

## SINUMERIK

### SINUMERIK 840D sl / 828D Fundamentals

#### Programming Manual

Valid for

Controllers  
SINUMERIK 840D sl / 840DE sl  
SINUMERIK 828D

Software  
CNC software

Version  
4.7 SP1

|                                          |    |
|------------------------------------------|----|
| Preface                                  |    |
| Fundamental safety instructions          | 1  |
| Fundamental Geometrical Principles       | 2  |
| Fundamental Principles of NC Programming | 3  |
| Creating an NC program                   | 4  |
| Tool change                              | 5  |
| Tool offsets                             | 6  |
| Spindle motion                           | 7  |
| Feed control                             | 8  |
| Geometry settings                        | 9  |
| Motion commands                          | 10 |
| Tool radius compensation                 | 11 |
| Path action                              | 12 |
| Coordinate transformations (frames)      | 13 |
| Auxiliary function outputs               | 14 |
| Supplementary commands                   | 15 |
| Other information                        | 16 |
| Tables                                   | 17 |
| Appendix                                 | A  |

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

|                                                                                                 |
|-------------------------------------------------------------------------------------------------|
|  <b>DANGER</b> |
|-------------------------------------------------------------------------------------------------|

|                                                                                                        |
|--------------------------------------------------------------------------------------------------------|
| indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken. |
|--------------------------------------------------------------------------------------------------------|

|                                                                                                  |
|--------------------------------------------------------------------------------------------------|
|  <b>WARNING</b> |
|--------------------------------------------------------------------------------------------------|

|                                                                                                       |
|-------------------------------------------------------------------------------------------------------|
| indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken. |
|-------------------------------------------------------------------------------------------------------|

|                                                                                                  |
|--------------------------------------------------------------------------------------------------|
|  <b>CAUTION</b> |
|--------------------------------------------------------------------------------------------------|

|                                                                                      |
|--------------------------------------------------------------------------------------|
| indicates that minor personal injury can result if proper precautions are not taken. |
|--------------------------------------------------------------------------------------|

|               |
|---------------|
| <b>NOTICE</b> |
|---------------|

|                                                                                |
|--------------------------------------------------------------------------------|
| indicates that property damage can result if proper precautions are not taken. |
|--------------------------------------------------------------------------------|

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

|                                                                                                    |
|----------------------------------------------------------------------------------------------------|
|  <b>WARNING</b> |
|----------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## SINUMERIK documentation

The SINUMERIK documentation is organized in the following categories:

- General documentation
- User documentation
- Manufacturer/service documentation

## Additional information

You can find information on the following topics at [www.siemens.com/motioncontrol/docu](http://www.siemens.com/motioncontrol/docu):

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

Please send any questions about the technical documentation (e.g. suggestions for improvement, corrections) to the following address:

[docu.motioncontrol@siemens.com](mailto:docu.motioncontrol@siemens.com)

## My Documentation Manager (MDM)

Under the following link you will find information to individually compile OEM-specific machine documentation based on the Siemens content:

[www.siemens.com/mdm](http://www.siemens.com/mdm)

## Training

For information about the range of training courses, refer under:

- [www.siemens.com/sitrain](http://www.siemens.com/sitrain)  
SITRAIN - Siemens training for products, systems and solutions in automation technology
- [www.siemens.com/sinutrain](http://www.siemens.com/sinutrain)  
SinuTrain - training software for SINUMERIK

## FAQs

You can find Frequently Asked Questions in the Service&Support pages under Product Support. <http://support.automation.siemens.com>

## **SINUMERIK**

You can find information on SINUMERIK under the following link:

[www.siemens.com/sinumerik](http://www.siemens.com/sinumerik)

## **Target group**

This publication is intended for:

- Programmers
- Project engineers

## **Benefits**

With the programming manual, the target group can develop, write, test, and debug programs and software user interfaces.

## **Standard scope**

This Programming Manual describes the functionality of the standard scope. Extensions or changes made by the machine tool manufacturer are documented by the machine tool manufacturer.

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

Furthermore, for the sake of clarity, this documentation does not contain all detailed information about all product types and cannot cover every conceivable case of installation, operation or maintenance.

## **Technical Support**

You will find telephone numbers for other countries for technical support in the Internet under <http://www.siemens.com/automation/service&support>

## Information on structure and contents

### Programming Manual, Fundamentals/Job Planning

The description of the NC programming is divided into two manuals:

1. **Fundamentals**

This "Fundamentals" Programming Manual is intended for use by skilled machine operators with the appropriate expertise in drilling, milling and turning operations. Simple programming examples are used to explain the commands and statements which are also defined according to DIN 66025.

2. **Job planning**

The Programming Manual "Advanced" is intended for use by technicians with in-depth, comprehensive programming knowledge. By virtue of a special programming language, the SINUMERIK control enables the user to program complex workpiece programs (e.g. for free-form surfaces, channel coordination, ...) and makes programming of complicated operations easy for technologists.

### Availability of the described NC language elements

All NC language elements described in the manual are available for the SINUMERIK 840D sl. The availability regarding SINUMERIK 828D should be taken from Table "Operations: Availability for SINUMERIK 828D (Page 419)".



# Table of contents

|          |                                                                        |           |
|----------|------------------------------------------------------------------------|-----------|
|          | <b>Preface.....</b>                                                    | <b>3</b>  |
| <b>1</b> | <b>Fundamental safety instructions.....</b>                            | <b>13</b> |
| 1.1      | General safety instructions.....                                       | 13        |
| 1.2      | Industrial security.....                                               | 13        |
| <b>2</b> | <b>Fundamental Geometrical Principles.....</b>                         | <b>15</b> |
| 2.1      | Workpiece positions.....                                               | 15        |
| 2.1.1    | Workpiece coordinate systems.....                                      | 15        |
| 2.1.2    | Cartesian coordinates.....                                             | 15        |
| 2.1.3    | Polar coordinates.....                                                 | 17        |
| 2.1.4    | Absolute dimensions.....                                               | 18        |
| 2.1.5    | Incremental dimension.....                                             | 20        |
| 2.2      | Working planes.....                                                    | 21        |
| 2.3      | Zero points and reference points.....                                  | 22        |
| 2.4      | Coordinate systems.....                                                | 24        |
| 2.4.1    | Machine coordinate system (MCS).....                                   | 24        |
| 2.4.2    | Basic coordinate system (BCS).....                                     | 26        |
| 2.4.3    | Basic zero system (BZS).....                                           | 28        |
| 2.4.4    | Settable zero system (SZS).....                                        | 29        |
| 2.4.5    | Workpiece coordinate system (WCS).....                                 | 30        |
| 2.4.6    | What is the relationship between the various coordinate systems? ..... | 31        |
| <b>3</b> | <b>Fundamental Principles of NC Programming.....</b>                   | <b>33</b> |
| 3.1      | Name of an NC program.....                                             | 33        |
| 3.2      | Structure and contents of an NC program.....                           | 34        |
| 3.2.1    | Blocks and block components.....                                       | 34        |
| 3.2.2    | Block rules.....                                                       | 37        |
| 3.2.3    | Value assignments.....                                                 | 38        |
| 3.2.4    | Comments.....                                                          | 38        |
| 3.2.5    | Skipping blocks.....                                                   | 39        |
| <b>4</b> | <b>Creating an NC program.....</b>                                     | <b>41</b> |
| 4.1      | Basic procedure.....                                                   | 41        |
| 4.2      | Available characters.....                                              | 42        |
| 4.3      | Program header.....                                                    | 43        |
| 4.4      | Program examples.....                                                  | 44        |
| 4.4.1    | Example 1: First programming steps.....                                | 44        |
| 4.4.2    | Example 2: NC program for turning.....                                 | 45        |
| 4.4.3    | Example 3: NC program for milling.....                                 | 47        |

|          |                                                                            |           |
|----------|----------------------------------------------------------------------------|-----------|
| <b>5</b> | <b>Tool change.....</b>                                                    | <b>51</b> |
| 5.1      | Tool change without tool management.....                                   | 51        |
| 5.1.1    | Tool change with T command.....                                            | 51        |
| 5.1.2    | Tool change with M6.....                                                   | 52        |
| 5.2      | Tool change with tool management (option).....                             | 53        |
| 5.2.1    | Tool change with T command with active tool management (option).....       | 54        |
| 5.2.2    | Tool change with M6 with active tool management (option).....              | 56        |
| 5.3      | Behavior with faulty T programming.....                                    | 57        |
| <b>6</b> | <b>Tool offsets.....</b>                                                   | <b>59</b> |
| 6.1      | General information about the tool offsets.....                            | 59        |
| 6.2      | Tool length compensation.....                                              | 59        |
| 6.3      | Tool radius compensation.....                                              | 60        |
| 6.4      | Tool compensation memory.....                                              | 61        |
| 6.5      | Tool types.....                                                            | 63        |
| 6.5.1    | General information about the tool types.....                              | 63        |
| 6.5.2    | Milling tools.....                                                         | 63        |
| 6.5.3    | Drills.....                                                                | 65        |
| 6.5.4    | Grinding tools.....                                                        | 66        |
| 6.5.5    | Turning tools.....                                                         | 67        |
| 6.5.6    | Special tools.....                                                         | 69        |
| 6.5.7    | Chaining rule.....                                                         | 70        |
| 6.6      | Tool offset call (D).....                                                  | 70        |
| 6.7      | Change in the tool offset data.....                                        | 72        |
| 6.8      | Programmable tool offset (TOFFL, TOFF, TOFFR).....                         | 73        |
| <b>7</b> | <b>Spindle motion.....</b>                                                 | <b>79</b> |
| 7.1      | Spindle speed (S), spindle direction of rotation (M3, M4, M5).....         | 79        |
| 7.2      | Cutting rate (SVC).....                                                    | 82        |
| 7.3      | Constant cutting rate (G96/G961/G962, G97/G971/G972, G973, LIMS, SCC)..... | 88        |
| 7.4      | Constant grinding wheel peripheral speed (GWPSON, GWPSOF).....             | 93        |
| 7.5      | Programmable spindle speed limitation (G25, G26).....                      | 95        |
| <b>8</b> | <b>Feed control.....</b>                                                   | <b>97</b> |
| 8.1      | Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF).....                        | 97        |
| 8.2      | Traverse positioning axes (POS, POSA, POSP, FA, WAITP, WAITMC).....        | 105       |
| 8.3      | Position-controlled spindle mode (SPCON, SPCOF).....                       | 108       |
| 8.4      | Positioning spindles (SPOS, SPOSA, M19, M70, WAITS).....                   | 109       |
| 8.5      | Feedrate for positioning axes / spindles (FA, FPR, FPRAON, FPRAOF).....    | 114       |
| 8.6      | Programmable feedrate override (OVR, OVRRAP, OVRA).....                    | 117       |
| 8.7      | Programmable acceleration override (ACC) (option).....                     | 118       |



|           |                                                                                                                                |            |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|------------|
| 8.8       | Feedrate with handwheel override (FD, FDA).....                                                                                | 120        |
| 8.9       | Feedrate optimization for curved path sections (CFTCP, CFC, CFIN).....                                                         | 123        |
| 8.10      | Several feedrate values in one block (F, ST, SR, FMA, STA, SRA).....                                                           | 126        |
| 8.11      | Non-modal feedrate (FB).....                                                                                                   | 129        |
| 8.12      | Tooth feedrate (G95 FZ).....                                                                                                   | 130        |
| <b>9</b>  | <b>Geometry settings.....</b>                                                                                                  | <b>137</b> |
| 9.1       | Settable zero offset (G54 to G57, G505 to G599, G53, G500, SUPA, G153).....                                                    | 137        |
| 9.2       | Selection of the working plane (G17/G18/G19).....                                                                              | 139        |
| 9.3       | Dimensions.....                                                                                                                | 142        |
| 9.3.1     | Absolute dimensions (G90, AC).....                                                                                             | 143        |
| 9.3.2     | Incremental dimensions (G91, IC).....                                                                                          | 145        |
| 9.3.3     | Absolute and incremental dimensions for turning and milling (G90/G91).....                                                     | 149        |
| 9.3.4     | Absolute dimensions for rotary axes (DC, ACP, ACN).....                                                                        | 150        |
| 9.3.5     | Inch or metric dimensions (G70/G700, G71/G710).....                                                                            | 152        |
| 9.3.6     | Channel-specific diameter/radius programming (DIAMON, DIAM90, DIAMOF, DIAMCYCOF).....                                          | 155        |
| 9.3.7     | Axis-specific diameter/radius programming (DIAMONA, DIAM90A, DIAMOFA, DIACYCOFA, DIAMCHANA, DIAMCHAN, DAC, DIC, RAC, RIC)..... | 157        |
| 9.4       | Position of workpiece for turning.....                                                                                         | 161        |
| <b>10</b> | <b>Motion commands.....</b>                                                                                                    | <b>163</b> |
| 10.1      | General information about the travel commands.....                                                                             | 163        |
| 10.2      | Travel commands with Cartesian coordinates (G0, G1, G2, G3, X..., Y..., Z...).....                                             | 165        |
| 10.3      | Travel commands with polar coordinates.....                                                                                    | 166        |
| 10.3.1    | Reference point of the polar coordinates (G110, G111, G112).....                                                               | 166        |
| 10.3.2    | Travel commands with polar coordinates (G0, G1, G2, G3, AP, RP).....                                                           | 168        |
| 10.4      | Rapid traverse motion (G0, RTLION, RTLIOF).....                                                                                | 172        |
| 10.5      | Linear interpolation (G1).....                                                                                                 | 176        |
| 10.6      | Circular interpolation.....                                                                                                    | 178        |
| 10.6.1    | Circular interpolation types (G2/G3, ...).....                                                                                 | 178        |
| 10.6.2    | Circular interpolation with center point and end point (G2/G3, X... Y... Z..., I... J... K...).....                            | 182        |
| 10.6.3    | Circular interpolation with radius and end point (G2/G3, X... Y... Z..., CR).....                                              | 185        |
| 10.6.4    | Circular interpolation with opening angle and center point (G2/G3, X... Y... Z.../ I... J... K..., AR).....                    | 187        |
| 10.6.5    | Circular interpolation with polar coordinates (G2/G3, AP, RP).....                                                             | 189        |
| 10.6.6    | Circular interpolation with intermediate point and end point (CIP, X... Y... Z..., I1... J1... K1...).....                     | 191        |
| 10.6.7    | Circular interpolation with tangential transition (CT, X... Y... Z...).....                                                    | 193        |
| 10.7      | Helical interpolation (G2/G3, TURN).....                                                                                       | 197        |
| 10.8      | Involute interpolation (INVCW, INVCCW).....                                                                                    | 199        |
| 10.9      | Contour definitions.....                                                                                                       | 204        |
| 10.9.1    | Contour definition programming.....                                                                                            | 204        |
| 10.9.2    | Contour definitions: One straight line.....                                                                                    | 205        |

|           |                                                                                                                              |            |
|-----------|------------------------------------------------------------------------------------------------------------------------------|------------|
| 10.9.3    | Contour definitions: Two straight lines.....                                                                                 | 207        |
| 10.9.4    | Contour definitions: Three straight lines.....                                                                               | 210        |
| 10.9.5    | Contour definitions: End point programming with angle.....                                                                   | 213        |
| 10.10     | Thread cutting.....                                                                                                          | 214        |
| 10.10.1   | Thread cutting with constant lead (G33, SF).....                                                                             | 214        |
| 10.10.2   | Programmed run-in and run-out path (DITS, DITE):.....                                                                        | 221        |
| 10.10.3   | Thread cutting with increasing or decreasing lead (G34, G35).....                                                            | 223        |
| 10.10.4   | Fast retraction during thread cutting (LFON, LFOF, DILF, ALF, LFTXT, LFWP, LFPOS, POLF, POLFMASK, POLFMLIN).....             | 224        |
| 10.10.5   | Convex thread (G335, G336).....                                                                                              | 228        |
| 10.11     | Tapping.....                                                                                                                 | 234        |
| 10.11.1   | Tapping without compensating chuck (G331, G332).....                                                                         | 234        |
| 10.11.2   | Tapping with compensating chuck (G63).....                                                                                   | 238        |
| 10.12     | Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM).....                                                                      | 239        |
| <b>11</b> | <b>Tool radius compensation.....</b>                                                                                         | <b>247</b> |
| 11.1      | Tool radius compensation (G40, G41, G42, OFFN).....                                                                          | 247        |
| 11.2      | Approaching and leaving contour (NORM, KONT, KONTC, KONTT).....                                                              | 256        |
| 11.3      | Compensation at the outside corners (G450, G451, DISC).....                                                                  | 264        |
| 11.4      | Smooth approach and retraction.....                                                                                          | 267        |
| 11.4.1    | Approach and retraction (G140 to G143, G147, G148, G247, G248, G347, G348, G340, G341, DISR, DISCL, DISRP, FAD, PM, PR)..... | 267        |
| 11.4.2    | Approach and retraction with extended retraction strategies (G460, G461, G462).....                                          | 278        |
| 11.5      | Collision detection (CDON, CDOF, CDOF2).....                                                                                 | 281        |
| 11.6      | 2D tool compensation (CUT2D, CUT2DF).....                                                                                    | 284        |
| 11.7      | Keep tool radius compensation constant (CUTCONON, CUTCONOF).....                                                             | 287        |
| 11.8      | Tools with a relevant cutting edge position.....                                                                             | 289        |
| <b>12</b> | <b>Path action.....</b>                                                                                                      | <b>293</b> |
| 12.1      | Exact stop (G60, G9, G601, G602, G603).....                                                                                  | 293        |
| 12.2      | Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS).....                                                 | 295        |
| <b>13</b> | <b>Coordinate transformations (frames).....</b>                                                                              | <b>305</b> |
| 13.1      | Frames.....                                                                                                                  | 305        |
| 13.2      | Frame instructions.....                                                                                                      | 307        |
| 13.3      | Programmable zero offset.....                                                                                                | 310        |
| 13.3.1    | Zero offset (TRANS, ATRANS).....                                                                                             | 310        |
| 13.3.2    | Axial zero offset (G58, G59).....                                                                                            | 314        |
| 13.4      | Programmable rotation (ROT, AROT, RPL).....                                                                                  | 316        |
| 13.5      | Programmable frame rotations with solid angles (ROTS, AROTS, CROTS).....                                                     | 323        |
| 13.6      | Programmable scaling factor (SCALE, ASCALE).....                                                                             | 326        |
| 13.7      | Programmable mirroring (MIRROR, AMIRROR).....                                                                                | 329        |
| 13.8      | Frame generation according to tool orientation (TOFRAME, TOROT, PAROT):.....                                                 | 334        |

|           |                                                                 |            |
|-----------|-----------------------------------------------------------------|------------|
| 13.9      | Deselect frame (G53, G153, SUPA, G500).....                     | 336        |
| 13.10     | Deselecting overlaid movements (DRFOF, CORROF).....             | 337        |
| <b>14</b> | <b>Auxiliary function outputs.....</b>                          | <b>341</b> |
| 14.1      | M functions.....                                                | 344        |
| <b>15</b> | <b>Supplementary commands.....</b>                              | <b>347</b> |
| 15.1      | Output messages (MSG).....                                      | 347        |
| 15.2      | Writing string in OPI variable (WRTPR).....                     | 348        |
| 15.3      | Working area limitation.....                                    | 349        |
| 15.3.1    | Working area limitation in BCS (G25/G26, WALIMON, WALIMOF)..... | 349        |
| 15.3.2    | Working area limitation in WCS/SZS (WALCS0 ... WALCS10).....    | 353        |
| 15.4      | Reference point approach (G74).....                             | 355        |
| 15.5      | Approaching a fixed point (G75).....                            | 356        |
| 15.6      | Travel to fixed stop (FXS, FXST, FXSW).....                     | 361        |
| 15.7      | Dwell time (G4).....                                            | 365        |
| 15.8      | Internal preprocessing stop.....                                | 366        |
| <b>16</b> | <b>Other information.....</b>                                   | <b>369</b> |
| 16.1      | Axes.....                                                       | 369        |
| 16.1.1    | Main axes/Geometry axes.....                                    | 369        |
| 16.1.2    | Special axes.....                                               | 371        |
| 16.1.3    | Main spindle, master spindle.....                               | 371        |
| 16.1.4    | Machine axes.....                                               | 371        |
| 16.1.5    | Channel axes.....                                               | 372        |
| 16.1.6    | Path axes.....                                                  | 372        |
| 16.1.7    | Positioning axes.....                                           | 372        |
| 16.1.8    | Synchronized axes.....                                          | 373        |
| 16.1.9    | Command axes.....                                               | 374        |
| 16.1.10   | PLC axes.....                                                   | 374        |
| 16.1.11   | Link axes.....                                                  | 374        |
| 16.1.12   | Lead link axes.....                                             | 376        |
| 16.2      | From travel command to machine movement.....                    | 378        |
| 16.3      | Path calculation.....                                           | 378        |
| 16.4      | Addresses.....                                                  | 379        |
| 16.5      | Names.....                                                      | 381        |
| 16.6      | Constants.....                                                  | 383        |
| <b>17</b> | <b>Tables.....</b>                                              | <b>385</b> |
| 17.1      | Operations.....                                                 | 385        |
| 17.2      | Operations: Availability for SINUMERIK 828D .....               | 419        |
| 17.3      | Addresses.....                                                  | 444        |
| 17.3.1    | Address letters.....                                            | 444        |
| 17.3.2    | Fixed addresses.....                                            | 445        |

|          |                                                    |            |
|----------|----------------------------------------------------|------------|
| 17.3.3   | Settable addresses.....                            | 449        |
| 17.4     | G commands.....                                    | 454        |
| 17.5     | Predefined procedures.....                         | 474        |
| 17.6     | Predefined procedures in synchronized actions..... | 494        |
| 17.7     | Predefined functions.....                          | 496        |
| 17.8     | Currently set language in the HMI.....             | 508        |
| <b>A</b> | <b>Appendix.....</b>                               | <b>509</b> |
| A.1      | List of abbreviations.....                         | 509        |
| A.2      | Documentation overview.....                        | 518        |
|          | <b>Glossary.....</b>                               | <b>519</b> |
|          | <b>Index.....</b>                                  | <b>541</b> |

# Fundamental safety instructions

## 1.1 General safety instructions

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                       |
| <p><b>Risk of death if the safety instructions and remaining risks are not carefully observed</b></p> <p>If the safety instructions and residual risks are not observed in the associated hardware documentation, accidents involving severe injuries or death can occur.</p> <ul style="list-style-type: none"> <li>• Observe the safety instructions given in the hardware documentation.</li> <li>• Consider the residual risks for the risk evaluation.</li> </ul> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                             |
| <p><b>Danger to life or malfunctions of the machine as a result of incorrect or changed parameterization</b></p> <p>As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.</p> <ul style="list-style-type: none"> <li>• Protect the parameterization (parameter assignments) against unauthorized access.</li> <li>• Respond to possible malfunctions by applying suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).</li> </ul> |

## 1.2 Industrial security

### Note

#### Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. For more information about industrial security, visit Hotspot-Text (<http://www.siemens.com/industrialsecurity>).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. For more information, visit Hotspot-Text (<http://support.automation.siemens.com>).



**WARNING**

**Danger as a result of unsafe operating states resulting from software manipulation**

Software manipulation (e.g. by viruses, Trojan horses, malware, worms) can cause unsafe operating states to develop in your installation which can result in death, severe injuries and/or material damage.

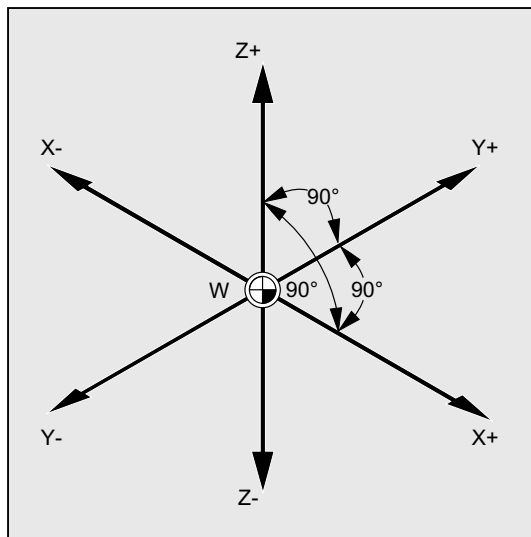
- Keep the software up to date.  
You will find relevant information and newsletters at this address (<http://support.automation.siemens.com>).
- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.  
You will find further information at this address (<http://www.siemens.com/industrialsecurity>).
- Make sure that you include all installed products into the holistic industrial security concept.

## Fundamental Geometrical Principles

### 2.1 Workpiece positions

#### 2.1.1 Workpiece coordinate systems

In order that the machine or the control can work with the positions specified in the NC program, these position specifications have to be made in a reference system that can be transferred to the directions of motion of the machine axes. Cartesian (i.e. clockwise, perpendicular) coordinate systems in accordance with DIN 66217 are used as workpiece coordinate system for machine tools.



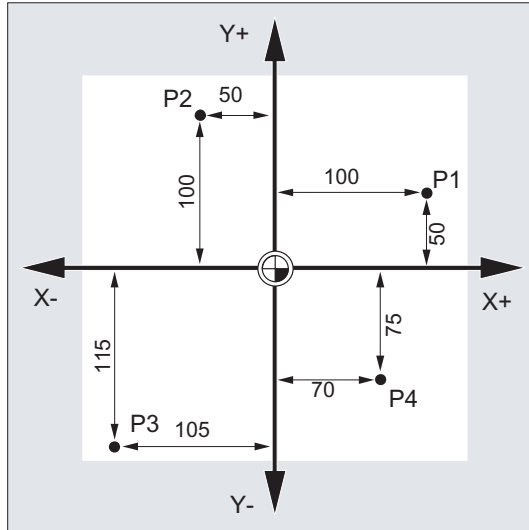
The workpiece zero (W) is the origin of the workpiece coordinate system.

#### 2.1.2 Cartesian coordinates

The axes in the coordinate system are assigned dimensions. In this way, it is possible to clearly describe every point in the coordinate system and therefore every workpiece position through the direction (X, Y and Z) and three numerical values. The workpiece zero always has the coordinates X0, Y0, and Z0.

### Position specifications in the form of Cartesian coordinates

To simplify things, we will only consider one plane of the coordinate system in the following example, the X/Y plane:

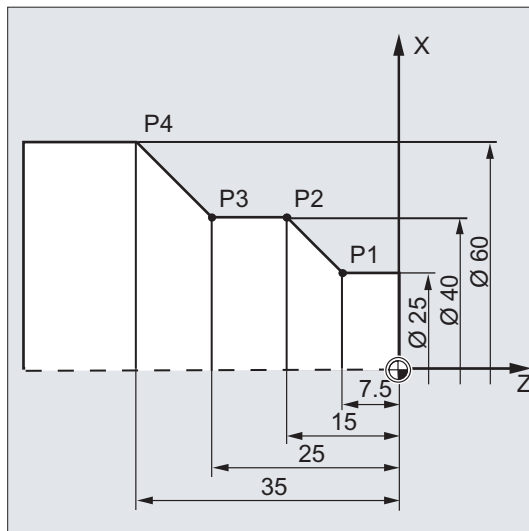


Points P1 to P4 have the following coordinates:

| Position | Coordinates |
|----------|-------------|
| P1       | X100 Y50    |
| P2       | X-50 Y100   |
| P3       | X-105 Y-115 |
| P4       | X70 Y-75    |

### Example: Workpiece positions for turning

With lathes, one plane is sufficient to describe the contour:



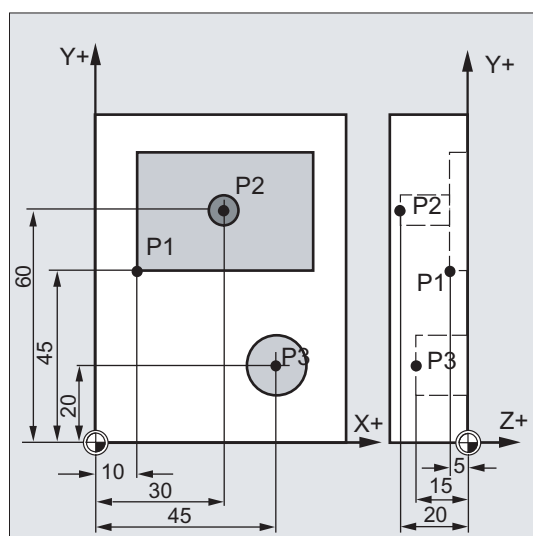


Points P1 to P4 have the following coordinates:

| Position | Coordinates |
|----------|-------------|
| P1       | X25 Z-7.5   |
| P2       | X40 Z-15    |
| P3       | X40 Z-25    |
| P4       | X60 Z-35    |

### Example: Workpiece positions for milling

For milling, the feed depth must also be described, i.e. the third coordinate (in this case Z) must also be assigned a numerical value.



Points P1 to P3 have the following coordinates:

| Position | Coordinates  |
|----------|--------------|
| P1       | X10 Y45 Z-5  |
| P2       | X30 Y60 Z-20 |
| P3       | X45 Y20 Z-15 |

### 2.1.3 Polar coordinates

Polar coordinates can be used instead of Cartesian coordinates to describe workpiece positions. This is useful when a workpiece or part of a workpiece has been dimensioned with radius and angle. The point from which the dimensioning starts is called the "pole".

#### Position specifications in the form of polar coordinates

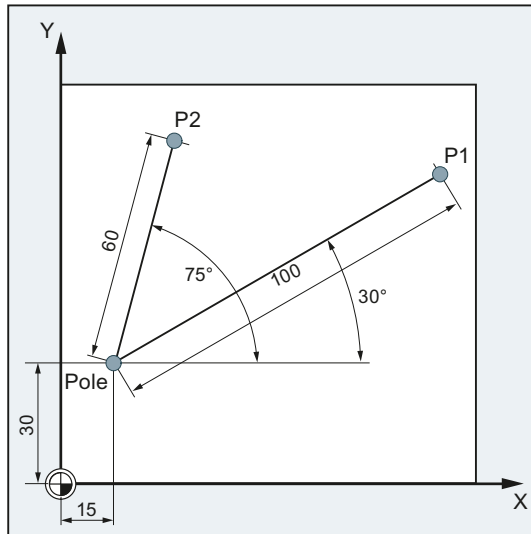
Polar coordinates are made up of the **polar radius** and the **polar angle**.

The polar radius is the distance between the pole and the position.

## 2.1 Workpiece positions

The polar angle is the angle between the polar radius and the horizontal axis of the working plane. Negative polar angles are in the clockwise direction, positive polar angles in the counterclockwise direction.

### Example



Points P1 and P2 can then be described – with reference to the pole – as follows:

| Position                            | Polar coordinates |
|-------------------------------------|-------------------|
| P1                                  | RP=100 AP=30      |
| P2                                  | RP=60 AP=75       |
| RP: Polar radius<br>AP: Polar angle |                   |

### 2.1.4 Absolute dimensions

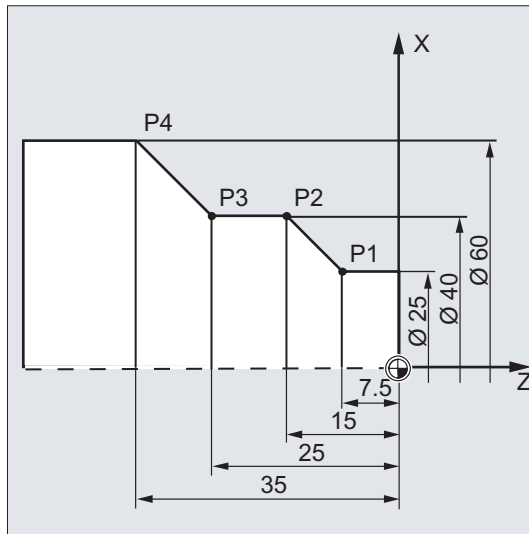
#### Position specifications in absolute dimensions

With absolute dimensions, all the position specifications refer to the currently valid zero point.

Applied to tool movement this means:

**the position, to which the tool is to travel.**

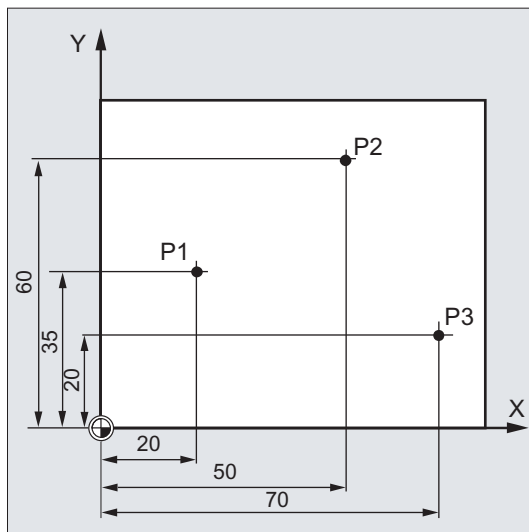
### Example: Turning



In absolute dimensions, the following position specifications result for points P1 to P4:

| Position | Position specification in absolute dimensions |
|----------|-----------------------------------------------|
| P1       | X25 Z-7.5                                     |
| P2       | X40 Z-15                                      |
| P3       | X40 Z-25                                      |
| P4       | X60 Z-35                                      |

### Example: Milling



## 2.1 Workpiece positions

In absolute dimensions, the following position specifications result for points P1 to P3:

| Position | Position specification in absolute dimensions |
|----------|-----------------------------------------------|
| P1       | X20 Y35                                       |
| P2       | X50 Y60                                       |
| P3       | X70 Y20                                       |

### 2.1.5 Incremental dimension

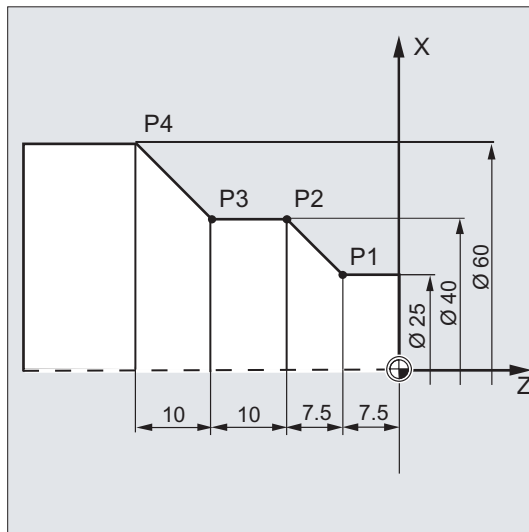
#### Position specifications in incremental dimensions

In production drawings, the dimensions often do not refer to a zero point, but rather to another workpiece point. So that these dimensions do not have to be converted, they can be specified in incremental dimensions. In this method of dimensional notation, a position specification refers to the previous point.

Applied to tool movement this means:

**The incremental dimensions describe the distance the tool is to travel.**

#### Example: Turning



In incremental dimensions, the following position specifications result for points P2 to P4:

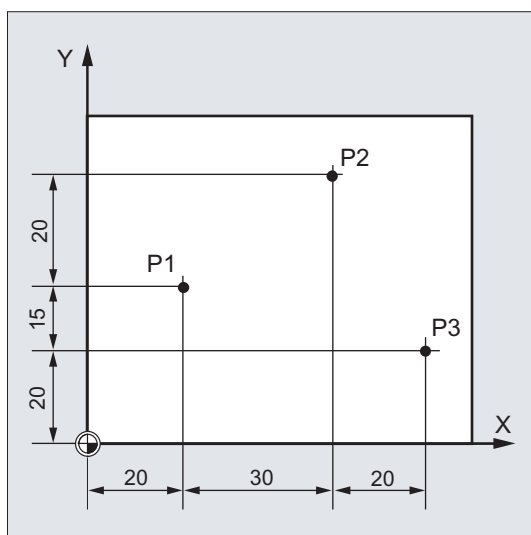
| Position | Position specification in incremental dimensions | The specification refers to: |
|----------|--------------------------------------------------|------------------------------|
| P2       | X15 Z-7.5                                        | P1                           |
| P3       | Z-10                                             | P2                           |
| P4       | X20 Z-10                                         | P3                           |

**Note**

With `DIAMOF` or `DIAM90` active, the set distance in incremental dimensions (`G91`) is programmed as a radius dimension.

**Example: Milling**

The position specifications for points P1 to P3 in incremental dimensions are:



In incremental dimensions, the following position specifications result for points P1 to P3:

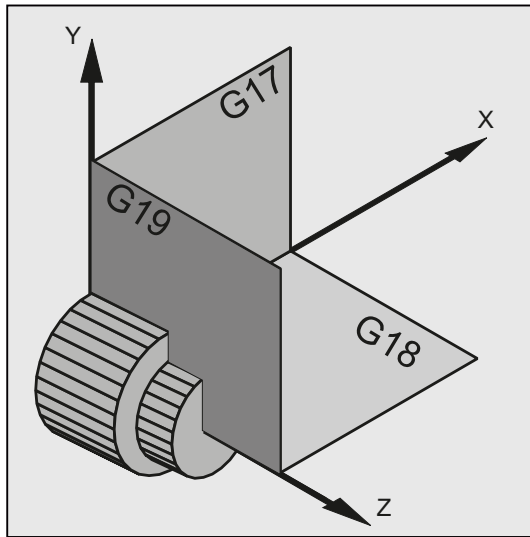
| Position | Position specification in incremental dimensions | The specification refers to: |
|----------|--------------------------------------------------|------------------------------|
| P1       | X20 Y35                                          | Zero point                   |
| P2       | X30 Y20                                          | P1                           |
| P3       | X20 Y -35                                        | P2                           |

## 2.2 Working planes

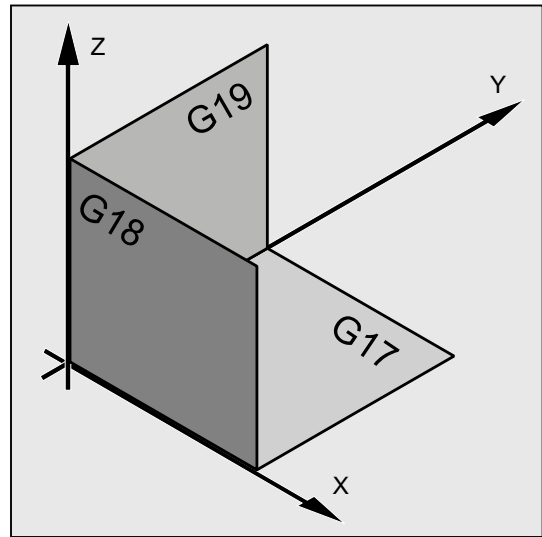
An NC program requires information about the machining plane, because only then can the control, for example, correct the tool correction values correctly. The specification of the working plane is also required for certain types of circular-path programming and polar coordinates.

The working plane is specified in the base Cartesian workpiece coordinate system with two coordinate axes. The third coordinate axis is perpendicular to this work plane and determines the infeed direction of the tool (e.g. for 2D machining).

## Working planes for turning/milling



Working planes for turning



Working planes for milling

## Activating a work plane

The working planes are activated defined in the NC program with the G commands G17, G18 and G19. The relationship is defined as follows:

| G command | Working plane | Abcissa | Ordinate | Applicate infeed direction |
|-----------|---------------|---------|----------|----------------------------|
| G17       | X/Y           | X       | Y        | Z                          |
| G18       | Z/X           | Z       | X        | Y                          |
| G19       | Y/Z           | Y       | Z        | X                          |

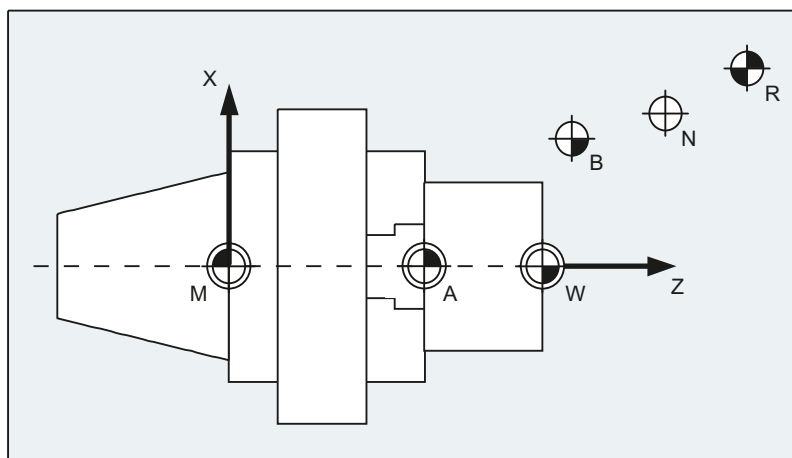
## 2.3 Zero points and reference points

Various zero points and reference points are defined on an NC machine:

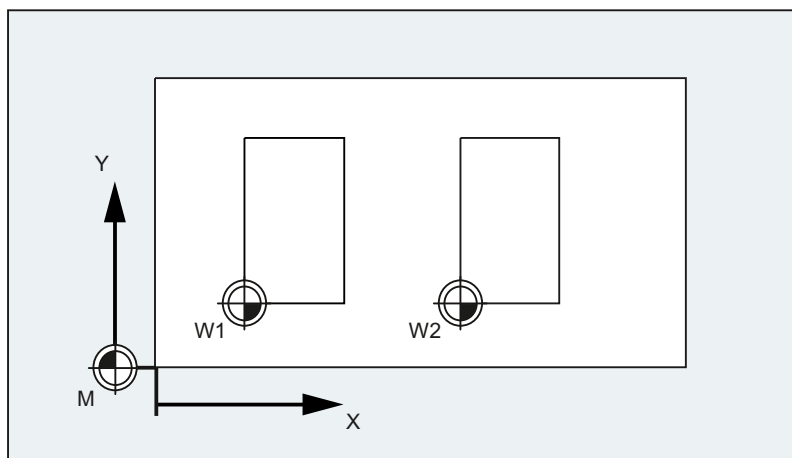
| Zero points |          |                                                                                                                                     |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------------------------|
|             | <b>M</b> | Machine zero<br>The machine zero defines the machine coordinate system (MCS). All other reference points refer to the machine zero. |
|             | <b>W</b> | Workpiece zero = program zero<br>The workpiece zero defines the workpiece coordinate system in relation to the machine zero.        |
|             | <b>A</b> | Blocking point<br>Can be the same as the workpiece zero (only for lathes).                                                          |

| Reference points                                                                  |          |                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <b>R</b> | Reference point<br>Position defined by output cam and measuring system. The distance to the machine zero <b>M</b> must be known so that the axis position at this point can be set exactly to this value. |
|  | <b>B</b> | Starting point<br>Can be defined by the program. The first machining tool starts here.                                                                                                                    |
|  | <b>T</b> | Toolholder reference point<br>Is on the toolholder. By entering the tool lengths, the control calculates the distance between the tool tip and the toolholder reference point.                            |
|  | <b>N</b> | Tool change point                                                                                                                                                                                         |

### Zero points and reference points for turning



### Zero points for milling



## 2.4 Coordinate systems

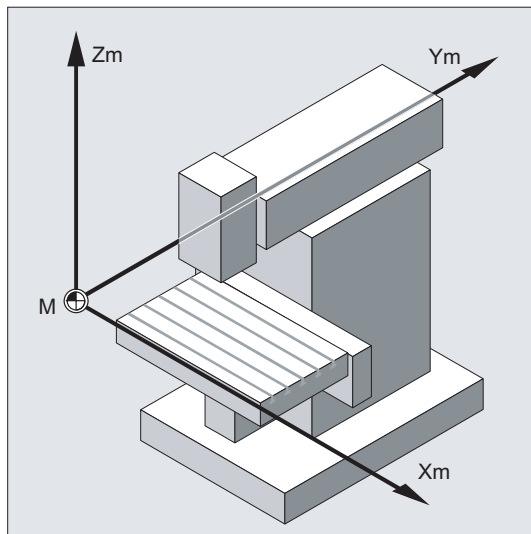
A distinction is made between the following coordinate systems:

- Machine coordinate system (MCS) (Page 24) with the machine zero **M**
- Basic coordinate system (BCS) (Page 26)
- Basic zero system (BZS) (Page 28)
- Settable zero system (SZS) (Page 29)
- Workpiece coordinate system (WCS) (Page 30) with the workpiece zero **W**

### 2.4.1 Machine coordinate system (MCS)

The machine coordinate system comprises all the physically existing machine axes.

Reference points and tool and pallet changing points (fixed machine points) are defined in the machine coordinate system.



If programming is performed directly in the machine coordinate system (possible with some G functions), the physical axes of the machine respond directly. Any workpiece clamping that is present is not taken into account.

#### Note

If there are various machine coordinate systems (e.g. 5-axis transformation), then an internal transformation is used to map the machine kinematics on the coordinate system in which the programming is performed.



### Three-finger rule

The orientation of the coordinate system relative to the machine depends on the machine type. The axis directions follow the so-called "three-finger rule" of the **right** hand (according to DIN 66217).

Seen from in front of the machine, the middle finger of the right hand points in the opposite direction to the infeed of the main spindle. Therefore:

- the thumb points in the +X direction
- the index finger points in the +Y direction
- the middle finger points in the +Z direction

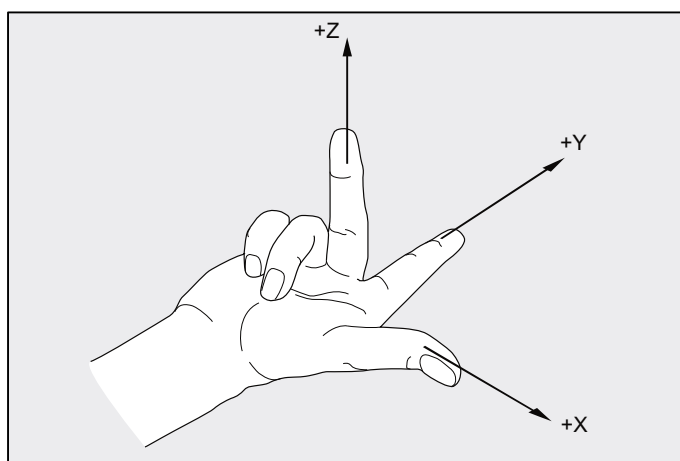
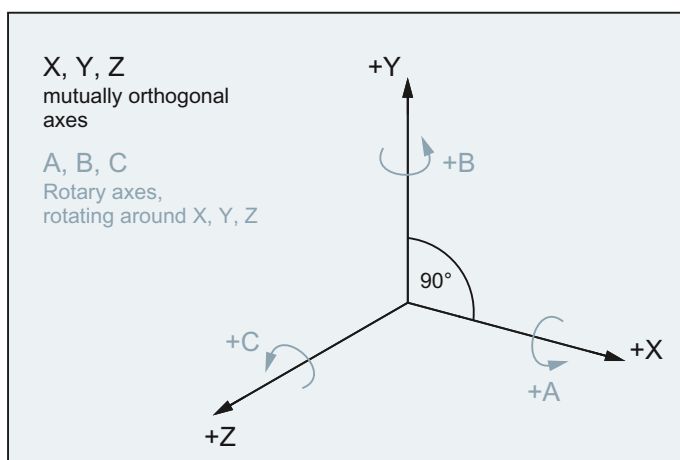


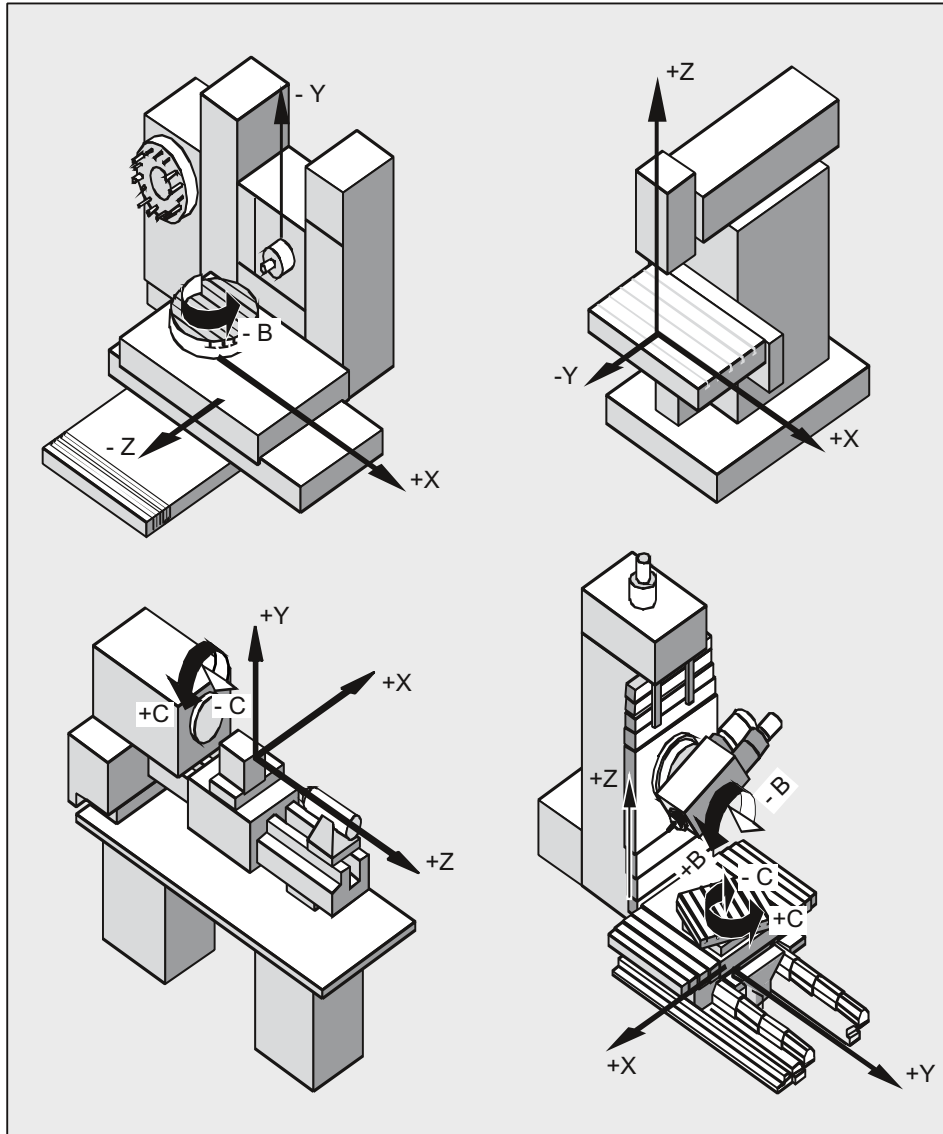
Figure 2-1 "Three-finger rule"

Rotary motions around the coordinate axes X, Y and Z are designated A, B and C. If the rotary motion is in a clockwise direction when looking in the positive direction of the coordinate axis, the direction of rotation is positive:



### Position of the coordinate system in different machine types

The position of the coordinate system resulting from the "three-finger rule" can have a different orientation for different machine types. Here are a few examples:



#### 2.4.2 Basic coordinate system (BCS)

The basic coordinate system (BCS) consists of three mutually perpendicular axes (geometry axes) as well as other special axes, which are not interrelated geometrically.

#### Machine tools without kinematic transformation

BCS and MCS always coincide when the BCS can be mapped onto the MCS without kinematic transformation (e.g. 5-axis transformation, TRANSMIT/TRACYL/TRAANG).

On such machines, machine axes and geometry axes can have the same names.

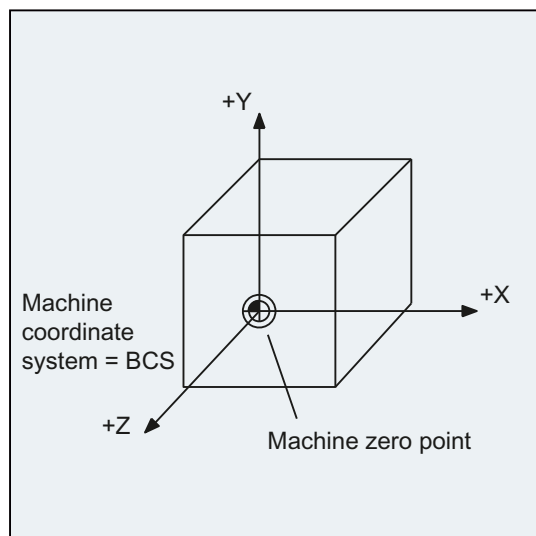


Figure 2-2 MCS = BCS without kinematic transformation

### Machine tools with kinematic transformation

BCS and MCS do not coincide when the BCS is mapped onto the MCS with kinematic transformation (e.g. 5-axis transformation, TRANSMIT/TRACYL/TRAANG).

On such machines the machine axes and geometry axes must have different names.

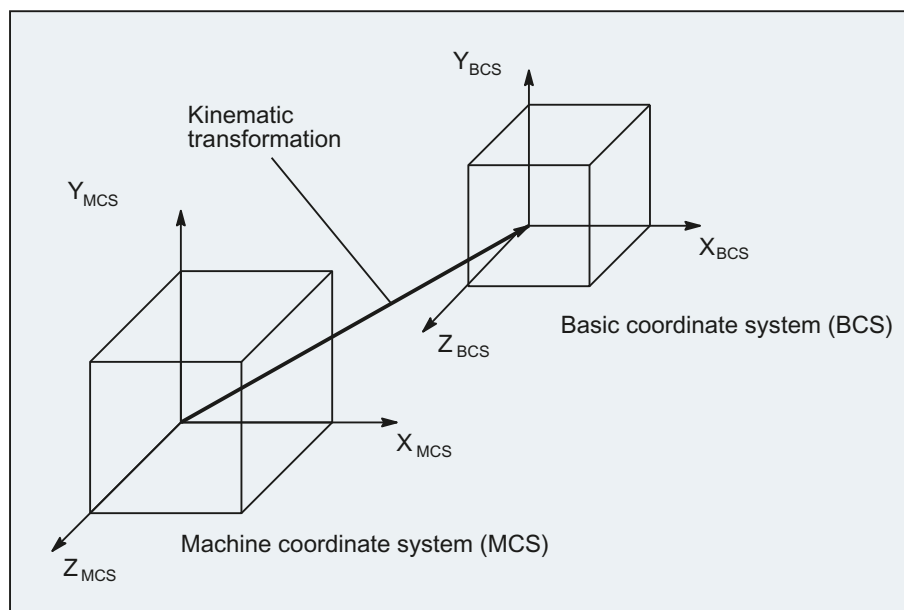


Figure 2-3 Kinematic transformation between the MCS and BCS

## Machine kinematics

The workpiece is always programmed in a two or three dimensional, right-angled coordinate system (WCS). However, such workpieces are being programmed ever more frequently on machine tools with rotary axes or linear axes not perpendicular to one another. Kinematic transformation is used to represent coordinates programmed in the workpiece coordinate system (rectangular) in real machine movements.

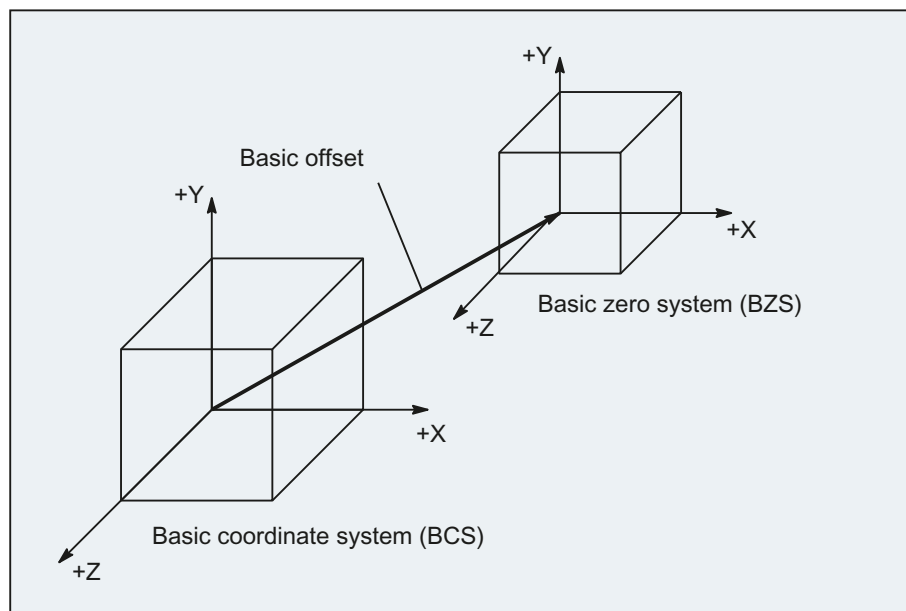
## References

Function Manual Expansion Functions; M1: Kinematic transformation

Function Manual, Special Functions; F2: Multi-axis transformations

### 2.4.3 Basic zero system (BZS)

The basic zero system (BZS) is the basic coordinate system with a basic offset.



## Basic offset

The basic offset describes the coordinate transformation between BCS and BZS. It can be used, for example, to define the palette window zero.

The basic offset comprises:

- External zero offset
- DRF offset
- Overlaid movement

- Chained system frames
- Chained basic frames

## References

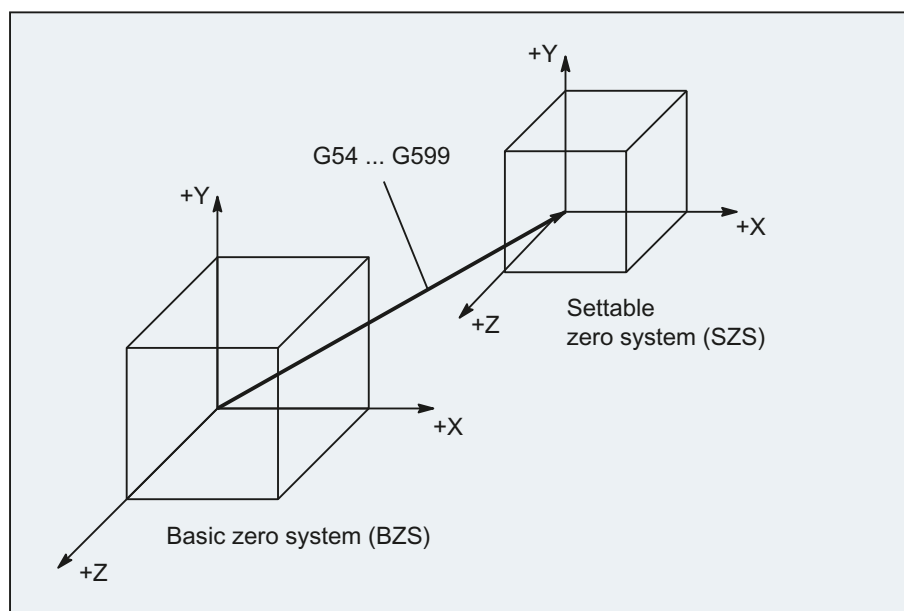
Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2)

### 2.4.4 Settable zero system (SZS)

#### Settable zero offset

The "settable zero system" (SZS) results from the basic zero system (BZS) through the settable zero offset.

Settable zero offsets are activated in the NC program with the G commands G54...G57 and G505...G599 as follows:



If no programmable coordinate transformations (frames) are active, then the "settable zero system" is the workpiece coordinate system (WCS).

#### Programmable coordinate transformations (frames)

Sometimes it is useful or necessary within an NC program, to move the originally selected workpiece coordinate system (or the "settable zero system") to another position and, if required, to rotate it, mirror it and/or scale it. This is performed using programmable coordinate transformations (frames).

See Section: "Coordinate transformations (frames)"

---

**Note**

Programmable coordinate transformations (frames) always refer to the "settable zero system".

### **2.4.5 Workpiece coordinate system (WCS)**

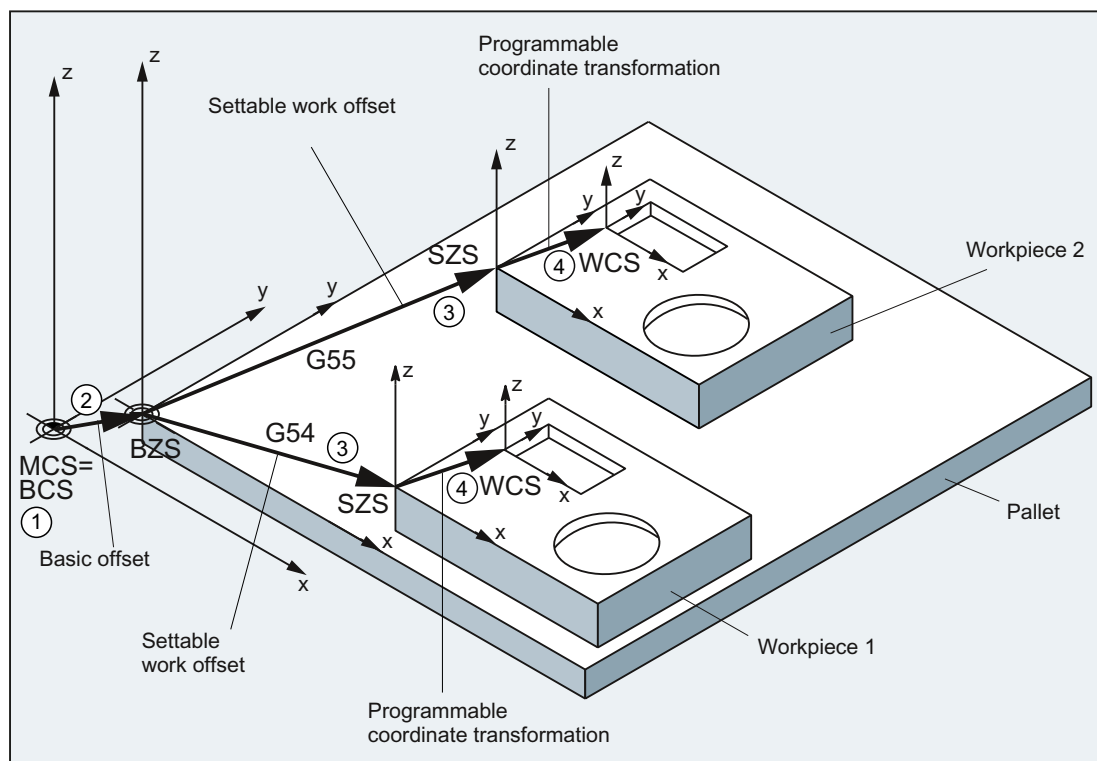
The geometry of a workpiece is described in the workpiece coordinate system (WCS). In other words, the data in the NC program refers to the workpiece coordinate system.

The workpiece coordinate system is always a Cartesian coordinate system and assigned to a specific workpiece.

## 2.4.6

## What is the relationship between the various coordinate systems?

The example in the following figure should help clarify the relationships between the various coordinate systems:



- ① A kinematic transformation is not active, i.e. the machine coordinate system and the basic coordinate system coincide.
- ② The basic zero system (BZS) with the pallet zero result from the basic offset.
- ③ The "settable zero system" (SZS) for Workpiece 1 or Workpiece 2 is specified by the settable zero offset G54 or G55.
- ④ The workpiece coordinate system (WCS) results from programmable coordinate transformation.





# Fundamental Principles of NC Programming

---

**Note**

DIN 66025 is the guideline for NC programming.

---

## 3.1 Name of an NC program

### Rules

Each NC program must be assigned a program name (designation) when it is created. The program name can be chosen freely providing the following rules are observed:

- Permissible characters:
  - Letters: A ... Z, a ... z
  - Numbers: 0 ... 9
  - Underscore: \_
- The first two characters **must** be two letters or an underscore followed by a letter.
- Maximum length: 24 characters

#### Uppercase/lowercase letters

The SINUMERIK NC language does **not** distinguish between uppercase and lowercase letters.

---

**Note**

To avoid problems with Windows applications, avoid using the following program names:

- CON, PRN, AUX, NUL
- COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9
- LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9

Further restrictions, see "Names (Page 381)".

---

### Control-internal extensions

The program name assigned when the program is created is expanded within the control with the addition of a prefix and a suffix.

- Prefix: `_N_`
- Suffix:
  - Main programs: `_MPF`
  - Subprograms: `_SPF`

### Files in punch tape format

Externally created program files that are read via the V.24 interface must be present in punch tape format.

The following additional rules apply for the program name of a file in punch tape format:

- First character: `%`
- Then a four-character file extension: `_xxx`

Examples:

- `%_N_SHAFT123_MPF`
- `%Flange3_MPF`

### References

For detailed information on downloading, creating and storing NC programs, see:  
Turning, milling and grinding operating manual; "Manage programs" section

## 3.2 Structure and contents of an NC program

### 3.2.1 Blocks and block components

#### Blocks

An NC program consists of a sequence of NC blocks. Each block contains the data for the execution of a step in the workpiece machining.

#### Block components

NC blocks consist of the following components:

- Commands (statements) according to DIN 66025
- Elements of the NC high-level language

## Commands according to DIN 66025

The commands according to DIN 66025 consist of an address character and a digit or sequence of digits representing an arithmetic value.

### Address character (address)

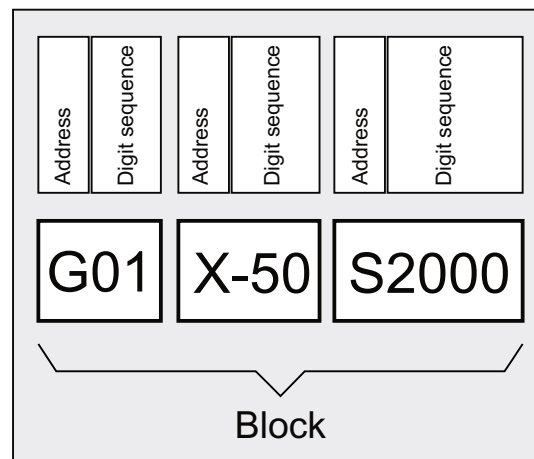
The address character (generally a letter) defines the meaning of the command.

Examples:

| Address character | Meaning                           |
|-------------------|-----------------------------------|
| G                 | G function (preparatory function) |
| X                 | Position data for the X axis      |
| S                 | Spindle speed                     |

### Digit sequence

The digit sequence is the value assigned to the address character. The sequence of digits can contain a sign and decimal point. The sign always appears between the address letter and the sequence of digits. Positive signs (+) and leading zeroes (0) do not have to be specified.



## Elements of the NC high-level language

As the command set according to DIN 66025 is no longer adequate for the programming of complex machining sequences in modern machine tools, it has been extended by the elements of the NC high-level language.

These include, for example:

- Commands of the NC high-level language  
In contrast to the commands according to DIN 66025, the commands of the NC high-level language consist of several address letters, e.g.
  - OVR for speed override
  - SPOS for spindle positioning
- Identifiers (defined names) for:
  - System variables
  - User-defined variables
  - Subprograms
  - Keywords
  - Jump markers
  - Macros

---

**Note**

An identifier must be unique and cannot be used for different objects.

---

- Comparison operators
- Logic operators
- Arithmetic functions
- Check structures

**References:**

Programming Manual, Job Planning; Section: "Flexible NC programming"

## **Effectiveness of commands**

Commands are either modal or non-modal:

- Modal  
Modal commands retain their validity with the programmed value (in all following blocks) until:
  - A new value is programmed under the same command
  - A command is programmed that revokes the effect of the previously valid command
- Non-modal  
Non-modal commands only apply for the block in which they were programmed.

## **End of program**

The last block in the execution sequence contains a special word for the end of program: M2, M17 or M30.

### 3.2.2 Block rules

#### Start of block

NC blocks can be identified at the start of the block by block numbers. These consist of the character "N" and a positive integer, e.g.

N40 . . .

The order of the block numbers is arbitrary, however, block numbers in rising order are recommended.

---

#### Note

Block numbers must be unique within a program in order to achieve an unambiguous result when searching.

---

#### End of block

A block ends with the character LF (LINE FEED = new line).

---

#### Note

The LF character does not have to be written. It is generated automatically by the line change.

---

#### Block length

A block can contain a maximum of **512 characters** (including the comment and end-of-block character LF).

---

#### Note

Three blocks of up to 66 characters each are normally displayed in the current block display on the screen. Comments are also displayed. Messages are displayed in a separate message window.

---

#### Order of the statements

In order to keep the block structure as clear as possible, the statements in a block should be arranged in the following order:

N... G... X... Y... Z... F... S... T... D... M... H...

| Address | Meaning                 |
|---------|-------------------------|
| N       | Address of block number |
| G       | Preparatory function    |
| X, Y, Z | Positional data         |
| F       | Feedrate                |
| S       | Speed                   |

|   |                     |
|---|---------------------|
| T | Tool                |
| D | Tool offset number  |
| M | Additional function |
| H | Auxiliary function  |

#### Note

Certain addresses can be used repeatedly within a block, e.g.

G..., M..., H...

### 3.2.3 Value assignments

Values can be assigned to the addresses. The following rules apply:

- An "=" sign must be inserted between the address and the value if:
  - The address comprises more than one letter.
  - The value includes more than one constant.

The "=" sign can be omitted if the address is a single letter and the value consists of only one constant.

- Signs are permitted.
- Separators are permitted after the address letter.

Examples:

|                    |                                                                               |
|--------------------|-------------------------------------------------------------------------------|
| X10                | Value assignment (10) to address X, "=" not required                          |
| X1=10              | Value assignment (10) to address (X) with numeric extension (1), "=" required |
| X=10*(5+SIN(37.5)) | Value assignment by means of a numeric expression, "=" required               |

#### Note

A numeric extension must always be followed by one of the special characters "=", "(", "[", ")", "]", ",", or an operator, in order to distinguish an address with numeric extension from an address letter with a value.

### 3.2.4 Comments

To make an NC program easier to understand, comments can be added to the NC blocks.

A comment is at the end of a block and is separated from the program section of the NC block by a semicolon (";").

Example 1:

| Program code        | Comment                           |
|---------------------|-----------------------------------|
| N10 G1 F100 X10 Y20 | ; Comment to explain the NC block |

Example 2:

| Program code | Comment                                                        |
|--------------|----------------------------------------------------------------|
| N10          | ; Company G&S, order no. 12A71                                 |
| N20          | ; Program written by H. Smith, Dept. TV 4 on November 21, 1994 |
| N50          | ; Section no. 12, housing for submersible pump type TP23A      |

#### Note

Comments are stored and appear in the current block display when the program is running.

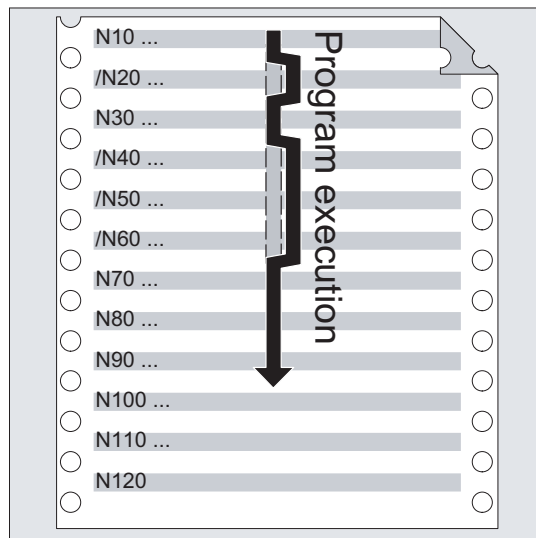
### 3.2.5 Skipping blocks

NC blocks which are not to be executed in every program pass (e.g. execute a trial program run), can be skipped.

#### Programming

Blocks which are to be skipped are marked with an oblique "/" in front of the block number. Several consecutive blocks can also be skipped. The statements in the skipped blocks are not executed; the program continues with the next block which is not skipped.

Example:



| Program code | Comment       |
|--------------|---------------|
| N10          | ; Is executed |
| /N20 ...     | ; Skipped     |
| N30 ...      | ; Is executed |
| /N40 ...     | ; Skipped     |
| N70 ...      | ; Is executed |

## Skip levels

Blocks can be assigned to skip levels (max. 10) which can be activated via the user interface.

Programming is performed by assigning a forward slash, followed by the number of the skip level. Only one skip level can be specified for each block.

Example:

| Program code | Comment                              |
|--------------|--------------------------------------|
| / ...        | ; Block is skipped (1st skip level)  |
| /0 ...       | ; Block is skipped (1st skip level)  |
| /1 N010...   | ; Block is skipped (2nd skip level)  |
| /2 N020...   | ; Block is skipped (3rd skip level)  |
| ...          |                                      |
| /7 N100...   | ; Block is skipped (8th skip level)  |
| /8 N080...   | ; Block is skipped (9th skip level)  |
| /9 N090...   | ; Block is skipped (10th skip level) |

### Note

The number of skip levels that can be used depends on a display machine data item.

### Note

System and user variables can also be used in conditional jumps in order to control program execution.



# Creating an NC program

## 4.1 Basic procedure

The programming of the individual operation steps in the NC language generally represents only a small proportion of the work in the development of an NC program.

Programming of the actual instructions should be preceded by the planning and preparation of the operation steps. The more accurately you plan in advance how the NC program is to be structured and organized, the faster and easier it will be to produce a complete program, which is clear and free of errors. Clearly structured programs are especially advantageous when changes have to be made later.

As every part is not identical, it does not make sense to create every program in the same way. However, the following procedure has shown itself to be suitable in the most cases.

### Procedure

1. **Prepare the workpiece drawing**
  - Define the workpiece zero
  - Draw the coordinate system
  - Calculate any missing coordinates
2. **Define the machining sequence**
  - Which tools are used when and for the machining of which contours?
  - In which order will the individual elements of the workpiece be machined?
  - Which individual elements are repeated (possibly also rotated) and should be stored in a subroutine?
  - Are there contour sections in other part programs or subroutines that could be used for the current workpiece?
  - Where are zero offsets, rotating, mirroring and scaling useful or necessary (frame concept)?

3. **Create a machining plan**  
Define all machining operations step-by-step, e.g.
  - Rapid traverse movements for positioning
  - Tool change
  - Define the machining plane
  - Retraction for checking
  - Switch spindle, coolant on/off
  - Call up tool data
  - Feed
  - Path correction
  - Approaching the contour
  - Retraction from the contour
  - etc.
4. **Compile machining steps in the programming language**
  - Write each individual step as an NC block (or NC blocks).
5. **Combine the individual steps into a program**

## 4.2 Available characters

The following characters are available for writing NC programs:

- Uppercase characters:  
A, B, C, D, E, F, G, H, I, J, K, L, M, N, (O), P, Q, R, S, T, U, V, W, X, Y, Z
- Lowercase characters:  
a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z
- Numbers:  
0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Special characters:  
See the table below.

| Special characters | Meaning                                                                    |
|--------------------|----------------------------------------------------------------------------|
| %                  | Program start character (used only for writing programs on an external PC) |
| (                  | For bracketing parameters or expressions                                   |
| )                  | For bracketing parameters or expressions                                   |
| [                  | For bracketing addresses or indexes                                        |
| ]                  | For bracketing addresses or indexes                                        |
| <                  | Less than                                                                  |
| >                  | Greater than                                                               |
| :                  | Main block, end of label, chain operator                                   |
| =                  | Assignment, part of equation                                               |

| Special characters | Meaning                                                                              |
|--------------------|--------------------------------------------------------------------------------------|
| /                  | Division, block suppression                                                          |
| *                  | Multiplication                                                                       |
| +                  | Addition                                                                             |
| -                  | Subtraction, minus sign                                                              |
| "                  | Double quotation marks, identifier for character string                              |
| '                  | Single quotation marks, identifier for special numerical values: hexadecimal, binary |
| \$                 | System variable identifiers                                                          |
| s_                 | Underscore, belonging to letters                                                     |
| ?                  | Reserved                                                                             |
| !                  | Reserved                                                                             |
| .                  | Decimal point                                                                        |
| ,                  | Comma, parameter separator                                                           |
| ;                  | Comment start                                                                        |
| &                  | Format character, same effect as space character                                     |
| LF                 | End of block                                                                         |
| Tab character      | Separator                                                                            |
| Blank              | Separator (blank)                                                                    |

**Note**

Take care to differentiate between the letter "O" and the digit "0".

**Note**

No distinction is made between uppercase and lowercase characters (exception: tool call).

**Note**

Non-printable special characters are treated like blanks.

## 4.3 Program header

The NC blocks that are placed in front of the actual motion blocks for the machining of the workpiece contour are called the program header.

The program header contains information/statements regarding:

- Tool change
- Tool offsets
- Spindle motion
- Feed control
- Geometry settings (zero offset, selection of the working plane)

## Program header for turning

The following example shows the typical structure of an NC program header for turning:

| Program code                 | Comment                                                                                                                    |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| N10 G0 G153 X200 Z500 T0 D0  | ; Retract toolholder before tool turret is rotated.                                                                        |
| N20 T5                       | ; Swing in tool 5.                                                                                                         |
| N30 D1                       | ; Activate cutting edge data set of the tool.                                                                              |
| N40 G96 S300 LIMS=3000 M4 M8 | ; Constant cutting rate (Vc) = 300 m/min, speed limitation = 3000 rpm, direction of rotation counterclockwise, cooling on. |
| N50 DIAMON                   | ; X axis will be programmed in the diameter.                                                                               |
| N60 G54 G18 G0 X82 Z0.2      | ; Call zero offset and working plane, approach starting position.                                                          |
| ...                          |                                                                                                                            |

## Program header for milling

The following example shows the typical structure of an NC program header for milling:

| Program code                | Comment                                              |
|-----------------------------|------------------------------------------------------|
| N10 T="SF12"                | ; Alternative: T123                                  |
| N20 M6                      | ; Trigger tool change.                               |
| N30 D1                      | ; Activate cutting edge data set of the tool.        |
| N40 G54 G17                 | ; Zero offset and working plane.                     |
| N50 G0 X0 Y0 Z2 S2000 M3 M8 | ; Approach to the workpiece, spindle and coolant on. |
| ...                         |                                                      |

If tool orientation / coordinate transformation is being used, any transformations still active should be deleted at the start of the program:

| Program code   | Comment                                      |
|----------------|----------------------------------------------|
| N10 CYCLE800() | ; Resetting of the swiveled plane            |
| N20 TRAFOOF    | ; Resetting of TRAORI, TRANSMIT, TRACYL, ... |
| ...            |                                              |

## 4.4 Program examples

### 4.4.1 Example 1: First programming steps

Program example 1 is to be used to perform and test the first programming steps on the NC.

## Procedure

1. Create a new part program (name)
2. Edit the part program
3. Select the part program
4. Activate single block
5. Start the part program

### References:

Operating Manual for the existing user interface

### Note

In order that the program can run on the machine, the machine data must have been set appropriately (→ machine manufacturer!).

### Note

Alarms can occur during program verification. These alarms have to be reset first.

## Program example 1

| Program code                     | Comment                                                        |
|----------------------------------|----------------------------------------------------------------|
| N10 MSG("THIS IS MY NC PROGRAM") | ; Message "THIS IS MY NC PROGRAM" displayed in the alarm line. |
| N20 F200 S900 T1 D2 M3           | ; Feedrate, spindle, tool, tool offset, spindle clockwise.     |
| N30 G0 X100 Y100                 | ; Approach position in rapid traverse.                         |
| N40 G1 X150                      | ; Rectangle with feedrate, straight line in X.                 |
| N50 Y120                         | ; Straight line in Y.                                          |
| N60 X100                         | ; Straight line in X.                                          |
| N70 Y100                         | ; Straight line in Y.                                          |
| N80 G0 X0 Y0                     | ; Retraction in rapid traverse.                                |
| N100 M30                         | ; End of block.                                                |

### 4.4.2 Example 2: NC program for turning

Program example 2 is intended for the machining of a workpiece on a lathe. It contains radius programming and tool radius compensation.

### Note

In order that the program can run on the machine, the machine data must have been set appropriately (→ machine manufacturer!).

## Dimension drawing of the workpiece

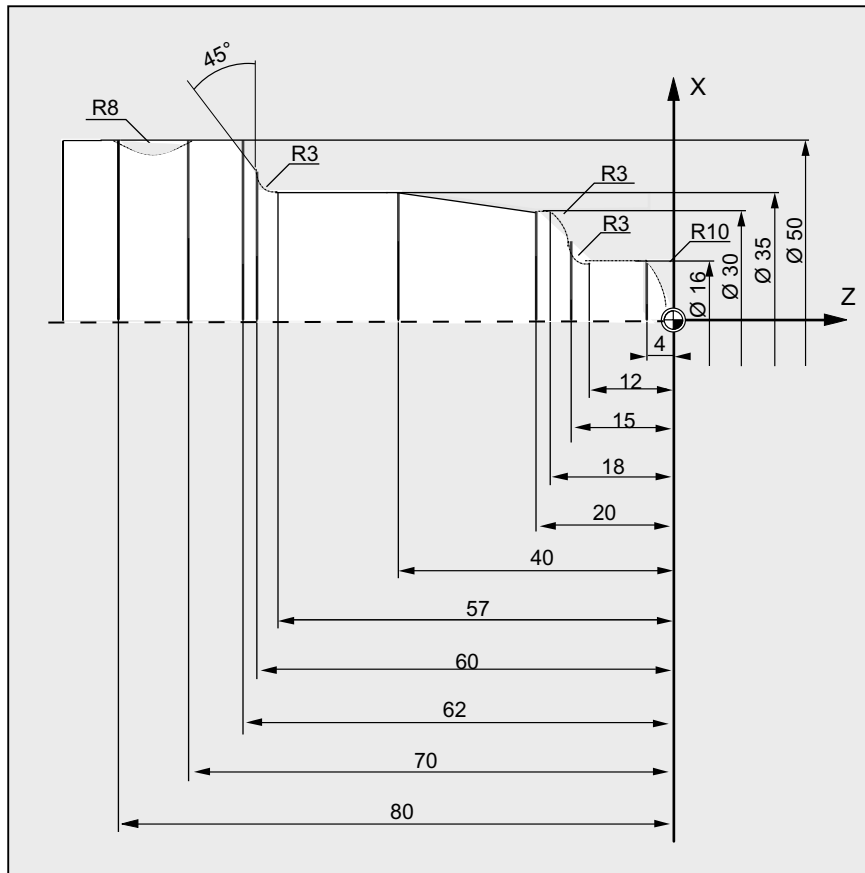


Figure 4-1 Top view

## Program example 2

| Program code           | Comment                                   |
|------------------------|-------------------------------------------|
| N5 G0 G53 X280 Z380 D0 | ; Starting point.                         |
| N10 TRANS X0 Z250      | ; Zero offset                             |
| N15 LIMS=4000          | ; Speed limitation (G96).                 |
| N20 G96 S250 M3        | ; Select constant cutting rate.           |
| N25 G90 T1 D1 M8       | ; Select tool selection and offset.       |
| N30 G0 G42 X-1.5 Z1    | ; Set tool with tool radius compensation. |
| N35 G1 X0 Z0 F0.25     |                                           |
| N40 G3 X16 Z-4 I0 K-10 | ; Turn radius 10.                         |
| N45 G1 Z-12            |                                           |
| N50 G2 X22 Z-15 CR=3   | ; Turn radius 3.                          |
| N55 G1 X24             |                                           |
| N60 G3 X30 Z-18 I0 K-3 | ; Turn radius 3.                          |
| N65 G1 Z-20            |                                           |
| N70 X35 Z-40           |                                           |

| Program code                | Comment                                                                |
|-----------------------------|------------------------------------------------------------------------|
| N75 Z-57                    |                                                                        |
| N80 G2 X41 Z-60 CR=3        | ; Turn radius 3.                                                       |
| N85 G1 X46                  |                                                                        |
| N90 X52 Z-63                |                                                                        |
| N95 G0 G40 G97 X100 Z50 M9  | ; Deselect tool radius compensation and approach tool change location. |
| N100 T2 D2                  | ; Call tool and select offset.                                         |
| N105 G96 S210 M3            | ; Select constant cutting rate.                                        |
| N110 G0 G42 X50 Z-60 M8     | ; Set tool with tool radius compensation.                              |
| N115 G1 Z-70 F0.12          | ; Turn diameter 50.                                                    |
| N120 G2 X50 Z-80 I6.245 K-5 | ; Turn radius 8.                                                       |
| N125 G0 G40 X100 Z50 M9     | ; Retract tool and deselect tool radius compensation.                  |
| N130 G0 G53 X280 Z380 D0 M5 | ; Approach tool change location.                                       |
| N135 M30                    | ; End of program.                                                      |

### 4.4.3 Example 3: NC program for milling

Program example 3 is intended for the machining of a workpiece on a vertical milling machine. It contains surface and side milling as well as drilling.

#### Note

In order that the program can run on the machine, the machine data must have been set appropriately (→ machine manufacturer!).

#### Dimension drawing of the workpiece

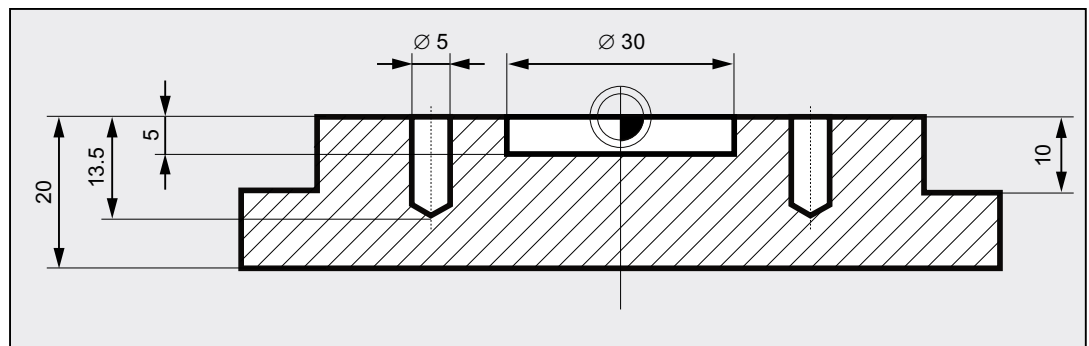


Figure 4-2 Side view

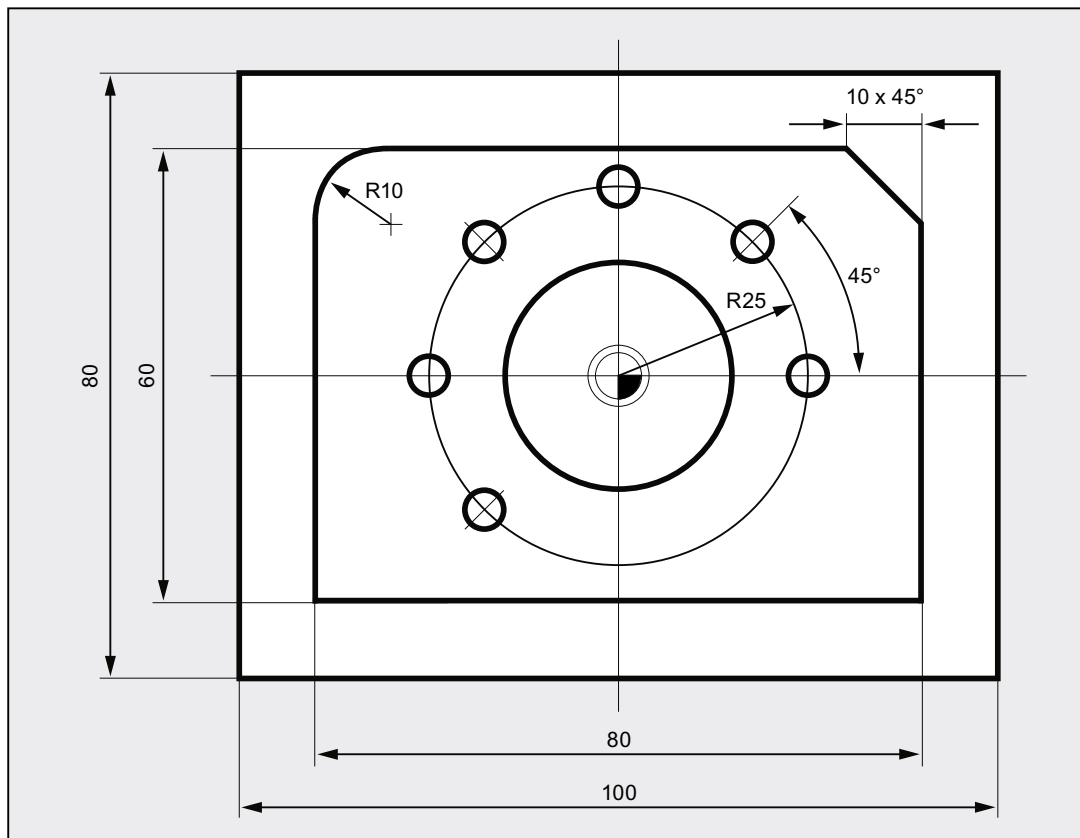


Figure 4-3 Top view

### Program example 3

| Program code                     | Comment                                                       |
|----------------------------------|---------------------------------------------------------------|
| N10 T="PF60"                     | ; Preselection of the tool with name PF60.                    |
| N20 M6                           | ; Load the tool into the spindle.                             |
| N30 S2000 M3 M8                  | ; Speed, direction of rotation, cooling on.                   |
| N40 G90 G64 G54 G17 G0 X-72 Y-72 | ; Basic settings of the geometry and approach starting point. |
| N50 G0 Z2                        | ; Z axis at safety clearance.                                 |
| N60 G450 CFTCP                   | ; Behavior with active G41/G42.                               |
| N70 G1 Z-10 F3000                | ; Milling tool at contact depth with feedrate = 3000 mm/min.  |
| N80 G1 G41 X-40                  | ; Activation of the milling tool radius compensation.         |
| N90 G1 X-40 Y30 RND=10 F1200     | ; Travel to the contour with feedrate = 1200 mm/min.          |



| Program code                                              | Comment                                                        |
|-----------------------------------------------------------|----------------------------------------------------------------|
| N100 G1 X40 Y30 CHR=10                                    |                                                                |
| N110 G1 X40 Y-30                                          |                                                                |
| N120 G1 X-41 Y-30                                         |                                                                |
| N130 G1 G40 Y-72 F3000                                    | ; Deselection of the milling tool radius compensation.         |
| N140 G0 Z200 M5 M9                                        | ; Retraction of the milling tool, spindle + cooling off.       |
| N150 T="SF10"                                             | ; Preselection of the tool with name SF10.                     |
| N160 M6                                                   | ; Load the tool into the spindle.                              |
| N170 S2800 M3 M8                                          | ; Speed, direction of rotation, cooling on.                    |
| N180 G90 G64 G54 G17 G0 X0 Y0                             | ; Basic settings for the geometry and approach starting point. |
| N190 G0 Z2                                                |                                                                |
| N200 POCKET4(2,0,1,-5,15,0,0,0,0,800,1300,0,21,5,,,2,0.5) | ; Call of the pocket milling cycle.                            |
| N210 G0 Z200 M5 M9                                        | ; Retraction of the milling tool, spindle + cooling off.       |
| N220 T="ZB6"                                              | ; Call center drill 6 mm.                                      |
| N230 M6                                                   |                                                                |
| N240 S5000 M3 M8                                          |                                                                |
| N250 G90 G60 G54 G17 X25 Y0                               | ; Exact stop G60 for exact positioning.                        |
| N260 G0 Z2                                                |                                                                |
| N270 MCALL CYCLE82(2,0,1,-2.6,,0)                         | ; Modal call of the drilling cycle.                            |
| N280 POSITION:                                            | ; Jump mark for repetition.                                    |
| N290 HOLES2(0,0,25,0,45,6)                                | ; Position pattern for drilling.                               |
| N300 ENDLABEL:                                            | ; End identifier for repetition.                               |
| N310 MCALL                                                | ; Resetting of the modal call.                                 |
| N320 G0 Z200 M5 M9                                        |                                                                |
| N330 T="SPB5"                                             | ; Call drill D 5 mm.                                           |
| N340 M6                                                   |                                                                |
| N350 S2600 M3 M8                                          |                                                                |
| N360 G90 G60 G54 G17 X25 Y0                               |                                                                |
| N370 MCALL CYCLE82(2,0,1,-13.5,,0)                        | ; Modal call of the drilling cycle.                            |
| N380 REPEAT POSITION                                      | ; Repetition of the position description from centering.       |
| N390 MCALL                                                | ; Resetting of the drilling cycle.                             |
| N400 G0 Z200 M5 M9                                        |                                                                |

| Program code | Comment           |
|--------------|-------------------|
| N410 M30     | ; End of program. |

# Tool change

## Tool change method

In chain, rotary-plate and box magazines, a tool change normally takes place in two stages:

1. The tool is sought in the magazine with the T command.
2. The tool is then loaded into the spindle with the M command.

In circular magazines on turning machines, the T command carries out the entire tool change, that is, locates and inserts the tool.

---

### Note

The tool change method is set via a machine data (→ machine manufacturer).

---

## Conditions

Together with the tool change:

- The tool offset values stored under a D number have to be activated.
- The appropriate working plane has to be programmed (basic setting: G18). This ensures that the tool length compensation is assigned to the correct axis.

## Tool management (option)

The programming of the tool change is performed differently for machines with active tool management (option) than for machines without active tool management. The two options are therefore described separately.

## 5.1 Tool change without tool management

### 5.1.1 Tool change with T command

There is a direct tool change when the T command is programmed.

## Application

For turning machines with circular magazine.

## 5.1 Tool change without tool management

## Syntax

Tool selection:

T&lt;number&gt;

T=&lt;number&gt;

T&lt;n&gt;=&lt;number&gt;

Tool deselection:

T0

T0=&lt;number&gt;

## Meaning

|           |                                                                                                                                                                                                                          |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| T:        | Command for tool selection including tool change and activation of the tool offset                                                                                                                                       |
| <n>:      | Spindle number as address extension<br><b>Note:</b><br>The possibility of programming a spindle number as address extension depends on the configuration of the machine;<br>→ see machine manufacturer's specifications. |
| <number>: | Number of the tool                                                                                                                                                                                                       |
|           | Range of values: 0 - 32000                                                                                                                                                                                               |
| T0:       | Command for deselection of the active tool                                                                                                                                                                               |

## Example

| Program code | Comment                                                    |
|--------------|------------------------------------------------------------|
| N10 T1 D1    | ; Loading of tool T1 and activation of the tool offset D1. |
| ...          |                                                            |
| N70 T0       | ; Deselect tool T1.                                        |
| ...          |                                                            |

## 5.1.2 Tool change with M6

The tool is selected when the T command is programmed. The tool only becomes active with M6 (including tool offset).

## Application

For milling machines with chain, rotary-plate or box magazines.

## Syntax

Tool selection:

T&lt;number&gt;

T=&lt;number&gt;

T&lt;n&gt;=&lt;number&gt;

Tool change:

M6

Tool deselection:

T0

T0=<number>

## Meaning

|           |                                                                                                                                                                                                                          |           |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| T:        | Command for the tool selection                                                                                                                                                                                           |           |
| <n>:      | Spindle number as address extension<br><b>Note:</b><br>The possibility of programming a spindle number as address extension depends on the configuration of the machine;<br>→ see machine manufacturer's specifications. |           |
| <number>: | Number of the tool                                                                                                                                                                                                       |           |
|           | Range of values:                                                                                                                                                                                                         | 0 - 32000 |
| M6:       | M function for the tool change (according to DIN 66025)<br>M6 activates the selected tool (T...) and the tool offset (D...).                                                                                             |           |
| T0:       | Command for deselection of the active tool                                                                                                                                                                               |           |

## Example

| Program code       | Comment                            |
|--------------------|------------------------------------|
| N10 T1 M6          | ; Loading of tool T1.              |
| N20 D1             | ; Selection of tool length offset. |
| N30 G1 X10 ...     | ; Machining with T1.               |
| ...                |                                    |
| N70 T5             | ; Preselection of tool T5.         |
| N80 ...            | ; Machining with T1.               |
| ...                |                                    |
| N100 M6            | ; Loading of tool T5.              |
| N110 D1 G1 X10 ... | ; Machining with tool T5.          |
| ...                |                                    |

## 5.2 Tool change with tool management (option)

### Tool management

The optional "Tool management" function ensures that at any given time the correct tool is in the correct location and that the data assigned to the tool are up to date. It also allows fast tool changes and avoids both scrap by monitoring the tool service life and machine downtimes by using spare tools.

**Tool name**

On a machine tool with active tool management, the tools must be assigned a name and number for clear identification (e.g. "Drill", "3").

The tool call can then be via the tool name, e.g.

T="Drill"

**Note**

The tool name may not contain any special characters.

**5.2.1 Tool change with T command with active tool management (option)**

There is a direct tool change when the T command is programmed.

**Application**

For turning machines with circular magazine.

**Syntax**

Tool selection:

T=<location>

T=<name>

T<n>=<location>

T<n>=<name>

Tool deselection:

T0

**Meaning**

|      |                                                                                                                                                                                   |                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| T=:  | Command for tool change and activation of the tool offset                                                                                                                         |                                                                                                       |
|      | The following specifications are possible:                                                                                                                                        |                                                                                                       |
|      | <location>:                                                                                                                                                                       | Number of the magazine location                                                                       |
| <n>: | <name>:                                                                                                                                                                           | Name of tool                                                                                          |
|      |                                                                                                                                                                                   | <b>Note:</b><br>The correct notation (uppercase/lowercase) must be used when programming a tool name. |
| <n>: | Spindle number as address extension                                                                                                                                               |                                                                                                       |
|      | <b>Note:</b><br>The possibility of programming a spindle number as an address extension depends on the configuration of the machine; → see machine manufacturer's specifications. |                                                                                                       |
| T0:  | Command for the tool deselection (magazine location not occupied)                                                                                                                 |                                                                                                       |

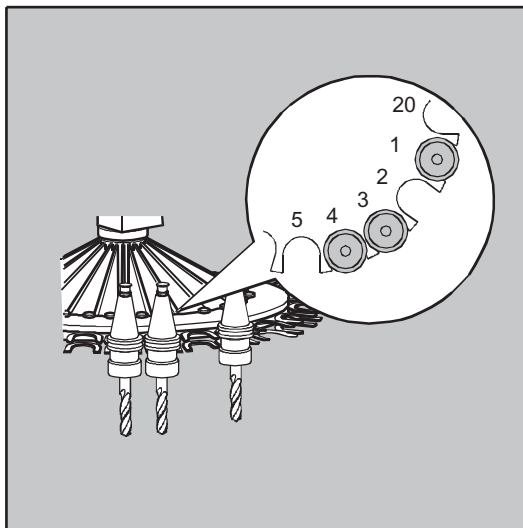
**Note**

If the selected magazine location is not occupied in a tool magazine, the command acts as for T0. The selection of the next occupied magazine location can be used to position the empty location.

**Example**

A circular magazine has locations 1 to 20 with the following tool assignment:

| Location | Tool                 | Tool group | State   |
|----------|----------------------|------------|---------|
| 1        | Drill, duplo no. = 1 | T15        | Blocked |
| 2        | Not occupied         |            |         |
| 3        | Drill, duplo no. = 2 | T10        | Enabled |
| 4        | Drill, duplo no. = 3 | T1         | Active  |
| 5 ... 20 | Not occupied         |            |         |



The following tool call is programmed in the NC program:

```
N10 T=1
```

The call is processed as follows:

1. Magazine location 1 is considered and the tool identifier determined.
2. The tool management recognizes that this tool is blocked and therefore cannot be used.

## 5.2 Tool change with tool management (option)

3. A tool search for T="drill" is initiated in accordance with the search method set:  
"Find the active tool; or else, select the one with the next highest duplo number."
4. The following usable tool is then found:  
"Drill", duplo no. 3 (at magazine location 4)  
**This completes the tool selection process and the tool change is initiated.**

### Note

If the "Select the first available tool from the group" search method is employed, the sequence must first be defined within the tool group being loaded. In this case group T10 is loaded, as T15 is blocked.

When the strategy "Take the first tool with "active" status from the group" is applied, T1 is loaded.

### 5.2.2 Tool change with M6 with active tool management (option)

The tool is selected when the T command is programmed. The tool only becomes active with M6 (including tool offset).

#### Application

For milling machines with chain, rotary-plate or box magazines.

#### Syntax

Tool selection:

T=<location>

T=<name>

T<n>=<location>

T<n>=<name>

Tool change:

M6

Tool deselection:

T0

#### Meaning

|     |                                            |                                                                                                       |
|-----|--------------------------------------------|-------------------------------------------------------------------------------------------------------|
| T=: | Command for the tool selection             |                                                                                                       |
|     | The following specifications are possible: |                                                                                                       |
|     | <location>:                                | Number of the magazine location                                                                       |
|     | <name>:                                    | Name of tool                                                                                          |
|     |                                            | <b>Note:</b><br>The correct notation (uppercase/lowercase) must be used when programming a tool name. |



|      |                                                                                                                                                                                                                          |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <n>: | Spindle number as address extension<br><b>Note:</b><br>The possibility of programming a spindle number as an address extension depends on the configuration of the machine; → see machine manufacturer's specifications. |
| M6:  | M function for the tool change (according to DIN 66025)<br>M6 activates the selected tool (T...) and the tool offset (D. . .).                                                                                           |
| T0:  | Command for the tool deselection (magazine location not occupied)                                                                                                                                                        |

**Note**

If the selected magazine location is not occupied in a tool magazine, the command acts as for T0. The selection of the next occupied magazine location can be used to position the empty location.

**Example**

| Program code       | Comment                                         |
|--------------------|-------------------------------------------------|
| N10 T=1 M6         | ; Loading of the tool from magazine location 1. |
| N20 D1             | ; Selection of tool length offset.              |
| N30 G1 X10 ...     | ; Machining with tool T=1.                      |
| ...                |                                                 |
| N70 T="Drill"      | ; Preselection of the tool with name "Drill".   |
| N80 ...            | ; Machining with tool T=1.                      |
| ...                |                                                 |
| N100 M6            | ; Loading of the drill.                         |
| N140 D1 G1 X10 ... | ; Machining with drill.                         |
| ...                |                                                 |

## 5.3 Behavior with faulty T programming

The behavior with faulty T programming depends on the configuration of the machine:

| MD22562 TOOL_CHANGE_ERROR_MODE |       |                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bit                            | Value | Meaning                                                                                                                                                                                                                                                                                                                               |
| 7                              | 0     | Basic setting!<br>With the T programming, a check is made immediately as to whether the NCK recognizes the T number. If not, an alarm is triggered.                                                                                                                                                                                   |
|                                | 1     | The programmed T number will only be checked following D selection. If the NCK does not recognize the tool number, an alarm is issued during D selection.<br>This response is desirable if, for example, tool programming is also intended to achieve positioning and the tool data is not necessarily available (circular magazine). |



## Tool offsets

### 6.1 General information about the tool offsets

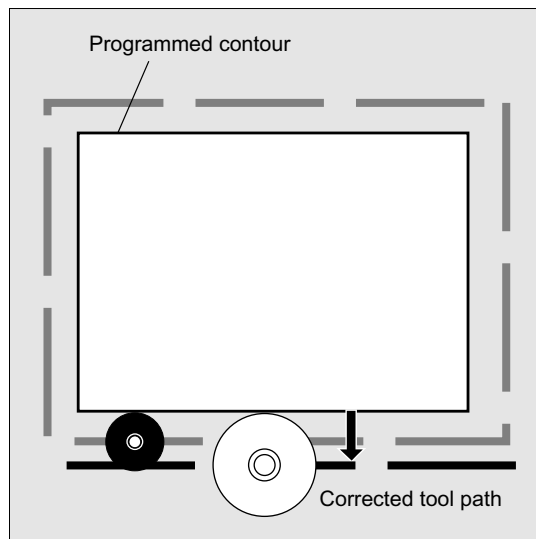
Workpiece dimensions are programmed directly (e.g. according to the production drawing). Therefore, tool data such as milling tool diameter, cutting edge position of the turning tool (counterclockwise/clockwise turning tool) and tool length does not have to be taken into consideration when creating the program.

#### The control corrects the travel path

When machining a workpiece, the tool paths are controlled according to the tool geometry such that the programmed contour can be machined using any tool.

In order that the control can calculate the tool paths, the tool data must be entered in the tool compensation memory of the control. Only the required tool (T . . .) and the required offset data record (D . . .) are called via the NC program.

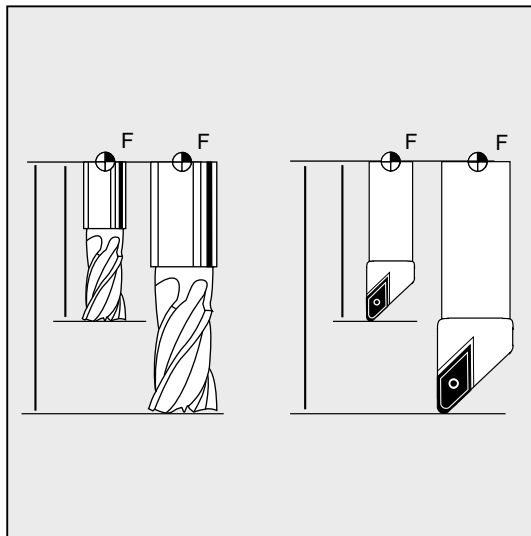
While the program is being processed, the control fetches the offset data it requires from the tool compensation memory and corrects the tool path individually for different tools:



### 6.2 Tool length compensation

The tool length compensation compensates for the differences in length between the tools used.

The tool length is the distance between the toolholder reference point and the tool tip:



This length is measured and entered in the tool compensation memory of the control together with definable wear values. From this data, the control calculates the traversing movements in the infeed direction.

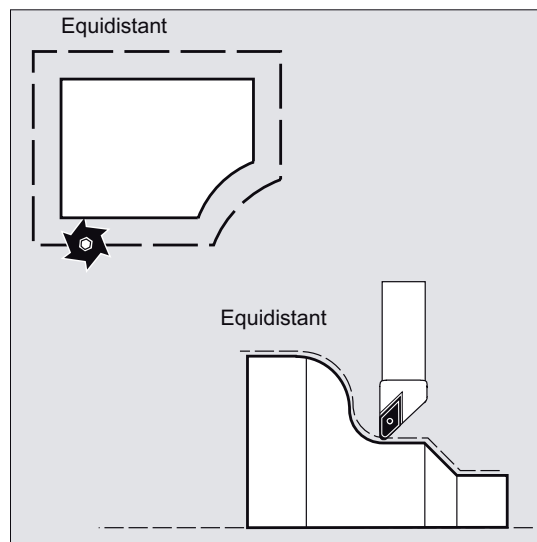
#### Note

The offset value for the tool length is dependent upon the spatial orientation of the tool.

## 6.3 Tool radius compensation

The contour and tool path are not identical. The milling tool or cutting edge center must travel along a path that is equidistant from the contour. To do this, the control requires data about the tool form (radius) from the tool compensation memory.

Depending on the radius and the machining direction, the programmed tool center point path is offset during the program processing in such a way that the tool edge travels exactly along the programmed contour:

**Note**

Tool radius compensation is applied according to the default CUT2D or CUT2DF (see " 2D tool compensation (CUT2D, CUT2DF) (Page 284) ").

**References**

The various options for the tool radius compensation are described in detail in Section "Tool radius compensations".

## 6.4 Tool compensation memory

The following data must be available in the tool compensation memory of the controller for each tool edge:

- Tool type
- Cutting edge position
- Tool geometry variables (length, radius)

This data is entered as tool parameters (max. 25). Which parameters are required for a tool depends on the tool type. Any tool parameters that are not required must be set to "zero" (corresponds to the default setting of the system).

**Note**

Values that have been entered once in the compensation memory are included in the processing at each tool call.

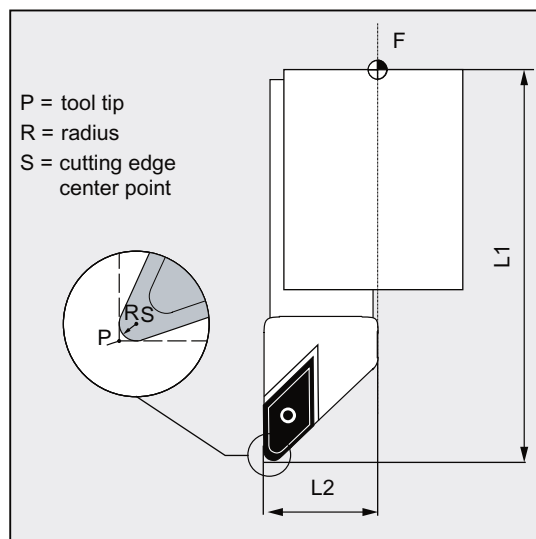
## Tool type

The tool type (drill, milling or turning tool) determines which geometry data is necessary and how this is taken into account.

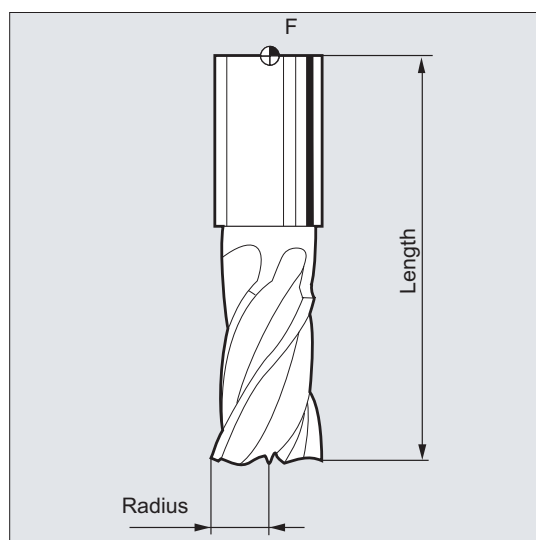
## Cutting edge position

The cutting edge position describes the position of the tool tip P in relation to the cutting edge center point S.

The cutting edge position is required together with the cutting edge radius for the calculation of the tool radius compensation for turning tools (tool type 5xx).



## Tool geometry variables (length, radius)



The tool geometry variables consist of several components (geometry, wear). The controller computes the components to a certain dimension (e.g. overall length 1, total radius). The respective overall dimension becomes effective when the compensation memory is activated.

How these values are calculated in the axes is determined by the tool type and the current plane (G17/G18/G19).

## References

Function Manual, Basic Functions; Tool Offsets (W1); Section "Tool edge"

## 6.5 Tool types

### 6.5.1 General information about the tool types

Tools are divided into tool types. Each tool type is assigned a 3-digit number. The first digit assigns the tool type to one of the following groups depending on the technology used:

| Tool type | Tool group                                     |
|-----------|------------------------------------------------|
| 1xy       | Milling tools (Page 63)                        |
| 2xy       | Drills (Page 65)                               |
| 3xy       | Reserved                                       |
| 4xy       | Grinding tools (Page 66)                       |
| 5xy       | Turning tools (Page 67)                        |
| 6xy       | Reserved                                       |
| 7xy       | Special tools (Page 69) such as a slotting saw |

### 6.5.2 Milling tools

The following tool types are available in the "Milling tools" group:

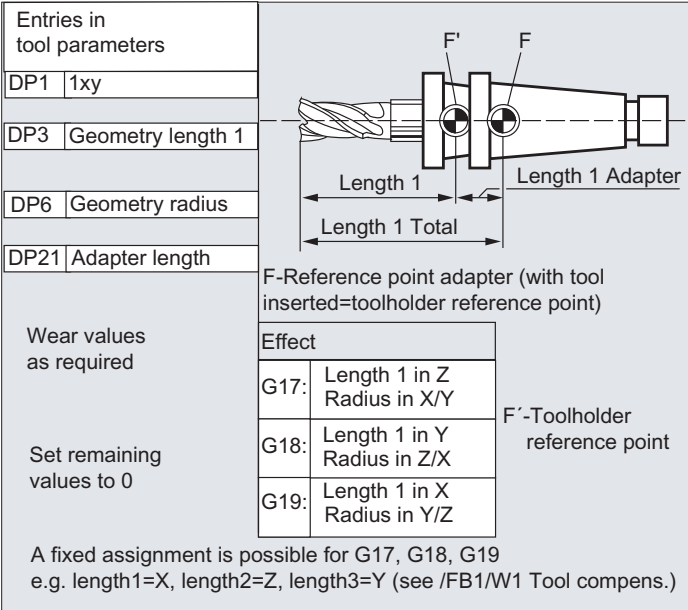
|     |                                                         |
|-----|---------------------------------------------------------|
| 100 | Milling tool according to CLDATA (Cutter Location Data) |
| 110 | Ballhead cutter (cylindrical die milling tool)          |
| 111 | Ballhead cutter (tapered die milling tool)              |
| 120 | End mill (without corner rounding)                      |
| 121 | End mill (with corner rounding)                         |
| 130 | Angle head cutter (without corner rounding)             |
| 131 | Angle head cutter (with corner rounding)                |
| 140 | Facing tool                                             |
| 145 | Thread cutter                                           |
| 150 | Side mill                                               |
| 151 | Saw                                                     |
| 155 | Bevel cutter (without corner rounding)                  |

6.5 Tool types

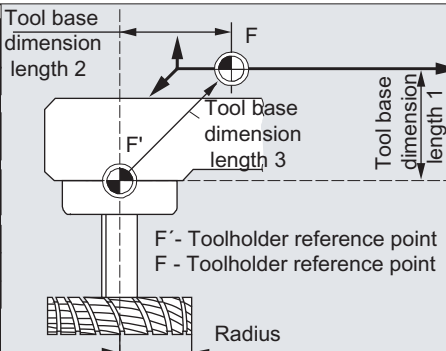
|     |                                     |
|-----|-------------------------------------|
| 156 | Bevel cutter (with corner rounding) |
| 157 | Tapered die milling tool            |
| 160 | Drill and thread milling cutter     |

Tool parameters

The following figures provide an overview of which tool parameters (DP...) for milling tools are entered in the compensation memory:





|                                                                                                                             |                   |                                                                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Entries in tool parameters                                                                                                  |                   |  <p>F' - Toolholder reference point<br/>F - Toolholder reference point</p> |
| DP1                                                                                                                         | 1xy               |                                                                                                                                                              |
| DP3                                                                                                                         | Geometry length 1 |                                                                                                                                                              |
| DP6                                                                                                                         | Geometry radius   |                                                                                                                                                              |
| DP21                                                                                                                        | Base length 1     |                                                                                                                                                              |
| DP22                                                                                                                        | Base length 2     |                                                                                                                                                              |
| DP23                                                                                                                        | Base length 3     |                                                                                                                                                              |
| Wear values acc. to requirements                                                                                            |                   |                                                                                                                                                              |
| Set remaining values to 0                                                                                                   |                   |                                                                                                                                                              |
| A fixed assignment is possible for G17, G18, G19<br>e.g. length 1=X, length 2=Y, length 3=Z (see /FB1/W1 Tool compensation) |                   |                                                                                                                                                              |

### Note

Brief description of the tool parameters can be found on the user interface.

For further information, see:

### References:

Function Manual, Basic Functions; Tool Offset (W1)

## 6.5.3

### Drills

The following tool types are available in the "Drills" group:

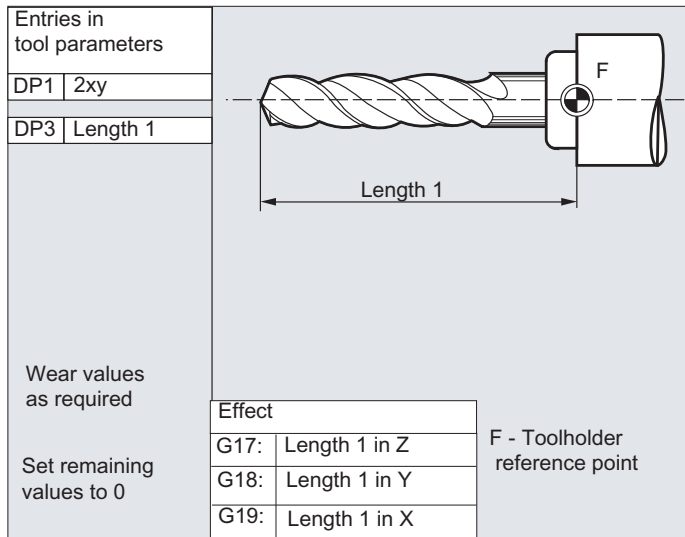
|     |                    |
|-----|--------------------|
| 200 | Twist drill        |
| 205 | Drill              |
| 210 | Boring bar         |
| 220 | Center drill       |
| 230 | Countersink        |
| 231 | Counterbore        |
| 240 | Tap regular thread |
| 241 | Tap fine thread    |

## 6.5 Tool types

|     |                      |
|-----|----------------------|
| 242 | Tap Whitworth thread |
| 250 | Reamer               |

## Tool parameters

The following figure provides an overview of which tool parameters (DP...) for drills are entered in the compensation memory:

**Note**

Brief description of the tool parameters can be found on the user interface.

For further information, see:

**References:**

Function Manual, Basic Functions; Tool Offset (W1)

## 6.5.4 Grinding tools

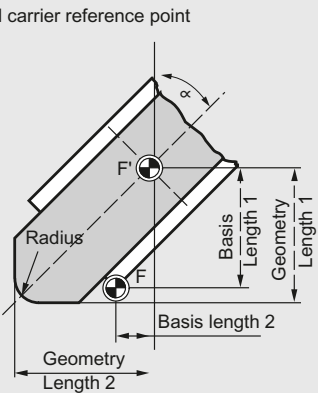
The following tool types are available in the "Grinding tools" group:

|     |                                                                                                        |
|-----|--------------------------------------------------------------------------------------------------------|
| 400 | Surface grinding wheel                                                                                 |
| 401 | Surface grinding wheel with monitoring                                                                 |
| 402 | Surface grinding wheel without monitoring without base dimension (TOOLMAN)                             |
| 403 | Surface grinding wheel with monitoring without base dimension for grinding wheel peripheral speed GWPS |
| 410 | Facing wheel                                                                                           |
| 411 | Facing wheel (TOOLMAN) with monitoring                                                                 |
| 412 | Facing wheel (TOOLMAN) without monitoring                                                              |

|     |                                                                                              |
|-----|----------------------------------------------------------------------------------------------|
| 413 | Facing wheel with monitoring without base dimension for grinding wheel peripheral speed GWPS |
| 490 | Dresser                                                                                      |

## Tool parameters

The following figure provides an overview of which tool parameters (DP...) for grinding tools are entered in the compensation memory:

| Entries in the tool parameters                                               |                                                 | TPG1                                                                                | Spindle number                       |
|------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------|
| DP1                                                                          | 403                                             | TPG2                                                                                | Chaining rule                        |
| DP2                                                                          | Position *                                      | TPG3                                                                                | Minimum wheel radius                 |
| DP3                                                                          | Length 1                                        | TPG4                                                                                | Min. wheel width                     |
| DP4                                                                          | Length 2                                        | TPG5                                                                                | Actual wheel width                   |
| DP6                                                                          | Radius                                          | TPG6                                                                                | Maximum speed                        |
|                                                                              |                                                 | TPG7                                                                                | Max. peripheral speed                |
| * Tool nose position                                                         |                                                 | TPG8                                                                                | Angle of the inclined wheel          |
| Wear values correspond to the requirement<br>Other values should be set to 0 |                                                 | TPG9                                                                                | Parameter No. for radius calculation |
| Effect                                                                       |                                                 |  |                                      |
| G17:                                                                         | Length 1 in Y<br>Length 2 in X<br>Radius in X/Y |                                                                                     |                                      |
| G18:                                                                         | Length 1 in X<br>Length 2 in Z<br>Radius in Z/X |                                                                                     |                                      |
| G19:                                                                         | Length 1 in Z<br>Length 2 in Y<br>Radius in Y/Z |                                                                                     |                                      |

### Note

Brief description of the tool parameters can be found on the user interface.

For further information, see:

### References:

Function Manual, Basic Functions; Tool Offset (W1)

## 6.5.5 Turning tools

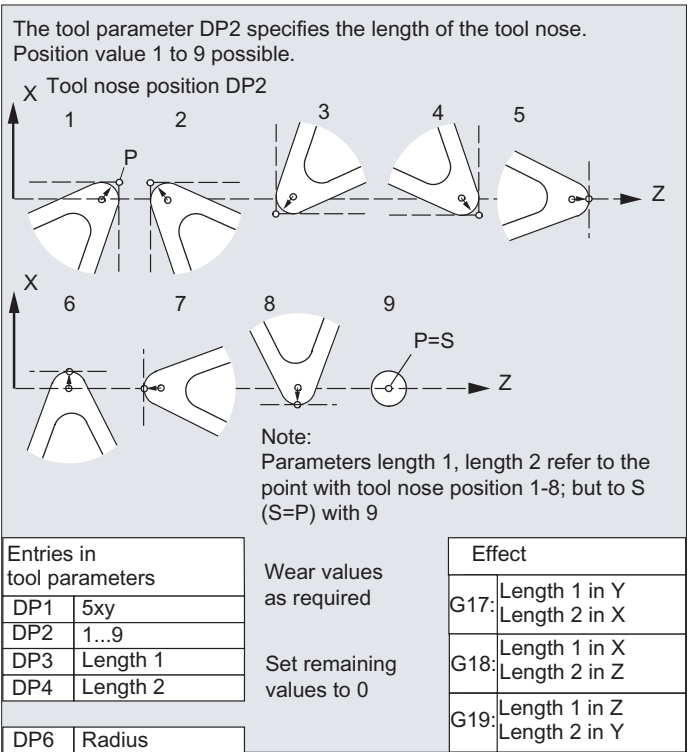
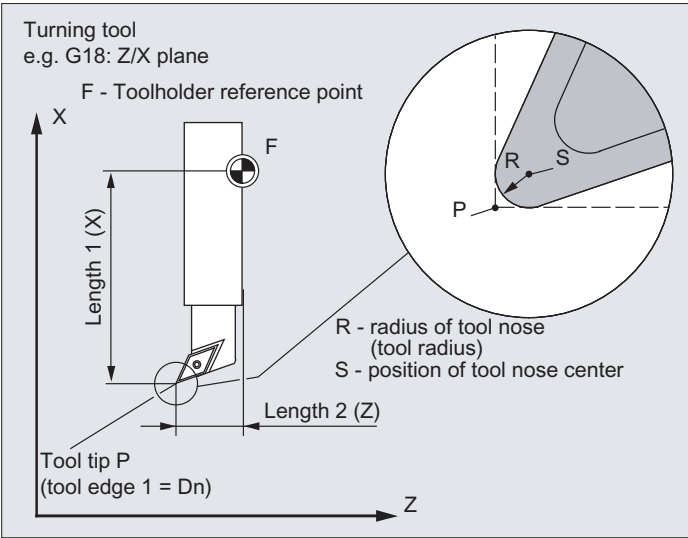
The following tool types are available in the "Turning tools" group:

|     |                |
|-----|----------------|
| 500 | Roughing tool  |
| 510 | Finishing tool |
| 520 | Plunge cutter  |
| 530 | Parting tool   |
| 540 | Threading tool |

|     |                                             |
|-----|---------------------------------------------|
| 550 | Button tool / forming tool (TOOLMAN)        |
| 560 | Rotary drill (ECOCUT)                       |
| 580 | Probe with cutting edge position parameters |

Tool parameters

The following figures provide an overview of which tool parameters (DP...) for turning tools are entered in the compensation memory:



## Note

Brief description of the tool parameters can be found on the user interface.

For further information, see:

## References:

Function Manual, Basic Functions; Tool Offset (W1)

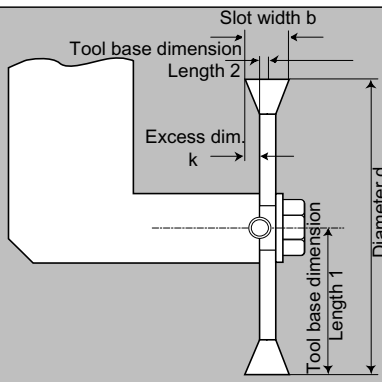
## 6.5.6 Special tools

The following tool types are available in the "Special tools" group:

|     |              |
|-----|--------------|
| 700 | Slotting saw |
| 710 | 3D probe     |
| 711 | Edge probe   |
| 730 | Stop         |

## Tool parameters

The following figure provides an overview of which tool parameters (DP...) for "Slotting saw" tool type are entered in the compensation memory:

|                            |                     |                                                                                      |                                                                          |                                       |
|----------------------------|---------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------|
| Entries in tool parameters |                     |  |                                                                          |                                       |
| DP3                        | Base length 1       |                                                                                      |                                                                          |                                       |
| DP4                        | Base length 2       |                                                                                      |                                                                          |                                       |
| DP6                        | Geometry diameter   |                                                                                      |                                                                          |                                       |
| DP7                        | Geometry zero width |                                                                                      |                                                                          |                                       |
| DP8                        | Geometry overshoot  |                                                                                      |                                                                          |                                       |
| Wear values as required    |                     | Effect                                                                               |                                                                          |                                       |
|                            |                     | G17:                                                                                 | Half diameter (L1) in X<br>Excess dim. in (L2) Y<br>Saw blade in (R) X/Y | Plane selection<br>1st-2nd axis (X-Y) |
|                            |                     | G18:                                                                                 | Half diameter (L1) in Y<br>Excess dim. in (L2) X<br>Saw blade in (R) Z/X | Plane selection<br>1st-2nd axis (X-Z) |
|                            |                     | G19:                                                                                 | Half diameter (L1) in Z<br>Excess dim. in (L2) Z<br>Saw blade in (R) Y/Z | Plane selection<br>1st-2nd axis (Y-Z) |
| Set remaining values to 0  |                     |                                                                                      |                                                                          |                                       |

## 6.6 Tool offset call (D)

---

### Note

Brief description of the tool parameters can be found on the user interface.

For further information, see:

### References:

Function Manual, Basic Functions; Tool Offset (W1)

---

## 6.5.7 Chaining rule

The geometry tool length compensations, wear and base dimension can be chained for both the left and the right tool nose radius compensation, i.e. if the tool length compensations are changed for the left cutting edge, then the values are also automatically entered for the right cutting edge and vice versa.

## References

Function Manual, Extended Functions; Grinding (W4)

## 6.6 Tool offset call (D)

Cutting edges 1 to 8 (with active tool management 12) of a tool can be assigned different tool offset data blocks (e.g. different offset values for the left and right cutting edge of a grooving tool).

Activation of the offset data (including the data for the tool length offset) of a special cutting edge is performed by calling the D number. When D0 is programmed, offsets for the tool have no effect.

A tool radius compensation must also be activated via G41/G42.

---

### Note

Tool length offsets take immediate effect when the D number is programmed. If no D number is programmed, the default setting defined via the machine data is active for a tool change (→ see machine manufacturer's specifications).

---

## Syntax

Activation of a tool offset data block:

D<number>

Activate the tool radius compensation:

G41 ...

G42 ...

Deactivation of the tool offsets:

D0

G40

## Meaning

|           |                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| D:        | Command for the activation of an offset data block for the active tool<br>The tool length offset is applied with the first programmed traverse of the associated length compensation axis.<br><b>Notice:</b><br>A tool length offset can also take effect without D programming, when the automatic activation of a tool edge has been configured for the tool change (→ see machine manufacturer's specifications). |           |
| <number>: | The tool offset data block to be activated is specified via the <number> parameter.<br>The type of D programming depends on the configuration of the machine (see paragraph "Type of D programming").                                                                                                                                                                                                                |           |
|           | Range of values:                                                                                                                                                                                                                                                                                                                                                                                                     | 0 - 32000 |
| D0:       | Command for the deactivation of the offset data block for the active tool                                                                                                                                                                                                                                                                                                                                            |           |
| G41:      | Command for the activation of the tool radius compensation with machining direction <b>left</b> of the contour                                                                                                                                                                                                                                                                                                       |           |
| G42:      | Command for the activation of the tool radius compensation with machining direction <b>right</b> of the contour                                                                                                                                                                                                                                                                                                      |           |
| G40:      | Command for the deactivation of the tool radius compensation                                                                                                                                                                                                                                                                                                                                                         |           |

### Note

The tool radius compensation is described in detail in the "Tool radius compensation" section.

## Type of D programming

The type of D programming is defined via machine data.

This can be done as follows:

- D number = cutting edge number  
D numbers ranging from 1 to max. 12 are available for every tool T<number> or T="Name" (with TOOLMAN). These D numbers are assigned directly to the tool cutting edges. An offset data block (\$TC\_DPx[t,d]) belongs to each D number (= cutting edge number).
- Free selection of D numbers  
The D numbers can be freely assigned to the cutting edge numbers of a tool. The upper limit for the D numbers that can be used is limited by a machine data.
- Absolute D number without reference to the T number  
Independence between D number and T number can be selected in systems without tool management. The reference of T number, cutting edge and offset by the D number is defined by the user. The range of D numbers is between 1 and 32000.

### References:

Function Manual, Basic Functions; Tool Offset (W1),

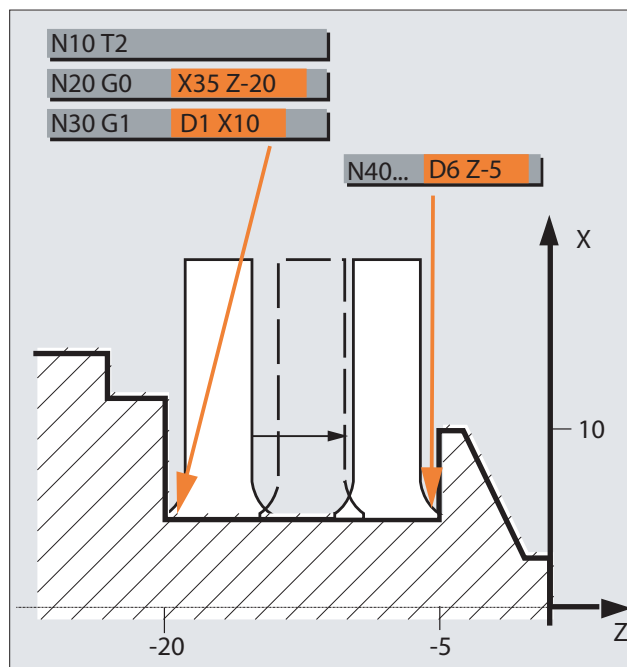
Function Manual, Tool Management, Section: "Variants of D-number assignments"

## Examples

## Example 1: Tool change with T command (turning)

| Program code     | Comment                                                      |
|------------------|--------------------------------------------------------------|
| N10 T1 D1        | ; Load tool T1 and activate tool offset data block D1 of T1. |
| N11 G0 X... Z... | ; The tool length offsets are applied.                       |
| N50 T4 D2        | ; Load tool T4 and activate tool offset data block D2 of T4. |
| ...              |                                                              |
| N70 G0 Z... D1   | ; Activate other cutting edge D1 for tool T4.                |

## Example 2: Different offset values for the left and right cutting edge of a grooving tool



## 6.7 Change in the tool offset data

## Effectiveness

A change in the tool offset data takes effect the next time the T or D number is programmed.

**Set tool offset data to be active immediately**

The following machine data can be used to specify that entered tool offset data takes effect immediately:



MD9440 \$MM\_ACTIVATE\_SEL\_USER

**WARNING****Risk of collision**

If MD9440 is set, tool offsets resulting from changes in tool offset data **during the part program stop**, are applied when the part program is continued.

## 6.8 Programmable tool offset (TOFFL, TOFF, TOFFR)

The user can use the commands `TOFFL/TOFF` and `TOFFR` to modify the effective tool length or the effective tool radius in the NC program, without changing the tool offset data stored in the compensation memory.

These programmed offsets are deleted again at the end of the program.

**Tool length offset**

Depending on the type of programming, programmed tool length offsets are assigned either to the tool length components L1, L2 and L3 (`TOFFL`) stored in the compensation memory or to the geometry axes (`TOFF`). The programmed offsets are treated accordingly for a plane change (`G17/G18/G19` ↔ `G17/G18/G19`):

- If the offset values are assigned to the tool length components, the directions in which the programmed offsets apply are replaced accordingly.
- If the offset values are assigned to the geometry axes, a plane change does not effect the assignment in relation to the coordinate axes.

**Tool radius offset**

The command `TOFFR` is available for the programming of a tool radius offset.

### Syntax

**Tool length offset:**

```
TOFFL=<value>
TOFFL[1]=<value>
TOFFL[2]=<value>
TOFFL[3]=<value>
TOFF[<geometry axis>]=<value>
```

**Tool radius offset:**

```
TOFFR=<value>
```

## 6.8 Programmable tool offset (TOFFL, TOFF, TOFFR)

## Meaning

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| TOFFL:           | <p>Command for the compensation of the effective tool length</p> <p>TOFFL can be programmed with or without index:</p> <ul style="list-style-type: none"> <li>• Without index: TOFFL=</li> <li>• With index: TOFFL[1]=, TOFFL[2]= or TOFFL[3]=</li> </ul> <p>The programmed offset value is applied in the same direction as the tool length component <b>L1</b> stored in the compensation memory.</p> <p>The programmed offset value acts in the same direction as the tool length component <b>L1, L2 or L3</b> stored in the offset memory.</p> <p>The commands TOFFL and TOFFL[1] have an identical effect.</p> <p><b>Note:</b></p> <p>How these tool length offset values are calculated in the axes is determined by the tool type and the current working plane (G17/G18/G19).</p> |      |
| TOFF:            | <p>Command for the compensation of the tool length in the component parallel to the specified geometry axis</p> <p>TOFF is applied in the direction of the tool length component which is effective with non-rotated tool (orientable toolholder or orientation transformation) parallel to the &lt;geometry axis&gt; specified in the index.</p> <p><b>Note:</b></p> <p>A frame does not influence the assignment of the programmed values to the tool length components, i.e. the workpiece coordinate system (WCS) is not used for the assignment of the tool length components to the geometry axes, but rather the tool in the basic tool position.</p>                                                                                                                               |      |
| <geometry axis>: | Identifier of the geometry axis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |
| TOFFR:           | <p>Command for the compensation of the effective tool radius</p> <p>TOFFR changes the effective tool radius <b>with active tool radius compensation</b> by the programmed offset value.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |
| <value>:         | Offset value for the tool length or radius                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |      |
|                  | Type:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | REAL |

**Note**

The TOFFR command has almost the same effect as the OFFN command (see "Tool radius compensation (Page 247)"). There is only a difference with active peripheral curve transformation (TRACYL) and active slot side compensation. In this case, the tool radius is affected by OFFN with a negative sign, but by TOFFR with a positive sign.

OFFN and TOFFR can be effective simultaneously. They then generally have an additive effect (except for slot side compensation).

## Further syntax rules

- The tool length can be changed simultaneously in all three components. However, commands of the TOFFL/TOFFL[1..3] group and commands of the TOFF[<geometry axis>] may not be used simultaneously in one block.  
TOFFL and TOFFL[1] may also not be written simultaneously in one block.
- If all three tool length components are not programmed in a block, the components not programmed remain unchanged. In this way, it is possible to build up offsets for several components block-by-block. However, this only applies as long as the tool components have been modified either only with TOFFL or only with TOFF. Changing the programming type from TOFFL to TOFF or vice versa deletes any previously programmed tool length offsets (see example 3).

## Supplementary conditions

- **Evaluation of setting data**  
The following setting data is evaluated when assigning the programmed offset values to the tool length components:  
SD42940 \$SC\_TOOL\_LENGTH\_CONST (change of tool length components on change of planes).  
SD42950 \$SC\_TOOL\_LENGTH\_TYPE (assignment of the tool length offset independent of tool type).  
If this setting data has valid values not equal to 0, then these take preference over the contents of G code group 6 (plane selection G17 - G19) or the tool type (\$TC\_DP1[<T no.>, <D no.>]) contained in the tool data, i.e. this setting data influences the evaluation of the offsets in the same way as the tool length components L1 to L3.
- **Tool change**  
All offset values are retained during a tool change (cutting edge change), e.g. they are also effective for the new tool (new cutting edge).

## Examples

### Example 1: Positive tool length offset

The active tool is a drill with length L1 = 100 mm.

The active plane is G17, i.e. the drill points in the Z direction.

The effective drill length is to be increased by 1 mm. The following variants are available for the programming of this tool length offset:

TOFFL=1

or

TOFFL[1]=1

or

TOFF[Z]=1

### Example 2: Negative tool length offset

The active tool is a drill with length L1 = 100 mm.

The active plane is G18, i.e. the drill points in the Y direction.

## 6.8 Programmable tool offset (TOFFL, TOFF, TOFFR)

The effective drill length is to be decreased by 1 mm. The following variants are available for the programming of this tool length offset:

TOFFL=-1

or

TOFFL[1]=-1

or

TOFF[Y]=1

### Example 3: Changing the programming type from TOFFL to TOFF

The active tool is a milling tool. The active plane is G17.

| Program code              | Comment                                 |
|---------------------------|-----------------------------------------|
| N10 TOFFL[1]=3 TOFFL[3]=5 | ; Effective offsets: L1=3, L2=0, L3=5   |
| N20 TOFFL[2]=4            | ; Effective offsets: L1=3, L2=4, L3=5   |
| N30 TOFF[Z]=1.3           | ; Effective offsets: L1=0, L2=0, L3=1.3 |

### Example 4: Plane change

| Program code           | Comment                                              |
|------------------------|------------------------------------------------------|
| N10 \$TC_DP1[1,1]=120  |                                                      |
| N20 \$TC_DP3[1,1]= 100 | ; Tool length L1=100 mm.                             |
| N30 T1 D1 G17          |                                                      |
| N40 TOFF[Z]=1.0        | ; Offset in Z direction (corresponds to L1 for G17). |
| N50 G0 X0 Y0 Z0        | ; Machine axis position X0 Y0 Z101.                  |
| N60 G18 G0 X0 Y0 Z0.   | ; Machine axis position X0 Y100 Z1.                  |
| N70 G17                |                                                      |
| N80 TOFFL=1.0          | ; Offset in L1 direction (corresponds to Z for G17). |
| N90 G0 X0 Y0 Z0        | ; Machine axis position X0 Y0 Z101.                  |
| N100 G18 G0 X0 Y0 Z0   | ; Machine axis position X0 Y101 Z0.                  |

In this example, the offset of 1 mm in the Z axis is retained when changing to G18 in block N60; the effective tool length in the Y axis is the unchanged tool length of 100 mm.

However, in block N100, the offset is effective in the Y axis when changing to G18 as it was assigned to tool length L1 in the programming and this length component is effective in the Y axis with G18.

## Further information

### Applications

The "Programmable tool offset" function is especially interesting for ball mills and milling tools with corner radii as these are often calculated in the CAM system to the ball center instead of the ball tip. However, generally the tool tip is measured when measuring the tool and stored as tool length in the compensation memory.

### System variables for reading the current offset values

## 6.8 Programmable tool offset (TOFFL, TOFF, TOFFR)

The currently effective offsets can be read with the following system variables:

| System variable             |                        | Meaning                                                                                                                                     |
|-----------------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| \$P_TOFFL [<n>]             | with $0 \leq n \leq 3$ | Reads the current offset value of TOFFL (for $n = 0$ ) or TOFFL[1...3] (for $n = 1, 2, 3$ ) in the preprocessing context.                   |
| \$P_TOFF [<geometry axis>]  |                        | Reads the current offset value of TOFF[<geometry axis>] in the preprocessing context.                                                       |
| \$P_TOFFR                   |                        | Reads the current offset value of TOFFR in the preprocessing context.                                                                       |
| \$AC_TOFFL [<n>]            | with $0 \leq n \leq 3$ | Reads the current offset value of TOFFL (for $n = 0$ ) or TOFFL[1...3] (for $n = 1, 2, 3$ ) in the main run context (synchronized actions). |
| \$AC_TOFF [<geometry axis>] |                        | Reads the current offset value of TOFF[<geometry axis>] in the main run context (synchronized actions).                                     |
| \$AC_TOFFR                  |                        | Reads the current offset value of TOFFR in the main run context (synchronized actions).                                                     |

**Note**

The system variables \$AC\_TOFFL, \$AC\_TOFF and AC\_TOFFR trigger an automatic preprocessing stop when reading from the preprocessing context (NC program).

*6.8 Programmable tool offset (TOFFL, TOFF, TOFFR)*

## Spindle motion

### 7.1 Spindle speed (S), spindle direction of rotation (M3, M4, M5)

The spindle speed and direction of rotation values set the spindle in rotary motion and provide the conditions for chip removal.

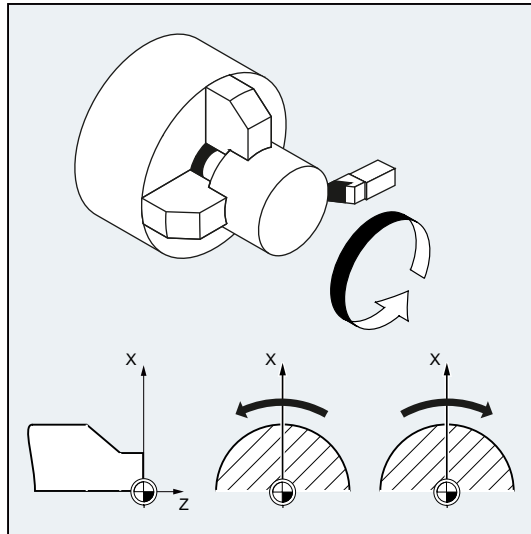


Figure 7-1 Spindle motion during turning

Other spindles may be available in addition to the main spindle (e.g. the counterspindle or an actuated tool on turning machines). As a rule, the main spindle is declared the master spindle in the machine data. This assignment can be changed using an NC command.

### Syntax

S... / S<n>=...

M3 / M<n>=3

M4 / M<n>=4

M5 / M<n>=5

|             |  |
|-------------|--|
| SETMS (<n>) |  |
| ...         |  |
| SETMS       |  |

## Meaning

|               |                                                                                               |
|---------------|-----------------------------------------------------------------------------------------------|
| S...:         | Spindle speed in rpm for the master spindle                                                   |
| S<n>=... :    | Spindle speed in rpm for spindle <n>                                                          |
|               | <b>Note:</b><br>The speed specified with S0=... applies to the master spindle                 |
| M3:           | Direction of spindle rotation clockwise for master spindle                                    |
| M<n>=3:       | Spindle direction of rotation clockwise for spindle <n>                                       |
| M4:           | Direction of spindle rotation counter-clockwise for master spindle                            |
| M<n>=4:       | Spindle direction of rotation counter-clockwise for spindle <n>                               |
| M5:           | Spindle stop for master spindle                                                               |
| M<n>=5:       | Spindle stop for spindle <n>                                                                  |
| SETMS (<n>) : | Set spindle <n> as master spindle                                                             |
| SETMS:        | If SETMS is programmed without a spindle name, the configured master spindle is used instead. |

### Note

Up to three S-values can be programmed per NC block, e.g.:

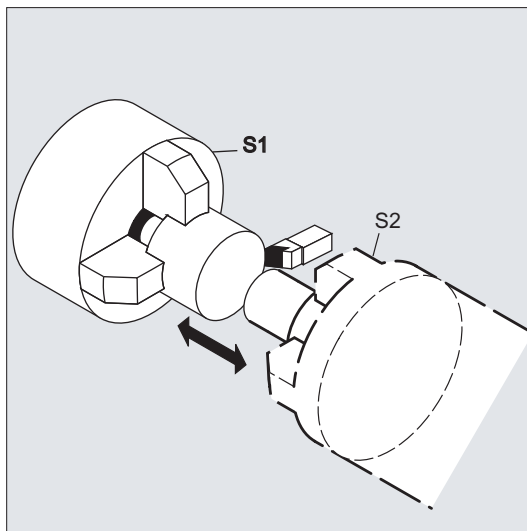
S... S2=... S3=...

### Note

SETMS must be in a separate block.

## Example

S1 is the master spindle, S2 is the second spindle. The part is to be machined from two sides. To do this, it is necessary to divide the operations into steps. After the cut-off point, the synchronizing device (S2) takes over machining of the workpiece after the cut off. To do this, this spindle S2 is defined as the master spindle to which G95 then applies.





## 7.1 Spindle speed (S), spindle direction of rotation (M3, M4, M5)

| Program code       | Comment                                                                       |
|--------------------|-------------------------------------------------------------------------------|
| N10 S300 M3        | ; Speed and direction of rotation for drive spindle = pre-set master spindle. |
| ...                | ; Machining of the right-hand workpiece side.                                 |
| N100 SETMS(2)      | ; S2 is now the master spindle.                                               |
| N110 S400 G95 F... | ; Speed for new master spindle.                                               |
| ...                | ; Machining of the left-hand workpiece side.                                  |
| N160 SETMS         | ; Switching back to master spindle S1.                                        |

## Further information

## Interpretation of the S-value for the master spindle

If function G331 or G332 is active in G function group 1 (modally valid motion commands), the programmed S-value will always be interpreted as the speed in rpm. Otherwise, the interpretation of the S-value will depend upon G function group 15 (feedrate type): If G96, G961 or G962 is active, the S-value is interpreted as a constant cutting rate in m/min; otherwise, it is interpreted as a speed in rpm.

Changing from G96/G961/G962 to G331/G332 sets the value of the constant cutting rate to zero; changing from G331/G332 to a function within the G function group 1 other than G331/G332 sets the speed value to zero. The corresponding S-values have to be reprogrammed if required.

## Preset M commands M3, M4, M5

In a block with axis commands, functions M3, M4, M5 are activated **before** the axis movements commence (basic setting on the control).

Example:

| Program code                | Comment                                                                       |
|-----------------------------|-------------------------------------------------------------------------------|
| N10 G1 F500 X70 Y20 S270 M3 | ; The spindle ramps up to 270 rpm and the movements then executed in X and Y. |
| N100 G0 Z150 M5             | ; Spindle stop before the retraction movement in Z.                           |

## Note

Machine data can be used to set when axis movements should be executed; either once the spindle has powered up to the setpoint speed, or immediately after the programmed switching operations have been traversed.

## Working with multiple spindles

Five spindles (master spindle plus four additional spindles) can be available in one channel at the same time.

One of the spindles is defined in machine data as the **master spindle**. Special functions such as thread cutting, tapping, revolutionary feedrate, and dwell time apply to this spindle. For the remaining spindles (e.g. a second spindle and an actuated tool) the numbers corresponding to the speed and the direction of rotation / spindle stop must be specified.

Example:

| Program code            | Comment                                                                      |
|-------------------------|------------------------------------------------------------------------------|
| N10 S300 M3 S2=780 M2=4 | ; Master spindle: 300 rpm, CW rotation<br>2nd spindle: 780 rpm, CCW rotation |

**Programmable switchover of master spindle**

The SETMS (<n>) command can be used in the NC program to define any spindle as the master spindle. SETMS must be in a separate block.

Example:

| Program code  | Comment                                |
|---------------|----------------------------------------|
| N10 SETMS (2) | ; Spindle 2 is now the master spindle. |

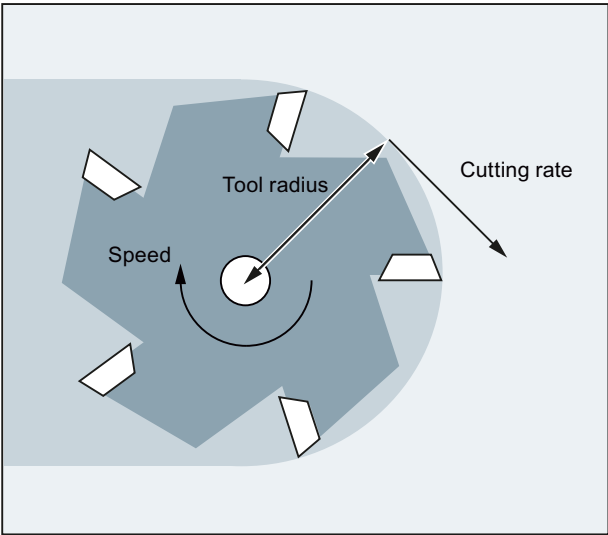
**Note**

The speed specified with S . . . , along with the functions programmed with M3, M4, M5, now apply to the newly declared master spindle.

If SETMS is programmed without a spindle name, the master spindle programmed in the machine data is used instead.

7.2 Cutting rate (SVC)

As an alternative to the spindle speed, the tool cutting rate, which is more commonly used in practice, can be programmed for milling operations.



|                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------|
| The control uses the radius of the active tool to calculate the effective spindle speed from the programmed tool cutting rate: |
| $S = (SVC * 1000) / (R_T * 2\pi)$                                                                                              |

|       |                  |                                 |
|-------|------------------|---------------------------------|
| with: | S:               | Spindle speed in rpm            |
|       | SVC:             | Cutting rate in m/min or ft/min |
|       | R <sub>T</sub> : | Radius of the active tool in mm |

The tool type (\$TC\_DP1) of the active tool is not taken into account.

The programmed cutting rate is independent of the path feedrate  $F$  and G function group 15. The direction of rotation and the spindle start are programmed using M3 and M4 respectively and the spindle stop using M5.

A change to the tool radius data in the offset memory will be applied the next time a tool offset is selected or the next time the active offset data is updated.

Changing the tool or selecting/deselecting a tool offset data set generates a recalculation of the effective spindle speed.

## Requirements

The programming of the cutting rate requires:

- The geometric ratios of a rotating tool (milling cutter or drilling tool)
- An active tool offset data set

## Syntax

SVC[<n>]=<value>

### Note

In the block with SVC, the tool radius must be known; in other words, a corresponding tool including a tool offset data set must be active or selected in the block. There is no fixed sequence for SVC and T/D selection during programming in the same block.

## Meaning

|      |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SVC: | Cutting rate |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|      | [<n>]:       | <p>Number of spindle</p> <p>This address extension specifies which spindle the programmed cutting rate is to be applied for. In the absence of an address extension, the rate is always applied to the master spindle.</p> <p><b>Note:</b><br/>A separate cutting rate can be preset for each spindle.</p> <p><b>Note:</b><br/>Programming SVC without an address extension requires that the master spindle has the active tool. If the master spindle changes, the user will need to select a tool accordingly.</p> |
|      | Unit:        | m/min or ft/min (dependent upon G700/G710)                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Note****Changing between SVC and S**

Changing between *SVC* and *S* programming is possible at will, even while the spindle is turning. In each case, the value that is not active is deleted.

**Note****Maximum tool speed**

System variable \$TC\_TP\_MAX\_VELO[<tool number>] can be used to preset a maximum tool speed (spindle speed).

If no speed limit has been defined, there will be no monitoring.

**Note**

*SVC* programming is not possible if the following are active:

- G96/G961/G962
- GWPS
- SPOS/SPOSA/M19
- M70

Conversely, programming one of these commands will lead to the deselection of *SVC*.

**Note**

The tool paths of "standard tools" generated, e.g. using CAD systems which already take the tool radius into account and only contain the deviation from the standard tool in the tool nose radius, are not supported in conjunction with *SVC* programming.

**Examples**

The following shall apply to all examples: Toolholder = spindle (for standard milling)

**Example 1: Milling cutter 6 mm radius**

| Program code           | Comment                                                                                                                                         |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G0 X10 T1 D1       | ; Selection of milling tool with, e.g.<br>\$TC_DP6[1,1] = 6 (tool radius = 6 mm)                                                                |
| N20 SVC=100 M3         | ; Cutting rate = 100 m/min<br><br>□ Resulting spindle speed:<br>$S = (100 \text{ m/min} * 1000) / (6.0 \text{ mm} * 2 * 3.14) =$<br>2653.93 rpm |
| N30 G1 X50 G95 FZ=0.03 | ; SVC and tooth feedrate                                                                                                                        |
| ...                    |                                                                                                                                                 |

**Example 2: Tool selection and SVC in the same block**

| Program code | Comment |
|--------------|---------|
| N10 G0 X20   |         |

| Program code        | Comment                                                                                |
|---------------------|----------------------------------------------------------------------------------------|
| N20 T1 D1 SVC=100   | ; Tool and offset data set selection together with SVC in block (no specific sequence) |
| N30 X30 M3          | ; Spindle start with CW direction of rotation, cutting rate 100 m/min                  |
| N40 G1 X20 F0.3 G95 | ; SVC and revolutionary feedrate                                                       |

**Example 3: Defining cutting rates for two spindles**

| Program code            | Comment                                                                                                                                  |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| N10 SVC[3]=100 M6 T1 D1 |                                                                                                                                          |
| N20 SVC[5]=200          | ; The tool radius of the active tool offset is the same for both spindles. The effective speed is different for spindle 3 and spindle 5. |

**Example 4:**

Assumptions:

Master or tool change is determined by the toolholder.

MD20124 \$MC\_TOOL\_MANAGEMENT\_TOOLHOLDER > 1

In the event of a tool change the old tool offset is retained. A tool offset for the new tool is only activated when D is programmed:

MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT = - 2

| Program code                   | Comment                                                                                             |
|--------------------------------|-----------------------------------------------------------------------------------------------------|
| N10 \$TC_MPP1[9998,1]=2        | ; Magazine location is toolholder                                                                   |
| N11 \$TC_MPP5[9998,1]=1        | ; Magazine location is toolholder 1                                                                 |
| N12 \$TC_MPP_SP[9998,1]=3      | ; Toolholder 1 is assigned to spindle 3                                                             |
| N20 \$TC_MPP1[9998,2]=2        | ; Magazine location is toolholder                                                                   |
| N21 \$TC_MPP5[9998,2]=4        | ; Magazine location is toolholder 4                                                                 |
| N22 \$TC_MPP_SP[9998,2]=6      | ; Toolholder 4 is assigned to spindle 6                                                             |
| N30 \$TC_TP2[2]="WZ2"          |                                                                                                     |
| N31 \$TC_DP6[2,1]=5.0          | ; Radius = 5.0 mm of T2, offset D1                                                                  |
| N40 \$TC_TP2[8]="WZ8"          |                                                                                                     |
| N41 \$TC_DP6[8,1]=9.0          | ; Radius = 9.0 mm of T8, offset D1                                                                  |
| N42 \$TC_DP6[8,4]=7.0          | ; Radius = 7.0 mm of T8, offset D4                                                                  |
| ...                            |                                                                                                     |
| N100 SETMTH(1)                 | ; Set master toolholder number                                                                      |
| N110 T="WZ2" M6 D1             | ; Tool T2 is loaded and offset D1 is activated.                                                     |
| N120 G1 G94 F1000 M3=3 SVC=100 | ; $S3 = (100 \text{ m/min} * 1,000) / (5.0 \text{ mm} * 2 * 3.14) = 3184.71 \text{ rpm}$            |
| N130 SETMTH(4)                 | ; Set master toolholder number                                                                      |
| N140 T="WZ8"                   | ; Corresponds to T8="WZ8"                                                                           |
| N150 M6                        | ; Corresponds to M4=6                                                                               |
|                                | Tool "WZ8" is in the master toolholder, but because MD20270=-2, the old tool offset remains active. |

## 7.2 Cutting rate (SVC)

| Program code | Comment                                                                                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N160 SVC=50  | ; $S3 = (50 \text{ m/min} * 1,000) / (5.0 \text{ mm} * 2 * 3.14) = 1592.36 \text{ rpm}$ .<br>The offset applied to toolholder 1 is still active and assigned to spindle 3. |
| N170 D4      | ; Offset D4 of the new tool "WZ8" becomes active (in toolholder 4).                                                                                                        |
| N180 SVC=300 | ; $S6 = (300 \text{ m/min} * 1,000) / (7.0 \text{ mm} * 2 * 3.14) = 6824.39 \text{ rpm}$<br>Spindle 6 is assigned to toolholder 4.                                         |

**Example 5:**

Assumptions:

Spindles are toolholders at the same time:

MD20124 \$MC\_TOOL\_MANAGEMENT\_TOOLHOLDER = 0

In the event of a tool change, tool offset data set D4 is selected automatically.

MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT = 4

| Program code                 | Comment                                                                                                                                                                    |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 \$TC_MPP1[9998,1]=2      | ; Magazine location is toolholder                                                                                                                                          |
| N11 \$TC_MPP5[9998,1]=1      | ; Magazine location is toolholder 1 = spindle 1                                                                                                                            |
| N20 \$TC_MPP1[9998,2]=2      | ; Magazine location is toolholder                                                                                                                                          |
| N21 \$TC_MPP5[9998,2]=3      | ; Magazine location is toolholder 3 = spindle 3                                                                                                                            |
| N30 \$TC_TP2[2]="WZ2"        |                                                                                                                                                                            |
| N31 \$TC_DP6[2,1]=5.0        | ; Radius = 5.0 mm of T2, offset D1                                                                                                                                         |
| N40 \$TC_TP2[8]="WZ8"        |                                                                                                                                                                            |
| N41 \$TC_DP6[8,1]=9.0        | ; Radius = 9.0 mm of T8, offset D1                                                                                                                                         |
| N42 \$TC_DP6[8,4]=7.0        | ; Radius = 7.0 mm of T8, offset D4                                                                                                                                         |
| ...                          |                                                                                                                                                                            |
| N100 SETMS(1)                | ; Spindle 1 = master spindle                                                                                                                                               |
| N110 T="WZ2" M6 D1           | ; Tool T2 is loaded and offset D1 is activated.                                                                                                                            |
| N120 G1 G94 F1000 M3 SVC=100 | ; $S1 = (100 \text{ m/min} * 1,000) / (5.0 \text{ mm} * 2 * 3.14) = 3184.71 \text{ rpm}$                                                                                   |
| N200 SETMS(3)                | ; Spindle 3 = master spindle                                                                                                                                               |
| N210 M4 SVC=150              | ; $S3 = (150 \text{ m/min} * 1,000) / (5.0 \text{ mm} * 2 * 3.14) = 4777.07 \text{ rpm}$ .<br>Refers to tool offset D1 of T="WZ2", S1 continues to turn at previous speed. |
| N220 T="WZ8"                 | ; Corresponds to T8="WZ8"                                                                                                                                                  |
| N230 M4 SVC=200              | ; $S3 = (200 \text{ m/min} * 1,000) / (5.0 \text{ mm} * 2 * 3.14) = 6369.43 \text{ rpm}$ .<br>Refers to tool offset D1 of T="WZ2".                                         |
| N240 M6                      | ; Corresponds to M3=6<br>Tool "WZ8" is in the master spindle, tool offset D4 of the new tool becomes active.                                                               |
| N250 SVC=50                  | ; $S3 = (50 \text{ m/min} * 1,000) / (7.0 \text{ mm} * 2 * 3.14) = 1137.40 \text{ rpm}$ .<br>Offset D4 on master spindle is active.                                        |
| N260 D1                      | ; Offset D1 of new tool "WZ8" active.                                                                                                                                      |

| Program code    | Comment                                                            |
|-----------------|--------------------------------------------------------------------|
| N270 SVC[1]=300 | ; S1 = (300 m/min * 1,000) / (9.0 mm * 2 * 3.14) =<br>5307.86 rpm. |
| ...             | S3 = (50 m/min * 1,000) / (9.0 mm * 2 * 3.14) = 884.64 rpm.        |

## Further information

### Tool radius

The following tool offset data (associated with the active tool) affect the tool radius when:

- \$TC\_DP6 (radius - geometry)
- \$TC\_DP15 (radius - wear)
- \$TC\_SCPx6 (offset for \$TC\_DP6)
- \$TC\_ECPx6 (offset for \$TC\_DP6)

The following are not taken into account:

- Online radius compensation
- Allowance on the programmed contour (OFFN)

### Tool radius compensation (G41/G42)

Although tool radius compensation (G41/G42) and SVC both refer to the tool radius, with regard to function, they are not linked and are independent of one another.

### Tapping without compensating chuck (G331, G332)

SVC programming is also possible in conjunction with G331 or G332.

### Synchronized actions

SVC cannot be programmed from synchronized actions.

### Reading the cutting rate and the spindle speed programming variant

The cutting rate of a spindle and the speed programming variant (spindle speed S or cutting rate SVC) can be read using system variables:

- With preprocessing stop in the part program via system variables:

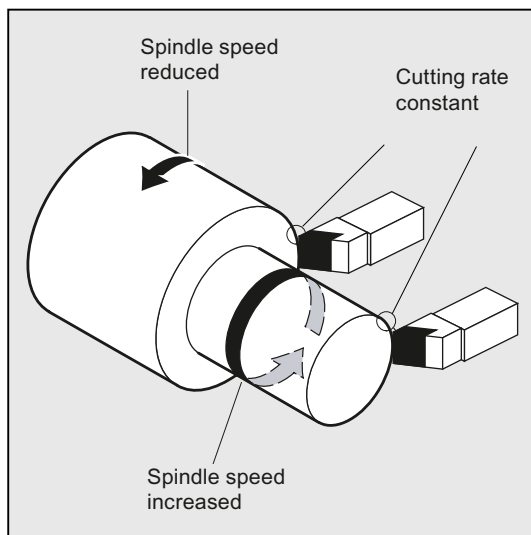
|  |                  |                                                                                                                     |                                     |
|--|------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|  | \$AC_SVC[<n>]    | Cutting rate applied when the current main run record for spindle number <n> was preprocessed.                      |                                     |
|  | \$AC_S_TYPE[<n>] | Spindle speed programming variant applied when the current main run record for spindle number <n> was preprocessed. |                                     |
|  |                  | <b>Value:</b>                                                                                                       | <b>Meaning:</b>                     |
|  |                  | 1                                                                                                                   | Spindle speed S in rpm              |
|  |                  | 2                                                                                                                   | Cutting rate SVC in m/min or ft/min |

- Without preprocessing stop in the part program via system variables:

|  |                 |                                                              |                                     |
|--|-----------------|--------------------------------------------------------------|-------------------------------------|
|  | \$P_SVC[<n>]    | Programmed cutting rate for spindle <n>                      |                                     |
|  | \$P_S_TYPE[<n>] | Programmed spindle speed programming variant for spindle <n> |                                     |
|  |                 | <b>Value:</b>                                                | <b>Meaning:</b>                     |
|  |                 | 1                                                            | Spindle speed S in rpm              |
|  |                 | 2                                                            | Cutting rate SVC in m/min or ft/min |

### 7.3 Constant cutting rate (G96/G961/G962, G97/G971/G972, G973, LIMS, SCC)

When the "Constant cutting rate" function is active, the spindle speed is modified as a function of the respective workpiece diameter so that the cutting rate S in m/min or ft/min remains constant at the tool edge.



This results in the following advantages:

- Uniformity and consequently improved surface quality of turned parts
- Machining with less wear on tools

#### Syntax

Activating/deactivating constant cutting rate for the master spindle:

```
G96/G961/G962
S...
...
G97/G971/G972/
G973
```

Speed limitation for the master spindle:

```
LIMS=<value>
LIMS[<spindle>]=<value>
```



## 7.3 Constant cutting rate (G96/G961/G962, G97/G971/G972, G973, LIMS, SCC)

Other reference axis for G96/G961/G962:

SCC[<axis>]

**Note**

SCC[<axis>] can be programmed together with G96/G961/G962 or in isolation.

**Meaning**

|           |                                                                                                                                                                                                                                                   |                                               |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| G96:      | Constant cutting rate with feedrate type G95: ON<br>G95 is activated automatically with G96. If G95 has not been activated previously, a new feedrate value $F \dots$ will have to be specified when G96 is called.                               |                                               |
| G961:     | Constant cutting rate with feedrate type G94: ON                                                                                                                                                                                                  |                                               |
| G962:     | Constant cutting rate with feedrate type G94 or G95: ON                                                                                                                                                                                           |                                               |
|           | <b>Note:</b><br>See "Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF) (Page 97)" for information about G94 and G95.                                                                                                                                 |                                               |
| S . . . : | In conjunction with G96, G961 or G962, S . . . is not interpreted as a spindle speed but rather as a cutting rate. The cutting rate is always applied to the master spindle.                                                                      |                                               |
|           | Unit:                                                                                                                                                                                                                                             | m/min (for G71/G710) or ft/min (for G70/G700) |
|           | Range of values:                                                                                                                                                                                                                                  | 0.1 m/min to 9999 9999.9 m/min                |
| G97:      | Deactivate constant cutting rate with feedrate type G95<br>After G97 (or G971), S . . . is again interpreted as a spindle speed in rpm. In the absence of a new spindle speed being specified, the last speed set with G96 (or G961) is retained. |                                               |
| G971:     | Deactivate constant cutting rate with feedrate type G94                                                                                                                                                                                           |                                               |
| G972:     | Deactivate constant cutting rate with feedrate type G94 or G95                                                                                                                                                                                    |                                               |
| G973:     | Deactivate constant cutting rate without activating spindle speed limitation                                                                                                                                                                      |                                               |
| LIMS:     | Speed limitation for the master spindle (only applied if G96/G961/G97 active)<br>On machines with selectable master spindles, limitations of differing values can be programmed for up to four spindles within one block.                         |                                               |
|           | <spindle>:                                                                                                                                                                                                                                        | Number of spindle                             |
|           | <value>:                                                                                                                                                                                                                                          | Spindle speed upper limit in rpm              |
| SCC:      | If any of the G96/G961/G962 functions are active, SCC[<axis>] can be used to assign any geometry axis as a reference axis.                                                                                                                        |                                               |

**Note**

When G96/G961/G962 is selected for the first time, a constant cutting rate S . . . must be entered; when G96/G961/G962 is selected again, the entry is optional.

**Note**

The speed limitation programmed with LIMS must not exceed the speed limit programmed with G26 or defined in the setting data.

**Note**

The reference axis for G96/G961/G962 must be a geometry axis assigned to the channel at the time when SCC[<axis>] is programmed. SCC[<axis>] can also be programmed when any of the G96/G961/G962 functions are active.

**Examples****Example 1: Activating the constant cutting rate with speed limitation**

| Program code                        | Comment                                                        |
|-------------------------------------|----------------------------------------------------------------|
| N10 SETMS (3)                       |                                                                |
| N20 G96 S100 LIMS=2500              | ; Constant cutting rate = 100 m/min,<br>max. speed = 2,500 rpm |
| ...                                 |                                                                |
| N60 G96 G90 X0 Z10 F8 S100 LIMS=444 | ; Max. speed = 444 rpm                                         |

**Example 2: Defining speed limitation for four spindles**

Speed limitations are defined for spindle 1 (master spindle) and spindles 2, 3, and 4:

| Program code                                         |
|------------------------------------------------------|
| N10 LIMS=300 LIMS[2]=450 LIMS[3]=800<br>LIMS[4]=1500 |
| ...                                                  |

**Example 3: Y-axis assignment for face cutting with X axis**

| Program code            | Comment                                                                                                                                                 |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G18 LIMS=3000 T1 D1 | ; Speed limitation at 3000 rpm                                                                                                                          |
| N20 G0 X100 Z200        |                                                                                                                                                         |
| N30 Z100                |                                                                                                                                                         |
| N40 G96 S20 M3          | ; Constant cutting rate = 20 m/min, is dependent upon<br>X axis.                                                                                        |
| N50 G0 X80              |                                                                                                                                                         |
| N60 G1 F1.2 X34         | ; Face cutting in X at 1.2 mm/revolution.                                                                                                               |
| N70 G0 G94 X100         |                                                                                                                                                         |
| N80 Z80                 |                                                                                                                                                         |
| N100 T2 D1              |                                                                                                                                                         |
| N110 G96 S40 SCC[Y]     | ; Y axis is assigned to G96 and G96 is activated (can<br>be achieved in a single block). Constant cutting rate<br>= 40 m/min, is dependent upon X axis. |
| ...                     |                                                                                                                                                         |
| N140 Y30                |                                                                                                                                                         |
| N150 G01 F1.2 Y=27      | ; Plunge-cutting in Y, feedrate F = 1.2 mm/revolution.                                                                                                  |
| N160 G97                | ; Constant cutting rate off.                                                                                                                            |
| N170 G0 Y100            |                                                                                                                                                         |

## Further information

### Calculation of the spindle speed

The ENS position of the face axis (radius) is the basis for calculating the spindle speed from the programmed cutting rate.

---

### Note

Frames between WCS and SZS (e.g. programmable frames such as SCALE, TRANS or ROT) are taken into account in the calculation of the spindle speed and can bring about a change in speed (for example, if there is a change in the effective diameter in the case of SCALE).

---

### Speed limitation LIMS

If a workpiece that varies greatly in diameter needs to be machined, it is advisable to specify a speed limit for the spindle with `LIMS` (maximum spindle speed). This prevents excessively high speeds with small diameters. `LIMS` is only applied when `G96`, `G961`, and `G97` are active. `LIMS` is not applied when `G971` is selected. On loading the block into the main run, all programmed values are transferred into the setting data.

---

### Note

The speed limits changed with `LIMS` in the part program are taken into the setting data and therefore remain saved after the end of program.

However, if the speed limits changed with `LIMS` are no longer to apply after the end of program, the following definition must be inserted in the GUD block of the machine manufacturer:

```
REDEF $SA_SPIND_MAX_VELO_LIMS PRLOC
```

---

### Deactivating the constant cutting rate (G97/G971/G973)

After `G97/G971`, the control interprets an `S` value as a spindle speed in rpm again. If you do not specify a new spindle speed, the last speed set with `G96/G961` is retained.

The `G96/G961` function can also be deactivated with `G94` or `G95`. In this case, the last speed programmed `S . . .` is used for subsequent machining operations.

`G97` can be programmed without `G96` beforehand. The function then has the same effect as `G95`; `LIMS` can also be programmed.

Using `G973`, the constant cutting rate can be deactivated without activating a spindle speed limitation.

---

### Note

The transverse axis must be defined in machine data.

---

### Rapid traverse G0

With rapid traverse `G0`, there is no change in speed.

Exception:

### 7.3 Constant cutting rate (G96/G961/G962, G97/G971/G972, G973, LIMS, SCC)

If the contour is approached in rapid traverse and the next NC block contains a G1/G2/G3/etc. path command, the speed is adjusted in the G0 approach block for the next path command.

#### Other reference axis for G96/G961/G962

If any of the G96/G961/G962 functions are active, SCC[<axis>] can be used to assign any geometry axis as a reference axis. If the reference axis changes, which will in turn affect the TCP (tool center point) reference position for the constant cutting rate, the resulting spindle speed will be reached via the set braking or acceleration ramp.

#### Axis replacement of the assigned channel axis

The reference axis property for G96/G961/G962 is always assigned to a geometry axis. In the event of an axis exchange involving the assigned channel axis, the reference axis property for G96/G961/G962 is retained in the old channel.

A geometry axis exchange will not affect how the geometry axis is assigned to the constant cutting rate. If the TCP reference position for G96/G961/G962 is affected by a geometry axis exchange, the spindle will reach the new speed via a ramp.

If no new channel axis is assigned as a result of a geometry axis exchange (e.g. GEOAX(0, X)), the spindle speed will be frozen in accordance with G97.

Examples for geometry axis exchange with assignments of the reference axis:

| Program code     | Comment                                                                      |
|------------------|------------------------------------------------------------------------------|
| N05 G95 F0.1     |                                                                              |
| N10 GEOAX(1, X1) | ; Channel axis X1 becomes the first geometry axis.                           |
| N20 SCC[X]       | ; First geometry axis (X) becomes the reference axis<br>; for G96/G961/G962. |
| N30 GEOAX(1, X2) | ; Channel axis X2 becomes the first geometry axis.                           |
| N40 G96 M3 S20   | ; Reference axis for G96 is channel axis X2.                                 |

| Program code     | Comment                                                                                          |
|------------------|--------------------------------------------------------------------------------------------------|
| N05 G95 F0.1     |                                                                                                  |
| N10 GEOAX(1, X1) | ; Channel axis X1 becomes the first geometry axis.                                               |
| N20 SCC[X1]      | ; X1 and implicitly the first geometry axis (X) becomes<br>the reference axis for G96/G961/G962. |
| N30 GEOAX(1, X2) | ; Channel axis X2 becomes the first geometry axis.                                               |
| N40 G96 M3 S20   | ; Reference axis for G96 is X2 or X, no alarm.                                                   |

| Program code     | Comment                                            |
|------------------|----------------------------------------------------|
| N05 G95 F0.1     |                                                    |
| N10 GEOAX(1, X2) | ; Channel axis X2 becomes the first geometry axis. |
| N20 SCC[X1]      | ; X1 is not a geometry axis, alarm.                |

| Program code | Comment |
|--------------|---------|
| N05 G0 Z50   |         |
| N10 X35 Y30  |         |

## 7.4 Constant grinding wheel peripheral speed (GWPSON, GWPSOF)

| Program code    | Comment                                                             |
|-----------------|---------------------------------------------------------------------|
| N15 SCC[X]      | ; Reference axis for G96/G961/G962 is X.                            |
| N20 G96 M3 S20  | ; Constant cutting rate ON at 10 mm/min.                            |
| N25 G1 F1.5 X20 | ; Face cutting in X at 1.5 mm/revolution.                           |
| N30 G0 Z51      |                                                                     |
| N35 SCC[Y]      | ; Reference axis for G96 is Y,<br>reduction of spindle speed (Y30). |
| N40 G1 F1.2 Y25 | ; Face cutting in Y at 1.2 mm/revolution.                           |

**References:**

Function Manual, Basic Functions; Transverse Axes (P1) and Feedrates (V1)

## 7.4 Constant grinding wheel peripheral speed (GWPSON, GWPSOF)

The "Constant grinding wheel peripheral speed (GWPS)" function is used to set the grinding wheel speed so that, taking account of the current radius, the grinding wheel peripheral speed remains constant.

**Syntax**

```
GWPSON(<t no.>)
GWPSOF(<t no.>)
S.../S<n>=...
```

**Meaning**

|           |                                                                                                                                              |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------|
| GWPSON:   | Select constant grinding wheel peripheral speed                                                                                              |
| GWPSOF:   | Deselect constant grinding wheel peripheral speed                                                                                            |
| <t no.>:  | It is only necessary to specify the T number if the tool with this T number is not active                                                    |
| S...:     | Peripheral speed in m/s or ft/s for the master spindle                                                                                       |
| S<n>=...: | Peripheral speed in m/s or ft/s for spindle <n><br><b>Note:</b><br>The peripheral speed specified with S0=... applies to the master spindle. |

**Note**

A grinding wheel peripheral speed can only be programmed for grinding tools (types 400 to 499).

**Example**

A constant grinding wheel peripheral speed is to be used for grinding tools T1 and T5.

## 7.4 Constant grinding wheel peripheral speed (GWPSON, GWPSOF)

T1 is the active tool.

| Program code     | Comment                                   |
|------------------|-------------------------------------------|
| N20 T1 D1        | ; Select T1 and D1.                       |
| N25 S1=1000 M1=3 | ; 1000 rpm for spindle 1.                 |
| N30 S2=1500 M2=3 | ; 1500 rpm for spindle 2.                 |
| ...              |                                           |
| N40 GWPSON       | ; Selection of GWPS for active tool.      |
| N45 S1=60        | ; Set GWPS to 60 m/s for active tool.     |
| ...              |                                           |
| N50 GWPSON(5)    | ; GWPS selection for tool 5 (spindle 2).  |
| N55 S2=40        | ; Set GWPS to 40 m/s for spindle 2.       |
| ...              |                                           |
| N60 GWPSOF       | ; Deactivate GWPS for active tool.        |
| N65 GWPSOF(5)    | ; Deactivate GWPS for tool 5 (spindle 2). |

## Further information

**Tool-specific parameters**

In order to activate the function "Constant peripheral speed", the tool-specific grinding data \$TC\_TPG1, \$TC\_TPG8 and \$TC\_TPG9 must be set accordingly. When the GWPS function is active, even online offset values (= wear parameters; cf. "Grinding-specific tool monitoring in the part program TMON, TMOF" or PUTFTOC, PUTFTOCF) must be taken into account when changing speed.

**Select GWPS: GWPSON, programming GWPS**

After selecting the GWPS with GWPSON, each subsequent S value for this spindle is interpreted as a grinding wheel peripheral speed.

Selection of grinding wheel peripheral speed with GWPSON does not cause the automatic activation of tool length compensation or tool monitoring.

The GWPS can be active for several spindles on a channel with different tool numbers.

If GWPS is to be selected for a new tool on a spindle where GWPS is already active, the active GWPS must first be deselected with GWPSOF.

**Deactivate GWPS: GWPSOF**

When GWPS is deselected with GWPSOF, the last speed to be calculated remains valid as the setpoint.

GWPS programming is reset at the end of the part program or on RESET.

**Query active GWPS: \$P\_GWPS[<spindle no.>]**

This system variable can be used to query from the part program whether the GWPS is active for a specific spindle.

TRUE: GWPS is **active**.

FALSE: GWPS is **inactive**.

## 7.5 Programmable spindle speed limitation (G25, G26)

The minimum and maximum spindle speeds defined in the machine and setting data can be modified by means of a part program command.

Programmed spindle speed limitations are possible for all spindles of the channel.

### Syntax

```
G25 S... S1=... S2=...
G26 S... S1=... S2=...
```

### Meaning

G25: **Lower** spindle speed limit  
 G26: **Upper** spindle speed limit  
 S... S1=... S2=... : Minimum or maximum spindle speed(s)  
**Note:**  
 A maximum of three spindle speed limits can be programmed for each block.  
 Range of values: 0.1 to 9999 9999.9 rpm

### Note

A spindle speed limitation programmed with G25 or G26 overwrites the speed limits in the setting data and, therefore, remains stored even after the end of the program.

However, if the speed limits changed with G25/G26 are no longer to apply after the end of program, the following definitions must be inserted in the GUD block of the machine manufacturer:

```
REDEF $SA_SPIND_MIN_VELO_G25 PRLOC
REDEF $SA_SPIND_MAX_VELO_G26 PRLOC
```

### Example

| Program code                | Comment                                                          |
|-----------------------------|------------------------------------------------------------------|
| N10 G26 S1400 S2=350 S3=600 | ; Upper speed limit for master spindle, spindle 2 and spindle 3. |





## Feed control

### 8.1 Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF)

These commands are used in the NC program to set the feedrates for all axes involved in the machining sequence.

#### Syntax

```
G93
G94
G95
F<value>
FGROUP(<axis_1>,<axis_2>,...)
FGREF[<rotary axis>]=<reference radius>
FL[<axis>]=<value>
```

#### Meaning

|          |                                                                                                                                                                                     |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G93:     | Path feed type: Inverse-time feedrate [rpm]                                                                                                                                         |
| G94:     | Path feed type: Linear feedrate [mm/min], [inch/min] or [degrees/min]                                                                                                               |
| G95:     | Path feed type: Revolutionary feedrate [mm/revolution] or [inch/revolution]<br>The revolutionary feedrate can be derived from a master spindle, any other spindle or a rotary axis. |
| F<value> | Path feedrate for all or the path axes selected with FGROUP.                                                                                                                        |
| FGROUP:  | Definition of the path axes to which the F-programmed path feed refers                                                                                                              |
| FGREF:   | FGREF is used to program the effective radius (<reference radius>) for each of the rotary axes specified under FGROUP                                                               |
| FL:      | Limit velocity for synchronized/path axes<br>The unit set with G94 applies<br>One FL value can be programmed per axis (channel axes, geometry axis or orientation axis)             |
| <axis>:  | Name of a channel axis, type: AXIS                                                                                                                                                  |

#### Examples

##### Example 1: Mode of operation of FGROUP

The following example is intended to demonstrate the effect of FGROUP on the path and path feedrate. The variable \$AC\_TIME contains the time of the block start in seconds. It can only be used in synchronized actions.

| Program code     | Comment |
|------------------|---------|
| N100 G0 X0 A0    |         |
| N110 FGROUP(X,A) |         |

## 8.1 Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF)

| Program code               | Comment                                                           |
|----------------------------|-------------------------------------------------------------------|
| N120 G91 G1 G710 F100      | ; Feedrate = 100mm/min or 100 degrees/min                         |
| N130 DO \$R1=\$AC_TIME     |                                                                   |
| N140 X10                   | ; Feedrate = 100 mm/min, path = 10 mm, R1 = approx. 6 s           |
| N150 DO \$R2=\$AC_TIME     |                                                                   |
| N160 X10 A10               | ; Feedrate = 100 mm/min, path = 14.14 mm, R2 = approx. 8 s        |
| N170 DO \$R3=\$AC_TIME     |                                                                   |
| N180 A10                   | ; Feedrate = 100 degrees/min, path = 10 degrees, R3 = approx. 6 s |
| N190 DO \$R4=\$AC_TIME     |                                                                   |
| N200 X0.001 A10            | ; Feedrate = 100 mm/min, path = 10 mm, R4 = approx. 6 s           |
| N210 G700 F100             | ; Feedrate = 2540 mm/min or 100 degrees/min                       |
| N220 DO \$R5=\$AC_TIME     |                                                                   |
| N230 X10                   | ; Feedrate = 2540 mm/min, path = 254 mm, R5 = approx. 6 s         |
| N240 DO \$R6=\$AC_TIME     |                                                                   |
| N250 X10 A10               | ; Feedrate = 2540 mm/min, path = 254.2 mm, R6 = approx. 6 s       |
| N260 DO \$R7=\$AC_TIME     |                                                                   |
| N270 A10                   | ; Feedrate = 100 degrees/min, path = 10 degrees, R7 = approx. 6 s |
| N280 DO \$R8=\$AC_TIME     |                                                                   |
| N290 X0.001 A10            | ; Feedrate = 2540 mm/min, path = 10 mm, R8 = approx. 0.288 s      |
| N300 FGREF[A]=360/(2*\$PI) | ; Set 1 degree = 1 inch via the effective radius                  |
| N310 DO \$R9=\$AC_TIME     |                                                                   |
| N320 X0.001 A10            | ; Feedrate = 2540 mm/min, path = 254 mm, R9 = approx. 6 s         |
| N330 M30                   |                                                                   |

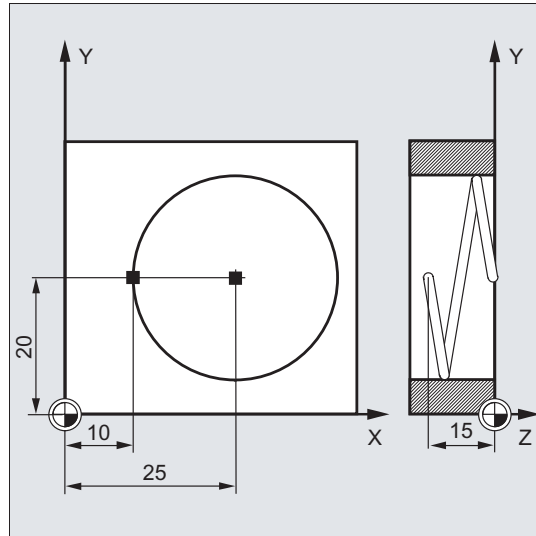
**Example 2: Traverse synchronized axes with limit speed FL**

The path velocity of the path axes is reduced if the synchronized axis Z reaches the limit velocity.

| Program code                           |
|----------------------------------------|
| N10 G0 X0 Y0                           |
| N20 FGROUP(X)                          |
| N30 G1 X1000 Y1000 G94 F1000 FL[Y]=500 |
| N40 Z-50                               |

**Example 3: Helical interpolation**

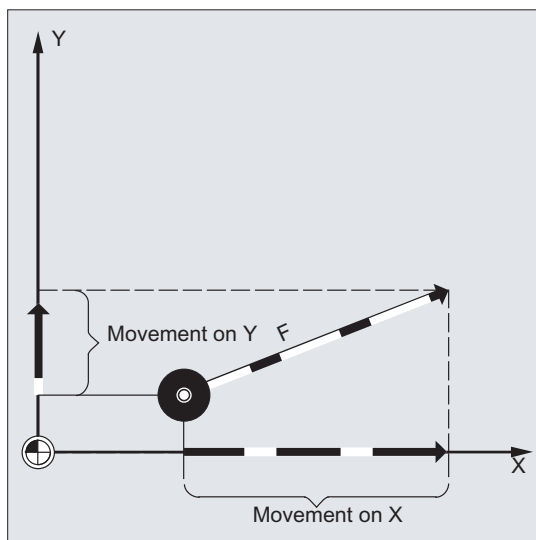
Path axes X and Y traverse with the programmed feedrate, the infeed axis Z is a synchronized axis.



| Program code                               | Comment                                                                                              |
|--------------------------------------------|------------------------------------------------------------------------------------------------------|
| N10 G17 G94 G1 Z0 F500                     | ; Feed of the tool.                                                                                  |
| N20 X10 Y20                                | ; Approach the starting position.                                                                    |
| N25 FGROUPE(X,Y)                           | ; Axes X/Y are path axes, Z is a synchronized axis.                                                  |
| N30 G2 X10 Y20 Z-15 I15 J0 F1000 FL[Z]=200 | ; On the circular path, the feedrate is 1,000 mm/min, traversing in the Z direction is synchronized. |
| ...                                        |                                                                                                      |
| N100 FL[Z]=\$MA_AX_VELO_LIMIT[0,Z]         | ; The limit speed is deselected by reading the speed from the MD. Read the value from the MD.        |
| N110 M30                                   | ; End of program                                                                                     |

**Further information****Feedrate for path axes (F)**

The path feedrate is generally composed of the individual speed components of all geometry axes participating in the movement and refers to the center point of the cutter or the tip of the turning tool.



The feedrate is specified under address **F**. Depending on the default setting in the machine data, the units of measurement specified with the G commands are either in mm or inch.

One **F** value can be programmed per NC block. The feedrate unit is defined using one of the G commands G93/G94/G95. The feedrate **F** acts only on path axes and remains active until a new feedrate is programmed. Separators are permitted after the address **F**.

Examples:

F100 or F 100

F.5

F=2\*FEED

#### Feedrate type (G93/G94/G95)

The G commands G93, G94 and G95 are modal. In the event of switching between G93, G94 and G95, the path feedrate value has to be reprogrammed. When machining with rotary axes, the feedrate can also be specified in degrees/min.

#### Inverse-time feedrate (G93)

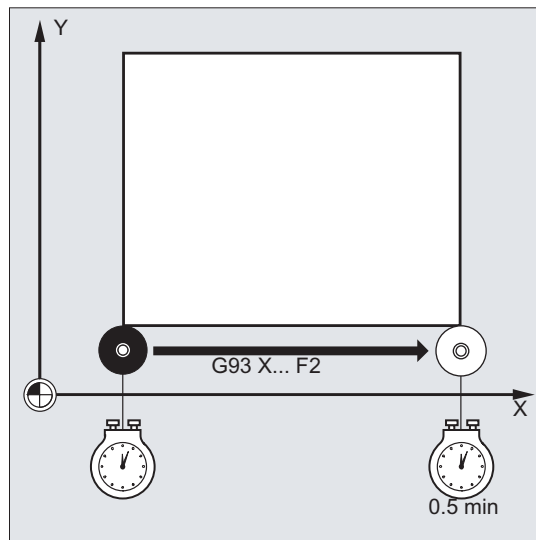
The inverse-time feedrate specifies the time required to execute the motion commands in a block.

Unit: rpm

Example:

N10 G93 G01 X100 F2

Means: The programmed path is traversed in 0.5 min.

**Note**

If the path lengths vary greatly from block to block, a new **F** value should be specified in each block with **G93**. When machining with rotary axes, the feedrate can also be specified in degrees/min.

**Feedrate for synchronized axes**

The feedrate programmed under address **F** applies to all the path axes programmed in a block but not to the synchronized axes. The synchronized axes are controlled such that they require the same time for their path as the path axes, and all axes reach their end point at the same time.

**Limit velocity for synchronized axes (FL)**

The **FL** command can be used to program a limit velocity for synchronized axes. In the absence of a programmed **FL**, the rapid traverse velocity applies. **FL** is deselected by assignment to MD (MD36200 \$MA\_AX\_VELO\_LIMIT).

**Traverse path axis as synchronized axis (FGROUP)**

**FGROUP** is used to define whether a path axis should be traversed with path feedrate or as a synchronized axis. In helical interpolation, for example, it is possible to define that only two geometry axes, X and Y, are to be traversed at the programmed feedrate. The infeed axis Z is the synchronized axis in this case.

Example: **FGROUP (X, Y)**

**Change FGROUP**

### 8.1 Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF)

The setting made with FGROUP can be changed:

1. By reprogramming FGROUP: e.g. FGROUP (X, Y, Z)
2. By programming FGROUP without a specific axis: FGROUP ( )  
In accordance with FGROUP ( ) , the initial setting in the machine data applies: Geometry axes are now once again traversed in the path axis grouping.

---

#### Note

With FGROUP, axis identifiers must be the names of channel axes.

---

#### Units of measurement for feedrate F

In addition to the geometrical settings G700 and G710, the G commands are also used to define the measuring system for the feedrates F. In other words:

- For G700: [inch/min]
- For G710: [mm/min]

---

#### Note

G70/G71 have no effect on feedrate settings.

---

#### Unit of measurement for synchronized axes with limit speed FL

The unit set for F using G command G700/G710 is also valid for FL.

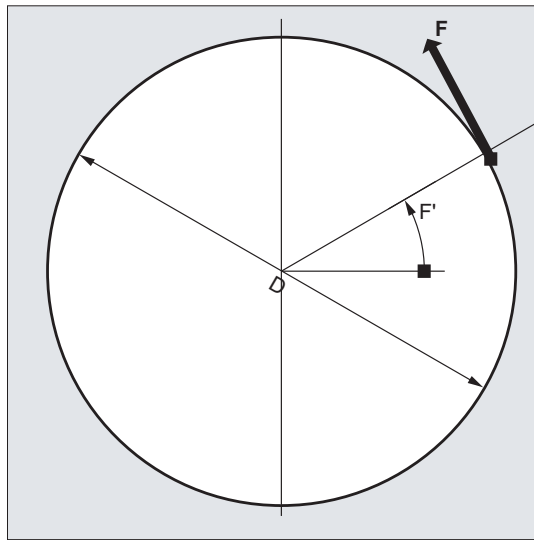
#### Unit for rotary and linear axes

For linear and rotary axes which are combined with FGROUP and traverse a path together, the feedrate is interpreted in the unit of the linear axes (depending on the default with G94/G95, in mm/min or inch/min and mm/rev or inch/rev).

The tangential velocity of the rotary axis in mm/min or inch/min is calculated according to the following formula:

$$F[\text{mm/min}] = F'[\text{degrees/min}] * \pi * D[\text{mm}]/360[\text{degrees}]$$

|       |     |                     |
|-------|-----|---------------------|
| with: | F:  | Tangential velocity |
|       | F': | Angular velocity    |
|       | π:  | Circle constant     |
|       | D:  | Diameter            |



### Traverse rotary axes with path velocity F (FGREF)

For machining operations in which the tool or the workpiece or both are moved by a rotary axis, the effective machining feedrate is to be interpreted as a path feed in the usual way by reference to the F value. This requires the specification of an effective radius (reference radius) for each of the rotary axes involved.

The unit of the reference radius depends on the G70/G71/G700/G710 setting.

All axes involved must be included in the FGROUP command to be taken into account in the calculation of the path feedrate.

In order to ensure compatibility with the behavior with no FGREF programming, the factor 1 degree = 1 mm is activated on system power up and RESET. This corresponds to a reference radius of  $FGREF = 360 \text{ mm} / (2\pi) = 57.296 \text{ mm}$ .

### Note

This default is independent of the active basic system (MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC) and the currently active G70/G71/G700/G710 setting.

### Special situations:

#### Program code

```
N100 FGROUP(X,Y,Z,A)
N110 G1 G91 A10 F100
N120 G1 G91 A10 X0.0001 F100
```

## 8.1 Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF)

With this type of programming, the F value programmed in N110 is evaluated as the rotary axis feedrate in degrees/min, while the feedrate evaluation in N120 is either 100 inch/min or 100 mm/min, dependent upon the currently active G70/G71/G700/G710 setting.

**NOTICE****Feedrate difference**

FGREF evaluation also works if only rotary axes are programmed in the block. The normal F value interpretation as degrees/min applies in this case only if the radius reference corresponds to the FGREF default:

- For G71/G710: FGREF[A]=57.296
- For G70/G700: FGREF[A]=57.296/25.4

**Read reference radius**

The value of the reference radius of a rotary axis can be read using system variables:

- In synchronized actions or with preprocessing stop in the part program via system variable:

|                    |                        |
|--------------------|------------------------|
| \$AA_FGREF[<axis>] | Current main run value |
|--------------------|------------------------|

- Without preprocessing stop in the part program via system variable:

|                    |                  |
|--------------------|------------------|
| \$PA_FGREF[<axis>] | Programmed value |
|--------------------|------------------|

If no values are programmed, the default  $360 \text{ mm}/(2\pi) = 57.296 \text{ mm}$  (corresponding to 1 mm per degree) will be read in both variables.

For linear axes, the value in both variables is always 1 mm.

**Read path axes affecting velocity**

The axes involved in path interpolation can be read using system variables:

- In synchronized actions or with preprocessing stop in the part program via system variables:

|                     |                                                                                                                                                                                                                  |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| \$AA_FGROUP[<axis>] | Returns the value "1" if the specified axis affects the path velocity in the current main run record by means of the basic setting or through FGROUP programming. Otherwise, the variable returns the value "0". |
| \$AC_FGROUP_MASK    | Returns a bit key of the channel axes programmed with FGROUP which are to affect the path velocity.                                                                                                              |

- Without preprocessing stop in the part program via system variables:

|                     |                                                                                                                                                                                   |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| \$PA_FGROUP[<axis>] | Returns the value "1" if the specified axis affects the path velocity by means of the basic setting or through FGROUP programming. Otherwise, the variable returns the value "0". |
| \$P_FGROUP_MASK     | Returns a bit key of the channel axes programmed with FGROUP which are to affect the path velocity.                                                                               |

**Path reference factors for orientation axes with FGREF**



## 8.2 Traverse positioning axes (POS, POSA, POSP, FA, WAITP, WAITMC)

With orientation axes the mode of operation of the `FGREF` [ ] factors is dependent upon whether the change in the orientation of the tool is implemented by means of rotary axis or vector interpolation.

In the case of **rotary axis interpolation**, as is the case with rotary axes, the relevant `FGREF` factors of the orientation axes are calculated individually as reference radius for the axis paths.

In the case of **vector interpolation**, an effective `FGREF` factor, which is calculated as the geometric mean value of the individual `FGREF` factors, is applied.

$FGREF[\text{effective}] = \text{nth root of } [(FGREF[A] * FGREF[B] \dots)]$

|       |    |                                         |
|-------|----|-----------------------------------------|
| with: | A: | Axis identifier of 1st orientation axis |
|       | B: | Axis identifier of 2nd orientation axis |
|       | C: | Axis identifier of 3rd orientation axis |
|       | n: | Number of orientation axes              |

Example:

Since there are two orientation axes for a standard 5-axis transformation, the effective factor is, therefore, the root of the product of the two axial factors:

$FGREF[\text{effective}] = \text{square root of } [(FGREF[A] * FGREF[B])]$

### Note

It is, therefore, possible to use the effective factor for orientation axes `FGREF` to define a reference point on the tool to which the programmed path feedrate refers.

## 8.2 Traverse positioning axes (POS, POSA, POSP, FA, WAITP, WAITMC)

Positioning axes are traversed independently of the path axes at a separate, axis-specific feedrate. There are no interpolation commands. The `POS/POSA/POSP` commands are used to traverse the positioning axes and coordinate the motion sequences at the same time.

The following are typical examples of positioning axes:

- Pallet feed equipment
- Gauging stations

`WAITP` can be used to identify a position in the NC program where the program is to wait until an axis programmed with `POSA` in a previous NC block reaches its end position.

`WAITMC` loads the next NC block immediately when the specified wait marker is received.

### Syntax

`POS[<axis>]=<position>`

`POSA[<axis>]=<position>`

`POSP[<axis>]=(<end position>,<partial length>,<mode>)`

## 8.2 Traverse positioning axes (POS, POSA, POSP, FA, WAITP, WAITMC)

FA[<axis>]=<value>

WAITP(<axis>) ; Programming in a separate NC block.

WAITMC(<wait marker>)

## Meaning

|           |                                                                                                                                                                                                               |                                                                                                     |                                                                                                                                            |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| POS/POSA: | Move positioning axis to specified position                                                                                                                                                                   |                                                                                                     |                                                                                                                                            |
|           | POS and POSA have the same functionality but differ in their block change behavior:                                                                                                                           |                                                                                                     |                                                                                                                                            |
|           | <ul style="list-style-type: none"><li>• POS delays the enabling of the NC block until the position has been reached.</li><li>• POSA enables the NC block even if the position has not been reached.</li></ul> |                                                                                                     |                                                                                                                                            |
|           | <axis>:                                                                                                                                                                                                       | Name of the axis to be traversed (channel or geometry axis identifier)                              |                                                                                                                                            |
|           | <position>:                                                                                                                                                                                                   | Axis position to be approached                                                                      |                                                                                                                                            |
|           | Type:                                                                                                                                                                                                         | REAL                                                                                                |                                                                                                                                            |
|           |                                                                                                                                                                                                               |                                                                                                     |                                                                                                                                            |
| POSP:     | Move positioning axis to specified end position in sections                                                                                                                                                   |                                                                                                     |                                                                                                                                            |
|           | <end position>:                                                                                                                                                                                               | Axis end position to be approached                                                                  |                                                                                                                                            |
|           | <partial length>:                                                                                                                                                                                             | Length of a section                                                                                 |                                                                                                                                            |
|           | <mode>:                                                                                                                                                                                                       | Approach mode                                                                                       |                                                                                                                                            |
|           |                                                                                                                                                                                                               | = 0:                                                                                                | For the last two sections, the path remaining until the end position is split into two residual sections of equal size (preset).           |
|           |                                                                                                                                                                                                               | = 1:                                                                                                | The partial length is adjusted so that the total of all calculated partial lengths corresponds exactly to the path up to the end position. |
|           | <b>Note:</b><br>POSP is used specifically to program oscillating motion.                                                                                                                                      |                                                                                                     |                                                                                                                                            |
|           | <b>References:</b><br>Programming Manual, Job Planning; Section "Oscillation"                                                                                                                                 |                                                                                                     |                                                                                                                                            |
| FA:       | Feedrate for the specified positioning axis                                                                                                                                                                   |                                                                                                     |                                                                                                                                            |
|           | <axis>:                                                                                                                                                                                                       | Name of the axis to be traversed (channel or geometry axis identifier)                              |                                                                                                                                            |
|           | <value>:                                                                                                                                                                                                      | Feedrate                                                                                            |                                                                                                                                            |
|           |                                                                                                                                                                                                               | Unit:                                                                                               | mm/min or inch/min or degrees/min                                                                                                          |
|           | <b>Note:</b><br>Up to five FA values can be programmed for each NC block.                                                                                                                                     |                                                                                                     |                                                                                                                                            |
| WAITP:    | Wait for a positioning axis to be traversed                                                                                                                                                                   |                                                                                                     |                                                                                                                                            |
|           | The subsequent blocks are not processed until the specified positioning axis programmed in a previous NC block with POSA has reached its end position (with exact stop fine).                                 |                                                                                                     |                                                                                                                                            |
|           | <axis>:                                                                                                                                                                                                       | Name of the axis (channel or geometry axis identifier) for which the WAITP command is to be applied |                                                                                                                                            |
|           | <b>Note:</b><br>With WAITP, an axis can be made available as an oscillating axis or for traversing as a concurrent positioning axis (via PLC).                                                                |                                                                                                     |                                                                                                                                            |
| WAITMC:   | Wait for the specified wait marker to be received                                                                                                                                                             |                                                                                                     |                                                                                                                                            |
|           | When the wait marker is received, the next NC block is loaded immediately.                                                                                                                                    |                                                                                                     |                                                                                                                                            |
|           | <wait marker>:                                                                                                                                                                                                | Number of the wait marker                                                                           |                                                                                                                                            |

**CAUTION****Travel with POSA**

If a command, which implicitly causes a preprocessing stop, is read in a following block, this block is not executed until all other blocks which are already preprocessed and stored have been executed. The previous block is stopped in exact stop (as G9).

**Examples****Example 1: Travel with POSA and access to machine status data**

The control generates an internal preprocessing stop on access to machine status data (\$A...). Machining is stopped until all preprocessed and saved blocks have been executed in full.

| Program code                         | Comment                          |
|--------------------------------------|----------------------------------|
| N40 POSA[X]=100                      |                                  |
| N50 IF \$AA_IM[X]==R100 GOTOF LABEL1 | ; Access to machine status data. |
| N60 G0 Y100                          |                                  |
| N70 WAITP(X)                         |                                  |
| N80 LABEL1:                          |                                  |
| N...                                 |                                  |

**Example 2: Wait for end of travel with WAITP**

Pallet feed equipment

Axis U: Pallet store

Transport of workpiece pallet to working area

Axis V: Transfer line to a gauging station where spot checks are carried out to assist the process

| Program code                          | Comment                                                                                   |
|---------------------------------------|-------------------------------------------------------------------------------------------|
| N10 FA[U]=100 FA[V]=100               | ; Axis-specific feedrate specifications for the individual positioning axes U and V.      |
| N20 POSA[V]=90 POSA[U]=100 G0 X50 Y70 | ; Traverse positioning and path axes.                                                     |
| N50 WAITP(U)                          | ; Program execution does not resume until axis U reaches the end point programmed in N20. |
| ...                                   |                                                                                           |

**Further information****Travel with POSA**

### 8.3 Position-controlled spindle mode (SPCON, SPCOF)

Block step enable or program execution is not affected by `POSA`. The movement to the end position can be performed during execution of subsequent NC blocks.

#### Travel with POS

The next block is not executed until all axes programmed under `POS` reach their end positions.

#### Wait for end of travel with WAITP

After a `WAITP`, assignment of the axis to the NC program is no longer valid; this applies until the axis is programmed again. This axis can then be operated as a positioning axis through the PLC, or as a reciprocating axis from the NC program/PLC or HMI.

#### Block change in the braking ramp with IPOBRKA and WAITMC

An axis is only decelerated if the wait marker has not yet been reached or if another end-of-block criterion is preventing the block change. After a `WAITMC`, the axis starts immediately if no other end-of-block criterion is preventing the block change.

## 8.3 Position-controlled spindle mode (SPCON, SPCOF)

Position-controlled spindle mode may be advisable in some cases, e.g. in conjunction with large-pitch thread cutting with `G33`, where better quality can be achieved.

The `SPCON` NC command is used to switch over to position-controlled spindle mode.

#### Note

`SPCON` requires a maximum of three interpolation cycles.

### Syntax

`SPCON/SPCON (<n>)/SPCON (<n>, <m>, etc.)`

...

`SPCOF/SPCOF (<n>)/SPCOF (<n>, <m>, etc.)`

### Meaning

|        |                                                                                                                                                                                               |                                                                                                                                                     |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| SPCON: | Activate position-controlled mode<br>The specified spindle is switched over from speed control to position control.<br><code>SPCON</code> is modal and is retained until <code>SPCOF</code> . |                                                                                                                                                     |
| SPCOF: | Deactivate position-controlled mode<br>The specified spindle is switched over from position control to speed control.                                                                         |                                                                                                                                                     |
|        | <n>:                                                                                                                                                                                          | Number of the spindle to be switched over.<br>If a spindle number is not specified, <code>SPCON/SPCOF</code> will be applied to the master spindle. |
|        | <n>, <m>, etc.:                                                                                                                                                                               | <code>SPCON</code> or <code>SPCOF</code> can even be used to switch over multiple spindles in one block.                                            |

**Note**

The speed is specified with S....

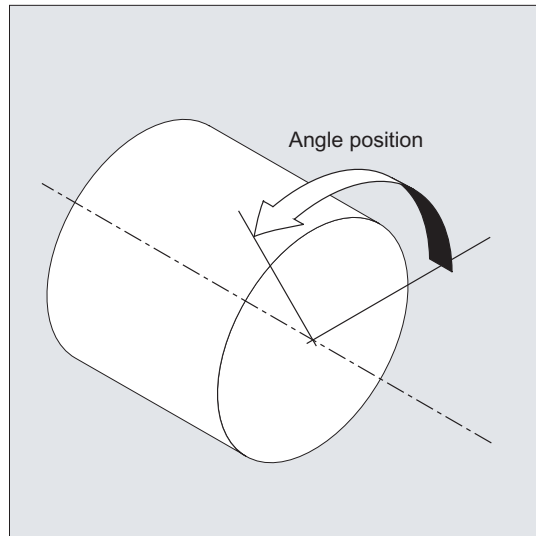
M3, M4 and M5 apply in respect of the directions of rotation and spindle stop.

**Note**

With synchronized spindle setpoint value linkage, the master spindle must be operated in position-control mode.

## 8.4 Positioning spindles (SPOS, SPOSA, M19, M70, WAITS)

SPOS, SPOSA or M19 can be used to set spindles to specific angular positions, e.g. during tool change.



SPOS, SPOSA and M19 induce a temporary switchover to position-controlled mode until the next M3/M4/M5/M41 to M45.

**Positioning in axis mode**

The spindle can also be operated as a path axis, synchronized axis or positioning axis at the address defined in the machine data. When the axis identifier is specified, the spindle is in axis mode. M70 switches the spindle directly to axis mode.

**End of positioning**

The end-of-motion criterion when positioning the spindle can be programmed using FINEA, CORSEA, IPOENDA or IPOBRKA.

The program advances to the next block if the end of motion criteria for all spindles or axes programmed in the current block plus the block change criterion for path interpolation are fulfilled.

**Synchronization**

#### 8.4 Positioning spindles (SPOS, SPOSA, M19, M70, WAITS)

In order to synchronize spindle movements, `WAITS` can be used to wait until the spindle position is reached.

### Requirements

The spindle to be positioned must be capable of operation in position-controlled mode.

### Syntax

Position spindle:

`SPOS=<value>/SPOS [<n>]=<value>`

`SPOSA=<value>/SPOSA [<n>]=<value>`

`M19/M<n>=19`

Switch spindle over to axis mode:

`M70/M<n>=70`

Define end-of-motion criterion:

`FINEA/FINEA [S<n>]`

`COARSEA/COARSEA [S<n>]`

`IPOENDA/IPOENDA [S<n>]`

`IPOBRKA/IPOBRKA (<axis>[, <instant in time>])` ; Programming in a separate NC block.

Synchronize spindle movements:

`WAITS/WAITS (<n>, <m>)` ; Programming in a separate NC block.

## 8.4 Positioning spindles (SPOS, SPOSA, M19, M70, WAITS)

## Meaning

|             |                                                                                                                                                                                                                |                                                                                                                                                                              |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SPOS/SPOSA: | Set spindle to specified angle                                                                                                                                                                                 |                                                                                                                                                                              |
|             | SPOS and SPOSA have the same functionality but differ in their block change behavior:                                                                                                                          |                                                                                                                                                                              |
|             | <ul style="list-style-type: none"> <li>SPOS delays the enabling of the NC block until the position has been reached.</li> <li>SPOSA enables the NC block even if the position has not been reached.</li> </ul> |                                                                                                                                                                              |
|             | <n>:                                                                                                                                                                                                           | Number of the spindle to be positioned.<br>If a spindle number is not specified or if the spindle number is set to "0", SPOS or SPOSA will be applied to the master spindle. |
|             | <value>:                                                                                                                                                                                                       | Angular position to which the spindle is to be set.                                                                                                                          |
|             |                                                                                                                                                                                                                | Unit: Degrees                                                                                                                                                                |
|             |                                                                                                                                                                                                                | Type: REAL                                                                                                                                                                   |
|             |                                                                                                                                                                                                                | The following options are available for programming the position approach mode:                                                                                              |
|             |                                                                                                                                                                                                                | =AC (<value>): Absolute dimensions                                                                                                                                           |
|             |                                                                                                                                                                                                                | Range of values: 0 ... 359,9999                                                                                                                                              |
|             |                                                                                                                                                                                                                | =IC (<value>): Incremental dimensions                                                                                                                                        |
|             |                                                                                                                                                                                                                | Range of values: 0 ... ±99 999,999                                                                                                                                           |
| M<n>=19:    | Set the master spindle (M19 or M0=19) or spindle number <n> (M<n>=19) to the angular position preset with SD43240 \$SA_M19_SPOS with the position approach mode preset in SD43250 \$SA_M19_SPOSMODE.           |                                                                                                                                                                              |
|             | The NC block is not enabled until the position has been reached.                                                                                                                                               |                                                                                                                                                                              |
| M<n>=70:    | Switch the master spindle (M70 or M0=70) or spindle number <n> (M<n>=70) over to axis mode.                                                                                                                    |                                                                                                                                                                              |
|             | No defined position is approached. The NC block is enabled after the switchover has been performed.                                                                                                            |                                                                                                                                                                              |
| FINEA:      | Motion end when "Exact stop fine" reached                                                                                                                                                                      |                                                                                                                                                                              |
| COARSEA:    | Motion end when "Exact stop coarse" reached                                                                                                                                                                    |                                                                                                                                                                              |
| IPOENDA:    | End of motion on reaching "interpolator stop"                                                                                                                                                                  |                                                                                                                                                                              |
| S<n>:       | Spindle for which the programmed end-of-motion criterion is to be effective                                                                                                                                    |                                                                                                                                                                              |
|             | <n>:                                                                                                                                                                                                           | Spindle number                                                                                                                                                               |
|             | If a spindle is not specified in [S<n>] or a spindle number of "0" is specified, the programmed end-of-motion criterion will be applied to the master spindle.                                                 |                                                                                                                                                                              |

## 8.4 Positioning spindles (SPOS, SPOSA, M19, M70, WAITS)

|          |                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                              |                                                                            |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| IPOBRKA: | A block change is possible in the braking ramp.                                                                                                                                                                                                    |                                                                                                                                                                                                                                              |                                                                            |
|          | <axis>:                                                                                                                                                                                                                                            | Channel axis identifier                                                                                                                                                                                                                      |                                                                            |
|          | <instant in time>:                                                                                                                                                                                                                                 | Instant in time of the block change with reference to the braking ramp                                                                                                                                                                       |                                                                            |
|          |                                                                                                                                                                                                                                                    | Unit:                                                                                                                                                                                                                                        | Percent                                                                    |
|          |                                                                                                                                                                                                                                                    | Range of values:                                                                                                                                                                                                                             | 100 (application point of the braking ramp) to 0 (end of the braking ramp) |
|          |                                                                                                                                                                                                                                                    | If a value is not assigned to the <instant in time> parameter, the current value of the setting data is applied:<br>SD43600 \$SA_IPOBRAKE_BLOCK_EXCHANGE<br><b>Note:</b><br>I BOBRKA with an instant in time of "0" is identical to IPOENDA. |                                                                            |
|          |                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                              |                                                                            |
| WAITS:   | Synchronization command for the specified spindle(s)<br>The subsequent blocks are not processed until the specified spindle(s) programmed in a previous NC block with SPOSA has (have) reached its (their) end position(s) (with exact stop fine). |                                                                                                                                                                                                                                              |                                                                            |
|          | WAITS after M5:                                                                                                                                                                                                                                    | Wait for the specified spindle(s) to come to a standstill.                                                                                                                                                                                   |                                                                            |
|          | WAITS after M3/M4:                                                                                                                                                                                                                                 | Wait for the specified spindle(s) to reach their setpoint speed.                                                                                                                                                                             |                                                                            |
|          | <n>, <m>:                                                                                                                                                                                                                                          | Numbers of the spindles to which the synchronization command is to be applied.<br><br>If a spindle number is not specified or if the spindle number is set to "0", WAITS will be applied to the master spindle.                              |                                                                            |

**Note**

Three spindle positions are possible for each NC block.

**Note**

With incremental dimensions IC(<value>), spindle positioning can take place over several revolutions.

**Note**

If position control was activated with SPCON prior to SPOS, this remains active until SPCOF is issued.

**Note**

The control detects the transition to axis mode automatically from the program sequence. Explicit programming of M70 in the part program is, therefore, essentially no longer necessary. However, M70 can continue to be programmed, e.g. to increase the legibility of the part program.



## Further information

### Positioning with SPOSA

The block step enable or program execution is not affected by SPOSA. The spindle positioning can be performed during execution of subsequent NC blocks. The program moves onto the next block if all the functions (except for spindle) programmed in the current block have reached their block end criterion. The spindle positioning operation may be programmed over several blocks (see WAITS).

### Note

If a command, which implicitly causes a preprocessing stop, is read in a following block, execution of this block is delayed until all positioning spindles are stationary.

### Positioning with SPOS/M19

The block step enabling condition is met when all functions programmed in the block reach their end-of-block criterion (e.g. all auxiliary functions acknowledged by the PLC, all axes at their end point) and the spindle reaches the programmed position.

Velocity of the movements:

The velocity and the delay response for positioning are stored in the machine data. The configured values can be modified by programming or by synchronized actions, see:

- Feedrate for positioning axes / spindles (FA, FPR, FPRAON, FPRAOF) (Page 114)
- Programmable acceleration override (ACC) (option) (Page 118)

Specification of spindle positions:

As the G90/G91 commands are not effective here, the corresponding dimensions apply explicitly, e.g. AC, IC, DC, ACN, ACP. If no specifications are made, traversing automatically takes place as for DC.

### Synchronize spindle movements with WAITS

WAITS can be used to identify a point at which the NC program waits until one or more spindles programmed with SPOSA in a previous NC block reach their positions.

### Example:

| Program code                | Comment                                                                                     |
|-----------------------------|---------------------------------------------------------------------------------------------|
| N10 SPOSA[2]=180 SPOSA[3]=0 |                                                                                             |
| ...                         |                                                                                             |
| N40 WAITS(2,3)              | ; The block waits until spindles 2 and 3 have reached the positions specified in block N10. |

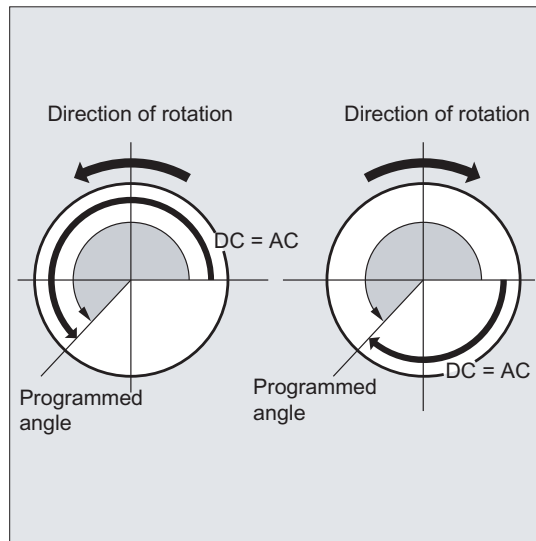
WAITS can be used after M5 to wait until the spindle(s) has (have) stopped. WAITS can be used after M3/M4 to wait until the spindle(s) has (have) reached the specified speed/direction of rotation.

#### Note

If the spindle has not yet been synchronized with synchronization marks, the positive direction of rotation is taken from the machine data (state on delivery).

#### Position spindle from rotation (M3/M4)

When M3 or M4 is active, the spindle comes to a standstill at the programmed value.



There is no difference between DC and AC dimensioning. In both cases, rotation continues in the direction selected by M3/M4 until the absolute end position is reached. With ACN and ACP, deceleration takes place if necessary, and the appropriate approach direction is taken. With IC, the spindle rotates additionally to the specified value starting at the current spindle position.

#### Position a spindle from standstill (M5)

The exact programmed distance is traversed from standstill (M5).

## 8.5 Feedrate for positioning axes / spindles (FA, FPR, FPRAON, FPRAOF)

It is also possible to derive the revolutionary feedrate for path and synchronized axes or for individual positioning axes/spindles from another rotary axis or spindle.

Positioning axes such as workpiece transport systems, tool turrets and end supports are traversed independently of path and synchronized axes. A separate feedrate is therefore defined for each positioning axis.

A separate axial feedrate can also be programmed for spindles.

## Syntax

Feedrate for positioning axis:

FA[<axis>]=...

Axis feedrate for spindle:

FA[SPI (<n>)] =...

FA[S<n>]=...

Derive revolutional feedrate for path/synchronized axes:

FPR (<rotary axis>)

FPR (SPI (<n>))

FPR (S<n>)

Derive rotational feedrate for positioning axes/spindles:

FPRAON (<axis>, <rotary axis>)

FPRAON (<axis>, SPI (<n>))

FPRAON (<axis>, S<n>)

FPRAON (SPI (<n>), <rotary axis>)

FPRAON (S<n>, <rotary axis>)

FPRAON (SPI (<n>), SPI (<n>))

FPRAON (S<n>, S<n>)

FPRAOF (<axis>, SPI (<n>), etc.)

FPRAOF (<axis>, S<n>, etc.)

## Meaning

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                 |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| FA[...]=... : | Feedrate for the specified positioning axis or positioning speed (axial feedrate) for the specified spindle                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                 |
|               | Unit:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | mm/min or inch/min or degrees/min                               |
|               | Range of values:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ... 999,999.999 mm/min, degrees/min<br>... 39 999.9999 inch/min |
| FPR (...):    | FPR is used to identify the rotary axis (<rotary axis>) or spindle (SPI (<n>)/S<n>) from which the revolutional feedrate for the revolutional feedrate of the path and synchronized axes programmed under G95 is to be derived.                                                                                                                                                                                                                                                                                                      |                                                                 |
| FPRAON (...): | <p>Derive rotational feedrate for positioning axes and spindles</p> <p>The first parameter (&lt;axis&gt;/SPI (&lt;n&gt;)/S&lt;n&gt;) identifies the positioning axis/spindle to be traversed with revolutional feedrate.</p> <p>The second parameter (&lt;rotary axis&gt;/SPI (&lt;n&gt;)/S&lt;n&gt;) identifies the rotary axis/spindle from which the revolutional feedrate is to be derived.</p> <p><b>Note:</b><br/>The second parameter can be omitted, in which case the feedrate will be derived from the master spindle.</p> |                                                                 |
| FPRAOF (...): | FPRAOF is used to deselect the derived revolutional feedrate for the specified axes or spindles.                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 |

## 8.5 Feedrate for positioning axes / spindles (FA, FPR, FPRAON, FPRAOF)

|                                                                                                                                       |                                                        |                |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------|
| <axis>:                                                                                                                               | Axis identifier (positioning or geometry axis)         |                |
| SPI (<n>)/S<n>:                                                                                                                       | Spindle identifier                                     |                |
|                                                                                                                                       | SPI (<n>) and S<n> are identical in terms of function. |                |
|                                                                                                                                       | <n>:                                                   | Spindle number |
| <b>Note:</b><br>SPI converts spindle numbers into axis identifiers. The transfer parameter (<n>) must contain a valid spindle number. |                                                        |                |

**Note**

The programmed feedrate FA[...] is modal.

Up to five feedrates for positioning axes or spindles can be programmed in each NC block.

**Note**

The derived feedrate is calculated according to the following formula:

Derived feedrate = programmed feedrate \* absolute master feedrate

**Examples****Example 1: Synchronous spindle coupling**

With synchronous spindle coupling, the positioning speed of the following spindle can be programmed independently of the master spindle, e.g. for positioning operations.

| Program code | Comment                                                                    |
|--------------|----------------------------------------------------------------------------|
| ...          |                                                                            |
| FA[S2]=100   | ; Positioning speed of the following spindle (spindle 2) = 100 degrees/min |
| ...          |                                                                            |

**Example 2: Derived revolutional feedrate for path axes**

Path axes X, Y must be traversed at the revolutional feedrate derived from rotary axis A:

| Program code         |
|----------------------|
| ...                  |
| N40 FPR(A)           |
| N50 G95 X50 Y50 F500 |
| ...                  |

**Example 3: Derive revolutional feedrate for master spindle**

| Program code      | Comment                                                                                 |
|-------------------|-----------------------------------------------------------------------------------------|
| N30 FPRAON(S1,S2) | ; The revolutional feedrate for the master spindle (S1) must be derived from spindle 2. |

## 8.6 Programmable feedrate override (OVR, OVRRAP, OVRA)

| Program code   | Comment                                                           |
|----------------|-------------------------------------------------------------------|
| N40 SPOS=150   | ; Position master spindle.                                        |
| N50 FPRAOF(S1) | ; Deselect derived revolutionary feedrate for the master spindle. |

**Example 4: Derive revolutionary feedrate for positioning axis**

| Program code            | Comment                                                                                      |
|-------------------------|----------------------------------------------------------------------------------------------|
| N30 FPRAON(X)           | ; The revolutionary feedrate for positioning axis X must be derived from the master spindle. |
| N40 POS[X]=50 FA[X]=500 | ; The positioning axis is traversing at 500 mm/revolution of the master spindle.             |
| N50 FPRAOF(X)           |                                                                                              |

**Further information****FA[...]**

The feedrate type is always G94. When G70/G71 is active, the unit is metric/inches according to the default setting in the machine data. G700/G710 can be used to modify the unit in the program.

**Note**

If no FA is programmed, the value defined in the machine data applies.

**FPR(...)**

As an extension of the G95 command (revolutional feedrate referring to the master spindle), FPR allows the revolutionary feedrate to be derived from any chosen spindle or rotary axis. G95 FPR (...) is valid for path and synchronized axes.

If the rotary axis/spindle specified in the FPR command is operating on position control, then the setpoint linkage is active. Otherwise the actual-value linkage is effective.

**FPRAON(...)**

FPRAON is used to derive the revolutionary feedrate for positioning axes and spindles from the current feedrate of another rotary axis or spindle.

**FPRAOF(...)**

The revolutionary feedrate can be deactivated for one or a number of axes/spindles simultaneously with the FPRAOF command.

## 8.6 Programmable feedrate override (OVR, OVRRAP, OVRA)

The velocity of path/positioning axes and spindles can be modified in the NC program.

## 8.7 Programmable acceleration override (ACC) (option)

## Syntax

```

OVR=<value>
OVERRAP=<value>
OVRA [<axis>]=<value>
OVRA [SPI (<n>)] =<value>
OVRA [S<n>]=<value>

```

## Meaning

|                 |                                                                                                                                       |                    |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| OVR:            | Feedrate modification for path feedrate F                                                                                             |                    |
| OVERRAP:        | Feedrate modification for rapid traverse velocity                                                                                     |                    |
| OVRA:           | Feedrate modification for positioning feedrate $F_A$ or for spindle speed S                                                           |                    |
| <axis>:         | Axis identifier (positioning or geometry axis)                                                                                        |                    |
| SPI (<n>)/S<n>: | Spindle identifier<br>SPI (<n>) and S<n> are identical in terms of function.                                                          |                    |
|                 | <n>:                                                                                                                                  | Spindle number     |
|                 | <b>Note:</b><br>SPI converts spindle numbers into axis identifiers. The transfer parameter (<n>) must contain a valid spindle number. |                    |
| <value>:        | Feedrate modification in percent<br>The value refers to or is combined with the feedrate override set on the machine control panel.   |                    |
|                 | Range of values:                                                                                                                      | ... 200%, integers |
|                 | <b>Note:</b><br>With path and rapid traverse override, the maximum velocities set in the machine data is not overshoot.               |                    |

## 8.7 Programmable acceleration override (ACC) (option)

In critical program sections, it may be necessary to limit the acceleration to below the maximum values, e.g. to prevent mechanical vibrations from occurring.

The programmable acceleration override can be used to modify the acceleration for each path axis or spindle via a command in the NC program. The limit is effective for all types of interpolation. The values defined in the machine data apply as 100% acceleration.

## Syntax

```

ACC [<axis>]=<value>
ACC [SPI (<n>)] =<value>
ACC (S<n>)=<value>

```

**Deactivate:**  
ACC [...]=100

## 8.7 Programmable acceleration override (ACC) (option)

## Syntax

|                 |                                                                                                                                       |                     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| ACC:            | Acceleration change for the specified path axis or speed change for the specified spindle.                                            |                     |
| <axis>:         | Channel axis name of path axis                                                                                                        |                     |
| SPI (<n>)/S<n>: | Spindle identifier<br>SPI (<n>) and S<n> are identical in terms of function.                                                          |                     |
|                 | <n>:                                                                                                                                  | Spindle number      |
|                 | <b>Note:</b><br>SPI converts spindle numbers into axis identifiers. The transfer parameter (<n>) must contain a valid spindle number. |                     |
| <value>:        | Acceleration change in percent<br>The value refers to or is combined with the feedrate override set on the machine control panel.     |                     |
|                 | Range of values:                                                                                                                      | 1 to 200%, integers |

**Note**

With a greater acceleration rate, the values permitted by the manufacturer may be exceeded.

## Example

| Program code       | Comment                                                                             |
|--------------------|-------------------------------------------------------------------------------------|
| N50 ACC[X]=80      | ; The axis slide in the X direction should only be traversed with 80% acceleration. |
| N60 ACC[SPI(1)]=50 | ; Spindle 1 should only accelerate or brake with 50% of the acceleration capacity.  |

## Further information

**Acceleration override programmed with ACC**

The acceleration override programmed with ACC[ . . . ] is always taken into consideration on output as in system variable \$AA\_ACC. Readout in the parts program and in synchronized actions takes place at different times in the NC processing run.

**In the part program**

The value written in the part program is then only taken into consideration in system variable \$AA\_ACC as written in the part program if ACC has not been changed in the meantime by a synchronized action.

**In synchronized actions**

The following thus applies: The value written to a synchronized action is then only considered in system variable \$AA\_ACC as written to the synchronized action if ACC has not been changed in the meantime by a part program.

The preset acceleration can also be changed via synchronized actions (see Function Manual, Synchronized Actions).

Example:

---

**Program code**

---

```
...
N100 EVERY $A_IN[1] DO POS[X]=50 FA[X]=2000 ACC[X]=140
```

The current acceleration value can be called with system variable \$AA\_ACC[<axis>]. Machine data can be used to define whether the last ACC value set should apply on RESET/part program end or whether 100% should apply.

## 8.8 Feedrate with handwheel override (FD, FDA)

The FD and FDA commands can be used to traverse axes with handwheels during execution of the part program. The programmed settings for traversing the axes are then overlaid with the handwheel pulses evaluated as path or velocity defaults.

### Path axes

In the case of path axes, the programmed path feedrate can be overlaid. The handwheel is evaluated as the first geometry axis of the channel. The handwheel pulses evaluated per interpolation cycle dependent on the direction of rotation correspond to the path velocity to be overlaid. The path velocity limit values which can be achieved by means of handwheel override are:

- Minimum: 0
- Maximum: Machine data limit values of the path axes involved in traversing

---

### Note

#### Path feedrate

The path feedrate F and the handwheel feedrate FD cannot be programmed in the same NC block.

---

### Positioning axes

In the case of positioning axes, the travel path or velocity can be overlaid as an axial value. The handwheel assigned to the axis is evaluated.

- Path override  
The handwheel pulses evaluated dependent on the direction of rotation correspond to the axis path to be traveled. Only handwheel pulses in the direction of the programmed position are evaluated.
- Velocity override  
The handwheel pulses evaluated per interpolation cycle dependent on the direction of rotation correspond to the axial velocity to be overlaid. The path velocity limit values which can be achieved by means of handwheel override are:
  - Minimum: 0
  - Maximum: Machine data limit values of the positioning axis

A detailed description of how to set handwheel parameters appears in:

### References:

/FB2/ Function Manual, Extended Functions; Manual Travel and Handwheel Travel (H1)



**Syntax**

```
FD=<velocity>
FDA[<axis>]=<velocity>
```

**Meaning**

FD=<velocity>:

Path feedrate and enabling of velocity override with handwheel

<velocity>:

- Value = 0: Not allowed!
- Value ≠ 0: Path velocity

Axial feedrate

FDA[<axis>]=<velocity>:

<velocity>:

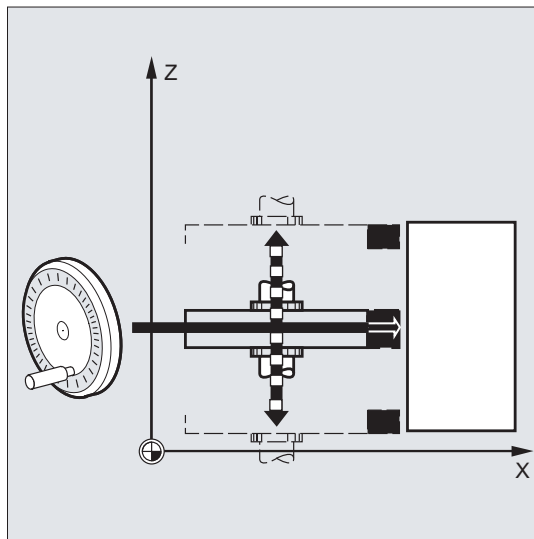
- Value = 0: Path default with handwheel
- Value ≠ 0: Axial velocity

<axis>:

Axis identifier of positioning axis

**Note**

FD and FDA are non-modal.

**Example**

Path definition: The grinding wheel oscillating in the Z direction is traversed to the workpiece in the X direction with the handwheel.

The operator can continue to feed manually until the sparks are flying uniformly. Activating "Delete distance-to-go" switches to the next NC block and machining continues in AUTOMATIC mode.

## Further information

### Traverse path axes with velocity override (FD=<velocity>)

The following conditions must be met for the part program block in which path velocity override is programmed:

- Path command G1, G2 or G3 active
- Exact stop G60 active
- Linear feedrate G94 active

### Feedrate override

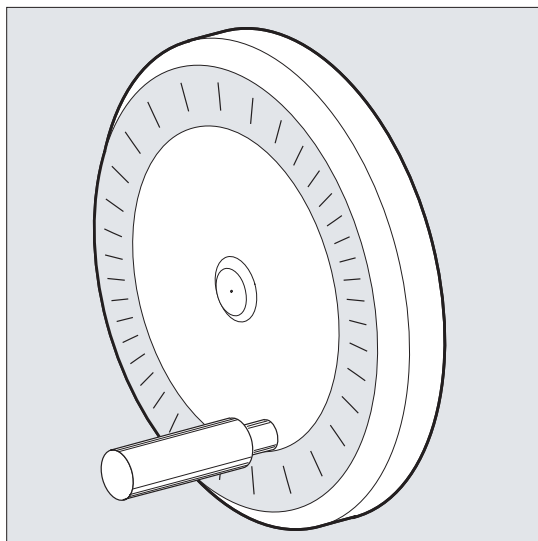
The feedrate override only affects the programmed path velocity and not the velocity component generated with the handwheel (exception: (except if feed override = 0)).

### Example:

| Program code         | Description                                                                                                                                                                                                                                       |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 X... Y... F500   | ; Feedrate = 500 mm/min                                                                                                                                                                                                                           |
| N20 X... Y... FD=700 | ; Feedrate = 700 mm/min and velocity override with handwheel.<br>; Acceleration from 500 to 700 mm/min in N20. The handwheel can be used to vary the speed dependent on the direction of rotation between 0 and the maximum value (machine data). |

### Traverse positioning axes with path default (FDA[<axis>]=0)

In the NC block with programmed FDA[<axis>]=0 the feed is set to zero so that the program cannot generate any travel movement. The programmed travel movement to the target position is now controlled exclusively by the operator rotating the handwheel.



## 8.9 Feedrate optimization for curved path sections (CFTCP, CFC, CFIN)

**Example:**

| Program code           | Description                                                                                                                                                                                                 |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ...                    |                                                                                                                                                                                                             |
| N20 POS[V]=90 FDA[V]=0 | ; Target position = 90 mm, axial feedrate = 0 mm/min and<br>path override with handwheel.<br>; Velocity of axis V at start of block = 0 mm/min.<br>; Path and speed defaults are set using handwheel pulses |

Direction of movement, travel velocity

The axes follow the path set by the handwheel in the direction of the sign. Forward and backwards travel is possible dependent on the direction of rotation. The faster the handwheel rotates, the higher the traversing speed.

Traversing range:

The traversing range is limited by the starting position and the programmed end point.

**Traverse positioning axis with velocity override (FDA[<axis>]=<velocity>)**

In NC blocks with programmed FDA[...] = ..., the feedrate from the last programmed FA value is accelerated or decelerated to the value programmed under FDA. Starting from the current feedrate FDA, the handwheel can be turned to accelerate the programmed movement to the target position or decelerate it to zero. The values set as parameters in the machine data serve as the maximum velocity.

Example:

| Program code              | Description                                                                                                                                                                                                                                                                                                 |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 POS[V]=... FA[V]=100  | ; Axial feedrate = 100 mm/min                                                                                                                                                                                                                                                                               |
| N20 POS[V]=100 FDA[V]=200 | ; Axial target position = 100, axial feedrate = 200 mm/min<br>; and velocity override with handwheel.<br>; Acceleration from 100 to 200 mm/min in N20. The<br>; Handwheel can be used to vary the velocity depending on the direc-<br>tion of rotation<br>; between 0 and the maximum value (machine data). |

Traversing range:

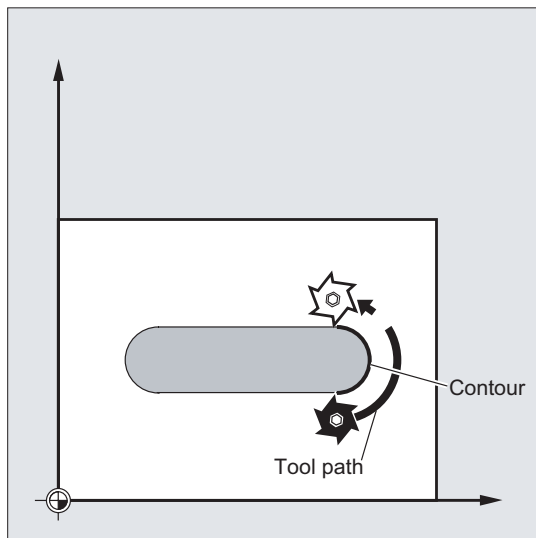
The traversing range is limited by the starting position and the programmed end point.

## 8.9 Feedrate optimization for curved path sections (CFTCP, CFC, CFIN)

With activated offset mode G41/G42, the programmed feedrate for the milling cutter radius initially refers to the milling cutter center path (see Section "Coordinate transformations (frames)").

When you mill a circle (the same applies to polynomial and spline interpolation) the extent to which the feedrate varies at the cutter edge is so significant under certain circumstances that it can impair the quality of the machined part.

Example: Milling a small outside radius with a large tool. The path that the outside of the milling tool must travel is considerably longer than the path along the contour.



Because of this, machining at the contour takes place with a very low feedrate. To prevent adverse effects, the feedrate needs to be controlled accordingly for curved contours.

## Syntax

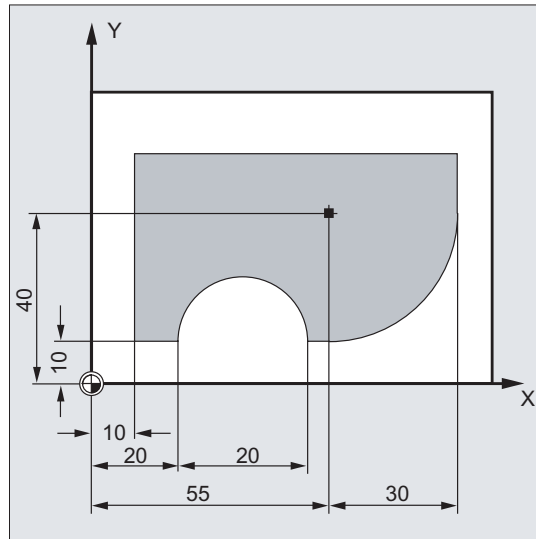
CFTCP  
CFC  
CFIN

## Meaning

|        |                                                                                                                                                                |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CFTCP: | Constant feedrate on the milling cutter center path<br>The control keeps the feedrate constant and feedrate offsets are deactivated.                           |
| CFC:   | Constant feedrate at the contour (tool cutting edge).<br>This function is preset per default.                                                                  |
| CFIN:  | Constant feedrate at the tool cutting edge only at concave contours, otherwise on the milling cutter center path.<br>The feedrate is reduced for inside radii. |

## 8.9 Feedrate optimization for curved path sections (CFTCP, CFC, CFIN)

## Example

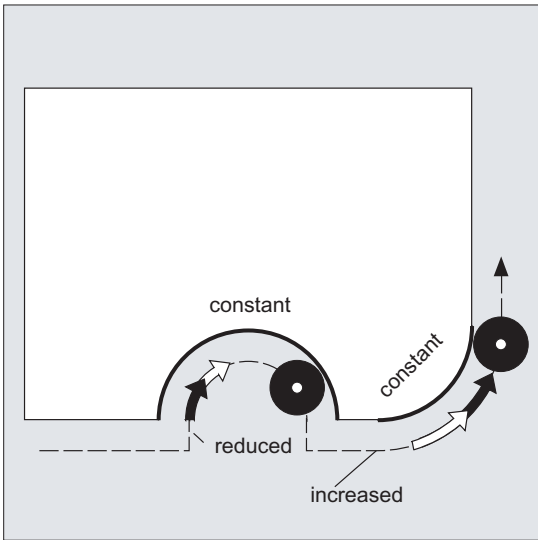


In this example, the contour is first produced with **CFC**-corrected feedrate. During finishing, the cutting base is also machined with **CFIN**. This prevents the cutting base being damaged at the outside radii by a feedrate that is too high.

| Program code              | Comment                        |
|---------------------------|--------------------------------|
| N10 G17 G54 G64 T1 M6     |                                |
| N20 S3000 M3 CFC F500 G41 |                                |
| N30 G0 X-10               |                                |
| N40 Y0 Z-10               | ; Feed to first cutting depth  |
| N50 CONTOUR1              | ; Subprogram call              |
| N40 CFIN Z-25             | ; Feed to second cutting depth |
| N50 CONTOUR1              | ; Subprogram call              |
| N60 Y120                  |                                |
| N70 X200 M30              |                                |

Further information

Constant feedrate on contour with CFC



The feedrate is reduced for inside radii and increased for outside radii. This ensures a constant speed at the tool edge and thus at the contour.

8.10 Several feedrate values in one block (F, ST, SR, FMA, STA, SRA)

The "Multiple feedrates in one block" function can be used to activate different feedrate values for an NC block, a dwell time or a retraction motion-synchronously, dependent on external digital and/or analog inputs.

Syntax

```
Path motion
F=... F7=... F6=... F5=... F4=... F3=... F2=... ST=... SR=...

Axial motion:
FA[<Ax>]=... FMA[7,<Ax>]=... FMA[6,<Ax>]=... FMA[5,<Ax>]=...
FMA[4,<Ax>]=... FMA[3,<Ax>]=... FMA[2,<Ax>]=... STA[<Ax>]=...
SRA[<Ax>]=...
```

Meaning

|         |                                                                                                              |       |
|---------|--------------------------------------------------------------------------------------------------------------|-------|
| F=... : | The path feedrate is programmed under the address F and remains valid during the absence of an input signal. |       |
|         | Effective:                                                                                                   | Modal |

8.10 Several feedrate values in one block (*F*, *ST*, *SR*, *FMA*, *STA*, *SRA*)

|                                          |                                                                                                                                                                                                                                          |           |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| F2=... to F7=... :                       | In addition to the path feedrate, up to six further feedrates can be programmed in the block. The numerical expansion indicates the bit number of the input that activates the feedrate when changed:                                    |           |
|                                          | Effective:                                                                                                                                                                                                                               | Non-modal |
| ST=... :                                 | Dwell time in s (for grinding technology: sparking-out time)                                                                                                                                                                             |           |
|                                          | Input bit:                                                                                                                                                                                                                               | 1         |
| SR=... :                                 | Retraction path<br>The unit for the retraction path refers to the current valid unit of measurement (mm or inch).                                                                                                                        |           |
|                                          | Input bit:                                                                                                                                                                                                                               | 0         |
| FA [<Ax>]=... :                          | The axial feedrate is programmed under the address FA and remains valid during the absence of an input signal.                                                                                                                           |           |
|                                          | Effective:                                                                                                                                                                                                                               | Modal     |
| FMA [2, <Ax>]=... to FMA [7, <Ax>]=... : | In addition to the axial feedrate FA up to six further feedrates per axis can be programmed in the block with FMA. The first parameter indicates the bit number of the input and the second the axis for which the feedrate is to apply. |           |
|                                          | Effective:                                                                                                                                                                                                                               | Non-modal |
| STA [<Ax>]=... :                         | Axial dwell time in s (for grinding technology: sparking-out time)                                                                                                                                                                       |           |
|                                          | Input bit:                                                                                                                                                                                                                               | 1         |
| SRA [<Ax>]=... :                         | Axial retraction path                                                                                                                                                                                                                    |           |
|                                          | Input bit:                                                                                                                                                                                                                               | 0         |
| <Ax>:                                    | Axis for which the feedrate is to apply                                                                                                                                                                                                  |           |
|                                          | Effective:                                                                                                                                                                                                                               | Non-modal |

**Note****Priority of the signals**

The signals are scanned in ascending order starting at input bit 0 (I0). Therefore, the retraction motion has the highest priority and the feedrate F7 the lowest priority. Dwell time and retraction motion end the feedrate motions that were activated with F2 to F7.

The signal with the highest priority determines the current feedrate.

## 8.10 Several feedrate values in one block (F, ST, SR, FMA, STA, SRA)

**Note****Delete distance-to-go**

If input bit 1 is activated for the dwell time or bit 0 for the return path, the distance to go for the path axes or the relevant single axes is deleted and the dwell time or return started.

**Note****Retraction path**

The unit for the retraction path refers to the current valid unit of measurement (mm or inch).

The reverse stroke is always made in the opposite direction to the current motion. SR/SRA always programs the value for the reverse stroke. No sign is programmed.

**Note****POS instead of POSA**

If feedrates, dwell time or return path are programmed for an axis on account of an external input, this axis must not be programmed as POSA axis (positioning axis over multiple blocks) in this block.

**Note****Status query**

It is also possible to poll the status of an input for synchronous commands of various axes.

**Note****LookAhead**

Look Ahead is also active for multiple feedrates in one block. In this way, the current feedrate can be restricted by the Look Ahead value.

**Examples****Example 1: Path motion**

| Program code                                       | Comment                                                                                                                                                                                           |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G1 X48 F1000 F7=200 F6=50 F5=25 F4=5 ST=1.5 SR=0.5 | ; Path feedrate = 1000<br>; Additional path feedrate values:<br>; 200 (input bit 7)<br>; 50 (input bit 6)<br>; 25 (input bit 5)<br>; 5 (input bit 4)<br>; Dwell time 1.5 s<br>; Retraction 0.5 mm |



**Example 2: Axial motion**

| Program code                                   | Comment                                                                                                                                                                |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| POS[A]=300 FA[A]=800 FMA[7,A]=720 FMA[6,A]=640 | ; Feedrate for axis A = 800                                                                                                                                            |
| FMA[5,A]=560 STA[A]=1.5 SRA[A]=0.5             | ; Additional feedrate values for axis A: 720<br>(input bit 7)<br>; 640 (input bit 6)<br>; 560 (input bit 5)<br>; Axial dwell time: 1.5 s<br>; Axial retraction: 0.5 mm |

**Example 3: Multiple operations in one block**

| Program code                                      | Comment                                                                                                                                                    |
|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N20 T1 D1 F500 G0 X100                            | Initial setting                                                                                                                                            |
| N25 G1 X105 F=20 F7=5 F3=2.5 F2=0.5 ST=1.5 SR=0.5 | ; Normal feedrate with F,<br>; roughing with F7,<br>; finishing with F3,<br>; smooth-finishing with F2,<br>; dwell time 1.5 s,<br>; retraction path 0.5 mm |
| ...                                               |                                                                                                                                                            |

**8.11 Non-modal feedrate (FB)**

The "Non-modal feedrate" function can be used to define a separate feedrate for a single block. After this block, the previous modal feedrate is active again.

**Syntax**

FB=<value>

**Meaning**

|          |                                                                                                                                                                                                                                                                                                         |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FB:      | Feedrate for current block only                                                                                                                                                                                                                                                                         |
| <VALUE>: | <p>The programmed value must be greater than zero.</p> <p>Values are interpreted based on the active feedrate type:</p> <ul style="list-style-type: none"> <li>• G94: feedrate in mm/min or degrees/min</li> <li>• G95: feedrate in mm/rev or inch/rev</li> <li>• G96: constant cutting rate</li> </ul> |

**Note**

If no traversing motion is programmed in the block (e.g. computation block), the **FB** has no effect.

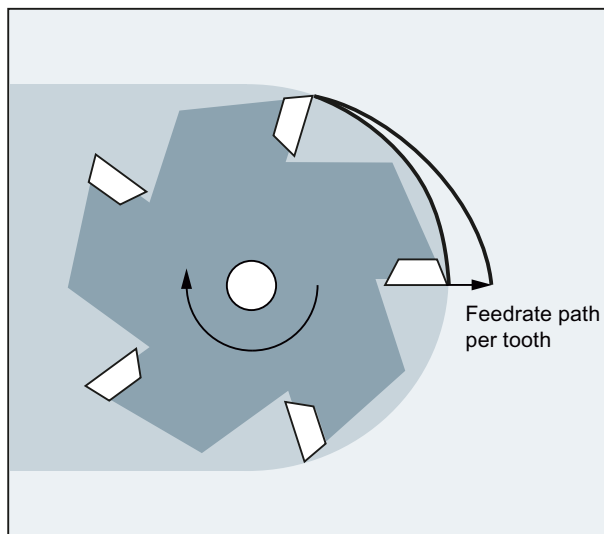
If no explicit feedrate for chamfering/rounding is programmed, then the value of **FB** also applies for any chamfering/rounding contour element in this block.

Feedrate interpolations **FLIN**, **FCUB**, etc. are also possible without restriction.

Simultaneous programming of **FB** and **FD** (handwheel travel with feedrate override) or **F** (modal path feedrate) is **not** possible.

**Example**

| Program code              | Comment                         |
|---------------------------|---------------------------------|
| N10 G0 X0 Y0 G17 F100 G94 | ;Initial setting                |
| N20 G1 X10                | ; Feedrate 100 mm/min           |
| N30 X20 FB=80             | ; Feedrate 80 mm/min            |
| N40 X30                   | ; Feedrate is 100 mm/min again. |
| ...                       |                                 |

**8.12 Tooth feedrate (G95 FZ)**

The control uses the \$TC\_DPNT (number of teeth) tool parameter associated with the active tool offset data block to calculate the effective revolutional feedrate for each traversing block from the programmed tooth feedrate.

$$F = FZ * \$TC\_DPNT$$

with: F: Revolutional feedrate in mm/rev or inch/rev  
 FZ: Tooth feedrate in mm/tooth or inch/tooth  
 \$TC\_DPNT: System variable tool parameter: Number of teeth/rev

The tool type (\$TC\_DP1) of the active tool is not taken into account.

The programmed tooth feedrate is independent of the tool change and the selection/deselection of a tool offset data block; it is retained in modal format.

A change to the \$TC\_DPNT tool parameter associated with the active tool cutting edge will be applied the next time a tool offset is selected or the next time the active offset data is updated.

Changing the tool or selecting/deselecting a tool offset data block generates a recalculation of the effective revolutional feedrate.

---

#### Note

The tooth feedrate refers only to the path (axis-specific programming is not possible).

---

## Syntax

G95 FZ...

## Meaning

|      |                                                                                                                                                                    |                                                   |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| G95: | Type of feedrate: Revolutional feedrate in mm/rev or inch/rev (dependent upon G700/G710)<br>For G95 see "Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF) (Page 97)" |                                                   |
| FZ:  | Tooth feedrate                                                                                                                                                     |                                                   |
|      | Activation:                                                                                                                                                        | with G95                                          |
|      | Effective:                                                                                                                                                         | Modal                                             |
|      | Unit:                                                                                                                                                              | mm/tooth or inch/tooth (dependent upon G700/G710) |

#### NOTICE

##### Tool change/Changing the master spindle

A subsequent tool change or changing the master spindle must be taken into account by the user by means of corresponding programming, e.g. reprogramming FZ.

**NOTICE****Tool operations undefined**

Technological concerns such as climb milling or conventional milling, front face milling or peripheral face milling, etc., along with the path geometry (straight line, circle, etc.), are not taken into account automatically. Therefore, these factors have to be given consideration when programming the tooth feedrate.

**Note****Switchover between G95 F... and G95 FZ...**

Switching over between G95 F... (revolutional feedrate) and G95 FZ... (tooth feedrate) will delete the non-active feedrate value in each case.

**Note****Derive feedrate with FPR**

As is the case with the revolutional feedrate, FPR can also be used to derive the tooth feedrate of any rotary axis or spindle (see "Feedrate for positioning axes / spindles (FA, FPR, FPRAON, FPRAOF) (Page 114)").

**Examples****Example 1: Milling cutter with five teeth (\$TC\_DPNE = 5)**

| Program code       | Comment                                          |
|--------------------|--------------------------------------------------|
| N10 G0 X100 Y50    |                                                  |
| N20 G1 G95 FZ=0.02 | ; Tooth feedrate 0.02 mm/tooth                   |
| N30 T3 D1          | ; Load tool and activate tool offset data block. |
| M40 M3 S200        | ; Spindle speed 200 rpm                          |
| N50 X20            | ; Milling with:                                  |
|                    | FZ = 0.02 mm/tooth                               |
|                    | effective revolutional feedrate:                 |
|                    | F = 0.02 mm/tooth * 5 teeth/rev = 0.1 mm/rev     |
|                    | or                                               |
|                    | F = 0.1 mm/rev * 200 rpm = 20 mm/min             |
| ...                |                                                  |

**Example 2: Switchover between G95 F... and G95 FZ...**

| Program code    | Comment                            |
|-----------------|------------------------------------|
| N10 G0 X100 Y50 |                                    |
| N20 G1 G95 F0.1 | ; Revolutional feedrate 0.1 mm/rev |
| N30 T1 M6       |                                    |
| N35 M3 S100 D1  |                                    |
| N40 X20         |                                    |
| N50 G0 X100 M5  |                                    |

| Program code          | Comment                                                                   |
|-----------------------|---------------------------------------------------------------------------|
| N60 M6 T3 D1          | ; Load tool with e.g. five teeth (\$TC_DPNT = 5).                         |
| N70 X22 M3 S300       |                                                                           |
| N80 G1 X3 G95 FZ=0.02 | ; Change G95 F... to G95 FZ..., tooth feedrate active with 0.02 mm/tooth. |
| ...                   |                                                                           |

**Example 3: Derive tooth feedrate of a spindle (FBR)**

| Program code       | Comment                                                  |
|--------------------|----------------------------------------------------------|
| ...                |                                                          |
| N41 FPR(S4)        | ; Tool in spindle 4 (not the master spindle).            |
| N51 G95 X51 FZ=0.5 | ; Tooth feedrate 0.5 mm/tooth dependent upon spindle S4. |
| ...                |                                                          |

**Example 4: Subsequent tool change**

| Program code       | Comment                                                                           |
|--------------------|-----------------------------------------------------------------------------------|
| N10 G0 X50 Y5      |                                                                                   |
| N20 G1 G95 FZ=0.03 | ; Tooth feedrate 0.03 mm/tooth                                                    |
| N30 M6 T11 D1      | ; Load tool with e.g. seven teeth (\$TC_DPNT = 7).                                |
| N30 M3 S100        |                                                                                   |
| N40 X30            | ; Effective revolutional feedrate 0.21 mm/rev                                     |
| N50 G0 X100 M5     |                                                                                   |
| N60 M6 T33 D1      | ; Load tool with e.g. five teeth (\$TC_DPNT = 5).                                 |
| N70 X22 M3 S300    |                                                                                   |
| N80 G1 X3          | ; Tooth feedrate modal 0.03 mm/tooth, effective revolutional feedrate 0.15 mm/rev |
| ...                |                                                                                   |

**Example 5: Changing the master spindle**

| Program code      | Comment                                                                                                                                                        |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 SETMS (1)     | ; Spindle 1 is the master spindle.                                                                                                                             |
| N20 T3 D3 M6      | ; Tool 3 is changed to spindle 1.                                                                                                                              |
| N30 S400 M3       | ; Speed S400 of spindle 1 (and therefore T3).                                                                                                                  |
| N40 G95 G1 FZ0.03 | ; Tooth feedrate 0.03 mm/tooth                                                                                                                                 |
| N50 X50           | ; Path motion, the effective feedrate is dependent upon:<br>- The tooth feedrate FZ<br>- The speed of spindle 1<br>- The number of teeth of the active tool T3 |
| N60 G0 X60        |                                                                                                                                                                |
| ...               |                                                                                                                                                                |
| N100 SETMS(2)     | ; Spindle 2 becomes the master spindle.                                                                                                                        |
| N110 T1 D1 M6     | ; Tool 1 is changed to spindle 2.                                                                                                                              |
| N120 S500 M3      | ; Speed S500 of spindle 2 (and therefore T1).                                                                                                                  |

## 8.12 Tooth feedrate (G95 FZ)

| Program code           | Comment                                                                                                                                                        |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N130 G95 G1 FZ0.03 X20 | ; Path motion, the effective feedrate is dependent upon:<br>- The tooth feedrate FZ<br>- The speed of spindle 2<br>- The number of teeth of the active tool T1 |

**Note**

Following the change in the master spindle (N100), a tool actuated by spindle 2 must be substituted (N110).

**Further information****Changing between G93, G94 and G95**

FZ can also be programmed when G95 is not active, although it will have no effect and is deleted when G95 is selected. In other words, when changing between G93, G94, and G95, in the same way as with F, the FZ value is also deleted.

**Reselection of G95**

Reselecting G95 when G95 is already active has no effect (unless a change between F and FZ has been programmed).

**Non-modal feedrate (FB)**

When G95 FZ . . . (modal) is active, a non-modal feedrate FB . . . is interpreted as a tooth feedrate.

**SAVE mechanism**

In subprograms with the SAVE attribute FZ is written to the value prior to the subprogram starting (in the same way as F).

**Multiple feedrate values in one block**

The "Multiple feedrate values in one block" function is not possible with tooth feedrate.

**Synchronized actions**

FZ cannot be programmed from synchronized actions.

**Read tooth feedrate and path feedrate type**

The tooth feedrate and the path feedrate type can be read using system variables.

- With preprocessing stop in the part program via system variables:

|  |             |                                                                                |                 |
|--|-------------|--------------------------------------------------------------------------------|-----------------|
|  | \$AC_FZ     | Tooth feedrate effective when the current main run block was preprocessed.     |                 |
|  | \$AC_F_TYPE | Path feedrate type effective when the current main run block was preprocessed. |                 |
|  |             | <b>Value:</b>                                                                  | <b>Meaning:</b> |
|  |             | 0                                                                              | mm/min          |
|  |             | 1                                                                              | mm/rev          |
|  |             | 2                                                                              | inch/min        |
|  |             | 3                                                                              | inch/rev        |
|  |             | 11                                                                             | mm/tooth        |
|  |             | 33                                                                             | inch/tooth      |

- Without preprocessing stop in the part program via system variables:

|  |            |                               |                 |
|--|------------|-------------------------------|-----------------|
|  | \$P_FZ     | Programmed tooth feedrate     |                 |
|  | \$P_F_TYPE | Programmed path feedrate type |                 |
|  |            | <b>Value:</b>                 | <b>Meaning:</b> |
|  |            | 0                             | mm/min          |
|  |            | 1                             | mm/rev          |
|  |            | 2                             | inch/min        |
|  |            | 3                             | inch/rev        |
|  |            | 11                            | mm/tooth        |
|  |            | 33                            | inch/tooth      |

### Note

If G95 is not active, the \$P\_FZ and \$AC\_FZ variables will always return a value of zero.





## Geometry settings

### 9.1 Settable zero offset (G54 to G57, G505 to G599, G53, G500, SUPA, G153)

The G54 to G57 and G505 to G599 commands activate the values of the associated parameterizable zero offsets of the workpiece coordinate system compared with the base coordinate system set from the user interface.

#### Syntax

##### Switching on:

G54  
...  
G57  
G505  
...  
G599

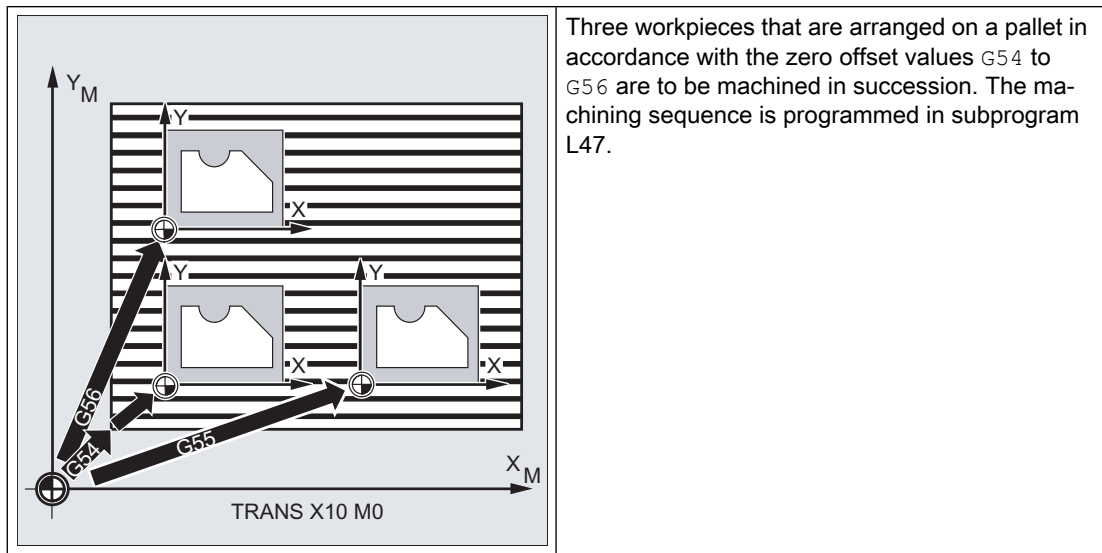
##### Switching off or suppressing:

G500  
G53  
G153  
SUPA

#### Meaning

|               |                                                                                                                                                                                                                          |                                                                                                                                                                      |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G54 to G57:   | Call of the 1st to 4th settable zero offset (WO)                                                                                                                                                                         |                                                                                                                                                                      |
| G505 to G599: | Call of the 5th to 99th settable zero offset                                                                                                                                                                             |                                                                                                                                                                      |
| G500:         | Deactivation of the current settable zero offset                                                                                                                                                                         |                                                                                                                                                                      |
|               | G500=zero frame:<br>(default setting; contains no offset, rotation, mirroring or scaling)                                                                                                                                | Deactivation of the settable zero offset until the next call, activation of the entire basic frame (\$P_ACTBFRAME).                                                  |
|               | G500 not equal to 0:                                                                                                                                                                                                     | Activation of the first settable zero offset (\$P_UIFR[0]) and activation of the entire basic frame (\$P_ACTBFRAME) or possibly a modified basic frame is activated. |
| G53:          | G53 suppresses the settable zero offset and the programmable zero offset non-modally.                                                                                                                                    |                                                                                                                                                                      |
| G153:         | G153 has the same effect as G53 and also suppresses the entire basic frame.                                                                                                                                              |                                                                                                                                                                      |
| SUPA:         | SUPA has the same effect as G153 and also suppresses: <ul style="list-style-type: none"> <li>• Handwheel offsets (DRF)</li> <li>• Overlaid movements</li> <li>• External zero offset</li> <li>• PRESET offset</li> </ul> |                                                                                                                                                                      |

## Example

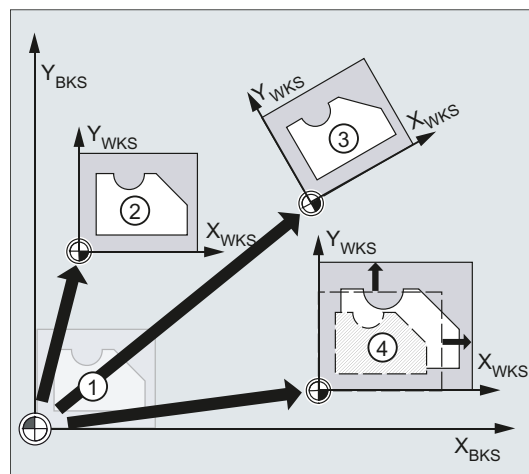


| Program code               | Comment                                    |
|----------------------------|--------------------------------------------|
| N10 G0 G90 X10 Y10 F500 T1 | ; Approach                                 |
| N20 G54 S1000 M3           | ; Call of the first WO, spindle clockwise  |
| N30 L47                    | ; Program pass as subprogram               |
| N40 G55 G0 Z200            | ; Call of the second WO, Z via obstruction |
| N50 L47                    | ; Program pass as subprogram               |
| N60 G56                    | ; Call of the third WO                     |
| N70 L47                    | ; Program pass as subprogram               |
| N80 G53 X200 Y300 M30      | ; Suppress zero offset, end of program     |

## Further information

A parameterized zero offset is in principle a set frame (Page 305). Consequently, the following components and frame values are also available for a parameterized zero offset:

- Offset
- Rotation
- Scaling
- Scale



- ① Initial position in the BCS
- ② Offset
- ③ Offset + rotation
- ④ Offset + scaling

Figure 9-1 Zero offsets

The frame values for the parameterized zero offsets are input from the user interface:

SINUMERIK Operate: "Parameters" > "Zero offsets" > "Details" operating area

### SINUMERIK 828D

For SINUMERIK 828D, the 5th and 6th parameterized zero offsets are called with G58 and G59, respectively.

The G505 and G506 commands are not available for SINUMERIK 828D.

### Parameterized number of parameterizable frames (G505 - G599)

The number of user-specific parameterized zero offsets (G505 - G599) can be set for each specific channel via:

MD28080 \$MC\_MM\_NUM\_USER\_FRAMES = <number>

### See also

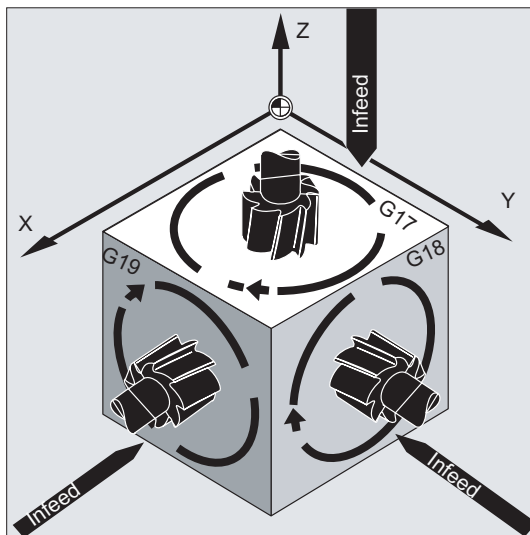
Axial zero offset (G58, G59) (Page 314)

## 9.2 Selection of the working plane (G17/G18/G19)

The specification of the working plane, in which the desired contour is to be machined, also defines the following functions:

- The plane for tool radius compensation
- The infeed direction for tool length offset depending on the tool type
- The plane for circular interpolation

## 9.2 Selection of the working plane (G17/G18/G19)



### Syntax

G17/G18/G19, etc.

### Meaning

|      |                                                                                  |
|------|----------------------------------------------------------------------------------|
| G17: | Working plane X/Y<br>Infeed direction Z, plane selection 1st - 2nd geometry axis |
| G18: | Working plane Z/X<br>Infeed direction Y, plane selection 3rd - 1st geometry axis |
| G19: | Working plane Y/Z<br>Infeed direction X, plane selection 2nd - 3rd geometry axis |

### Note

In the default setting, G17 (X/Y plane) is defined for milling and G18 (Z/X plane) is defined for turning.

When calling the tool path correction G41/G42 (see Section "Tool radius compensation (Page 247)"), the working plane must be defined so that the control can correct the tool length and radius.

### Example

The "conventional" approach for milling is:

1. Define working plane (G17 default setting for milling).
2. Select tool type (T) and tool offset values (D).
3. Switch on path correction (G41).
4. Program traversing movements.

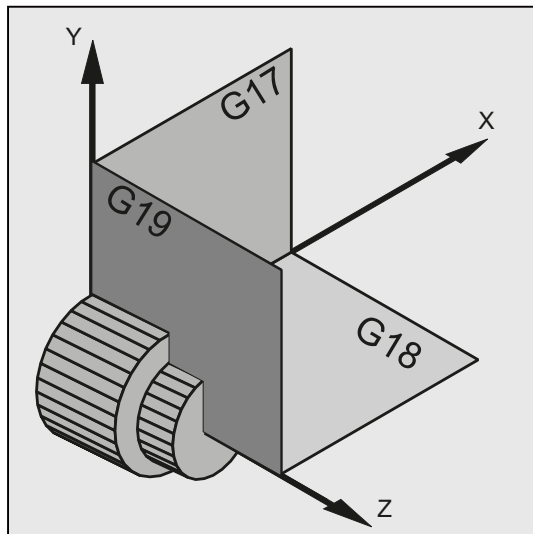
| Program code                | Comment                                                                                     |
|-----------------------------|---------------------------------------------------------------------------------------------|
| N10 G17 T5 D8               | ; Call of working plane X/Y, tool call. Tool length offset is performed in the Z direction. |
| N20 G1 G41 X10 Y30 Z-5 F500 | ; Radius compensation is performed in the X/Y plane.                                        |
| N30 G2 X22.5 Y40 I50 J40    | ; Circular interpolation / tool radius compensation in the X/Y plane.                       |

## Further information

### General

It is recommended that the working plane G17 to G19 be selected at the start of the program. In the default setting, the Z/X plane is preset for turning G18.

Turning:



The control requires the specification of the working plane for the calculation of the direction of rotation (see circular interpolation G2/G3).

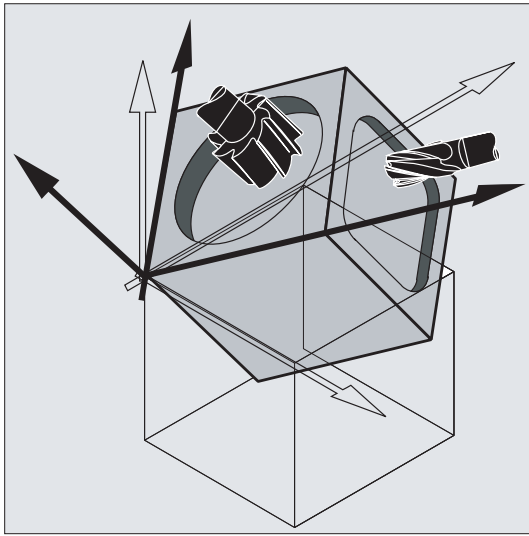
### Machining on inclined planes

Rotate the coordinate system with ROT (see Section "Coordinate system offset") to position the coordinate axes on the inclined surface. The working planes rotate accordingly.

### Tool length compensation on inclined planes

As a general rule, the tool length compensation always refers to the fixed, non-rotated working plane.

Milling:



---

**Note**

The tool length components can be calculated according to the rotated working planes with the functions for "Tool length compensation for orientable tools".

---

The compensation plane is selected with CUT2D, CUT2DF. For further information on this and for the description of the available calculation methods, see Chapter "Tool radius compensation (Page 247)".

The control provides convenient coordinate transformation functions for the spatial definition of the working plane. Please see Chapter "Coordinate transformations (frames) (Page 305)" for more information.

## 9.3 Dimensions

The basis of most NC programs is a workpiece drawing with specific dimensions.

These dimensions can be:

- In absolute dimensions or in incremental dimensions
- In millimeters or inches
- In radius or diameter (for turning)

Specific programming commands are available for the various dimension options so that the data from a dimension drawing can be transferred directly (without conversion) to the NC program.

### 9.3.1 Absolute dimensions (G90, AC)

With absolute dimensions, the position specifications always refer to the zero point of the currently valid coordinate system, i.e. the absolute position is programmed, on which the tool is to traverse.

#### Modal absolute dimensions

Modal absolute dimensions are activated with the G90 command. Generally it applies to all axes programmed in subsequent NC blocks.

#### Non-modal absolute dimensions

With preset incremental dimensions (G91), the AC command can be used to set non-modal absolute dimensions for individual axes.

---

#### Note

Non-modal absolute dimensions (AC) are also possible for spindle positioning (SPOS, SPOSA) and interpolation parameters (I, J, K).

---

#### Syntax

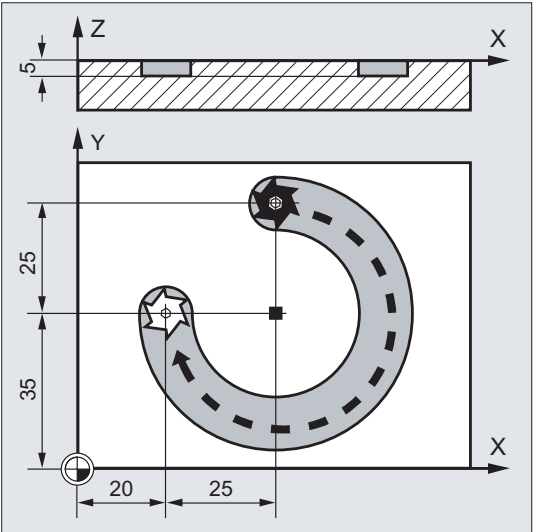
```
G90  
<axis>=AC(<value>)
```

#### Meaning

|          |                                                                      |
|----------|----------------------------------------------------------------------|
| G90:     | Command for the activation of modal absolute dimensions              |
| AC:      | Command for the activation of non-modal absolute dimensions          |
| <axis>:  | Axis identifier of the axis to be traversed                          |
| <value>: | Position setpoint of the axis to be traversed in absolute dimensions |

Examples

Example 1: Milling



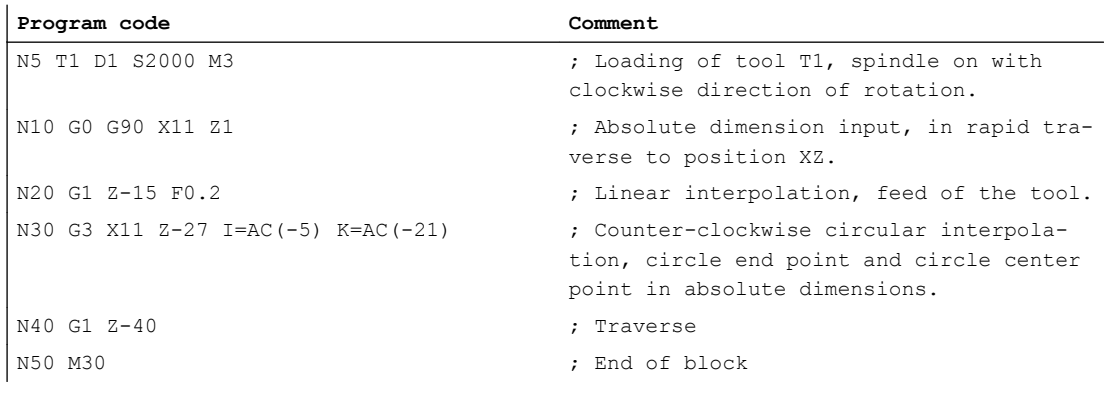
| Program code                      | Comment                                                                                                                                    |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G90 G0 X45 Y60 Z2 T1 S2000 M3 | ; Absolute dimension input, in rapid tra-<br>verse to position XYZ, tool selection,<br>spindle on with clockwise direction of<br>rotation. |
| N20 G1 Z-5 F500                   | ; Linear interpolation, feed of the tool.                                                                                                  |
| N30 G2 X20 Y35 I=AC(45) J=AC(35)  | ; Clockwise circular interpolation, cir-<br>cle end point and circle center point in<br>absolute dimensions.                               |
| N40 G0 Z2                         | ; Traverse                                                                                                                                 |
| N50 M30                           | ; End of block                                                                                                                             |

Note

For information on the input of the circle center point coordinates I and J, see Section "Circular interpolation".

Example 2: Turning





For information on the input of the circle center point coordinates I and J, see Section "Circular interpolation".

Absolute and incremental dimensions for turning and milling (G90/G91) (Page 149)

With incremental dimensions, the position specification refers to the last point approached, i.e. the programming in incremental dimensions describes by how much the tool is to be traversed.

Modal incremental dimensions are activated with the **G91** command. Generally it applies to all axes programmed in subsequent NC blocks.

Fundamentals  
Programming Manual, 01/2015, 6FC5398-1BP40-5BA2

With preset absolute dimensions (G90), the IC command can be used to set non-modal incremental dimensions for individual axes.

#### Note

Non-modal incremental dimensions (IC) are also possible for spindle positioning (SPOS, SPOSA) and interpolation parameters (I, J, K).

### Syntax

```
G91
<axis>=IC (<value>)
```

### Meaning

|          |                                                                         |
|----------|-------------------------------------------------------------------------|
| G91:     | Command for the activation of modal incremental dimensions              |
| IC:      | Command for the activation of non-modal incremental dimensions          |
| <axis>:  | Axis identifier of the axis to be traversed                             |
| <value>: | Position setpoint of the axis to be traversed in incremental dimensions |

### G91 extension

For certain applications, such as scratching, it is necessary that only the programmed distance is traversed in incremental dimensions. The active zero offset or tool length offset is not traversed.

This behavior can be set separately for the active zero offset and tool length offset via the following setting data:

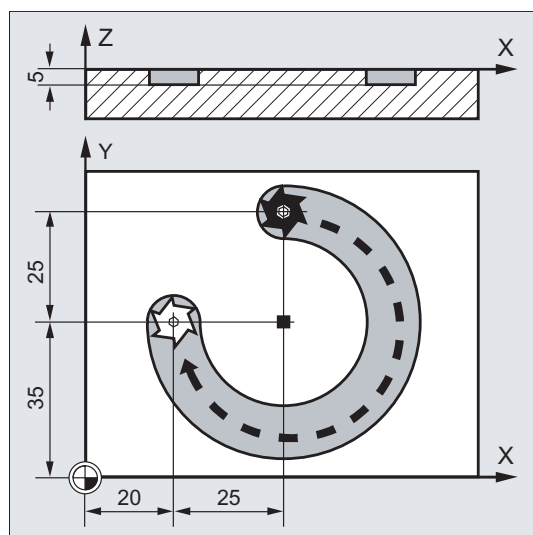
SD42440 \$SC\_FRAME\_OFFSET\_INCR\_PROG (zero offsets in frames)

SD42442 \$SC\_TOOL\_OFFSET\_INCR\_PROG (tool length offsets)

| Value | Meaning                                                                                                                              |
|-------|--------------------------------------------------------------------------------------------------------------------------------------|
| 0     | With incremental programming (incremental dimensions) of an axis, the zero offset or the tool length offset is <b>not</b> traversed. |
| 1     | With incremental programming (incremental dimensions) of an axis, the zero offset or the tool length offset is traversed.            |

## Examples

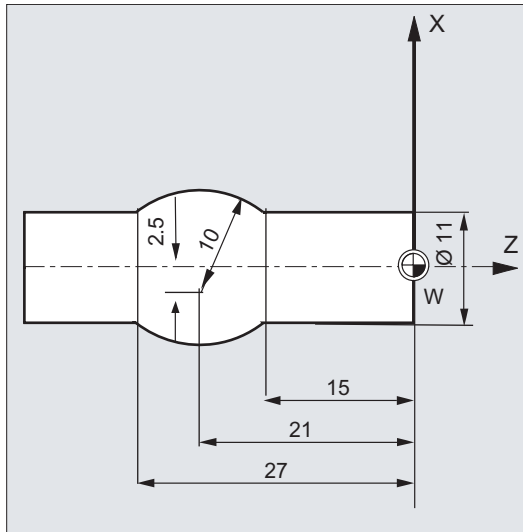
## Example 1: Milling



| Program code                      | Comment                                                                                                                        |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| N10 G90 G0 X45 Y60 Z2 T1 S2000 M3 | ; Absolute dimension input, in rapid traverse to position XYZ, tool selection, spindle on with clockwise direction of rotation |
| N20 G1 Z-5 F500                   | ; Linear interpolation, feed of the tool.                                                                                      |
| N30 G2 X20 Y35 I0 J-25            | ; Clockwise circular interpolation, circle end point in absolute dimensions, circle center point in incremental dimensions.    |
| N40 G0 Z2                         | ; Traverse                                                                                                                     |
| N50 M30                           | ; End of block                                                                                                                 |

**Note**

For information on the input of the circle center point coordinates I and J, see Section "Circular interpolation".



| Program code            | Comment                                                                                                                             |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| N5 T1 D1 S2000 M3       | ; Loading of tool T1, spindle on with clockwise direction of rotation.                                                              |
| N10 G0 G90 X11 Z1       | ; Absolute dimension input, in rapid traverse to position XZ.                                                                       |
| N20 G1 Z-15 F0.2        | ; Linear interpolation, feed of the tool.                                                                                           |
| N30 G3 X11 Z-27 I-8 K-6 | ; Counter-clockwise circular interpolation, circle end point in absolute dimensions, circle center point in incremental dimensions. |
| N40 G1 Z-40             | ; Traverse                                                                                                                          |
| N50 M30                 | ; End of block                                                                                                                      |

For information on the input of the circle center point coordinates I and J, see Section "Circular interpolation".

- G54 contains an offset in X of 25
- SD42440 \$SC\_FRAME\_OFFSET\_INCR\_PROG = 0

| Program code        | Comment                                                                                          |
|---------------------|--------------------------------------------------------------------------------------------------|
| N10 G90 G0 G54 X100 |                                                                                                  |
| N20 G1 G91 X10      | ; Incremental dimensions active, traversing in X of 10 mm<br>(the zero offset is not traversed). |

| Program code | Comment                                                                                |
|--------------|----------------------------------------------------------------------------------------|
| N30 G90 X50  | ; Absolute dimensions active, traverse to position X75 (the zero offset is traversed). |

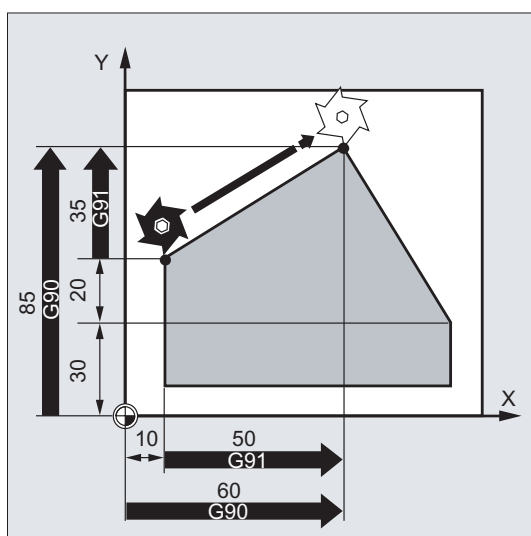
## See also

Absolute and incremental dimensions for turning and milling (G90/G91) (Page 149)

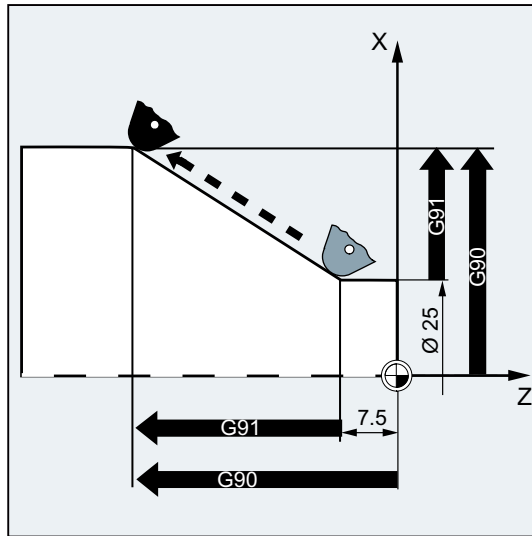
### 9.3.3 Absolute and incremental dimensions for turning and milling (G90/G91)

The two following figures illustrate the programming with absolute dimensions (G90) or incremental dimensions (G91) using turning and milling technology examples.

#### Milling:



### Turning:



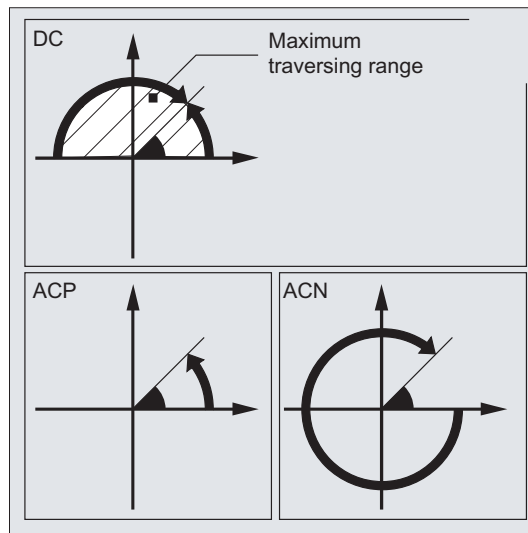
#### Note

On conventional turning machines, it is usual to consider incremental traversing blocks in the transverse axis as radius values, while diameter specifications apply for the reference dimensions. This conversion for G90 is performed using the commands `DIAMON`, `DIAMOF` or `DIAM90`.

### 9.3.4 Absolute dimensions for rotary axes (DC, ACP, ACN)

The non-modal and G90/G91-independent commands `DC`, `ACP` and `ACN` are available for the positioning of rotary axes in absolute dimensions.

`DC`, `ACP` and `ACN` differ in the basic approach strategy:



## Syntax

```
<rotary axis>=DC(<value>)
<rotary axis>=ACP(<value>)
<rotary axis>=ACN(<value>)
```

## Meaning

|                |                                                                                                                                                                                                |                 |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <rotary axis>: | Identifier of the rotary axis that is to be traversed (e.g. A, B or C)                                                                                                                         |                 |
| DC:            | Command for the <b>direct</b> approach to the position<br>The rotary axis approaches the programmed position directly on the shortest path. The rotary axis traverses a maximum range of 180°. |                 |
| ACP:           | Command to approach the position in a <b>positive</b> direction<br>The rotary axis traverses to the programmed position in the positive direction of axis rotation (counter-clockwise).        |                 |
| ACN:           | Command to approach the position in a <b>negative</b> direction<br>The rotary axis traverses to the programmed position in the negative direction of axis rotation (clockwise).                |                 |
| <value>:       | Rotary axis position to be approached in absolute dimensions                                                                                                                                   |                 |
|                | Range of values:                                                                                                                                                                               | 0 - 360 degrees |

### Note

The positive direction of rotation (clockwise or counter-clockwise) is set in the machine data.

### Note

The traversing range between 0° and 360° must be set in the machine data (modulo behavior) for positioning with direction specification (ACP, ACN). G91 or IC must be programmed to traverse modulo rotary axes more than 360° in a block.

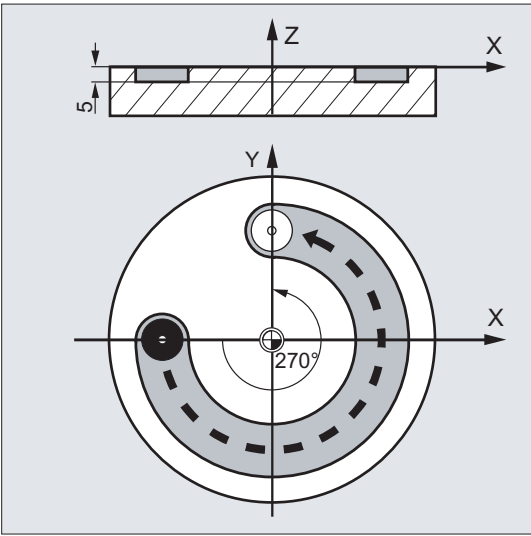
**Note**

The commands `DC`, `ACP` and `ACN` can also be used for spindle positioning (`SPOS`, `SPOSA`) from standstill.

Example: `SPOS=DC (45)`

Example

Milling on a rotary table



The tool is stationary, the table turns to 270° in a clockwise direction to produce a circular groove.

| Program code             | Comment                                                                              |
|--------------------------|--------------------------------------------------------------------------------------|
| N10 SPOS=0               | ; Spindle in position control.                                                       |
| N20 G90 G0 X-20 Y0 Z2 T1 | ; Absolute dimensions, feed tool T1 in rapid tra-verse.                              |
| N30 G1 Z-5 F500          | ; Lower tool during feed.                                                            |
| N40 C=ACP(270)           | ; Table turns clockwise to 270 degrees (positive), the tool mills a circular groove. |
| N50 G0 Z2 M30            | ; Retraction, end of program.                                                        |

References

Function Manual, Extended Functions; Rotary Axes (R2)

9.3.5 Inch or metric dimensions (G70/G700, G71/G710)

The following G functions can be used to switch between the metric measuring system and the inch measuring system.



## Syntax

G70/G71

G700/G710

## Meaning

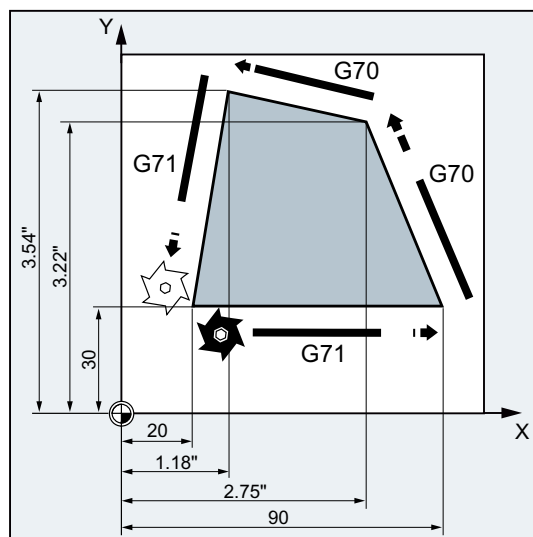
|       |                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G70:  | <p>Activation of the inch measuring system</p> <p>The inch measuring system is used to read and write geometric data in units of length. Technological data in units of length, e.g. feedrates, tool offsets or settable zero offsets, as well as machine data and system variables, are read and written using the parameterized basic system (MD10240 \$MN_SCALING_SYSTEM_IS_METRIC).</p>     |
| G71:  | <p>Activation of the metric measuring system</p> <p>The metric measuring system is used to read and write geometric data in units of length. Technological data in units of length, e.g. feedrates, tool offsets or settable zero offsets, as well as machine data and system variables, are read and written using the parameterized basic system (MD10240 \$MN_SCALING_SYSTEM_IS_METRIC).</p> |
| G700: | <p>Activation of the inch measuring system</p> <p>All geometrical and technological data in units of length (see above) are read and written using the inch measuring system.</p>                                                                                                                                                                                                               |
| G710: | <p>Activation of the metric measuring system</p> <p>All geometrical and technological data in units of length (see above) are read and written using the metric measuring system.</p>                                                                                                                                                                                                           |

## Example

### Changeover between inch system and metric system

The parameterized basic system is metric:

MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC = TRUE



| Program code                      | Comment                                                              |
|-----------------------------------|----------------------------------------------------------------------|
| N10 G0 G90 X20 Y30 Z2 S2000 M3 T1 | ; X=20 mm, Y=30 mm, Z=2 mm, F=rapid traverse mm/min                  |
| N20 G1 Z-5 F500                   | ; Z=-5 mm, F=500 mm/min                                              |
| N30 X90                           | ; X=90 mm                                                            |
| N40 G70 X2.75 Y3.22               | ; Prog. meas. system: inch<br>X=2.75 inch, Y=3.22 inch, F=500 mm/min |
| N50 X1.18 Y3.54                   | ; X=1.18 inch, Y=3.54 inch, F=500 mm/min                             |
| N60 G71 X20 Y30                   | ; Prog. meas. system: metric<br>X=20 mm, Y=30 mm, F=500 mm/min       |
| N70 G0 Z2                         | ; Z=2 mm, F=rapid traverse mm/min                                    |
| N80 M30                           | ; End of program                                                     |

## Further information

### G70/G71

With G70/G71 active, only the following geometric data is interpreted in the relevant measuring system:

- Position data (X, Y, Z, ...)
- Circular-path programming:
  - Interpolation point coordinates (I1, J1, K1)
  - Interpolation parameters (I, J, K)
  - Circle radius (CR)
- Pitch (G34, G35)
- Programmable work offset (TRANS)
- Polar radius (RP)

### Synchronized actions

If, in a synchronized action (condition component and/or action component) no explicit measuring system is programmed (G70/G71/G700/G710), the measuring system which was active in the channel at the point of execution will be applied to the synchronized action (condition component and/or action component).

---

### Note

#### Read position data in synchronized actions

If a measuring system has not been explicitly programmed in the synchronized action (condition component and/or action component), **position data specified in units of length** in the synchronized action is always read in the **parameterized basic system**.

---

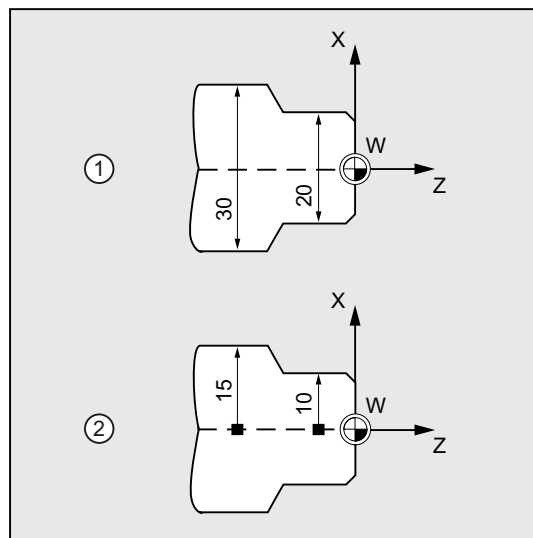
### References

- Function Manual, Basic Functions; Speeds, Setpoint/Actual-Value System, Closed-Loop Control (G2), Section "Metric/inch dimension system"
- Programming Manual, Job Planning; Section "Motion-synchronous actions"
- Function Manual, Synchronized Actions

### 9.3.6

### Channel-specific diameter/radius programming (DIAMON, DIAM90, DIAMOF, DIAMCYCOF)

During turning, the dimensions **for the transverse axis** can be specified in the diameter (①) or in the radius (②):



So that the dimensions from a technical drawing can be transferred directly (without conversion) to the NC program, channel-specific diameter or radius programming is activated using the modal commands `DIAMON`, `DIAM90`, `DIAMOF`, and `DIAMCYCOF`.

### Note

The channel-specific diameter/radius programming refers to the geometry axis defined as transverse axis via MD20100 `$MC_DIAMETER_AX_DEF` (→ see machine manufacturer's specifications).

Only one transverse axis per channel can be defined via MD20100.

### Syntax

```
DIAMON
DIAM90
DIAMOF
```

## Meaning

|            |                                                                                                                                                                                                                                                                                              |                            |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| DIAMON:    | Command for the activation of the <b>independent</b> channel-specific diameter programming.<br>The effect of DIAMON is independent of the programmed dimensions mode (absolute dimensions G90 or incremental dimensions G91):                                                                |                            |
|            | • For G90:                                                                                                                                                                                                                                                                                   | Dimensions in the diameter |
|            | • For G91:                                                                                                                                                                                                                                                                                   | Dimensions in the diameter |
| DIAM90:    | Command for the activation of the <b>dependent</b> channel-specific diameter programming.<br>The effect of DIAM90 depends on the programmed dimensions mode:                                                                                                                                 |                            |
|            | • For G90:                                                                                                                                                                                                                                                                                   | Dimensions in the diameter |
|            | • For G91:                                                                                                                                                                                                                                                                                   | Dimensions in the radius   |
| DIAMOF:    | Command for the deactivation of the channel-specific diameter programming<br>Channel-specific radius programming takes effect when diameter programming is deactivated. The effect of DIAMOF is independent of the programmed dimensions mode:                                               |                            |
|            | • For G90:                                                                                                                                                                                                                                                                                   | Dimensions in the radius   |
|            | • For G91:                                                                                                                                                                                                                                                                                   | Dimensions in the radius   |
| DIAMCYCOF: | Command for the deactivation of channel-specific diameter programming during cycle processing.<br>In this way, computations in the cycle can always be made in the radius. The last G function active in this group remains active for the position indicator and the basic block indicator. |                            |
|            |                                                                                                                                                                                                                                                                                              |                            |

## Note

With DIAMON or DIAM90, the transverse-axis actual values will always be displayed as a diameter. This also applies to reading of actual values in the workpiece coordinate system with MEAS, MEAW, \$P\_EP[x] and \$AA\_IW[x].

## Example

| Program code              | Comment                                                                                           |
|---------------------------|---------------------------------------------------------------------------------------------------|
| N10 G0 X0 Z0              | ; Approach starting point.                                                                        |
| N20 DIAMOF                | ; Diameter programming off.                                                                       |
| N30 G1 X30 S2000 M03 F0.7 | ; X axis = transverse axis, radius programming active; traverse to radius position X30.           |
| N40 DIAMON                | ; The diameter programming is active for the transverse axis.                                     |
| N50 G1 X70 Z-20           | ; Traverse to diameter position X70 and Z-20.                                                     |
| N60 Z-30                  |                                                                                                   |
| N70 DIAM90                | ; Diameter programming for absolute dimensions and radius programming for incremental dimensions. |
| N80 G91 X10 Z-20          | ; Incremental dimensions active.                                                                  |
| N90 G90 X10               | ; Absolute dimensions active.                                                                     |

| Program code | Comment          |
|--------------|------------------|
| N100 M30     | ; End of program |

## Further information

### Diameter values (DIAMON/DIAM90)

The diameter values apply for the following data:

- Actual value display of the transverse axis in the workpiece coordinate system
- JOG mode: Increments for incremental dimensions and handwheel travel
- Programming of end positions:  
Interpolation parameters I, J, K for G2/G3, if these have been programmed absolutely with AC.  
If I, J, K are programmed incrementally (IC), the radius is always calculated.
- Reading actual values in the workpiece coordinate system for:  
MEAS, MEAW, \$P\_EP[X], \$AA\_IW[X]

## 9.3.7 Axis-specific diameter/radius programming (DIAMONA, DIAM90A, DIAMOFA, DIACYCOFA, DIAMCHANA, DIAMCHAN, DAC, DIC, RAC, RIC)

In addition to channel-specific diameter programming, the axis-specific diameter programming function enables the modal or non-modal dimensions and display in the diameter for one or more axes.

### Note

The axis-specific diameter programming is only possible for axes that are permitted as further transverse axes for the axis-specific diameter programming via MD30460 \$MA\_BASE\_FUNCTION\_MASK (→ see machine manufacturer's specifications).

## Syntax

Modal axis-specific diameter programming for several transverse axes in the channel:

```
DIAMONA [<axis>]
DIAM90A [<axis>]
DIAMOFA [<axis>]
DIACYCOFA [<axis>]
```

Acceptance of the channel-specific diameter/radius programming:

```
DIAMCHANA [<axis>]
DIAMCHAN
```

Non-modal axis-specific diameter/radius programming:

```
<axis>=DAC (<value>)
<axis>=DIC (<value>)
<axis>=RAC (<value>)
<axis>=RIC (<value>)
```

## Meaning

| Modal axis-specific diameter programming                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DIAMONA:                                                                                                                                                                                                                            | Command for the activation of the <b>independent</b> axis-specific diameter programming<br>The effect of DIAMONA is independent of the programmed dimensions mode (G90/G91 or AC/IC):                                                                                                         |                                                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                                                     | • For G90, AC:                                                                                                                                                                                                                                                                                | Dimensions in the diameter                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                     | • For G91, IC:                                                                                                                                                                                                                                                                                | Dimensions in the diameter                                                                                                                                                                                                                                                                                     |
| DIAM90A:                                                                                                                                                                                                                            | Command for the activation of the <b>dependent</b> axis-specific diameter programming<br>The effect of DIAM90A depends on the programmed dimensions mode:                                                                                                                                     |                                                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                                                     | • For G90, AC:                                                                                                                                                                                                                                                                                | Dimensions in the diameter                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                     | • For G91, IC:                                                                                                                                                                                                                                                                                | Dimensions in the radius                                                                                                                                                                                                                                                                                       |
| DIAMOFA:                                                                                                                                                                                                                            | Command for the deactivation of the axis-specific diameter programming<br>Axis-specific radius programming takes effect when diameter programming is deactivated. The effect of DIAMOFA is independent of the programmed dimensions mode:                                                     |                                                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                                                     | • For G90, AC:                                                                                                                                                                                                                                                                                | Dimensions in the radius                                                                                                                                                                                                                                                                                       |
|                                                                                                                                                                                                                                     | • For G91, IC:                                                                                                                                                                                                                                                                                | Dimensions in the radius                                                                                                                                                                                                                                                                                       |
| DIACYCOFA:                                                                                                                                                                                                                          | Command for the deactivation of axis-specific diameter programming during cycle processing.<br><br>In this way, computations in the cycle can always be made in the radius. The last G function active in this group remains active for the position indicator and the basic block indicator. |                                                                                                                                                                                                                                                                                                                |
| <axis>:                                                                                                                                                                                                                             | Axis identifier of the axis for which the axis-specific diameter programming is to be activated.<br>Permitted axis identifiers are as follows: <ul style="list-style-type: none"><li>• Geometry/channel axis name<br/>or</li><li>• Machine axis name</li></ul>                                |                                                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                                                     | Range of values:                                                                                                                                                                                                                                                                              | The axis specified must be a known axis in the channel.<br>Other conditions: <ul style="list-style-type: none"><li>• The axis must be permitted for the axis-specific diameter programming via MD30460 \$MA_BASE_FUNCTION_MASK.</li><li>• Rotary axes are not permitted to serve as transverse axes.</li></ul> |
|                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |
| Acceptance of the channel-specific diameter/radius programming                                                                                                                                                                      |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |
| DIAMCHANA:                                                                                                                                                                                                                          | With the DIAMCHANA[<axis>] command, the <b>specified axis</b> accepts the channel status of the diameter/radius programming and is then assigned to the channel-specific diameter/radius programming.                                                                                         |                                                                                                                                                                                                                                                                                                                |
| DIAMCHAN:                                                                                                                                                                                                                           | With the DIAMCHAN command, <b>all</b> axes permitted for the axis-specific diameter programming accept the channel status of the diameter/radius programming and are then assigned to the channel-specific diameter/radius programming.                                                       |                                                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |
| Non-modal axis-specific diameter/radius programming                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |
| The non-modal axis-specific diameter/radius programming specifies the dimension type as a diameter or radius value in the part program and synchronized actions. The modal status of diameter/radius programming remains unchanged. |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                |

|      |                                                                                                                                       |
|------|---------------------------------------------------------------------------------------------------------------------------------------|
| DAC: | The <code>DAC</code> command sets the following dimensions to non-modal for the specified axis:<br>Diameter in absolute dimensions    |
| DIC: | The <code>DIC</code> command sets the following dimensions to non-modal for the specified axis:<br>Diameter in incremental dimensions |
| RAC: | The <code>RAC</code> command sets the following dimensions to non-modal for the specified axis:<br>Radius in absolute dimensions      |
| RIC: | The <code>RIC</code> command sets the following dimensions to non-modal for the specified axis:<br>Radius in incremental dimensions   |

**Note**

With `DIAMONA[<axis>]` or `DIAM90A[<axis>]`, the transverse-axis actual values are always displayed as a diameter. This also applies to reading of actual values in the workpiece coordinate system with `MEAS`, `MEAW`, `$P_EP[x]` and `$AA_IW[x]`.

**Note**

During the replacement of an additional transverse axis because of a `GET` request, the status of the diameter/radius programming in the other channel is accepted with `RELEASE[<axis>]`.

**Examples****Example 1: Modal axis-specific diameter/radius programming**

X is the transverse axis in the channel, axis-specific diameter programming is permitted for Y.

| Program code        | Comment                                                                                             |
|---------------------|-----------------------------------------------------------------------------------------------------|
| N10 G0 X0 Z0 DIAMON | ; Channel-specific diameter programming active for X.                                               |
| N15 DIAMOF          | ; Channel-specific diameter programming off.                                                        |
| N20 DIAMONA[Y]      | ; Modal axis-specific diameter programming active for Y.                                            |
| N25 X200 Y100       | ; Radius programming active for X.                                                                  |
| N30 DIAMCHANA[Y]    | ; Y accepts the status of the channel-specific diameter/radius programming and is assigned to this. |
| N35 X50 Y100        | ; Radius programming active for X and Y.                                                            |
| N40 DIAMON          | ; Channel-specific diameter programming on.                                                         |
| N45 X50 Y100        | ; Diameter programming active for X and Y.                                                          |

**Example 2: Non-modal axis-specific diameter/radius programming**

X is the transverse axis in the channel, axis-specific diameter programming is permitted for Y.

| Program code                               | Comment                                                                                             |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------|
| N10 DIAMON                                 | ; Channel-specific diameter programming on.                                                         |
| N15 G0 G90 X20 Y40 DIAMONA[Y]              | ; Modal axis-specific diameter programming active for Y.                                            |
| N20 G01 X=RIC(5)                           | ; Dimensions effective in this block for X: Radius in incremental dimensions.                       |
| N25 X=RAC(80)                              | ; Dimensions effective in this block for X: Radius in absolute dimensions.                          |
| N30 WHEN \$SAA_IM[Y]> 50 DO POS[X]=RIC(1)  | ; X is command axis.<br>Dimensions effective in this block for X: Radius in incremental dimensions. |
| N40 WHEN \$SAA_IM[Y]> 60 DO POS[X]=DAC(10) | ; X is command axis.<br>Dimensions effective in this block for X: Radius in absolute dimensions.    |
| N50 G4 F3                                  |                                                                                                     |

**Further information****Diameter values (DIAMONA/DIAM90A)**

The diameter values apply for the following data:

- Actual value display of the transverse axis in the workpiece coordinate system
- JOG mode: Increments for incremental dimensions and handwheel travel
- Programming of end positions:  
Interpolation parameters I, J, K for G2/G3, if these have been programmed absolutely with AC.  
If I, J, K are programmed incrementally (IC), the radius is always calculated.
- Reading actual values in the workpiece coordinate system for:  
MEAS, MEAW, \$P\_EP[X], \$AA\_IW[X]

**Non-modal axis-specific diameter programming (DAC, DIC, RAC, RIC)**

The statements DAC, DIC, RAC, RIC are permissible for any commands for which channel-specific diameter programming is relevant:

- Axis position: X . . . , POS, POSA
- Oscillating: OSP1, OSP2, OSS, OSE, POSP
- Interpolation parameters: I, J, K
- Contour definition: Straight line with specified angle



- Rapid retraction: POLF [AX]
- Movement in tool direction: MOV T
- Smooth approach and retraction:  
G140 to G143, G147, **G148**, G247, G248, G347, G348, G340, G341

## 9.4 Position of workpiece for turning

### Axis identifiers

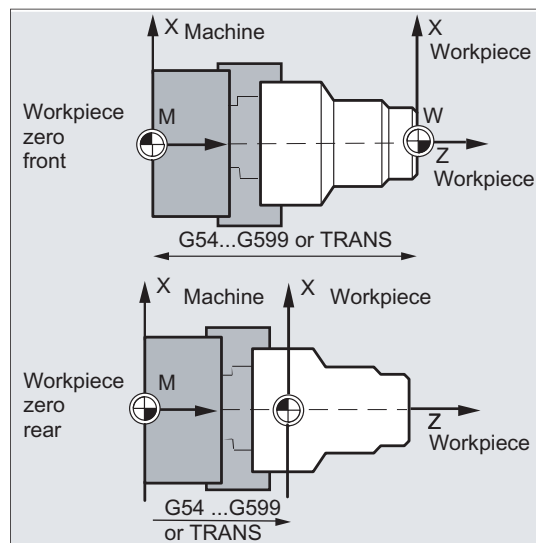
The two geometry axes perpendicular to one another are usually called:

|                          |                     |
|--------------------------|---------------------|
| <b>Longitudinal axis</b> | = Z axis (abscissa) |
| <b>Transverse axis</b>   | = X axis (ordinate) |

### Workpiece zero

Whereas the machine zero is permanently defined, the workpiece zero can be freely selected on the longitudinal axis. Generally the workpiece zero is on the front or rear side of the workpiece.

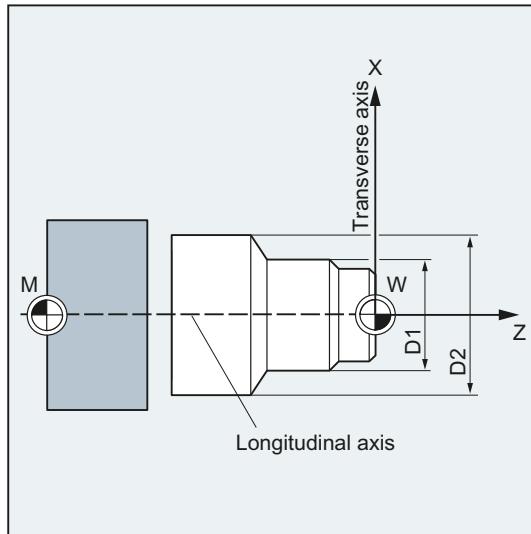
Both the machine and the workpiece zero are on the turning center. The settable offset on the X axis is therefore zero.



|                         |                                             |
|-------------------------|---------------------------------------------|
| M                       | Machine zero                                |
| W                       | Workpiece zero                              |
| Z                       | Longitudinal axis                           |
| X                       | Transverse axis                             |
| G54 to G599<br>or TRANS | Call for the position of the workpiece zero |

## Transverse axis

Generally the dimensions for the transverse axis are diameter specifications (double path dimension compared to other axes):



The geometry axis that is to serve as transverse axis is defined in the machine data (→ machine manufacturer).

## Motion commands

### 10.1 General information about the travel commands

#### Contour elements

The programmed workpiece contour can be made up of the following contour elements:

- Straight lines
- Circular arcs
- Helical curves (through overlaying of straight lines and circular arcs)

#### Travel commands

The following travel commands are available for the creation of these contour elements:

- Rapid traverse motion (G0)
- Linear interpolation (G1)
- Circular interpolation clockwise (G2)
- Circular interpolation counter-clockwise (G3)

The travel commands are modal.

#### Target positions

A motion block contains the target positions for the axes to be traversed (path axes, synchronized axes, positioning axes).

The target positions can be programmed in Cartesian coordinates or in polar coordinates.

---

#### Note

The axis address may only be programmed once per block.

---

#### Starting point - target point

The traversing motion is always for the last point reached to the programmed target position. This target position is then the starting position for the next travel command.

## Workpiece contour

### NOTICE

#### Tool operation undefined

Before machining, the workpiece must be positioned in such a way that the tool or workpiece cannot be damaged.

The motion blocks produce the workpiece contour when performed in succession:

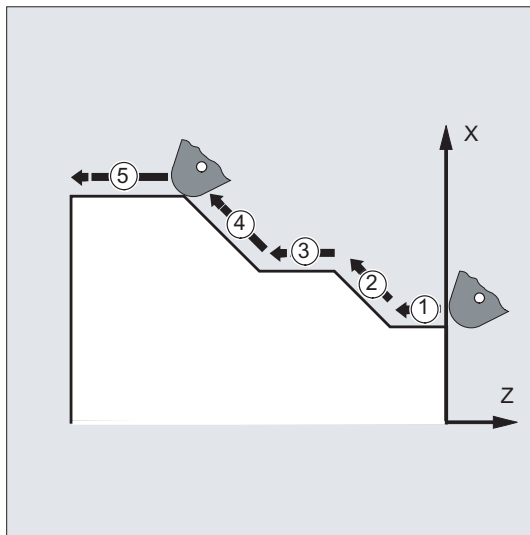


Figure 10-1 Motion blocks for turning

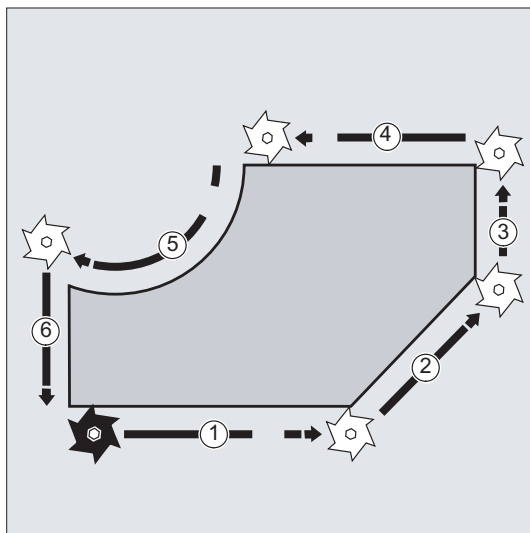


Figure 10-2 Motion blocks for milling

## 10.2 Travel commands with Cartesian coordinates (G0, G1, G2, G3, X..., Y..., Z...)

The position specified in the NC block with Cartesian coordinates can be approached with rapid traverse motion G0, linear interpolation G1 or circular interpolation G2 / G3.

### Syntax

```
G0 X... Y... Z...
G1 X... Y... Z...
G2 X... Y... Z... ...
G3 X... Y... Z... ...
```

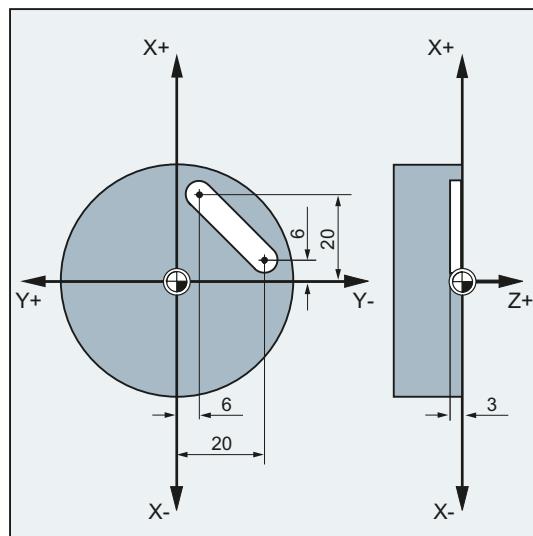
### Meaning

|       |                                                                        |
|-------|------------------------------------------------------------------------|
| G0:   | Command for the activation of rapid traverse motion                    |
| G1:   | Command for the activation of linear interpolation                     |
| G2:   | Command for the activation of clockwise circular interpolation         |
| G3:   | Command for the activation of counter-clockwise circular interpolation |
| X...: | Cartesian coordinate of the target position in the X direction         |
| Y...: | Cartesian coordinate of the target position in the Y direction         |
| Z...: | Cartesian coordinate of the target position in the Z direction         |

### Note

In addition to the coordinates of the target position X... , Y... , Z... , the circular interpolation G2 / G3 also requires further data (e.g. the circle center point coordinates; see "Circular interpolation types (G2/G3, ...) (Page 178)").

### Example



| Program code      | Comment                                                                                    |
|-------------------|--------------------------------------------------------------------------------------------|
| N10 G17 S400 M3   | ; Selection of the working plane, spindle clockwise                                        |
| N20 G0 X40 Y-6 Z2 | ; Approach of the starting position specified with Cartesian coordinates in rapid traverse |
| N30 G1 Z-3 F40    | ; Activation of the linear interpolation, feed of the tool                                 |
| N40 X12 Y-20      | ; Travel on an inclined line to an end position specified with Cartesian coordinates       |
| N50 G0 Z100 M30   | ; Retraction in rapid traverse for tool change                                             |

## 10.3 Travel commands with polar coordinates

### 10.3.1 Reference point of the polar coordinates (G110, G111, G112)

The point from which the dimensioning starts is called the pole.

The pole can be specified in Cartesian or polar coordinates.

The reference point for the pole coordinates is clearly defined with the G110 to G112 commands. Absolute or incremental dimension inputs therefore have no effect.

#### Syntax

```
G110/G111/G112 X... Y... Z...
G110/G111/G112 AP=... RP=...
```

#### Meaning

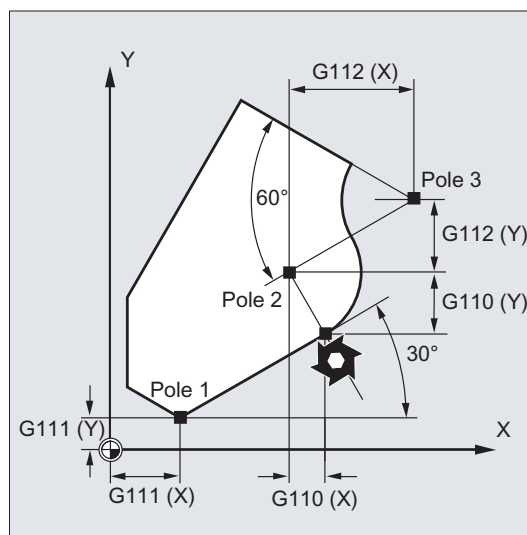
|                 |                                                                                                                                   |                                                                                                                                                                              |            |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| G110 ...:       | With the command G110, the following pole coordinates refer to <b>the last position reached</b> .                                 |                                                                                                                                                                              |            |
| G111 ...:       | With the command G111, the following pole coordinates refer to <b>the zero point of the current workpiece coordinate system</b> . |                                                                                                                                                                              |            |
| G112 ...:       | With the command G112, the following pole coordinates refer to <b>the last valid pole</b> .                                       |                                                                                                                                                                              |            |
|                 | <b>Note:</b><br>The commands G110...G112 must be programmed in a separate NC block.                                               |                                                                                                                                                                              |            |
| X... Y... Z...: | Specification of the pole in Cartesian coordinates                                                                                |                                                                                                                                                                              |            |
| AP=... RP=...:  | Specification of the pole in polar coordinates                                                                                    |                                                                                                                                                                              |            |
|                 | AP=...:                                                                                                                           | Polar angle<br>Angle between the polar radius and the horizontal axis of the working plane (e.g. X axis for G17). The positive direction of rotation runs counter-clockwise. |            |
|                 |                                                                                                                                   | Range of values:                                                                                                                                                             | ± 0...360° |
|                 | RP=...:                                                                                                                           | Polar radius<br>The specification is <b>always in absolute positive values</b> in [mm] or [inch].                                                                            |            |

**Note**

It is possible to switch block-by-block in the NC program between polar and Cartesian dimensions. It is possible to return directly to the Cartesian system by using Cartesian coordinate identifiers (X..., Y..., Z...). The defined pole is moreover retained up to program end.

**Note**

If no pole has been specified, the zero point of the current workpiece coordinate system applies.

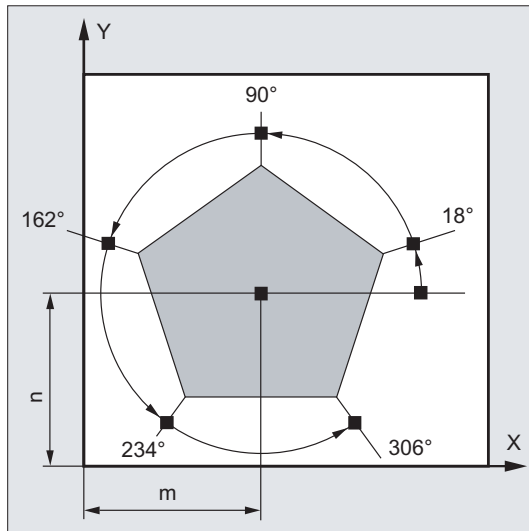
**Example**

Poles 1 to 3 are defined as follows:

- Pole 1 with G111 X... Y...
- Pole 2 with G110 X... Y...
- Pole 3 with G112 X... Y...

### 10.3.2 Travel commands with polar coordinates (G0, G1, G2, G3, AP, RP)

Travel commands with polar coordinates are useful when the dimensions of a workpiece or part of the workpiece are measured from a central point and the dimensions are specified in angles and radii (e.g. for drilling patterns).



#### Syntax

G0/G1/G2/G3 AP=... RP=...

#### Meaning

|                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------|------------------------------------------------------------|--|--------------|--------------------------|--------------|-----------------------------|-----------------------------------------------------------------------------------|--|
| G0:                                                                               | Command for the activation of rapid traverse motion                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| G1:                                                                               | Command for the activation of linear interpolation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| G2:                                                                               | Command for the activation of clockwise circular interpolation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| G3:                                                                               | Command for the activation of counter-clockwise circular interpolation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| AP:                                                                               | <p>Polar angle</p> <p>Angle between the polar radius and the horizontal axis of the working plane (e.g. X axis for G17). The positive direction of rotation runs counter-clockwise.</p> <table border="1"> <tr> <td>Range of values:</td><td><math>\pm 0 \dots 360^\circ</math></td></tr> <tr> <td colspan="2">The angle can be specified either incremental or absolute:</td></tr> <tr> <td>AP=AC (...):</td><td>Absolute dimension input</td></tr> <tr> <td>AP=IC (...):</td><td>Incremental dimension input</td></tr> <tr> <td colspan="2">With incremental dimension input, the last programmed angle applies as reference.</td></tr> </table> <p>The polar angle remains stored until a new pole is defined or the working plane is changed.</p> | Range of values: | $\pm 0 \dots 360^\circ$ | The angle can be specified either incremental or absolute: |  | AP=AC (...): | Absolute dimension input | AP=IC (...): | Incremental dimension input | With incremental dimension input, the last programmed angle applies as reference. |  |
| Range of values:                                                                  | $\pm 0 \dots 360^\circ$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| The angle can be specified either incremental or absolute:                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| AP=AC (...):                                                                      | Absolute dimension input                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| AP=IC (...):                                                                      | Incremental dimension input                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| With incremental dimension input, the last programmed angle applies as reference. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |
| RP:                                                                               | <p>Polar radius</p> <p>The specification is <b>always in absolute positive values</b> in [mm] or [inch].</p> <p>The polar radius remains stored until a new value is entered.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                  |                         |                                                            |  |              |                          |              |                             |                                                                                   |  |



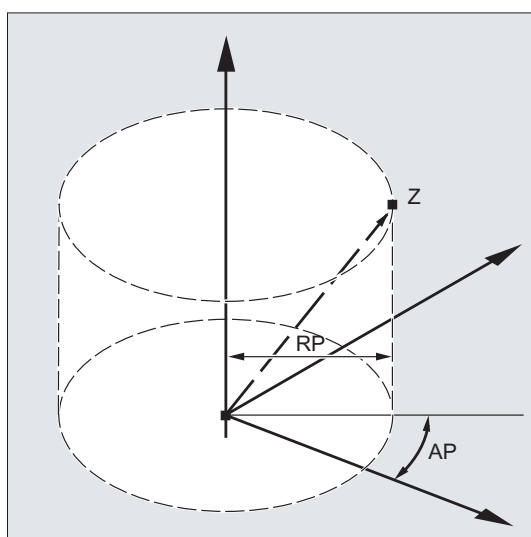
**Note**

The polar coordinates refer to the pole specified with G110 ... G112 and apply in the working plane selected with G17 to G19.

**Note**

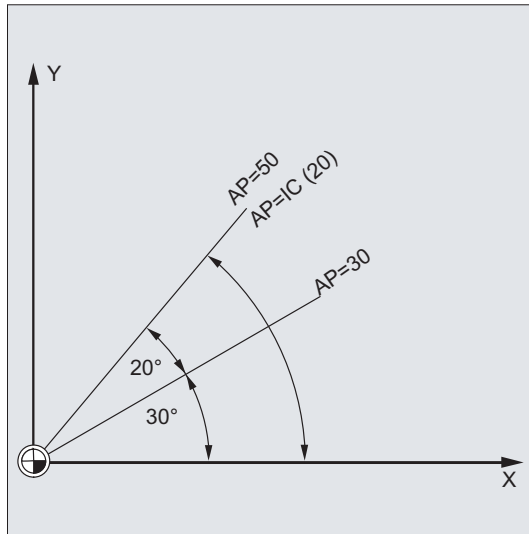
The 3rd geometry axis, which lies perpendicular to the working plane, can also be specified in Cartesian coordinates (see the following diagram). This enables spatial parameters to be programmed in cylindrical coordinates.

Example: G17 G0 AP... RP... Z...



### Supplementary conditions

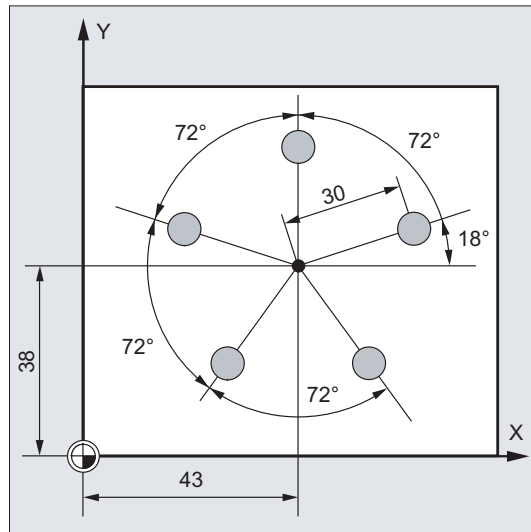
- No Cartesian coordinates such as interpolation parameters, axis addresses, etc. may be programmed for the selected working plane in NC blocks with polar end point coordinates.
- If a pole has not been defined with G110 ... G112, then the zero point of the current workpiece coordinate system is automatically considered as the pole:



- Polar radius  $RP = 0$   
The polar radius is calculated from the distance between the starting point vector in the pole plane and the active pole vector. The calculated polar radius is then saved as modal. This applies irrespective of the selected pole definition (G110 ... G112). If both points have been programmed identically, this radius = 0 and alarm 14095 is generated.
- Only polar angle AP has been programmed  
If no polar radius RP has been programmed in the current block, but a polar angle AP, then when there is a difference between the current position and pole in the workpiece coordinates, this difference is used as polar radius and saved as modal. If the difference = 0, then the pole coordinates are specified again and the modal polar radius remains at zero.

## Example

## Creation of a drilling pattern



The positions of the holes are specified in polar coordinates.

Each hole is machined with the same production sequence:

Rough-drilling, drilling as dimensioned, reaming ...

The machining sequence is stored in the sub-program.

| Program code               | Comment                                                                                                                                                         |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G17 G54                | ; Working plane X/Y, workpiece zero.                                                                                                                            |
| N20 G111 X43 Y38           | ; Specification of the pole.                                                                                                                                    |
| N30 G0 RP=30 AP=18 Z5      | ; Approach starting point, specification in cylindrical coordinates.                                                                                            |
| N40 L10                    | ; Subprogram call.                                                                                                                                              |
| N50 G91 AP=72              | ; Approach next position in rapid traverse, polar angle in incremental dimensions, polar radius from block N30 remains saved and does not have to be specified. |
| N60 L10                    | ; Subprogram call.                                                                                                                                              |
| N70 AP=IC(72)              | .                                                                                                                                                               |
| N80 L10                    | ...                                                                                                                                                             |
| N90 AP=IC(72)              | .                                                                                                                                                               |
| N100 L10                   | ...                                                                                                                                                             |
| N110 AP=IC(72)             | .                                                                                                                                                               |
| N120 L10                   | ...                                                                                                                                                             |
| N130 G0 X300 Y200 Z100 M30 | ; Retract tool, end of program.                                                                                                                                 |

## See also

Circular interpolation types (G2/G3, ...) (Page 178)

## 10.4 Rapid traverse motion (G0, RTLION, RTLIOF)

The rapid traverse velocity of an axis is its maximum permissible velocity defined using machine data:

- MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity) will still apply even after the coupling is activated

Rapid traverse motion is used, for example:

- Quickly positioning a tool
- Passing around the workpiece
- Approaching tool change points
- Retracting the tool

---

### Note

The function is not suitable for workpiece machining!

---

### Syntax

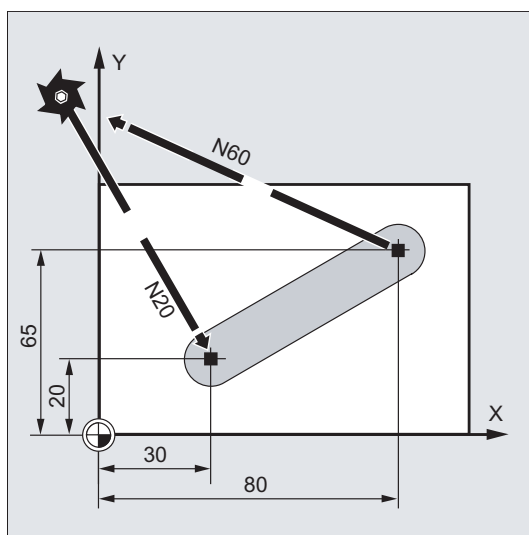
```
G0 X... Y... Z...
G0 AP=...
G0 RP=...
RTLIOF
RTLION
```

### Meaning

|                 |                                                                                                             |       |
|-----------------|-------------------------------------------------------------------------------------------------------------|-------|
| G0:             | Traversing the axis with rapid traverse velocity                                                            |       |
|                 | Effective:                                                                                                  | Modal |
| X... Y... Z...: | Specifying the end point in Cartesian coordinates                                                           |       |
| AP=...:         | Specifying the end point in polar coordinates <b>angle</b>                                                  |       |
| RP=...:         | Specifying the end point in polar coordinates <b>radius</b>                                                 |       |
| RTLIOF:         | Non-linear interpolation of the path axes ⇒ all path axes reach their endpoint independently of one another |       |
| RTLION:         | Linear interpolation of the path axes ⇒ all path axes reach their endpoint simultaneously                   |       |

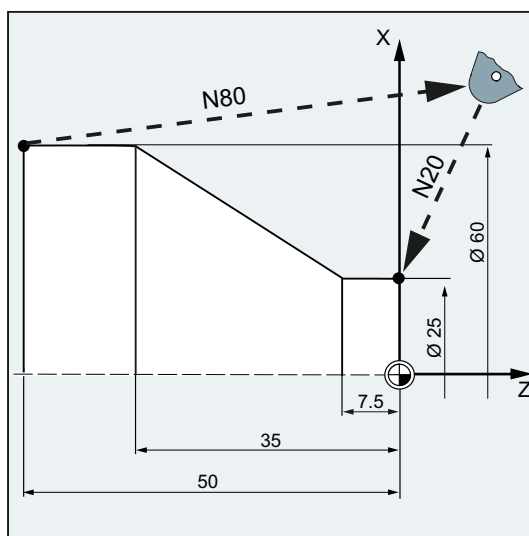
## Examples

## Example 1: Milling



| Program code              | Comment                                       |
|---------------------------|-----------------------------------------------|
| N10 G90 S400 M3           | ; Absolute dimension input, spindle clockwise |
| N20 G0 X30 Y20 Z2         | ; Approach the starting position              |
| N30 G1 Z-5 F1000          | ; Tool infeed                                 |
| N40 X80 Y65               | ; Traversing along a straight line            |
| N50 G0 Z2                 |                                               |
| N60 G0 X-20 Y100 Z100 M30 | ; Retract tool, end of program                |

## Example 2: Turning



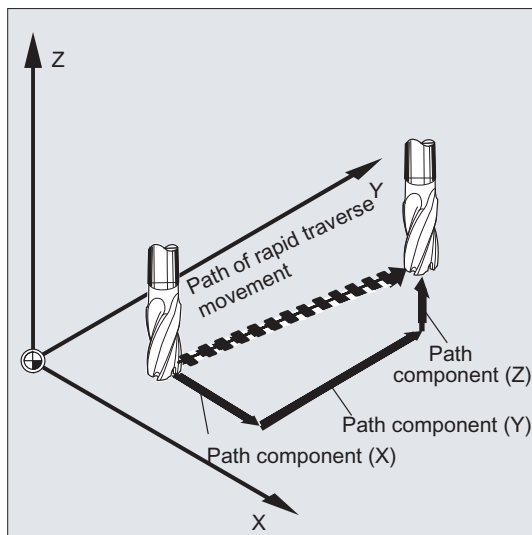
## 10.4 Rapid traverse motion (G0, RTLION, RTLIOF)

| Program code        | Comment                                       |
|---------------------|-----------------------------------------------|
| N10 G90 S400 M3     | ; Absolute dimension input, spindle clockwise |
| N20 G0 X25 Z5       | ; Approach the starting position              |
| N30 G1 G94 Z0 F1000 | ; Tool infeed                                 |
| N40 G95 Z-7.5 F0.2  |                                               |
| N50 X60 Z-35        | ; Traversing along a straight line            |
| N60 Z-50            |                                               |
| N70 G0 X62          |                                               |
| N80 G0 X80 Z20 M30  | ; Retract tool, end of program                |

## Further information

## Rapid traverse velocity

The tool movement programmed with G0 is executed at the highest possible speed (rapid traverse). The rapid traverse speed is defined separately for each axis in machine data. If the rapid traverse movement is executed simultaneously on several axes, the rapid traverse speed is determined by the axis which requires the most time for its section of the path.



## Traverse path axes as positioning axes with G0

Path axes can travel in one of two different modes to execute movements in rapid traverse:

- **Linear interpolation (RTLION):**  
The path axes are interpolated together.
- **Non-linear interpolation (RTLIOF):**  
Each path axis interpolates as a single axis (positioning axis) independently of the other axes of the rapid traverse motion.

With non-linear interpolation, the setting for the appropriate positioning axis (BRISKA, SOFTA, DRIVEA) applies with reference to the axial jerk.

#### NOTICE

##### Risk of collision

For non-linear interpolation, generally another contour is traversed along than for linear interpolation. As a consequence, synchronized actions that refer to path coordinates, are under certain circumstances not active.

In spite of programmed rapid traverse (G0), linear interpolation (G01) is applied in the following cases:

- For a G code combination with G0 that does not permit positioning motion (e.g. tool radius correction G40/G41/G42)
- When using G0 together with continuous path mode G64, G641, ... G645
- For active compressor (COMPCAD)
- For active transformation

Example:

##### Program code

```
G0 X0 Y10
G0 G40 X20 Y20
G0 G95 X100 Z100 M3 S100
```

Path POS[X]=0 POS[Y]=10 is traversed in path mode. No revolutional feedrate is active if path POS[X]=100 POS[Z]=100 is traversed.

#### Settable block change time with G0

For single-axis interpolation, a new end-of-motion criterion FINEA or COARSEA or IPOENDA can be set for block change even within the braking ramp.

#### Consecutive axes are handled in G0 like positioning axes.

With the combination of

- "Block change settable in the braking ramp of the single axis interpolation" and
- "Traversing path axes in rapid traverse movement as positioning axes with G0"

all axes can travel to their end point independently of one another. In this way, two sequentially programmed X and Z axes are treated like positioning axes in conjunction with G0.

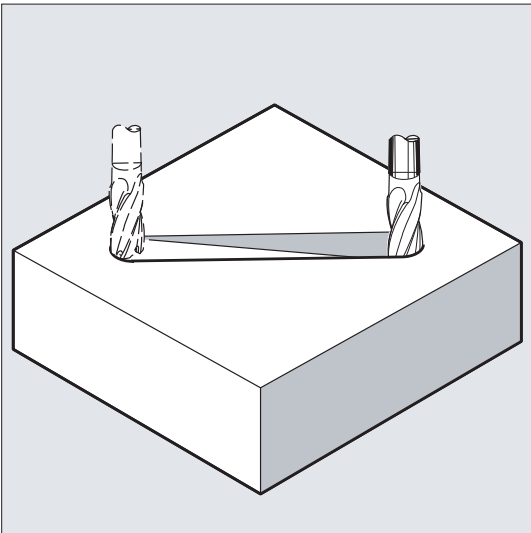
The block change to axis Z can be initiated by axis X as a function of the braking ramp time setting (100-0%). Axis Z starts to move while axis X is still in motion. Both axes approach their end point independently of one another.

For additional information, see Chapter Feedrate control (Page 97) and spindle motion (Page 79).

# 10.5 Linear interpolation (G1)

With G1 the tool travels on paraxial, inclined or straight lines arbitrarily positioned in space. Linear interpolation permits machining of 3D surfaces, grooves, etc.

**Milling:**



## Syntax

G1 X... Y... Z ... F...  
G1 AP=... RP=... F...

## Meaning

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G1:             | Linear interpolation with feedrate (linear interpolation)                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| X... Y... Z...: | End point in Cartesian coordinates                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| AP=...:         | End point in polar coordinates, in this case polar angle                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| RP=...:         | End point in polar coordinates, in this case polar radius                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| F...:           | <p>Feedrate in mm/min. The tool travels at feedrate F along a straight line from the current starting point to the programmed destination point. You can enter the destination point in Cartesian or polar coordinates. The workpiece is machined along this path.</p> <p>Example: G1 G94 X100 Y20 Z30 A40 F100</p> <p>The end point on X, Y, Z is approached at a feedrate of 100 mm/min; the rotary axis A is traversed as a synchronized axis, ensuring that all four movements are completed at the same time.</p> |



### Note

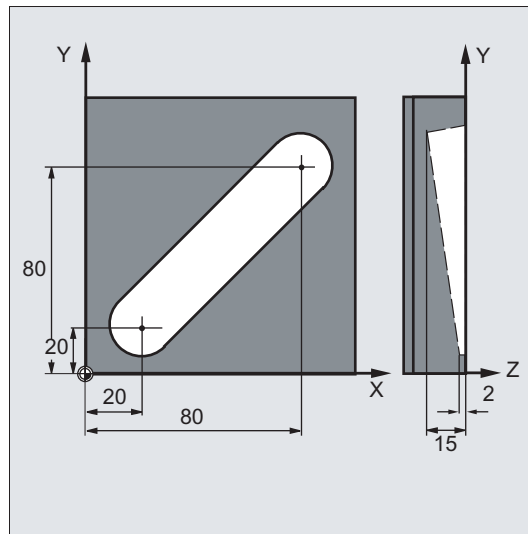
G1 is modal.

Spindle speed  $S$  and spindle direction M3/M4 must be specified for the machining.

Axis groups, for which path feedrate  $F$  applies, can be defined with  $FGROUP$ . You will find more information in the "Path behavior" section.

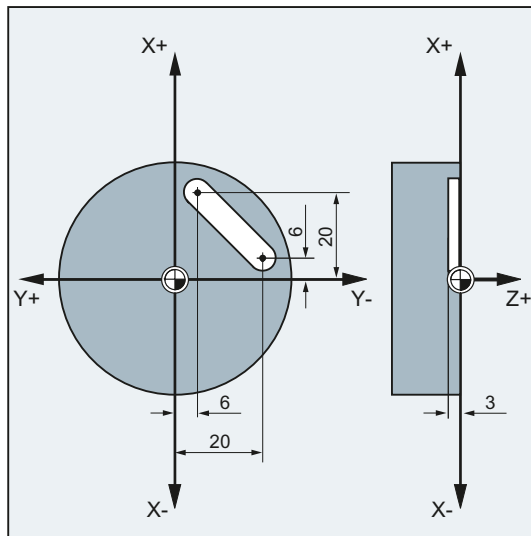
## Examples

### Example 1: Machining of a groove (milling)



The tool travels from the starting point to the end point in the X/Y direction. Infeed takes place simultaneously in the Z direction.

| Program code      | Comment                                             |
|-------------------|-----------------------------------------------------|
| N10 G17 S400 M3   | ; Selection of the working plane, spindle clockwise |
| N20 G0 X20 Y20 Z2 | ; Approach the starting position                    |
| N30 G1 Z-2 F40    | ; Tool infeed                                       |
| N40 X80 Y80 Z-15  | ; Travel on an inclined line                        |
| N50 G0 Z100 M30   | ; Retraction for tool change                        |

**Example 2: Machining of a groove (turning)**

| Program code      | Comment                                             |
|-------------------|-----------------------------------------------------|
| N10 G17 S400 M3   | ; Selection of the working plane, spindle clockwise |
| N20 G0 X40 Y-6 Z2 | ; Approach the starting position                    |
| N30 G1 Z-3 F40    | ; Tool infeed                                       |
| N40 X12 Y-20      | ; Travel on an inclined line                        |
| N50 G0 Z100 M30   | ; Retraction for tool change                        |

**10.6 Circular interpolation****10.6.1 Circular interpolation types (G2/G3, ...)**

Possibilities of programming circular movements

The control provides a range of different ways to program circular movements. This allows you to implement almost any type of drawing dimension directly. The circular motion is described by the:

- Center point and end point in the absolute or incremental dimension (default)
- Radius and end point in Cartesian coordinates
- Opening angle and end point in Cartesian coordinates or center point under the addresses
- Polar coordinates with the polar angle AP= and the polar radius RP=
- Intermediate and end point
- End point and tangent direction at the start point.

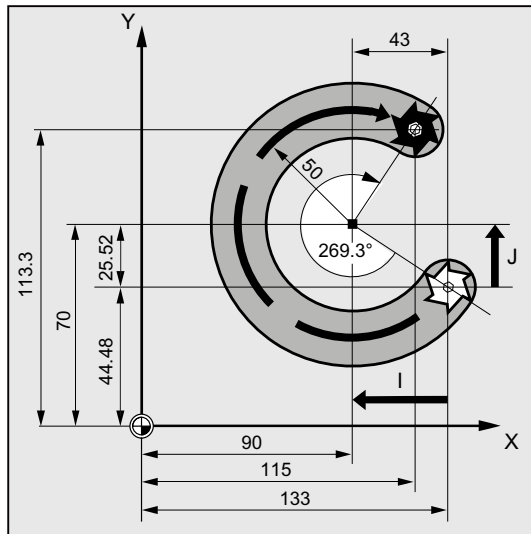
## Syntax

|                                                          |                                                                                    |
|----------------------------------------------------------|------------------------------------------------------------------------------------|
| G2/G3 X... Y... Z...                                     |                                                                                    |
| I=AC (...) J=AC (...) K=AC (...) ;                       | Absolute center point and end point with reference to the work-piece zero          |
| G2/G3 X... Y... Z... I... J... K... ;                    | Center point in incremental dimensions with reference to the circle starting point |
| G2/G3 X... Y... Z... CR=... ;                            | Circle radius CR= ..., end point in Cartesian coordinates X..., Y..., Z...         |
| G2/G3 X... Y... Z... AR=... ;                            | Opening angle AR=..., end point in Cartesian coordinates X..., Y..., Z...          |
| G2/G3 I... J... K... AR=... ;                            | Opening angle AR=..., center point at addresses I..., J..., K...                   |
| G2/G3 AP=... RP=... ;                                    | Polar coordinates: Polar angle AP=..., polar radius RP=...                         |
| CIP X... Y... Z... I1=AC (...) J1=AC (...) K1=AC (...) ; | The intermediate point at addresses I1=, J1=, K1=                                  |
| CT X... Y... Z... ;                                      | Circle through starting and end point and tangent direction at starting point      |

## Meaning

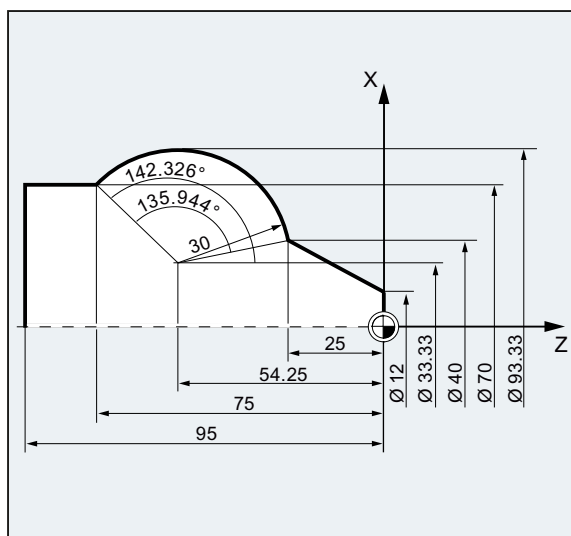
|                        |                                                                                          |
|------------------------|------------------------------------------------------------------------------------------|
| G2:                    | Circular interpolation clockwise                                                         |
| G3:                    | Circular interpolation counter-clockwise                                                 |
| CIP:                   | Circular interpolation through intermediate point                                        |
| CT:                    | Circle with tangential transition defines the circle                                     |
| X... Y... Z... :       | End point in Cartesian coordinates                                                       |
| I... J... K... :       | Circle center point in Cartesian coordinates in X, Y, Z direction                        |
| CR=... :               | Circle radius                                                                            |
| AR=... :               | Opening angle                                                                            |
| AP=... :               | End point in polar coordinates, in this case polar angle                                 |
| RP=... :               | End point in polar coordinates, in this case polar radius corresponding to circle radius |
| I1=... J1=... K1=... : | Intermediate points in Cartesian coordinates in X, Y, Z direction                        |

### Example 1: Milling



| Program code                                                | Comment                                                                            |
|-------------------------------------------------------------|------------------------------------------------------------------------------------|
| N10 G0 G90 X133 Y44.48 S800 M3                              | ; Approach starting point                                                          |
| N20 G17 G1 Z-5 F1000                                        | ; Tool infeed                                                                      |
| N30 G2 X115 Y113.3 I-43 J25.52                              | ; Circle end point, center point in incremental dimensions                         |
| N30 G2 X115 Y113.3 I=AC(90) J=AC(70)                        | ; Circle end point, center point in absolute dimensions                            |
| N30 G2 X115 Y113.3 CR=-50                                   | ; Circle end point, circle radius                                                  |
| N30 G2 AR=269.31 I-43 J25.52                                | ; Opening angle, center point in incremental dimensions                            |
| N30 G2 AR=269.31 X115 Y113.3                                | ; Opening angle, circle end point                                                  |
| N30 CIP X115 Y113.3 Z-10 I1=IC(-...) J1=IC(...) K1=IC(-...) | ; Circle end point and intermediate point: Coordinates for all three geometry axes |
| N40 M30                                                     | ; End of program                                                                   |

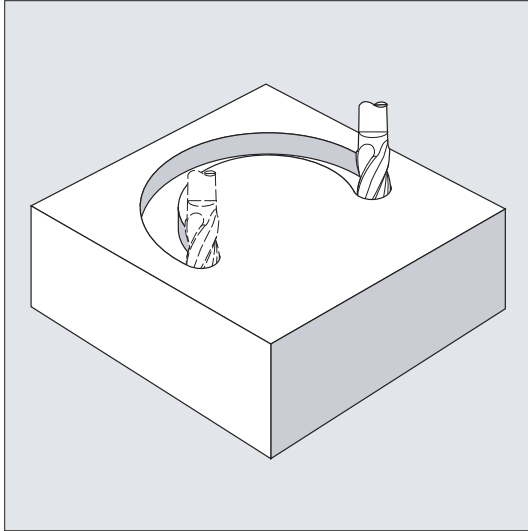
## Example 2: Turning



| Program code                                | Comment                                                    |
|---------------------------------------------|------------------------------------------------------------|
| N.. ...                                     |                                                            |
| N120 G0 X12 Z0                              |                                                            |
| N125 G1 X40 Z-25 F0.2                       |                                                            |
| N130 G3 X70 Y-75 I-3.335 K-29.25            | ; Circle end point, center point in incremental dimensions |
| N130 G3 X70 Y-75 I=AC(33.33) K=AC(-54.25)   | ; Circle end point, center point in absolute dimensions    |
| N130 G3 X70 Z-75 CR=30                      | ; Circle end point, circle radius                          |
| N130 G3 X70 Z-75 AR=135.944                 | ; Opening angle, circle end point                          |
| N130 G3 I-3.335 K-29.25 AR=135.944          | ; Opening angle, center point in incremental dimensions    |
| N130 G3 I=AC(33.33) K=AC(-54.25) AR=135.944 | ; Opening angle, center point in absolute dimensions       |
| N130 G111 X33.33 Z-54.25                    | ; Polar coordinates                                        |
| N135 G3 RP=30 AP=142.326                    | ; Polar coordinates                                        |
| N130 CIP X70 Z-75 I1=93.33 K1=-54.25        | ; Circular arc with intermediate point and end point       |
| N140 G1 Z-95                                |                                                            |
| N.. ...                                     |                                                            |
| N40 M30                                     | ; End of program                                           |

### 10.6.2 Circular interpolation with center point and end point (G2/G3, X... Y... Z..., I... J... K...)

Circular interpolation enables machining of full circles or arcs.



The circular motion is described by:

- The end point in Cartesian coordinates X, Y, Z and
- The circle center point at addresses I, J, K.

If the circle is programmed with a center point but no end point, the result is a full circle.

#### Syntax

G2/G3 X... Y... Z... I... J... K...

G2/G3 X... Y... Z... I=AC (...) J=AC (...) K=(AC...)

#### Meaning

|            |                                                           |
|------------|-----------------------------------------------------------|
| G2:        | Circular interpolation clockwise                          |
| G3:        | Circular interpolation counter-clockwise                  |
| X Y Z :    | End point in Cartesian coordinates                        |
| I:         | Coordinates of the circle center point in the X direction |
| J:         | Coordinates of the circle center point in the Y direction |
| K:         | Coordinates of the circle center point in the Z direction |
| =AC (...): | Absolute dimensions (non-modal)                           |

### Note

G2 and G3 are modal.

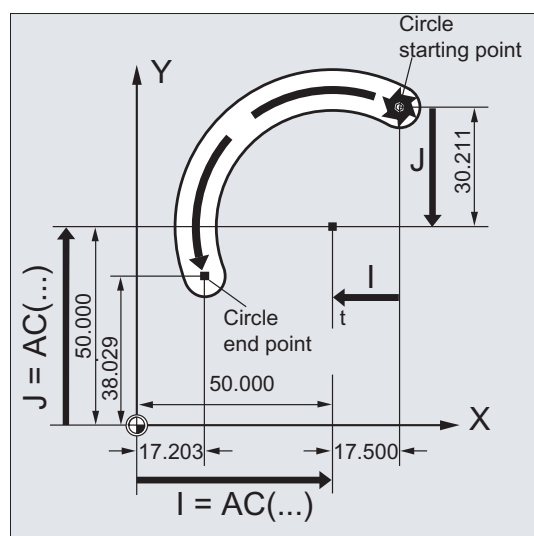
The default settings G90/G91 absolute and incremental dimensions are only valid for the circle end point.

Per default, the center point coordinates I, J, K are entered in incremental dimensions in relation to the circle starting point.

You can program the absolute center point dimensions in relation to the workpiece zero block-by-block with: I=AC (...), J=AC (...), K=AC (...). One interpolation parameter I, J, K with value 0 can be omitted, but the associated second parameter must always be specified.

## Examples

### Example 1: Milling



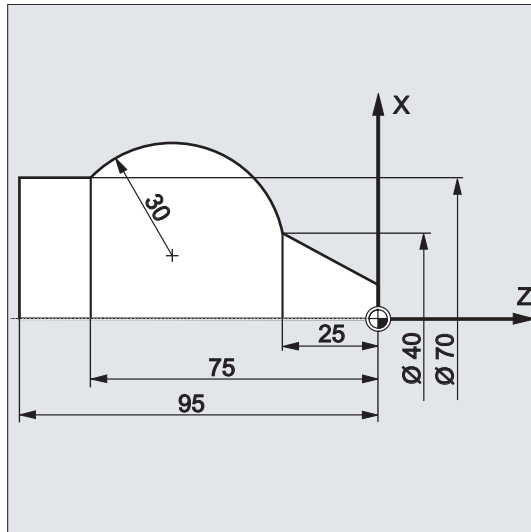
#### Center point data using incremental dimensions

```
N10 G0 X67.5 Y80.211
N20 G3 X17.203 Y38.029 I-17.5 J-30.211 F500
```

#### Center point data using absolute dimensions

```
N10 G0 X67.5 Y80.211
N20 G3 X17.203 Y38.029 I=AC(50) J=AC(50)
```

### Example 2: Turning



#### Center point data using incremental dimensions

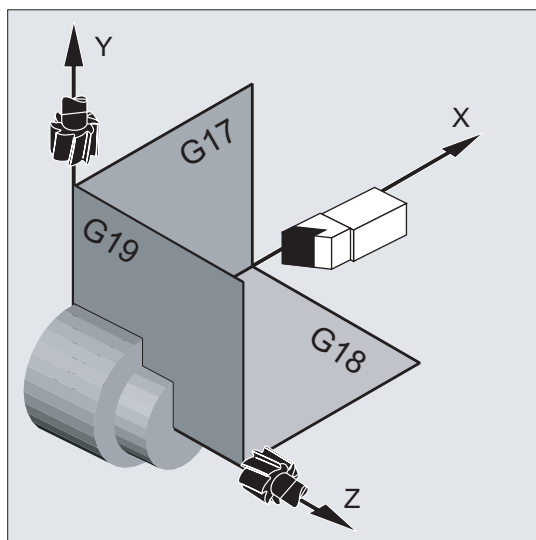
```
N120 G0 X12 Z0
N125 G1 X40 Z-25 F0.2
N130 G3 X70 Z-75 I-3.335 K-29.25
N135 G1 Z-95
```

#### Center point data using absolute dimensions

```
N120 G0 X12 Z0
N125 G1 X40 Z-25 F0.2
N130 G3 X70 Z-75 I=AC(33.33) K=AC(-54.25)
N135 G1 Z-95
```

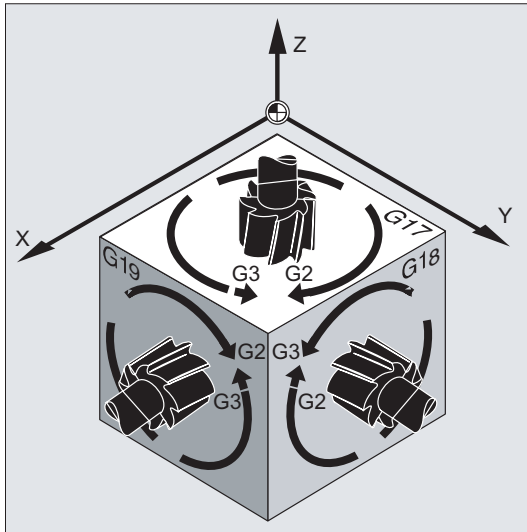
### Further information

#### Indication of working plane





The control needs the working plane parameter (G17 to G19) to calculate the direction of rotation for the circle (G2 is clockwise or G3 is counter-clockwise).



It is advisable to specify the working plane generally.

Exception:

You can also machine circles outside the selected working plane (not with arc angle and helix parameters). In this case, the axis addresses that you specify as an end point determine the circle plane.

#### Programmed feedrate

FGROUP can be used to specify which axes are to be traversed with a programmed feedrate. For more information please refer to the Path behavior section.

### 10.6.3 Circular interpolation with radius and end point (G2/G3, X... Y... Z..., CR)

The circular motion is described by the:

- Circle radius CR=**and**
- End point in Cartesian coordinates X, Y, Z.

In addition to the circle radius, you must also specify the leading sign +/- to indicate whether the traversing angle is to be greater than or less than 180°. A positive leading sign can be omitted.

---

#### Note

There is no practical limitation on the maximum size of the programmable radius.

---

#### Syntax

G2/G3 X... Y... Z... CR=...

Meaning

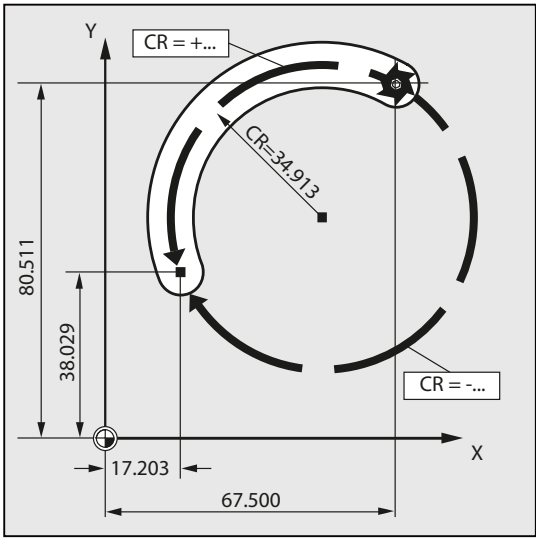
|                  |                                                                                                                                |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|
| G2:              | Circular interpolation clockwise                                                                                               |
| G3:              | Circular interpolation counter-clockwise                                                                                       |
| X... Y... Z... : | End point in Cartesian coordinates. These specifications depend on the travel commands G90/G91 or ...=AC(...)/...=IC(..)       |
| CR=... :         | Circle radius<br>The meanings are as follows:<br>CR=+...: Angle less than or equal to 180°<br>CR=-...: Angle greater than 180° |

**Note**

You don't need to specify the center point with this procedure. Full circles (traversing angle 360°) are not programmed with CR=, but via the circle end position and interpolation parameters.

Examples

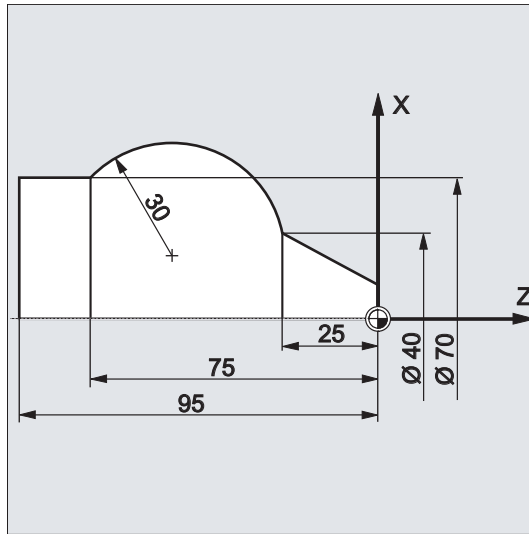
Example 1: Milling



**Program code**

```
N10 G0 X67.5 Y80.511
N20 G3 X17.203 Y38.029 CR=34.913 F500
...
```

### Example 2: Turning



#### Program code

```
...
N125 G1 X40 Z-25 F0.2
N130 G3 X70 Z-75 CR=30
N135 G1 Z-95
...
```

## 10.6.4 Circular interpolation with opening angle and center point (G2/G3, X... Y... Z.../ I... J... K..., AR)

The circular motion is described by:

- The opening angle AR = and
- The end point in Cartesian coordinates X, Y, Z or
- The circle center at addresses I, J, K

### Syntax

G2/G3 X... Y... Z... AR=

G2/G3 I... J... K... AR=

### Meaning

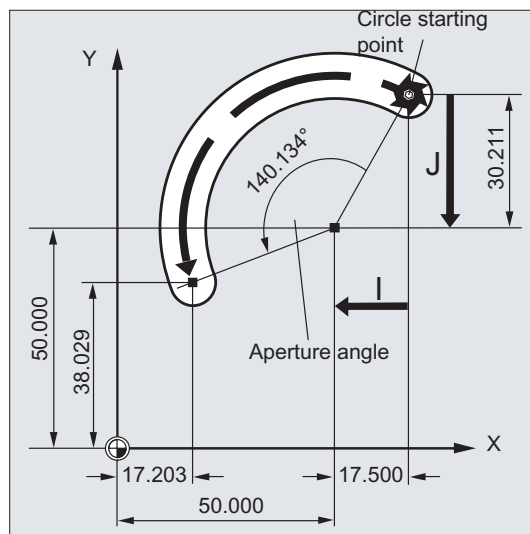
|         |                                          |
|---------|------------------------------------------|
| G2:     | Circular interpolation clockwise         |
| G3:     | Circular interpolation counter-clockwise |
| X Y Z : | End point in Cartesian coordinates       |

|            |                                                                                                                                                                                                                                                                                                  |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I J K :    | Circle center point in Cartesian coordinates (in X, Y, Z direction)<br>The meanings are as follows:<br>I: Coordinate of the circle center point in the X direction<br>J: Coordinate of the circle center point in the Y direction<br>K: Coordinate of the circle center point in the Z direction |
| AR= :      | Opening angle, range of values 0° to 360°                                                                                                                                                                                                                                                        |
| =AC (...): | Absolute dimensions (non-modal)                                                                                                                                                                                                                                                                  |

**Note**

Full circles (traversing angle 360°) cannot be programmed with AR=, but must be programmed using the circle end position and interpolation parameters. Per default, the center point coordinates I, J, K are entered in incremental dimensions in relation to the circle starting point.

You can program the absolute center point dimensions in relation to the workpiece zero block-by-block with: I=AC(...), J=AC(...), K=AC(...). One interpolation parameter I, J, K with value 0 can be omitted, but the associated second parameter must always be specified.

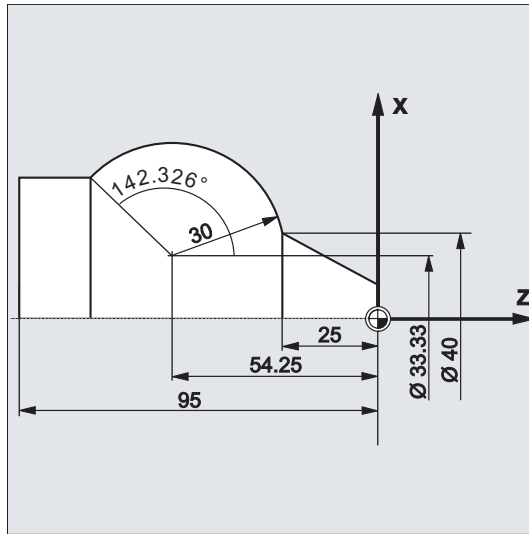
**Examples****Example 1: Milling****Program code**

```

N10 G0 X67.5 Y80.211
N20 G3 X17.203 Y38.029 AR=140.134 F500
N20 G3 I-17.5 J-30.211 AR=140.134 F500

```

### Example 2: Turning



#### Program code

```
N125 G1 X40 Z-25 F0.2
N130 G3 X70 Z-75 AR=135.944
N130 G3 I-3.335 K-29.25 AR=135.944
N130 G3 I=AC(33.33) K=AC(-54.25) AR=135.944
N135 G1 Z-95
```

## 10.6.5 Circular interpolation with polar coordinates (G2/G3, AP, RP)

The circular motion is described by:

- The polar angle AP=...
- The polar radius RP=...

The following rule applies:

- The pole lies at the circle center.
- The polar radius corresponds to the circle radius.

### Syntax

G2/G3 AP= RP=

### Meaning

|         |                                          |
|---------|------------------------------------------|
| G2:     | Circular interpolation clockwise         |
| G3:     | Circular interpolation counter-clockwise |
| X Y Z : | End point in Cartesian coordinates       |

## Examples

|     |      |           |                 |
|-----|------|-----------|-----------------|
| N10 | G0   | X67.5     | Y80.211         |
| N20 | G111 | X50       | Y50             |
| N30 | G3   | RP=34.913 | AP=200.052 F500 |

Technical drawing of a mechanical part with dimensions and a coordinate system. The part is shown in a 3D perspective view. The dimensions are as follows:

- Overall width: 95
- Distance from the left face to the center of the circular feature: 54.25
- Radius of the circular feature: 30
- Angle of the circular feature:  $142.326^\circ$
- Distance from the center of the circular feature to the right face: 25
- Coordinate system: The Z-axis is horizontal, pointing to the right. The X-axis is vertical, pointing upwards. The origin is located at the center of the circular feature.
- Two diameters are indicated on the right face:  $\varnothing 33.33$  and  $\varnothing 40$ .

**Program code**

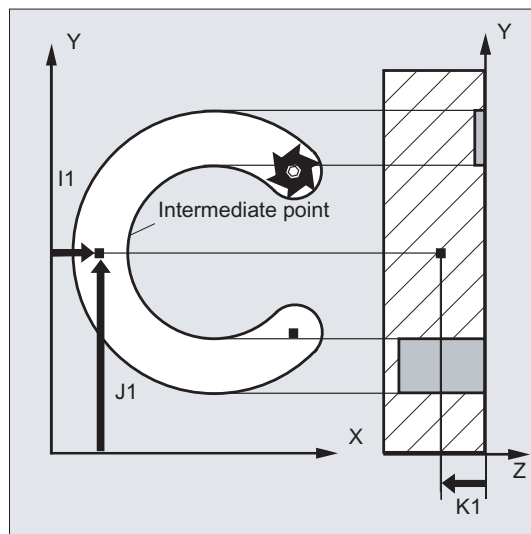
```
N125 G1 X40 Z-25 F0.2
N130 G111 X33.33 Z-54.25
N135 G3 RP=30 AP=142.326
N140 G1 Z-95
```

## 10.6.6 Circular interpolation with intermediate point and end point (CIP, X... Y... Z..., I1... J1... K1...)

CIP can be used to program arcs. These arcs can also be inclined in space. In this case, you describe the intermediate and end points with three coordinates.

The circular motion is described by:

- The intermediate point at addresses I1=, J1=, K1= and
- The end point in Cartesian coordinates X, Y, Z.



The traversing direction is determined by the order of the starting point, intermediate point and end point.

### Syntax

CIP X... Y... Z... I1=AC (...) J1=AC (...) K1=(AC...)

### Meaning

|         |                                                                                                                          |       |
|---------|--------------------------------------------------------------------------------------------------------------------------|-------|
| CIP:    | Circular interpolation through intermediate point                                                                        |       |
|         | Effective:                                                                                                               | Modal |
| X Y Z : | End point in Cartesian coordinates. These specifications depend on the travel commands G90/G91 or ...=AC(...)/...=IC(..) |       |

|               |                                                                                               |                                                         |
|---------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------------|
| I1= J1= K1= : | Interpolation parameters: Intermediate points in Cartesian coordinates (in X, Y, Z direction) |                                                         |
|               | The meanings are as follows:                                                                  |                                                         |
|               | I1:                                                                                           | Coordinate of the intermediate point in the X direction |
|               | J1:                                                                                           | Coordinate of the intermediate point in the Y direction |
| =AC (...):    | K1:                                                                                           | Coordinate of the intermediate point in the Z direction |
|               | Absolute dimensions (non-modal)                                                               |                                                         |
| =IC (...):    | Incremental dimensions (non-modal)                                                            |                                                         |

Input in absolute and incremental dimensions

The G90/G91 defaults for absolute or incremental dimensions are valid for the intermediate and circle end points.

With G91, the circle starting point is used as the reference for the intermediate point and end point.

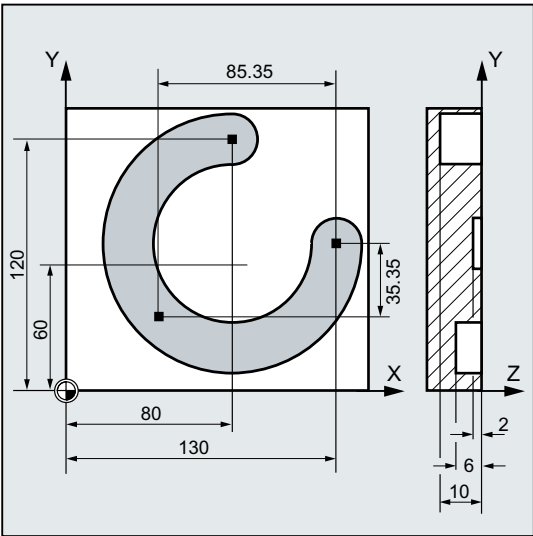
Turning technology

Note

The diameter programming of the interpolation parameter for the transverse axis is not supported with CIP in the circular-path programming. The interpolation parameter for the transverse axis must therefore be programmed in the radius.

Examples

Example 1: Milling



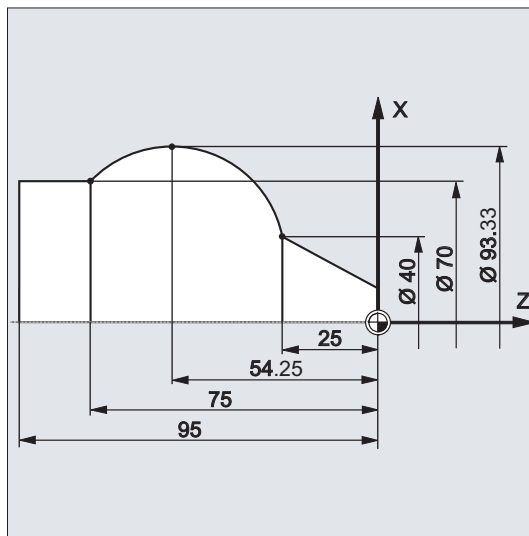
In order to machine an inclined circular groove, a circle is described by specifying the intermediate point with three interpolation parameters, and the end point with three coordinates.

| Program code                   | Comment                    |
|--------------------------------|----------------------------|
| N10 G0 G90 X130 Y70.70 S800 M3 | ; Approach starting point. |



| Program code                                               | Comment                                                                                                |
|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| N20 G17 G1 Z-2 F100                                        | ; Feed of the tool.                                                                                    |
| N30 CIP X80 Y120 Z-10 I1=IC(-85.35) J1=IC(-35.35)<br>K1=-6 | ; Circle end point and inter-<br>mediate point.<br><br>; Coordinates for all three ge-<br>ometry axes. |
| N40 M30                                                    | ; End of program                                                                                       |

### Example 2: Turning



| Program code                                     |                                                                                              |
|--------------------------------------------------|----------------------------------------------------------------------------------------------|
| N125 G1 X40 Z-25 F0.2                            |                                                                                              |
| N130 CIP X70 Z-75 I1=IC(26.665)<br>K1=IC(-29.25) | ; Interpolation parameter I1 for trans-<br>verse axis must be programmed in the ra-<br>dius. |
| or                                               |                                                                                              |
| N130 CIP X70 Z-75 I1=46.665 K1=-54.25            |                                                                                              |
| N135 G1 Z-95                                     |                                                                                              |

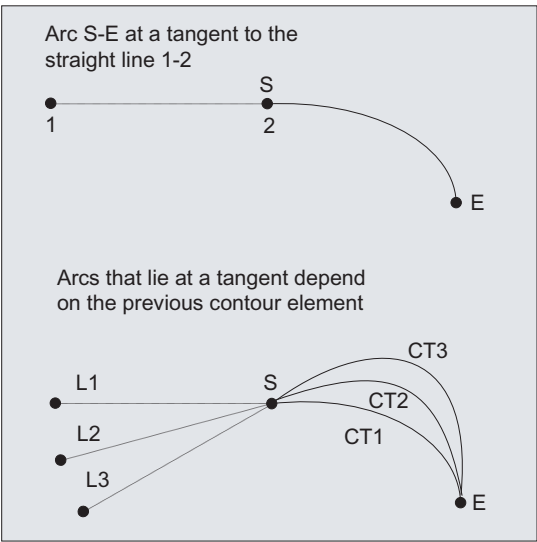
## 10.6.7 Circular interpolation with tangential transition (CT, X... Y... Z...)

The Tangential transition function is an expansion of the circle programming.

The circle is defined by:

- The start and end point and
- The tangent direction at the start point.

The G code **CT** produces an arc that lies at a tangent to the contour element programmed previously.



Determination of the tangent direction

The tangent direction in the starting point of a CT block is determined from the end tangent of the programmed contour of the last block with a traversing motion.

There can be any number of blocks without traversing information between this block and the current block.

Syntax

CT X... Y... Z...

Meaning

|                  |                                    |
|------------------|------------------------------------|
| CT:              | Circle with tangential transition  |
| X... Y... Z... : | End point in Cartesian coordinates |

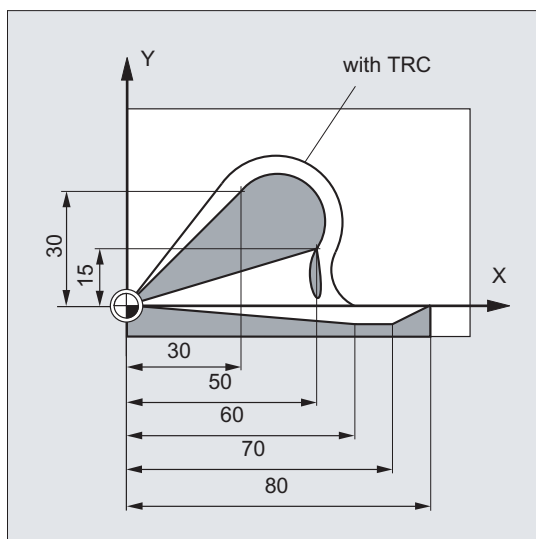
Note

CT is modal.

As a rule, the circle is clearly defined by the tangent direction as well as the starting point and end point.

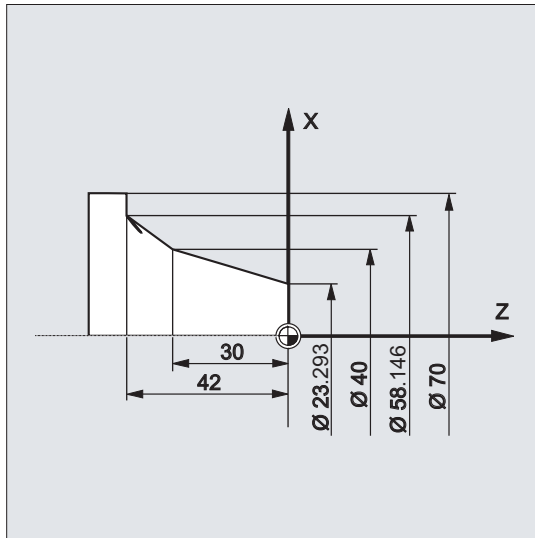
## Examples

### Example 1: Milling



Milling a circular arc with CT directly after the straight part.

| Program code              | Comment                                                 |
|---------------------------|---------------------------------------------------------|
| N10 G0 X0 Y0 Z0 G90 T1 D1 |                                                         |
| N20 G41 X30 Y30 G1 F1000  | ; Activation of TRC.                                    |
| N30 CT X50 Y15            | ; Circular-path programming with tangential transition. |
| N40 X60 Y-5               |                                                         |
| N50 G1 X70                |                                                         |
| N60 G0 G40 X80 Y0 Z20     |                                                         |
| N70 M30                   |                                                         |

**Example 2: Turning**

| Program code           | Comment                                                 |
|------------------------|---------------------------------------------------------|
| N110 G1 X23.293 Z0 F10 |                                                         |
| N115 X40 Z-30 F0.2     |                                                         |
| N120 CT X58.146 Z-42   | ; Circular-path programming with tangential transition. |
| N125 G1 X70            |                                                         |

**Further information****Splines**

In the case of splines, the tangential direction is defined by the straight line through the last two points. In the case of A and C splines with active ENAT or EAUTO, this direction is generally not the same as the direction at the end point of the spline.

The transition of B splines is always tangential, the tangent direction is defined as for A or C splines and active ETAN.

**Frame change**

If a frame change takes place between the block defining the tangent and the CT block, the tangent is also subjected to this change.

**Limit case**

If the extension of the start tangent runs through the end point, a straight line is produced instead of a circle (limit case: circle with infinite radius). In this special case, TURN must either not be programmed or the value must be TURN=0.

**Note**

When the values tend towards this limit case, circles with an unlimited radius are produced and machining with TURN unequal 0 is generally aborted with an alarm due to violation of the software limits.

**Position of the circle plane**

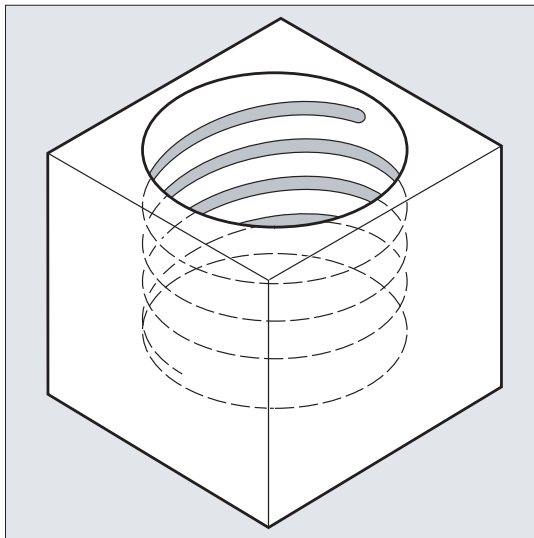
The position of the circle plane depends on the active plane (G17-G19).

If the tangent of the previous block does not lie in the active plane, its projection in the active plane is used.

If the start and end points do not have the same position components perpendicular to the active plane, a helix is produced instead of a circle.

## 10.7 Helical interpolation (G2/G3, TURN)

The helical interpolation enables, for example, the production of threads or oil grooves.



With helical interpolation, two motions are superimposed and executed in parallel:

- A plane circular motion on which
- A vertical linear motion is superimposed.

**Syntax**

G2/G3 X... Y... Z... I... J... K... TURN=

G2/G3 X... Y... Z... I... J... K... TURN=

G2/G3 AR=... I... J... K... TURN=

G2/G3 AR=... X... Y... Z... TURN=

G2/G3 AP... RP=... TURN=

**Meaning**

|     |                                                          |
|-----|----------------------------------------------------------|
| G2: | Travel on a circular path in clockwise direction         |
| G3: | Travel on a circular path in counter-clockwise direction |

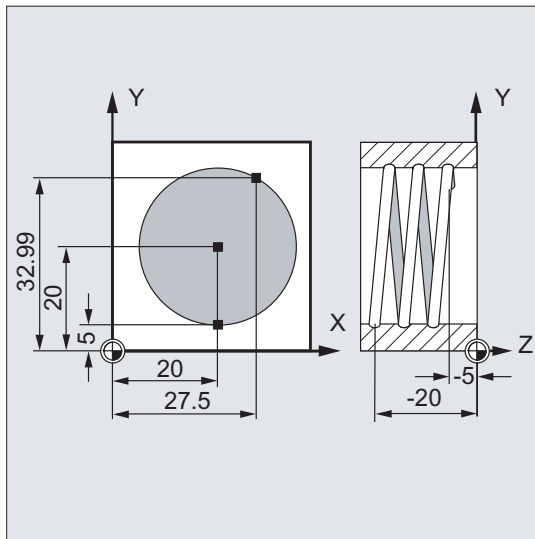
## 10.7 Helical interpolation (G2/G3, TURN)

|         |                                                                 |
|---------|-----------------------------------------------------------------|
| X Y Z : | End point in Cartesian coordinates                              |
| I J K : | Circle center point in Cartesian coordinates                    |
| AR:     | Opening angle                                                   |
| TURN= : | Number of additional circular passes in the range from 0 to 999 |
| AP= :   | Polar angle                                                     |
| RP= :   | Polar radius                                                    |

**Note**

G2 and G3 are modal.

The circular motion is performed in those axes that are defined by the specification of the working plane.

**Example**

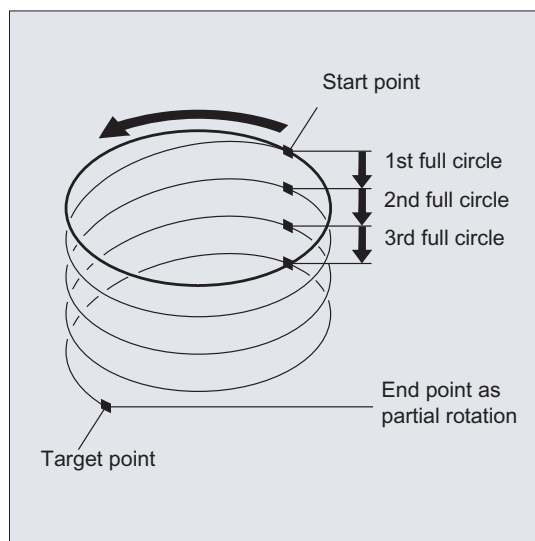
| Program code                                | Comment                                                                                                          |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| N10 G17 G0 X27.5 Y32.99 Z3                  | ; Approach the starting position.                                                                                |
| N20 G1 Z-5 F50                              | ; Feed of the tool.                                                                                              |
| N30 G3 X20 Y5 Z-20 I=AC(20) J=AC(20) TURN=2 | ; Helix with the specifications: Execute two full circles after the starting position, then travel to end point. |
| N40 M30                                     | ; End of program                                                                                                 |

## Further information

### Sequence of motions

1. Approach starting point
2. Execute the full circles programmed with `TURN=`.
3. Approach circle end position, e.g. as part rotation.
4. Execute steps 2 and 3 across the infeed depth.

The pitch, with which the helix is to be machined is calculated from the number of full circles plus the programmed circle end position (executed across the infeed depth).



### Programming the end point for helical interpolation

Please refer to circular interpolation for a detailed description of the interpolation parameters.

### Programmed feedrate

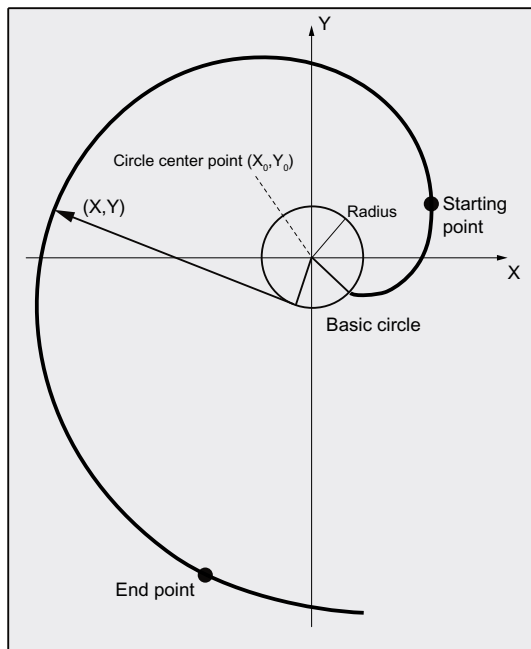
For helical interpolation, it is advisable to specify a programmed feedrate override (`CFC`). `FGROUP` can be used to specify which axes are to be traversed with a programmed feedrate. For more information please refer to the Path behavior section.

## 10.8 Involute interpolation (INVCW, INVCCW)

The involute of the circle is a curve traced out from the end point on a "piece of string" unwinding from the curve.

Involute interpolation allows trajectories along an involute. It is executed in the plane in which the basic circle is defined and runs from the programmed starting point to the programmed end point.

## 10.8 Involute interpolation (INVCW, INVCCW)



The end point can be programmed in two ways:

1. Directly via Cartesian coordinates
2. Indirectly by specifying an opening angle (also refer to the programming of the opening angle for the circular-path programming)

If the starting point and the end point are in the plane of the basic circle, then, analogous to the helical interpolation for circles, there is a superimposition to a curve in space.

With additional specification of paths perpendicular to the active plane, an involute can be traversed in space (comparable to the helical interpolation for circles).

## Syntax

```
INVCW X... Y... Z... I... J... K... CR=...
INVCCW X... Y... Z... I... J... K... CR=...
INVCW I... J... K... CR=... AR=...
INVCCW I... J... K... CR=... AR=...
```

## Meaning

|                  |                                                                                                                                                                                                             |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| INVCW:           | Command to travel on an involute in clockwise direction                                                                                                                                                     |
| INVCCW:          | Command to travel on an involute in counter-clockwise direction                                                                                                                                             |
| X... Y... Z... : | Direct programming of the end point in Cartesian coordinates                                                                                                                                                |
| I... J... K... : | Interpolation parameters for the description of the center point of the basic circle in Cartesian coordinates<br><b>Note:</b><br>The coordinate specifications refer to the starting point of the involute. |
| CR=... :         | Radius of the basic circle                                                                                                                                                                                  |



|             |                                                                                                                                                                                                        |                                                                                                                                                                                                     |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AR= . . . : | Indirect programming of the end point through specification of an opening angle (angle of rotation)<br>The origin of the opening angle is the line from the circle center point to the starting point. |                                                                                                                                                                                                     |
|             | AR > 0:                                                                                                                                                                                                | The path of the involute moves <b>away from the basic circle</b> .                                                                                                                                  |
|             | AR < 0:                                                                                                                                                                                                | The path of the involute moves <b>towards the basic circle</b> .<br>For AR < 0, the maximum angle of rotation is restricted by the fact that the end point must always be outside the basic circle. |

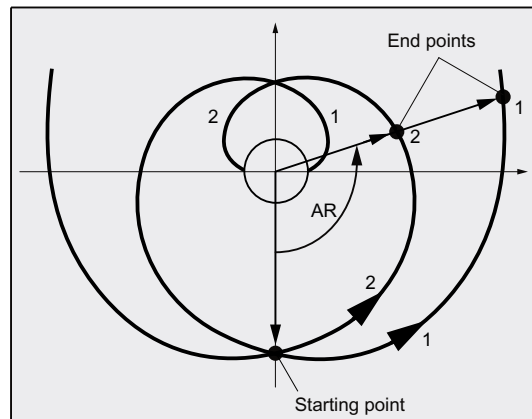
### Indirect programming of the end point through specification of an opening angle

#### NOTICE

##### Opening angle undefined

With the indirect programming of the end point through specification of an opening angle  $AR$ , the sign of the angle must be taken into account, as a sign change would result in another involute and therefore another path.

This is demonstrated in the following example:

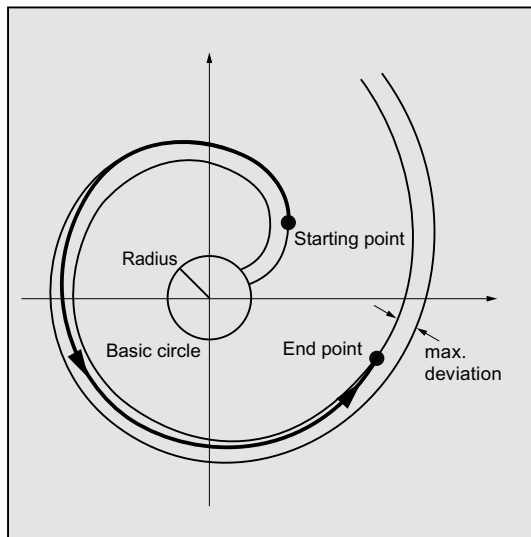


The specifications of the radius and center point of the basic circle as well as the starting point and direction of rotation (INVCW/INVCCW) are the same for involutes 1 and 2. The only difference is in the sign of the opening angle:

- With  $AR > 0$ , the path is on involute 1 and end point 1 is approached.
- With  $AR < 0$ , the path is on involute 2 and end point 2 is approached.

### Supplementary conditions

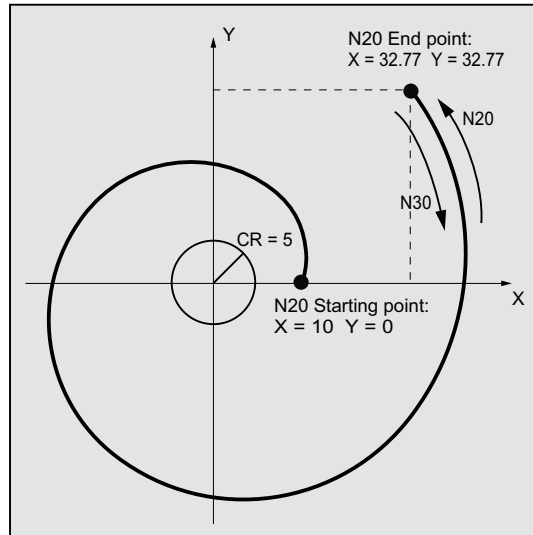
- Both the starting point and the end point must be outside the area of the basic circle of the involute (circle with radius CR around the center point specified by I, J, K). If this condition is not satisfied, an alarm is generated and the program processing is aborted.
- The two options for the programming of the end point (directly via Cartesian coordinates or indirectly via the specification of an opening angle) are mutually exclusive. Consequently, only one of the two programming options may be used in a block.
- If the programmed end point does not lie exactly on the involute defined by the starting point and basic circle, interpolation takes place between the two involutes defined by the starting and end points (see following figure).



The maximum deviation of the end point is determined by a machine data (→ machine manufacturer). If the deviation of the programmed end point in the radial direction is greater than that by the MD, then an alarm is generated and the program processing aborted.

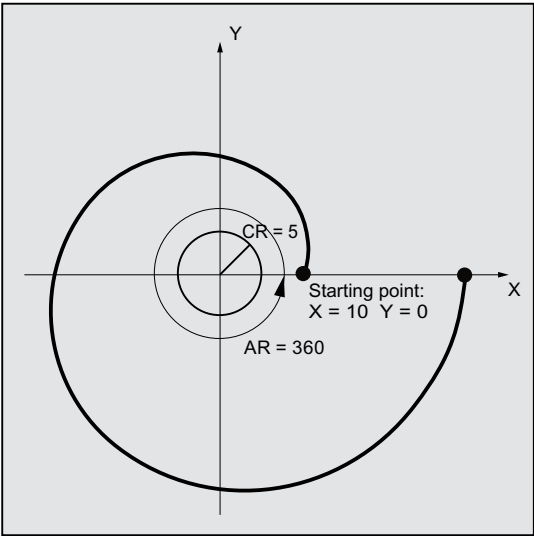
## Examples

**Example 1: Counter-clockwise involute from the starting point to the programmed end point and back again as clockwise involute**



| Program code                          | Comment                                                                                                                                                                                                      |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G1 X10 Y0 F5000                   | ; Approach the starting position.                                                                                                                                                                            |
| N15 G17                               | ; Selection of the X/Y plane as working plane.                                                                                                                                                               |
| N20 INVCCW X32.77 Y32.77 CR=5 I-10 J0 | ; Counter-clockwise involute, end point in Cartesian coordinates.                                                                                                                                            |
| N30 INVCW X10 Y0 CR=5 I-32.77 J-32.77 | ; Clockwise involute, starting point is end point from N20, new end point is starting point from N20, new circle center point refers to a new starting point and is the same as the old circle center point. |
| ...                                   |                                                                                                                                                                                                              |

**Example 2: Counter-clockwise involute with indirect programming of the end point through specification of an opening angle**



| Program code                   | Comment                                                                                                                               |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| N10 G1 X10 Y0 F5000            | ; Approach the starting position.                                                                                                     |
| N15 G17                        | ; Selection of the X/Y plane as working plane.                                                                                        |
| N20 INVCCW CR=5 I-10 J0 AR=360 | ; Counter-clockwise involute and away from the basic circle (as positive angle specification) with one full revolution (360 degrees). |
| ...                            |                                                                                                                                       |

**References**

For more information about machine data and supplementary conditions that are relevant to involute interpolation, see:

Function Manual, Basic Functions; Various NC/PLC interface signals and functions (A2), Section: "Settings for involute interpolation"

**10.9 Contour definitions**

**10.9.1 Contour definition programming**

**Function**

The contour definition programming is used for the quick input of simple contours.

Programmable are contour definitions with one, two, three or more points with the transition elements chamfer or rounding, through specification of Cartesian coordinates and/or angles (ANG or ANG1 and ANG2).

Arbitrary further NC addresses can be used, e.g. address letters for further axes (single axes or axis perpendicular to the machining plane), auxiliary function specifications, G codes, velocities, etc. in the blocks that describe contour definitions.

---

**Note****Contour calculator**

The contour definitions can be programmed easily with the aid of the contour calculator. This is a user interface tool that enables the programming and graphic display of simple and complex workpiece contours. The contours programmed via the contour calculator are transferred to the part program.

**References:**

Operating Manual

---

## Parameterization

The identifiers for angle, radius and chamfer are defined via machine data:

MD10652 \$MN\_CONTOUR\_DEF\_ANGLE\_NAME (name of the angle for contour definitions)

MD10654 \$MN\_RADIUS\_NAME (name of the radius for contour definitions)

MD10656 \$MN\_CHAMFER\_NAME (name of the chamfer for contour definitions)

---

**Note**

See machine manufacturer's specifications.

---

### 10.9.2 Contour definitions: One straight line

---

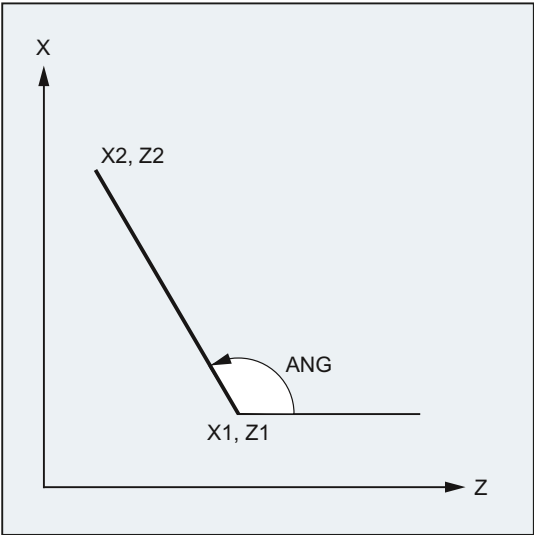
**Note**

In the following description it is assumed that:

- G18 is active ( $\Rightarrow$  active working plane is the Z/X plane).  
(However, the programming of contour definitions is also possible without restrictions with G17 or G19.)
  - The following identifiers have been defined for angle, radius and chamfer:
    - ANG (angle)
    - RND (radius)
    - CHR (chamfer)
-

The end point of the straight line is defined by the following specifications:

- Angle ANG
- **One** Cartesian end point coordinate (X2 or Z2)



ANG:        Angle of the straight line  
X1, Z1:     Start coordinates  
X2, Z2:     End point coordinates of the straight line

Syntax

X... ANG=...  
Z... ANG=...

Meaning

|           |                                                                                                                                       |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------|
| X . . . : | End point coordinate in the X direction                                                                                               |
| Z . . . : | End point coordinate in the Z direction                                                                                               |
| ANG:      | Identifier for angle programming<br>The specified value (angle) refers to the abscissa of the active working plane (Z axis with G18). |

Example

| Program code         | Comment                                  |
|----------------------|------------------------------------------|
| N10 X5 Z70 F1000 G18 | ; Approach the starting position         |
| N20 X88.8 ANG=110    | ; Straight line with angle specification |
| N30 ...              |                                          |

or

| Program code         | Comment                                  |
|----------------------|------------------------------------------|
| N10 X5 Z70 F1000 G18 | ; Approach the starting position         |
| N20 Z39.5 ANG=110    | ; Straight line with angle specification |
| N30 ...              |                                          |

### 10.9.3 Contour definitions: Two straight lines

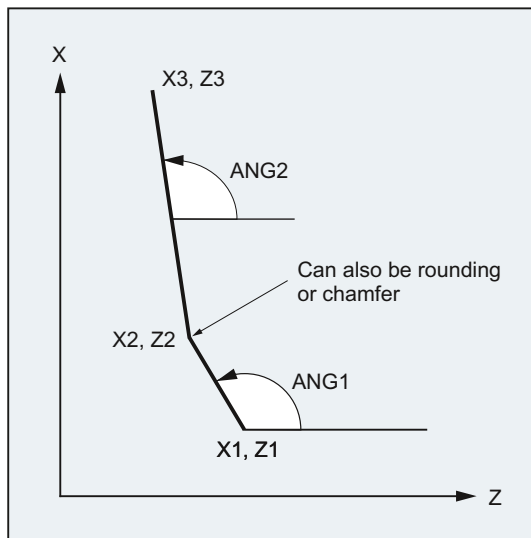
---

#### Note

In the following description it is assumed that:

- G18 is active ( $\Rightarrow$  active working plane is the Z/X plane).  
(However, the programming of contour definitions is also possible without restrictions with G17 or G19.)
  - The following identifiers have been defined for angle, radius and chamfer:
    - ANG (angle)
    - RND (radius)
    - CHR (chamfer)
- 

The end point of the first straight line can be programmed by specifying the Cartesian coordinates or by specifying the angle of the two straight lines. The end point of the second straight line must always be programmed with Cartesian coordinates. The intersection of the two straight lines can be designed as a corner, curve or chamfer.



- ANG1: Angle of the first straight line
- ANG2: Angle of the second straight line
- X1, Z1: Start coordinates of the first straight line
- X2, Z2: End point coordinates of the first straight line or start coordinates of the second straight line
- X3, Z3: End point coordinates of the second straight line

## Syntax

### Programming of the end point of the first straight line by specifying the angle

- Corner as transition between the straight lines:

```
ANG=...
X... Z... ANG=...
```

- Rounding as transition between the straight lines:

```
ANG=... RND=...
X... Z... ANG=...
```

- Chamfer as transition between the straight lines:

```
ANG=... CHR=...
X... Z... ANG=...
```

### Programming of the end point of the first straight line by specifying the coordinates

- Corner as transition between the straight lines:

```
X... Z...
```



X... Z...

- Rounding as transition between the straight lines:

X... Z... RND=...

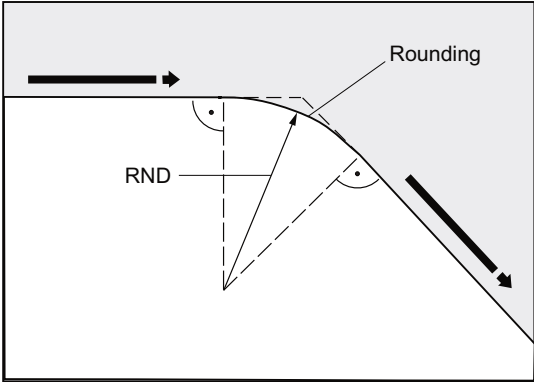
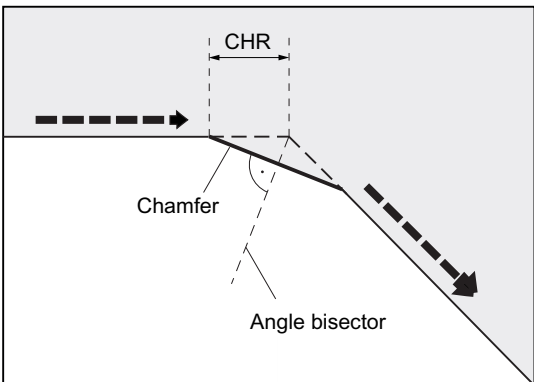
X... Z...

- Chamfer as transition between the straight lines:

X... Z... CHR=...

X... Z...

## Meaning

|           |                                                                                                                                                                                                                                 |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANG=... : | <p>Identifier for angle programming</p> <p>The specified value (angle) refers to the abscissa of the active working plane (Z axis with G18).</p>                                                                                |
| RND=... : | <p>Identifier for programming a rounding</p> <p>The specified value corresponds to the radius of the rounding:</p>                           |
| CHR=... : | <p>Identifier for programming a chamfer</p> <p>The specified value corresponds to the width of the chamfer in the direction of motion:</p>  |
| X... :    | Coordinates in the X direction                                                                                                                                                                                                  |
| Z... :    | Coordinates in the Z direction                                                                                                                                                                                                  |

**Note**

For further information on the programming of a chamfer or rounding, see "Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM) (Page 239)".

---

**Example**

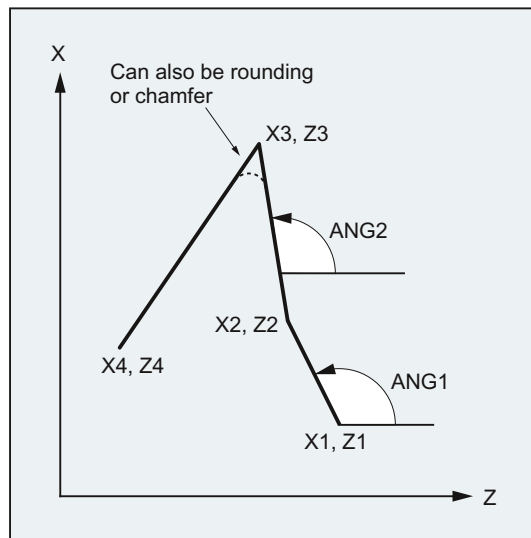
| Program code           | Comment                                                 |
|------------------------|---------------------------------------------------------|
| N10 X10 Z80 F1000 G18  | ; Approach the starting position.                       |
| N20 ANG=148.65 CHR=5.5 | ; Straight line with angle and chamfer specification.   |
| N30 X85 Z40 ANG=100    | ; Straight line with angle and end point specification. |
| N40 ...                |                                                         |

**10.9.4 Contour definitions: Three straight lines****Note**

In the following description it is assumed that:

- G18 is active (⇒ active working plane is the Z/X plane).  
(However, the programming of contour definitions is also possible without restrictions with G17 or G19.)
  - The following identifiers have been defined for angle, radius and chamfer:
    - ANG (angle)
    - RND (radius)
    - CHR (chamfer)
- 

The end point of the first straight line can be programmed by specifying the Cartesian coordinates or by specifying the angle of the two straight lines. The end point of the second and third straight lines must always be programmed with Cartesian coordinates. The intersection of the straight lines can be designed as a corner, a curve, or a chamfer.



- ANG1: Angle of the first straight line  
 ANG2: Angle of the second straight line  
 X1, Z1: Start coordinates of the first straight line  
 X2, Z2: End point coordinates of the first straight line or start coordinates of the second straight line  
 X3, Z3: End point coordinates of the second straight line or start coordinates of the third straight line  
 X4, Z4: End point coordinates of the third straight line

#### Note

The programming described here for a three point contour definition can be expanded arbitrarily for contour definitions with more than three points.

## Syntax

### Programming of the end point of the first straight line by specifying the angle

- Corner as transition between the straight lines:

```
ANG=...
X... Z... ANG=...
X... Z...
```

- Rounding as transition between the straight lines:

```
ANG=... RND=...
X... Z... ANG=... RND=...
X... Z...
```

- Chamfer as transition between the straight lines:

```
ANG=... CHR=...  
X... Z... ANG=... CHR=...  
X... Z...
```

Programming of the end point of the first straight line by specifying the coordinates

- Corner as transition between the straight lines:

```
X... Z...  
X... Z...  
X... Z...
```

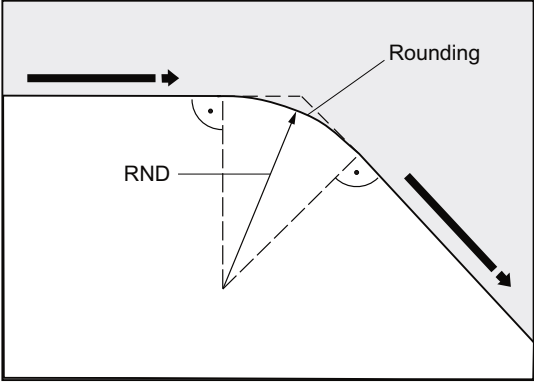
- Rounding as transition between the straight lines:

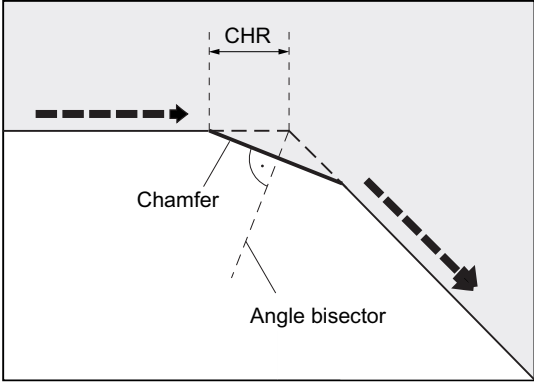
```
X... Z... RND=...  
X... Z... RND=...  
X... Z...
```

- Chamfer as transition between the straight lines:

```
X... Z... CHR=...  
X... Z... CHR=...  
X... Z...
```

Meaning

|              |                                                                                                                                                                                                 |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANG= . . . : | Identifier for angle programming<br>The specified value (angle) refers to the abscissa of the active working plane (Z axis with G18).                                                           |
| RND= . . . : | Identifier for programming a rounding<br>The specified value corresponds to the radius of the rounding:<br> |

|           |                                                                                                                                                                                                                               |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CHR=... : | <p>Identifier for programming a chamfer</p> <p>The specified value corresponds to the width of the chamfer in the direction of motion:</p>  |
| X... :    | Coordinates in the X direction                                                                                                                                                                                                |
| Z... :    | Coordinates in the Z direction                                                                                                                                                                                                |

#### Note

For further information on the programming of a chamfer or rounding, see " Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM) (Page 239) ".

### Example

| Program code                  | Comment                                                                     |
|-------------------------------|-----------------------------------------------------------------------------|
| N10 X10 Z100 F1000 G18        | ; Approach the starting position                                            |
| N20 ANG=140 CHR=7.5           | ; Straight line with angle and chamfer specification.                       |
| N30 X80 Z70 ANG=95.824 RND=10 | ; Straight line to intermediate point with angle and chamfer specification. |
| N40 X70 Z50                   | ; Straight line to end point.                                               |

## 10.9.5 Contour definitions: End point programming with angle

### Function

If the address letter A appears in an NC block, either none, one or both of the axes in the active plane may also be programmed.

### Number of programmed axes

- If **no axis** of the active plane has been programmed, then this is either the first or second block of a contour definition consisting of two blocks.  
If it is the second block of such a contour definition, then this means that the starting point and end point in the active plane are identical. The contour definition is then at best a motion perpendicular to the active plane.
- If **exactly one axis** of the active plane has been programmed, then this is either a single straight line whose end point can be clearly defined via the angle and programmed Cartesian coordinate or the second block of a contour definition consisting of two blocks.  
In the second case, the missing coordinate is set to the same as the last (modal) position reached.
- If **two axes** of the active plane have been programmed, then this is the second block of a contour definition consisting of two blocks. If the current block has not been preceded by a block with angle programming without programmed axes of the active plane, then this block is not permitted.

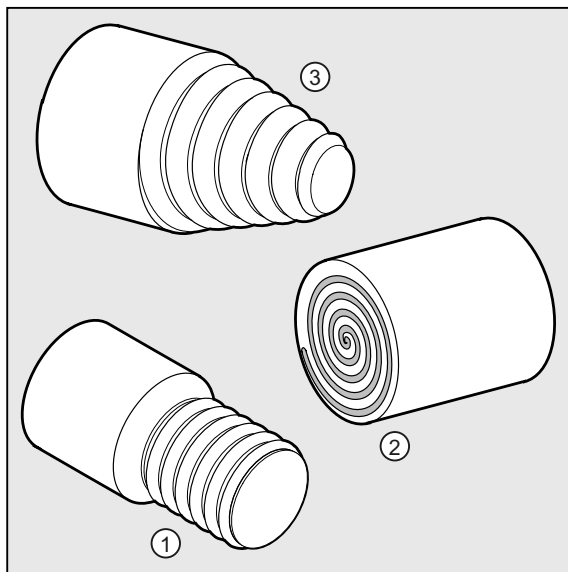
Angle A may only be programmed for linear or spline interpolation.

## 10.10 Thread cutting

### 10.10.1 Thread cutting with constant lead (G33, SF)

Threads with constant lead can be machined with G33:

- Cylindrical thread ①
- Face thread ②
- Taper thread ③



---

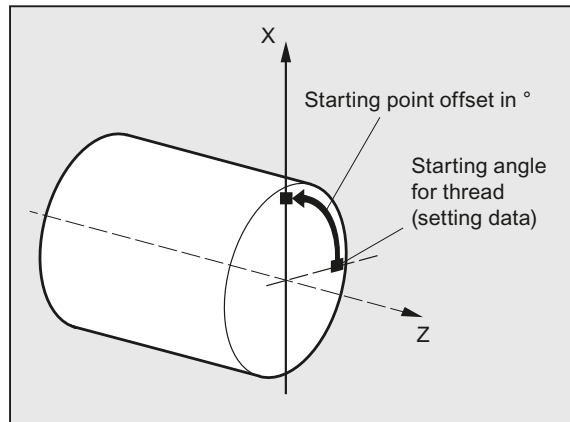
**Note**

Technical requirement for thread cutting with G33 is a variable-speed spindle with position measuring system.

---

**Multiple thread**

Multiple thread (thread with offset cuts) can be machined by specifying a starting point offset. The programming is performed in the G33 block at address SF.



---

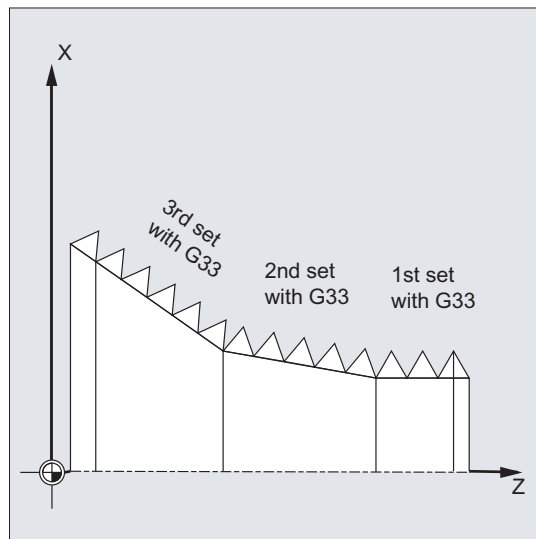
**Note**

If no starting point offset is specified, the "starting angle for thread" defined in the setting data is used.

---

**Thread chain**

A thread chain can be machined with several G33 blocks programmed in succession:



**Note**

With continuous-path mode G64, the blocks are linked by the look-ahead velocity control in such a way that there are no velocity jumps.

**Direction of rotation of the thread**

The direction of rotation of the thread is determined by the direction of rotation of the spindle:

- Clockwise with M3 produces a right-hand thread
- Counter-clockwise with M4 produces a left-hand thread

**Syntax**

Cylinder thread:

G33 Z... K...

G33 Z... K... SF=...

Face thread:

G33 X... I...

G33 X... I... SF=...

Tapered thread:

G33 X... Z... K...

G33 X... Z... K... SF=...

G33 X... Z... I...

G33 X... Z... I... SF=...

**Meaning**

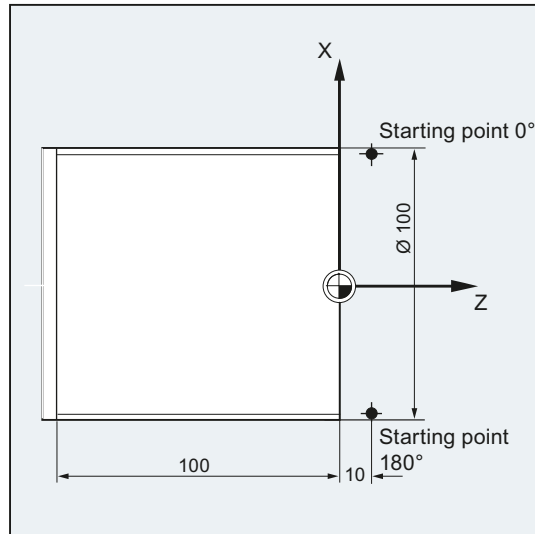
|                  |                                                             |                                                                                 |
|------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------|
| G33:             | Command for thread cutting with constant lead               |                                                                                 |
| X... Y... Z... : | End point(s) in Cartesian coordinates                       |                                                                                 |
| I... :           | Thread lead in X direction                                  |                                                                                 |
| J... :           | Thread lead in Y direction                                  |                                                                                 |
| K... :           | Thread lead in Z direction                                  |                                                                                 |
| Z:               | Longitudinal axis                                           |                                                                                 |
| X:               | Transverse axis                                             |                                                                                 |
| Z... K... :      | Thread length and lead for cylinder threads                 |                                                                                 |
| X... I... :      | Thread diameter and thread lead for face threads            |                                                                                 |
| I... or K... :   | Thread lead for tapered threads                             |                                                                                 |
|                  | The specification (I... or K...) refers to the taper angle: |                                                                                 |
|                  | < 45°:                                                      | The thread lead is specified with K... (thread lead in longitudinal direction). |
|                  | > 45°:                                                      | The thread lead is specified with I... (thread lead in transverse direction).   |
|                  | = 45°:                                                      | The thread lead can be specified with I... or K...                              |



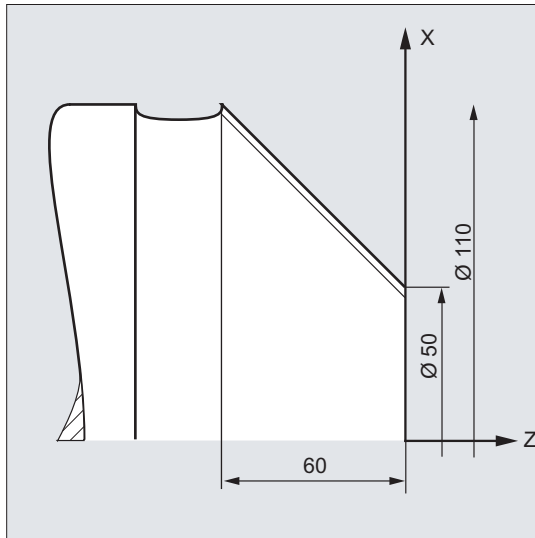
|          |                                                                                                                                     |                           |
|----------|-------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| SF=... : | Starting point offset (only required for multiple threads)<br>The starting point offset is specified as an absolute angle position. |                           |
|          | Range of values:                                                                                                                    | 0.0000 to 359.999 degrees |

## Examples

### Example 1: Double cylinder thread with 180° starting point offset



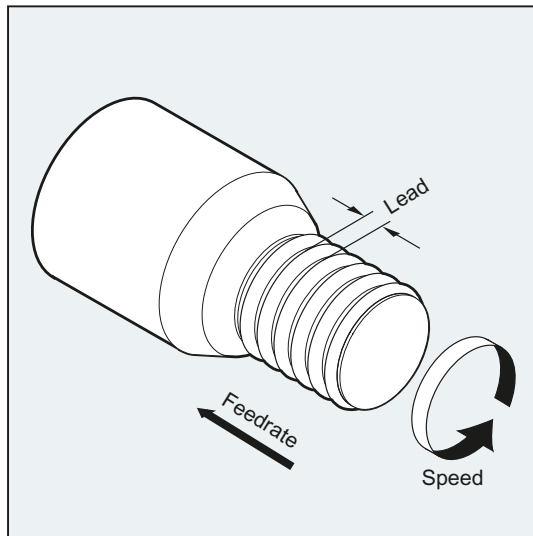
| Program code                    | Comment                                                   |
|---------------------------------|-----------------------------------------------------------|
| N10 G1 G54 X99 Z10 S500 F100 M3 | ; Work offset, approach starting point, activate spindle. |
| N20 G33 Z-100 K4                | ; Cylinder thread: End point in Z.                        |
| N30 G0 X102                     | ; Retraction to starting position.                        |
| N40 G0 Z10                      |                                                           |
| N50 G1 X99                      |                                                           |
| N60 G33 Z-100 K4 SF=180         | ; 2nd cut: Starting point offset 180°.                    |
| N70 G0 X110                     | ; Retract tool.                                           |
| N80 G0 Z10                      |                                                           |
| N90 M30                         | ; End of program                                          |

**Example 2: Tapered thread with angle less than 45°**

| Program code               | Comment                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------|
| N10 G1 X50 Z0 S500 F100 M3 | ; Approach starting point, activate spindle.                                                                       |
| N20 G33 X110 Z-60 K4       | ; Tapered thread: End point in X and Z, specification of thread lead with K... in Z direction (since angle < 45°). |
| N30 G0 Z0 M30              | ; Retraction, end of program.                                                                                      |

**Further information****Feedrate for thread cutting with G33**

From the programmed spindle speed and the thread lead, the control calculates the required feedrate with which the turning tool is traversed over the thread length in the longitudinal and/or transverse direction. The feedrate *F* is not taken into account for G33, the limitation to maximum axis velocity (rapid traverse) is monitored by the control.



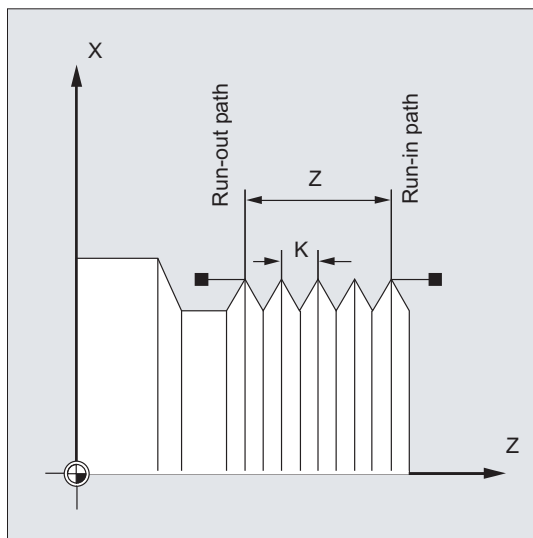
### Cylinder thread

The cylinder thread is described by:

- Thread length
- Thread lead

The thread length is entered with one of the Cartesian coordinates X, Y or Z in absolute or incremental dimensions (for turning machines preferably in the Z direction). Allowance must also be made for the run-in and run-out paths, across which the feed is accelerated or decelerated.

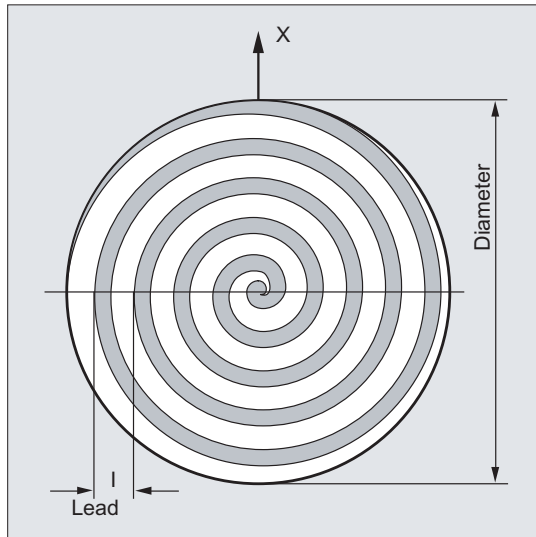
The thread lead is entered at addresses I, J, K (K is preferable for turning machines).



### Face thread

The face thread is described by:

- Thread diameter (preferably in the X direction)
- Thread lead (preferably with  $\pm$ )



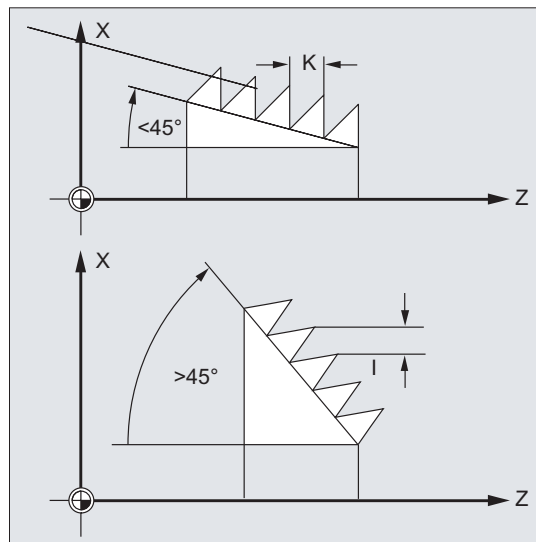
### Tapered thread

The tapered thread is described by:

- End point in the longitudinal and transverse direction (taper contour)
- Thread lead

The taper contour is entered in Cartesian coordinates X, Y, Z in absolute or incremental dimensions - preferentially in the X and Z direction for machining on turning machines. Allowance must also be made for the run-in and run-out paths, across which the feed is accelerated or decelerated.

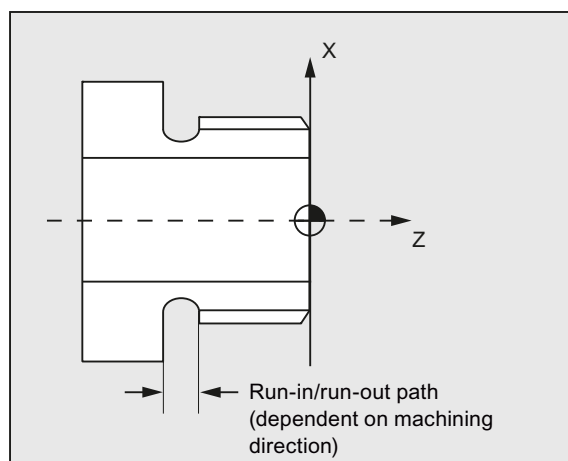
The specification of the lead depends on the taper angle (angle between the longitudinal axis and the outside of the taper):



### 10.10.2 Programmed run-in and run-out path (DITS, DITE):

The **DITS** and **DITE** commands can be used to program the path ramp for acceleration and braking, providing a means of adapting the feedrate accordingly if the tool run-in/run-out is too short:

- **Run-in path too short**  
Due to the collar on the thread runin, little room is left for the tool start ramp. This must therefore be specified shorter via **DITS**.
- **Run-out path too short**  
Because of the shoulder at the thread run-out, there is not much room for the tool braking ramp, introducing a **risk of collision** between the workpiece and the tool cutting edge. The tool braking ramp can be specified shorter using **DITE**. However, there is still a risk of collision.  
Run-out: Program a shorter thread, reduce the spindle speed.



**Syntax**

DITS=<value>  
DITE=<value>

**Meaning**

|          |                                                 |              |
|----------|-------------------------------------------------|--------------|
| DITS:    | Define thread run-in path                       |              |
| DITE:    | Define thread run-out path                      |              |
| <value>: | Value specification for the run-in/run-out path |              |
|          | Range of values:                                | -1, 0, ... n |

**Note**

Only paths, and not positions, are programmed with DITS and DITE.

**Note**

The DITS and DITE commands relate to setting data SD42010 \$SC\_THREAD\_RAMP\_DISP[0,1], in which the programmed paths are written. If no run-in/deceleration path is programmed before or in the first thread block, the corresponding value is determined by the current value of SD42010.

**References:**

Function Manual, Basic Functions; Feedrates (V1)

**Example**

| Program code                        | Comment                         |
|-------------------------------------|---------------------------------|
| ...                                 |                                 |
| N40 G90 G0 Z100 X10 SOFT M3 S500    |                                 |
| N50 G33 Z50 K5 SF=180 DITS=1 DITE=3 | ; Start of smoothing with Z=53. |
| N60 G0 X20                          |                                 |

**Further information**

If the run-in and/or run-out path is very short, the acceleration of the thread axis is higher than the configured value. This causes an acceleration overload on the axis.

Alarm 22280 ("Programmed run-in path too short") is then issued for the thread run-in (with the appropriate configuration in MD11411 \$MN\_ENABLE\_ALARM\_MASK). The alarm is purely for information and has no effect on part program execution.

MD10710 \$MN\_PROG\_SD\_RESET\_SAVE\_TAB can be used to specify that the value written by the part program is written to the corresponding setting data during RESET. The values are, therefore, retained following power off/on.

#### Note

DITE acts at the end of the thread as a rounding clearance. This achieves a smooth change in the axis movement.

When a block with the DITS and/or DITE command is loaded to the interpolator, the path programmed under DITS is written to SD42010 \$SC\_THREAD\_RAMP\_DISP[0] and the path programmed under DITE is written to SD42010 \$SC\_THREAD\_RAMP\_DISP[1].

The current dimensions setting (inch/metric) is applied to the programmed run-in/run-out path.

### 10.10.3 Thread cutting with increasing or decreasing lead (G34, G35)

With the commands G34 and G35, the G33 functionality has been extended with the option of programming a change in the thread lead at address F. With G34, this results in a linear increase and with G35 to a linear decrease of the thread lead. The commands G34 and G35 can therefore be used for the machining of self-tapping threads.

#### Syntax

Cylinder thread with increasing lead:

G34 Z... K... F... .

Cylinder thread with decreasing lead:

G35 Z... K... F... .

Face thread with increasing lead:

G34 X... I... F... .

Face thread with decreasing lead:

G35 X... I... F... .

Taper thread with increasing lead:

G34 X... Z... K... F... .

G34 X... Z... I... F... .

Taper thread with decreasing lead:

G35 X... Z... K... F... .

G35 X... Z... I... F... .

#### Meaning

|                  |                                                               |
|------------------|---------------------------------------------------------------|
| G34:             | Command for thread cutting with linear <b>increasing</b> lead |
| G35:             | Command for thread cutting with linear <b>decreasing</b> lead |
| X... Y... Z... : | End point(s) in Cartesian coordinates                         |
| I... :           | Thread lead in X direction                                    |
| J... :           | Thread lead in Y direction                                    |

|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |                                                                    |         |                                                             |         |                    |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------|---------|-------------------------------------------------------------|---------|--------------------|
| K...:   | Thread lead in Z direction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |         |                                                                    |         |                                                             |         |                    |
| F...:   | <p>Thread lead change</p> <p>If you already know the starting and final lead of a thread, you can calculate the thread lead change to be programmed according to the following equation:</p> $F = \frac{k_e^2 - k_a^2}{2 * l_G} [\text{mm/rev}^2]$ <p>The meanings are as follows:</p> <table> <tr> <td><math>k_e</math>:</td><td>Thread lead (thread lead of axis target point coordinate) [mm/rev]</td></tr> <tr> <td><math>k_a</math>:</td><td>Starting thread lead (programmed under I, J, or K) [mm/rev]</td></tr> <tr> <td><math>l_G</math>:</td><td>Thread length [mm]</td></tr> </table> | $k_e$ : | Thread lead (thread lead of axis target point coordinate) [mm/rev] | $k_a$ : | Starting thread lead (programmed under I, J, or K) [mm/rev] | $l_G$ : | Thread length [mm] |
| $k_e$ : | Thread lead (thread lead of axis target point coordinate) [mm/rev]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                    |         |                                                             |         |                    |
| $k_a$ : | Starting thread lead (programmed under I, J, or K) [mm/rev]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |         |                                                                    |         |                                                             |         |                    |
| $l_G$ : | Thread length [mm]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                    |         |                                                             |         |                    |

### Example

| Program code                    | Comment                                                              |
|---------------------------------|----------------------------------------------------------------------|
| N1608 M3 S10                    | ; Spindle on.                                                        |
| N1609 G0 G64 Z40 X216           | ; Approach starting point.                                           |
| N1610 G33 Z0 K100 SF=R14        | ; Thread cutting with constant lead (100 mm/rev).                    |
| N1611 G35 Z-200 K100 F17.045455 | ; Lead decrease: 17.0454 mm/rev2<br>Lead at end of block: 50 mm/rev. |
| N1612 G33 Z-240 K50             | ; Traverse thread block without jerk.                                |
| N1613 G0 X218                   |                                                                      |
| N1614 G0 Z40                    |                                                                      |
| N1615 M17                       |                                                                      |

### References

Function Manual, Basic Functions; Feedrates (V1), Section "Linear increasing/decreasing thread lead change with G34 and G35"

#### 10.10.4 Fast retraction during thread cutting (LFON, LFOF, DILF, ALF, LFTXT, LFWP, LFPOS, POLF, POLFMASK, POLFMLIN)

The "Rapid retraction during thread cutting (G33)" function can be used to interrupt thread cutting without causing irreparable damage in the following circumstances:

- NC stop via NC/PLC interface signal: DB21, ... DBX7.3 (NC stop)
- Alarms that implicitly trigger NC stop
- Switching of a rapid input

#### References

Programming Manual, Job Planning; Section "Rapid retraction from the contour"



The retraction motion can be programmed via:

- Retraction path and retraction direction (relative)
- Retraction position (absolute)

---

#### Note

##### NC stop signals

The following NC stop signals do not trigger a rapid retraction during thread cutting:

- DB21, ... DBX3.4 (NC stop axes plus spindles)
- DB21, ... DBX7.2 (NC stop at the block limit)

##### Tapping

The "Rapid retraction" function **cannot** be used with **tapping** (G331/G332).

---

## Syntax

Enable rapid retraction, retraction motion via retraction path and retraction direction:

```
G33 ... LFON DILF=<value> LFTXT/LFWP ALF=<value>
```

Enable rapid retraction, retraction motion via retraction position:

```
POLF[<axis identifier>]=<value> LFPOS
POLFMASK/POLFMLIN(<axis 1 name>,<axis 2 name>, etc.)
G33 ... LFON
```

Disable rapid retraction during thread cutting:

```
LFOF
```

## Meaning

|                |                                                                                                                                                                                                                |                                                                                                                                    |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| LFON:          | Enable rapid retraction during thread cutting (G33)                                                                                                                                                            |                                                                                                                                    |
| LFOF:          | Disable rapid retraction during thread cutting (G33)                                                                                                                                                           |                                                                                                                                    |
| DILF= :        | Define length of retraction path                                                                                                                                                                               |                                                                                                                                    |
|                | The value preset during MD configuration (MD21200 \$MC_LIFTFAST_DIST) can be modified in the part program by programming DILF.<br><b>Note:</b><br>The configured MD value is always active following NC-RESET. |                                                                                                                                    |
| LFTXT<br>LFWP: | The retraction direction is controlled in conjunction with ALF with G functions LFTXT and LFWP.                                                                                                                |                                                                                                                                    |
|                | LFTXT:                                                                                                                                                                                                         | The plane in which the retraction motion is executed is calculated from the path tangent and the tool direction (default setting). |
|                | LFWP:                                                                                                                                                                                                          | The plane in which the retraction motion is executed is the active working plane.                                                  |

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                              |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ALF= :             | The direction is programmed in discrete degree increments with ALF in the plane of the retraction motion.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                              |
|                    | <p>With LFTXT, retraction in the tool direction is defined for ALF=1.</p> <p>For LFWP, the direction in the working/machining plane has the following assignment:</p> <ul style="list-style-type: none"> <li>• G17 (X/Y plane)<br/>ALF=1 ; Retraction in the X direction<br/>ALF=3 ; Retraction in the Y direction</li> <li>• G18 (Z/X plane)<br/>ALF=1 ; Retraction in the Z direction<br/>ALF=3 ; Retraction in the X direction</li> <li>• G19 (Y/Z plane)<br/>ALF=1 ; Retraction in the Y direction<br/>ALF=3 ; Retraction in the Z direction</li> </ul> |                                                                                                                                                                                                                                                                                                                              |
|                    | <p><b>References:</b><br/>Programming options with ALF are also described in "Traverse direction for rapid retraction from the contour" in the Programming Manual, Job Planning.</p>                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                              |
| LFPOS:             | Retraction of the axis declared with POLFMASK or POLFMLIN to the absolute axis position programmed with POLF.                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                              |
| POLFMASK:          | Release of axes (<axis 1 name>, <axis 1 name>, etc.) for independent retraction to absolute position.                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                              |
| POLFMLIN:          | <p>Release of axes for retraction to absolute position in linear relation</p> <p><b>Note:</b><br/>Depending on the dynamic response of all the axes involved, the linear relation cannot always be established before the lift position is reached.</p>                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                              |
| POLF[]:            | Define absolute retraction position for the geometry axis or machine axis in the index                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                              |
|                    | Effective:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Modal                                                                                                                                                                                                                                                                                                                        |
|                    | =<value>:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>In the case of geometry axes, the assigned value is interpreted as a position in the workpiece coordinate system. In the case of machine axes, it is interpreted as a position in the machine coordinate system.</p> <p>The values assigned can also be programmed as incremental dimensions:</p> <p>=IC&lt;value&gt;</p> |
| <axis identifier>: | Identifier of a geometry axis or machine axis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                              |

**Note**

LFON or LFOF can always be programmed, but the evaluation is performed exclusively during thread cutting (G33).

**Note**

POLF with POLFMASK/POLFMLIN are not restricted to thread cutting applications.

## Examples

### Example 1: Enable rapid retraction during thread cutting

| Program code                           | Comment                                                                                                                                                                                    |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N55 M3 S500 G90 G18                    | ; Active machining plane                                                                                                                                                                   |
| ...                                    | ; Approach the starting position                                                                                                                                                           |
| N65 MSG ("thread cutting")             | ; Tool infeed                                                                                                                                                                              |
| MM_THREAD:                             |                                                                                                                                                                                            |
| N67 \$AC_LIFTFAST=0                    | ; Reset before starting the thread.                                                                                                                                                        |
| N68 G0 Z5                              |                                                                                                                                                                                            |
| N68 X10                                |                                                                                                                                                                                            |
| N70 G33 Z30 K5 LFON DILF=10 LFWP ALF=7 | ; Enable rapid retraction during thread cutting.<br>Retraction path = 10 mm<br>Retraction plane: Z/X (because of G18)<br>Retraction direction: -X<br>(with ALF=3: Retraction direction +X) |
| N71 G33 Z55 X15                        |                                                                                                                                                                                            |
| N72 G1                                 | ; Deselect thread cutting.                                                                                                                                                                 |
| N69 IF \$AC_LIFTFAST GOTOB MM_THREAD   | ; If thread cutting has been interrupted.                                                                                                                                                  |
| N90 MSG ("")                           |                                                                                                                                                                                            |
| ...                                    |                                                                                                                                                                                            |
| N70 M30                                |                                                                                                                                                                                            |

### Example 2: Switch off rapid retraction before tapping.

| Program code             | Comment                                       |
|--------------------------|-----------------------------------------------|
| N55 M3 S500 G90 G0 X0 Z0 |                                               |
| ...                      |                                               |
| N87 MSG ("tapping")      |                                               |
| N88 LFOF                 | ; Deactivate rapid retraction before tapping. |
| N89 CYCLE...             | ; Tapping cycle with G33.                     |
| N90 MSG ("")             |                                               |
| ...                      |                                               |
| N99 M30                  |                                               |

### Example 3: Rapid retraction to absolute retraction position

Path interpolation of X is suppressed in the event of a stop and a motion executed to position POLF[X] at maximum velocity instead. The motion of the other axes continues to be determined by the programmed contour or the thread lead and the spindle speed.

| Program code               | Comment |
|----------------------------|---------|
| N10 G0 G90 X200 Z0 S200 M3 |         |

| Program code          | Comment                                           |
|-----------------------|---------------------------------------------------|
| N20 G0 G90 X170       |                                                   |
| N22 POLF[X]=210 LFPOS |                                                   |
| N23 POLFMASK(X)       | ; Activate (enable) rapid retraction from axis X. |
| N25 G33 X100 I10 LFON |                                                   |
| N30 X135 Z-45 K10     |                                                   |
| N40 X155 Z-128 K10    |                                                   |
| N50 X145 Z-168 K10    |                                                   |
| N55 X210 I10          |                                                   |
| N60 G0 Z0 LFOF        |                                                   |
| N70 POLFMASK()        | ; Disable lift for all axes.                      |
| M30                   |                                                   |

### 10.10.5 Convex thread (G335, G336)

The G functions G335 and G336 can be used to turn convex threads (= differing to the cylindrical form). Application is the machining of extremely large components that sag in the machine because of their self-weight. Paraxial thread would result in the thread being too small in the middle of the component. This can be compensated with convex threads.

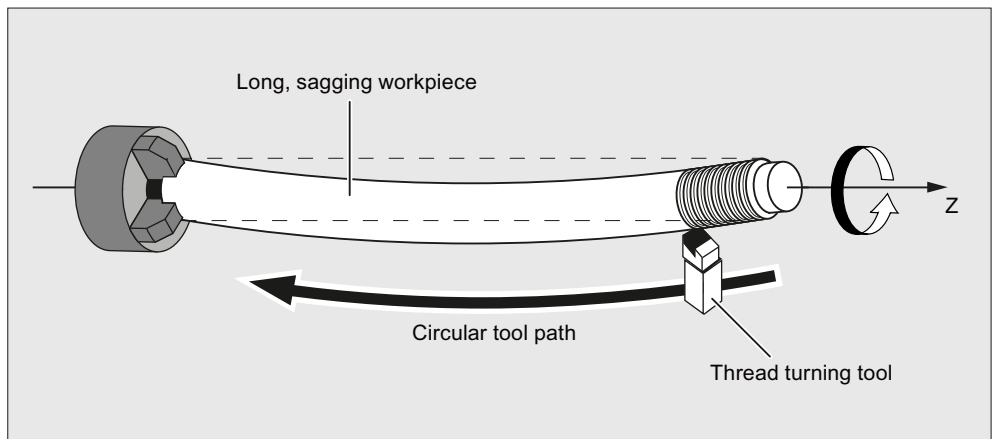


Figure 10-3 Turning a convex thread

### Programming

The turning of a convex thread is programmed with G335 or G336:

|       |                                                                                            |
|-------|--------------------------------------------------------------------------------------------|
| G335: | Turning of a convex thread on a circular tool path in a <b>clockwise direction</b>         |
| G336: | Turning of a convex thread on a circular tool path in a <b>counter-clockwise direction</b> |

The programming is performed first as for a linear thread by specifying the axial block end points and the pitch via parameters I, J and K (see "Thread cutting with constant lead (G33, SF) (Page 214)").

An arc is also specified. As for G2/G3, this can be programmed via the center point, radius, opening angle or intermediate point specification (see "Circular interpolation (Page 178)"). When programming the convex thread with center point programming, the following must be taken into account: Since I, J and K are used for the pitch in thread cutting, the circle parameters in the center point programming must be programmed with IR= . . . , JR= . . . and KR= . . . .

|             |                                                                     |
|-------------|---------------------------------------------------------------------|
| IR= . . . : | Cartesian coordinate for the circle center point in the X direction |
| JR= . . . : | Cartesian coordinate for the circle center point in the Y direction |
| KR= . . . : | Cartesian coordinate for the circle center point in the Z direction |

### Note

IR, JR and KR are the default values of the interpolation parameter names for a convex thread that can be set via machine data (MD10651 \$MN\_IPO\_PARAM\_THREAD\_NAME\_TAB).

Differences to the default values must be taken from the specifications of the machine manufacturer.

Optionally, a starting point offset SF can also be specified (see "Thread cutting with constant lead (G33, SF) (Page 214)").

### Syntax

The syntax for the programming of a convex thread therefore has the following general form: G335/G336 <axis target point coordinate(s)> <pitch> <arc> [<starting point offset>]

## Examples

### Example 1: Convex thread in the clockwise direction with end and center point programming

| Program code                           | Comment                                          |
|----------------------------------------|--------------------------------------------------|
| N5 G0 G18 X50 Z50                      | ; Approach starting point.                       |
| N10 G335 Z100 K=3.5 KR=25 IR=-20 SF=90 | ; Turn convex thread in the clockwise direction. |

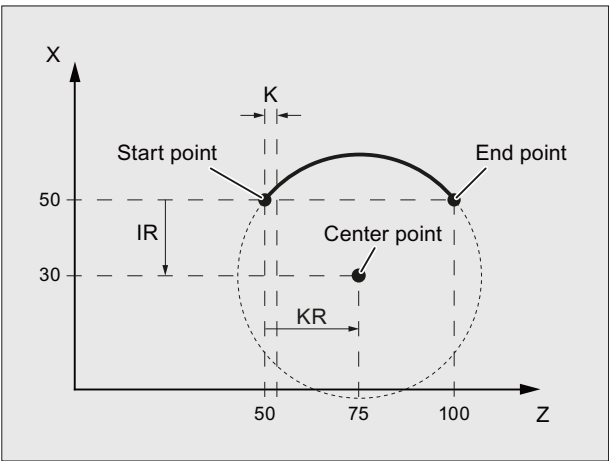


Figure 10-4 Convex thread in the clockwise direction with end and center point programming

**Example 2: Convex thread in the counter-clockwise direction with end and center point programming**

| Program code                          | Comment                                                  |
|---------------------------------------|----------------------------------------------------------|
| N5 G0 G18 X50 Z50                     | ; Approach starting point.                               |
| N10 G336 Z100 K=3.5 KR=25 IR=20 SF=90 | ; Turn convex thread in the counter-clockwise direction. |

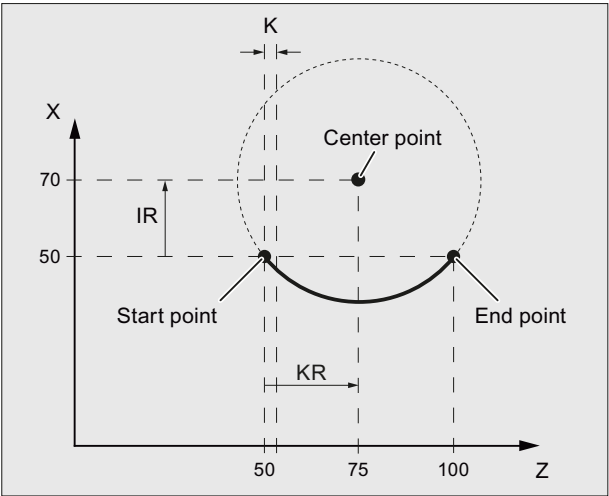


Figure 10-5 Convex thread in the counter-clockwise direction with end and center point programming

**Example 3: Convex thread in the clockwise direction with end point and radius programming**

| Program code                    | Comment |
|---------------------------------|---------|
| N5 G0 G18 X50 Z50               |         |
| N10 G335 Z100 K=3.5 CR=32 SF=90 |         |

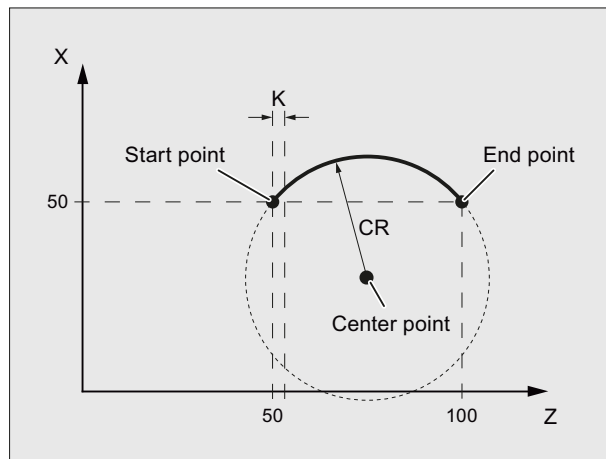


Figure 10-6 Convex thread in the clockwise direction with end point and radius programming

**Example 4: Convex thread in the clockwise direction with end point and opening angle programming**

**Program code**

```
N5 G0 G18 X50 Z50
N10 G335 Z100 K=3.5 AR=102.75 SF=90
```

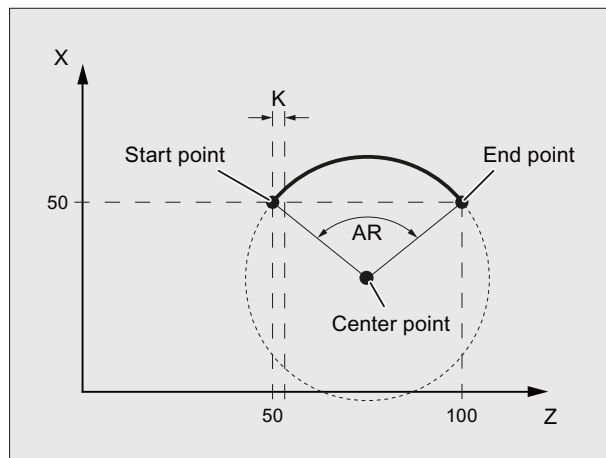


Figure 10-7 Convex thread in the clockwise direction with end point and opening angle programming

**Example 5: Convex thread in the clockwise direction with center point and opening angle programming**

**Program code**

```
N5 G0 G18 X50 Z50
N10 G335 K=3.5 KR=25 IR=-20 AR=102.75 SF=90
```

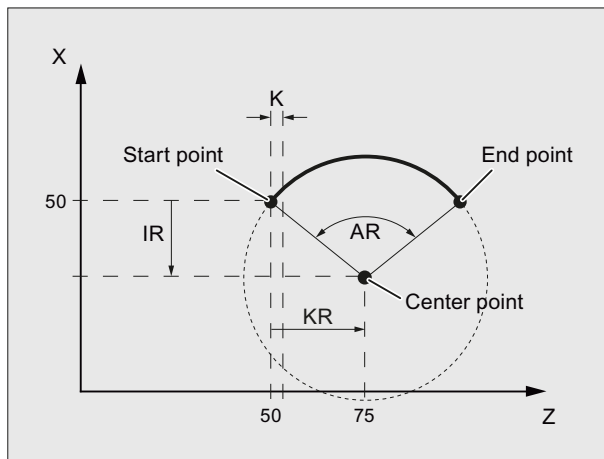


Figure 10-8 Convex thread in the clockwise direction with center point and opening angle programming

**Example 6: Convex thread in the clockwise direction with end and intermediate point programming**

**Program code**

```
N5 G0 G18 X50 Z50
N10 G335 Z100 K=3.5 I1=60 K1=64
```

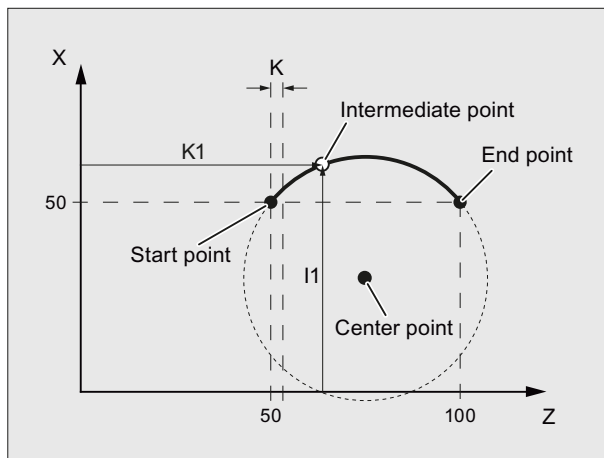


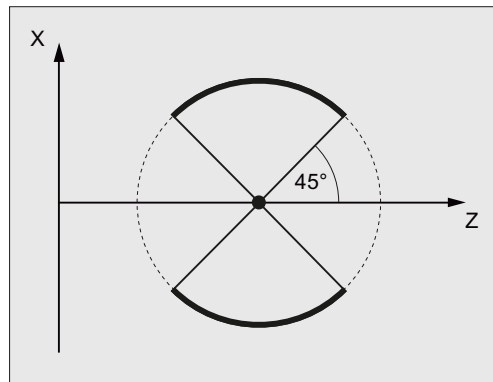
Figure 10-9 Convex thread in the clockwise direction with end and intermediate point programming



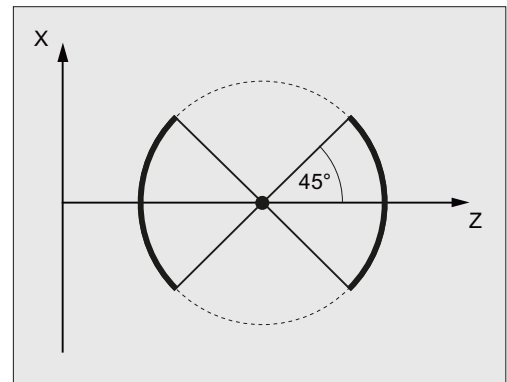
## Further information

### Permissible arc areas

The arc programmed at G335/G336 must be in an area in which the specified thread main axis (I, J or K) has the main axis share on the arc over the entire arc:



Permissible areas for the Z axis (pitch programmed with K)



Permissible areas for the X axis (pitch programmed with I)

A change of the thread main axis as shown in the following figure is **not** permitted:

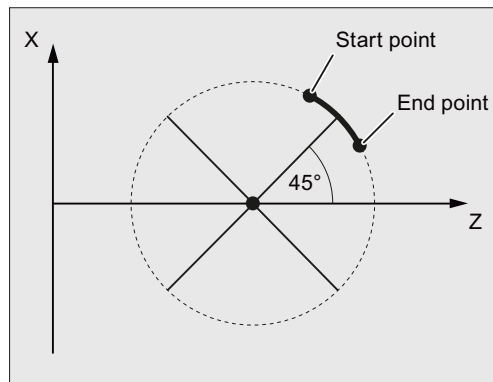


Figure 10-10 Convex thread: Area that is not permissible

### Frames

G335 and G336 are also possible with active frames. However, you must ensure that the permissible arc areas are maintained in the basic coordinate system (BCS).

### Supplementary conditions for the circular-path programming

The supplementary conditions described for the circular-path programming with G2/G3 apply for the circular-path programming under G335/G336 (see "Circular interpolation (Page 178)").

## 10.11 Tapping

### 10.11.1 Tapping without compensating chuck (G331, G332)

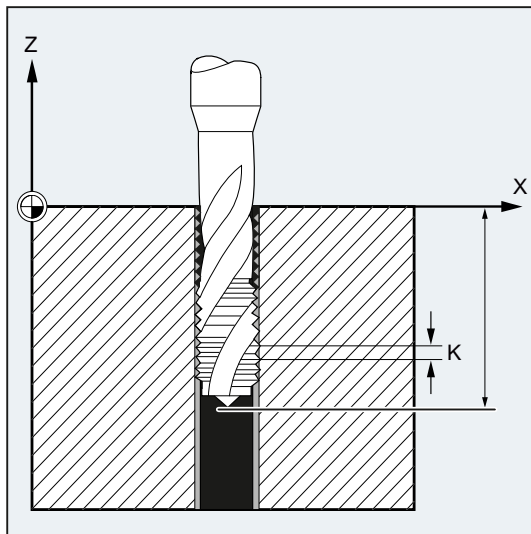
#### Requirement

With regard to technology, tapping without compensating chuck requires a position-controlled spindle with position measuring system.

#### Function

Tapping without compensating chuck is programmed using the G331 and G332 commands. The spindle prepared for tapping can make the following movements in position-controlled operation with distance measuring system:

- G331: Tapping with thread lead in tapping direction up to end point
- G332: Retraction movement with the same lead as G331



Right-hand or left-hand threads are defined by the sign of the lead:

- Positive lead → clockwise (as M3)
- Negative lead → counter-clockwise (as M4)

The desired speed is also programmed at address S.

#### Syntax

SPOS=<value>

G331 S...

G331 X... Y... Z... I... J... K...

G332 X... Y... Z... I... J... K...

- SPOS (or M70) only has to be programmed prior to tapping:
  - For threads requiring multiple machining operations for their production
  - For production processes requiring a defined thread starting position

Conversely, when machining multiple threads one after the other, SPOS (or M70) does not have to be programmed (advantage: Saves time).

- The spindle speed has to be in a dedicated G331 block without axis motion before tapping (G331 X... Y... Z... I... J... K...).

## Meaning

|                 |                                                                                                                                                                        |                          |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| G331:           | Command: Tapping<br>The hole is defined by the drilling depth and the thread lead.                                                                                     |                          |
|                 | Effective:                                                                                                                                                             | Modal                    |
| G332:           | Command: Tapping retraction<br>This movement is described with the same lead as the G331 movement. The direction of rotation of the spindle is reversed automatically. |                          |
|                 | Effective:                                                                                                                                                             | Modal                    |
| X... Y... Z...: | Drilling depth (end point of the thread in Cartesian coordinates)                                                                                                      |                          |
| I...:           | Thread lead in X direction                                                                                                                                             |                          |
| J...:           | Thread lead in Y direction                                                                                                                                             |                          |
| K...:           | Thread lead in Z direction                                                                                                                                             |                          |
|                 | Value range of lead:                                                                                                                                                   | ±0.001 to 2000.00 mm/rev |

### Note

After G332 (retraction), the next thread can be tapped with G331.

### Note

#### Second gear-stage data block

To achieve effective adaptation of spindle speed and motor torque and be able to accelerate faster, a second gear-stage data block for two further configurable switching thresholds (maximum speed and minimum speed) can be preset in axis-specific machine data deviating from the first gear step data block and also independent of these speed switching thresholds. Please see the machine manufacturer's specifications for further details.

### References:

Function Manual, Basic Functions; Spindles (S1), Section: "Configurable gear adaptations".

## Examples

## Example 1: G331 and G332

| Program code                        | Comment                                                                             |
|-------------------------------------|-------------------------------------------------------------------------------------|
| N10 SPOS[n]=0                       | ; Prepare tapping.                                                                  |
| N20 G0 X0 Y0 Z2                     | ; Approach starting point.                                                          |
| N30 G331 Z-50 K-4 S200              | ; Tapping, drilling depth 50, lead K negative = counter-clockwise spindle rotation. |
| N40 G332 Z3 K-4                     | ; Retraction, automatic reversal of direction.                                      |
| N50 G1 F1000 X100 Y100 Z100 S300 M3 | ; Spindle operates in spindle mode again.                                           |
| N60 M30                             | ; End of program                                                                    |

## Example 2: Output the programmed drilling speed in the current gear stage

| Program code          | Comment                                                                                                           |
|-----------------------|-------------------------------------------------------------------------------------------------------------------|
| N05 M40 S500          | ; Gear stage 1 is engaged since the programmed spindle speed of 500 rpm is in the range between 20 and 1,028 rpm. |
| ...                   |                                                                                                                   |
| N55 SPOS=0            | ; Align spindle.                                                                                                  |
| N60 G331 Z-10 K5 S800 | ; Machine thread, spindle speed is 800 rpm in gear stage 1.                                                       |

The appropriate gear stage for the programmed spindle speed S500 with M40 is determined on the basis of the first gear-stage data block. The programmed drilling speed S800 is output in the current gear stage and, if necessary, is limited to the maximum speed of the gear stage. No automatic gear-stage change is possible following an SPOS operation. In order for an automatic change in gear stage to be performed, the spindle must be in speed-control mode.

**Note**

If gear stage 2 is selected at a spindle speed of 800 rpm, then the switching thresholds for the maximum and minimum speed must be configured in the relevant machine data of the second gear-stage data block (see the examples below).

## Example 3: Application of the second gear-stage data block

The switching thresholds of the second gear-stage data block for the maximum and minimum speed are evaluated for G331/G332 and when programming an S value for the active master spindle. Automatic M40 gear-stage change must be active. The gear stage as determined in the manner described above is compared with the active gear stage. If they are found to be different, a gear-stage change is performed.

| Program code | Comment                     |
|--------------|-----------------------------|
| N05 M40 S500 | ; Gear stage 1 is selected. |

| Program code     | Comment                                                                    |
|------------------|----------------------------------------------------------------------------|
| ...              |                                                                            |
| N50 G331 S800    | ; Master spindle with 2nd gear-stage data block: Gear stage 2 is selected. |
| N55 SPOS=0       | ; Align spindle.                                                           |
| N60 G331 Z-10 K5 | ; Tapping, spindle acceleration from second gear-stage data block.         |

#### Example 4: No speed programming → monitoring of the gear stage

If no speed is programmed when using the second gear-stage data block with G331, then the last speed programmed will be used to produce the thread. The gear stage does not change. However, monitoring is performed in this case to check that the last speed programmed is within the preset speed range (defined by the maximum and minimum speed thresholds) for the active gear stage. If it is not, alarm 16748 is signaled.

| Program code     | Comment                                                                                                                     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------|
| N05 M40 S800     | ; Gear stage 1 is selected, the first gear-stage data block is active.                                                      |
| ...              |                                                                                                                             |
| N55 SPOS=0       |                                                                                                                             |
| N60 G331 Z-10 K5 | ; Monitoring of spindle speed 800 rpm with gear-stage data block 2: Gear stage 2 should be active, alarm 16748 is signaled. |

#### Example 5: Gear stage cannot be changed → monitoring of gear stage

If the spindle speed is programmed in addition to the geometry in the G331 block when using the second gear-stage data block, if the speed is not within the preset speed range (defined by the maximum and minimum speed thresholds) of the active gear stage, it will not be possible to change gear stages, because the path motion of the spindle and the infeed axis (axes) would not be retained.

As in the example above, the speed and gear stage are monitored in the G331 block and alarm 16748 is signaled if necessary.

| Program code          | Comment                                                                                                                                                   |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| N05 M40 S500          | ; Gear stage 1 is selected.                                                                                                                               |
| ...                   |                                                                                                                                                           |
| N55 SPOS=0            |                                                                                                                                                           |
| N60 G331 Z-10 K5 S800 | ; Gear stage cannot be changed, monitoring of spindle speed 800 rpm with gear-stage data block 2: Gear stage 2 should be active, alarm 16748 is signaled. |

#### Example 6: Programming without SPOS

| Program code | Comment                     |
|--------------|-----------------------------|
| N05 M40 S500 | ; Gear stage 1 is selected. |

| Program code     | Comment                                                                    |
|------------------|----------------------------------------------------------------------------|
| ...              |                                                                            |
| N50 G331 S800    | ; Master spindle with 2nd gear-stage data block: Gear stage 2 is selected. |
| N60 G331 Z-10 K5 | ; Machine thread, spindle acceleration from second gear-stage data block.  |

Thread interpolation for the spindle starts from the current position, which is determined by the previously processed section of the part program, e.g. if the gear stage was changed. Therefore, it might not be possible to remachine the thread.

### Note

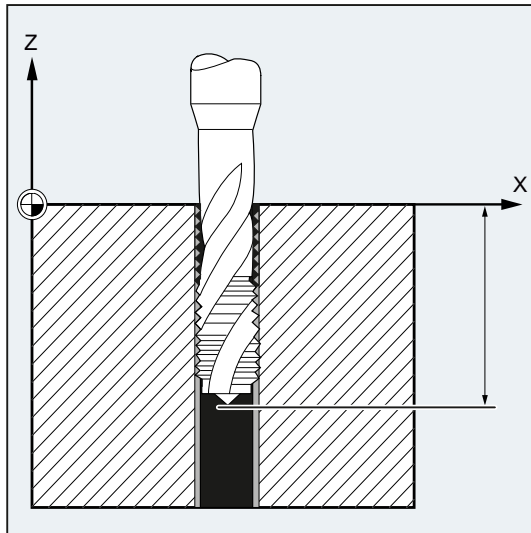
Please note that when machining with multiple spindles, the drill spindle also has to be the master spindle. `SETMS(<spindle number>)` can be programmed to set the drill spindle as the master spindle.

## 10.11.2 Tapping with compensating chuck (G63)

With `G63` you can tap a compensating chuck. The following are programmed:

- Drilling depth in Cartesian coordinates
- Spindle speed and direction
- Feedrate

The chuck compensates for any deviations occurring in the path.



### Retraction movement

Programming also with `G63`, but with spindle rotation in the opposite direction.

## 10.12 Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM)

## Syntax

G63 X... Y... Z...

## Meaning

|                 |                                                     |
|-----------------|-----------------------------------------------------|
| G63:            | Tapping with compensating chuck                     |
| X... Y... Z...: | Drilling depth (end point) in Cartesian coordinates |

**Note**

G63 is non-modal.

After a block with programmed G63, the last interpolation command programmed (G0, G1, G2, etc.) is reactivated.

**Feedrate****Note**

The programmed feedrate must match the ratio of the speed to the thread lead of the tap.

Thumb rule:

**Feedrate F in mm/min = spindle speed S in rpm \* thread lead in mm/rev**

Not only the feedrate, but also the spindle speed override switch are set to 100% with G63.

## Example

In this example, an M5 thread is to be drilled. The lead of an M5 thread is 0.8 (according to the table).

With a selected speed of 200 rpm, the feedrate F = 160 mm/min.

| Program code                  | Comment                                         |
|-------------------------------|-------------------------------------------------|
| N10 G1 X0 Y0 Z2 S200 F1000 M3 | ; Approach starting point, activate spindle.    |
| N20 G63 Z-50 F160             | ; Tapping, drilling depth 50.                   |
| N30 G63 Z3 M4                 | ; Retraction, programmed reversal of direction. |
| N40 M30                       | ; End of program                                |

## 10.12 Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM)

Contour corners within the active working plane can be executed as roundings or chamfers.

For optimum surface quality, a separate feedrate can be programmed for chamfer/rounding. If a feedrate is not programmed, the standard path feedrate F will be applied.

The "Modal rounding" function can be used to round multiple contour corners in the same way one after the other.

## Syntax

Chamfer the contour corner:

```
G... X... Z... CHR/CHF=<value> FRC/FRCM=<value>
G... X... Z...
```

Round the contour corner:

```
G... X... Z... RND=<value> FRC=<value>
G... X... Z...
```

Modal rounding:

```
G... X... Z... RNDM=<value> FRCM=<value>
...
RNDM=0
```

### Note

The technology (feedrate, feedrate type, M commands, etc.) for chamfer/rounding is derived from either the previous or the next block dependent on the setting of bit 0 in machine data MD20201 \$MC\_CHFRND\_MODE\_MASK (chamfer/rounding behavior). The recommended setting is the derivation from the previous block (bit 0 = 1).

## Meaning

|            |                                                                                        |                                                                                                       |
|------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| CHF=... :  | Chamfer the contour corner                                                             |                                                                                                       |
|            | <value>:                                                                               | Length of the chamfer (unit corresponding to G70/G71)                                                 |
| CHR=... :  | Chamfer the contour corner                                                             |                                                                                                       |
|            | <value>:                                                                               | Width of the chamfer in the original direction of motion (unit corresponding to G70/G71)              |
| RND=... :  | Round the contour corner                                                               |                                                                                                       |
|            | <value>:                                                                               | Radius of the rounding (unit corresponding to G70/G71)                                                |
| RNDM=... : | Modal rounding (rounding multiple contour corners in the same way one after the other) |                                                                                                       |
|            | <value>:                                                                               | Radius of the roundings (unit corresponding to G70/G71)                                               |
|            |                                                                                        | Modal rounding is deactivated with RNDM=0.                                                            |
| FRC=... :  | Non-modal feedrate for chamfer/rounding                                                |                                                                                                       |
|            | <value>:                                                                               | Feedrate in mm/min (with active G94) or mm/rev (with active G95)                                      |
| FRCM=... : | Modal feedrate for chamfer/rounding                                                    |                                                                                                       |
|            | <value>:                                                                               | Feedrate in mm/min (with active G94) or mm/rev (with active G95)                                      |
|            |                                                                                        | FRCM=0 deactivates modal feedrate for chamfer/rounding and activates the feedrate programmed under F. |



**Note****Chamfer/rounding too high**

If the values programmed for chamfer (CHF/CHR) or rounding (RND/RNDM) are too high for the contour elements involved, chamfer or rounding will automatically be adapted:

1. If MD11411 \$MN\_ENABLE\_ALARM\_MASK bit 4 is set, alarm 10833 "Chamfer or rounding must be reduces" is output (cancel alarm).
  2. The chamfer/rounding is reduced until it fits in the contour corner. This results in at least one block without motion. At this block, the required motion is stopped.
- 

**Note****Chamfer/rounding not possible**

No chamfer/rounding is performed if:

- No straight or circular contour is available in the plane
  - A movement takes place outside the plane
  - The plane is changed
  - The number of blocks specified in the machine data that are not to contain any information about traversing (e.g. only command outputs) is exceeded
- 

**Note****FRC/FRCM**

FRC/FRCM has no effect if a chamfer is traversed with G0; the command can be programmed according to the F value without error message.

FRC is only effective if a chamfer/rounding is programmed in the block or if RNDM has been activated.

FRC overwrites the F or FRCM value in the current block.

The feedrate programmed under FRC must be greater than zero.

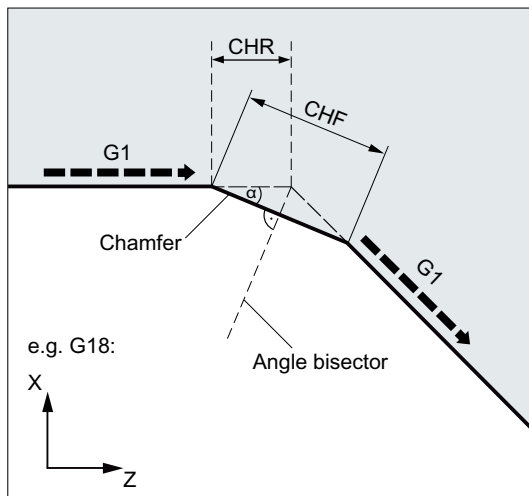
FRCM=0 activates the feedrate programmed under F for chamfer/rounding.

If FRCM is programmed, the FRCM value will need to be reprogrammed like F on change G94 ↔ G95, etc. If only F is reprogrammed and if the feedrate type FRCM > 0 before the change, an error message will be output.

---

## Examples

## Example 1: Chamfer between two straight lines



- MD20201 Bit 0 = 1 (derived from previous block).
- G71 is active.
- The width of the chamfer in the direction of motion (CHR) should be 2 mm and the feedrate for chamfer 100 mm/min.

Programming can be performed in two ways:

- Programming with CHR

---

**Program code**

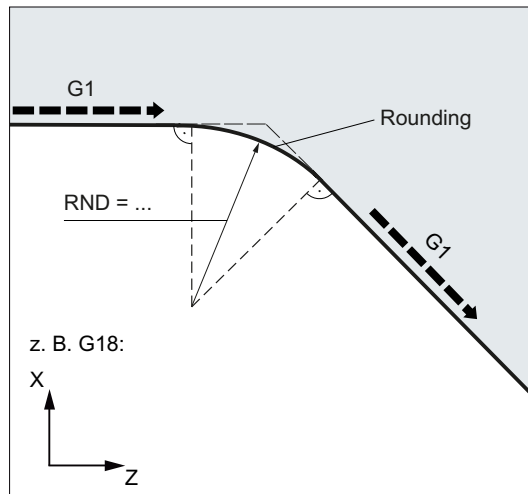
```
...
N30 G1 Z... CHR=2 FRC=100
N40 G1 X...
...
```

- Programming with CHF

---

**Program code**

```
...
N30 G1 Z... CHF=2 (cos α * 2) FRC=100
N40 G1 X...
...
```

**Example 2: Rounding between two straight lines**

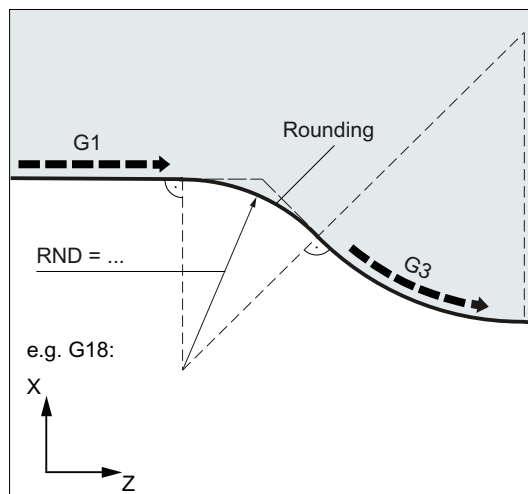
- MD20201 Bit 0 = 1 (derived from previous block).
- G71 is active.
- The radius of the rounding should be 2 mm and the feedrate for rounding 50 mm/min.

**Program code**

```
...
N30 G1 Z... RND=2 FRC=50
N40 G1 X...
...
```

**Example 3: Rounding between straight line and circle**

The RND function can be used to insert a circle contour element with tangential connection between the linear and circle contours in any combination.



- MD20201 Bit 0 = 1 (derived from previous block).
- G71 is active.
- The radius of the rounding should be 2 mm and the feedrate for rounding 50 mm/min.

**Program code**

```
...
```

## 10.12 Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM)

**Program code**

```
N30 G1 Z... RND=2 FRC=50
N40 G3 X... Z... I... K...
...
```

**Example 4: Modal rounding to deburr sharp workpiece edges****Program code****Comment**

```
...
N30 G1 X... Z... RNDM=2 FRCM=50      ; Activate modal rounding.
                                       Radius of rounding: 2 mm
                                       Feedrate for rounding: 50 mm/min
N40...
N120 RNDM=0                          ; Deactivate modal rounding.
...
```

**Example 5: Apply technology from following block or previous block**

- MD20201 Bit 0 = 0: Derived from following block (default setting!)

**Program code****Comment**

```
N10 G0 X0 Y0 G17 F100 G94
N20 G1 X10 CHF=2                      ; Chamfer N20-N30 with F=100 mm/min
N30 Y10 CHF=4                        ; Chamfer N30-N40 with FRC=200 mm/min
N40 X20 CHF=3 FRC=200                ; Chamfer N40-N60 with FRCM=50 mm/min
N50 RNDM=2 FRCM=50
N60 Y20                              ; Modal rounding N60-N70 with FRCM=50 mm/min
N70 X30                              ; Modal rounding N70-N80 with FRCM=50 mm/min
N80 Y30 CHF=3 FRC=100                ; Chamfer N80-N90 with FRC=100 mm/min
N90 X40                              ; Modal rounding N90-N100 with F=100 mm/min (de-
                                       selection of FRCM)
N100 Y40 FRCM=0                      ; Modal rounding N100-N120 with G95 FRC=1 mm/rev
N110 S1000 M3
N120 X50 G95 F3 FRC=1
...
M02
```

- MD20201 Bit 0 = 1: Derived from previous block (recommended setting!)

**Program code****Comment**

```
N10 G0 X0 Y0 G17 F100 G94
N20 G1 X10 CHF=2                      ; Chamfer N20-N30 with F=100 mm/min
N30 Y10 CHF=4 FRC=120                ; Chamfer N30-N40 with FRC=120 mm/min
N40 X20 CHF=3 FRC=200                ; Chamfer N40-N60 with FRC=200 mm/min
```

## 10.12 Chamfer, rounding (CHF, CHR, RND, RNDM, FRC, FRCM)

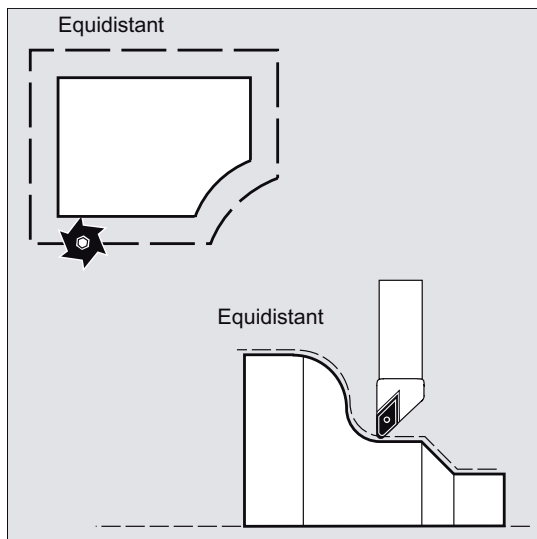
| Program code                | Comment                                       |
|-----------------------------|-----------------------------------------------|
| N50 RNDM=2 FRCM=50          |                                               |
| N60 Y20                     | ; Modal rounding N60-N70 with FRCM=50 mm/min  |
| N70 X30                     | ; Modal rounding N70-N80 with FRCM=50 mm/min  |
| N80 Y30 CHF=3 FRC=100       | ; Chamfer N80-N90 with FRC=100 mm/min         |
| N90 X40                     | ; Modal rounding N90-N100 with FRCM=50 mm/min |
| N100 Y40 FRCM=0             | ; Modal rounding N100-N120 with F=100 mm/min  |
| N110 S1000 M3               |                                               |
| N120 X50 CHF=4 G95 F3 FRC=1 | ; Chamfer N120-N130 with G95 FRC=1 mm/rev     |
| N130 Y50                    | ; Modal rounding N130-N140 with F=3 mm/rev    |
| N140 X60                    |                                               |
| ...                         |                                               |
| M02                         |                                               |



## Tool radius compensation

### 11.1 Tool radius compensation (G40, G41, G42, OFFN)

When tool radius compensation (TRC) is active, the control automatically calculates the equidistant tool paths for various tools.



#### Syntax

|                                                             |  |
|-------------------------------------------------------------|--|
| G0/G1 X... Y... Z... <b>G41/G42</b> [ <b>OFFN</b> =<value>] |  |
| ...                                                         |  |
| <b>G40</b> X... Y... Z...                                   |  |

#### Meaning

|               |                                                                                                                                 |
|---------------|---------------------------------------------------------------------------------------------------------------------------------|
| G41:          | Activate TRC with machining direction <b>left</b> of the contour.                                                               |
| G42:          | Activate TRC with machining direction <b>right</b> of the contour.                                                              |
| OFFN=<value>: | Allowance on the programmed contour (normal contour offset) (optional), e.g. to generate equidistant paths for rough finishing. |
| G40:          | Deactivate TRC.                                                                                                                 |

**Note**

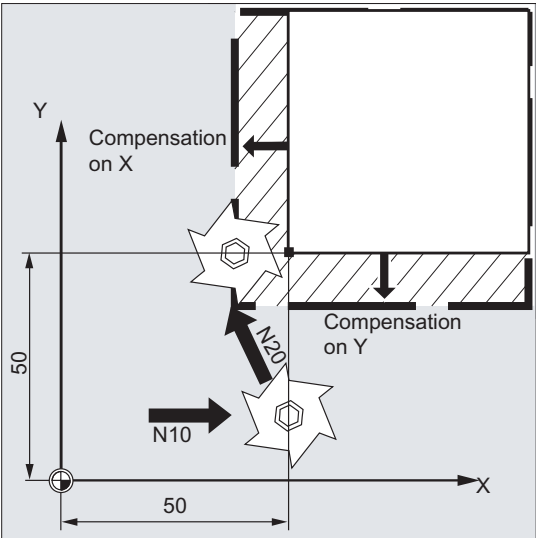
In the NC block with G40/G41/G42, G0 or G1 has to be active and at least one axis has to be specified on the selected working plane.

If only one axis is specified on activation, the last position on the second axis is added automatically and traversed with **both** axes.

The two axes must be active as geometry axes in the channel. This can be achieved by means of GEOAX programming.

**Examples**

**Example 1: Milling**



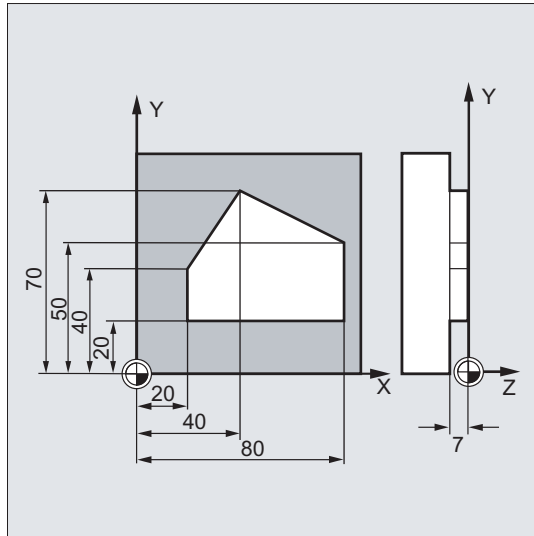
| Program code        | Comment                                                                               |
|---------------------|---------------------------------------------------------------------------------------|
| N10 G0 X50 T1 D1    | ; Only tool length compensation is activated. X50 is approached without compensation. |
| N20 G1 G41 Y50 F200 | ; Radius compensation is activated, point X50/Y50 is approached with compensation.    |
| N30 Y100            |                                                                                       |
| ...                 |                                                                                       |



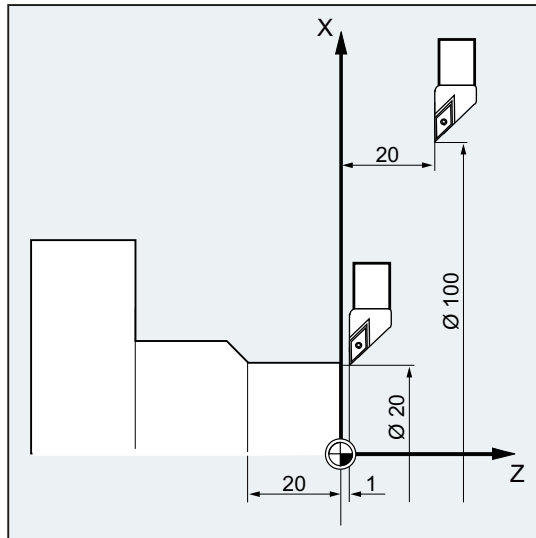
**Example 2: "Conventional" procedure using milling as an example**

"Conventional" procedure:

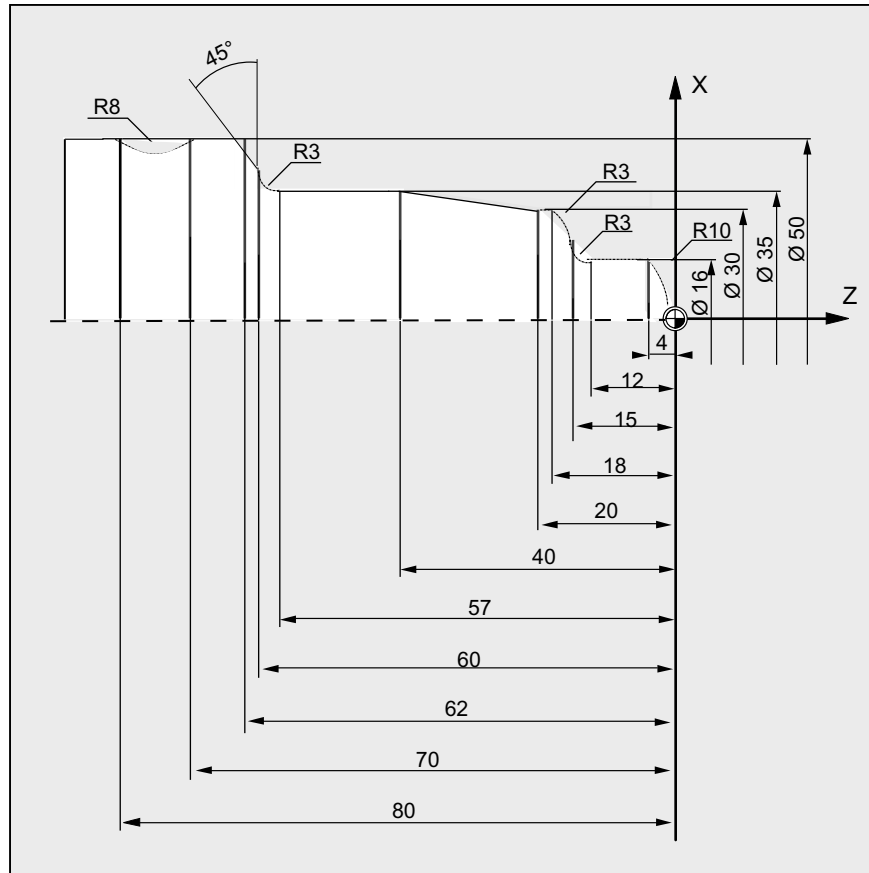
1. Tool call.
2. Change tool.
3. Activate working plane and tool radius compensation.



| Program code               | Comment                                                                        |
|----------------------------|--------------------------------------------------------------------------------|
| N10 G0 Z100                | ; Retraction for tool change.                                                  |
| N20 G17 T1 M6              | ; Tool change                                                                  |
| N30 G0 X0 Y0 Z1 M3 S300 D1 | ; Call tool offset values, select length compensation.                         |
| N40 Z-7 F500               | ; Feed in tool.                                                                |
| N50 G41 X20 Y20            | ; Activate tool radius compensation, tool machines to the left of the contour. |
| N60 Y40                    | ; Mill contour.                                                                |
| N70 X40 Y70                |                                                                                |
| N80 X80 Y50                |                                                                                |
| N90 Y20                    |                                                                                |
| N100 X20                   |                                                                                |
| N110 G40 G0 Z100 M30       | ; Retract tool, end of program.                                                |



| Program code     | Comment                                                                           |
|------------------|-----------------------------------------------------------------------------------|
| ...              |                                                                                   |
| N20 T1 D1        | ; Only tool length compensation is activated.                                     |
| N30 G0 X100 Z20  | ; X100 Z20 is approached without compensation.                                    |
| N40 G42 X20 Z1   | ; Radius compensation is activated, point X20/Z1 is approached with compensation. |
| N50 G1 Z-20 F0.2 |                                                                                   |
| ...              |                                                                                   |

**Example 4: Turning**

| Program code           | Comment                                   |
|------------------------|-------------------------------------------|
| N5 G0 G53 X280 Z380 D0 | ; Starting point.                         |
| N10 TRANS X0 Z250      | ; Work offset.                            |
| N15 LIMS=4000          | ; Speed limitation (G96).                 |
| N20 G96 S250 M3        | ; Select constant feedrate                |
| N25 G90 T1 D1 M8       | ; Select tool selection and offset.       |
| N30 G0 G42 X-1.5 Z1    | ; Set tool with tool radius compensation. |
| N35 G1 X0 Z0 F0.25     |                                           |
| N40 G3 X16 Z-4 I0 K-10 | ; Turn radius 10.                         |
| N45 G1 Z-12            |                                           |
| N50 G2 X22 Z-15 CR=3   | ; Turn radius 3.                          |
| N55 G1 X24             |                                           |
| N60 G3 X30 Z-18 I0 K-3 | ; Turn radius 3.                          |
| N65 G1 Z-20            |                                           |
| N70 X35 Z-40           |                                           |
| N75 Z-57               |                                           |
| N80 G2 X41 Z-60 CR=3   | ; Turn radius 3.                          |
| N85 G1 X46             |                                           |
| N90 X52 Z-63           |                                           |

## 11.1 Tool radius compensation (G40, G41, G42, OFFN)

| Program code                | Comment                                                                |
|-----------------------------|------------------------------------------------------------------------|
| N95 G0 G40 G97 X100 Z50 M9  | ; Deselect tool radius compensation and approach tool change location. |
| N100 T2 D2                  | ; Call tool and select offset.                                         |
| N105 G96 S210 M3            | ; Select constant cutting rate.                                        |
| N110 G0 G42 X50 Z-60 M8     | ; Set tool with tool radius compensation.                              |
| N115 G1 Z-70 F0.12          | ; Turn diameter 50.                                                    |
| N120 G2 X50 Z-80 I6.245 K-5 | ; Turn radius 8.                                                       |
| N125 G0 G40 X100 Z50 M9     | ; Retract tool and deselect tool radius compensation.                  |
| N130 G0 G53 X280 Z380 D0 M5 | ; Approach tool change location.                                       |
| N135 M30                    | ; End of program.                                                      |

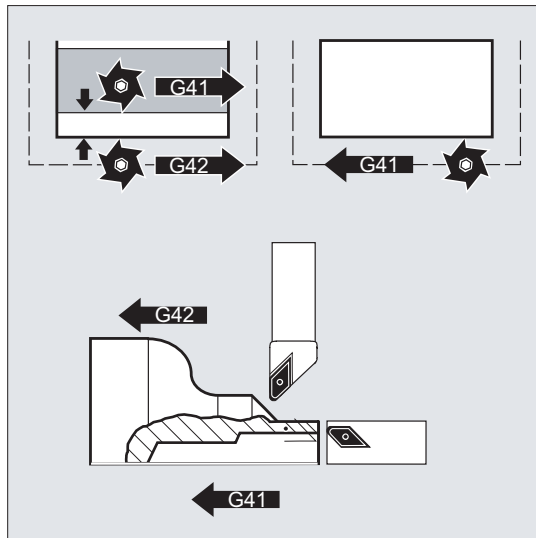
### Further information

The control requires the following information in order to calculate the tool paths:

- Tool no. (T...), cutting edge no. (D...)
- Machining direction (G41/G42)
- Working plane (G17/G18/G19)

#### Tool no. (T...), cutting edge no. (D...)

The distance between tool path and workpiece contour is calculated from the milling cutter radii or cutting edge radii and the tool point direction parameters.



With a flat D number structure, only the D number has to be programmed.

**Machining direction (G41/G42)**

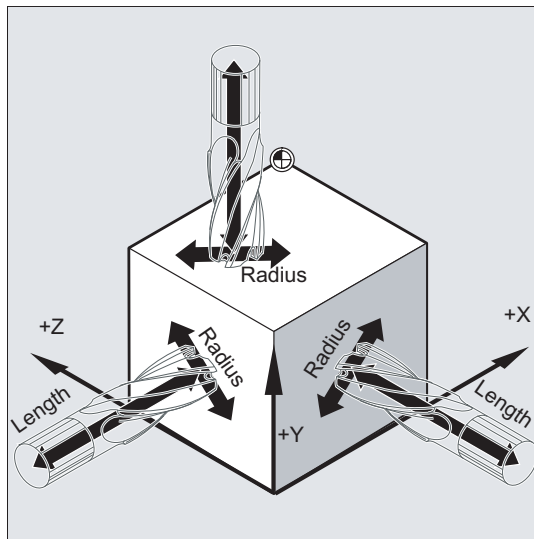
From this information, the control detects the direction in which the tool path is to be displaced.

**Note**

A negative offset value has the same significance as a change of offset side (G41 ↔ G42).

**Working plane (G17/G18/G19)**

From this information, the control detects the plane and therefore the axis directions for compensation.



Example: Milling tool

| Program code    | Comment                                                                                                               |
|-----------------|-----------------------------------------------------------------------------------------------------------------------|
| ...             |                                                                                                                       |
| N10 G17 G41 ... | ; The tool radius compensation is performed in the X/Y plane, the tool length offset is performed in the Z direction. |
| ...             |                                                                                                                       |

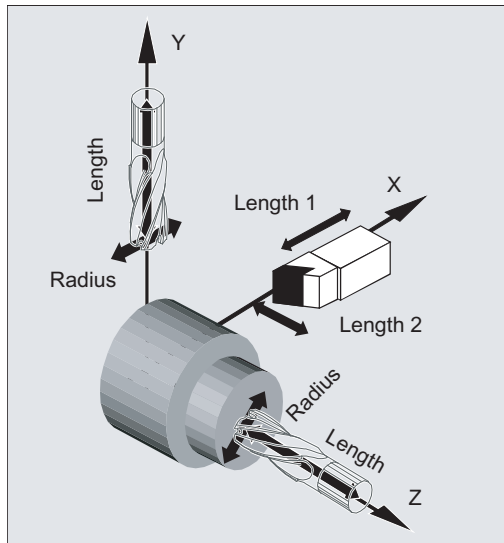
**Note**

On 2-axis machines, tool radius compensation is only possible in "real" planes, usually with G18.

**Tool length offset**

The wear parameter assigned to the diameter axis on tool selection can be defined as the diameter value using an MD. This assignment is not automatically altered when the plane is subsequently changed. To do this, the tool must be selected again after the plane has been changed.

Turning:



**NORM** and **KONT** can be used to define the tool path on activation and deactivation of compensation mode (see "Approaching and leaving contour (**NORM**, **KONT**, **KONTC**, **KONTT**) (Page 256)").

#### Point of intersection

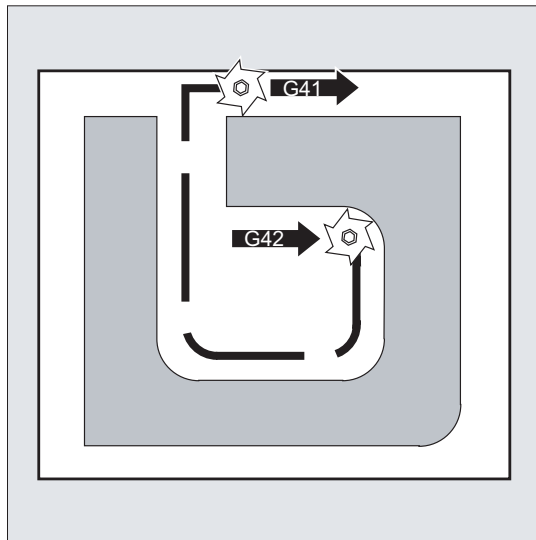
The intersection point is selected in the setting data:

SD42496 \$SC\_CUTCOM\_CLSD\_CONT (response of tool radius compensation with closed contour)

| Value | Meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FALSE | <p>If two intersections appear on the inside when offsetting a (virtually) closed contour, which consists of two circle blocks following on from one another, or from one circle block and one linear block, the intersection positioned closer to the end of block on the first partial contour is selected, in accordance with the standard procedure.</p> <p>A contour is deemed to be (virtually) closed if the distance between the starting point of the first block and the end point of the second block is less than 10% of the effective compensation radius, but not more than 1000 path increments (corresponds to 1 mm with 3 decimal places).</p> |
| TRUE  | In the same situation as described above, the intersection positioned on the first partial contour closer to the block start is selected.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

#### Change in compensation direction (G41 ↔ G42)

A change in compensation direction (G41 ↔ G42) can be programmed without an intermediate G40.



### Change in the working plane

The working plane (G17/G18/G19) **cannot** be changed if G41/G42 is active.

### Change in tool offset data set (D...)

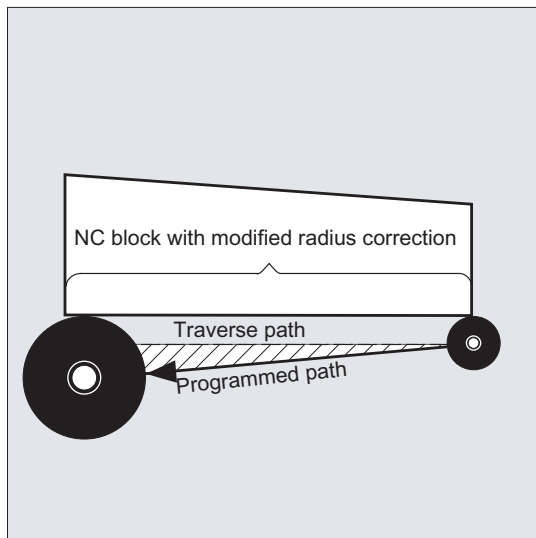
The tool offset data set can be changed in compensation mode.

A modified tool radius is active with effect from the block in which the new D number is programmed.

## Note

The radius change or compensation movement is performed across the entire block and only reaches the new equidistance at the programmed end point.

In the case of linear movements, the tool travels along an inclined path between the starting point and end point:



Circular interpolation produces spiral movements.

#### Changing the tool radius

The change can be made, e.g. using system variables. The sequence is the same as when changing the tool offset data set (D...).

#### Note

The modified values only take effect the next time T or D is programmed. The change only applies with effect from the next block.

#### Compensation mode

Compensation mode may only be interrupted by a certain number of consecutive blocks or M functions which do not contain drive commands or positional data in the compensation plane.

#### Note

The number of consecutive blocks or M commands can be set in a machine data item (see machine manufacturer's specifications).

#### Note

A block with a path distance of zero also counts as an interruption!

## 11.2 Approaching and leaving contour (NORM, KONT, KONTC, KONTT)

#### Requirement

The KONTC and KONTT commands will only be available if the "Polynomial interpolation" option has been enabled in the control.

#### Function

If tool radius compensation is active (G41/G42), the NORM, KONT, KONTC or KONTT command can be used to adapt the tool's approach and retract paths to the required contour profile or blank form.

KONTC or KONTT ensure observance of the continuity conditions in all three axes. It is, therefore, permissible to program a path component perpendicular to the offset plane simultaneously.

#### Syntax

|                                                     |  |
|-----------------------------------------------------|--|
| G41/G42 <b>NORM/KONT/KONTC/KONTT</b> X... Y... Z... |  |
| ...                                                 |  |
| G40 X... Y... Z...                                  |  |



## Meaning

|        |                                                                                                                                  |
|--------|----------------------------------------------------------------------------------------------------------------------------------|
| NORM:  | Activate direct approach/retraction to/from a straight line.<br>The tool is oriented perpendicular to the contour point.         |
| KONT:  | Activate approach/retraction with travel around the starting/end point according to the programmed corner behavior G450 or G451. |
| KONTC: | Activate approach/retraction with constant curvature.                                                                            |
| KONTT: | Activate approach/retraction with constant tangent.                                                                              |

### Note

Only G1 blocks are permissible as original approach/retraction blocks for KONTC and KONTT. The control replaces these with polynomials for the appropriate approach/retract path.

## Supplementary conditions

KONTT and KONTC are not available in 3D variants of tool radius compensation (CUT3DC, CUT3DCC, CUT3DF). If they are programmed, the control switches internally to NORM without an error message.

## Example

### KONTC

The full circle is approached beginning at the circle center point. The direction and curvature radius at the block end point of the approach block are identical to the values of the next circle. Infeed takes place in the Z direction in both approach/retraction blocks simultaneously. The figure below shows the perpendicular projection of the tool path.

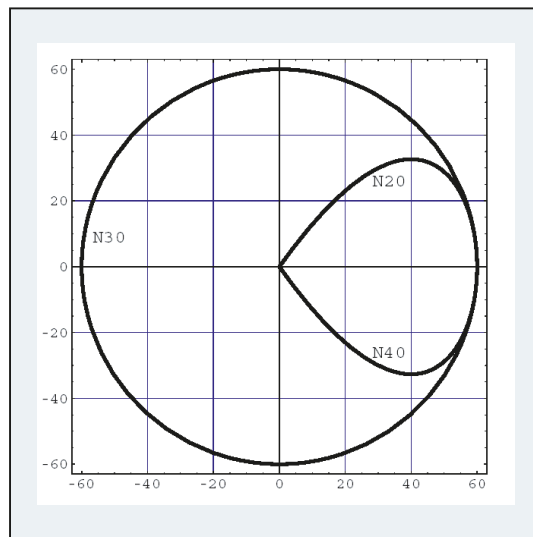


Figure 11-1 Perpendicular projection

The associated NC program segment is as follows:

| Program code                      | Comment        |
|-----------------------------------|----------------|
| \$TC_DP1[1,1]=121                 | ; Milling tool |
| \$TC_DP6[1,1]=10                  | ; Radius 10 mm |
| N10 G1 X0 Y0 Z60 G64 T1 D1 F10000 |                |
| N20 G41 KONTC X70 Y0 Z0           | ; Approach     |
| N30 G2 I-70                       | ; Full circle  |
| N40 G40 G1 X0 Y0 Z60              | ; Retract      |
| N50 M30                           |                |

At the same time as the curvature is being adapted to the circular path of the full circle, traversing is performed from Z60 to the plane of the circle Z0:

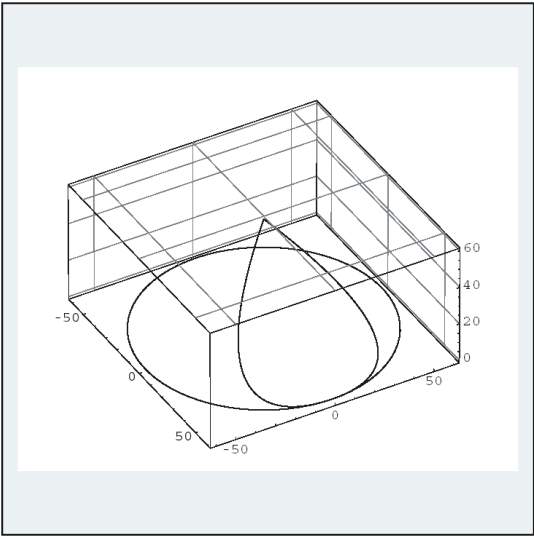


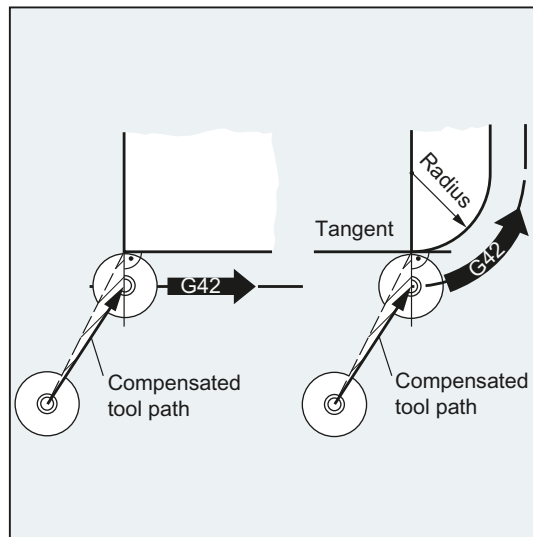
Figure 11-2 3D representation.

## Further information

### Approach/retraction with NORM

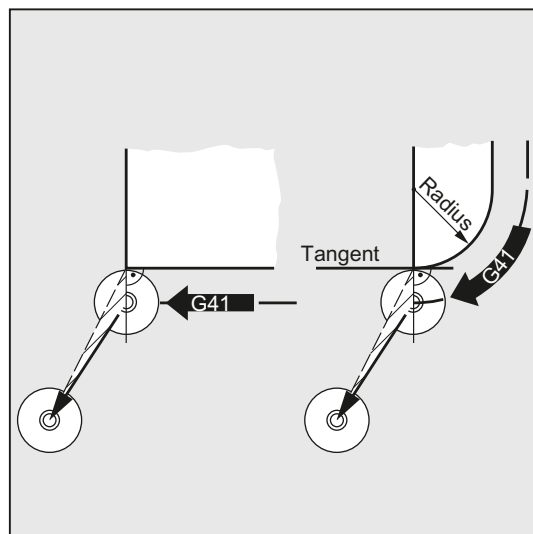
#### 1. Approach:

If **NORM** is activated, the tool will move directly to the compensated start position along a straight line (irrespective of the preset approach angle programmed for the travel movement) and is positioned perpendicular to the path tangent at the starting point.

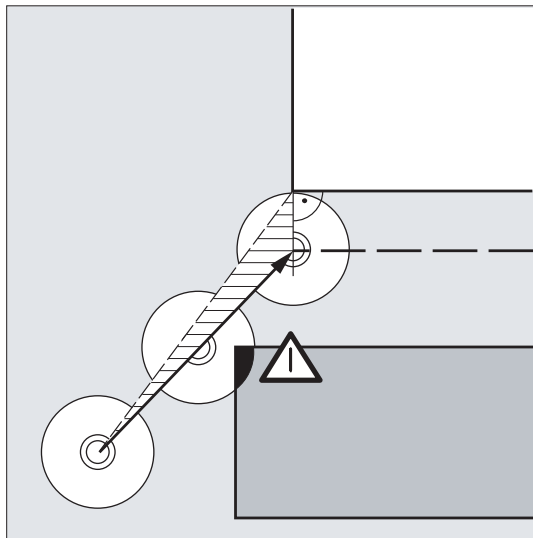


#### 2. Retraction:

The tool is perpendicular to the last compensated path end point and then moves (irrespective of the preset approach angle programmed for the travel movement) directly in a straight line to the next uncompensated position, e.g. to the tool change point.



Modifying approach/retract angles introduces a collision risk:



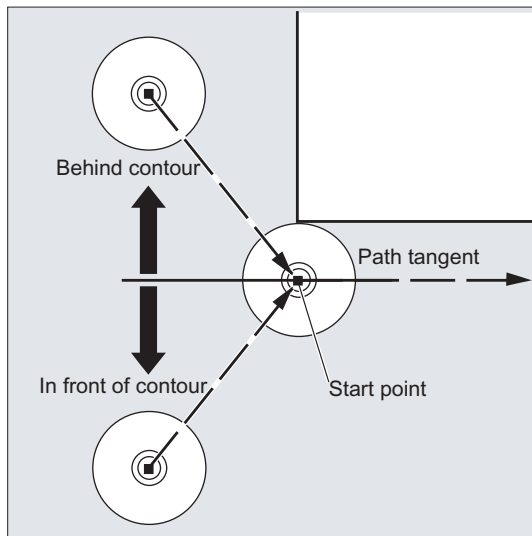
#### NOTICE

##### Risk of collision

Modified approach/retract angles must be taken into account during programming in order that potential collisions can be avoided.

#### Approach/retraction with KONT

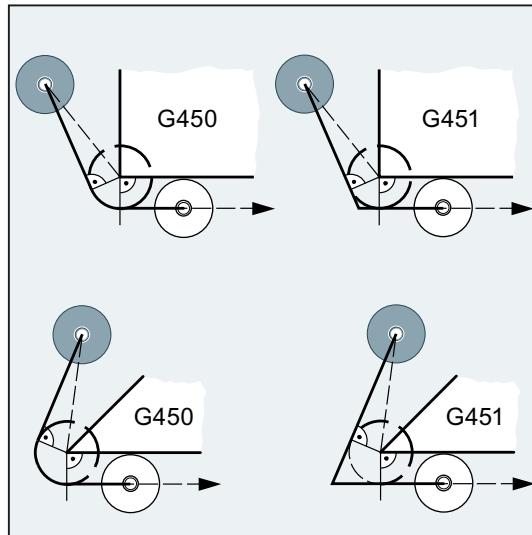
Prior to the approach, the tool can be located **in front of** or **behind** the contour. The path tangent at the starting point serves as a separation line:



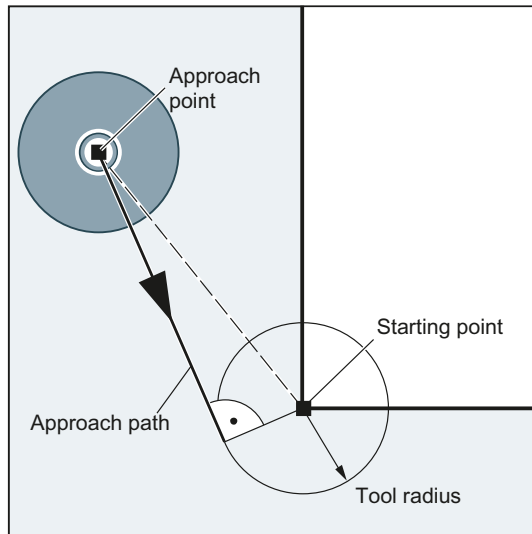
Accordingly, two scenarios need to be distinguished where approach/retraction with `KONT` is concerned:

1. The tool is located in front of the contour.  
→ The approach/retract strategy is the same as with `NORM`.
2. The tool is located behind the contour.

- Approach:  
The tool travels around the starting point either along a circular path or over the intersection of the equidistant paths depending on the programmed corner behavior (G450/G451).  
The commands G450/G451 apply to the transition from the current block to the next block:



In both cases (G450/G451), the following approach path is generated:



A straight line is drawn from the uncompensated approach point. This line is a tangent to a circle with circle radius = tool radius. The center point of the circle is on the starting point.

- Retraction:  
The same applies to retraction as to approach, but in the reverse order.

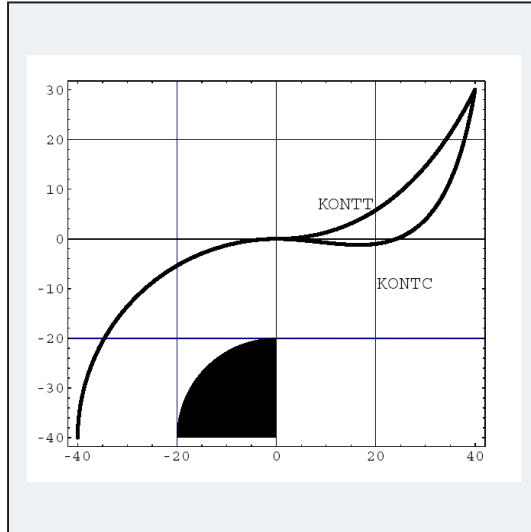
#### Approach/retraction with KONTC

## 11.2 Approaching and leaving contour (NORM, KONT, KONTC, KONTT)

The contour point is approached/exited with constant curvature. There is no jump in acceleration at the contour point. The path from the start point to the contour point is interpolated as a polynomial.

**Approach/retraction with KONTT**

The contour point is approached/exited with constant tangent. A jump in the acceleration can occur at the contour point. The path from the start point to the contour point is interpolated as a polynomial.

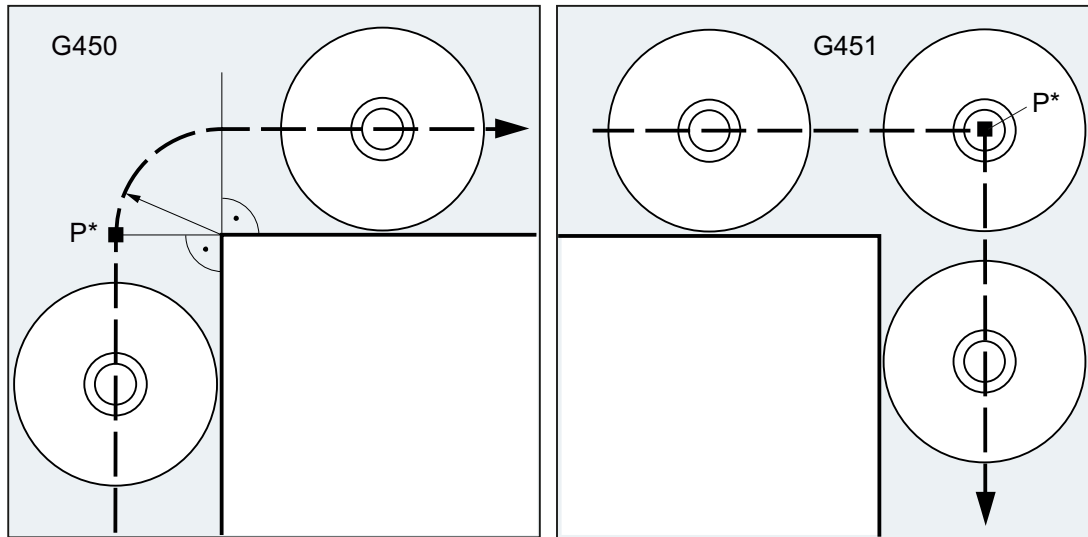
**Difference between KONTC and KONTT**

The figure below shows the differences in approach/retraction behavior between `KONTT` and `KONTC`. A circle with a radius of 20 mm about the center point at X0 Y-40 is compensated with a tool with an external radius of 20 mm. The tool center point therefore moves along a circular path with radius 40 mm. The end point of the approach blocks is at X40 Y30. The transition between the circular block and the retraction block is at the zero point. Due to the extended continuity of curvature associated with `KONTC`, the retraction block first executes a movement with a negative Y component. This will often be undesired. This response does not occur with the `KONTT` retraction block. However, with this block, an acceleration step change occurs at the block transition.

If the `KONTT` or `KONTC` block is the approach block rather than the retraction block, the contour is exactly the same, but it is machined in the opposite direction.

## 11.3 Compensation at the outside corners (G450, G451, DISC)

With tool radius compensation activated (G41/G42), command G450 or G451 can be used to define the course of the compensated tool path when traveling around outside corners:



With G450, the tool center point travels around the workpiece corner across an arc with tool radius.

With G451, the tool center point approaches the intersection of the two equidistants which lie in the distance between the tool radius and the programmed contour. G451 applies only to circles and straight lines.

### Note

G450/G451 is also used to define the approach path with KONT active and approach point behind the contour (see "Approaching and leaving contour (NORM, KONT, KONTC, KONTT) (Page 256)").

The DISC command can be used to distort the transition circles with G450, thereby producing sharper contour corners.

### Syntax

G450 [DISC=<value>]

G451



## 11.3 Compensation at the outside corners (G450, G451, DISC)

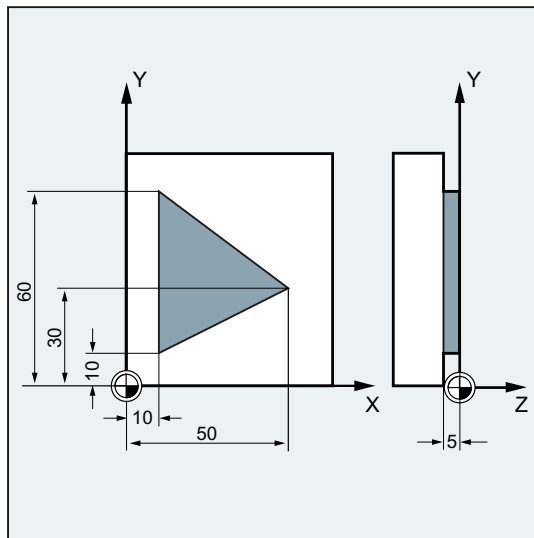
## Meaning

|       |                                                                                                                                                              |                  |                  |                                                           |  |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------|-----------------------------------------------------------|--|
| G450: | G450 is used to travel around workpiece corners on a circular path.                                                                                          |                  |                  |                                                           |  |
| DISC: | Flexible programming of the circular path with G450 (optional)                                                                                               |                  |                  |                                                           |  |
|       | <value>:                                                                                                                                                     | Type:            | INT              |                                                           |  |
|       |                                                                                                                                                              | Range of values: | 0, 1, 2, ... 100 |                                                           |  |
|       |                                                                                                                                                              | Meaning:         | 0                | Transition circle                                         |  |
|       |                                                                                                                                                              |                  | 100              | Intersection of the equidistant paths (theoretical value) |  |
| G451: | G451 is used to approach the intersection point of the two equidistant paths in the case of workpiece corners. The tool backs off from the workpiece corner. |                  |                  |                                                           |  |

## Note

DISC only applies with call of G450, but can be programmed in a previous block without G450. Both commands are modal.

## Example



In this example, a transition radius is programmed for all outside corners (corresponding to the programming of the corner behavior in block N30). This prevents the tool stopping and backing off at the change of direction.

| Program code                     | Comment                                                                                 |
|----------------------------------|-----------------------------------------------------------------------------------------|
| N10 G17 T1 G0 X35 Y0 Z0 F500     | ; Starting conditions.                                                                  |
| N20 G1 Z-5                       | ; Feed in tool.                                                                         |
| N30 G41 KONT <b>G450</b> X10 Y10 | ; <b>Activate</b> TRC with KONT approach/retract mode and <b>corner behavior G450</b> . |
| N40 Y60                          | ; Mill the contour.                                                                     |
| N50 X50 Y30                      |                                                                                         |
| N60 X10 Y10                      |                                                                                         |
| N80 G40 X-20 Y50                 | ; Deactivate compensation mode, retraction on transition circle.                        |

| Program code  | Comment |
|---------------|---------|
| N90 G0 Y100   |         |
| N100 X200 M30 |         |

## Further information

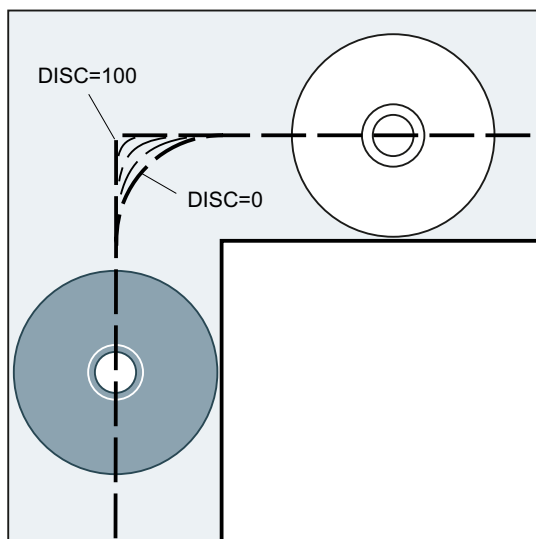
### G450/G451

At intermediate point P\*, the control executes operations such as infeed movements or switching functions. These operations are programmed in blocks inserted between the two blocks forming the corner.

With G450 the transition circle belongs to the next travel command with respect to the data.

### DISC

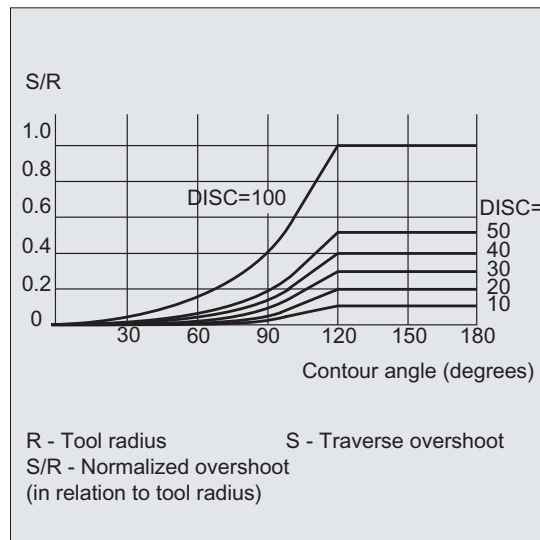
When DISC values greater than 0 are specified, intermediate circles are shown with a magnified height – the result is transition ellipses or parabolas or hyperbolas:



An upper limit can be defined in machine data – generally DISC=50.

### Traversing behavior

When G450 is activated and with acute contour angles and high DISC values, the tool is lifted off the contour at the corners. In the case of contour angles equal to or greater than 120°, there is uniform travel around the contour:

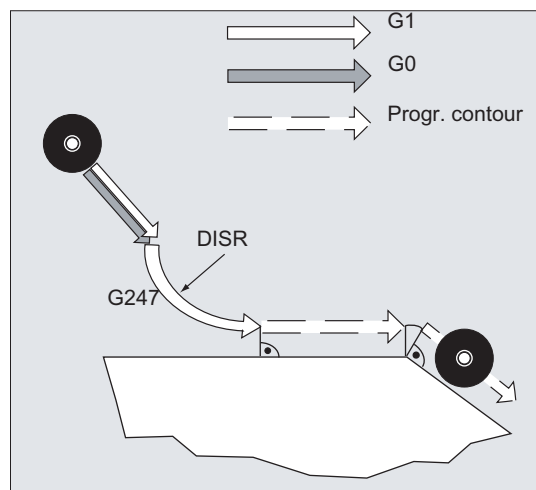


When G451 is activated and with acute contour angles, superfluous non-cutting tool paths can result from lift-off movements. A parameter can be used in the machine data to define automatic switchover to transition circle in such cases.

## 11.4 Smooth approach and retraction

### 11.4.1 Approach and retraction (G140 to G143, G147, G148, G247, G248, G347, G348, G340, G341, DISR, DISCL, DISRP, FAD, PM, PR)

The SAR (Smooth Approach and Retraction) function is used to achieve a tangential approach to the start point of a contour, regardless of the position of the start point.



This function is used preferably in conjunction with the tool radius compensation.

When the function is activated, the control calculates the intermediate points in such a way that the transition to the following block (or the transition from previous block during retraction) is performed in accordance with the specified parameters.

The approach movement consists of a maximum of four sub-movements. The starting point of the movement is called  $P_0$ , the end point  $P_4$  in the following. Up to three intermediate points  $P_1$ ,  $P_2$  and  $P_3$  can be between these points. Points  $P_0$ ,  $P_3$  and  $P_4$  are always defined. Intermediate points  $P_1$  and  $P_2$  can be omitted, according to the parameters defined and the geometrical conditions. On retraction, the points are traversed in the reverse direction, i.e. starting at  $P_4$  and ending at  $P_0$ .

## Syntax

### Smooth approach:

- With a straight line:  
G147 G340/G341 ... DISR=..., DISCL=..., DISRP=... FAD=...
- With a quadrant/semicircle:  
G247/G347 G340/G341 G140/G141/G142/G143 ... DISR=... DISCL=...  
DISRP=... FAD=...

### Smooth retraction:

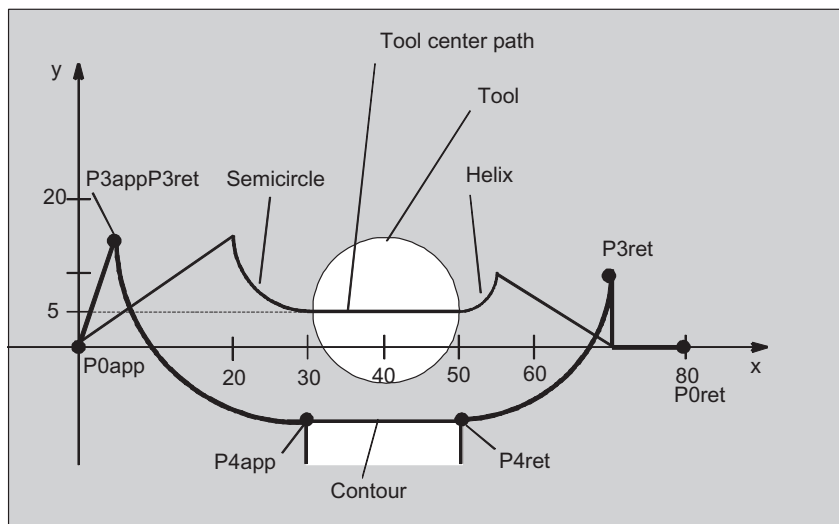
- With a straight line:  
G148 G340/G341 ... DISR=..., DISCL=..., DISRP=... FAD=...
- With a quadrant/semicircle:  
G248/G348 G340/G341 G140/G141/G142/G143 ... DISR=... DISCL=...  
DISRP=... FAD=...

## Meaning

|       |                                                                                                                         |
|-------|-------------------------------------------------------------------------------------------------------------------------|
| G147: | Approach with a straight line                                                                                           |
| G148: | Retraction with a straight line                                                                                         |
| G247: | Approach with a quadrant                                                                                                |
| G248: | Retraction with a quadrant                                                                                              |
| G347: | Approach with a semicircle                                                                                              |
| G348: | Retraction with a semicircle                                                                                            |
| G340: | Approach and retraction in space (default setting)                                                                      |
| G341: | Approach and retraction in the plane                                                                                    |
| G140: | Approach and retraction direction dependent on the current compensation side (default setting)                          |
| G141: | Approach from the left or retraction to the left                                                                        |
| G142: | Approach from the right or retraction to the right                                                                      |
| G143: | Approach and retraction direction dependent on the relative position of the start or end point to the tangent direction |

|                  |                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DISR=...:        | <ol style="list-style-type: none"> <li>For approach and retraction with straight lines (G147/G148):<br/>Distance of the cutter edge from the starting point of the contour</li> <li>For approach and retraction with circles (G247, G347/G248, G348):<br/>Radius of the tool center point path</li> </ol> <p><b>Notice:</b><br/>For REPOS with a semicircle, DISR is the circle diameter</p> |
| DISCL=...:       | Distance of the end point for the fast infeed motion from the machining plane<br>DISCL=AC( ... ) Specification of the absolute position of the end point for the fast infeed motion                                                                                                                                                                                                          |
| DISCL=AC( ... ): | Specification of the absolute position of the end point for the fast infeed motion                                                                                                                                                                                                                                                                                                           |
| DISRP:           | Distance of point P1 (retraction plane) from the machining plane                                                                                                                                                                                                                                                                                                                             |
| DISRP=AC( ... ): | Specification of the absolute position of point P1                                                                                                                                                                                                                                                                                                                                           |
| FAD=...:         | Speed of the slow feed movement<br>The programmed value acts in accordance with the active feedrate type (G function group 15).                                                                                                                                                                                                                                                              |
| FAD=PM( ... ):   | The programmed value is interpreted as linear feedrate (like G94) irrespective of the active feedrate type.                                                                                                                                                                                                                                                                                  |
| FAD=PR( ... ):   | The programmed value is interpreted as revolutionary feedrate (like G95) irrespective of the active feedrate type.                                                                                                                                                                                                                                                                           |

## Example



- Smooth approach (block N20 activated)
- Approach with quadrant (G247)
- Approach direction not programmed, G140 applies, i.e. TRC is active (G41)
- Contour offset OFFN=5 (N10)
- Current tool radius=10, and so the effective compensation radius for TRC=15, the radius of the SAR contour =25, with the result that the radius of the tool center path is equal to DISR=10

## 11.4 Smooth approach and retraction

- The end point of the circle is obtained from N30, since only the Z position is programmed in N20
  - Infeed movement
    - From Z20 to Z7 (DISCL=AC(7)) with rapid traverse.
    - Then to Z0 with FAD=200.
    - Approach circle in X-Y-plane and following blocks with F1500 (for this velocity to take effect in the following blocks, the active G0 in N30 must be overwritten with G1, otherwise the contour would be machined further with G0).
  - Smooth retraction (block N60 activated)
  - Retraction with quadrant (G248) and helix (G340)
  - FAD not programmed, since irrelevant for G340
  - Z=2 in the starting point; Z=8 in the end point, since DISCL=6
  - When DISR=5, the radius of the SAR contour=20, the radius of the tool center point path=5
- Retraction movements from Z8 to Z20 and the movement parallel to the X-Y plane to X70 Y0.

| Program code                                           | Comment                 |
|--------------------------------------------------------|-------------------------|
| \$TC_DP1[1,1]=120                                      | ; Tool definition T1/D1 |
| \$TC_DP6[1,1]=10                                       | ; Radius                |
| N10 G0 X0 Y0 Z20 G64 D1 T1 OFFN=5                      | ; (P0 app)              |
| N20 G41 G247 G341 Z0 DISCL=AC(7) DISR=10 F1500 FAD=200 | ; Approach (P3 app)     |
| N30 G1 X30 Y-10                                        | ; (P4 app)              |
| N40 X40 Z2                                             |                         |
| N50 X50                                                | ; (P4 ret)              |
| N60 G248 G340 X70 Y0 Z20 DISCL=6 DISR=5 G40 F10000     | ; Retraction (P3 ret)   |
| N70 X80 Y0                                             | ; (P0 ret)              |
| N80 M30                                                |                         |

## Further information

## Selecting the approach and retraction contour

The approach and retraction contour are selected with the appropriate G function from the 2nd G function group:

|       |                                 |
|-------|---------------------------------|
| G147: | Approach with a straight line   |
| G247: | Approach with a quadrant        |
| G347: | Approach with a semicircle      |
| G148: | Retraction with a straight line |
| G248: | Retraction with a quadrant      |
| G348: | Retraction with a semicircle    |

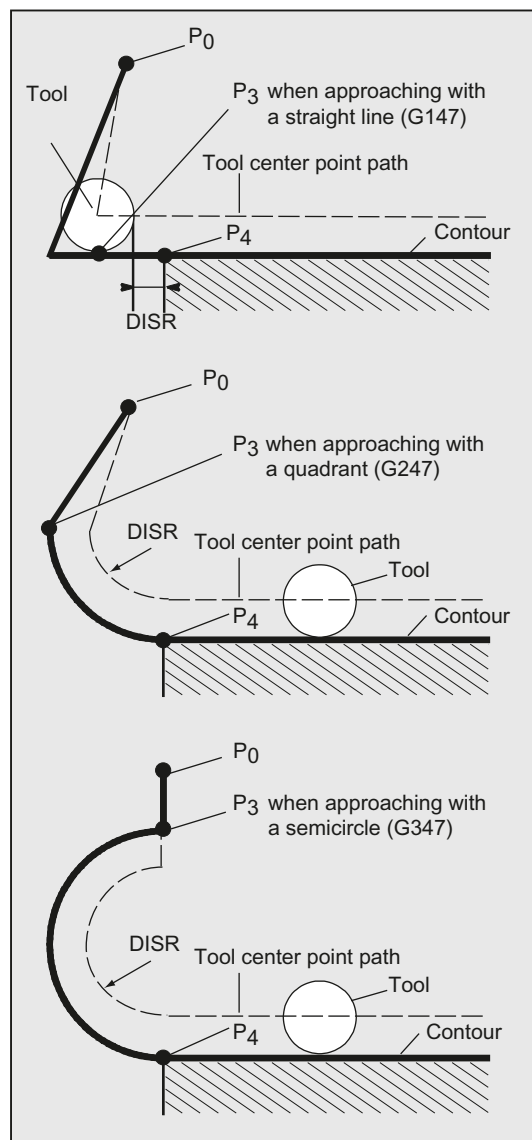


Figure 11-3 Approach movements with simultaneous activation of the tool radius compensation

### Selecting the approach and retraction direction

Use the tool radius compensation (G140, default setting) to determine the approach and retraction direction with positive tool radius:

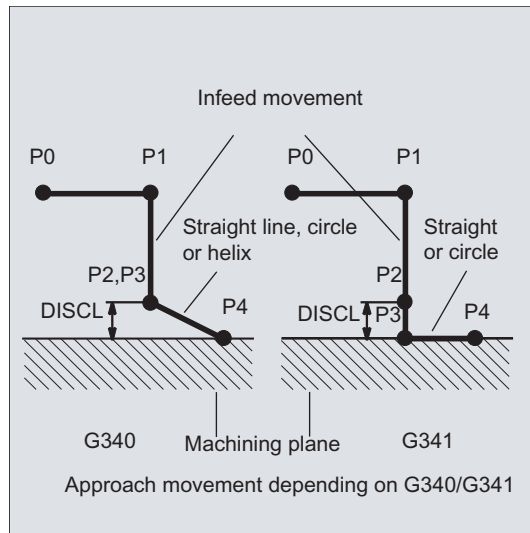
- G41 active → approach from left
- G42 active → approach from right

G141, G142 and G143 provide further approach options.

The G codes are only significant when the approach contour is a quadrant or a semicircle.

**Motion steps between start point and end point (G340 and G341).**

In all cases, the movements are made up of one or more straight lines and, depending on the G function for determining the approach contour, an additional straight line or a quadrant or semicircle. The two variants of the path segmentation are shown in the following figure:



|       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G340: | <p>Approach with a straight line from point <math>P_0</math> to point <math>P_1</math>. This straight line is parallel to the machining plane, if parameter DISRP has not been programmed.</p> <p>Infeed perpendicular to the machining plane from point <math>P_1</math> to point <math>P_3</math> to the safety clearance to the machining plane defined by the DISCL parameter.</p> <p>Approach to end point <math>P_4</math> with the curve determined by the G function of the second group (straight line, circle, helix). If G247 or G347 is active (quadrant or semicircle) and start point <math>P_3</math> is outside the machining plane defined by the end point <math>P_4</math>, a helix is inserted instead of a circle. Point <math>P_2</math> is not defined or coincides with <math>P_3</math>.</p> <p>The circle plane or the helix axis is determined by the plane, which is active in the SAR block (G17/G18/G19), i.e. the projection of the start tangent is used by the following block, instead of the tangent itself, to define the circle.</p> <p>The movement from point <math>P_0</math> to point <math>P_3</math> takes place along two straight lines at the velocity valid before the SAR block.</p> |
| G341: | <p>Approach with a straight line from point <math>P_0</math> to point <math>P_1</math>. This straight line is parallel to the machining plane, if parameter DISRP has not been programmed.</p> <p>Infeed perpendicular to the machining plane from point <math>P_1</math> up to the safety clearance to the machining plane defined by the DISCL parameter in point <math>P_2</math>.</p> <p>Infeed perpendicular to the machining plane from point <math>P_2</math> to point <math>P_3</math>. Approach to end point with the curve determined by the G function of the second group. <math>P_3</math> and <math>P_4</math> are located within the machining plane, with the result that a circle is always inserted instead of a helix with G247 or G347.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

In all cases that include the position of the active plane G17/G18/G19 (circular plane, helical axis, infeed motion perpendicular to the active plane), any active rotating frame is taken into account.



**Length of the approach straight line or radius for approach circles (DISR)**

- Approach/retract with straight lines

DISR specifies the distance of the cutter edge from the starting point of the contour, i.e. the length of the straight line when TRC is active is the sum of the tool radius and the programmed value of DISR. The tool radius is only taken into account when it is positive. The resulting straight line length must be positive, i.e. negative values for DISR are allowed provided that the absolute value of DISR is less than the tool radius.

- Approach/retract with circles

DISR specifies the radius of the tool center point path. If TRC is activated, a circle is produced with a radius that results in the tool center point path with the programmed radius.

**Distance of point P2 from the machining plane (DISCL)**

If the position of point  $P_2$  is to be specified by an absolute reference on the axis perpendicular to the circle plane, the value must be programmed in the form `DISCL=AC ( . . . )`.

The following applies for `DISCL=0`:

- With G340: The whole of the approach motion now only consists of two blocks ( $P_1$ ,  $P_2$  and  $P_3$  are combined). The approach contour is formed by  $P_1$  to  $P_4$ .
- With G341: The whole approach contour consists of three blocks ( $P_2$  and  $P_3$  are combined). If  $P_0$  and  $P_4$  are on the same plane, only two blocks result (infeed movement from  $P_1$  to  $P_3$  is omitted).
- The point defined by DISCL is monitored to ensure that it is located between  $P_1$  and  $P_3$ , i.e. the sign must be identical for the component perpendicular to the machining plane in all motions that possess such a component.
- On detection of a reversal of direction, a tolerance defined by the machine data MD20204 `$MC_SAR_CLEARANCE_TOLERANCE` is permitted.

**Distance of point P1 (retraction plane) from the machining plane (DISRP)**

If the position of point  $P_1$  is to be specified by an absolute reference on the axis perpendicular to the machining plane, the value must be programmed in the form `DISRP=AC ( . . . )`.

If this parameter is not programmed, point  $P_1$  has the same distance to the machining plane as point  $P_0$ , i.e. the approach straight line  $P_0 \rightarrow P_1$  is parallel to the machining plane.

The system checks that the point defined by DISRP lies between  $P_0$  and  $P_2$ , i.e. in all movements that have a component perpendicular to the machining plane (e.g. infeed movements, approach movements from  $P_3$  to  $P_4$ ), this component must have the same leading sign. It is not permitted to change direction. An alarm is output if this condition is violated.

On detection of a reversal of direction, a tolerance defined by the machine data MD20204 `$MC_SAR_CLEARANCE_TOLERANCE` is permitted. However, if  $P_1$  is outside the range defined by  $P_0$  and  $P_2$ , but the deviation is less than or equal to this tolerance, it is assumed that  $P_1$  is in the plane defined by  $P_0$  or  $P_2$ .

**Programming of the end point**

The end point is generally programmed with X... Y... Z...

The programming of the contour end point when approaching differs greatly from that for retraction. Both cases are therefore treated separately here.

**Programming of end point P4 for approach**

End point  $P_4$  can be programmed in the actual SAR block. Alternatively,  $P_4$  can be determined by the end point of the next traversing block. More blocks can be inserted between an SAR block and the next traversing block without moving the geometry axes.

Example:

| Program code                           | Comment                |
|----------------------------------------|------------------------|
| \$TC_DP1[1,1]=120                      | ;Milling tool T1/D1    |
| \$TC_DP6[1,1]=7                        | ;Tool with 7 mm radius |
| N10 G90 G0 X0 Y0 Z30 D1 T1             |                        |
| N20 X10                                |                        |
| N30 G41 G147 DISCL=3 DISR=13 Z=0 F1000 |                        |
| N40 G1 X40 Y-10                        |                        |
| N50 G1 X50                             |                        |
| ...                                    |                        |

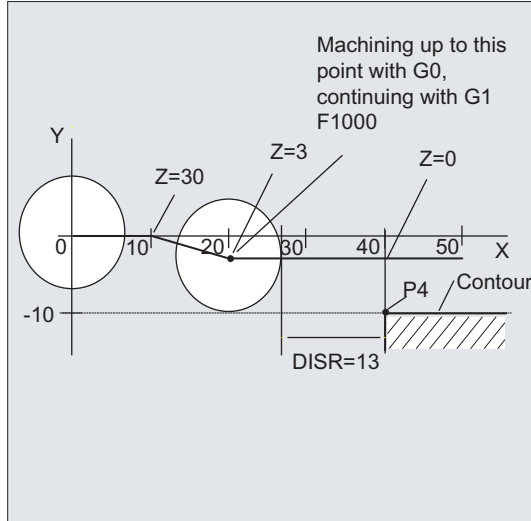
N30/N40 can be replaced by:

N30 G41 G147 DISCL=3 DISR=13 X40 Y-10 Z0 F1000

or

N30 G41 G147 DISCL=3 DISR=13 F1000

N40 G1 X40 Y-10 Z0

**Programming of end point P0 for retraction**

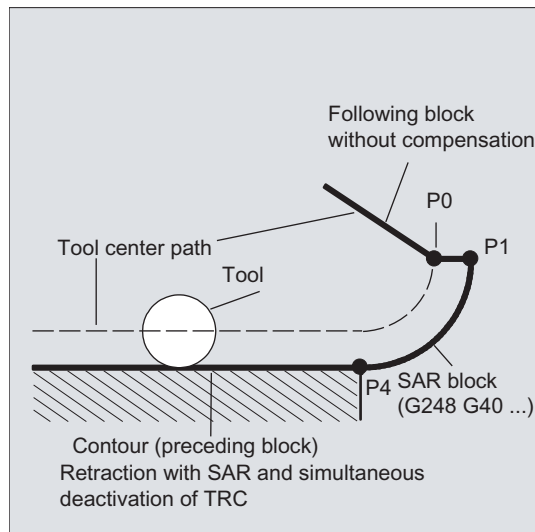
For retraction, the end point of the SAR contour cannot be programmed in a following block, i.e. the end position is always taken from the SAR block, irrespective of how many axes have

been programmed. When determining the end point, a distinction is made between the following three cases:

1. No geometry axis is programmed in the SAR block. In this case, the contour ends at point  $P_1$  (if DISRP has been programmed), at point  $P_2$  (if DISCL, but not DISRP has been programmed) or point  $P_3$  (if neither DISCL nor DISRP has been programmed). The position in the axes, which describe the machining plane, is determined by the retraction contour (end point of the straight line or arc). The axis component perpendicular to this is defined by DISCL or DISPR. If in this case both DISCL=0 and DISRP=0, the motion is completely in the plane, i.e. points  $P_0$  to  $P_3$  coincide.
2. Only the axis perpendicular to the machining plane is programmed in the SAR block. In this case, the contour ends at point  $P_0$ . If DISRP has been programmed (i.e. points  $P_0$  and  $P_1$  do not coincide), the straight line  $P_1 \rightarrow P_0$  is perpendicular to the machining plane. The positions of the two other axes are determined in the same way as in 1.
3. At least one axis of the machining plane is programmed. The second axis of the machining plane can be determined modally from its last position in the preceding block.

The position of the axis perpendicular to the machining plane is generated as described in 1. or 2., depending on whether this axis is programmed or not. The position generated in this way defines the end point  $P_0$ . If the SAR retraction block is also used to deactivate the tool radius compensation, in the first two cases, an additional path component is inserted in the machining plane from  $P_1$  to  $P_0$  so that no movement is produced when the tool radius compensation is deactivated at the end of the retraction contour, i.e. this point defines the tool center point and not a position on a contour to be corrected. In case 3, no special measures are required for deselection of the tool radius compensation, because the programmed point  $P_0$  already directly defines the position of the tool center point at the end of the complete contour.

The behavior in cases 1 and 2, i.e. when an end point is not explicitly programmed in the machining plane with simultaneous deselection of the tool radius compensation, is shown in the following figure:

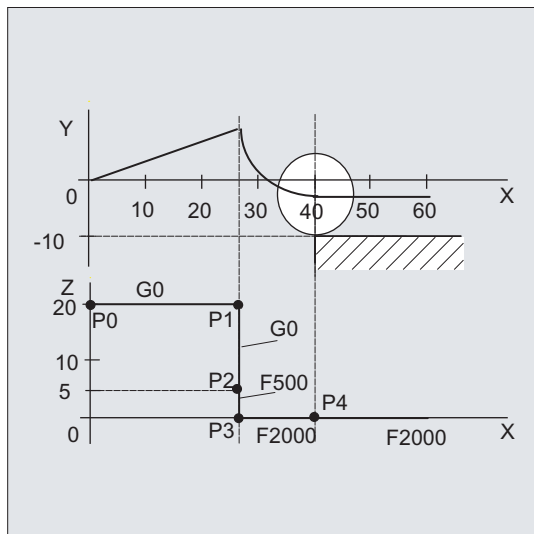


**Approach and retraction velocities**

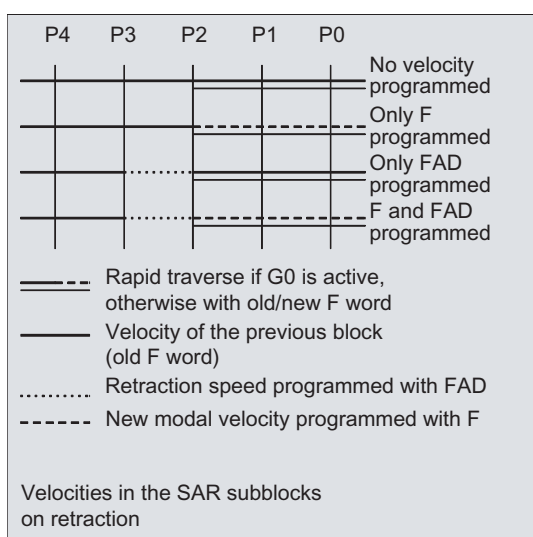
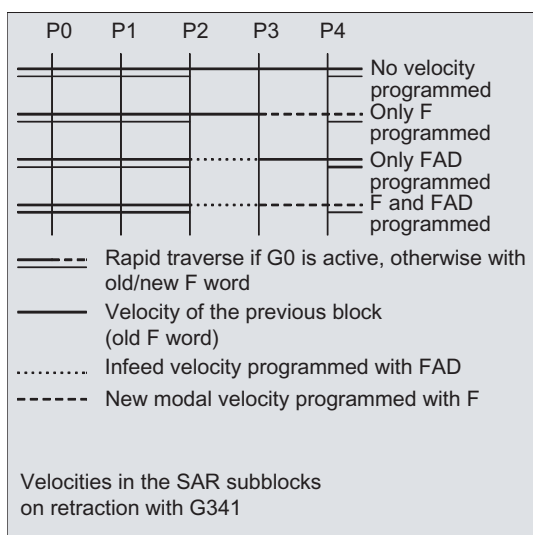
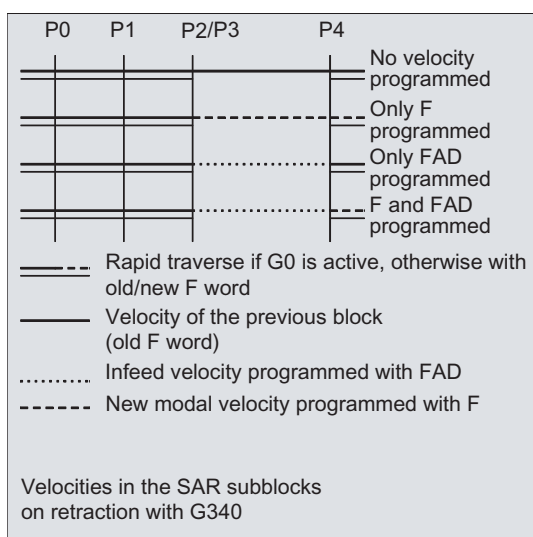
- Velocity of the previous block (G0)  
All motions from  $P_0$  up to  $P_2$  are executed at this velocity, i.e. the motion parallel to the machining plane and the part of the infeed motion up to the safety clearance.
- Programming with FAD  
Specification of the feedrate for
  - G341: Infeed movement perpendicular to the machining plane from  $P_2$  to  $P_3$
  - G340: From point  $P_2$  or  $P_3$  to  $P_4$ .  
If FAD is not programmed, this part of the contour is traversed at the speed which is active modally from the preceding block, in the event that no F command defining the speed is programmed in the SAR block.
- Programmed feedrate F  
This feedrate value is effective as of  $P_3$  or  $P_2$  if FAD is not programmed. If no F word is programmed in the SAR block, the speed of the previous block is active.

Example:

| Program code                                                    | Comment                |
|-----------------------------------------------------------------|------------------------|
| \$TC_DP1[1,1]=120                                               | ;Milling tool T1/D1    |
| \$TC_DP6[1,1]=7                                                 | ;Tool with 7 mm radius |
| N10 G90 G0 X0 Y0 Z20 D1 T1                                      |                        |
| N20 G41 G341 G247 DISCL=AC(5) DISR=13 FAD 500 X40 Y-10 Z=0 F200 |                        |
| N30 X50                                                         |                        |
| N40 X60                                                         |                        |
| ...                                                             |                        |



During retraction, the roles of the modally active feedrate from the previous block and the programmed feedrate value in the SAR block are reversed, i.e. the actual retraction contour is traversed with the old feedrate and a new speed programmed with the F word applies from  $P_2$  up to  $P_0$ .



**Reading positions**

Points  $P_3$  and  $P_4$  can be read in the WCS as a system variable during approach.

- \$P\_APR: reading P
- $_3$  (initial point)
- \$P\_AEP: reading P
- $_4$  (contour starting point)
- \$P\_APDV: read whether \$P\_APR and \$P\_AEP contain valid data

**11.4.2 Approach and retraction with extended retraction strategies (G460, G461, G462)**

In certain special geometrical situations, special extended approach and retraction strategies, compared with the previous implementation with activated collision detection for the approach and retraction block, are required in order to activate or deactivate tool radius compensation. A collision detection can result, for example, in a section of the contour not being completely machined, see following figure:

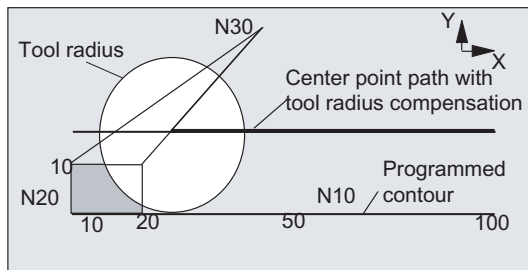


Figure 11-4 Retraction behavior with G460

**Syntax**

G460

G461

G462

**Meaning**

|       |                                                                                                                                                                                                                                                                                                                                                                        |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G460: | As previously (activation of the collision detection for the approach and retraction block).                                                                                                                                                                                                                                                                           |
| G461: | <p>Insertion of a circle in the TRC block, if it is not possible to have an intersection whose center point is in the end point of the uncorrected block, and whose radius is the same as the tool radius.</p> <p>Up to the intersection, machining is performed with an <b>auxiliary circle</b> around the contour end point (i.e. up to the end of the contour).</p> |
| G462: | <p>Insertion of a circle in the TRC block, if it is not possible to have an intersection; the block is extended by its end tangent (default setting).</p> <p>Machining is performed up to the <b>extension</b> of the last contour element (i.e. until shortly before the end of the contour).</p>                                                                     |

**Note**

The approach behavior is symmetrical to the retraction behavior.

The approach/retraction behavior is determined by the state of the G command in the approach/retraction block. The approach behavior can therefore be set independently of the retraction behavior.

**Examples****Example 1: Retraction behavior with G460**

The following example describes only the situation for deactivation of tool radius compensation: The behavior for approach is exactly the same.

| Program code    | Comment             |
|-----------------|---------------------|
| G42 D1 T1       | ; Tool radius 20 mm |
| ...             |                     |
| G1 X110 Y0      |                     |
| N10 X0          |                     |
| N20 Y10         |                     |
| N30 G40 X50 Y50 |                     |

**Example 2: Approach with G461**

| Program code           | Comment             |
|------------------------|---------------------|
| N10 \$TC_DP1[1,1]=120  | ; Milling tool type |
| N20 \$TC_DP6[1,1]=10   | ; Tool radius       |
| N30 X0 Y0 F10000 T1 D1 |                     |
| N40 Y20                |                     |
| N50 G42 X50 Y5 G461    |                     |
| N60 Y0 F600            |                     |
| N70 X30                |                     |
| N80 X20 Y-5            |                     |
| N90 X0 Y0 G40          |                     |
| N100 M30               |                     |

**Further information****G461**

If no intersection is possible between the last TRC block and a preceding block, the offset curve of this block is extended with a circle whose center point lies at the end point of the uncorrected block and whose radius is equal to the tool radius.

The control attempts to cut this circle with one of the preceding blocks.

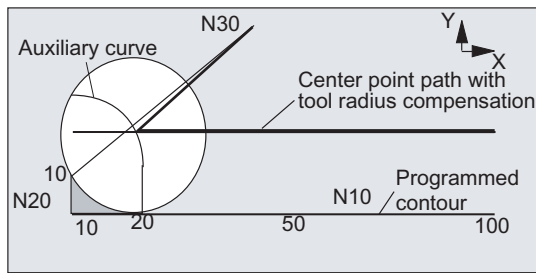


Figure 11-5 Retraction behavior with G461

#### Collision monitoring CDON, CDOF

If CDOF is active (see section Collision monitoring, CDON, CDOF), the search is aborted when an intersection is found, i.e., the system does not check whether further intersections with previous blocks exist.

If CDON is active, the search continues for further intersections after the first intersection is found.

An intersection point, which is found in this way, is the new end point of a preceding block and the start point of the deactivation block. The inserted circle is used exclusively to calculate the intersection and does not produce a traversing movement.

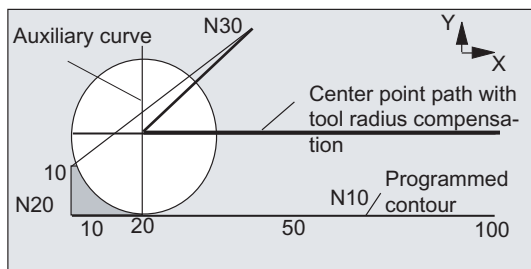
#### Note

If no intersection is found, alarm 10751 (collision danger) is output.

#### G462

If no intersection is possible between the last TRC block and a preceding block, a straight line is inserted, on retraction with G462 (initial setting), at the end point of the last block with tool radius compensation (the block is extended by its end tangent).

The search for the intersection is then identical to the procedure for G461.



Retraction behavior with G462 (see example)

With G462, the corner generated by N10 and N20 in the example program is not machined to the full extent actually possible with the tool used. However, this behavior may be necessary if the part contour (as distinct from the programmed contour), to the left of N20 in the example, is not permitted to be violated even with y values greater than 10 mm.

#### Corner behavior with KONT



If KONT is active (travel round contour at start or end point), the behavior differs according to whether the end point is in front of or behind the contour.

- **End point in front of contour**

If the end point is in front of the contour, the retraction behavior is the same as with NORM. This property does not change even if the last contour block for G451 is extended with a straight line or a circle. Additional circumnavigation strategies to avoid a contour violation in the vicinity of the contour end point are therefore not required.

- **End point behind contour**

If the end point is behind the contour, a circle or straight line is always inserted depending on G450/G451. In this case, G460-462 has no effect. If the last traversing block in this situation has no intersection with a preceding block, an intersection with the inserted contour element or with the straight line of the end point of the bypass circle to the programmed endpoint can result.

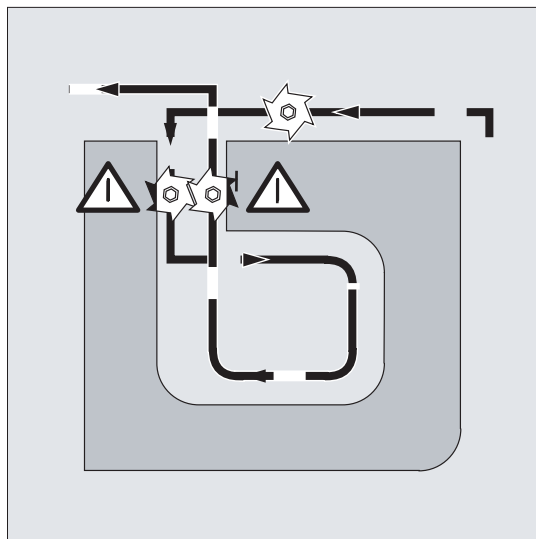
If the inserted contour element is a circle (G450), and this forms an interface with the preceding block, this is equal to the interface that would occur with NORM and G461. In general, however, a remaining section of the circle still has to be traversed. For the linear part of the retraction block, no further calculation of intersection is required.

In the second case, if no interface of the inserted contour element with the preceding blocks is found, the intersection between the retraction straight line and a preceding block is traversed.

Therefore, a behavior that deviates from G460 can only occur with active G461 or G462 either if NORM is active or the behavior with KONT is geometrically identical to that with NORM.

## 11.5 Collision detection (CDON, CDOF, CDOF2)

With the collision detection and active tool radius compensation, the tool paths are monitored through look-ahead contour calculation. This look-ahead function allows possible collisions to be detected in advance and permits the control to actively avoid them.



Collision detection can be activated or deactivated in the NC program.

## Syntax

CDON  
CDOF  
CDOF2

## Meaning

|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CDON:  | Command for the <b>activation</b> of the collision detection.                                                                                                                                                                                                                                                                                                                                                                                                                          |
| CDOF:  | Command for the <b>deactivation</b> of the collision detection.<br><br>With deactivated collision detection, a search is made in the <b>previous</b> traversing block (at inside corners) for a common intersection for the current block; if necessary the search is extended to even earlier blocks.<br><br><b>Note:</b><br>CDOF can be used to avoid the faulty detection of bottlenecks, resulting, for example, from missing information that is not available in the NC program. |
| CDOF2: | Command for the <b>deactivation</b> of the collision detection <b>during 3D circumferential milling</b> .<br><br>The tool offset direction is determined from adjacent block parts with CDOF2. CDOF2 is only effective for 3D circumferential milling and has the same meaning as CDOF for all other types of machining (e.g. 3D face milling).                                                                                                                                        |

## Note

The number of NC blocks that are included in the collision detection, can be set via machine data.

## Example

## Milling on the center point path with standard tool

The NC program describes the center point path of a standard tool. The contour for a tool that is actually used results in undersize, which is shown unrealistically large to demonstrate the geometric relationships in the following figure. The control also only has an overview of three blocks in the example.

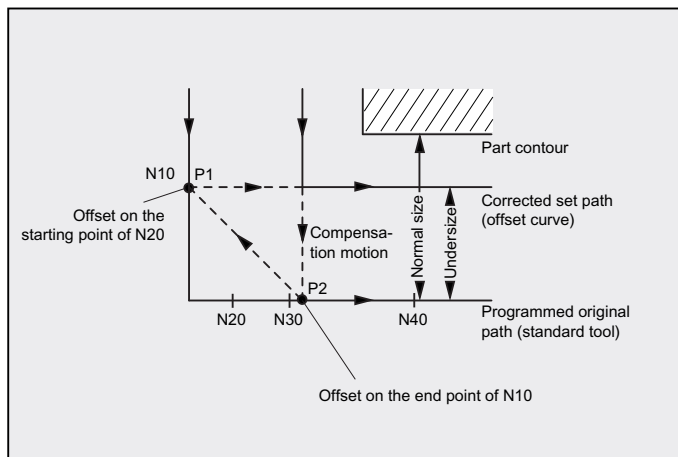


Figure 11-6 Compensation motion for missing intersection

Since an intersection exists only between the offset curves of the two blocks N10 and N40, the two blocks N20 and N30 would have to be omitted. In the example, the control does not know in block N40 if N10 has to be completely processed. Only a single block can therefore be omitted.

With active CDOF2, the compensation motion shown in the figure is executed and not stopped. In this situation, an active CDOF or CDON would result in an alarm.

## Further information

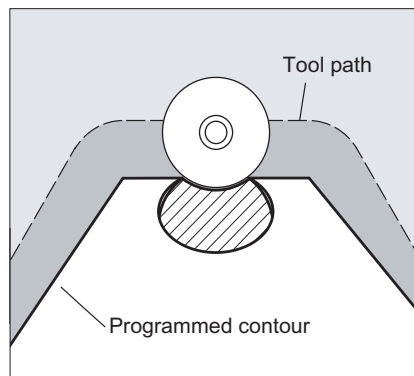
### Program test

To avoid program stops, the tool with the largest radius from the range of used tools should always be used during the program test.

### Examples of compensation motions for critical machining situations

The following examples show critical machining situations that are detected by the control and compensated through modified tool paths. In all examples, a tool with too large a radius has been used for the machining of the contour.

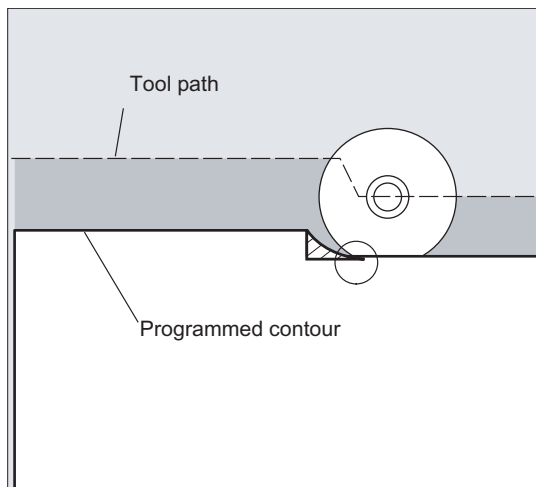
#### Example 1: Bottleneck detection



As the tool radius selected for the machining of this inside contour is too large, the "bottleneck" is bypassed.

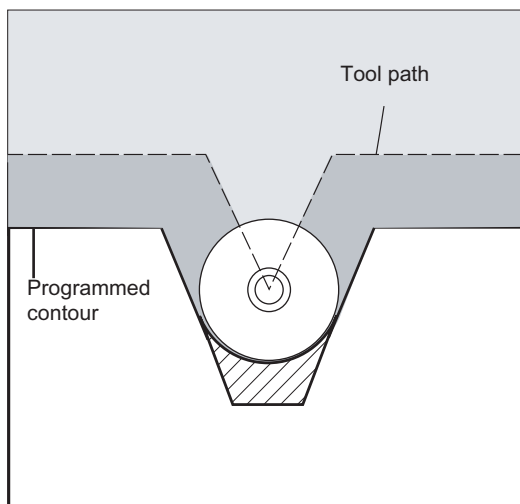
An alarm is output.

### Example 2: Contour path shorter than tool radius



The tool bypasses the workpiece corner on a transition circle, then continues on the programmed path.

### Example 3: Tool radius too large for internal machining



In such cases, the contours are machined only as much as is possible without causing a contour violation.

### References

Function Manual, Basic Functions; Tool Offset (W1), Section: "Collision detection and bottleneck detection"

## 11.6 2D tool compensation (CUT2D, CUT2DF)

With CUT2D or CUT2DF you define how the tool radius compensation is to act or to be interpreted when machining in inclined planes.

**Tool length compensation**

The tool length compensation generally always refers to the fixed, non-rotated working plane.

**2D tool radius compensation with contour tools**

The tool radius compensation for contour tools is used for automatic cutting-edge selection in the case of non-axially symmetrical tools that can be used for piece-by-piece machining of individual contour segments.

**Syntax**

CUT2D

CUT2DF

2D tool radius compensation for contour tools is activated if either of the two machining directions G41 or G42 is programmed with CUT2D or CUT2DF.

**Note**

If tool radius compensation is not activated, a contour tool will behave like a standard tool with only the first cutting edge.

**Meaning**

|         |                                                                                                                    |
|---------|--------------------------------------------------------------------------------------------------------------------|
| CUT2D:  | Activate 2 1/2 D radius compensation (default)                                                                     |
| CUT2DF: | Activate 2 1/2 D radius compensation, tool radius compensation relative to the current frame or to inclined planes |

CUT2D is used when the orientation of the tool cannot be changed and the workpiece is rotated for machining on inclined surfaces.

CUT2D is generally the standard setting and does not, therefore, have to be specified explicitly.

**Cutting-edge selection with contour tools**

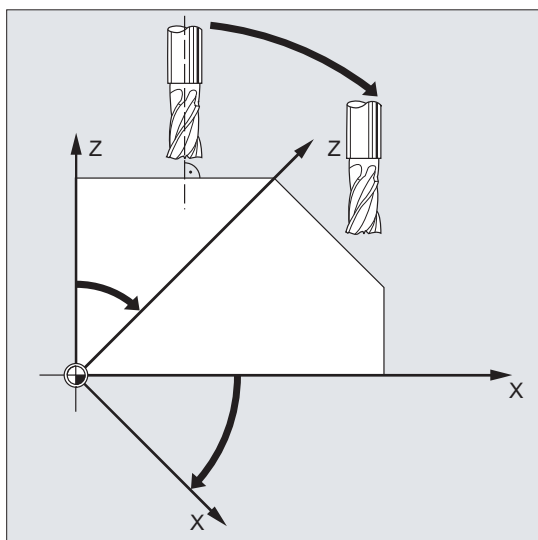
Up to a maximum of twelve cutting edges can be assigned to each contour tool in any order.

**Machine manufacturer**

The valid tool types for non-axially symmetrical tools and the maximum number of cutting edges ( $D_n = D1$  to  $D12$ ) are defined by the machine manufacturer via machine data. Please contact the machine manufacturer if not all of the 12 cutting edges are available.

**Further information****Tool radius compensation, CUT2D**

As for many applications, tool length compensation and tool radius compensation are calculated in the **fixed** working plane specified with G17 to G19.



Example of G17 (X/Y plane):

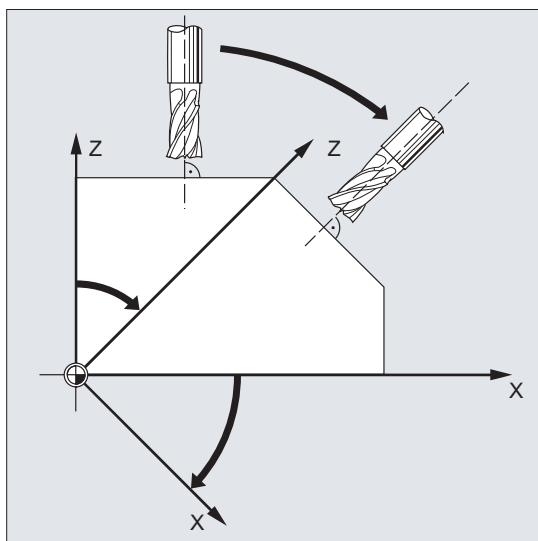
Tool radius compensation is active in the non-rotated X/Y plane, tool length compensation in the Z direction.

Tool offset values

For machining on inclined surfaces, the tool offset values have to be defined accordingly, or be calculated using the functions for "Tool length compensation for orientable tools". For more information on this calculation method, see Section "Tool orientation and tool length compensation".

#### Tool radius compensation, CUT2DF

In this case, it is possible to arrange the tool orientation perpendicular to the inclined working plane on the machine.



---

**11.7 Keep tool radius compensation constant (CUTCONON, CUTCONOF)**

If a frame containing a rotation is programmed, the compensation plane is also rotated with CUT2DF. The tool radius compensation is calculated in the rotated machining plane.

**Note**

The tool length compensation continues to be active relative to the non-rotated working plane.

**Definition of contour tools, CUT2D, CUT2DF**

A contour tool is defined by the number of cutting edges (on the basis of D nos) associated with a T no. The first cutting edge of a contour tool is the cutting edge that is selected when the tool is activated. If, for example, D5 is activated on T3 D5, then it is this cutting edge and the subsequent cutting edges that define the contour tool either partially or as a whole. The previous cutting edges will be ignored.

**References**

Function Manual, Basic Functions; Tool Offset (W1)

**11.7 Keep tool radius compensation constant (CUTCONON, CUTCONOF)**

The "Keep tool radius compensation constant" function is used to suppress tool radius compensation for a number of blocks, whereby a difference between the programmed and the actual tool center path traveled set up by tool radius compensation in the previous blocks is retained as the compensation. It can be an advantage to use this method when several traversing blocks are required during line milling in the reversal points, but the contours produced by the tool radius compensation (follow strategies) are not wanted. It can be used independently of the type of tool radius compensation ( $2\frac{1}{2}D$ , 3D face milling, 3D circumferential milling).

**Syntax**

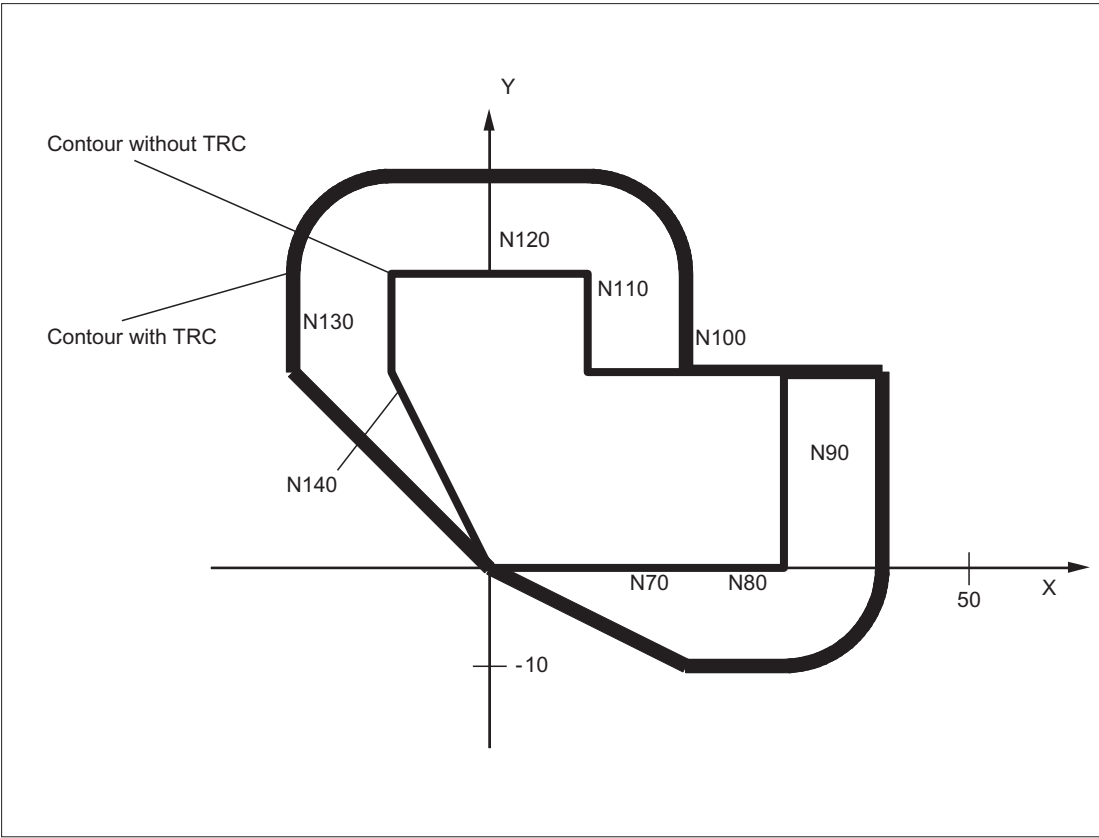
CUTCONON

CUTCONOF

**Meaning**

|           |                                                                             |
|-----------|-----------------------------------------------------------------------------|
| CUTCONON: | Command to activate the "Keep tool radius compensation constant" function   |
| CUTCONOF: | Command to deactivate the "Keep tool radius compensation constant" function |

Example



| Program code                     | Comment                                                                             |
|----------------------------------|-------------------------------------------------------------------------------------|
| N10                              | ; Definition of tool d1.                                                            |
| N20 \$TC_DP1[1,1] = 110          | ; Type                                                                              |
| N30 \$TC_DP6[1,1]= 10.           | ; Radius                                                                            |
| N40                              |                                                                                     |
| N50 X0 Y0 Z0 G1 G17 T1 D1 F10000 |                                                                                     |
| N60                              |                                                                                     |
| N70 X20 G42 NORM                 |                                                                                     |
| N80 X30                          |                                                                                     |
| N90 Y20                          |                                                                                     |
| N100 X10 CUTCONON                | ; Activation of the compensation suppression.                                       |
| N110 Y30 KONT                    | ; If required, insert bypass circle when deactivating the compensation suppression. |
| N120 X-10 CUTCONOF               |                                                                                     |
| N130 Y20 NORM                    | ; No bypass circle when deactivating the TRC.                                       |
| N140 X0 Y0 G40                   |                                                                                     |
| N150 M30                         |                                                                                     |



## Further information

Tool radius compensation is normally active before the compensation suppression and is still active when the compensation suppression is deactivated again. In the last traversing block before `CUTCONON`, the offset point in the block end point is approached. All following blocks in which offset suppression is active are traversed without offset. However, they are offset by the vector from the end point of the last offset block to its offset point. These blocks can have any type of interpolation (linear, circular, polynomial).

The deactivation block of the compensation suppression, i.e. the block that contains `CUTCONOF`, is compensated normally. It starts in the offset point of the starting point. One linear block is inserted between the end point of the previous block, i.e. the last programmed traversing block with active `CUTCONON`, and this point.

Circular blocks, for which the circle plane is perpendicular to the compensation plane (vertical circles), are treated as though they had `CUTCONON` programmed. This implicit activation of the offset suppression is automatically canceled in the first traversing block that contains a traversing motion in the offset plane and is not such a circle. Vertical circle in this sense can only occur during circumferential milling.

## 11.8 Tools with a relevant cutting edge position

In the case of tools with a relevant tool point direction (turning and grinding tools - tool types 400-599; see Section "Sign evaluation wear"), a change from G40 to G41/G42 or vice-versa is treated as a tool change. If a transformation is active (e.g., `TRANSMIT`), this leads to a preprocessing stop (decoding stop) and hence possibly to deviations from the intended part contour.

This original functionality changes with regard to:

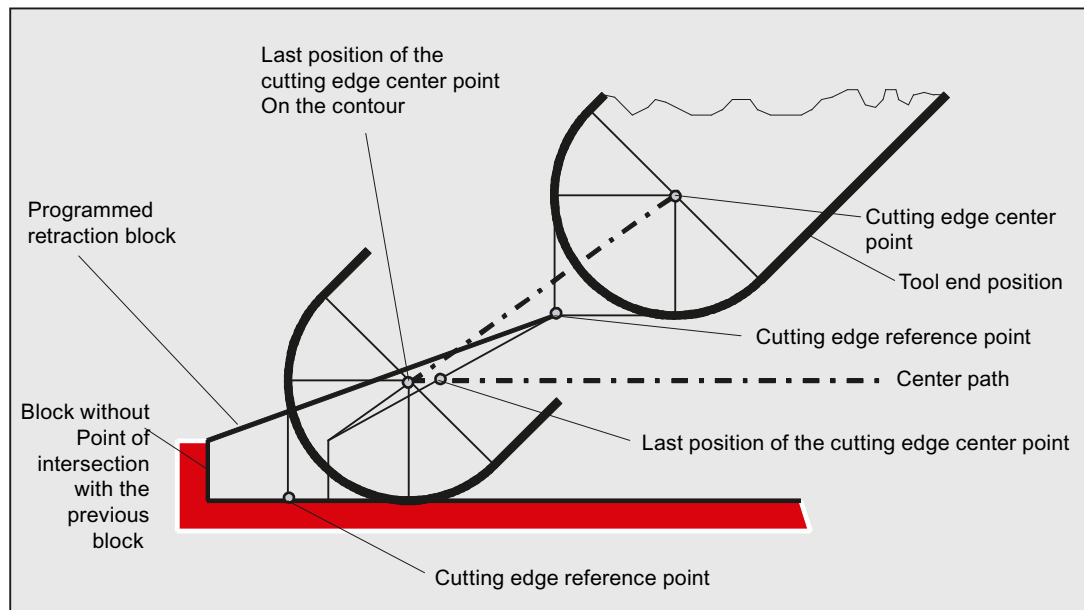
1. Preprocessing stop on `TRANSMIT`
2. Calculation of intersection points at approach and retraction with `KONT`
3. Tool change with active tool radius compensation
4. Tool radius compensation with variable tool orientation at transformation

## Further information

The original functionality has been modified as follows:

- A change from G40 to G41/G42 and vice-versa is no longer treated as a tool change. Therefore, a preprocessing stop no longer occurs with TRANSMIT.
- The straight line between the tool edge center points at the block start and block end is used to calculate intersection points with the approach and retraction block. The difference between the tool edge reference point and the tool edge center point is superimposed on this movement.

On approach and retraction with KONT (tool circumnavigates the contour point, see above subsection "Contour approach and retraction"), superimposition takes place in the linear part block of the approach or retraction motion. The geometric conditions are therefore identical for tools with and without a relevant tool point direction. Deviations from the previous behavior occur only in relatively rare cases where the approach or retraction block does not intersect with an adjacent traversing block, see the following figure:



- In circle blocks and in motion blocks containing rational polynomials with a denominator degree  $> 4$ , it is not permitted to change a tool with active tool radius compensation in cases where the distance between the tool edge center point and the tool edge reference point changes. With other types of interpolation, it is now possible to change when a transformation is active (e.g., TRANSMIT).
- For tool radius compensation with variable tool orientation, the transformation from the tool edge reference point to the tool edge center point can no longer be performed by means of a simple zero offset. Tools with a relevant tool point direction are therefore not permitted for 3D peripheral milling (an alarm is output).

---

**Note**

The subject is irrelevant with respect to face milling as only defined tool types without relevant tool point direction are permitted for this operation anyway. (A tool with a type, which has not been explicitly approved, is treated as a ball end mill with the specified radius. A tool point direction parameter is ignored).

---



## Path action

### 12.1 Exact stop (G60, G9, G601, G602, G603)

In exact stop traversing mode, all path axes and special axes involved in the traversing motion that are not traversed modally, are decelerated at the end of each block until they come to a standstill.

Exact stop is used when sharp outside corners have to be machined or inside corners finished to exact dimensions.

The exact stop specifies how exactly the corner point has to be approached and when the transition is made to the next block:

- "Exact stop fine"  
The block change is performed as soon as the axis-specific tolerance limits for "Exact stop fine" are reached for all axes involved in the traversing motion.
- "Exact stop coarse"  
The block change is performed as soon as the axis-specific tolerance limits for "Exact stop coarse" are reached for all axes involved in the traversing motion.
- "Interpolator end"  
The block change is performed as soon as the control has calculated a set velocity of zero for all axes involved in the traversing motion. The actual position or the following error of the axes involved are not taken into account

---

#### Note

The tolerance limits for "Exact stop fine" and "Exact stop coarse" can be set for each axis via the machine data.

---

#### Syntax

```
G60 ...
G9 ...
G601/G602/G603, etc.
```

#### Meaning

|       |                                                                                 |
|-------|---------------------------------------------------------------------------------|
| G60:  | Command for activation of the <b>modal</b> exact stop                           |
| G9:   | Command for activation of the <b>non-modal</b> exact stop                       |
| G601: | Command for activation of the exact stop criterion " <b>Exact stop fine</b> "   |
| G602: | Command for activation of the exact stop criterion " <b>Exact stop coarse</b> " |
| G603: | Command for activation of the exact stop criterion " <b>Interpolator end</b> "  |

**Note**

The commands for activating the exact stop criteria (G601/G602/G603) are only effective if G60 or G9 is active.

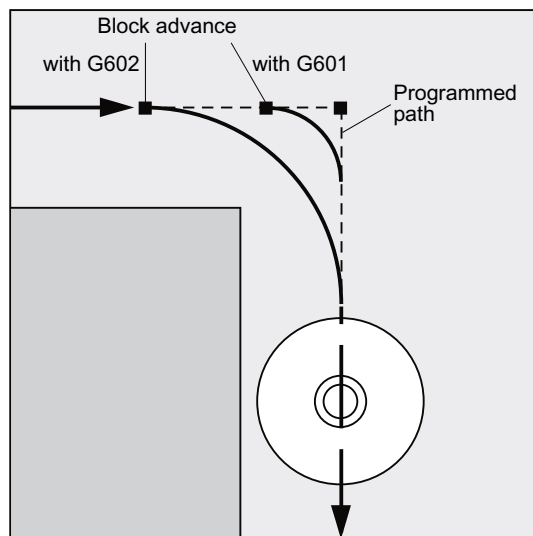
**Example**

| Program code    | Comment                                   |
|-----------------|-------------------------------------------|
| N5 G602         | ; Criterion "Exact stop coarse" selected. |
| N10 G0 G60 Z... | ; Exact stop modal active.                |
| N20 X... Z...   | ; G60 continues to act.                   |
| ...             |                                           |
| N50 G1 G601     | ; Criterion "Exact stop fine" selected.   |
| N80 G64 Z...    | ; Switchover to continuous-path mode.     |
| ...             |                                           |
| N100 G0 G9      | ; Exact stop acts only in this block.     |
| N110 ...        | ; Continuous-path mode active again.      |

**Further information****G60, G9**

G9 generates the exact stop in the current block, G60 in the current block and in all following blocks.

Continuous-path-mode commands G64 or G641 - G645 are used to deactivate G60.

**G601, G602**

## 12.2 Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS)

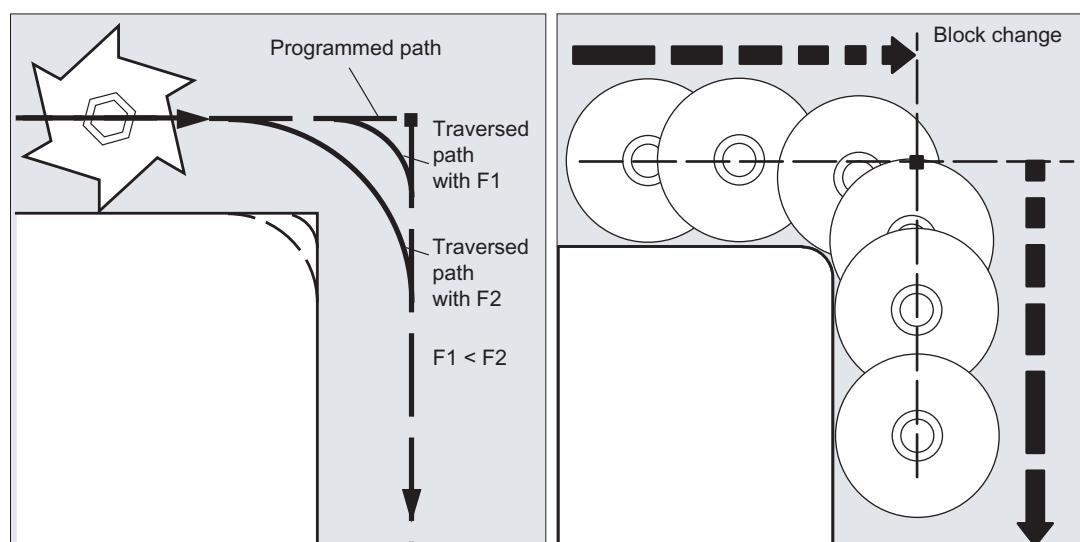
The movement is decelerated and stopped briefly at the corner point.

### Note

Do not set the limits for the exact stop criteria any tighter than necessary. The tighter the limits, the longer it takes to position and approach the target position.

### G603

The block change is initiated when the control has calculated a set velocity of zero for the axes involved. At this point, the actual value lags behind by a proportionate factor depending on the dynamic response of the axes and the path velocity. The workpiece corners can now be rounded.



### Configured exact stop criterion

A channel-specific setting can be made for G0 and the other commands in the first G function group indicating that contrary to the programmed exact stop criterion a preset criterion should be used automatically (see machine manufacturer's specifications).

### References

Function Manual, Basic Functions, Continuouspath Mode, Exact Stop, Look Ahead (B1)

## 12.2 Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS)

In continuous-path mode, the path velocity at the end of the block (for the block change) is not decelerated to a level which would permit the fulfillment of an exact stop criterion. The objective of this mode is, in fact, to avoid rapid deceleration of the path axes at the block-change point so that the axis velocity remains as constant as possible when the program moves to the next block. To achieve this objective, the "Look-head" function is also activated when continuous-path mode is selected.

Continuous-path mode with smoothing facilitates the tangential shaping and/or smoothing of angular block transitions caused by local changes in the programmed contour.

Continuous path mode:

- Rounds the contour
- Reduces machining times by eliminating braking and acceleration processes that are required to fulfill the exact-stop criterion
- Improves cutting conditions because of the more constant velocity

Continuous-path mode is suitable if:

- A contour needs to be traversed as quickly as possible (e.g. with rapid traverse)
- The exact contour may deviate from the programmed contour within a specific tolerance for the purpose of obtaining a continuous contour

Continuous-path mode is not suitable if:

- A contour needs to be traversed precisely
- An absolutely constant velocity is required

---

#### Note

Continuous-path mode is interrupted by blocks which trigger a preprocessing stop implicitly, e.g. due to:

- Access to specific machine status data (\$A...)
  - Auxiliary function outputs
- 

## Syntax

```
G64 ...
G641 ADIS=...
G641 ADISPOS=...
G642 ...
G643 ...
G644 ...
G645 ...
```

## Meaning

|               |                                                                       |
|---------------|-----------------------------------------------------------------------|
| G64:          | Continuous-path mode with reduced velocity as per the overload factor |
| G641:         | Continuous-path mode with smoothing as per distance criterion         |
| ADIS=... :    | Distance criterion with G641 for path functions G1, G2, G3, etc.      |
| ADISPOS=... : | Distance criterion with G641 for rapid traverse G0                    |



---

12.2 Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS)

|       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|       | <p>The distance criterion (= rounding clearance) <b>ADIS</b> or <b>ADISPOS</b> describes the maximum distance the rounding block may cover before the end of the block, or the distance after the end of block within which the rounding block must be terminated respectively.</p> <p><b>Note:</b><br/>If <b>ADIS/ADISPOS</b> is not programmed, a value of "zero" applies and the traversing behavior therefore corresponds to <b>G64</b>. The rounding clearance is automatically reduced (by up to 36%) for short traversing distances.</p>                                     |
| G642: | <p>Continuous-path mode with smoothing within the defined tolerances</p> <p>In this mode, under normal circumstances smoothing takes place within the maximum permissible path deviation. However, instead of these axis-specific tolerances, observation of the maximum contour deviation (contour tolerance) or the maximum angular deviation of the tool orientation (orientation tolerance) can be configured.</p> <p><b>Note:</b><br/>Expansion to include contour and orientation tolerance is only supported on systems featuring the "Polynomial interpolation" option.</p> |
| G643: | <p>Continuous-path mode with smoothing within the defined tolerances (block-internal)</p> <p>G643 differs from G642 in that is not used to generate a separate rounding block; instead, axis-specific block-internal rounding movements are inserted. The rounding clearance can be different for each axis.</p>                                                                                                                                                                                                                                                                    |
| G644: | <p>Continuous-path mode with smoothing with maximum possible dynamic response</p> <p><b>Note:</b><br/>G644 is not available with an active kinematic transformation. The system switches internally to G642.</p>                                                                                                                                                                                                                                                                                                                                                                    |
| G645: | <p>Continuous-path mode with smoothing and tangential block transitions within the defined tolerances</p> <p>G645 has the same effect on corners as G642. With G645, rounding blocks are also only generated on tangential block transitions if the curvature of the original contour exhibits a jump in at least one axis.</p>                                                                                                                                                                                                                                                     |

**Note**

Rounding cannot be used as a substitute for smoothing (**RND**). The user should not make any assumptions with respect to the appearance of the contour within the rounding area. The type of rounding can depend on dynamic conditions, e.g. on the tool path velocity. Rounding on the contour is therefore only practical with small **ADIS** values. **RND** must be used if a defined contour is to be traversed at the corner.

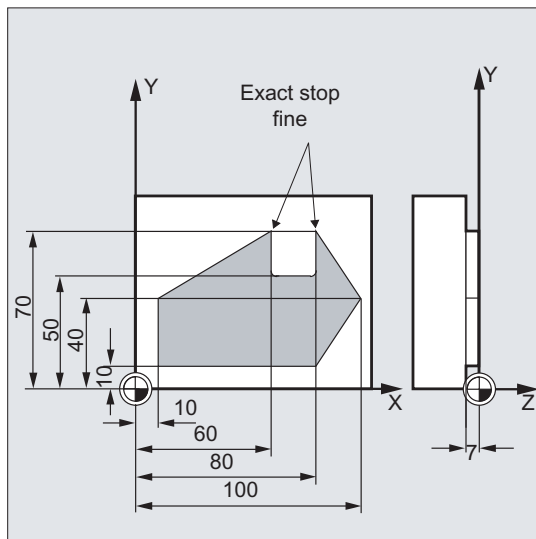
---

**Note**

If a rounding movement initiated by **G641**, **G642**, **G643**, **G644** or **G645** is interrupted, the starting or end point of the original traversing block (as appropriate for **REPOS** mode) will be used for subsequent repositioning (**REPOS**), rather than the interruption point.

---

## Example



The two outside corners on the groove are to be approached exactly. Otherwise machining should be performed in continuous-path mode.

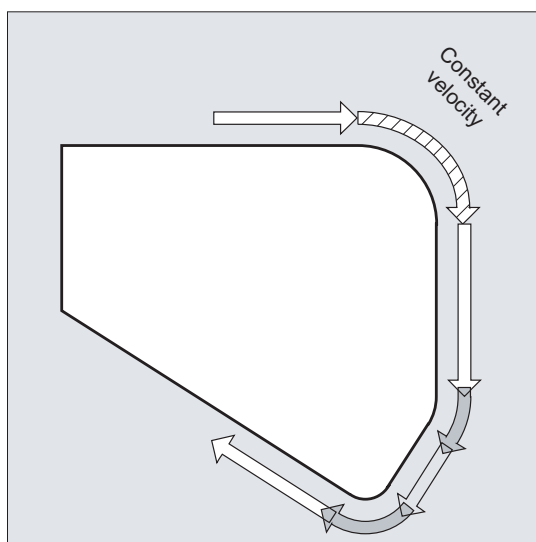
| Program code                         | Comment                                                            |
|--------------------------------------|--------------------------------------------------------------------|
| N05DIAMOF                            | ; Radius as dimension                                              |
| N10 G17 T1 G41 G0 X10 Y10 Z2 S300 M3 | ; Approach starting position, activate spindle, path compensation. |
| N20 G1 Z-7 F8000                     | ; Feed in tool.                                                    |
| N30 G641 ADIS=0.5                    | ; Contour transitions are smoothed.                                |
| N40 Y40                              |                                                                    |
| N50 X60 Y70 G60 G601                 | ; Approach position exactly with exact stop fine.                  |
| N60 Y50                              |                                                                    |
| N70 X80                              |                                                                    |
| N80 Y70                              |                                                                    |
| N90 G641 ADIS=0.5 X100 Y40           | ; Contour transitions are smoothed.                                |
| N100 X80 Y10                         |                                                                    |
| N110 X10                             |                                                                    |
| N120 G40 G0 X-20                     | ; Deactivate path compensation                                     |
| N130 Z10 M30                         | ; Retract tool, end of program.                                    |

## Further information

### Continuous-path mode G64

In continuous-path mode, the tool travels across tangential contour transitions with as constant a path velocity as possible (no deceleration at block boundaries). LookAhead deceleration is applied before corners and blocks with exact stop.

---

12.2 Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS)


Corners are also traversed at a constant velocity. In order to minimize the contour error, the velocity is reduced according to an acceleration limit and an overload factor.

---

**Note**

The extent of smoothing the contour transitions depends on the feedrate and the overload factor. The overload factor can be set in MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR.

Setting MD20490 \$MC\_IGNORE\_OVL\_FACTOR\_FOR\_ADIS means that block transitions will always be rounded irrespective of the set overload factor.

---

The following points should be noted in order to prevent an undesired stop in path motion (relief cutting):

- Auxiliary functions, which are enabled after the end of the motion or before the next motion, interrupt the continuous path mode (exception: fast auxiliary functions).
- Positioning axes always traverse according to the exact stop principle, positioning window fine (as for G601). If an NC block has to wait for positioning axes, continuous-path mode is interrupted on the path axes.

However, intermediate blocks containing only comments, calculation blocks or subprogram calls do not affect continuous-path mode.

---

**Note**

If `FGROUP` does not contain all the path axes, there is often a step change in the velocity at block transitions for those axes excluded from `FGROUP`; the control limits this change in velocity to the permissible values set in MD32300 \$MA\_MAX\_AX\_ACCEL and MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR. This braking operation can be avoided through the application of a rounding function, which "smoothes" the specific positional interrelationship between the path axes.

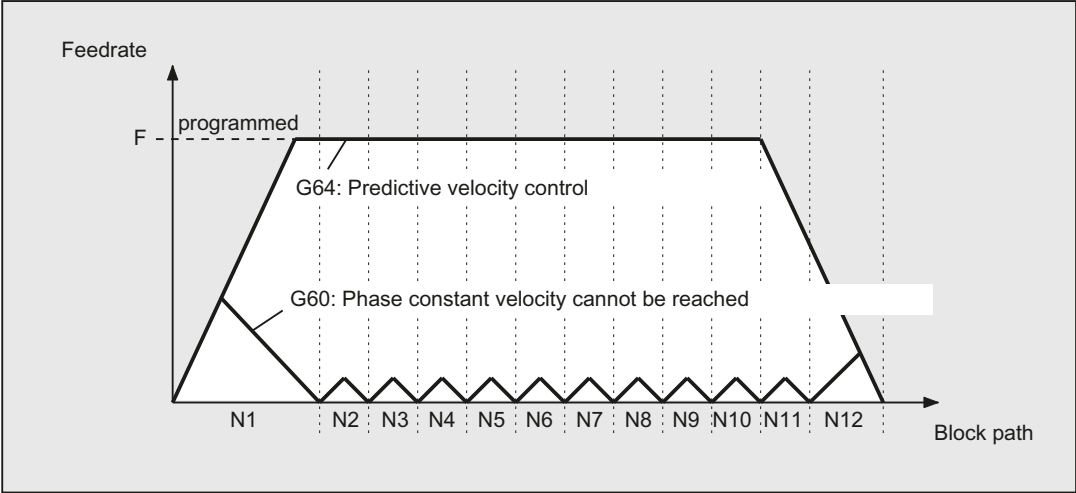
---

**LookAhead predictive velocity control**

In continuous-path mode, the control automatically determines the velocity control for several NC blocks in advance. This enables acceleration and deceleration across multiple blocks with almost tangential transitions.

Look Ahead is particularly suitable for the machining of motion sequences comprising short traverse paths with high path feedrates.

The number of NC blocks included in the Look Ahead calculation can be defined in machine data.



**Continuous-path mode with smoothing as per distance criterion (G641)**

With G641, the control inserts transition elements at contour transitions. The rounding clearance ADIS (or ADISPOS for G0) specifies the maximum extent to which the corners can be rounded. Within this rounding clearance, the control is free to ignore the path construct and replace it with a dynamically optimized distance.

Disadvantage: Only one ADIS value is available for all axes.

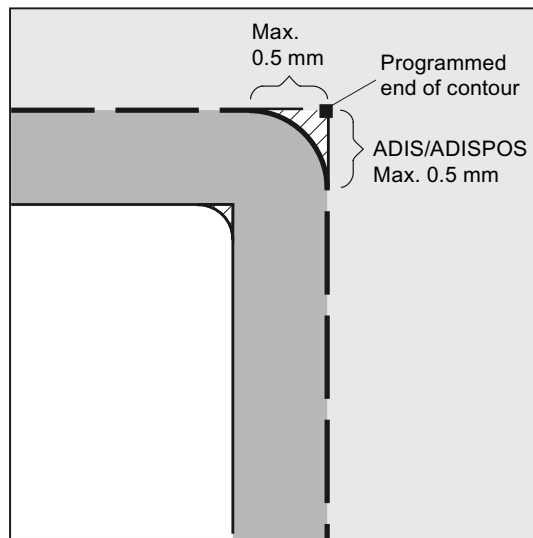
The effect of G641 is similar to RNDM; however, it is not restricted to the axes of the working plane.

Like G64, G641 works with LookAhead predictive velocity control. Corner rounding blocks with a high degree of curvature are approached at reduced velocity.

Example:

| Program code                   | Comment                                                                                                                                                                   |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 G641 ADIS=0.5 G1 X... Y... | ; The rounding block must begin no more than 0.5 mm before the programmed end of the block and must finish 0.5 mm after the end of the block. This setting remains modal. |

## 12.2 Continuous-path mode (G64, G641, G642, G643, G644, G645, ADIS, ADISPOS)



### Note

Smoothing cannot and should not replace the functions for defined smoothing (RND, RNDM, ASPLINE, BSPLINE, CSPLINE).

### Smoothing with axial precision with G642

With G642, smoothing does not take place within a defined ADIS range, but the axial tolerances defined with MD33100 \$MA\_COMPRESS\_POS\_TOL are complied with. The rounding clearance is determined based on the shortest rounding clearance of all axes. This value is taken into account when generating a rounding block.

### Block-internal smoothing with G643

The maximum deviations from the precise contour in the case of smoothing with G643 are defined for each axis using machine data MD33100 \$MA\_COMPRESS\_POS\_TOL.

G643 is not used to generate a separate rounding block, but axis-specific block-internal rounding motions are inserted. In the case of G643, the rounding clearance of each axis can be different.

### Smoothing with contour and orientation tolerance with G642/G643

MD20480 \$MC\_SMOOTHING\_MODE can be used to configure rounding with G642 and G643 so that instead of the axis-specific tolerances, a contour tolerance and an orientation tolerance can be applied.

The contour tolerance and orientation tolerance are set in the channel-specific setting data:

SD42465 \$SC\_SMOOTH\_CONTUR\_TOL (maximum contour deviation)

SD42466 \$SC\_SMOOTH\_ORI\_TOL (maximum angular deviation of the tool orientation)

The setting data can be programmed in the NC program; this means that it can be specified differently for each block transition. Very different specifications for the contour tolerance and the tolerance of the tool orientation can only take effect with G643.

---

**Note**

Expansion to include contour and orientation tolerance is only supported on systems featuring the "Polynomial interpolation" option.

---



---

**Note**

An orientation transformation must be active for smoothing within the orientation tolerance.

---

**Corner rounding with greatest possible dynamic response in G644**

Smoothing with maximum possible dynamic response is configured in the thousands place with MD20480 \$MC\_SMOOTHING\_MODE.

| Value | Meaning                                                                                                                                                                                                                                                                                                                                                                                   |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | Specification of maximum axial deviations with:<br>MD33100 \$MA_COMPRESS_POS_TOL                                                                                                                                                                                                                                                                                                          |
| 1     | Specification of maximum rounding clearance by programming:<br>ADIS=... or ADISPOS=...                                                                                                                                                                                                                                                                                                    |
| 2     | Specification of the maximum possible frequencies of each axis occurring in the rounding area with:<br>MD32440 \$MA_LOOKAH_FREQUENCY<br>The rounding area is defined such that no frequencies in excess of the specified maximum can occur while the rounding motion is in progress.                                                                                                      |
| 3     | When rounding with G644, neither the tolerance nor the rounding distance are monitored. Each axis traverses around a corner with the maximum possible dynamic response.<br>With SOFT, both the maximum acceleration and the maximum jerk of each axis is maintained.<br>With the BRISK command, the jerk is not limited; instead, each axis travels at the maximum possible acceleration. |

**Smoothing of tangential block transitions with G645**

With G645, the smoothing motion is defined so that the acceleration of all axes involved remains smooth (no jumps) and the parameterized maximum deviations from the original contour (MD33120 \$MA\_PATH\_TRANS\_POS\_TOL) are not exceeded.

In the case of angular non-tangential block transitions, the smoothing behavior is the same as with G642.

**No intermediate rounding blocks**

An intermediate rounding block is not inserted in the following cases:

- The axis stops between the two blocks.  
This occurs when:
  - The following block contains an auxiliary function output before the motion.
  - The following block does not contain a path motion.
  - An axis is traversed for the first time as a path axis for the following block when it was previously a positioning axis.
  - An axis is traversed for the first time as a positioning axis for the following block when it was previously a path axis.
  - The previous block traverses geometry axes and the following block does not.
  - The following block traverses geometry axes and the previous block does not.
  - Before tapping, the following block uses G33 as preparatory function and the previous block does not.
  - A change is made between BRISK and SOFT.
  - Axes involved in the transformation are not completely assigned to the path motion (e.g. for oscillation, positioning axes).
- The rounding block would slow down the part program execution.  
This occurs:
  - Between very short blocks.  
Since each block requires at least one interpolator clock cycle, the added intermediate block would double the machining time.
  - If a block transition G64 (continuous-path mode without smoothing) can be traversed without a reduction in velocity.  
Corner rounding would increase the machining time. This means that the value of the permitted overload factor (MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR) affects whether a block transition is rounded or not. The overload factor is only taken into account for corner rounding with G641/G642. The overload factor has no effect in the case of smoothing with G643 (this behavior can also be set for G641 and G642 by setting MD20490 \$MC\_IGNORE\_OVL\_FACTOR\_FOR\_ADIS to TRUE).

- Rounding is not parameterized.  
This occurs when:
  - For G641 in G0 blocks ADISPOS = 0 (default!)
  - For G641 in non-G0 blocks ADIS = 0 (default!)
  - For G641 on transition from G0 and non-G0 or non-G0 and G0 respectively, the smaller value from ADISPOS and ADIS applies.
  - For G642/G643, all axis-specific tolerances are zero.
- The block does not contain traversing motion (zero block).  
This occurs when:
  - Synchronized actions are active.  
Normally, the Interpreter eliminates zero blocks. However, if synchronous actions are active, this zero block is included and also executed. In so doing, an exact stop is initiated corresponding to the active programming. This allows the synchronous action to also switch.
  - Zero blocks are generated by program jumps.

#### **Continuous-path mode in rapid traverse G0**

One of the specified functions G60/G9 or G64, or G641 - G645, also has to be specified for rapid traverse motion. Otherwise, the default in the machine data is used.

#### **References**

For further information about the continuous-path mode see:

Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop, LookAhead (B1).



## Coordinate transformations (frames)

### 13.1 Frames

#### Frame

The frame is a self-contained arithmetic rule that transforms one Cartesian coordinate system into another Cartesian coordinate system.

#### Basic frame (basic offset)

The basic frame describes coordinate transformation from the basic coordinate system (BCS) to the basic zero system (BZS) and has the same effect as settable frames.

See Basic coordinate system (BCS) (Page 26).

#### Settable frames

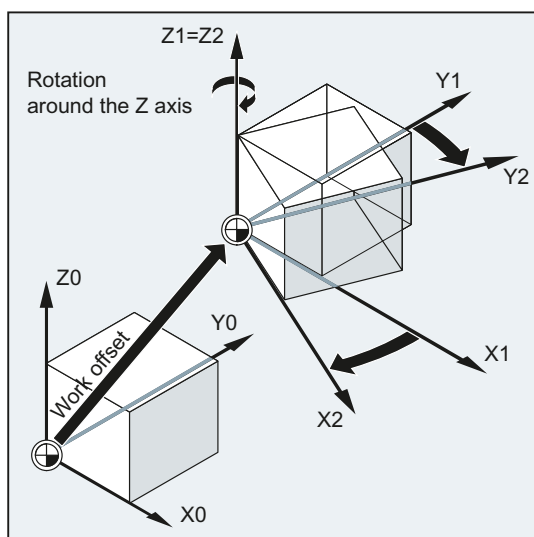
Settable frames are the configurable zero offsets which can be called from within any NC program with the G54 to G57 and G505 to G599 commands. The offset values are predefined by the user and stored in the zero offset memory on the controller . They are used to define the settable zero system (SZS).

See:

- Settable zero system (SZS) (Page 29)
- Settable zero offset (G54 to G57, G505 to G599, G53, G500, SUPA, G153) (Page 137)

## Programmable frames

Sometimes it is useful or necessary within an NC program, to move the originally selected workpiece coordinate system (or the "settable zero system") to another position and, if required, to rotate it, mirror it and/or scale it. This can be achieved using programmable frames.



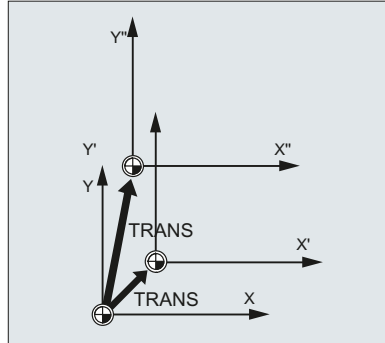
See Frame instructions (Page 307).

## 13.2 Frame instructions

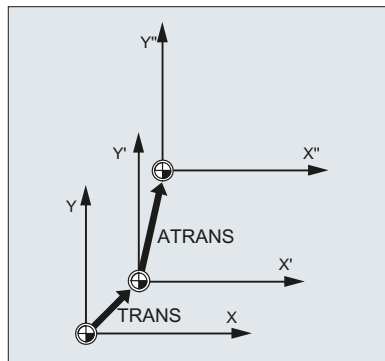
### Function

The statements for programmable frames apply in the current NC program. They function as either additive or substitute elements:

- **Substitute statement**  
Deletes all previously programmed frame statements. The reference is provided by the last settable zero offset called (G54 to G57, G505 to G599).



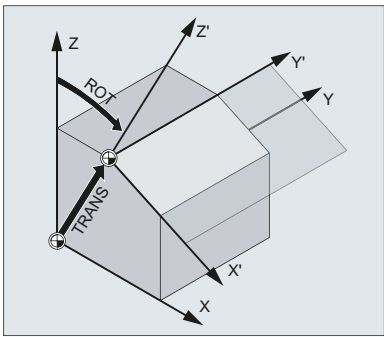
- **Additive statement**  
Appended to existing frames. The reference is provided by the currently set workpiece zero or the last workpiece zero programmed with a frame statement.



### Application example

1. Move the zero point of the workpiece coordinate system (WCS).
2. Rotate the workpiece coordinate system (WCS) to orientate a plane parallel to the desired work plane.

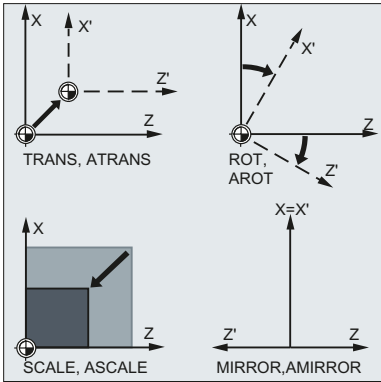
13.2 Frame instructions

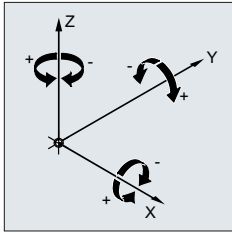


Syntax

| Substituting statements | Additive statements   |
|-------------------------|-----------------------|
| TRANS X... Y... Z...    | ATrans X... Y... Z... |
| ROT X... Y... Z...      | AROT X... Y... Z...   |
| ROT RPL=...             | AROT RPL=...          |
| ROTS/CROTS X... Y...    | AROTS X... Y...       |
| SCALE X... Y... Z...    | ASCALE X... Y... Z... |
| MIRROR X0/Y0/Z0         | AMIRROR X0/Y0/Z0      |

Meaning



|                 |                                                                                                                                                                                                                                                                                             |                                                                                    |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| TRANS/ATRANS:   | Workpiece coordinate system offset in the direction of the specified geometry axis or axes                                                                                                                                                                                                  |                                                                                    |
| ROT/AROT:       | Workpiece coordinate system rotation: <ul style="list-style-type: none"> <li>By linking individual rotations around the specified geometry axis or axes<br/>or</li> <li>Around the angle <math>RPL = \dots</math> in the current working plane (G17/G18/G19)</li> </ul>                     |                                                                                    |
|                 | Direction of rotation:                                                                                                                                                                                                                                                                      |  |
|                 | Rotation sequence:                                                                                                                                                                                                                                                                          | With RPY notation: Z, Y', X''                                                      |
|                 |                                                                                                                                                                                                                                                                                             | With Euler angle: Z, X', Z''                                                       |
|                 | Range of values:                                                                                                                                                                                                                                                                            | The angles of rotation are only defined unambiguously in the following ranges:     |
|                 |                                                                                                                                                                                                                                                                                             | With RPY notation:                                                                 |
|                 |                                                                                                                                                                                                                                                                                             | $-180 \leq x \leq 180$                                                             |
|                 |                                                                                                                                                                                                                                                                                             | $-90 < y < 90$                                                                     |
|                 |                                                                                                                                                                                                                                                                                             | $-180 \leq z \leq 180$                                                             |
|                 |                                                                                                                                                                                                                                                                                             | With Euler angle:                                                                  |
|                 |                                                                                                                                                                                                                                                                                             | $0 \leq x < 180$                                                                   |
|                 |                                                                                                                                                                                                                                                                                             | $-180 \leq y \leq 180$                                                             |
|                 |                                                                                                                                                                                                                                                                                             | $-180 \leq z \leq 180$                                                             |
| ROTS/AROTS:     | Workpiece coordinate system rotation by means of the specification of solid angles<br><br>The orientation of a plane in space is defined unambiguously by specifying two solid angles. Therefore, up to two solid angles may be programmed:<br>ROTS/AROTS X... Y... / Z... X... / Y... Z... |                                                                                    |
| CROTS:          | CROTS works in the same way as ROTS but refers to the valid frame in the database.                                                                                                                                                                                                          |                                                                                    |
| SCALE/ASCALE:   | Scaling in the direction of the specified geometry axis or axes to increase/reduce the size of a contour                                                                                                                                                                                    |                                                                                    |
| MIRROR/AMIRROR: | Workpiece coordinate system mirroring by means of mirroring (direction change) the specified geometry axis                                                                                                                                                                                  |                                                                                    |
|                 | Value:                                                                                                                                                                                                                                                                                      | Freely selectable (in this case: "0")                                              |

### Supplementary conditions

- Frame statements must be programmed in a separate NC block.
- Frame statements can be used individually or combined as required.
- Frame statements are executed in the programmed sequence.
- Additive statements are frequently used in subprograms. The basic statements defined in the main program are not lost after the end of the subprogram if the subprogram has been programmed with the SAVE attribute.

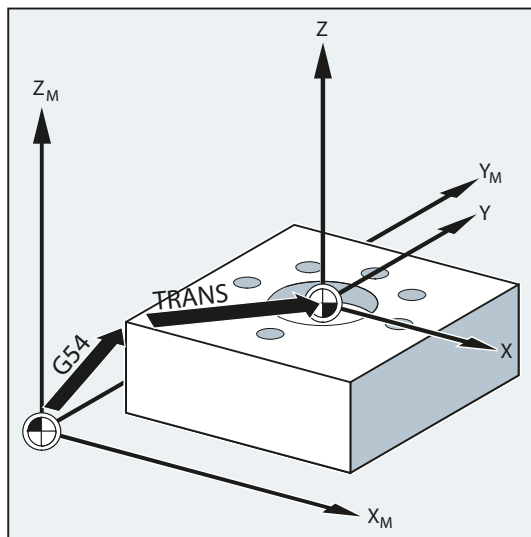
## 13.3 Programmable zero offset

### 13.3.1 Zero offset (TRANS, ATRANS)

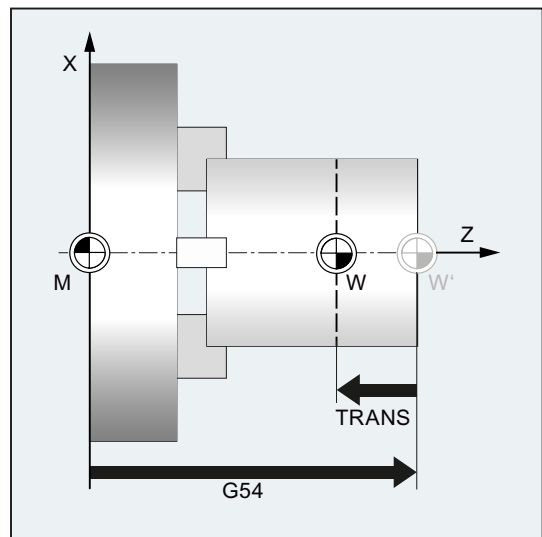
The **TRANS** statement moves the WCS absolutely based on the ENS created with a parameterized zero offset (G54 ... G57, G505 ... G599).

The **ATrans** statement moves additively the WCS created with **TRANS**.

Milling:



Turning:



### Syntax

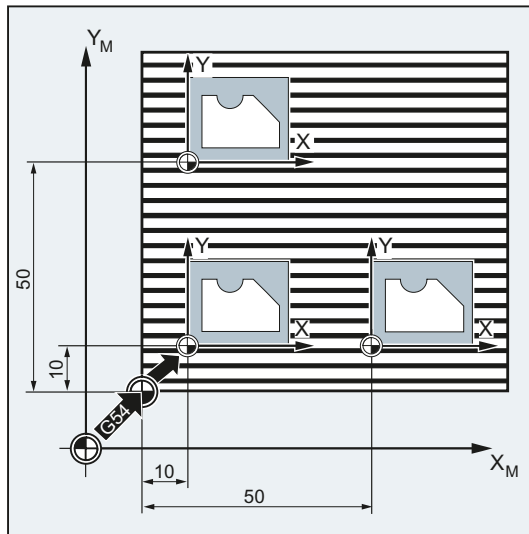
```
TRANS X... Y... Z...
ATrans X... Y... Z...
```

## Meaning

|                 |                                                                                                                                                                |                                                               |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| TRANS:          | Absolute offset of the WCS with reference to the parameterized workpiece zero (ENS) set with the parameterized zero point offset (G54 ... G57, G505 ... G599). |                                                               |
|                 | Alone in the block:                                                                                                                                            | yes                                                           |
| ATRANS:         | Additive zero offset of the WCS with reference to the parameterized workpiece zero set with TRANS                                                              |                                                               |
|                 | Alone in the block:                                                                                                                                            | yes                                                           |
| X... Y... Z...: |                                                                                                                                                                | Offset values in the direction of the specified geometry axes |

## Examples

### Example 1: Milling



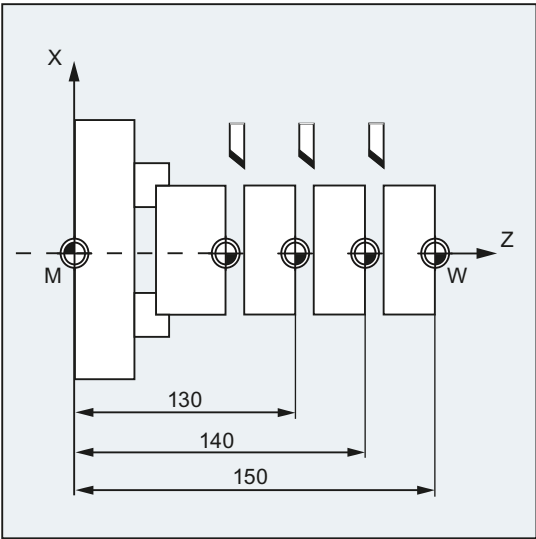
With this workpiece, the shapes shown recur in a program.

The machining sequence for this shape is stored in a subprogram.

Zero offset is used to set the workpiece zeros required in each case and then call the subprogram.

| Program code      | Comment                             |
|-------------------|-------------------------------------|
| N10 G1 G54        | ; Working plane X/Y, workpiece zero |
| N20 G0 X0 Y0 Z2   | ; Approach starting point           |
| N30 TRANS X10 Y10 | ; Absolute offset                   |
| N40 L10           | ; Subprogram call                   |
| N50 TRANS X50 Y10 | ; Absolute offset                   |
| N60 L10           | ; Subprogram call                   |
| N70 M30           | ; End of program                    |

Example 2: Turning



| Program code                       | Comment         |
|------------------------------------|-----------------|
| N.. ...                            |                 |
| N10 TRANS X0 Z150                  | Absolute offset |
| N15 L20                            | Subprogram call |
| N20 TRANS X0 Z140 (or ATRANS Z-10) | Absolute offset |
| N25 L20                            | Subprogram call |
| N30 TRANS X0 Z130 (or ATRANS Z-10) | Absolute offset |
| N35 L20                            | Subprogram call |
| N.. ...                            |                 |

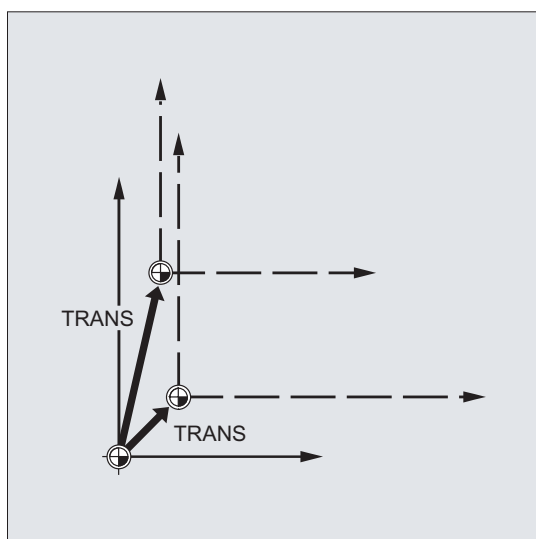
Further information

TRANS X... Y... Z...

Translation through the offset values programmed in the specified axis directions (path, synchronized axes and positioning axes). The reference is provided by the last settable work offset called (G54 to G57, G505 to G599).

|                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                             |
| <b>No original frame</b><br>The TRANS command resets all frame components of the previously activated programmable frame. |

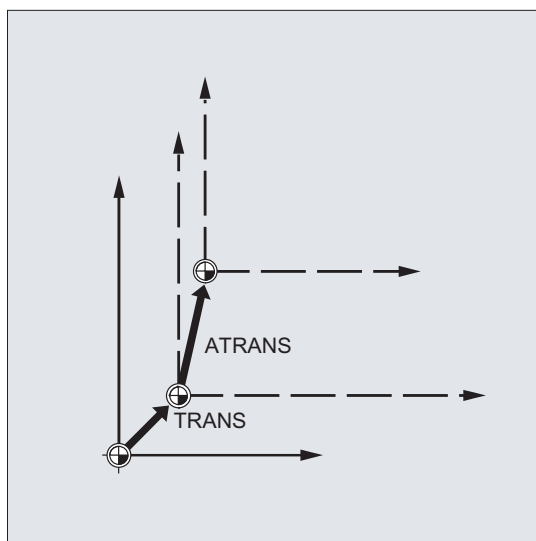


**Note**

ATRANS can be used to program an offset to be added to existing frames.

**ATRANS X... Y... Z...**

Translation through the offset values programmed in the specified axis directions. The currently set or last programmed zero point is used as the reference.



### 13.3.2 Axial zero offset (G58, G59)

#### Note

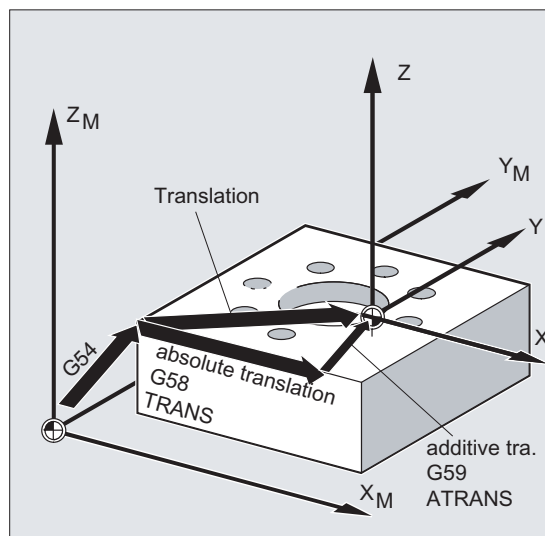
For SINUMERIK 828D the statements G58/G59 have a different function than for SINUMERIK 840D sl:

- G58: Calls the 5th settable zero offset (this corresponds to statement G505 for SINUMERIK 840D sl)
- G59: Calls the 6th settable zero offset (this corresponds to statement G506 for SINUMERIK 840D sl)

Therefore, the following description of G58/G59 is only valid for SINUMERIK 840D sl.

The G58 and G59 functions can be used to substitute translation components of the programmable zero offset with specific axes:

- G58 is used for the absolute translation component (coarse offset)
- G59 is used for the additive translation component (fine offset)



#### Requirements

The G58 and G59 functions can only be used if fine offset has been configured (MD24000 \$MC\_FRAME\_ADD\_COMPONENTS = 1).

#### Syntax

```
G58 X... Y... Z... A...
G59 X... Y... Z... A...
```

#### Note

Each of the substitute operations G58 and G59 has to be programmed in a separate NC block.

## Meaning

|                 |                                                                                                                                                                                                                                                         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G58:            | G58 replaces the absolute translation component of the programmable zero offset for the specified axis, but the programmed additive offset remains valid. The reference is provided by the last settable zero offset called (G54 to G57, G505 to G599). |
| G59:            | G59 replaces the additive translation component of the programmable zero offset for the specified axis, but the programmed absolute offset remains valid.                                                                                               |
| X... Y... Z...: | Offset values in the direction of the specified geometry axes                                                                                                                                                                                           |

## Example

| Program code          | Comment                                      |
|-----------------------|----------------------------------------------|
| ...                   |                                              |
| N50 TRANS X10 Y10 Z10 | ; Absolute translation component X10 Y10 Z10 |
| N60 ATRANS X5 Y5      | ; Additive translation component X5 Y5       |
|                       | → total offset: X15 Y15 Z10                  |
| N70 G58 X20           | ; Absolute translation component X20         |
|                       | + additive translation component X5 Y5       |
|                       | → total offset X25 Y15 Z10                   |
| N80 G59 X10 Y10       | ; Additive translation component X10 Y10     |
|                       | + absolute translation component X20 Y10     |
|                       | → total offset X30 Y20 Z10                   |
| ...                   |                                              |

## Further information

The absolute translation component or coarse offset is modified by the following statements:

- TRANS
- G58
- CTRANS
- CFINE
- \$P\_PFRAME[X, TR]

The additive translation component or fine offset is modified by the following statements:

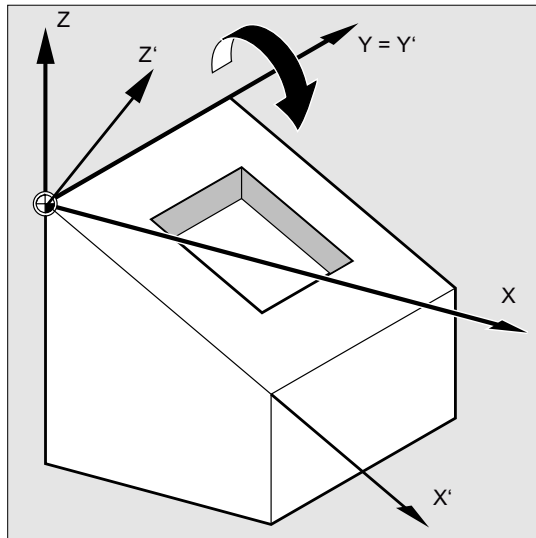
- ATRANS
- G59
- CTRANS
- CFINE
- \$P\_PFRAME[X, FI]

## Examples

| Statement           | Coarse or absolute offset $V_C$ | Fine or additive offset $V_F$ |
|---------------------|---------------------------------|-------------------------------|
| TRANS X10           | $V_C = 10$                      | unchanged                     |
| G58 X10             | $V_C = 10$                      | unchanged                     |
| \$P_PFRAME[X,TR]=10 | $V_C = 10$                      | unchanged                     |
| ATRANS X10          | unchanged                       | $V_F = V_F + 10$              |
| G59 X10             | unchanged                       | $V_F = 10$                    |
| \$P_PFRAME[X,FI]=10 | unchanged                       | $V_F = 10$                    |
| CTRANS(X,10)        | $V_C = 10$                      | $V_F = 0$                     |
| CTRANS()            | $V_C = 0$                       | $V_F = 0$                     |
| CFINE(X,10)         | $V_C = 0$                       | $V_F = 10$                    |

## 13.4 Programmable rotation (ROT, AROT, RPL)

The workpiece coordinate system can be rotated in space with the ROT/AROT statements. The statements refer exclusively to the programmable frame \$P\_PFRAME.



## Syntax

```

ROT <1st GeoAx><angle> <2nd GeoAx><angle> <3rd GeoAx><angle>
ROT RPL=<angle>
AROT <1st GeoAx><angle> <2nd GeoAx><angle> <3rd GeoAx><angle>
AROT RPL=<angle>

```

**Note****Euler angle**

The rotations of the workpiece coordinate system are performed via Euler angles. A detailed description can be found in:

**References**

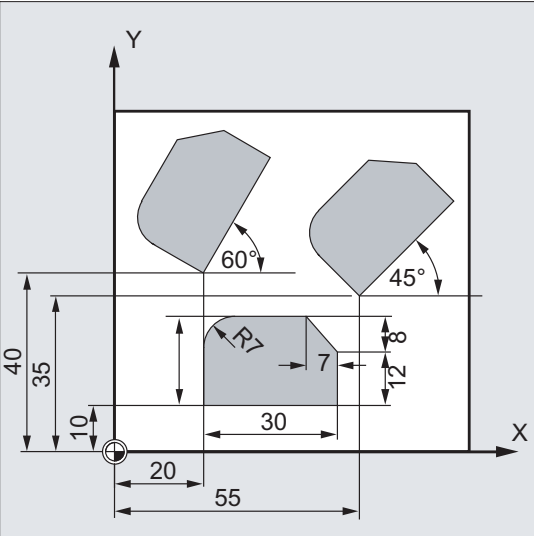
Function Manual, Basic Functions; Section "Axes, coordinate systems, frames (K2)" > "Frames" > "Frame components" > "Rotation ..."

**Meaning**

|              |                                                                                                                                                                                                                 |                                                                                           |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| ROT:         | Absolute rotation                                                                                                                                                                                               |                                                                                           |
|              | Reference frame:                                                                                                                                                                                                | Programmable frame \$P_PFRAME                                                             |
|              | Reference point:                                                                                                                                                                                                | Zero point of the current workpiece coordinate system set with G54 ... G57, G505 ... G599 |
| AROT:        | Additive rotation                                                                                                                                                                                               |                                                                                           |
|              | Reference frame:                                                                                                                                                                                                | Programmable frame \$P_PFRAME                                                             |
|              | Reference point:                                                                                                                                                                                                | Zero point of the current workpiece coordinate system set with G54 ... G57, G505 ... G599 |
| <nth GeoAx>: | Identifier of the nth geometry axis around which rotation is to be performed with the specified angle.<br>The value 0° is implicitly set as angle of rotation for a geometry axis that has not been programmed. |                                                                                           |
| RPL:         | Rotation around the geometry axis perpendicular to the active plane (G17, G18, G19) by the specified angle                                                                                                      |                                                                                           |
|              | Reference frame:                                                                                                                                                                                                | Programmable frame \$P_PFRAME                                                             |
|              | Reference point:                                                                                                                                                                                                | Zero point of the current workpiece coordinate system set with G54 ... G57, G505 ... G599 |
| <Angle>      | Angle specification in degrees.                                                                                                                                                                                 |                                                                                           |
|              | Range of values:                                                                                                                                                                                                | $-360^{\circ} \leq \text{angle} \leq 360^{\circ}$                                         |

Examples

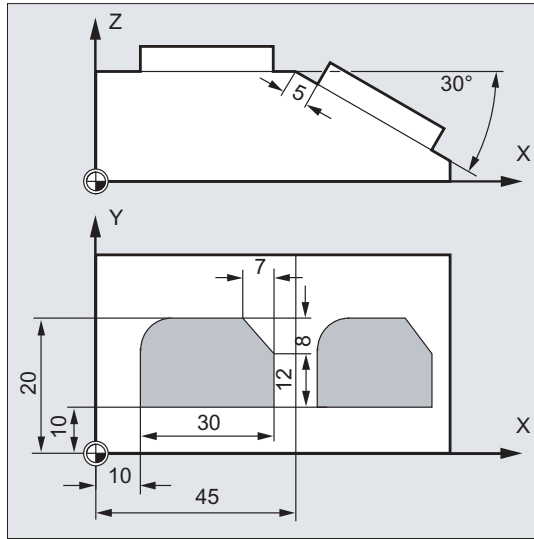
Example 1: Rotation in the G17 plane



With this workpiece, the shapes shown recur in a program. In addition to the zero offset, rotations have to be performed, as the shapes are not arranged paraxially.

| Program code      | Comment                                                                               |
|-------------------|---------------------------------------------------------------------------------------|
| N10 G17 G54       | ; Working plane X/Y, workpiece zero                                                   |
| N20 TRANS X20 Y10 | ; Absolute offset                                                                     |
| N30 L10           | ; Subprogram call                                                                     |
| N40 TRANS X55 Y35 | ; Absolute offset                                                                     |
| N50 AROT RPL=45   | ; Additive rotation around the Z axis perpendicular;<br>to the G17 plane through 45°  |
| N60 L10           | ; Subprogram call                                                                     |
| N70 TRANS X20 Y40 | ; Absolute offset<br>(resets all previous offsets)                                    |
| N80 AROT RPL=60   | ; Additive rotation around the Z axis perpendicular<br>; to the G17 plane through 60° |
| N90 L10           | ; Subprogram call                                                                     |
| N100 G0 X100 Y100 | ; Retraction                                                                          |
| N110 M30          | ; End of program                                                                      |

### Example 2: Spatial rotation around the Y axis



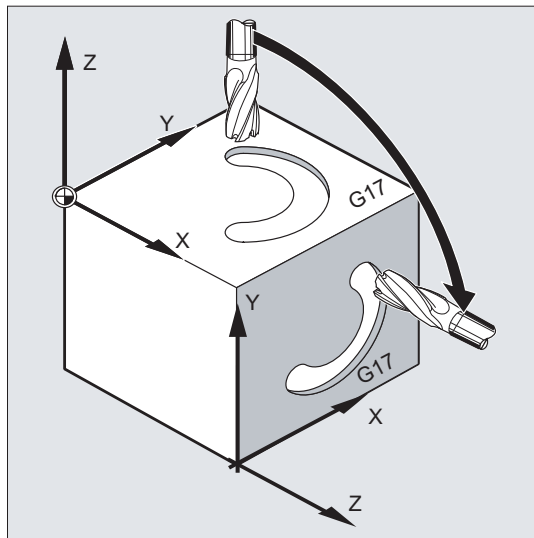
In this example, paraxial and inclined work-piece surfaces are to be machined in a clamping.

Condition:

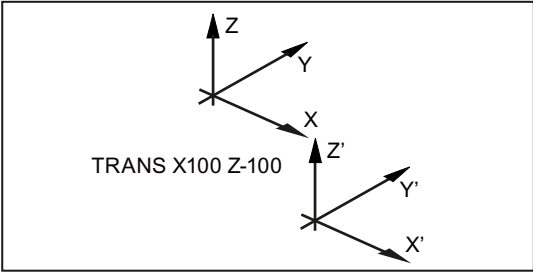
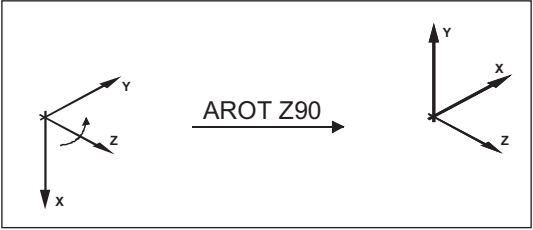
The tool must be aligned perpendicular to the inclined surface in the rotated Z direction.

| Program code         | Comment                               |
|----------------------|---------------------------------------|
| N10 G17 G54          | ; Working plane X/Y, workpiece zero   |
| N20 TRANS X10 Y10    | ; Absolute offset                     |
| N30 L10              | ; Subprogram call                     |
| N40 ATRANS X35       | ; Additive offset                     |
| N50 AROT Y30         | ; Additive rotation around the Y axis |
| N60 ATRANS X5        | ; Additive offset                     |
| N70 L10              | ; Subprogram call                     |
| N80 G0 X300 Y100 M30 | ; Retraction, end of program          |

### Example 3: Multi-face machining



In this example, identical shapes are machined in two workpiece surfaces perpendicular to one another via subprograms. In the new coordinate system on the right-hand workpiece surface, infeed direction, working plane and the zero point have been set up as on the top surface. Therefore, the conditions required for the subprogram execution still apply: Working plane G17, coordinate plane X/Y, infeed direction Z.

| Program code         | Comment                                                                              |
|----------------------|--------------------------------------------------------------------------------------|
| N10 G17 G54          | ; Working plane X/Y, workpiece zero                                                  |
| N20 L10              | ; Subprogram call                                                                    |
| N30 TRANS X100 Z-100 | ; Absolute offset of the WCS                                                         |
|                      |    |
| N40 AROT Y90         | ; Additive rotation of the WCS around Y through 90°                                  |
|                      |    |
| N50 AROT Z90         | ; Additive rotation of the WCS around Z through 90°                                  |
|                      |  |
| N60 L10              | ; Subprogram call                                                                    |
| N70 G0 X300 Y100 M30 | ; Retraction, end of program                                                         |

Further information

Rotation in the active plane

When programming using RPL=..., the WCS is rotated around the axis perpendicular to the active plane.



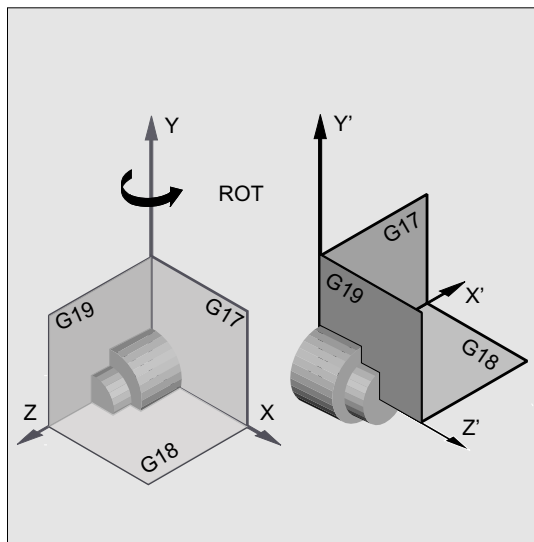


Figure 13-1 Rotation around the Y axis or in the G18 plane

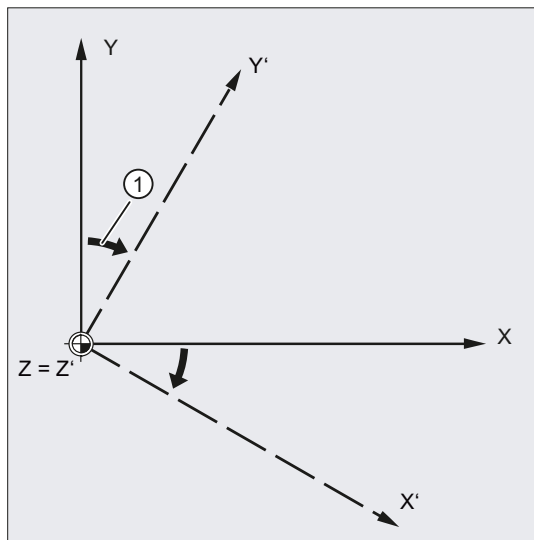
**WARNING****Plane change**

If a plane change (G17, G18, G19) is programmed after a rotation, the current angles of rotation of the respective axes are retained and are also effective in the new plane. It is therefore strongly recommended that the current angles of rotation be reset to 0 before a plane change:

- N100 ROT X0 Y0 Z0 ; explicit angle programming
- N100 ROT ; implicit angle programming

**Absolute rotation with ROT X... Y... Z...**

The WCS is rotated around the specified axes to the programmed angles of rotation.

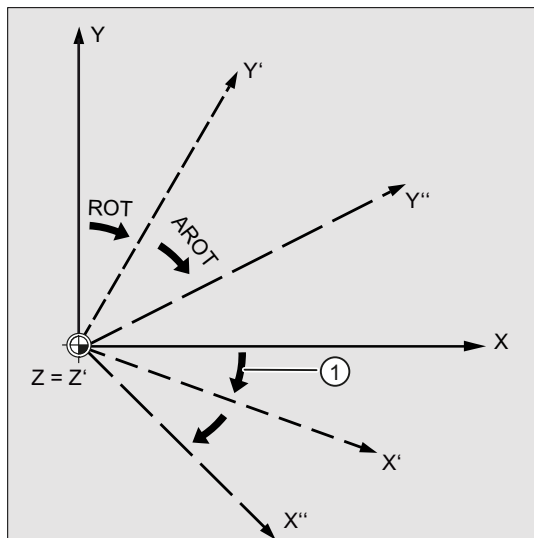


① Angle of rotation

Figure 13-2 Absolute rotation around the Z axis

#### Additive rotation with AROT X... Y... Z...

The WCS is rotated further around the specified axes through the programmed angles of rotation.



① Angle of rotation

Figure 13-3 Absolute and additive rotation around the Z axis

#### Rotation of the working plane

During a rotation using ROT/AROT, the working plane (G17, G18, G19) also rotates.

Example: Working plane G17

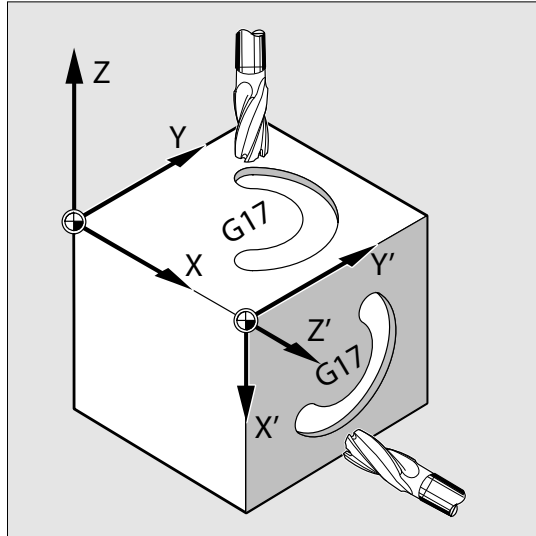
The WCS is positioned on the top surface of the workpiece. Using offset and rotation, the coordinate system is moved to one of the side faces. Working plane G17 also rotates. In this

way, traversing motions can still be programmed in the G17 plane via X and Y and infeeds via Z.

Requirement:

The tool must be perpendicular to the working plane and the positive direction of the infeed axis points in the direction of the tool base.

Specifying `CUT2DF` activates the tool radius compensation in the rotated plane.



## 13.5

### Programmable frame rotations with solid angles (ROTS, AROTS, CROTS)

Rotations of the workpiece coordinate system can be specified in solid angles with the `ROTS`, `AROTS` and `CROTS` statements. Solid angles are the angles formed by the intersections of the plane rotated in space with the main planes of the not yet rotated WCS.

#### Note

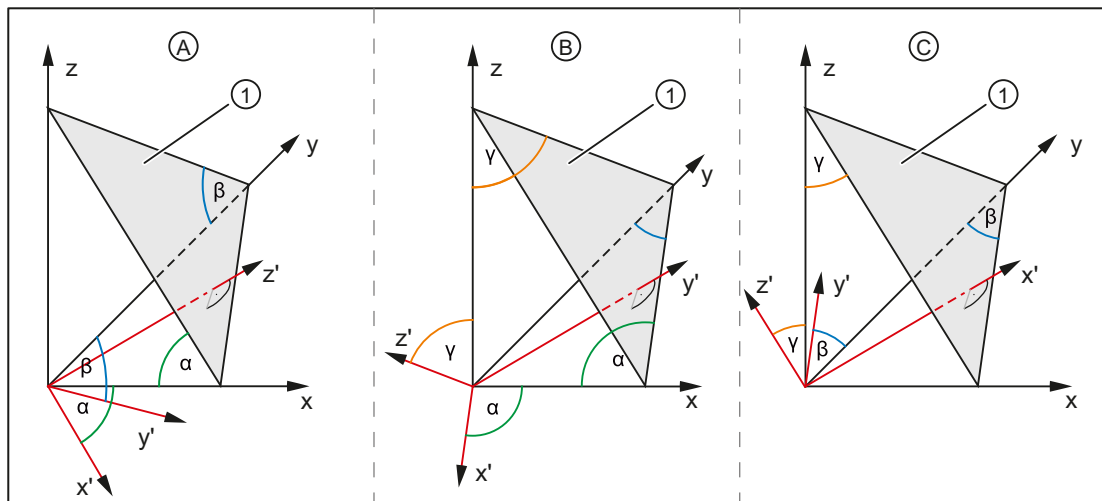
##### Geometry axis identifiers

The following definition is made as an example for the further description:

- 1. geometry axis: X
- 2. 2nd geometry axis: Y
- 3. 3rd geometry axis: Z

As shown in the following figure, the programming of `ROTS Xα Yβ` results in an alignment of the G17 plane of the WCS parallel to the displayed inclined plane. The position of the zero point of the WCS remains unchanged.

The orientation of the rotated WCS is defined so that the first rotated axis lies in the plane formed by this and the 3rd axis of the original coordinate system. In the example: X' is in the original X/Z plane.



① Inclined plane

$\alpha, \beta, \gamma$  Solid angle

- A New G17' plane parallel to the inclined plane:
- 1. rotation of x around y through the angle  $\alpha$
  - 2nd rotation of y around  $x'$  through the angle  $\beta$
- B New G18' plane parallel to the inclined plane:
- 1. rotation of z around x through the angle  $\gamma$
  - 2nd rotation of x around  $z'$  through the angle  $\alpha$
- C New G19' plane parallel to the inclined plane:
- 1. rotation of y around z through the angle  $\beta$
  - 2nd rotation of z around  $y'$  through the angle  $\gamma$

## Syntax

### Requirements

The position of a plane in space is clearly defined by two solid angles. The plane would be "over-defined" by the specification of a third solid angle. It is therefore not permitted.

If only one solid angle is programmed, the rotation of the WCS is identical to ROT, AROT (see Section "Programmable rotation (ROT, AROT, RPL) (Page 316)").

Through the two programmed axes, a plane is specified according to the plane definitions for G17, G18, G19. This defines the sequence of the coordinate axes (1st axis / 2nd axis of the plane) or the sequence of the rotations through the solid angles:

| Plane | 1. 1st axis | 2. Axis |
|-------|-------------|---------|
| G17   | X           | Y       |
| G18   | Z           | X       |
| G19   | Y           | Z       |

## 13.5 Programmable frame rotations with solid angles (ROTS, AROTS, CROTS)

**Alignment of the G17 plane  $\Rightarrow$  solid angle for X and Y**

- 1. Rotation X around Y through the angle  $\alpha$
- 2. Rotation Y around X' through the angle  $\beta$
- Orientation: X' is in the original Z/X plane.

ROTS X< $\alpha$ > Y< $\beta$ >AROTS X< $\alpha$ > Y< $\beta$ >CROTS X< $\alpha$ > Y< $\beta$ >**Alignment of the G18 plane  $\Rightarrow$  solid angle for Z and X**

- 1. 1st rotation: Z around X through the angle  $\gamma$
- 2. Rotation X around Z' through the angle  $\alpha$
- Orientation: Z' is in the original Y/Z plane

ROTS Z< $\gamma$ > X< $\alpha$ >AROTS Z< $\gamma$ > X< $\alpha$ >CROTS Z< $\gamma$ > X< $\alpha$ >**Alignment of the G19 plane  $\Rightarrow$  solid angle for Y and Z**

- 1. Rotation Y around Z through the angle  $\beta$
- 2. Rotation Z around Y' through the angle  $\gamma$
- Orientation: Y' is in the original X/Z plane.

ROTS Y< $\beta$ > Z< $\gamma$ >AROTS Y< $\beta$ > Z< $\gamma$ >CROTS Y< $\beta$ > Z< $\gamma$ >**Meaning**

|                         |                                                                                                                                                                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ROTS:                   | Absolute frame rotations with solid angles,<br>reference frame: Programmable frame \$P_PFRAME                                                                                                                                            |
| AROTS:                  | Additive frame rotations with solid angles,<br>reference frame: Programmable frame \$P_PFRAME                                                                                                                                            |
| CROTS:                  | Absolute frame rotations with solid angles,<br>reference frame: Programmed frame \$P_...                                                                                                                                                 |
| X, Y, Z:                | Geometry axis identifiers (see note above: Geometry axis identifiers)                                                                                                                                                                    |
| A, $\beta$ , $\gamma$ : | Solid angle in relation to the appropriate geometry axis: <ul style="list-style-type: none"> <li>• <math>\alpha \rightarrow X</math></li> <li>• <math>\beta \rightarrow Y</math></li> <li>• <math>\gamma \rightarrow Z</math></li> </ul> |

## 13.6 Programmable scaling factor (SCALE, ASCALE)

SCALE/ASCALE can be used to program up or down scale factors for all path, synchronized, and positioning axes in the direction of the axes specified in each case. This makes it possible, therefore, to take geometrically similar shapes or different shrinkage allowances into account in the programming.

### Syntax

```
SCALE X... Y... Z...
ASCALE X... Y... Z...
```

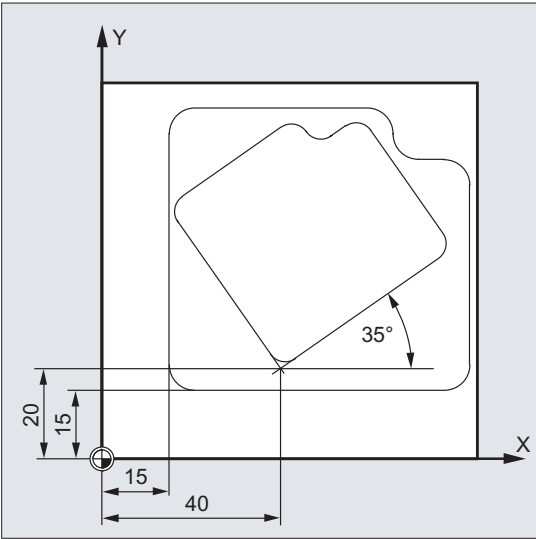
### Note

Each frame operation is programmed in a separate NC block.

### Meaning

|                 |                                                                                                                |
|-----------------|----------------------------------------------------------------------------------------------------------------|
| SCALE:          | Scale up/down absolute in relation to the currently valid coordinate system set with G54 to G57, G505 to G599. |
| ASCALE:         | Scale up/down additive in relation to the currently valid set or programmed coordinate system.                 |
| X... Y... Z...: | Scale factors in the direction of the specified geometry axes.                                                 |

### Example



The pocket occurs twice on this workpiece, but with different sizes and rotated in relation to one another. The machining sequence is stored in the subprogram.

The required workpiece zeroes are set with zero offset and rotation, the contour is scaled down with scaling and the subprogram is then called again.

| Program code      | Comment                             |
|-------------------|-------------------------------------|
| N10 G17 G54       | ; Working plane X/Y, workpiece zero |
| N20 TRANS X15 Y15 | ; Absolute offset                   |
| N30 L10           | ; Machine large pocket              |

| Program code         | Comment                               |
|----------------------|---------------------------------------|
| N40 TRANS X40 Y20    | ; Absolute offset                     |
| N50 AROT RPL=35      | ; Rotation in the plane through 35°   |
| N60 ASCALE X0.7 Y0.7 | ; Scaling factor for the small pocket |
| N70 L10              | ; Machine small pocket                |
| N80G0 X300 Y100 M30  | ; Retraction, end of program          |

## Further information

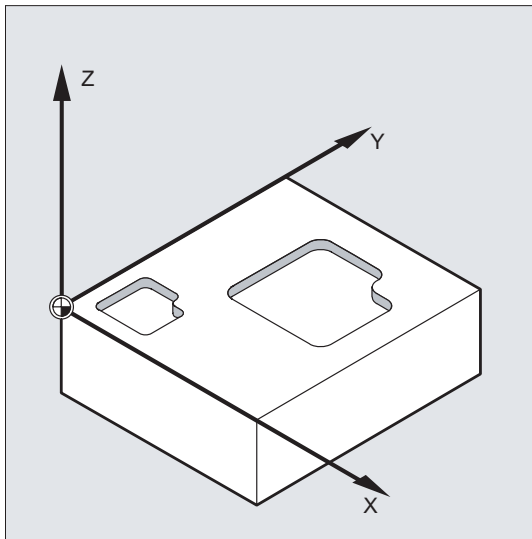
### SCALE X... Y... Z...

You can specify an individual scale factor for each axis, by which the shape is to be reduced or enlarged. The scale refers to the workpiece coordinate system set with G54 to G57, G505 to G599.

#### NOTICE

##### No original frame

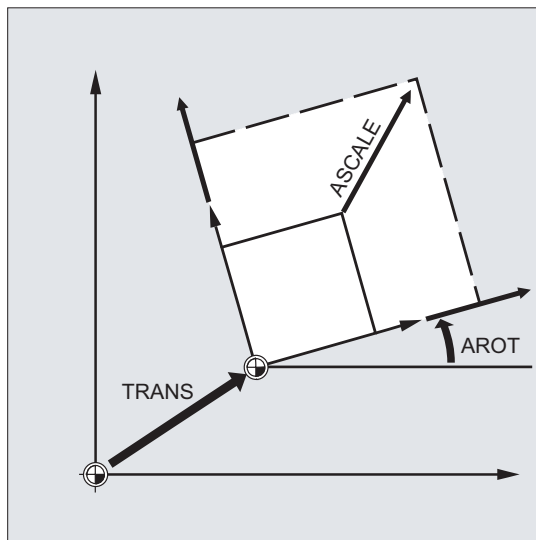
The **SCALE** command resets all frame components of the previously activated programmable frame.



### ASCALE X... Y... Z...

The **ASCALE** command is used to program scale changes to be added to existing frames. In this case, the last valid scale factor is multiplied by the new one.

The currently set or last programmed coordinate system is used as the reference for the scale change.



### Scaling and offset

#### Note

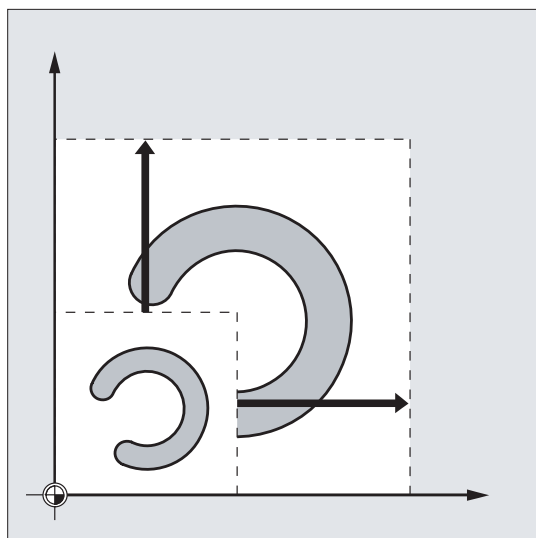
If an offset is programmed with `ATRANS` after `SCALE`, the offset values will also be scaled.

### Different scale factors

#### NOTICE

##### Risk of collision

Please take great care when using different scale factors! Circular interpolations can, for example, only be scaled using identical factors.





**Note**

However, different scale factors can be used specifically to program distorted circles.

## 13.7 Programmable mirroring (MIRROR, AMIRROR)

MIRROR/AMIRROR can be used to mirror workpiece shapes on coordinate axes. All traversing movements programmed after the mirror call (e.g. in the subprogram) are executed with mirroring.

**Syntax**

```
MIRROR X... Y... Z...
AMIRROR X... Y... Z...
```

**Note**

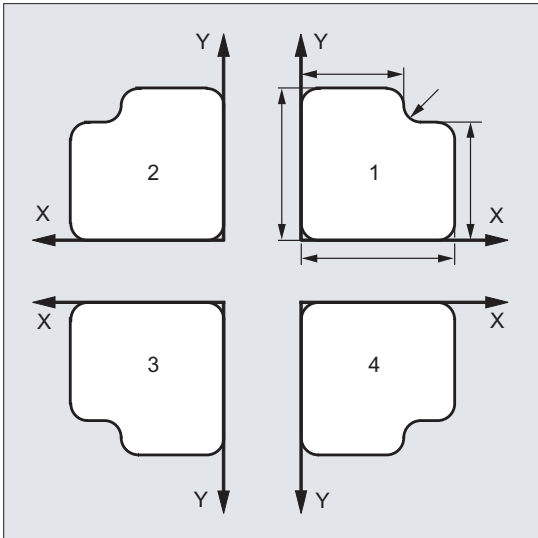
Each frame operation is programmed in a separate NC block.

**Meaning**

|                 |                                                                                                               |
|-----------------|---------------------------------------------------------------------------------------------------------------|
| MIRROR:         | Mirror absolute in relation to the currently valid coordinate system set with G54 to G57, G505 to G599.       |
| AMIRROR:        | Additive mirror image with reference to the currently valid set or programmed coordinate system.              |
| X... Y... Z...: | Geometry axis whose direction is to be changed. The value specified here can be chosen freely, e.g. X0 Y0 Z0. |

Examples

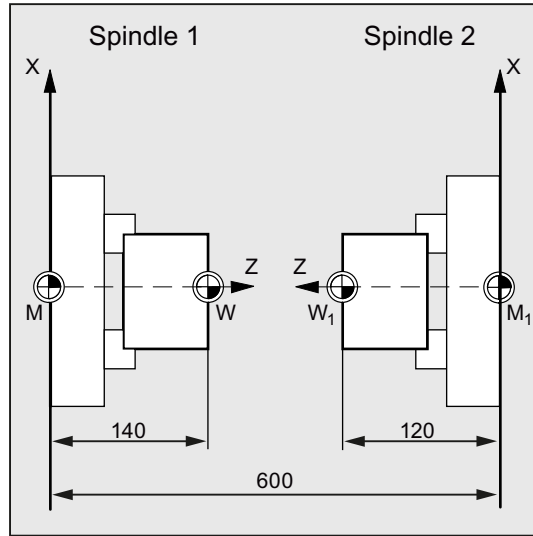
Example 1: Milling



The contour shown here is programmed once as a subprogram. The three other contours are generated using mirroring. The workpiece zero is located at the center of the contours.

| Program code          | Comment                                                                        |
|-----------------------|--------------------------------------------------------------------------------|
| N10 G17 G54           | ; Working plane X/Y, workpiece zero                                            |
| N20 L10               | ; Machine first contour at top right                                           |
| N30 MIRROR X0         | ; Mirror X axis (the direction is changed in X)                                |
| N40 L10               | ; Machine second contour at top left                                           |
| N50 AMIRROR Y0        | ; Mirror Y axis (the direction is changed in Y)                                |
| N60 L10               | ; Machine third contour at bottom left                                         |
| N70 MIRROR Y0         | ; MIRROR resets previous frames. Mirror Y axis (the direction is changed in Y) |
| N80 L10               | ; Machine fourth contour at bottom right                                       |
| N90 MIRROR            | ; Deactivate mirroring                                                         |
| N100 G0 X300 Y100 M30 | ; Retraction, end of program                                                   |

### Example 2: Turning



The actual machining is stored as a subprogram and execution at the respective spindle is implemented by means of mirroring and offsets.

| Program code      | Comment                                       |
|-------------------|-----------------------------------------------|
| N10 TRANS X0 Z140 | ; Zero offset to W                            |
| ...               | ; Machining of the first side with spindle 1  |
| N30 TRANS X0 Z600 | ; Zero offset to spindle 2                    |
| N40 AMIRROR Z0    | ; Mirroring of the Z axis                     |
| N50 ATRANS Z120   | ; Zero offset to W1                           |
| ...               | ; Machining of the second side with spindle 2 |

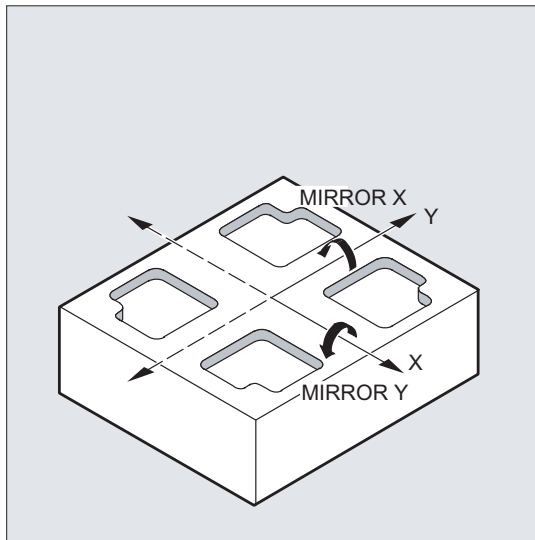
### Further information

#### MIRROR X... Y... Z...

The mirror is programmed by means of an axial change of direction in the selected working plane.

Example: Working plane G17 X/Y

The mirror (on the Y axis) requires a direction change in X and, accordingly, is programmed with MIRROR X0. The contour is then mirrored on the opposite side of the mirror axis Y.



Mirroring is implemented in relation to the currently valid coordinate system set with G54 to G57, G505 to G599.

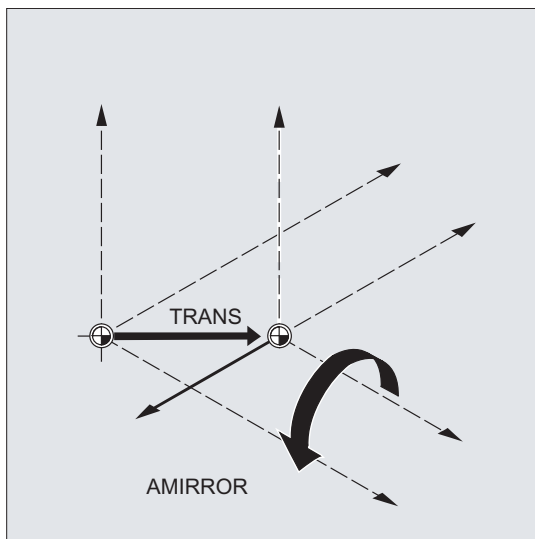
#### NOTICE

##### No original frame

The `MIRROR` command resets all frame components of the previously activated programmable frame.

#### AMIRROR X... Y... Z...

A mirror image, which is to be added to an existing transformation, is programmed with `AMIRROR`. The currently set or last programmed coordinate system is used as the reference.



#### Deactivate mirroring

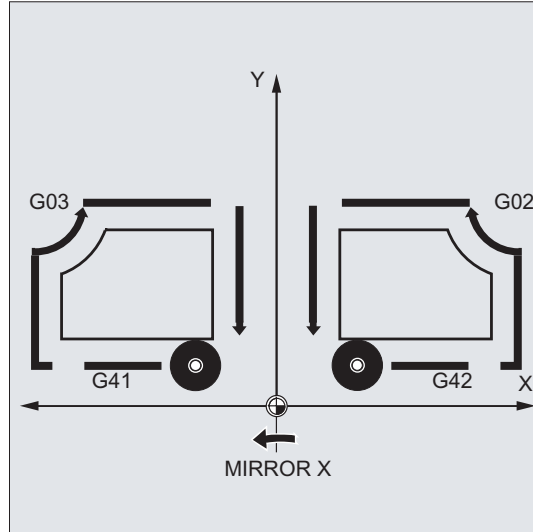
For all axes: `MIRROR` (without axis parameter)

All frame components of the previously programmed frame are reset.

### Tool radius compensation

#### Note

The mirror command causes the control to automatically change the path compensation commands (G41/G42 or G42/G41) according to the new machining direction.



The same applies to the direction of circle rotation (G2/G3 or G3/G2).

#### Note

If you program an additive rotation with `AROT` after `MIRROR`, you may have to work with reversed directions of rotation (positive/negative or negative/positive). Mirrors on the geometry axes are converted automatically by the control into rotations and, where appropriate, mirrors on the mirror axis specified in the machine data. This also applies to settable zero offsets.

### Mirror axis

The axis to be mirrored can be set in machine data:

MD10610 \$MN\_MIRROR\_REF\_AX = <value>

| Value | Meaning                                                                 |
|-------|-------------------------------------------------------------------------|
| 0     | Mirroring is performed around the programmed axis (negation of values). |
| 1     | The reference axis is the X axis.                                       |
| 2     | The reference axis is the Y axis.                                       |
| 3     | The reference axis is the Z axis.                                       |

### Interpreting the programmed values

Machine data is used to specify how the programmed values are to be interpreted:

MD10612 \$MN\_MIRROR\_TOGGLE = &lt;value&gt;

| Value | Meaning                                                                                                                                                                                                                                                           |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | Programmed axis values are not evaluated.                                                                                                                                                                                                                         |
| 1     | Programmed axis values are evaluated: <ul style="list-style-type: none"> <li>For programmed axis values <math>\neq 0</math>, the axis is mirrored if it has not yet been mirrored.</li> <li>For a programmed axis value = 0, mirroring is deactivated.</li> </ul> |

## 13.8

**Frame generation according to tool orientation (TOFRAME, TOROT, PAROT):**

**TOFRAME** generates a rectangular frame whose Z axis coincides with the current tool orientation. This means that the user can retract the tool in the Z direction without risk of collision (e.g. after a tool break in a 5-axis program).

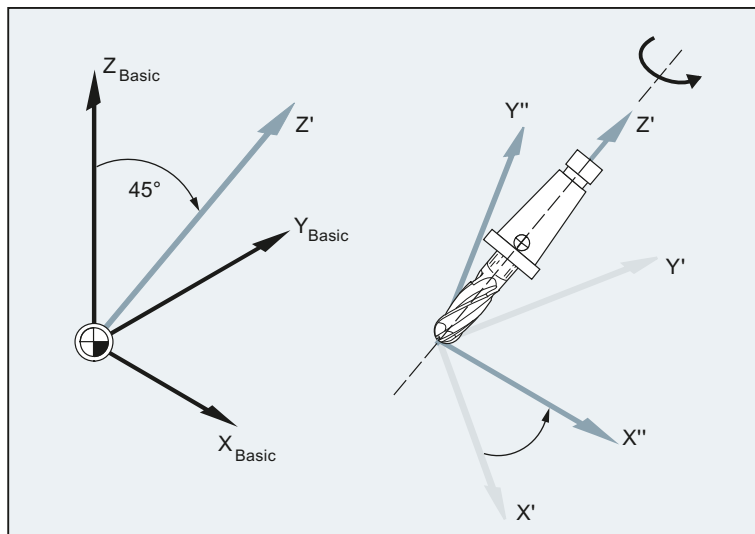
The position of the X and Y axes is determined by the setting in machine data MD21110 \$MC\_X\_AXES\_IN\_OLD\_X\_Z\_PLANE (coordinate system with automatic frame definition). The new coordinate system is either left as generated from the machine kinematics or is turned around the new Z axis additionally so that the new X axis lies in the old Z/X plane (see machine manufacturer's specifications).

The resulting frame describing the orientation is written in the system variable for the programmable frame (\$P\_PFRAME).

**TOROT** only overwrites the rotation component in the programmed frame. All other components remain unchanged.

**TOFRAME** and **TOROT** are designed for milling operations in which G17 (working plane X/Y) is typically active. In the case of turning operations or generally when G18 or G19 is active, however, frames are needed where the X or Y axis matches the orientation of the tool. These frames are programmed with the **TOFRAMEX/TOROTX** or **TOFRAMEY/TOROTY** statements.

**PAROT** aligns the workpiece coordinate system on the workpiece.



## 13.8 Frame generation according to tool orientation (TOFRAME, TOROT, PAROT):

## Syntax

TOFRAME/TOFRAMEZ/TOFRAMEY/TOFRAMEX

...

TOROTOF

TOROT/TOROTZ/TOROTY/TOROTX

...

TOROTOF

PAROT

...

PAROTOF

## Meaning

|           |                                                                                                                                                             |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TOFRAME:  | Align Z axis of the WCS by rotating the frame parallel to the tool orientation                                                                              |
| TOFRAMEZ: | As TOFRAME                                                                                                                                                  |
| TOFRAMEY: | Align Y axis of the WCS by rotating the frame parallel to the tool orientation                                                                              |
| TOFRAMEX: | Align X axis of the WCS by rotating the frame parallel to the tool orientation                                                                              |
| TOROT:    | Align Z axis of the WCS by rotating the frame parallel to the tool orientation<br>The rotation defined with TOROT is the same as that defined with TOFRAME. |
| TOROTZ:   | As TOROT                                                                                                                                                    |
| TOROTY:   | Align Y axis of the WCS by rotating the frame parallel to the tool orientation                                                                              |
| TOROTX:   | Align X axis of the WCS by rotating the frame parallel to the tool orientation                                                                              |
| TOROTOF:  | Deactivate orientation parallel to tool orientation                                                                                                         |
| PAROT:    | Rotate frame to align workpiece coordinate system on workpiece<br>Translations, scaling and mirroring in the active frame remain valid                      |
| PAROTOF:  | The workpiece-specific frame rotation activated with PAROT is deactivated with PAROTOF.                                                                     |

## Note

The TOROT statement ensures consistent programming with active orientable toolholders for each kinematic type.

Just as in the situation for rotatable toolholders, PAROT can be used to activate a rotation of the work table. This defines a frame which changes the position of the workpiece coordinate system in such a way that no compensatory movement is performed on the machine. Language command PAROT is not rejected if no toolholder with orientation capability is active.

**Example**

| Program code             | Comment                                                                                                              |
|--------------------------|----------------------------------------------------------------------------------------------------------------------|
| N100 G0 G53 X100 Z100 D0 |                                                                                                                      |
| N120 TOFRAME             |                                                                                                                      |
| N140 G91 Z20             | ; TOFRAME is included in the calculation, all programmed geometry axis movements refer to the new coordinate system. |
| N160 X50                 |                                                                                                                      |
| ...                      |                                                                                                                      |

**Further information****Assigning axis direction**

If one of the TOFRAMEX, TOFRAMEY, TOROTX, TOROTY statements is programmed instead of TOFRAME/TOFRAMEZ or TOROT/TOROTZ, the axis direction statements listed in this table will apply:

| Statement                          | Tool direction (applied) | Secondary axis (abscissa) | Secondary axis (ordinate) |
|------------------------------------|--------------------------|---------------------------|---------------------------|
| TOFRAME/TOFRAMEZ /<br>TOROT/TOROTZ | Z                        | X                         | Y                         |
| TOFRAMEY/TOROTY                    | Y                        | Z                         | X                         |
| TOFRAMEX/TOROTX                    | X                        | Y                         | Z                         |

**Separate system frame for TOFRAME or TOROT**

The frames resulting from TOFRAME or TOROT can be written in a separate system frame \$P\_TOOLFRAME. For this purpose, bit 3 must be enabled in machine data MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK. The programmable frame remains unchanged. Differences occur when the programmable frame is processed further elsewhere.

**References**

For further information about machines with orientable toolholder, see:

- Programming Manual, Job Planning; Chapter: "Tool orientation"
- Function Manual, Basic Functions; Tool Offset (W1), Chapter: "Toolholder with orientation capability"

**13.9 Deselect frame (G53, G153, SUPA, G500)**

When executing certain processes, such as approaching the tool change point, various frame components have to be defined and suppressed at different times.

Settable frames can either be deactivated modally or suppressed non-modally.

Programmable frames can be suppressed or deleted non-modally.



**Syntax**

G53  
 G153  
 SUPA  
 G500  
 TRANS  
 ROT  
 SCALE  
 MIRROR

**Meaning**

|                         |                                                                                                                                                                                                                          |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G53:                    | Non-modal suppression of all programmable and settable frames                                                                                                                                                            |
| G153:                   | G153 has the same effect as G53 and also suppresses the entire basic frame (\$P_ACTBFRAME).                                                                                                                              |
| SUPA:                   | SUPA has the same effect as G153 and also suppresses: <ul style="list-style-type: none"> <li>• Handwheel offsets (DRF)</li> <li>• Overlaid movements</li> <li>• External zero offset</li> <li>• PRESET offset</li> </ul> |
| G500:                   | Modal deactivation of all settable frames (G54 to G57, G505 to G599) if G500 does not contain a value.                                                                                                                   |
| TRANS ROT SCALE MIRROR: | Without axis details, a deletion of the programmable frames acts.                                                                                                                                                        |

**13.10 Deselecting overlaid movements (DRFOF, CORROF)**

The additive zero offsets set by means of handwheel traversal (DRF offsets) and the position offsets programmed using system variable \$AA\_OFF[<axis>] can be deselected using the part program statements DRFOF and CORROF.

Deselection triggers a preprocessing stop and the position component of the deselected overlaid movement (DRF offset or position offset) is written to the position in the basic coordinate system (in other words, no axes are traversed). The value of system variable \$AA\_IM[<axis>] (current machine coordinate system setpoint of an axis) does not change; the value of system variable \$AA\_IW[<axis>] (current workpiece coordinate system setpoint of an axis) does change, because it now contains the deselected component from the overlaid movement.

**Syntax**

DRFOF  
 CORROF (<axis>,"<character string>"[,<axis>,"<character string>"])

## Meaning

|         |                                                                                                                 |                                                                |                                                |
|---------|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------|
| DRFOF:  | Statement for the deactivation (deselection) of DRF handwheel offsets for all active axes in the channel        |                                                                |                                                |
|         | Effective:                                                                                                      | Modal                                                          |                                                |
| CORROF: | Statement for the deactivation (deselection) of the DRF offset / position offset (\$AA_OFF) for individual axes |                                                                |                                                |
|         | Effective:                                                                                                      | Modal                                                          |                                                |
|         | <axis>:                                                                                                         | Axis identifier (channel, geometry or machine axis identifier) |                                                |
|         | <character string>":                                                                                            | == "DRF":                                                      | DRF offset of axis is deselected               |
|         |                                                                                                                 | == "AA_OFF":                                                   | \$AA_OFF position offset of axis is deselected |

### Note

CORROF is only possible from the part program, not via synchronized actions.

## Examples

### Example 1: Axial deselection of a DRF offset (1)

A DRF offset is generated in the X axis by DRF handwheel traversal. No DRF offsets are operative for any other axes in the channel.

| Program code        | Comment                                     |
|---------------------|---------------------------------------------|
| N10 CORROF(X,"DRF") | ; CORROF has the same effect as DRFOF here. |
| ...                 |                                             |

### Example 2: Axial deselection of a DRF offset (2)

A DRF offset is generated in the X and Y axes by DRF handwheel traversal. No DRF offsets are operative for any other axes in the channel.

| Program code        | Comment                                                                                                                                                     |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N10 CORROF(X,"DRF") | ; Only the DRF offset of the X axis is deselected; the DRF offset of the Y axis is retained (in the case of DRFOF both offsets would have been deselected). |
| ...                 |                                                                                                                                                             |

### Example 3: Axial deselection of a \$AA\_OFF position offset

| Program code                          | Comment                                                   |
|---------------------------------------|-----------------------------------------------------------|
| N10 WHEN TRUE DO \$AA_OFF[X]=10 G4 F5 | ; A position offset == 10 is interpolated for the X axis. |
| ...                                   |                                                           |

| Program code           | Comment                                                                                                                                                                      |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N80 CORROF(X,"AA_OFF") | ; The position offset of the X axis is deselected with: \$AA_OFF[X]=0<br>The X axis is not traversed.<br>The position offset is added to the current position of the X axis. |
| ...                    |                                                                                                                                                                              |

**Example 4: Axial deselection of a DRF offset and a \$AA\_OFF position offset (1)**

A DRF offset is generated in the X axis by DRF handwheel traversal. No DRF offsets are operative for any other axes in the channel.

| Program code                          | Comment                                                                                                               |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| N10 WHEN TRUE DO \$AA_OFF[X]=10 G4 F5 | ; A position offset == 10 is interpolated for the X axis.                                                             |
| ...                                   |                                                                                                                       |
| N70 CORROF(X,"DRF",X,"AA_OFF")        | ; Only the DRF offset and the position offset of the X axis are deselected; the DRF offset of the Y axis is retained. |
| ...                                   |                                                                                                                       |

**Example 5: Axial deselection of a DRF offset and a \$AA\_OFF position offset (2)**

A DRF offset is generated in the X and Y axes by DRF handwheel traversal. No DRF offsets are operative for any other axes in the channel.

| Program code                          | Comment                                                                                                                        |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| N10 WHEN TRUE DO \$AA_OFF[X]=10 G4 F5 | ; A position offset == 10 is interpolated for the X axis.                                                                      |
| ...                                   |                                                                                                                                |
| N70 CORROF(Y,"DRF",X,"AA_OFF")        | ; The DRF offset of the Y axis and the position offset of the X axis are deselected; the DRF offset of the X axis is retained. |
| ...                                   |                                                                                                                                |

**Further information****\$AA\_OFF\_VAL**

Once the position offset has been deselected by means of \$AA\_OFF, system variable \$AA\_OFF\_VAL (integrated distance of axis override) for the corresponding axis will equal zero.

### 13.10 Deselecting overlaid movements (DRFOF, CORROF)

#### **\$AA\_OFF in JOG mode**

Also in JOG mode, if \$AA\_OFF changes, the position offset will be interpolated as an overlaid movement if this function has been enabled via machine data MD 36750 \$MA\_AA\_OFF\_MODE.

#### **\$AA\_OFF in synchronized action**

If a synchronized action which immediately resets \$AA\_OFF (DO \$AA\_OFF[<axis>]=<value>) is active when the position offset is deselected using the CORROF(<axis>, "AA\_OFF") part program statement, then \$AA\_OFF will be deselected and not reset, and alarm 21660 will be signaled. However, if the synchronized action becomes active later, e.g. in the block after CORROF, \$AA\_OFF will remain set and a position offset will be interpolated.

#### **Automatic channel axis exchange**

If an axis that is active in another channel has been programmed for a CORROF, it will be fetched into the channel with an axis replacement (requirement: MD30552 \$MA\_AUTO\_GET\_TYPE > 0) and the position offset and/or the DRF offset deselected.

## Auxiliary function outputs

### Function

The auxiliary function output sends information to the PLC indicating when the NC program needs the PLC to perform specific switching operations on the machine tool. The auxiliary functions are output, together with their parameters, to the PLC interface. The values and signals must be processed by the PLC user program.

### Auxiliary functions

The following auxiliary functions can be transferred to the PLC:

| Auxiliary Function | Address |
|--------------------|---------|
| Tool selection     | T       |
| Tool offset        | D, DL   |
| Feedrate           | F/FA    |
| Spindle speed      | S       |
| M functions        | M       |
| H functions        | H       |

For each function group or single function, machine data is used to define whether the output is triggered **before**, **with** or **after** the traversing motion.

The PLC can be programmed to acknowledge auxiliary function outputs in various ways.

## Properties

Important properties of the auxiliary function are shown in the following overview table:

| Function                                                                                                           | Address extension                        |              | Value                                                 |             |                            | Explanations                                                                                                                                                              | Maximum number per block |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------|-------------------------------------------------------|-------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                                                                                                                    | Meaning                                  | Range        | Range                                                 | Type        | Meaning                    |                                                                                                                                                                           |                          |
| M                                                                                                                  | -                                        | 0 (implicit) | 0 ... 99                                              | INT         | Function                   | The address extension is 0 for the range between 0 and 99.<br>Mandatory without address extension:<br>M0, M1, M2, M17, M30                                                | 5                        |
|                                                                                                                    | Spindle no.                              | 1 - 12       | 1 ... 99                                              | INT         | Function                   | M3, M4, M5, M19, M70 with address extension spindle no. (e.g. M2=5; spindle stop for spindle 2) .<br>Without spindle number, the function applies for the master spindle. |                          |
|                                                                                                                    | Any                                      | 0 - 99       | 100 ... 2147483647                                    | INT         | Function                   | User M function*                                                                                                                                                          |                          |
| S                                                                                                                  | Spindle no.                              | 1 - 12       | 0 ... $\pm 1.8 \cdot 10^{308}$                        | REAL        | Speed                      | Without spindle number, the function applies for the master spindle.                                                                                                      | 3                        |
| H                                                                                                                  | Any                                      | 0 - 99       | 0 ... $\pm 2147483647$<br>$\pm 1.8 \cdot 10^{308}$    | INT<br>REAL | Any                        | Functions have no effect in the NCK; only to be implemented on the PLC.*                                                                                                  | 3                        |
| T                                                                                                                  | Spindle no. (for active tool management) | 1 - 12       | 0 - 32000 (or tool names with active tool management) | INT         | Tool selection             | Tool names are not passed to the PLC interface.                                                                                                                           | 1                        |
| D                                                                                                                  | -                                        | -            | 0 - 12                                                | INT         | Tool offset selection      | D0: Deselection<br>Default setting: D1                                                                                                                                    | 1                        |
| DL                                                                                                                 | Location-dependent offset                | 1 - 6        | 0 ... $\pm 1.8 \cdot 10^{308}$                        | REAL        | Tool fine offset selection | Refers to previously selected D number.                                                                                                                                   | 1                        |
| F                                                                                                                  | -                                        | -            | 0.001 - 999 999.999                                   | REAL        | Path feed-rate             |                                                                                                                                                                           | 6                        |
| FA                                                                                                                 | Axis No.                                 | 1 - 31       | 0.001 - 999 999.999                                   | REAL        | Axial feed-rate            |                                                                                                                                                                           |                          |
| * The meaning of the functions is defined by the machine manufacturer (see machine manufacturer's specifications). |                                          |              |                                                       |             |                            |                                                                                                                                                                           |                          |

## Further information

### Number of function outputs per NC block

Up to 10 function outputs can be programmed in one NC block. Auxiliary functions can also be output from the action component of **synchronized actions**.

**References:**

Function Manual, Synchronized Actions

**Grouping**

The functions described can be grouped together. Group assignment is predefined for some M commands. The acknowledgment behavior can be defined by the grouping.

**High-speed function outputs (QU)**

Functions, which have not been programmed as high-speed outputs, can be defined as high-speed outputs for individual outputs with the keyword `QU`. Program execution continues without waiting for the acknowledgment of the miscellaneous function (the program waits for the transport acknowledgment). This helps avoid unnecessary hold points and interruptions to traversing movements.

**Note**

The appropriate machine data must be set for the "High-speed function outputs" function (→ **machine manufacturer**).

**Function outputs for travel commands**

The transfer of information as well as waiting for the appropriate response takes time and therefore influences the traversing movements.

**High-speed acknowledgment without block change delay**

Block change behavior can be influenced by machine data. When the "without block change delay" setting is selected, the system response with respect to high-speed auxiliary functions is as follows:

| Auxiliary function output  | Response                                                                                                                                                                                                                                                                                                           |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Before</b> the movement | The block transition between blocks with high-speed auxiliary functions occurs <b>without</b> interruption and <b>without</b> a reduction in velocity. The auxiliary function output takes place in the first interpolator clock cycle of the block. The following block is executed with no acknowledgment delay. |
| <b>During</b> the movement | The block transition between blocks with high-speed auxiliary functions occurs <b>without</b> interruption and <b>without</b> a reduction in velocity. The auxiliary function output takes place during the block. The following block is executed with no acknowledgment delay.                                   |
| <b>After</b> the movement  | The movement stops at the end of the block. The auxiliary function output takes place at the end of the block. The following block is executed with no acknowledgment delay.                                                                                                                                       |

**CAUTION****Function outputs in continuous-path mode**

Function outputs **before** the traversing movements interrupt the continuous-path mode (G64/G641) and generate an exact stop for the previous block.

Function outputs **after** the traversing movements interrupt the continuous-path mode (G64/G641) and generate an exact stop for the current block.

**Important:** A wait for an outstanding acknowledgment signal from the PLC can also interrupt the continuous-path mode, e.g. for M command sequences in blocks with extremely short path lengths.

## 14.1 M functions

The M functions initiate switching operations, such as "Coolant ON/OFF" and other functions on the machine.

### Syntax

```
M<value>
M[<address extension>] = <value>
```

### Meaning

|                      |                                                                                                                              |                                   |
|----------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| M:                   | Address for the programming of the M functions.                                                                              |                                   |
| <address extension>: | The extended address notation applies for some M functions (e.g. specification of the spindle number for spindle functions). |                                   |
| <value>:             | Assignment is made to a certain machine function through the value assignment (M function number).                           |                                   |
|                      | Type:                                                                                                                        | INT                               |
|                      | Range of values:                                                                                                             | 0 ... 2147483647 (max. INT value) |

### Predefined M functions

Certain important M functions for program execution are supplied as standard with the control:

| M function | Meaning                               |
|------------|---------------------------------------|
| M0*        | Programmed stop                       |
| M1*        | Optional stop                         |
| M2*        | End of program, main program (as M30) |
| M3         | Spindle clockwise                     |
| M4         | Spindle counter-clockwise             |
| M5         | Spindle stop                          |
| M6         | Tool change (default setting)         |



| M function | Meaning                              |
|------------|--------------------------------------|
| M17*       | End of subprogram                    |
| M19        | Spindle positioning                  |
| M30*       | End of program, main program (as M2) |
| M40        | Automatic gear change                |
| M41        | Gear stage 1                         |
| M42        | Gear stage 2                         |
| M43        | Gear stage 3                         |
| M44        | Gear stage 4                         |
| M45        | Gear stage 5                         |
| M70        | Spindle is switched to axis mode     |

**Note**

Extended address notation cannot be used for the functions marked with \*.

The functions M0, M1, M2, M17 and M30 are always triggered **after** the traversing movement.

**M functions defined by the machine manufacturer**

All free M function numbers can be used by the machine manufacturer, e.g. for switching functions to control the clamping devices or for the activation/deactivation of further machine functions.

**Note**

The functions assigned to the free M function numbers are machine-specific. A certain M function can therefore have a different functionality on another machine.

Refer to the machine manufacturer's specifications for the M functions available on a machine and their functions.

**Examples****Example 1: Maximum number of M functions in the block**

| Program code                      | Comment                                                                                          |
|-----------------------------------|--------------------------------------------------------------------------------------------------|
| N10 S...                          |                                                                                                  |
| N20 X... M3                       | ; M function in the block with axis movement,<br>; spindle accelerates prior to X axis movement. |
| N180 M789 M1767 M100 M102<br>M376 | ; Maximum of five M functions in the block.                                                      |

**Example 2: M function as high-speed output**

| Program code            | Comment                 |
|-------------------------|-------------------------|
| N10 H=QU(735)           | ; Fast output for H735. |
| N10 G1 F300 X10 Y20 G64 |                         |
| N20 X8 Y90 M=QU(7)      | ; Fast output for M7.   |

M7 has been programmed as fast output so that the continuous-path mode (G64) is not interrupted.

**Note**

Only use this function in special cases as, for example, the chronological alignment is changed in combination with other function outputs.

**Further information about the predefined M commands****Programmed stop: M0**

The machining is stopped in the NC block with M0. You can now remove chips, remeasure, etc.

**Programmed stop 1 - optional stop: M1**

M1 can be set via:

- HMI / dialog box "Program Control"
- or
- NC/PLC interface

The program execution of the NC is stopped by the programmed blocks.

**Programmed stop 2 - an auxiliary function associated with M1 with stop in the program execution**

Programmed stop 2 can be set via the HMI / dialog box "Program Control" and allows the technological sequences to be interrupted at any time at the end of the part to be machined. In this way, the operator can interrupt the production, e.g. to remove chip flows.

**End of program: M2, M17, M30**

A program is ended with M2, M17 or M30. If the main program is called from another program (as subprogram), M2/M30 has the same effect as M17 and vice versa, i.e. M17 has the same effect in the main program as M2/M30.

**Spindle functions: M3, M4, M5, M19, M70**

The extended address notation with specification of the spindle number applies for all spindles.

**Example:**

| Program code | Comment                                             |
|--------------|-----------------------------------------------------|
| M2=3         | ; Clockwise spindle rotation for the second spindle |

If an address extension has not been programmed, the function applies for the master spindle.

## Supplementary commands

### 15.1 Output messages (MSG)

Using the `MSG ()` statement, any character string from the part program can be output as message to the operator.

#### Syntax

```
MSG("<Message text>"[,<Execution>])
...
MSG ()
```

#### Meaning

|                 |                                                                                                                                                      |                                                                  |                                                                                                                                                                                |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MSG:            | Predefined subprogram call for output of a message                                                                                                   |                                                                  |                                                                                                                                                                                |
| <message text>: | Any character string to be displayed as message                                                                                                      |                                                                  |                                                                                                                                                                                |
|                 | Type:                                                                                                                                                | STRING                                                           |                                                                                                                                                                                |
|                 | Maximum length:                                                                                                                                      | 124 characters; the display takes up two lines (2*62 characters) |                                                                                                                                                                                |
|                 | By using the link operator "<<", variables can also be output in the message text.                                                                   |                                                                  |                                                                                                                                                                                |
| <Execution>:    | Parameter to define the time when the message is written (optional)                                                                                  |                                                                  |                                                                                                                                                                                |
|                 | Type:                                                                                                                                                | INT                                                              |                                                                                                                                                                                |
|                 | Value:                                                                                                                                               | 0 (basic setting)                                                | To write the message, a dedicated main run block is not generated. This is realized in the next NC block that can be executed. Active continuous-path mode is not interrupted. |
|                 |                                                                                                                                                      | 1                                                                | To write the message, a dedicated main run block is generated. Active continuous-path mode is interrupted.                                                                     |
| MSG () :        | The actual message can be deleted by programming MSG () without message text. If not deleted, the display remains until the next message is present. |                                                                  |                                                                                                                                                                                |

#### Note

If the message is to be output in the language active at the user interface, then the user requires information about the language that is currently set at the HMI. This information can be interrogated in the part program and in the synchronized actions using system variable `$AN_LANGUAGE_ON_HMI` (see "Currently set language in the HMI (Page 508)").

## Examples

## Example 1: Output/delete message

| Program code                    | Comment                                                                        |
|---------------------------------|--------------------------------------------------------------------------------|
| N10 G91 G64 F100                | ; Continuous path mode                                                         |
| N20 X1 Y1                       |                                                                                |
| N... X... Y...                  |                                                                                |
| N20 MSG ("Machining part 1")    | ; The message is first output with N30.<br>; continuous-path mode is retained. |
| N30 X... Y...                   |                                                                                |
| N... X... Y...                  |                                                                                |
| N400 X1 Y1                      |                                                                                |
| N410 MSG ("Machining part 2",1) | ; The message is output with N410.<br>; continuous-path mode is interrupted.   |
| N420 X1 Y1                      |                                                                                |
| N... X... Y...                  |                                                                                |
| N900 MSG ()                     | ; Delete message.                                                              |

## Example 2: Message text with variable

| Program code                                | Comment                                 |
|---------------------------------------------|-----------------------------------------|
| N10 R12=\$AA_IW [X]                         | ; Actual position of the X axis in R12. |
| N20 MSG ("Check position of X axis"<<R12<<) | ; Output message with variable R12.     |
| ...                                         |                                         |
| N90 MSG ()                                  | ; Clear message from N20.               |

## 15.2 Writing string in OPI variable (WRTPR)

Using the `WRTPR()` function, you can write any character string from the part program into the OPI variable `progProtText`.

## Syntax

`WRTPR(<character string>[,<execution>])`

## Meaning

|                     |                                                                                        |                |
|---------------------|----------------------------------------------------------------------------------------|----------------|
| WRTPR:              | Function to output a character string.                                                 |                |
| <character string>: | Any character string, which is written to the OPI variable <code>progProtText</code> . |                |
|                     | Type:                                                                                  | STRING         |
|                     | Maximum length:                                                                        | 128 characters |
| <Execution>:        | Optional parameters to define the instant in time when the string is written.          |                |
|                     | Range of values:                                                                       | 0, 1           |

|  |                |                                                                                                                                                                               |
|--|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Default value: | 0                                                                                                                                                                             |
|  | <b>Value</b>   | <b>Meaning</b>                                                                                                                                                                |
|  | 0              | To write the string, a dedicated main run block is not generated. This is realized in the next NC block that can be executed. Active continuous-path mode is not interrupted. |
|  | 1              | To write the string, a dedicated main run block is generated. Active continuous-path mode is interrupted.                                                                     |

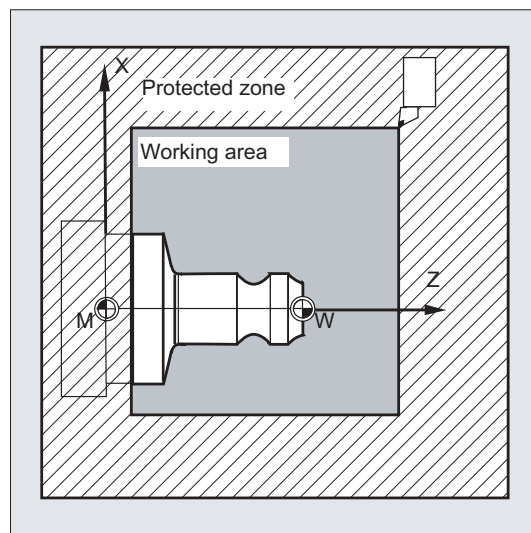
## Examples

| Program code       | Comment                                                                         |
|--------------------|---------------------------------------------------------------------------------|
| N10 G91 G64 F100   | ; continuous path mode                                                          |
| N20 X1 Y1          |                                                                                 |
| N30 WRTPR("N30")   | ; The string "N30" is first written to N40.<br>; Continuous-path mode is kept.  |
| N40 X1 Y1          |                                                                                 |
| N50 WRTPR("N50",1) | ; The string "N50" is written to N50.<br>; Continuous-path mode is interrupted. |
| N60 X1 Y1          |                                                                                 |

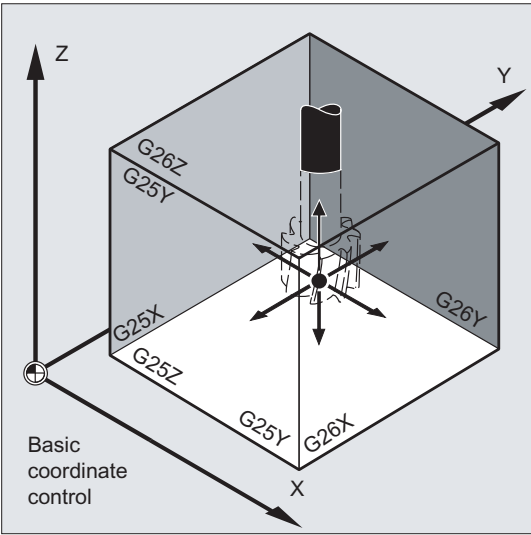
## 15.3 Working area limitation

### 15.3.1 Working area limitation in BCS (G25/G26, WALIMON, WALIMOF)

G25/G26 limits the working area (working field, working space) in which the tool can traverse. The areas outside the working area limitations defined with G25/G26 are inhibited for any tool motion.



The coordinates for the individual axes apply in the basic coordinate system:



The working area limitation for all validated axes must be programmed with the `WALIMON` command. The `WALIMOF` command deactivates the working area limitation. `WALIMON` is the default setting. Therefore, it only has to be programmed if the working area limitation has been disabled beforehand.

Syntax

```
G25 X...Y...Z...
G26 X...Y...Z...
WALIMON
WALIMOF
```

Meaning

|                 |                                                                                                                              |
|-----------------|------------------------------------------------------------------------------------------------------------------------------|
| G25:            | <b>Lower</b> working area limitation<br>Assignment of values in channel axes in the basic coordinate system                  |
| G26:            | <b>Upper</b> working area limitation<br>Assignment of values in channel axes in the basic coordinate system                  |
| X... Y... Z...: | Lower or upper working area limits for individual channel axes<br>The limits specified refer to the basic coordinate system. |
| WALIMON:        | Switch working area limitation <b>on</b> for all axes                                                                        |
| WALIMOF:        | Switch working area limitation <b>off</b> for all axes                                                                       |

In addition to programming values using `G25/G26`, values can also be entered using axis-specific setting data:

```
SD43420 $SA_WORKAREA_LIMIT_PLUS (Working area limitation plus)
SD43430 $SA_WORKAREA_LIMIT_MINUS (Working area limitation minus)
```

Activating and deactivating the working area limitation, parameterized using SD43420 and SD43430, are carried out for a specific direction using the axis-specific setting data that becomes immediately effective:

SD43400 \$SA\_WORKAREA\_PLUS\_ENABLE (Working area limitation active in the positive direction)

SD43410 \$SA\_WORKAREA\_MINUS\_ENABLE (Working area limitation active in the negative direction)

Using the direction-specific activation/deactivation, it is possible to limit the working range for an axis in just one direction.

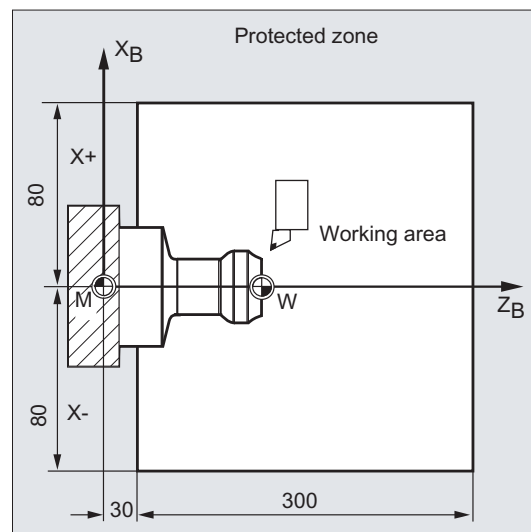
#### Note

The programmed working area limitation, programmed with G25/G26, has priority and overwrites the values entered in SD43420 and SD43430.

#### Note

G25/G26 can also be used to program limits for spindle speeds at the address S. For more information see "Programmable spindle speed limitation (G25, G26) (Page 95)".

### Example



Using the working area limitation G25/26, the working area of a lathe is limited so that the surrounding devices and equipment - such as revolver, measuring station, etc. are protected against damage.  
Default setting: WALIMON

| Program code       | Comment                                                     |
|--------------------|-------------------------------------------------------------|
| N10 G0 G90 F0.5 T1 |                                                             |
| N20 G25 X-80 Z30   | ; Define the lower limit for the individual coordinate axes |
| N30 G26 X80 Z330   | ;Define the upper limit                                     |
| N40 L22            | ;Cutting program                                            |
| N50 G0 G90 Z102 T2 | ;To tool change location                                    |

| Program code    | Comment                             |
|-----------------|-------------------------------------|
| N60 X0          |                                     |
| N70 WALIMOF     | ;Deactivate working area limitation |
| N80 G1 Z-2 F0.5 | ;Drill                              |
| N90 G0 Z200     | ;Back                               |
| N100 WALIMON    | ; Switch on working area limitation |
| N110 X70 M30    | ; End of program                    |

## Further information

### Reference point at the tool

When tool length offset is active, the tip of the tool is monitored as reference point, otherwise it is the toolholder reference point.

Consideration of the tool radius must be activated separately. This is done using channel-specific machine data:

MD21020 \$MC\_WORKAREA\_WITH\_TOOL\_RADIUS

If the tool reference point lies outside the working area defined by the working area limitation or if this area is left, the program sequence is stopped.

### Note

If transformations are active, the tool data taken into consideration (tool length and tool radius) can deviate from the described behavior.

### References:

Function Manual, Basic Functions; Axis Monitoring, Protection Zones (A3),  
Section: "Monitoring the working area limitation"

### Programmable working area limitation, G25/G26

An upper (G26) and a lower (G25) working area limitation can be defined for each axis. These values are effective immediately and remain effective for the corresponding MD setting (→ MD10710 \$MN\_PROG\_SD\_RESET\_SAVE\_TAB) after RESET and after being powered-up again.

### Note

The CALCPOSI subprogram is described in the Job Planning Programming Manual Using this subprogram before any traversing motion is made, it can be checked as to whether the predicted path is moved through taking into account the working area limits and/or the protection zones.



### 15.3.2 Working area limitation in WCS/SZS (WALCS0 ... WALCS10)

The "working area limitation in WCS/ENS" enables a channel-specific, flexible workpiece-specific limitation of the traversing range of the channel axes in the workpiece coordinate system (WCS) or settable zero system (SZS). It is intended mainly for use in conventional lathes.

#### Requirement

The channel axes must be homed.

#### Working area limitation group

In order that the axis-specific working area limits do not have to be rewritten for all channel axes when switching axis assignments, e.g. when switching transformations or the active frame on/off, working area limitation groups are available.

A working area limitation group comprises the following data:

- Working area limits for all channel axes
- Reference system of the working area limitation

#### Syntax

```
...
$P_WORKAREA_CS_COORD_SYSTEM[<group>] = <value>
$P_WORKAREA_CS_PLUS_ENABLE[<group>,<channel axis name>]=<value>
$P_WORKAREA_CS_LIMIT_PLUS[<group>,<channel axis name>]=<value>
$P_WORKAREA_CS_MINUS_ENABLE[<group>,<channel axis name>]=<value>
$P_WORKAREA_CS_LIMIT_MINUS[<group>,<channel axis name>]=<value>
...
WALCS<n>
...
WALCS0
```

## Meaning

|                                                  |                                                                                                         |                                                                                                                                                       |                            |  |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--|
| \$P_WORKAREA_CS_COORD_SYSTEM[<n>]=<value>:       | The coordinate system to which the working area limitation group refers                                 |                                                                                                                                                       |                            |  |
|                                                  | <n>:                                                                                                    | Number of the working area limitation group                                                                                                           |                            |  |
|                                                  |                                                                                                         | Type:                                                                                                                                                 | INT                        |  |
|                                                  |                                                                                                         | Range of values:                                                                                                                                      | 1 ... 10                   |  |
|                                                  |                                                                                                         | <b>Note:</b><br>The actual available number of working area limitation groups depends on the configuring (→ see details of the machine manufacturer). |                            |  |
|                                                  | <value>:                                                                                                | Value of the type INT                                                                                                                                 |                            |  |
|                                                  | 1                                                                                                       | Workpiece coordinate system (WCS)                                                                                                                     |                            |  |
|                                                  | 3                                                                                                       | Settable zero system (SZS)                                                                                                                            |                            |  |
| \$P_WORKAREA_CS_PLUS_ENABLE [<n>,<Ax>]=<value>:  | Enable the working area limitation in the <b>positive</b> axis direction for the specified channel axis |                                                                                                                                                       |                            |  |
| \$P_WORKAREA_CS_MINUS_ENABLE [<n>,<Ax>]=<value>: | Enable the working area limitation in the <b>negative</b> axis direction for the specified channel axis |                                                                                                                                                       |                            |  |
|                                                  | <n>:                                                                                                    | Number of the working area limitation group                                                                                                           |                            |  |
|                                                  | <Ax>:                                                                                                   | Channel axis name                                                                                                                                     |                            |  |
|                                                  | <value>:                                                                                                | Value of the type BOOL                                                                                                                                |                            |  |
|                                                  |                                                                                                         | 0 (FALSE)                                                                                                                                             | This has not been released |  |
|                                                  |                                                                                                         | 1 (TRUE)                                                                                                                                              | Enable                     |  |
| \$P_WORKAREA_CS_LIMIT_PLUS [<n>,<Ax>]=<value>:   | Working area limitation in the <b>positive</b> direction of the specified channel axis                  |                                                                                                                                                       |                            |  |
| \$P_WORKAREA_CS_LIMIT_MINUS [<n>,<Ax>]=<value>:  | Working area limitation in the <b>negative</b> direction of the specified channel axis                  |                                                                                                                                                       |                            |  |
|                                                  | <n>:                                                                                                    | Number of the working area limitation group                                                                                                           |                            |  |
|                                                  | <Ax>:                                                                                                   | Channel axis name                                                                                                                                     |                            |  |
|                                                  | <value>:                                                                                                | Value of the type REAL                                                                                                                                |                            |  |
| WALCS<n>:                                        | Activation of the working area limitations of group <n>                                                 |                                                                                                                                                       |                            |  |
| WALCS0:                                          | Deactivation of the working area limits active in the channel                                           |                                                                                                                                                       |                            |  |

## Example

Three axes are defined in the channel: X, Y and Z

A working area limitation group No. 2 is to be defined and then activated in which the axes are to be limited in the WCS according to the following specifications:

- X axis in the plus direction: 10 mm
- X axis in the minus direction: No limitation
- Y axis in the plus direction: 34 mm
- Y axis in the minus direction: -25 mm
- Z axis in the plus direction: No limitation
- Z axis in the minus direction: -600 mm

| Program code                                | Comment                                                                              |
|---------------------------------------------|--------------------------------------------------------------------------------------|
| ...                                         |                                                                                      |
| N51 \$P_WORKAREA_CS_COORD_SYSTEM[2]=1       | ; The working area limitation of working area limitation group 2 applies in the WCS. |
| N60 \$P_WORKAREA_CS_PLUS_ENABLE[2,X]=TRUE   |                                                                                      |
| N61 \$P_WORKAREA_CS_LIMIT_PLUS[2,X]=10      |                                                                                      |
| N62 \$P_WORKAREA_CS_MINUS_ENABLE[2,X]=FALSE |                                                                                      |
| N70 \$P_WORKAREA_CS_PLUS_ENABLE[2,Y]=TRUE   |                                                                                      |
| N73 \$P_WORKAREA_CS_LIMIT_PLUS[2,Y]=34      |                                                                                      |
| N72 \$P_WORKAREA_CS_MINUS_ENABLE[2,Y]=TRUE  |                                                                                      |
| N73 \$P_WORKAREA_CS_LIMIT_MINUS[2,Y]=-25    |                                                                                      |
| N80 \$P_WORKAREA_CS_PLUS_ENABLE[2,Z]=FALSE  |                                                                                      |
| N82 \$P_WORKAREA_CS_MINUS_ENABLE[2,Z]=TRUE  |                                                                                      |
| N83 \$P_WORKAREA_CS_LIMIT_PLUS[2,Z]=-600    |                                                                                      |
| ...                                         |                                                                                      |
| N90 WALCS2                                  | ; Activate working area limitation group 2.                                          |
| ...                                         |                                                                                      |

## Further information

### Effectivity

The working area limitation with WALCS1 - WALCS10 acts independently of the working area limitation with WALIMON. If both functions are active, that limit becomes effective which the axis motion first reaches.

### Reference point at the tool

Taking into account the tool data (tool length and tool radius) and therefore the reference point at the tool when monitoring the working area limitation corresponds to the behavior for the working area limitation with WALIMON.

## 15.4 Reference point approach (G74)

When the machine has been powered up (where incremental position measuring systems are used), all of the axis slides must approach their reference mark. Only then can traversing movements be programmed.

The reference point can be approached in the NC program with G74.

## Syntax

G74 X1=0 Y1=0 Z1=0 A1=0 ... ; Programmed in a separate NC block

## Meaning

|                      |                                                                                                                |
|----------------------|----------------------------------------------------------------------------------------------------------------|
| G74:                 | G function call for reference point approach                                                                   |
| X1=0 Y1=0 Z1=0 ... : | The specified machine axis address X1, Y1, Z1 ... for <b>linear axes</b> is approached as the reference point. |
| A1=0 B1=0 C1=0 ... : | The specified machine axis address A1, B1, C1 ... for <b>rotary axes</b> is approached as the reference point. |

### Note

A transformation must not be programmed for an axis which is to approach the reference point with G74.

The transformation is deactivated with command TRAFOOF.

## Example

When the measuring system is changed, the reference point is approached and the workpiece zero point is set up.

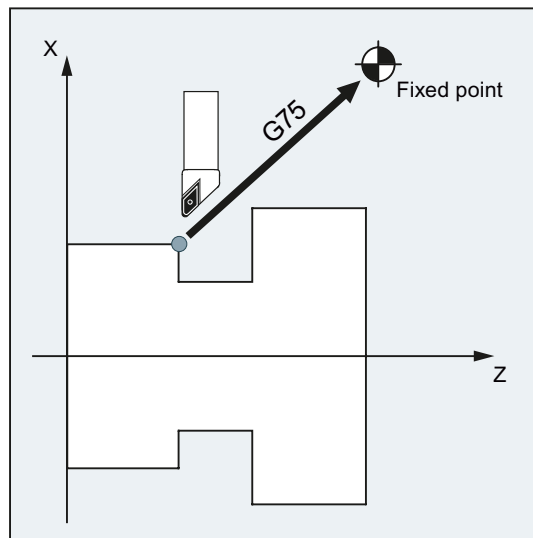
| Program code                | Comment                                                   |
|-----------------------------|-----------------------------------------------------------|
| N10 SPOS=0                  | ;Spindle in position control                              |
| N20 G74 X1=0 Y1=0 Z1=0 C1=0 | ;Reference point approach for linear axes and rotary axes |
| N30 G54                     | ; Zero offset                                             |
| N40 L47                     | ;Cutting program                                          |
| N50 M30                     | ; End of program                                          |

## 15.5 Approaching a fixed point (G75)

The non-modal command G75 can be used to move axes individually and independently of one another to fixed points in the machine space, e.g. to tool change points, loading points, pallet change points, etc.

The fixed points are positions in the machine coordinate system which are stored in the machine data (MD30600 \$MA\_FIX\_POINT\_POS[n]). A maximum of four fixed points can be defined for each axis.

The fixed points can be approached from every NC program irrespective of the current tool or workpiece positions. An internal preprocessing stop is executed prior to moving the axes.



## Requirements

The following requirements must be satisfied to approach fixed points with G75:

- The fixed-point coordinates must have been calculated exactly and written to machine data.
- The fixed points must be located within the valid traversing range (→ note the software limit switch limits!)
- The axes to be traversed must be referenced.
- No tool radius compensation must be active.
- A kinematic transformation may not be active.
- None of the axes to be traversed must be involved in active transformation.
- None of the axes to be traversed must be a following axis in an active coupling.
- None of the axes to be traversed must be an axis in a gantry grouping.
- Compile cycles must not activate motion components.

## Syntax

G75 <axis name><axis position> ... FP=<n>

## Meaning

|                  |                                                                                                    |
|------------------|----------------------------------------------------------------------------------------------------|
| G75:             | Fixed point approach                                                                               |
| <axis name>:     | Name of the machine axis to be traversed to the fixed point<br>All axis identifiers are permitted. |
| <axis position>: | The position value has no significance. A value of "0" is, therefore, usually specified.           |

## 15.5 Approaching a fixed point (G75)

|      |                                                                                                                                                                |                    |            |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------|
| FP=: | Fixed point that is to be approached                                                                                                                           |                    |            |
|      | <n>:                                                                                                                                                           | Fixed point number |            |
|      |                                                                                                                                                                | Range of values:   | 1, 2, 3, 4 |
|      | <b>Note:</b><br>In the absence of FP=<n> or a fixed point number, or if FP=0 has been programmed, this is interpreted as FP=1 and fixed point 1 is approached. |                    |            |

**Note**

Multiple axes can be programmed in one G75 block. The axes are then traversed simultaneously to the specified fixed point.

**Note**

The value of the address FP must not be greater than the number of fixed points specified for each programmed axis (MD30610 \$MA\_NUM\_FIX\_POINT\_POS).

**Example**

For a tool change, axes X (= AX1) and Z (= AX3) need to move to the fixed machine axis position 1 where X = 151.6 and Z = -17.3.

Machine data:

- MD30600 \$MA\_FIX\_POINT\_POS[AX1,0] = 151.6
- MD30600 \$MA\_FIX\_POINT[AX3,0] = 17.3

NC program:

| Program code           | Comment                                                                                                                                                                                                                                                                                                               |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ...                    |                                                                                                                                                                                                                                                                                                                       |
| N100 G55               | ; Activate settable zero offset.                                                                                                                                                                                                                                                                                      |
| N110 X10 Y30 Z40       | ; Approach positions in the WCS.                                                                                                                                                                                                                                                                                      |
| N120 G75 X0 Z0 FP=1 M0 | ; The X axis moves to 151.6<br>; and the Z axis moves to 17.3 (in the MCS).<br>; Each axis travels at its maximum velocity.<br>; No additional movements are permitted to be active in this block.<br>; A stop is inserted here so that after reaching<br>; the end positions,<br>; no additional motion takes place. |
| N130 X10 Y30 Z40       | ; The position of N110 is approached again.<br>; The zero offset is reactivated.                                                                                                                                                                                                                                      |
| ...                    |                                                                                                                                                                                                                                                                                                                       |

**Note**

If the "Tool management with magazines" function is active, the auxiliary function `T...` or `M...` (typically `M6`) will not be sufficient to trigger a block change inhibit at the end of `G75` motion.

Reason: If "Tool management with magazines" is active, auxiliary functions for tool change are not output to the PLC.

---

**Further information****G75**

The axes are traversed as machine axes in rapid traverse. The motion is mapped internally using the "SUPA" (suppress all frames) and "G0 RTLIOF" (rapid traverse motion with single-axis interpolation) functions.

If the conditions for "RTLIOF" (single-axis interpolation) are not met, the fixed point is approached as a path.

When the fixed point is reached, the axes come to a standstill within the "Exact stop fine" tolerance window.

**Parameterizable dynamic response for G75**

The required dynamic response mode can be set via the following machine data for positioning movements to fixed-point positions (`G75`):

MD18960 \$MN\_POS\_DYN\_MODE (type of positioning axis dynamic response)

**References**

Function Manual, Basic Functions, Chapter "Acceleration (B2)" > "Functions" > "Jerk limiting for single axis interpolation (SOFTA) (axis-specific)"

**Additional axis movements**

The following additional axis movements are taken into account at the instant in time at which the `G75` block is interpolated:

- External zero offset
- DRF
- Synchronization offset (\$AA\_OFF)

After this, the additional axis movements are not permitted to change until the end of traversing is reached by the `G75` block.

Additional movements following interpretation of the `G75` block will offset the approach to the fixed point accordingly.

The following additional movements are not taken into account, irrespective of the point at which interpolation takes place, and will offset the target position accordingly:

- Online tool offset
- Additional movements from compile cycles in the BCS and machine coordinate system

### **Active frames**

All active frames are ignored. Traversing is performed in the machine coordinate system.

### **Working area limitation in the workpiece coordinate system/SZS**

Coordinate-system-specific working area limitation (WALCS0 ... WALCS10) is not effective in the block with G75. The destination point is monitored as the starting point of the following block.

### **Axis/Spindle movements with POSA/SPOSA**

If programmed axes/spindles were previously traversed with POSA or SPOSA, these movements will be completed first before the fixed point is approached.

### **Spindle functions in the G75 block**

If the spindle is excluded from "fixed-point approach", then additional spindle functions (e.g. positioning with SPOS/SPOSA) can be programmed in the G75.

### **Modulo axes**

In the case of modulo axes, the fixed point is approached along the shortest distance.

### **References**

For further information about "Fixed-point approach", see:

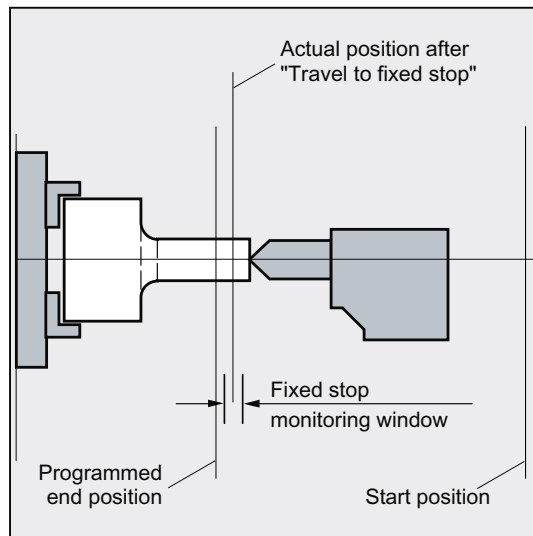
Function Manual, Extended Functions; Manual and Handwheel Travel (H1), Section: "Fixed-point approach in JOG"



## 15.6 Travel to fixed stop (FXS, FXST, FXSW)

### Function

The "Travel to fixed stop" function can be used to establish defined forces for clamping workpieces, such as those required for tailstocks, quills and grippers. The function can also be used for the approach of mechanical reference points.



With sufficiently reduced torque, it is also possible to perform simple measurement operations without connecting a probe. The "travel to fixed stop" function can be implemented for axes as well as for spindles with axis-traversing capability.

### Syntax

```
FXS[<axis>]=...
FXST[<axis>]=...
FXSW[<axis>]=...
FXS[<axis>]=... FXST[<axis>]=...
FXS[<axis>]=... FXST[<axis>]=... FXSW[<axis>]=...
```

### Meaning

|         |                                                                                |
|---------|--------------------------------------------------------------------------------|
| FXS:    | Command for activation and deactivation of the "Travel to fixed stop" function |
|         | FXS[<axis>]=1:      Activate function                                          |
|         | FXS[<axis>]=0:      Deactivate function                                        |
| FXST:   | Optional command for setting the clamping torque                               |
|         | Specified as % of the maximum drive torque                                     |
| FXSW:   | Optional command for setting the window width for the fixed stop monitoring    |
|         | Specified in mm, inches or degrees                                             |
| <axis>: | Machine axis name                                                              |
|         | Machine axes (X1, Y1, Z1, etc.) are programmed                                 |

**Note**

The commands `FXS`, `FXST` and `FXSW` are modal.

The programming of `FXST` and `FXSW` is optional: If no parameter is specified, the last programmed value or the value set in the relevant machine data applies.

**Activate travel to fixed stop: `FXS[<axis>] = 1`**

The movement to the destination point can be described as a path or positioning axis movement. With positioning axes, the function can be performed across block boundaries.

Travel to fixed stop can be performed simultaneously for several axes and parallel to the movement of other axes. The fixed stop must be located between the start and end positions.

**NOTICE**

**Risk of collision**

It is not permissible to program a new position for an axis if the "Travel to fixed stop" function has already been activated for an axis/spindle.

Spindles must be switched to position-controlled mode before the function is selected.

Example:

| Program code                                      | Comment                                                                                                  |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| X250 Y100 F100 FXS[X1]=1 FXST[X1]=12.3 FXSW[X1]=2 | ; Axis X1 travels with feedrate F100 (specification optional) to target position X=250 mm.               |
|                                                   | The clamping torque is 12.3% of the maximum drive torque, monitoring is performed in a 2 mm wide window. |
| ...                                               |                                                                                                          |

**Deactivate travel to fixed stop: `FXS[<axis>] = 0`**

Deselection of the function triggers a preprocessing stop.

The block with `FXS [<axis>]=0` may and should contain traversing movements.

#### NOTICE

##### Risk of collision

The traversing movement to the retraction position must move away from the fixed stop, otherwise damage to the stop or to the machine may result.

The block change takes place when the retraction position has been reached. If no retraction position is specified, the block change takes place immediately after the torque limit has been deactivated.

Example:

| Program code                      | Comment                                                                                               |
|-----------------------------------|-------------------------------------------------------------------------------------------------------|
| X200 Y400 G01 G94 F2000 FXS[X1]=0 | ; Axis X1 is retracted from the fixed stop to position X = 200 mm. All other parameters are optional. |
| ...                               |                                                                                                       |

## Clamping torque (FXST) and monitoring window (FXSW)

Any programmed torque limiting `FXST` is effective from the block start, i.e. the fixed stop is also approached at a reduced torque. `FXST` and `FXSW` can be programmed and changed in the part program at any time. The changes take effect before traversing movements in the same block.

#### NOTICE

##### Risk of collision

Programming of a new fixed stop monitoring window causes a change not only in the window width, but also in the reference point for the center of the window if the axis has moved prior to reprogramming. The actual position of the machine axis when the window is changed is the new window center point.

The window must be selected such that only a breakaway from the fixed stop causes the fixed stop monitoring to respond.

## Further information

### Rise ramp

A rate of rise ramp for the new torque limit can be defined in MD to prevent any abrupt changes to the torque limit setting (e.g. insertion of a quill).

### Alarm suppression

The fixed stop alarm can be suppressed for applications by the part program by masking the alarm in a machine data item and activating the new MD setting with `NEW_CONF`.

### Activation

## 15.6 Travel to fixed stop (FXS, FXST, FXSW)

The commands for travel to fixed stop can be called from synchronized actions or technology cycles. They can be activated without initiation of a motion, the torque is limited instantaneously. As soon as the axis is moved via a setpoint, the limit stop monitor is activated.

### Activation from synchronized actions

Example:

If the expected event (\$R1) occurs and travel to fixed stop is not yet running, FXS should be activated for axis Y. The torque must correspond to 10% of the rated torque value. The width of the monitoring window is set to the default.

---

#### Program code

```
N10 IDS=1 WHENEVER (($R1=1) AND ($AA_FXS[Y]==0)) DO $R1=0 FXS[Y]=1
FXST[Y]=10
```

---

The normal part program must ensure that \$R1 is set at the desired point in time.

### Deactivation from synchronized actions

Example:

If an anticipated event (\$R3) has occurred and the status "Limit stop contacted" (system variable \$AA\_FXS) is reached, then FXS must be deselected.

---

#### Program code

```
IDS=4 WHENEVER (($R3==1) AND ($AA_FXS[Y]==1)) DO FXS[Y]=0
FA[Y]=1000 POS[Y]=0
```

---

### Fixed stop reached

When the fixed stop has been reached:

- The distance-to-go is deleted and the position setpoint is corrected.
- The drive torque increases to the programmed limit value FXSW and then remains constant.
- Fixed stop monitoring is activated within the specified window width.

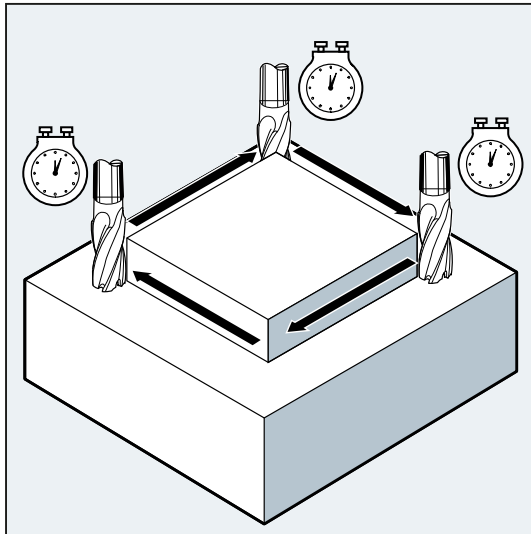
#### Supplementary conditions

- Measurement with delete distance-to-go  
"Measurement with delete distance-to-go" (MEAS command) and "Travel to fixed stop" cannot be programmed at the same time in one block.  
Exception:  
One function acts on a path axis and the other on a positioning axis or both act on positioning axes.
- Contour monitoring  
Contour monitoring is not performed while "Travel to fixed stop" is active.
- Positioning axes  
For "Travel to fixed stop" with positioning axes, the block change is performed irrespective of the fixed stop movement.

- Link and container axes  
Travel to fixed stop is also permitted for link and container axes.  
The status of the assigned machine axis is maintained beyond the container rotation. This also applies for modal torque limiting with FOCON.  
**References:**
  - Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Distributed Systems (B3)
  - Programming Manual, Job Planning; Subject: "Travel to fixed stop (FXS and FOCON/FOCOF)"
- Travel to fixed stop is not possible:
  - With gantry axes
  - For concurrent positioning axes that are controlled exclusively from the PLC (FXS must be selected from the NC program).
- If the torque limit is reduced too far, the axis will not be able to follow the specified setpoint; the position controller then goes to the limit and the contour deviation increases. In this operating state, an increase in the torque limit may result in sudden, jerky movements. To ensure that the axis can follow the setpoint, check the contour deviation to make sure it is not greater than the deviation with an unlimited torque.

## 15.7 Dwell time (G4)

G4 can be used to program a "dwell time" between two NC blocks during which workpiece machining is interrupted.



---

### Note

G4 interrupts continuous-path mode.

---

Application

For example, for relief cutting.

Syntax

```
G4 F.../S<n>=...
```

Note

G4 must be programmed in a separate NC block.

Meaning

|           |                                                                   |                                                                                                                                                                                                        |
|-----------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G4:       | Activate dwell time                                               |                                                                                                                                                                                                        |
| F...:     | The dwell time is programmed in seconds at address F.             |                                                                                                                                                                                                        |
| S<n>=...: | The dwell time is programmed in spindle revolutions at address S. |                                                                                                                                                                                                        |
|           | <n>:                                                              | The numeric extension indicates the number of the spindle to which the dwell time is to be applied. In the absence of a numeric extension (S...) the dwell time will be applied to the master spindle. |

Note

Addresses F and S are only used for time parameters in the G4 block. The feedrate F... and the spindle speed S... programmed upstream of the G4 block are retained.

Example

| Program code            | Comment                                                                                                       |
|-------------------------|---------------------------------------------------------------------------------------------------------------|
| N10 G1 F200 Z-5 S300 M3 | ;Feed F; spindle speed S                                                                                      |
| N20 G4 F3               | ; Dwell time: 3 s                                                                                             |
| N30 X40 Y10             |                                                                                                               |
| N40 G4 S30              | ; Dwelling 30 revolutions of the spindle (at S=300 rpm and 100% speed override, corresponds to: t = 0.1 min). |
| N50 X...                | ; The feedrate and spindle speed programmed in N10 continue to apply.                                         |

15.8 Internal preprocessing stop

Function

The control generates an internal preprocessing stop on access to machine status data (\$A...). The following block is not executed until all preprocessed and saved blocks have been executed in full. The previous block is stopped in exact stop (as G9).

## Example

| Program code                         | Comments                                                                                                |
|--------------------------------------|---------------------------------------------------------------------------------------------------------|
| ...                                  |                                                                                                         |
| N40 POSA[X]=100                      |                                                                                                         |
| N50 IF \$AA_IM[X]==R100 GOTOF MARKE1 | ; Access to machine status data (\$A...),<br>the control generates an internal pre-<br>processing stop. |
| N60 G0 Y100                          |                                                                                                         |
| N70 WAITP(X)                         |                                                                                                         |
| N80 LABEL1:                          |                                                                                                         |
| ...                                  |                                                                                                         |





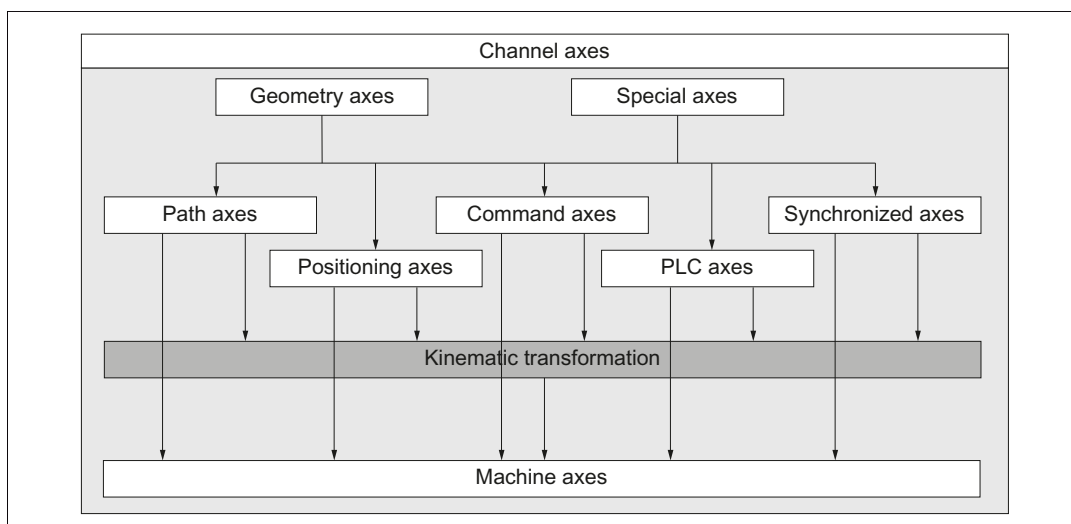
## Other information

### 16.1 Axes

#### Axis types

A distinction is made between the following types of axis types when programming:

- Machine axes
- Geometry axes
- Special axes
- Path axes
- Synchronized axes
- Positioning axes
- Command axes
- PLC axes / competing positioning axes
- Link axes (function NCU link)
- Lead link axes (function NCU link)



#### 16.1.1 Main axes/Geometry axes

The main axes define a right-angled, right-handed coordinate system. Tool movements are programmed in this coordinate system.

In NC technology, the main axes are called geometry axes. This term is also used in this Programming Guide.

### Replaceable geometry axes

The "Replaceable geometry axes" function (see Function Manual, Job Planning) can be used to alter the geometry axes grouping configured using machine data from the part program. Here any geometry axis can be replaced by a channel axis defined as a synchronous special axis.

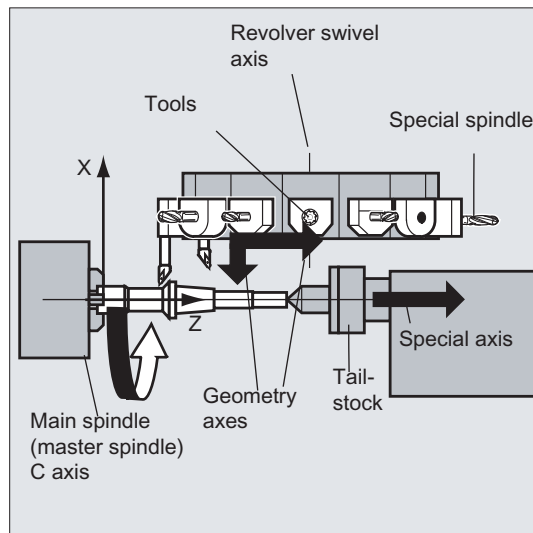
### Axis identifier

The name/identifier of a geometry axis can be defined using the following machine data:

MD20060 \$MC\_AXCONF\_GEOAX\_NAME\_TAB (name of the geometry axis in the channel)

Standard identifier for turning machines:

1. Geometry axis: X
2. Geometry axis: Z



Standard identifier for milling machines:

1. Geometry axis: X
2. Geometry axis: Y
3. Geometry axis: Z

### Further information

A maximum of three geometry axes are used for programming frames and the workpiece geometry (contour).

The identifiers for geometry and channel axes may be the same, provided a reference is possible.

Geometry and channel axis names must be the same in all channels. This means that a program can be executed in any channel.

### 16.1.2 Special axes

In contrast to the geometry axes, no geometrical relationship is defined between the special axes.

Typical special axes are:

- Tool revolver axes
- Swivel table axes
- Swivel head axes
- Loader axes

#### Axis identifier

On a turning machine with circular magazine, for example:

- Revolver position U
- Tailstock V

#### Programming example

| Program code                                | Comment                       |
|---------------------------------------------|-------------------------------|
| N10 G1 X100 Y20 Z30 A40 F300                | ; Path axis movements         |
| N20 POS[U]=10 POS[X]=20 FA[U]=200 FA[X]=350 | ; Positioning axis movements. |
| N30 G1 X500 Y80 POS[U]=150 FA[U]=300 F550   | ; Path and positioning axis.  |
| N40 G74 X1=0 Z1=0                           | ; Approach reference point.   |

### 16.1.3 Main spindle, master spindle

The machine kinematics determine, which spindle is the main spindle. This spindle is usually declared as the master spindle in the machine data.

This assignment can be changed with the `SETMS(<spindle number>)` program command. `SETMS` can be used without specifying a spindle number to switch back to the master spindle defined in the machine data.

Special functions such as thread cutting are supported by the master spindle.

#### Spindle identifier

S or S0

### 16.1.4 Machine axes

Machine axes are the axes physically existing on a machine.

The programmed motion of a path or additional axis can act on several machine axes due to transformation (TRANSMIT, TRACYL or TRAORI) active in the channel.

Machine axes are only directly addressed in the program in special circumstances (e.g. for reference point or fixed point approach).

### Axis identifier

The name/identifier of a machine axis can be defined using the following NC-specific machine data:

MD10000 \$MN\_AXCONF\_MACHAX\_NAME\_TAB (machine axis name)

Default setting: X1, Y1, Z1, A1, B1, C1, U1, V1

Further, machine axes have fixed axis identifiers, which can always be used, independent of the names set in the machine data:

AX1, AX2, ..., AX<n>

## 16.1.5 Channel axes

All geometry, special and machine axes, which are assigned to a channel, are called channel axes.

### Axis identifier

The channel-specific name/identifier of a geometry and special axis can be defined using the following machine data:

MD20080 \$MC\_AXCONF\_CHANAX\_NAME\_TAB (channel axis name)

Default setting: X, Y, Z, A, B, C, U, V

The assignment regarding on which machine axis a geometry or special axis is emulated in the channel, is defined in the following machine data:

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axes used)

## 16.1.6 Path axes

Path axes define the path and therefore the movement of the tool in space.

The programmed feed is active for this path. The axes involved in this path reach their position at the same time. As a rule, these are the geometry axes.

However, default settings define, which axes are the path axes, and therefore determine the velocity.

Path axes can be specified in the NC program with `FGROUP`.

For more information about `FGROUP`, see "Feedrate (G93, G94, G95, F, FGROUP, FL, FGREF) (Page 97)".

## 16.1.7 Positioning axes

Positioning axes are interpolated separately; in other words, each positioning axis has its own axis interpolator and its own feedrate. Positioning axes do not interpolate with the path axes.

Positioning axes are traversed by the NC program or the PLC. If an axis is to be traversed simultaneously by the NC program and the PLC, an error message appears.

Typical positioning axes are:

- Loaders for moving workpieces to the machine
- Loaders for moving workpieces away from the machine
- Tool magazine/turret

## Types

A distinction is made between positioning axes with synchronization at the block end or over several blocks.

### POS axes

Block change occurs at the end of the block when all the path and positioning axes programmed in this block have reached their programmed end point.

### POSA axes

The movement of these positioning axes can extend over several blocks.

### POSP axes

The movement of these positioning axes for approaching the end position takes place in sections.

---

### Note

Positioning axes become synchronized axes if they are traversed without the special POS/POSA identifier.

Continuous-path mode (G64) for path axes is only possible if the positioning axes (POS) reach their final position before the path axes.

Path axes programmed with POS/POSA are removed from the path axis grouping for the duration of this block.

---

For more information about POS, POSA, and POSP, see "Traverse positioning axes (POS, POSA, POSP, FA, WAITP, WAITMC) (Page 105)".

## 16.1.8 Synchronized axes

Synchronized axes traverse synchronously to the path from the start position to the programmed end position.

The feedrate programmed in  $F$  applies to all the path axes programmed in the block, but does not apply to synchronized axes. Synchronized axes take the same time as the path axes to traverse.

A synchronized axis can be a rotary axis, which is traversed synchronously to the path interpolation.

### 16.1.9 Command axes

Command axes are started from synchronized actions in response to an event (command). They can be positioned, started, and stopped fully asynchronous to the parts program. An axis cannot be moved from the part program and from synchronized actions simultaneously.

Command axes are interpolated separately; in other words, each command axis has its own axis interpolator and its own feedrate.

**References:**

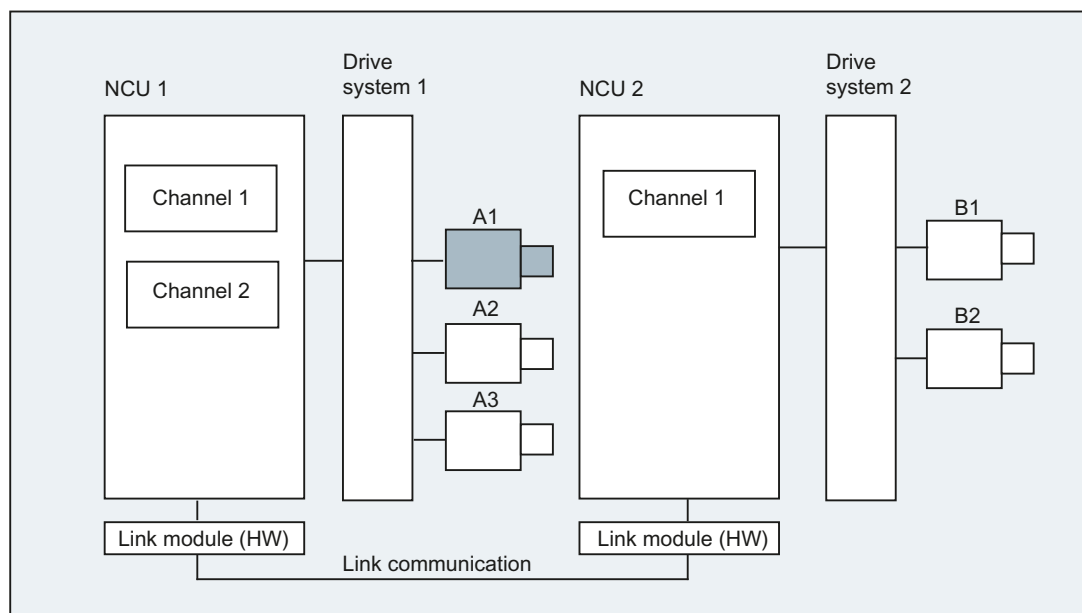
Function Manual, Synchronized Actions

### 16.1.10 PLC axes

PLC axes are traversed by the PLC via special function blocks in the basic program; their movements can be asynchronous to all other axes. Traversing movements take place independently of path and synchronized movements.

### 16.1.11 Link axes

Link axes are axes, which are physically connected to another NCU and whose position is controlled from this NCU. Link axes can be assigned dynamically to channels of **another** NCU. Link axes are non-local axes from the perspective of a specific NCU.



The **axis container** concept is used for the dynamic modification of the assignment to an NCU. Axis exchange with `GET` and `RELEASE` from the part program is **not** available for link axes.

## Further information

### Requirements

- The participating NCUs, NCU1 and NCU2, must be connected by means of high-speed communication via the link module.  
References:  
Configuration Manual, NCU
- The axis must be configured appropriately by machine data.
- The "Link axis" option must be installed.

### Description

The position control is implemented on the NCU on which the axis is physically connected to the drive. This NCU also contains the associated axis VDI interface. The position setpoints for link axes are generated on another NCU and communicated via the NCU link.

The link communication must provide the means of interaction between the interpolators and the position controller or PLC interface. The setpoints calculated by the interpolators must be transported to the position control loop on the home NCU and, vice versa, the actual values must be returned from there back to the interpolators.

References:

For more detailed information about link axes see:

Function Manual, Advanced Functions; Multiple Operator Panels and NCUs (B3)

### Axis container

An axis container is a circular buffer data structure, in which local axes and/or link axes are assigned to channels. The entries in the circular buffer can be **shifted cyclically**.

In addition to the direct reference to local axes or link axes, the link axis configuration in the logical machine axis image also allows references to axis containers. This type of reference consists of:

- A container number **and**
- A slot (circular buffer location within the container)

The entry in a circular buffer location contains:

- A local axis **or**
- A link axis

Axis container entries contain local machine axes or link axes from the perspective of an individual NCU. The entries in the logical machine axis image (MD10002 \$MN\_AXCONF\_LOGIC\_MACHAX\_TAB) of an individual NCU are fixed.

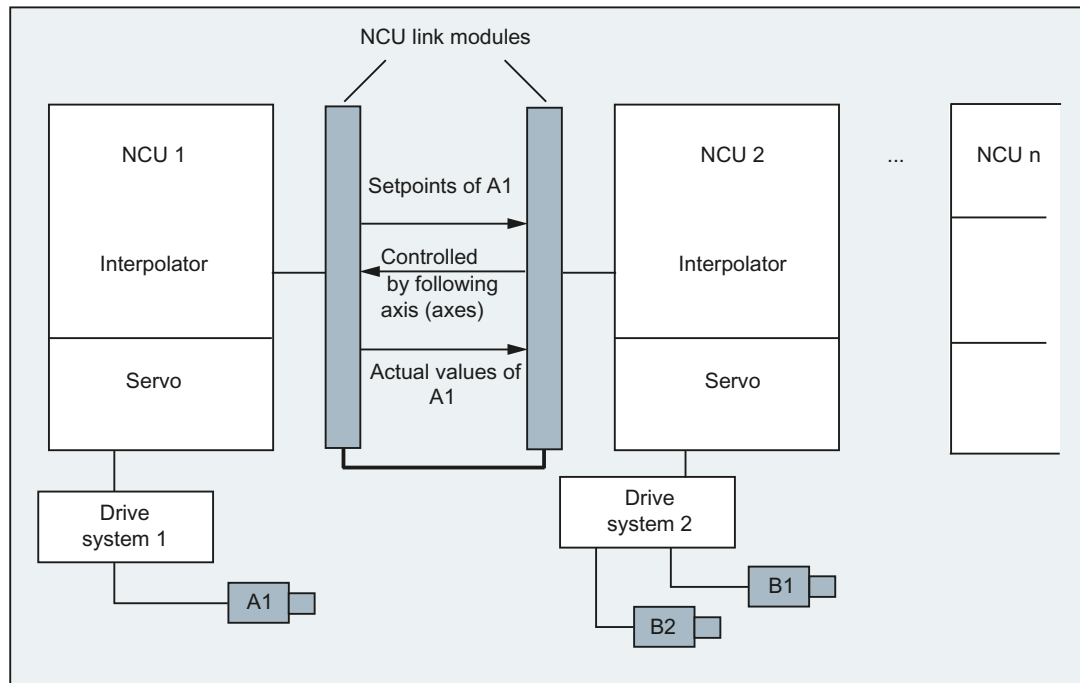
References:

The axis container function is described in:

Function Manual, Advanced Functions; Multiple Operator Panels and NCUs (B3)

### 16.1.12 Lead link axes

A leading link axis is one that is interpolated by one NCU and utilized by one or several other NCUs as the master axis for controlling slave axes.



An axial position controller alarm is sent to all other NCUs, which are connected to the affected axis via a leading link axis.

NCUs that are dependent on the leading link axis can utilize the following coupling relationships with it:

- Master value (setpoint, actual master value, simulated master value)
- Coupled motion
- Tangential correction
- Electronic gear (ELG)
- Synchronous spindle

#### Programming

Master NCU:

Only the NCU, which is physically assigned to the master value axis can program travel motions for this axis. The travel program must not contain any special functions or operations.

NCUs of slave axes:

The travel program on the NCUs of the slave axes must not contain any travel commands for the leading link axis (master value axis). Any violation of this rule triggers an alarm.

The leading link axis is addressed in the usual way via channel axis identifiers. The states of the leading link axis can be accessed by means of selected system variables.



## Further information

### Conditions

- The NCUs involved, i.e., NCU1 to NCU<n> (<n> equals max. of 8), must be interconnected via the link module for high-speed communication.  
Reference:  
Device Manual Configuration NCU
- The axis must be configured appropriately via machine data.
- The "Link axis" option must be installed.
- The same interpolator clock cycle must be configured for all NCUs connected to the leading link axis.

### Restrictions

- A master axis which is a leading link axis cannot be a link axis, i.e. it cannot be traversed by NCUs other than its home NCU.
- A master axis which is a leading link axis cannot be a container axis, i.e. it cannot be addressed alternately by different NCUs.
- A leading link axis cannot be the programmed leading axis in a gantry grouping.
- Couplings with leading link axes cannot be cascaded.
- Axis replacement can only be implemented within the home NCU of the leading link axis.

### System variables

The following system variables can be used in conjunction with the channel axis identifier of the leading link axis:

| System variables | Meaning                           |
|------------------|-----------------------------------|
| \$AA_LEAD_SP     | Simulated master value - position |
| \$AA_LEAD_SV     | Simulated master value - velocity |

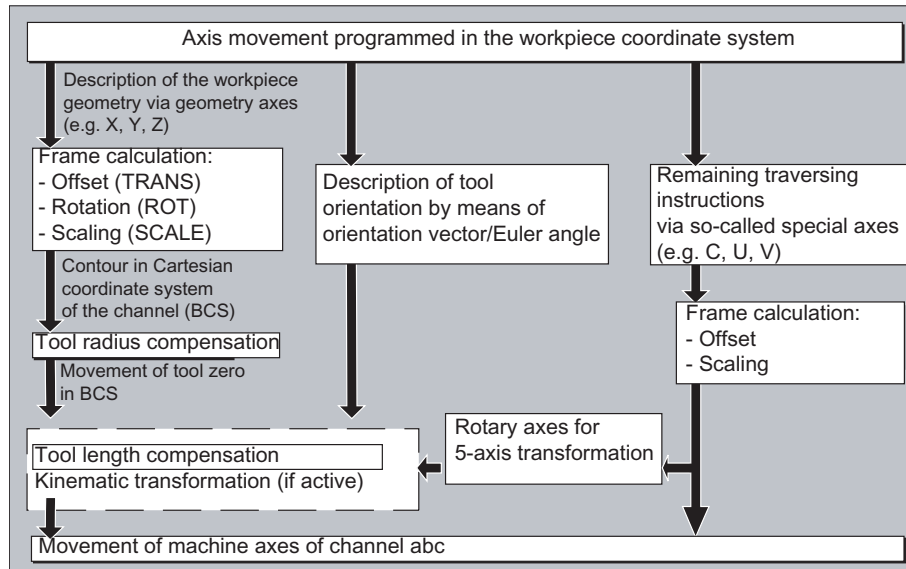
If these system variables are updated by the home NCU of the master axis, the new values are also transferred to any other NCUs, which wish to control slave axes as a function of this master axis.

References:

Function Manual, Extended Functions; Multiple Operator Panels and NCUs (B3)

## 16.2 From travel command to machine movement

The relationship between the programmed axis movements (travel commands) and the resulting machine movements is illustrated in the following figure:

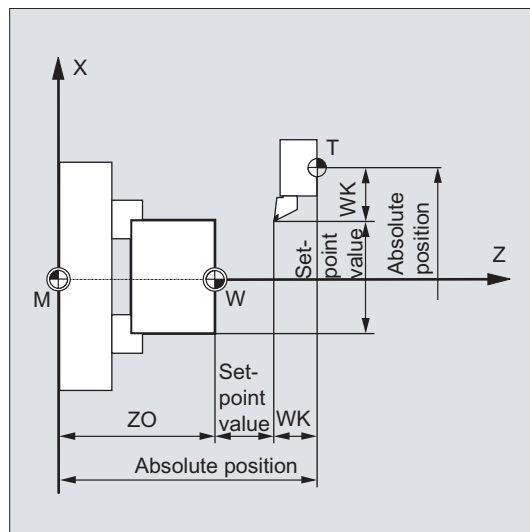


## 16.3 Path calculation

The path calculation determines the distance to be traversed in a block, taking into account all offsets and compensations.

In general:

Distance =  
setpoint - actual value + zero offset (ZO) + tool offset (TO)



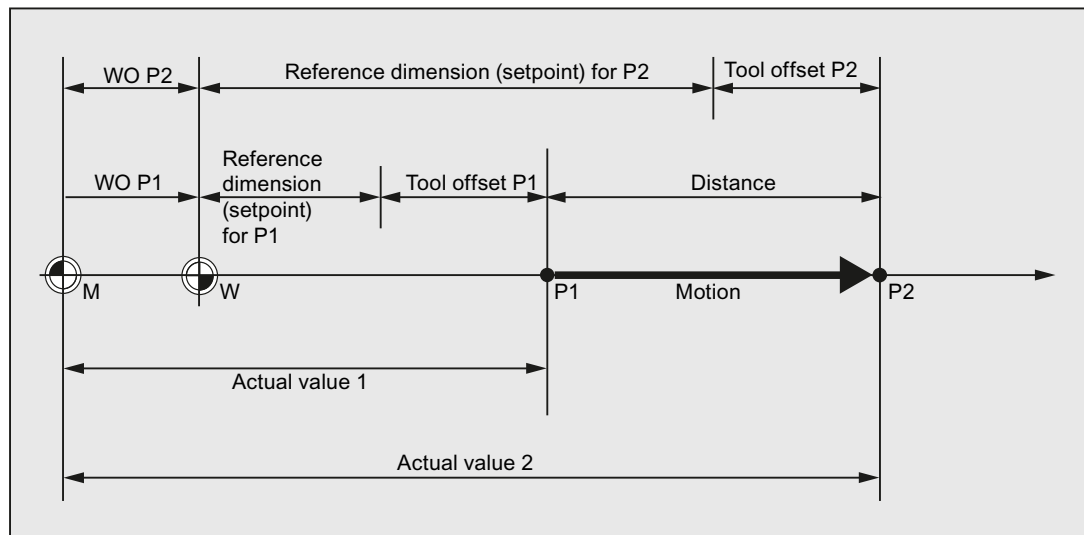
If a new zero offset and a new tool offset are programmed in a new program block, the following applies:

- With absolute dimensioning:

$$\text{Distance} = (\text{absolute dimension P2} - \text{absolute dimension P1}) + (\text{WO P2} - \text{WO P1}) + (\text{TO P2} - \text{TO P1}).$$

- With incremental dimensioning:

$$\text{Distance} = \text{incremental dimension} + (\text{WO P2} - \text{WO P1}) + (\text{TO P2} - \text{TO P1}).$$



## 16.4 Addresses

### Fixed addresses

These addresses are permanently set, i.e. the address characters cannot be changed.

A list can be found in Table "Fixed addresses (Page 445)".

### Settable addresses

The machine manufacturer may assign another name to these addresses via machine data.

#### Note

Settable addresses must be unique within the control, i.e. the same address name must not be used for different address types (axis values and end points, tool orientation, interpolation parameters, etc.).

A list can be found in Table "Settable addresses (Page 449)".

## Modal/non-modal addresses

Modal addresses remain valid with the programmed value (in all subsequent blocks) until a new value is programmed at the same address.

Non-modal addresses only apply in the block, in which they were programmed.

Example:

| Program code     | Comment                                                               |
|------------------|-----------------------------------------------------------------------|
| N10 G01 F500 X10 |                                                                       |
| N20 X10          | ; Feedrate F from N10 remains active until a new feedrate is entered. |

## Addresses with axial extension

In addresses with axial extension, an axis name is inserted in square brackets after the address. The axis name assigns the axis.

Example:

| Program code | Comment                              |
|--------------|--------------------------------------|
| FA[U]=400    | ; Axis-specific feedrate for U axis. |

See also Table "Fixed addresses (Page 445)".

## Extended address notation

Extended address notation enables a larger number of axes and spindles to be organized in a system.

An extended address consists of a numeric extension and an arithmetic expression assigned with an "=" character. The numeric extension has one or two digits and is always positive.

The extended address notation is only permitted for the following direct addresses:

| Address      | Meaning                  |
|--------------|--------------------------|
| X, Y, Z, ... | Axis addresses           |
| I, J, K      | Interpolation parameters |
| S            | Spindle speed            |
| SPOS, SPOSA  | Spindle position         |
| M            | Special functions        |
| H            | Auxiliary functions      |
| T            | Tool number              |
| F            | Feedrate                 |

Examples:

| Program code | Comment                                                                      |
|--------------|------------------------------------------------------------------------------|
| X7           | ; No "=" required, 7 is a value, but the "=" character can also be used here |

| Program code | Comment                            |
|--------------|------------------------------------|
| X4=20        | ; Axis X4; "=" is required         |
| CR=7.3       | ; Two letters; "=" are required    |
| S1=470       | ; Speed for first spindle: 470 rpm |
| M3=5         | ;Spindle stop for 3rd spindle      |

The numeric extension can be replaced by a variable for addresses M, H, S and for SPOS and SPOSA. The variable identifier is enclosed in square brackets.

Examples:

| Program code | Comment                                                                               |
|--------------|---------------------------------------------------------------------------------------|
| S[SPINU]=470 | ; Speed for the spindle whose number is stored in the SPINU variable.                 |
| M[SPINU]=3   | ; Clockwise rotation for the spindle whose number is stored in the SPINU variable.    |
| T[SPINU]=7   | ; Selection of the tool for the spindle whose number is stored in the SPINU variable. |

## 16.5 Names

The commands according to DIN 66025 are supplemented with named objects, etc. by the NC high-level language.

The named objects include:

- System variables
- User-defined variables
- Axes/spindles
- Subprograms
- Keywords
- Jump markers
- Macros

---

### Note

Identifiers must be unique. It is not permissible to use the same identifier for different objects.

---

## Naming rules

A name can be chosen freely providing the following rules are observed:

- Permissible characters:
  - Letters: A ... Z, a ... z
  - Numbers: 0 ... 9
  - Underscore: \_
- The first two characters **must** be letters or underscores.
- Maximum length: :
  - Program names (Page 33)
  - Axis names: 8 characters
  - Variable names: 31 characters

---

### Note

Reserved keywords must not be used as identifiers.

---

## Cycles

To prevent name conflicts, we recommend that the following specification for the assignment of names for user cycles is observed:

| Character string                                                                                                                                    | Reserved for names for |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <ul style="list-style-type: none"> <li>• CYCLE</li> <li>• CUST_</li> <li>• GROUP_</li> <li>• _</li> <li>• S_</li> <li>• E_</li> <li>• F_</li> </ul> | SIEMENS cycles         |
| <ul style="list-style-type: none"> <li>• CCS_</li> </ul>                                                                                            | SIEMENS compile cycles |
| <ul style="list-style-type: none"> <li>• CC_</li> </ul>                                                                                             | User compile cycles    |

### User cycles

We recommend that the names of user cycles begin with U\_.

## Variables

A detailed description of the name assignment for variables appears in:

Programming Manual, Job Planning

- **System variables**  
"Flexible NC programming" > "Variables" > "System variable" section
- **User variables**  
"Flexible NC programming" > "Variables" > "Definition of user variables (DEF)" section

## 16.6 Constants

### Constant (general)

A constant is a data element whose value does not change during the execution of a program, e.g. a value assignment to an address.

### Decimal constant

The numeric value of a decimal constant is displayed in the decimal system.

### INTEGER constant

An INTEGER constant is an integer value, i.e. a sequence of digits without decimal point, with or without sign.

Examples:

|      |                                                                                       |
|------|---------------------------------------------------------------------------------------|
| X10  | Assignment of the value +10 to address X                                              |
| X-35 | Assignment of the value -35 to address X                                              |
| X0   | Assignment of the value 0 to address X<br><b>Note:</b><br>X0 cannot be replaced by X. |

### REAL constant

A REAL constant is a sequence of digits with decimal point, with or without sign and with or without exponent.

Examples:

|           |                                                                |
|-----------|----------------------------------------------------------------|
| X10.25    | Assignment of the value +10.25 to address X                    |
| X-10.25   | Assignment of the value -10.25 to address X                    |
| X0.25     | Assignment of the value +0.25 to address X                     |
| X.25      | Assignment of the value +0.25 to address X without leading "0" |
| X=-.1EX-3 | Assignment of the value -0.1*10 <sup>-3</sup> to address X     |

**Note**

If, in an address, which permits decimal point input, more decimal places are specified than actually provided for the address, then they are rounded to fit the number of places provided.

---

**Hexadecimal constant**

Constants can also be interpreted as hexadecimal format, i.e. based on 16. The letters A to F are hexadecimal digits with the decimal values 10 to 15.

Hexadecimal constants are enclosed in single quotation marks and start with the letter "H", followed by the value in hexadecimal notation. Separators are permitted between the letters and digits.

Example:

| Program code                                 | Comment                                                                                            |
|----------------------------------------------|----------------------------------------------------------------------------------------------------|
| <code>\$MC_TOOL_MANAGEMENT_MASK='H7F'</code> | <code>; By assigning the hexadecimal constant,<br/>bits 0 to 7 are set in the machine data.</code> |

---

**Note**

The maximum number of characters is limited by the value range of the integer data type.

---

**Binary constant**

Constants can also be interpreted in binary format. In this case, only the digits "0" and "1" are used.

Binary constants are enclosed in single quotation marks and start with the letter "B", followed by the binary value. Separators are permitted between the digits.

Example:

| Program code                                   | Comment                                                                                           |
|------------------------------------------------|---------------------------------------------------------------------------------------------------|
| <code>\$MN_AUXFU_GROUP_SPEC='B10000001'</code> | <code>; By assigning the binary constant, bit 0<br/>and bit 7 are set in the machine data.</code> |

---

**Note**

The maximum number of characters is limited by the value range of the integer data type.

---



# Tables

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                    |                 |                  |                  |                               |
| :                                                       | O                  | NC main block number, jump label termination, concatenation operator                                               |                 | +                |                  | PGAsI                         |
| *                                                       | O                  | Operator for multiplication                                                                                        |                 | +                |                  | PGAsI                         |
| +                                                       | O                  | Operator for addition                                                                                              |                 | +                |                  | PGAsI                         |
| -                                                       | O                  | Operator for subtraction                                                                                           |                 | +                |                  | PGAsI                         |
| <                                                       | O                  | Comparison operator, less than                                                                                     |                 | +                |                  | PGAsI                         |
| <<                                                      | O                  | Concatenation operator for strings                                                                                 |                 | +                |                  | PGAsI                         |
| <=                                                      | O                  | Comparison operator, less than or equal to                                                                         |                 | +                |                  | PGAsI                         |
| =                                                       | O                  | Assignment operator                                                                                                |                 | +                |                  | PGAsI                         |
| >=                                                      | O                  | Comparison operator, greater than or equal to                                                                      |                 | +                |                  | PGAsI                         |
| /                                                       | O                  | Operator for division                                                                                              |                 | +                |                  | PGAsI                         |
| /0                                                      |                    | block is skipped (1st skip level)                                                                                  |                 | +                |                  | PGsI                          |
| ...                                                     |                    | ...                                                                                                                |                 |                  |                  |                               |
| ...                                                     |                    | ...                                                                                                                |                 |                  |                  |                               |
| /7                                                      |                    | block is skipped (8th skip level)                                                                                  |                 |                  |                  |                               |
| O                                                       | O                  | Axis name                                                                                                          | m/s             | +                |                  | PGAsI                         |
| A2                                                      | O                  | Tool orientation: RPY or Euler angle                                                                               | s               | +                |                  | PGAsI                         |
| A3                                                      | O                  | Tool orientation: Direction/surface normal vector component                                                        | s               | +                |                  | PGAsI                         |
| A4                                                      | O                  | Tool orientation: Surface normal vector for beginning of block                                                     | s               | +                |                  | PGAsI                         |
| A5                                                      | O                  | Tool orientation: Surface normal vector for end of block                                                           | s               | +                |                  | PGAsI                         |
| ABS                                                     | F                  | Absolute value (amount)                                                                                            |                 | +                | +                | PGAsI                         |
| AC                                                      | K                  | Absolute dimensions of coordinates/positions                                                                       | s               | +                |                  | PGsI                          |
| ACC                                                     | K                  | Effect of current axial acceleration                                                                               | m               | +                | +                | PGsI                          |
| ACCLIMA                                                 | K                  | Effect of current maximum axial acceleration                                                                       | m               | +                | +                | PGAsI                         |
| ACN                                                     | K                  | Absolute dimensions for rotary axes, approach position in negative direction                                       | s               | +                |                  | PGsI                          |
| ACOS                                                    | F                  | Arc cosine (trigon. function)                                                                                      |                 | +                | +                | PGAsI                         |
| ACP                                                     | K                  | Absolute dimensions for rotary axes, approach position in positive direction                                       | s               | +                |                  | PGsI                          |
| ACTBLOCNO                                               | P                  | Output of current block number of an alarm block, even if "current block display suppressed" (DIS-PLOF) is active! |                 | +                |                  | PGAsI                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                                | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                        |                 |                  |                  |                               |
| ADDFRAME                                                | F                  | Inclusion and possible activation of a measured frame                                                                                  |                 | +                | -                | PGAsl, FB1sl (K2)             |
| ADIS                                                    | O                  | Rounding clearance for path functions G1, G2, G3, ...                                                                                  | m               | +                |                  | PGsl                          |
| ADISPOS                                                 | O                  | Rounding clearance for rapid traverse G0                                                                                               | m               | +                |                  | PGsl                          |
| ADISPOSA                                                | P                  | Size of the tolerance window for IPOBRKA                                                                                               | m               | +                | +                | PGAsl                         |
| ALF                                                     | O                  | LIFTFAST angle                                                                                                                         | m               | +                |                  | PGAsl                         |
| AMIRROR                                                 | G                  | Programmable mirroring                                                                                                                 | s               | +                |                  | PGsl                          |
| AND                                                     | K                  | Logical AND                                                                                                                            |                 | +                |                  | PGAsl                         |
| ANG                                                     | O                  | Contour angle                                                                                                                          | s               | +                |                  | PGsl                          |
| AP                                                      | O                  | Polar angle                                                                                                                            | m/s             | +                |                  | PGsl                          |
| APR                                                     | K                  | Read/show access protection                                                                                                            |                 | +                |                  | PGAsl                         |
| APRB                                                    | K                  | Read access right, OPI                                                                                                                 |                 | +                |                  | PGAsl                         |
| APRP                                                    | K                  | Read access right, part program                                                                                                        |                 | +                |                  | PGAsl                         |
| APW                                                     | K                  | Write access protection                                                                                                                |                 | +                |                  | PGAsl                         |
| APWB                                                    | K                  | Write access right, OPI                                                                                                                |                 | +                |                  | PGAsl                         |
| APWP                                                    | K                  | Write access right, part program                                                                                                       |                 | +                |                  | PGAsl                         |
| APX                                                     | K                  | Definition of the access right for executing the specified language element                                                            |                 | +                |                  | PGAsl                         |
| AR                                                      | O                  | Opening angle                                                                                                                          | m/s             | +                |                  | PGsl                          |
| AROT                                                    | G                  | Programmable rotation                                                                                                                  | s               | +                |                  | PGsl                          |
| AROTS                                                   | G                  | Programmable frame rotations with solid angles                                                                                         | s               | +                |                  | PGsl                          |
| AS                                                      | K                  | Macro definition                                                                                                                       |                 | +                |                  | PGAsl                         |
| ASCALE                                                  | G                  | Programmable scaling                                                                                                                   | s               | +                |                  | PGsl                          |
| ASIN                                                    | F                  | Arithmetic function, arc sine                                                                                                          |                 | +                | +                | PGAsl                         |
| ASPLINE                                                 | G                  | Akima spline                                                                                                                           | m               | +                |                  | PGAsl                         |
| ATAN2                                                   | F                  | Arc tangent 2                                                                                                                          |                 | +                | +                | PGAsl                         |
| ATOL                                                    | K                  | Axis-specific tolerance for compressor functions, orientation smoothing and smoothing types                                            |                 | +                |                  | PGAsl                         |
| ATRANS                                                  | G                  | Additive programmable translation                                                                                                      | s               | +                |                  | PGsl                          |
| AUXFUDEL                                                | P                  | Delete auxiliary function channel-specifically from the global list                                                                    |                 | +                | -                | FB1sl (H2)                    |
| AUXFUDELG                                               | P                  | Delete all auxiliary functions of an auxiliary function group channel-specifically from the global list                                |                 | +                | -                | FB1sl (H2)                    |
| AUXFUMSEQ                                               | P                  | Determine output sequence of M auxiliary functions                                                                                     |                 | +                | -                | FB1sl (H2)                    |
| AUXFUSYNC                                               | P                  | Generate a complete part program block for the channel-specific SERUPRO end ASUB as string from the global list of auxiliary functions |                 | +                | -                | FB1sl (H2)                    |
| AX                                                      | K                  | Variable axis identifier                                                                                                               | m/s             | +                |                  | PGAsl                         |
| AXCTSWE                                                 | P                  | Rotate axis container                                                                                                                  |                 | +                | -                | PGAsl                         |
| AXCTSWEC                                                | P                  | Canceling enable for axis container rotation                                                                                           |                 | +                | +                | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                    |                 |                  |                  |                               |
| AXCTSWED                                                | P                  | Rotating axis container (command variant for commissioning!)                                                       |                 | +                | -                | PGAsI                         |
| AXIS                                                    | K                  | Axis identifier, axis address                                                                                      |                 | +                |                  | PGAsI                         |
| AXNAME                                                  | F                  | Converts input string into axis identifier                                                                         |                 | +                | -                | PGAsI                         |
| AXSTRING                                                | F                  | Converts string spindle number                                                                                     |                 | +                | -                | PGAsI                         |
| AXTOCHAN                                                | P                  | Request axis for a specific channel. Possible from NC program and synchronized action.                             |                 | +                | +                | PGAsI                         |
| AXTOSPI                                                 | F                  | Converts axis identifier into a spindle index                                                                      |                 | +                | -                | PGAsI                         |
| B                                                       | O                  | Axis name                                                                                                          | m/s             | +                |                  | PGAsI                         |
| B2                                                      | O                  | Tool orientation: RPY or Euler angle                                                                               | s               | +                |                  | PGAsI                         |
| B3                                                      | O                  | Tool orientation: Direction/surface normal vector component                                                        | s               | +                |                  | PGAsI                         |
| B4                                                      | O                  | Tool orientation: Surface normal vector for beginning of block                                                     | s               | +                |                  | PGAsI                         |
| B5                                                      | O                  | Tool orientation: Surface normal vector for end of block                                                           | s               | +                |                  | PGAsI                         |
| B_AND                                                   | O                  | Bit-by-bit AND                                                                                                     |                 | +                |                  | PGAsI                         |
| B_OR                                                    | O                  | Bit-by-bit OR                                                                                                      |                 | +                |                  | PGAsI                         |
| B_NOT                                                   | O                  | Bit-by-bit negation                                                                                                |                 | +                |                  | PGAsI                         |
| B_XOR                                                   | O                  | Bit-by-bit exclusive OR                                                                                            |                 | +                |                  | PGAsI                         |
| BAUTO                                                   | G                  | Definition of the first spline section by means of the next 3 points                                               | m               | +                |                  | PGAsI                         |
| BLOCK                                                   | K                  | Together with the keyword TO defines the program part to be processed in an indirect subprogram call               |                 | +                |                  | PGAsI                         |
| BLSYNC                                                  | K                  | Processing of interrupt routine is only to start with the next block change                                        |                 | +                |                  | PGAsI                         |
| BNAT <sup>6)</sup>                                      | G                  | Natural transition to first spline block                                                                           | m               | +                |                  | PGAsI                         |
| BOOL                                                    | K                  | Data type: Boolean value TRUE/FALSE or 1/0                                                                         |                 | +                |                  | PGAsI                         |
| BOUND                                                   | F                  | Tests whether the value falls within the defined value range. If the values are equal, the test value is returned. |                 | +                | +                | PGAsI                         |
| BRISK <sup>6)</sup>                                     | G                  | Fast non-smoothed path acceleration                                                                                | m               | +                |                  | PGAsI                         |
| BRISKA                                                  | P                  | Switch on brisk path acceleration for the programmed axes                                                          |                 | +                | -                | PGAsI                         |
| BSPLINE                                                 | G                  | B spline                                                                                                           | m               | +                |                  | PGAsI                         |
| BTAN                                                    | G                  | Tangential transition to first spline block                                                                        | m               | +                |                  | PGAsI                         |
| C                                                       | O                  | Axis name                                                                                                          | m/s             | +                |                  | PGAsI                         |
| C2                                                      | O                  | Tool orientation: RPY or Euler angle                                                                               | s               | +                |                  | PGAsI                         |
| C3                                                      | O                  | Tool orientation: Direction/surface normal vector component                                                        | s               | +                |                  | PGAsI                         |
| C4                                                      | O                  | Tool orientation: Surface normal vector for beginning of block                                                     | s               | +                |                  | PGAsI                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                     |                 |                  |                  |                               |
| C5                                                      | O                  | Tool orientation: Surface normal vector for end of block                            | s               | +                |                  | PGAsl                         |
| CAC                                                     | K                  | Absolute position approach                                                          |                 | +                |                  | PGAsl                         |
| CACN                                                    | K                  | Absolute approach of the value listed in the table in negative direction            |                 | +                |                  | PGAsl                         |
| CACP                                                    | K                  | Absolute approach of the value listed in the table in positive direction            |                 | +                |                  | PGAsl                         |
| CALCDAT                                                 | F                  | Calculates radius and center point of circle from 3 or 4 points                     |                 | +                | -                | PGAsl                         |
| CALCPOSI                                                | F                  | Checking for protection area violation, working area limitation and software limits |                 | +                | -                | PGAsl                         |
| CALL                                                    | K                  | Indirect subprogram call                                                            |                 | +                |                  | PGAsl                         |
| CALLPATH                                                | P                  | Programmable search path for subprogram calls                                       |                 | +                | -                | PGAsl                         |
| CANCEL                                                  | P                  | Cancel modal synchronized action                                                    |                 | +                | -                | FBSYsl                        |
| CASE                                                    | K                  | Conditional program branch                                                          |                 | +                |                  | PGAsl                         |
| CDC                                                     | K                  | Direct approach of a position                                                       |                 | +                |                  | PGAsl                         |
| CDOF <sup>6)</sup>                                      | G                  | Collision detection OFF                                                             | m               | +                |                  | PGsl                          |
| CDOF2                                                   | G                  | Collision detection OFF, for 3D circumferential milling                             | m               | +                |                  | PGsl                          |
| CDON                                                    | G                  | Collision detection ON                                                              | m               | +                |                  | PGsl                          |
| CFC <sup>6)</sup>                                       | G                  | Constant feedrate on contour                                                        | m               | +                |                  | PGsl                          |
| CFIN                                                    | G                  | Constant feedrate for internal radius only, not for external radius                 | m               | +                |                  | PGsl                          |
| CFINE                                                   | F                  | Assignment of fine offset to a FRAME variable                                       |                 | +                | -                | PGAsl                         |
| CFTCP                                                   | G                  | Constant feedrate in tool center point (center point path)                          | m               | +                |                  | PGsl                          |
| CHAN                                                    | K                  | Specify validity range for data                                                     |                 | +                |                  | PGAsl                         |
| CHANDATA                                                | P                  | Set channel number for channel data access                                          |                 | +                | -                | PGAsl                         |
| CHAR                                                    | K                  | Data type: ASCII character                                                          |                 | +                |                  | PGAsl                         |
| CHF                                                     | O                  | Chamfer; value = length of chamfer                                                  | s               | +                |                  | PGsl                          |
| CHKDM                                                   | F                  | Uniqueness check within a magazine                                                  |                 | +                | -                | FBWsl                         |
| CHKDNO                                                  | F                  | Check for unique D numbers                                                          |                 | +                | -                | PGAsl                         |
| CHR                                                     | O                  | Chamfer; value = length of chamfer in direction of movement                         |                 | +                |                  | PGsl                          |
| CIC                                                     | K                  | Approach position by increments                                                     |                 | +                |                  | PGAsl                         |
| CIP                                                     | G                  | Circular interpolation through intermediate point                                   | m               | +                |                  | PGsl                          |
| CLEARM                                                  | P                  | Reset one/several markers for channel coordination                                  |                 | +                | +                | PGAsl                         |
| CLRINT                                                  | P                  | Deselect interrupt                                                                  |                 | +                | -                | PGAsl                         |
| CMIRROR                                                 | F                  | Mirror on a coordinate axis                                                         |                 | +                | -                | PGAsl                         |
| COARSEA                                                 | K                  | Motion end when "Exact stop coarse" reached                                         | m               | +                |                  | PGAsl                         |
| COLLPAIR                                                | F                  | Check whether part of a collision pair                                              |                 | +                |                  | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                     |                 |                  |                  |                               |
| COMPCAD                                                 | G                  | Compressor ON: Optimum surface quality for CAD programs                             | m               | +                |                  | PGAsI                         |
| COMPCURV                                                | G                  | Compressor ON: Polynomials with constant curvature                                  | m               | +                |                  | PGAsI                         |
| COMPLETE                                                |                    | Control instruction for reading and writing data                                    |                 | +                |                  | PGAsI                         |
| COMPOF <sup>6)</sup>                                    | G                  | Compressor OFF                                                                      | m               | +                |                  | PGAsI                         |
| COMPON                                                  | G                  | Compressor ON                                                                       |                 | +                |                  | PGAsI                         |
| CONTDCON                                                | P                  | Tabular contour decoding ON                                                         |                 | +                | -                | PGAsI                         |
| CONTPRON                                                | P                  | Activate reference preprocessing                                                    |                 | +                | -                | PGAsI                         |
| CORROF                                                  | P                  | All active overlaid movements are deselected.                                       |                 | +                | -                | PGsI                          |
| COS                                                     | F                  | Cosine (trigon. function)                                                           |                 | +                | +                | PGAsI                         |
| COUPDEF                                                 | P                  | Definition ELG group/synchronous spindle group                                      |                 | +                | -                | PGAsI                         |
| COUPDEL                                                 | P                  | Delete ELG group                                                                    |                 | +                | -                | PGAsI                         |
| COUPOF                                                  | P                  | ELG group / synchronous spindle pair OFF                                            |                 | +                | -                | PGAsI                         |
| COUPOFS                                                 | P                  | Deactivate ELG group/synchronous spindle pair with stop of following spindle        |                 | +                | -                | PGAsI                         |
| COUPON                                                  | P                  | ELG group / synchronous spindle pair ON                                             |                 | +                | -                | PGAsI                         |
| COUPONC                                                 | P                  | Transfer activation of ELG group/synchronous spindle pair with previous programming |                 | +                | -                | PGAsI                         |
| COUPRES                                                 | P                  | Reset ELG group                                                                     |                 | +                | -                | PGAsI                         |
| CP <sup>6)</sup>                                        | G                  | Path motion                                                                         | m               | +                |                  | PGAsI                         |
| CPBC                                                    | K                  | Generic coupling: Block change criterion                                            |                 | +                | +                | FB3sl (M3)                    |
| CPDEF                                                   | K                  | Generic coupling: Creating a coupling module                                        |                 | +                | +                | FB3sl (M3)                    |
| CPDEL                                                   | K                  | Generic coupling: Deletion of a coupling module                                     |                 | +                | +                | FB3sl (M3)                    |
| CPFMOF                                                  | K                  | Generic coupling: Behavior of the following axis at complete switch-off             |                 | +                | +                | FB3sl (M3)                    |
| CPFMON                                                  | K                  | Generic coupling: Behavior of the following axis when switching on                  |                 | +                | +                | FB3sl (M3)                    |
| CPFMSON                                                 | K                  | Generic coupling: Synchronization mode                                              |                 | +                | +                | FB3sl (M3)                    |
| CPFPOS                                                  | K                  | Generic coupling: Synchronized position of the following axis                       |                 | +                | +                | FB3sl (M3)                    |
| CPFRS                                                   | K                  | Generic coupling: Coordinate reference system                                       |                 | +                | +                | FB3sl (M3)                    |
| CPLA                                                    | K                  | Generic coupling: Definition of a leading axis                                      |                 | +                | -                | FB3sl (M3)                    |
| CPLCTID                                                 | K                  | Generic coupling: Number of the curve table                                         |                 | +                | +                | FB3sl (M3)                    |
| CPLDEF                                                  | K                  | Generic coupling: Definition of a leading axis and creation of a coupling module    |                 | +                | +                | FB3sl (M3)                    |
| CPLDEL                                                  | K                  | Generic coupling: Deleting a leading axis of a coupling module                      |                 | +                | +                | FB3sl (M3)                    |
| CPLDEN                                                  | K                  | Generic coupling: Denominator of the coupling factor                                |                 | +                | +                | FB3sl (M3)                    |
| CPLINSC                                                 | K                  | Generic coupling: Scaling factor of the input value of a leading axis               |                 | +                | +                | FB3sl (M3)                    |

## 17.1 Operations

| Operation                                               | Typ<br>e <sup>1)</sup> | Meaning                                                                                     | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|------------------------|---------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                        |                                                                                             |                 |                  |                  |                               |
| CPLINTR                                                 | K                      | Generic coupling: Offset value of the input value of a leading axis                         |                 | +                | +                | FB3sl (M3)                    |
| CPLNUM                                                  | K                      | Generic coupling: Numerator of the coupling factor                                          |                 | +                | +                | FB3sl (M3)                    |
| CPLOF                                                   | K                      | Generic coupling: Switching off a leading axis of a coupling module                         |                 | +                | +                | FB3sl (M3)                    |
| CPLON                                                   | K                      | Generic coupling: Switching on a leading axis of a coupling module                          |                 | +                | +                | FB3sl (M3)                    |
| CPLOUTSC                                                | K                      | Generic coupling: Scaling factor for the output value of a coupling                         |                 | +                | +                | FB3sl (M3)                    |
| CPLOUTTR                                                | K                      | Generic coupling: Offset value for the output value of a coupling                           |                 | +                | +                | FB3sl (M3)                    |
| CPLPOS                                                  | K                      | Generic coupling: Synchronized position of the leading axis                                 |                 | +                | +                | FB3sl (M3)                    |
| CPLSETVAL                                               | K                      | Generic coupling: Coupling reference                                                        |                 | +                | +                | FB3sl (M3)                    |
| CPMALARM                                                | K                      | Generic coupling: Suppression of special coupling-related alarm outputs                     |                 | +                | +                | FB3sl (M3)                    |
| CPMBRAKE                                                | K                      | Generic coupling: Response of the following axis to certain stop signals and stop commands  |                 | +                | -                | FB3sl (M3)                    |
| CPMPRT                                                  | K                      | Generic coupling: Coupling response at part program start under search run via program test |                 | +                | +                | FB3sl (M3)                    |
| CPMRESET                                                | K                      | Generic coupling: Coupling behavior for RESET                                               |                 | +                | +                | FB3sl (M3)                    |
| CPMSTART                                                | K                      | Generic coupling: Coupling behavior at part program start                                   |                 | +                | +                | FB3sl (M3)                    |
| CPMVDI                                                  | K                      | Generic coupling: Response of the following axis to certain NC/PLC interface signals        |                 | +                | +                | FB3sl (M3)                    |
| CPOF                                                    | K                      | Generic coupling: Switching off a coupling module                                           |                 | +                | +                | FB3sl (M3)                    |
| CPON                                                    | K                      | Generic coupling: Switching on a coupling module                                            |                 | +                | +                | FB3sl (M3)                    |
| CPRECOF <sup>6)</sup>                                   | G                      | Programmable contour accuracy OFF                                                           | m               | +                |                  | PGAsl                         |
| CPRECON                                                 | G                      | Programmable contour accuracy ON                                                            | m               | +                |                  | PGAsl                         |
| CPRES                                                   | K                      | Generic coupling: Activates the configured data of the synchronous spindle coupling         |                 | +                | -                | FB3sl (M3)                    |
| CPROT                                                   | P                      | Channel-specific protection area ON/OFF                                                     |                 | +                | -                | PGAsl                         |
| CPROTDEF                                                | P                      | Definition of a channel-specific protection area                                            |                 | +                | -                | PGAsl                         |
| CPSETTYPE                                               | K                      | Generic coupling: Coupling type                                                             |                 | +                | +                | FB3sl (M3)                    |
| CPSYNCOF                                                | K                      | Generic coupling: Threshold value of position synchronism "Coarse"                          |                 | +                | +                | FB3sl (M3)                    |
| CPSYNCOF2                                               | K                      | Generic coupling: Threshold value of position synchronism "Coarse" 2                        |                 | +                | +                | FB3sl (M3)                    |
| CPSYNCOV                                                | K                      | Generic coupling: Threshold value of velocity synchronism "Coarse"                          |                 | +                | +                | FB3sl (M3)                    |
| CPSYNFIP                                                | K                      | Generic coupling: Threshold value of position synchronism "Fine"                            |                 | +                | +                | FB3sl (M3)                    |
| CPSYNFIP2                                               | K                      | Generic coupling: Threshold value of position synchronism "Fine" 2                          |                 | +                | +                | FB3sl (M3)                    |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                    |                 |                  |                  |                               |
| CPSYNFIV                                                | K                  | Generic coupling: Threshold value of velocity synchronism "Fine"                   |                 | +                | +                | FB3sl (M3)                    |
| CR                                                      | O                  | Circle radius                                                                      | s               | +                |                  | PGsl                          |
| CROT                                                    | F                  | Rotation of the current coordinate system                                          |                 | +                | -                | PGAsl                         |
| CROTS                                                   | F                  | Programmable frame rotations with solid angles (rotation in the specified axes)    | s               | +                | -                | PGsl                          |
| CRPL                                                    | F                  | Frame rotation in any plane                                                        |                 | +                | -                | FB1sl (K2)                    |
| CSCALE                                                  | F                  | Scale factor for multiple axes                                                     |                 | +                | -                | PGAsl                         |
| CSPLINE                                                 | F                  | Cubic spline                                                                       | m               | +                |                  | PGAsl                         |
| CT                                                      | G                  | Circle with tangential transition                                                  | m               | +                |                  | PGsl                          |
| CTAB                                                    | F                  | Define following axis position according to leading axis position from curve table |                 | +                | +                | PGAsl                         |
| CTABDEF                                                 | P                  | Table definition ON                                                                |                 | +                | -                | PGAsl                         |
| CTABDEL                                                 | P                  | Clear curve table                                                                  |                 | +                | -                | PGAsl                         |
| CTABEND                                                 | P                  | Table definition OFF                                                               |                 | +                | -                | PGAsl                         |
| CTABEXISTS                                              | F                  | Checks the curve table with number n                                               |                 | +                | +                | PGAsl                         |
| CTABFNO                                                 | F                  | Number of curve tables still possible in the memory                                |                 | +                | +                | PGAsl                         |
| CTABFPOL                                                | F                  | Number of polynomials still possible in the memory                                 |                 | +                | +                | PGAsl                         |
| CTABFSEG                                                | F                  | Number of curve segments still possible in the memory                              |                 | +                | +                | PGAsl                         |
| CTABID                                                  | F                  | Returns table number of the nth curve table                                        |                 | +                | +                | PGAsl                         |
| CTABINV                                                 | F                  | Define leading axis position according to following axis position from curve table |                 | +                | +                | PGAsl                         |
| CTABISLOCK                                              | F                  | Returns the lock state of the curve table with number n                            |                 | +                | +                | PGAsl                         |
| CTABLOCK                                                | P                  | Delete and overwrite, lock                                                         |                 | +                | +                | PGAsl                         |
| CTABMEMTYP                                              | F                  | Returns the memory in which curve table number n is created.                       |                 | +                | +                | PGAsl                         |
| CTABMPOL                                                | F                  | Max. number of polynomials still possible in the memory                            |                 | +                | +                | PGAsl                         |
| CTABMSEG                                                | F                  | Max. number of curve segments still possible in the memory                         |                 | +                | +                | PGAsl                         |
| CTABNO                                                  | F                  | Number of defined curve tables in SRAM or DRAM                                     |                 | +                | +                | FB3sl (M3)                    |
| CTABNOMEM                                               | F                  | Number of defined curve tables in SRAM or DRAM                                     |                 | +                | +                | PGAsl                         |
| CTABPERIOD                                              | F                  | Returns the table periodicity of curve table number n                              |                 | +                | +                | PGAsl                         |
| CTABPOL                                                 | F                  | Number of polynomials already used in the memory                                   |                 | +                | +                | PGAsl                         |
| CTABPOLID                                               | F                  | Number of the curve polynomials used by the curve table with number n              |                 | +                | +                | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                   | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                           |                 |                  |                  |                               |
| CTABSEG                                                 | F                  | Number of curve segments already used in the memory                                       |                 | +                | +                | PGAsI                         |
| CTABSEGID                                               | F                  | Number of the curve segments used by the curve table with number n                        |                 | +                | +                | PGAsI                         |
| CTABSEV                                                 | F                  | Returns the final value of the following axis of a segment of the curve table             |                 | +                | +                | PGAsI                         |
| CTABSSV                                                 | F                  | Returns the initial value of the following axis of a segment of the curve table           |                 | +                | +                | PGAsI                         |
| CTABTEP                                                 | F                  | Returns the value of the leading axis at curve table end                                  |                 | +                | +                | PGAsI                         |
| CTABTEV                                                 | F                  | Returns the value of the the following axis at curve table end                            |                 | +                | +                | PGAsI                         |
| CTABTMAX                                                | F                  | Returns the maximum value of the following axis of the curve table                        |                 | +                | +                | PGAsI                         |
| CTABTMIN                                                | F                  | Returns the minimum value of the following axis of the curve table                        |                 | +                | +                | PGAsI                         |
| CTABTSP                                                 | F                  | Returns the value of the leading axis at curve table start                                |                 | +                | +                | PGAsI                         |
| CTABTSV                                                 | F                  | Returns the value of the following axis at curve table start                              |                 | +                | +                | PGAsI                         |
| CTABUNLOCK                                              | P                  | Revoke delete and overwrite lock                                                          |                 | +                | +                | PGAsI                         |
| CTOL                                                    | K                  | Contour tolerance for compressor functions, orientation smoothing and smoothing types     |                 | +                |                  | PGAsI                         |
| CTRANS                                                  | F                  | Zero offset for multiple axes                                                             |                 | +                | -                | PGAsI                         |
| CUT2D <sup>6)</sup>                                     | G                  | 2D tool offset                                                                            | m               | +                |                  | PGsI                          |
| CUT2DF                                                  | G                  | 2D tool offset The tool offset is applied relative to the current frame (inclined plane). | m               | +                |                  | PGsI                          |
| CUT3DC                                                  | G                  | 3D tool offset circumferential milling                                                    | m               | +                |                  | PGAsI                         |
| CUT3DCC                                                 | G                  | 3D tool offset circumferential milling with limitation surfaces                           | m               | +                |                  | PGAsI                         |
| CUT3DCCD                                                | G                  | 3D tool offset circumferential milling with limitation surfaces with differential tool    | m               | +                |                  | PGAsI                         |
| CUT3DF                                                  | G                  | 3D tool offset face milling                                                               | m               | +                |                  | PGAsI                         |
| CUT3DFF                                                 | G                  | 3D tool offset face milling with constant tool orientation dependent on active frame      | m               | +                |                  | PGAsI                         |
| CUT3DFS                                                 | G                  | 3D tool offset face milling with constant tool orientation independent of active frame    | m               | +                |                  | PGAsI                         |
| CUTCONOF <sup>6)</sup>                                  | G                  | Constant radius compensation OFF                                                          | m               | +                |                  | PGsI                          |
| CUTCONON                                                | G                  | Constant radius compensation ON                                                           | m               | +                |                  | PGsI                          |
| CUTMOD                                                  | K                  | Activate "Modification of the offset data for rotatable tools"                            |                 | +                |                  | PGAsI                         |
| CYCLE60                                                 | C                  | Engraving cycle                                                                           |                 | +                |                  | PGAsI                         |
| CYCLE61                                                 | C                  | Face milling                                                                              |                 | +                |                  | PGAsI                         |
| CYCLE62                                                 | C                  | Contour call                                                                              |                 | +                |                  | PGAsI                         |
| CYCLE63                                                 | C                  | Contour pocket milling                                                                    |                 | +                |                  | PGAsI                         |



| Operation                                               | Type <sup>1)</sup> | Meaning                                                 | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|---------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                         |                 |                  |                  |                               |
| CYCLE64                                                 | C                  | Contour pocket predrilling                              |                 | +                |                  | PGAsI                         |
| CYCLE70                                                 | C                  | Thread milling                                          |                 | +                |                  | PGAsI                         |
| CYCLE72                                                 | C                  | Path milling                                            |                 | +                |                  | PGAsI                         |
| CYCLE76                                                 | C                  | Milling the rectangular spigot                          |                 | +                |                  | PGAsI                         |
| CYCLE77                                                 | C                  | Circular spigot milling                                 |                 | +                |                  | PGAsI                         |
| CYCLE78                                                 | C                  | Mill cutting thread                                     |                 | +                |                  | PGAsI                         |
| CYCLE79                                                 | C                  | Multiple edge                                           |                 | +                |                  | PGAsI                         |
| CYCLE81                                                 | C                  | Drilling, centering                                     |                 | +                |                  | PGAsI                         |
| CYCLE82                                                 | C                  | Drilling, counterboring                                 |                 | +                |                  | PGAsI                         |
| CYCLE83                                                 | C                  | Deep-hole drilling                                      |                 | +                |                  | PGAsI                         |
| CYCLE84                                                 | C                  | Tapping without compensating chuck                      |                 | +                |                  | PGAsI                         |
| CYCLE85                                                 | C                  | Reaming                                                 |                 | +                |                  | PGAsI                         |
| CYCLE86                                                 | C                  | Boring                                                  |                 | +                |                  | PGAsI                         |
| CYCLE92                                                 | C                  | Parting                                                 |                 | +                |                  | PGAsI                         |
| CYCLE95                                                 | C                  | Stock removal along the contour                         |                 | +                |                  | PGAsI                         |
| CYCLE98                                                 | C                  | Thread chain                                            |                 | +                |                  | PGAsI                         |
| CYCLE99                                                 | C                  | Thread cutting                                          |                 | +                |                  | PGAsI                         |
| CYCLE495                                                | C                  | Form-truing                                             |                 | +                |                  | PGAsI                         |
| CYCLE751                                                | C                  | Open / perform / close an optimization session          |                 | +                |                  | FB3sl (T4)                    |
| CYCLE752                                                | C                  | Add axis to an optimization session                     |                 | +                |                  | FB3sl (T4)                    |
| CYCLE753                                                | C                  | Select optimization mode                                |                 | +                |                  | FB3sl (T4)                    |
| CYCLE754                                                | C                  | Add / remove language block                             |                 | +                |                  | FB3sl (T4)                    |
| CYCLE755                                                | C                  | Backing up/restoring data block                         |                 | +                |                  | FB3sl (T4)                    |
| CYCLE756                                                | C                  | Activate optimization results                           |                 | +                |                  | FB3sl (T4)                    |
| CYCLE757                                                | C                  | Store optimization data                                 |                 | +                |                  | FB3sl (T4)                    |
| CYCLE758                                                | C                  | Changing the parameter value                            |                 | +                |                  | FB3sl (T4)                    |
| CYCLE759                                                | C                  | Read parameter value                                    |                 | +                |                  | FB3sl (T4)                    |
| CYCLE800                                                | C                  | Swiveling                                               |                 | +                |                  | PGAsI                         |
| CYCLE801                                                | C                  | Grid or frame                                           |                 | +                |                  | PGAsI                         |
| CYCLE802                                                | C                  | Arbitrary positions                                     |                 | +                |                  | PGAsI                         |
| CYCLE830                                                | C                  | Deep-hole drilling 2                                    |                 | +                |                  | PGAsI                         |
| CYCLE832                                                | C                  | High-Speed Settings                                     |                 | +                |                  | PGAsI                         |
| CYCLE840                                                | C                  | Tapping with compensating chuck                         |                 | +                |                  | PGAsI                         |
| CYCLE899                                                | C                  | Open slot milling                                       |                 | +                |                  | PGAsI                         |
| CYCLE930                                                | C                  | Groove                                                  |                 | +                |                  | PGAsI                         |
| CYCLE940                                                | C                  | Undercut forms                                          |                 | +                |                  | PGAsI                         |
| CYCLE951                                                | C                  | Stock removal                                           |                 | +                |                  | PGAsI                         |
| CYCLE952                                                | C                  | Contour grooving                                        |                 | +                |                  | PGAsI                         |
| CYCLE4071                                               | C                  | Longitudinal grinding with infeed at the reversal point |                 | +                |                  | PGAsI                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                   | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|---------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                           |                 |                  |                  |                               |
| CYCLE4072                                               | C                  | Longitudinal grinding with infeed at the reversal point and cancel signal |                 | +                |                  | PGAsI                         |
| CYCLE4073                                               | C                  | Longitudinal grinding with continuous infeed                              |                 | +                |                  | PGAsI                         |
| CYCLE4074                                               | C                  | Longitudinal grinding with continuous infeed and cancel signal            |                 | +                |                  | PGAsI                         |
| CYCLE4075                                               | C                  | Surface grinding with infeed at the reversal point                        |                 | +                |                  | PGAsI                         |
| CYCLE4077                                               | C                  | Surface grinding with infeed at the reversal point and cancel signal      |                 | +                |                  | PGAsI                         |
| CYCLE4078                                               | C                  | Surface grinding with continuous infeed                                   |                 | +                |                  | PGAsI                         |
| CYCLE4079                                               | C                  | Surface grinding with intermittent infeed                                 |                 | +                |                  | PGAsI                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                         | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                 |                 |                  |                  |                               |
| D                                                       | O                  | Tool offset number                                                                                                              |                 | +                |                  | PGsI                          |
| D0                                                      | O                  | With D0, offsets for the tool are ineffective                                                                                   |                 | +                |                  | PGsI                          |
| DAC                                                     | K                  | Absolute non-modal axis-specific diameter programming                                                                           | s               | +                |                  | PGsI                          |
| DC                                                      | K                  | Absolute dimensions for rotary axes, approach position directly                                                                 | s               | +                |                  | PGsI                          |
| DCI                                                     | K                  | Assign data class I (= Individual) (only SINUMERIK 828D)                                                                        |                 | +                |                  | PGAsI                         |
| DCM                                                     | K                  | Assign data class M (= Manufacturer) (only SINUMERIK 828D)                                                                      |                 | +                |                  | PGAsI                         |
| DCU                                                     | K                  | Assign data class U (= User) (only SINUMERIK 828D)                                                                              |                 | +                |                  | PGAsI                         |
| DEF                                                     | K                  | Variable definition                                                                                                             |                 | +                |                  | PGAsI                         |
| DEFAULT                                                 | K                  | Branch in CASE branch                                                                                                           |                 | +                |                  | PGAsI                         |
| DEFINE                                                  | K                  | Keyword for macro definitions                                                                                                   |                 | +                |                  | PGAsI                         |
| DELAYFSTOF                                              | P                  | Define the end of a stop delay section                                                                                          | m               | +                | -                | PGAsI                         |
| DELAYFSTON                                              | P                  | Define the start of a stop delay section                                                                                        | m               | +                | -                | PGAsI                         |
| DELDL                                                   | F                  | Delete additive offsets                                                                                                         |                 | +                | -                | PGAsI                         |
| DELDTG                                                  | P                  | Delete distance-to-go                                                                                                           |                 | -                | +                | FBSYsI                        |
| DELETE                                                  | P                  | Delete the specified file. The file name can be specified with path and file identifier.                                        |                 | +                | -                | PGAsI                         |
| DELMOWNER                                               | F                  | Delete owner magazine location of the tool                                                                                      |                 | +                | -                | FBWsI                         |
| DELMRES                                                 | F                  | Delete magazine location reservation                                                                                            |                 | +                | -                | FBWsI                         |
| DELMT                                                   | P                  | Delete multitool                                                                                                                |                 | +                | -                | FBWsI                         |
| DELOBJ                                                  | F                  | Deletion of elements from kinematic chains, protection areas, protection area elements, collision pairs and transformation data |                 | +                |                  | PGAsI                         |
| DELT                                                    | P                  | Delete Tool                                                                                                                     |                 | +                | -                | FBWsI                         |
| DELTC                                                   | P                  | Delete toolholder data record                                                                                                   |                 | +                | -                | FBWsI                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                     |                 |                  |                  |                               |
| DELTOOLNV                                               | F                  | Delete data records describing tool environments                                                    |                 | +                | -                | FB1sl (W1)                    |
| DIACYCOFA                                               | K                  | Axis-specific modal diameter programming: OFF in cycles                                             | m               | +                |                  | FB1sl (P1)                    |
| DIAM90                                                  | G                  | Diameter programming for G90, radius programming for G91                                            | m               | +                |                  | PGAsl                         |
| DIAM90A                                                 | K                  | Axis-specific modal diameter programming for G90 and AC, radius programming for G91 and IC          | m               | +                |                  | PGsl                          |
| DIAMCHAN                                                | K                  | Transfer of all axes from MD axis functions to diameter programming channel status                  |                 | +                |                  | PGsl                          |
| DIAMCHANA                                               | K                  | Transfer of the diameter programming channel status                                                 |                 | +                |                  | PGsl                          |
| DIAMCYCOF                                               | G                  | Channel-specific diameter programming: OFF in cycles                                                | m               | +                |                  | FB1sl (P1)                    |
| DIAMOF <sup>6)</sup>                                    | G                  | Diameter programming: OFF<br>Normal position, see machine manufacturer                              | m               | +                |                  | PGsl                          |
| DIAMOFA                                                 | K                  | Axis-specific modal diameter programming: OFF<br>Normal position, see machine manufacturer          | m               | +                |                  | PGsl                          |
| DIAMON                                                  | G                  | Diameter programming: ON                                                                            | m               | +                |                  | PGsl                          |
| DIAMONA                                                 | K                  | Axis-specific modal diameter programming: ON<br>Activation, see machine manufacturer                | m               | +                |                  | PGsl                          |
| DIC                                                     | K                  | Relative non-modal axis-specific diameter programming                                               | s               | +                |                  | PGsl                          |
| DILF                                                    | O                  | Retraction path (length)                                                                            | m               | +                |                  | PGsl                          |
| DISABLE                                                 | P                  | Interrupt OFF                                                                                       |                 | +                | -                | PGAsl                         |
| DISC                                                    | O                  | Transition circle overshoot tool radius compensation                                                | m               | +                |                  | PGsl                          |
| DISCL                                                   | O                  | Clearance between the end point of the fast infeed motion and the machining plane                   |                 | +                |                  | PGsl                          |
| DISPLOF                                                 | PA                 | Suppress current block display                                                                      |                 | +                |                  | PGAsl                         |
| DISPLON                                                 | PA                 | Revoke suppression of the current block display                                                     |                 | +                |                  | PGAsl                         |
| DISPR                                                   | O                  | Path differential for repositioning                                                                 | s               | +                |                  | PGAsl                         |
| DISR                                                    | O                  | Distance for repositioning                                                                          | s               | +                |                  | PGAsl                         |
| DISRP                                                   | O                  | Distance between the retraction plane and the machining plane during smooth approach and retraction |                 | +                |                  | PGsl                          |
| DITE                                                    | O                  | Thread run-out path                                                                                 | m               | +                |                  | PGsl                          |
| DITS                                                    | O                  | Thread run-in path                                                                                  | m               | +                |                  | PGsl                          |
| DIV                                                     | K                  | Integer division                                                                                    |                 | +                |                  | PGAsl                         |
| DL                                                      | O                  | Select location-dependent additive tool offset (DL, total set-up offset)                            | m               | +                |                  | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                      | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                              |                 |                  |                  |                               |
| DO                                                      | O                  | Keyword for synchronized action, triggers action when condition is fulfilled |                 | -                | +                | FBSYsl                        |
| DRFOF                                                   | P                  | Deactivation of handwheel offsets (DRF)                                      | m               | +                | -                | PGAsl                         |
| DRIVE                                                   | G                  | Velocity-dependent path acceleration                                         | m               | +                |                  | PGAsl                         |
| DRIVEA                                                  | P                  | Activate knee-shaped acceleration characteristic for the programmed axes     |                 | +                | -                | PGAsl                         |
| DYNFINISH                                               | G                  | Dynamic response for smooth finishing                                        | m               | +                |                  | PGAsl                         |
| DYNNORM <sup>6)</sup>                                   | G                  | Standard dynamic response                                                    | m               | +                |                  | PGAsl                         |
| DYNPOS                                                  | G                  | Dynamic response for positioning mode, tapping                               | m               | +                |                  | PGAsl                         |
| DYNROUGH                                                | G                  | Dynamic response for roughing                                                | m               | +                |                  | PGAsl                         |
| DYNSEMIFIN                                              | G                  | Dynamic response for finishing                                               | m               | +                |                  | PGAsl                         |
| DZERO                                                   | P                  | Marks all D numbers of the TO unit as invalid                                |                 | +                | -                | PGAsl                         |
| EAUTO                                                   | G                  | Definition of the last spline section by means of the last 3 points          | m               | +                |                  | PGAsl                         |
| EGDEF                                                   | P                  | Definition of an electronic gear                                             |                 | +                | -                | PGAsl                         |
| EGDEL                                                   | P                  | Delete coupling definition for the following axis                            |                 | +                | -                | PGAsl                         |
| EGOFC                                                   | P                  | Turn off electronic gear continuously                                        |                 | +                | -                | PGAsl                         |
| EGOFS                                                   | P                  | Turn off electronic gear selectively                                         |                 | +                | -                | PGAsl                         |
| EGON                                                    | P                  | Turn on electronic gear                                                      |                 | +                | -                | PGAsl                         |
| EGONSYN                                                 | P                  | Turn on electronic gear                                                      |                 | +                | -                | PGAsl                         |
| EGONSYNE                                                | P                  | Turn on electronic gear, with specification of approach mode                 |                 | +                | -                | PGAsl                         |
| ELSE                                                    | K                  | Program branch, if IF condition not fulfilled                                |                 | +                |                  | PGAsl                         |
| ENABLE                                                  | P                  | Interrupt ON                                                                 |                 | +                | -                | PGAsl                         |
| ENAT <sup>6)</sup>                                      | G                  | Natural transition to next traversing block                                  | m               | +                |                  | PGAsl                         |
| ENDFOR                                                  | K                  | End line of FOR counter loop                                                 |                 | +                |                  | PGAsl                         |
| ENDIF                                                   | K                  | End line of IF branch                                                        |                 | +                |                  | PGAsl                         |
| ENDLABEL                                                | K                  | End label for part program repetitions with REPEAT                           |                 | +                |                  | PGAsl, FB1sl (K1)             |
| ENDLOOP                                                 | K                  | End line of endless program loop LOOP                                        |                 | +                |                  | PGAsl                         |
| ENDPROC                                                 | K                  | End line of program with start line PROC                                     |                 | +                |                  |                               |
| ENDWHILE                                                | K                  | End line of WHILE loop                                                       |                 | +                |                  | PGAsl                         |
| ESRR                                                    | P                  | Parameterizing drive-autonomous ESR retraction in the drive                  |                 | +                |                  | PGAsl                         |
| ESRS                                                    | P                  | Parameterizing drive-autonomous ESR shutdown in the drive                    |                 | +                |                  | PGAsl                         |
| ETAN                                                    | G                  | Tangential transition to next traversing block at spline begin               | m               | +                |                  | PGAsl                         |
| EVERY                                                   | K                  | Execute synchronized action on transition of condition from FALSE to TRUE    |                 | -                | +                | FBSYsl                        |
| EX                                                      | K                  | Keyword for value assignment in exponential notation                         |                 | +                |                  | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                        |                 |                  |                  |                               |
| EXECSTRING                                              | P                  | Transfer of a string variable with the executing part program line                                     |                 | +                | -                | PGAsl                         |
| EXECTAB                                                 | P                  | Execute an element from a motion table                                                                 |                 | +                | -                | PGAsl                         |
| EXECUTE                                                 | P                  | Program execution ON                                                                                   |                 | +                | -                | PGAsl                         |
| EXP                                                     | F                  | Exponential function ex                                                                                |                 | +                | +                | PGAsl                         |
| EXTCALL                                                 | O                  | Execute external subprogram                                                                            |                 | +                | +                | PGAsl                         |
| EXTCLOSE                                                | P                  | Closing external device / file that was opened for writing                                             |                 | +                | -                | PGAsl                         |
| EXTERN                                                  | K                  | Declaration of a subprogram with parameter transfer                                                    |                 | +                |                  | PGAsl                         |
| EXTOPEN                                                 | P                  | Opening external device / file for the channel for writing                                             |                 | +                | -                | PGAsl                         |
| F                                                       | O                  | Feedrate value<br>(in conjunction with G4 the dwell time is also programmed with F)                    |                 | +                | +                | PGsl                          |
| FA                                                      | K                  | Axial feedrate                                                                                         | m               | +                | +                | PGsl                          |
| FAD                                                     | O                  | Infeed rate for soft approach and retraction                                                           |                 | +                |                  | PGsl                          |
| FALSE                                                   | K                  | Logical constant: Incorrect                                                                            |                 | +                | +                | PGAsl                         |
| FB                                                      | O                  | Non-modal feedrate                                                                                     |                 | +                |                  | PGsl                          |
| FCTDEF                                                  | P                  | Define polynomial function                                                                             |                 | +                | -                | PGAsl                         |
| FCUB                                                    | G                  | Feedrate variable according to cubic spline                                                            | m               | +                |                  | PGAsl                         |
| FD                                                      | O                  | Path feedrate for handwheel override                                                                   | s               | +                |                  | PGsl                          |
| FDA                                                     | K                  | Axis feedrate for handwheel override                                                                   | s               | +                |                  | PGsl                          |
| FENDNORM <sup>6)</sup>                                  | G                  | Corner deceleration OFF                                                                                | m               | +                |                  | PGAsl                         |
| FFWOF <sup>6)</sup>                                     | G                  | Feedforward control OFF                                                                                | m               | +                |                  | PGAsl                         |
| FFWON                                                   | G                  | Feedforward control ON                                                                                 | m               | +                |                  | PGAsl                         |
| FGREF                                                   | K                  | Reference radius for rotary axes or path reference factors for orientation axes (vector interpolation) | m               | +                |                  | PGsl                          |
| FGROUP                                                  | P                  | Definition of axis/axes with path feedrate                                                             |                 | +                | -                | PGsl                          |
| FI                                                      | K                  | Parameter for access to frame data: Fine off-set                                                       |                 | +                |                  | PGAsl                         |
| FIFOCTRL                                                | G                  | Control of preprocessing buffer                                                                        | m               | +                |                  | PGAsl                         |
| FILEDATE                                                | P                  | Returns date of most recent write access to file                                                       |                 | +                | -                | PGAsl                         |
| FILEINFO                                                | P                  | Returns summary information listing FILE-DATE, FILESIZE, FILESTAT, and FILETIME                        |                 | +                | -                | PGAsl                         |
| FILESIZE                                                | P                  | Returns current file size                                                                              |                 | +                | -                | PGAsl                         |
| FILESTAT                                                | P                  | Returns file status of rights for read, write, execute, display, delete (rwxsd)                        |                 | +                | -                | PGAsl                         |
| FILETIME                                                | P                  | Returns time of most recent write access to file                                                       |                 | +                | -                | PGAsl                         |
| FINEA                                                   | K                  | End of motion when "Exact stop fine" reached                                                           | m               | +                |                  | PGAsl                         |
| FL                                                      | K                  | Limit velocity for synchronized axis                                                                   | m               | +                |                  | PGsl                          |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                    | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                            |                 |                  |                  |                               |
| FLIN                                                    | G                  | Feed linear variable                                                                                       | m               | +                |                  | PGAsl                         |
| FMA                                                     | K                  | Multiple feedrates axial                                                                                   | m               | +                |                  | PGsl                          |
| FNORM <sup>6)</sup>                                     | G                  | Feedrate normal to DIN 66025                                                                               | m               | +                |                  | PGAsl                         |
| FOC                                                     | K                  | Non-modal torque/force limitation                                                                          | s               | -                | +                | FBSYsl                        |
| FOCOF                                                   | K                  | Switch off modal torque/force limitation                                                                   | m               | -                | +                | FBSYsl                        |
| FOCON                                                   | K                  | Switch on modal torque/force limitation                                                                    | m               | -                | +                | FBSYsl                        |
| FOR                                                     | K                  | Counter loop with fixed number of passes                                                                   |                 | +                |                  | PGAsl                         |
| FP                                                      | O                  | Fixed point: Number of fixed point to be approached                                                        | s               | +                |                  | PGsl                          |
| FPO                                                     | K                  | Feedrate characteristic programmed via a polynomial                                                        |                 | +                |                  | PGAsl                         |
| FPR                                                     | P                  | Rotary axis identifier                                                                                     |                 | +                | -                | PGsl                          |
| FPRAOF                                                  | P                  | Deactivate revolutionary feedrate                                                                          |                 | +                | -                | PGsl                          |
| FPRAON                                                  | P                  | Activate revolutionary feedrate                                                                            |                 | +                | -                | PGsl                          |
| FRAME                                                   | K                  | Data type for the definition of coordinate systems                                                         |                 | +                |                  | PGAsl                         |
| FRC                                                     | O                  | Feedrate for radius and chamfer                                                                            | s               | +                |                  | PGsl                          |
| FRCM                                                    | O                  | Feedrate for radius and chamfer, modal                                                                     | m               | +                |                  | PGsl                          |
| FROM                                                    | K                  | The action is executed if the condition is fulfilled once and as long as the synchronized action is active |                 | -                | +                | FBSYsl                        |
| FTOC                                                    | P                  | Change fine tool offset                                                                                    |                 | -                | +                | FBSYsl                        |
| FTOCOF <sup>6)</sup>                                    | G                  | Online fine tool offset OFF                                                                                | m               | +                |                  | PGAsl                         |
| FTOCON                                                  | G                  | Online fine tool offset ON                                                                                 | m               | +                |                  | PGAsl                         |
| FXS                                                     | K                  | Travel to fixed stop ON                                                                                    | m               | +                | +                | PGsl                          |
| FXST                                                    | K                  | Torque limit for travel to fixed stop                                                                      | m               | +                | +                | PGsl                          |
| FXSW                                                    | K                  | Monitoring window for travel to fixed stop                                                                 |                 | +                | +                | PGsl                          |
| FZ                                                      | K                  | Tooth feedrate                                                                                             | m               | +                |                  | PGsl                          |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                          | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                  |                 |                  |                  |                               |
| G0                                                      | G                  | Linear interpolation with rapid traverse (rapid traverse motion) | m               | +                |                  | PGsl                          |
| G1 <sup>6)</sup>                                        | G                  | Linear interpolation with feedrate (linear interpolation)        | m               | +                |                  | PGsl                          |
| G2                                                      | G                  | Circular interpolation clockwise                                 | m               | +                |                  | PGsl                          |
| G3                                                      | G                  | Circular interpolation counter-clockwise                         | m               | +                |                  | PGsl                          |
| G4                                                      | G                  | Dwell time, preset                                               | s               | +                |                  | PGsl                          |
| G5                                                      | G                  | Oblique plunge-cut grinding                                      | s               | +                |                  | PGAsl                         |
| G7                                                      | G                  | Compensatory motion during oblique plunge-cut grinding           | s               | +                |                  | PGAsl                         |
| G9                                                      | G                  | Exact stop - deceleration                                        | s               | +                |                  | PGsl                          |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                    |                 |                  |                  |                               |
| G17 <sup>6)</sup>                                       | G                  | Selection of working plane X/Y                                                     | m               | +                |                  | PGsl                          |
| G18                                                     | G                  | Selection of working plane Z/X                                                     | m               | +                |                  | PGsl                          |
| G19                                                     | G                  | Selection of working plane Y/Z                                                     | m               | +                |                  | PGsl                          |
| G25                                                     | G                  | Lower working area limitation                                                      | s               | +                |                  | PGsl                          |
| G26                                                     | G                  | Upper working area limitation                                                      | s               | +                |                  | PGsl                          |
| G33                                                     | G                  | Thread cutting with constant lead                                                  | m               | +                |                  | PGsl                          |
| G34                                                     | G                  | Thread cutting with linear increasing lead                                         | m               | +                |                  | PGsl                          |
| G35                                                     | G                  | Thread cutting with linear decreasing lead                                         | m               | +                |                  | PGsl                          |
| G40 <sup>6)</sup>                                       | G                  | Tool radius compensation OFF                                                       | m               | +                |                  | PGsl                          |
| G41                                                     | G                  | Tool radius compensation left of contour                                           | m               | +                |                  | PGsl                          |
| G42                                                     | G                  | Tool radius compensation right of contour                                          | m               | +                |                  | PGsl                          |
| G53                                                     | G                  | Suppression of current zero offset (non-modal)                                     | s               | +                |                  | PGsl                          |
| G54                                                     | G                  | 1st settable zero offset                                                           | m               | +                |                  | PGsl                          |
| G55                                                     | G                  | 2. Settable work offset                                                            | m               | +                |                  | PGsl                          |
| G56                                                     | G                  | 3. Settable work offset                                                            | m               | +                |                  | PGsl                          |
| G57                                                     | G                  | 4. Settable work offset                                                            | m               | +                |                  | PGsl                          |
| G58 (840D sl)                                           | G                  | Axial programmable zero offset, absolute, coarse offset                            | s               | +                |                  | PGsl                          |
| G58 (828D)                                              | G                  | 5. Settable work offset                                                            | m               | +                |                  | PGsl                          |
| G59 (840D sl)                                           | G                  | Axial programmable zero offset, additive, fine offset                              | s               | +                |                  | PGsl                          |
| G59 (828D)                                              | G                  | 6. Settable work offset                                                            | m               | +                |                  | PGsl                          |
| G60 <sup>6)</sup>                                       | G                  | Exact stop - deceleration                                                          | m               | +                |                  | PGsl                          |
| G62                                                     | G                  | Corner deceleration at inside corners when tool radius offset is active (G41, G42) | m               | +                |                  | PGAsl                         |
| G63                                                     | G                  | Tapping with compensating chuck                                                    | s               | +                |                  | PGsl                          |
| G64                                                     | G                  | Continuous-path mode                                                               | m               | +                |                  | PGsl                          |
| G70                                                     | G                  | Inch dimensions for geometric specifications (lengths)                             | m               | +                | +                | PGsl                          |
| G71 <sup>6)</sup>                                       | G                  | Metric dimensions for geometric specifications (lengths)                           | m               | +                | +                | PGsl                          |
| G74                                                     | G                  | Search for reference                                                               | s               | +                |                  | PGsl                          |
| G75                                                     | G                  | Fixed point approach                                                               | s               | +                |                  | PGsl                          |
| G90 <sup>6)</sup>                                       | G                  | Absolute dimensions                                                                | m/s             | +                |                  | PGsl                          |
| G91                                                     | G                  | Incremental dimensions                                                             | m/s             | +                |                  | PGsl                          |
| G93                                                     | G                  | Inverse-time feedrate rpm                                                          | m               | +                |                  | PGsl                          |
| G94 <sup>6)</sup>                                       | G                  | Linear feedrate F in mm/min or inch/min and degree/min                             | m               | +                |                  | PGsl                          |
| G95                                                     | G                  | Revolutional feedrate F in mm/rev or inch/rev                                      | m               | +                |                  | PGsl                          |
| G96                                                     | G                  | Constant cutting rate (as for G95) ON                                              | m               | +                |                  | PGsl                          |
| G97                                                     | G                  | Constant cutting rate (as for G95) OFF                                             | m               | +                |                  | PGsl                          |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                  | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                          |                 |                  |                  |                               |
| G110                                                    | G                  | Pole programming relative to the last programmed setpoint position       | s               | +                |                  | PGsl                          |
| G111                                                    | G                  | Pole programming relative to zero of current workpiece coordinate system | s               | +                |                  | PGsl                          |
| G112                                                    | G                  | Pole programming relative to the last valid pole                         | s               | +                |                  | PGsl                          |
| G140 <sup>6)</sup>                                      | G                  | SAR approach direction defined by G41/G42                                | m               | +                |                  | PGsl                          |
| G141                                                    | G                  | SAR approach direction to left of contour                                | m               | +                |                  | PGsl                          |
| G142                                                    | G                  | SAR approach direction to right of contour                               | m               | +                |                  | PGsl                          |
| G143                                                    | G                  | SAR approach direction tangent-dependent                                 | m               | +                |                  | PGsl                          |
| G147                                                    | G                  | Soft approach with straight line                                         | s               | +                |                  | PGsl                          |
| G148                                                    | G                  | Soft retraction with straight line                                       | s               | +                |                  | PGsl                          |
| G153                                                    | G                  | Suppression of current frames including basic frame                      | s               | +                |                  | PGsl                          |
| G247                                                    | G                  | Soft approach with quadrant                                              | s               | +                |                  | PGsl                          |
| G248                                                    | G                  | Soft retraction with quadrant                                            | s               | +                |                  | PGsl                          |
| G290 <sup>6)</sup>                                      | G                  | Switch over to SINUMERIK mode ON                                         | m               | +                |                  | FBWsl                         |
| G291                                                    | G                  | Switch over to ISO2/3 mode ON                                            | m               | +                |                  | FBWsl                         |
| G331                                                    | G                  | Rigid tapping, positive lead, clockwise                                  | m               | +                |                  | PGsl                          |
| G332                                                    | G                  | Rigid tapping, negative lead, counter-clockwise                          | m               | +                |                  | PGsl                          |
| G335                                                    | G                  | Turning a convex thread in clockwise direction                           | m               | +                |                  | PGsl                          |
| G336                                                    | G                  | Turning a convex thread in counter-clockwise direction                   | m               | +                |                  | PGsl                          |
| G340 <sup>6)</sup>                                      | G                  | Spatial approach block (depth and in plane at the same time (helix))     | m               | +                |                  | PGsl                          |
| G341                                                    | G                  | Initial infeed on perpendicular axis (z), then approach in plane         | m               | +                |                  | PGsl                          |
| G347                                                    | G                  | Soft approach with semicircle                                            | s               | +                |                  | PGsl                          |
| G348                                                    | G                  | Soft retraction with semicircle                                          | s               | +                |                  | PGsl                          |
| G450 <sup>6)</sup>                                      | G                  | Transition circle                                                        | m               | +                |                  | PGsl                          |
| G451                                                    | G                  | Intersection of equidistances                                            | m               | +                |                  | PGsl                          |
| G460 <sup>6)</sup>                                      | G                  | Activation of collision detection for the approach and retraction block  | m               | +                |                  | PGsl                          |
| G461                                                    | G                  | Insertion of a circle into the TRC block                                 | m               | +                |                  | PGsl                          |
| G462                                                    | G                  | Insertion of a straight line into the TRC block                          | m               | +                |                  | PGsl                          |
| G500 <sup>6)</sup>                                      | G                  | Deactivation of all adjustable frames, basic frames are active           | m               | +                |                  | PGsl                          |
| G505 ... G599                                           | G                  | 5 ... 99. Settable work offset                                           | m               | +                |                  | PGsl                          |
| G601 <sup>6)</sup>                                      | G                  | Block change at exact stop fine                                          | m               | +                |                  | PGsl                          |
| G602                                                    | G                  | Block change at exact stop coarse                                        | m               | +                |                  | PGsl                          |
| G603                                                    | G                  | Block change at IPO block end                                            | m               | +                |                  | PGsl                          |
| G621                                                    | G                  | Corner deceleration at all corners                                       | m               | +                |                  | PGAsl                         |



| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                    |                 |                  |                  |                               |
| G641                                                    | G                  | Continuous-path mode with smoothing as per distance criterion (= programmable rounding clearance)  | m               | +                |                  | PGsl                          |
| G642                                                    | G                  | Continuous-path mode with smoothing within the defined tolerances                                  | m               | +                |                  | PGsl                          |
| G643                                                    | G                  | Continuous-path mode with smoothing within the defined tolerances (block-internal)                 | m               | +                |                  | PGsl                          |
| G644                                                    | G                  | Continuous-path mode with smoothing with maximum possible dynamic response                         | m               | +                |                  | PGsl                          |
| G645                                                    | G                  | Continuous-path mode with smoothing and tangential block transitions within the defined tolerances | m               | +                |                  | PGsl                          |
| G700                                                    | G                  | Inch dimensions for geometric and technological specifications (lengths, feedrate)                 | m               | +                | +                | PGsl                          |
| G710 <sup>6)</sup>                                      | G                  | Metric dimensions for geometric and technological specifications (lengths, feedrate)               | m               | +                | +                | PGsl                          |
| G810 <sup>6)</sup> , ..., G819                          | G                  | G group reserved for the OEM user                                                                  |                 | +                |                  | PGAsl                         |
| G820 <sup>6)</sup> , ..., G829                          | G                  | G group reserved for the OEM user                                                                  |                 | +                |                  | PGAsl                         |
| G931                                                    | G                  | Feedrate specified by traversing time                                                              | m               | +                |                  |                               |
| G942                                                    | G                  | Freeze linear feedrate and constant cutting rate or spindle speed                                  | m               | +                |                  |                               |
| G952                                                    | G                  | Freeze revolutional feedrate and constant cutting rate or spindle speed                            | m               | +                |                  |                               |
| G961                                                    | G                  | Constant cutting rate and linear feedrate                                                          | m               | +                |                  | PGsl                          |
| G962                                                    | G                  | Linear or revolutional feedrate and constant cutting rate                                          | m               | +                |                  | PGsl                          |
| G971                                                    | G                  | Freeze spindle speed and linear feedrate                                                           | m               | +                |                  | PGsl                          |
| G972                                                    | G                  | Freeze linear or revolutional feedrate and constant spindle speed                                  | m               | +                |                  | PGsl                          |
| G973                                                    | G                  | Revolutional feedrate without spindle speed limitation                                             | m               | +                |                  | PGsl                          |
| GEOAX                                                   | P                  | Assign new channel axes to geometry axes 1 - 3                                                     |                 | +                | -                | PGAsl                         |
| GET                                                     | P                  | Replace enabled axis between channels                                                              |                 | +                | +                | PGAsl                         |
| GETACTT                                                 | F                  | Gets active tool from a group of tools with the same name                                          |                 | +                | -                | FBWsl                         |
| GETACTTD                                                | F                  | Gets the T number associated with an absolute D number                                             |                 | +                | -                | PGAsl                         |
| GETD                                                    | P                  | Replace axis directly between channels                                                             |                 | +                | -                | PGAsl                         |
| GETDNO                                                  | F                  | Returns the D number of a cutting edge (CE) of a tool (T)                                          |                 | +                | -                | PGAsl                         |
| GETEXET                                                 | P                  | Reading of the loaded T number                                                                     |                 | +                | -                | FBWsl                         |
| GETFREELOC                                              | P                  | Find a free space in the magazine for a given tool                                                 |                 | +                | -                | FBWsl                         |
| GETSELT                                                 | P                  | Return selected T number                                                                           |                 | +                | -                | FBWsl                         |
| GETT                                                    | F                  | Get T number for tool name                                                                         |                 | +                | -                | FBWsl                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                     |                 |                  |                  |                               |
| GETTCOR                                                 | F                  | Read out tool lengths and/or tool length components                                                                 |                 | +                | -                | FB1sl (W1)                    |
| GETTENV                                                 | F                  | Read T, D and DL numbers                                                                                            |                 | +                | -                | FB1sl (W1)                    |
| GETVARAP                                                | F                  | Read access rights to a system/user variable                                                                        |                 | +                | -                | PGAsl                         |
| GETVARDFT                                               | F                  | Read default value of a system/user variable                                                                        |                 | +                | -                | PGAsl                         |
| GETVARLIM                                               | F                  | Read limit values of a system/user variable                                                                         |                 | +                | -                | PGAsl                         |
| GETVARPHU                                               | F                  | Read physical unit of a system/user variable                                                                        |                 | +                | -                | PGAsl                         |
| GETVARTYP                                               | F                  | Read data type of a system/user variable                                                                            |                 | +                | -                | PGAsl                         |
| GOTO                                                    | K                  | Jump operation first forward then backward (direction initially to end of program and then to beginning of program) |                 | +                |                  | PGAsl                         |
| GOTOB                                                   | K                  | Jump backward (toward the beginning of the program)                                                                 |                 | +                |                  | PGAsl                         |
| GOTOC                                                   | K                  | As GOTO, but suppress alarm 14080 "Jump destination not found"                                                      |                 | +                |                  | PGAsl                         |
| GOTOF                                                   | K                  | Jump forward (toward the end of the program)                                                                        |                 | +                |                  | PGAsl                         |
| GOTOS                                                   | K                  | Jump back to beginning of program                                                                                   |                 | +                |                  | PGAsl                         |
| GP                                                      | K                  | Keyword for the indirect programming of position attributes                                                         |                 | +                |                  | PGAsl                         |
| GWPSOF                                                  | P                  | Deselect constant grinding wheel peripheral speed (GWPS)                                                            | s               | +                | -                | PGsl                          |
| GWPSON                                                  | P                  | Select constant grinding wheel peripheral speed (GWPS)                                                              | s               | +                | -                | PGsl                          |
| H...                                                    | O                  | Auxiliary function output to the PLC                                                                                |                 | +                | +                | PGsl/FB1sl (H2)               |
| HOLES1                                                  | C                  | Row of holes                                                                                                        |                 | +                |                  | PGAsl                         |
| HOLES2                                                  | C                  | Circle of holes                                                                                                     |                 | +                |                  | PGAsl                         |
| I                                                       | O                  | Interpolation parameters                                                                                            | s               | +                |                  | PGsl                          |
| I1                                                      | O                  | Intermediate point coordinate                                                                                       | s               | +                |                  | PGsl                          |
| IC                                                      | K                  | Incremental dimensions                                                                                              | s               | +                |                  | PGsl                          |
| ICYCOF                                                  | P                  | All blocks of a technology cycle are processed in one interpolation cycle following ICYCOF                          |                 | +                | +                | FBSYsl                        |
| ICYCON                                                  | P                  | Each block of a technology cycle is processed in a separate interpolation cycle following ICYCON                    |                 | +                | +                | FBSYsl                        |
| ID                                                      | K                  | Identifier for modal synchronized actions                                                                           | m               | -                | +                | FBSYsl                        |
| IDS                                                     | K                  | Identifier for modal static synchronized actions                                                                    |                 | -                | +                | FBSYsl                        |
| IF                                                      | K                  | Introduction of a conditional jump in the part program/technology cycle                                             |                 | +                | +                | PGAsl                         |
| INDEX                                                   | F                  | Define index of character in input string                                                                           |                 | +                | -                | PGAsl                         |
| INICF                                                   | K                  | Initialization of variables at NewConfig                                                                            |                 | +                |                  | PGAsl                         |
| INIPO                                                   | K                  | Initialization of variables at POWER ON                                                                             |                 | +                |                  | PGAsl                         |
| INIRE                                                   | K                  | Initialization of variables at reset                                                                                |                 | +                |                  | PGAsl                         |
| INIT                                                    | P                  | Selection of a particular NC program for execution in a particular channel                                          |                 | +                | -                | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                          | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|----------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                  |                 |                  |                  |                               |
| INITIAL                                                 |                    | Generation of an INI file across all areas                                       |                 | +                |                  | PGAsI                         |
| INT                                                     | K                  | Data type: Integer with sign                                                     |                 | +                |                  | PGAsI                         |
| INTERSEC                                                | F                  | Calculate intersection between two contour elements                              |                 | +                | -                | PGAsI                         |
| INVCCW                                                  | G                  | Trace involute, counter-clockwise                                                | m               | +                |                  | PGsI                          |
| INVCW                                                   | G                  | Trace involute, clockwise                                                        | m               | +                |                  | PGsI                          |
| INVFRAME                                                | F                  | Calculate the inverse frame from a frame                                         |                 | +                | -                | FB1sI (K2)                    |
| IP                                                      | K                  | Variable interpolation parameter                                                 |                 | +                |                  | PGAsI                         |
| IPOBRKA                                                 | P                  | Motion criterion from braking ramp activation                                    | m               | +                | +                |                               |
| IPOENDA                                                 | K                  | End of motion when "IPO stop" reached                                            | m               | +                |                  | PGAsI                         |
| IPTRLOCK                                                | P                  | Freeze start of the untraceable program section at next machine function block.  | m               | +                | -                | PGAsI                         |
| IPTRUNLOCK                                              | P                  | Set end of untraceable program section at current block at time of interruption. | m               | +                | -                | PGAsI                         |
| IR                                                      | O                  | Center of circle coordinate (X axis) when turning a convex thread                |                 | +                |                  | PGsI                          |
| ISAXIS                                                  | F                  | Check if geometry axis 1 specified as parameter                                  |                 | +                | -                | PGAsI                         |
| ISD                                                     | O                  | Insertion depth                                                                  | m               | +                |                  | PGAsI                         |
| ISFILE                                                  | F                  | Check whether the file exists in the NCK application memory                      |                 | +                | -                | PGAsI                         |
| ISNUMBER                                                | F                  | Check whether the input string can be converted to a number                      |                 | +                | -                | PGAsI                         |
| ISOCALL                                                 | K                  | Indirect call of a program programmed in an ISO language                         |                 | +                |                  | PGAsI                         |
| ISVAR                                                   | F                  | Check whether the transfer parameter contains a variable declared in the NC      |                 | +                | -                | PGAsI                         |
| J                                                       | O                  | Interpolation parameters                                                         | s               | +                |                  | PGsI                          |
| J1                                                      | O                  | Intermediate point coordinate                                                    | s               | +                |                  | PGsI                          |
| JERKA                                                   | P                  | Activate acceleration response set via MD for programmed axes                    |                 | +                | -                |                               |
| JERKLIM                                                 | K                  | Reduction or overshoot of maximum axial jerk                                     | m               | +                |                  | PGAsI                         |
| JERKLIMA                                                | K                  | Reduction or overshoot of maximum axial jerk                                     | m               | +                | +                | PGAsI                         |
| JR                                                      | O                  | Center of circle coordinate (Y axis) when turning a convex thread                |                 | +                |                  | PGsI                          |
| K                                                       | O                  | Interpolation parameters                                                         | s               | +                |                  | PGsI                          |
| K1                                                      | O                  | Intermediate point coordinate                                                    | s               | +                |                  | PGsI                          |
| KONT                                                    | G                  | Travel around contour on tool offset                                             | m               | +                |                  | PGsI                          |
| KONTC                                                   | G                  | Approach/retract with continuous-curvature polynomial                            | m               | +                |                  | PGsI                          |
| KONTT                                                   | G                  | Approach/retract with continuous-tangent polynomial                              | m               | +                |                  | PGsI                          |
| KR                                                      | O                  | Center of circle coordinate (Z axis) when turning a convex thread                |                 | +                |                  | PGsI                          |
| L                                                       | O                  | Subprogram number                                                                | s               | +                | +                | PGAsI                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                     |                 |                  |                  |                               |
| LEAD                                                    | O                  | Lead angle<br>1. Tool orientation<br>2. Orientation polynomial                                                                      | m               | +                |                  | PGAsl                         |
| LEADOF                                                  | P                  | Axial master value coupling OFF                                                                                                     |                 | +                | +                | PGAsl                         |
| LEADON                                                  | P                  | Axial master value coupling on                                                                                                      |                 | +                | +                | PGAsl                         |
| LENTOAX                                                 | F                  | Provides information about the assignment of tool lengths L1, L2, and L3 of the active tool to the abscissa, ordinate and applicate |                 | +                | -                | FB1sl (W1)                    |
| LFOF <sup>6)</sup>                                      | G                  | Fast retraction for thread cutting OFF                                                                                              | m               | +                |                  | PGsl                          |
| LFON                                                    | G                  | Fast retraction for thread cutting ON                                                                                               | m               | +                |                  | PGsl                          |
| LFPOS                                                   | G                  | Retraction of the axis declared with POLFMASK or POLFMLIN to the absolute axis position programmed with POLF                        | m               | +                |                  | PGsl                          |
| LFTXT <sup>6)</sup>                                     | G                  | The plane of the retraction movement for fast retraction is determined from the path tangent and the current tool direction         | m               | +                |                  | PGsl                          |
| LFWP                                                    | G                  | The plane of the retraction movement for fast retraction is determined by the current working plane (G17/G18/G19)                   | m               | +                |                  | PGsl                          |
| LIFTFAST                                                | K                  | Fast retraction                                                                                                                     |                 | +                |                  | PGsl                          |
| LIMS                                                    | K                  | Speed limitation for G96/G961 and G97                                                                                               | m               | +                |                  | PGsl                          |
| LLI                                                     | K                  | Lower limit value of variables                                                                                                      |                 | +                |                  | PGAsl                         |
| LN                                                      | F                  | Natural logarithm                                                                                                                   |                 | +                | +                | PGAsl                         |
| LOCK                                                    | P                  | Disable synchronized action with ID (stop technology cycle)                                                                         |                 | -                | +                | FBSYsl                        |
| LONGHOLE                                                | C                  | Elongated hole                                                                                                                      |                 | +                |                  | PGAsl                         |
| LOOP                                                    | K                  | Introduction of an endless loop                                                                                                     |                 | +                |                  | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                        |                 |                  |                  |                               |
| M0                                                      |                    | Programmed stop                                        |                 | +                | +                | PGsl                          |
| M1                                                      |                    | Optional stop                                          |                 | +                | +                | PGsl                          |
| M2                                                      |                    | End of program, main program (as M30)                  |                 | +                | +                | PGsl                          |
| M3                                                      |                    | CW spindle rotation                                    |                 | +                | +                | PGsl                          |
| M4                                                      |                    | CCW spindle rotation                                   |                 | +                | +                | PGsl                          |
| M5                                                      |                    | Spindle stop                                           |                 | +                | +                | PGsl                          |
| M6                                                      |                    | Tool change                                            |                 | +                | +                | PGsl                          |
| M17                                                     |                    | End of subprogram                                      |                 | +                | +                | PGsl                          |
| M19                                                     |                    | Spindle positioning to the position entered in SD43240 |                 | +                | +                | PGsl                          |
| M30                                                     |                    | End of program, main program (as M2)                   |                 | +                | +                | PGsl                          |
| M40                                                     |                    | Automatic gear change                                  |                 | +                | +                | PGsl                          |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                               | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-----------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                       |                 |                  |                  |                               |
| M41 ... M45                                             |                    | Gear stage 1 ... 5                                                    |                 | +                | +                | PGsl                          |
| M70                                                     |                    | Transition to axis mode                                               |                 | +                | +                | PGsl                          |
| MASLDEF                                                 | P                  | Define master/slave axis grouping                                     |                 | +                | +                | PGAsl                         |
| MASLDEL                                                 | P                  | Uncouple master/slave axis grouping and clear grouping definition     |                 | +                | +                | PGAsl                         |
| MASLOF                                                  | P                  | Deactivation of a temporary coupling                                  |                 | +                | +                | PGAsl                         |
| MASLOFS                                                 | P                  | Deactivation of a temporary coupling with automatic slave axis stop   |                 | +                | +                | PGAsl                         |
| MASLON                                                  | P                  | Activation of a temporary coupling                                    |                 | +                | +                | PGAsl                         |
| MATCH                                                   | F                  | Search for string in string                                           |                 | +                | -                | PGAsl                         |
| MAXVAL                                                  | F                  | Larger value of two variables (arithm. function)                      |                 | +                | +                | PGAsl                         |
| MCALL                                                   | K                  | Modal subprogram call                                                 |                 | +                |                  | PGAsl                         |
| MEAC                                                    | K                  | Continuous axial measurement without delete distance-to-go            | s               | +                | +                | PGAsl                         |
| MEAFRAME                                                | F                  | Frame calculation from measuring points                               |                 | +                | -                | PGAsl                         |
| MEAS                                                    | O                  | Measurement with deletion of distance-to-go                           | s               | +                |                  | PGAsl                         |
| MEASA                                                   | K                  | Axial measurement with delete distance-to-go                          | s               | +                | +                | PGAsl                         |
| MEASURE                                                 | F                  | Calculation method for workpiece and tool measurement                 |                 | +                | -                | FB1sl (M5)                    |
| MEAW                                                    | O                  | Measurement without delete distance-to-go                             | s               | +                |                  | PGAsl                         |
| MEAWA                                                   | K                  | Axial measurement without delete distance-to-go                       | s               | +                | +                | PGAsl                         |
| MI                                                      | K                  | Access to frame data: Mirroring                                       |                 | +                |                  | PGAsl                         |
| MINDEX                                                  | F                  | Define index of character in input string                             |                 | +                | -                | PGAsl                         |
| MINVAL                                                  | F                  | Smaller value of two variables (arithm. function)                     |                 | +                | +                | PGAsl                         |
| MIRROR                                                  | G                  | Programmable mirroring                                                | s               | +                |                  | PGAsl                         |
| MMC                                                     | P                  | Call the dialog window interactively from the part program on the HMI |                 | +                | -                | PGAsl                         |
| MOD                                                     | K                  | Modulo division                                                       |                 | +                |                  | PGAsl                         |
| MODAXVAL                                                | F                  | Determine modulo position of a modulo rotary axis                     |                 | +                | -                | PGAsl                         |
| MOV                                                     | K                  | Start positioning axis                                                |                 | -                | +                | FBSYsl                        |
| MOVT                                                    | O                  | Specify end point of a traversing motion in the tool direction        |                 |                  |                  | FB1(K2)                       |
| MSG                                                     | P                  | Programmable messages                                                 | m               | +                | -                | PGsl                          |
| MVTOOL                                                  | P                  | Language command to move tool                                         |                 | +                | -                | FBWsl                         |
| N                                                       | O                  | NC auxiliary block number                                             |                 | +                |                  | PGsl                          |
| NAMETOINT                                               | F                  | Determining the system variable index                                 |                 | +                |                  | PGAsl                         |
| NCK                                                     | K                  | Specify validity range for data                                       |                 | +                |                  | PGAsl                         |
| NEWCONF                                                 | P                  | Apply modified machine data (corresponds to "Activate machine data")  |                 | +                | -                | PGAsl                         |
| NEWMT                                                   | F                  | Create new multitool                                                  |                 | +                | -                | FBWsl                         |
| NEWT                                                    | F                  | Create new tool                                                       |                 | +                | -                | FBWsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                    | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                            |                 |                  |                  |                               |
| NORM <sup>6)</sup>                                      | G                  | Standard setting in starting point and end point with tool offset                          | m               | +                |                  | PGsl                          |
| NOT                                                     | K                  | Logic NOT (negation)                                                                       |                 | +                |                  | PGAsl                         |
| NPROT                                                   | P                  | Machine-specific protection area ON/OFF                                                    |                 | +                | -                | PGAsl                         |
| NPROTDEF                                                | P                  | Definition of a machine-specific protection area                                           |                 | +                | -                | PGAsl                         |
| NUMBER                                                  | F                  | Convert input string to number                                                             |                 | +                | -                | PGAsl                         |
| OEMIPO1                                                 | G                  | OEM interpolation 1                                                                        | m               | +                |                  | PGAsl                         |
| OEMIPO2                                                 | G                  | OEM interpolation 2                                                                        | m               | +                |                  | PGAsl                         |
| OF                                                      | K                  | Keyword in CASE branch                                                                     |                 | +                |                  | PGAsl                         |
| OFFN                                                    | O                  | Allowance on the programmed contour                                                        | m               | +                |                  | PGsl                          |
| OMA1                                                    | O                  | OEM address 1                                                                              | m               | +                |                  | PGAsl                         |
| OMA2                                                    | O                  | OEM address 2                                                                              | m               | +                |                  | PGAsl                         |
| OMA3                                                    | O                  | OEM address 3                                                                              | m               | +                |                  | PGAsl                         |
| OMA4                                                    | O                  | OEM address 4                                                                              | m               | +                |                  | PGAsl                         |
| OMA5                                                    | O                  | OEM address 5                                                                              | m               | +                |                  | PGAsl                         |
| OR                                                      | K                  | Logic operator, OR operation                                                               |                 | +                |                  | PGAsl                         |
| ORIXES                                                  | G                  | Linear interpolation of machine axes or orientation axes                                   | m               | +                |                  | PGAsl                         |
| ORIXPOS                                                 | G                  | Orientation angle via virtual orientation axes with rotary axis positions                  | m               | +                |                  | PGAsl                         |
| ORIC <sup>6)</sup>                                      | G                  | Orientation changes at outside corners are superimposed on the circle block to be inserted | m               | +                |                  | PGAsl                         |
| ORICONCCW                                               | G                  | Interpolation on a circular peripheral surface in CCW direction                            | m               | +                |                  | PGAsl/FB3sl (F3)              |
| ORICONCW                                                | G                  | Interpolation on a circular peripheral surface in CW direction                             | m               | +                |                  | PGAsl/FB3sl (F4)              |
| ORICONIO                                                | G                  | Interpolation on a circular peripheral surface with intermediate orientation setting       | m               | +                |                  | PGAsl/FB3sl (F4)              |
| ORICONTO                                                | G                  | Interpolation on circular peripheral surface in tangential transition (final orientation)  | m               | +                |                  | PGAsl/FB3sl (F5)              |
| ORICURVE                                                | G                  | Interpolation of orientation with specification of motion of two contact points of tool    | m               | +                |                  | PGAsl/FB3sl (F6)              |
| ORID                                                    | G                  | Orientation changes are performed before the circle block                                  | m               | +                |                  | PGAsl                         |
| ORIEULER <sup>6)</sup>                                  | G                  | Orientation angle via Euler angle                                                          | m               | +                |                  | PGAsl                         |
| ORIMKS                                                  | G                  | Tool orientation in the machine coordinate system                                          | m               | +                |                  | PGAsl                         |
| ORIPATH                                                 | G                  | Tool orientation in relation to path                                                       | m               | +                |                  | PGAsl                         |
| ORIPATHS                                                | G                  | Tool orientation in relation to path, blips in the orientation characteristic are smoothed | m               | +                |                  | PGAsl                         |
| ORIPANE                                                 | G                  | Interpolation in a plane (corresponds to ORIVECT), large-radius circular interpolation     | m               | +                |                  | PGAsl                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                                         | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                                 |                 |                  |                  |                               |
| ORIRESET                                                | P                  | Initial tool orientation with up to 3 orientation axes                                                                                          |                 | +                | -                | PGAsl                         |
| ORIROTA <sup>6)</sup>                                   | G                  | Angle of rotation to an absolute direction of rotation                                                                                          | m               | +                |                  | PGAsl                         |
| ORIROTC                                                 | G                  | Tangential rotational vector in relation to path tangent                                                                                        | m               | +                |                  | PGAsl                         |
| ORIROTR                                                 | G                  | Angle of rotation relative to the plane between the start and end orientation                                                                   | m               | +                |                  | PGAsl                         |
| ORIROTT                                                 | G                  | Angle of rotation relative to the change in the orientation vector                                                                              | m               | +                |                  | PGAsl                         |
| ORIRPY                                                  | G                  | Orientation angle via RPY angle (XYZ)                                                                                                           | m               | +                |                  | PGAsl                         |
| ORIRPY2                                                 | G                  | Orientation angle via RPY angle (ZYX)                                                                                                           | m               | +                |                  | PGAsl                         |
| ORIS                                                    | O                  | Change in orientation                                                                                                                           | m               | +                |                  | PGAsl                         |
| ORISOF <sup>6)</sup>                                    | G                  | Smoothing of the orientation characteristic OFF                                                                                                 | m               | +                |                  | PGAsl                         |
| ORISON                                                  | G                  | Smoothing of the orientation characteristic ON                                                                                                  | m               | +                |                  | PGAsl                         |
| ORIVECT <sup>6)</sup>                                   | G                  | Large-circle interpolation (identical to ORI-PLANE)                                                                                             | m               | +                |                  | PGAsl                         |
| ORIVIRT1                                                | G                  | Orientation angle via virtual orientation axes (definition 1)                                                                                   | m               | +                |                  | PGAsl                         |
| ORIVIRT2                                                | G                  | Orientation angle via virtual orientation axes (definition 1)                                                                                   | m               | +                |                  | PGAsl                         |
| ORIWKS <sup>6)</sup>                                    | G                  | Tool orientation in the workpiece coordinate system                                                                                             | m               | +                |                  | PGAsl                         |
| OS                                                      | K                  | Oscillation on/off                                                                                                                              |                 | +                |                  | PGAsl                         |
| OSB                                                     | K                  | Oscillating: Starting point                                                                                                                     | m               | +                |                  | FB1sl (P5)                    |
| OSC                                                     | G                  | Continuous tool orientation smoothing                                                                                                           | m               | +                |                  | PGAsl                         |
| OSCILL                                                  | K                  | Axis: 1 - 3 infeed axes                                                                                                                         | m               | +                |                  | PGAsl                         |
| OSCTRL                                                  | K                  | Oscillation options                                                                                                                             | m               | +                |                  | PGAsl                         |
| OSD                                                     | G                  | Smoothing of tool orientation by specifying smoothing distance with SD                                                                          | m               | +                |                  | PGAsl                         |
| OSE                                                     | K                  | Oscillation end position                                                                                                                        | m               | +                |                  | PGAsl                         |
| OSNSC                                                   | K                  | Oscillating: Number of spark-out cycles                                                                                                         | m               | +                |                  | PGAsl                         |
| OSOF <sup>6)</sup>                                      | G                  | Tool orientation smoothing OFF                                                                                                                  | m               | +                |                  | PGAsl                         |
| OSP1                                                    | K                  | Oscillating: Left reversal point                                                                                                                | m               | +                |                  | PGAsl                         |
| OSP2                                                    | K                  | Oscillation right reversal point                                                                                                                | m               | +                |                  | PGAsl                         |
| OSS                                                     | G                  | Tool orientation smoothing at end of block                                                                                                      | m               | +                |                  | PGAsl                         |
| OSSE                                                    | G                  | Tool orientation smoothing at start and end of block                                                                                            | m               | +                |                  | PGAsl                         |
| OST                                                     | G                  | Smoothing of tool orientation by specifying angular tolerance in degrees with SD (maximum deviation from programmed orientation characteristic) | m               | +                |                  | PGAsl                         |
| OST1                                                    | K                  | Oscillating: Stopping point in left reversal point                                                                                              | m               | +                |                  | PGAsl                         |
| OST2                                                    | K                  | Oscillating: Stopping point in right reversal point                                                                                             | m               | +                |                  | PGAsl                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                   | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                           |                 |                  |                  |                               |
| OTOL                                                    | K                  | Orientation tolerance for compressor functions, orientation smoothing and smoothing types                                 |                 | +                |                  | PGAsI                         |
| OVR                                                     | K                  | Speed offset                                                                                                              | m               | +                |                  | PGAsI                         |
| OVRA                                                    | K                  | Axial speed offset                                                                                                        | m               | +                | +                | PGAsI                         |
| OVRRAP                                                  | K                  | Rapid traverse override                                                                                                   | m               | +                |                  | PGAsI                         |
| P                                                       | O                  | Number of subprogram repetitions                                                                                          |                 | +                |                  | PGAsI                         |
| PAROT                                                   | G                  | Align workpiece coordinate system on work-piece                                                                           | m               | +                |                  | PGsI                          |
| PAROTOF <sup>6)</sup>                                   | G                  | Deactivate frame rotation in relation to work-piece                                                                       | m               | +                |                  | PGsI                          |
| PCALL                                                   | K                  | Call subprograms with absolute path and parameter transfer                                                                |                 | +                |                  | PGAsI                         |
| PDELAYOF                                                | G                  | Punching with delay OFF                                                                                                   | m               | +                |                  | PGAsI                         |
| PDELAYON <sup>6)</sup>                                  | G                  | Punching with delay ON                                                                                                    | m               | +                |                  | PGAsI                         |
| PHI                                                     | K                  | Angle of rotation of the orientation around the direction axis of the taper                                               |                 | +                |                  | PGAsI                         |
| PHU                                                     | K                  | Physical unit of a variable                                                                                               |                 | +                |                  | PGAsI                         |
| PL                                                      | O                  | 1. B spline: Node clearance<br>2. Polynomial interpolation: Length of the parameter interval for polynomial interpolation | s               | +                |                  | PGAsI                         |
| PM                                                      | K                  | Per minute                                                                                                                |                 | +                |                  | PGsI                          |
| PO                                                      | K                  | Polynomial coefficient for polynomial interpolation                                                                       | s               | +                |                  | PGAsI                         |
| POCKET3                                                 | C                  | Milling the rectangular pocket                                                                                            |                 | +                |                  | PGAsI                         |
| POCKET4                                                 | C                  | Milling the circular pocket                                                                                               |                 | +                |                  | PGAsI                         |
| POLF                                                    | K                  | LIFTFAST retraction position                                                                                              | m               | +                |                  | PGsI/PGAsI                    |
| POLFA                                                   | P                  | Start retraction position of single axes with \$AA_ESR_TRIGGER                                                            | m               | +                | +                | PGsI                          |
| POLFMASK                                                | P                  | Enable axes for retraction without a connection between the axes                                                          | m               | +                | -                | PGsI                          |
| POLFMLIN                                                | P                  | Enable axes for retraction with a linear connection between the axes                                                      | m               | +                | -                | PGsI                          |
| POLY                                                    | G                  | Polynomial interpolation                                                                                                  | m               | +                |                  | PGAsI                         |
| POLYPATH                                                | P                  | Polynomial interpolation can be selected for the AXIS or VECT axis groups                                                 | m               | +                | -                | PGAsI                         |
| PON                                                     | G                  | Punching ON                                                                                                               | m               | +                |                  | PGAsI                         |
| PONS                                                    | G                  | Punching ON in interpolation cycle                                                                                        | m               | +                |                  | PGAsI                         |
| POS                                                     | K                  | Axis positioning                                                                                                          |                 | +                | +                | PGsI                          |
| POSA                                                    | K                  | Position axis across block boundary                                                                                       |                 | +                | +                | PGsI                          |
| POSM                                                    | P                  | Position magazine                                                                                                         |                 | +                | -                | FBWsl                         |
| POSMT                                                   | P                  | Position multitool on toolholder at location number                                                                       |                 | +                | -                | FBWsl                         |
| POSP                                                    | K                  | Positioning axis in parts (oscillation)                                                                                   |                 | +                |                  | PGsI                          |



| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                             | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                     |                 |                  |                  |                               |
| POSRANGE                                                | F                  | Determine whether the currently interpolated position setpoint of an axis is located in a window at a predefined reference position |                 | +                | +                | FBSYsl                        |
| POT                                                     | F                  | Square (arithmetic function)                                                                                                        |                 | +                | +                | PGAsl                         |
| PR                                                      | K                  | Per revolution                                                                                                                      |                 | +                |                  | PGsl                          |
| PREPRO                                                  | PA                 | Identify subprograms with preparation                                                                                               |                 | +                |                  | PGAsl                         |
| PRESETON                                                | P                  | Actual value setting with loss of the referencing status                                                                            |                 | +                | +                | PGAsl                         |
| PRESETONS                                               | P                  | Actual value setting with loss of the referencing status                                                                            |                 | +                | +                | PGAsl                         |
| PRIO                                                    | K                  | Keyword for setting the priority for interrupt processing                                                                           |                 | +                |                  | PGAsl                         |
| PRLOC                                                   | K                  | Initialization of variables at reset only after local change                                                                        |                 | +                |                  | PGAsl                         |
| PROC                                                    | K                  | First operation in a program                                                                                                        |                 | +                |                  | PGAsl                         |
| PROTA                                                   | P                  | Request for a recalculation of the collision model                                                                                  |                 | +                |                  | PGAsl                         |
| PROTD                                                   | F                  | Calculating the distance between two protection areas                                                                               |                 | +                |                  | PGAsl                         |
| PROTS                                                   | P                  | Setting the protection area status                                                                                                  |                 | +                |                  | PGAsl                         |
| PSI                                                     | K                  | Opening angle of the taper                                                                                                          |                 | +                |                  | PGAsl                         |
| PTP                                                     | G                  | Point-to-point motion                                                                                                               | m               | +                |                  | PGAsl                         |
| PTPG0                                                   | G                  | Point-to-point motion only with G0, otherwise CP                                                                                    | m               | +                |                  | PGAsl                         |
| PUNCHACC                                                | P                  | Travel-dependent acceleration for nibbling                                                                                          |                 | +                | -                | PGAsl                         |
| PUTFTOC                                                 | P                  | Tool fine offset for parallel dressing                                                                                              |                 | +                | -                | PGAsl                         |
| PUTFTOCF                                                | P                  | Tool fine offset dependent on a function for parallel dressing defined with FCTDEF                                                  |                 | +                | -                | PGAsl                         |
| PW                                                      | O                  | B spline, point weight                                                                                                              | s               | +                |                  | PGAsl                         |
| QU                                                      | K                  | Fast additional (auxiliary) function output                                                                                         |                 | +                |                  | PGsl                          |
| R...                                                    | O                  | Arithmetic parameter also as settable address identifier and with numerical extension                                               |                 | +                |                  | PGAsl                         |
| RAC                                                     | K                  | Absolute non-modal axis-specific radius programming                                                                                 | s               | +                |                  | PGsl                          |
| RDISABLE                                                | P                  | Read-in disable                                                                                                                     |                 | -                | +                | FBSYsl                        |
| READ                                                    | P                  | Reads one or more lines in the specified file and stores the information read in the array                                          |                 | +                | -                | PGAsl                         |
| REAL                                                    | K                  | Data type: Floating-point variable with sign (real numbers)                                                                         |                 | +                |                  | PGAsl                         |
| REDEF                                                   | K                  | Redefinition of system variables, user variables, and NC language commands                                                          |                 | +                |                  | PGAsl                         |
| RELEASE                                                 | P                  | Release machine axes for axis exchange                                                                                              |                 | +                | +                | PGAsl                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                    | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|----------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                            |                 |                  |                  |                               |
| REP                                                     | K                  | Keyword for initialization of all elements of an array with the same value |                 | +                |                  | PGAsI                         |
| REPEAT                                                  | K                  | Repetition of a program loop                                               |                 | +                |                  | PGAsI                         |
| REPEATB                                                 | K                  | Repetition of a program line                                               |                 | +                |                  | PGAsI                         |
| REPOSA                                                  | G                  | Linear repositioning with all axes                                         | s               | +                |                  | PGAsI                         |
| REPOSH                                                  | G                  | Repositioning with semicircle                                              | s               | +                |                  | PGAsI                         |
| REPOSHA                                                 | G                  | Repositioning with all axes; geometry axes in semicircle                   | s               | +                |                  | PGAsI                         |
| REPOSL                                                  | G                  | Linear repositioning                                                       | s               | +                |                  | PGAsI                         |
| REPOSQ                                                  | G                  | Repositioning in a quadrant                                                | s               | +                |                  | PGAsI                         |
| REPOSQA                                                 | G                  | Linear repositioning with all axes, geometry axes in quadrant              | s               | +                |                  | PGAsI                         |
| RESET                                                   | P                  | Reset technology cycle                                                     |                 | -                | +                | FBSYsI                        |
| RESETMON                                                | P                  | Language command for setpoint activation                                   |                 | +                | -                | FBWsI                         |
| RET                                                     | P                  | End of subprogram                                                          |                 | +                | +                | PGAsI                         |
| RETB                                                    | P                  | End of subprogram                                                          |                 | +                | +                | PGAsI                         |
| RIC                                                     | K                  | Relative non-modal axis-specific radius programming                        | s               | +                |                  | PGsI                          |
| RINDEX                                                  | F                  | Define index of character in input string                                  |                 | +                | -                | PGAsI                         |
| RMB                                                     | G                  | Repositioning to start of block                                            | m               | +                |                  | PGAsI                         |
| RMBBL                                                   | G                  | Repositioning to start of block                                            | s               | +                |                  | PGAsI                         |
| RME                                                     | G                  | Repositioning to end of block                                              | m               | +                |                  | PGAsI                         |
| RMEBL                                                   | G                  | Repositioning to end of block                                              | s               | +                |                  | PGAsI                         |
| RMI <sup>6)</sup>                                       | G                  | Repositioning to interrupt point                                           | m               | +                |                  | PGAsI                         |
| RMIBL <sup>6)</sup>                                     | G                  | Repositioning to interrupt point                                           | s               | +                |                  | PGAsI                         |
| RMN                                                     | G                  | Repositioning to the nearest path point                                    | m               | +                |                  | PGAsI                         |
| RMNBL                                                   | G                  | Repositioning to the nearest path point                                    | s               | +                |                  | PGAsI                         |
| RND                                                     | O                  | Round the contour corner                                                   | s               | +                |                  | PGsI                          |
| RNDM                                                    | O                  | Modal rounding                                                             | m               | +                |                  | PGsI                          |
| ROT                                                     | G                  | Programmable rotation                                                      | s               | +                |                  | PGsI                          |
| ROTS                                                    | G                  | Programmable frame rotations with solid angles                             | s               | +                |                  | PGsI                          |
| ROUND                                                   | F                  | Rounding of decimal places                                                 |                 | +                | +                | PGAsI                         |
| ROUNDUP                                                 | F                  | Rounding up of an input value                                              |                 | +                | +                | PGAsI                         |
| RP                                                      | O                  | Polar radius                                                               | m/s             | +                |                  | PGsI                          |
| RPL                                                     | O                  | Rotation in the plane                                                      | s               | +                |                  | PGsI                          |
| RT                                                      | K                  | Parameter for access to frame data: Rotation                               |                 | +                |                  | PGAsI                         |
| RTLIOF                                                  | G                  | G0 without linear interpolation (single-axis interpolation)                | m               | +                |                  | PGsI                          |
| RTLION <sup>6)</sup>                                    | G                  | G0 with linear interpolation                                               | m               | +                |                  | PGsI                          |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                            | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                    |                 |                  |                  |                               |
| S                                                       | O                  | Spindle speed<br>(with G4, G96/G961 different meaning)                                                                             | m/s             | +                | +                | PGsl                          |
| SAVE                                                    | PA                 | Attribute for saving information when subprograms are called                                                                       |                 | +                |                  | PGAsl                         |
| SBLOF                                                   | P                  | Suppress single block                                                                                                              |                 | +                | -                | PGAsl                         |
| SBLON                                                   | P                  | Revoke suppression of single block                                                                                                 |                 | +                | -                | PGAsl                         |
| SC                                                      | K                  | Parameter for access to frame data: Scaling                                                                                        |                 | +                |                  | PGAsl                         |
| SCALE                                                   | G                  | Programmable scaling                                                                                                               | s               | +                |                  | PGsl                          |
| SCC                                                     | K                  | Selective assignment of transverse axis to G96/G961/G962. Axis identifiers may take the form of geometry, channel or machine axes. |                 | +                |                  | PGsl                          |
| SCPARA                                                  | K                  | Program servo parameter set                                                                                                        |                 | +                | +                | PGAsl                         |
| SD                                                      | O                  | Spline degree                                                                                                                      | s               | +                |                  | PGAsl                         |
| SET                                                     | K                  | Keyword for initialization of all elements of an array with listed values                                                          |                 | +                |                  | PGAsl                         |
| SETAL                                                   | P                  | Set alarm                                                                                                                          |                 | +                | +                | PGAsl                         |
| SETDNO                                                  | F                  | Assign the D number of a cutting edge (CE) of a tool (T)                                                                           |                 | +                | -                | PGAsl                         |
| SETINT                                                  | K                  | Define which interrupt routine is to be activated when an NCK input is present                                                     |                 | +                |                  | PGAsl                         |
| SETM                                                    | P                  | Setting of markers in dedicated channel                                                                                            |                 | +                | +                | PGAsl                         |
| SETMS                                                   | P                  | Reset to the master spindle defined in machine data                                                                                |                 | +                | -                | PGsl                          |
| SETMS(n)                                                | P                  | Set spindle n as master spindle                                                                                                    |                 | +                |                  | PGsl                          |
| SETMTH                                                  | P                  | Set master toolholder number                                                                                                       |                 | +                | -                | FBWsl                         |
| SETPIECE                                                | P                  | Set piece number for all tools assigned to the spindle                                                                             |                 | +                | -                | FBWsl                         |
| SETTA                                                   | P                  | Activate tool from wear group                                                                                                      |                 | +                | -                | FBWsl                         |
| SETTCOR                                                 | F                  | Modification of tool components taking all supplementary conditions into account                                                   |                 | +                | -                | FB1sl (W1)                    |
| SETTIA                                                  | P                  | Deactivate tool from wear group                                                                                                    |                 | +                | -                | FBWsl                         |
| SF                                                      | O                  | Starting point offset for thread cutting                                                                                           | m               | +                |                  | PGsl                          |
| SIN                                                     | F                  | Sine (trigon. function)                                                                                                            |                 | +                | +                | PGAsl                         |
| SIRELAY                                                 | F                  | Activate the safety functions parameterized with SIRELIN, SIRELOUT, and SIRELTIME                                                  |                 | -                | +                | FBSlsl                        |
| SIRELIN                                                 | P                  | Initialize input variables of function block                                                                                       |                 | +                | -                | FBSlsl                        |
| SIRELOUT                                                | P                  | Initialize output variables of function block                                                                                      |                 | +                | -                | FBSlsl                        |
| SIRELTIME                                               | P                  | Initialize timers of function block                                                                                                |                 | +                | -                | FBSlsl                        |
| SLOT1                                                   | C                  | Longitudinal groove                                                                                                                |                 | +                |                  | PGAsl                         |
| SLOT2                                                   | C                  | Circumferential groove                                                                                                             |                 | +                |                  | PGAsl                         |
| SOFT                                                    | G                  | Soft path acceleration                                                                                                             | m               | +                |                  | PGsl                          |
| SOFTA                                                   | P                  | Activate jerk-limited axis acceleration for the programmed axes                                                                    |                 | +                | -                | PGsl                          |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                               | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                       |                 |                  |                  |                               |
| SON                                                     | G                  | Nibbling ON                                                                                                           | m               | +                |                  | PGAsI                         |
| SONS                                                    | G                  | Nibbling ON in interpolation cycle                                                                                    | m               | +                |                  | PGAsI                         |
| SPATH <sup>6)</sup>                                     | G                  | Path reference for FGROUP axes is arc length                                                                          | m               | +                |                  | PGAsI                         |
| SPCOF                                                   | P                  | Switch master spindle or spindle(s) from position control to speed control                                            | m               | +                | -                | PGsI                          |
| SPCON                                                   | P                  | Switch master spindle or spindle(s) from speed control to position control                                            | m               | +                | -                | PGAsI                         |
| SPI                                                     | F                  | Converts spindle number into axis identifier                                                                          |                 | +                | -                | PGAsI                         |
| SPIF1 <sup>6)</sup>                                     | G                  | Fast NCK inputs/outputs for punching/nibbling byte 1                                                                  | m               | +                |                  | FB2sI (N4)                    |
| SPIF2                                                   | G                  | Fast NCK inputs/outputs for punching/nibbling byte 2                                                                  | m               | +                |                  | FB2sI (N4)                    |
| SPLINEPATH                                              | P                  | Define spline grouping                                                                                                |                 | +                | -                | PGAsI                         |
| SPN                                                     | O                  | Number of path sections per block                                                                                     | s               | +                |                  | PGAsI                         |
| SPOF <sup>6)</sup>                                      | G                  | Stroke OFF, nibbling, punching OFF                                                                                    | m               | +                |                  | PGAsI                         |
| SPOS                                                    | K                  | Spindle position                                                                                                      | m               | +                | +                | PGsI                          |
| SPOSA                                                   | K                  | Spindle position across block boundaries                                                                              | m               | +                |                  | PGsI                          |
| SPP                                                     | O                  | Length of a path section                                                                                              | m               | +                |                  | PGAsI                         |
| SPRINT                                                  | F                  | Returns an input string formatted                                                                                     |                 | +                |                  | PGAsI                         |
| SQRT                                                    | F                  | Square root (arithmetic function)                                                                                     |                 | +                | +                | PGAsI                         |
| SR                                                      | O                  | Oscillation retraction path for synchronized action                                                                   | s               | +                |                  | PGsI                          |
| SRA                                                     | K                  | Oscillation retraction path with external input axial for synchronized action                                         | m               | +                |                  | PGsI                          |
| ST                                                      | O                  | Oscillation sparking-out time for synchronized action                                                                 | s               | +                |                  | PGsI                          |
| STA                                                     | K                  | Oscillation sparking-out time axial for synchronized action                                                           | m               | +                |                  | PGsI                          |
| START                                                   | P                  | Start selected programs simultaneously in several channels from current program                                       |                 | +                | -                | PGAsI                         |
| STARTFIFO <sup>6)</sup>                                 | G                  | Execute; fill preprocessing memory simultaneously                                                                     | m               | +                |                  | PGAsI                         |
| STAT                                                    |                    | Position of joints                                                                                                    | s               | +                |                  | PGAsI                         |
| STOLF                                                   | K                  | G0 tolerance factor                                                                                                   | m               | +                |                  | PGAsI                         |
| STOPFIFO                                                | G                  | Stop machining; fill preprocessing memory until STARTFIFO is detected, preprocessing memory is full or end of program | m               | +                |                  | PGAsI                         |
| STOPRE                                                  | P                  | Preprocessing stop until all prepared blocks in the main run are executed                                             |                 | +                | -                | PGAsI                         |
| STOPREOF                                                | P                  | Revoke preprocessing stop                                                                                             |                 | -                | +                | FBSYsI                        |
| STRING                                                  | K                  | Data type: Character string                                                                                           |                 | +                |                  | PGAsI                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                                                                                                        | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                                                                                                |                 |                  |                  |                               |
| STRINGIS                                                | F                  | Checks the present scope of NC language and the NC cycle names, user variables, macros, and label names belonging specifically to this command to establish whether these exist, are valid, defined or active. |                 | +                | -                | PGAsl                         |
| STRLEN                                                  | F                  | Define string length                                                                                                                                                                                           |                 | +                | -                | PGAsl                         |
| SUBSTR                                                  | F                  | Define index of character in input string                                                                                                                                                                      |                 | +                | -                | PGAsl                         |
| SUPA                                                    | G                  | Suppression of current zero offset, including programmed offsets, system frames, handwheel offsets (DRF), external zero offset, and overlaid movement                                                          | s               | +                |                  | PGsl                          |
| SVC                                                     | K                  | Tool cutting rate                                                                                                                                                                                              | m               | +                |                  | PGsl                          |
| SYNFCT                                                  | P                  | Evaluation of a polynomial as a function of a condition in the motion-synchronous action                                                                                                                       |                 | -                | +                | FBSYsl                        |
| SYNR                                                    | K                  | The variable is read synchronously, i.e. at the time of execution                                                                                                                                              |                 | +                |                  | PGAsl                         |
| SYNRW                                                   | K                  | The variable is read and written synchronously, i.e. at the time of execution                                                                                                                                  |                 | +                |                  | PGAsl                         |
| SYNW                                                    | K                  | The variable is written synchronously, i.e. at the time of execution                                                                                                                                           |                 | +                |                  | PGAsl                         |
| T                                                       | O                  | Call tool (only change if specified in machine data; otherwise M6 command necessary)                                                                                                                           |                 | +                |                  | PGsl                          |
| TAN                                                     | F                  | Tangent (trigon. function)                                                                                                                                                                                     |                 | +                | +                | PGAsl                         |
| TANG                                                    | P                  | Definition of axis grouping tangential correction                                                                                                                                                              |                 | +                | -                | PGAsl                         |
| TANGDEL                                                 | P                  | Deletion of definition of axis grouping tangential correction                                                                                                                                                  |                 | +                | -                | PGAsl                         |
| TANGOF                                                  | P                  | Tangential correction OFF                                                                                                                                                                                      |                 | +                | -                | PGAsl                         |
| TANGON                                                  | P                  | Tangential correction ON                                                                                                                                                                                       |                 | +                | -                | PGAsl                         |
| TCA (828D: _TCA)                                        | P                  | Tool selection/tool change irrespective of tool status                                                                                                                                                         |                 | +                | -                | FBWsl                         |
| TCARR                                                   | O                  | Request toolholder (number "m")                                                                                                                                                                                |                 | +                |                  | PGAsl                         |
| TCI                                                     | P                  | Load tool from buffer into magazine                                                                                                                                                                            |                 | +                | -                | FBWsl                         |
| TCOABS <sup>6)</sup>                                    | G                  | Determine tool length components from the current tool orientation                                                                                                                                             | m               | +                |                  | PGAsl                         |
| TCOFR                                                   | G                  | Determine tool length components from the orientation of the active frame                                                                                                                                      | m               | +                |                  | PGAsl                         |
| TCOFRX                                                  | G                  | Determine tool orientation of an active frame on selection of tool, tool points in X direction                                                                                                                 | m               | +                |                  | PGAsl                         |
| TCOFRY                                                  | G                  | Determine tool orientation of an active frame on selection of tool, tool points in Y direction                                                                                                                 | m               | +                |                  | PGAsl                         |
| TCOFRZ                                                  | G                  | Determine tool orientation of an active frame on selection of tool, tool points in Z direction                                                                                                                 | m               | +                |                  | PGAsl                         |
| THETA                                                   | O                  | Angle of rotation                                                                                                                                                                                              | s               | +                |                  | PGAsl                         |
| TILT                                                    | O                  | Tilt angle                                                                                                                                                                                                     | m               | +                |                  | PGAsl                         |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                                                         | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                                                                 |                 |                  |                  |                               |
| TLIFT                                                   | P                  | In tangential control insert intermediate block at contour corners                                                                              |                 | +                | -                | PGAsI                         |
| TML                                                     | P                  | Tool selection with magazine location number                                                                                                    |                 | +                | -                | FBWsl                         |
| TMOF                                                    | P                  | Deselect tool monitoring                                                                                                                        |                 | +                | -                | PGAsI                         |
| TMON                                                    | P                  | Activate tool monitoring                                                                                                                        |                 | +                | -                | PGAsI                         |
| TO                                                      | K                  | Designates the end value in a FOR counter loop                                                                                                  |                 | +                |                  | PGAsI                         |
| TOFF                                                    | K                  | Tool length offset in the direction of the tool length component that is effective parallel to the geometry axis specified in the index.        | m               | +                |                  | PGsl                          |
| TOFFL                                                   | K                  | Tool length offset in the direction of the tool length component L1, L2 or L3                                                                   | m               | +                |                  | PGsl                          |
| TOFFOF                                                  | P                  | Deactivate online tool offset                                                                                                                   |                 | +                | -                | PGAsI                         |
| TOFFON                                                  | P                  | Activate online tool length offset                                                                                                              |                 | +                | -                | PGAsI                         |
| TOFFR                                                   | O                  | Tool radius offset                                                                                                                              | m               | +                |                  | PGsl                          |
| TOFRAME                                                 | G                  | Align Z axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOFRAMEX                                                | G                  | Align X axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOFRAMEY                                                | G                  | Align Y axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOFRAMEZ                                                | G                  | As TOFRAME                                                                                                                                      | m               | +                |                  | PGsl                          |
| TOLOWER                                                 | F                  | Convert the letters of a string into lowercase                                                                                                  |                 | +                | -                | PGAsI                         |
| TOOLENV                                                 | F                  | Save current states which are of significance to the evaluation of the tool data stored in the memory                                           |                 | +                | -                | FB1sl (W1)                    |
| TOOLGNT                                                 | F                  | Determine number of tools of a tool group                                                                                                       |                 | +                | -                | FBWsl                         |
| TOOLGT                                                  | F                  | Determine T number of a tool from a tool group                                                                                                  |                 | +                | -                | FBWsl                         |
| TOROT                                                   | G                  | Align Z axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOROTOF <sup>6)</sup>                                   | G                  | Frame rotations in tool direction OFF                                                                                                           | m               | +                |                  | PGsl                          |
| TOROTX                                                  | G                  | Align X axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOROTY                                                  | G                  | Align Y axis of the WCS by rotating the frame parallel to the tool orientation                                                                  | m               | +                |                  | PGsl                          |
| TOROTZ                                                  | G                  | As TOROT                                                                                                                                        | m               | +                |                  | PGsl                          |
| TOUPPER                                                 | F                  | Convert the letters of a string into uppercase                                                                                                  |                 | +                | -                | PGAsI                         |
| TOWBCS                                                  | G                  | Wear values in the basic coordinate system (BCS)                                                                                                | m               | +                |                  | PGAsI                         |
| TOWKCS                                                  | G                  | Wear values in the coordinate system of the tool head for kinetic transformation (differs from machine coordinate system through tool rotation) | m               | +                |                  | PGAsI                         |
| TOWMCS                                                  | G                  | Wear values in machine coordinate system                                                                                                        | m               | +                |                  | PGAsI                         |
| TOWSTD <sup>6)</sup>                                    | G                  | Initial setting value for offsets in tool length                                                                                                | m               | +                |                  | PGAsI                         |
| TOWTCS                                                  | G                  | Wear values in the tool coordinate system (tool-holder ref. point T at the tool holder)                                                         | m               | +                |                  | PGAsI                         |

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                                      | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                                              |                 |                  |                  |                               |
| TOWWCS                                                  | G                  | Wear values in workpiece coordinate system                                                                   | m               | +                |                  | PGAsl                         |
| TR                                                      | K                  | Offset component of a frame variable                                                                         |                 | +                |                  | PGAsl                         |
| TRAANG                                                  | P                  | Transformation inclined axis                                                                                 |                 | +                | -                | PGAsl                         |
| TRACON                                                  | P                  | Cascaded transformation                                                                                      |                 | +                | -                | PGAsl                         |
| TRACYL                                                  | P                  | Cylinder: Peripheral surface transformation                                                                  |                 | +                | -                | PGAsl                         |
| TRAFOOF                                                 | P                  | Deactivate active transformations in the channel                                                             |                 | +                | -                | PGAsl                         |
| TRAILOF                                                 | P                  | Asynchronous coupled motion OFF                                                                              |                 | +                | +                | PGAsl                         |
| TRAILON                                                 | P                  | Asynchronous coupled motion ON                                                                               |                 | +                | +                | PGAsl                         |
| TRANS                                                   | G                  | Programmable offset                                                                                          | s               | +                |                  | PGsl                          |
| TRANSMIT                                                | P                  | Pole transformation (face machining)                                                                         |                 | +                | -                | PGAsl                         |
| TRAORI                                                  | P                  | 4-axis, 5-axis transformation, generic transformation                                                        |                 | +                | -                | PGAsl                         |
| TRUE                                                    | K                  | Logical constant: True                                                                                       |                 | +                |                  | PGAsl                         |
| TRUNC                                                   | F                  | Truncation of decimal places                                                                                 |                 | +                | +                | PGAsl                         |
| TU                                                      |                    | Axis angle                                                                                                   | s               | +                |                  | PGAsl                         |
| TURN                                                    | O                  | Number of turns for helix                                                                                    | s               | +                |                  | PGsl                          |
| ULI                                                     | K                  | Upper limit value of variables                                                                               |                 | +                |                  | PGAsl                         |
| UNLOCK                                                  | P                  | Enable synchronized action with ID (continue technology cycle)                                               |                 | -                | +                | FBSYsl                        |
| UNTIL                                                   | K                  | Condition for end of REPEAT loop                                                                             |                 | +                |                  | PGAsl                         |
| UPATH                                                   | G                  | Path reference for FGROUP axes is curve parameter                                                            | m               | +                |                  | PGAsl                         |
| VAR                                                     | K                  | Keyword: Type of parameter transfer                                                                          |                 | +                |                  | PGAsl                         |
| VELOLIM                                                 | K                  | Reduction of the maximum axial velocity                                                                      | m               | +                |                  | PGAsl                         |
| VELOLIMA                                                | K                  | Reduction or increase of the maximum axial velocity of the following axis                                    | m               | +                | +                | PGAsl                         |
| WAITC                                                   | P                  | Wait for the coupling block change criterion to be fulfilled for the axes/spindles                           |                 | +                | -                | PGAsl                         |
| WAITE                                                   | P                  | Wait for end of program in another channel.                                                                  |                 | +                | -                | PGAsl                         |
| WAITENC                                                 | P                  | Wait for synchronized or restored axis positions                                                             |                 | +                | -                | PGAsl                         |
| WAITM                                                   | P                  | Wait for marker in specified channel; terminate previous block with exact stop.                              |                 | +                | -                | PGAsl                         |
| WAITMC                                                  | P                  | Wait for marker in specified channel; exact stop only if the other channels have not yet reached the marker. |                 | +                | -                | PGAsl                         |
| WAITP                                                   | P                  | Wait for end of travel of the positioning axis                                                               |                 | +                | -                | PGsl                          |
| WAITS                                                   | P                  | Wait for spindle position to be reached                                                                      |                 | +                | -                | PGsl                          |
| WALCS0 <sup>6)</sup>                                    | G                  | Workpiece coordinate system working area limitation deselected                                               | m               | +                | -                | PGsl                          |
| WALCS1                                                  | G                  | WCS working area limitation group 1 active                                                                   | m               | +                | -                | PGsl                          |
| WALCS2                                                  | G                  | WCS working area limitation group 2 active                                                                   | m               | +                | -                | PGsl                          |
| WALCS3                                                  | G                  | WCS working area limitation group 3 active                                                                   | m               | +                | -                | PGsl                          |
| WALCS4                                                  | G                  | WCS working area limitation group 4 active                                                                   | m               | +                | -                | PGsl                          |

## 17.1 Operations

| Operation                                               | Type <sup>1)</sup> | Meaning                                                                                       | W <sup>2)</sup> | TP <sup>3)</sup> | SA <sup>4)</sup> | Description see <sup>5)</sup> |
|---------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------------------|
| 1) 2) 3) 4) 5) for explanations, see legend (Page 417). |                    |                                                                                               |                 |                  |                  |                               |
| WALCS5                                                  | G                  | WCS working area limitation group 5 active                                                    | m               | +                | -                | PGsl                          |
| WALCS6                                                  | G                  | WCS working area limitation group 6 active                                                    | m               | +                | -                | PGsl                          |
| WALCS7                                                  | G                  | WCS working area limitation group 7 active                                                    | m               | +                | -                | PGsl                          |
| WALCS8                                                  | G                  | WCS working area limitation group 8 active                                                    | m               | +                | -                | PGsl                          |
| WALCS9                                                  | G                  | WCS working area limitation group 9 active                                                    | m               | +                | -                | PGsl                          |
| WALCS10                                                 | G                  | WCS working area limitation group 10 active                                                   | m               | +                | -                | PGsl                          |
| WALIMOF                                                 | G                  | BCS working area limitation OFF                                                               | m               | +                | -                | PGsl                          |
| WALIMON <sup>6)</sup>                                   | G                  | BCS working area limitation ON                                                                | m               | +                | -                | PGsl                          |
| WHEN                                                    | K                  | The action is executed once whenever the condition is fulfilled.                              |                 | -                | +                | FBSYsl                        |
| WHENEVER                                                | K                  | The action is executed cyclically in each interpolator cycle when the condition is fulfilled. |                 | -                | +                | FBSYsl                        |
| WHILE                                                   | K                  | Start of WHILE program loop                                                                   |                 | +                |                  | PGAsl                         |
| WRITE                                                   | P                  | Write text to file system.<br>Appends a block to the end of the specified file.               |                 | +                | -                | PGAsl                         |
| WRTPR                                                   | P                  | Delays the machining job without interrupting continuous-path mode                            |                 | +                | -                | PGAsl                         |
| X                                                       | O                  | Axis name                                                                                     | m/s             | +                | +                | PGsl                          |
| XOR                                                     | O                  | Logic exclusive OR                                                                            |                 | +                |                  | PGAsl                         |
| Y                                                       | O                  | Axis name                                                                                     | m/s             | +                | +                | PGsl                          |
| Z                                                       | O                  | Axis name                                                                                     | m/s             | +                | +                | PGsl                          |



---

## Legend

---

1) Type of operation:

A Address

Identifier to which a value is assigned (e.g. OVR=10). There are also some addresses that switch on or off a function without value assignment (e.g. CPLON and CPLOF).

C Technological cycle

Predefined part program in which a generally valid specific cycle (machining operation), such as tapping of a thread or milling a pocket, is programmed. The adaptation to a specific machine situation is realized via parameters that are transferred to the cycle during the call.

F Predefined function (supplies a return value)

The call of the predefined function can be an operand in an expression.

G G function

G functions are divided into function groups. Only one G function of a group can be programmed in a block. A G function can be either modal (until it is canceled by another function of the same group) or only effective for the block in which it is programmed (non-modal).

K Keyword

Identifier that defines the syntax of a block. No value is assigned to a keyword, and no NC function can be switched on/off with a keyword.

Examples: Control structures (IF, ELSE, ENDIF, WHEN, ... ), program execution (GOTOB, GOTO, RET ... )

O Operator

Operator for a mathematical, comparison or logical operation

P Predefined procedure (does not supply a return value)

PA Program attribute

Program attributes are at the end of the definition line of a subprogram:

`PROC <program name>(...) <program attribute>`

They determine the behavior during execution of the subprogram.

2) Effectiveness of the operation:

m Modal

s Non-modal

3) Programmability in part program:

+ Programmable

- Not programmable

4) Programmability in synchronized actions:

+ Programmable

- Not programmable

T Programmable only in technology cycles

<sup>5)</sup> Reference to the document containing the detailed description of the operation:

*PGs/*        Programming Manual, Fundamentals

*PGAs/*      Programming Manual, Job Planning

## 17.2 Operations: Availability for SINUMERIK 828D

|                  |                                                                                                                                |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <i>BNMsl</i>     | Programming Manual Measuring Cycles                                                                                            |
| <i>BHDsl</i>     | Operating Manual, Turning                                                                                                      |
| <i>BHFsl</i>     | Operating Manual, Milling                                                                                                      |
| <i>FB1sl</i> ( ) | Function Manual, Basic Functions (with the alphanumeric abbreviation of the corresponding function description in brackets)    |
| <i>FB2sl</i> ( ) | Function Manual, Extended Functions (with the alphanumeric abbreviation of the corresponding function description in brackets) |
| <i>FB3sl</i> ( ) | Function Manual, Special Functions (with the alphanumeric abbreviation of the corresponding function description in brackets)  |
| <i>FBSsl</i>     | Function Manual, Safety Integrated                                                                                             |
| <i>FBSYsl</i>    | Function Manual, Synchronized Actions                                                                                          |
| <i>FBWsl</i>     | Function Manual, Tool Management                                                                                               |

<sup>6)</sup> Default setting at beginning of program (factory settings of the control, if nothing else programmed).

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ○ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| :               | •                    | •       | •                | •       | •                | •       |
| *               | •                    | •       | •                | •       | •                | •       |
| +               | •                    | •       | •                | •       | •                | •       |
| -               | •                    | •       | •                | •       | •                | •       |
| <               | •                    | •       | •                | •       | •                | •       |
| <<              | •                    | •       | •                | •       | •                | •       |
| <=              | •                    | •       | •                | •       | •                | •       |
| =               | •                    | •       | •                | •       | •                | •       |
| >=              | •                    | •       | •                | •       | •                | •       |
| /               | •                    | •       | •                | •       | •                | •       |
| /0              | •                    | •       | •                | •       | •                | •       |
| ...             |                      |         |                  |         |                  |         |
| ...             | ○                    | ○       | ○                | ○       | ○                | ○       |
| /7              |                      |         |                  |         |                  |         |
| A               | •                    | •       | •                | •       | •                | •       |
| A2              | -                    | -       | -                | -       | -                | -       |
| A3              | -                    | -       | -                | -       | -                | -       |
| A4              | -                    | -       | -                | -       | -                | -       |
| A5              | -                    | -       | -                | -       | -                | -       |
| ABS             | •                    | •       | •                | •       | •                | •       |
| AC              | •                    | •       | •                | •       | •                | •       |
| ACC             | •                    | •       | •                | •       | •                | •       |
| ACCLIMA         | •                    | •       | •                | •       | •                | •       |

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| ACN                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| ACOS                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ACP                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| ACTBLOCNO                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| ADDFRAME                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| ADIS                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ADISPOS                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| ADISPOSA                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| ALF                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| AMIRROR                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| AND                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| ANG                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| AP                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| APR                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| APRB                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| APRP                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| APW                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| APWB                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| APWP                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| APX                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| AR                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| AROT                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| AROTS                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| AS                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| ASCALE                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| ASIN                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ASPLINE                                                | -                    | ○       | -                | ○       | -                | ○       |
| ATAN2                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| ATOL                                                   | -                    | ●       | -                | ●       | -                | ●       |
| ATRANS                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| AUXFUDEL                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| AUXFUDELG                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| AUXFUMSEQ                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| AUXFUSYNC                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| AX                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| AXCTSWE                                                | -                    | -       | -                | -       | -                | -       |
| AXCTSWEC                                               | -                    | -       | -                | -       | -                | -       |
| AXCTSWED                                               | -                    | -       | -                | -       | -                | -       |
| AXIS                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| AXNAME                                    | •                    | •       | •                | •       | •                | •       |
| AXSTRING                                  | •                    | •       | •                | •       | •                | •       |
| AXTOCHAN                                  | •                    | •       | •                | •       | •                | •       |
| AXTOSPI                                   | •                    | •       | •                | •       | •                | •       |
| B                                         | •                    | •       | •                | •       | •                | •       |
| B2                                        | -                    | -       | -                | -       | -                | -       |
| B3                                        | -                    | -       | -                | -       | -                | -       |
| B4                                        | -                    | -       | -                | -       | -                | -       |
| B5                                        | -                    | -       | -                | -       | -                | -       |
| B_AND                                     | •                    | •       | •                | •       | •                | •       |
| B_OR                                      | •                    | •       | •                | •       | •                | •       |
| B_NOT                                     | •                    | •       | •                | •       | •                | •       |
| B_XOR                                     | •                    | •       | •                | •       | •                | •       |
| BAUTO                                     | -                    | ○       | -                | ○       | -                | ○       |
| BLOCK                                     | •                    | •       | •                | •       | •                | •       |
| BLSYNC                                    | •                    | •       | •                | •       | •                | •       |
| BNAT                                      | -                    | ○       | -                | ○       | -                | ○       |
| BOOL                                      | •                    | •       | •                | •       | •                | •       |
| BOUND                                     | •                    | •       | •                | •       | •                | •       |
| BRISK                                     | •                    | •       | •                | •       | •                | •       |
| BRISKA                                    | •                    | •       | •                | •       | •                | •       |
| BSPLINE                                   | -                    | ○       | -                | ○       | -                | ○       |
| BTAN                                      | -                    | ○       | -                | ○       | -                | ○       |
| C                                         | •                    | •       | •                | •       | •                | •       |
| C2                                        | -                    | -       | -                | -       | -                | -       |
| C3                                        | -                    | -       | -                | -       | -                | -       |
| C4                                        | -                    | -       | -                | -       | -                | -       |
| C5                                        | -                    | -       | -                | -       | -                | -       |
| CAC                                       | •                    | •       | •                | •       | •                | •       |
| CACN                                      | •                    | •       | •                | •       | •                | •       |
| CACP                                      | •                    | •       | •                | •       | •                | •       |
| CALCDAT                                   | •                    | •       | •                | •       | •                | •       |
| CALCPOSI                                  | •                    | •       | •                | •       | •                | •       |
| CALL                                      | •                    | •       | •                | •       | •                | •       |
| CALLPATH                                  | •                    | •       | •                | •       | •                | •       |
| CANCEL                                    | •                    | •       | •                | •       | •                | •       |
| CASE                                      | •                    | •       | •                | •       | •                | •       |
| CDC                                       | •                    | •       | •                | •       | •                | •       |
| CDOF                                      | •                    | •       | •                | •       | •                | •       |

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| ● Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| CDOF2                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| CDON                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CFC                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| CFIN                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CFINE                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| CFTCP                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHAN                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHANDATA                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHAR                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHF                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHKDM                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHKDNO                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| CHR                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| CIC                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| CIP                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| CLEARM                                    | -                    | -       | -                | -       | -                | -       |
| CLRINT                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| CMIRROR                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| COARSEA                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| COLLPAIR                                  | -                    | -       | -                | -       | -                | -       |
| COMPCAD                                   | -                    | ○       | -                | ○       | -                | ○       |
| COMPCURV                                  | -                    | ○       | -                | ○       | -                | ○       |
| COMPLETE                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| COMPOF                                    | -                    | ○       | -                | ○       | -                | ○       |
| COMPON                                    | -                    | ○       | -                | ○       | -                | ○       |
| CONTDCON                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| CONTPRON                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| CORROF                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| COS                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| COUPDEF                                   | ○                    | -       | ○                | -       | ○                | -       |
| COUPDEL                                   | ○                    | -       | ○                | -       | ○                | -       |
| COUPOF                                    | ○                    | -       | ○                | -       | ○                | -       |
| COUPOFS                                   | ○                    | -       | ○                | -       | ○                | -       |
| COUPON                                    | ○                    | -       | ○                | -       | ○                | -       |
| COUPONC                                   | ○                    | -       | ○                | -       | ○                | -       |
| COUPRES                                   | ○                    | -       | ○                | -       | ○                | -       |
| CP                                        | ●                    | ●       | ●                | ●       | ●                | ●       |
| CPBC                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CPDEF                                     | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| CPDEL                                     | •                    | •       | •                | •       | •                | •       |
| CPFMOF                                    | •                    | •       | •                | •       | •                | •       |
| CPFMON                                    | •                    | •       | •                | •       | •                | •       |
| CPFMSON                                   | •                    | •       | •                | •       | •                | •       |
| CPFPOS                                    | •                    | •       | •                | •       | •                | •       |
| CPFRS                                     | •                    | •       | •                | •       | •                | •       |
| CPLA                                      | •                    | •       | •                | •       | •                | •       |
| CPLCTID                                   | •                    | •       | •                | •       | •                | •       |
| CPLDEF                                    | •                    | •       | •                | •       | •                | •       |
| CPLDEL                                    | •                    | •       | •                | •       | •                | •       |
| CPLDEN                                    | •                    | •       | •                | •       | •                | •       |
| CPLINSC                                   | •                    | •       | •                | •       | •                | •       |
| CPLINTR                                   | •                    | •       | •                | •       | •                | •       |
| CPLNUM                                    | •                    | •       | •                | •       | •                | •       |
| CPLOF                                     | •                    | •       | •                | •       | •                | •       |
| CPLON                                     | •                    | •       | •                | •       | •                | •       |
| CPLOUTSC                                  | •                    | •       | •                | •       | •                | •       |
| CPLOUTTR                                  | •                    | •       | •                | •       | •                | •       |
| CPLPOS                                    | •                    | •       | •                | •       | •                | •       |
| CPLSETVAL                                 | •                    | •       | •                | •       | •                | •       |
| CPMALARM                                  | •                    | •       | •                | •       | •                | •       |
| CPMBRAKE                                  | •                    | •       | •                | •       | •                | •       |
| CPMPRT                                    | •                    | •       | •                | •       | •                | •       |
| CPMRESET                                  | •                    | •       | •                | •       | •                | •       |
| CPMSTART                                  | •                    | •       | •                | •       | •                | •       |
| CPMVDI                                    | •                    | •       | •                | •       | •                | •       |
| CPOF                                      | •                    | •       | •                | •       | •                | •       |
| CPON                                      | •                    | •       | •                | •       | •                | •       |
| CPRECOF                                   | •                    | •       | •                | •       | •                | •       |
| CPRECON                                   | •                    | •       | •                | •       | •                | •       |
| CPRES                                     | •                    | •       | •                | •       | •                | •       |
| CPROT                                     | •                    | •       | •                | •       | •                | •       |
| CPROTDEF                                  | •                    | •       | •                | •       | •                | •       |
| CPSETTYPE                                 | •                    | •       | •                | •       | •                | •       |
| CPSYNCOF                                  | •                    | •       | •                | •       | •                | •       |
| CPSYNCOF2                                 | •                    | •       | •                | •       | •                | •       |
| CPSYNCOV                                  | •                    | •       | •                | •       | •                | •       |
| CPSYNFIP                                  | •                    | •       | •                | •       | •                | •       |
| CPSYNFIP2                                 | •                    | •       | •                | •       | •                | •       |

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| ● Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| CPSYNFIV                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| CR                                        | ●                    | ●       | ●                | ●       | ●                | ●       |
| CROT                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CROTS                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| CRPL                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| CSCALE                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| CSPLINE                                   | -                    | ○       | -                | ○       | -                | ○       |
| CT                                        | ●                    | ●       | ●                | ●       | ●                | ●       |
| CTAB                                      | -                    | -       | -                | -       | -                | -       |
| CTABDEF                                   | -                    | -       | -                | -       | -                | -       |
| CTABDEL                                   | -                    | -       | -                | -       | -                | -       |
| CTABEND                                   | -                    | -       | -                | -       | -                | -       |
| CTABEXISTS                                | -                    | -       | -                | -       | -                | -       |
| CTABFNO                                   | -                    | -       | -                | -       | -                | -       |
| CTABFPOL                                  | -                    | -       | -                | -       | -                | -       |
| CTABFSEG                                  | -                    | -       | -                | -       | -                | -       |
| CTABID                                    | -                    | -       | -                | -       | -                | -       |
| CTABINV                                   | -                    | -       | -                | -       | -                | -       |
| CTABISLOCK                                | -                    | -       | -                | -       | -                | -       |
| CTABLOCK                                  | -                    | -       | -                | -       | -                | -       |
| CTABMEMTYP                                | -                    | -       | -                | -       | -                | -       |
| CTABMPOL                                  | -                    | -       | -                | -       | -                | -       |
| CTABMSEG                                  | -                    | -       | -                | -       | -                | -       |
| CTABNO                                    | -                    | -       | -                | -       | -                | -       |
| CTABNOMEM                                 | -                    | -       | -                | -       | -                | -       |
| CTABPERIOD                                | -                    | -       | -                | -       | -                | -       |
| CTABPOL                                   | -                    | -       | -                | -       | -                | -       |
| CTABPOLID                                 | -                    | -       | -                | -       | -                | -       |
| CTABSEG                                   | -                    | -       | -                | -       | -                | -       |
| CTABSEGID                                 | -                    | -       | -                | -       | -                | -       |
| CTABSEV                                   | -                    | -       | -                | -       | -                | -       |
| CTABSSV                                   | -                    | -       | -                | -       | -                | -       |
| CTABTEP                                   | -                    | -       | -                | -       | -                | -       |
| CTABTEV                                   | -                    | -       | -                | -       | -                | -       |
| CTABTMAX                                  | -                    | -       | -                | -       | -                | -       |
| CTABTMIN                                  | -                    | -       | -                | -       | -                | -       |
| CTABTSP                                   | -                    | -       | -                | -       | -                | -       |
| CTABTSV                                   | -                    | -       | -                | -       | -                | -       |
| CTABUNLOCK                                | -                    | -       | -                | -       | -                | -       |



## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| CTOL                                      | -                    | ○       | -                | ○       | -                | ○       |
| CTRANS                                    | •                    | •       | •                | •       | •                | •       |
| CUT2D                                     | •                    | •       | •                | •       | •                | •       |
| CUT2DF                                    | •                    | •       | •                | •       | •                | •       |
| CUT3DC                                    | -                    | -       | -                | -       | -                | -       |
| CUT3DCC                                   | -                    | -       | -                | -       | -                | -       |
| CUT3DCCD                                  | -                    | -       | -                | -       | -                | -       |
| CUT3DF                                    | -                    | -       | -                | -       | -                | -       |
| CUT3DFF                                   | -                    | -       | -                | -       | -                | -       |
| CUT3DFS                                   | -                    | -       | -                | -       | -                | -       |
| CUTCONOF                                  | •                    | •       | •                | •       | •                | •       |
| CUTCONON                                  | •                    | •       | •                | •       | •                | •       |
| CUTMOD                                    | •                    | •       | •                | •       | •                | •       |
| CYCLE60                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE61                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE62                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE63                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE64                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE70                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE72                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE76                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE77                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE78                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE79                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE81                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE82                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE83                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE84                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE85                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE86                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE92                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE95                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE98                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE99                                   | •                    | •       | •                | •       | •                | •       |
| CYCLE495                                  | •                    | •       | •                | •       | •                | •       |
| CYCLE751                                  | -                    | -       | -                | -       | -                | -       |
| CYCLE752                                  | -                    | -       | -                | -       | -                | -       |
| CYCLE753                                  | -                    | -       | -                | -       | -                | -       |
| CYCLE754                                  | -                    | -       | -                | -       | -                | -       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| CYCLE755                                               | -                    | -       | -                | -       | -                | -       |
| CYCLE756                                               | -                    | -       | -                | -       | -                | -       |
| CYCLE757                                               | -                    | -       | -                | -       | -                | -       |
| CYCLE758                                               | -                    | -       | -                | -       | -                | -       |
| CYCLE759                                               | -                    | -       | -                | -       | -                | -       |
| CYCLE800                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE801                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE802                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE830                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE832                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE840                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE899                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE930                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE940                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE951                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE952                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4071                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4072                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4073                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4074                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4075                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4077                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4078                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| CYCLE4079                                              | ●                    | ●       | ●                | ●       | ●                | ●       |

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| D                                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| D0                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| DAC                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| DC                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| DCI                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| DCM                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| DCU                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| DEF                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| DEFINE                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| DEFAULT                                                | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ○ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| DELAYFSTON      | •                    | •       | •                | •       | •                | •       |
| DELAYFSTOF      | •                    | •       | •                | •       | •                | •       |
| DELDL           | •                    | •       | •                | •       | •                | •       |
| DELDTG          | •                    | •       | •                | •       | •                | •       |
| DELETE          | •                    | •       | •                | •       | •                | •       |
| DELMLOWNER      | •                    | •       | •                | •       | •                | •       |
| DEMLRES         | •                    | •       | •                | •       | •                | •       |
| DELMT           | •                    | •       | •                | •       | •                | •       |
| DELOBJ          | -                    | -       | -                | -       | -                | -       |
| DELT            | •                    | •       | •                | •       | •                | •       |
| DELTC           | •                    | •       | •                | •       | •                | •       |
| DELTOOLNV       | •                    | •       | •                | •       | •                | •       |
| DIACYCOFA       | •                    | •       | •                | •       | •                | •       |
| DIAM90          | •                    | •       | •                | •       | •                | •       |
| DIAM90A         | •                    | •       | •                | •       | •                | •       |
| DIAMCHAN        | •                    | •       | •                | •       | •                | •       |
| DIAMCHANA       | •                    | •       | •                | •       | •                | •       |
| DIAMCYCOF       | •                    | •       | •                | •       | •                | •       |
| DIAMOF          | •                    | •       | •                | •       | •                | •       |
| DIAMOFA         | •                    | •       | •                | •       | •                | •       |
| DIAMON          | •                    | •       | •                | •       | •                | •       |
| DIAMONA         | •                    | •       | •                | •       | •                | •       |
| DIC             | •                    | •       | •                | •       | •                | •       |
| DILF            | •                    | •       | •                | •       | •                | •       |
| DISABLE         | •                    | •       | •                | •       | •                | •       |
| DISC            | •                    | •       | •                | •       | •                | •       |
| DISCL           | •                    | •       | •                | •       | •                | •       |
| DISPLOF         | •                    | •       | •                | •       | •                | •       |
| DISPLON         | •                    | •       | •                | •       | •                | •       |
| DISPR           | •                    | •       | •                | •       | •                | •       |
| DISR            | •                    | •       | •                | •       | •                | •       |
| DISRP           | •                    | •       | •                | •       | •                | •       |
| DITE            | •                    | •       | •                | •       | •                | •       |
| DITS            | •                    | •       | •                | •       | •                | •       |
| DIV             | •                    | •       | •                | •       | •                | •       |
| DL              | -                    | -       | -                | -       | -                | -       |
| DO              | •                    | •       | •                | •       | •                | •       |
| DRFOF           | •                    | •       | •                | •       | •                | •       |
| DRIVE           | •                    | •       | •                | •       | •                | •       |

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| DRIVEA                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| DYNFINISH                                              | ●                    | ●       | ●                | ●       | ●                | ●       |
| DYNNORM                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| DYNPOS                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| DYNROUGH                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| DYNSEMIFIN                                             | ●                    | ●       | ●                | ●       | ●                | ●       |
| DZERO                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| EAUTO                                                  | -                    | ○       | -                | ○       | -                | ○       |
| EGDEF                                                  | ○                    | -       | ○                | -       | ○                | -       |
| EGDEL                                                  | ○                    | -       | ○                | -       | ○                | -       |
| EGOFC                                                  | ○                    | -       | ○                | -       | ○                | -       |
| EGOFS                                                  | ○                    | -       | ○                | -       | ○                | -       |
| EGON                                                   | ○                    | -       | ○                | -       | ○                | -       |
| EGONSYN                                                | ○                    | -       | ○                | -       | ○                | -       |
| EGONSYNE                                               | ○                    | -       | ○                | -       | ○                | -       |
| ELSE                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENABLE                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENAT                                                   | -                    | ○       | -                | ○       | -                | ○       |
| ENDFOR                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENDIF                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENDLABEL                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENDLOOP                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENDPROC                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| ENDWHILE                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| ESRR                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ESRS                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| ETAN                                                   | -                    | ○       | -                | ○       | -                | ○       |
| EVERY                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| EX                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXECSTRING                                             | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXECTAB                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXECUTE                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXP                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXTCALL                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXTCLOSE                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXTERN                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| EXTOPEN                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| F                                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| FA                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ○ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| FAD             | •                    | •       | •                | •       | •                | •       |
| FALSE           | •                    | •       | •                | •       | •                | •       |
| FB              | •                    | •       | •                | •       | •                | •       |
| FCTDEF          | -                    | -       | -                | -       | -                | -       |
| FCUB            | •                    | •       | •                | •       | •                | •       |
| FD              | •                    | •       | •                | •       | •                | •       |
| FDA             | •                    | •       | •                | •       | •                | •       |
| FENDNORM        | •                    | •       | •                | •       | •                | •       |
| FFWOF           | •                    | •       | •                | •       | •                | •       |
| FFWON           | •                    | •       | •                | •       | •                | •       |
| FGREF           | •                    | •       | •                | •       | •                | •       |
| FGROUP          | •                    | •       | •                | •       | •                | •       |
| FI              | •                    | •       | •                | •       | •                | •       |
| FIFOCTRL        | •                    | •       | •                | •       | •                | •       |
| FILEDATE        | •                    | •       | •                | •       | •                | •       |
| FILEINFO        | •                    | •       | •                | •       | •                | •       |
| FILESIZE        | •                    | •       | •                | •       | •                | •       |
| FILESTAT        | •                    | •       | •                | •       | •                | •       |
| FILETIME        | •                    | •       | •                | •       | •                | •       |
| FINEA           | •                    | •       | •                | •       | •                | •       |
| FL              | •                    | •       | •                | •       | •                | •       |
| FLIN            | •                    | •       | •                | •       | •                | •       |
| FMA             | -                    | -       | -                | -       | -                | -       |
| FNORM           | •                    | •       | •                | •       | •                | •       |
| FOCOF           | ○                    | -       | ○                | -       | ○                | -       |
| FOCON           | ○                    | -       | ○                | -       | ○                | -       |
| FOR             | •                    | •       | •                | •       | •                | •       |
| FP              | •                    | •       | •                | •       | •                | •       |
| FPO             | -                    | -       | -                | -       | -                | -       |
| FPR             | •                    | •       | •                | •       | •                | •       |
| FPRAOF          | •                    | •       | •                | •       | •                | •       |
| FPRAON          | •                    | •       | •                | •       | •                | •       |
| FRAME           | •                    | •       | •                | •       | •                | •       |
| FRC             | •                    | •       | •                | •       | •                | •       |
| FRCM            | •                    | •       | •                | •       | •                | •       |
| FROM            | •                    | •       | •                | •       | •                | •       |
| FTOC            | •                    | •       | •                | •       | •                | •       |
| FTOCOF          | •                    | •       | •                | •       | •                | •       |
| FTOCON          | •                    | •       | •                | •       | •                | •       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| FXS                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| FXST                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| FXSW                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| FZ                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G0                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G1                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G2                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G3                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G4                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G5                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G7                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G9                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| G17                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G18                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G19                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G25                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G26                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G33                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G34                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G35                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G40                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G41                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G42                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G53                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G54                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G55                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G56                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G57                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G58                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G59                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G60                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G62                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G63                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G64                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G70                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G71                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G74                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G75                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G90                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| G91                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G93                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G94                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G95                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G96                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G97                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| G110                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G111                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G112                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G140                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G141                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G142                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G143                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G147                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G148                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G153                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G247                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G248                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G290                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G291                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G331                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G332                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G335                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G336                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G340                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G341                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G347                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G348                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G450                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G451                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G460                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G461                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G462                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G500                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G505 ... G599                                          | ●                    | ●       | ●                | ●       | ●                | ●       |
| G601                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G602                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G603                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| G621                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ◦ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| G641            | •                    | •       | •                | •       | •                | •       |
| G642            | •                    | •       | •                | •       | •                | •       |
| G643            | •                    | •       | •                | •       | •                | •       |
| G644            | •                    | •       | •                | •       | •                | •       |
| G645            | •                    | •       | •                | •       | •                | •       |
| G700            | •                    | •       | •                | •       | •                | •       |
| G710            | •                    | •       | •                | •       | •                | •       |
| G810 ... G819   | -                    | -       | -                | -       | -                | -       |
| G820 ... G829   | -                    | -       | -                | -       | -                | -       |
| G931            | •                    | •       | •                | •       | •                | •       |
| G942            | •                    | •       | •                | •       | •                | •       |
| G952            | •                    | •       | •                | •       | •                | •       |
| G961            | •                    | •       | •                | •       | •                | •       |
| G962            | •                    | •       | •                | •       | •                | •       |
| G971            | •                    | •       | •                | •       | •                | •       |
| G972            | •                    | •       | •                | •       | •                | •       |
| G973            | •                    | •       | •                | •       | •                | •       |
| GEOAX           | •                    | •       | •                | •       | •                | •       |

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ◦ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| GET             | •                    | •       | •                | •       | •                | •       |
| GETACTT         | •                    | •       | •                | •       | •                | •       |
| GETACTTD        | •                    | •       | •                | •       | •                | •       |
| GETD            | •                    | •       | •                | •       | •                | •       |
| GETDNO          | •                    | •       | •                | •       | •                | •       |
| GETEXET         | •                    | •       | •                | •       | •                | •       |
| GETFREELOC      | •                    | •       | •                | •       | •                | •       |
| GETSELT         | •                    | •       | •                | •       | •                | •       |
| GETT            | •                    | •       | •                | •       | •                | •       |
| GETTCOR         | •                    | •       | •                | •       | •                | •       |
| GETTENV         | •                    | •       | •                | •       | •                | •       |
| GETVARAP        | •                    | •       | •                | •       | •                | •       |
| GETVARDFT       | •                    | •       | •                | •       | •                | •       |
| GETVARLIM       | •                    | •       | •                | •       | •                | •       |
| GETVARPHU       | •                    | •       | •                | •       | •                | •       |
| GETVARTYP       | •                    | •       | •                | •       | •                | •       |



## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ○ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| GOTO            | •                    | •       | •                | •       | •                | •       |
| GOTOB           | •                    | •       | •                | •       | •                | •       |
| GOTOC           | •                    | •       | •                | •       | •                | •       |
| GOTOF           | •                    | •       | •                | •       | •                | •       |
| GOTOS           | •                    | •       | •                | •       | •                | •       |
| GP              | •                    | •       | •                | •       | •                | •       |
| GWPSOF          | •                    | •       | •                | •       | •                | •       |
| GWPSON          | •                    | •       | •                | •       | •                | •       |
| H...            | •                    | •       | •                | •       | •                | •       |
| HOLES1          | •                    | •       | •                | •       | •                | •       |
| HOLES2          | •                    | •       | •                | •       | •                | •       |
| I               | •                    | •       | •                | •       | •                | •       |
| I1              | •                    | •       | •                | •       | •                | •       |
| IC              | •                    | •       | •                | •       | •                | •       |
| ICYCOF          | •                    | •       | •                | •       | •                | •       |
| ICYCON          | •                    | •       | •                | •       | •                | •       |
| ID              | •                    | •       | •                | •       | •                | •       |
| IDS             | •                    | •       | •                | •       | •                | •       |
| IF              | •                    | •       | •                | •       | •                | •       |
| INDEX           | •                    | •       | •                | •       | •                | •       |
| INIPO           | •                    | •       | •                | •       | •                | •       |
| INIRE           | •                    | •       | •                | •       | •                | •       |
| INICF           | •                    | •       | •                | •       | •                | •       |
| INIT            | -                    | -       | -                | -       | -                | -       |
| INITIAL         | •                    | •       | •                | •       | •                | •       |
| INT             | •                    | •       | •                | •       | •                | •       |
| INTERSEC        | •                    | •       | •                | •       | •                | •       |
| INVCCW          | -                    | -       | -                | -       | -                | -       |
| INVCW           | -                    | -       | -                | -       | -                | -       |
| INVFRAME        | •                    | •       | •                | •       | •                | •       |
| IP              | •                    | •       | •                | •       | •                | •       |
| IPOBRKA         | •                    | •       | •                | •       | •                | •       |
| IPOENDA         | •                    | •       | •                | •       | •                | •       |
| IPTRLOCK        | •                    | •       | •                | •       | •                | •       |
| IPTRUNLOCK      | •                    | •       | •                | •       | •                | •       |
| IR              | •                    | •       | •                | •       | •                | •       |
| ISAXIS          | •                    | •       | •                | •       | •                | •       |
| ISD             | -                    | -       | -                | -       | -                | -       |
| ISFILE          | •                    | •       | •                | •       | •                | •       |

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| ISNUMBER                                  | •                    | •       | •                | •       | •                | •       |
| ISOCALL                                   | •                    | •       | •                | •       | •                | •       |
| ISVAR                                     | •                    | •       | •                | •       | •                | •       |
| J                                         | •                    | •       | •                | •       | •                | •       |
| J1                                        | •                    | •       | •                | •       | •                | •       |
| JERKA                                     | •                    | •       | •                | •       | •                | •       |
| JERKLIM                                   | •                    | •       | •                | •       | •                | •       |
| JERKLIMA                                  | •                    | •       | •                | •       | •                | •       |
| JR                                        | •                    | •       | •                | •       | •                | •       |
| K                                         | •                    | •       | •                | •       | •                | •       |
| K1                                        | •                    | •       | •                | •       | •                | •       |
| KONT                                      | •                    | •       | •                | •       | •                | •       |
| KONTC                                     | •                    | •       | •                | •       | •                | •       |
| KONTT                                     | •                    | •       | •                | •       | •                | •       |
| KR                                        | •                    | •       | •                | •       | •                | •       |
| L                                         | •                    | •       | •                | •       | •                | •       |
| LEAD                                      |                      |         |                  |         |                  |         |
| Tool orientation                          | -                    | -       | -                | -       | -                | -       |
| Orientation polynomial                    | -                    | -       | -                | -       | -                | -       |
| LEADOF                                    | -                    | -       | -                | -       | -                | -       |
| LEADON                                    | -                    | -       | -                | -       | -                | -       |
| LENTOAX                                   | •                    | •       | •                | •       | •                | •       |
| LFOF                                      | •                    | •       | •                | •       | •                | •       |
| LFON                                      | •                    | •       | •                | •       | •                | •       |
| LFPOS                                     | •                    | •       | •                | •       | •                | •       |
| LFTXT                                     | •                    | •       | •                | •       | •                | •       |
| FWP                                       | •                    | •       | •                | •       | •                | •       |
| LIFTFAST                                  | •                    | •       | •                | •       | •                | •       |
| LIMS                                      | •                    | •       | •                | •       | •                | •       |
| LLI                                       | •                    | •       | •                | •       | •                | •       |
| LN                                        | •                    | •       | •                | •       | •                | •       |
| LOCK                                      | •                    | •       | •                | •       | •                | •       |
| LONGHOLE                                  | -                    | -       | -                | -       | -                | -       |
| LOOP                                      | •                    | •       | •                | •       | •                | •       |
| M0                                        | •                    | •       | •                | •       | •                | •       |
| M1                                        | •                    | •       | •                | •       | •                | •       |
| M2                                        | •                    | •       | •                | •       | •                | •       |
| M3                                        | •                    | •       | •                | •       | •                | •       |
| M4                                        | •                    | •       | •                | •       | •                | •       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                                                                               | 828D control version |         |                  |         |                  |         |
|---------------------------------------------------------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                                                                         | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                                                                         | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| <ul style="list-style-type: none"> <li>● Standard</li> <li>○ Option</li> <li>- not available</li> </ul> |                      |         |                  |         |                  |         |
| M5                                                                                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| M6                                                                                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| M17                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| M19                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| M30                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| M40                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| M41 ... M45                                                                                             | ●                    | ●       | ●                | ●       | ●                | ●       |
| M70                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| MASLDEF                                                                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| MASLDEL                                                                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| MASLOF                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MASLOFS                                                                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| MASLON                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MATCH                                                                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| MAXVAL                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MCALL                                                                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| MEAC                                                                                                    | -                    | -       | -                | -       | -                | -       |
| MEAFRAME                                                                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| MEAS                                                                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| MEASA                                                                                                   | -                    | -       | -                | -       | -                | -       |
| MEASURE                                                                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| MEAW                                                                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| MEAWA                                                                                                   | -                    | -       | -                | -       | -                | -       |
| MI                                                                                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| MINDEX                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MINVAL                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MIRROR                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| MMC                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| MOD                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| MODAXVAL                                                                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| MOV                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| MOVT                                                                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| MSG                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| MVTOOL                                                                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| N                                                                                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| NAMETOINT                                                                                               | -                    | -       | -                | -       | -                | -       |
| NCK                                                                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| NEWCONF                                                                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| NEWMT                                                                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| NEWT                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| NORM                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| NOT                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| NPROT                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| NPROTDEF                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| NUMBER                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| OEMIPO1                                                | -                    | -       | -                | -       | -                | -       |
| OEMIPO2                                                | -                    | -       | -                | -       | -                | -       |
| OF                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| OFFN                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| OMA1                                                   | -                    | -       | -                | -       | -                | -       |
| OMA2                                                   | -                    | -       | -                | -       | -                | -       |
| OMA3                                                   | -                    | -       | -                | -       | -                | -       |
| OMA4                                                   | -                    | -       | -                | -       | -                | -       |
| OMA5                                                   | -                    | -       | -                | -       | -                | -       |
| OR                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| ORIXES                                                 | -                    | -       | -                | -       | -                | -       |
| ORIXPOS                                                | -                    | -       | -                | -       | -                | -       |
| ORIC                                                   | -                    | -       | -                | -       | -                | -       |
| ORICONCCW                                              | -                    | -       | -                | -       | -                | -       |
| ORICONCW                                               | -                    | -       | -                | -       | -                | -       |
| ORICONIO                                               | -                    | -       | -                | -       | -                | -       |
| ORICONTO                                               | -                    | -       | -                | -       | -                | -       |
| ORICURVE                                               | -                    | -       | -                | -       | -                | -       |
| ORID                                                   | -                    | -       | -                | -       | -                | -       |
| ORIEULER                                               | -                    | -       | -                | -       | -                | -       |
| ORIMKS                                                 | -                    | -       | -                | -       | -                | -       |
| ORIPATH                                                | -                    | -       | -                | -       | -                | -       |
| ORIPATHS                                               | -                    | -       | -                | -       | -                | -       |
| ORIPANE                                                | -                    | -       | -                | -       | -                | -       |
| ORIRESET                                               | -                    | -       | -                | -       | -                | -       |
| ORIROTA                                                | -                    | -       | -                | -       | -                | -       |
| ORIROTC                                                | -                    | -       | -                | -       | -                | -       |
| ORIROTR                                                | -                    | -       | -                | -       | -                | -       |
| ORIROTT                                                | -                    | -       | -                | -       | -                | -       |
| ORIRPY                                                 | -                    | -       | -                | -       | -                | -       |
| ORIRPY2                                                | -                    | -       | -                | -       | -                | -       |
| ORIS                                                   | -                    | -       | -                | -       | -                | -       |
| ORISOF                                                 | -                    | -       | -                | -       | -                | -       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| ORISON                                    | -                    | -       | -                | -       | -                | -       |
| ORIVECT                                   | -                    | -       | -                | -       | -                | -       |
| ORIVIRT1                                  | -                    | -       | -                | -       | -                | -       |
| ORIVIRT2                                  | -                    | -       | -                | -       | -                | -       |
| ORIWKS                                    | -                    | -       | -                | -       | -                | -       |
| OS                                        | -                    | -       | -                | -       | -                | -       |
| OSB                                       | -                    | -       | -                | -       | -                | -       |
| OSC                                       | -                    | -       | -                | -       | -                | -       |
| OSCILL                                    | -                    | -       | -                | -       | -                | -       |
| OSCTRL                                    | -                    | -       | -                | -       | -                | -       |
| OSD                                       | -                    | -       | -                | -       | -                | -       |
| OSE                                       | -                    | -       | -                | -       | -                | -       |
| OSNSC                                     | -                    | -       | -                | -       | -                | -       |
| OSOF                                      | -                    | -       | -                | -       | -                | -       |
| OSP1                                      | -                    | -       | -                | -       | -                | -       |
| OSP2                                      | -                    | -       | -                | -       | -                | -       |
| OSS                                       | -                    | -       | -                | -       | -                | -       |
| OSSE                                      | -                    | -       | -                | -       | -                | -       |
| OST                                       | -                    | -       | -                | -       | -                | -       |
| OST1                                      | -                    | -       | -                | -       | -                | -       |
| OST2                                      | -                    | -       | -                | -       | -                | -       |
| OTOL                                      | -                    | •       | -                | •       | -                | •       |
| OVR                                       | •                    | •       | •                | •       | •                | •       |
| OVRA                                      | •                    | •       | •                | •       | •                | •       |
| OVRRAP                                    | •                    | •       | •                | •       | •                | •       |
| P                                         | •                    | •       | •                | •       | •                | •       |
| PAROT                                     | •                    | •       | •                | •       | •                | •       |
| PAROTOF                                   | •                    | •       | •                | •       | •                | •       |
| PCALL                                     | •                    | •       | •                | •       | •                | •       |
| PDELAYOF                                  | -                    | -       | -                | -       | -                | -       |
| PDELAYON                                  | -                    | -       | -                | -       | -                | -       |
| PHI                                       | -                    | -       | -                | -       | -                | -       |
| PHU                                       | •                    | •       | •                | •       | •                | •       |
| PL                                        | -                    | ○       | -                | ○       | -                | ○       |
|                                           | -                    | -       | -                | -       | -                | -       |
| PM                                        | •                    | •       | •                | •       | •                | •       |
| PO                                        | -                    | -       | -                | -       | -                | -       |
| POCKET3                                   | •                    | •       | •                | •       | •                | •       |
| POCKET4                                   | •                    | •       | •                | •       | •                | •       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ◦ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| POLF            | •                    | •       | •                | •       | •                | •       |
| POLFA           | •                    | •       | •                | •       | •                | •       |
| POLFMASK        | •                    | •       | •                | •       | •                | •       |
| POLFMLIN        | •                    | •       | •                | •       | •                | •       |
| POLY            | -                    | -       | -                | -       | -                | -       |
| POLYPATH        | -                    | -       | -                | -       | -                | -       |
| PON             | -                    | -       | -                | -       | -                | -       |
| PONS            | -                    | -       | -                | -       | -                | -       |
| POS             | •                    | •       | •                | •       | •                | •       |
| POSA            | •                    | •       | •                | •       | •                | •       |
| POSM            | •                    | •       | •                | •       | •                | •       |
| POSMT           | •                    | •       | •                | •       | •                | •       |
| POSP            | •                    | •       | •                | •       | •                | •       |
| POSRANGE        | •                    | •       | •                | •       | •                | •       |
| POT             | •                    | •       | •                | •       | •                | •       |

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ◦ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| PR              | •                    | •       | •                | •       | •                | •       |
| PREPRO          | •                    | •       | •                | •       | •                | •       |
| PRESETON        | •                    | •       | •                | •       | •                | •       |
| PRESETONS       | •                    | •       | •                | •       | •                | •       |
| PRIO            | •                    | •       | •                | •       | •                | •       |
| PRLOC           | •                    | •       | •                | •       | •                | •       |
| PROC            | •                    | •       | •                | •       | •                | •       |
| PROTA           | -                    | -       | -                | -       | -                | -       |
| PROTD           | -                    | -       | -                | -       | -                | -       |
| PROTS           | -                    | -       | -                | -       | -                | -       |
| PSI             | -                    | -       | -                | -       | -                | -       |
| PTP             | •                    | •       | •                | •       | •                | •       |
| PTPG0           | •                    | •       | •                | •       | •                | •       |
| PUNCHACC        | -                    | -       | -                | -       | -                | -       |
| PUTFTOC         | •                    | •       | •                | •       | •                | •       |
| PUTFTOCF        | •                    | •       | •                | •       | •                | •       |
| PW              | -                    | ◦       | -                | ◦       | -                | ◦       |
| QU              | •                    | •       | •                | •       | •                | •       |
| R...            | •                    | •       | •                | •       | •                | •       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation       | 828D control version |         |                  |         |                  |         |
|-----------------|----------------------|---------|------------------|---------|------------------|---------|
|                 | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                 | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard      |                      |         |                  |         |                  |         |
| ○ Option        |                      |         |                  |         |                  |         |
| - not available |                      |         |                  |         |                  |         |
| RAC             | •                    | •       | •                | •       | •                | •       |
| RDISABLE        | •                    | •       | •                | •       | •                | •       |
| READ            | •                    | •       | •                | •       | •                | •       |
| REAL            | •                    | •       | •                | •       | •                | •       |
| REDEF           | •                    | •       | •                | •       | •                | •       |
| RELEASE         | •                    | •       | •                | •       | •                | •       |
| REP             | •                    | •       | •                | •       | •                | •       |
| REPEAT          | •                    | •       | •                | •       | •                | •       |
| REPEATB         | •                    | •       | •                | •       | •                | •       |
| REPOSA          | •                    | •       | •                | •       | •                | •       |
| REPOSH          | •                    | •       | •                | •       | •                | •       |
| REPOSHA         | •                    | •       | •                | •       | •                | •       |
| REPOSL          | •                    | •       | •                | •       | •                | •       |
| REPOSQ          | •                    | •       | •                | •       | •                | •       |
| REPOSQA         | •                    | •       | •                | •       | •                | •       |
| RESET           | •                    | •       | •                | •       | •                | •       |
| RESETMON        | •                    | •       | •                | •       | •                | •       |
| RET             | •                    | •       | •                | •       | •                | •       |
| RETB            | •                    | •       | •                | •       | •                | •       |
| RIC             | •                    | •       | •                | •       | •                | •       |
| RINDEX          | •                    | •       | •                | •       | •                | •       |
| RMB             | •                    | •       | •                | •       | •                | •       |
| RME             | •                    | •       | •                | •       | •                | •       |
| RMI             | •                    | •       | •                | •       | •                | •       |
| RMN             | •                    | •       | •                | •       | •                | •       |
| RND             | •                    | •       | •                | •       | •                | •       |
| RNDM            | •                    | •       | •                | •       | •                | •       |
| ROT             | •                    | •       | •                | •       | •                | •       |
| ROTS            | •                    | •       | •                | •       | •                | •       |
| ROUND           | •                    | •       | •                | •       | •                | •       |
| ROUNDUP         | •                    | •       | •                | •       | •                | •       |
| RP              | •                    | •       | •                | •       | •                | •       |
| RPL             | •                    | •       | •                | •       | •                | •       |
| RT              | •                    | •       | •                | •       | •                | •       |
| RTLIOF          | •                    | •       | •                | •       | •                | •       |
| RTLION          | •                    | •       | •                | •       | •                | •       |
| S               | •                    | •       | •                | •       | •                | •       |
| SAVE            | •                    | •       | •                | •       | •                | •       |
| SBLOF           | •                    | •       | •                | •       | •                | •       |

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| ● Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| SBLON                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SC                                        | ●                    | ●       | ●                | ●       | ●                | ●       |
| SCALE                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SCC                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| SCPARA                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| SD                                        | -                    | ○       | -                | ○       | -                | ○       |
| SET                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETAL                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETDNO                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETINT                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETM                                      | -                    | -       | -                | -       | -                | -       |
| SETMS                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETMS(n)                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETMTH                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETPIECE                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETTA                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETTCOR                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| SETTIA                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| SF                                        | ●                    | ●       | ●                | ●       | ●                | ●       |
| SIN                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| SIRELAY                                   | -                    | -       | -                | -       | -                | -       |
| SIRELIN                                   | -                    | -       | -                | -       | -                | -       |
| SIRELOUT                                  | -                    | -       | -                | -       | -                | -       |
| SIRELTIME                                 | -                    | -       | -                | -       | -                | -       |
| SLOT1                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SLOT2                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SOFT                                      | ●                    | ●       | ●                | ●       | ●                | ●       |
| SOFTA                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SON                                       | -                    | -       | -                | -       | -                | -       |
| SONS                                      | -                    | -       | -                | -       | -                | -       |
| SPATH                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SPCOF                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SPCON                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| SPI                                       | ●                    | ●       | ●                | ●       | ●                | ●       |
| SPIF1                                     | -                    | -       | -                | -       | -                | -       |
| SPIF2                                     | -                    | -       | -                | -       | -                | -       |
| SPLINEPATH                                | -                    | ○       | -                | ○       | -                | ○       |
| SPN                                       | -                    | -       | -                | -       | -                | -       |
| SPOF                                      | -                    | -       | -                | -       | -                | -       |



## 17.2 Operations: Availability for SINUMERIK 828D

| Operation           | 828D control version |         |                  |         |                  |         |
|---------------------|----------------------|---------|------------------|---------|------------------|---------|
|                     | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                     | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard          |                      |         |                  |         |                  |         |
| ○ Option            |                      |         |                  |         |                  |         |
| - not available     |                      |         |                  |         |                  |         |
| SPOS                | •                    | •       | •                | •       | •                | •       |
| SPOSA               | •                    | •       | •                | •       | •                | •       |
| SPP                 | -                    | -       | -                | -       | -                | -       |
| SPRINT              | •                    | •       | •                | •       | •                | •       |
| SQRT                | •                    | •       | •                | •       | •                | •       |
| SR                  | -                    | -       | -                | -       | -                | -       |
| SRA                 | -                    | -       | -                | -       | -                | -       |
| ST                  | -                    | -       | -                | -       | -                | -       |
| STA                 | -                    | -       | -                | -       | -                | -       |
| START               | -                    | -       | -                | -       | -                | -       |
| STARTFIFO           | •                    | •       | •                | •       | •                | •       |
| STAT                | •                    | •       | •                | •       | •                | •       |
| STOLF               | -                    | -       | -                | -       | -                | -       |
| STOPFIFO            | •                    | •       | •                | •       | •                | •       |
| STOPRE              | •                    | •       | •                | •       | •                | •       |
| STOPREOF            | •                    | •       | •                | •       | •                | •       |
| STRING              | •                    | •       | •                | •       | •                | •       |
| STRINGFELD          | •                    | •       | •                | •       | •                | •       |
| STRINGIS            | •                    | •       | •                | •       | •                | •       |
| STRINGVAR           | -                    | -       | -                | -       | -                | -       |
| STRLEN              | •                    | •       | •                | •       | •                | •       |
| SUBSTR              | •                    | •       | •                | •       | •                | •       |
| SUPA                | •                    | •       | •                | •       | •                | •       |
| SVC                 | •                    | •       | •                | •       | •                | •       |
| SYNFCT              | •                    | •       | •                | •       | •                | •       |
| SYNR                | •                    | •       | •                | •       | •                | •       |
| SYNRW               | •                    | •       | •                | •       | •                | •       |
| SYNW                | •                    | •       | •                | •       | •                | •       |
| T                   | •                    | •       | •                | •       | •                | •       |
| TAN                 | •                    | •       | •                | •       | •                | •       |
| TANG                | -                    | -       | -                | -       | -                | -       |
| TANGDEL             | -                    | -       | -                | -       | -                | -       |
| TANGOF              | -                    | -       | -                | -       | -                | -       |
| TANGON              | -                    | -       | -                | -       | -                | -       |
| TCA<br>(828D: _TCA) | •                    | •       | •                | •       | •                | •       |
| TCARR               | -                    | •       | -                | •       | -                | •       |
| TCI                 | •                    | •       | •                | •       | •                | •       |
| TCOABS              | -                    | •       | -                | •       | -                | •       |

| Operation<br>● Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| TCOFR                                                  | -                    | ●       | -                | ●       | -                | ●       |
| TCOFRX                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TCOFRY                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TCOFRZ                                                 | -                    | ●       | -                | ●       | -                | ●       |
| THETA                                                  | -                    | -       | -                | -       | -                | -       |
| TILT                                                   | -                    | -       | -                | -       | -                | -       |
| TLIFT                                                  | -                    | -       | -                | -       | -                | -       |
| TML                                                    | ●                    | ●       | ●                | ●       | ●                | ●       |
| TMOF                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| TMON                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| TO                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFF                                                   | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFFL                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFFOF                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFFON                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFFR                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFRAME                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFRAMEX                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFRAMEY                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOFRAMEZ                                               | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOLOWER                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOOLENV                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOOLGNT                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOOLGT                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOROT                                                  | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOROTOF                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOROTX                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOROTY                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOROTZ                                                 | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOUPPER                                                | ●                    | ●       | ●                | ●       | ●                | ●       |
| TOWBCS                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TOWKCS                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TOWMCS                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TOWSTD                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TOWTCS                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TOWWCS                                                 | -                    | ●       | -                | ●       | -                | ●       |
| TR                                                     | ●                    | ●       | ●                | ●       | ●                | ●       |
| TRAANG                                                 | -                    | -       | -                | -       | ○                | -       |
| TRACON                                                 | -                    | -       | -                | -       | ○                | -       |

## 17.2 Operations: Availability for SINUMERIK 828D

| Operation                                 | 828D control version |         |                  |         |                  |         |
|-------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                           | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                           | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| • Standard<br>○ Option<br>- not available |                      |         |                  |         |                  |         |
| TRACYL                                    | ○                    | ○       | ○                | ○       | ○                | ○       |
| TRAFOOF                                   | •                    | •       | •                | •       | •                | •       |
| TRAILOF                                   | •                    | •       | •                | •       | •                | •       |
| TRAILON                                   | •                    | •       | •                | •       | •                | •       |
| TRANS                                     | •                    | •       | •                | •       | •                | •       |
| TRANSMIT                                  | ○                    | ○       | ○                | ○       | ○                | ○       |
| TRAORI                                    | -                    | -       | -                | -       | -                | -       |
| TRUE                                      | •                    | •       | •                | •       | •                | •       |
| TRUNC                                     | •                    | •       | •                | •       | •                | •       |
| TU                                        | •                    | •       | •                | •       | •                | •       |
| TURN                                      | •                    | •       | •                | •       | •                | •       |
| ULI                                       | •                    | •       | •                | •       | •                | •       |
| UNLOCK                                    | •                    | •       | •                | •       | •                | •       |
| UNTIL                                     | •                    | •       | •                | •       | •                | •       |
| UPATH                                     | •                    | •       | •                | •       | •                | •       |
| VAR                                       | •                    | •       | •                | •       | •                | •       |
| VELOLIM                                   | •                    | •       | •                | •       | •                | •       |
| VELOLIMA                                  | •                    | •       | •                | •       | •                | •       |
| WAITC                                     | -                    | -       | -                | -       | ○                | -       |
| WAITE                                     | -                    | -       | -                | -       | -                | -       |
| WAITENC                                   | -                    | -       | -                | -       | -                | -       |
| WAITM                                     | -                    | -       | -                | -       | -                | -       |
| WAITMC                                    | -                    | -       | -                | -       | -                | -       |
| WAITP                                     | •                    | •       | •                | •       | •                | •       |
| WAITS                                     | •                    | •       | •                | •       | •                | •       |
| WALCS0                                    | •                    | •       | •                | •       | •                | •       |
| WALCS1                                    | •                    | •       | •                | •       | •                | •       |
| WALCS2                                    | •                    | •       | •                | •       | •                | •       |
| WALCS3                                    | •                    | •       | •                | •       | •                | •       |
| WALCS4                                    | •                    | •       | •                | •       | •                | •       |
| WALCS5                                    | •                    | •       | •                | •       | •                | •       |
| WALCS6                                    | •                    | •       | •                | •       | •                | •       |
| WALCS7                                    | •                    | •       | •                | •       | •                | •       |
| WALCS8                                    | •                    | •       | •                | •       | •                | •       |
| WALCS9                                    | •                    | •       | •                | •       | •                | •       |
| WALCS10                                   | •                    | •       | •                | •       | •                | •       |
| WALIMOF                                   | •                    | •       | •                | •       | •                | •       |
| WALIMON                                   | •                    | •       | •                | •       | •                | •       |
| WHEN                                      | •                    | •       | •                | •       | •                | •       |

## 17.3 Addresses

| Operation<br>• Standard<br>○ Option<br>- not available | 828D control version |         |                  |         |                  |         |
|--------------------------------------------------------|----------------------|---------|------------------|---------|------------------|---------|
|                                                        | PPU240.3 / 241.3     |         | PPU260.3 / 261.3 |         | PPU280.3 / 281.3 |         |
|                                                        | Turning              | Milling | Turning          | Milling | Turning          | Milling |
| WHENEVER                                               | •                    | •       | •                | •       | •                | •       |
| WHILE                                                  | •                    | •       | •                | •       | •                | •       |
| WRITE                                                  | •                    | •       | •                | •       | •                | •       |
| WRTPR                                                  | •                    | •       | •                | •       | •                | •       |
| X                                                      | •                    | •       | •                | •       | •                | •       |
| XOR                                                    | •                    | •       | •                | •       | •                | •       |
| Y                                                      | •                    | •       | •                | •       | •                | •       |
| Z                                                      | •                    | •       | •                | •       | •                | •       |

## 17.3 Addresses

### 17.3.1 Address letters

| Letter | Meaning                                                                                      | Numeric extension |
|--------|----------------------------------------------------------------------------------------------|-------------------|
| A      | Settable address identifier                                                                  | x                 |
| B      | Settable address identifier                                                                  | x                 |
| C      | Settable address identifier                                                                  | x                 |
| D      | Selection/deselection of tool length compensation, tool cutting edge                         |                   |
| E      | Settable address identifier                                                                  | x                 |
| F      | Feedrate<br>Dwell time in seconds                                                            | x                 |
| G      | G function                                                                                   |                   |
| H      | H function                                                                                   | x                 |
| I      | Settable address identifier                                                                  | x                 |
| J      | Settable address identifier                                                                  | x                 |
| K      | Settable address identifier                                                                  | x                 |
| L      | Subprogram name, subprogram call                                                             |                   |
| M      | M function                                                                                   | x                 |
| N      | Subblock number                                                                              |                   |
| O      | Unassigned                                                                                   |                   |
| P      | Number of program runs                                                                       |                   |
| Q      | Settable address identifier                                                                  | x                 |
| R      | Variable identifier (R parameter)<br>Settable address identifier (without numeric extension) | x                 |

| Letter | Meaning                                         | Numeric extension |
|--------|-------------------------------------------------|-------------------|
| S      | Spindle value                                   | x                 |
|        | Dwell time in spindle revolutions               | x                 |
| T      | Tool number                                     | x                 |
| U      | Settable address identifier                     | x                 |
| V      | Settable address identifier                     | x                 |
| W      | Settable address identifier                     | x                 |
| X      | Settable address identifier                     | x                 |
| Y      | Settable address identifier                     | x                 |
| Z      | Settable address identifier                     | x                 |
| %      | Start character and separator for file transfer |                   |
| :      | Main block number                               |                   |
| /      | Skip identifier                                 |                   |

### 17.3.2 Fixed addresses

#### Fixed addresses without axial extension

| Address identifier | Address type                         | Modal/non-modal             | G70/G71 | G700/G710 | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | QU | Data type of the assigned value |
|--------------------|--------------------------------------|-----------------------------|---------|-----------|---------|----|----|--------------|---------------------------|----|---------------------------------|
| L                  | Subprogram number                    | s                           |         |           |         |    |    |              |                           |    | Unsigned INT                    |
| P                  | Number of subprogram repetitions     | s                           |         |           |         |    |    |              |                           |    | Unsigned INT                    |
| N                  | Block number                         | s                           |         |           |         |    |    |              |                           |    | Unsigned INT                    |
| G                  | G function                           | See list of the G functions |         |           |         |    |    |              |                           |    | Unsigned INT                    |
| F                  | Feed, dwell time                     | m, s                        | x       |           |         |    |    |              |                           | x  | Unsigned REAL                   |
| OVR                | Override                             | m                           |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| OVRRAP             | Override for rapid traverse velocity | m                           |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| S                  | Spindle, dwell time                  | m, s                        |         |           |         |    |    |              |                           | x  | Unsigned REAL                   |

## 17.3 Addresses

| Address identifier | Address type                                      | Modal/<br>non-modal | G70/<br>G71 | G700/<br>G710 | G90/<br>G91 | IC | AC | DC,<br>ACN,<br>ACP | CIC,<br>CAC,<br>CDC,<br>CACN,<br>CACP | QU | Data type of the<br>assigned value  |
|--------------------|---------------------------------------------------|---------------------|-------------|---------------|-------------|----|----|--------------------|---------------------------------------|----|-------------------------------------|
| SPOS               | Spindle position                                  | m                   |             |               |             | x  | x  | x                  |                                       |    | REAL                                |
| SCC                | Assignment of a transverse axis to G96 /G961/G962 | m                   |             |               |             |    |    |                    |                                       |    | REAL                                |
| SPOSA              | Spindle position across block boundaries          | m                   |             |               |             | x  | x  | x                  |                                       |    | REAL                                |
| T                  | Tool number                                       | m                   |             |               |             |    |    |                    |                                       | x  | Unsigned INT                        |
| D                  | Offset number                                     | m                   |             |               |             |    |    |                    |                                       | x  | Unsigned INT                        |
| M, H               | Auxiliary functions                               | s                   |             |               |             |    |    |                    |                                       | x  | M:<br>unsigned<br>INT<br>H:<br>REAL |

## Fixed addresses with axial extension

| Address identifier | Address type                             | Modal/<br>non-modal | G70/<br>G71 | G700/<br>G710 | G90/<br>G91 | IC | AC | DC,<br>ACN,<br>ACP | CIC,<br>CAC,<br>CDC,<br>CACN,<br>CACP | QU | Data type of the<br>assigned value                              |
|--------------------|------------------------------------------|---------------------|-------------|---------------|-------------|----|----|--------------------|---------------------------------------|----|-----------------------------------------------------------------|
| AX                 | Variable axis identifier                 | <sup>1)</sup>       | x           | x             | x           | x  | x  | x                  |                                       |    | REAL                                                            |
| IP                 | Variable interpolation parameter         | s                   | x           | x             | x           | x  | x  |                    |                                       |    | REAL                                                            |
| POS                | Positioning axis                         | m                   | x           | x             | x           | x  | x  | x                  | x                                     |    | REAL                                                            |
| POSA               | Positioning axis across block boundaries | m                   | x           | x             | x           | x  | x  | x                  | x                                     |    | REAL                                                            |
| POSP               | Positioning axis in parts (oscillation)  | m                   | x           | x             | x           | x  | x  | x                  |                                       |    | REAL:<br>End position<br>Real:<br>Partial length<br>INT: Option |

| Address identifier | Address type                                       | Modal/non-modal | G70/G71 | G700/G710 | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | QU | Data type of the assigned value |
|--------------------|----------------------------------------------------|-----------------|---------|-----------|---------|----|----|--------------|---------------------------|----|---------------------------------|
| MOV                | Start positioning axis                             | m               | x       | x         | x       | x  | x  | x            | x                         |    | REAL                            |
| PO                 | Polynomial coefficient                             | s               | x       | x         |         | x  | x  | x            |                           |    | Unsigned REAL                   |
| FA                 | Axial feedrate                                     | m               | x       |           |         |    |    |              |                           | x  | Unsigned REAL                   |
| FL                 | Axial feedrate limit                               | m               | x       |           |         |    |    |              |                           |    | Unsigned REAL                   |
| OVRA               | Axial override                                     | m               | x       |           |         |    |    |              |                           |    | Unsigned REAL                   |
| ACC                | Axial acceleration                                 | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| VELOLIM            | Axial velocity limitation                          | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| JERKLIM            | Axial jerk limitation                              | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| ACCLIMA            | Axial acceleration limitation of following axis    | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| VELOLIMA           | Axial velocity limitation of following axis        | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| JERKLIMA           | Axial jerk limitation of following axis            | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| FMA                | Synchronous feedrate axial                         | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| STA                | Sparking out time axial                            | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| SRA                | Retraction path on external input axial            | m               |         |           |         |    |    |              |                           |    | Unsigned REAL                   |
| OS                 | Oscillation ON/OFF                                 | m               |         |           |         |    |    |              |                           |    | Unsigned INT                    |
| OST1               | Stopping time at left reversal point (oscillation) | m               |         |           |         |    |    |              |                           |    | REAL                            |

## 17.3 Addresses

| Address identifier | Address type                                          | Modal/<br>non-modal | G70/<br>G71 | G700/<br>G710 | G90/<br>G91 | IC | AC | DC,<br>ACN,<br>ACP | CIC,<br>CAC,<br>CDC,<br>CACN,<br>CACP | QU | Data type of the<br>assigned value                               |
|--------------------|-------------------------------------------------------|---------------------|-------------|---------------|-------------|----|----|--------------------|---------------------------------------|----|------------------------------------------------------------------|
| OST2               | Stopping time at right reversal point (oscillation)   | m                   |             |               |             |    |    |                    |                                       |    | REAL                                                             |
| OSP1               | Left reversal point (oscillation)                     | m                   | x           | x             | x           | x  | x  | x                  |                                       |    | REAL                                                             |
| OSP2               | Right reversal point (oscillation)                    | m                   | x           | x             | x           | x  | x  | x                  |                                       |    | REAL                                                             |
| OSB                | position                                              | m                   | x           | x             | x           | x  | x  | x                  |                                       |    | REAL                                                             |
| OSE                | Oscillation end position                              | m                   | x           | x             | x           | x  | x  | x                  |                                       |    | REAL                                                             |
| OSNSC              | Number of spark-out cycles (oscillation)              | m                   |             |               |             |    |    |                    |                                       |    | Unsigned INT                                                     |
| OSCTRL             | Oscillation options                                   | m                   |             |               |             |    |    |                    |                                       |    | Unsigned INT:<br>Setting options,<br>unsigned INT: Reset options |
| OSCILL             | Axis assignment for oscillation, activate oscillation | m                   |             |               |             |    |    |                    |                                       |    | Axis:<br>1 - 3 infeed axes                                       |
| FDA                | Axis feed for handwheel override                      | s                   | x           |               |             |    |    |                    |                                       |    | Unsigned REAL                                                    |
| FGREF              | Reference radius                                      | m                   | x           | x             |             |    |    |                    |                                       |    | Unsigned REAL                                                    |
| POLF               | LIFTFAST position                                     | m                   | x           | x             |             |    |    |                    |                                       |    | Unsigned REAL                                                    |
| FXS                | Travel to fixed stop ON                               | m                   |             |               |             |    |    |                    |                                       |    | Unsigned INT                                                     |
| FXST               | Torque limit for travel to fixed stop                 | m                   |             |               |             |    |    |                    |                                       |    | REAL                                                             |
| FXSW               | Monitoring window for travel to fixed stop            | m                   |             |               |             |    |    |                    |                                       |    | REAL                                                             |



| Address identifier | Address type                                    | Modal/non-modal | G70/G71 | G700/G710 | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | QU | Data type of the assigned value      |
|--------------------|-------------------------------------------------|-----------------|---------|-----------|---------|----|----|--------------|---------------------------|----|--------------------------------------|
| FOC                | Travel with limited torque, non-modal           | s               |         |           |         |    |    |              |                           |    | REAL                                 |
| FOCON              | Travel with limited torque ON, modal            | m               |         |           |         |    |    |              |                           |    | REAL                                 |
| FOCOF              | Travel with limited torque OFF, modal           | m               |         |           |         |    |    |              |                           |    | REAL                                 |
| MEASA              | Axial measurement with delete distance-to-go    | s               |         |           |         |    |    |              |                           |    | INT<br>Mode and 1 - 4 trigger events |
| MEAWA              | Axial measurement without delete distance-to-go | s               |         |           |         |    |    |              |                           |    | INT<br>Mode and 1 - 4 trigger events |
| MEAC               | Cyclic measuring                                | s               |         |           |         |    |    |              |                           |    | INT<br>Mode and 1 - 4 trigger events |

<sup>1)</sup> Absolute end points: Modal, incremental end points: Non-modal, otherwise modal/non-modal depending on the G function that determines the syntax.

### 17.3.3 Settable addresses

| Address identifier (default setting) | Address type | Modal/non-modal   | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|--------------|-------------------|---------|----|----|--------------|---------------------------|--------|----|-------------|---------------------------------|
| <b>Axis values and end points</b>    |              |                   |         |    |    |              |                           |        |    |             |                                 |
| X, Y, Z, A, B, C                     | Axis         | <sup>1)</sup>     | x       | x  | x  | x            |                           |        |    | 8           | REAL                            |
| AP                                   | Polar angle  | m/s <sup>1)</sup> | x       | x  | x  |              |                           |        |    | 1           | REAL                            |
| RP                                   | Polar radius | m/s <sup>1)</sup> | x       | x  | x  |              |                           |        |    | 1           | Unsigned REAL                   |

## 17.3 Addresses

| Address identifier (default setting) | Address type                                          | Modal/non-modal | G90/G91 | IC     | AC     | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|-------------------------------------------------------|-----------------|---------|--------|--------|--------------|---------------------------|--------|----|-------------|---------------------------------|
| <b>Tool orientation</b>              |                                                       |                 |         |        |        |              |                           |        |    |             |                                 |
| A2, B2, C2                           | Euler angle or RPY angle                              | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| A3, B3, C3                           | Direction vector component                            | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| A4, B4, C4 for start of block        | Normal vector component                               | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| A5, B5, C5 for end of block          | Normal vector component                               | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| A6, B6, C6                           | Direction vector component                            | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| A7, B7, C7                           | Intermediate orientation component                    | s               |         |        |        |              |                           |        |    | 3           | REAL                            |
| LEAD                                 | Lead angle                                            | m               |         |        |        |              |                           |        |    | 1           | REAL                            |
| THETA                                | Angle of rotation, rotation around the tool direction | m               |         | x      | x      |              |                           |        |    | 1           | REAL                            |
| TILT                                 | Tilt angle                                            | m               |         |        |        |              |                           |        |    | 1           | REAL                            |
| ORIS                                 | Orientation change (in relation to the path)          | m               |         |        |        |              |                           |        |    | 1           | REAL                            |
| <b>Interpolation parameters</b>      |                                                       |                 |         |        |        |              |                           |        |    |             |                                 |
| I, J, K                              | Interpolation parameter intermediate point coordinate | s               |         | $x^2)$ | $x^2)$ |              |                           |        |    | 3           | REAL                            |
| I1, J1, K1                           |                                                       | s               | x       | x      | x      |              |                           |        |    | 3           | REAL                            |
| RPL                                  | Rotation in the plane                                 | s               |         |        |        |              |                           |        |    | 1           | REAL                            |
| CR                                   | Circle radius                                         | s               |         |        |        |              |                           |        |    | 1           | Unsigned REAL                   |
| AR                                   | Opening angle                                         | s               |         |        |        |              |                           |        |    | 1           | Unsigned REAL                   |
| TURN                                 | Number of turns for helix                             | s               |         |        |        |              |                           |        |    | 1           | Unsigned INT                    |
| PL                                   | Parameter interval length                             | s               |         |        |        |              |                           |        |    | 1           | Unsigned REAL                   |
| PW                                   | weight                                                | s               |         |        |        |              |                           |        |    | 1           | Unsigned REAL                   |
| SD                                   | Spline degree                                         | m               |         |        |        |              |                           |        |    | 1           | Unsigned INT                    |

| Address identifier (default setting) | Address type                                           | Modal/non-modal | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|--------------------------------------------------------|-----------------|---------|----|----|--------------|---------------------------|--------|----|-------------|---------------------------------|
| TU                                   | Axis angle                                             | s               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| STAT                                 | Position of joints                                     | m               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| SF                                   | Starting point offset for thread cutting               | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| DISCL                                | Safety clearance SAR                                   | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| DISR                                 | Repositioning clearance / SAR clearance                | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| DISPR                                | Path differential for repositioning                    | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| ALF                                  | Rapid lift angle                                       | m               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| DILF                                 | Rapid lift length                                      | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| FP                                   | Fixed point:<br>Number of fixed point to be approached | s               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| RNDM                                 | Modal rounding                                         | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| RND                                  | Non-modal rounding                                     | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| CHF                                  | Chamfer non-modal                                      | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| CHR                                  | Chamfer in original direction of motion                | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| ANG                                  | Contour angle                                          | s               |         |    |    |              |                           |        |    | 1           | REAL                            |
| ISD                                  | Insertion depth                                        | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| DISC                                 | Transition circle overshoot tool radius compensation   | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| OFFN                                 | Offset contour normal                                  | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| DITS                                 | Thread run-in path                                     | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| DITE                                 | Thread run-out path                                    | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| <b>Corner rounding criteria</b>      |                                                        |                 |         |    |    |              |                           |        |    |             |                                 |

## 17.3 Addresses

| Address identifier (default setting) | Address type                                                                                | Modal/non-modal | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|---------------------------------------------------------------------------------------------|-----------------|---------|----|----|--------------|---------------------------|--------|----|-------------|---------------------------------|
| ADIS                                 | Rounding clearance                                                                          | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| ADISPOS                              | Rounding clearance for rapid traverse                                                       | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| <b>Measurement</b>                   |                                                                                             |                 |         |    |    |              |                           |        |    |             |                                 |
| MEAS                                 | Measurement with touch-trigger probe                                                        | s               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| MEAW                                 | Measurement with touch-trigger probe without deletion of distance-to-go                     | s               |         |    |    |              |                           |        |    | 1           | Unsigned INT                    |
| <b>Axis, spindle behavior</b>        |                                                                                             |                 |         |    |    |              |                           |        |    |             |                                 |
| LIMS                                 | Spindle speed limitation                                                                    | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| COARSEA                              | Block change behavior: Exact stop coarse axial                                              | m               |         |    |    |              |                           |        |    |             |                                 |
| FINEA                                | Block change behavior: Exact stop fine axial                                                | m               |         |    |    |              |                           |        |    |             |                                 |
| IPOENDA                              | Block change behavior: Interpolator stop axial                                              | m               |         |    |    |              |                           |        |    |             |                                 |
| DIACYCOFA                            | Transverse axis: Axial diameter programming OFF in cycles                                   | m               |         |    |    |              |                           |        |    |             |                                 |
| DIAM90A                              | Transverse axis: Axial diameter programming for G90                                         | m               |         |    |    |              |                           |        |    |             |                                 |
| DIAMCHAN                             | Transverse axis: Transfer of all transverse axes in the diameter programming channel status | m               |         |    |    |              |                           |        |    |             |                                 |
| DIAMCHANA                            | Transverse axis: Transfer of the diameter programming channel status                        | m               |         |    |    |              |                           |        |    |             |                                 |

| Address identifier (default setting) | Address type                                          | Modal/non-modal | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|-------------------------------------------------------|-----------------|---------|----|----|--------------|---------------------------|--------|----|-------------|---------------------------------|
| DIAMOFA                              | Transverse axis: Axial diameter programming OFF       | m               |         |    |    |              |                           |        |    |             |                                 |
| DIAMONA                              | Transverse axis: Axial diameter programming ON        | m               |         |    |    |              |                           |        |    |             |                                 |
| GP                                   | Position: Indirect programming of position attributes | m               |         |    |    |              |                           |        |    |             |                                 |
| <b>Feedrates</b>                     |                                                       |                 |         |    |    |              |                           |        |    |             |                                 |
| FAD                                  | Speed of the slow feed movement                       | s               |         |    |    |              |                           | x      |    | 1           | Unsigned REAL                   |
| FD                                   | Path feedrate for handwheel override                  | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| FRC                                  | Feedrate for radius and chamfer                       | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| FRCM                                 | Feedrate for radius and chamfer, modal                | m               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| FB                                   | Non-modal feedrate                                    | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| <b>Nibbling/punching</b>             |                                                       |                 |         |    |    |              |                           |        |    |             |                                 |
| SPN                                  | Number of path sections per block                     | s               |         |    |    |              |                           |        |    | 1           | INT                             |
| SPP                                  | Length of a path section                              | m               |         |    |    |              |                           |        |    | 1           | REAL                            |
| <b>Grinding</b>                      |                                                       |                 |         |    |    |              |                           |        |    |             |                                 |
| ST                                   | Sparking-out time                                     | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| SR                                   | Retraction path                                       | s               |         |    |    |              |                           |        |    | 1           | Unsigned REAL                   |
| <b>Tool selection</b>                |                                                       |                 |         |    |    |              |                           |        |    |             |                                 |
| TCARR                                | Toolholder                                            | m               |         |    |    |              |                           |        |    | 1           | INT                             |
| <b>Tool management</b>               |                                                       |                 |         |    |    |              |                           |        |    |             |                                 |

| Address identifier (default setting) | Address type                                                                  | Modal/non-modal | G90/G91 | IC | AC | DC, ACN, ACP | CIC, CAC, CDC, CACN, CACP | PR, PM | QU | Max. number | Data type of the assigned value |
|--------------------------------------|-------------------------------------------------------------------------------|-----------------|---------|----|----|--------------|---------------------------|--------|----|-------------|---------------------------------|
| DL                                   | Total tool offset                                                             | m               |         |    |    |              |                           |        |    | 1           | INT                             |
| <b>OEM addresses</b>                 |                                                                               |                 |         |    |    |              |                           |        |    |             |                                 |
| OMA1                                 | OEM address 1                                                                 | m               |         | x  | x  | x            |                           |        |    | 1           | REAL                            |
| OMA2                                 | OEM address 2                                                                 | m               |         | x  | x  | x            |                           |        |    | 1           | REAL                            |
| OMA3                                 | OEM address 3                                                                 | m               |         | x  | x  | x            |                           |        |    | 1           | REAL                            |
| OMA4                                 | OEM address 4                                                                 | m               |         | x  | x  | x            |                           |        |    | 1           | REAL                            |
| OMA5                                 | OEM address 5                                                                 | m               |         | x  | x  | x            |                           |        |    | 1           | REAL                            |
| <b>Miscellaneous</b>                 |                                                                               |                 |         |    |    |              |                           |        |    |             |                                 |
| CUTMOD                               | Cutting data modification for tools that can be rotated ON                    | m               |         |    |    |              |                           |        |    |             | INT                             |
| TOFF                                 | Tool length offset parallel to the specified geometry axis                    | m               |         |    |    |              |                           |        |    |             |                                 |
| TOFFL                                | Tool length offset in the direction of the tool length component L1, L2 or L3 | m               |         |    |    |              |                           |        |    |             |                                 |
| TOFFR                                | Tool radius offset                                                            | m               |         |    |    |              |                           |        |    |             |                                 |

- 1) Absolute end points: Modal, incremental end points: Non-modal, otherwise modal/non-modal depending on the G function that determines the syntax.
- 2) As circle center points, IPO parameters act incrementally. They can be programmed in absolute mode with AC. The address modification is ignored when the parameters have other meanings (e.g. thread lead).

## 17.4 G commands

The G commands are divided into G groups. In part programs or synchronized actions, in a block, only a G command of a G group can be written. A G command can be modal or non-modal.

Modal: up to programming another G command of the same G group.

### G groups

- G group 1 ... 15 (Page 454)
- G group 16 ... 30 (Page 460)

- G group 31 ... 45 (Page 464)
- G group 46 ... 62 (Page 468)
- Legend for the G group tables (Page 474)

Table 17-1

| <b>G group 1: Modally valid motion commands</b> |                          |                                                        |                              |                        |                          |           |
|-------------------------------------------------|--------------------------|--------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                         | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                 |                          |                                                        |                              |                        | <b>SAG</b>               | <b>MM</b> |
| G0                                              | 1                        | Rapid traverse                                         | +                            | m                      |                          |           |
| G1                                              | 2                        | Linear interpolation (linear interpolation)            | +                            | m                      | x                        |           |
| G2                                              | 3                        | Circular interpolation clockwise                       | +                            | m                      |                          |           |
| G3                                              | 4                        | Circular interpolation counter-clockwise               | +                            | m                      |                          |           |
| CIP                                             | 5                        | Circular interpolation through intermediate point      | +                            | m                      |                          |           |
| ASPLINE                                         | 6                        | Akima spline                                           | +                            | m                      |                          |           |
| BSPLINE                                         | 7                        | B spline                                               | +                            | m                      |                          |           |
| CSPLINE                                         | 8                        | Cubic spline                                           | +                            | m                      |                          |           |
| POLY                                            | 9                        | Polynomial interpolation                               | +                            | m                      |                          |           |
| G33                                             | 10                       | Thread cutting with constant lead                      | +                            | m                      |                          |           |
| G331                                            | 11                       | Tapping                                                | +                            | m                      |                          |           |
| G332                                            | 12                       | Retraction (tapping)                                   | +                            | m                      |                          |           |
| OEMIPO1                                         | 13                       | Reserved                                               | +                            | m                      |                          |           |
| OEMIPO2                                         | 14                       | Reserved                                               | +                            | m                      |                          |           |
| CT                                              | 15                       | Circle with tangential transition                      | +                            | m                      |                          |           |
| G34                                             | 16                       | Thread cutting with linear increasing lead             | +                            | m                      |                          |           |
| G35                                             | 17                       | Thread cutting with linear decreasing lead             | +                            | m                      |                          |           |
| INVCW                                           | 18                       | Involute interpolation clockwise                       | +                            | m                      |                          |           |
| INVCCW                                          | 19                       | Counter-clockwise involute interpolation               | +                            | m                      |                          |           |
| G335                                            | 20                       | Turning a convex thread in clockwise direction         | +                            | m                      |                          |           |
| G336                                            | 21                       | Turning a convex thread in counter-clockwise direction | +                            | m                      |                          |           |

Table 17-2

| <b>G group 2: Non-modally valid motion, dwell time</b> |                          |                                               |                              |                        |                          |           |
|--------------------------------------------------------|--------------------------|-----------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                       | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                        |                          |                                               |                              |                        | <b>SAG</b>               | <b>MM</b> |
| G4                                                     | 1                        | Dwell time, preset                            | -                            | s                      |                          |           |
| G63                                                    | 2                        | Tapping without synchronization               | -                            | s                      |                          |           |
| G74                                                    | 3                        | Reference point approach with synchronization | -                            | s                      |                          |           |
| G75                                                    | 4                        | Fixed-point approach                          | -                            | s                      |                          |           |
| REPOSL                                                 | 5                        | Linear repositioning                          | -                            | s                      |                          |           |
| REPOSQ                                                 | 6                        | Repositioning in a quadrant                   | -                            | s                      |                          |           |
| REPOSH                                                 | 7                        | Repositioning in semicircle                   | -                            | s                      |                          |           |

## 17.4 G commands

| G group 2: Non-modally valid motion, dwell time |                   |                                                               |                       |                 |                   |    |
|-------------------------------------------------|-------------------|---------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                       | No. <sup>1)</sup> | Meaning                                                       | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                 |                   |                                                               |                       |                 | SAG               | MM |
| REPOSA                                          | 8                 | Linear repositioning with all axes                            | -                     | s               |                   |    |
| REPOSQA                                         | 9                 | Linear repositioning with all axes, geometry axes in quadrant | -                     | s               |                   |    |
| REPOSHA                                         | 10                | Repositioning with all axes; geometry axes in semicircle      | -                     | s               |                   |    |
| G147                                            | 11                | Approach contour with straight line                           | -                     | s               |                   |    |
| G247                                            | 12                | Approach contour with quadrant                                | -                     | s               |                   |    |
| G347                                            | 13                | Approach contour with semicircle                              | -                     | s               |                   |    |
| G148                                            | 14                | Leave contour with straight line                              | -                     | s               |                   |    |
| G248                                            | 15                | Leave contour with quadrant                                   | -                     | s               |                   |    |
| G348                                            | 16                | Leave contour with semicircle                                 | -                     | s               |                   |    |
| G5                                              | 17                | Oblique plunge-cut grinding                                   | -                     | s               |                   |    |
| G7                                              | 18                | Compensatory motion during oblique plunge-cut grinding        | -                     | s               |                   |    |

Table 17-3

| G group 3: Programmable frame, working area limitation and pole programming |                   |                                                                              |                       |                 |                   |    |
|-----------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                                   | No. <sup>1)</sup> | Meaning                                                                      | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                             |                   |                                                                              |                       |                 | SAG               | MM |
| TRANS                                                                       | 1                 | TRANSLATION: Programmable offset                                             | -                     | s               |                   |    |
| ROT                                                                         | 2                 | ROTATION: Programmable rotation                                              | -                     | s               |                   |    |
| SCALE                                                                       | 3                 | SCALE: Programmable scaling                                                  | -                     | s               |                   |    |
| MIRROR                                                                      | 4                 | MIRROR: Programmable mirroring                                               | -                     | s               |                   |    |
| ATRANS                                                                      | 5                 | Additive TRANSLATION: Additive programmable translation                      | -                     | s               |                   |    |
| AROT                                                                        | 6                 | Additive ROTATION: Programmable rotation                                     | -                     | s               |                   |    |
| ASCALE                                                                      | 7                 | Additive SCALE: Programmable scaling                                         | -                     | s               |                   |    |
| AMIRROR                                                                     | 8                 | Additive MIRROR: Programmable mirroring                                      | -                     | s               |                   |    |
| -                                                                           | 9                 | Unassigned                                                                   | -                     | -               |                   |    |
| G25                                                                         | 10                | Minimum working area limitation/spindle speed limitation                     | -                     | s               |                   |    |
| G26                                                                         | 11                | Maximum working area limitation/spindle speed limitation                     | -                     | s               |                   |    |
| G110                                                                        | 12                | Pole programming relative to the last programmed set-point position          | -                     | s               |                   |    |
| G111                                                                        | 13                | Polar programming relative to origin of current work-piece coordinate system | -                     | s               |                   |    |
| G112                                                                        | 14                | Pole programming relative to the last valid pole                             | -                     | s               |                   |    |
| G58                                                                         | 15                | Programmable offset, absolute axial substitution                             | -                     | s               |                   |    |
| G59                                                                         | 16                | Programmable offset, additive axial substitution                             | -                     | s               |                   |    |



| G group 3: Programmable frame, working area limitation and pole programming |                   |                                    |                       |                 |                   |    |
|-----------------------------------------------------------------------------|-------------------|------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                                   | No. <sup>1)</sup> | Meaning                            | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                             |                   |                                    |                       |                 | SAG               | MM |
| ROTS                                                                        | 17                | Rotation with solid angle          | -                     | s               |                   |    |
| AROTS                                                                       | 18                | Additive rotation with solid angle | -                     | s               |                   |    |

Table 17-4

| G group 4: FIFO |                   |                                                                                                                       |                       |                 |                   |    |
|-----------------|-------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command       | No. <sup>1)</sup> | Meaning                                                                                                               | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                 |                   |                                                                                                                       |                       |                 | SAG               | MM |
| STARTFIFO       | 1                 | Start FIFO<br>Execute and simultaneously fill preprocessing memory                                                    | +                     | m               | x                 |    |
| STOPFIFO        | 2                 | STOP FIFO<br>Stop machining; fill preprocessing memory until<br>STARTFIFO is detected, FIFO is full or end of program | +                     | m               |                   |    |
| FIFOCTRL        | 3                 | Activation of automatic preprocessing memory control                                                                  | +                     | m               |                   |    |

Table 17-5

| G group 6: Plane selection |                   |                                         |                       |                 |                   |    |
|----------------------------|-------------------|-----------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                  | No. <sup>1)</sup> | Meaning                                 | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                            |                   |                                         |                       |                 | SAG               | MM |
| G17                        | 1                 | Plane selection 1st - 2nd geometry axis | +                     | m               | x                 |    |
| G18                        | 2                 | Plane selection 3rd - 1st geometry axis | +                     | m               |                   |    |
| G19                        | 3                 | Plane selection 2nd - 3rd geometry axis | +                     | m               |                   |    |

Table 17-6

| G group 7: Tool radius compensation |                   |                                           |                       |                 |                   |    |
|-------------------------------------|-------------------|-------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                           | No. <sup>1)</sup> | Meaning                                   | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                     |                   |                                           |                       |                 | SAG               | MM |
| G40                                 | 1                 | No tool radius compensation               | +                     | m               | x                 |    |
| G41                                 | 2                 | Tool radius compensation left of contour  | -                     | m               |                   |    |
| G42                                 | 3                 | Tool radius compensation right of contour | -                     | m               |                   |    |

## 17.4 G commands

Table 17-7

| G group 8: Settable work offset |                   |                                                                 |                       |                 |                   |    |
|---------------------------------|-------------------|-----------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                       | No. <sup>1)</sup> | Meaning                                                         | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                 |                   |                                                                 |                       |                 | SAG               | MM |
| G500                            | 1                 | Deactivation of settable zero offset (G54 to G57, G505 to G599) | +                     | m               | x                 |    |
| G54                             | 2                 | 1. settable work offset                                         | +                     | m               |                   |    |
| G55                             | 3                 | 2. settable work offset                                         | +                     | m               |                   |    |
| G56                             | 4                 | 3. settable work offset                                         | +                     | m               |                   |    |
| G57                             | 5                 | 4. settable work offset                                         | +                     | m               |                   |    |
| G505                            | 6                 | 5. settable work offset                                         | +                     | m               |                   |    |
| ...                             | ...               | ...                                                             | +                     | m               |                   |    |
| G599                            | 100               | 99. settable work offset                                        | +                     | m               |                   |    |

Each of the G commands in this group is used to activate an adjustable user frame \$P\_UIFR[ ].  
G54 corresponds to frame \$P\_UIFR[1], G505 corresponds to frame \$P\_UIFR[5].  
The number of adjustable user frames and therefore the number of G commands in this G group, can be set using machine data MD28080 \$MC\_MM\_NUM\_USER\_FRAMES.

Table 17-8

| G group 9: Frame suppression |                   |                                                                                                                                                                                                        |                       |                 |                   |    |
|------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                    | No. <sup>1)</sup> | Meaning                                                                                                                                                                                                | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                              |                   |                                                                                                                                                                                                        |                       |                 | SAG               | MM |
| G53                          | 1                 | Suppression of current frames:<br><br>Programmable frame including<br><br>system frame for TOROT and TOFRAME and<br><br>active adjustable frame (G54 to G57, G505 to G599)                             | -                     | s               |                   |    |
| SUPA                         | 2                 | As for G153 including suppression of<br>system frames for actual-value setting, scratching, ext.<br>zero offset, PAROT including handwheel offsets<br>(DRF), [external zero offset], overlaid movement | -                     | s               |                   |    |
| G153                         | 3                 | As for G53 including suppression of all channel-specif-<br>ic and/or NCU-global basic frames                                                                                                           | -                     | s               |                   |    |

Table 17-9

| G group 10: Exact stop - continuous-path mode |                   |                                                                                                      |                       |                 |                   |    |
|-----------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                     | No. <sup>1)</sup> | Meaning                                                                                              | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                               |                   |                                                                                                      |                       |                 | SAG               | MM |
| G60                                           | 1                 | Exact stop                                                                                           | +                     | m               | x                 |    |
| G64                                           | 2                 | Continuous-path mode                                                                                 | +                     | m               |                   |    |
| G641                                          | 3                 | Continuous-path mode with smoothing as per distance<br>criterion (= programmable rounding clearance) | +                     | m               |                   |    |

| <b>G group 10: Exact stop - continuous-path mode</b> |                   |                                                                                                    |                       |                 |                   |    |
|------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                            | No. <sup>1)</sup> | Meaning                                                                                            | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                      |                   |                                                                                                    |                       |                 | SAG               | MM |
| G642                                                 | 4                 | Continuous-path mode with smoothing within the defined tolerances                                  | +                     | m               |                   |    |
| G643                                                 | 5                 | Continuous-path mode with smoothing within the defined tolerances (block-internal)                 | +                     | m               |                   |    |
| G644                                                 | 6                 | Continuous-path mode with smoothing with maximum possible dynamic response                         | +                     | m               |                   |    |
| G645                                                 | 7                 | Continuous-path mode with smoothing and tangential block transitions within the defined tolerances | +                     | m               |                   |    |

Table 17-10

| <b>G group 11: Exact stop, non-modal</b> |                   |            |                       |                 |                   |    |
|------------------------------------------|-------------------|------------|-----------------------|-----------------|-------------------|----|
| G command                                | No. <sup>1)</sup> | Meaning    | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                          |                   |            |                       |                 | SAG               | MM |
| G9                                       | 1                 | Exact stop | -                     | s               |                   |    |

Table 17-11

| <b>G group 12: Block change criteria at exact stop (G60/G9)</b> |                   |                                   |                       |                 |                   |    |
|-----------------------------------------------------------------|-------------------|-----------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                       | No. <sup>1)</sup> | Meaning                           | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                 |                   |                                   |                       |                 | SAG               | MM |
| G601                                                            | 1                 | Block change at exact stop fine   | +                     | m               | x                 |    |
| G602                                                            | 2                 | Block change at exact stop coarse | +                     | m               |                   |    |
| G603                                                            | 3                 | Block change at IPO block end     | +                     | m               |                   |    |

Table 17-12

| <b>G group 13: Workpiece measuring inch/metric</b> |                   |                                                                       |                       |                 |                   |    |
|----------------------------------------------------|-------------------|-----------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                          | No. <sup>1)</sup> | Meaning                                                               | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                    |                   |                                                                       |                       |                 | SAG               | MM |
| G70                                                | 1                 | Input system inches (length)                                          | +                     | m               |                   |    |
| G71                                                | 2                 | Input system metric mm (lengths)                                      | +                     | m               | x                 |    |
| G700                                               | 3                 | Input system inch, inch/min (lengths + velocity + system variable)    | +                     | m               |                   |    |
| G710                                               | 4                 | Input system metric mm, mm/min (lengths + velocity + system variable) | +                     | m               |                   |    |

## 17.4 G commands

Table 17-13

| G group 14: Workpiece measuring absolute/incremental |                   |                        |                       |                 |                   |    |
|------------------------------------------------------|-------------------|------------------------|-----------------------|-----------------|-------------------|----|
| G command                                            | No. <sup>1)</sup> | Meaning                | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                      |                   |                        |                       |                 | SAG               | MM |
| G90                                                  | 1                 | Absolute dimension     | +                     | m               | x                 |    |
| G91                                                  | 2                 | Incremental dimensions | +                     | m               |                   |    |

Table 17-14

| G group 15: Feed type |                   |                                                                                        |                       |                 |                   |    |
|-----------------------|-------------------|----------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command             | No. <sup>1)</sup> | Meaning                                                                                | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                       |                   |                                                                                        |                       |                 | SAG               | MM |
| G93                   | 1                 | Inverse-time feedrate rpm                                                              | +                     | m               |                   |    |
| G94                   | 2                 | Linear feedrate in mm/min, inch/min                                                    | +                     | m               | x                 |    |
| G95                   | 3                 | Revolutional feedrate in mm/rev, inch/rev                                              | +                     | m               |                   |    |
| G96                   | 4                 | Constant cutting rate and type of feedrate as for G95 ON                               | +                     | m               |                   |    |
| G97                   | 5                 | Constant cutting rate and type of feedrate as for G95 OFF                              | +                     | m               |                   |    |
| G931                  | 6                 | Feedrate specification by means of traversing time, deactivate constant path velocity  | +                     | m               |                   |    |
| G961                  | 7                 | Constant cutting rate and type of feedrate as for G94 ON                               | +                     | m               |                   |    |
| G971                  | 8                 | Constant cutting rate and type of feedrate as for G94 OFF                              | +                     | m               |                   |    |
| G942                  | 9                 | Freeze linear feedrate and constant cutting rate or spindle speed                      | +                     | m               |                   |    |
| G952                  | 10                | Freeze revolutional feedrate and constant cutting rate or spindle speed                | +                     | m               |                   |    |
| G962                  | 11                | Linear feedrate or revolutional feedrate and constant cutting rate                     | +                     | m               |                   |    |
| G972                  | 12                | Freeze linear feedrate or revolutional feedrate and constant cutting rate              | +                     | m               |                   |    |
| G973                  | 13                | Revolutional feedrate without spindle speed limitation (G97 without LIMS for ISO mode) | +                     | m               |                   |    |

Table 17-15

| G group 16: Feedrate override at inside and outside curvature |                   |                                                                              |                       |                 |                   |    |
|---------------------------------------------------------------|-------------------|------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                     | No. <sup>1)</sup> | Meaning                                                                      | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                               |                   |                                                                              |                       |                 | SAG               | MM |
| CFC                                                           | 1                 | Constant feedrate at contour effective for internal and external radius      | +                     | m               | x                 |    |
| CFTCP                                                         | 2                 | Constant feedrate in tool center point (center point path)                   | +                     | m               |                   |    |
| CFIN                                                          | 3                 | Constant feedrate for internal radius only, acceleration for external radius | +                     | m               |                   |    |

Table 17-16

| <b>G group 17: Approach and retraction response, tool offset</b> |                   |                                                  |                       |                 |                   |    |
|------------------------------------------------------------------|-------------------|--------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                        | No. <sup>1)</sup> | Meaning                                          | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                  |                   |                                                  |                       |                 | SAG               | MM |
| NORM                                                             | 1                 | Normal position at starting and end points       | +                     | m               | x                 |    |
| KONT                                                             | 2                 | Travel around contour at starting and end points | +                     | m               |                   |    |
| KONTT                                                            | 3                 | Approach/retraction with constant tangent        | +                     | m               |                   |    |
| KONTC                                                            | 4                 | Approach/retraction with constant curvature      | +                     | m               |                   |    |

Table 17-17

| <b>G group 18: Corner behavior, tool offset</b> |                   |                                                                                 |                       |                 |                   |    |
|-------------------------------------------------|-------------------|---------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                       | No. <sup>1)</sup> | Meaning                                                                         | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                 |                   |                                                                                 |                       |                 | SAG               | MM |
| G450                                            | 1                 | Transition circle<br>(tool travels around workpiece corners on a circular path) | +                     | m               | x                 |    |
| G451                                            | 2                 | Intersection of equidistant paths<br>(tool backs off from the workpiece corner) | +                     | m               |                   |    |

Table 17-18

| <b>G group 19: Curve transition at beginning of spline</b> |                   |                                                                      |                       |                 |                   |    |
|------------------------------------------------------------|-------------------|----------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                  | No. <sup>1)</sup> | Meaning                                                              | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                            |                   |                                                                      |                       |                 | SAG               | MM |
| BNAT                                                       | 1                 | Natural transition to first spline block                             | +                     | m               | x                 |    |
| BTAN                                                       | 2                 | Tangential transition to first spline block                          | +                     | m               |                   |    |
| BAUTO                                                      | 3                 | Definition of the first spline section by means of the next 3 points | +                     | m               |                   |    |

Table 17-19

| <b>G group 20: Curve transition at end of spline</b> |                   |                                                                     |                       |                 |                   |    |
|------------------------------------------------------|-------------------|---------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                            | No. <sup>1)</sup> | Meaning                                                             | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                      |                   |                                                                     |                       |                 | SAG               | MM |
| ENAT                                                 | 1                 | Natural transition to next traversing block                         | +                     | m               | x                 |    |
| ETAN                                                 | 2                 | Tangential transition to next traversing block                      | +                     | m               |                   |    |
| EAUTO                                                | 3                 | Definition of the last spline section by means of the last 3 points | +                     | m               |                   |    |

## 17.4 G commands

Table 17-20

| G group 21: Acceleration profile |                   |                                      |                       |                 |                   |    |
|----------------------------------|-------------------|--------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                        | No. <sup>1)</sup> | Meaning                              | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                  |                   |                                      |                       |                 | SAG               | MM |
| BRISK                            | 1                 | Fast non-smoothed path acceleration  | +                     | m               | x                 |    |
| SOFT                             | 2                 | Soft smoothed path acceleration      | +                     | m               |                   |    |
| DRIVE                            | 3                 | Velocity-dependent path acceleration | +                     | m               |                   |    |

Table 17-21

| G group 22: Tool offset type |                   |                                                                                                                       |                       |                 |                   |    |
|------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                    | No. <sup>1)</sup> | Meaning                                                                                                               | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                              |                   |                                                                                                                       |                       |                 | SAG               | MM |
| CUT2D                        | 1                 | 2½D tool offset determined by G17-G19                                                                                 | +                     | m               | x                 |    |
| CUT2DF                       | 2                 | 2½D tool offset determined by frame<br>The tool offset is effective in relation to the current frame (inclined plane) | +                     | m               |                   |    |
| CUT3DC                       | 3                 | 3D tool offset circumferential milling                                                                                | +                     | m               |                   |    |
| CUT3DF                       | 4                 | 3D tool offset face milling with non-constant tool orientation                                                        | +                     | m               |                   |    |
| CUT3DFS                      | 5                 | 3D tool offset face milling with constant tool orientation independent of active frame                                | +                     | m               |                   |    |
| CUT3DFF                      | 6                 | 3D tool offset face milling with fixed tool orientation dependent on active frame                                     | +                     | m               |                   |    |
| CUT3DCC                      | 7                 | 3D tool offset circumferential milling with limitation surfaces                                                       | +                     | m               |                   |    |
| CUT3DCCD                     | 8                 | 3D tool offset circumferential milling with limitation surfaces and differential tool                                 | +                     | m               |                   |    |

Table 17-22

| G group 23: Collision monitoring at inside contours |                   |                                                        |                       |                 |                   |    |
|-----------------------------------------------------|-------------------|--------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                           | No. <sup>1)</sup> | Meaning                                                | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                     |                   |                                                        |                       |                 | SAG               | MM |
| CDOF                                                | 1                 | Collision detection OFF                                | +                     | m               | x                 |    |
| CDON                                                | 2                 | Collision detection ON                                 | +                     | m               |                   |    |
| CDOF2                                               | 3                 | Collision detection OFF<br>(currently only for CUT3DC) | +                     | m               |                   |    |

Table 17-23

| <b>G group 24: Precontrol</b> |                          |                         |                              |                        |                          |           |
|-------------------------------|--------------------------|-------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>              | <b>No. <sup>1)</sup></b> | <b>Meaning</b>          | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                               |                          |                         |                              |                        | <b>SAG</b>               | <b>MM</b> |
| FFWOF                         | 1                        | Feedforward control OFF | +                            | m                      | x                        |           |
| FFWON                         | 2                        | Feedforward control ON  | +                            | m                      |                          |           |

Table 17-24

| <b>G group 25: Tool orientation reference</b> |                          |                                                       |                              |                        |                          |           |
|-----------------------------------------------|--------------------------|-------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                              | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                        | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                               |                          |                                                       |                              |                        | <b>SAG</b>               | <b>MM</b> |
| ORIWKS                                        | 1                        | Tool orientation in workpiece coordinate system (WCS) | +                            | m                      | x                        |           |
| ORIMKS                                        | 2                        | Tool orientation in machine coordinate system (MCS)   | +                            | m                      |                          |           |

Table 17-25

| <b>G group 26: Repositioning mode for REPOS (modal)</b> |                          |                                         |                              |                        |                          |           |
|---------------------------------------------------------|--------------------------|-----------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                        | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                          | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                         |                          |                                         |                              |                        | <b>SAG</b>               | <b>MM</b> |
| RMB                                                     | 1                        | Repositioning to start of block         | -                            | m                      |                          |           |
| RMI                                                     | 2                        | Repositioning to interrupt point        | -                            | m                      | x                        |           |
| RME                                                     | 3                        | Repositioning to end of block           | -                            | m                      |                          |           |
| RMN                                                     | 4                        | Repositioning to the nearest path point | -                            | m                      |                          |           |

Table 17-26

| <b>G group 27: Tool offset for change in orientation at outside corners</b> |                          |                                                                                            |                              |                        |                          |           |
|-----------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                                            | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                                                             | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                                             |                          |                                                                                            |                              |                        | <b>SAG</b>               | <b>MM</b> |
| ORIC                                                                        | 1                        | Orientation changes at outside corners are superimposed on the circle block to be inserted | +                            | m                      | x                        |           |
| ORID                                                                        | 2                        | Orientation changes are performed before the circle block                                  | +                            | m                      |                          |           |

Table 17-27

| <b>G group 28: Working area limitation</b> |                          |                             |                              |                        |                          |           |
|--------------------------------------------|--------------------------|-----------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                           | <b>No. <sup>1)</sup></b> | <b>Meaning</b>              | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                            |                          |                             |                              |                        | <b>SAG</b>               | <b>MM</b> |
| WALIMON                                    | 1                        | Working area limitation ON  | +                            | m                      | x                        |           |
| WALIMOF                                    | 2                        | Working area limitation OFF | +                            | m                      |                          |           |

## 17.4 G commands

Table 17-28

| G group 29: Radius/diameter programming |                   |                                                                                                                                      |                       |                 |                   |    |
|-----------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                               | No. <sup>1)</sup> | Meaning                                                                                                                              | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                         |                   |                                                                                                                                      |                       |                 | SAG               | MM |
| DIAMOF                                  | 1                 | Modal channel-specific diameter programming OFF<br>Deactivation activates channel-specific radius programming.                       | +                     | m               | x                 |    |
| DIAMON                                  | 2                 | Modal independent channel-specific diameter programming ON<br>The effect is independent of the programmed dimensions mode (G90/G91). | +                     | m               |                   |    |
| DIAM90                                  | 3                 | Modal dependent channel-specific diameter programming ON<br>The effect is dependent on the programmed dimensions mode (G90/G91).     | +                     | m               |                   |    |
| DIAMCYCOF                               | 4                 | Modal channel-specific diameter programming during cycle processing OFF                                                              | +                     | m               |                   |    |

Table 17-29

| G group 30: NC block compression |                   |                                 |                       |                 |                   |    |
|----------------------------------|-------------------|---------------------------------|-----------------------|-----------------|-------------------|----|
| G command                        | No. <sup>1)</sup> | Meaning                         | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                  |                   |                                 |                       |                 | SAG               | MM |
| COMPOF                           | 1                 | NC block compression OFF        | +                     | m               | x                 |    |
| COMPON                           | 2                 | Compressor function COMPON ON   | +                     | m               |                   |    |
| COMPCURV                         | 3                 | Compressor function COMPCURV ON | +                     | m               |                   |    |
| COMPCAD                          | 4                 | Compressor function COMPCAD ON  | +                     | m               |                   |    |

Table 17-30

| G group 31: OEM G commands |                   |               |                       |                 |                   |    |
|----------------------------|-------------------|---------------|-----------------------|-----------------|-------------------|----|
| G command                  | No. <sup>1)</sup> | Meaning       | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                            |                   |               |                       |                 | SAG               | MM |
| G810                       | 1                 | OEM G command | -                     | m               |                   |    |
| G811                       | 2                 | OEM G command | -                     | m               |                   |    |
| G812                       | 3                 | OEM G command | -                     | m               |                   |    |
| G813                       | 4                 | OEM G command | -                     | m               |                   |    |
| G814                       | 5                 | OEM G command | -                     | m               |                   |    |
| G815                       | 6                 | OEM G command | -                     | m               |                   |    |
| G816                       | 7                 | OEM G command | -                     | m               |                   |    |
| G817                       | 8                 | OEM G command | -                     | m               |                   |    |
| G818                       | 9                 | OEM G command | -                     | m               |                   |    |
| G819                       | 10                | OEM G command | -                     | m               |                   |    |

Two G command groups are reserved for the OEM user. This enables the OEM to program functions that can be customized.



Table 17-31

| <b>G group 32: OEM G commands</b>                                                                                      |                   |               |                       |                 |                   |    |
|------------------------------------------------------------------------------------------------------------------------|-------------------|---------------|-----------------------|-----------------|-------------------|----|
| G command                                                                                                              | No. <sup>1)</sup> | Meaning       | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                                                                        |                   |               |                       |                 | SAG               | MM |
| G820                                                                                                                   | 1                 | OEM G command | -                     | m               |                   |    |
| G821                                                                                                                   | 2                 | OEM G command | -                     | m               |                   |    |
| G822                                                                                                                   | 3                 | OEM G command | -                     | m               |                   |    |
| G823                                                                                                                   | 4                 | OEM G command | -                     | m               |                   |    |
| G824                                                                                                                   | 5                 | OEM G command | -                     | m               |                   |    |
| G825                                                                                                                   | 6                 | OEM G command | -                     | m               |                   |    |
| G826                                                                                                                   | 7                 | OEM G command | -                     | m               |                   |    |
| G827                                                                                                                   | 8                 | OEM G command | -                     | m               |                   |    |
| G828                                                                                                                   | 9                 | OEM G command | -                     | m               |                   |    |
| G829                                                                                                                   | 10                | OEM G command | -                     | m               |                   |    |
| Two G function groups are reserved for the OEM user. This enables the OEM to program functions that can be customized. |                   |               |                       |                 |                   |    |

Table 17-32

| <b>G group 33: Settable fine tool offset</b> |                   |                             |                       |                 |                   |    |
|----------------------------------------------|-------------------|-----------------------------|-----------------------|-----------------|-------------------|----|
| G command                                    | No. <sup>1)</sup> | Meaning                     | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                              |                   |                             |                       |                 | SAG               | MM |
| FTOCOF                                       | 1                 | Online fine tool offset OFF | +                     | m               | x                 |    |
| FTOCON                                       | 2                 | Online fine tool offset ON  | -                     | m               |                   |    |

Table 17-33

| <b>G group 34: Tool orientation smoothing</b> |                   |                                                                  |                       |                 |                   |    |
|-----------------------------------------------|-------------------|------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                     | No. <sup>1)</sup> | Meaning                                                          | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                               |                   |                                                                  |                       |                 | SAG               | MM |
| OSOF                                          | 1                 | Tool orientation smoothing OFF                                   | +                     | m               | x                 |    |
| OSC                                           | 2                 | Continuous tool orientation smoothing                            | +                     | m               |                   |    |
| OSS                                           | 3                 | Tool orientation smoothing at end of block                       | +                     | m               |                   |    |
| OSSE                                          | 4                 | Tool orientation smoothing at start and end of block             | +                     | m               |                   |    |
| OSD                                           | 5                 | Block-internal smoothing with specification of path length       | +                     | m               |                   |    |
| OST                                           | 6                 | Block-internal smoothing with specification of angular tolerance | +                     | m               |                   |    |

## 17.4 G commands

Table 17-34

| G group 35: Punching and nibbling |                   |                                       |                       |                 |                   |    |
|-----------------------------------|-------------------|---------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                         | No. <sup>1)</sup> | Meaning                               | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                   |                   |                                       |                       |                 | SAG               | MM |
| SPOF                              | 1                 | Stroke OFF, nibbling and punching OFF | +                     | m               | x                 |    |
| SON                               | 2                 | Nibbling ON                           | +                     | m               |                   |    |
| PON                               | 3                 | Punching ON                           | +                     | m               |                   |    |
| SONS                              | 4                 | Nibbling ON in interpolation cycle    | -                     | m               |                   |    |
| PONS                              | 5                 | Punching ON in interpolation cycle    | -                     | m               |                   |    |

Table 17-35

| G group 36: Punching with delay |                   |                         |                       |                 |                   |    |
|---------------------------------|-------------------|-------------------------|-----------------------|-----------------|-------------------|----|
| G command                       | No. <sup>1)</sup> | Meaning                 | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                 |                   |                         |                       |                 | SAG               | MM |
| PDELAYON                        | 1                 | Punching with delay ON  | +                     | m               | x                 |    |
| PDELAYOF                        | 2                 | Punching with delay OFF | +                     | m               |                   |    |

Table 17-36

| G group 37: Feedrate profile |                   |                                             |                       |                 |                   |    |
|------------------------------|-------------------|---------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                    | No. <sup>1)</sup> | Meaning                                     | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                              |                   |                                             |                       |                 | SAG               | MM |
| FNORM                        | 1                 | Feedrate normal to DIN 66025                | +                     | m               | x                 |    |
| FLIN                         | 2                 | Feed linear variable                        | +                     | m               |                   |    |
| FCUB                         | 3                 | Feedrate variable according to cubic spline | +                     | m               |                   |    |

Table 17-37

| G group 38: Assignment of fast inputs/outputs for punching/nibbling |                   |                                                      |                       |                 |                   |    |
|---------------------------------------------------------------------|-------------------|------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                           | No. <sup>1)</sup> | Meaning                                              | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                     |                   |                                                      |                       |                 | SAG               | MM |
| SPIF1                                                               | 1                 | Fast NCK inputs/outputs for punching/nibbling byte 1 | +                     | m               | x                 |    |
| SPIF2                                                               | 2                 | Fast NCK inputs/outputs for punching/nibbling byte 2 | +                     | m               |                   |    |

Table 17-38

| G group 39: Programmable contour accuracy |                   |                                   |                       |                 |                   |    |
|-------------------------------------------|-------------------|-----------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                 | No. <sup>1)</sup> | Meaning                           | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                           |                   |                                   |                       |                 | SAG               | MM |
| CPRECOF                                   | 1                 | Programmable contour accuracy OFF | +                     | m               | x                 |    |
| CPRECON                                   | 2                 | Programmable contour accuracy ON  | +                     | m               |                   |    |

Table 17-39

| <b>G group 40: Tool radius compensation constant</b> |                          |                                       |                              |                        |                          |           |
|------------------------------------------------------|--------------------------|---------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                     | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                        | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                      |                          |                                       |                              |                        | <b>SAG</b>               | <b>MM</b> |
| CUTCONOF                                             | 1                        | Constant tool radius compensation OFF | +                            | m                      | x                        |           |
| CUTCONON                                             | 2                        | Constant tool radius compensation ON  | +                            | m                      |                          |           |

Table 17-40

| <b>G group 41: Interruptible thread cutting</b> |                          |                                  |                              |                        |                          |           |
|-------------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                   | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                 |                          |                                  |                              |                        | <b>SAG</b>               | <b>MM</b> |
| LFOF                                            | 1                        | Interruptible thread cutting OFF | +                            | m                      | x                        |           |
| LFON                                            | 2                        | Interruptible thread cutting ON  | +                            | m                      |                          |           |

Table 17-41

| <b>G group 42: Toolholder</b> |                          |                                                                                                |                              |                        |                          |           |
|-------------------------------|--------------------------|------------------------------------------------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>              | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                                                                 | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                               |                          |                                                                                                |                              |                        | <b>SAG</b>               | <b>MM</b> |
| TCOABS                        | 1                        | Determine tool length components from the current tool orientation                             | +                            | m                      | x                        |           |
| TCOFR                         | 2                        | Determine tool length components from the orientation of the active frame                      | +                            | m                      |                          |           |
| TCOFRZ                        | 3                        | Determine tool orientation of an active frame on selection of tool, tool points in Z direction | +                            | m                      |                          |           |
| TCOFRY                        | 4                        | Determine tool orientation of an active frame on selection of tool, tool points in Y direction | +                            | m                      |                          |           |
| TCOFRX                        | 5                        | Determine tool orientation of an active frame on selection of tool, tool points in X direction |                              | m                      |                          |           |

Table 17-42

| <b>G group 43: SAR approach direction</b> |                          |                                            |                              |                        |                          |           |
|-------------------------------------------|--------------------------|--------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                          | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                             | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                           |                          |                                            |                              |                        | <b>SAG</b>               | <b>MM</b> |
| G140                                      | 1                        | SAR approach direction defined by G41/G42  | +                            | m                      | x                        |           |
| G141                                      | 2                        | SAR approach direction to left of contour  | +                            | m                      |                          |           |
| G142                                      | 3                        | SAR approach direction to right of contour | +                            | m                      |                          |           |
| G143                                      | 4                        | SAR approach direction tangent-dependent   | +                            | m                      |                          |           |

## 17.4 G commands

Table 17-43

| G group 44: SAR path segmentation |                   |                                                                                         |                       |                 |                   |    |
|-----------------------------------|-------------------|-----------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                         | No. <sup>1)</sup> | Meaning                                                                                 | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                   |                   |                                                                                         |                       |                 | SAG               | MM |
| G340                              | 1                 | Spatial approach block; in other words, infeed depth and approach in plane in one block | +                     | m               | x                 |    |
| G341                              | 2                 | Start with infeed on perpendicular axis (Z), then approach in plane                     | +                     | m               |                   |    |

Table 17-44

| G group 45: Path reference for FGROUP axes |                   |                                                   |                       |                 |                   |    |
|--------------------------------------------|-------------------|---------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                  | No. <sup>1)</sup> | Meaning                                           | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                            |                   |                                                   |                       |                 | SAG               | MM |
| SPATH                                      | 1                 | Path reference for FGROUP axes is arc length      | +                     | m               | x                 |    |
| UPATH                                      | 2                 | Path reference for FGROUP axes is curve parameter | +                     | m               |                   |    |

Table 17-45

| G group 46: Plane selection for fast retraction |                   |                                                                                |                       |                 |                   |    |
|-------------------------------------------------|-------------------|--------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                       | No. <sup>1)</sup> | Meaning                                                                        | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                 |                   |                                                                                |                       |                 | SAG               | MM |
| LFTXT                                           | 1                 | The plane is determined from the path tangent and the current tool orientation | +                     | m               | x                 |    |
| LFWP                                            | 2                 | The plane is determined by the current working plane (G17/G18/G19)             | +                     | m               |                   |    |
| LFPOS                                           | 3                 | Axial retraction to a position                                                 | +                     | m               |                   |    |

Table 17-46

| G group 47: Mode switchover for external NC code |                   |                                  |                       |                 |                   |    |
|--------------------------------------------------|-------------------|----------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                        | No. <sup>1)</sup> | Meaning                          | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                  |                   |                                  |                       |                 | SAG               | MM |
| G290                                             | 1                 | Activate SINUMERIK language mode | +                     | m               | x                 |    |
| G291                                             | 2                 | Activate ISO language mode       | +                     | m               |                   |    |

Table 17-47

| <b>G group 48: Approach and retraction response with tool radius compensation</b> |                   |                                                                        |                       |                 |                   |    |
|-----------------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                                         | No. <sup>1)</sup> | Meaning                                                                | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                                                   |                   |                                                                        |                       |                 | SAG               | MM |
| G460                                                                              | 1                 | Collision detection for approach and retraction block ON               | +                     | m               | x                 |    |
| G461                                                                              | 2                 | Extend border block with arc if no intersection in TRC block           | +                     | m               |                   |    |
| G462                                                                              | 3                 | Extend border block with straight line if no intersection in TRC block | +                     | m               |                   |    |

Table 17-48

| <b>G group 49: Point-to-point motion</b> |                   |                                                              |                       |                 |                   |    |
|------------------------------------------|-------------------|--------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                | No. <sup>1)</sup> | Meaning                                                      | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                          |                   |                                                              |                       |                 | SAG               | MM |
| CP                                       | 1                 | Path motion                                                  | +                     | m               | x                 |    |
| PTP                                      | 2                 | Point-to-point motion (synchronized axis motion)             | +                     | m               |                   |    |
| PTPG0                                    | 3                 | Point-to-point motion only with G0, otherwise path motion CP | +                     | m               |                   |    |

Table 17-49

| <b>G group 50: Orientation programming</b> |                   |                                                                           |                       |                 |                   |    |
|--------------------------------------------|-------------------|---------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                  | No. <sup>1)</sup> | Meaning                                                                   | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                            |                   |                                                                           |                       |                 | SAG               | MM |
| ORIEULER                                   | 1                 | Orientation angle via Euler angle                                         | +                     | m               | x                 |    |
| ORIRPY                                     | 2                 | Orientation angle via RPY angle (rotation sequence XYZ)                   | +                     | m               |                   |    |
| ORIVIRT1                                   | 3                 | Orientation angle via virtual orientation axes (definition 1)             | +                     | m               |                   |    |
| ORIVIRT2                                   | 4                 | Orientation angle via virtual orientation axes (definition 2)             | +                     | m               |                   |    |
| ORIXPOS                                    | 5                 | Orientation angle via virtual orientation axes with rotary axis positions | +                     | m               |                   |    |
| ORIRPY2                                    | 6                 | Orientation angle via RPY angle (rotation sequence ZYX)                   | +                     | m               |                   |    |

## 17.4 G commands

Table 17-50

| G group 51: Interpolation type for orientation programming |                   |                                                                                            |                       |                 |                   |    |
|------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                  | No. <sup>1)</sup> | Meaning                                                                                    | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                            |                   |                                                                                            |                       |                 | SAG               | MM |
| ORIVECT                                                    | 1                 | Large-circle interpolation (identical to ORIPLANE)                                         | +                     | m               | x                 |    |
| ORIXES                                                     | 2                 | Linear interpolation of machine axes or orientation axes                                   | +                     | m               |                   |    |
| ORIPATH                                                    | 3                 | Tool orientation trajectory referred to path                                               | +                     | m               |                   |    |
| ORIPLANE                                                   | 4                 | Interpolation in plane (identical to ORIVECT)                                              | +                     | m               |                   |    |
| ORICONCW                                                   | 5                 | Interpolation on the peripheral surface of a taper in the clockwise direction              | +                     | m               |                   |    |
| ORI-<br>CONCCW                                             | 6                 | Interpolation on the peripheral surface of a taper in the counter-clockwise direction      | +                     | m               |                   |    |
| ORICONIO                                                   | 7                 | Interpolation on a conical peripheral surface with intermediate orientation setting        | +                     | m               |                   |    |
| ORICONTO                                                   | 8                 | Interpolation on a peripheral surface of the cone with tangential transition               | +                     | m               |                   |    |
| ORICURVE                                                   | 9                 | Interpolation with additional space curve for orientation                                  | +                     | m               |                   |    |
| ORIPATHS                                                   | 10                | Tool orientation in relation to path, blips in the orientation characteristic are smoothed | +                     | m               |                   |    |

Table 17-51

| G group 52: Frame rotation in relation to workpiece |                   |                                                                                                            |                       |                 |                   |    |
|-----------------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                           | No. <sup>1)</sup> | Meaning                                                                                                    | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                     |                   |                                                                                                            |                       |                 | SAG               | MM |
| PAROTOF                                             | 1                 | Frame rotation in relation to workpiece OFF                                                                | +                     | m               | x                 |    |
| PAROT                                               | 2                 | Frame rotation in relation to workpiece ON<br>The workpiece coordinate system is aligned on the workpiece. | +                     | m               |                   |    |

Table 17-52

| G group 53: Frame rotation in relation to tool |                   |                                                                                |                       |                 |                   |    |
|------------------------------------------------|-------------------|--------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                      | No. <sup>1)</sup> | Meaning                                                                        | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                |                   |                                                                                |                       |                 | SAG               | MM |
| TOROTOF                                        | 1                 | Frame rotation in relation to tool OFF                                         | +                     | m               | x                 |    |
| TOROT                                          | 2                 | Align Z axis of the WCS by rotating the frame parallel to the tool orientation | +                     | m               |                   |    |
| TOROTZ                                         | 3                 | As TOROT                                                                       | +                     | m               |                   |    |
| TOROTY                                         | 4                 | Align Y axis of the WCS by rotating the frame parallel to the tool orientation | +                     | m               |                   |    |
| TOROTX                                         | 5                 | Align X axis of the WCS by rotating the frame parallel to the tool orientation | +                     | m               |                   |    |
| TOFRAME                                        | 6                 | Align Z axis of the WCS by rotating the frame parallel to the tool orientation | +                     | m               |                   |    |

| <b>G group 53: Frame rotation in relation to tool</b> |                          |                                                                                |                              |                        |                          |           |
|-------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                      | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                                                 | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                       |                          |                                                                                |                              |                        | <b>SAG</b>               | <b>MM</b> |
| TOFRAMEZ                                              | 7                        | As TOFRAME                                                                     | +                            | m                      |                          |           |
| TOFRAMEY                                              | 8                        | Align Y axis of the WCS by rotating the frame parallel to the tool orientation | +                            | m                      |                          |           |
| TOFRAMEX                                              | 9                        | Align X axis of the WCS by rotating the frame parallel to the tool orientation | +                            | m                      |                          |           |

Table 17-53

| <b>G group 54: Vector rotation for polynomial programming</b> |                          |                                                          |                              |                        |                          |           |
|---------------------------------------------------------------|--------------------------|----------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                              | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                           | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                               |                          |                                                          |                              |                        | <b>SAG</b>               | <b>MM</b> |
| ORIROTA                                                       | 1                        | Vector rotation absolute                                 | +                            | m                      | x                        |           |
| ORIROTR                                                       | 2                        | Vector rotation relative                                 | +                            | m                      |                          |           |
| ORIROTT                                                       | 3                        | Vector rotation tangential                               | +                            | m                      |                          |           |
| ORIROTC                                                       | 4                        | Tangential rotational vector in relation to path tangent | +                            | m                      |                          |           |

Table 17-54

| <b>G group 55: Rapid traverse with/without linear interpolation</b> |                          |                                                                                                                          |                              |                        |                          |           |
|---------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                                    | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                                                                                           | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                                     |                          |                                                                                                                          |                              |                        | <b>SAG</b>               | <b>MM</b> |
| RTLION                                                              | 1                        | Rapid traverse motion with linear interpolation ON                                                                       | +                            | m                      | x                        |           |
| RTLIOF                                                              | 2                        | Rapid traverse motion with linear interpolation OFF<br>Rapid traverse motion is achieved with single-axis interpolation. | +                            | m                      |                          |           |

Table 17-55

| <b>G group 56: Taking into account tool wear</b> |                          |                                                      |                              |                        |                          |           |
|--------------------------------------------------|--------------------------|------------------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                 | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                                       | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                  |                          |                                                      |                              |                        | <b>SAG</b>               | <b>MM</b> |
| TOWSTD                                           | 1                        | Initial setting value for offsets in tool length     | +                            | m                      | x                        |           |
| TOWMCS                                           | 2                        | Wear values in the machine coordinate system (MCS)   | +                            | m                      |                          |           |
| TOWWCS                                           | 3                        | Wear values in the workpiece coordinate system (WCS) | +                            | m                      |                          |           |
| TOWBCS                                           | 4                        | Wear values in the basic coordinate system (BCS)     | +                            | m                      |                          |           |

| G group 56: Taking into account tool wear |                   |                                                                                                                                                 |                       |                 |                   |    |
|-------------------------------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                 | No. <sup>1)</sup> | Meaning                                                                                                                                         | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                           |                   |                                                                                                                                                 |                       |                 | SAG               | MM |
| TOWTCS                                    | 5                 | Wear values in the tool coordinate system (toolholder ref. point T at the toolholder)                                                           | +                     | m               |                   |    |
| TOWKCS                                    | 6                 | Wear values in the coordinate system of the tool head for kinetic transformation (differs from machine coordinate system through tool rotation) | +                     | m               |                   |    |

Table 17-56

| G group 57: Corner deceleration |                   |                                                                                         |                       |                 |                   |    |
|---------------------------------|-------------------|-----------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                       | No. <sup>1)</sup> | Meaning                                                                                 | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                 |                   |                                                                                         |                       |                 | SAG               | MM |
| FENDNORM                        | 1                 | Corner deceleration OFF                                                                 | +                     | m               | x                 |    |
| G62                             | 2                 | Corner deceleration at inside corners when tool radius compensation is active (G41/G42) | +                     | m               |                   |    |
| G621                            | 3                 | Corner deceleration at all corners                                                      | +                     | m               |                   |    |

Table 17-57

| G group 59: Dynamic response mode for path interpolation |                   |                                 |                       |                 |                   |    |
|----------------------------------------------------------|-------------------|---------------------------------|-----------------------|-----------------|-------------------|----|
| G command                                                | No. <sup>1)</sup> | Meaning                         | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                                          |                   |                                 |                       |                 | SAG               | MM |
| DYNNORM                                                  | 1                 | Standard dynamic, as previously | +                     | m               | x                 |    |
| DYNPOS                                                   | 2                 | Positioning mode, tapping       | +                     | m               |                   |    |
| DYNROUGH                                                 | 3                 | Roughing                        | +                     | m               |                   |    |
| DYNSEMIFIN                                               | 4                 | Finishing                       | +                     | m               |                   |    |
| DYNFINISH                                                | 5                 | Smooth finishing                | +                     | m               |                   |    |

Table 17-58

| G group 60: Working area limitation |                   |                                                         |                       |                 |                   |    |
|-------------------------------------|-------------------|---------------------------------------------------------|-----------------------|-----------------|-------------------|----|
| G command                           | No. <sup>1)</sup> | Meaning                                                 | MD20150 <sup>2)</sup> | W <sup>3)</sup> | STD <sup>4)</sup> |    |
|                                     |                   |                                                         |                       |                 | SAG               | MM |
| WALCS0                              | 1                 | Workpiece coordinate system working area limitation OFF | +                     | m               | x                 |    |
| WALCS1                              | 2                 | WCS working area limitation group 1 active              | +                     | m               |                   |    |
| WALCS2                              | 3                 | WCS working area limitation group 2 active              | +                     | m               |                   |    |
| WALCS3                              | 4                 | WCS working area limitation group 3 active              | +                     | m               |                   |    |
| WALCS4                              | 5                 | WCS working area limitation group 4 active              | +                     | m               |                   |    |
| WALCS5                              | 6                 | WCS working area limitation group 5 active              | +                     | m               |                   |    |
| WALCS6                              | 7                 | WCS working area limitation group 6 active              | +                     | m               |                   |    |



| <b>G group 60: Working area limitation</b> |                          |                                             |                              |                        |                          |           |
|--------------------------------------------|--------------------------|---------------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                           | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                              | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                            |                          |                                             |                              |                        | <b>SAG</b>               | <b>MM</b> |
| WALCS7                                     | 8                        | WCS working area limitation group 7 active  | +                            | m                      |                          |           |
| WALCS8                                     | 9                        | WCS working area limitation group 8 active  | +                            | m                      |                          |           |
| WALCS9                                     | 10                       | WCS working area limitation group 9 active  | +                            | m                      |                          |           |
| WALCS10                                    | 11                       | WCS working area limitation group 10 active | +                            | m                      |                          |           |

Table 17-59

| <b>G group 61: Tool orientation smoothing</b> |                          |                                |                              |                        |                          |           |
|-----------------------------------------------|--------------------------|--------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                              | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                 | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                               |                          |                                |                              |                        | <b>SAG</b>               | <b>MM</b> |
| ORISOF                                        | 1                        | Tool orientation smoothing OFF | +                            | m                      | x                        |           |
| ORISON                                        | 2                        | Tool orientation smoothing ON  | +                            | m                      |                          |           |

Table 17-60

| <b>G group 62: Repositioning mode for REPOS (non-modal)</b> |                          |                                         |                              |                        |                          |           |
|-------------------------------------------------------------|--------------------------|-----------------------------------------|------------------------------|------------------------|--------------------------|-----------|
| <b>G command</b>                                            | <b>No. <sup>1)</sup></b> | <b>Meaning</b>                          | <b>MD20150 <sup>2)</sup></b> | <b>W <sup>3)</sup></b> | <b>STD <sup>4)</sup></b> |           |
|                                                             |                          |                                         |                              |                        | <b>SAG</b>               | <b>MM</b> |
| RMBBL                                                       | 1                        | Repositioning to start of block         | -                            | s                      |                          |           |
| RMIBL                                                       | 2                        | Repositioning to interrupt point        | -                            | s                      | x                        |           |
| RMEBL                                                       | 3                        | Repositioning to end of block           | -                            | s                      |                          |           |
| RMNBL                                                       | 4                        | Repositioning to the nearest path point | -                            | s                      |                          |           |

## Legend

- 1) Internal number (e.g. for PLC interface)
- 2) Configurability of the G command as a reset setting for the G group on power up, reset or end of part program (with MD20150 \$MC\_GCODE\_RESET\_VALUES):
  - + Configurable
  - Not configurable
- 3) Effectiveness of the G command:
  - m modal
  - s Non-modal
- 4) Reset setting, see the following machine data
  - MD20149GCODE\_RESET\_S\_VALUES (reset position of G groups (fix))
  - MD20150GCODE\_RESET\_VALUES (reset position of G groups)
  - MD20151GCODE\_RESET\_S\_MODE (reset behavior of G groups (fix))
  - MD20152GCODE\_RESET\_MODE (reset behavior of G groups)
  - MD20154EXTERN\_GCODE\_RESET\_VALUES (reset position of G groups in the ISO mode)
  - MD20156EXTERN\_GCODE\_RESET\_MODE (reset behavior of external G groups)

SAG Default setting **Siemens AG**

MM Default setting **Machine Manufacturer** (see machine manufacturer's specifications)

Figure 17-1 Legend for the G group tables

## 17.5 Predefined procedures

The call of a predefined procedure triggers the execution of a predefined NCK function. A predefined procedure does **not** supply a return value in contrast to a predefined function.

| Coordinate system |                                             |                                          |          |          |                                                                                 |
|-------------------|---------------------------------------------|------------------------------------------|----------|----------|---------------------------------------------------------------------------------|
| Identifier        | Parameter                                   |                                          |          |          | Explanation                                                                     |
|                   | 1.                                          | 2.                                       | 3. - 15. | 4. - 16. |                                                                                 |
| PRESETON          | AXIS *):<br>Axis identifier of machine axis | REAL:<br>Preset offset G700/G710 context | As 1 ... | As 2 ... | Set actual value for the programmed axes with loss of the referencing status    |
| PRESETONS         | AXIS *):<br>Axis identifier of machine axis | REAL:<br>Preset offset G700/G710 context | As 1 ... | As 2 ... | Set actual value for the programmed axes without loss of the referencing status |
| DRFOF             |                                             |                                          |          |          | Deletes the DRF offset for all axes assigned to the channel.                    |

\*) As a general rule, geometry or special axis identifiers can also be used instead of the machine axis identifier, as long as the reference is unambiguous.

| Axis groupings |                                     |                                            |         |         |                                                                                                                                                                                                                        |
|----------------|-------------------------------------|--------------------------------------------|---------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier     | Parameter                           |                                            |         |         | Explanation                                                                                                                                                                                                            |
|                |                                     |                                            |         |         |                                                                                                                                                                                                                        |
| GEOAX          | 1.                                  | 2.                                         | 3. / 5. | 4. / 6. | Selection of a parallel coordinate system                                                                                                                                                                              |
|                | INT:<br>Geometry axis number 1 - 3  | AXIS:<br>Channel axis identifier           | As 1    | As 2    |                                                                                                                                                                                                                        |
|                |                                     |                                            |         |         |                                                                                                                                                                                                                        |
| FGROUP         | 1. – 8.                             |                                            |         |         | Variable F value reference: Definition of the axes to which the path feed refers<br><br>Maximum number of axes: 8<br><br>The default setting for the F value reference is activated with FGROUP ( ) without parameters |
|                | AXIS:<br>Channel axis identifier    |                                            |         |         |                                                                                                                                                                                                                        |
|                |                                     |                                            |         |         |                                                                                                                                                                                                                        |
| SPLINEPATH     | 1.                                  | 2. - 9.                                    |         |         | Definition of the spline grouping<br><br>Maximum number of axes: 8                                                                                                                                                     |
|                | INT:<br>Spline grouping (must be 1) | AXIS:<br>Geometry of additional identifier |         |         |                                                                                                                                                                                                                        |
|                |                                     |                                            |         |         |                                                                                                                                                                                                                        |
| POLYPATH       | 1.                                  | 2.                                         |         |         | Activation of the polynomial interpolation for selective axis groups                                                                                                                                                   |
|                | STRING                              | STRING                                     |         |         |                                                                                                                                                                                                                        |

| Coupled motion |                                |                      |                          |                         |                                                                    |                                                                                          |                                                                                                                                                                                                                                                                                 |
|----------------|--------------------------------|----------------------|--------------------------|-------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier     | Parameter                      |                      |                          |                         |                                                                    |                                                                                          | Explanation                                                                                                                                                                                                                                                                     |
|                | 1.                             | 2.                   | 3.                       | 4.                      | 5.                                                                 | 6.                                                                                       |                                                                                                                                                                                                                                                                                 |
| TANG           | AXIS: Axis name following axis | AXIS: Leading axis 1 | AXIS: Leading axis 2     | REAL: Coupling factor   | CHAR: Option: "B": Tracking in the BCS<br>"W": Tracking in the WCS | CHAR optimization: "S": Standard<br>"P": Autom. with rounding clearance, angle tolerance | Preparatory operation for the definition of tangential tracking: The tangent for the follow-up is determined by the two master axes specified. The coupling factor specifies the relationship between a change in the angle of tangent and the following axis. It is usually 1. |
| TANGON         | AXIS: Axis name following axis | REAL: Offset angle   | REAL: Rounding clearance | REAL: Angular tolerance |                                                                    |                                                                                          | Tangential tracking ON                                                                                                                                                                                                                                                          |

## 17.5 Predefined procedures

| Coupled motion |                                           |                           |                             |    |    |    |                                                                                              |
|----------------|-------------------------------------------|---------------------------|-----------------------------|----|----|----|----------------------------------------------------------------------------------------------|
| Identifier     | Parameter                                 |                           |                             |    |    |    | Explanation                                                                                  |
|                | 1.                                        | 2.                        | 3.                          | 4. | 5. | 6. |                                                                                              |
| TANGOF         | AXIS: Ax-<br>is name<br>following<br>axis |                           |                             |    |    |    | Tangential tracking OFF                                                                      |
| TLIFT          | AXIS:<br>Tracked<br>axis                  | REAL:<br>Lift-off<br>path | REAL:<br>Factor             |    |    |    | Tangential tracking, stop at contour<br>corner, if necessary, with rotary ax-<br>is lift-off |
| TRAILON        | AXIS:<br>Follow-<br>ing axis              | AXIS:<br>Leading<br>axis  | REAL:<br>Coupling<br>factor |    |    |    | Asynchronous coupled motion ON                                                               |
| TRAILOF        | AXIS:<br>Follow-<br>ing axis              | AXIS:<br>Leading<br>axis  |                             |    |    |    | Asynchronous coupled motion OFF                                                              |
| TANGDEL        | AXIS:<br>Follow-<br>ing axis              |                           |                             |    |    |    | Delete tangential tracking                                                                   |

| Curve tables |                      |                     |                                               |                                                |                                               |                                                                                    |
|--------------|----------------------|---------------------|-----------------------------------------------|------------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------------|
| Identifier   | Parameter            |                     |                                               |                                                |                                               | Explanation                                                                        |
|              | 1.                   | 2.                  | 3.                                            | 4.                                             | 5.                                            |                                                                                    |
| CTABDEF      | AXIS: Following axis | AXIS: Leading axis  | INT: Table number                             | INT: Behavior at edges of the definition range | STRING: Specification of the storage location | Table definition ON<br>The following motion blocks determine the curve table       |
| CTABEND      | AXIS: Following axis | AXIS: Leading axis  | INT: Table number                             | INT: Behavior at edges of the definition range |                                               | Table definition OFF                                                               |
| CTABDEL      | INT: Table number n  | INT: Table number m | STRING: Specification of the storage location |                                                |                                               | Clear curve table                                                                  |
| CTABLOCK     | INT: Table number n  |                     |                                               |                                                |                                               | Locks the curve table with number n, i.e. this table cannot be deleted/overwritten |
| CTABUNLOCK   | INT: Table number n  |                     |                                               |                                                |                                               | Releases the table with the number n protected with CTABLOCK again                 |
| LEADON       | AXIS: Following axis | AXIS: Leading axis  | INT: Table number                             |                                                |                                               | Master value coupling ON                                                           |
| LEADOF       | AXIS: Following axis | AXIS: Leading axis  |                                               |                                                |                                               | Master value coupling OFF                                                          |

| Axial acceleration profile |           |                                                                                                     |
|----------------------------|-----------|-----------------------------------------------------------------------------------------------------|
| Identifier                 | Parameter |                                                                                                     |
|                            | 1. – 8.   |                                                                                                     |
| BRISKA                     | AXIS      | Activate stepped axis acceleration for the programmed axes                                          |
| SOFTA                      | AXIS      | Activate jerk-limited axis acceleration for the programmed axes                                     |
| DRIVEA                     | AXIS      | Activate knee-shaped acceleration characteristic for the programmed axes                            |
| JERKA                      | AXIS      | The acceleration behavior set in machine data \$MA_AX_JERK_ENABLE is active for the programmed axes |

| Revolutional feedrate |                                                                                                                                                                     |                                                                                                                                                                     |                                                                                                                                                                            |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier            |                                                                                                                                                                     | Parameter                                                                                                                                                           | Explanation                                                                                                                                                                |
| FPRAON                | 1.                                                                                                                                                                  | 2.                                                                                                                                                                  | Axial revolutional feedrate ON                                                                                                                                             |
|                       | AXIS:<br>Axis for which revolutional feedrate is activated                                                                                                          | AXIS:<br>Axis/spindle from which revolutional feedrate is derived.<br>If no axis has been programmed, the revolutional feedrate is derived from the master spindle. |                                                                                                                                                                            |
| FPRAOF                | 1. - n.                                                                                                                                                             |                                                                                                                                                                     | Axial revolutional feedrate OFF<br>The revolutional feedrate can be deactivated for several axes simultaneously. You can program as many axes as are permitted in a block. |
|                       | AXIS:<br>Axes for which revolutional feedrate is deactivated                                                                                                        |                                                                                                                                                                     |                                                                                                                                                                            |
| FPR                   | 1.                                                                                                                                                                  |                                                                                                                                                                     | Selection of a rotary axis or spindle from which the revolutional feedrate of the path is derived for G95.<br>The setting made with FPR is modal.                          |
|                       | AXIS:<br>Axis/spindle from which revolutional feedrate is derived.<br>If no axis has been programmed, the revolutional feedrate is derived from the master spindle. |                                                                                                                                                                     |                                                                                                                                                                            |

| Transformations |                                      |                                        |    |                                                                                                                                                                                                                                                                                                                                                      |
|-----------------|--------------------------------------|----------------------------------------|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier      | Parameter                            |                                        |    | Explanation                                                                                                                                                                                                                                                                                                                                          |
|                 | 1.                                   | 2.                                     | 3. |                                                                                                                                                                                                                                                                                                                                                      |
| TRACYL          | REAL:<br>Working diameter            | INT:<br>Number of the transformation   |    | Cylinder: Peripheral surface transformation<br>Several transformations can be set per channel. The transformation number specifies which transformation is to be activated. If the second parameter is omitted, the transformation group defined in the MD is activated.                                                                             |
| TRANSMIT        | INT:<br>Number of the transformation |                                        |    | Transmit: Polar transformation<br>Several transformations can be set per channel. The transformation number specifies which transformation is to be activated. If the parameter is omitted, the transformation group defined in the MD is activated.                                                                                                 |
| TRAANG          | REAL:<br>Angle                       | INT:<br>Number of the transformation   |    | Transformation inclined axis<br>Several transformations can be set per channel. The transformation number specifies which transformation is to be activated. If the second parameter is omitted, the transformation group defined in the MD is activated.<br>If the angle is not programmed (TRAANG ( ,2) or TRAANG) the last angle applies modally. |
| TRAORI          | INT:<br>Number of the transformation |                                        |    | 4-axis, 5-axis transformation<br>Several transformations can be set per channel. The transformation number specifies which transformation is to be activated.                                                                                                                                                                                        |
| TRACON          | INT:<br>Number of the transformation | REAL: Further parameters, MD-dependent |    | Cascaded transformation<br>The meaning of the parameters depends on the type of cascading.                                                                                                                                                                                                                                                           |
| TRAFOOF         |                                      |                                        |    | Deactivate transformation                                                                                                                                                                                                                                                                                                                            |

| Spindle    |                        |                        |                                                                                                                                                                          |
|------------|------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier | Parameter              |                        | Explanation                                                                                                                                                              |
|            | 1                      | 2. - n.                |                                                                                                                                                                          |
| SPCON      | INT:<br>Spindle number | INT:<br>Spindle number | Switch to position-controlled spindle operation.                                                                                                                         |
| SPCOF      | INT:<br>Spindle number | INT:<br>Spindle number | Switch to speed-controlled spindle operation.                                                                                                                            |
| SETMS      | INT:<br>Spindle number |                        | Declaration of spindle as master spindle for the current channel<br>With SETMS( ), the machine data default applies automatically without any need for parameterization. |

| Grinding   |                        |                                                                                                                                                                                |
|------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier | Parameter              | Explanation                                                                                                                                                                    |
|            | 1.                     |                                                                                                                                                                                |
| GWPSON     | INT:<br>Spindle number | Constant grinding wheel peripheral speed ON<br>If the spindle number is not programmed, the grinding wheel peripheral speed for the spindle of the active tool is selected.    |
| GWPSOF     | INT:<br>Spindle number | Constant grinding wheel peripheral speed OFF<br>If the spindle number is not programmed, the grinding wheel peripheral speed for the spindle of the active tool is deselected. |
| TMON       | INT:<br>T number       | Grinding-specific tool monitoring ON<br>If no T number is programmed, monitoring is activated for the active tool.                                                             |
| TMOF       | INT:<br>T number       | Tool monitoring OFF<br>If no T number is programmed, monitoring is deactivated for the active tool.                                                                            |

| Stock removal |                                |                                  |                                    |                                      |                                                                                                                                                                                                                                |
|---------------|--------------------------------|----------------------------------|------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier    | Parameter                      |                                  |                                    |                                      | Explanation                                                                                                                                                                                                                    |
|               | 1.                             | 2.                               | 3.                                 | 4.                                   |                                                                                                                                                                                                                                |
| CONTPRON      | REAL [ , 11]:<br>Contour table | CHAR: Ma-<br>chining type        | INT:<br>Number of re-<br>lief cuts | INT:<br>Status of the<br>calculation | Activate reference preprocessing<br>The contour programs or NC blocks which are called in the following steps are divided into individual movements and stored in the contour table.<br>The number of relief cuts is returned. |
| CONTDCON      | REAL [ , 6]:<br>Contour table  | INT:<br>Machining di-<br>rection |                                    |                                      | Contour decoding<br>The blocks for a contour are stored in a named table with one table line per block and coded to save memory.                                                                                               |
| EXECUTE       | INT: Error sta-<br>tus         |                                  |                                    |                                      | Activate program execution<br>This switches back to normal program execution from reference point editing mode or after setting up a protection zone.                                                                          |

| Execute table |                                          |                                        |
|---------------|------------------------------------------|----------------------------------------|
| Identifier    | Parameter                                | Explanation                            |
|               | 1.                                       |                                        |
| EXECTAB       | REAL [ 11]:<br>Element from motion table | Execute an element from a motion table |

| Protection zones |                                       |                                                |                                                                                                                                                                              |                               |                                |                                                  |
|------------------|---------------------------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|--------------------------------|--------------------------------------------------|
| Identifier       | Parameter                             |                                                |                                                                                                                                                                              |                               |                                | Explanation                                      |
|                  | 1.                                    | 2.                                             | 3.                                                                                                                                                                           | 4.                            | 5.                             |                                                  |
| CPROTDEF         | INT:<br>Number of the protection zone | BOOL:<br>TRUE:<br>Tool-related protection zone | INT:<br>0:<br>4th and 5th parameters are not evaluated<br>1:<br>4th parameter is evaluated<br>2:<br>5th parameter is evaluated<br>3:<br>4th and 5th parameters are evaluated | REAL: Limit in plus direction | REAL: Limit in minus direction | Definition of a channel-specific protection zone |
| NPROTDEF         | INT:<br>Number of the protection zone | BOOL:<br>TRUE:<br>Tool-related protection zone | INT:<br>0:<br>4th and 5th parameters are not evaluated<br>1:<br>4th parameter is evaluated<br>2:<br>5th parameter is evaluated<br>3:<br>4th and 5th parameters are evaluated | REAL: Limit in plus direction | REAL: Limit in minus direction | Definition of a machine-specific protection zone |



| Protection zones |                                       |                                                                                                                                                                                             |                                                                |                                                                 |                                                                |                                         |
|------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------|
| Identifier       | Parameter                             |                                                                                                                                                                                             |                                                                |                                                                 |                                                                | Explanation                             |
|                  | 1.                                    | 2.                                                                                                                                                                                          | 3.                                                             | 4.                                                              | 5.                                                             |                                         |
| CROT             | INT:<br>Number of the protection zone | INT: Option<br>0: Protection area OFF<br>1: Preactivate protection zone<br>2: Protection area ON<br>3: Preactivate protection zone with conditional stop, only with protection zones active | REAL: Offset of the protection zone in the first geometry axis | REAL: Offset of the protection zone in the second geometry axis | REAL: Offset of the protection zone in the third geometry axis | Channel-specific protection zone ON/OFF |
| NPROT            | INT:<br>Number of the protection zone | INT: Option<br>0: Protection area OFF<br>1: Preactivate protection zone<br>2: Protection area ON<br>3: Preactivate protection zone with conditional stop, only with protection zones active | REAL: Offset of the protection zone in the first geometry axis | REAL: Offset of the protection zone in the second geometry axis | REAL: Offset of the protection zone in the third geometry axis | Machine-specific protection zone ON/OFF |

| Preprocessing / single block |           |                                                                           |
|------------------------------|-----------|---------------------------------------------------------------------------|
| Identifier                   | Parameter | Explanation                                                               |
| STOPRE                       |           | Preprocessing stop until all prepared blocks in the main run are executed |
| SBLOF                        |           | Suppress single-block processing                                          |
| SBLON                        |           | Cancel suppression of the single-block processing                         |

| Interrupts |                                       |                                                                                                                                                                                                                                                     |
|------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier | Parameter                             |                                                                                                                                                                                                                                                     |
|            | 1.                                    |                                                                                                                                                                                                                                                     |
| DISABLE    | INT:<br>Number of the interrupt input | Deactivates the interrupt routine assigned to the specified hardware input. Fast retraction is not executed. The assignment between the hardware input and the interrupt routine made with SETINT remains valid and can be reactivated with ENABLE. |
| ENABLE     | INT:<br>Number of the interrupt input | Reactivation of the interrupt routine assignment deactivated with DISABLE.                                                                                                                                                                          |
| CLRINT     | INT:<br>Number of the interrupt input | Delete assignment of interrupt routines and attributes to an interrupt input. The interrupt routine is deactivated and no reaction occurs when the interrupt is generated.                                                                          |

| Synchronized actions |                                           |                                                                                                                 |
|----------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Identifier           | Parameter                                 |                                                                                                                 |
|                      | 1. – n.                                   |                                                                                                                 |
| CANCEL               | INT:<br>Number of the synchronized action | Aborts the modal synchronized action with the specified ID. Several IDs, separated by commas, can be specified. |

| Function definition |                         |                            |                            |                               |                                                                       |
|---------------------|-------------------------|----------------------------|----------------------------|-------------------------------|-----------------------------------------------------------------------|
| Identifier          | Parameter               |                            |                            |                               | Explanation                                                           |
|                     | 1.                      | 2.                         | 3.                         | 4.-7.                         |                                                                       |
| FCTDEF              | INT:<br>Function number | REAL:<br>Lower limit value | REAL:<br>Upper limit value | REAL:<br>Coefficients a0 - a3 | Define polynomial function<br>This is evaluated in SYFCT or PUTFTOCF. |

| Communication |                    |                                                                                                                                          |                                                                                    |
|---------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Identifier    | Parameter          |                                                                                                                                          | Explanation                                                                        |
|               | 1.                 | 2.                                                                                                                                       |                                                                                    |
| MMC           | STRING:<br>Command | CHAR:<br>Acknowledgement mode*)<br>"N": Without acknowledgement<br>"S": Synchronous acknowledgement<br>"A": Asynchronous acknowledgement | Command to HMI command Interpreter for the configuration of windows via NC program |

\*) Commands are acknowledged on request from the executing component (channel, NC, etc.).

| Program coordination |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
|----------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Identifier           |                                                                 | Parameter                                                       |                                  |                                                                                                                                                       | Explanation                                           |
|                      |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
| INIT                 | 1.                                                              | 2.                                                              | 3.                               |                                                                                                                                                       | Selection of an NC program for execution in a channel |
|                      | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) | STRING:<br>Path specification                                   | CHAR:<br>Acknowledgement mode**) |                                                                                                                                                       |                                                       |
|                      |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
|                      | 1. - n.                                                         |                                                                 |                                  |                                                                                                                                                       |                                                       |
| START                | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) |                                                                 |                                  | Start selected programs simultaneously in several channels from current program<br><br>This command has no effect for the own channel                 |                                                       |
| WAITE                | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) |                                                                 |                                  | Wait for end of program in one or more other channels                                                                                                 |                                                       |
|                      |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
|                      | 1.                                                              | 2. - n.                                                         |                                  |                                                                                                                                                       |                                                       |
| WAITM                | INT:<br>Marker number                                           | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) |                                  | Wait until a marker is reached in the specified channels<br><br>The previous block is terminated with exact stop                                      |                                                       |
| WAITMC               | INT:<br>Marker number                                           | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) |                                  | Wait until a marker is reached in the specified channels<br><br>An exact stop is initiated only if the other channels have not yet reached the marker |                                                       |
|                      |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
|                      | 1. - n.                                                         |                                                                 |                                  |                                                                                                                                                       |                                                       |
| SETM                 | INT:<br>Marker number                                           |                                                                 |                                  | Set one or more markers for the channel coordination<br><br>The processing in own channel is not affected by this                                     |                                                       |
| CLEARM               | INT:<br>Marker number                                           |                                                                 |                                  | Delete one or more markers for the channel coordination<br><br>The processing in own channel is not affected by this                                  |                                                       |
|                      |                                                                 |                                                                 |                                  |                                                                                                                                                       |                                                       |
|                      | 1. - n.                                                         |                                                                 |                                  |                                                                                                                                                       |                                                       |
| WAITP                | AXIS:<br>Axis identifier                                        |                                                                 |                                  | Wait until the specified positioning axes that were previously programmed with POSA, reach their programmed end point                                 |                                                       |

## 17.5 Predefined procedures

| Program coordination |                                                                |                                                                                            |                                                                 |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier           | Parameter                                                      |                                                                                            |                                                                 |                                                    | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| WAITS                | INT:<br>Spindle number                                         |                                                                                            |                                                                 |                                                    | Wait until the specified spindles that were previously programmed with SPOSA, reach their programmed end point                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                      |                                                                |                                                                                            |                                                                 |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| RET                  | 1.                                                             | 2.                                                                                         | 3.                                                              | 4.                                                 | End of subprogram with no function output to the PLC<br><br>When specifying the first parameter (jump target), a return jump is first made to the block after the calling block. The target is then sought depending on the programming (RET or RETB) according to the following strategy: <ul style="list-style-type: none"><li>RET:<br/>Search in the direction of the end of the program. A search is made toward the start of the program if the search was not successful.</li><li>RETB:<br/>Search in the direction of the start of the program. A search is made toward the end of the program if the search was not successful.</li></ul> |
|                      | INT (or STRING):<br>Jump target (block no./ marker) for return | INT:<br>0:<br>Return to jump target from 1st par.<br>> 0:<br>Return to the following block | INT:<br>Number of subprogram levels to be skipped               | BOOL:<br>Return to first block in the main program |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| RETB                 | INT (or STRING):<br>Jump target (block no./ marker) for return | INT:<br>0:<br>Return to jump target from 1st par.<br>> 0:<br>Return to the following block | INT:<br>Number of subprogram levels to be skipped               | BOOL:<br>Return to first block in the main program |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                      |                                                                |                                                                                            |                                                                 |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                      | 1. - n.                                                        |                                                                                            |                                                                 |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| GET                  | AXIS:<br>Axis identifier ***)                                  |                                                                                            |                                                                 |                                                    | Assign machine axis(axes)<br><br>The specified axes must be released in the other channel with RELEASE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| GETD                 | AXIS:<br>Axis identifier ***)                                  |                                                                                            |                                                                 |                                                    | Assign machine axis(axes) directly<br><br>The specified axes must <b>not</b> be released with RELEASE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| RELEASE              | AXIS:<br>Axis identifier ***)                                  |                                                                                            |                                                                 |                                                    | Release machine axis(axes)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                      |                                                                |                                                                                            |                                                                 |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                      | 1.                                                             | 2.                                                                                         | 3.                                                              | 4.                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| PUTFTOC              | REAL:<br>Offset value                                          | INT:<br>Parameter number                                                                   | INT:<br>Channel number<br><br>or<br>channel name from MD20000*) | INT: Spindle number                                | Change of fine tool compensation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Program coordination |                                         |                                                                                    |                               |                                                                          |                                                                                                                                                                            |
|----------------------|-----------------------------------------|------------------------------------------------------------------------------------|-------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier           | Parameter                               |                                                                                    |                               |                                                                          | Explanation                                                                                                                                                                |
| PUTFTOCF             | INT:<br>No. of the<br>function          | VAR REAL:<br>Reference<br>value                                                    | INT: Pa-<br>rameter<br>number | INT:<br>Channel<br>number<br><br>or<br>channel<br>name from<br>MD20000*) | Change of fine tool compensation depending<br>on a function defined with FCTDEF<br>(max. 3rd degree polynomial)<br><br>The number used here must be specified in<br>FCTDEF |
| AXTOCHAN             | 1.<br><br>AXIS:<br>Axis identifi-<br>er | 2.<br><br>INT:<br>Channel<br>number<br><br>or<br>channel<br>name from<br>MD20000*) | 3. - n.<br><br>As 1 ...       | 4. - m.<br><br>As 2 ...                                                  | Axes transferred to other channels                                                                                                                                         |

\*) Instead of channel numbers, the channel names defined via MD20000 \$MC\_CHAN\_NAME can also be programmed.

\*\*) Commands are acknowledged on request from the executing component (channel, NC, etc.).

\*\*\*) The SPI function can also be used to program a spindle instead of an axis. E.g. GET(SPI(1))

| Data access |                                       |                                                                                                                                                           |
|-------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier  | Parameter                             | Explanation                                                                                                                                               |
| CHANDATA    | 1.<br><br>INT:<br>Channel num-<br>ber | Set channel number for channel data access (only permitted in the initialization block).<br>The following access refers to the channel set with CHANDATA. |
| NEWCONF     |                                       | Accept changed machine data                                                                                                                               |

| Messages   |                    |                   |                                                                         |
|------------|--------------------|-------------------|-------------------------------------------------------------------------|
| Identifier | Parameter          |                   | Explanation                                                             |
|            | 1.                 | 2.                |                                                                         |
| MSG        | STRING:<br>Message | INT:<br>Execution | Output arbitrary character string as message on the user in-<br>terface |

| File access |                   |                         |                                                   |                                    |                                                                          |                                                            |
|-------------|-------------------|-------------------------|---------------------------------------------------|------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------|
| Identifier  | Parameter         |                         |                                                   |                                    |                                                                          | Explanation                                                |
| READ        | 1.                | 2.                      | 3.                                                | 4.                                 | 5.                                                                       | Read blocks from file system                               |
|             | VAR INT:<br>Error | CHAR[160]:<br>File name | INT:<br>Start line of the file section to be read | INT:<br>Number of lines to be read | VAR CHAR[255]:<br>Variable array in which the read information is stored |                                                            |
| WRITE       | 1.                | 2.                      | 3.                                                | 4.                                 |                                                                          | Write block to file system (or to an external device/file) |
|             | VAR INT:<br>Error | CHAR[160]:<br>File name | STRING:<br>Device/file for external output        | CHAR[200]:<br>Block                |                                                                          |                                                            |
| DELETE      | 1.                | 2.                      |                                                   |                                    |                                                                          | Delete file                                                |
|             | VAR INT:<br>Error | CHAR[160]:<br>File name |                                                   |                                    |                                                                          |                                                            |

| Alarms     |                                     |                             |                                                                                                                                                                                                                                                                                                                                                      |
|------------|-------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier | Parameter                           |                             | Explanation                                                                                                                                                                                                                                                                                                                                          |
|            | 1.                                  | 2.                          |                                                                                                                                                                                                                                                                                                                                                      |
| SETAL      | INT:<br>Alarm number (cycle alarms) | STRING:<br>Character string | <p>Set alarm</p> <p>A character string with up to four parameters can be specified in addition to the alarm number.</p> <p>The following predefined parameters are available:</p> <p>%1 = channel number<br/>           %2 = block number, label<br/>           %3 = text index for cycle alarms<br/>           %4 = additional alarm parameters</p> |

| Tool management |                                |                   |  |                                                                                   |
|-----------------|--------------------------------|-------------------|--|-----------------------------------------------------------------------------------|
| Identifier      | Parameter                      |                   |  | Explanation                                                                       |
|                 | 1.                             | 2.                |  |                                                                                   |
| DELDL           | INT:<br>T no.                  | INT:<br>D no.     |  | Delete all additive offsets of the tool edge (or of a tool if D is not specified) |
| DELT            | STRING[32]:<br>Tool identifier | INT:<br>Duplo no. |  | Delete tool<br>Duplo number can be omitted                                        |

| Tool management |                                                             |                                            |                                               |                                            |                                              |                          |                                                                                  |
|-----------------|-------------------------------------------------------------|--------------------------------------------|-----------------------------------------------|--------------------------------------------|----------------------------------------------|--------------------------|----------------------------------------------------------------------------------|
| Identifier      | Parameter                                                   |                                            |                                               |                                            |                                              |                          | Explanation                                                                      |
| DELTC           | INT:<br>Data set no. n                                      | INT:<br>Data set no. m                     |                                               |                                            |                                              |                          | Delete toolholder data set number n to m                                         |
| DZERO           |                                                             |                                            |                                               |                                            |                                              |                          | Set D numbers of all tools of the TO unit assigned to the channel to invalid     |
|                 | 1.                                                          | 2.                                         | 3.                                            | 4.                                         | 5.                                           | 6.                       |                                                                                  |
| GETFREELOC      | VAR INT:<br>Magazine no.<br>(return value)                  | VAR INT:<br>Location no.<br>(return value) | INT:<br>T no.                                 | INT:<br>Reference magazine no.             | CHAR:<br>Specification dep. on 4th parameter | INT:<br>Reservation mode | Find empty location for a tool                                                   |
|                 | 1.                                                          | 2.                                         |                                               |                                            |                                              |                          |                                                                                  |
| GETSELT         | VAR INT:<br>T no. (return value)                            | INT:<br>Spindle no.                        |                                               |                                            |                                              |                          | Returns the T number of the tool preselected for the spindle                     |
| GETEXET         | VAR INT:<br>T no. (return value)                            | INT:<br>Spindle no.                        |                                               |                                            |                                              |                          | Returns the T number of the tool active from the point of view of the NC program |
| GETTENV         | STRING:<br>Name of the tool environment                     | INT ARRAY[3]:<br>Return values             |                                               |                                            |                                              |                          | Reads the T, D and DL numbers stored in a tool environment                       |
|                 | 1.                                                          | 2.                                         | 3.                                            | 4.                                         |                                              |                          |                                                                                  |
| POSM            | INT:<br>No. of the location for positioning                 | INT:<br>No. of the magazine to be moved    | INT:<br>Location no. of the internal magazine | INT: Magazine no. of the internal magazine |                                              |                          | Position magazine                                                                |
| RESETMON        | VAR INT:<br>Status = result of the operation (return value) | INT: Internal T no.                        | INT:<br>D no. of the tool                     | INT:<br>Optional bit-coded parameter       |                                              |                          | Set actual value of tool to setpoint                                             |
|                 | 1.                                                          | 2.                                         | 3.                                            |                                            |                                              |                          |                                                                                  |
| SETDNO          | INT:<br>T no.                                               | INT: Cutting edge no.                      | INT:<br>D no.                                 |                                            |                                              |                          | Set offset number (D) of the cutting edge of the tool (T)                        |

## 17.5 Predefined procedures

| Tool management |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
|-----------------|-------------------------------------------------------------|------------------------|------------------------|--------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Identifier      | Parameter                                                   |                        |                        |                                |                                       | Explanation                                                                                                                           |
| SETMTH          | 1.                                                          |                        |                        |                                |                                       | Set toolholder no.                                                                                                                    |
|                 | INT:<br>Toolholder no.                                      |                        |                        |                                |                                       |                                                                                                                                       |
|                 |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
| SETPIECE        | 1.                                                          | 2.                     |                        |                                |                                       | Decrement workpiece counter of the spindle<br><br>Update the count monitoring data of the tools associated with the machining process |
|                 | INT:<br>Value used when decrementing                        | INT: Spindle no.       |                        |                                |                                       |                                                                                                                                       |
|                 |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
|                 | 1.                                                          | 2.                     | 3.                     | 4.                             |                                       |                                                                                                                                       |
| SETTA           | VAR INT:<br>Status = result of the operation (return value) | INT: Magazine no.      | INT: Wear group no.    | INT: Tool subgroup             |                                       | Activate tool from wear group                                                                                                         |
| SETTIA          | VAR INT:<br>Status = result of the operation (return value) | INT: Magazine no.      | INT: Wear group no.    | INT: Tool subgroup             |                                       | Deactivate tool from wear group                                                                                                       |
|                 |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
| TCA             | 1.                                                          | 2.                     | 3.                     |                                |                                       | Tool selection/change irrespective of the tool status                                                                                 |
|                 | STRING[32]:<br>Tool identifier                              | INT:<br>Duplo no.      | INT:<br>Toolholder no. |                                |                                       |                                                                                                                                       |
|                 |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
| TCI             | 1.                                                          | 2.                     |                        |                                |                                       | Load tool from buffer into the magazine                                                                                               |
|                 | INT:<br>No. of the buffer                                   | INT:<br>Toolholder no. |                        |                                |                                       |                                                                                                                                       |
|                 |                                                             |                        |                        |                                |                                       |                                                                                                                                       |
| MVTOOL          | 1.                                                          | 2.                     | 3.                     | 4.                             | 5.                                    | Language command to move tool                                                                                                         |
|                 | INT:<br>Status                                              | INT: Magazine no.      | INT: Location no.      | INT: Magazine no. after moving | INT: Target location no. after moving |                                                                                                                                       |



| Tool orientation |                                                   |                                                   |                                                   |                                         |
|------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|-----------------------------------------|
| Identifier       | Parameter                                         |                                                   |                                                   | Explanation                             |
|                  | 1.                                                | 2.                                                | 3.                                                |                                         |
| ORIRESET         | REAL:<br>Initial setting,<br>1st geometry<br>axis | REAL:<br>Initial setting,<br>2nd geometry<br>axis | REAL:<br>Initial setting,<br>3rd geometry<br>axis | Initial setting of the tool orientation |

| Synchronous spindle |                                      |                             |                                                                 |                                                           |                                             |                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------|--------------------------------------|-----------------------------|-----------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier          | Parameter                            |                             |                                                                 |                                                           |                                             |                                | Explanation                                                                                                                                                                                                                                                                                                                                                                                             |
|                     | 1.                                   | 2.                          | 3.                                                              | 4.                                                        | 5.                                          | 6.                             |                                                                                                                                                                                                                                                                                                                                                                                                         |
| COUPDEF             | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle | REAL:<br>Numerator<br>of transmis-<br>sion ratio                | REAL:<br>Denomina-<br>tor of trans-<br>mission ra-<br>tio | STRING[8]:<br>Block<br>change be-<br>havior | STRING[2]:<br>Coupling<br>type | Define synchronous<br>spindle grouping                                                                                                                                                                                                                                                                                                                                                                  |
| COUPDEL             | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle |                                                                 |                                                           |                                             |                                | Delete synchronous<br>spindle grouping                                                                                                                                                                                                                                                                                                                                                                  |
| COUPRES             | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle |                                                                 |                                                           |                                             |                                | Reset coupling param-<br>eters to configured MD<br>and SD values                                                                                                                                                                                                                                                                                                                                        |
| COUPON              | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle | REAL:<br>Switch-on<br>position of<br>the follow-<br>ing spindle |                                                           |                                             |                                | Switch-on synchro-<br>nous spindle coupling<br>If a switch-on position<br>is specified for the fol-<br>lowing spindle (angu-<br>lar offset between FS<br>and LS that refers --<br>absolutely or incre-<br>mentally -- to the zero<br>degree position of the<br>LS in the positive direc-<br>tion of rotation), the<br>coupling is only switch-<br>ed on when the speci-<br>fied position is<br>crossed. |
| COUPONC             | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle |                                                                 |                                                           |                                             |                                | Switch-on synchro-<br>nous spindle coupling<br>With COUPONC, the<br>currently active speed<br>of the following spindle<br>is taken over when<br>switching on the cou-<br>pling<br>(M3/M4 S..).                                                                                                                                                                                                          |

| Synchronous spindle |                                      |                                               |                                                                                |                                                                              |    |    |                                                                                                                                                                                                                                                                                                                        |
|---------------------|--------------------------------------|-----------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier          | Parameter                            |                                               |                                                                                |                                                                              |    |    | Explanation                                                                                                                                                                                                                                                                                                            |
|                     | 1.                                   | 2.                                            | 3.                                                                             | 4.                                                                           | 5. | 6. |                                                                                                                                                                                                                                                                                                                        |
| COUPOF              | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle                   | REAL:<br>Switch-off<br>position of<br>the follow-<br>ing spindle<br>(absolute) | REAL:<br>Switch-off<br>position of<br>the leading<br>spindle (ab-<br>solute) |    |    | Switch-off synchro-<br>nous spindle coupling<br>If positions are speci-<br>fied, the coupling is on-<br>ly cancelled when all<br>the specified positions<br>have been overtrav-<br>eled<br>The following spindle<br>continues to revolve at<br>the last speed pro-<br>grammed before deac-<br>tivation of the coupling |
| COUPOFS             | AXIS:<br>Follow-<br>ing spin-<br>dle | AXIS:<br>Leading<br>spindle                   | REAL:<br>Switch-off<br>position of<br>the follow-<br>ing spindle<br>(absolute) |                                                                              |    |    | Switch off the synchro-<br>nous spindle coupling<br>with stop of the follow-<br>ing spindle<br>If a position is speci-<br>fied, the coupling is on-<br>ly cancelled when the<br>specified position is<br>crossed                                                                                                       |
| WAITC               | AXIS:<br>Follow-<br>ing spin-<br>dle | STRING<br>[8]:<br>Block<br>change<br>behavior | AXIS:<br>Following<br>spindle                                                  | STRING[8]:<br>Block<br>change be-<br>havior                                  |    |    | Wait until the coupling<br>block change criterion<br>for the spindles (max.<br>2) has been fulfilled<br>If the block change be-<br>havior is not specified,<br>the block change be-<br>havior specified in the<br>definition with COUP-<br>DEF applies                                                                 |

| Electronic gear |                              |                               |                               |  |  |  |                                                                  |
|-----------------|------------------------------|-------------------------------|-------------------------------|--|--|--|------------------------------------------------------------------|
| Identifier      | Parameter                    |                               |                               |  |  |  | Explanation                                                      |
| EGDEL           | 1.                           |                               |                               |  |  |  | Delete cou-<br>pling defini-<br>tion for the fol-<br>lowing axis |
|                 | AXIS:<br>Follow-<br>ing axis |                               |                               |  |  |  |                                                                  |
| EGDEF           | 1.                           | 2. / 4. /<br>6. / 8. /<br>10. | 3. / 5. /<br>7. / 9. /<br>11. |  |  |  | Definition of<br>an electronic<br>gear                           |
|                 | AXIS:<br>Follow-<br>ing axis | AXIS:<br>Leading<br>axis      | INT:<br>Coupling<br>type      |  |  |  |                                                                  |

| Electronic gear |                         |                               |                                                   |                                        |                                                 |                                                 |                                          |                                          |                                                                                |
|-----------------|-------------------------|-------------------------------|---------------------------------------------------|----------------------------------------|-------------------------------------------------|-------------------------------------------------|------------------------------------------|------------------------------------------|--------------------------------------------------------------------------------|
| Identifier      |                         | Parameter                     |                                                   |                                        |                                                 |                                                 |                                          |                                          | Explanation                                                                    |
| EGON            | 1.                      | 2.                            | 3. / 6. / 9. / 12. / 15.                          | 4. / 7. / 10. / 13. / 16.              | 5. / 8. / 11. / 14. / 17.                       |                                                 |                                          |                                          | Electronic gear ON without synchronization                                     |
|                 | AXIS: Following axis    | STRING: Block change behavior | AXIS: Leading axis                                | REAL: Numerator of the coupling factor | REAL: Denominator of the coupling factor        |                                                 |                                          |                                          |                                                                                |
| EGONSYN         | 1.                      | 2.                            | 3.                                                | 4. / 8. / 12. / 16. / 20.              | 5. / 9. / 13. / 17. / 21.                       | 6. / 10. / 14. / 18. / 22.                      | 7. / 11. / 15. / 19. / 23.               |                                          | Electronic gear ON with synchronization                                        |
|                 | AXIS: Following axis    | STRING: Block change behavior | REAL: Synchronized position of the following axis | AXIS: Leading axis                     | REAL: Synchronized position of the leading axis | REAL: Numerator of the coupling factor          | REAL: Denominator of the coupling factor |                                          |                                                                                |
| EGONSYNE        | 1.                      | 2.                            | 3.                                                | 4.                                     | 5. / 9. / 13. / 17. / 21.                       | 6. / 10. / 14. / 18. / 22.                      | 7. / 11. / 15. / 19. / 23.               | 8. / 12. / 16. / 20. / 24.               | Electronic gear ON with synchronization and specification of the approach mode |
|                 | AXIS: Following axis    | STRING: Block change behavior | REAL: Synchronized position of the following axis | STRING: Approach mode                  | AXIS: Leading axis                              | REAL: Synchronized position of the leading axis | REAL: Numerator of the coupling factor   | REAL: Denominator of the coupling factor |                                                                                |
| EGOFS           | 1.                      | 2. - n.                       |                                                   |                                        |                                                 |                                                 |                                          |                                          | Turn off electronic gear selectively                                           |
|                 | AXIS: Following axis    | AXIS: Leading axis            |                                                   |                                        |                                                 |                                                 |                                          |                                          |                                                                                |
| EGOFC           | 1.                      |                               |                                                   |                                        |                                                 |                                                 |                                          |                                          | Switch off electronic gear (version only for spindles)                         |
|                 | AXIS: Following spindle |                               |                                                   |                                        |                                                 |                                                 |                                          |                                          |                                                                                |

| Nibbling   |                               |                               |                               |                             |                                        |
|------------|-------------------------------|-------------------------------|-------------------------------|-----------------------------|----------------------------------------|
| Identifier | Parameter                     |                               |                               |                             | Explanation                            |
|            | 1.                            | 2.                            | 3.                            | 4.                          |                                        |
| PUNCHAAC   | REAL:<br>Minimum hole spacing | REAL:<br>Initial acceleration | REAL:<br>Maximum hole spacing | REAL:<br>Final acceleration | Activate travel-dependent acceleration |

| Information functions in the passive file system |                           |                         |                                                                                 |                                                                                                                                                                                                                  |  |
|--------------------------------------------------|---------------------------|-------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Identifier                                       | Parameter                 |                         |                                                                                 | Explanation                                                                                                                                                                                                      |  |
|                                                  | 1.                        | 2.                      | 3.                                                                              |                                                                                                                                                                                                                  |  |
| FILEDATE                                         | VAR INT:<br>Error message | CHAR[160]:<br>File name | VAR CHAR[8]:<br>Date in the format "dd.mm.yy"                                   | Returns the date of the last write access to a file                                                                                                                                                              |  |
| FILETIME                                         | VAR INT:<br>Error message | CHAR[160]:<br>File name | VAR CHAR[8]:<br>Time in the format "hh.mm.ss"                                   | Returns the time of the last write access to a file                                                                                                                                                              |  |
| FILESIZE                                         | VAR INT:<br>Error message | CHAR[160]:<br>File name | VAR INT:<br>File size                                                           | Returns the current size of a file                                                                                                                                                                               |  |
| FILESTAT                                         | VAR INT:<br>Error message | CHAR[160]:<br>File name | VAR CHAR[5]:<br>Date in the format "rwxsd"                                      | Returns the status of a file with respect to the following rights: <ul style="list-style-type: none"> <li>• r: read</li> <li>• w: write</li> <li>• x: execute</li> <li>• s: show</li> <li>• d: delete</li> </ul> |  |
| FILEINFO                                         | VAR INT:<br>Error message | CHAR[160]:<br>File name | VAR CHAR[32]:<br>Date in the format "rwxsd<br>nnnnnnnn<br>dd.mm.yy<br>hh:mm:ss" | Returns the sum of the information for a file that can be read out via FILEDATE, FILETIME, FILESIZE, and FILESTAT                                                                                                |  |

| Axis container |                         |                                                            |
|----------------|-------------------------|------------------------------------------------------------|
| Identifier     | Parameter               | Explanation                                                |
|                | 1. - n.                 |                                                            |
| AXCTSWE        | AXIS:<br>Axis container | Rotate axis container                                      |
| AXCTSWED       | AXIS:<br>Axis container | Rotate axis container (command variant for commissioning!) |
| AXCTSWEC:      | AXIS:<br>Axis container | Cancel enable for axis container rotation                  |

| Master/slave coupling |                          |                                                                          |
|-----------------------|--------------------------|--------------------------------------------------------------------------|
| Identifier            | Parameter                |                                                                          |
|                       | 1. - n.                  |                                                                          |
| MASLON                | AXIS:<br>Axis identifier | Switch on master/slave coupling                                          |
| MASLOF                | AXIS:<br>Axis identifier | Separate master/slave coupling                                           |
| MASLOFS               | AXIS:<br>Axis identifier | Separate master/slave coupling and automatically brake slave spindles    |
| MASLDEF               | AXIS:<br>Axis identifier | Define master/slave coupling<br>The last axis is the master axis         |
| MASLDEL               | AXIS:<br>Axis identifier | Separate master/slave coupling and delete the definition of the grouping |

| Online tool length offset |                           |                                           |                                                                      |
|---------------------------|---------------------------|-------------------------------------------|----------------------------------------------------------------------|
| Identifier                | Parameter                 |                                           | Explanation                                                          |
|                           | 1.                        | 2.                                        |                                                                      |
| TOFFON                    | AXIS:<br>Offset direction | REAL:<br>Offset value in offset direction | Activate online tool length offset in the specified offset direction |
| TOFFOF                    | AXIS:<br>Offset direction |                                           | Reset online tool length offset in the specified offset direction    |

| SERUPRO    |           |                                          |
|------------|-----------|------------------------------------------|
| Identifier | Parameter | Explanation                              |
| IPTRLOCK   |           | Start of untraceable program section     |
| IPTRUNLOCK |           | End of search-suppressed program section |

| Retraction |                                        |                                                                          |
|------------|----------------------------------------|--------------------------------------------------------------------------|
| Identifier | Parameter                              | Explanation                                                              |
|            | 1. - n.                                |                                                                          |
| POLFMASK   | AXIS:<br>Geometry or machine axis name | Enable axes for rapid retraction (without a connection between the axes) |
| POLFMLIN   | AXIS:<br>Geometry or machine axis name | Enable axes for linear rapid retraction                                  |

## 17.6 Predefined procedures in synchronized actions

| Retraction |                                  |              |                |                                     |
|------------|----------------------------------|--------------|----------------|-------------------------------------|
| Identifier | Parameter                        |              |                | Explanation                         |
| POLFA      | 1.                               | 2.           | 3.             | Retraction position for single axes |
|            | AXIS:<br>Channel axis identifier | INT:<br>Type | REAL:<br>Value |                                     |

| Collision avoidance |                 |                                 |                                                    |
|---------------------|-----------------|---------------------------------|----------------------------------------------------|
| Identifier          | Parameter       |                                 | Explanation                                        |
| PROTA               | 1.              |                                 | Request for a recalculation of the collision model |
|                     | STRING:<br>"R"  |                                 |                                                    |
| PROTS               | 1.              | 2. - n.                         | Set protection zone status                         |
|                     | CHAR:<br>Status | STRING:<br>Protection zone name |                                                    |

## 17.6 Predefined procedures in synchronized actions

The following predefined procedures are only available in synchronized actions.

| Synchronous procedures |                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier             | Parameter                                                                                                                                         | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                          |
| STOPREOF               |                                                                                                                                                   | Revoke preprocessing stop<br>A synchronized action with a STOPREOF command causes a preprocessing stop after the next output block (= block for the main run). The preprocessing stop is canceled with the end of the output block or when the STOPREOF condition is fulfilled. All synchronized action operations with the STOPREOF command are therefore interpreted as having been executed.                                      |
| RDISABLE               |                                                                                                                                                   | Read-in disable                                                                                                                                                                                                                                                                                                                                                                                                                      |
| DELDTG                 | 1.<br>AXIS:<br>Axis for axial delete distance-to-go (optional). If the axis is omitted, delete distance-to-go is triggered for the path distance. | Delete distance-to-go<br>A synchronized action with a DELDTG command causes a preprocessing stop after the next output block (= block for the main run). The preprocessing stop is canceled with the end of the output block or when the first DELDTG condition is fulfilled. The axial distance to the destination point on an axial delete distance-to-go is stored in \$AA_DELT[axis]; the distance-to-go is stored in \$AC_DELT. |

## 17.6 Predefined procedures in synchronized actions

| Program coordination of technology cycles |                                                      |                                                                                                      |
|-------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Identifier                                | Parameter                                            | Explanation                                                                                          |
|                                           | 1.                                                   |                                                                                                      |
| LOCK                                      | INT:<br>ID of the synchronized action to be disabled | Lock synchronized action with ID or stop technology cycle<br>One or more IDs can be programmed       |
| UNLOCK                                    | INT:<br>ID of the synchronized action to be unlocked | Unlock synchronized action with ID or continue technology cycle<br>One or more IDs can be programmed |
| RESET                                     | INT:<br>ID of the technology cycle to be reset       | Reset technology cycle<br>One or more IDs can be programmed                                          |
| ICYCON                                    |                                                      | Each block of a technology cycle is processed in a separate interpolation cycle following ICYCON     |
| ICYCOF                                    |                                                      | All blocks of a technology cycle are processed in one interpolation cycle following ICYCOF           |

| Polynomial functions |                                                               |                                 |                                 |                        |                        |                                                                                                                                                                                                                                              |
|----------------------|---------------------------------------------------------------|---------------------------------|---------------------------------|------------------------|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier           | Parameter                                                     |                                 |                                 |                        |                        | Explanation                                                                                                                                                                                                                                  |
|                      | 1.                                                            | 2.                              | 3.                              |                        |                        |                                                                                                                                                                                                                                              |
| SYNFCT               | INT:<br>Number of the polynomial function defined with FCTDEF | VAR REAL:<br>Result variable *) | VAR REAL:<br>Input variable **) |                        |                        | If the condition in the motion-synchronous action is fulfilled, the polynomial determined by the first expression is evaluated at the input variable. The upper and lower range of the value is limited and the result variable is assigned. |
|                      | 1.                                                            | 2.                              | 3.                              | 4.                     | 5.                     |                                                                                                                                                                                                                                              |
| FTOC                 | INT:<br>Number of the polynomial function defined with FCTDEF | VAR REAL:<br>Input variable **) | INT:<br>Length<br>1, 2, 3       | INT:<br>Channel number | INT:<br>Spindle number | Change of fine tool compensation depending on a function defined with FCTDEF (max. 3rd degree polynomial).<br>The number used here must be specified in FCTDEF.                                                                              |

\*) Only special system variables are permissible as result variables (see Function Manual, Synchronized Actions).

\*\*) Only special system variables are permissible as input variables (see Function Manual, Synchronized Actions).

## 17.7 Predefined functions

The call of a predefined function triggers the execution of a predefined NCK function, which in contrast to the predefined procedure, supplies a return value. The call of the predefined function can be an operand in an expression.

| Coordinate system |              |                          |                                 |                |                |                                                                                                                                                                          |
|-------------------|--------------|--------------------------|---------------------------------|----------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier        | Return value | Parameter                |                                 |                |                | Explanation                                                                                                                                                              |
|                   |              |                          |                                 |                |                |                                                                                                                                                                          |
|                   |              | 1.                       | 2.                              | 3. - 15.       | 4. - 16.       |                                                                                                                                                                          |
| CTrans            | FRAME        | AXIS:<br>Axis identifier | REAL: Offset                    | As parameter 1 | As parameter 2 | Translation: Zero offset<br>COARSE for multiple axes                                                                                                                     |
| CFINE             | FRAME        | AXIS:<br>Axis identifier | REAL: Offset                    | As parameter 1 | As parameter 2 | Translation: Zero offset<br>for FINE multiple axes                                                                                                                       |
| CSCALE            | FRAME        | AXIS:<br>Axis identifier | REAL:<br>Scale factor           | As parameter 1 | As parameter 2 | Scale: Scale factor for<br>multiple axes                                                                                                                                 |
|                   |              |                          |                                 |                |                |                                                                                                                                                                          |
|                   |              | 1.                       | 2.                              | 3. / 5.        | 4. / 6.        |                                                                                                                                                                          |
| CROT              | FRAME        | AXIS:<br>Axis identifier | REAL: Rotation                  | As parameter 1 | As parameter 2 | Rotation: Rotation of the<br>current coordinate system<br><br>Maximum number of parameters: 6<br>(one axis identifier and one value per geometry axis).                  |
| CROTS             | FRAME        | AXIS:<br>Axis identifier | REAL: Rotation with solid angle | As parameter 1 | As parameter 2 | Rotation: Rotation of the<br>current coordinate system with solid angle<br><br>Maximum number of parameters: 6<br>(one axis identifier and one value per geometry axis). |
|                   |              |                          |                                 |                |                |                                                                                                                                                                          |
| CMIRROR           |              | 1.                       | 2. - 8.                         |                |                | Mirror: Mirror on a coordinate axis                                                                                                                                      |
|                   | FRAME        | AXIS                     | As parameter 1                  |                |                |                                                                                                                                                                          |
|                   |              |                          |                                 |                |                |                                                                                                                                                                          |



| Coordinate system |                                                                                                                                              |                                                                    |                                                             |                                                                                                            |                                                                                                                                                                                                             |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier        | Return value                                                                                                                                 | Parameter                                                          |                                                             |                                                                                                            | Explanation                                                                                                                                                                                                 |
|                   |                                                                                                                                              | 1.                                                                 | 2.                                                          |                                                                                                            |                                                                                                                                                                                                             |
| CRPL              | FRAME                                                                                                                                        | INT:<br>Rotary axis                                                | REAL:<br>Angle of rotation                                  |                                                                                                            | Frame rotation in any plane                                                                                                                                                                                 |
| ADDFRAME          | INT:<br>0 = OK<br>1 = Specified target (string) is incorrect<br>2 = Target frame is not configured<br>3 = Rotation in frame is not permitted | FRAME:<br>Additively measured or calculated frame                  | STRING:<br>Specified target frame                           |                                                                                                            | Calculates the target frame specified by the string<br><br>The target frame is calculated in such a way that the new complete frame appears as a chain of the old complete frame and the transferred frame. |
| INVFRAME          | FRAME                                                                                                                                        | 1.<br><br>FRAME                                                    |                                                             |                                                                                                            | Calculates the inverse frame from a frame<br><br>The frame chaining of a frame with its inverse frame always results in a zero frame                                                                        |
| MEAFRAME          | FRAME                                                                                                                                        | 1.<br><br>REAL[3,3]:<br>Coordinates of the measured spatial points | 2.<br><br>REAL[3,3]:<br>Coordinates of the specified points | 3.<br><br>VAR REAL:<br>Variable with which the information on the quality of FRAME calculation is returned | Frame calculation from 3 measuring points in space                                                                                                                                                          |

| Geometry functions |                       |                                                                                           |                                                         |                                                                                          |                                                                                                                                                                                                           |
|--------------------|-----------------------|-------------------------------------------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier         | Return value          | Parameter                                                                                 |                                                         |                                                                                          | Explanation                                                                                                                                                                                               |
|                    |                       | 1.                                                                                        | 2.                                                      | 3.                                                                                       |                                                                                                                                                                                                           |
| CALCDAT            | BOOL:<br>Error status | VAR REAL [2]:<br>Table with input points (abscissa and ordinate for points 1, 2, 3, etc.) | INT:<br>Number of input points for calculation (3 or 4) | VAR REAL [3]:<br>Result: Abscissa, ordinate and radius of calculated circle center point | Calculates radius and center point of a circle from 3 or 4 points (according to parameter 1), which must lie on a circle. The points must be different.                                                   |
| INTERSEC           | BOOL:<br>Error status | VAR REAL [11]:<br>First contour element                                                   | VAR REAL [11]:<br>Second contour element                | VAR REAL [2]:<br>Result vector: Intersection coordinate, abscissa and ordinate           | Calculation of intersection<br>The intersection between two contour elements is calculated. The intersection coordinates are return values. The error status indicates whether an intersection was found. |

| Curve table functions |                                  |                                |                                             |                               |                                     |                                     |                                   |                                                                                                                                                                                       |
|-----------------------|----------------------------------|--------------------------------|---------------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier            | Return value                     | Parameter                      |                                             |                               |                                     |                                     |                                   | Explanation                                                                                                                                                                           |
|                       |                                  | 1.                             | 2.                                          | 3.                            | 4.                                  | 5.                                  | 6.                                |                                                                                                                                                                                       |
| CTAB                  | REAL:<br>Following axis position | REAL:<br>Leading axis position | INT:<br>Table number                        | VAR REAL [ ]:<br>Pitch result | AXIS:<br>Following axis for scaling | AXIS:<br>Leading axis for scaling   |                                   | Determines the following axis position to the specified leading axis position from the curve table<br><br>If parameters 4/5 are not programmed, calculation is with standard scaling. |
| CTABINV               | REAL:<br>Following axis position | REAL:<br>Leading axis position | REAL:<br>Leading position                   | INT:<br>Table number          | VAR REAL [ ]:<br>Pitch result       | AXIS:<br>Following axis for scaling | AXIS:<br>Leading axis for scaling | Determines the leading axis position to the specified following axis position from the curve table<br><br>If parameters 5/6 are not programmed, calculation is with standard scaling. |
| CTABID                | INT:<br>Table number             | INT:<br>Entry number in memory | STRING:<br>Storage location: "SRAM", "DRAM" |                               |                                     |                                     |                                   | Returns the curve table number entered under the specified number in the memory                                                                                                       |
| CTABISLOCK            | INT:<br>Lock state               | INT:<br>Table number           |                                             |                               |                                     |                                     |                                   | Returns the lock state of the curve table                                                                                                                                             |

| Curve table functions |                                  |                                                   |                                                            |    |    |    |    |                                                                                                                                                                                                      |
|-----------------------|----------------------------------|---------------------------------------------------|------------------------------------------------------------|----|----|----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier            | Return value                     | Parameter                                         |                                                            |    |    |    |    | Explanation                                                                                                                                                                                          |
|                       |                                  | 1.                                                | 2.                                                         | 3. | 4. | 5. | 6. |                                                                                                                                                                                                      |
| CTABEXISTS            | INT:<br>Lock state               | INT:<br>Table number                              |                                                            |    |    |    |    | Checks whether the curve table is in the static or dynamic NC memory                                                                                                                                 |
| CTABMEMTYP            | INT:<br>Storage location         | INT:<br>Table number                              |                                                            |    |    |    |    | Returns the storage location of the curve table                                                                                                                                                      |
| CTABPERIOD            | INT:<br>Periodicity              | INT:<br>Table number                              |                                                            |    |    |    |    | Determines the periodicity of the curve table                                                                                                                                                        |
| CTABNO                | INT:<br>Number of tables         |                                                   |                                                            |    |    |    |    | Determines the total number of defined curve tables (in the static and dynamic NC memory)                                                                                                            |
| CTABNOMEM             | INT:<br>Number of tables         | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" |                                                            |    |    |    |    | Determines the number of defined curve tables in the specified memory                                                                                                                                |
| CTABFNO               | INT:<br>Number of tables         | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" |                                                            |    |    |    |    | Determines the number of curve tables still possible in the specified memory                                                                                                                         |
| CTABSEG               | INT:<br>Number of curve segments | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" | STRING:<br>Segment type:<br>"L": Linear<br>"P": Polynomial |    |    |    |    | Determines the number of used curve segments of the specified segment type in the specified memory<br><br>If parameter 3 is not programmed, the sum of the linear and polynomial segments is output. |
| CTABSEGID             | INT:<br>Number of curve segments | INT:<br>Table number                              | STRING:<br>Segment type:<br>"L": Linear<br>"P": Polynomial |    |    |    |    | Determines the number of curve segments of the specified segment type used by the curve table                                                                                                        |

| Curve table functions |                                     |                                                   |                                                            |                             |                                     |                                   |    |                                                                                                                     |
|-----------------------|-------------------------------------|---------------------------------------------------|------------------------------------------------------------|-----------------------------|-------------------------------------|-----------------------------------|----|---------------------------------------------------------------------------------------------------------------------|
| Identifier            | Return value                        | Parameter                                         |                                                            |                             |                                     |                                   |    | Explanation                                                                                                         |
|                       |                                     | 1.                                                | 2.                                                         | 3.                          | 4.                                  | 5.                                | 6. |                                                                                                                     |
| CTABFSEG              | INT:<br>Number of curve segments    | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" | STRING:<br>Segment type:<br>"L": Linear<br>"P": Polynomial |                             |                                     |                                   |    | Determines the number of still possible curve segments of the specified segment type in the specified memory        |
| CTABMSEG              | INT:<br>Number of curve segments    | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" | STRING:<br>Segment type:<br>"L": Linear<br>"P": Polynomial |                             |                                     |                                   |    | Determines the maximum possible number of curve segments of the specified segment type in the specified memory      |
| CTABPOL               | INT:<br>Number of curve polynomials | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" |                                                            |                             |                                     |                                   |    | Determines the number of used curve polynomials in the specified memory                                             |
| CTABPOLID             | INT:<br>Number of curve polynomials | INT:<br>Table number                              |                                                            |                             |                                     |                                   |    | Determines the number of curve polynomials used by the curve table                                                  |
| CTABFPOL              | INT:<br>Number of curve polynomials | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" |                                                            |                             |                                     |                                   |    | Determines the maximum possible number of curve polynomials in the specified memory                                 |
| CTABMPOL              | INT:<br>Number of curve polynomials | STRING:<br>Storage location:<br>"SRAM",<br>"DRAM" |                                                            |                             |                                     |                                   |    | Determines the maximum possible number of curve polynomials in the specified memory                                 |
| CTABSSV               | REAL:<br>Following axis position    | REAL:<br>Leading axis position                    | INT:<br>Table number                                       | VAR REAL[:]<br>Pitch result | AXIS:<br>Following axis for scaling | AXIS:<br>Leading axis for scaling |    | Determines the following axis value at the start of the curve segment belonging to the specified leading axis value |
| CTABSEV               | REAL:<br>Following axis position    | REAL:<br>Leading axis position                    | INT:<br>Table number                                       | VAR REAL[:]<br>Pitch result | AXIS:<br>Following axis for scaling | AXIS:<br>Leading axis for scaling |    | Determines the following axis value at the end of the curve segment belonging to the specified leading axis value   |

| Curve table functions                                                                     |                                                         |                         |                                                                    |                                                          |                              |                          |    |                                                                                                                                                    |
|-------------------------------------------------------------------------------------------|---------------------------------------------------------|-------------------------|--------------------------------------------------------------------|----------------------------------------------------------|------------------------------|--------------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier                                                                                | Return value                                            | Parameter               |                                                                    |                                                          |                              |                          |    | Explanation                                                                                                                                        |
|                                                                                           |                                                         | 1.                      | 2.                                                                 | 3.                                                       | 4.                           | 5.                       | 6. |                                                                                                                                                    |
| CTABTSV                                                                                   | REAL:<br>Follow-<br>ing axis<br>position                | INT:<br>Table<br>number | VAR RE-<br>AL[ ]:<br>Pitch re-<br>sult at<br>start of<br>the table | AXIS:<br>Follow-<br>ing axis                             |                              |                          |    | Determines the follow-<br>ing axis value at the<br>start of the curve table                                                                        |
| CTABTEV                                                                                   | REAL:<br>Follow-<br>ing axis<br>position                | INT:<br>Table<br>number | VAR RE-<br>AL[ ]:<br>Pitch re-<br>sult at<br>end of<br>the table   | AXIS:<br>Follow-<br>ing axis                             |                              |                          |    | Determines the follow-<br>ing axis value at the<br>end of the curve table                                                                          |
| CTABTSP                                                                                   | REAL:<br>Leading<br>axis posi-<br>tion                  | INT:<br>Table<br>number | VAR RE-<br>AL[ ]:<br>Pitch re-<br>sult at<br>start of<br>the table | AXIS:<br>Leading<br>axis                                 |                              |                          |    | Determines the lead-<br>ing axis value at the<br>start of the curve table                                                                          |
| CTABTEP                                                                                   | REAL:<br>Leading<br>axis posi-<br>tion                  | INT:<br>Table<br>number | VAR RE-<br>AL[ ]:<br>Pitch re-<br>sult at<br>end of<br>the table   | AXIS:<br>Leading<br>axis                                 |                              |                          |    | Determines the lead-<br>ing axis value at the<br>end of the curve table                                                                            |
| CTABTMIN                                                                                  | REAL:<br>Minimum<br>following<br>axis val-<br>ue        | INT:<br>Table<br>number | REAL:<br>Leading<br>value in-<br>terval<br>lower lim-<br>it        | REAL:<br>Leading<br>value in-<br>terval up-<br>per limit | AXIS:<br>Follow-<br>ing axis | AXIS:<br>Leading<br>axis |    | Determines the mini-<br>mum value of the fol-<br>lowing axis in the en-<br>tire definition range of<br>the curve table or in a<br>defined interval |
| CTABTMAX                                                                                  | REAL:<br>Maxi-<br>mum fol-<br>lowing<br>axis val-<br>ue | INT:<br>Table<br>number | REAL:<br>Leading<br>value in-<br>terval<br>lower lim-<br>it        | REAL:<br>Leading<br>value in-<br>terval up-<br>per limit | AXIS:<br>Follow-<br>ing axis | AXIS:<br>Leading<br>axis |    | Determines the maxi-<br>mum value of the fol-<br>lowing axis in the en-<br>tire definition range of<br>the curve table or in a<br>defined interval |
| <b>Note:</b><br>The curve table functions can also be programmed in synchronized actions. |                                                         |                         |                                                                    |                                                          |                              |                          |    |                                                                                                                                                    |

| Axis functions |                          |                                 |    |    |    |                                                 |
|----------------|--------------------------|---------------------------------|----|----|----|-------------------------------------------------|
| Identifier     | Return value             | Parameter                       |    |    |    | Explanation                                     |
|                |                          | 1.                              | 2. | 3. | 4. |                                                 |
| AXNAME         | AXIS:<br>Axis identifier | STRING [ ]:<br><br>Input string |    |    |    | Converts input string in-<br>to axis identifier |
| AXSTRING       | STRING[ ]:<br>Axis name  | AXIS:<br>Axis identifier        |    |    |    | Converts axis identifier<br>into string         |

## 17.7 Predefined functions

| Axis functions |                                                                             |                                              |                                                      |                                |                           |                                                                                                                                                                   |
|----------------|-----------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------|--------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier     | Return value                                                                | Parameter                                    |                                                      |                                |                           | Explanation                                                                                                                                                       |
|                |                                                                             | 1.                                           | 2.                                                   | 3.                             | 4.                        |                                                                                                                                                                   |
| ISAXIS         | BOOL:<br>Axis present (TRUE) or not (FALSE)                                 | INT:<br>Number of the geometry axis (1 to 3) |                                                      |                                |                           | Checks whether the geometry axes 1 to 3 specified as parameters are present in accordance with machine data MD20050<br>\$MC_AXCONF_GEO-AX_ASSIGN_TAB              |
| SPI            | AXIS:<br>Axis identifier                                                    | INT:<br>Spindle number                       |                                                      |                                |                           | Converts spindle number into axis identifier                                                                                                                      |
| AXTOSPI        | INT:<br>Spindle number                                                      | AXIS:<br>Axis identifier                     |                                                      |                                |                           | Converts axis identifier into spindle number                                                                                                                      |
| MODAXVAL       | REAL:<br>Modulo value                                                       | AXIS:<br>Axis identifier                     | REAL:<br>Axis position                               |                                |                           | Calculates the remaining modulo values from the entered axis position<br><br>If the specified axis is not a modulo axis, the axis position is returned unchanged. |
| POSRANGE       | BOOL:<br>Position setpoint within the position window (TRUE) or not (FALSE) | AXIS:<br>Axis identifier                     | REAL:<br>Reference position in the coordinate system | REAL:<br>Position window width | INT:<br>Coordinate system | Determines whether the position setpoint of an axis is located in a window at a predefined reference position                                                     |

| Tool management |                                      |                                           |                                  |                  |                                                                     |
|-----------------|--------------------------------------|-------------------------------------------|----------------------------------|------------------|---------------------------------------------------------------------|
| Identifier      | Return value                         | Parameter                                 |                                  |                  | Explanation                                                         |
|                 |                                      | 1.                                        | 2.                               | 3.               |                                                                     |
| CHKDM           | INT:<br>Status = result of the check | INT:<br>Magazine number                   | INT:<br>D number                 |                  | Checks the uniqueness of the D number within a magazine             |
| CHKDNO          | INT:<br>Status = result of the check | INT:<br>T number of the 1st tool          | INT:<br>T number of the 2nd tool | INT:<br>D number | Checks the uniqueness of the D number                               |
| GETACTT         | INT:<br>Status                       | INT:<br>T number                          | STRING [32]:<br>Tool name        |                  | Determines the active tool from a group of tools with the same name |
| GETACTTD        | INT:<br>Status = result of the check | VAR INT:<br>T number found (return value) | INT:<br>D number                 |                  | Determines the associated T number for an absolute D number         |

| Tool management |                  |                           |                                                      |    |                                                                                                                                                                   |
|-----------------|------------------|---------------------------|------------------------------------------------------|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier      | Return value     | Parameter                 |                                                      |    | Explanation                                                                                                                                                       |
|                 |                  | 1.                        | 2.                                                   | 3. |                                                                                                                                                                   |
| GETDNO          | INT:<br>D number | INT:<br>T number          | INT:<br>Cutting edge<br>number                       |    | Returns the D number of the cutting edge of tool T                                                                                                                |
| GETT            | INT:<br>T number | STRING [32]:<br>Tool name | INT:<br>Duplo number                                 |    | Determines the T number for tool identifier                                                                                                                       |
| NEWT            | INT:<br>T number | STRING [32]:<br>Tool name | INT:<br>Duplo number                                 |    | Creates a new tool (prepare tool data)<br>The duplo number can be omitted.                                                                                        |
| TOOLENV         | INT:<br>Status   | STRING:<br>Name           |                                                      |    | Saves a tool environment with the specified name in the static NC memory                                                                                          |
| DELTOOLENV      | INT:<br>Status   | STRING:<br>Name           |                                                      |    | Deletes a tool environment with the specified name in the static NC memory<br>Deletes all tool environments if no name is specified.                              |
| GETTENV         | INT:<br>Status   | STRING:<br>Name           | INT:<br>Number = [0]<br>Number = [1]<br>Number = [2] |    | Reading:<br><ul style="list-style-type: none"> <li>• T number</li> <li>• D number</li> <li>• DL number</li> </ul> from a tool environment with the specified name |

| Arithmetic |              |           |      |    |                                               |
|------------|--------------|-----------|------|----|-----------------------------------------------|
| Identifier | Return value | Parameter |      |    | Explanation                                   |
|            |              | 1.        | 2.   | 3. |                                               |
| SIN        | REAL         | REAL      |      |    | Sine                                          |
| ASIN       | REAL         | REAL      |      |    | Arc sine                                      |
| COS        | REAL         | REAL      |      |    | Cosine                                        |
| ACOS       | REAL         | REAL      |      |    | Arc cosine                                    |
| TAN        | REAL         | REAL      |      |    | Tangent                                       |
| ATAN2      | REAL         | REAL      | REAL |    | Arc tangent 2                                 |
| SQRT       | REAL         | REAL      |      |    | Square root                                   |
| POT        | REAL         | REAL      |      |    | Square                                        |
| TRUNC      | REAL         | REAL      |      |    | Truncation of decimal places                  |
| ROUND      | REAL         | REAL      |      |    | Rounding of decimal places                    |
| ABS        | REAL         | REAL      |      |    | Generate absolute value                       |
| LN         | REAL         | REAL      |      |    | Natural logarithm                             |
| EXP        | REAL         | REAL      |      |    | Exponential function $e^x$                    |
| MINVAL     | REAL         | REAL      | REAL |    | Determines the smaller value of two variables |

| Arithmetic |                    |               |               |                         |                                                                               |
|------------|--------------------|---------------|---------------|-------------------------|-------------------------------------------------------------------------------|
| Identifier | Return value       | Parameter     |               |                         | Explanation                                                                   |
|            |                    | 1.            | 2.            | 3.                      |                                                                               |
| MAXVAL     | REAL               | REAL          | REAL          |                         | Determines the larger value of two variables                                  |
| BOUND      | REAL: Check status | REAL: Minimum | REAL: Maximum | REAL: Checking variable | Checks whether the variable value lies within the defined min/max value range |

**Note:**

The arithmetic functions can also be programmed in synchronized actions. These arithmetic functions are calculated and evaluated in the main run. The synchronized action parameter \$AC\_PARAM[<n>] can also be used for calculations and as buffer.

| INT: functions |              |           |        |     |                                                                                                                                                                                                                                                               |
|----------------|--------------|-----------|--------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier     | Return value | Parameter |        |     | Explanation                                                                                                                                                                                                                                                   |
|                |              | 1.        | 2.     | 3.  |                                                                                                                                                                                                                                                               |
| ISNUMBER       | BOOL         | STRING    |        |     | Checks whether the input string can be converted to a number.                                                                                                                                                                                                 |
| NUMBER         | REAL         | STRING    |        |     | Converts the input string into a number.                                                                                                                                                                                                                      |
| TOUPPER        | STRING       | STRING    |        |     | Converts all alphabetic characters in the input string to upper case.                                                                                                                                                                                         |
| TOLOWER        | STRING       | STRING    |        |     | Converts all alphabetic characters in the input string to lower case.                                                                                                                                                                                         |
| STRLEN         | INT          | STRING    |        |     | The result is the length of the input string up to the end of the string (0).                                                                                                                                                                                 |
| INDEX          | INT          | STRING    | CHAR   |     | Searches for the character (2nd parameter) in the input string (1st parameter).<br>The reply gives the place, at which the character was first found. The search is from left to right. The 1st character in the string has the index 0.                      |
| RINDEX         | INT          | STRING    | CHAR   |     | Searches for the character (2nd parameter) in the input string (1st parameter).<br>The reply gives the place, at which the character was first found. The search is from right to left. The 1st character in the string has the index 0.                      |
| MINDEX         | INT          | STRING    | STRING |     | Searches for one of the characters specified in the 2nd parameter in the input string (1st parameter).<br>The place where one of the characters was first found is output. The search is from left to right. The 1st character in the string has the index 0. |
| SUBSTR         | STRING       | STRING    | INT    | INT | Returns the substring of the input string (1st parameter), defined by the start character (2nd parameter) and number of characters (3rd parameter).                                                                                                           |
| SPRINT         | STRING       | STRING    |        |     | Returns the input string (1st parameter).                                                                                                                                                                                                                     |



| Functions for measuring cycles |                |                                                       |                                                                                 |                                                        |                                                   |                                                    |                                                                      |                                                                                                                                                                                                                                                              |
|--------------------------------|----------------|-------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------|---------------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier                     | Return value   | Parameter                                             |                                                                                 |                                                        |                                                   |                                                    |                                                                      | Explanation                                                                                                                                                                                                                                                  |
|                                |                | 1.                                                    | 2.                                                                              | 3.                                                     | 4.                                                | 5.                                                 | 6.                                                                   |                                                                                                                                                                                                                                                              |
| CALCPOSI                       | INT:<br>Status | REAL[3]:<br>Starting position in the WCS              | REAL[3]:<br>Incremental path specification in relation to the starting position | REAL[5]:<br>Minimum distances to the monitoring limits | REAL[3]:<br>Return array for the poss. incr. path | BOOL:<br>Conversion of the measuring system Yes/No | INT:<br>Type of limit monitoring                                     | Checks whether the geometry axes can traverse a defined path without violating the axis limits starting from a specified starting point.<br><br>If the defined path cannot be traversed without violating limits, the maximum permissible value is returned. |
| GETTCOR                        | INT:<br>Status | REAL [11]:                                            | STRING:<br>Tool length component: Coordinate system                             | STRING:<br>Name of the tool environment                | INT:<br>Internal T no. of the tool                | INT:<br>Cutting-edge number (D no.) of the tool    | INT:<br>Number of the location-dependent offset (DL no. of the tool) | Read tool lengths and tool length components from tool environment or current environment.                                                                                                                                                                   |
| LENTOAX                        | INT:<br>Status | 1.<br>INT[3]:<br>Axis assignment of the geometry axes | 2.<br>REAL[3]:<br>Matrix for mapping the tool lengths in the coordinate system  | 3.<br>STRING:<br>Coordinate system for the assignment  |                                                   |                                                    |                                                                      | Provides information about the assignment of the tool lengths L1, L2, L3 of the active tools to abscissa, ordinate, applycate.<br><br>The assignment to the geometry axes is affected by frames and the active plane (G17 - 19).                             |

| Functions for measuring cycles |                |                                                       |                                                       |                                                                   |                                                        |                                                          |                                                          |                                                     |                                       |                                              |                                                                                                                                                                                                |
|--------------------------------|----------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|---------------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identifier                     | Return value   | Parameter                                             |                                                       |                                                                   |                                                        |                                                          |                                                          |                                                     |                                       |                                              | Explanation                                                                                                                                                                                    |
| SETTCOR                        | INT:<br>Status | 1.<br>REAL<br>[3]:<br>Offset<br>vector<br>in<br>space | 2.<br>STR.:<br>Com-<br>po-<br>nent<br>identi-<br>fier | 3.<br>INT:<br>Com-<br>po-<br>nent(s)<br>to be<br>offset<br>0 - 11 | 4.<br>INT:<br>Type of<br>write op-<br>eration<br>0 - 3 | 5.<br>INT:<br>Index<br>of the<br>geom-<br>etry ax-<br>is | 6.<br>STRING:<br>Name of<br>the tool<br>environ-<br>ment | 7.<br>INT:<br>Int.<br>T<br>no.<br>of<br>the<br>tool | 8.<br>INT:<br>D no.<br>of the<br>tool | 9.<br>INT:<br>DL<br>no.<br>of<br>the<br>tool | Changes<br>tool com-<br>ponents<br>taking into<br>account all<br>supple-<br>mentary<br>conditions<br>that are in-<br>cluded in<br>the evalua-<br>tion of the<br>individual<br>compo-<br>nents. |

| Other functions |                                                       |                                                            |                              |    |    |    |    |                                                                                                                                                                                  |  |
|-----------------|-------------------------------------------------------|------------------------------------------------------------|------------------------------|----|----|----|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Identifier      | Return value                                          | Parameter                                                  |                              |    |    |    |    | Explanation                                                                                                                                                                      |  |
|                 |                                                       | 1.                                                         | 2.                           | 3. | 4. | 5. | 6. |                                                                                                                                                                                  |  |
| STRINGIS        | INT:<br>Informa-<br>tion<br>about the<br>string       | STRING:<br>Name of<br>the ele-<br>ment to<br>be<br>checked |                              |    |    |    |    | Checks whether the<br>specified string is avail-<br>able as element of the<br>NC programming lan-<br>guage in the current<br>language scope.                                     |  |
| ISVAR           | BOOL:<br>Variable<br>known<br>Yes/No                  | STRING:<br>Name of<br>the varia-<br>ble                    |                              |    |    |    |    | Checks whether the<br>transfer parameter con-<br>tains a variable known<br>in the NC (machine da-<br>ta, setting data, system<br>variable, general varia-<br>bles such as GUDs). |  |
| GETVARTYP       | INT:<br>Data type                                     | STRING:<br>Name of<br>the varia-<br>ble                    |                              |    |    |    |    | Reads the data type of<br>a system/user variable                                                                                                                                 |  |
| GETVARPHU       | INT:<br>Numeric<br>value of<br>the physi-<br>cal unit | STRING:<br>Name of<br>the varia-<br>ble                    |                              |    |    |    |    | Reads the physical unit<br>of a system/user varia-<br>ble                                                                                                                        |  |
| GETVARAP        | INT:<br>Protec-<br>tion level<br>for ac-<br>cess      | STRING:<br>Name of<br>the varia-<br>ble                    | STRING:<br>Type of<br>access |    |    |    |    | Reads the access right<br>to a system/user varia-<br>ble                                                                                                                         |  |

| Other functions |                                                |                                              |                                                                |                                                              |                                                                         |                                                 |    |                                                                                                                                 |
|-----------------|------------------------------------------------|----------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------|----|---------------------------------------------------------------------------------------------------------------------------------|
| Identifier      | Return value                                   | Parameter                                    |                                                                |                                                              |                                                                         |                                                 |    | Explanation                                                                                                                     |
|                 |                                                | 1.                                           | 2.                                                             | 3.                                                           | 4.                                                                      | 5.                                              | 6. |                                                                                                                                 |
| GETVARLIM       | INT:<br>Status                                 | STRING:<br>Name of the variable              | CHAR:<br>Specifies which limit value should be read out        | VAR REAL:<br>Return of the limit value                       |                                                                         |                                                 |    | Reads the lower/upper limit value of a system/user variables                                                                    |
| GETVARDFT       | INT:<br>Status                                 | STRING:<br>Name of the variable              | VAR REAL / STRING/ FRAME:<br>Return of the default value       | INT:<br>Index to the first dimension (optional)              | INT:<br>Index to the second dimension (optional)                        | INT:<br>Index to the third dimension (optional) |    | Reads the default value of a system/user variable                                                                               |
| COLLPAIR        | INT:<br>Check result                           | STRING:<br>Name of the 1st protection zone   | STRING:<br>Name of the 2nd protection zone                     | BOOL:<br>Alarm suppression (optional)                        |                                                                         |                                                 |    | Check whether part of a collision pair                                                                                          |
| PROTD           | REAL:<br>Clearance of the two protection zones | STRING:<br>Name of the 1st protection zone   | STRING:<br>Name of the 2nd protection zone                     | VAR REAL:<br>Return value: 3-dimensional clearance vector    | BOOL:<br>Measuring system for clearance and clearance vector (optional) |                                                 |    | Calculates the clearance of the two specified protection zones                                                                  |
| DELOBJ          | INT:<br>Error code                             | STRING:<br>Component type to be deleted      | INT:<br>Start index of the components to be deleted (optional) | INT:<br>End index of the components to be deleted (optional) | BOOL:<br>Alarm suppression (optional)                                   |                                                 |    | Deletion of elements from kinematic chains, protection zones, protection zone elements, collision pairs and transformation data |
| NAMETOINT       | INT:<br>System variable index                  | STRING:<br>Name of the system variable array | STRING:<br>Character string / name                             | BOOL:<br>Alarm suppression (optional)                        |                                                                         |                                                 |    | Determines the associated system variable index based on the character string                                                   |

## 17.8 Currently set language in the HMI

The table below lists all of the languages available at the user interface.

The currently set language can be queried in the part program and in the synchronized actions using the following system variable:

`$AN_LANGUAGE_ON_HMI = <value>`

| <value> | Language                | Language code |
|---------|-------------------------|---------------|
| 1       | German (Germany)        | GER           |
| 2       | French                  | FRA           |
| 3       | English (Great Britain) | ENG           |
| 4       | Spanish                 | ESP           |
| 6       | Italian                 | ITA           |
| 7       | Dutch                   | NLD           |
| 8       | Simplified Chinese      | CHS           |
| 9       | Swedish                 | SVE           |
| 18      | Hungarian               | HUN           |
| 19      | Finnish                 | FIN           |
| 28      | Czech                   | CSY           |
| 50      | Portuguese (Brazil)     | PTB           |
| 53      | Polish                  | PLK           |
| 55      | Danish                  | DAN           |
| 57      | Russian                 | RUS           |
| 68      | Slovakian               | SKY           |
| 72      | Rumanian                | ROM           |
| 80      | Traditional Chinese     | CHT           |
| 85      | Korean                  | KOR           |
| 87      | Japanese                | JPN           |
| 89      | Turkish                 | TRK           |

### Note

`$AN_LANGUAGE_ON_HMI` is updated:

- after the system boots.
- after NCK and/or PLC reset.
- after switching over to another NCK within the scope of M2N.
- after changing over the language on the HMI.

# Appendix

## A.1 List of abbreviations

| <b>A</b> |                                                                                                              |
|----------|--------------------------------------------------------------------------------------------------------------|
| O        | Output                                                                                                       |
| ADI4     | (Analog drive interface for 4 axes)                                                                          |
| AC       | Adaptive Control                                                                                             |
| ALM      | Active Line Module                                                                                           |
| ARM      | Rotating induction motor                                                                                     |
| AS       | Automation system                                                                                            |
| ASCII    | American Standard Code for Information Interchange: American coding standard for the exchange of information |
| ASIC     | Application-Specific Integrated Circuit: User switching circuit                                              |
| ASUB     | Asynchronous subprogram                                                                                      |
| AUXFU    | Auxiliary function: Auxiliary function                                                                       |
| STL      | Statement List                                                                                               |
| UP       | User Program                                                                                                 |

| <b>B</b> |                                                               |
|----------|---------------------------------------------------------------|
| OP       | Operating Mode                                                |
| BAG      | Mode group                                                    |
| BCD      | Binary Coded Decimals: Decimal numbers encoded in binary code |
| BERO     | Contact-less proximity switch                                 |
| BI       | Binector Input                                                |
| BICO     | Binector Connector                                            |
| BIN      | BINary files: Binary files                                    |
| BIOS     | Basic Input Output System                                     |
| BCS      | Basic Coordinate System                                       |
| BO       | Binector Output                                               |
| OPI      | Operator Panel Interface                                      |

| <b>C</b> |                                                                      |
|----------|----------------------------------------------------------------------|
| CAD      | Computer-Aided Design                                                |
| CAM      | Computer-Aided Manufacturing                                         |
| CC       | Compile Cycle: Compile cycles                                        |
| CI       | Connector Input                                                      |
| CF Card  | Compact Flash Card                                                   |
| CNC      | Computerized Numerical Control: Computer-Supported Numerical Control |

| C      |                                                                |
|--------|----------------------------------------------------------------|
| CO     | Connector Output                                               |
| CoL    | Certificate of License                                         |
| COM    | Communication                                                  |
| CPA    | Compiler Projecting Data: Configuring data of the compiler     |
| CRT    | Cathode Ray Tube: picture tube                                 |
| CSB    | Central Service Board: PLC module                              |
| CU     | Control Unit                                                   |
| CP     | Communication Processor                                        |
| CPU    | Central Processing Unit: Central processing unit               |
| CR     | Carriage Return                                                |
| CTS    | Clear To Send: Ready to send signal for serial data interfaces |
| CUTCOM | Cutter radius Compensation: Tool radius compensation           |

| D          |                                                                            |
|------------|----------------------------------------------------------------------------|
| DAC        | Digital-to-Analog Converter                                                |
| DB         | Data Block (PLC)                                                           |
| DBB        | Data Block Byte (PLC)                                                      |
| DBD        | Data Block Double word (PLC)                                               |
| DBW        | Data Block Word (PLC)                                                      |
| DBX        | Data block bit (PLC)                                                       |
| DDE        | Dynamic Data Exchange                                                      |
| DDS        | Drive Data Set: Drive data set                                             |
| DIN        | Deutsche Industrie Norm                                                    |
| DIO        | Data Input/Output: Data transfer display                                   |
| DIR        | Directory: Directory                                                       |
| DLL        | Dynamic Link Library                                                       |
| DO         | Drive Object                                                               |
| DPM        | Dual Port Memory                                                           |
| DPR        | Dual Port RAM                                                              |
| DRAM       | Dynamic memory (non-buffered)                                              |
| DRF        | Differential Resolver Function: Differential revolver function (handwheel) |
| DRIVE-CLiQ | Drive Component Link with IQ                                               |
| DRY        | Dry Run: Dry run feedrate                                                  |
| DSB        | Decoding Single Block: Decoding single block                               |
| DSC        | Dynamic Servo Control / Dynamic Stiffness Control                          |
| DW         | Data Word                                                                  |
| DWORD      | Double Word (currently 32 bits)                                            |

| E   |                                 |
|-----|---------------------------------|
| I   | Input                           |
| EES | Execution from External Storage |

| <b>E</b>             |                                                                                              |
|----------------------|----------------------------------------------------------------------------------------------|
| I/O                  | Input/Output                                                                                 |
| ENC                  | Encoder: Actual value encoder                                                                |
| EFM                  | Compact I/O module (PLC I/O module)                                                          |
| ESD                  | Electrostatic Sensitive Devices                                                              |
| EMC                  | ElectroMagnetic Compatibility                                                                |
| EN                   | European standard                                                                            |
| ENC                  | Encoder: Actual value encoder                                                                |
| EnDat                | Encoder interface                                                                            |
| EPROM                | Erasable Programmable Read Only Memory: Erasable, electrically programmable read-only memory |
| ePS Network Services | Services for Internet-based remote machine maintenance                                       |
| EQN                  | Designation for an absolute encoder with 2048 sine signals per revolution                    |
| ES                   | Engineering System                                                                           |
| ESR                  | Extended Stop and Retract                                                                    |
| ETC                  | ETC key ">"; softkey bar extension in the same menu                                          |

| <b>F</b> |                                                                                                                                       |
|----------|---------------------------------------------------------------------------------------------------------------------------------------|
| FB       | Function Block (PLC)                                                                                                                  |
| FC       | Function Call: Function Block (PLC)                                                                                                   |
| FEPRM    | Flash EPROM: Read and write memory                                                                                                    |
| FIFO     | First In First Out: Memory that works without address specification and whose data is read in the same order in which they was stored |
| FIPO     | Fine interpolator                                                                                                                     |
| FPU      | Floating Point Unit: Floating Point Unit                                                                                              |
| CRC      | Cutter Radius Compensation                                                                                                            |
| FST      | Feed Stop: Feedrate stop                                                                                                              |
| FBD      | Function Block Diagram (PLC programming method)                                                                                       |
| FW       | Firmware                                                                                                                              |

| <b>G</b> |                                                                                                     |
|----------|-----------------------------------------------------------------------------------------------------|
| GC       | Global Control (PROFIBUS: Broadcast telegram)                                                       |
| GDIR     | Global part program memory                                                                          |
| GEO      | Geometry, e.g. geometry axis                                                                        |
| GIA      | Gear Interpolation dAta: Gear interpolation data                                                    |
| GND      | Signal Ground                                                                                       |
| GP       | Basic program (PLC)                                                                                 |
| GS       | Gear Stage                                                                                          |
| GSD      | Device master file for describing a PROFIBUS slave                                                  |
| GSDML    | Generic Station Description Markup Language: XML-based description language for creating a GSD file |
| GUD      | Global User Data: Global user data                                                                  |

| H    |                                                   |
|------|---------------------------------------------------|
| HEX  | Abbreviation for hexadecimal number               |
| AuxF | Auxiliary function                                |
| HLA  | Hydraulic linear drive                            |
| HMI  | Human Machine Interface: SINUMERIK user interface |
| MSD  | Main Spindle Drive                                |
| HW   | Hardware                                          |

| I   |                                                               |
|-----|---------------------------------------------------------------|
| IBN | Commissioning                                                 |
| ICA | Interpolatory compensation                                    |
| IM  | Interface Module: Interconnection module                      |
| IMR | Interface Module Receive: Interface module for receiving data |
| IMS | Interface Module Send: Interface module for sending data      |
| INC | Increment: Increment                                          |
| INI | Initializing Data: Initializing data                          |
| IPO | Interpolator                                                  |
| ISA | Industry Standard Architecture                                |
| ISO | International Standardization Organization                    |

| J   |                     |
|-----|---------------------|
| JOG | Jogging: Setup mode |

| K             |                                         |
|---------------|-----------------------------------------|
| $K_v$         | Gain factor of control loop             |
| $K_p$         | Proportional gain                       |
| $K_{\bar{U}}$ | Transformation ratio                    |
| LAD           | Ladder Diagram (PLC programming method) |

| L   |                                                      |
|-----|------------------------------------------------------|
| LAI | Logic Machine Axis Image: Logical machine axes image |
| LAN | Local Area Network                                   |
| LCD | Liquid Crystal Display: Liquid crystal display       |
| LED | Light Emitting Diode: Light-emitting diode           |
| LF  | Line Feed                                            |
| PMS | Position Measuring System                            |
| LR  | Position controller                                  |
| LSB | Least Significant Bit: Least significant bit         |
| LUD | Local User Data: User data (local)                   |



| <b>M</b> |                                              |
|----------|----------------------------------------------|
| MAC      | Media Access Control                         |
| MAIN     | Main program: Main program (OB1, PLC)        |
| MB       | Megabyte                                     |
| MCI      | Motion Control Interface                     |
| MCIS     | Motion Control Information System            |
| MCP      | Machine Control Panel: Machine control panel |
| MD       | Machine Data                                 |
| MDA      | Manual Data Automatic: Manual input          |
| MDS      | Motor Data Set: Motor data set               |
| MSGW     | Message Word                                 |
| MCS      | Machine Coordinate System                    |
| MM       | Motor Module                                 |
| MPF      | Main Program File: Main program (NC)         |
| MCP      | Machine control panel                        |

| <b>N</b> |                                                                                    |
|----------|------------------------------------------------------------------------------------|
| NC       | Numerical Control: Numerical Control                                               |
| NCK      | Numerical Control Kernel: NC kernel with block preparation, traversing range, etc. |
| NCU      | Numerical Control Unit: NCK hardware unit                                          |
| NRK      | Name for the operating system of the NCK                                           |
| IS       | Interface Signal                                                                   |
| NURBS    | Non-Uniform Rational B-Spline                                                      |
| WO       | Work Offset                                                                        |
| NX       | Numerical Extension: Axis expansion board                                          |

| <b>O</b> |                                                                          |
|----------|--------------------------------------------------------------------------|
| OB       | Organization block in the PLC                                            |
| OEM      | Original Equipment Manufacturer                                          |
| OP       | Operator Panel: Operating equipment                                      |
| OPI      | Operator Panel Interface: Interface for connection to the operator panel |
| OPT      | Options: Options                                                         |
| OLP      | Optical Link Plug: Fiber optic bus connector                             |
| OSI      | Open Systems Interconnection: Standard for computer communications       |

| <b>P</b> |                                                   |
|----------|---------------------------------------------------|
| PIQ      | Process Image Output                              |
| PII      | Process Image Input                               |
| PC       | Personal Computer                                 |
| PCIN     | Name of the SW for data exchange with the control |

| <b>P</b> |                                                                                                                                                      |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| PCMCIA   | Personal Computer Memory Card International Association: Plug-in memory card standardization                                                         |
| PCU      | PC Unit: PC box (computer unit)                                                                                                                      |
| PG       | Programming device                                                                                                                                   |
| PKE      | Parameter identification: Part of a PIV                                                                                                              |
| PIV      | Parameter identification: Value (parameterizing part of a PPO)                                                                                       |
| PLC      | Programmable Logic Control: Adaptation control                                                                                                       |
| PN       | PROFINET                                                                                                                                             |
| PNO      | PROFIBUS user organization                                                                                                                           |
| PO       | POWER ON                                                                                                                                             |
| POU      | Program Organization Unit                                                                                                                            |
| POS      | Position/positioning                                                                                                                                 |
| POSMO A  | Positioning Motor Actuator: Positioning motor                                                                                                        |
| POSMO CA | Positioning Motor Compact AC: Complete drive unit with integrated power and control module as well as positioning unit and program memory; AC infeed |
| POSMO CD | Positioning Motor Compact DC: Like CA but with DC infeed                                                                                             |
| POSMO SI | Positioning Motor Servo Integrated: Positioning motor, DC infeed                                                                                     |
| PPO      | Parameter Process data Object: Cyclic data telegram for PROFIBUS DP transmission and "Variable speed drives" profile                                 |
| PPU      | Panel Processing Unit (central hardware for a panel-based CNC, e.g SINUMERIK 828D)                                                                   |
| PROFIBUS | Process Field Bus: Serial data bus                                                                                                                   |
| PRT      | Program Test                                                                                                                                         |
| PSW      | Program control word                                                                                                                                 |
| PTP      | Point-To-Point: Point-To-Point                                                                                                                       |
| PUD      | Program global User Data: Program-global user variables                                                                                              |
| PZD      | Process data: Process data part of a PPO                                                                                                             |

| <b>Q</b> |                             |
|----------|-----------------------------|
| QEC      | Quadrant Error Compensation |

| <b>R</b> |                                                                                                                                  |
|----------|----------------------------------------------------------------------------------------------------------------------------------|
| RAM      | Random Access Memory: Read/write memory                                                                                          |
| REF      | REFeRence point approach function                                                                                                |
| REPOS    | REPOSition function                                                                                                              |
| RISC     | Reduced Instruction Set Computer: Type of processor with small instruction set and ability to process instructions at high speed |
| ROV      | Rapid Override: Input correction                                                                                                 |
| RP       | R Parameter, arithmetic parameter, predefined user variable                                                                      |
| RPA      | R Parameter Active: Memory area on the NCK for R parameter numbers                                                               |
| RPY      | Roll Pitch Yaw: Rotation type of a coordinate system                                                                             |
| RTLI     | Rapid Traverse Linear Interpolation: Linear interpolation during rapid traverse motion                                           |

| <b>R</b> |                                                              |
|----------|--------------------------------------------------------------|
| RTS      | Request To Send: Control signal of serial data interfaces    |
| RTCP     | Real Time Control Protocol                                   |
| <b>S</b> |                                                              |
| SA       | Synchronized Action                                          |
| SBC      | Safe Brake Control: Safe Brake Control                       |
| SBL      | Single Block: Single block                                   |
| SBR      | Subroutine: Subprogram (PLC)                                 |
| SD       | Setting Data                                                 |
| SDB      | System Data Block                                            |
| SEA      | Setting Data Active: Identifier (file type) for setting data |
| SERUPRO  | SEArch RUn by PROgram test: Search run by program test       |
| SFB      | System Function Block                                        |
| SFC      | System Function Call                                         |
| SGE      | Safety-related input                                         |
| SGA      | Safety-related output                                        |
| SH       | Safe standstill                                              |
| SIM      | Single in Line Module                                        |
| SK       | Softkey                                                      |
| SKP      | Skip: Function for skipping a part program block             |
| SLM      | Synchronous Linear Motor                                     |
| SM       | Stepper Motor                                                |
| SMC      | Sensor Module Cabinet Mounted                                |
| SME      | Sensor Module Externally Mounted                             |
| SMI      | Sensor Module Integrated                                     |
| SPF      | Sub Routine File: Subprogram (NC)                            |
| PLC      | Programmable Logic Controller                                |
| SRAM     | Static RAM (non-volatile)                                    |
| TNRC     | Tool Nose Radius Compensation                                |
| SRM      | Synchronous Rotary Motor                                     |
| LEC      | Leadscrew Error Compensation                                 |
| SSI      | Serial Synchronous Interface: Synchronous serial interface   |
| SSL      | Block search                                                 |
| STW      | Control word                                                 |
| GWPS     | Grinding Wheel Peripheral Speed                              |
| SW       | Software                                                     |
| SYF      | System Files: System files                                   |
| SYNACT   | SYNchronized ACTION: Synchronized Action                     |

| <b>T</b> |                                                                                               |
|----------|-----------------------------------------------------------------------------------------------|
| TB       | Terminal Board (SINAMICS)                                                                     |
| TCP      | Tool Center Point: Tool tip                                                                   |
| TCP/IP   | Transport Control Protocol / Internet Protocol                                                |
| TCU      | Thin Client Unit                                                                              |
| TEA      | Testing Data Active: Identifier for machine data                                              |
| TIA      | Totally Integrated Automation                                                                 |
| TM       | Terminal Module (SINAMICS)                                                                    |
| TO       | Tool Offset: Tool offset                                                                      |
| TOA      | Tool Offset Active: Identifier (file type) for tool offsets                                   |
| TRANSMIT | Transform Milling Into Turning: Coordination transformation for milling operations on a lathe |
| TTL      | Transistor-Transistor Logic (interface type)                                                  |
| TZ       | Technology cycle                                                                              |

| <b>U</b> |                              |
|----------|------------------------------|
| UFR      | User Frame: Work offset      |
| SR       | Subprogram                   |
| USB      | Universal Serial Bus         |
| UPS      | Uninterruptible Power Supply |

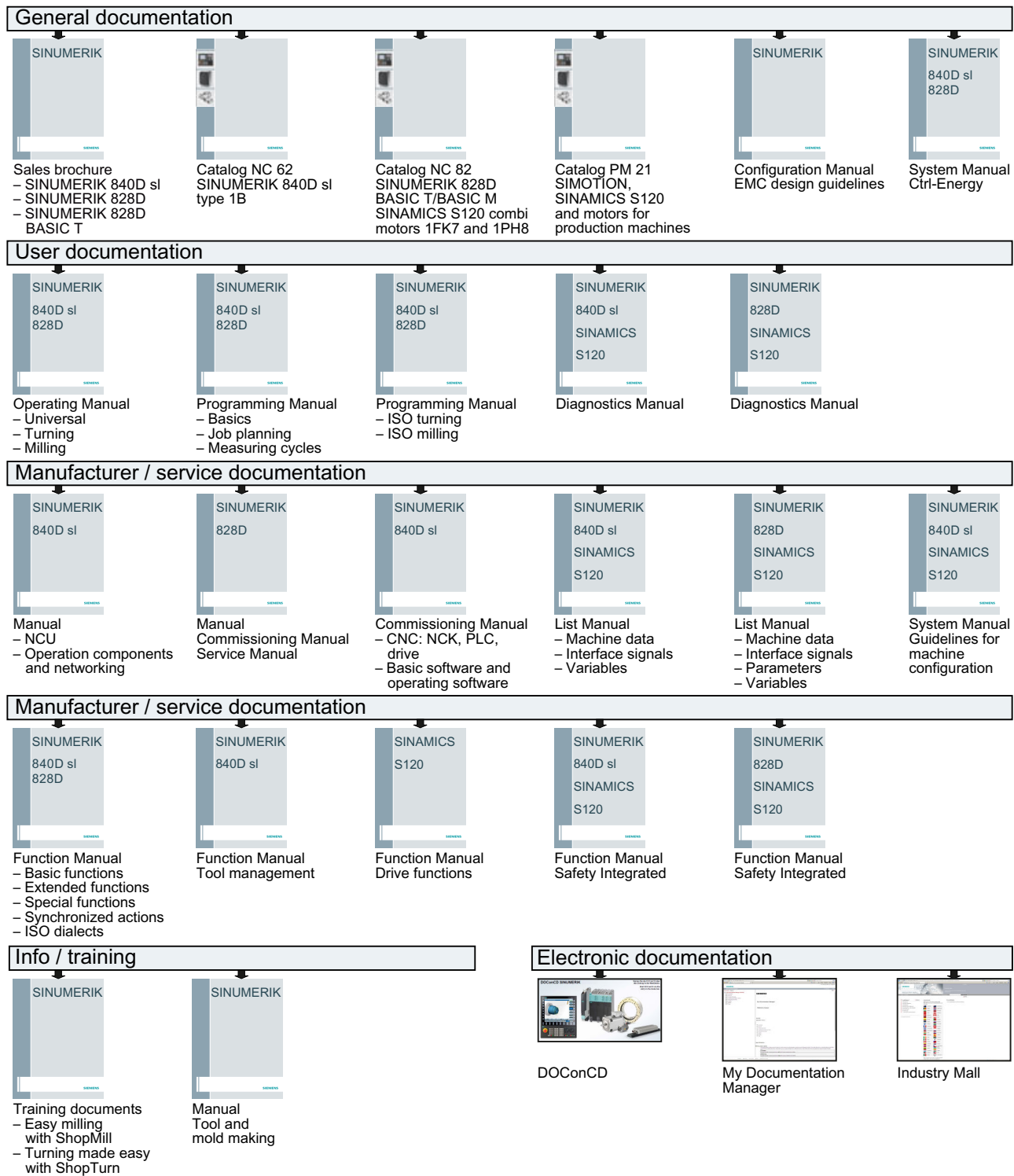
| <b>V</b> |                                                                                 |
|----------|---------------------------------------------------------------------------------|
| VDI      | Internal communication interface between NCK and PLC                            |
| VDI      | Verein Deutscher Ingenieure [Association of German Engineers]                   |
| VDE      | Verband Deutscher Elektrotechniker [Association of German Electrical Engineers] |
| VI       | Voltage Input                                                                   |
| VO       | Voltage Output                                                                  |
| FDD      | Feed Drive                                                                      |

| <b>W</b> |                                          |
|----------|------------------------------------------|
| SAR      | Smooth Approach and Retraction           |
| WCS      | Workpiece Coordinate System              |
| T        | Tool                                     |
| TLC      | Tool Length Compensation                 |
| WOP      | Workshop-Oriented Programming            |
| WPD      | Workpiece Directory: Workpiece directory |
| TRC      | Tool Radius Compensation                 |
| T        | Tool                                     |
| TO       | Tool Offset                              |
| TM       | Tool Management                          |
| TC       | Tool change                              |

|          |                            |
|----------|----------------------------|
| <b>X</b> |                            |
| XML      | Extensible Markup Language |

|          |                                                 |
|----------|-------------------------------------------------|
| <b>Z</b> |                                                 |
| WOA      | Work Offset Active: Identifier for work offsets |
| ZSW      | Status word (of drive)                          |

## A.2 Documentation overview



# Glossary

## Absolute dimensions

A destination for an axis motion is defined by a dimension that refers to the origin of the currently active coordinate system. See → Incremental dimension

## Acceleration with jerk limitation

In order to optimize the acceleration response of the machine whilst simultaneously protecting the mechanical components, it is possible to switch over in the machining program between abrupt acceleration and continuous (jerk-free) acceleration.

## Address

An address is the identifier for a certain operand or operand range, e.g. input, output, etc.

## Alarms

All → messages and alarms are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

1. Alarms and messages in the part program:  
Alarms and messages can be displayed in plain text directly from the part program.
2. Alarms and messages from the PLC:  
Alarms and messages for the machine can be displayed in plain text from the PLC program.  
No additional function block packages are required for this purpose.

## Archiving

Reading out of files and/or directories on an **external** memory device.

## Asynchronous subprogram

Part program that can be started asynchronously to (independently of) the current program status using an interrupt signal (e.g. "Rapid NC input" signal).

## Automatic

Operating mode of the controller (block sequence operation according to DIN): Operating mode for NC systems in which a → subprogram is selected and executed continuously.

## Auxiliary functions

Auxiliary functions enable → part programs to transfer → parameters to the → PLC, which then trigger reactions defined by the machine manufacturer.

## Axes

In accordance with their functional scope, the CNC axes are subdivided into:

- Axes: Interpolating path axes
- Auxiliary axes: Non-interpolating feed and positioning axes with an axis-specific feedrate. Auxiliary axes are not involved in actual machining, e.g. tool feeder, tool magazine.

## Axis address

See → Axis name

## Axis name

To ensure clear identification, all channel and → machine axes of the control system must be designated with unique names in the channel and control system. The → geometry axes are called X, Y, Z. The rotary axes rotating around the geometry axes → are called A, B, C.

## Backlash compensation

Compensation for a mechanical machine backlash, e.g. backlash on reversal for ball screws. Backlash compensation can be entered separately for each axis.

## Backup battery

The backup battery ensures that the → user program in the → CPU is stored so that it is safe from power failure and so that specified data areas and bit memory, timers and counters are stored retentively.

## Basic axis

Axis whose setpoint or actual value position forms the basis of the calculation of a compensation value.

## Basic Coordinate System

Cartesian coordinate system which is mapped by transformation onto the machine coordinate system.

The programmer uses axis names of the basic coordinate system in the → part program. The basic coordinate system exists parallel to the → machine coordinate system if no → transformation is active. The difference lies in the → axis names.



**Baud rate**

Rate of data transfer (bits/s).

**Blank**

Workpiece as it is before it is machined.

**Block**

"Block" is the term given to any files required for creating and processing programs.

**Block search**

For debugging purposes or following a program abort, the "Block search" function can be used to select any location in the part program at which the program is to be started or resumed.

**Booting**

Loading the system program after power ON.

**C axis**

Axis around which the tool spindle describes a controlled rotational and positioning motion.

**C spline**

The C spline is the most well-known and widely used spline. The transitions at the interpolation points are continuous, both tangentially and in terms of curvature. 3rd order polynomials are used.

**Channel**

A channel is characterized by the fact that it can process a → part program independently of other channels. A channel exclusively controls the axes and spindles assigned to it. Part program runs of different channels can be coordinated through → synchronization.

**Circular interpolation**

The → tool moves on a circle between specified points on the contour at a given feedrate, and the workpiece is thereby machined.

**CNC**

See → NC

Computerized Numerical Control: includes the components → NCK, → PLC, HMI, → COM.

## **CNC**

See → NC

Computerized Numerical Control: includes the components → NCK, → PLC, HMI, → COM.

## **COM**

Component of the NC for the implementation and coordination of communication.

## **Compensation axis**

Axis with a setpoint or actual value modified by the compensation value

## **Compensation table**

Table containing interpolation points. It provides the compensation values of the compensation axis for selected positions on the basic axis.

## **Compensation value**

Difference between the axis position measured by the encoder and the desired, programmed axis position.

## **Continuous-path mode**

The objective of continuous-path mode is to avoid substantial deceleration of the → path axes at the part program block boundaries and to change to the next block at as close to the same path velocity as possible.

## **Contour**

Contour of the → workpiece

## **Contour monitoring**

The following error is monitored within a definable tolerance band as a measure of contour accuracy. An unacceptably high following error can cause the drive to become overloaded, for example. In such cases, an alarm is output and the axes are stopped.

## **Coordinate system**

See → Machine coordinate system, → Workpiece coordinate system

## **CPU**

Central processing unit, see → PLC

**Curvature**

The curvature  $k$  of a contour is the inverse of radius  $r$  of the nestling circle in a contour point ( $k = 1/r$ ).

**Cycles**

Protected subprograms for execution of repetitive machining operations on the → workpiece.

**Data block**

1. Data unit of the → PLC that → HIGHSTEP programs can access.
2. Data unit of the → NC: Data modules contain data definitions for global user data. This data can be initialized directly when it is defined.

**Data word**

Two-byte data unit within a → data block.

**Diagnostics**

1. Operating area of the controller.
2. The controller has a self-diagnostics program as well as test functions for servicing purposes: status, alarm, and service displays

**Dimensions specification, metric and inches**

Position and pitch values can be programmed in inches in the machining program. Irrespective of the programmable dimensions (*G70/G71*), the controller is set to a basic system.

**DRF**

Differential Resolver Function: NC function which generates an incremental zero offset in Automatic mode in conjunction with an electronic handwheel.

**Drive**

The drive is the unit of the CNC that performs the speed and torque control based on the settings of the NC.

**Dynamic feedforward control**

Inaccuracies in the → contour due to following errors can be practically eliminated using dynamic, acceleration-dependent feedforward control. This results in excellent machining accuracy even at high → path velocities. Feedforward control can be selected and deselected on an axis-specific basis via the → part program.

## **Editor**

The editor makes it possible to create, edit, extend, join, and import programs/texts/program blocks.

## **Exact stop**

When an exact stop statement is programmed, the position specified in a block is approached exactly and, if necessary, very slowly. To reduce the approach time, → exact stop limits are defined for rapid traverse and feed.

## **Exact stop limit**

When all path axes reach their exact stop limits, the controller responds as if it had reached its precise destination point. A block advance of the → part program occurs.

## **External zero offset**

Zero offset specified by the → PLC.

## **Fast retraction from the contour**

When an interrupt occurs, a motion can be initiated via the CNC machining program, enabling the tool to be quickly retracted from the workpiece contour that is currently being machined. The retraction angle and the distance retracted can also be parameterized. An interrupt routine can also be executed following the fast retraction.

## **Feed override**

The programmed velocity is overridden by the current velocity setting made via the → machine control panel or from the → PLC (0 to 200%). The feedrate can also be corrected by a programmable percentage factor (1 to 200%) in the machining program.

## **Finished-part contour**

Contour of the finished workpiece. See → Raw part.

## **Fixed machine point**

Point that is uniquely defined by the machine tool, e.g. machine reference point.

## **Fixed-point approach**

Machine tools can approach fixed points such as a tool change point, loading point, pallet change point, etc. in a defined way. The coordinates of these points are stored in the controller. The controller moves the relevant axes in → rapid traverse, whenever possible.

**Frame**

A frame is an arithmetic rule that transforms one Cartesian coordinate system into another Cartesian coordinate system. A frame contains the following components: → zero offset, → rotation, → scaling, → mirroring.

**Geometry**

Description of a → workpiece in the → workpiece coordinate system.

**Geometry axis**

The geometry axes form the 2 or 3-dimensional → workpiece coordinate system in which, in → part programs, the geometry of the workpiece is programmed.

**Ground**

Ground is taken as the total of all linked inactive parts of a device which will not become live with a dangerous contact voltage even in the event of a malfunction.

**Helical interpolation**

The helical interpolation function is ideal for machining internal and external threads using form milling cutters and for milling lubrication grooves.

The helix comprises two motions:

- Circular motion in one plane
- A linear motion perpendicular to this plane

**High-level CNC language**

The high-level language is used to write NC programs, → synchronized actions, and → cycles. It provides: control structures → user-defined variables, → system variables, → macro programming.

**High-speed digital inputs/outputs**

The digital inputs can be used for example to start fast CNC program routines (interrupt routines). High-speed, program-driven switching functions can be initiated via the digital CNC outputs

**HIGHSTEP**

Summary of programming options for → PLCs of the AS300/AS400 system.

## **HW Config**

SIMATIC S7 tool for the configuration and parameterization of hardware components within an S7 project

## **Identifier**

In accordance with DIN 66025, words are supplemented using identifiers (names) for variables (arithmetic variables, system variables, user variables), subprograms, key words, and words with multiple address letters. These supplements have the same meaning as the words with respect to block format. Identifiers must be unique. It is not permissible to use the same identifier for different objects.

## **Inch measuring system**

Measuring system which defines distances in inches and fractions of inches.

## **Inclined surface machining**

Drilling and milling operations on workpiece surfaces that do not lie in the coordinate planes of the machine can be performed easily using the function "inclined-surface machining".

## **Increment**

Travel path length specification based on number of increments. The number of increments can be stored as → setting data or be selected by means of a suitably labeled key (i.e. 10, 100, 1000, 10000).

## **Incremental dimension**

Also incremental dimension: A destination for axis traversal is defined by a distance to be covered and a direction referenced to a point already reached. See → Absolute dimension.

## **Intermediate blocks**

Motions with selected → tool offset (G41/G42) may be interrupted by a limited number of intermediate blocks (blocks without axis motions in the offset plane), whereby the tool offset can still be correctly compensated for. The permissible number of intermediate blocks which the controller reads ahead can be set in system parameters.

## **Interpolator**

Logic unit of the → NCK that defines intermediate values for the motions to be carried out in individual axes based on information on the end positions specified in the part program.

**Interpolatory compensation**

Mechanical deviations of the machine are compensated for by means of interpolatory compensation functions, such as → leadscrew error, sag, angularity, and temperature compensation.

**Interrupt routine**

Interrupt routines are special → subprograms that can be started by events (external signals) in the machining process. A part program block which is currently being worked through is interrupted and the position of the axes at the point of interruption is automatically saved.

**Inverse-time feedrate**

The time required for the path of a block to be traversed can also be programmed for the axis motion instead of the feed velocity (G93).

**JOG**

Control operating mode (setup mode): In JOG mode, the machine can be set up. Individual axes and spindles can be traversed in JOG mode by means of the direction keys. Additional functions in JOG mode include: → Reference point approach, → Repos, and → Preset (set actual value).

**Key switch**

The key switch on the → machine control panel has four positions that are assigned functions by the operating system of the controller. The key switch has three different colored keys that can be removed in the specified positions.

**Keywords**

Words with specified notation that have a defined meaning in the programming language for → part programs.

**KÜ**

Transformation ratio

**KV**

Servo gain factor, a control variable in a control loop.

**Leading axis**

The leading axis is the → gantry axis that exists from the point of view of the operator and programmer and, thus, can be influenced like a standard NC axis.

### Leadscrew error compensation

Compensation for the mechanical inaccuracies of a leadscrew participating in the feed. The controller uses stored deviation values for the compensation.

### Limit speed

Maximum/minimum (spindle) speed: The maximum speed of a spindle can be limited by specifying machine data, the → PLC or → setting data.

### Linear axis

In contrast to a rotary axis, a linear axis describes a straight line.

### Linear interpolation

The tool travels along a straight line to the destination point while machining the workpiece.

### Load memory

The load memory is the same as the → working memory for the CPU 314 of the → PLC.

### Look Ahead

The **Look Ahead** function is used to achieve an optimal machining speed by looking ahead over an assignable number of traversing blocks.

### Machine axes

Physically existent axes on the machine tool.

### Machine control panel

An operator panel on a machine tool with operating elements such as keys, rotary switches, etc., and simple indicators such as LEDs. It is used to directly influence the machine tool via the PLC.

### Machine coordinate system

A coordinate system, which is related to the axes of the machine tool.

### Machine zero

Fixed point of the machine tool to which all (derived) measuring systems can be traced back.



**Machining channel**

A channel structure can be used to shorten idle times by means of parallel motion sequences, e.g. moving a loading gantry simultaneously with machining. Here, a CNC channel must be regarded as a separate CNC control system with decoding, block preparation and interpolation.

**Macro techniques**

Grouping of a set of statements under a single identifier. The identifier represents the set of consolidated statements in the program.

**Main block**

A block prefixed by ":" introductory block, containing all the parameters required to start execution of a -> part program.

**Main program**

The term "main program" has its origins during the time when part programs were split strictly into main and → subprograms. This strict division no longer exists with today's SINUMERIK NC language. In principle, any part program in the channel can be selected and started. It then runs through in → program level 0 (main program level). Further part programs or → cycles as subprograms can be called up in the main program.

**MDA**

Control operating mode: Manual Data Automatic. In the MDA mode, individual program blocks or block sequences with no reference to a main program or subprogram can be input and executed immediately afterwards through actuation of the NC start key.

**Messages**

All messages programmed in the part program and → alarms detected by the system are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

**Metric measuring system**

Standardized system of units: For length, e.g. mm (millimeters), m (meters).

**Mirroring**

Mirroring reverses the signs of the coordinate values of a contour, with respect to an axis. It is possible to mirror with respect to more than one axis at a time.

**Mode**

An operating concept on a SINUMERIK controller. The following modes are defined: → Jog, → MDA, → Automatic.

## Mode group

Axes and spindles that are technologically related can be combined into one mode group. Axes/spindles of a mode group can be controlled by one or more → channels. The same → mode type is always assigned to the channels of the mode group.

## NC

Numerical Control component of the → CNC that executes the → part programs and coordinates the movements of the machine tool.

## Network

A network is the connection of multiple S7-300 and other end devices, e.g. a programming device via a → connecting cable. A data exchange takes place over the network between the connected devices.

## NRK

Numeric robotic kernel (operating system of → NCK)

## NURBS

The motion control and path interpolation that occurs within the controller is performed based on NURBS (**N**on **U**niform **R**ational **B**-**S**plines). This provides a uniform procedure for all internal interpolations.

## OEM

The scope for implementing individual solutions (OEM applications) has been provided for machine manufacturers, who wish to create their own user interface or integrate technology-specific functions in the controller.

## Offset memory

Data range in the control, in which the tool offset data is stored.

## Oriented spindle stop

Stops the workpiece spindle in a specified angular position, e.g. in order to perform additional machining at a particular location.

## Oriented tool retraction

**RETOOL:** If machining is interrupted (e.g. when a tool breaks), a program command can be used to retract the tool in a user-specified orientation by a defined distance.

**Overall reset**

In the event of an overall reset, the following memories of the → CPU are deleted:

- → Working memory
- Read/write area of → load memory
- → System memory
- → Backup memory

**Override**

Manual or programmable control feature which enables the user to override programmed feedrates or speeds in order to adapt them to a specific workpiece or material.

**Part program**

Series of statements to the NC that act in concert to produce a particular → workpiece. Likewise, this term applies to execution of a particular machining operation on a given → raw part.

**Part program block**

Part of a → part program that is demarcated by a line feed. There are two types: → main blocks and → subblocks.

**Part program management**

Part program management can be organized by → workpieces. The size of the user memory determines the number of programs and the amount of data that can be managed. Each file (programs and data) can be given a name consisting of a maximum of 24 alphanumeric characters.

**Path axis**

Path axes include all machining axes of the → channel that are controlled by the → interpolator in such a way that they start, accelerate, stop, and reach their end point simultaneously.

**Path feedrate**

Path feed affects → path axes. It represents the geometric sum of the feedrates of the → geometry axes involved.

**Path velocity**

The maximum programmable path velocity depends on the input resolution. For example, with a resolution of 0.1 mm the maximum programmable path velocity is 1000 m/min.

## PCIN data transfer program

PCIN is an auxiliary program for sending and receiving CNC user data (e.g. part programs, tool offsets, etc.) via a serial interface. The PCIN program can run in MS-DOS on standard industrial PCs.

## Peripheral module

I/O modules represent the link between the CPU and the process.

I/O modules are:

- → Digital input/output modules
- → Analog input/output modules
- → Simulator modules

## PLC

**Programmable Logic Controller:** → Programmable logic controller. Component of → NC:  
Programmable control for processing the control logic of the machine tool.

## PLC program memory

SINUMERIK 840D sl: The PLC user program, the user data and the basic PLC program are stored together in the PLC user memory.

## PLC programming

The PLC is programmed using the **STEP 7** software. The STEP 7 programming software is based on the **WINDOWS** standard operating system and contains the STEP 5 programming functions with innovative enhancements.

## Polar coordinates

A coordinate system which defines the position of a point on a plane in terms of its distance from the origin and the angle formed by the radius vector with a defined axis.

## Polynomial interpolation

Polynomial interpolation enables a wide variety of curve characteristics to be generated, such as **straight line, parabolic, exponential functions** (SINUMERIK 840D sl).

## Positioning axis

Axis that performs an auxiliary motion on a machine tool (e.g. tool magazine, pallet transport). Positioning axes are axes that do not interpolate with → path axes.

**Pre-coincidence**

Block change occurs already when the path distance approaches an amount equal to a specifiable delta of the end position.

**Program block**

Program blocks contain the main program and subprograms of → part programs.

**Program level**

A part program started in the channel runs as a → main program on program level 0 (main program level). Any part program called up in the main program runs as a → subprogram on a program level 1 ... n of its own.

**Programmable frames**

Programmable → frames enable dynamic definition of new coordinate system output points while the part program is being executed. A distinction is made between absolute definition using a new frame and additive definition with reference to an existing starting point.

**Programmable logic controller**

Programmable logic controllers (PLCs) are electronic controllers, the function of which is stored as a program in the control unit. This means that the layout and wiring of the device do not depend on the function of the controller. The programmable logic control has the same structure as a computer; it consists of a CPU (central module) with memory, input/output modules and an internal bus system. The peripherals and the programming language are matched to the requirements of the control technology.

**Programmable working area limitation**

Limitation of the motion space of the tool to a space defined by programmed limitations.

**Programming key**

Characters and character strings that have a defined meaning in the programming language for → part programs.

**Protection zone**

Three-dimensional zone within the → working area into which the tool tip must not pass.

**Quadrant error compensation**

Contour errors at quadrant transitions, which arise as a result of changing friction conditions on the guideways, can be virtually entirely eliminated with the quadrant error compensation. Parameterization of the quadrant error compensation is performed by means of a circuit test.

## **R parameters**

Arithmetic parameter that can be set or queried by the programmer of the → part program for any purpose in the program.

## **Rapid traverse**

The highest traverse rate of an axis. For example, rapid traverse is used when the tool approaches the → workpiece contour from a resting position or when the tool is retracted from the workpiece contour. The rapid traverse velocity is set on a machine-specific basis using a machine data element.

## **Reference point**

Machine tool position that the measuring system of the → machine axes references.

## **Rotary axis**

Rotary axes apply a workpiece or tool rotation to a defined angular position.

## **Rotation**

Component of a → frame that defines a rotation of the coordinate system around a particular angle.

## **Rounding axis**

Rounding axes rotate a workpiece or tool to an angular position corresponding to an indexing grid. When a grid index is reached, the rounding axis is "in position".

## **RS-232-C**

Serial interface for data input/output. Machining programs as well as manufacturer and user data can be loaded and saved via this interface.

## **Safety functions**

The controller is equipped with permanently active monitoring functions that detect faults in the → CNC, the → PLC, and the machine in a timely manner so that damage to the workpiece, tool, or machine is largely prevented. In the event of a fault, the machining operation is interrupted and the drives stopped. The cause of the malfunction is logged and output as an alarm. At the same time, the PLC is notified that a CNC alarm has been triggered.

## **Scaling**

Component of a → frame that implements axis-specific scale modifications.

**Setting data**

Data which communicates the properties of the machine tool to the NC as defined by the system software.

**Softkey**

A key, whose name appears on an area of the screen. The choice of softkeys displayed is dynamically adapted to the operating situation. The freely assignable function keys (softkeys) are assigned defined functions in the software.

**Software limit switch**

Software limit switches limit the traversing range of an axis and prevent an abrupt stop of the slide at the hardware limit switch. Two value pairs can be specified for each axis and activated separately by means of the → PLC.

**Spline interpolation**

With spline interpolation, the controller can generate a smooth curve characteristic from only a few specified interpolation points of a set contour.

**Standard cycles**

Standard cycles are provided for machining operations which are frequently repeated:

- For the drilling/milling technology
- For turning technology

The available cycles are listed in the "Cycle support" menu in the "Program" operating area. Once the desired machining cycle has been selected, the parameters required for assigning values are displayed in plain text.

**Subblock**

Block preceded by "N" containing information for a sequence, e.g. positional data.

**Subprogram**

The term "subprogram" has its origins during the time when part programs were split strictly into →main and subprograms. This strict division no longer exists with today's SINUMERIK NC language. In principle, any part program or any → cycle can be called up as a subprogram within another part program. It then runs through in the next → program level (x+1) (subprogram level (x+1)).

**Synchronization**

Statements in → part programs for coordination of sequences in different → channels at certain machining points.

## Synchronized actions

1. Auxiliary function output  
During workpiece machining, technological functions (→ auxiliary functions) can be output from the CNC program to the PLC. For example, these auxiliary functions are used to control additional equipment for the machine tool, such as quills, grabbers, clamping chucks, etc.
2. Fast auxiliary function output  
For time-critical switching functions, the acknowledgement times for the → auxiliary functions can be minimized and unnecessary hold points in the machining process can be avoided.

## Synchronized axes

Synchronized axes take the same time to traverse their path as the geometry axes take for their path.

## Synchronized axis

A synchronized axis is the → gantry axis whose set position is continuously derived from the motion of the → leading axis and is, thus, moved synchronously with the leading axis. From the point of view of the programmer and operator, the synchronized axis "does not exist".

## System memory

The system memory is a memory in the CPU in which the following data is stored:

- Data required by the operating system
- The operands timers, counters, markers

## System variable

A variable that exists without any input from the programmer of a → part program. It is defined by a data type and the variable name preceded by the character \$. See → User-defined variable.

## Tapping without compensating chuck

This function allows threads to be tapped without a compensating chuck. By using the interpolating method of the spindle as a rotary axis and the drilling axis, threads can be cut to a precise final drilling depth, e.g. for blind hole threads (requirement: spindles in axis operation).

## Text editor

See → Editor

## TOA area

The TOA area includes all tool and magazine data. By default, this area coincides with the → channel area with regard to the access of the data. However, machine data can be used to



specify that multiple channels share one → TOA unit so that common tool management data is then available to these channels.

## **TOA unit**

Each → TOA area can have more than one TOA unit. The number of possible TOA units is limited by the maximum number of active → channels. A TOA unit includes exactly one tool data block and one magazine data block. In addition, a TOA unit can also contain a toolholder data block (optional).

## **Tool**

Active part on the machine tool that implements machining (e.g. turning tool, milling tool, drill, LASER beam, etc.).

## **Tool nose radius compensation**

Contour programming assumes that the tool is pointed. Because this is not actually the case in practice, the curvature radius of the tool used must be communicated to the controller which then takes it into account. The curvature center is maintained equidistantly around the contour, offset by the curvature radius.

## **Tool offset**

Consideration of the tool dimensions in calculating the path.

## **Tool radius compensation**

To directly program a desired → workpiece contour, the control must traverse an equidistant path to the programmed contour taking into account the radius of the tool that is being used (G41/G42).

## **Transformation**

Additive or absolute zero offset of an axis.

## **Travel range**

The maximum permissible travel range for linear axes is  $\pm 9$  decades. The absolute value depends on the selected input and position control resolution and the unit of measurement (inch or metric).

## **User interface**

The user interface (UI) is the display medium for a CNC in the form of a screen. It features horizontal and vertical softkeys.

## User memory

All programs and data, such as part programs, subprograms, comments, tool offsets, and zero offsets/frames, as well as channel and program user data, can be stored in the shared CNC user memory.

## User program

User programs for the S7-300 automation systems are created using the programming language STEP 7. The user program has a modular layout and consists of individual blocks.

The basic block types are:

- Code blocks  
These blocks contain the STEP 7 commands.
- Data blocks  
These blocks contain constants and variables for the STEP 7 program.

## User-defined variable

Users can declare their own variables for any purpose in the → part program or data block (global user data). A definition contains a data type specification and the variable name. See → System variable.

## Variable definition

A variable definition includes the specification of a data type and a variable name. The variable names can be used to access the value of the variables.

## Velocity control

In order to achieve an acceptable traverse rate in the case of very slight motions per block, an anticipatory evaluation over several blocks (→ Look Ahead) can be specified.

## WinSCP

WinSCP is a freely available open source program for Windows for the transfer of files.

## Working area

Three-dimensional zone into which the tool tip can be moved on account of the physical design of the machine tool. See → Protection zone.

## Working area limitation

With the aid of the working area limitation, the traversing range of the axes can be further restricted in addition to the limit switches. One value pair per axis may be used to describe the protected working area.

**Working memory**

The working memory is a RAM in the → CPU that the processor accesses when processing the application program.

**Workpiece**

Part to be made/machined by the machine tool.

**Workpiece contour**

Set contour of the → workpiece to be created or machined.

**Workpiece coordinate system**

The workpiece coordinate system has its starting point in the → workpiece zero-point. In machining operations programmed in the workpiece coordinate system, the dimensions and directions refer to this system.

**Workpiece zero**

The workpiece zero is the starting point for the → workpiece coordinate system. It is defined in terms of distances to the → machine zero.

**Zero offset**

Specifies a new reference point for a coordinate system through reference to an existing zero point and a → frame.

1. **Settable**  
A configurable number of settable zero offsets are available for each CNC axis. The offsets - which are selected by means of G functions - take effect alternatively.
2. **External**  
In addition to all the offsets which define the position of the workpiece zero, an external zero offset can be overridden by means of the handwheel (DRF offset) or from the PLC.
3. **Programmable**  
Zero offsets can be programmed for all path and positioning axes using the `TRANS` statement.



# Index

## \$

- \$AA\_ACC, 119
- \$AA\_FGREF, 104
- \$AA\_FGROUP, 104
- \$AC\_F\_TYPE, 135
- \$AC\_FGROUP\_MASK, 104
- \$AC\_FZ, 135
- \$AC\_S\_TYPE, 87
- \$AC\_SVC, 87
- \$AC\_TOFF, 77
- \$AC\_TOFFL, 77
- \$AC\_TOFFR, 77
- \$AN\_LANGUAGE\_ON\_HMI, 508
- \$P\_AEP, 278
- \$P\_APDV, 278
- \$P\_APR, 278
- \$P\_F\_TYPE, 135
- \$P\_FGROUP\_MASK, 104
- \$P\_FZ, 135
- \$P\_GWPS, 94
- \$P\_S\_TYPE, 88
- \$P\_SVC, 88
- \$P\_TOFF, 77
- \$P\_TOFFL, 77
- \$P\_TOFFR, 77
- \$P\_WORKAREA\_CS\_COORD\_SYSTEM, 354
- \$P\_WORKAREA\_CS\_LIMIT\_MINUS, 354
- \$P\_WORKAREA\_CS\_LIMIT\_PLUS, 354
- \$P\_WORKAREA\_CS\_MINUS\_ENABLE, 354
- \$P\_WORKAREA\_CS\_PLUS\_ENABLE, 354
- \$PA\_FGREF, 104
- \$PA\_FGROUP, 104
- \$TC\_TP\_MAX\_VELO, 84

## A

- Absolute dimensions, 18
- AC, 143
- ACC, 118
- ACN, 150
- ACP, 150
- Address
  - Value assignment, 38
- Address letters, 444
- Addresses, 379
- ADIS, 295

ADISPOS, 295

ALF

- For rapid retraction during thread cutting, 224

AMIRROR, 329

ANG, 204

ANG1, 204

ANG2, 204

AP, 168

Approach point/angle, 259

AR

- Circular-path programming, 187

AROT, 316

AROTS, 323

ASCALE, 326

ATRANS, 310

Auxiliary function output

- High-speed, 343

- In continuous-path mode, 344

Auxiliary function outputs, 341

Availability

- System-dependent, 5

Axes

- Channel, 372

- Command, 374

- Geometry, 369

- Lead link axis, 376

- Link, 374

- Machine, 371

- Main, 369

- Path, 372

- PLC, 374

- Positioning, 372

- Special, 371

- Synchronized, 373

Axial zero offset, 314

Axis

- Container, 375

- types, 369

## B

Basic coordinate system, 26

Basic offset, 28

Basic zero system, 28

BCS, 26

Binary constant, 384

Block, 34

- End, 37

- end LF, 43

- Length, 37
  - number, 37
- Order of the statements, 37
- Skip, 39
- Blocking point, 22
- Bottleneck
  - Detection, 283
- BZS, 28

## C

- CALCPOSI, 352
- Cartesian coordinates, 16
- CDOF, 281
- CDOF2, 281
- CDON, 281
- CFC, 123
- CFIN, 123
- CFTCP, 123
- Chamfer, 239
- Channel
  - axes, 372
- Character set, 42
- CHF, 239
- CHR, 239
- CIP, 191
- Circular interpolation
  - Helical interpolation, 197
- Circular-path programming
  - Interpolation types, 178
  - With center and end points, 182
  - With interpolation and end points, 191
  - With opening angle and center point, 187
  - With polar coordinates, 189
  - With radius and end point, 185
- Clamping torque
  - fixed stop, 363
- Collision detection, 281
- Command, 34
  - Axes, 374
- Comments, 38
- Compensation
  - Plane, 287
  - Tool length, 59
  - Tool radius, 60
- Constant, 383
- Continuous-path mode, 295
- Contour
  - Approach/leave, 256
  - Calculator, 205
  - element, 163

- Contour corner
  - Chamfering, 239
  - Round, 239
- Contour definition programming, 204
- Convex thread, 228
- Coordinate system
  - Basic, 26
  - Overview, 24
  - Workpiece, 30
- Coordinate transformations (frames), 29
- Coordinates
  - Cartesian, 16
  - Cylindrical, 169
  - Polar, 17
- Corner rounding, 295
- CORROF, 337
- CR, 185
- CROTS, 323
- CT, 193
- CUT2D, 284
- CUT2DF, 284
- CUTCONOF, 287
- CUTCONON, 287
- Cutting edge
  - number, 71
- Cutting edges
  - Center point, 62
  - Number of contour tools, 285
  - Position, 62
  - radius, 62
  - reference point, 289
  - relevant position, 289
- Cutting rate (constant), 88
- Cutting speed, 82
- Cylinder thread, 219
- Cylindrical coordinates, 169

## D

- D..., 70
- D0, 70
- DAC, 157
- DC, 150
- Decimal constant, 383
- DIACYCOFA, 157
- DIAM90, 155
- DIAM90A, 157
- DIAMCHAN, 157
- DIAMCHANA, 157
- DIAMCYCOF, 155
- Diameter programming, 155
- DIAMOF, 155

DIAMOFA, 157  
 DIAMON, 155  
 DIAMONA, 157  
 DIC, 157  
 DILF, 224  
 Dimensions  
     For rotary axes and spindles, 150  
     in inches, 152  
     in millimeters, 152  
     in the diameter, 155  
     in the radius, 155  
     Options, 142  
 Dimensions in inches, 152  
 Dimensions in millimeters, 152  
 DIN 66217, 25  
 Direction of rotation, 25  
 DISC, 264  
 DISCL, 267  
 DISR, 267  
 DISRP, 267  
 Distance  
     Calculation, 378  
 DITE, 221  
 DITS, 221  
 DRFOF, 337  
 Drill, 65  
 Dwell time, 365

## E

Exact stop, 293  
 Extended address notation, 380

## F

F...  
     For feedrate, 97  
     For linear interpolation, 176  
     For thread cutting G34 G35, 223  
 FA, 114  
 Face thread, 219  
 FAD, 267  
 FB, 129  
 FD, 120  
 FDA, 120  
 Feedrate  
     for path axes, 99  
     for positioning axes, 114  
     for synchronized axes, 101  
     Inverse-time, 100  
     Override, 122

-override, 117  
 -rate, 176  
 Rules, 97  
 units, 102  
 with handwheel override, 120

FGREF, 97  
 FGROU, 97  
 Fixed point  
     Approach, 356  
 Fixed stop, 361  
 FL, 97  
 FMA, 126  
 FP, 356  
 FPR, 114  
 FPRAOF, 114  
 FPRAON, 114  
 Frame  
     Deselect, 336  
     -mirroring, 329  
     -scaling, 326  
     -Statements, 307  
 Frames, 305  
 FRC, 239  
 FRCM, 239  
 Function  
     Predefined, 496

## G

G commands  
     Group overview, 454  
 G0, 172  
 G1, 176  
 G110, 166  
 G111, 166  
 G112, 166  
 G140, 267  
 G141, 267  
 G142, 267  
 G143, 267  
 G147, 267  
 G148, 267  
 G153  
     For deselect frame, 336  
     For zero offset, 137  
 G17, 139  
 G18, 139  
 G19, 139  
 G2, 178  
 G247, 267  
 G248, 267

G25  
     Spindle speed limitation, 95  
     Working area limitation, 349  
 G26  
     Spindle speed limitation, 95  
     Working area limitation, 349  
 G3, 178  
 G33, 214  
 G331, 234  
 G332, 234  
 G335, 228  
 G336, 228  
 G34, 223  
 G340, 267  
 G341, 267  
 G347, 267  
 G348, 267  
 G35, 223  
 G4, 365  
 G40, 247  
 G41, 247  
 G42, 247  
 G450, 264  
 G451, 264  
 G460, 278  
 G461, 278  
 G462, 278  
 G500  
     For zero offset, 137  
 G505 ... G599, 137  
 G53  
     For deselect frame, 336  
     For zero offset, 137  
 G54 ... G57, 137  
 G58, 314  
 G59, 314  
 G60, 293  
 G601, 293  
 G602, 293  
 G603, 293  
 G63, 238  
 G64, 295  
 G641, 295  
 G642, 295  
 G643, 295  
 G644, 295  
 G645, 295  
 G70, 152  
 G700, 152  
 G71, 152  
 G710, 152  
 G74, 355

G75, 356  
 G9, 293  
 G90, 143  
 G91, 145  
 G93, 97  
 G94, 97  
 G95, 97  
 G96, 88  
 G961, 88  
 G962, 88  
 G97, 88  
 G971, 88  
 G972, 88  
 G973, 88  
 Geometry  
     -axes, 369  
 Grinding tools, 66  
 Grinding wheel  
     Peripheral speed, 93  
 GWPS, 93  
 GWPSOF, 93  
 GWPSON, 93

## H

Handwheel  
     Override, 120  
 Helix interpolation, 197  
 Hexadecimal constant, 384

## I

I...  
     For circular interpolation, 178  
     For tapping without compensating chuck, 234  
     For thread cutting G33, 214  
     For thread cutting G34 G35, 223  
 IC, 145  
 Identifier, 33  
     for character string, 43  
     for special numerical values, 43  
     for system variables, 43  
 Incremental dimension, 20  
 Incremental dimensions, 20, 145  
 INTEGER constant, 383  
 Internal preprocessing stop, 366  
 Interpolation  
     Linear, 174  
     Non-linear, 174  
 INVCCW, 199  
 INVCW, 199



Involute, 199  
IR, 228

## J

J...  
    For circular interpolation, 178  
    For tapping without compensating chuck, 234  
    For thread cutting G34 G35, 223  
JR, 228

## K

K...  
    For circular interpolation, 178  
    For tapping without compensating chuck, 234  
    For thread cutting G33, 214  
    For thread cutting G34 G35, 223  
KONT, 256  
KONTC, 256  
KONTT, 256  
KR, 228

## L

Left-hand thread, 216  
LF, 37  
LFOF, 224  
LFON, 224  
LFPOS, 224  
LFTXT, 224  
LFWP, 224  
LIMS, 88  
LINE FEED, 37  
Link  
    Axes, 374  
    Lead link axis, 376  
LookAhead, 300

## M

M functions, 344  
M..., 344  
M0, 344  
M1, 344  
M19  
    For spindle positioning, 109  
    M functions, 344  
M2, 344  
M3, 79

M4, 79  
M40, 344  
M41, 344  
M42, 344  
M43, 344  
M44, 344  
M45, 344  
M5, 79  
M6, 52, 344  
M70, 109  
Machine coordinate system, 24  
Machines  
    -axes, 371  
Main entry, 160  
Master spindle, 371  
MCS, 24  
MD10651, 229  
Messages, 347  
Milling tools, 63  
MIRROR, 329  
Modal, 36  
Monitoring  
    -fixed stop, 363  
MSG, 347

## N

NC high-level language, 35  
NC program  
    Creating, 41  
NC programming  
    Character set, 42  
Non-modal, 36  
NORM, 256  
Numeric extension, 380

## O

OFFN, 247  
Offset  
    Tool length, 73  
    Tool radius, 73  
Operation, 34  
Optional stop, 346  
OVR, 117  
OVRA, 117  
OVERRAP, 117

## P

PAROT, 334

PAROTOF, 334  
 Path axes, 372  
 PLC  
     -axes, 374  
 PM, 267  
 Polar angle, 18  
 Polar coordinates, 17  
 Polar radius, 17  
 Pole, 166  
 POLF  
     For rapid retraction during thread cutting, 224  
 POLFMASK  
     For rapid retraction during thread cutting, 224  
 POLFMLIN  
     For rapid retraction during thread cutting, 224  
 POS, 105  
 POSA, 105  
 Position offset, 337  
 Positioning axes, 372  
 POSP, 105  
 PR, 267  
 Preprocessing stop  
     Internal, 366  
 Procedure  
     Predefined, 474  
 Program  
     End, 36, 346  
     Header, 43  
     name, 33  
 Programmed stop, 346  
 Punch tape format, 34

## Q

QU, 343

## R

RAC, 157  
 Radius  
     Effective, 103  
 Radius programming, 155  
 Rapid retraction  
     Thread cutting, 224  
 Rapid traverse motion, 172  
 REAL constant, 383  
 Reference point, 23  
 Reference points, 22  
 Reference radius, 103  
 Retraction  
     Direction for thread cutting, 225

RIC, 157  
 Right-hand thread, 216  
 RND, 239  
 RNDM, 239  
 ROT, 316  
 Rotation  
     Programmable, 316  
 ROTS, 323  
 Rounding, 239  
 RP, 168  
 RPL, 316  
 RTLIOF, 172  
 RTLION, 172

## S

S, 79  
 SAR, 267  
 SCALE, 326  
 Scale factor, 326  
 SCC, 88  
 SD42440, 146  
 SD42442, 146  
 SD42465, 301  
 SD43240, 111  
 SD43250, 111  
 Search for reference, 355  
 SETMS, 79  
 SF, 214  
 Skip levels, 40  
 Slotting saw, 69  
 SPCOF, 108  
 SPCON, 108  
 Special axes, 371  
 Special characters, 42, 43  
 Special tools, 69  
 Spindle  
     direction of rotation, 79  
     M functions, 346  
     Main, 371  
     -mode, position-controlled, 108  
     Positioning, 109  
     speed, 79, 82  
     Speed limitation, 95  
 SPOS, 109  
 SPOSA, 109  
 SR, 126  
 SRA, 126  
 ST, 126  
 STA, 126  
 Start point offset  
     For thread cutting, 215

Starting point, 23  
 Starting point - target point, 163  
 Stop  
   At the end of the cycle, 346  
   Optional, 346  
   Programmed, 346  
 Straight lines  
   -interpolation, 176  
 SUPA  
   For deselect frame, 336  
   For zero offset, 137  
 S-value  
   Interpretation, 81  
 SVC, 82  
 Synchronized  
   Axes, 373  
 System  
   -dependent availability, 5  
 SZS, 29

## T

T0, 51  
 Tapered thread, 220  
 Tapping  
   With compensating chuck, 238  
   Without compensating chuck, 234  
 Target point, 163  
 Thread  
   Chain, 215  
   -cutting G33, 214  
   -cutting G34 G35, 223  
   -direction of rotation, 216  
   -lead, 223  
   -multiple, 215  
 Three-finger rule, 25  
 TOFF, 73  
 TOFFL, 73  
 TOFFR, 73  
 TOFRAME, 334  
 TOFRAMEX, 334  
 TOFRAMEY, 334  
 TOFRAMEZ, 334  
 Tool  
   change point, 23  
   -change with M6, 52  
   change with T command, 51  
   Cutting edge, 70  
   Group, 63  
   Length compensation, 59  
   -offset memory, 61  
   Radius compensation, 60, 247

Tip, 62  
 Type, 63  
 Type number, 63  
 Tool Offset  
   Offset, 73  
 Tool radius compensation  
   At outside corners, 264  
   CUT2D, 285  
   CUT2DF, 286  
 Tool speed  
   maximum, 84  
 Toolholder  
   reference point, 23  
 TOROT, 334  
 TOROTO, 334  
 TOROTX, 334  
 TOROTY, 334  
 TOROTZ, 334  
 TRANS, 310  
 Transition circle, 284  
 Transition radius, 265  
 Transverse axis, 162  
 Travel command, 163  
 TURN, 197  
 Turning tools, 67

## V

Value assignment, 38

## W

WAITMC, 105  
 WAITP, 105  
 WAITS, 109  
 WALCS<n>, 353  
 WALCS0, 353  
 WALIMOF, 349  
 WALIMON, 349  
 WCS, 30  
   Align on workpiece, 334  
 Working area limitation  
   in BCS, 349  
 Working plane, 21  
 Workpiece  
   Contour, 164  
 WRTPR, 348

## X

X..., 165

## **Y**

Y..., 165

## **Z**

Z..., 165

Zero frame, 137

Zero offset

    Axial, 314

    Settable, 29, 137

Zero point

    Machine, 22

    -offset, 310

    Workpiece, 22

Zero points

    For turning, 161

Zero system

    Basic, 28

    Settable, 29