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SINUMERIK

SINUMERIK 808D Milling Part 3: Programming (ISO dialects)

Programming and Operating Manual

Valid for:
SINUMERIK 808D Milling (software version: V4.4.2)

Target group:
End users and service engineers

12/2012
6FC5398-4DP10-0BA0

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1 Principles of programming

1.1 Introductory comments

1.1.1 Siemens mode

The following conditions are valid in the Siemens mode:

- The default of the G commands can be defined for each channel via the machine data 20150 $MC_GCODE_RESET_VALUES.
- No language commands from the ISO dialects can be programmed in the Siemens mode.

1.1.2 ISO dialect mode

The following conditions are valid in the active ISO dialect mode:

- The ISO dialect mode can be set with the machine data as the default setting of control system. The control system reboots by default in the ISO dialect mode subsequently.
- Only G functions from the ISO dialect can be programmed; the programming of Siemens G functions is not possible in the ISO Mode.
- Mixing of ISO dialect and Siemens language in the same NC block is not possible.
- Switching between ISO Dialect M and ISO Dialect T with a G command is not possible.
- Subroutines that are programmed in the Siemens mode can be called.
- If Siemens functions are to be used, one must first switch to the Siemens mode.

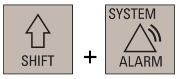
1.1.3 Switching between the modes

The SINUMERIK 808D supports the following two programming language modes:

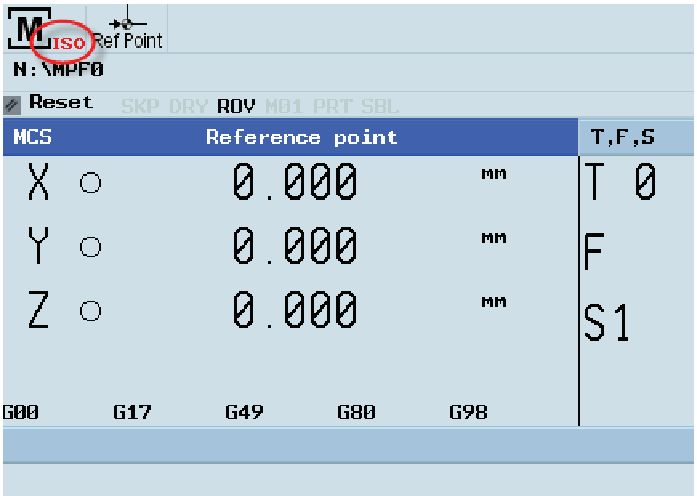
- Siemens language mode
- ISO dialect mode

Note that the active tool, tool offsets and workpiece offsets are not influenced by the mode changeover.

Procedure



1. Select the desired operating area and enter its main screen.



2. Press this softkey on the verticial softkey bar. The control system automatically starts the mode change from Siemens mode to ISO dialect mode. After the changeover , "ISO" is shown on the upper left corner of the screen.

   To change from ISO mode back to Siemens mode, press the same softkey again.

1.1.4 Display of the G code

The G code is displayed in the same language (Siemens or ISO Dialect) as the relevant current block. If the display of the blocks is suppressed with DISPLOF, the G codes continue to be displayed in the language in which the active block is displayed.

Example

The G functions of the ISO dialect mode are used to call the Siemens standard cycles. To do this, DISPLOF is programmed at the start of the relevant cycle; this way the G functions that are programmed in the ISO dialect language continue to be displayed.

```
PROC CYCLE328 SAVE DISPLOF
N10 ...
...
N99 RET
```

Procedure

The Siemens shell cycles are called via main programs. The Siemens mode is selected automatically by calling the shell cycle.

With DISPLOF, the block display is frozen on calling the cycle; the display of the G code continues in the ISO Mode.

The G codes that were changed in the shell cycle, are reset to their original status at the end of the cycle with the "SAVE" attribute.

1.1.5 Maximum number of axes/axis identifiers

The maximum number of axes in the ISO dialect mode is 9. The axis identifiers for the first three axes are defined permanently with X, Y and Z. All the other axes can be identified with letters A, B, C, U, V and W.

1.1.6 Decimal point programming

In the ISO dialect mode, there are two notations for evaluating programmed values without decimal point:

- Pocket calculator notation

  Values without decimal points are interpreted as mm, inch or degree.

- Standard notation

  Values without decimal point are multiplied by a conversion factor.

The setting is done over MD10884 $MN_EXTERN_FLOATINGPOINT_PROG.

There are two different conversion factors, IS-B and IS-C. This weighting is related to the addresses X Y Z U V W A B C I J K Q R and F.

The setting is done over MD10886 EXTERN_INCREMENT_SYSTEM.

Example:

Linear axis in mm:

- X 100.5

  corresponds to a value with decimal point: 100.5 mm

- X 1000
  – Pocket calculator notation: 1,000 mm
  – Standard notation:

    IS-B: 1000 * 0.001= 1 mm

    IS-C: 1000 * 0.0001 = 0.1 mm

ISO dialect milling

Table 1- 1 Different conversion factors for IS-B and IS-C

Address	Unit	IS-B	IS-C
Linear axis	mm inch	0,001 0,0001	0,0001 0,00001
Rotary axis	Degree	0,001	0,0001
F feed G94 (mm/inch per min.)	mm inch	1 0,01	1 0,01
F feed G95 (mm/inch per rev.)	mm inch	0,01 0,0001	0,01 0,0001
F thread lead	mm inch	0,01 0,0001	0,01 0,0001
C chamfer	mm inch	0,001 0,0001	0,0001 0,00001
R radius, G10 toolcorr	mm inch	0,001 0,0001	0,0001 0,00001
Q	mm inch	0,001 0,0001	0,0001 0,00001
I, J, K IPO parameters	mm inch	0,001 0,0001	0,0001 0,00001
G04 X or U	s	0,001	0,001
A angle contour definition	Degree	0,001	0,0001
G74, G84 tapping cycles $MC_EXTERN_FUNCTION_MASK Bit8 = 0 F as feed such as G94, G95 Bit8 = 1 F as thread lead			

1.1.7 Comments

In the ISO dialect mode, brackets are interpreted as comment signs. In the Siemens mode, ";" is interpreted as comment. To simplify matters, an ";" is also understood as comment in the ISO dialect mode.

If the comment start sign '(' is used inside a comment again, the comment is ended only if all the open brackets are closed again.

Example:

```
N5 (comment) X100 Y100
N10 (comment(comment)) X100 Y100
N15 (comment(comment) X100) Y100
```

X100 Y100 is executed in block N5 and N10, but only Y100 in block N15, because the first bracket is closed only after X100. Everything up to that point is interpreted as comment.

1.1.8 Skip block

The sign of skipping or suppression of blocks "/" can be used at any convenient position in a block, i.e. even in the middle of the block. If the programmed block skip level is active on the date of the compilation, the block is not compiled from this point up to the end of the block. An active block skip level has the same effect as a block end.

Example:

N5 G00 X100. /3 YY100 --> Alarm 12080 "Syntax error"
N5 G00 X100. /3 YY100 --> no alarm, if block skip level 3 is active

Block skip signs within a comment are not interpreted as block skip signs

Example:

N5 G00 X100. (/3 Part1) Y100
;the Y axis is traversed even when the block skip level 3 is active

The block skip levels /1 to /9 can be active. Block skip values <1 and >9 lead to alarm 14060 "Impermissible skip level for differential block skip".

The function is mapped to the existing Siemens skip levels. Unlike the ISO Dialect original, "/" and "/1" are separate skip levels that must also be activated separately.

Note

The "0" in "/0" can be omitted.

1.2 Preconditions for the feed

The following Section describes the feed function with which the feedrate (covered path per minute or per rotation) of a cutting tool is defined.

1.2.1 Rapid traverse

Rapid traverse is used for positioning (G00) as well as for manual traverse with rapid traverse (JOG). In rapid traverse, each axis is traversed with the rapid traverse rate set for the individual axes. The rapid traversing rate is defined by the machine manufacturer and it is specified by the machine data for the individual axes. As the axes traverse independently of each other, each axis reaches its target point at a different time. Hence, the resulting tool path is generally not a straight line.

1.2.2 Path feed (F function)

Note

Unless something else is specified, the unit "mm/min" always stands for feedrate of the cutting tool in this documentation.

The feed with which a tool should be traversed in linear interpolation (G01) or circular interpolation (G02, G03) is designated with the address character "F".

The feed of the cutting tool in "mm/min" is specified after the address character "F".

The permissible range of F values is specified in the documentation of the machine manufacturer.

Possibly, the feed is limited by the servo system and the mechanical system in the upward direction. The maximum feed is set in the machine data and limited to the value defined there before an overshoot.

The path feed is generally composed of the individual speed components of all geometry axes participating in the movement and refers to the cutter center (see the two following figures).

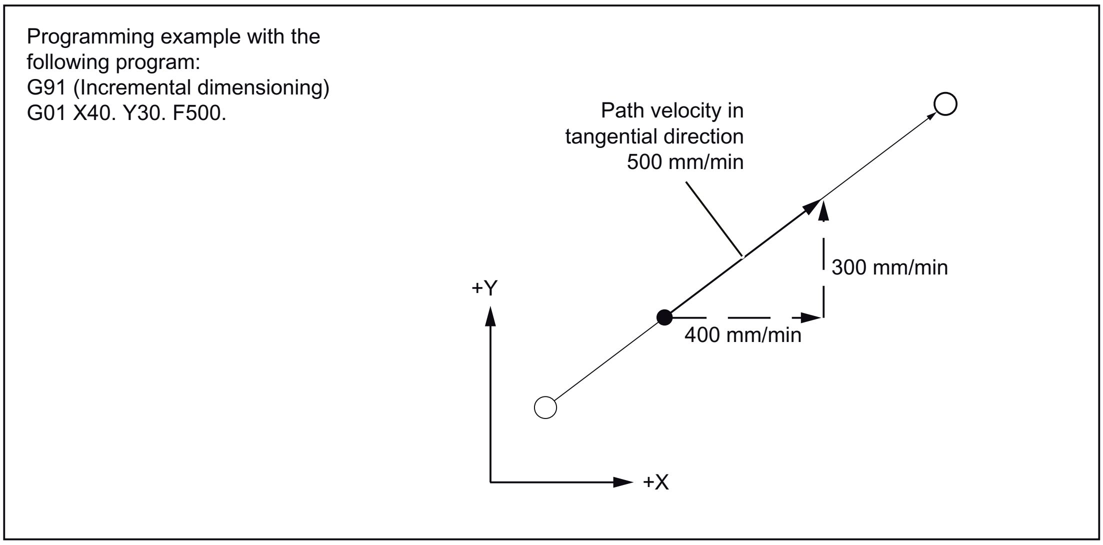


Figure 1-1 Linear interpolation with 2 axes

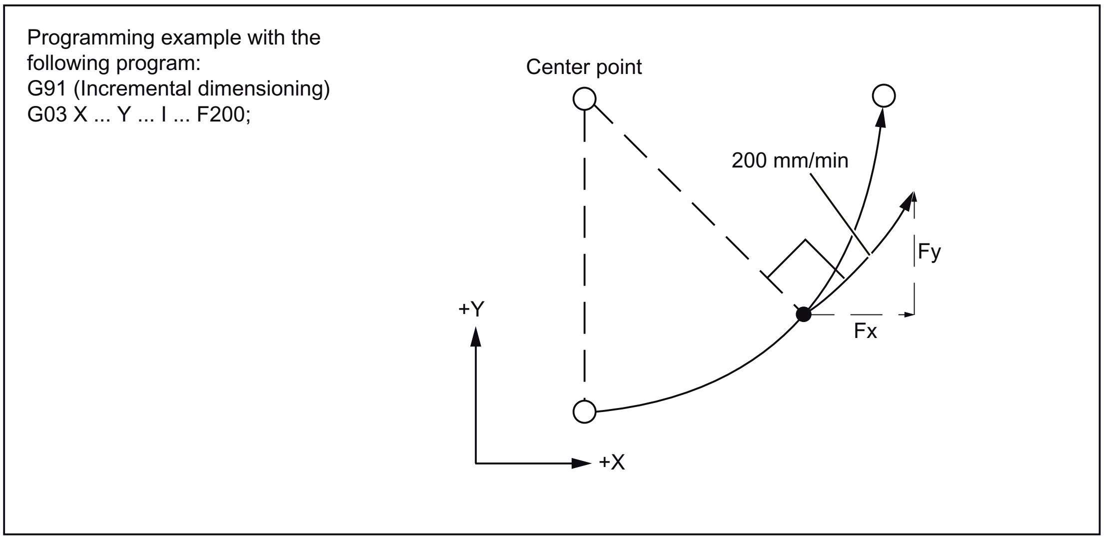


Figure 1-2 Circular interpolation with 2 axes

In 3D interpolation, the feed of the resulting straight lines programmed with F are maintained in the space.

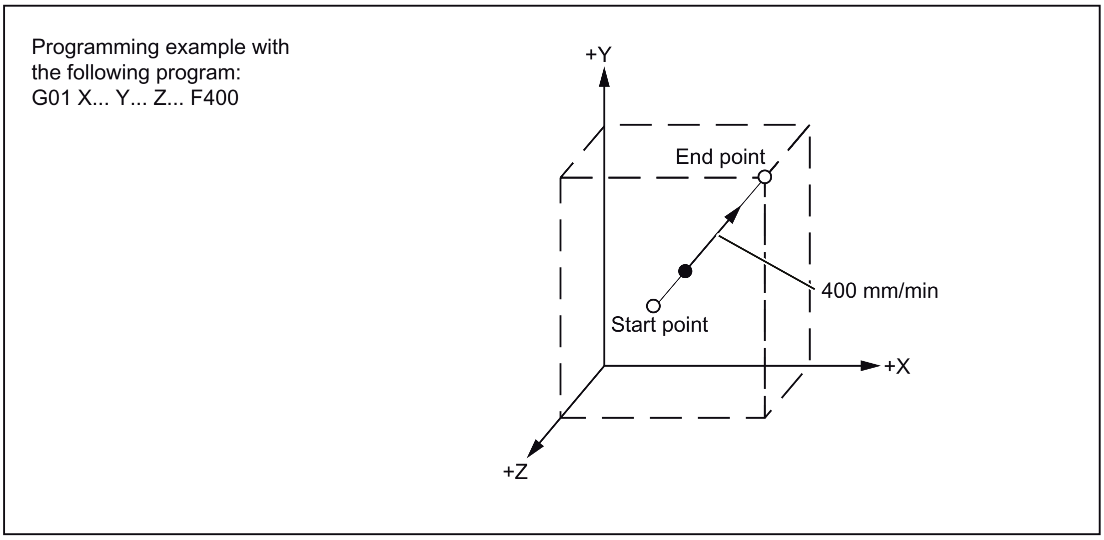


Figure 1-3 Feed in case of 3D interpolation

Note

If "F0" is programmed and the function "Fixed feedrate" is not active, then the Alarm 14800 "Programmed path velocity less than or equal to zero" is output.

1.2.3 Linear feed (G94)

On specifying G94, the feed given after the address character F is executed in the mm/min, inch/min or degree/min unit.

1.2.4 Inverse-time feed (G93)

On specifying G93, the feed given after the address character F is executed in the 1/min unit. G93 is a modally effective G function.

Example

```
N10 G93 G1 X100 F2 ;
```

i.e., the programmed path is traversed within half a minute.

1.2.5 Revolutional feedrate (G95)

On specifying G95, the feed is executed in the mm/revolution unit or inch/revolution related to the master spindle.

Note

All of the commands are modal. If the G feed command is switched among G93, G94 or G95, the path feed must be reprogrammed. The feed can also be specified in degree/revolution for the machining with rotary axes.

---

2 G code table

Table 2- 1 G code table - milling

G code		Description
Group 1		
G00 1)	1	Rapid traverse
G01	2	Linear movement
G02	3	Circle/helix in clockwise direction
G03	4	Circle/helix in the counterclockwise direction
Group 2		
G17 1)	1	XY plane
G18	2	ZX plane
G19	3	YZ plane
Group 3		
G90 1)	1	Absolute programming
G91	2	Incremental programming
Group 5		
G93	3	inverse-time feedrate (1/min)
G94 1)	1	Feedrate in [mm/min, inch/min]
G95	2	Revolutional feedrate in [mm/rev, inch/rev]
Group 6		
G20 1)	1	Inch input system
G21	2	Metric input system
Group 7		
G40 1)	1	Deselection of cutter radius compensation
G41	2	Compensation left of contour
G42	3	Compensation to right of contour
Group 8		
G43	1	Positive tool length compensation on
G44	2	Negative tool length compensation on
G49 1)	3	Tool length compensation off
Group 9		
G73	1	High-speed deep hole drilling cycle with chip breakage
G74	2	Left tapping cycle
G76	3	Fine drill cycle
G80 1)	4	Cycle off
G81	5	Drilling cycle counterboring
G82	6	Countersink drilling cycle
G83	7	Deep hole drilling cycle with chip removal

G code		Description
G84	8	Right tapping cycle
G85	9	Boring cycle, retraction with G01 after reaching the end in axis Z, without spindle stop
G86	10	Boring cycle, spindle stops and then retraction with G00 after reaching the end in axis Z
G87	11	Reverse countersinking
G89	12	Boring cycle, stay for a while and then retraction with G01, without spindle rotation direction change
Group 10		
G98 1)	1	Return to starting point in fixed cycles
G99	2	Return to point R in fixed cycles
Group 11		
G50 1)2)	1	Scaling off
G51 2)	2	Scaling on
Group 12		
G66 2)	1	Macro module call
G67 1)2)	2	Delete macro module call
Group 13		
G96	1	constant cutting rate on
G97 1)	2	constant cutting rate off
Group 14		
G54 1)	1	Selecting work offset
G55	2	Selecting work offset
G56	3	Selecting work offset
G57	4	Selecting work offset
G58	5	Selecting work offset
G59	6	Selecting work offset
G54 P0	1	external work offset
Group 15		
G61	1	Exact stop modal
G63	2	Tapping mode
G64 1)	3	Continuous-path mode
Group 16		
G68	1	Rotation ON, 2D/3D
G69 1)	2	Rotation OFF
Group 17		
G15 1)	1	Polar coordinates off
G16	2	Polar coordinates on
Group 18 (non-modal effective)		
G04	1	Dwell time in [s] or spindle revolutions
G05	18	High-speed cycle cutting
G05.1 2)	22	High-speed cycle -> Call CYCLE305
G08	12	Pre-control ON/OFF

G code		Description
G09	2	Exact stop
G10 [2)]	3	Write work offset/tool offset
G10.6	17	Retraction from contour (POLF)
G11	4	End parameter entry
G27	13	Checking the reference position
G28	5	1. Approaching a reference point
G30	6	2./3./4. Approaching a reference point
G30.1	19	Reference point position
G31		Measuring with "delete distance-to-go"
G52	8	programmable work offset
G53	9	Approach position in machine coordinate system
G60	22	directed positioning
G65 [2)]	10	Macro call
G72.1 [2)]	14	Contour repetition with rotation
G72.2 [2)]	15	Linear contour repetition
G92	11	Setting actual value
G92.1	21	Delete actual value, reset the WKS
Group 22		
G50.1	1	Mirroring on programmed axis OFF
G51.1	2	Mirroring on programmed axis ON
Group 31		
G290 [1)]	1	Selection of Siemens mode
G291	2	Selection of ISO dialect mode

Note

In general, the G functions mentioned in [1)] are defined by the NC during activation of the control system or during RESET. Data about the actual settings can be found in the documentation of your machine manufacturer.

The G functions mentioned in [2)] are optional. Whether the relevant function is available on your control system can be found out from the documentation of your machine manufacturer.

3 Drive commands

3.1 Interpolation commands

The positioning and interpolation commands, with which the tool path along the programmed contour, such as a straight line or a circular arc, is monitored, are described in the next Section.

3.1.1 Rapid traverse (G00)

You can use rapid traverse to position the tool rapidly, to traverse around the workpiece or to approach tool change points.

The following G functions can be used to call the positioning (refer to following table):

Table 3- 1 G function for positioning

G function	Function	G group
G00	Rapid traverse	01
G01	Linear movement	01
G02	Circle/helix in the clockwise direction	01
G03	Circle/helix in the counterclockwise direction	01

Positioning (G00)

Format

G00 X... Y... Z... ;

Explanation

The tool movement programmed with G00 is executed at the highest possible traversing speed (rapid traverse). The rapid traverse rate is defined separately for each axis in machine data. If the rapid traverse movement is executed simultaneously on several axes, the rapid traverse rate is determined by the axis which requires the most time for its section of the path.

Axes that are not programmed in a G00 block are not traversed. In positioning, the individual axes traverse independently of each other with the rapid traverse rate specified for each axis. The precise speeds of your machine can be consulted in the documentation of the manufacturer.

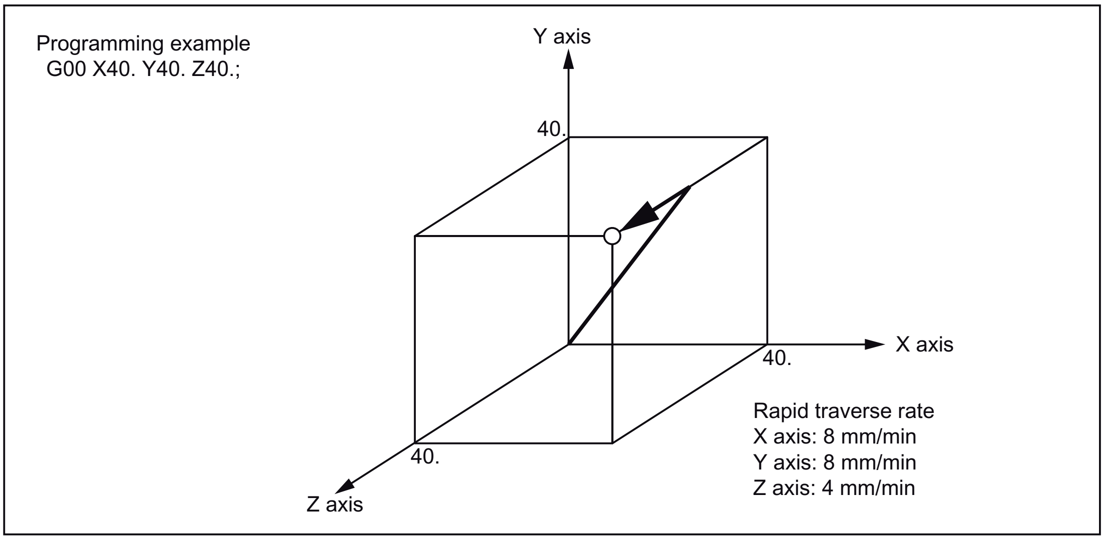


Figure 3-1 Positioning in the run state with 3 simultaneously controllable axes

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Note

As in positioning with G00, the axes traverse independently of each other (not interpolated), each axis reaches its end point at a different time. Hence, one must be very careful in positioning with several axes, so that a tool does not collide with a workpiece of the tool during the positioning.

Linear interpolation (G00)

Linear interpolation with G00 is defined by setting the machine data 20732 $MC_EXTERN_GO_LINEAR_MODE. Here, all programmed axes traverse in rapid traverse with linear interpolation and reach their target positions simultaneously.

3.1.2 Linear interpolation (G01)

With G01 the tool travels on paraxial, inclined or straight lines arbitrarily positioned in space. Linear interpolation permits machining of 3D surfaces, grooves, etc.

Format

G01 X... Y... Z... F... ;

In G01, the linear interpolation is executed with the path feed. The axes that are not specified in the block with G01 are not traversed. The linear interpolation is programmed as in the example given above.

Feed F for path axes

The feedrate is specified under the address F. Depending on the default setting in the machine data, the units of measurement specified with the G commands (G93, G94, G95) are either in mm or inch.

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

Note

An alarm is triggered while executing a G01 block if no feed was programmed in a block with G01 or in the previous blocks.

The end point can be specified either as absolute or as incremental. For more information, refer to Section "Absolute/incremental dimensioning (G90, G91) (Page 40)".

Programming example
G01 X40. Y40. Z40. F100;

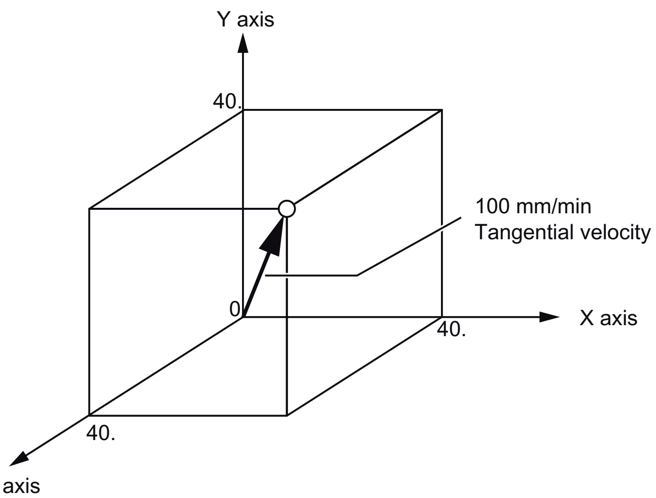


Figure 3-2 Linear interpolation

3.1.3 Circular interpolation (G02, G03)

Format

To start the circular interpolation, please execute the commands specified in the following table.

Table 3- 2 Commands to be executed for circular interpolation

Element	Command	Description
Designation of the plane	G17	Circular arc in Plane X-Y
	G18	Circular arc in Plane Z-X
	G19	Circular arc in Plane Y-Z
Direction of rotation	G02	clockwise
	G03	counterclockwise
End-point position	Two axes from X, Y or Z	End-point position in a workpiece coordinate system
	Two axes from X, Y or Z	Distance of start point - end point with sign
Distance between start point - center	Two axes from I, J or K	Distance start point - circle center with sign
Radius of circular arc	R	Radius of circular arc
Feed	F	Speed along the circular arc

Designation of the plane

With the commands specified below, a tool traverses along the specified circular arc in the plane X-Y, Z-X or Y-Z, so that the feed specified with "F" is maintained on the circular arc.

- in Plane X-Y:

  G17 G02 (or G03) X... Y... R... (or I... J...) F... ;
- in Plane Z-X:

  G18 G02 (or G03) Z... X... R... (or K... I...) F... ;
- in the Plane Y-Z:

  G19 G02 (or G03) Y... Z... R... (or J... K...) F... ;

Before the circle radius programming (with G02, G03), one must first select the desired interpolation plane with G17, G18 or G19. Circular interpolation is not allowed for the 4th and 5th axes, if these are linear axes.

Plane selection is also used to select the plane in which the tool radius compensation (G41/G42) is performed. The Plane X-Y (G17) is set automatically after activating the control system.

G17	X-Y plane
G18	Z-X plane
G19	Y-Z plane

The working planes should be specified, in general.

Circles can also be created outside the selected working plane. In this case, the axis addresses (specification of circle end positions) determine the circular plane.

Circular interpolation is possible in the Xβ, Zβ or Yβ plane while selecting an optional 5th linear axis, which also contains a 5th axis besides the X-Y, Y-Z and Z-X planes (β=U, V or W)

- Circular interpolation in the Xβ plane

  G17 G02 (or G03) X... β... R... (or I... J...) F... ;
- Circular interpolation in the Zβ plane

  G18 G02 (or G03) Z... β... R... (or K... I...) F... ;
- Circular interpolation in the Yβ plane

  G19 G02 (or G03) Y... β... R... (or J... K...) F... ;
- If the address characters for the 4th and 5th axes are omitted - such as in the commands "G17 G02 X... R... (or I... J...) F... ;", then the X-Y plane is selected automatically as the interpolation plane. Circular interpolation with the 4th and 5th axes is not possible if these additional axes are rotary axes.

Direction of rotation

The direction of rotation of the circular arc is to be specified as given in the following figure.

G02	clockwise
G03	counterclockwise

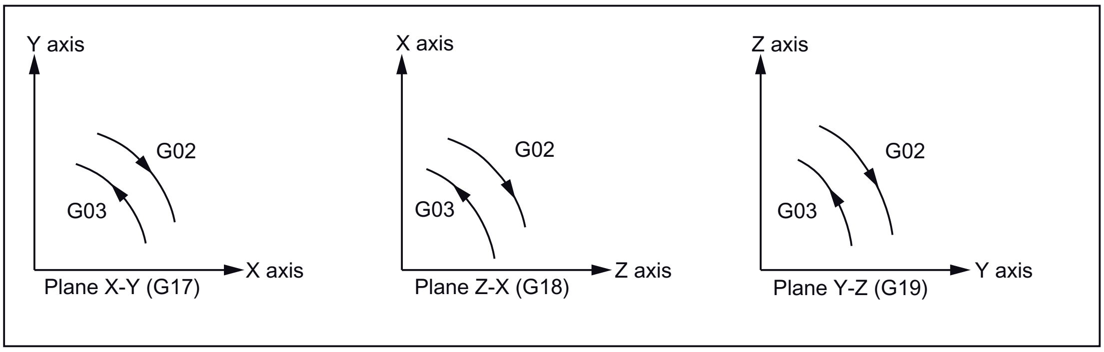


Figure 3-3 Direction of rotation of the circular arc

End point

The end point can be specified corresponding to the definition with G90 or G91 as absolute or incremental.

If the specified end point does not lie on the circular arc, the system outputs Alarm 14040 "Error in end point of circle".

Possibilities of programming circular movements

The control system offers two options of programming circular movements.

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

  For a circular interpolation with a central angle <= 180 degree, the programming should be "R > 0" (positive).

  For a circular interpolation with a central angle > 180 degree, the programming should be "R < 0" (negative).

Programming example
G17 G02 X... Y... R ± ... F... ;

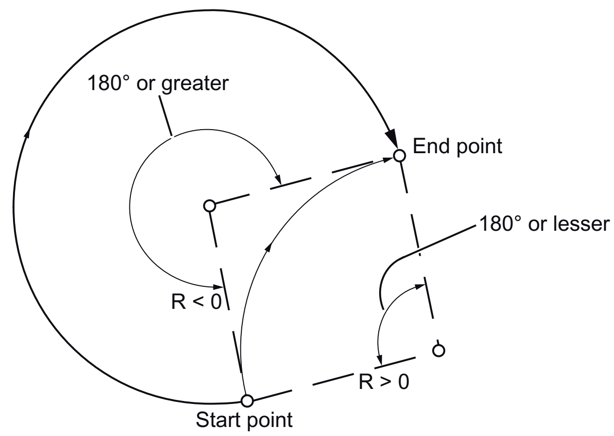


Figure 3-4 Circular interpolation with specification of Radius R

Feed

During the circular interpolation, the feed can be specified exactly as during linear interpolation (see Chapter "Linear interpolation (G01)").

3.1.4 Contour definition programming and addition of chamfers or radiuses

Chamfers or radiuses can be added after each traversing block between linear and circular contours. For example, to grind sharp edges of workpieces.

The following combinations are possible during addition:

- between two straight lines
- between two circular arcs
- between a circular arc and a straight line
- between a straight line and a circular arc

Format

, C...; Chamfer

, R...; Rounding

Example

```
N10 G1 X10. Y100. F1000 G17
N20, A140, C7.5
N30 X80. Y70., A95.824, R10
```

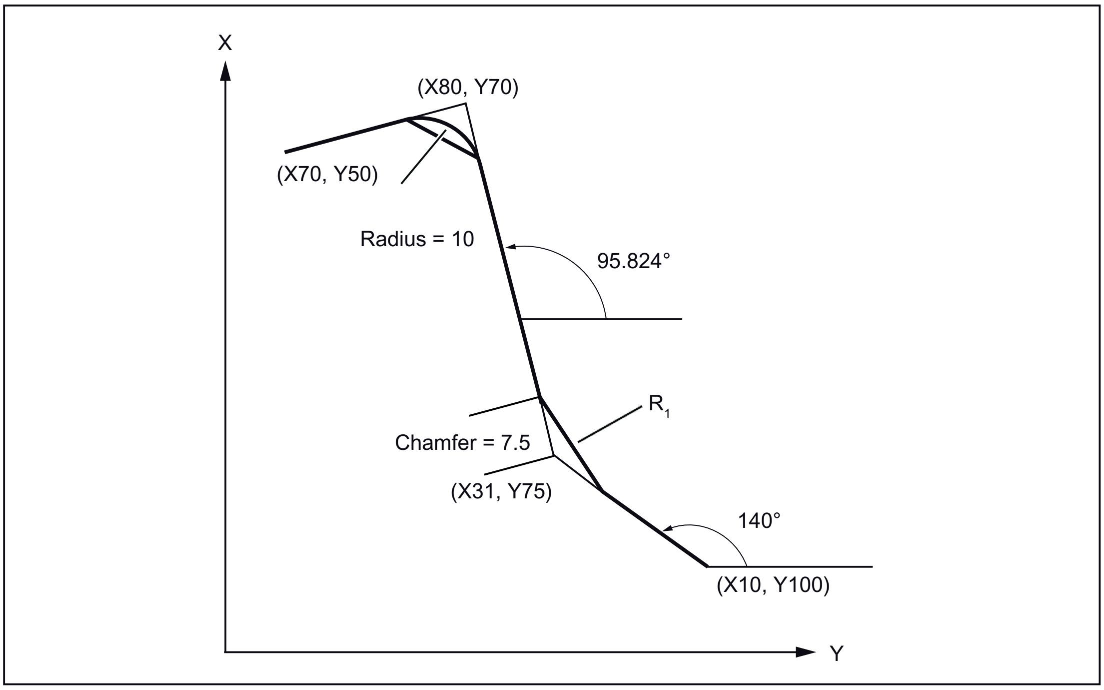


Figure 3-5 3 straight lines

ISO dialect mode

In the ISO dialect original, the address C can be used as axis name as well as for denoting a chamfer on the contour.

The address R can either be a cycle parameter or an identifier of the radius of a contour.

The address A is the angle in contour definition.

To differentiate between these two possibilities, a comma "," must be used while programming the contour definition before the address "A", "R" or "C".

Siemens mode

The identifiers of chamfer and radius are defined in the Siemens mode using the machine data. Name conflicts can be avoided this way. There should be no comma before the identifier of the radius or chamfer.

Selection of plane

Chamfer or fillet is possible only in the plane specified through the plane selection (G17, G18 or G19). These functions cannot be used on parallel axes.

Note

No chamfer/rounding is inserted, if

- No straight- or circular contour is available in the plane,
- a movement takes place outside the plane,
- The plane is changed or a number of blocks specified in the machine data, that do not contain any information about traversing (e.g., only command outputs), is exceeded.

Coordinate system

After a block that changes the coordinate system (G92 or G52 to G59) or that contains a command of reference point approach (G28 to G30), should not contain any command for chamfering or rounding of corners.

Thread cutting

The specification of fillet in thread cutting blocks is not permissible.

3.1.5 Helical interpolation (G02, G03)

With helical interpolation, two motions are superimposed and executed in parallel:

- A plane circular motion on which
- A vertical linear motion is superimposed.

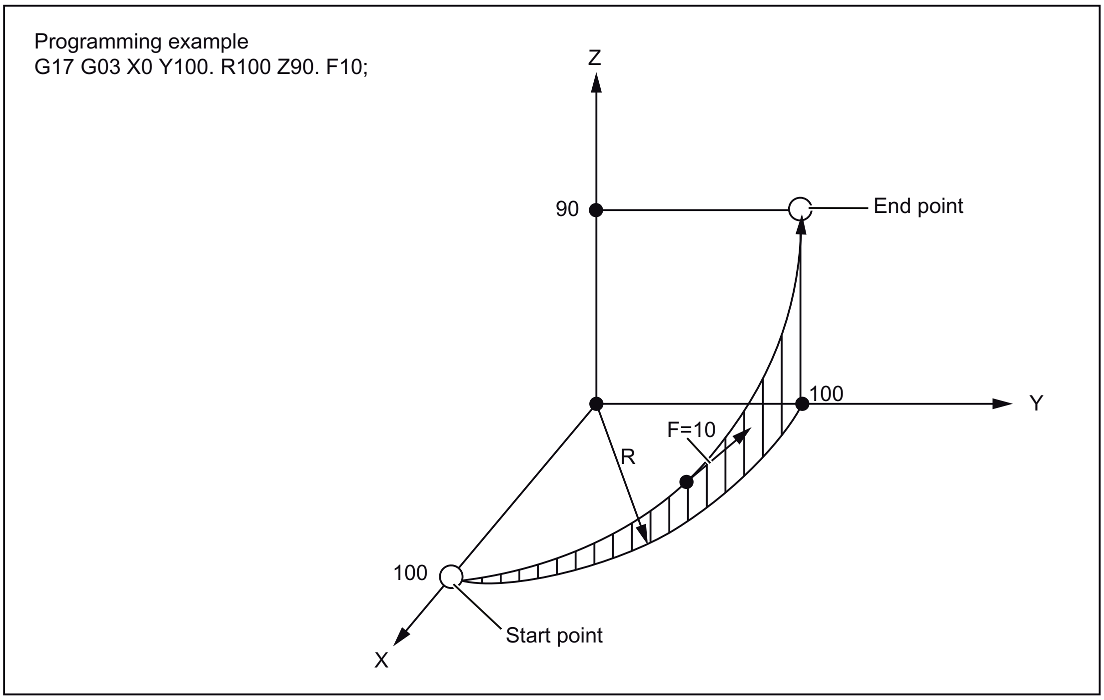


Figure 3-6 Helical interpolation

Note

G02 and G03 are modal. The circular motion is performed in those axes that are defined by the specification of the working plane.

3.2 Reference point approach with G functions

3.2.1 Reference point approach with intermediate point (G28)

Format

G28 X... Y... Z... ;

The commands "G28 X... Y... Z... ;" can be used to traverse the programmed axes to their reference point. Here, the axes are first traversed to the specified position with rapid traverse, and from there to the reference point automatically. The axes not programmed in the block with G28 are not traversed to their reference point.

Reference position

When the machine has been powered up (where incremental position measuring systems are used), all the axes must approach their reference mark. Only then can traversing movements be programmed. The reference point can be approached in the NC program with G28. The reference point coordinates are defined with the machine data 34100 $_MA_REFP_SET_POS[0] up to [3]). A total of four reference positions can be defined.

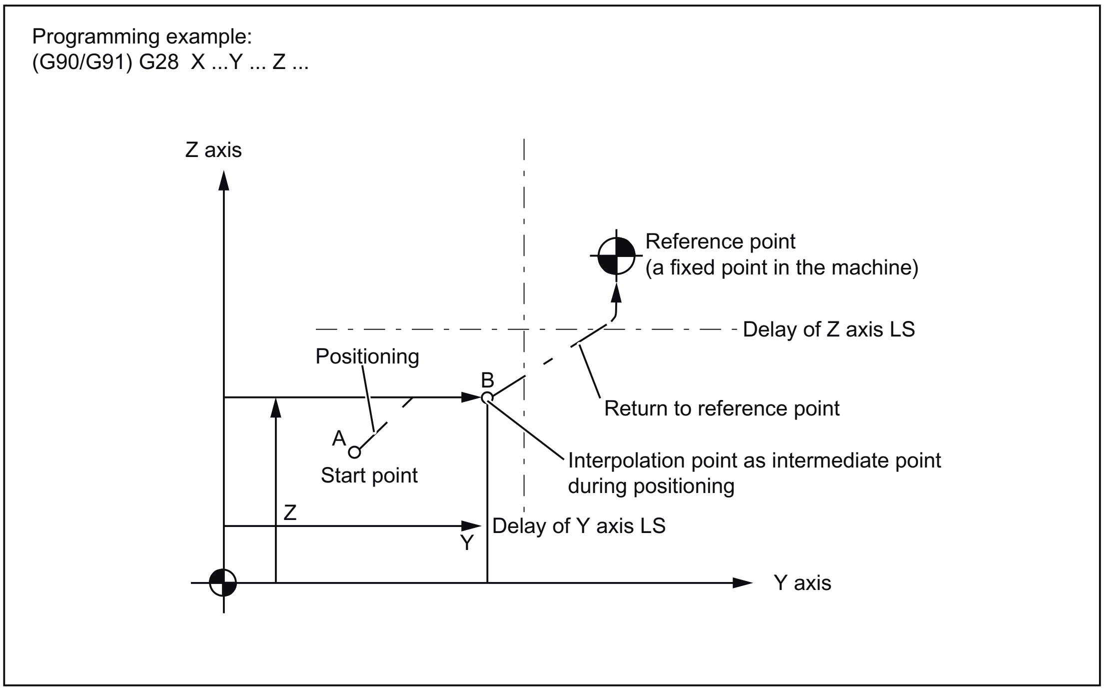


Figure 3-7 Automatic reference point approach

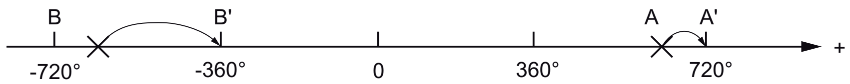
Return to reference point

Note

The G28 function is implemented with the shell cycle cycle328.spf. A transformation must not be programmed for an axis which is to approach the reference point with G28 which must approach the reference mark. The transformation is deactivated in cycle328.spf.

Automatic reference point approach for rotary axes

Rotary axes can be used for automatic reference point approach exactly as linear axes. The approach direction of the reference traverse is defined with the machine data 34010 MD_$MA_REFP_CAM_DIR_IS_MINUS.



(Return to reference point: The positive traversing direction was selected as the direction of return to the reference point.)

Figure 3-8 Return to reference point - rotary axes

Additions to the commands for automatic reference point approach:

Tool radius compensation and defined cycles

G28 should not be used in operation with tool radius compensation (G41, G42) or in a defined cycle!

⚠ WARNING

G28 is used to interrupt the tool radius compensation (G40) with eventual axis traverse movement to the reference point. Hence, tool radius compensation is to be deactivated before G28 is issued.

Tool offset in G28

In G28, the interpolation point is approached with the current tool offset. The tool offset is deselected when the reference point is finally approached.

3.2.2 Checking the reference position (G27)

Format

G27 X... Y... Z... ;

This function is used to check whether the axes are on their reference point.

Test procedure

If the check with G27 is successful, the processing is continued with the next part program block. If one of the axes programmed with G27 is not on the reference point, Alarm 61816 "Axes not on reference point" is triggered and the Automatic mode is interrupted.

Note

Function G27 is implemented with the cycle 328.spf as with G28.

To avoid a positioning error, the function "mirroring" should be deselected before executing G27.

3.2.3 Reference point approach with reference point selection (G30)

Format

G30 Pn X... Y... Z... ;

For the commands "G30 Pn X... Y... Z;" the axes are positioned on the specified intermediate point in the continuous-path mode, and finally traversed to the reference point selected with P2 - P4. With "G30 P3 X30. Y50.;", The X- and Y-axes return to the third reference point. The second reference point is selected on omitting "P". Axes that are not programmed in a G30 block are also not traversed.

Reference point positions

The positions of all the reference points are always determined in relation to the first reference point. The distance of the first reference point from all subsequent reference points is set in the following machine data:

Table 3- 3 Reference points

Element	MD
2. Reference point	$_MA_REFP_SET_POS[1]
3. Reference point	$_MA_REFP_SET_POS[2]
4. Reference point	$_MA_REFP_SET_POS[3]

Note

Further details of the points that were considered in the programming of G30 are available in the Chapter "Reference point approach with intermediate point (G28)". Function G30 is implemented with the cycle 328.spf as with G28.

Motion commands 4

4.1 The coordinate system

The position of a tool is defined uniquely by its coordinates in the coordinate system. These coordinates are defined through axis positions. If, for instance, the three involved Axes are denoted by X, Y and Z, the coordinates are specified as follows:

X... Y... Z...

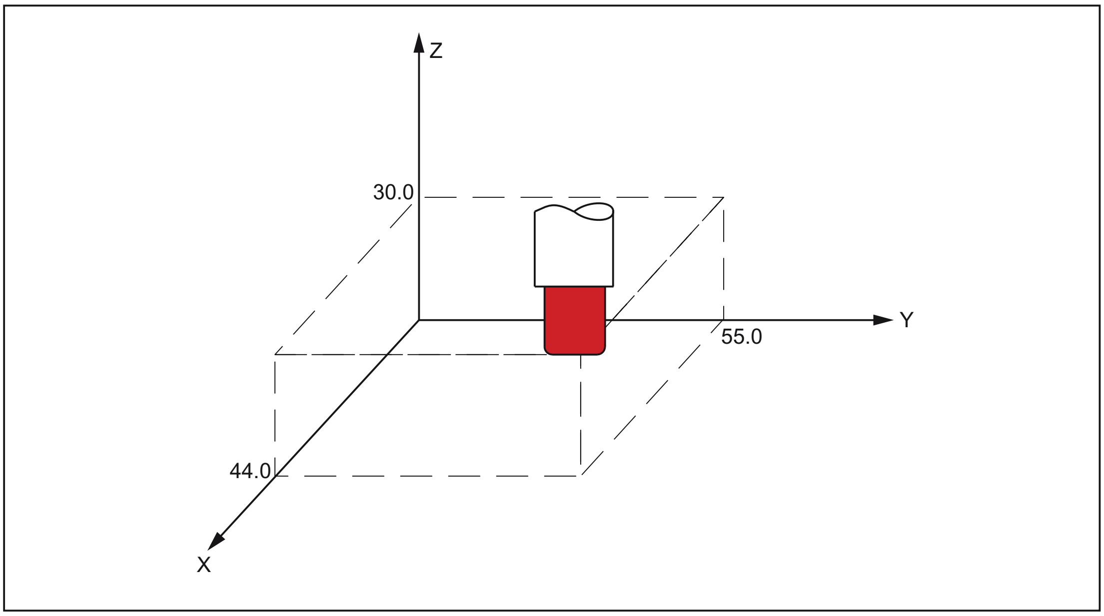


Figure 4-1 Tool positions specified with X... Y... Z...

The following coordinate systems are used to specify the coordinates:

1. Machine coordinate systems (G53)
2. Workpiece coordinate system (G92)
3. Local coordinate system (G52)

4.1.1 Machine coordinate systems (G53)

Defining machine coordinate system

The machine zero defines the machine coordinate system MCS. All other reference points refer to the machine zero.

The machine zero is a fixed point on the machine tool which can be referenced by all (derived) measuring systems.

Format

(G90) G53 X... Y... Z... ;

X, Y, Z: absolute dimension word

Selection of machine coordinate system (G53)

G53 suppresses the programmable and adjustable work offset. Traversing in the machine coordinate system on the basis of G53 are always programmed if the tool is to traverse to a machine-specific position.

Compensation deselection

If MD10760 $MN_G53_TOOLCORR = 0, then the active tool length and tool radius compensation remains active in a block with G53

If MD10760 $MN_G53_TOOLCORR = 1, then the active tool length and tool radius compensations in a block are suppressed with G53.

4.1.2 Workpiece coordinate system (G92)

Before machining, you must create a coordinate system for the workpiece, the so-called work piece coordinate system. This section describes different methods of setting, selecting and changing a workpiece coordinate system.

Setting a tool coordinate system

The following two methods can be used to set a tool coordinate system:

1. With G92 in the part program
2. manually through the HMI operator panel

Format

(G90) G92 X... Y... Z... ;

The base point traverses to the specified position on outputting an absolute command. The difference between tool tips and the base point is compensated through the tool length compensation; this way the tool tip can traverse to the target position in any case.

4.1.3 Resetting the tool coordinate system (G92.1)

With G92.1, one can reset a shifted coordinate system before the shift. The tool coordinate system is reset to the coordinate system that is defined by the active adjustable work offsets (G54-G59). The tool coordinate system is set to the reference position if no adjustable work offset is active. G92.1 resets shifts carried out through G92 or G52. However, only the axes that are programmed, are reset.

Example 1:

```
N10 G0 X100 Y100      ;Display: WCS: X100 Y100     MCS: X100 Y100
N20 G92 X10 Y10       ;Display: WCS: X10 Y10       MCS: X100 Y100
N30 G0 X50 Y50        ;Display: WCS: X50 Y50       MCS: X140 Y140
N40 G92.1 X0 Y0       ;Display: WCS: X140 Y140     MCS: X140 Y140
```

Example 2:

```
N10 G10 L2 P1 X10 Y10
N20 G0 X100 Y100      ;Display: WCS: X100 Y100     MCS: X100 Y100
N30 G54 X100 Y100     ;Display: WCS: X100 Y100     MCS: X110 Y110
N40 G92 X50 Y50       ;Display: WCS: X50 Y50       MCS: X110 Y110
N50 G0 X100 Y100      ;Display: WCS: X100 Y100     MCS: X160 Y160
N60 G92.1 X0 Y0       ;Display: WCS: X150 Y150     MCS: X160 Y160
```

4.1.4 Selection of a workpiece coordinate system

As mentioned above, the user can select one of the already set workpiece coordinate systems.

1. G92

   Absolute commands function in connection with a workpiece coordinate system only if a workpiece coordinate system was selected earlier.

2. Selection of a workpiece coordinate system from a selection of specified workpiece coordinate systems via the HMI operator panel

   A workpiece coordinate system can be selected by specifying a G function in the area G54 to G59.

   Workpiece coordinate systems are setup after the reference point approach after Power On. The closed position of the coordinate system is set in MD20154[13].

4.1.5 Writing work offset/tool offsets (G10)

The workpiece coordinate systems defined through G54 to G59 or G54 P{1 ... 93} can be changed with the following two processes.

1. Data inputting at HMI operator panel
2. with the program commands G10 or G92 (setting actual value)

Format

Modified by G10:

G10 L2 Pp X... Y... Z... ;

p=0:	External workpiece work offset
p=1 to 6:	The value of the workpiece work offset corresponds to the workpiece coordinate system G54 to G59 (1 = G54 to 6 = G59)
X, Y, Z:	Workpiece work offset for each axis during an absolute command (G90). Value that must be added during an incremental command (G91) for each axis to the specified workpiece work offset.

G10 L20 Pp X... Y... Z... ;

p=1 to 93:	The value of the workpiece work offset corresponds to the workpiece coordinate system G54 P1 ... P93. The number of work offsets (1 to 93) can be set through MD18601 $MN_MM_NUM_GLOBAL_USER_FRAMES or MD28080 $MC_MM_NUM_USER_FRAMES.
X, Y, Z:	Workpiece work offset for each axis during an absolute command (G90). Value that must be added during an incremental command (G91) for each axis to the specified workpiece work offset.

Modified by G92:

G92 X... Y... Z... ;

Explanations

Modified by G10:

G10 can be used to change each workpiece coordinate system individually. If the work offset with G10 is to be written only when the G10 block is executed on the machine (main run block), then MD20734 $MC_EXTERN_FUNCTION_MASK, Bit 13 must be set. An internal STOPRE is executed in that case with G10. The machine data bits affect all G10 commands in the ISO Dialect T and ISO Dialect M.

Modified by G92:

By specifying G92 X... Y... Z..., a workpiece coordinate system that was selected earlier with a G command G54 to G59 or G54 P{1 ...93}, can be shifted and thus a new workpiece coordinate system can be set. If X, Y and Z are programmed incrementally, the workpiece coordinate system is defined in such a way that the current tool position matches the total of the specified incremental value and the coordinates of the previous tool position (shift of coordinate system). Finally, the value of the coordinate system shift is added to each individual value of the workpiece work offset. To put it another way: All workpiece coordinate systems are shifted systematically by the same value.

Example

The tool in operation with G54 is positioned at (190, 150), and the workpiece coordinate system 1 (X' - Y') is created each time in G92X90Y90 with a shift of Vector A.

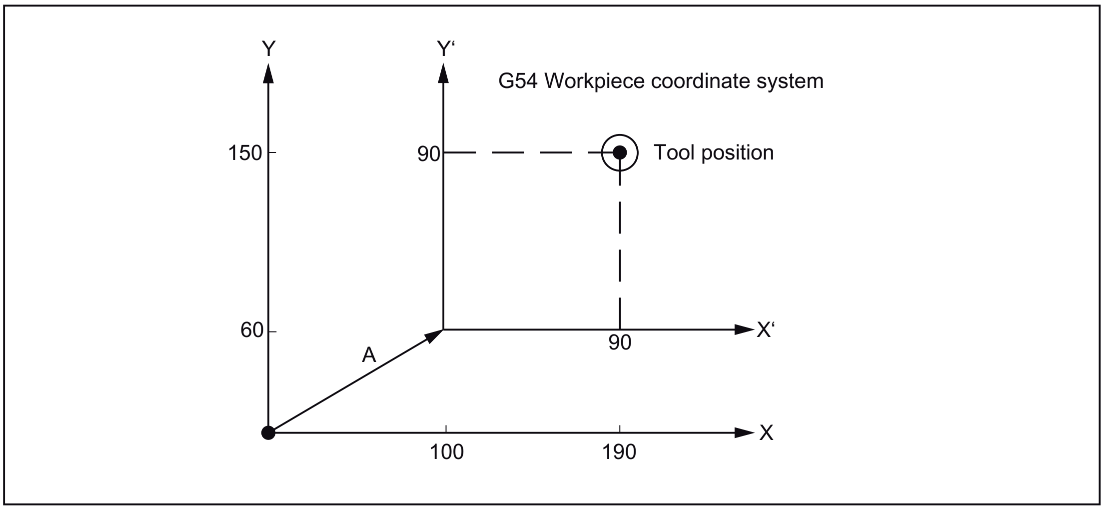


Figure 4-2 Example of setting coordinates

4.1.6 Local coordinate system (G52)

For programming simplification, a type of workpiece coordinate system can be setup to create a program in the workpiece coordinate system. This part coordination system is also called local coordinate system.

Format

G52 X... Y... Z... ; Setting the local coordinate system

G52 X0 Y0 Z0 ; Deselection of the local coordinate system

X, Y, Z: Origin of the local coordinate system

Explanations

G52 can be used to program work offsets for all path and positioning axes in the direction of the specified axis. In this way one can work with changing zero points, e.g. during repetitive machining operations at different workpiece positions.

G52 X... Y... Z... is a work offset around the offset values programmed in the relevant specified axis directions. The last specified adjustable work offset (G54 to G59, G54 P1 - P93) serves as reference.

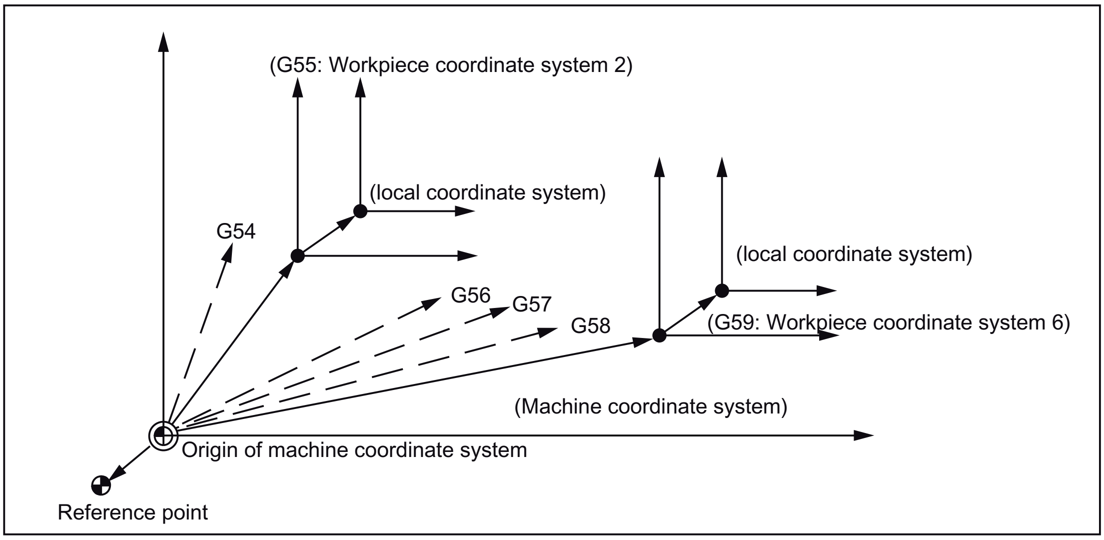


Figure 4-3 Setting the local coordinate system

4.1.7 Selection of the plane (G17, G18, G19)

The selection of the plane in which the circular interpolation, tool radius compensation and rotation of the coordinate system took place is done by specifying the following G functions.

Table 4- 1 G functions for selecting the plane

G function	Function	G group
G17	X-Y plane	02
G18	Z-X plane	02
G19	Y-Z plane	02

The plane is defined as described below (with a help of the example of Plane X-Y):

The horizontal axis in the first quadrant is the Axis +X, and the vertical axis in the same quadrant is Y+.

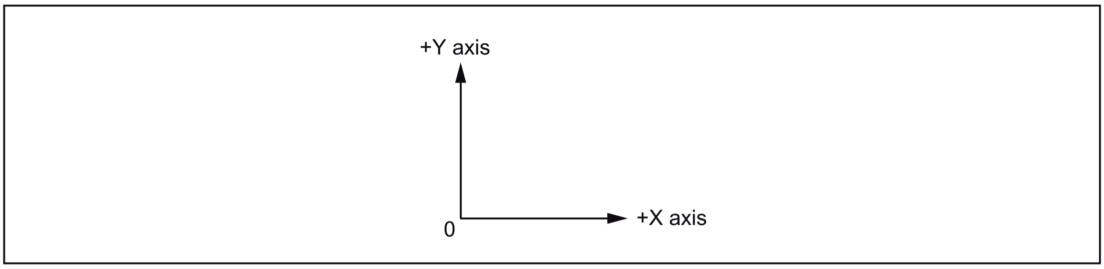


Figure 4-4 Selection of plane

- The Plane X-Y (G17) is selected automatically after activating the control system.
- The command for moving an individual axis can be specified independently of the plane selection by G17, G18 or G19. Thus for instance, the Z axis can be shifted by specifying "G17 Z ....;".
- The plane in which the tool radius compensation is executed with G41 or G42 is defined by specifying G17, G18 or G19.

4.1.8 Parallel axes (G17, G18, G19)

An axis located parallel to one of the three main axes of the coordinate system can be activated by using the function G17 (G18, G19) <Axis name>.

The three main axes are, e.g., X, Y and Z.

Example

G17 U0 Y0

The parallel axis U is activated when the X axis in the G17 plane is replaced.

Explanations

- An associated parallel axis can be defined for each geometry axis with machine data $MC_EXTERN_PARALLEL_GEOAX[ ].
- Only geometry axes from a plane defined with (G17, G18, G19) can be replaced.
- On replacing the axes, normally all shifts (frames) - with the exception of the handwheel and external shifts - are deleted. The following machine data is to be set to prevent the values from being deleted:

  Shifts (frames)
  $MN_FRAME_GEOAX_CHANGE_MODE
- Details are available in the machine data description.
- Alarm 12726 "Impermissible plane selection with parallel axes" is output if a main axis is programmed along with the associated parallel axis with a command for selecting the plane.

4.1.9 Rotation of the coordinate system (G68, G69)

Properties of G68 and G69

A coordinate system can be rotated through the following G functions.

Table 4- 2 G functions for rotating a coordinate system

G function	Function	G group
G68	Rotation of the coordinate system	16
G69	Deselection of Rotation of the coordinate system	16

G68 and G69 are modal G functions of the G group 16. G69 is set automatically on activating the control system and resetting the NC.

The blocks containing G68 and G69 should not contain any other G functions.

The rotation of the coordinate system is called with G68 and deselected with G69.

Format

G68 X_ Y_ R_ ;

X_, Y_ :

Absolute coordinate values of the rotation center. The actual position is accepted as the rotation center if these are omitted.

R_ :

Angle of rotation as a function of G90/G91 absolute or incremental. If R is not specified, the value of the channel-specific setting from the setting data 42150 $SC_DEFAULT_ROT_FACTOR_R is used as angle of rotation.

- By specifying G17 (or G18, G19) G68 X... Y... R... ; " the commands specified in the following blocks are rotated by the angle specified with R around the point (X, Y). The angle of rotation can be specified in units of 0.001 degree.

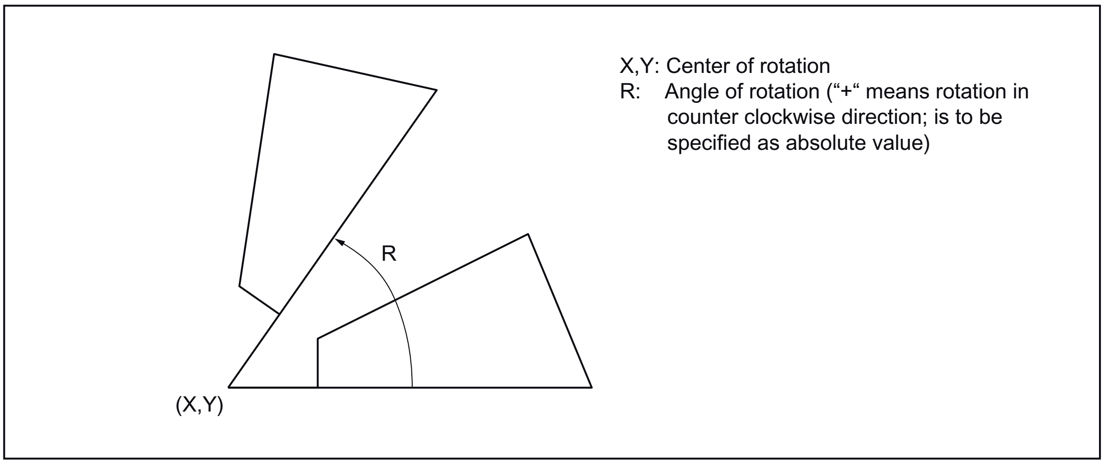


Figure 4-5 Rotation of a coordinate system

- The deselection of the coordinate system rotation takes place through G69.
- G68 is executed in the plane that was selected through G68. The 4th and 5th axes must be linear axes.

  G17: X-Y plane

  G18: Z-X plane

  G19: Y-Z plane

Additions to the commands for rotating the coordinate systems

- If "X" and "Y" are omitted, the current position is used as the rotation center for the coordinate rotation.
- The positional data for the rotation of a coordinate system are specified in the rotated coordinate system.
- If you program a change of plane (G17 to G19) after a rotation, the angles of rotation programmed for the axes are retained and continue to apply in the new working plane. It is therefore advisable to deactivate the rotation before a change of plane.

4.1.10 3D rotation G68/G69

G code G68 is extended for 3D rotation.

G68 must be programmed in a single block and the blocks containing G68 and G69 should not contain any other G functions.

Format

G68 X.. Y.. Z.. I.. J.. K.. R..

X.. Y.. Z..:	Coordinates of the pivot point related to the current workpiece zero. If no coordinate is programmed, the pivot point lies in the workpiece zero. The value is always interpreted as absolute. The coordinates of the pivot point act as a work offset. G90/G91 in the block does not affect the G68 command.
I.. J.. K..:	Vector in pivot point. The coordinate system is rotated around this vector at angle R.
R..:	Angle of rotation. The angle of rotation is always absolute.

The 2D or 3D rotation differentiation takes place only through the programming of the vector I, J, K. If there is no vector in the block, G68 2DRot is selected. If there is a vector in the block, G68 3DRot is selected. In the cases of both 2D rotation and 3D rotation, if no angle is programmed, the angle from the setting data 42150 $SC_DEFAULT_ROT_FACTOR_R is active.

If a vector is programmed with the length 0 (I0, Y0, K0), the Alarm 12560 "Programmed value outside the permissible limits" is triggered.

Two rotations can be switched one after the other with G68. If so far no G68 is active in a block containing G68, the rotation is written to the second ISO system frame. If G68 is already active, the rotation is written to the third ISO system frame. Thus, both rotations follow one another.

The 3D rotation is ended with G69. If two rotations are active, both are deselected with G69. G69 must not be alone in the block.

4.2 Defining the input modes of the coordinate values

4.2.1 Absolute/incremental dimensioning (G90, G91)

Whether the dimensions after an axis address should be absolute or relative (incremental) is specified with these G commands.

Properties of G90, G91

Table 4- 3 G commands for defining the absolute/incremental dimensioning

G command	Function	G group
G90	Absolute dimensioning	03
G91	Incremental dimensioning	03

- G90 and G91 are modal G functions of the G group 03. If G90 and G91 are programmed in the same block, the last G function in the block is effective.
- The closed position of G90 or G91 is set in machine data MD20154 $MC_EXTERN_GCODE_RESET_VALUES[2].

Format

- The programmed values are interpreted as absolute axis positions for all axis positions programmed according to G90, e.g. X, Y, Z.
- The programmed values are interpreted as incremental axis positions for all axis positions programmed according to G91, e.g. X, Y, Z.

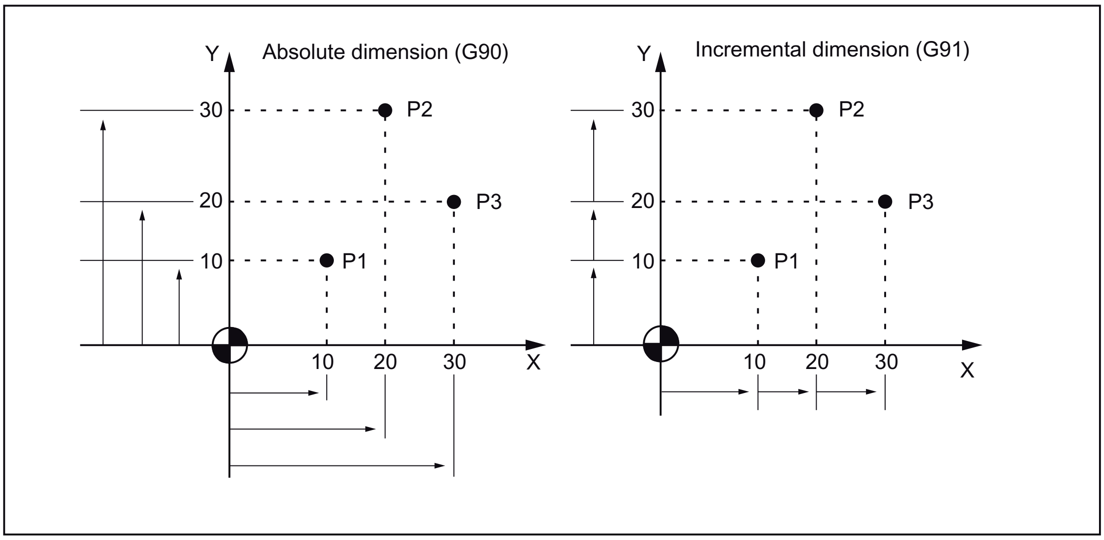


Figure 4-6 Absolute and incremental dimensioning (G90, G91)

4.2.2 Inch/metric input (G20, G21)

Workpiece-related axes can be programmed in metric or inch dimensions alternately, depending on the dimensioning in the production drawing. The input unit is selected with the following G functions.

Table 4- 4 G command for selecting the unit of measurement

G command	Function	G group
G20	Input in "inch"	06
G21	Input in "mm"	06

Format

G20 and G21 are always to be programmed at the start of the block and should not exist along with other commands in a block. The following values are processed in the selected unit of measurement while executing the G function for selecting the unit of measurement: All the following programs, offset values, certain parameters as well as certain manual operation and readout data.

```
G291;
G20;
.        ———————— Defining the input format "inch"
.
.
```

Figure 4-7 Programming example

Additions to the commands for defining the unit of measurement

- The closed position is defined via the machine data MD20154 $MC_EXTERN_GCODE_RESET_VALUES[5].
- During changeover, the values of the work offsets are changed completely.
- If the unit of measurement is changed over during program execution, the following must be executed in advance:

  While using a workpiece coordinate system (G54 to G59), this is to be traced back to the basic coordinate system.

  All tool offsets are to be deactivated (G41 to G44 and G49).
- The following is to be done after switching the measuring system from G20 to G21:

  G92 must be executed before specifying the traversing commands for the axes (to setup the coordinate system).
- G20 and G21 are not used to switch the hand wheel- and incremental weighting. This takes place through the PLC program. The machine data responsible for this is called $MA_JOG_INCR_WEIGHT.

4.2.3 Scaling (G50, G51)

Properties of G50, G51

The form defined by a part program can be enlarged or reduced according to the required scale. The desired scaling can be selected and deselected via the following functions.

Table 4- 5 G functions for selecting the scale

G command	Function	G group
G50	Scaling OFF	11
G51	Scaling ON	11

The selection for scaling and mirroring takes place with G51. A distinction is made between two options in scaling:

- Axial scaling with the parameters I, J, K

  If I, J, K is not programmed in the G51 block, the relevant default value from the setting data 43120 $A_DEFAULT_SCALE_FACTOR_AXIS is effective.

  Negative axial scaling factors lead additionally to mirroring.
- Scaling in all axes with the scaling factor P

  If P is not written in the block G51, the default value from the setting data is effective.

  Negative P values are not possible.

Format

There are two different types of scaling.

Scaling along all axes with the same scaling factor

G51 X... Y... Z... P... ; Start scaling

G50; Deselection of scaling

X, Y, Z: Center coordinate value for the scaling (absolute command)

P: Scaling factor

Scaling along each individual axis with different scaling factors

G51 X... Y... Z... I... J... K... ; Start scaling
G50; Deselection of scaling

X, Y, Z: Reference point of scaling (absolute command)
I, J, K: Scaling factor for the X-, Y- and Z-axis

The type of the scaling factor depends on MD22914 $MC_AXES_SCALE_ENABLE.

$MC_AXES_SCALE_ENABLE = 0:
The scaling factor is specified with "P". If "I,J,K" is programmed in this setting, the setting data 42140 $SC_DEFAULT_SCALE_FACTOR_P is used for the scaling factor.

$MC_AXES_SCALE_ENABLE = 1:
The scaling factor is specified with "I,J,K". If only "P" is programmed in this MD setting, the setting data 43120 $SA_DEFAULT_SCALE_FACTOR_AXIS is used for the scaling factors.

Weighting of scaling factors

The scaling factors are multiplied either with 0.001 or 0.00001. The factors are selected with MD22910 $MC_WEIGHTING_FACTOR_FOR_SCALE=0, scaling factor 0.001, $MC_WEIGHTING_FACTOR_FOR_SCALE=1, scaling factor 0.00001.

The workpiece zero is always the reference point for the scaling. A reference point cannot be programmed.

Programmable mirroring (negative scaling)

A mirror image can be created with a negative value of the axial scaling factor.

To do this, MD22914 $MC_AXES_SCALE_ENABLE = 1 must be active. If I, J or. K is omitted from the blocks with G51, the values preset in the setting data 43120 $SA_DEFAULT_SCALE_FACTOR_AXIS are activated.

Example

```
_N_0512_MPF                         ;(Part program)
N10 G17 G90 G00 X0 Y0               ;Start position for the approach motion
N30 G90 G01 G94 F6000
N32 M98 P0513                       ;1) Contour programmed as in the subroutine
N34 G51 X0. Y0. I-1000 J1000        ;2) Contour, mirrored on X
N36 M98 P0513
N38 G51 X0. Y0. I-1000 J-1000       ;3) Contour, mirrored on X and Y
N40 M98 P0513
N42 G51 X0. Y0. I1000 J-1000        ;4) Contour, mirrored on Y
N44 M98 P0513
N46 G50                             ;Deselection of scaling and mirroring
N50 G00 X0 Y0
N60 M30

_N_0513_MPF                         ;(Subroutine of 00512)
N10 G90 X10. Y10.
N20 X50
N30 Y50
N40 X10. Y10.
N50 M99
```

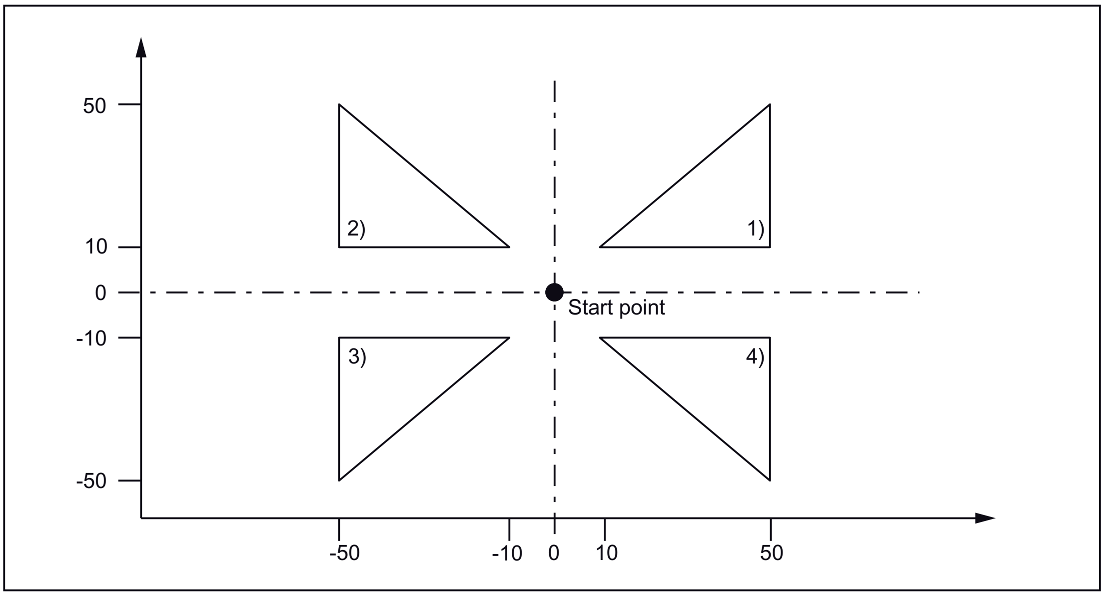


Figure 4-8 Scaling for each axis and programmable mirroring

Tool offset

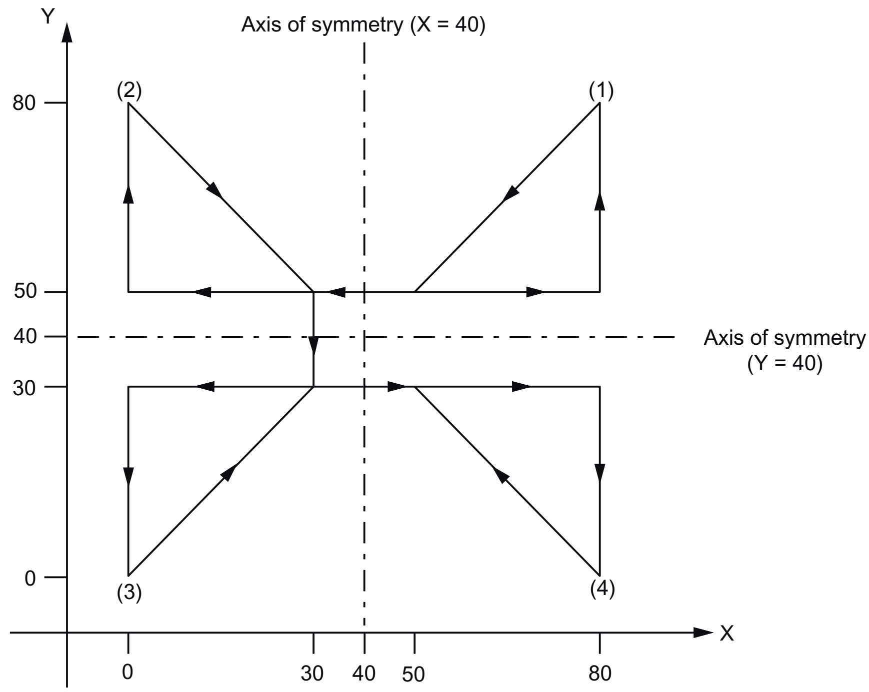
This scaling is not valid for cutter radius compensations, tool length compensations and tool offset values.

Commands for reference point approach and for changing the coordinate system

The G27, G28 and G30 functions as well as commands related to the coordinate system (G52 to G59, G92), should not be used when scaling is active.

4.2.4 Programmable mirroring (G50.1, G51.1)

G51.1 can be used to mirror workpiece shapes on coordinate axes. All programmed traversing movements are then executed as mirrored.



(1) Programmed contour original
(2) Symmetrical mapping with reference to the line that runs parallel to Y and intersects X at 40
(3) Symmetrical mapping with reference to the Point (40,40)
(4) Symmetrical mapping with reference to the line that runs parallel to X and intersects Y at 40

Figure 4-9 Programmable Mirroring

Format

X, Y, Z: Positions and mirroring axis

G51.1: Command for activating the mirroring

Mirroring takes place on a mirroring axis which is parallel to X, Y or Z and whose position is programmed with X, Y or Z. G51.1 X0 is used to mirror on the X axis, G51.1 X10 is used to mirror on a mirroring axis that runs 10 mm parallel to the X axis.

Example

```
N1000 G51.1 X... Y... Z...    ; Activate mirroring
...                           ; All the axis positions mirrored in the following
                              blocks are mirrored at the mirroring axis programmed in
                              N1000
...                           ;
...                           ;
...                           ;
G50.1 X... Y... Z..           ; Deselection of programmable mirroring
N32 M98 P0513                 ; 1) Contour programmed as in the subroutine
```

Mirroring with reference to a single axis in a specified plane

The following commands can change if the mirroring is used on one of the axes in the specified plane as described below:

Table 4- 6 Individual axes in specified plane

Command	Explanation
Circular interpolation	G02 and G03 are exchanged mutually
Cutter radius compensation	G41 and G42 are exchanged with each other
Coordinate rotation	The "clockwise" (CW) and "counter-clockwise" (CCW) directions of rotation are exchanged mutually.

Commands for reference point approach and for changing the coordinate system

The G27, G28 and G30 functions as well as commands related to the coordinate system (G52 to G59, G92, etc), should not be used when mirroring is active.

4.3 Time-controlled commands

One can use G04 to interrupt workpiece machining between two NC blocks for a programmed time/number of spindle revolutions, e.g. for backing off.

One can set with MD20734 $MC_EXTERN_FUNCTION_MASK, whether the dwell time for Bit 2 is to be interpreted as time (s or ms) or alternatively as spindle revolutions. If $MC_EXTERN_FUNCTION_MASK, Bit 2=1 is set, the dwell time is interpreted in seconds if G94 is active; it is specified in spindle revolutions (R) if G95 is selected.

Format

G04 X_; or G04 P_;

X_: Time display (commas possible)

P_: Time display (commas not possible)

- The dwell time (G04 ..) must be programmed alone in a block.

If the values of X and U are programmed in the standard notation (without decimal point), they are converted to internal units, depending on IS B, IS C (for input resolution, see Chapter "Decimal point programming"). P is always interpreted in internal units.

```
N5 G95 G04 X1000
```

Standard notation: 1000*0.001 = 1 Spindle revolution

Calculator notation: 1000 spindle revolutions

4.4 Tool offset functions

4.4.1 Tool offset data memory

The Siemens tool data memory must be used, as programs in the Siemens Mode and in the ISO Direct Mode must run alternately on the control system. Hence, length, geometry and wear exist in each tool offset data memory. In the Siemens mode, the offset data memory is addressed with "T" (Tool No.) and "D" (cutting edge no.), abbreviated as T/D No.

In the programs that are written in ISO dialect, the tool offset no. is addressed with "D" (radius) or H (length), denoted hereafter as D/H No.

For unique assignment between D and H numbers or the T/D number, one must add the $TC_DPH[t,d] element to the tool data offset memory. The D/H number is input in ISO dialect in this element.

Table 4- 7 Example: Set tool offset data

T	D/cutting edge	ISO_H $TC_DPH	Radius	Length
1	1	10		
1	2	11		
1	3	12		
2	1	13		
2	2	14		
2	3	15		

For an assignment of tool length compensations of the geometry axes that is independent of the plane selection, the setting data $SC_TOOL_LENGTH_CONST must contain the value "17". Length 1 is always assigned to the Z axis in this case.

4.4.2 Tool length compensation (G43, G44, G49)

In tool length compensation, the amount of the specified values in the program stored in the tool offset data memory is added to the Z axis or subtracted from it to undertake a offset of the programmed paths according to the length of the cutting tool.

Commands

While executing the tool length compensation, the addition or subtraction of the tool offset data is determined through the used G function and the direction of offset is determined with the H functions.

G functions used for the tool length compensation

The tool length compensation is called with the following G functions.

Table 4- 8 G functions used for the tool length compensation

G function	Function	G group
G43	Addition	08
G44	Subtraction	08
G49	Deselection	08

- G43 and G44 are modal and remain active till they are deselected through G49. The tool length compensation is deselected with G49. H00 can also be used to deselect the tool length compensation.
- By specifying "G43 (or G44) Z... H... ; " the tool offset amount specified with the H function is added to or subtracted from the specified position of the Z axis, and the Z axis then traverses to the corrected target position, i.e., the target position of the Z axis specified in the program is shifted by the magnitude of the tool offset.
- By specifying "(G01) Z... ; G43 (or G44) H... ; " the Z axis traverses the path that corresponds to the tool offset amount specified via the H function.
- By specifying "G43 (or G44) Z...H...H... ; " the Z axis traverses the path that corresponds to the difference between the previous tool offset amount and the new tool offset amount.

H function for specification of the tool offset direction

The direction of tool offset is determined by the sign of the tool length compensation that is activated by the H function, and the programmed G function.

Table 4- 9 Signs are present before the amount of tool offset and direction of tool offset

	Signs of tool offset amount (H function)	
	positive	negative
G43	Tool offset in positive direction	Tool offset in negative direction
G44	Tool offset in negative direction	Tool offset in positive direction

```
Programming example
H10 ....... Offset -3.0
H11 ....... Offset 4.0
            Position data indicator
            including offset
            (Z axis only)

N101  G92 Z0; 0.000
N102  G90 G00 X1.0 Y2.0; 0.000
N103  G43 Z-20. H10; -23.000
N104  G0I Z-30. FI000; -33.000
N105  G00  Z0H00; 0.000
   .    .
   .    .
   .    .
N201 G00 X-2.0 Y-2.0
N202 G44 Z-30 H11; -34.000
N203 G01 Z-40 F1000; -44.000
N204 G00 Z0 H00; 0.000
```

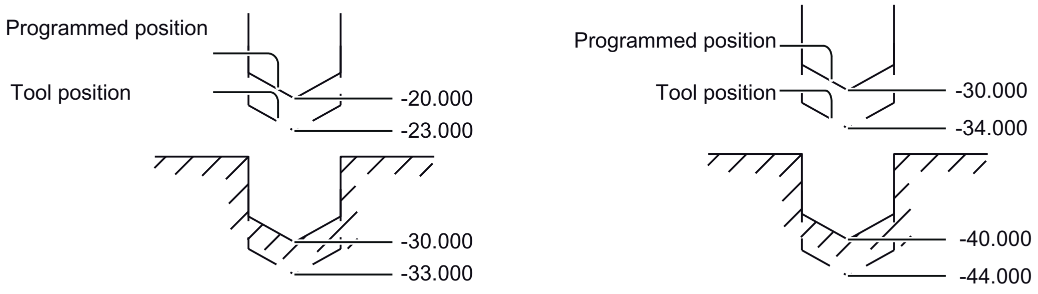


Figure 4-10 Tool position offset

Settings

- The machine data $MC_TOOL_CORR_MOVE_MODE determines whether the tool length compensation is to be undertaken with the selection of the tool offset or only during the programming of an axis motion.

  $MC_CUTTING_EDGE_DEFAULT = 0 defines that initially no tool length compensation is active during a tool change.

  $MC_AUXFU_T_SYNC_TYPE defines whether the output of the T function to the PLC takes place during or after the traversing movement.

  $MC_RESET_MODE_MASK, Bit 6, can be used to define that the currently active tool length compensation will remain active even after a RESET.
- The cutter radius compensation can also be called for an operation with tool length compensation.

Tool length compensation in several axes

Tool length compensation can also be activated for several axes. A display of the resulting tool length compensation is not possible any more in that case.

4.4.3 Cutter radius compensation (G40, G41, G42)

In cutter radius compensation, the programmed tool paths are automatically shifted by the radius of the cutting tool used. The path to be corrected (radius of the cutting tool) can be stored in the tool offset data memory using the NC operator panel. The tool offsets can also be overwritten with the G10 command in the part program; G10 cannot be used to create new tools.

The tool offset data in the program is called by specifying the number of the tool offset data memory with a D function.

Commands

The cutter radius compensation is called with the following G functions.

Table 4- 10 G functions for calling the cutter radius compensation

G function	Function	G group
G40	Deselection of the tool radius compensation	07
G41	Tool radius compensation (tool works in machining direction to the left of the contour)	07
G42	Tool radius compensation (tool works in machining direction to the right of the contour)	07

The tool radius compensation is called by executing G41 or G42 and deselected through G40. The offset direction is determined through the specified G function (G41, G42) and the offset amount is determined through the D function.

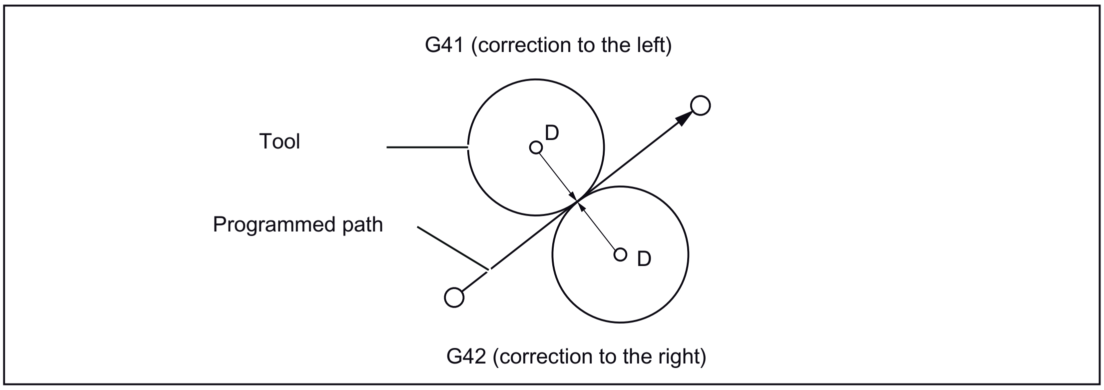


Figure 4-11 Cutter radius compensation

- A negative offset value of the tool radius is equivalent to a change of compensation side (G41, G42). The D function must either be programmed in the same block as G41 or G42 or in a previous block. D00 means tool radius = "0".
- The selection of the plane in which the tool radius is active is done with G17, G18 or G19. The G function used to select the plane is to be programmed in the same block as G41 or G42 or in the block before G41 or G42.

Table 4- 11 G functions for selecting the plane

G function	Function	G group
G17	Selection of plane X-Y	02
G18	Selection of plane Z-X	02
G19	Selection of plane Y-Z	02

- The selected plane should not be changed if the tool offset is selected, otherwise there is an error message.

Activation/deactivation of tool radius compensation

A drive command must be programmed with G0 or G1 if an NC block contains G40, G41 or G42. At least one axis of the selected working plane must be specified in this drive command.

Note

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: Standard 3.

Note

Machine manufacturer

The number of successive interruptions blocks or M functions can be set via the machine data 20250 CUTCOM_MAXNUM_DUMMY_BLOCKS (refer to machine manufacturer).

Note

A block with path zero is also taken as interruption!

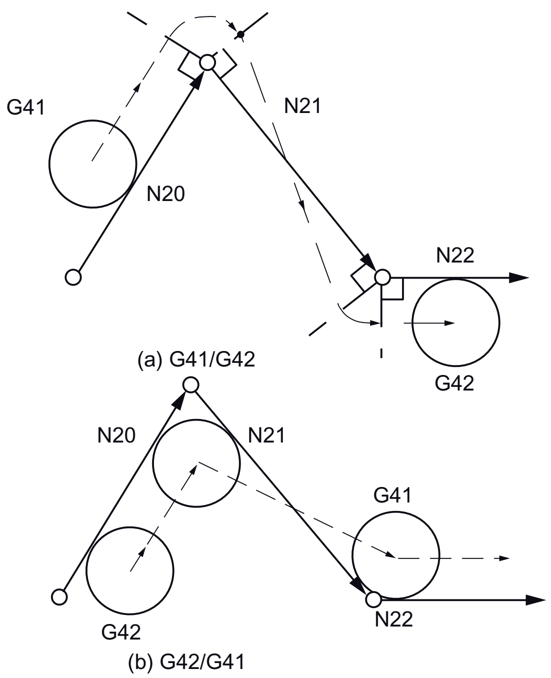
Changeover between G41 and G42 in operation with cutter radius compensation

The offset direction (left or right) can be changed over directly without having to leave the compensation mode.

The new offset direction is approached with the next block, through an axis motion.

Programming example
N10 G17 G01 F... ;
N11 G41 (G42) X... Y... ;
.
.
.
N20 G01 X... Y... F... ;
N21 G42 (G41) X... Y... ;
N22 X... ;

Set for switching the offset direction



Note: If the content of Block N21 is reproduced in two blocks as specified below,
G42 (or G41);
X Y;
the offset direction is also switched over in the same way.

Figure 4-12 Changeover of the tool offset direction at block start and end of block

Deselection of the tool offset

There are two methods of deselecting the tool offset, which can be set through the setting data 42494 $SC_CUTCOM_ACT_DEACT_CTRL.

1. Method A:

   If G40 is programmed in a block without axis motion, the tool radius compensation is deselected only with the next block through an axis motion.

2. Method B:

   If G40 is programmed in a block without axis motion, the tool radius compensation is deselected immediately. In other words, that linear interpolation (G00 or G01) must be active in the block, because the tool radius compensation can be deselected only with a linear movement. An alarm is triggered if no linear interpolation is active during the selection of the tool radius compensation.

Deselection of the compensation mode at an internal angle (smaller than 180°):

Straight line - straight line

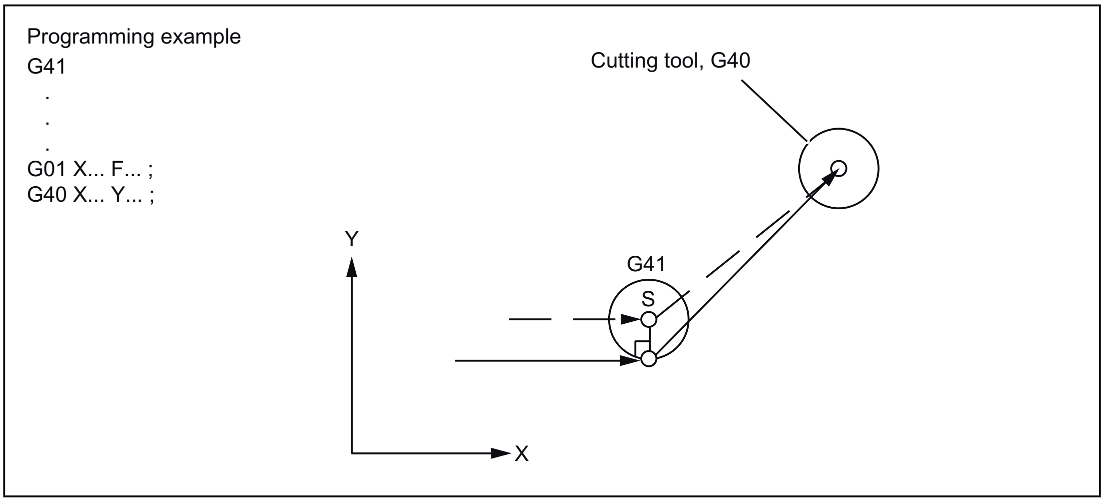


Figure 4-13 Deselection of the compensation mode at an internal angle (straight line - straight line)

Circular arc - straight line

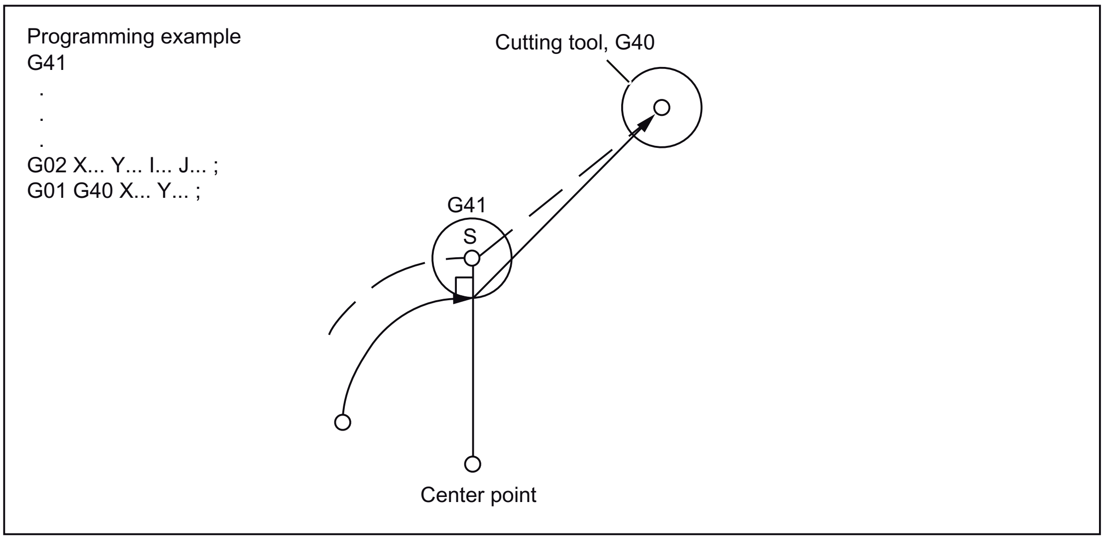


Figure 4-14 Deselection of the compensation mode at an internal angle (circular arc - straight line)

4.4.4 Collision detection

Activation via the NC program

Although the "Collision detection" function is available only in the Siemens mode, it can also be used in the ISO dialect mode. Activation and deactivation must be undertaken only in the Siemens mode.

```
G290        ;Activation of the Siemens mode
CDON        ;Activation of the detection of bottlenecks
G291        ;Activation of the ISO dialect mode
...
...
G290        ;Activation of the Siemens mode
CDOF        ;Deactivation of the detection of bottlenecks
G291        ;Activation of the ISO dialect mode
```

Activation by setting machine data

MD20150 $MC_GCODE_RESET_VALUES[22] = 2: CDON (effective modal)

MD20150 $MC_GCODE_RESET_VALUES[22] = 1: CDOF (not effective modal)

Function

With active CDON (Collision Detection ON) and active tool radius compensation, the control system monitors tool paths 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.

With deactivated bottleneck detection (CDOF), a search is made in the previous traversing block (at inside corners) for a common point of intersection for the current block; if necessary the search is extended to even earlier blocks. An error message is triggered if no point of intersection is found with this method.

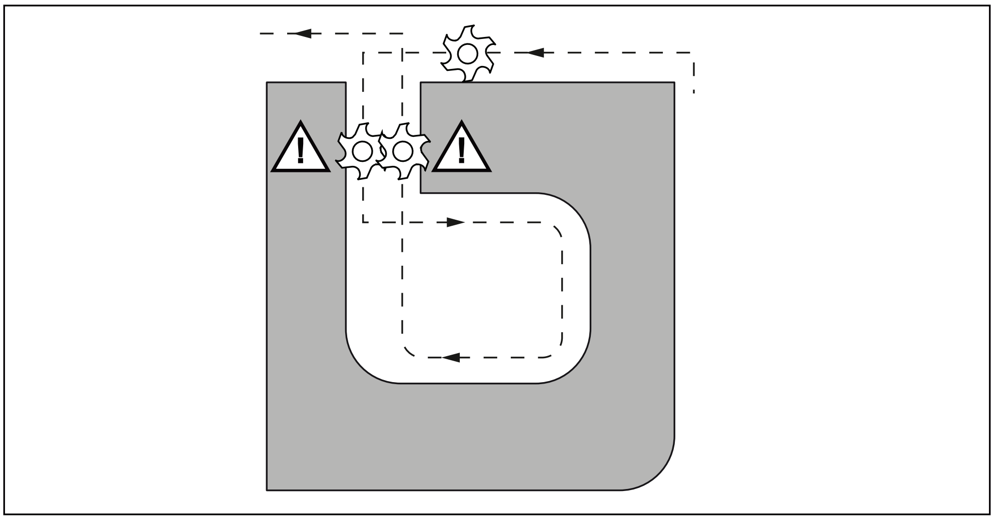


Figure 4-15 Collision detection

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.

Note

Machine manufacturer

The number of NC blocks that are included in the monitoring can be set via machine data (see machine manufacturer).

Examples

In the following pages, you will find a few examples of critical machining situations that can be detected by the control system and corrected through changes in the tool paths.

To avoid program interruptions, during program validation only the ones that have the biggest radius from among all tools should be selected.

In each of the following examples, a tool with a too large radius was selected for machining the contour.

Detection of bottlenecks

As the selected tool radius for machining this inside contour is too big, the bottlenecks are bypassed. An alarm is output.

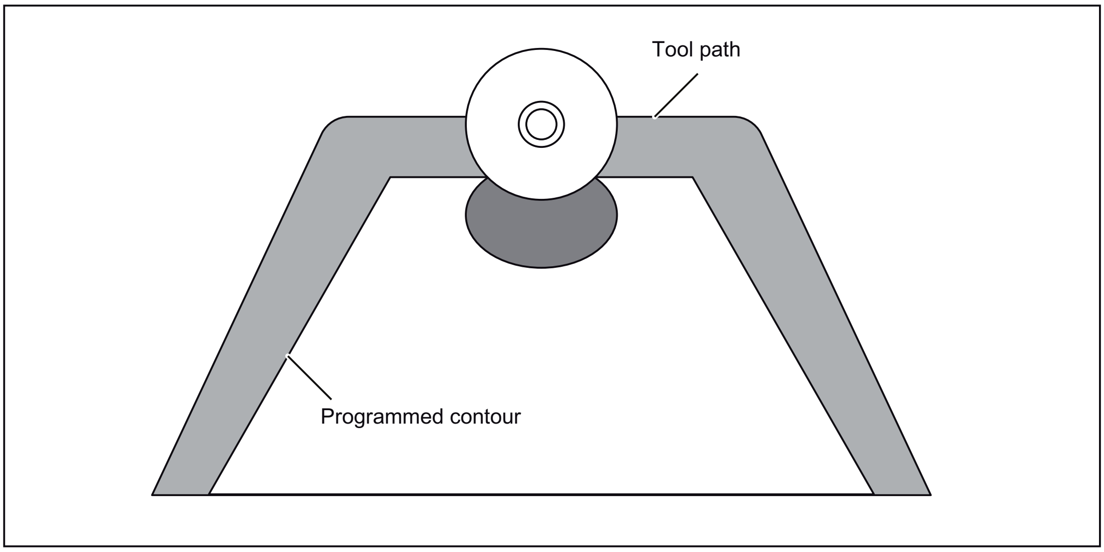


Figure 4-16 Detection of bottlenecks

Contour definition shorter than tool radius

The tool traverses the tool angle on a transition circle and then follows exactly the programmed contour.

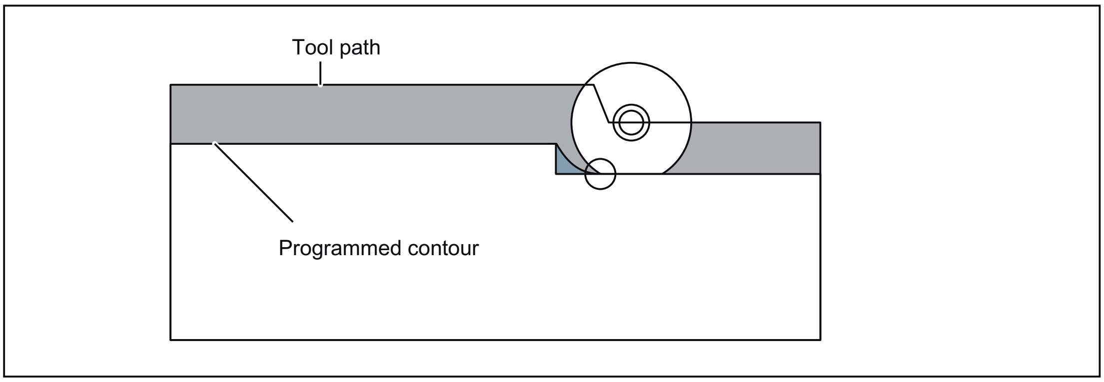


Figure 4-17 Contour definition shorter than tool radius

Tool radius too large for internal machining

In such cases, a machining of the contour takes place only to the extent possible without damaging the contour.

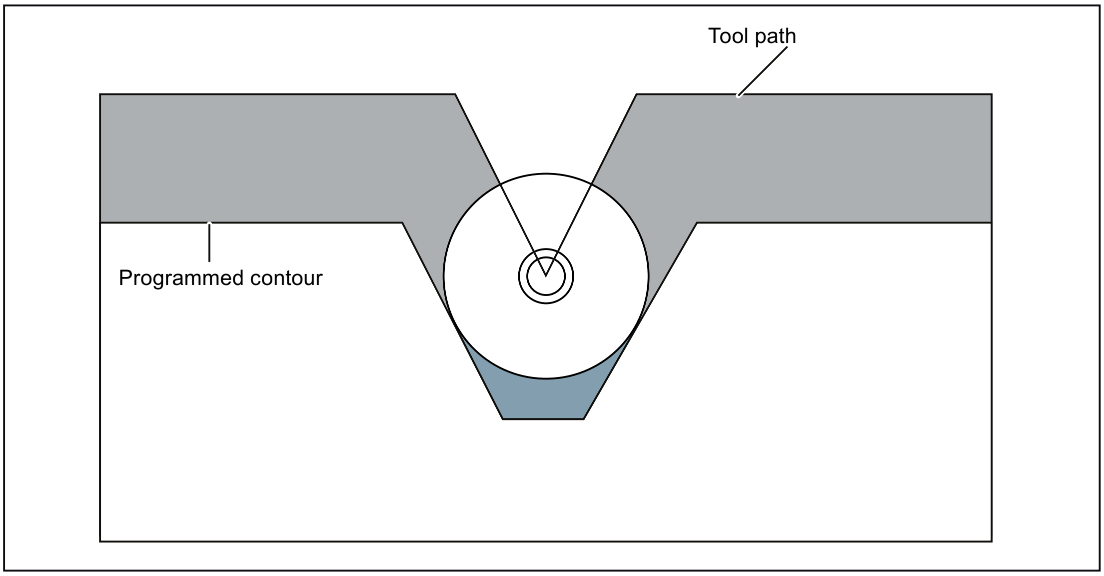


Figure 4-18 Tool radius too large for internal machining

4.5 S-, T-, M- and B functions

4.5.1 Spindle function (S function)

The spindle speed is specified in rpm in Address S. The direction of spindle rotation is selected with M3 and M4. M3 = right direction of spindle rotation, M4 = left direction of spindle rotation. The spindle stops with M5. Details are available in the documentation of your machine manufacturer.

- S commands are modal, i.e., they remain active up to the next S command once they are programmed. The S command is maintained if the spindle is stopped with M05. If M03 or M04 is programmed thereafter without specifying an S command, then the spindle starts at the originally programmed speed.
- If the spindle speed is changed, please pay attention to which gear stage is currently set for the spindle. Details are available in the documentation of your machine manufacturer.
- The lower limit for the S command (S0 or an S command near S0) depends on the drive motor and the drive system of the spindle and is different from machine to machine. Negative values are not permitted for S! Details are available in the documentation of your machine manufacturer.

4.5.2 Tool function

There are different options of command output for the tool function. Details are available in the documentation of your machine manufacturer.

4.5.3 Additional function (M function)

The M functions initiate switching operations, such as "Coolant ON/OFF" and other functions on the machine. Various M functions have already been assigned a fixed functionality by the CNC manufacturer (see the following section).

Programming

M... Possible values: 0 to 9999 9999 (max. INT value), integer

All free M function numbers can be assigned by the machine manufacturer, e.g. for switching functions to control the clamping devices or for switching on/off of further machine functions. See data of the machine manufacturer.

The NC-specific M functions are described below.

M functions to stop operations (M00, M01, M02, M30)

A program stop is triggered with this M function and the machining is interrupted or ended. Whether the spindle is also stopped depends on the specification of the machine manufacturer. Details are available in the documentation of your machine manufacturer.

M00 (program stop)

The machining is stopped in the NC block with M00. One can now, e.g., remove chips, re-measure, etc. A signal is output to the PLC. The program can be continued with <CYCLE START>.

M01 (optional stop)

M01 can be set via

- HMI/dialog box "Program control" or the
- VDI interface

The program processing of the NC is maintained with M01 only when the corresponding signal of the VDI interface is set or "Program control" was selected in the HMI/dialog box.

M30 or M02 (end of program)

A program is ended with M30 or M02.

Note

A signal is output to the PLC with M00, M01, M02 or M30.

Note

Data on whether spindle is stopped with the commands M00, M01, M02 or M30 or the coolant supply is interrupted is available in the documentation of your machine manufacturer.

4.5.4 M functions of spindle control

Table 4- 12 M functions of spindle control

M function	Function
M19	Positioning the spindle
M29	Changeover of spindle to the axis/open-loop control mode

The spindle is traversed to the spindle position defined in the setting data 43240 $SA_M19_SPOS[spindle number] with M19. The positioning mode is stored in $SA_M19_SPOS.

The M function number for the changeover of the spindle mode (M29) can also be set over a machine data variable. MD20095 $MC_EXTERN_RIGID_TAPPING_N_NR is used to pre-set the M function number. Only the M function numbers that are not used as standard M functions can be assigned. For example, M0, M5, M30, M98, M99 etc are not allowed.

4.5.5 M functions for subroutine calls

Table 4- 13 M functions for subroutine calls

M function	Function
M98	Subprogram call
M99	Subprogram end

In the ISO mode, the spindle is switched to the axis mode with M29.

4.5.6 Macro call via M function

Via M numbers, one can call a subroutine (macro) similar to G65.

The configuration of a maximum of 10 M functions replacements is undertaken via machine data 10814 $MN_EXTERN_M_NO_MAC_CYCLE and machine data 10815 $MN_EXTERN_M_NO_MAC_CYCLE_NAME.

Programming takes place identical to G65. Repetitions can be programmed with the L address.

Restrictions

Only one M function replacement (or only one subroutine call) can be executed per part program line. Conflicts with other subroutine calls are signaled by alarm 12722. There is no further M function replacement in the replaced subroutine.

Otherwise, the same restrictions are valid as in G65.

Conflicts with pre-defined and other defined M numbers are rejected with an alarm.

Configuration example

Call of subroutine M101_MAKRO via the M101 M function:

$MN_EXTERN_M_NO_MAC_CYCLE[0] = 101

$MN_EXTERN_M_NO_MAC_CYCLE_NAME[0] = "M101_MAKRO"

Call of subroutine M6_MAKRO via the M6 M function:

$MN_EXTERN_M_NO_MAC_CYCLE[1] = 6

$MN_EXTERN_M_NO_MAC_CYCLE_NAME[1] = "M6_MAKRO"

Programming example for tool change with M function:

```
PROC MAIN
...
N10             M6 X10 V20                    ;Call of M6_MAKRO program
...
N90             M30
PROC M6_MAKRO
...
N0010           R10 = R10 + 11.11
N0020           IF $C_X_PROG == 1 GOTOF N40   ;($C_X_PROG)
N0030           SETAL(61000)                  ;programmed variable not
                                              ;transferred correctly
N0040           IF $C_V == 20 GTOF N60        ;($C_V)
N0050           SETAL(61001)
N0060           M17
```

4.5.7 M functions

General M functions

The non-specific M functions are defined by the machine manufacturer. A representative example of the use of general M functions is available under. Details are available in the documentation of your machine manufacturer. If an M command is programmed with an axis motion in the same block, whether the M function is to be executed at the start or end of the block on reaching the axis position depends on the machine data setting of the machine manufacturer. Details are available in the documentation of your machine manufacturer.

Table 4- 14 Other general M functions

M function	Function	Remarks
M08	Coolant ON	These M functions are defined by the machine manufacturer.
M09	Coolant OFF	

Specification of several M functions in one block

A maximum of five M functions can be programmed in on block. Possible combinations of M functions and possible restrictions are specified in the documentation of your machine manufacturer.

Additional auxiliary functions (B functions)

If B is not used as axis identifier, B can be used as extended auxiliary function. B functions are output to the PLC as auxiliary functions (H functions with the address extension H1=).

Example: B1234 is output as H1=1234.

4.6 Controlling the feedrate

4.6.1 Compressor in the ISO dialect mode

The commands COMPON, COMPCURV, COMPCAD are commands of the Siemens language and they activate a compressor function that combines several linear blocks into one machining section. If this function is activated in the Siemens mode, even linear blocks in the ISO mode can be compressed with this function.

The blocks can at the most consist of the following commands:

- Block number
- G01, modal or in block
- Axis assignments
- Feedrate
- Comments

If a block contains other commands (e.g., auxiliary functions, other G codes, etc.), compression does not take place.

Value assignments with $x for G, axes and feedrate are possible, just as the skip function.

Example: These blocks are compressed

```
N5    G290
N10   COMPON
N15   G291
N20   G01 X100. Y100. F1000
N25   X100 Y100 F$3
N30   X$3 /1 Y100
N35   X100 (Axis 1)
```

These blocks are **not** compressed

```
N5    G290
N10   COMPON
N20   G291
N25   G01 X100 G17              ; G17
N30   X100 M22                  ; Auxiliary function in block
N35   X100 S200                 ; Spindle speed in block
```

4.6.2 Exact stop (G09, G61), Continuous-path mode (G64), tapping (G63)

The path feedrate is controlled as specified in the table below.

Table 4- 15 Control of the path feedrate

Identifier	G function	Efficacy of the G functions	Description
Exact stop	G09	effective only in the block in which the relevant G function is programmed	Braking and stop at end of block and position control before transition to the next block
Exact stop	G61	Modal G function; remains effective till it is deselected via G63 or G64.	Braking and stop at end of block and position control before transition to the next block
Continuous-path mode	G64	Modal G function; remains effective till it is deselected via G61 or G63.	No braking at end of block before transition to the next block
Tapping	G63	Modal G function; remains effective till it is deselected via G61 or G64.	No braking at end of block before transition to the next block; feedrate override is not effective

Format

G09 X... Y... Z...	;	Exact stop, non-modal
G61	;	Exact stop, modal
G64	;	Continuous-path mode
G63	;	Tapping

Additional functions 5

5.1 Program supporting functions

5.1.1 Fixed drilling cycles

The fixed drilling cycles simplify the creation of new programs for the programmer. Frequently occurring machining steps can be executed with a G function; without fixed cycles, several NC blocks must be programmed. Thus fixed drilling cycles shorten the machining program and save memory space.

In the ISO dialect mode, a shell cycle is called which uses the functionality of the Siemens standard cycles. This way, the addresses programmed in the NC block are transferred to the shell cycle via system variables. The shell cycle adjusts this data and calls a Siemens standard cycle.

A fixed cycle could be canceled only with G80 or a G code of G code Group 1 before the program can be continued with a blockwise cycle.

The fixed drilling cycles are called with the following G functions.

Table 5- 1 Overview of drilling cycles

G function	Drilling (-Z direction)	Machining at drilling base	Return (+Z direction)	Applications
G73	Interrupted working feedrate (delay possible at each in-feed)	—	Rapid traverse	High-speed deep hole drilling
G74	Cutting feedrate	Spindle stop → Spindle revolution after dwelling in the opposite direction	Cutting feedrate → dwell time → Spindle turns in the opposite direction	Left-hand thread boring (in the opposite direction)
G76	Cutting feedrate	Spindle positioning → Withdraw lift-off path	Rapid traverse → Return lift-off path, spindle start	Precision drilling boring
G80	—	—	—	Deselection
G81	Cutting feedrate	—	Rapid traverse	Drilling, Preboring
G82	Cutting feedrate	Dwell	Rapid traverse	Drilling, countersinking
G83	Interrupted working feedrate	—	Rapid traverse	Deep-hole drilling
G84	Cutting feedrate	Spindle stop→ Spindle start after dwelling in the opposite direction	Cutting feedrate → dwell time → Spindle turns in the opposite direction	Tapping

G function	Drilling (-Z direction)	Machining at drilling base	Return (+Z direction)	Applications
G85	Cutting feedrate	—	Cutting feedrate	Drilling
G86	Cutting feedrate	Spindle stop	Rapid traverse → spindle start	Drilling
G87	Spindle positioning → Withdraw lift-off path → Rapid traverse → Return lift-off path → Spindle run right → Cutting feedrate	Spindle positioning after dwelling → Withdraw lift-off path	Rapid traverse → Return lift-off path → Spindle start	Drilling
G89	Cutting feedrate	Dwell	Cutting feedrate	Drilling

Explanations

On using fixed cycles, the sequence of operation in general is always as described below:

- 1. Working cycle

  Positioning in X-Y plane with cutting feedrate or rapid traverse rate
- 2. Working cycle

  Rapid traverse movement to plane R
- 3. Working cycle

  Machining up to drilling depth Z
- 4. Working cycle

  Machining at drilling base
- 5. Working cycle

  Return up to plane R with cutting feedrate or rapid traverse rate
- 6. Working cycle

  Rapid retraction with rapid traverse rate to positioning plane X-Y

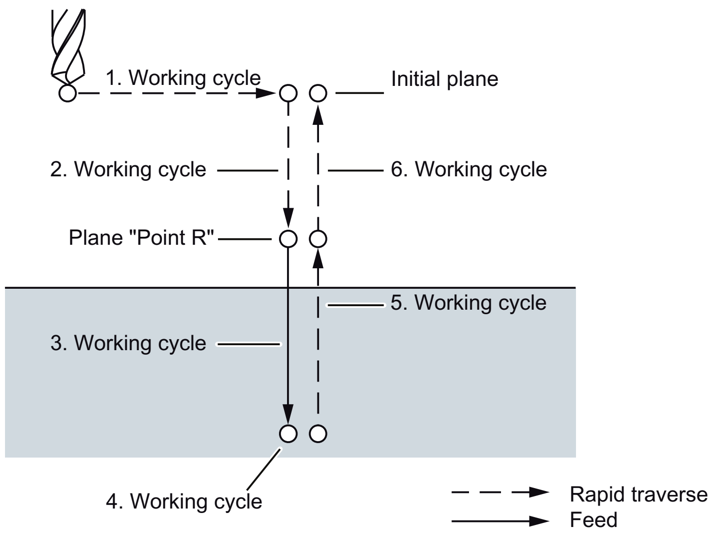


Figure 5-1 Sequence of operations in the drilling cycle

If the term "drill" is used in this Chapter, it refers only to the working cycle that are executed with the help of fixed cycles, even though naturally there are fixed cycles for tapping, boring or drilling cycles too.

Definition of the current plane

In drilling cycles, one generally assumes that the current coordinate system in which the machining operation is to be executed, is defined through the selection of plane G17, G18 or G19 and activation of a programmable work offset. Drilling axis is then always the application of this coordinate system.

Before calling the cycle, one must always select a tool length compensation. It is always effective perpendicular to the selected plane and remains active even beyond the end of the cycle.

Table 5- 2 Positioning plane and drilling axis

G function	Positioning plane	Drilling axis
G17	Xp-Yp plane	Zp
G18	Zp-Xp plane	Yp
G19	Yp-Zp plane	Xp

Xp: X axis or an axis parallel to the X axis

Yp: Y axis or an axis parallel to the Y axis

Zp: Z axis or an axis parallel to the Z axis

Note

Whether the Z axis should always be used as the drilling axis can be defined with USER DATA, _ZSFI[0]. The Z axis is then always the drilling axis, if _ZSFI[0] is equal to "1".

Execution of a fixed cycle

The following is necessary to execute a fixed cycle:

1. Cycle call

   G73, 74, 76, 81 to 87 and 89

   as a function of the desired machining

2. Data format G90/91

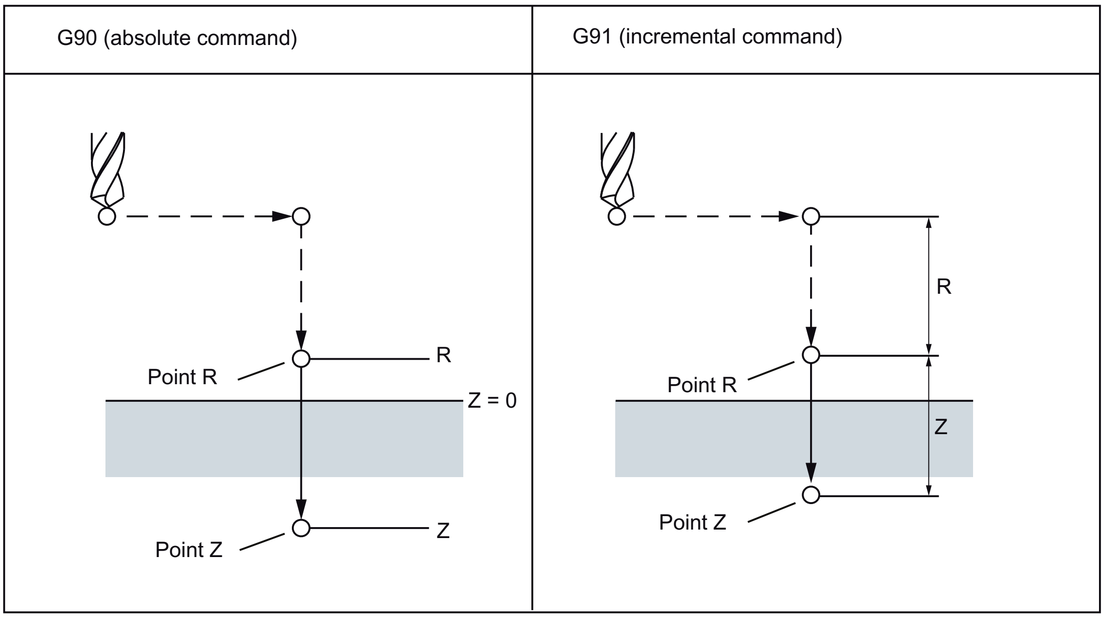


Figure 5-2 Absolute/incremental command G90/G91

3. Drilling mode

   G73, G74, G76 and G81 to G87 and G89 are modal G functions and they remain active till they are deselected. The selected drilling cycle is called in each block. The complete parameter assignment of the drilling cycles must be programmed only during the selection (e.g., G81). Only the parameters that are supposed to change are to be programmed In the following blocks.

4. Positioning/reference plane (G98/G99)

   While using the fixed cycles, the retraction plane for the Z-axis is defined with G98/99. G98/G99 are modal G functions. The closed position is normally G98.

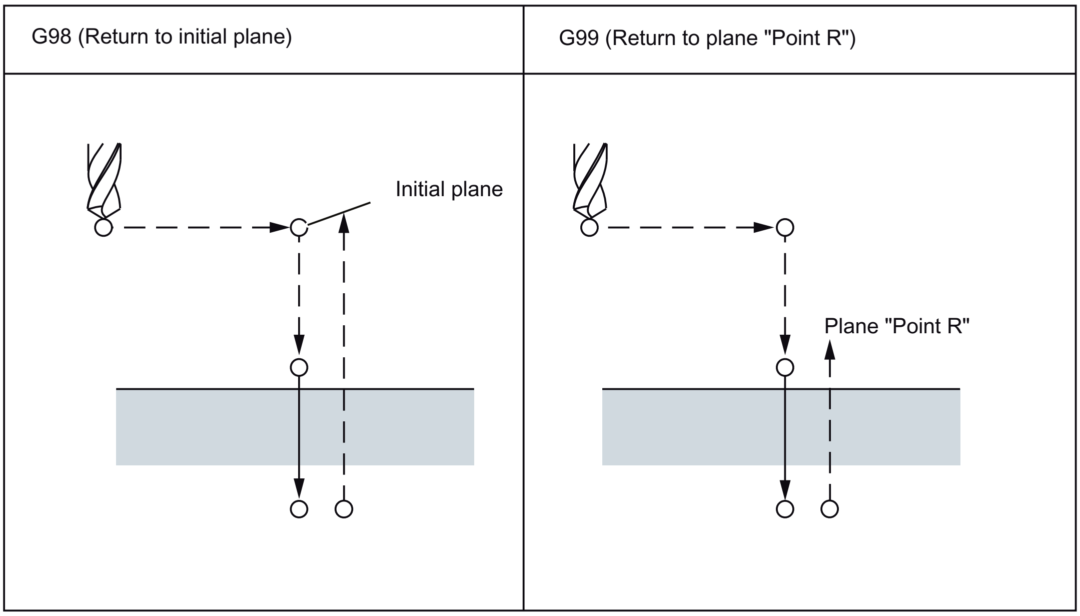


Figure 5-3 Plane for the return point (G98/G99)

Repeat

If several holes are drilled at uniform spacing, the number of repetitions is specified with "K". "K" is effective only in the block in which it is programmed. If the drilled hole position is programmed as absolute (G90), drilling is done at the same position again; hence the drilled hole position is to be specified as incremental (G91).

Comments

A cycle call remains active till it is deselected again with the G functions G80, G00, G01, G02 or G03 or another cycle call.

Symbols and numbers

The individual fixed cycles are explained in the following sections. The following symbols are used in the numbers occurring in these explanations:

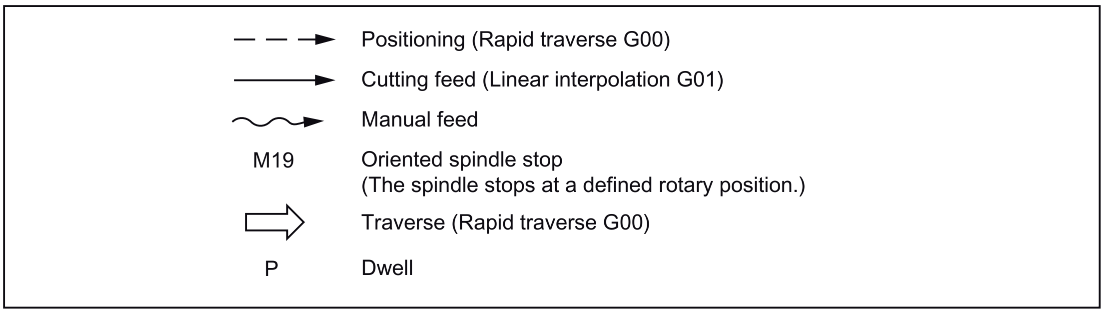


Figure 5-4 Icons in the numbers

5.1.2 High-speed deep hole drilling cycle with chip breakage (G73)

The tool drills at the programmed spindle speed and feedrate to the entered final drilling depth. Deep hole drilling is performed with a depth infeed of a maximum defined depth executed several times, increasing gradually until the final drilling depth is reached. Optionally, the twist drill can be retracted after each infeed depth either to the reference plane + safety clearance for chip removal or by the length of the programmed retraction path for chip breakage.

Format

G73 X.. Y... R... Q... F... K... ;

X,Y: Drilled hole position

Z: Distance from Point R to the base of the drilled hole

R: Distance from the initial plane to plane R

Q: Single drilling depth

F: Feedrate

K: Number of repetitions

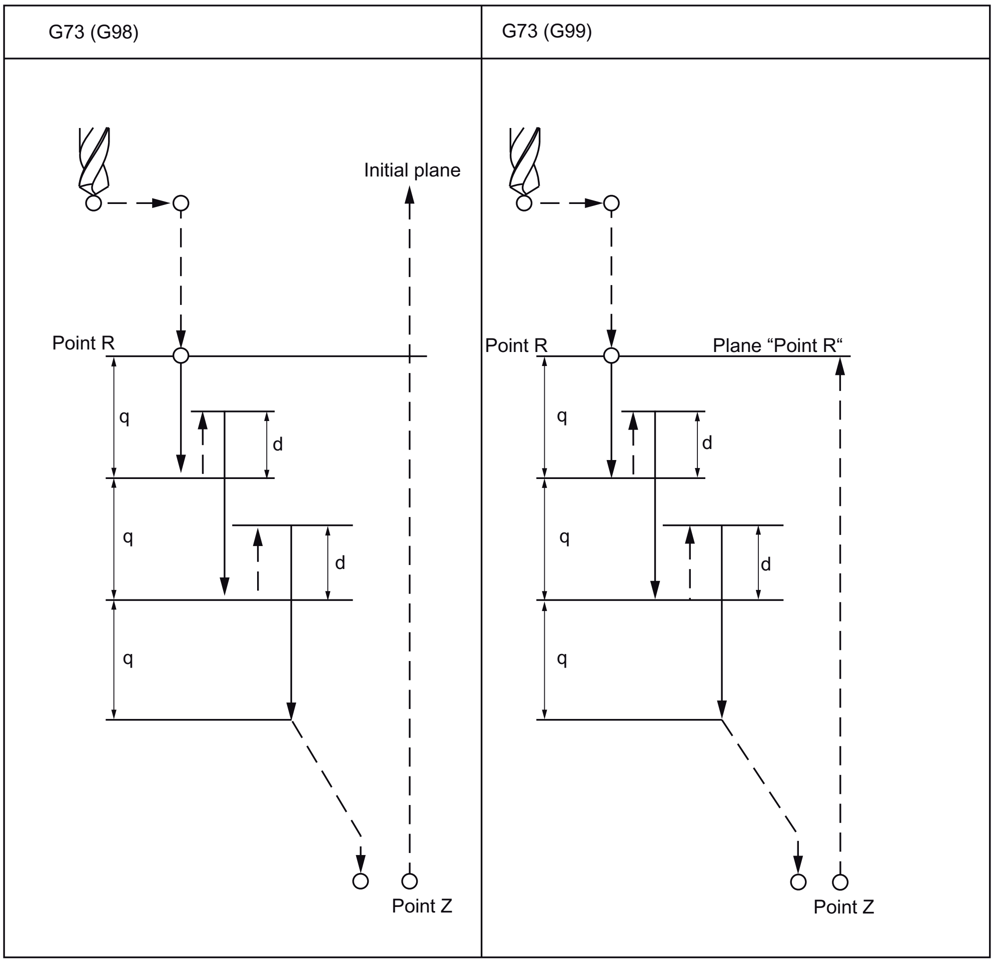


Figure 5-5 High-speed deep hole drilling cycle with chip breakage (G73)

Explanations

On using the G73 cycle, the retraction motion takes place after the drilling with rapid traverse. The safety clearance can be specified with GUD _ZSFR[0]. The retraction amount from chip breaking (d) is defined with GUD _ZSFR[1]:

_ZSFR[1] > 0 Retraction amount as input

_ZSFR[1] = 0 Retraction amount in chip breaking is always 1 mm

The in-feed takes place by using the cutting depth for each cutting Q which is incremented with the retraction amount d as second in-feed.

A rapid drilling infeed results with this drilling cycle. Chip removal takes place through the retraction motion.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Deep-hole drilling

The drilling cycle is executed only if an axis motion, e.g., is programmed with X, Y, Z or R.

Q/R

Always program Q and R in one block with an axis motion, otherwise the programmed values will not be stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G73 should not be used together in one block, as otherwise G73 is deselected

Example

```
M3 S1500                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G73 X200. Y-150. Z-100.   ;Positioning, drilled hole 1,
R50. Q10. F150.                   ;then return to Point R
Y-500.                            ;Positioning, drilled hole 2,
                                  ;then return to Point R
Y-700.                            ;Positioning, drilled hole 3,
                                  ;then return to Point R
X950.                             ;Positioning, drilled hole 4,
                                  ;then return to Point R
Y-500.                            ;Positioning, drilled hole 5,
                                  ;then return to Point R
G98 Y-700.                        ;Positioning, drilled hole 6,
                                  ;then return to initial plane
G80                               ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                  ;Return to reference position
M5                                ;Spindle stop
```

5.1.3 Fine drilling cycle (G76)

Precision drilling takes place with the fine drilling cycle.

Format

G76 X... Y... R... Q... P... F... K... ;

X,Y: Drilled hole position

Z_: Distance from point R to the bottom of the hole

R_: Distance from the initial plane to plane "Point R"

Q_: Amount of offset at the bottom of a hole

P_: Dwell time at the bottom of a hole

F_: Feedrate

K_: Number of repetitions

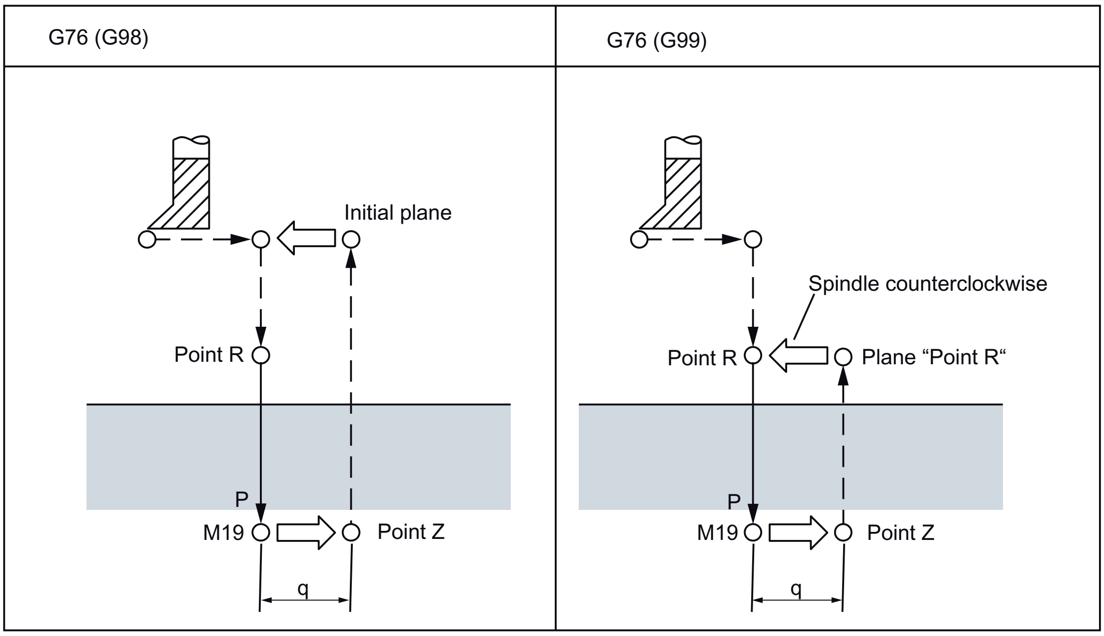
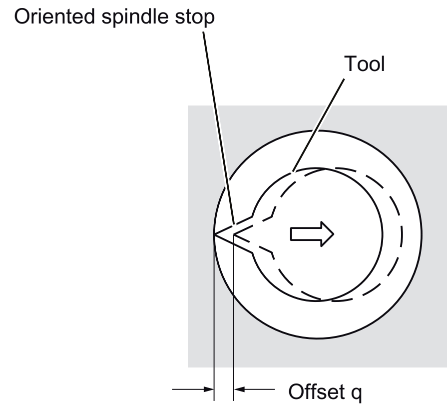


Figure 5-6 Fine drilling cycle (G76)



WARNING

Address Q is a modal value that is stored in the fixed cycles. Please ensure that this address is also used as interface for the cycles G73 and G83!

Explanations

The spindles stops at a fixed spindle position after the bottom of a hole is reached. The tool is returned opposite the tool tip.

The safety clearance can be specified with GUD _ZSFR[0]. The lift-off path can be specified with _ZSFI[5].

	G17	G18	G19
_ZSFI[5] = 1	+X	+Z	+Y
_ZSFI[5] = 0 or 2	-X	-Z	-Y
_ZSFI[5] = 3	+Y	+X	+Z
_ZSFI[5] = 4	-Y	-X	-Z

The angle must therefore be specified in USER DATA, _ZSFR[2] in such a way that the tool tip points at the opposite direction after the spindle stop, for the lift-off path.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

Q/R

Always program Q and R only in one block with a retracting movement, otherwise the programmed values are not stored modally.

Only one positive value is to be specified in each case for the value of Address Q. If a negative value is specified for Q, the sign is ignored. Q is set as equal to "0" if no lift-off path is programmed. In this case, the cycle is executed without lifting.

Deselection

The G functions of Group 01 (G00 to G03) and G76 should not be used together in one block, as otherwise G76 is deselected.

Example

```
M3 S300                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G76 X200. Y-150. Z-100.  ;Positioning, drilling of drilled hole 1,
R50. Q10. P1000 F150.            ;then return to point R and
                                 ;for 1 s stop at the bottom of a hole
Y-500.                           ;Positioning, drilled hole 2,
                                 ;then return to point R
Y-700.                           ;Positioning, drilled hole 3,
                                 ;then return to point R
X950.                            ;Positioning, drilled hole 4,
                                 ;then return to point R
Y-500.                           ;Positioning, drilled hole 5,
                                 ;then return to point R
G98 Y-700.                       ;Positioning, drilled hole 6,
                                 ;then return to initial plane
G80                              ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                 ;Return to reference position
M5                               ;Spindle stop
```

5.1.4 Drilling cycle, counterboring (G81)

This cycle can be used for centering and preboring. The retraction motion starts immediately with rapid traverse rate on reaching the drilling depth Z.

Format

G81 X... Y... R... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to plane R

F: Cutting feedrate

K: Number of repetitions

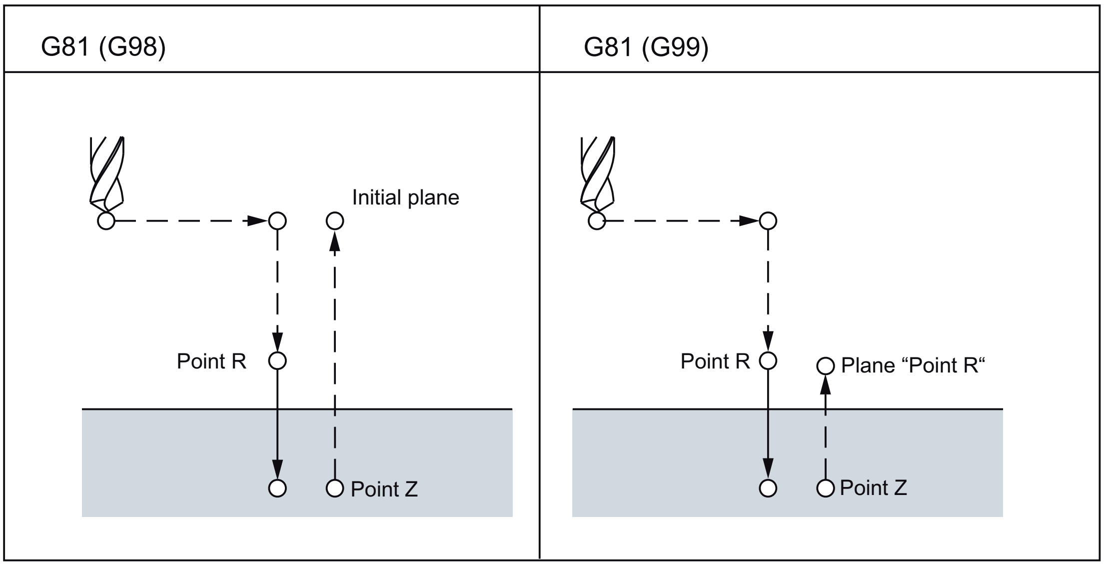


Figure 5-7 Drilling cycle counterboring (G81)

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G76 should not be used together in one block, as otherwise G76 is deselected.

Example

```
M3 S1500                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G81 X200. Y-150. Z-100.  ;Positioning, drilled hole 1,
R50. F150.                        ;then return to point R and
                                  ;for 1 s stop at the bottom of a hole
Y-500.                            ;Positioning, drilled hole 2,
                                  ;then return to point R
Y-700.                            ;Positioning, drilled hole 3,
                                  ;then return to point R
X950.                             ;Positioning, drilled hole 4,
                                  ;then return to point R
Y-500.                            ;Positioning, drilled hole 5,
                                  ;then return to point R
G98 Y-700.                        ;Positioning, drilled hole 6,
                                  ;then return to initial plane
G80                               ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                  ;Return to reference position
M5                                ;Spindle stop
```

5.1.5 Countersink drilling cycle (G82)

This cycle can be used for normal drilling. A programmed dwell time can be active on reaching the drilling depth Z; the retraction motion is then executed in rapid traverse.

Format

G82 X... Y... R... P... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to plane R

P: Dwell time at the bottom of a hole

F: Feedrate

K: Number of repetitions

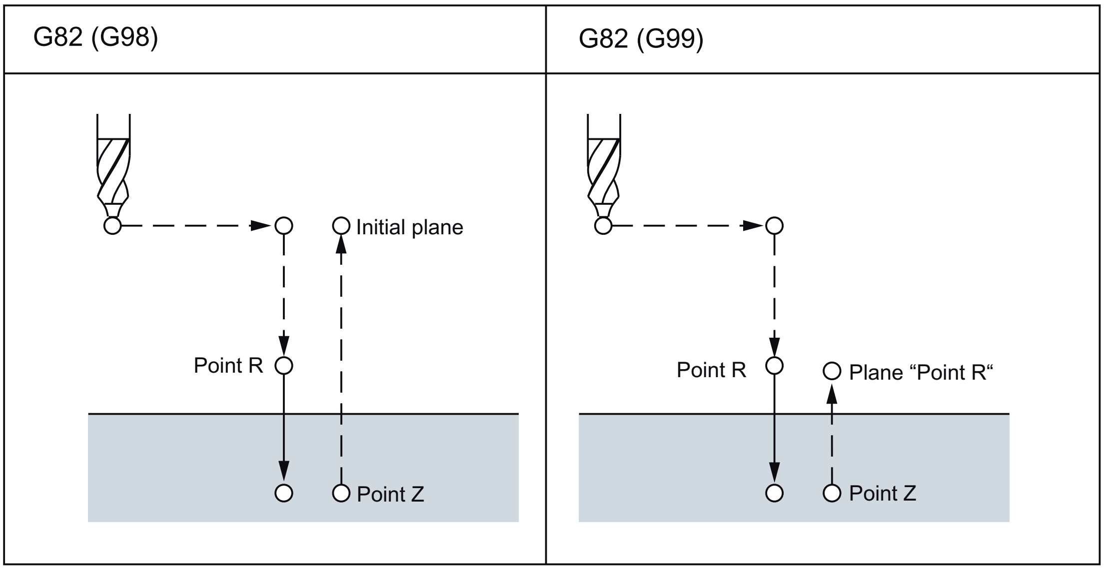


Figure 5-8 Countersink drilling cycle (G82)

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G82 should not be used together in one block, as otherwise G82 is deselected.

Example

```
M3 S2000                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G82 X200. Y-150. Z-100.   ;Positioning, drilled hole 1,
R50. P1000 F150.                  ;stop on the bottom of a hole for 1 s
                                  ;then return to point R
Y-500.                            ;Positioning, drilled hole 2,
                                  ;then return to point R
Y-700.                            ;Positioning, drilled hole 3,
                                  ;then return to point R
X950.                             ;Positioning, drilled hole 4,
                                  ;then return to point R
Y-500.                            ;Positioning, drilled hole 5,
                                  ;then return to point R
G98 Y-700.                        ;Positioning, drilled hole 6,
                                  ;then return to initial plane
G80                               ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                  ;Return to reference position
M5                                ;Spindle stop
```

5.1.6 Deep hole drilling cycle with chip removal (G83)

The cycle "Deep hole drilling with chips removal" can, e.g., be used for deep hole drilling with recutting.

Format

G83 X... Y... R... Q... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to plane R

Q: Cutting depth for each cutting feedrate

F: Feedrate

K: Number of repetitions

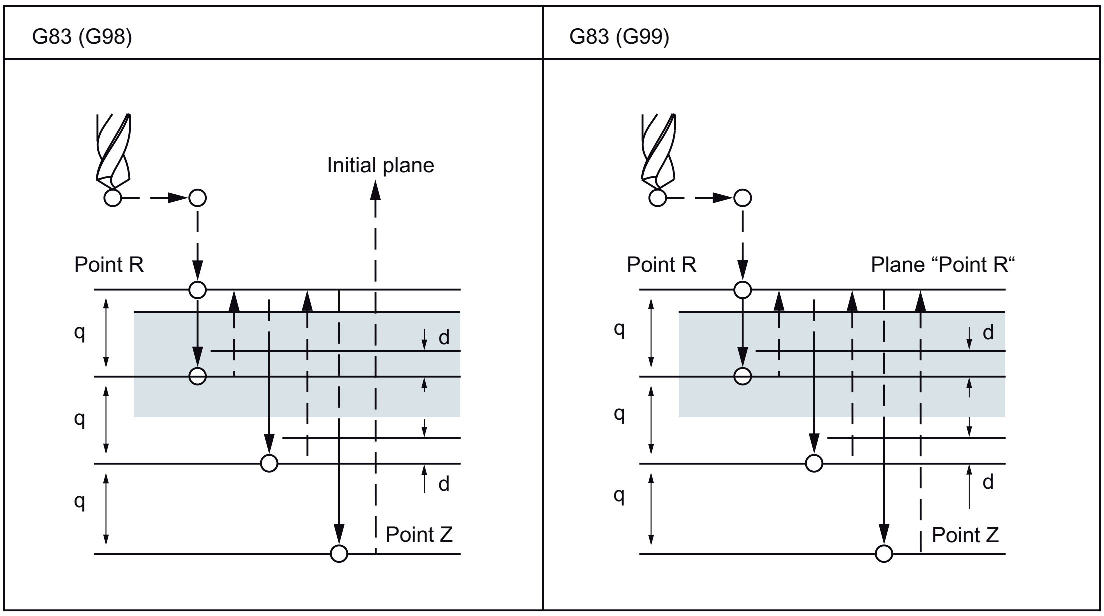


Figure 5-9 Deep hole drilling cycle with chip removal (G83)

Restrictions

Explanations

After the programmed cutting depth is reached for each cutting feedrate Q, the return to the reference plane R takes place in rapid traverse. The approach motion for a renewed step is also executed in rapid traverse, around the path (d) that can be set in USER DATA, _ZSFR[10]. The path and the cutting depth for each cutting feedrate Q are traversed with cutting feedrate. Q is incremental without having to specify signs.

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. X, Y, Z or R is programmed.

Q/R

Always program Q and R in one block with an axis motion, otherwise the programmed values will not be stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G83 should not be used together in one block, as otherwise G83 is deselected.

Example

```
M3 S2000                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G83 X200. Y-150. Z-100.   ;Positioning, drilled hole 1,
R50. Q10. F150.                   ;then return to point R
Y-500.                            ;Positioning, drilled hole 2,
                                  ;then return to point R
Y-700.                            ;Positioning, drilled hole 3,
                                  ;then return to point R
X950.                             ;Positioning, drilled hole 4,
                                  ;then return to point R
Y-500.                            ;Positioning, drilled hole 5,
                                  ;then return to point R
G98 Y-700.                        ;Positioning, drilled hole 6,
                                  ;then return to initial plane
G80                               ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                  ;Return to reference position
M5                                ;Spindle stop
```

Note

If _ZSFR[10]

- > 0 = Value is used for the derivative path "d" (minimum distance 0.001)
- = 0 = The derivative path is 30 mm and the value of the derivative path is always 0.6 mm. The drilling depth/50 formula is always used for larger drilling depths (maximum value 7 mm).

5.1.7 Boring cycle (G85)

Format

G85 X... Y... R... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to plane R

F: Feedrate

K: Number of repetitions

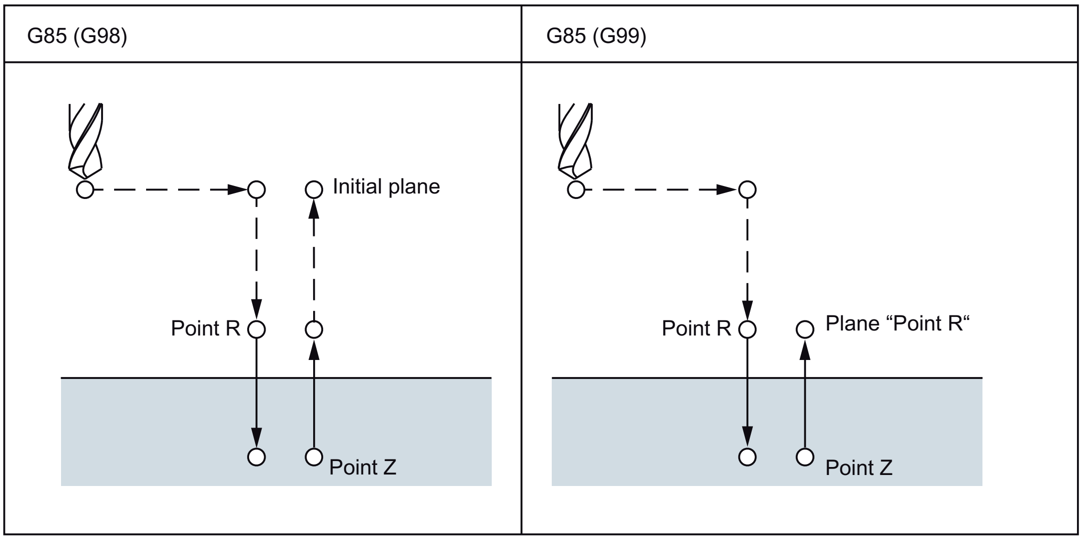


Figure 5-10 Boring cycle (G85)

Explanations

A traversing movement takes place to point R in rapid traverse after the positioning along the X and Y axis. Drilling takes place from point R to point Z. On reaching point Z, a retraction motion to point R takes place with cutting feedrate.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G85 should not be used together in one block, as otherwise G85 is deselected.

Example

```
M3 S150                             ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G85 X200. Y-150. Z-100.  ;Positioning, drilled hole 1,
R50. F150.                          ;then return to point R
Y-500.                              ;Positioning, drilled hole 2,
                                    ;then return to point R
Y-700.                              ;Positioning, drilled hole 3,
                                    ;then return to point R
X950.                               ;Positioning, drilled hole 4,
                                    ;then return to point R
Y-500.                              ;Positioning, drilled hole 5,
                                    ;then return to point R
G98 Y-700.                          ;Positioning, drilled hole 6,
                                    ;then return to initial plane
G80                                 ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                    ;Return to reference position
M5                                  ;Spindle stop
```

5.1.8 Boring cycle (G86)

Format

G86 X... Y... R... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to point R

F: Feedrate

K: Number of repetitions

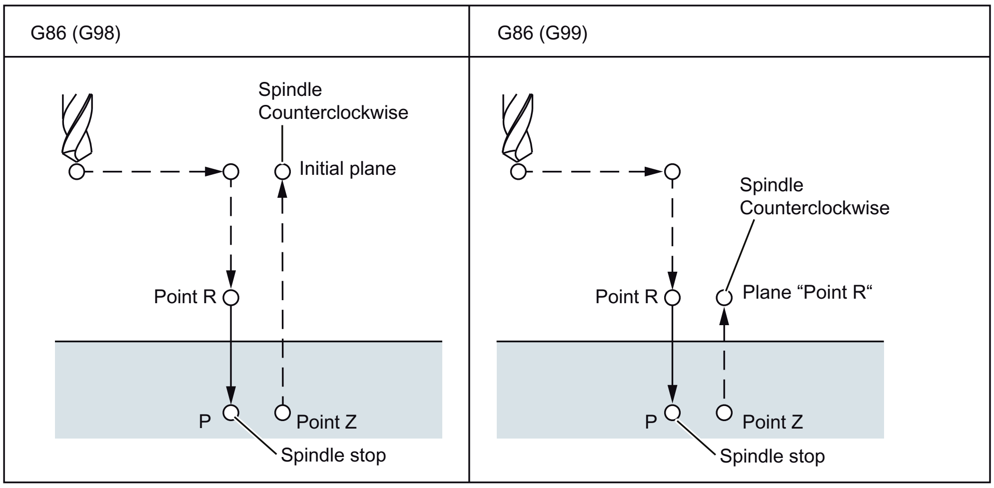


Figure 5-11 Boring cycle (G86)

Explanations

Point R is approached in rapid traverse after positioning the X and Y axes. Drilling takes place from point R to point Z. The tool returns in rapid traverse mode after the spindle is stopped at the bottom of a hole.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G86 should not be used together in one block, as otherwise G86 is deselected.

Example

```
M3 S150                         ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G86 X200. Y-150. Z-100. ;Positioning, drilled hole 1,
R50. F150.                      ;then return to point R
Y-500.                          ;Positioning, drilled hole 2,
                                ;then return to point R
Y-700.                          ;Positioning, drilled hole 3,
                                ;then return to point R
X950.                           ;Positioning, drilled hole 4,
                                ;then return to point R
Y-500.                          ;Positioning, drilled hole 5,
                                ;then return to point R
G98 Y-700.                      ;Positioning, drilled hole 6,
                                ;then return to initial plane
G80                             ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                ;Return to reference position
M5                              ;Spindle stop
```

5.1.9 Boring cycle - reverse countersinking (G87)

This cycle can be used for precision drilling.

Format

G87 X... Y... R... Q... P... F... K... ;

X,Y: Drilled hole position

Z: Distance from bottom of the hole to point Z

R: Distance from the initial plane to plane R (bottom of a hole)

Q: Tool offset amount

P: Dwell time

F: Feedrate

K: Number of repetitions

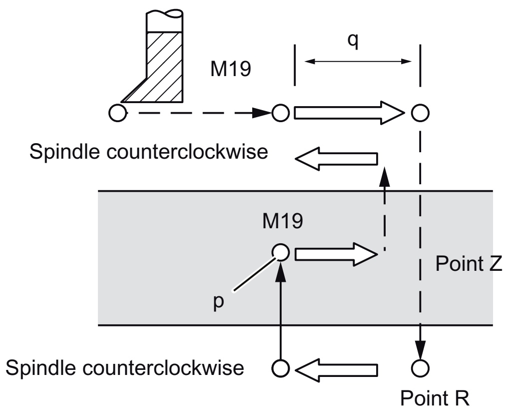
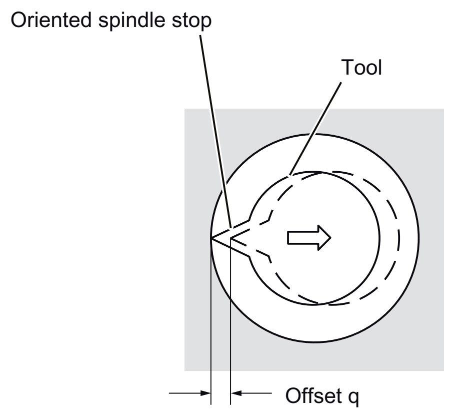
G87 (G98)	G87 (G99)
	Is not used

Figure 5-12 Boring cycle, reverse countersinking (G87)



> **WARNING**
>
> Address Q (gear change at the base of a drilled hole) is a modal value that is stored in fixed cycles. Please ensure that this address is also used as interface for the cycles G73 and G83!

Explanations

The spindle stops at a fixed rotary position after positioning along the X and Y axis. The tool travels in the direction opposite to that of the tool tip. It is positioned on the bottom of a hole (Point R) at rapid traverse.

Finally, the tool is shifted in the direction of the tool tip and the spindle is moved with clockwise rotation. Drilling takes place along the Z axis in the positive direction up to point Z.

The spindles stops at a fixed spindle position after the bottom of a hole is reached. The tool is returned opposite the tool tip.

The safety clearance can be specified with GUD _ZSFR[0].

The lift-off path can be specified with _ZSFI[5].

	G17	G18	G19
_ZSFR[5] = 1	+X	+Z	+Y
_ZSFI[5] = 0 or 2	-X	-Z	-Y
_ZSFI[5] = 3	+Y	+X	+Z
_ZSFI[5] = 4	-Y	-X	-Z

The angle must therefore be specified in USER DATA, _ZSFR[2] in such a way that the tool tip points at the opposite direction after the spindle stop for the lift-off path.

Example:

If plane G17 is activated, the tool tip must point in direction +X.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

Q/R

Always program Q and R in one block with an axis motion, otherwise the programmed values will not be stored modally.

Only one positive value is to be specified in each case for the value of Address Q. If a negative value is specified for "Q", the sign is ignored. "Q" is set as equal to "0" if no lift-off path is programmed. In this case, the cycle is executed without lifting.

Deselection

The G functions of Group 01 (G00 to G03) and G87 should not be used together in one block, as otherwise G87 is deselected.

Example

```
M3 S400                           ;Rotary motion of stem
G90 G0 Z100.
G90 G87 X200. Y-150. Z-100.       ;Positioning, drilled hole 1,
R50. Q3. P1000 F150.              ;orientation towards initial plane,
                                  ;then travel 3 mm,
                                  ;halt for 1 s at point Z
Y-500.                            ;Positioning, drilled hole 2
Y-700.                            ;Positioning, drilled hole 3
X950.                             ;Positioning, drilled hole 4
Y-500.                            ;Positioning, drilled hole 5
G98 Y-700.                        ;Positioning, drilled hole 6
G80                               ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                  ;Return to reference position
M5                                ;Spindle stop
```

5.1.10 Boring cycle (G89)

Format

G89 X... Y... R... P... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to point R

P: Dwell time at the bottom of a hole

F: Feedrate

K: Number of repetitions

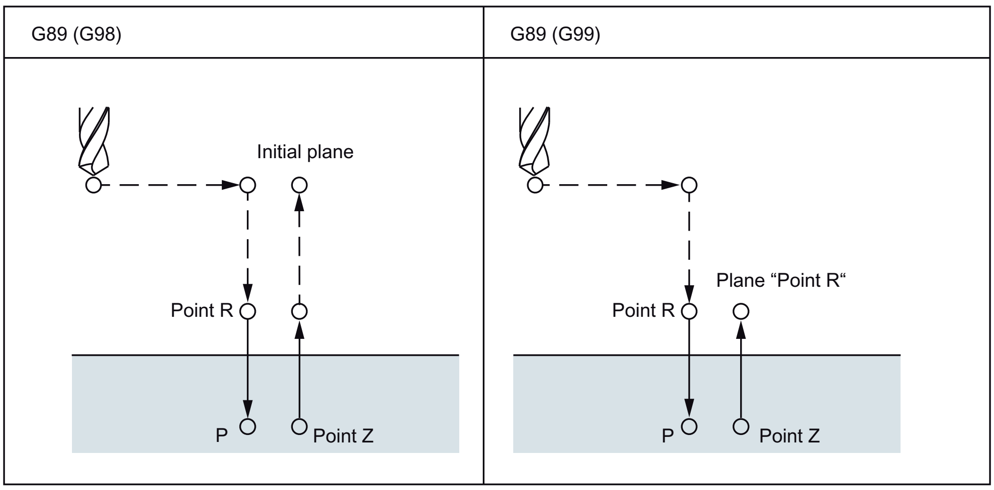


Figure 5-13 Boring cycle (G89)

Explanations

This cycle is similar to G86, with the only exception that here, a dwell time at the bottom of the hole is still available.

Before programming G89, the spindle must be started with an M function.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle.

Drilling

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G89 should not be used together in one block, as otherwise G89 is deselected.

Example

```
M3 S150                          ;Rotary motion of stem
G90 G0 Z100.
G90 G99 G89 X200. Y-150. Z-100.  ;Positioning, drilled hole 1,
R50. P1000 F150.                 ;then 1 s stop at the bottom of a hole
Y-500.                           ;Positioning, drilled hole 2,
                                 ;then return to point R
Y-700.                           ;Positioning, drilled hole 3,
                                 ;then return to point R
X950.                            ;Positioning, drilled hole 4,
                                 ;then return to point R
Y-500.                           ;Positioning, drilled hole 5,
                                 ;then return to point R
G98 Y-700.                       ;Positioning, drilled hole 6,
                                 ;then return to initial plane
G80                              ;Deselection of the fixed cycle
G28 G91 X0 Y0 Z0                 ;Return to reference position
M5                               ;Spindle stop
```

5.1.11 "Drilling a right-hand thread without any compensating chuck" cycle (G84)

The tool drills at the programmed spindle speed and feedrate to the entered final thread depth. With G84 you can produce rigid tapping.

Note

G84 can be used if the spindle to be used for the drilling operation is technically able to be operated in the position-controlled spindle mode.

Format

G84 X... Y... Z... R... P... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to plane R

P: Dwell time at the bottom of the hole and at point R during return

F: Cutting feedrate

K: Number of repetitions (if necessary)

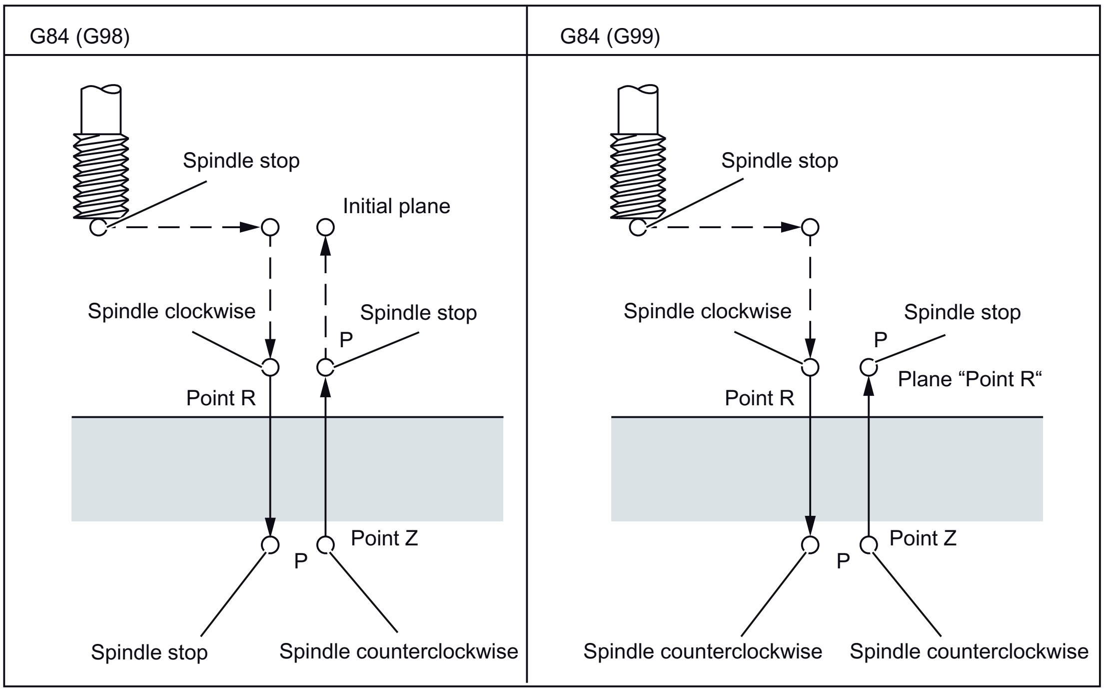


Figure 5-14 "Drilling a right-hand thread without any compensating chuck" cycle (G84)

Explanations

The cycle creates the following sequence of motions:

- Approach of reference plane shifted by the amount of the safety clearance with G0.
- Oriented spindle stop and transfer of spindle in the Axis mode.
- Tapping to the final drilling depth.
- Execution of dwell time at thread depth.
- Retraction to the reference plane and reversion of direction of rotation brought forward by the safety clearance.
- Retraction to the retraction plane with G0.

During tapping, rapid traverse override and spindle override are accepted at 100%.

The speed of rotation can be affected during the retraction with GUD _ZSFI[2]. Example: _ZSFI[2]=120; the retraction takes place at 120% of the speed during tapping.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle. An alarm is output if the drilling axis in the "Drilling without compensating chuck" mode is changed over.

Tapping

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G84 should not be used together in one block, as otherwise G84 is deselected.

S command

An error message is displayed if the specified gear stage is one step higher than the maximum permissible value.

F function

An error message is displayed if the value specified for the cutting feedrate exceeds the maximum permissible value.

Unit of the F command

	Metric input	Input in inch	Remarks
G94	1 mm/min	0.01 inch/min	Decimal point programming is permitted
G95	0.01 mm/rev	0.0001 inch/rev	Decimal point programming is permitted

Example

Feedrate for the Z axis 1000 mm/min

Spindle speed 1000 rev/min

Thread lead 1.0 mm

```
<Programming as feedrate per minute>
S100 M03S1000
G94                              ;Feedrate per minute
G00 X100.0 Y100.0                ;Positioning
G84 Z-50.0 R-10.0 F1000          ;Tapping without compensating chuck
<Programming as revolutional feedrate>
G95                              ; Rev. feedrate
G00 X100.0 Y100.0                ;Positioning
G84 Z-50.0 R-10.0 F1.0           ;Tapping without compensating chuck
```

5.1.12 "Drilling a left-hand thread without any compensating chuck" cycle (G74)

The tool drills at the programmed spindle speed and feedrate to the entered final thread depth. With G74 you can produce left rigid tapping.

Note

G74 can be used if the spindle to be used for the drilling operation is technically able to be operated in the position-controlled spindle mode.

Format

G74 X... Y... Z... R... P... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to point R

P: Dwell time at the bottom of the hole and at point R during return

F: Cutting feedrate

K: Number of repetitions (if necessary)

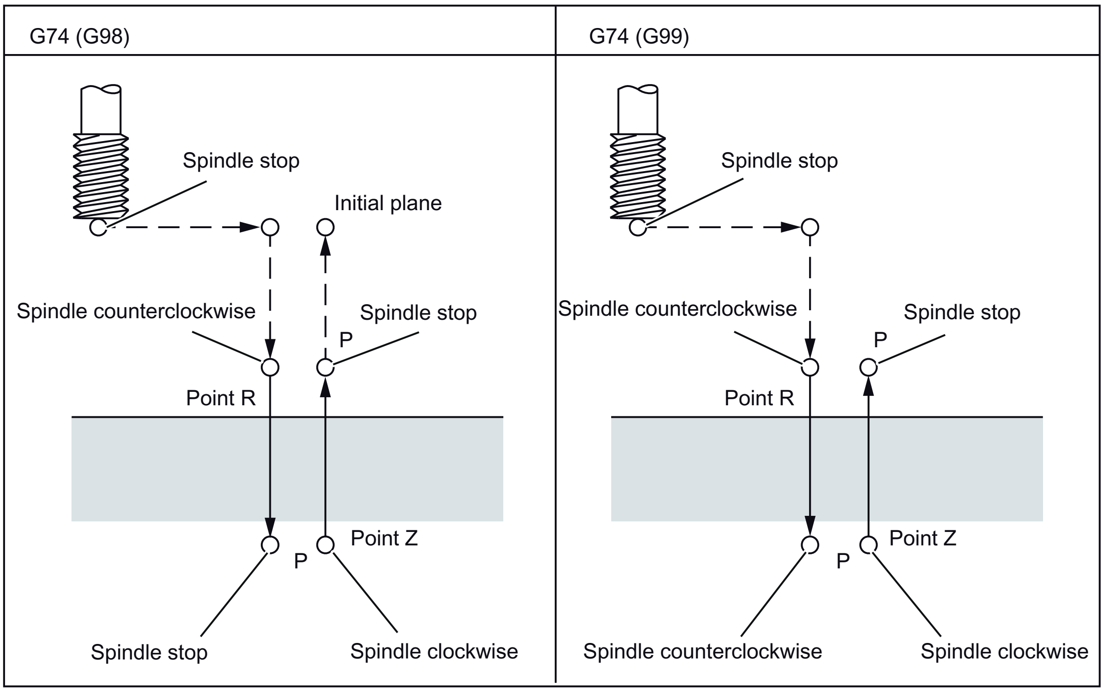


Figure 5-15 "Drilling a left-hand thread without any compensating chuck" cycle (G74)

Explanations

The cycle creates the following sequence of motions:

- Approach of reference plane shifted by the amount of the safety clearance with G0.
- Oriented spindle stop and transfer of spindle in the Axis mode.
- Tapping to the final drilling depth.
- Execution of dwell time at thread depth.
- Retraction to the reference plane and reversion of direction of rotation brought forward by the safety clearance.
- Retraction to the retraction plane with G0.

During tapping, rapid traverse override and spindle override are accepted at 100%.

The speed of rotation can be affected during the retraction with GUD _ZSFI[2]. Example: _ZSFI[2]=120; the retraction takes place at 120% of the speed during tapping.

Restrictions

Changeover of the axes

Before changing over the drilling axis, one must first deselect the fixed cycle. An alarm is output if the drilling axis in the "Drilling without compensating chuck" mode is changed over.

Tapping

The drilling cycle is executed only if an axis motion, e.g. is programmed with X, Y, Z or R.

R

Always program R only in one block with an axis motion, otherwise the programmed values are not stored modally.

Deselection

The G functions of Group 01 (G00 to G03) and G74 should not be used together in one block, as otherwise G74 is deselected.

S command

An error message is displayed if the specified gear stage is one step higher than the maximum permissible value.

F function

An error message is displayed if the value specified for the cutting feedrate exceeds the maximum permissible value.

Unit of the F command

	Metric input	Input in inch	Remarks
G94	1 mm/min	0.01 inch/min	Decimal point programming is permitted
G95	0.01 mm/rev	0.0001 inch/rev	Decimal point programming is permitted

Example

Feedrate for the Z axis 1000 mm/min

Spindle speed 1000 rev/min

Thread lead 1.0 mm

```
<Programming as feedrate per minute>
S100 M03S1000
G94                             ;Feedrate per minute
G00 X100.0 Y100.0               ;Positioning
G74 Z-50.0 R-10.0 F1000         ;Tapping without any compensating chuck
<Programming as revolutional feedrate>
G95                             ; Rev. feedrate
G00 X100.0 Y100.0               ;Positioning
G74 Z-50.0 R-10.0 F1.0          ;Tapping without any compensating chuck
```

5.1.13 Left or right tapping cycle (G84/G74)

Due to the chips adhering to the tool and an increased resistance associated with this, it may be difficult to perform the deep hole tapping without compensating chuck. In such cases the tapping cycle with chip breakage or chip removal is helpful.

The cutting movement is executed in this cycle till the root is reached. There are a total of two tapping cycles for this: Deep hole tapping with chip breakage and deep hole tapping with chip removal.

The G84 and G74 cycles can be selected with GUD _ZSFI[1] as follows:

_ZSFI[1] = 2: Deep hole tapping with chip breakage

_ZSFI[1] = 3: Deep hole tapping with chip removal

Format

G84 (or G74) X... Y... Z... R... P... Q... F... K... ;

X,Y: Drilled hole position

Z: Distance from point R to the bottom of the hole

R: Distance from the initial plane to "Point R"

P: Dwell time at the bottom of the hole and at point R during return

Q: Cutting depth for each cutting feedrate

F: Feedrate

K: Number of repetitions

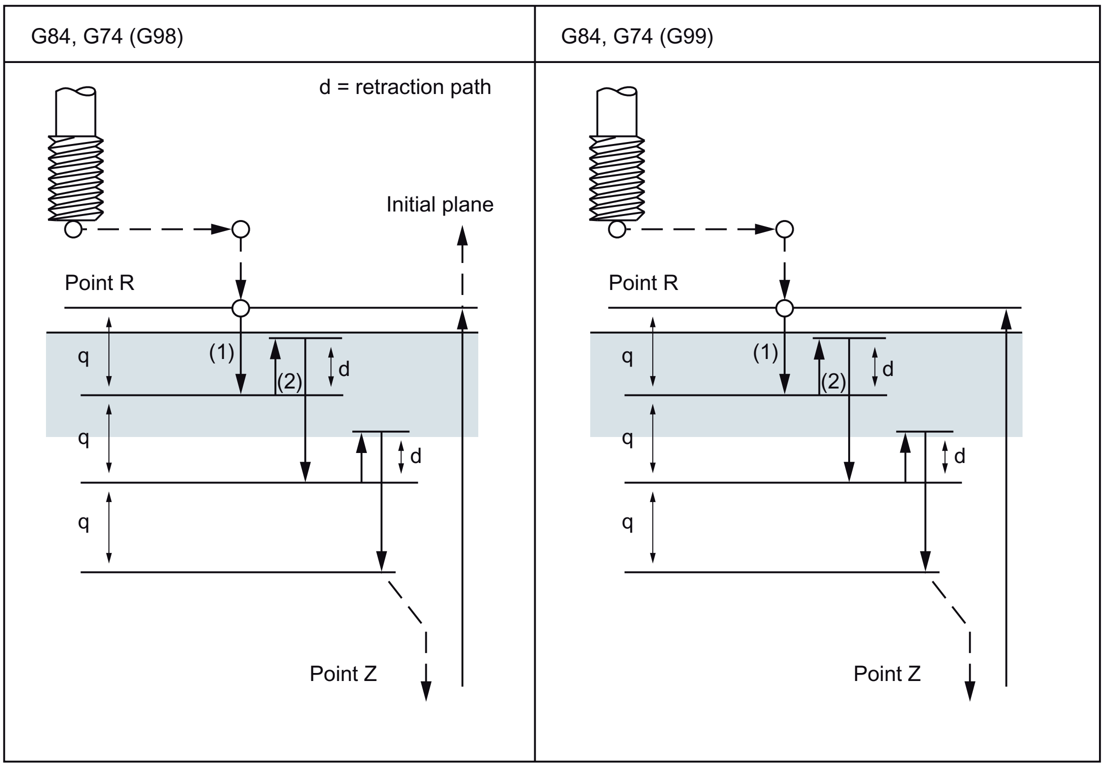


Figure 5-16 Deep hole tapping with chip breakage (USER DATA, _ZSFI[1] = 2)

1. The tool is traversed with the programmed feedrate.
2. The retraction velocity can be affected with USER DATA, _ZSFI[2].

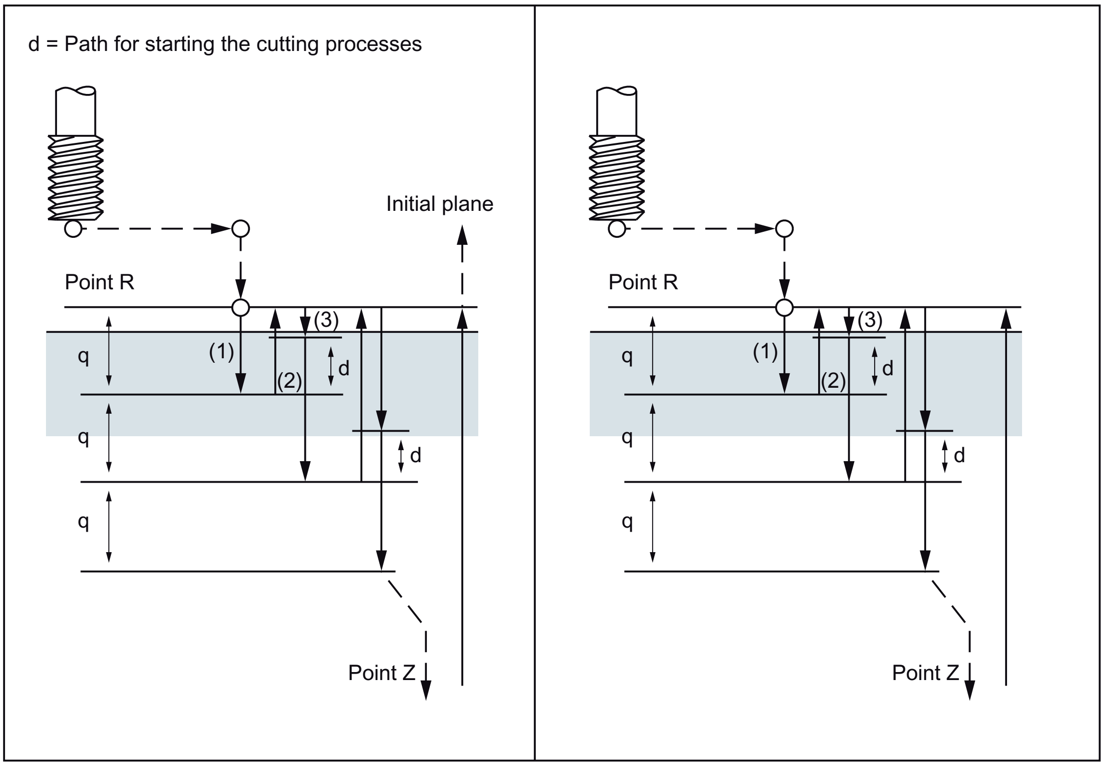


Figure 5-17 Deep hole tapping with chip breakage (USER DATA, _ZSFI[1] = 3)

Deep hole tapping with chip breakage/removal

After positioning along the X and Y axes, there is a traversing movement at rapid traverse to point R. The machining is done from point R onwards with a cutting depth Q (cutting depth per cutting feedrate). Finally, the tool is retracted by the distance d. If a value not equal to 100% is specified in USER DATA, _ZSFI[2], it can be specified whether the retraction is overlaid or not. The spindle stops as soon as point Z is reached; the direction of rotation is finally reversed and a retraction is executed. The retraction path d is set in USER DATA, _ZSFR[1].

Note

If 0 is specified in _ZSFR[1], the default setting of 1 mm or 1 inch is effective for the retraction distance.

If 0 mm or 0 inch is to be specified, a value less than the travel triggering should be specified.

5.1.14 Deselection of a fixed cycle (G80)

Fixed cycles can be deselected with G80.

Format

G80;

Explanations

All modal cycles are deselected in the ISO mode with G80 or with a G function of the 1st group (G00, G03,...).

5.1.15 Program example with a tool length compensation and fixed cycles

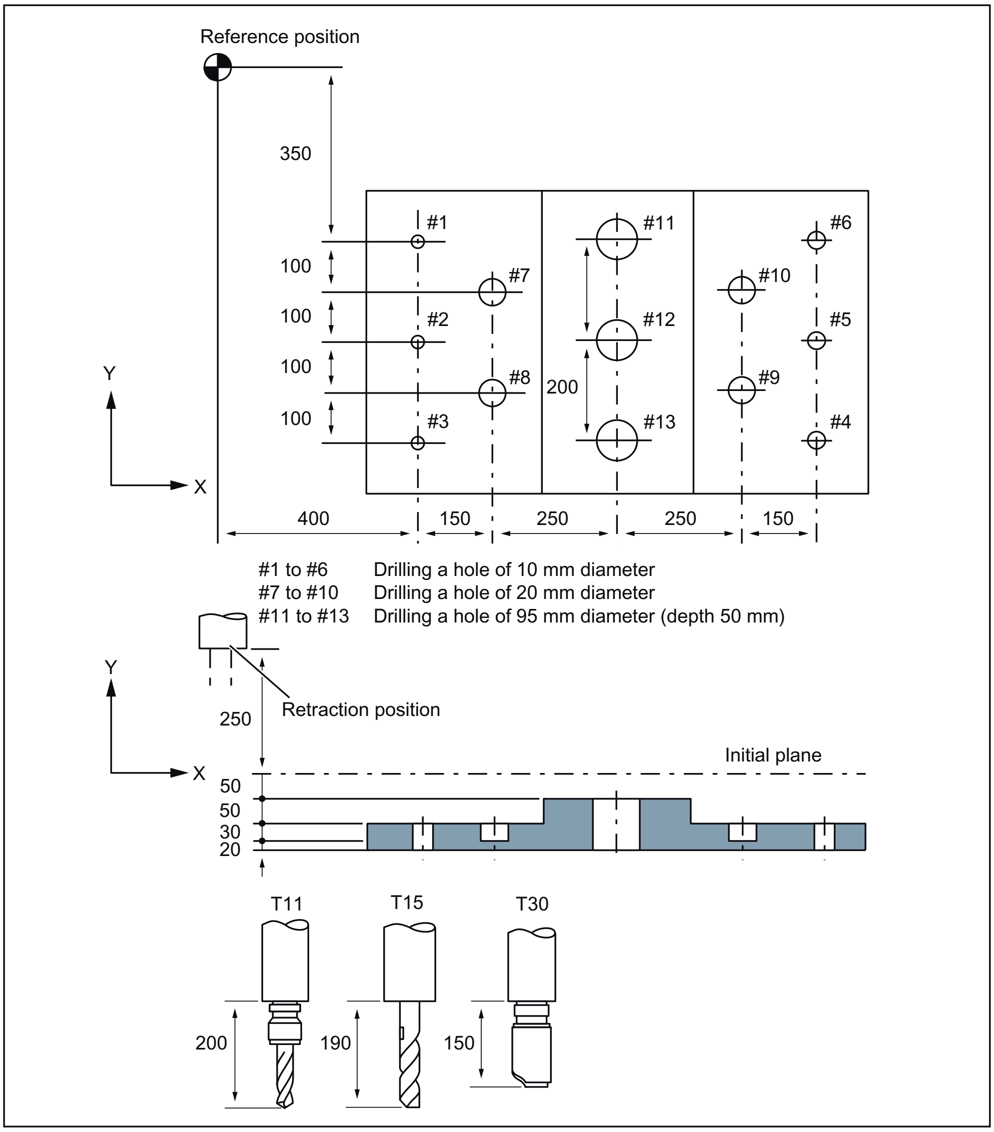


Figure 5-18 Program example (drilling cycle)

Offset value +200.0 is set in TO No. 11, +190.0 is set in TO No. 15 and +150.0 is set in tool offset No. 30.

Sample program

```
;
N001 G49                          ; Deselect the tool length compensation
N002 G10 L10 P11 R200.            ; Setting the tool offset 11 to +200.
N003 G10 L10 P15 R190.            ; Setting the tool offset 15 to +190.
N004 G10 L10 P30 R150.            ; Setting the tool offset 30 to +150.
N005 G92 X0 Y0 Z0                 ; Setting the coordinates at the reference
                                  ; position
N006 G90 G00 Z250.0 T11 M6        ; Tool change
N007 G43 Z0 H11                   ; Initial plane, tool length compensation
N008 S30 M3                       ; Spindle start
N009 g99 G81 X400.0 Y-350.0 Z-153.0  ; Positioning, then drill #1
R-97.0 F1200
N010 Y-550.0                      ; Positioning, then drilling #2 and return to
                                  ; plane point R
N011 G98 Y-750.0                  ; Positioning, then drilling #3 and return to
                                  ; initial plane
N012 G99 X1200.0                  ; Positioning, then drilling #4 and return to
                                  ; plane point R
N013 Y-550.0                      ; Positioning, then drilling #5 and return to
                                  ; plane point R
N014 G98 Y-350.0                  ; Positioning, then drilling #6 and return to
                                  ; initial plane
N015 G00 X0 Y0 M5                 ; Return to reference position,
                                  ; Spindle stop
N016 G49 Z250.0 T15 M6            ; Deselection of tool length compensation, tool
                                  ; change
N017 G43 Z0 H15                   ; Initial plane, tool length compensation
N018 S20 M3                       ; Spindle start
N019 G99 G82 X550.0 Y-450.0 Z-130.0  ; Positioning, then drilling #7 and return to
R-97.0 P300 F700                  ; plane point R
N020 G98 Y-650.0                  ; Positioning, then drilling #8 and return to
                                  ; initial plane
N021 G99 X1050.0                  ; Positioning, then drilling #9 and return to
                                  ; plane point R
N022 G98 Y-450.0                  ; Positioning, then drilling #10 and return to
                                  ; initial plane
N023 G00 X0 Y0 M5                 ; Return to reference position,
                                  ; Spindle stop
N024 G49 Z250.0 T30 M6            ; Deselection of tool length compensation, tool
                                  ; change
 N025 G43 Z0 H30                  ; Initial plane, tool length compensation
N026 S10 M3                       ; Spindle start
N027 G85 G99 X800.0 Y-350.0 Z-153.0  ; Positioning, then drilling #11 and return to
R47.0 F500                        ; plane point R
N028 G91 Y-200.0 K2               ; Positioning, then drilling #12 and 13, and
                                  ; return to plane point R
G80                               ; Deselection of the fixed cycle
N029 G28 X0 Y0 M5                 ; Return to reference position,
                                  ; Spindle stop
N030 G49 Z0                       ; Deselect the tool length compensation
N031 M30                          ; End of the program
```

5.2 Programmable data input (G10)

5.2.1 Changing the tool offset value

Existing tool offsets can be overwritten via G10. It is not possible to create new tool offsets.

Format

G10 L10 P... R... ; Tool length compensation, geometry

G10 L11 P... R... ; Tool length compensation, wear and tear

G10 L12 P... R... ; Tool radius compensation, geometry

G10 L13 P... R... ; Tool radius compensation, wear and tear

P: Number of tool offset memory

R: Value statement

L1 can also be programmed instead of L11.

5.2.2 M function for calling subroutines (M98, M99)

This function can be used if subroutines are stored in the part program memory. Subroutines that are registered in the memory and whose program numbers are assigned can be called and executed any number of times.

Commands

The following M functions are used to call subroutines.

Table 5- 3 M functions for calling subroutines

M function	Function
M98	Subprogram call
M99	End of subroutine

Subroutine call (M98)

- M98 Pnnnnmmmm

  m: Program no. (max. 4 digits)
  n: No. of repetitions (max. 4 digits)

  Before using program M98 Pnnnnmmmm to call a program, name the program correctly, that is, add the program number always to 4 digits with 0.
- If for example, M98 P21 is programmed, the part program memory is browsed by program name 21.mpf and the subroutine is executed once. To call the subroutine three times, one must program M98 P30021. An alarm is output if the specified program no. is not found.
- A nesting of subroutines is possible, up to 16 subroutines are allowed. An alarm is output if more subroutine levels are assigned than is allowed.

End of subroutine (M99)

A subroutine is ended with the command M99 Pxxxx and program processing is continued in Block No. Nxxxx. The control system first searches forward for the block number (from the subroutine call up to the end of the program). If no matching block number is found, the part program is eventually searched in the reverse direction (in the direction of the part start of program).

If M99 is without a block number (Pxxxx) in a main program, the control goes to the start of the main program and the main program is processed afresh. In case of M99 with navigation to the block number in the main program (M99xxxx), the block number is always searched from the start of program.

5.3 Eight-digit program number

An eight-digit program number selection is activated with the machine data 20734 $MC_EXTERN_FUNCTION_MASK, Bit 6=1. This function affects M98 and G65/66.

y: Number of program runs

x: Program number

Subprogram call

$MC_EXTERN_FUNCTION_MASK, Bit 6 = 0

M98 Pyyyyxxxx or

M98 Pxxxx Lyyyy

Max. four-digit program number

Addition of program number always to 4 digits with 0

Example:

M98 P20012: calls 0012.mpf 2 flows

M98 P123 L2: calls 0123.mpf 2 flows

$MC_EXTERN_FUNCTION_MASK, Bit 6 = 1

M98 Pxxxxxxxx Lyyyy

There is no extension with 0, even if the program number has less than 4 digits.

The programming of number of passes and program number in P(Pyyyyxxxxx) is not possible, the number of passes must always be programmed with L!

Example:

M98 P123: calls 123.mpf 1 Pass

M98 P20012: calls 20012.mpf 1 Pass

Caution: This is no longer compatible with ISO dialect original

M98 P12345 L2: calls 12345.mpf 2 Passes

Modal and blockwise Macro G65/G66

$MC_EXTERN_FUNCTION_MASK, Bit 6 = 0

G65 Pxxxx Lyyyy

Addition of program number to 4 digits with 0. Program number with more than 4 digits leads to an alarm.

$MC_EXTERN_FUNCTION_MASK, Bit 6 = 1

G65 Pxxxx Lyyyy

There is no extension with 0, even if the program number has less than 4 digits. A program number with more than 8 digits leads to an alarm.

Interrupt M96

$MC_EXTERN_FUNCTION_MASK, Bit6 = 0

M96 Pxxxx

Addition of program number always to 4 digits with 0

$MC_EXTERN_FUNCTION_MASK, Bit6 = 1

M96 Pxxxx

There is no extension with 0, even if the program number has less than 4 digits. A program number with more than 8 digits leads to an alarm.

5.4 Polar coordinates (G15, G16)

While programming in polar coordinates, the positions in the coordinate system are defined with a radius and/or angle. Polar coordinate programming is selected with G16. It is deselected again with G15. The first axis of the plane is interpreted as polar radius, the second axis as polar angle.

Format

G17 (G18, G19) G90 (G91) G16	;Polar coordinates command ON
G90 (G91) X... Y... Z...	;Polar coordinates command
...	
...	
G15	;Polar coordinates command OFF

G16: Polar coordinates command

G15: Deselection of polar coordinates command

G17, G18, G19: Selection of plane

G90: The pole is located on the workpiece zero.

G91: The pole is located on the current position.

X, Y, Z: First axis: Radius of polar coordinate, second axis: Angle of polar coordinate

Note

If the pole is moved from the current position to the workpiece zero, the radius is calculated as the distance from the current position to the workpiece zero.

Example

```
N5 G17 G90 X0 Y0
N10 G16 X100. Y45.         ;Polar coordinates ON,
                           ;the pole is at the workpiece zero,
                           ;Position X 70,711 Y 70,711
                           ;in the Cartesian coordinate system
N15 G91 X100 Y0            ;the pole is the current Position,
                           ;i.e. the Position X 141.421 Y 141.421
N20 G90 Y90.               ;No X in the block
                           ;The pole is on the workpiece zero,
                           ;Radius = SORT(X*X +Y*Y) = 184.776
G15
```

The polar radius is always taken as absolute value, while the polar angle can be interpreted as absolute value as well as incremental value.

5.5 Measuring functions

5.5.1 Rapid lift with G10.6

Quintessence

A retraction position for the rapid lifting of a tool can be activated with G10.6 <Axis position> (e.g., in case of tool breakage). The retraction motion itself is started with a digital signal. The second rapid input of NC is used as the start signal.
Another rapid input (1-3) can also be selected with machine data 10820 $MN_EXTERN_INTERRUPT_NUM_RETRAC (1 - 3).

The interrupt program (ASUP) CYCLE3106.spf must always be available for the rapid retraction with G10.6. If the CYCLE3106.spf is not available in the part program memory, the Alarm 14011 "Program CYCLE3106 not available or not released for processing" is output with G10.6 in a part program block.

The response of the control system after the rapid retraction is defined in ASUP CYCLE3106.spf. If the axes and the spindle are stopped after the rapid retraction, M0 and M5 must be programmed in CYCLE3106.spf. If CYCLE3106.spf is a dummy program that contains only M17, the part program is continued without any interruption after the rapid retraction.

If the rapid retraction is activated with the programming G10.6 <Axis position>, then the change in the input signal of the 2nd NC rapid input from 0 to 1 aborts the current movement and the position programmed in the G10.6 block is moved at rapid traverse. Here, the positions are approached as absolute or incremental, as programmed in the G10.6 block.

The function is deactivated with G10.6 (without position specification). Rapid retraction via the input signal of the 2nd rapid NC input is blocked.

Restrictions

Only one axis can be programmed for rapid retraction.

5.5.2 Measuring with "delete distance-to-go" (G31)

Measuring with "Delete distance-to-go possible" is activated by specifying "G31 X... Y... Z... F... ;". The linear interpolation is interrupted and the distance-to-go of the axes is deleted if, during the linear interpolation, the measurement input of the 1st probe is active. The program is continued with the next block.

Format

G31 X... Y... Z... F... ;

G31: Non-modal G function (operates only in the block in which it is programmed)

PLC signal "Measurement input = 1"

With the rising edge of the measurement input 1, the current axis positions are stored in the axial system parameters or $AA_MM[<Axis>], $AA_MW[<Axis>]. These parameters can be read in the Siemens mode.

$AA_MW[X]	Saving the coordinate value of the X axis in the workpiece coordinate system
$AA_MW[Y]	Saving the coordinate value of the Y axis in the workpiece coordinate system
$AA_MW[Z]	Saving the coordinate value of the Z axis in the workpiece coordinate system
$AA_MM[X]	Saving the coordinate value of the X axis in the machine coordinate system
$AA_MM[Y]	Saving the coordinate value of the Y axis in the machine coordinate system
$AA_MM[Z]	Saving the coordinate value of the Z axis in the machine coordinate system

Note

Alarm 21700 is output if G31 is activated when the measuring signal is still active.

Program continuation after the measuring signal

If incremental axis positions are programmed in the next block, these axis positions are related to the measuring point, i.e. the reference point of the incremental position is the axis position at which the delete distance-to-go was executed by the measuring signal.

If the axis positions in the next block are programmed as absolute, then the programmed positions are approached.

Note

No cutter radius compensation should be active in a block containing G31. Hence, the cutter radius compensation is to be deselected before programming of G31, with G40.

Example

G31 with incremental position specification

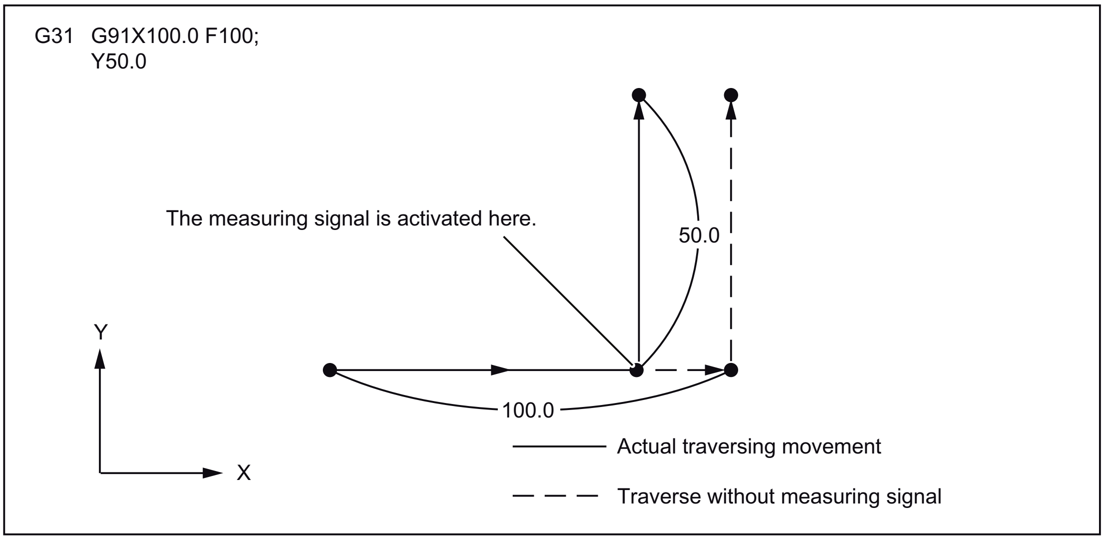


Figure 5-19 G31 with incremental position specification of one axis

G31 is an absolute position specification

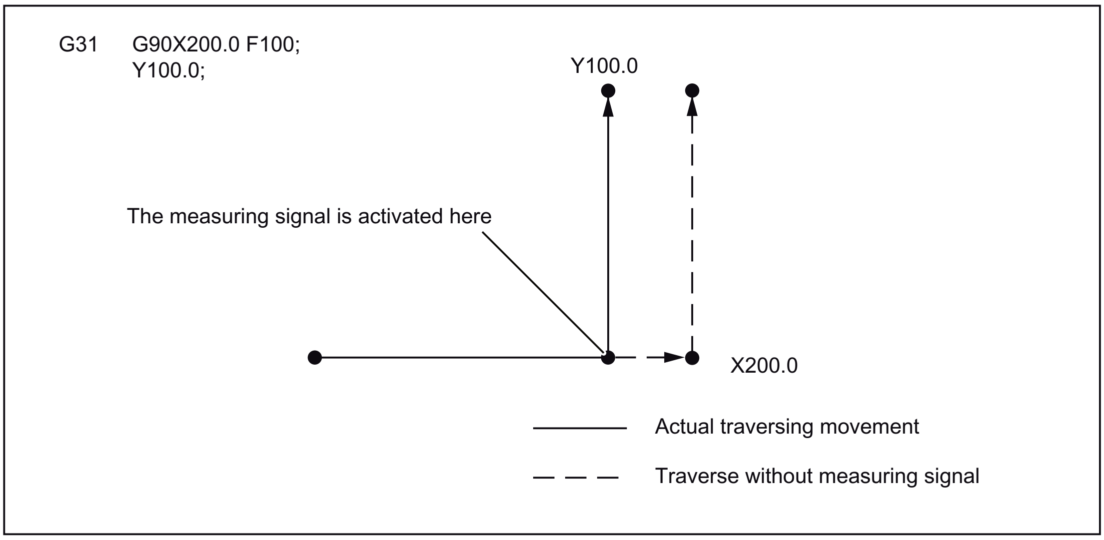


Figure 5-20 G31 with absolute position specification of one axis

G31 is an absolute command for 2 axes.

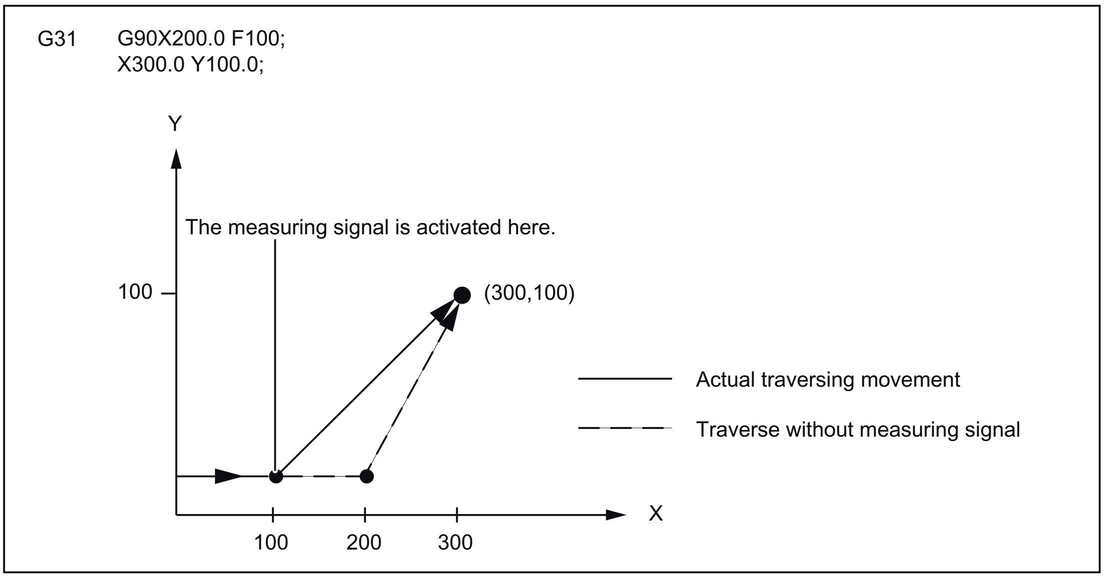


Figure 5-21 G31 is an absolute command for 2 axes

5.5.3 Measuring with G31, P1 - P4

The function G31 P1 (.. P4) is different from G31 in that different inputs for the measuring signal can be selected with P1 to P4. Several inputs can also be monitored on a rising edge of a measuring signal simultaneously. The assignment of the inputs to the addresses P1 to P4 is defined through machine data.

Format

G31 X... Y... Z... F... P... ;

X, Y, Z: End point

F...: Feedrate

P...: P1 - P4

Explanation

The digital inputs are assigned to the Addresses P1 to P4 via machine data as follows:

P1: $MN_EXTERN_MEAS_G31_P_SIGNAL[0]

P2: $MN_EXTERN_MEAS_G31_P_SIGNAL[1]

P3: $MN_EXTERN_MEAS_G31_P_SIGNAL[2]

P4: $MN_EXTERN_MEAS_G31_P_SIGNAL[3]

Explanations for selection (P1, P2, P3 or P4) can be found in the documentation of your machine manufacturer.

5.5.4 Interrupt program with M96, M97

M96

A subroutine can be defined as an interrupt routine with the M96 P<Program No.>.

The start of this program is triggered by an external signal. To start the interrupt routine, the 1st rapid NC input is used from among the eight inputs available in the Siemens mode. Another rapid input (1 to 3) can also be selected with MD10818 $MN_EXTER_INTERRUPT_NUM_ASUP.

Format

M96 Pxxxx	;Activation of program interrupt
M97	;Deactivation of program interrupt

M97 and M96 P_ must be alone in the block.

So that on triggering the interrupt, the cover cycle CYCLE396 is called first and it calls the interrupt program programmed with Pxxxx in the ISO mode. At the end of the cover cycle, the machine data 10808 $MN_EXTERN_INTERRUPT_BITS_M96, Bit 1 is evaluated and either positioned on the interruption point with REPOS or continued with the next block.

End of interruption (M97)

The interrupt program is deactivated with M97. Only after the next activation with M96 can the interrupt routine be started with the external signal.

If the interrupt program programmed with M96 Pxx is to be called directly with the interrupt signal (without intermediate step with CYCLE396), then machine data 20734 $MC_EXTERN_FUNCTION_MASK, Bit 10 must be zero. The subroutine programmed with Pxx is then called in the Siemens mode during a signal change from 0 -> 1.

The M function numbers for the interrupt function are set through machine data. Machine data 10804 $MN_EXTERN_M_NO_SET_INT is used to determine the M number for activating an interrupt routine, machine data 10806 $MN_EXTERN_M_NO_DISABLE_INT is used to determine the M number for suppressing an interrupt routine.

Only the M functions not reserved for standard M functions can be used. The default of the M functions is M96 and M97. To activate the function, one must set bit 0 in machine data 10808 $MN_EXTERN_INTERRUPT_BITS_M96. The M functions are not output to the PLC. The M functions are interpreted as normal auxiliary functions if Bit 0 is not set.

At the end of the interrupt program, one normally traverses to the end position of the part program block following the interruption block. If the part program is to be processed further from the interruption point, there must be a REPOS instruction at the end of the interrupt program, e.g. REPOSA. For this, the interrupt program must be written in the Siemens mode.

The M function for activating and deactivating an interrupt program must be alone in the block. The system issues Alarm 12080 (syntax error) if addresses other than "M" and "P" are programmed in the block.

Machine data

The response of the interrupt program function can be determined from the following machine data:

MD10808 $MN_EXTERN_INTERRUPT_BITS_M96:
Bit 0 = 0
Interrupt program is not possible as M96/M97 are normal M functions.
Bit 0 = 1
Activation of an interrupt program with M96/M97 is allowed.

Bit 1 = 0
The part program is processed further with the end position of the block immediately after the interruption block (REPOSL RME).
Bit 1 = 1
The part program is continued from the interruption position (REPOSL RMI).

Bit 2 = 0
The interrupt signal interrupts the current block immediately and starts the interrupt routine.
Bit 2 = 1
The interrupt routine is started only at the end of the block.

Bit 3 = 0
The execution cycle is interrupted immediately after an interrupt signal arrives.
Bit 3 = 1
The interrupt program is started only at the end of the execution cycle (evaluation in the shell cycles).

Bit 3 is evaluated in the shell cycles, and the cycle sequence is adapted accordingly.

Bit 1 is evaluated in cover cycle CYCLE396.

If the interrupt program is not called via the cover cycle CYCLE396, ($MC_EXTERN_FUNCTION_MASK, Bit 10 = 1) must be evaluated with Bit 1. If Bit 1 = TRUE, REPOSL RMI must be used for positioning on the interruption point, otherwise REPOSL RME must be used for positioning on the block end position.

Example:

N100 M96 P1234	;Activate ASUP 1234spf. In the case of a rising edge of the ;1st rapid input, the program ;1234.spf is started
....	
....	
N300 M97	;Deactivation of ASUP

Restrictions

The interrupt routine is treated as a normal subroutine. In other words, to be able to execute interrupt routines, at least one subroutine level must be free. (16 program levels are available, plus two levels that are reserved for the ASUP interrupt programs.)

The interrupt routine is started only during an edge change of the interrupt signal from 0 to 1. If the interrupt signal remains permanently on 1, then the interrupt program is not restarted any more.

5.5.5 "Tool life control" function

Tool life monitoring and workpiece count can be undertaken with Siemens Tool Management.

5.6 Macro programs

Macros may consist of several part program blocks that are completed with M99. In principle, macros are subroutines that are called with G65 Pxx or G66 Pxx in the part program.

Macros that are called with G65 are non-modal. Macros that are called with G66 are modal and are deselected again with G67.

5.6.1 Differences with subroutines

Macro programs (G65, G66) can be used to specify parameters that can be evaluated in the macro programs. No parameters can be specified in subroutine calls (M98).

5.6.2 Macro program call (G65, G66, G67)

Macro programs are generally executed immediately after their call.

The procedure of calling a macro program is described in the table below.

Table 5- 4 Format for calling a macro program

Call method	Command code	Remarks
Simple call	G65	
Modal call (a)	G66	Deselection through G67

Simple call (G65):
Format

G65 P_ L_ ;

A macro program to which a program number was assigned with "P" is called and executed "L" times by specifying "G65 P ... L... <Argument>; ".

The required parameters must be programmed in the same block (with G65).

Explanation

In a part program block containing G65 or G66, the address Pxx is interpreted as program number of the subroutine in which the macro functionality is programmed. The number of passes of the macro can be defined with the address Lxx. All other addresses in this part program block are interpreted as transfer parameters and their programmed values are stored in the system variables $C_A to $C_Z. These system variables can be read in the subroutine and evaluated for the macro functionality. If other macros with parameter transfer are called in a macro (subroutine), then the transfer parameters in the subroutine must be saved in internal variable before the new macro call.

To enable internal variable definitions, one must switch automatically to the Siemens mode during macro call. One can do this by inserting the instruction PROC<Program name> in the first line of the macro program. If another macro call is programmed in the subroutine, then the ISO-dialect-mode must be reselected in advance.

Table 5- 5 The P and L command

Address	Description	Number of digits
P	Program number	4 to 8 digits
L	Number of repetitions	

System variables for the addresses I, J, K

As the addresses I, J, and K can be programmed up to 10 times in a block containing macro call, the system variables of these addresses must be accessed with an array index. The syntax of these three system variables thus is $C_I[..], $C_J[..], $C_K[..]. The values remain in the programmed sequence in the array. The number of I, J, K addresses programmed in the block is given in the variables $C_I_NUM, $C_J_NUM, $C_K_NUM.

The transfer parameters I, J, K for macro calls are treated in each case as one block even if the individual addresses are not programmed. If a parameter is reprogrammed, or a following parameter based on the I, J, K sequence was programmed, it belongs to the next block.

The system variables $C_I_ORDER, $C_J_ORDER, $C_K_ORDER are set to detect the programming sequence in the ISO mode. These are identical arrays of $C_I, $C_K and they contain the associated numbers of the parameters.

Note

The transfer parameters can be read only in the subroutine in the Siemens mode.

Example:

```
N5 I10 J10 K30 J22 K55 I44 K33

  Block1  Block2  Block3

$C_I[0]=10

$C_I[1]=44

$C_I_ORDER[0]=1

$C_I_ORDER[1]=3


$C_J[0]=10

$C_J[1]=22

$C_J_ORDER[0]=1

$C_J_ORDER[1]=2


$C_K[0]=30

$C_K[1]=55

$C_K[2]=33

$C_K_ORDER[0]=1

$C_K_ORDER[1]=2

$C_K_ORDER[2]=3
```

Cycle parameter $C_x_PROG

In the ISO-dialect-0 mode, the programmed values can be evaluated in different ways, depending on the programming method (integer or actual value). The different evaluation is activated through a machine data.

If the MD is set, the control system responds as in the following example:

X100 ; X axis is traversed by 100 mm (100. with point) => actual value

Y200 ; Y-axis is traversed by 0.2 mm (200 without point) => integer value

If the addresses programmed in the block are used as transfer parameters of cycles, then the programmed values always exist as real values in the $C_x variables. For integer values, one cannot take recourse to the programming method (real/integer) in the cycles any more, and therefore there is no evaluation of the programmed values with the correct conversion factor.

There are two system variables $C_TYP_PROG. $C_TYP_PROG for information as to whether REAL or INTEGER programming was undertaken. The structure is the same as that of $C_ALL_PROG and $C_INC_PROG. If the value is programmed as INTEGER, then Bit is set to 0, for REAL it is set to 1. If the value is programmed over a variable $<Number>, then the corresponding bit is also set to 1.

Example:

P1234 A100. X100 -> $C_TYP_PROG == 1.

Only Bit 0 is present, because only A was programmed as REAL.

P1234 A100. C20. X100 -> $C_TYP_PROG == 5.

Bit 1 and Bit 3 (A and C) are present.

Restrictions:

A maximum of ten I, J, K parameters can be programmed in each block. Only one bit each is provided for I, J, K in the variable $C_TYP_PROG. Hence in $C_TYP_PROG the corresponding bit for I, J and K is always set to 0. Therefore it cannot be derived whether I, J or K is programmed as REAL or as INTEGER.

Modal call (G66, G67)

A modal macro program is called with G66. The specified macro program is executed only if the specified conditions are fulfilled.

- The modal macro program is activated on specifying "G66 P... L... <Parameters>;". The transfer parameters are handled as in G65.
- G66 is deselected by G67.

Table 5- 6 Modal call conditions

Call conditions	Function for mode selection	Function for mode deselection
after executing a traversing command	G66	G67

Specification of a parameter

The transfer parameters are defined by programming an Address A - Z.

Interrelation between address- and system variables

Table 5- 7 Interrelation between addresses and variables and addresses that can be used to call commands

Interrelation between addresses and variables	
Address	System variable
A	$C_A
B	$C_B
C	$C_C
D	$C_D
E	$C_E
F	$C_F
H	$C_H
I	$C_I[0]
J	$C_J[0]
K	$C_K[0]
M	$C_M
Q	$C_Q
R	$C_R
S	$C_S
T	$C_T
U	$C_U
V	$C_V
W	$C_W
X	$C_X
Y	$C_Y
Z	$C_Z

Interrelation between address- and system variables

To be able to use I, J and K, these must be specified in the I, J, K sequence.

As the I, J and K addresses in a block containing a macro call can be programmed up to 10 times, access to the system variables within the macro program for these addresses must take place with an index. The syntax of these three system variables thus is $C_I[..], $C_J[..], $C_K[..]. The corresponding values are saved in the matrix in the sequence in which they were programmed. The number of I, J, K addresses programmed in the block is saved in the variables $C_I_NUM, $C_J_NUM and $C_K_NUM.

Unlike for the remaining variables, one index must always be specified while reading the three variables. The index "0" is always used for cycle calls (e.g. G81), for example, N100 R10 = $C_I[0]

Table 5- 8 Interrelation between addresses and variables and addresses that can be used to call commands

Interrelation between addresses and variables	
Address	**System variable**
A	$C_A
B	$C_B
C	$C_C
I1	$C_I[0]
J1	$C_J[0]
K1	$C_K[0]
I2	$C_I[1]
J2	$C_J[1]
K2	$C_K[1]
I3	$C_I[2]
J3	$C_J[2]
K3	$C_K[2]
I4	$C_I[3]
J4	$C_J[3]
K4	$C_K[3]
I5	$C_I[4]
J5	$C_J[4]
K5	$C_K[4]
I6	$C_I[5]
J6	$C_J[5]
K6	$C_K[5]
I7	$C_I[6]
J7	$C_J[6]
K7	$C_K[6]
I8	$C_I[7]
J8	$C_J[7]
K8	$C_K[7]
I9	$C_I[8]
J9	$C_J[8]
K9	$C_K[8]
I10	$C_I[9]
J10	$C_J[9]
K10	$C_K[9]

Note

If more than one block of I, J or K addresses are specified, then the sequence of the addresses for each block of I/J/K is determined in such a way that the numbers of the variables are defined according to their sequence.

Example of entering a parameter

The value of the parameter contains a sign and a decimal point, independently of the address.

The value of the parameters is always saved as actual value.

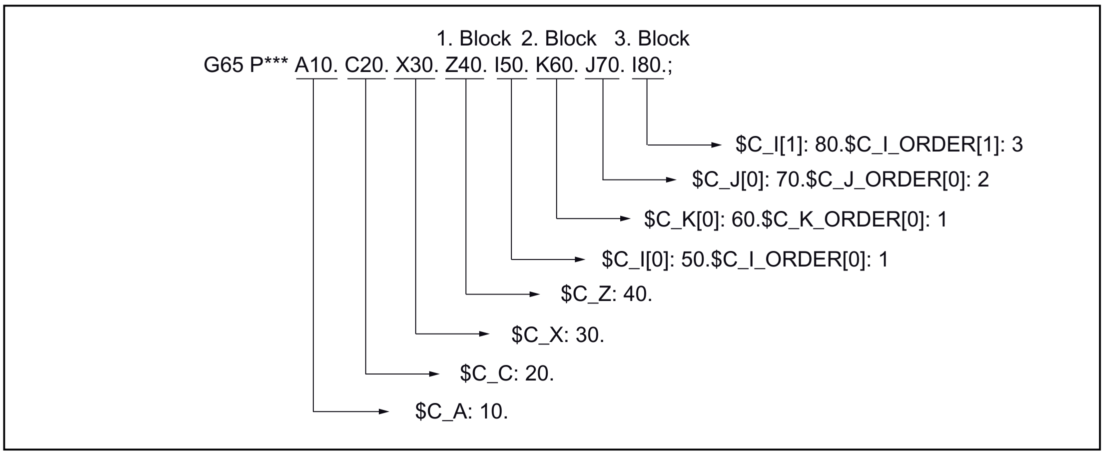


Figure 5-22 Example of entering an argument

Execution of macro programs in the Siemens and ISO modes

A called macro program can be called either in the Siemens mode or in the ISO mode. The language mode in which the program is executed is defined in the first block of the macro program.

If a PROC <Program name> instruction exists in the first block of a macro program, then an automatic changeover to the Siemens mode is conducted. If this instruction is missing, the processing is done in the ISO mode.

The transfer parameters can be saved in local variables by executing a program in the Siemens mode. In the ISO mode however, it is not possible to store transfer parameters in local variables.

To read transfer parameters in a macro program executed in the ISO mode, one must first change over to the Siemens mode with the G290 command.

Examples

Main program with macro call:

```
_N_M10_MPF:

N10 M3 S1000 F1000

N20 X100 Y50 Z33

N30 G65 P10 F55 X150 Y100 S2000

N40 X50

N50 ....

N200 M30
```

Tool Macro program in the Siemens mode:

```
_N_0010_SPF:
PROC 0010 ; Changeover to the Siemens mode
N10 DEF REAL X_AXIS ,Y_AXIS, S_SPEED, FEED
N15 X_AXIS = $C_X Y_AXIS = $C_Y S_SPEED = $C_S FEED = $C_F
N20 G01 F=FEED G95 S=S_SPEED
...
N80 M17
```

Macro program in the ISO mode:

```
_N_0010_SPF:
G290; Changeover to the Siemens mode,
    ; to read the transfer parameters
N15 X_AXIS = $C_X Y_AXIS = $C_Y S_SPEED = $C_S FEED = $C_F
N20 G01 F=$C_F G95 S=$C_S
N10 G1 X=$C_X Y=$C_Y
G291; Changeover to the ISO mode,
N15 M3 G54 T1
N20
...
N80 M99
```

5.6.3 Macro call via G function

Macro call

A macro can be called with a G number analogous to G65.

The replacement of 50 G functions can be configured via machine data:

10816 $MN_EXTERN_G_NO_MAC_CYCLE and

10817 $MN_EXTERN_G_NO_MAC_CYCLE_NAME.

The parameters programmed in the block are stored in the $C_Variables. The number of macro repetitions is programmed with Address L. The number of the programmed G macros is stored in the variable $C_G. All the other G functions programmed in the block are treated as normal G functions. The programming sequence of the addresses and G functions in the block is random, and it does not have any effect on the functionality.

Further information about the parameters programmed in this block is available in Chapter "Macro Program Call (G65, G66, G67)".

Restrictions

- The macro call with a G function can be executed only in the ISO mode (G290).
- Only one G function can be replaced per part program line (or in general, only one subroutine call). If there are possible conflicts with other subroutine calls, e.g. if a modal subroutine is active, the system outputs Alarm 12722 "Several ISO_M/T macro- or cycle calls in block".
- No other G or M macro or M subroutine can be called if a G macro is active. In this case, M macros or M subroutines are executed as M functions. G macros are executed as G functions, provided a corresponding G function exists; otherwise Alarm 12470 "Unknown G function" is output.
- Otherwise the same restrictions are applicable as for G65.

Configuration examples

Calling the subroutine G21_MAKRO via G function G21

$MN_EXTERN_G_NO_MAC_CYCLE[0] = 21

$MN_EXTERN_G_NO_MAC_CYCLE_NAME[0] = "G21_MAKRO"

$MN_EXTERN_G_NO_MAC_CYCLE[1] = 123

$MN_EXTERN_G_NO_MAC_CYCLE_NAME[1] = "G123_MAKRO"

$MN_EXTERN_G_NO_MAC_CYCLE[2] = 421

$MN_EXTERN_G_NO_MAC_CYCLE_NAME[2] = "G123_MAKRO"

Programming example

```
PROC MAIN
. . .
N0090 G291                              ; ISO mode
N0100 G1 G21 X10 Y20 F1000 G90          ; Call of G21_MAKRO.spf,
                                        ; G1 and G90 are activated
                                        ; before the call of
                                        ; G21_MAKRO.spf
. . .
N0500 G90 X20 Y30 G123 G1 G54           ; Call of G123_MAKRO.spf,
                                        ; G1, G54 and G90 are activated
                                        ; before the call of
                                        ; G123_MAKRO.spf
. . .
N0800 G90 X20 Y30 G421 G1 G54           ; Call of G123_MAKRO.spf,
                                        ; G1, G54 and G90 are activated
                                        ; before the call of
                                        ; G123_MAKRO.spf
. . .
N0900 M30
PROC G21_MAKRO
```

```
. . .
N0010 R10 = R10 + 11.11
N0020 IF $C_X_PROG == 0
N0030 SETAL(61000)                      ; programmed variable not transferred
                                        ; correctly
N0040 ENDIF
N0050 IF $C_Y_PROG == 0
N0060 SETAL(61001)
N0070 ENDIF
N0080 IF $C_F_PROG == 0
N0090 SETAL(61002)
N0100 ENDIF
N0110 G90 X=$C_X Y=$C_Y
N0120 G291
N0130 G21 M6 X100                       ; G21->activate metric measuring
                                        ; system (no macro call)
N0140 G290
. . .
N0150 M17
PROC G123_MAKRO
. . .
N0010 R10 = R10 + 11.11
N0020 IF $C_G == 421 GOTOF label_G421   ; Macro functionality for G123
N0040 G91 X=$C_X Y=$C_Y F500
. . .
. . .
N1990 GOTOF label_end
N2000 label_G421:                       ; Macro functionality for G421
N2010 G90 X=$C_X
Y=$C_Y F100
N2020
. . .
. . .
N3000 G291
N3010 G123                              ; Alarm 12470, because G123 is not a
                                        ; G function and a
                                        ; macro call is not possible for
                                        ; active macro
                                        ;
                                        ; Exception: The macro was called
                                        ; as subroutine with CALL
                                          G123_MAKRO.
N4000 label_end: G290
N4010 M17
```

5.7 Special functions

5.7.1 Contour repetition (G72.1, G72.2)

A contour programmed once can be repeated easily with G72.1 and G72.2. This function can be used to create either a linear copy (G72.2) or a rotational copy (G72.1).

Format

G72.1 X... Y... (Z...) P... L... R...

X, Y, Z: Reference point for coordinate rotation

P: Subroutine number

L: Number of subroutine passes

R: Roll angle

A subroutine containing the contour to be copied can be called multiple times with G72.1. The coordinate system is rotated by a certain angle before calling each subroutine. The coordinate rotation is executed around a vertical axis on the selected plane.

G72.2 I... J... K... P... L...

I, J, K: Position to which the X, Y Z axes are traversed before calling the subroutine.

P: Subroutine number

L: Number of subroutine passes

A subroutine containing the contour to be repeated can be called multiple times with G72.2. The axes programmed with I, J and K must be traversed incrementally before each subroutine call. The cycle (CYCLE3721) is used to call the subroutine as often as is specified in Address "L". A distance programmed in I, J and K and calculated from the starting point is traversed before each subroutine call.

Examples

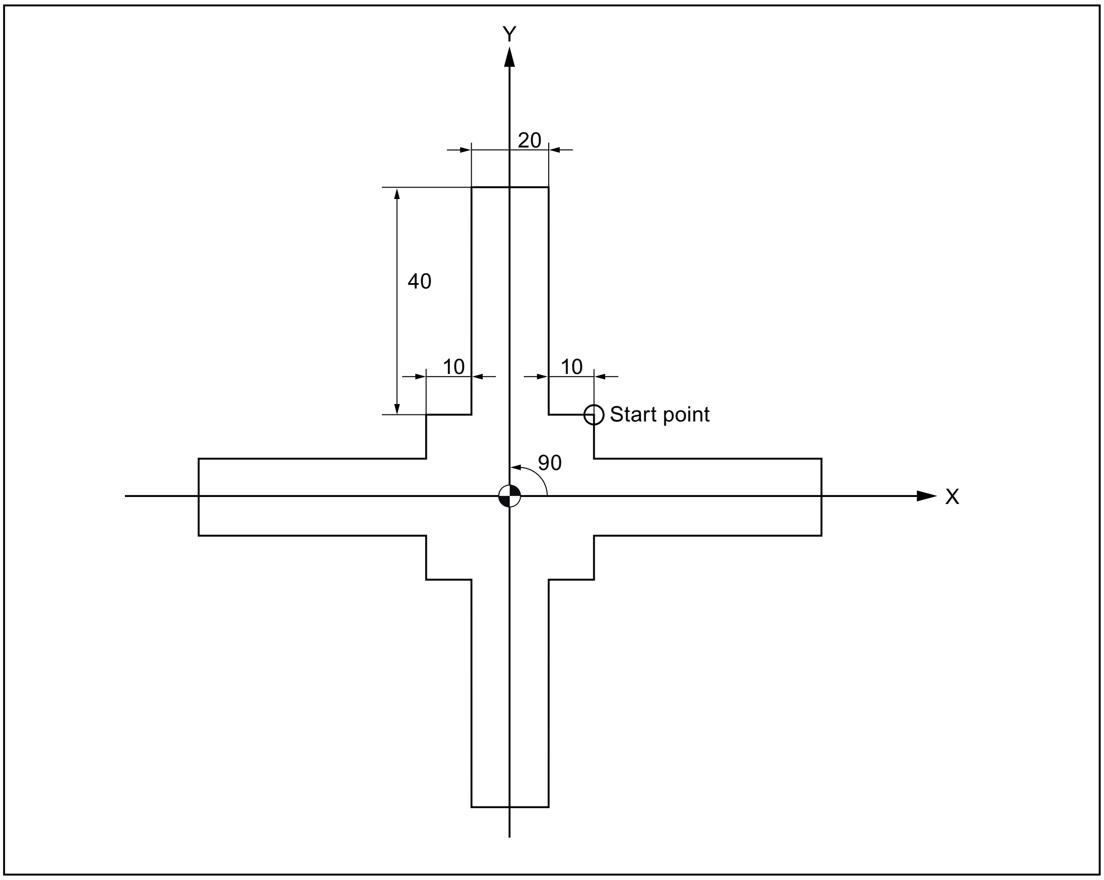


Figure 5-23 Contour repetition with G72.1

Main program

```
N10 G92 X40.0 Y50.0
N20 G01 G90 G17 G41 20 Y20 G43H99 F1000
N30 G72.1 P123 L4 X0 Y0 R90.0
N40 G40 G01 X100 Y50 Z0
N50 G00 X40.0 Y50.0 ;
N60 M30 ;
```

Subroutine 1234.spf

```
N100 G01 X10.
N200 Y50.
N300 X-10.
N400 Y10.
N500 X-20.
N600 M99
```

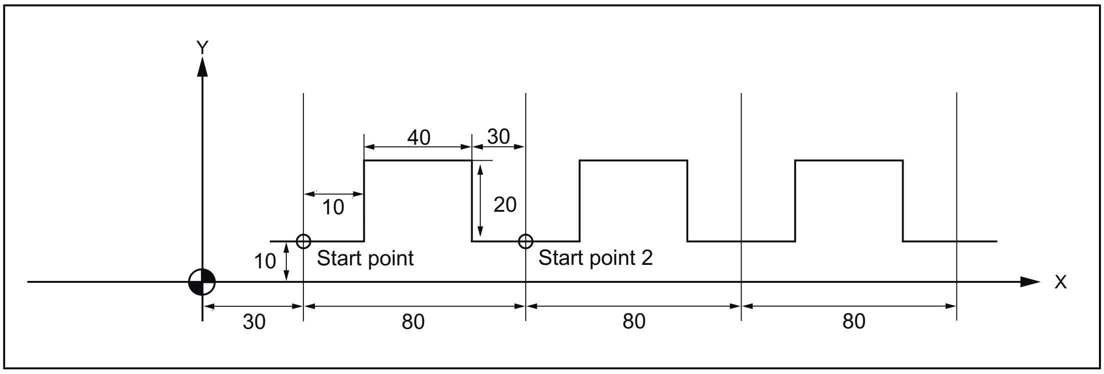


Figure 5-24 Contour repetition with G72.2

Main program

```
N10 G00 G90 X0 Y0

N20 G01 G17 G41 X30. Y0 G43H99 F1000

N30 Y10.

N40 X30.

N50 G72.2 P2000 L3 I80. J0
```

Subroutine 2000.mpf

```
G90 G01 X40.

N100 Y30.

N200 G01 X80.

N300 G01 Y10.

N400 X110.

500 M99
```

5.7.2 Switchover modes for DryRun and skip levels

Changeover of the skip levels (DB3200.DBB2) always represents an intervention in the program run, which has led to a short-term drop in velocity on the path. The same is true of the changeover of the DryRun mode (DryRun = dry run feedrate DB3200.DBX0.6) from DryRunOff to DryRunOn or vice-versa.

All the drops in velocity can be avoided with a changeover mode that is limited in its function.

No drop in velocity is required with a setting machine data 10706 $MN_SLASH_MASK==2 while changing the skip levels (i.e., a new value in the PLC->NCK-Chan interface DB3200.DBB2).

Note

The NCL processes blocks in two steps, the preprocessing and main runs (also pre-travel and main run). The result of the premachining changes to the preprocessing memory. The main machining takes the relevant oldest block out of the preprocessing memory and traverses its geometry.

Note

The premachining is changeover with the setting machine data $MN_SLASH_MASK==2 during a change of the skip level! All blocks located in the preprocessing memory are traversed with the old skip level. The user normally does not have any control over the fill level of the preprocessing memory. The user can see the following effect: **A new skip level is effective "some time" after the changeover!**

Note

The part program command STOPRE vacates the preprocessing memory. If one switches the skip level before STOPRE, then all the blocks after STOPRE are changed over securely. The same is valid for an implicit STOPRE.

No drop in velocity is required while changing the DryRun mode with the setting machine data 10704 $MN_DRYRUN_MASK==2. Here too, only the premachining that leads to the above-mentioned restrictions, is switched. The following analogy is apparent from this: **Notice! This will also be active "sometime" after the changeover of the DryRun mode!**

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