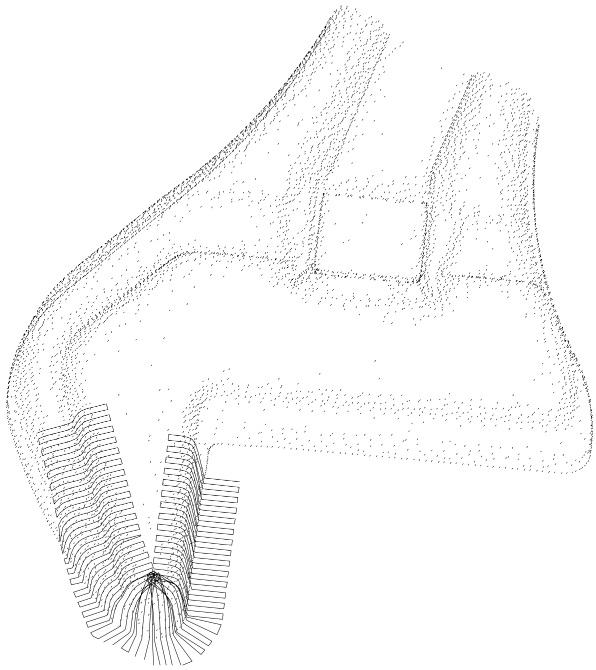
Dialog box



Output file

Milling path with extension "FIN"

The diagram below shows how line finishing works:



With line finishing, too, you can choose between rapid return and zig-zag machining.

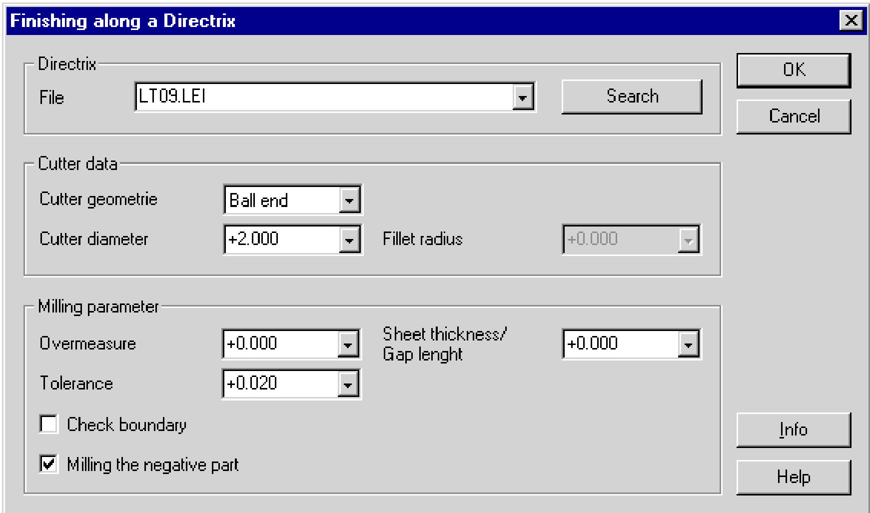
5.4.9 Guide line finishing

As the name suggests, in this finishing function milling is performed along a defined line. This guide line can either be recorded by the digitizing system or subsequently generated interactively with the function *Polygon* (s. Section 6.1). This function is especially suitable for remachining chamfers or fine contour lines. Machining parallel to a contour e.g. with an end mill is also possible with this function.

Input file

Contour

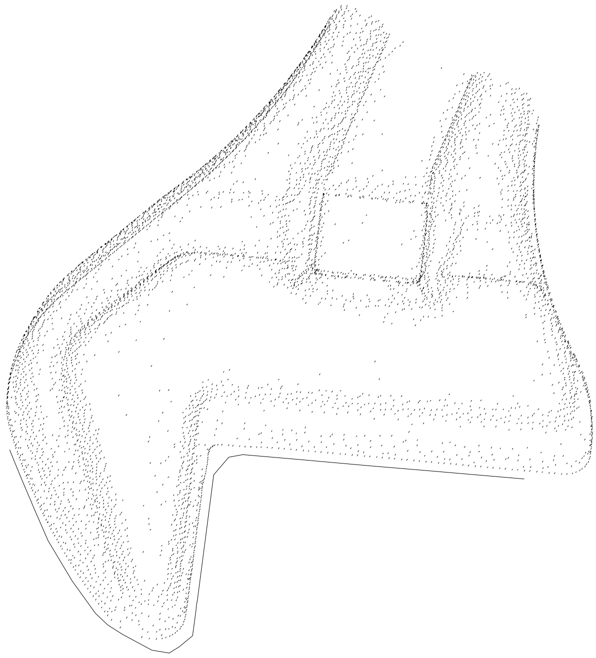
Dialog box



Output file

Milling path with extension "FIN"

The diagram below shows how guide line finishing works:



5.5 2D Offset

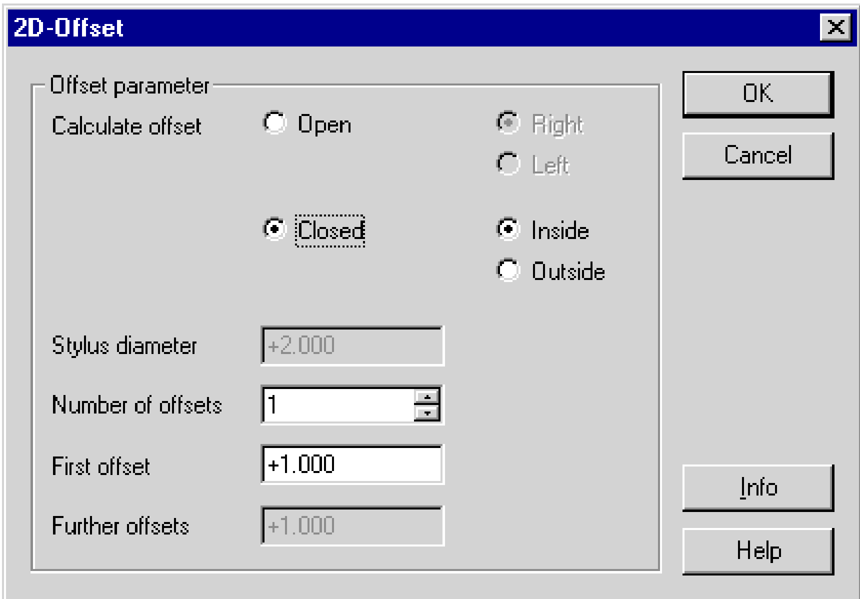
The function *2D offset* calculates 2D offsets for open or closed lines that lie on a common Z plane. These lines can be recorded as an outline or manually with the digitizing system or entered at the computer using the mouse with function *Polygon* (s. Section 6.1). The position of the calculated offsets can be chosen by the user. The function thus allows the calculation of milling paths on the inner side of a contour scanned from the outside and vice versa.

The lines can lie on several planes (outline scanning). In this case, however, each plane must only contain one line. The offsets can then be calculated in a single run for all planes.

Input file

Path/Fence

Dialog box



Output file

Path/fence with extension "OFF"

Open/Closed

Closed

This parameter informs the function whether or not the line is closed. If a line is closed the starting point and end point are identical.

Right/Left, Inside/Outside

Direction of offset

The direction of the calculated offset is defined with this parameter. You can apply the offsets internally or externally, or to the left or right with open lines.

Number of offsets

Number of offsets

This number defines the number of offsets calculated. If the line is closed and the calculation is to be made towards the inside, all possible offsets can be calculated by entering "0".

1st offset

First offset

This values determines the clearance of the first offset path. Here you can allow for the stylus radius, the finishing allowance and wall thickness etc.; see examples.

Additional offsets

2nd... offset

This value determines the distance between the other offsets. Here, you can allow for the mill diameter if solid machining parallel to the contour is required.

Example of application of a 2D offset

A 2D outline has been digitized from the outside. A pocket is to be milled within the 2D outline, taking into account a wall thickness and allowance.

Specifications:

- stylus radius:	2 mm
- wall thickness:	3 mm
- allowance:	0.5 mm
- Mill radius:	5 mm
- file name:	e.g. UMRISS1.FMP

Two basic options are available for pocket milling:

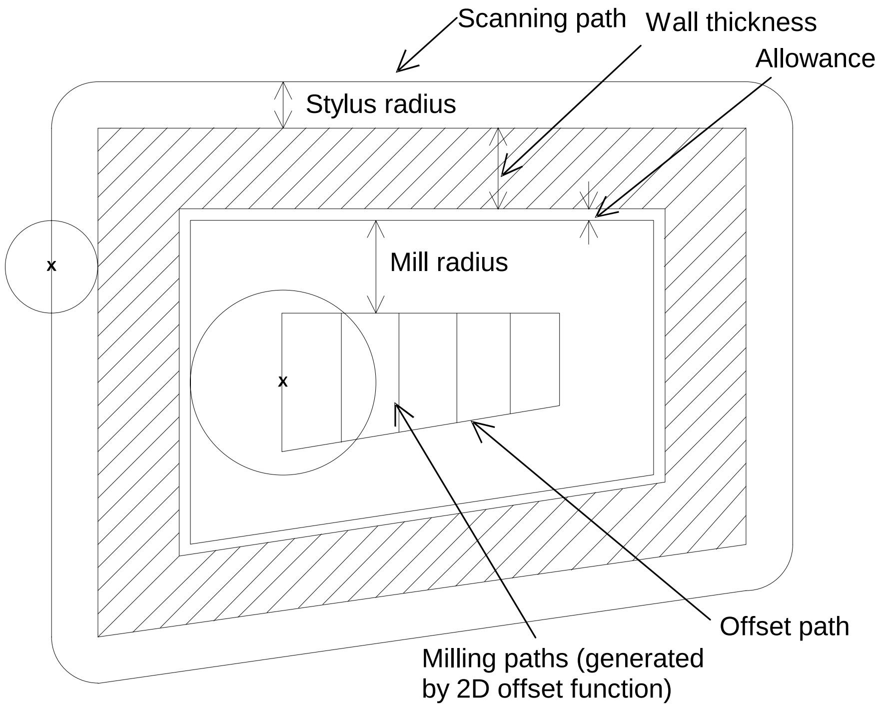
1) Meandering solid milling with the function *pocket milling*
2) Solid milling parallel to the contour with the function *2D offset*

Option 1):

Parameters for offset calculation and solid milling with the function *2D pocket milling* (Section 5.6):

- input file UMRISS1.FMP
- output file UMRISS1.OFF
- closed outline: yes
- calculate offset: inside
- number of 2D offsets: 1
- 1st 2D offset 10.5 (stylus radius+wall thickness +allowance+milling radius); only one offset

```
            outline scanning (*.FMP file)
                          |
offset calculation ——→|  (calc. inside offset - 10.5mm)
                          |
                          |
                          ↓
                  offset file (*.OFF)
                          |
pocket milling     ——→|
                          |
                          |
                          ↓
                    paths (*.POL)
                          |
NC code               ——→|
                          |
                          |
                          ↓
                  CNC file (*.CNC)
```

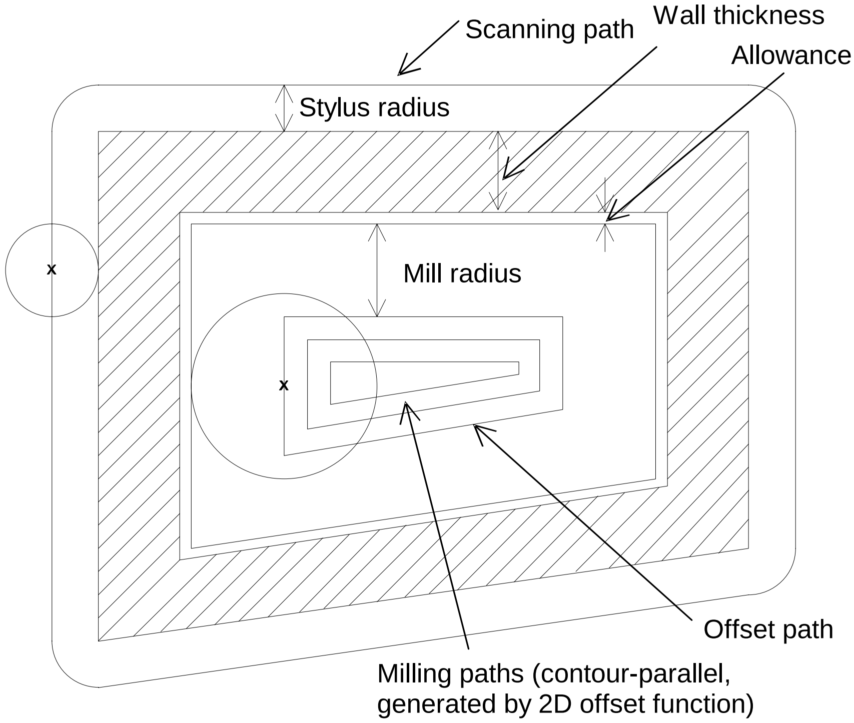


Option 2):

Parameters for solid milling parallel to the contour with the function *2D offset* (Section 5.5):

- input file	UMRISS1.FMP
- output file	UMRISS1.OFF
- closed outline: yes	
- calculate offset: inside	
- number of 2D offsets:	0 (all possible offsets)
- 1st 2D offset	10.5 (stylus radius+wall thickness +allowance+milling radius); only one offset
- 2nd 2D offset	5 (infeed = mill radius)

outline scanning (*.FMP file)
|
calculate offset ⟶ | (1st offset = 10.5mm,
| additional offsets = 5mm)
|
|
↓
offset file (*.OFF)
|
NC code ⟶ |
|
|
↓
CNC file (*.CNC)



Other application examples:

1. If an open line is calculated with a positive offset, the result is an offset to the right of the starting line with reference to the scanning direction.
2. If a closed line is calculated with a negative offset, the result is an offset that lies within the starting line (internal offset).

Restrictions:

- At the moment, only one fence or FMP path per plane can be entered.
- Solid milling parallel to the contour with the offset function is currently only possible for a polygon without island(s) per plane.
- Not more than approx. 5000 points per fence/FMP path, otherwise a reduction must first be performed.

Note:

An open contour can also be calculated as a closed contour. In this case, the contour is automatically closed by connecting the last point to the first point by a straight line.

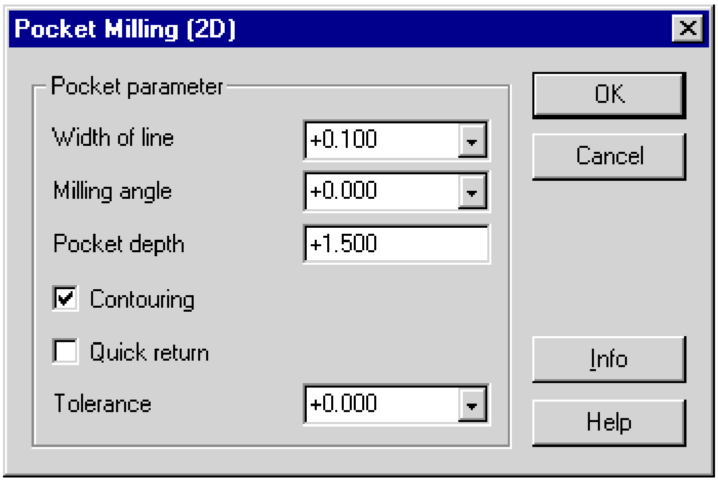
5.6 2D pocket machining

This function can solid mill pockets that are limited by a fence or outline file.

Input file

Fence/Polygon

Dialog box



Output file

Milling path with extension "POL"

The pocket is solid milled by line-shaped milling to a defined depth at any angle. Once solid milling is completed the machine can mill along the edge again as an option.

Pocket machining assumes "1:1 machining", i.e. the shape and diameter of the mill correspond to that of the stylus. The result of pocket milling can either be processed with NC Path or converted to an NC program. If "1:1 machining" is not to be performed or if a contour is to be scanned from the outside, a 2D offset must first be calculated (see Section 5.5, 2D offset).

Line width

Line width

The line width defines the distance between two successive paths. It should be smaller than the stylus diameter so that solid milling removes all the material.

Milling angle

Milling angle

The angle parameter (any angle between 0 and 360 degrees) determines the direction of the milling paths. Milling angle = 0 degrees lies parallel to the X axis; 90 degrees = parallel to Y axis.... The milling angle is positive in the counterclockwise direction.

Pocket depth

Pocket depth

The pocket depth is the depth to which the pocket is solid machined. If the pocket has to be divided into several roughing layers this is done with the function *path planning*.

Machine edge

Machine edge

To activate machining along the contour, select this option.

Rapid return

Rapid return

Milling can be performed with rapid return (i.e. milling in one direction only) or in reciprocation mode (i.e. milling in alternating directions).

Tolerance

Tolerance

The tolerance determines the number of fence points and the accuracy of the edge.

You can always use tolerance = 0 for small fences and should only define a tolerance for larger fences (max. 48,000 points).

5.7 Delete retraction points

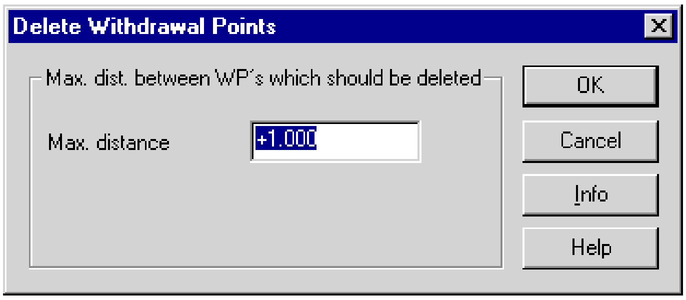
Retraction points are often generated in milling programs as a safety measure when milling paths are calculated. However, they are not always necessary. In the calculation of finishing paths this often happens when fence limitation is used. The end point of one line and the starting point of the next might be further apart than the actual line width.

The function described below is available for deleting these additional retraction points.

Input file

Milling path

Dialog box



Output file

Milling path with extension "NRR"

Max. distance

The only parameter of the function defines the maximum distance between one retraction point and the next point. If the points are further apart than this max. distance, that retraction point must not be deleted. This ensures that areas that have not been scanned continue to be passed at a safety height.

Caution: Relevant retraction points might also be deleted if the distance entered is too large. Look carefully at the critical points in the output file and reduce the distance if you are unsure.

5.8 Insert retraction points

Data that you read in from an external source may have been recorded/output in rapid return mode. If the resulting ASCII file does not contain any beginning or end of line identifiers, the lines cannot be divided up when the file is converted to the internal data format. Far worse, the movement from the end of one line to the beginning of the next might run directly through the part. These data must be prepared before they can be processed.

If a retraction point is inserted at the end of each line, infeed will then be performed on the retraction plane.

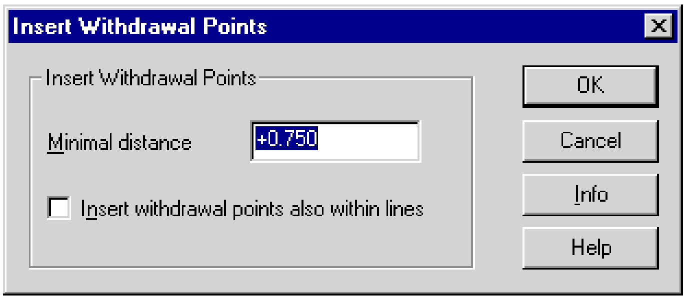
The parameter *distance* defines the maximum distance between two points that can be bridged without a retraction point.

Another application is for the processing of data from optical systems. Here again, it can often be helpful to insert retraction points.

Input file

Milling path

Dialog box



Output file

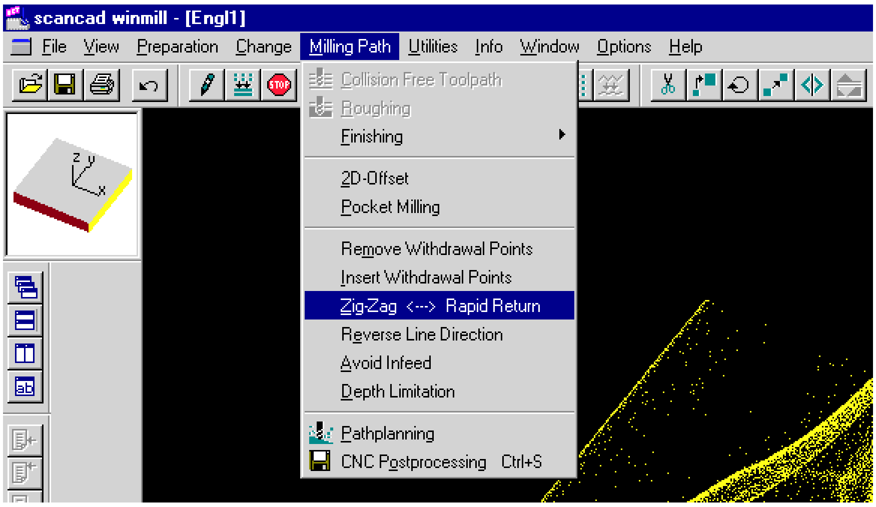
Milling path with extension "IRP"

5.9 Reciprocation <-> Rapid return

With this function, a milling path digitized or calculated in reciprocation mode can be converted to a file with rapid return movements. With it, milling paths that have already been calculated can be output to meet specific requirements. If the input file has been output in rapid return mode, the output direction is converted to reciprocation.

Input file

Milling path



Output file

Milling path with extension "EIL"

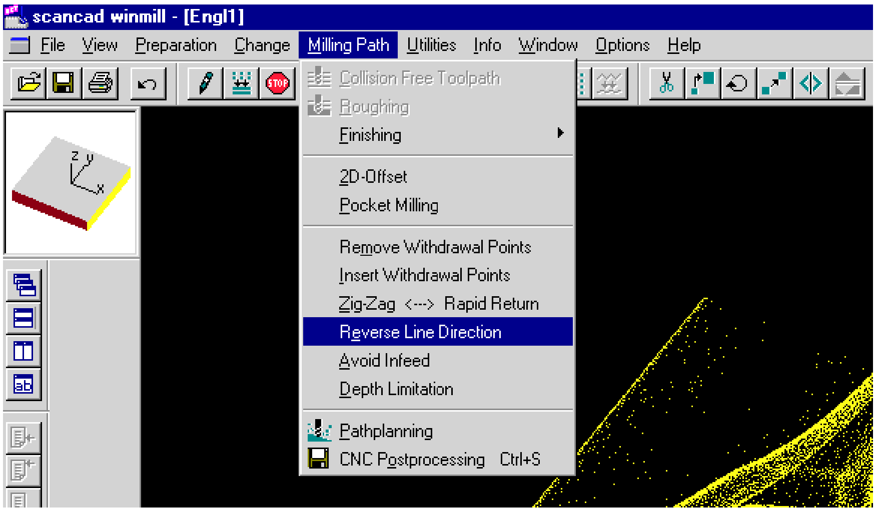
5.10 Reverse line direction

In order to produce a uniform milling pattern, the line direction can be reversed. In this way, the milling direction of two adjacent segments can be adapted to each other.

If a segment is mirrored, for example, the milling direction in the mirrored section is the reverse of that in the output segment. If both segments are to be milled, the milling pattern will be better if the line direction in the mirrored segment is reversed. Then the milling paths of the original segment and the mirrored segment run in the same direction.

Input file

Milling path



Output file

Milling path with extension "REV"

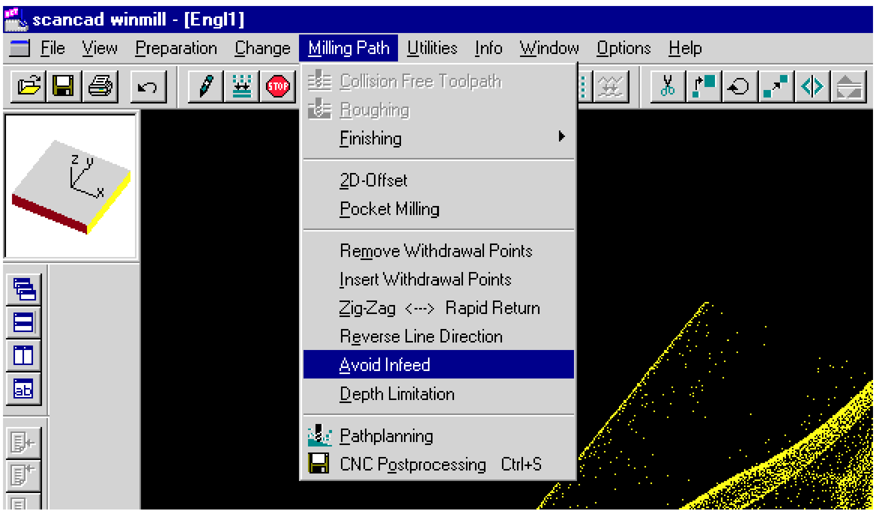
5.11 Inward interruption

When the milling paths are generated, the tool is moved both up and down. This might cause problems if a mill is used that cannot cut beyond the center. For very simple geometries machining can be implemented with the function *Inward interruption* which prevents the tool from plunging.

The function inward interruption is often used in combination with the function *Reverse line direction*. When the first machining operation is complete the line direction is reversed and then milled again with the function inward interruption.

On larger and more complex workpieces, however, you should use the other functions for creating a milling program for these special tools.. The roughing function offers you an easy-to-use calculation method for this purpose.

Input file Milling path



Output file Milling path with extension "OUP"

5.12 Depth limit

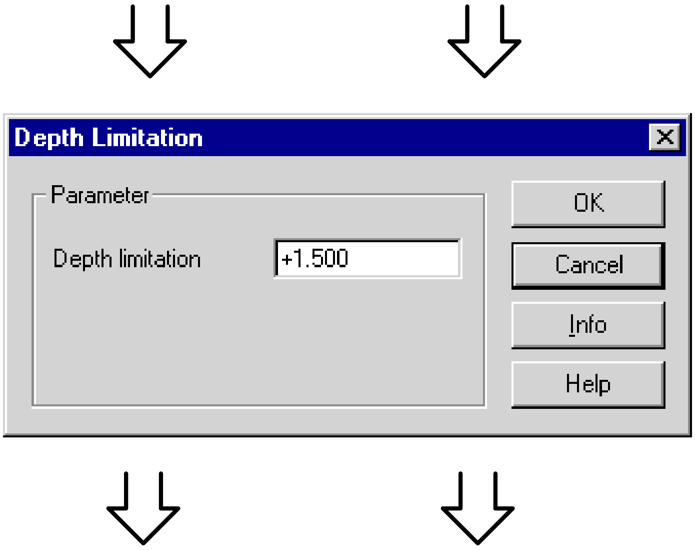
If the data acquired also include very deep areas that are not to be milled, these areas can be recalculated to be raised up to a depth limit. All values in the input file that are below this value are set to the depth limit. This prevents the tool from plunging too deeply.

Input file

Milling path

Contour

Dialog box



Output file

Path with extension "TGR"

Contour with extension "TGR"

5.13 Path planning

Previous version under DOS

The DOS version of scancad mill contained the function *NC code*. This function was used both for cut segmentation and for generating the actual control-specific NC program. One disadvantage of this combination lay in the limited possibilities for calculating NC paths. If an existing program was to be used on another NC control this often meant performing the entire calculation again.

Current software version under Windows

The current Windows version of scancad mill comprises two different functions for generating NC programs both of which are entirely separate:

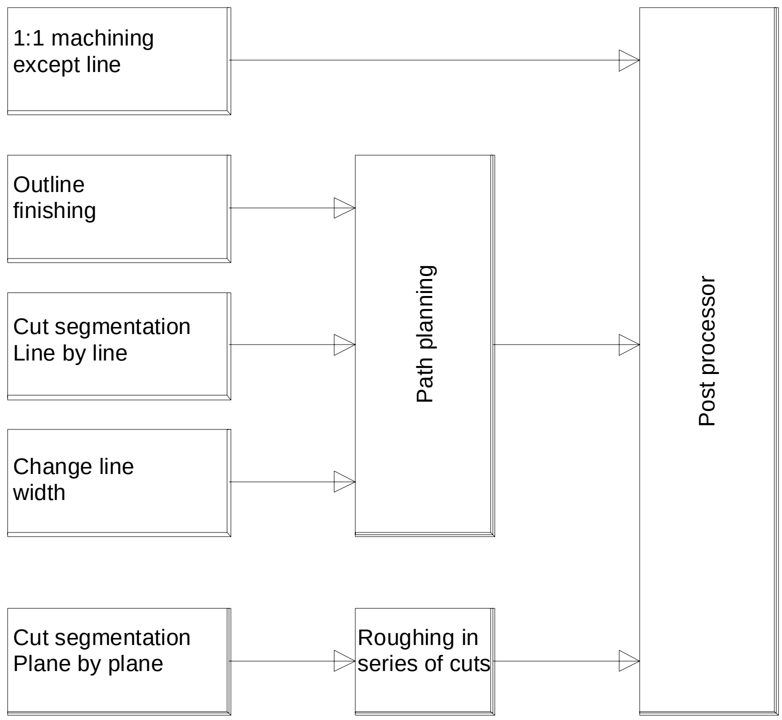
1) The function *path planning* described in this section is used exclusively to generate milling paths. Once they have been calculated, the paths are in a control-independent format and already include all the tool movements. Milling movements are displayed in yellow on the screen whereas infeed movements performed in rapid traverse are displayed in blue.
2) These paths can then be converted to the necessary format by postprocessing. It is then that the additional movements are generated.

Division of the calculation tasks provides a good basis for future expansion of the system and simplifies handling considerably. Path planning is the penultimate step in the NC machining chain.

But this does not mean that path planning has to be used in every single case. The roughing module, for example, generates output files that already contain all tool movements. Data produced directly by scanning can be used for simple 1:1 machining without using path planning. The unknown values for the retraction planes are then generated by the NC module.

An exception to this are the data scanned in the outline. Even for 1:1 machining these data have to be subjected to path planning because the sequence of the lines has to be reversed. (Scanning performed from bottom to top, milling in the other direction).

Path planning is usually only necessary if changes need to be made to the line width or if simple segmentation is to be performed. These relationships are clearly shown in the diagram below.



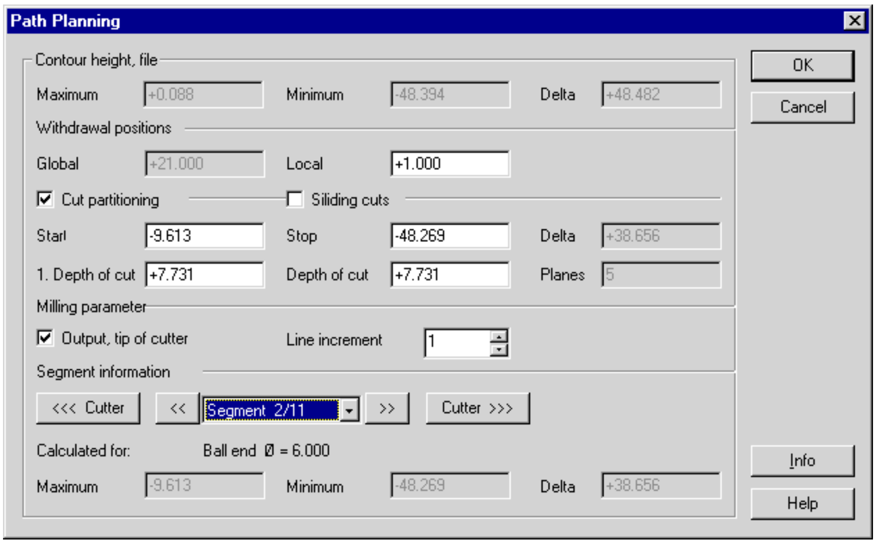
The user can influence the method by which the NC paths are calculated with several parameters. The meaning of these parameters is explained in detail in the following section. Tips on fast and simple operation of the function are also given.

The dialog box for calculating the NC path is divided in a compact and simple way into functions. Parameters which have to be specified for the entire model appear in the upper part of the dialog box. The lower part of the dialog box displays the parameters for the segment to which the above parameters belong.

Input file

Milling path

Dialog box



Output file

NC path with all tool movements with extension "NCP"

5.13.1 Retraction positions

Global retraction position

Retraction position (global)

Before it is positioned between two individual segments of the workpiece the tool is retracted to a "safe" height. This height, the global retraction position, is used to pass over the entire part.

The retraction height must be higher than the blank height. The default value is automatically calculated on the basis of the contour height (see information about the file in the upper section of the screen) of the entire digitized area with a 10 mm safety clearance.

Local retraction position

Retraction position (local)

Whereas the global retraction height is used for the movement between the individual segments, the local retraction height refers to movements within each segment. A low retraction height can therefore be specified for a lower or flat segment because the mill will return to the global retraction height when it moves on to the next segment. The lower limit for the local retraction height is the maximum height of the segment in question plus a safety clearance. The segment height is specified in the lower section of the dialog box.

5.13.2 Cut segmentation

Machining type

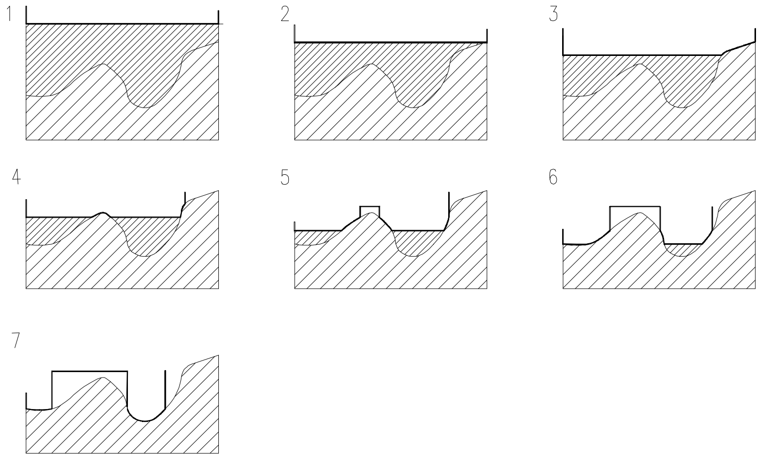
For many types of machining it is not possible to used the scanned paths directly for NC manufacturing. Frequently, different tools are used (see calculation of a collision-free tool path) or the milling operation has to be divided up into several steps to prevent overloading the tool. These calculations can be performed by a special method with the function *Roughing*. If machining in layers is not necessary, path planning can be used to produce line-oriented cut segmentation for calculating the NC milling paths.

Cut segmentation "OFF"

For simple machining operations without cut segmentation, the milling paths in the file are processed without changing the machining type or sequence. If cut segmentation is disabled the input fields for the cut parameters are also deactivated.

Cut segmentation "ON"

For operations with cut segmentation the NC paths are divided into layers. The input fields for cut segmentation are now activated. Machining is performed in lines! Areas that have already been machined are passed over at an automatically adapted retraction height. The principle of this cut segmentation is shown in the following figure:



Machining with cut segmentation "ON"

Parameters for cut segmentation "ON"

Start

Start

Enter the height of the blank. Cut segmentation starts here with the first infeed.

The maximum height of the scanned area is suggested (see figure). However, a larger height can be selected.

Stop

Stop

The stop position is the height at which the last milling path is to be traversed. The minimum height of the scanned area is suggested (see figure). If the workpiece is not to be milled right to the bottom, enter a stop height that is higher than the suggested value.

1st cutting depth

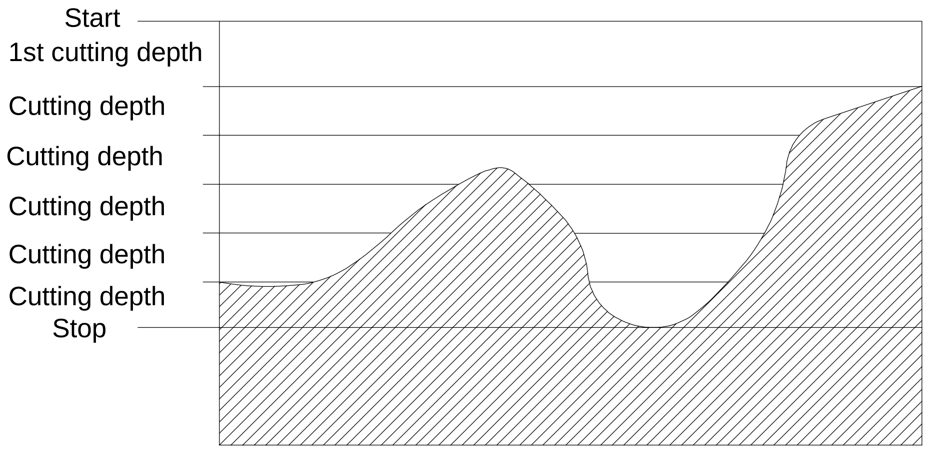
1st cutting depth

Here, you define the first cutting depth (see figure). It does not have to be identical with the remaining cutting depths.

Cutting depth

Additional cutting depths

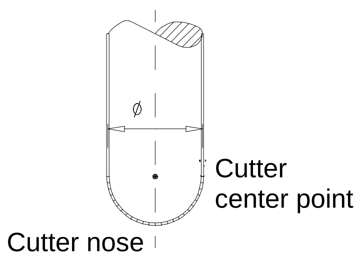
The value you enter here specifies the depth of each subsequent cut (see figure). At the end of machining this value might be reduced automatically if a full infeed to the bottom is no longer possible.



5.13.3 Milling parameters

Output cutter nose (for spherical cutters only)

Here you can define whether the coordinates of the cutter nose ("ON") or of the center point of the milling cutter ("OFF") are to be output as the NC path. You an output the digitizing data in a format familiar to you from your NC operations.



Line increment

Line increment determines the width of the cut

Multiples of the line width (2 x, 3 x...) used for scanning or calculation of collision-free tool paths can be used to generate the tool paths. If, for example, only every second line is to be machined, the tool is lifted at the end of a machined line, returns to the local retraction height and then performs an infeed movement at the beginning of the next line. Rapid return mode is used automatically. If, for example, only every third line is to be machined, the tool again retracts at the end of the machined line for safety reasons, and then infeeds to the beginning of the next line to be machined. This lifting movement prevents damage to the part.

5.13.4 Segment information

The digitizing data are processed segment by segment with the function *path planning*. Important information about the segment is displayed at the bottom of the screen to guide the user through the input file. As path planning only works with milling path files, the current milling cutter diameter is also displayed. If you want to change it, recalculate the collision-free tool path for other milling cutters.

At this stage you will usually have to define the path planning for every segment in the input file. To save time with the entries for each individual parameter, the dialog box contains buttons with which you can jump from segment to segment quickly. You will find these buttons in the lower section of the dialog box to the left and right of the display for the current segment (*next segment / previous segment*). To the right and left of these buttons you will find further buttons that take you to the next or previous milling cutter (*next mill / previous mill*).

Operation with these options is described here in more detail. Let us assume for this purpose that you want to process a file with several segments. The segments have been calculated for different milling cutters.

When you call the function, the dialog box for path planning of the first segment appears on the screen. In the lower part you can see the parameters for the segment, the buttons *next segment / previous mill* are activated. Now enter the parameters for the current segment. When you have completed this entry you can jump to the next segment of the file with the button *next segment*. You must make sure that the system has automatically accepted all the information from the dialog box for segment 1. In most cases, this method will save you a lot of time because the cut segmentation, for example, does not have to be entered again each time. Of course, you can change the values entered by the system whenever you wish, if this is necessary because a different cutter is being used.

You will want to enter different values for small and large tools. Using this method you can move quickly through the individual segments. When you have completed the dialog box for the last segment you can start calculation by clicking on the *OK* button.

It is important that the system automatically accepts the values of the previous segment. This procedure can be used to reduce the number of entries you have to make even more. If you complete a box for a particular segment and then jump to the first segment that was calculated for a different cutter, all the intermediate segments are processed with the same parameters as the first segment. So when you jump to the next cutter the parameters are not lost. You can therefore also define the type of machining by jumping to different cutters. The best input method for your individual applications will depend heavily on the type of input file. Test the behavior on a small file that consists of several segments using different cutters in some of them.

5.14 NC code generation

The new function *NC code generation* is the last step towards generating an NC program. Up until this point all tool movements exist in a neutral format. Postprocessing finally produces a program that will run on your machine.

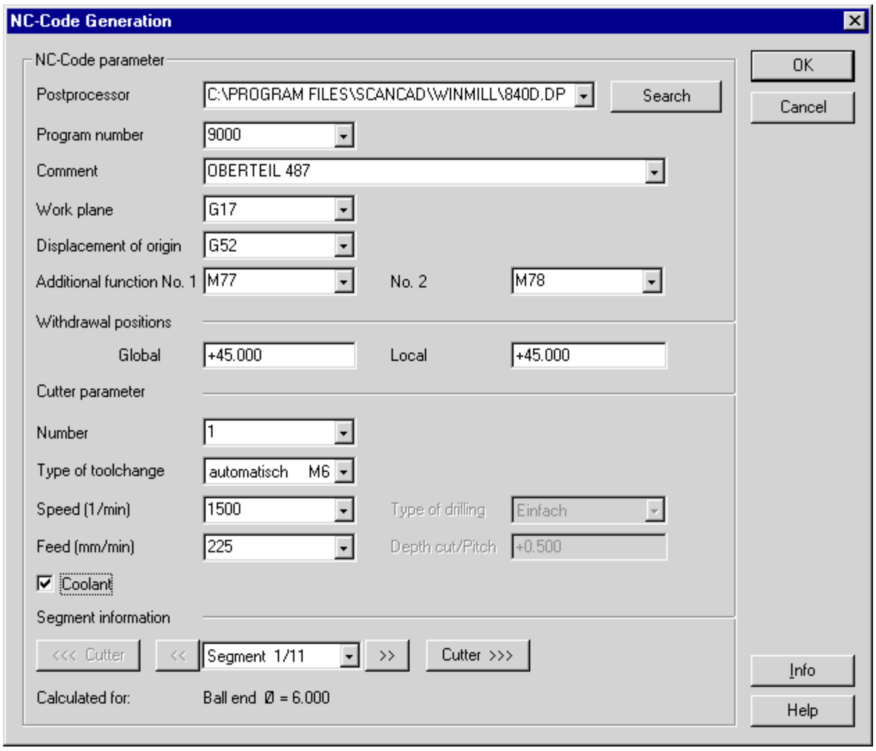
Unlike the DOS version, this function does not calculate any additional tool movements. Cut segmentation during NC code generation is therefore no longer possible (see Section 5.13, Path planning). The input file for this function must already include all tool movements. This might be a file calculated with the roughing function or an output file of the path planning function. Data directly acquired from digitization can also be used for input. These data, however, can only be used for 1:1 machining along the digitization path. This is intended as a fast calculation method for generating finishing programs directly on the scanning data. All changes regarding line width, etc. are executed by the path planning function.

All important technological parameters for the machining process can be defined during conversion of the milling paths to the actual NC code.

Input file

Path planning file, roughing file, milling path

Dialog box



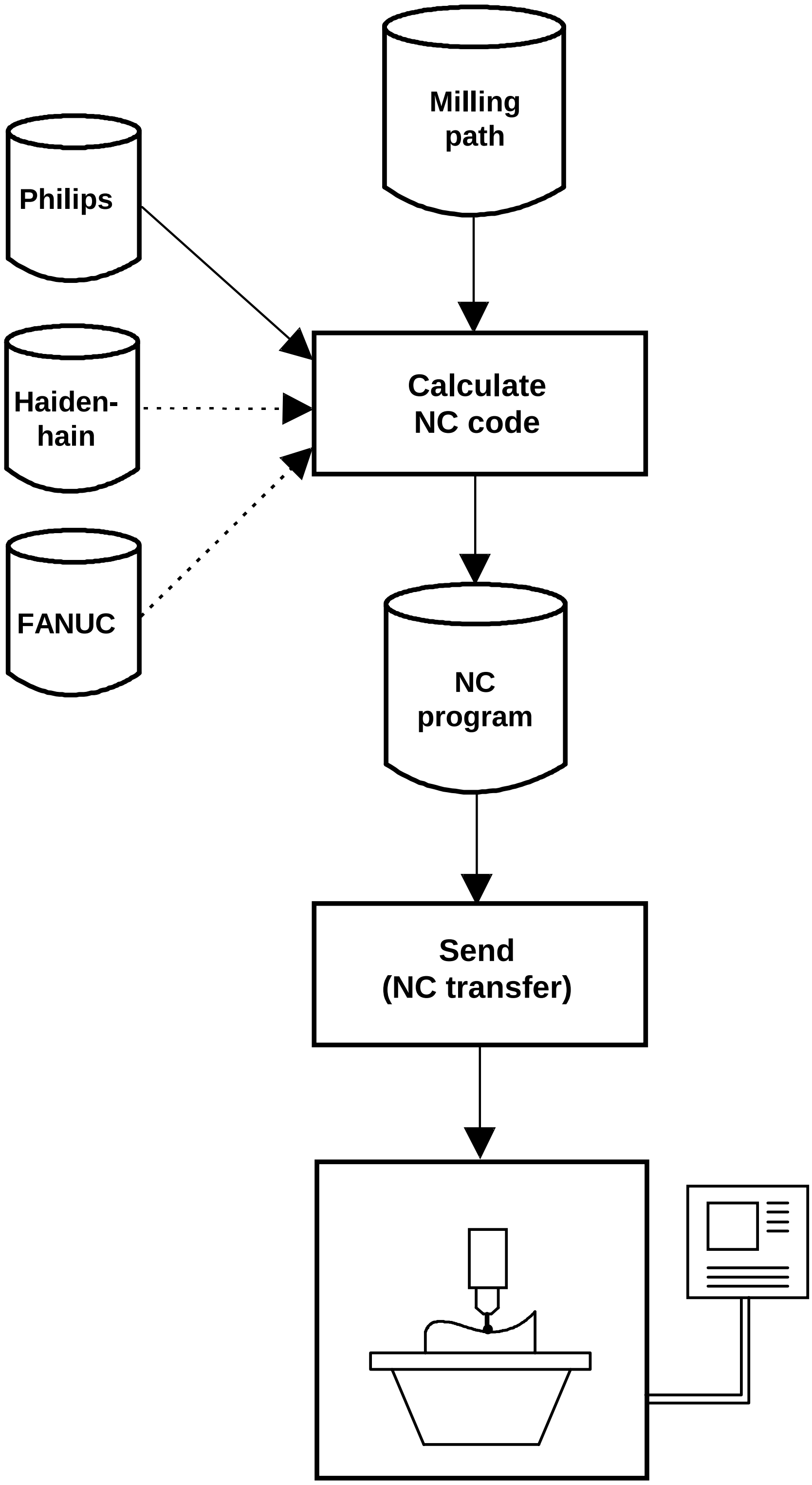
Output file

NC code depending on the selected postprocessor

The actual output format of the NC code depends on the NC postprocessor used. A selection of postprocessors for all common NC controls is available. If several postprocessors exist because the scanning data are to be processed on different controls, you can select the processors you need from a drop-down menu.

The NC program can be sent from the PC directly to the machine via a transmission program (see diagram below).

The individual parameters required for NC processing are described in the following section.



Schematic diagram: NC module with postprocessors

5.14.1 NC code generation parameters

Post processor

Post processor

If several postprocessors are installed, select the postprocessor you want here.

Program number

Program number

The program number is transferred to the NC program. It can also contain letters if the control is set up for this. Please consult the control manual to find out which entries are permitted. Caution: No range check is performed!

Comment

Comment

You can enter any comment after the program number. Select a comment that will help you find the correct program later on.

Machining plane

Plane selection

You can make your selection from one of the usual machining planes (G17, G18, G19). Transformation for each plane is defined in the post processor. You can change these transformations in special cases.

Zero offset

Zero offset

You can activate a zero offset for the control in question. To activate it enter the zero point designation for your control (e.g. G54).

Miscellaneous function No. 1 / No. 2

Miscellaneous functions

Two fields are available for entering special NC commands. The entry within the fields can be made in any way. The field entries are accepted directly into the NC program by the appropriate postprocessor.

5.14.2 Retraction positions

Retraction position global
(only for 1:1 milling of *.FMP files)

Retraction position (global)

Unlike files that are generated with the roughing function or the path planning, the original scanned data do not contain any information about retraction heights. During scanning, values can be used that are not useful for NC machining. That is why the retraction heights have to be defined when the scanned data are processed.

The height of the global retraction position is used to travel over the entire part. This value must be higher than the blank height. The suggested value is calculated using the maximum height of the entire digitized part (+ 10 mm safety clearance).

Retraction position local
(only for 1:1 milling of *.FMP files)

Retraction position (local)

The local retraction position refers to the segment in question. A low retraction height can therefore be specified for a low segment because the mill will return to the global retraction height when it moves on to the next segment.

5.14.3 Tool parameters

Number

Tool number

Enter the number of the tool you are using here. The input range depends on the control.

Changing method

Changing method

Here you can choose from:

- automatic:	Tool change automatic (M6)
- manual:	Tool change by hand (M66)
- load data only:	The tool is already in the spindle, only load the tool data from the memory of the control (M67)

Speed

Spindle speed

The value for the spindle speed entered here is taken over unchanged into the NC program.

Feedrate

Feedrate

This value defined the feedrate required for normal machining. A different feedrate can be calculated for engaging the tool by a factor that can be set in the postprocessor.

Coolant

Coolant

With the checkbox *Coolant* you can activate or deactivate the coolant supply.

5.14.4 Segment information

The digitizing data are processed segment by segment by the postprocessor. The number of the current segment is displayed together with the corresponding tool. You can select different technological values for each segment.

In order to simplify input, only those values that can actually be changed can be entered for all subsequent segments. Fixed values such as the program number and machining plane are only displayed for information purposes.

In most cases, however, all the segments of an input file are processed with the same technological data, in which case the data of the previous segment can be accepted. To move within a file you can use the *previous/next* segment buttons and if the segments contain different milling cutters, the *previous/next mill* buttons in the same way as you do for path planning. The method by which values are taken over from the previous segment corresponds to the mechanism described in Section 5.13.

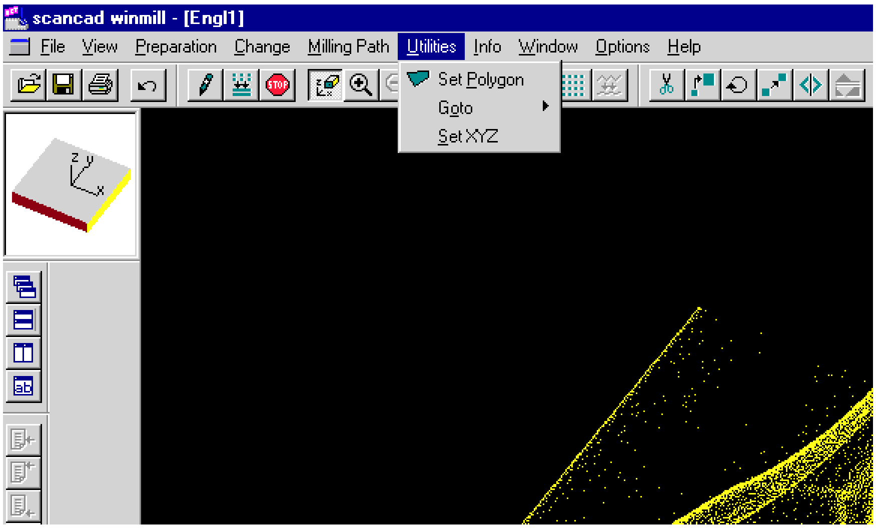
Example of a CNC file with a Philips postprocessor (abridged)

```
%PM
N9001
N1 (TRIAL DATE 31.03.1993 )
N2 (SCANNING DATE 31.03.1993 )
N3 (PROCESSING DATE 31.03.1993 )
N4 (Segment: 1/1 )
N5 (stylus diameter 10.000 mm VABTAST 900 mm/min )
N6 (Tolerance ONLine: 0.05    OFFLine: 0.1 )
N7 (milling path calculated for mill diameter.: 10.000mm)
N8 (metal thickness: 0.000 mm )
N9 (diameter of end mill to be inserted: 10 mm)
N10 (working range: file )
N11 (Xmin: 0.000 Xmax: 170.000)
N12 (Ymin: 10.000 Ymax: 35.000)
N13 (Zmin: 10.000 Zmax: 50.000)
N14 (working range: segment )
N15 (Xmin: 0.000 Xmax: 170.000)
N16 (Ymin: 10.000 Ymax: 35.000)
N17 (Zmin: 10.000 Zmax: 50.000)
N18 G18
N19 G52
N20 T1 M6
N21 S500 F300
N22 M03
N23 G00 Y285.638M09
N24 G00X-165.404Z335.638
N25 G01Y277.638
N26 X-165.403Z335.631Y277.626
N27 X-165.324Z335.617Y277.585
N28 Z335.463Y277.576
N29 X-165.347Z330.938Y275.638
N30 X-165.091Z147.453Y278.038
              .
              .
N1212 X-14.083Z331.060Y246.286
N1213 G00Y285.638
N1214 G00X-4.577Z323.273
N1215 G00Y266.286
N1216 G01Y246.286
N1217 X-4.798Z293.080Y244.526
N1218 X-4.876Z257.539Y241.415
N1219 X-4.537Z162.448Y246.286
N1220 G00Y285.638
N1221 G51
N1222 M30
```

Notes

6 Auxiliary Functions

Menu



Functions

This section describes how the various auxiliary functions work and how to extract specific information about the current file. You will find the functions under menu items *auxiliary functions* and *Info*. The following functions are available:

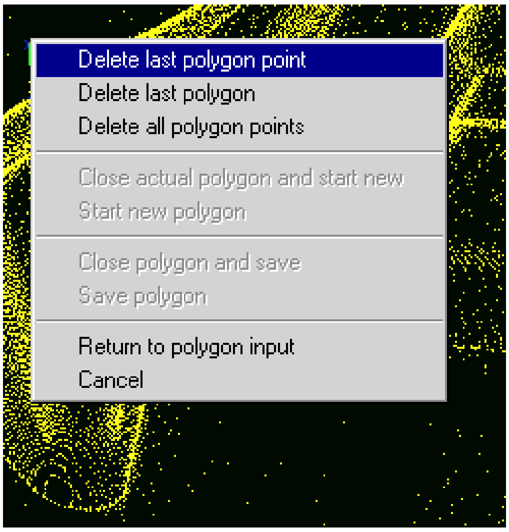
6.1 Polygon	Activates polygon definition
6.2 Go to	Goes to a specific position in the ASCII display
6.3 Set XYZ	Defines axis values

6.1 Polygon

The *polygon* function is used to enter areas/lines which can then be processed separately.

This function is used to define these boundaries - also called fences. Once the function is activated, it waits for you to enter the corner points of the polygon. While you are entering values, the cursor pulls the actual line like an elastic band behind it. The lines of the polygon that have already been defined are displayed in green, the elastic band in white. At this point you can call up a special context menu with other functions for entering or changing the boundary lines. Press the right mouse button to open the context menu. This menu contains all the functions that you will need to edit the boundary lines. You can delete the last point the entire polygon in this way. You can create new polygons and close and save existing ones. Automatic closing causes a line to be generated that coincides exactly with the starting point of the polygon. You do not therefore have to pinpoint the starting point exactly.

Context menu



The menu contains the functions:

- Delete last polygon point
- Delete last polygon
- Delete all polygon points
- Close polygon and start new one
- Start new polygon
- Close and save polygon
- Save polygon
- Back
- Cancel

To close input either select *Cancel* or a menu item that allows you to save/back up your entries.

You should choose extensions that show what the file contains, for example:

- *.LIN for line
- *.FEN for fence
- *.GUI for guide line.

In the way described above you can thus enter:

- Boundaries (*.FEN) for XZ, YZ and oblique milling,
- lines (*.LIN) for line milling and
- guide lines (*.GUI) for milling along guide lines.

See also Section 5.4, Finishing.

6.2 Go to

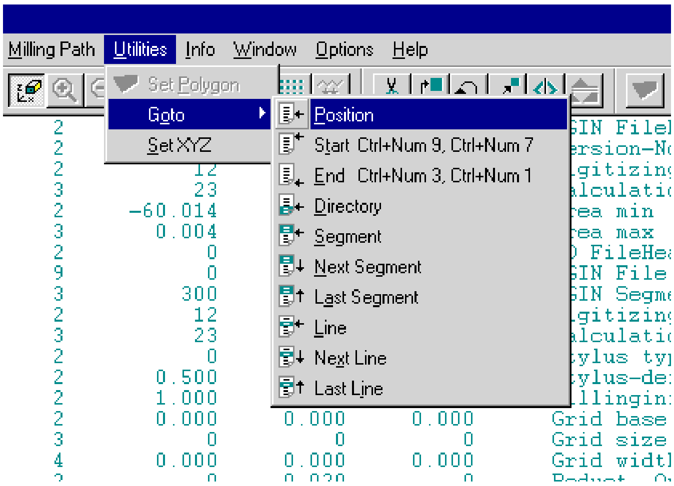
Menu: "Window"

Via the menu *Window* you can display a file in ASCII mode. This display mode shows the contents of the file in the format in which it is used internally by the scancad system.

Scanning files are usually very large and often contain several thousand lines. The submenu *Go to* will help you to move through this ASCII view much more quickly. It contains all the functions required for quick positioning.

Supports positioning to:

- a particular data record
- the beginning of the file
- the end of the file
- the beginning of the directory
- a particular segment
- the previous segment
- the next segment
- a particular line
- the previous line
- the next line



Toolbar

These positioning options are also contained in the toolbar which can be activated via menu item *View*, *Toolbars*.

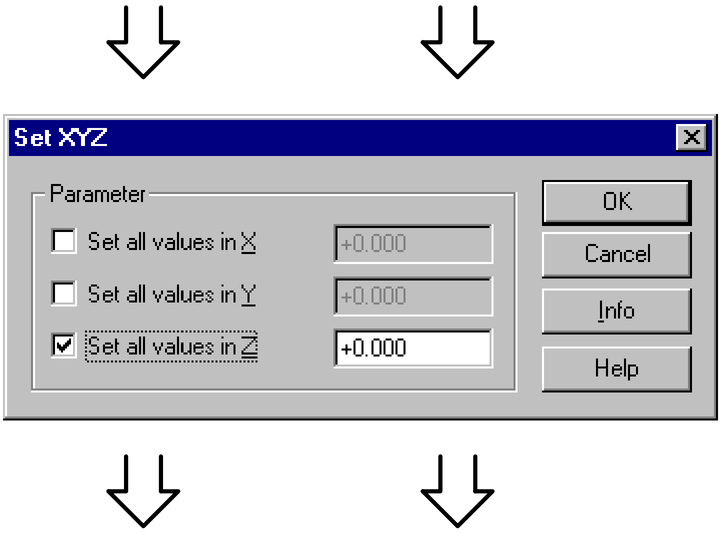
6.3 Set XYZ

In some applications (especially 2D), it can be helpful to set the value of a coordinate to a particular value. For a single outline the Z coordinate can thus be set to a defined value. Any variations in the Z direction can thus be eliminated.

Input file

Path Contour

Dialog box



Output file

Path with extension "SET" Contour with extension "SET"

Set all values in X, Y or Z

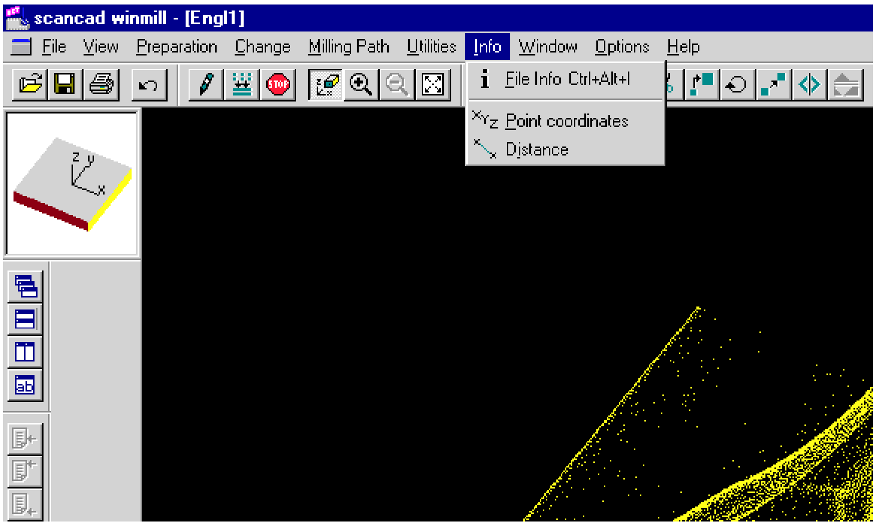
New values for in X, Y, Z

Mark the axis or axes whose coordinates you wish to define and enter the values at which the coordinates of the individual axes are to be set.

Notes

7 Info

Menu



Functions

You will find the following functions under menu item *Info*:

7.1 File info	Displays file information
7.2 Point coordinates	Displays the coordinates of points
7.3 Distance between points	Displays the distances between two points

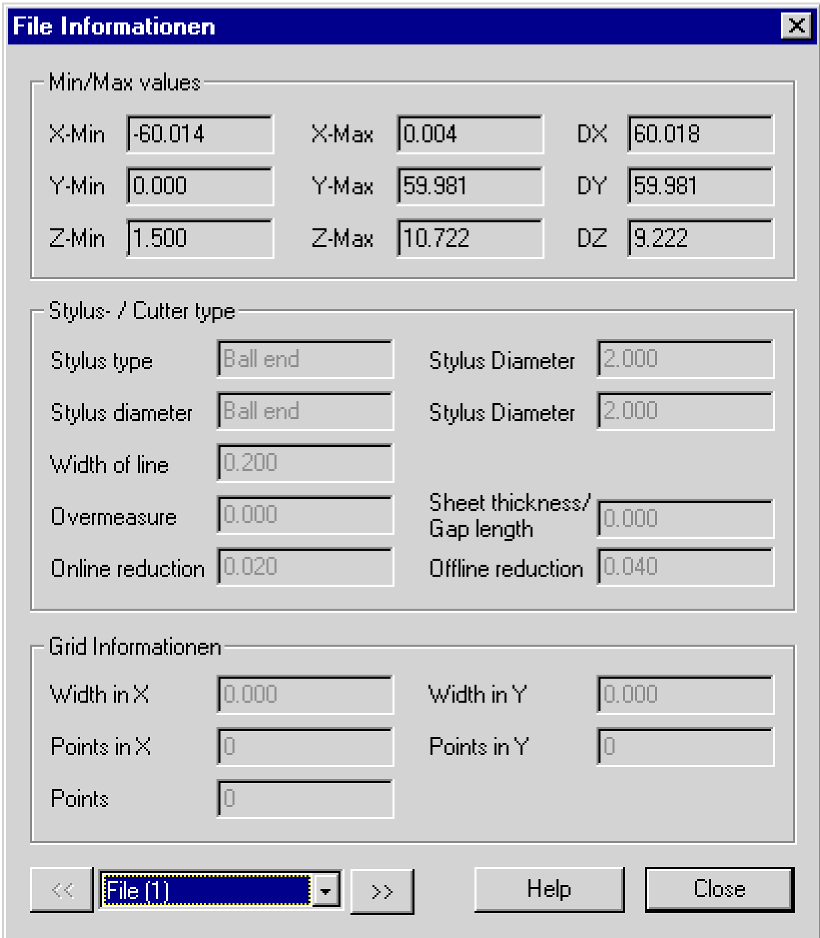
7.1 File info

Scanning and milling information

The function *File info* displays the most important scanning and milling information on the current scancad files in a window. Information both about the entire file and individual segments is given.

You can also call this info window from several dialog boxes by pressing the info button.

Info window



Segment selection

If the file consists of several segments you can call up information about following/previous segments via buttons. To call up a segment directly, you can select it from a list. As often very large volumes of data have to be read from the hard disk, it may take a few moments before the data for the segment in question can be displayed.

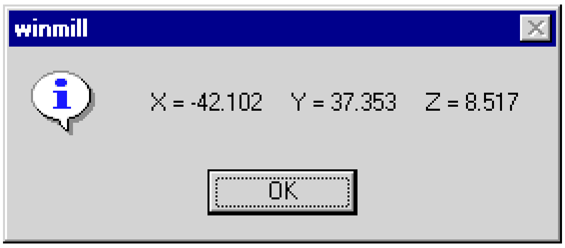
7.2 Point coordinates

Whereas the function *File info* displays important information about the entire scanning segment, the functions *point coordinates* and *distance between points* give special localized information about the scanning data.

Point coordinates

When processing scanning data it can sometimes be helpful to display the coordinates of a particular point in the data set. To do this, select the function *point coordinates* and then pick the point in question in the display.

Info window

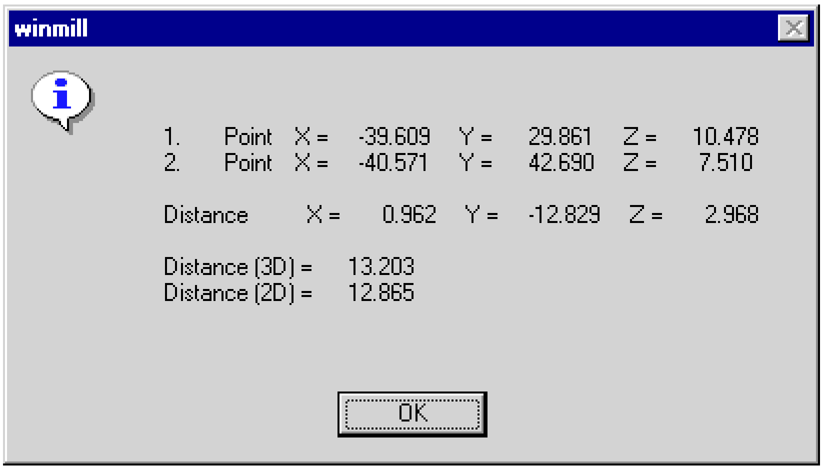


7.3 Distance between points

Distance between points

You can select the function *distance between points* to measure the distance between two points. When you have picked the two points in question, the distance is displayed both in 2D and 3D.

Info window



Notes

Index

Appendix

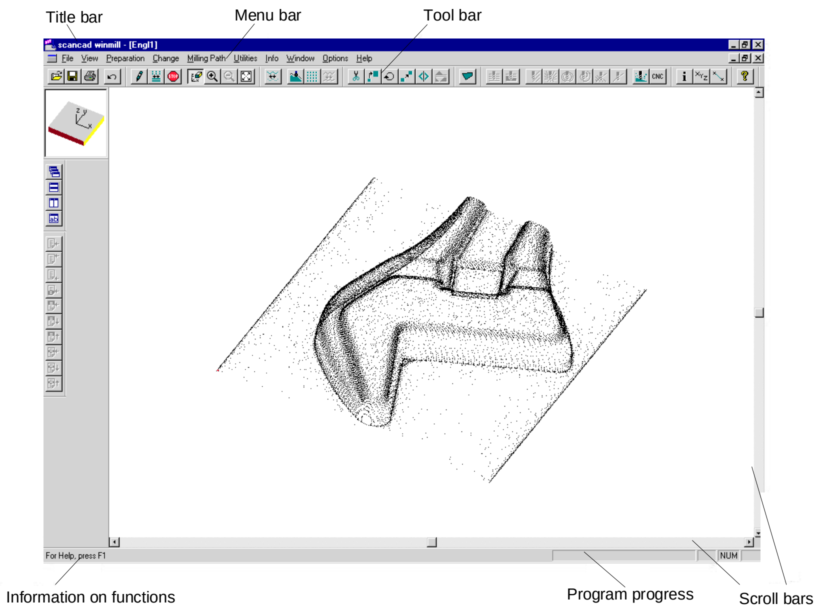
This section deals with the following topics:

A.1 Files	An explanation of the scancad file system
A.2 File types	Description of the file types
A.3 Filename extensions	A list of the different filename extensions
A.4 Graphic-interactive operation	An introduction to Windows operation
A.5 Shortcuts	A list of the most important key combinations (shortcuts)
A.6 Toolbar buttons	Fast program selection via toolbar buttons

Program start

After you have started a scancad program module, the main menu appears on the screen. Let us take a look at the screen layout first.

Main menu



For a general description of handling typical Windows elements, see Section A.4 below.

A.1 Files

The complete designation of a file consists of the drive letter, the path, and the filename with its extension:

drive:\path\FILENAME.EXT

C:\DATEN\KUGEL1.FMP

Drive C:

The drive letter designates the data medium on which the file is located. Usually, diskette drives are named "A:" or "B:", and "C:" is used for the hard disk drive.

Path
\DATEN

The path describes the position of the file in the directory structure. The first "\" after the drive letter stands for the root directory, which is followed by one or more subdirectory names, each separated off by a "\". The filename is also separated from the path by a "\".

Filename and extension
KUGEL1.FMP

The filename can consist of up to 256 characters. It is followed by the extension separated from it by a ".". The extension must be three characters long.

Caution: Do not use blanks! Filenames containing blanks cannot be used by scancad programs.

Entry of filenames is facilitated by the use of "jokers" (also called place holders or wildcards). These are used in place of one or more characters of a filename or extension. The *Open file* dialog box shows all the subdirectories and files in the current directory.

To simply entering filenames for complicated processing operations still further, it is possible to select a file from a list of the last 4 to 10 filenames entered from the file menu.

Input file
(scancad mill)

The input file contains the output data of each calculation. It is not altered by the calculation.

Output file
(scancad mill)

The output file is generated by applying the various calculation functions to the input file. Usually, the output file is assigned the file name of the input file with a new function-dependent extension. You can change the file name but you should accept the default extension.

A.2 File types

A.2.1 scancad scan/laser

Different file types are used by the program system scancad scan. Unlike extensions used to keep order amongst the files, files with different file types have different logical contains. You cannot simply mix them up. The meanings of the individual file types are explained briefly here.

Path

A path file contains probe and milling cutter center points. This file contains the path that describes the probe tip or laser point when digitizing a part. You can use these data for direct milling (milling cutter geometry/radius = probe geometry/ radius). This type of file is called "path" here. It is the most important file type.

Scanning project

Files of this type contain a complete description of the scanning process. All data about digitizing, e.g. division into segments, parameters of each segment, and the associated limits, are stored in this file. The actual scan data are not included. With these project files it is easy to repeat a scanning operation. For example, if a model has been modified, you can use the project file you created previously to scan again. Of course, this only works if the segment structure can be taken over.

A.2.2 scancad mill

Different file types are used by the program system scancad scan. Unlike extensions used to keep order amongst the files, files with different file types have different logical contains. You cannot simply mix them up. The meanings of the individual file types are explained briefly here. Many of the scancad mill functions do not change the file type as a result of the calculation. Functions that make changes are listed in a table at the end of this section.

Path

A path file contains probe and milling cutter center points. This file contains the path that describes the probe tip or laser point when digitizing a part. You can use these data for direct milling (milling cutter geometry/radius = probe geometry/ radius). This type of file is called "path" here. It is the most important file type.

Contour

Files of this type contain a model description in the form of surface points. Depending on the scanning method used, these data are either available immediately after scanning (laser digitizing) or must be generated by simulating the scanning procedure (contour calculation).

The surface points cannot be used directly for creating a milling program because controls cannot calculate a cutter compensation on the basis of these data.

The module *collision-free tool path* calculates these offset tool paths so that the NC control does not have to perform radius compensation.

ASCII

This file contains data that can be processed with any common editor or word processing program.

Fence

This file contains a boundary acquired by scanning (see also fence acquisition in the documentation for the digitizing system scancad scan and laser).

Caution: Many functions such as cutout, translation and rotation do not change the file type.

The following table gives a summary of the functions that change the file type:

Function	Input file type	Output file type
Contour calculation	Path	Contour
Collision-free tool path	Contour	Milling path
NC code	Path	ASCII
Export functions	Path	ASCII
	Contour	ASCII
Import functions	ASCII	Path
	ASCII	Contour

A.3 Filename extensions

A.3.1 scancad scan/laser

The filename extension listed here are only used to distinguish files. They are not binding. All extension must consist of three characters!

FMP: File with digitizing or milling paths
SCN: Project files with data for scanning but without scanned data

A.3.2 scancad mill

The filename extension listed here are only used to distinguish files. They are not binding. All extension must consist of three characters!

ASC: ASCII file
AUS: Output file of the cutout calculation
AUF: Output file of an allowance calculation
BLE: Output of the gap width calculation/metal thickness
CMB: Extension of complete file after merging
CMP: Interpolated file
DAT: Output file of the shrinkage calculation
DEL: File from which outliers have been deleted
EIL: Rapid return file
FEN: Input file for pocket machining (fence)
FIL: File after outliers have been filtered
FIN: File with finish machining
FMP: File with digitizing or milling paths
FUL: File after holes have been filled
IGS: IGES file
IRP: After insertion of retraction points
KOL: Collision-free tool path
KON: Output file of 3D contour calculation
KOS: File with roughing in vertical layers
MIR: Output file after mirroring
NCP: File with full tool path
NEG: Output file of negative calculation
NRP: File from which retraction points have been deleted
OFF: 2D offset file
OFL: Spline offset file (special application)
OUP: File with calculated inward interruption
OUT: File with reduced data set
POL: Output file for pocket machining (fence)
REV: Line direction has been reversed
ROT: Output file for rotation

RST: Contour calculation after 3D contour conversion

SCA: Scaled contour description

SET: Output file for function *set XYZ*

SPL: Output file for spline calculation (special application)

SMO: Output file after smoothing function

TGR: Output file after calculation of depth limit

TRA: Output file for translation

VDA: File with description in VDAFS 2.0 format

CNC, HNC, FIA...: NC code file (depends on postprocessor)

A.4 Graphic-interactive operation

This section explains terms and basic actions that are used both by Microsoft Windows 95, and within the scancad program system.

A.4.1 Using the mouse

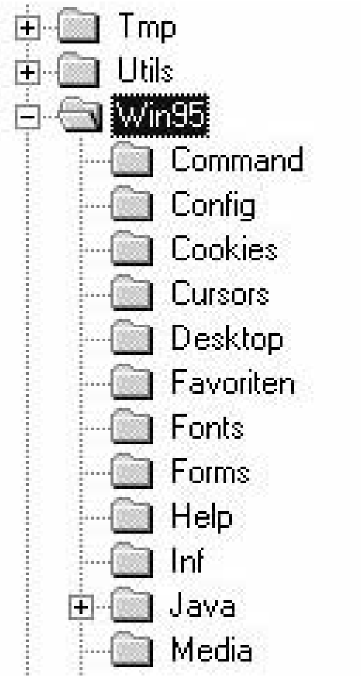
A mouse works on the principle that you first select an element on the screen and then click it with a mouse button to execute an action on the element. When you move the mouse on a flat surface, the mouse cursor moves on the screen. For long movements, you can lift up the mouse and place it elsewhere on the flat surface. Once the mouse cursor is on the required element or the required area of the screen you can execute one of four different actions.

Clicking:	You can press the left mouse button. This is used to select and start functions, for example.
Double-clicking:	Press the left mouse button twice in quick succession and then release it.
Clicking with the right mouse button:	Press the right mouse button briefly and then release it. This is used to call up a context menu, if one is available.
Dragging:	To move an element to another position, you must first point to the element. Then drag the object to its new position holding the left or right mouse button pressed. After that, you can release the mouse button again. By dragging with the mouse, you can select texts, entries, etc.

A.4.2 Task bar

In a standard configuration, the task bar is displayed on the lower edge of the screen. It contains the *Start* button. You can also drag this bar to another position as described above. Simply click on an empty part of it.

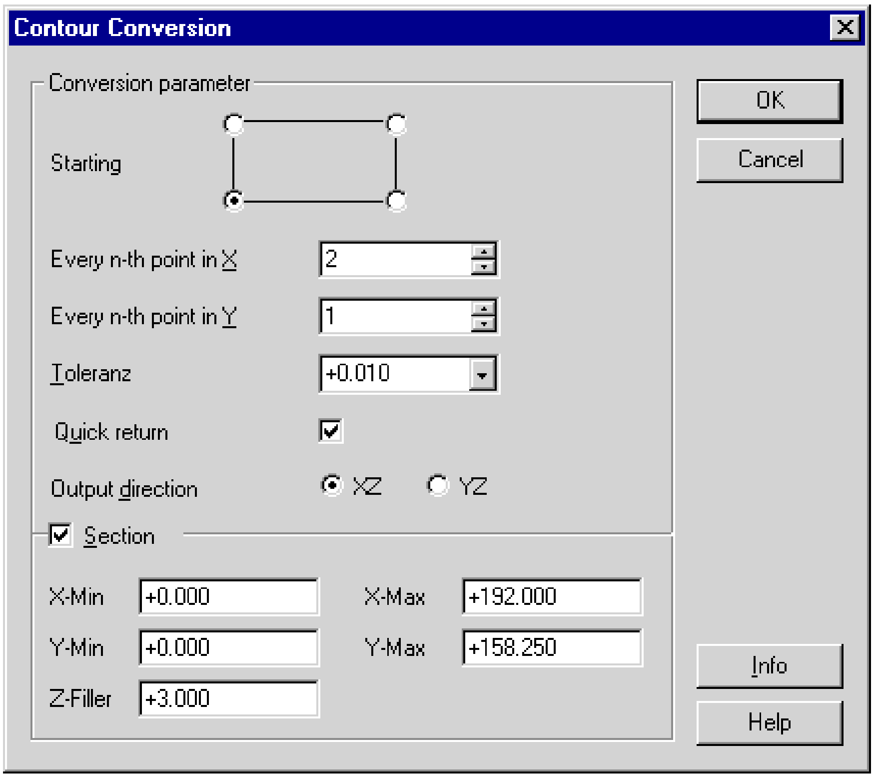
A.4.3 Tree structure



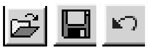
A special display is used to display hierarchical structures. If you click on a node with a plus sign, the level below that is selected. This nesting of sublevels under main levels can be repeated any number of times. After a more detailed level has been opened, you can return to the less detailed structure by clicking on the minus sign. The must frequent use of this type of display is for the Windows Explorer. Here, the directories/subdirectories are displayed in a tree structure.

A.4.4 Dialog box

Example of a dialog box



You can use dialog boxes to enter data under Windows. The most important elements in a dialog box are:

1. Buttons 

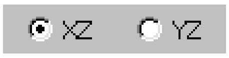
If you click one of these operating elements, also called "icons", actions are started or stopped, etc.

You will find a list of the buttons on the tool bar used in scancad mill in the section A1.6.

2. Control elements

In some input fields, you can make a selection by clicking on an arrow icon.

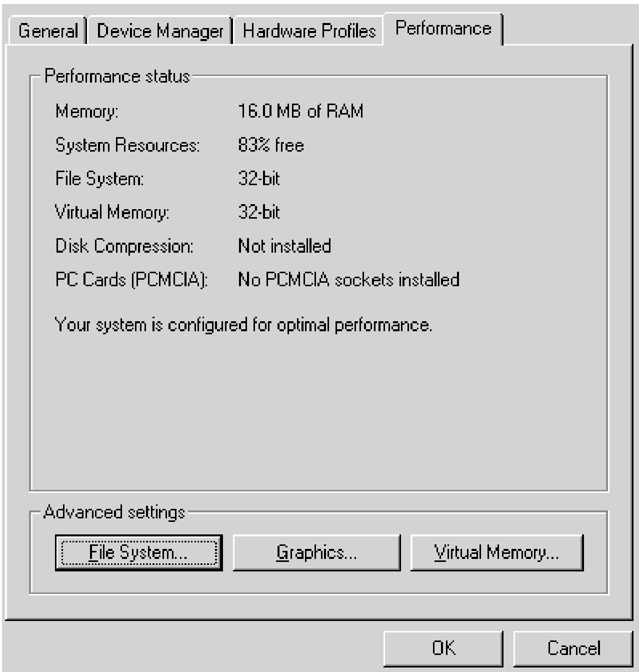
If you click on the arrow icons, you increment or decrement the input value in steps.



These are used to select options. Caution: Only one option can ever by selected in a group. When an option is selected, the circle is filled with a dot.

This activates a setting. In this case, you can select more than one option in a group. When the checkbox is activated a checkmark is displayed in it.

For complicated calculations or process defined by numerous parameters, the space in a screen dialog box is often not sufficient. In that case, the various parameters can be distributed over different dialogs on tab cards. You can select a tab card be its tab. This provides a clear way of handling large amounts of information.



A.4.5 Windows

You can change the size and shape of the windows used in Windows. There are two ways of doing this.

1. Using the buttons.

With the *Minimize* button you can make the window smaller. The window then becomes a button on the task bar. With the *Maximize* button you can make the window larger so that it fills the whole screen.

The *Restore* button resets the window to its previous size. It is displayed after window has been maximized.

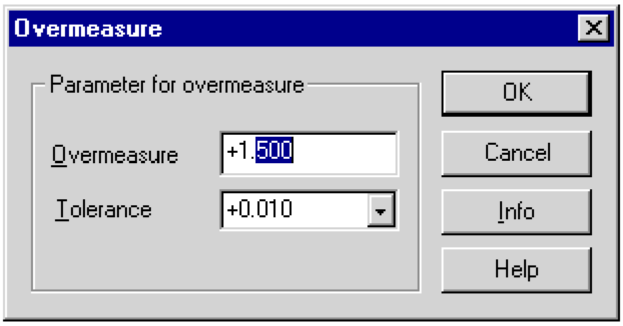
2. Using the mouse

To resize the window, move the mouse onto the border of the window. The cursor then changes shape to show in what directions you can change the size of the window.

Moving windows

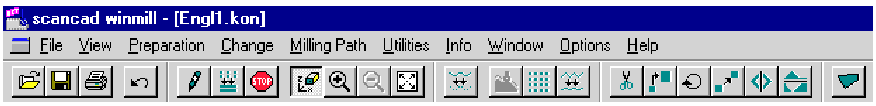
To be able use the options offered by individual applications at the same time, you can position windows as required. Just place the mouse cursor on the title bar of the window.

Marking entries



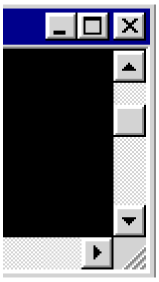
To select entries (e.g. numeric values or texts) position the mouse cursor at the position at which you want the selection to begin. Then, holding the left mouse button pressed, drag the cursor up to the end of the selection. Then release the mouse button. You can now edit or copy to another location the data you have selected in this way.

A.4.6 Tool bar



To simplify operation, many programs have tool bars. They contain commands that are also available in the menus. Operation using the tool bar provides a faster way of accessing functions to the advanced user. You can often customize the tool bar to meet your own requirements. If the most mouse cursor is on a button, the meaning of the button is displayed in a small box.

A.4.7 Scroll bars



If a window is not large enough to display all the information at once, scroll bars are displayed along the right-hand or lower border of the window. If you drag the scroll bar using the arrow buttons, you can scroll through the content of the window.

A.5 Shortcuts

Several key combinations (shortcuts) are available to accelerate working with the software. The shortcuts trigger commands that you can also start with the mouse or the menus of the operating system.

General shortcuts

Function	Shortcut
Call up help about the selected element of the dialog box	F1
Exit the program	ALT+F4
Display a context menu for the selected element	SHIFT+F10
Display the Start menu	CTRL+ESC
Switch to the last or next window (press ALT and TAB several times)	ALT+TAB
Cut	CTRL+X
Copy	CTRL+C
Paste	CTRL+V
Delete	DEL
Undo an action	CTRL+Z
Deactivate automate replay when inserting a CD	Press SHIFT while inserting the CD.

Shortcuts for "My Computer", the desktop and the Windows Explorer

Function	Shortcut
Rename an element	F2
Search for a folder or file	F3
Delete without moving the element into the Recycle Bin	SHIFT+DEL
Display element properties	ALT+RETURN or ALT+double-click
Copy a file	Press CTRL and drag a file at the same time
Create a link	CTRL+SHIFT and drag a file

Shortcuts for "My Computer" and the Windows Explorer

Function	Shortcut
Select all	CTRL+A
Update the window	F5
Display higher-level folder	BACKSPACE
Close a selected folder and any higher-level folders	Press SHIFT and close at the same time
Switch between the right and left section	F6

Shortcuts for the Windows Explorer

Function	Shortcut
Go to	CTRL+G
Switch between the left and right section	F6
Display all lower-level folders of the selected folder	NUM+asterisk (* on numeric keypad)
Display selected folder	NUM+PLUS SIGN (+ on numeric keypad)
Hide all lower-level folders of the selected folder	NUM+MINUS SIGN (- on numeric keypad)
Display the current selection (if not displayed, otherwise select the first lower-level folder)	RIGHT ARROW KEY
Hide the current selection (if displayed, otherwise the higher-level folder is selected)	LEFT ARROW KEY

Shortcuts for properties dialog boxes

Function	Shortcut
Move through the options on after the other	TAB
Move through the options on after the other in reverse order	SHIFT+TAB
Move through the tabs on after the other	CTRL+TAB
Function	Shortcut
Move through the tabs on after the other in reverse order	CTRL+SHIFT+TAB

Shortcuts for the dialog boxes "Open" and "Save as"

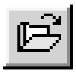
Function	Shortcut
Open the list "Save as" or "Look in"	F4
Update	F5
Open higher-level folder	BACKSPACE

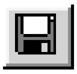
Shortcuts for the Accessibility Options

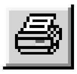
Function	Shortcut
StickyKeys on/off	5 times SHIFT
FilterKeys on/off	RIGHT SHIFT KEY for 8 seconds
ToggleKeys on/off	NUM for 5 seconds
MouseKeys on/off	LEFT ALT KEY+LEFT SHIFT KEY+NUM
High Contrast on/off	LEFT ALT KEY+LEFT SHIFT KEY+PRINT SCRN

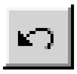
A.6 Toolbar buttons

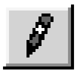
You can click on any of the tool bar buttons listed below to select functions quickly.

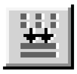

Opens an existing document (see Section 1.1)


Saves the current DIGIT file under a new name in the chosen format. (s. Section 1.2)

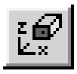

Prints out the active document

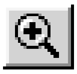

Undoes the last action

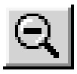

Redraw (s. Section 2.4)

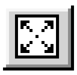

Line representation on / off (s. Section 2.6)

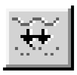
Cancels drawing (s. Section 2.5)

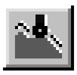

Show / hide cuboid (see Section 2.8)

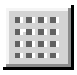

Zoom (s. Section 2.2)

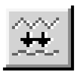

Rezoom (s. Section 2.3)

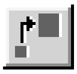

Full view (s. Section 2.1)

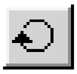

Reduce data set (s. Section 3.1)

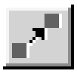

Contour calculation for tactile data (s. Section 3.3.1)

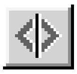

Grid calculation for optical data (s. Section 3.4.1)

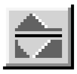

Filter / fill and smooth optical/rough data (s. Section 3.4.2)

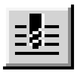

Calculate scaling / shrinkage (s. Section 4.2)

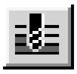

Rotate data set (s. Section 4.3)

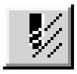

Translate data set (s. Section 4.4)

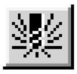

Mirror data set (s. Section 4.5)

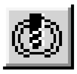

Calculate positive / negative conversion (s. Section 4.8)

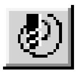

Calculate collision-free tool path (s. Section 5.2)

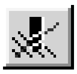

Calculate roughing path (s. Section 5.3)

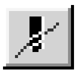

Oblique finishing (s. Section 5.4.4)

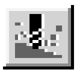

Radial finishing (s. Section 5.4.5)

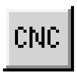

Circular finishing (s. Section 5.4.6)


Spiral finishing (s. Section 5.4.7)


Line finishing (s. Section 5.4.8)

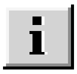

Guide line finishing (s. Section 5.4.9)

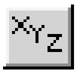

Start path planning for NC code generation
(s. Section 5.13)

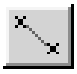


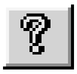
Start NC code generation (s. Section 1.2)

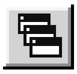

Enter polygon (s. Section 6.1)

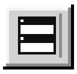

Display most important file information
(s. Section 7.1)

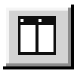

Display coordinates of selected point (s. Section 7.2)

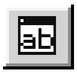

Display distance between two points (s. Section 7.3)

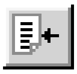

Display program information, version and copyright

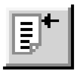

Cascade windows


Tile windows horizontally


Tile windows vertically


Open ASCII window for active document


Go to data record (for ASCII window only)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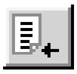
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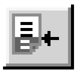
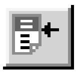

Go to file directory (for ASCII window only)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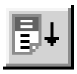
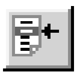

Go one segment forwards (for ASCII window only)


Go one segment back (for ASCII window only)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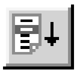
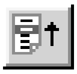
 Go one line forwards (for ASCII window only)

 Go one line back (for ASCII window only)

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