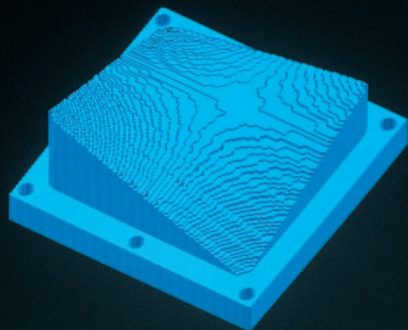


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# TNC 426

# TNC 430












NC Software  
280 474-xx  
280 475-xx

**User's Manual**  
**Conversational**  
**Programming**






Controls on the visual display unit

-  Split screen layout
-  Switch between machining or programming modes
-  Soft keys for selecting functions in screen
-  Switching the soft-key rows
-  Changing the screen settings (only BC 120)



Typewriter keyboard for entering letters and symbols

-       File name  
Comments
-      ISO programs






Machine operating modes

-  MANUAL OPERATION
-  ELECTRONIC HANDWHEEL Operating Modes
-  POSITIONING WITH MANUAL DATA INPUT (MDI)
-  PROGRAM RUN, SINGLE BLOCK
-  PROGRAM RUN, FULL SEQUENCE






Programming modes

-  PROGRAMMING AND EDITING
-  TEST RUN

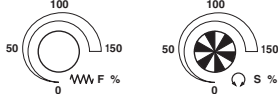
Program/file management,TNC functions

-  Select or delete programs and files  
External data transfer
-  Enter program call in a program
-  MOD functions
-  Displaying help texts for NC error messages
-  Pocket calculator










Moving the cursor, going directly to blocks, cycles and parameter functions

-     Move highlight
-  Go directly to blocks, cycles and parameter functions



Override control knobs for feed rate/spindle speed









Programming path movements

-  Approach/depart contour
-  FK free contour programming
-  Straight line
-  Circle center/pole for polar coordinates
-  Circle with center
-  Circle with radius
-  Circular arc with tangential connection
-  Chamfer
-  Corner rounding
















Tool functions

-   Enter or call tool length and radius

Cycles, subprograms and program section repeats

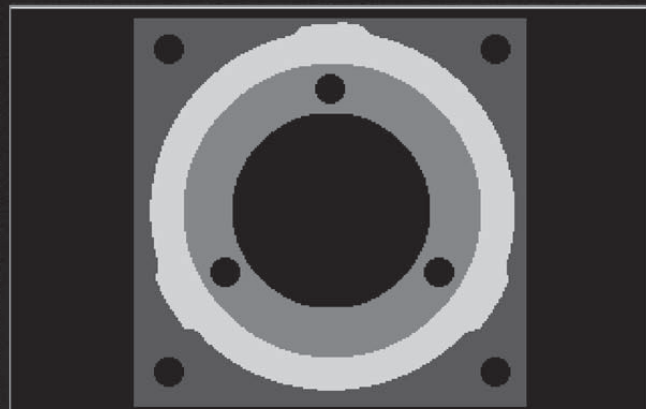
-   Define and call cycles
-   Enter and call labels for subprogramming and program section repeats
-  Program stop in a program
-  Enter touch probe functions in a program

Coordinate axes and numbers, editing

-  ...  Select coordinate axes or enter them in a program
-  ...  Numbers
-  Decimal point
-  Change arithmetic sign
-  Polar coordinates
-  Incremental dimensions
-  Q parameters
-  Capture actual position
-  Skip dialog questions, delete words
-  Confirm entry and resume dialog
-  End block
-  Clear numerical entry or TNC error message
-  Abort dialog, delete program section



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# TNC Models, Software and Features

This manual describes functions and features provided by the TNCs as of the following NC software numbers.

TNC Model	NC Software No.
TNC 426 CB, TNC 426 PB	280 474-xx
TNC 426 CF, TNC 426 PF	280 475-xx
TNC 426 M	280 474-xx
TNC 426 ME	280 475-xx
TNC 430 CA, TNC 430 PA	280 474-xx
TNC 430 CE, TNC 430 PE	280 475-xx
TNC 430 M	280 474-xx
TNC 430 ME	280 475-xx

The suffixes E and F indicate the export versions of the TNC which have the following limitations:

- Linear movement is possible in no more than 4 axes simultaneously

The machine tool builder adapts the useable features of the TNC to his machine by setting machine parameters. Some of the functions described in this manual may not be among the features provided by your machine tool.

TNC functions that may not be available on your machine include:

- Probing function for the 3-D touch probe
- Digitizing option
- Tool measurement with the TT 120
- Rigid tapping
- Returning to the contour after an interruption

Please contact your machine tool builder to become familiar with the individual implementation of the control on your machine.

Many machine manufacturers, as well as HEIDENHAIN, offer programming courses for the TNCs. We recommend these courses as an effective way of improving your programming skill and sharing information and ideas with other TNC users.



### Touch Probe Cycles User's Manual:

All of the touch probe functions are described in a separate manual. Please contact HEIDENHAIN if you require a copy of this User's Manual. Id. Nr.: 329 203-xx.

### Location of use

The TNC complies with the limits for a Class A device in accordance with the specifications in EN 55022, and is intended for use primarily in industrially-zoned areas.



# Contents

Introduction	1
Manual Operation and Setup	2
Positioning with Manual Data Input (MDI)	3
Programming: Fundamentals of NC, File Management, Programming Aids	4
Programming: Tools	5
Programming: Programming Contours	6
Programming: Miscellaneous Functions	7
Programming: Cycles	8
Programming: Subprograms and Program Section Repeats	9
Programming: Q Parameters	10
Test Run and Program Run	11
MOD Functions	12
Tables and Overviews	13

## **1 INTRODUCTION ..... 1**

- 1.1 TheTNC 426, theTNC 430 ..... 2
- 1.2 Visual Display Unit and Keyboard ..... 3
- 1.3 Modes of Operation ..... 5
- 1.4 Status Displays ..... 7
- 1.5 Accessories: HEIDENHAIN 3-DTouch Probes and Electronic Handwheels ..... 12

## **2 MANUAL OPERATION AND SETUP ..... 15**

- 2.1 Switch-on, Switch-off ..... 16
- 2.2 Moving the Machine Axes ..... 17
- 2.3 Spindle Speed S, Feed Rate F and Miscellaneous Functions M ..... 19
- 2.4 Datum Setting (Without a 3-DTouch Probe) ..... 20
- 2.5 Tilting theWorking Plane ..... 21

## **3 POSITIONING WITH MANUAL DATA INPUT (MDI) ..... 25**

- 3.1 Programming and Executing Simple Machining Operations ..... 26

## **4 PROGRAMMING: FUNDAMENTALS OF NC, FILE MANAGEMENT, PROGRAMMING AIDS, PALLET MANAGEMENT ..... 29**

- 4.1 Fundamentals of NC ..... 30
- 4.2 File Management: Fundamentals ..... 35
- 4.3 Standard File Management ..... 36
- 4.4 File Management withAdditional Functions ..... 42
- 4.5 Creating andWriting Programs ..... 55
  - Editing a program ..... 58
- 4.6 Interactive Programming Graphics ..... 60
- 4.7 Structuring Programs ..... 61
- 4.8 Adding Comments ..... 62
- 4.9 CreatingText Files ..... 63
- 4.10 Integrated Pocket Calculator ..... 66
- 4.11 HELP for NC error messages ..... 67
- 4.12 Managing PalletTables ..... 68



## 5 PROGRAMMING: TOOLS ..... 71

- 5.1 Entering Tool-Related Data ..... 72
- 5.2 Tool Data ..... 73
- 5.3 Tool Compensation ..... 84
- 5.4 Three-Dimensional Tool Compensation ..... 88
- 5.5 Working with Cutting Data Tables ..... 94

## 6 PROGRAMMING: PROGRAMMING CONTOURS ..... 101

- 6.1 Overview of Tool Movements ..... 102
- 6.2 Fundamentals of Path Functions ..... 103
- 6.3 Contour Approach and Departure ..... 106
  - Overview: Types of paths for contour approach and departure ..... 106
  - Important positions for approach and departure ..... 106
  - Approaching on a straight line with tangential connection: APPR LT ..... 107
  - Approaching on a straight line perpendicular to the first contour point: APPR LN ..... 108
  - Approaching on a circular arc with tangential connection: APPR CT ..... 108
  - Approaching on a circular arc with tangential connection from a straight line to the contour:  
APPR LCT ..... 109
  - Departing tangentially on a straight line: DEP LT ..... 110
  - Departing on a straight line perpendicular to the last contour point: DEP LN ..... 110
  - Departing tangentially on a circular arc: DEP CT ..... 111
  - Departing on a circular arc tangentially connecting the contour and a straight line: DEP LCT ..... 111
- 6.4 Path Contours — Cartesian Coordinates ..... 112
  - Overview of path functions ..... 112
  - Straight line L ..... 113
  - Inserting a chamfer CHF between two straight lines ..... 113
  - Circle center CC ..... 114
  - Circular path C around circle center CC ..... 115
  - Circular path CR with defined radius ..... 116
  - Circular path CT with tangential connection ..... 117
  - Corner Rounding RND ..... 118
  - Example: Linear movements and chamfers with Cartesian coordinates ..... 119
  - Example: Circular movements with Cartesian coordinates ..... 120
  - Example: Full circle with Cartesian coordinates ..... 121

6.5 Path Contours—Polar Coordinates .....	122
Polar coordinate origin: Pole CC .....	122
Straight line LP .....	123
Circular path CP around pole CC .....	123
Circular path CTP with tangential connection .....	124
Helical interpolation .....	124
Example: Linear movement with polar coordinates .....	127
Example: Helix .....	127
6.6 Path Contours — FK Free Contour Programming .....	128
Fundamentals .....	128
Graphics during FK programming .....	128
Initiating the FK dialog .....	129
Free programming of straight lines .....	130
Free programming of circular arcs .....	130
Auxiliary points .....	132
Relative data .....	133
Closed contours .....	135
Converting FK programs .....	135
Example: FK programming 1 .....	136
Example: FK programming 2 .....	137
Example: FK programming 3 .....	138
6.7 Path Contours - Spline Interpolation .....	140

## 7 PROGRAMMING: MISCELLANEOUS FUNCTIONS ..... 143

- 7.1 Entering Miscellaneous Functions M and STOP ..... 144
- 7.2 Miscellaneous Functions for Program Run Control, Spindle and Coolant ..... 145
- 7.3 Miscellaneous Functions for Coordinate Data ..... 145
- 7.4 Miscellaneous Functions for Contouring Behavior ..... 148
  - Smoothing corners: M90 ..... 148
  - Insert rounding arc between straight lines: M112 ..... 149
  - Machining small contour steps: M97 ..... 149
  - Machining open contours: M98 ..... 150
  - Feed rate factor for plunging movements: M103 ..... 151
  - Feed rate in microns per spindle revolution: M136 ..... 151
  - Feed rate at circular arcs: M109/M110/M111 ..... 152
  - Calculating the radius-compensated path in advance (LOOK AHEAD): M120 ..... 152
  - Superimposing handwheel positioning during program run: M118 ..... 153
- 7.5 Miscellaneous Functions for Rotary Axes ..... 154
  - Feed rate in mm/min on rotary axes A, B, C: M116 ..... 154
  - Shorter-path traverse of rotary axes: M126 ..... 154
  - Reducing display of a rotary axis to a value less than 360°: M94 ..... 155
  - Automatic compensation of machine geometry when working with tilted axes: M114 ..... 156
  - Maintaining the position of the tool tip when positioning with tilted axes (TCPM\*): M128 ..... 157
  - Exact stop at corners with nontangential transitions: M134 ..... 159
  - Selecting tilting axes: M138 ..... 159
- 7.6 Miscellaneous Functions for Laser Cutting Machines ..... 160

**8 PROGRAMMING: CYCLES ..... 161**

- 8.1 General Information on Cycles ..... 162
- 8.2 Drilling Cycles ..... 164
  - PECKING (Cycle 1) ..... 164
  - DRILLING (Cycle 200) ..... 166
  - REAMING (Cycle 201) ..... 167
  - BORING (Cycle 202) ..... 168
  - UNIVERSAL DRILLING (Cycle 203) ..... 169
  - BACK BORING (Cycle 204) ..... 171
  - UNIVERSAL PECKING (Cycle 205) ..... 173
  - BORE MILLING (Cycle 208) ..... 175
  - TAPPING with a floating tap holder (Cycle 2) ..... 177
  - TAPPING NEW with floating tap holder (Cycle 206) ..... 178
  - RIGIDTAPPING (Cycle 17) ..... 180
  - RIGIDTAPPING without a floating tap holderTAPPING (Cycle 207) ..... 181
  - THREAD CUTTING (Cycle 18) ..... 183
  - Example: Drilling cycles ..... 184
  - Example: Drilling cycles ..... 185
- 8.3 Cycles for milling pockets, studs and slots ..... 186
  - POCKET MILLING (Cycle 4) ..... 187
  - POCKET FINISHING (Cycle 212) ..... 188
  - STUD FINISHING (Cycle 213) ..... 190
  - CIRCULAR POCKET MILLING (Cycle 5) ..... 191
  - CIRCULAR POCKET FINISHING (Cycle 214) ..... 193
  - CIRCULAR STUD FINISHING (Cycle 215) ..... 194
  - SLOT MILLING (Cycle 3) ..... 196
  - SLOT with reciprocating plunge-cut (Cycle 210) ..... 197
  - CIRCULAR SLOT with reciprocating plunge-cut (Cycle 211) ..... 199
  - Example: Milling pockets, studs and slots ..... 201
- 8.4 Cycles for Machining Hole Patterns ..... 203
  - CIRCULAR PATTERN (Cycle 220) ..... 204
  - LINEAR PATTERN (Cycle 221) ..... 205
  - Example: Circular hole patterns ..... 207



8.5 SL Cycles .....	209
CONTOUR GEOMETRY (Cycle 14) .....	211
Overlapping contours .....	211
CONTOUR DATA (Cycle 20) .....	213
PILOT DRILLING (Cycle 21) .....	215
ROUGH-OUT (Cycle 22) .....	216
FLOOR FINISHING (Cycle 23) .....	217
SIDE FINISHING (Cycle 24) .....	217
CONTOURTRAIN (Cycle 25) .....	218
CYLINDER SURFACE (Cycle 27) .....	220
CYLINDER SURFACE slot milling (Cycle 28) .....	222
Example: Roughing-out and fine-roughing a pocket .....	224
Example: Pilot drilling, roughing-out and finishing overlapping contours .....	226
Example: Contour train .....	228
Example: Cylinder surface .....	230
8.6 Cycles for Multipass Milling .....	232
RUN DIGITIZED DATA (Cycle 30) .....	232
MULTIPASS MILLING (Cycle 230) .....	234
RULED SURFACE (Cycle 231) .....	236
Example: Multipass milling .....	238
8.7 CoordinateTransformation Cycles .....	239
DATUM SHIFT (Cycle 7) .....	240
DATUM SHIFT with datum tables (Cycle 7) .....	241
MIRROR IMAGE (Cycle 8) .....	244
ROTATION (Cycle 10) .....	245
SCALING FACTOR (Cycle 11) .....	246
AXIS-SPECIFIC SCALING (Cycle 26) .....	247
WORKING PLANE (Cycle 19) .....	248
Example: Coordinate transformation cycles .....	253
8.8 Special Cycles .....	255
DWEELLTIME (Cycle 9) .....	255
PROGRAM CALL (Cycle 12) .....	255
ORIENTED SPINDLE STOP (Cycle 13) .....	256
TOLERANCE (Cycle 32) .....	257

**9 PROGRAMMING: SUBPROGRAMS AND PROGRAM SECTION REPEATS ..... 259**

- 9.1 Marking Subprograms and Program Section Repeats ..... 260
- 9.2 Subprograms ..... 260
- 9.3 Program Section Repeats ..... 261
- 9.4 Program as Subprogram ..... 262
- 9.5 Nesting ..... 263
  - Subprogram within a subprogram ..... 263
  - Repeating program section repeats ..... 264
  - Repeating a subprogram ..... 265
- 9.6 Programming Examples ..... 266
  - Example: Milling a contour in several infeeds ..... 266
  - Example: Groups of holes ..... 267
  - Example: Groups of holes with several tools ..... 268

**10 PROGRAMMING: Q PARAMETERS ..... 271**

- 10.1 Principle and Overview ..... 272
- 10.2 Part Families — Q Parameters in Place of Numerical Values ..... 274
- 10.3 Describing Contours Through Mathematical Functions ..... 275
- 10.4 Trigonometric Functions ..... 277
- 10.5 Calculating Circles ..... 278
- 10.6 If-Then Decisions with Q Parameters ..... 279
- 10.7 Checking and Changing Q Parameters ..... 280
- 10.8 Additional Functions ..... 281
- 10.9 Entering Formulas Directly ..... 293
- 10.10 Preassigned Q Parameters ..... 296
- 10.11 Programming Examples ..... 299
  - Example: Ellipse ..... 299
  - Example: Concave cylinder machined with spherical cutter ..... 301
  - Example: Convex sphere machined with end mill ..... 303

**11 TEST RUN AND PROGRAM RUN ..... 305**

- 11.1 Graphics ..... 306
- 11.2 Functions for Program Display in Program Run and Test Run ..... 311
- 11.3 Test run ..... 311
- 11.4 Program Run ..... 313
- 11.5 Optional block skip ..... 318

**12 MOD FUNCTIONS ..... 319**

- 12.1 Selecting, Changing and Exiting the MOD Functions ..... 320
- 12.2 Software Numbers and Option Numbers ..... 321
- 12.3 Code Number ..... 321
- 12.4 Setting the Data Interfaces ..... 322
- 12.5 Ethernet Interface ..... 326
- 12.6 Configuring PGM MGT ..... 333
- 12.7 Machine-Specific User Parameters ..... 333
- 12.8 Showing the Workpiece in the Working Space ..... 333
- 12.9 Position Display Types ..... 335
- 12.10 Unit of Measurement ..... 335
- 12.11 Programming Language for \$MDI ..... 336
- 12.12 Selecting the Axes for Generating L Blocks ..... 336
- 12.13 Axis Traverse Limits, Datum Display ..... 336
- 12.14 Displaying HELP files ..... 337
- 12.15 Machining Times ..... 338

**13 TABLES AND OVERVIEWS ..... 339**

- 13.1 General User Parameters ..... 340
- 13.2 Pin Layout and Connecting Cable for the Data Interfaces ..... 355
- 13.3 Technical Information ..... 359
- 13.4 Exchanging the Buffer Battery ..... 362







# 1

## Introduction

## 1.1 The TNC 426, the TNC 430

HEIDENHAIN TNC controls are workshop-oriented contouring controls that enable you to program conventional machining operations right at the machine in an easy-to-use conversational programming language. They are designed for milling, drilling and boring machines, as well as for machining centers. The TNC 426 can control up to 5 axes; the TNC 430 can control up to 9 axes. You can also change the angular position of the spindle under program control.

An integrated hard disk provides storage for as many programs as you like, even if they were created off-line or by digitizing. For quick calculations you can call up the on-screen pocket calculator at any time.

Keyboard and screen layout are clearly arranged in a such way that the functions are fast and easy to use.

### Programming: HEIDENHAIN conversational and ISO formats

HEIDENHAIN conversational programming is an especially easy method of writing programs. Interactive graphics illustrate the individual machining steps for programming the contour. If a production drawing is not dimensioned for NC, the HEIDENHAIN FK free contour programming carries out the necessary calculations automatically. Workpiece machining can be graphically simulated either during or before actual machining. It is also possible to program in ISO format or DNC mode.

You can also enter and test one program while the TNC is running another.

### Compatibility

The TNC can execute all part programs that were written on HEIDENHAIN controls TNC 150 B and later.



## 1.2 Visual Display Unit and Keyboard

### Visual display unit

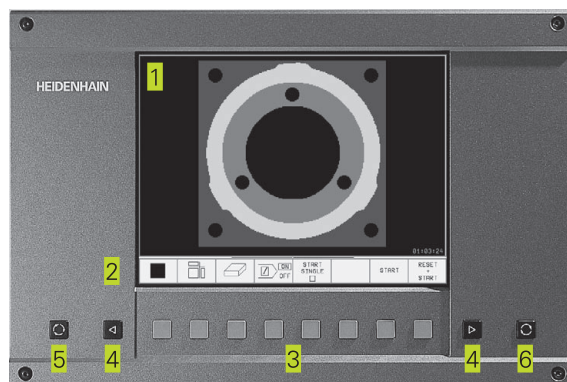
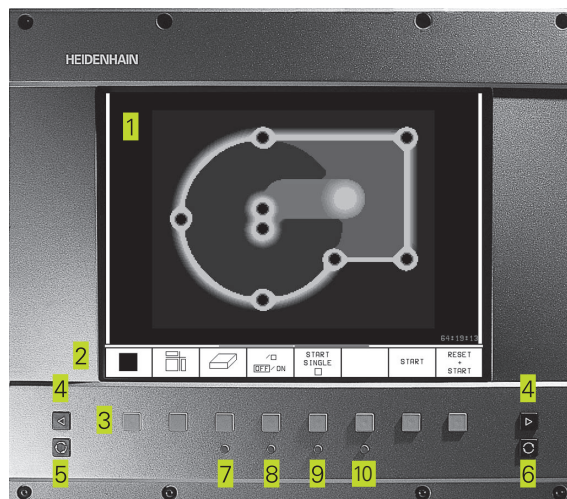
The TNC is available with either a color CRT screen (BC 120) or a TFT flat panel display (BF 120). The figures at right show the keys and controls on the BC 120 (upper right) and the BF 120 (middle right).

- 1 Header  
When the TNC is on, the selected operating modes are shown in the screen header: the machining mode at the left and the programming mode at right. The currently active mode is displayed in the larger box, where the dialog prompts and TNC messages also appear (unless the TNC is showing only graphics).
- 2 Soft keys  
In the footer the TNC indicates additional functions in a soft-key row. You can select these functions by pressing the keys immediately below them 3. The lines immediately above the soft-key row indicate the number of soft-key rows that can be called with the black arrow keys to the right and left. The line representing the active soft-key row is highlighted.
- 3 Soft key selector keys
- 4 Switching the soft-key rows
- 5 Setting the screen layout
- 6 Shift key for switchover between machining and programming modes

#### Keys on BC 120 only

- 7 Screen demagnetization;  
Exit main menu for screen settings
- 8 Select main menu for screen settings;  
In the main menu: Move highlight downward  
In the submenu: Reduce value  
Move picture to the left or downward
- 9 In the main menu: Move highlight upward  
In the submenu: Increase value  
Move picture to the right or upward
- 10 In the main menu: Select submenu  
In the submenu: Exit submenu

See next page for the screen settings.



Main menu dialog	Function
BRIGHTNESS	Adjust brightness
CONTRAST	Adjust contrast
H-POSITION	Adjust horizontal position
H-SIZE	Adjust picture width
V-POSITION	Adjust vertical position
V-SIZE	Adjust picture height
SIDE-PIN	Correct barrel-shaped distortion
TRAPEZOID	Correct trapezoidal distortion
ROTATION	Correct tilting
COLORTEMP	Adjust color temperature
R-GAIN	Adjust strength of red color
B-GAIN	Adjust strength of blue color
RECALL	No function

The BC 120 is sensitive to magnetic and electromagnetic noise, which can distort the position and geometry of the picture. Alternating fields can cause the picture to shift periodically or to become distorted.

Screen layout

You select the screen layout yourself: In the PROGRAMMING AND EDITING mode of operation, for example, you can have the TNC show program blocks in the left window while the right window displays programming graphics. You could also display the program structure in the right window instead, or display only program blocks in one large window. The available screen windows depend on the selected operating mode.

To change the screen layout:



Press the switch-over key: The soft-key row shows the available layout options (see section 1.3 "Modes of Operation").



Select the desired screen layout.

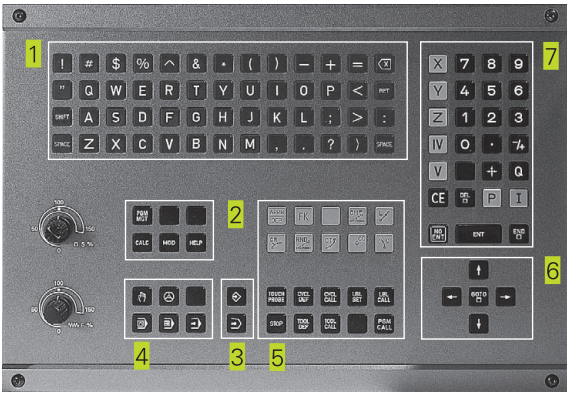


### Keyboard

The figure at right shows the keys of the keyboard grouped according to their functions:

- 1 Alphanumeric keyboard for entering texts and file names, as well as for programming in ISO format
- 2 File management, pocket calculator, MOD functions, HELP functions
- 3 Programming modes
- 4 Machine operating modes
- 5 Initiation of programming dialog
- 6 Arrow keys and GOTO jump command
- 7 Numerical input and axis selection

The functions of the individual keys are described on the inside front cover. Machine panel buttons, e.g. NC START, are described in the manual for your machine tool.



## 1.3 Modes of Operation

The TNC offers the following modes of operation for the various functions and working steps that you need to machine a workpiece:





### Manual Operation and Electronic Handwheel

The Manual Operation mode is required for setting up the machine tool. In this operating mode, you can position the machine axes manually or by increments, set the datums, and tilt the working plane.

The Electronic Handwheel mode of operation allows you to move the machine axes manually with the HR electronic handwheel.

**Soft keys for selecting the screen layout**  
(select as described previously)

Screen windows	Soft key
Positions	POSITION
Left: positions. Right: status display.	POSITION + STATUS

Manual operation				Programming and editing	
ACTL.	X	+150.0000	<div>DIST.</div> <div>X +350.0000 C +350.0000</div> <div>Y +350.0000</div> <div>Z +350.0000</div> <div>A +350.0000</div> <div>B +90.0000</div>		
	Y	-50.0000			
	Z	+100.0000			
	A	+0.0000			
	B	+180.0000			
	C	+90.0000			
		<div></div> <div>A +0.0000</div> <div>B+180.0000</div> <div>C +90.0000</div>			
		<div></div> <div>Basic rotation +12.3570</div>			
T		M 5/9			
M	S	F	TOUCH PROBE	DATUM SET	INCRE- MENT <div>OFF ON</div>
					3D ROT <div></div>
					TOOL TABLE

Positioning with Manual Data Input (MDI)

This mode of operation is used for programming simple traversing movements, such as for face milling or pre-positioning. You can also define point tables for setting the digitizing range in this mode.

Soft keys for selecting the screen layout

Screen windows	Soft key
Program	PGM
Left: program blocks, right: status display	PGM + STATUS

Programming and Editing

In this mode of operation you can write your part programs. The FK free programming feature, the various cycles and the Q parameter functions help you with programming and add necessary information. If desired, you can have the programming graphics show the individual steps, or you can use a separate screen window to prepare your program structure.

Soft keys for selecting the screen layout

Screen windows	Soft key
Program	PGM
Left: program blocks, right: program structure	PGM + SECTS
Left: program blocks, right: programming graphics	PGM + GRAPHICS

Test run

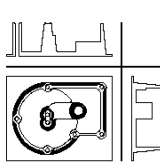
In the Test Run mode of operation, the TNC checks programs and program sections for errors, such as geometrical incompatibilities, missing or incorrect data within the program or violations of the work space. This simulation is supported graphically in different display modes.

Soft keys for selecting the screen layout

Same as in the Program Run operating modes on the next page.

Positioning with manl.data input		Programming and editing
0 BEGIN PGM 1MDI MM 1 CYCL DEF 204 COUNTERBORE BACK Q200=2 ;SET-UP CLEARANCE Q249=+5 ;DEPTH OF COUNTERBORE Q250=20 ;MATERIAL THICKNESS Q251=3.5 ;OFF-CENTER DISTANCE Q252=15 ;TOOL EDGE HIGHT Q253=750 ;F PRE-POSITIONING Q254=200 ;F COUNTERBORING		DIST. X +0.0000 C +0.0000 Y +0.0000 Z +0.0000 A +0.0000 B +0.0000  A +0.0000 B+100.0000 C +90.0000  Basic rotation +12.3570  +150.0000 Y -50.0000 Z +100.0000 A +0.0000 B +180.0000 C +90.0000  ACTL. T 0 M 5/9
STATUS PGM	STATUS POS.	STATUS TOOL
STATUS COORD. TRANSF.	STATUS TOOL PROBE	PNT
		TOOL TABLE

Manual operation	Programming and editing
0 BEGIN PGM 1GB MM 1 BLK FORM 0.1 Z X+0 Y+0 Z-40 2 BLK FORM 0.2 X+100 Y+100 Z-0 3 * - Make hole pattern ID 27943KL1 4 TOOL CALL 1 Z S4500 5 L Z+100 R0 F MAX 6 CYCL DEF 203 UNIVERSAL-BOHREN Q200=2 ;SICHERHEITS-ABST. Q201=-50 ;TIEFE Q206=250 ;VORSCHUB TIEFENZUST. Q202=0 ;ZUSTELL-TIEFE Q210=0 ;VERWEILZEIT OBEN Q203=+0 ;KDDR. OBERFLAECH Q204=100 ;2. SICHERHEITS-ABST. Q212=0 ;ABNAHMEBETRAG	BEGIN PGM 1GB - Make hole pattern ID 27943KL1 - Parameter definition - Make pocket - Rough out - Finishing - Make hole pattern - Center drill - Pecking - Tapping END PGM 1GB
BEGIN	END
PAGE	PAGE
FIND	CHANGE WINDOW

Manual operation	Test run
47 CYCL CALL 48 CYCL DEF 14.0 CONTOUR GEOMETRY 49 CYCL DEF 14.1 CONTOUR LABEL 1 /3 /4 /5 /9 /10 50 CYCL DEF 14.2 CONTOUR LABEL 11 /12 51 CYCL DEF 6.0 ROUGH-OUT 52 CYCL DEF 6.1 SET UP 26 DEPTH -12 53 CYCL DEF 6.2 PLNGNG 4 F300 ALLOW +0.7 54 CYCL DEF 6.3 ANGLE +90 F600 55 CYCL CALL 56 CYCL DEF 14.0 CONTOUR GEOMETRY 57 CYCL DEF 14.1 CONTOUR LABEL 13 /14 /15 /16 /17 /18	 X +70.4 Y +55.5 99:59:59
START SINGLE	STOP AT
START	RESET + START

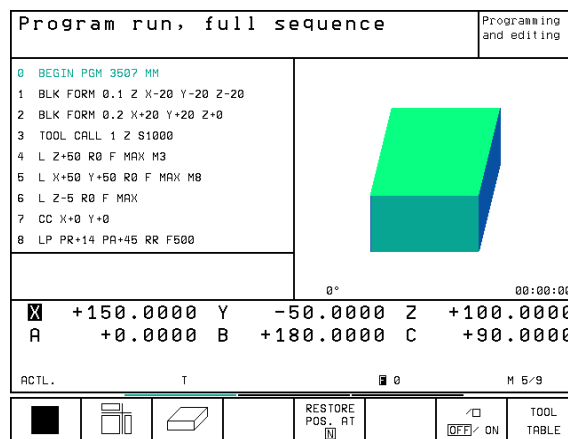
## Program Run, Full Sequence and Program Run, Single Block

In the Program Run, Full Sequence mode of operation the TNC executes a part program continuously to its end or to a manual or programmed stop. You can resume program run after an interruption.

In the Program Run, Single Block mode of operation you execute each block separately by pressing the machine START button.

## Soft keys for selecting the screen layout

Screen windows	Soft key
Program	PGM
Left: program blocks, right: program structure	PGM + SECTS
Left: program blocks, right: STATUS	PGM + STATUS
Left: program blocks, right: graphics	PGM + GRAPHICS
Graphics	GRAPHICS



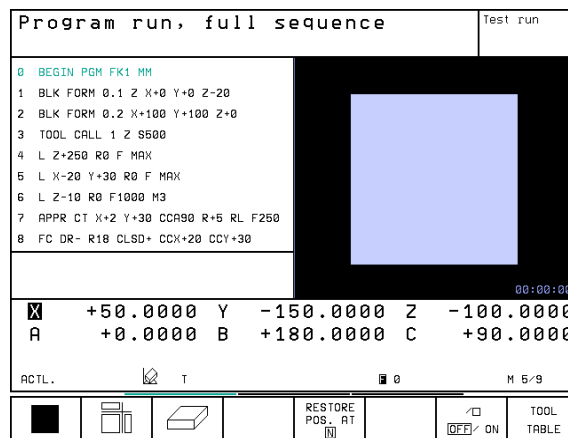
## 1.4 Status Displays

### "General" status display



The status display informs you of the current state of the machine tool. It is displayed automatically in the following modes of operation:

- Program Run, Single Block and Program Run, Full Sequence, except if the screen layout is set to display graphics only, and
- Positioning with Manual Data Input (MDI).

In the operating modes Manual and Electronic Handwheel, the status display is shown in the large window.





Information in the status display

The	Meaning
ACTL.	Actual or nominal coordinates of the current position
XYZ	Machine axes; the TNC displays auxiliary axes in lower-case letters. The sequence and quantity of displayed axes is determined by the machine tool builder. Refer to your machine manual for more information
F S M	The displayed feed rate in inches corresponds to one tenth of the effective value. Spindle speed S, feed rate F and active M functions
*	Program run started
→←	Axis locked
⊙	Axis can be moved with the handwheel
	Axes are moving in a tilted working plain
	Axes are moving under a basic rotation

Additional status displays

The additional status displays contain detailed information on the program run. They can be called in all operating modes, except in the Programming and Editing mode of operation.

To switch on the additional status display:

-  Call the soft-key row for screen layout.
-  Select the layout option for the additional status display.

Program run, full sequence

Test run

0 BEGIN PGM FK1 MM

1 BLK FORM 0.1 Z X+0 Y+0 Z-20

2 BLK FORM 0.2 X+100 Y+100 Z+0

3 TOOL CALL 1 Z S500

4 L Z+250 R0 F MAX

5 L X-20 Y+30 R0 F MAX

6 L Z-10 R0 F1000 M3

7 APPR CT X+2 Y+30 CCR90 R+5 RL F250

8 FC DR- R18 CLSD+ CCX+20 CCY+30

DIST.


X +0.0000 C +0.0000

Y +0.0000

Z +0.0000


A +0.0000

B +0.0000

 A +0.0000

B+100.0000

C +90.0000

 Basic rotation +0.0000

⊗

+50.0000

Y

-150.0000

Z

-100.0000

Z

+90.0000

A

+0.0000


B


+180.0000

C

+90.0000

ACTL.

 T

 0

M 6/9

PAGE

PAGE

BEGIN

END

RESTORE

POS. AT

OFF

ON

TOOL

TABLE

You can choose between several additional status displays with the following soft keys:



Shift the soft-key rows until the STATUS soft keys appear.

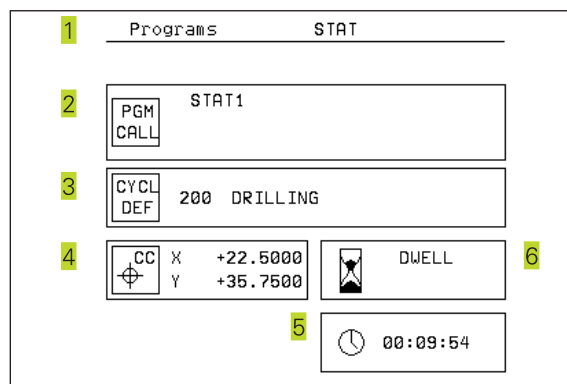


Select the desired additional status display, e.g. general program information.



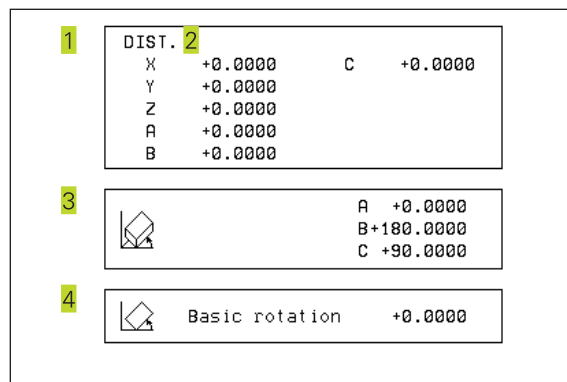
## General program information

- 1 Name of main program
- 2 Active programs
- 3 Active machining cycle
- 4 Circle center CC (pole)
- 5 Operating time
- 6 Dwell time counter



## Positions and coordinates






- 1 Position display
- 2 Type of position display, e.g. actual positions
- 3 Tilt angle of the working plane
- 4 Angle of a basic rotation



STATUS  
TOOL

## Information on tools

- 1 T: Tool number and name  
RT: Number and name of a replacement tool
- 2 Tool axis
- 3 Tool length and radii
- 4 Oversizes (delta values) from TOOL CALL (PGM) and the tool table (TAB)
- 5 Tool life, maximum tool life (TIME 1) and maximum tool life for TOOL CALL (TIME 2)
- 6 Display of the active tool and the (next) replacement tool





1	Tool data RT 2															
2		3	<table><tr><td>L</td><td>-3.0000</td></tr><tr><td>R</td><td>+3.0000</td></tr><tr><td>R2</td><td>+0.0000</td></tr></table>		L	-3.0000	R	+3.0000	R2	+0.0000						
L	-3.0000															
R	+3.0000															
R2	+0.0000															
4	<table><tr><td></td><td>DL</td><td>DR</td><td>DR2</td></tr><tr><td>TAB</td><td>+0.0100</td><td>+0.1000</td><td></td></tr><tr><td>PGM</td><td>+0.1000</td><td>+0.1000</td><td></td></tr></table>					DL	DR	DR2	TAB	+0.0100	+0.1000		PGM	+0.1000	+0.1000	
	DL	DR	DR2													
TAB	+0.0100	+0.1000														
PGM	+0.1000	+0.1000														
5		CUR.TIME	TIME1	TIME2												
		01:43	03:20	03:00												
6	<table><tr><td>TOOL CALL</td><td>1</td></tr><tr><td>RT</td><td></td></tr></table>				TOOL CALL	1	RT									
TOOL CALL	1															
RT																

STATUS  
COORD.  
TRANSF.

## Coordinate transformations

- 1 Name of main program
- 2 Active datum shift (Cycle 7)
- 3 Active rotation angle (Cycle 10)
- 4 Mirrored axes (Cycle 8)
- 5 Active scaling factor(s) (Cycles 11 / 26)
- 6 Scaling datum

See also section 8.7 "Coordinate Transformation Cycles."

1	Programs		STAT									
2	<div>Datum shift <table><tr><td>X</td><td>+152.0000</td></tr><tr><td>Y</td><td>+100.0000</td></tr></table></div>		X	+152.0000	Y	+100.0000	3	<div>Rotation <table><tr><td></td><td>+12.5000</td></tr></table></div>		+12.5000		
X	+152.0000											
Y	+100.0000											
	+12.5000											
		4	<div>Mirror image <table><tr><td>X Y</td><td></td></tr></table></div>	X Y								
X Y												
	<div>Scaling <table><tr><td>X</td><td>+0.0000</td><td>0.999500</td></tr><tr><td>Y</td><td>+0.0000</td><td>0.999500</td></tr><tr><td>Z</td><td>+0.0000</td><td>0.999500</td></tr></table><div></div></div>			X	+0.0000	0.999500	Y	+0.0000	0.999500	Z	+0.0000	0.999500
X	+0.0000	0.999500										
Y	+0.0000	0.999500										
Z	+0.0000	0.999500										
6		5										

STATUS  
TOOL  
PROBE

## Tool measurement

- 1 Number of the tool to be measured
- 2 Display whether the tool radius or the tool length is being measured
- 3 MIN and MAX values of the individual cutting edges and the result of measuring the rotating tool (DYN = dynamic measurement)
- 4 Cutting edge number with the corresponding measured value. If the measured value is followed by an asterisk, the allowable tolerance in the tool table was exceeded.

1

Tool data

L 2

MIN	2
MAX	3
DYN	

+1.9664

+2.0035

4

1 +1.9909

2 +1.9664 \*

3 +2.0035

4 +1.9986



## Active miscellaneous functions M

- 1 List of the active M functions with fixed meaning.
- 2 List of the active M functions with function assigned by machine manufacturer.

M-Functions	
1	<div>M103</div> <div>M107</div> <div>M118</div> <div>M132</div>
2	<div>M0</div> <div>M5</div>

## 1.5 Accessories: HEIDENHAIN 3-D Touch Probes and Electronic Handwheels

### 3-D Touch Probes

With the various HEIDENHAIN 3-D touch probe systems you can:

- Automatically align workpieces
- Quickly and precisely set datums
- Measure the workpiece during program run
- Digitize 3-D surfaces (option), and
- Measure and inspect tools



All of the touch probe functions are described in a separate manual. Please contact HEIDENHAIN if you require a copy of this User's Manual. Id. Nr.: 329 203 xx.

#### TS 220 and TS 630 touch trigger probes

These touch probes are particularly effective for automatic workpiece alignment, datum setting, workpiece measurement and for digitizing. The TS 220 transmits the triggering signals to the TNC via cable and is a cost-effective alternative for applications where digitizing is not frequently required.

The TS 630 features infrared transmission of the triggering signal to the TNC. This makes it highly convenient for use on machines with automatic tool changers.

Principle of operation: HEIDENHAIN triggering touch probes feature a wear resisting optical switch that generates an electrical signal as soon as the stylus is deflected. This signal is transmitted to the TNC, which stores the current position of the stylus as an actual value.

During digitizing the TNC generates a program containing straight line blocks in HEIDENHAIN format from a series of measured position data. You can then output the program to a PC for further processing with the SUSA evaluation software. This evaluation software enables you to calculate male/female transformations or correct the program to account for special tool shapes and radii that differ from the shape of the stylus tip. If the tool has the same radius as the stylus tip you can run these programs immediately.

#### TT 120 tool touch probe for tool measurement

The TT 120 is a triggering 3-D touch probe for tool measurement and inspection. Your TNC provides three cycles for this touch probe with which you can measure the tool length and radius automatically — either with the spindle rotating or stopped.

The TT 120 features a particularly rugged design and a high degree of protection, which make it insensitive to coolants and swarf. The triggering signal is generated by a wear-resistant and highly reliable optical switch.



### HR electronic handwheels

Electronic handwheels facilitate moving the axis slides precisely by hand. A wide range of traverses per handwheel revolution is available. Apart from the HR 130 and HR 150 integral handwheels, HEIDENHAIN also offers the HR 410 portable handwheel (see figure at right).







# 2

**Manual Operation and Setup**

## 2.1 Switch-on, Switch-off

### Switch-On



Switch-on and traversing the reference points can vary depending on the individual machine tool. Your machine manual provides more detailed information.

- Switch on the power supply for control and machine.

The TNC automatically initiates the following dialog

#### Memory Test

The TNC memory is automatically checked.

#### Power Interrupted



TNC message that the power was interrupted — clear the message.

#### Translate PLC Program

The PLC program of the TNC is automatically compiled.

#### Relay Ext. DC Voltage Missing



Switch on the control voltage.  
The TNC checks the functioning of the EMERGENCY STOP circuit.

#### Manual Operation

##### Traverse Reference Points



Cross the reference points manually in the displayed sequence: For each axis press the machine START button, or



cross the reference points in any sequence: Press and hold the machine axis direction button for each axis until the reference point has been traversed.

The TNC is now ready for operation in the Manual Operation mode.



The reference points need only be traversed if the machine axes are to be moved. If you intend only to write, edit or test programs, you can select the Programming and Editing or Test Run modes of operation immediately after switching on the control voltage.

You can then traverse the reference points later by pressing the PASS OVER REFERENCE soft key in the Manual Operation mode.

### Traversing the reference point in a tilted working plane

The reference point of a tilted coordinate system can be traversed by pressing the machine axis direction buttons. The "tilting the working plane" function (see section 2.5 "Tilting the Working Plane") must be active in the Manual Operation mode. The TNC then interpolates the corresponding axes.

The NC START button is not effective. Pressing this button may result in an error message.

Make sure that the angle values entered in the menu for tilting the working plane match the actual angle of the tilted axis.

### Switch-off

To prevent data being lost at switch-off, you need to run down the operating system as follows:

- Select the Manual mode



- Select the function for run-down, confirm again with the YES soft key.

- When the TNC displays the message „Now you can switch off the TNC“ in a superimposed window, you may cut off the power supply to the TNC.



Inappropriate switch-off of the TNC can lead to data loss.

## 2.2 Moving the Machine Axes



Traversing with the machine axis direction buttons is a machine-dependent function. Refer to your machine tool manual for more information.

### To traverse with the machine axis direction buttons:



Select the Manual Operation mode.



Press the machine axis direction button and hold it as long as you wish the axis to move.

...or move the axis continuously:



and



Press and hold the machine axis direction button, then press the machine START button: The axis continues to move after you release the keys.



To stop the axis, press the machine STOP button.

You can move several axes at a time with these two methods. You can change the feed rate at which the axes are traversed with the F soft key (see „2.3 Spindle Speed S, Feed Rate F and Miscellaneous Functions M).



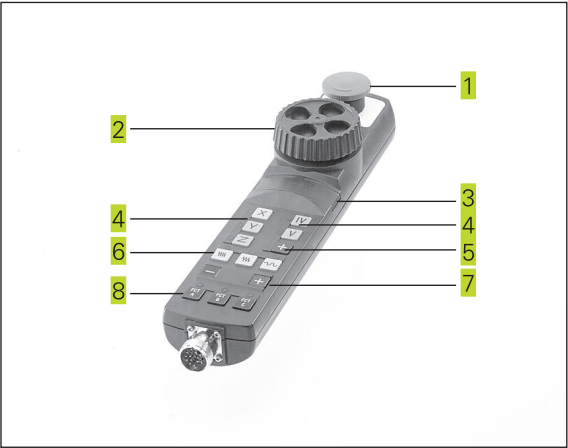
Traversing with the HR 410 electronic handwheel

The portable HR 410 handwheel is equipped with two permissive buttons. The permissive buttons are located below the star grip. You can only move the machine axes when an permissive button is depressed (machine-dependent function).

The HR 410 handwheel features the following operating elements:

- 1 EMERGENCY STOP
- 2 Handwheel
- 3 Permissive buttons
- 4 Axis address keys
- 5 Actual-position-capture key
- 6 Keys for defining the feed rate (slow, medium, fast; the feed rates are set by the machine tool builder)
- 7 Direction in which the TNC moves the selected axis
- 8 Machine function (set by the machine tool builder)

The red indicators show the axis and feed rate you have selected. It is also possible to move the machine axes with the handwheel during a program run.



To move an axis:



Select the Electronic Handwheel mode of operation



Press and hold the permissive button.



Select the axis.




Select the feed rate.




Move the active axis in the positive or negative direction.

### Incremental jog positioning

With incremental jog positioning you can move a machine axis by a preset distance.





Select Manual or Electronic Handwheel mode of operation




Select incremental jog positioning: Switch the INCREMENT soft key to ON

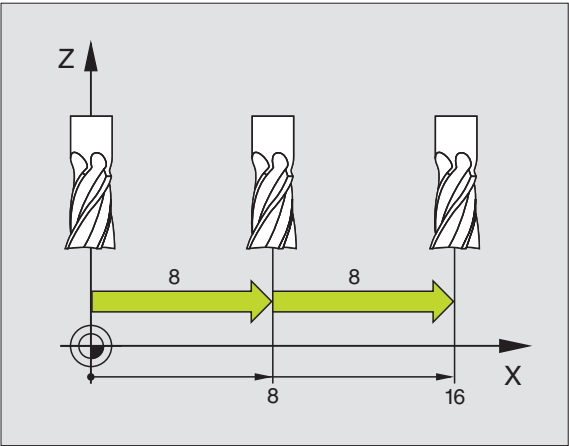
**Jog increment =**



Enter the jog increment in millimeters (here, 8 mm).



Press the machine axis direction button as often as desired.



## 2.3 Spindle Speed S, Feed Rate F and Miscellaneous Functions M

In the operating modes Manual and Electronic Handwheel, you can enter the spindle speed S, feed rate F and the miscellaneous functions M with soft keys. The miscellaneous functions are described in Chapter 7 "Programming: Miscellaneous Functions."

Entering values

Example: Entering the spindle speed S



To enter the spindle speed, press the S soft key.

Spindle speed S=

1000

Enter the desired spindle speed,



and confirm your entry with the machine START button.

The spindle speed S with the entered rpm is started with a miscellaneous function.

The following is valid for feed rate F:

- If you enter F=0, then the lowest feed rate from MP1020 is effective
- F is not lost during a power interruption

Changing the spindle speed and feed rate

With the override knobs you can vary the spindle speed S and feed rate F from 0% to 150% of the set value.



The knob for spindle speed override is effective only on machines with an infinitely variable spindle drive.

The machine tool builder determines which miscellaneous functions M are available on your TNC and what effects they have.



2.4 Datum Setting  
(Without a 3-D Touch Probe)



For datum setting with a 3-D touch probe, refer to the new Touch Probe Cycles Manual

You fix a datum by setting the TNC position display to the coordinates of a known position on the workpiece.

Preparation

- ▶ Clamp and align the workpiece.
- ▶ Insert the zero tool with known radius into the spindle.
- ▶ Ensure that the TNC is showing the actual position values.

## Datum setting

Fragile workpiece? If the workpiece surface must not be scratched, you can lay a metal shim of known thickness  $d$  on it. Then enter a tool axis datum value that is larger than the desired datum by the value  $d$ .



Select the Manual Operation mode.



Move the tool slowly until it touches the workpiece surface.



Select an axis (all axes can also be selected via the ASCII keyboard)

**Datum Set Z=**

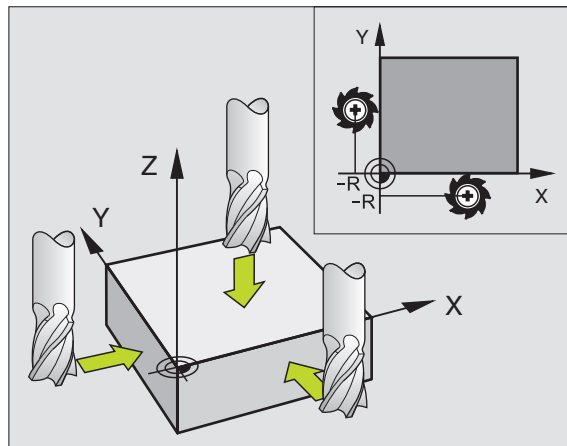


ENT

Zero tool in spindle axis: Set the display to a known workpiece position (here, 0) or enter the thickness  $d$  of the shim. In the tool axis, offset the tool radius.

Repeat the process for the remaining axes.

If you are using a preset tool, set the display of the tool axis to the length  $L$  of the tool or enter the sum  $Z=L+d$ .

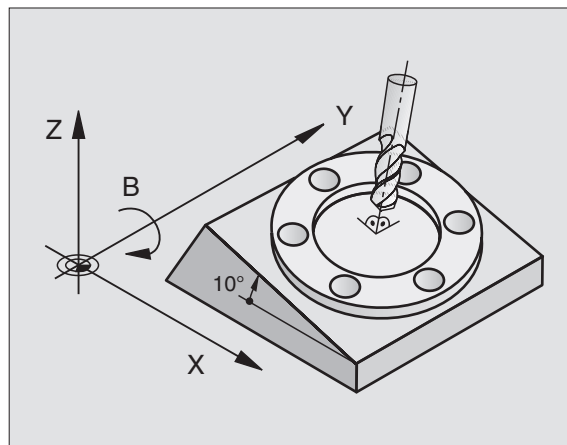


## 2.5 Tilting the Working Plane



The functions for tilting the working plane are interfaced to the TNC and the machine tool by the machine tool builder. With some swivel heads and tilting tables, the machine tool builder determines whether the entered angles are interpreted as coordinates of the tilt axes or as angular components of a tilted plane. Your machine manual provides more detailed information.

The TNC supports the tilting functions on machine tools with swivel heads and/or tilting tables. Typical applications are, for example, oblique holes or contours in an oblique plane. The working plane is always tilted around the active datum. The program is written as usual in a main plane, such as the X/Y plane, but is executed in a plane that is tilted relative to the main plane.



There are two functions available for tilting the working plane

- 3-D ROT soft key in the Manual mode and Electronic Handwheel mode (described below)
- Tilting under program control: Cycle 19 WORKING PLANE in the part program: see „8.7 Coordinate Transformation Cycles“

The TNC functions for “tilting the working plane” are coordinate transformations in which the working plane is always perpendicular to the direction of the tool axis.

When tilting the working plane, the TNC differentiates between two machine types

### Machines with tilting tables:

- You must tilt the **workpiece** into the desired position for machining by positioning the tilting table, for example with an L block.
- The position of the transformed tool axis **does not change** in relation to the machine-based coordinate system. Thus if you rotate the table — and therefore the workpiece — by 90° for example, the coordinate system **does not rotate**. If you press the Z+ axis direction button in the Manual Operation mode, the tool moves in Z+ direction.
- In calculating the transformed coordinate system, the TNC considers only the mechanically influenced offsets of the particular tilting table (the so-called “translational” components).

### Machines with swivel heads

- You must bring the **tool** into the desired position for machining by positioning the swivel head, for example with an L block.
- The position of the transformed tool axis **changes** in relation to the machine-based coordinate system. Thus if you rotate the swivel head — and therefore the tool — in the B axis by 90° for example, **the coordinate system rotates also**. If you press the Z+ axis direction button in the Manual Operation mode, the tool moves in X+ direction of the machine-based coordinate system.
- In calculating the transformed coordinate system, the TNC considers both the mechanically influenced offsets of the particular swivel head (the so-called “translational” components) **and** offsets caused by tilting of the tool (3-D tool length compensation).

### Traversing the reference points in tilted axes

With tilted axes, you use the machine axis direction buttons to cross over the reference points. The TNC interpolates the corresponding axes. Be sure that the function for tilting the working plane is active in the Manual Operation mode and the actual angle of the tilted axis was entered in the menu field.

### Setting the datum in a tilted coordinate system

After you have positioned the rotary axes, set the datum in the same way as for a non-tilted system. The TNC then converts the datum for the tilted coordinate system. If your machine tool features axis control, the angular values for this calculation are taken from the actual position of the rotary axis.



You must not set the datum in the tilted working plane if in machine parameter 7500 bit 3 is set. If you do, the TNC will calculate the wrong offset.

If your machine tool is not equipped with axis control, you must enter the actual position of the rotary axis in the menu for manual tilting: The actual positions of one or several rotary axes must match the entry. Otherwise the TNC will calculate an incorrect datum.

### Datum setting on machines with rotary tables



The behavior of the TNC during datum setting depends on the machine. Your machine manual provides more detailed information.

The TNC automatically shifts the datum if you rotate the table and the tilted working plane function is active.

#### MP 7500, bit 3=0

To calculate the datum, the TNC uses the difference between the REF coordinate during datum setting and the REF coordinate of the tilting axis after tilting. The method of calculation is to be used when you have clamped your workpiece in proper alignment when the rotary table is in the 0° position (REF value).

#### MP 7500, bit 3=1

If you rotate the table to align a workpiece that has been clamped in an unaligned position, the TNC must no longer calculate the offset of the datum from the difference of the REF coordinates. Instead of the difference from the 0° position, the TNC uses the REF value of the tilting table after tilting. In other words, it assumes that you have properly aligned the workpiece before tilting.

### Position display in a tilted system

The positions displayed in the status window (ACTL. and NOML.) are referenced to the tilted coordinate system.

### Limitations on working with the tilting function

- The touch probe function Basic Rotation cannot be used.
- PLC positioning (determined by the machine tool builder) is not possible.
- Positioning blocks with M91/M92 are not permitted.

To activate manual tilting:



To select manual tilting, press the 3-D ROT soft key.  
You can now select the desired menu option with the arrow keys.


Enter the tilt angle.

To set the desired operating mode in menu option “Tilt working plane” to Active, select the menu option and shift with the ENT key.





To conclude entry, press the END soft key.

To reset the tilting function, set the desired operating modes in menu “Tilt working plane” to Inactive.

If the Working Plane function is active and the TNC moves the machine axes in accordance with the tilted axes, the status display shows the symbol .

If you set the function “Tilt working plane” for the operating mode Program Run to Active, the tilt angle entered in the menu becomes active in the first block of the part program. If you are using Cycle 19 WORKING PLANE in the part program, the angular values defined in the cycle (starting at the cycle definition) are effective. Angular values entered in the menu will be overwritten.

Manual operation				Test run			
Tilt working plane							
Program run:				Inactive			
Manual operation				Active			
A = +0		°					
B = +180		°					
C = +90		°					
X		+50.0000		Y		-150.0000	
Z		-100.0000					
A		+0.0000		B		+180.0000	
C		+90.0000					
ACTL.  T  0 H 5/9							





# 3

**Positioning with Manual Data  
Input (MDI)**

### 3.1 Programming and Executing Simple Machining Operations

The operating mode Positioning with Manual Data Input is particularly convenient for simple machining operations or pre-positioning of the tool. It enables you to write a short program in HEIDENHAIN conversational programming or in ISO format, and execute it immediately. You can also call TNC cycles. The program is stored in the file \$MDI. In the operating mode Positioning with MDI, the additional status displays can also be activated.



Select the Positioning with MDI mode of operation. Program the file \$MDI as you wish.



To start program run, press the machine START button.

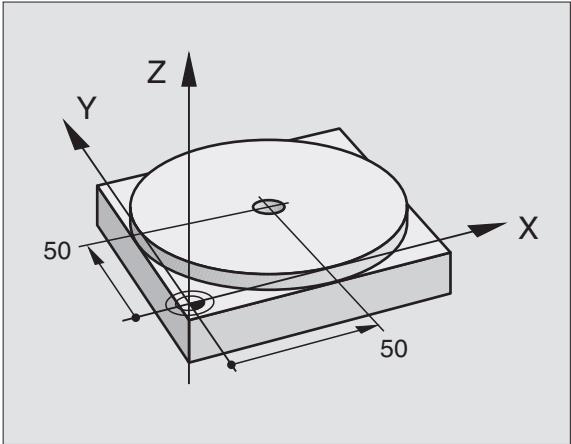


Limitation: FK free contour programming, programming graphics and program run graphics cannot be used. The \$MDI file must not contain a program call (PGM CALL).

#### Example 1

A hole with a depth of 20 mm is to be drilled into a single workpiece. After clamping and aligning the workpiece and setting the datum, you can program and execute the drilling operation in a few lines.

First you pre-position the tool in L blocks (straight-line blocks) to the hole center coordinates at a setup clearance of 5 mm above the workpiece surface. Then drill the hole with Cycle 1 PECKING.



0 BEGIN PGM \$MDI MM	
1 TOOL DEF 1 L+0 R+5	Define tool: zero tool, radius 5
2 TOOL CALL 1 Z S2000	Call tool: tool axis Z Spindle speed 2000 rpm
3 L Z+200 R0 F MAX	Retract tool (F MAX = rapid traverse)
4 L X+50 Y+50 R0 F MAX M3	Move the tool at FMAX to a position above the borehole, spindle on
5 L Z+5 F2000	Position tool to 5 mm above hole
6 CYCL DEF 1.0 PECKING	Define PECKING cycle:

7 CYCL DEF 1.1 SET UP 5	Setup clearance of the tool above the hole
8 CYCL DEF 1.2 DEPTH -20	Total hole depth (Algebraic sign=working direction)
9 CYCL DEF 1.3 PECKG 10	Depth of each infeed before retraction
10 CYCL DEF 1.4 DWELL 0.5	Dwell time in seconds at the hole bottom
11 CYCL DEF 1.5 F250	Feed rate for pecking
12 CYCL CALL	Call PECKING cycle
13 L Z+200 RO F MAX M2	Retract tool
14 END PGM \$MDI MM	End of program

The straight-line function is described in section 6.4 “Path Contours — Cartesian Coordinates,” the PECKING cycle in section 8.2 “Drilling Cycles.”

Example 2


Correcting workpiece misalignment on machines with rotary tables

Use the 3-D touch probe to rotate the coordinate system. See the User's Manual for Touch Probe Cycles, chapter “Touch Probe Cycles in the Manual and Electronic Handwheel Modes,” section “Compensating Workpiece Misalignment.”

Write down the Rotation Angle and cancel the Basic Rotation.



Select operating mode: Positioning with MDI.




IV

Select the axis of the rotary table, enter the rotation angle you wrote down previously and set the feed rate.  
For example: L C+2.561 F50



Conclude entry.



Press the machine START button: The rotation of the table corrects the misalignment.

Protecting and erasing programs in \$MDI

The \$MDI file is generally intended for short programs that are only needed temporarily. Nevertheless, you can store a program, if necessary, by proceeding as described below:



Select operating mode: Programming and Editing



To call the file manager, press the PGM MGT key (program management).



Move the highlight to the \$MDI file.



Select „Copy file“: Press the COPY soft key

Target file =

BOREHOLE

Enter the name under which you want to save the current contents of the \$MDI file.



Copy the file.



To close the file manager, press the END soft key.

Erasing the contents of the \$MDI file is done in a similar way: Instead of copying the contents, however, you erase them with the DELETE soft key. The next time you select the Positioning with MDI operating mode, the TNC will display an empty \$MDI file.



If you wish to delete \$MDI, then  
you must not have selected the Positioning with MDI mode (not even in the background).  
you must not have selected the \$MDI file in the Programming and Editing mode.

For further information, refer to section 4.2 “File Management.”



# 4

**Programming:**

**Fundamentals of NC, File  
Management,  
Programming Aids, Pallet  
Management**

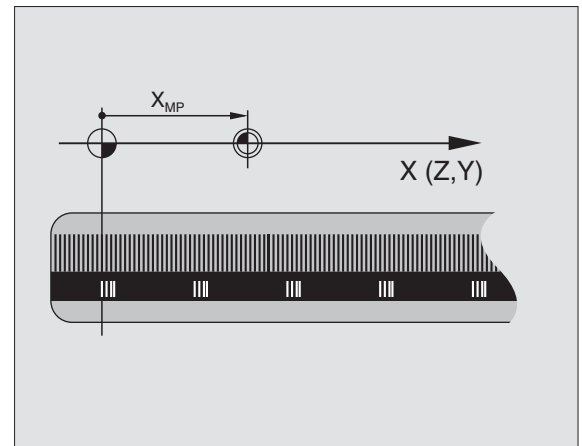
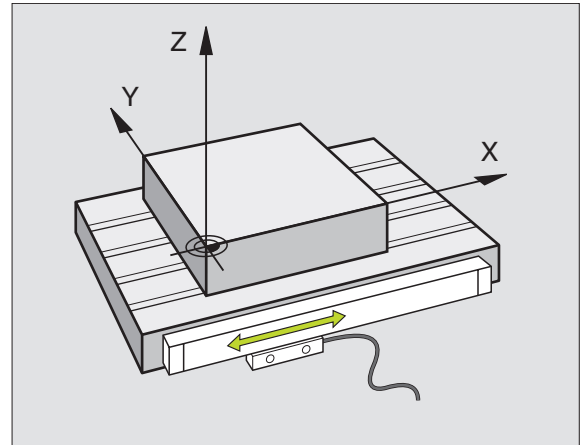
## 4.1 Fundamentals of NC

### Position encoders and reference marks

The machine axes are equipped with position encoders that register the positions of the machine table or tool. When a machine axis moves, the corresponding position encoder generates an electrical signal. The TNC evaluates this signal and calculates the precise actual position of the machine axis.

If there is an interruption of power, the calculated position will no longer correspond to the actual position of the machine slide. The CNC can re-establish this relationship with the aid of reference marks when power is returned. The scales of the position encoders contain one or more reference marks that transmit a signal to the TNC when they are crossed over. From the signal the TNC identifies that position as the machine-axis reference point and can re-establish the assignment of displayed positions to machine axis positions.

Linear encoders are generally used for linear axes. Rotary tables and tilt axes have angle encoders. If the position encoders feature distance-coded reference marks, you only need to move each axis a maximum of 20 mm (0.8 in.) for linear encoders, and 20° for angle encoders, to re-establish the assignment of the displayed positions to machine axis positions.



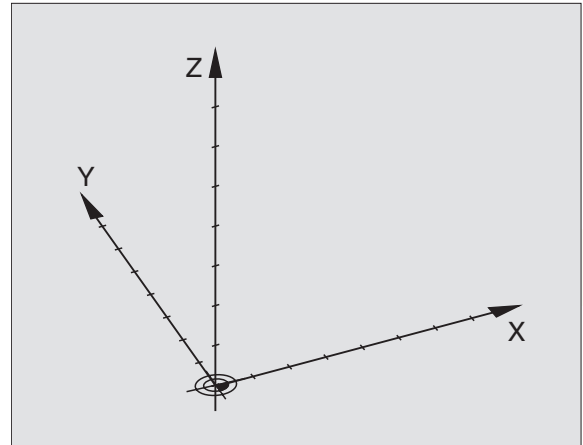


## Reference system

A reference system is required to define positions in a plane or in space. The position data are always referenced to a predetermined point and are described through coordinates.

The Cartesian coordinate system (a rectangular coordinate system) is based on three coordinate axes X, Y and Z. The axes are mutually perpendicular and intersect at one point called the datum. A coordinate identifies the distance from the datum in one of these directions. A position in a plane is thus described through two coordinates, and a position in space through three coordinates.

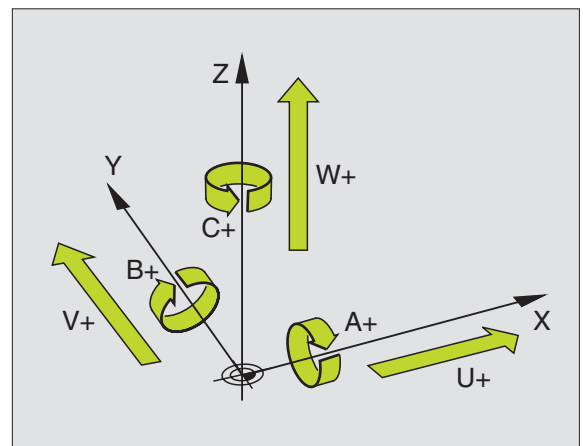
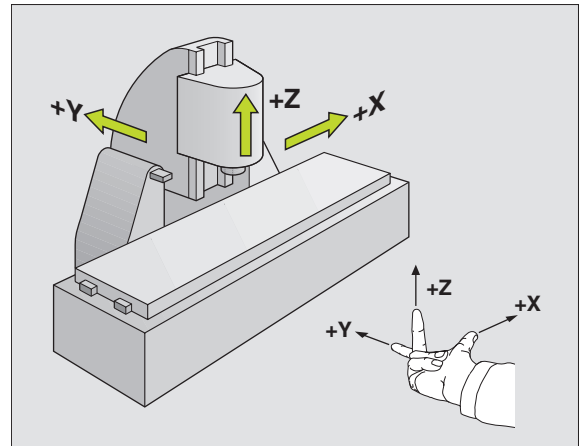
Coordinates that are referenced to the datum are referred to as absolute coordinates. Relative coordinates are referenced to any other known position (datum) you define within the coordinate system. Relative coordinate values are also referred to as incremental coordinate values.



## Reference systems on milling machines

When using a milling machine, you orient tool movements to the Cartesian coordinate system. The illustration at right shows how the Cartesian coordinate system describes the machine axes. The figure at right illustrates the "right-hand rule" for remembering the three axis directions: the middle finger is pointing in the positive direction of the tool axis from the workpiece toward the tool (the Z axis), the thumb is pointing in the positive X direction, and the index finger in the positive Y direction.

The TNC 426 can control a machine tool in up to 5 axes; the TNC 430 controls up to 9 axes. The axes U, V and W are secondary linear axes parallel to the main axes X, Y and Z, respectively. Rotary axes are designated as A, B and C. The illustration at lower right shows the assignment of secondary axes and rotary axes to the main axes.





Polar coordinates

If the production drawing is dimensioned in Cartesian coordinates, you also write the part program using Cartesian coordinates. For parts containing circular arcs or angles it is often simpler to give the dimensions in polar coordinates.

While the Cartesian coordinates X, Y and Z are three-dimensional and can describe points in space, polar coordinates are two-dimensional and describe points in a plane. Polar coordinates have their datum at a circle center (CC), or pole. A position in a plane can be clearly defined by the

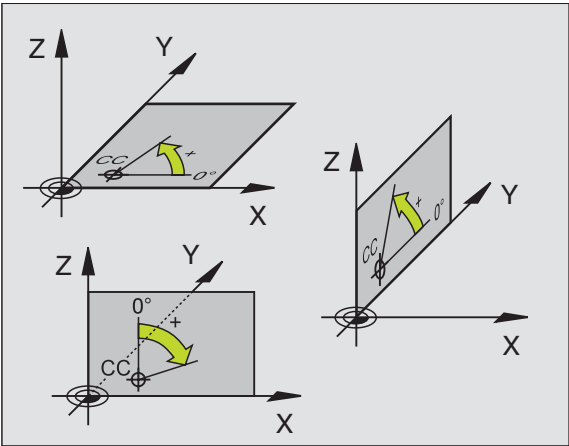
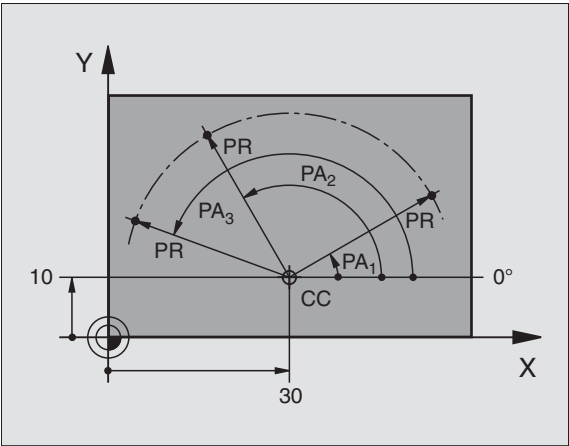
- Polar Radius, the distance from the circle center CC to the position, and the
- Polar Angle, the size of the angle between the reference axis and the line that connects the circle center CC with the position.

See figure at lower right.

Definition of pole and angle reference axis

The pole is set by entering two Cartesian coordinates in one of the three planes. These coordinates also set the reference axis for the polar angle PA.

Coordinates of the pole (plane)	Reference axis of the angle
XY	+X
YZ	+Y
ZX	+Z



## Absolute and relative workpiece positions

### Absolute workpiece positions

Absolute coordinates are position coordinates that are referenced to the datum of the coordinate system (origin). Each position on the workpiece is uniquely defined by its absolute coordinates.

#### Example 1: Holes dimensioned in absolute coordinates

Hole 1	Hole 2	Hole 3
X=10 mm Y=10 mm	X=30 mm Y=20 mm	X=50 mm Y=30 mm

### Relative workpiece positions

Relative coordinates are referenced to the last programmed nominal position of the tool, which serves as the relative (imaginary) datum. When you write a part program in incremental coordinates, you thus program the tool to move by the distance between the previous and the subsequent nominal positions. Incremental coordinates are therefore also referred to as chain dimensions.

To program a position in incremental coordinates, enter the prefix "I" before the axis.

#### Example 2: Holes dimensioned with relative coordinates

Absolute coordinates of hole 4:

X= 10 mm  
Y= 10 mm

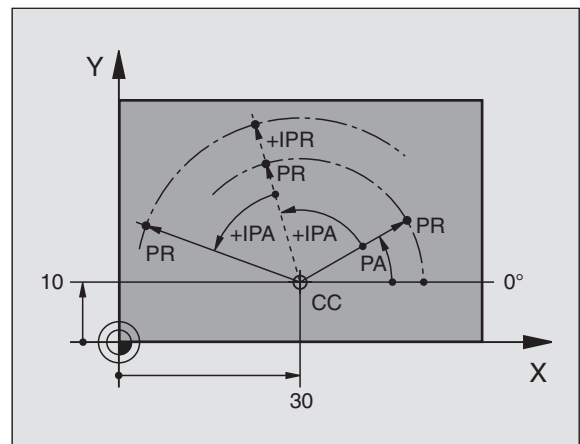
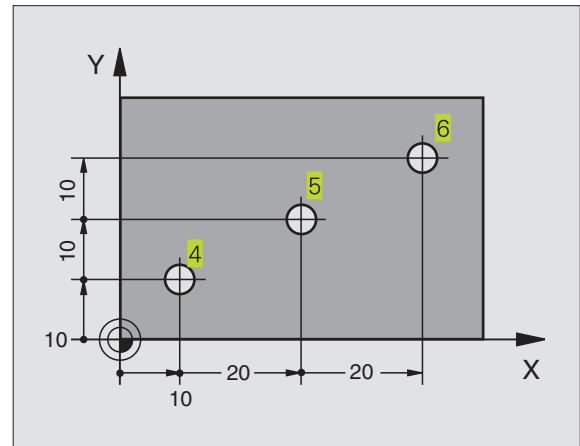
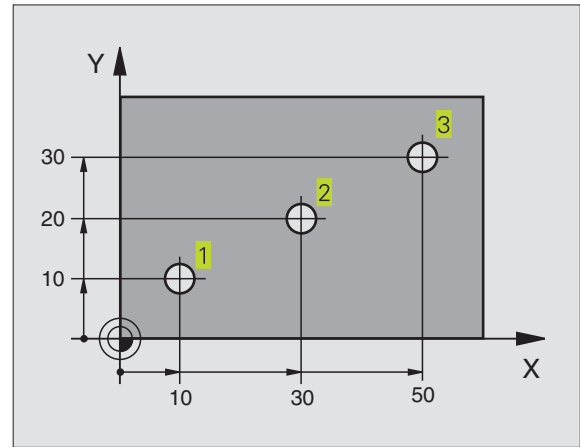
Hole 5 referenced to hole 4      Hole 6 referenced to hole 5

IX= 20 mm      IX= 20 mm  
IY= 10 mm      IY= 10 mm

### Absolute and incremental polar coordinates

Absolute polar coordinates always refer to the pole and the reference axis.

Incremental polar coordinates always refer to the last programmed nominal position of the tool.



## Selecting the datum

A production drawing identifies a certain form element of the workpiece, usually a corner, as the absolute datum. Before setting the datum, you align the workpiece with the machine axes and move the tool in each axis to a known position relative to the workpiece. You then set the TNC display to either zero or a predetermined position value. This establishes the reference system for the workpiece, which will be used for the TNC display and your part program.

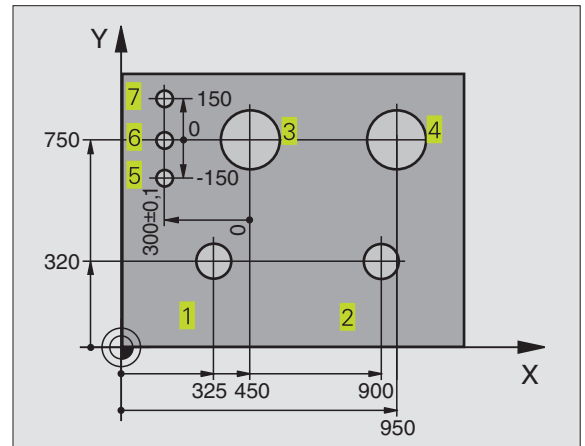
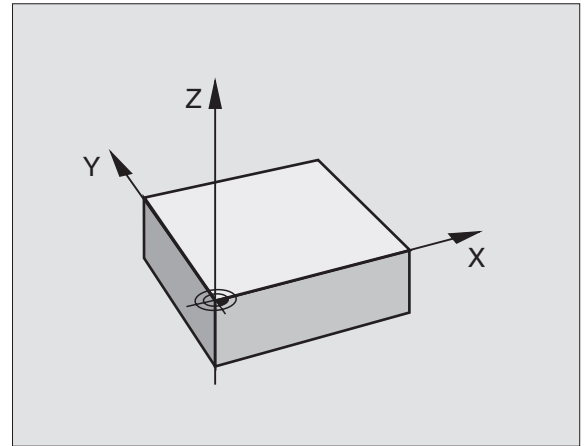
If the production drawing is dimensioned in relative coordinates, simply use the coordinate transformation cycles. For further information, refer to section 8.7 "Coordinate Transformation Cycles."

If the production drawing is not dimensioned for NC, set the datum at a position or corner on the workpiece, which is the most suitable for deducing the dimensions of the remaining workpiece positions.

The fastest, easiest and most accurate way of setting the datum is by using a 3-D touch probe from HEIDENHAIN. See the new Touch Probe Cycles User's Manual, chapter „Setting the Datum with a 3-D Touch Probe“.

### Example

The workpiece drawing at right illustrates the holes 1 to 4, which are dimensioned to an absolute datum with the coordinates  $X=0$   $Y=0$ . The holes 5 to 7 are referenced to a relative datum with the absolute coordinates  $X=450$   $Y=750$ . By using the DATUM SHIFT cycle you can shift the datum temporarily to the position  $X=450$ ,  $Y=750$  and program the holes 5 to 7 without any further calculations.



## 4.2 File Management: Fundamentals



Using the MOD function PGM MGT (see Section 12.6), select between **standard** file management and **file management** with additional functions.

If the TNC is connected to a network (optional), then use file management with additional functions.

### Files

When you write a part program on the TNC, you must first enter a file name. The TNC then stores the program on the hard disk as a file with this name. You can also store texts and tables as files.

The TNC provides a special file management window in which you can easily find and manage your files. Here you can call, copy, rename and erase files.

You can manage any number of files on the TNC’s hard disk. Their total size, however, must not exceed 1500 MB.

#### File names

The name of a file can have up to 16 characters. When you store programs, tables and texts as files, the TNC adds an extension to the file name, separated by a point. This extension identifies the file type (see table at right).



### Data security

We recommend saving newly written programs and files on a PC at regular intervals. You can do this with the cost-free backup program TNCBACK.EXE from HEIDENHAIN. Your machine tool builder can provide you with a copy of TNCBACK.EXE.


You also need a floppy disk on which all the machine-specific data (PLC program, machine parameters, etc.) of your machine tool are stored. Please contact your machine tool builder for more information on both the backup program and the floppy disk.



Saving the contents of the entire hard disk (up to 1500 MB) can take up to several hours. In this case, it is a good idea to save the data outside of working hours, (e.g. overnight), or to use the PARALLEL EXECUTE function to copy in the background while you work.

Files in theTNC	Type
<b>Programs</b>	
in HEIDENHAIN conversational format	.H
in ISO format	.I
<b>Tables for</b>	
Tools	.T
Tool changer	.TCH
Pallets	.P
Datums	.D
Points (digitizing range for measuring touch probe)	.PNT
Cutting data	.CDT
Cutting materials and other materials	.TAB
<b>Texts as</b>	
ASCII files	.A

4.3 Standard File Management



Use the standard file manager if you want to store all of the files in one directory, or if you are used to working with the file manager on old TNC controls.

Set the MOD function PGM MGT to Standard (see Section 12.6) .


Calling the file manager



Press the PGM MGT:  
The TNC displays the file management window (see Fig. at top right)



The window shows you all of the files that are stored in the TNC. Each file is shown with additional information, see table at center right.

Selecting a file.




Calling the file manager


Use the arrow keys to move the highlight to the file you wish to select:








Move the highlight up or down.



or



Select a file: Press the SELECT soft key or ENT

Manual operation		Program table editing	
		File name =\$MDI.H	
TNC:\*.*			
File name		bytes	Status
%TCHPRNT		.A 73	
CVREPORT		.A 7753	
FRAESEN		.A 7570	
FRAESEN		.CDT 6580	
\$MDI		.H 332	
11		.H 192	
111		.H 1194	
112		.H 258	
12		.H 238	
123		.H 240	
1GT5		.H 226	
39 file(s) 915072 kbyte vacant			
PAGE ↑	PAGE ↓	SELECT 	DELETE 
		COPY 	EXT 
		LAST FILES 	
		END	

display.	Meaning
FILE NAME	Name with max. 16 characters and file type
BYTE	File size in bytes
STATUS E	Property of the file: Program is in the Programming and Editing mode of operation
S	Program is in the Test Run mode of operation.
M	Program is in the Program Run mode of operation.
P	File is protected against editing and erasure (Protected)

Display of long file directories	Soft key
Move pagewise up through the file directory.	PAGE ↑
Move pagewise down through the file directory	PAGE ↓

## Deleting a file



Calling the file manager

Use the arrow keys to move the highlight to the file you wish to delete:



Move the highlight up or down.



Delete a file: Press the DELETE soft key

**Delete ..... file ?**



Press the YES soft key to confirm, or



the NO soft key to abort.

## Copying a file



Calling the file manager

Use the arrow keys to move the highlight to the file you wish to copy:



Move the highlight up or down.



Copy a file: Press the COPY soft key

**Target file =**

Enter the name of the new file and confirm your entry with the ENT key or EXECUTE soft key. A status window appears on the TNC, informing about the copying progress. As long as the TNC is copying, you can no longer work, or

If you wish to copy very long programs, enter the new file name and confirm with the PARALLEL EXECUTE soft key. The file will now be copied in the background, so you can continue to work while the TNC is copying.

Data transfer to or from an external data medium

Before you can transfer data to an external data medium, you must set the interface (see „Section 12.4 Setting the Data Interfaces“).



Calling the file manager



Activate data transfer: press the EXT soft key. In the left half of the screen, the TNC shows all of the 1 files that are stored on the TNC, and in the right half of the screen, 2 all of the files that are stored on the external data medium.

Manual operation		Programming and editing	
		File name =111.H	
TNC:\*.*		RS232:\*.*	
File name		bytes	Status
%TCHPRNT		.A	73
CVREPOR		.A	7753
FRAESEN		.A	7570
GFB30		.A	245K
FRAESEN		.CDT	6580
#MDI		.H	332
11		.H	192
111		.H	1194 E
112		.H	258
12		.H	238
123		.H	248
41 file(s) 914800 kbyte vacant			
PAGE	PAGE	COPY	TNC EXT
↑	↓	TNC EXT	TAG
		TNC	EXT
		TAG	TNC
		END	

Use the arrow keys to highlight the file(s) that you want to transfer:



Move the highlight up and down within a window



Move the highlight from the left to the right window, and vice versa.

If you are transferring from the TNC to the external medium, move the highlight in the left window onto the file that is to be transferred.

If you are transferring from the external medium to the TNC, move the highlight in the right window onto the file that is to be transferred.



Transfer a single file: Press the COPY soft key, or



Transfer several files: Press TAG (marking functions, see table on right), or



transfer all files by pressing the TNC EXT soft key

Tagging functions	Soft key
Tag a single file	TAG FILE
Tag all files	TAG ALL FILES
Untag a single file	UNTAG FILE
Untag all files	UNTAG ALL FILES
Copy all tagged files	COPY TAG



Confirm with the EXECUTE or with the ENT key. A status window appears on the TNC, informing about the copying progress, or

If you wish to transfer more than one file or longer files, press the PARALLEL EXECUTE soft key. The TNC then copies the file in the background.



To stop transfer, press the TNC soft key. The standard file manager window is displayed again.

### Selecting one of the last 10 files selected.



Calling the file manager



Display the last 10 files selected: Press LAST FILES soft key

Use the arrow keys to move the highlight to the file you wish to select:




Move the highlight up or down.



or



Select a file: Press the SELECT soft key or ENT

Positioning with mdi	Programming and editing						
0: TNC:\NK\SCRDP\NEU.H 1: TNC:\NK\SCRDP\3507.H 2: TNC:\NK\SCRDP\1GB.H 3: TNC:\NK\SCRDP\3516.H 4: TNC:\NK\SCRDP\35071.H 5: TNC:\NK\SCRDP\BLK.H 6: TNC:\FRAESEN.CDT 7: TNC:\FRAESEN.A 8: TNC:\WTAB\FRAESER.CDT 9: TNC:\CUTTING\FRAESER.CDT							
SELECT							END

## Renaming a file



Calling the file manager

Use the arrow keys to move the highlight to the file you wish to rename:



Move the highlight up or down.



To rename the file, press the RENAME key.

**Target file =**

Enter the name of the new file and confirm your entry with the ENT key or EXECUTE soft key.

## Convert an FK program into HEIDENHAIN conversational format



Calling the file manager

Use the arrow keys to move the highlight to the file you wish to convert:



Move the highlight up or down.



Press the CONVERT  
FK -> H to select the convert function

**Target file =**

Enter the name of the new file and confirm your entry with the ENT key or EXECUTE soft key.

## Protect file / Cancel file protection



Calling the file manager

Use the arrow keys to move the highlight to the file you wish to protect or whose protection you wish to cancel:



Move the highlight up or down.




Press the PROTECT soft key to enable file protection. The file now has status P, or



To cancel file protection, press the UNPROTECT soft key. The P status is canceled.

## 4.4 File Management with Additional Functions




Select the file manager with additional functions if you wish to store files in various different directories.

Set the MOD function PGM MGT (see Section 12.6) to **Enhanced**!

See also Section „4.2 File Management: Fundamentals“!

### Directories

To ensure that you can easily find your files, we recommend that you organize your hard disk into directories. You can divide a directory up into further directories, which are called subdirectories.



The TNC can manage up to 6 directory levels!

If you save more than 512 files in one directory, the TNC no longer sorts them alphabetically!

### Directory names

The name of a directory can contain up to 8 characters and does not have an extension. If you enter more than 8 characters for the directory name, the TNC will shorten the name to 8 characters.

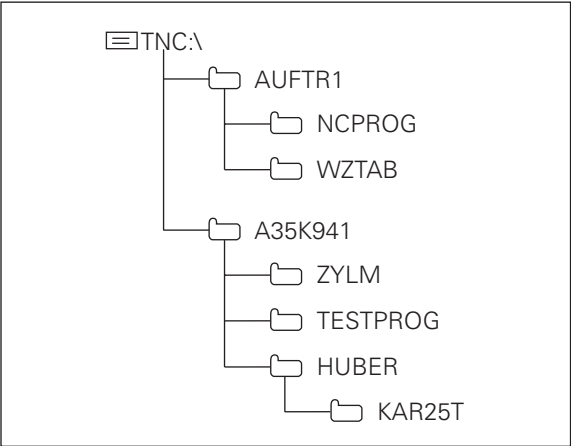
### Paths

A path indicates the drive and all directories and subdirectories under which a file is saved. The individual names are separated by the symbol “\”.














Example: On drive TNC:\, the directory AUFTR1 was created. Under this directory, the subdirectory NCPROG was created, and the part program PROG1.H copied into this subdirectory. The part program now has the following path:

TNC:\AUFTR1\NCPROG\PROG1.H

The chart at right illustrates an example of a directory display with different paths.



# Overview: Functions of the expanded file manager

Function	Soft key
Copy (and convert) individual files	
Display a specific file type	
Display the last 10 files that were selected	
Erase a file or directory	
Tag a file	
Renaming a file	
Convert an FK program into HEIDENHAIN conversational format	
Protect a file against editing and erasure	
Cancel file protection	
Network drive management (Ethernet option only)	
Copying a directory	
Display all the directories of a particular drive	
Delete directory with all its subdirectories	

Calling the file manager

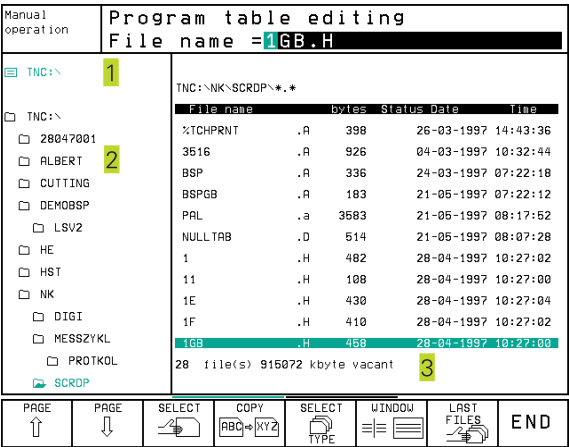


Press the PGM MGT:  
The TNC displays the file management window (see Fig. at top right for default setting. If the TNC displays a different screen layout, press the WINDOW soft key)

The narrow window at left shows three drives **1** . If the TNC is connected to a network, it also displayed the connected network drives. Drives designate devices with which data are stored or transferred. One drive is the hard disk of the TNC. Other drives are the interfaces (RS232, RS422, Ethernet), which can be used, for example, to connect a personal computer. The selected (active) drive is shown in a different color.

In the lower part of the narrow window the TNC shows all directories **2** of the selected drive. A drive is always identified by a file symbol to the left and the directory name to the right. The TNC displays a subdirectory to the right of and below its parent directory. The selected (active) directory is depicted in a different color.

The wide window at on the right side shows all the files **3** that are stored in the selected directory. Each file is shown with additional information that is illustrated in the table on the next page.



Display	Meaning
FILE NAME	Name with max. 16 characters and file type
BYTE	File size in bytes
STATUS	Property of the file:
E	Program is selected Programming and Editing mode of operation
S	Program is selected Test Run mode of operation
M	Program is in the Program Run mode of operation.
P	File is protected against editing and erasure (Protected)
DATE	Date the file was last changed
TIME	Time the file was last changed

**To select drives, directories and files:**

Calling the file manager

With the arrow keys or the soft keys, you can move the highlight to the desired position on the screen:



Move the highlight from the left to the right window, and vice versa.



Move the highlight up and down within a window



Move the highlight one page up or down within a window

**1st step: select drive:**

Move the highlight to the desired drive in the left window:



or



Select drive: Press the SELECT soft key or ENT

**2nd step: select directory:**

Move the highlight to the desired directory in the left window — the right window automatically shows all files stored in the highlighted directory.

3rd step: select a file:



Press the SELECTTYPE soft key



Press the soft key for the desired file type, or



To display all files, press the SHOW ALL soft key or

4\* .H



use wildcard characters, e.g., to show all files of the file type .H that begin with 4.

Move the highlight to the desired file in the right window



or



The selected file is opened in the operating mode from which you have the called file manager: Press ENT or the SELECT soft key.

To create a new directory (only possible on the TNC's hard disk drive):

Move the highlight in the left window to the directory in which you want to create a subdirectory.

NEW



Enter the new file name, and confirm with ENT.

Create \NEW directory ?



Press the YES soft key to confirm, or



the NO soft key to abort.



## Copying a file

- Move the highlight to the file you wish to copy.



- Press the COPY soft key to select the copying function.

- Enter the name of the destination file and confirm your entry with the ENT key or EXECUTE soft key: The TNC copies the file into the active directory. The original file is retained.  
Press the PARALLEL EXECUTE soft key to copy the file in the background. Copying in the background permits you to continue working while the TNC is copying. This can be useful if you are copying very large files that take a long time. While the TNC is copying in the background you can press the INFO PARALLEL EXECUTE soft key (under MORE FUNCTIONS, second soft-key row) to check the progress of copying.

### Copying a table

If you are copying tables, you can overwrite individual lines or columns in the target table with the REPLACE FIELDS soft key.  
Prerequisites:

- The target table must exist.
- The file to be copied must only contain the columns or lines you want to replace.

#### Example:

With a tool presetter you have measured the length and radius of 10 new tools. The tool presetter then generates the tool table TOOL.T with 10 lines (for the 10 tools) and the columns

- Tool number
- Tool length
- Tool radius

If you wish to copy this file to the TNC, the TNC asks if you wish to overwrite the existing TOOL.T tool table:

- If you press the YES soft key, the TNC will completely overwrite the current TOOL.T tool table. After this copying process the new TOOL.T table consists of 10 lines. The only remaining columns in the table are tool number, tool length and tool radius.
- If you press the REPLACE FIELDS soft key, the TNC merely overwrites the first 10 lines of the columns number, length and radius in the TOOL.T file. The data of the other lines and columns is not changed.

## Copying a directory

Move the highlight in the left window onto the directory you want to copy. Press the COPY DIR soft key instead of the COPY soft key. Subdirectories are also copied at the same time.

Selecting one of the last 10 files selected.



Calling the file manager



Display the last 10 files selected: Press LAST FILES soft key

Use the arrow keys to move the highlight to the file you wish to select:



Move the highlight up or down.



or



Select a file: Press the SELECT soft key or ENT

Deleting a file

► Move the highlight to the file you want to delete.



► To select the erasing function, press the DELETE soft key.  
The TNC inquires whether you really intend to erase the file.

► To confirm, press the YES soft key;  
To abort erasure, press the NO soft key.

Erase a directory

► Erase all files and subdirectories stored in the directory that you wish to erase.

► Move the highlight to the directory you want to delete.



► To select the erasing function, press the DELETE soft key. The TNC inquires whether you really intend to erase the directory.

► To confirm, press the YES soft key;  
To abort erasure, press the NO soft key.

Positioning with mdi	Programming and editing
<div>0: TNC:\NK\SCRDP\NEU.H</div> <div>1: TNC:\NK\SCRDP\3507.H</div> <div>2: TNC:\NK\SCRDP\1GB.H</div> <div>3: TNC:\NK\SCRDP\3516.H</div> <div>4: TNC:\NK\SCRDP\35071.H</div> <div>5: TNC:\NK\SCRDP\BLK.H</div> <div>6: TNC:\FRAESEN.CDT</div> <div>7: TNC:\FRAESEN.A</div> <div>8: TNC:\WTAB\FRAESER.CDT</div> <div>9: TNC:\CUTTING\FRAESER.CDT</div>	
SELECT 	<div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <div>END</div>

## Tagging files

Some functions, such as copying or erasing files, can not only be used for individual files, but also for several files at once. To tag several files, proceed as follows:

Move the highlight to the first file.



To display the marking functions, press the TAG soft key.



Tag a file by pressing the TAG FILE soft key.

Move the highlight to the next file you wish to tag:



You can tag several files in this way, as desired.



To copy the tagged files, press the COPY TAG soft key, or




Delete the tagged files by pressing END to end the marking function, and then DELETE to delete the tagged files.

## Renaming a file

- Move the highlight to the file you wish to rename.



- ▶ Select the renaming function.
- ▶ Enter the new file name; the file type cannot be changed.
- ▶ To execute renaming, press the ENT key.

Tagging functions	Soft key
Tagging single files	TAG FILE
Tag all files in the directory	TAG ALL FILES
Untag a single file	UNTAG FILE
Untag all files	UNTAG ALL FILES
Copy all tagged files	COPY TAG 

## Additional Functions

### Protecting a file/Canceling file protection

- Move the highlight to the file you want to protect.



- To select the additional functions, press the MORE FUNCTIONS key.



- To enable file protection, press the PROTECT soft key. The file now has status P.

To cancel file protection, proceed in the same way using the UNPROTECT soft key.

### Converting an FK program into HEIDENHAIN conversational format

- Move the highlight to the file you want to convert.



- To select the additional functions, press the MORE FUNCTIONS key.



- To select the converting function, press the CONVERT FK->H soft key

- Enter the name of the destination file.
- To execute conversion, press the ENT key.

### Erase a directory together with all its subdirectories and files.

- Move the highlight in the left window onto the directory you want to erase.



- To select the additional functions, press the MORE FUNCTIONS key.



- Press DELETE ALL to erase the directory together with its subdirectories.
- To confirm, press the YES soft key;  
To abort erasure, press the NO soft key.

# Data transfer to or from an external data medium



Before you can transfer data to an external data medium, you must set the interface (see „Section 12.4 Setting the Data Interfaces“).



Calling the file manager



Select the screen layout for data transfer: press the WINDOW soft key. In the left half of the screen, the TNC shows all of the 1 files that are stored on the TNC, and in the right half of the screen, 2 all of the files that are stored on the external data medium.

Use the arrow keys to highlight the file(s) that you want to transfer:



Move the highlight up and down within a window



Move the highlight from the left to the right window, and vice versa.

If you are transferring from the TNC to the external medium, move the highlight in the left window onto the file that is to be transferred.

If you are transferring from the external medium to the TNC, move the highlight in the right window onto the file that is to be transferred.



Transfer a single file: Press the COPY soft key, or



To transfer several files, use the TAG soft key (in the second soft-key row, see also Tagging functions earlier on in this chapter), or



transfer all files by pressing the TNC EXT soft key

Manual operation		Program table editing	
		File name = 212.H	
TNC:\NK\SCRD\*,* 1		TNC:\*,* 2	
File name	bytes Status	File name	bytes Status
%TCHPRNT	.A 398	1GT5	.H 226
3516	.A 926	GFB30	.H 1745K
BSP	.A 336	GRMK3R1	.H 1031K
BSPGB	.A 183	HERMLE4	.H 470
PAL	.a 3583	TEST	.H 264
NULLTAB	.D 514	TEST1	.H 474
1	.H 482	TEST12	.H 322
11	.H 108	212	.H 226
1E	.H 430	TEST	.HLP 11
1F	.H 410	1	.I 12
1GB	.H 458	10	.I 314
28 file(s) 915072 kbyte vacant		39 file(s) 915072 kbyte vacant	
PAGE	PAGE	SELECT	COPY
↑	↓	SELECT	WINDOW
		TYPE	PATH
			END

---

Confirm with the EXECUTE or with the ENT key. A status window appears on the TNC, informing about the copying progress, or

---

If you wish to transfer more than one file or longer files, press the PARALLEL EXECUTE soft key. The TNC then copies the file in the background.



To end data transfer, move the highlight into left window and then press the WINDOW soft key. The standard file manager window is displayed again.



To select another directory, press the PATH soft key and then select the desired directory using the arrow keys and the ENT key!

## Copying files into another directory

- Select the screen layout with the two equally sized windows.
- To display directories in both windows, press the PATH soft key.

In the right window:

- Move the highlight to the directory into which you wish to copy the files, and display the files in this directory with the ENT key

In the left window:

- Select the directory with the files that you wish to copy and press ENT to display them.



- Display the file tagging functions.



- Move the highlight to the file you want to copy and tag it. You can tag several files in this way, as desired.



- Copy the tagged files into the target directory.

For additional tagging functions see „Tagging files“.

If you have marked files in the left and right windows, the TNC copies from the directory in which the highlight is located.


## Overwriting files

If you copy files into a directory in which other files are stored under the same name, the TNC will ask whether the files in the target directory should be overwritten:

- Press the YES soft key to overwrite all files, or
- Press the NO soft key if no file is to be overwritten
- To confirm each file separately before overwriting it, press the CONFIRM key.

If you wish to overwrite a protected file, this must also be confirmed or aborted separately.

The TNC in a network  
(applies only for Ethernet interface option)




To connect the Ethernet card to your network, refer to Chapter "12.5 Ethernet Interface"!


The TNC logs error messages during network operation (see section "12.5 Ethernet Interface").

If the TNC is connected to a network, the directory window displays up to 7 drives **1** (see screen at upper right). All the functions described above (selecting a drive, copying files, etc.) also apply to network drives, provided that you have been given the corresponding rights.





Connecting and disconnecting network drives



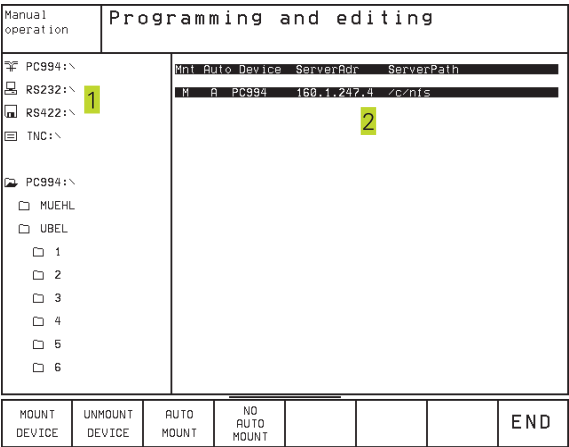
► To select the program management: Press the PGM MGT key. If necessary, press the WINDOW soft key to set up the screen as it is shown to the upper right.



► To manage the network drives: Press the "Network" soft key. In the right-hand window **2** the TNC shows the network drives available for access. With the following soft keys you can define the connection for each drive.

Function	Soft key
Establish network connection. If the connection is active, the TNC shows an M in the Mnt column. You can connect up to 7 additional drives with the TNC.	
Delete network connection	
Automatically establish connection whenever the TNC is switched on. The TNC show in the Auto column an A if the connection is established automatically.	
Do not network connection automatically when the TNC is switched on	

It may take some time to mount a network device. At the upper right of the screen the TNC displays [READ DIR] to indicate that a connection is being established. The maximum data transmission rate lies between 200 and 1000 kilobaud, depending on the file type being transmitted.



Printing the file with a network printer

If you have defined a network printer (see section "12.5 Ethernet Interface"), you can print the files directly:

- To call the file manager, press the PGM MGT key.
- Move the highlight to the file you wish to print.
- Press the COPY soft key.
- Press the PRINT soft key: If you have define only one printer, the TNC will print the file immediately.

If you have defined more than one printer, the TNC opens a window listing all defined printers. Use the arrow keys to select the desired printer, then press ENT.



## 4.5 Creating and Writing Programs

### Organization of an NC program in HEIDENHAIN conversational format.

A part program consists of a series of program blocks. The figure at right illustrates the elements of a block.

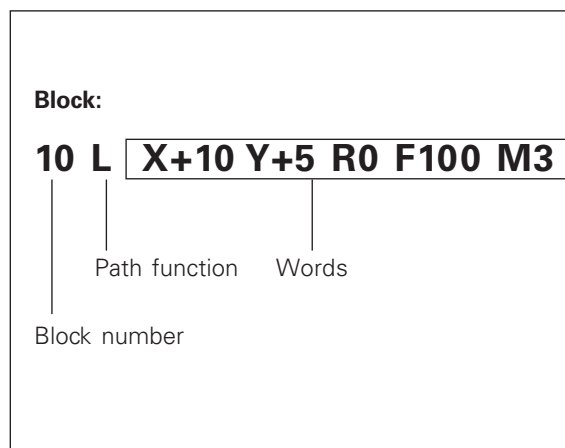
The TNC numbers the blocks in ascending sequence.

The first block of a program is identified by "BEGIN PGM," the program name and the active unit of measure.

The subsequent blocks contain information on:

- The blank form
- Tool definitions, tool calls
- Feed rates and spindle speeds as well as
- Path contours, cycles and other functions

The last block of a program is identified by "END PGM," the program name and the active unit of measure.



### Defining the blank form — BLK FORM

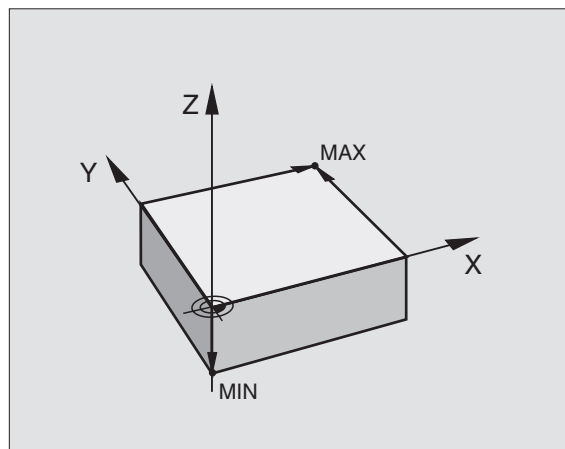
Immediately after initiating a new program, you define a cuboid workpiece blank. This definition is needed for the TNC's graphic simulation feature. The sides of the workpiece blank lie parallel to the X, Y and Z axes and can be up to 100 000 mm long. The blank form is defined by two of its corner points:

- MIN point: the smallest X, Y and Z coordinates of the blank form, entered as absolute values.
- MAX point: the largest X, Y and Z coordinates of the blank form, entered as absolute or incremental values.

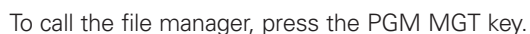
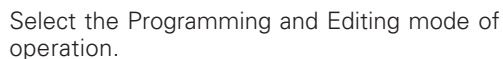


You only need to define the blank form if you wish to run a graphic test for the program!

The TNC can only display the graphic if the ratio of the shortest to the longest side of the **BLK FORM** is less than 1 : 64.



You always enter a part program in the Programming and Editing mode of operation.



Select the directory in which you wish to store the new program

File name = OLD.H



Enter the new program name and confirm your entry with the ENT key.



To select the unit of measure, press the MM or INCH soft key. The TNC switches the screen layout and initiates the dialog for defining the BLK FORM.

Working spindle axis X/Y/Z ?



Enter the spindle axis.

**Def BLK FORM: Min-corner ?**

ENT

Enter in sequence the X, Y and Z coordinates of the MIN point.

ENT

ENT

**Def BLK FORM: Max-corner ?**

ENT

Enter in sequence the X, Y and Z coordinates of the MAX point.

ENT

ENT

Program run full sequence	Programming and editing Def BLK FORM: max-corner?
0	BEGIN PGM BLK MM
1	BLK FORM 0.1 Z X+0 Y+0 Z-40
2	BLK FORM 0.2 X+100 Y+100
	Z+0
3	END PGM BLK MM

If you do not wish to define a blank form, cancel the dialog with the DEL key.

The program blocks window shows the following BLK FORM definition

0 BEGIN PGM NEW MM	Program begin, name, unit of measure
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Tool axis, MIN point coordinates
2 BLK FORM 0.2 X+100 Y+100 Z+0	MAX point coordinates
3 END PGM NEW MM	Program end, name, unit of measure

The TNC automatically generates the block numbers as well as the BEGIN and END blocks.

### Programming tool movementstool movements in conversational format

To program a block, initiate the dialog by pressing a function key. In the screen headline, the TNC then asks you for all the information necessary to program the desired function.

#### Example of a dialog

Initiate the dialog.

Coordinates ?

X 10

Enter the target coordinate for the X axis.

Y 5

ENT

Enter the target coordinate for the Y axis, and go to the next question with ENT.

Radius comp. RL/RR/no comp. ?

ENT

Enter "No radius compensation" and go to the next question with ENT.

Feed rate F=? / F MAX = ENT

100

ENT

Enter a feed rate of 100 mm/min for this path contour; go to the next question with ENT.

Miscellaneous function M ?

3

ENT

Enter the miscellaneous function M3 "spindle ON"; pressing the ENT key will terminate this dialog.

Positioning with mdi	Programming and editing
	Miscellaneous function M?
1	BLK FORM 0.1 Z X+0 Y+0 Z-40
2	BLK FORM 0.2 X+100 Y+100 Z+0
3	TOOL CALL 1 Z S3500 DL+1 DR+1
4	L Z+250 R0 F MAX
5	L X-20 Y+50 R0 F MAX M3
6	END PGM NEU MM

Functions during the dialog	Key
Ignore the dialog question	NO ENT
End the dialog immediately	END
Abort the dialog and erase the block	DEL

Functions for setting the feed rate	Soft key
Rapid traverse	F MAX
Traverse feed rate automatically calculated in TOOL CALL block	F AUTO

The program blocks window will display the following line:

3 L X+10 Y+5 R0 F100 M3
-------------------------

HEIDENHAIN TNC 426, TNC 430

57

Editing a program

While you are creating or editing a part program, you can select any desired line in the program or individual words in a block with the arrow keys or the soft keys (see table at right).

Inserting blocks at any desired location

- ▶ Select the block after which you want to insert a new block and initiate the dialog.

Editing and inserting words

- ▶ Select a word in a block and overwrite it with the new one. The plain-language dialog is available while the word is highlighted.
- ▶ To accept the change, press the END key.

If you want to insert a word, press the horizontal arrow key repeatedly until the desired dialog appears. You can then enter the desired value.

Looking for the same words in different blocks

Set the AUTO DRAW soft key to OFF.



To select a word in a block, press the arrow keys repeatedly until the highlight is on the desired word.



Select a block with the arrow keys.

The word that is highlighted in the new block is the same as the one you selected previously.

Finding any text

- ▶ To select the search function, press the FIND soft key. The TNC displays the dialog prompt FIND TEXT:
- ▶ Enter the text that you wish to find.
- ▶ To find the text, press the EXECUTE soft key.

Selecting blocks or words	Soft keys/keys
Go to the previous page	
Go to the next page	
Jump to beginning of program	
Jump to end of program	
Move from one block to the next	
Select individual words in a block	

Erasing blocks and words	Key
Set the selected word to zero	
Erase an incorrect number	
Clear a (non-blinking) error message	
Delete the selected word	
Delete the selected block	
Erase cycles and program sections: First select the last block of the cycle or program section to be erased, then erase with the DEL key.	

### Marking, copying, deleting and inserting program sections

The TNC provides certain functions (listed in table at right) for copying program sections within an NC program or into another NC program.

To copy a program section, proceed as follows:

- ▶ Select the soft-key row using the marking function.
- ▶ Select the first (last) block of the section you wish to copy.
- ▶ To mark the first (last) block: Press the SELECT BLOCK soft key. The TNC then highlights the first character of the block and superimposes the soft key CANCEL SELECTION.
- ▶ Move the highlight to the last (first) block of the program section you wish to copy or delete. The TNC shows the marked blocks in a different color. You can end the marking function at any time by pressing the CANCEL SELECTION soft key.
- ▶ To copy the selected program section: Press the COPY BLOCK soft key, and to delete the selected section: Press the DELETE BLOCK soft key. The TNC stores the selected block.
- ▶ Using the arrow keys, select the block after which you wish to insert the copied (deleted) program section.



To insert the section into another program, select the corresponding program using the File Manager and then mark the block after which you wish to insert the copied block.

- ▶ To insert the block: Press the INSERT BLOCK soft key

Function	Soft key
Switch on marking function	SELECT BLOCK
Switch off marking function	CANCEL SELECTION
Delete marked block	DELETE BLOCK
Insert block that is stored in the buffer memory	INSERT BLOCK
Copy marked block	COPY BLOCK

4.6 Interactive Programming Graphics

While you are writing the part program, you can have the TNC generate a graphic illustration of the programmed contour.

To generate/not generate graphics during programming:

► To switch the screen layout to displaying program blocks to the left and graphics to the right, press the SPLIT SCREEN key and PGM + GRAPHICS soft key.



► Set the AUTO DRAW soft key to ON. While you are entering the program lines, the TNC generates each path contour you program in the graphics window in the right screen half.

If you do not wish to have graphics generated during programming, set the AUTO DRAW soft key to OFF.

Even when AUTO DRAW is switched ON, graphics are not generated for program section repeats.

Generating a graphic for an existing program

► Use the arrow keys to select the block up to which you want the graphic to be generated, or press GOTO and enter the desired block number.



► To generate graphics, press the RESET + START soft key.

Additional functions are listed in the table at right.

Block number display ON/OFF



► Shift the soft-key row (see figure at right)



► To show block numbers: Set the SHOW OMIT BLOCK NR. soft key to SHOW.

► To omit block numbers: Set the SHOW OMIT BLOCK NR. soft key to OMIT.

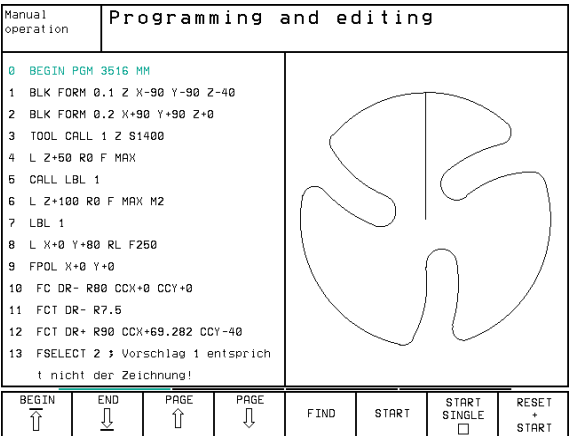
To erase the graphic:



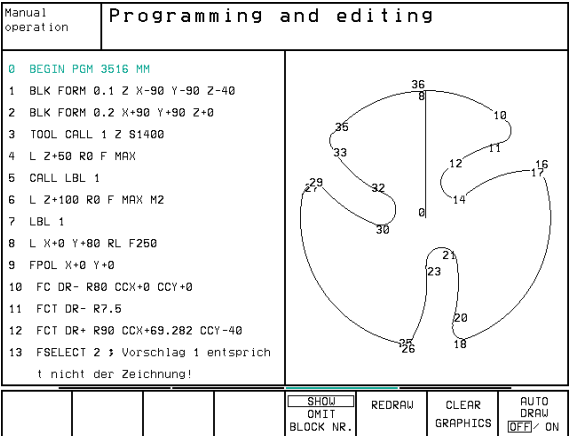
► Shift the soft-key row (see figure at right)



► Delete graphic: Press CLEAR GRAPHIC soft key



Functions	Soft key
Generate interactive graphic blockwise	START SINGLE □
Generate a complete graphic or complete it after RESET + START	START
Interrupt interactive graphics This soft key only appears while the TNC generates the interactive graphics	STOP



Magnifying or reducing a detail

You can select the graphics display by selecting a detail with the frame overlay. You can now magnify or reduce the selected detail.

- Select the soft-key row for detail magnification/reduction (second row, see figure at right)  
The following functions are available:

Function	Soft key
Show and move the frame overlay. Press and hold the desired soft key to move the frame overlay.	<div>←</div> <div>→</div> <div>↑</div> <div>↓</div>
Reduce the frame overlay — press and hold the soft key to reduce the detail	<div>&lt;&lt;</div>
Enlarge the frame overlay — press and hold the soft key to magnify the detail	<div>&gt;&gt;</div>



- With the WINDOW DETAIL soft key, Confirm the selected area.

With the WINDOW BLK FORM soft key, you can restore the original section.

4.7 Structuring Programs

This TNC function enables you to comment part programs in structuring blocks. Structuring blocks are short texts with up to 244 characters and are used as comments or headlines for the subsequent program lines.

With the aid of appropriate structuring blocks, you can organize long and complex programs in a clear and comprehensible way. This function is particularly convenient if you want to change the program later. Structuring blocks can be inserted into the part program at any point. They can also be displayed in a separate window, and edited or added to, as desired. A second level is provided for subdividing a structuring block. The texts in this level are indented.

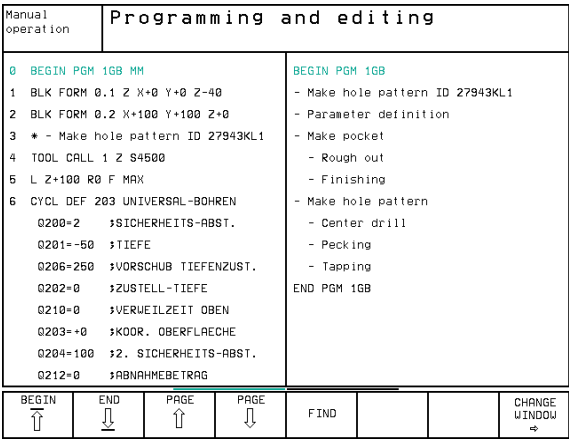
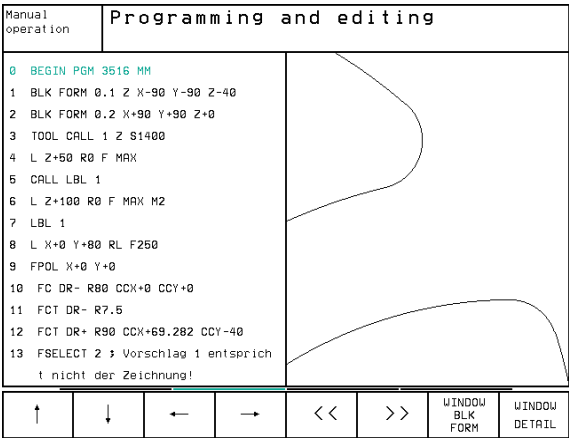
To display the program structure window / change the active window:




- To display the program structure window, select the screen display PGM+SECTS block



- To change the active window, press the CHANGE WINDOW soft key.



**To insert a structuring block in the (left) program window**

- ▶ Select the block after which the structuring block is to be inserted.
-  ▶ Press the INSERT SECTION soft key.
- ▶ Enter the structuring text with the alphabetic keyboard.

If necessary, change the level with the CHANGE LEVEL soft key.

**To insert a structuring block in the (right) structure window**

- ▶ Select the structuring block after which the new block is to be inserted.
- ▶ Enter the text with the alphabetic keyboard — the TNC automatically inserts the new block.

**Selecting blocks in the program structure window**

If you are scrolling through the program structure window block by block, the TNC at the same time automatically moves the corresponding NC blocks in the program window. This way you can quickly skip large program sections.

**4.8 Adding Comments**

You can add comments to any desired block in the part program to explain program steps or make general notes. There are three possibilities to add comments:

**1. To enter comments during programming:**

- ▶ Enter the data for a program block, then press the semicolon key “;” on the alphabetic keyboard — the TNC displays the dialog prompt COMMENT ?
- ▶ Enter your comment and conclude the block by pressing the END key.

**2. To insert comments after program entry:**

- ▶ Select the block to which a comment is to be added.
- ▶ Select the last word in the block with the right arrow key:  
A semicolon appears at the end of the block and the TNC displays the dialog prompt COMMENT ?
- ▶ Enter your comment and conclude the block by pressing the END key.

**3. To enter a comment in a separate block:**

- ▶ Select the block after which the comment is to be inserted.
- ▶ Initiate the programming dialog with the semicolon key “;” on the alphabetic keyboard.
- ▶ Enter your comment and conclude the block by pressing the END key.

Positioning with mdi	Programming and editing
9	RND R1
10	FC DR+ R2.5 CLSD+
11	FLT AN+180.925
12	FCT DR+ R10.5 CCX+0 CCY+0
13	; solution 2 is not correct
14	FSELECT 1
15	FLT AN+269.025
16	RND R2.5
17	FL AN+0.975
18	FCT DR+ R10.5 CCX+0 CCY+0
19	FLT AN+89.025
20	FCT DR+ R2.5 CLSD-
21	RND R1
22	LP IPR+20 R0 F MAX
23	L Z+50 R0 F MAX M0



## 4.9 Creating Text Files

You can use the TNC's text editor to write and edit texts. Typical applications:

- Recording test results
- Documenting working procedures
- Creating formularies

Text files are type .A files (ASCII files). If you want to edit other types of files, you must first convert them into type .A files.

### Opening and exiting text files

- ▶ Select the Programming and Editing mode of operation.
- ▶ To call the file manager, press the PGM MGT key.
- ▶ To display type .A files, press the SELECT TYPE and then the SHOW .A soft keys.
- ▶ Select a file and open it with the SELECT soft key or ENT key, **or** create a new file by entering the new file name and confirming your entry with the ENT key.

To leave the text editor, call the file manager and select a file of a different file type, for example a part program.

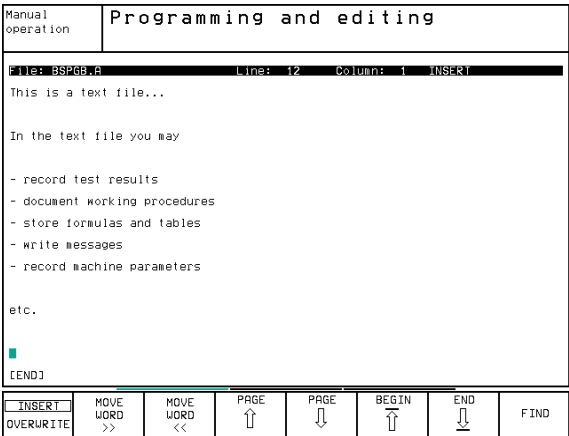
### Editing texts

The first line of the text editor is an information headline which displays the file name, and the location and writing mode of the cursor:

File:	Name of the text file
Line:	Line in which the cursor is presently located
Column:	Column in which the cursor is presently located
Insert:	Insert new text, pushing the existing text to the right
Overwrite:	Write over the existing text, erasing it where it is replaced with the new text.

The text is inserted or overwritten at the location of the cursor. You can move the cursor to any desired position in the text file by pressing the arrow keys.

The line in which the cursor is presently located is depicted in a different color. A line can have up to 77 characters. To start a new line, press the RET key or the ENT key.



Cursor movements	Soft key
Move one word to the right	MOVE WORD >>
Move one word to the left	MOVE WORD <<
Go to the next screen page	PAGE (down arrow)
Go to the previous screen page	PAGE (up arrow)
Go to beginning of file	BEGIN (up arrow)
Go to end of file	END (down arrow)

Editing functions	Key
Begin a new line	RET
Erase the character to the left of the cursor	X (left arrow)
Insert a blank space	SPACE
Switch between upper and lower case letters	SHIFT + SPACE

Erasing and inserting characters, words and lines

With the text editor, you can erase words and even lines, and insert them at any desired location in the text. See the table at right.

To move a word or line to a different location:

- ▶ Move the cursor to the word or line you wish to erase and insert at a different place in the text.
- ▶ Press the DELETE WORD or DELETE LINE soft key: The text is deleted and stored temporarily.
- ▶ Move the cursor to the location where you wish insert the text, and press the RESTORE LINE/WORD soft key.

Editing text blocks

You can copy and erase text blocks of any size, and insert them at other locations. Before carrying out any of these editing functions, you must first select the desired text block:

- ▶ To select a text block, move the cursor to the first character of the text you wish to select.

SELECT  
BLOCK

- ▶ Press the SELECT BLOCK soft key.
- ▶ Move the cursor to the last character of the text you wish to select. You can select whole lines by moving the cursor up or down directly with the arrow keys — the selected text is shown in a different color.

After selecting the desired text block, you can edit the text with the following soft keys:

Function	Soft key
----------	----------

Delete the selected text and store temporarily

DELETE  
BLOCK

Store marked block temporarily without erasing (copy )

COPY  
BLOCK

If necessary, you can now insert the temporarily stored block at a different location

- ▶ Move the cursor to the location where you want to insert the temporarily stored text block.

INSERT  
BLOCK

- ▶ Press the INSERT BLOCK soft key \_ the text block in inserted.

You can insert the temporarily stored text block as often as desired.

Delete functions	Soft key
Delete and temporarily store a line	DELETE LINE
Delete and temporarily store a word	DELETE WORD
Delete and temporarily store a character	DELETE CHAR
Insert a line or word from temporary storage	INSERT LINE / WORD

Manual operation	Programming and editing					
File: 3516.R Line: 10 Column: 27 INSERT						
0 BEGIN PGM 3516 MM						
1 BLK FORM 0.1 Z X-90 Y-90 Z-40						
2 BLK FORM 0.2 X+90 Y+90 Z+0						
3 TOOL DEF 50						
4 TOOL CALL 1 Z S1400						
5 L Z+50 R0 F MAX						
6 L X+0 Y+100 R0 F MAX M3						
7 L Z-20 R0 F MAX						
8 L X+0 Y+80 RL F250						
9 FPOL X+0 Y+0						
10 FC DR- R80 CCK+0 CCY+0						
11 FCT DR- R7,5						
12 FCT DR+ R90 CCK+69,282 CCY-40						
13 FSELECT 2						
SELECT BLOCK	DELETE BLOCK	INSERT BLOCK	COPY BLOCK		APPEND TO FILE	READ FILE

**To transfer the selected text to a different file:**

- ▶ Select the text block as described previously.
- ▶ Press the APPEND TO FILE soft key — the TNC displays the dialog prompt Destination file =
- ▶ Enter the path and name of the target file. The TNC appends the selected text to the end of the specified file. If no target file with the specified name is found, the TNC creates a new file with the selected text.

APPEND  
TO FILE

**To insert another file at the cursor position:**

- ▶ Move the cursor to the location in the text where you wish to insert another file.
- ▶ Press the READ FILE soft key. The TNC displays the dialog prompt File name =
- ▶ Enter the path and name of the file you want to insert.

READ  
FILE

**Finding text sections**

With the text editor, you can search for words or character strings in a text. Two functions are available:

**1. Finding the current text**

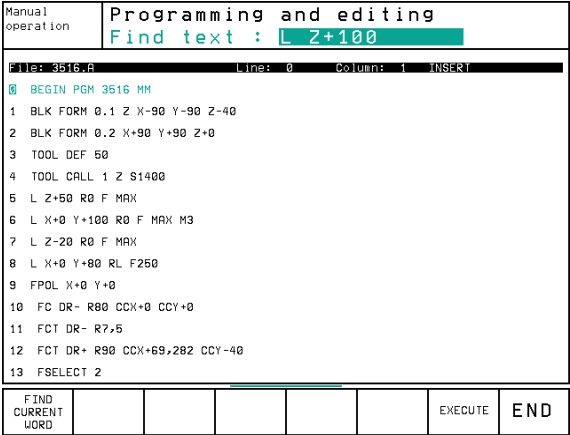
The search function is to find the next occurrence of the word in which the cursor is presently located:

- ▶ Move the cursor to the desired word.
- ▶ To select the search function, press the FIND soft key.
- ▶ Press the FIND CURRENT WORD soft key

**2. Finding any text**

- ▶ To select the search function, press the FIND soft key. The TNC displays the dialog prompt Find text:
- ▶ Enter the text that you wish to find.
- ▶ To find the text, press the EXECUTE soft key.

To leave the search function, press the END soft key.



4.10 Integrated Pocket Calculator

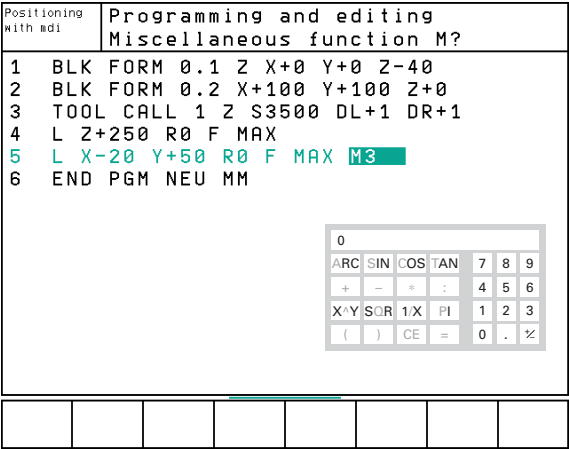
The TNC features an integrated pocket calculator with the basic mathematical functions.

With the CALC key you can open and close an additional window for calculations. You can move the window to any desired location on the TNC screen with the arrow keys.

The calculator is operated with short commands through the alphabetic keyboard. The commands are shown in a special color in the calculator window:

Mathematical function	Command
Addition	+
Subtraction	-
Multiplication	*
Division	:
Sine	S
Cosine	C
Tangent	T
Arc sine	AS
Arc cosine	AC
Arc tangent	AT
Powers	^
Square root	Q
Inversion	/
Parenthetic calculations	()
p (3.14159265359)	P
Display result	=

If you are writing a program and the programming dialog is active, you can use the actual-position-capture key to transfer the result to the highlight position in the current block.



# 4.11 HELP for NC error messages

The TNC automatically generates error messages when it detects problems such as

- Incorrect data input
- Logical errors in the program
- Contour elements that are impossible to machine
- Incorrect use of the touch probe system

An error message that contains a program block number was caused by an error in the indicated block or in the preceding block. The TNC error messages can be canceled with the CE key, after the cause of the error has been removed.

If you require more information on a particular error message, press the HELP key. A window is then superimposed where the cause of the error is explained and suggestions are made for correcting the error.

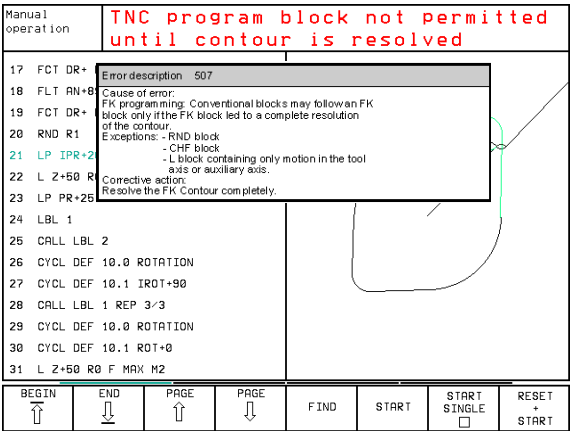
## Display HELP

if an error message appears at the top of screen:



- ▶ To display Help, press the HELP key
- ▶ Read the description of the error and the possibilities for correcting it. Close the Help window with the CE, thus canceling the error message
- ▶ Remove the cause of the error as described in the Help window.

The TNC displays the Help text automatically if the error message is flashing. The TNC needs to be restarted after blinking error messages. To restart the TNC, press the END key and hold for two seconds.



4.12 Managing Pallet Tables



Pallet table management is a machine-dependent function. The standard functional range will be described in the following. Refer to your machine manual for more information.

Pallet tables are used for machining centers with pallet changer: The pallet table calls the part programs that are required for the different pallets, and activates datum shifts or datum tables.

You can also use pallet tables to run in succession several programs that have different datums.

Pallet tables contain the following information:

- PAL/PGM (entry obligatory): Identification for pallet or NC program (select with ENT or NO ENT)
- NAME (entry obligatory): Pallet or program name. The machine tool builder determines the pallet name (see Machine Manual). The program name must be stored in the same directory as the pallet table. Otherwise you must enter the full path name for the program.
- DATUM (entry optional): Name of the datum table. The datum table must be stored in the same directory as the pallet table. Otherwise you must enter the full path name for the datum table. Datums from the datum table can be activated in the NC program with Cycle 7 DATUM SHIFT
- X, Y, Z (entry optional; other axes also possible): For pallet names, the programmed coordinates are referenced to the machine datum. For NC programs, the programmed coordinates are referenced to the pallet datum. These entries overwrite the datum that you last set in the Manual mode of operation. With the miscellaneous function M104 you can reactivate the datum that was last set. With the “actual-position-capture” key, the TNC opens a window that enables you to have the TNC enter various points as datums (see next page):

Manual  
operation

Program table editing  
Pallet=PAL / NC program=PGM

File: PAL.P

NR PAL/PGM NAME

0 PAL 12359

1 PGM TNC:\DRILL\PA35.H

2 PGM TNC:\DRILL\PA36.H

3 PGM TNC:\MILL\SLI135.I

4 PGM TNC:\MILL\FK35.H

5 PAL 123510

6 PGM TNC:\DRILL\QST35.H

7 PGM TNC:\DRILL\K15.I

8 PAL 123511

9 PGM TNC:\CYCLE\MILLING\C210.H

10 PGM TNC:\DRILL\K17.H

11

12

BEGIN  
↑

END  
↓

PAGE  
↑

PAGE  
↓

INSERT  
LINE

DELETE  
LINE

NEXT  
LINE

APPEND  
N LINES

Function	Soft key
Select beginning of table	BEGIN ↑
Select end of table	END ↓
Select previous page in table	PAGE ↑
Select next page in table	PAGE ↓
Insert the last line in the table	INSERT LINE
Delete the last line in the table	DELETE LINE
Go to the beginning of the next line	NEXT LINE
Add the entered number of lines to the end of the table	APPEND N LINES
Copy the highlighted field (2nd soft-key row)	COPY FIELD
Insert the copied field (2nd soft-key row)	PASTE FIELD

Position	Meaning
Actual values	Enter the coordinates of the current tool position relative to the active coordinate system.
Reference values	Enter the coordinates of the current tool position relative to the machine datum.
ACTL measured values	Enter the coordinates relative to the active coordinate system of the datum last probed in the Manual operating mode.
REF measured values	Enter the coordinates relative to the machine datum of the datum last probed in the Manual operating mode.

With the arrow keys and ENT, select the position that you wish to confirm. Then press the ALL VALUES soft key so that the TNC saves the respective coordinates of all active axes in the pallet table. With the PRESENT VALUE soft key, the TNC saves the coordinates of the axis on which the highlight in the pallet table is presently located.



If you have not defined a pallet before an NC program, the programmed coordinates are then referenced to the machine datum. If you do not define an entry, the datum that was set manually remains active.

#### To select a pallet table:

- ▶ Call the file manager in the Programming and Editing or Program Run mode: Press the PGM MGT key.
- ▶ Display all .P files: Press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select a pallet table with the arrow keys, or enter a new file name to create a new table.
- ▶ Confirm your entry with the ENT key.

#### To leave the pallet file:

- ▶ To select the file manager, press the Taste PGM MGT key.
- ▶ To select a different type of file, press the SELECT TYPE soft key and the soft key for the desired file type, for example SHOW.H.
- ▶ Select the desired file.

#### To execute the pallet file



In machine parameter 7683, set whether the pallet table is to be executed blockwise or continuously (see „13.1 General User Parameters“).

- ▶ Select the file manager in the operating mode Program Run, Full Sequence or Program Run, Single Block: Press the PGM MGT key.
- ▶ Display all .P files: Press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select pallet table with the arrow keys and confirm with ENT.
- ▶ To execute pallet table: Press the NC Start button. The TNC executes the pallets as set in Machine Parameter 7683.







# 5

**Programming:**  
**Tools**

## 5.1 Entering Tool-Related Data

### Feed rate F

The feed rate is the speed (in millimeters per minute or inches per minute) at which the tool center moves. The maximum feed rates can be different for the individual axes and are set in machine parameters.

#### Input

You can enter the feed rate in the TOOL CALL block and in every positioning block. See section 6.2, "Fundamentals of Path Contours."

#### Rapid traverse

If you wish to program rapid traverse, enter FMAX. To enter FMAX, press the ENT key or the FMAX soft key as soon as the dialog question "Feed rate F = ?" appears on the TNC screen.

#### Duration of effect

A feed rate entered as a numerical value remains in effect until a block with a different feed rate is reached. F MAX is only effective in the block in which it is programmed. After the block with F MAX is executed, the feed rate will return to the last feed rate entered as a numerical value.

#### Changing during program run

You can adjust the feed rate during program run with the feed-rate override knob.

### Spindle speed S

The spindle speed S is entered in revolutions per minute (rpm) in a TOOL CALL block.

#### Programmed change

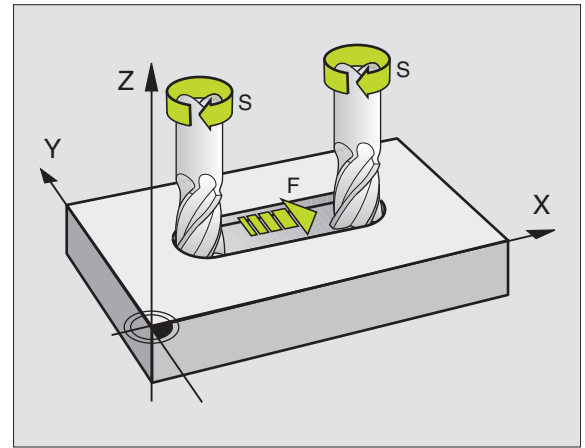
In the part program, you can change the spindle speed in a TOOL CALL block by entering the spindle speed only:



- ▶ To program a tool call, press the TOOL CALL key.
- ▶ Ignore the dialog question for "Tool number ?" with the NO ENT key.
- ▶ Ignore the dialog question for "Working spindle axis X/ Y/Z ?" with the NO ENT key.
- ▶ Enter the new spindle speed for the dialog question "Spindle speed S= ?" and confirm with END.

#### Changing during program run

You can adjust the spindle speed during program run with the spindle-speed override knob.



## 5.2 Tool Data

You usually program the coordinates of path contours as they are dimensioned in the workpiece drawing. To allow the TNC to calculate the tool center path — i.e. the tool compensation — you must also enter the length and radius of each tool you are using.

Tool data can be entered either directly in the part program with TOOL DEF or separately in a tool table. In a tool table, you can also enter additional data on the specific tool. The TNC will consider all the data entered for the tool when executing the part program.

### Tool numbers and tool names

Each tool is identified by a number between 0 and 254. If you are working with tool tables, you can use higher numbers and you can also enter a tool name for each tool.

The tool number 0 is automatically defined as the zero tool with the length  $L=0$  and the radius  $R=0$ . In tool tables, tool 0 should also be defined with  $L=0$  and  $R=0$ .

### Tool length L

There are two ways to determine the tool length L:

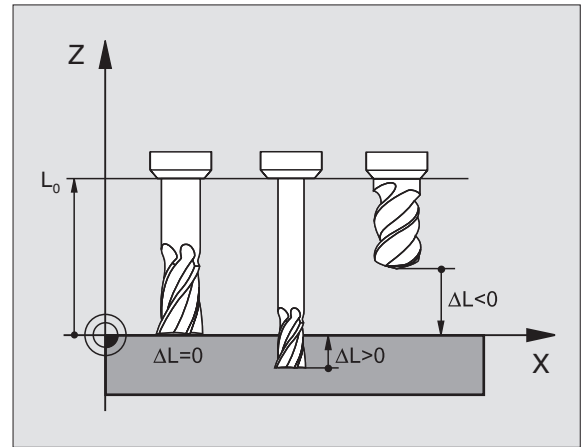
- 1 The length L is the difference between the length of the tool and that of a zero tool  $L_0$ .

For the algebraic sign:

- The tool is longer than the zero tool  $L > L_0$
- The tool is shorter than the zero tool:  $L < L_0$

To determine the length:

- Move the zero tool to the reference position in the tool axis (e.g. workpiece surface with  $Z=0$ ).
  - Set the datum in the tool axis to 0 (datum setting).
  - Insert the desired tool.
  - Move the tool to the same reference position as the zero tool.
  - The TNC displays the difference between the current tool and the zero tool.
  - Enter the value in the TOOL DEF block or in the tool table by pressing the actual-position-capture key.
- 2 Determine the tool length L with a tool presetter. This allows you to enter the determined value directly in the TOOL DEF tool definition block or in the tool table without further calculations.



## Tool radius R

You can enter the tool radius R directly.

## Delta values for lengths and radii

Delta values are offsets in the length and radius of a tool.

A positive delta value describes a tool oversize (DL, DR, DR2>0). If you are programming the machining data with an allowance, enter the oversize value in the TOOL CALL block of the part program.

A negative delta value describes a tool undersize (DL, DR, DR2<0). An undersize is entered in the tool table for wear.

Delta values are usually entered as numerical values. In a TOOL CALL block, you can also assign the values to Q parameters.

Input range: You can enter a delta value with up to  $\pm 99.999$  mm.

## Entering tool data into the program

The number, length and radius of a specific tool is defined in the TOOL DEF block of the part program.



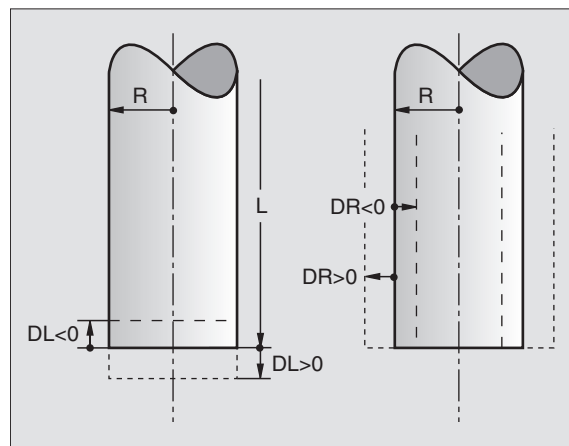
- To select tool definition, press the TOOL DEF key.
- Enter the Tool number: Each tool is uniquely identified by its number.
- Enter the tool length: Enter the compensation value for the tool length.
- Enter the Tool radius.



In the programming dialog, you can transfer the value for tool length directly into the input line with the actual-position-capture key. You only need to make sure that the highlight in the status display is placed on the tool axis.

### Resulting NC block:

```
4 TOOL DEF 5 L+10 R+5
```



## Entering tool data in tables

You can define and store up to 32767 tools and their tool data in a tool table. In Machine Parameter 7260, you can define how many tool places are to be reserved by the TNC when a new table is set up. See also the Editing Functions at a later stage in this Chapter. In order to be able to assign various compensation data to a tool (indexing tool number), machine parameter 7262 must not be equal to 0.

You must use tool tables if

- you wish to use indexed tool such as stepped drills with more than one length compensation value (for input see "Editing Functions for Tool Tables" later in this chapter),
- your machine tool has an automatic tool changer,
- you want to measure tools automatically with the TT 120 touch probe (see the new Touch Probe Cycles User's Manual, Chapter 4),
- you want to rough-mill the contour with Cycle 22, see section 8.5, "SL Cycles, ROUGH-OUT,"
- you want to work with automatic cutting data calculations.

**Tool table: For input possibilities, see next page.**

Abbr.	Input	Dialog	Width of column
T	Number by which the tool is called in the program (e.g. 5, indexed: 5.2)	–	
NAME	Name by which the tool is called in the program	Tool name?	
L	Value for tool length compensation L	Tool length?	
R	Compensation value for the tool radius R	Tool radius?	
R2	Tool radius R2 for toroid cutters (only for 3-D radius compensation or graphical representation of a machining operation with spherical cutter)	Tool radius 2?	
DL	Delta value for tool length	Tool length oversize?	
DR	Delta value for tool radius R	Tool radius oversize?	
DR2	Delta value for tool radius R2	Tool radius oversize 2?	
LCUTS	Tooth length of the tool for Cycle 22	Tool length in the tool axis?	
ANGLE	Maximum plunge angle of the tool for reciprocating plunge-cut in Cycles 22 and 208	Maximum plunge angle?	
TL	Set tool lock ( <b>TL</b> : Tool Locked)	Tool locked? Yes = ENT / No = NO ENT	
RT	Number of a replacement tool, if available (see also TIME2)	Replacement tool?	
TIME1	Maximum tool life in minutes. This function can vary depending on the individual machine tool. Your machine manual provides more information on TIME1.	Maximum tool age?	
TIME2	Maximum tool life in minutes during TOOL CALL: If the current tool age exceeds this value, the TNC changes the tool during the next TOOL CALL (see also CUR.TIME).	Maximum tool age for TOOL CALL?	
CUR.TIME	Time in minutes the tool has been in use: The TNC automatically counts the current tool life. A starting value can be entered for used tools.	Current tool life?	
DOC	Comment on tool (up to 16 characters)	Tool description?	
PLC	Information on this <b>tool</b> that is to be sent to the PLC	PLC status?	
PLCVAL	Value of this tool that is to be sent to the PLC	PLC value?	

**Tool table: Tool data required for automatic tool measurement**

For a description of the cycles governing automatic tool measurement, see the new Touch Probe Cycles Manual, Chapter 4.

Abbr.	Input	Dialog
CUT.	Number of teeth (20 teeth maximum)	Number of teeth ?
LTOL	Permissible deviation from tool length L for wear detection. If the entered value is exceeded, the TNC locks the tool (status L). Input range: 0 to 0.9999 mm	Wear tolerance: length ?
RTOL	Permissible deviation from tool radius R for wear detection. If the entered value is exceeded, the TNC locks the tool (status L). Input range: 0 to 0.9999 mm	Wear tolerance: radius ?
DIRECT.	Cutting direction of the tool for measuring the tool during rotation	Cutting direction (M3 = -) ?
TT:R-OFFS	Tool length measurement: tool offset between stylus center and tool center. Preset value: Tool radius R (NO ENT means R)	Tool offset: radius ?
TT:L-OFFS	Tool radius measurement: tool offset in addition to MP6530 (see „13.1 General User Parameters“) between upper surface of stylus and lower surface of tool. Preset value: 0	Tool offset: length ?
LBREAK	Permissible deviation from tool length L for break detection. If the entered value is exceeded, the TNC locks the tool (status L). Input range: 0 to 0.9999 mm	Breakage tolerance: length ?
RBREAK	Permissible deviation from tool radius R for break detection. If the entered value is exceeded, the TNC locks the tool (status L). Input range: 0 to 0.9999 mm	Breakage tolerance: radius ?

**Tool table: Additional tool data for automatic speed/feed rate calculations.**

Abbr.	Input	Dialog
TYPE	Tool type (MILL=for milling, DRILL=for drilling or boring, TAP=for tapping): Press the SELECT TYPE soft key (3rd soft-key row): The TNC superimposes a window where you can select the type of tool you want.	Tool type ?
TMAT	Tool material: Press the SELECT MATERIAL soft key (3rd soft-key row): The TNC superimposes a window where you can select the type of material you want.	Tool material ?
CDT	Cutting data table: Press the SELECT CDT soft key (3rd soft-key row): The TNC superimposes a window where you can select a cutting data table.	Name of cutting data table ?

Editing tool tables

The tool table that is active during execution of the part program is designated as TOOL.T. You can only edit TOOL.T in one of the machine operating modes. Other tool tables that are used for archiving or test runs are given different file names with the extension .T .

To open the tool table TOOL.T:

- Select any machine operating mode.



- To select the tool table, press the TOOL TABLE soft key.



- Set the EDIT soft key to ON.

To open any other tool table

- Select the Programming and Editing mode of operation.



- Calling the file manager
- To select the file type, press the SELECT TYPE soft key.
- To show type .T files, press the SHOW soft key.
- Select a file or enter a new file name. Conclude your entry with the ENT key or SELECT soft key.

When you have opened the tool table, you can edit the tool data by moving the cursor to the desired position in the table with the arrow keys or the soft keys (see figure at upper right). You can overwrite the stored values, or enter new values at any position. Refer to the table (on the next page) for additional editing functions.
















If the TNC cannot show all positions in the tool table in one screen page, the highlight bar at the top of the table will display the symbol >> or << .

To leave the tool table:

- Call the file manager and select a file of a different type, e.g. a part program.

Tool table editing										Programming and editing	
Tool radius?											
<<File: TOOL.T MM>>											
T	L	R	R2	DL	DR	DR2	TL R1				
0	+0	+0	+0	+0	+0	+0					
1	-27.25	+4	+0.1	+0.25	+0.15	+0	2				
2	-3	+3	+0	+0.01	+0.1	+0					
3	-22.5	+1.5	+0.25	+0.1	+0.1	+0					
4	-5	+2.5	+0	+0	+0	+0					
5	-6	+3	+3	+0	+0.5	+0					
6	-7	+0	+0	+0.1	+0	+0					
<input checked="" type="checkbox"/> +150.0000 Y -50.0000 Z +100.0000											
A +0.0000 B +180.0000 C +90.0000											
ACTL. T 0 H 5/9											
BEGIN	END	PAGE	PAGE		EDIT OFF / ON	FIND TOOL NAME	POCKET TABLE				
↑	↓	↑	↓								



Editing functions for tool tables	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Look for the tool name in the table	
Show tool information in columns or show the information on one tool on one screen page	
Move to beginning of line	
Move to end of line	
Copy the highlighted field	
Insert the copied field	
Add the entered number of lines (tools) to the end of the table	
Insert a line for the indexed tool number after the active line. The function is only active if you are permitted to store various compensation data for a tool (machine parameter 7262 not equal to 0). The TNC inserts a copy of the tool data after the last available index and increases the index by 1. Application: e.g. stepped drill with more than one length compensation value.	
Delete current line (tool)	
Display / Do not display pocket numbers	
Display all tools / only those tools that are stored in the pocket table	

### Additional notes on tool tables

Machine parameter 7266.x defines which data can be entered in the tool table and in what sequence the data is displayed.



You can overwrite individual columns or lines of a tool table with the contents of another file. Prerequisites:

- The target file must exist.
- The file to be copied must contain only the columns (or lines) you want to replace.

To copy individual columns or lines, press the REPLACE FIELDS soft key (see section 4.4 "Enhanced File Management").

## Pocket table for tool changer

For automatic tool changing you need the pocket table TOOL\_PTCH. The TNC can manage several pocket tables with any file names. To activate a specific pocket table for program run you must select it in the file management of a Program Run mode of operation (status M).

### Editing a pocket table in a Program Run operating mode:

TOOL TABLE	▶ To select the tool table, press the TOOL TABLE soft key.
POCKET TABLE	▶ To select the pocket table, press the POCKET TABLE soft key
EDIT OFF / <b>ON</b>	▶ Set the EDIT soft key to ON

**Selecting a pocket table in the Programming and Editing operating mode (only TNC 426, TNC 430 with NC software 280 474-xx):**

- ▶ Calling the file manager
- ▶ To select the file type, press the SELECT TYPE soft key.
- ▶ To show files of the type .TCH, press the soft key TCH FILES (second soft-key row).
- ▶ Select a file or enter a new file name. Conclude your entry with the ENT key or SELECT soft key.

You can enter the information below on a tool into a pocket table

Pocket table editing

Special tool

Program name editing

Yes=ENT/No=NOENT

File: TOOL.T

P T S F L PLC

00%00000000

1%00000000

22S F%00000000

3%00000000

44%00000000

5L%00000000

66%00000000

X

+150.0000

Y

-50.0000

Z

+100.0000

A

+0.0000

B

+180.0000

C

+90.0000

ACTL.

T

0

M 5/9

BEGIN

END

PAGE

PAGE

RESET  
POCKET  
TABLE

EDIT  
OFF / 

ON

NEXT  
LINE

TOOL  
TABLE

Editing functions for pocket tables	Soft key
Select beginning of table	BEGIN ↑
Select end of table	END ↓
Select previous page in table	PAGE ↑
Select next page in table	PAGE ↓
Reset pocket table	RESET POCKET TABLE
Go to the beginning of the next line.	NEXT LINE
Column for active tool number T	RESET COLUMN T
Move to end of line	END LINE →

Column	Input	Dialog
P	Pocket number of the tool in the tool magazine	–
T	Tool number	Tool number ?
ST	Special tool with a large radius requiring several pockets in the tool magazine. If your special tool takes up pockets in front of and behind its actual pocket, these additional pockets need to be locked in column L (status L).	Special tool ?
F	Fixed tool number. The tool is always returned to the same pocket in the tool magazine	Fixed pocket ? Yes = ENT / No = NO ENT
L	Locked pocket(see also column ST)	Pocket locked Yes = ENT / No = NO ENT
PLC	Information on this <b>tool pocket</b> that is to be sent to the PLC	PLC status?
TNAME	Display of the tool name from TOOL.T	–

## Calling tool data

A TOOL CALL block in the part program is defined with the following data:



- ▶ Select the tool call function with the TOOL CALL key.
- ▶ Tool number: Enter the number or name of the tool. The tool must already be defined in a TOOL DEF block or in the tool table. To call a tool by the tool name, enter the name in quotation marks. The tool name always refers to the entry in the active tool table TOOL .T. If you wish to call a tool with other compensation values, enter also the index you defined in the tool table after the decimal point.
- ▶ Working spindle axis X/Y/Z: Enter the tool axis.
- ▶ Spindle speed S: Enter the spindle speed directly or allow the TNC to calculate the spindle speed if you are working with cutting data tables. Press the S CALCULATE AUTOMAT. soft key. The TNC limits the spindle speed to the maximum value set in MP 3515.
- ▶ Feed rate F: Enter the feed rate directly or allow the TNC to calculate the feed rate if you are working with cutting data tables. Press the F CALCULATE AUTOMAT. soft key. The TNC limits the feed rate to the maximum feed rate of the „longest axis“ (set in MP 1010). F is effective until you program a new feed rate in a positioning block or a TOOL CALL block.
- ▶ Tool length oversize: Enter the delta value for the tool length.
- ▶ Tool radius oversize: Enter the delta value for the tool radius.
- ▶ Tool radius oversize 2: Enter the delta value for the tool radius 2.

### Example:

Call tool number 5 in the tool axis Z with a spindle speed 2500 rpm and a feed rate of 350 mm/min. The tool length is to be programmed with an oversize of 0.2 mm, the tool radius 2 with an oversize of 0.05 mm, and the tool radius with an undersize of 1 mm.

```
20 TOOL CALL 5.2 Z S2500 F350 DL+0.2 DR-1 DR2:+0.05
```

The character D preceding L and R designates delta values.

### Tool preselection with tool tables

If you are working with tool tables, use TOOL DEF to preselect the next tool. Simply enter the tool number or a corresponding Q parameter, or type the tool name in quotation marks.

## Tool change



The tool change function can vary depending on the individual machine tool. Refer to your machine tool manual.

### Tool change position

A tool change position must be approachable without collision. With the miscellaneous functions M91 and M92, you can enter machine-referenced (rather than workpiece-referenced) coordinates for the tool change position. If TOOL CALL 0 is programmed before the first tool call, the TNC moves the tool spindle in the tool axis to a position that is independent of the tool length.

### Manual tool change

To change the tool manually, stop the spindle and move the tool to the tool change position:

- ▶ Move to the tool change position under program control.
- ▶ Interrupt program run (see section 11.4 "Program Run").
- ▶ Change the tool.
- ▶ Resume the program run (see section 11.4 "Program Run").

### Automatic tool change

If your machine tool has automatic tool changing capability, the program run is not interrupted. When the TNC reaches a TOOL CALL, it replaces the inserted tool by another from the tool magazine.

### Automatic tool change if the tool life expires: M101



This function can vary depending on the individual machine tool. Refer to your machine tool manual.

The TNC automatically changes the tool if the tool life TIME2 expires during program run. To use this miscellaneous function, activate M101 at the beginning of the program. M101 is reset with M102.

The tool is not always changed immediately, but, depending on the workload of the control, a few NC blocks later.

### Prerequisites for standard NC blocks with radius compensation R0, RR, RL

The radius of the replacement tool must be the same as that of the original tool. If the radii are not equal, the TNC displays an error message and does not replace the tool.

### Prerequisites for NC blocks with surface-normal vectors and 3-D compensation (see Chapter 5.4 „Three-Dimensional Tool Compensation“)

The radius of the replacement tool can differ from the radius of the original tool. The tool radius is not included in program blocks transmitted from CAD systems. You can enter the delta value (DR) either in the tool table or in the TOOL CALL block.

If DR is positive, the TNC displays an error message and does not replace the tool. You can suppress this message with the M function M107, and reactivate it with M108.

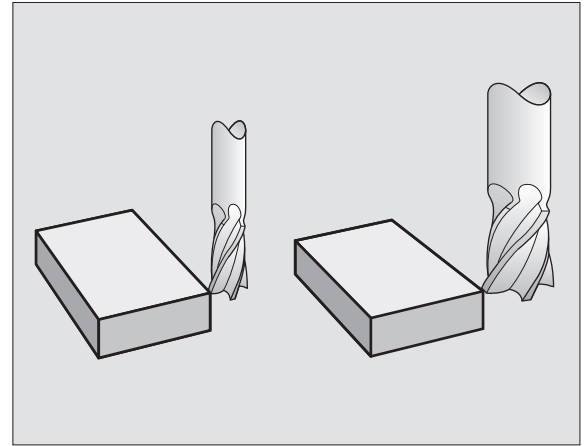
## 5.3 Tool Compensation

The TNC adjusts the spindle path in the tool axis by the compensation value for the tool length. In the working plane, it compensates the tool radius.

If you are writing the part program directly on the TNC, the tool radius compensation is effective only in the working plane. The TNC accounts for the compensation value in up to five axes including the rotary axes.



If a part program generated by a CAD system contains surface-normal vectors, the TNC can perform three-dimensional tool compensation. For more information, refer to section 5.4 "Three-Dimensional Tool Compensation."



### Tool length compensation

Length compensation becomes effective automatically as soon as a tool is called and the tool axis moves. To cancel length compensation call a tool with the length  $L=0$ .



If you cancel a positive length compensation with TOOL CALL 0, the distance between tool and workpiece will be reduced.

After TOOL CALL, the path of the tool in the tool axis, as entered in the part program, is adjusted by the difference between the length of the previous tool and that of the new one.

For tool length compensation, the TNC takes the delta values from both the TOOL CALL block and the tool table into account:

Compensation value =  $L + DL_{\text{TOOL CALL}} + DL_{\text{TAB}}$ , where

- $L$  is the tool length  $L$  from the TOOL DEF block or tool table
- $DL_{\text{TOOL CALL}}$  is the oversize for length  $DL$  in the TOOL CALL block (not taken into account by the position display)
- $DL_{\text{TAB}}$  is the oversize for length  $DL$  in the tool table

## Tool radius compensation

The NC block for programming a tool movement contains:

- RL or RR for compensation in the tool radius
- R+ or R- for radius compensation in single-axis movements
- R0 if no radius compensation is required

Radius compensation becomes effective as soon as a tool is called and is moved in the working plane with RL or RR.



The TNC cancels radius compensation if you:

- program a positioning block with R0
- depart the contour with the DEP function
- program a PGM CALL
- select a new program with PGM MGT

For tool radius compensation, the TNC takes the delta values from both the TOOL CALL block and the tool table into account:

Compensation value =  $R + DR_{\text{TOOL CALL}} + DR_{\text{TAB}}$ , where

R is the tool radius R from the TOOL DEF block or tool table

$DR_{\text{TOOL CALL}}$  is the oversize for radius DR in the TOOL CALL block (not taken into account by the position display)

$DR_{\text{TAB}}$  is the oversize for radius DR in the tool table

### Tool movements without radius compensation: R0

The tool center moves in the working plane to the programmed path or coordinates.

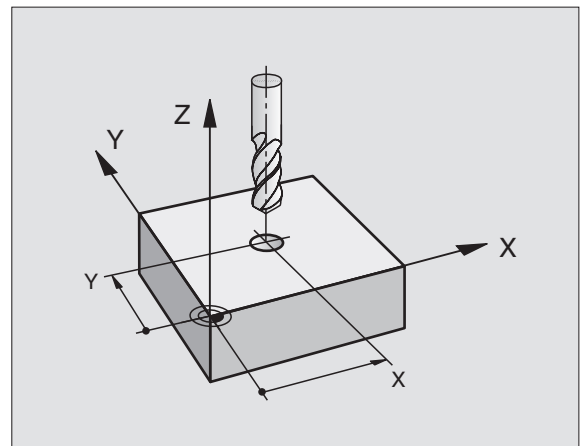
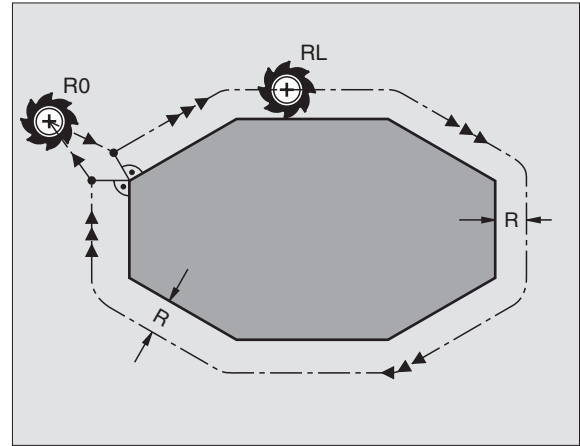
Applications: Drilling and boring, pre-positioning (see figure at right)

### Tool movements with radius compensation: RR and RL

**RR** The tool moves to the right of the programmed contour

**RL** The tool moves to the left of the programmed contour

The tool center moves along the contour at a distance equal to the radius. "Right" or "left" are to be understood as based on the direction of tool movement along the workpiece contour (see illustrations on the next page).



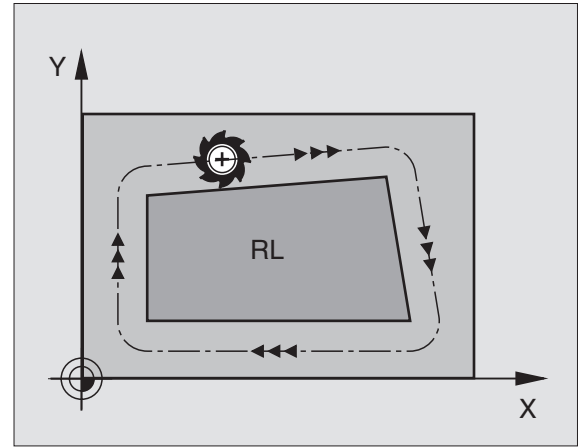


Between two program blocks with different radius compensations (RR and RL) you must program at least one block without radius compensation (that is, with R0).

Radius compensation does not come into effect until the end of the block in which it is first programmed.

You can also activate the radius compensation for secondary axes in the working plane. Program the secondary axes too in each following block, since otherwise the TNC will execute the radius compensation in the principal axis again.

Whenever radius compensation is activated with RR/RL or canceled with R0, the TNC positions the tool perpendicular to the programmed starting or end position. Position the tool at a sufficient distance from the first or last contour point to prevent the possibility of damaging the contour.



## Entering radius compensation

When you program a path contour, the following dialog question is displayed after entry of the coordinates:

**Radius comp.: RL/RR/no comp. ?**

RL

To select tool movement to the left of the contour, press the RL soft key, or

RR

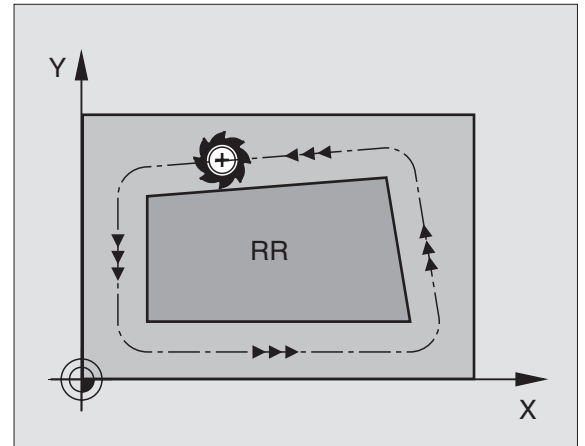
To select tool movement to the right of the contour, press the RR soft key, or

ENT

To select tool movement without radius compensation or to cancel radius compensation, press the ENT key.

END

To terminate the dialog, press the END key.





## Radius compensation: Machining corners

### Outside corners

If you program radius compensation, the TNC moves the tool around outside corners either on a transitional arc or on a spline (selectable via MP7680). If necessary, the TNC reduces the feed rate at outside corners to reduce machine stress, for example at very great changes of direction.

### Inside corners

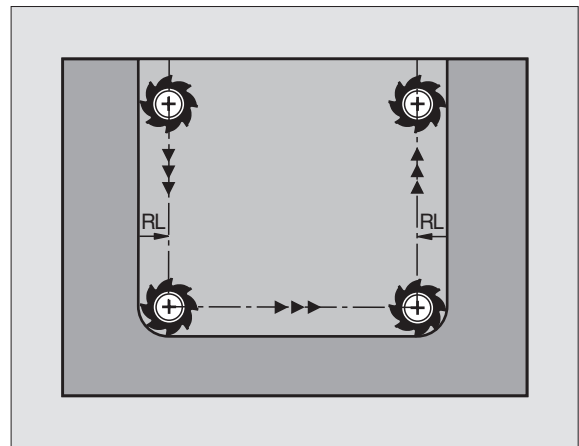
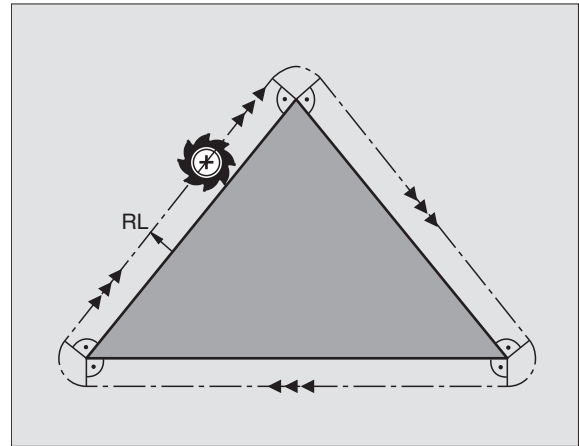
The TNC calculates the intersection of the tool center paths at inside corners under radius compensation. From this point it then starts the next contour element. This prevents damage to the workpiece. The permissible tool radius, therefore, is limited by the geometry of the programmed contour.



To prevent the tool from damaging the contour, be careful not to program the starting or end position for machining inside corners at a corner of the contour.

### Machining corners without radius compensation

If you program the tool movement without radius compensation, you can change the tool path and feed rate at workpiece corners with the miscellaneous function M90 (see section 7.4 +Miscellaneous Functions for Contouring Behavior+).



## 5.4 Three-Dimensional Tool Compensation

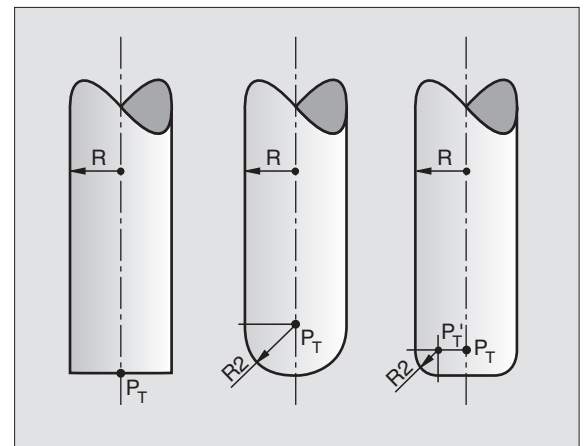
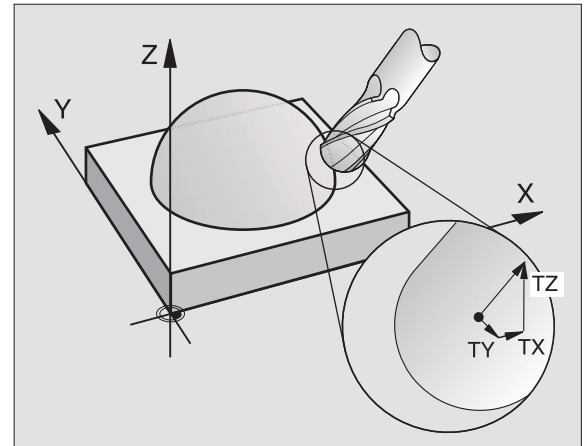
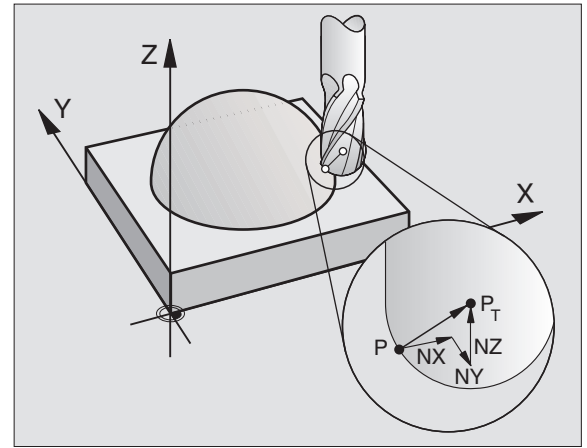
The TNC can carry out a three-dimensional tool compensation (3-D compensation) for straight-line blocks. Apart from the X, Y and Z coordinates of the straight-line end point, these blocks must also contain the components NX, NY and NZ of the surface-normal vector (see figure above right and explanation further down on this page). If, in addition, you want to carry out a tool orientation or a three-dimensional radius compensation, these blocks need also a normalized vector with the components TX, TY and TZ, which determines the tool orientation (see figure at center right). The straight-line end point, the components for the surface-normal vector as well as those for the tool orientation must be calculated by a CAD system.

### Application possibilities

- Use of tools with dimensions that do not correspond with the dimensions calculated by the CAD system (3-D compensation without definition of the tool orientation)
- Face milling: compensation of the milling machine geometry in the direction of the surface-normal vector (3-D compensation with and without definition of the tool orientation). Cutting is usually with the end face of the tool
- Peripheral milling: compensation of the mill radius perpendicular to the direction of movement and perpendicular to the tool orientation (3-D radius compensation with definition of the tool orientation). Cutting is usually with the lateral surface of the tool

### Definition of a normalized vector

A normalized vector is a mathematical quantity with a value of 1 and a direction. The TNC requires up to two normalized vectors for LN blocks, one to determine the direction of the surface-normal vector, and another (optional) to determine the tool orientation direction. The direction of a surface-normal vector is determined by the components NX, NY and NZ. With an end mill and a radius mill, this direction is perpendicular from the workpiece surface to be machined to the tool datum  $P_T$ , and with a toroid cutter through  $P_T'$  or  $P_T$  (see figure at bottom right). The direction of the tool orientation is determined by the components TX, TY and TZ.





The coordinates for the X, Y, Z positions and the surface-normal components NX, NY, NZ, as well as TX, TY, TZ must be in the same sequence in the NC block.

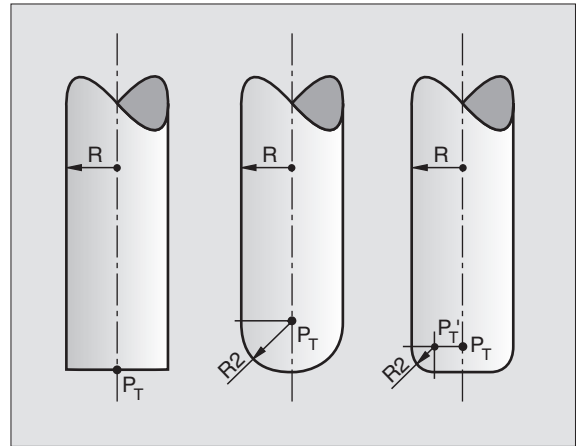
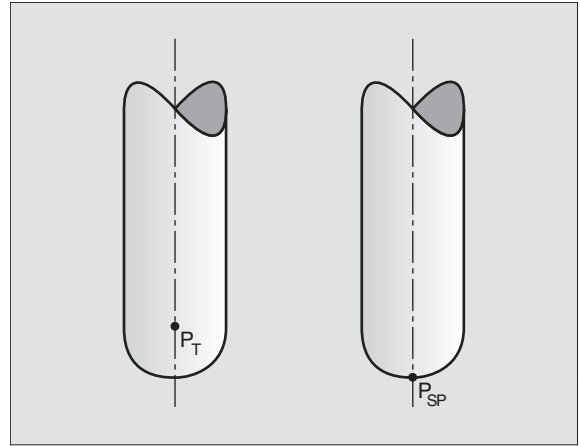
Always indicate all of the coordinates and all of the surface-normal vectors in an LN block, even if the values have not changed from the previous block.

3-D compensation with surface-normal vectors is only effective for coordinates in the main axes X, Y, Z.

If you insert a tool with oversize (positive delta value), the TNC outputs an error message. You can suppress the error message with the M function M107 (see section 5.2 "Tool Data, Tool Change").

The TNC will **not** display an error message if an entered tool oversize would cause damage to the contour.

Machine parameter 7680 defines whether the CAD system has calculated the tool length compensation from the center of sphere  $P_T$  or the south pole of the sphere  $P_{SP}$  (see figure at upper right).



## Permissible tool forms

You can describe the permissible tool shapes in the tool table via tool radius R and R2 (see figure at center right):

Tool radius: R

Distance from the tool center to the tool circumference.

Tool radius 2: R2

Radius of the curvature between tool tip and tool circumference.

The ratio of R to R2 determines the shape of the tool:

$R2 = 0$  End mill

$R2 = R$  Toroid cutter

$0 < R2 < R$  Spherical cutter

These data also specify the coordinates of the tool datum  $P_T$ .

Using other tools:delta values

If you want to use tools that have different dimensions than the ones you originally programmed, you can enter the difference between the tool lengths and radii as delta values in the tool table or TOOL CALL:

- Positive delta value DL, DR, DR2  
The tool is larger than the original tool (oversize).
- Negative delta value DL, DR, DR2  
The tool is smaller than the original tool (undersize).

The TNC then compensates the tool position by the sum of the delta values from the tool table and the tool call.

3-D compensation without tool orientation

The TNC displaces the tool in the direction of the surface-normal vectors by the sum of the delta values (tool table and TOOL CALL).

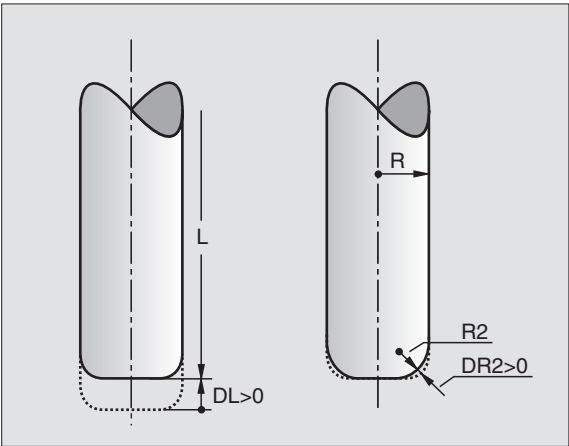
Block format with surface-normal vectors

```
LN      X+31.737 Y+21.954 Z+33.165
NX+0.2637581 NY+0.0078922 NZ-0.8764339 F1000 M3
```

- LN Straight line with 3-D compensation
- X,Y,Z Compensated coordinates of the straight-line end point
- NX, NY, NZ Components of the surface-normal vector
- F Feed rate
- M Miscellaneous function

The feed rate F and miscellaneous function M can be entered and changed in the Programming and Editing mode of operation.

The coordinates of the straight-line end point and the components of the surface-normal vectors are to be defined by the CAD system.



## Face Milling: 3-D compensation with and without tool orientation

The TNC displaces the tool in the direction of the surface-normal vectors by the sum of the delta values (tool table and TOOL CALL).

If **M128 is active**, the TNC maintains the tool perpendicular to the workpiece contour if no tool orientation is programmed in the LN block (see „7.5 Miscellaneous Functions for Rotary Axes“).

If there is a tool orientation defined in the LN block, then the TNC will position the rotary axes automatically so that the tool can reach the defined orientation.



The TNC is not able to automatically position the rotary axes on all machines. Your machine manual provides more detailed information.

### **Danger of collision!**

On machines whose rotary axes only allow limited traverse, sometimes automatic positioning can require the table to be rotated by 180°. In this case, make sure that the tool head does not collide with the workpiece or the clamps.

### **Block format with surface-normal vectors without workpiece orientation.**

```
LN   X+31.737 Y+21.954 Z+33.165
      NX+0.2637581 NY+0.0078922 NZ-0.8764339 F1000 M128
```

### **Block format with surface-normal vectors and with workpiece orientation**

```
LN   X+31.737 Y+21.954 Z+33.165
      NX+0.2637581 NY+0.0078922 NZ-0.8764339
      TX+0.0078922 TY-0.8764339 TZ+0.2590319 F1000 M128
```

LN	Straight line with 3-D compensation
X,Y,Z	Compensated coordinates of the straight-line end point
NX,NY,NZ	Components of the surface-normal vector
TX,TY,TZ	Components of the normalized vector for workpiece orientation
F	Feed rate
M	Miscellaneous function

The feed rate F and miscellaneous function M can be entered and changed in the Programming and Editing mode of operation.

The coordinates of the straight-line end point and the components of the surface-normal vectors are to be defined by the CAD system.

Peripheral milling: 3-D radius compensation with workpiece orientation

The TNC displaces the tool perpendicular to the direction of movement and perpendicular to the tool direction by the sum of the delta values DR (tool table and TOOL CALL). Determine the compensation direction with radius compensation RL/RR (see figure at upper right, traverse direction Y+). For the TNC to be able to reach the set tool orientation, you need to activate the function **M128** (see „7.5 Miscellaneous Functions for Rotary Axes“). The TNC then positions the rotary axes automatically so that the tool can reach the defined orientation with the active compensation.



The TNC is not able to automatically position the rotary axes on all machines. Your machine manual provides more detailed information.

Danger of collision!

On machines whose rotary axes only allow limited traverse, sometimes automatic positioning can require the table to be rotated by 180°. In this case, make sure that the tool head does not collide with the workpiece or the clamps.

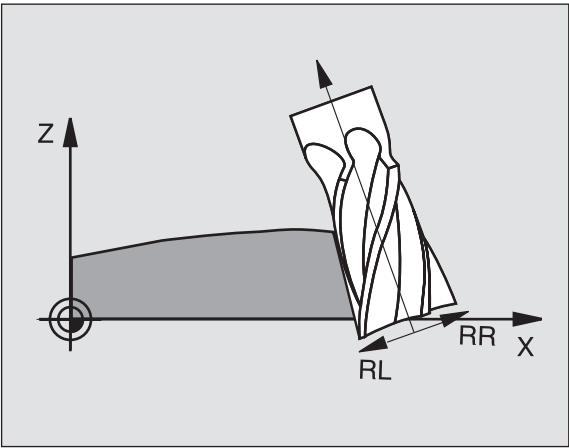
There are two ways to define the tool orientation:

- In an LN block with the components TX, TY and TZ
- In an L block by indicating the coordinates of the rotary axes

Block format with tool orientation

```
LN      X+31.737 Y+21.954 Z+33.165
      TX+0.0078922 TY-0.8764339 TZ+0.2590319 F1000 M128
```

LN	Straight line with 3-D compensation
X,Y,Z	Compensated coordinates of the straight-line end point
TX,TY,TZ	Components of the normalized vector for workpiece orientation
F	Feed rate
M	Miscellaneous function



**Block format with rotary axes****L    X+31.737 Y+21.954 Z+33.165****B+12.357 C+5.896 F1000 M128**

L	Straight line
X, Y, Z	Compensated coordinates of the straight-line end point
B, C	Coordinates of the rotary axes for tool orientation
F	Feed rate
M	Miscellaneous function

5.5 Working with Cutting Data Tables



The TNC must be specially prepared by the machine tool builder for the use of cutting data tables.

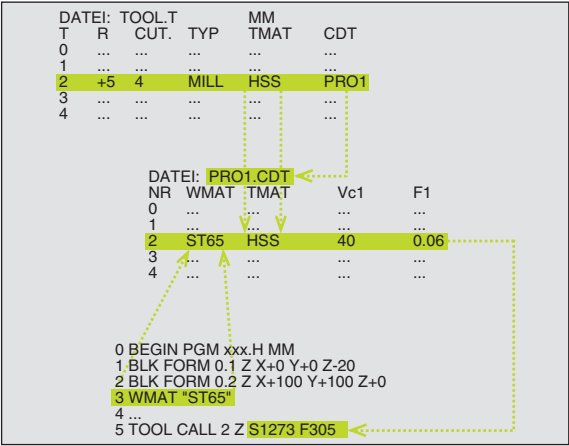
Some functions or additional functions described here may not be provided on your machine tool. Your machine manual provides more detailed information.

In cutting data tables containing various workpiece and cutting material combinations, the TNC can use the cutting speed  $V_c$  and the tooth feed  $f_z$  to calculate the spindle speed  $S$  and the feed rate  $F$ . This calculation is only possible if you defined the workpiece material in the program and various tool-specific features in the tool table.



Before you let the TNC automatically calculate the cutting data, the tool table from which the TNC is to take the tool-specific data must be first be activated in the Test Run mode (status S).

Editing function for cutting data tables	Soft key
Insert line	INSERT LINE
Delete line	DELETE LINE
Go to the beginning of the next line	NEXT LINE
Sort the table (column oriented)	ORDER
Copy the highlighted field (2nd soft-key level)	COPY FIELD
Insert the copied field (2nd soft-key level)	PASTE FIELD
Edit the table format (2nd soft-key level)	EDIT FORMAT





## Table for workpiece materials

Workpiece materials are defined in the table WMAT.TAB (see figure at center right). WMAT.TAB is stored in the TNC:\ directory and can contain as many materials as you want. The name of the material type can have a max. of 32 characters (including spaces). The TNC displays the contents of the NAME column when you are defining the workpiece material in the program (see the following section).



If you change the standard workpiece material table, you must copy it into a new directory. Otherwise your changes will be overwritten during a software update by the HEIDENHAIN standard data. Define the path in the TNC.SYS file with the code word WMAT= (see "Configuration File TNC.SYS" later in this chapter).

To avoid losing data, save the WMAT.TAB file at regular intervals.

Manual operation		Table editing	
		NAME ?	
File: WMAT.TAB			
NR	NAME	DOC	
12	80 CrMoV 9	Verg.-Stahl 1.7707	
13	30 CrNiMo 8	Verg.-Stahl 1.6580	
14	31 CrMo 12	Nitrier-Stahl 1.8515	
15	31 CrMoV 9	Nitrier-Stahl 1.8519	
16	32 CrMo 12	Verg.-Stahl 1.7361	
17	34 CrAl 6	Nitrier-Stahl 1.8504	
18	34 CrAlMo 5	Nitrier-Stahl 1.8507	
19	34 CrAlNi 7	Nitrier-Stahl 1.8550	
20	34 CrAlS 5	Nitrier-Stahl 1.8506	
21	34 CrMo 4	Verg.-Stahl 1.7220	
22	35 NiCr 18	Verg.-Stahl 1.5864	
23	35 NiCrMo 16	Werkz.-Stahl 1.2766	
24	40 CrMnMo 7	Werkz.-Stahl 1.2311	
BEGIN ↑	END ↓	PAGE ↑	PAGE ↓
INSERT LINE		DELETE LINE	
		NEXT LINE	
		ORDER	

BEGIN	END	PAGE	PAGE	INSERT LINE	DELETE LINE	NEXT LINE	ORDER

### Defining the workpiece material in the NC program

In the NC program select the workpiece material from the WMAT.TAB table using the WMAT soft key:



► Program the workpiece material: In the Programming and Editing operating mode, press the WMAT soft key.



► The WMAT.TAB table is superimposed: Press the SELECT WORKPIECE MATERIAL soft key and the TNC displays in a second window the list of materials that are stored in the WMAT.TAB table.

► Select your workpiece material by using the arrow keys to move the highlight onto the material you wish to select and confirming with the ENT key. The TNC transfers the selected material to the WMAT block. To scroll through the table more quickly, press and hold SHIFT and then the arrow keys. The TNC then moves page by page.

► To terminate the dialog, press the END key.



If you change the WMAT block in a program, the TNC outputs a warning. Check whether the cutting data stored in the TOOL CALL block are still valid.



### Creating a new cutting data table.

- ▶ Select the Programming and Editing mode of operation.
- ▶ To select the file manager, press the Taste PGM MGT key.
- ▶ Select the directory where the cutting data table is to be stored.
- ▶ Enter any file name with file name extension .CDT, and confirm with ENT.
- ▶ On the right half of the screen, the TNC displays various table formats (machine-dependent, see example in figure at right). These tables differ from each other in the number of cutting speed/feed rate combinations they allow. Use the arrow keys to move the highlight onto the table format you wish to select and confirm with ENT. The TNC generates a new, empty cutting data table.

Program run full sequence	Programming and editing Select table format					
RS232:\						
RS422:\						
TNC:\						
TNC:\						
28047001						
ALBERT						
CUTTING						
DEMOBSP						
LSV2						
HE						
HST						
NK						
DIGI						
MESSZYKL						
SELECT						END

### Data required for the tool table

- Tool radius – under R (DR)
- Number of teeth (only with tools for milling) – under CUT.
- Tool type – under TYPE  
The tool type influences the calculation of the feed rate:  
Tools for milling:  $F = S \cdot f_z \cdot z$   
All other tools:  $F = S \cdot f_U$   
S = spindle speed  
 $f_z$  = feed rate per tooth  
 $f_U$  = feed rate per revolution  
z = no. of teeth
- Tool cutting material – under TMAT
- Name of the cutting data table for which this tool will be used - under CDT


In the tool table, select the tool type, tool cutting material and the name of the cutting data table via soft key (see „5.2 Tool Data“).

Working with automatic speed/feed rate calculation

- 1 If it has not already been entered, enter the type of workpiece material in the file WMAT.TAB
- 2 If it has not already been entered, enter the type of cutting material in the file TMAT.TAB
- 3 If not already entered, enter all of the required tool-specific data in the tool table:
  - Tool radius
  - Number of teeth
  - Tool type
  - Tool cutting material
  - The cutting data table for each tool
- 4 If not already entered, enter the cutting data in any cutting data table (CDT file)
- 5 Test Run operating mode: Activate the tool table from which the TNC is to take the tool-specific data (status S).
- 6 In the NC program, set the workpiece material by pressing the WMAT soft key.
- 7 In the NC program, let the TOOL CALL block automatically calculate spindle speed and feed rate via soft key

Changing the table structure

Cutting data tables constitute so-called „freely-definable tables“ for the TNC. You can change the format of freely definable tables by using the structure editor.



The TNC can process up to 200 characters per line and up to 30 column.

If you insert an additional column into an existing table, the TNC does not automatically shift the values that have been entered.

Calling the structure editor

Press the EDIT FORMAT soft key (2nd soft-key level). The TNC opens the editing window (see figure at right), in which the table structure is shown “rotated by 90°.” In other words, a line in the editing window defines a column in the associated table. The meanings of the structure commands (header entries) are shown in the table at right.

Exiting the structure editor.

Press the END key. The TNC changes data that was already in the table into the new format. Elements that the TNC could not convert into the new structure are indicated with a hash mark # (e.g., if you have narrowed the column width).

Structure command	Meaning
NR	Column number
NAME	Overview of columns
TYPE	N: Numerical input C: Alphanumeric input
WIDTH	Width of column For type N including algebraic sign, comma, and decimal places
DEC	Number of decimal places (max. 4, effective only for type N)
ENGLISH to HUNGARIAN	Language-dependent dialogs (max. 32 characters)

Manual operation

Table editing  
Field name?

File: 03HMC020.DIR

>>

NR	NAME	TYPE	WIDTH	DEC	ENGLISH
0	WMAT	C	16	0	Workpiece material?
1	TMAT	C	16	0	Tool material?
2	Vc1	N	7	3	Cutting speed Vc1?
3	F1	N	7	3	Feed rate Fz1?
4	Vc2	N	7	3	Cutting speed Vc2?
5	F2	N	7	3	Feed rate Fz2?
[END]					

BEGIN

END

PAGE

PAGE

INSERT LINE

DELETE LINE

NEXT LINE

## Data transfer from cutting data tables

If you output a file type .TAB or .CDT via an external data interface, the TNC also transfers the structural definition of the table. The structural definition begins with the line #STRUCTBEGIN and ends with the line #STRUCTEND. The meanings of the individual code words are shown in the table "Structure Command" (see previous page). Behind #STRUCTEND the TNC saves the actual content of the table.

## Configuration file TNC.SYS

You must use the configuration file TNC.SYS if your cutting data tables are not stored in the standard directory TNC:\. In TNC.SYS you must then define the paths in which you have stored your cutting data tables.



The TNC.SYS file must be stored in the root directory TNC:\.

Entries in TNC.SYS	Meaning
WMAT=	Path for workpiece material table
TMAT=	Path for cutting material table
PCDT=	Path for cutting data tables

### Example of TNC.SYS:

```
WMAT=TNC:\CUTTAB\WMAT_GB.TAB
```

```
TMAT=TNC:\CUTTAB\TMAT_GB.TAB
```

```
PCDT=TNC:\CUTTAB\
```





# 6

**Programming:**  
**Programming Contours**



## 6.1 Overview of Tool Movements

### Path functions

A workpiece contour is usually composed of several contour elements such as straight lines and circular arcs. With the path functions, you can program the tool movements for **straight lines** and **circular arcs**.

### Free contour (FK) programming

If a production drawing is not dimensioned for NC and the dimensions given are not sufficient for creating a part program, you can program the workpiece contour with the FK free contour programming and have the TNC calculate the missing data.

With FK programming, you also program tool movements for **straight lines** and **circular arcs**.

### Miscellaneous functions M

With the TNC's miscellaneous functions you can affect

- Program run, e.g., a program interruption
- Machine functions, such as switching spindle rotation and coolant supply on and off
- Contouring behavior of the tool

### Subprograms and program section repeats

If a machining sequence occurs several times in a program, you can save time and reduce the chance of programming errors by entering the sequence once and then defining it as a subprogram or program section repeat. If you wish to execute a specific program section only under certain conditions, you also define this machining sequence as a subprogram. In addition, you can have a part program call a separate program for execution.

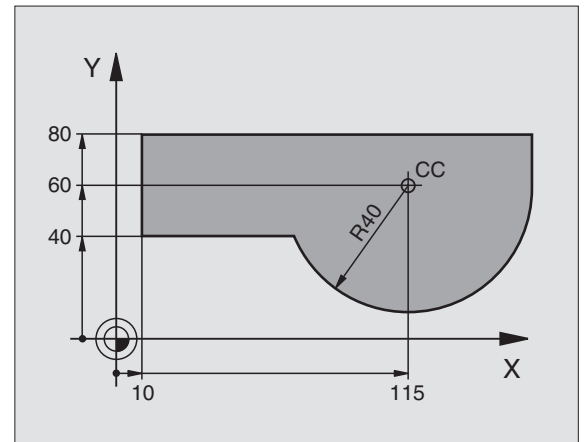
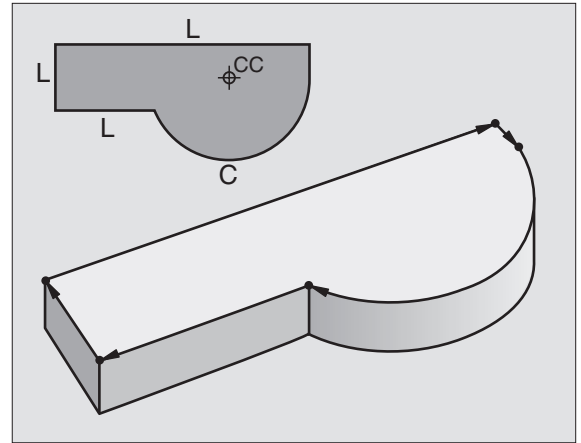
How subprograms and program section repeats are used in programming is described in Chapter 9.

### Programming with Q parameters

Instead of programming numerical values in a part program, you enter markers called Q parameters. You assign the values to the Q parameters separately with the Q parameter functions. You can use the Q parameters for programming mathematical functions that control program execution or describe a contour.

In addition, parametric programming enables you to measure with the 3-D touch probe during program run.

Programming with Q parameter is described in Chapter 10.





## 6.2 Fundamentals of Path Functions

### Programming tool movements for workpiece machining

You create a part program by programming the path functions for the individual contour elements in sequence. You usually do this by entering **the coordinates of the end points of the contour elements** given in the production drawing. The TNC calculates the actual path of the tool from these coordinates, and from the tool data and radius compensation.

The TNC moves all axes programmed in a single block simultaneously.

#### Movement parallel to the machine axes

The program block contains only one coordinate. The TNC thus moves the tool parallel to the programmed axis.

Depending on the individual machine tool, the part program is executed by movement of either the tool or the machine table on which the workpiece is clamped. Nevertheless, you always program path contours as if the tool moves and the workpiece remains stationary.

Example:

**L X+100**

**L** Path function for "straight line"

**X+100** Coordinate of the end point

The tool retains the Y and Z coordinates and moves to the position X=100. See figure at upper right.

#### Movement in the main planes

The program block contains two coordinates. The TNC thus moves the tool in the programmed plane.

Example:

**L X+70 Y+50**

The tool retains the Z coordinate and moves in the XY plane to the position X=70, Y=50. See figure at center right.

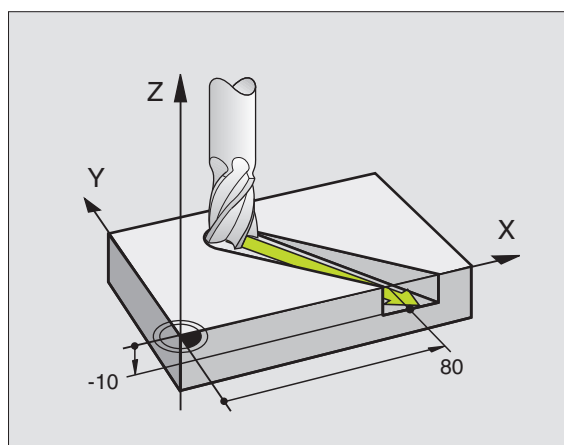
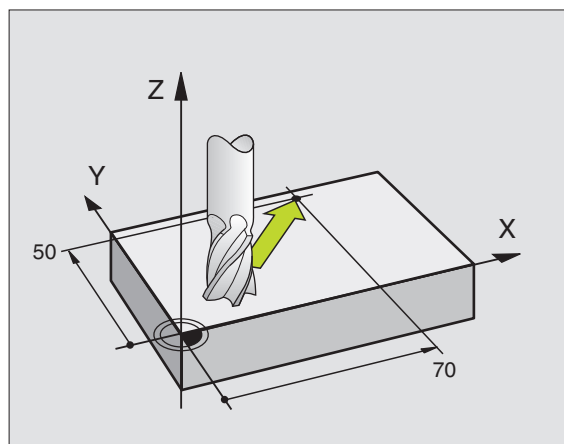
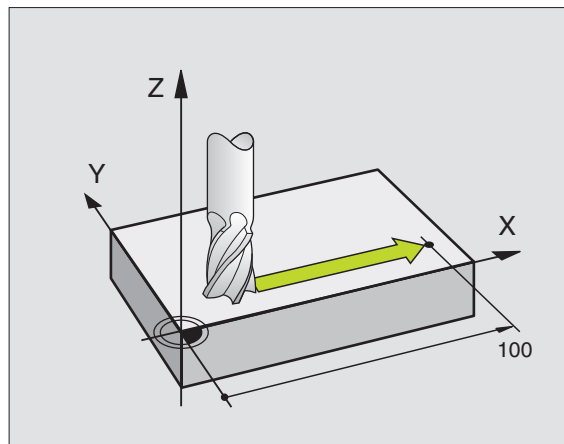
#### Three-dimensional movement

The program block contains three coordinates. The TNC thus moves the tool in space to the programmed position.

Example:

**L X+80 Y+0 Z-10**

See figure at lower right.



Entering more than three coordinates

Machining with 5 axes, for example, moves 3 linear and 2 rotary axes simultaneously.

Such programs are too complex to program at the machine, however, and are usually created with a CAD system.

Example:

```
L X+20 Y+10 Z+2 A+15 C+6 R0 F100 M3
```

The TNC graphics cannot simulate movements in more than three axes.

Circles and circular arcs

The TNC moves two axes simultaneously in a circular path relative to the workpiece. You can define a circular movement by entering the circle center CC.

When you program a circle, the TNC assigns it to one of the main planes. This plane is defined automatically when you set the spindle axis during a tool call:

Spindle axis	Main plane
Z	XY, also UV, XV, UY
Y	ZX, also WU, ZU, WX
X	YZ, also VW, YW, VZ

You can program circles that do not lie parallel to a main plane by using the function for tilting the working plane (see Chapter 8) or Q parameters (see Chapter 10).

Direction of rotation DR for circular movements

When a circular path has no tangential transition to another contour element, enter the direction of rotation DR:

Clockwise direction of rotation: DR-  
Counterclockwise direction of rotation: DR+

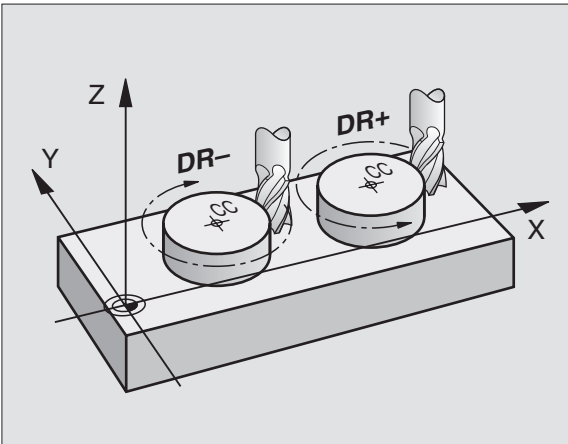
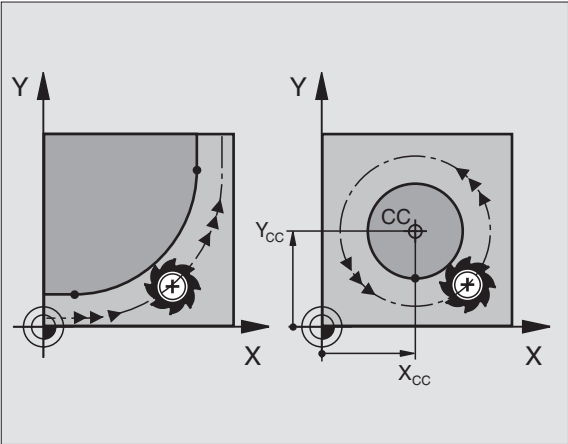
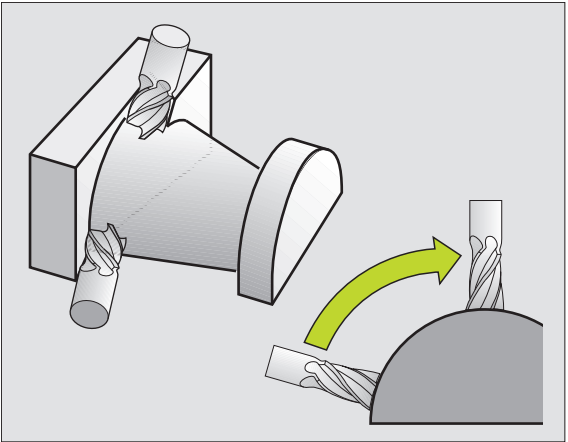
Radius compensation

The radius compensation must be in the block in which you move to the first contour element. You cannot begin radius compensation in a circle block. It must be activated beforehand in a straight-line block or approach block (APPR block).

For detailed information on approach and straight-line blocks, refer to sections 6.3 “Contour Approach and Departure” and 6.4 “Path Contours — Cartesian Coordinates.”

Pre-positioning


Before running a part program, always pre-position the tool to prevent the possibility of damaging it or the workpiece.



Creating the program blocks with the path function keys

The gray path function keys initiate the plain language dialog. The TNC asks you successively for all the necessary information and inserts the program block into the part program.

Example — programming a straight line:



Initiate the programming dialog (here, for a straight line).

Coordinates ?

X 10

Enter the coordinates of the straight-line end point.

Y 5

ENT

Radius comp. RL/RR/no comp. ?

RL

Select the radius compensation (here, press the RL soft key — the tool moves to the left of the programmed contour).

Feed rate F=? / F MAX = ENT

100

ENT

Enter the feed rate (here, 100 mm/min), and confirm your entry with ENT. For programming in inches, enter 100 for a feed rate of 10 ipm.

F MAX

Move at rapid traverse: press the FMAX soft key, or

F AUTO

Move at automatically calculated speed (cutting data table); press the FAUTO soft key.

Miscellaneous function M ?

3

ENT

Enter a miscellaneous function (here, M3), and terminate the dialog with ENT.

The part program now contains the following line:









L X+10 Y+5 RL F100 M3

Positioning with mdi	Programming and editing
	Miscellaneous function M?
1	BLK FORM 0.1 Z X+0 Y+0 Z-40
2	BLK FORM 0.2 X+100 Y+100 Z+0
3	TOOL CALL 1 Z S3500 DL+1 DR+1
4	L Z+250 R0 F MAX
5	L X-20 Y+50 R0 F MAX M3
6	END PGM NEU MM

### 6.3 Contour Approach and Departure

#### Overview: Types of paths for contour approach and departure

The functions for contour approach and departure are activated with the APPR/DEP key. You can then select the desired path function with the corresponding soft key:

Function	Soft keys: Approach Departure	
Straight line with tangential connection		
Straight line perpendicular to a contour point		
Circular arc with tangential connection		
Circular arc with tangential connection to the contour. Approach and departure to an auxiliary point outside of the contour on a tangentially connecting line.		

#### Approaching and departing a helix

The tool approaches and departs a helix on its extension by moving in a circular arc that connects tangentially to the contour. You program helix approach and departure with the APPR CT and DEP CT functions.

#### Important positions for approach and departure

- Starting point  $P_S$   
You program this position in the block before the APPR block.  $P_S$  lies outside the contour and is approached without radius compensation (R0).
- Auxiliary point  $P_H$   
Some of the paths for approach and departure go through an auxiliary point  $P_H$  that the TNC calculates from your input in the APPR or DEP block.
- First contour point  $P_A$  and last contour point  $P_E$   
You program the first contour point  $P_A$  in the APPR block. The last contour point  $P_E$  can be programmed with any path function.
- If the APPR block also contains a Z axis coordinate, the TNC will first move the tool to  $P_H$  in the working plane, and then move it to the entered depth in the tool axis.
- End point  $P_N$   
The position  $P_N$  lies outside of the contour and results from your input in the DEP block. If the DEP block also contains a Z axis coordinate, the TNC will first move the tool to  $P_H$  in the working plane, and then move it to the entered depth in the tool axis.

Manual operation

Programming and editing

```

2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL CALL 1 Z S3500
4 L Z+250 R0 F MAX
5 L X-20 Y+50 R0 F MAX
6 L Z-5 R0 F2000
7 END PGM NEU MM
  
```

APPR LT

APPR LN

APPR CT

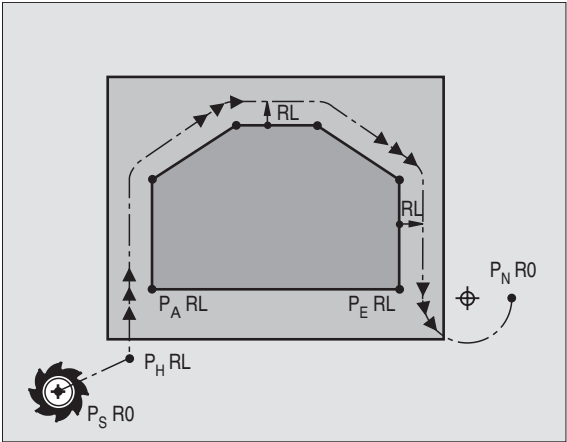
APPR LCT

DEP LT

DEP LN

DEP CT

DEP LCT



You can enter the position data in absolute or incremental coordinates and in Cartesian or polar coordinates.

The TNC does not check whether the programmed contour will be damaged when moving from the actual position to the auxiliary point  $P_H$ . Use the test graphics to simulate approach and departure before executing the part program.

When approaching the contour, allow sufficient distance between the starting point  $P_S$  and the first contour point  $P_A$  to assure that the TNC will reach the programmed feed rate for machining.

The TNC moves the tool from the actual position to the auxiliary point  $P_H$  at the feed rate that was last programmed.

### Radius compensation

The tool radius compensation is programmed together with the first contour point  $P_A$  in the APPR block. The DEP blocks automatically remove the tool radius compensation.

Contour approach without radius compensation: If you program the APPR block with R0, the TNC will calculate the tool path for a tool radius of 0 mm and a radius compensation RR! The radius compensation is necessary to set the direction of contour approach and departure in the APPR/DEP LN and APPR/DEP CT functions.

### Approaching on a straight line with tangential connection: APPR LT

The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves from  $P_H$  to the first contour point  $P_A$  on a straight line that connects tangentially to the contour. The auxiliary point  $P_H$  is separated from the first contour point  $P_A$  by the distance LEN.

- Use any path function to approach the starting point  $P_S$ .

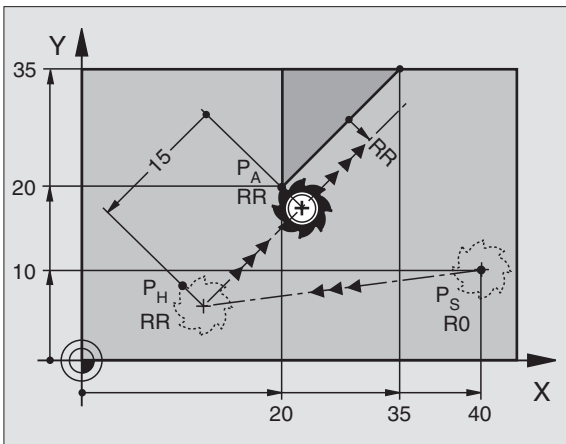


- Initiate the dialog with the APPR/DEP key and APPR LT soft key:
- Coordinates of the first contour point  $P_A$
- LEN: Distance from the auxiliary point  $P_H$  to the first contour point  $P_A$
- Radius compensation for machining

### Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LT X+20 Y+20 Z-10 LEN15 RR F100	$P_A$ with radius comp. RR, distance $P_H$ to $P_A$ : LEN=15
9 L X+35 Y+35	End point of the first contour element
10 L ...	Next contour element

Abbreviation	Meaning
APPR	Approach
DEP	Departure
L	Line
C	Circle
T	Tangential (smooth connection)
N	Normal (perpendicular)



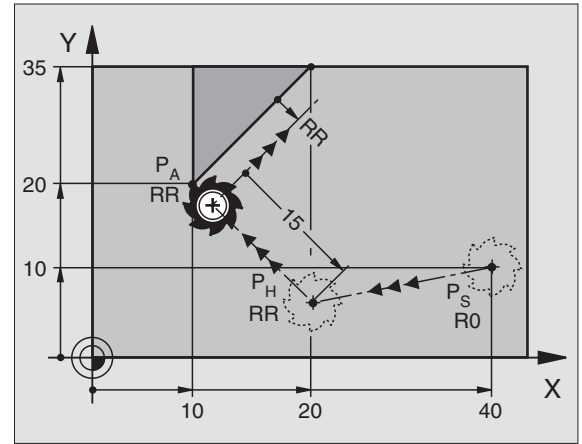
## Approaching on a straight line perpendicular to the first contour point: APPR LN

The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves from  $P_H$  to the first contour point  $P_A$  on a straight line perpendicular to the first contour element. The auxiliary point  $P_H$  is separated from the first contour point  $P_A$  by the distance LEN plus the tool radius.

- Use any path function to approach the starting point  $P_S$ .
- Initiate the dialog with the APPR/DEP key and APPR LN soft key:



- Coordinates of the first contour point  $P_A$
- Length: Distance to the auxiliary point  $P_H$ . Always enter LEN as a positive value!
- Radius compensation RR/RL for machining



### Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LN X+10 Y+20 Z-10 LEN+15 RR F100	$P_A$ with radius comp. RR
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element

## Approaching on a circular arc with tangential connection: APPR CT

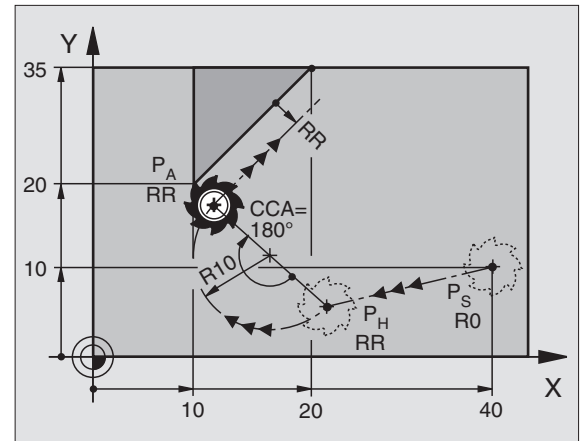
The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves from  $P_H$  to the first contour point  $P_A$  following a circular arc that is tangential to the first contour element.

The arc from  $P_H$  to  $P_A$  is determined through the radius  $R$  and the center angle CCA. The direction of rotation of the circular arc is automatically derived from the tool path for the first contour element.

- Use any path function to approach the starting point  $P_S$ .
- Initiate the dialog with the APPR/DEP key and APPR CT soft key:



- Coordinates of the first contour point  $P_A$
- Radius  $R$  of the circular arc
  - If the tool should approach the workpiece in the direction defined by the radius compensation: Enter  $R$  as a positive value.
  - If the tool should approach the workpiece opposite to the radius compensation: Enter  $R$  as a negative value.
- Center angle CCA of the arc
  - CCA can be entered only as a positive value.
  - Maximum input value  $360^\circ$
- Radius compensation RR/RL for machining



**Example NC blocks**

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR CT X+10 Y+20 Z-10 CCA180 R+10 RR F100	$P_A$ with radius comp. RR, Radius $R=10$
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element

### Approaching on a circular arc with tangential connection from a straight line to the contour: APPR LCT

The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves from  $P_H$  to the first contour point  $P_A$  on a circular arc.

The arc is connected tangentially both to the line  $P_S - P_H$  as well as to the first contour element. Once these lines are known, the radius then suffices to completely define the tool path.

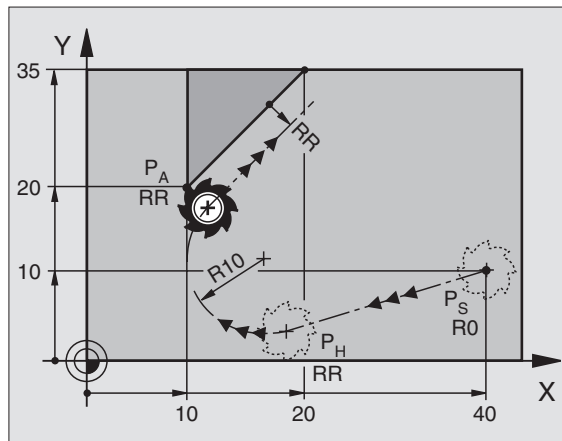
- Use any path function to approach the starting point  $P_S$ .
- Initiate the dialog with the APPR/DEP key and APPR LCT soft key:



- Coordinates of the first contour point  $P_A$

- Radius  $R$  of the arc  
Always enter  $R$  as a positive value.

- Radius compensation for machining

**Example NC blocks**

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LCT X+10 Y+20 Z-10 R10 RR F100	$P_A$ with radius compensation RR, radius $R=10$
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element

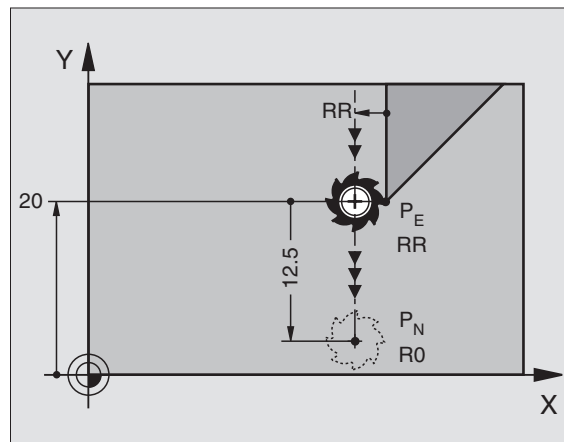
## Departing tangentially on a straight line: DEP LT

The tool moves on a straight line from the last contour point  $P_E$  to the end point  $P_N$ . The line lies in the extension of the last contour element.  $P_N$  is separated from  $P_E$  by the distance LEN.

- Program the last contour element with the end point  $P_E$  and radius compensation.
- Initiate the dialog with the APPR/DEP key and DEP LT soft key:



- LEN: Enter the distance from the last contour element  $P_E$  to the end point  $P_N$ .



### Example NC blocks

23 L Y+20 RR F100

Last contour element:  $P_E$  with radius compensation

24 DEP LT LEN 12.5 F100

Depart contour by LEN = 12.5 mm

25 L Z+100 FMAX M2

Retract in Z, return to block 1, end program

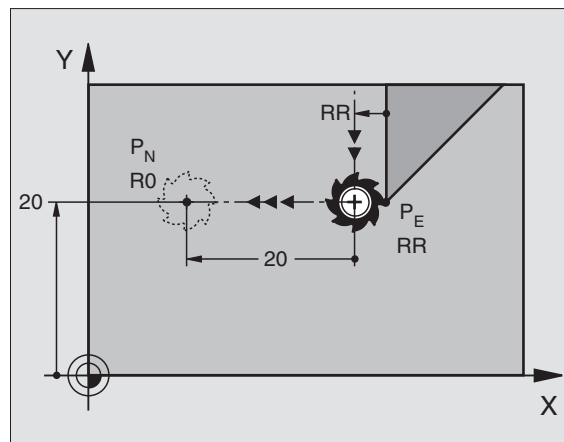
## Departing on a straight line perpendicular to the last contour point: DEP LN

The tool moves on a straight line from the last contour point  $P_E$  to the end point  $P_N$ . The line departs on a perpendicular path from the last contour point  $P_E$ .  $P_N$  is separated from  $P_E$  by the distance LEN plus the tool radius.

- Program the last contour element with the end point  $P_E$  and radius compensation.
- Initiate the dialog with the APPR/DEP key and DEP LN soft key:



- LEN: Enter the distance from the last contour element  $P_E$  to the end point  $P_N$ . Important: Always enter LEN as a positive value!



### Example NC blocks

23 L Y+20 RR F100

Last contour element:  $P_E$  with radius compensation

24 DEP LN LEN+20 F100

Depart perpendicular to contour by LEN = 20 mm

25 L Z+100 FMAX M2

Retract in Z, return to block 1, end program



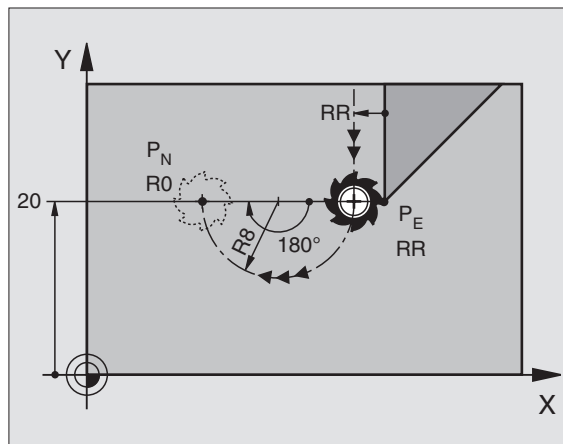
## Departing tangentially on a circular arc: DEP CT

The tool moves on a circular arc from the last contour point  $P_E$  to the end point  $P_N$ . The arc is tangentially connected to the last contour element.

- Program the last contour element with the end point  $P_E$  and radius compensation.
- Initiate the dialog with the APPR/DEP key and DEP CT soft key:



- Radius  $R$  of the circular arc
- If the tool should depart the workpiece in the direction of the radius compensation (i.e. to the right with  $RR$  or to the left with  $RL$ ): Enter  $R$  as a positive value.
- If the tool should depart the workpiece in the direction **opposite** to the radius compensation: Enter  $R$  as a negative value.
- Center angle  $CCA$  of the arc



### Example NC blocks

23 L Y+20 RR F100	Last contour element: $P_E$ with radius compensation
24 DEP CT CCA 180 R+8 F100	Center angle=180°, arc radius=10 mm
25 L Z+100 FMAX M2	Retract in Z, return to block 1, end program

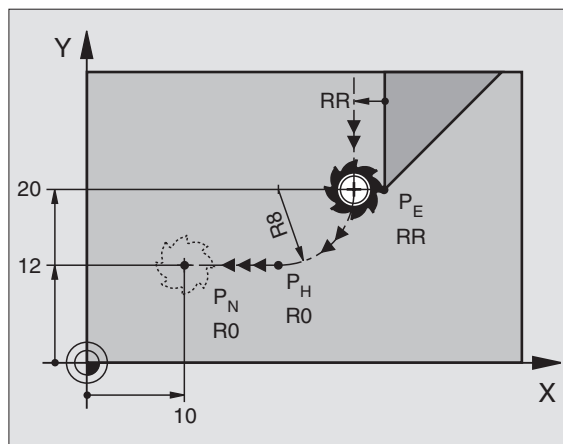
## Departing on a circular arc tangentially connecting the contour and a straight line: DEP LCT

The tool moves on a circular arc from the last contour point  $P_E$  to an auxiliary point  $P_H$ . It then moves on a straight line to the end point  $P_N$ . The arc is tangentially connected both to the last contour element and to the line from  $P_H$  to  $P_N$ . Once these lines are known, the radius  $R$  then suffices to completely define the tool path.

- Program the last contour element with the end point  $P_E$  and radius compensation.
- Initiate the dialog with the APPR/DEP key and DEP LCT soft key:



- Enter the coordinates of the end point  $P_N$ .
- Radius  $R$  of the arc  
Always enter  $R$  as a positive value











### Example NC blocks

23 L Y+20 RR F100	Last contour element: $P_E$ with radius compensation
24 DEP LCT X+10 Y+12 R+8 F100	Coordinates $P_N$ , arc radius = 10 mm
25 L Z+100 FMAX M2	Retract in Z, return to block 1, end program

## 6.4 Path Contours — Cartesian Coordinates

### Overview of path functions

Function	Path function key	Tool movement	Required input
Line <b>L</b>		Straight line	Coordinates of the straight-line end point
<b>CHamFer</b>		Chamfer between two straight lines	Chamfer side length
Circle <b>C</b> enter		No tool movement	Coordinates of the circle center or pole
Circle		Circular arc around a circle center CC to an arc end point	Coordinates of the arc end point, direction of rotation
Circle by <b>R</b> adius		Circular arc with a certain radius	Coordinates of the arc end point, arc radius, direction of rotation
Circle <b>T</b> angential Circle <b>T</b> angential		Circular arc with tangential connection to the preceding contour element	Coordinates of the arc end point
Corner <b>R</b> ouNDing		Circular arc with tangential connection to the preceding and subsequent contour elements	Rounding-off radius R
FK Free Contour Programming		Straight line or circular path with any connection to the preceding contour element	See section 6.6

## Straight line L

The TNC moves the tool in a straight line from its current position to the straight-line end point. The starting point is the end point of the preceding block.



► Enter the coordinates of the end point for the line.

Further entries, if necessary:

- Radius compensation RL/RR/R0
- Feed rate F
- Miscellaneous function M

### Example NC blocks

```
7 L X+10 Y+40 RL F200 M3
```

```
8 L IX+20 IY-15
```

```
9 L X+60 IY-10
```

### Actual position capture

You can also generate a straight-line block (L block) by using the actual-position-capture key:

- In the Manual Operation mode, move the tool to the position you wish to capture.
- Switch the screen display to Programming and Editing.
- Select the program block after which you want to insert the L block.



► Press the actual-position-capture key: The TNC generates an L block with the actual position coordinates.



In the MOD function, you define the number of axes that the TNC saves in an L block (see Chapter 12 "MOD Functions," section "Selecting the Axes for Generating L Blocks").

## Inserting a chamfer CHF between two straight lines

The chamfer enables you to cut off corners at the intersection of two straight lines.

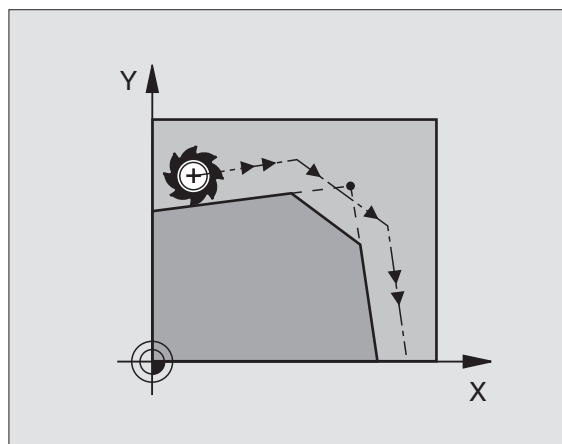
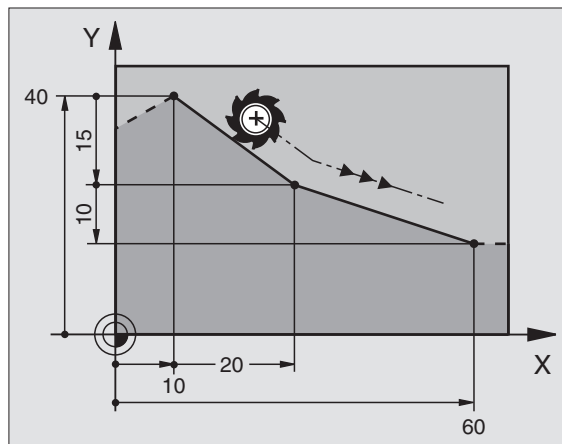
- The blocks before and after the CHF block must be in the same working plane.
- The radius compensation before and after the chamfer block must be the same.
- An inside chamfer must be large enough to accommodate the current tool.



► Chamfer side length: Enter the length of the chamfer

Further entries, if necessary:

- Feed rate F (only effective in CHF block)



Please observe the notes on the next page!

### Example NC blocks

```
7 L X+0 Y+30 RL F300 M3
8 L X+40 IY+5
9 CHF 12 F250
10 L IX+5 Y+0
```

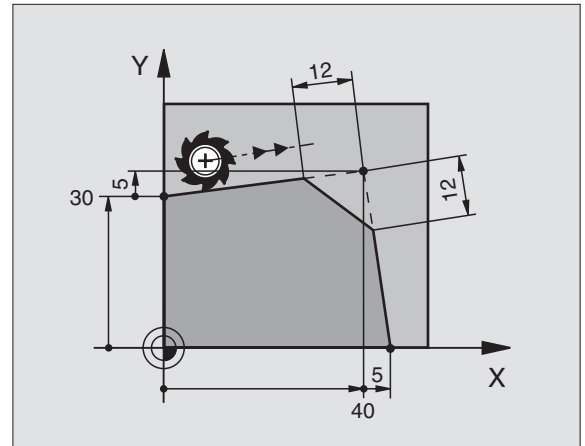


You cannot start a contour with a CHF block.

A chamfer is possible only in the working plane.

A feed rate programmed in the CHF block is effective only in that block. After the CHF block, the previous feed rate becomes effective again.

The corner point is cut off by the chamfer and is not part of the contour.



### Circle center CC

You can define a circle center CC for circles that are programmed with the C key (circular path C). This is done in the following ways:

- Entering the Cartesian coordinates of the circle center
- Using the circle center defined in an earlier block
- Capturing the coordinates with the actual-position-capture key



► Coordinates CC: Enter the circle center coordinates

If you want to use the last programmed position, do not enter any coordinates.

### Example NC blocks

```
5 CC X+25 Y+25
```

or

```
10 L X+25 Y+25
```

```
11 CC
```

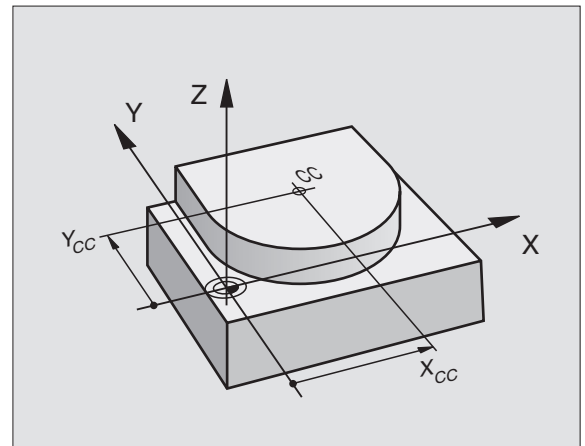
The program blocks 10 and 11 do not refer to the illustration.

### Duration of effect

The circle center definition remains in effect until a new circle center is programmed. You can also define a circle center for the secondary axes U, V and W.

### Entering the circle center CC incrementally

If you enter the circle center with incremental coordinates, you have programmed it relative to the last programmed position of the tool.





The only effect of CC is to define a position as circle center: The tool does not move to this position.  
The circle center is also the pole for polar coordinates.

### Circular path C around circle center CC

Before programming a circular path C, you must first enter the circle center CC. The last programmed tool position before the C block is used as the circle starting point.

► Move the tool to the circle starting point.



► Enter the coordinates of the circle center.



► Enter the coordinates of the arc end point

► Direction of rotation DR

Further entries, if necessary:

► Feed rate F

► Miscellaneous function M

### Example NC blocks

5 CC X+25 Y+25

6 L X+45 Y+25 RR F200 M3

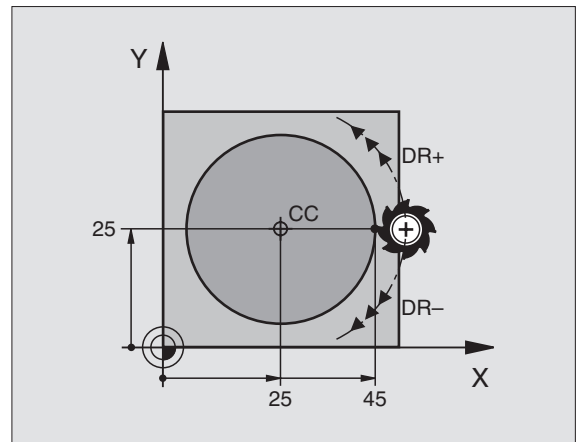
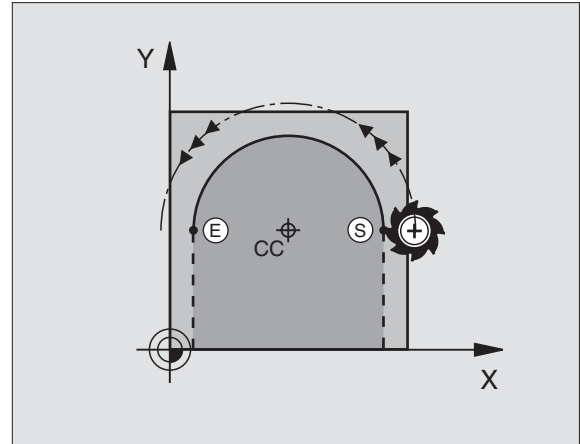
7 C X+45 Y+25 DR+

### Full circle

Enter the same point you used as the starting point for the end point in a C block.



The starting and end points of the arc must lie on the circle.  
Input tolerance: up to 0.016 mm (selected with MP7431).

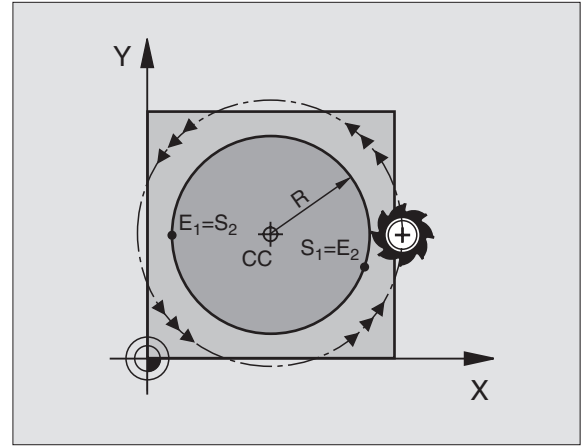


## Circular path CR with defined radius

The tool moves on a circular path with the radius R.



- ▶ Enter the coordinates of the arc end point.
  - ▶ Radius R  
Note: The algebraic sign determines the size of the arc.
  - ▶ Direction of rotation DR  
Note: The algebraic sign determines whether the arc is concave or convex.
- Further entries, if necessary:
- ▶ Feed rate F
  - ▶ Miscellaneous function M



### Full circle

For a full circle, program two CR blocks in succession:

The end point of the first semicircle is the starting point of the second. The end point of the second semicircle is the starting point of the first. See figure at upper right.

### Central angle CCA and arc radius R

The starting and end points on the contour can be connected with four arcs of the same radius:

Smaller arc:  $CCA < 180^\circ$

Enter the radius with a positive sign  $R > 0$

Larger arc:  $CCA > 180^\circ$

Enter the radius with a negative sign  $R < 0$

The direction of rotation determines whether the arc is curving outward (convex) or curving inward (concave):

Convex: Direction of rotation DR- (with radius compensation RL)

Concave: Direction of rotation DR+ (with radius compensation RL)

### Example NC blocks

See figures at middle and lower right.

10 L X+40 Y+40 RL F200 M3

11 CR X+70 Y+40 R+20 DR- (arc 1)

or

11 CR X+70 Y+40 R+20 DR+ (arc 2)

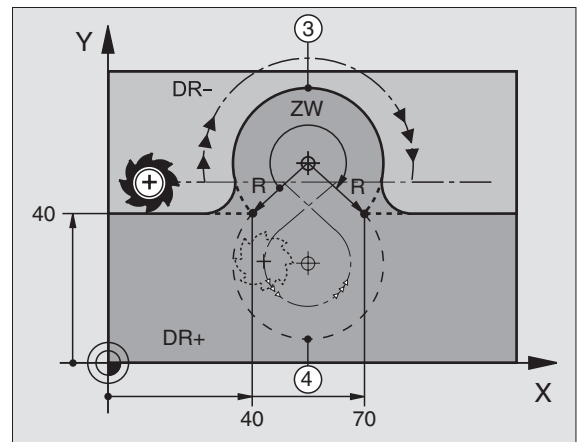
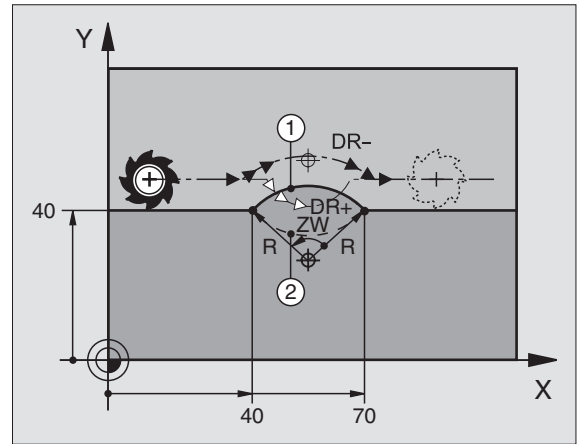
or

11 CR X+70 Y+40 R-20 DR- (arc 3)

or

11 CR X+70 Y+40 R-20 DR+ (arc 4)

Please observe the notes on the next page!





The distance from the starting and end points of the arc diameter cannot be greater than the diameter of the arc.

The maximum possible radius is 99.9999 m.

You can also enter rotary axes A, B and C.

## Circular path CT with tangential connection

The tool moves on an arc that starts at a tangent with the previously programmed contour element.

A transition between two contour elements is called "tangential" when there is no kink or corner at the intersection between the two contours — the transition is smooth.

The contour element to which the tangential arc connects must be programmed immediately before the CT block. This requires at least two positioning blocks.



► Enter the coordinates of the arc end point.

Further entries, if necessary:

► Feed rate F

► Miscellaneous function M

### Example NC blocks

```
7 L X+0 Y+25 RL F300 M3
```

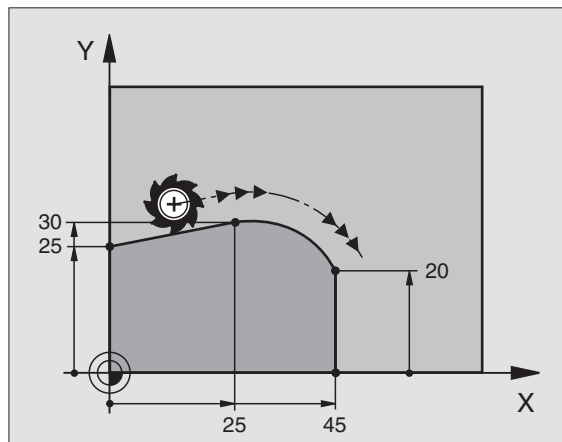
```
8 L X+25 Y+30
```

```
9 CT X+45 Y+20
```

```
10 L Y+0
```



A tangential arc is a two-dimensional operation: the coordinates in the CT block and in the contour element preceding it must be in the same plane of the arc.



Corner Rounding RND

The RND function is used for rounding off corners.

The tool moves on an arc that is tangentially connected to both the preceding and subsequent contour elements.

The rounding arc must be large enough to accommodate the tool.



- ▶ Rounding-off radius: Enter the radius of the arc.
- Further entries, if necessary:
- ▶ Feed rate F (only effective in RND block)

Example NC blocks

```
5 L X+10 Y+40 RL F300 M3
6 L X+40 Y+25
7 RND R5 F100
8 L X+10 Y+5
```

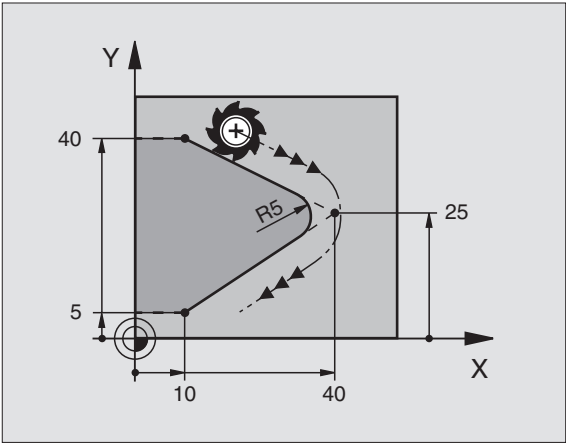


In the preceding and subsequent contour elements, both coordinates must lie in the plane of the rounding arc. If you machine the contour without tool-radius compensation, you must program both coordinates in the working plane.

The corner point is cut off by the rounding arc and is not part of the contour.

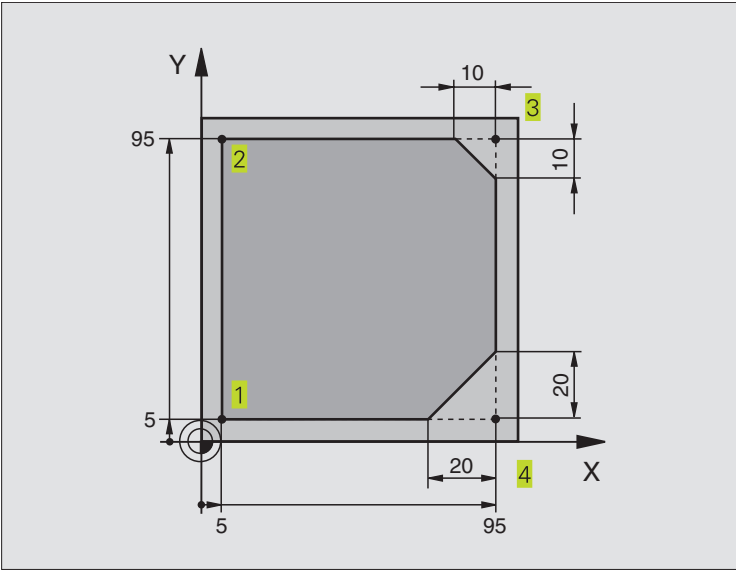
A feed rate programmed in the RND block is effective only in that block. After the RND block, the previous feed rate becomes effective again.

You can also use an RND block for a tangential contour approach if you do not want to use an APPR function.



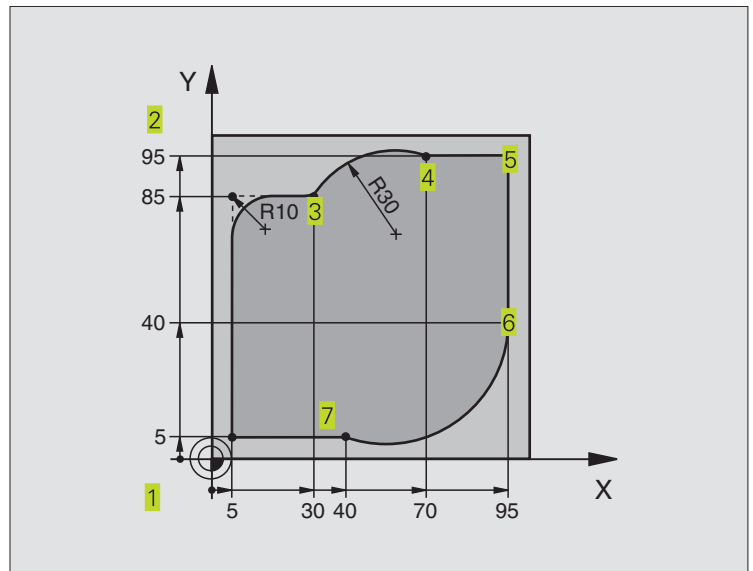


# Example: Linear movements and chamfers with Cartesian coordinates



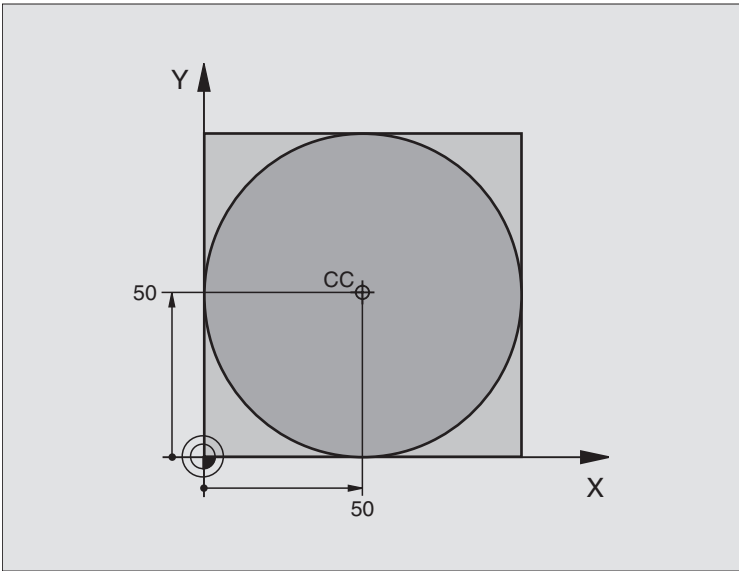
0	BEGIN PGM LINEAR MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define blank form for graphic workpiece simulation
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	T00L DEF 1 L+0 R+10	Define tool in the program
4	T00L CALL 1 Z S4000	Call tool in the spindle axis and with the spindle speed S
5	L Z+250 R0 F MAX	Retract tool in the spindle axis at rapid traverse FMAX
6	L X-10 Y-10 R0 F MAX	Pre-position the tool
7	L Z-5 R0 F1000 M3	Move to working depth at feed rate F = 1000 mm/min
8	APPR LT X+5 Y+5 LEN10 RL F300	Approach the contour at point 1 on a straight line with tangential connection
9	L Y+95	Move to point 2
10	L X+95	Point 3: first straight line for corner 3
11	CHF 10	Program chamfer with length 10 mm
12	L Y+5	Point 4: 2nd straight line for corner 3, 1st straight line for corner 4
13	CHF 20	Program chamfer with length 20 mm
14	L X+5	Move to last contour point 1, second straight line for corner 4
15	DEP LT LEN10 F1000	Depart the contour on a straight line with tangential connection
16	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
17	END PGM LINEAR MM	

## Example: Circular movements with Cartesian coordinates



0	BEGIN PGM CIRCULAR MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define blank form for graphic workpiece simulation
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+10	Define tool in the program
4	TOOL CALL 1 Z S4000	Call tool in the spindle axis and with the spindle speed S
5	L Z+250 R0 F MAX	Retract tool in the spindle axis at rapid traverse FMAX
6	L X-10 Y-10 R0 F MAX	Pre-position the tool
7	L Z-5 R0 F1000 M3	Move to working depth at feed rate F = 1000 mm/min
8	APPR LCT X+5 Y+5 R5 RL F300	Approach the contour at point 1 on a circular arc with tangential connection
9	L X+5 Y+85	Point 2: first straight line for corner 2
10	RND R10 F150	Insert radius with R = 10 mm, feed rate: 150 mm/min
11	L X+30 Y+85	Move to point 3: Starting point of the arc with CR
12	CR X+70 Y+95 R+30 DR-	Move to point 4: End point of the arc with CR, radius 30 mm
13	L X+95	Move to point 5
14	L X+95 Y+40	Move to point 6
15	CT X+40 Y+5	Move to point 7: End point of the arc, radius with tangential connection to point 6, TNC automatically calculates the radius
16	L X+5	Move to last contour point 1
17	DEP LCT X-20 Y-20 R5 F1000	Depart the contour on a circular arc with tangential connection
18	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
19	END PGM CIRCULAR MM	

# Example: Full circle with Cartesian coordinates



0	BEGIN PGM C-CC MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+12.5	Define the tool
4	TOOL CALL 1 Z S3150	Call the tool
5	CC X+50 Y+50	Define the circle center
6	L Z+250 R0 F MAX	Retract the tool
7	L X-40 Y+50 R0 F MAX	Pre-position the tool
8	L Z-5 R0 F1000 M3	Move to working depth
9	APPR LCT X+0 Y+50 R5 RL F300	Approach the starting point of the circle on a circular arc with tangential connection
10	C X+0 DR-	Move to the circle end point (= circle starting point)
11	DEP LCT X-40 Y+50 R5 F1000	Depart the contour on a circular arc with tangential connection
12	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
13	END PGM CCC MM	





### 6.5 Path Contours— Polar Coordinates

With polar coordinates you can define a position in terms of its angle PA and its distance PR relative to a previously defined pole CC. See section "4.1 Fundamentals of NC."

Polar coordinates are useful with:

- Positions on circular arcs
- Workpiece drawing dimensions in degrees, e.g. bolt hole circles

Overview of path functions with polar coordinates

Function	Path function keys	Tool movement	Required input
Line <b>LP</b>	 + <b>P</b>	Straight line	Polar radius, polar angle of the straight-line end point
Circular arc <b>CP</b>	 + <b>P</b>	Circular path around circle center/ pole CC to arc end point	Polar angle of the arc end point, direction of rotation
Circular arc <b>CTP</b>	 + <b>P</b>	Circular path with tangential connection to the preceding contour element	Polar radius, polar angle of the arc end point
Helical interpolation	 + <b>P</b>	Combination of a circular and a linear movement	Polar radius, polar angle of the arc end point, coordinate of the end point in the tool axis

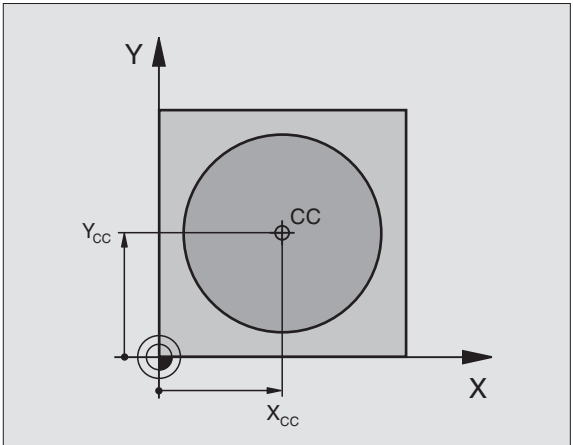
Polar coordinate origin: Pole CC

You can define the pole CC anywhere in the part program before blocks containing polar coordinates. Enter the pole in Cartesian coordinates as a circle center in a CC block.



► Coordinates CC: Enter Cartesian coordinates for the pole, or:

If you want to use the last programmed position, do not enter any coordinates.



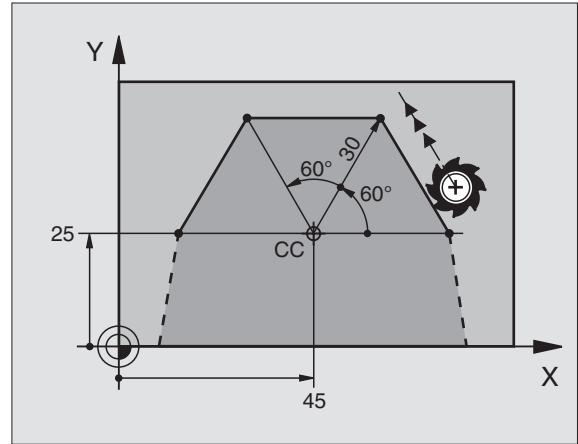
## Straight line LP

The tool moves in a straight line from its current position to the straight-line end point. The starting point is the end point of the preceding block.



- Polar-coordinates radius PR: Enter the distance from the pole CC to the straight-line end point.
- Polar-coordinates angle PA: Angular position of the straight-line end point between  $-360^\circ$  and  $+360^\circ$

The sign of PA depends on the angle reference axis:  
Angle from angle reference axis to PR is counterclockwise:  $PA > 0$   
Angle from angle reference axis to PR is clockwise:  $PA < 0$



### Example NC blocks

```
12 CC X+45 Y+25
13 LP PR+30 PA+0 RR F300 M3
14 LP PA+60
15 LP IPA+60
16 LP PA+180
```

## Circular path CP around pole CC

The polar coordinate radius PR is also the radius of the arc. It is defined by the distance from the starting point to the pole CC. The last programmed tool position before the CP block is the starting point of the arc.



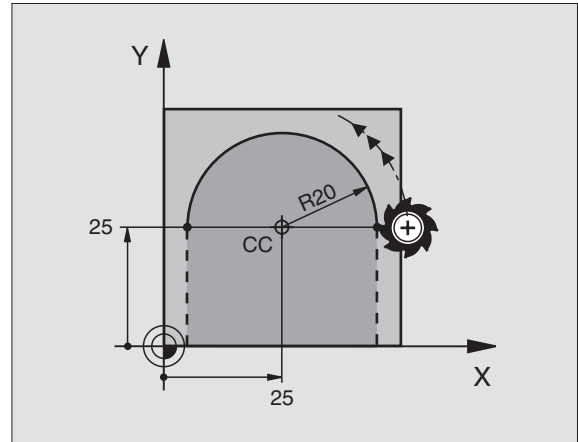
- Polar coordinates angle PA: Angular position of the arc end point between  $-5400^\circ$  and  $+5400^\circ$
- Direction of rotation DR

### Example NC blocks

```
18 CC X+25 Y+25
19 LP PR+20 PA+0 RR F250 M3
20 CP PA+180 DR+
```



For incremental coordinates, enter the same sign for DR and PA.



Circular path CTP with tangential connection


The tool moves on a circular path, starting tangentially from a preceding contour element.

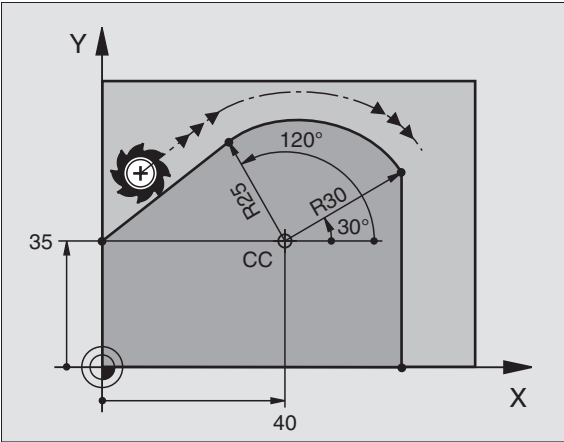
- CTP

P
- ▶ Polar coordinates radius PR: Distance from the arc end point to the pole CC.
  - ▶ Polar coordinates angle PA: Angular position of the arc end point.

Example NC blocks

```
12 CC X+40 Y+35
13 L X+0 Y+35 RL F250 M3
14 LP PR+25 PA+120
15 CTP PR+30 PA+30
16 L Y+0
```

 The pole CC is **not** the center of the contour arc!



Helical interpolation

A helix is a combination of a circular movement in a main plane and a linear movement perpendicular to this plane.

A helix is programmed only in polar coordinates.

Application

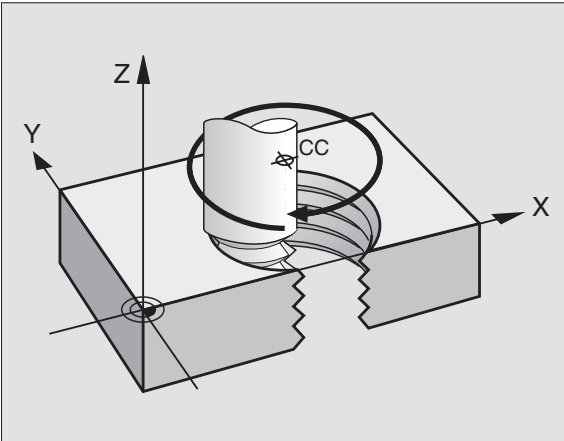
- Large-diameter internal and external threads
- Lubrication grooves

Calculating the helix

To program a helix, you must enter the total angle through which the tool is to move on the helix in incremental dimensions, and the total height of the helix.

For calculating a helix that is to be cut in a upward direction, you need the following data:

Thread revolutions n	Thread revolutions + thread overrun at the start and end of the thread
Total height h	Thread pitch P x thread revolutions n
Incremental total angle IPA	Thread revolutions x 360° + angle for beginning of thread + angle for thread overrun
Starting coordinate Z	Thread pitch P x (thread revolutions + thread overrun at start of thread)



## Shape of the helix

The table below illustrates in which way the shape of the helix is determined by the work direction, direction of rotation and radius compensation.

Internal thread	Work direction	Direction	Radius comp.
Right-handed	Z+	DR+	RL
Left-handed	Z+	DR–	RR
Right-handed	Z–	DR–	RR
Left-handed	Z–	DR+	RL
External thread			
Right-handed	Z+	DR+	RR
Left-handed	Z+	DR–	RL
Right-handed	Z–	DR–	RL
Left-handed	Z–	DR+	RR

## Programming a helix

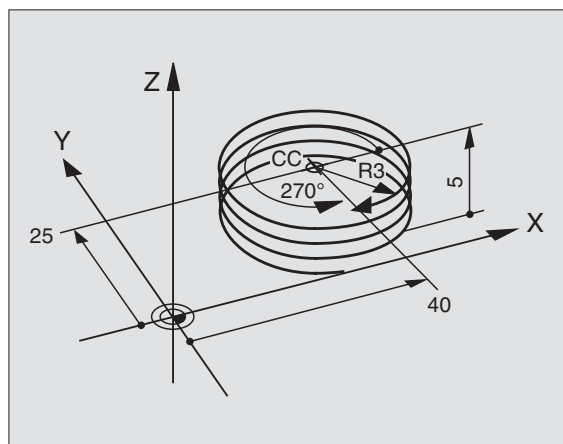


Always enter the same algebraic sign for the direction of rotation DR and the incremental total angle IPA. The tool may otherwise move in a wrong path and damage the contour.

For the total angle IPA, you can enter a value from  $-5400^\circ$  to  $+5400^\circ$ . If the thread has of more than 15 revolutions, program the helix in a program section repeat (see section 9.3 “Program Section Repeats”).



- Polar coordinates angle: Enter the total angle of tool traverse along the helix in incremental dimensions.  
**After entering the angle, identify the tool axis with an axis selection key.**
- Enter the coordinate for the height of the helix in incremental dimensions.
- Direction of rotation DR  
Clockwise helix: DR–  
Counterclockwise helix: DR+
- Radius compensation RL/RR/R0  
Enter the radius compensation according to the table above.



## Example NC blocks

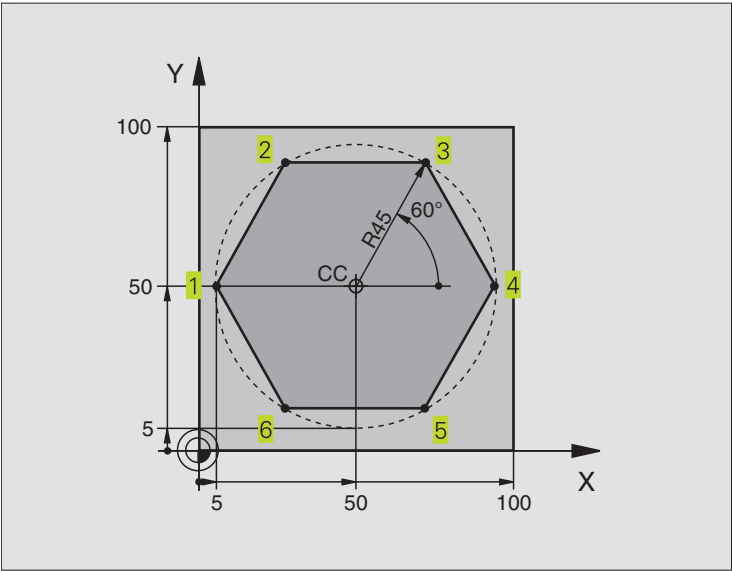
```
12 CC X+40 Y+25
```

```
13 Z+0 F100 M3
```

```
14 LP PR+3 PA+270 RL F50
```

```
15 CP IPA-1800 IZ+5 DR-
```

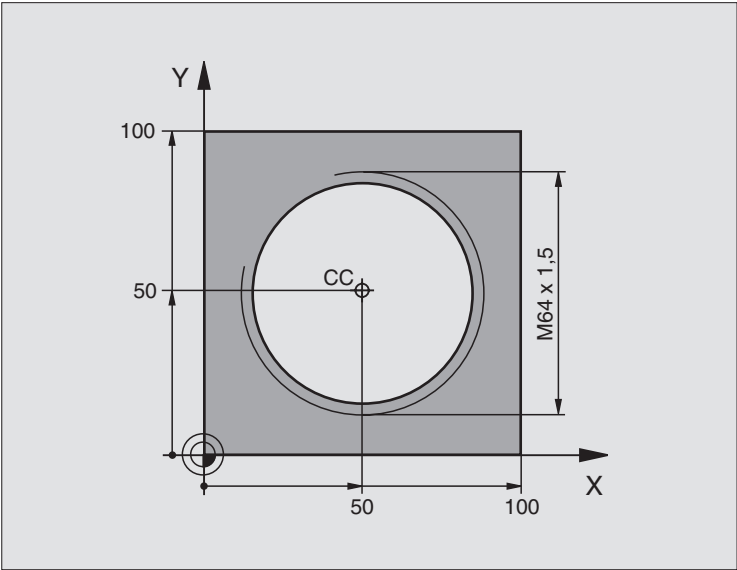
Example: Linear movement with polar coordinates



0	BEGIN PGM LINEARPO MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+7.5	Define the tool
4	TOOL CALL 1 Z S4000	Call the tool
5	CC X+50 Y+50	Define the datum for polar coordinates
6	L Z+250 R0 F MAX	Retract the tool
7	LP PR+60 PA+180 R0 F MAX	Pre-position the tool
8	L Z-5 R0 F1000 M3	Move to working depth
9	APPR PLCT PR+45 PA+180 R5 RL F250	Approach the contour at point 1 on a circular arc with tangential connection
10	LP PA+120	Move to point 2
11	LP PA+60	Move to point 3
12	LP PA+0	Move to point 4
13	LP PA-60	Move to point 5
14	LP PA-120	Move to point 6
15	LP PA+180	Move to point 1
16	DEP PLCT PR+60 PA+180 R5 F1000	Depart the contour on a circular arc with tangential connection
17	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
18	END PGM LINEARPO MM	



Example: Helix



0	BEGIN PGM HELIX MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+5	Define the tool
4	TOOL CALL 1 Z S1400	Call the tool
5	L Z+250 R0 F MAX	Retract the tool
6	L X+50 Y+50 R0 F MAX	Pre-position the tool
7	CC	Transfer the last programmed position as the pole
8	L Z-12.75 R0 F1000 M3	Move to working depth
9	APPR PCT PR+32 PA-180 CCA180 R+2	Approach the contour on a circular arc with tangential
	RL F100	connection
10	CP IPA+3240 IZ+13.5 DR+ F200	Helical interpolation
11	DEP CT CCA180 R+2	Depart the contour on a circular arc with tangential connection
12	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
13	END PGM HELIX MM	

To cut a thread with more than 16 revolutions

...	
8 L Z-12.75 R0 F1000	
9 APPR PCT PR+32 PA-180 CCA180 R+2 RL F100	
10 LBL 1	Identify beginning of program section repeat
11 CP IPA+360 IZ+1.5 DR+ F200	Enter the thread pitch as an incremental IZ dimension
12 CALL LBL 1 REP 24	Program the number of repeats (thread revolutions)
13 DEP CT CCA180 R+2	

## 6.6 Path Contours — FK Free Contour Programming

### Fundamentals

Workpiece drawings that are not dimensioned for NC often contain unconventional coordinate data that cannot be entered with the gray path function keys. You may, for example, have only the following data on a specific contour element:

- Known coordinates on the contour element or in its proximity
- Coordinate data that are referenced to another contour element
- Directional data and data regarding the course of the contour

You can enter such dimensional data directly by using the FK free contour programming function. The TNC derives the contour from the known coordinate data and supports the programming dialog with the interactive programming graphics. The figure to the upper right shows a workpiece drawing for which FK programming is the most convenient programming method.

If you wish to run FK programs on old TNC models, use the conversion function (see „4.3 Standard File Management; Converting an FK program into HEIDENHAIN conversational format“).

### Graphics during FK programming



If you wish to use graphic support during FK programming, select the PGM + GRAPHICS screen layout (see „1.3 Modes of Operation, Soft keys for selecting the screen layout“)

Incomplete coordinate data often are not sufficient to fully define a workpiece contour. In this case, the TNC indicates the possible solutions in the FK graphic. You can then select the contour that matches the drawing. The FK graphic displays the elements of the workpiece contour in different colors:

- White** The contour element is fully defined.
- Green** The entered data describe a limited number of possible solutions: select the correct one.
- Red** The entered data are not sufficient to determine the contour element: enter further data.

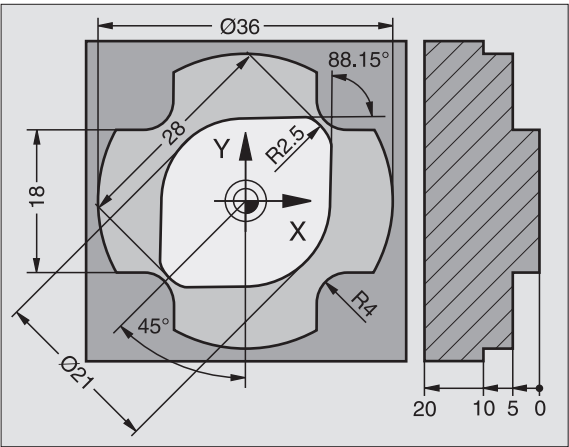
If the entered data permit a limited number of possible solutions and the contour element is displayed in green, select the correct contour element as follows:

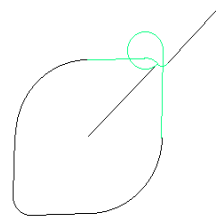


► Press the SHOW soft key repeatedly until the correct contour element is displayed.



► If the displayed contour element matches the drawing, select the contour element with FSELECT.



Manual operation		Programming and editing					
14 RND R2.5 15 FL AN+0.975 16 FCT DR+ R10.5 CCK+0 CCY+0 17 FLT AN+89.025 18 FCT DR+ R2.5 CLSD- 19 END PGM 35071 MM							
SHOW SOLUTION	SELECT SOLUTION					START SINGLE <input type="checkbox"/>	END SELECT

Select the green contour elements as soon as possible with the FSELECT soft key. In this way, you can reduce the ambiguity of subsequent elements.

If you do not yet wish to select a green contour element, press the EDIT soft key to continue the FK dialog.



The machine tool builder may use other colors for the FK graphics.

NC blocks from a program that you called with PGM CALL are displayed in another color.

### Initiating the FK dialog

If you press the gray FK button, the TNC displays the soft keys you can use to initiate an FK dialog: See table on the right. Press the FK button a second time to deselect the soft keys.

If you initiate the FK dialog with one of these soft keys, the TNC shows additional soft-key rows that you can use for entering known coordinates, directional data and data regarding the course of the contour.



**The following prerequisites for FK programming must be observed:**

The FK free contour programming feature can only be used for programming contour elements that lie in the working plane. The working plane is defined in the first BLK FORM block of the part program.

You must enter all available data for every contour element. Even the data that does not change must be entered in every block — otherwise it will not be recognized.

Q parameters are permissible in all FK elements, except in elements with relative references (e.g. RX or RAN), or in elements that are referenced to other NC blocks.

If both FK blocks and conventional blocks are entered in a program, the FK contour must be fully defined before you can return to conventional programming.

The TNC needs a fixed point from which it can calculate the contour elements. Use the gray path function keys to program a position that contains both coordinates of the working plane immediately before programming the FK contour. Do not enter any Q parameters in this block.

If the first block of an FK contour is an FCT or FLT block, you must program at least two NC block with the gray path function keys to fully define the direction of contour approach.

Do not program an FK contour immediately after an LBL label.

Contour element	Soft key
Straight line with tangential connection	
Straight line without tangential connection	
Circular arc with tangential connection	
Circular arc without tangential connection	

Free programming of straight lines



► To display the soft keys for free contour programming, press the FK key



► To initiate the dialog for free programming of straight lines, press the FL soft key. The TNC displays additional soft keys — see table at right.

► Enter all known data in the block by using these soft keys. The FK graphic displays the programmed contour element in red until sufficient data are entered. If the entered data describe several solutions, the graphic will display the contour element in green. See "Graphics during FK programming."

See next page for the resulting NC blocks.

Straight line with tangential connection

If the straight line connects tangentially to another contour element, initiate the dialog with the FLT soft key:



► To display the soft keys for free contour programming, press the FK key



► To initiate the dialog, press the FLT soft key.

► Use the soft keys (listed in the table at right) to enter all known data in the block.

Free programming of circular arcs



► To display the soft keys for free contour programming, press the FK key



► To initiate the dialog for free programming of circular arcs, press the FC soft key. The TNC displays soft keys with which you can enter direct data on the circular arc or data on the circle center — see table at right.

► Enter all known data in the block by using these soft keys. The FK graphic displays the programmed contour element in red until sufficient data are entered. If the entered data describe several solutions, the graphic will display the contour element in green (see "Graphics during FK programming").

Circular arc with tangential connection

If the circular arc connects tangentially to another contour element, initiate the dialog with the FCT soft key:



► To display the soft keys for free contour programming, press the FK key



► To initiate the dialog, press the FCT soft key.

► Use the soft keys (listed in the table at right) to enter all known data in the block.

Known data	Soft key
X coordinate of the straight-line end point	
Y coordinate of the straight-line end point	
Polar coordinate radius	
Polar coordinate angle	
Length of a straight line	
Gradient angle of a straight line	
Beginning or end of a closed contour	

For data that are based on other blocks see "Relative data," for auxiliary points see "Auxiliary points" in this section.

Direct data on a circular arc	Soft key
X coordinate of the arc end point	
Y coordinate of the arc end point	
Polar coordinate radius	
Polar coordinate angle	
Rotational direction of the arc	
Radius of the arc	
Angle of the leading axis to the arc end point	

**Gradient angle of an arc**

The gradient angle AN of an arc is the angle of the entry tangent. See figure at right.

**Chord length of an arc**

The chord length LEN of an arc is the linear distance LEN between its end points. See figure at right.

**Centers of free-programmed circles**

The TNC calculates a circle center for free-programmed arcs from the data you enter. This makes it possible to program full circles in an FK program block.

If you wish to define circle centers in polar coordinates you must use FPOL, not CC, to define the pole. FPOL is entered in Cartesian coordinates and remains in effect until the TNC encounters a block in which another FPOL is defined.

A circle center that was calculated or programmed conventionally is then no longer valid as a pole or circle center for the new FK contour: If you enter conventional polar coordinates that refer to a pole from a CC block you have defined previously, then you must enter the pole again in a CC block after the FK contour.

**Resulting NC blocks for FL, FPOL and FCT**

7 FPOL X+20 Y+30

8 FL IX+10 Y+20 RR F100

9 FCT PR+15 IPA+30 DR+ R15

See figure at lower right.

**Data on the circle center****Soft key**

X coordinate of the circle center



Y coordinate of the circle center



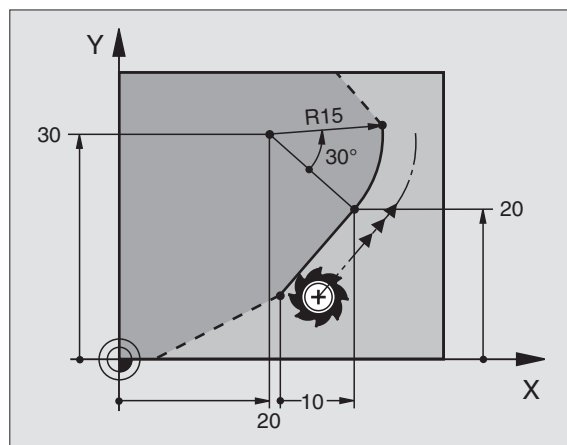
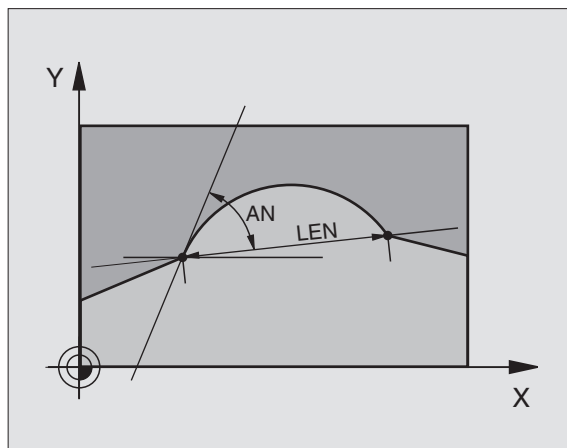
Polar coordinate radius of the circle center



Polar coordinate angle of the circle center



For data that are based on other blocks see “Relative data,” for auxiliary points see “Auxiliary points” in this section.





## Relative data

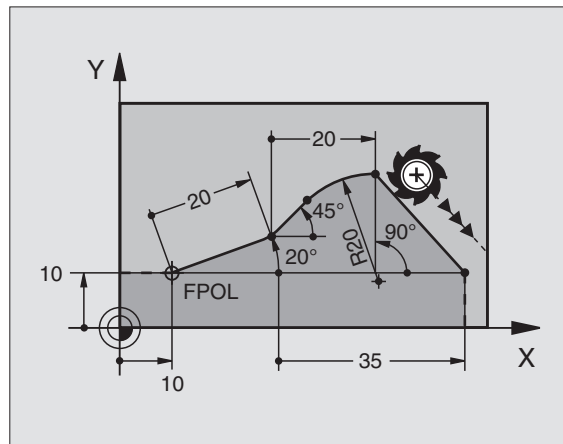
Data whose values are based on another contour element are called relative data. The soft keys and program words for entries begin with the letter **R** for **Relative**. The figure at right shows the entries that should be programmed as relative data.

The coordinates and angles for relative data are always programmed in **incremental** dimensions. You must also enter the block number of the contour element on which the data are based.



The block number of the contour element on which the relative data are based can only be located up to 64 positioning blocks before the block in which you program the reference.

If you delete a block on which relative data are based, the TNC will display an error message. Change the program first before you clear this message.



### Relative data for a free-programmed straight line Soft key

Coordinate relative to an end point of block N

RX [N]

RV [N]

Change in the polar coordinate radius relative to block N

RPR [N]

Change in the polar coordinate angle relative to block N

RPA [N]

Angle between a straight line and another element

RAN [N]

Straight line parallel to another contour element

PAR [N]

Distance from a straight line to a parallel contour element



### Relative data for coordinates of an arc Soft key

Coordinates relative to an end point of block N

RX [N]

RV [N]

Change in the polar coordinate radius relative to block N

RPR [N]

Change in the polar coordinate angle relative to block N

RPA [N]

Angle between the entry tangent of the arc and another contour element

RAN [N]

Relative data for circle center coordinates	Soft key
CC coordinates relative to an end point of block N	<div>RCCV<sup>Ⓐ</sup></div> <div>RCCV<sup>Ⓑ</sup></div>
Change in the polar coordinate radius relative to block N	<div>RCCPR<sup>Ⓐ</sup></div>
Change in the polar coordinate angle relative to block N	<div>RCCPA<sup>Ⓐ</sup></div>

**Example NC blocks**  
The known coordinates are relative to block N (see figure at upper right):

12 FPOL X+10 Y+10

13 FL PR+20 PA+20

14 FL AN+45

15 FCT IX+20 DR- R20 CCA+90 RX 13

16 FL IPR+35 PA+0 RPR 13

The known direction and the known distance from the contour element are relative to block N (see figure at center right):

17 FL LEN 20 AN+15

18 FL AN+105 LEN 12.5

19 FL PAR 17 DP 12.5

20 FSELECT 2

21 FL LEN 20 IAN+95

22 FL IAN+220 RAN 18

The known circle center coordinates are relative to block N (see figure at lower right):

12 FL X+10 Y+10 RL

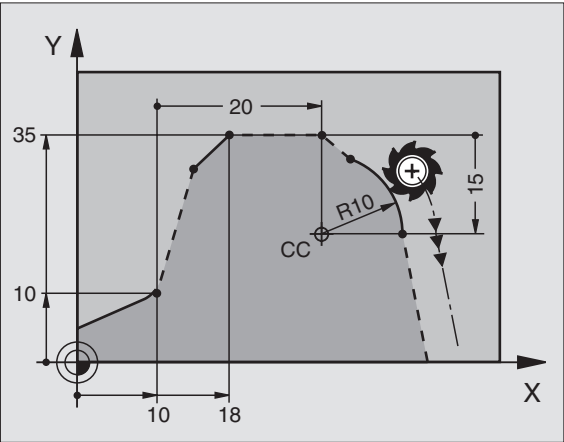
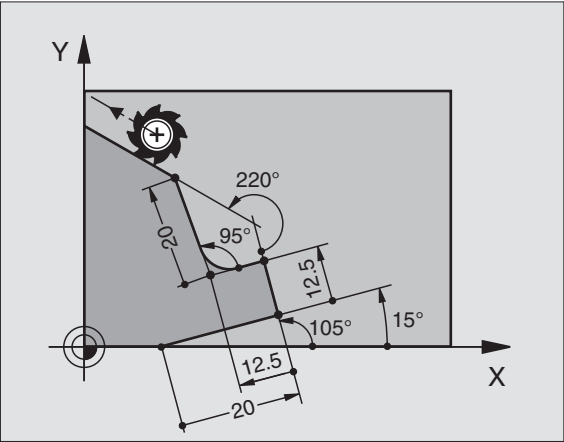
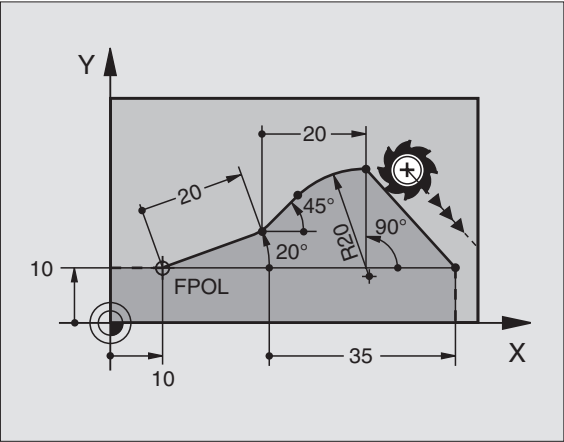
13 FL ...

14 FL X+18 Y+35

15 FL ...

16 FL ...

17 FC DR- R10 CCA+0 ICCX+20 ICCY-15 RCCX12 RCCY14





## Closed contours

You can identify the beginning and end of a closed contour with the CLSD soft key. This reduces the number of possible solutions for the last contour element.

Enter CLSD as an addition to another contour data entry in the first and last blocks of an FK section.

## Converting FK programs

You can convert an FK program into HEIDENHAIN conversational format by using the file manager:

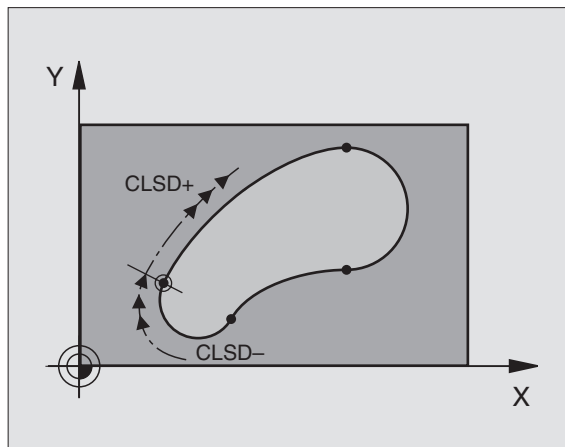
- Call the file manager and display the files.
- Move the highlight to the file you wish to convert.



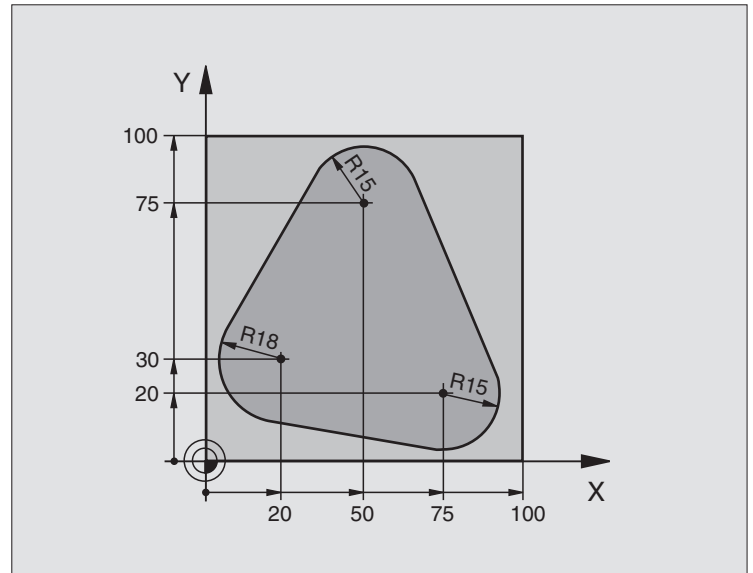
- Press the soft keys MORE FUNCTIONS and then CONVERT FK->H. The TNC converts all FK blocks into HEIDENHAIN dialog blocks.



Circle centers that you have entered before programming an FK contour may need to be redefined in the converted program. We recommend that you test the converted part program before executing it.

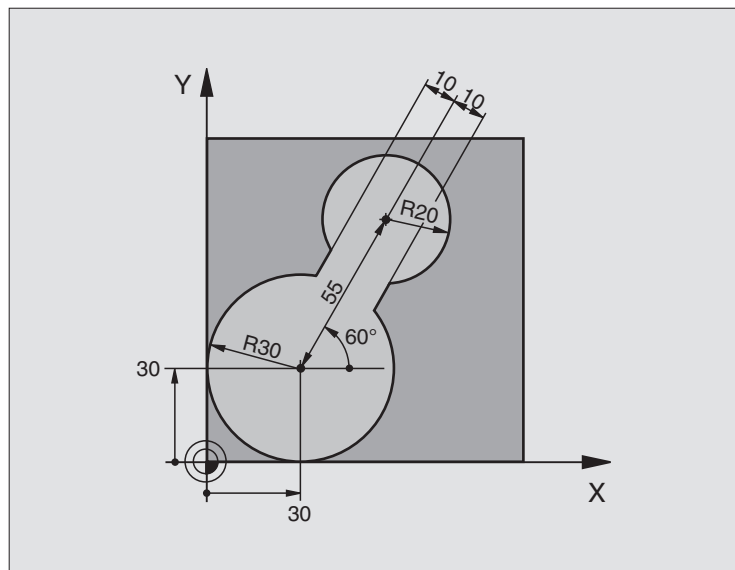


# Example: FK programming 1



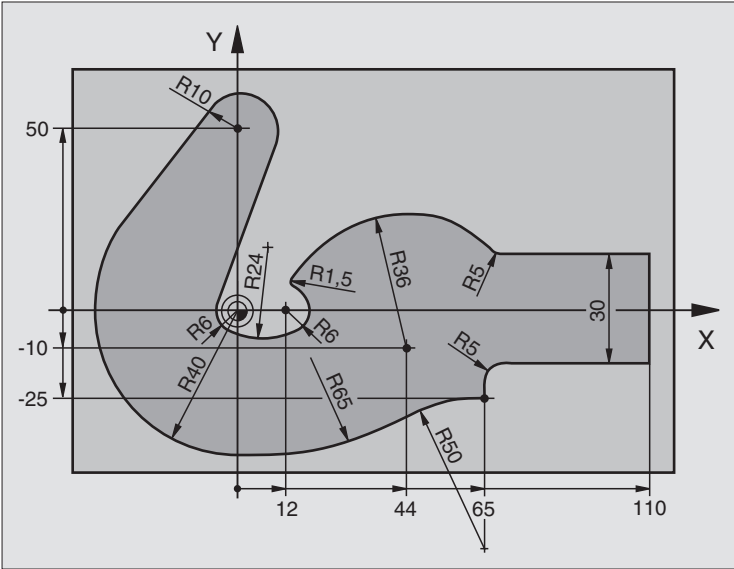
0	BEGIN PGM FK1 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+10	Define the tool
4	TOOL CALL 1 Z S500	Call the tool
5	L Z+250 R0 F MAX	Retract the tool
6	L X-20 Y+30 R0 F MAX	Pre-position the tool
7	L Z-10 R0 F1000 M3	Move to working depth
8	APPR CT X+2 Y+30 CCA90 R+5 RL F250	Approach the contour on a circular arc with tangential connection
9	FC DR- R18 CLSD+ CCX+20 CCY+30	FK contour:
10	FLT	Program all known data for each contour element
11	FCT DR- R15 CCX+50 CCY+75	
12	FLT	
13	FCT DR- R15 CCX+75 CCY+20	
14	FLT	
15	FCT DR- R18 CLSD- CCX+20 CCY+30	
16	DEP CT CCA90 R+5 F1000	Depart the contour on a circular arc with tangential connection
17	L X-30 Y+0 R0 F MAX	
18	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
19	END PGM FK1 MM	

## Example: FK programming 2



0	BEGIN PGM FK2 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+2	Define the tool
4	TOOL CALL 1 Z S4000	Call the tool
5	L Z+250 R0 F MAX	Retract the tool
6	L X+30 Y+30 R0 F MAX	Pre-position the tool
7	L Z+5 R0 F MAX M3	Pre-position the tool in the tool axis
8	L Z-5 R0 F100	Move to working depth
9	APPR LCT X+0 Y+30 R5 RR F350	Approach the contour on a circular arc with tangential connection
10	FPOL X+30 Y+30	FK contour:
11	FC DR- R30 CCX+30 CCY+30	Program all known data for each contour element
12	FL AN+60 PDX+30 PDY+30 D10	
13	FSELECT 3	
14	FC DR- R20 CCPR+55 CCPA+60	
15	FSELECT 2	
16	FL AN-120 PDX+30 PDY+30 D10	
17	FSELECT 3	
18	FC X+0 DR- R30 CCX+30 CCY+30	
19	FSELECT 2	
20	DEP LCT X+30 Y+30 R5	Depart the contour on a circular arc with tangential connection
21	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
22	END PGM FK2 MM	

Example: FK programming 3




0	BEGIN PGM FK3 MM	
1	BLK FORM 0.1 Z X-45 Y-45 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+120 Y+70 Z+0	
3	TOOL DEF 1 L+0 R+3	Define the tool
4	TOOL CALL 1 Z S4500	Call the tool
5	L Z+250 R0 F MAX	Retract the tool
6	L X-70 Y+0 R0 F MAX	Pre-position the tool
7	L Z-5 R0 F1000 M3	Move to working depth
8	APPR CT X-40 Y+0 CCA90 R+5 RL F250	Approach the contour on a circular arc with tangential connection
9	FC DR- R40 CCX+0 CCY+0	FK contour:
10	FLT	Program all known data for each contour element
11	FCT DR- R10 CCX+0 CCY+50	
12	FLT	
13	FCT DR+ R6 CCX+0 CCY+0	
14	FCT DR+ R24	
15	FCT DR+ R6 CCX+12 CCY+0	
16	FSELECT 2	
17	FCT DR- R1.5	
18	FCT DR- R36 CCX+44 CCY-10	
19	FSELECT 2	
20	FCT DR+ R5	
21	FLT X+110 Y+15 AN+0	
22	FL AN-90	

23	FL X+65 AN+180 PAR21 DP30	
24	RND R5	
25	FL X+65 Y-25 AN-90	
26	FC DR+ R50 CCX+65 CCY-75	
27	FCT DR- R65	
28	FSELECT 1	
29	FCT Y+0 DR- R40 CCX+0 CCY+0	
30	FSELECT 4	
31	DEP CT CCA90 R+5 F1000	Depart the contour on a circular arc with tangential connection
32	L X-70 R0 F MAX	
33	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
34	END PGM FK3 MM	

### 6.7 Path Contours - Spline Interpolation

If you wish to machine contours that are described in a CAD system as splines, you can transfer them directly to the TNC and execute them. The TNC features a spline interpolator for executing third-degree polynomials in two, three, four, or five axes.

 Except for the feed rate F and the miscellaneous function M, you cannot edit spline blocks in the TNC.

**Example: Block format for two axes**

7	L X+33,909 Z+75.107 F MAX	Spline starting point
8	SPL X+39.824 Z+77.425	Spline end point
	K3X+0.0983 K2X-0.441 K1X-5.5724	Spline parameters for X axis
	K3Z+0.0015 K2Z-0.9549 K1Z+3.0875 F10000	Spline parameters for Z axis
9	SPL X+44.862 Z+73.44	Spline end point
	K3X+0.0934 K2X-0.7211 K1X-4.4102	Spline parameters for X axis
	K3Z-0.0576 K2Z-0.7822 K1Z+4.8246	Spline parameters for Z axis
10	...	

The TNC executes the spline block according to the following third-degree polynomials:

$X(t) = K3X \cdot t^3 + K2X \cdot t^2 + K1X \cdot t + X$

$Z(t) = K3Z \cdot t^3 + K2Z \cdot t^2 + K1Z \cdot t + Z$

whereby the variable t runs from 1 to 0.

**Example: Block format for five axes**

7	L X+33.909 Y-25.838 Z+75.107 A+17 B-10.103 F MAX	Spline starting point
8	SPL X+39.824 Y-28.378 Z+77.425 A+17.32 B-12.75	Spline end point
	K3X+0.0983 K2X-0.441 K1X-5.5724	Spline parameters for X axis
	K3Y-0.0422 K2Y+0.1893 K1Y+2.3929	Spline parameters for Y axis
	K3Z+0.0015 K2Z-0.9549 K1Z+3.0875	Spline parameters for Z axis
	K3A+0.1283 K2A-0.141 K1A-0.5724	Spline parameters for A axis
	K3B+0.0083 K2B-0.413 E+2 K1B-1.5724 E+1 F10000	Spline parameters for B axis with exponential notation
9	...	

The TNC executes the spline block according to the following third-degree polynomials:

$$X(t) = K3X \cdot t^3 + K2X \cdot t^2 + K1X \cdot t + X$$

$$Y(t) = K3Y \cdot t^3 + K2Y \cdot t^2 + K1Y \cdot t + Y$$

$$Z(t) = K3Z \cdot t^3 + K2Z \cdot t^2 + K1Z \cdot t + Z$$

$$A(t) = K3A \cdot t^3 + K2A \cdot t^2 + K1A \cdot t + A$$

$$B(t) = K3B \cdot t^3 + K2B \cdot t^2 + K1B \cdot t + B$$

whereby the variable  $t$  runs from 1 to 0.



For every end-point coordinate in the spline block, the spline parameters K3 to K1 must be programmed. The end-point coordinates can be programmed any sequence within the spline block.

The TNC always expects the spline parameters K for each axis in the sequence K3, K2, K1.

Besides the principal axes X, Y and Z the TNC can also process the secondary axes U, V and W, and the rotary axes A, B and C. The respective corresponding axis must then be programmed in the spline parameter K (e.g., K3A+0.0953 K2A-0.441 K1A+0.5724).

If the absolute value of a spline parameter K becomes greater than 9.999 999 99, then the post processor must output K in exponential notation (e.g. K3X+1.2750 E2).

The TNC can execute a program with spline blocks even when the working plane is tilted.

Ensure that the transitions from one spline to the next are as tangential as possible (directional changes of less than 0.1°). The TNC otherwise performs an exact stop if the filter functions are disabled, resulting in a jolting of the machine tool. If the filter functions are active, the TNC decreases the feed rate accordingly at these positions.

**Input ranges**

- Spline end point: -99 999.9999 to +99 999.9999
- Spline parameter K: -9.999 999 99 to +9.999 999 99
- Exponent for spline parameter K: -255 to +255 (whole number).







# 7

**Programming:**  
**Miscellaneous functions**

## 7.1 Entering Miscellaneous Functions M and STOP

With the TNC's miscellaneous functions - also called M functions - you can affect:

- Program run, e.g., a program interruption
- Machine functions, such as switching spindle rotation and coolant supply on and off
- Contouring behavior of the tool



The machine tool builder may add some M functions that are not described in this User's Manual. Your machine manual provides more detailed information.

M functions are always entered at the end of a positioning block. The TNC then displays the following dialog question:

**Miscellaneous function M ?**

You usually enter only the number of the M function in the programming dialog. Some M functions can be programmed with additional parameters. In this case, the dialog is continued for the parameter input.

In the operating modes Manual and Electronic Handwheel, you enter the miscellaneous functions with the soft key M.

Please note that some F functions become effective at the start of a positioning block, and others at the end.

M functions come into effect in the block in which they are called. Unless the M function is only effective blockwise, it is canceled in a subsequent block or at the end of the program. Some M functions are effective only in the block in which they are called.

### Entering an M function in a STOP block

If you program a STOP block, the program run or test run is interrupted at the block, for example for tool inspection. You can also enter an M function in a STOP block:



- ▶ To program an interruption of program run, press the STOP key.
- ▶ Enter miscellaneous function M

### Example NC block

**87 STOP M6**

## 7.2 Miscellaneous Functions for Program Run Control, Spindle and Coolant

M	Effect	Effective at
<b>M00</b>	Stop program run Spindle STOP Coolant OFF	Block end
<b>M02</b>	Stop program run Spindle STOP Coolant OFF Go to block 1 Clear the status display (dependent on machine parameter 7300)	Block end
<b>M03</b>	Spindle ON clockwise	Block start
<b>M04</b>	Spindle ON counterclockwise	Block start
<b>M05</b>	Spindle STOP	Block end
<b>M06</b>	Tool change Spindle STOP Program run stop (dependent on machine parameter 7440)	Block end
<b>M08</b>	Coolant ON	Block start
<b>M09</b>	Coolant OFF	Block end
<b>M13</b>	Spindle ON clockwise Coolant ON	Block start
<b>M14</b>	Spindle ON counterclockwise Coolant ON	Block start
<b>M30</b>	Same as M02	Block end

## 7.3 Miscellaneous Functions for Coordinate Data

### Programming machine-referenced coordinates: M91/M92

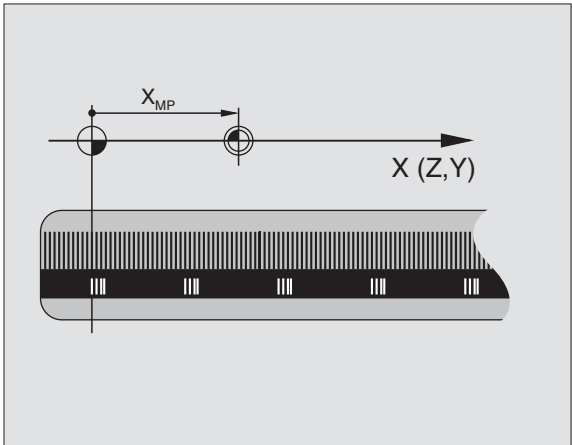
#### Scale reference point

On the scale, a reference mark indicates the position of the scale reference point.

#### Machine datum

The machine datum is required for the following tasks:

- Defining the limits of traverse (software limit switches)
- Moving to machine-referenced positions (such as tool change positions)
- Setting the workpiece datum



The distance in each axis from the scale reference point to the machine datum is defined by the machine tool builder in a machine parameter.

## Standard behavior

The TNC references coordinates to the workpiece datum (see "Datum setting").

## Behavior with M91 — Machine datum

If you want the coordinates in a positioning block to be referenced to the machine datum, end the block with M91.

The coordinate values on the TNC screen are referenced to the machine datum. Switch the display of coordinates in the status display to REF (see section 1.4 "Status Displays").

## Behavior with M92 — Additional machine datum



In addition to the machine datum, the machine tool builder can also define an additional machine-based position as a reference point.

For each axis, the machine tool builder defines the distance between the machine datum and this additional machine datum. Refer to the machine manual for more information.

If you want the coordinates in a positioning block to be based on the additional machine datum, end the block with M92.



Radius compensation remains the same in blocks that are programmed with M91 or M92. The tool length, however, is **not** compensated.

M91 and M92 are not effective in a tilted working plane. If you program these M functions in a tilted plane, the TNC will display an error message.

## Effect

M91 and M92 are effective only in the blocks in which they are programmed with M91 or M92.

M91 and M92 become effective at the start of block.

## Workpiece datum

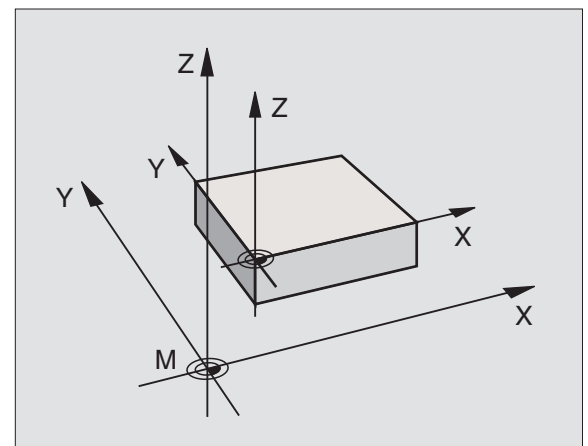
If you want the coordinates to always be referenced to the machine datum, you can inhibit datum setting for one or more axes (see machine parameter 7295).

If datum setting is inhibited for all axes, the TNC no longer displays the soft key DATUM SET in the Manual Operation mode.

The figure at right shows coordinate systems with the machine datum and workpiece datum.

## M91/M92 in the test run mode

In order to be able to graphically simulate M91/M92 movements, you need to activate working space monitoring and display the workpiece blank referenced to the set datum (see Chapter „12.8 Showing the Workpiece in the Working Space“).



### Activating the most recently entered datum: M104

When processing pallet tables, the TNC may overwrite your most recently entered datum with values from the pallet table. With M104 you can reactivate the original datum.

#### Effect

M104 is effective only in the blocks in which it is programmed.

M104 becomes effective at the end of block.

### Moving to position in an non-tilted coordinate system with a tilted working plane: M130

#### Standard behavior with a tilted working plane

The TNC places the coordinates in the positioning blocks in the tilted coordinate system.

#### Behavior with M130

The TNC places coordinates in **straight line blocks** in the untilted coordinate system

The TNC then positions the (tilted) tool to the programmed coordinates of the untilted system.

#### Effect

M130 functions only in straight-line blocks without tool radius compensation and in blocks in which M130 is programmed.

## 7.4 Miscellaneous Functions for Contouring Behavior

### Smoothing corners: M90

#### Standard behavior

The TNC stops the tool briefly in positioning blocks without tool radius compensation. This is called an accurate stop.

In program blocks with radius compensation (RR/RL), the TNC automatically inserts a transition arc at outside corners.

#### Behavior with M90

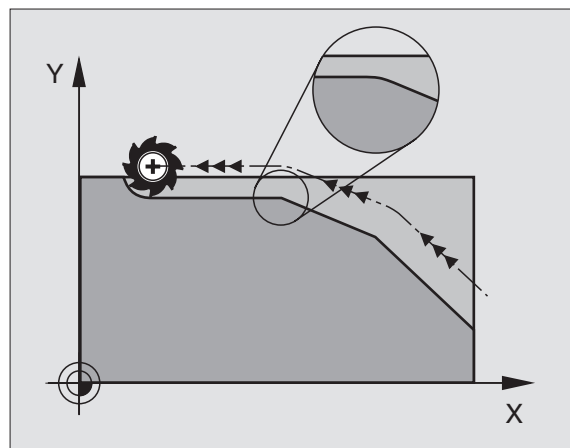
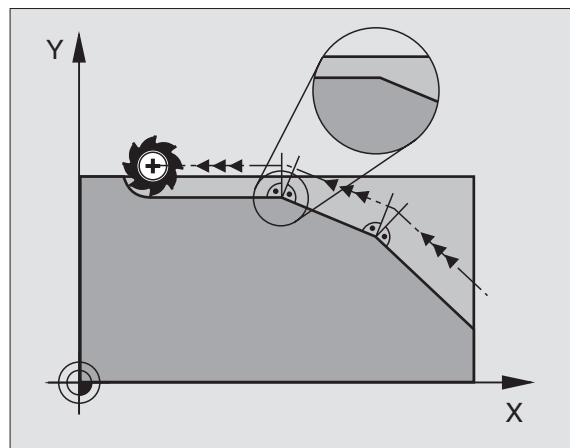
The tool moves at corners with constant speed: This provides a smoother, more continuous surface. Machining time is also reduced. See figure at center right.

Example application: Surface consisting of a series of straight line segments.

#### Effect

M90 is effective only in the blocks in which it is programmed with M90.

M90 becomes effective at the start of block. Operation with servo lag must be active.



### Insert rounding arc between straight lines: M112

For reasons of compatibility, the M112 function is still available. However, to define the tolerance for fast contour milling, HEIDENHAIN recommends the use of the TOLERANCE cycle (see section 8.8 "Special Cycles").

### Machining small contour steps: M97

#### Standard behavior

The TNC inserts a transition arc at outside corners. If the contour steps are very small, however, the tool would damage the contour. See figure at upper right.

In such cases the TNC interrupts program run and generates the error message "Tool radius too large."

#### Behavior with M97

The TNC calculates the intersection of the contour elements — as at inside corners — and moves the tool over this point. See figure at lower right.

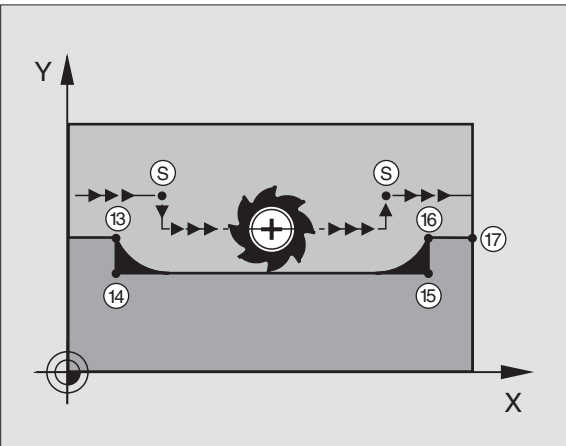
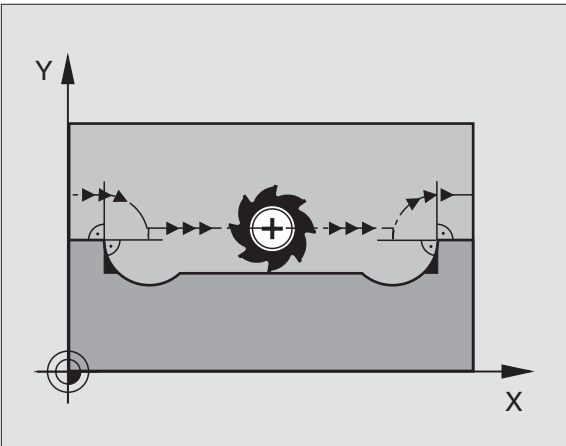
Program M97 in the same block as the outside corner.

#### Effect

M97 is effective only in the blocks in which it is programmed with M97.



A corner machined with M97 will not be completely finished. You may wish to rework the contour with a smaller tool.



#### Example NC blocks

5	T00L DEF L ... R+20	Large tool radius
...		
13	L X ... Y ... R.. F.. M97	Move to contour point 13
14	L IY-0.5 .... R.. F..	Machine small contour step 13 to 14
15	L IX+100 ...	Move to contour point 15
16	L IY+0.5 ... R.. F.. M97	Machine small contour step 15 to 16
17	L X .. Y ...	Move to contour point 17

## Machining open contours: M98

### Standard behavior

The TNC calculates the intersections of the cutter paths at inside corners and moves the tool in the new direction at those points.

If the contour is open at the corners, however, this will result in incomplete machining (see figure at upper right).

### Behavior with M98

With the miscellaneous function M98, the TNC temporarily suspends radius compensation to ensure that both corners are completely machined (see figure at lower right).

### Effect

M98 is effective only in the blocks in which it is programmed with M98.

M98 becomes effective at the end of block.

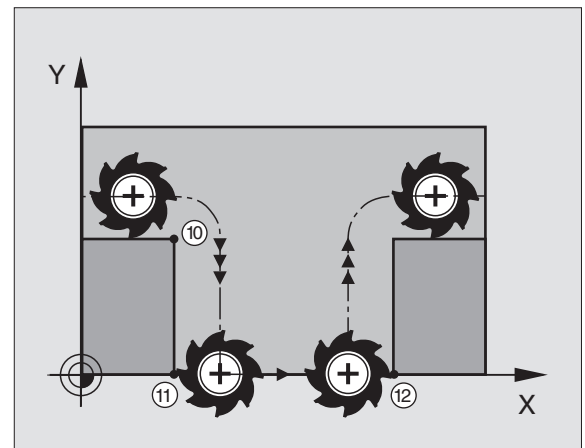
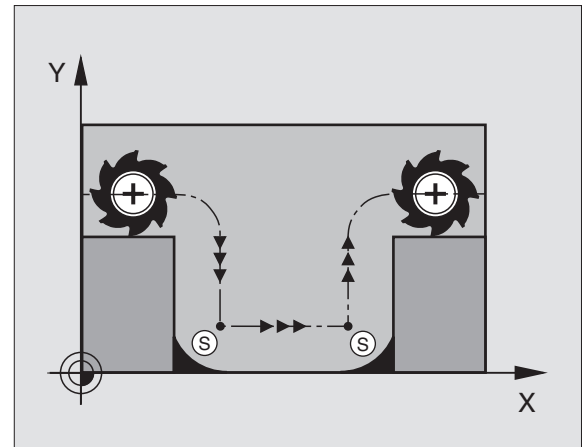
### Example NC blocks

Move to the contour points 10, 11 and 12 in succession:

```
10 L X ... Y... RL F
```

```
11 L X... IY... M98
```

```
12 L IX+ ...
```





## Feed rate factor for plunging movements: M103

### Standard behavior

The TNC moves the tool at the last programmed feed rate, regardless of the direction of traverse.

### Behavior with M103

The TNC reduces the feed rate when the tool moves in the negative direction of the tool axis. The feed rate for plunging FZMAX is calculated from the last programmed feed rate FPROG and a factor F%:

$$FZMAX = FPROG \times F\%$$

### Programming M103

If you enter M103 in a positioning block, the TNC continues the dialog by asking you the factor F.

### Effect

M103 becomes effective at the start of block.

To cancel M103, program M103 once again **without a factor**.

### Example NC blocks

The feed rate for plunging is to be 20% of the feed rate in the plane.

...	Actual contouring feed rate (mm/min):
17 L X+20 Y+20 RL F500 M103 F20	500
18 L Y+50	500
19 L IZ-2.5	100
20 L IY+5 IZ-5	141
21 L IX+50	500
22 L Z+5	500



M103 is activated with machine parameter 7440; see section 13.1 "General User Parameters."

## Feed rate in microns per spindle revolution: M136

### Standard behavior

The TNC moves the tool at the programmed feed rate F in mm/min.

### Behavior with M136

With M136, the TNC does not move the tool in mm/min, but rather at the programmed feed rate F in microns per spindle revolution. If you change the spindle speed by using the spindle override, the TNC changes the feed rate accordingly.

### Effect

M136 becomes effective at the start of block.

You can cancel M136 by programming M137.

## Feed rate at circular arcs: M109/M110/M111

### Standard behavior

The TNC applies the programmed feed rate to the path of the tool center.

### Behavior at circular arcs with M109

The TNC adjusts the feed rate for circular arcs at inside and outside contours such that the feed rate at the tool cutting edge remains constant.

### Behavior at circular arcs with M110

The TNC keeps the feed rate constant for circular arcs at inside contours only. At outside contours, the feed rate is not adjusted.



M110 is also effective for the inside machining of circular arcs using contour cycles.

### Effect

M109 and M110 become effective at the start of the block. To cancel M109 or M110, enter M111.

## Calculating the radius-compensated path in advance (LOOK AHEAD): M120

### Standard behavior

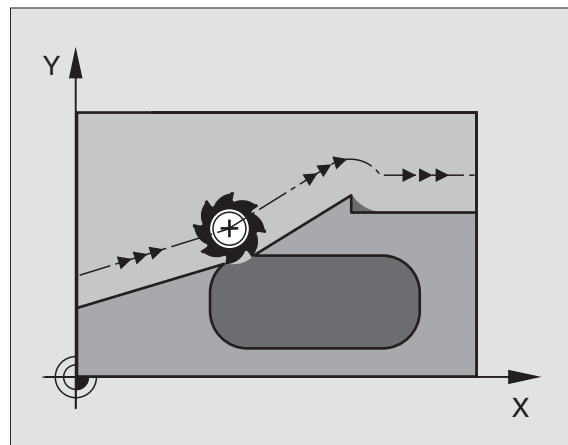
If the tool radius is larger than the contour step that is to be machined with radius compensation, the TNC interrupts program run and generates an error message. Although you can use M97 to inhibit the error message (see "Machining small contour steps: M97"), this will result in dwell marks and will also move the corner.

If the programmed contour contains undercut features, the tool may damage the contour. —See figure at right.

### Behavior with M120

The TNC checks radius-compensated paths for contour undercuts and tool path intersections, and calculates the tool path in advance from the current block. Areas of the contour that might be damaged by the tool, are not machined (dark areas in figure at right). You can also use M120 to calculate the radius compensation for digitized data or data created on an external programming system. This means that deviations from the theoretical tool radius can be compensated.

Use LA (**L**ook **A**head) behind M120 to define the number of blocks (maximum: 99) that you want the TNC to calculate in advance. Note that the larger the number of blocks you choose, the higher the block processing time will be.



**Input**

If you enter M120 in a positioning block, the TNC continues the dialog for this block by asking you the number of blocks LA that are to be calculated in advance.

**Effect**

M120 must be located in an NC block that also contains radius compensation RL or RR. M120 is then effective from this block until

- radius compensation is canceled, or
- M120 LA0 is programmed, or
- M120 is programmed without LA.
- another program is called with PGM CALL

M120 becomes effective at the start of block.

**Limitations**

- After an external or internal stop, you can only re-enter the contour with the function RESTORE POS. AT N.
- If you are using the path functions RND and CHF, the blocks before and after RND or CHF must contain only coordinates of the working plane.
- If you want to approach the contour on a tangential path, you must use the function APPR LCT. The block with APPR LCT must contain only coordinates of the working plane.
- If you want to approach the contour on a tangential path, use the function DEP LCT. The block with DEP LCT must contain only coordinates of the working plane.

**Superimposing handwheel positioning during program run: M118****Standard behavior**

In the program run modes, the TNC moves the tool as defined in the part program.

**Behavior with M118**

M118 permits manual corrections by handwheel during program run. You can use this miscellaneous function by entering axis-specific values X, Y and Z (in mm) behind M118.

**Programming M118**

If you enter M118 in a positioning block, the TNC continues the dialog for this block by asking you the axis-specific values. The coordinates are entered with the orange axis direction buttons or the ASCII keyboard.

**Effect**

Cancel handwheel positioning by programming M118 once again without X, Y and Z.

M118 becomes effective at the start of block.

**Example NC block**

You wish to be able to use the handwheel during program run to move the tool in the working plane X/Y by  $\pm 1$  mm of the programmed value:

```
L X+0 Y+38.5 RL F125 M118 X1 Y1
```



M118 is always effective in the original coordinate system, even if the working plane is tilted!

M118 also functions in the Positioning with MDI mode of operation!

If M118 is active, the MANUAL OPERATION function is not available after a program interruption


## 7.5 Miscellaneous Functions for Rotary Axes

### Feed rate in mm/min on rotary axes A, B, C: M116

#### Standard behavior

The TNC interprets the programmed feed rate in a rotary axis in degrees per minute. The contouring feed rate therefore depends on the distance from the tool center to the center of the rotary axis. The larger this distance becomes, the greater the contouring feed rate.

#### Feed rate in mm/min on rotary axes with M116



The machine geometry must be entered in machine parameters 7510 ff. by the machine tool builder.

The TNC interprets the programmed feed rate in a rotary axis in mm/min. With this miscellaneous function, the TNC calculates the feed rate for each block at the **start** of the individual block. The feed rate is not changed during execution of the block even if the tool moves toward the center of the rotary axis.

#### Effect

M116 is effective in the working plane  
With M117 you can reset M116. M116 is also canceled at the end of the program.

M116 becomes effective at the start of block.

### Shorter-path traverse of rotary axes: M126

#### Standard behavior

The standard behavior of the TNC while positioning rotary axes whose display has been reduced to values less than 360° is dependent on machine parameter 7682. In machine parameter 7682 is set whether the TNC should consider the difference between nominal and actual position, or whether the TNC should always (even without M126) choose the shortest path traverse to the programmed position. The table at upper right shows examples.

#### Behavior with M126

With M126, the TNC will move the axis on the shorter path of traverse if you reduce display of a rotary axis to a value less than 360°. The table at lower right shows examples.

#### Effect

M126 becomes effective at the start of block. To cancel M126, enter M127. At the end of program, M126 is automatically canceled.

#### Standard behavior of the TNC

Actual position	Nominal position	Traverse
350°	10°	-340°
10°	340°	+330°

#### Behavior with M126

Actual position	Nominal position	Traverse
350°	10°	+20°
10°	340°	-30°

## Reducing display of a rotary axis to a value less than 360°: M94

### Standard behavior

The TNC moves the tool from the current angular value to the programmed angular value.

Example:

Current angular value: 538°

Programmed angular value: 180°

Actual distance of traverse: -358°

### Behavior with M94

At the start of block, the TNC first reduces the current angular value to a value less than 360° and then moves the tool to the programmed value. If several rotary axes are active, M94 will reduce the display of all rotary axes. To have the TNC reduce the display for a specific rotary axis only, enter the axis after M94.

### Example NC blocks

To reduce display of all active rotary axes:

```
L M94
```

To reduce display of the C axis only

```
L M94 C
```

To reduce display of all active rotary axes and then move the tool in the C axis to the programmed value:

```
L C+180 FMAX M94
```

### Effect

M94 is effective only in the block in which M94 is programmed.

M94 becomes effective at the start of block.

## Automatic compensation of machine geometry when working with tilted axes: M114

### Standard behavior

The TNC moves the tool to the positions given in the part program. If the position of a tilted axis changes in the program, the resulting offset in the linear axes must be calculated by a postprocessor (see figure at top right) and traversed in a positioning block. As the machine geometry is also relevant, the NC program must be calculated separately for each machine tool.

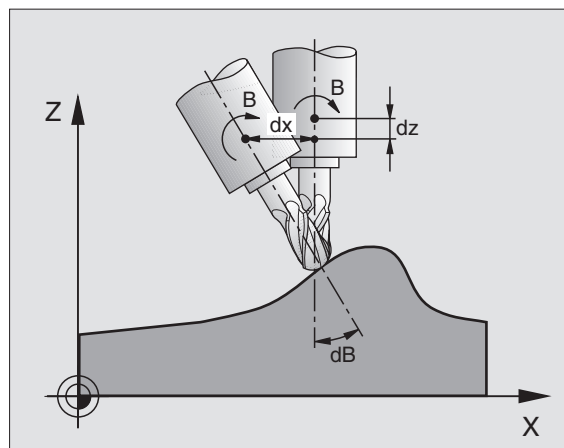
### Behavior with M114

If the position of a controlled tilted axis changes in the program, the TNC automatically compensates the tool offset by a 3-D length compensation. As the geometry of the individual machine tools is set in machine parameters, the TNC also compensates machine-specific offsets automatically. Programs only need to be calculated by the postprocessor once, even if they are being run on different machines with TNC control.

If your machine tool does not have controlled tilted axes (head tilted manually or positioned by the PLC), you can enter the current valid swivel head position after M114 (e.g. M114 B+45, Q parameters permitted).

The radius compensation must be calculated by a CAD system or by a postprocessor. A programmed radius compensation RL/RR will result in an error message.

If the tool length compensation is calculated by the TNC, the programmed feed rate refers to the point of the tool. Otherwise it refers to the tool datum.



If your machine tool is equipped with a swivel head that can be tilted under program control, you can interrupt program run and change the position of the tilted axis, for example with the handwheel.

With the RESTORE POS. AT N function, you can then resume program run at the block at which the part program was interrupted. If M114 is active, the TNC automatically calculates the new position of the tilted axis.

If you wish to use the handwheel to change the position of the tilted axis during program run, use M118 in conjunction with M128.

### Effect

M114 becomes effective at the start of block, M115 at the end of block. M114 is not effective when tool radius compensation is active.

To cancel M114, enter M115. At the end of program, M114 is automatically canceled.



The machine geometry must be entered in machine parameters 7510 ff. by the machine tool builder.

## Maintaining the position of the tool tip when positioning with tilted axes (TCPM\*): M128

### Standard behavior

The TNC moves the tool to the positions given in the part program. If the position of a tilted axis changes in the program, the resulting offset in the linear axes must be calculated and traversed in a positioning block (see figure on the left with M114).

### Behavior with M128

If the position of a controlled tilted axis changes in the program, the position of the tool tip to the workpiece remains the same.

If you wish to use the handwheel to change the position of the tilted axis during program run, use M118 in conjunction with M128. Handwheel positioning in a machine-based coordinate is possible when M128 is active.



For tilted axes with Hirth coupling: Do not change the position of the tilted axis after retracting the tool. Otherwise you might damage the contour.

After M128 you can program another feed rate, at which the TNC will carry out the compensation movements in the linear axes. If you program no feed rate here, or if you program a larger feed rate than is defined in machine parameters 7471, the feed rate from machine parameter 7471 will be effective.




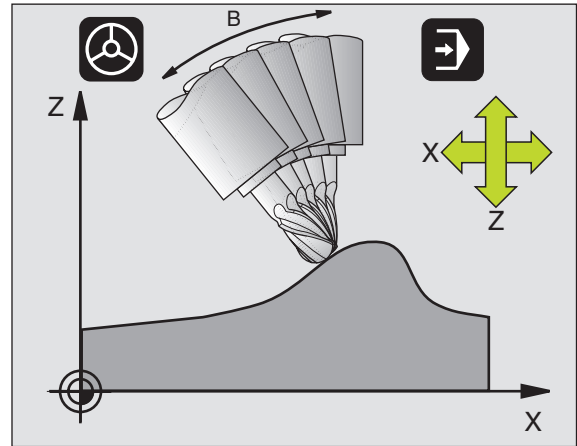
Reset M128 before positioning with M91 or M92 and before a TOOL CALL.

To avoid contour gouging you must use only spherical cutters with M128.

The tool length must refer to the spherical center of the tool tip.

The TNC does not adjust the active radius compensation in accordance with the new position of the tilted axis. The result is an error which is dependent on the angular position of the rotary axis.

If M128 is active, the TNC shows in the status display the following symbol: .



\*) TCPM = Tool Center Point Management

## M128 on tilting tables

If you program a tilting table movement while M128 is active, the TNC rotates the coordinate system accordingly. If for example you rotate the C axis by 90° (through a positioning command or datum shift) and then program a movement in the X axis, the TNC executes the movement in the machine axis Y.

The TNC also transforms the defined datum, which has been shifted by the movement of the rotary table.

## M128 with 3-D tool compensation

If you carry out a 3-D tool compensation with active M128 and active radius compensation RL/RR, the TNC will automatically position the rotary axes for certain machine geometries (Peripheral milling, see „5.4 3-D Tool Compensation“).

## Effect

M128 becomes effective at the start of block, M129 at the end of block. M128 is also effective in the manual operating modes and remains active even after a change of mode. The feed rate for the compensation movement will be effective until you program a new feed rate or until you reset M128 with M129.

To cancel M128, enter M129. The TNC also resets M128 if you select a new program in a program run operating mode.



The machine geometry must be entered in machine parameters 7510 ff. by the machine tool builder.

## Example NC block

Moving at 1000 mm/min to compensate a radius.

```
L X+0 Y+38.5 RL F125 M128 F1000
```



## Exact stop at corners with nontangential transitions: M134

### Standard behavior

The standard behavior of the TNC during positioning with rotary axes is to insert a transitional element in nontangential contour transitions. The contour of the transitional element depends on the acceleration, the rate of acceleration (jerk), and the defined tolerance for contour deviation.



With the machine parameters 7440 you can change the standard behavior of the TNC so that M134 becomes active automatically whenever a program is selected (see section 14.1 "General User Parameters").

### Behavior with M134

The moves the tool during positioning with rotary axes so as to perform an exact stop at nontangential contour transitions.

### Effect

M134 becomes effective at the start of block, M135 at the end of block.

You can reset M134 with M135. The TNC also resets M134 if you select a new program in a program run operating mode.

## Selecting tilting axes: M138

### Standard behavior

The TNC performs M114 and M128, and tilts the working plane, only in those axes for which the machine tool builder has set the appropriate machine parameters.

### Behavior with M138

The TNC performs the above functions only in those tilting axes that you have defined using M138.

### Effect

M138 becomes effective at the start of block.

You can reset M138 by reprogramming it without entering any axes.

### Example NC block

Perform the above-mentioned functions only in the tilting axis C:

```
L Z+100 R0 FMAX M138 C
```

## 7.6 Miscellaneous Functions for Laser Cutting Machines

The TNC can control the cutting efficiency of a laser by transferring voltage values through the S-analog output. You can influence laser efficiency during program run through the miscellaneous functions M200 to M204.

### Entering miscellaneous functions for laser cutting machines

If you enter an M function for laser cutting machines in a positioning block, the TNC continues the dialog by asking you the required parameters for the programmed function.

All miscellaneous functions for laser cutting machines become effective at the start of block.

### Output the programmed voltage directly: M200

The TNC outputs the value programmed after M200 as the voltage V.

Input range: 0 to 9.999 V

#### Effect

M200 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

### Output voltage as a function of distance: M201

M201 outputs the voltage in dependence on the distance to be covered. The TNC increases or decreases the current voltage linearly to the value programmed for V.

Input range: 0 to 9.999 V

#### Effect

M201 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

### Output voltage as a function of speed: M202

The TNC outputs the voltage as a function of speed. In the machine parameters, the machine tool builder defines up to three characteristic curves FNR in which specific feed rates are assigned to specific voltages. Use miscellaneous function M202 to select the curve FNR from which the TNC is to determine the output voltage.

Input range: 1 to 3

#### Effect

M202 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

### Output voltage as a function of time (time-dependent ramp): M203

The TNC outputs the voltage V as a function of the time TIME. The TNC increases or decreases the current voltage linearly to the value programmed for V within the time programmed for TIME.

#### Input range

Voltage V: 0 to 9.999 Volt  
TIME: 0 to 1.999 seconds

#### Effect

M203 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

### Output voltage as a function of time (time-dependent pulse): M204

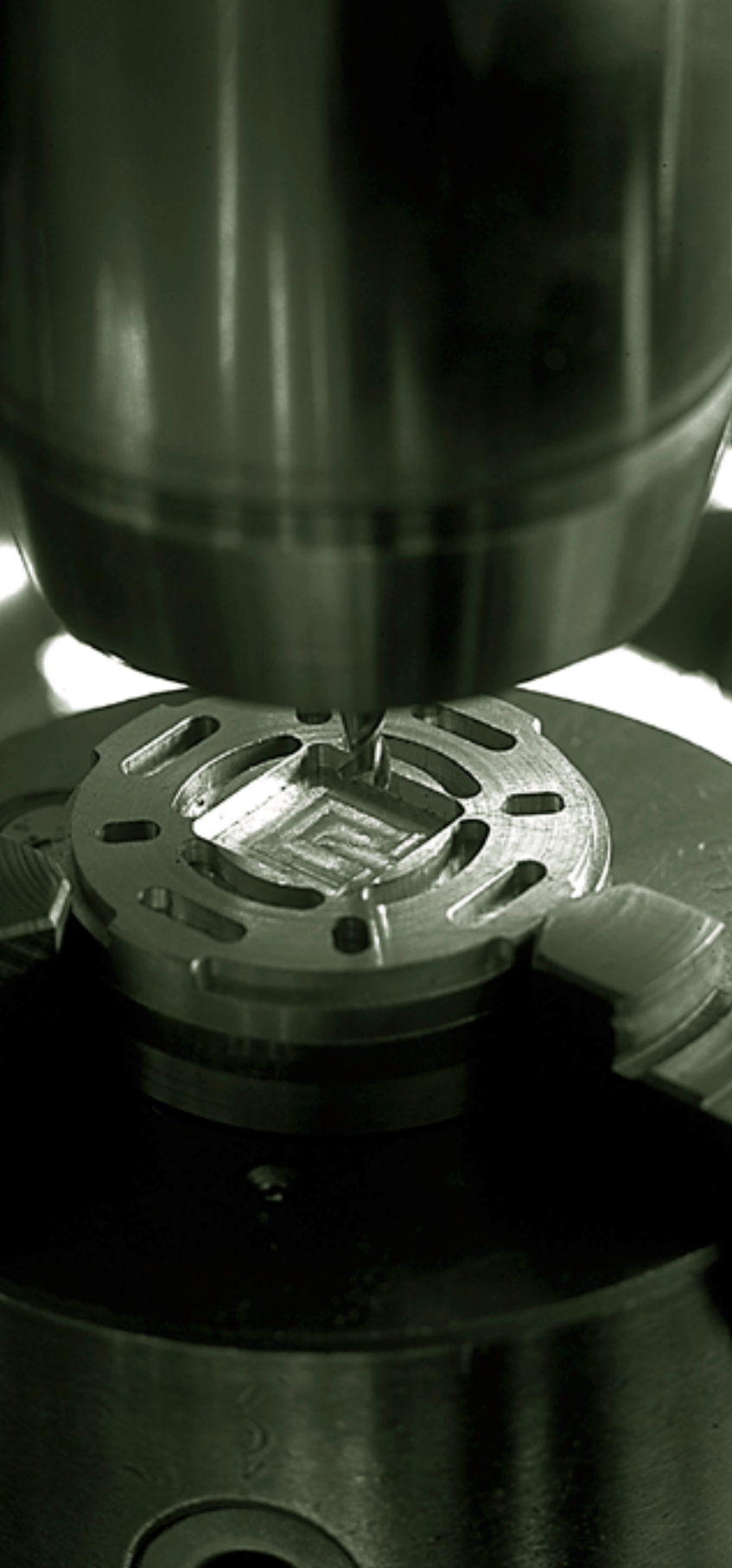
The TNC outputs a programmed voltage as a pulse with a programmed duration TIME.

#### Input range

Voltage V: 0 to 9.999 Volt  
TIME: 0 to 1.999 seconds

#### Effect

M204 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.



# 8

**Programming:  
Cycles**

8.1 General Information on Cycles

Frequently recurring machining cycles that comprise several working steps are stored in the TNC memory as standard cycles. Coordinate transformations and other special cycles are also provided as standard cycles. The table at right lists the various cycle groups.

Fixed cycles with number starting with 200 use Q parameters as transfer parameters. Parameters with specific functions that are required in several cycles always have the same number: For example, Q200 is always assigned the setup clearance, Q202 the plunging depth, etc.

Defining a cycle using soft keys



► The soft-key row shows the available groups of cycles



► Press the soft key for the desired group of cycles, for example DRILLING for the drilling cycles



► Select the desired cycle, for example PECKING. The TNC initiates the programming dialog and asks all required input values. At the same time a graphic of the input parameters is displayed in the right screen window. The parameter that is asked for in the dialog prompt is highlighted

► Enter all parameters asked by the TNC and conclude each entry with the ENT key

► The TNC terminates the dialog when all required data have been entered

Defining a cycle using the GOTO function



► The soft-key row shows the available groups of cycles



► The TNC shows an overview of cycles in a window. Use the arrow keys to select the desired cycle, or enter the cycle number. Confirm with ENT. The TNC then initiates the cycle dialog as described above.

Example NC blocks

CYCL DEF 1.0	PECKING
CYCL DEF 1.1	set up 2
CYCL DEF 1.2	depth -30
CYCL DEF 1.3	PLNGNG 5
CYCL DEF 1.4	dwell 1
CYCL DEF 1.5	F150

Group of Cycles	Soft key
Cycles for peck drilling, reaming, boring, counterboring, tapping and thread cutting	DRILLING
Cycles for milling pockets, studs and slots	POCKETS/ STUDS/ SLOTS
Cycles for producing hole patterns, such as circular or linear patterns	PATTERN
SL (Subcontour List) cycles, which allow the contour-parallel machining of relatively complex contours consisting of several overlapping subcontours, cylinder surface interpolation	SL II
Cycles for face milling of flat or twisted surfaces	MULTIPASS MILLING
Coordinate transformation cycles which enable datum shift, rotation, mirror image, enlarging and reducing for various contours	COORD. TRANSF.
Special cycles such as dwell time, program call, oriented spindle stop and tolerance	SPECIAL CYCLES



If you use indirect parameter assignments in fixed cycles with numbers greater than 200 (e.g. Q210 = Q1), any change in the assigned parameter (e.g. Q1) will have no effect after the cycle definition. Define the cycle parameter (e.g. Q210) directly in such cases.

In order to be able to run cycles 1 to 17 on older TNC models, you must program an additional negative sign before the values for safety clearance and plunging depth.

## Calling the Cycle



### Prerequisites

The following data must always be programmed before a cycle call

- BLK FORM for graphic display (needed only for test graphics)
- Tool call
- Direction of spindle rotation (M functions M3/M4)
- Cycle definition (CYCL DEF).

For some cycles, additional prerequisites must be observed. They are described with the individual cycle.

The following cycles become effective automatically as soon as they are defined in the part program. These cycles cannot and must not be called:

- Cycles for circular and linear hole patterns
- SL cycle CONTOUR GEOMETRY
- SL cycle CONTOUR DATA
- Cycle 32 TOLERANCE
- Coordinate transformation cycles
- DWELL TIME cycle

All other cycles are called as described below.

If the TNC is to execute the cycle once after the last programmed block, program the cycle call with the miscellaneous function M99 or with CYCL CALL:



- ▶ To program the cycle call, press the CYCL CALL key.
- ▶ Enter a miscellaneous function, for example for coolant supply.

If the TNC is to execute the cycle automatically after every positioning block, program the cycle call with M89 (depending on machine parameter 7440).

To cancel M89, enter

- M99 or
- CYCL CALL or
- CYCL DEF








## Working with the secondary axes U/V/W







The TNC performs infeed movements in the axis that was defined in the TOOL CALL block as the spindle axis. It performs movements in the working plane only in the principle axes X, Y or Z. Exceptions:

- You program secondary axes for the side lengths in cycles 3 SLOT MILLING and 4 POCKET MILLING.
- You program secondary axes in the contour geometry subprogram of an SL cycle.

## 8.2 Drilling Cycles

The TNC offers 13 cycles for all types of drilling operations:

Cycle	Soft key
1 PECKING Without automatic pre-positioning	
200 DRILLING With automatic pre-positioning and 2nd set-up clearance	
201 REAMING With automatic pre-positioning and 2nd set-up clearance	
202 BORING With automatic pre-positioning and 2nd set-up clearance	
203 UNIVERSAL DRILLING With automatic pre-positioning, 2nd setup clearance, chip breaking, and decrement	
204 BACK BORING With automatic pre-positioning, 2nd set-up clearance	
205 UNIVERSAL PECKING With automatic pre-positioning, 2nd set-up clearance, chip breaking, and decrement	

Cycle	Soft key
2 TAPPING With a floating tap holder	
17 RIGID TAPPING Without a floating tap holder	
18 THREAD CUTTING	
206 TAPPING NEW With a floating tap holder, with automatic pre-positioning, 2nd setup clearance	
207 RIGID TAPPING NEW Without a floating tap holder, with automatic pre-positioning, 2nd setup clearance	
208 BORE MILLING With automatic pre-positioning, 2nd setup clearance	

## PECKING (Cycle 1)

- 1 The tool drills from the current position to the first plunging depth at the programmed feed rate F.
- 2 When it reaches the first plunging depth, the tool retracts in rapid traverse FMAX to the starting position and advances again to the first plunging depth minus the advanced stop distance t.
- 3 The advanced stop distance is automatically calculated by the control:
  - At a total hole depth of up to 30 mm:  $t = 0.6 \text{ mm}$
  - At a total hole depth exceeding 30 mm:  $t = \text{hole depth} / 50$

Maximum advanced stop distance: 7 mm
- 4 The tool then advances with another infeed at the programmed feed rate F.
- 5 The TNC repeats this process (1 to 4) until the programmed total hole depth is reached.
- 6 After a dwell time at the hole bottom, the tool is returned to the starting position in rapid traverse FMAX for chip breaking.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

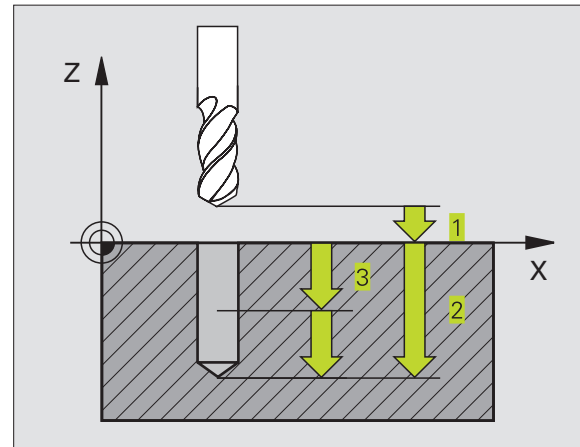
Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

The algebraic sign for the cycle parameter TOTAL HOLE DEPTH determines the working direction.



- ▶ Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface
- ▶ Total hole depth **2** Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper)
- ▶ Plunging depth **3** (incremental value): Infeed per cut. The tool will drill to the total hole depth in one movement if:
  - The plunging depth is equal to the total hole depth
  - The plunging depth is greater than the total hole depth

The total hole depth does not have to be a multiple of the plunging depth.
- ▶ Dwell time in seconds: Amount of time the tool remains at the total hole depth for chip breaking
- ▶ Feed rate F: Traversing speed of the tool during drilling in mm/min



### Example NC blocks:

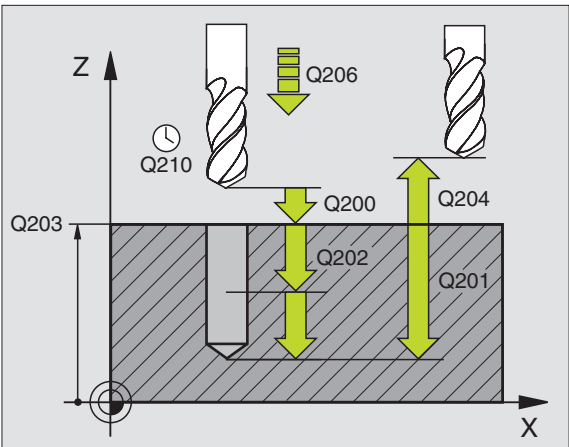
```

1 CYCL DEF 1.0 PECKING
2 CYCL DEF 1.1 SET UP 2
3 CYCL DEF 1.2 DEPTH -20
4 CYCL DEF 1.3 PECKG 5
5 CYCL DEF 1.4 DWELL 0
6 CYCL DEF 1.5 F500

```

DRILLING (Cycle 200)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The tool drills to the first plunging depth at the programmed feed rate F.
- 3 The TNC returns the tool at FMAX to the setup clearance, dwells there (if a dwell time was entered), and then moves at FMAX to the setup clearance above the first plunging depth.
- 4 The tool then drills deeper by the plunging depth at the programmed feed rate F.
- 5 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 6 At the hole bottom, the tool is retracted to set-up clearance or — if programmed — to the 2nd set-up clearance in rapid traverse FMAX.



Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the depth parameter determines the working direction.



- Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface. Enter a positive value.
- Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper)
- Feed rate for plunging Q206: Traversing speed of the tool during drilling in mm/min
- Plunging depth Q202 (incremental value): Infeed per cut The TNC will go to depth in one movement if:
  - the plunging depth is equal to the depth
  - the plunging depth is greater than the depthThe depth does not have to be a multiple of the plunging depth.
- Dwell time at top Q210: Time in seconds that the tool remains at set-up clearance after having been retracted from the hole for chip release.

Example NC blocks:

7	CYCL DEF 200 DRILLING
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;PLUNGING DEPTH
Q210=0	;DWELL TIME AT TOP
Q203=+0	;SURFACE COORDINATE
Q204=50	;2. SET-UP CLEARANCE
Q211=0.25	;DWELL TIME AT BOTTOM



- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Dwell time at depth Q211: Time in seconds that the tool remains at the hole bottom

## REAMING (Cycle 201)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool reams to the entered depth at the programmed feed rate F.
- 3 If programmed, the tool remains at the hole bottom for the entered dwell time.
- 4 The tool then retracts to set-up clearance at the feed rate F, and from there — if programmed — to the 2nd set-up clearance in FMAX.



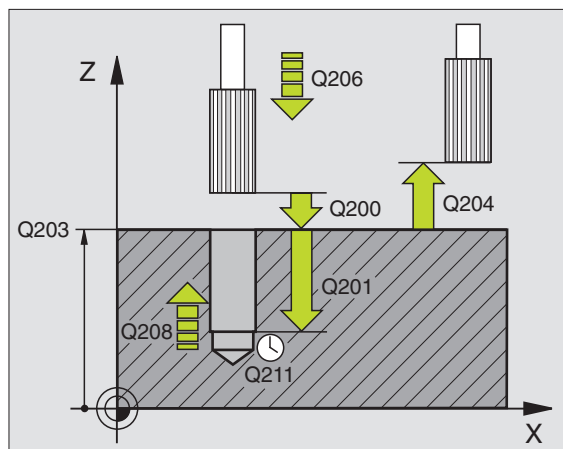
### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the depth parameter determines the working direction.



- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole
- ▶ Feed rate for plunging Q206: Traversing speed of the tool during reaming in mm/min
- ▶ Dwell time at depth Q211: Time in seconds that the tool remains at the hole bottom
- ▶ Retraction feed rate Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the tool retracts at the reaming feed rate.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.



### Example NC blocks:

<b>8 CYCL DEF 201 REAMING</b>	
<b>Q200=2</b>	<b>; SET-UP CLEARANCE</b>
<b>Q201=-20</b>	<b>; DEPTH</b>
<b>Q206=150</b>	<b>; FEED RATE FOR PLUNGING</b>
<b>Q211=0.25</b>	<b>; DWELL TIME AT BOTTOM</b>
<b>Q208=500</b>	<b>; RETRACTION FEED TIME</b>
<b>Q203=+0</b>	<b>; SURFACE COORDINATE</b>
<b>Q204=50</b>	<b>; 2. SET-UP CLEARANCE</b>

BORING (Cycle 202)



Machine and control must be specially prepared by the machine tool builder to enable Cycle 202.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The tool drills to the programmed depth at the feed rate for plunging.
- 3 If programmed, the tool remains at the hole bottom for the entered dwell time with active spindle rotation for cutting free.
- 4 The TNC then orients the spindle to the 0° position with an oriented spindle stop.
- 5 If retraction is selected, the tool retracts in the programmed direction by 0.2 mm (fixed value).
- 6 The TNC moves the tool at the retraction feed rate to the set-up clearance and then, if entered, to the 2nd set-up clearance with FMAX. If Q214=0 the tool point remains on the wall of the hole.



Before programming, note the following:

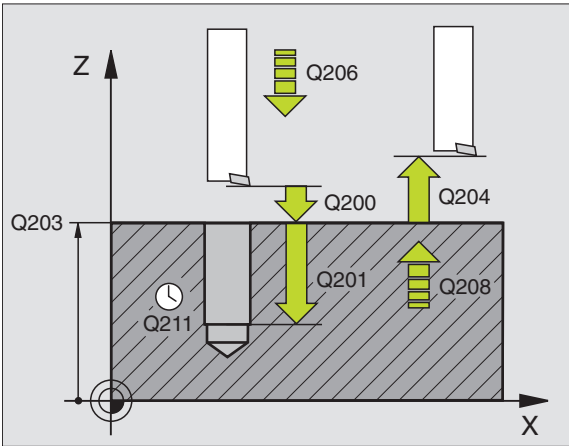
Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the cycle parameter TOTAL HOLE DEPTH determines the working direction.

After the cycle is completed, the TNC restores the coolant and spindle conditions that were active before the cycle call.



- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole
- ▶ Feed rate for plunging Q206: Traversing speed of the tool during boring in mm/min
- ▶ Dwell time at depth Q211: Time in seconds that the tool remains at the hole bottom
- ▶ Retraction feed rate Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the tool retracts at feed rate for plunging.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.



Example NC blocks:

9	CYCL DEF 202 BORING
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q211=0.5	;DWELL TIME AT BOTTOM
Q208=500	;RETRACTION FEED TIME
Q203=+0	;SURFACE COORDINATE
Q204=50	;2. SET-UP CLEARANCE
Q214=1	;DISENGAGING DIRECTN
Q336=0	;ANGLE OF SPINDLE

- ▶ Disengaging direction (0/1/2/3/4) Q214: Determine the direction in which the TNC retracts the tool at the hole bottom (after spindle orientation).

- 0:** Do not retract tool
- 1:** Retract tool in the negative main axis direction
- 2:** Retract tool in the negative secondary axis direction
- 3:** Retract tool in the positive main axis direction
- 4:** Retract tool in the positive secondary axis direction



#### **Danger of collision!**

Check the position of the tool tip when you program a spindle orientation to the angle that you enter in Q336 (for example, in the Positioning with Manual Data Input mode of operation). Set the angle so that the tool tip is parallel to a coordinate axis. Select a disengaging direction in which the tool moves away from the edge of the hole.

- ▶ Angle for spindle orientation Q336 (absolute): angle at which the TNC positions the tool before retracting it.

### **UNIVERSAL DRILLING (Cycle 203)**

- 1** The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2** The tool drills to the first plunging depth at the programmed feed rate F.
- 3** If you have programmed chip breaking, the tool then retracts by the entered retraction value. If you are working without chip breaking, the tool retracts at the retraction feed rate to setup clearance, remains there — if programmed — for the entered dwell time, and advances again in FMAX to the setup clearance above the first PLUNGING DEPTH.
- 4** The tool then advances with another infeed at the programmed feed rate. If programmed, the plunging depth is decreased after each infeed by the decrement.
- 5** The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 6** The tool remains at the hole bottom — if programmed — for the entered DWELL TIME to cut free, and then retracts to set-up clearance at the retraction feed rate. If you have entered a 2nd set-up clearance, the tool subsequently moves to that position in FMAX.



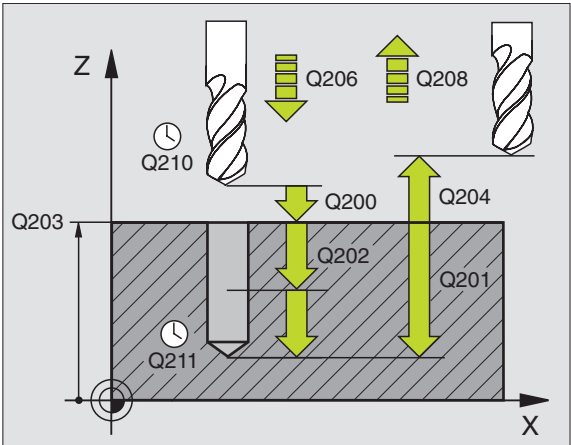
**Before programming, note the following:**

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the cycle parameter TOTAL HOLE DEPTH determines the working direction.



- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
  - ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper)
  - ▶ Feed rate for plunging Q206: Traversing speed of the tool during drilling in mm/min
  - ▶ Plunging depth Q202 (incremental value): Infeed per cut The TNC will go to depth in one movement if:
    - the plunging depth is equal to the depth
    - the plunging depth is greater than the depth
- The depth does not have to be a multiple of the plunging depth.
- ▶ Dwell time at top Q210: Time in seconds that the tool remains at set-up clearance after having been retracted from the hole for chip release.
  - ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
  - ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
  - ▶ Decrement Q212 (incremental value): Value by which the TNC decreases the plunging depth after each infeed.
  - ▶ Nr of breaks before retracting Q213: Number of chip breaks after which the TNC is to withdraw the tool from the hole for chip release. For chip breaking, the TNC retracts the tool each time by the value Q256.
  - ▶ Minimum plunging depth Q205 (incremental value): If you have entered a decrement, the TNC limits the plunging depth to the value entered with Q205.
  - ▶ Dwell time at depth Q211: Time in seconds that the tool remains at the hole bottom
  - ▶ Retraction feed rate Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the tool retracts at the feed rate in Q206.
  - ▶ Retraction rate for chip breaking Q256 (incremental): value by which the TNC retracts the tool during chip breaking



**Example NC blocks:**

10	CYCL DEF 203	UNIVERSAL DRILLING
	Q200=2	;SET-UP CLEARANCE
	Q201=-20	;DEPTH
	Q206=150	;FEED RATE FOR PLUNGING
	Q202=5	;PLUNGING DEPTH
	Q210=0	;DWELL TIME AT TOP
	Q203=+0	;SURFACE COORDINATE
	Q204=50	;2. SET-UP CLEARANCE
	Q212=0.2	;DECREMENT
	Q213=3	;BREAKS
	Q205=3	;MIN. PLUNGING DEPTH
	Q211=0.25	;DWELL TIME AT BOTTOM
	Q208=500	;RETRACTION FEED TIME
	Q256=0.2	;DIST FOR CHIP BRKNG

**BACK BORING (Cycle 204)**

Machine and TNC must be specially prepared by the machine tool builder to perform back boring.

Special boring bars for upward cutting are required for this cycle.

This cycle allows holes to be bored from the underside of the workpiece.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The TNC then orients the spindle to the 0° position with an oriented spindle stop, and displaces the tool by the off-center distance.
- 3 The tool is then plunged into the already bored hole at the feed rate for pre-positioning until the tooth has reached set-up clearance on the underside of the workpiece.
- 4 The TNC then centers the tool again over the bore hole, switches on the spindle and the coolant and moves at the feed rate for boring to the depth of bore.
- 5 If a dwell time is entered, the tool will pause at the top of the bore hole and will then be retracted from the hole again. The TNC carries out another oriented spindle stop and the tool is once again displaced by the off-center distance.
- 6 The TNC moves the tool at the pre-positioning feed rate to the set-up clearance and then, if entered, to the 2nd set-up clearance with FMAX.

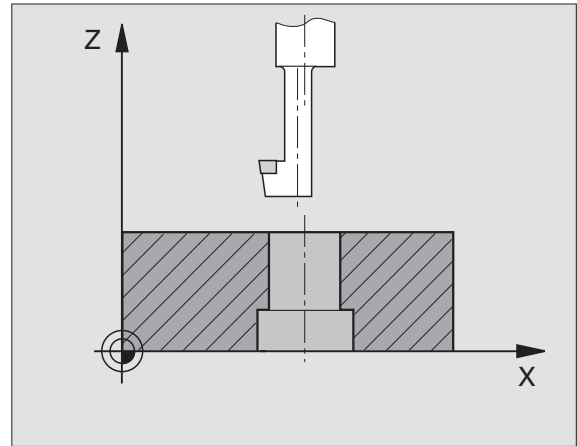
**Before programming, note the following:**

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the cycle parameter depth determines the working direction. Note: A positive sign bores in the direction of the positive spindle axis.

The entered tool length is the total length to the underside of the boring bar and not just to the tooth.

When calculating the starting point for boring, the TNC considers the tooth length of the boring bar and the thickness of the material.





- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth of counterbore Q249 (incremental value): Distance between underside of workpiece and the top of the hole. A positive sign means the hole will be bored in the positive spindle axis direction.
- ▶ Material thickness Q250 (incremental value): Thickness of the workpiece
- ▶ Off-center distance Q251 (incremental value): Off-center distance for the boring bar; value from tool data sheet
- ▶ Tool edge height Q252 (incremental value): Distance between the underside of the boring bar and the main cutting tooth; value from tool data sheet
- ▶ Feed rate for pre-positioning Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min
- ▶ Feed rate for counterboring Q254: Traversing speed of the tool during counterboring in mm/min
- ▶ Dwell time Q255: Dwell time in seconds at the top of the bore hole
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Disengaging direction (0/1/2/3/4) Q214: Determine the direction in which the TNC displaces the tool by the off-center distance (after spindle orientation).

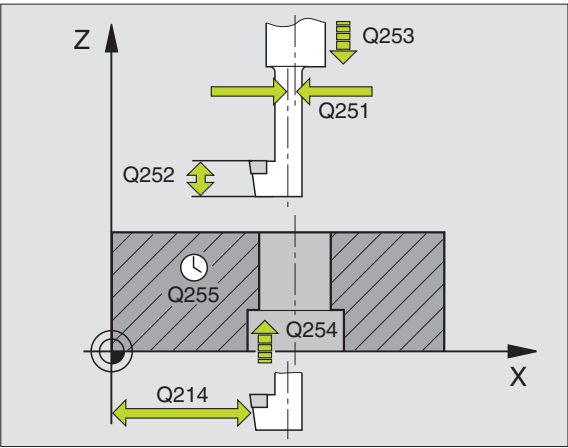
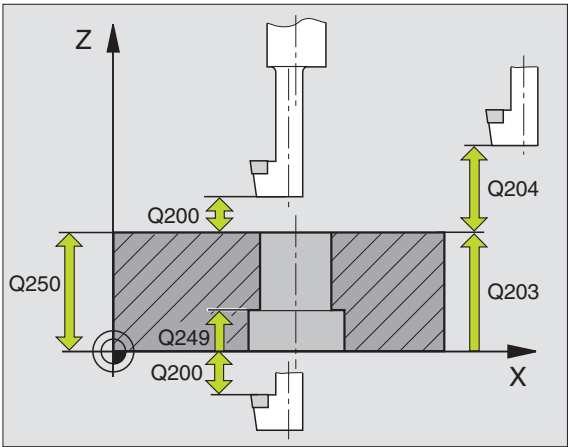
- 1: Displace tool in the negative main axis direction
- 2: Displace tool in the negative secondary axis direction
- 3: Displace tool in the positive main axis direction
- 4: Displace tool in the positive secondary axis direction



**Danger of collision!**

Check the position of the tool tip when you program a spindle orientation to the angle that you enter in Q336 (for example, in the Positioning with Manual Data Input mode of operation). Set the angle so that the tool tip is parallel to a coordinate axis. Select a disengaging direction in which the tool moves away from the edge of the hole.

- ▶ Angle for spindle orientation Q336 (absolute): angle at which the TNC positions the tool before it is plunged into or retracted from the bore hole.



**Example NC blocks:**

11 CYCL DEF 204 BACK BORING	
Q200=2	;SET-UP CLEARANCE
Q249=+5	;DEPTH OF COUNTERBORE
Q250=20	;MATERIAL THICKNESS
Q251=3.5	;OFF-CENTER DISTANCE
Q252=15	;TOOL EDGE HEIGHT
Q253=750	;F PRE-POSITIONING
Q254=200	;F COUNTERBORING
Q255=0	;DWELL TIME
Q203=+0	;SURFACE COORDINATE
Q204=50	;2. SET-UP CLEARANCE
Q214=1	;DISENGAGING DIRECTN
Q336=0	;ANGLE OF SPINDLE

## UNIVERSAL PECKING (Cycle 205)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the first plunging depth at the programmed feed rate F.
- 3 If you have programmed chip breaking, the tool then retracts by the entered retraction value. If you are working without chip breaking, the tool is moved at rapid traverse to setup clearance and then at FMAX to the entered starting position above the first plunging depth.
- 4 The tool then advances with another infeed at the programmed feed rate. If programmed, the plunging depth is decreased after each infeed by the decrement.
- 5 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 6 The tool remains at the hole bottom — if programmed — for the entered DWELL TIME to cut free, and then retracts to set-up clearance at the retraction feed rate. If you have entered a 2nd set-up clearance, the tool subsequently moves to that position in FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the cycle parameter TOTAL HOLE DEPTH determines the working direction.

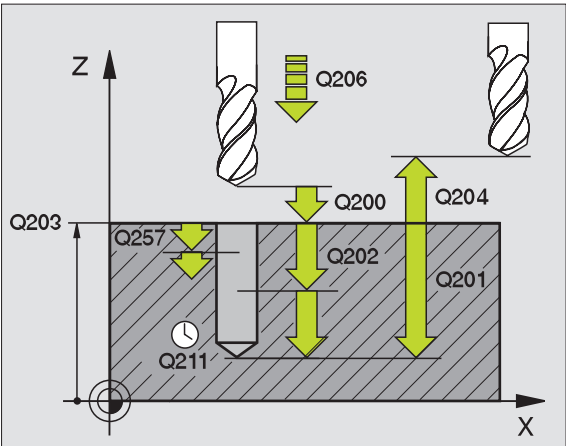


- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
  - ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper)
  - ▶ Feed rate for plunging Q206: Traversing speed of the tool during drilling in mm/min
  - ▶ Plunging depth Q202 (incremental value): Infeed per cut The TNC will go to depth in one movement if:
    - the plunging depth is equal to the depth
    - the plunging depth is greater than the depth
- The depth does not have to be a multiple of the plunging depth.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
  - ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
  - ▶ Decrement Q212 (incremental value): Value by which the TNC decreases the plunging depth Q202.
  - ▶ Minimum plunging depth Q205 (incremental value): If you have entered a decrement, the TNC limits the plunging depth to the value entered with Q205.
  - ▶ Upper advanced stop distance Q258 (incremental): setup clearance for rapid traverse positioning when the TNC moves the tool again to the current plunging depth after retraction from the hole; value for the first plunging depth
  - ▶ Lower advanced stop distance Q259 (incremental): setup clearance for rapid traverse positioning when the TNC moves the tool again to the current plunging depth after retraction from the hole; value for the last plunging depth



If you enter Q258 not equal to Q259, the TNC will change the advance stop distances between the first and last plunging depths at the same rate.

- ▶ Infeed depth for chip breaking Q257 (incremental value): Depth at which the TNC carries out chip breaking. There is no chip breaking if 0 is entered.
- ▶ Retraction rate for chip breaking Q256 (incremental): value by which the TNC retracts the tool during chip breaking
- ▶ Dwell time at depth Q211: Time in seconds that the tool remains at the hole bottom



**Example NC blocks:**

12	CYCL DEF 205	UNIVERSAL PECKING
	Q200=2	;SET-UP CLEARANCE
	Q201=- 80	;DEPTH
	Q206=150	;FEED RATE FOR PLUNGING
	Q202=15	;PLUNGING DEPTH
	Q203=+0	;SURFACE COORDINATE
	Q204=50	;2. SET-UP CLEARANCE
	Q212=0.5	;DECREMENT
	Q205=3	;MIN. PLUNGING DEPTH
	Q258=0.5	;UPPER ADV STOP DIST
	Q259=1	;LOWER ADV STOP DIST
	Q257=5	;DEPTH FOR CHIP BRKNG
	Q256=0.2	;DIST FOR CHIP BRKNG
	Q211=0.25	;DWELL TIME AT BOTTOM



**BORE MILLING (Cycle 208)**

- 1** The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface and then moves the tool to the bore hole circumference on a rounded arc (if enough space is available).
- 2** The tool drills in a helix from the current position to the first plunging depth at the programmed feed rate F.
- 3** When the drilling depth is reached, the TNC once again traverses a full circle to remove the material remaining after the initial plunge
- 4** The TNC then positions the tool at the center of the hole again
- 5** Finally the TNC returns to the setup clearance at FMAX. If you have entered a 2nd set-up clearance, the tool subsequently moves to that position in FMAX.

**Before programming, note the following:**

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the cycle parameter TOTAL HOLE DEPTH determines the working direction.

If you have entered the bore hole diameter to be the same as the tool diameter, the TNC will bore directly to the entered depth without any helical interpolation.



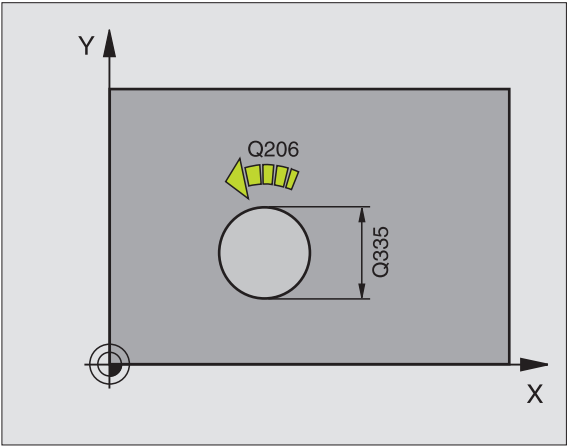
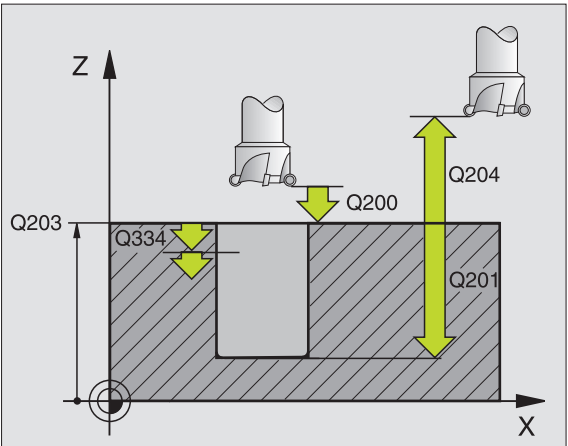
- Set-up clearance Q200 (incremental value): Distance between tool lower edge and workpiece surface.
- Depth Q201 (incremental value): Distance between workpiece surface and bottom of hole
- Feed rate for plunging Q206: Traversing speed of the tool during helical drilling in mm/min
- Infeed per helix Q334 (incremental): depth of the tool plunge with each helix (=360°).



Note that if the infeed distance is too large, the tool or the workpiece may be damaged.

To prevent the infeeds being too large, enter the max. plunge angle of the tool in the tool table, column ANGLE (see „5.2 Tool Data). The TNC then calculates automatically the max. infeed permitted and changes your entered value accordingly.

- Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- Nominal diameter Q335 (absolute): Bore-hole diameter. If you have entered the nominal diameter to be the same as the tool diameter, the TNC will bore directly to the entered depth without any helical interpolation.



**Example NC blocks:**

12	CYCL DEF 208	BORE MILLING
Q200=2	;SET-UP CLEARANCE	
Q201=- 80	;DEPTH	
Q206=150	;FEED RATE FOR PLUNGING	
Q334=1.5	;PLUNGING DEPTH	
Q203=+0	;SURFACE COORDINATE	
Q204=50	;2. SET-UP CLEARANCE	
Q335=25	;NOMINAL DIAMETER	

## TAPPING with a floating tap holder (Cycle 2)

- 1 The tool drills to the total hole depth in one movement
- 2 Once the tool has reached the total hole depth, the direction of spindle rotation is reversed and the tool is retracted to the starting position at the end of the DWELL TIME.
- 3 At the starting position, the direction of spindle rotation reverses once again.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

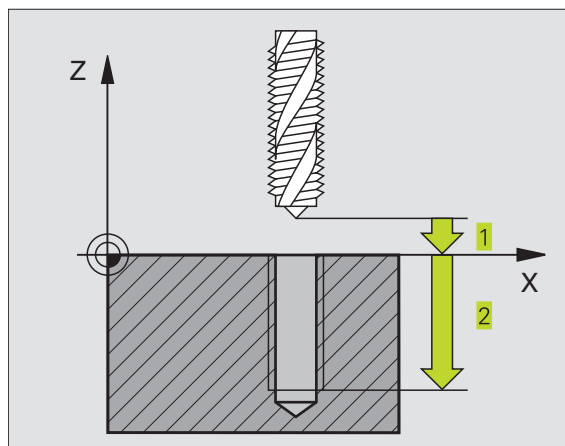
Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

The algebraic sign for the depth parameter determines the working direction.

A floating tap holder is required for tapping. It must compensate the tolerances between feed rate and spindle speed during the tapping process.

When a cycle is being run, the spindle speed override knob is disabled. The feed rate override knob is active only within a limited range, which is defined by the machine tool builder (refer to your machine manual).

For tapping right-hand threads activate the spindle with M3, for left-hand threads use M4.



### Example NC blocks:

```
13 CYCL DEF 2.0 TAPPING
```

```
14 CYCL DEF 2.1 SET UP 2
```

```
15 CYCL DEF 2.2 DEPTH -20
```

```
16 CYCL DEF 2.3 DWELL 0
```

```
17 CYCL DEF 2.4 F100
```



- ▶ Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface. Standard value: approx. 4 times the thread pitch
- ▶ Total hole depth **2** (thread length, incremental value): Distance between workpiece surface and end of thread
- ▶ Dwell time in seconds: Enter a value between 0 and 0.5 seconds to avoid wedging of the tool during retraction.
- ▶ Feed rate F: Traversing speed of the tool during tapping

**The feed rate is calculated as follows:  $F = S \times p$ , where**

F is the feed rate in mm/min),  
S is the spindle speed in rpm,  
and p is the thread pitch in mm

### Retracting after a program interruption

If you interrupt program run during tapping with the machine stop button, the TNC will display a soft key with which you can retract the tool.

### TAPPING NEW with floating tap holder (Cycle 206)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the total hole depth in one movement
- 3 Once the tool has reached the total hole depth, the direction of spindle rotation is reversed and the tool is retracted to the set-up clearance at the end of the DWELL TIME. If you have entered a 2nd set-up clearance, the tool subsequently moves to that position in FMAX.
- 4 At the set-up clearance, the direction of spindle rotation reverses once again.



#### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with RADIUS COMPENSATION R0.

The algebraic sign for the depth parameter determines the working direction.

A floating tap holder is required for tapping. It must compensate the tolerances between feed rate and spindle speed during the tapping process.

When a cycle is being run, the spindle speed override knob is disabled. The feed rate override knob is active only within a limited range, which is defined by the machine tool builder (refer to your machine manual).

For tapping right-hand threads activate the spindle with M3, for left-hand threads use M4.



- Set-up clearance Q200 (incremental): Distance between the tool tip (starting position) and the workpiece surface; approximate value: 4x spindle pitch
- Total hole depth Q201 (thread length, incremental): Distance between workpiece surface and end of thread
- Feed rate F Q206: Traversing speed of the tool during tapping

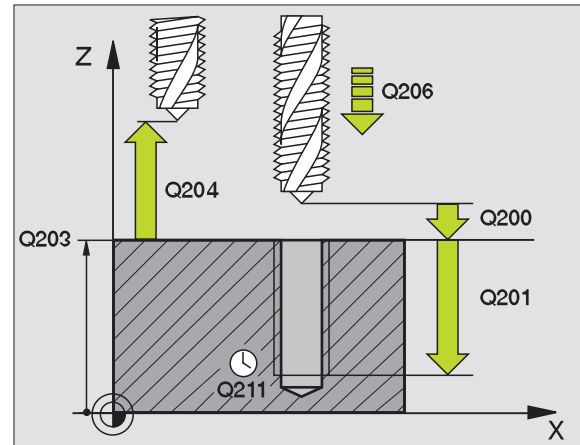
**The feed rate is calculated as follows:  $F = S \times p$ , where**

F is the feed rate in mm/min),  
S is the spindle speed in rpm,  
and p is the thread pitch in mm

- Dwell time at bottom Q211: Enter a value between 0 and 0.5 seconds to avoid wedging of the tool during retraction.
- Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

### Retracting after a program interruption

If you interrupt program run during tapping with the machine stop button, the TNC will display a soft key with which you can retract the tool.



### Example NC blocks:

```
25 CYCL DEF 206 TAPPING NEW
```

```
Q200=2 ;SET-UP CLEARANCE
```

```
Q201=-20 ;DEPTH
```

```
Q206=150 ;FEED RATE FOR PLUNGING
```

```
Q211=0.25 ;DWELL TIME AT BOTTOM
```

```
Q203=+0 ;SURFACE COORDINATE
```

```
Q204=50 ;2ND SET-UP CLEARANCE
```

**RIGID TAPPING (Cycle 17)**

Machine and control must be specially prepared by the machine tool builder to enable rigid tapping.

The TNC cuts the thread without a floating tap holder in one or more passes.

Rigid tapping offers the following advantages over tapping with a floating tap holder

- Higher machining speeds possible
- Repeated tapping of the same thread is possible; repetitions are enabled via spindle orientation to the 0° position during cycle call (depending on machine parameter 7160).
- Increased traverse range of the spindle axis due to absence of a floating tap holder.

**Before programming, note the following:**

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

The algebraic sign for the parameter total hole depth determines the working direction.

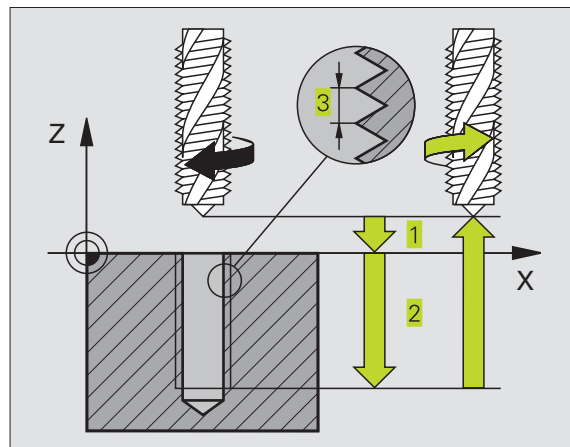
The TNC calculates the feed rate from the spindle speed. If the spindle speed override is used during tapping, the feed rate is automatically adjusted.

The feed-rate override knob is disabled.

At the end of the cycle the spindle comes to a stop. Before the next operation, restart the spindle with M3 (or M4).



- Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface
- Total hole depth **2** (incremental value): Distance between workpiece surface (beginning of thread) and end of thread
- PITCH **3**: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
 + = right-hand thread  
 - = left-hand thread

**Example NC blocks:**

```
18 CYCL DEF 17.0 RIGID TAPPING GS
```

```
19 CYCL DEF 17.1 SET UP 2
```

```
20 CYCL DEF 17.2 DEPTH -20
```

```
21 CYCL DEF 17.3 PITCH +1
```

**Retracting after a program interruption**

If you interrupt program run during tapping with the machine stop button, the TNC will display the soft key MANUAL OPERATION. If you press the MANUAL OPERATION key, you can retract the tool under program control. Simply press the positive axis direction button of the active tool axis.

## RIGID TAPPING without a floating tap holder TAPPING (Cycle 207)



Machine and control must be specially prepared by the machine tool builder to enable rigid tapping.

The TNC cuts the thread without a floating tap holder in one or more passes.

Rigid tapping offers the following advantages over tapping with a floating tap holder: See Cycle 17

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the total hole depth in one movement
- 3 Once the tool has reached the total hole depth, the direction of spindle rotation is reversed and the tool is retracted to the set-up clearance at the end of the DWELL TIME. If you have entered a 2nd set-up clearance, the tool subsequently moves to that position in FMAX.
- 4 The TNC stops the spindle turning at set-up clearance



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the parameter total hole depth determines the working direction.

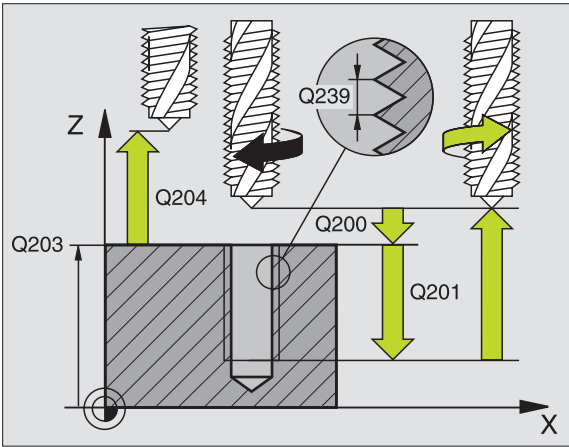
The TNC calculates the feed rate from the spindle speed. If the spindle speed override is used during tapping, the feed rate is automatically adjusted.

The feed-rate override knob is disabled.

At the end of the cycle the spindle comes to a stop. Before the next operation, restart the spindle with M3 (or M4).



- Set-up clearance Q200 (incremental): Distance between tool tip (at starting position) and workpiece surface
- Total hole depth Q201 (incremental): Distance between workpiece surface (beginning of thread) and end of thread
- Thread pitch Q239  
Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
+ = right-hand thread  
- = left-hand thread
- Workpiece surface coordinate Q203 (absolute value):  
Coordinate of the workpiece surface
- 2nd set-up clearance Q204 (incremental value):  
Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.



**Retracting after a program interruption**

If you interrupt program run during thread cutting with the machine stop button, the TNC will display the soft key MANUAL OPERATION. If you press the MANUAL OPERATION key, you can retract the tool under program control. Simply press the positive axis direction button of the active tool axis.

**Example NC blocks:**

26	CYCL DEF	207	RIGID TAPPING NEW
	Q200=2		; SET-UP CLEARANCE
	Q201=-20		; DEPTH
	Q239=+1		; THREAD PITCH
	Q203=+0		; SURFACE COORDINATE
	Q204=50		; 2ND SET-UP CLEARANCE



## THREAD CUTTING (Cycle 18)



Machine and control must be specially prepared by the machine tool builder to enable thread cutting.

Cycle 18 THREAD CUTTING is performed by means of spindle control. The tool moves with the active spindle speed from its current position to the entered depth. As soon as it reaches the end of thread, spindle rotation is stopped. Tool approach and departure must be programmed separately. The most convenient way to do this is by using OEM cycles. The machine tool builder can give you further information.



### Before programming, note the following:

The TNC calculates the feed rate from the spindle speed. If the spindle speed override is used during thread cutting, the feed rate is automatically adjusted.

The feed-rate override knob is disabled.

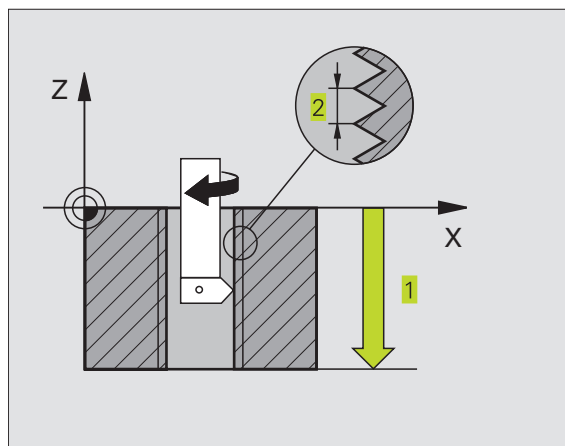
The TNC automatically activates and deactivates spindle rotation. Do not program M3 or M4 before cycle call.



- Total hole depth **1**: Distance between current tool position and end of thread.

The algebraic sign for the total hole depth determines the working direction (a negative value means a negative working direction in the tool axis)

- PITCH **2**:  
Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
+ = right-hand thread (M3 with negative depth)  
- = left-hand thread (M4 with negative depth)



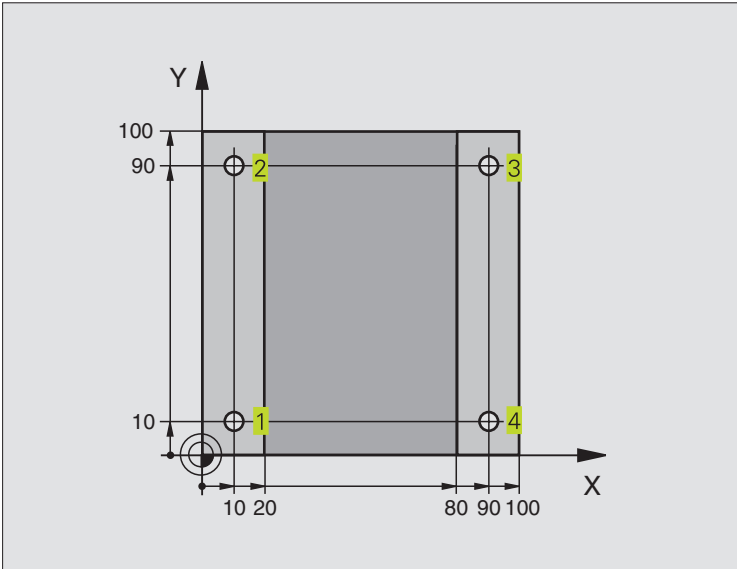
### Example NC blocks:

```
22 CYCL DEF 18.0 THREAD CUTTING
```

```
23 CYCL DEF 18.1 DEPTH -20
```

```
24 CYCL DEF 18.2 PITCH +1
```

Example: Drilling cycles

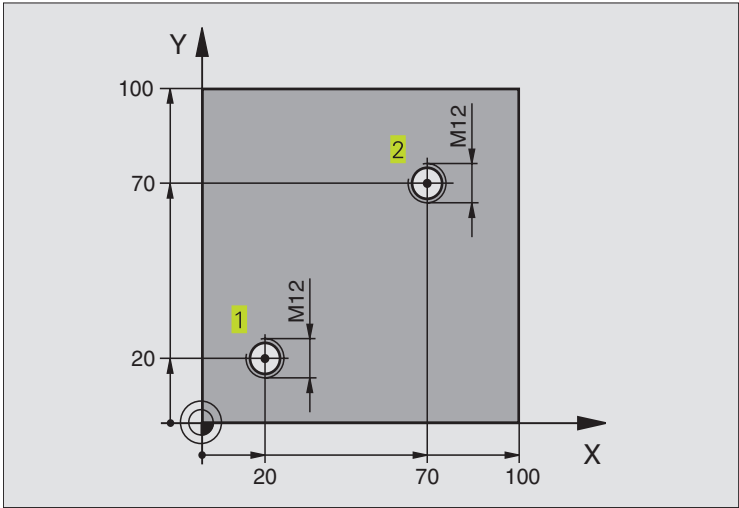


0	BEGIN PGM C200 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+3	Define the tool
4	TOOL CALL 1 Z S4500	Tool call
5	L Z+250 R0 F MAX	Retract the tool
6	CYCL DEF 200 DRILLING	Define cycle
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-15 ;DEPTH	
	Q206=250 ;F PLUNGING	
	Q202=5 ;PLUNGING DEPTH	
	Q210=0 ;DWELL TIME AT TOP	
	Q203=-10 ;SURFACE COORDINATE	
	Q204=20 ;2nd SET-UP CLEARANCE	
	Q211=0.2 ;DWELL TIME AT BOTTOM	
7	L X+10 Y+10 R0 F MAX M3	Approach hole 1, spindle ON
8	CYCL CALL	Call the cycle
9	L Y+90 R0 F MAX M99	Approach hole 2, call cycle
10	L X+90 R0 F MAX M99	Approach hole 3, call cycle
11	L Y+10 R0 F MAX M99	Approach hole 4, call cycle
12	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
13	END PGM C200 MM	

### Example: Drilling cycles










#### Program sequence

- Program the drilling cycle in the main program
- Program the machining operation in a subprogram (see section 9 "Programming: Subprograms and Program Section Repeats")



0	BEGIN PGM C18 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+6	Define the tool
4	TOOL CALL 1 Z S100	Tool call
5	L Z+250 RO F MAX	Retract the tool
6	CYCL DEF 18.0 THREAD CUTTING	Define THREAD CUTTING cycle
7	CYCL DEF 18.1 DEPTH +30	
8	CYCL DEF 18.2 PITCH -1.75	
9	L X+20 Y+20 RO F MAX	Approach hole 1
10	CALL LBL 1	Call subprogram 1
11	L X+70 Y+70 RO F MAX	Approach hole 2
12	CALL LBL 1	Call subprogram 1
13	L Z+250 RO F MAX M2	Retract tool, end of main program
14	LBL 1	Subprogram 1: Thread cutting
15	CYCL DEF 13.0 ORIENTATION	Orient spindle (makes it possible to cut repeatedly)
16	CYCL DEF 13.1 ANGLE 0	
17	L IX-2 RO F1000	Tool offset to prevent collision during tool infeed (dependent on core diameter and tool)
18	L Z+5 RO F MAX	Pre-position in rapid traverse
19	L Z-30 RO F1000	Move to starting depth
20	L IX+2	Reset the tool to hole center
21	CYCL CALL	Call Cycle 18
22	L Z+5 RO F MAX	Retract tool
23	LBL 0	End of subprogram 1
24	END PGM C18 MM	

8.3 Cycles for milling pockets, studs and slots

Cycle	Soft key
4 POCKET MILLING (rectangular) Roughing cycle without automatic pre-positioning	
212 POCKET FINISHING (rectangular) Finishing cycle with automatic pre-positioning and 2nd set-up clearance	
213 STUD FINISHING (rectangular) Finishing cycle with automatic pre-positioning and 2nd set-up clearance	
5 CIRCULAR POCKET MILLING Roughing cycle without automatic pre-positioning	
214 CIRCULAR POCKET FINISHING Finishing cycle with automatic pre-positioning and 2nd set-up clearance	
215 CIRCULAR STUD FINISHING Finishing cycle with automatic pre-positioning and 2nd set-up clearance	
3 SLOT MILLING Roughing/finishing cycle without automatic pre-positioning, vertical downfeed	
210 SLOT WITH RECIPROCATING PLUNGE-CUT Roughing/finishing cycle with automatic pre-positioning and reciprocating plunge-cut	
211 CIRCULAR SLOT Roughing/finishing cycle with automatic pre-positioning and reciprocating plunge-cut	

## POCKET MILLING (Cycle 4)

- 1 The tool penetrates the workpiece at the starting position (pocket center) and advances to the first plunging depth.
- 2 The cutter begins milling in the positive axis direction of the longer side (on square pockets, always starting in the positive Y direction) and then roughs out the pocket from the inside out.
- 3 This process (1 to 2) is repeated until the depth is reached.
- 4 At the end of the cycle, the TNC retracts the tool to the starting position.



### Before programming, note the following:

Program a positioning block for the starting point (pocket center) in the working plane with RADIUS COMPENSATION R0.

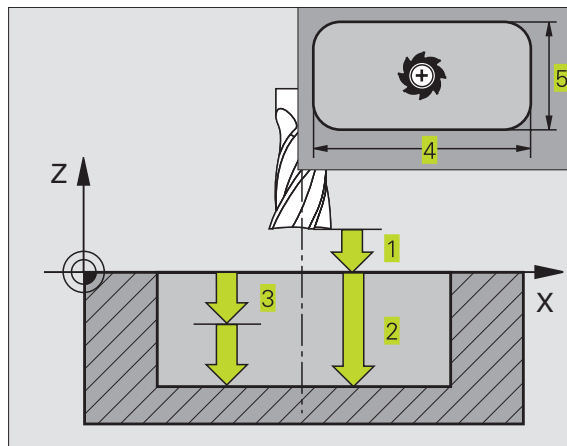
Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

The algebraic sign for the depth parameter determines the working direction.

This cycle requires a center-cut end mill (ISO 1641), or pilot drilling at the pocket center.

The following condition must be met for the second line length:

2nd side length greater than  $[(2 \times \text{rounding-off radius}) + \text{stepover factor } k]$ .



### Example NC blocks:

27	CYCL DEF 4.0 POCKET MILLING
28	CYCL DEF 4.1 SET UP 2
29	CYCL DEF 4.2 DEPTH -20
30	CYCL DEF 4.3 PLNGNG 5 F100
31	CYCL DEF 4.4 X80
32	CYCL DEF 4.5 Y60
33	CYCL DEF 4.6 F275 DR+ RADIUS 5



- ▶ Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface
- ▶ Milling depth **2** (incremental value): Distance between workpiece surface and bottom of pocket
- ▶ Plunging depth **3** (incremental value): Infeed per cut. The tool will advance to the depth in one movement if:
  - n the plunging depth equals the depth
  - n the plunging depth is greater than the depth
- ▶ Feed rate for plunging: Traversing speed of the tool during penetration
- ▶ 1st side length **4**: Pocket length, parallel to the main axis of the working plane
- ▶ 2nd side length **5**: Pocket width
- ▶ Feed rate F: Traversing speed of the tool in the working plane

- Direction of the milling path  
DR + : climb milling with M3  
DR - : up-cut milling with M3
- Rounding radius: Radius of the pocket corners. If radius = 0 is entered, the pocket corners will be rounded with the radius of the cutter.

## Calculations:

Stepover factor  $k = K \times R$

where

K is the overlap factor, preset in machine parameter 7430, and  
R is the cutter radius

## POCKET FINISHING (Cycle 212)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or — if programmed — to the 2nd set-up clearance, and subsequently to the center of the pocket.
- 2 From the pocket center, the tool moves in the working plane to the starting point for machining. The TNC takes the allowance and tool radius into account for calculating the starting point. If necessary, the TNC plunge-cuts into the pocket center.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance, or - if programmed - to the 2nd set-up clearance, and finally to the center of the pocket (end position = starting position).

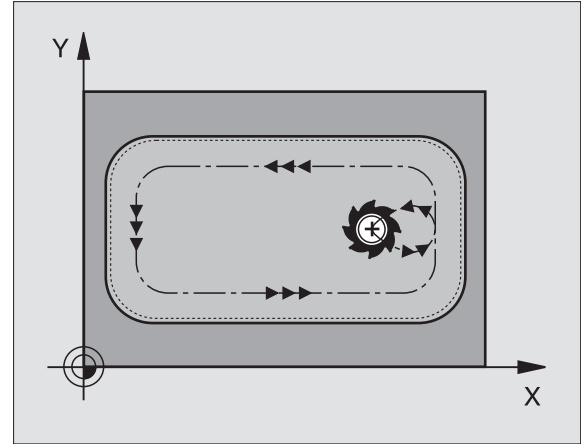


### Before programming, note the following:

The algebraic sign for the depth parameter determines the working direction.

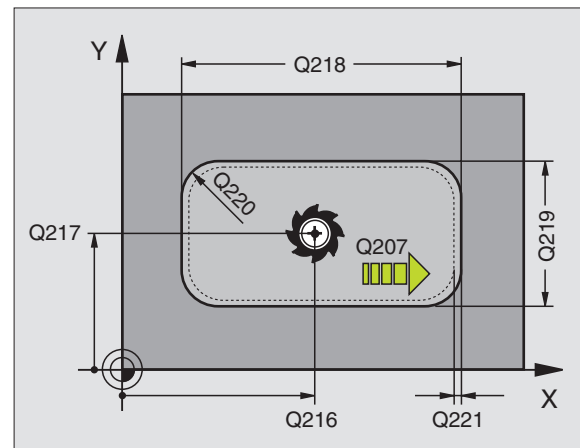
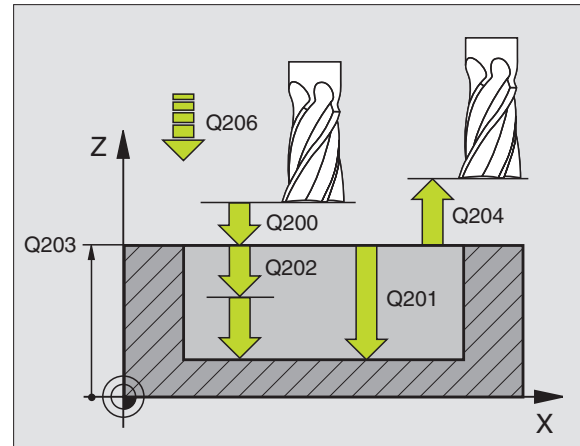
If you want to clear and finish the pocket with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.

Minimum size of the pocket: 3 times the tool radius.





- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of pocket
- ▶ Feed rate for plunging Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a lower value than that defined in Q207.
- ▶ Plunging depth Q202 (incremental value): Infeed per cut; enter a value greater than 0.
- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Center in 1st axis Q216 (absolute value): Center of the pocket in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the pocket in the secondary axis of the working plane
- ▶ First side length Q218 (incremental value): Pocket length, parallel to the main axis of the working plane
- ▶ Second side length Q219 (incremental value): Pocket length, parallel to the secondary axis of the working plane
- ▶ Corner radius Q220: Radius of the pocket corner If you make no entry here, the TNC assumes that the corner radius is equal to the tool radius.
- ▶ Allowance in 1st axis Q221 (incremental value): Allowance in the main axis of the working plane referenced to the length of the pocket.



#### Example NC blocks:

<b>34 CYCL DEF 212 POCKET FINISHING</b>	
<b>Q200=2</b>	<b>;SET-UP CLEARANCE</b>
<b>Q201=-20</b>	<b>;DEPTH</b>
<b>Q206=150</b>	<b>;FEED RATE FOR PLUNGING</b>
<b>Q202=5</b>	<b>;PLUNGING DEPTH</b>
<b>Q207=500</b>	<b>;FEED RATE FOR MILLING</b>
<b>Q203=+0</b>	<b>;SURFACE COORDINATE</b>
<b>Q204=50</b>	<b>;2. SET-UP CLEARANCE</b>
<b>Q216=+50</b>	<b>;CENTER IN 1ST AXIS</b>
<b>Q217=+50</b>	<b>;CENTER IN 2ND AXIS</b>
<b>Q218=80</b>	<b>;1ST SIDE LENGTH</b>
<b>Q219=60</b>	<b>;2ND SIDE LENGTH</b>
<b>Q220=5</b>	<b>;CORNER RADIUS</b>
<b>Q221=0</b>	<b>;ALLOWANCE</b>

## STUD FINISHING (Cycle 213)

- 1 The TNC moves the tool in the tool axis to set-up clearance, or — if programmed — to the 2nd set-up clearance, and subsequently to the center of the stud.
- 2 From the stud center, the tool moves in the working plane to the starting point for machining. The starting point lies to the right of the stud by a distance approx. 3.5 times the tool radius.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in FMAX to set-up clearance, or — if programmed — to the 2nd set-up clearance, and finally to the center of the stud (end position = starting position).



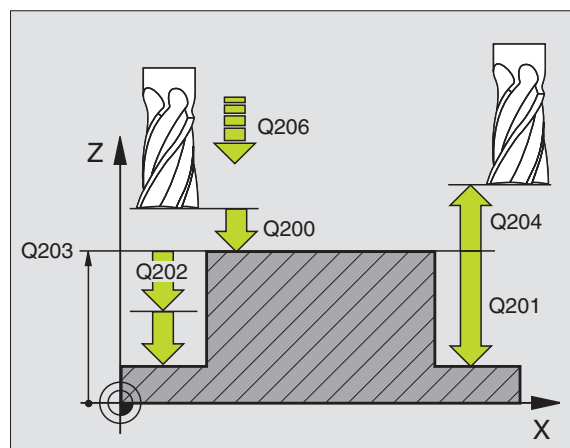
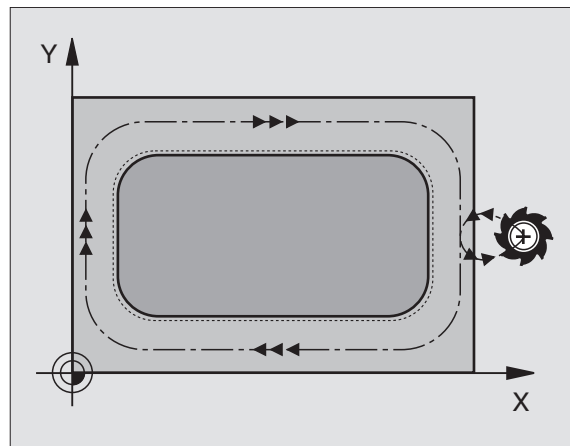
### Before programming, note the following:

The algebraic sign for the depth parameter determines the working direction.

If you want to clear and finish the stud with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



- Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- Depth Q201 (incremental value): Distance between workpiece surface and bottom of stud
- Feed rate for plunging Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a low value; if you have already cleared the stud, enter a higher feed rate.
- Plunging depth Q202 (incremental value): Infeed per cut Enter a value greater than 0.
- Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.

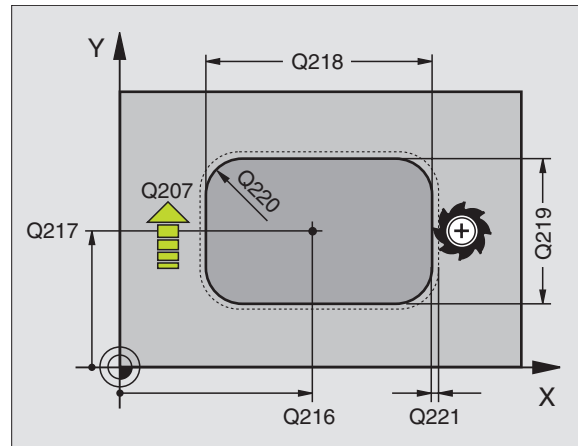


### Example NC blocks:

35 CYCL DEF 213 STUD FINISHING	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;PLUNGING DEPTH
Q207=500	;FEED RATE FOR MILLING
Q203=+0	;SURFACE COORDINATE
Q204=50	;2. SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q218=80	;1ST SIDE LENGTH
Q219=60	;2ND SIDE LENGTH
Q220=5	;CORNER RADIUS
Q221=0	;ALLOWANCE



- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Center in 1st axis Q216 (absolute value): Center of the stud in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the stud in the secondary axis of the working plane
- ▶ First side length Q218 (incremental value): Stud length, parallel to the main axis of the working plane
- ▶ Second side length Q219 (incremental value): Stud length, parallel to the secondary axis of the working plane
- ▶ Corner radius Q220: Radius of the stud corner
- ▶ Allowance in 1st axis Q221 (incremental value): Allowance in the main axis of the working plane referenced to the length of the stud.



## CIRCULAR POCKET MILLING (Cycle 5)

- 1 The tool penetrates the workpiece at the starting position (pocket center) and advances to the first plunging depth.
- 2 The tool subsequently follows a spiral path at the feed rate  $F$  — see figure at right. For calculating the stepover factor  $k$ , see Cycle 4 POCKET MILLING.
- 3 This process is repeated until the depth is reached.
- 4 At the end of the cycle, the TNC retracts the tool to the starting position.



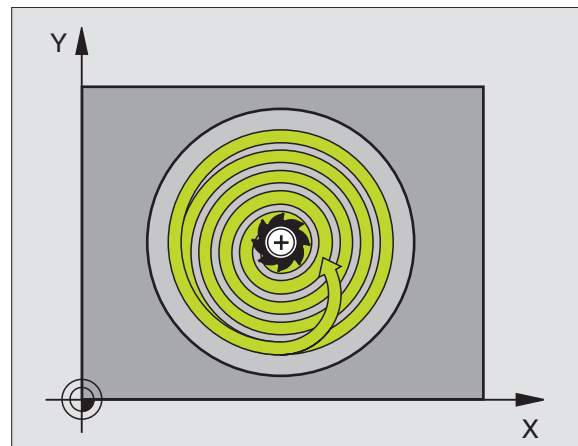
### Before programming, note the following:

Program a positioning block for the starting point (pocket center) in the working plane with RADIUS COMPENSATION R0.

Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

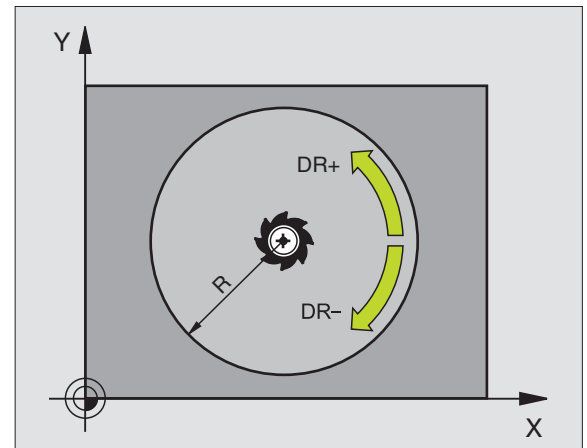
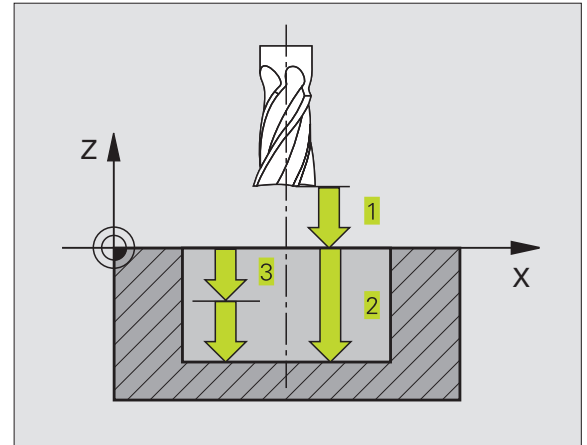
The algebraic sign for the depth parameter determines the working direction.

This cycle requires a center-cut end mill (ISO 1641), or pilot drilling at the pocket center.





- ▶ Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface
- ▶ Milling depth **2** (incremental value): Distance between workpiece surface and bottom of pocket
- ▶ Plunging depth **3** (incremental value): Infeed per cut. The tool will advance to the depth in one movement if:
  - the plunging depth equals the depth
  - the plunging depth is greater than the depth
- ▶ Feed rate for plunging: Traversing speed of the tool during penetration
- ▶ Circular radius: Radius of the circular pocket
- ▶ Feed rate F: Traversing speed of the tool in the working plane
- ▶ Direction of the milling path
  - DR + : climb milling with M3
  - DR - : up-cut milling with M3



## Example NC blocks:

```

36 CYCL DEF 5.0 CIRCULAR POCKET
37 CYCL DEF 5.1 SET UP 2
38 CYCL DEF 5.2 DEPTH -20
39 CYCL DEF 5.3 PLNGNG 5 F100
40 CYCL DEF 5.4 RADIUS 40
41 CYCL DEF 5.5 F250 DR+
    
```

## CIRCULAR POCKET FINISHING (Cycle 214)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or — if programmed — to the 2nd set-up clearance, and subsequently to the center of the pocket.
- 2 From the pocket center, the tool moves in the working plane to the starting point for machining. The TNC takes the workpiece blank diameter and tool radius into account for calculating the starting point. If you enter a workpiece blank diameter of 0, the TNC plunge-cuts into the pocket center.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in FMAX to set-up clearance, or - if programmed - to the 2nd set-up clearance, and finally to the center of the pocket (end position = starting position).



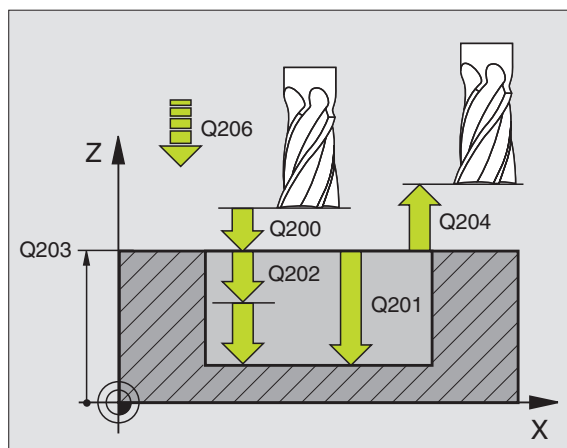
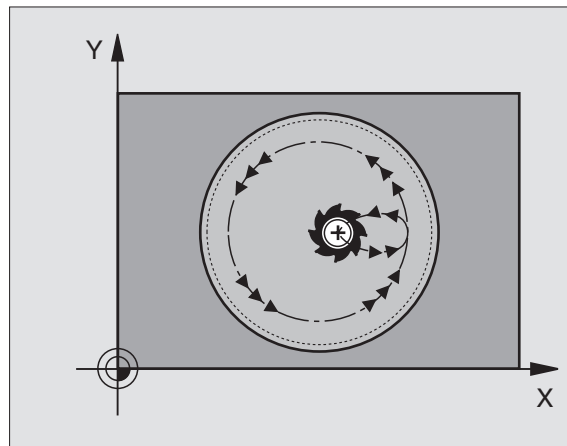
### Before programming, note the following:

The algebraic sign for the depth parameter determines the working direction.

If you want to clear and finish the pocket with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



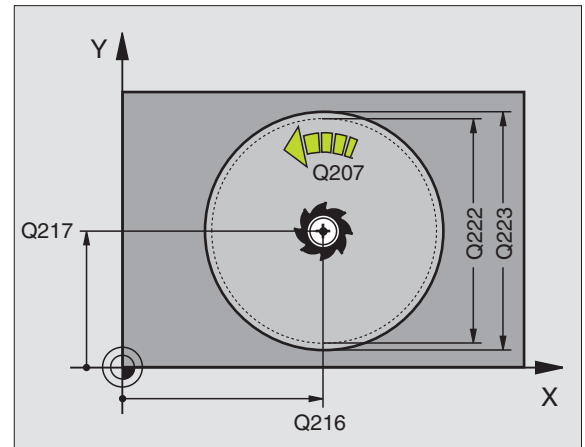
- Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- Depth Q201 (incremental value): Distance between workpiece surface and bottom of pocket
- Feed rate for plunging Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a lower value than that defined in Q207.
- Plunging depth Q202 (incremental value): Infeed per cut



### Example NC blocks:

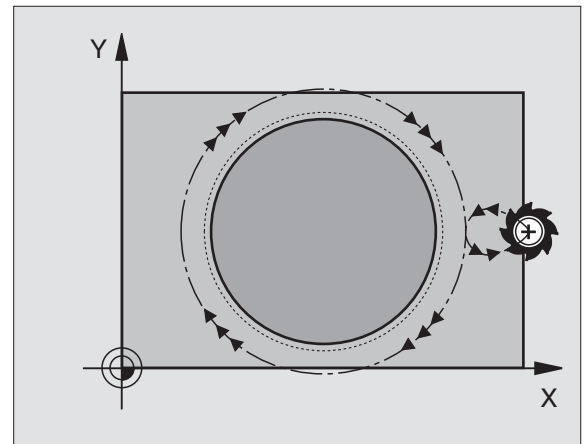
42 CYCL DEF 214 CIRCULAR POCKET FINISHING	
Q200=2	; SET-UP CLEARANCE
Q201=-20	; DEPTH
Q206=150	; FEED RATE FOR PLUNGING
Q202=5	; PLUNGING DEPTH
Q207=500	; FEED RATE FOR MILLING
Q203=+0	; SURFACE COORDINATE
Q204=50	; 2. SET-UP CLEARANCE
Q216=+50	; CENTER IN 1ST AXIS
Q217=+50	; CENTER IN 2ND AXIS
Q222=79	; WORKPIECE BLANK DIA.
Q223=80	; FINISHED PART DIA.

- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Center in 1st axis Q216 (absolute value): Center of the pocket in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the pocket in the secondary axis of the working plane
- ▶ Workpiece blank dia. Q222: Diameter of the premachined pocket. Enter the workpiece blank diameter to be less than the diameter of the finished part.
- ▶ Finished part dia. Q223: Diameter of the finished pocket. Enter the diameter of the finished part to be greater than the workpiece blank diameter.



## CIRCULAR STUD FINISHING (Cycle 215)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or — if programmed - to the 2nd set-up clearance, and subsequently to the center of the stud.
- 2 From the stud center, the tool moves in the working plane to the starting point for machining. The starting point lies to the right of the stud by a distance approx. 3.5 times the tool radius.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in FMAX to set-up clearance, or - if programmed - to the 2nd set-up clearance, and finally to the center of the pocket (end position = starting position).





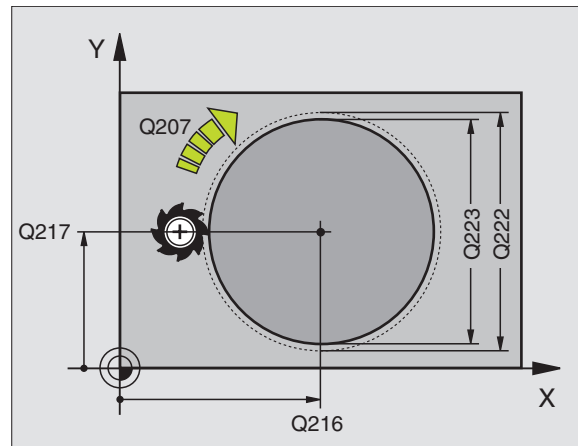
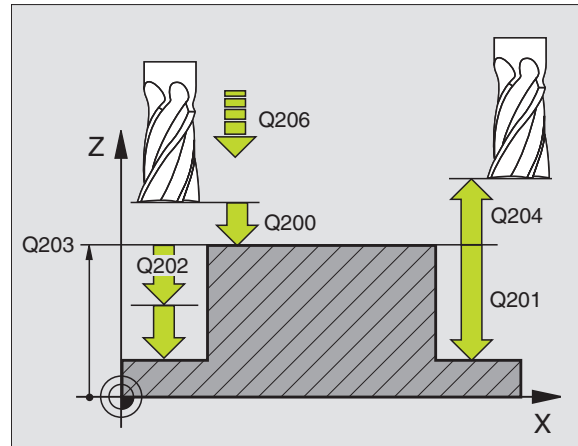
### Before programming, note the following:

The algebraic sign for the depth parameter determines the working direction.

If you want to clear and finish the stud with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of stud
- ▶ Feed rate for plunging Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a low value; if you have already cleared the stud, enter a higher feed rate.
- ▶ Plunging depth Q202 (incremental value): Infeed per cut; enter a value greater than 0.
- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Center in 1st axis Q216 (absolute value): Center of the stud in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the stud in the secondary axis of the working plane
- ▶ Workpiece blank diameter Q222: Diameter of the premachined stud. Enter the workpiece blank diameter to be greater than the diameter of the finished part.
- ▶ Diameter of finished part Q223: Diameter of the finished stud. Enter the diameter of the finished part to be less than the workpiece blank diameter.



### Example NC blocks:

43	CYCL DEF 215 C. STUD FINISHING
Q200=2	; SET-UP CLEARANCE
Q201=-20	; DEPTH
Q206=150	; FEED RATE FOR PLUNGING
Q202=5	; PLUNGING DEPTH
Q207=500	; FEED RATE FOR MILLING
Q203=+0	; SURFACE COORDINATE
Q204=50	; 2. SET-UP CLEARANCE
Q216=+50	; CENTER IN 1ST AXIS
Q217=+50	; CENTER IN 2ND AXIS
Q222=81	; WORKPIECE BLANK DIA.
Q223=80	; FINISHED PART DIA.

## SLOT MILLING (Cycle 3)

### Roughing process

- 1 The TNC moves the tool inward by the milling allowance (half the difference between the slot width and the tool diameter). From there it plunge-cuts into the workpiece and mills in the longitudinal direction of the slot.
- 2 After downfeed at the end of the slot, milling is performed in the opposite direction.

This process is repeated until the programmed milling depth is reached.

### Finishing process

- 3 The TNC advances the tool at the slot bottom on a tangential arc to the outside contour. The tool subsequently climb mills the contour (with M3).
- 4 At the end of the cycle, the tool is retracted in rapid traverse FMAX to set-up clearance.

If the number of infeeds was odd, the tool returns to the starting position at the level of the set-up clearance.



### Before programming, note the following:

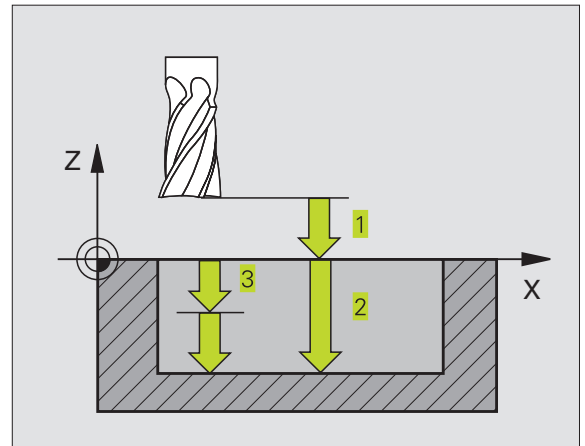
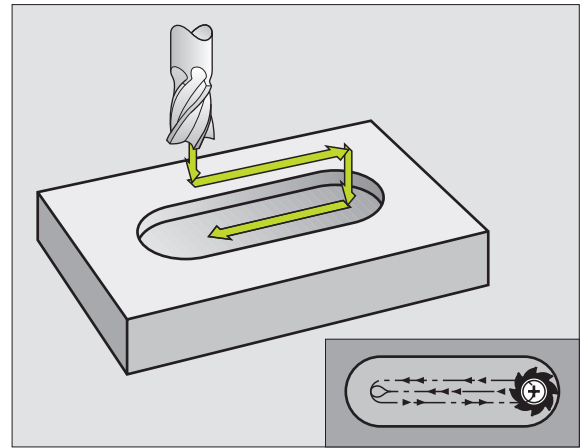
Program a positioning block for the starting point in the working plane — to the center of the slot (second side length) and, within the slot, offset by the tool radius — with RADIUS COMPENSATION R0.

Program a positioning block for the starting point in the tool axis (set-up clearance above the workpiece surface).

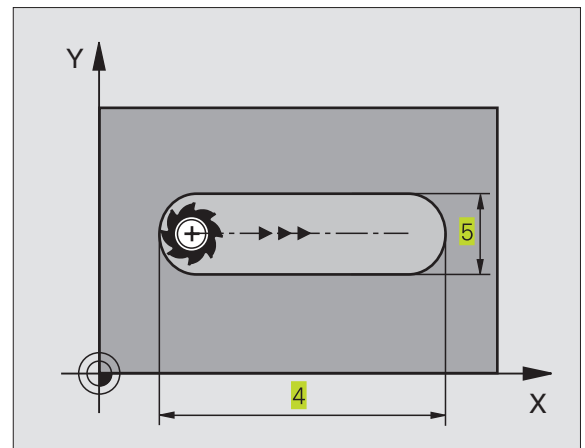
The algebraic sign for the depth parameter determines the working direction.

This cycle requires a center-cut end mill (ISO 1641), or pilot drilling at the starting point.

The cutter diameter must be not be larger than the slot width and not smaller than half the SLOT WIDTH.



- ▶ Setup clearance **1** (incremental value): Distance between tool tip (at starting position) and workpiece surface
- ▶ Milling depth **2** (incremental value): Distance between workpiece surface and bottom of pocket
- ▶ Plunging depth **3** (incremental value): Infeed per cut; the TNC will advance to the depth in one movement if:
  - the plunging depth equals the depth
  - the plunging depth is greater than the depth



- ▶ Feed rate for plunging: Traversing speed of the tool during penetration
- ▶ 1st side length **4**: Slot length; specify the sign to determine the first milling direction
- ▶ 2nd side length **5**: Slot width
- ▶ Feed rate F: Traversing speed of the tool in the working plane

**Example NC blocks:**

```

44 CYCL DEF 3.0 SLOT MILLING
45 CYCL DEF 3.1 SET UP 2
46 CYCL DEF 3.2 DEPTH -20
47 CYCL DEF 3.3 PLNGNG 5 F100
48 CYCL DEF 3.4 X+80
49 CYCL DEF 3.5 Y12
50 CYCL DEF 3.6 F275

```

**SLOT with reciprocating plunge-cut (Cycle 210)****Before programming, note the following:**

The algebraic sign for the depth parameter determines the working direction.

The cutter diameter must not be larger than the slot width and not smaller than a third of the slot width.

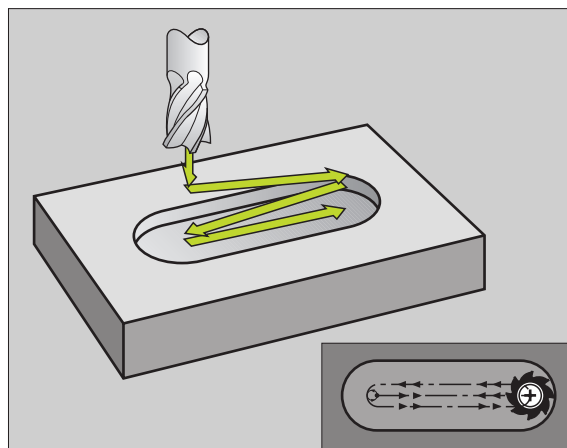
The cutter diameter must be smaller than half the slot length. The TNC otherwise cannot execute this cycle.

**Roughing process**

- 1** At rapid traverse, the TNC positions the tool in the tool axis to the 2nd set-up clearance and subsequently to the center of the left circle. From there, the TNC positions the tool to set-up clearance above the workpiece surface.
- 2** The tool moves at the feed rate for milling to the workpiece surface. From there, the cutter advances in the longitudinal direction of the slot — plunge-cutting obliquely into the material — until it reaches the center of the right circle.
- 3** The tool then moves back to the center of the left circle, again with oblique plunge-cutting. This process is repeated until the programmed milling depth is reached.
- 4** At the milling depth, the TNC moves the tool for the purpose of face milling to the other end of the slot and then back to the center of the slot.

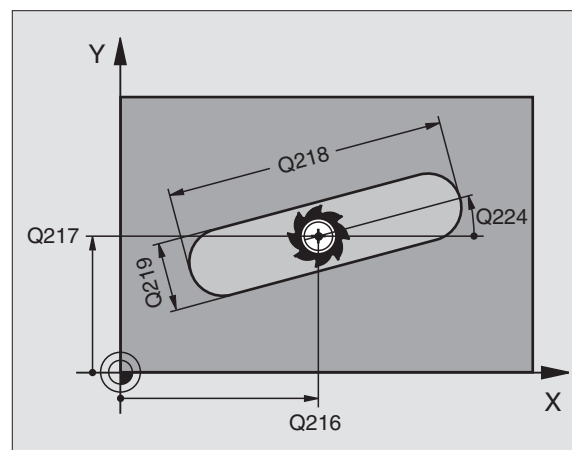
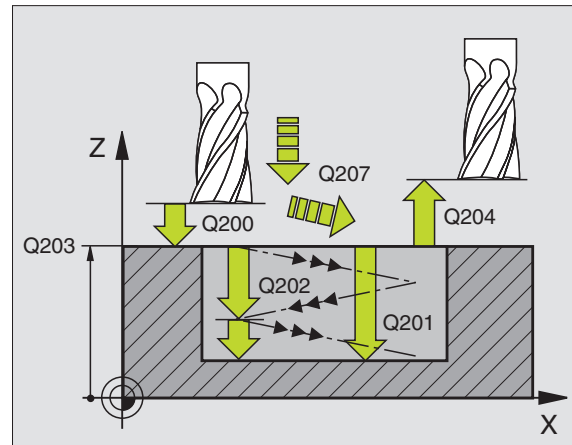
**Finishing process**

- 5** The TNC advances the tool from the slot center tangentially to the contour of the finished part. The tool subsequently climb mills the contour (with M3), and if so entered, in more than one infeed.
- 6** When the tool reaches the end of the contour, it departs the contour tangentially and returns to the center of the slot.
- 7** At the end of the cycle, the tool is retracted in rapid traverse FMAX to set-up clearance and — if programmed — to the 2nd set-up clearance.





- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Depth Q201 (incremental value): Distance between workpiece surface and bottom of slot
- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- ▶ Plunging depth Q202 (incremental value): Total extent by which the tool is fed in the tool axis during a reciprocating movement.
- ▶ Machining operation (0/1/2) Q215:  
Define the extent of machining:  
0: Roughing and finishing  
1: Roughing only  
2: Finishing only
- ▶ Workpiece SURFACE COORDINATE Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Z coordinate at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Center in 1st axis Q216 (absolute value): Center of the slot in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the slot in the secondary axis of the working plane
- ▶ First side length Q218 (value parallel to the main axis of the working plane): Enter the length of the slot
- ▶ Second side length Q219 (value parallel to the secondary axis of the working plane): Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling).
- ▶ Angle of rotation Q224 (absolute value): Angle by which the entire slot is rotated. The center of rotation lies in the center of the slot.
- ▶ Infeed for finishing Q338 (incremental): Infeed per cut. Q338=0: Finishing in one infeed.



## Example NC blocks:

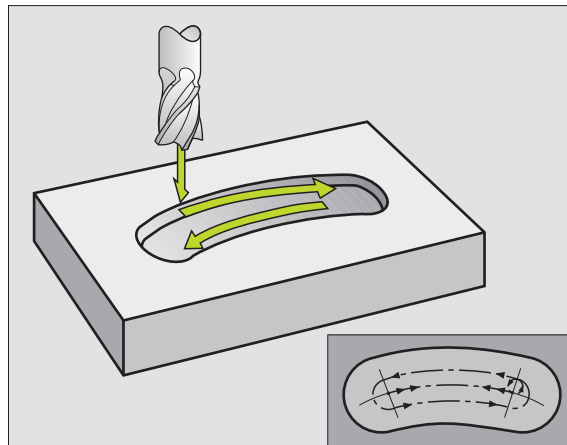
51	CYCL DEF 210 SLOT RECIP. PLNG
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q207=500	;FEED RATE FOR MILLING
Q202=5	;PLUNGING DEPTH
Q215=0	;MACHINING OPERATION
Q203=+0	;SURFACE COORDINATE
Q204=50	;2. SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q218=80	;1ST SIDE LENGTH
Q219=12	;2ND SIDE LENGTH
Q224=+15	;ANGLE OF ROTATION
Q338=5	;INFEED FOR FINISHING



## CIRCULAR SLOT with reciprocating plunge-cut (Cycle 211)

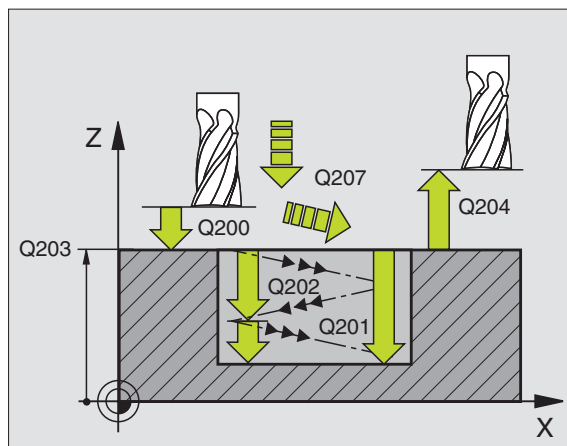
### Roughing process

- 1 At rapid traverse, the TNC positions the tool in the tool axis to the 2nd set-up clearance and subsequently to the center of the right circle. From there, the tool is positioned to the programmed set-up clearance above the workpiece surface.
- 2 The tool moves at the milling feed rate to the workpiece surface. From there, the cutter advances — plunge-cutting obliquely into the material — to the other end of the slot.
- 3 The tool then moves at a downward angle back to the starting point, again with oblique plunge-cutting. This process (2 to 3) is repeated until the programmed milling depth is reached.
- 4 At the milling depth, the TNC moves the tool for the purpose of face milling to the other end of the slot.



### Finishing process

- 5 The TNC advances the tool from the slot center tangentially to the contour of the finished part. The tool subsequently climb mills the contour (with M3), and if so entered, in more than one infeed. The starting point for the finishing process is the center of the right circle.
- 6 When the tool reaches the end of the contour, it departs the contour tangentially.
- 7 At the end of the cycle, the tool is retracted in rapid traverse FMAX to set-up clearance and — if programmed — to the 2nd set-up clearance.



### Before programming, note the following:

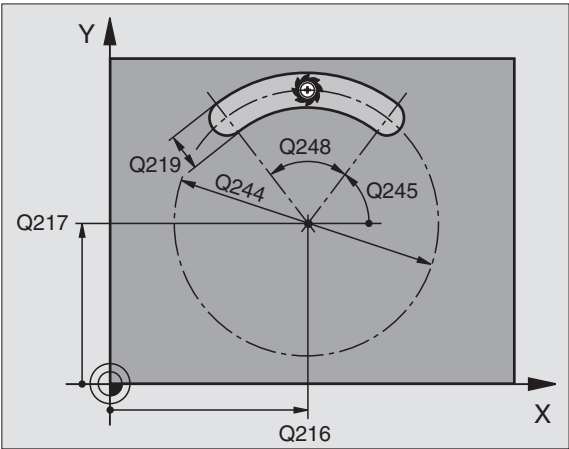
The algebraic sign for the depth parameter determines the working direction.

The cutter diameter must not be larger than the slot width and not smaller than a third of the slot width.

The cutter diameter must be smaller than half the slot length. The TNC otherwise cannot execute this cycle.



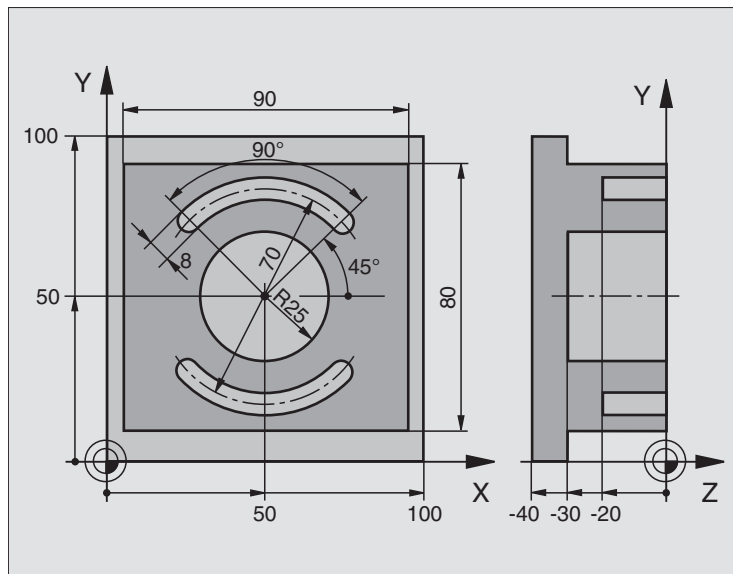
- Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- Depth Q201 (incremental value): Distance between workpiece surface and bottom of slot
- Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- Plunging depth Q202 (incremental value): Total extent by which the tool is fed in the tool axis during a reciprocating movement.
- Machining operation (0/1/2) Q215:  
Define the extent of machining:  
**0:** Roughing and finishing  
**1:** Roughing only  
**2:** Finishing only
- Workpiece SURFACE COORDINATE Q203 (absolute value): Coordinate of the workpiece surface
- 2nd set-up clearance Q204 (incremental value): Z coordinate at which no collision between tool and workpiece (clamping devices) can occur.
- Center in 1st axis Q216 (absolute value): Center of the slot in the main axis of the working plane
- Center in 2nd axis Q217 (absolute value): Center of the slot in the secondary axis of the working plane
- Pitch circle diameter Q244: Enter the diameter of the pitch circle
- Second side length Q219: Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling).
- Starting angle Q245 (absolute value): Enter the polar angle of the starting point.
- Angular length Q248 (incremental value): Enter the angular length of the slot
- Infeed for finishing Q338 (incremental): Infeed per cut.  
Q338=0: Finishing in one infeed.



**Example NC blocks:**

52	CYCL DEF 211	CIRCULAR SLOT
	Q200=2	;SET-UP CLEARANCE
	Q201=-20	;DEPTH
	Q207=500	;FEED RATE FOR MILLING
	Q202=5	;PLUNGING DEPTH
	Q215=0	;MACHINING OPERATION
	Q203=+0	;SURFACE COORDINATE
	Q204=50	;2. SET-UP CLEARANCE
	Q216=+50	;CENTER IN 1ST AXIS
	Q217=+50	;CENTER IN 2ND AXIS
	Q244=80	;PITCH CIRCLE DIAMETER
	Q219=12	;2ND SIDE LENGTH
	Q245=+45	;STARTING ANGLE
	Q248=90	;ANGULAR LENGTH
	Q338=5	;INFEED FOR FINISHING

## Example: Milling pockets, studs and slots



0	BEGIN PGM C210 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	T00L DEF 1 L+0 R+6	Define the tool for roughing/finishing
4	T00L DEF 2 L+0 R+3	Define slotting mill
5	T00L CALL 1 Z S3500	Call tool for roughing/finishing
6	L Z+250 R0 F MAX	Retract the tool
7	CYCL DEF 213 STUD FINISHING	Define cycle for machining the contour outside
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-30 ;DEPTH	
	Q206=250 ;FEED RATE FOR PLNGNG	
	Q202=5 ;PLUNGING DEPTH	
	Q207=250 ;FEED RATE FOR MILLNG	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=20 ;2ND SET-UP CLEARANCE	
	Q216=+50 ;CENTER IN 1ST AXIS	
	Q217=+50 ;CENTER IN 2ND AXIS	
	Q218=90 ;FIRST SIDE LENGTH	
	Q219=80 ;SECOND SIDE LENGTH	
	Q220=0 ;CORNER RADIUS	
	Q221=5 ;ALLOWANCE	
8	CYCL CALL M3	Call cycle for machining the contour outside

### 8.3 Cycle for Milling Pockets, Studs and Slots

9	CYCL DEF 5.0 CIRCULAR POCKET	Define CIRCULAR POCKET MILLING cycle
10	CYCL DEF 5.1 SET UP 2	
11	CYCL DEF 5.2 DEPTH -30	
12	CYCL DEF 5.3 PLNGNG 5 F250	
13	CYCL DEF 5.4 RADIUS 25	
14	CYCL DEF 5.5 F400 DR+	
15	L Z+2 R0 F MAX M99	Call CIRCULAR POCKET MILLING cycle
16	L Z+250 R0 F MAX M6	Tool change
17	TOOL CALL 2 Z S5000	Call slotting mill
18	CYCL DEF 211 CIRCULAR SLOT	Define cycle for slot 1
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-20 ;DEPTH	
	Q207=250 ;FEED RATE FOR MILLNG	
	Q202=5 ;PLUNGING DEPTH	
	Q215=0 ;MACHINING OPERATION	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=100 ;2ND SET-UP CLEARANCE	
	Q216=+50 ;CENTER IN 1ST AXIS	
	Q217=+50 ;CENTER IN 2ND AXIS	
	Q244=70 ;PITCH CIRCLE DIA.	
	Q219=8 ;SECOND SIDE LENGTH	
	Q245=+45 ;STARTING ANGLE	
	Q248=90 ;ANGULAR LENGTH	
	Q338=5 ;INFEEED FOR FINISHING	
19	CYCL CALL M3	Call cycle for slot 1
20	FN 0: Q245 = +225	New starting angle for slot 2
21	CYCL CALL	Call cycle for slot 2
22	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
23	END PGM C210 MM	

# 8.4 Cycles for Machining Hole Patterns

The TNC provides two cycles for machining hole patterns:

Cycle	Soft key
220 CIRCULAR PATTERN	
221 LINEAR PATTERN	

You can combine Cycle 220 and Cycle 221 with the following fixed cycles:

Cycle 1	PECKING
Cycle 2	TAPPING with a floating tap holder
Cycle 3	SLOT MILLING
Cycle 4	POCKET MILLING
Cycle 5	CIRCULAR POCKET MILLING
Cycle 17	RIGID TAPPING without a floating tap holder
Cycle 18	THREAD CUTTING
Cycle 200	DRILLING
Cycle 201	REAMING
Cycle 202	BORING
Cycle 203	UNIVERSAL DRILLING
Cycle 204	BACK BORING
Cycle 205	UNIVERSAL PECKING
Cycle 206	TAPPING NEW with a floating tap holder
Cycle 207	RIGID TAPPING NEW without a floating tap holder
Cycle 208	BORE MILLING
Cycle 212	POCKET FINISHING
Cycle 213	STUD FINISHING
Cycle 214	CIRCULAR POCKET FINISHING
Cycle 215	CIRCULAR STUD FINISHING

## CIRCULAR PATTERN (Cycle 220)

- 1 At rapid traverse, the TNC moves the tool from its current position to the starting point for the first machining operation.

The tool is positioned in the following sequence:

- Move to 2nd set-up clearance (tool axis)
- Approach starting point in the working plane
- Move to set-up clearance above the workpiece surface (tool axis)

- 2 From this position, the TNC executes the last defined fixed cycle.
- 3 The tool then approaches the starting point for the next machining operation on a straight line at set-up clearance (or 2nd set-up clearance).
- 4 This process (1 to 3) is repeated until all machining operations have been executed.



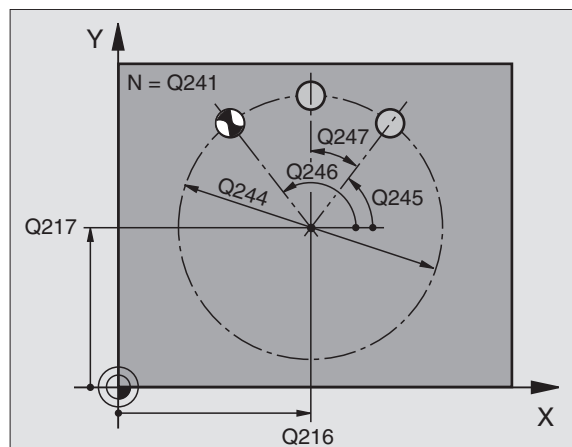
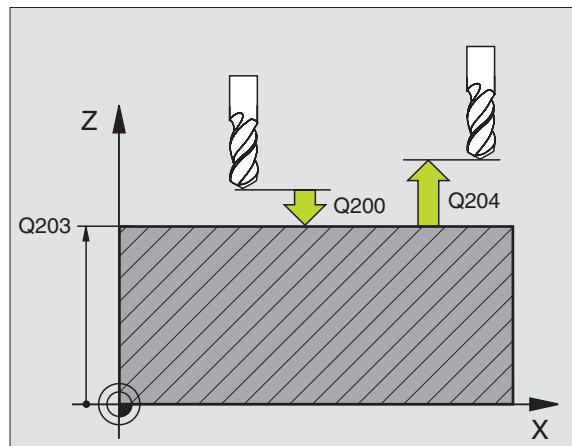
### Before programming, note the following:

Cycle 220 is DEF active, which means that Cycle 220 automatically calls the last defined fixed cycle.

If you combine Cycle 220 with one of the fixed cycles 200 to 208 and 212 to 215, the set-up clearance, workpiece surface and 2nd set-up clearance that you defined in Cycle 220 will be effective for the selected fixed cycle.



- ▶ Center in 1st axis Q216 (absolute value): Center of the pitch circle in the main axis of the working plane
- ▶ Center in 2nd axis Q217 (absolute value): Center of the pitch circle in the secondary axis of the working plane
- ▶ Pitch circle diameter Q244: Diameter of the pitch circle
- ▶ Starting angle Q245 (absolute value): Angle between the main axis of the working plane and the starting point for the first machining operation on the pitch circle
- ▶ Stopping angle Q246 (absolute value): Angle between the main axis of the working plane and the starting point for the last machining operation on the pitch circle (does not apply to complete circles). Do not enter the same value for the stopping angle and starting angle. If you enter the stopping angle greater than the starting angle, machining will be carried out counterclockwise; otherwise, machining will be clockwise.
- ▶ ANGLE STEP Q247 (incremental): Angle between two machining operations on a pitch circle. If you enter an ANGLE STEP of 0, the TNC will calculate the ANGLE STEP from the STARTING and STOPPING ANGLES and the number of pattern repetitions. If you enter a value other than 0, the TNC will not take the STOPPING ANGLE into account. The sign for the ANGLE STEP determines the working direction (- = clockwise).



### Example NC blocks:

53 CYCL DEF 220 POLAR PATTERN		
Q216=+50	;CENTER IN 1ST AXIS	
Q217=+50	;CENTER IN 2ND AXIS	
Q244=80	;PITCH CIRCLE DIAMETER	
Q245=+0	;STARTING ANGLE	
Q246=+360	;STOPPING ANGLE	
Q247=+0	;STEPPING ANGLE	
Q241=8	;NR OF REPETITIONS	
Q200=2	;SET-UP CLEARANCE	
Q203=+0	;SURFACE COORDINATE	
Q204=50	;2. SET-UP CLEARANCE	
Q301=1	;TRAVERSE TO CLEARANCE HEIGHT	

- ▶ Number of repetitions Q241: Number of machining operations on a pitch circle
- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface. Enter a positive value.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Traversing to clearance height Q301: definition of how the tool is to move between machining processes:
  - 0: Move to set-up clearance
  - 1: Move to 2nd set-up clearance

## LINEAR PATTERN (Cycle 221)



### Before programming, note the following:

Cycle 221 is DEF active, which means that Cycle 221 calls the last defined fixed cycle automatically.

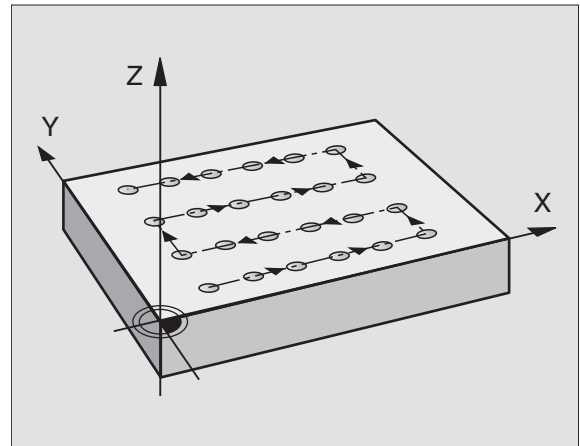
If you combine Cycle 221 with one of the fixed cycles 200 to 208 and 212 to 215, the set-up clearance, workpiece surface and 2nd set-up clearance that you defined in Cycle 221 will be effective for the selected fixed cycle.

- 1 The TNC automatically moves the tool from its current position to the starting point for the first machining operation.

The tool is positioned in the following sequence:

- Move to 2nd set-up clearance (spindle axis)
- Approach starting point in the working plane
- Move to set-up clearance above the workpiece surface (spindle axis)

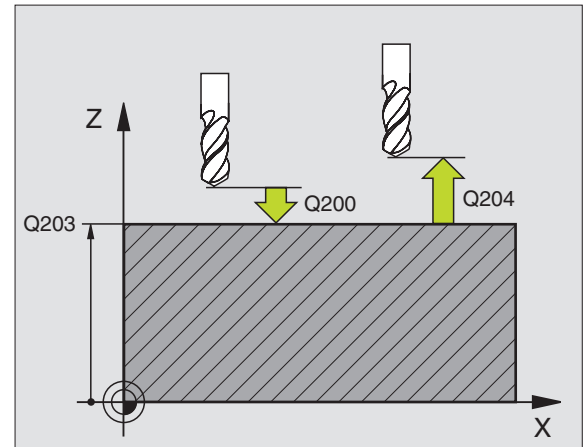
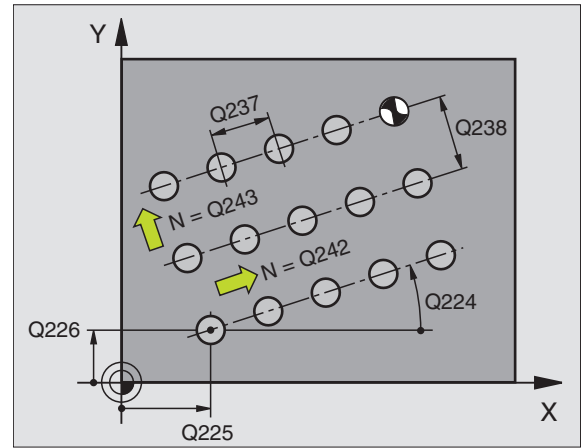
- 2 From this position, the TNC executes the last defined fixed cycle.
- 3 The tool then approaches the starting point for the next machining operation in the positive main axis direction at set-up clearance (or 2nd set-up clearance).
- 4 This process (1 to 3) is repeated until all machining operations on the first line have been executed. The tool is located above the last point on the first line.



- 5 The tool subsequently moves to the last point on the second line where it carries out the machining operation.
- 6 From this position, the tool approaches the starting point for the next machining operation in the negative main axis direction.
- 7 This process (6) is repeated until all machining operations in the second line have been executed.
- 8 The tool then moves to the starting point of the next line.
- 9 All subsequent lines are processed in a reciprocating movement.



- ▶ Starting point 1st axis Q225 (absolute value): Coordinate of the starting point in the main axis of the working plane
- ▶ Starting point 2nd axis Q226 (absolute value): Coordinate of the starting point in the secondary axis of the working plane
- ▶ Spacing in 1st axis Q237 (incremental value): Spacing between the individual points on a line
- ▶ Spacing in 2nd axis Q238 (incremental): Spacing between the individual lines
- ▶ Number of columns Q242: Number of machining operations on a line
- ▶ Number of lines Q243: Number of passes
- ▶ Angle of rotation Q224 (absolute value): Angle by which the entire pattern is rotated. The center of rotation lies in the starting point.
- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ Workpiece surface coordinate Q203 (absolute value): Coordinate of the workpiece surface
- ▶ 2nd set-up clearance Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ Traversing to clearance height Q301: definition of how the tool is to move between machining processes:
  - 0: Move to set-up clearance
  - 1: Move to 2nd set-up clearance

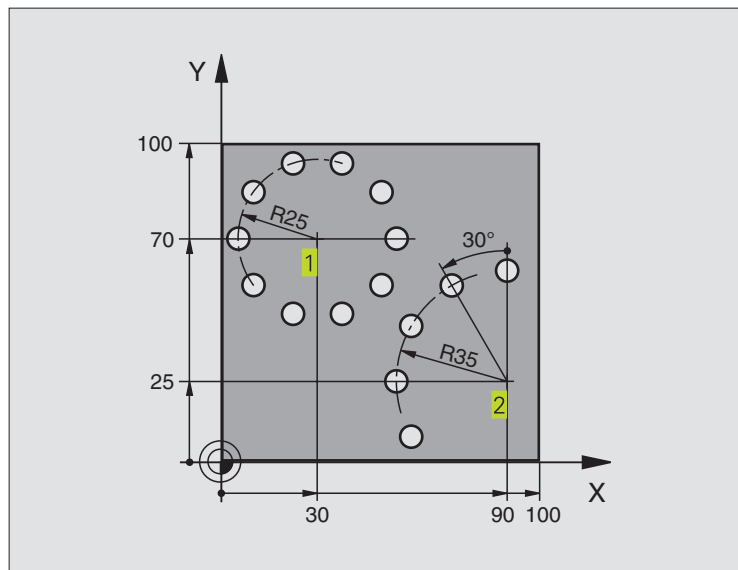


## Example NC blocks:

54	CYCL DEF 221	CARTESIAN PATTRN
Q225=+15	;STARTNG PNT 1ST AXIS	
Q226=+15	;STARTNG PNT 2ND AXIS	
Q237=+10	;SPACING IN 1ST AXIS	
Q238=+8	;SPACING IN 2ND AXIS	
Q242=6	;NUMBER OF COLUMNS	
Q243=4	;NUMBER OF LINES	
Q224=+15	;ANGLE OF ROTATION	
Q200=2	;SET-UP CLEARANCE	
Q203=+0	;SURFACE COORDINATE	
Q204=50	;2. SET-UP CLEARANCE	
Q301=1	;TRAVERSE TO CLEARANCE HEIGHT	



## Example: Circular hole patterns



0	BEGIN PGM HOLEPAT MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+3	Define the tool
4	TOOL CALL 1 Z S3500	Tool call
5	L Z+250 R0 F MAX M3	Retract the tool
6	CYCL DEF 200 DRILLING	Cycle definition: drilling
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-15 ;DEPTH	
	Q206=250 ;FEED RATE FOR PLNGNG	
	Q202=4 ;PLUNGING DEPTH	
	Q210=0 ;DWELL TIME AT TOP	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=10 ;2ND SET-UP CLEARANCE	
	Q211=0.25 ;DWELL TIME AT BOTTOM	

7	CYCL DEF 220 POLAR PATTERN	Define cycle for circular pattern 1, CYCL 200 is called automatically,
	Q216=+30 ;CENTER IN 1ST AXIS	Q200, Q203 and Q204 are effective as defined in Cycle 220.
	Q217=+70 ;CENTER IN 2ND AXIS	
	Q244=50 ;PITCH CIRCLE DIA.	
	Q245=+0 ;STARTING ANGLE	
	Q246=+360 ;STOPPING ANGLE	
	Q247=+0 ;STEPPING ANGLE	
	Q241=10 ;NR OF REPETITIONS	
	Q200=2 ;SET-UP CLEARANCE	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=100 ;2ND SET-UP CLEARANCE	
	Q301=1 ;TRAVERSE TO CLEARANCE HEIGHT	
8	CYCL DEF 220 POLAR PATTERN	Define cycle for circular pattern 2, CYCL 200 is called automatically,
	Q216=+90 ;CENTER IN 1ST AXIS	Q200, Q203 and Q204 are effective as defined in Cycle 220.
	Q217=+25 ;CENTER IN 2ND AXIS	
	Q244=70 ;PITCH CIRCLE DIA.	
	Q245=+90 ;STARTING ANGLE	
	Q246=+360 ;STOPPING ANGLE	
	Q247=+30 ;STEPPING ANGLE	
	Q241=5 ;NR OF REPETITIONS	
	Q200=2 ;SET-UP CLEARANCE	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=100 ;2ND SET-UP CLEARANCE	
	Q301=1 ;TRAVERSE TO CLEARANCE HEIGHT	
9	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
10	END PGM BOHRB MM	

## 8.5 SL Cycles

SL cycles allow the contour-oriented machining of complex contours and achieve a particularly high degree of surface finish.

### Characteristics of the contour

- A contour can be composed of several overlapping subcontours (up to 12 subcontours are possible). Islands and pockets can form a subcontour.
- The subcontour list (subprogram numbers) is entered in Cycle 14 CONTOUR GEOMETRY. The TNC calculates the contour from the subcontours.
- The individual subcontours are defined in subprograms.
- The memory capacity for programming an SL cycle is limited. All subprograms together can contain, for example, up to 128 straight-line blocks.

### Characteristics of the subprograms

- Coordinate transformations are allowed.
- The TNC ignores feed rates F and miscellaneous functions M.
- The TNC recognizes a pocket if the tool path lies inside the contour, for example if you machine the contour clockwise with radius compensation RR.
- The TNC recognizes an island if the tool path lies outside the contour, for example if you machine the contour clockwise with radius compensation RL.
- The subprograms must not contain tool axis coordinates.
- The working plane is defined in the first coordinate block of the subprogram. The secondary axes U,V,W are permitted.

### Characteristics of the fixed cycles

- The TNC automatically positions the tool to set-up clearance before a cycle.
- Each level of infeed depth is milled without interruptions since the cutter traverses around islands instead of over them.
- The radius of "inside corners" can be programmed — the tool keeps moving to prevent surface blemishes at inside corners (this applies for the outermost pass in the Rough-out and Side-Finishing cycles).
- The contour is approached in a tangential arc for side finishing.
- For floor finishing, the tool again approaches the workpiece in a tangential arc (for tool axis Z, for example, the arc may be in the Z/X plane).
- The contour is machined throughout in either climb or up-cut milling.



With MP7420 you can determine where the tool is positioned at the end of Cycles 21 to 24.

The machining data (such as milling depth, finishing allowance and setup clearance) are entered as CONTOUR DATA in Cycle 20.

Overview of SL cycles

Cycle	Soft key
14 CONTOUR GEOMETRY (essential)	
20 CONTOUR DATA (essential)	
21 PILOT DRILLING (optional)	
22 ROUGH-OUT (essential)	
23 FLOOR FINISHING (optional)	
24 SIDE FINISHING (optional)	

Enhanced cycles:

Cycle	Soft key
25 CONTOUR TRAIN	
27 CYLINDER SURFACE	
28 CYLINDER SURFACE slot milling	

Program structure: Working with SL cycles

```
0 BEGIN PGM SL2 MM
...
12 CYCL DEF 14.0 contour geometry ...
13 CYCL DEF 20.0 contour data ...
...
16 CYCL DEF 21.0 pilot drilling ...
17 CYCL CALL
...
18 CYCL DEF 22.0 rough-out ...
19 CYCL CALL
...
22 CYCL DEF 23.0 floor finishing ...
23 CYCL CALL
...
26 CYCL DEF 24.0 side finishing ...
27 CYCL CALL
...
50 L Z+250 R0 FMAX M2
51 LBL 1
...
55 LBL 0
56 LBL 2
...
60 LBL 0
...
99 END PGM SL2 MM
```

## CONTOUR GEOMETRY (Cycle 14)

All subprograms that are superimposed to define the contour are listed in Cycle 14 CONTOUR GEOMETRY.



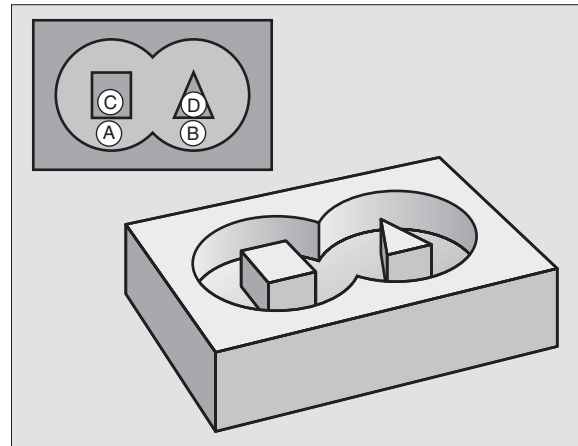
Before programming, note the following:

Cycle 14 is DEF active which means that it becomes effective as soon as it is defined in the part program.

You can list up to 12 subprograms (subcontours) in Cycle 14.



► Label numbers for the contour: Enter all label numbers for the individual subprograms that are to be superimposed to define the contour. Confirm every label number with the ENT key. When you have entered all numbers, conclude entry with the END key.



### Example NC blocks:

55 CYCL DEF 14.0 CONTOUR GEOMETRY

56 CYCL DEF 14.1 CONTOUR LABEL 1 /2 /3

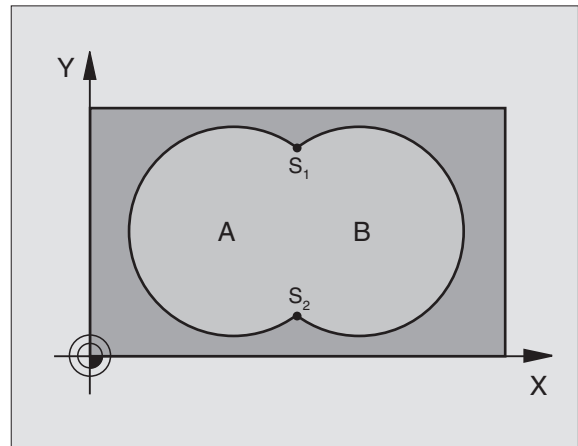
### Overlapping contours

Pockets and islands can be overlapped to form a new contour. You can thus enlarge the area of a pocket by another pocket or reduce it by an island.

#### Subprograms: Overlapping pockets



The subsequent programming examples are contour subprograms that are called by Cycle 14 CONTOUR GEOMETRY in a main program.



Pockets A and B overlap.

The TNC calculates the points of intersection  $S_1$  and  $S_2$  (they do not have to be programmed).

The pockets are programmed as full circles.

Subprogram 1: Left pocket

```
51 LBL 1
52 L X+10 Y+50 RR
53 CC X+35 Y+50
54 C X+10 Y+50 DR-
55 LBL 0
```

Subprogram 2: Right pocket

```
56 LBL 2
57 L X+90 Y+50 RR
58 CC X+65 Y+50
59 C X+90 Y+50 DR-
60 LBL 0
```

Area of inclusion

Both surfaces *A* and *B* are to be machined, including the mutually overlapped area:

- The surfaces *A* and *B* must be pockets.
- The first pocket (in Cycle 14) must start outside the second pocket.

Surface A:

```
51 LBL 1
52 L X+10 Y+50 RR
53 CC X+35 Y+50
54 C X+10 Y+50 DR-
55 LBL 0
```

Surface B:

```
56 LBL 2
57 L X+90 Y+50 RR
58 CC X+65 Y+50
59 C X+90 Y+50 DR-
60 LBL 0
```

Area of exclusion

Surface *A* is to be machined without the portion overlapped by *B*

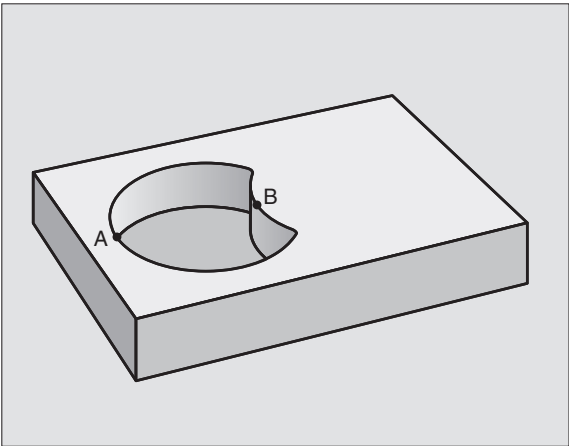
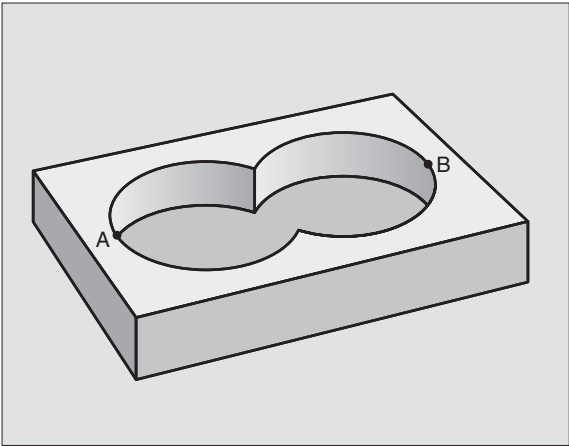
- Surface *A* must be a pocket and *B* an island.
- *A* must start outside of *B*.

Surface A:

```
51 LBL 1
52 L X+10 Y+50 RR
53 CC X+35 Y+50
54 C X+10 Y+50 DR-
55 LBL 0
```

Surface B:

```
56 LBL 2
57 L X+90 Y+50 RL
58 CC X+65 Y+50
59 C X+90 Y+50 DR-
60 LBL 0
```



### Area of intersection

Only the area overlapped by both *A* and *B* is to be machined. (The areas covered by *A* or *B* alone are to be left unmachined.)

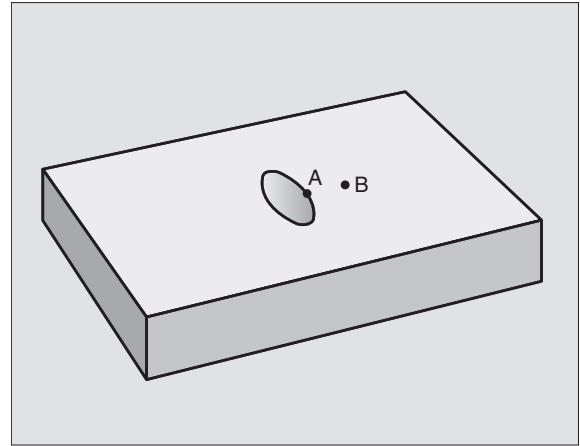
- *A* and *B* must be pockets.
- *A* must start inside of *B*.

Surface A:

```
51 LBL 1
52 L X+60 Y+50 RR
53 CC X+35 Y+50
54 C X+60 Y+50 DR-
55 LBL 0
```

Surface B:

```
56 LBL 2
57 L X+90 Y+50 RR
58 CC X+65 Y+50
59 C X+90 Y+50 DR-
60 LBL 0
```



### CONTOUR DATA (Cycle 20)

Machining data for the subprograms describing the subcontours are entered in Cycle 20.



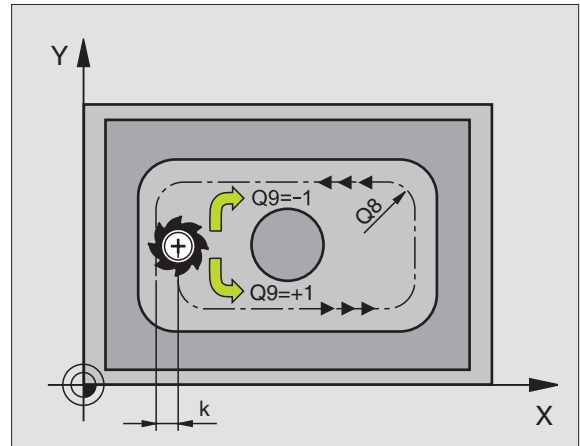
#### Before programming, note the following:

Cycle 20 is DEF active which means that it becomes effective as soon as it is defined in the part program.

The algebraic sign for the depth parameter determines the working direction.

The machining data entered in Cycle 20 are valid for Cycles 21 to 24.

If you are using the SL cycles in Q parameter programs, the cycle parameters Q1 to Q19 cannot be used as program parameters.



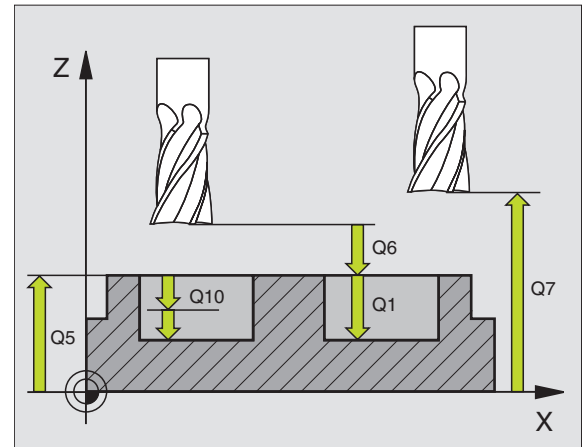
- ▶ Milling depth Q1 (incremental value): Distance between workpiece surface and pocket floor
- ▶ Path overlap factor Q2:  $Q2 \times \text{tool radius} = \text{stepover factor } k$
- ▶ Finishing allowance for side Q3 (incremental value): Finishing allowance in the working plane
- ▶ Finishing allowance for floor Q4 (incremental value): Finishing allowance in the tool axis
- ▶ Workpiece surface coordinate Q5 (absolute value): Absolute coordinate of the workpiece surface

- ▶ Set-up clearance Q6 (incremental value): Distance between tool tip and workpiece surface
- ▶ Clearance height Q7 (absolute value): Absolute height at which the tool cannot collide with the workpiece (for intermediate positioning and retraction at the end of the cycle)
- ▶ Inside corner radius Q8: Inside „corner“ rounding radius; entered value is referenced to the tool midpoint path
- ▶ Direction of rotation ? Clockwise = -1 Q9: Machining direction for pockets
  - Clockwise (Q9 = -1 up-cut milling for pocket and island)
  - Counterclockwise (Q9 = +1 climb milling for pocket and island)

You can check the machining parameters during a program interruption and overwrite them if required.

## Example NC blocks:

57	CYCL DEF 20.0 CONTOUR DATA
Q1=-20	;MILLING DEPTH
Q2=1	;TOOL PATH OVERLAP
Q3=+0.2	;ALLOWANCE FOR SIDE
Q4=+0.1	;ALLOWANCE FOR FLOOR
Q5=+0	;SURFACE COORDINATE
Q6=+2	;SET-UP CLEARANCE
Q7=+50	;CLEARANCE HEIGHT
Q8=0.5	;ROUNDING RADIUS
Q9=+1	;DIRECTION OF ROTATION





# PILOT DRILLING (Cycle 21)



When calculating the infeed points, the TNC does not account for the delta value DR programmed in a TOOL CALL block.

## Process

Same as Cycle 1 Pecking (see "8.2 Drilling Cycles").

## Application

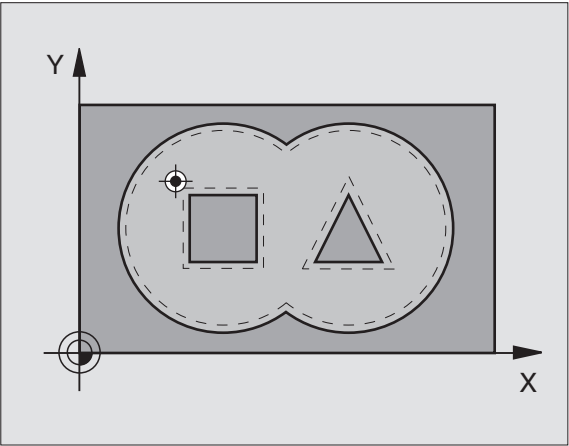
Cycle 21 is for PILOT DRILLING of the cutter infeed points. It accounts for the allowance for side and the allowance for floor as well as the radius of the rough-out tool. The cutter infeed points also serve as starting points for roughing.



- ▶ Plunging depth Q10 (incremental value): Dimension by which the tool drills in each infeed (negative sign for negative working direction)
- ▶ Feed rate for plunging Q11: Traversing speed in mm/min during drilling
- ▶ Rough-out tool number Q13: Tool number of the roughing mill


## Example NC blocks:

58	CYCL DEF 21.0 PILOT DRILLING
Q10=+5	; PLUNGING DEPTH
Q11=100	; FEED RATE FOR PLUNGING
Q13=1	; ROUGH_OUT TOOL



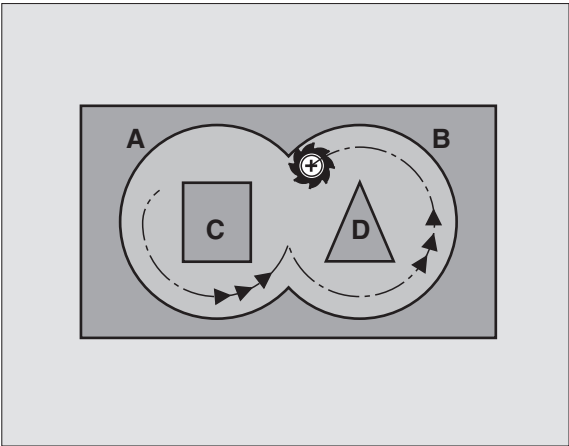
ROUGH-OUT (Cycle 22)

- 1 The TNC positions the tool over the cutter infeed point, taking the allowance for side into account.
- 2 In the first plunging depth, the tool mills the contour from inside outward at the milling feed rate.
- 3 First the island contours (C and D in the figure at right) are rough-milled until the pocket contour (A, B) is approached.
- 4 Then the pocket contour is rough-milled and the tool is retracted to the clearance height.



**Before programming, note the following:**

This cycle requires a center-cut end mill (ISO 1641) or pilot drilling with Cycle 21.



- ▶ Plunging depth Q10 (incremental value):  
Dimension by which the tool plunges in each infeed
- ▶ Feed rate for plunging Q11: Traversing speed of the tool in mm/min during penetration
- ▶ Feed rate for milling Q12: Traversing speed for milling in mm/min
- ▶ Coarse roughing tool number Q18: Number of the tool with which the TNC has already coarse-roughed the contour. If the contour has not been coarse-roughed, enter zero. If you enter a value other than 0, the TNC will only rough-out the portion that could not be machined with the coarse roughing tool. If the portion that is to be fine-roughed cannot be approached from the side, the TNC will mill in a reciprocating plunge-cut. For this purpose, you must enter the tooth length LCUTS and the maximum plunge angle ANGLE of the tool in the tool table TOOL.T (see Chapter 5.2). The TNC will otherwise generate an error message.
- ▶ Reciprocation feed rate Q19: Traversing speed of the tool in mm/min during reciprocating plunge-cut

Example NC blocks:

59	CYCL DEF 22.0	ROUGH-OUT
	Q10=+5	; PLUNGING DEPTH
	Q11=100	; FEED RATE FOR PLUNGING
	Q12=350	; FEED RATE FOR MILLING
	Q18=1	; COARSE ROUGHING TOOL
	Q19=150	; RECIPROCATION FEED RATE

## FLOOR FINISHING (Cycle 23)



The TNC automatically calculates the starting point for finishing. The starting point depends on the available space in the pocket.

The tool approaches the machining plane smoothly (in a vertically tangential arc). The tool then clears the finishing allowance remaining from rough-out.



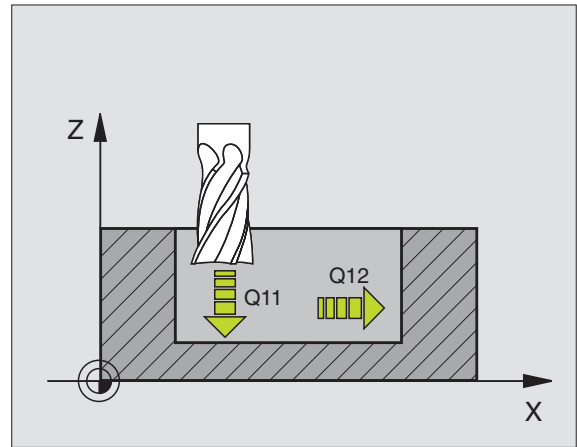
- ▶ Feed rate for plunging: Traversing speed of the tool during penetration
- ▶ Feed rate for milling Q12: Traversing speed for milling

### Example NC blocks:

```
60 CYCL DEF 23.0 FLOOR FINISHING
```

```
Q11=100 ;FEED RATE FOR PLUNGING
```

```
Q12=350 ;FEED RATE FOR MILLING
```



## SIDE FINISHING (Cycle 24)

The subcontours are approached and departed on a tangential arc. Each subcontour is finish-milled separately.



### Before programming, note the following:

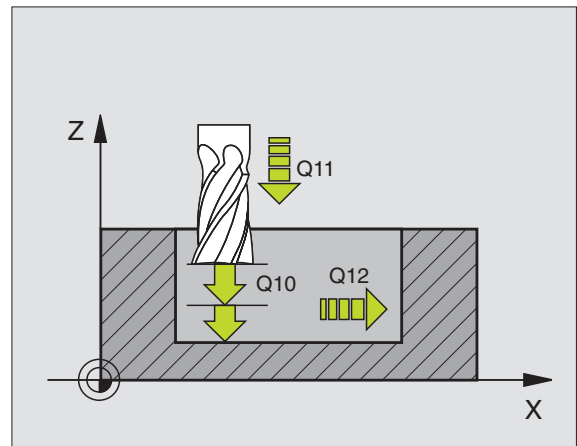
The sum of allowance for side (Q14) and the radius of the finish mill must be smaller than the sum of allowance for side (Q3, Cycle 20) and the radius of the rough mill.

This calculation also holds if you run Cycle 24 without having roughed out with Cycle 22; in this case, enter "0" for the radius of the rough mill.

The TNC automatically calculates the starting point for finishing. The starting point depends on the available space in the pocket.



- ▶ Direction of rotation ? Clockwise = -1 Q9:  
Direction of machining:  
+1: Counterclockwise  
-1: Clockwise
- ▶ Plunging depth Q10 (incremental value):  
Dimension by which the tool plunges in each feed
- ▶ Feed rate for plunging Q11: Traversing speed of the tool during penetration
- ▶ Feed rate for milling Q12: Traversing speed for milling
- ▶ Finishing allowance for side Q14 (incremental value):  
Enter the allowed material for several finish-milling operations. If you enter Q14 = 0, the remaining finishing allowance will be cleared.



### Example NC blocks:

```
61 CYCL DEF 24.0 SIDE FINISHING
```

```
Q9=+1 ;DIRECTION OF ROTATION
```

```
Q10=+5 ;PLUNGING DEPTH
```

```
Q11=100 ;FEED RATE FOR PLUNGING
```

```
Q12=350 ;FEED RATE FOR MILLING
```

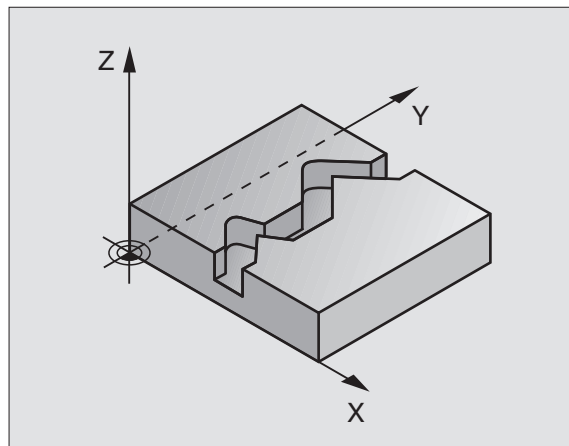
```
Q14=+0 ;ALLOWANCE FOR SIDE
```

## CONTOUR TRAIN (Cycle 25)

In conjunction with Cycle 14 CONTOUR GEOMETRY, this cycle facilitates the machining of open contours (where the starting point of the contour is not the same as its end point).

Cycle 25 CONTOUR TRAIN offers considerable advantages over machining an open contour using positioning blocks:

- The TNC monitors the operation to prevent undercuts and surface blemishes. It is recommended that you run a graphic simulation of the contour before execution.
- If the radius of the selected tool is too large, the corners of the contour may have to be reworked.
- The contour can be machined throughout by up-cut or by climb milling. The type of milling even remains effective when the contours are mirrored.
- The tool can traverse back and forth for milling in several infeeds: This results in faster machining.
- Allowance values can be entered in order to perform repeated rough-milling and finish-milling operations.



### Before programming, note the following:

The algebraic sign for the depth parameter determines the working direction.

The TNC takes only the first label of Cycle 14 CONTOUR GEOMETRY into account.

The memory capacity for programming an SL cycle is limited. For example, you can program up to 128 straight-line blocks in one SL cycle.

Cycle 20 CONTOUR DATA is not required.

Positions that are programmed in incremental dimensions immediately after Cycle 25 are referenced to the position of the tool at the end of the cycle.



- ▶ Milling depth Q1 (incremental value): Distance between workpiece surface and contour floor
- ▶ Finishing allowance for side Q3 (incremental value): Finishing allowance in the working plane
- ▶ Workpiece surface coordinate Q5 (absolute value): Absolute coordinate of the workpiece surface referenced to the workpiece datum
- ▶ Clearance height Q7 (absolute value): Absolute height at which the tool cannot collide with the workpiece. Position for tool retraction at the end of the cycle.
- ▶ Plunging depth Q10 (incremental value): Dimension by which the tool plunges in each infeed
- ▶ Feed rate for plunging Q11: Traversing speed of the tool in the tool axis
- ▶ Feed rate for milling Q12: Traversing speed of the tool in the working plane
- ▶ Climb or up-cut ? Up-cut = -1 Q15:  
 Climb milling: Input value = +1  
 Conventional up-cut milling Input value = -1  
 To enable climb milling and up-cut milling alternately in several infeeds Input value = 0

**Example NC blocks:**

<b>62</b>	<b>CYCL DEF 25.0 CONTOUR TRAIN</b>
<b>Q1=-20</b>	<b>;MILLING DEPTH</b>
<b>Q3=+0</b>	<b>;ALLOWANCE FOR SIDE</b>
<b>Q5=+0</b>	<b>;SURFACE COORDINATE</b>
<b>Q7=+50</b>	<b>;CLEARANCE HEIGHT</b>
<b>Q10=+5</b>	<b>;PLUNGING DEPTH</b>
<b>Q11=100</b>	<b>;FEED RATE FOR PLUNGING</b>
<b>Q12=350</b>	<b>;FEED RATE FOR MILLING</b>
<b>Q15=+1</b>	<b>;CLIMB OR UP-CUT</b>

## CYLINDER SURFACE (Cycle 27)



The machine tool and the TNC must be prepared by the machine tool builder for the use of Cycle 27 CYLINDER SURFACE.

This cycle enables you to program a contour in two dimensions and then roll it onto a cylindrical surface for 3-D machining. Use Cycle 28 if you wish to mill guide notches onto the cylinder surface.

The contour is described in a subprogram identified in Cycle 14 CONTOUR GEOMETRY.

The subprogram contains coordinates in a rotary axis and in its parallel axis. The rotary axis C, for example, is parallel to the Z axis. The path functions L, CHF, CR, RND are available.

The dimensions in the rotary axis can be entered as desired either in degrees or in mm (or inches). You can select the desired dimension type in the cycle definition.

- 1 The TNC positions the tool over the cutter infeed point, taking the allowance for side into account.
- 2 At the first plunging depth, the tool mills along the programmed contour at the milling feed rate Q12.
- 3 At the end of the contour, the TNC returns the tool to the setup clearance and returns to the point of penetration;
- 4 Steps 1 to 3 are repeated until the programmed milling depth Q1 is reached.
- 5 Then the tool moves to the setup clearance.



### Before programming, note the following:

The memory capacity for programming an SL cycle is limited. For example, you can program up to 128 straight-line blocks in one SL cycle.

The algebraic sign for the depth parameter determines the working direction.

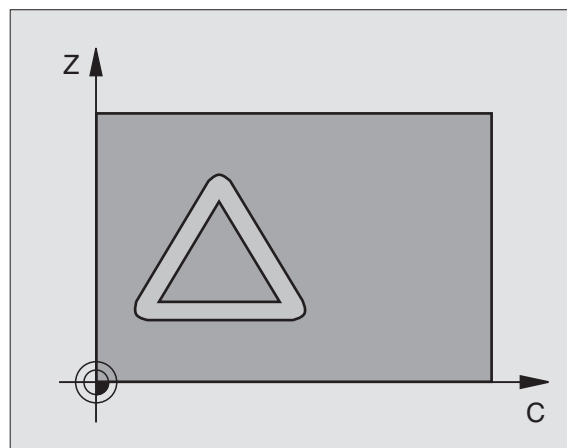
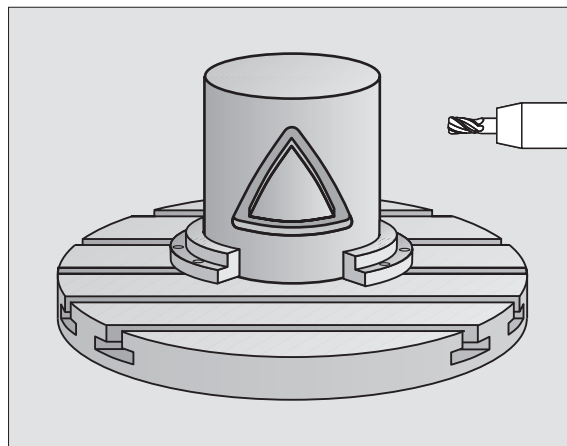
This cycle requires a center-cut end mill (ISO 1641).

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in Machine Parameter 810.x. If the error message „Contour programming error“ is output, set MP 810.x = 0.





- ▶ Milling depth Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour
- ▶ Finishing allowance for Q3 (incremental value): Finishing allowance in the plane of the unrolled cylindrical surface. This allowance is effective in the direction of the radius compensation.
- ▶ Set-up clearance Q6 (incremental value): Distance between the tool tip and the cylinder surface
- ▶ Plunging depth Q10 (incremental value): Dimension by which the tool plunges in each infeed
- ▶ Feed rate for plunging Q11: Traversing speed of the tool in the tool axis
- ▶ Feed rate for milling Q12: Traversing speed of the tool in the working plane
- ▶ Radius Q16: Radius of the cylinder on which the contour is to be machined
- ▶ Dimension type ? Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1)

#### Example NC blocks:

63	CYCL DEF 27.0 CYLINDER SURFACE
Q1=-8	;MILLING DEPTH
Q3=+0	;ALLOWANCE FOR SIDE
Q6=+0	;SET-UP CLEARANCE
Q10=+3	;PLUNGING DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR MILLING
Q16=25	;RADIUS
Q17=0	;DIMENSION TYPE

## CYLINDER SURFACE slot milling (Cycle 28)



The TNC and the machine tool must be specially prepared by the machine tool builder for the use of Cycle 28 CYLINDER SURFACE.

This cycle enables you to program a guide notch in two dimensions and then transfer it onto a cylindrical surface. Unlike Cycle 27, with this cycle the TNC adjusts the tool so that, with radius compensation active, the walls of the slot are always parallel. Program the center-line path of the contour.

- 1 The TNC positions the tool over the cutter infeed point.
- 2 At the first plunging depth, the tool mills along the programmed slot wall at the milling feed rate Q12 while respecting the finishing allowance for the side.
- 3 At the end of the contour, the TNC moves the tool to the opposite wall and returns to the infeed point.
- 4 Steps 2 to 3 are repeated until the programmed milling depth Q1 is reached.
- 5 Then the tool moves to the setup clearance.



### Before programming, note the following:

The memory capacity for programming an SL cycle is limited. For example, you can program up to 128 straight-line blocks in one SL cycle.

The algebraic sign for the depth parameter determines the working direction.

This cycle requires a center-cut end mill (ISO 1641).

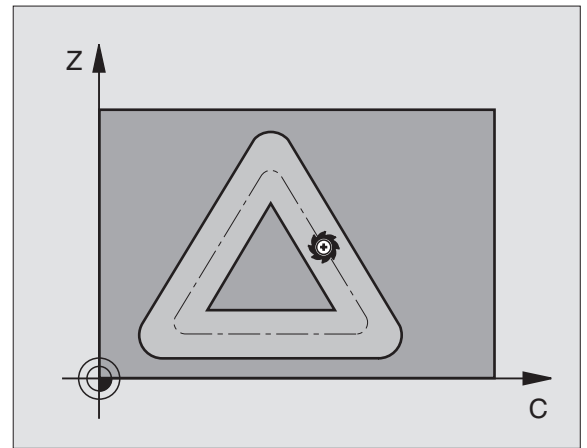
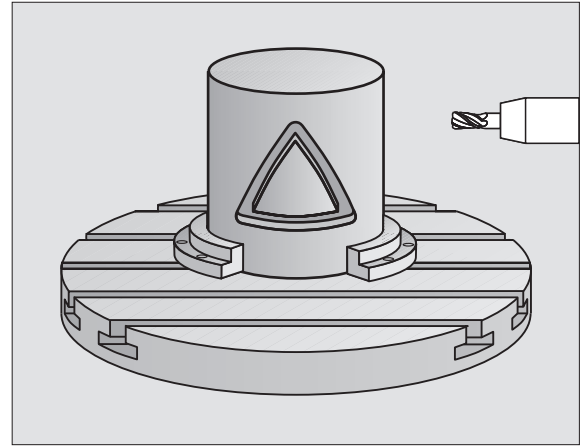
If the cutter diameter is smaller than half the slot width, you may want to run Cycle 27 with an R0 tool radius for roughing.

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in Machine Parameter 810.x. If the error message „Contour programming error“ is output, set MP 810.x = 0.





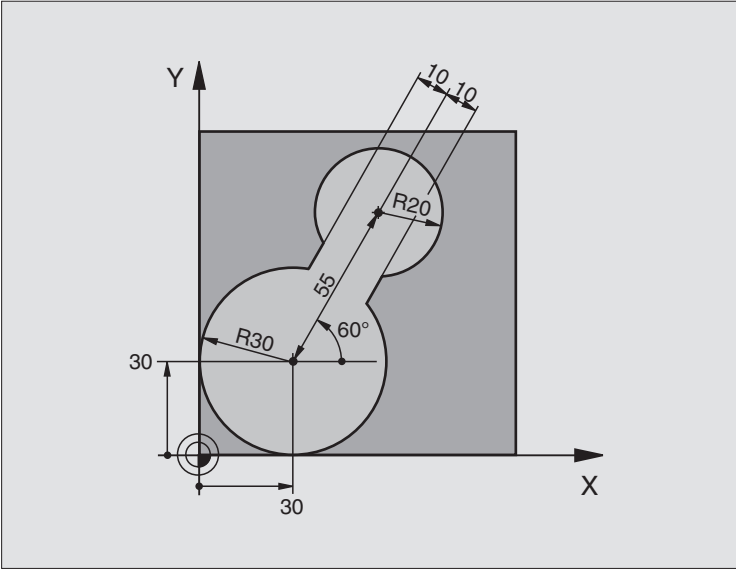


- ▶ Milling depth Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour
- ▶ Finishing allowance for Q3 (incremental value): Finishing allowance in the plane of the unrolled cylindrical surface. This allowance is effective in the direction of the radius compensation.
- ▶ Set-up clearance Q6 (incremental value): Distance between the tool tip and the cylinder surface
- ▶ Plunging depth Q10 (incremental value): Dimension by which the tool plunges in each infeed
- ▶ Feed rate for plunging Q11: Traversing speed of the tool in the tool axis
- ▶ Feed rate for milling Q12: Traversing speed of the tool in the working plane
- ▶ Radius Q16: Radius of the cylinder on which the contour is to be machined
- ▶ Dimension type ? Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1)
- ▶ Slot width Q20: Width of the slot to be machined

**Example NC blocks:**

<b>63</b>	<b>CYCL DEF 28.0 CYLINDER SURFACE</b>
<b>Q1=-8</b>	<b>;MILLING DEPTH</b>
<b>Q3=+0</b>	<b>;ALLOWANCE FOR SIDE</b>
<b>Q6=+0</b>	<b>;SET-UP CLEARANCE</b>
<b>Q10=+3</b>	<b>;PLUNGING DEPTH</b>
<b>Q11=100</b>	<b>;FEED RATE FOR PLUNGING</b>
<b>Q12=350</b>	<b>;FEED RATE FOR MILLING</b>
<b>Q16=25</b>	<b>;RADIUS</b>
<b>Q17=0</b>	<b>;DIMENSION TYPE</b>
<b>Q20=12</b>	<b>;SLOT WIDTH</b>

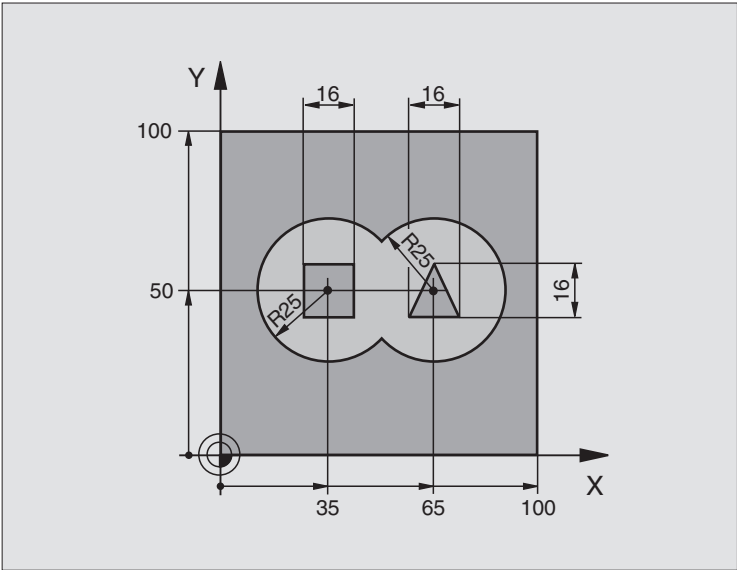
### Example: Roughing-out and fine-roughing a pocket



0	BEGIN PGM C20 MM	
1	BLK FORM 0.1 Z X-10 Y-10 Z-40	
2	BLK FORM 0.2 X+100 Y+100 Z+0	Define the workpiece blank
3	TOOL DEF 1 L+0 R+15	Tool definition: coarse roughing tool
4	TOOL DEF 2 L+0 R+7.5	Tool definition: fine roughing tool
5	TOOL CALL 1 Z S2500	Tool call: coarse roughing tool
6	L Z+250 R0 F MAX	Retract the tool
7	CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
8	CYCL DEF 14.1 CONTOUR LABEL 1	
9	CYCL DEF 20.0 CONTOUR DATA	Define general machining parameters
	Q1=-20 ;MILLING DEPTH	
	Q2=1 ;TOOL PATH OVERLAP	
	Q3=+0 ;ALLOWANCE FOR SIDE	
	Q4=+0 ;ALLOWANCE FOR FLOOR	
	Q5=+0 ;SURFACE COORDINATE	
	Q6=2 ;SET-UP CLEARANCE	
	Q7=+100 ;CLEARANCE HEIGHT	
	Q8=0.1 ;ROUNDING RADIUS	
	Q9=-1 ;DIRECTION OF ROTATION	

10	CYCL DEF 22.0 ROUGH-OUT	Cycle definition: Coarse roughing
	Q10=5 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=350 ;FEED RATE FOR MILLING	
	Q18=0 ;COARSE ROUGHING TOOL	
	Q19=150 ;RECIPROCATION FEED RATE	
11	CYCL CALL M3	Cycle call: Coarse roughing
12	L Z+250 R0 F MAX M6	Tool change
13	TOOL CALL 2 Z S3000	Tool call: fine roughing tool
14	CYCL DEF 22.0 ROUGH-OUT	Define the fine roughing cycle
	Q10=5 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=350 ;FEED RATE FOR MILLING	
	Q18=1 ;COARSE ROUGHING TOOL	
	Q19=150 ;RECIPROCATION FEED RATE	
15	CYCL CALL M3	Cycle call: Fine roughing
16	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
17	LBL 1	Contour subprogram
18	L X+0 Y+30 RR	(see second FK programming example in section "6.6 Path
19	FC DR- R30 CCX+30 CCY+30	Contours FK Free Contour Programming")
20	FL AN+60 PDX+30 PDY+30 D10	
21	FSELECT 3	
22	FPOL X+30 Y+30	
23	FC DR- R20 CCPR+55 CCPA+60	
24	FSELECT 2	
25	FL AN-120 PDX+30 PDY+30 D10	
26	FSELECT 3	
27	FC X+0 DR- R30 CCX+30 CCY+30	
28	FSELECT 2	
29	LBL 0	
30	END PGM C20 MM	

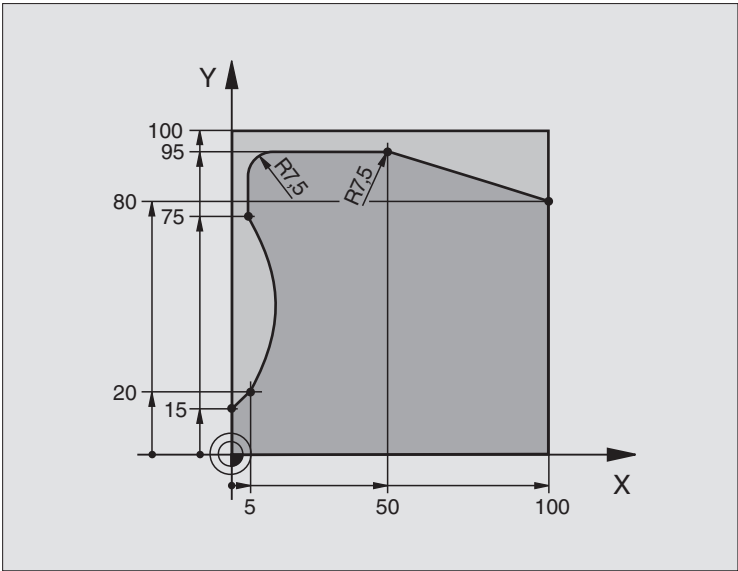
Example: Pilot drilling, roughing-out and finishing overlapping contours



0	BEGIN PGM C21 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+6	Tool definition: drill
4	TOOL DEF 2 L+0 R+6	Define the tool for roughing/finishing
5	TOOL CALL 1 Z S2500	Call the drilling tool
6	L Z+250 R0 F MAX	Retract the tool
7	CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
8	CYCL DEF 14.1 CONTOUR LABEL 1 /2 /3 /4	
9	CYCL DEF 20.0 CONTOUR DATA	Define general machining parameters
	Q1=-20 ;MILLING DEPTH	
	Q2=1 ;TOOL PATH OVERLAP	
	Q3=+0.5 ;ALLOWANCE FOR SIDE	
	Q4=+0.5 ;ALLOWANCE FOR FLOOR	
	Q5=+0 ;SURFACE COORDINATE	
	Q6=2 ;SET-UP CLEARANCE	
	Q7=+100 ;CLEARANCE HEIGHT	
	Q8=0.1 ;ROUNDING RADIUS	
	Q9=-1 ;DIRECTION OF ROTATION	
10	CYCL DEF 21.0 PILOT DRILLING	Cycle definition: PILOT DRILLING
	Q10=5 ;PLUNGING DEPTH	
	Q11=250 ;FEED RATE FOR PLUNGING	
	Q13=2 ;ROUGH-OUT TOOL	
11	CYCL CALL M3	Cycle call: PILOT DRILLING

12	L Z+250 RO F MAX M6	Tool change
13	TOOL CALL 2 Z S3000	Call tool for roughing/finishing
14	CYCL DEF 22.0 ROUGH-OUT	Cycle definition: ROUGH-OUT
	Q10=5 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=350 ;FEED RATE FOR MILLING	
	Q18=0 ;COARSE ROUGHING TOOL	
	Q19=150 ;RECIPROCATION FEED RATE	
15	CYCL CALL M3	Cycle call: ROUGH-OUT
16	CYCL DEF 23.0 FLOOR FINISHING	Cycle definition: FLOOR FINISHING
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=200 ;FEED RATE FOR MILLING	
17	CYCL CALL	Cycle call: FLOOR FINISHING
18	CYCL DEF 24.0 SIDE FINISHING	Cycle definition: SIDE FINISHING
	Q9=+1 ;DIRECTION OF ROTATION	
	Q10=5 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=400 ;FEED RATE FOR MILLING	
	Q14=+0 ;ALLOWANCE FOR SIDE	
19	CYCL CALL	Cycle call: SIDE FINISHING
20	L Z+250 RO F MAX M2	Retract in the tool axis, end program
21	LBL 1	Contour subprogram 1: left pocket
22	CC X+35 Y+50	
23	L X+10 Y+50 RR	
24	C X+10 DR-	
25	LBL 0	
26	LBL 2	Contour subprogram 2: right pocket
27	CC X+65 Y+50	
28	L X+90 Y+50 RR	
29	C X+90 DR-	
30	LBL 0	
31	LBL 3	Contour subprogram 3: square left island
32	L X+27 Y+50 RL	
33	L Y+58	
34	L X+43	
35	L Y+42	
36	L X+27	
37	LBL 0	
38	LBL 4	Contour subprogram 4: triangular right island
39	L X+65 Y+42 RL	
40	L X+57	
41	L X+65 Y+58	
42	L X+73 Y+42	
43	LBL 0	
44	END PGM C21 MM	


Example: Contour train

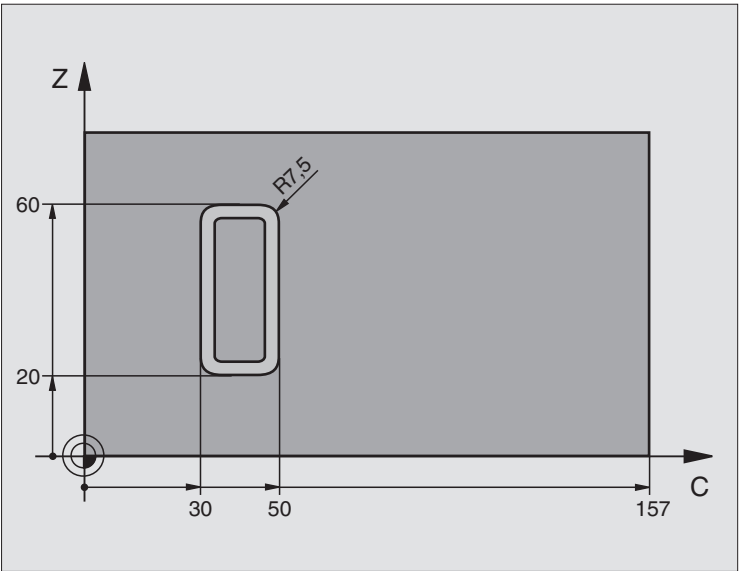


0	BEGIN PGM C25 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+10	Define the tool
4	TOOL CALL 1 Z S2000	Tool call
5	L Z+250 R0 F MAX	Retract the tool
6	CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
7	CYCL DEF 14.1 CONTOUR LABEL 1	
8	CYCL DEF 25.0 CONTOUR TRAIN	Define machining parameters
	Q1=-20 ;MILLING DEPTH	
	Q3=+0 ;ALLOWANCE FOR SIDE	
	Q5=+0 ;SURFACE COORDINATE	
	Q7=+250 ;CLEARANCE HEIGHT	
	Q10=5 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=200 ;FEED RATE FOR MILLING	
	Q15=+1 ;CLIMB OR UP-CUT	
9	CYCL CALL M3	Call the cycle
10	L Z+250 R0 F MAX M2	Retract in the tool axis, end program

11	LBL 1	Contour subprogram
12	L X+0 Y+15 RL	
13	L X+5 Y+20	
14	CT X+5 Y+75	
15	L Y+95	
16	RND R7.5	
17	L X+50	
18	RND R7.5	
19	L X+100 Y+80	
20	LBL 0	
21	END PGM C25 MM	

Example: Cylinder surface

 Cylinder centered on rotary table.  
Datum at center of rotary table



0	BEGIN PGM C27 MM	
1	TOOL DEF 1 L+0 R+3.5	Define the tool
2	TOOL CALL 1 Y S2000	Call tool, tool axis is Y
3	L Y+250 R0 FMAX	Retract the tool
4	L X+0 R0 FMAX	Position tool on rotary table center
5	CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
6	CYCL DEF 14.1 CONTOUR LABEL 1	
7	CYCL DEF 27.0 CYLINDER SURFACE	Define machining parameters
	Q1=-7 ;MILLING DEPTH	
	Q3=+0 ;ALLOWANCE FOR SIDE	
	Q6=2 ;SET-UP CLEARANCE	
	Q10=4 ;PLUNGING DEPTH	
	Q11=100 ;FEED RATE FOR PLUNGING	
	Q12=250 ;FEED RATE FOR MILLING	
	Q16=25 ;RADIUS	
	Q17=1 ;DIMENSION TYPE (ANG/LIN)	
8	L C+0 R0 F MAX M3	Pre-position rotary table
9	CYCL CALL	Call the cycle
10	L Y+250 R0 F MAX M2	Retract in the tool axis, end program



11	LBL 1	Contour subprogram
12	L C+40 Z+20 RL	Data for the rotary axis are entered in mm (Q17=1)
13	L C+50	
14	RND R7.5	
15	L Z+60	
16	RND R7.5	
17	L IC-20	
18	RND R7.5	
19	L Z+20	
20	RND R7.5	
21	L C+40	
22	LBL 0	
23	END PGM C27 MM	

## 8.6 Cycles for Multipass Milling

The TNC offers four cycles for machining surfaces with the following characteristics:

- Created by digitizing or with a CAD/CAM system
- Flat, rectangular surfaces
- Flat, oblique-angled surfaces
- Surfaces that are inclined in any way
- Twisted surfaces

Cycle	Soft key
30 RUN DIGITIZED DATA For multipass milling of digitized surface data in several infeeds	
230 MULTIPASS MILLING For flat rectangular surfaces	
231 RULED SURFACE For oblique, inclined or twisted surfaces	

### RUN DIGITIZED DATA (Cycle 30)

- 1 From the current position, the TNC positions the tool in rapid traverse FMAX in the tool axis to the set-up clearance above the MAX point that you have programmed in the cycle.
- 2 The tool then moves in FMAX in the working plane to the MIN point you have programmed in the cycle.
- 3 From this point, the tool advances to the first contour point at the feed rate for plunging.
- 4 The TNC subsequently processes all points that are stored in the digitizing data file at the feed rate for milling. If necessary, the TNC retracts the tool between machining operations to set-up clearance if specific areas are to be left unmachined.
- 5 At the end of the cycle, the tool is retracted in FMAX to set-up clearance.



### Before programming, note the following:

You can use Cycle 30 to run digitizing data and PNT files.

If you want to run PNT files in which no tool axis coordinate is programmed, the milling depth is derived from the programmed MIN point in the tool axis.

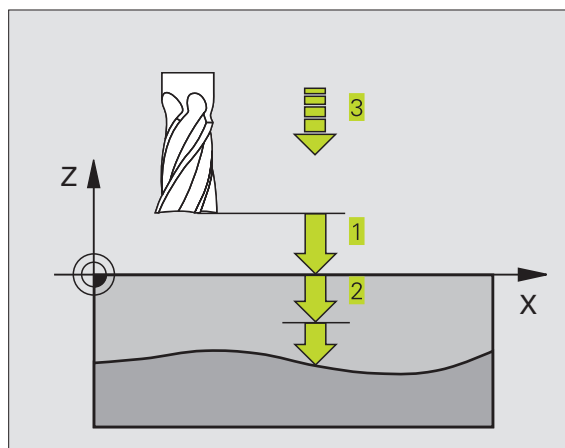
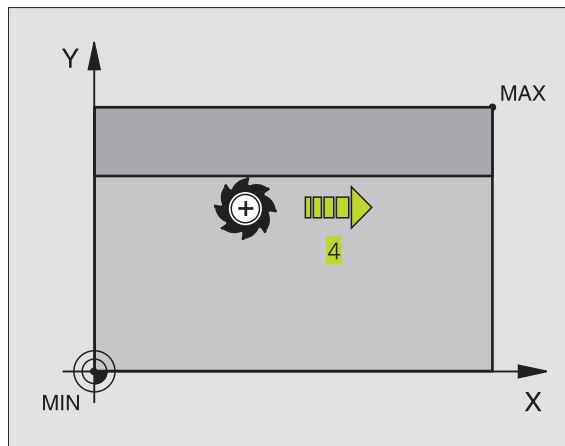


- ▶ PGM Name digitizing data: Enter the name of the file in which the digitizing data is stored. If the file is not stored in the current directory, enter the complete path. If you wish to execute a point table, enter also the file type .PNT.
- ▶ Min. point range: Lowest coordinates (X, Y and Z coordinates) in the range to be milled
- ▶ Max. point range: Highest coordinates (X, Y and Z coordinates) in the range to be milled
- ▶ Setup clearance **1** (incremental value): Distance between tool tip and workpiece surface for tool movements in rapid traverse
- ▶ Plunging depth **2** (incremental value): Dimension by which the tool is advanced in each infeed
- ▶ Feed rate for plunging **3**: Traversing speed of the tool in mm/min during penetration
- ▶ Feed rate for milling **4**: Traversing speed of the tool in mm/min while milling
- ▶ Miscellaneous function M: Optional entry of a miscellaneous function, for example M13

### Example NC blocks:

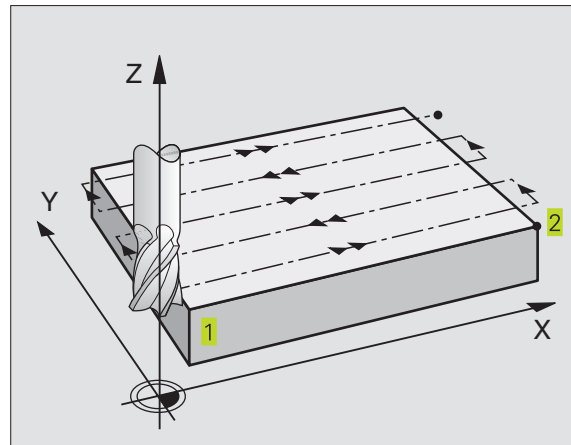
```

64 CYCL DEF 30.0 RUN DIGITIZED DATA
65 CYCL DEF 30.1 PGM DIGIT.: BSP.H
66 CYCL DEF 30.2 X+0 Y+0 Z-20
67 CYCL DEF 30.3 X+100 Y+100 Z+0
68 CYCL DEF 30.4 SET UP 2
69 CYCL DEF 30.5 PLNGNG +5 F100
70 CYCL DEF 30.6 F350 M8
  
```



## MULTIPASS MILLING (Cycle 230)

- 1 From the current position, the TNC positions the tool in rapid traverse in the working plane to the starting position. 1 During this movement, the TNC also offsets the tool by its radius to the left and upward.
- 2 The tool then moves in FMAX in the tool axis to set-up clearance. From there it approaches the programmed starting position in the tool axis at the feed rate for plunging.
- 3 The tool subsequently advances to the stopping point 2 at the feed rate for milling. 2 The stopping point is calculated from the programmed starting point, the programmed length and the tool radius.
- 4 The TNC offsets the tool to the starting point in the next pass at the stepover feed rate. The offset is calculated from the programmed width and the number of cuts.
- 5 The tool then returns in the negative direction of the first axis.
- 6 Multipass milling is repeated until the programmed surface has been completed.
- 7 At the end of the cycle, the tool is retracted in FMAX to set-up clearance.





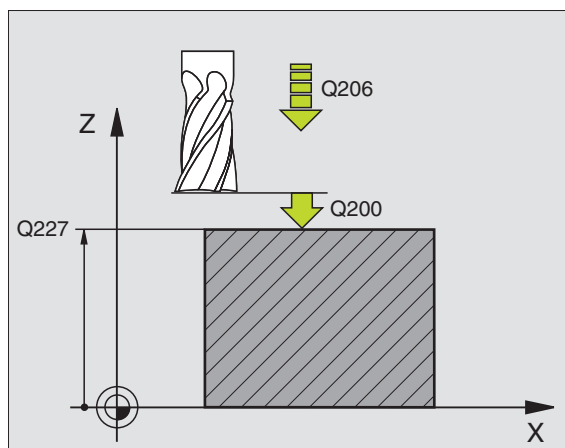
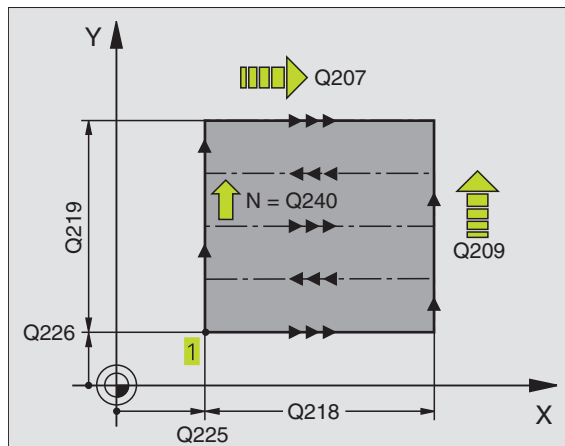
### Before programming, note the following:

From the current position, the TNC positions the tool at the starting point 1, first in the working plane and then in the tool axis. **1**.

Pre-position the tool in such a way that no collision between tool and clamping devices can occur.



- ▶ Starting point in 1st axis Q225 (absolute value): Min. point coordinate of the surface to be multipass-milled in the main axis of the working plane
- ▶ Starting point in 2nd axis Q226 (absolute value): Min. point coordinate of the surface to be multipass-milled in the secondary axis of the working plane
- ▶ Starting point in 3rd axis Q227 (absolute value): Height in the spindle axis at which multipass-milling is carried out.
- ▶ First side length Q218 (incremental value): Length of the surface to be multipass-milled in the main axis of the working plane, referenced to the starting point in 1st axis
- ▶ Second side length Q219 (incremental value): Length of the surface to be multipass-milled in the secondary axis of the working plane, referenced to the starting point in 2nd axis
- ▶ Number of cuts Q240: Number of passes to be made over the width
- ▶ Feed rate for plunging Q206: Traversing speed of the tool in mm/min when moving from set-up clearance to the milling depth
- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling.
- ▶ Stepper feed rate Q209: Traversing speed of the tool in mm/min when moving to the next pass. If you are moving the tool transversely in the material, enter Q209 to be smaller than Q207. If you are moving it transversely in the open, Q209 may be greater than Q207.
- ▶ Set-up clearance Q200 (incremental value): Distance between tool tip and milling depth for positioning at the start and end of the cycle.



### Example NC blocks:

71	CYCL DEF 230 MULTIPASS MILLING
Q225=+10	; STARTNG PNT 1ST AXIS
Q226=+12	; STARTNG PNT 2ND AXIS
Q227=+2.5	; STARTING PNT 3RD AXIS
Q218=150	; 1ST SIDE LENGTH
Q219=75	; 2ND SIDE LENGTH
Q240=25	; NUMBER OF CUTS
Q206=150	; FEED RATE FOR PLUNGING
Q207=500	; FEED RATE FOR MILLING
Q209=200	; STEPOVER FEED RATE
Q200=2	; SET-UP CLEARANCE

## RULED SURFACE (Cycle 231)

- 1 From the current position, the TNC positions the tool in a linear 3-D movement to the starting point 1. **1**
- 2 The tool subsequently advances to the stopping point 2 at the feed rate for milling. **2**
- 3 From this point, the tool moves in rapid traverse FMAX by the tool diameter in the positive tool axis direction, and then back to starting point 1. **1**
- 4 At the starting position **1** the TNC moves the tool back to the the last traversed Z value.
- 5 Then the TNC moves the tool in all three axes from point **1** in the direction of point **4** to the next line.
- 6 From this point, the tool moves to the stopping point on this pass. The TNC calculates the stopping point using point **2** and an offset in the direction of point **3**.
- 7 Multipass milling is repeated until the programmed surface has been completed.
- 8 At the end of the cycle, the tool is positioned above the highest programmed point in the tool axis, offset by the tool diameter.

### Cutting motion

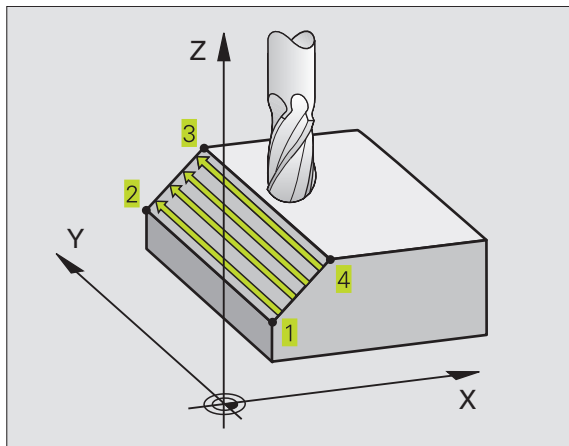
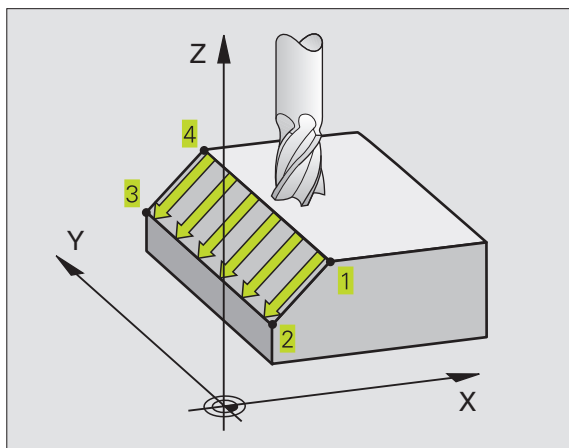
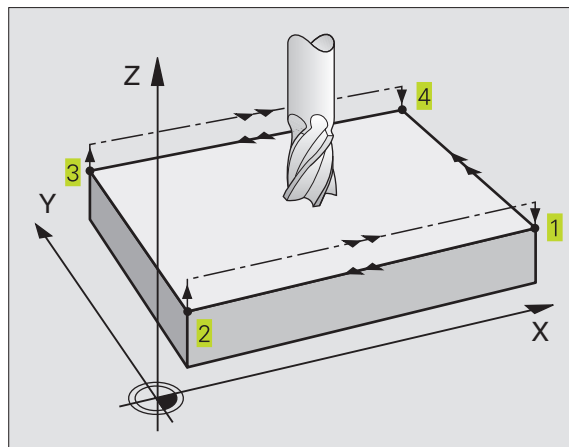
You can freely choose the starting point and thus the milling direction since the TNC always performs the individual cuts from point **1** to point **2** and the process sequence is executed from point **1** / **2** to point **3** / **4**. You can position point **1** in any corner of the surface to be machined.

If you are using an end mill for the machining operation, you can optimize the surface finish in the following ways

- a shaping cut (tool axis coordinate of point **1** greater than tool axis coordinate of point **2**) for slightly inclined surfaces.
- a drawing cut (tool axis coordinate of point **1** less than tool axis coordinate of point **2**) for steep surfaces
- When milling twisted surfaces, program the main cutting direction (from point **1** to point **2**) parallel to the direction of the steeper inclination. See figure at center right.

If you are using a spherical cutter for the machining operation, you can optimize the surface finish in the following way

- When milling twisted surfaces, program the main cutting direction (from point **1** to point **2**) perpendicular to the direction of the steeper inclination. See figure at lower right.





### Before programming, note the following:

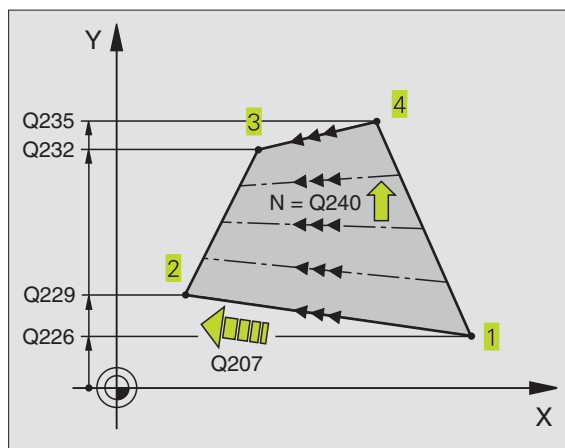
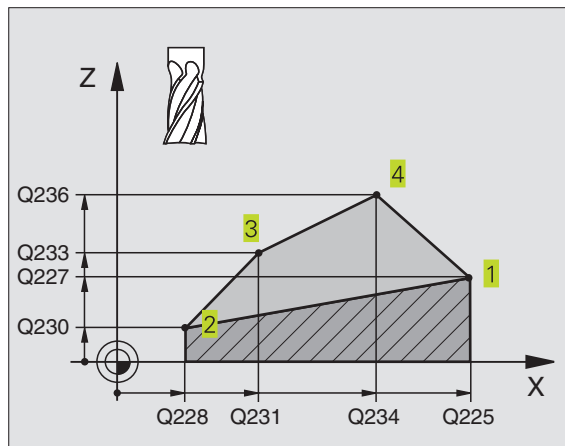
From the current position, the TNC positions the tool in a linear 3-D movement to the starting point **1**. Pre-position the tool in such a way that no collision between tool and clamping devices can occur.

The TNC moves the tool with radius compensation R0 to the programmed positions.

If required, use a center-cut end mill (ISO 1641).



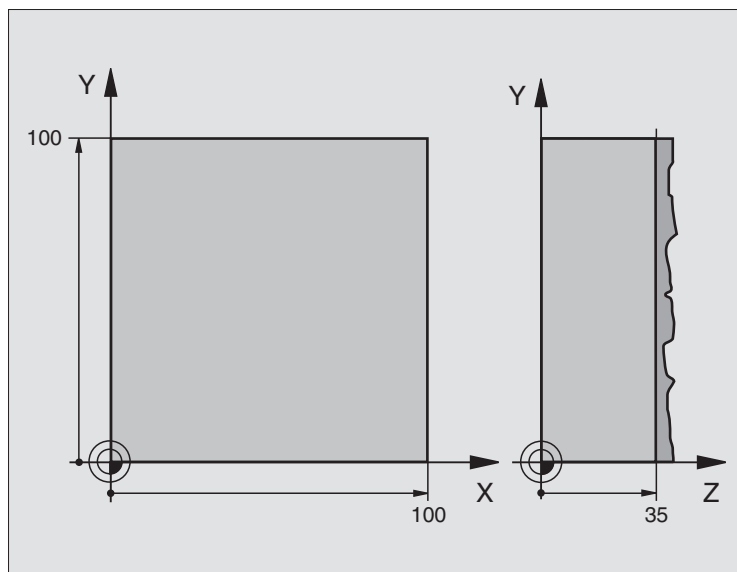
- ▶ Starting point in 1st axis Q225 (absolute value): Starting point coordinate of the surface to be multipass-milled in the main axis of the working plane
- ▶ Starting point in 2nd axis Q226 (absolute value): Starting point coordinate of the surface to be multipass-milled in the secondary axis of the working plane
- ▶ Starting point in 3rd axis Q227 (absolute value): Starting point coordinate of the surface to be multipass-milled in the tool axis
- ▶ 2nd point in 1st axis Q228 (absolute value): Stopping point coordinate of the surface to be multipass milled in the main axis of the working plane
- ▶ 2nd point in 2nd axis Q229 (absolute value): Stopping point coordinate of the surface to be multipass milled in the secondary axis of the working plane
- ▶ 2nd point in 3rd axis Q230 (absolute value): Stopping point coordinate of the surface to be multipass milled in the tool axis
- ▶ 3rd point in 1st axis Q231 (absolute value): Coordinate of point **3** in the main axis of the working plane
- ▶ 3rd point in 2nd axis Q232 (absolute value): Coordinate of point **3** in the subordinate axis of the working plane
- ▶ 3rd point in 3rd axis Q233 (absolute value): Coordinate of point **3** in the tool axis
- ▶ 4th point in 1st axis Q234 (absolute value): Coordinate of point **4** in the main axis of the working plane
- ▶ 4th point in 2nd axis Q235 (absolute value): Coordinate of point **4** in the subordinate axis of the working plane
- ▶ 4th point in 3rd axis Q236 (absolute value): Coordinate of point **4** in the tool axis
- ▶ Number of cuts Q240: Number of passes to be made between points **1** and **4**, and between points **2** and **3**
- ▶ Feed rate for milling Q207: Traversing speed of the tool in mm/min while milling. The TNC performs the first step at half the programmed feed rate.



### Example NC blocks:

72	CYCL	DEF	231	RULED SURFACE
				Q225=+0 ; STARTNG PNT 1ST AXIS
				Q226=+5 ; STARTNG PNT 2ND AXIS
				Q227=-2 ; STARTING PNT 3RD AXIS
				Q228=+100 ; 2ND POINT 1ST AXIS
				Q229=+15 ; 2ND POINT 2ND AXIS
				Q230=+5 ; 2ND PNT 3RD AXIS
				Q231=+15 ; 3RD POINT 1ST AXIS
				Q232=+125 ; 3RD PNT IN 2ND AXIS
				Q233=+25 ; 3RD PNT IN 3RD AXIS
				Q234=+85 ; 4TH PNT IN 1ST AXIS
				Q235=+95 ; 4TH PNT IN 2ND AXIS
				Q236=+35 ; 4TH PNT IN 3RD AXIS
				Q240=40 ; NUMBER OF CUTS
				Q207=500 ; FEED RATE FOR MILLING

## Example: Multipass milling









0	BEGIN PGM C230 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z+0	Define the workpiece blank
2	BLK FORM 0.2 X+100 Y+100 Z+40	
3	TOOL DEF 1 L+0 R+5	Define the tool
4	TOOL CALL 1 Z S3500	Tool call
5	L Z+250 R0 F MAX	Retract the tool
6	CYCL DEF 230 MULTIPASS MILLNG	Cycle definition: MULTIPASS MILLING
	Q225=+0 ;STARTNG PNT 1ST AXIS	
	Q226=+0 ;STARTNG PNT 2ND AXIS	
	Q227=+35 ;STARTNG PNT 3RD AXIS	
	Q218=100 ;FIRST SIDE LENGTH	
	Q219=100 ;SECOND SIDE LENGTH	
	Q240=25 ;NUMBER OF CUTS	
	Q206=250 ;FEED RATE FOR PLNGNG	
	Q207=400 ;FEED RATE FOR MILLNG	
	Q209=150 ;STEPOVER FEED RATE	
	Q200=2 ;SET-UP CLEARANCE	
7	L X+-25 Y+0 R0 F MAX M3	Pre-position near the starting point
8	CYCL CALL	Call the cycle
9	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
10	END PGM C230 MM	



## 8.7 Coordinate Transformation Cycles

Once a contour has been programmed, you can position it on the workpiece at various locations and in different sizes through the use of coordinate transformations. The TNC provides the following coordinate transformation cycles:

Cycle	Soft key
7 DATUM SHIFT For shifting contours directly within the program or with datum tables	
8 MIRROR IMAGE For mirroring contours	
10 ROTATION For rotating contours in the working plane	
11 SCALING FACTOR For increasing or reducing the size of contours	
26 AXIS-SPECIFIC SCALING For increasing or reducing the size of contours with axis-specific scaling factors	
19 WORKING PLANE For executing machining operations in a tilted coordinate system on machines with swivel heads and/or tilting tables	

### Effect of coordinate transformations

A coordinate transformation becomes effective as soon as it is defined — it is not called. It remains in effect until it is changed or canceled.

### To cancel coordinate transformations:

- Define cycles for basic behavior with a new value, such as scaling factor 1.0
- Execute a miscellaneous function M02, M30, or an END PGM block (depending on machine parameter 7300)
- Select a new program

## DATUM SHIFT (Cycle 7)

A datum shift allows machining operations to be repeated at various locations on the workpiece.

### Effect

When the DATUM SHIFT cycle is defined, all coordinate data is based on the new datum. The TNC displays the datum shift in each axis in the additional status display. Input of rotary axes is also permitted.



► Datum shift: Enter the coordinates of the new datum. Absolute values are referenced to the manually set workpiece datum. Incremental values are always referenced to the datum which was last valid — this can be a datum which has already been shifted.

### Example NC blocks:

```
73 CYCL DEF 7.0 DATUM SHIFT
```

```
74 CYCL DEF 7.1 X+10
```

```
75 CYCL DEF 7.2 Y+10
```

```
76 CYCL DEF 7.3 Z-5
```

### Cancellation

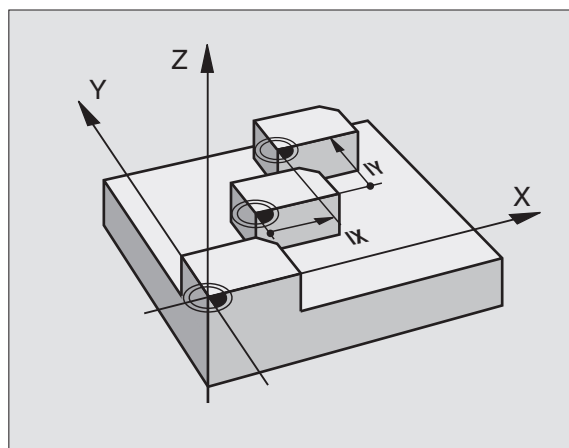
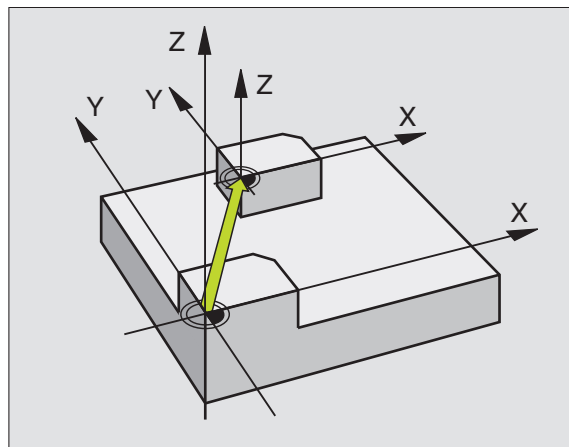
A datum shift is canceled by entering the datum shift coordinates X=0, Y=0 and Z=0.

### Graphics

If you program a new BLK FORM after a datum shift, you can use machine parameter 7310 to determine whether the BLK FORM is referenced to the current datum or to the original datum. Referencing a new BLK FORM to the current datum enables you to display each part in a program in which several pallets are machined.

### Status Displays

- The actual position values are referenced to the active (shifted) datum.
- All of the position values shown in the additional status display are referenced to the manually set datum.



## DATUM SHIFT with datum tables (Cycle 7)



If you are using the interactive programming graphics with the datum tables, you must select the desired datum table (status S) in the TEST RUN mode of operation before starting the programming graphics.

If you are working with only one datum table, be sure to activate the correct datum in the program run modes of operation.

Datums from a datum table can be referenced either to the current datum or to the machine datum (depending on machine parameter 7475).

The datum points from datum tables are only effective with absolute coordinate values.

New lines can only be inserted at the end of the table.

### Application

Datum tables are used for

- frequently recurring machining sequences at various locations on the workpiece
- frequent use of the same datum shift

Within a program, you can either program datum points directly in the cycle definition or call them from a datum table.



- Datum shift: Enter the number of the datum from the datum table or a Q parameter. If you enter a Q parameter, the TNC activates the datum number found in the Q parameter.

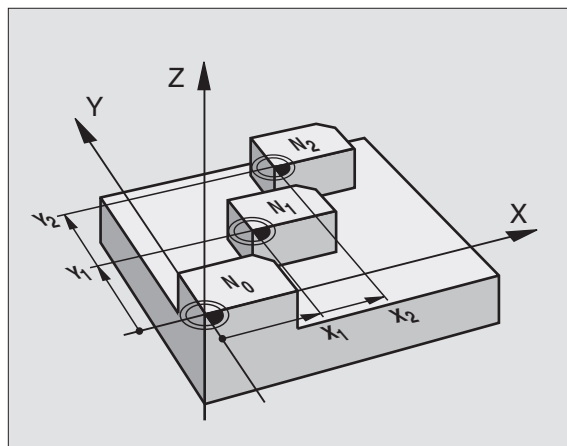
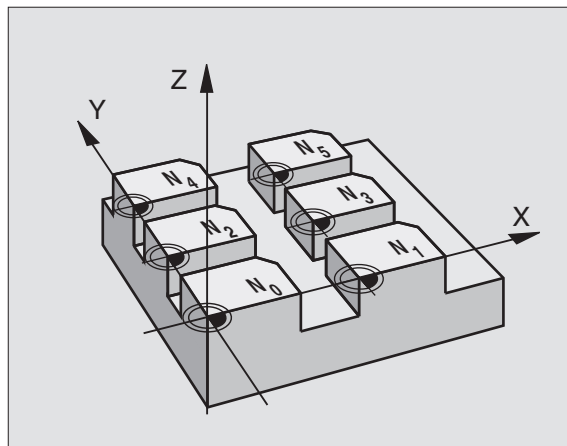
### Example NC blocks:

```
77 CYCL DEF 7.0 DATUM SHIFT
```

```
78 CYCL DEF 7.1 #12
```

### Cancellation

- Call a datum shift to the coordinates X=0; Y=0 etc. from a datum table.
- Execute a datum shift to the coordinates X=0; Y=0 etc. directly via cycle definition.



Status Displays

If datums in the table are referenced to the machine datum, then:

- The actual position values are referenced to the active (shifted) datum.
- All of the position values shown in the additional status display are referenced to the machine datum, whereby the TNC accounts for the manually set datum.

Editing a datum table

Select the datum table in the PROGRAMMING AND EDITING mode of operation.



- ▶ To call the file manager, press the PGM MGT key — see section 4.2 “File Management” for more information.
- ▶ Display the datum tables: Press the soft keys SELECT TYPE and SHOW .D
- ▶ Select the desired table or enter a new file name.
- ▶ Edit the file. The soft-key row comprises the following functions for editing:

Function	Soft key
Select beginning of table	<div>BEGIN</div> <div>↑</div>
Select end of table	<div>END</div> <div>↓</div>
Go to the previous page	<div>PAGE</div> <div>↑</div>
Go to the next page	<div>PAGE</div> <div>↓</div>
Insert line (only possible at the end of table)	<div>INSERT</div> <div>L.INE</div>
Delete line	<div>DELETE</div> <div>L.INE</div>
Confirm the entered line and go to the beginning of the next line	<div>NEXT</div> <div>L.INE</div>

Manual operation		Datum table editing				
		Datum shift?				
File: NULLTAB.D						
MM						
D	X	Y	Z	B	C	
0	+0	+0	+0	+0	+0	
1	+25	+25	+0	+0	+0	
2	+0	+50	+2.5	+0	+0	
3	+0	+0	+0	+90	+0	
4	+27.25	+0	-3.5	+0	+0	
5	+250	+250	+0	+0	+0	
6	+350	+350	+10.2	+0	+0	
7	+1200	+0	+0	+0	+0	
8	+1700	+1200	-25	+0	+0	
9	-1700	-1200	+25	+0	+0	
10	+0	+0	+0	+0	+0	
11	+0	+0	+0	+0	+0	
12	+0	+0	+0	+0	+0	
X	Y	Z	R	B	C	U
OFF / ON	OFF / ON	OFF / ON	OFF / ON	OFF / ON	OFF / ON	OFF / ON

**Configuring the datum table**

On the second and third soft-key rows you can define for each datum table the axes for which you wish to set the datums. In the standard setting all of the axes are active. If you wish to exclude an axis, set the corresponding soft key to OFF. The TNC then deletes that column from the datum table.

**To leave a datum table**

Select a different type of file in file management and choose the desired file.

**Activate a datum table for a program run or test run**

To activate a datum table in the program run or test run operating modes, proceed as described under the section „Editing Datum Tables.“ Instead of entering a new name, press the SELECT soft key.

## MIRROR IMAGE (Cycle 8)

The TNC can machine the mirror image of a contour in the working plane. See figure at upper right.

### Effect

The MIRROR IMAGE cycle becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active mirrored axes are shown in the additional status display.

- If you mirror only one axis, the machining direction of the tool is reversed (except in fixed cycles).
- If you mirror two axes, the machining direction remains the same.

The result of the mirror image depends on the location of the datum

- If the datum lies on the contour to be mirrored, the element simply flips over — see figure at lower right.
- If the datum lies outside the contour to be mirrored, the element also “jumps” to another location — see figure at lower right.



► Mirror image axis ?: Enter the axis to be mirrored. You can mirror all axes, including rotary axes, except for the spindle axis and its auxiliary axes.

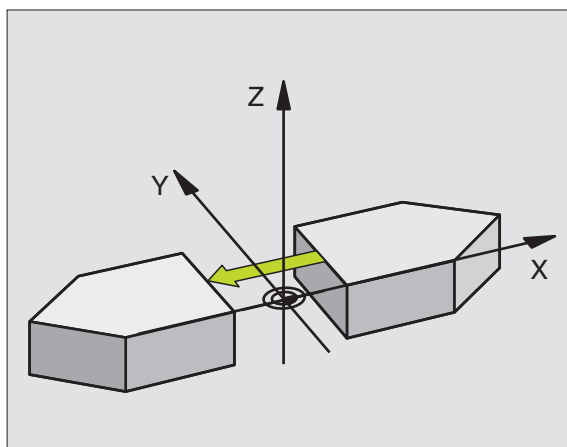
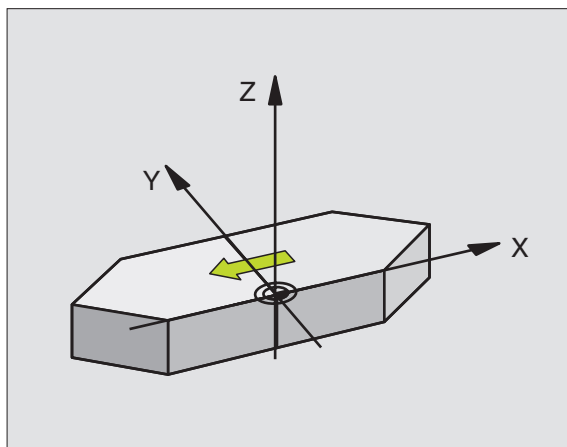
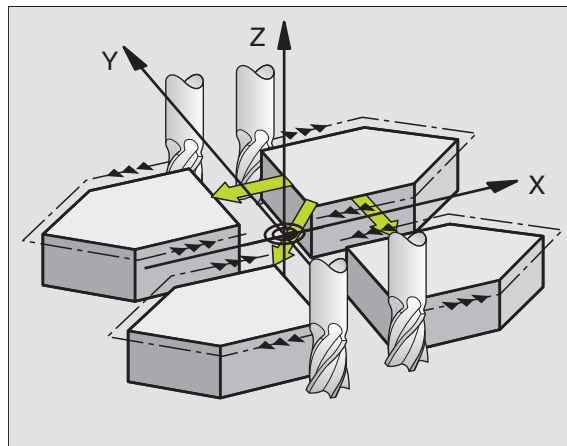
### Example NC blocks:

```
79 CYCL DEF 8.0 MIRROR IMAGE
```

```
80 CYCL DEF 8.1 X Y
```

### Cancellation

Program the MIRROR IMAGE cycle once again with NO ENT.



## ROTATION (Cycle 10)

The TNC can rotate the coordinate system about the active datum in the working plane within a program.

### Effect

The ROTATION cycle becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active rotation angle is shown in the additional status display.

Reference axis for the rotation angle:

- X/Y plane    X axis
- Y/Z plane    Y axis
- Z/X plane    Spindle axis



### Before programming, note the following:

An active radius compensation is canceled by defining Cycle 10 and must therefore be reprogrammed, if necessary.

After defining Cycle 10, you must move both axes of the working plane to activate rotation for all axes.



- Rotation: Enter the rotation angle in degrees (°). Input range:  $-360^\circ$  to  $+360^\circ$  (absolute or incremental).

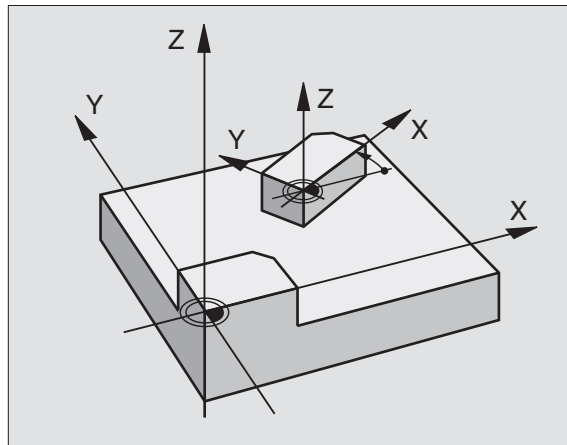
### Example NC blocks:

```
81 CYCL DEF 10.0 ROTATION
```

```
82 CYCL DEF 10.1 ROT+12.357
```

### Cancellation

Program the ROTATION cycle once again with a rotation angle of  $0^\circ$ .



## SCALING FACTOR (Cycle 11)

The TNC can increase or reduce the size of contours within a program, enabling you to program shrinkage and oversize allowances.

### Effect

The SCALING FACTOR becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active scaling factor is shown in the additional status display.

The scaling factor can be applied

- in the working plane, or on all three coordinate axes at the same time (depending on machine parameter 7410)
- to the dimensions in cycles
- to the parallel axes U,V,W

### Prerequisite

It is advisable to set the datum to an edge or a corner of the contour before enlarging or reducing the contour.



► Scaling factor ? : Enter the scaling factor SCL. The TNC multiplies the coordinates and radii by the SCL factor (as described under "Activation" above)

Enlargement: SCL greater than 1 (up to 99.999 999)

Reduction SCL less than 1 (down to 0.000 001)

### Example NC blocks:

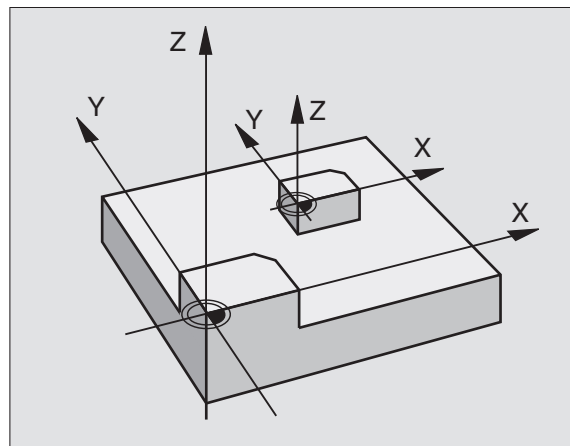
```
83 CYCL DEF 11.0 SCALING
```

```
84 CYCL DEF 11.1 SCL0.99537
```

### Cancellation

Program the SCALING FACTOR cycle once again with a scaling factor of 1.

You can also enter scaling factors for axis-specific scaling (see Cycle 26).





## AXIS-SPECIFIC SCALING (Cycle 26)



### Before programming, note the following:

Coordinate axes sharing coordinates for arcs must be enlarged or reduced by the same factor.

You can program each coordinate axis with its own axis-specific scaling factor.

In addition, you can enter the coordinates of a center for all scaling factors.

The size of the contour is enlarged or reduced with reference to the center, and not necessarily (as in Cycle 11 SCALING FACTOR) with reference to the active datum.

### Effect

The SCALING FACTOR becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active scaling factor is shown in the additional status display.



- ▶ Axis and scaling factor: Enter the coordinate axis/axes as well as the factor(s) involved in enlarging or reducing. Enter a positive value up to 99.999 999.
- ▶ Center coordinates: Enter the center of the axis-specific enlargement or reduction.

The coordinate axes are selected with soft keys.

### Cancellation

Program the AXIS-SPECIFIC SCALING cycle once again with a scaling factor of 1 for the same axis.

### Example

Axis-specific scaling factors in the working plane

Preset: Quadrangle (see figure at lower right)

**Corner 1:** X = 20.0 mm Y = 2.5 mm

**Corner 2:** X = 32.5 mm Y = 15.0 mm

**Corner 3:** X = 20.0 mm Y = 27.5 mm

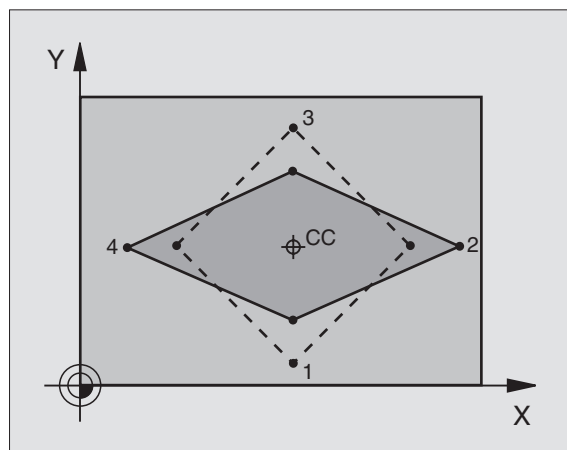
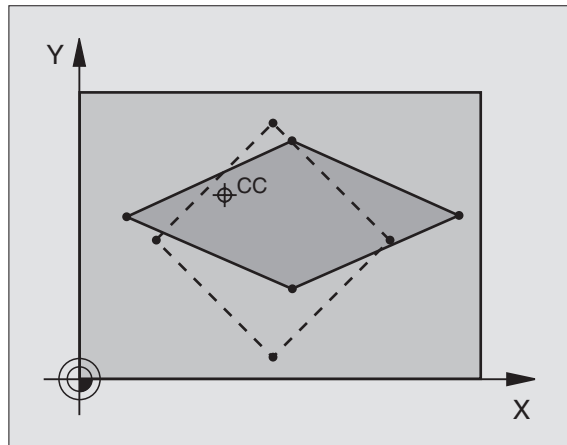
**Corner 4:** X = 7.5 mm Y = 15.0 mm

- Enlarge X axis by factor 1.4
- Reduce Y axis by factor 0.6
- Center at CCX = 15 mm CCY = 20 mm

### Resulting NC blocks

```
CYCL DEF 26.0 axis-spec. scaling
```

```
CYCL DEF 26.1 X1.4 Y0.6 CCX+15 CCY+20
```



## WORKING PLANE (Cycle 19)



The functions for tilting the working plane are interfaced to the TNC and the machine tool by the machine tool builder. With some swivel heads and tilting tables, the machine tool builder determines whether the entered angles are interpreted as coordinates of the tilt axes or as mathematical angles of a tilted plane. Your machine manual provides more detailed information.



The working plane is always tilted around the active datum.

The fundamentals of this TNC function are described in section 2.5 "Tilting the Working Plane." It is important that you read through this section thoroughly.

### Effect

In Cycle 19 you define the position of the working plane - i.e. the position of the tool axis referenced to the machine coordinate system - by entering tilt angles. There are two ways to determine the position of the working plane:

- Enter the slope of the tilted axes directly (see figure at upper right)
- Describe the position of the working plane using up to 3 rotations (spatial angle) of the **machine-referenced** coordinate system. The required spatial angle can be calculated by cutting a perpendicular line through the tilted working plane and considering it from the axis around which you wish to tilt (see figures at center right and at bottom right). With two spatial angles, every tool position in space can be defined exactly.

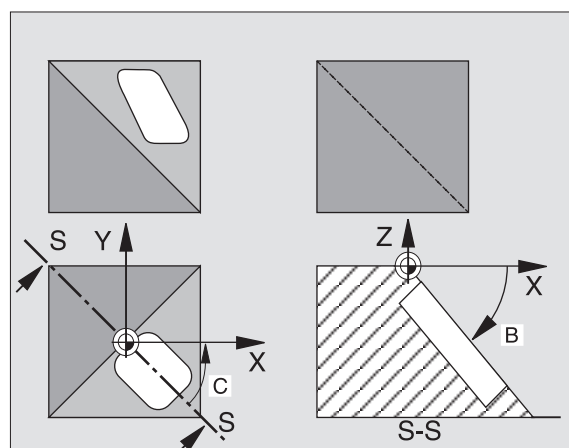
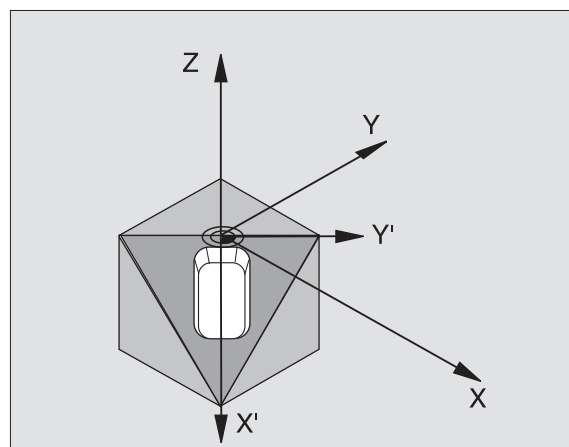
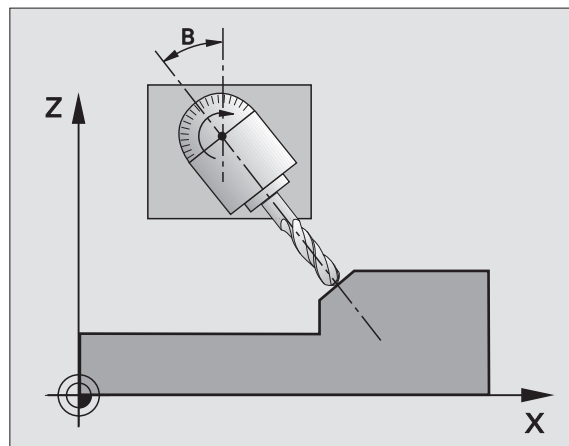


Note that the position of the tilted coordinate system, and therefore also all movement in the tilted system, are dependent on your description of the tilted plane.

If you program the position of the working plane via spatial angles, the TNC will calculate the required angle positions of the tilted axes automatically and will store these in the parameters Q120 (A-axis) to Q122 (C-axis). If two solutions are possible, the TNC will choose the shorter path from the zero position of the rotary axes.

The axes are always rotated in the same sequence for calculating the tilt of the plane: The TNC first rotates the A axis, then the B axis, and finally the C axis.

Cycle 19 becomes effective as soon as it is defined in the program. As soon as you move an axis in the tilted system, the compensation for this specific axis is activated. You have to move all axes to activate compensation for all axes.



If you set the function TILTING program run to ACTIVE in the Manual Operation mode (see section 2.5 “Tilting the Working Plane”), the angular value entered in this menu is overwritten by Cycle 19 WORKING PLANE.



- ▶ Tilt axis and tilt angle: The axes of rotation together with the associated tilt angles. The rotary axes A, B and C are programmed using soft keys.

If the TNC automatically positions the rotary axes, you can enter the following parameters

- ▶ Feed rate ? F=: Traverse speed of the rotary axis during automatic positioning
- ▶ Set-up clearance ? (incremental): the TNC positions the tilting head so that the position that results from the extension of the tool by the set-up clearance does not change relative to the workpiece.

### Cancellation

To cancel the tilt angle, redefine the WORKING PLANE cycle and enter an angular value of 0° for all axes of rotation. You must then program the WORKING PLANE cycle once again by answering the dialog question with the NO ENT key to disable the function.

### Positioning an axis of rotation



The machine tool builder determines whether Cycle 19 positions the axes of rotation automatically or whether they must be pre-positioned in the program. Your machine manual provides more detailed information.

If the axes are positioned automatically in Cycle 19:

- The TNC can position only controlled axes
- In order for the tilted axes to be positioned, you must enter a feed rate and a set-up clearance in addition to the tilting angles, during cycle definition.
- You can use only preset tools (with the full tool length defined in the TOOL DEF block or in the tool table)
- The position of the tool tip as referenced to the workpiece surface remains nearly unchanged after tilting
- The TNC tilts the working plane at the last programmed feed rate. The maximum feed rate that can be reached depends on the complexity of the swivel head or tilting table.

If the axes are not positioned automatically in Cycle 19, position them before defining the cycle, for example with an L block:

Example NC blocks

L Z+100 R0 FMAX	
L X+25 Y+10 R0 FMAX	
L B+15 R0 F1000	Positioning an axis of rotation
CYCL DEF 19.0 WORKING PLANE	Define the angle for calculation of the compensation
CYCL DEF 19.1 B+15	
L Z+80 R0 FMAX	Activate compensation for the tool axis
L X-7.5 Y-10 R0 FMAX	Activate compensation for the working plane

Position display in the tilted system

On activation of Cycle 19, the displayed positions (ACTL. and NOML.) and the datum indicated in the additional status display are referenced to the tilted coordinate system. The positions displayed immediately after cycle definition may not be the same as the coordinates of the last programmed position before Cycle 19.

Workspace monitoring

The TNC monitors only those axes in the tilted coordinate system that are moved. If any of the software limit switches is traversed the TNC will display an error message.

Positioning in a tilted coordinate system

With the miscellaneous function M130 you can move the tool, while the coordinate system is tilted, to positions that are referenced to the non-tilted coordinate system (see section "7.3 Miscellaneous Functions for Coordinate Data").

Combining coordinate transformation cycles

When combining coordinate transformation cycles, always make sure the working plane is swiveled around the active datum. You can program a datum shift before activating Cycle 19. In this case, you are shifting the "machine-based coordinate system."

If you program a datum shift after having activated Cycle 19, you are shifting the "tilted coordinate system."

Important: When resetting the cycles, use the reverse sequence used for defining the them:

- 1. Activate datum shift
- 2. Activate tilting function
- 3. Activate rotation
- ...
- Machining
- ...
- 1. Reset rotation
- 2. Reset tilting function
- 3. Reset datum shift

### Automatic workpiece measurement in the tilted system

The TNC measuring cycles enable you to have the TNC measure a workpiece in a tilted system automatically. The TNC stores the measured data in Q parameters for further processing (for example, for printout).

### Procedure for working with Cycle 19 WORKING PLANE

#### 1 Write the program

- Define the tool (not required, when TOOL.T is active), and enter the full tool length.
- Call the tool.
- Retract the tool in the tool axis to a position where there is no danger of collision with the workpiece (clamping devices) during tilting.
- If required, position the tilt axis or axes with an L block to the appropriate angular value(s) (depending on a machine parameter).
- Activate datum shift if required.
- Define Cycle 19 WORKING PLANE; enter the angular values for the tilt axes.
- Traverse all main axes (X, Y, Z) to activate compensation.
- Write the program as if the machining process were to be executed in a non-tilted plane.
- Reset Cycle 19 WORKING PLANE; program 0° for all tilt axes.
- Disable the WORKING PLANE function; redefine Cycle 19 and answer the dialog question with "NO ENT."
- Reset datum shift if required.
- Position the tilt axes to the 0° position if required.

#### 2 Clamp the workpiece

#### 3 Preparations in the operating mode

##### Positioning with MDI

Pre-position the tilt axis/axes to the corresponding angular value(s) for setting the datum. The angular value depends on the selected reference plane on the workpiece.

#### 4 Preparations in the operating mode

##### Manual Operation

Use the 3D-ROT soft key to set the function TILT WORKING PLANE to ACTIVE in the Manual Operation mode. Enter the angular values for the tilt axes into the menu if the axes are not controlled.

If the axes are not controlled, the angular values entered in the menu must correspond to the actual position(s) of the tilted axis or axes, respectively. The TNC will otherwise calculate a wrong datum.

**5 Setting the datum**

- Manually by touching the workpiece with the tool in the non-tilted coordinate system (see section 2.4 "Setting the Datum Without a 3-D Touch Probe")
- Automatically by using a HEIDENHAIN 3-D touch probe (see the new Touch Probe Cycles Manual, chapter 2)
- Automatically by using a HEIDENHAIN 3-D touch probe (see the new Touch Probe Cycles Manual, chapter 3)

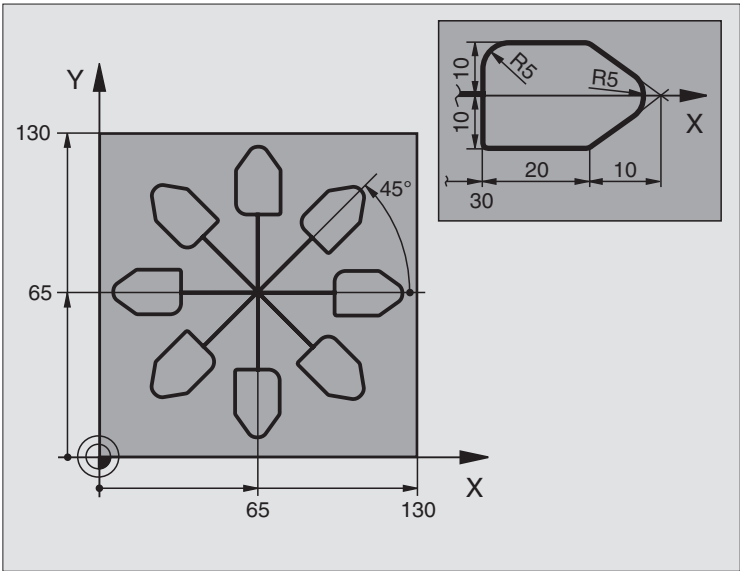
**6 Start the part program in the operating mode Program Run, Full Sequence****7 Manual Operation mode**

Use the 3D-ROT soft key to set the function TILT WORKING PLANE to INACTIVE. Enter an angular value of 0° for each axis in the menu (see section 2.5 "Tilting the Working Plane").

### Example: Coordinate transformation cycles

#### Program sequence

- Program the coordinate transformations in the main program
- Program the machining operation in subprogram 1 (see section 9 "Programming: Subprograms and Program Section Repeats")



0	BEGIN PGM KOUMR MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2	BLK FORM 0.2 X+130 Y+130 Z+0	
3	TOOL DEF 1 L+0 R+1	Define the tool
4	TOOL CALL 1 Z S4500	Tool call
5	L Z+250 RO F MAX	Retract the tool
6	CYCL DEF 7.0 DATUM SHIFT	Shift datum to center
7	CYCL DEF 7.1 X+65	
8	CYCL DEF 7.2 Y+65	
9	CALL LBL 1	Call milling operation
10	LBL 10	Set label for program section repeat
11	CYCL DEF 10.0 ROTATION	Rotate by 45° (incremental)
12	CYCL DEF 10.1 IROT+45	
13	CALL LBL 1	Call milling operation
14	CALL LBL 10 REP 6/6	Return jump to LBL 10; execute the milling operation six times
15	CYCL DEF 10.0 ROTATION	Reset the rotation
16	CYCL DEF 10.1 ROT+0	
17	CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
18	CYCL DEF 7.1 X+0	
19	CYCL DEF 7.2 Y+0	
20	L Z+250 RO F MAX M2	Retract in the tool axis, end program

21	LBL 1	Subprogram 1:
22	L X+0 Y+0 R0 F MAX	Define milling operation
23	L Z+2 R0 F MAX M3	
24	L Z-5 R0 F200	
25	L X+30 RL	
26	L IY+10	
27	RND R5	
28	L IX+20	
29	L IX+10 IY-10	
30	RND R5	
31	L IX-10 IY-10	
32	L IX-20	
33	L IY+10	
34	L X+0 Y+0 R0 F500	
35	L Z+20 R0 F MAX	
36	LBL 0	
37	END PGM KOUMR MM	



## 8.8 Special Cycles

### DWELL TIME (Cycle 9)

This cycle causes the execution of the next block within a running program to be delayed by the programmed dwell time. A dwell time can be used for such purposes as chip breaking.

#### Effect

Cycle 9 becomes effective as soon as it is defined in the program. Modal conditions such as spindle rotation are not affected.



- Dwell time in seconds: Enter the dwell time in seconds

Input range 0 to 3600 s (1 hour) in 0.001 s steps

#### Example NC blocks

```
89 CYCL DEF 9.0 DWELL TIME
```

```
90 CYCL DEF 9.1 DWELL 1.5
```

### PROGRAM CALL (Cycle 12)

Routines that you have programmed (such as special drilling cycles or geometrical modules) can be written as main programs and then called like fixed cycles.



#### Before programming, note the following:

If the program you are defining to be a cycle is located in the same directory as the program you are calling it from, you need only to enter the program name.

If the program you are defining to be a cycle is not located in the same directory as the program you are calling it from, you must enter the complete path (for example \CONV35\FK1\50.H).

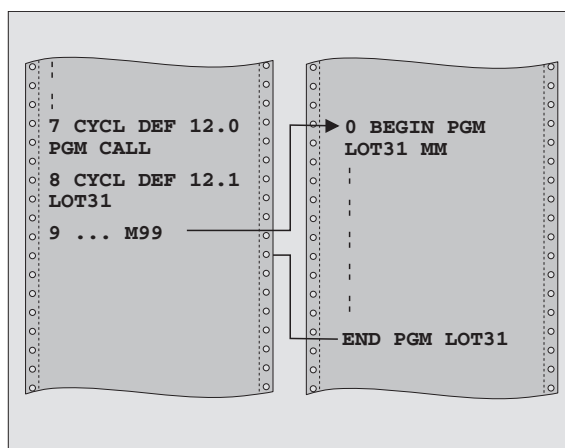
If you want to define an ISO program to be a cycle, enter the file type .I behind the program name.



- Program name: Enter the name of the program you want to call and, if necessary, the directory it is located in.

The program is called with

- CYCL CALL (separate block) or
- M99 (blockwise) or
- M89 (modally)



#### Example: Program call

A callable program 50 is to be called into a program via a cycle call.


#### Example NC blocks

```
55 CYCL DEF 12.0 PGM CALL
```

```
56 CYCL DEF 12.1 PGM \KLAR35\FK1\50.H
```

```
57 L X+20 Y+50 FMAX M99
```

ORIENTED SPINDLE STOP (Cycle 13)

 The TNC and the machine tool must be specially prepared by the machine tool builder for the use of Cycle 13.

The control can control the machine tool spindle and rotate it to a given angular position.

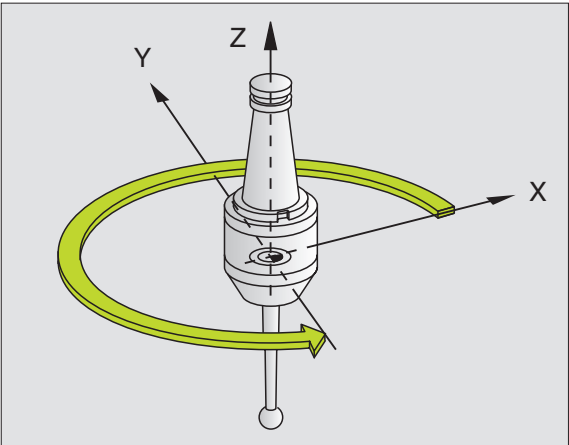
Oriented spindle stops are required for

- Tool changing systems with a defined tool change position
- Orientation of the transmitter/receiver window of HEIDENHAIN 3-D touch probes with infrared transmission

Effect

The angle of orientation defined in the cycle is positioned to by entering M19 or M20 (depending on the machine).

If you program M19 or M20 without having defined Cycle 13, the TNC positions the machine tool spindle to an angle that has been set in a machine parameter (see your machine manual).



► Angle of orientation: Enter the angle according to the reference axis of the working plane.

Input range            0 to 360°

Input resolution       0.1°

Example NC blocks

```
93 CYCL DEF 13.0 ORIENTATION
94 CYCL DEF 13.1 ANGLE 180
```

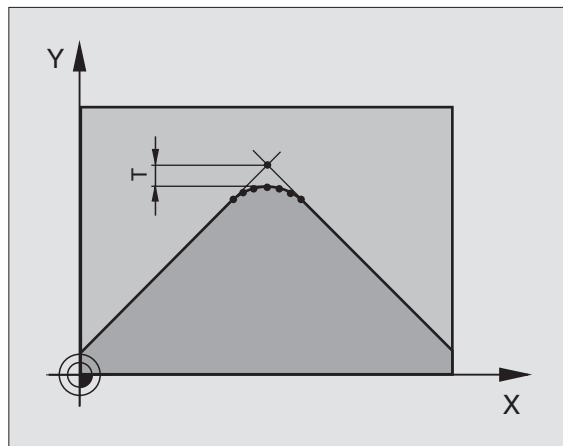
## TOLERANCE (Cycle 32)



Fast contour milling is adapted to suit both the TNC and your machine by the machine manufacturer. Your machine manual provides more detailed information.

The TNC automatically smooths the contour between two path elements (whether compensated or not). The tool has constant contact with the workpiece surface. If necessary, the TNC automatically reduces the programmed feed rate so that the program can be machined at the fastest possible speed without +jerk+. As a result the surface quality is improved and the machine is protected.

A contour deviation results from the smoothing out. The size of this deviation (tolerance value) is set in a machine parameter by the machine manufacturer. You can change the pre-set tolerance value with Cycle 32 (see figure at top right).



### Before programming, note the following:

Cycle 32 is DEF active which means that it becomes effective as soon as it is defined in the part program.

You can reset Cycle 32 by defining it again and confirming the dialog question after the TOLERANCE VALUE with NO ENT. Resetting Cycle 32 reactivates the pre-set tolerance:



► Tolerance value: Permissible contour deviation in mm

### Example NC blocks

```
95 CYCL DEF 32.0 TOLERANCE
```

```
96 CYCL DEF 32.1 T0.05
```





# 9

**Programming:**

**Subprograms and  
Program Section Repeats**

## 9.1 Marking Subprograms and Program Section Repeats

Subprograms and program section repeats enable you to program a machining sequence once and then run it as often as desired.

### Labels

The beginnings of subprograms and program section repeats are marked in a part program by labels.

A label is identified by a number between 1 and 254. Each label can be set only once with LABEL SET in a program.



If a label is set more than once, the TNC sends an error message at the end of the LBL SET block. With very long programs, you can limit the number of blocks to be checked for repeated labels with MP7229.

LABEL 0 (LBL 0) is used exclusively to mark the end of a subprogram and can therefore be used as often as desired.

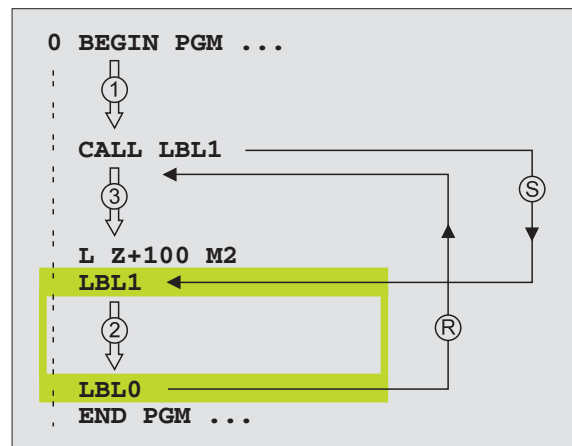
## 9.2 Subprograms

### Operating sequence

- 1 The TNC executes the part program up to the block in which a subprogram is called with CALL LBL.
- 2 The subprogram is then executed from beginning to end. The subprogram end is marked with LBL 0.
- 3 The TNC then resumes the part program from the block after the subprogram call.

### Programming notes

- A main program can contain up to 254 subprograms.
- You can call subprograms in any sequence and as often as desired.
- A subprogram cannot call itself.
- Write subprograms at the end of the main program (behind the block with M2 or M30).
- If subprograms are located before the block with M02 or M30, they will be executed at least once even if they are not called.



**Programming a subprogram**

- ▶ To mark the beginning, press the LBL SET key and enter a label number.
- ▶ Enter the subprogram.
- ▶ To mark the end, press the LBL SET key and enter the label number "0".

**Calling a subprogram**

- ▶ To call a subprogram, press the LBL CALL key.
- ▶ Label number: Enter the label number of the subprogram you wish to call.
- ▶ Repeat REP: Ignore the dialog question with the NO ENT key. Repeat REP is used only for program section repeats.



CALL LBL 0 is not permitted (label 0 is only used to mark the end of a subprogram).

## 9.3 Program Section Repeats

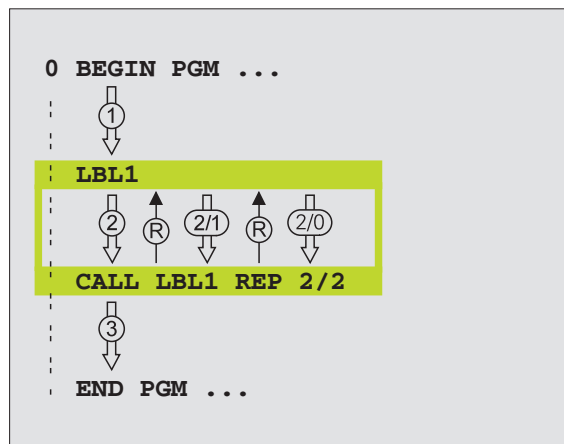
The beginning of a program section repeat is marked by the label LBL. The end of a program section repeat is identified by CALL LBL /REP.

**Operating sequence**

- 1 The TNC executes the part program up to the end of the program section (CALL LBL /REP)
- 2 Then the program section between the called LBL and the label call is repeated the number of times entered after REP.
- 3 The TNC then resumes the part program after the last repetition.

**Programming notes**

- You can repeat a program section up to 65 534 times in succession.
- The number behind the slash after REP indicates the number of repetitions remaining to be run.
- The total number of times the program section is executed is always one more than the programmed number of repeats.



### Programming a program section repeat



- ▶ To mark the beginning, press the LBL SET key and enter a LABEL NUMBER for the program section you wish to repeat.
- ▶ Enter the program section.

### Calling a program section repeat



- ▶ Press the LBL CALL key and enter the label number of the program section you want to repeat as well as the number of repeats (with Repeat REP).

## 9.4 Program as Subprogram

- 1 The TNC executes the part program up to the block in which another program is called with CALL PGM.
- 2 Then the other program is run from beginning to end.
- 3 The TNC then resumes the first (calling) part program with the block behind the program call.

### Programming notes

- No labels are needed to call any program as a subprogram.
- The called program must not contain the miscellaneous functions M2 or M30.
- The called program must not contain a program call into the calling program.

### Calling any program as a subprogram



- ▶ To call the program, press the PGM CALL key and enter the program name of the program you wish to call.



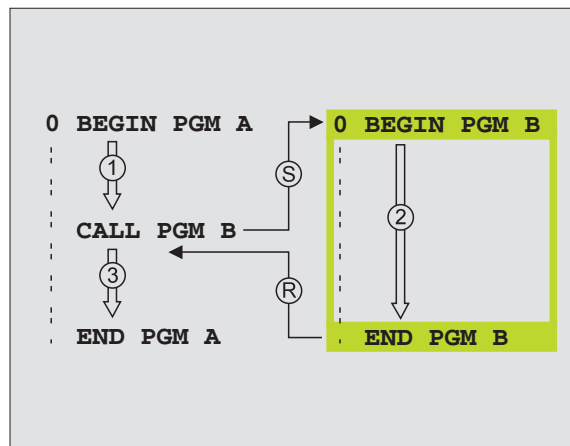
The program you are calling must be stored on the hard disk of your TNC.

You need only enter the program name if the program you want to call is located in the same directory as the program you are calling it from.

If the called program is not located in the same directory as the program you are calling it from, you must enter the complete path, e.g. TNC:\ZW35\ROUGH\PGM1.H

If you want to call an ISO program, enter the file type .I after the program name.

You can also call a program with Cycle 12 PGM CALL.





## 9.5 Nesting

You can nest subprograms and program section repeats in the following ways:

- Subprograms within a subprogram
- Program section repeats within a program section repeat
- Subprograms repeated
- Program section repeats within a subprogram

### Nesting depth

The nesting depth is the number of successive levels in which program sections or subprograms can call further program sections or subprograms.

- Maximum nesting depth for subprograms: 8
- Maximum nesting depth for calling main programs: 4
- You can nest program section repeats as often as desired

### Subprogram within a subprogram

#### Example NC blocks

0	BEGIN PGM SUBPGM MM	
...		
17	CALL LBL 1	Call the subprogram marked with LBL1
...		
35	L Z+100 R0 FMAX M2	Last program block of the
		main program (with M2)
36	LBL 1	Beginning of subprogram 1
...		
39	39 CALL LBL 2	Call the subprogram marked with LBL2
...		
45	LBL 0	End of subprogram 1
46	LBL 2	Beginning of subprogram 2
...		
62	LBL 0	End of subprogram 2
63	END PGM SUBPGM MM	

Program execution

- 1st step: Main program UPGMS is executed up to block 17.
- 2nd step: Subprogram 1 is called, and executed up to block 39.
- 3rd step: Subprogram 2 is called, and executed up to block 62. End of subprogram 2 and return jump to the subprogram from which it was called.
- 4th step: Subprogram 1 is called, and executed from block 40 up to block 45. End of subprogram 1 and return jump to the main program UPGMS.
- 5th step: Main program UPGMS is executed from block 18 up to block 35. Return jump to block 1 and end of program.

Repeating program section repeats

Example NC blocks

0	BEGIN PGM REPS MM	
...		
15	LBL 1	Beginning of program section repeat 1
...		
20	LBL 2	Beginning of program section repeat 2
...		
27	CALL LBL 2 REP 2/2	The program section between this block and LBL 2 (block 20) is repeated twice.
...		
35	CALL LBL 1 REP 1/1	The program section between this block and LBL 1 (block 15) is repeated once.
...		
50	END PGM REPS MM	

Program execution

- 1st step: Main program REPS is executed up to block 27.
- 2nd step: Program section between block 27 and block 20 is repeated twice.
- 3rd step: Main program REPS is executed from block 28 to block 35.
- 4th step: Program section between block 35 and block 15 is repeated once (including the program section repeat between 20 and block 27).
- 5th step: Main program REPS is executed from block 36 to block 50 (end of program).

### Repeating a subprogram

#### Example NC blocks

0	BEGIN PGM UPGREP MM	
...		
10	LBL 1	Beginning of the program section repeat
11	CALL LBL 2	Subprogram call
12	CALL LBL 1 REP 2/2	The program section between this block and LBL1
...		(block 10) is repeated twice
19	L Z+100 R0 FMAX M2	Last program block of the main program with M2
20	LBL 2	Beginning of subprogram
...		
28	LBL 0	End of subprogram
29	END PGM UPGREP MM	

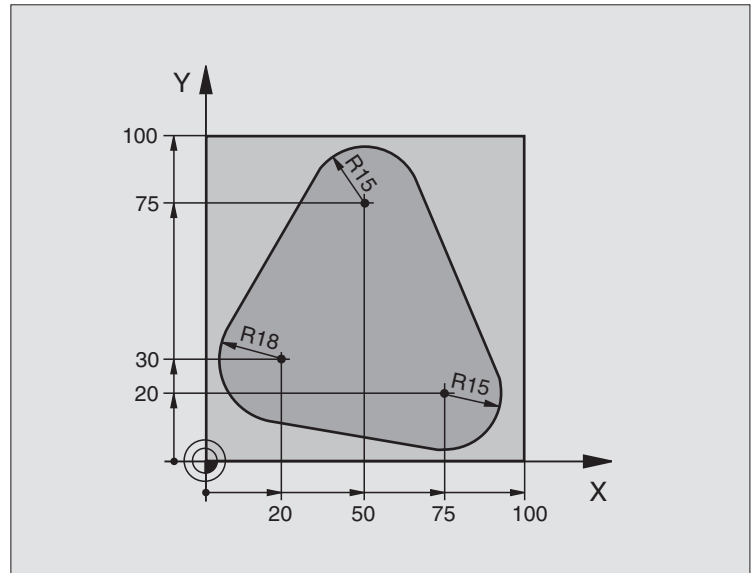
#### Program execution

- 1st step: Main program UPGREP is executed up to block 11.
- 2nd step: Subprogram 2 is called and executed.
- 3rd step: Program section between block 12 and block 10 is repeated twice. This means that subprogram 2 is repeated twice.
- 4th step: Main program UPGREP is executed from block 13 to block 19. End of program.

## Example: Milling a contour in several infeeds

### Program sequence

- Pre-position the tool to the workpiece surface
- Enter the infeed depth in incremental values
- Mill the contour
- Repeat downfeed and contour-milling

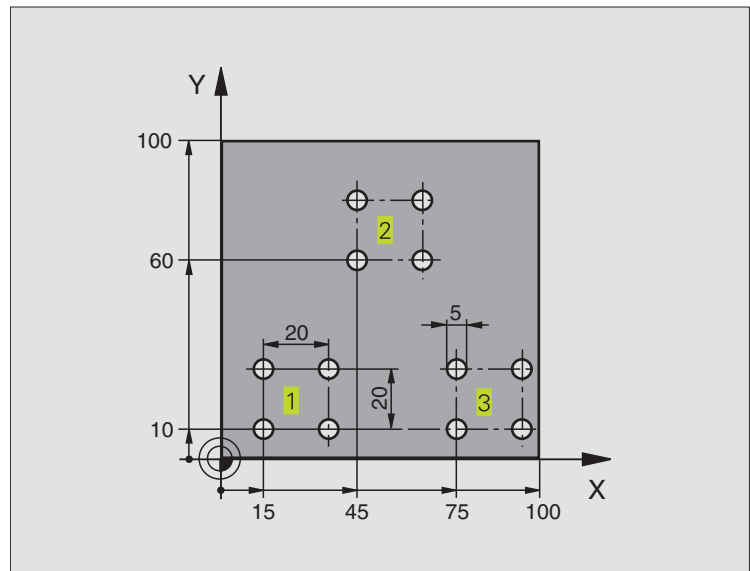


0	BEGIN PGM PGMWDH MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-40	
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+10	Define the tool
4	TOOL CALL 1 Z S500	Tool call
5	L Z+250 R0 F MAX	Retract the tool
6	L X-20 Y+30 R0 F MAX	Pre-position in the working plane
7	L Z+0 R0 F MAX M3	Pre-position to the workpiece surface
8	LBL 1	Set label for program section repeat
9	L IZ-4 R0 F MAX	Infeed depth in incremental values (in the open)
10	APPR CT X+2 Y+30 CCA90 R+5 RL F250	Approach contour
11	FC DR- R18 CLSD+ CCX+20 CCY+30	Contour
12	FLT	
13	FCT DR- R15 CCX+50 CCY+75	
14	FLT	
15	FCT DR- R15 CCX+75 CCY+20	
16	FLT	
17	FCT DR- R18 CLSD- CCX+20 CCY+30	
18	DEP CT CCA90 R+5 F1000	Depart contour
19	L X-20 Y+0 R0 F MAX	Retract tool
20	CALL LBL 1 REP 4/4	Return jump to LBL 1; section is repeated a total of 4 times
21	L Z+250 R0 F MAX M2	Retract in the tool axis, end program
22	END PGM PGMWDH MM	

## Example: Groups of holes

### Program sequence

- Approach the groups of holes in the main program
- Call the group of holes (subprogram 1)
- Program the group of holes only once in subprogram 1



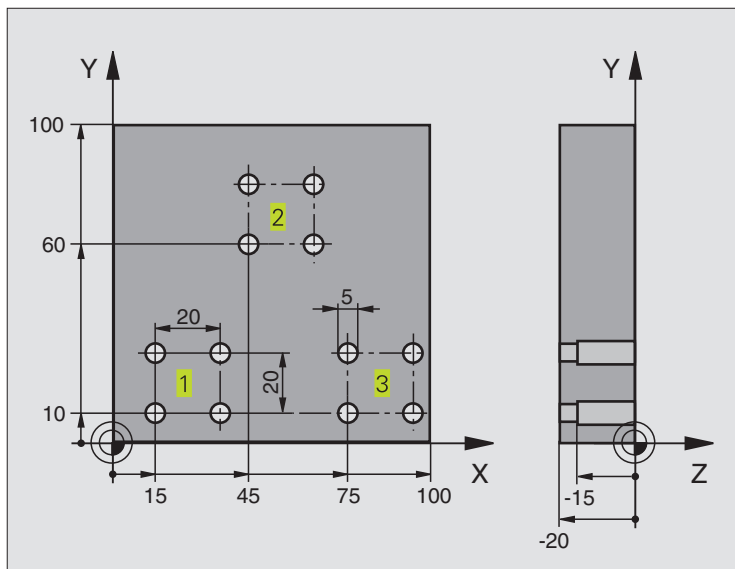
0	BEGIN PGM UP1 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+2.5	Define the tool
4	TOOL CALL 1 Z S5000	Tool call
5	L Z+250 R0 F MAX	Retract the tool
6	CYCL DEF 200 DRILLING	Cycle definition: drilling
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-10 ;DEPTH	
	Q206=250 ;F PLUNGING	
	Q202=5 ;PLUNGING DEPTH	
	Q210=0 ;DWELL TIME AT TOP	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=10 ;2nd SET-UP CLEARANCE	
	Q211=0.25 ;DWELL TIME AT BOTTOM	
7	L X+15 Y+10 R0 F MAX M3	Move to starting point for group 1
8	CALL LBL 1	Call the subprogram for the group
9	L X+45 Y+60 R0 F MAX	Move to starting point for group 2
10	CALL LBL 1	Call the subprogram for the group
11	L X+75 Y+10 R0 F MAX	Move to starting point for group 3
12	CALL LBL 1	Call the subprogram for the group
13	L Z+250 R0 F MAX M2	End of main program

14	LBL 1	Beginning of subprogram 1: Group of holes
15	CYCL CALL	1st hole
16	L IX+20 R0 F MAX M99	Move to 2nd hole, call cycle
17	L IY+20 R0 F MAX M99	Move to 3rd hole, call cycle
18	L IX-20 R0 F MAX M99	Move to 4th hole, call cycle
19	LBL 0	End of subprogram 1
20	END PGM UP1 MM	

### Example: Groups of holes with several tools

#### Program sequence

- Program the fixed cycles in the main program
- Call the entire hole pattern (subprogram 1)
- Approach the group of holes in subprogram 1, call group of holes (subprogram 2)
- Program the group of holes only once in subprogram 2

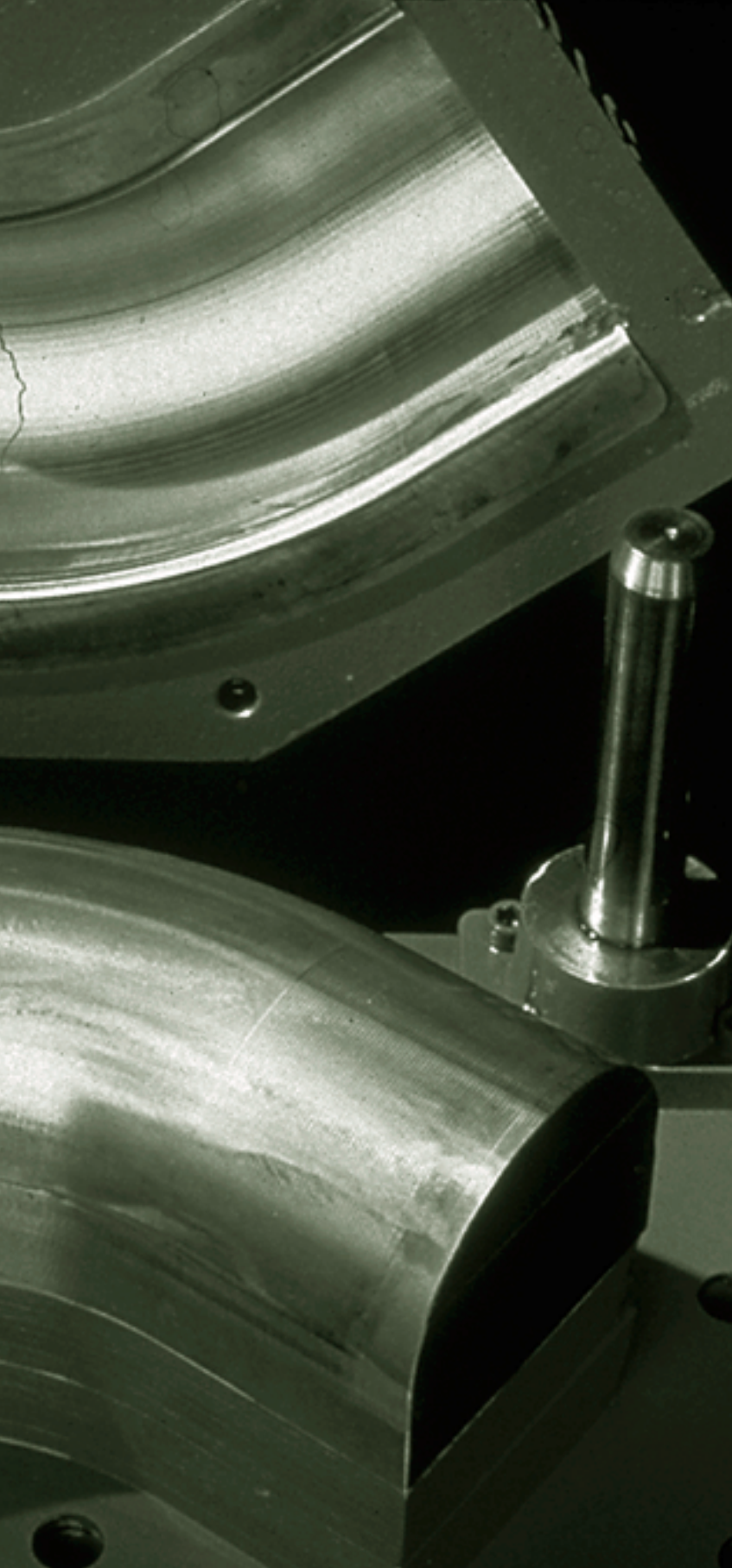


0	BEGIN PGM UP2 MM	
1	BLK FORM 0.1 Z X+0 Y+0 Z-20	
2	BLK FORM 0.2 X+100 Y+100 Z+0	
3	TOOL DEF 1 L+0 R+4	Define tool: center drill
4	TOOL DEF 2 L+0 R+3	Tool definition: drill
5	TOOL DEF 3 L+0 R+3.5	Define tool: reamer
6	TOOL CALL 1 Z S5000	Call tool: center drill
7	L Z+250 R0 F MAX	Retract the tool

8	CYCL DEF 200 DRILLING	Cycle definition: Centering
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-3 ;DEPTH	
	Q206=250 ;F PLUNGING	
	Q202=3 ;PLUNGING DEPTH	
	Q210=0 ;DWELL TIME AT TOP	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=10 ;2nd SET-UP CLEARANCE	
	Q211=0.25 ;DWELL TIME AT BOTTOM	
9	CALL LBL 1	Call subprogram 1 for the entire hole pattern
10	L Z+250 R0 F MAX M6	Tool change
11	TOOL CALL 2 Z S4000	Call the drilling tool
12	FN 0: Q201 = -25	New depth for drilling
13	FN 0: Q202 = +5	New plunging depth for drilling
14	CALL LBL 1	Call subprogram 1 for the entire hole pattern
15	L Z+250 R0 F MAX M6	Tool change
16	TOOL CALL 3 Z S500	Tool call: reamer
17	CYCL DEF 201 REAMING	Cycle definition: REAMING
	Q200=2 ;SET-UP CLEARANCE	
	Q201=-15 ;DEPTH	
	Q206=250 ;F PLUNGING	
	Q211=0,5 ;DWELL TIME AT DEPTH	
	Q208=400 ;RETRACTION FEED RATE	
	Q203=+0 ;SURFACE COORDINATE	
	Q204=10 ;2nd SET-UP CLEARANCE	
18	CALL LBL 1	Call subprogram 1 for the entire hole pattern
19	L Z+250 R0 F MAX M2	End of main program
20	LBL 1	Beginning of subprogram 1: Entire hole pattern
21	L X+15 Y+10 R0 F MAX M3	Move to starting point for group 1
22	CALL LBL 2	Call subprogram 2 for the group
23	L X+45 Y+60 R0 F MAX	Move to starting point for group 2
24	CALL LBL 2	Call subprogram 2 for the group
25	L X+75 Y+10 R0 F MAX	Move to starting point for group 3
26	CALL LBL 2	Call subprogram 2 for the group
27	LBL 0	End of subprogram 1
28	LBL 2	Beginning of subprogram 2: Group of holes
29	CYCL CALL	1st hole with active fixed cycle
30	L IX+20 R0 F MAX M99	Move to 2nd hole, call cycle
31	L IY+20 R0 F MAX M99	Move to 3rd hole, call cycle
32	L IX-20 R0 F MAX M99	Move to 4th hole, call cycle
33	LBL 0	End of subprogram 2
34	END PGM UP2 MM	







# 10

**Programming:**

**Q Parameters**

10.1 Principle and Overview

You can program an entire family of parts in a single part program. You do this by entering variables called *Q parameters* instead of fixed numerical values.

Q parameters can represent information such as:

- Coordinate values
- Feed rates
- RPM
- Cycle data

Q parameters also enable you to program contours that are defined through mathematical functions. You can also use Q parameters to make the execution of machining steps depend on logical conditions. In conjunction with FK programming you can also combine contours that do not have NC-compatible dimensions with Q parameters.

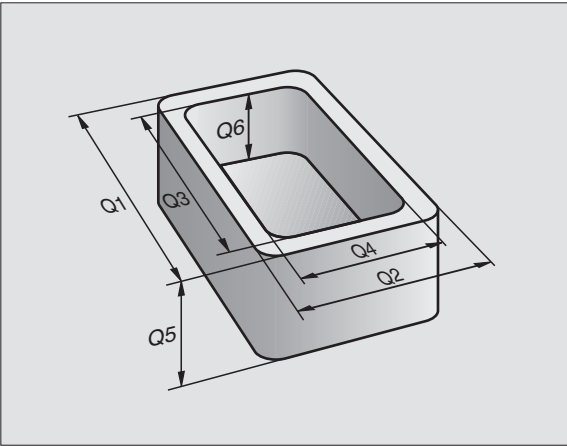
Q parameters are designated by the letter Q and a number between 0 and 299. They are grouped according to three ranges:

Meaning	Range
Freely applicable parameters, global for all programs in the TNC memory.	Q0 to Q99
Parameters for special TNC functions	Q100 to Q199
Parameters that are primarily used for cycles, globally effective for all programs that are stored in the TNC memory	Q200 to Q399

Programming notes

You can mix Q parameters and fixed numerical values within a program.

Q parameters can be assigned numerical values between -99 999.9999 and +99 999.9999. Internally, the TNC can calculate up to a width of 57 bits before and 7 bits after the decimal point (32-bit data width corresponds to a decimal value of 4 294 967 296).





Some Q parameters are always assigned the same data by the TNC. For example, Q108 is always assigned the current tool radius. For further information, see section "10.10 Preassigned Q Parameters."

If you are using the parameters Q1 to Q99 in OEM cycles, define via MP7251 whether the parameters are only to be used locally in the OEM cycles, or may be used globally.

Calling Q parameter functions

When you are writing a part program, press the "Q" key (below the -/+ key in the keypad for numerical input and axis selection). The TNC then displays the following soft keys:

Function group	Soft key
Basic arithmetic (assign, add, subtract, multiply, divide, square root)	<div>BASIC ARITHM.</div>
Trigonometric functions	<div>TRIGO- NOMETRY</div>
Function for calculating circles	<div>CIRCLE CALCU- LATION</div>
If/then conditions, jumps	<div>JUMP</div>
Other functions	<div>DIVERSE FUNCTION</div>
Entering Formulas Directly	<div>FORMULA</div>

### 10.2 Part Families — Q Parameters in Place of Numerical Values

The Q parameter function FN0: ASSIGN assigns numerical values to Q parameters. This enables you to use variables in the program instead of fixed numerical values.

**Example NC blocks**

15 FN0: Q10 = 25	ASSIGN:
...	Q10 contains the value 25
25 L X +Q10	Means L X +25

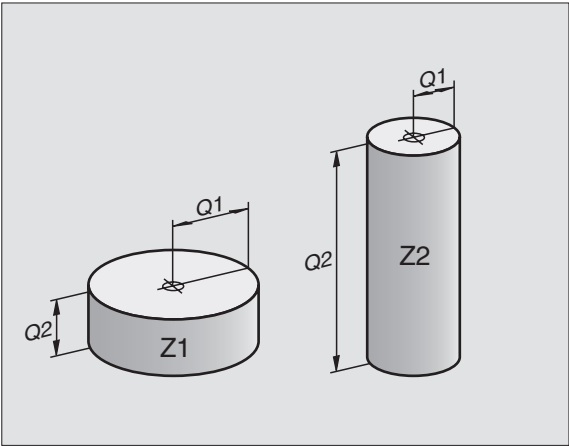
You need write only one program for a whole family of parts, entering the characteristic dimensions as Q parameters.

To program a particular part, you then assign the appropriate values to the individual Q parameters.

**Example**

Cylinder with Q parameters

Cylinder radius	R	=	Q1
Cylinder height	H	=	Q2
Cylinder Z1	Q1	=	+30
	Q2	=	+10
Cylinder Z2	Q1	=	+10
	Q2	=	+50



### 10.3 Describing Contours Through Mathematical Functions

The Q parameters listed below enable you to program basic mathematical functions in a part program:

- To select the Q parameter function, press the Q key (at the right, in the keypad for numerical input). The Q parameter functions are displayed in a soft-key row.
- To select the mathematical functions: Press the BASIC ARITHMETIC soft key. The TNC then displays the following soft keys:

Function	Soft key
<b>FN0: ASSIGN</b> Example: FN0: Q5 = +60 Assigns a numerical value.	<div>FN0</div> <div>X = Y</div>
<b>FN1: ADDITION</b> Example: FN1: Q1 = -Q2 + -5 Calculates and assigns the sum of two values.	<div>FN1</div> <div>X + Y</div>
<b>FN2: SUBTRACTION</b> Example: FN2: Q1 = +10 - +5 Calculates and assigns the difference of two values.	<div>FN2</div> <div>X - Y</div>
<b>FN3: MULTIPLICATION</b> Example: FN3: Q2 = +3 * +3 Calculates and assigns the product of two values.	<div>FN3</div> <div>X * Y</div>
<b>FN4: DIVISION</b> Example: FN4: Q4 = +8 DIV +Q2 Calculates and assigns the product of two value <b>Not permitted:</b> Division by 0	<div>FN4</div> <div>X / Y</div>
<b>FN5: SQUARE ROOT</b> Example: FN5: Q20 = SQRT 4 Calculates and assigns the square root of a number. <b>Not permitted:</b> square root of a negative number	<div>FN5</div> <div>SQRT</div>

At the right of the "=" character you can enter:

- Two numbers
- Two Q parameters
- A number and a Q parameter

The Q parameters and numerical values in the equations can be entered with positive or negative signs.

Example: Programming fundamental operations



To select the Q parameter functions, press the Q key.



To select the mathematical functions: Press the BASIC ARITHMETIC soft key.



To select the Q parameter function ASSIGN, press the FN0 X = Y soft key.

Parameter number for result?

5



Enter a parameter number, for example 5.

1st value or parameter ?

10



Assign a value to Q5, for example 10.



To select the Q parameter functions, press the Q key.



To select the mathematical functions: Press the BASIC ARITHMETIC soft key.



To select the Q parameter function MULTIPLICATION, press the FN3 X \* Y soft key.

Parameter number for result?

12



Enter a Q parameter number, for example 12.

1st value or parameter ?

Q5



Enter Q5 for the first value.

2nd value or parameter ?

7



Enter 7 for the second value.

The TNC displays the following program blocks:

```
16 FN0: Q5 = +10
17 FN3: Q12 = +Q5 * +7
```

10.4 Trigonometric Functions

Sine, cosine and tangent are terms designating the ratios of sides of right triangles. For a right triangle, the trigonometric functions of the angle  $\alpha$  are defined by the following equations:

- Sine:**  $\sin \alpha = a / c$
- Cosine:**  $\cos \alpha = b / c$
- Tangent:**  $\tan \alpha = a / b = \sin \alpha / \cos \alpha$

where

- $c$  is the side opposite the right angle
- $a$  is the side opposite the angle  $\alpha$
- $b$  is the third side.

The TNC can find the angle from the tangent  
 $\alpha = \arctan a = \arctan (a / b) = \arctan (\sin \alpha / \cos \alpha)$

**Example:**  
 $a = 10 \text{ mm}$   
 $b = 10 \text{ mm}$   
 $\alpha = \arctan (a / b) = \arctan 1 = 45^\circ$

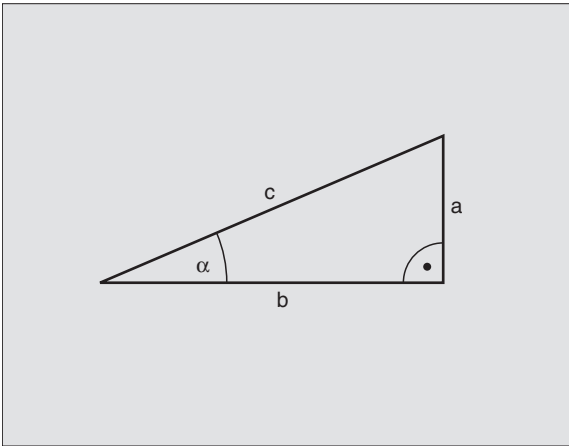
Furthermore:

$a^2 + b^2 = c^2$  (where  $a^2 = a \times a$ )  
 $c = \sqrt{(a^2 + b^2)}$

Programming trigonometric functions

Press the TRIGONOMETRY soft key to call the trigonometric functions. The TNC then displays the soft keys that are listed in the table at right.

Programming: compare „Example: Programming fundamental operations“.



Function	Soft key
FN6: SINE Example: FN6: Q20 = SIN-Q5 Calculate the sine of an angle in degrees (°) and assign it to a parameter.	FN6 SIN(X)
FN7: COSINE Example: FN7: Q21 = COS-Q5 Calculate the cosine of an angle in degrees (°) and assign it to a parameter.	FN7 COS(X)
FN8: ROOT-SUM OF SQUARES Example: FN8: Q10 = +5 LEN +4 Calculate and assign length from two values	FN8 X LEN V
FN13: ANGLE Example: FN13: Q20 = +10 ANG-Q1 Calculate the angle from the arc tangent of two sides or from the sine and cosine of the angle (0 < angle < 360°) and assign it to a parameter.	FN13 X ANG V

## 10.5 Calculating Circles

The TNC can use the functions for calculating circles to calculate the circle center and the circle radius from three or four given points on the circle. The calculation is more accurate if four points are used.

Application: These functions can be used if you wish to determine the location and size of a bore hole or a pitch circle using the programmable probing function.

Function	Soft key
----------	----------

FN23: Determining the CIRCLE DATA from three points  
e.g. FN23: Q20 = CDATA Q30



The coordinate pairs for three points of the circle must be stored in Parameter Q30 and in the following five parameters - here to Q35. The TNC then stores the circle center of the reference axis (X with spindle axis Z) in Parameter Q20, the circle center of the minor axis (Y with spindle axis Z) in Parameter Q21 and the circle radius in Parameter Q22.

FN24: Determining the CIRCLE DATA from four points  
e.g. FN24: Q20 = CDATA Q30



The coordinate pairs for four points of the circle must be stored in Parameter Q30 and in the following seven parameters - here to Q37. The TNC then stores the circle center of the reference axis (X with spindle axis Z) in Parameter Q20, the circle center of the minor axis (Y with spindle axis Z) in Parameter Q21 and the circle radius in Parameter Q22.



Note that FN23 and FN24 beside the resulting parameter also overwrite the two following parameters.



## 10.6 If-Then Decisions with Q Parameters

The TNC can make logical If-Then decisions by comparing a Q parameter with another Q parameter or with a numerical value. If the condition is fulfilled, the TNC continues the program at the label that is programmed after the condition (for information on labels, see section 9 “Subprograms and Program Section Repeats”). If it is not fulfilled, the TNC continues with the next block.

To call another program as a subprogram, enter PGM CALL after the block with the target label.

### Unconditional jumps

An unconditional jump is programmed by entering a conditional jump whose condition is always true. Example:

FN9: IF+10 EQU+10 GOTO LBL1

### Programming If-Then decisions

Press the JUMP soft key to call the if-then conditions. The TNC then displays the following soft keys:

Function	Soft key
<b>FN9: IF EQUAL, JUMP</b> Example: FN9: IF +Q1 EQU +Q3 GOTO LBL 5 If the two values or parameters are equal, jump to the given label.	<div>FN9</div> <div>IF X EQ V</div> <div>GOTO</div>
<b>FN10: IF NOT EQUAL, JUMP</b> Example: FN10: IF +10 NE -Q5 GOTO LBL 10 If the two values or parameters are not equal, jump to the given label.	<div>FN10</div> <div>IF X NE V</div> <div>GOTO</div>
<b>FN11: IF GREATER THAN, JUMP</b> Example: FN11: IF+Q1 GT+10 GOTO LBL 5 If the first parameter or value is greater than the second value or parameter, jump to the given label.	<div>FN11</div> <div>IF X GT V</div> <div>GOTO</div>
<b>FN12: IF LESS THAN, JUMP</b> Example: FN12: IF+Q5 LT+0 GOTO LBL 1 If the first value or parameter is less than the second value or parameter, jump to the given label.	<div>FN12</div> <div>IF X LT V</div> <div>GOTO</div>

<b>Abbreviations used:</b>	
<b>IF</b>	If
<b>EQU</b>	Equals
<b>NE</b>	Not equal
<b>GT</b>	Greater than
<b>LT</b>	Less than
<b>GOTO</b>	Go to

## 10.7 Checking and Changing Q Parameters

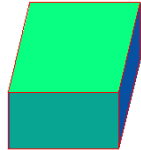
During a program run or test run, you can check or change Q parameters if necessary.

- ▶ If you are in a program run, interrupt it (for example by pressing the machine STOP button and the INTERNAL STOP soft key). If you are doing a test run, interrupt it.



- ▶ To call the Q parameter functions, press the Q key.
- ▶ Enter the Q parameter number and press the ENT key. The TNC displays the current value of the Q parameter in the dialog line.
- ▶ If you wish to change the value, enter a new value, confirm it with the ENT key and conclude your entry with the END key.

To leave the value unchanged, terminate the dialog with the END key.

Program run full sequence	Test run <b>Q10 = -50</b>
<pre>0 BEGIN PGM 3507 MM 1 BLK FORM 0.1 Z X-20 Y-20 Z-20 2 BLK FORM 0.2 X+20 Y+20 Z+0 3 TOOL CALL 1 Z S1000 4 L Z+50 R0 F MAX M3 5 L X+50 Y+50 R0 F MAX M8 6 L Z-5 R0 F MAX 7 CC X+0 Y+0 8 LP PR+14 PR+45 RR F500 9 RND R1 10 FC DR+ R2.5 CLSD+ 11 FLT AN+100.925 12 FCT DR+ R10.5 CCK+0 CCY+0 13 ; solution 2 is not correct 14 FSELECT 1</pre>	 <div>0° 00:00:00</div>
	END

## 10.8 Additional Functions

Press the DIVERSE FUNCTION soft key to call the additional functions. The TNC then displays the following soft keys:

Function	Soft key
FN14:ERROR Display error messages	<div>FN14 ERROR=</div>
FN15:PRINT Unformatted output of texts or Q parameter values	<div>FN15 PRINT</div>
FN16:F-PRINT Formatted output of texts or Q parameter values	<div>FN16 F-PRINT</div>
FN18:SYS-DATUM READ Read system data	<div>FN18 SYS-DATUM READ</div>
FN19:PLC Transfer values to the PLC	<div>FN19 PLC=</div>
FN20:WAIT FOR NC and PLC synchronization	<div>FN20 WAIT FOR</div>
FN26:TABOPEN Open a freely definable table	<div>FN26 OPEN TABLE</div>
FN27:TABWRITE Write to a freely definable table	<div>FN27 WRITE TO TABLE</div>
FN28:TABREAD Read from a freely definable table	<div>FN28 READ FROM TABLE</div>

**FN14: ERROR**  
**Display error messages**

With the function FN14: ERROR you can call messages under program control. The messages were preprogrammed by the machine tool builder or by HEIDENHAIN. If the TNC encounters a block with FN 14 during program run, it will interrupt the run and display an error message. The program must then be restarted. The error number are listed in the table below.

**Example NC block**


The TNC is to display the text stored under error number 254:

**180 FN 14:ERROR = 254**

Range of error numbers	Standard dialog text
0 ... 299	FN 14: Error code 0 .... 299
300 ... 999	Machine-dependent dialog
1000 ... 1099	Internal error messages (see table at right)

Error code and text	
1000	Spindle ?
1001	Tool axis is missing
1002	Slot width too large
1003	Tool radius too large
1004	Range exceeded
1005	Start position incorrect
1006	ROTATION not permitted
1007	SCALING FACTOR not permitted
1008	MIRRORING not permitted
1009	Datum shift not permitted
1010	Feed rate is missing
1011	Entry value incorrect
1012	Wrong sign programmed
1013	Entered angle not permitted
1014	Touch point inaccessible
1015	Too many points
1016	Contradictory entry
1017	CYCL incomplete
1018	Plane wrongly defined
1019	Wrong axis programmed
1020	Wrong RPM
1021	Radius comp. undefined
1022	Rounding-off undefined
1023	Rounding radius too large
1024	Program start undefined
1025	Excessive subprogramming
1026	Angle reference missing
1027	No fixed cycle defined
1028	Slot width too small
1029	Pocket too small
1030	Q202 not defined
1031	Q205 not defined
1032	Enter Q218 greater than Q219
1033	CYCL 210 not permitted
1034	CYCL 211 not permitted
1035	Q220 too large
1036	Q222 must be greater than Q223
1037	Q244 must be greater than 0
1038	Q245 must not equal Q246
1039	Angle range must be under 360°
1040	Q223 must be greater than Q222
1041	Q214: 0 not permitted

FN15: PRINT  
Unformatted output of texts or Q parameter values



Setting the data interface: In the menu option PRINT or PRINT-TEST, you must enter the path for storing the texts or Q parameters. See „12 MOD Functions, Setting the Data Interface“.

The function FN15: PRINT transfers Q parameter values and error messages through the data interface, for example to a printer. When you save the data in the TNC memory or transfer them to a PC, the TNC stores the data in the file %FN15RUN.A (output in program run mode) or in the file %FN15SIM.A (output in test run mode).

**To output dialog texts and error messages with FN15: PRINT “numerical value”**  
Numerical values from 0 to 99:     Dialog texts for OEM cycles  
Numerical values exceeding 100:    PLC error messages  
Example: Output of dialog text 20


67 FN 15: PRINT20

**To output dialog texts and error messages with FN 15: PRINT “Q parameter”**  
Application example: Recording workpiece measurement.  
You can transfer up to six Q parameters and numerical values simultaneously. The TNC separates them with slashes.  
Example: Output of dialog text 1 and numerical value for Q1

70 FN 15: PRINT1/Q1

Program run full sequence		Programming and editing					
RS232 interface			RS422 interface				
Mode of op.: LSV-2			Mode of op.: FE1				
Baud rate			Baud rate				
FE : 115200			FE : 9600				
EXT1 : 57600			EXT1 : 9600				
EXT2 : 19200			EXT2 : 9600				
LSV-2: 115200			LSV-2: 9600				
Assign:							
Print : TNC:\NK\SCRDP\							
Print-test :							
PGM MGT: Enhanced							
0	RS232 RS422 SETUP	USER PARAMETER	HELP			END	

**FN16: F-PRINT**  
**Formatted output of text and Q parameter values**



Setting the data interface: In the menu option PRINT or PRINT-TEST, you must enter the path for storing the text file. See „12 MOD Functions, Setting the Data Interface“

The function FN16: F-PRINT transfers Q parameter values and texts in a selectable format through the data interface, for example to a printer. If you save the values internally or send them to a computer, the TNC saves the data in the file that you defined in the FN 16 block.

To output the formatted texts and Q parameter values, create a text file with the TNC’s text editor, and define the output format and Q parameters in this file.

Example of a text file to define the output format:

```
"TEST RECORD IMPELLER CENTER OF GRAVITY";  
"_____";  
"NO. OF MEASURED VALUES : = 1";  
"*****";  
"X1 = %5.3LF", Q31;  
"Y1 = %5.3LF", Q32;  
"Z1 = %5.3LF", Q33;  
"*****";
```

When you create a text file, use the following formatting functions:

Special character	Function
"....."	Define output format for texts and variables between the quotation marks
%5.3LF	Define format for Q parameter: (long, floating):5 places before and 4 places behind the decimal point
%S	Format for text variable
,	Separator between output format and parameter
;	End of block character

The following functions allow you to include the following additional information in the protocol log file:

Code word	Function
CALL_PATH	Gives the path for the NC program where you will find the FN16 function. Example: "Measuring program: %S";CALL_PATH;
M_CLOSE	Closes the file to which you are writing with FN16.Example: M_CLOSE;
L_ENGLISH	Output text only for English conversational language
L_GERMAN	Output text only for German conversational language
L_CZECH	Output text only for Czech conversational language
L_FRENCH	Output text only for French conversational language
L_ITALIAN	Output text only for Italian conversational language
L_SPANISH	Output text only for Spanish conversational language
L_DANISH	Output text only for Danish conversational language
L_FINNISH	Output text only for Finnish conversational language
L_DUTCH	Output text only for Dutch conversational language
L_POLISH	Output text only for Polish conversational language
L_HUNGARIA	Output text only for Hungarian conversational language
L_ALL	Output text independent of the conversational language
hour	Number of hours from the real-time clock
min	Number of minutes from the real-time clock
sec	Number of seconds from the real-time clock
day	Day from the real-time clock
month	Month as number from the real-time clock
str_month	Month as string abbreviation from the real-time clock
year2	Two-digit year from the real-time clock
year4	Four-digit year from the real-time clock

In the part program, program FN 16: F-PRINT, to activate the output:

```
96 FN16:F-PRINT TNC:\MASKE\MASKE1.A /
RS232:\PROT1.TXT
```

The TNC then outputs the file PROT1.TXT through the serial interface:

```
CALIBRAT. CHART IMPELLER CENTER GRAVITY
-----
NO. OF MEASURED VALUES : = 1
*****
X1 = 149.360
Y1 = 25.509
Z1 = 37.000
*****
```



If you use FN 16 several times in the program, the TNC saves all texts in the file that you have defined with the first FN 16 function. The file is not output until the TNC reads the END PGM block, or you press the NC stop button, or you close the file with M\_CLOSE.

# FN18: SYS-DATUM READ

## Read system data

With the function FN 18: SYS-DATUM READ you can read system data and store them in Q parameters. You select the system data through a group number (ID number),and additionally through a number and an index.

Group name, ID No.	Number	Index	System data
Program information, 10	1	–	MM/inch condition
	2	–	Overlap factor for pocket milling
	3	–	Number of active fixed cycle
Machine status, 20	1	–	Active tool number
	2	–	Prepared tool number
	3	–	Active tool axis 0=X, 1=Y, 2=Z, 6=U, 7=V, 8=W
	4	–	Programmed spindle rpm
	5	–	Active spindle status: -1=undefined, 0=M3 active, 1=M4 active, 2=M5 after M3, 3=M5 after M4
	8	–	Coolant status: 0=off, 1=on
	9	–	Active feed rate
	10	–	Index of the prepared tool
	11	–	Index of the active tool
Cycle parameter, 30	1	–	Setup clearance of active fixed cycle
	2	–	Drilling depth / milling depth of active fixed cycle
	3	–	Plunging depth of active fixed cycle
	4	–	Feed rate for pecking in active fixed cycle
	5	–	1st side length for rectangular pocket cycle
	6	–	2nd side length for rectangular pocket cycle
	7	–	1st side length for slot cycle
	8	–	2nd side length for slot cycle
	9	–	Radius for circular pocket cycle
	10	–	Feed rate for milling in active fixed cycle
	11	–	Direction of rotation for active fixed cycle
	12	–	Dwell time for active fixed cycle
	13	–	Thread pitch for Cycles 17, 18
	14	–	Milling allowance for active fixed cycle
	15	–	Direction angle for rough out in active fixed cycle



Group name, ID No.	Number	Index	System data
Data from the tool table, 50	1	Tool no.	Tool length
	2	Tool no.	Tool radius
	3	Tool no.	Tool radius R2
	4	Tool no.	Oversize for tool length DL
	5	Tool no.	Oversize for tool radius DR
	6	Tool no.	Oversize for tool radius DR2
	7	Tool no.	Tool inhibited (0 or 1)
	8	Tool no.	Number of replacement tool
	9	Tool no.	Maximum tool age TIME1
	10	Tool no.	Maximum tool age TIME2
	11	Tool no.	Current tool age CUR. TIME
	12	Tool no.	PLC status
	13	Tool no.	Maximum tooth length LCUTS
	14	Tool no.	Maximum plunge angle ANGLE
	15	Tool no.	TT: Number of teeth CUT
	16	Tool no.	TT: Wear tolerance for length LTOL
	17	Tool no.	TT: Wear tolerance for radius RTOL
	18	Tool no.	TT: Rotational direction DIRECT (0=positive/-1=negative)
	19	Tool no.	TT: Offset for radius R-OFFS
	20	Tool no.	TT: Offset for length L-OFFS
	21	Tool no.	TT: Breakage tolerance in length LBREAK
	22	Tool no.	TT: Breakage tolerance in radius RBREAK
No index: Data of the currently active tool			
Pocket table data, 51	1	Pocket number	Tool number
	2	Pocket number	Special tool: 0=no, 1=yes
	3	Pocket number	Fixed pocket: 0=no, 1=yes
	4	Pocket number	Locket pocket: 0=no, 1=yes
	5	Pocket number	PLC status
Pocket number of a tool in the tool pocket table, 52	1	Tool no.	Pocket number
Immediately after TOOL CALL programmed position, 70	1	–	Position valid / invalid (1/0)
	2	1	X axis
	2	2	Y axis
	2	3	Z axis
	3	–	Programmed feed rate (-1: no feed rate programmed)
Active tool compensation, 200	1	–	Tool radius (including delta values)
	2	–	Tool length (including delta values)

Group name, ID No.	Number	Index	System data
Active transformations, 210	1	–	Basic rotation in MANUAL OPERATION mode
	2	–	Programmed rotation with Cycle 10
	3	–	Active mirror axis
			0: mirroring not active
			+1: X axis mirrored
			+2: Y axis mirrored
			+4: Z axis mirrored
			+64: U axis mirrored
			+128: V axis mirrored
			+256: W axis mirrored
			Combinations = sum of individual axes
	4	1	Active scaling factor in X axis
	4	2	Active scaling factor in Y axis
	4	3	Active scaling factor in Z axis
	4	7	Active scaling factor in U axis
	4	8	Active scaling factor in V axis
	4	9	Active scaling factor in W axis
	5	1	3D ROT A axis
	5	2	3D ROT B axis
	5	3	3D ROT C axis
	6	–	Tilted working plane active / inactive (-1/0)
Active datum shift, 220	2	1 to 9	Index 1=X axis      2=Y axis      3=Z axis
			Index 4=A axis      5=B axis      6=C axis
			Index 7=U axis      8=V axis      9=W axis
Traverse range, 230	2	1 to 9	Negative software limit switch Axes 1 to 9
	3	1 to 9	Positive software limit switch Axes 1 to 9
Nominal position in the REF system, 240	1	1 to 9	Index 1=X axis      2=Y axis      3=Z axis Index 4=A axis      5=B axis      6=C axis Index 7=U axis      8=V axis      9=W axis
Nominal positions in the input system, 270	1	1 to 9	Index 1=X axis      2=Y axis      3=Z axis Index 4=A axis      5=B axis      6=C axis Index 7=U axis      8=V axis      9=W axis
Status of M128, 280	1	–	0: M128 inactive, -1: M128 active
	2	–	Feed rate that was programmed with M128
Triggering touch probe, 350	10	–	Touch probe axis
	11	–	Effective ball radius
	12	–	Effective length
	13	–	Radius setting ring
	14	1	Center misalignment in main axis
		2	Center misalignment in secondary axis
	15	–	Direction of center misalignment compared with 0° position

Group name, ID No.	Number	Index	System data
Tool touch probe 120	20	1	Center point X-axis (REF system)
		2	Center point Y-axis (REF system)
		3	Center point Z-axis (REF system)
	21	–	Probe contact radius
Measuring touch probe, 350	30	–	Calibrated stylus length
	31	–	Stylus radius 1
	32	–	Stylus radius 2
	33	–	Setting ring diameter
	34	1	Center misalignment in main axis
		2	Center misalignment in secondary axis
	35	1	Compensation factor for 1st axis
		2	Compensation factor for 2nd axis
		3	Compensation factor for 3rd axis
	36	1	Power ratio for 1st axis
		2	Power ratio for 2nd axis
		3	Power ratio for 3rd axis
Last touch point in TCH PROBE- cycle 0 or last touch point from manual operating mode, 360	1	1 – 9	Position in the active coordinate system Axes 1 to 9
	2	1 – 9	Position in the REF system Axes 1 to 9
Data from the active datum table, 500	(datum number)	1 to 9	Index 1=X axis      2=Y axis      3=Z axis Index 4=A axis      5=B axis      6=C axis Index 7=U axis      8=V axis      9=W axis
Datum table selected, 505	1	–	Acknowledgement value = 0: No datum table active Acknowledgement value = 1: Datum table active
Data from the active pallet table, 510	1	–	Active line
	2	–	Palette number from PAL/PGM field
Machine parameter exists, 1010	MP number	MP index	Acknowledgement value = 0: MP does not exist Acknowledgement value = 1: MP exists

Example: Assign the value of the active scaling factor for the Z axis to Q25.

**55 FN18: SYSREAD Q25 = ID210 NR4 IDX3**


**FN19: PLC**  
**Transferring values to the PLC**

The function FN19: PLC transfers up to two numerical values or Q parameters to the PLC. Increments and units: 0.1 µm or 0.0001°

Example: Transfer the numerical value 10 (which means 1 µm or 0.001°) to the PLC

```
56 FN 19: PLC=+10/+Q3
```

**FN20: WAIT FOR**  
**NC and PLC synchronization**



This function may only be used with the permission of your machine tool builder.

With function FN20: WAIT FOR you can synchronize the NC and PLC with each other during a program run. The NC stops machining until the condition that you have programmed in the FN20 block is fulfilled. With FN10 the TNC can check the following operands:

PLC Operand	Abbreviation	Address range
Marker	M	0 to 4999
Input	I	0 to 31, 128 to 152 64 to 126 (first PL 401 B) 192 to 254 (second PL 401 B)
Output	O	0 to 30 32 to 62 (first PL 401 B) 64 to 94 (second PL 401 B)
Counter	C	48 to 79
Timer	T	0 to 95
Byte	B	0 to 4095
Word	W	0 to 2047
Doubleword	D	2048 to 4095

The following conditions are permitted in the FN 20 block:

Condition	Abbreviation
Equals	==
Less than	<
Greater than	>
Less than or equal	<=
Greater than or equal	>=

Example: Stop program run until the PLC sets marker 4095 to 1

```
32 FN20: WAIT FOR M4095==1
```

## FN25: PRESET

### Setting a new datum



This function can only be programmed if you have entered the code number 555343 (see „12.3 Entering Code Number“).

With the function FN 25: PRESET, it is possible to set a new datum in an axis of choice during program run.

- ▶ To select the Q parameter function, press the Q key (at the right, in the keypad for numerical input). The Q parameter functions are displayed in a soft-key row.
- ▶ Select the miscellaneous functions: press the DIVERSE FUNCTION soft key .
- ▶ Select FN25: Switch the soft-key row to the second level, press the FN25 DATUM SET soft key
- ▶ Axis?: Enter the axis where you wish to set the new datum and confirm with ENT
- ▶ Value to be calculated?: Enter the coordinate for the new datum point in the active coordinate system
- ▶ New datum?: Enter the value that the new datum point will have in the new coordinate system

Example: Set a new datum at the current coordinate X+100

```
56 FN 25: PRESET = X / +100 / +0
```

Example: The current coordinate Z+50 will have the value -20 in the new coordinate system

```
56 FN 25: PRESET = Z / +50 / -20
```

## FN26: TABOPEN

### Opening a freely definable table

With FN 26: TABOPEN you can define a table to be written with FN27, or to be read from with FN28.



Only one table can be open in an NC program. A new block with TABOPEN automatically closes the last opened table.

The table to be opened must have the file name extension .TAB.


Example: Open the table TAB1.TAB, which is save in the directory TNC:DIR1.

```
56 FN 26: TABOPEN TNC:\DIR1\TAB1.TAB
```

**FN27: TABWRITE**  
**Writing to a freely definable table**

After you have opened a table with FN 26 TABOPEN, you can use function FN 27: TABWRITE to write to it.

You can define and write in up to 8 column names in a TABWRITE block. The column names must be written between quotation marks and separated by a comma. You define the values that the TNC is to write to the respective column with Q parameters.



You can write only to numerical table fields.

If you wish to write to more than one column in a block, you must save the values under successive Q parameter numbers.

Example: You wish to write to the columns "Radius," "Depth" and "D" in line 5 of the presently opened table. The value to be written in the table must be saved in the Q parameters Q5, Q6 and Q7.

53 FN 0: Q5 = 3.75

54 FN 0: Q6 = -5


55 FN 0: Q7 = 7.5

56 FN 27: TABWRITE 5 / "Radius,Depth,D" = Q5

**FN28: TABREAD**  
**Reading from a freely definable table**

After you have opened a table with FN 26 TABOPEN, you can use function FN 28: TABREAD to read from it.

You can define, i.e. read in, up to 8 column names in a TABREAD block. The column names must be written between quotation marks and separated by a comma. In the FN 28 block you can define the Q parameter number in which the TNC is to write the value that is first read.



You can read only numerical table fields.

If you wish to read from more than one column in a block, the TNC will save the values under successive Q parameter numbers.

Example: You wish to read the values of the columns "Radius," "Depth" and "D" from line 6 of the presently opened table. Save the first value in Q parameter Q10 (second value in Q11, third value in Q12).

56 FN 28: TABREAD Q10 = 6 / "Radius,Depth,D"

## 10.9 Entering Formulas Directly

You can enter mathematical formulas that include several operations directly into the part program by soft key.

### Entering formulas

Press the FORMULA soft key to call the formula functions. The TNC displays the following soft keys in several soft-key rows:

Mathematical function	Soft key
<b>Addition</b> Example: Q10 = Q1 + Q5	<div>+</div>
<b>Subtraction</b> Example: Q25 = Q7 – Q108	<div>–</div>
<b>Multiplication</b> Example: Q12 = 5 * Q5	<div>*</div>
<b>Division</b> Example: Q25 = Q1 / Q2	<div>/</div>
<b>Open parentheses</b> Example: Q12 = Q1 * (Q2 + Q3)	<div>(</div>
<b>Close parentheses</b> Example: Q12 = Q1 * (Q2 + Q3)	<div>)</div>
<b>Square</b> Example: Q15 = SQ 5	<div>SQ</div>
<b>Square root</b> Example: Q22 = SQRT 25	<div>SQRT</div>
<b>Sine of an angle</b> Example: Q44 = SIN 45	<div>SIN</div>
<b>Cosine of an angle</b> Example: Q45 = COS 45	<div>COS</div>
<b>Tangent of an angle</b> Example: Q46 = TAN 45	<div>TAN</div>

Mathematical function	Soft key
<b>Arc sine</b> Inverse of the sine. Determine the angle from the ratio of the opposite side to the hypotenuse. Example: Q10 = ASIN 0.75	ASIN
<b>Arc cosine</b> Inverse of the cosine. Determine the angle from the ratio of the adjacent side to the hypotenuse. Example: Q11 = ACOS Q40	ACOS
<b>Arc tangent</b> Inverse of the tangent. Determine the angle from the ratio of the opposite to the adjacent side. Example: Q12 = ATAN Q50	ATAN
<b>Powers</b> Example: Q15 = 3^3	^
<b>Constant "pi" (3.14159)</b> e.g. Q15 = PI	PI
<b>Natural logarithm (LN) of a number</b> Base 2.7183 Example: Q15 = LN Q11	LN
<b>Logarithm of a number, base 10</b> Example: Q33 = LOG Q22	LOG
<b>Exponential function, 2.7183<sup>n</sup></b> Example: Q1 = EXP Q12	EXP
<b>Negate (multiplication by -1)</b> Example: Q2 = NEG Q1	NEG
<b>Drop places after the decimal point</b> (form an integer) Example: Q3 = INT Q42	INT
<b>Absolute value</b> Example: Q4 = ABS Q22	ABS
<b>Drop places before the decimal point</b> (form a fraction) Example: Q5 = FRAC Q23	FRAC

Rules for formulas

Mathematical formulas are programmed according to the following rules:

■ **Higher-level operations are performed first**  
(multiplication and division before addition and subtraction)

12 Q1 = 5 \* 3 + 2 \* 10 = 35

1st step: 5 \* 3 = 15  
2nd step: 2 \* 10 = 20  
3rd step: 15 + 20 = 35

13 Q2 = SQ 10 - 3^3 = 73

1st step: 10<sup>2</sup> = 100  
2nd step: 3<sup>3</sup> = 27  
3rd step: 100 - 27 = 73

■ **Distributive law**  
for calculating with parentheses  
 $a * (b + c) = a * b + a * c$



**Programming example**

Calculate an angle with arc tangent as opposite side (Q12) and adjacent side (Q13); then store in Q25.



To select the formula entering function, press the Q key and FORMULA soft key.

**Parameter number for result?**

Enter the parameter number.



Shift the soft-key row and select the arc tangent function.



Shift the soft-key row and open parentheses.



Enter Q parameter number 12.



Select division.



Enter Q parameter number 13.



Close parentheses and conclude formula entry.

**Example NC block**

```
37 Q25 = ATAN (Q12/Q13)
```

10.10 Preassigned Q Parameters

The Q parameters Q100 to Q122 are assigned values by the TNC. These values include:

- Values from the PLC
- Tool and spindle data
- Data on operating status, etc.

Values from the PLC: Q100 to Q107

The TNC uses the parameters Q100 to Q107 to transfer values from the PLC to an NC program.

Active tool radius: Q108

The active value of the tool radius is assigned to Q108. Q108 is calculated from:

- Tool radius R (Tool table or TOOL DEF block)
- Delta value DR from the tool table
- Delta value DR from the TOOL CALL block

Tool axis: Q109

The value of Q109 depends on the current tool axis:

Tool axis	Parameter value
No tool axis defined	Q109 = -1
X axis	Q109 = 0
Y axis	Q109 = 1
Z axis	Q109 = 2
U axis	Q109 = 6
V axis	Q109 = 7
W axis	Q109 = 8

Spindle status: Q110

The value of Q110 depends on which M function was last programmed for the spindle:

M function	Parameter value
No spindle status defined	Q110 = -1
M03: Spindle ON, clockwise	Q110 = 0
M04: Spindle ON, counterclockwise	Q110 = 1
M05 after M03	Q110 = 2
M05 after M04	Q110 = 3

Coolant on/off: Q111

M function	Parameter value
M08: Coolant ON	Q111 = 1
M09: Coolant OFF	Q111 = 0

**Overlap factor: Q112**

The overlap factor for pocket milling (MP7430) is assigned to Q112.

**Unit of measurement for dimensions in the program: Q113**

The value of parameter Q113 specifies whether the highest-level NC program (for nesting with PGM CALL) is programmed in millimeters or inches.

Dimensions of the main program	Parameter value
Metric system (mm)	Q113 = 0
Inch system (inches)	Q113 = 1

**Tool length: Q114**

The current value for the tool length is assigned to Q114.

**Coordinates after probing during program run**

The parameters Q115 to Q119 contain the coordinates of the spindle position at the moment of contact during programmed measurement with the 3-D touch probe.

The length and radius of the probe tip are not compensated in these coordinates.

Coordinate axis	Parameter
X axis	Q115
Y axis	Q116
Z axis	Q117
IVth axis (dependent on MP100)	Q118
Vth axis (dependent on MP100)	Q119

**Deviation between actual value and nominal value during automatic tool measurement with the TT 120**

Actual-nominal deviation	Parameter
Tool length	Q115
Tool radius	Q116

**Tilting the working plane with mathematical angles: Rotary axis coordinates calculated by the TNC**

Coordinates	Parameters
A axis	Q120
B axis	Q121
C axis	Q122

Results of measurements with touch probe cycles

(see also Touch Probe Cycles User's Manual)

Measured actual values	Parameter
Center in reference axis	Q151
Center in minor axis	Q152
Diameter	Q153
Length of pocket	Q154
Width of pocket	Q155
Length in the axis selected in the cycle	Q156
Position of the center line	Q157
Angle of the A axis	Q158
Angle of the B axis	Q159
Coordinate of the axis selected in the cycle	Q160

Measured deviation	Parameter
Center in reference axis	Q161
Center in minor axis	Q162
Diameter	Q163
Length of pocket	Q164
Width of pocket	Q165
Measured length	Q166
Position of the center line	Q167

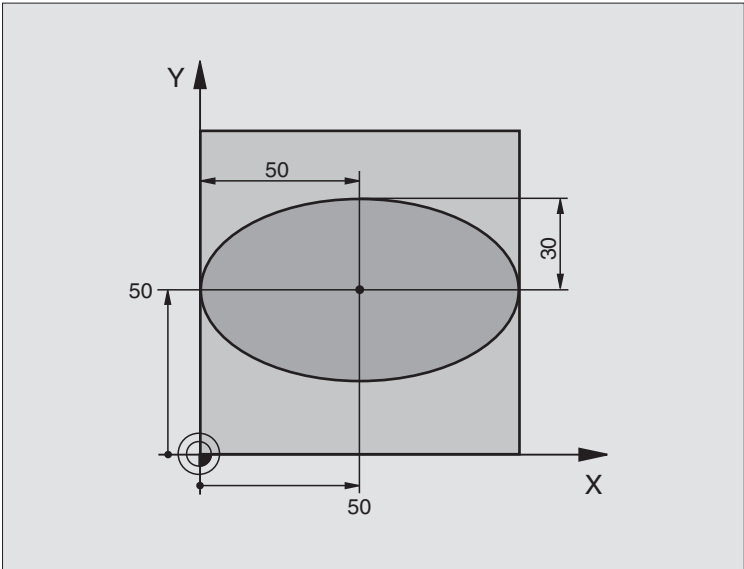
Workpiece status	Parameter
Good	Q180
Re-work	Q181
Scrap	Q182

Reserved for internal use	Parameter
Markers for cycles (machining graphics)	Q197

# Example: Ellipse

## Program sequence

- The contour of the ellipse is approximated by many short lines (defined in Q7). The more calculating steps you define for the lines, the smoother the curve becomes.
- The machining direction can be altered by changing the entries for the starting and end angles in the plane:  
Clockwise machining direction:  
starting angle > end angle  
Counterclockwise machining direction:  
starting angle < end angle
- The tool radius is not taken into account.



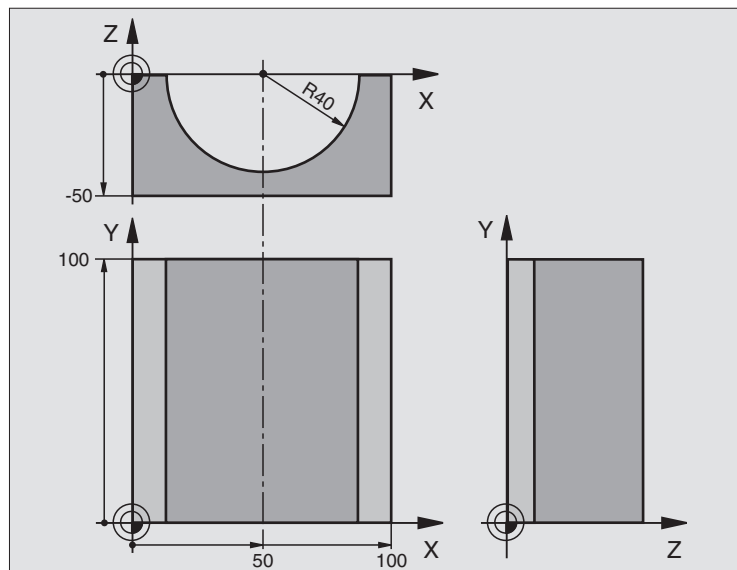
0	BEGIN PGM ELLIPSE MM	
1	FN 0: Q1 = +50	Center in X axis
2	FN 0: Q2 = +50	Center in Y axis
3	FN 0: Q3 = +50	Semiasis in X
4	FN 0: Q4 = +30	Semiasis in Y
5	FN 0: Q5 = +0	Starting angle in the plane
6	FN 0: Q6 = +360	End angle in the plane
7	FN 0: Q7 = +40	Number of calculating steps
8	FN 0: Q8 = +0	Rotational position of the ellipse
9	FN 0: Q9 = +5	Milling depth
10	FN 0: Q10 = +100	Feed rate for plunging
11	FN 0: Q11 = +350	Feed rate for milling
12	FN 0: Q12 = +2	Setup clearance for pre-positioning
13	BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
14	BLK FORM 0.2 X+100 Y+100 Z+0	
15	TOOL DEF 1 L+0 R+2.5	Define the tool
16	TOOL CALL 1 Z S4000	Tool call
17	L Z+250 RO F MAX	Retract the tool
18	CALL LBL 10	Call machining operation
19	L Z+100 RO F MAX M2	Retract in the tool axis, end program

20	LBL 10	Subprogram 10: Machining operation
21	CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of ellipse
22	CYCL DEF 7.1 X+Q1	
23	CYCL DEF 7.2 Y+Q2	
24	CYCL DEF 10.0 ROTATION	Account for rotational position in the plane
25	CYCL DEF 10.1 ROT+Q8	
26	Q35 = (Q6 - Q5) / Q7	Calculate angle increment
27	Q36 = Q5	Copy starting angle
28	Q37 = 0	Set counter
29	Q21 = Q3 * COS Q36	Calculate X coordinate for starting point
30	Q22 = Q4 * SIN Q36	Calculate Y coordinate for starting point
31	L X+Q21 Y+Q22 R0 F MAX M3	Move to starting point in the plane
32	L Z+Q12 R0 F MAX	Pre-position in tool axis to setup clearance
33	L Z-Q9 R0 FQ10	Move to working depth
34	LBL 1	
35	Q36 = Q36 + Q35	Update the angle
36	Q37 = Q37 + 1	Update the counter
37	Q21 = Q3 * COS Q36	Calculate the current X coordinate
38	Q22 = Q4 * SIN Q36	Calculate the current Y coordinate
39	L X+Q21 Y+Q22 R0 FQ11	Move to next point
40	FN 12: IF +Q37 LT +Q7 GOTO LBL 1	Unfinished? If not finished, return to LBL 1
41	CYCL DEF 10.0 ROTATION	Reset the rotation
42	CYCL DEF 10.1 ROT+0	
43	CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
44	CYCL DEF 7.1 X+0	
45	CYCL DEF 7.2 Y+0	
46	L Z+Q12 R0 F MAX	Move to setup clearance
47	LBL 0	End of subprogram
48	END PGM ELLIPSE MM	

## Example: Concave cylinder machined with spherical cutter

### Program sequence

- Program functions only with a spherical cutter.  
The tool length refers to the sphere center.
- The contour of the cylinder is approximated by many short line segments (defined in Q13). The more line segments you define, the smoother the curve becomes.
- The cylinder is milled in longitudinal cuts (here: parallel to the Y axis).
- The machining direction can be altered by changing the entries for the starting and end angles in space:  
Clockwise machining direction:  
starting angle > end angle  
Counterclockwise machining direction:  
starting angle < end angle
- The tool radius is compensated automatically.



0	BEGIN PGM CYLIN MM	
1	FN 0: Q1 = +50	Center in X axis
2	FN 0: Q2 = +0	Center in Y axis
3	FN 0: Q3 = +0	Center in Z axis
4	FN 0: Q4 = +90	Starting angle in space (Z/X plane)
5	FN 0: Q5 = +270	End angle in space (Z/X plane)
6	FN 0: Q6 = +40	Radius of the cylinder
7	FN 0: Q7 = +100	Length of the cylinder
8	FN 0: Q8 = +0	Rotational position in the X/Y plane
9	FN 0: Q10 = +5	Allowance for cylinder radius
10	FN 0: Q11 = +250	Feed rate for plunging
11	FN 0: Q12 = +400	Feed rate for milling
12	FN 0: Q13 = +90	Number of cuts
13	BLK FORM 0.1 Z X+0 Y+0 Z-50	Define the workpiece blank
14	BLK FORM 0.2 X+100 Y+100 Z+0	
15	TOOL DEF 1 L+0 R+3	Define the tool
16	TOOL CALL 1 Z S4000	Call the tool
17	L Z+250 RO F MAX	Retract the tool
18	CALL LBL 10	Call machining operation
19	FN 0: Q10 = +0	Reset allowance
20	CALL LBL 10	Call machining operation
21	L Z+100 RO F MAX M2	Retract in the tool axis, end program

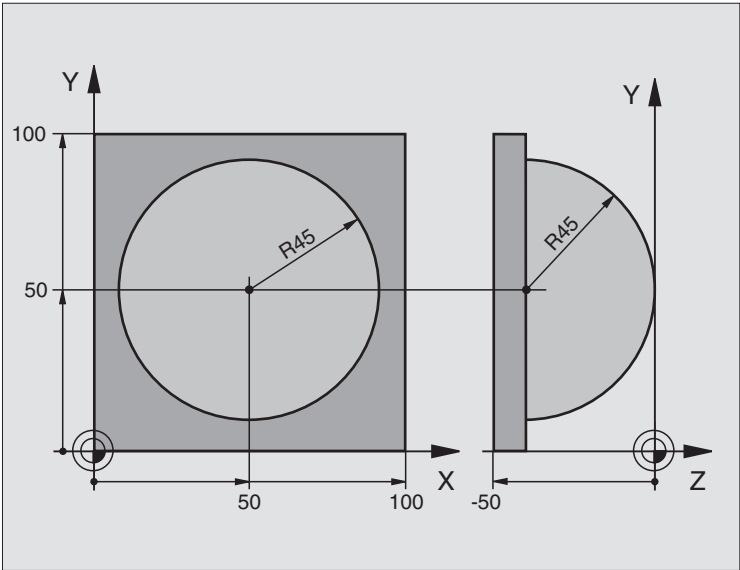
22	LBL 10	Subprogram 10: Machining operation
23	Q16 = Q6 - Q10 - Q108	Account for allowance and tool, based on the cylinder radius
24	FN 0: Q20 = +1	Set counter
25	FN 0: Q24 = +Q4	Copy starting angle in space (Z/X plane)
26	Q25 = (Q5 - Q4) / Q13	Calculate angle increment
27	CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of cylinder (X axis)
28	CYCL DEF 7.1 X+Q1	
29	CYCL DEF 7.2 Y+Q2	
30	CYCL DEF 7.3 Z+Q3	
31	CYCL DEF 10.0 ROTATION	Account for rotational position in the plane
32	CYCL DEF 10.1 ROT+Q8	
33	L X+0 Y+0 R0 F MAX	Pre-position in the plane to the cylinder center
34	L Z+5 R0 F1000 M3	Pre-position in the tool axis
35	CC Z+0 X+0	Set pole in the Z/X plane
36	LP PR+Q16 PA+Q24 FQ11	Move to starting position on cylinder, plunge-cutting obliquely into the material
37	LBL 1	
38	L Y+Q7 R0 FQ11	
39	FN 1: Q20 = +Q20 + +1	Longitudinal cut in Y+ direction
40	FN 1: Q24 = +Q24 + +Q25	Update the counter
41	FN 11: IF +Q20 GT +Q13 GOTO LBL 99	Update solid angle
42	LP PR+Q16 PA+Q24 FQ12	Finished? If finished, jump to end.
43	L Y+0 R0 FQ11	Move in an approximated "arc" for the next longitudinal cut
44	FN 1: Q24 = +Q24 + +Q25	Longitudinal cut in Y- direction
45	FN 1: Q20 = +Q20 + +1	Update the counter
46	FN 12: IF +Q20 LT +Q13 GOTO LBL 1	Update solid angle
47	LBL 99	Unfinished? If not finished, return to LBL 1
48	CYCL DEF 10.0 ROTATION	
49	CYCL DEF 10.1 ROT+0	Reset the rotation
50	CYCL DEF 7.0 DATUM SHIFT	
51	CYCL DEF 7.1 X+0	Reset the datum shift
52	CYCL DEF 7.2 Y+0	
53	CYCL DEF 7.3 Z+0	
54	LBL 0	
55	END PGM CYLIN MM	End of subprogram



### Example: Convex sphere machined with end mill

**Program sequence**

- This program requires an end mill.
- The contour of the sphere is approximated by many short lines (in the Z/X plane, defined via Q14). The smaller you define the angle increment, the smoother the curve becomes.
- You can determine the number of contour cuts through the angle increment in the plane (defined in Q18).
- The tool moves upward in three-dimensional cuts.
- The tool radius is compensated automatically.



0	BEGIN PGM BALL MM	
1	FN 0: Q1 = +50	Center in X axis
2	FN 0: Q2 = +50	Center in Y axis
3	FN 0: Q4 = +90	Starting angle in space (Z/X plane)
4	FN 0: Q5 = +0	End angle in space (Z/X plane)
5	FN 0: Q14 = +5	Angle increment in space
6	FN 0: Q6 = +45	Radius of the sphere
7	FN 0: Q8 = +0	Starting angle of rotational position in the X/Y plane
8	FN 0: Q9 = +360	End angle of rotational position in the X/Y plane
9	FN 0: Q18 = +10	Angle increment in the X/Y plane for roughing
10	FN 0: Q10 = +5	Allowance in sphere radius for roughing
11	FN 0: Q11 = +2	Setup clearance for pre-positioning in the tool axis
12	FN 0: Q12 = +350	Feed rate for milling
13	BLK FORM 0.1 Z X+0 Y+0 Z-50	Define the workpiece blank
14	BLK FORM 0.2 X+100 Y+100 Z+0	
15	TOOL DEF 1 L+0 R+7.5	Define the tool
16	TOOL CALL 1 Z S4000	Call the tool
17	L Z+250 RO F MAX	Retract the tool
18	CALL LBL 10	Call machining operation
19	FN 0: Q10 = +0	Reset allowance
20	FN 0: Q18 = +5	Angle increment in the X/Y plane for finishing
21	CALL LBL 10	Call machining operation
22	L Z+100 RO F MAX M2	Retract in the tool axis, end program

23	LBL 10	Subprogram 10: Machining operation
24	FN 1: Q23 = +Q11 + +Q6	Calculate Z coordinate for pre-positioning
25	FN 0: Q24 = +Q4	Copy starting angle in space (Z/X plane)
26	FN 1: Q26 = +Q6 + +Q108	Compensate sphere radius for pre-positioning
27	FN 0: Q28 = +Q8	Copy rotational position in the plane
28	FN 1: Q16 = +Q6 + -Q10	Account for allowance in the sphere radius
29	CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of sphere
30	CYCL DEF 7.1 X+Q1	
31	CYCL DEF 7.2 Y+Q2	
32	CYCL DEF 7.3 Z-Q16	
33	CYCL DEF 10.0 ROTATION	Account for starting angle of rotational position in the plane
34	CYCL DEF 10.1 ROT+Q8	
35	CC X+0 Y+0	Set pole in the X/Y plane for pre-positioning
36	LP PR+Q26 PA+Q8 RO FQ12	Pre-position in the plane
37	LBL 1	Pre-position in the tool axis
38	CC Z+0 X+Q108	Set pole in the Z/X plane, offset by the tool radius
39	L Y+0 Z+0 FQ12	Move to working depth
40	LBL 2	
41	LP PR+Q6 PA+Q24 RO FQ12	Move upward in an approximated "arc"
42	FN 2: Q24 = +Q24 - +Q14	Update solid angle
43	FN 11: IF +Q24 GT +Q5 GOTO LBL 2	Inquire whether an arc is finished. If not finished, return to LBL 2.
44	LP PR+Q6 PA+Q5	Move to the end angle in space
45	L Z+Q23 RO F1000	Retract in the tool axis
46	L X+Q26 RO F MAX	Pre-position for next arc
47	FN 1: Q28 = +Q28 + +Q18	Update rotational position in the plane
48	FN 0: Q24 = +Q4	Reset solid angle
49	CYCL DEF 10.0 ROTATION	Activate new rotational position
50	CYCL DEF 10.1 ROT+Q28	
51	FN 12: IF +Q28 LT +Q9 GOTO LBL 1	
52	FN 9: IF +Q28 EQU +Q9 GOTO LBL 1	Unfinished? If not finished, return to label 1
53	CYCL DEF 10.0 ROTATION	Reset the rotation
54	CYCL DEF 10.1 ROT+0	
55	CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
56	CYCL DEF 7.1 X+0	
57	CYCL DEF 7.2 Y+0	
58	CYCL DEF 7.3 Z+0	
59	LBL 0	End of subprogram
60	END PGM BALL MM	



# 11

**Test Run  
and Program Run**

### 11.1 Graphics

In the program run modes of operation as well as in the Test Run mode, the TNC provides the following three display modes: Using soft keys, select whether you desire:


- Plan view
- Projection in 3 planes
- 3-D view

The TNC graphic depicts the workpiece as if it were being machined with a cylindrical end mill. If a tool table is active, you can also simulate the machining operation with a spherical cutter. For this purpose, enter R2 = R in the tool table.

The TNC will not show a graphic if

- the current program has no valid blank form definition
- no program is selected

With machine parameters 7315 to 7317 you can have the TNC display a graphic even if no tool axis is defined or moved.



A graphic simulation is not possible for program sections or programs in which rotary axis movements or a tilted working plane are defined. In this case, the TNC will display an error message.

The TNC graphic does not show a radius oversize (DR) that has been programmed in the TOOL CALL block.

#### Overview of display modes

The TNC displays the following soft keys in the program run and Test Run modes of operation:

Display mode	Soft key
Plan view	
Projection in 3 planes	
3-D view	

### Limitations during program run

A graphical representation of a running program is not possible if the microprocessor of the TNC is already occupied with complicated machining tasks or if large areas are being machined. Example: Multipass milling over the entire blank form with a large tool. The TNC interrupts the graphics and displays the text ERROR in the graphics window. The machining process is continued, however.

### Plan view



► Press the soft key for plan view.



► Select the number of depth levels (after shifting the soft-key row). You can choose between 16 or 32 shades of depth.

The deeper the surface, the darker the shade.

Plan view is the fastest of the three graphic display modes.

### Projection in 3 planes

Similar to a workpiece drawing, the part is displayed with a plan view and two sectional planes. A symbol to the lower left indicates whether the display is in first angle or third angle projection according to ISO 6433 (selected with MP7310).

Details can be isolated in this display mode for magnification (see "Magnifying details").

In addition, you can shift the sectional planes with the corresponding soft keys:



► Press the soft key for projection in three planes.

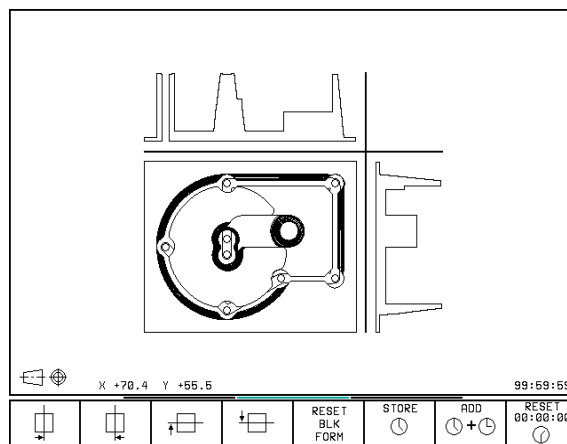
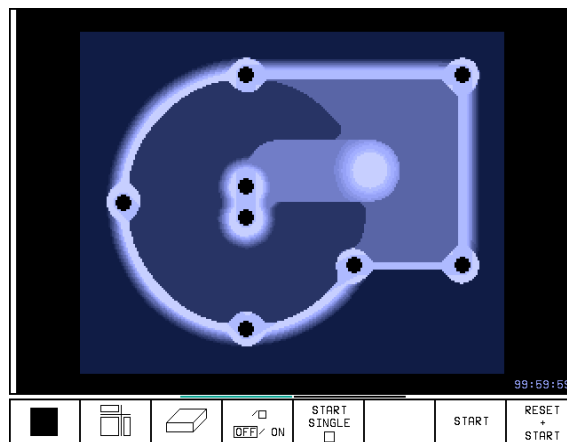
► Shift the soft-key row until the TNC displays the following soft keys:

Function	Soft keys	
Shift the vertical sectional plane to the right or left		
Shift the horizontal sectional plane upwards or downwards		

The positions of the sectional planes are visible during shifting.

### Coordinates of the line of intersection

At the bottom of the graphics window, the TNC displays the coordinates of the line of intersection, referenced to the workpiece datum. Only the coordinates of the working plane are shown. This function is activated with machine parameter 7310.



3-D view

The workpiece is displayed in three dimensions, and can be rotated about the vertical axis.

The workpiece is displayed in three dimensions, and can be rotated about the vertical axis. The shape of the workpiece blank can be depicted by a frame overlay at the beginning of the graphic simulation.



In the Test Run mode of operation you can isolate details for magnification (see "Magnifying details").



► Press the soft key for plan view.

To rotate the 3-D view

Shift the soft-key row until the following soft keys appear:

Function	Soft keys
Rotate the workpiece in 27° steps about the vertical axis	 

Switch the frame overlay display for the workpiece blank on/off:



► Show the frame overlay with SHOW BLK-FORM



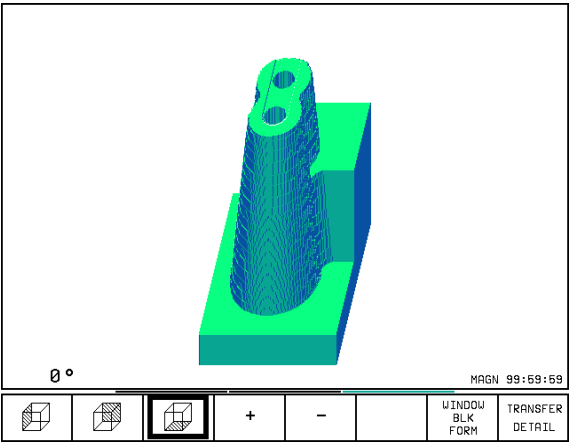
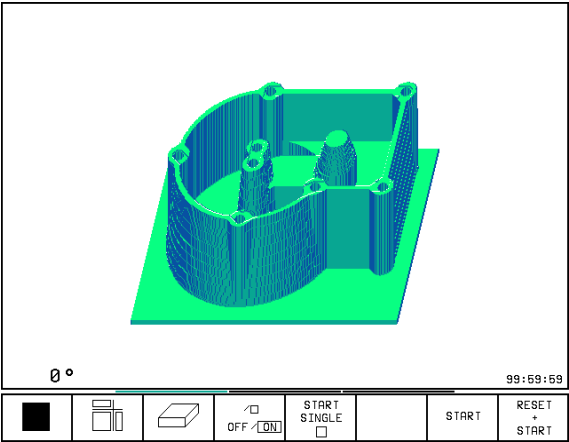
► Omit the frame overlay with OMIT BLK FORM

Magnifying details










You can magnify details in the Test Run mode of operation in the following display modes, provided that the graphic simulation is stopped:

- Projection in three planes
- 3-D view

The graphic simulation must first have been stopped. A detail magnification is always effective in all display modes.



Shift the soft-key row in the Test Run mode of operation until the following soft keys appear:

Function	Soft keys	
Select the left/right workpiece surface		
Select the front/back workpiece surface		
Select the top/bottom workpiece surface		
Shift the sectional plane to reduce or magnify the blank form		
Select the isolated detail		

**To change the detail magnification:**

The soft keys are listed in the table above.

- ▶ Interrupt the graphic simulation, if necessary.
- ▶ Select the workpiece surface with the corresponding soft key (see table).
- ▶ To reduce or magnify the blank form, press and hold the minus or plus soft key, respectively.
- ▶ To select the isolated detail, press the TRANSFER DETAIL soft key
- ▶ Restart the test run or program run by pressing the START soft key (RESET + START returns the workpiece blank to its original state).

**Cursor position during detail magnification**

During detail magnification, the TNC displays the coordinates of the axis that is currently being isolated. The coordinates describe the area determined for magnification. To the left of the slash is the smallest coordinate of the detail (MIN point), to the left is the largest (MAX point).


If a graphic display is magnified, this is indicates with MAGN at the lower right of the graphics window.

If the workpiece blank cannot be further enlarged or reduced, the TNC displays an error message in the graphics window. To clear the error message, enlarge or reduce the workpiece blank.

Repeating graphic simulation

A part program can be graphically simulated as often as desired, either with the complete workpiece or with a detail of it.

Function	Soft key
Restore workpiece blank to the detail magnification in which it was last shown	<div>RESET BLK FORM</div>
Reset detail magnification so that the machined workpiece or workpiece blank is displayed as it was programmed with BLK FORM	<div>WINDOW BLK FORM</div>



The WINDOW BLK FORM soft key will return the blank form to its original shape or size, even if a detail has been isolated and not yet magnified with TRANSFER DETAIL.

Measuring the machining time

Program run modes of operation

The timer counts and displays the time from program start to program end. The timer stops whenever machining is interrupted.


Test run

The timer displays the approximate time which the TNC calculates from the duration of tool movements. The time calculated by the TNC cannot be used for calculating the production time because the TNC does not account for the duration of machine-dependent interruptions, such as tool change.

To activate the stopwatch function

Shift the soft-key rows until the TNC displays the following soft keys with the stopwatch functions:

Stopwatch functions	Soft key
Store displayed time	<div>STORE ⌚</div>
Display the sum of stored time and displayed time	<div>ADD ⌚ + ⌚</div>
Clear displayed time	<div>RESET 00:00:00 ⌚</div>

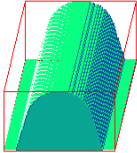


The soft keys available to the left of the stopwatch functions depend on the selected screen layout.

Manual operation



Test run

0 BEGIN PGM 3DJOINT MM  
1 BLK FORM 0.1 Z X+0 Y+0 Z-52  
2 BLK FORM 0.2 X+100 Y+100 Z+0  
3 TOOL DEF 1 L+0 R+10  
4 TOOL CALL 1 Z  
5 L Z+20 R0 F MAX MG  
6 CYCL DEF 7.0 DATUM SHIFT  
7 CYCL DEF 7.1 X-10  
8 CALL LBL 1  
9 CYCL DEF 7.0 DATUM SHIFT  
10 CYCL DEF 7.1 X+0  
11 CALL LBL 1  
12 CYCL DEF 7.0 DATUM SHIFT  
13 CYCL DEF 7.1 X+110  
14 CYCL DEF 7.2 Y+100



0°

36:05:46



SHOW  
BLK-FORM

OMIT  
BLK-FORM

RESET  
BLK  
FORM

STORE  
⌚

ADD  
⌚ + ⌚

RESET  
00:00:00  
⌚



## 11.2 Functions for Program Display in Program Run and Test Run

In the program run modes of operation as well as in the Test Run mode, the TNC provides the following soft keys for displaying a part program in pages:

Function	Soft key
Go back in the program by one screen	<div>PAGE ↑</div>
Go forward in the program by one screen	<div>PAGE ↓</div>
Go to the beginning of the program	<div>BEGIN ↑</div>
Go to the end of the program	<div>END ↓</div>

## 11.3 Test run

In the Test Run mode of operation you can simulate programs and program sections to prevent errors from occurring during program run. The TNC checks the programs for the following:

- Geometrical incompatibilities
- Missing data
- Impossible jumps
- Violation of the machine's working space

The following functions are also available:

- Blockwise test run
- Interrupt test at any block
- Optional block skip
- Functions for graphic simulation
- Measuring the machining time
- Additional status display

Program run, full sequence				Programming and editing
0	BEGIN PGM 3507 MM			
1	BLK FORM 0.1 Z X-20 Y-20 Z-20			
2	BLK FORM 0.2 X+20 Y+20 Z+0			
3	TOOL CALL 1 Z S1000			
4	L Z+50 R0 F MAX M3			
5	L X+50 Y+50 R0 F MAX M8			
6	L Z-5 R0 F MAX			
7	CC X+0 Y+0			
8	LP PR+14 PA+45 RR F500			
<input checked="" type="checkbox"/>	+150.0000	Y	-50.0000	Z +100.0000
A	+0.0000	B	+180.0000	C +90.0000
ACTL.       T      0      M 5/9				
PAGE ↑	PAGE ↓	BEGIN ↑	END ↓	RESTORE POS. AT 
				<input type="checkbox"/> ON      TOOL TABLE

Running a program test

If the central tool file is active, a tool table must be active (status S) to run a program test. Select a tool table via the file manager (PGM MGT) in the Test Run mode of operation.

With the MOD function BLANK IN WORD SPACE, you can activate work space monitoring for the test run (see Chapter 12 “MOD Functions, Showing the Workpiece in the Working Space”).



- ▶ Select the Test Run mode of operation.
- ▶ Call the file manager with the PGM MGT key and select the file you wish to test, or
- ▶ Go to the program beginning: Select line “0” with the GOTO key and confirm you entry with the ENT key.

The TNC then displays the following soft keys:

Function	Soft key
Test the entire program	START
Test each program block individually	START SINGLE □
Show the blank form and test the entire program	RESET START
Interrupt the test run	STOP

Running a program test up to a certain block

With the STOP AT N function the TNC does a test run up to the block with block number N.

- ▶ Go to the beginning of program in the Test Run mode of operation.
- ▶ To run a program test up to a specific block, press the STOP AT N soft key.



- ▶ Stop at N: Enter the block number at which you wish the test to stop.
- ▶ Program: Enter the name of the program that contains the block with the selected block number. The TNC displays the name of the selected program. If the test run is to be interrupted in a program that was called with PGM CALL, you must enter this name.
- ▶ Repetitions: If N is located in a program section repeat, enter the number of repeats that you want to run.
- ▶ To test a program section, press the START soft key. The TNC will test the program up to the entered block.

Program run full sequence

Test run

```
0 BEGIN PGM AYD_DAU MM
1 BLK FORM 0.1 Z X+0 Y+0 Z+200
2 BLK FORM 0.2 X+400 Y+400 Z+400
3 ; >>> WZ:1,2,3,4,5,10,15,20 <<<
/4 LBL 1
/5 TOOL CALL 0 Z S6300 F5000
/6 L X+200 R0 F MAX M3
/7 X+500
/8 TOOL CALL 1 Z ; N-WZ
/9 L X+200 M4
/10 X+500
/11 TOOL CALL 2 Z ; N-WZ
/12 X+200
/13 X+500
/14 TOOL
```

Program test termination

Stop at: N = 88

Program = AYD\_DAU.H

Repetitions = 1

OFF / ON

START SINGLE □

STOP AT N

START

RESET + START

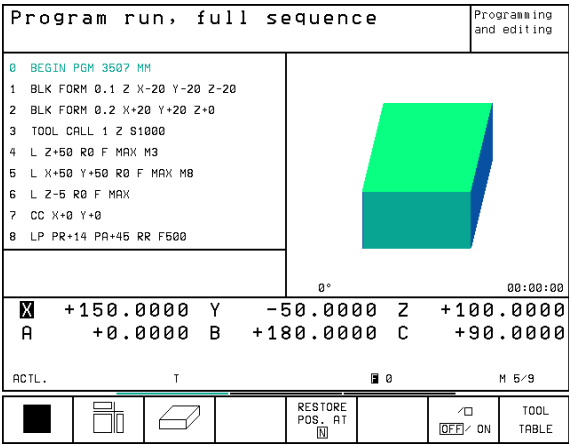
# 11.4 Program Run

In the Program Run, Full Sequence mode of operation the TNC executes a part program continuously to its end or up to a program stop.

In the Program Run, Single Block mode of operation you must start each block separately by pressing the machine START button.

The following TNC functions can be used in the program run modes of operation:

- Interrupt program run
- Start program run from a certain block
- Optional block skip
- Editing the tool table TOOL.T
- Checking and changing Q parameters
- Superimposing handwheel positioning
- Functions for graphic simulation
- Additional status display



## Running a part program

### Preparation

- 1 Clamp the workpiece to the machine table.
- 2 Datum setting
- 3 Select the necessary tables and pallet files (status M).
- 4 Select the part program (status M).



You can adjust the feed rate and spindle speed with the override knobs.

It is possible to reduce the rapid traverse speed when starting the NC program using the FMAX soft key. The entered value remains active even after the machine is switched off and on again. To restore the original rapid traverse velocity you must reenter the corresponding numerical value.

### Program Run, Full Sequence

- Start the part program with the machine START button.

### Program Run, Single Block

- Start each block of the part program individually with the machine START button.

## Interrupting machining

There are several ways to interrupt a program run:

- Programmed interruptions
- Machine STOP button
- Switching to Program Run, Single Block

If the TNC registers an error during program run, it automatically interrupts the machining process.

### Programmed interruptions

You can program interruptions directly in the part program. The TNC interrupts the program run at a block containing one of the following entries:

- STOP (with and without a miscellaneous function)
- Miscellaneous function M0, M2 or M30
- Miscellaneous function M6 (determined by the machine tool builder)

### To interrupt machining with the machine STOP button:

- ▶ Press the machine STOP button: The block which the TNC is currently executing is not completed. The asterisk in the status display blinks.
- ▶ If you do not wish to continue the machining process you can reset the TNC with the INTERNAL STOP soft key. The asterisk in the status display goes out. In this case, the program must be restarted from the program beginning.

### Interruption of machining by switching to the Program Run, Single Block mode of operation.

You can interrupt a program that is being run in the Program Run, Full Sequence mode of operation by switching to Program Run, Single Block. The TNC interrupts the machining process at the end of the current block.

## Moving the machine axes during an interruption

You can move the machine axes during an interruption in the same way as in the Manual Operation mode.



### **Danger of collision!**

If you interrupt program run while the working plane is tilted, you can change from a tilted to a non-tilted coordinate system, and vice versa, by pressing the 3-D ON/OFF soft key.

The functions of the axis direction buttons, the electronic handwheel and the positioning logic for return to contour are then evaluated by the TNC. When retracting the tool make sure the correct coordinate system is active and the angular values of the tilt axes are entered in the 3-D ROT menu.

### **Example:**

#### **Retracting the spindle after tool breakage**

- ▶ Interrupting machining
- ▶ Enable the external direction keys: Press the MANUAL OPERATION soft key.
- ▶ Move the axes with the machine axis direction buttons.



On some machines you may have to press the machine START button after the MANUAL OPERATION soft key to enable the axis direction buttons. Your machine manual provides more detailed information.

## Resuming program run after an interruption



If a program run is interrupted during a fixed cycle, the program must be resumed from the beginning of the cycle. This means that some machining operations will be repeated.

If you interrupt a program run during execution of a subprogram or program section repeat, use the RESTORE POS AT N function to return to the position at which the program run was interrupted.

When a program run is interrupted, the TNC stores:

- The data of the last defined tool
- Active coordinate transformations (e.g. datum shift, rotation, mirroring)
- The coordinates of the circle center that was last defined



Note that the stored data remains active until it is reset (e.g. if you select a new program).

The stored data are used for returning the tool to the contour after manual machine axis positioning during an interruption (RESTORE POSITION).

### Resuming program run with the START button

You can resume program run by pressing the machine START button if the program was interrupted in one of the following ways:

- The machine STOP button was pressed
- A programmed interruption

### Resuming program run after an error

- If the error message *is not blinking*
  - ▶ Remove the cause of the error.
  - ▶ To clear the error message from the screen, press the CE key.
  - ▶ Restart the program, or resume program run at the place at which it was interrupted.
- If the error message *is blinking*
  - ▶ Press and hold the END key for two seconds. This induces a TNC system restart.
  - ▶ Remove the cause of the error.
  - ▶ Start again.

If you cannot correct the error, write down the error message and contact your repair service agency.

### Mid-program startup (block scan)



The RESTORE POS AT N feature must be enabled and adapted by the machine tool builder. Your machine manual provides more detailed information.

With the RESTORE POS AT N feature (block scan) you can start a part program at any block you desire. The TNC scans the program blocks up to that point. Machining can be graphically simulated.

If you have interrupted a part program with an INTERNAL STOP, the TNC automatically offers the interrupted block N for mid-program startup.



Mid-program startup must not begin in a subprogram.

All necessary programs, tables and pallet files must be selected in a program run mode of operation (status M).

If the program contains a programmed interruption before the startup block, the block scan is interrupted. Press the machine START button to continue the block scan.

After a block scan, return the tool to the calculated position with RESTORE POSITION.

If you are working with nested programs, you can use machine parameter 7680 to define whether the block scan is to begin at block 0 of the main program or at block 0 of the last interrupted program.

If the working plane is tilted, you can use the 3-D ON/OFF soft key to define whether the TNC is to return to the contour in a tilted or in a non-tilted coordinate system.

- To go to the first block of the current program to start a block scan, enter GOTO "0".
- To select mid-program startup, press the RESTORE POS AT N soft key.



- Start-up at N: Enter the block number N at which the block scan should end.
- Program: Enter the name of the program containing block N.
- Repetitions: If block N is located in a program section repeat, enter the number of repetitions to be calculated in the block scan.
- To start the block scan, press the machine START button.
- To return to the contour, proceed as described below in "Returning to the contour."

Program run, full sequence		Programming and editing
<pre> 0 BEGIN PGM AYD_DAU MM 1 BLK FORM 0.1 Z X+0 Y+0 Z+200 2 BLK FORM 0.2 X+400 Y+400 Z+400 3 ; &gt;&gt;&gt; WZ:1,2,3,4,5,10,15,20 &lt;&lt;&lt; /4 LBL 1 /5 TOOL CALL 0 Z S6300 F5000 /6 L X+200 R0 F MAX M3 /7 X+500 /8 TOOL CALL 1 Z ; N-WZ         </pre>		
<input checked="" type="checkbox"/>	+30	Mid-program startup
B	+32	Start-up at: N = 25 Program = AYD_DAU.H Repetitions = 1
ACTL.		M 5/9
PAGE ↑	PAGE ↓	BEGIN ↑ END ↓ RESTORE POS. AT N F MAX [OFF] ON TOOL TABLE

## Returning to the contour

With the RESTORE POSITION function, the TNC returns to the workpiece contour in the following situations:

- Return to the contour after the machine axes were moved during a program interruption that was not performed with the INTERNAL STOP function.
  - Return to the contour after a block scan with RESTORE POS AT N, for example after an interruption with INTERNAL STOP.
  - Depending on the machine, if the position of an axis has changed after the control loop has been opened during a program interruption:
- ▶ To select a return to contour, press the RESTORE POSITION soft key.
  - ▶ To move the axes in the sequence that the TNC suggests on the screen, press the machine START button.
  - ▶ To move the axes in any sequence, press the soft keys RESTORE X, RESTORE Z, etc., and activate each axis with the machine START key.
  - ▶ To resume machining, press the machine START key.

## 11.5 Optional block skip

In a test run or program run, the TNC can skip over blocks that begin with a slash (/):



- ▶ To run or test the program without the blocks preceded by a slash, set the soft key to ON.



- ▶ To run or test the program with the blocks preceded by a slash, set the soft key to OFF.



This function does not work for TOOL DEF blocks.

After a power interruption the TNC returns to the most recently selected setting.





# 12

**MOD Functions**

### 12.1 Selecting, Changing and Exiting the MOD Functions

The MOD functions provide additional displays and input possibilities. The available MOD functions depend on the selected operating mode.

**To select the MOD functions**

Call the mode of operation in which you wish to change the MOD function.



► To select the MOD functions, press the MOD key. The figures at right show typical screen menus in Programming and Editing (figure at upper right), Test Run (figure at center right) and in a machine operating mode (see figure on next page).

**Changing the settings**

► Select the desired MOD function in the displayed menu with the arrow keys.

There are three possibilities for changing a setting, depending on the function selected:

- Enter a numerical value directly, e.g. when determining traverse range limit
- Change a setting by pressing the ENT key, e.g. when setting program input
- Change a setting via a selection window. If there are more than one possibilities for a particular setting available, you can superimpose a window listing all of the given possibilities by pressing the GOTO key. Select the desired setting directly by pressing the corresponding numerical key (to the left of the colon), or using the arrow keys and then confirming with ENT. If you don't want to change the setting, close the window again with END.

**To exit the MOD functions:**

► Close the MOD functions with the END soft key or key.

**Overview of MOD functions**

Depending on the selected mode of operation, you can make the following changes:

Programming and Editing:

- Display software numbers
- Enter code number
- Set data interface
- Machine-specific user parameters
- HELP files (if provided)

Manual operation	Programming and editing						
Code number <div></div>							
NC : software number 280472 00M							
PLC: software number							
OPT: %00000011							
	RS232 RS422 SETUP	USER PARAMETER	HELP				END

Manual operation	Test run						
Code number <div></div>							
NC : software number 280472 00M							
PLC: software number							
OPT: %00000011							
	RS232 RS422 SETUP	BLANK IN WORK SPACE	USER PARAMETER	HELP			END

Test Run:

- Display software numbers
- Enter code number
- Setting the Data Interface
- Showing the Workpiece in the Working Space
- Machine-specific user parameters
- HELP files (if provided)

In all other modes:

- Display software numbers
- Display code digits for installed options
- Select position display
- Unit of measurement (mm/inches)
- Programming language for MDI
- Select the axes for actual position capture
- Axis traverse limits
- Display datums
- Display operating time
- HELP files (if provided)

Manual operation						Programming and editing
Position display 1 <b>ACTL.</b> Position display 2 DIST. Change MM/INCH MM Program input HEIDENHAIN Axis selection %00000						
NC : software number 280472 00M PLC: software number OPT: %00000011						
POSITION/ INPUT PGM	AXIS LIMITS	HELP	MACHINE TIME ⌚			END

## 12.2 Software Numbers and Option Numbers

The software numbers of the NC, PLC and the SETUP floppy disks appear in the TNC screen after the MOD functions have been selected. Directly below them are the code numbers for the installed options (OPT:):

- No option OPT: 00000000
- Option for digitizing with triggering touch probe OPT: 00000001
- Option for digitizing with measuring touch probe OPT: 00000011

## 12.3 Code Number

A code number is required for access to the following function:

Function	Code number
Select user parameters	123
Configuring an Ethernet card	NET123
Enable special functions	555343

12.4 Setting the Data Interfaces

To setup the data interfaces, press the RS 232- / RS 422 - SETUP soft key. to call a menu for setting the data interfaces:


Setting the RS-232 interface

The mode of operation and baud rates for the RS-232 interface are entered in the upper left of the screen.

Setting the RS-422 interface

The mode of operation and baud rates for the RS-422 interface are entered in the upper right of the screen.






Setting the OPERATING MODE of the external device




The functions “Transfer all files,” “Transfer selected file,” and “Transfer directory” are not available in the operating modes FE2 and EXT.

Setting the BAUD RATE

You can set the BAUD-RATE (data transfer speed) from 110 to 115,200 baud.

External device	Mode	Symbol
HEIDENHAIN floppy disk units FE 401 B FE 401 from prog. no. 230 626 03	FE1 FE1	
HEIDENHAIN floppy disk unit FE 401 up to prog. no. 230 626 02	FE2	
PC with HEIDENHAIN data transfer Software TNCremo	FE1	
Non-HEIDENHAIN devices such as Punchers, PC without TNCremo	EXT1, EXT2	
PC with HEIDENHAIN software TNCremo for remote operation of the TNC	LSV2	

Program run full sequence		Programming and editing					
RS232 interface			RS422 interface				
Mode of op.: LSV-2			Mode of op.: FE1				
Baud rate			Baud rate				
FE : 115200			FE : 9600				
EXT1 : 57600			EXT1 : 9600				
EXT2 : 19200			EXT2 : 9600				
LSV-2: 115200			LSV-2: 9600				
Assign:							
Print : TNC:\NK\SCRDP\							
Print-test :							
PGM MGT: Enhanced							
	RS232 RS422 SETUP	USER PARAMETER	HELP			END	

### ASSIGN

This function sets the destination for the transferred data.

Applications:

- Transferring values with Q parameter function FN15
- Transferring values with Q parameter function FN16
- Path on the TNC's hard disk in which the digitized data are stored

The TNC mode of operation determines whether the PRINT or PRINT TEST function is used:

TNC mode of operation	Transfer function
Program Run, Single Block	PRINT
Program Run, Full Sequence	PRINT
Test run	PRINT TEST

You can set PRINT and PRINT TEST as follows:

Function	Path
Output data via RS-232	RS232:\...
Output data via RS-422	RS422:\...
Save data to the TNC's hard disk	TNC:\...
Save data in directory in which the program with FN15/FN16 or the program with the digitizing cycles is located	- vacant -

File names

Data	Operating mode	File name
Digitizing data	Program Run	Defined in the RANGE cycle
Values with FN15	Program Run	%FN15RUN.A
Values with FN15	Test run	%FN15SIM.A
Values with FN16	Program Run	%FN16RUN.A
Values with FN16	Test run	%FN16SIM.A

## Software for data transfer

For transfer of files to and from the TNC, we recommend using the HEIDENHAIN TNCremo data transfer software. With TNCremo, data transfer is possible with all HEIDENHAIN controls via serial interface.



Please contact your HEIDENHAIN agent if you would like to receive the TNCremo data transfer software for a nominal fee.

### System requirements for TNCremo

- AT personal computer or compatible system
- 640 KB working memory
- 1 MB free memory space on your hard disk
- One free serial interface
- Operating system MS-DOS/PC-DOS 3.00 or later, Windows 3.1 or later, OS/2
- A Microsoft-compatible mouse (for ease of operation, not essential)

### Installation under Windows

- ▶ Start the SETUP.EXE installation program in the file manager (explorer)
- ▶ Follow the instructions of the setup program

### Starting TNCremo under Windows

Windows 3.1, 3.11, NT:

- ▶ Doubleclick on the icon in the program group HEIDENHAIN Applications

Windows 95:

- ▶ Click on <Start>, <Programs>, <HEIDENHAIN Applications>, <TNCremo>

When you start TNCremo for the first time, you will be asked for the type of control you have connected, the interface (COM1 or COM2) and the data transfer speed. Enter the necessary information.

## Data transfer between the TNC and TNCremo

Ensure that:

- The TNC is connected to the correct serial port on your PC
- The data transfer speed set on the TNC for LSV2 operation is the same as that set on TNCremo.

Once you have started TNCremo, you will see a list of all of the files that are stored in the active directory on the left of main window **1**. Using the menu items <Directory>, <Change>, you can change the active directory or select another directory on your PC.

To establish the connection with your TNC, select the items <Connect>, <Link (LSV-2)>. The TNCremo now receives the file and directory structure from the TNC and displays this at the bottom left of the main window **2**. To transfer a file from the TNC to the PC, select the file in the TNC window (highlighted with a mouse click) and activate the functions <File> <Transfer>.

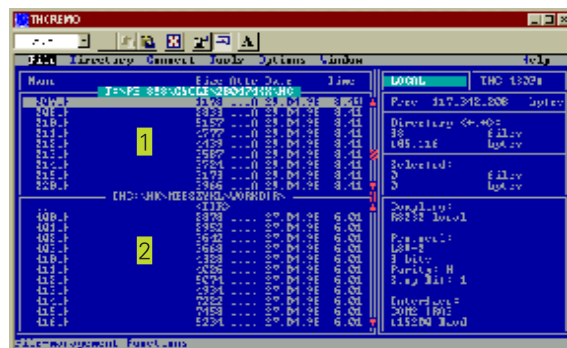
To transfer a file from the PC to the TNC, select the file in the PC window and activate the functions <File> <Transfer>.

## EndTNCremo

Select the menu items <File>, <Exit>, or press the key combination ALT+X



Refer also to the TNCremo help texts where all of the functions are explained in more detail.



## 12.5 Ethernet Interface


### Introduction

As an option, you can equip the TNC with an Ethernet card to connect the control as a client in your network. The TNC transmits data through the Ethernet card in accordance with the Transmission Control Protocol/Internet Protocol (TCP/IP) family of protocols and with the aid of the Network File System (NFS). Since TCP/IP and NFS are implemented in UNIX systems, you can usually connect the TNC in the UNIX world without any additional software.

The PC world with Microsoft operating systems, however, also works with TCP/IP, but not with NFS. You will therefore need additional software to connect the TNC to a PC network. For the operating systems Windows 95, Windows 98 and Windows NT 4.0, HEIDENHAIN recommends the network software **CimcoNFS for HEIDENHAIN** which you can order separately or together with the Ethernet card for the TNC.:

Item	HEIDENHAIN ID number
Only software CimcoNFS for HEIDENHAIN	339 737-01
Ethernet card and software CimcoNFS for HEIDENHAIN	293 890-71

### Installing an Ethernet card



Switch-off the TNC and the machine before you install an Ethernet card!

Read the installation instruction supplied with the Ethernet card!



## Connection Possibilities

You can connect the Ethernet card in your TNC to your network through a BNC connection (X25, coax cable 10Base2) or through the RJ45 connection (X26, 10BaseT). You can only use one of the two connections at one time. Both connections are metallically isolated from the control electronics.

### BNC connection X25 (coaxial cable 10Base2, see figure at upper right)

The 10Base2 connection is also commonly known as Thin-Ethernet or CheaperNet. For the 10Base2 cable you need a BNC-T connector to connect the TNC to your network.

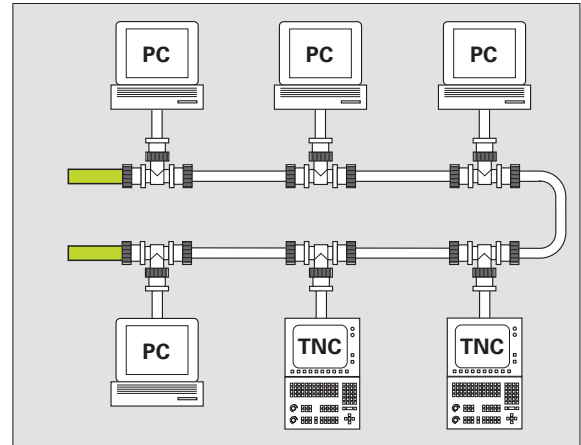


The distance between two T-connectors must be at least 0.5 meters (1.7 ft).

The number of T-connectors must not exceed 30.

Open ends of the bus must be provided with terminal resistors of 50 ohms.

The maximum cable segment length, i.e., the distance between two terminating resistors, is 185 m (600 ft). You can connect up to 5 cable segments with each other via signal amplifier (repeater).



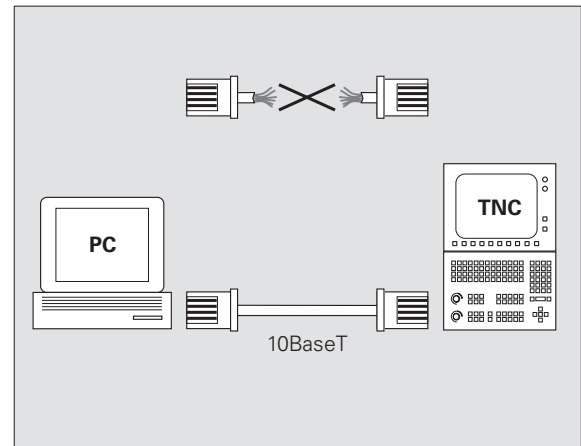
### RJ45 connection X26 (10BaseT, see figure at center right)

For a 10BaseT connection you need a Twisted Pair cable to connect the TNC to your network.




For unshielded cable, the maximum cable length between the TNC and a node is 100 meters (329 ft). For shielded cable, it is 400 meters (1300 ft).

If you connect the TNC directly with a PC you must use a transposed cable.



Configuring the TNC



Make sure that the person configuring your TNC is a network specialist.

- ▶ In the Programming and Editing mode of operation, press the MOD key. Enter the code word NET123. The TNC will then display the main screen for network configuration.

General network settings

- ▶ Press the DEFINE NET soft key to enter the general network settings (see figure at upper right) and enter the following information:

Setting	Meaning
ADDRESS	Address that your network manager must assign to the TNC. Input: four decimal numbers separated by points, e.g. <b>160.1.180.20</b>
MASK	The SUBNET MASK for expanding the number of available addresses within your network. Input: four decimal numbers separated by points. Ask your network manager for the number of your address, e.g. <b>255.255.0.0</b>
ROUTER	Internet address of your default router. Enter the Internet address only if your network consists of several parts. Input: four decimal numbers separated by points. Ask your network manager for the number of your subnet mask. e.g. 160.2.0.2.
PROT	Definition of the transmission protocol. <b>RFC:</b> Transmission protocol according to RFC 894 <b>IEEE:</b> Transmission protocol according to IEE 802.2/802.3
HW	Definition of the connection used <b>10BASET:</b> for use of 10BaseT <b>10BASE2:</b> for use of 10Base2
HOST	Name, under which the TNC identifies itself in the network. If you are using a host name, you must enter the „Fully Qualified Hostname“ here. If you do not enter a name here, the TNC uses the so-called null authentication. The UID, GID, DCM and FCM settings specific to the device (see next page), are then ignored by the TNC.

Manual operation

Network configuration  
Internet address of TNC

File: TP4.N00 >>

NR	ADDRESS	MASK	ROUTER	PROT
0	160.1.180.20	255.255.0.0		RFC

[END]

BEGIN  
↑

END  
↓

PAGE  
↑

PAGE  
↓

NEXT LINE

Network settings specific to the device

► Press the soft key DEFINE MOUNT to enter the network setting for a specific device (see figure at upper right). You can define any number of network settings, but you can manage only seven at one time.

Setting	Meaning
ADDRESS	Address of your server. Input: four decimal numbers separated by points. Ask your network manager for the number of your address. e.g. 160.1.13.4.
RS	Packet size in bytes for data reception. Input range: 512 to 4096. Input 0: The TNC uses the optimal packet size as reported by the server.
WS	Packet size in bytes for data transmission. Input range: 512 to 4096. Input 0: The TNC uses the optimal packet size as reported by the server.
TIMEOUT	Time in ms, after which the TNC repeats a Remote Procedure Call. Input range: 0 to 100 000. Standard input: 0, which corresponds to a TIMEOUT of 7 seconds. Use higher values only if the TNC must communicate with the server through several routers. Ask your network manager for the proper timeout setting.
HM	Definition of whether the TNC should repeat the Remote Procedure Call until the NFS server answers. <b>0</b> : Always repeat the Remote Procedure Call <b>1</b> : Do not repeat the Remote Procedure Call
DEVICENAME	Name that the TNC shows in the file manager for a connected device.
PATH	Directory of the NFS server that you wish to connect to the TNC. Be sure to differentiate between small and capital letters when entering the path.
UID	Definition of the user identification under which you access files in the network. Ask your network manager for the proper timeout setting.
GID	Definition of the group identification with you access files in the network. Ask your network manager for the proper timeout setting.

Manual operation	Network configuration					
	Internet address of server					
File: TP4.M00 >>>						
NR	ADDRESS	RS	WS	TIMEOUT	HM	DEVICENAME
0	160.1.13.4	0	0	0	1	WORLD
1	160.1.247.3	0	0	0	1	LINUX
2		0	0	0	0	
3		0	0	0	0	
4		0	0	0	0	
5		0	0	0	0	
6		0	0	0	0	
7		0	0	0	0	
8		0	0	0	0	
9		0	0	0	0	
10		0	0	0	0	
11		0	0	0	0	
12		0	0	0	0	
BEGIN ↑	END ↓	PAGE ↑	PAGE ↓	INSERT LINE	DELETE LINE	NEXT LINE

Setting	Meaning
DCM	Here you enter the <b>rights of access to files</b> on the NFS server (see figure at upper right). Enter a binary coded value. Example: 111101000 <b>0</b> : Access not permitted <b>1</b> : Access permitted
DCM	Here you enter the <b>rights of access to files</b> on the NFS server (see figure at upper right). Enter the value in binary coded form. Example: 111101000 <b>0</b> : Access not permitted <b>1</b> : Access permitted
AM	Definition of whether the TNC upon switch-on should automatically connect with the network. <b>0</b> : Do not connect automatically <b>1</b> : Connect automatically

Defining the network printer

- Press the DEFINE PRINT soft key if you wish to print the files on the network printer directly from the TNC.

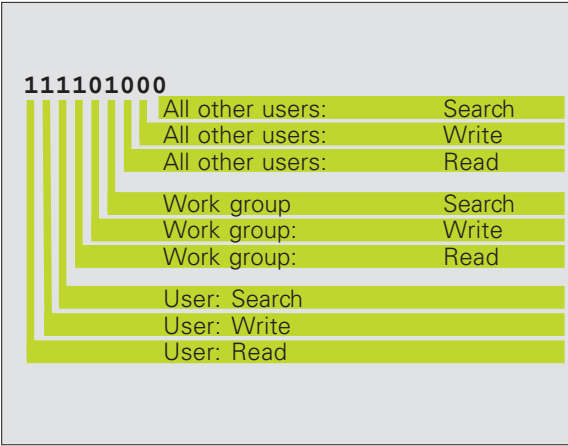
Setting	Meaning
ADDRESS	Address of your server. Input: four decimal numbers separated by points. Ask your network manager for the number of your address. e.g. 160.1.13.4.
DEVICE NAME	Name of the printer that the TNC shows when the PRINT soft key is pressed (see also „4.4 File Management with Additional Functions“)
PRINTER NAME	Name of the printer in your network. Ask your network manager.

Checking the network connection

- Press the PING soft key.
- Enter the Internet address of the device with which you wish to check the connection, and confirm your entry with ENT. The TNC transmits data packets until you exit the test monitor by pressing the END key.

In the TRY line the TNC shows the number of data packets that were transmitted to the previously defined addressee. Behind the number of transmitted data packets the TNC shows the status:

Status display	Meaning
HOST RESPOND	Data packet was received again, connection is OK.
TIMEOUT	Data packet was not received, check the connection.
CAN NOT ROUTE	Data packet could not be transmitted. Check the Internet address of the server and of the router to the TNC.



Manual operation	Network configuration
PING MONITOR	
INTERNET ADDRESS : 160.1.13.4	
TRY	27 : HOST RESPOND

--	--	--	--	--	--	--	--

**Displaying the error log**

- Press the SHOW ERROR soft key if you would like to see the error log. Here the TNC records all errors that have occurred in the network since the TNC was last switched on.

The listed error messages are divided into two categories:

Warnings are indicated with (W). Warnings occur when the TNC was able to establish the network connection, but had to correct settings in order to do so.

Error messages are indicated with (E). Error messages occur when the TNC was unable to establish a network connection.

Error message	Cause
LL: (W) CONNECTION xxxxx UNKNOWN USING DEFAULT 10BASET	The name you entered in DEFINE NET, HW was incorrect
LL: (E) PROTOCOL xxxxx UNKNOWN	The name you entered in DEFINE NET, PROT was incorrect
IP4: (E) INTERFACE NOT PRESENT	The TNC was unable to find an Ethernet card.
IP4: (E) INTERNETADDRESS NOT VALID	You used an invalid Internet address for the TNC.
IP4: (E) SUBNETMASK NOT VALID	The SUBNET MASK does not match the Internet address of the TNC.
IP4: (E) SUBNETMASK OR HOST ID NOT VALID	You used an invalid Internet address for the TNC, or you entered an incorrect SUBNET MASK, or you set all of the HostID bits to 0 (1)
IP4: (E) SUBNETMASK OR SUBNET ID NOT VALID	All bits of the SUBNET ID are 0 or 1
IP4: (E) DEFAULTROUTERADDRESS NOT VALID	You used an invalid Internet address for the router.
IP4: (E) CAN NOT USE DEFAULTROUTER	The default router does not have the same net ID or subnet ID as the TNC.
IP4: (E) I AM NOT A ROUTER	You defined the TNC as a router.
MOUNT: <Device name> (E) DEVICENAME NOT VALID	The device name is either too long or it contains illegal characters.
MOUNT: <device name> (E) DEVICENAME ALREADY ASSIGNED	You have already defined a device with this name.
MOUNT: <Device name> (E) DEVICETABLE OVERFLOW	You have attempted to connect more than seven network drives to the TNC.
NFS2: <Device name> (W) READSIZE SMALLER THEN x SET TO x	The value that you entered for DEFINE MOUNT, RS is too small. The TNC sets RS to 512 bytes.
NFS2: <Device name> (W) READSIZE LARGER THEN x SET TO x	The value that you entered for DEFINE MOUNT, RS is too large The TNC sets RS to 4096 bytes.

Error message	Cause
NFS2: <Device name> (W) WRITESIZE SMALLER THEN x SET TO x	The value that you entered for DEFINE MOUNT, WS is too small. The TNC sets WS to 512 bytes.
NFS2: <Device name> (W) WRITESIZE LARGER THEN x SET TO x	The value that you entered for DEFINE MOUNT, WS is too large. The TNC sets WS to 4096 bytes.
NFS2: <Device name> (E) MOUNTPATH TOO LONG	The value that you entered for DEFINE MOUNT, PATH is too long.
NFS2: <Device name> (E) NOT ENOUGH MEMORY	At the moment there is too little main memory available to establish a network connection.
NFS2: <Device name> (E) HOSTNAME TOO LONG	The name you entered in DEFINE NET, HOST is too long.
NFS2: <Device name> (E) CAN NOT OPEN PORT	The TNC cannot open the port required to establish the network connection.
NFS2: <Device name> (E) ERROR FROM PORTMAPPER	The TNC has received implausible data from the portmapper.
NFS2: <Device name> (E) ERROR FROM MOUNTSERVER	The TNC has received implausible data from the mountserver.
NFS2: <Device name> (E) CANT GET ROOTDIRECTORY	The mount server does not permit a connection with the directory defined in DEFINE MOUNT, PATH.
NFS2: <Device name> (E) UID OR GID 0 NOT ALLOWED	You entered 0 for DEFINE MOUNT, UID or GID 0. The input value 0 is reserved for the system administrator.

# 12.6 Configuring PGM MGT

- With this function you can determine the features of the file manager:
- Standard: Simple file management without directory display
  - Expanded range: File management with additional functions and directory display

See also „section 4.3 Standard File Management“ and „section 4.4 File Management with Additional Functions“.

## Changing the setting

- ▶ Select the file manager in the Programming and Editing mode of operation: press the PGM MGT key
- ▶ Select the MOD function: Press the MOD key
- ▶ Select the PGM MGT setting: using the arrow keys, move the highlight onto the PGM MGT setting and use the ENT key to switch between STANDARD and ENHANCED.

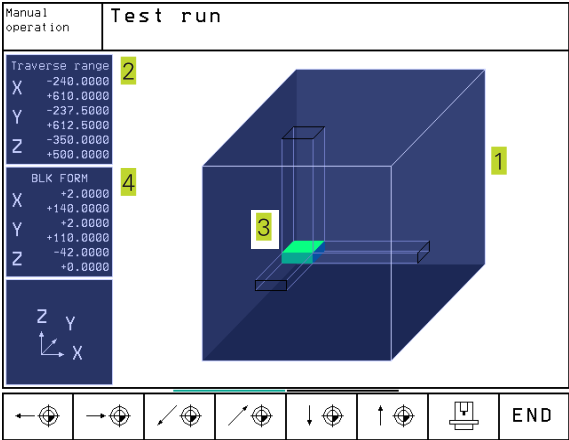
# 12.7 Machine-Specific User Parameters

The machine tool builder can assign functions to up to 16 user parameters. Your machine manual provides more detailed information.

# 12.8 Showing the Workpiece in the Working Space

This MOD function enables you to graphically check the position of the workpiece blank in the machine's working space and to activate work space monitoring in the Test Run mode of operation. This function is activated with the BLANK IN WORD SPACE soft key.













The TNC displays a cuboid **1** for the working space. Its dimensions are shown in the "Traverse range" **2** window. The TNC takes the dimensions for the working space from the machine parameters for the active traverse range. Since the traverse range is defined in the reference system of the machine, the datum of the cuboid is also the machine datum. You can see the position of the machine datum in the cuboid by pressing the soft key M91 in the 2nd soft-key row.



Another cuboid (3) represents the blank form. The TNC takes its dimensions (4) from the workpiece blank definition in the selected program. The workpiece cuboid defines the coordinate system for input. Its datum lies within the cuboid. You can see in the cuboid the position of the datum for input by pressing the corresponding soft key in the 2nd soft-key row.

For a test run it normally does not matter where the workpiece blank is located within the working space. However, if you test programs that contain movements with M91 or M92, you must graphically shift the workpiece blank to prevent contour damage. Use the soft keys shown in the table at right.

You can also activate the working-space monitor for the Test Run mode in order to test the program with the current datum and the active traverse ranges (see table at right, bottommost soft key).

Function	Soft key
Move workpiece blank to the left (graphically)	
Move workpiece blank to the right (graphically)	
Move workpiece blank forward (graphically)	
Move workpiece blank backward (graphically)	
Move workpiece blank upward (graphically)	
Move workpiece blank downward (graphically)	
Show workpiece blank referenced to the set datum	
Show the entire traversing range referenced to the displayed workpiece blank	
Show the machine datum in the working space	
(Show the position defined in the working space (e.g. tool change position) as defined by the machine tool builder	
Show the workpiece datum in the working space	
Enable (ON) or disable (OFF) work space monitoring	



# 12.9 Position Display Types

In the Manual Operation mode and in the program run modes of operation, you can select the type of coordinates to be displayed.

The figure at right shows the different tool positions:

- 1 Starting position
- 2 Target position of the tool
- 3 Workpiece datum
- 4 Machine datum

The TNC position displays can show the following coordinates:

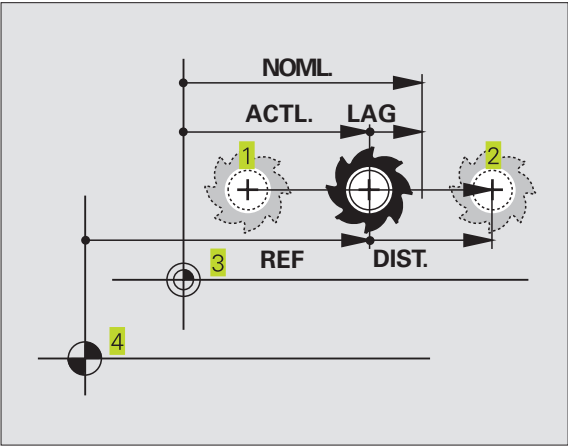
Function	Display
Nominal position: the value presently commanded by the TNC	NOML.
Actual position; current tool position	ACTL.
Reference position; the actual position relative to the machine datum	REF
Distance remaining to the programmed position; difference between actual and target positions	DIST.
Servo lag: difference between nominal and actual positions	LAG
Deflection of the measuring touch probe	DEFL.
Traverses that were carried out with handwheel superpositioning (M118) (only position display 2)	M118

With the MOD function Position display 1 you can select the position display in the status display. With Position display 2 you can select the position display in the additional status display.

## 12.10 Unit of Measurement

This MOD function determines whether the coordinates are displayed in millimeters (metric system) or inches.

- To select the metric system (e.g. X = 15.789 mm) set the Change mm/inches function to mm. The value is displayed with 3 digits after the decimal point.
- To select the inch system (e.g. X = 0.6216 inch) set the Change mm/inches function to inches. The value is displayed to 4 decimal places.



## 12.11 Programming Language for \$MDI

The Program input mod function lets you decide whether to program the \$MDI file in HEIDENHAIN conversational dialog or in ISO format:

- To program the \$MDI.H file in conversational dialog, set the Program input function to HEIDENHAIN.
- To program the \$MDI.I file according to ISO, set the Program input function to ISO.

## 12.12 Selecting the Axes for Generating L Blocks

The axis selection input field enables you to define the current tool position coordinates that are transferred to an L block. To generate a separate L block, press the ACTUAL-POSITION-CAPTURE soft key. The axes are selected by bit-oriented definition similar to programming the machine parameters:

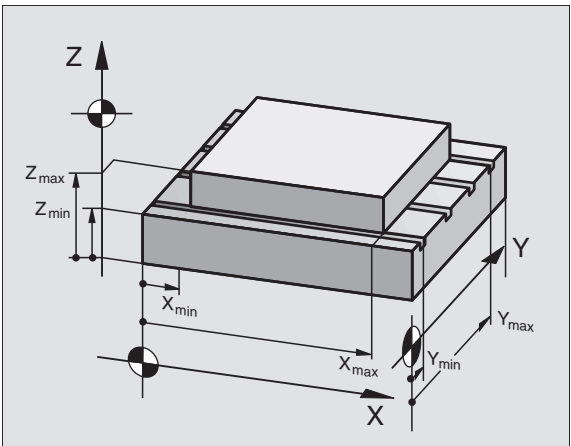
Axis selection	%11111	Transfer the X, Y, Z, IV and V axes
Axis selection	%01111	Transfer the X, Y, Z, IV axes
Axis selection	%00111	Transfer the X, Y and Z axes
Axis selection	%00011	Transfer the X and Y
Axis selection	%00001	Transfer the X axis

## 12.13 Axis Traverse Limits, Datum Display

The AXIS LIMIT mod function allows you to set limits to axis traverse within the machine's actual working envelope.

Possible application:  
to protect an indexing fixture against tool collision.

The maximum range of traverse of the machine tool is defined by software limit switches. This range can be additionally limited through the AXIS LIMIT mod function. With this function, you can enter the maximum and minimum traverse positions for each axis, referenced to the machine datum. If several traverse ranges are possible on your machine, you can set the limits for each range separately using the soft keys LIMIT SWITCH (1) to LIMIT SWITCH (3).



### Working without additional traverse limits

To allow a machine axis to use its full range of traverse, enter the maximum traverse of the TNC (+/- 99999 mm) as the AXIS LIMIT.

#### To find and enter the maximum traverse:

- ▶ Set the Position display mod function to REF.
- ▶ Move the spindle to the positive and negative end positions of the X, Y and Z axes.
- ▶ Write down the values, including the algebraic sign.
- ▶ To select the MOD functions, press the MOD key.



- ▶ Enter the limits for axis traverse: Press the LIMIT SWITCH soft key and enter the values that you wrote down as limits in the corresponding axes
- ▶ To exit the MOD function, press the END soft key



The tool radius is not automatically compensated in the axis traverse limit value.

The traverse range limits and software limit switches become active as soon as the reference points are traversed.

### Datum display

The values shown at the lower left of the screen are the manually set datums referenced to the machine datum. They cannot be changed in the menu.

Manual operation				Programming and editing			
Limits:							
X-	-500	X+	+500				
Y-	-500	Y+	+500				
Z-	+0	Z+	+400				
A-	+0	A+	+360				
B-	-90	B+	+90				
C-	-30000	C+	+30000				
Datum points:							
X	+150	Y	-50	Z	+100		
A	+0	B	+180	C	+90		
U	+0	V	+0	W	+0		
POSITION/ INPUT PGM	AXIS LIMITS	HELP	MACHINE TIME				END

## 12.14 Displaying HELP files

Help files can aid you in situations in which you need clear instructions before you can continue (for example, to retract the tool after an interruption of power). The miscellaneous functions may also be explained in a help file. The figure at right shows the screen display of a help file.



HELP files are not provided on every machine. Refer to your machine tool builder for more information.


### Selecting HELP files

- ▶ Select the MOD function: Press the MOD key
- ▶ To select the last active HELP file, press the HELP soft key.
- ▶ Call the file manager (PGM MGT key) and select a different help file, if necessary.



Manual operation	Programming and editing						
File: MACH1.HELP Line: 6 Column: 1 INSERT							
Commands for the tool changer							
#1111 chain forward							
#2222 chain backward							
[END]							
INSERT OVERWRITE	MOVE WORD >>	MOVE WORD <<	PAGE ↑	PAGE ↓	BEGIN ↑	END ↓	FIND

12.15 Machining Times



The machine tool builder can provide further operating time displays. Refer to your machine tool manual.

The MACHINE TIME soft key enables you to show different operating time displays:

Operating time	Meaning
Control ON	Operating time of the control since its commissioning
Machine ON	Operating time of the machine tool since its commissioning
Program Run	Duration of controlled operation since initial setup

Manual operation							Programming and editing	
Control on = 582:58:20 Machine on = 0:00:00 Program run = 0:00:00								
								END



# 13

Tables and Overviews

## 13.1 General User Parameters

General user parameters are machine parameters affecting TNC settings that the user may want to change in accordance with his requirements.

Some examples of user parameters are:

- Dialog language
- Interface behavior
- Traversing speeds
- Sequence of machining
- Effect of overrides

### Input possibilities for machine parameters

Machine parameters can be programmed as

- **Decimal numbers**  
Enter only the number
- **Pure binary numbers**  
Enter a percent sign (%) before the number
- **Hexadecimal numbers**  
Enter a dollar sign (\$) before the number

#### Example:

Instead of the decimal number 27 you can also enter the binary number %11011 or the hexadecimal number \$1B.

The individual machine parameters can be entered in the different number systems.

Some machine parameters have more than one function. The input value for these machine parameters is the sum of the individual values. For these machine parameters the individual values are preceded by a plus sign.

### Selecting general user parameters

General user parameters are selected with code number 123 in the MOD functions.



The MOD functions also include machine-specific user parameters.

External data transfer

Integrating TNC interfaces EXT1 (5020.0) and EXT2 (5020.1) to an external device

<b>MP5020.x</b>
7 data bits (ASCII code, 8th bit = parity): <b>+0</b>
8 data bits (ASCII code, 9th bit = parity): <b>+1</b>
Block Check Character (BCC) any: <b>+0</b>
Block Check Character (BCC) control character not permitted: <b>+2</b>
Transmission stop through RTS active: <b>+4</b>
Transmission stop through RTS inactive: <b>+0</b>
Transmission stop through DC3 active: <b>+8</b>
Transmission stop through DC3 inactive: <b>+0</b>
Character parity even: <b>+0</b>
Character parity odd: <b>+16</b>
Character parity not desired: <b>+0</b>
Character parity desired: <b>+32</b>
1 1/2 stop bits: <b>+0</b>
2 stop bits: <b>+64</b>
1 stop bit: <b>+128</b>
1 stop bit: <b>+192</b>

Example:

Use the following setting to adjust the TNC interface EXT2 (MP 5020.1) to an external non-HEIDENHAIN device:

8 data bits, any BCC, transmission stop through DC3, even character parity, character parity desired, 2 stop bits

Input for **MP 5020.1**: 1+0+8+0+32+64 = **105**


Integrating TNC interfaces EXT1 (5030.0) and EXT2 (5030.1) to external device

<b>MP5030.x</b>
Standard transmission: <b>0</b>
Interface for blockwise transfer: <b>1</b>

3-D touch probes and digitizing

Select touch probe (only with option for digitizing with measuring touch probe)	<b>MP6200</b> Triggering touch probe: <b>0</b> Measuring touch probe: <b>1</b>
Select signal transmission	<b>MP6010</b> Touch probe with cable transmission: <b>0</b> Touch probe with infrared transmission: <b>1</b>
Probing feed rate for triggering touch probes	<b>MP6120</b> <b>1 to 3000</b> [mm/min]
Maximum traverse to first probe point	<b>MP6130</b> <b>0.001 to 99 999.9999</b> [mm]
Safety clearance to probing point during automatic measurement	<b>MP6140</b> <b>0.001 to 99 999.9999</b> [mm]
Rapid traverse for triggering touch probes	<b>MP6150</b> <b>1 to 300 000</b> [mm/min]
Measure center misalignment of the stylus when calibrating a triggering touch probe	<b>MP6160</b> No 180° rotation of the 3-D touch probe during calibration: <b>0</b> M function for 180° rotation of the 3-D touch probe during calibration: <b>1 to 88</b>
Multiple measurement for programmable probe function	<b>MP6170</b> <b>1 to 3</b>
Confidence range for multiple measurement	<b>MP6171</b> <b>0.001 to 0.999</b> [mm]
Automatic calibration cycle: Center of the calibration ring in the X-axis referenced to the machine datum	<b>MP6180.0 (traverse range 1) to MP6180.2 (traverse range 3)</b> <b>0 to 99 999.9999</b> [mm]
Automatic calibration cycle: Center of the calibration ring in the Y-axis referenced to the machine datum for	<b>MP6181 (traverse range 1) to MP6180.2 (traverse range 3)</b> <b>0 to 99 999.9999</b> [mm]
Automatic calibration cycle: Center of the calibration ring in the Z-axis referenced to the machine datum for	<b>MP6182 (traverse range 1) to MP6180.2 (traverse range 3)</b> <b>0 to 99 999.9999</b> [mm]



<b>Automatic calibration cycle: distance below the upper edge of the ring where the calibration is carried out by the TNC</b>	
<b>MP6185</b>	
<b>0.1 to 99 999.9999 [mm]</b>	
<b>Infeed of the stylus when digitizing with the measuring touch probe</b>	
<b>MP6310</b>	
<b>0.1 to 2.0000 [mm] (recommended input value: 1 mm)</b>	
<b>Measure center misalignment of the stylus when calibrating a measuring touch probe</b>	
<b>MP6321</b>	
Measure center misalignment: <b>0</b>	
Do not measure center misalignment: <b>1</b>	
<b>Assign touch probe axis to machine axis for a measuring touch probe</b>	
 Ensure that the touch probe axes are correctly assigned to the machine axes. Wrong assignment could lead to a stylus break.	<b>MP6322.0</b>
	Machine <b>X</b> axis parallel to touch probe axis X: <b>0</b> , Y: <b>1</b> , Z: <b>2</b>
	<b>MP6322.1</b>
	Machine <b>Y</b> axis parallel to touch probe axis X: <b>0</b> , Y: <b>1</b> , Z: <b>2</b>
	<b>MP6322.2</b>
	Machine <b>Z</b> axis parallel to touch probe axis X: <b>0</b> , Y: <b>1</b> , Z: <b>2</b>
<b>Maximum stylus deflection of the measuring touch probe</b>	
<b>MP6330</b>	
<b>0.1 to 4.0000 [mm]</b>	
<b>Feed rate for positioning measuring touch probes at MIN point and approaching the contour</b>	
<b>MP6350</b>	
<b>1 to 3000 [mm/min]</b>	
<b>Probe feed rate for measuring touch probes</b>	
<b>MP6360</b>	
<b>1 to 3000 [mm/min]</b>	
<b>Rapid traverse for measuring touch probes in the probe cycle</b>	
<b>MP6361</b>	
<b>10 to 3 000 [mm/min]</b>	
<b>Feed rate reduction when the stylus of a measuring touch probe is deflected to the side</b>	
The TNC decreases the feed rate according to a preset characteristic curve. The minimum input value is 10% of the programmed digitizing feed rate.	
<b>MP6362</b>	
Feed rate reduction not active: <b>0</b>	
Feed rate reduction active: <b>1</b>	

Radial acceleration during digitizing with the measuring touch probe

MP6370 enables you to limit the feed rate of the TNC for circular movements during digitizing. Circular movements are caused, for example, by sharp changes of direction.

As long as the programmed digitizing feed rate is less than the feed rate calculated with MP6370, the TNC will move at the programmed feed rate. Determine the appropriate value for your requirements by trial and error.

**MP6370**  
**0.001 to 5.000** [m/s²] (recommended input value: 0.1)

Target window for digitizing contour lines with a measuring touch probe

When you are digitizing contour lines the individual contour lines do not end exactly in their starting points.

With machine parameter MP6390 you can define a square target window within which the end point must lie after the touch probe has orbited the model. Enter half the side length of the target window for the side length.

**MP6390**  
**0.1 to 4.0000** [mm]

Radius measurement with the TT 120 touch probe: Probing direction

**MP6505.0 (traverse range 1) to 6505.2 (traverse range 3)**  
Positive probing direction in the angle reference axis (0° axis): **0**  
Positive probing direction in the +90° axis: **1**  
Negative probing direction in the angle reference axis (0° axis): **2**  
Negative probing direction in the +90° axis: **3**

Probing feed rate for second measurement with TT 120, stylus shape, corrections in TOOL.T

**MP6507**  
Calculate feed rate for second measurement with TT 120, with constant tolerance: **+0**  
Calculate feed rate for second measurement with TT 120, with variable tolerance: **+1**  
Constant feed rate for second measurement with TT 120: **+2**

Maximum permissible measuring error with TT 120 during measurement with rotating tool

Required for calculating the probing feed rate in connection with MP6570

**MP6510**  
**0.001 to 0.999** [mm] (recommended input value: 0.005 mm)

Feed rate for probing a stationary tool with the TT 120

**MP6520**  
**1 to 3000** [mm/min]

Radius measurement with the TT 120: Distance from lower edge of tool to upper edge of stylus

**MP6530.0 (traverse range 1) to MP6530.2 (traverse range 3)**

Set-up clearance in the tool axis above the stylus of the TT 120 for pre-positioning	MP6540.0 0.001 to 30 000.000 [mm]
Clearance zone in the machining plane around the stylus of the TT 120 for pre-positioning	MP6540.1 0.001 to 30 000.000 [mm]
Rapid traverse for TT 120 in the probe cycle	MP6550 10 to 10 000 [mm/min]
M function for spindle orientation when measuring individual teeth	MP6560 0 to 88
Measuring rotating tools: Permissible rotational speed at the circumference of the milling tool	
Required for calculating rpm and probe feed rate	MP6570 1.000 to 120.000 [m/min]
Coordinates of the TT 120 stylus center relative to the machine datum	
	MP6580.0 (traverse range 1) X axis
	MP6580.1 (traverse range 1) Y axis
	MP6580.2 (traverse range 1) Z-axis
	MP6581.0 (traverse range 2) X-axis
	MP6581.1 (traverse range 2) Y-axis
	MP6581.2 (traverse range 2) Z-axis
	MP6582.0 (traverse range 3) X-axis
	MP6582.1 (traverse range 3) Y-axis
	MP6582.2 (traverse range 3) Z-axis

TNC displays, TNC editor

Programming station

**MP7210**  
TNC with machine: **0**  
TNC as programming station with active PLC: **1**  
TNC as programming station with inactive PLC: **2**

Acknowledgment of POWER INTERRUPTED after switch-on

**MP7212**  
Acknowledge with key: **0**  
Acknowledge automatically: **1**


ISO programming: Set the block number increment

**MP7220**  
**0 to 150**

Disabling the selection of file types

**MP7224.0**  
All file types selectable via soft key: **+0**  
Disable selection of HEIDENHAIN programs (soft key SHOW .H): **+1**  
Disable selection of ISO programs (soft key SHOW .I): **+2**  
Disable selection of tool tables (soft key SHOW .T): **+4**  
Disable selection of datum tables (soft key SHOW .D): **+8**  
Disable selection of pallet tables (soft key SHOW .P): **+16**  
Disable selection of text files (soft key SHOW .A): **+32**  
Disable selection of point tables (soft key SHOW .PNT): **+64**

Disabling the editor for certain file types

 If a particular file type is inhibited, the TNC will erase all files of this type.

**MP7224.1**  
Do not disable editor: **+0**  
Disable editor for  
■ HEIDENHAIN programs: **+1**  
■ ISO programs: **+2**  
■ Tool table: **+4**  
■ Datum tables: **+8**  
■ Pallet tables: **+16**  
■ Text files: **+32**  
■ Pallet tables: **+64**

Configure pallet files

**MP7226.0**  
Pallet table inactive: **0**  
Number of pallets per pallet table: **1 to 255**

Configure datum files

**MP7226.1**  
Datum table inactive: **0**  
Number of datums per datum table: **1 to 255**

Program length for program check	<b>MP7229.0</b> Blocks <b>100</b> to <b>9 999</b>
Program length up to which FK blocks are permitted	<b>MP7229.1</b> Blocks <b>100</b> to <b>9 999</b>
Dialog language	<b>MP7230</b> English: <b>0</b> Swedish: <b>7</b> German: <b>1</b> Danish: <b>8</b> Czech: <b>2</b> Finnish: <b>9</b> French: <b>3</b> Dutch: <b>10</b> Italian: <b>4</b> Polish: <b>11</b> Spanish: <b>5</b> Hungarian: <b>12</b> Portuguese: <b>6</b>
Internal clock of the TNC	<b>MP7235</b> Universal time (Greenwich Mean Time): <b>0</b> Central European Time (CET): <b>1</b> Central European Summertime: <b>2</b> Time difference to universal time: <b>-23</b> to <b>+23</b> [hours]
Configure tool tables	<b>MP7260</b> Inactive: <b>0</b> Number of tools generated by the TNC when a new tool table is opened: <b>1</b> to <b>254</b> If you require more than 254 tools, you can expand the tool table with the function APPEND N LINES (see also „5.2 Tool Data“)
Configure pocket tables	<b>MP7261</b> Inactive: <b>0</b> Number of pockets per pocket table: <b>1</b> to <b>254</b>
Index tool numbers in order to be able to assign different compensation data to one tool number	<b>MP7262</b> Do not index: <b>0</b> Number of permissible indices: <b>1</b> to <b>9</b>
Soft key for pocket tables	<b>MP7263</b> Show the POCKET TABLE soft key in the tool table: <b>0</b> Do not show the POCKET TABLE soft key in the tool table: <b>1</b>

**Configure tool table (To omit from the table: enter 0);**  
**Column number in the tool table for**

<b>MP7266.0</b>	Tool name – NAME: <b>0</b> to <b>27</b> ; column width: 16 characters
<b>MP7266.1</b>	Tool length – L: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.2</b>	Tool radius – R: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.3</b>	Tool radius 2 – R2: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.4</b>	Oversize length – DL: <b>0</b> to <b>27</b> ; column width: 8 characters
<b>MP7266.5</b>	Oversize radius – DR: <b>0</b> to <b>27</b> ; column width: 8 characters
<b>MP7266.6</b>	Oversize radius 2 – DR2: <b>0</b> to <b>27</b> ; column width: 8 characters
<b>MP7266.7</b>	Tool locked – TL: <b>0</b> to <b>27</b> ; column width: 2 characters
<b>MP7266.8</b>	Replacement tool – RT: <b>0</b> to <b>27</b> ; column width: 3 characters
<b>MP7266.9</b>	Maximum tool life – TIME1: <b>0</b> to <b>27</b> ; column width: 5 characters
<b>MP7266.10</b>	Maximum tool life for TOOL CALL – TIME2: <b>0</b> to <b>27</b> ; column width: 5 characters
<b>MP7266.11</b>	Current tool life — CUR. TIME: <b>0</b> to <b>27</b> ; column width: 8 characters
<b>MP7266.12</b>	Tool comment – DOC: <b>0</b> to <b>27</b> ; column width: 16 characters
<b>MP7266.13</b>	Number of teeth – CUT.: <b>0</b> to <b>27</b> ; column width: 4 characters
<b>MP7266.14</b>	Tolerance for wear detection in tool length – LTOL: <b>0</b> to <b>27</b> ; column width: 6 characters
<b>MP7266.15</b>	Tolerance for wear detection in tool radius – RTOL: <b>0</b> to <b>27</b> ; column width: 6 characters
<b>MP7266.16</b>	Cutting direction – DIRECT.: <b>0</b> to <b>27</b> ; column width: 7 characters
<b>MP7266.17</b>	PLC status – PLC: <b>0</b> to <b>27</b> ; column width: 9 characters
<b>MP7266.18</b>	Offset of the tool in the tool axis in addition to MP6530 – TT:L-OFFS: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.19</b>	Offset of the tool between stylus center and tool center – TT:R-OFFS: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.20</b>	Tolerance for break detection in tool length – LBREAK.: <b>0</b> to <b>27</b> ; column width: 6 characters
<b>MP7266.21</b>	Tolerance for break detection in tool radius – RBREAK: <b>0</b> to <b>27</b> ; column width: 6 characters
<b>MP7266.22</b>	Tooth length (Cycle 22) – LCUTS: <b>0</b> to <b>27</b> ; column width: 11 characters
<b>MP7266.23</b>	maximum plunge angle (Cycle 22) – ANGLE.: <b>0</b> to <b>27</b> ; column width: 7 characters
<b>MP7266.24</b>	Tool type – TYPE: <b>0</b> to <b>27</b> ; column width: 5 characters
<b>MP7266.25</b>	Tool material – TMAT: <b>0</b> to <b>27</b> ; column width: 16 characters
<b>MP7266.26</b>	Cutting data table – CDT: <b>0</b> to <b>27</b> ; column width: 16 characters

Configure pocket tables (to omit from table enter 0); Column number in the tool table for	<b>MP7267.0</b> Tool number — T: 0 to 5	
	<b>MP7267.1</b> Special tool — ST: 0 to 5	
	<b>MP7267.2</b> Fixed pocket — F: 0 to 5	
	<b>MP7267.3</b> Pocket locked — L: 0 to 5	
	<b>MP7267.4</b> PLC status — PLC: 0 to 5	
Manual Operation mode: Display of feed rate	<b>MP7270</b> Display feed rate F only if an axis direction button is pressed: 0 Display feed rate F even if no axis direction button is pressed (feed rate defined using F soft key or feed rate of the “slowest” axis): 1	
Decimal character	<b>MP7280</b> The decimal character is a comma: 0 The decimal character is a point: 1	
Position display in the tool axis	<b>MP7285</b> Display is referenced to the tool datum: 0 Display in the tool axis is referenced to the tool face: 1	
Display step for the X axis	<b>MP7290.0</b> 0.1 mm: 0 0.05 mm: 1                      0.001 mm: 4 0.01 mm: 2                      0.0005 mm: 5 0.005 mm: 3                    0.0001 mm: 6	
Display step for the Y axis	<b>MP7290.1</b> For input values, see MP7290.0	
Display step for the Z axis	<b>MP7290.2</b> For input values, see MP7290.0	
Display step for the IVth axis	<b>MP7290.3</b> For input values, see MP7290.0	
Display step for the V axis	<b>MP7290.4</b> For input values, see MP7290.0	

Display step for the 6th axis	<b>MP7290.5</b> For input values, see MP7290.0
Display step for the 7th axis	<b>MP7290.6</b> For input values, see MP7290.0
Display step for the 8th axis	<b>MP7290.7</b> For input values, see MP7290.0
Display step for the 9th axis	<b>MP7290.8</b> For input values, see MP7290.0
Disable datum setting	<b>MP7295</b> Do not disable datum setting: <b>+0</b> Disable datum setting in the X axis: <b>+1</b> Disable datum setting in the Y axis: <b>+2</b> Disable datum setting in the Z axis: <b>+4</b> Disable datum setting in the IV axis: <b>+8</b> Disable datum setting in the V axis: <b>+16</b> Disable datum setting in the 6th axis: <b>+32</b> Disable datum setting in the 7th axis: <b>+64</b> Disable datum setting in the 8th axis: <b>+128</b> Disable datum setting in the 9th axis: <b>+256</b>
Disable datum setting with the orange axis keys	<b>MP7296</b> Do not inhibit datum setting: <b>0</b> Disable datum setting with the orange axis keys: <b>1</b>
Reset status display, Q parameters and tool data	<b>MP7300</b> Reset them all when a program is selected: <b>0</b> Reset them all when a program is selected and with M02, M30, END PGM: <b>1</b> Reset only status display and tool data when a program is selected: <b>2</b> Reset only status display and tool data when a program is selected and with M02, M30, END PGM: <b>3</b> Reset status display and Q parameters when a program is selected: <b>4</b> Reset status display and Q parameters when a program is selected and with M02, M30, END PGM: <b>5</b> Reset status display when a program is selected: <b>6</b> Reset status display when a program is selected and with M02, M30, END PGM: <b>7</b>



Graphic display mode

**MP7310**  
Projection in three planes according to ISO 6433, projection method 1: **+0**  
Projection in three planes according to ISO 6433, projection method 2: **+1**  
Do not rotate coordinate system for graphic display: **+0**  
Rotate coordinate system for graphic display by 90°: **+2**  
Display new BLK FORM in Cycle 7 DATUM SHIFT referenced to the previous datum **+0**  
Display new BLK FORM in Cycle 7 DATUM SHIFT referenced to the new datum: **+4**  
Do not show cursor position during projection in three planes: **+0**  
Show cursor position during projection in three planes: **+8**

Graphic simulation without programmed tool axis: Tool radius

**MP7315**  
**0** to **99 999.9999** [mm]

Graphic simulation without programmed tool axis: Penetration depth

**MP7316**  
**0** to **99 999.9999** [mm]

Graphic simulation without programmed tool axis: M function for start

**MP7317.0**  
**0** to **88** (0: Function inactive)

Graphic simulation without programmed tool axis: M function for end

**MP7317.1**  
**0** to **88** (0: Function inactive)

Screen saver

Enter the time after which the TNC should start the screen saver

**MP7392**  
**0** to **99** [min] (0: Function inactive)

Machining and program run

Cycle 17: Oriented spindle stop at beginning of cycle

**MP7160**  
Oriented spindle stop: **0**  
No oriented spindle stop: **1**

Effect of Cycle 11 SCALING FACTOR

**MP7410**  
SCALING FACTOR effective in 3 axes: **0**  
SCALING FACTOR effective in the working plane only: **1**

Tool data in programmable probe cycle TOUCH-PROBE 0

**MP7411**  
Overwrite current tool data by the calibrated data from the 3-D touch probe system: **0**  
Current tool data are retained: **1**

SL Cycles

MP7420

Mill channel around the contour — clockwise for islands and counterclockwise for pockets: **+0**  
Mill channel around the contour — clockwise for pockets and counterclockwise for islands: **+1**  
First mill the channel, then rough out the contour: **+0**  
First rough out the contour, then mill the channel: **+2**  
Combine compensated contours: **+0**  
Combine uncompensated contours: **+4**  
Complete one process for all infeeds before switching to the other process: **+0**  
Mill channel and rough-out for each infeed depth before continuing to the next depth: **+8**

The following note applies to the Cycles 6, 15, 16, 21, 22, 23, and 24:  
At the end of the cycle, move the tool to the position that was last programmed before the cycle call: **+0**  
At the end of the cycle, retract the tool in the tool axis only: **+16**

Cycle 4 POCKET MILLING and Cycle 5 CIRCULAR POCKET MILLING: Overlap factor

MP7430

0.1 to 1.414

Permissible deviation of circle radius between circle end point and circle starting point

MP7431

0.0001 to 0.016 [mm]

Behavior of M functions

MP7440

Program stop with M06: **+0**  
No program stop with M06: **+1**  
No cycle call with M89: **+0**  
Cycle call with M89: **+2**  
Program stop with M functions: **+0**  
No program stop with M functions: **+4**  
 $k_v$  factors cannot be switched through M105 and M106: **+0**  
 $k_v$  factors can be switched through M105 and M106: **+8**  
Reduce the feed rate in the tool axis with M103 F. , function inactive: **+0**  
Reduce the feed rate in the tool axis with M103 F. , function active: **+16 Positioning with rotary axes active: +32**



The  $k_v$  factors for position loop gain are set by the machine tool builder. Refer to your machine manual.

Running fixed cycles when M3 or M4 not active

MP7441

Error message when M3/M4 not active: **0**  
Suppress error message when M3/M4 not active: **1**

Maximum contouring speed at a feed rate override setting of 100% in the program run modes	<b>MP7470</b> 0 to 99 999 [mm/min]
Feed rate for rotary-axis compensation movements	<b>MP7471</b> 0 to 99 999 [mm/min]
Datums from a datum table are referenced to the	<b>MP7475</b> Workpiece datum: 0 Machine datum: 1
Running pallet tables	<b>MP7683</b> Program run, single block: Run one line of the active NC program at every NC start: <b>+0</b> Program run, single block: Run the entire NC program at every NC start: <b>+1</b> Program run, full sequence: Run the entire NC program at every NC start: <b>+0</b> Program run, full sequence: Run all NC programs up to the next pallet at every NC start: <b>+2</b> Program run, full sequence: Run the entire NC program at every NC start: <b>+0</b> Program run, full sequence: Run the entire pallet file at every NC start: <b>+4</b> Program run, full sequence: Run the entire pallet file at every NC start: <b>+0</b> Program run, full sequence: If running of the complete pallet file is selected (+4), then run the pallet file without interruption, i.e. until you press NC stop: <b>+8</b>

Electronic handwheels

Handwheel type

**MP7640**  
Machine without handwheel: **0**  
HR 330 with additional keys — the handwheel keys for traverse direction and rapid traverse are evaluated by the NC: **1**  
HR 130 without additional keys: **2**  
HR 330 with additional keys — the handwheel keys for traverse direction and rapid traverse are evaluated by the PLC: **3**  
HR 332 with twelve additional keys: **4**  
Multi-axis handwheel with additional keys: **5**  
HR 410 with auxiliary functions: **6**

Interpolation factor

**MP7641**  
Interpolation factor is entered on the keyboard: **0**  
Interpolation factor is set by the PLC: **1**

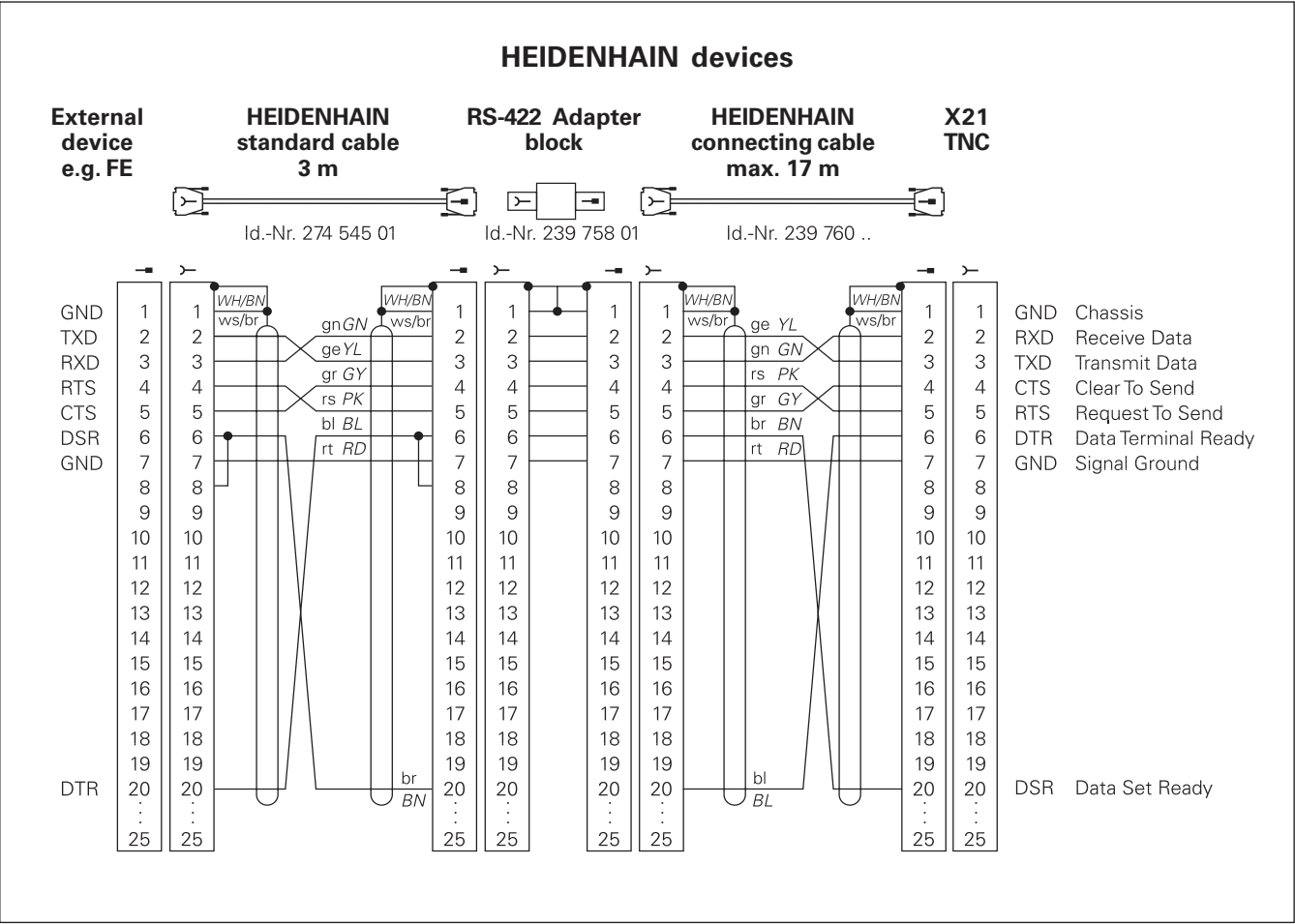
Machine parameters that can be set for the handwheel by the machine tool builder

<b>MP 7645.0</b>	<b>0 to 255</b>
<b>MP 7645.1</b>	<b>0 to 255</b>
<b>MP 7645.2</b>	<b>0 to 255</b>
<b>MP 7645.3</b>	<b>0 to 255</b>
<b>MP 7645.4</b>	<b>0 to 255</b>
<b>MP 7645.5</b>	<b>0 to 255</b>
<b>MP 7645.6</b>	<b>0 to 255</b>
<b>MP 7645.7</b>	<b>0 to 255</b>

# 13.2 Pin Layout and Connecting Cable for the Data Interfaces

## RS-232-C/V.24 Interface

HEIDENHAIN devices

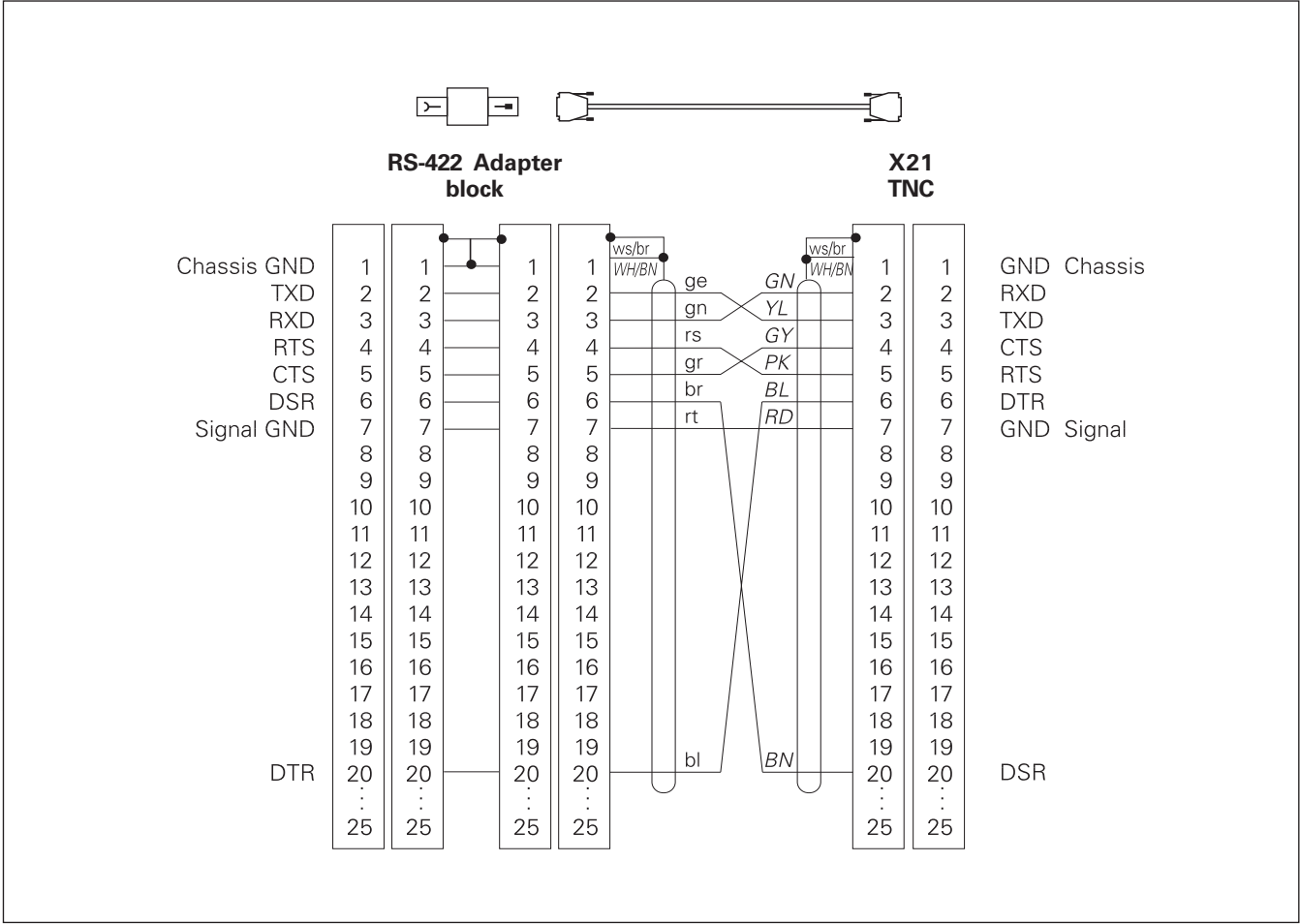


The connector pin layout on the adapter block differs from that on the TNC logic unit (X21).

Non-HEIDENHAIN devices

The connector pin layout of a non-HEIDENHAIN device may differ considerably from that on a HEIDENHAIN device.

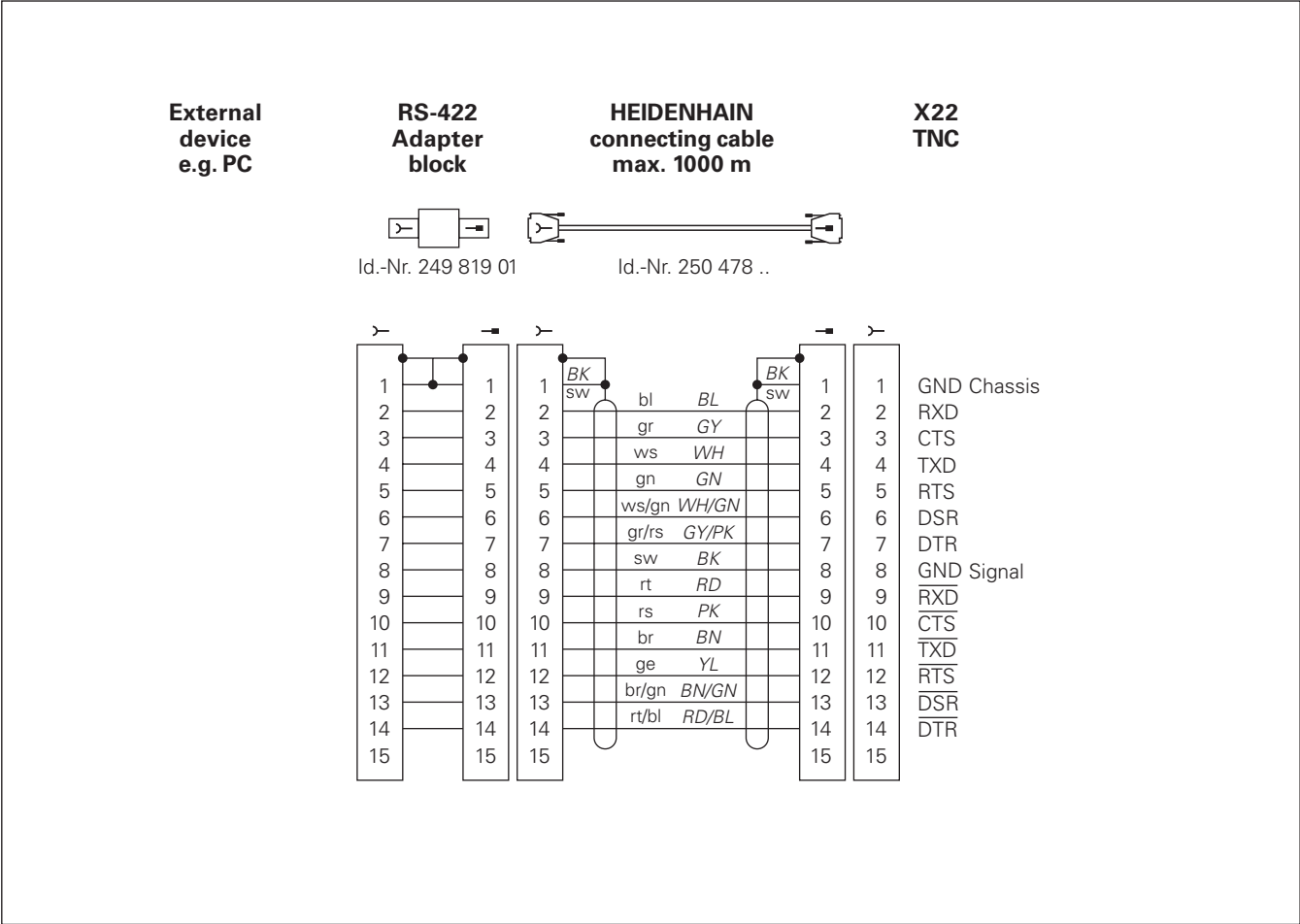
This often depends on the unit and type of data transfer. The figure below shows the connector pin layout on the adapter block.



RS-422/V.11 Interface

Only non-HEIDENHAIN devices are connected to the RS-422 interface.

The pin layouts on the TNC logic unit (X22) and on the adapter block are identical.



Ethernet interface RJ45 socket (option)

Maximum cable length:   Unshielded: 100 m  
                                  Shielded: 400 m

Pin	Signal	Description
1	TX+	Transmit Data
2	TX-	Transmit Data
3	REC+	Receive Data
4	Vacant-	
5	Vacant-	
6	REC-	Receive Data
7	Vacant-	
8	Vacant-	

Ethernet interface BNC socket (option)

Maximum cable length: 180 m

Pin	Signal	Description
1	Data (RXI,TXO)	Inner conductor (core)
2	GND	Shielding



## 13.3 Technical Information

### TNC features

<b>Description</b>	Contouring control for machines with up to 9 axes plus oriented spindle stop. The TNC 426 CB and TNC 430 CA feature analog speed control, the TNC 426 PB and TNC 430 PB feature digital speed control and integrated current controller.
<b>Components</b>	<ul style="list-style-type: none"> <li>■ Logic unit</li> <li>■ Keyboard unit</li> <li>■ Visual display unit with soft keys</li> </ul>
<b>Data interfaces</b>	<ul style="list-style-type: none"> <li>■ RS-232 /V.24</li> <li>■ RX 422 /V.11</li> <li>■ Ethernet interface (option)</li> <li>■ Expanded data interface with LSV-2 protocol for remote operation of the TNC through the data interface with HEIDENHAIN software TNCremo</li> </ul>
<b>Simultaneous axis control for contour elements</b>	<ul style="list-style-type: none"> <li>■ Straight lines: up to 5 axis</li> </ul> <p>Export versions TNC 426 CF, TNC 426 PF, TNC 430 CE, TNC 430 PE: 4 axes</p> <ul style="list-style-type: none"> <li>■ Circles: up to 3 axes (with tilted working plane)</li> <li>■ Helixes: 3 axes</li> </ul>
<b>Look Ahead</b>	<ul style="list-style-type: none"> <li>■ Defined rounding of discontinuous contour transitions (such as for 3-D surfaces)</li> <li>■ Collision prevention with the SL cycle for open contours</li> <li>■ Geometry precalculation of radius-compensated positions for feed rate adaptation</li> </ul>
<b>Background programming</b>	One part program can be edited while the TNC runs another program
<b>Graphics</b>	<ul style="list-style-type: none"> <li>■ Interactive programming graphics</li> <li>■ Test run graphics</li> <li>■ Program run graphics</li> </ul>
<b>File types</b>	<ul style="list-style-type: none"> <li>■ HEIDENHAIN conversational programming</li> <li>■ ISO programming</li> <li>■ Tool tables</li> <li>■ Cutting data tables</li> <li>■ Datum tables</li> <li>■ Point tables</li> <li>■ Pallet files</li> <li>■ Text files</li> <li>■ System files</li> </ul>

<b>Program memory</b>	<ul style="list-style-type: none"> <li>■ Hard disk with 1500 MB for NC programs</li> <li>■ No limit on number of files</li> </ul>
<b>Tool definitions</b>	Up to 254 tools in the program or any number in tables
<b>Programming support</b>	<ul style="list-style-type: none"> <li>■ Functions for approaching and departing the contour</li> <li>■ On-screen pocket calculator</li> <li>■ Structuring long programs</li> <li>■ Comment blocks</li> <li>■ Direct help on output error messages (context-sensitive)</li> </ul>
<b>Programmable functions</b>	
<b>Contour elements</b>	<ul style="list-style-type: none"> <li>■ Straight line</li> <li>■ Chamfer</li> <li>■ Circular arc</li> <li>■ Circle center</li> <li>■ Circle radius</li> <li>■ Tangentially connecting circle</li> <li>■ Corner rounding</li> <li>■ Straight lines and circular arcs for contour approach and departure</li> <li>■ B spline</li> </ul>
<b>FK free contour programming</b>	For all contour elements not dimensioned for conventional NC programming
<b>Three-dimensional tool radius compensation</b>	For changing tool data without having to recalculate the program
<b>Program jumps</b>	<ul style="list-style-type: none"> <li>■ Subprograms</li> <li>■ Program section repeats</li> <li>■ Program as Subprogram</li> </ul>
<b>Fixed cycles</b>	<ul style="list-style-type: none"> <li>■ Drilling cycles for drilling, pecking, reaming, boring, tapping with a floating tap holder, rigid tapping</li> <li>■ Milling and finishing rectangular and circular pockets</li> <li>■ Cycles for milling linear and circular slots</li> <li>■ Linear and circular hole patterns</li> <li>■ Cycles for multipass-milling of flat and twisted surfaces</li> <li>■ Milling pockets and islands from a list of subcontour elements</li> <li>■ Cylindrical surface interpolation</li> </ul>

<b>Coordinate transformations</b>	<ul style="list-style-type: none"> <li>■ Datum shift</li> <li>■ Mirroring</li> <li>■ Rotation</li> <li>■ Scaling</li> <li>■ Tilting the working plane</li> </ul>
<b>3-D touch probe applications</b>	<ul style="list-style-type: none"> <li>■ Touch probe functions for compensating workpiece misalignment</li> <li>■ Touch probe functions for setting datums</li> <li>■ Touch probe functions for automatic workpiece measurement</li> <li>■ Digitizing 3-D surfaces with the measuring touch probe (optional)</li> <li>■ Digitizing 3-D surfaces with the triggering touch probe (optional)</li> <li>■ Automatic tool measurement with the TT 120</li> </ul>
<b>Mathematical functions</b>	<ul style="list-style-type: none"> <li>■ Basic arithmetic +, -, x and /</li> <li>■ Trigonometry sin, cos, tan, arcsin, arccos, arctan</li> <li>■ Square root (<math>\sqrt{a}</math>) and root sum of squares (<math>\sqrt{a^2 + b^2}</math>)</li> <li>■ Squaring (SQ)</li> <li>■ Powers (^)</li> <li>■ Constant PI (3.14)</li> <li>■ Logarithms</li> <li>■ Exponential functions</li> <li>■ Negation (NEG)</li> <li>■ Forming an integer (INT)</li> <li>■ Forming an absolute number (ABS)</li> <li>■ Truncating values before the decimal point (FRAC)</li> <li>■ Function for calculating circles</li> <li>■ Logical comparisons (greater than, less than, equal to, not equal to)</li> </ul>

## TNC Specifications

<b>Block processing time</b>	4 milliseconds per block
<b>Control loop cycle time</b>	<ul style="list-style-type: none"> <li>■ TNC 426 CB, TNC 430 CA: Contouring interpolation: 3 ms Fine interpolation: 0.6 ms (contour)</li> <li>■ TNC 426 PB, TNC 430 PB: Contouring interpolation: 3 ms Fine interpolation: 0.6 ms (speed)</li> </ul>
<b>Data transfer rate</b>	Maximum 115,200 baud via V.24/V.11 Maximum 1 megabaud via Ethernet interface (optional)
<b>Ambient temperature</b>	<ul style="list-style-type: none"> <li>■ Operation: 0° C to +45° C (32° to 113° F)</li> <li>■ Storage: -30° C to +70° C (-22° to 158° F)</li> </ul>
<b>Traverse range</b>	Maximum 100 m (2540 in.)
<b>Traversing speed</b>	Maximum 300 m/min (11 811 ipm)
<b>Spindle speed</b>	Maximum 99 999 rpm
<b>Input range</b>	<ul style="list-style-type: none"> <li>■ Minimum 0.1 <math>\mu</math>m (0.000 01 in.) or 0.0001°</li> <li>■ Maximum 99 999.999 mm (3937 in.) or 99 999.999°</li> </ul>

## 13.4 Exchanging the Buffer Battery

A buffer battery supplies the TNC with current to prevent the data in RAM memory from being lost when the TNC is switched off.

If the TNC displays the error message Exchange buffer battery, then you must replace the batteries. The buffer batteries are located next to the power supply unit in the logic unit (round, black case). The TNC also has an power storage device that provide the control with current while you are exchanging the batteries (for a maximum of 24 hours).



To exchange the buffer battery, first switch off the TNC!

The buffer battery must be exchanged only by trained service personnel!

Battery type: Three AA-size cells, leak-proof, IEC designation „LR6“

**SYMBOLS**

- 3-D compensation ... 88
  - Delta values ... 90
  - Normalized vector ... 88
  - Peripheral milling ... 91
  - Peripheral milling ... 92
  - Tool forms ... 89
  - Tool orientation ... 91
- 3-D view ... 308

**A**

- Accessories ... 12
- Actual position capture ... 113
- Adding comments ... 62
- Angle functions ... 277
- Approach contour ... 106
- ASCII files ... 63
- Automatic cutting data calculations ... 76, 94
- Automatic tool measurement ... 76
- Auxiliary axes ... 31

**B**

- Back boring ... 171
- Blank definition ... 55
- Blocks
  - Changing ... 58
  - Deleting ... 58
  - Inserting ... 58
- Bolt hole circle ... 204
- Boring ... 168
- Buffer battery, exchanging ... 362

**C**

- Calculating the machining time ... 310
- Chamfer ... 113
- Circle calculations ... 278
- Circle center CC ... 114
- Circular arc ... 115, 116, 117, 123, 124

**C**

- Circular pocket
  - Finishing ... 193
  - Roughing ... 191
- Circular stud finishing ... 194
- Code number ... 321
- Constant contouring speed :M90 148
- Contour cycles. See SL cycles
- Contour train ... 218
- Conversational dialog ... 57
- Conversational programming ... 57
- Converting FK program to HEIDENHAIN conversational format 40
- Coordinate transformation
  - Overview ... 239
- Copying program blocks ... 59
- Copying program sections ... 59
- Corner rounding ... 118
- Cutting data calculation ... 94
- Cutting data table ... 94
  - Data transfer ... 99
- Cycle
  - Calling ... 163
  - Defining ... 162
  - Groups ... 162
- Cylinder ... 300
- Cylinder surface ... 220, 222

**D**

- Data backup ... 35
- Data interface
  - Assignment ... 323
  - Connector layout ... 355
  - Setting up ... 322
- Data transfer speed ... 322
- Data transfer software ... 324
- Datum selection ... 34
- Datum setting ... 20
  - during program run ... 291
  - without a 3-D touch probe ... 20

**D**

- Datum shift
    - With datum tables ... 241
    - Withing the program ... 240
  - Depart contour ... 106
  - Digitized data
    - Execution ... 232
  - Directory ... 42
    - Copying ... 47
    - Creating ... 46
  - Drilling ... 166, 169
  - Drilling cycles ... 164
  - Dwell time ... 255
- E**
- Ellipse ... 298
  - Error messages ... 67
    - HELP for ... 67
    - Output ... 282
  - Ethernet interface
    - Configuration ... 328
    - Connecting and disconnecting network drives 54
    - Connection possibilities ... 327

**F**

- Feed rate ... 19
  - Changing ... 20
  - For rotary axes: M116 ... 154
- Feed rate factor ... 151
- Feed rate factor for plunging: M103 ... 151
- Feed rate in micrometer/spindle revolution ... 151

**F**

- File management
  - Calling ... 36, 44
  - Configuration via MOD ... 333
  - Copying files ... 37, 47
  - Copying table ... 47
  - Deleting files ... 37, 48
  - Directory
    - Copying ... 47
    - Creating ... 46
  - Extended ... 42
    - Overview ... 43
  - File name ... 35
  - File type ... 35
  - For external data transfer ... 38, 51
  - Marking files ... 49
  - Overwriting files ... 53
  - Protecting files ... 41, 50
  - Renaming files ... 40, 49
  - Selecting files ... 36, 46
  - Standard ... 36
- File status ... 36, 44
- FK programming ... 128
  - Auxiliary points ... 132
  - Circular arcs ... 130
  - Closed contours ... 135
  - Dialog initiation ... 129
  - FK program, converting ... 135
  - Fundamentals ... 128
  - Graphics ... 128
  - Relative datums ... 133
  - Straight line ... 130
- Floor finishing ... 217
- FN xx. See Q Parameter Programming
- Full circle ... 115
- Fundamentals 30

**G**

- Graphical simulation ... 310
- Graphics
  - Detail magnification ... 61
  - During programming ... 60
- Graphics
  - Detail enlargement ... 308
  - Views ... 306

**H**

- Handwheel positioning, superimposing ... 153
- Hard disk ... 35
- Helical finish milling ... 175
- Helix ... 124
- Helix interpolation ... 124
- HELP files
  - Showing ... 337
- Help for error messages ... 67
- Hole patterns
  - On Circles ... 204
  - On lines ... 205
  - Overview ... 203

**I**

- Indexed tools ... 79
- Interrupting machining ... 314

**K**

- Keyboard ... 5

**L**

- Laser cutting, Miscellaneous functions ... 160
- L-block generation 336
- Look ahead ... 152

**M**

- M functions. See Miscellaneous functions
- Machine parameters
  - For 3-D touch probes ... 342
  - For external data transfer ... 341
  - For TNC displays and TNC editor 345
- Machine-referenced coordinates: M91/M92 145
- Main axes ... 31
- Mid-program startup ... 317
- Mirroring ... 244
- Miscellaneous functions ... 144
  - Entering ... 144
  - For contouring behavior ... 148
  - For coordinate data ... 145
  - For laser cutting machines ... 160
  - For program run checking ... 145
  - For rotary axes ... 154
  - For the spindle ... 145
- MOD functions
  - Exiting ... 320
  - Selecting ... 320
- Modes of operation 5
- Moving the machine axes ... 17
  - in jog increments ... 19
  - with electronic handwheel ... 18
  - with machine direction keys ... 17

**N**

- NC and PLC synchronization ... 290, 291
- NC error messages ... 67
- Nesting ... 263
- Network connection ... 54
- Network printer ... 54, 330
- Network settings ... 328

**O**

Open contour corners: M98 ... 150  
 Operating times ... 338  
 Option number ... 321

**P**

Pallet table  
     Confirming coordinates ... 68  
     Executing ... 69  
 Parameter programming. See Q parameter programming  
 Parentheses ... 293  
 Part families ... 274  
 Path ... 42  
 Path contours  
     Cartesian coordinates ... 112  
         Circular arc with tangential transition ... 117  
         Circular path around circle center ... 115  
         Circular path with defined radius ... 116  
         Overview ... 112  
         Straight line ... 113  
 Path contours ... 112  
     Polar coordinates ... 122  
         Circular arc with tangential connection ... 124  
         Circular path around pole CC 123  
         Overview ... 122  
         Straight line ... 123  
 Path functions ... 103  
     Fundamentals ... 103  
         Circles and circular arcs ... 104  
         Pre-positioning ... 105  
 Path movements ... 112  
     Free contour programming FK  
     See FK programming  
 Pecking ... 165, 173  
 Pin layout for data interfaces ... 355

**P**

Plan view ... 307  
 PLC and NC synchronizing ... 290, 291  
 Pocket calculator ... 66  
 Polar coordinates  
     Fundamentals ... 32  
     Setting the pole ... 32  
 Positioning  
     In tilted working plane ... 147  
     With manual data input ... 26  
 Probing cycles. See User's Manual "Touch Probe Cycles"  
 Program  
     Editing ... 58  
     Opening ... 56  
     Ordering ... 61  
     Structure ... 55  
 Program call  
     Calling any program as subprogram ... 262  
     Via cycle ... 255  
 Program management. See File Management.  
 Program name See File management: File name  
 Program Run  
     Block skipping ... 318  
     Executing ... 313  
     Interruption ... 314  
     Mid-program startup ... 317  
     Overview ... 313  
     Resuming after an interruption ... 316  
 Program section repeats ... 261  
     Calling ... 262  
     Principle ... 261  
     Programming ... 262  
     Programming notes ... 261  
 Programming graphics ... 60  
 Projection in 3 planes ... 307

**Q**

Q parameter programming ... 272  
     Additional functions ... 281  
     Angle functions ... 277  
     Basic mathematical functions ... 275  
     Circle calculation ... 278  
     Circle calculation ... 278  
     If/then decisions ... 279  
     Programming notes ... 272  
 Q parameters ... 283  
     Checking ... 280  
     Formatted output ... 284  
     Non-formatted output ... 283  
     Pre-assigned ... 296  
     Transferring values to PLC ... 290, 291, 292

**R**

Radius compensation ... 85  
     Entering ... 86  
     Inside corners ... 87  
     Machining corners ... 87  
     Outside corners ... 87  
 Rapid traverse ... 72  
 Read system data ... 286  
 Reaming ... 167  
 Rectangular pocket  
     Finishing ... 188  
     Roughing ... 187  
 Rectangular stud finishing ... 190  
 Reference system ... 31  
 Reference-point traverse ... 16  
 Returning to the contour ... 318  
 Rotary axis ... 154  
     Reducing the display ... 155  
     Shorter-path traverse ... 154  
 Rotation ... 245  
 Rough-out See SL Cycles  
 Round slot milling ... 199  
 Ruled surface ... 236

**S**

- Scaling factor ... 246
- Scaling factor, axis-specific ... 247
- Screen layout 4
- Setting the BAUD RATE ... 322
- Shorter-path traverse of rotary axes: M126 ... 154
- Side finishing ... 217
- SL cycles
  - Contour data ... 213
  - Cycle contour ... 211
  - Floor finishing ... 217
  - Overview ... 209
  - Pilot drilling ... 215
  - Roughing ... 216
  - Side finishing ... 217
  - Superimposed contours ... 211
- Slot milling ... 196
  - Reciprocating ... 197
- Slot milling ... 197
- Software number ... 321
- Sphere ... 302
- Spindle orientation ... 256
- Spindle speed ... 19
  - Changing ... 20
  - Entering ... 20, 72
- Spline interpolation ... 140
  - Block format ... 140
  - Input ranges ... 141
- Status display ... 7
  - Additional ... 8
  - General ... 7
- Straight line ... 113, 123
- Structuring of programs ... 61
- Subprogram ... 260
  - Calling ... 261
  - Operating principle ... 260
  - Programming ... 261
  - Programming notes ... 260
- Switch off ... 16
- Switching between large and small characters ... 63

**T**

- Tapping
  - Rignt tapping ... 180, 181
  - With floating tap holder ... 177, 178
- Test run
  - Executing ... 312
  - Overview ... 311
  - Up to a certain block 312
- Text files
  - Deleting functions ... 64
  - Editing functions ... 63
  - Exiting ... 63
  - Finding text blocks ... 65
  - Opening ... 63
- Thread cutting ... 183
- Tilt working plane ... 21
  - Cycle ... 248
  - Guide ... 251
  - Manual ... 21
- Tilting axes ... 156
- Tilting the working plane ... 21, 248
- TNC 426, TNC 430 ... 2
- TNCremo ... 324
- Tool change ... 83
  - Automatic ... 83
- Tool compensation
  - Length ... 84
  - Radius ... 85
  - Three-dimensional ... 88
- Tool data
  - Calling ... 82
  - Delta values ... 74
  - Entering in the program ... 74
  - Entering into tables 75
  - Indexing ... 79
- Tool length ... 73
- Tool materials ... 96
- Tool measurement ... 76
- Tool movements
  - Programming ... 57

**T**

- Tool name ... 73
- Tool number ... 73
  - Indexing ... 79
- Tool pocket table ... 80
- Tool radius ... 74
- Tool table
  - Editing ... 78
  - Editing functions ... 79
  - Exiting ... 78
  - Input possibilities ... 75
- Tool type, selecting ... 76
- Trigonometry ... 277

**U**

- Unit of measurement, selecting ... 56
- Universal drilling ... 169
- User parameters ... 333
  - General
    - For 3-D touch probes and digitizing ... 342
    - For external data transfer ... 341
    - For machining and program run ... 351
    - For TNC displays, TNC editor ... 346
  - Machine-specific ... 333

**V**

- Visual display unit 3

**W**

- WMAT.TAB ... 95
- Working space monitoring ... 312, 333
- Workpiece material, defining ... 95, 96
- Workpiece positions
  - Absolute ... 33
  - Incremental ... 33
  - Relative ... 33





M	Effect of M function	Effective at block -	start	end	page
M00	Stop program run/spindle STOP/coolant OFF			■	145
M02	Stop program/Spindle STOP/Coolant OFF/Clear status display (depending on machine parameter)/Go to block 1			■	145
M03	Spindle ON clockwise		■		
M04	Spindle ON counterclockwise		■		
M05	Spindle STOP			■	145
M06	Tool change/Stop program run (depending on machine parameter)/Spindle STOP			■	145
M08	Coolant ON		■		
M09	Coolant OFF			■	145
M13	Spindle ON clockwise/coolant ON		■		
M14	Spindle ON counterclockwise/Coolant ON		■		145
M30	Same function as M02			■	145
M89	Vacant miscellaneous function <b>or</b> Cycle call, modally effective (depending on machine parameter)		■		
				■	163
M90	Only in lag mode: Constant contouring speed at corners			■	148
M91	Within the positioning block: Coordinates are referenced to machine datum		■		145
M92	Within the positioning block: Coordinates are referenced to position defined by machine tool builder, such as tool change position		■		145
M94	Reduce display of rotary axis to value under 360°		■		155
M97	Machine small contour steps			■	149
M98	Machine open contours completely			■	150
M99	Blockwise cycle call			■	163
M101	Automatic tool change with replacement tool if maximum tool life has expired		■		
M102	Reset M101			■	83
M103	Reduce feed rate during plunging to factor F (percentage)		■		151
M104	Reactivate the datum as last defined		■		68
M105	Machining with second kv factor		■		
M106	Machining with first kv factor		■		352
M107	Suppress error message for replacement tools		■		
M108	Reset M107			■	83
M109	Constant contouring speed at tool cutting edge (increase and decrease feed rate)		■		
M110	Constant contouring speed at tool cutting edge (feed rate decrease only)		■		
M111	Reset M109/M110			■	152
M114	Automatic compensation of machine geometry when working with tilted axes:				
M115	Reset M114			■	156
M116	Feed rate for angular axes in mm/min		■		
M117	Reset M116			■	154
M118	Superimpose handwheel positioning during program run		■		153
M120	Pre-calculate radius-compensated contour (LOOK AHEAD)		■		152
M126	Shorter-path traverse of rotary axes		■		
M127	Reset M126			■	154
M128	Maintain the position of the tool tip when positioning with tilted axes (TCPM)		■		
M129	Reset M128			■	155
M130	Moving to position in an untilted coordinate system with a tilted working plane		■		147
M134	Exact stop at nontangential contour transitions when positioning with rotary axes		■		
M135	Reset M134			■	159
M136	Feed rate F in micrometers per spindle revolution		■		
M137	Reset M136			■	151
M138	Select tilting axes		■		159
M200	Laser cutting: Output programmed voltage directly		■		
M201	Laser cutting: Output voltage as a function of distance		■		
M202	Laser cutting: Output voltage as a function of speed		■		
M203	Laser cutting: Output voltage as a function of time (ramp)		■		
M204	Laser cutting: Output voltage as a function of time (pulse)		■		160

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